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CHEMISTRY—SEPARATION PROCESSES
FOR PLUTONIUM AND URANIUM

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# BIBLIOGRAPHY ON NUCLEAR REACTOR FUEL REPROCESSING AND WASTE DISPOSAL

Volume 1

Chemistry and Physics of Important Elements

T. F. Connolly

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# PROCESSING OF NUCLEAR REACTOR FUELS – A BIBLIOGRAPHY

## Introduction

This volume includes Section 1.0 of eight sections of a bibliography on nuclear reactor fuel reprocessing and waste disposal. The collection will be a unit, and cross references are made between volumes. The decimal coding of headings is designed for ease of cross referencing, filing, expansion, and for future use in an automatic microfilm viewer-printer now being developed.

Cutoff points are somewhat arbitrary: overlapping into the area of feed materials, for example, is kept to a minimum, even though fuel reprocessing and fuel refabrication can be a continuous operation. Continuous on-site reprocessing of aqueous reactor fuels is only lightly covered.

Section 1.0, Chemistry and Physics of Important Elements, contains many references to separation methods and conditions, particularly on a laboratory scale. Cross references to that section from Sections 2.0, 3.0, and 6.0 – to each of which it may be considered as peripheral – would be too numerous to be included and should be assumed for each element. Special tests or uses (e.g., as construction materials or reagents in standard processes) are treated in the appropriate sections.

The complete collection includes about 7000 abstracts, nearly all from Nuclear Science Abstracts, representing books, bibliographies, symposia, journals, and contractors' topical reports. Most of the material dates from the 1955 Geneva Conference to the present. A serious lack is material from progress reports, and a program for the detailed abstracting and indexing of progress reports is therefore under way at ORNL (with the helpful cooperation of the Cataloging Section of the AEC-DTI Extension).

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# ALUMINUM 1.01

**16373**
STUDIES OF THE ANODIC BEHAVIOR OF ALUMINUM. I. THE DIRECTION OF IONIC MOVEMENT. John E. Lewis and Robert C. Plumb (Aluminum Co. of America, New Kensington, Penna.). J. Electrochem. Soc. 105, 496-8(1958) Sept.

It is demonstrated, by a series of marker experiments, in which layers of nonporous anodic oxide were tagged by incorporating radioactive material in them, that nonporous anodic oxide grows at, or close to, the oxide-electrolyte interface; it is concluded that the aluminum ion is the mobile species. Similar experiments with a porous oxide may also be interpreted in terms of formation of the oxide at the oxide-electrolyte interface, but in this case the interface is at the bottom of pores filled with electrolyte. (auth)

STUDY OF THE COMBINATIONS OF THE SULFIDES OF THE RARE EARTHS AND OF ALUMINUM.
Jean Flahaut, Madeleine Patrie, and Louis Domange. Compt. rend. 247, 1866-9(1958) Nov. 24. (In French)

Aluminum sulfide, as well as gallium sulfide, gives with the rare earth sulfides some well crystallized equimolecular combinations, whose crystallographic properties are described. In the case of lanthanum sulfide, the addition of aluminum sulfide with the ratio Al/Al+La approximately 0.69 leads to the formation of a glass amorphous to x rays and with a low fusion point. (tr-auth)

**7218**
THERMOLUMINESCENCE STUDIES OF ALUMINUM OXIDE. James K. Rieke and Farrington Daniels (Univ. of Wisconsin, Madison). J. Phys. Chem. 61, 629-33(1957) May.

Gamma-ray induced thermoluminescence of aluminum oxides depends on the extent of hydration and the crystal form produced by different calcining treatments. A peak at 236°C depends on sodium impurity. Surface thermoluminescence can be induced by visible light in partially hydrated alumina. (auth)

**10941** NYO-6633
Carnegie Inst. of Tech., Pittsburgh.
LONG-LIVED ALUMINUM-26 (thesis). Robert A. Rightmire. June 3, 1957. 166p. Contract AT(30-1)-844. $4.25(OTS).

Theoretical and experimental evidence has indicated a level in $Al^{26}$ below the 6 sec $0^+$ level. The ground state lies 4.01 ± 0.02 Mev above that of $Mg^{26}$, has a $5^+$ configuration, and evidently is very long-lived. $Al^{26}$ and $Na^{22}$ are produced simultaneously by deuteron and proton bombardment of magnesium targets. Chemical procedures for isolating each nuclide in carrier-free and radiochemically pure state were developed. The maximum positron energy of the long-lived ground state of $Al^{26}$ was determined to be 1.16 ± 0.02 Mev. The scintillation gamma spectrum shows four full-energy peaks. The most intense, at 0.51 Mev, is due to positron annihilation. A strong peak at 1.83 Mev and two weak peaks at 1.14 and 2.97 Mev correspond to transitions from the known $Mg^{26}$ first and second excited states. The relative intensities of the annihilation and gamma radiations indicate that $Al^{26}$ undergoes 85.5 ± 1.8% positron emission to the 1.83 Mev state of $Mg^{26}$; 11.5 ± 1.9% electron capture to the same state; 3.7 ± 0.3% electron capture to the 2.97 Mev state followed by emission of 1.14 and 1.83 Mev gamma rays; 0.30 ± 0.06% electron capture to the same state followed by 2.97 Mev radiation. The resulting disintegration scheme is shown. Thick target bombardment yields of natural magnesium with 15-Mev deuterons were determined to be: $Al^{26}$, (1.4 ± 0.13) dis/min/μah; $Na^{22}$, (4.6 ± 0.3) × $10^6$ dis/min/μah. Yields using 20.8 Mev protons gave: $Al^{26}$, (3.5 ± 0.4) dis/min/μah; $Na^{22}$, (1.92 ± 0.19) × $10^6$ dis/min/μah. A total of 2300 ± 300 dis/min of $Al^{26}$ was isolated from an aluminum sheet exposed to 8 × $10^{20}$ neutrons/$cm^2$ in a reactor. The half-life of $Al^{26}$ was estimated at 1 × $10^6$ yrs from the ratio of $Al^{26}$ activity to $Na^{22}$ activity. A determination of the half-life by the specific activity method yielded a preliminary result of (6 ± 3) × $10^5$ years. (W.D.M.)

# ALUMINUM 1.01

~~10122~~

RESONANT ABSORPTION OF GAMMA RADIATION FROM THE $Al^{27}(p,\gamma)Si^{28}$ REACTION. P. B. Smith and P. M. Endt (Rijksuniversiteit, Utrecht). Phys. Rev. 110, 397-402(1958) Apr. 15.

Gamma rays emitted by excited $Si^{28}$ formed in the reaction $Al^{27}(p,\gamma)Si^{28}$ at $E_p$ = 771 kev have been selectively absorbed in silicon. Selective, or resonant, absorption occurs when the absorber is placed at such an angle that the loss of energy upon emission and reabsorption of the photons is restored by the Doppler shift resulting from the forward motion of the excited $Si^{28}$ nucleus. A narrow slit in a lead collimator is filled with silicon powder, and the transmitted gamma radiation is detected by a scintillation counter. The absorption dip observed as the collimator is rotated through the resonant angle has a width of 0.75 degree, the maximum absorption amounting to 21%. From the integral of the absorption as a function of angle, and from an absolute measurement of the $(p,\gamma)$ integral cross section, the radiation width for transition to the ground state ($E_\gamma$ = 12.33 Mev) is determined to be 5.2 ± 0.5 ev, while 2.0 ± 0.5 ev is found for the proton width, and 9.0 ± 0.8 ev for the total width. The half life calculated from the latter is $(4.5 \pm 0.4) \times 10^{-17}$ sec. These values, together with the angular distribution of the ground-state radiation, are consistent with a $1^+$ assignment to the resonance level. (auth)

$Al^{26}$ DECAY SCHEME. James M. Ferguson (Massachusetts Inst. of Tech., Cambridge). Phys. Rev. 112, 1238-40(1958) Nov. 15.

The energies and intensities of the beta and gamma radiations from the long-lived ground level of $Al^{26}$ were studied with scintillation spectrometers. The positron spectrum was obtained using a plastic scintillator with $4\pi$ geometry and was found to have a forbidden shape and an endpoint of 1.160 ± 0.008 Mev. The positrons are in coincidence with a gamma ray with an energy of 1.84 ± 0.01 Mev, which is presumably from the first excited level of $Mg^{26}$. There is also a weak gamma ray with an energy of 1.10 ± 0.05 Mev, in coincidence with the 184-Mev gamma ray, and with an intensity of 0.03 relative to the 1.84-Mev gamma ray. This would be from the second excited level of $Mg^{26}$, to which the $Al^{26}$ decays weakly by electron capture. No other gamma rays are observed. It appears that a peak in the pulse-height spectrum at 700 kev is due to scattering effects rather than a gamma-ray photopeak. (auth)

**4237**

AN ENHANCEMENT OF CATALYTIC ACTIVITY BY GAMMA RADIATION. Ellision H. Taylor and Harold W. Kohn (Oak Ridge National Lab., Tenn.). J. Am. Chem. Soc. 79, 252-3(1957) ~~Jan. 5.~~

Evidence is presented for the production by $\gamma$-rays of a marked increase in catalytic activity of $Al_2O_3$. (W.L.H.)

# AMERICIUM 1.02

See also, this section,

CURIUM (1.13)

and

TRANSURANICS (GENERAL) (1.42)

6491 A/CONF.15/P/2127
THE INVESTIGATION ON THE AMERICIUM CHEMISTRY. G. N. Yakovlev and V. N. Kosyakov (U.S.S.R.) 40p.

A number of methods are known for the separation of Am and Cm, including precipitation reactions and extraction and chromatographic methods. New data obtained during the study of some of these processes are presented and discussed. Some problems of the americium chemistry are examined, such as the solubility of low-soluble compounds, the composition and absorption spectra of crystals of double sulphates of Am(III) with alkali metals, and oxidation-reduction reactions occurring in Am solutions of different valences. The results of studies of the disproportionation reaction of Am(V), depending on acidity, acid anion, and temperature are given. Radiation-chemical processes in aqueous solutions due to high specific activity of $Am^{241}$ are considered. (auth)

AMERICIUM AND CURIUM. Thomas K. Keenan (Los Alamos Scientific Lab., N. Mex.). J. Chem. Educ. 36, 27-31(1959) Jan.

The chemistry of americium and curium is discussed, and methods for producing these elements are reviewed. Americium shows reactions typical of a highly electropositive metal and is capable of existing in solution as a hydrated trivalent ion or as a doubly oxygenated (V) or (VI) ion. Tetravalent americium can exist in certain solid compounds but has never been found in acid solution because of its ability to oxidize water or undergo disproportionation. The solution chemistry of the (V) and (VI) states of Am is complicated by the self-reduction of the ion concerned and has not been examined thoroughly. It has not been possible to attain any oxidation state of curium other than (III) in solution although a (IV) state can exist in the solid. The use of curium-244 (which has a 17.9 year half life) enabled certain new discoveries to be made in curium chemistry which probably never would have been possible with extremely active curium-242. (J.H.M.)

11352
THE PROPERTIES OF AMERICIUM AND EUROPIUM AND THEIR HOMOLOGY IN THE PERIODIC TABLE. G. E. Villar (Instituto de Tecnologia y Quimica de la Facultad de Ingeniería, Montevideo, Uruguay). Anales fac. quim. farm. 4, 33-40(1955). (In Spanish)

The physical and chemical properties of americium and europium are compared, and the differences which are found, especially in the valencies, indicate that the electron shells of the two are not necessarily the same. A $5f^6$, $6d^1$, $7s^2$ configuration is suggested for americium, although spectroscopic evidence indicates that europium has a $4f^7$, $6s^2$ configuration. (J.S.R.)

11135
THE SELF-REDUCTION OF AMERICIUM(V) AND (VI) AND THE DISPROPORTIONATION OF AMERICIUM(V) IN AQUEOUS SOLUTION. G. R. Hall and T. L. Markin (Atomic Energy Research Establishment, Harwell, Berks). J. Inorg. and Nuclear Chem. 4, 296-303(1957).

The kinetics of the self-reduction of Am(V) and Am(VI) have been studied in $HClO_4$. A mechanism is postulated which accounts for the nonappearance of Am(III) during the simultaneous self-reduction of Am(V) and Am(VI) in dilute acid solutions. Am(IV), produced by the disproportionation of Am(V) in moderately concentrated perchloric acid solutions, is reduced to Am(III) and does not react with Am(V) The decrease in the value of the rate constant for the self-reduction of Am(VI) with increasing sulfuric acid concentration, is shown to be due to the increase in the rate of disproportionation of Am(V). (auth)

14233 NP-7514
KINETIKA VOSSTANOVLENIYA AMERITSIYA(V) PEREKIS'YU VODORODA. (Kinetics of Americium(V) Reduction by Hydrogen Peroxide.) A. A. Zaitsev, V. N. Kosyakov, A. G. Rykov, Yu. P. Sobolev, and G. N. Yakovlev. [nd]. 9p.

The kinetics of americium(V) reduction by hydrogen peroxide in 0.1 M hydrochloric acid was investigated. The reactor rate constants determined at 25, 30, and 35°C were 14.8 ± 1.5, 21.6 + 2.2, and 30.3 ± 3.0 moles/l/hr. The reaction activation energy (Arrhenius) and the activated complex enthalpy changes were $\Delta E$ = 13.3 kcal/mole and $\Delta H^{\perp}$ = 12.7 kcal/mole. (tr-auth)

# AMERICIUM 1.02

**5149**
THE STATE OF MICROQUANTITIES OF RADIOELEMENTS IN SOLUTIONS. XIV. INVESTIGATION OF AMERICIUM IN AQUEOUS SOLUTIONS. I. E. Starik and F. L. Ginzburg. Radiokhimiya 1, 435-8(1959). (In Russian)

The adsorption of Am by quartz glass was studied as a function of pH. The maximum adsorption from nitric acid solutions with americium concentration $10^{-9}$ M is found at pH 6.5 to 7.0. Microquantities of colloidal americium were determined by ultrafiltration. The adsorption, desorption, and ultrafiltration data indicate predominantly ion dispersion americium in solutions with pH 1 to 4.5. An increase of pH tends to enhance hydrolysis, and with pH > 7 leads to colloidal particle formation. (R.V.J.)

United Kingdom Atomic Energy Authority. Research Group. Atomic Energy Research Establishment, Harwell, Berks, England.
BIBLIOGRAPHY ON AMERICIUM. Apr. 1952. 6p. (AERE-Inf/Bib-86).

The bibliography contains report literature and a listing of published literature taken from *Chemical Abstracts* since 1945.

**14235** NP-7517
DISPROPORTSIONIROVANIE AMERITSIYA(IV). (Disproportionation of Americium(IV).) A. A. Zaitsev, V. N. Kosyakov, A. G. Rykov, Yu. P. Sobolev, and G. P. Yakovlev. [nd]. 7p.

Qualitative studies were made of the americium(IV) disproportionation reaction in sulfuric acid solutions. The total disproportionation reaction is 3 Am(IV) → 2 Am(III) + Am(VI), following two parallel reactions: $2\ Am^{4+} + 2H_2O \rightarrow Am^{3+} + AmO_2^+ + 4H^+$, $Am^{4+} + AmO_2^+ \rightarrow Am^{3+} + AmO_2^{2+}$. (tr-auth)

**7154** AEC-tr-2919
THE ATOMIC SPECTRUM OF AMERICIUM. M. N. Oganov, A. R. Striganov, and Yu. P. Sobolev. Translated by L. Bovey from Optika i Spektroskopiya 1, 965-71(1956). 3p.

**8321**
THE ALPHA HALF-LIFE OF $Am^{241}$. G. R. Hall and T. L. Markin (Atomic Energy Research Establishment, Harwell, Berks, England). J. Inorg. and Nuclear Chem. 2, 202-3 (1956) Mar.

A mean value of 461.3 ± 1.7 yr was obtained for the $\alpha$ half life of $Am^{241}$. The corresponding value for the half life of $Pu^{241}$ is 13.25 yr. (C.W.H.)

**1102** CRDC-805
Atomic Energy of Canada Ltd. Chalk River Project, Chalk River, Ont.
RAPID SIMULTANEOUS DETERMINATION OF Pu-IV AND Am-III IN NITRIC ACID SOLUTION. T. Bruce. Aug. 1958. 13p. (AECL-699). $0.50(AECL).

A rapid method for the separation and determination of Americium(III) and Plutonium(IV) was developed. Zirconium is added to the solution to be analyzed as a carrier for the plutonium, and phenyl arsonic acid is added as a precipitant. The zirconium together with the plutonium is precipitated, leaving the americium in the supernatant phase. The americium and plutonium are then determined by alpha counting. The americium values obtained are about 5% high and the plutonium values are low by a like amount. Precision obtained is about ±2%. The report is divided into two principal parts. Part A describes development of the analytical method using synthetic solutions made from standard americium and plutonium solutions. Part B describes the application of the procedure to a process solution.

RADIATIONS OF AMERICIUM-246. H. L. Smith, C. I. Browne, D. C. Hoffman, J. P. Mize, and M. E. Bunker (Los Alamos Scientific Lab., N. Mex.). J. Inorg. and Nuclear Chem. 3, 93-103(1956) Sept.

The beta spectra of an equilibrium sample of $Pu^{246}-Am^{246}$ were examined with a magnetic-lens beta-ray spectrometer and a scintillation spectrometer. The $Pu^{246}-Am^{246}$ equilibrium sample and samples of $Am^{246}$ were investigated with gamma-ray scintillation spectrometers. Coincidence studies of the radiations were also performed. The data indicate that the decay of $Am^{246}$ is extremely complex, involving five beta-ray groups and many gamma rays. On the basis of gamma-beta coincidence measurements, the disintegration energy is 2.41 ± 0.10 Mev. (auth)

**2210**
THE NEW ISOTOPES $Pu^{246}$ AND $Am^{246}$. D. Engelkemeir, P. R. Fields, S. Fried, G. L. Pyle, and C. M. Stevens (Argonne National Lab., Lemont, Ill.) and L. B. Asprey, C. I. Browne, H. Louise Smith, and R. W. Spence (Los Alamos Scientific Lab., N. Mex.). J. Inorg. and Nuclear Chem. 1, 345-51(1955) Dec.

The half lives of $Pu^{246}$ and $Am^{246}$ were estimated to be 11.2 ± 0.2 days and 25 ± 0.2 min, respectively. The total disintegration energy of $Am^{246}$ was determined to be 2.29 Mev. (C.W.H.)

# AMERICIUM 1.02

**459**

THE DECAY CHAIN $Pu^{245}-Am^{245}-Cm^{245}$. C. I. Browne, D. C. Hoffman, W. T. Crane, J. P. Balagna, G. H. Higgins, J. W. Barnes, R. W. Hoff, H. L. Smith, J. P. Mize, and M. E. Bunker (Los Alamos Scientific Lab., N. Mex.). J. Inorg. and Nuclear Chem. 1, 254-61(1955) Oct.

$Pu^{245}$ and $Am^{245}$, have been produced by neutron irradiation methods. The study of the radiations of these nuclides is described and a preliminary decay scheme for $Am^{245}$ is presented. (auth)

**2208**

ALPHA-DECAY PROPERTIES OF $Am^{239}$. Frank Asaro, F. S. Stephens, Jr., W. M. Gibson, R. A. Glass, and I. Perlman (Univ. of California, Berkeley). Phys. Rev. 100, 1541-2 (1955) Dec. 1.

A study was made of the $Am^{239}$ decay in order to determine whether the favored alpha transition led to a state of $Np^{235}$ which was de-excited by an E1 transition. The sample was prepared by deuteron irradiation of $Pu^{239}$, and a ZnS screen was used for the $\alpha$ detector. The $\alpha$-$\gamma$ coincidence spectrum and the $Am^{239}$ decay scheme are shown. Results show that almost every $\alpha$ disintegration of $Am^{239}$ goes through a 48-kev state to $Np^{235}$, and the transition is identified as E1. (B.J.H.)

RADIOACTIVE DECAY OF THE ISOMERS OF AMERICIUM-242. R. W. Hoff, H. Jaffe, T. O. Passell, F. S. Stephens, E. K. Hulet, and S. G. Thompson (Univ. of California Radiation Lab., Berkeley). Phys. Rev. 100, 1403-6(1955) Dec. 1.

The decay characteristics of the two isomers of $Am^{242}$ have been investigated. The $\beta$ decay of the 16-hour $Am^{242m}$ has a branching ratio of 51 ± 5% to the first-excited state (42.3 kev) of $Cm^{242}$ with the remainder of the decay going to the ground state. The electron-capture decay of $Am^{242m}$ has a branching ratio of approximately 60% to the first-excited state (44.8 kev) of $Pu^{242}$. An upper limit of 6% has been set for the fraction of $Am^{242m}$ decay via isomeric transition. The $\beta$ decay of the 100-year $Am^{242}$ has a branching ratio of 45 ± 5% to the first-excited state of $Cm^{242}$, with the remainder of the decay going to the ground state. The $\beta$-spectrum end points for $Am^{242m}$ and $Am^{242}$ have been measured to be 620 ± 10 kev and 585 ± 10 kev, respectively. A decay scheme for the two isomers has been proposed. Log ft values have been calculated for $\beta$ and electron-capture decay of the isomers and are discussed in conjunction with spin and parity assignments. (auth)

**5539**

THE MASS YIELD CURVE FOR FISSION OF $Am^{241}$ BY NEUTRONS. J. G. Cuninghame (Atomic Energy Research Establishment, Harwell, Didcot, Berks). J. Inorg. and Nuclear Chem. 4, 1-7(1957) Feb.

Relative yields for the fission of $Am^{241}$ by pile neutrons have been measured for mass numbers 89, 91, 95, 97, 99, 111, 113, 115, 121, 131, 132, 136, (shielded), 137, 139, 140, 141, 143, 144, 147 and 153. The peak-to-trough ratio is ~160 and $\bar{\nu}$ is 3 ± 0.5. The light peak has moved two mass units towards the heavy peak when compared with the $Pu^{239}$ thermal fission curve. (auth)

MEAN NUMBER OF NEUTRONS EMITTED IN $Am^{241}$ FISSION BY THERMAL NEUTRONS. V. I. Lebedev and V. I. Kalashnikova. Atomnaya Energ. 5, 176-7 (1958). (In Russian)

The mean number of neutrons emitted in a single $Am^{241}$ fission ($\nu$) by thermal neutrons was determined in relation to the magnitude of $\nu$ for $U^{235}$. The ratio $\nu(Am^{241})/\nu(U^{235}) = 1.27 \pm 0.01$ was obtained on the basis of the universally accepted value $\nu(U^{235}) = 2.47 \pm 0.03$.

**1914**

**NEUTRON YIELDS FROM AMERICIUM-BERYLLIUM ALLOYS. O. J. C. Runnalls and R. R. Boucher (Atomic Energy of Canada, Ltd., Chalk River, Ont.). Nature 176, 1019-20(1955) Nov. 26.**

**Two Am-Be alloys were prepared having atom ratios of 1:263 and 1:14. The respective neutron yields were 2.13 ± 0.02 × $10^5$ and 1.57 ± 0.02 × $10^5$ n/sec. Methods of alloy preparation and counting techniques are described. (D.E.B.)**

**3024** ANL-WMM-1140

Argonne National Lab., Lemont, Ill.

THE COMPOSITION OF PLUTONIUM, AMERICIUM, AND CURIUM RESULTING FROM IRRADIATION OF $Am^{241}$ IN A HIGH NEUTRON FLUX. Paul Fields and Molly Ann Weiss. Feb. 20, 1953. Decl. Nov. 22, 1955. 10p. Contract [W-31-109-Eng-38].

The isotopic composition of americium and the conversion of $Am^{241}$ to $Cm^{242}$ as a function of time of irradiation in a high neutron flux has been calculated using the known cross sections. The major components of the plutonium and curium fractions from the $Am^{241}$ irradiation were also calculated where sufficient data on cross sections were available. (auth)

# ANTIMONY 1.03

**16304**

THE SOLVENT EXTRACTION OF TRACE ANTIMONY (V). George K. Schweitzer and L. Eldon Storms (Univ. of Tennessee, Knoxville). Anal. Chim. Acta 19, 154-61(1958) Aug.

An investigation of the extraction of trace amounts of antimony(V) from aqueous hydrochloric acid solutions into various ethers and chloroform has been carried out. Before extractions were made, mutual solubility studies of the two-phased systems were conducted. Then extraction experiments were performed using original aqueous acid concentrations from 0 to 12N and non-aqueous phases of ethyl ether, isopropyl ether, isoamyl ether, n-hexyl ether, and chloroform. Dielectric constant determinations were made in the equilibrated non-aqueous phases, and spectrophotometric and salting-out studies were carried out on the ethyl ether system. It was found that the isopropyl ether system presents the most advantageous conditions for the extraction of trace antimony(V). (auth)

**7414**

THE MOLECULAR STRUCTURE OF ANTIMONY PENTAFLUORIDE. J. Gaunt and J. B. Ainscough (Atomic Energy Research Establishment, Harwell, Berks and United Kingdom Atomic Energy Authority, Salwick, Lancs., Eng.). Spectrochim. Acta 10, 57-60(1957) Nov.

The infrared and Raman spectra of antimony pentafluoride have been investigated. Five Raman lines were observed and have been assigned as fundamentals. An interpretation of the infrared spectrum has been made in a manner consistent with the rigid selection rules for the trigonal bipyramid structure ($D_{3h}$). The thermodynamic properties have been calculated on the simple harmonic oscillator approximation. (auth)

**9317**

INTERNAL BREMSSTRAHLUNG AND DECAY SCHEME OF $Sb^{119}$. J. L. Olsen, L. G. Mann, and M. Lindner (Univ. of California, Livermore). Phys. Rev. 106, 985-90(1957) June 1.

The spectrum and yield of internal bremsstrahlung accompanying electron capture from S and P states in $Sb^{119}$ were measured and compared with the theory of Glauber and Martin. $Sb^{119}$ was obtained as the daughter from $Te^{119}$ produced by the $Sb(d,xn)Te^{119}$ and $Sn(\alpha,xn)Te^{119}$ reactions. The decay is by orbital electron capture to the 23.83-kev state in $Sn^{119}$. The following results were obtained: $Sb^{119}$ half life, 38.0 hr; $Sb^{119}-Sn^{119}$ decay energy, 579 ± 20 kev; half life of the 23.83-kev state and its total conversion coefficient, $(1.85 \pm 0.1) \times 10^{-8}$ sec and 6.3 ± 0.4, respectively. The intensity of internal bremsstrahlung for capture from S states was $(1.06 \pm 0.15) \times 10^{-4}$ quanta/K capture. This agrees with the theoretical prediction of $0.97 \pm 10^{-4}$. The large contribution at low energies from P-state capture was measured down to 70 kev and agrees with the theory in its present state of completion. (auth)

**9516**

NEW HALF-LIFE IN THE FAMILY OF ANTIMONY ISOTOPES. H. Bosch and H. Munczek (Comisión de Energía Atómica, Buenos Aires, Argentina). Phys. Rev. 106, 983-5 (1957) June 1.

By using scintillation techniques in analyzing the $\gamma$ radiation following the $\beta$ decay of a fission-product antimony sample, evidence of a new half life of 149 ± 4 hours was found in the family of antimony isotopes. (auth)

**6029** ISC-665

Ames Lab., Ames, Iowa.

THE NUCLEAR CHEMISTRY OF ANTIMONY AND TELLURIUM. Marion C. Day, Jr. and Adolf F. Voight. Dec. 1955. Contract W-7405-eng-82. $0.40(OTS).

Decay schemes, spin and parity assignments, and $\beta$ and $\gamma$ energies of $Sb^{127}$, $Sb^{129}$, $Te^{127}$, and $Te^{129}$ are reported. (C.W.H.)

# BARIUM 1.04

Technical Information Service Extension, AEC.
BARIUM; A BIBLIOGRAPHY OF UNCLASSIFIED LITERATURE. Simone B. Schwind. June 9, 1952. 452p. (TID-369).

This is a comprehensive bibliography which is both annotated and indexed. It includes over 4200 references to information on Ba (excepting biological studies) covering the period 1903 to 1951.

~~7225~~ ✓ AEC-tr-2711
THE DIELECTRIC CONSTANT OF BARIUM TITANATE. I. P. Kozlobaev. Translated from Doklady Akad. Nauk S.S.S.R. 104, 387-8(1955). 3p.

5184 ✓ CEA-tr-X-152
SÉPARATION ET DOSAGE DE FAIBLES QUANTITÉS DE BARYUM EN PRÉSENCE DE STRONTIUM ET DE CALCIUM. (Separation and Determination of Small Quantities of Barium in the Presence of Strontium and Calcium). A. Tockstein and V. Novak. Translated into French from Chem. listy 52, 269-75(1958). 19p.

The displacing power of $Co^{2+}$ with respect to EDTA complexes of alkaline earth metals was used in a micromethod for quantitative separation of small quantities of Ba (< 1 mg) as sulfate in the presence of great excesses of Ca and Sr. The $BaSO_4$ was then polarographically determined. For a large number of determinations 81% had errors less than 3%, and in the remaining 19% the error was less than 4.5%. (T.R.H.)

~~1414~~ ✓
THE HALF-LIFE OF $^{139}Ba$. J. P. Butler and B. J. Bowles (Atomic Energy Research Establishment, Harwell, Berks, Eng.). J. Inorg. & Nuclear Chem. 6, 346(1958) July.

Samples of $Ba^{139}$ were prepared by three different methods of irradiation, and chemically purified. A value of 82.9 ± 0.1 min was proposed for the half life. (J.R.D.)

ELECTRON CAPTURE OF $Ba^{133}$ AND EXCITED STATES OF $Cs^{133}$. Steven D. Koički, Anka M. Mijatović, and Jovan M. Simić. Bull. Inst. Nuclear Sci. "Boris Kidrich" (Belgrade) 8, 1-15(1958) Mar.

The decay $Ba^{133} \rightarrow Cs^{133}$ has been investigated by means of a coincidence scintillation spectrometer. The energy values of the most intense transitions are determined to be 81, 302, and 355 Kev. Five new gamma transitions were found having the energies 53, 78, 160, 274, and 380 Kev. The results of the coincidence measurements are given for these gamma rays. A consistent decay scheme is proposed for $Ba^{133} \rightarrow Cs^{133}$. The spin and parity values for the states in $Cs^{133}$ are discussed, together with possible consequences for the Coulomb excitation of $Cs^{133}$. It is also found that the mean mode of the decay of $Ba^{133}$ is the K capture to the highest excited level of $Cs^{133}$, which disagree with the previously reported results. The possible explanation of this capture is discussed. (auth)

ON THE DECAY OF $^{133}Ba$. R. K. Gupta, S. Jha, M. C. Joshi, and B. K. Madan (Tata Inst. of Fundamental Research, Bombay). Nuovo cimento (10) 8, 48-59 (1958) Apr. 1.

The results of $\beta$-ray spectrometer studies and scintillation spectrometer studies of $Ba^{133}$ are presented. A new level in $Cs^{133}$ at 160 kev has been found. The $\gamma$ rays of energies 56, 79, 160, 224, 277, 302, 358, 383, and 437 kev have been detected. The conversion coefficients of some of the $\gamma$ rays have been estimated. It has been found by a combination of the summing technique and the conventional coincidence technique that $Ba^{133}$ decays with an energy of (53 ± 2) kev to the 437 kev state of $Cs^{133}$ by K-electron captures (46%) and L-electron captures (54%). A decay scheme is suggested. (auth)

# BARIUM 1.04

**13757**

DETERMINATION OF THE FISSION YIELDS OF $Ba^{141}$ AND $Ba^{142}$. J. Malý, V. Knobloch, D. Imrišová, Z. Prášil, and Z. Urbanec (Tschechoslowakische Akademie der Wissenschaften, Prague). Collection Czechoslov. Chem. Communs. 23, 1886-95(1958) Oct. (In German)

The fission yields and half lives of the isotopes $Ba^{141}$ and $Ba^{142}$ from $U^{235}$ fission were determined by a radiochemical method, with respect to the $Ba^{139}$ yield at 6.3%. The energy of the beta radiation was determined by an absorption method. The fission yield of $Ba^{141}$ was found to be 5.26 ± 0.32%; the beta energy, 1.93 ± 0.1 Mev; and the half life, 18.3 min. The fission yield of $Ba^{142}$ was found to be 4.90 ± 0.53%; the beta energy, 0.76 ± 0.07 Mev; and the half life, 5.9 min. (tr-auth)

GAMMA RAYS IN THE DECAY OF BARIUM-131. William C. Beggs, Berol. L. Robinson, and Richard W. Fink (Univ. of Arkansas, Fayetteville). Phys. Rev. 101, 149-52(1956) Jan. 1.

Gamma rays accompanying electron capture of 12-day $Ba^{131}$ have been studied with a single-channel scintillation spectrometer. Relative intensities have been determined for the 122-kev (198), 214-kev (148), 372-kev (100), 496-kev plus satellite (360), and 620-kev (33) gamma rays. Three new gamma rays have been found at 823 ± 20 kev (2.0), 917 ± 15 kev (7.2), and 1032 ± 15 kev (11.0), and their assignment to $Ba^{131}$ has been established by chemical purification and half-life. Crystal summing studies confirm that the 620-kev transition is the crossover of the 122-kev and 496-kev transitions, and no significant crystal summing is found for the three new gamma rays. A peak corresponding to 83 kev was observed, which appears to be due to two or more unresolved gamma rays, but no gamma ray could be found at 100 kev. The decay of $Ba^{131}$ was followed for 9 half lives using an end-window beta proportional counter, and the half-life was found to be 11.52 ± 0.08 days. The ratio of the pile neutron cross section for the activation of $Ba^{131}$ to that of long-lived $Ba^{133}$ has been found to be $\sigma(Ba^{130})/\sigma(Ba^{132}) = 1.2 \pm 0.3$. (auth)

# BERKELIUM 1.05

BERKELIUM AND CALIFORNIUM. B. B. Cunningham (Univ. of California, Berkeley). J. Chem. Educ. 36, 32-7(1959) Jan.

A brief review of the discovery and formation of berkelium and californium is given. Isotopes $Bk^{243}$ and $Cf^{245}$, plus those prepared since the initial discovery, are listed. The tabulation includes information on half life, mode of disintegration, and source. Discussions are presented on chemical properties of the elements, chemical investigations by tracer techniques, and isotopic composition. (J.H.M.)

10304 UCRL-3322

~~California. Univ., Berkeley.~~ Radiation Lab.
LIGHT ISOTOPES OF BERKELIUM AND CALIFORNIUM (thesis). Alfred Chetham-Strode, Jr. June 26, 1956. 94p. ~~Contract W-7405-eng-48. $15.30(ph OTS); $6.40 (mf OTS).~~

An experimental study has been made of the light isotopes of Bk and Cf. The new isotopes $Bk^{244}$, $Bk^{247}$, $Bk^{248}$, and $Cf^{244}$ were identified and their properties studied. Radiations from the Bk isotopes of mass numbers 244 through 249 and of the Cf isotopes of mass numbers 244 through 247 were investigated by nuclear spectroscopic and coincidence techniques. Decay schemes are suggested for several of these isotopes, and observed regularities in the decay patterns of analogous nuclides are discussed. Further information is presented on the production of Am and Cm target materials and the yields of Bk and Cf isotopes from the helium-ion bombardment of Am and Cm. (auth)

PROPERTIES OF $Bk^{245}$. L. B. Magnusson, A. M. Friedman, D. Engelkemeir, P. R. Fields, and F. Wagner, Jr. (Argonne National Lab., Lemont, Ill.). Phys. Rev. 102, 1097-1103 (1956) May 15.

The radiation of 5-day electron-capturing $Bk^{245}$ were measured with electron spectrometer, scintillation spectrometer, and alpha pulse analyzer. Conversion electrons from 250-kev and ~390-kev transitions were observed. The electromagnetic spectrum contains L and K x rays and 250- and 380-kev gamma rays. The relative contributions to the x-ray intensities from the primary capture processes and from excited state conversions were determined by counting coincidences between the electromagnetic radiations. $Bk^{245}$ decays primarily by electron capture (L/K = 0.33) to a 250-kev level in $Cm^{245}$. The K and L conversion coefficients of the 250-kev transition are 1.76 and 0.44, respectively, indicating that the transition is M1. About 6% branching decay goes to a level at 630 kev. The lifetimes of the excited states are less than $2 \times 10^{-9}$ sec. The intensity of alpha-particle emission is $1.05 \times 10^{-3}$ per disintegration (alpha half-life 13 yr). Three alpha groups were resolved: 5.89 Mev (26%), 6.17 Mev (41%), and 6.37 Mev (33%). (auth)

# BERYLLIUM 1.06

See also, under HAZARDS AND PROTECTION,

BERYLLIUM (4.01.02).

**5068** ✓ IGR-160(RD/R)
United Kingdom Atomic Energy Authority. Industrial Group H. Q., Risley, Lancs, England.
BERYLLIUM DATA MANUAL. E. L. Francis, comp. June 1, 1959. 37p. BIS.
A compilation of the best available unclassified data on the chemical, mechanical, and physical properties of beryllium is presented. 47 references. (J.R.D.)

**1782** ✓ IG-IS-59(RD/S)
BERYLLIUM. P. Vachet. Translated by R. L. Tams (U.K.A.E.A., Risley) from Chim. & ind. (Paris) 81, 64-77 (1959). 15p.
A review of the chemical and physical properties of Be is presented. Extraction processes are described along with preparation of Be metal. Information on casting and aspects of working are included as well as information on properties and uses of oxides and alloys. (J.R.D.)

**550** ✓ UCRL-5705
California. Univ., Livermore. Lawrence Radiation Lab.
CURRENT BERYLLIUM LITERATURE; A SELECTED BIBLIOGRAPHY, JANUARY 1958 – AUGUST 1959. Zanier D. Lane. Sept. 29, 1959. 33p. Contract W-7405-eng-48. OTS.
This bibliography lists selected articles on beryllium which have appeared in journals received in the library of the Lawrence Radiation Laboratory, Livermore, California, and articles, reports, and books which have appeared in the following abstracting services between January, 1958 and August 1959; Metallurgical Abstracts, U.S. Library of Congress Monthly List of Russian Accessions, Nuclear Science Abstracts, and A.S.M. Review of Metal Literature. Sources for the references are noted in parentheses at the end of entries in the bibliography. (auth)

**4179**
SOME OBSERVATIONS ON THE CHEMISTRY AND BIOCHEMISTRY OF BERYLLIUM. Jack Schubert (Universität, Bern). Chimia (Switz.) 13, 321-8(1959) Oct. (In German)
The history and development of Be are reviewed, and its geochemistry, radiochemistry, analytical chemistry, chemical properties, biochemistry, and toxicology are discussed. (T.R.H.)

THE PROPERTIES OF BERYLLIUM-11. D. E. Alburger and D. H. Wilkinson (Brookhaven National Lab., Upton, N. Y.). Phil. Mag. (8) 3, 1332-3(1958) Nov.
Ajzenburg and Lauritsen (1955) suggested that the energy difference between the ground states of $Be^{11}$ and $B^{11}$ should be about 11.5 Mev and that $Be^{11}$ should therefore be stable by about 0.5 Mev against neutron emission. In this case the Q-value for the reaction $B^{11}(n,p)Be^{11}$ would be about −10.7 Mev. Nurmia and Fink (1958) discovered a beta activity of half life 14.1 ± 0.3 seconds induced in boron by the 14-Mev neutrons and ascribed it to $Be^{11}$. The reaction has been studied by the authors in the same manner. The assignment to $Be^{11}$ has been confirmed, and certain properties of decay have been determined. (A.C.)

**[2487]** ✓ MAB-129-M
National Research Council. Materials Advisory Board.
REPORT OF THE PANEL ON BERYLLIUM. PART I. RAW MATERIALS GROUP. PART II. PHYSICAL METALLURGY GROUP. June 25, 1958. 101p. Contract DA-36-039-sc-76436.
The sources of Be, mining and beneficiating the ores, production, consumption and price history of beryl, development of new sources, and economic and political factors affecting the United States Be supply are surveyed. (J.E.D.)

**4473**
THE METAL BERYLLIUM. D. W. White, Jr. and Je Burke, eds. Cleveland, The American Society for Metals. 1955. 711p.
Sources and uses of Be, its role in the Atomic Energy Program and in industry, the occurrence of the ores, preparation of Be, fluoride and sulfate extraction from beryl, production by electrolysis of $BeCl_2$, methods of fabrication, relation of purity to brittleness in Be, ductility as related to single crystal deformation and fracture and to preferred orientation and grain structure, recovery and recrystallization of cold worked Be, metallography of Be and Be-rich alloys, corrosion in air, water, and liquid metals, preparation of Be-rich alloys, refractory compounds and ceramics of Be, refractory properties of Be oxide, health hazards from Be, and analytical chemistry of Be are discussed. (J.E.D.)

# BERYLLIUM 1.06

~~9721~~

PREPARATION OF BERYLLIUM FLUORIDE FROM BERYLLIA. K. R. Hyde, D. J. O'Connor, and E. Wait (Atomic Energy Research Establishment, Harwell, Berks, Eng.). J. Inorg. and Nuclear Chem. 6, 14-18 (1958) Feb.

The preparation of beryllium fluoride from two samples of beryllia (calcined at 500 and 1400°C) by treatment with anhydrous hydrogen fluoride has been studied in relation to temperature and time of reaction. The optimum temperature is about 220°C, and the amount converted, which may be as high as 98.4 per cent, does not increase appreciably after 1 hr. X-ray analysis has given no evidence for solid solution formation between $BeF_2$ and unreacted BeO. (auth)

~~3268~~

THE SEPARATION OF BERYLLIUM FROM IRON, ALUMINIUM AND TITANIUM BY ION EXCHANGE, AND ITS APPLICATION TO THE ANALYSIS OF BERYL. M. N. Nadkarni, M. S. Varde, and V. T. Athavale (~~Atomic Energy Establishment, Bombay, India~~). Anal. Chim. Acta 16, 421-5(1957) May.

A new ion exchange method is proposed for the separation of Be from Al, Fe, Ti, Ca and phosphate, by preferentially adsorbing it on cation exchange resin Amberlite IR-120, after complexing the other ions with EDTA and $H_2O_2$. The successful application of the method to the analysis of beryls is demonstrated. (auth)

DIMORPHIC MODIFICATIONS OF BERYLLIUM DIIODIDE, $BeI_2$. Rowland E. Johnson, E. Staritzky, and R. M. Douglass (Los Alamos Scientific Lab., N. Mex.). J. Am. Chem. Soc. 79, 2037-9(1957) May 5.

Two polymorphic modifications of beryllium diiodide have been found. Form I apparently corresponds to the previously described phase, and form II is a heretofore undescribed high-temperature phase stable above 350°. Form I is tetragonal. Powder x-ray diffraction data indicate cell dimensions $a_0 = 6.12 \pm 0.01$ A., $c_0 = 10.63 \pm 0.02$ A., Z = 4. Form II is orthorhombic with cell dimensions $a_0 = 16.48 \pm 0.02$ A., $b_0 = 16.702 \pm <0.01$ A., $c_0 = 11.629 \pm <0.01$ A., Z = 32. Volume per formular unit and Lorentz-Lorenz refraction, respectively, of the two forms are nearly identical. (auth)

~~10366~~ UCRL-5065

[California. Univ., Livermore. Radiation Lab.] BERYLLIUM-OXIDE. A Bibliography. Maggie Cason. Mar. 22, 1957. 5p. Contract [W-7405-eng-48]. (M-6298). $1.80(ph OTS); $1.80(mf OTS).

This bibliography consists of published literature references selected from the following sources: Chemical Abstracts, 1951 to 1955; Physics Abstracts, 1951 to 1955; Industrial Arts Index, 1955 to Jan. 1957; and the library card catalog. (L.T.W.)

~~4428~~

CHEMISTRY OF BERYLLIUM. PART I. FORMATION OF BERYLLATES. Sarju Prasad and Kashi Prasad Srivastava (Banaras Hindu Univ.). J. Indian Chem. Soc. 33, 791-5 (1956) Nov.

The formation of calcium, strontium, barium, magnesium zinc, cobalt and nickel beryllates has been studied at high temperatures and the following compounds have been obtained: CaO·3BeO, 2CaO·3BeO; SrO·3BeO, 2SrO·3BeO, SrO·BeO; BaO·3BeO; 2BaO·3BeO, BaO·BeO; MgO·3BeO; ZnO·3BeO; CoO·BeO; NiO·BeO. (auth)

BERYLLIUM FLUORIDES. PART I. STUDIES ON HYDROLYSIS OF FLUOBERYLIATE ION ($BeF_4^{2-}$) BY CONDUCTIVITY AND THERMOMETRY. Apurba Kumar Sen Gupta. J. Indian Chem. Soc. 33, 433-6(1956) June.

By conductivity, thermometry and chemical methods it has been shown that the primary reaction between NaOH and $BeF_4^{2-}$ occurs according to the equation: $BeF_4^{2-} + 2OH^- = Be(OH)_2 + 4F$; the secondary reaction, i.e. the dissolution of $Be(OH)_2$ in excess of alkali, occurs subsequently, forming beryllate ion; no indication of the formation of $[BeF_3OH]^{2-}$ has been found. (auth)

7974

A RAPID, QUANTITATIVE SEPARATION OF TRACES OF BERYLLIUM. Jack Schubert, Arthur Lindenbaum, and William Westfall (Argonne National Lab., Lemont, Ill.). Chimia (Switz.) 11, 50-1(1957).

A method for separation of micro amounts of Be from bone and rock, and from interfering ions such as $Cu^{++}$ is given. The Be is selectively eluted from Dowex-50 cation exchange resin with > 0.02 M sulfosalicylic or gentisic acid, at a pH of 3 to 4.5. (T.R.H.)

# BERYLLIUM 1.06

~~5856~~ BMI-1165
Battelle Memorial Inst., Columbus, Ohio.
PROPERTIES OF BERYLLIUM OXIDE AND CARBIDES OF BERYLLIUM, MOLYBDENUM, NIOBIUM, TANTALUM, AND TITANIUM. William P. Weber, John F. Quirk, Alexis W. Lemmon, Jr., and Robert B. Filbert, Jr. Feb. 11, 1957. 41p. Contract W-7405-eng-92. $0.35(OTS).

LOW INTENSITY TRANSITIONS IN THE DECAY OF $Be^{214}$, $Tl^{210}$, AND $Tl^{208}$. H. Daniel. Z. Naturforsch. 12a, 194-200 (1957) Mar. (In German)

An anthracene scintillation counter with single-channel pulse height selection was used as a low-background detector in a magnetic-lens $\beta$-ray spectrometer. By analyzing the spectrum of the Compton electrons ejected from a thick converter three new $\gamma$ rays in the decay RaC → RaC′ were found: 2.72 ± 0.02 Mev, 2.89 ± 0.05 Mev, and 3.03 ± 0.03 Mev, with intensities of 0.026, 0.005, and 0.013, resp., setting the intensity of the 2.204-Mev $\gamma$ ray equal to unity. $\beta$-ray groups, if existing, from RaC″ to RaD-levels ≤ 1.07 Mev have an intensity $< 5 \times 10^{-3}$ per RaC″ decay. The upper limit for the intensity of a 3.20-Mev crossover $\gamma$ ray in the decay ThC″ → ThD was measured to $1.5 \times 10^{-4}$ per ThC″ decay. (auth)

~~1302~~
ENERGY LEVELS OF $Be^9$. C. K. Bockelman, A. Leveque, and W. W. Buechner (~~Massachusetts Inst. of Tech.~~, ~~Cambridge~~). Phys. Rev. 104, 456-60(1956) Oct. 15.

Magnetic analysis of the alpha-particle groups from the deuteron bombardment of boron and of the proton bombardment of beryllium confirms previous work indicating the existence of levels in $Be^9$ at 2.43 and 3.04 Mev. The energy of the edge of a broad distribution at 1.664-Mev excitation is taken to indicate that it arises from a three-body reaction; the shape of the edge indicates the influence of the $Be^8$–n interaction. (auth)

~~12793~~ ✓
NEW ISOTOPE OF BERYLLIUM. M. J. Nurmia and R. W. Fink (Univ. of Arkansas, Fayetteville). Phys. Rev. Letters 1, 23-4(1958) July 1.

Several samples of $B_4C$, BN, $B_2O_3$, and elemental boran of natural isotopic composition were irradiated with a flux of $10^8$ to $10^9$ 14.8-Mev neutrons/$cm^2$ sec. A 14.1-sec activity which was not previously reported is assigned tentatively to a new isotope, $Be^{11}$, from the $B^{11}$(n,p) reaction. (M.H.R.)

# BISMUTH 1.07

~~7212~~ UCRL-3712
California. Univ., Berkeley. Radiation Lab.
THE HEAT OF DISSOCIATION OF $Bi_2$. Elizabeth Brackett and Leo Brewer. Mar. 8, 1957. 5p. Contract W-7405-eng-48. $0.15 ~~(OTS)~~

Widely different values are reported for the heat of dissociation of $Bi_2$. However, if the data are recalculated by use of the third-law method, the values are found to agree, giving a dissociation energy for $Bi_2$ of 47 ± 1 kcal. The vapor-pressure data are then re-evaluated to give $\Delta H_{298}$ for Bi = 49.5 ± 1 kcal, and $\Delta H_{298}$ for $Bi_2$ = 52.5 ± 2 kcal. (auth)

**11095**
THE ANALYSIS OF BISMUTH–URANIUM ALLOYS. R. A. J. Shelton (Univ. of Manchester). Analyst 82, 531-2 (1957) July.

The recovery of U and Bi from solutions containing uranyl and Bi ions is confirmed, and results are tabulated. (auth)

**13750**
NEW METHOD FOR THE SEPARATION OF BISMUTH FROM CADMIUM AND COPPER AND ITS DETERMINATION. Fr. Mihai. Acad. rep. populare Romine Baza cercetari stiint. Timisoara Studii cercetari stiint. Ser. stiint. chim. 4, No. 3-4, 123-8(1957). (In Roumanian)

A rapid method for the separation of bismuth from cadmium and copper and their determination is given. The separation and determination of bismuth is made on the bismuth gallate and the determination of cadmium and copper is made on the dilitirate. The bismuth is weighed directly as the gallate, and the determination takes from 15 to 20 minutes. As the copper and cadmium do not precipitate with the gallic acid, one can determine them in the filtrate by precipitation with dilituric acid. They are weighed as the diliturates. The reduction of the volume takes approximately 30 min, and the determination of the elements in the mixture can be made in one hour. (tr-auth)

~~6869~~ ✓ A/CONF.15/P/1285
AN UPPER LIMIT FOR THE VAPOUR PRESSURE OF BISMUTH (ThC) AT ROOM TEMPERATURE. J. S. Auslander, V. Labău, and St. Meitert (Inst. de Physique Atomique, Bucharest). 7p.

By the photographic method developed previously the vapor pressure of bismuth in the form of $Bi^{212}$ is measured at room temperature. The method is improved by use of a cylindrical vessel of large volume, ~1500 liters. (auth)

**5877** AERE-R/M-138
United Kingdom Atomic Energy Authority. Research Group. Atomic Energy Research Establishment, Harwell, Berks, England.
SOME STUDIES OF THE REACTION BETWEEN SODIUM AND BISMUTH. R. I. Hawes. Sept. 1957. 13p.

In a circulating fuel, liquid metal fuelled reactor, a secondary liquid metal coolant circuit is likely to be used. There is interest in a solution of U in Bi as a fuel and Na as a secondary coolant. An exothermic reaction occurs between Na and Bi leading to a high melting point intermetallic compound. This paper discusses the effects which might occur if a leak occurred in the primary heat exchanger and reports some experiments which were carried out to investigate these effects. (auth)

EVIDENCE ON THE NATURE OF BISMUTH(I) CHLORIDE FORMED BY SOLUTION OF BISMUTH IN BISMUTH(III) CHLORIDE. John D. Corbett (Iowa State Coll., Ames). J. Phys. Chem. 62, 1149-50(1958)

Reported vapor pressure data of the $Bi-BiCl_3$ system at low temperatures are explained in terms of the essentially ideal solutions of $Bi_4Cl_4$ in $BiCl_3$. A different solution process probably must be invoked in order to account for the complete miscibility present in the system at high temperatures. (T.B.A.)

BISMUTH(I) CHLORIDE. John D. Corbett (Iowa State Coll., Ames). J. Am. Chem. Soc. 80, 4757-60(1958).

The reaction of $BiCl_3$ with excess bismuth below 323° results in the formation of solid BiCl. Although this three-phase system is metastable, limited contact between the trichloride and metal phases apparently restricts the yield to about 75 mole % BiCl. That the product is the reported bismuth(I) chloride is confirmed by its isolation in 98 to 99% purity by sublimation or benzene extraction of the unreacted $BiCl_3$ from the $BiCl-BiCl_3$ mixtures. The monochloride's principal reaction is disproportionation; it decomposes to trichloride and metal phases at 323°. The black, diamagnetic material is rather stable in air at room temperature. Powder pattern data given in the literature for $BiCl-BiCl_3$ mixtures as well as for two forms of $BiCl_3$ are found to be primarily those for the products of reaction of $BiCl_3$ with atmospheric moisture. No evidence for a non-stoichiometric BiCl phase or for the existence of $BiCl_2$ is found. The apparent occurrence of the monochloride as $(BiCl)_n$ is discussed. (auth)

# BISMUTH 1.07

**13595** MLM-368-1(Extract)
[Mount Lab., Miamisburg, Ohio].
BISMUTH COMPLEXES AT LOW HYDROCHLORIC ACID CONCENTRATIONS. J. H. Payne, Jr. [1949]. Decl. Mar. 27, 1957. 27p. $4.80(ph OTS); $2.70(mf OTS).

There is evidence of the formation of $Bi^{3+}$, $BiCl^{2+}$, $BiCl_2^+$, and $BiCl_4^-$ in the $Cl^-$ concentration range 0.3 to 1.0M. Absorption spectra studies were made, and the extinction coefficients determined for each complex in this concentration range. (D.E.B.)

ON THE DECAY SCHEME OF $_{83}Bi^{214}$(RaC). R. A. Ricci and G. Trivero (Istituto di Fisica sperimentale del Politecnico, Torin, Italy). Nuovo cimento (10) 2, 745-59(1955) Oct. (In Italian) (cf. NSA 9-2976 and 9-4629)

Experiments have been continued concerning the spectrum of $Bi^{214}$, analyzing the absorption of the $\beta$ radiation and the determination of $\beta$-$\gamma$ coincidences with complete separation of the $\gamma$ rays from $Po^{214}$. The results are consistent with those of Wapstra and Latishev referring to the maximum energy of the $\beta$ transition in the fundamental state (3.17 Mev) (relative intensity 13%), and confirm the presence of a transition energy of 2.56 Mev at the first excited state of $Po^{214}$, already reported by us, of relative intensity of about 6%. The spectrum analysis reveals the presence of other $\beta$ transitions of energy 1.720 Mev (relative intensity 7%), 1.44 Mev (30%), and 1.03 Mev (22%). Transitions of energy less than 1 Mev certainly exist and their relative intensity, following our results, should be ≈20%. From this a $\beta$-decay scheme may be deduced for $Bi^{214}$ which is in fairly good accord with the scheme of $\gamma$ levels of $Po^{214}$ recently proposed by Demichelis and Malvano. (auth)

**4630** AERE-R/M-93
Gt. Brit. Atomic Energy Research Establishment, Harwell, Berks, England.
THE ACTIVATION RESONANCE INTEGRAL OF BISMUTH. P. N. Cooper. Nov. 1956. 12p.

The resonance integral for $\beta$ activation of Bi has been determined by measuring the Cd ratio in a pile spectrum. In the same spectrum the Cd ratio of Mn, having a known resonance integral, was determined in order to calibrate the epithermal component of the spectrum. The value obtained for the resonance integral, not including the (1/v) contribution, was $(3.79 \pm 0.38)\sigma_0$ or $76 \pm 8$ mb referred to a 2200 m/s activation cross section, $\sigma_0$, of 20 mb. (auth)

ON THE DECAY OF $Bi^{204}$. R. Stockendal, T. Novakov, B. Johansson, and M. Schmorak (Nobel Inst. of Physics, Stockholm). Arkiv Fysik 14, 65-84(1958).

Energy levels in $Pb^{204}$ were studied in the electron capture decay of 12 hr $Bi^{204}$. 45 transitions and about 20 weak unassigned conversion lines were found. Energies and intensities of conversion lines were measured in permanent magnet and double-focusing spectrometers. Relative gamma intensities were obtained by use of a scintillation spectrometer. Electron-gamma and gamma-gamma coincidence measurements were performed with instruments including a 100-channel pulse-height analyzer. A tentative decay scheme is discussed.

**12768**
THE EFFECT OF UNIFORM COMPRESSION UPON THE MAGNETIC PROPERTIES OF BISMUTH AT LOW TEMPERATURES. B. I. Verkin, I. M. Dimitrenko, and B. G. Lazarev (Academy of Sciences, Ukrainian SSR). Soviet Phys. JETP 4, 432-4(1957) Apr.

**8833**
A STUDY OF THE GAMMA RAYS OF $Pb^{206}$ FROM THE DECAY OF $Bi^{206}$ BY THE METHOD OF EXTERNAL CONVERSION IN URANIUM. Tihomir Novakov, Sölve Hultberg, and Birgit Andersson (Nobel Inst. of Physics, Stockholm). Arkiv Fysik 13, 117-28(1958).

Relative intensities of 20 gamma rays following the decay of $Bi^{206}$ have been determined from a beta-spectrometric study of photoelectrons ejected in a 3 mg/cm$^2$ uranium converter. The instrumental resolution was 0.4% at high energies. A new method of analysis of the recorded photolines has been applied. Together with the earlier measurements of the internal conversion by Alburger and Pryce, the gamma ray intensities found permitted a determination of relative conversion coefficients with an accuracy of about 15%. In most cases the earlier multipolarity assignments were confirmed. (auth)

# BISMUTH 1.07

10950 ✓
RADIATIONS FROM DECAY OF BISMUTH-203, BISMUTH-204, LEAD-204m, AND BISMUTH-205.
A. R. Fritsch and J. M. Hollander (Univ. of California, Berkeley). J. Inorg. & Nuclear Chem. 6, 165-80(1958) June.

A study has been made of the radiations from the neutron-deficient isotopes $Bi^{203}$, $Bi^{204}$, $Bi^{205}$, and $Pb^{204m}$, principally by conversion electron spectroscopy with four 180° electron spectrographs of the permanent-magnet type. The decay schemes of the bismuth isotopes are found to be very complex, and in spite of high-resolution studies and some coincidence work, unique level schemes cannot be given in any case. A new transition in the decay of the 1 hr $Pb^{204}$ isomer has been identified at 289.5 kev, and this is interpreted as arising from a $4^+$ state of $Pb^{204}$ at 1563 kev. A comparison is given of the results of the present study of $Bi^{205}$ decay with those of other recent spectroscopic studies of the $Pb^{205}$ levels. (auth)

A NEW ISOTOPE OF BISMUTH. Sergio De Benedetti, Ugo Farinelli, Filippo Ferrero, Renato Malvano, Gabriele Pelli, and Carlo Tribuno. Atti. acad. nazl. Lincei Rend. Classe sci. fis. mat. e nat. 23, 58-9(1957) July-Aug. (In Italian)

An investigation was made to determine whether the activity excited by gamma radiation of $Bi^{209}$ could be attributed to an excited state of $Bi^{208}$ or $Bi^{209}$. The excitation curve obtained is given, but no definite assignment could be made. The probability of a $Bi^{209}(\gamma,n)$ reaction was determined to be of the order of 1.5%.

ON THE $Tl^{208}$ LEVEL SCHEMES. A. G. Sergeev, E. M. Krysyuk, G. D. Latyshev, V. D. Vorob'ev, and T. I. Kol'chinskaya (Obraztsov Leningrad Inst. of Transportation). Izvest. Akad. Nauk S.S.S.R. Ser. Fiz. 22, 785-7 (1958) July. (In Russian)

The $\gamma$ transition multiplicities in $Bi^{212} \rightarrow Tl^{208}$ decay were determined on the basis of studies made of the radium-thorium precipitation spectrum of internal conversion electrons. The relative intensities of $\alpha$ transitions, with consideration for the displaced angular momentum, were calculated in order to verify and correct the $Tl^{208}$ excitation levels. It is shown that consideration of the angular momentum improves considerably the theoretical and experimental agreement. The $Tl^{208}$ decay levels are presented. Levels at 328, 473, 493, and 619 kev can be explained by the spallation of the $d_{5/2}g_{9/2}$ configuration. The spallation produces a quadruplet with spins $3^+$, $4^+$, $5^+$, and $6^+$. The values $3^+$ and $6^+$ for the levels 493 and 619 kev are in good agreement with the configuration; however, for the levels with spins $4^+$ and $5^+$ the sequence is not yet clear. (R.V.J.)

# BORON 1.08

See also, under HAZARDS AND PROTECTION,

DUSTS AND POWDERS (4.01.03).

Technical Information Service Extension, AEC.
CHEMISTRY OF BORON AND BORON COMPOUNDS. A Literature Search. William E. Bost, comp. Jan. 1959. 27p. $0.75(OTS). (TID 3523)

Included are 244 references from the AEC-held unclassified report literature on the chemistry (preparation, determination, and chemical properties and reactions) of boron and boron compounds. The references are divided into two parts: unpublished reports and reports published in journals. The arrangement of both parts is alpha-numeric by report number. (auth)

BORON AND BORON-CONTAINING MATERIALS. H. C. Cowen (United Kingdom Atomic Energy Authority). Nuclear Eng. 4, 11-17(1959) Jan.

The concentrations of B in the earth's crust along with the most important workable deposits are discussed. Methods of separating B isotopes are presented. The properties of B and B-containing materials are reported. The fabrication of B by powder metallurgy techniques is described. (W.L.H.)

**12107** ✓ NP-6805
Olin Mathieson Chemical Corp. Niagara Falls, N. Y.
CURRENT LITERATURE ABSTRACT BULLETIN. VOL. 7, NO. 6. F. J. Celli. June 1958. 42p. Contract AF33(600)-33920.

One hundred seven abstracts from the current literature on boron compounds are given. An author index is included. (A.C.)

**10362** ✓ NP-6735
Olin Mathieson Chemical Corp., Niagara Falls, N. Y.
CURRENT LITERATURE ABSTRACTS BULLETIN. VOL. 7, NO. 5. May 1958. 147p.

This bulletin consists of 120 abstracts from the current literature on boron compounds. (W.L.H.)

**10364** ✓ NP-6761
Olin Mathieson Chemical Corp., Niagara Falls, N. Y.
CURRENT LITERATURE ABSTRACTS BULLETIN. Volume 7, Number 2. Feb. 1958. 29p.

This bulletin consists of 80 abstracts from the current literature on boron compounds. (W.L.H.)

**10363** ✓ NP-6760
Olin Mathieson Chemical Corp., Niagara Falls, N. Y.
CURRENT LITERATURE ABSTRACTS BULLETIN. Volume 7, Number 1. Jan. 1958. 31p.

This bulletin consists of 75 abstracts from the current literature on boron compounds. (W.L.H.)

Library of Congress. Technical Information Div., Washington, D. C.
REPORTS ON BORON COMPOUNDS. (ABSTRACT BULLETIN U6). July 29, 1955. 9p. (NP-5025).

This supplement contains 19 annotated references to report and published literature.

**5857** JPL-PR-20-252
California Inst. of Tech., Pasadena. Jet Propulsion Lab.
STABILITY OF TITANIUM DIBORIDE AND ZIRCONIUM DIBORIDE IN AIR, OXYGEN, AND NITROGEN. Frank H. Brown, Jr. Feb. 25, 1955. 16p. Contract DA-04-495-Ord-18.

Compressed specimens of $TiB_2$ and $ZrB_2$ powders were studied at temperatures between 900 and 2400°F in air, $N_2$, and $O_2$. X-ray-diffraction methods were used to analyze those structures which exist after the treatments in order to determine the effects of the three gases on the two materials. (auth)

**6449** ✓
B-10 PLANT INVITES NON-AEC CUSTOMERS. Chem. Eng. 64, No. 5, 176, 178(1957) Apr.

The applications, availability, and cost of boron with 61 to 95% $B^{10}$ enrichment are discussed. (T.R.H.)

**3327** CCC-1024-TR-213
Callery Chemical Co., Penna.
CHEMICAL PROPERTIES OF SODIUM TRIETHYLHYDROBORATE AND SODIUM TRIISOPPROPOXYHYDROBORATE. R. K. Pearson and L. J. Edwards — P. M. Maginnity, ed. Dec. 13, 1956. 13p. Contract [NOa(s)-52-1024-c].

Sodium hydride and triethylborane react to form sodium triethylhydroborate, $NaBH(C_2H_5)_3$. This compound, a liquid at room temperature, was found to be soluble in hexane and mineral oil. A study was made of the thermal decomposition of sodium triethylhydroborate and its behavior toward boron trifluoride, boron trichloride, methyl borate, carbon dioxide, silane, and ethylene. Sodium triisopropoxyhydroborate, $NaBH(OC_3H_7)_3$, was prepared and also found to be soluble in hexane and mineral oil. The reactions of this compound with methyl borate, triethylborane, silicon tetrachloride, and boron trichloride were investigated.

# BORON 1.08

THE HEATS OF FORMATION OF BORIDES OF SOME TRANSITION METALS. G. V. Samsonov (Moscow Inst. of Non-Ferrous Metals and Gold.). Zhur. Fiz. Khim. 30, 2057-60(1956) Sept. (In Russian)

Approximate values have been obtained for the heats of formation of Ti, Zr, Nb, Ta, and Cr diborides. (R.V.J.)

**908** MCC-1023-TR-229

Ohio State Univ. Research Foundation, Columbus.

HEAT OF VAPORIZATION OF DIBORANE. L. J. Paridon, G. E. MacWood, and Jeh-Heng Hu. Aug. 7, 1956. 8p. [For Olin Mathieson Chemical Corp. Contract NOa(s)-52-1023-c].

The heats of vaporization of diborane have been measured from the normal boiling point to within 4°C of the critical point. Over this range, the heat of vaporization, $L_v$, is expressed by the equation: $L_v = 546.2(T_c - T)^{0.39}$ where $T_c$ is the critical temperature (auth)

**8430**

RECENT DEVELOPMENTS IN THE APPLICATION OF TRANSITION METAL BORIDES. Arnold Blum and William Ivanick (Borolite Corp., Yonkers, N. Y.). Powder Met. Bull. 7, 75-8(1956) Apr.

Some of the transition metal borides ($CrB_2$, $ZrB_2$, and $MoB_2$) have been described which are now being used widely for their outstanding liquid metal corrosion resistance, high-temperature stability in vacuum, and superior oxidation resistance at high temperatures. (F.S.)

**7930** ✓ CCC-1024-TR-238

Kansas. Univ., Lawrence.

MECHANISM STUDIES OF THE OXIDATION OF TRIALKYL BORANES. C. A. VanderWerf, W. E. McEwen, and C. McMillin. Apr. 24, 1957. 23p. For Callery Chemical Co. Contract [NOa(s)-52-1024-c].

A study was made of the oxidation of trialkyl boranes, and attempts were made to establish a mechanism for this type of reaction. Carbon tetrachloride, $CHCl_3$, $CHBr_3$, $C_6H_5CH_3$, and cumene were used as solvents for the oxidation of tri-n-propylborane and tri-n-pentylborane to substantiate the existence of free radicals. Products which resulted from the dimerization, the disproportionation, and the reaction with the solvent of the n-propyl and the n-pentyl radicals were isolated from the reaction mixtures of the respective alkyl boranes. The results indicated that the mechanism for the cleavage of the carbon-boron bond must involve the formation of a free alkyl radical. A detailed mechanism consistent with all the known facts concerning the oxidation of trialkyl boranes is presented. (auth)

CHEMISTRY OF BORIDES. G. V. Samsonov and L. Ya. Markovskiĭ. Uspekhi Khim. 25, 190-241(1956) Feb. (In Russian)

A review is given of the methods of preparation, crystal structure, and physical and chemical properties of elementary boron and of borides of various groups of elements. Phase studies, thermal expansion, electroconductivity, solubility, and other properties of alkaline earth metals of the first group on the periodic table: Cu, Ag, and Au, and Be, Mg, dissoluble Mg, and hexaborides of Ca, Sr, and Ba of the second group are described. Studies were made of borides of rare earth elements in the third group: the La, Ce, Nd, Yb, Y, Ge, and the Al borides. The fourth group (even parity subgroup)—the boron carbides were analyzed for their chemical resistance, their interactions with other carbides and high melting point alloys. Detailed descriptions of the physical and chemical properties at elevated temperatures of boron nitrides in the fifth group (uneven parity subgroup), the distribution of boron atoms in borides, and the table of structure classifications for transition metals are presented. Methods for preparation of transition metal borides, boride precipitation from gas phase, electrolysis, and preparations of solid specimens are discussed. Phase and x-radiation studies were made of the fifth group borides (uneven parity subgroup) of V, Nb, and Ta; of sixth group (uneven parity), Cr, Mo, and W borides; and, the eighth group—the iron borides. The properties of actinide borides and the general use and applications of borides are given. 233 references. (R.V.J.)

Library of Congress. Technical Information Div., Washington, D. C.

REPORTS ON BORON COMPOUNDS. (ABSTRACT BULLETIN U4). Oct. 25, 1954. 17p. (NP-5023).

**136** ✓

Library of Congress. Technical Information Div., Washington, D. C.

REPORTS ON BORON COMPOUNDS. (ABSTRACT BULLETIN U3). July 19, 1954. 10p. (NP-5022).

The bibliography consists of 21 annotated references to various government reports.

Library of Congress. Technical Information Div., Washington, D. C.

REPORTS ON BORON COMPOUNDS. (ABSTRACT BULLETIN U2). Apr. 19, 1954. 9p. (NP-5021).

The annotated bibliography consists of 20 references to unclassified government publications.

# BORON 1.08

Library of Congress. Technical Information Div., Washington, D. C.
REPORTS ON BORON COMPOUNDS. (ABSTRACT BULLETIN U5). Feb. 9, 1953. 13p. (NP-5024).
An annotated bibliography of 28 references to reports issued under various contracts is included.

BORON TRIFLUORIDE AND ITS DERIVATIVES. H. S. Booth and D. R. Martin. N. Y., John Wiley and Sons. 1949. 315p.
The book is documented by 950 references. The references are arranged by author.

Louisville, Ky. Univ. Inst. of Industrial Research.
A BIBLIOGRAPHY OF SELECTED BORIDES, NITRIDES, AND PHOSPHIDES. T. R. Bailey, Henry James, and LeRoy A. Peterson. 1949. 14p. Contract N8onr-80200. (AD-46550).
The bibliography consists of 148 references to published literature, arranged by subject.

**8296** ✓ HEC-88
Hooker Electrochemical Co., Niagara Falls, N. Y.
DEGRADATION AND PASSIVATION OF ELEMENTAL BORON. George T. Miller. Apr. 18, 1958. 9p. Contract AT(30-1)-1524. $1.80(ph OTS); $1.80(mf OTS).
Elemental boron was found to degrade during processing and storage by adsorbing gases and water vapor. Heating to 700°C in an inert atmosphere greatly increased the rate of adsorption. It was found that the boron could be passivated by drying in an oxygen atmosphere, under vacuum at 100°C. (auth)

**8819** ✓ CCC-1024-TR-240
Boston. Univ.
THERMODYNAMICS OF SODIUM TETRAMETHOXYBORATE AND TETRAMETHOXYBORATE ION. L. V. Coulter and J. R. Sinclair—M. G. Haddaway, ed. May 6, 1957. 12p. For Callery Chemical Co. Contract [NOa(s)-52-1024-c].
The heat capacity of sodium tetramethoxyborate has been determined from 14 to 300°K by means of an adiabatic calorimeter. At 298.15°K the entropy was found to be 68.60 cal. deg.$^{-1}$ mole$^{-1}$; the heat content ($H^\circ - H_0^\circ$), 1037 cal. mole$^{-1}$; and the heat capacity, 54.70 cal. deg$^{-1}$ mole$^{-1}$. The heat of solution in liquid ammonia at -33°C was found to be 0.0 kcal. ± 1 kcal. For the solution reaction of solid sodium tetramethoxyborate in liquid ammonia at -33°, $\Delta F^\circ = 4.1$ kcal. and $\Delta S^\circ = -17 \pm 3$ cal. deg.$^{-1}$ mole$^{-1}$. Relative to $S^\circ [H^+(am)] = 0$ in liquid ammonia at -33°C, $\bar{S}^\circ[B(OCH_3)_4^-(am)] = 28 \pm 3$ cal. deg.$^{-1}$ mole for the tetramethoxyborate ion in the hypothetical one molal solution. (auth)

**60** ✓ CCC-1024-TR-143
Callery Chemical Co., Penna.
SOME PHYSICAL PROPERTIES OF METHYL BORATE AND METHYL BORATE–METHANOL AZEOTROPE. C. F. Boynton, J. F. Masi, P. E. Gallagher, and R. Kosahovich. Oct. 17, 1955. 15p.
Miscellaneous physical properties of methyl borate and of two component systems containing methyl borate are reported. Included are density and viscosity of methyl borate and of methyl borate–methanol azeotrope, boiling point-composition diagram for the system methyl borate–diethylene glycol dimethyl ether, and refractive index of methyl borate–mineral oil mixtures. (auth)

**6262** ✓
APPLICATIONS OF ANION EXCHANGE RESINS TO DETERMINATION OF BORON. John D. Wolszon and John R. Hayes (Pennsylvania State Univ., University Park) and William H. Hill (Univ. of Pittsburgh). Anal. Chem. 29, 829-32(1957) May.
The behavior of boric acid and of several known interferences has been investigated using both weak and strong base anion exchange resins. A simple, rapid chromatographic technique employs $Cl^-$ as an elution indicator, applicable to the concentration and separation of B from dilute solutions of low total salt content. Boron is separated from most of the known titrimetric interferences by a mixed bed ion exchange column. The procedure is rapid, requires no special treatment of the sample prior to the exchange process, and compares favorably with existing techniques. However, it cannot be recommended for separation of B prior to colorimetric determination. (auth)

**1724** MCC-1023-TR-177
Delaware. Univ., Newark.
THE SORPTION OF BORON COMPOUNDS (thesis). Klaus Robert Lange. Nov. 1955. 65p. [For Olin Mathieson Chemical Corp. Contract NOa(s)-52-1023-c].
Data are presented for the sorption of diborane, $B_2H_6$, on cocoanut charcoal, Pd black, silica–alumina, and other sorbents. Sorption data for deutero-diborane and trimethyl borane are also included. The effect of surface-active agents on the pyrolysis of $B_2H_6$ was studied. (C.W.H.)

# BORON 1.08

**7524**

CONCENTRATION AND DETERMINATION OF BORON FROM DILUTED SOLUTIONS CONTAINING STRONG AND WEAK ELECTROLYTES. E. Cerrai, and C. Testa (CISE – Milan). Energia nucleare (Milan) 5, 824-30 (1958) Dec.

A method is reported for the concentration and purification of boron from diluted aqueous solutions containing strong and/or weak electrolytes. This method, based on ion exchange resins, is applied to analytical determination by means of colorimetry. (auth)

ON THE INTERACTION OF BORON CARBIDE AND SILICON. K. I. Portnoi, G. V. Samsonov, and L. A. Solonnikova (Inst. of Metal Ceramics and Special Alloys, Academy of Sciences, Ukrainian, S.S.R.). Doklady Akad. Nauk S.S.S.R. 125, 823-5(1959) Apr. 1. (In Russian)

The preparation and properties of the radial cross sections of $B_4C-Si$ and of the $B-Si-C$ system were studied. The alloys were prepared with boron carbide and silicon powders pressed at 1700 to 2350°C for 1.5 to 8 min. Pycnometric measurements of the specific weight of the alloy showed the maximum at 25 to 30 wt. % Si. With the increase of silicon the hardness of the second phase increases, reaching the maximum of ~ 7000 kg/mm$^2$ with 40 to 50 wt. % Si, after which it drops to 3500 to 4000 kg/mm$^2$. The maximum electric conductivity is found at 25 to 35% Si. It is shown that it is possible to obtain a triple phase boron with silicon and carbon of the $B_5SiC_2$ composition, with ~ 7000 kg/mm$^2$ microhardness, which has a high resistance to oxidation in air up to 1200°C and in mineral acids and mixtures at room or boiling temperatures (losses in weight at boiling temperature 0.0003 to 0.0008 g/cm$^2$ per day). (R.V.J.)

**14651** A/CONF.15/P/923

Johns Hopkins Univ., Baltimore.

APPLICATION OF ISOTOPES TO BORON HYDRIDE CHEMISTRY. Walter S. Koski and J. E. Todd. 11p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The exchange of deuterium and $B^{10}$ between diborane and several of the more common boron hydrides was studied because a knowledge of the exchange mechanism gives a better insight into the nature of the intermediate fragments that play an important role in the chemistry of these compounds. Evidence has been accumulated for at least three mechanisms by which isotopic exchange proceeds in the boron hydrides. In the diborane self-exchange the reaction appears to involve borane as an entity and the ratio of deuterium rate to boron rate is three. In the $B_2D_6-B_5H_9$ exchange the rate-determining step is the reaction of borane with the terminal hydrogens of pentaborane. The bridge hydrogens are not involved at all and the borons do not exchange. A similar situation exists in the diborane-decaborane exchange. In the $B_2D_6-B_5H_{11}$ reaction the fraction-order kinetics indicate that the $B_5H_{11}$ is fragmenting. All of the borons and all of the hydrogens in both molecules are participating in the exchange. Only one rate of exchange has been observed but there is experimental evidence that exchange can proceed by an intramolecular mechanism. In the case of the $B_2D_6-B_4H_{10}$ reaction one has at least two mechanisms of isotopic exchange and evidence has been obtained for an exchange that proceeds by an intramolecular mechanism. Kinetic measurements indicate that the tetraborane is fragmenting. The intramolecular process is an indication of the lability of the hydrogens and the borons in some of the less stable boron hydrides. Details of the measurements are discussed for the diborane-tetraborane exchange and the $B^{10}$ self-exchange in diborane. The application of some of these results to pyrolysis reactions of boron hydrides is pointed out. (auth)

# BORON 1.08

**3326** CCC-1024-TR-209
Callery Chemical Co., Penna.
REACTIONS OF SODIUM BOROHYDRIDE WITH AMINE SALTS. H. W. McDanel and L. S. Stone — P. M. Maginnity, ed. Nov. 20, 1956. 16p. Contract [NOa(s)-52-1024-c].

Reactions of sodium borohydride with various amine hydrochlorides were investigated to prepare volatile boron-nitrogen hydrides. Compounds obtained include N, N′, N″-trimethylborazine (from methylammonium chloride), ethylenediammonium diborohydride, ethylenediamine-bisborane, trimethylamineborane, pyridine-borane, dimethylaminodiborane (from dimethylammonium hydrogen sulfate), and diborane diammoniate (from ammonia-boron trifluoride). The desired products were not obtained from anilinium chloride, ammonium hydrogen sulfate, or several alkyl amine compounds with boron trifluoride. (auth)

**11058** NP-6366
University of Southern Calif., Los Angeles.
STUDIES ON BORON HYDRIDES. Final Technical Report of INVESTIGATIONS ON WATER-REACTIVE CHEMICAL COMPOUNDS. Anton B. Burg. June 1957. 34p. Project NR-052-050. Contract N6onr-238(I).

This summary deals with the chemistry of boron hydride derivatives wherein boron is bonded to elements in the fifth and sixth main groups of the periodic system. The material is divided into sections on aminoboron hydrides, phosphorus–boron chemistry, boron compounds of As and Sb, boron chemistry involving oxygen or sulfur, and miscellaneous chemistry of boron–carbon compounds. (T.R.H.)

**6233** ✓ CCC-1024-TR-235
Callery Chemical Co., Penna.
REACTIONS OF PENTABORANES WITH SODIUM AMALGAM OR SODIUM HYDRIDE. M. D. Ford, W. V. Hough, L. J. Edwards, — P. M. Maginnity, ed. Apr. 5, 1957. 8p. Contract [NOa(s)-52-1024-c].

Neither sodium amalgam nor sodium hydride reacted with pentaborane(9) in ethyl ether at room temperature. The complex reaction of sodium amalgam with pentaborane(11) in ethyl ether at room temperature was incompletely defined, although formation of some $NaB_3H_8$ was verified. Pentaborane(11) decomposed in the ether more rapidly than it reacted with the sodium. (auth)

Callery Chemical Co., Penna.
PHYSICAL PROPERTIES OF BORON TRIBROMIDE. W. F. Barber, C. F. Boynton, and P. E. Gallagher — S. L. Harvey, ed. Mar. 25, 1959. 18p. Project ZIP. Contract NOa(s) 58-454-d.

The triple point of a sample of 99.96 mole % boron tribromide was found to be −46.482°C. Over the temperature range −20 to 90°C, the density values were found to fit the equation $d_{(g/ml)} = 2.6954 - [2.962 \times 10^{-3} t_{(°C)}]$. Over the temperature range 0 to 90°C, the viscosity values fit the equation $\log \eta_{(millipoises)} = 331/t - 0.250$. Over the temperature range 22 to 84°C, the surface tension values fit the equation $\gamma_{(dynes/cm)} = 31.9 - 0.128\ t_{(°C)}$. Over the temperature range 0 to 90°C, the vapor pressure values fit the equation $\log P_{(mm)} = 6.9795 - 1311/[t_{(°C)} + 230]$. (auth)

HIGH-PURITY CRYSTALLINE BORON. David R. Stern and Lahmer Lynds (American Potash & Chemical Corp., Whittier, Calif.). J. Electrochem. Soc. 105, 676-82 (1958) Nov.

Vapor phase reduction of boron trichloride with hydrogen on electrically heated filaments in flow systems was investigated as a potential method for the preparation of high-purity boron. Experiments were conducted on laboratory and bench-scale flow reactors. Conversion efficiency was a function of mole ratio of reactants, residence time, mass of deposit, and deposition temperature. Massive deposits of crystalline boron analyzing as high as 99.6% by direct chemical analyses were obtained. Purity of boron appeared to be a function of both filament diffusion and boron trichloride purity. Titanium filaments were found to be most satisfactory, since contamination due to titanium could be removed by chlorination at 300°C. X-ray-diffraction studies indicated that titanium probably existed in solid solution with boron rather than as a boride. (auth)

# BORON 1.08

**7482** IGR-R/CA-248

United Kingdom Atomic Energy Authority. Industrial Group. Capenhurst Works, Capenhurst, Ches., England.

THE CONDENSATION COEFFICIENT OF BORON TRIFLUORIDE. M. C. Paterson and R. Hulse. Nov. 1957. 15p.

Experiments were performed to study the rate of condensation of boron trifluoride on a copper surface maintained at liquid-nitrogen temperature (−195°C). The condensation coefficient was found to be in the range $(2.85 \pm 23\%) \times 10^{-2}$. Using this value for the condensation coefficient, values for the thermal conductivity of the solid deposit are deduced; a mean value is $(9.3 \pm 2.8\%) \times 10^{-4}$ cal/cm s deg C at −166°C, which is in agreement with that found by other investigators. (auth)

BORON FLUORIDE AND ITS COMPOUNDS AS CATALYSTS IN ORGANIC CHEMISTRY. International Series of Monographs on Organic Chemistry. Volume 2. (Translation from the Russian). A. V. Topchiev, S. V. Zavgorodnii, and Ya. M. Paushkin. New York, Pergamon Press, 1959. 326p.

A monograph is presented in which the use of $BF_3$ as a catalyst in organic chemistry is examined. In addition, a number of $BF_3$ derivatives and coordination compounds are discussed. Catalysts based on $BF_3$ are more active in many reactions than mineral acids and halogen compounds of metals, and at the same time do not give rise to undesirable side reactions such as the destructive changes observed when $AlCl_3$ is used, or in sulfonation and fluorination. (J.R.D.)

THE BINARY SYSTEM BORON FLUORIDE–WATER. Stephan Pawlenko. Z. anorg. u. allgem. Chem. 300, 152-8(1959). (In German)

Solidification points and densities of the system $BF_3$–$H_2O$ have been determined. There is a eutectic point between $BF_3 \cdot H_2O$ ($H[BF_3OH]$) and $BF_3 \cdot 2\ H_2O$ ($H_3O[BF_3OH]$) at 73.7 per cent by weight $BF_3$ and a temperature of −44°C. The results are discussed and compared with those of former investigations. (auth)

**11503**

CONVERSION OF DIMETHYL ETHER–BORON TRIFLUORIDE COMPLEX TO POTASSIUM FLUOBORATE. A. R. Eberle (to U. S. Atomic Energy Commission). U. S. Patent 2,796,323. June 18, 1957.

A method of preparing $KBF_4$ from the dimethyl ether complex of $BF_3$ is given. This may be accomplished by introducing the dimethyl ether complex of $BF_3$ into an aqueous solution of KF and alcohol, expelling the ether liberated from the complex by heating or stirring and recovering the $KBF_4$ so formed. The $KBF_4$ is then filtered from the alcohol-water solution, which may be recycled, to reduce the loss of $KBF_4$ which is not recovered by filtration. (auth)

**9984** ✓ HEC-77

Hooker Electrochemical Co., Niagara Falls, N. Y.

THE DIRECT REACTION OF CALCIUM FLUORIDE–BORON TRIFLUORIDE COMPLEX WITH ALUMINUM CHLORIDE. E. A. Belmore and A. M. Teller. Feb. 20, 1957. 16p. Contract AT-(30-1)-1524. $3.30(ph OTS); $2.40(mf OTS).

This reaction was investigated in order to provide temporary relief from the severe mechanical trouble which was experienced with the vapor phase $BF_3$–$AlCl_3$ reaction originally installed in the Boron Metal Plant. It was found that as much as 80% conversion to $BCl_3$ could be obtained by adding finely ground $AlCl_3$, in considerable excess, to the $CaF_2$–$2BF_3$ complex in an agitated vessel, and continuously heating the contents. Most of the additional 20% was driven off as unconverted $BF_3$. This could be collected on activated C adsorbers and later converted by desorbing through heated towers packed with $AlCl_3$. This work was discontinued when the electrolytic method of reduction was adopted, and $BCl_3$ was no longer required as feed material. It is still felt, however, that the vapor-phase type of reactor is the most sound approach to this problem, in spite of the severe mechanical problems inherent to it. (auth)

SOME REACTIONS OF MONOAMMONIA–BORON TRIFLUORIDE WITH SOLUTIONS OF ALKALI METALS IN AMMONIA. W. J. McDowell and C. W. Keenan (Univ. of Tennessee, Knoxville). J. Am. Chem. Soc. 78, 2065-9(1956) May 20.

The reactions of the alkali metals, Li, Na, K, and Cs, with liquid $NH_3$ solutions of $BF_3 \cdot NH_3$ have been studied. Differences in the stoichiometry of reaction for these metals have been observed: the mole ratio of metal: $BF_3 \cdot NH_3$ is 3.0 for Li, 2.5 for Na and 1.0 for both K and Cs. The products of the reaction of $BF_3 \cdot NH_3$ with K have been studied and proposals have been made as to the nature of the products of the reactions with the other metals. (auth)

# CADMIUM 1.09

**16201**

EFFECT OF THE CONCENTRATION OF VARIOUS SALTS ON THE DISSOLUTION OF CADMIUM IN AIR-SATURATED SOLUTIONS. Charles J. Boone (American Viscose Corp., Marcus Hook, Penna.) and Cecil C. Lynch (Univ. of Delaware, Newark). Corrosion 14, 409t-11t(1958) Sept.

The initial rate of dissolution of cadmium in various concentrations of carbon dioxide-free, air-saturated, neutral salt solutions at 25°C was examined polarographically. The salts employed were potassium chloride, sodium chloride, barium chloride, potassium bromide, sodium bromide, potassium iodide, sodium iodide, sodium perchlorate, and barium perchlorate. The experiments were conducted in such a manner that the only variable was the concentration of salt in the solutions. The order of reaction due to the salt was calculated at 25°C for the initial rate of dissolution of cadmium for each of the above salts. The nature of the anion was shown to have a much greater effect on the rate than does the nature of the cation. The perchlorate ion appears to act as an inhibitor and the iodide salts to have a maximum in the corrosion rate versus concentration curves. These results may be explained on the basis of anion polarization. (auth)

**5038**

FORMATION OF $Cd^{115}$ ISOMERS IN HIGH-ENERGY FISSION OF BISMUTH. Norbert T. Porile (Univ. of Chicago, Ill.). Phys. Rev. 108, 1526-30(1957) Dec. 15.

The relative yields and recoil properties of the $Cd^{115}$ isomers independently formed in the 450-Mev proton fission of bismuth have been measured. The 43-day $Cd^{115m}$ isomer has a higher yield and smaller range than the 53-hr $Cd^{115}$. $Cd^{115m}$ is also formed in a higher deposition energy process than $Cd^{115}$. These results are explained in terms of the high-spin states of the fission fragments resulting both from the high bombarding energy and from the fission act proper. (auth)

**5876**

THE LEVEL SCHEME OF $Cd^{112}$. R. K. Girgis and R. Van Lieshout (Instituut voor kernphysisch Onderzoek, Amsterdam). Physica 25, 1200-10(1959) Nov. (In English)

The level scheme of $Cd^{112}$ was investigated by studying the gamma spectrum from the decay of $Ag^{112}$ which excites levels in this nucleide. A source of $Pd^{112}-Ag^{112}$ in equilibrium was used. Gamma rays of 615, 690, 785, 855, 980, 1090, 1210, 1310, 1400, 1490, 1620, 1810, 1930, 2110, 2240, 2300, 2520, 2540, 2680, 2710, 2830, 2950, 3100, and 3280 kev were found to follow the decay of $Ag^{112}$. The summing spectrum was examined using a well type NaI(Tl) crystal with the source in different geometries; summing peaks of 3560, 3300, 3130, 2830, 2710, 2450, 2230, and 2050 kev were observed. Gamma-gamma coincidences were performed using a conventional fast-slow coincidence circuit. The results of these coincidence measurements are listed. A level scheme for $Cd^{112}$, based on the intensity values of the various gamma rays following the decay of $Ag^{112}$ and on the summing and gamma-gamma coincidence measurements is presented. (auth)

# CALIFORNIUM 1.10

**5990** CF-59-12-16
**Oak Ridge National Lab., Tenn.**
**EFFECT OF NON-THERMAL CAPTURE ON CALIFORNIUM PRODUCTION IN THE HFIR. H. C. Claiborne. Dec. 3, 1959. 12p. OTS.**

**Non-thermal neutron capture was estimated to enhance the production rate of $Cf^{252}$ in the HFIR by 50 to 100% depending on the $Cm^{248}$ cross section. The optimum ratio of non-thermal to thermal neutron flux was very dependent on the $Cm^{248}$ thermal cross section. It was concluded that the present nuclear design is close to the practical optimum with respect to the ratio of thermal to non-thermal neutron flux. (auth)**

DELAYED NEUTRONS FROM THE SPONTANEOUS FISSION OF $Cf^{252}$. S. Cox, P. Fields, A. Friedman, R. Sjoblom, and A. Smith (Argonne National Lab., Lemont, Ill.). Phys. Rev. 112, 960-3(1958) Nov. 1.

The periods and absolute yields of delayed neutrons emitted following the spontaneous fission of $Cf^{252}$ were measured. Delayed-neutron periods of $\tau_{1/2} = 0.5 \pm 0.4$, $2.0 \pm 0.4$, and $20.0 \pm 0.5$ sec with respective absolute yields of 0.35, 0.29, and 0.22% were found. The experimental results are correlated with delayed-neutron emission from other fission processes and with existing precursor systematics. (auth)

**10951**
SOME FURTHER FISSION YIELDS IN SPONTANEOUS FISSION OF $^{252}Cf$. J. G. Cuninghame (Atomic Energy Research Establishment, Harwell, Berks, Eng. and Argonne National Lab., Lemont, Ill.). J. Inorg. & Nuclear Chem. 6, 181-3(1958) June.

Six new fission yields were measured on the wings of the $Cf^{252}$ spontaneous fission curve. The width of the peaks at half maximum height is found to be $13 \pm 1$ mass units. (auth)

**6958**
SPALLATION REACTIONS OF CALIFORNIUM-252 WITH HELIUM IONS. T. Sikkeland, S. Amiel, and S. G. Thompson (Univ. of California, Berkeley). J. Inorg. & Nuclear Chem. 11, 261-3(1959) Dec.

Cross sections were determined for $Cf^{252}(\alpha,xn)$ and $(\alpha,pxn)$ reactions. The product of the $(\alpha,3n)$ reaction, $Fm^{253}$, was found to have a half life of $3.0 \pm 0.2$ days and the most abundant $\alpha$-particle energy was $6.95 \pm 0.05$ Mev. From the decay of $Fm^{253}$, the electron-capture daughter $Es^{253}$ was found to have an electron-capture to $\alpha$-decay branching ratio of $8.5 \pm 1.0$. (C.J.G.)

**10125**
PROMPT NEUTRON EMISSION FROM SPONTANEOUS-FISSION MODES OF $Cf^{252}$. William E. Stein and Stanley L. Whetstone, Jr. (Los Alamos Scientific Lab., N. Mex.). Phys. Rev. 110, 476-84(1958) Apr. 15.

The number of prompt neutrons emitted and the velocities of the fragment pairs have been measured for individual spontaneous fissions of $Cf^{252}$. The time-of-flight measurements of the fragment velocities have sufficient resolution to provide a good determination of the mode of fission as characterized by the total kinetic energy $E_K$ and the mass ratio $R_A$ of the fragments. The neutrons are detected with high efficiency in a large cadmium-loaded liquid scintillator. It is found that the dependence of the average number of neutrons per fission, $\bar{\nu}$, on the parameters $E_K$ and $R_A$ may be approximated by a plane $\bar{\nu}(E_K,R_A)$ over the region that includes the majority of the fission events. The slopes that specify the orientation of this plane are determined to be $\partial\bar{\nu}(E_K,R_A)/\partial E_K = -0.143 \pm 0.020$ (neutrons/fission)/Mev and $\partial\bar{\nu}(E_K,R_A)/\partial R_A = -6.3 \pm 1.1$ (neutrons/fission)/unit mass ratio. The value of the first slope indicates that the average total excitation energy of the fragments, required for the emission of one more neutron on the average, is $7.0 \pm 1.0$ Mev. From this number and the measured dependence of $\bar{\nu}$ on mass ratio, the average excitation energy $\bar{E}_X$ of the fragments is determined as a function of the mass ratio. This function $\bar{E}_X(R_A)$ and the measured dependence $\bar{E}_K(R_A)$ determine the average prompt energy of fission as a function of mass ratio. The widths of the neutron-number distributions have been obtained as functions of $E_K$ and $R_A$. The data do not support the statistical theory of fission proposed by Fong. (auth)

**3322**
YIELD OF CALIFORNIUM ISOTOPES PRODUCED IN THE INTERACTION BETWEEN CARBON IONS AND URANIUM NUCLEI. Yu. B. Gerlit, L. I. Guseva, et al. (Academy of Sciences, USSR). Zhur. Eksptl'. i Teoret. Fiz. 33, 339-42 (1957) Aug. (In Russian)

The yield of the californium isotopes $Cf^{246}$, $Cf^{245}$, and $Cf^{244}$ produced in the reaction between 90-Mev carbon ions and a thick uranium target was investigated. The absolute californium yield per incident particle is $1.5 \cdot 10^{-9}$ $Cf^{246}$ nuclei, $\sim 3.0 \cdot 10^{-9}$ $Cf^{245}$ nuclei, and $9 \cdot 10^{-11}$ $Cf^{244}$ nuclei. Comparison of the obtained results with the cross section for fission of uranium by carbon ions indicates that fission is $3.8 \cdot 10^3$ times more probable in this case than neutron evaporation from the compound $Cf^{250}$ nucleus. (tr-auth)

# CALIFORNIUM 1.10

**6048**

NEUTRON EMISSION FROM FISSION MODES. R. B. Leachman and C. S. Kazek, Jr. (Los Alamos Scientific Lab., N. Mex.). Phys. Rev. 105, 1511-13(1957) March 1.

The number and energy of neutrons and the average energy of prompt gamma rays emitted from various fission modes are estimated from the excitation-energy distributions of fragments from these modes. These excitation-energy distributions are derived from the mass equation of fission and the measured kinetic energies of the fragments. Simple considerations of neutron boil-off are used with these excitations. For the most probable mass ratios of fragments, the variation in the average number of neutrons $\bar{\nu}$ with the total kinetic energy $E_K$ of the fragments is found to be $d\bar{\nu}/dE_K = 0.121$ Mev$^{-1}$ for thermal-neutron fission of $U^{235}$ and $-0.116$ Mev$^{-1}$ for spontaneous fission of $Cf^{252}$. The spectra of neutron energies resulting from this analysis are found to have negligible change with $E_\gamma$, but the neutrons from $Cf^{252}$ fission are more energetic than those from thermal neutron fission of $U^{235}$. The average energy $E_K$ of prompt gamma rays from $Cf^{252}$ fission is found to be 4.0 Mev, with a variation $dE_\gamma/dE_K = -0.0167$ for the most probable mass ratios of fragments. (auth)

**6047**

CORRELATIONS BETWEEN THE NEUTRON MULTIPLICITIES AND SPONTANEOUS FISSION MODES OF CALIFORNIUM-252. Donald A. Hicks, John Isle, Jr., Robert V. Pyle, Gregory Choppin, and Bernard Harvey (Univ. of California, Berkeley). Phys. Rev. 105, 1507-11(1957).

The numbers of prompt neutrons associated with specific fission modes of $Cf^{252}$ have been measured. The average number of neutrons per fission depends largely upon the total kinetic energy of the fission fragments, decreasing by at least 0.06 neutron per fission for an increase of 1 Mev in the total kinetic energy. A less marked variation with the ratio of fragment masses is observed. (auth)

COMPLEX ALPHA AND GAMMA SPECTRA OF $Cf^{250,252}$. Frank Asaro, Frank S. Stephens, Jr., B. G. Harvey, and I. Perlman (Univ. of California, Berkeley). Phys. Rev. 100, 137-52(1955). Oct. 1.

The alpha and gamma spectra of $Cf^{250}$ and $Cf^{252}$ have been investigated with an $\alpha$-particle spectrograph and an $\alpha$-particle $\gamma$-ray coincidence counter. Alpha groups of 6.112 (84.5%) and 6.069 Mev (15.5%) belonging to $Cf^{252}$ were found, as were groups of 6.024 (83%) and 5.980 Mev (17%), belonging to $Cf^{250}$. L x rays and $\gamma$ rays of 42 (0.014%) and 100 kev ($0.01_3$%) were assigned to $Cf^{252}$. Other $\gamma$ rays were assigned to odd-mass californium isotopes. The results are evaluated with respect to the current theory and systematics of complex $\alpha$ spectra and excited states of even-even nuclei. (auth)

# CERIUM 1.11

**12490** ✓
THE APPARENT SOLUBILITY PRODUCT OF CEROUS FLUORIDE. Joyce L. Weaver and William C. Purdy (Univ. of Connecticut, Storrs). Anal. Chim. Acta 20, 376-9(1959) Apr.

The apparent solubility product of cerous fluoride was determined to be $(8.1 \pm 1.1) \times 10^{-16}$ and $(1.1 \pm 0.5) \times 10^{-15}$ by radiometric and conductometric methods, respectively. Hydrolysis of cerous fluoride is thought to be negligible. The effect of hydrogen-ion concentration on the solubility of cerous fluoride was measured in solutions of perchloric acid of varying acidity. The solubility was found to decrease slightly as the pH decreased from 5 to 2 and then to increase rapidly as the pH further decreased from 2 to 0. (auth)

**102** ✓ AEC-tr-3851
FLUORESCENCE OF CERIUM IN SODIUM FLUORIDE MELTS. Nataliya Belegishanin. Translated for Argonne National Lab. from Glasnik Khem. Drushtva, Beograd 21, 271-6(1956). 5p. JCL.

This paper was previously abstracted from the original language and appears in NSA, Vol. 13, as abstract No. 9742.

**104** ✓
THE KINETICS AND MECHANISM OF THE REACTION BETWEEN CERIUM(III) AND PERSULPHATE. Sture Fronaeus and Carl Otto Östman (Univ. of Lund, Sweden). Acta Chem. Scand. 9, No. 6, 902-11(1955).

The kinetics of the thermal decomposition of $S_2O_8^{2-}$ in aqueous solutions and of the redox reaction between $Ce^{3+}$ and $S_2O_8^{2-}$ are investigated in a perchlorate ionic medium and in a mixed perchlorate-sulphate medium. It is found that the oxidizing agent in the redox agent in the redox reaction is the intermediate radical ion $SO_4^-$, formed in a decomposition reaction of $S_2O_8^{2-}$ that is uncatalyzed by $H^+$. Evidence is also given that only one $SO_4^-$ can be formed from every $S_2O_8^{2-}$ decomposing in this way. The mechanism previously proposed for the persulphate decomposition is changed so as to be consistent with these results. The fact observed that cerous sulphate complexes are oxidized more rapidly than the hydrated $Ce^{3+}$ is discussed in terms of an electron transfer mechanism. (auth)

**9066** AEC-tr-3222
DETERMINATION OF THE HEAT OF TRANSITION IN CERIUM UNDER PRESSURE. M. G. Gonikberg, G. P. Shakhovskoi, and V. P. Butuzov. Translated from Zhur. Fiz. Khim. 31, 350-3(1957). 7p.

The heat of transition of cerium was determined as 880 ± 40 cal/g-atom at temperatures of 13 to 18°C and a pressure of about 7000 kg/cm$^2$. The study confirms the identity of the cerium modification which occurs under high pressure with its low temperature modification.

**17461**
TEMPERATURE DEPENDENCE OF THE PHASE TRANSITION IN CERIUM. R. Herman and C. A. Swenson (Iowa State Coll., Ames). J. Chem. Phys. 29, 398-9(1958) Aug.

The cubic-condensed cubic transition in cerium has been observed as a function of temperature and pressure from 360°K and 11,000 atm to 78°K and zero pressure. The data which were obtained definitely link the high pressure, room temperature and the low temperature, zero pressure transitions which have been observed previously. While the data show some unexplained features, the calculated value for the latent heat of transition at 288°K (1150 ± 100 cal/mole) agrees as to order of magnitude with a directly measured value (880 ± 40 cal/mole) by other workers. (auth)

**15101** ✓
KINETICS OF THE OXIDATION OF CERIUM (III) BY CONCENTRATED NITRIC ACID. R. W. Johnson and D. S. Martin, Jr. (Iowa State Coll., Ames). J. Inorg. & Nuclear Chem. 10, 94-102(1959) Apr.

The oxidation of $Ce^{3+}$ by concentrated nitric acid solutions was shown to be a reversible reaction. The kinetics for the oxidation at 90 to 110°C in 12 to 16 N $HNO_3$ were studied by a procedure in which volatile oxides of nitrogen were swept away by inert gas. The kinetics were consistent with an electron transfer reaction between $Ce^{3+}$ and $NO_2^+$, first order in each reactant. An over-all activation energy for the process of 8 kcal was indicated. (auth)

# CERIUM 1.11

**1285**

**OXIDATION OF CERIUM(III) TO CERIUM(IV) ION BY MEANS OF COBALT(III) ION. N. Hofman-Bang and I. Wulff (Technical Univ. of Denmark, Copenhagen). Acta Chem. Scand. 9, No. 7, 1230-40(1955).**

**Cobaltic ion, $Ce^{3+}$, quantitatively oxidizes cerous ion, $Ce^{3+}$, to ceric ion, $Ce^{4+}$, in aqueous acid solutions. The green cobaltic carbonato complex yields the blue cobaltic aquo ion when acidified with an excess of $H_2SO_4$ or $HNO_3$. (C.W.H.)**

**9252**

MECHANISM FOR THE REDUCTION OF CERIC ION BY FORMIC ACID INDUCED BY COBALT-60 GAMMA-RADIATION. Thomas J. Sworski (Oak Ridge National Lab., Tenn.). Radiation Research 6, 645-52(1957) June.

In the radiolysis of air-saturated $H_2SO_4$ solutions containing ceric ion-cerous ion-formic acid mixtures at constant initial $(Ce^{3+})/(HCOOH)$, the initial $G(Ce^{3+})$ decreases with decreasing total concentration of cerous ion and formic acid. These data are quantitatively interpreted by the assumption that cerous ion, formic acid, and $H_2SO_4$ compete with each other for reaction with OH radical. Although the OH radical reacts with both cerous ion and formic acid, it is assumed that the $HSO_4$ radical (formed by reaction of OH radical with sulfuric acid) oxidizes cerous ion but does not react with formic acid. Thus, kinetic evidence is presented for an influence of $H_2SO_4$ on reactions of OH radical in sulfuric acid solutions. (auth)

**16054**

**THE REDUCTION OF CERIC IONS BY $Po^{210}$ ALPHA PARTICLES. J. Weiss and N. Miller (Univ. of Edinburgh). J. Phys. Chem. 63, 888-9(1959) June.**

**Solutions of ceric sulfate, cerous sulfate, and thallous sulfate in 0.8N sulfuric acid were irradiated using a one-curie $Po^{210}$ $\alpha$ source external to the solutions. The yield of ceric ion reduction was determined, and a qualitative explanation of the results given. The $G(Ce^{3+})$ without added solute was found to be 2.88 ± 0.02 for 3.4-Mev $\alpha$ particles. (auth)**

**4748**

THE HYDROGEN PEROXIDE-INDUCED Ce*(III)–Ce(IV) EXCHANGE SYSTEM. Paul B. Sigler and B. J. Masters (Los Alamos Scientific Lab., N. Mex.). J. Am. Chem. Soc. 79, 6353-7(1957) Dec. 20.

The technique of isotopic exchange in non-stable systems has been applied to study the kinetics of the reaction between Ce(IV) and $H_2O_2$ in 0.8 N $H_2SO_4$ solution. In addition to the bimolecular electron exchange reaction between Ce*(III) and Ce(IV), an induced exchange reaction is found to occur at a rate proportional to the concentration ratio [Ce(III)]/[Ce(IV)]. The results are consistent with the mechanisms $H_2O_2 + Ce(IV) \overset{k_1}{\rightleftharpoons} HO_2 + Ce(III) + H^+$ and $HO_2 + Ce(IV) \xrightarrow{k_1k_2} Ce(III) + O_2 + H^+$. (auth)

**5248**

AN INVESTIGATION OF THE SPECIES EXISTING IN NITRIC ACID SOLUTIONS CONTAINING CERIUM(III) AND CERIUM (IV). Bernard D. Blaustein and John W. Gryder (Johns Hopkins Univ., Baltimore, Md.). J. Am. Chem. Soc. 79, 540-7(1957) Feb. 5.

Extraction data and electromotive force measurements are interpreted as indicating the existence of $Ce^{4+}-Ce^{4+}$ and $Ce^{4+}-Ce^{3+}$ polymers in 5.5 f $HNO_3$ solutions. If the polymers are assumed to be dimers, the association constants for the reactions $2Ce^{4+} = (Ce^{4+})_2$, $Ce^{4+} + Ce^{3+} = Ce^{4+}Ce^{3+}$ in this medium are 17 ± 2 and 2.0 ± 0.7 at 30.0 ± 0.03° where total concentration of monomer and of dimer are used in the equilibrium expressions. Contradictory reports in the literature are reconciled by the existence of these dimeric species. The $Ce^{4+}$ species extracted by ether is shown to contain no ionizable $H_2$. (auth)

**91**

THE MECHANISM OF THE EXCHANGE REACTION BETWEEN CERIUM(III) AND CERIUM(IV) AT PLATINUM SURFACES. Sture Fronaeus and Carl Otto Ostman (Univ. of Lund, Sweden). Acta Chem. Scand. 10, No. 5, 769-78 (1956).

The heterogeneous electron exchange reaction between $Ce^{3+}$ and $Ce^{4+}$ at Pt surfaces under equilibrium electrode potential is investigated in a perchlorate ionic medium by means of a radioactive tracer. A general relationship for the combination of rates of consecutive steps in exchange reactions is given. From the kinetic law obtained in the present case it is established that at 0°C and in approximately 3M $HClO_4$ the resultant rate of the reaction is controlled both by the electron transfer step and by the dif-

# CERIUM 1.11

fusion of $Ce^{4+}$ up to the interface. The measurements indicate that the uptake of electrons from platinum by $Ce^{4+}$ takes place via a dimer of $Ce^{4+}$. Thus this species together with the corresponding mixed $Ce^{3+}-Ce^{4+}$ product, operating in the reverse process, are directly potential adjusting, although the concentrations of both species are very low in comparison with the total concentrations of Ce. The mechanism proposed is discussed in connection with other facts about some homogeneous redox reactions in which Ce is involved. (auth)

**9065** AEC-tr-3208
INTERACTION BETWEEN CERIUM AND HYDROGEN. V. I. Miheyev and M. E. Kost. Translated by Lydia Venters from Doklady Akad. Nauk S.S.S.R. 115, 100-2 (1957). 6p.

The hydrogenation of metallic cerium can be achieved at room temperature without using a preliminary heat treatment of the cerium samples, if the initial substances are carefully purified. The hydrogen absorption of cerium at room temperature (14 to 21°) results in the formation of hydride with chemical composition $CeH_3-CeH_{3.16}$, and this reaction does not depend on hydrogen pressure. The variation curves of the composition of hydride and the temperature and the curves of the hydrogenation rate confirm the formation of specific hydrides $CeH_2$ and $CeH_3$ and the pressure of a phase of changeable composition between $CeH_2$ and $CeH_{3.16}$. (auth)

**13799**
DOUBLE CHLORIDES OF CERIUM GROUP ELEMENTS WITH TRIMETHYLAMINE CHLORIDE. N. N. Sakharova and S. V. Zemskov (Chernyshevskii Saratov State Univ.). Doklady Akad. Nauk S.S.S.R. 120, 539-40(1958) May 21. (In Russian)

Binary chlorides of rare elements with trimethylamine in the presence of 96% ethyl alcohol, expressed by the general formula $MeCl_3 \cdot 4(CH_3)_3N \cdot HCl$, where Me is La, Ce, Pr, and Nd, were obtained. Properties of these compounds were studied, and their solubility in water and organic solvents was determined. (R.V.J.)

**9739**
PREPARATION OF CERIUM MONOSULFIDE. G. V. Samsonov, N. M. Popova, and L. I. Tikhomirova. Zhur. Priklad. Khim. 31, 153-7(1958) Feb. (In Russian)

A simple method was devised for producing cerium monosulfide CeS. $CeO_2$ (98% $CeO_2$, < 0.01% Fe), carbon black with 99.4% C and 0.4% ash, and sulfur (99.9%) were calcined at 900 and 400°. (R.V.J.)

**13812**
ON CERIUM HYDRIDES. V. I. Mikheeva and M. E. Kost. Zhur. Neorg. Khim. 3, 260-8(1958) Feb. (In Russian)

Experiments on cerium hydridation were made with prepared cerium with admixtures of <0.001% Cu, 0.037% Fe, 0.03% Mg, 1.8% Nd, 0.001% Pb, 1.1% Pr, 0.015% S, and 0.02% Si. Absorption of hydrogen reaches up to $CeH_{3.15}$. Hydrides of alternating compositions and stoichiometric hydrides $CeH_3$ and $CeH_2$ were observed. The cerium hydride is stable up to 200°C; with further heating it decomposes by hydrogen liberation and forms $CeH_2$. $CeH_2$ melts at 1080°C; melting is followed by decomposition. The existence of $CeH_3$ is confirmed by the synthesis of double hydrides from $Ce(AlH_4)_3$. (R.V.J.)

ON THE CERIUM SALT COMPOUNDS WITH PYRIDINE AND QUINOLINE. V. V. Serebrennikov, E. I. Ivanova, and L. A. Alekseenko. Zhur. Neorg. Khim. 4, 1377-81 (1959) June. (In Russian)

Problems arising in trichloride and cerium sulfate interactions with pyridine and quinoline and the effects of temperature on the stability of compounds $CeCl_3 \cdot nPy[CePy_6][Cr(CNS)_6]$ and $[CeChin_6][Cr(CNS)_6]$, as well as their pyridine and quinoline yield in storage over sulfuric acid, are analyzed. (R.V.J.)

**5143**
DETERMINATION OF THE COMPOSITION AND STABILITY CONSTANT OF CERIUM OXALATE COMPLEXES BY ION EXCHANGE. K. B. Zaborenko, A. V. Zaval'skaya and V. V. Fomin. Radiokhimiya 1, 387-90(1959). (In Russian)

Studies of cerium ion distribution between cations (KU-2) and solution with or without $C_2O_4^{2-}$ complexing revealed the presence of $CeC_2O_4^+$ ions with a stability constant $\beta_1 = 1.1 \times 10^4$ in the solution with unit ion force. (R.V.J.)

**~~6237~~**
THE REACTION OF CERIUM(III) WITH 2-METHYL-8-QUINOLINOL. Wesley W. Wendlandt (Texas Tech. Coll., Lubbock). J. Inorg. and Nuclear Chem. 4, 133-4(1957) Mar.

Cerium(III) reacted with 2-methyl-8-quinolinol to form a purple colored chelate that precipitated out of solution. The general formula for this precipitate is $Ce(C_{10}H_8NO)_4$. (W.L.H.)

# CERIUM 1.11

**15109**
COMPOSITION AND STABILITY CONSTANT OF A COMPLEX OF CERIUM AND AMMONIUM CITRATE AT ALKALINE pH. R. S. Leal (C.E.E.N., Lisbon). J. Inorg. & Nuclear Chem. 10, 159-61(1959) Apr.

The composition and stability constant of a complex of cerium and citrate ion were determined by the ion exchange method. The adsorbent used was Zeocarb-225, in the $NH_4^+$ form and 70/100 mesh size. (W.L.H.)

**6515**
ON THE EFFECT OF IRON ON COLORIMETRIC DETERMINATION OF CERIUM. R. K. Korabel'nik. Zhur. Anal. Khim. 11, No. 4, 419-22(1956). (Translated from Referat. Zhur. Khim. No. 4, 1957, Abstract No. 12063).

For a colorimetric determination of $Ce^{4+}$ ferroin was utilized which, on oxidative action of $Ce^{4+}$ with $Fe^{3+}$, yields an azure-colored complex. Into a 100 ml flask is poured, from a burette, a definite volume of $Ce(SO_4)_2$ solution, an excess of 0.0025 M ferroin (10 drops) is added, the solution is brought up to 100 ml and subjected to colorimetry, in a photometer of photocolorimeter, using a yellow light filter. Determination of $Ce^{4+}$ is interfered with by all oxidizing agents having a normal potential above + 1.14v ($MnO_4^-$, $Cr_2O_7^{2-}$). $Fe^{3+}$, although its potential is + 0.77v, still vitiates the results of the determination. The distortion, in the opinion of the author, is due to formation of $Ce^{4+}$ and $Fe^{3+}$ complexes, at a ratio of 3:1, the existence of which was confirmed by microcrystalloscopic and spectrophotometric experiments.

**14030** ✓
THE COMPOSITION, RESISTIVITY, AND THERMOELECTRIC POWER OF CERIUM OXIDES BELOW 500°C. A. W. Czanderna and J. M. Honig (Purdue Univ., Lafayette, Ind.). Phys. and Chem. Solids 6, 96-7(1958) July.

The results of a study on the stoichiometry, resistivity, and thermoelectric power of cerium oxide in high vacuum and in oxygen for the temperature range 45 to 485°C are presented. By heating the oxide, considerable quantities of gases were evolved but little change in the resistivity of the sample was detected up to 160°C. An incipient decomposition occurred in the temperature range 160 to 485°C. The sample composition remained stable in high vacuum in the region 485 to 600°C. (J.E.D.)

**2732** AFOSR-TN-57-602
Purdue Univ., Lafayette, Ind.
THE STOICHIOMETRY, RESISTIVITY, AND THERMOELECTRIC POWER OF CERIUM DIOXIDE BELOW 500°C. A. W. Czanderna and J. M. Honig. Sept. 1957. 33p. (AD-136-591).

**4995** ✓
DECAY OF RADIOACTIVE $Ce^{143}$ (33.4 hr). D. W. Martin, M. K. Brice, J. M. Cork, and S. B. Burson (Argonne National Lab., Lemont, Ill.). Phys. Rev. 101, 182-8(1956) Jan. 1.

The beta and gamma radiations of $Ce^{143}$ have been studie with a ten-channel scintillation coincidence spectrometer, with a double-focusing magnetic spectrometer, and with photographic magnetic spectrographs. Five beta-ray components and ten gamma rays are identified with the activity, and the decay scheme is established involving six excited states of the daughter $Pr^{143}$ nucleus. It is found that no beta rays of measurable intensity proceed directly to the $Pr^{143}$ ground state. Spin and parity assignments are made for several of the levels. (auth)

**5671** ✓
ON THE DECAY OF $^{141}Ce$. G. B. Zorzoli. Nuovo cimento (10) 5, 289-90(1957) Jan.

The conversion coefficient for the K shell and the ratio between K and L electrons were measured for $Ce^{141}$. A high-transmission intermediate image $\beta$-ray spectrometer was used to measure the $\beta$ spectrum, and the $\gamma$ and x radiations were analyzed with a 20-channel pulse analyzer. (B.J.H.)

DECAY OF $Ce^{144}$. Ira Pullman and Peter Axel (Univ. of Illinois, Urbana). Phys. Rev. 102, 1366-72(1956) June 1.

The decay scheme of 282-day $Ce^{144}$ was investigated using a thin-lens beta spectrometer, proportional counters, and scintillation counters. Intensity measurements and coincidence studies were used to obtain the decay scheme. Two beta rays were found; the main branch is a 76%, 309 ± 5-kev beta ray to the ground state while the 24 ± 5%, 175-kev beta ray goes to a 134-kev level in $Pr^{144}$. From this level there are three parallel $\gamma$-ray branches: In 15.3% of the Ce disintegrations one observes a 134-kev gamma ray, in 7.2% a cascade of 81-kev and 54-kev gamma rays, and in 1.5% a cascade of 100 kev and 34 kev. For the conversion of the 134-kev gamma ray, $\alpha_K = 0.71 \pm 0.20$ and $K/L = 7.1 \pm 0.5$, while for the 81-kev gamma ray, $\alpha_K = 1.2 \pm 0.3$ and $K/L = 5.8 \pm 0.7$. There is insufficient intensity in the 54-kev gamma ray to explain observed coincidences, and a strong unobserved 42-kev gamma ray is implied. (auth)

# CERIUM 1.11

**8838**

INVESTIGATIONS OF $Ce^{144}$ DECAY USING $\beta-\gamma$ COINCIDENCES. V. P. Parfenova, N. V. Forfontov, and V. S. Shpinel. Izvest. Akad. Nauk S.S.S.R. Ser. Fiz. 21, No. 12, 1601-6(1957) Dec. (In Russian)

The decay scheme of $Ce^{144}-Pr^{144}$ was studied. Results indicate that $\beta$ spectra coincidences with three different areas of $\gamma$ spectra are quite complex. In basic transition into $Pr^{144}$ spectrum $\beta_4$ falls out. Observations of $\beta-\gamma$ cascades point out that $\beta$ transitions of $\beta_3(E_{\beta\ max} = 230$ kev) and $\beta_2(E_{\beta\ max} = 175$ kev) excite $Pr^{144}$ levels with the energy of 80 and 134 kev, respectively. The spectrum $\beta_1(E_{\beta\ max} = 130$ kev) was observed on all rectified graphs. The $\beta$ spectrum softer than 175 kev indicates the evidence of $Pr^{144}$ excitation level located above 134 kev level. (R.V.J.)

**2148**

NUCLEAR ORIENTATION OF CERIUM-141. C. F. M. Cacho, M. A. Grace, C. E. Johnson, A. C. Knipper, R. G. Scurlock, and R. T. Taylor (Clarendon Lab., Oxford, England). Phil. Mag. (7) 46, 1287-94(1955) Dec.

$Ce^{141}$ has been aligned by the method of magnetic hfs (alignment) in a crystal of cerium ethyl sulfate. From measurements of the angular distribution and the plane of polarization of the $\gamma$ radiation it is concluded that the $\gamma$-ray transition is principally M1 with a small admixture of E2 ($\delta = +0.08 \pm 0.02$). Values of $0.75 \pm 0.20$ and $0.66 \pm 0.16$ nuclear magnetons are found for the nuclear moment of $Ce^{141}$, depending on whether the $\beta$ transition involves a spin change of 1 or 0. (auth)

**1403**

THE MAGNETIC SUSCEPTIBILITY OF METALLIC CERIUM. L. F. Bates, S. J. Leach, and R. G. Loasby (Univ. of Nottingham, England). Proc. Phys. Soc. (London) B68, 859-61(1955) Nov. 1.

The magnetic susceptibility of pure metallic cerium has been measured over the temperature range 90 to 1057°K. At 293°K, the susceptibility is $17.5 \pm 0.2$ e.m.u. per gram, and between 90 and 295°K, the relation $\chi = 0.00588/(T + 42)$ is followed. The observed temperature variation of susceptibility can be explained on the basis of a change in thermal population of $^2F_{5/2}$ and $^2F_{7/2}$ levels separated by 1340 $cm^{-1}$, upon which is superimposed a small temperature-independent paramagnetism. (auth)

RADIOACTIVITY OF THE CERIUM-137 ISOMERS. A. R. Brosi and B. H. Ketelle (Oak Ridge National Lab., Tenn.). Phys. Rev. 100, 169-70(1955) Oct. 1.

A cerium isotope with an 8.7-hr half life has been assigned to $Ce^{137}$ and shown to decay be electron capture with about 3% of the captures to a 445-kev level in $La^{137}$. The 34.5-hr decay period previously characterized as electron capture of $Ce^{137}$ is an isomeric transition from a 255-kev level in $Ce^{137}$.

**9170**

THE SPECIFIC HEATS AND MAGNETIC SUSCEPTIBILITIES OF ALLOYS OF CERIUM WITH LANTHANUM AT LOW TEMPERATURES. Lois M. Roberts and J. M. Lock (Royal Radar Establishment, Gt. Malvern, Worcs.). Phil. Mag. (8) 2, 811-19(1957) June.

Specific heat measurements between 1.5 and 20°K, and magnetic susceptibility measurements between 1.5 and 290°K have been made on four alloys containing respectively 78.9%, 37.6%, 27.0% and 5.03% by weight of Ce in La. Comparison is made with similar previous measurements on pure Ce. The single anomaly in the specific heat of pure Ce at 12.3°K splits into two in the alloys, and as the dilution is increased these anomalies move to lower temperatures. The lower of the two only is accompanied by a change in the magnetic properties, a maximum occurring in the susceptibility of the most concentrated alloy and temperature-independent paramagnetism setting in suddenly in the next two. In the most dilute alloy the anomalies in both the specific heat and in the susceptibility appear to have moved to temperatures below 1.5°K. Above 80°K the magnetic susceptibilities of all the alloys obeyed a Curie-Weiss law, $x = C/(T-\theta)$. The Curie constant C varied smoothly from $56.1 \times 10^{-4}$ e.m.u./g Ce for the most concentrated alloy (cf. $55.3 \times 10^{-4}$ e.m.u./g for pure Ce) to about $140 \times 10^{-4}$ e.m.u./g Ce for the most dilute alloy. As in pure Ce, antiferromagnetism is believed to be the explanation of the anomalous magnetic behavior of the alloys. However, the double specific heat anomalies in the latter suggest that the ordering of the 4f electronic orbitals takes place in two stages, while the temperature-independent paramagnetism of the more dilute alloys may be the consequence of freedom of the direction of magnetic ordering to orient itself perpendicular to the applied field. The increase in the Curie constant suggests that the population of the 4f shell increases, with dilution of the alloys, to 2 or 3 electrons per atom of Ce. (auth)

# CESIUM 1.12

**14259** TID-7568(Pt. 2)(p.192-7)
Westinghouse Electric Corp. Bettis Plant, Pittsburgh.
RADIOCHEMICAL AND MASS SPECTROMETRIC STUDIES OF FISSION PRODUCT CESIUM. A[lfred] J. Moses and H. D. Cook. p.192-7 [of] ANALYTICAL CHEMISTRY IN NUCLEAR REACTOR TECHNOLOGY. PART 2. INSTRUMENTATION, REMOTE CONTROL TECHNIQUES, AND NUCLEONICS. Second Conference, Gatlinburg, Tennessee, September 29–October 1, 1958. 6p.

The accuracy of fission determinations by $Cs^{137}$ analyses depends in part on a knowledge of the half-life of this isotope. In this work, the half-life of $Cs^{137}$ was redetermined by isotope dilution and 4-$\pi$ beta counting. The resultant value is $28.6^{+2}_{-1}$ years. A method was developed to purify carrier-free, fission-product cesium by an ion-exchange separation. The isotopic composition of the purified cesium and the total cesium content were determined by mass spectrometric methods. The number of $Cs^{137}$ atoms thus obtained was compared with data obtained by conventional radiochemical methods. (auth)

**18954** ✓ CEA-tr-X-138
SÉPARATION DU CÉSIUM EN QUANTITÉ FAIBLE PAR CHROMATOGRAPHIE ET PAR ÉCHANGE D'IONS. (Separation of Cesium in Low Quantities by Chromatography and Ion Exchange.) N. Yamagata. Translated into French by E. Hera from Nippon Kagaku Zasshi 78, 513-17(1957). 9p.

As a preliminary study of the quantitative analysis of cesium in sea water, potassium chloride containing no cesium was prepared by removal of the cesium by chromatography and ion exchange. The equilibrium constant of cesium in a solution of potassium was measured by utilization of $Cs^{137}$ with carrier. Sodium, potassium, and cesium in sea water can be separated on ion exchange resins. The conditions are described. (tr-auth)

**8683** ✓
THE REACTION BETWEEN CESIUM AND CARBON DIOXIDE. Ralph Setton. Bull. soc. chim. France No. 11-12, 1400-4(1958) Nov.-Dec. (In French)

The reaction between cesium and carbon dioxide gives a product of the formula $Cs_2CO_3$, which appears to be "cesium cesioformate" or CsCOOCs. Its hydrolysis gives a molecule of cesium formate and one of hydroxide. Heated, the cesium cesioformate gives the oxalate $(CsCOO)_2$ and metallic cesium. (tr-auth)

**1207** AERE-I/M-40
Gt. Brit. Atomic Energy Research Establishment, Harwell, Berks, England.
THE PREPARATION OF CAESIUM METABORATE. K. D. Kilburn. July 1957. 6p.

Although the large scale preparation of cesium metaborate would most conveniently use an ion exchange resin, the following method was convenient for a small laboratory preparation: cesium nitrate was converted to the bisulfate, and this with barium hydroxide gave cesium hydroxide. Excess barium hydroxide was precipitated by passing carbon dioxide through the slurry. After filtering, the filtrate was analyzed for cesium, the calculated quantity of boric acid was added, and the water was evaporated off to leave an amorphous powder which, on fusing in vacuo, gave the pure anhydrous borate. (auth)

**1418**
OPTICAL PROPERTIES OF CESIUM IODIDE. William S. Rodney (National Bureau of Standards, Washington, D. C.). J. Opt. Soc. Amer. 45, 987-92(1955) Nov.

The refractive indices of CsI were determined at three temperatures near 15, 24, and 34°C for wavelengths from 0.29 micron in the ultraviolet to 53 microns in the infrared. The thermal coefficients of index were determined for each wavelength and all data were reduced to 24°C. A dispersion equation of the Sellmeier type having five terms was fitted to these data. Four of the terms contained absorption wavelengths which were either known experimentally or had been computed from the lattice constants of the crystal. The fifth was adjusted to fit the data and has a value of about 0.02 micron. The formula was extrapolated to infinite wavelength, and the value of $n_\infty^2$ agreed with the known dielectric constant at 30 cm. The dispersion of CsI for infrared wavelengths from about 30 to 40 microns is less than that of CsBr but only by a factor of about 2. At 50 microns the dispersion of CsI is practically equal to the 40-micron dispersion of CsBr. (auth)

**12048**
THE YIELD OF $Cs^{138}$ IN THERMAL NEUTRON FISSION OF $U^{235}$. Rosalie M. Bartholomew and A. P. Baerg (Atomic Energy of Canada Ltd., Chalk River, Ont.). Can. J. Chem. 34, 201-5(1956) Mar.

The yield of $Cs^{138}$ in thermal neutron fission of $U^{235}$ has been investigated using the 4$\pi$ counting technique. The value obtained for the fission yield is (7.22 ± 0.29)% based on a value of 6.32% for the fission yield of $Ba^{140}$. The half life of $Cs^{138}$ was determined and found to be 32.2 ± 0.1 min.

# CESIUM 1.12

**11309**

THE ABSOLUTE YIELD OF $Cs^{137}$ IN FAST-NEUTRON FISSION OF $U^{235}$ AND $Pu^{239}$. P. Kafalas and C. E. Crouthamel (Argonne National Lab., Lemont, Ill.). J. Inorg. and Nuclear Chem. 4, 239-44(1957).

The absolute fission yield of $Cs^{137}$ has been determined for fast-neutron fission of $U^{235}$ and $Pu^{239}$. The number of fissions was determined by absolute counting of the fission fragments. The $Cs^{137}$ was determined by absolute $\beta$ counting with an end-window proportional counter. The yields were found to be 6.87 and 7.45% for $U^{235}$ and $Pu^{239}$, respectively. These values are based on a $Cs^{137}$ half life of 32.6 years. (auth)

**508**

THE YIELD OF $Cs^{137}$ IN THE PILE NEUTRON FISSION OF NATURAL URANIUM. F. Brown (Atomic Energy Research Establishment, Harwell, Berks, England). J. Inorg. and Nuclear Chem. 1, 248-52(1955) Oct.

The ratio of $Cs^{137}/Ba^{140}$ yields from the pile neutron fission of natural U is $0.985\ ^{+0.03}_{-0.02}$. (auth)

**458**

THE HALF-LIFE OF $Cs^{137}$. F. Brown, G. R. Hall, and A. J. Walter (Atomic Energy Research Establishment, Harwell, Berks, England). J. Inorg. and Nuclear Chem. 1, 241-7(1955) Oct.

The $\beta$-decay half-life of $Cs^{137}$ has been obtained from a specific activity measurement. The disintegration rate was measured in a $4\pi$-type proportional counter. The number of atoms of $Cs^{137}$ was measured by mass spectrometry, using the isotopic dilution method. The result is $30.0^{+0.3}_{-0.4}$ years, (auth)

**9512**

BETA INTERACTION IN THE DECAY OF $Cs^{137}$. Toshio Katoh, Masao Nozawa, and Yasukazu Yoshizawa (Osaka Univ.) and Yujiro Koh (Osaka City Univ.). J. Phys. Soc. Japan 12, 738(1957) June.

An attempt was made to determine the sign of the ratio of $G_s/G_T$ in the beta interaction by investigating the higher component of beta rays from $Cs^{137}$. (M.H.R.)

**4878**

HALF LIFE OF THE 122 KEV LEVEL OF $Cs^{131}$. Hamlet Vartapetian, Louis Dick, Roger Foucher, and Nils Perrin. Compt. rend. 242, 103-5(1956) Jan. 4. (In French)

The half life of the 122-kev level of $Cs^{131}$ was measured by the method of delayed coincidences. Its value is $(4 \pm 0.3) \times 10^{-9}$ sec. This transition is interpreted as being of the M1 forbidden type with $\Delta l = 2$, with a $g_{7/2}$ level. (tr-auth)

DESCRIPTION AND CALIBRATION OF A BETA SPECTROMETER WITH DOUBLE FOCUSSING. THE BETA SPECTRUM OF $Cs^{137}$. J. Demuynck and J. Verhaeghe (Univ. of Gent, Belgium). Mededel. Koninkl. Vlaam. Acad. Wetenschap. Belg. 16, No. 11, 21p. (1954). (In Dutch)

A detailed description is given of the design of a double-focusing beta spectrometer. The focusing conditions are derived, and the equations of the magnetic field are given. The standardization of the electronic measuring system and the field measurements are discussed. The conversion spectrum of $Cs^{137}$ was measured with this spectrometer. (J.S.R.)

**10417** ORO-151

~~Arkansas. Univ., Fayetteville.~~

ELECTROMAGNETIC RADIATIONS OF CESIUM 132. Berol L. Robinson and Richard W. Fink. July 1956. 19p. ~~Contract AT(40-1)-277. 30.20(OTS).~~

A sample of $Cs^{132}$ was prepared by bombarding CsCl with 80-Mev protons in the Rochester 130-inch cyclotron followed by radiochemical purification. The half life was $6.2 \pm 0.2$ days by gamma counting. Scintillation spectrometer studies showed gamma rays at $669 \pm 3$ kev, $1100 \pm 40$ kev, and $1265 \pm 20$ kev, having intensities of $1000:(7 \pm 2):(8 \pm 2)$, respectively. By means of K x-ray–gamma coincidence experiments, the branching ratio to the 669-kev level was found to be $0.9 \pm 0.2$. Major sources of error in this measurement arise from uncertainties in the absolute calibration of a $Cs^{137}$ standard, and in the decay constants of $Cs^{132}$ and $Cs^{131}$, the latter being present as a

# CESIUM 1.12

contaminant. From the branching ratio, it is deduced that electron capture to the ground-state is forbidden and that $Cs^{132}$ has $I \geq 2$, in agreement with shell model predictions. Because of ft value shows the transition to the 669-kev level to be allowed, the spin must be less than 4. Gamma–gamma coincidences were observed, but the 1265-kev gamma ray is not coincident with the 669-kev transition. Gamma rays at 395 ± 10 kev and 550 ± 30 kev were observed and are attributed to $Cs^{128}$, as they decayed with a half life of about 31 hours. ~~(auth)~~

MODIFICATIONS OF THE Cs ABSORPTION SPECTRUM DUE TO INTERATOMIC INTERACTIONS. Oleg Jefimenko and Shang-Yi Ch'en (Univ. of Oregon, Eugene). J. Chem. Phys. 26, 913-19(1957) Apr.

Absorption spectra of Cs in the presence of $H_2$, $D_2$, $N_2$, He, Ne, A, Kr, Xe, methane, ethane, propane, n-butane, n-pentane, n-hexane, n-heptane, n-octane, and benzene were investigated following a similar work with Rb. It was found that the spectra of all these mixtures of Cs and foreign gas exhibit diffuse bands in the neighborhood of certain Cs atomic lines. Over one-hundred such bands were identified, the positions of the bands were measured, and some of the regularities in the occurrence of the bands were determined. The results of this investigation in general were found to be in qualitative agreement with the statistical theory of pressure broadening of the atomic lines if both the attractive and the repulsive interatomic forces are taken into account. It is, however, not certain that the statistical theory is capable of explaining the observed phenomena in their entirety. (auth)

# CURIUM 1.13

**258**

California. Univ., Berkeley. Radiation Lab.
SOME PHYSICAL AND CHEMICAL PROPERTIES OF CURIUM, (Thesis). W. W. T. Crane. Apr. 16, 1951. 34p. (AECD-3161).

Twenty references to the journal literature are given.

**2282**

EVIDENCE FOR QUADRIVALENT CURIUM. II. CURIUM TETRAFLUORIDE. L. B. Asprey and F. H. Ellinger (Los Alamos Scientific Lab., N. Mex.); S. Fried (Argonne National Lab., Lemont, Ill.); and W. H. Zachariasen (Univ. of Chicago, Ill.). J. Am. Chem. Soc. 79, 5825(1957) Nov. 5.

**4557**

POSSIBLE EXISTENCE OF $Cm^{247}$ OR ITS DAUGHTERS IN NATURE. H. Diamond, A. M. Friedman, J. E. Gindler, and P. R. Fields (Argonne National Lab., Lemont, Ill.). Phys. Rev. 105, 679-80(1957) Jan. 15.

The absence of any detectable $Pu^{243}$ daughter activity in a sample of curium containing two micrograms of $Cm^{247}$ indicates that the alpha half life of $Cm^{247}$ exceeds $4 \times 10^7$ years and probably exceeds $9 \times 10^7$ years. The possibilities of finding $Cm^{247}$ in nature and of finding high $U^{235}$:$U^{238}$ ratios in very old rare-earth minerals are discussed. (auth)

**14192**

CURIUM-249. T. A. Eastwood and R. P. Schuman (Atomic Energy of Canada Ltd., Chalk River, Ont. and Knolls Atomic Power Lab., Schenectady, N. Y.). J. Inorg. & Nuclear Chem. 6, 261-2(1958) July.

The assignment of the 65 min $\beta$-activity in curium to $Cm^{249}$ was confirmed by neutron irradiations of curium containing 86% $Cm^{248}$. The half-life and maximum $\beta$-particle energy of $Cm^{249}$ were found to be 64 ± 3 min and 0.86 ± 0.10 Mev, respectively. The yield of $Cm^{249}$ from the irradiations corresponds to a capture cross-section of about 6 barns for $Cm^{248}$. (auth)

**10502**

THE ABSORPTION SPECTRUM OF AQUEOUS CURIUM (III). W. T. Carnall, P. R. Fields, and D. C. Stewart (Argonne National Lab., Lemont, Ill.) and T. K. Keenan (Los Alamos Scientific Lab., N. Mex.). J. Inorg. & Nuclear Chem. 6, 213-16(1958) June.

The absorption spectrum of aqueous $curium^{3+}$ has been studied in 0.04 N $HClO_4$, using the isotope $Cm^{244}$. Three prominent absorption peaks have been discovered at 3754 A, 3812 A, and 3965 A, in addition to absorption in the far ultra-violet. These same peaks are found in HCl, $HNO_3$, and $H_2SO_4$ solutions. The general characteristics of the spectra in these three acids and some general observations on the radiation decomposition of aqueous curium solutions are reported. (auth)

**13421**

$Cm^{242}$ $\alpha$-DECAY. L. N. Kondrat'ev, V. B. Dedov, and L. L. Gol'din. Izvest. Akad. Nauk S.S.S.R. Ser. Fiz. 22, 99-100(1958) Feb. (In Russian)

Experimental measurements were made of the $\alpha$ decay energies for non-spherical nuclei at the second excitation level $4^+$, and the results were compared with the theoretical values. The values were not in agreement for $Cm^{242}$ and $Cm^{244}$, and it is shown that the discrepancy is real. The $\alpha$ levels are tabulated. (R.V.J.)

**5895**

CROSS SECTION FOR PRODUCTION OF $Cm^{240}$ BY IRRADIATION OF $Th^{232}$ WITH $C^{12}$ AND $C^{13}$ IONS. L. I. Guseva, B. F. Myasoedov; N. I. Tarantin, and K. V. Filippova. Zhur. Eksptl'. i Teoret. Fiz. 37, 973-7 (1959) Oct. (In Russian)

The dependence of the cross sections of the reactions $Th^{232}(C^{12},4n)Cm^{240}$ and $Th^{232}(C^{13},5n)Cm^{240}$ on the energy of the bombarding particles was determined by irradiating a stack of thin foils and subsequently analyzing the reaction products. The curves for the reaction cross sections have distinct peaks characteristic of reactions of evaporation of neutrons from a compound nucleus. The peak values of the cross sections for the reactions $Th^{232}(C^{12}$ $4n)Cm^{240}$ and $Th^{232}(C^{13}, 5n)Cm^{240}$ are, respectively, $8 \times 10^{-29}$ $cm^2$ and $1.8 \times 10^{-29}$ $cm^2$. Comparison of the reaction cross sections obtained by bombarding thorium with the cross sections of other nuclear reactions shows that the cross section for reactions involving evaporation of neutrons does not depend on $Z^2/A$ in a simple manner. (auth)

SPONTANEOUS FISSION HALF-LIFE OF $Cm^{246}$. S. M. Fried, G. L. Pyle, C. M. Stevens, and J. R. Huizenga (Argonne National Lab., Lemont, Ill.). J. Inorg. and Nuclear Chem. 2, 415-16(1956) July.

A value of $(2.0 \pm 0.8) \times 10^7$ years has been obtained for the spontaneous fission half life of $Cm^{246}$. (C.W.H.)

**2353** UCRL-78

California. Univ., Berkeley. Radiation Lab.
SPECTRAL LINES OF CURIUM FROM 3100 A TO 4200 A. John G. Conway and Milton F. Moore. Apr. 7, 1948. Decl. Nov. 28, 1955. 5p. Contract W-7405-eng-48. $1.80(ph OTS); $1.80(mf OTS)

Fifty-four spectral lines of Cu are listed together with estimated intensities. A brief description of the manner of taking the spectra and of measuring the lines is given. (auth)

# EINSTEINIUM 1.14

~~9763~~

THE HALF-LIFE, NEUTRON CAPTURE AND FISSION CROSS-SECTIONS OF LONG LIVED EINSTEINIUM-254. R. P. Schuman, T. A. Eastwood, H. G. Jackson, and J. P. Butler (~~Knolls Atomic Power Lab.~~, Schenectady, N. Y. and Atomic Energy of Canada, Ltd., Chalk River, ~~Ont.~~). J. Inorg. and Nuclear Chem. 6, 1-2(1958) Feb.

The half life of long-lived $Es^{254}$ has been found to be 480 ± 70 days. A measurement of the burn-up of $Es^{254}$ gave a reactor neutron destruction cross section of 2700 ± 600 barns. No $Fm^{255}$, in equilibrium with $Es^{255}$ was detected after the irradiation, so that the reactor neutron capture cross section of $Es^{254}$ is less than 40 barns. ~~(auth)~~

# EUROPIUM 1.15

THE PREPARATION AND PROPERTIES OF EUROPIUM. F. H. Spedding, J. J. Hanak, and A. H. Daane (~~Iowa State~~ Coll., ~~Ames.~~). Trans. Met. Soc. AIME 212, 379-83(1958) June.

A quantity of 70.4 g of europium metal of high purity was prepared by heating $Eu_2O_3$ with lanthanum metal in vacuo at 1200°C. The properties determined are listed. Vapor pressure was determined as a function of temperature. The data were fitted to a straight line, yielding the formula $\log P_{mm} = (-8982 \pm 16)/T + (8.160 \pm 0.027)$. The other properties determined are as follows: melting point, 826 ± 10°C; boiling point (calculated), 1489°C; lattice constant at 298°C (bcc lattice), 4.5820 ± 0.0004 A; density at 298°K (calculated), 5.245 g/cm$^3$; heat of sublimation at 298°K, 42,066 ± 75 (calculated); compressibility at 300°K, $6.99 \times 10^{-6}$ cm$^2$/kg; electric resistivity at 298°K, $81.3 \times 10^{-6}$ ohm-cm; temperature coefficient of electrical resistance at 298°K, 0.00480 (°C)$^{-1}$; coefficient of linear thermal expansion, $26 \times 10^{-6}$(°C)$^{-1}$; change of volume on melting, +4.8%. Europium reacts rapidly in moist air, following a linear law, $Eu(OH)_2 \cdot H_2O$ resulting. (auth)

**1474**

SOLUTIONS OF EUROPIUM AND YTTERBIUM METALS IN LIQUID AMMONIA. James C. Warf and William L. Korst (Univ. of Southern California, Los Angeles). J. Phys. Chem. 60, 1590-1(1956) Nov.

Both Eu and Yb dissolve in liquid $NH_3$ at −78°. The Eu was more soluble, and Sm was apparently insoluble. The heat of solution of Eu was estimated at 26 kcal/g atom. The solubility of Am in liquid $NH_3$ is discussed. (T.R.H.)

**7554** AD-53504

Washington Univ., St. Louis.

SOME ELECTRON-TRANSFER REACTIONS INVOLVING EUROPIUM AND YTTERBIUM (thesis). Lowell Alvin King. Jan. 1955. 30p.

The reduction of $Eu^{2+}$ by $Yb^{2+}$ and the oxidations of $Eu^{2+}$ by $V^{3+}$, $Cr^{3+}$, $Tl^{3+}$, and $Ce^{4+}$ were investigated in 0.5F and 1F $HClO_4$ at reactant concentrations of $\sim 10^{-2}$M. These reactions were all found to be much more rapid than the $Eu^{2+}-Eu^{3+}$ exchange reaction. Some preliminary experiments were performed on the $Yb^{2+}-Yb^{3+}$ exchange reaction in 0.5F $HClO_4$ and in water at reactant concentrations of $\sim 10^{-2}$M. Evidence was found that the exchange was incomplete after ~5 seconds. (auth)

**12038**

EUROPIUM HEXABORIDE. G. V. Samsonov, V. P. Dzeganovskii, and I. A. Semashko (Inst. of Ceramics and Special Alloys, Academy of Sciences, Ukrainian SSR). Doklady Akad. Nauk S.S.S.R. 119, 506-7(1958) Mar. 21. (In Russian)

The x-ray-diffraction diagram of europium hexaboride ($Eu_2O_3 + 3B_4C \rightarrow 2\ EuB_6 + 3\ Co$) revealed that the compound possesses a cubic lattice with a = 4.167 ± 0.002 A (the spatial group $O_h^1$ is typical of all hexaborides of rare earth metals). The x-ray density is 4.99 ± 0.01 g/cm$^3$. (R.V.J.)

# EUROPIUM 1.15

**22016**

THE SULFIDES AND OXYSULFIDES OF EUROPIUM. Louis Domange, Jean Flahaut, and Micheline Guittard. Compt. rend. 249, 697-9(1959) Aug. 3. (In French)

The trivalent europium compound $Eu_2S_3$ could be prepared, but EuS, $Eu_3S_4$, $Eu_2S_{3.81}$, and $Eu_2O_2S$ were prepared. The crystal structures were determined and the effects of heating in a vacuum and in air were studied. The molecular magnetic susceptibilities were measured at 18°C and are, with respect to the metallic atom, $22.6 \times 10^3$ for EuS, $11.5 \times 10^{-3}$ for $Eu_3S_4$, and $5.8 \times 10^{-3}$ for $Eu_2S_{3.81}$. (J.S.R.)

**4581** KAPL-M-JCC-2

Knolls Atomic Power Lab., Schenectady, N. Y.
THE BURNUP OF EUROPIUM AND DYSPROSIUM UNDER NEUTRON IRRADIATION. J. C. Corelli and F. Feiner. Oct. 29, 1959. 33p. Contract W-31-109-Eng-52. OTS.

Measurements on the fractional change in cross section were made on samples of natural Eu and Dy at the MTR fa cility. The specimens were exposed to a flux ranging from $2.5 \times 10^{20}$ to $1.2 \times 10^{21}$ n/cm$^2$. The data were compared to calculated values which were obtained by use of a FORTRAN code written to compute isotopic transmutations occurring as a result of neutron irradiation. For the case of dysprosium the calculated and measured values were in very good agreement, while for europium the agreement was satisfactory. (W.D.M.)

**8999** UCRL-3733

California. Univ., Berkeley. Radiation Lab.
COINCIDENCE NUCLEAR SPECTROMETRY WITH APPLICATIONS TO EUROPIUM-154 AND EUROPIUM-155 (thesis). Jose O. Juliano. Apr. 1957. 105p. Contract W-7405-eng-48. $16.80(ph OTS); $5.70(mf OTS).

An iron-free beta-ray spectrometer for electron-electron or electron-gamma coincidences using a time-to-height-converter as a coincidence unit was constructed, tested with $Bi^{207}$ and $Hg^{203}$, and used in the study of the decay of $Eu^{154}$. From the conversion-electron and gamma-ray data a decay scheme is proposed for $Eu^{154}$ and $Eu^{155}$ Spins, parities, and quantum numbers of Nilsson's wave functions were assigned to the excited states whenever possible from the transition multipolarities. The relative intensities of the stronger conversion-electron lines of $Th^{231}$ were determined with a thin-window magnetic spectrometer, and multipolarities were assigned based on the K-conversion coefficients of Sliv and the L and M subshell conversion coefficients of Rose et al. (auth)

**16821**

RADIOACTIVE DECAY OF $Eu^{154}$. S. K. Bhattacharjee, Shree Raman, and S. K. Mitra (Tata Inst. of Fundamental Research, Bombay). Proc. Indian Acad. Sci. A47, 295-309(1958) May.

The radioactive decay of $Eu^{154}$ ($t_{1/2}$ = 16y), obtained from thermal neutron irradiations of 95% enriched $Eu^{153}$, was studied by using the Seigbahn-Slätis intermediate image spectrometer, a thin lens magnetic spectrometer, and a coincidence scintillation spectrometer. The following gamma-rays (energy in kev) were identified as belonging to this isotope: 123, 248, 585, 717, 759, 875, 998, 1007, 1285, 1600. Beta end points of $Eu^{154}$ were measured at 275 (20%), 590 (45%), 890 (23%) and 1860 (12%). The K-conversion coefficient of 123 kev gamma-ray was experimentally determined to be ≈ 0.5. On the basis of gamma-gamma and beta-gamma coincidences, the decay scheme of $Eu^{154}$ was deduced: the resulting level-structure of $Gd^{154}$ conforms well with the predictions of the unified nuclear model. (auth)

DECAY OF $Eu^{152m}$. Ingvar Marklund (Inst. of Physics, Uppsala). Nuclear Phys. 9, 83-7(1958-59). Nov. (3).

The decay of $Eu^{152m}$ (9.2h) is investigated by means of coincidence measurements. The $\gamma$ energies and intensities are measured with a crystal spectrometer and a double-focusing iron yoke spectrometer. Results: 121.78, 344.3, 841.6, 963.3, 970.3, 1315.0, and 1389.3 kev. (auth)

**15605** AECU-4182

Michigan. Univ., Ann Arbor. Harrison M. Randall Lab. of Physics.
DECAY OF $Eu^{152m}$. R. E. Sund, R. G. Arns, and M. L. Wiedenbeck. [1959]. 15p. $3.30(ph), $2.40(mf) OTS.

Presented at the 1959 Spring Meeting of the Am. Phys. Soc.

The gamma rays in $Sm^{152}$ and $Gd^{152}$ following the decay of the 9.3 hour metastable state of $Eu^{152}$ were studied in permanent magnet spectrographs. A number of new weak transitions were observed, and a decay scheme is proposed. Directional correlation measurements were made on two cascades in $Sm^{152}$ and on one cascade in $Gd^{152}$. The measurements confirm the spin and parity assignments of 1- and 2+ for the 0.963 Mev and 0.122 Mev levels in $Sm^{152}$. Possible spin assignments for the 1.511 Mev level in $Sm^{152}$ are discussed. The 1.315 Mev and 0.344 Mev levels in $Gd^{152}$ have a spin and parity of 1- and 2+, respectively. Multipolarities are given for the principal gamma transitions. (auth)

# EUROPIUM 1.15

STUDIES ON THE LONG- LIVED ACTIVITIES OF EUROPIUM. S. K. Bhattacherjee and Shree Raman (Tata Inst. of Fundamental Research, Bombay). Nuclear Phys. 4, 44-60(1957) Aug.

Long-lived activities of europium, $Eu^{152}$ (13y) and $Eu^{154}$ (16y), were studied by a coincidence scintillation spectrometer. The measured gamma-ray energies (kev) and their relative intensities are 80 ± 4(0.52), 124 ± 4(1.85), 244 ± 7(1.00), 340 ± 10(2.16), 410 ± 20(0.15), 710 ± 25(0.34), 770 ± 22(1.27), 870 ± 30(0.57), 970 ± 20(1.93), 1090 ± 21 (1.88), 1260 ± 40(0.5), 1410 ± 25(1.99). X-gamma and gamma-gamma coincidence experiments were carried out by employing pulse-height selection; beta-gamma coincidence were recorded by using an anthracene crystal spectrometer. Decay schemes for the two isotopes are proposed on the basis of our experimental results. The first two excited states of $Sm^{152}$ reached by the capture decay of $Eu^{152}$ at 121 and 365 kev are identified as rotational levels belonging to the ground state configuration; higher excited states in $Sm^{152}$ (N = 90) were also reached by capture decay of $Eu^{152}$. On the other hand the first two excited states of $Gd^{152}$ (N = 88) reached by $\beta$ decay of $Eu^{152}$ at 340 and 750 kev are probably vibrational in origin. The ground state spin of $Eu^{152}$ is assigned as 4. The newly found gamma ray of energy 80 kev is identified as the one arising from de-excitation of the first rotational level of $Sm^{154}$, a state which has also been observed in Coulomb excitation experiments. Decay schemes are discussed in the light of the unified nuclear model. (auth)

8837 ✓

SPECTRA OF INTERNAL CONVERSION ELECTRONS OF THE LONG-LIVED ISOTOPES $Eu^{152}$ and $Eu^{154}$. B. V. Bobykin and K. M. Novik (Leningrad Physico-Technical Inst.). Izvest. Akad. Nauk S.S.S.R. Ser. Fiz. 21, No. 12, 1556-72(1957) Dec. (In Russian)

Radioactivity of $Eu^{152}$ and $Eu^{154}$ with half lives of 13 and 16 years, respectively, and products of their decay $Sm^{152}$, $Gd^{152}$, $Gd^{154}$, and possibly $Sm^{154}$ were investigated. Improved tables are presented of the identification and relative intensities of conversion lines in $Eu^{152}$ and $Eu^{154}$ decay. Comparisons were made of experimental and theoretical relations for conversion coefficients. Decay schemes for $Eu^{152}$ and $Eu^{154}$ and absolute magnitudes of conversion coefficients of the K shell developed on the relative intensities of K lines and relative intensities of $\gamma$ rays are included. (R.V.J.)

13593 ✓

A RE-MEASUREMENT OF TWO GAMMA RAY LINES FROM $^{152}Eu$ AND $^{154}Eu$. B. Andersson. Proc. Phys. Soc. (London) 72, 148(1958) July.

A new measurement of the 0.122- and 0.123-Mev gamma-ray lines was made with a curved-crystal gamma spectrometer. The line profiles were studied on both sides of the zero point of the spectrometer. (W.D.M.)

10361 ✓

THE LOW-LYING ENERGY LEVELS OF $^{151}Eu$. A. Bisi, E. Germagnoli, and L. Zappa. Nuclear Phys. 3, 670-8 (1957) July.

The radioactive decay of $Gd^{151}$ has been investigated. Measurements of electron conversion spectrum and $\gamma$ spectrum show the existence of $\gamma$ rays accompanying the electron capture process. The energies of the $\gamma$ rays were found to be 21.3, 80, (144), 155, 176, 240, 299 kev. A decay scheme is proposed. (auth)

HALF-LIVES OF THE EXCITED LEVELS OF $Eu^{153}$. Michel Vergnes and Nadine Marty (Collège de France, Paris). J. phys. radium 17, 908-10(1956) Oct. (In French)

**PARAMAGNETIC RESONANCE OF EUROPIUM AND GADOLINIUM IN FLUORIDES. Charles Ryter and Roger Lacroix. Compt. rend. 242, 2812-14(1956) June 11. (In French)**

# FLUORINE 1.16

See also, under HAZARDS AND PROTECTION,

FLUORINE (4.01.05).

## HF 1.16.01

~~14032~~ A/CONF.15/P/930
Oak Ridge Gaseous Diffusion Plant, Tenn.
MOLECULAR PROPERTIES OF HYDROGEN FLUORIDE. D. F. Smith. 16p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The vibrational and rotational constants of hydrogen fluoride have been evaluated from the frequencies of the lines of the rotation and vibration-rotation spectrum. The intensities of the lines of the fundamental vibration-rotation band, when used with the internuclear distance, 0.9171 A, indicate that the dipole moment increases at the rate of 1.6 Debye units per Angstrom as the internuclear distance is increased. The permanent dipole moment, 1.736 Debye units, was determined from dielectric constant measurements at microwave frequencies. In addition to the hydrogen fluoride vapor spectrum of monomer, the polymer spectrum has also been studied. It has been established that this polymer spectrum originates from dimeric, tetrameric, and hexameric hydrogen fluoride, with dimer and tetramer always minor constituents. From the dielectric constant studies, the 2nd virial coefficient of the monomer is found to be sizable. When this is taken into account, the vapor density measurements can be reconciled with the present interpretation. The hexamer has a small dielectric constant and probably has a cyclic structure. In addition to the hydrogen fluoride polymers, the spectrum of vapor phase mixtures sometimes contains a band of a molecular complex such as $ClF_3 \cdot HF$, $SO_2 \cdot HF$, or $CO_2 \cdot HF$, present in very small concentration. On the other hand, large concentrations of complexes are found from the spectrum of mixtures of hydrogen fluoride with vapors of diethyl ether, acetone, and methanol. In dilute liquid solutions, the spectrum of hydrogen fluoride contains bands of hydrogen fluoride polymer. In very dilute solutions the polymer spectrum is reduced in intensity. With some solvents, such as uranium hexafluoride and molybdenum hexafluoride, the absorption remaining corresponds to monomeric hydrogen fluoride. In other cases, as with bromine trifluoride, sulfur dioxide, and chlorine trifluoride, the hydrogen fluoride absorption corresponds to a molecular complex which obscures the monomer absorption. The adjustment of the concentrations in a mixed solvent, such chlorine trifluoride-molybdenum hexafluoride, can be so accomplished as to permit the observation of both monomer and complex bands. (auth)

16178 MCW-1417
Mallinckrodt Chemical Works, St. Louis.
AN INVESTIGATION OF THE WATER GAS REACTION AS A MEANS OF UPGRADING AQUEOUS HF. T. A. Baggett, R. Cutler, E. N. Nelson, and J. A. Kennelley. Aug. 15, 1958. 15p. Contract W-14-108-eng-8. $0.75(OTS).

The water gas reaction, $C + H_2O = CO + H_2$, has been investigated as a method of converting 70% HF to anhydrous HF. Marked variations in carbon reactivity were observed. Two types of charcoal yielded a product assaying 99+% HF at 900 and 1000°C with contact times of ten seconds or less; foundry coke, however, required a contact time of 20 seconds at 1000°C to yield an equivalent product. All carbon source materials tested required very extended contact times (60 seconds or more) to produce essentially anhydrous HF at 800°C. The feasibility of this process has been demonstrated in a laboratory-sized apparatus, but associated problems such as heat transfer and materials of construction would make large scale applications of this process unattractive. ~~(auth)~~

~~8853~~
IONIZATION POTENTIALS OF HYDROGEN FLUORIDE AND THE GROUND-STATE OF THE $HF^+$ ION. J. A. R. Coope, D. C. Frost, and C. A. McDowell, ~~(Univ.~~ of British Columbia, Vancouver~~)~~. Nature 179, 1186(1957), June 8.

5231
THE CHLORINE TRIFLUORIDE–HYDROGEN FLUORIDE SYSTEM. SOME VAPOR PRESSURE AND CONDUCTANCE MEASUREMENTS. Max T. Rogers, John L. Speirs, and Morton B. Panish (Michigan State Univ., East Lansing). J. Phys. Chem. 61, 366(1957) March.

~~12681~~
THE HYDROGEN FLUORIDE SOLVENT SYSTEM. II. SALTS OF THE FLUORO ACIDS. SOLVOLYSIS. A. F. Clifford and A. G. Morris ~~(Univ. of Deleware, Newark)~~. J. Inorg. and Nuclear Chem. 5, 71-5(1957).

The stoichiometries of a number of solid salts of fluoro acids have been determined by evaporation of anhydrous HF solutions of the salts containing excess of the volatile acidic constituent. Salts of fluoro acids of P, As, Ge, Se, Te, and I have been examined. Many of these are highly solvolyzed. The new bifluoride $BaHF_3$ is reported. (auth)

# FLUORINE 1.16

## HF 1.16.01

AEC-tr-3392
RESEARCH ON THE SYSTEM $ClF_3$–HF. N. S. Nikolaev and I. M. Maliukov. Translated for Oak Ridge Gaseous Diffusion Plant from Zhur. Neorg. Khim. 2, 1587-90 (1957). 10p.

Polythermal analysis was used to study the $ClF_3$–HF system. Unlimited mutual solubility of $ClF_3$ and HF was established, and the eutectic system 44.0% $ClF_3$–56% HF was investigated. The equation for dissociation of $ClF_3$ in HF was determined. (J.R.D.)

THE BROMINE PENTAFLUORIDE–HYDROGEN FLUORIDE SYSTEM. SOLID-LIQUID EQUILIBRIA, VAPOR PRESSURES, MOLAR VOLUMES AND SPECIFIC CONDUCTANCES. Mat T. Rogers, John L. Speirs, and Morton B. Panish (Michigan State Univ., East Lansing). J. Am. Chem. Soc. 78, 3288-9(1956), July 20.

Various physical properties of the bromine pentafluoride–hydrogen fluoride system have been investigated. The solid-liquid phase diagram shows a eutectic point at −85.61° and 95.2 mole per cent hydrogen fluoride. The vapor pressure-composition diagram shows large positive deviations from Raoult's law. The deviations from ideality become larger at higher temperatures, and at at 25°C there is probably an azeotrope with maximum vapor pressure. Average molar volumes observed are lower than calculated for an ideal solution, the contraction on mixing being 2 to 3%. The specific conductance of a carefully purified sample of bromine pentafluoride was $9.1 \times 10^{-8}$ $ohm^{-1}$ $cm^{-1}$. Conductances of bromine pentafluoride–hydrogen fluoride mixtures were studied over a range of temperatures and compositions. (auth)

THE HAMMETT ACIDITY FUNCTION $H_0$ FOR HYDROFLUORIC ACID SOLUTIONS. Herbert H. Hyman, Martin Kilpatrick, and Joseph J. Katz, (Argonne National Lab. and Illinois Inst. of Tech., Lemont). J. Am. Chem. Soc. 79, 3668-71(1957), July 20.

The Hammett acidity function $H_0$ value has been determined for HF in the concentration range from anhydrous material down to about 40% HF. The dryest HF prepared had an $H_0$ value of −10.2. In the course of this investigation, improved spectrophotometric cells were developed for handling HF acid solutions and the spectrum of anhydrous HF in the near infrared was determined. The effect of NaF and water on the near infrared HF spectrum was investigated and an analytical method for water in HF was developed based on measurements of the water absorption of 1.95 μ. (auth)

## INORGANIC 1.16.02

Oak Ridge National Lab., Tenn.
GENERAL INFORMATION CONCERNING FLUORIDES. Mary E. Lee. Mar. 17, 1953. 22p. (ORNL-1490).

This compilation contains 74 references taken from *Chemical Abstracts* concerning the fluorides of Al, Ba, Be, Ca, Cs, Pb, Li, Mg, K, Rb, Na, Sr, and U. This report supplements ORNL-1252.

3583 ✓ ORNL-2150(Del.)
Oak Ridge National Lab., Tenn.
A PHYSICAL PROPERTY SUMMARY FOR FLUORIDE MIXTURES. S. I. Cohen, W. D. Powers, and N. D. Greene. Sept. 5, 1956. Decl. with deletions Nov. 13, 1958. 117p. Contract W-7405-eng-26. $18.30(ph OTS); $6.00(mf OTS).

A summary of certain experimentally determined physical properties of fluoride mixtures which were formulated at ORNL is presented. These properties include the density, enthalpy, heat capacity, heat of fusion, thermal conductivity, viscosity, Prandtl number, electrical conductivity, and surface tension. In addition to the experimental data, values were predicted for the heat capacity and density of the other mixtures from the correlations of these properties. Estimates of the viscosity were also made for a number of the mixtures on which no experimental data were available. (auth)

16618
A THEORETICAL STUDY OF THE FLUORINE MOLECULE. J. Eve (King's Coll., Newcastle upon Tyne, Eng.). Proc. Roy. Soc. (London) A246, 582-9(1958) Aug. 26.

A calculation, on the ground state of the $F_2$ molecule, was carried out using approximations inherent in Roothaan's method. Approximations to the ionization potentials, certain of the excitation energies, and the quadrupole moment were obtained from solutions which also predicted an unstable molecule. For the purpose of comparison, simplified equations resulting from neglecting inner- and outer-shell mixing were also solved. A limited configuration interaction calculation was carried out for the ground state of $F_2$; a fairly good value for the binding energy resulted. (auth)

# FLUORINE 1.16

## INORGANIC 1.16.02

**13776**

THE VAPOR PRESSURE OF NICKEL FLUORIDE. Milton Farber, Richard T. Meyer, and John L. Margrave (California Inst. of Tech., Pasadena and Univ. of Wisconsin, Madison). J. Phys. Chem. 62, 883-4(1958) July.

The vapor pressure of $NiF_2$ was measured by two different methods to determine if metal fluorides were sufficiently volatile at high temperatures to complicate the interpretation of fluorine dissociation energy data taken from metal systems. The resulting vapor pressure equation is presented. The data indicate a negligible effect on fluorine dissociation measurements. (D.E.B.)

**~~11073~~**

A STUDY OF THE BROMINE–BROMINE TRIFLUORIDE AND BROMINE PENTAFLUORIDE SYSTEMS, PRIMARILY BY CONDUCTIVITY METHODS. Lloyd A. Quarterman, Herbert H. Hyman, and Joseph J. Katz (Argonne National Lab., Lemont, Ill.). J. Phys. Chem. 61, 912-16(1957) July.

The electrical conductivity of solutions of $BrF_3$ and $Br_2$, and $BrF_3$ and $BrF_5$ have been measured. Poly-(chlorotrifluoroethylene) cells with bright platinum electrodes and Teflon insulators were employed. At 25°, bromine added to pure bromine trifluoride reduces the specific conductivity from $8.02 \times 10^{-3}$ ohm$^{-1}$ cm.$^{-1}$ to a minimum of $7.22 \times 10^{-3}$ at 3.5 mole % and then increases it to $12.90 \times 10^{-3}$ at 17.7 mole %, which represents the limit of the miscible region. Banks, Emêleus and Woolf first showed that at higher temperatures, the conductivity of bromine trifluoride is lowered, indicating lower stability for ionic species. This effect is accentuated by increased bromine concentration. The visible absorption spectra of dilute solutions of $Br_2$ in $BrF_3$ show deviations from Beer's law in the region close to the absorption maximum (400–500 mμ). In bromine the molar conductivity of bromine trifluoride at 25° increases steadily from the lowest to the highest concentration at which conductivity was measured 2.55 to 6.42 mole %. The rate of increase of conductivity with concentration increases sharply at about 4.3 mole %. These data are interpreted in terms of the changing dielectric constant of the medium, a mobile equilibrium involving bromine monofluoride in the $Br_2$–$BrF_3$ system, and the nature of the ionic species present. On the other hand $BrF_3$ and $BrF_5$ are completely miscible and the conductivity versus concentration plot gives a smooth curve. Mixtures of HF and $BrF_5$ in general are more conducting than either pure reagent with the maximum conductivity near 70 mole % HF. (auth)

**7955**

CRYSTALLOGRAPHIC DATA: ALUMINUM TRIFLUORIDE, $AlF_3$. Eugene Staritzky and L. B. Asprey (Los Alamos Scientific Lab., N. Mex.). Anal. Chem. 29, 984(1957) June. MOLYBDENUM METAPHOSPHATE, $Mo(PO_3)_3$. R. M. Douglass and Eugene Staritzky (Los Alamos Scientific Lab., N. Mex.). Anal. Chem. 29, 985(1957) June.

**9244**

ELECTRONIC SPECTRUM AND DISSOCIATION ENERGY OF FLUORINE. A. L. G. Rees (Commonwealth Scientific and Industrial Research Organization, Melbourne, Australia). J. Chem. Phys. 26, 1567-71(1957) June.

The continuous absorption spectrum of molecular fluorine and the Raman displacement for the 0 → 1 vibrational transition have been used to compute the potential energy curve for the repulsive $^1\Pi_u$ state dissociating to two normal fluorine atoms. This curve is consistent with a value of 37.1 ± 0.85 kcal/mole for the dissociation energy of the ground state. A weak absorption, attributed, on the grounds of location and intensity, to $^3\Pi_{0^+u} \leftarrow {}^1\Sigma_g{}^+$, has been shown to occur in the long wavelength region of the main absorption and a segment of the potential energy curve for $^3\Pi_{0\ u}$ has been deduced. Absorption curves, calculated from the potential energy curves and the ground-state anharmonic eigenfunctions, fit the observed data satisfactorily. (auth)

**387**

Technical Information Service Extension, AEC.
U.S. ATOMIC ENERGY COMMISSION REPORTS ON ELEMENTAL FLUORINE. A Literature Search. Sidney F. Lanier, comp. May 1957. 12p. (TID-3507).

This bibliography includes 42 annotated references on Technical Information Service, AEC. June 1953. 122p. (TID-3036(Rev.)).

The bibliography contains 1414 references to published literature and unclassified report literature. Emphasis was placed on separation methods, isotopic exchange reactions, and kinetics of isotope exchange. Author, subject, and report number indexes are included.

**~~10358~~** (NLCO-728)

~~National Lead Co. of Ohio, Cincinnati.~~

MAGNESIUM FLUORIDES–A LITERATURE SEARCH. Earl W. Mautz. Apr. 4, 1958. 9p. ~~Contract AT(30-1)-1156. $0.50(OTS).~~

A literature search on "Magnesium Fluorides" from Chemical Abstracts and U.S.A.E.C. Abstract services is presented. The subheadings excluded were: mineralogy, $MgF_2$–metal fluoride and oxide systems, use as optical glass coating, effects on $Al_2O_3$ and electrolytic baths, crucibles from, precipitation of, adsorption of $UF_4$ by, and solubility in hydrochloric and nitric acids. (auth)

# FLUORINE 1.16

## INORGANIC 1.16.02

**5229**

CHEMICAL EQUILIBRIA IN THE GASEOUS SYSTEM BROMINE–BROMINE TRIFLUORIDE–BROMINE MONOFLUORIDE. Robert K. Steunenberg, Richard C. Vogel, and Jack Fischer (Argonne National Lab., Lemont, Ill.). J. Am. Chem. Soc. 79, 1320-3(1957) March 20.

Equilibrium constants were determined for the gas-phase reaction $BrF_3 + Br_2 \rightleftharpoons 3BrF$. The extent of the reaction was derived from manometric measurements at constant volume and the absorption spectra of the mixtures. Equilibrium constants obtained at different temperatures were used to calculate the standard free energy and enthalpy of formation of $BF_3$. (auth)

**4319**

THERMODYNAMIC FUNCTIONS OF SOME SIMPLE FLUORINE COMPOUNDS. Robert L. Potter (Bell Aircraft Corp., Buffalo, N. Y.). J. Chem. Phys. 26, 394-7(1957) Feb.

The thermodynamic functions of F(g), $F_2$(g), $H^1F$(g), $D^2F$(g), and the naturally occurring isotopic mixture of $H^1F$(g) and $D^2F$(g) have been calculated for these substances in the ideal gas state from 298.16°K to 5000°K by standard methods of statistical mechanics using available spectroscopic data. (auth)

**4318** HW-47813

Hanford Atomic Products Operation, Richland, Wash.
LIQUID-VAPOR EQUILIBRIUM IN THE SYSTEM NITRIC ACID–WATER–TRACE FLUORIDE. Robert Lee Moore. Jan. 14, 1957. 15p. Contract W-31-109-Eng-52. $0.20 (OTS).

The distribution of trace fluoride between liquid and vapor was determined as a function of $HNO_3$ concentration, both at atmospheric pressure and at a reduced pressure of 100 mm Hg absolute, employing an Othmer–type equilibrium still constructed of stainless steel. All measurements were made at the boiling point of the solutions employed. The logarithm of the fluoride distribution coefficient was found to be roughly linear in the concentration of $HNO_3$ in the liquid phase and increased with the latter. The behavior at 100 mm Hg was almost identical to that at atmospheric pressure. (auth)

**7520**

THE DENSITY OF LIQUID FLUORINE BETWEEN 67 AND 103°K. Roger L. Jarry and Henry C. Miller (Pennsylvania Salt Manufacturing Co., Whitemarsh Research Laboratories). J. Am. Chem. Soc. 78, 1552-3(1956) Apr. 5.

The density of liquid $F_2$ has been measured over the temperature range 67 to 103°K. An all metal system was used. The data obtained have been fitted to the equation, $d = 1.907 - 2.201 \times 10^{-3}T - 2.948 \times 10^{-5}T^2$, where d is the density in g/cm$^3$ at temperature T. The uncertainty in the density is estimated to be ±0.1%, and in temperature ±0.05°. (auth)

**12275**

DISSOCIATION ENERGY OF FLUORINE MOLECULES AND THE RULE OF THERMOCHEMICAL LOGARITHMICS. A. F. Kanustinskiy. Trudy Moskov. Khim. Tekhnol. Inst. im. D. I. Mendeleeva 22, 17-20(1956). ~~(Translated from Referat. Zhur. Fiz. No. 3, Abstract No. 6217.)~~

The author obtains the dissociation energy D of $F_2$ (the experimental determination of which is difficult) by tracing the variation of D over the elements that comprise its group in the periodic system. The value obtained for D, 71 kcal/mole (at 298°K), is close to the value obtained by Birge (see E. V. Britske et al, Thermoconstants, Published by Academy of Sciences, USSR, 1949).

**2647**

THE MOLAR REFRACTIONS OF SOME COMPLEX IONS IN SOLUTION. Max T. Rogers and Jim G. Malik (Michigan State Univ., East Lansing). J. Am. Chem. Soc. 77, 6515-17(1955) Dec. 20.

The refractive indices at 20°C of aqueous solutions of several compounds containing complex fluoride ions were measured. Ionic refractivities of $BF_4^-$, $SiF_6^{2-}$, $TiF_6^{2-}$, $Fe(CN)_6^{3-}$ and $Fe(CN)_6^{4-}$, were determined. (C.W.H.)

# FLUORINE 1.16

## INORGANIC 1.16.02

**1263**

THE PHYSICAL PROPERTIES OF SOME FLUORINE COMPOUNDS AND THEIR SOLUTIONS. PART 2. THE SYSTEM SULPHUR HEXAFLUORIDE + PROPANE. H. P. Clegg and J. S. Rowlinson (Univ. of Manchester, England). Trans. Faraday Soc. 51, 1333-40(1955) Oct.

The pressure and density of the liquid and vapor phases of six mixtures of $SF_6$ and propane have been measured from 21°C to the critical points. The system shows: (i) large positive deviations from Raoult's law, forming an azeotrope at a mole fraction of propane of about 0.15; (ii) a minimum in the graph of critical (or plait-point) temperature against composition at about the same mole fraction of propane; (iii) both minimum and maximum in a similar graph of the critical pressure; (iv) maxima in the volumes of the orthobaric liquid densities and in the critical volume, and (v) a small amount of retrograde behavior in mixtures rich in propane. These deviations from the laws of ideal solutions are large for a mixture of substances of almost identical critical volumes and similar critical temperatures, and are consistent with the interaction energy between a molecule of $SF_6$ and one of propane being weaker than that between molecules of either pure substance. Both the arithmetic mean and the cube of the difference of the orthobaric densities of these mixtures are linear functions of the temperature as for pure substances. (auth)

**1262**

THE PHYSICAL PROPERTIES OF SOME FLUORINE COMPOUNDS AND THEIR SOLUTIONS. PART 1. SULPHUR HEXAFLUORIDE. H. P. Clegg, J. S. Rowlinson, and J. R. Sutton (Univ. of Manchester, England). Trans. Faraday Soc. 51, 1327-33(1955) Oct.

The following properties of $SF_6$ have been measured: (i) the vapor pressure from 0°C to the critical point, (ii) the orthobaric densities from 20°C to the critical point, (iii) the critical constants, and (iv) the density in the one-phase region from 34 to 131°C and up to 100 atm pressure, from which the second and third virial coefficients have been calculated. These properties are compared with those of the inert gases by means of the principle of corresponding states. It is shown that the differences can be accounted for by a perturbation treatment previously developed to allow for the effect of orientational intermolecular forces on equilibrium properties. The significance of this agreement is discussed. (auth)

**50**

THE CRYSTAL STRUCTURE OF HEXAFLUOROPHOSPHORIC ACID. Hans Bode and Günther Teufer (Chemisches Staatsinstitut, Hamburg, Netherlands). Acta Cryst. 8, 611-14(1955) Oct. (In Dutch)

The acid $HPF_6 \cdot 6H_2O$ is cubic (space group $O^9$-Im3m; a = 7.678 A; Z = 2). The water molecules form cuboctahedral cages of 24 oxygen atoms, in the centers of which the phosphorus atoms of the $PF_6$ groups are situated. This cage-like or clathrate structure is different from that in the gas hydrates. (auth)

**7120** AD-120678

THE THERMAL REACTION OF FLUORINE AND CHLORINE HEXOXIDE ($Cl_2O_6$). (Die Thermische Reaktion zwischen Fluor und Chlorhexoxyd ($Cl_2O_6$).) A. J. Arvia, W. H. Basualdo, and H. J. Schumacher. Translated from Angew. Chem. 67, 616(1955). 4p.

In experiments to produce $FClO_2$ from $F_2$ and $Cl_2O_6$ the products obtained were $FClO_2$, $Cl_2O_7$, and very small amounts of a compound supposedly $ClO_3F$, an isomer of $FClO_3$. (T.R.H.)

**7121** AD-120679

THE THERMAL STABILITY OF CHLORYL FLUORIDE ($FClO_2$). (Die Thermische Stabilität des Chlorylfluorids ($FClO_2$).) H. J. Schumacher and W. H. Basualdo. Translated from Angew. Chem. 67, 231(1955).

**532** CF-54-5-91

Oak Ridge National Lab., Tenn.

FREE ENERGIES OF FORMATION OF OXIDES AND FLUORIDES. J. M. Cisar. May 5, 1954. Changed from OFFICIAL USE ONLY Sept. 26, 1958. 16p. $3.30(ph OTS); $2.40(mf OTS).

A compilation of data from the open literature for the free energies of formation of several simple fluorides and oxides was made. In addition, the free energies of oxide to fluoride reactions were computed. The values are tabulated and presented in graphs constructed as straight lines except in a few cases in which the deviations from linearity were large. ~~The error which may~~

Hazelton Labs., Falls Church, Va.

CHLORINE TRIFLUORIDE. Nellie Perry Watts. Sept. 15, 1952. 29p. Contract DA 18-108-cml-4399. (AD-1779; MLCR-12).

A survey is presented of the historical background, and the chemical, physical, and biological properties of $ClF_3$. An annotated bibliography of 25 references is included.

# FLUORINE 1.16

## INORGANIC 1.16.02

California Inst. of Tech. Pasadena. Jet Propulsion Lab.
THE PROPERTIES OF FLUORINE, OXYGEN BIFLUORIDE, AND CHLORINE TRIFLUORIDE. R. N. Doescher. Sept. 20, 1950. 69p. (NP-1770).

This covers chemical and physical properties, corrosive effects, reactions, purifications, liquefaction, and handling information. Thirty-eight tables and a bibliography of 90 references are given.

9720 GAT-P-11
CONCERNING A NEW REACTION OF CHLORINE DIOXIDE. THE FORMATION OF A COMPOUND WITH THE FORMULA $ClO_2F$. H. Schmitz and H. J. Schumacher. Translated by J. R. Arndt and J. W. Whisler from Z. anorg. allgem. Chem. 249, 238-44(1942). 7p.

From gaseous $ClO_2$ and $F_2$, it is possible to prepare a compound of the formula $ClO_2F$, provided that proper conditions are maintained such as a $ClO_2$ pressure of 25 mm or less, an $F_2$ pressure of approximately 50 mm and diluted with the addition of several hundred mm of inert gas to a total pressure of one atmosphere. $ClO_2F$ is a colorless gas at ordinary temperatures. The boiling point of the colorless liquid is −6°C. It solidifies at approximately −115°C into a white crystalline mass. The vapor pressure was measured in the range of −80 to −6°C. From these data, the average molar heat of vaporization was calculated to be 6.2 kcal. Trouton's constant was 23.2. The compound is highly reactive with water. Even moist air reacts to form a thick, white cloud. It may be stored relatively well in a dry quartz vessel. With respect to the effects of heat, however, it is much less reactive than chlorine dioxide.

## ORGANIC 1.16.03

19824 NP-7875
British Columbia. Univ., Vancouver.
VOLATILE FLUORO COMPOUNDS. Technical Report No. 1. R. G. Cavell, H. C. Clark, and C. J. Willis. July 1959. 34p. Project NR-052-403. Contract Nonr-2659(00).

A study of new organometallic derivatives containing the trifluoromethyl group and in particular these derivatives of the elements of periodic groups three and four is presented. A study of the physical and chemical properties of volatile transition metal fluorides is included. (W.L.H.)

~~14831~~ A/CONF.15/P/922
~~Illinois Inst. of Tech., Chicago. Armour Research~~ Foundation.
THE RADIATION CHEMISTRY OF FLUORINATED ORGANIC COMPOUNDS. P. Y. Feng. 14p. ~~$0.50 (OTS).~~

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Although organic fluorine compounds have exceptional physical and chemical properties, development of their application is often limited by practical difficulties with synthesis. Much of the difficulty is a direct consequence of the high reactivity of the fluorine and the high stability of the C-F bond. Metathetical reactions provide a convenient route for the preparation of the fluorochemicals and it is pointed out that such reactions are possible with nuclear techniques. Fundamental information on the radiation chemistry of organic fluorine compounds is presented. A series of selected fluorine compounds in both the pure state and as mixtures were studied. The methods used included scavengers, polymer degradation, and product analysis. The results show that organic fluorine compounds are considerably more stable than their other halogen counterparts and compare with the hydrocarbons in radiation sensitivity. Such behavior is explained by the fact that dissociative electron attachment is possible for C−Cl, C−Br, and C−I bonds but not for C−F bonds with electrons of thermal energy. In addition, the very strong electron seeking character of fluorine serves to rule out any significant contribution to the radiation sensitivity of fluorine compounds due to the inductive effect. A comparison of the radical yield results and the product analysis shows that reactions such as $CF_4 + C_6H_6 \rightarrow C_6H_5F$ (or $C_6H_5CF_3$) + $CHF_3$ (or HF) cannot be explained by radical processes alone. A number of possible mechanisms, including the formation of ionic intermediates, are discussed. Studies of organic halogen compounds containing more than one halogen atom are also reported. The data are examined from the viewpoint of Burton's statistical principle and the effect of chemical structure is discussed. (auth)

# FLUORINE 1.16

## ORGANIC 1.16.03

**113** ORNL-2363
Oak Ridge National Lab., Tenn.
$F^{18}$ EXCHANGE BETWEEN FLUOROCARBONS AND SOME FLUORINE-CONTAINING COMPOUNDS. T. A. Gens. Oct. 17, 1957. 124p. Contract W-7405-Eng-26. $3.00(OTS).

Isotopic exchange between solid inorganic fluorides and gaseous fluorocarbons was observed for the first time. Rates of many of these exchange reactions were studied at temperatures as low as 0°. Of the inorganic fluorides studied, the exchange was most rapid with alkali metal fluorides. Among the alkali fluorides the rate of the exchange reaction increased markedly with increasing atomic number of the cation. (W.L.H.)

**10048** NP-6070
Florida. Univ., Gainesville.
PREPARATION OF FLUORINE CONTAINING COMPOUNDS. Quarterly Technical Report [for] May 1, 1956 to July 31, 1956. H. C. Brown, ~~R. D.~~ Dresdner, J. A. Wethington, Jr., and J. A. Young. 49p. ~~Contract Nonr-580(03).~~

Chemical reactions of $(CF_3)_2NCF_2COOH$, $CF_3N=CF_3C=CCF_3$, and pyrolysis of $CF_2OCF_2CF_2NC_2F_5$ and $(C_2F_5)_2O$ were studied. Several physical properties of $(C_2F_5)_2SF_4$ are tabulated. Fluorocarbon reactions with alkali metal vapors, fluorine exchange reactions, polymerization of tetrafluoroethylene, and other reactions of fluoroörganic compounds are described. (For preceding period see NP-5952.) (C.W.H.)

**2644** ✓ NRL-4686
Naval Research Lab., Washington, D. C.
BOUNDARY LUBRICATION STUDIES OF TYPICAL FLUOROESTERS. Interim Report. R. C. Bowers, R. L. Cottington, T. M. Thomas, and W. A. Zisman. Dec. 28, 1955. 42p. Project NR-602-030.

The boundary lubricating and wear preventive properties of some new fluorinated diesters which offer many advantages as high temperature lubricants have been investigated. These diesters were synthesized from aliphatic dibasic acids and nearly completely fluorinated alcohols. Friction and wear measurements were made at temperatures from 77 to 400°F. Fluoroesters containing typical antiwear or oiliness additives were also studied. For comparative purposes results obtained with the familiar unfluorinated diester, bis(2-ethylhexyl) sebacate, are included. The frictional properties of the two classes of diesters did not differ sufficiently to be of practical significance. However, the fluoroesters had better wear-preventive properties, especially at higher temperatures. Friction was markedly reduced by the addition of one % stearic acid to either type of diester. The addition of two % tricresyl phosphate was more effective in the fluoroester as an antiwear agent for hard steel on hard steel; approximately the same low wear rates were observed at 140, 266, and 400°F. (auth)

**2646** ✓
NON-EXCHANGE OF $F^{18}$ BETWEEN HF AND FLUORINATED METHANES. James E. Boggs, E. R. Van Artsdalen, and A. R. Brosi (Oak Ridge National Lab., Tenn.) J. Am. Chem. Soc. 77, 6505-6(1955) Dec. 20.

No exchange of F was observed between HF and the compounds $CH_2F_2$, $CHF_3$, $CF_4$, or $CF_2Cl_2$ in 1 hr at temperatures up to 500°C or between $CH_3F$ and HF up to 400°C in 1 hr. (auth)

# GADOLINIUM 1.17

**14817** A/CONF.15/P/696
Bureau of Mines, Albany, Oreg.
GADOLINIUM AND EUROPIUM ALLOYS—THEIR PREPARATION, MELTING AND PROPERTIES. M. L. Wright, F. E. Block, and H. Kato. 15p. ~~$0.50(OTS).~~

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The investigation included the preparation of rare earth metals, the preparation of alloys involving rare earth elements, and the evaluation of the alloys by chemical analyses and physical tests. By preparing rare earth metals from their fluoride salts rather than from the chloride salts, the oxygen content was reduced from a value within the range of 1000 to 1500 ppm to a value within the range of 200 to 400 ppm. All gadolinium used in this investigation was made from the fluoride by reduction with calcium. Elemental europium was prepared by reducing the oxide with lanthanum in vacuum. The resulting metal contained 98 to 99% europium with impurities of calcium 0.1 to 1%, carbon 470 to 500 ppm and nitrogen 40 to 150 ppm. Homogeneous gadolinium–titanium and gadolinium–stainless steel alloys containing up to 20% gadolinium were successfully made in small melts by arc-melting in an inert atmosphere. Hardness and brittleness of nickel, Inconel, and stainless steel were found to increase with increasing gadolinium content, however, titanium–gadolinium alloys were found to be ductile. Stainless steel or titanium alloys with 0.2 to 0.5% europium could be cold-rolled from the as-cast condition through reductions of 93 to 96%. Both titanium and stainless steel alloys containing up to 25% gadolinium were found to be resistant to the corrosive action of pressurized hot water and steam; similar zirconium base alloys were found to be non-resistant. (auth)

**7556**
THE GADOLINIUM–HYDROGEN SYSTEM. Gladys E. Sturdy and Robert N. R. Mulford (Los Alamos Scientific Lab., N. Mex.). J. Am. Chem. Soc. 78, 1083-7(1956) Mar. 20.

Pressure-temperature-composition data are presented for the gadolinium–hydrogen system. Two hydride phases exist, the first being a cubic structure of ideal composition close to $GdH_2$, the second being a hexagonal structure of ideal composition close to $GdH_3$. Both hydrides exist over composition ranges. A partial phase diagram and x-ray data for the Gd–H system are presented. An enthalpy change of –46.9 kcal/mol of $H_2$ is obtained from the P-T-C data for the conversion of hydrogen-saturated Gd to hydrogen-deficient $GdH_2$ at temperatures from 600 to 800°C. (auth)

**GADOLINIUM IN FLUORIDES.** Charles Ryter and Roger Lacroix. Compt. rend. 242, 2812-14(1956) June 11. (In French)

**13803**
THE SPECIFIC HEATS OF GADOLINIUM AND TERBIUM BETWEEN 0.2°K AND 6°K. N. Kurti and R. S. Safrata (Clarendon Lab., Oxford). Phil. Mag. (8) 3, 780-3(1958) July.

Ingots of pure gadolinium and terbium weighing about 20 g each were used in the determination of their specific heats from 0.2 to 6°K. (J.R.D.)

DECAY OF $Gd^{153}$. S. K. Bhattacherjee and Shree Raman (Tata Inst. of Fundamental Research, Bombay). Nuclear Phys. 1, 486-98(1956) June.

The decay by electron capture of $Gd^{153}$ (half life 236 days) is studied with a coincidence scintillation spectrometer. Two $\gamma$ rays are observed with energies 72 ± 8 kev and 100 ± 4 kev and relative intensities of 7:100. Both these $\gamma$ rays are coincident with K x rays of Eu. From the coincidence data the K-shell conversion ciefficient of the 100-kev $\gamma$ transition has been determined to be 0.67 ± 0.12; the comparison with theory then leads to assigning this $\gamma$-ray predominantly to a magnetic dipole transition. From the experimental L/K capture ratio the energy involved in the capture process is estimated. Our results show that the levels in $Eu^{153}$ which are reached by the capture decay of $Gd^{153}$ are not identical with the levels that were observed in coulomb excitation of Eu. On the basis of our findings we propose a decay scheme for $Gd^{153}$. (auth)

DECAY OF GADOLINIUM-159. S. S. Malik, N. Nath, and C. E. Mandeville (Franklin Inst., Swarthmore, Penna.). Phys. Rev. 112, 262-6(1958) Oct. 1.

The decay of $Gd^{159}$ has been studied with the aid of a thin magnetic lens beta-ray spectrometer and coincident scintillation spectrometers. Two principal beta-ray groups, with the end-point energies 580 ± 10 and 940 ± 15 kev have been observed to decay with the 18-hour half-life of $Gd^{159}$, revealing energy levels in the residual nucleus, $Tb^{159}$, at 56, 136, and 361 kev. The coincidence measurements gave evidence of a third beta component, with the end-point energy of 880 ± 20 kev, coincident with the 56-kev gamma ray. The intensities of the three components (580 ± 10, 880 ± 20, and 940 ± 15 kev) have been estimated to be approximately 20, 6, and 74%, respectively. Internal conversion coefficient measurements indicated the 361-kev gamma ray to be a mixed (M1 and E2) transition. (auth)

# GADOLINIUM 1.17

**12980**

NATURAL RADIOACTIVITY OF GADOLINIUM-152 AND HAFNIUM-174. W. Riezler and G. Kauw (Univ. of Bonn). Z. Naturforsch. 14a, 196(1959) Feb. (In German)

The alpha decay of $Gd^{152}$ was studied with the nuclear emulsion technique using samples enriched in the 152 isotope. The tracks and their range gave a decay constant of $\lambda = 7.3 \times 10^{-16}$ per year and a half life $T = 9.5 \times 10^{14}$ year. Enriched samples of $Hf^{174}$ were also studied. The decay constant was $\lambda = 1.6 \times 10^{-16}$ per year and the half life was $T = 4.3 \times 10^{15}$ year. (J.S.R.)

**4529** CEA-tr-R557

SUR LES NOMBRES DE MASSE DES ISOTOPES DU TERBIUM DEFICIENTS EN NEUTRONS. (The Mass Numbers of Neutron-Deficient Terbium Isotopes.) V. I. Baranovskii (Baranovsky), A. N. Murin (Mourine), V. N. Pokrovskii (A. N. Prokrovsky), and I. A. Ytlandov (Ioutlandov). Translated from Izvest. Akad. Nauk S.S.S.R., Ser. Fiz. 22, 808-10(1958). 10p.

The short-lived spallation products of 660-Mev protons on Ta were studied to establish the branching $Tb^{149}$ to $Gd^{149}$. The mass number of $Tb^{149}$ having been established, the presence of this branching indicates that the value of A for $Gd^{149}$ is equally exact. (T.R.H.)

**8849**

ELECTRON-CAPTURE DECAY ON GADOLINIUM-151. Virginia S. Shirley and John O. Rasmussen (Univ. of California, Berkeley). Phys. Rev. 109, 2092-7(1958) Mar. 15.

The photon and conversion electron spectra following electron-capture decay of $Gd^{151}$ were studied. Transitions of 21.59 (M1), 153.7, 175.0 (M2), 243.8 (E1), and 308.4 kev seen in these spectra and a very weak transition of 155 ± 5 kev seen in coincidence with the 153.7-kev transition were assigned to the decay of $Gd^{151}$. Relative photon, conversion-electron, and transition intensities were determined for some of the transitions, and coincidence measurements were made at resolving times of 4 and 40 microseconds. The 175.0-kev transition was observed to depopulate a metastable state with a half-life of 58 ± 10 microseconds. A level scheme is proposed for $Eu^{151}$ including the levels populated by Coulomb excitation, $\beta^-$ decay of $Sm^{151}$, and electron-capture decay of $Gd^{151}$. (auth)

# GENERAL 1.18

See also, under PROCESS CHEMISTRY AND ENGINEERING,

RADIATION EFFECTS--On Electronic Components --General (6.15.02.01).

## CROSS-SECTIONS 1.18.01

**4784** WASH-1026
Nuclear Cross Sections Advisory Group, AEC.
REPORTS TO THE AEC NUCLEAR CROSS SECTIONS ADVISORY GROUP, OAK RIDGE NATIONAL LABORATORY, OAK RIDGE, TENNESSEE, OCTOBER 28-29, 1959. John A. Harvey. 72p. OTS.

The cross section measurement programs at ANL, BNL, Columbia Univ., Duke Univ., HAPO, LASL, ORNL, Phillips Petroleum, Rice Institute, and UCLRL are reviewed. An informal statement is given of recent developments, changes of emphasis, and preliminary data which are of importance to the cross section measurement program of the AEC. Persons who might make use of these data for serious computations should contact the experimenter directly to verify the numbers. (For preceding report see WASH-1021.) (W.D.M.)

**3002**
NEW "WORLD-AVERAGE" THERMAL CROSS SECTIONS. Donald J. Hughes (Brookhaven National Lab., Upton, N. Y.). Nucleonics 17, No. 11, 132-3(1959) Nov.

A fourth "world-consistent set" of thermal-cross section values for U-233, U-235, and Pu-239 is reported. The greatest change on the order of 1%, of the "World-weighted Averages" for 1959 compared to the "world-consistent set" occurred in U-233. The major discrepancies between countries seem confined to Pu-239 The accuracy of the final averages for 1959 compared to the "world-consistent set" was on the order of 2%. The 1959 world averages for U-235 were almost identical with the "world-consistent set." (C.J.G.)

**[illegible]**
CROSS SECTIONS. Nucleonics 16, No. 9, 107, 126, 128(1958) Sept.

The cross section data presented at Geneva on thermal cross sections, resonance parameters, partial cross sections, and prediction from theory are surveyed. (J.S.R.)

**12929** WASH-1018
Nuclear Cross Section Advisory Group, AEC.
REPORTS TO THE AEC NUCLEAR CROSS SECTIONS ADVISORY GROUP [MEETING AT] RICE INSTITUTE, HOUSTON, TEXAS, MARCH 4-5, 1959. V. L. Sailor. Apr. 1959. 68p. $2.00(OTS).

Cross section measurement programs at ANL, BNL, Columbia Univ., Duke Univ., HAPO, LASL, ORNL, Phillips Petroleum Co., Rensselaer Poly. Inst., Rice Inst., and UCRL are reviewed. Informal statements of recent developments, changes in emphasis, and preliminary cross section data are included. (For preceding period see WASH-1013.) (A.C.)

**[illegible]** TNCC(Can)-11
Atomic Energy of Canada Ltd. Chalk River Project, Chalk River, Ont.
RADIOCHEMICAL MEASUREMENTS OF THE NEUTRON CAPTURE CROSS SECTIONS OF SOME FISSION PRODUCTS AND PROTOACTINIUM-233. T. A. Eastwood, A. P. Baerg, F. Brown, W. E. Grummitt, J. C. Roy, and L. P. Roy. Mar. 1958. 21p.

A survey made in 1957 showed that neutron cross sections were lacking for about 15% of fission products of potential significence in power reactors. To remedy this situation, a number of measurements were made and are summarized. The methods used for the various measurements are given. (A.C.)

**19472** A/CONF.15/P/673
Oak Ridge National Lab., Tenn.
LOW ENERGY NEUTRON CROSS SECTIONS OF RADIOACTIVE FISSION PRODUCT NUCLIDES. J. A. Harvey, R. C. Block, G. G. Slaughter, W. J. Martin, and G. W. Parker. 11p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Data on $Sm^{151}$ and $Pm^{147}$ were obtained, and resonances were assigned. Transmission measurements were also made on fission product samples of Zr and I, but no resonances could definitely be assigned to $I^{129}$ and $Zr^{93}$ in the energy range from 1 to 100 ev. (M.H.R.)

# GENERAL 1.18

## CROSS-SECTIONS 1.18.01

**14974** A/CONF.15/P/685
Argonne National Lab., Lemont, Ill.
SLOW NEUTRON CROSS SECTIONS OF $Pu^{240}$, $Pu^{242}$ AND $Am^{243}$. R. E. Coté, Lowell M. Bollinger, R. F. Barnes, and H. Diamond. 12p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The results on $Pu^{240}$ cover only the resonance structure which could be studied through the $Pu^{240}$ impurity in some samples of $Pu^{239}$ which were used in an exhaustive study of the latter nuclide. The study of $Pu^{242}$ revealed only two resonances between thermal energies and several kv. Resonance parameters were obtained for these at 2.65 ev and 53.6 ev. Comparison of these results and the thermal activation shows that the resonance at 2.65 ev accounts for the measured thermal activation cross section, but the observed resonances do not account for the measured value of the resonance activation integral. The measurement of the total cross section of $Am^{243}$ was done with only 7 mg of the material. Because the sample was so thin, no measure of the off-resonance cross section could be made except in the thermal region. The measurements at thermal energies show the cross section does not vary as 1/v. Eleven transmission dips were observed below 25 ev, all of which appear to be caused by single resonances. Resonance parameters were derived from these dips and values of the average level spacing per spin state and of the strength function have been computed from these parameters. The properties of these nuclides and of other heavy nuclides are compared. (auth)

**11676** TID-7547
Columbia Univ., New York.
THE INTERNATIONAL CONFERENCE ON THE NEUTRON INTERACTIONS WITH THE NUCLEUS, HELD AT COLUMBIA UNIVERSITY, SEPTEMBER 9-13, 1957. W. W. Havens, Jr., ed. 291p. $3.25(OTS).

Papers are presented on the following subjects: present status of measurements, low-energy neutron spectroscopy, interpretation of low-energy neutron spectroscopy, neutron interactions with fissionable nuclei, fission physics, fast neutron cross sections, and neutron capture gamma rays. Separate abstracts have been prepared for each paper. (M.H.R.)

**11701** TID-7547(p.92-7)
Gt. Brit. Atomic Energy Research Establishment, Harwell, Berks, England.
ON THE CORRELATION OF THE NUCLEAR ENERGY LEVELS OF $U^{235}$ AND $Pu^{240}$. P. A. Egelstaff. p.92-7 [of] THE INTERNATIONAL CONFERENCE ON THE NEUTRON INTERACTIONS WITH THE NUCLEUS HELD AT COLUMBIA UNIVERSITY, SEPTEMBER 9-13, 1957. 6p.

Experimental data on the fission and total cross sections of $U^{235}$ and the fission cross section of $Pu^{239}$ were analyzed by group analysis methods. Correlograms and other plots of the data are shown. It is concluded that there is evidence for a correlation effect in the slow neutron cross sections of $U^{235}$ and $Pu^{239}$. (M.H.R.)

**11703** TID-7547(p.105-6)
Oak Ridge National Lab., Tenn.
LOW ENERGY NEUTRON CROSS SECTIONS OF FISSION PRODUCTS. J. A. Harvey, R. C. Block, and G. G. Slaughter. p.105-6 [of] THE INTERNATIONAL CONFERENCE ON THE NEUTRON INTERACTIONS WITH THE NUCLEUS, HELD AT COLUMBIA UNIVERSITY, SEPTEMBER 9-13, 1957. 2p.

The Oak Ridge fast chopper time-of-flight spectrometer at the Low Intensity Training Reactor was used to make transmission measurements on fission product samples. The total cross sections of fission product samarium and promethium are given. (M.H.R.)

**8151**
STATISTICAL EVALUATION OF FISSION-PRODUCT ABSORPTION CROSS SECTIONS AT INTERMEDIATE AND HIGH ENERGIES. P. Greebler, H. Hurwitz, Jr., and M. L. Storm (Knolls Atomic Power Lab., Schenectady, N. Y.). Nuclear Sci. and Eng. 2, 334-51(1957) May.

The use of the statistical properties of nuclear resonances to calculate fission-product poisoning in the intermediate energy range is described. On the basis of the available theoretical and experimental information, estimates of the average fission-product cross section as a function of energy are given for the energy range $10^2$ to $10^6$ electron volts. Comparison is made with direct experimental measurements of intermediate energy absorption cross sections for several isotopes. Because of the unusually large level spacings for target nuclei which have even proton and neutron numbers or near-magic neutron numbers, the average fission-product cross sections obtained here are lower than those obtained in estimates which ignore this effect. The influence of various assumed statistical distributions of reduced neutron widths on the average cross section is discussed. (auth)

# GENERAL 1.18

## CROSS-SECTIONS 1.18.01

**7311** ✓ LA-2114
Los Alamos Scientific Lab., N. Mex.
SUMMARY OF NEUTRON-INDUCED FISSION CROSS SECTIONS. R. L. Henkel. Feb. 25, 1957. 12p. Contract W-7405-eng-36. $3.30(ph OTS); $2.40(mf OTS).

This report supersedes part of LA-1714.

High-energy neutron fission cross sections for $U^{233}$, $U^{235}$, $U^{238}$, and $Pu^{239}$ are graphed. Most of the data are from recent measurements, as yet not published. (M.H.R.)

NEW DATA FOR NEUTRON CROSS SECTIONS. P. K. (K. P.). Atomnaya Energiya 3, No. 8, 169-70(1957).

On the basis of data obtained from the U.S.A., the U.S.S.R., and England, the most probable values for the neutron cross sections and criticality constants for $U^{233}$, $U^{235}$, and $Pu^{239}$ are tabulated. (J.S.R.)

**9543** ORNL-2142
Oak Ridge National Lab., Tenn.
SUMMARY OF SOME NEW NUCLEAR DATA. P. R. Kasten. Aug. 21, 1956. 13p. ~~Contract W-7405-eng-26. $0.20(OTS)~~.

Results obtained by different investigators of nuclear constants of $U^{233}$, $Pu^{239}$, $Pu^{241}$, $U^{235}$, $Pu^{240}$, $Pu^{238}$, $Pu^{242}$, and $Am^{243}$, are summarized. (B.J.H.)

NONFISSION INELASTIC EVENTS IN URANIUM AND THORIUM INDUCED BY HIGH-ENERGY PROTONS. M. Lindner and R. N. Osborne (Univ. of California Radiation Lab., Livermore). Phys. Rev. 103, 378-85(1956) July 15.

Activation cross sections for about thirty products of high-energy proton-induced disintegration of $U^{238}$ and $Th^{232}$ have been measured by the radiochemical method. These products range from polonium (Z = 84) to neptunium (Z = 93). The energy dependence of some of these cross sections has been determined for formation from $U^{238}$. Because of fission competition, the spallation cross section of $U^{238}$ is considerably less than that of $Th^{232}$. The data suggest that light isotopes of uranium are primarily responsible for the fission generally associated with high-energy particle bombardment of $U^{238}$. (auth)

**4867** CF-56-6-21
Oak Ridge National Lab., Tenn.
CROSS SECTION PROGRAM AT OAK RIDGE NATIONAL LABORATORY. J. L. Fowler and J. A. Harvey. June 4, 1956. 15p. Contract [W-7405-eng-26]. $3.30(ph OTS); $2.40(mf OTS).

The ORNL cross section program is briefly surveyed, and all new cross sections are listed. (B.J.H.)

**9595**
INTERNATIONAL VALUES FOR THE THERMAL CROSS SECTION OF FISSIONABLE ISOTOPES. Soviet Phys. JETP 2, 271(1956) Mar. (In English)

**7026** ✓ A/CONF.15/P/2472
PHOTOFISSION CROSS SECTIONS NEAR THE THRESHOLD OF (γ,n) REACTIONS. A. I. Baz and Ya. A. Smorodinskii (Smorodinsky) (U.S.S.R.). 11p.

It is believed the (γ,n) reaction threshold energies for $Th^{232}$, $U^{235}$, and $U^{238}$ lie in the energy region close to 6 Mev. Simple formulas which described this effect are presented. (W.L.H.)

## FISSION, DECAY, AND HALF-LIVES 1.18.02

### DECAY 1.18.02.01

**20352** TID-3536
Technical Information Service Extension, AEC.
FISSION PRODUCTS DECAY ENERGY. A Literature Search. James M. Jacobs, comp. Sept. 1959. 11p. $0.50(OTS).

Seventy-five unclassified reports concerning energy release in various forms from irradiated materials are cited. The references are grouped alphabetically by corporate author (issuing agency) and are arranged alpha-numerically by primary report number within each grouping. The primary report number is that number under which the report was cataloged by the Technical Information Service Extension (TISE). (auth)

DIRECT ESTIMATION OF GAMMA-RAY ABUNDANCES IN RADIONUCLIDE MIXTURES. COMPLEMENT SUBTRACTION METHOD. William Lee (Naval Radiological Defense Lab., San Francisco). Anal. Chem. 31, 800-6 (1959) May.

A method is described for directly determining the absolute abundances of gamma-emitting radionuclides in complex mixtures without manipulation of data. A pure standard of known disintegration rate is subtracted directly from pulse height data stored in the Argonne-type 256-channel analyzer. Abundance is determined by comparing counting times read directly from a timing scaler. The technique can be applied to any mixture in which the photopeak of interest can be definitely identified. As the correct end point is determined by visual inspection of the analyzer display screen, other constituents of the mixture need not be known. The method is adequately demonstrated by quantitative estimation of each component in four-component mixtures. (auth)

# GENERAL 1.18

## FISSION, DECAY, AND HALF-LIVES 1.18.02

### DECAY 1.18.02.01

**15602** AE-17
Aktiebolaget Atomenergi, Stockholm.
RADIOACTIVE NUCLIDES FORMED BY IRRADIATION OF THE NATURAL ELEMENTS WITH THERMAL NEUTRONS. Kim Ekberg. Feb. 1959. 31p.

The radioactive nuclides formed by the irradiation of the natural elements with thermal neutrons are listed with their half life and tenth life, $\beta$ energy or type of decay, and energy and abundance of gamma decay. The 2200 m/sec neutron absorption cross sections and the saturation activity per gram for a certain flux are given for the natural elements. (W.D.M.)

**12659** UCRL-8289
California. Univ., Berkeley. Radiation Lab.
DECAY SCHEMES. D. Strominger and J. M. Hollander. June 1958. 50p. Contract W-7405-eng-48. $1.50 OTS).

The disintegration schemes presented were constructed from information contained in the Table of Isotopes, by Strominger, Hollander, and Seaborg, published as a supplement to the April, 1958, issue of the Reviews of Modern Physics. They are arranged according to mass number so as to show more clearly than was possible in the Table of Isotopes the various isobaric and parent-daughter relationships encountered in alpha and beta decay. References to the original literature are not given. (auth)

**9163**
RESOLVING COMPLEX DECAY CURVES. D. H. Perkel (Tracerlab, Inc., Richmond, Calif.). Nucleonics 15, No. 6, 103-6(1957) June.

An analytical method is described for resolving complex decay curves, which can be applied to a limited decay curve. It is shown how this linear method can be applied to 3-component decays and can detect and measure contamination in a 2-component sample. The method is limited to cases where decay constants are known accurately and the contribution of a fourth activity can be assumed negligible. (T.R.H.)

**14971** A/CONF.15/P/672
Oak Ridge National Lab., Tenn.
STUDIES OF SHORT-LIVED FISSION PRODUCTS AND THEIR IMPORTANCE TO REACTOR TECHNOLOGY. G. D. O'Kelley, E. Eichler, and N. R. Johnson. 13p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A systematic study of the decay schemes of some of the important alkali metal isotopes was made. Information is available on 17.8-minute $Rb^{88}$, 14.9-minute $Rb^{89}$, and 2.6-minute $Rb^{90}$. The decay characteristics of these nuclides show the general features exhibited by all of the short-lived fission products studied so far, namely, the short half-lives are related to high beta decay energies, which in turn permit the excitation of many nuclear levels at relatively high energies. Consequently, the gamma-ray spectra are very complex. For example, the maximum beta-ray energies in $Rb^{88}$, $Rb^{89}$, and $Rb^{90}$ are 5.30, 3.92, and 6.2 Mev, respectively, and the most energetic gamma-rays are 4.87, 3.52, and 5.25 Mev, respectively. The radiations from halogen fission products are also under investigation. $Br^{84}$ (32 minutes) was intensively studied. Besides the well-known beta-ray group at 4.7 Mev, several other high-energy beta groups were characterized. From a shielding point of view it was disquieting to discover a series of intense gamma rays from 0.81 to 3.93 Mev in the $Br^{84}$ decay. Studies on 52-minute $I^{134}$ and 86-second $I^{136}$ have proved interesting, since they excite similar energy levels in $Xe^{134}$ and $Xe^{136}$. The beta-ray spectrum of $I^{134}$ exhibits an energetic component of 3.5 Mev, and at least 4 components of lower energy. The gamma-ray spectrum of $I^{134}$ extends to 1.78 Mev, but the intense radiations are found in the region of 0.5 to 1.3 Mev, of which the most intense are at 0.84 and 0.89 Mev. The $I^{136}$ decay is similar but the radiations are more energetic. Beta-ray transitions of 7.0 and 5.7 Mev energy are a striking feature of the $I^{136}$ beta spectrum. A pair of gamma rays at 1.32 Mev dominates the $I^{136}$ gamma-ray spectrum, although there are six additional gamma rays to a maximum energy of 3.18 Mev. (auth)

# GENERAL 1.18

## FISSION, DECAY, AND HALF LIVES 1.18.02

### DECAY 1.18.02.01

**3165** ~~USNRDL-TR-160~~
Naval Radiological Defense Lab., San Francisco.
PROPOSED DECAY SCHEMES FOR SOME FISSION-PRODUCT AND OTHER RADIONUCLIDES. C. F. Miller. May 27, 1957. 118p. ~~Project NS-083-001.~~

The photon energy and photon emissions have been summed for some fission-product and other radionuclides using reported proposed decay scheme data up to about November 1956. The results are presented as proposed decay schemes giving the photon abundances per 100 disintegrations, the total photon energy emitted per disintegration, the average photon energy, and the number of photons per disintegration. (auth)

**9165** ✓
GAMMA-GAMMA ANGULAR CORRELATION IN THE DECAY OF $^{203}$Pb. B. van Nooijen and A. H. Wapstra. Physica 23, 404-6(1957) May.

The electron-capture decay of $Pb^{203}$ is followed by a cascade of two gamma rays of 404 and 279 kev, and by a cross-over gamma ray of 683 kev. The angular correlation values, previously obtained, for the first two gamma rays were checked. The data taken together indicate that the anisotropy does depend on the physical state of the source, due to extranuclear fields. A comparison of various values for conversion coefficients for the 404-kev transition in $Tl^{203}$ is given. (M.H.R.)

TABLE OF ALPHA DISINTEGRATION ENERGIES OF THE HEAVY ELEMENTS. F. Asaro and I. Perlman (Univ. of California). Reviews Modern Physics 29, 4, pp.831-6, 1957.

This is a revision of the table published in Reviews of Modern Physics Vol. 26, p.456, 1954 (same authors). Included are new alpha emitters and revisions of earlier data. A bibiography of 83 references is included.

**652** ✓
Atomic Energy of Canada Ltd., Chalk River, Ont.
DECAY SCHEMES OF RADIOACTIVE ISOTOPES. V. S. Dzelepov and L. K. Peker. Translated from a publication of the Academy of Sciences, U.S.S.R., Moscow-Leningrad, 1957. 176p. (AECL-457).

Available data on the decay characteristics of nuclei having mass numbers between 1 and 253 were compiled, and decay schemes are presented. Both the decay schemes and numerical data were taken from the most reliable data published prior to May 1956. The references are arranged by nuclei running from 0 to 101.

**9161** NP-6325
Tulane Univ., New Orleans.
STUDY OF NUCLEAR DISINTEGRATIONS. Final Report. [for] July 1, 1953 to May 31, 1957. Charles L. Peacock. 63p. DA Project No. 5-B-99-01-004. Contracts DA-01-009-ORD-344 and DA-01-009-ORD-458.

The results of studies on the following radioisotopes: $Ag^{110}$, $Sb^{124}$, $Cs^{134}$, $Br^{82}$, $Ba^{140}$, and $Sc^{46}$ are given. The beta spectra and gamma rays of each isotope were studied. (M.H.R.)

**0541** ORO-26(Rev.)
REVISED TABLES TO CORRECT FOR PHYSICAL DECAY OF SOME FREQUENTLY USED RADIOISOTOPES. H. D. Bruner, Emory Univ. June 1, 1956. 83p. $0.50(OTS).

The original version of this report was prepared by Oak Ridge Inst. of Nuclear Studies, Inc. under Contract AT-40-1-Gen-133.

Tables are presented which were prepared for the purpose of facilitating correction for the physical decay of some of the more frequently used radioisotopes. The tables are arranged to provide the value of $e^{-\lambda t}$ for the time interval, t, noted in the left margin and fractionally across the top of the table. This value is then used in the expression $N = N_0 \cdot e^{-\lambda t}$ in the usual manner where N is the activity after the time interval, t, and $N_0$ is the original activity. The values for half life used in computing the tables were supplied by Dr. William H. Sullivan of the Oak Ridge National Laboratory. (auth)

**7063**
LOG-LOG SCALE BECOMES DECAY TABLE. R. Hobart Ellis, Jr. Nucleonics 14, No. 6, 86(1956) June.

A method is given for the computation of radioactive decays using the LLO scale of a log slide rule. (F.S.)

# GENERAL 1.18

## FISSION, DECAY, AND HALF LIVES 1.18.02

### DECAY 1.18.02.01

**5006** CEA-tr-R554
LA DÉSINTÉGRATION-$\alpha$. ($\alpha$ Disintegration.) L. L. Goldine, L. K. Peker, and G. I. Novikova. Translated by [H.] Bourrely from Uspekhi Fiz. Nauk 59, 459-542 (1956). 97p.

A review is presented of the experimental and theoretical work on alpha decay. The topics discussed include experimental techniques and alpha and gamma correlations, classical theory of alpha decay, alpha decay with respect to the ground levels of the daughters, non-sphericity of levels, the rotation structure of excited levels, rotation level and the fine structure of alpha radiation, intensity of radiations in alpha decay and preferred and forbidden transitions, and intensity of alpha transition on rotation levels. 286 references.

**12762** √ AERE-C/M-58
Gt. Brit. Atomic Energy Research Establishment, Harwell, Berks, England.
THE GROWTH, DECAY AND $\beta$ ABSORPTION CHARACTERISTICS OF THE LONG-LIVED FISSION PRODUCTS. I. TABLES OF FISSION PRODUCT GROWTH AND DECAY. G. B. Cook and F. Morgan. Feb. 1950. 10p.

The growth, decay and $\beta$ absorption characteristics of the long-lived fission products are presented graphically. Values are presented throughout as relative disintegration activities. The product of fissions/sec times the factor (resulting from multiplying the fission yield by the fraction of saturation) gives the activity in disintegrations/sec. (J.R.D.)

**8753** ✓
RADIOACTIVITY ASSOCIATED WITH URANIUM, THORIUM, AND PLUTONIUM. S. A. Reynolds (Oak Ridge National Lab., Tenn.). pp. 562-72 in "Progress in Nuclear Energy. Series III. Process Chemistry. Volume 2."

Nuclear data for the common isotopes of uranium, thorium, and plutonium are tabulated. Methods of calculation of daughter "build-up" are illustrated. (auth)

**7010** √ A/CONF.15/P/2040
MASS-SPECTROSCOPIC STUDIES OF FISSION PRODUCTS OF URANIUM-233, URANIUM-235 AND PLUTONIUM-239. M. P. Anikina, P. M. Aron, V. K. Gorshkov, et al. (U.S.S.R.). 8p.

Yields of some $U^{233}$, $U^{235}$, and $Pu^{239}$ fission products produced by thermal neutrons were determined using the mass spectrometer. The results were used for calculating the values of neutron capture cross sections for a number of nuclei and for determining the half lives of individual isotopes. (auth)

**2969** ✓ ORNL-2790
Oak Ridge National Lab., Tenn.
SCINTILLATION SPECTROSCOPY MEASUREMENTS OF GAMMA-RAY ENERGIES FROM SOURCES OF $Y^{88}$, $Mn^{54}$, AND $Zn^{65}$. R. W. Peelle and T. A. Love. Nov. 20, 1959. 34p. Contract W-7405-eng-26. OTS.

A series of experiments employing NaI(Tl) scintillation spectroscopy techniques was performed to determine the energies of the strong gamma rays in the decays of $Y^{88}$, $Mn^{54}$, and $Zn^{65}$. A variety of calibration sources and counter geometries was used, including some which employed coincidence techniques to observe "double-escape" peaks corresponding to the loss of $2m_ec^2$ from the scintillator. Care was taken to avoid effects from drifts and to correct for nonlinearities of the system. The average gamma-ray energies measured are (1.840 ± 0.002) Mev and (0.8988 ± 0.0012) Mev for $Y^{88}$, (0.8347 ± 0.0011) Mev for $Mn^{54}$, and (1.114 ± 0.004) Mev for $Zn^{65}$. These values are consistent with averages of published values, but the quoted errors are smaller except in the case of $Zn^{65}$. When values were deduced for already well-known energies of other gamma-ray transitions, discrepancies between the present measurements and accepted values were consistent with quoted errors. (auth)

# GENERAL 1.18

## FISSION, DECAY, AND HALF LIVES 1.18.02

### FISSION 1.18.02.02

**12942**

THE EXCITATION ENERGIES OF FISSION FRAGMENTS. B. T. Geilikman. Atomnaya Energ. 6, 298-305(1959) Mar. (In Russian)

It is shown that the excitation energies of fission fragments can be found in the solution of equation systems for fragment deformation parameters and the distances between them. The initial conditions of these equations were obtained, and fragment excitation energies for several nuclei were determined. The excitation energy dependence on the Z and A of the fissioned nucleus was investigated. (tr-auth)

FISSION OF EXCITED HEAVY NUCLEI. B. D. Pate (Brookhaven National Lab., Upton, N. Y.). Can. J. Chem. 36, 1707-19(1958) Dec.

The results of published calculations on the prompt nuclear cascade and nuclear evaporation processes are combined with some assumptions regarding the nuclear fission process and fission widths to calculate the average neutron-to-proton ratios of fission products from Th + 8-Mev protons, Th + 87-Mev protons, and U + 450-Mev protons. Comparison of the results with experimental data indicates that the fission charge distribution mode characterized by the equal charge displacement hypothesis, hitherto considered a low energy phenomenon, persists in uranium and thorium up to the highest energy studied. There is also some evidence that fission occurs in excited heavy nuclei before complete de-excitation by particle emission, in agreement with other experimental work. (auth)

**13824**

PROCEEDINGS OF THE SECOND UNITED NATIONS INTERNATIONAL CONFERENCE ON THE PEACEFUL USES OF ATOMIC ENERGY, HELD IN GENEVA, 1 SEPTEMBER–13 SEPTEMBER 1958. VOLUME 15. PHYSICS IN NUCLEAR ENERGY. Geneva, United Nations, 1958. 484p. $12.50.

This volume covers subjects of importance to both fundamental and applied sciences, such as, fast neutron cross sections, neutron capture and nuclear levels, and the mechanisms and data for the fission process. (W.D.M.)

**13709** LAMS-2302

Los Alamos Scientific Lab., N. Mex.

BIBLIOGRAPHY ON FISSION, 1952 TO PRESENT. Patricia E. Bell and Soliska R. Harris, comps. Sept. 1958. 208p. Contract W-7405-eng-36. $3.50(OTS).

References to 1012 reports are arranged alphabetically according to author. If no author is given, the reference is interfiled alphabetically by title. Literature from Chemical Abstracts, Nuclear Science Abstracts, Physics Abstracts, and Los Alamos Laboratory Report Library Card Catalog was searched. (J.E.D.)

**368**

United Kingdom Atomic Energy Authority. Industrial Group H.Q., Risley, Lancs, England.

FISSION PRODUCT FORMATION AND DECAY CHARACTERISTICS. Information Bibliography. Dec. 1957. 10p. (IGRL-IB/R-29).

Utilization of fission products is excluded in this selection of 60 report and journal references issued up to December, 1956. Sources used were U.K., Canadian, and U.S. reports abstracts: *Nuclear Science Abstracts; Engineering Index* (1950-1955); and *Industrial Arts Index* (1956).

**10917**

THEORY OF NUCLEAR FISSION. B. T. Geilikman. Soviet J. Atomic Energy (English Translation) Suppl. No. 1, 5-20(1957).

A survey is presented on the theory of nuclear fission. In the first section calculations of the fission barrier are reviewed. The second section considers fission probability. Qualitative considerations concerning the fission process are presented in the third section. The fourth section is devoted to work on the mass, charge, and angular distributions of fission fragments. 76 references. (J.S.R.)

**10919**

MASS AND CHARGE DISTRIBUTION OF FISSION PRODUCTS. A. N. Murin. Soviet J. Atomic Energy (English Translation) Suppl. No. 1, 25-37(1957).

A survey of fission research, in particular of problems related to mass and charge distributions of the fragment yields, is presented. 45 references. (J.S.R.)

# GENERAL 1.18

## FISSION, DECAY, AND HALF LIVES 1.18.02

### FISSION 1.18.02.02

**10921**

ANISOTROPY IN FISSION PROCESSES. I. M. Frank. Soviet J. Atomic Energy (English Translation) Suppl. No. 1, 42-50(1957).

The problems connected with the asymmetries in the mass distribution of the fragments and the angular anisotropy in the emission of fragments in fission induced by particles of low and intermediate energy are discussed. The theoretical work being done to solve these problems is reviewed. 31 references. (J.S.R.)

**5991**

EMISSION OF PROMPT NEUTRONS FROM FISSION. R. B. Leachman (Los Alamos Scientific Lab., N. Mex.). Phys. Rev. 101, 1005-11(1956) Feb. 1.

An analysis of the total energies of the fragment pairs from fission is used with the mass equation of fission to estimate the distributions in the excitation energy of the fragments from spontaneous and neutron-induced fission of several nuclides. These excitations are used with simple neutron boil-off considerations to calculate the probabilities of emission of 0, 1, 2, 3··· prompt neutrons. The calculated results are in good agreement with recent measurements. The same excitation energy distributions and neutron boil-off considerations are used with an assumption of an isotropic angular relation between the fragments and the emitted neutrons to calculate the energy spectrum of neutrons from thermal and 3-Mev neutron-induced fission of $U^{235}$. For thermal-neutron fission, the calculated spectrum is in fair agreement with recent measurements. The calculations indicate little change in the spectrum for 3-Mev fission. The average energy of the prompt gamma rays is 3.8 Mev from this analysis. (auth)

**5993**

PROBABILITIES OF PROMPT-NEUTRON EMISSION FROM SPONTANEOUS FISSION. Donald A. Hicks, John Ise, Jr. and Robert V. Pyle (Univ. of California, Berkeley). Phys. Rev. 101, 1016-20(1956) Feb. 1.

The neutron number distributions from the spontaneous fission of seven isotopes have been measured by use of a cadmium-loaded liquid scintillation tank. The experimental distributions can be roughly approximated by binomial distributions. The average number of neutrons per spontaneous fission have been found to be 2.30 ± 0.19 for $Pu^{236}$, 2.33 ± 0.08 for $Pu^{238}$, 2.18 ± 0.09 for $Pu^{242}$, 2.65 ± 0.09 for $Cm^{242}$, 2.84 ± 0.09 for $Cm^{244}$, and 3.82 ± 0.12 for $Cf^{252}$, all based on 2.257 ± 0.046 for $Pu^{240}$. (auth)

**5992**

MULTIPLICITIES OF FISSION NEUTRONS. B. C. Diven, H. C. Martin, R. F. Taschek, and J. Terrell (Los Alamos Scientific Lab., N. Mex.). Phys. Rev. 101, 1012-15(1956) Feb. 1.

A large liquid scintillator with approximately 80% efficiency for detection of neutrons has been used to obtain data on numbers of neutrons emitted per fission for several fissioning nuclides. Reported here are the average number of neutrons per fission, $\bar{\nu}$, and the respective probabilities of 0, 1, 2, ··· neutrons per fission, for spontaneous fission of $Pu^{240}$, $Cm^{244}$, and $Cf^{252}$, and for fission induced in $U^{233}$, $U^{235}$, and $Pu^{239}$ by 80-kev neutrons. The values of $\bar{\nu}$ for these cases are respectively, 2.257 ± 0.045, 2.810 ± 0.059, 3.869 ± 0.078, 2.585 ± 0.062, 2.47 ± 0.03, and 3.048 ± 0.079. The thermal neutron value for $U^{235}$ (2.46 ± 0.03), obtained by other methods, was used here as a standard for calibrating the detector efficiency. The efficiency was also measured by another method, involving scattering neutrons into the scintillator, with results in good agreement. The probabilities of 0, 1, 2, ··· neutrons per fission approach closely a binomial type distribution, with the maximum number of neutrons equal to 5, 6, or 7, depending on $\bar{\nu}$. (auth)

**1526**

SYSTEMATICS OF FISSION ASYMMETRY. W. J. Swiatecki (Institute for Mechanics and Mathematical Physics) and Gustaf Werner (Inst. of Nuclear Chemistry, Uppsala, Sweden). Phys. Rev. 100, 936-7(1955) Nov. 1.

The square of the relative degree of fission asymmetry was plotted against $Z^2/A$ of the target nucleus. The asymmetry was found to decrease with $Z^2/A$, and semi-empirical relations between $Z^2/A$ and the degree of fission asymmetry are given. (B.J.H.)

**7024** A/CONF.15/P/2467

THE FISSION PROCESS—MECHANISMS AND DATA. R. B. Leachman (Los Alamos Scientific Lab., N. Mex.). 42p.

The purpose of this review is to examine briefly many of the aspects of the fission process by particularly considering fission induced by excitations up to tens of Mev. Greater bombarding energies involve uncertainties in the nature of the deposition energy that are apart from the fission process itself. Results of neutron-induced fission are considered, partly because of simplicities of barrier penetration and absorption into nuclear matter and because of the practical importance of neutron-induced fission in this energy range.

# GENERAL 1.18

## FISSION, DECAY, AND HALF LIVES 1.18.02

### HALF-LIVES 1.18.02.03

**22936**
DECAY OF SHORT-LIVED BARIUM AND LANTHANUM FISSION PRODUCTS. R. P. Schuman, E. H. Turk, and R. L. Heath (Phillips Petroleum Co., Idaho Falls, Idaho). Phys. Rev. 115, 185-7(1959) July 1.

The half lives and gamma-ray spectra of the short-lived barium and lanthanum fission products were measured. $Ba^{141}$ has a half life of 18 ± 1 min and emits x rays and gamma rays of 120, 190, 290, ~350, 460, 640, and 740 kev. $Ba^{142}$ has a half life of 11 ± 1 min and emits x rays and gamma rays of 80, ~260, 890, 970, 1080, 1200, 1360, and 1680 kev. $La^{141}$ has a half life of 3.85 ± 0.10 hr and emits a low intensity gamma ray at 1370 kev. $La^{142}$ has a half life of 85 ± 6 min and emits gamma rays of 640, 900, 1030, 1080, 1370, 1540, 1750, 1920, 2080, 2400, 2570, 3000, 3300, and 3650 kev. (auth)

**14338**
THE HALF-LIVES OF SOME SHORT-LIVED ISOTOPES. M. V. Mihailović and B. Povh (Inst. "J. Stefan," Ljubljana, Yugoslavia). Nuclear Phys. 7, 296(1958) June (3).

The half lives of $Mg^{23}$, $Al^{26}$, $Si^{27}$, $S^{31}$, $Cl^{34}$, $K^{38}$, and $Ca^{39}$ have been measured with better precision than before. The activities were induced by x rays from a 31-Mev betatron. The results are tabulated. (A.C.)

**11811**
THE DETERMINATION OF THE β HALF LIFE OF $Lu^{176}$ BY THE DETECTION OF RADIOGENIC $Hf^{176}$. W. Herr and E. Merz (Max-Planck-Institut für Chemie, Mainz) and P. Eberhardt and P. Signer (Univ. of Bern). Z. Naturforsch. 13a, 268-73(1958) Apr. (In German)

A re-examination of the half life of lutetium was carried out by an analysis of the probable decay products, and the applicability of this β radioactivity for geological dating was tested. In various rare earth minerals the lutetium and hafnium content, as well as the isotopic abundance of hafnium, was determined. In a gadolinite mineral radiogenic $Hf^{176}$ was detected. The mineral age of this mineral was determined. Under the assumption that the possibility of K capture in place of the beta decay of $Lu^{176}$ could be ignored, the half life of $Lu^{176}$ was calculated to be $(2.17 \pm 0.35) \times 10^{10}$ yr. (tr-auth)

**11810**
NUCLEAR ISOMERISM AND STRUCTURE OF ATOMIC NUCLEI. L. I. Rusinov and G. M. Drabkin. Uspekhi Fiz. Nauk 64, No. 1, 93-112(1958) Jan. (In Russian)

Properties of isomeric nuclei were correlated with the data obtained with the generalized nuclear mode. Isomeric transitions and half lives are given for 33 isotopes. (R.V.J.)

**8576** BNL-487
Brookhaven National Lab., Upton, N. Y.
TABLE OF RADIOISOTOPES ARRANGED ACCORDING TO HALF-LIFE. Elaine Daniels, comp. Dec. 1957. 60p. $1.75(OTS).

The tabulated data on radioisotopes are taken directly from the General Electric Chart of the Nuclides, Fifth Edition. The half lives, decay particles and energies, gamma energies, and total energy or mass are included in the table. (J.E.D.)

**10150**
HALF-LIVES OF RADIONUCLIDES. I. H. W. Wright, E. I. Wyatt, S. A. Reynolds, W. S. Lyon, and T. H. Handley (Oak Ridge National Lab., Tenn.). Nuclear Sci. and Eng. 2, 427-30(1957) July.

Half lives of thirty radionuclides are reported. Most of the samples were chemically purified after bombardment. In general, the activity of a given sample was followed for two or more half lives, employing a gamma ionization chamber, gamma scintillation counter, or a Geiger-Mueller counter. The data were analyzed by the least squares method. Some of the half-life values are significantly different from earlier ones; others merely confirm those already established. (auth)

**11260** USNRDL-TR-159
Naval Radiological Defense Lab., San Francisco.
NOMOGRAM FOR RADIOACTIVITY IN GROSS FISSION PRODUCT ANALYSES. M. H. Rowell and E. C. Freiling. May 22, 1957. 7p. Project NS-081-001.

A nomogram is presented which facilitates calculations involving the age and size of fission product samples and the fission yields, half lives, and residual activities of the individual fission product nuclides. Although all important fission products of half-life greater than 1 hr are conveniently indicated, the nomogram is applicable to many more. (auth)

**9461**
THE DECAY OF $Ga^{65}$. I. HALF LIFE AND β SPECTRA. H. Daniel. Z. Naturforsch. 12a, 363-5(1957) May. (In German)

# GENERAL 1.18

## FISSION, DECAY, AND HALF LIVES 1.18.02

### HALF-LIVES 1.18.02.03

**6054**

HALF-LIVES OF $Sc^{46}$, $Co^{60}$, $Zn^{65}$, $Ag^{110m}$, $Cs^{134}$, AND $Eu^{152,154}$
K. W. Geiger (National Research Council, Ottawa, Can.).
Phys. Rev. 105, 1539-40(1957) March 1.

The half lives of six gamma-emitting nuclides were determined by comparison with radium standards, using a lead-shielded ionization chamber. The following results were obtained: $Sc^{46}$: 83.89 ± 0.12 days; $Co^{60}$: 5.24 ± 0.03 years; $Zn^{65}$: 243.5 ± 0.8 days; $Ag^{110m}$: 252.5 ± 1.5 days; $Cs^{134}$: 2.07 ± 0.02 years; $Eu^{152,154}$: 12.2 ± 0.2 years. The errors quoted are twice the standard deviation calculated from a least-squares analysis. (auth)

**11328** AECU-3144
Rensselaer Polytechnic Inst., Troy, N. Y.
A TABLE OF RADIONUCLIDES ARRANGED ACCORDING TO HALF-LIFE. Herbert Mottram Clark and Donald Emmett Neil. Dec. 1955. 226p. $1.25(OTS).

**1948** UCRL-3176
California. Univ., Berkeley. Radiation Lab.
SEMI-EMPIRICAL CORRELATIONS OF ALPHA DECAY RATES AND ENERGIES. Charles J. Gallagher, Jr. and John O. Rasmussen. Oct. 26, 1955. 22p. Contract W-7405-eng-48.

Data on $\alpha$ decay rates and energy for all observed $\alpha$ groups emitted from nuclei with more than 128 neutrons have been studied in an attempt to establish correlations. Results are presented in the form of hindrance factor histograms to illustrate the distribution of the deviations from simple theory. (M.P.G.)

**1474**

CONTRIBUTION TO THE STANDARDIZATION OF RADIO-ELEMENTS. PRECISE MEASUREMENTS OF RADIO-ACTIVE HALF LIVES. Jacques Tobailem. Ann. phys. 10, 783-829(1955) Sept.-Oct. (In French)

The problem of the precise measurement of radioactive half lives was approached by a differential ionization technique using an electrometer tube. By this method, it is possible to obtain rapid and precise measurements. The experimental apparatus is described in detail. Radioactive half lives from several hours to a number of years were measured accurately by this method. (B.J.H.)

## SURVEYS 1.18.03

See also, under SURVEYS (GENERAL), CHEMISTRY (7.01.01).

**4339**

THEORETICAL FOUNDATIONS OF RADIATION CHEMISTRY. Aron Kuppermann (Univ. of Illinois, Urbana).
J. Chem. Educ. 36, No. 6, 279-85(1959) June.

Theoretical foundations of processes in radiation chemistry are reviewed. The physical stage, consisting of the dissipation of radiant energy in the system, is reviewed relative to loss of energy by charged particles and high-energy photons and the effect of energy transfer on the medium. The physicochemical stage, consisting of the processes which lead to the establishment of thermal equilibrium in the system, is discussed. The chemical stage, consisting of diffusion and chemical reaction of the reactive species leading to the establishment of chemical equilibrium, is reviewed relative to ionic and free radical reactions and diffusion kinetics of these reactions. (C.J.G.)

**4337**

DEVELOPMENT OF THE RADIATION CHEMISTRY OF AQUEOUS SOLUTIONS. Edwin J. Hart (Argonne National Lab., Lemont, Ill.). J. Chem. Educ. 36, No. 6, 266-72 (1959) June.

An historical review is presented on the development of the radiation chemistry of aqueous solutions relative to three periods: 1900 to 1925, 1925 to 1940, and 1940 to the present. The development of dosimetry and methods of analyzing chemical reactions are discussed. (C.J.G.)

**4338**

DEVELOPMENT OF CURRENT CONCEPTS OF ELEMENTARY PROCESSES IN RADIATION CHEMISTRY. Milton Burton (Univ. of Notre Dame, Ind.). J. Chem. Educ. 36, No. 6, 273-8(1959) June.

The development of theories governing elementary processes in radiation chemistry such as the iron-cluster and EHT theories and theories on the mechanism of a neutralization process are discussed. The study of excited molecules in liquids and related systems is discussed. Theories on free-radical diffusion in liquids and electron trapping are presented. (C.J.G.)

# GENERAL 1.18

## SURVEYS 1.18.03

**156**

ADVANCES IN INORGANIC CHEMISTRY AND RADIOCHEMISTRY. H. J. Emeleus and A. G. Sharpe, eds. New York, Academic Press Inc., 1959. 453p.

Progress in the fields of inorganic chemistry and radiochemistry are reported up to January, 1959. The topics covered include; mechanisms of redox reactions of simple chemistry, compounds of aromatic ring systems and metals, studies on boron hydrides, lattice energies in inorganic chemistry, graphite intercalation compounds, Szilard-Chalmers reaction in solids, activation analysis, phosphonitrilic halides and their derivatives, and sulfuric acid solvent system. (C.J.G.)

**229**

THE CHEMISTRY OF THE ARTIFICIAL RADIOELEMENTS. C. Fisher (Commissariat à l'Énergie Atomique, Paris). Inds. atomiques 3, No. 7-8, 49-54 (1959) (In French)

The chemistry of artificial radioelements is discussed. Target preparation and treatment after irradiation is described. Techniques for labeling molecules are summarized, and the part played by fission products is pointed out. The chemical, radioactive, and radiochemical purity is also discussed. (T.R.H.)

**21941** ANL-RCV-SL-1545

Argonne National Lab., Lemont, Ill.

LITERATURE SURVEY OF THE PROPERTIES OF FISSION PRODUCT OXIDES, FLUORIDES, AND OXYFLUORIDES. G. Tennenhouse and M. J. Steindler. July 30, 1959. 75p. $12.30(ph), $4.50(mf) OTS.

A literature survey is presented of the reactions and properties of oxides and fluorides of fission products. Only the dry chemistry of the materials is covered. The thermodynamic properties, heats, and free energies of formation are included. (W.L.H.)

THE MECHANISM OF NUCLEAR REACTIONS. U. Facchini (Università, Turin and CISE, Milan). Energia nucleare (Milan) 6, 441-57(1959) July. (In Italian)

The work done in recent years on the mechanism of nuclear reactions and on the structure of the nucleus is briefly reviewed. Reactions at low and medium energies with heavy and medium nuclei are discussed. 38 references. (J.S.R.)

**14667** A/CONF.15/P/941

Argonne National Lab., Lemont, Ill.

REACTION KINETICS OF THE ACTINIDE ELEMENTS. J. C. Hindman. 29p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

An effort has been made not only to summarize the available data but also to determine what the principal factors governing the rates of the different kinds of reactions are with the idea that useful predictions can be made for cases where data is not yet available. Data on isotope exchange reactions, the reactions involving ions of the same element, and reactions of the actinide elements with various anions and cations are considered. (auth)

**12811**

A NEW CLASSIFICATION OF THE ELEMENTS. Rose Aynard. Compt. rend. 248, 2165-7(1959) Apr. 13. (In French)

A new classification system of the elements based on the electron shell structure of the atom and their magnetic properties is presented. (J.S.R.)

**15611** UCRL-5419

California. Univ., Livermore. Lawrence Radiation Lab.

TABLES OF NUCLEAR REACTION Q VALUES. Val J. Ashby and Henry C. Catron. Feb. 10, 1959. 337p. Contract W-7405-eng-48. $5.00(OTS).

Tables of nuclear reaction Q values were calculated from nuclide masses, when possible, for those 42 reactions involving $\gamma$, n, p, d, t, $He^3$, or $He^4$ as either incident or product particle for about 650 target nuclides. Approximately 8000 Q values are tabulated. (auth)

**20958**

ENCYCLOPEDIA OF CHEMICAL REACTIONS. VOLUME VIII. TUNGSTEN, URANIUM, VANADIUM, YTTERBIUM, YTTRIUM, ZINC, ZIRCONIUM, ADDENDA. C. A. Jacobson, comp. and Clifford A. Hampel, ed. New York, Reinhold Publishing Corporation, 1959. 540p.

This is the final volume of the Encyclopedia of Chemical Reactions. It includes entries on the reactions of W, U, V, Yb, Y, Zn, and Zr. Following these is a section comprising entries received subsequent to the publication of the earlier volumes containing reactions of the elements with which they are concerned. (W.L.H.)

# GENERAL 1.18

## SURVEYS 1.18.03

**12969**

SIZE AND SHAPE OF THE ATOMIC NUCLEUS. Hans Kopfermann (Univ. of Heidelberg, Ger.). Strahlentherapie 108, 489-506(1959) Apr. (In German)

To-day it is possible to determine the shape of the nuclei of atoms despite their minuity at a fair accuracy by means of free or bound leptons, which are electrons and $\mu$ mesons. It was found that all nuclei, protons, and neutrons as well, have a finite dimension. The radius of the nucleus increases proportional to the cubic root of the number of parts of the nucleus, in agreement with theoretical considerations. Only a few nuclei have spheric arrangement of their charge. Most of them are rotation symetrical. The deviation from a sphere is generally little. In some parts of the periodic system, e.g., among the rare earths, considerable deformations are present with elongation of the shape of the nucleus in the direction of the rotational axis of the nucleus. Independent of their spheric or rotation symmetrical shape the nuclei have a border area in which the charge of the spheric nuclei decreases rapidly, the charge of the rotation symmetrical nuclei decreases slowly towards zero. (auth)

**13822**

NUCLEAR SPECTROSCOPY TABLES. A. H. Wapstra, G. J. Nijgh, and R. Van Lieshout. Amsterdam, North-Holland Publishing Company, 1959. 141p.

A concise introduction of several subjects is presented concerning alpha, beta, and gamma spectroscopy. Tables and graphs helpful in analyzing and interpreting experimental material are included. (W.D.M.)

ON THE SIMILARITY IN THE CHEMICAL NATURE OF ACTINIDES. E. S. Makarov (Vernadskii Inst. of Geochemistry and Analytical Chemistry, Academy of Sciences, USSR). Zhur. Neorg. Khim. 3, 1079-88(1958) May. (In Russian)

The actinide and thorium hypotheses are reviewed, and isostructural complexes of actinides, lanthanides, and IVa, Va, and VIa elements are analyzed. The "isomorphous analysis" serves as an additional crystallo-chemical and physico-chemical confirmation of the chemical similarity of actinide elements (especially thorium and uranium) to IVa, Va, VIa elements. The chemical similarities between the actinides and IVa, Va, and VIa elements and the similarity with lanthanides indicate the chemical similarity of actinides. (R.V.J.)

SOURCE MATERIAL FOR RADIOCHEMISTRY. Nuclear Science Series Report Number 27. NRC Pub. No. 654. Washington, D. C., National Research Council, 1959. 25p.

About 59 references to literature in the field of radiochemistry are presented. (W.L.H.)

THE CURRENT STATE OF NUCLEAR CHEMISTRY. A. K. Lavrukhina. Uspekhi Khim. 27, No. 5, 517-50 (1958) May. (In Russian)

After a short review of the history of the subject, the main subjects of review are: methods of nuclear chemistry; nuclear reactions produced by slow particles (neutron-induced reactions, charged-particle-induced reactions, slow neutron fission of heavy nuclei); (fast protons, deuterons, $\alpha$-particles, and neutrons); typical features of spallation; typical features of fission at high energies; emission of light nuclei; secondary reactions; reactions caused by heavy ions; $\gamma$-ray-induced reactions; $\pi$-meson-induced reactions; production of new particles; and nuclear reactions in nature. (tr-auth)

**11573**

MASSES OF LEAD ISOTOPES. R. A. Demirkhanov, T. I. Gutkin, and V. V. Dorokhov. Doklady Akad. Nauk S.S.S.R. 118, 1103-4(1958) Feb. 21. (In Russian)

The masses of $Pb^{204}$, $Pb^{206}$, $Pb^{207}$, and $Pb^{208}$ were measured to determine the energy of the nucleonic bond in nuclei in the magic number region with 82 protons and 126 neutrons. The mass of $Pb^{208}$ was corrected and used as the basic magnitude for calculations of the mass for the heavy isotopes with $Z \leq 82$. The results showed that within the limits of error the value $\Delta M$ for each doublet $Pb^{208}-C_{14}H_{18}O_2$, $Pb^{207}-C_{14}H_7O_2$, and $Pb^{206}-C_{16}H_{14}$ coincides regardless of the ionic origin (atomic or dissociative). (R.V.J.)

**10965**

NEW NUCLEAR DATA. 1957 CUMULATION. M. Yamada, ed., G. H. Fuller, D. N. Kundu, J. B. Marion, C. L. McGinnis, and K. Way. Washington, National Research Council, 1958. 167p. Available from U. S. Government Printing Office, Washington, D. C., for $1.25.

Nuclear data collected from 44 journals from about November 1956 to August 1957 is cumulated. The data from Nuclear Science Abstracts, Vol. 11, nos. 6B and 12B are included. A separate list of data on elastic and inelastic scattering of charged particles is a new feature of this cumulation, and it covers experimental data appearing since 1950. The tabular presentation of previous cumulations is retained. (T.R.H.)

# GENERAL 1.18

## SURVEYS 1.18.03

**14652** A/CONF.15/P/949
Argonne National Lab., Lemont, Ill.
PHOTOCHEMICAL CONTRIBUTIONS TO RADIATION CHEMISTRY. Max S. Matheson. 16p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The literature is reviewed for a comparison of photochemistry with radiation chemistry in studies on diffusion theory, track effects, rate constant measurements, G values, hot radical and ion-molecule reactions, and the reaction of specific fragments and excited states. It is suggested that the potential value of such comparisons has not been sufficiently exploited. (auth)

**4696** CEA-766
France. Commissariat à l'Énergie Atomique, Paris.
SUR LE STRUCTURE DES MÉTAUX LOURDS. (On the Structure of Heavy Metals.) J. Friedel. 1958. 14p.

The properties of the last series of Mendeleef's table are compared with those of the elements of the preceding series. This comparison suggests an electronic structure of the "transition metal" type, with narrow bands, at the beginning of this series (up to certain phases at least of plutonium); then of the rare earth metal type, with independent non-saturated internal layers, further on in the series. The 5f orbits seem to play an important part in these two types of structure, from uranium on. A more detailed study of the very heavy elements (americium and beyond) and alloys would allow these conclusions to be confirmed. Certain general points, concerning the nature of homopolar connections and paramagnetism in the transition metals, are developed in an additional section. (auth)

**11712** TID-7547(p.135-8)
Oak Ridge National Lab., Tenn.
FISSION FRAGMENT STUDIES WITH A MAGNETIC SPECTROGRAPH. B. L. Cohen and C. B. Fulmer. p.135-8 [of] THE INTERNATIONAL CONFERENCE ON THE NEUTRON INTERACTIONS WITH THE NUCLEUS, HELD AT COLUMBIA UNIVERSITY, SEPTEMBER 9-13, 1957. 4p.

A brief summary of work done with a fission fragment magnetic spectrograph in the Oak Ridge graphite reactor from November, 1955 to May, 1957, is given. Observed $H_\rho$ distributions for mass 91, 97, and 131 are plotted. (M.H.R.)

**1231** TID-7015(Sec. 2)
Oak Ridge National Lab., Tenn.
ORNL MASTER ANALYTICAL MANUAL. SECTION 2. RADIOCHEMICAL METHODS. Nov. 1957. 304p. $6.50 (OTS).

Issued in loose-leaf form to facilitate periodic supplements.

**6242**
ON THE RELATIONSHIP OF DYNAMIC AND STATISTICAL REGULARITIES IN ATOMIC PHENOMENA. S. V. Vonsovskii and G. A. Kursanov. Vestnik Akad. Nauk S.S.S.R. 27, No. 4, 31-45(1957) Apr. (In Russian)

**8856** IDO-14396
Phillips Petroleum Co. Atomic Energy Div., Idaho Falls, Idaho.
ANALYTICAL CONTROL LABORATORY OPERATING MANUAL. M. J. Painter and G. A. Huff, comps. and eds. Mar. 21, 1957. 140p. Contracts AT(10-1)-205. $0.70 (OTS).

This manual describes briefly the theory and operational procedure of apparatus and instruments used in the Analytical Control Laboratory. Also, it contains pertinent facts and information dealing with Control Laboratory operation. The manual is divided into twelve major sections; General Information, Safety and Security, Accountability, Precision and Accuracy, Records, Dilution Factors, Laboratory Equipment (Warm Laboratory), Remote Apparatus ("B" Line), Remote Apparatus ("A" Line), Training and Testing, Table of Conversion Factors and References. (auth)

**9524**
MENDELEEV'S PERIODIC SYSTEM AND MODERN DEVELOPMENT OF PHYSICS AND CHEMISTRY. V. K. Semenchenko. Zhur. Fiz. Khim. 31, 273-82(1957) Feb. (In Russian)

**4316**
ATOMIC WEIGHTS COMPUTED FROM PHYSICAL MEASUREMENTS. A. H. Wapstra. J. Inorg. and Nuclear Chem. 3, 329-32(1957) Jan.

Chemical atomic weights are calculated from isotopic abundance ratios and earlier computations of isotopic masses. (auth)

**4462** CEA-tr-X-111
LE MÉCANISME DE LA RÉACTION RADIOCHIMIQUE. (The Mechanism of the Radiochemical Reaction.) K. Hiroda. Translated by S. S. Minn from Kôgyô Kagaku Zasshi 60, 808-13(1957). 9p.

The mechanisms of radiochemical reactions are discussed and compared to photochemical reactions.

# GENERAL 1.18

## SURVEYS 1.18.03

NUCLEAR CHEMISTRY AND ITS APPLICATIONS. M. Haissinsky. Paris, Masson and Company, 1957. 657p. (In French)

The scope of this treatment of the broad field of nuclear chemistry is indicated by the table of contents: the history of radioactivity, physics, and nuclear chemistry; the fundamental particles; the nucleus; spontaneous radioactive transformations; nuclear reactions; fission and nuclear reactors; the natural radioelements; isotopic effects and separations; geochemical, geological and astrophysicl applications; dissipation of the energy of radiations in matter; chemical action of ionizing radiations, generalities and reactions in gases; radiolysis of water and aqueous solutions; radiolysis of organic compounds and biological effects of radiations; action of radiations on solids; fluorescence and coloration produced by radiations; chemical effects associated with nuclear transformations; radioactive indicators; isotopic exchange; electrochemical applications; partition of microcomponents between two phases; analytical applications; applications in the study of chemical reaction mechanisms; biochemical and physiological applications of isotopic indicators; technical and industrial applications.

**7058**

THE RADIOACTIVE ELEMENTS. Je. Bresler. Berlin, Veb Verlag Technik, 1957. 346p. (In German)

The book The Radioactive Elements, translated from the original Russian, is intended primarily for the chemist. The radioactive decay series are discussed briefly. Then the enrichment and separation of radioactive material, the adsorption of radioactive material, the chemistry of the radioelements, short-lived radioactivity and nuclear reactions, the preparation of short-lived radioisotopes and their compounds, the most important radioisotopes such as tritium, radiocarbon, phosphorus, and sulfur, and finally marked atoms as research tools are all considered. (J.S.R.)

**7222**

THE CALCULATION OF ATOMIC STRUCTURES. Douglas R. Hartree. New York, John Wiley & Sons, Inc., 1957. 190p.

**2418**

CHEMISTRY OF NEW ELEMENTS OF TECHNETIUM, PROMETHIUM, ASTATINE AND FRANCIUM. Yu. B. Gerlit, F. I. Pavlotskaya, and S. S. Rodin. Khim. Nauka i Prom. 4, 465-72(1959). (In Russian)

Chemical properties and application of At, Fr, Pn, and Te were studied and methods for their separation and determination are discussed. 114 references. (R.V.J.)

**10449**

SOVIET RADIOCHEMISTRY. A. N. Murin. Atomnaya Energiya 3, 459-64(1957). (In Russian)

Soviet achievements in the field of radiation chemistry are chronologically listed. The most important developments were concerned with the radioelements in the physical-chemical system, chemistry of the radioelements, and chemical methods for the investigation of nuclear reactions. (J.S.R.)

THE ROLE OF CHEMISTRY IN A NUCLEAR ENERGY PROJECT. R. Spence (Atomic Energy Research Establishment, Harwell, Berks, England). Brit. J. Appl. Phys., Suppl. No. 5, 88-91(1956).

The development of atomic energy has been unique from a chemical point of view, in that a whole series of new elements, the actinide series, has been produced and some of these, such as neptunium, plutonium, and americium, play a major role in the technology. Furthermore, many elements which were previously little known and of academic interest only, have become of technical importance in the project, as for example, ruthenium, zirconium, and protactinium. Atomic energy can be divided into the following broad fields, from the chemical point of view, viz., raw materials; production of fuel elements and other special reactor materials; reactor chemistry; chemical processing of irradiated materials; disposal and utilization of radioactive waste materials. Although the provision of materials and the processing of irradiated fuel elements are of great importance, the nuclear reactor itself has always been the centre of interest. The earlier forms of reactor did not in themselves present any very serious chemical problems. Newer forms of reactor, however, operate at high temperatures and frequently bear more resemblance to chemical or metallurgical plants than they do to mechanical apparatus. (auth)

**7499** NP-5906

Advance Technology Corp., White Plains, N. Y.
RADIOCHEMICAL LABORATORY MANUAL. Nov. 15, 1953. Decl. Mar. 20, 1956. 379p. For Kewaunee Mfg. Co., Adrian, Mich. Contract DA-118-108-CML-4522.

The manual which is to be used as a guide for radiochemical analyses at the Theater Chemical Laboratory contains information on basic principles of nuclear physics and radiochemistry, laboratory techniques, and selected analytical procedures. Health-physics regulations and tables of pertinent data are included. (C.W.H.)

# GENERAL 1.18

## SURVEYS 1.18.03

**5543**
MENDELEEV PERIODIC SYSTEM AND ATOMIC ELECTRON SHELL STRUCTURE. V. I. Semishin. Zhur. Obshcheĭ Khim. 25, 2375-80(1955) Dec. (In Russian).
A long-period table is proposed for the Mendeleev periodic system, which divides all elements into four basic types or groups (s, p, d and f). In the suggested table, the elements are distributed not only according to the increasing number, but also on the basis of actual electron distributions in atomic sublevels. (R.V.J.)

**1254**
ON THE ANOMALY OF ATOMIC WEIGHTS IN MENDELEEV'S PERIODIC SYSTEM. G. P. Maitak. Zhur. Obshchei Khim. 25, 2017-23(1955) Nov. (In Russian)

NUCLEAR AND RADIOCHEMISTRY. G. Friedlander and J. W. Kennedy. New York, Wiley, 1955. 468 p. $7.50.
Contents: Radioactivity; atomic nuclei; nuclear reactions; production and study of nuclear reactions; equations of radioactive decay and growth; nuclear states and radioactive processes; interaction of radiations with matter; radiation detection and measurement; statistical considerations in radioactivity measurements; techniques for the study of radionuclides; tracers in chemical applications: nuclear energy; and some cosmic problems.

**6425**
A SURVEY OF ATOMIC CONSTANTS. J. A. Bearden and John S. Thomsen. Baltimore, The Johns Hopkins University. 145p.
Recent adjustments of the atomic constants have shown a serious discrepancy between the adjusted value of $\lambda_g/\lambda_s$ (the conversion factor from the Siegbahn x-ray scale to absolute units) and the accepted average of the direct experimental results by ruled grating measurements. As an attempt to resolve this discrepancy and for other reasons, a general survey of the atomic constants has been made. Much information which is chiefly of historical interest has been included. An attempt was made to reevaluate errors wherever this appeared necessary and to choose the most reliable experiments for inclusion in the present adjustment. (auth)

**2806** UCRL-5612
Stanford Research Inst., Menlo Park, Calif.
A TABLE OF EMISSION LINES IN THE VACUUM ULTRAVIOLET FOR ALL ELEMENTS (6 ANGSTROMS TO 2000 ANGSTROMS). Raymond L. Kelly. [Jan. 1959]. 524p. [For] Univ. of California Lawrence Radiation Lab. OTS.
All the published atomic emission lines contained in the literature up to January 1959, are presented. Each line of data contains the vacuum wavelength in Angstroms, the element and spectroscopic notation for ionization, the intensity, and reference numbers which refer to the list of references at the end of the report. Lists of intense lines arranged by ions, lines arranged by element, and binding lists are included. The intensities given in the tables are those published for spark sources. (W.D.M.)

# INDIUM 1.19

**11655**

5

**THE POTENTIALS OF INDIUM AND THALLIUM ON ELECTROLYSIS OF THEIR SALTS WITH A MERCURY ELECTRODE. P. P. Tsyb. Sbornik Trudov Vsesoyuz. Nauch. Issledovatel. Inst. Tsvetnoi Met. No. 1, 181-8 (1956). (Translated from Referat. Zhur. Met. No. 4, 1958, p.334.)**

**The relationship between cathode and anode potentials (CP, AP) in the electrolysis of the aqueous salts of In and Tl with an Hg cathode relative to the amount of metal in the amalgam at different D and temperatures is discussed. It is established that the potentials required for deposition of In and Tl on an Hg cathode are more electropositive than their normal potentials and shift in the direction of the more electronegative values as the concentration of metal in the amalgam increases. As D increases, the CP of In shifts toward the electronegative values and the AP toward the electropositive. The CP of Tl is virtually independent of D. With rising temperature, the CP of In salt electrolysis shifts toward the more electropositive values, while the AP undergoes virtually no change. In the electrolysis of Tl salts, both the CP and the AP are virtually independent of temperature. Experiments in the electrolytic decomposition of the amalgam show that, under certain conditions, the In and Tl are almost completely extracted from the amalgam by electrolysis.**

**2714** AERE-Med/M-18

Gt. Brit. Atomic Energy Research Establishment, Harwell, Berks, England.

SOME NOTES ON INDIUM—WITH SPECIAL REFERENCE TO ITS TOXIC PROPERTIES. Frances M. Turner. Aug. 1957. 4p.

**9251**

DIMERIZATION OF SOLID GROUP IIIB TRIHALIDES. III. BROMINE, GALLIUM, AND INDIUM QUADRUPOLE RESONANCES IN $GaBr_3$, $GaI_3$, $InBr_3$, AND $InI_3$. R. G. Barnes ~~and S~~ L. ~~Segel~~ (~~Iowa State Coll.~~, Ames) and P. J. Bray and P. A. Casabella (Brown Univ., Providence, ~~R. I.~~). J. Chem. Phys. 26, 1345-6(1957) May.

4

DECAY OF $In^{114m}$ AND $In^{114}$. Lee Grodzins and Henry Motz (Brookhaven National Lab., Upton, N. Y.). Phys. Rev. 102, 761-5(1956) May 1.

Scintillation counter experiments have been performed on the 72-second activity of $In^{114}$ produced by (p,n) and (d,2n) cyclotron bombardment of enriched $Cd^{114}$ and on the 49-day activity of $In^{114m}$ produced by neutron activation. The well-known 556-722-kev cascade radiation of $Cd^{114}$ is shown to be excited by a K-capture transition from the 49-day isomeric level. The weak 1300-kev gamma ray previously assigned to $Cd^{114}$ is shown to come from the first excited state of $Sn^{114}$ and is in coincidence with a low-energy beta spectrum having an end point of 675 ± 40 kev. No gamma rays in $Cd^{114}$ other than the 556- and 722-kev lines have been observed from the decay of $In^{114m}$ or $In^{114}$. A 1.9% K-capture branch from $In^{114}$ to the ground state of $Cd^{114}$ has been found. A positron branch of ~0.004% between these two states is shown to have an end point of 400 ± 25 kev. (auth)

**2204**

**DECAY SCHEME OF $In^{107}$. Wayne A. Cassatt, Jr. and W. Wayne Meinke (Univ. of Michigan, Ann Arbor). Phys. Rev. 100, 1372-3(1955) Dec. 1.**

**The $\gamma$ radiations of $In^{107}$ have been investigated with a scintillation spectrometer. The $In^{107}$ was produced in a cyclotron by a (d,n) reaction on electromagnetically enriched $Cd^{106}$. Beta-gamma and $\gamma$-$\gamma$ coincidence experiments showed, in addition to the annihilation radiation, only one $\gamma$ ray of 0.22-Mev associated with the 2-Mev positron. (auth)**

# IODINE 1.20

ION-MOLECULE REACTIONS OF METHYL AND ETHYL IODIDES. R. F. Pottie, R. Barker, and W. H. Hamill (Univ. of Notre Dame, Ind.). Radiation Research 10, 664-70(1959) June.

Ion-molecule reactions from methyl iodide, ethyl iodide, and their mixture were observed in the mass spectrometer. Appearance potentials of the important primary ions and of all secondary ions and the reaction cross sections were measured. (auth)

**6270**

THE KINETICS OF THE REACTION OF FLUORINE WITH IODINE PENTAFLUORIDE TO FORM IODINE HEPTAFLUORIDE. Jack Fischer and Robert K. Steunenberg (Argonne National Lab., Lemont, Ill.). J. Am. Chem. Soc. 79, 1876-8(1957) Apr. 20.

The kinetics of the vapor phase reaction of fluorine with iodine pentafluoride to form iodine heptafluoride has been studied from 55.6 to 95°. The rate of the reaction was found to be second order with respect to the reactant pressures. The rate constants showed an Arrhenius temperature dependence, with an activation energy of 14 kcal. per mole. The reaction was homogeneous, suggesting that the rate-determining step is a bimolecular collision. (auth)

IDO-16494

Phillips Petroleum Co. Atomic Energy Div., Idaho Falls, Idaho.

METHOD FOR DETERMINING THE FISSION YIELD OF I-135 WITH THE RMF. R. G. Nisle and E. Fast. May 13, 1959. 26p. Contract AT(10-1)-205. $0.75 (OTS).

A procedure is described for determining the iodine-135 yield in fission. The fuel sample is irradiated in the MTR, and subsequent measurements of reactivity are made in the RMF in two positions. The effect due to fuel and poison can be determined independently because of the difference in the fission and slow neutron weighting factors in these locations. Values of cross section as a function of time are read from smoothed curves and the theoretical equation is fitted by least-squares methods to the resulting smoothed data. One of the coefficients obtained in this manner is a function of the fission yield of $I^{135}$. The procedure is demonstrated in a determination of the yield of $I^{135}$ from fission in 160 mg of $Pu^{239}$. A value of 5.9 ± 0.7 percent was obtained for fission in the neutron energy spectrum of MTR experimental position L-43. (auth)

DECAY PROPERTIES OF $I^{136}$. Noah R. Johnson and G. D. O'Kelley (Oak Ridge National Lab., Tenn.). Phys. Rev. 114, 279-85(1959) Apr. 1.

$I^{136}$, produced from the slow neutron fission of uranium, has been studied with scintillation techniques. From the single-crystal (NaI) and gamma-gamma coincidence spectra, gamma rays were found at energies of 0.20, 0.27, 0.39, 0.46, 0.53, 0.71, 1.00, 1.321 ± 0.006, 1.55, 1.72, 1.91, 2.25, 2.40, 2.63, 2.84, and 3.2 Mev. Also, from single-crystal (anthracene) and beta-gamma coincidence measurements, four beta-ray groups were observed with energies of 2.73, 4.23, 5.62, and 7.00 Mev, where the latter represents the $I^{136}$-$Xe^{136}$ mass difference and is present in about 6% of the total beta-ray transitions. A partial decay scheme has been proposed, with energy levels in $Xe^{136}$ at 1.32, 2.64, 2.84, 3.03, 3.23, 3.57, 3.74, and 4.20 Mev. The half-life of $I^{136}$ was measured as 82.8 ± 1.5 seconds. In the course of this investigation a source of 3.8-minute $Xe^{137}$ was prepared, and was found to emit prominent gamma rays of 0.26 and 0.45 Mev. (auth)

MEASUREMENTS ON THE RADIATION FROM THE DECAY OF $I^{134}$ AND $I^{133}$. Goran Holm and Hans Ryde (Nobel Inst. of Physics, Stockholm). Arkiv Fysik 15, 387-96(1959).

The beta and gamma radiations from the radioactive decay of the isotopes $I^{134}$ and $I^{133}$ have been studied by means of magnetic beta spectrometers and scintillation techniques. A Fermi analysis of the beta-ray spectrum from the decay of $I^{134}$ shows that it is very complex. The maximum energy is found to be 2.35 Mev, and the measured energies of two further components are 1.57 and 1.3 Mev. The energies of the gamma rays following the decay of $I^{134}$ are 0.138, 0.21, 0.42, 0.63, 0.86 (there seem to be two gamma rays with about this energy), 1.07, 1.14, 1.45, 1.62, and 1.80 Mev. Coincidence experiments have been carried out, and the beta disintegration energy ($Q_{\beta^-}$ value) for the decay of $I^{134}$ to $Xe^{134}$ is estimated as 4.1 Mev. As regards the decay of $I^{133}$, the maximum energy of the beta-ray spectrum is found to be 1.27 Mev. Furthermore, beta components are found having energies of about 0.94 and 0.7 Mev.

Gamma rays with the following energies are associated with this decay: 0.35, 0.53, 0.71, 0.87, 1.05, 1.24, and 1.30 Mev. (auth)

# IODINE 1.20

**12969** ✓ AERE-C/M-342
United Kingdom Atomic Energy Authority. Research Group. Atomic Energy Research Establishment, Harwell, Berks, England.
THE DIFFUSION OF IODINE IN AIR. H. J. de Nordwall and R. H. Flowers. May 1958. 13p.
An experiment to measure the rate of diffusion of iodine vapor, at very low partial pressure, in air is presented. (W.L.H.)

**10183**
THE HALF-LIFE OF IODINE-131. L. Burkinshaw (Univ. of Cambridge, Eng.). Phys. in Med. Biol. 2, 255-7(1958) Jan.
A measurement of the half-life of the principal mode of decay of $I^{131}$ gave the value 8.054 ± 0.010 days. Combining this figure with other published values, the most probable half-life and its standard error are found to be 8.0545 ± 0.0063 days.

**2469**
MEASUREMENT OF THE $Xe^{135}$ CROS SECTION AND $U^{235}$ FISSION YIELD OF $I^{135}$. G. R. Hopkins and C. P. Jamieson (Westinghouse Electric Corp., Pittsburgh). J. Appl. Phys. 28, 1362-3(1957) Nov.

**555** ORNL-2293
Oak Ridge National Lab., Tenn.
RECOVERY AND HALF-LIFE DETERMINATION OF $I^{129}$. H. T. Russell. May 24, 1957. 7p. Contract W-7405-eng-26. $1.80(ph OTS); $1.80(mf OTS).
A simple, rapid, and efficient separation method for the recovery of $I^{129}$ activity is described. Radioactive $I^{129}$, a product of $U^{235}$ fission through the $Sb^{129}-Te^{129}$ decay chain, was separated and purified for the radioisotope distribution program at Oak Ridge National Laboratory. It was found by mass spectrographic analysis that 51.28 ± 0.05% of the iodine in the product solution is present as $I^{129}$ and that the remaining 48.72 ± 0.05% is stable $I^{129}$. The $I^{129}$ activity was determined by beta-gamma coincidence counting to be 0.261 μc/ml. The total iodine concentration was ascertained by potentiometric analyses as 2.866 mg/ml. The half life, which is calculated from the above data, is $1.56 \times 10^7$ years. (auth)

**12051**
THE YIELDS OF $^{129}I$ IN NATURAL AND IN NEUTRON-INDUCED FISSION OF URANIUM. B. C. Purkayastha and G. R. Martin (Univ. of Durham, England). Can. J. Chem. 34, 293-300(1956) Mar.
Measurements have been made, by a radioactivation technique, of the $I^{129}$ formed in U by pile-neutron-induced fission, and in pitchblende by the natural fission of U. The amount found in the pile-neutron-irradiated U corresponds to a fission yield of 0.90% at mass 129. The natural production of $I^{129}$ in pitchblende is discussed in the light of the mass-spectrometric measurements of spontaneous fission xenon made by Thode and his collaborators. An upper limit of 1 part in $10^8$ can be set for the occurrence of $I^{129}$ in natural iodine. The pile neutron capture cross section of $I^{129}$ has been measured as 35 barns. (auth)

**6045** ✓
INVESTIGATIONS OF $I^{128}$. N. Benczer, B. Farrelly, L. Koerts, and C. S. Wu (Columbia Univ., New York). Phys. Rev. 101, 1027-30(1956) Feb. 1.
The $\beta^-$, $\gamma$ and electron capture processes of $I^{128}$ were investigated with the solenoidal magnetic spectrometer, a single-channel scintillation spectrometer, a multiple-channel selective coincidence scintillation spectrometer, and a proportional counter spectrometer. Three $\beta^-$ groups with energies 2.120, 1.665, and 1.125 Mev and relative abundance 76.0 : 15.5 : 2.0, and four $\gamma$ radiations with energies 0.455, 0.540, 0.750, and 0.990 Mev and relative intensities 100 : 9.7 : 1.7 : 1.8 were found. The electron capture branch was determined to be 6.4% of the total disintegration. The ratio of electron capture to the ground to that to the first excited state of $Te^{128}$ is 19:1. Spin and parity were assigned to the ground and excited states of the daughter nuclei $Te^{128}$ and $Xe^{128}$, and a decay scheme was proposed for $I^{128}$. (auth)

**7023** ✓ A/CONF.15/P/2464
GAMMA RADIATION FROM $I^{128}$. H. Bosch, R. Radicella, et al (Comisión Nacional de Energía Atómica, Buenos Aires). 7p.
The decay of $I^{128}$ was investigated. The method of source preparation is described, along with the technique of measurement. It was concluded that the disintegration produces four gamma rays, the intensities of which are listed. The energies of the first excited levels of some Xe and Te nuclides are given. (J.R.D.)

# KRYPTON 1.21

**1218**

THE DIFFUSION OF FISSION KRYPTON FROM METALLIC URANIUM. Myron B. Reynolds (Knolls Atomic Power Lab., Schenectady, N. Y.). Nuclear Sci. and Eng. 1, 374-82 (1956) Oct.

The rare gases have not been shown to exhibit measurable equilibrium solubility in metals, nor do any common metals exhibit measurable permeability to the rare gases. By means of nuclear reactions, however, "solid solutions" of rare gases in metals may be produced which permit the rare gas diffusion process to be studied. Results of work on the system radiokrypton–uranium are presented. Diffusion of radiokrypton from small cylinders of irradiated normal uranium was found to be negligible at temperatures below 1000°C. The diffusion rate was found to be quite temperature-sensitive and was considerably enhanced by thermal cycling. Swelling of the metal specimen during the diffusion process and the fact that the theoretical time dependence was never observed, leads to the conclusion that gas escape is by way of grain boundaries or microcracks. A possible mechanism to explain the thermal cycling behavior is presented. (auth)

**2192** ✓ UK/C/5/117

Atomic Energy of Canada Ltd. Chalk River Project, Chalk River, Ont.

DIFFUSION OF FISSION PRODUCT GASES FROM COMPACTED $UO_2$. [Paper presented at] Fifth UK/Canada Technical Conference, October 22 to 24, 1956. A. H. Booth and R. F. S. Robertson. Sept. 1956. 12p.

Laboratory determinations of diffusion constants of stable isotopes of krypton and xenon released in the fission of compacted $UO_2$ specimens were made. Results lead to the conclusion that a large fraction of the gases may be liberated from the fuel during long irradiation; however, it is thought that the results of the laboratory experiments cannot be extrapolated to reactor operating conditions. The experiments are described as a basis for discussion. In addition, defect tests of compacted $UO_2$ specimens sheathed in Zircaloy-2 were carried out in NRX loops. The results of each irradiation are briefly described. (J.R.D.)

**7595** ✓

ENTROPY OF KRYPTON ADSORBED ON TITANIUM DIOXIDE (ANATASE). E. L. Pace, W. T. Berg and A. R. Siebert (Morley Chemical Laboratory, Western Reserve University). J. Am. Chem. Soc. 78, 1531-3(1956) Apr. 5.

Calorimetric measurements of the heat capacity, adsorption isotherms, and heat of adsorption between 12 and 140°K have been used to determine the zero point entropy of Kr adsorbed on $TiO_2$ of the anatase form. The zero point entropy of 0.00765, 0.01396, and 0.02421 mole of adsorbed gas corresponding to the monolayer fractions 0.13, 0.23, and 0.40 are, respectively, 1.1 ± 1.1, 1.5 ± 0.6, and 1.3 ± 0.3 cal/deg/mol. The results indicate strongly that thermodynamic equilibrium has not been attained between the surface and the adsorbed gas. The experimental procedure which was used as well as theoretical consideration leads one to believe that most of the randomness in the system existing at approximately 50°K. was preserved at temperatures below this value. (auth)

**9176** ✓

THE L-SERIES EMISSION SPECTRUM OF KRYPTON. H. R. Moore (Dominion Physical Lab., New Zealand). Proc. Phys. Soc. (London) A70, 466-73(1957) June.

The L spectrum of krypton has been observed in emission from an electrodeless discharge source and recorded photographically with a bent crystal spectrometer. Wavelength values are given for seven diagram lines ($L\beta_1$: 7547 X.U.; $L\alpha_{1,2}$: 7788 X.U.), one quadrupole line and ten satellite lines. The half widths and intensities of the latter are compared with those of their parent lines $L\beta_1$ and $L\alpha_{1,2}$. The x-ray energy levels $L_I$(1920 ev), $M_{IV,V}$(87 ev) and $N_I$ (20 ev) are evaluated. A quasi-optical origin for some extra lines observed in this spectrum is proposed. (auth)

# LANTHANUM 1.22

**20949**

ON LANTHANUM AND CERIUM CHLORIDES WITH ETHYL ALCOHOL AND KETONES. Z. A. Sheka and E. E. Kress. Zhur. Neorg. Khim. 4, 1809-13(1959) Aug. (In Russian)

Complex compounds of lanthanum and cerium chlorides with ethyl alcohol of the type $LuCl_3 \cdot 3C_2H_5OH$ were prepared. It was found that in alcohol-benzol solutions the complexes interact with ketones and pyridine and one, two, and three (in case of pyridine) alcohol molecules are replaced. The interaction of cerium chloride alcohol complex with ketones is weaker than that of lanthanum chloride. The physico-chemical data on complex formation characteristics are included. (R.V.J.)

**19930**

LANTHANUM COMPLEXES WITH GLUCONIC ACID. Ya. A. Fialkov and N. A. Kostromina (Inst. of General and Inorganic Chemistry, Academy of Sciences, Ukrainian S.S.R.). Zhur. Neorg. Khim. 4, 1507-16 (1959) July. (In Russian)

A physicochemical analysis was made of $LaCl_3$ complexed with gluconic acid. The influence of pH on the component ratio and concentration conditions were studied. (R.V.J.)

LANTHANUM SALICYLATE COMPLEXES. Ya. A. Fialkov and V. I. Ermolenko (Inst. of Generae and Inorganic Chemistry, Academy of Sciences, Ukrainian S.S.R.). Zhur. Neorg. Khim. 4, 1369-76(1959) June. (In Russian)

It was found that lanthanum salicylate is soluble in alkali solution of sodium salicylate (0.5 to 4 mole/l) with added caustic soda up to 10 to 13 pH. Potentiometric titration of lanthanum salicylate (1 mole) with caustic soda in 2 to 4 M sodium salicylate solution showed that lanthanum titrates as a weak dibasic acid. The acid dissociation constants are given. Formation of complex lanthanum salicylates and their instability constants were established on the basis of studies of $La(OH)_3-NaSal-NaOH-H_2O$. (R.V.J.)

**15107**

OBSERVATIONS ON THE RARE EARTHS. LXIX. AN ELECTROCHEMICAL INVESTIGATION OF ETHYLENEDIAMINE SOLUTIONS OF LANTHANUM NITRATE. T. Moeller and G. W. Cullen (Univ. of Illinois, Urbana). J. Inorg. & Nuclear Chem. 10, 148-52(1959) Apr.

The solubility of anhydrous lanthanum nitrate in ethylenediamine is markedly dependent upon the water content of the latter. Conductance data for both completely anhydrous solutions and those containing controlled quantities of water show generalized weak electrolyte behavior. Electrolyses of such solutions yield cathode deposits that apparently contain small quantities of elemental lanthanum. X-ray characterization of such deposits is negated by oxide absorption of radiation diffracted by the metal. Some of the techniques essential to handling materials under anhydrous conditions are described. (auth)

THE POLYSELENIDES OF THE LANTHANIDES, LANTHANUM, AND GADOLINIUM. André Benacerraf, Louis Domange, and Jean Flahaut. Compt. rend. 248, 1672-5(1959) Mar. 16. (In French)

The polyselenides of Ce, Pr, Sm, Nd, La, and Gd have a homogeneous range extending approximately from $Me_2Se_4$ to $Me_2Se_{3.6}$. They are quadratic and true polycompounds. The magnetic susceptibilities, related to an atom of the metal, are approximately that of the corresponding simple selenides. The chemical properties and their stability are considered. The polyselenide of europium was not obtained. (J.S.R.)

HEAT OF FORMATION OF $La_2O_3$ AND $La(OH)_3$. H. v. Wartenberg (Universität, Gottingen, Ger.). Z. anorg. u. allgem. Chem. 299, 227-31(1959) Mar. (In German)

The heat of reaction $2\ La + 1.5\ O_2 = La_2O_3$ was determined to 446 ± 2 kcal/mole by measuring the heats of solution of $La_2O_3$ in 0.1 N HCl and comparing it with the heat of solution of La in 0.1 N HCl by Bommer and Hohmann. The older values of the heat of combustion were discussed and the mistake of the extreme value of Roth cleared up. The heat of hydration $\frac{1}{2}\ La_2O_3 + 1.5\ H_2O = La(OH)_3$ was determined to 20.2 ± 0.7 kcal/mole by measuring the heat of solution of crystallized $La(OH)_3$ in 0.1 N HCl. (auth)

# LANTHANUM 1.22

**13814**
LANTHANUM ACETATE PENTAHYDRATE. V. N. Maksimov and K. N. Semenenko. Zhur. Neorg. Khim. 3, 1468-9(1958) June. (In Russian)
Lanthanum acetate pentahydrate crystals were prepared by slow crystallization of an aqueous solution of lanthanum acetate at temperatures below 18 to 20°C. The crystal structure and thermal stability of the compound were measured. (R.V.J.)

**13429** ✓
GAMMA SPECTRUM OF $La^{140}$. V. P. Prikhodtseva and Yu. V. Khol'nov (Khlopin Radium Inst., Academy of Sciences, USSR). Izvest. Akad. Nauk S.S.S.R. Ser. Fiz. 22, 176-8(1958) Feb. (In Russian)
Results of two series of measurements on two different sources of $La_2O_3$, wt. ~ 2g, with initial activity near 1.5 are presented. The corrections for $\gamma$ line energies and spectra and the new $\gamma$ lines 868 and 2343 kev are discussed. (R.V.J.)

**9168** ✓
LANTHANUM SULFIDES. N. P. Zvereva. Doklady Akad. Nauk S.S.S.R. 113, 333-4(1957) Mar. 11. (In Russian)
Monocrystals of LaS prepared from lanthanum nitrates and metallic lanthanum had two microstructure phases, a large oval yellow grain of LaS with a light gray border phase of lanthanum oxysulfide. The composition of the monosulfide was 95 to 97% LaS and ~3 to 5% oxysulfide; the microhardness with 20g load was 197 ± 1.5 kg/mm$^2$. Specimens of LaS heated in vacuum up to 2100° did not melt. (R.V.J.)

**969** ANL-5624
Argonne National Lab., Lemont, Ill.
ABSORPTION SPECTRA OF LANTHANIDE AND ACTINIDE RARE EARTHS. III. THE HEAVIER LANTHANIDE ELEMENTS IN AQUEOUS PERCHLORIC ACID SOLUTION. D. C. Stewart. Oct. 1956. 16p. Contract W-31-109-eng-38. $0.20(OTS).
The absorption spectra of the heavier lanthanides in aqueous $HClO_4$ in the range 220 to 1400 m$\mu$ are given. (T.R.H.)

**10081** NP-6078
University of Southern Calif., Los Angeles.
LANTHANUM MONOXIDE. Technical Report No. IX [on] STUDIES OF THE RARE-EARTH HYDRIDES. James C. Warf and William L. Korst. June 30, 1956. 7p. Project NR 356-290. Contract Nonr-228(03).

**9675** AD-70911
Ohio State Univ., Columbus.
ORBITAL ELECTRON CAPTURE IN LANTHANUM$^{137}$ (thesis). Michael David Lubin. 1955. 27p.
Radioactivity was studied in $La^{137}$, which results from the decay of the 1.5-day $Ce^{137}$. The $Ce^{137}$ was produced by neutron irradiation of Ce enriched in the isotope of mass 136. Barium K x rays were observed and attributed to $La^{137}$. These x rays, and the fact that no other radiations were detected, indicate that $La^{137}$ decays by K capture to the ground state of $Ba^{137}$ in at least 97% of the disintegrations. The half life of the $La^{137}$ is estimated to be $5.9 \times 10^5$ years on the basis of calculations involving the absolute counting rate, the neutron flux, amount of material used, and the neutron capture cross section of $Ce^{136}$. (auth)

**1107** ✓
THE DECAY SCHEME OF $^{140}$La. C. F. Coleman (Atomic Energy Research Establishment, Harwell, Berks, England). Phil. Mag. (7) 46, 1132-4(1955) Oct.
Investigation of the $La^{140}$ decay revealed $\gamma$ rays of energies 328, 486, 815, 893 ± 40, 1597, and 2570 ± 150 kev with relative intensities of 25 ± 10, 48 ± 8, 27 ± 5, 11 ± 4, 100 and 4 ± 1. (D.E.B.)

# MERCURY 1.23

See also, under HAZARDS AND PROTECTION,

MERCURY (4.01.08).

**6516**

EXCITED LEVELS IN $Hg^{200}$ STUDIED FROM THE DECAY OF $Tl^{200}$. C. J. Herrlander (Nobel Inst. of Physics, Stockholm) and T. R. Gerholm (Univ. of Uppsala). Nuclear Phys. 3, 161-84(1957) Apr.

The half life of $Tl^{200}$ has been found to be (26.1 ± 0.4) h. Conversion lines corresponding to 14 transitions in $Hg^{200}$ were found. In addition, a few unidentified conversion lines were also observed. With the aid of coincidence spectrometer measurements, a level scheme was established, including the following excited levels: 368.0, 947.4, 1574.8, 1594.9, 1659.6, 1732.3, 1776.0, 1884.7 and 2136.7 kev. Conversion coefficients and K/L ratios were measured. The 368 and 579-kev transitions were found to be pure E2 transitions, suggesting the assignments 2+ and 4+ for the two first excited levels. For most of the other transitions in the decay-scheme, multipolarity assignments are discussed. A weak positron spectrum was also found in the decay of $Tl^{200}$, probably consisting of three components going to the ground state and the two first excited levels. The log ft-values of the two most energetic transitions are found to be 9.1 and 7.8, consistent with first forbidden transitions. The ground-state of $Tl^{200}$ is 2−, and the mass excess, as calculated from our data, is (34550 ± 3020) $\mu$MU. Finally, the level scheme is compared with results of neutron-capture experiments on mercury. (auth)

**HETEROGENEOUS ISOTOPIC EXCHANGE BETWEEN LIQUID MERCURY AND MERCURY IONS IN AQUEOUS SOLUTION. D. G. Tuck. Translated for Phillips Petroleum Co. from J. chim. phys. 54, 896-901(1957). 11p.** (AEC-tr-3418)

**This paper was previously abstracted from the original language and appears in NSA, Vol. 12, as abstract No. 6533. (J.E.D.)**

# MOLYBDENUM 1.24

**HIGHER COMPLEX FLUORIDES OF MOLYBDENUM. G. B. Hargreaves and R. D. Peacock (Imperial Coll., London). J. Chem. Soc. 4390-3(1958) Dec.**

**From the interaction of molybdenum hexafluorides with alkali fluoride the salts, $K_2MoF_8$, $K_3MoF_8$, $RbMoF_7$, $RbMoOF_5$, and $CsMoOF_5$ have been obtained and characterized. (auth)**

**13724**

THE VAPORIZATION OF MOLYBDENUM AND TUNGSTEN OXIDES. Paul E. Blackburn, Michael Hoch, and Herrick L. Johnston (Ohio State Univ., Columbus). J. Phys. Chem. 62, 769-73(1958) July.

**9342**

MOLYBDENUM. L. Northcott. New York, Academic Press Inc., 1956. 234p.

The history, extraction, physical properties, mechanical properties, powder metallurgy, oxidation, and protection of Mo and its alloys are discussed at length in this volume. (W.L.H.)

THE CHEMICAL BEHAVIOUR OF $Mo^{99}$ FORMED ON NEUTRON IRRADIATION OF URANIUM COMPOUNDS. L. V. Shiryayeva and G. M. Tolmachev. Atomnaya Energiya 3, No. 10, 318-20(1957).

$U_3O_8$ and $UO_2$ (5 to 50 g) were for 1.5 hr heated to temperatures of from 400 to 1200°C, after irradiation with neutrons, in oxygen and hydrogen. The yield of $Mo^{99}$ was measured. For $U_3O_8$ the yield of $Mo^{99}$ depends mainly upon the annealing temperature but not upon the nature of the gas. The transformation of $U_3O_8$ into $UO_2$ has no influence upon the Mo yield on the occasion of the heating of $U_3O_8$ in hydrogen. During heating of $U_3O_8$ in oxygen T = 1200°C) about 15% $Mo^{99}$ evaporates. In the case of hydrogen annealing no $Mo^{99}$ evaporation was observed in the total temperature range. If $UO_2$ is annealed in hydrogen, the $Mo^{99}$ yield increases at higher temperatures and attains 11% at 1200°C. In the case of annealing in oxygen, however, the $Mo^{99}$ yield at 1000°C attains a maximum of 83.5%. At 1200°C 40% of the total $Mo^{99}$ evaporates. If this sample is then treated with certain liquids, 57% evaporates. It does not seem wrong to assume that a certain part of $Mo^{99}$ is produced in the form of $MoO_3$ on the occasion of fission. (TCO)

# MOLYBDENUM 1.24

**8899** ACR-12
Office of Naval Research, Washington, D. C.
TECHNOLOGY OF MOLYBDENUM AND ITS ALLOYS. Symposium [held at] Detroit, September 18-19, 1956. 20p. (PB-131793). $0.75(OTS).

Abstracts of papers presented at a symposium on the technology of molybdenum and its alloys are presented. Presentations were made on preparation and fabrication, arc casting, working, and joining of the metal and its alloys. In addition, the ductile-to-brittle transition in Mo was examined as well as the effects of C, O, and N on ductility. Powder metallurgy of Mo and its alloys was discussed, and some of the properties of arc-cast alloys are given. Aspects of Mo alloy application to gas turbines were considered with the emphasis on design consideration, protection from high-temperature oxidation, turbine bucket forging, and the effects of hot-cold work on the properties of the alloys. (J.R.D.)

**1851**

THE STRUCTURE OF $MoBe_{12}$. Richard F. Raeuchle and Fred W. von Batchelder (Naval Research Lab., Washington, D. C.). Acta Cryst. 8, 691-4(1955) Nov.

The structure of $MoBe_{12}$ has been determined. Formal valences of 3.36 for molybdenum and 1.85, 2.27, and 2.59 for beryllium have been calculated using Pauling's single-bonded metallic radii, and are interpreted in terms of electron shift. (auth)

NUCLEAR MOMENTS OF $Mo^{95}$, $Mo^{97}$, $Zr^{91}$, $I^{127}$, $Sb^{121}$, AND $Sb^{123}$. Kiyoshi Murakawa (Institute of Science and Technology, Tokyo, Japan). Phys. Rev. 100, 1369-72(1955) Dec. 1.

The hyperfine structure (hfs) of the spectrum of Mo I was studied, and it was found that both $Mo^{95}$ and $Mo^{97}$ have nuclear spins equal to $^7/_2$. Substituting this in the g-values of $Mo^{95}$ and $Mo^{97}$ given in the literature, the magnetic moments $\mu(Mo^{95}) = -1.2736$ nm and $\mu(Mo^{97}) = -1.3006$ nm (without diamagnetic correction) are obtained. Hfs investigation of the spectrum of Zr I yielded the result that $\mu(Zr^{91}) = -1.9 \pm 0.2$ nm. The quadrupole moment of $I^{127}$ as derived from the hfs of the visible spectrum and as derived from the atomic beam resonance technique published in the literature is discussed, and it is concluded that $Q(I^{127}) = (-0.69 \pm 0.03) \times 10^{-24}$ cm$^2$ including the polarization correction due to Sternheimer. Data concerning the hfs of the spectrum of Sb II are discussed, and it is shown that they support the values $Q(Sb^{121}) = (-0.59 \pm 0.10) \times 10^{-24}$ cm$^2$ and $Q(Sb^{123}) = (-0.68 \pm 0.10) \times 10^{-24}$ cm$^2$ (including the polarization correction) that were deduced previously.

**10770** M-4232
Princeton Univ., N. J. Frick Chemical Lab.
THE DISTRIBUTION OF MOLYBDENUM BETWEEN DIETHYL ETHER AND AQUEOUS SOLUTIONS. N. H. Furman, R. J. Mundy, and G. H. Morrison. Apr. 1947. Decl. Oct. 6, 1955. 9p. $1.80(ph OTS); $1.80(mf OTS).

# NEODYMIUM 1.25

**2265**
ON THE SOLVOLYSIS OF NEODYMIUM IONS IN ALCOHOL–AQUEOUS SOLUTIONS. I. S. Pominov (Ul'yanov-Lenin Kazan State Univ.). Zhur. Fiz. Khim. 31, 1926-9 (1957) Sept.

It has been observed that in cases where the water present is not sufficient for complete hydration of all Nd ions, the aqueous and alcohol molecules jointly solvate the rest of the Nd ions. From the absorption spectra of neodymium chlorite alcohol-aqueous solutions it appears that alcohol molecules are not displaced completely from the Nd ion solvate shell by water molecules even when 20 to 30 water molecules per one neodymium chloride molecule are added to the alcohol solution. Some considerations are offered to show why the ratio of water molecules to salt molecules should be so high for a complete displacement of alcohol by water in the $Nd^{3+}$ ion solvate shell. (tr-auth)

**5757** ✓ AERE-C/M-301
Gt. Brit. Atomic Energy Research Establishment, Harwell, Berks, England.
THE SOLUBILITY OF NEODYMIUM SULPHATE IN WATER AND IN A SODIUM SULPHATE SOLUTION AT HIGH TEMPERATURES. C. J. L. Lock. Jan. 1957. 6p.

The solubilities of $Nd_2(SO_4)_3$ in water and in a $Na_2SO_4$ solution were measured by tracer methods up to 270°C. The solubility of $Nd_2(SO_4)_3$ in water decreased with temperature. At room temperature, the solubility was much less in 1.6M $Na_2SO_4$ solution, but at higher temperatures there was very little difference in the solubilities. (auth)

**8851** ✓
ELECTRON NUCLEAR DOUBLE RESONANCE OF NEODYMIUM. Donald Halford, Clyde A. Hutchison, Jr., and Peter M. Llewellyn (Univ. of Chicago). Phys. Rev. 110, 284-6(1958) Apr. 1.

The method of electron nuclear double resonance has recently been employed by Feher for investigation of some solid-state problems. In this letter the application of this method for an investigation of $Nd^{3+}$ in $LaCl_3$ crystals is discussed. A tabulation is made of the frequencies so far observed at which the second resonance for $Nd^{145}$ occurs when the c axis is parallel to H. The remainder of the measurements are in progress. (A.C.)

**5837** NP-8221
Rio de Janeiro. Centro Brasileiro de Pesquisas Físicas.
GAMMA RAYS IN THE DECAY OF $^{141}Nd$. E. W. Cybulska and L. Marquez. 1959. 6p. (Notas de Física Vol. V, No. 12).

The gamma rays in the decay of $Nd^{141}$ were studied with scintillation spectrometers and coincidences. Seven lines were established with energies of 38, 145, 420, 510, 880, 1150, and 1300 kev. Their relative intensities are 100, 1.7, 0.6, 9.7, 1.2, 2.3, and 1.5, respectively. The line of 38 kev is due to K-capture in $Nd^{141}$ and the line of 510 kev is due to annihilation radiation from the positrons of $Nd^{141}$. The remaining five lines are due to levels in $Pr^{141}$. A decay scheme is proposed. (auth)

**13425** ✓
DECAY OF $Nd^{140} \rightarrow Pr^{140} - Ce^{140}$. K. Ya. Gromov, B. S. Dzhelepov, A. G. Dmitriev, and B. K. Preobrazhenskii (Khlopin Radium Inst., Academy of Sciences, USSR). Izvest. Akad. Nauk S.S.S.R. Ser. Fiz. 22, 153-7(1958) Feb. (In Russian)

The yield of Auger electrons of K series $e_K/K_\Sigma$ (where $e_K$ is the number of Auger electrons, $K_\Sigma$ is the number of K captures per decay of $Nd^{140}$ and $Pr^{140}$) was calculated. The results $\beta^+/K_\Sigma = 0.55$ agree within the experimental error (~30 to 40%) with the results expected for the chain of $Nd^{140} \rightarrow Pr^{140} \rightarrow Ce^{140}$. (R.V.J.)

THE DECAY OF NEODYMIUM-147. P. Rice Evans (Univ. of London). Phil. Mag. (8) 3, 1061-8(1958) Oct.

The $\beta$ transitions from $Nd^{147}$ were studied in the new prolate spheroidal field spectrometer. Three components of the spectrum were separated by $\beta-\gamma$ coincidence techniques. The $\gamma$-rays were studied in a scintillation counter and coincidences between conversion lines and $\gamma$-rays were recorded. On the basis of these results a new mode of decay for $Nd^{147}$ is proposed.

## NEODYMIUM 1.25

**10186**

ADDITIONAL DATA ON THE RADIOACTIVE DECAY OF $Ho^{166}$ (27 hr), $Nd^{147}$, AND $Sm^{153}$. J. M. Cork, M. K. Brice, R. G. Helmer, and R. M. Woods, Jr. (Univ. of Michigan, Ann Arbor). Phys. Rev. 110, 526-8(1958) Apr. 15.

By using chemically pure $Ho^{165}$ and enriched isotopes of $Nd^{148}$ and $Sm^{152}$, high-activity samples of $Ho^{166}$, $Nd^{147}$, and $Sm^{153}$ were made by neutron capture. Studies of the strong sources by both magnetic and scintillation spectrometers showed the existence of some gamma rays not previously reported, yielded more exact energy values for the low-energy gamma rays, and made possible better resolution of the components of the beta spectra. In $Ho^{166}$, gamma rays occur at 80.25, 970, 1377, 1540, and 1620 kev, and the maximum beta energies are 1839, 1756, 869, 412, and 230 kev. $Nd^{147}$ yields gamma rays at 91.3, 120.6, 198.2, 277, 321, 400, 441, 533, and 688 kev, with beta components at 812, 380, and 230 kev. In $Sm^{153}$ gamma rays are found at 69.8, 103.5, 173.6, and 540 kev and beta components at 813, 710, and 640 kev. A level scheme in agreement with the observed data is presented for each nucleus. (auth)

**6519**

NUCLEAR ALIGNMENT OF $^{147}Nd$. G. R. Bishop, M. A. Grace, C. E. Johnson, H. R. Lemmer, and J. Perez y Jorba (Clarendon Lab., Oxford). Phil. Mag. (8) 2, 534-40(1957) Apr.

Neodymium 147 has been aligned in a crystal of neodymium ethyl sulphate. The directional distributions and states of polarization of the 90- and 530-kev $\gamma$ rays have been measured. It is concluded that both transitions are mixtures of M1 and E2 radiation ($\delta E2/M1 = -0.17 \pm 0.15$ for the 90-kev and $+0.75 \pm 0.25$ for the 530-kev $\gamma$ rays) and that the 530-kev state has spin $7/2^+$. From the 530 kev results a value for the nuclear magnetic moment of $Nd^{147}$ of $0.44 \pm 0.06$ nuclear magnetons is found. (auth)

## NEPTUNIUM 1.26

See also, this section,

PLUTONIUM (1.28).

**6342** A/CONF.15/P/304

THE CHEMISTRY AND METALLURGY OF NEPTUNIUM. H. A. C. McKay and M. B. Waldron (Atomic Energy Research Establishment, Harwell, Berks, Eng.), and J. S. Nairn (United Kingdom Atomic Energy Authority, Risley, Lancs, Eng.). 22p.

Gram quantities of neptunium were isolated from process wastes. $NpO_2$ and $Np_3O_8$ were prepared by the ignition of precipitated Np(V) hydroxide, the former at high temperatures (600 or 1000°C) and the latter at lower temperatures (150 or 300°C) in air. Their stoichiometry and crystal structure were studied, as well as the decomposition of $Np_3O_8$ on heating. $NpF_4$ was prepared by heating $NpO_2$ to 600°C in a stream of HF and $O_2$, and its structure confirmed. Reduction of $NpF_4$ with excess Ca in an argon atmosphere yielded Np metal in 98.7% yield. The use of Fe(II) and $N_2H_4$ to reduce neptunium to the IV-state in nitric acid solution and of $O_3$ to oxidize it to the VI-state was studied. Electron transfer spectra due to Np(IV) complexes with nitrate, sulfate, and chloride and to Np(VI) complexes with nitrate and sulfate were observed in the ultraviolet. The threshold wavelengths fall in the order expected from the electron affinities and ionization potentials of the ions concerned. Correlations can be made with spectral changes at longer wavelengths due to complexing. No such changes could be found in the Np(V) spectrum between 400 and 1000 m$\mu$ over a range 1 to 8M in nitrate ion. The extraction of Np(IV) and Np(VI) from nitrate solutions by dibutyl carbitol and tributyl phosphate was investigated. Physical property measurements were carried out on 20 g of neptunium metal. These demonstrated the existence of three allotropic modifications $\alpha$, $\beta$, and $\gamma$ between 20°C and the melting point, 640 ± 5°C. The specific heat of the $\alpha$ phase over the range 60 to 200°C varies between 0.03 and 0.04 cal/g°C which gives a value for the atomic heat in excess of the theoretical Dulong and Petit value. The $\alpha$ phase has a Vickers hardness number of 355; the Meyer index and number are 2.19 and 458, respectively. (auth)

# NEPTUNIUM 1.26

**2829**

SOME PHYSICAL PROPERTIES OF NEPTUNIUM METAL. I. A DETERMINATION OF THE SPECIFIC HEAT OF $\alpha$-NEPTUNIUM. J. P. Evans and P. G. Mardon (Atomic Energy Research Establishment, Harwell, Berks, Eng.). Phys. and Chem. Solids 10, 311-13(1959) Aug.

The specific heat of neptunium over the $\alpha$-phase range has been determined by a simple calorimetric method. The value of $C_p$ increases from $0.031_4$ cal/g at 60°C to $0.40_2$ cal/g at 207°C. In a separate determination, the latent heat of the $\alpha \rightarrow \beta$ transformation was found to be 2.0 ± 0.2 kcal/mole. (auth)

NEPTUNIUM AND PLUTONIUM. James C. Hindman (Argonne National Lab., Lemont, Ill.). J. Chem. Educ. 36, 22-6(1959) Jan.

Some aspects of the solid state and solution chemistry of Np and Pu are summarized. The metals in their metallic state are described, and some physical properties of Pu are listed. Discussions are included on Np and Pu oxides and halides and oxidation potentials, complex ion equilibria, and reactor kinetics of Np and Pu. (J.H.M.)

ANALYTICAL CHEMISTRY OF NEPTUNIUM. I. P. Alimarin and Yu. A. Zolotov. Uspekhi Khim. 26 625-38 (1957) June. (In Russian)

A review is given of the data on chemical analysis, separation, and extraction of Np. (R.V.J.)

**7207**

SOME PROPERTIES OF NEPTUNIUM METAL. V. W. Eldred and G. C. Curtis (Windscale Works, Sellafield, Cumberland). Nature 179, 910(1957) May 4.

**5200**

DETERMINATION OF THE VALENCE STATES OF NEPTUNIUM IONS IN SOLUTION BY CONTROLLED POTENTIAL COULOMETRY. Robert W. Stromatt (General Electric Co., Richland, Wash.). Anal. Chem. 32, 134-5(1960) Jan.

Procedures are discussed for producing neptunium(V), (IV), and (III) from a standard solution of neptunium, which contained only neptunium(VI). A controlled potential coulometer was used in making the determinations. (B.O.G.)

SELECTIVE SOLVATION AND DIELECTRIC SATURATION AS RELATED TO ELECTRON EXCHANGE REACTIONS. Edward S. Amis (Univ. of Arkansas, Fayetteville). J. Chem. Phys. 26, 880-1(1957) Apr.

The Np(V)–Np(VI) electron exchange reaction has been found to be independent of the composition and of the gross properties, dielectric constant, refractive index, viscosity, etc., of two mixed solvents. To account for these phenomena, the critical complex is assumed to consist of a region containing the reactant ions and the solvent component of highest dielectric constant. This component preferentially solvates the ionic reactants. In this region, complete dielectric saturation is also assumed. (auth)

**12431** HW-59032

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

AN ANALYTICAL METHOD FOR NEPTUNIUM-237 USING ANION EXCHANGE. F. P. Roberts. Jan. 28, 1959. 14p. Contract W-31-109-Eng-52. $0.50(OTS).

A method was developed for separation of neptunium from plutonium, uranium, americium, curium, and fission products by anion exchange with sufficient decontamination to permit neptunium-237 estimation by alpha energy analysis and neptunium-239 estimation by gamma spectrometry. The sample is spiked with neptunium-239 tracer to permit yield corrections and loaded on a small column of Dowex 1, X-4 (100-200 mesh) from 8 M nitric acid in the presence of ferrous sulfamate and semicarbazide. After washing the resin with 30 to 40 column volumes of a 4.5 M nitric acid solution containing ferrous sulfamate and semicarbazide, the neptunium is eluted with 0.005 M ceric sulfate in dilute nitric acid and mounted for total alpha counting, alpha energy analysis, and gamma energy analysis. Neptunium recoveries of 95% have been obtained while plutonium decontamination factors are $5 \times 10^4$. Decontamination factors for uranium, americium, curium, and gross fission products are all greater than $10^4$. Uranium, up to 180 g/l in the column feed, does not interfere. The plutonium decontamination factor can be increased by a factor of 10 to 100 by following the nitric acid-ferrous sulfamate-semicarbazide wash by a wash with 0.1 M $NH_4I$ in 12 M HCl. This is followed by neptunium elution with 6.5 M HCl containing 0.004 M HF. The method is applicable to the high salt samples from the Redox process as well as Purex process samples. (auth)

# NEPTUNIUM 1.26

**4149** ✓ ORNL-961
Oak Ridge National Lab., Tenn.
A SOLVENT EXTRACTION METHOD FOR NEPTUNIUM (237) ANALYSIS. Fletcher L. Moore. July 10, 1951. Decl. Jan. 6, 1956. 15p. Contract W-7405-eng-26. $3.30 (ph OTS); $2.40(mf OTS).

A rapid and quantitative radiochemical method for the analysis of $Np^{237}$ is described. The method is based on the extraction of neptunium (IV) with thenoyltrifluoracetone in xylene. $Neptunium^{237}$ is separated free from other alpha emitters and from non-radioactive interferences, and the method may be readily adapted to remote control. (auth)

**5141** ✓
SPECTROPHOTOMETRIC STUDIES OF NEPTUNYL ION COMPLEX FORMATION WITH ACETATES. M. P. Meford'eva, P. I. Artyukhin, and A. D. Gel'man. Radiokhimiya 1, 309-16(1959). (In Russian)

Spectrophotometric studies were made of neptunyl ion–acetate ion systems in perchloric acid. Complexes of $NpO_2Ac_2^+$ and $NpO_2Ac_3^-$ were formed. The formation constants were calculated for neptunyl diacetate and triacetate. (R.V.J.)

**19937** ✓
**ON THE FORMATION OF PENTAVALENT NEPTUNIUM COMPLEXES. Yu. A. Zolotov and Yu. P. Novikov (Vernadskii Inst. of Geochemistry and Analytical Chemistry, Academy of Sciences, U.S.S.R.). Zhur. Neorg. Khim. 4, 1693-7(1959) July. (In Russian)**

**The formation of $NpO_2^+$ complexes with tartaric, trioxyglutaric, citric, salicylic, 2, 3-dioxyterephthalic, acetic, phthalic, and ethylenediamine tetraacetic acids was determined by the variations in absorption spectra. (R.V.J.)**

A KINETIC STUDY OF THE REDUCTION OF NEPTUNIUM(VI) BY HYDROGEN PEROXIDE. A. J. Aielen, J. C. Sullivan, D. Cohen, and J. C. Hindman (Argonne National Lab., Lemont, Ill.). J. Am. Chem. Soc. 80, 5632-5(1958) Nov. 5.

The rate of the forward reaction in the stoichiometric equation $2NpO_2^{+2} + H_2O_2 = 2NpO_2^+ + 2H^+ + O_2$ was studied in a perchloric acid–sodium perchlorate medium. The rate law deduced, $(dNpO_2^+/dt)_{t=0} = k[H_2O_2][NpO_2^{+2}]/[H^+](1 + k'[NpO_2^+]/[NpO_2^{+2}])$ was verified for a wide range of the explicit variables. The effects of temperature, ionic strength and deuterium on the rate were determined. (auth)

4

**10500**
REDUCTION OF NEPTUNIUM TO THE TRIVALENT STATE BY CHEMICAL METHOD. A. D. Gel'man and M. P. Mefod'eva. Atomnaya Energiya 4, 271-4(1958) Mar. (In Russian)

Spectrographic analysis showed that Np(IV) is reduced to Np(III) by rongalite. The reaction takes place in a nitrogen or air atmosphere; however, in the nitrogen atmosphere the recovery and stability of Np(III) are higher. It is also shown that an increase in the general content of the reducing agent (in the solution of hydrazinerongalite) affects favorably the reduction of Np up to the trivalent state. In nitric acid solutions the Np recovery averages 70% and in the hydrochloric acid up to 95%. In the rongalite reduction of Np(V) the Np(IV) and Np(III) form a mixture in which the Np(III) shows considerable resistance to oxidation by air. (tr-auth)

AEC-tr-3380

ON THE PROBLEM OF PRODUCTION OF TRIVALENT NEPTUNIUM. A.D. Gelman and M.P. Mefodieva. Translated by Lydia Venters (Argonne National Lab.) from Doklady Akad. Nauk S.S.S.R. 117, 225-6 (1957). 5p.

The preparation of Np(III) by the action of sodium sulfoxylate formaldehyde on acid solutions of Np(IV) was investigated. Almost complete reduction to Np(III) takes place in hydrochloric acid solution and to a lesser degree in nitric acid solution. (J.R.D.)

KINETICS OF THE NEPTUNIUM(III)–NEPTUNIUM(V) REACTION IN PERCHLORATE SOLUTION. J. C. Hindman, J. C. Sullivan, and Donald Cohen (Argonne National Lab., Lemont, Ill.). J. Am. Chem. Soc. 80, 1812-14(1958) Apr. 20.

The kinetics of the Np(III)–Np(V) reaction is perchlorate solution have been investigated. The rate law for the forward reaction can be written as $-\partial[NpO_2^+]/\partial t = k_1[Np^{+3}][NpO_2^+][H^+]$. At 25° and $\mu = 2.0$, $k_1 = 2590$ $l.^2$ $mole^{-2}$ $min^{-1}$. The rate is slightly decreased in a deuterated medium. The experimental activation energy is 6.5 ± 0.5 kcal in $HClO_4$ solution and 5.6 ± 0.5 kcal in $DClO_4$ solution. Possible mechanisms for the reaction are considered.

# NEPTUNIUM 1.26

KINETICS OF REACTIONS INVOLVING NEPTUNIUM(IV), NEPTUNIUM(V) AND NEPTUNIUM(VI) IONS IN SULFATE MEDIA. J. C. Sullivan, Donald Cohen, and J. C. Hindman (Argonne National Lab., Lemont, Ill.). J. Am. Chem. Soc. 79, 4029-34(1957) Aug. 5.

The rates of the forward and reverse reactions involved in the equilibrium $Np^{4+} + Np^{6+} \rightleftharpoons 2Np^{5+}$ have been measured in sulfate solution. Both forward and reverse reactions involve multiple parallel reaction paths. The rate of the forward reaction can be expressed in the form $R = k_0'[Np^{4+}][NpO_2^{2+}][H^+]^{-2} + \{k_1[NpSO_4^{2+}][NpO_2^{2+}] + k_2[NpSO_4^{2+}][NpO_2SO_4]\}\{k_3[H^+]^{-2} + k_4[H^+]^{-3}\}$. At 25° and $\mu = 2.2$, $k_0' = 2.69$ mole $l.^{-1}$, $k_1 = 4.27$ $mole^{-1}$ l. $min.^{-1}$, $k_2 = 7.12$ $mole^{-1}$ l. $min.^{-1}$, $k_3 = 3.6$ $mole^2$ $l.^{-2}$ and $k_4 = 1.7$ $mole^3$ $l.^{-3}$. The rate of the disproportionation reaction may be represented by $R = \{k_5[NpO_2^+]^2[HSO_4^-] + k_6[NpO_2^+]^2[HSO_4^-]^2\}\{k_7 + k_8[H^+]\}$. At 25° and $\mu = 2.2$, $k_5 = 0.30$ $mole^{-2}$ $l.^2$ $min.^{-1}$, $k_6 = 0.090$ $mole^{-3}$ $l.^3$ $min.^{-1}$, $k_7 = 0.74$, and $k_8 = 0.14$ mole $l.^{-1}$. Apparent activation energies are given. Probable restrictions on the geometrical configurations for the transition state complexes and the mechanism of the electron transfer processes are considered. Relationships of the reactions in sulfate solution to similar reactions occurring in perchlorate media are discussed. (auth)

**9764 ✓**

SOME OBSERVATIONS ON THE PREPARATION OF NEPTUNIUM OXIDES. D. A. Collins and G. M. Phillip (United Kingdom Atomic Energy Authority, Sellafield, Cumb, Eng.). J. Inorg. and Nuclear Chem. 6, 67-9 (1958) Feb.

Three neptunium oxides have been reported: NpO, $NpO_2$, and $Np_3O_8$. Data to support and extend published information concerning physical properties, preparation, and x-ray data are presented. (J.R.D.)

**9686**

ELECTRON CAPTURE AND ALPHA DECAY OF $Np^{235}$. Richard W. Hoff, James L. Olsen, and Lloyd G. Mann (Univ. of California Radiation Lab., Livermore). Phys. Rev. 102, 805-7(1956) May 1.

The electron capture and alpha decay of $Np^{235}$ have been investigated. An L/K capture ratio of 30 ± 2 is found from absolute L and K x-ray measurements. No gamma rays are observed in the electron capture decay of $Np^{235}$. An alpha branching ratio of $(3.5 \pm 0.4) \times 10^{-5}$ was measured for this nuclide. The alpha particles have coincident 26- and 85-kev gamma rays with an intensity of 0.054 ± 0.005 gamma per alpha disintegration for the 85-kev gamma ray. The intensity of the 26-kev gamma ray is comparable, although somewhat more uncertain. (auth)

**14966 ✓** A/CONF.15/P/650

California. Univ., Berkeley. Radiation Lab. and Indiana. Univ., Bloomington.

BETA RADIOACTIVITY AND ENERGY LEVELS OF HEAVY NUCLEI: DECAY SCHEMES OF $Np^{239}$, $U^{237}$ AND $Np^{238}$. J. M. Hollander, J. O. Rasmussen, R. G. Albridge, Jr., and W. G. Smith. 22p. (UCRL-8072). $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The isotopes, $Np^{239}$, $U^{237}$, $Np^{238}$, and $Pa^{233}$, were produced by intensive neutron irradiations in the Materials Testing Reactor. High resolution magnetic electron spectrographs and scintillation gamma-ray spectrometers were used. The energy-level spacings, rotational spectra, general photon transition-probability relationships, and other results are summarized. (M.H.R.)

**12432 ✓** HW-59642

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

THE SPECIFIC ACTIVITY AND HALF-LIFE OF $Np^{237}$. F. P. Brauer, R. W. Stromatt, J. D. Ludwick, F. P. Roberts, and W. L. Lyon. Mar. 13, 1959. 6p. Contract W-31-109-Eng-52. $1.80(ph), $1.80(mf) OTS.

The $Np^{237}$ specific activity has been determined to be 1562 ± 7 disintegrations per minute per microgram which corresponds to a half-life value of $2.14 \pm 0.01 \times 10^6$ years. The previously reported value was $2.2 \pm 0.1 \times 10^6$ years. The new value was obtained by the absolute alpha counting of known amounts of $Np^{237}$ using both low geometry proportional counting and $4\pi$ liquid scintillation counting. The samples of $Np^{237}$ counted were taken from a standard solution prepared from neptunium metal and checked by coulometric titration. The specific activity of $Np^{237}$ was determined by the absolute alpha counting of known amounts of $Np^{237}$ using both low geometry proportional counting and $4\pi$ liquid scintillation counting. The aliquots of $Np^{237}$ were taken from a standard solution prepared from neptunium metal and checked by controlled potential coulometric titration. The observed alpha disintegration rate was corrected for the contribution of the plutonium impurity as determined by alpha energy analysis. The neptunium used was analyzed isotopically to insure that isotopes other than $Np^{237}$ were present at a sufficiently low concentration to be neglected. The standardizations and other experimental details are discussed in the following sections. (auth)

# NEPTUNIUM 1.26

**Y9590**

ENERGY LEVELS OF $Np^{237}$ POPULATED BY ALPHA DECAY OF $Am^{241}$. J. M. Hollander, W. G. Smith, and J. O. Rasmussen (Univ. of California, Berkeley). Phys. Rev. 102, 1372-7(1956) June 1.

The conversion electron spectrum following alpha decay of $Am^{241}$ has been reinvestigated with 180° focusing beta-ray spectrographs at ~0.1% resolution. Multipolarity assignments for several gamma transitions are made, principally on the basis of relative L-subshell conversion coefficients. Energy-level spacings and relative transition probabilities are compared and discussed in terms of the Bohr-Mottelson model. The excellent agreement of energy-level spacings with the rotational formula and the general pattern of radiative transitions firmly establish the essentially rotational nature of these bands of levels. However, calculations involving M1 transition probabilities and magnetic moments lead to discrepancies with the simple theory in the case of the ground rotational band. (auth)

**11371**

NEUTRON TOTAL CROSS SECTION OF $Np^{237}$ FROM 0.02 to 2.8 ev. M. S. Smith, R. R. Smith, E. G. Joki, and J. E. Evans (Phillips Petroleum Co., Idaho Falls). Phys. Rev. 107, 525-7(1957) July 15.

The total neutron cross section of $Np^{237}$ has been measured in the energy region 0.02 to 2.8 ev with the Materials Testing Reactor crystal spectrometer. Measurements were made on a sample containing 152 mg of $Np^{237}$ in oxide form dissolved in deuterated $HNO_3$. A value for the absorption cross section at 0.025 ev of 170 ± 22 b was obtained. Resonances were observed at energies 0.489 ± 0.002, 1.337 ± 0.015, and 1.488 ± 0.018 ev, with the respective values of $\sigma_0\Gamma$ being 84.2 ev b, approximately 29 ev b, and approximately 140 ev b. Values for $\sigma_0$ of 2600 ± 100 b, $\Gamma$ of 0.032 ± 0.003 ev, and $g\Gamma_n$ of 0.016 mv were determined for the 0.489-ev resonance. (auth)

**6611** USNRDL-TR-72

Naval Radiological Defense Lab., San Francisco.

DETERMINATION OF $Np^{239}$, "TOTAL FISSIONS", $Mo^{99}$, AND $Ce^{141}$ IN FISSION PRODUCT MIXTURES BY GAMMA-RAY SCINTILLATION SPECTROMETRY. L. D. McIsaac. Jan. 5, 1956. 18p. Project NS 081 001.

A gamma-ray scintillation spectrometric method, involving no other chemistry than sample dissolution, has been developed for the rapid determination of $Np^{239}$ and "total fissions" in fission-product samples. A single channel NaI(Tl) scintillation spectrometer was used, and analysis required about 1 hr. The 140-kev gamma rays of $Tc^{99m}$ and $Ce^{141}$ were used while the 105-kev gamma ray plus conversion x ray accompanying the decay of $Np^{239}$ was employed to measure the $Np^{239}$ concentration. Determination of the disintegration rates of $Mo^{99}$, $Tc^{99m}$, and $Ce^{141}$ is also possible by this technique. An accuracy of about 10% or better can be obtained. (auth)

**4388** AERE-HP/M-80

Gt. Brit. Atomic Energy Research Establishment, Harwell, Berks, England.

A NOTE ON THE BETA COUNTING OF $U^{237}$ AND $U^{239}$. N. G. Stewart. Sept. 14, 1954. Decl. Dec. 20, 1956. 2p.

The determination of the disintegration rates of samples of $U^{237}$ and $Np^{239}$ by beta counting in an end-window system is rendered difficult by the presence of internal conversion electrons. This report gives the results of experiments carried out to determine over-all correction factors which take account of both counter window absorption and the conversion electron fraction of these two isotopes when measured in a standard EHM2 counter assembly. (auth)

**1313**

INFRARED SPECTRA OF $NpF_6$ AND $PuF_6$. John G. Malm, Bernard Weinstock, and Howard H. Claassen (Argonne National Lab., Lemont, Ill.). J. Chem. Phys. 23, 2192-3(1955) Nov.

The infrared spectra of $PuF_6$ and $NpF_6$ were measured in the range 2 to 38 $\mu$. From the data it was concluded that these hexafluorides have the symmetry of a regular octahedron (point group $O_h$). (C.W.H.)

**2205**

NEW GAMMA RAYS IN THE NEPTUNIUM-239 DECAY. Harlan W. Lefevre, Edwin M. Kinderman, and Harold H. Van Tuyl (Hanford Atomic Products Operation, Richland, Wash.). Phys. Rev. 100, 1374(1955) Dec. 1.

Two unreported $\gamma$ rays of energy 0.44 and 0.49 Mev are assigned to $Np^{239}$ by reason of chemical properties and decay constant. The intensities of these $\gamma$ rays relative to a previously reported $Np^{239}$ gamma at 0.334 Mev have been determined to be $\gamma_1$(0.33 Mev) : $\gamma_2$(0.44 Mev) : $\gamma_3$(0.49 Mev) = 100 : 0.40 : 0.50. Measured yields ($\gamma$ rays per decay) for the 0.44- and 0.49-Mev gammas are $1.6 \times 10^{-4}$ and $1.9 \times 10^{-4}$ $\gamma$ rays per decay. It seems probable that both of these $\gamma$ rays originate from a single $Pu^{239}$ level at 0.49 Mev. (auth)

**8381**

HYPERFINE STRUCTURE MEASUREMENTS ON NEPTUNIUM-239. J. C. Hubbs and R. Marrus (Univ. of California, Berkeley). Phys. Rev. 110, 287-9(1958) Apr. 1.

The atomic-beam magnetic-resonance method has been used to investigate the 2.36 day $Np^{239}$ in the low-field or Zeeman region of hyperfine structure. The spin of this nuclide is found to be $5/2$, in agreement with the conclusions of Hollander, Smith, and Mihelich from beta and gamma spectroscopy and with the predictions of the Bohr-Mottelson model, but apparently in conflict with measurements by the methods of optical and paramagnetic spectroscopy. (A.C.)

# NIOBIUM 1.27

NIOBIUM (COLUMBIUM)—ITS FUTURE PROSPECTS. J. Sandor (Warren Spring Lab., Dept. of Scientific and Industrial Research, Eng.). Metallurgia 59, 185-94 (1959) Apr.

Estimates are given on past and possible future consumption of niobium in its various fields of application, and some results of research in the development of niobium-base alloys are reviewed. Information is also included on the following: sources of niobium, extraction of the ores, and a system for niobium–tantalum separation. (J.H.M.)

NIOBIUM AND ITS ALLOYS. C. R. Tottle (U.K.A.E.A., Dounreay Experimental Establishment). Nuclear Eng. 3, 212-16(1958) May.

Niobium has much to offer in the field of liquid-cooled reactors not involving oxidizing conditions, particularly where high temperatures are involved. The extraction process is tedious, but manufacture is comparatively free from severe troubles arising from peculiar properties. The production and fabrication of the metal and its alloys will always be expensive owing to the necessity for protection from atmospheric attack during sintering, melting, heat treatment, and joining. Future development should simplify techniques and improve the properties in such a way that the cost is justified by the behavior in service. Tables of all the available properties of niobium are presented. (W.D.M.)

Oak Ridge National Lab., Tenn.
SUMMARY OF THE PROPERTIES OF NIOBIUM. C. K. McGlothlan. Jan. 6, 1958. 21p. Contract [W-7405-eng-26]. $4.80(ph), $2.70(mf) OTS.

A literature survey of the atomic, thermal, electrical, and mechanical properties and general information of niobium is reported. (J.E.D.)

**302**
NIOBIUM: THE MEDIUM-RARE METAL. Ind. Eng. Chem. 49, 42A-7A(1957) Oct.

The uses, chemical properties, production, and relative abundance of Nb is given. (W.L.H.)

**13140** NP-6843
Fansteel Metallurgical Corp., North Chicago, Ill.
BIBLIOGRAPHY OF COLUMBIUM. L. F. Yntema, S. Allan Kline, and D. E. Deutsch, comps. Aug. 31, 1956. 161p.

This inclusive bibliography contains references from both domestic and foreign published literature on columbium (niobium) and is considered up to date to Aug. 31, 1956. (A.C.)

**6408**
THE PHYSICAL AND MECHANICAL PROPERTIES OF NIOBIUM. C. R. Tottle (Dounreay Works, Caithness). J. Inst. Metals 85, 375-8(1957) Apr.

The possible employment of Nb or its alloys in reactor components is partially dependent on its possesing suitable physical and mechanical properties. It was therefore necessary to assemble accurate data, covering the range of temperatures involved in reactor operation, on thermal expansion, thermal conductivity, and tensile and creep properties, using metal of a suitable standard of purity for fabrication into complex shapes. Experimental methods already established for metals readily attacked by atmospheric gases were employed. Thermal conductivity is shown to increase, and tensile properties to decrease relatively slowly, with rise in temperature. Tensile properties are markedly affected by small additions of oxygen and creep measurements are susceptible to serious error if oxygen gains access to the system during long periods of test. Reference is made to preliminary results on the effect of alloying elements. (auth)

**177** MAB-101-M
National Research Council. Materials Advisory Board.
COLUMBIUM–TANTALUM. Oct. 21, 1955. 20p. Contract DA-49-025-sc-83.

Data are summarized on the availability and applications of Nb and Ta. Restrictions on the use of the metals are reviewed, and data are presented on the production, present usage, and probable consumption and uses of these metals when restrictions are removed. (C.H.)

**16471**
THE CRYSTAL STRUCTURE OF $NbCl_5$. Allan Zalkin and Donald E. Sands (Univ. of California, Livermore). Acta Cryst. 11, 615-19(1958) Sept.

$NbCl_5$ crystallizes in the monoclinic system with a = 18.30, b = 17.96, c = 5.888 A, $\beta$ = 90.6°. The space group is C2/m, and there are 12 $NbCl_5$ units in the unit cell. The structure consists of dimers ($Nb_2Cl_{10}$) with the chlorine atoms forming two octahedra which share a common edge. The niobium atoms occupy the centers of the octahedra and are joined by two chlorine bridge bonds. The Nb–Cl bridge bond length is 2.56 A; the Nb–Cl non-bridge bond lengths are 2.25 and 2.30 A. $NbBr_5$ and $TaCl_5$ appear to be isomorphous with the above structure. (auth)

# NIOBIUM 1.27

VAPOR PRESSURE OF NIOBIUM. Rudolph Speiser (Ohio State Univ., Columbus), P. Blackburn (Westinghouse Electric Corp., Pittsburgh) and H. L. Johnston (H. L. Johnston Associates, Columbus, Ohio). J. Electrochem. Soc. 106, 52-3(1959) Jan.

The Langmuir method was used to determine the vapor pressure of niobium. An accommodation coefficient of unity was assumed. Least square treatment of the vapor pressure data yields the equation $\log P_{atm} = -(40,169)/T + 8.872$. The heat of sublimation at absolute zero, $\Delta H^{\circ}_{0}$, is 171.80 ± 0.49 and $\Delta H^{\circ}_{298.15}$ is 172.53 kcal/g atom. (auth)

**5136**

THE CONDITION OF MICROQUANTITIES OF RADIOELEMENTS IN SOLUTIONS. VI. THE CONDITION OF NIOBIUM IN AQUEOUS SOLUTIONS. I. E. Starik and I. A. Skul'skii. Radiokhimiya 1, 77-81(1959). (In Russian)

The condition of niobium in nitric acid solutions with concentration $10^{-11}$ g-atom/l was investigated. Studies of adsorption by quartz and of the effects of ultrafiltration and centrifugation indicate that in solutions with pH < 2 the niobium is in an ionic state; with pH > 2, true colloidal solutions of niobium are formed. Also with pH < 2, positively and negatively charged niobium ions exist simultaneously. (R.V.J.)

**6407**

THE MELTING POINT OF NIOBIUM. T. H. Schofield (National Physical Lab., Teddington, Middlesex). J. Inst. Metals 85, 372-4(1957) Apr.

The melting point of Nb has been redetermined by a technique which avoids the use of refractories. Under approximately full-radiator conditions, the melting point of samples containing about 0.12% gaseous impurities ($O_2$ and $N_2$) and 1.9% Ta is 2468° ± 10° C. It is probable that the value for the pure metal is not substantially different. (auth)

**5333** IGR-R/C-190

Gt. Brit. Culcheth Labs., Culcheth, Lancs, England.
THE NIOBIUM–HYDROGEN SYSTEM. D. R. Knowles. Mar. 1957. 32p.

The Nb–$H_2$ system has been discussed and compared with the Ta–$H_2$ and Pa–$H_2$ systems. It has been shown that all three systems are similar, consisting of two solid solutions separated by an interval of immiscibility. It has been confirmed that the distended solid solution is distorted, and that the true unit cell is probably face centered orthorhombic. It has also been shown that the cell size of the distended solid solution increases with $H_2$ content. (auth)

**6452**

INVESTIGATION OF ISOTOPIC EXCHANGE OF OXYGEN BETWEEN HEAVY OXYGEN WATER AND SOME NIOBATES AND TANTALATES. V. I. Spitsyn, A. V. Lapitskii, R. I. Aistova, D. Nishanov, and V. A. Pchelkin (Lomonosov Moscow State Univ.). Doklady Akad. Nauk S.S.S.R. 118, 107-9(1958) Jan. 1. (In Russian)

Experiments were made with saturated solutions of sodium pentatantalate (6.88 $Na_2O \cdot 5Ta_2O_5 \cdot 29.1\ H_2O$), sodium hexatantalate (3.92 $Na_2O \cdot 3Ta_2O_5 \cdot 26.1\ H_2O$), potassium hexaniobate (7.04 $K_2O \cdot 6Nb_2O_5 \cdot 22.0\ H_2O$), potassium methaniobate (0.96 $K_2O \cdot Nb_2O_5 \cdot 4.36\ H_2O$), and heavy oxygen water (with 1.28 at. % $O^{18}$), investigated for 5 hr at 95° temperature. Due to hydrolysis the salt solutions had an alkaline reaction (pH = 11 to 12). Results of the isotopic exchange of oxygen between the water and sodium tantalates and potassium niobates and calculations of the $O^{18}$ content in the solvent after the exchange are tabulated. (R.V.J.)

CHEMISTRY OF THE GROUP VB PENTOXIDES. VI. THE POLYMORPHISM OF $Nb_2O_5$. Frederic Holtzberg, Arnold Reisman, Margaret Berry, and Melvin Berkenblit (Columbia Univ., New York). J. Am. Chem. Soc. 79, 2039-43 (1957) May 5.

The polymorphism of $Nb_2O_5$ has been reinvestigated. Experimental results indicate the definite existence of two modifications and the possible existence of a third. The δ-modification recently reported has been shown to be a poorly crystallized state of the γ-phase. It is proposed that the α- and β-phases are identical, with the β-modification existing as a two-dimensional array. Transformation temperatures were found to be: amorphous to γ 435°, γ to α 830°. The densities are: amorphous 4.36 g./cm.$^3$ at 25°, γ, 5.17 g./cm.$^3$ at 25° and α, 4.55 g./cm.$^3$ at 25°. None of the transformations was reversible. The α-phase was reindexed on the basis of a monoclinic unit cell with a = 21.34 A., b = 2.816 A., c = 19.47 A. and ∢ β = 120°20′ having 14 molecules/unit cell and an x-ray density of 4.52 g./cm.$^3$. The freezing point of $Nb_2O_5$ obtained in the study was 1491°. (auth)

# NIOBIUM 1.27

**4825** BMI-1232
Battelle Memorial Inst., Columbus, Ohio.
PROGRESS RELATING TO CIVILIAN APPLICATIONS DURING OCTOBER 1957. Russell W. Dayton and Clyde R. Tipton, Jr. Nov. 1, 1957. Decl. Dec. 6, 1957. 58p. Contract W-7405-eng-92. $1.50(OTS).

The creep properties of annealed Zircaloy-2, Zircaloy-3, and 15% cold-worked Zircaloy-2 at elevated temperatures were determined. The metallurgical bond formed between electropolished U and Zr cladding by hydrostatic pressing is being evaluated. Oxidation data are given for Nb and Nb alloys in dry air at various temperatures. A study of the phase relationships which occur between the delta phases of the U–Zr and U–Mo systems is nearly complete. The solid-solid reactions of some uranium nitrates and carbides at 1800°C are given. The creep properties of Ta at 1200°F in a helium atmosphere were investigated. (For preceding period see BMI-1226.) (W.L.H.)

THE POLAROGRAPHY OF NIOBIUM. D. J. Ferrett and G. W. C. Milner (Atomic Energy Research Establishment, Harwell, Berks, England). J. Chem. Soc., 1186-92(1956) May.

The polarographic behavior of Nb in various complexing solutions has been studied with conventional polarographic equipment and with the square-wave polarograph. Previous work in sulphuric, hydrochloric, tartaric, and oxalic acid has been re-investigated. Polarographic steps for Nb have been found in a new series of complexing solutions, e.g., malic, lactic, gluconic, and citric acid. The polarography of Nb in ethylenediaminetetra-acetic acid solutions has been studied in detail. Of these complexes, that of Nb citrate is the most stable to hydrolysis and is easily prepared. The step at −0.86 V (vs. S.C.E.) from 2M-citric acid solutions of pH 1 can be used for the determination of from 0.1 to at least 250 μg of Nb per ml. This step is free from interference by manganese, nickel, chromium, iron, or tungsten, but antimony, titanium, or molybdenum interferes. (auth)

COMPATIBILITY OF NIOBIUM WITH BISMUTH. G. W. Parry and L. W. Graham (Hawker Siddeley Nuclear Power Co., Ltd., Langley, Slough, Bucks, Eng.). J. Inst. Metals 87, 125-6(1958) Dec.

A series of tests was made to determine the solubility of Nb in Bi at 600°C and its compatibility at 1000°C. The results indicated that Nb is not a suitable material for the containment of liquid Bi even under oxygen-free conditions. In nonisothermal systems operating below 600°C Nb loops suffer from more serious mass-transfer effects than systems constructed from low-alloy steels.

United Kingdom Atomic Energy Authority. Industrial Group. Culcheth Labs., Culcheth, Lancs, England.
REDUCTION OF NIOBIUM COMPOUNDS BY METAL REDUCTANTS. W. E. Dennis and A. F. Adamson. Aug. 18, 1954. 11p.

The reduction of niobium pentoxide and niobium trichloride by calcium and magnesium has been studied. The available niobium compounds varied both in origin and composition, and thus a systematic study of the process was not possible. However, the results obtained indicate that ductile niobium can be produced from pure niobium pentoxide or niobium trichloride by calcium reduction. (auth)

**4186** A-2388(WEC)
Westinghouse Electric Corp. Aviation Gas Turbine Div., Kansas City, Mo.
DEVELOPMENT OF NIOBIUM BASE ALLOYS. Quarterly Progress Report No. 5 [for] March 15, 1957 to June 15, 1957. R. T. Begley. June 1, 1957. 35p. Contract AF33(616)-3316.

Niobium of high purity with respect to interstitial contaminants was produced by cage-zone melting. The recrystallization behavior, ductile-to-brittle transition properties, and electrical resistivity of the high purity cage-zone melted material were determined. Recrystallization and electrical resistivity studies were also conducted on Nb provided by a supplier using an electron bombardment technique to melt the material. The electron bombardment process was found to be extremely effective in reducing the level of gaseous contaminants. Flexure fatigue studies on annealed and cold worked powder metallurgy Nb were completed. A new multiple hearth levitation melting unit was designed for melting of alloys for phase diagram studies. Effort continued on the development of analytical techniques and the preparation of a new chamber for welding studies. (For preceding period see A-2293-WEC.) (auth)

**1401**
EFFECTS OF NIOBIUM AND TITANIUM ON THE PROPERTIES OF STAINLESS STEEL. A. M. Samarin and A. A. Yuskevich. Invest. Akad. Nauk S.S.S.R. Otdel. Tekh. Nauk No. 10, 107-16(1955) Oct. (In Russian)

Experiments with various steels proved that niobium is more effective than titanium in increasing steel resistance to intercrystalline corrosion. Niobium improves the welding properties of steel and the wear resistance of tempered steel to acid. (R.V.J.)

# NIOBIUM 1.27

**8927** ✓
OBSERVATIONS ON ETCH PITS AND SUB-BOUNDARIES IN COLUMBIUM. A. B. Michael and F. J. Heugel (Fansteel Metallurgical Corp., North Chicago, Ill.). Acta Met. 5, 339-41(1957) June.

**5569**
SEPARATION OF NIOBIUM AND TANTALUM. CONTRIBUTION ON THE STUDY BY PAPER ELECTROPHORESIS. E. Bruninx, J. Eeckhout, and J. Gillis (Univ. of Gand, Belgium). Anal. Chim. Acta 14, 74-88(1956) Jan.

The separation of Nb and Ta on a micro-scale by paper electrophoresis, using oxalic and citric complexes and different buffer solutions has been studied. A fairly good separation is obtained by using oxalic complexes and, as buffer solution, a mixture of citric acid and potassium citrate of pH 3.42 and ionic strength 0.4. Different factors influencing the displacement of ions by paper electrophoresis have been examined. It is shown that, if saturation currents are minimized, the displacement is practically proportional to the time of electrophoresis, and more difficult separations become possible using longer strips. (auth)

**10908**
SOME WATER-SOLUBLE COMPLEXES OF PENTAVALENT NIOBIUM AND TANTALUM. Fred Fairbrother, Derek Robinson, and John B. Taylor (Manchester Univ., Eng.). J. Inorg. & Nuclear Chem. 8, 296-301(1958).

It has been known for a long time that the hydrated oxides will dissolve in aqueous solutions of oxalic, tartaric, and citric acids and in alkaline solutions of catechol and pyrogallol. It has been shown that water-soluble complexes can be formed with a variety of $\alpha$-hydroxy acids, which may be phenolic or carboxylic, and with a number of amines. Complex formation with hydroxy compounds occurs through a condensation mechanism, akin to the flocculation or aging of the hydroxides, in which small units are attached to the complexing agent by elimination of water. Amine complex formation appears to occur through co-ordination by a usual type of donor-acceptor mechanism and is affected by steric considerations and may be correlated with the basic dissociation constant of the amine. One outstanding feature of the dissolution in solutions of these complexing agents is the much greater solubility of pure niobic acid as compared with pure tantalic acid. When the two oxides are co-precipitated however, part of the tantalum may be carried into solution with the niobium. This is a consequence of the polynuclear character of the complexes. (auth)

**16207**
THE PREPARATION OF CADMIUM NIOBATE BY AN ANODIC SPARK REACTION. William McNeill (Frankford Arsenal, Philadelphia). J. Electrochem. Soc. 105, 544-7(1958) Sept.

A new method of preparing cadmium niobate was demonstrated. This method involved the anodic spark reaction of cadmium in a niobate solution and crystallization of the anode product by heating at 650°C. The crystallized anode product was made into a solid wafer by pressing it at 350,000 psi, and electrical measurements were made. Even though there was some evidence of impurity or porosity in the sample, a dielectric constant of about 600 was found at room temperature. It is believed that anodic spark reactions might be employed to prepare a wide variety of complex oxides and possibly other compounds. (auth)

**7385**
EXTRACTION OF NIOBIUM. J. M. Fletcher, D. F. C. Morris, and A. G. Wain (to U. K. Atomic Energy Authority). British Patent 767,038. Nuclear Eng. 2, 224(1957) May.

Ferroniobium or crushed niobium-bearing mineral concentrate is dissolved in a mixture of hydrofluoric acid and nitric acid. The solution is contacted with equal volumes of 100% tributyl phosphate in a continuous extractor, the extract collected and backwashed with aqueous hydrofluoric acid. Ammonia gas is passed through the backwash until precipitation of the niobic acid appears to be complete. When using sulfuric acid in the mixture, batch extraction is preferable. (auth)

**1811** ISC-793
Ames Lab., Ames, Iowa.
SEPARATION OF NIOBIUM AND TANTALUM; A LITERATURE SURVEY. Ernest L. Koerner and Morton Smutz. Aug. 15, 1956. 14p. Contract W-7405-eng-82. $0.15 (OTS).

**2475**
SEPARATION OF SMALL QUANTITIES OF NIOBIUM AND TITANIUM BY PYROGALLIC ACID. A. P. Savostin and I. P. Alimarin. Vestnik Moskov. Univ. Ser. Mat., Mekhan. Astron., Fiz. i Khim. No. 6, 111-19(1959). (In Russian)

Small quantities of niobium, in the presence of 100 and 1000 folds of titanium, were precipitated by pyrogallic acid in the presence of fluoride ion. It is shown that triple precipitation recovered 60 to 70% of the Nb. In the final precipitate the ratio of Nb : Ti was about 1 : 0.5 to 0.6, i.e., up to 2000 folds of enrichment. (R.V.J.)

# NIOBIUM 1.27

**2476**

SEPARATION OF Nb AND Ti BY ION EXCHANGE CHROMOTOGRAPHY. I. P. Alimarin and N. P. Borzenkova. Vestnik Moskov. Univ. Ser. Mat., Mekhan. Astron., Fiz. i Khim. No. 6, 191-9(1959). (In Russian)

Niobium and titanium absorption by citric and sulfuric acid ionites was studied in order to determine their separation. Colorimetric recordings were taken of titanium absorption in hydrogen peroxide, and niobium absorption was checked radiometrically by $Nb^{95}$ $\gamma$ emission. (R.V.J.)

**7109** GS-B-1029-A

Geological Survey.

ANNOTATED BIBLIOGRAPHY OF THE ANALYTICAL CHEMISTRY OF NIOBIUM AND TANTALUM, JANUARY 1935–JUNE 1953. Frank Cuttitta. 1957. 75p. $0.25 (GPO).

This annotated bibliography includes reports of work published in the period January 1935 to June 1953 and has been compiled mainly from Chemical Abstracts and from Nuclear Science Abstracts. It refers the reader to the original publications and to abstracts and discussions (summaries) of them. Author and subject indexes are supplied, and also lists of abbreviations used for the serials to which reference is made, and of AEC code designations and depository libraries where reports so designated can be examined or obtained. (auth)

**10404** WAPD-CTA(GLA)-542

Westinghouse Electric Corp. Bettis Plant, Pittsburgh.

THE DETERMINATION OF TANTALUM IN NIOBIUM. Mary Louise Theodore. Feb. 27, 1958. 7p. $1.80(ph OTS); $1.80(mf OTS).

The metal is dissolved in hydrofluoric and nitric acids. Hydrochloric acid is added and the tantalum is extracted with methyl isobutyl ketone. The tantalum is removed from the ketone layer by precipitation with ammonium hydroxide. The tantalum precipitate is dissolved in hydrofluoric and hydrochloric acids, re-extracted from a hydrochloric acid medium and converted to the hydroxide. The hydroxide is fused with potassium pyrosulfate, and the tantalum determined spectrophotometrically using the tantalum pyrogallol system. Photometric measurement is made at a wave length of 355 $\mu$ in 5 cm cells. (auth)

**7951**

TANTALUM DETERMINATION IN PRESENCE OF NIOBIUM BY PRECIPITATION WITH N-BENZOYL-N-PHENYLHYDROXYLAMINE. Ross W. Moshier and James E. Schwarberg (Wright-Patterson Air Force Base, Ohio). Anal. Chem. 29, 947-51(1957) June.

Tantalum is separated quantitatively from Nb, Ti, and Zr by two to three precipitations with N-benzoyl-N-phenylhydroxylamine from $HF-H_2SO_4$ solution at pH 1.0. Operating time is much less than that of other methods and precipitate, which is ignited to oxide, is uncontaminated by other metals. (auth)

**6243**

NIOBIUM AND TANTALUM PENTACHLORIDES AND THEIR BINARY SYSTEM. J. B. Ainscough, R. J. W. Holt, and F. W. Trowse (U.K.A.E.A., Industrial Group, Springfields Works, Preston, Lancs.). J. Chem. Soc. 1034-7 (1957) Mar.

The boiling points of $NbCl_5$ and $TaCl_5$ have been measured over a range of pressures. At 760 mm pressure they were found to be 247.4° ± 0.1° and 232.9° ± 0.1° respectively, and the heats of vaporization were calculated at 12.6 and 13.1 kcal $mole^{-1}$ respectively. The triple points have been determined as 203.4° ± 0.2° and 215.9° ± 0.1° respectively. The liquid-vapor equilibrium in the system $NbCl_5-TaCl_5$ has been examined and the relative volatility ($TaCl_5 : NbCl_5$) at atmospheric pressure found to be 1.36 over the whole range of mixture compositions. (auth)

THE MOLECULAR STRUCTURE OF NIOBIUM PENTACHLORIDE. J. Guant and J. B. Ainscough (Atomic Energy Research Establishment, Harwell, Berks and United Kingdom Atomic Energy Authority, Salwick, Lancs., Eng.). Spectrochim. Acta 10, 52-6(1957) Nov.

The infrared and Raman spectra of niobium pentachloride have been measured. An interpretation of the spectra has been made in a manner consistent with the rigid selection rules for the trigonal bipyramid structure ($D_{3h}$) and the thermodynamic properties have been calculated on the simple harmonic oscillator approximation. An unsuccessful attempt has also been made to examine the infrared and Raman spectra of niobium trichloride and tetrachloride. (auth)

# NIOBIUM 1.27

**10496**

PREPARATION OF THE NIOBIUM(IV) AND NIOBIUM(III) IODIDES. John D. Corbett and Pyrtle X. Seabaugh (Iowa State Coll., Ames). J. Inorg. & Nuclear Chem. 6, 207-9(1958) June.

Conditions are reported for the preparation of $NbI_5$, the preparation and sublimation of $NbI_4$ by thermal decomposition of the pentaiodide, and the subsequent disproportionation to $NbI_3$. Properties and powder patterns are given for the three iodides. (auth)

**16200**

THE PREPARATION OF SOME MIXED HALOGENIDES OF NIOBIUM AND TANTALUM. Marcel Chaigneau. Compt. rend. 247, 300-2(1958) July 21. (In French)

The preparation of the mixed halides of niobium and of tantalum was studied. Niobium pentoxide was heated with aluminum bromide and aluminum iodide in proportions of 1 mole of bromide for 2 moles of iodide and also in the reverse proportions at 230°C for 24 hours. The only compound formed was isolated by sublimation in a vacuum at 350°C. It was a black acicular crystal with a density of 4.68 at 18°C and had the formula $NbBrI_2$. Tantalum pentoxide heated with one mole of $AlI_3$ and two moles of $AlBr_3$ at 230°C for 48 hours gave a black crystal which could be separated by sublimation at 350°C in the form of triangular tables with mordore reflections presenting in some places efflorescences. The density is 5.47 at 18°C and the formula is $TaBr_4I$. If the pentoxide is heated with one mole of $AlBr_3$ and two moles of $AlI_3$, a dark brown crystal is formed with a density of 5.85 at 18°C. Its formula is $TaBrI_4$. The mixed halides are instable in air and are attacked by water, ammonia, and dilute acids. Niobium bromoiodide is insoluble in the usual organic solvents. Tantalum bromoiodides are insoluble in ether, carbon sulfide, and carbon tetrachloride, but are soluble in acetone, ethyl and methyl alcohols, dioxane, and glycerine. (J.S.R.)

THE DECAY OF $^{90}Nb$. Raymond K. Sheline. Physica 23, 923-42(1957) Oct.

$Nb^{90}$ produced by the (p,n) reaction on separated $Zr^{90}$ was studied by scintillation beta and gamma spectroscopic methods. The 14.56 ± 0.05 hr activity emitted positions with an end point of 1.48 ± 0.03 Mev and photons of 0.0176 ± 0.001, 0.133 ± 0.003, 0.142 ± 0.002, 0.370 ± 0.005, 0.511 ± 0.003, 0.900 ± 0.010, 1.137 ± 0.006, 2.200 ± 0.020, and 2.330 ± 0.010 Mev. Relative intensities of most of the transitions have been determined. The anisotropy of the 0.142 to 1.137 Mev cascade is −0.112 ± 0.046. These measurements together with coincidence measurements have been used to assign the following levels (in Mev) and spins in the daughter nucleus $Zr^{90}$. 1.77 (0+), 2.20 (2+), 2.33(5−), 3.10, 3.47 (6+), and 3.61 (8+). Following the suggestion of Ford, these levels are interpreted as proton levels arising from the ground state configuration $(p_{1/2})^2$ and the two excited state configurations $(g_{9/2})^2$ and $(g_{9/2}\ p_{1/2})$. All states expected from these configurations are observed, with the exception of the $(g_{9/2}\ p_{1/2})_{4-}$ and the $(g_{9/2})^2_{4+}$ states. The relative population of the ground and first excited $0^+$ states in the beta decay of $Y^{90}$, and in the deexcitation of the 2.20 (2+) state in $Nb^{90}$, indicate that these states are highly mixed $(p_{1/2})^2$ and $(g_{9/2})^2$ states. Other states are shown by a variety of criteria to be relatively pure. A simple method to calculate the half life of the 1.77 Mev 0 + → 0 + transition in $Zr^{90}$ yields the value $2.0 \times 10^{-9}$ sec. (auth)

# PLUTONIUM 1.28

See also, this section,

NEPTUNIUM (1.26).

## ANALYTICAL SEPARATION 1.28.01

**19813** HW-25074
General Electric Co. Hanford Atomic Products Operation, Richland, Wash.
ANALYTICAL PROCEDURES FOR THE PLUTONIUM METAL FABRICATION PROCESS. VII. THE CUPFERRON EXTRACTION-COPPER SPARK METHOD. T. K. Bierlein, L. F. Kendall, and H. H. Van Tuyl. July 25, 1952. Decl. July 1, 1959. 23p. $4.80(ph), $2.70(mf) OTS.

Tri- or tetravalent plutonium is separated from impurity elements by extraction of plutonium cupferride into chloroform. The aqueous phase is evaporated along with cobalt internal standard and placed on copper electrodes which are sparked to produce the impurity spectrum. The amounts of impurities present are determined by comparison of the densities of impurity lines with standard spectra and correcting for the recovery of cobalt internal standard. (auth)

**14622** A/CONF.15/P/926
Los Alamos Scientific Lab., N. Mex.
THE CHEMICAL ANALYSIS OF PLUTONIUM-RICH FAST REACTOR FUEL. Charles F. Metz, George M. Matlack, and Glenn R. Waterbury. 9p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The basic chemistry of plutonium applicable to the analysis of plutonium-containing materials is described. Included are, potentiometric methods for plutonium assay, radiochemical methods for gamma-counting of americium in plutonium, and methods of separating plutonium for measurement by alpha-counting techniques. Ion exchange methods and precipitation methods are discussed for separating plutonium from a number of alloying elements. Spectrochemical methods and micromethods are discussed for the determination of trace impurities. Methods of analysis, chemical and radiochemical, of plutonium-rich fast reactor fuel for major fission elements are included. Of very great value in the identification of plutonium compounds has been the study of the optical properties of their crystals under the polarizing microscope. A description of these techniques is also included. (auth)

THE ANALYTICAL CHEMISTRY OF PLUTONIUM.
Charles F. Metz (Los Alamos Scientific Lab., N. Mex.).
Anal. Chem. 29, 1748-56(1957) Dec.

General chemistry of Pu and applications of its analytical chemistry are reviewed. Plutonium may be separated from impurities by precipitation, ion exchange, and solvent extraction. It may be determined by potentiometric titration, spectrophotometric, and radiochemical methods. Spectrochemical methods may be used to determine a large number of metallic impurities. (auth)

**11139** ✓
ISOTOPIC EXCHANGE BETWEEN Pu(III) AND Pu(IV).
Thomas K. Keenan (Los Alamos Scientific Lab., N. Mex.).
J. Phys. Chem. 61, 1117-20(1957) Aug.

The rate of exchange between Pu(III) and Pu(IV) in aqueous perchlorate media has been investigated. The exchange is rapid so that it was necessary to work in the concentration range of $10^{-6}$ to $10^{-5}$ f total plutonium. Satisfactory separation techniques were developed for this concentration region. Over the temperature range 0 to 25°, at ionic strength 2.00, the rate law may be approximated: rate (mole-liter$^{-1}$-min.$^{-1}$) = $1.8 \times 10^{10}$ $[Pu^{+3}]$ $[Pu^{+4}]$ exp( $-7700/RT$) + $1.3 \times 10^{8}$ $[Pu^{+3}]$ $[Pu(OH)^{+3}]$exp( $-2800/RT$). The rate increases with increasing ionic strength. (auth)

**1110** ✓ LA-387(Del.)
[Los Alamos Scientific Lab., N. Mex.]
SPECTROCHEMICAL ANALYSIS OF PLUTONIUM AND ITS COMPOUNDS. II. THE CUPFERRON PROCEDURE. N. H. Nachtrieb, H. A. Potratz, O. R. Simi, S. Wexler, and B. S. Wildi. [Sept. 14, 1945]. Decl. July 19, 1957. 33p. Contract [W-7405-eng-36]. $6.30(ph OTS); $3.00 (mf OTS).

A method is described whereby milligram samples of iron, antimony, vanadium, tantalum, titanium, niobium, zirconium, tin, bismuth, uranium, or plutonium may be analyzed for parts per million of thirty-nine impurity elements. The procedure consists in forming the acid-insoluble cupferride of one of the above elements and extracting the compound from the impurities by means of chloroform. The aqueous solution containing the impurities is evaporated on copper electrodes which are sparked to produce the impurity spectrum. (auth)

# PLUTONIUM 1.28

## ANALYTICAL SEPARATION 1.28.01

**8877**

THE REMOVAL OF PLUTONIUM BEFORE THE ANALYSIS OF MIXED FISSION PRODUCTS. G. Phillips and E. N. Jenkins (Atomic Energy Research Establishment, Harwell, Didcot, Berks). J. Inorg. and Nuclear Chem. 4, No. 3 and 4, 220-4(1957).

Methods are presented for the complete removal of up to 100 mg of Pu as an initial step in the radiochemical analysis of certain individual products in irradiated Pu metal of Pu–U alloy. (auth)

**10825** KAPL-M-MC-2

Knolls Atomic Power Lab., Schenectady, N. Y.
TOTAL PLUTONIUM ASSAY IN THE PRESENCE OF ALUMINUM BY $La(OH)_2$–$LaF_3$ CARRIER PRECIPITATIONS. M. Cefola and W. S. Andrus. Sept. 23, 1949. Decl. Feb. 23, 1957. 4p. Contract W-31-109-Eng-52. $1.80(ph OTS); $1.80(mf OTS).

It has been established in many laboratories that the $LaF_3$ method for total Pu content in a solution containing Al ions gives incorrect results. This may be totally or in part caused by complex formation. Since many of the waste streams such as 1AW and 2AW in the Redox Process contain large amounts of $Al(NO_3)_3 \cdot 9H_2O$ it becomes quite important to have a method which will determine with some degree of accuracy the plutonium in these solutions. For unexplained reasons, substituting $La(OH)_3$ as a carrier precipitate, after having reduced the Pu to Pu(III) state by $NH_2OH \cdot HCl$, still gave low results even when the $La(OH)_3$ was converted to $LaF_3$ for mounting. The conversion was found necessary in order to eliminate large errors caused by the absorption of $\alpha$ particles by the former precipitate. The precipitation of $La(OH)_3$ by NaOH has the effect of separating Al from Pu by keeping the first in solution. A slight modification of the above scheme has been found to give satisfactory results in the presence of fairly large amounts of Al. Instead of using $NH_2OH \cdot HCl$ as a reducing agent, $SnCl_2$ in 6M HCl has been substituted. Precipitation of $La(OH)_3$ with NaOH should keep both Al and tin in solution by complex formation. (auth)

## BURNUP AND YIELD 1.28.02

See also, under SURVEYS (GENERAL),

FUEL CYCLE (7.03).

**14720** A/CONF.15/P/644

Naval Radiological Defense Lab., San Francisco.
EXTENSION OF THE FISSION PRODUCT REGION AND YIELDS OF HEAVY PRODUCTS IN THE NEUTRON FISSION OF $Pu^{239}$. L. R. Bunney, E. M. Scadden, J. O. Abriam, and N. E. Ballou. 4p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Information on observations of new fission product elements and on the more accurate definition of the $Pu^{239}$ fission yield curve in the heavy mass region is presented. Radiochemical studies, utilizing ion exchange chromatography, of the pile neutron fission of $Pu^{239}$ were made in the region beyong mass number 144. The fission product region was extended to include $Dy^{166}$ and $Ho^{166}$. Chain yields were measured relative to $Mo^{99}$ for masses 147, 149, 153, 156, 159, 161, and 166. The mass distribution of the fission products of $Pu^{239}$ is wider than that of $U^{233}$ or $U^{235}$ since the heavy mass peak shifts toward higher mass numbers. It also exhibits a different shape on the high mass number side of the heavy peak. Fission yield values obtained in these studies expressed in % are: mass 147–2.2, mass 149–1.2, mass 153–0.35, mass 156–0.11, mass 159–0.021, mass 161–0.0040 and mass 166–0.00007. The results obtained for masses 153 and 156 are in fair agreement with previously reported values of 0.39 and 0.12%, respectively. (auth)

THE CUMULATIVE FISSION YIELDS OF LIGHT MASS FRAGMENTS IN THE THERMAL NEUTRON FISSION OF $Pu^{239}$. H. R. Fickel and R. H. Tomlinson (McMaster Univ., Hamilton, Ont., Can.). Can. J. Phys. 37, 916-25 (1959) Aug.

The relative cumulative yields of 19 light mass fragments of rubidium, strontium, yttrium, zirconium, molybdenum, and ruthenium formed in the thermal neutron fission of $Pu^{239}$ have been determined with a mass spectrometer using the isotope dilution technique. The yields of the fission product isotopes of these elements, together with the previously published relative yields of three krypton isotopes, have made possible the determination of the absolute yields of 22 light fragment mass chains. (auth)

# PLUTONIUM 1.28

## BURNUP AND YIELD 1.28.02

NEW METHOD FOR THERMAL BREEDING OF PLUTONIUM. Kurt Diebner. German Patent DAS 1028 249. Atompraxis 4, 477(1958). (In German)

**9884** UCRL-1125
California. Univ., Berkeley. Radiation Lab.
IV. PRODUCTION AND HEATING. Harold Brown. Feb. 12, 1951. Decl. Mar. 5, 1957. 3p. Contract [W-7405-eng-48]. $1.80(ph OTS); $1.80(mf OTS).

Calculations are developed which indicate the Pu production in an infinite lattice. (D.E.R.)

**6957** A/CONF.15/P/187(Rev. 1)
ABSOLUTE YIELDS OF THE ISOTOPES OF XENON AND KRYPTON IN THE NEUTRON FISSION OF Pu-239. K. Fritze, C. C. McMullen, and H. G. Thode (McMaster Univ., Hamilton, Ont., Can.). 11p. (AECL-597). $0.25(AECL).

Using isotope dilution techniques and mass spectrometry, absolute yields of the Xe and Kr isotopes in the neutron-induced fission of $Pu^{239}$ were determined. Nine of these yields lead to cumulative yields of the respective mass chains 131, 132, 134, 136, 83, 84, 85, 86, and two give absolute independent yields of the shielded precursors in their respective mass chains, namely $I^{128}$ and $I^{130}$. (W.D.M.)

**6848** A/CONF.15/P/7
RARE EARTH FISSION PRODUCT YIELDS FROM HIGHLY IRRADIATED PLUTONIUM 239. E. A. C. Crouch and I. G. Swainbank (Atomic Energy Research Establishment, Harwell, Berks, Eng.). 11p.

The rare earth fission products were isolated from the products of the irradiation of $Pu^{239}$ with a total dose of $2.3 \times 10^{22}$ neutrons/cm$^2$. The rare earths, after separations from the transuranic elements, were themselves separated by means of a micro cation-exchange column, and the isotopic composition and absolute quantity of each element determined by mass spectrometry and micro-chelatometry, or by neutron activation analysis. The isotopes estimated were $La^{139}$, $Ce^{140}$, $Ce^{142}$, $Ce^{144}$, $Pr^{141}$, $Nd^{142}$, $Nd^{143}$, $Nd^{144}$, $Nd^{145}$, $Nd^{146}$, $Nd^{148}$, $Nd^{150}$, $Sm^{147}$, $Sm^{148}$, $Sm^{150}$, $Sm^{151}$, $Sm^{152}$, $Sm^{154}$, $Eu^{152}$, $Eu^{153}$, $Eu^{154}$, $Eu^{155}$, $Gd^{156}$, $Gd^{158}$, $Gd^{160}$. The isotopes $Tb^{159}$, $Dy^{160}$, $Dy^{162}$, $Dy^{163}$, $Dy^{164}$ were also found to be present but were not estimated. (auth)

**2029** CF-3211
Hanford Engineer Works, Richland, Wash.
CORRELATIONS AND PREDICTIONS CONCERNING THE RADIOACTIVE PROPERTIES OF HEAVY ISOTOPES. W. H. Sullivan and T. P. Kohman—I. Perlman, ed. Aug. 4, 1945. Decl. Feb. 16, 1957. 14p. Reissued under auspices of Contract W-7401-eng-37. (HW-3-3048; SE-PC-68). $3.30(ph OTS); $2.40(mf OTS).

Correlations of data concerning known heavy isotopes were made to predict the formation of other heavy isotopes in the pile. How these isotopes will affect chemical processing and Pu product is discussed. (T.R.H.)

**9762** ANL-5077
Argonne National Lab., Lemont, Ill.
PLUTONIUM PRODUCTION ANALYSIS—GRAPHICAL METHOD. J. F. Mumm and L. J. Templin. Jan. 1954. Decl. Feb. 16, 1957. 58p. Contract W-31-109-eng-38. $0.40(OTS).

In the study of plutonium production, the analytical solutions of the various isotope production equations are difficult and time consuming when spatial variation of the flux is considered. In an effort to reduce the time and labor required to determine the integrated production of a given thermal reactor, a graphical method of analysis is presented. The method is based on the assumption that the reactor may be divided into a relatively small number of regions such that the flux in each of these regions may be assumed constant. The production of the given isotope for each region is then read from the appropriate graph. The total production is obtained by adding the productions of all of the regions. (auth)

STUDY OF THE VARIATION OF THE NUMBER OF NEUTRONS EMITTED BY THE FISSION OF $Pu^{239}$ IN THE THERMAL AND DPI-THERMAL REGIONS. J. M. Auclair, M. Jacob, and H. Landon (Neutronique Experimentale, Saclay). J. phys. radium 17, 563(1956) July. (In French)

The study of the variation of the average number of neutrons emitted per fission of $Pu^{239}$ as a function of the energy of the incident neutron shows that within an accuracy of about 1% this number is constant from thermal energy up to several electron-volts. (auth)

# PLUTONIUM 1.28

## BURNUP AND YIELD 1.28.02

A COMPARISON OF THE AVERAGE NUMBER OF NEUTRONS EMITTED IN FISSION OF SOME URANIUM AND PLUTONIUM ISOTOPES. J. E. Sanders (Atomic Energy Research Establishment, Harwell, Berks, England). J. Nuclear Energy 2, 247-54(1956) June.

Measurements of the relative prompt neutron yields per fission of $U^{233}$, $U^{235}$, $Pu^{239}$, and $Pu^{241}$ by thermal neutrons are described. A coincidence technique is employed. Absolute values have been determined using a natural uranium spontaneous fission source to calibrate the neutron detector.

**8367** ✓ WAPD-P-699

Westinghouse Electric Corp. Bettis Plant, Pittsburgh.
A METHOD FOR DETERMINATION OF PLUTONIUM PRODUCTION IN REACTORS. W. Baer, D. Klein, and N. Carbone. May 1956. 12p. $3.30(ph OTS); $2.40 (mf OTS).

A radiochemical separation technique for neptunium was developed to assist in the measurement of plutonium production in reactors. The method is useful in rapid determination of such quantities as the resonance escape probability and the conversion ratio with simplified experimental techniques. (auth)

**12049**

SOME CUMULATIVE YIELDS OF ISOTOPES FORMED IN THE THERMAL NEUTRON FISSION OF $Pu^{239}$. D. M. Wiles, J. A. Petruska, and R. H. Tomlinson (McMaster Univ., Hamilton, Ont., Canada). Can. J. Chem. 34, 227-32(1956) Mar.

The relative yields of the isotopes of Cs, Ce, Nd, and Sm, produced by the thermal neutron fission of $Pu^{239}$ have been determined with a mass spectrometer. Preliminary values of the absolute yields of 16 isotopes of these elements together with four yields of the xenon isotopes have been assigned by means of isotope dilution techniques. (auth)

**4553** AERE-RP/M-58

Gt. Brit. Atomic Energy Research Establishment, Harwell, Berks, England.
COMPOSITION OF RECYCLED FISSILE MATERIALS. F. W. Fenning. Jan. 14, 1955. Decl. Dec. 20, 1956. 4p.

The re-irradiation compositions of radiation produced Pu and $U^{233}$ are given and discussed. (T.R.H.)

**9847** ✓ NAA-SR-Memo-49

North American Aviation, Inc., [Downey, Calif.].
SECULAR CHANGES IN Pu PRODUCTION IN A HOMOGENEOUS REACTOR. E. R. Cohen. July 30, 1951. Decl. Feb. 27, 1957. 4p. $1.80(ph OTS); $1.80(mf OTS).

Equations are given for Pu production in a form which separates thermal from resonance capture. Plutonium production is tabulated as a function of irradiation. (B.J.H.)

## FISSION PRODUCTS, ISOTOPES, AND DECAY 1.28.03

### FISSION PRODUCTS AND ISOTOPES 1.28.03.01

**20657** ✓

CHEMICAL PRODUCTS WHICH ARE FORMED IN A NUCLEAR REACTOR. Dizdar. Technika (Belgrade) 12, No. 3, (1957). (Translated from Referat. Zhur. Khim. No. 12, 1958, Abstract No. 40166.)

Chemical products which are formed in nuclear reactors (Pu, degradation products, radioisotopes) are discussed. Importance of Pu and its chemical, physical, and nuclear properties are also examined.

THE CUMULATIVE FISSION YIELDS OF 21 HEAVY MASS NUCLIDES PRODUCED IN THE THERMAL FISSION OF $Pu^{239}$. H. R. Fickel and R. H. Tomlinson (McMaster Univ., Hamilton, Ont., Can.). Can. J. Phys. 37, 926-36(1959) Aug.

Mass spectrometric analysis of cesium, barium, cerium, neodymium, and samarium produced in the thermal fission of $Pu^{239}$ has made possible the determination of the cumulative yields of 17 mass chains. With previously published mass spectrometric yields of four xenon isotopes normalized to the present data a total of 21 cumulative yields are reported. (auth)

THE SPECIFIC $\alpha$-ACTIVITIES OF $Pu^{239}$ AND $Pu^{240}$. Ya. P. Dokuchaev. Atomnaya Energ. 6, 74(1959) Jan. (In Russian)

The specific $\alpha$ activities of $Pu^{239}$ and $Pu^{240}$ were determined using twelve specimens with isotopic content: $Pu^{239}$ = 91.26 to 99.11; $Pu^{240}$, (0.87 ± 0.06) to (7.57 ± 0.1); $Pu^{241}$, (1.3 ± 0.3) × $10^{-2}$ to (1.04 ± 0.05); $Pu^{238}$, (1.62 ± 0.1) × $10^{-3}$ to (1.75 ± 0.05) × $10^{-2}$; and $Pu^{242}$ + $Np^{237}$, 0.01 to 0.1 (wt. %). Alpha activity per $\mu$g of $Pu^{239}$ was 136,200 ± 200 decays per min, corresponding to a half life of 24,390 ± 30 years. For $Pu^{240}$, 500,000 ± 4000 decays/min/$\mu$g, corresponding to a half life of 6,620 ± 50 years. The results are in good agreement with published data. (R.V.J.)

ALPHA HALF-LIFE OF $Pu^{244}$. Herbert Diamond and Raymond F. Barnes (Argonne National Lab., Lemont, Ill.). Phys. Rev. 101, 1064-6(1956) Feb. 1.

The half life of $Pu^{244}$ was found to be (7.6 ± 2) × $10^7$ years by measuring the activity of its $Np^{240}$ decay product. The possibility of detecting $Pu^{244}$ in nature with current techniques and the role of $Pu^{244}$ and its daughters as an early source of terrestrial heat are discussed. (auth)

# PLUTONIUM 1.28

## FISSION PRODUCTS, ISOTOPES, AND DECAY 1.28.03

### FISSION PRODUCTS AND ISOTOPES 1.28.03.01

**11700** ✓ TID-7547(p.85-91)
Argonne National Lab., Lemont, Ill.
EXPERIMENTAL TESTS OF FISSION AND REACTION THEORY FOR SLOW NEUTRONS. L. M. Bollinger. p.85-91 [of] THE INTERNATIONAL CONFERENCE ON THE NEUTRON INTERACTIONS WITH THE NUCLEUS, HELD AT COLUMBIA UNIVERSITY, SEPTEMBER 9-13, 1957. 7p.

Experimental results for the neutron cross sections of $Pu^{239}$ and the dependence of fission fragment mass distribution on the incident neutron energy are examined. Data given for $Pu^{238}$ are: total neutron cross sections, fission cross sections, fission widths, radiation widths, and neutrons emitted per neutron absorbed. The findings show that the number of channels available for fission of $Pu^{239}$ by slow neutrons is small, probably one or two. The average fission width seems to be of the same order of magnitude for both spin states. Differences in the mass distribution from resonance to resonance, if present, are difficult to establish. (M.H.R.)

**8195** ✓
FISSION MODES OF $_{94}Pu^{242}$. A. B. Smith, P. R. Fields, and A. M. Friedman (Argonne National Lab., Lemont, Ill.). Phys. Rev. 106, 779-81(1957) May 15.

The neutron induced fission of $Pu^{241}$ ($Pu^{241} + n_{th} = Pu^{242*}$) and the spontaneous fission of $Pu^{242}$ were studied by using a back-to-back ionization chamber. The two processes were found to be asymmetric and essentially identical. The most probable values of the mass ratio and total fragment kinetic energy were measured to be 1.38 and 174 Mev, respectively. The experimental results are compared with those from other fission processes and with existing theory.

HALF-LIVES AND NEUTRON CAPTURE CROSS SECTIONS OF THE HEAVY PLUTONIUM ISOTOPES. J. P. Butler and T. A. Eastwood (Atomic Energy of Canada, Ltd., Chalk River, Ont.) and T. L. Collins, M. E. Jones, F. M. Rourke, and R. P. Schuman (Knolls Atomic Power Lab., Schenectady, N. Y.). Phys. Rev. 103, 634-7(1956) Aug. 1.

Specific alpha activities have been obtained for $Pu^{240}$ and $Pu^{242}$ corresponding to half-lives of 6600 ± 100 years and 379,000 ± 5000 years, respectively. A half-life of (7.5 ± 2) × $10^7$ years has been obtained for $Pu^{244}$ by separating uranium daughters. The irradiation of a sample of Pu containing $Pu^{244}$ gave a neutron capture cross section of 2.1 ± 0.3 barns for $Pu^{244}$ and yielded 10.6 ± 0.4 hr $Pu^{245}$ and its 124 ± 1 min $Am^{245}$ daughter. (auth)

**7007** ✓ A/CONF.15/P/2031
SPECTRUM OF FRAGMENTS OF Pu-240 SPONTANEOUS FISSION. T. A. Mostovaya (U.S.S.R.). 10p.

The results of energy distribution measurements for fragments from $Pu^{239}$ and $Pu^{240}$ fission induced by neutrons with energies corresponding to the known levels within the region from 0 to 10 ev are reported and compared. For fragment energy measurements a grid ionization chamber with an amplitude analyzer was used. Selection of fission events induced by monochromatic neutrons was made by means of a mechanical velocity selector and a time analyzer. The results of fragment energy distribution measurements are given for spontaneous and induced fission. The experimental data obtained are discussed according to modern conceptions of the fission process. (auth)

### ACTIVITY SPECTRA 1.28.03.02

**169** JENER-51
Joint Establishment for Nuclear Energy Research, Kjeller, Norway.
WAVELENGTH AND INTENSITY MEASUREMENTS IN THE SPARK EXCITED SPECTRUM OF PLUTONIUM. J. Haaland. Aug. 1957. 21p.

The wavelength of some four hundred Pu lines were measured with a Zeiss Abbe-comparator with an estimated accuracy of ± 0.01 A. The spectrograms were obtained with a 21 ft 15000 lines per inch grating spectrograph. Relative intensities of most of the lines were measured photometrically. The spectral sensitivity of the photoplates have been taken into account, and all lines are corrected for background. (auth)

**3393**
ALPHA DECAY OF $Pu^{240}$. L. N. Kondrat'ev, G. I. Novikov, Iu. P. Sobolev, and L. L. Gol'din. Soviet Phys. JETP 4, 645-7(1957) June.

In this work results are given of investigations on the $\alpha$ spectrum of $Pu^{240}$ carried out with the help of an $\alpha$ spectrometer. The $\alpha$ spectra obtained are presented along with a level scheme for the $U^{236}$ nucleus. The parameters of the $4^+$ level are given with precision; the first $\alpha$ line corresponding to the transition to a $6^+$ level is observed, and the parameters of this level measured; two weak lines are found which can be assigned to the $\alpha$ decay of $Pu^{240}$. A comparison of the experimental data with the theoretical formula of Landau is made for the intensities of the $0^+$, $2^+$, $4^+$, and $6^+$ levels. (auth)

# PLUTONIUM 1.28

## FISSION PRODUCTS, ISOTOPES, AND DECAY 1.28.03

### ACTIVITY SPECTRA 1.28.03.02

**13901**

THE ALPHA HALF-LIFE OF PLUTONIUM-239. T. L. Markin (Atomic Energy Research Establishment, Harwell, Berks, Eng.). J. Inorg. & Nuclear Chem. 9, 320-2 (1959) Mar.

Values for the alpha half life of $Pu^{239}$ ranging from 24,000 ± 240 years to 24,400 ± 100 years are reported. The isotopic content of the plutonium used for the half life determination was as follows: 99.92% $Pu^{239}$, 0.072 ± 0.003% $Pu^{240}$, and 0.003 ± 0.001% $Pu^{241}$. (J.H.M.)

$Pu^{238}$ $\alpha$ DECAY. L. N. Kondrat'ev, G. I. Novikova, et al. Izvest. Akad. Nauk S.S.S.R. Ser. Fiz. 21, 907-8(1957) July. (In Russian)

The high excitation rotational states of $U^{234}$, recorded during $Pu^{238}$ $\alpha$ decay, were measured with a magnetic $\alpha$ spectrometer. The $Pu^{238}$ was obtained as the product of $Cm^{242}$ $\alpha$ decay formed during $Am^{241}$ bombardment in a flux of slow neutrons. A chromatographic method was used to achieve a complete separation of Pu and Am; thus $Am^{241}$ $\alpha$ lines were not observed in the obtained $\alpha$ spectra. Measurements at 40 and 110 hr were taken, and the decay scheme of $Pu^{238}$ and energy levels of $U^{234}$ are shown. Measurements revealed $\alpha$ lines with energies of 5.352 and 5.208 Mev. Intensities of corresponding transitions were 0.13 ± 0.01% and $(5 \pm 1) \times 10^{-3}$%. In the energy level from 5.210 to 5.350 Mev the intensity lines do not exceed $2 \times 10^{-3}$%. The weak $\alpha$ line obviously belongs to $Pu^{238}$. Results of all measurements are presented in tabular form. The levels fit well into the rotational scheme for even-even parity nuclei. (R.V.J.)

**6049**

BETA DECAY AND ELECTRON CAPTURE BRANCHING TO THE LEVELS OF $Pu^{239}$. Jack M. Hollander (Univ. of California, Berkeley). Phys. Rev. 105, 1518-20(1957) March 1.

The experimental log ft values of the $Np^{239}$ beta decay and $Am^{239}$ electron capture are analyzed according to the asymptotic selection rules proposed by Alaga for deformed nuclei. It is found that, with a reasonable choice of state assignments from the Nilsson energy level diagram, a consistent interpretation can be given of the observed logft values. All "allowed" transitions are retarded by a least an order of magnitude, whereas the "first forbidden" transitions observed here proceed with normal ft values. The interesting case of an "allowed" transition with log ft > 8 is discussed. (auth)

**9075**

HALF-LIFE OF $Pu^{236}$. Darlene C. Hoffman, George P. Ford, and Francine O. Lawrence (Los Alamos Scientific Lab., N. Mex.). J. Inorg. and Nuclear Chem. 4, No. 3 and 4, 143-5(1957).

The half-life of the alpha emitter, $Pu^{236}$, was measured by a direct decay method. Corrections were applied for the alpha-emitting daughters of $Pu^{236}$. The results of three sets of data were: 2.855 yr, s = 0.009 yr; 2.817 yr, s = 0.04 yr; 2.836 yr, s = 0.021 yr. The weighted average is 2.851 yr with s = 0.008 yr. (auth)

**11481**

ALPHA DECAY IN PLUTONIUM-237. Darleane C. Hoffman (Los Alamos Scientific Lab., N. Mex.). J. Inorg. and Nuclear Chem. 4, 383-5(1957).

**9561**

ENERGY LEVELS OF $Pu^{239}$ POPULATED BY THE BETA DECAY OF $Np^{239}$. J. M. Hollander, W. G. Smith, and J. W. Mihelich (Univ. of California, Berkeley). Phys. Rev. 102, 740-6(1956) May 1.

The conversion electron spectrum arising from the beta decay of 2.3-day $Np^{239}$ has been studied with three 180° permanent magnet photographic spectrographs. The following transitions, with multipolarities where known, were observed (energy in kev): 44.64 (M1 + E2), 49.40 (M1 + E2), 57.25 (E2), 61.4 (E1), 67.82 (E2), 106.1 (E1) 106.4, 181.8, 209.9 (M1), 226.4, 228.4 (M1), 254.6, 273.1, 277.7 (M1), 285.6, 316.1, and 334.5. Gamma-gamma coincidence experiments have also been performed. It is necessary in order to account for the present data to modify the previously accepted level scheme for $Pu^{239}$; a revised scheme is presented, with spin and relative parity assignments. The energy and intensity data are discussed in terms of the Bohr-Mottelson unified nuclear model. A rough measurement of the Auger coefficient in Z = 94 is reported, and also an experimental value for the K-electron binding energy in plutonium is given. (auth)

THE PREPARATION AND PROPERTIES OF $Pu^{242}$. J. P. Butler, M. Lounsbury, and J. S. Merritt (Atomic Energy of Canada Ltd., Chalk River, Ont.). Can. J. Chem. 34, 253-8 (1956) Mar.

Three samples of plutonium rich in $Pu^{242}$ and containing from 1.7 to 8.6% $Pu^{238}$ have been prepared by the neutron irradiation of $Am^{241}$. From mass analyses and measurements of the alpha abundance of $Pu^{242}$, the alpha half life of $Pu^{242}$ was determined as $3.73 \pm .05 \times 10^5$ yr. The spontaneous fission half life of $Pu^{242}$ was also measured as $6.6_4 \pm 0.10 \times 10^{10}$ yr. (auth)

# PLUTONIUM 1.28

## FISSION PRODUCTS, ISOTOPES, AND DECAY 1.28.03

### ACTIVITY SPECTRA 1.28.03.02

**7153** AEC-tr-2918
THE ATOMIC SPECTRUM OF PLUTONIUM. A. R. Striganov and L. A. Korostyleva (Korostileva). Translated by L. Bovey from Optika i Spektroskopiya 1, 957-64(1956). 6p.

**2929**
LONG RANGE PARTICLES EMITTED BY A $Pu^{239}$ SOURCE. Marie Ader. Compt. rend. 241, 1748-9(1955) Dec. 14. (In French)

Nuclear emulsions were exposed to a source of $Pu^{239}$ and were then examined for tracks of length greater than 50μ. The general characteristics of these longer tracks are discussed briefly. (B.J.H.)

**400**
DISTRIBUTION OF THE NUMBER OF PROMPT NEUTRONS FROM THE SPONTANEOUS FISSION OF $Pu^{240}$. J. E. Hammel and J. F. Kephart (Los Alamos Scientific Lab., N. Mex.). Phys. Rev. 100, 190-2(1955) Oct. 1.

A measurement of the distribution of the number of neutrons per fission of $Pu^{240}$ yielded the following probabilities, $P_m$, for 0,1,2, etc. neutrons: $P_0 = 0.062$, $P_1 = 0.198$, $P_2 = 0.374$, $P_3 = 0.228$, $P_4 = 0.114$, $P_5 = 0.027$, $P_6 = 0.000$. The measurement was made with a liquid scintillation counter. (auth)

**4207** HW-34431
Hanford Atomic Products Operation, Richland, Wash.
THE ALPHA HALF-LIFE OF THE ISOTOPE $Pu^{241}$. M. W. Gift. Feb. 15, 1955. Decl. Jan. 6, 1956. 10p. Contract W-31-109-eng-52. $1.80(ph OTS); $1.80(mf OTS).

A Pu solution of known $Pu^{241}$ content was purified by solvent extraction techniques to remove U and Am impurities. Portions of this purified solution were then analyzed for $U^{237}$ as a function of time. Since the growth of $U^{237}$ occurs directly by the α decay of $Pu^{241}$, these measurements provided sufficient data for calculation of the $Pu^{241}$ α half life, which was found to be $2.91 \pm 0.50 \times 10^5$ years.

**3666** CF-54-2-159
Oak Ridge National Lab., Tenn.
NUCLEAR CONSTANTS FOR $Pu^{239}$ AT 250°C AND 300°C. P. N. Haubenreich. Feb. 16, 1954. Decl. Dec. 6, 1955. 8p. Contract W-7405-eng-26. $1.80(ph OTS); $1.80(mf OTS).

Information from BNL-170, BNL-170B, and BNL-221 were used to evaluate the nuclear constants for $Pu^{239}$ at 250 and 300°C. Data are tabulated. (C.H.)

**2556** ANL-4926
Argonne National Lab., Lemont, Ill.
THE HALF-LIFE OF $Pu^{241}$. Joseph Mech and Gray Pyle. Dec. 1953. Decl. Dec. 9, 1955. 9p. Contract W-31-109-eng-38. $1.80(ph OTS); $1.80(mf OTS).

The β half life of $Pu^{241}$ was obtained by measuring the increase in the number of α particles due to $Am^{241}$ formed by the β decay of $Pu^{241}$ in samples of Pu of known isotopic constitutions. The value determined from measurements on 3 samples was 12.8 ± 0.3 years. (M.P.G.)

## FLUORIDES 1.28.04

PREPARATION OF HALIDES OF PLUTONIUM. C. S. Garner and I. B. Johns (to U. S. Atomic Energy Commission). U. S. Patent 2,851,332. Sept. 9, 1958.

A dry chemical method is described for preparing plutonium halides, which consists in contacting plutonyl nitrate with dry gaseous HCl or HF at an elevated temperature. The addition to the reaction gas of a small quantity of an oxidizing gas or a reducing gas will cause formation of the tetra- or tri-halide of plutonium as desired.

**2755** AEC-tr-3505
INVESTIGATION OF PHYSICOCHEMICAL PROPERTIES OF PLUTONYL FLUORIDE. (Izucheniye Fiziko-Khimicheskikh Svoistv Ftoristago Plutonila). Translated by Lydia Venters (Argonne National Lab.) from Zhur. Neorg. Khim. 3, 951-5(1958). 10p.

A technique of synthesis of $PuO_2F_2$ by its precipitation from chloride solutions of hexavalent Pu by liquid HF is presented. A chemical investigation of $PuO_2F_2$ is carried out; its composition expressed by the formula $PuO_2F_2$ is established on the basis of these studies. The electron and infrared absorption spectra of $PuO_2F_2$ proving the presence of $PuO_2^{2+}$ ions and the absence of tetravalent Pu in the compound were studied. The crystalline structure of $PuO_2F_2$ corresponding to rhombohedral lattice with constants a = 5.797 ± 0.005A; α = 42° ± 3′ was determined. The solubility of $PuO_2F_2$ in water at 20°C equal to 1.07 g/liter is established.

# PLUTONIUM 1.28

## FLUORIDES 1.28.04

**1321** ANL-5796
Argonne National Lab., Lemont, Ill.
THE TRANSFER OF PLUTONIUM HEXAFLUORIDE IN THE VAPOR PHASE. M. D. Adams, R. K. Steunenberg, and R. C. Vogel. Oct. 1957. 14p. Contract W-31-109-eng-38. $0.50(OTS).

Plutonium hexafluoride is decomposed by heat, by its alpha radiation, and by reactions with most materials of construction. Laboratory experiments were performed to investigate means by which plutonium losses due to these reactions can be minimized during vapor-phase transfers of the compound. The experiments showed that plutonium hexafluoride vapor could be transferred satisfactorily through well fluorinated nickel equipment in a stream of fluorine or helium. The decomposition product of plutonium hexafluoride was refluorinated at 250°C by fluorine. (auth)

**10113** NAA-SR-1649
Atomics International Div., North American Aviation, Inc., Canoga Park, Calif.
EXPERIMENTAL ESTIMATE OF FREE ENERGY OF FORMATION OF PLUTONIUM TRIFLUORIDE. A. G. Buyers. Sept. 1, 1956. 16p. Contract AT-11-1-GEN-8. $3.30(ph OTS); $2.40(mf OTS).

A study involving equilibration at 1573°K of fused $UF_4$ and molten irradiated U has permitted calculation of the free energy of formation $PuF_3$ at 1573°K. During equilibration, Pu is extracted into molten uranium fluoride as represented by one of the following equations: $\frac{1}{3}$ Pu (l) + $\frac{1}{4}$ $UF_4$ (l) $\rightleftharpoons$ $\frac{1}{3}$ $PuF_3$ (l) + $\frac{1}{4}$ U (l); $\frac{1}{3}$ Pu (l) + $\frac{1}{3}$ $UF_3$ (l) $\rightleftharpoons$ $\frac{1}{3}$ $PuF_3$ (l) + $\frac{1}{3}$ U (l); or, $\frac{1}{5}$ $UF_4$(l) + $\frac{1}{15}$ $UF_3$ (l) + $\frac{1}{3}$ Pu (l) $\rightleftharpoons$ $\frac{1}{3}$ $PuF_3$ (l) + $\frac{4}{15}$ U (l). Free energy values for the formation of $PuF_3$ are calculated from experimentally determined equilibrium constants and the free energies of formation of $UF_4$ and $UF_3$, using the expressions: $\frac{1}{3}\Delta F^\circ_{PuF_3} = \frac{1}{4}\Delta F^\circ_{UF_4} - 2.3\ R\ T \log K_e\ (UF_4)$; or $\frac{1}{3}\Delta F^\circ_{PuF_3} = \frac{1}{5}\Delta F^\circ_{UF_4} + \frac{1}{15}\Delta F^\circ_{UF_3} - 2.3\ R\ T \log K_e$ (for mixtures of $UF_4$ and $UF_3$). The free energy of formation at 1573°K for $PuF_3$ was found to be 93 Kcal/equivalent as compared to an estimated value of 94 Kcal/equivalent at 1500°K based on other work. (auth)

**10116**
PLUTONIUM HEXAFLUORIDE. C. J. Mandleberg, H. K. Rae, R. Hurst, G. Long, D. Davies, and K. E. Francis (Atomic Energy Research Establishment, Harwell, Berks, England). J. Inorg. and Nuclear Chem. 2, 358-60(1956) July.

The preparation of $PuF_6$ by the fluorination of $PuF_3$, $PuF_4$, or $PuO_2$ is described, and the effect of temperature, rate of flow of $F_2$, duration of reaction, and nature of the starting material is discussed in some detail. The formula $PuF_6$ has been confirmed by chemical analysis. Several properties of $PuF_6$ are described, including the vapor pressure, melting-point, decomposition under $\alpha$-particle irradiation, and reactions with $H_2O$ and $H_2SO_4$. (auth)

**~~10117~~**
PREPARATION AND PROPERTIES OF PLUTONIUM HEXAFLUORIDE AND IDENTIFICATION OF PLUTONIUM (VI) OXYFLUORIDE. Alan E. Florin, Irving R. Tannenbaum, and Joe F. Lemons (Los Alamos Scientific Lab., N. Mex.). J. Inorg. and Nuclear Chem. 2, 368-79(1956) July.

Plutonium hexafluoride has been identified and characterized. A method of preparation by the fluorination of $PuF_4$ is outlined. The vapor pressure, which corresponds closely to that of $UF_6$, has been measured between 0 and 63°C. The vapor pressure is represented by the equations: $Log_{10}P_{liquid}$ (mm) = 7.6923 − 1614.3/T and $Log_{10}P_{solid}$ (mm) = 10.841 − 2634.3/T. The boiling-point is 62.3°C. The heat of sublimation is calculated to be 12.1 kcal/mol. The melting point is 50.7°C. The heat of vaporization is 7.4 kcal/mol. The heat of fusion is 4.7 kcal/mol, and the corresponding entropy of fusion is 14.5 cal/mol °C. A study of the equilibrium, $PuF_4 + F_2 \rightleftharpoons PuF_6$, has resulted in values of 11.5 kcal/mol and 7.8 e.u. for $\Delta H$ and $\Delta S$ in the temperature range from 167 to 308°C. Respective values of 6.77 and −0.3 were obtained in the range from 308 to 600°. The rates of thermal decomposition and radiolysis were investigated. A solid compound produced when plutonium hexafluoride $PuF_6$ to moist air was identified as plutonium(VI) oxyfluoride, $PuO_2F_2$. (auth)

# PLUTONIUM 1.28

## FLUORIDES 1.28.04

**10118**

THE PROPERTIES OF PLUTONIUM HEXAFLUORIDE.
Bernard Weinstock and John G. Malm (Argonne National Lab., Lemont, Ill.). J. Inorg. and Nuclear Chem. 2, 380-94(1956) July.

$PuF_6$ is formed rapidly at 750°C by the reaction between $PuF_4$ and $F_2$, and high yields are obtained if the $PuF_6$ is quickly condensed. $AmF_6$ is not produced under similar conditions. Techniques for the handling, purification, and storage of $PuF_6$ are described. The molecular structure and crystal structure of $PuF_6$ are the same as those of $UF_6$. The melting-point of $PuF_6$ is 50.75°C. Radiation decomposition of $PuF_6$ into $PuF_4$ and $F_2$ occur at the rate of 1.5% per day for the solid phase. The rate of radiation decomposition is much smaller in the vapor phase, and the system may reach a steady state. Solid $PuF_6$ is slightly paramagnetic. The absorption spectrum of $PuF_6$ vapor shows six groups of bands between 5000 and 25,000 A, arising from electronic transitions in the molecule. $PuF_6$ is a strong fluorinating agent, and its reactions with $BrF_3$, $UF_4$, and $PuF_4$ are described. Thermal decomposition of $PuF_6$ is not observed at room temperature, but is found to be very rapid at 280°C. The equilibrium constant for the dissociation of $PuF_6$ into $F_2$ and $PuF_4$ is $1.86 \times 10^3$ at 220°C; at 25°C, $\Delta F^\circ = -7.6$ kcal mole$^{-1}$, $\Delta H^\circ = -8.3$ kcal mole$^{-1}$, and $\Delta S^\circ = -2.3$ cal mole$^{-1}$ deg$^{-1}$ for this dissociation. (auth)

**1312**

INFRARED SPECTRUM OF PLUTONIUM HEXAFLUORIDE.
N. J. Hawkins, H. C. Mattraw, and W. W. Sabol (Knolls Atomic Power Lab., Schenectady, N. Y.). J. Chem. Phys. 23, 2191-2(1955) Nov.

The infrared spectrum of $PuF_6$ was measured in the range 2 to 23 $\mu$. The molecule was assigned to $O_h$-symmetry. The vibrational contributions to thermodynamic properties were calculated from the fundamental vibration frequencies using the harmonic oscillator approximation. (C.W.H.)

**6143** N-1617

Chicago. Univ. Metallurgical Lab.
THE THERMODYNAMIC PROPERTIES OF SOME FLUORIDES OF U AND Pu. N. R. Davidson. Sept. 18, 1944. Decl. Jan. 30, 1956. 4p. (MUC-GTS-1012). $1.80 (ph OTS); $1.80 (mf OTS).

Data are summarized on the heat of formation, entropy, oxidation, and hydrolysis of $UF_4$. Chemical reactions involving plutonium fluorides are also discussed. (B.J.H.)

**19807** AERE-C/R-1042

Gt. Brit. Atomic Energy Research Establishment, Harwell, Berks, England.
SOME ASPECTS OF THE DRY CHEMISTRY OF PLUTONIUM FLUORIDES. J. K. Dawson, R. M. Elliott, R. Hurst, and A. E. Truswell. Nov. 7, 1952. Decl. July 10, 1953. 14p.

A method for the preparation of plutonium trifluoride and tetrafluoride on the milligram scale is described. The reaction of plutonium trifluoride with very dry oxygen has been studied and the free energy and heat of formation of plutonium tetrafluoride deduced from measurements of the oxygen pressure developed by the reverse reaction. The vacuum dehydration, and decomposition of plutonium tetrafluoride has also been investigated, $2PuF_4 \cdot 5H_2O$ in vacuum at 200°C gives $PuF_4 \cdot H_2O$ and at higher temperatures the main product of the dehydration is $PuF_3$. Anhydrous plutonium tetrafluoride undergoes disproportionation at 900°C in vacuum to give $PuF_3$ and probably the more volatile $PuF_5$. (auth)

**6413** A/CONF.15/P/2208

POLUCHENIE I SVOISTVA NEKOTORYKH DVOINYKH FTORIDOV CHETYREKHVALENTNOGO PLUTONIYA. (Preparation and Properties of Plutonium Fluorides.)
I. F. Alenchikova, L. L. Zaitseva, et al. (U.S.S.R.). 20p.

Some results of investigation on methods of preparing complex plutonium fluorides and studying their properties are presented. (auth)

# PLUTONIUM 1.28

## METALLURGY 1.28.05

A HISTORY OF THE EARLY BRITISH WORK ON PLUTONIUM METALLURGY. J. G. Ball (Imperial Coll. of Science and Tech., London) and W. B. H. Lord (A.W.R.E., Aldermaston, Eng.). J. Brit. Nuclear Energy Conf. 3, 225-36(1958) Oct.

The work on plutonium metallurgy from its beginning to the end of 1953 is described. The experiments included the use of dilatometry and thermal analysis to investigate the allotropy and alloying behavior of the metal, with other work on casting, forging and extrusion, electrical resistivity, magnetic susceptibility, and the determination of crystal structures. (J.E.D.)

RADIOGRAPHY AND AUTORADIOGRAPHY OF PLUTONIUM. D. E. Elliott and G. H. Tenney. J. Soc. Non-Destructive Testing 16, 430-7(1958) Sept.-Oct.

The use of radiography and autoradiography as inspection methods for plutonium is discussed. Experiments made on three samples examined by these techniques are described. The effect of various object-to-film distances, the effect of lead front screens as radiation filters, radiographic exposure data for Pu, and radiographic sensitivity were considered in the radiographic inspection of Pu. (auth)

**2976** HW-57130

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

THE TENSILE PROPERTIES OF PURE PLUTONIUM. H. R. Gardner and J. M. Jefferes. Aug. 6, 1958. 16p. Contract W-31-109-Eng-52. $0.50(OTS).

As-cast and as-cast delta-phase-annealed 0.250 and 0.500 inch diameter tensile specimens were tested at an average temperature of 31°C. The average tensile properties for as-cast plutonium of 99.50% purity, 19.50 g/cc density, and 270 DPH hardness are: ultimate strength, 62,000 psi; 0.02 per cent yield strength, 37,000 psi; modulus of elasticity, $13.8 \times 10^6$ psi; and modulus of resilience, 12.7 to 26.1 in.-lb/in.$^3$. A delta-phase anneal did not significantly alter the tensile properties of as-cast plutonium. (auth)

**13860**

NOTE ON THE SPECIFIC HEAT OF PLUTONIUM METAL. D. J. Dean, A. E. Kay, and R. G. Loasby (Atomic Weapons Research Establishment, Aldermaston, Berks, Eng.). J. Inst. Metals 86, 464(1958) June.

Values are reported for the specific heat of plutonium over the range −40° to 550°C and for the latent heats of transformation at the various phase transitions. (auth)

**13855** HW-55778

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

TRANSFORMATION KINETICS OF PLUTONIUM. PART I. A STUDY OF THE BETA TO ALPHA AND ALPHA TO BETA TRANSFORMATIONS. R. D. Nelson. Apr. 17, 1958. 26p. Contract W-31-109-Eng-52. $4.80(ph OTS); $2.70(mf OTS).

The transformation kinetics of alpha and beta plutonium were determined by using a fluid displacement technique. The rate of formation of the alpha phase from the beta phase was determined after beta heat treating and allowing the sample to transform isothermally in the alpha range. Isothermal reaction curves were obtained from −78 to +90°C. A time-temperature-transformation curve showed the maximum rate of transformation to be approximately −20°C. The beta phase did not transform completely to the alpha when the transformation was allowed to take place isothermally. A relationship between the fraction untransformed beta and the transformation temperature has been established. Isothermal reaction curves and a time-temperature-transformation curve of the $\alpha \rightarrow \beta$ transformation were obtained. Portions of the time-transformation curves of the $\beta \rightarrow \alpha$ transformation of four purities were plotted. The effects of beta heat treating times and temperatures were studied. Photomicrographs of a specimen having transformed from the beta to the alpha phase at different rates of transformation are presented. (auth)

**14724** A/CONF.15/P/1030

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

TRANSFORMATION KINETICS OF PLUTONIUM. R. D. Nelson and I. D. Thomas. 11p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The transformation kinetics of the alpha, beta, gamma, and delta phases of plutonium were determined using density measurements. Isothermal reaction curves of metastable beta, gamma, and delta were obtained and the time-temperature-transformation curves were sketched. The rate of transformation of alpha in the beta temperature range was determined. The temperature of the maximum rate of transformation of beta was between 0 and −20°C. The reaction was quite sluggish above 80°C. Increasing the amount of normal impurities decreases the rate of transformation and shifts the T-T-T- curves to the right. (auth)

# PLUTONIUM 1.28

## METALLURGY 1.28.05

REACTIONS OF Pu WITH OTHER METALS, AS RELATED TO THEIR POSITIONS IN THE PERIODIC TABLE BY D. I. MENDELEEV. A. A. Bochvar, S. T. Konobeevskii, et al. Atomnaya Energ. 5, 303-9(1958). (In Russian)

A report is presented on the regularities found in plutonium interactions with various metals as related to their position in the periodic table. A table of crystal structures of some binary compounds and phase diagrams for Pu alloyed with Al, Be, Bi, Co, Cr, Fe, Mo, Os, Pb, Th, U, and Zr are included. (R.V.J.)

**2847**

PLUTONIUM AND ITS ALLOYS. K. Q. Bagley (Culcheth Labs., U.K.A.E.A.I.G.). Nuclear Eng. 2, 461-8(1957) Nov.

The occurrence, availability, extraction, nuclear properties, physical properties, compatibility, fabrication, and handling of Pu and its alloys are described. (W.L.H.)

**170**

CRYSTAL STRUCTURE OF ALPHA-PLUTONIUM METAL. W. H. Zachariasen (Univ. of Chicago, Ill.) and Finley Ellinger (Los Alamos Scientific Lab., N. Mex.). J. Chem. Phys. 27, 811-12(1957) Sept.

**11134**

THE CRYSTAL STRUCTURE OF $PuAl_3$. Allen C. Larson, Don T. Cromer, and C. K. Stambaugh (Los Alamos Scientific Lab., N. Mex.). Acta Cryst. 10, 443-6(1957) July.

The crystal structure of $PuAl_3$ has been determined by single-crystal methods. The structure is hexagonal with $\alpha = 6.10 \pm 0.02$, $c = 14.47 \pm 0.04$ A, Z = 6 units of $PuAl_3$ per unit cell, and most probable space group $P6_3/mmc$. The structure is a new type of $AB_3$ structure and is an example of a type of hexagonal closest packing in which the stacking sequence is ...A B C A C B A..., rather than ...A B A B... as in the usual hexagonal closest-packing structure. This structure is related to that of the cubic substance $UAl_3$ through an ordered rearrangement of the close-packed layers parallel to the (111) plane and a slight distortion of this 'ideal' structure caused by the relative size difference between Pu atoms and Al atoms. (auth)

**16208** LA-1000

Los Alamos Scientific Lab., N. Mex.

ALLOYS OF PLUTONIUM WITH ALUMINUM. R. D. Moeller and F. W. Schonfeld. Feb. 13, 1950. Decl. Mar. 26, 1957. 71p. Contract [W-7405-eng-36]. $12.30(ph), $4.50(mf) OTS.

On the basis of incomplete data, tentative suggestions are made concerning features of the equilibrium diagram of aluminum–plutonium alloys. Data, deductions, and speculations are presented graphically as a tentative phase diagram. (J.E.D.)

THE LIMITING HEAT OF SOLUTION OF PLUTONIUM IN SOME RARE EARTH METALS. D. E. McKenzie, W. M. Jenkinson, and A. S. Denovan (Atomic Energy of Canada Ltd., Chalk River, Ont.). Can. J. Chem. 34, 1176-81 (1956) Sept.

The distribution of plutonium between neutron-irradiated U and some rare earth metals has been examined as a function of temperature in the range 1160 to 1350°C. The results are used to calculate $\bar{L}^{\circ}_{Pu}$, the limiting partial molal heat content of plutonium, at 1250°C in La, Ce, Nd, and a commercial preparation of mixed rare earths (misch metal). The following values (in kilocalories) were obtained: lanthanum 2.9, cerium 1.1, neodymium 0.0, and misch metal 1.1. The maximum error associated with these values is ±0.4 kilocalories. (auth)

**5911** AERE-C/R-985

Gt. Brit. Atomic Energy Research Establishment, Harwell, Berks, England.

THE MAGNETIC SUSCEPTIBILITY OF PLUTONIUM IN THE REGION 20-350°C. J. K. Dawson. July 17, 1952. 11p.

The magnetic susceptibility of Pu has been measured in the $\alpha$, $\beta$, $\gamma$, and $\delta$ phases, and the transition temperatures have been determined on the purest available material. The results are also discussed in terms of the possible electron states of the metal. (auth)

**12413** LA-1390

Los Alamos Scientific Lab., N. Mex.

A DETERMINATION OF THE COEFFICIENT OF THERMAL EXPANSION OF ALPHA PLUTONIUM. R. O. Elliott and R. E. Tate. Mar. 3, 1952. Decl. Mar. 26, 1957. 19p. Contract W-7405-Eng-36. $0.30(OTS).

The coefficient of linear expansion of alpha Pu has been determined for the range −180 to +100°C by the silica-tube and dial-indicator method. Included are a detailed description of the apparatus and a discussion of the method. (auth)

# PLUTONIUM 1.28

## METALLURGY 1.28.05

**3553** CN-795 ✓
Ames Lab., Ames, Iowa.
CHEMICAL RESEARCH—CHEMISTRY OF 94 (PLUTONIUM). Report for Month Ending July 15, 1943. Decl. Dec. 13, 1955. 5p. Contract [W-7405-eng-82]. (A-988). $1.80(ph OTS); $1.80(mf OTS).

The metallurgical separation of Pu from U metal was studied. In the process, the U is alloyed with Sn, the Sn–U alloy converted to hydride, the hydride dissolved in acid, and the Pu separated from this solution. Removal of 93% of the Pu from 90% of the U has been achieved. (C.W.H.)

**6835** ✓ A/CONF.15/P/2230
NEKOTORYE FIZICHESKIE SVOISTVA URANA, PLUTONIYA I IKH SPLAVOV. (Some Physical Properties of Uranium, Plutonium and their Alloys.) S. T. Konobeevskii (Konobeevsky), A. S. Zaimovskii (Zaimovsky), B. M. Levitskii (Levitsky), et al. (U.S.S.R.). 34p.

Data are given on the phase transformation heat of plutonium and on its latent heat of fusion. The results of investigations of the paramagnetic susceptibility of uranium and plutonium alloys with Co, Ni, Mn, Zr, Be, Al, and Fe are reported. The physical properties of metallic uranium were studied. The structure and physical properties of Mo–U alloys were studied and the equilibrium diagram is given. (J.S.R.)

**6784** ✓ A/CONF.15/P/327
QUELQUES PROPRIETES DU PLUTONIUM ET DE L'ALLIAGE ALUMINIUM–PLUTONIUM. (Some Properties of Plutonium and Its Alloys.) R. Abramson, R. Boucher, R. Fabre, and H. Monti (Commissariat à l'Énergie Atomique, Paris). 28p.

The results of a dilatometric study of the phase changes of very pure plutonium are reported. Very sharp phase changes with strong expansions from one phase to the other were observed. The $\delta \rightleftharpoons \delta'$ and $\delta \rightleftharpoons \epsilon$ transitions are very clear. The existence of a second order transformation in the $\delta$ phase on cooling was detected. The $\delta \rightleftharpoons \delta$ transformation is very rapid with a discontinuous character and it is independent of the cooling rate. In the $\epsilon$ phase the metal is plastic with deformations caused by very weak stresses. Al–Pu alloys were prepared with from 5 to 60 wt. % Pu. A comparative thermal analysis was made of Al–Pu and Al–U alloys and a precise determination was made of the temperature and eutectic compositions. The temperature of the peritectic reactions $UAl_3$ + liq → $UAl_4$ and $PuAl_3$ + liq → $PuAl_4$ was also determined. The coalescence kinetics of the Al–$PuAl_4$ eutectic were studied by a micrographic method and by following the evolution of hardness. The $PuAl_3$ → $PuAl_4$ transformation to the solid state was investigated. (J.S.R.)

**6768** ✓ A/CONF.15/P/71
**THE PHYSICAL METALLURGY OF PLUTONIUM.**
**M. B. Waldron, J. Garstone, J. A. Lee, P. G. Mardon, J. A. C. Marples, D. M. Poole, and G. K. Williamson (Atomic Energy Research Establishment, Harwell, Berks, Eng.). 24p.**

**Some physical properties of plutonium were redetermined using high-purity metal, including transition temperatures by thermal analysis and dilatometry, expansion coefficients, and thermo-electric power. Thermal properties and the kinetics of the $\alpha \rightleftharpoons \beta$ transformation were studied on metal of lower purity. The effect of aluminum additions on the negative expansion coefficient of the delta-phase was studied over the range 30 to 600°C. Partial or complete phase diagrams are presented for the alloy systems of plutonium with aluminum, iron, thorium, uranium, zirconium, and ternary uranium–molybdenum–plutonium alloys. (auth)**

PLUTONIUM CONSTITUTIONAL DIAGRAMS. F. W. Schonfeld, E. M. Cramer, W. N. Miner, F. H. Ellinger, and A. S. Coffinberry. p.579-99 in "Progress in Nuclear Energy. Series V. Metallurgy and Fuels. Volume 2."

The binary constitutional diagrams presented are taken from the report by Schonfeld and Ellinger (1956), with some additions and corrections. Data on which these diagrams are based are in most cases sufficient for tentative conclusions only, and all the diagrams should be considered subject to change and refinement as additional experimental data are determined. (auth)

# PLUTONIUM 1.28

## OTHER REACTIONS AND PROPERTIES 1.28.06

### COMPLEX FORMATION 1.28.06.01

**19874**

**THE COMPOSITIONS AND DISSOCIATION CONSTANTS OF THE EDTA COMPLEXES OF Pu(III) AND Pu(V). A. D. Gel'man, A. I. Moskvin, and P. I. Artyukhin. Atomnaya Energ. 7, 162-3(1959) Aug. (In Russian)**

**The ion exchange method was used in complexing Pu(V) with ethylenediaminetetraactetic acid (EDTA). Preliminary experiments carried out with macro-quantities of Pu(V) showed that it remained stable for several days. The original solution of Pu(V) was prepared by hydrogen peroxide recovery at pH = 3 to 4. The ion exchange method was also used in complexing Pu(III) in EDTA solution at pH 1.2 to 3.4. The partition of Pu(III) between the solution and adsorbent was carried out with an ion force of $\mu$ = (in 1M $NH_4Cl$). Complexing of various plutonium ions can be expressed by the sequence: $Pu^{4+} > Pu^{3+} > PuO_2^{2+} > PuO_2^{+}$. (R.V.J.)**

STUDIES OF COMPLEX FORMATION OF PENTAVALENT PLUTONIUM IN ETHYLENEDIAMINETETRAACETATE SOLUTIONS BY AN ION EXCHANGE METHOD. A. D. Gel'man, P. I. Artyukhin, and A. I. Moskvin (Inst. of Physical Chemistry, Academy of Sciences, U.S.S.R.). Zhur. Neorg. Khim. 4, 1332-5 (1959) June. (In Russian)

Studies of $PuO_2^{+}$ complex formation in ethylene diaminetetraacetate solutions showed that a complex ion $PuO_2Y^{3-}$, with dissociation constant $6.8 \times 10^{-11}$, forms in the pH 4 to 5 region. A relative tendency of plutonium to complex formation with $Y^{4-}$ ion was investigated, and it is shown that the tendency is in direct relation to the ion potential of plutonium in various valencies. (R.V.J.)

PLUTONIUM ALKOXIDES. D. C. Bradley, B. Harder, and F. Hudswell (Atomic Energy Research Establishment, Harwell, near Didcot, Berks). J. Chem. Soc. 3318(1957) July.

Since Pu appears not to form stable anhydrous tetrachloride, preparation of plutonium(IV) tetra-alkoxides started from the stable pyridinium chloride complex $(C_5H_6N)_2PuCl_6$. The complex chloride, when treated in suspension in benzene-propan-2-ol with excess $NH_3$, gave a soluble product corresponding in analysis to a mixture of $Pu(OPr)_4$ and $Pu(OPr)_4 \cdot C_5H_5N$. The Pu product, on crystallization from propan-2-ol, gave an emerald-green solvate $Pu(OPr)_4 \cdot PrOH$. (W.L.H.)

AEC-tr-3309

A STUDY OF COMPLEX OXALATES OF PLUTONIUM BY USING THE POLAROGRAPHIC METHOD. V.V. Fromin, S.P. Vorob'ev, and M.A. Andreev. Translated by the Oak Ridge Nat. Lab. Library Staff from Atomnaya Energ. 4, 57-62 (1958). 14p.

The composition and stability of complex ions of tri- and tetravalent plutonium in oxalate solutions were investigated. The oxalate ion concentration range was $10^{-13}$ to 1.2M, and a polarograph with an automatic recorder was used to produce the current-force-voltage curves. The experimental procedure is described, and results are tabulated. (J.R.D.)

**13862**

CARBONATE AND CARBONATE-OXALATE COMPLEX COMPOUNDS OF PLUTONIUM(IV). I. PLUTONIUM POTASSIUM CARBONATE. A. D. Gel'man and L. M. Zaitsev. Zhur. Neorg. Khim. 3, 1304-11(1958) June. (In Russian)

A method was developed for preparation of carbonate complex compounds of plutonium(IV). Four complexes of plutonium, $K_4[Pu(ClO_3)_4] \cdot nH_2O$, $K_6[Pu(CO_3)_5] \cdot (3 \text{ to } 4)H_2O$, $K_6[Pu(CO_3)_6] \cdot nH_2O$, and $K_{12}[Pu(CO_3)_8] \cdot nH_2O$, were prepared and investigated. It was found that the coördinated volume of the internal sphere of these complexes per $CO_3^{2-}$ ion can equal eight. (R.V.J.)

**8377**

POLAROGRAPHIC METHOD OF STUDIES OF COMPLEX PLUTONIUM OXALATES. V. V. Fomin, S. P. Vorol'ev, and M. A. Andreeva. Atomnaya Energiya 4, 57-62(1958) Jan. (In Russian)

Polarographic studies were made of the composition and stability of tri- and tetra-valent Pu in oxalate solutions. Complexes of $Pu(C_2O_4)_4^{4-}$ and $Pu(C_2O_4)_4^{5-}$ were formed in potassium oxalate solutions with pH 3.5 to 6. In the above conditions the $Pu^{4+}$ produced a well expressed wave reaction suitable for quantitative polarographic determination. The oxidation-reduction potential of the reaction in 1M potassium oxalate equaled 0.205 v. Two simultaneous complexes of $Pu^{4+}$ were observed in the solution with pH 6 to 8. The instability constants for the complex oxalate ions $Pu(C_2O_4)_3^{3-}$ and $Pu(C_2O_4)^{5-}$ were determined on the basis of the solubility of $Pu(C_2O_4)_3^{3-}$ and on the basis of the polarographic data for $Pu(C_2O_4)_4^{4-}$. (tr-auth)

# PLUTONIUM 1.28

## OTHER REACTIONS AND PROPERTIES 1.28.06

### COMPLEX FORMATION 1.28.06.01

PREPARATIONS AND PROPERTIES OF HEXAVALENT PLUTONIUM OXALATE COMPLEXES. A. D. Gel'man and L. E. Drabkina. Zhur. Neorg. Khim. 3, 1105-8 (1958) May. (In Russian)

A solution of plutonyl oxalate was prepared and the formula determined as $PuO_2C_2O_4 \cdot 3H_2O$. The solubility of plutonium oxalate in nitric acid (0.5 to 3N) in the presence of oxalic acid and ammonium oxalate was determined. The formula for simple complex plutonium, obtained in plutonium oxalate solution in aluminum oxalate, is written as $(NH_4)_2(PuO_2(C_2O_4)_2)$. (R.V.J.)

~~8378~~

INVESTIGATION OF THE OXALATE AND CARBONATE COMPLEXES OF PLUTONIUM(IV) IN AQUEOUS SOLUTIONS BY THE SOLUBILITY METHOD. A. D. Gel'man and A. I. Moskvin. Doklady Akad. Nauk S.S.S.R. 118, 493-6 (1958). (In Russian)

The content and instability constants of oxalate and carbonate complexes of $Pu^{4+}$ were analyzed. The solubility of $Pu(C_2O_4)_2 \cdot 6H_2O$ in various solutions and the solubility of $Pu(OH)_4$ in aqueous solutions of $K_2CO_3$ are tabulated. A qualitative comparison of the relative tendencies of $Pu^{3+}$, $Pu^{4+}$, and $Pu^{6+}$ to complex formation was made, based on data on the stability of Pu oxalate complex ions in various valence states. Tables of ionic potentials of Pu in various valence states and instability constants of complex $Pu^{4+}$ ions are included. (R.V.J.)

PYROLYSIS OF Pu(IV) AND Pu(III) OXALATES. R. E. Kartushova, T. I. Rudenko, and V. V. Fomin. Atomnaya Energ. 5, 24-8(1958). (In Russian)

It is shown that freshly precipitated Pu(IV) oxalate loses three molecules of water. After 3 to 4 days an additional 1.5 to 2.7% of CO + $CO_2$ precipitates due to the disintegration of oxalate under Pu $\alpha$ irradiation at 110°C. Simultaneously, partial recovery of Pu(III) takes place. Two additional water molecules and 13% CO + $CO_2$ precipitate at 170 to 200°C with the recovery of Pu(III) in the initial $Pu_2(C_2O_4)H_2O$; at 380°C the oxalate transforms into $PuO_2$. At 140°C the oxalate of Pu(III) completely dehydrates and at 270°C in the atmosphere it transforms into $PuO_2$. In inert media at 330°C oxalate decomposes forming carbonate oxalate. At 460°C the carbonate oxalate decomposes and Pu(III) oxidizes into Pu(IV) with the formation of dioxide. (tr-auth)

5246

SOLUBILITY AND ION EXCHANGE METHODS FOR DETERMINING THE COMPLEX FORMATION OF PLUTONIUM AND AMERICIUM III IN AQUEOUS SOLUTIONS. A. I. Moskin. Radiokhimiya 1, 430-4(1959). (In Russian)

The formation of Pu(IV) complexes in phosphoric acid solutions and the dissociation constants of Pu(IV) phosphate complexes were studied by solubility methods. The Me: addend ratio of various Pu(IV) phosphate complexes and complexes of other investigated systems tends to shift, with the increase of complex forming agent concentration, toward the side of complexes with larger coordination numbers. The method of ion exchange was used in studies of tri- and pentavalent plutonium complex formation in oxalate and ethylenediaminetetraacetate solutions. Also, the distribution of small quantities of plutonium and americium between the solutions and KU-2 ammonium resin was studied with and without a complex forming agent in the pH range 1 to 5 at 20 ± 1°C. The content of plutonium and americium(III) was determined radiometrically. The pK magnitudes for examined complexes were calculated using the pK equation calculated for trivalent transuranium elements, and $pK = 0.0645 \times A^{1.24}$. The pK's for Np(III) and Bk(III) EDTA complexes were also estimated. The similarity of trivalent plutonium and americium behavior was observed as well as the behavior of tetra, penta-, and hexavalent plutonium with other actinides of identical valence. (R.V.J.)

~~10504~~

THE NITRATE COMPLEXES OF TETRAVALENT PLUTONIUM. Presented at Nuclear Engineering and Science Conference, held at Chicago, March 17 to 21, 1958. Preprint 8, Session 37. J. A. Brothers, R. G. Hart, and W. G. Mathers (Atomic Energy of Canada, Ltd.). New York, American Institute of Chemical Engineers, 1958. 15p.

An equilibration technique using liquid amines possessing ion exchange properties has been used to study the nitrate complexes of tetravalent plutonium. It has been shown that practically all the plutonium present in nitrate salt solutions above 1 M or in 1 to 4 M nitric acid is present as undissociated $Pu(NO_3)_4$. The plutonium species which absorbs on anion exchange resins has been shown to be $Pu(NO_3)_6^{2-}$. A study of the spectra in liquid amine-toluene solution and in 11 M nitric acid has led to the conclusion that $H_2Pu(NO_3)_6$ is the sole tetravalent plutonium species present in strong nitric acid. Spectra at intermediate nitric acid concentrations suggest the possibility of the existence of the species $HPu(NO_3)_5$. (auth)

# PLUTONIUM 1.28

## OTHER REACTIONS AND PROPERTIES 1.28.06

### COMPLEX FORMATION 1.28.06.01

**13333** CEA-tr-R-638
OXALATES COMPLEXES DU PLUTONIUM(IV). (Complex Oxalates of Plutonium(IV)). A. D. Gel'man (Guelman) and L. P. Sokhina. Translated into French by B. de Trezvinski from Zhur. Neorg. Khim. 3, 1100-4(1958). 15p.
This paper was previously abstracted from the original language and appears in NSA, Vol. 13, as abstract No. 3635.

**11138**
CHLORIDE COMPLEX IONS OF Pu(VI). T. W. Newton and F. B. Baker (Los Alamos Scientific Lab., N. Mex.). J. Phys. Chem. 61, 934-8(1957) July.
The effect of chloride ion on the absorption spectrum of Pu(VI) has been investigated in solutions with $\mu = 2$. At eight different wave lengths the absorption was determined as a function of ($Cl^-$) from 0 to 1.8 M. Making the usual assumptions, it was found that the data at any one wave length were consistent with the formation of a single complex ion with a constant association quotient and constant absorptivity. However, the apparent association quotients obtained in this way were not constant, but were a function of wave length. In order to explain this behavior it was found necessary to assume that a higher complex is present, the absorptivities are dependent on ($Cl^-$) at some of the wave lengths, or both. Experiments at 50° indicated more complexing at higher temperatures. (auth)

**2354** UCRL-226
California. Univ., Berkeley. Radiation Lab.
THE ACTIVITY COEFFICIENT OF PLUTONIUM(IV) SALTS IN ACIDIC SOLUTIONS. R. E. Connick and W. H. Reas. Nov. 1948. Decl. Dec. 7, 1955. Contract W-7405-eng-48B. $9.30(ph OTS); $3.60(mf OTS).
The activity coefficient of $Pu(ClO_4)_4$ was measured in perchloric acid solutions. The procedure used was to measure the extraction of the neutral plutonium(IV)-TTA chelate into benzene-TTA solutions at different perchloric acid concentrations. Equations are presented which show the relation of the extraction coefficients, obtained in the above manner, to the activity coefficient of plutonium(IV) perchlorate. (auth)

**14362** ✓ CEA-tr-R-641
PREPARATION ET ÉTUDES DE PROPRIÉTÉS DE QUELQUES COMPLEXES OXALIQUES DU PuVI. (Preparation and Study of the Properties of Some Pu(VI) Oxalic Complexes.) A. D. Gelman (Guelman) and L. E. Drabkina. Translated into French by B. de Trezvinsky from Zhur. Neorg. Khim. 3, 1105-8(1958). 10p.
This paper was previously abstracted from the original language and appears in NSA, Vol. 13, as abstract No. 3633.

### GENERAL 1.28.06.02

**4550** IGR-161(RD/R)
United Kingdom Atomic Energy Authority. Industrial Group H. Q., Risley, Lancs, England.
PLUTONIUM DATA MANUAL. E. L. Francis, comp. June 1, 1959. 44p. BIS.
A compilation of the best available unclassified data on the physical, mechanical, and chemical properties of plutonium and some of its alloys is presented. A list of references (37) cited is appended. (J.R.D.)

METHOD OF MAKING PLUTONIUM DIOXIDE. C. S. Garner (to U. S. Atomic Energy Commission). U. S. Patent 2,868,620. Jan. 13, 1959.
A process is presented for converting both trivalent and tetravalent plutonium oxalate to substantially pure plutonium dioxide. The plutonium oxalate is carefully dried in the temperature range of 130 to 300°C by raising the temperature gradually throughout this range. The temperature is then raised to 600°C in the period of about 0.3 of an hour and held at this level for about the same length of time to obtain the plutonium dioxide.

PREPARATION OF PLUTONIUM HALIDES. N. R. Davidson and J. J. Katz (to U. S. Atomic Energy Commission). U. S. Patent 2,859,097. Nov. 4, 1958.
A process is presented for the preparation of plutonium trihalides. Plutonium oxide or a compound which may be readily converted to plutonium oxide, for example, a plutonium hydroxide or plutonium oxalate is contacted with a suitable halogenating agent. Specific agents mentioned are carbon tetrachloride, carbon tetrabromide, sulfur dioxide, and phosphorus pentachloride. The reaction is carried out under superatmospheric pressure at about 300°C.

# PLUTONIUM 1.28

## OTHER REACTIONS AND PROPERTIES 1.28.06

### GENERAL 1.28.06.02

THE PREPARATION AND PROPERTIES OF SOME PLUTONIUM COMPOUNDS. PART VIII. PLUTONIUM(IV) SULPHATE. J. L. Drummond and G. A. Welch (U. K. Atomic Energy Authority, Dounreay, nr. Thurso, Caithness, Eng.). J. Chem. Soc. 3218-19(1958) Sept.

Plutonium(IV) sulfate was prepared from purified plutonium nitrate solution by repeated evaporation with fuming sulfuric acid and heating between 450 and 650°C. The sulfate was moistened with 18N sulfuric acid and heated at the same temperature until the weight was constant to within 0.1%. (auth)

**13218** ✓ HW-55357

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

SOLUBILITY OF PLUTONIUM(IV) SULFATE IN NITRIC ACID SOLUTIONS. H. D. Warren and A. Brunstad. Mar. 14, 1958. 9p. Contract W-31-109-Eng-52. $1.80(ph), $1.80(mf) OTS.

The solubility of Pu(IV) sulfate in 2, 4, and 6 M $HNO_3$ solutions was determined at 25°C and in 6 M $HNO_3$ at 55°C. Log-log plots of the solubility data resulted in a family of curves concave away from the axis rather than the expected straight lines. An explanation for the deviation is presented. (J.R.D.)

**9765** ✓

A SIMPLE PREPARATION OF Pu(VI) SULPHATE SOLUTIONS. D. W. Grant (Atomic Energy Research Establishment, Harwell, Berks, Eng.). J. Inorg. and Nuclear Chem. 6, 69-71(1958) Feb.

Plutonium(VI) sulfate has been prepared by ozone conversion of plutonium(IV) sulfate. It is pointed out that while this conversion is quantitative, it may be limited to dilute sulfuric acid solutions because of the reduction of plutonium(VI) by water at high acid concentrations.

EMISSION AND ABSORPTION SPECTRA OF PLUTONIUM EXCITED IN A KING FURNACE. L. Bovey (Atomic Energy Research Establishment, Harwell, Berks, Eng.). Spectrochim. Acta 10, 383-94(1958) Feb.

A list is given of wavelengths of plutonium absorption and emission lines excited in a King-type furnace and photographed in the second order of a 3 m grating instrument over the region 2791-6888 Å. The problems connected with measurement of such lines are briefly discussed and tentative conclusions reached from an attempt to find the energy levels are given. (auth)

**4436** CEA-796

France. Commissariat à l'Énergie Atomique, Paris.

BIBLIOGRAPHIE SUR LE PLUTONIUM ET SES COMPOSÉS. (Bibliography on Plutonium and its Compounds.) J. Dirian and J. Choquet. Jan. 1958. 103p.

A bibliography is presented which contains 937 references to scientific journals and reports of the USAEC, AECL, and the UKAEA. The following topics, with relation to Pu, are covered: preparation, extraction, purification, determination, analysis, physical properties, nuclear properties and isotopes, chemical properties, metallurgy, alloys, and principal compounds. (T.R.H.)

**14721** A/CONF.15/P/701

Los Alamos Scientific Lab., N. Mex.

THERMODYNAMICS AND PHASE RELATIONSHIPS FOR PLUTONIUM OXIDES. C. E. Holley, Jr., R. N. R. Mulford, E. J. Huber, Jr., E. L. Head, F. H. Ellinger, and C. W. Bjorklund. 13p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A compilation of available fundamental information concerning plutonium oxides. Methods of preparation, thermodynamic data, phase relationships, crystal structures. and some information on mixed oxide systems are considered. A bibliography is included. Methods of preparing $PuO_2$ by the peroxide and the oxalate processes and of lower oxides by the reduction of $PuO_2$ are described and some chemical properties of plutonium oxides of interest in processing ceramic fuel elements are given. The fabrication of $PuO_2$ into discs is discussed. Measurements of heats of combustion of Pu, and $Pu_2O_3$ are described and the heats of formation of lower oxides and $PuO_2$ are given. Free energy data obtained by combining estimated entropies with the measured heats of formation are tabulated for the oxides. A tentative phase diagram for the Pu-O system is presented which includes the limiting solubility of oxygen in liquid plutonium, the ranges of stability of the three known oxide phases, hexagonal $Pu_2O_3$, a cubic oxide inaccurately designated as "cubic $Pu_2O_3$," and $PuO_2$, and some melting point data. (The crystal structures of the plutonium oxides have already been described in the literature and this will be reviewed.) Crystal structure data and methods of preparation for the $PuO_2$-$UO_2$, $PuO_2$-$ThO_2$, and $PuO_2$-$CeO_2$ solid solutions are described. (auth)

**4512**

THE CRYSTAL STRUCTURES OF PuAs, PuTe, PuP AND PuOSe. Alvin E. Gorum (Los Alamos Scientific Lab., N. Mex.). Acta Cryst. 10, 144(1957) Feb.

# PLUTONIUM 1.28

## OTHER REACTIONS AND PROPERTIES 1.28.06

### GENERAL 1.28.06.02

14363 ✓ CEA-tr-R-642
PREPARATION ET ÉTUDE DES PROPRIÉTÉS DE CERTAINS CARBONATES DE PuVI. (Preparation and Study of the Properties of Some Pu(VI) Carbonates.) L. E. Drabkina. Translated into French by B. de Trezvinsky from Zhur. Neorg. Khim. 3, 1109-10(1958). 6p.

This paper was previously abstracted from the original language and appears in NSA, Vol. 13, as abstract No. 3634.

317
CONVERSION CHEMISTRY OF PLUTONIUM NITRATE. M. K. Harmon and W. H. Reas. May 1, 1957. p.332-48 of SYMPOSIUM ON THE REPROCESSING OF IRRADIATED FUELS HELD AT BRUSSELS, BELGIUM, MAY 20-5, 1957. 1165p. (TID-7534(Bks. 1-3); HW-49597A)

THE ELECTRONIC STRUCTURE AND MAGNETIC PROPERTIES OF URANYL-LIKE IONS. II. PLUTONYL. J. C. Eisenstein (Pennsylvania State Univ., University Park) and M. H. L. Pryce (Univ. of Bristol, England). Proc. Roy. Soc. (London) A238, 31-45(1956) Dec. 4.

The electronic configuration and bonding in $(PuO_2)^{2+}$ are considered. The calculated energy levels can be correlated satisfactorily with the absorption spectrum of $(PuO_2)^{2+}$ in aqueous solution by a plausible choice of numerical parameters. The microwave resonance absorption and paramagnetic susceptibility are derived on the basis of the model, and are in good agreement with experimental results. (auth)

THE PREPARATION AND PROPERTIES OF SOME PLUTONIUM COMPOUNDS. PART V. COLLOIDAL QUADRIVALENT PLUTONIUM. D. W. Ockenden and G. A. Welch (U. K. Atomic Energy Authority, Windscale Works, Cumb., England). J. Chem. Soc., 3358-63(1956) Sept.

Colloidal, or polymeric, quadrivalent Pu has been separated from the ionic species of Pu by ion exchange. The absorption spectrum of the colloid is distinctive, quite different from those of other species of Pu and varies slightly with the method of preparation. The rate of formation of the polymer in dilute $HNO_3$, its stability in more concentrated acid, its adsorption on certain surfaces, and other properties have been studied. The minimum and maximum molecular weights of the colloid have been calculated from diffusion experiments and from work with nuclear emulsion plates. (auth)

4402
PRECIPITATION CONDITIONS FOR TRACE AMOUNTS OF PLUTONIUM WITH MANDELIC ACID AS PRECIPITATION REAGENT. E. Merz (Max-Planck-Institut für Chemie, Mainz). Z. anal. Chem. 166, 417-22(1959). (In German)

Mandelic acid and its derivative p-bromomandelic acid were found to be suitable precipitation reagents for tri- and tetravalent Pu ions. $Pu^{3+}$ is precipitated by both reagents from very weak acid solutions together with Yb carrier. $Pu^{4+}$ on the other hand is precipitated almost completely from strongly acid solutions with Zr carrier while $Pu^{3+}$ remains in solution. Under these conditions $Pu^{6+}$ is neither in neutral nor in acid solution taken down. This new reagent is so effective that certain valences of Pu can be separated from each other. Moreover it is possible to separate $Pu^{4+}$ from U in weakly acid solutions. The p-bromomandelic acid is superior to D, L-mandelic acid both in speed and completeness of precipitation. (T.R.H.)

1323 HW-44744
General Electric Co. Hanford Atomic Products Operation, Richland, Wash.
ABSORPTION SPECTRA OF PLUTONIUM AND IMPURITY IONS IN NITRIC ACID SOLUTION. M. N. Myers. July 31, 1956. Decl. Sept. 16, 1957. 22p. Contract W-31-109-Eng-52. $0.50(OTS).

10115
THE PREPARATION AND PROPERTIES OF SOME PLUTONIUM COMPOUNDS. PART IV. CRYSTALLINE PLUTONIUM NITRATE. J. L. Drummond and G. A. Welch (Chemical Defence Experimental Establishment, Porton, Wilts, England). J. Chem. Soc., 2565-7(1956) July.

A gummy semicrystalline solid phase is formed when concentrated solutions of $Pu^{4+}$ in 1 to 4 M $HNO_3$ is evaporated the composition of which is not known. It was found that concentrated solutions of Pu tetranitrate in acid will deposit well-formed crystals when allowed to evaporate. Chemical and spectrographic analysis has shown that Pu is the only cation and nitrate the only anion present in the crystals. (W.L.H.)

239
THE KINETICS OF THE REACTION BETWEEN $Pu^{3+}$ AND $PuO_2^{2+}$. A. E. Ogard and S. W. Rabideau (Los Alamos Scientific Lab., N. Mex.). J. Phys. Chem. 60, 812-13(1956) June.

# PLUTONIUM 1.28

## OTHER REACTIONS AND PROPERTIES 1.28.06

### GENERAL 1.28.06.02

**4567**

THE PLUTONIUM–URANIUM SYSTEM. F. H. Ellinger, R. O. Elliott, and E. M. Gramer (Los Alamos Scientific Lab., N. Mex). J. Nuclear Materials 1, 233-43(1959) Oct. (In English)

The plutonium-uranium phase diagram was constructed from thermal, dilatometric, metallographic and x-ray diffraction data. All alloys solidify as a body-centered cubic solid solution, the phase resulting from the complete mutual solid solubility of epsilon plutonium and gamma uranium. Epsilon plutonium is the only plutonium allotrope in which uranium is appeciably soluble, whereas alpha uranium dissolves a maximum of 15 at % plutonium, and beta uranium dissolves about 20 at % plutonium. Two intermediate phases, both having wide homogeneity ranges, exist in this alloy system, and one of them is stable at elevated temperatures only. (auth)

**2676**

THE PREPARATION AND PROPERTIES OF SOME PLUTONIUM COMPOUNDS. PART II. PLUTONIUM NITRIDE. F. Brown, Heather M. Ockenden, and G. A. Welch (U. K. Atomic Energy Authority (Industrial Group), Windscale Works, Cumberland, England). J. Chem Soc. 4196-4201(1955) Dec.

Plutonium nitride has been prepared by two methods: by heating the metal in nitrogen to a high temperature and by heating plutonium hydride in nitrogen to a temperature above 230°. In each case the product was the same, PuN. Unlike the mixture of refractory uranium nitrides obtained under similar conditions, plutonium nitride is quite reactive and very easily decomposed. Complete hydrolysis occurred within a few hours at 80 to 90° in moist air or within a few days at room temperature. The use of a thermobalance has provided data on the formation and oxidation of the nitride. (auth)

**4567**

THE PREPARATION AND PROPERTIES OF SOME PLUTONIUM COMPOUNDS. PART I. PLUTONIUM HYDRIDE. F. Brown, Heather M. Ockenden, and G. A. Welch (United Kingdom Atomic Energy Authority (Industrial Group, Windscale Works, Cumberland, England). J. Chem. Soc., 3932-6(1955) Nov.

Plutonium hydride with the approximate composition $PuH_{2.7}$ has been obtained by direct combination of Pu with $H_2$ at temperatures between 150 and 250°C. Its chemical properties have been found to be very similar to those of Pu. By means of a thermobalance the hydride has been found to be stable in air up to 150°C. X-ray-diffraction photographs showed two patterns, one of which was cubic and similar to that of $PuO_2$, and the other hexagonal. (auth)

**12414** LA-1869

Los Alamos Scientific Lab., N. Mex.

SOME OBSERVATIONS ON THE REACTIVITY OF PLUTONIUM DIOXIDE. C. W. Bjorklund and Eugene Staritzky. Nov. 1, 1954. Decl. Oct. 23, 1957. 21p. Contract W-7405-Eng-36. $0.75(OTS).

The index of refraction of $PuO_2$ made by thermal decomposition of $Pu(C_2O_4)_2 \cdot 6H_2O$ gradually increases from a value < 1.9 to 2.40 as the decomposition temperature is increased from 150° to 1000°C. This change in refractive index parallels a gradual change in the x-ray-diffraction pattern from weak, diffuse lines for $PuO_2$ ignited at 150° to sharp, well-resolved lines for $PuO_2$ ignited at 1000°C. Similar results are observed for $PuO_2$ made by thermal decomposition of $Pu_2(C_2O_4)_3 \cdot 11H_2O$. The refractive index of $PuO_2$ made from Pu metal at 170°C is 2.40 and is not affected by further ignition at higher temperatures, although crystal growth does occur. The rate of solution of $PuO_2$ in an HCl–KI solution is greatest for samples prepared at low temperatures and decreases markedly for oxides ignited at higher temperatures. These observations have been interpreted to mean that ignition at higher temperatures causes a gradual perfection of the originally highly distorted and impurity-containing $PuO_2$ lattice obtained by low temperature decomposition of the oxalates and promotes the slow growth of crystallites. Both factors decrease the reactivity of the $PuO_2$. (auth)

# PLUTONIUM 1.28

## OTHER REACTIONS AND PROPERTIES 1.28.06

### GENERAL 1.28.06.02

**8375** KAPL-1007
Knolls Atomic Power Lab., Schenectady, N. Y.
INFRARED SPECTRUM AND THERMODYNAMIC PROPERTIES OF $PuF_6$. N. J. Hawkins, H. C. Mattraw, and W. W. Sabol. May 24, 1954. Decl. Oct. 13, 1955. 21p. Contract W-31-109-Eng-52. $0.15(OTS).

The infrared spectrum of $PuF_6$ was observed from 2 to 23 $\mu$. The spectrum exhibited a very intense band centered at 617 $cm^{-1}$ which was assigned as the fundamental $\nu_3$. A number of combination bands was observed which indicated that the molecule had the symmetry of the $O_h$ point group and from which values of the other five fundamental vibration frequencies could be calculated. Upon comparison of the vibration spectrum of $PuF_6$ with $UF_6$, it was noted that the Pu–F bond distance is shorter than the U–F bond distance in $UF_6$. The heat capacity at constant pressure, the entropy, and the free energy function $-(F^0-E_0^0)/T$ were calculated for various temperatures between 100 and 500°K for one mol of the perfect gas at atmospheric pres sure using the harmonic oscillator–rigid rotor approximation. The results at 25°C are: $C_p^0$ is 30.901, $S^0$ is 88.03, and $-(F^0-E_0^0)/T$ is 67.24, all in cal/°K/mol. (auth)

**12436** LA-2291
Los Alamos Scientific Lab., N. Mex.
THE PREPARATION OF HIGH-PURITY PLUTONIUM DIOXIDE AND PLUTONIUM(III) CHLORIDE SOLUTION. James E. Rein, Arthur L. Langhorst, Jr., and Maxine C. Elliott. Jan. 12, 1953. [Issued] Apr. 3, 1959. 25p. Contract W-7405-eng-36. $1.00(OTS).

A method is described for the preparation of high-purity $PuO_2$. The purification process consists of a partial removal of impurities by electrolysis into a Hg cathode and a subsequent further purification by precipitation of the Pu as the peroxide. The peroxide precipitate is ignited to the dioxide at 900°C in a platinum-lined furnace under noncontaminating conditions. The product contained about 2 ppm Mn as the only detectable metal impurity exceeding 1 ppm. This high quality is readily reproduced batchwise. The preparation of a high-purity Pu(III) chloride solution is readily achieved by dissolving the above-mentioned peroxide in quartz-distilled HCl. (auth)

**4447** AERE-M/R-1181
Gt. Brit. Atomic Energy Research Establishment, Harwell, Berks, England.
AN APPROXIMATE DETERMINATION OF THE SPECIFIC HEAT OF $\alpha$-PLUTONIUM. P. G. Mardon, J. A. L. Robertson, and J. G. Ball. Apr. 30, 1953. Decl. Dec. 20, 1956. 11p.

A description is given of a calorimetric method for determining the specific heat of $\alpha$ plutonium. The results are tabulated and a value for the atomic heat of the metal calculated. The significance of the latter result is discussed. The specific heat is found to be 0.036 ± 0.0025 cal/gm/°C over the temperature range 20° to 80°C. This corresponds to an atomic heat of 8.6 ± 0.6 cal/°C. (auth)

[Chicago. Univ.] Metallurgical Lab.
CHEMICAL RESEARCH—BASIC CHEMISTRY OF PLUTONIUM REPORT FOR MONTH ENDING JUNE 1, 1944. June 26, 1946. ~~Decl. Dec. 13, 1955.~~ 35p. (A-2431) ~~$6.30(ph OTS); $3.00(mf OTS).~~ (CN-1702)

Progress is reported in the following studies: measurements of oxidation potentials of Pu(III)–Pu(IV) couples; measurements of the solubilities of Pu(III) and Pu(IV) phosphates and Pu(III) and Pu(IV) oxalates in HCl or $HNO_3$ at various temperatures; the co-separation of Pu with various carriers; the crystal structure of Pu(IV) phosphate and oxalate; the ether extraction of Pu; the hydrolysis of Pu(III) and Pu(IV); the precipitation of $Pu(OH)_4$ from nitrate and from sulfate solution; the rate of oxidation of Pu(IV) by $HNO_3$ in various concentrations of $H_2SO_4$; the rate of reduction of Pu(IV) by $SO_2$; the rate of oxidation of Pu(IV) by ceric nitrate and by dicromate in nitric acid; variations in the optical density of the Pu(III) absorption bands with concentration of Pu; basic chemical studies on the $BiPO_4$ extraction of Pu; and the purification of Pu following recovery from a large variety of materials.

**2350** LA-639
[Los Alamos Scientific Lab., N. Mex.]
THERMAL ANALYSIS OF PLUTONIUM. L. G. Doom and Robert Kamm. May 28, 1944. Decl. Dec. 8, 1955. 12p. Contract [W-7405-eng-36]. $3.30(ph OTS); $2.40(mf OTS).

The apparatus used for determination of thermal arrests in Pu was essentially a vacuum furnace with means of obtaining a fairly constant rate of temperature increase of the sample while measuring the sample temperature accurately. A melting point of 627 ± 3°C was established. (L.M.T.)

# PLUTONIUM 1.28

## OTHER REACTIONS AND PROPERTIES 1.28.06

### IRRADIATION EFFECTS 1.28.06.03

**5320** ✓ **LAMS-2236**
**Los Alamos Scientific Lab., N. Mex.**
**ALPHA-PARTICLE OXIDATION AND REDUCTION IN AQUEOUS PLUTONIUM SOLUTIONS. Sherman W. Rabideau, Mildred J. Bradley, and Helen D. Cowan. June 1958. 28p. Contract W-7405-eng-36. $1.00 (OTS).**

**Studies were made of the rate of change of the mean oxidation number of plutonium solutions in perchloric, hydrochloric, and in mixed perchloric-hydrochloric acid solvents. Hydrogen peroxide concentrations were determined in the plutonium solutions. The hydrogen peroxide concentrations in perchloric acid solutions of plutonium are markedly dependent upon the temperature. The higher hydrogen peroxide concentrations are found at the lower temperatures. The rate of alpha particle reduction of plutonium solutions in molar perchloric acid was found to be only slightly influenced by temperature changes. From chemical analyses and gas analyses it was concluded that the perchlorate ion is reduced to the chloride ion by the alpha particle radiation. In hydrochloric acid solutions, the hydrogen peroxide concentrations and the rates of decrease of the mean oxidation number are much lower than in perchloric acid solutions of similar concentration. This inhibition of the reduction process presumably occurs through lowered yields of hydroxyl radicals and the interaction of chlorine and hypochlorous ion with hydrogen peroxide. In perchloric acid solutions of plutonium containing bromide ion, an increase in the mean oxidation number, an alpha particle oxidation process, is found. (auth)**

**2031** ✓ AEC-tr-3459
EFFECT OF IRRADIATION ON THE VALENCE STATE OF PLUTONIUM IN NITRIC ACID SOLUTIONS. N. I. Popov, V. I. Medvedovskii, and N. A. Bakh. Translated by Lydia Venters (Argonne National Lab.) from Atomnaya Energ. 4, 154-60(1958). 15p.

The valence states of plutonium in nitrate solutions under irradiation were investigated. In addition to pure nitrate solutions, those containing both uranyl nitrate and potassium bichromate, which posesses the capability of reducing or oxidizing plutonium under the effect of radiation were studied. The experimental technique is described, and the results obtained in plutonium oxidation and reduction processes in solutions containing nitric acid, sodium nitrate, uranyl nitrate, and potassium bichromate in various concentrations and combinations are discussed. (J.R.D.)

**5321** **AEC-tr-3534**
**ON THE REDUCTION OF PLUTONYL SULFATE BY γ RADIATION. M. Pages, C. Ferradini, and M. Haissinskii (Haissinsky). Translated by R. E. Biggers (Oak Ridge National Lab.) from Compt. rend. 245, 1128-9(1957). 3p. $1.80(ph); $1.80(mf) JCL or LC.**

**The behavior of plutonyl salts in exposure to gamma radiation was examined. Plutonyl sulfate free from Pu(IV) was prepared in sulfuric acid solution and irradiated with radioactive cobalt. The reduction by gamma radiation in aerated sulfuric acid stops at the IV valence state and varies linearly with the absorbed energy. The yield diminishes with the increase of sulfuric acid concentration. (J.R.D.)**

# PLUTONIUM 1.28

## OTHER REACTIONS AND PROPERTIES 1.28.06

### IRRADIATION EFFECTS 1.28.06.03

DECOMPOSITION OF PLUTONIUM OXALATES BY INTRINSIC ALPHA RADIATION. V. V. Fomin, R. E. Kartushova, and T. I. Rudenko. Soviet J. Atomic Energy, No. 3, 409-13(1956).

Decomposition of the oxalates of tri-, tetra- and hexavalent plutonium was studied in air and in a vacuum at room temperature and −80° both under illumination and in darkness. It was found that the decomposition is caused by alpha radiation from the plutonium, but in the oxalates of tetra- and hexavalent plutonium the carbon monoxide which is formed acts as a reducing agent which transforms the tetravalent plutonium to the trivalent form and the hexavalent to the tetravalent. The oxalates are then transformed into carbonates and, apparently, also partially into oxides or an oxyoxalate−carbonate mixture. (auth)

6446 ✓ A/CONF.15/P/1156

ACTION DES RAYONS $\gamma$ ET $\alpha$ SUR LES SOLUTIONS DE PLUTONIUM. (Effect of $\alpha$ and $\gamma$-Rays on Plutonium Solutions). M. Pagès and M. Haissinsky (Univ. of Paris). 8p.

The radiochemical reduction of $PuO_2SO_4$ was studied in sulfuric acid solution. After irradiation with $Co^{60}$ $\gamma$-rays, the product first observed is $Pu^{4+}$. Small amounts of $Pu^{3+}$ appear after prolonged irradiation. The yield for reduction to $Pu^{4+}$ in 0.5N $H_2SO_4$ solution varies in the usual way with the initial concentration of $Pu^{6+}$: first increasing with concentration, then becoming independent. The plateau is reached at about $2 \times 10^{-3}$M and the yield is then G = 1.7. For an initial concentration of $Pu^{6+}$ equal to $3 \times 10^{-3}$M, G($Pu^{4+}$) falls from 2 to 1 as the acid concentration increases from 0.1 to 2N. If the concentration of $SO^{2-}$ ions is fixed, G moves in the opposite direction, increasing from 0.5 to 1 as $H^+$ increases from 0.2 to 0.8N, then appearing to rise more rapidly for greater acidities. At constant acidity, on the other hand, the yield falls from 2.0 to zero as the $SO_4^{2-}$ concentration is increased from 0.1 to 0.9M. The effect of $SO_4^{2-}$ is therefore greater than that of $H^+$ ions. Self-reduction by plutonium $\alpha$ rays varies with sulfate and hydrogen ion concentrations in much the same way as has just been described for $Co^{60}$ $\gamma$ rays with similar G values, in both cases, for the same dissipation of energy. For $PuO_2^{2+}$ concentrations between $5 \times 10^{-5}$ and $9 \times 10^{-3}$M, however, the self-reduction yield does not vary with concentration.

# PLUTONIUM 1.28

## OTHER REACTIONS AND PROPERTIES 1.28.06

### OXIDATION AND REDUCTION 1.28.06.04

**22169**

METHOD OF MAINTAINING PLUTONIUM IN A HIGHER STATE OF OXIDATION DURING PROCESSING. S. G. Thompson and D. R. Miller (to U. S. Atomic Energy Commission). U. S. Patent 2,892,678. June 30, 1959.

This patent deals with the oxidation of tetravalent plutonium contained in an aqueous acid solution together with fission products to the hexavalent state, prior to selective fission product precipitation, by adding to the solution bismuthate or ceric ions as the oxidant and a water-soluble dichromate as a holding oxidant. Both oxidant and holding oxidant are preferably added in greater than stoichiometric quantities with regard to the plutonium present.

**10503**

KINETICS OF OXIDATION REDUCTION REACTIONS OF PLUTONIUM. THE REACTION BETWEEN PLUTONIUM(VI) AND PLUTONIUM(III) IN PERCHLORATE SOLUTION. Sherman W. Rabideau and Robert J. Kline (Los Alamos Scientific Lab., N. Mex.). J. Phys. Chem. 62, 617-20(1958) May.

The rapid, reversible reaction, $Pu^{+3} + PuO_2^{+2} \rightarrow Pu^{+4} + PuO_2^{+}$, was studied spectrophotometrically by following the rate of disappearance of $PuO_2^{+2}$ through the absorption peak at 8304 A. The reaction rates were found to be conveniently measurable even at temperatures of 35° with concentrations of $PuO_2^{+2}$ and $Pu^{+3}$ in the $10^{-4}$ and $10^{-3}$ M ranges, respectively. The reaction is first order in each of the reactants and is independent of the hydrogen ion concentration over the ranges of acidity investigated: namely, 0.1 to 1.0 M. Specific reaction rate constants as functions of temperature have been obtained for both the forward and the reverse reactions in deuterium oxide and in ordinary aqueous perchloric acid solutions of unit ionic strength. Heats, free energies and entropies of activation have been obtained for both forward and reverse reactions in the two solvents. The observation was made that the specific reaction rate constant for the forward reaction decreased by a factor of 1.7 upon changing the solvent from ordinary water to deuterium oxide; however, the specific reaction rate constant for the back reaction was greater by a factor of 1.5 in the deuterium oxide solvent. Thus at comparable acidities, the value of the equilibrium quotient, $[PuO_2^{+2}][Pu^{+3}]/[Pu^{+4}][PuO_2^{+}]$, increases approximately threefold upon changing the solvent from ordinary water to deuterium oxide. Addition of chloride ion to an extent threefold greater than the total plutonium concentration did not bring about a measurable change in either the forward or the reverse specific reaction rate constants. (auth)

**9766**

KINETICS OF OXIDATION-REDUCTION REACTIONS OF PLUTONIUM. THE REACTION BETWEEN PLUTONIUM(VI) AND VANADIUM(III) IN PERCHLORATE SOLUTION. Sherman W. Rabideau (Los Alamos Scientific Lab., N. Mex.). J. Phys. Chem. 62, 414-17(1958) Apr.

The kinetics of the reaction between $PuO_2^{+2}$ and $V^{+3}$ has been studied by spectrophotometric measurements at 8304 Å. The stoichiometry of the reaction is given by the equation $PuO_2^{+2} + V^{+3} + H_2O \rightarrow PuO_2^{+} + VO^{+2} + 2H^{+}$. This second-order reaction has been found to be dependent upon both an inverse first and an inverse second power of the hydrogen ion concentration. Values of k′ and k″, the rate constants associated with the inverse first and the inverse second power of the hydrogen ion concentration, have been found to be 2.12 ± 0.03 $sec.^{-1}$ and 0.228 ± 0.006 mole $liter^{-1}$ $sec.^{-1}$, respectively, for perchlorate solutions of ionic strength two at a temperature of 25°. (auth)

# PLUTONIUM 1.28

## OTHER REACTIONS AND PROPERTIES 1.28.06

### OXIDATION AND REDUCTION 1.28.06.04

OXIDATION OF PLUTONIUM(III) BY SODIUM NITRITE. A. Brunstad. July 17, 1957. Decl. Nov. 12, 1957. 12p. (HW-51655)

The reaction velocity constant for the oxidation of Pu(III) by nitrite in $HNO_3$ solution containing ferrous sulfamate is given. The reaction rate was found to be measurable by means of spectrophotometry. The data indicate the reaction to be a pseudo first-order reaction in the region of $HNO_3$ and nitrite concentration of interest. The reaction velocity constant, expressed as a first-order reaction with respect to Pu, was found for several values of $HNO_3$ and nitrite concentrations. The $HNO_3$ reaction velocity constant relationship is given. The oxidation of the ferrous sulfamate–Pu(III) solution proceeds successively through the sulfamate, ferrous, and Pu(III) ions. An autocatalytic mechanism is associated with the oxidation of both ferrous and Pu ions which obviates the possibility of simple calculations of constants based on nitrite concentration. An empirical relationship between the reaction velocity constant and the (added) nitrite concentration is given

**1322** CRDC-697

Atomic Energy of Canada Ltd. Chalk River Project, Chalk River, Ontario.

OXIDATION OF Pu(IV) TO Pu(VI) IN SOLUTIONS OF NITRIC ACID, ALUMINIUM NITRATES, SODIUM NITRATE, AND URANYL NITRATE. I. H. Crocker. May 1957. 57p. (AECL-488).

The effects of temperature, Pu concentration, $HNO_3$ concentration, and $NO_3^-$ concentration on the oxidation of $Pu^{4+}$ to $Pu^{6+}$ have been studied. The rate of oxidation increases as temperature and Pu concentration increase, decreases as the $HNO_3$ concentration increases, and, in general, decreases as the $NO_3^-$ concentration increases, particularly when the ion is supplied by a highly ionized nitrate salt, such as $NaNO_3$ or $Al(NO_3)_3$. $UO_2(NO_3)_2$, which is strongly complexed in $HNO_3$ solution, inhibits $Pu^{6+}$ formation when present in high concentration, but enhances its formation when present in low concentration. Quantitative data were obtained over a range of acid–salt concentrations, that should enable prediction of the oxidation state of Pu in most process solutions. (auth)

**2345** / BC-71

California. Univ., Berkeley. Radiation Lab.

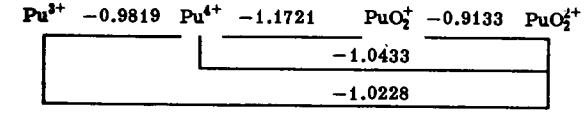
THE REDUCTION OF Pu(VI) BY NITROUS ACID. Robert E. Connick. Sept. 1, 1946. Revised Aug. 4, 1947. Decl. Dec. 6, 1955. 20p. $3.30(ph OTS); $2.40(mf OTS).

The reduction of Pu(VI) by nitrous acid in nitric acid solutions is discussed. The available information in the project literature relating to this reaction are examined and interpreted. In nitric acid solutions Pu(VI) is rapidly reduced to Pu(V) until an equilibrium between Pu(V), Pu(VI), $HNO_2$ and $NO_3^-$ is established. The observed effect of acidity on this equilibrium is in agreement with that predicted from the equilibrium expression. Using the concentrations of Pu(V), Pu(VI), $HNO_2$ and $NO_3^-$ at equilibrium it was possible to calculate the potential of the Pu(V)–Pu(VI) couple. The mechanism of the reduction below the +5 oxidation state is discussed. In sulfuric acid solution containing uranyl nitrate the equilibrium between Pu(V), Pu(VI), $HNO_2$ and $NO_3^-$ appears to be rapidly established. Reduction below the +5 oxidation state is faster than in nitric acid solutions. (auth)

**9237**

THERMODYNAMIC FUNCTIONS AND FORMAL POTENTIALS OF THE PLUTONIUM(V)-(VI) COUPLE. Sherman W. Rabideau (Los Alamos Scientific Lab., N. Mex.). J. Am. Chem. Soc. 78, 2705-7(1956) June 20.

The formal potentials of the Pu couples in 1M $HClO_4$ at 25.00°C are:



# PLUTONIUM 1.28

## OTHER REACTIONS AND PROPERTIES 1.28.06

### OXIDATION AND REDUCTION 1.28.06.04

**2675**

ELECTROLYTIC OXIDATION OF PLUTONIUM. Roy Ko (Hanford Atomic Products Operation, Richland, Wash.). Anal. Chem. 28, 274(1956) Feb.

The electrolytic oxidation of $Pu^{4+}$ to $Pu^{6+}$ in perchloric acid solutions is described. The plutonium was 98% oxidized under the following conditions: acid concentration—0.5M $HClO_4$; current—60ma; anodic current density—3ma/cm$^2$; and electrolysis time—1 hr. (C.W.H.)

THE PREPARATION OF METALLIC PLUTONIUM. E. Grison (Centre d'Études Nucleaire, Saclay, France). p.91-7 in "Progress in Nuclear Energy. Series V. Metallurgy and Fuels. Volume 2."

The preparation of Pu by the reduction of $PuO_2$, $PuF_4$, and $PuF_3$ with Al, Ca, and Mg is discussed. Various methods for preparing the plutonium fluorides are reported. Methods are presented for the direct preparation of Pu alloys by reducing plutonium fluoride in a crucible with the alloying metal. (W.L.H.)

# POLONIUM 1.29

CHEMISTRY OF THE RARE RADIOELEMENTS, POLONIUM-ACTINIUM. K. W. Bagnall. New York, Academic Press, Inc. and London, Butterworths Scientific Publications, 1957. 183p.

All of the present data on the chemistry of polonium, astatine, francium, radon, radium, and actinium are collected and evaluated in this book. The methods used for the study of their chemistry are described. (J.S.R.)

**7533**

POLONIUM. A. Dorabialska. Nukleonika 3, 369-81 (1958). (In Polish)

The chemical properties of polonium are analyzed, and the microcalorimetric method of measuring heat emission and half life of polonium is described.

**5146**

THE STATE OF MICROQUANTITIES OF RADIOELEMENTS IN SOLUTIONS. XI. ELECTROPHORETIC MOTION OF POLONIUM IN AQUEOUS SOLUTIONS. I. E. Starik and N. I. Ampelogova. Radiokhimiya 1, 414-18(1959). (In Russian)

Anion polonium is prevalent in 0.1N HCl; about 30% cations are found. The isoelectric point of cation and anion equilibrium is found at pH 2 to 3; the second isoelectric point, corresponding to polonium colloid particle coagulation, is at 0.01N KOH. The cations of polonium, sorbed by negative charged impurities, are prevalent at pH 5 to 7. In 0.1N KOH and above, anion polonium is found as $PoO_3^{2-}$. (R.V.J.)

**9519**

THE AGGREGATION OF MICROQUANTITIES OF RADIOELEMENTS IN THE LIQUID AND SOLID PHASES. I. E. Starik. Uspekhi Khim. 26, 389-98(1957) Apr. (In Russian)

Concentrations of microquantities of radioelements in liquid phases were studied by investigating the colloidal and adsorptive properties of Po. The constitution of radioelements formed in solid phases from mother substances were studied by leaching Ra, U, Th, and ThX. (R.V.J.)

**94**

COLLOIDAL PROPERTIES OF POLONIUM. I. E. Starik, N. I. Alekseenko, and N. G. Rozovskaya (Khlopin Radium Inst.). Izvest. Akad. Nauk S.S.S.R. Otdel. Khim. Nauk 755-63(1956) July. (In Russian)

Colloidal properties of Po were studied by methods of vitreous absorption and desorption, by electrochemical separation from copper, and by centrifugation and ultrafiltration of alternating concentrations of Po. The results verified the existence of true Po colloids and established the conditions in which Po can be found in various states. Electrochemical separation of Po permitted an approximate evaluation of the solubility of Po complexes. The values obtained were of relative accuracy but sufficient enough to express the order of magnitude and to explain the formation of colloidal radioelements. The method can be adapted for studies of uranium, ruthenium, radium, etc. (R.V.J.)

# POLONIUM 1.29

**2334** UCRL-1294
California. Univ., Berkeley. Radiation Lab.
ION EXCHANGE EXPERIMENTS WITH POLONIUM.
Edward R. Tompkins. May 11, 1951. Decl. Dec. 7, 1955. 15p. Contract W-7405-eng-48. $3.30(ph OTS); $2.40(mf OTS).

The state of Po in aqueous solutions was investigated by means of ion exchange equilibrium studies. The distribution of the Po between the solid and liquid phases was determined for solutions of various compositions using both a cation and an anion exchanger. These studies show that in the absence of a complexing agent Po is hydrolyzed to such a degree that it forms monovalent cations and anions whose charge was not investigated in this study. On the basis of these results and previous work it appears that these ions may be $PoO(OH)^+$ and $PoO_3^{-4}$. The addition of a complexing anion such as chloride decreases both the cationic and anionic form of Po up to a chloride concentration of about 0.01M. At higher chloride concentrations the cation concentration continues to decrease while the percentage of Po in the anionic state increases. In the absence of a complexing anion, no effect of H ion on the state of hydrolysis of the Po could be noted. In the presence of chloride the H ion concentration is very important in determining the fractions of Po in the cationic, neutral and anionic states. (auth)

**12225** ✓
ON THE VOLATILITY OF POLONIUM COMPOUNDS.
Hisao Mabuchi (Univ. of Tokyo, Hongo). Bull. Chem. Soc. Japan 31, 245-6(1958) Mar.

To determine whether the sublimation of polonium dithizonate is characteristic of dithizonate, the volatility of polonium compounds with other organic reagents and polonium compounds extracted in the absence of organic reagents was investigated. (T.R.H.)

**8944**
SOLUBILITY OF SOME POLONIUM COMPOUNDS. K. W. Bagnall and J. H. Freeman (A.E.R.E., Harwell). J. Chem. Soc. 2161-3(1957) May.

The dependence of the solubility of polonium hydroxide on hydroxyl-ion concentration indicates that this compound is only feebly acidic; the solubilities of polonium acetate and cyanide have been determined for a wide concentration range of acetic acid and potassium cyanide respectively and some observations made on a formate, oxalate, and tartrate. (auth)

**5139** ✓
SOLUBILITY OF POLONIUM HYDROXIDE. D. M. Ziv and I. A. Efros. Radiokhimiya 1, 290-94(1959). (In Russian)

The mean solubility of polonium hydroxide is $(3.7 \pm 1.5) \times 10^{-5}$ mole/l. The solubility product is $L_{Po(OH)_4} = 10^{-37}$. (R.V.J.)

**5147** ✓
STATE OF MICROQUANTITIES OF RADIOELEMENTS IN SOLUTIONS. XII. DETERMINATION OF POLONIUM STATE IN AQUEOUS SOLUTION BY ELECTROCHEMICAL METHOD. I. E. Starik and N. I. Ampelogova. Radiokhimiya 1, 419-24(1959). (In Russian)

Polonium chloride hydrolysis occurs in two steps: $Po^{4+} + 2H_2O \rightarrow Po(OH)_2^{2+} + 2H^+$ at pH = 3.3 and $Po(OH)_2^{2+} + 2H_2O \rightarrow Po(OH)_4 + 2H^+$ at pH = 7.8. At pH 8 to 11 the deposition of polonium on copper is at a minimum. The solubility of polonium hydroxide is $6 \times 10^{-39}$ (complete dissociation). Polonium is easily extracted by copper in acid media (0.01 to 1N HCl) and in alkali media (0.01 to 0.1N KOH); however, with increased concentration of alkali up to 1N deposition tends to decrease due to polonium transition into anion $PoO_3^{2-}$. (R.V.J.)

# POLONIUM 1.29

**2257** LA-1550
Los Alamos Scientific Lab., N. Mex.
ELECTROCHEMICAL EXCHANGE OF SILVER AND POLONIUM. Leonard H. Treiman and Melvin G. Bowman. Mar. 1953. Decl. Dec. 12, 1955. 8p. Contract W-7405-eng-36. $1.80(ph OTS); $1.80(mf OTS).

It has been found that two Ag atoms replace one Po ion during the electrochemical exchange of $Po^{2+}$ with Ag. The most probable exchange reaction may be described by the equation $Po^{2+} + 2Ag = Po + 2Ag^{+}$. From the concentrations of $Po^{2+}$ ion and $Ag^{+}$ ion when the exchange reactions were terminated, calculations indicate $Po = Po^{2+} + 2e^{-}$, $E^{0} < -0.7$. (auth)

**4526**
THE POLONIUM HALIDES. PART II. BROMIDES. K. W. Bagnall, R. W. M. D'Eye, and J. H. Freeman (Atomic Energy Research Establishment, Harwell, Berks, England). J. Chem. Soc., 3959-63(1955) Nov.

The preparation, properties, and crystal structure of $PoBr_2$, $PoBr_4$, $(NH_4)_2PoBr_6$, and $Cs_2PoBr_6$ are described. (C.W.H.)

**95**
THE POLONIUM HALIDES. PART III. POLONIUM TETRAIODIDE. K. W. Bagnall, R. W. M. D'Eye, and J. H. Freeman (Atomic Energy Research Establishment, Harwell, Berks, England). J. Chem. Soc., 3385-9(1956) Sept.

Polonium tetraiodide and cesium hexaiodopolonite have been prepared and evidence for the existence of hexaiodo-

polonous acid has been obtained. The crystal structures of the Cs salt and its Te analogue have been determined. (auth)

**6542**
POLONIUM OXIDES. E. A. Terent'ev (All Union Inst. of Scientific and Technical Infor. Academy of Science) Priroda, 45, 84(1956) Feb. (In Russian).

Experiments determined that $PoO_2$ obtained from oxygen oxidation of metallic Po and the oxide produced from decomposition of polonium nitrate are identical. This oxide exists in two crystalline forms. The first is stable only for a short period and possesses tetragonal structure; the second is more stable and has structure similar to fluorine. (R.V.J.)

**11477**
THE DISPLACEMENT OF ATOMS IN POLONIUM AND ITS COMPOUNDS BY RADIOACTIVE DECAY. R. W. M. D'Eye (Atomic Energy Research Establishment, Harwell, Nr. Didcot, Berks). J. Inorg. and Nuclear Chem. 4, 367-9 (1957).

The number of Po atoms likely to be displaced from their normal lattice sites by $\alpha$ particles or recoiling nuclei is calculated to be $2 \times 10^{19}$/day. The importance of this fact in in explaining phase transitions is discussed. (T.R.H.)

**1428** MLM-615
Mound Lab., Miamisburg, Ohio.
THE TEMPERATURE OF THE PHASE TRANSITION OF POLONIUM. Final Report. J. M. Goode. Oct. 1, 1951. Decl. Nov. 16, 1955. 21p. Contract AT-33-1-gen-53.

An apparatus is described for obtaining x-ray diffraction data from high-specific-activity radioactive materials without high scatter from cover materials and with little danger of contamination of personnel or equipment. A method for determining the phase-transition temperature of radioactive materials near room temperature is described. The phase transition of $\alpha$ to $\beta$ polonium was observed to occur at 54 ± 1.5°C. The reverse transition was found to occur at 18 ± 1.5°C. The transition temperature of Po was set at 36 ± 1.5°C. The two phases probably coexist over a short temperature range of either side of 36°C. (auth)

**1429** MLM-677
Mound Lab., Miamisburg, Ohio.
METAL–POLONIUM COMPOUNDS. Interim Report. J. M. Goode. Apr. 1, 1952. Decl. Nov. 16, 1955. 22p. Contract AT-33-1-Gen-53.

Compounds of Po and Zn, Pb, Na, Pt, Ni, and Ag have been prepared and investigated by x-ray diffraction. The Zn, Pb, and Na polonides have face-centered-cubic structures with $a_0$ equal to 6.28 ± 0.02A, 6.599 ± 0.003A, and 7.473 ± 0.004A, respectively. The Pt and Ni polonides have hexagonal structures with $a_0$ and C equal to 4.104 ± 0.004A and 1.366, and 3.973 ± 0.001A and 1.425, respectively. The Ag polonide has either orthorhombic or monoclinic structure. In addition, it was observed that Bi alloyed with Po while Ta, Au, Be, Fe, and Al did not react with Po under the conditions of preparation. (auth)

# POLONIUM 1.29

**1427** ✓ MLM-205
Mound Lab., Miamisburg, Ohio.
CRYSTAL STRUCTURE OF SOME COMPOUNDS OF POLONIUM. (Information Meeting Paper No. 15). R. E. Brocklehurst. Sept. 30, 1948. Decl. Nov. 16, 1955. 9p. Contract AT-33-1-GEN-53.

An investigation of polonium valence states is made. Valence states of $Po^{2-}$ and $Po^{4+}$ are confirmed, and the densities and ionic radii of characteristic compounds obtained. (D.E.B.)

**6460** ✓ A/CONF.15/P/1322
SOME STUDIES ON THE TRACER CHEMISTRY OF POLONIUM. Kenjiro Kimura and Tomitaro Ishimori (Atomic Energy Research Inst., Japan). 15p.

A summary is presented of studies on the tracer chemistry of polonium. The formation and composition of polonium dithizonate, polonium diethyldithiocarbamate, and polonium hydroxyluinolate are reported. The volatility of polonium compounds formed with various organic reagents was investigated. A method for the solvent extraction of polonium with isopropyl ether from hydrochloric acid solutions is given. It was confirmed that a carrier-free separation of $Po^{210}$, $Pb^{210}$, and $Bi^{210}$ could be performed by ion exchange using hydrochloric acid and nitric acid as elutriants. A procedure for the distillation separation of $Po^{210}$ and $Bi^{210}$ is given. (J.S.R.)

ON THE RADIATION OF $Po^{210}$. Marie Ader. Compt. rend. 246, 97-8(1958) Jan. 6.

An artificial Po source emits ionizing particles with long trajectories and neutrons whose spectra are identical to spectra of radiation emitted from sources of natural Po. (tr-auth)

**8037** TID-5221
Mound Lab., Miamisburg, Ohio.
POLONIUM. Harvey V. Moyer, ed. 1955. Decl. Oct. 12, 1955. 402p. $1.75(OTS).

A survey was made of $\gamma$, $\alpha$, and x radiations associated with the decay of $Po^{210}$. The nuclear, physical and chemical properties of Po are analyzed. Chemical separation methods and separation by distillation are studied for extraction of Po from irradiated Bi. Polonium from Pb residues and neutron and alpha sources are described. Biological research related to Po and health physics concerning with personnel protection and waste disposal are discussed. (R.V.J.)

INVESTIGATION OF THE DECAY OF POLONIUM-210. Brat Pal Singh, H. S. Hans, and P. S. Gill (Muslim Univ., Aligarh, India). Nuovo cimento (10) 9, 699-705 (1958) Aug. 16.

The conversion coefficient of 800 kev $\gamma$-rays from the decay of $Po^{210}$ was measured, using scintillation methods, at $0.039 \pm 0.01$. The value of the conversion coefficient was also obtained by the measurement of conversion electrons with an end window type G.M. counter. The absorption curve for electrons is given and its shape has been interpreted in the light of the results of Lagasse and Doyeb. The value of the conversion coefficient obtained in this way is $0.014 \pm 0.005$. The discrepancy between the two values is due to K and L shell ionization by $\alpha$-particles. No coincidences were found between the different parts of $\gamma$-ray spectrum. (auth)

# POLONIUM 1.29

**7999** √ AERE-M/M-119
Gt. Brit. Atomic Energy Research Establishment, Harwell, Berks, England.
POLONIUM PRODUCTION AND DECAY IN A BISMUTH REACTOR SYSTEM. W. H. L. Porter. June 1956. 7p. (LMFP/P3).

ENERGY LEVELS IN $Bi^{207}$ FROM THE DECAY OF $Po^{207}$. E. Arbman, J. Burde, and T. R. Gerholm (Univ. of Uppsala). Arkiv Fysik 13, 501-38(1958).

The energy levels in $Bi^{207}$ have been studied from the decay of 5.7 hr $Po^{207}$. The experiments include measurements of the energies and intensities of conversion electron lines and positron distributions in a double focusing spectrometer; measurements of gamma-ray spectrum in a scintillation spectrometer and to some extent in the double focusing spectrometer by the use of a lead converter; measurements of coincidences between pairs of conversion lines and between positrons and conversion lines in a double lens coincidence spectrometer, and coincidences between positrons and gamma rays in a beta-gamma coincidence spectrometer. Two positron components of maximum energies 1140 kev and 893 kev were found, establishing the total decay energy of $Po^{207}$ as 2.906 Mev. The proposed decay scheme contains 16 excited levels, 11 of which are considered to be well established. Spins and parities for the ground state of $Po^{207}$ and the most strongly populated excited levels in $Bi^{207}$ are given. The decay of $Po^{207}$ is discussed on the basis of the shell model. (auth)

# PRASEODYMIUM 1.30

**9250**
PRASEODYMIUM OXIDES. IV. A STUDY OF THE REGION $PrO_{1.83}-PrO_{2.00}$. C. L. Sieglaff and L. Eyring (State Univ. of Iowa, Iowa City). J. Am. Chem. Soc. 79, 3024-6(1957) June 20.

This is a study of the phase relationships of the higher praseodymium oxides. X-ray powder diagrams of quenched, analyzed samples were taken to determine the phases present. A two-phase system was found for the region $PrO_{1.83}-PrO_{2.00}$ at preparation temperatures below 350° and oxygen pressures less than ten atmospheres. Lattice constants are given for the various phases found. (auth)

**10467**
NEW QUALITATIVE REACTIONS FOR PRASEODYMIUM IN THE PRESENCE OF NEODYMIUM AND OTHER RARE-EARTH ELEMENTS OF THE CERIUM SUBGROUP. M. N. Ambrozhiy, L. M. Kul'berg, and A. G. Fedorova (Saratov Univ.). Uchenye Zapiski Saratov. Inst. 43, 149-53(1956). (Translated from Referat Zhur. Khim. No. 9, 1957, abstract no. 30987.)

Topochemical oxidation-reduction reactions have been developed for detection of Pr in the presence of Nd and other rare-earth elements of the Ce group. It was found that of the 7 qualitative reactions which have been studied the most effective are those utilizing the leuco-compounds of the triphenyl methane dyes (leuco malachite green, leuco brilliant green, and leuco-compounds of crystal violet). As a reagent for Pr in admixture with other rare-earth elements, octamethyl tetramino tetraphenyl ethylene, diethyl-p-phenylene diamine, and dimethyl-p-phenylene diamine can also be used.

# PRASEODYMIUM 1.30

**1950**

ON THE INTERNAL AND EXTERNAL BREMSSTRAHLUNG OF $Pm^{147}$ AND $Pr^{143}$. Helene Langevin-Joliot. Compt. rend. 241, 1286-8(1955). November 7. (In French)

The internal bremsstrahlung spectrum of $Pm^{147}$, obtained by a scintillation spectrometer in an appropriate arrangement, disagrees with theory in both its shape and intensity. The number of photons reaches 450% of the theoretical value above 60 kev. The first results on $Pr^{143}$ also indicate an excess of photons. (tr-auth)

**1614** ✓

ACTIVATION CROSS SECTIONS OF $Y^{90}$ AND $Pr^{142}$. R. R. Smith and S. D. Reeder (Phillips Petroleum Co., Idaho Falls, Idaho). J. Chem. Phys. 23, 2108-10(1955) Nov.

The irradiation of $Y^{89}$ and $Pr^{141}$ under a sufficiently high thermal neutron flux produces small amounts of $Y^{91}$ and $Pr^{143}$ by secondary neutron capture. A measurement of the second-order activities, although completely unobservable at the end of the irradiation, may be made after the shorter lived first-order activities have disappeared. From relative measurements of the first- and second-order activities induced in $Y^{89}$ and $Pr^{141}$ values for the activation cross sections of $Y^{90}$ and $Pr^{142}$ have been established. For $Pr^{142}$ a value of $\sigma_{act} = 18 \pm 3$ barns was found; for $Y^{90}$ a value of 6.5 barns was established as an effective upper limit. (auth)

ABSORPTION SPECTRUM AND QUANTUM STATES OF THE PRASEODYMIUM ION. II. ANHYDROUS PRASEODYMIUM FLUORIDE IN FILMS. Edward V. Sayre and Simon Freed (Brookhaven National Lab., Upton, N. Y.). J. Chem. Phys. 23, 2066-8(1955) Nov.

The absorption spectra of anhydrous $PrF_3$ were examined to confirm term designations derived from the spectra of anhydrous $PrCl_3$. In the fluoride, Pr ion is at the center of a micro-field of $C_{2V}$ symmetry and in the chloride it is in a field of $C_{3h}$ symmetry. There was complete consistency in the interpretations of the spectra of the two compounds. A new phenomenon appeared in the spectrum of the fluoride, however. The selection rules prohibiting some of the possible transitions of an ion in a field of $C_{2V}$ symmetry valid at the temperature of liquid $N_2$ were lifted at the temperature of liquid helium, where in fact all possible transitions occurred. There is evidence against any gross crystallographic transformation. It is surmised that the positions of energy minimum for the ions lie slightly off the symmetric positions possibly due to higher order interactions such as occurs in the case of barium titanate. (auth)

**1612** ✓

ABSORPTION SPECTRUM AND QUANTUM STATES OF THE PRASEODYMIUM ION. I. SINGLE CRYSTALS OF PRASEODYMIUM CHLORIDE. Edward V. Sayre, Kenneth M. Sancier, and Simon Freed (Brookhaven National Lab., Upton, N. Y.). J. Chem. Phys. 23, 2060-5 (1955) Nov.

The structure of the polarization spectra exhibited by single crystals of anhydrous $PrCl_3$ permitted the assignment of quantum states of the praseodymium ion because of the fact that the symmetry of the crystal fields had previously been determined by x rays. The crystals which were diluted with isomorphic, colorless $LaCl_3$, were grown from melts. Observations of transitions over the range from 2200 to 18 000 A at the temperatures of liquid $N_2$ and liquid He led to the identification of seven upper states as well as the substates into which they were split by the crystal fields. The four lowest substates of the ground state also were characterized. The F triplet was found inverted. All the transitions were forced electric dipole in nature. (auth)

# PROTACTINIUM 1:31

**13295**
SOLVENT EXTRACTION FROM HALIDE SOLUTIONS. PART I. SYNERGISTIC BEHAVIOUR WITH MIXED SOLVENTS. A. G. Goble and A. G. Maddock (University Chemical Labs., Cambridge, Eng.). Trans. Faraday Soc. 55, 591-603(1959) Apr.

The extraction of protactinium from hydrochloric acid solution by a variety of two-component mixtures of solvents have been investigated, and the relation between the extraction and the composition of the mixed solvent determined. While in some systems one of the solvents appeared to behave as an inert diluent, in others the mixture extracted much more than either pure solvent. The interpretation of the behavior of the latter group of mixtures is discussed. (auth)

**19935**
CHEMICAL DATA ON PROTACTINIUM. A. V. Nikolaev, A. G. Kurnakova, and Z. G. Rumyantseva. Zhur. Neorg. Khim. 4, 1682-6(1959) July. (In Russian)

A specimen of $Pa^{233}$ was prepared by irradiating solid thorium nitrate (hydrated) for 20 hours. The half life is 27 days. Various experiments were carried out to determine the chemical behavior of protactinium in thorium, thorium chromates and salicylates, $MnO(OH)_2$, and $Fe(OH)_3^0$. Studies were also made of the behavior of protactinium during extraction by salicylosalicylic acid and acetone. (R.V.J.)

THE CHEMISTRY OF PROTACTINIUM-IV. SOME SPECTROPHOTOMETRIC OBSERVATIONS. A. T. Casey and A. G. Maddock (University Chemical Lab., Cambridge, Eng.). J. Inorg. & Nuclear Chem. 10, 58-68(1959) Apr.

True solutions of protactinium in hydrochloric acid, above 4 N in acid, are free from absorption bands down to at least 300 mμ. At lower wavelengths a band appears with its maximum below 210 mμ. The onset of hydrolysis and disappearance of the solvent extractability of the protactinium from the solution coincides with the appearance of an absorption band with its maximum at 260 mμ. Protactinium gives color reactions with pyrogallol, cathechol, gallic and tannic acids as well as quinalizarin and 8-hydroxyquinoline. The absorption spectra of the first three complexes show maxima at 355, 323, and 343 mp. respectively; the molar extinction coefficients for the three complexes are $2.6 \cdot 10^4$, $4.8 \cdot 10^3$, and $5.3 \cdot 10^3$. The pyrogallol complex seems suitable for the chlorination estimation of protactinium. (auth)

STUDIES ON PROTACTINIUM(V) IN NITRIC ACID SOLUTIONS. C. J. Hardy, D. Scargill, and J. M. Fletcher (Atomic Energy Research Establishment, Harwell, Berks, Eng.). J. Inorg. & Nuclear Chem. 7, 257-75(1958) Oct.

Reproducible solutions less than $10^{-4}$ M in protactinium-231 in 1–12 M nitric acid have been prepared and examined. Extraction of Pa by tributylphosphate resembles that of zirconium and equilibrium is rapidly attained. The relative strengths of fluoro-complexing of Pa(V) and Th(IV) in nitric acid have been derived by similar extraction experiments. Distribution coefficients using butex, solutions of tri-n-octylamine and di(2-ethylhexyl) phosphoric acid in inert organic diluents, and cation and anion exchange resins have also been measured. The protactinium species in nitric acid are interpreted as a series of hydroxo-nitrato complexes.

**12437** LS-6
Israel. Atomic Energy Commission, Tel-Aviv. LITERATURE SURVEY ON: 1. THE CHEMISTRY OF ACTINIUM AND PROTACTINIUM—ESPECIALLY IN AQUEOUS SOLUTIONS. 2. DETERMINATION OF ACTINIUM AND PROTACTINIUM. 3. TECHNICAL INFORMATION ON RADIUM INDUSTRY RESIDUES. Sept. 1958. 34p.

This survey includes 250 references from the report and published literature on the subjects of interest. Sources considered included bibliographies, books, and reports in the library of the Israel Atomic Energy Comission. Also, Analytical Abstracts, Jan. 1954 to July 1958, Nuclear Science Abstracts, Jan. 1948 to June 15, 1958, and Chemical Abstracts, Jan. 1921 to July 25, 1958, were consulted. (L.T.W.)

**5144**
ACID DISSOCIATION OF PROTACTINIUM AQUEOUS COMPLEXES. V. A. Mikhaĭlov. Radiokhimiya 1, 395-9 (1959). (In Russian)

An estimate was made of the dissociation constants of protactinium aqueous complex with diisoamylphosphoric acid, and some considerations are offered on the inconclusiveness of ionic force rules. (R.V.J.)

# PROTACTINIUM 1.31

**2268** NAA-SR-1988
Atomics International Div., North American ~~Aviation~~, Inc., Canoga Park, Calif.
AN ESTIMATE OF THE VAPOR PRESSURES OF THORIUM AND PROTACTINIUM. E. W. Murbach. Nov. 1, 1957. 13p. ~~Contract AT-11~~-1-GEN-8 $0.50(OTS).

Vapor pressures of Th and Pa have been estimated from arc melting data by a method utilizing the following assumptions: (1) ideal solutions of Th with U and Pa, (2) that during the melting operation the entire top surface of the sample button is molten and that this is the area available for volatilization, and (3) that temperature can be determined by measuring the amount of U volatilized, since the vapor pressure of U has been precisely determined. The vapor pressures of Th and Pa were estimated to be $4.2 \times 10^{-6}$ atmospheres and $5.1 \times 10^{-5}$ atmospheres at 2200°K. (auth)

**1236**
DETERMINATION OF PROTACTINIUM-233. F. L. Moore and S. A. Reynolds (Oak Ridge National Lab., Tenn.). Anal. Chem. 29, 1596-9(1957) Nov.

A liquid-liquid extraction system using diisobutylcarbinol as the organic phase is basis for a simple, rapid, control-type method for separation of $Pa^{233}$. Extraction is made from 6M hydrochloric acid–4% oxalic acid to inhibit extraction of $Nb^{95}$. If sample contains thorium, an extraction is first made without oxalic acid. (auth)

**4558**
PROTACTINIUM. I. ANALYTICAL SEPARATIONS.
J. Golden and A. G. Maddock (Radiochemical Lab., Cambridge, England). J. Inorg. and Nuclear Chem. 2, 46-59(1956) Jan.

The conditions for the separation of Pa from other elements by solvent extraction of a chloride complex by diisopropyl ketone have been investigated. The complex appears to contain three molecules of the solvent. Its heat of formation is small. Evidence for the existence of a sparingly soluble salt $BaPaF_7$ is advanced. (auth)

Refer also to abstracts 4540 and 4551.

**1524**
$4.1 \times 10^{-8}$ SECOND METASTABLE STATE IN $Pa^{231}$.
D. Strominger and J. O. Rasmussen (Univ. of California, Berkeley). Phys. Rev. 100, 844(1955) Nov. 1.

A metastable state of $Pa^{231}$ with a half life of $(4.1 \pm 0.4) \times 10^{-8}$ second has been observed. The half life is exhibited by both 26- and 85-kev E1 gamma transitions. A comparison is made with the metastable state in $Pa^{233}$. Upper limits on lifetimes are given for the E1 gamma transitions in $Np^{239}$ and $Ac^{225}$. The erratic variation in the lifetimes for E1 transitions is discussed. (auth)

SPECTRA OF PROTACTINIUM (IV) AND (V) IN HYDROCHLORIC ACID. D. Brown, A. J. Smith, and R. G. Wilkins (Sheffield Univ., Eng.). J. Chem. Soc., 1463-6 (1959) Apr.

Spectral changes occurring when $Pa^{5+}$ is reduced by zinc amalgam are noted. (auth)

# RARE EARTHS 1.32

## COMPLEX FORMATION 1.32.01

PREPARATION OF SOME BASIC AND ANHYDROUS RARE EARTH ACETATES. THEIR PROPERTIES AND REACTIONS IN ACETIC ACID AS SOLVENT. J. A. Seaton, F. G. Sherif, and L. F. Audrieth (Univ. of Illinois, Urbana). J. Inorg. & Nuclear Chem. 9, 222-31(1959) Mar.

Solutions of rare earth oxides in anhydrous acetic acid represent metastable systems from which hydroxo-acetates, $Ln_2(OH)_3(OAc)_3 \cdot 2HOAc$, gradually precipitate. Presence of equivalent amounts of acetic anhydride causes formation of so-called basic acetates which are best represented as binuclear oxo- complexes with type formula, $Ln_2O(OAc)_4 \cdot 2HOAc$ (where Ln = La, Nd, Sm). The anhydrous acetates were prepared by refluxing the oxides with acetic anhydride. The solubility of neodymium acetate in acetic acid increases markedly in the presence of potassium acetate to form a negatively charged complex ion, suggesting that the anhydrous rare earth acetates exhibit amphoteric characteristics in acetic acid. Conductometric titrations of solutions of the oxo- and anhydrous acetates in acetic acid with various acids show complete neutralization only with perchloric acid; with sulfuric and oxalic acids, minima correspond to formation of insoluble 1:1 compounds (moles acid per mole rare earth); with phosphoric and citric acids, maxima suggest formation of soluble 1:1 compounds, followed by minima corresponding to insoluble compounds with 3:2 and 2:1 mole ratios, respectively. (auth)

**12303**

THE 8-QUINOLINOL-5-SULFONIC ACID CHELATES OF SOME RARE EARTH METAL IONS. Ben F. Freasier, A. G. Oberg, and Wesley W. Wendlandt (Texas Tech. Coll., Lubbock). J. Phys. Chem. 62, 700-2(1958) June.

The formation constants for the 8-quinolinol-5-sulfonic acid chelates of lanthanum, cerium(III), praseodymium, neodymium, samarium, gadolinium, and erbium were determined at three different ionic strengths and at three different temperatures. The three thermodynamic functions, $\Delta F^0$, $\Delta H^0$, and $\Delta S^0$, were calculated for the metal chelates at 25° and $\mu = 0$. The bonding in the complexes was shown to be ionic in nature. (auth)

**8347** AECU-3662

Illinois. Univ., Urbana. Noyes Lab. of Chemistry. BEHAVIOR OF POLYVALENT METALLIC IONS IN 100% ACETIC ACID; REACTIONS OF RARE EARTH COMPOUNDS IN ACETIC ACID. Final Report. L. F. Audrieth, J. A. Seaton, and F. G. Sherif. Oct. 31, 1957. 73p. Project No. 18. Contract AT(11-1)-67. $13.80(ph OTS); $4.80(mf OTS).

The solution of a polymeric oxide such as a rare earth oxide in protonic solvents such as acetic acid may be regarded as a step-wise process involving rupture of Ln-O-Ln linkages, to form "hydroxyacetates" of varying molecular size and complexity. Intermediate oxo- and hydroxo- bridged aggregates could therefore be formed by solvolytic processes. Further reaction with acetic acid (in the presence of acetic anhydride) could effect dehydration of such "hydroxyacetates," to yield oxo-bridged basic acetates, $Ln_2O(OAc)_4 \cdot 2HOAc$. Such basic acetates may also be obtained when either the hydrated rare earth hydroxides or nitrates are allowed to react with acetic anhydride. It is believed that previous attempts to prepare "anhydrous" rare earth acetates have yielded only such basic acetates. Rare earth oxides react with acetic anhydride to form anhydrous rare earth acetates, which differ in x-ray-diffraction patterns, solubilities, chemical reactions, and infrared absorption from the basic acetates. Long refluxing of the basic acetates in acetic anhydride results in conversion to the anhydrous acetates. Rare earth oxide-acetic acid solutions, as well as solutions of rare earth acetates in acetic acid were titrated conductometrically with various acids. The reactions which appear to take place are listed: $Ln_2(OH)_2(OAc)_4 + 6HClO_4 \rightarrow 2Ln(ClO_4)_3 + 4HOAc + 2H_2O$; $Ln(OAc)_3 + 3HClO_4 \rightarrow Ln(ClO_4)_3 + 3HOAc$; $Ln_2(OH)_2(OAc)_4 + 2H_2B \rightarrow Ln_2(OH)_2(B)_2 \cdot 2HOAc + 2HOAc$; and $Ln(OAc)_3 + H_2B \rightarrow Ln(OAc)(B) \cdot HOAc + HOAc$, where $B = SO_4^{=}$, $C_2O_4^{=}$, $HCit^{=}$ (with two additional moles of solvated acetic acid). Treatment of neodymium oxide-acetic acid solutions with phosphoric acid yielded a material of variable composition. The visible and ultraviolet absorption spectra of neodymium acetate in water and in acetic acid were found to be similar with slightly smaller molar absorptivities in the acetic acid solutions. Neodymium acetate shows amphoteric properties in that its solubility in acetic acid is increased as the concentration of potassium acetate

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## COMPLEX FORMATION 1.32.01

becomes greater. Transference experiments suggest the existence of anionic neodymium species in such solutions. Anhydrous neodymium chloride was found to be soluble to the extent of 12.3 gm per 100 gm of anhydrous acetic acid. Partial solvolysis with the elimination of hydrogen chloride occurs when such solutions are refluxed. Yttrium oxide does not dissolve in, or react with, either anhydrous acetic acid or acetic anhydride. However, hydrated yttrium hydroxide forms a basic acetate upon treatment with acetic anhydride. (auth)

**2264**

COMPLEX COMPOUNDS OF RARE-EARTH ELEMENTS. E. A. Terent'eva. Uspekhi Khim. 26, 1007-35(1957) Sept. (In Russian)

The capacity of rare earth elements to form complex compounds was studied with 59 organic and inorganic agents. Experiments confirmed the ability of rare earths to combine into complex compounds and showed that as a rule their capacity to combine improves with decreasing ionic radii. The coordinate number of rare earth elements in trivalent state in most cases equals six. Tetravalent Pr and Ce and in some cases divalent Eu and Sm form complex compounds. However, in contrast to such active metals as Pt, Pd, Fe, and Co the rare earth elements do not form stable complex compounds with $Cl^-$, $NH_3$, $CN^-$ and NO. The most stable compounds were formed with organic groups. The stability of the complexes with organic acids depended on the base and structure of the acid. (R.V.J.)

**8278**

OBSERVATIONS ON THE RARE EARTHS. LXVII. SOME OBSERVATIONS ON THE ABSORPTION SPECTRA OF NON-AQUEOUS SOLUTIONS OF SOME ACETYLACETONE CHELATES. Therald Moeller and William F. Ulrich (Univ. of Ill., Urbana). J. Inorg. and Nuclear Chem. 2, 164-75(1956) Mar.

Measurements of the absorption spectra of solutions of acetylacetonates of certain of the tripositive rare-earth metal ions in various non-aqueous solvents yield alterations in absorption intensities and resolutions of principal bands which support the view that the natures of these bands are determined by electrical fields imposed upon the $4f$ electrons by the associated anionic-type groups. For each species studied, only certain absorption bands are affected. The effects upon these bands are dependent upon the solvent used, but bear no simple relationship to dielectric constant. The absorption spectra of such solutions are in accord with Beer's law. Cryoscopic measurements show the solutes to be monomolecular in benzene and in carbon tetrachloride. (auth)

**4552**

ELECTROCHEMICAL STUDIES IN THE RARE EARTH SERIES. PART I. RARE EARTH OXALOACETATES. E. Gelles and G. H. Nancollas (Univ. of Glasgow, Scotland). Trans. Faraday Soc. 52, 98-102(1956) Jan.

Thermodynamic equilibrium constants for the association of La, Gd, Y, Dy, and Lu ions with oxalacetic acid in aqueous solution have been obtained from potentiometric measurements at 25°C over a range of concentration and pH. (auth)

**4296**

THE INTERACTION OF RARE EARTH IONS WITH DIETHYLENETRIAMINEPENTAACETIC ACID. R. Harder and S. Chaberek (Dow Chemical Co., Framingham, Mass.). J. Inorg. & Nuclear Chem. 11, 197-209(1959) Oct.

The interactions of rare earth ions with diethylenetriaminepentaacetic acid (DTPA) were investigated by potentiometric procedures. Metal chelate formation constants were calculated and compared with those defining similar interactions with ethylenediaminetetraacetic acid and N-hydroxyethylethylenediaminetriacetic acid. (auth)

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**3596** CEA-tr-R388
I. ETUDE DES COMPOSÉS COMPLEXES DE NEODYME, PRASÉODYME ET ERBIUM AVEC L'ACIDE CITRIQUE PAR LA MÉTHODE SPECTROGRAPHIQUE. (Study of the Complex Compounds of Neodymium, Praseodymium, and Erbium with Citric Acid by a Spectrophotometric Method. I.) V. M. Pechkova and M. I. Gromova. Translated by B. Vinogradoff from Zhur. Neorg. Khim. 2, 1356-64(1957). 20p.

Modifications in the absorption spectra of the salts of Nd, Pr, and Er in the presence of citric acid make it possible to follow the formation processes of these elements. The formation processes depend on the element/citric acid ratio and on the pH of the solution, which is proved by the displacement of the absorption maxima of Nd and Pr towards the longer wave lengths and by the appearance of a new peak in the absorption maximum of Er near the short wave lengths. For large values of the ratio element/citric acid, the formation of four complexes with citric acid for definite pH intervals is established by the displacement of the absorption maxima of Nd and Pr. The complexes of Pr are formed for larger pH values than those of Nd. In an alkaline medium, the compounds of Pr are less stable than those of Nd and decompose at pH values higher than 12.7. For erbium, in the same conditions, only one complex was found in which the absorption maximum is displaced towards the shorter wave lengths with respect to the absorption maximum of erbium salts. A comparison of the data obtained with that from the chromatographic separation of Pr and Nd, with citric acid as eluant, shows that the best results for the separation are obtained with an eluant pH which corresponds to the beginning of the complex formation (1.6 to 2.4). (tr-auth)

**8277**
ON BINARY SALTS OF LANTHANUM, CESIUM, PRASEODYMIUM AND NEODYMIUM WITH NITRATE OF TRIPHENYLBENZYLPHOSPHONIUM. G. V. Medoks (Saratov Inst. of Agriculture). Zhur. Obshechei Khim. 26, 382-4 (1956) Feb. (In Russian)

Investigations are made of binary salts of $La(NO_3)_3$, $Ce(NO_3)_3$, $Pr(NO_3)_3$, and $Nd(NO_3)_3$ with $(C_6H_5)_3(C_6H_5CH_2)P$. Experiments established a considerable difference in solubility of praseodymium and neodymium salts. (tr-auth)

**11113**
THE COMPLEXING OF CERIUM(III), LANTHANUM(III) AND GADOLINIUM(III) BY FLUORIDE IONS IN AQUEOUS SOLUTION. J. W. Kury, Z. Z. Hugus, Jr., and W. M. Latimer (Univ. of California, Berkeley). J. Phys. Chem. 61, 1021(1957) July.

The experimental techniques in measuring the extent of complexing of Ce(III), La(III), and Gd(III) by fluoride ions is based upon the competition between the rare earth ions and Te(III) for fluoride ions in a ferrous-ferric concentration cell. (auth)

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**10031**

COMPLEX COMPOUNDS OF LANTHANUM, CERIUM, PRASEODYMIUM, AND NEODYMIUM WITH THIOUREA. N. N. Sakharova (Chernyskevskiĭ Saratov State Univ.). Doklady Akad. Nauk S.S.S.R. 113, 1073-5(1957) Apr. 11. (In Russian)

Anhydrous rare-earth acetates and thiourea with melting points 180 to 182° were used to prepare the complex rare-earth elements. The molecular ratio was taken as 1 : 2, anhydrous acetate metal to thiourea. The prepared compounds were stable in water and easily recrystallized without changing their chemical composition. For La complex the melting point was at 258 to 260°, for Ce at 225 to 226°, for Pr at 292 to 293°, and for Nd at 297 to 298°. At the above temperatures the complex compounds melted with disintegration. Analysis of rare-earth element contents in the anhydrous complexes is presented. (R.V.J.)

**1281**

THE THERMAL DECOMPOSITION OF THE 5,7-DIHALO-8-QUINOLINOL RARE EARTH METAL CHELATES. Wesley W. Wendlandt (Texas Tech. Coll., Lubbock). Anal. Chim. Acta 17, 428-33(1957) Oct.

The thermal decomposition of the 5,7-dichloro-, 5,7-dibromo- and 5,7-diiodo-8-quinolinol chelates of La, Ce, Pr, Nd, Sm, and Y was investigated on the thermobalance. The chelates decomposed in the temperature range from 65 to 125°C while the oxide levels were obtained from 395 to 805°C. Although the chelate thermal stability temperatures varied little with the chelating agent, the minimum oxide level temperatures were largely dependent on the halogen substitution on the 8-quinolinol molecule. Results of this study were correlated with previous studies on the rare earth metal chelates with 8-quinolinol and 2-methyl-8-quinolinol. (auth)

**2656**

THE THERMOLYSIS OF THE NEOCUPFERRON CHELATES OF YTTRIUM AND THE RARE EARTH ELEMENTS. Wesley W. Wendlandt and John M. Bryant (Texas Technological Coll., Lubbock). Anal. Chim Acta 13, 550-3(1955) Dec.

The thermolysis curves of the neocupferron chelates of Y, La, $Ce^{3+}$, $Ce^{4+}$, Pr, Nd, Sm, and Gd were determined. It was found that the chelates were stable up to 80°, with the oxide levels being reached at 460 to 750°C. (auth)

**13800**

PHOSPHATES AND POLYPHOSPHATES OF THE RARE EARTH ELEMENTS. II. PYROPHOSPHATO AND TRIPHOSPHATO COMPLEXES OF NEODYMIUM AND YTTRIUM. Ernesto Giesbrecht and L. F. Audrieth (Univ. of Illinois, Urbana). J. Inorg. & Nuclear Chem. 6, 308-13(1958) July.

The hydrogen ion displacement method was employed to verify formation of the normal phosphate, pyrophosphate, and triphosphate of yttrium when precipitation of these substances is effected by reaction of aqueous solutions adjusted to pH of 4.5. Titration of yttrium and neodymium salts with standard solutions of pyro- and triphosphates indicates formation of the normal pyro- and triphosphates in the more acid solutions, and in the case of triphosphate, the formation of a soluble anionic species in which the ratio of rare earth metal ion to triphosphate is 1 : 2. Solution of rare earth pyrophosphates in excess of pyrophosphate can also be effected. Elution of these rare earths from a typical cation exchange agent (Amerlite IR-120) with triphosphate at pH of 8.5 affords additional evidence for formation of the bis-triphosphato rare earth complex. Large ratios of pyrophosphate to rare earth are needed to effect elution with pyrophosphate. The absorption spectrum of a solution of the bis-triphosphato neodymium complex differs only slightly from that of an aqueous neodymium chloride solution. (auth)

**9738**

INTRAMOLECULAR ENERGY TRANSFER IN YTTERBIUM ORGANIC CHELATES. G. A. Crosby and M. Kasha (Florida State Univ., Tallahassee). Spectrochim. Acta 10, 377-82(1958) Feb.

The $^2F_{5/2} \rightarrow {}^2F_{7/2}$ intra-multiplet transition has been observed as a luminescence emission in the tris-dibenzoylmethane-$Yb^{3+}$ chelate. A single strong luminescence line was recorded at 9710 ± 40 Å upon excitation of the broad $\pi,\pi^*$ absorption band of the chelate with 3650 Å light. The transition frequency agrees well with earlier observations on the unique intra-multiplet transition of $Yb^{3+}$. The intramolecular energy transfer is unusual in that the apparent electronic energy difference between the initial and final states is over 10,000 $cm^{-1}$. The importance of vibrational interaction in the mechanism of energy transfer is pointed out. (auth)

# RARE EARTHS 1.32

## COMPLEX FORMATION 1.32.01

**14350**

ON YTTERBIUM CITRATE COMPLEXES. M. M. Senyavin and A. M. Sorochan. Zhur. Neorg. Khim. 3, 301-8(1958) Feb. (In Russian)

The existence of negatively charged ytterbium complexes was confirmed by the ionic exchange method. The conductometric method for determination of compositions of ytterbium complexes with citric acid produced a negative result. The composition and stability of ytterbium citrate complexes at various pH (in the pH interval 3 to 6) and various ratios of nitric acid and ytterbium were found by potentiometric titration. It is shown that the instability constant of the complex $(Yb\ Cit_2)^{3-}$ equals $1 \times 10^{-8}$; the ratio of instability constants of $(HYbCit_2)^{2-}$ and $(YbCit_2)^{3-}$ equals $10^{-5}$. Formation of complexes $(YbOH\ Cit)^{-}$, $(Yb(OH)_3Cit)^{3-}$, and $(Yb\ Cit)^{-}$ at pH 5 and 6 and with small quantities of citric acid was observed, and tentative data for the magnitude of their constants of instability ($10^{-6}$, $10^{-36}$, and $10^{-8}$, respectively) are included. (R.V.J.)

**148**

THE FORMATION OF COMPLEX COMPOUNDS OF NEODYMIUM AND YTTERBIUM WITH ETHYLENEDIAMINE TETRAACETIC ACID ON CATION-EXCHANGE CHROMATOGRAPHY. L. I. Martynenko. Nauch. Doklady Vysshei Shkoly, Khim. i Khim. Tekhnol., No. 1, 84-88(1959).

The washing out of neodymium and ytterbium ions by means of ethylenediamine tetraacetic acid (abbreviated $H_4A$) is observed on a cation exchanger on the basis of synthetic resin. With neodymium $H_4A$ is retained in the resin. The analysis of the compound eluted from the resin showed the complex acid H(NdA) and its salt, respectively. Since the hexahydrate of this acid shows good solubility, the retention of $H_4A$ cannot be due to the crystallization of the acid in the resin. In this case the rate of elution was too high. Crystals of the complex acid readily tending towards supersaturation did not separate before hours had passed after the emergence from the column. Neodymium is adsorbed in the resin in the form of the "autosalt" $Nd(NdA)_3$. In the elution with water a desorption takes place, while the "autosalt" again enters reaction in an unchanged form. The process in the individual resin layers is different; thus the concentration fluctuations of $H_4A$ depending on the length of the adsorption column can be explained. The special tendency of $Nd(NdA)_3$ towards adsorption is to be explained by a further investigation. With ytterbium no concentration fluctuations appear in the extract, the complex compound between $Yb^{3+}$ and $H_4A$ obviously has no special tendency towards adsorption. This difference in the behavior of the complex compounds of neodymium and ytterbium offers an opportunity of separating the two elements by ion exchange. (TCO)

# RARE EARTHS 1.32

## METALLURGY 1.32.02

METALS FOR THE FUTURE, THE RARE EARTHS. R. B. Howes (St. Eloi Corp., Cincinnati). Metal Progr. 75, No. 6, 108-12(1959) June.

Properties and metallography of the rare earths are discussed. Discussions also cover use of the rare earths in the fields of nucleonics, electronics, and metallurgy. (C.J.G.)

**14225** ✓ **ISC-934**
**Ames Lab., Ames, Iowa**
**THE HEATS OF COMBUSTION OF SOME RARE-EARTH METALS. F. H. Spedding, R. E. Eberts, and A. W. Naumann. May 15, 1959. 16p. Contract W-7405-eng-82. $0.50(OTS).**

**A bomb calorimeter for measuring the heats of combustion of Nd, Sa, Gd, and Er is described. The heats of combustion and the heats of formation of their oxides are reported. (auth)**

**16997**
PHYSICO-CHEMICAL PROPERTIES AND USES OF RARE-EARTH METALS. E. M. Savitskii (Inst. of Metallurgy, Academy of Sciences, USSR). Metalloved. i Obrabotka Metal. No. 8, 2-13(1958) Aug. (In Russian)

A review is presented on the properties, applications, and production of rare-earth metals. (R.V.J.)

**14219** ✓ AFOSR-TN-58-593
Horizons, Inc., Cleveland.
STUDIES ON RARE EARTH CARBIDES—III. Technical Note No. 3. R. C. Vickery, R. Sedlacek, and Ardys Ruben. July 17, 1958. 13p. Contract AF49(638)-80. (AD-162117).

K-edge absorption of some rare-earth carbides has been studied in further attempts to rationalize the structure of these compounds. The attainment of bivalent states in samarium and ytterbium carbides receives further confirmation, while from consideration of energy values the "free electron" concept appears substantiated. (auth)

**14220** ✓ AFOSR-TN-58-594
Horizons, Inc., Cleveland.
STUDIES ON RARE EARTH CARBIDES—II. Technical Note No. 2. R. C. Vickery, R. Sedlacek, and Ardys Ruben. July 17, 1958. 8p. Contract AF49(638)-80. (AD-162118).

The intrinsic paramagnetism of tervalent rare earth ions is shown to be affected only to a minor degree upon carbide formation. Except for samarium and ytterbium carbides, the small negative difference noted between theoretical and observed magnetism is attributed to partial spin coupling or quenching of the orbital angular moments. As carbides, samarium and ytterbium are considered to adopt their bivalent states. Bohr magneton numbers and Curie-Weiss constants are presented for the carbides studied. (auth)

**14217** ✓ AFOSR-TN-58-38
Horizons, Inc., Cleveland.
STUDIES ON RARE EARTH CARBIDES—I. Technical Note No. 1. R. C. Vickery, R. Sedlacek, and Ardys Ruben. Jan. 2, 1958. 19p. Contract AF49(638)-80. (AD-148079).

The synthesis and some properties of the higher carbides of some rare earths are reported. The reaction exploited is that between rare-earth oxides and carbon at high temperatures and under low pressures of argon. Carbide formation proceeds via metal production, and interstitial compounds can exist of rare-earth metal held in the carbide lattice. The higher carbides ($LaC_2$) adopt a tetragonal structure, but scandium differs from the Lanthanons and yttrium in forming only a hexagonal monocarbide (ScC); this is basically attributed to the small size of the scandium ion which sterically permits its association with only one carbon atom. (auth)

**14218** ✓ AFOSR-TN-58-57
Purdue Univ., Lafayette, Ind.
LITERATURE REVIEW ON PROPERTIES OF PRASEODYMIUM AND CERIUM OXIDES. J. M. Honig. Jan. 1958. 65p. Contract AF18(603)-45. (AD-148098).

A review of information on the chemical properties of $Ce_2O_3$ and $Pr_2O_3$ is presented. Crystal structure, stoichiometry, and magnetic and electrical properties are discussed. (110 references). (T.R.H.)

# RARE EARTHS 1.32

## METALLURGY 1.32.02

**4750**
THERMAL EXPANSION OF RARE EARTH METALS. F. Barson, S. Legvold, and F. H. Spedding (Iowa State Coll., Ames). Phys. Rev. 105, 418-24(1957) Jan. 15.

Thermal expansion measurements at temperatures ranging up to 900°C for polycrystalline samples of La, Ce, Pr, Nd, Gd, Tb, Dy, Er, and Yb metals are reported. La, Ce, Pr, and Nd exhibit plastic flow properties at temperatures well below their melting points. High-temperature phase transformations are reported for Pr, Nd, and Yb. The coefficient of expansion for Yb is found to be three times as large as the coefficients for the other metals reported. Negative coefficients are observed near the Curie points of Gd, Tb, and Dy. (auth)

THE CRYSTAL STRUCTURES AND LATTICE PARAMETERS OF HIGH-PURITY SCANDIUM, YTTRIUM, AND THE RARE EARTH METALS. F. H. Spedding, A. H. Daane, and K. W. Herrmann (Iowa State Coll., Ames). Acta Cryst. 9, 559-63(1956) July.

The crystal structures and accurate lattice constants of scandium, yttrium and the rare earth metals are given, and the values of their calculated mole-atomic volumes, densities, axial ratios and metallic radii are graphically compared. Expected variations due to the 'lanthanide contraction' and structure differences are noted, and additional irregularities in the axial ratio and metallic radii plots are indicated. (auth)

**10079** NP-6076
University of Southern Calif., Los Angeles.
CRYSTAL STRUCTURE OF THE RARE-EARTH METALS. Technical Report No. VII [on] STUDIES OF THE RARE-EARTH HYDRIDES. James C. Warf and William L. Korst. June 30, 1956. 28p. Project NR 356-290. Contract Nonr-228(03)

**5816**
SOME PHYSICAL PROPERTIES OF THE RARE EARTH METALS. F. H. Spedding, S. Legvold, A. H. Daane, and L. D. Jennings. Progr. in Low Temperature Phys. 2, 368-94(1956).

The rare earth metals are soft and have a low Debye temperature. They have low coefficients of expansion, comparable to those of glasses. In addition, the room temperature resistivities are high. (W.L.H.)

**9210**
SOME PROPERTIES OF HEXABORIDES OF ALKALI AND RARE EARTH METALS. G. V. Samsonov and A. E. Grodshteĭn (Kalinin Inst. of Non-ferros metals and Gold). Zhur. Fiz. Khim, 30, 379-82(1956) Feb. (In Russian)

Specific weights, microhardness indices, coefficients of thermal expansion, specific resistances and thermionic emission of hexaborides of Ce, La, Ba, and Ca have been evaluated and the periods of their crystal lattices have been determined. The relation between the above properties and the characteristics of hexaboride electronic structures are discussed. (tr-auth)

**2199** AEC-tr-3479
RARE EARTH METALS. Felix Trombe. Translated for Ames Lab. from Rev. met. 52, 2-33(1956). 114p.

The metallurgy of the rare earths is discussed including alloying effects, separation, and purification. After a discussion of the physical properties of rare earths, special topics are discussed: allotopic transformations of Ce; physical phenomena accompanying the magnetic anomalies of Gd and Dy; influence of pressure on the properties of some rare-earth metals; chemical properties of rare-earth metals; phase diagrams; alloys with the Fe group; alloys with Mg; industrial utilization of rare earths; rare-earth metals in cast irons; rare earths in steel; rare earths in Al; and rare earths in Mg. 186 references. (T.R.H.)

# RARE EARTHS 1.32

## METALLURGY 1.32.02

**2657**

THE HEAT OF COMBUSTION OF SAMARIUM. Elmer J. Huber, Jr., Clayton O. Matthews, and Charles E. Holley, Jr. (Los Alamos Scientific Lab., N. Mex.). J. Am. Chem. Soc. 77, 6493-4(1955) Dec. 20.

Calorimetric combustions of Sm metal were conducted at an initial temperature of 25° under an oxygen pressure of 25 atm. The energy of combustion under these conditions was found to be 6020.0 ± 6.6 joules/g. The corresponding standard heat of formation of the sesquioxide (B-type) from the elements is calculated to be −1815.4 ± 2.0 kjoules/mole. (auth)

**12861**

DISTRIBUTION OF ELECTRONS IN ATOMS OF THE RARE EARTH METALS. T. I. Kakushadze, G. S. Gordadze, and M. G. Kokonova. Trudy Tbilis. Gosudarst. Pedagog. Inst. 10, 573-85(1955). (Translated from Referat. Zhur. Fiz. No. 4, 1957, Abstract No. 8929.)

The electron configurations of the neutral atoms of the lanthanides are taken in the specialized literature to be $4f^{0-14}5d^{1}6s^{2}$ and $4f^{0-14}6s^{2}$. In the authors' opinion, both these configurations exist simultaneously. The first gives the magnetic properties and the normal valence of the lanthanides, and the second gives the spectroscopic characteristic of the lanthanides. By virtue of this it is necessary to retain in the literature both configurations.

**17299** TID-2501(Del.)(p.395-400)

[Ames Lab., Ames, Iowa].

THE PRODUCTION OF THE LIGHT RARE EARTHS IN THE MASSIVE METALLIC STATE. F. H. Spedding, H. A. Wilhelm, W. H. Keller, D. H. Ahmann, A. H. Daane, C. C. Hach, and R. P. Ericson. p.395-400 [of] NUCLEAR SCIENCE AND TECHNOLOGY. (EXTRACTS FROM JOURNAL OF METALLURGY AND CERAMICS. ISSUE NOS. 1 TO 6, JULY 1948–JANUARY 1951). 6p. (AECD-3208; ISC-75).

Also issued separately as AECD-3208 and previously abstracted in NSA, Vol. 5, abstract No. 3208.

THE CRYSTAL STRUCTURES OF SOME OF THE RARE EARTH CARBIDES. F.H. Spedding, K. Gschneider, Jr., and A.H. Daane (Iowa State Coll., Ames). J. Am. Chem. Soc. 80, 4499-4503 (1958) Sept. 5.

A study of the rare earth-carbon systems was made. The existence of the reported $LaC_2$, $CeC_2$, $PrC_2$, $NdC_2$ and $SmC_2$, and the $Ce_2C_3$ was confirmed. The existence of the tetragonal $CaC_2$ type structure for the other rare earth dicarbides was shown. The lattice constants of these compounds decrease in a regular fashion, except for the $YbC_2$, whose lattice parameters lie between those of $HoC_2$ and $ErC_2$. The body-centered cubic $Pu_2C_3$type structure exists in all of the rare earths from La to Ho. The lattice constants decrease in a normal manner, except for $Ce_2C_3$, whose lattice parameter is smaller than would be expected. A new rare earth carbide was found, $R_3C$, which is similar to the face-centered cubic NaCl type structure, except that it is deficient in carbon. This compound appears to exist over a range of composition, i.e., in the case of yttrium it was found to vary from $YC_{0.25}$ to $YC_{0.40}$. This compound exists in the rare earth-carbon systems of Sm to Lu, and the lattice parameters decrease in a regular manner. No x-ray evidence was found for the existence of this lower carbide in the La-, Ce-, Pr-, and Nd-C systems. (auth)

# RARE EARTHS 1.32

## OTHER REACTIONS AND PROPERTIES 1.32.03

### GENERAL 1.32.03.01

**16570**
USE OF LESS EXPENSIVE RARE EARTHS AS CONTROL MATERIALS. J. A. Ransohoff. Nucleonics 17, No. 7, 80-2; 84(1959) July.

The rare earths europium, gadolinium, samarium, dysprosium, and erbium are discussed as possible control rod materials. Tabulations are given of physical and nuclear properties, cost, and availability. (A.C.)

$\gamma$-RAYS FOLLOWING THE $\beta$-DECAY OF RARE-EARTH $\alpha$-EMITTERS. K. S. Toth and J. O. Rasmussen (Univ. of California, Berkeley). J. Inorg. & Nuclear Chem. 10, 198-204(1959) May.

The $\beta$-decay properties of the rare-earth $\alpha$ emitters, $Dy^{150}$, $Dy^{151}$, $Dy^{152}$, and $Tb^{149}$, are discussed. By bombardment of stable praseodymium with $N^{14}$ ions at different energies in the Berkeley heavy-ion linear accelerator, the three dysprosium isotopes have been produced. Gamma-spectra have been obtained, and the following $\gamma$ rays have been assigned to the decay of the three nuclides; 390 kev ($Dy^{150}$), 145 kev ($Dy^{151}$), and 255 kev ($Dy^{152}$). Annihilation peaks have been observed to decay with the half lives of the three isotopes, indicating that the nuclides must emit positrons. In addition, the mass assignments of $Dy^{150}$ and $Dy^{151}$, the 8 min and 19 min dysprosium $\alpha$ emitters respectively, have been determined with certainty. $Tb^{149}$ has been produced by bombarding stable praseodymium with $C^{12}$ ions. The energies of the $\gamma$ rays following the decay of $Tb^{149}$ are 170, 230, 360, and 640 kev. (auth)

**13698** BM-RI-5468
Bureau of Mines, Denver.
THERMODYNAMICS OF RARE-EARTH COMPOUNDS. R. L. Montgomery. Oct. 1958. 25p.

The literature was surveyed and values recalculated for the heats and free energies of formation of solid rare-earth compounds at 298°K. In most instances it was necessary to estimate the entropies. Thermodynamic properties of aqueous rare-earth ions have also been calculated. (auth)

**11353**
ON THE THERMODYNAMICS OF THE RARE-EARTH METAL OXIDE CHLORINATION BY GASEOUS CHLORINE. I. S. Morozov and B. G. Korshunov (Kurnakov Inst. of General and Inorganic Chemistry). Doklady Akad. Nauk S.S.S.R. 119, 523-5(1958) Mar. 21. (In Russian)

The equilibrium of the reactions $4\ MeCl_3(t) + 3\ O_2(g) \rightleftharpoons 2\ Me_2O_3(t) + 6\ Cl_2(g)$ (where Me is Sc, La, Nd, and Sm) was investigated. Chlorination of oxides and oxidation of chlorides proceed without intermediate products. Analysis of Sc, La, Nd, and Sm oxides at 400° revealed the chlorides $ScCl_3$, $LaCl_3$, $NdCl_3$, and $SmCl_3$ with the ratio Me:3Cl equal to 0.421, 1.30, 1.32, and 1.40, respectively; theoretical figures are 0.424, 1.30, 1.36, and 1.42. (R.V.J.)

**1285**
RARE EARTH GRAPHITE INTERCALATES. R. C. Vickery and N. Lucile Campbell (Horizons, Inc., Cleveland, Ohio). J. Am. Chem. Soc. 79, 5897-9(1957) Nov. 20.

Intercalation in graphite of the whole series of rare earth chlorides has been investigated and some disagreements found with pre-existing incomplete studies. Only yttrium and gadolinium chlorides are found to intercalate consistently and in appreciable quantities. The light lanthanons do not intercalate, and inconsistent intercalation of heavy lanthanous appears attributable to variable degrees of hydration of the parent chlorides. Hall coefficient and magnetic susceptibility measurements confirm that the intercalates are ionic, while x-ray studies appear to confirm beliefs that the ions are located at imperfections in the graphite lattice. There appears some foundation for believing that ionic size and electronic structure are the major factors influencing intercalation. (auth)

**10359**
ELECTRICAL RESISTIVITIES AND PHASE TRANSFORMATIONS OF LANTHANUM, CERIUM, PRASEODYMIUM, AND NEODYMIUM. F. H. Spedding, A. H. Daane, and K. W. Herrmann (Iowa State Coll., Ames). J. Metals 9, 895-7 (1957) July.

The electrical resistivities of high-purity La, Ce, Pr, and Nd were investigated as a function of temperature over the range from room temperature to near the melting points of the metals. Transformation temperatures were observed in these metals which were confirmed by supplementary x-ray-diffraction studies. (auth)

# RARE EARTHS 1.32

## OTHER REACTIONS AND PROPERTIES 1.32.03

### GENERAL 1.32.03.01

**4353**
CATALYTIC PROPERTIES OF RARE EARTHS. V. I. Komarewsky (Illinois Inst. of Tech., Chicago). Ind. Eng. Chem. 49, 264-5(1957) Feb.
Because they are by-products of atomic piles and of titanium production, rare earth elements are becoming increasingly available materials. Their physical and chemical properties, characterized by changing valency and paramagnetism, make them promising as catalysts. The action of neodymium and samarium oxides on alcohols and hydrocarbons is reported. Both oxides exhibit dehydrogenation activity. (auth)

**5535** NP-6789
Aluminum-Industrie-Aktien-Gesellschaft, Neuhausen am Rheinfall, Switzerland.
BIBLIOGRAPHY [ON] GALLIUM. Pierre de la Breteque, comp. Mar. 1, 1958. 214p.
This bibliography lists studies up to 1957 which have appeared about Ga or Ga compounds since its discovery in 1875. (W.L.H.)

**972**
THE THERMOLYSIS OF THE RARE EARTH AND OTHER METAL NITRATES. Wesley W. Wendlandt (Texas Tech. Coll., Lubbock). Anal. Chim. Acta 15, 435-9(1956) Nov.
The thermolysis curves of the nitrates of La, $Ce^{3+}$, Pr, Nd, Sm, Y, Sc, Th, $U^{6+}$ and Zr were determined. The oxide levels were obtained in the temperature range of 450 to 830°. (auth)

**10078** NP-6075
University of Southern Calif., Los Angeles.
PRESSURE-TEMPERATURE-COMPOSITION STUDIES OF THE LANTHANUM-, CERIUM-, PRASEODYMIUM-, NEODYMIUM-, SAMARIUM-, AND YTTERBIUM-HYDROGEN SYSTEMS. RESULTS. Technical Report No. IV [on] STUDIES OF THE RARE-EARTH HYDRIDES. James C. Warf and William L. Korst. June 30, 1956. 44p. Project NR 356-290. Contract Nonr-228(03).

**7964** KAPL-M-GLP-1
Knolls Atomic Power Lab., Schenectady, N. Y.
THERMAL EXPANSION OF FOUR RARE EARTH OXIDES. G. L. Ploetz, C. W. Krystyniak, and H. E. Dumes. Mar. 28, 1957. 7p. Contract W-31-109-Eng-52. $1.80(ph OTS); $1.80(mf OTS).
The coefficients of linear thermal expansion for 95% dense samples for 4 rare earth oxides were determined using an interferometer. The values reported are: $Sm_2O_3$, $10.8 \times 10^{-6}$ cm/cm/°C from 30 to 740°C; $Eu_2O_3$; $10.5 \times 10^{-6}$ cm/cm/°C from 30 to 840°C; $Gd_2O_3$, $10.0 \times 10^{-6}$ cm/cm/°C from 30 to 840°C; and $Dy_2O_3$, $8.3 \times 10^{-6}$ cm/cm/°C. (T.R.H.)

Technical Information Service Extension, AEC.
A LIST OF REFERENCES ON LANTHANIDE SERIES RARE EARTHS. Robert L. Morgan, comp. May 29, 1952. 6p. (TID-3029).
This annotated bibliography consists of 51 references which are arranged by issuing installation.

**4352** IGRL-T/C-38
MOLAR EXTINCTION-COEFFICIENTS OF THE RARE-EARTHS AND THEIR ANALYTICAL USE. L. Holleck and L. Hartinger. Translated by J. Standring from Angew. Chem. 67, 648-51(1955). 9p.
The absorption spectra of the chlorides of Pr, Nd, Sm, Eu, Gd, Th, Dy, Ho, Er, Tm, and Yb were plotted on a spectrophotometer and molar extinction coefficients determined, some for the first time. In particular, their applicability for analytical purposes is illustrated. (auth)

# RARE EARTHS 1.32

## OTHER REACTIONS AND PROPERTIES 1.32.03

### COMPOUNDS 1.32.03.02

IODIDE SOLUBILITY IN IODIDE SOLUTIONS OF RARE-EARTH ELEMENTS. V. V. Serebrennikov and N. P. Votinova. Zhur. Neorg. Khim. 4, 1428-30(1959) June. (In Russian)

Data are presented on iodide solubility in iodide solutions of lanthanum and cerium. The data are correlated with data on neodymium, praseodymium, and samarium. It is shown that iodide solubility increases with the increase of lanthanum and cerium iodide concentrations due to the appearance of polyiodides. (R.V.J.)

THE THERMAL DECOMPOSITION OF YTTRIUM AND THE RARE EARTH METAL SULPHATE HYDRATES. Wesley W. Wendlandt (Texas Technological Coll., Lubbock). J. Inorg. and Nuclear Chem. 7, 51-4 (1958) Aug.-Sept.

The thermal decomposition of lanthanum, cerium (III), praseodymium, neodymium, samarium, gadolinium, dysprosium, holmium, erbium, ytterbium, and yttrium sulfate hydrates was studied on the thermobalance. The formation of intermediate hydrates was more pronounced with the lighter rare earth elements than with the heavier ones. The first weight loss temperatures for the hydrated salts ranged from 40 to 110°C, while the minimum temperatures for the anhydrous metal sulfate levels ranged from 155 to 295°C. (auth)

THE SULFIDES OF YTTERBIUM. Louis Domange, Jean Flahaut, Micheline Guittard, and Jean Loriers. Compt. rend. 247, 1614-16(1958) Nov. 10. (In French)

The sulfide $Yb_2S_3$ is formed by heating $Yb_2O_3$ in contact with hydrogen sulfide to 1300°C to eliminate the oxygen. The resulting compound is then heated with sulfur at 1100°C for one hour or at 800°C for three or four hours. The crystalline structure is an orthorhombic cell with the parameters $a$ = 6.78, $b$ = 9.95, and $c$ = 3.61. The density is 6.02, and the magnetic susceptibility at room temperature is $7130 \times 10^{-6}$. Heating $Yb_2O_3$ to 1350 to 1400°C in hydrogen sulfide leads to the production of a compound with the approximate composition $YbS_{1.43}$. Heating $Yb_2S_3$ leads to a product with a very similar x-ray spectrum, but with a composition $YbS_{1.33}$ ($Yb_3S_4$). The densities are 6.44 and 6.72, respectively, and the magnetic susceptibilities are $2977 \times 10^{-6}$ and $2197 \times 10^{-6}$. The heating of the other sulfides in a vacuum produces a compound with the composition $YbS_{1.11}$. X-ray-diffraction patterns show a cubic phase of the NaCl type, whose $a$ parameters vary with the sulfur content. All the products are deep blue and are easily attacked by dilute acids. (J.S.R.)

12302 ✓

EUROPIUM HEXABORIDE AND LANTHANUM TETRABORIDE. Edward J. Felten, Ira Binder, and Ben Post (Brooklyn Polytechnic Inst., N. Y.). J. Am. Chem. Soc. 80, 3479(1958) July 5.

To check a size anomaly observed in rare earths, $EuB_6$ was prepared and the lattice constant measured. $EuB_4$ could not be prepared, a fact probably related to the large effective size of the metal atom. To check this $LaB_4$ was prepared. (T.R.H.)

# RARE EARTHS 1.32

## OTHER REACTIONS AND PROPERTIES 1.32.03

### COMPOUNDS 1.32.03.02

**531** AERE-Inf/Bib-115

**United Kingdom Atomic Energy Authority. Research Group. Atomic Energy Research Establishment, Harwell, Berks, England.**

**THE PREPARATION AND PROPERTIES OF THE CARBIDES OF SCANDIUM, YTTRIUM, THE ACTINIDES AND THE LANTHANIDES. A BIBLIOGRAPHY.**

**R. G. P. Towndrow, comp. July 1958. 17p. $0.45**

**One hundred and three references to American and British reports and the published literature are given.**

**13798**

THE OXYSULFIDES $Me_2O_2S$ OF THE ELEMENTS OF THE RARE EARTH GROUP. Jean Flahaut, Micheline Guittard, and Madeleine Patrie (Laboratoire de Chimie Minerale, Paris). Bull. soc. chim. France No. 7, 990-4(1958) July. (In French)

The oxysulfides of the general formula $Me_2O_2S$ were prepared with ten elements of the rare earths, Ce, La, Pr, Nd, Sm, Gd, Dy, Er, Yb, and Y. They all have the same crystal structure, the $Ce_2O_2S$ type. They posses particularly high melting points, above 2000°. Differences were observed in their chemical properties which develop progressively from the beginning to the end of the series. In particular, the cerium oxysulfides are easily attacked by acids, the yttrium derivatives less, and the ytterbium oxysulfide is only decomposed by aqua regia. Oxidation in air is not observed below 600° except for cerium oxysulfide which can not be kept in air. Aluminum affects them at high temperatures by selective fixation of oxygen and by leaving a residue of subsulfide MeS. (tr-auth)

**9737** ✓ AFOSR-TN-58-382

Ohio State Univ. Research Foundation, Columbus.

RARE EARTH OXIDES. PART II. THE VAPORIZATION OF LANTHANUM SESQUIOXIDE, $La_2O_3$, AND YTTRIUM SESQUIOXIDE, $Y_2O_3$; DISSOCIATION ENERGIES OF LaO, YO, AND TaO. Technical Note No. 2. Patrick N. Walsh and David White. Feb. 1958. 22p. Project No. 77520. Contract AF-18(600)-1545. (AD-154289).

The vaporization of $La_2O_3$ and $Y_2O_3$ from tungsten and tantalum refractories has been studied by the Knudsen effusion method in the temperature ranges 2000 to 2450°K and 2000 to 2700°K, respectively. The sesquioxides decompose to the corresponding monoxides and oxygen on vaporization from tungsten cells. The dissociation energies of the monoxides are $D_0^0(LaO) = 8.02 \pm 0.17$ e.v., and $D_0^0(YO) = 7.25 \pm 0.3$ e.v. LaO(g) and TaO(g) are the principal products formed in the vaporization of $La_2O_3$ from a tantalum effusion cell. $Y_2O_3$ also reacts with tantalum, yielding a mixture of YO(g), Y(g), and TaO(g). From the determination of the heats of these reactions, the dissociation energy of TaO(g) is found to be $D_0^0(TaO) = 9.34 \pm 0.06$ e.v. A method is described for deriving equilibrium concentrations and heats of formation from Knudsen effusion data when more than one reaction occurs in the Knudsen cell. (auth)

# RARE EARTHS 1.32

## OTHER REACTIONS AND PROPERTIES 1.32.03

### COMPOUNDS 1.32.03.02

**11293** ✓ AFOSR-TN-58-291
Ohio State Univ. Research Foundation, Columbus.
RARE EARTH OXIDES. I. THE VAPORIZATION OF NEODYMIUM SESQUIOXIDE, $Nd_2O_3$. DISSOCIATION ENERGY OF NdO AND TaO. Technical Note No. 1. Harold Goldstein, Patrick N. Walsh, and David White. Jan. 1958. 19p. Project No. 77520. Contract AF18 (600)-1545. (AD-154196).

The vaporization of $Nd_2O_3$ has been studied by the Knudsen effusion method in the temperature range 2040 to 2450°K. Both tungsten and tantalum effusion cells were used in the experiments. From the tungsten refractory, the vaporization of $Nd_2O_3$ proceeds predominantly by dissociation to NdO(g) and O(g), whereas in the case of the tantalum refractory the $Nd_2O_3$ reacts with the cell, yielding primarily the gaseous species NdO and TaO. From the vapor pressure determinations, with the aid of free energy functions, $\Delta H_0^0$'s for the following reactions were established:

Tungsten Knudsen cell

$Nd_2O_3(s) \rightarrow 2NdO(g) + O(g)$

$\Delta H_0^0 = 423.3$ kcal

Tantalum Knudsen cell

$Nd_2O_3(s) + Ta(s) \rightarrow 2NdO(g) + TaO(g)$

$\Delta H_0^0 = 393.9$ kcal

and the dissociation energies for TaO and NdO calculated to be $D_0^0(NdO) = 7.34 \pm 0.2$ e.v. $D_0^0(TaO) = 9.36 \pm 0.2$ e.v. The dissociation energy of TaO is not in agreement with the recent value reported from mass spectrometric studies. Some reasons for this apparent discrepancy are given. (auth)

**15977** ✓ AEC-tr-3734
THERMODYNAMICS OF CHLORINATION OF OXIDES OF RARE EARTH METALS BY GASEOUS CHLORINE. I. S. Morozov and B. G. Korshunov. Translated for General Electric Co. Aircraft Nuclear Propulsion Project from Doklady Akad. Nauk S.S.S.R. 119, 523-5 (1958). 3p. $1.80(ph), $1.80(mf) JCL or LC.

This paper was previously abstracted from the original language and appears in NSA, Vol. 12, as abstract No. 11353.

**8332** ✓ UCRL-3894
California. Univ., Berkeley. Radiation Lab.
THE REACTIONS OF MIXED CRYSTALS OF RARE EARTH FLUORIDES WITH FLUORINE GAS (thesis). William P. Bryan. Aug. 1957. 65p. Contract W-7405-eng-48. $10.80(ph OTS); $3.90(mf OTS).

The reactions of mixed crystals of rare earth fluorides with fluorine gas have been studied gravimetrically by determining the weight increases of mixed trifluoride samples upon exposure to fluorine at a pressure of 1 atmosphere and a temperature of 250°C. A special nickel helix balance was developed for directly studying these weight changes in an atmosphere of fluorine. The nature of the phases produced upon fluorination was studied by x-ray-diffraction methods. The following cerium-containing mixed trifluoride systems were studied over the whole range of compositions: $CeF_3-LaF_3$, $CeF_3-YF_3$, and $CeF_3-PrF_3$. In all these systems the cerium is completely oxidized to the +4 state, and in a restricted range of the $CeF_3-PrF_3$ system some of the praseodymium is oxidized to the +4 state. The following terbium-containing mixed trifluoride systems were studied over the whole range of compositions: $TbF_3-LaF_3$ and $TbF_3-YF_3$. In neither case does complete oxidation of terbium to the +4 state occur after certain amounts of $LaF_3$ or $YF_3$ have been added to the $TbF_3$. The above results are explained thermodynamically and the $\Delta F°$ value for the reaction $TbF_3 + \frac{1}{2} F_2 = TbF_4$ is estimated as being in the range between −278 calories and 0 calories at 250°C. (auth)

# RARE EARTHS 1.32

## OTHER REACTIONS AND PROPERTIES 1.32.03

### COMPOUNDS 1.32.03.02

**6431**

CRYSTALLOGRAPHIC DATA: YTTRIUM TRIFLUORIDE, $YF_3$, ORTHORHOMBIC FORM. SAMARIUM TRIFLUORIDE, $SmF_3$, ORTHORHOMBIC FORM. YTTERBIUM TRIFLUORIDE, $YbF_3$, ORTHORHOMBIC FORM. LANTHANUM TRIFLUORIDE, $LaF_3$. NEODYMIUM TRIFLUORIDE, $NdF_3$. Eugene Staritzky and L. B. Asprey (Los Alamos Scientific Lab., N. Mex.). Anal. Chem. 29, 855-7(1957) May.

**10465**

NEW BORIDES OF RARE-EARTH ELEMENTS. V. S. Neshpor and G. V. Samsonov. Dopovidi Akad. Nauk Ukr. R.S.R. No. 5, 478-9(1957). (In Russian)

The borides of dysprosium, holmium and lutecium were obtained by means of the vacuum-thermal method. They were subjected to x ray and chemical analyses. Roentgenograms of all these compounds are very similar and indicate the presence in each of them of two phases: cubic and tetragonal. Therefore, the composition of these borides is as follows: $DyB_6$, $DyB_4$, $HoB_6$, $HoB_4$, $LuB_6$ and $LuB_4$. The lattice constants are tabulated. The intensities of the lines of the two phases in the roentgenograms are approximately equal; most of the lines are ascribed to the phase of $MeB_4$. (TCO)

**2263**

PHOSPHATES AND POLYPHOSPHATES OF THE RARE-EARTH ELEMENTS. I. THE HYDROGEN ION DISPLACEMENT METHOD FOR THE CHARACTERIZATION OF THE PHOSPHATES AND POLYPHOSPHATES OF SOME RARE EARTHS. A. G. Buyers, E. Giesbrecht, and L. F. Audrieth (Univ. of Illinois, Urbana). J. Inorg. and Nuclear Chem. 5, 133-40(1957).

Addition of sodium phosphates (and polyphosphates) to rare-earth solutions, both adjusted to a pH of 4.5, results in the precipitation of the normal phosphates (and polyphosphates) corresponding to the formulas $RPO_4$, $R_4(P_2O_7)_3$, and $R_5(P_3O_{10})_3$, accompanied by displacement of hydrogen ion from the respective ionic species, $H_2PO_4^-$, $H_2P_2O_7$ = and $H_2P_3O_{10}^{-3}$. This displacement reaction has been evaluated for the $H_2PO_4^-$ rare-earth reaction as a method for determination of average atomic weights and has been found to give results which in general are somewhat higher than those based on the accepted oxide-oxalate ratio. Preliminary evidence is also presented to demonstrate that the trivalent rare earths form water-soluble pyrophosphato and triphosphato complexes. (auth)

**5815**

A NEW METHOD OF PREPARATION OF ANHYDROUS ACETATES OF RARE-EARTH ELEMENTS. S. Panda and D. Patnaik. J. Indian Chem. Soc. 33, 877-8(1956) Dec.

The anhydrous acetates of thorium, cerium and lanthanum have been prepared by the action of the respective nitrate on acetic anhydride. This method can be applied, in general, for preparation of the acetates of other rare earths and elements, the nitrates of which are partially soluble in acetic anhydride. (auth)

# RARE EARTHS 1.32

## OTHER REACTIONS AND PROPERTIES 1.32.03

### COMPOUNDS 1.32.03.02

University of Southern Calif., Los Angeles.
A SURVEY OF THE LITERATURE CONCERNING THE RARE-EARTH HYDRIDES. Technical Report No. 1 [on] STUDIES OF THE RARE-EARTH HYDRIDES. James C. Warf and William L. Korst. June 30, 1956. 186p. Project NR-356-290. Contract Nonr-228(03). (NP-6073).

The literature survey consists of approximately 150 references to published literature. The references are arranged alphabetically by senior author. The period covered by this review is 1891-1955.

8276
ON CAMPHORATES OF SOME RARE-EARTH ELEMENTS. Ya. Ya. Dodonov and S. B. Pirkes (Saratov State Univ.). Zhur. Obshchei Khim. 26, 379-81(1956) Feb. (In Russian)

A method is presented for the preparation of d-camphorates of La, Ce, Pr, and Nd by the reaction of their aqueous chloride solutions with sodium comphorate. It has been established that d-camphorates of the Ce group are moderately soluble in $H_2O$; that the solublity of rare earth elements decreases in the following order: Nd, Pr, Ce, La, and Th; that the solubility of d-camphorates of rare earth elements and Th increases with cooling and decreases with heating. Also, it was observed that d-camphorates of rare earth elements are easily hydrolized and an ethyl alcohol precipitation can be used for their separation (without hydrolysis) from aqueous solutions. (R.V.J.)

58 CCC-1024-TR-140
Howard Univ., Washington, D. C.
PREPARATION AND PROPERTIES OF BOROHYDRIDES OF THE ALKALINE EARTH METALS. M. D. Taylor, L. R. Grant, C. A. Sands, and M. B. Templeman. Oct. 6, 1955. 13p.

Experiments have been performed for the preparation of Ca, Ba, and La borohydrides. The first two compounds appear to have been obtained as solvates in a reasonably pure state but only in rather small yields. The reactions were generally performed with lithium or sodium borohydride and the appropriate metal iodide in some non-aqueous solvent. Pyridine and tetrahydrofuran were the solvents most commonly used. Two new general methods for preparing anhydrous alkaline earth iodides have been developed and specifically applied in the cases of LiI and $BaI_2$. Essentially quantitative yields of pure products are obtained by the reaction of the alkaline earth hydride and either $I_2$ or $NH_4I$ in a non-aqueous solvent. (auth)

# RARE EARTHS 1.32

## YIELD 1.32.04

**3024** ✓

DECAY OF $Pm^{144}$. Kenneth S. Toth and O. B. Nielsen (Univ. of Copenhagen). Phys. Rev. 115, 1004-7(1959) Aug. 15.

$Pm^{144}$ was produced by an ($\alpha$,n) reaction on $Pr^{141}$ in the Copenhagen cyclotron. The half-life of $Pm^{144}$ was determined and found to be closer to 450 days than to the previously reported 300 days. The decay of the nuclide to levels in $Nd^{144}$ was studied, using a 100-channel gamma-ray analyzer and a six-gap $\beta$-ray spectrometer. Three $\gamma$ rays were found, with the following energies: 474, 615, and 695 kev, respectively. It was determined that the three $\gamma$ rays are E2 transitions and that they are in cascade with one another. A decay scheme for $Pm^{144}$, consistent with the experimental data, was proposed. (auth)

**10363**

SOME NEW ISOMERIC TRANSITIONS IN RARE EARTH NUCLEI. J. W. Mihelich (Univ. of Notre Dame, Ind.) and B. Harmatz (Oak Ridge National Lab., Tenn.). Phys. Rev. 106, 1232-5(1957) June 15.

The following isomeric transitions have been observed in neutron-deficient rare earth isotopes: $Tb^{158m}$ (5.5 hr) 88.2 kev (E3); $Ho^{160m}$ (5.0 hr) 60.1 kev (E3); $Er^{167m}$ (2.5 sec) 208 kev (E3); $Er^{168m}$ ($10^{-7}$ sec); and $Yb^{171m}$ ($T_{1/2}$?) 75.8 kev (E3). All the E3 transitions may proceed between levels predicted by Mottelson and Nilsson. (auth)

**9518**

ISOMERIC TRANSITIONS IN THE RARE-EARTH ELEMENTS. C. L. Hammer and M. G. Stewart (Iowa State Coll., Ames). Phys. Rev. 106, 1001-7(1957) June 1.

A search was made for isomeric transitions in the rare-earth elements with half lives greater than 5 $\mu$ and less than ~30 min which arise in the decay of photoexcited nuclei. Four isomeric transitions were found and identified as follows: $Tb^{158}$, 50 kev <E<200 kev, 11.0 ± 0.1 sec, M3 or E3; $Ho^{163}$, 305 kev, 0.8 ± 0.1 sec, E3; $Er^{165,167,\text{or }169}$, 213 kev, 2.5 ± 0.1 sec, E3; $Lu^{174}$, 133 kev, 75 ± 2 $\mu$sec, E2. These results are compared with the predictions of the nuclear models which have been proposed by Nilsson and Gottfried. (auth)

RARE-EARTH SOLUTIONS FOR $4\pi$ COUNTING. Juan Pascual and Edward C. Freiling (U. S. Naval Radiological Defense Lab., San Francisco, Calif.). Nucleonics 15, No. 5, 94(1957) May.

A method of preparation of solid-free solutions for rare-earth absolute-disintegration-rate determinations by $4\pi$ counting is described. (T.R.H.)

**9054** ✓✓ PR-P-33

Atomic Energy of Canada Ltd. Chalk River Project, Chalk River, Ont.

PHYSICS DIVISION PROGRESS REPORT [FOR] JANUARY 1, 1957 TO MARCH 31, 1957. 93p. (AECL-448).

A combination Geiger and scintillation apparatus for use in cosmic ray meson experiments is described. Revisions in the semi-empirical atomic mass formula are discussed and preliminary results from studies of fission reactions are given. Results are reported from decay studies of $Tb^{160}$, $Eu^{154}$, $Eu^{156}$, $Pr^{144}$, and $Y^{90}$ The use of a circular polarization analyzer in parity conversion experiments is reviewed. Velocity measurements on coincident pairs of fragments from $Cf^{252}$ spontaneous fission were completed and are reported. Experiments with the $Al^{27}(p,\gamma)Si^{28}$ reaction gave evidence of a 4.64 Mev level in $Si^{28}$ which cascades to the ground state via a cross-over transition at 1.77 Mev. Quantitative data were obtained for the first nine excited states of $B^{11}$ observed in the reaction $Be^{9}(He^{3},p\gamma)B^{11}$. Some of the characteristics of excited states observed in $Al^{27}(p,p'\gamma)$ and $B^{10}(He^{3},p)C^{12}$ reactions are discussed. Results obtained in neutron diffraction studies of Mn–Co alloy, $UO_2$, solid Ne and He, and $UMn_2$, $UFe_2$ and $UCo_2$ alloys are discussed. Progress in the development of various radiation detection instruments is reviewed. (For preceding period see PR-P-32.) (D.E.B.)

# RARE EARTHS 1.32

## YIELD 1.32.04

**4806**
RADIOACTIVE DECAY OF $Dy^{159}$. B. H. Ketelle and A. R. Brosi (Oak Ridge National Lab., Tenn.). Phys. Rev. 116, 98-101(1959) Oct. 1.

$Dy^{159}$ decay feeds three excited levels in $Tb^{159}$. Gamma rays with energies of 58, 200, 290, and 350 kev were observed and electron-capture branching ratios were determined. Only L electron capture to the 350-kev level was detected. The half-life of the 58-kev level in $Tb^{159}$ was shown to be less than $1 \times 10^{-9}$ sec. The K conversion coefficient of the 58-kev gamma ray was measured and found to be $5 \pm 1.5$. The disintegration energy of $Dy^{159}$ was shown to lie between 360 and 400 kev; the half-life was remeasured and found to be $144.4 \pm 0.2$ days. (auth)

**6572**
RADIOACTIVE ISOTOPES OF RARE EARTHS FORMED IN SPALLATION REACTION. G. M. Gorodinski, et al. (Khlopin Radium Inst., Acad. of Sciences U.S.S.R.). Doklady Akad. Nauk S.S.S.R. 112, 405-6(1957) Jan. 21. (In Russian)

Determination of rare earth isotopes, the half lives, the type and energy of radiation and $\gamma$ spectra taken with scintillation spectrometers with NaI(Tl) and CsI(Tl) crystals enabled a series of already known radioisotopes to be identified. New Gd isotopes were revealed and new gamma lines of the investigated nuclei were found. A short account of the obtained results is given in separate fractions for Ce, Ne, Eu, Gd, Tb, Dy, Yb, Lu, and fractions of Ho, Er, and Tm. (R.V.J.)

**9169**
THE ISOTOPIC COMPOSITION OF RARE-EARTH ELEMENTS FORMED BY FISSION OF URANIUM, THORIUM, AND BISMUTH WITH 680-MeV PROTONS. F. I. Pavlotskaya and A. K. Lavrukhina. J. Nuclear Energy 5, No. 1, 149-57(1957).

Results are given of a radiochemical investigation of the rare earths formed by fission of U, Th, and Bi nuclei with 680-Mev protons. In this work, which was carried out in 1954, special attention was given to methods of separation of these elements. The influence of various factors on the degree of separation was studied to find the optimum conditions for an ion-exchange chromatographic separation method. These factors were the nature of complexing agents (ammonium acetate, citrate, oxalate, and lactate), the pH of the eluant and the concentration of rare earths. A decay-curve method allowed us to detect radioisotopes of almost all the rare earths and to determine yields of some of them. The formation of a new isotope of Sm with half life approximately 20 days is also proposed. (auth)

**378** AEC-tr-3061
YIELD OF FISSION PRODUCTS OF $U^{235}$ IN THE RARE EARTH REGION. V. K. Gorshkov, R. N. Ivanov, G. N. Kukavadeze, and I. A. Reformatskii. Translated from Atomnaya Energ. III, 11-14(1957). 12p.

A description is given of results of measurements of the yields of the fission product of $U^{235}$ using the integral mass spectrographic method, which makes it possible to simultaneously determine the concentration of several elements in their mixtures. Using the integral mass spectrographic method, measurements of the yields of $La^{139}$, $Pr^{141}$, $Pm^{147}$, and $Pm^{149}$ are given for the first time. From these data the absorption cross sections for $Pm^{147}$ and $Sm^{147}$ are calculated, and the lower absorption cross section boundary for $Sm^{149}$ is given. (auth)

# RARE EARTHS 1.32

## YIELD 1.32.04

11779 ✓ HW-13959
Hanford Works, Richland, Wash.
RATE OF BURNOUT OF ABSORBERS. P. R. Gillette. July 19, 1949. Decl. Feb. 25, 1957. 5p. Contract W-31-109-Eng-52. $1.80(ph OTS); $1.80(mf OTS).

Some rare earth elements contain a series of several isotopes of consecutive mass number, all of which are either stable or of such long half life and high thermal neutron absorption cross section that the probability of neutron absorption will, for obtainable fluxes, be much greater than the probability of radioactive decay. Under such conditions a chain reaction occurs in which lighter isotopes move up the series by successive n,$\gamma$ reactions. The absorptivity of a material containing such an element will vary with time of irradiation in a complex manner, depending on the variation in cross section from isotope to isotope. Relations were derived which give the relative absorptivity, as a function of time, of series containing one or more isotopes with a given high cross section and one or more isotopes with another lower cross section, arranged in various orders. Results of calculations using these relations show that the absorptivity may exhibit a rapid decrease from its original value, a rapid increase to several times its original value followed by a slow decrease, or almost any kind of behavior between these two extremes, depending on the order in which high and low cross sections occur. Since the relations are exactly analogous to those for a radioactive decay chain similar conclusions can be drawn for chains in which long- and short-lived elements appear in various orders. (auth)

7028 ✓ A/CONF.15/P/2477
RESEARCH IN NEUTRON-DEFICIENT RARE EARTHS. A. Bashilov, K. Gromov, et al. (Leningrad State Univ.). 25p.

A study of neutron-deficient rare earths obtained by 680-Mev proton irradiation of Ta is reported. The following new isotopes were discovered: $Eu^{146}$, $Gd^{146}$, $Gd^{147}$, $Dy^{153}$, $Dy^{155}$, $Ho^{156}$, $Tm^{161}$, and $Lu^{167}$. Mass numbers were established by studying genetic bonds with the aid of multiple extractions of daughter fractions. Decay schemes are given for $Gd^{146}$, $Gd^{147}$, $Gd^{149}$, $Gd^{151}$, $Eu^{146}$, $Eu^{147}$, $Tb^{153}$, $Tb^{155}$, $Ho^{160}$, $Tm^{166}$, $Tm^{167}$, $Tm^{168}$, $Lu^{171}$, and $Lu^{173}$. (W.D.M.)

5007 CEA-tr-R556
NOMBRES DE MASSE DES ISOTOPES DU DYSPROSIUM DÉFICIENTS EN NEUTRONS. (Mass Numbers of Neutron-Deficient Dysprosium Isotopes.) A. N. Dobronova, L. M. Krijansky, A. M. Mourine, and V. N. Pokrovsky. Translated from Izvest. Akad. Nauk S.S.S.R. 22, 815-16(1958). 5p.

Studies of the genetic bonds of Dy isotopes with Tb and Gd daughter elements indicated the possible existence of isotopes with A = 159, 157, 155, and 153. To verify this, an attempt was made to determine directly the Dy isotopic masses formed in Ta deep spallation. The Dy fraction was separated by mass spectrometer, and the $\gamma$ spectra of separated Dy isotopes were determined with a scintillation spectrometer. The results confirmed the existence of Dy with A = 159, 157, 155, 153, and possibly, 151. The weak activity of $Dy^{159}$ and still weaker $Dy^{151}$ prevented further studies. The following data were found for $Dy^{157}$: $T_{1/2} = 8.5 + 0.5$ hr; no daughter activity observed; $\gamma$ spectrum lines 80 and 325 kev. For $Dy^{155}$: $T_{1/2} = 9 \pm 2$ hr; daughter activity with $T_{1/2} \sim 5$ days ($Tb^{155}$); $\gamma$ spectrum lines 80 and 227 kev. For $Dy^{153}$: $T_{1/2} = 7 \pm 3$ hours; daughter activity with $T_{1/2} \sim 2$ days ($Tb^{153}$); $\gamma$ spectrum line 80 kev. (R.V.J.)

# RHODIUM 1.33

**2206**
RADIOACTIVE DECAYS OF $Rh^{106}$ AND $Ag^{106}$. D. E. Alburger and B. J. Toppel (Brookhaven National Lab., Upton, N. Y.). Phys. Rev. 100, 1357-63(1955) Dec. 1.

Transitions in $Pd^{106}$ occurring in the decays of $Rh^{106}$ and $Ag^{106}$ have been examined with a three-crystal pair spectrometer using gray-wedge pulse-height analysis, single and coincidence scintillation spectrometer techniques and an intermediate-image $\beta$ spectrometer. In addition to lines previously known, $\gamma$ rays of 1.77, 1.96, 2.10, and 2.66 Mev and a possible $\gamma$ ray of 1.14 Mev are found in $Rh^{106}$ decay. Gamma rays of energies 0.22, 0.409, 0.51, 0.62, 0.72, 0.805, 1.045, 1.131, 1.205, 1.23, 1.39, 1.55, 1.77, 1.85, 2.1, and 2.63 Mev are observed in $Ag^{106}$ decay. Most of the data can be satisfied by postulating in addition to the five previously known states in $Pd^{106}$ three new weakly excited levels at 1.85, 2.27, and 2.66 Mev. A lower limit of $\sim 10^{-8}$ sec is estimated for the partial half-life of the 0-0 transition between the second excited and ground states of $Pd^{106}$. (auth)

**1018**
AN ISOMER OF $Rh^{106}$. G. B. Baro, W. Seelmann-Eggebert, and I. Zabala. Publ. com. nacl. energia atomica (Buenos Aires), Ser. quim. 1, No. 4, 29-41(1955). (In Spanish)

A new rhodium activity of 117-minute half life was found. It is formed by (n, p) (n, $\alpha$) and d, $\alpha$) reaction, but not as a normal fission product or as a daughter of $Ru^{106}$. The maximum energy of the negatrons emitted is 0.7 Mev. The total disintegration energy Q is about 3.6 Mev. The mass number of the new rhodium activity is 106, probably a higher isomer of the known 30-second $Rh^{106}$. The newly found $Rh^{106m}$ does not disintegrate by gamma rays (<1%) to the normal state of $Rh^{106}$. It emits the same gamma rays as the 30-second $Rh^{106}$ and the $Ag^{106}$, as well as other gamma lines. (auth)

# RUBIDIUM 1.34

**21986** AEC-tr-3820
DEVELOPMENT AND RECENT STATUS OF TECHNOLOGY OF RUBIDIUM AND CESIUM AND THEIR COMPOUNDS. V. E. Pliushchev and I. V. Shako. Translated for Los Alamos Scientific Lab. from Uspekhi Khim. 26, 944-64(1957). 45p. $7.80(ph), $3.30(mf) JCL or LC.

This paper was previously abstracted from the original language and appears in NSA, Vol. 12, as abstract No. 12990.

**11330** CF-58-1-26
Oak Ridge National Lab., Tenn.
THE CRYSTAL STRUCTURE OF $Rb_3UF_7$. L. A. Harris. Jan. 6, 1958. 3p. Contract [W-7405-eng-26]. $1.80 (ph OTS); $1.80(mf OTS).

The compound whose chemical composition is $Rb_3UF_7$ was observed to be an optically isotropic single-phase material. The phase gave x-ray powder spectrometer data which were found to index well on the basis of a face-centered cubic unit cell. The cube edge was calculated to be 9.58 ± 0.03 A, and the calculated density assuming four molecules per unit cell is 4.78 gms/cm$^3$. (auth)

**450**
DISINTEGRATION SCHEME OF $Rb^{83}$. M. L. Perlman and Joan P. Welker (Brookhaven National Lab., Upton, N. Y.). Phys. Rev. 100, 81-2(1955) Oct. 1.

The decay of $Rb^{83}$ has been determined to proceed by electron capture to an excited state of $Kr^{83}$ which is 0.566 Mev above the ground state. This excited state is depopulated exclusively by emission of a 0.525-Mev gamma ray (M1) to the 0.041-Mev state, $Kr^{83m}$. Little or no electron capture direct to the 0.041-Mev level or to lower levels occurs. The spin-parity designation of the 0.566-Mev state is $p_{3/2}$, and that of the $Rb^{83}$ ground state is $f_{5/2}$. (auth)

**1878** ISC-795
Ames Lab., Ames, Iowa.
TABULATION, BIBLIOGRAPHY, AND STRUCTURE OF BINARY INTERMETALLIC COMPOUNDS. I. COMPOUNDS OF LITHIUM, SODIUM, POTASSIUM, AND RUBIDIUM. S. G. Epstein, D. M. Bailey, R. L. Smythe, G. R. Kipp, and J. F. Smith. Sept. 1, 1956. 31p. Contract W-7405-eng-82. $0.25(OTS).

# RUBIDIUM 1.34

**12938** ✓

IONIZATION FOLLOWING BETA DECAY IN KRYPTON-85. Arthur H. Snell and Frances Pleasonton (Oak Ridge National Lab., Tenn.). Phys. Rev. 107, 740-5(1957) Aug. 1.

Following beta decay in the 9.4-year radioactivity of $Kr^{85}$, the product rubidium atoms are found to be distributed in the following charge spectrum (figures in percent): charge 1, 79.2 ± 1.0; charge 2, 10.9 ± 2; charge 3, 3.9 ± 0.1; charge 4, 3.1 ± 0.1; charge 5, 1.51 ± 0.07; charge 6, 0.66 ± 0.04; charge 7, 0.40 ± 0.02; charge 8, 0.19 ± 0.02; charge 9, 0.093 ± 0.01; charge 10, 0.026 ± 0.006; charge 11, unobservable. An interpretation is made in terms of the "shaking off" of extranuclear electrons by the sudden change by + 1 in the nuclear charge, the intensity of the charge-2 ions being taken as a direct measure of the probability of "shake-off" from the combined 4s and 4p shells. The combined intensities of charge 3 and higher are correspondingly equated to the summed probabilities of primary ionizations in the n = 1, 2, and 3 shells. (auth)

**4864** ✓ AD-53503

Washington Univ., St. Louis.

BETA SPECTRA OF VANADIUM-48 AND RUBIDIUM-86 (thesis). Lawrence Eugene Killion. Feb. 1955. 160p.

The disintegration schemes of a positron emitter ($V^{48}$) and a negatron emitter ($Rb^{86}$) are critically analyzed. A review of the essentials of the Fermi theory of $\beta$ decay is presented along with an extension to forbidden transitions, spectral shape, and the transformation necessary to restore linearity to F-K plots in the case of unique type spectra. $\beta$-ray spectroscopy is discussed with particular reference to the 180° magnetic spectrometer which was used in experiments. Results indicated no evidence of the existence of a second positron group in $V^{48}$; in the case of $Rb^{86}$, however, evidence was found for an additional $\beta$ group not previously reported in the literature. $Rb^{86}$ data indicated that recent serious differences in experimental findings should not be attributed entirely to the conventional subtraction method of data analysis. (ASTIA abst.)

# RUTHENIUM 1.35

Kansas. Univ., Lawrence.

THE CHEMISTRY OF RUTHENIUM. D. D. Deford. May 1948. 176p. (NP-1104).

This is a dissertation with chapters as follows: introduction; brief survey of chemistry of Ru; review of chemistry of Ru in detail; work of author on cyanide complexes of Ru; survey of analytical methods for Ru; and details of colorimetric method of analysis developed by author. An extensive bibliography of 257 references to American and foreign journals is included.

**6492** ✓ A/CONF.15/P/2143

CHEMISTRY OF RADIORUTHENIUM. O. E. Zvyagintsev, V. D. Nikolskii (Nikolsky), et al. (U.S.S.R.). 24p.

Some Ru compounds of the general type $Me(RuNO(C_2O_4)_2)$ were synthesized, and some of their properties were studied. The process of electrical reduction of the compounds of $RuNOAc_2$ type were investigated, where Ac is the acid remnant. A study was made of the extraction capacity of various nitroso compounds of Ru by organic solvents at different acidity. (W.L.H.)

**2011** ✓

NITRATO AND NITRO COMPLEXES OF NITROSYLRUTHENIUM. J. M. Fletcher, I. L. Jenkins, F. M. Lever, F. S. Martin, A. R. Powell, and R. Todd (Atomic Energy Research Establishment, Harwell, Berks, England). J. Inorg. and Nuclear Chem. 1, 378-401(1955) Dec.

A series of nitratoaquo nitrosylruthenium complexes, of general formula $[RuNO(NO_3)_y(OH)_{3-y}(H_2O)_2]$, has been identified. In aqueous solution they give rise to anionic and cationic ruthenium species; the higher nitrato complexes are hydrolyzed at room temperature at a rapid but measurable rate to lower nitrato complexes; condensation to polynuclear species accompanies these reactions. The trinitrato complex has been prepared by the action of boiling 8M $HNO_3$ on nitrosylruthenium hydroxide or the nitro complex $Na_2[RuNO(NO_2)_4OH]$ (hitherto considered a nitro complex of Ru(3+)), both of which are conveniently made from ruthenium chloride. Nitro and nitrato complexes of nitrosylruthenium are also formed from ruthenium tetroxide and ruthenium alloys by the action of nitrogen oxides or $HNO_3$. The stronger complexing of nitrosylruthenium by $NO_2^-$ than by $NO_3^-$, as well as the degree of complexing of $RuNO^{3+}$ by ligands such as $F^-$, $Cl^-$, point to the general similarity of these coordination complexes to those of Co(3+) and Pt(4+). The nitrosylruthenium complexes are converted by sulfides to an insoluble nitrosylruthenium hydrosulfide. (auth)

# RUTHENIUM 1.35

**12535** AERE-C/R-816
Gt. Brit. Atomic Energy Research Establishment, Harwell, Berks, England.
THE CHEMISTRY OF RUTHENIUM. PART I. THE FORMATION AND EXAMINATION OF AN EXTRACTABLE RUTHENIUM NITRATE IN MACROSCOPIC AMOUNTS. PART II. THE EFFECT OF FERROUS SULPHAMATE TREATMENT. F. S. Martin and G. M. Gillies. Dec. 10, 1951. Decl. Apr. 30, 1959. 23p.

The formation in macroscopic quantities of an extractable ruthenium compound from Ru(IV) hydroxy nitrate and nitrous acid is described. It obeys the simple partition coefficient law, with partition coefficient into cyclo-hexanone of 2.3. Twelve hour contact with the solvent converts it to a compound of partition coefficient 13. The possible existence of this and other forms of ruthenium nitrate in plant solutions is discussed. The effect on the extractability of the compound of heating with ferrous sulfamate is shown to reach a maximum in two hours at 90°C in 0.5N nitric acid. Other reducing agents produce the same effect but differ in efficiency. The treatment does not result in reduction of the ruthenium atom in the molecule and it is concluded that the treatment is effective as a result of interaction with the nitrose group which is believed to be present. (auth)

**10899**
THE NITRATONITROSYLRUTHENIUM COMPLEX, $RuN_3O_{7.5}$. F. S. Martin, J. M. Fletcher, P. G. M. Brown, and B. M. Gatehouse (Atomic Energy Research Establishment, Harwell, Berks, Eng. and University Coll., London). J. Chem. Soc. 76-9(1959) Jan.

The ruthenium compound obtained by the reaction of nitric oxide with ruthenium tetroxide in carbon tetrachloride and referred to as $Ru_2N_6O_{15}$ by Martin and by Fletcher et al. was studied. Infrared examination included the use of the $N^{15}$ form of the complex. The reactions involved in its preparation and its behavior in both organic and aqueous media indicate that it may be a nitrato-complex containing two bisnitrosylruthenium groups linked by an oxo-bridge. Infrared absorptions of a number of other compounds containing the Ru–O bond are reported. (auth)

**85** DP-391
Du Pont de Nemours (E. I.) & Co. Savannah River Lab., Aiken, S. C.
NUCLEAR MAGNETIC RESONANCE SPECTRA OF NITROGEN-14 IN RUTHENIUM NITROSYL COMPLEXES. Bruce B. Murray. June 1959. 8p. Contract AT(07-2)-1. OTS.

Measurements were made of the nuclear magnetic resonance (NMR) spectra of $N^{14}$ in $Na_2RuNO(NO_2)_4OH$, $RuNO(Cl)_3(H_2O)_2 \cdot 3H_2O$, and $RuNO(NO_3)_3(H_2O)_2 \cdot xH_2O$. The NMR spectra observed for $Na_2RuNO(NO_2)_4OH$ were interpreted to show that the nitrogen atom in each of two of the $NO_2$ groups was bonded differently from the nitrogen atoms in the other groups. The nitrato groups in $RuNO(NO_3)_3(H_2O)_2 \cdot xH_2O$ were inferred to be equivalent and their nitrogen atoms to be bonded similarly to the nitrogen atoms in the nitrate ions in aqueous solutions of $NH_4NO_3$. (auth)

**2010**
RUTHENIUM(IV) NITRATES. J. S. Anderson and J. D. M. McConnell (Atomic Energy Research Establishment, Harwell, Berks, England). J. Inorg. and Nuclear Chem. 1, 371-7 (1955) Dec.

A solution of $RuO_4$ in $HNO_3$ is reduced by $H_2O_2$ to give a deep red solution. On evaporation to dryness, a dark red solid is obtained, which decomposes fairly rapidly. The properties of solutions of this solid, which are strongly acidic, are consistent with the hypothesis that it contains a series of hydroxo-aquo ruthenium complexes of quadrivalent ruthenium of the general formula $[Ru(OH)_x(H_2O)_{6-x}](NO_3)_{4-x}$. On neutralization with alkali there appears to be a slow polymerization process after $[Ru(OH)_3(H_2O)_3]NO_3$ has been formed, leading finally to a precipitate, probably hydrated $RuO_2$. (auth)

# RUTHENIUM 1.35

**8997** NP-tr-69

COMPLEX ACID-NITROSO COMPOUNDS OF RUTHENIUM. O. E. Zvyagintsev and S. M. Starostin. Translated by J. B. Sykes from Zhur. Neorg. Khim. 2, 1281-8(1957). 14p.

Complex acid-nitroso compounds of ruthenium were investigated, and an attempt was made to discover the reasons for their stability. Several new compounds of ruthenium were obtained: $RuNO(NO_3)_2 \cdot 2H_2O$, $RuNO(NO_3)_2 \cdot 3H_2O$, $RuNO(CH_3COO)_2$, $Na[RuNO(CH_3COO)_3] \cdot H_2O$, $H_2[RuNO(C_2O_4)_2]$, $H_2[RuNO(C_2O_4)] \cdot H_2O$, $(NH_4)_2[RuNO(C_2O_4)_2]$, $Mg[RuNO(C_2O_4)_2]$, and $H[Ru(C_2O_4)_2] \cdot 2.5H_2O$. The valency of ruthenium in all the nitroso compounds obtained must be even since they are diamagnetic. It is almost certainly 2 from their composition and monomerism. These arguments are insufficient, however, for a final decision on the valency as there exist diamagnetic compounds of tervalent ruthenium. The coördination numbers in some of the compounds were unusual, such as 3 and 5. The NO group is not an ordinary addend. No case was observed in which more than one NO group was added. In this respect the nitroso compounds of ruthenium resemble those of platinum. A second property of this addend is that it is very firmly bound to the ruthenium, and is not broken off by exchange reactions in the internal sphere of the complex compound. This addend easily enters the internal sphere of complex ruthenium compounds when gaseous NO acts on them. Finally, the presence of the NO group stabilizes all the complex compounds which it enters. The nitroso compounds of ruthenium are chemically very stable and the ruthenium does not give the characteristic reactions. The great stability of the ruthenium nitroso compounds, which are very likely to be formed in the treatment of nuclear fuels, may explain the difficulty of removing radio-ruthenium. (auth)

**6349** A/CONF.15/P/483

THE BEHAVIOUR OF RUTHENIUM IN SOLUTIONS OF SOME ORGANIC ACIDS. Š. Mesarić and M. Branica (Inst. Rudjer Bošković, Zagreb). 19p.

The behavior of ruthenium tetroxide in solutions of oxalic, citric, and tartaric acid was investigated. Absorption spectra at 250 to 700 mμ, polarographic half-wave potentials, and diffusion coefficients are presented. In addition, electrophoretic mobilities of ruthenium ions in solutions of oxalic, citric, and tartaric acid were investigated, as well as adsorption of ruthenium complexes on an ion exchanger at equilibrium conditions from solutions of various concentrations of organic acids. Spectrophotometric, polarographic, electrophoretic, and ion exchange results are compared, and the behavior of the ruthenium complexes in the various organic acids is discussed. (auth)

**6192** GA-942

General Atomic Div., General Dynamics Corp., San Diego, Calif.

HIGH-TEMPERATURE CHEMISTRY OF FISSION-PRODUCT ELEMENTS. Summary Report [for] July 26, 1958 to August 1, 1959. Ulrich Merten and W. E. Bell. Sept. 2, 1959. 31p. Project No. 35. Includes Appendix: THE DISSOCIATION PRESSURE OF RUTHENIUM TRICHLORIDE. W. E. Bell, M. C. Garrison, and Ulrich Merten. J. Phys. Chem. 64, 145-6(1960). Contract AT(04-3)-164. (GA-892). OTS.

An analysis of the effects of vapor diffusion in ruthenium–chlorine system transpiration experiments was used for interpreting the results of experiments in which the effects of flow rate on the quantity of vapor transported were studied. Data are presented graphically for the $RuCl_3-Cl_2$ system at 700°C by plotting the gas flow rate against the vapor transport. Vapor-pressure studies in the ruthenium–chlorine system are reported, and data at 600 to 1000°C are given. Results show that the chlorine effect is due to $RuCl_4$ rather than $RuCl_3$ (g) as originally assumed. $RuCl_3$ (g) apparently becomes important at higher temperatures. Data and discussions related to pressure dependence of the solid-vapor equilibrium are presented for the $Ru-Cl_2$ system. Also, data on the temperature dependence for the equilibrium of the $RuCl_3-RuCl_4$ gaseous and solid systems are included. Thermodynamic properties of gaseous ruthenium chlorides are also listed. Data on the dissociation of rhodium chloride were obtained, and vapor pressures of the rhodium–chlorine system at 800 and 900°C are tabulated. Palladium chloride was also studied and data on the dissociation pressure at 700 to 850°C are given along with data on effects of chlorine in the system Cl–Pd on vapor pressure. The dissociation of $RuCl_3$ was determined at 650 to 839°C by static and dynamic methods. (For preceding period see GA-461.) (J.R.D.)

**20174** NP-7856

Battelle Memorial Inst., Columbus, Ohio.

HIGH-TEMPERATURE PROPERTIES AND ALLOYING BEHAVIOR OF THE REFRACTORY PLATINUM-GROUP METALS. R. W. Douglass, F. C. Holden, and R. I. Jaffee. Aug. 14, 1959. 128p. Contract NOnr-2547(00), NR 039-067.

A survey of the literature pertaining to the platinum-group metals and their alloys has been conducted as a part of the study of the metallurgical properties of the refractory platinum-group metals. Major emphasis was placed on the four more refractory metals: rhodium, iridium, osmium, and ruthenium. A selected bibliography and a list of references are included. (auth)

# RUTHENIUM 1.35

**5150**

THE ION EXCHANGE METHOD IN STUDIES OF THE STATE OF MATTER IN SOLUTION. VI. COMPLEXING RUTHENIUM(IV) IN HYDROCHLORIC AND PERCHLORIC ACIDS. V. I. Paramonova and E. F. Latyshev. Radiokhimiya 1, 458-64(1959). (In Russian)

Investigations of "deep" ruthenium hydrolysis revealed that hydrolysis takes place in solutions with total salt concentration of 1M when the acidity is less than 0.05M. Ruthenium(IV) complex formation in HCl and in systems composed of HCl and $HClO_4$ was studied. Calculations of the instability constant of $[Ru(OH)_2Cl_2]^0$ complex show a magnitude of $(1.6 \pm 0.3) \times 10^{-4}$ with $\mu = 1$. The instability constant of $[Ru(OH)_2Cl_4]^{2-}$ with dissociation to the neutral state has a magnitude of $4.3 \pm 0.7$ with $\mu = 1$. The common instability constant for $[Ru(OH)_2Cl_4]^{2-}$ is $(0.7 \pm 0.2) \times 10^{-2}$ with $\mu = 1$. (R.V.J.)

**6237** ✓

THE DISSOCIATION PRESSURE OF RUTHENIUM TRICHLORIDE. W. E. Bell, M. C. Garrison, and Ulrich Merten (General Atomic Div., General Dynamics Corp., San Diego, Calif.). J. Phys. Chem. 64, 145-6(1960) Jan.

The dissociation pressure of $RuCl_3$ was measured at 650 to 839°C. From the slope of the log P versus 1/T line and an estimated $\Delta C_p$ of 4.5 cal/mole °K, $\Delta H^0_{1020°K} = -57.2 \pm 1.0$ kcal/mole and $\Delta H^0_{298} = -60.5 \pm 2.0$ kcal/mole for Ru(s) + $^3/_2Cl_2(g) = RuCl_3(s)$. $S^0_{298}$ $RuCl_3(s)$ is calculated to be 30.5 eu, and the dissociation pressure is calculated to be 1 atmos at 853°C. No other ruthenium chlorides appear to exist as stable condensed phases in the temperature range investigated under chlorine pressures up to 1 atm. (auth)

**19936** ✓

ON THE VOLATILE HIGHER RUTHENIUM CHLORIDE. S. A. Shchukarev, N. I. Kolbin, and A. N. Ryabov (Zhdanov Leningrad State Univ.). Zhur. Neorg. Khim. 4, 1692-3(1959) July. (In Russian)

Studies of metallic ruthenium chlorination by gaseous chlorine at 400°C revealed a $RuCl_3$ amorphous film on the cooler walls. An assumption was made that a higher chloride forms in a $RuCl_3$–chloride reaction, followed by disintegration into $RuCl_3$ and $Cl_2$. In order to confirm the assumption, correlations were made of the volume of ruthenium carried from the combustion boat in chlorine and in nitrogen. (R.V.J.)

**12320**

THE DETERMINATION OF THE FORMULAS OF AQUEOUS RUTHENIUM(III) SPECIES BY MEANS OF ION-EXCHANGE RESIN: $Ru^{+3}$, $RuCl^{+2}$ AND $RuCl_2^+$. Howard H. Cady and Robert E. Connick (Univ. of California, Berkeley). J. Am. Chem. Soc. 80, 2646-52 (1958) June 5.

The formulas of some aqueous ruthenium(III) species have been determined by a method which utilizes the properties of ion-exchange resins. The method is applicable when equilibria between the species of interest and other species of significant concentration are established slowly, and when the species of interest can be isolated in solution, as for example certain complex ions. In one experiment the charge per metal atom is found from the equivalents of charge exchanged with an ion-exchange resin per gram atom of the metal. In a second experiment the total charge per species is determined from the concentration dependence of the ion-exchange equilibrium of the unknown species with an ion of known charge. The total charge divided by the charge per atom gives the degree of polymerization of the species. The stoichiometric formula can be inferred when a single anion is involved in complexing. The method has been employed to establish the formulas of the species $Ru^{+3}$ and $RuCl^{+2}$. A species shown to have a total charge of +1 is probably $RuCl_2^+$. The separation of the ruthenium species was accomplished by "pushing" with cerous ion a dilute mixture of species on an ion-exchange column, with the result that nearly pure bands of the individual species were obtained at high concentration. (auth)

**271** AERE-M/M-107(Del.)

Gt. Brit. Atomic Energy Research Establishment, Harwell, Berks, England.

SOME OBSERVATIONS ON URANIUM-RICH URANIUM RUTHENIUM ALLOYS. J. R. Murray and S. J. Lloyd. Jan. 1956. 9p.

The solidus and liquidus depressions in U-rich U–Ru alloys are approximately 5 and 1°C for 0.1 at.% Ru addition, respectively. A eutectic occurs at 900°C and 18 at.% Ru between U and an intermetallic compound of unknown composition. The $\alpha \rightarrow \beta$ and $\beta \rightarrow \gamma$ transformation temperatures in U are lowered by additions of Ru, but in alloys containing up to 20 at.% Ru sharp arrests can be detected at heating and cooling rates of $1^1/_2$°C/min. The solubility of Ru in $\gamma$ uranium is approximately 10 at.% at 900°C, the solubility in $\alpha$ uranium being considerably lower. (auth)

# RUTHENIUM 1.35

**118**

SOME CRYSTALLOCHEMICAL FEATURES OF COMPLEX COMPOUNDS OF RUTHENIUM AND OSMIUM.
G. B. Bokii, L. O. Atovmian, and T. S. Khodasheva (Kurnakov Inst. of General and Inorganic Chemistry, Academy of Sciences, USSR). Doklady Akad. Nauk S.S.S.R. 128, 78-80(1959) Sept. 1.

New data are presented on the structures of complex ruthenium and osmium complexes with No, N, $H_2O$, and Cl. The complexes $K_2(RuNoCl_5)$ and $K_2(RuCl_5H_2O)$ are isostructural and belong to the distorted-structure type $K_2PtCl_6$. The structure $K_2(RuNOCl_5)$ is analyzed in detail. The Ru–N–O linear bond with the distance Ru–N = 1.70 and N–O = 1.25A; agreeing with the Me ≡ $^+N-^-O$ bond concept. $K_2OsNCl_5$ and $KOsNBr_4 \cdot 2H_2O$ are isostructural in spite of their different formulas. In $K_2(OsNCl_5)$ and $K(OsNBr_4H_2O)H_2O$ structures the distance Os–N ~ 1.60 is much shorter than the sum of covalent radii (1.35 + 0.55) = 1.90. The chlorine atom transposed with respect to the nitrogen atom has a shortened distance along the coordinate N–Os–Cl (~2.1A) and are close to the sum of normal covalent radii (1.35 + 0.99). A hypothesis is postulated on the existence of the linear group O–Os–O. Similar shorter distances of metal–N and O bond series were observed in both Ru and Os complexes. The hypothesis on linear groups for osmium suggests a new structural expression for a series of complexes. (R.V.J.)

**POLAROGRAPHIC DETERMINATION OF RUTHENIUM IN CITRATES AND TARTRATES SOLUTIONS.**
**M. Branica and S. Mesaric (Inst. "Rudjer Boskovic", Zagreb). Croat. Chem. Acta 30, 89-93(1958).**

**Polarographic methods are proposed for the determination of small amounts of ruthenium in two new supporting electrolytes: a. citric acid (0.3 M) and sodium hydroxide (0.15 M); b. tartaric acid (0.2 M), sodium hydroxide (0.1 M), and thymol (0.009%). Determination of ruthenium is applicable in the concentration range from 4 to 120 μg of ruthenium per ml with a relative standard errors from 15 to 0.8% in both electrolytes. Hydrochloric, sulfuric, and perchloric acids (up to 0.5 N) do not interfere, but in the presence of nitric acid (any traces of nitrites) polarographic determinations are impossible. (auth)**

**SPECTROPHOTOMETRIC AND POLAROGRAPHIC DETERMINATION OF RUTHENIUM IN OXALIC ACID.**
**S. Mesaric and M. Branica (Inst. "Rudjer Boskovic", Zagreb). Croat. Chem. Acta 30, 81-7(1958).**

**A spectrophotometric and polarographic method is proposed for the determination of ruthenium tetroxide absorbed in oxalic acid. Spectrophotometric measurements of ruthenium in 1N oxalic acid were made at 375 mμ. In the concentration range from 2 to 36 μg of ruthenium per ml the relative standard error amounted 14 to 1%, respectively. The polarographic determination was performed in a supporting electrolyte containing 1N oxalic acid and 0.006% thymol (as a maximum suppressor). The determination is applicable in the concentration range from 4 to 120 μg ruthenium per ml with a relative standard error of 15 to 0.7%, respectively. Hydrochloric sulfuric, and perchloric acid up to 0.5N does not interf . In the presence of nitric acid spectrophotometric and polarographic determinations of ruthenium are impossible. (auth)**

RADIOACTIVE DECAY OF RUTHENIUM-95. Eduardo Schalscha (Instituut voor Kernphysisch Onderzoek, Amsterdam). Nuclear Phys. 1, 481-5(1956) June.

Ruthenium 95, produced by a (n,2n) reaction, was studied by scintillation spectrometry, and the half-life and position energy were determined by magnetic deflector and absorption measurements in Geiger-Müller beta counters. The isotope decays with a half-life of 1.65 ± 0.05 h by emission of positions with a maximum energy of 1.2 ± 0.1 Mev and by electron capture combined with emission of γ-rays of 145, 340, 640 and 1110 kev. Nuclear level schemes are discussed. (auth)

**16458** AD-208137
Ohio State Univ., Columbus.
GAMMA RAYS OBSERVED IN RUTHENIUM 101 (thesis).
Henry Wisner Parlett. 1958. 109p.

**The half life of the short-lived isomer of $Rh^{101}$ was determined to be 4.52 ± 0.5 days, and the energy levels of its daughter $Ru^{101}$ were determined to be 0.129, 0.307, 0.320, 0.545, 0.721, and 1.746 Mev. Other levels are possible but could not be definitely established. (auth)**

# RUTHENIUM 1.35

**11074**

POTENTIAL OF THE Ru(VII)–Ru(VIII) COUPLE. Robert E. Connick and C. Robert Hurley (Univ. of California, Berkeley). J. Phys. Chem. 61, 1018-20(1957) July.

**13538**

DECAY OF $Rh^{106}$. E. P. Grigor'ev, A. V. Zolotavin, I. I. Kuz'min, and E. D. Pavlitskaya (Zhdanov Leningrad State Univ.). Izvest. Akad. Nauk S.S.S.R. Ser. Fiz. 22, 194-7(1958) Feb. (In Russian)

Radioactive transformation of $Ru^{106} \rightarrow Rh^{106} \rightarrow Pd^{106}$ was studied with a double-focusing $\beta$ spectrometer. The conversion lines, the total $\beta$ spectra, and photoelectron spectra were studied. The decay scheme showing the intensity and energy of $\beta$ and $\gamma$ transition and spin and parity levels is included. (R.V.J.)

**3209** HW-40459

Hanford Atomic Products Operation, Richland, Wash.
A METHOD FOR THE DETERMINATION OF ISOTOPIC RATIO AND ACTIVITY IN $Ru^{103}$–$Ru^{106}$ MATERIALS. H. G. Rieck, Jr., and R. J. Walker. Dec. 15, 1955. 21p. Contract W-31-109-eng-52. $4.80(ph OTS); $2.70(mf OTS).

The isotopic ratio and activity in material containing Ru were determined by analysis of a gamma energy scan. Isotopic ratio was measured by comparing the two photo peaks resulting from the 0.50 and 0.61 Mev $\gamma$ of $Ru^{103}$ and the 0.51 and 0.62 Mev $\gamma$ of $Ru^{106}$. The activity was determined by application of a geometry factor to the 0.50–0.51 Mev $\gamma$ photo peak height. (auth)

**2876**

HYPERFINE STRUCTURE OF THE SPECTRUM OF RUTHENIUM. PART III. Kiyoshi Murakawa (Institute of Science and Technology, Tokyo). J. Phys. Soc. Japan 10, 919-26(1955) Nov.

The hyperfine structure of the spectrum of Ru I was studied, and it was found that the ratio of the distances of the components due to the even isotopes is given by $\Delta(104-102)$: $\Delta(102-100)$: $\Delta(100-96)/2 = 1 : 1.05 \pm 0.10 : 0.75 \pm 0.15$. There is reason to suppose that the shift $\Delta(98-96)$ is anomalously small compared with the shift $\Delta(104-102)$ or $\Delta(102-100)$. The magnetic moments of the odd isotopes were calculated to be $\mu(Ru^{101}) = -0.69 \pm 0.15$ nm. and $\mu(Ru^{99}) = -0.63 \pm 0.15$ nm. (auth)

**934**

TWO NEW ISOTOPES OF RUTHENIUM AND RHODIUM. G. B. Baro, P. Rey, and W. Seelmann-Eggebert. Publ. com. nacl. energia atomica (Buenos Aires), Ser. quim. 1, No. 3, 19-28(1955). (In Spanish)

A new series of mass number 108 (110) was found. The half life of $Ru^{108}$ is nearly the same as that of the $Ru^{107}$ with a mean value of 4 minutes for both of them. The half life of $Rh^{108}$ is 18 ± 2 seconds and its maximum $\beta$ energy is about 4.5 Mev. It also emits $\gamma$ rays of several energies, so that the total disintegration energy is likely to be higher than 4.5 Mev. The $Ru^{107}$ was produced by a $Pd^{110}$ (n, $\alpha$) $Ru^{107}$ reaction, which confirms the mass number of the mother substance of 23-minute rhodium as 107. The $Ru^{107}$ emits $\beta$ rays with maximum energy of about 4 Mev and $\gamma$ rays as well. The $Ru^{105}$ was also found by a (n, $\alpha$) reaction. The half life of $Rh^{107}$ was found to be 23 ± 0.5 minutes, its maximum $\beta$ energy being 1.25 Mev. The Laboratories of Nuclear Spectroscopy of the Comisión Nacional de la Energia Atomica found several $\gamma$ lines. One line of 315 kev coincides probably with the 1.25 Mev $\beta$ particles, so that the total Q value is about 1.5 Mev. No Ru isotopes with half lives between 1.5 and 4 minutes were found among fission products. (auth)

**457**

RADIOACTIVE DECAY OF RUTHENIUM-97. J. M. Cork, M. K. Brice, L. C. Schmid, and R. G. Heimer (Univ. of Michigan, Ann Arbor). Phys. Rev. 100, 188-90(1955) Oct. 1.

Ruthenium enriched in mass 96 was irradiated for short and long periods in the pile, and the radioactivity of $Ru^{97}$, produced by neutron capture, was studied by magnetic and scintillation spectrometers. Several $\gamma$ rays not previously reported were found to exist. The observed $\gamma$ rays in $Tc^{97}$, following K capture in $Ru^{97}$, have energies of 109.1, 216.1, 325.1, and 570 kev. A long-lived metastable state in $Tc^{97}$ decays by the emission of $\gamma$ rays whose conversion electrons indicate $\gamma$ energies of 90.2 and 99.2 kev. The multipolarities of most of the transitions are determined and a satisfactory nuclear level scheme is proposed. (auth)

# STRONTIUM 1.36

**540** BM-IC-7933
Bureau of Mines.
STRONTIUM. A Materials Survey. Albert E. Schreck and Joseph C. Arundale. 1959. 49p.

A report on the uses, properties and substitutes for strontium is presented. The mineralogy and geology of this element are set forth along with techniques used in mining, milling, and processing. In addition, information on the domestic supply is given as well as data on world production and trade. (J.R.D.)

**5255** CRC-688
Atomic Energy of Canada Ltd. Chalk River Project, Chalk River, Ont. and Canada. Dept. of National Health and Welfare, Ottawa.
RADIOCHEMICAL PROCEDURES FOR STRONTIUM AND YTTRIUM. Feb. 1957. Includes Paper: ION-EXCHANGE METHODS FOR THE QUANTITATIVE SEPARATION OF THE ALKALINE EARTHS AND THEIR APPLICATION TO THE DETERMINATION OF $Sr^{90}$ IN MILK ASH. Gwen M. Milton and W. E. Grummitt. 37p.

A detailed ion exchange procedure is given for the determination of radiostrontium and $Y^{90}$ in prepared samples, and a report covering the development of the cation method is included in an appendix. Two methods are described for the preparation of various organic materials for analyses. (auth)

**9554**
ON THE RATIO BETWEEN THE ACTIVATION CROSS SECTIONS OF $^{84}Sr$ AND $^{88}Sr$ FOR SLOW NEUTRONS. M. Asdente, A. Bisi, E. Germagnoli, and L. Zappa (Istituto di Fisica Sperimentale del Politecnico, Milan). Nuclear Phys. 1, 420-4(1956) May.

Samples of $SrCO_3$, irradiated in a nuclear reactor, have been used to determine the ratio between the activation cross sections of the two processes $Sr^{84}(n, \gamma)\ Sr^{85}$(65 d) and $Sr^{88}(n, \gamma)\ Sr^{89}$. Methods of absolute $\beta$ and $\gamma$ counting have been used for this purpose. The ratio between the two isotopic cross sections is found to be 318 ± 21, from which an activation cross section of 1.59 ± 0.11 barns can be calculated for the reaction $Sr^{84}(n, \gamma)\ Sr^{85}$(65 d), if the value $5 \times 10^{-3}$ barns is assumed for the cross section of the process $Sr^{88}(n, \gamma)\ Sr^{89}$. (auth)

**5931**
NUCLEAR LEVELS IN $Sr^{88}$ FROM THE DISINTEGRATION OF $Rb^{88}$ AND $Y^{88}$. N. H. Lazar, E. Eichler, and G. D. O'Kelley (Oak Ridge National Lab., Tenn.). Phys. Rev. 101, 727-32(1956) Jan. 15.

The nuclear level structure of $Sr^{88}$ has been studied through the $\gamma$ radiation following the decays of 17.8-minute $Rb^{88}$ and 104-day $Y^{88}$. Gamma rays from $Rb^{88}$ with energies of 0.909 ± 0.004, 1.39, 1.850 ± 0.008, 2.11, 2.68, 3.01, 3.24, 3.52, 3.68, and 4.87 Mev have been resolved and fitted into a level scheme with the assistance of coincidence spectroscopy using cylindrical 3-inch × 3-inch NaI(Tl) crystals. The intensity of the ground state beta ray transition from $Rb^{88}$ was determined by comparing the total beta ray activity to the intensity of the 1.85-Mev $\gamma$ ray. It was found that 75.9 ± 5.0 percent of the decays are directly to the ground state. From the $\gamma$-ray intensities, the comparative half lives of all the $\beta$ groups could be determined and, thus, parity assignments were made to all the levels. The relative intensities of $\gamma$ rays leaving the same level is discussed in relation to single-particle transition probabilities. (auth)

**2969**
CONCERNING THE SEARCH FOR Sr AND Y ISOTOPES FROM U FISSION. Von Günter Herrmann and Fritz Strassmann (Aus dem Anorganisch-Chemischen Institut der Universität Mainz). Z. Naturforsch. 11a, 946-54(1956) Nov. (In German)

NOTE ON THE DECAY OF $^{82}Sr$. V. Sanglust (Istituto di Fisica Sperimentale del Politecnico, Milan). Nuovo cimento (10) 9. 446-50(1958) Aug. 1.

$\gamma$ and x radiation accompanying the decay of $Sr^{82}$ were investigated. $\gamma$ rays of 775 and 1400 kev were found. $Rb^{82}$ daughter of $Sr^{82}$, is shown to decay through $\beta^+$ emission, not only to the ground state but also to excited levels of $Kr^{82}$. (auth)

# TECHNETIUM 1.37

INVESTIGATION OF MEASURABLE QUANTITIES OF TECHNETIUM. V. I. Spitsyn and A. F. Kuzina (Inst. of Physical Chemistry, Academy of Sciences, U.S.S.R.). Doklady Akad. Nauk S.S.S.R. 124, 846-8(1959) Feb. 1. (In Russian)

The preparation of chemically pure technetium compounds, heptasulfide and ammonium pertechnetate, is described. The absorption spectra of the pertechnetate ion were studied, and measurable quantities of the heptasulfide were analyzed. The absolute activity of the recovered preparations of technetium was measured.

**9848**

TECHNETIUM. V. Baran. Jaderna Energie 4, 73-80 (1958). (In Czech.)

A survey is given of the physical and chemical properties of technetium. 52 references. (R.V.J.)

**1477**

SOME ASPECTS OF THE POLAROGRAPHIC BEHAVIOUR OF TECHNETIUM AND RHENIUM. R. J. Magee, I. A. P. Scott, and C. L. Wilson (Queen's Univ., Belfast). Talanta 2, 376-9(1959) Aug.

The oxidation-reduction behavior of technetium was investigated polarographically by means of ultramicro methods. Rhenium was examined as a control and a guide. The behavior of technetium was found to be similar to that of rhenium more than to that of manganese. (C.J.G.)

**11648**

NEW OXIDATION STATES OF TECHNETIUM. J. E. Fergusson and R. S. Nyholm (University Coll., London). Nature 183, 1039-40(1959) Apr. 11.

Ditertiary arsine (D) chelates of $Tc^{3+}$ and $Tc^{2+}$ were prepared and studied, establishing these two oxidation states of Tc. (T.R.H.)

United Kingdom Atomic Energy Authority. Research Group. Atomic Energy Research Establishment, Harwell, Berks, England.

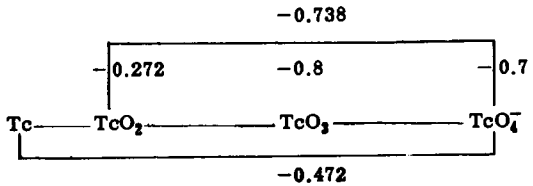
A BIBLIOGRAPHY ON TECHNETIUM. June 1951. 11p. (AERE-Inf/Bib-74).

A total of 122 references on technetium are listed that were located in *Nuclear Science Abstracts* and *Chemical Abstracts*. Both report and published literature are included.

**71**

REVISION OF THE ELECTRODE-POTENTIAL DIAGRAM FOR TECHNETIUM. G. H. Cartledge and ~~William~~ T. Smith, Jr. ~~(Oak Ridge National Lab., Tenn.)~~ J. Phys. Chem. 59, 1111-12(1955) Oct.

The revised potential diagram for Tc is




**7850**

SEARCH FOR TECHNETIUM-98 BY NEUTRON ACTIVATION ANALYSIS. Edward Anders, R. N. Sen Sarma, and P. H. Kato (Univ. of Illinois, Urbana). J. Chem. Phys. 24, 622-4(1956) Mar.

The existence of $Tc^{98}(t^1/_2 > 10^4$ yr) is further confirmed by results of neutron activation of selected minerals. Technetium$^{99m}$ was formed by two processes, decay of $Mo^{99}$ and $Tc^{98}(n, \gamma)$ reaction. (C.W.H.)

**10123**

NEUTRON ACTIVATION CROSS SECTION OF TECHNETIUM-98. Edward Anders (Univ. of Chicago). Phys. Rev. 110, 427-30(1958) Apr. 15.

The cross section for the reaction $Tc^{98}(n,\gamma)Tc^{99m}$ was determined by thermal neutron irradiation of a cyclotron-produced sample containing $Tc^{95}$, $Tc^{97m}$, $Tc^{97g}$, $Tc^{96}$, and $Tc^{99}$. The degree of selectivity and background reduction required to permit an accurate measurement of the $Tc^{98}$ content, 2.68 ± 0.54 disintegrations per minute, was attained by means of $\beta$-(740-kev $\gamma$) coincidence counting. At a thermal flux of $2.1 \times 10^{12}$ neutrons $cm^{-2}$ $sec^{-1}$, a saturation activity of 375 ± 85 dis/min $Tc^{99m}$ per dis/min of $Tc^{98}$ was obtained. Using the latest value of the half life of $Tc^{98}$, $(1.5 \pm 0.7) \times 10^6$ years, one finds a cross section of 2.6 ± 1.3 barns. Relative cross sections are also given for the production of several technetium isotopes by bombardment of molybdenum with 10.2-Mev deuterons. (auth)

# TECHNETIUM 1.37

DECAY OF $Tc^{97}$ GROUND STATE. Seymour Katcoff (Brookhaven National Lab., Upton, N. Y.). Phys. Rev. 111, 575-8(1958) July 15.

The half-life of the ground state of $Tc^{97}$ was found to be $(2.6 \pm 0.4) \times 10^6$ years by comparison of its K x-ray intensity with that from the 90-day $Tc^{97m}$ isomeric state. The L/K-capture ratio of $Tc^{97}$ was compared with that of $Tc^{96}$; a somewhat larger ratio is indicated for the former. No $\gamma$ rays were observed that could be attributed to $Tc^{97}$.

**6155** ✓

DETERMINATION OF THE ENERGY AVAILABLE FOR THE $\beta^+$ DISINTEGRATION OF THE LONG LIVED ISOMER OF TECHNETIUM 95. Christiane Lévi and Lily Papineau. Compt. rend. 244, 1358-61(1957) March 4. (In French)

The threshold of $Mo^{95}(p,n)Te^{95}$ was redetermined and found equal to 2.47 ± 0.03 Mev which corresponds to an energy available for the $\beta^+$ of $Tc^{95}$ (60d) of 710 ± 30 kev. A threshold observed at 3.19 ± 0.03 Mev corresponds to an excited level of $Tc^{95}$. (tr-auth)

**7319** ✓

ON THE MEASUREMENT OF 18- AND 4.5-Min-Tc AND A NEW SHORT LIVED $Tc^{103}$. J. Flegenheimer and D. Geithoff. Z. Naturforsch. 12a, 351(1957) Apr. (In German)

**3392**

THE DECAY SCHEMES OF THE FISSION-PRODUCT NUCLIDES: $Mo^{102}$, $Mo^{105}$, $Tc^{102}$, AND $Tc^{105}$. J. Flegenheimer and W. Seelmann-Eggebert. Publs. com. nacl. energia atomica (Buenos Aires) Ser. quim. 1, No. 7, 63-79(1956). (In Spanish)

A half life of 5 sec ± 1 sec was found for the technetium daughter of the 11 minute molybdenum present in the fission products, whose probable mass number is 102. Absorption measurements show a maximum beta energy of 4.4 Mev ± 0.3 Mev. From the absorption curves a half life of 11.5 min ± 0.5 min is found for $Mo^{102}$ The $Tc^{105}$ half life was found to be 10 min ± 1 min through timed precipitations from a stock solution of fission technetium and measurements of the $Ru^{105}$ formed. $Ru^{106}$ as radioactive indicator was used to show the purity of technetium isolations or to avoid weighing when distilling ruthenium. Through technetium isolations from quickly purified fission-molybdenum, an upper limit of 2 minutes could be established for the half life of $Mo^{105}$. No other technetium half lifes were found when milking from fission molybdenum. (auth)

# TELLURIUM 1.38

**1405** ✓

TEMPERATURE EFFECTS ON DENSITY AND ELECTRO-CONDUCTIVITY OF Te–Se MOLTEN ALLOYS. N. P. Mokrovskiĭ and A. R. Regel. Zhur. Tekh. Phys. 25, 2093-6(1955) Dec. (In Russian)

Analyses proved that in temperature near the melting point tellurium retains its chain-like structure. At higher temperature, metallization bonds increase while the chain structure and valence bonds disintegrate. At 550°C tellurium becomes practically a metal. Addition of selenium slows down the disintegration process in the chain structure. (R.V.J.)

THERMODYNAMIC FUNCTIONS FOR THE ISOTOPIC HYDROGEN SELENIDES AND HYDROGEN TELLURIDE. A. P. Altshuller. J. Phys. Chem. 61, 509-11(1957) Apr.

Calculations of the thermodynamic functions of $H_2Se$, HDSe, $D_2Se$, and $H_2Te$ are given. (W.L.H.)

THERMODYNAMICS OF NONSTOICHIOMETRIC NICKEL TELLURIDES. II. DISSOCIATION PRESSURES AND PHASE RELATIONS OF TELLURIUM-RICH COMPOSITIONS. Edgar F. Westrum, Jr. and R. E. Machol (Univ. of Michigan, Ann Arbor). J. Chem. Phys. 29, 824-8(1958) Oct.

Dissociation pressures of tellurium over liquid and solid nickel telluride solutions have been measured with a silica Bourdon gage at compositions corresponding to $NiTe_{1.5}$, $NiTe_{1.7}$, $NiTe_{1.9}$, $NiTe_{2.0}$, and $NiTe_9$ at temperatures up to 780°. Modifications of the manometric technique are described which permit accuracies of 0.1 mm pressure and 0.1° at high temperatures with corrosive substances where the pressure is sensitive to impurities or to composition changes. The results, together with data on the vapor pressure of pure tellurium, define the partial molal free energies and entropies of tellurium and, together with direct eutectic temperature measurement, delineate features of the phase diagram for compositions with more than 60 at. % tellurium.

# TELLURIUM 1.38

**1602**

DISINTEGRATION SCHEMES OF THE $Te^{127}$ AND $Te^{129}$ GROUND STATES. M. C. Day, Jr., G. W. Eakins, and A. F. Voigt (Iowa State Coll., Ames). Phys. Rev. 100, 796-8 (1955) Nov. 1.

A coincidence scintillation spectrometer was used to study the decay of the 9.3-hour $Te^{127}$ isomer and the 72-minute $Te^{129}$ isomer. The $Te^{127}$ isomer was found to decay by a simple beta ray with an end-point energy of 0.683 ± 0.010 Mev. The beta-ray spectrum of the $Te^{129}$ isomer consists of two beta groups with end-point energies of 1.46 ± 0.01 and 1.01 ± 0.02 Mev. Two gamma rays with energies of 0.450 ± 0.005 and 0.035 Mev were observed, and they were found to be in coincidence. The 0.450-Mev gamma ray was shown to be in coincidence with the 1.01-Mev beta ray, and the 0.035-Mev gamma ray was shown to be in coincidence with the 1.46-Mev beta ray. The results are consistent with level assignments based on the shell model of the nucleus. (auth)

**8435**

REACTION OF TELLURIUM DIOXIDE AND SELENIUM TETRAFLUORIDE: PREPARATION OF TELLURIUM TETRAFLUORIDE. R. Campbell and P. L. Robinson (King's Coll., Newcastle upon Tyne, England). J. Chem. Soc., 785(1956) Mar.

**9509**

HALF-LIVES OF ISOMERIC STATES IN $Pb^{202}$, $Pb^{203}$, $Pb^{206}$ AND $Tl^{202}$. Björn Aström (Nobel Inst. of Physics, Stockholm, Sweden). Arkiv Fysik 12, No. 3, 237-45 (1957).

The isomeric transitions in $Pb^{202}$ (E4, E5), $Pb^{203}$ (M4), $Pb^{206}$ (E3) and $Tl^{202}$ (E3) are associated with high-multipolarities. The half lives of $Pb^{202m}$ and $Pb^{203m}$ were accurately measured by means of an automatic recording arrangement. In the case of $Pb^{206m}$ and $Tl^{202m}$ a modified delayed-coincidence technique was used. The following half lives were found: $Pb^{202m}$: 3.62 ± 0.03 hours, $Pb^{203m}$: 6.09 ± 0.10 sec, $Pb^{206m}$: 128 ± 5 μsec, and $Tl^{202m}$: 600 ± 200 μsec. (auth)

LIGHT ISOTOPES OF Te. M. Ya. Kuznetsova, V. N. Mekhedov, V. N. Rybakov, and V. A. Khalkin. Atomnaya Energ. 4, 583(1958). (In Russian)

Attempts are made to determine the mass number and life of tellurium isotopes with A < 118, according to the daughter products. The results showed $t_{1/2}$ for $Te^{116}$ to be 2.5 hr, and for $Te^{117}$ it is 1.7 hr. (R.V.J.)

**6037**

DISINTEGRATION OF $Te^{129}$. William E. Graves and Allan C. G. Mitchell (Indiana Univ., Bloomington). Phys. Rev. 101, 701-5(1956) Jan. 15.

The disintegration of $Te^{129}$ has been investigated with the help of a magnetic lens spectrometer, permanent field spectrometer with photographic recording, and scintillation counters. The half lives of the isomeric states in the parent were found to be 41 days and 74 minutes, respectively. The 74-minute state decays to $I^{129}$ with the emission of beta-ray groups whose end-point energies and relative abundances are 1.453 Mev (71%), 0.989 Mev (15%), 0.69 Mev (4%), and 0.29 Mev (10%). Gamma rays of 0.027, 0.21, 0.475, 0.72, and 1.12 Mev were found. The 41-day state decays, for the most part, to the 74-minute state of $Te^{129}$ with the emission of a highly internally converted gamma ray of energy 106.3 ± 0.1 kev for which the K/L ratio is unity. A beta-ray transition, of low intensity, from the 41-day state of $Te^{129}$ to the ground state of the product is postulated. Gamma-gamma and beta-gamma emits a gamma ray of energy 130 kev. No quantum radiations of higher energies were detectable. Some coincidence measurements have been performed on the complex gamma-ray spectrum of $Pt^{191}$. (auth)

RADIATIONS OF $Te^{127}$ AND $Te^{127m}$. J. D. Knight, J. P. Mize, J. W. Starner, and J. W. Barnes (Los Alamos Scientific Lab., N. Mex.). Phys. Rev. 102, 1592-7(1956) June 15.

The radiations of $Te^{127}$ and $Te^{127m}$ have been examined by beta-ray spectrometry and gamma-ray scintillation spectrometry. $Te^{127}$ (9.35 ± 0.10 hr) decays predominantly (99%) by a beta transition of end-point energy 695 ± 10 kev to the ground state of $I^{127}$. The remaining 1.0 ± 0.2% of the decay is accompanied by gamma rays of energies 58.5 ± 1, 145 ± 2, 203 ± 3, 215 ± 4, 360 ± 4, and 418 ± 2 kev. By means of gamma-gamma coincidence measurements, these gamma rays have been fitted into a consistent decay scheme which involves levels in $I^{127}$ at 58.5, 203, and 418 kev. $Te^{127m}$ (105 ± 2 days), which decays predominantly by the well-known 89-kev isomeric transition, also has a 1.5 ± 0.5% beta branch which populates the 58.5-kev level in $I^{127}$ and another beta branch of total intensity ~0.013% which is accompanied by a gamma ray of energy 665 ± 5 kev. Plausible spin and parity assignments for the excited levels of $I^{127}$ are discussed. (auth)

OXIDATION OF TELLUROUS ACID IN AQUEOUS SOLUTION BY γ RAYS. M. Haissinsky and A. S. Ghosh-Mazumdar (Institut du Radium, Paris). J. chim. phys. 53, 782-3(1956) Sept. (In French)

# TELLURIUM 1.38

**2154**

ANGULAR CORRELATION MEASUREMENTS IN $Te^{121}$ AND $Te^{123}$. Norman Goldberg and Sherman Frankel (Univ. of Pennsylvania, Philadelphia). Phys. Rev. 100, 1350-4 (1955) Dec. 1.

Measurements of the angular correlation of the two-step transition in $Te^{121}$ and $Te^{123}$ have been made using a thin Te source ($< 1\mu g/cm^2$). K conversion electron-gamma, L conversion electron-gamma and K conversion-K conversion cascades were investigated in both isomers using a thin lens beta spectrometer as the fixed detector and scintillation counters for the movable detector. The measured correlation was found to be of the form $1 + A_2P_2(\cos\theta)$ in agreement with the theoretically predicted angular correlation for the known spin sequence in the tellurium isomers ($11/2 \rightarrow 3/2 \rightarrow 1/2$). The measured values of $A_2$ corrected for geometry are $-0.097 \pm 0.004$, $-0.092 \pm 0.009$, $-0.06 \pm 0.03$ for the K-$\gamma$, L-$\gamma$, and K-K cascades respectively in $Te^{123}$ and $-0.015 \pm 0.007$, $-0.007 \pm 0.007$, and $-0.10 \pm 0.04$ for the same cascades in $Te^{121}$. Comparison of the results of the K-$\gamma$ cascades with theory shows that the second transition is a mixture of $(1.3 \pm 0.1)\%$ E2 and 98.7% M1 in $Te^{123}$ and $(5.6 \pm 0.5)\%$ E2 and 94.4% M1 in $Te^{121}$. The ratio of reduced matrix elements is plus in both cases using the Biedenharn and Rose notation. The results for the K-K angular correlation are consistent with the K-$\gamma$ correlations and are used to prove that the correlations, which are small than the M4-M1 correlation, cannot result from reduction of the M4-M1 correlation by the action of extra-nuclear fields. (auth)

**2149**

COULOMB EXCITATION OF TELLURIUM AND SILVER. L. W. Fagg, E. A. Wolicki, R. O. Bondelid, K. L. Dunning, and S. Snyder (Naval Research Lab., Washington, D. C.). Phys. Rev. 100, 1299-1302(1955) Dec. 1.

Coulomb excitation has revealed gamma rays at 159, 274, 342, 436, and 504 kev in $Te^{123}$; 435 and 633 kev in $Te^{125}$; 319 and 419 kev in $Ag^{107}$; and 306 and 412 kev in $Ag^{109}$. Interpretation of these results in conjunction with excitation curves and coincidence measurements is discussed in terms of proposed energy level schemes. In the case of $Te^{123}$ it is concluded that three levels are independently excited. Values are given for the quadrupole moments, $Q_0$, based on the Bohr-Mottelson unified model and for the reduced transition probabilities for excitation, $B_e(E2)$. (auth)

**12034**

DECAY OF TELLURIUM-132. G. D. Cheever, W. S. Koski, D. R. Tilley, and Leon Madansky (Johns Hopkins Univ., Baltimore). Phys. Rev. 110, 922-3 (1958) May 15.

The decay of $Te^{132}$ produced by fission of uranium has been investigated by using a scintillation spectrometer. In addition to the previously reported 0.23-Mev gamma ray and the iodine K x ray, a 0.053-Mev gamma ray has been observed. Coincidence measurements permitted the determination of K-shell conversion coefficients for the two transitions. Probable decay schemes compatible with the observations are discussed. (auth)

# THORIUM 1.39

## ANALYTICAL SEPARATION 1.39.01

**6263**
SELECTIVE PRECIPITATION OF THORIUM IODATE FROM A TARTARIC ACID–HYDROGEN PEROXIDE MEDIUM. APPLICATION TO RAPID SPECTROPHOTOMETRIC DETERMINATION OF THORIUM IN SILICATE ROCKS AND IN ORES. F. S. Grimaldi, Lillie B. Jenkins, and Mary H. Fletcher (U. S. Geological Survey, Washington). Anal. Chem. 29, 848-51(1957) May.

A selective iodate separation of Th from $HNO_3$ medium containing d-tartaric acid and $H_2O_2$ is presented. The catalytic decomposition of $H_2O_2$ is prevented by the use of 8-quinolinol. A few μg of Th are separated sufficiently clean from 30 mg of such oxides as Ce Zr, Ti, Nb, Ta, Sc, or Fe with one iodate precipitation to allow an accurate determination of Th with the thoron-mesotartaric acid spectrophotometric method. The method is successful for the determination of 0.001% or more of $ThO_2$ in silicate rocks and for 0.01% or more in black sand, monazite, thorite, thorianite, eschynite, euxenite, and zircon. (auth)

**16229** TID-7555(p.79-114)
Ames Lab., Ames, Iowa.
RECENT DEVELOPMENTS IN THE ANALYTICAL CHEMISTRY OF THORIUM AND ITS COMPOUNDS. Charles V. Banks. p.79-114 [of] FIRST CONFERENCE —ANALYTICAL CHEMISTRY IN NUCLEAR REACTOR TECHNOLOGY, NOVEMBER 4-6, 1957, GATLINBURG, TENNESSEE. 36p.

Methods for the detection, separation and determination of thorium and for the estimation of diverse elements in thorium and compounds of thorium, which have been reported in the literature in recent years, are reviewed. Included are gravimetric, titrimetric, spectrophotometric and polarographic methods. Organic reagents which have been found to be useful in methods for the determination of thorium as precipitation, complexation, chromogenic or indicator reagents are listed with pertinent data relative to their applicability. A bibliography of the analytical chemistry of thorium is presented which consists of 152 references, principally to recent papers and comprehensive reviews of the analytical chemistry of thorium. (auth)

## FISSION PRODUCTS, ISOTOPES, AND DECAY 1.39.02

### FISSION PRODUCTS AND ISOTOPES 1.39.02.01

LIFETIME OF THE 186-kev LEVEL OF THORIUM-231. D. Strominger (California. Univ., Berkeley. Radiation Lab.). Phys. Rev. 114, 502-4(1959) Apr. 15.

The lifetime of the 186-kev level of $Th^{231}$ has been studied following $U^{235}$ alpha decay. The half-life value of this level is 0.77 ± 0.12 mμsec. (auth)

Phillips Petroleum Co. Atomic Energy Div., Idaho Falls, Idaho. IDO-16504
CALCULATION OF ISOTOPE PRODUCTION BY THE CYCLIC IRRADIATION OF THORIUM. R. G. Nisle. Mar. 26, 1959. 26p. Contract AT(10-1)-205. $0.75 (OTS).

Irradiation products of natural Th at flux levels of $10^{12}$, $10^{13}$, $5 \times 10^{13}$, and $10^{14}$ neutrons/cm$^2$/sec were calculated by the IBM-650 for the continuous and two cyclic irradiation cases. Production graphs of $U^{233}$ and $Pa^{233}$ are given. The calculations show that the eventual production of $U^{233}$ is not materially altered by cyclical irradiation at fluxes below $10^{13}$. At fluxes of $10^{14}$ the loss in $U^{233}$ after about 25 MTR cycles is about 4% of what would have been produced in continuous irradiation. It is shown that continuous irradiation is preferable when the first consideration is the production of $U^{233}$ for later separation from thorium. In a power-breeder system, on the other hand, where energy production is of prime importance, cyclic irradiation is acceptable since the loss in $U^{233}$ production is more than compensated by an increase in the number of fissions. (auth)

**6941** MLM-747
Mound Lab., Miamisburg, Ohio.
$Ac^{227}$ AND $Th^{228}$ PRODUCTION AS A FUNCTION OF TIME FOR VARIOUS VALUES OF NEUTRON FLUX. (Information Report). G. R. Grove, L. N. Russell, and S. R. Orr. Aug. 28, 1952. Decl. Nov. 24, 1959. 11p. Contract AT-33-1-GEN-53. OTS.

The amount of $Ac^{227}$ per curie of $Ra^{226}$ was calculated for various values of neutron flux and various irradiation times. The amount of $Th^{228}$ produced per curie of $Ra^{226}$ and the percentage of $Ac^{227}$ converted to $Th^{228}$ relative to the total amount of $Ac^{227}$ produced were also calculated. (W.D.M.)

# THORIUM 1.39

## FISSION PRODUCTS, ISOTOPES, AND DECAY 1.39.02

### FISSION PRODUCTS AND ISOTOPES 1.39.02.01

RADIOCHEMICAL INVESTIGATION OF PHOTOFISSION OF $Th^{232}$. I. A. Vasilev and K. A. Petrzhak (Leningrad Technological Inst.). Zhur. Eksptl'. i Teoret. Fiz. 35, 1135-40(1958) Nov. (In Russian)

Twelve fragments from the photofission of $Th^{232}$ for a peak bremsstrahlung energy of 10 Mev were identified by a radiochemical method. The mass number dependence of the fission product yields was determined. The dependence of the peak-to-valley ratio of the $Th^{232}$ and $U^{238}$ photofission yield curves on the peak bremsstrahlung energy was determined in the energy range from 8 to 14 Mev. Results of calculation of the photofission of thorium and uranium by Fong's method are presented. (tr-auth)

**11268** ✓

THE CUMULATIVE YIELDS OF THE KRYPTON AND XENON ISOTOPES PRODUCED IN THE FAST NEUTRON FISSION OF $Th^{232}$. T. J. Kennett and H. G. Thode (McMaster Univ., Hamilton, Ontario). Can. J. Phys. 35, 969-79(1957) Aug.

The relative fission yields for mass chains ending in stable Kr and Xe isotopes have been measured for the fast neutron-induced fission of $Th^{232}$. Isotope dilution techniques were used to determine the Kr/Xe ratio to assist in obtaining the absolute fission yields for these mass chains. The absolute yields were determined by the use of two methods, both giving results which were in excellent agreement. The fine structure observed for the $Th^{232}$ mass-yield curve is compared with that of heavier fissile nuclides. (auth)

**1373** ORNL-1817

Oak Ridge National Lab., Tenn.

PRODUCTS PRODUCED IN CONTINUOUS NEUTRON IRRADIATION OF THORIUM. A. T. Gresky and E. D. Arnold. Feb. 16, 1956. Decl. Sept. 7, 1956. 63p. Contract W-7405-eng-26. $0.50(OTS).

Calculated data and graphs describing the effects of continuous thermal-neutron irradiation of Th, the usual method of operation of homogeneous reactors, are presented. The buildup and decay of $U^{232}$, $Pa^{233}$, other heavy isotopes, and fission products are considered on the basis of best available cross-section and fission-yield data. The effects of the heavy isotopes and fission products on neutron economy are discussed. (auth)

SPONTANEOUS FISSION OF $Th^{232}$ AND THE STABILITY OF NUCLEONS. G. N. Flerov, D. S. Klochkov, V. S. Skobkin, and V. V. Terent'ev (Academy of Sciences, USSR). Soviet Phys. (Doklady) 3, 79-80(1958) Jan.-Feb.

A new determination was made of the half life of $Th^{232}$ for spontaneous fission. Increased sensitivity was obtained by increasing the total amount of active substance and by reducing the background. The background was reduced by using a proportional counter as the detector of fission fragments. Special attention was given to the attenuation of the background from spontaneous fission of a possible uranium impurity. To increase the total amount of active material, several counters of the same kind were used. Measurements covering 7000 g-hr yielded not a single act of spontaneous fission. It was concluded that the half life for the spontaneous fission of $Th^{232}$ is greater than $10^{21}$ yr. (J.S.R.)

**4888**

PROPERTIES OF $Em^{221}$. F. F. Momyer, Jr. and E. K. Hyde (Univ. of California, Berkeley). Phys. Rev. 101, 136-8(1956) Jan. 1.

A new isotope of the element emanation has been identified among the spallation products of thorium bombarded with 110-Mev protons. This isotope, $Em^{221}$, decays with a half life of 25 minutes. The decay goes 80% by $\beta$ emission to $Fr^{221}$ identified by its characteristic alpha particle groups and by the observance of the alpha particles of the decay products, $At^{217}$ and $Po^{213}$. In 20% of its disintegrations $Em^{221}$ emits an alpha particle of 6.0-Mev energy unresolved from the 6.0-Mev alpha particle of $Fr^{221}$, and gives rise to $Po^{217}$, a previously unreported isotope of polonium. $Po^{217}$ has a half-life of less than 10 seconds and emits alpha particles of 6.54 ± 0.02 Mev. An attempt was made to isolate $Em^{221}$ from a sample of $Th^{229}$ where it should be found as a result of slight alpha branching of $Ra^{225}$ The experiment was negative and a lower limit of 500 years was placed on the partial alpha half-life of $Ra^{225}$. (auth)

**7437** CF-55-6-27

Oak Ridge National Lab., Tenn.

EXAMINATION OF IRRADIATED $ThO_2$ SLUGS FOR THE $U^{233}$/Th RATIO. R. P. Wischow. June 2, 1955. Decl. Feb. 14, 1957. 6p. Contract [W-7405-eng-26]. $1.80 (ph OTS); $1.80(mf OTS).

# THORIUM 1.39

## FISSION PRODUCTS, ISOTOPES, AND DECAY 1.39.02

### ACTIVITY SPECTRA 1.39.02.02

EXAMINATION OF IRRADIATED $ThO_2$ SLUGS FOR THE $U^{233}$/Th RATIO. R. P. Wischow. June 2, 1955. Decl. Feb. 14, 1957. 6p. (CF-55-6-27)

**15603** ✓ AECU-4169

Harvard Univ., Cambridge, Mass. Lyman Lab. of Physics.

NUCLEAR SPECTRA OF THE THORIUM ACTIVE DEPOSIT. Technical Report No. 1-9. Guy Trask Emery. Nov. 22, 1958. 94p. Sponsored by ONR and AEC under Contract Nonr-1866(19). $15.30(ph), $5.40(mf) OTS.

The relative intensities of the gamma rays of the descendants of radiothorium were studied by measuring the photoelectron spectrum from thorium and platinum foils. The relative sensitivity of the arrangement at different energies was found by using other sources having gamma rays of known relative intensity. Some of the previous work on the radiations from the thorium active deposit is reviewed. Comparison of the measured gamma-ray intensities with the measurements by others of internal conversion intensities allowed internal conversion coefficients to be computed and the multipolarities of many transitions to be determined. An electric monopole transition was found in polonium-212. The gamma intensities were used to find the intensities of beta branches and the nature of the beta transitions. Gamma intensities were compared with the known intensities of long range alpha particles from polonium-212 and some gamma half lives were computed for that nucleus. The level schemes of polonium-212, lead-208, thallium-208, and bismuth-212 are discussed in the light of the information found here and other recent information, and are compared with the predictions of the shell and collective models. A listing of much of the previous work on the radiations from and decay schemes of these nuclei is included. (auth)

**464**

RADIOACTIVE DISINTEGRATION OF $^{232}$Th. S. W. Peat and M. A. S. Ross (Univ. of Edinburgh, England). Proc. Phys. Soc. (London) A68, 923-5(1955) Oct. 1.

An improved nuclear emulsion method was used to resolve discrepancies reported for the excitation energy of the first excited state of $Ra^{228}$ from $\alpha$ decay of $Th^{232}$. A study of the three-dimensional ranges of 142 conversion electrons associated with the $\alpha$ particles gave a value of 59 ± 1 kev for this state. (L.M.T.)

THERMAL-NEUTRON-INDUCED FISSION OF $Th^{229}$. A. Smith, P. Fields, A. Friedman, and R. Sjoblom (Argonne National Lab., Lemont, Ill.). Phys. Rev. 111, 1633-5(1958) Sept. 15.

A back-to-back ionization chamber is used to measure the $Th^{229}$ fission fragment kinetic energy distribution. This fission process is found to be the most asymmetric known, with a most probable mass ratio of 1.57. The measured total fragment energy is 160.2 ± 3 Mev. The experimental results are compared with the characteristics of other fission processes and with theory. (auth)

**13589**

NUCLEAR SPECTROSCOPIC INVESTIGATIONS OF THE NUCLIDES $^{228}_{90}$Th, $^{224}_{88}$Ra, $^{212}_{82}$Pb, $^{212}_{83}$Bi, $^{208}_{81}$Tl. F. Demichelis, B. Chinaglia, and G. Trivero (Istituto di Fisica Sperimentale del Politecnico, Turin). Nuovo cimento (10) 8, 369-77(1958) May 1.

The $\gamma$ spectrum of $Th^{228}$ in equilibrium with its decay products has been investigated by means of two scintillation spectrometers and a fast slow coincidence set up in the range 0.05 to 0.76 Mev. From the results the decay schemes of the nuclides $Pb^{212}$ and $Th^{228}$ are confirmed. For the nuclides $Ra^{224}$ and $Bi^{212}$ the existence of two $\gamma$ rays which fit the energy levels already proposed by other authors as ascertained, through a direct measurement. Moreover some till now unknown $\gamma$ rays are found which must be assigned to the $Tl^{208} \rightarrow Pb^{208}$ decay. According to these data a new decay scheme for $Tl^{208}$ is proposed. (auth)

**5094**

SPECTRAL COMPOSITION OF $\gamma$ RADIATION FROM ELEMENTS OF THE URANIUM AND THORIUM FAMILY. T. I. Sisigina. (Inst. of Applied Geophysics, Acad. of Sciences, U.S.S.R.). Izvest. Akad. Nauk S.S.S.R. Ser. Geofiz, No. 12, 1484-90(1957) Dec. (In Russian)

Tables of spectral composition of $\gamma$ radiation for uranium and thorium family elements ($Bi^{212}$, $Tl^{208}$, $Th^{234}$, $Pa^{234}$, Ra, $Pb^{214}$, $Bi^{214}$, $Pb^{210}$, $Ac^{228}$, $Th^{228}$, $Pb^{212}$) were developed on the basis of available data, and equations were derived for the $\gamma$ energies of the elements. (R.V.J.)

# THORIUM 1.39

## FISSION PRODUCTS, ISOTOPES, AND DECAY 1.39.02

### ACTIVITY SPECTRA 1.39.02.02

**5903**

ALPHA DECAY OF $Th^{229}$, INTERACTIONS OF NUCLEAR LEVELS. L. L. Gol'din, G. I. Novikova, N. I. Pirogova, and E. F. Tret'yakov. Zhur. Eksptl'. i Teoret. Fiz. 37, 1155-7(1959) Oct. (In Russian)

A magnetic $\alpha$ spectrometer was used in studies of $Th^{229}$ $\alpha$ decay and the $Ra^{225}$ conversion electron spectrum was studied by means of a strong-light toroidal $\beta$ spectrometer using $\alpha-\beta$ coincidence schemes. The energies and transition intensities of the obtained 12 $\alpha$ lines are tabulated as well as forbidden factors $\eta$. (R.V.J.)

BETA SPECTRUM OF $Th^{233}$. B. J. Dropesky and L. M. Langer (Los Alamos Scientific Lab., N. Mex.). Phys. Rev. 108, 90-1(1957) Oct. 1.

The beta spectrum of $Th^{233}$ has been measured in a ring-focus solenoidal spectrometer and was not found to exhibit an anomalous shape, as had been previously reported. The end point is 1.23 ± 0.01 Mev, in agreement with the earlier value. It is shown that $Th^{233}$ decays predominantly to the ground state of $Pa^{233}$. Half-life measurements yield a value of (22.4 ± 0.1) min for $Th^{233}$, somewhat shorter than the previously reported values. (auth)

**2209**

RADIATIONS FROM 1− STATES IN EVEN-EVEN NUCLEI. F. S. Stephens, Jr., Frank Asaro, and I. Perlman (Univ. of California, Berkeley). Phys. Rev. 100, 1543-5(1955) Dec. Dec. 1.

The gamma ray spectrum of $Th^{230}$ was taken with a NaI scintillation spectrometer. The decay scheme is shown, giving a 1− state at 253 kev. This decay is typical of those from even-even nuclei. (B.J.H.)

**9166**

SEARCH FOR A RARE $\alpha$-EMISSION IN $^{228}Ra$ (MaTh 1). N. Feather, N. Miller, and S. W. Peat (Edinburgh Univ.) Proc. Phys. Soc. (London) A70, 478-80(1957) June.

The search for a branching in the thorium series at $Ra^{228}$ by $\alpha$ decay to $Em^{224}$ was carried out by attempting to detect $Ra^{224}$, the point of return to the main chain. After many chemical procedures, a solution of the residue was used to impregnate a nuclear emulsion in order to detect the decay of $Ra^{224}$ by means of its star of three or more $\alpha$ tracks. Results were inconclusive as such stars were not found in significantly greater numbers than background. (M.H.R.)

DECAY OF IONIUM ($Th^{230}$). E. Booth, L. Madansky, and F. Rasetti (Johns Hopkins Univ., Baltimore). Phys. Rev. 102, 800-1(1956) May 1.

Gamma-ray coincidence studies of the decay of ionium yield the total conversion coefficient of the 68-kev gamma ray as $\alpha = 46 \pm 5$, and a value of $f = 0.52 \pm 0.05$ for the fluorescent yield from the L shell of $Ra^{226}$. The mean lifetime of the 68-kev state of $Ra^{226}$ was found to be $T_{1/e} \leq 10^{-9}$ second. (auth)

**5892**

RADIOACTIVE DECAY OF $Ac^{227}$ AND EXCITED LEVELS of $Fr^{223}$ AND $Th^{227}$. G. I. Novikova, E. A. Volkova, L. L. Gol'din, D. M. Ziv, and E. F. Tret'yakov. Zhur. Eksptl'. i Teoret. Fiz. 37, 928-37(1959) Oct. (In Russian)

Radioactive decay of $Ac^{227}$ was investigated. Alpha decay of $Ac^{227}$ was studied with an $\alpha$ spectrometer. A $\beta$ spectrometer in conjunction with an $\alpha-\beta$ coincidence circuit was employed to study $\beta$ decay and the spectra of conversion electrons which accompany $\alpha$ and $\beta$ decay of $Ac^{227}$. A fine structure has been detected in the $Ac^{227}$ $\alpha$ spectrum. The energies of 7 new lines and the intensities of the corresponding transitions were determined. A number of $\gamma$ transitions between levels of the daughter $Fr^{223}$ nucleus were detected. A level scheme for $Fr^{223}$ is proposed. Three levels were detected in the spectrum of $Th^{227}$ which is obtained as a result of $\beta$ decay of $Ac^{227}$. The energies of the levels and the intensities of $\beta$-decay to them were measured. (auth)

## METALLURGY 1.39.03

THE THORIUM−CERIUM SYSTEM. R. T. Weiner, W. E. Freeth, and G. V. Raynor (Birmingham Univ., Eng.). J. Inst. Metals 87, 106-7(1958) Oct.

An explanation and substantiation of a report of research on lattice spacing vs. composition of thorium−cerium alloys are presented. The initial sharp fall in the lattice spacing vs. composition curve up to about 1.4 at. % cerium is discussed, and it is pointed out that the spacing of thorium is not sufficiently understood to justify empirical calculations for pure thorium or in alloys containing a small quantity of cerium. In addition, it is felt unlikely that the sharp drop in lattice spacing on the initial addition of cerium to the thorium sample is due to the reaction of the solute with hydrogen present in the thorium. (J.R.D.)

# THORIUM 1.39

## METALLURGY 1.39.03

11279 ✓

THE CRYSTAL STRUCTURES OF THORIUM BISMUTHIDES. Riccardo Ferro (Genoa Univ., Italy). Acta Cryst. 10, 476-7 (1957) July.

8942 ✓/ NAA-SR-1885

Atomics International Div., North American Aviation, Inc., Canoga Park, Calif.

SOLID STATE PHYSICS SEMIANNUAL PROGRESS REPORT [FOR] JULY–DECEMBER 1956. John F. Hove, ed. June 1, 1957. 40p. Contract AT-11-1-GEN-8. $0.30 (OTS).

A brief description is given of the results to date of a metallurgical study of the Th rich end of the Th–U phase diagram. Both a metallographic and a lattice structure investigation imply a room temperature solid solubility of about 1% U in Th, although some very careful electrical resistivity studies appear to indicate no unusual behavior, other than a change in the $\alpha-\beta$ transformation temperature, up to 8% U, the maximum value studied. The electrical resistivity of a U single crystal has been measured as a function of temperature (4 to 300°K), orientation, and magnetic field. The one direction in which the resistivity is markedly higher is not the same direction in which the thermal expansion coefficient is markedly different (but in this case, negative), though an anisotropic crystal will usually have one odd direction in which all the direction-sensitive properties will be different from their values in the other two directions. The Hall coefficient of a polycrystalline sample of U has been measured as a function of temperature. The value is positive and shows a striking decrease (by almost a factor of three) in the region of 50°K. A sample of high-purity Cu was measured and a similar algebraic decrease, although only by about 20%, was noted in approximately the same temperature range. The explanation is thought to lie in a hitherto uninvestigated dependence of the Hall effect on electron scattering, although no quantitative theoretical explanation has been successfully formulated. The electronic energy band structure of $\alpha$–Th has been worked out and a two-band approximation made to the actual energy surfaces in the vicinity of the Fermi level. Since the effective masses of the various electrons and holes are theoretically computed, only the two relaxation times can be treated as disposable constants. Evaluating these from the electrical resistivity and thermoelectric power standpoint, it is found that the Hall coefficient and magnetoresistivity can be predicted almost exactly. This agreement is very gratifying and lends a high credence to the validity of the calculations. A few preliminary measurements were made of the electrical resistivity changes of Cu and Ni under bombardment at about 10°K. Preliminary annealing measurements indicate that some 50 to 80% of the change recovers by about 60°K. The changes in Young's modulus and internal damping in Cu due to electron bombardment have been measured. The modulus rises rapidly with flux, reaching an early saturation followed by a slow decrease. The rapid rise is attributed to dislocation pinning while the slow decrease is thought to be a "bulk effect," i.e., a change due to lattice distortion and not a dislocation effect. (auth)

THE CRYSTAL STRUCTURES OF $ThHg_3$, $ThIn_3$, $ThTl_3$, $ThSn_3$, AND $ThPb_3$. Riccardo Ferro (Genoa Univ.). Acta Cryst. 11, 737-8(1958) Oct.

The alloys prepared were found to be rather oxidizable, and the ones with heavier metals appear fairly pyrophoric. This fact can be related to what happens when the thorium alloys with the heavier metal are also pyrophoric as contrasted with the more stable compounds with arsenic and antimony. (auth)

METALLIC THORIUM. G. A. Meerson and A. F. Islankina. Atomnaya Energ. 5, 155-65(1958). (In Russian)

A short review is presented on thorium metallurgy. Soviet investigations in thorium powder metallurgy are described. The physico-chemical properties and electrolytic and calciothermal compression characteristics of thorium powder are discussed. A theoretical review is given of the basic factors in sintering processes and the relation between the changes in durability and plasticity of thorium compacts made from electrolytic and calciothermal powders, and the temperature and holding time are shown graphically. Cakes of calciothermal powder on calcination at 1150 to 1200°C change their shape due to the intensive calcium evaporation. To obtain dense metal from calciothermic powder, the cakes must be subjected to secondary or calibrated compression at low temperature, followed by annealing. Finally, the data on physical and mechanical properties of thorium produced from electrolytic and calciothermal powder are described. Electrolytic thorium is more plastic ($\delta$ = 35 to 43%) and less stable ($\delta_b \sim 16.5$ kg/mm$^2$) than calciothermal thorium ($\delta$ = 17 to 23% and $\delta_b$ = 22 kg/mm$^2$). (tr-auth)

# THORIUM 1.39

## METALLURGY 1.39.03

**10565** UCRL-3805
California. Univ., Berkeley. Radiation Lab.
CALCULATION OF THE ThS–U AND ThS–Ti PHASE DIAGRAMS. Leo Brewer. June 1957. 4p. Contract W-7405-eng-48. $0.10(OTS).

The thermodynamic quantities necessary for the calculation of the ThS–Ti and ThS–U phase diagrams are estimated and the phase diagrams calculated. (auth)

**13935** BMI-1300
Battelle Memorial Inst., Columbus, Ohio.
CONSTITUTION OF URANIUM AND THORIUM ALLOYS. Frank A. Rough and Arthur A. Bauer. June 2, 1958. 138p. Contract W-7405-eng-92. $2.75(OTS).

A compilation of constitution diagrams of uranium and thorium alloys is presented. The transformation and melting temperatures of the base metal are discussed, followed by the various alloys in alphabetical order. References are included on each alloy. (J.R.D.)

**8018**
PREPARATION OF THORIUM BISMUTH DISPERSIONS FROM ELECTROLYTIC THORIUM. M. E. Sibert and M. A. Steinberg (Horizons Inc., Cleveland, Ohio) and R. J. Teitel (Dow Chemical Co., Midland, Mich.). J. Electrochem. Soc. 104, 374-8(1957) June.

The preparation of $Th_3Bi_5$ dispersions in liquid Bi utilizing electrolytic Th has been investigated by three techniques. These materials are potentially useful as fuels for liquid metal reactors. Dispersions have been prepared successfully in desired concentration, particle size, and shape by addition of crushed Th cathode deposits to Bi, addition of as-deposited cathode to Bi in the cell, and by electrolysis of $ThCl_4$ using a liquid Bi cathode. Procedures, conditions, and results are fully described. (auth)

**11241**
THE SOLUBILITY OF THORIUM IN LIQUID ZINC. M. V. Smirnov, N. G. Ilyushchenko, et al. (Sverdlovsk, Academy of Sciences, Ural Div.). Zhur. Fiz. Khim. 31, 1013-8(1957) May. (In Russian)

Investigations were made of Th–Zn alloys containing up to 25% Th by wt. The phases of pure Zn and of metallic compounds of $Th_2Zn_{17}$ were found. The Th was isolated from the alloy by dissolving the excess Zn in aqueous solutions of ammonium salts or in alkalis. The solubility of Th in liquid Zn was determined at 419 to 825°C. (R.V.J.)

Refer also to abstract 11170.

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METALLURGY OF URANIUM AND THORIUM. A. Cacciari, R. De Leone, C. Fizzotti, and M. Gabaglio. Energia nucleare (Milan) 3, 154-67(1956) June 15. (In Italian)

The status of U production throughout the world is surveyed. (B.J.H.)

**7423** FMPC-173
National Lead Co. of Ohio, Cincinnati.
REVIEW OF FMPC THORIUM PRODUCTION OPERATION AND SURVEY OF DEVELOPMENT NEEDS. E. W. Mautz, O. R. Magoteaux, and T. C. Runion. Mar. 26, 1953. Decl. Feb. 16, 1957. 24p. Contract AT-(30-1)-1156. $0.35 (OTS).

A survey of the Th production operation designed for the FMPC by the Catalytic Construction Company has been conducted to indicate the need for further development work in the event of full scale production requirements for Th, and to supply operating supervisors with a brief summary of the process chemistry and metallurgy relating to the standard operating procedures for the plant. (auth)

**9308** AECU-3290
Illinois Inst. of Tech., Chicago. Armour Research Foundation.
THE SYSTEM THORIUM–MERCURY. Progress Report No. 6 [for] March 1, 1956–April 30, 1956. R. F. Domagala and W. Rostoker. May 14, 1956. 10p. Project No. B 076. For Oak Ridge National Lab. Contract W-7405-Eng-26, Subcontract No. 765. $1.80(ph OTS); $1.80(mf OTS).

Phase relationships in the binary system Th–Hg are being studied. In addition, a study of the increase in Th content of Hg–Th products by distillation as a function of time, temperature and initial mercury content is being pursued. Four large samples of an alloy containing 25% Th have been prepared and will be used for the beneficiation work. Several alloys for phase relationship study have been made and additional compositions are currently being prepared. All alloys will be made by grinding Th chips into a pool of Hg in a Vycor tube under a protective A atmosphere and flame sealing the bulb in vacuo when the proper composition is reached. Experimental work to resolve the problem of $ThO_2$ patterns observed in X-ray films of certain alloys in earlier work is in progress. (auth)

# THORIUM 1.39

## METALLURGY 1.39.03

**12410** ✓ TID-7521(Pt. 1(Del.))
Division of Production, AEC.
PAPERS FOR THORIUM–URANIUM-233 INFORMATION MEETING HELD AT WILMINGTON, AUGUST 3, 1955. Dec. 1956. Decl. with deletions Mar. 14, 1957. 99p. $15.30(ph OTS); $5.40(mf OTS).

Separate abstracts have been prepared on three papers presented at this meeting: Direct Reduction of Thorium Oxide; The Preparation of Thorium Metal Powder by Fused Salt; and Cold Compacting and Arc Melting of Thorium Powder. (W.L.H.)

POWDER METALLURGY OF THORIUM HYDRIDES. Samuel Storchheim (Martin Co., Baltimore). Powder Met. Bull. 7, 158-62(1956) Apr.

From a study of the powder metallurgy of $ThH_2$ and $ThH_4$, it is conceivable that hydride powders can complete economically with compacts made from pure Th starting powder. $ThH_2$ compacts to higher densities than $ThH_4$ but $ThH_4$ is easier to handle even though it takes an extra step in the fabrication cycle. (F.S.)

**9801** SEP-138
Sylvania Electric Products Inc. Atomic Energy Div., Bayside, N. Y.
INVESTIGATION OF THE POWDER METALLURGY OF THORIUM. PART I. W. G. Lidman and T. Weissman. Dec. 22, 1953. Decl. Jan. 20, 1956. 26p. Contract AT-30-1-GEN-366. (DCF-4441). $0.25(OTS).

An investigation was made of the effect of compacting pressure, sintering time, temperature, and atmosphere on the density, hardness, and microstructures of Th prepared by powder metallurgy. At 1400°C and above, the compacting pressure did not appreciably affect the density of either Metal Hydrides' Th or Th prepared by decomposition of the hydride during sintering. The density of Horizons' Th increased markedly with increased compacting pressure. The highest densities obtained were 11.12 g/cc for Metal Hydrides' powder compacted at 40 tsi and sintered at 1400°C for 1000 min in vacuum; 11.58 g/cc for Horizons' powder compacted at 75 tsi and sintered at 1450°C for 60 min in A; and 11.63 g/cc for Sylvania's Th compacted at 75 tsi and sintered at 1550°C for 180 min in A. (auth)

THE METAL THORIUM. Proceedings of the Conference on Thorium Held October 11, 1956 at Cleveland, Ohio. Harley A. Wilhelm, ed. Cleveland, American Society for Metals, 1958. 402p.

The following topics were presented at the conference: role of Th metal in the nuclear field; nonnuclear application of Th; Th in Mg technology; production of Th compounds; preparation of $ThO_2$ and $ThF_4$ from $Th(NO_3)_4$; development of the thorium tetrafluoride–calcium process for thorium metal; preparation of iodide Th; consumable-electrode arc melting of Th; electrolytic refining of Th; physical constants, crystal structure, and thermodynamic properties; electronic structure of Th metal; preferred orientation in Th; mechanical properties of Th and high-Th alloys; recrystallization of Th; fabrication and cladding of Th metal; corrosion of Th and its alloys; effects of irradiation on Th; metallography of Th; hazards associated with Th Metallurgy; constitution of Th alloys; chemical analysis of Th metal; and spectrographic analysis of Th. (W.L.H.)

**13589** ✓ FMPC-131
National Lead Co. of Ohio, Cincinnati.
REVIEW OF AMES THORIUM PROCESS. E. W. Mautz and O. R. Magoteaux. [1953?]. Decl. Mar. 13, 1957. 49p. Contract AT(30-1)-1156. $7.80(ph OTS); $3.30(mf OTS).

A summary of the Ames Th process as reported in progress reports by NLO personnel during an extended training program at Ames to obtain background information for the startup and operation of the Fernald Th production plant is given. A general study of the Ames Th process included thorium oxalate precipitation, filtration, drying and calcination, hydrofluorination of $ThO_2$, reduction of $ThF_4$, Th–Zn alloy dezincing, Th metal casting, Ca distillation and preparation for bomb reduction, $ZnCl_2$ drying, analytical, spectrographic, and metallographic determinations, $ZnF_2$ drying for bomb reduction, and mesothorium consideration. (auth)

**9738** ✓ CT-3714
Iowa State Coll., Ames.
THORIUM METALLURGY. H. A. Wilhelm, A. S. Newton, A. H. Daane, and C. Neher, comps. Feb. 22, 1946. Decl. Feb. 18, 1957. 55p. Contract W-7405-eng-82. $9.30(ph OTS); $3.60(mf OTS).

A comprehensive survey including production, fabrication, physical properties, alloys, and metallography of Th is presented. (T.R.H.)

# THORIUM 1.39

## METALLURGY 1.39.03

**1409**
POWDER METALLURGY MAKES BETTER REACTOR FUELS AND COMPONENTS. Nucleonics 13, No. 12, 24-6(1955) Dec.

The techniques and advantages of powder metallurgy for reactor uses are summarized. In particular, the powder metallurgy of Th and U is discussed. (B.J.H.)

**9740** ✓ ISC-297
Ames Lab., Ames, Iowa.
TERMINAL REPORT OF AN INVESTIGATION OF THE PROPERTIES OF THORIUM AND SOME OF ITS ALLOYS. G. C. Danielson, Glenn Murphy, D. Peterson, and B. A. Rogers. Oct. 1, 1952. Decl. Feb. 26, 1957. 86p. Contract W-7405-eng-82. $0.50(OTS).

Data are included on the physical properties of unalloyed Th, the mechanical properties of production Th, the effect of impurities on the physical properties of Th, the effect of crucible materials on the properties of Th metal, and on the properties of Th alloys and the Th–Zr system. (B.J.H.)

**12493** ✓ NYO-1185
National Research Corp., Cambridge, Mass.
THE CONTAMINATION OF MOLTEN THORIUM BY ZIRCONIA AND BERYLLIA CRUCIBLES. James H. Moore. Apr. 23, 1952. Decl. Mar. 12, 1957. 7p. $1.80(ph OTS); $1.80(mf OTS).

Dezinced Th was melted in beryllia and in zirconia crucibles by means of a metal tank-type vacuum furnace containing an induction-coil assembly for a crucible ~2¾ in. in diameter and 5 in. high. Heating was done at as rapid a rate as possible, and all melts were held at soak temperature, 1750 to 1900°C, for 30 min. The melt was then allowed to solidify in the crucible. Correlation between temperature and degree of contamination and relative contamination by zirconia and beryllia are discussed. (J.E.D.)

**16242** ✓ AEC-tr-3722
THE SYSTEM ALUMINUM–THORIUM. Ad. Leber. Translated for Atomics International from Z. anorg. u allgem. Chem. 166, 16-26(1927). 12p. $3.30(ph), $2.40(mf) JCL.

The preparation, analysis, thermal properties, structure, and phase studies are presented for Al–Th alloys. (W.L.H.)

**12495** ✓ ORNL-1090
Oak Ridge National Lab., Tenn.
METALLURGY OF THORIUM AND THORIUM ALLOYS. Interim Report [for] July 1, 1949 to July 1, 1951. D. E. Hamby. Dec. 7, 1951. Decl. Mar. 4. 1957. 93p. Contract W-7405-eng-26. $0.60(OTS).

A comprehensive study has been made of the physical metallurgy of Th and some of its alloys. Mechanical properties such as tensile strength, ductility, modulus of elasticity, Poisson's ratio, shear modulus, and impact strength were determined for Ames Ca-reduced Th. A few tests were made on iodide Th and Westinghouse powder-compacted Th. Density determinations are reported for Ames, iodide, and Westinghouse Th samples. Precision measurements of the lattice parameters of iodide Th made by x-ray diffraction are given. Work-hardening characteristics and recrystallization temperatures were established for both Ames and iodide Th. The fabricating characteristics of Th were studied by rolling, swaging, extrusion, forging, and welding. Cladding of Th with Zr was accomplished by extrusion. Thermal cycling of Th was carried out in NaK at temperatures of 100 to 500°C to investigate dimensional stability. A preliminary investigation is reported on binary Th alloys containing additions of Be, Si, Zr, Ti, Al, Nb, Cr, Mn, and Ce. Melting ranges, fabricating characteristics, hardness, and tensile properties were studied. Ternary alloys containing Zr–Ti and Zr–Si were investigated in like manner. Corrosion tests in water at 95°C were carried out on Ames Th and all the alloys under study. (auth)

## OTHER REACTIONS AND PROPERTIES 1.39.04

### CHLORIDES 1.39.04.01

**8835** ✓
THE CHEMISTRY OF THORIUM. VIII. SOME ELECTROCHEMICAL CHARACTERISTICS OF ANHYDROUS THORIUM CHLORIDE IN ANHYDROUS ETHYLENEDIAMINE. Therald Moeller and Thirumalusubbu Muniyappan (Univ. of Illinois, Urbana). J. Inorg. and Nuclear Chem. 4, No. 3 and 4, 216-19(1957).

Anhydrous $ThCl_4$ dissolves vigorously and readily in anhydrous ethylenediamine. The resulting solutions show the conductance behavior of solutions of weak electrolytes. Electrolysis of such solutions give cathodic evolution of hydrogen and transport of Th to the anode compartment, but does not give cathodic deposition of Th metal. (auth)

# THORIUM 1.39

## OTHER REACTIONS AND PROPERTIES 1.39.04

### CHLORIDES 1.39.04.01

**5772**

THE PREPARATION OF ANYDROUS THORIUM TETRACHLORIDE. O. C. Dean and J. M. Chandler (Oak Ridge National Lab., Tenn.). Nuclear Sci. and Eng. 2, 57-72 (1957) Feb.

Thorium tetrachloride is an important intermediate in the production of Th metal. The readiness with which the hydrated salt hydrolyzes at high temperatures with its own water of hydration makes use of the anhydrous salt necessary for this purpose. The preparation of pure anhydrous $ThCl_4$ from aqueous solutions is very nearly impossible because of its hydrolytic behavior. The dry chlorination of the oxide, oxalate, carbonate, carbides, sulfides, and nitrate with various chlorinating agents has been evaluated on a laboratory scale. Chlorination of the oxide, oxalate, and carbonate in the presence of carbon and direct chlorination of the carbide with chlorine appear to be the most promising methods. The results of laboratory studies of the $ThO_2-C-Cl_2$, the $Th(C_2O_4)_2-CCl_4-Cl_2$, and the $Th(C_2O_4)_2-CO-Cl_2$ systems on a 1-lb batch scale are presented. Flowsheets, optimum conditions, and the thermochemistry of the reactions involved are discussed. (auth)

### COMPLEX FORMATION 1.39.04.02

**1461**

THERMODYNAMICS OF THE SULFATE COMPLEXES OF THORIUM. A. J. Zielen (Argonne National Lab., Lemont, Ill.). J. Am. Chem. Soc. 81, 5022-8(1959) Oct. 5.

By use of the cation-exchange resin technique in perchloric acid solutions at an ionic strength of 2.00 and at 25°C, thorium(IV) was observed to associate with sulfate according to the stepwise reactions: $Th^{+4} + HSO_4^- = ThSO_4^{+2} + H^+$ and $ThSO_4^{+2} + HSO_4^- = Th(SO_4)_2 + H^+$ with the association constants $K_1 = 166 \pm 8$ and $K_2 = 21.7 \pm 1.5$. The heats and entropy changes of the reactions were determined calorimetrically with the results: $\Delta H_1$ and $\Delta H_2$ equal $-0.54 \pm 0.05$ and $-0.89 \pm 0.08$ kcal./mole, respectively and $\Delta S_1$ and $\Delta S_2$ equal $8.4 \pm 0.2$ and $3.2 \pm 0.3$ cal. deg.$^{-1}$ mole$^{-1}$, respectively. The heat of ionization of bisulfate ion at an ionic strength of 2.00 and at 25°C was also measured calorimetrically with the result $\Delta H$ equals $-5.54 \pm 0.17$ kcal./mole. (auth)

STUDIES ON THE HYDROLYSIS OF METAL IONS. 22. EQUILIBRIUM STUDIES IN SELF-MEDIUM; APPLICATION TO THE HYDROLYSIS OF $Th^{4+}$. Sirkka Hietanen and Lars Gunnar Sillen (Royal Inst. of Tech., Stockholm). Acta Chem. Scand. 13, 533-50(1959).

It is suggested that added information on polynuclear complexes, $A_pB_q$, between the reagents A and B, may be obtained by working with an ionic medium where one of the reagents, say B, forms the major part of the ions of one charge. This is termed the "self-medium method," as distinguished from the "inert medium method," e.g., with $NaClO_4$, in current use. The self-medium method favors complexes $A_pB_q$ with low values for p/q so that information may be obtained about such complexes with a greater certainty than from work with inert media. The self-medium method has been applied to the hydrolysis of $Th^{4+}$. The data indicate the two reactions $2Th^{4+} + 2H_2O \rightleftharpoons Th_2(OH)_2^{6+} + 2H^+$ (equil. const. $\beta_{22}$) and $2Th^{4+} + H_2O \rightleftharpoons Th_2OH^{7+} + H^+$ ($\beta_{12}$). In the medium 0.5 Th, 2.2 (Na)Cl, $\log \beta_{22} = -5.02 \pm 0.04$, $\log \beta_{12} = -2.8 \pm 0.2$. In 0.7 Th, 3.0 (Na)Cl, $\log \beta_{22} = -5.09 \pm 0.04$, $\log \beta_{12} = -2.9 \pm 0.2$. Temperature 25°C. (auth)

**19971**

RESEARCH ON COMPLEXING IN SOLUTIONS BY THE DISTRIBUTION METHOD. THE SYSTEM: SELENOYL-2-ACETONE-Th(IV)-$CHCL_3$-$H_2O$. V. M. Peshkova and A. P. Zozulya (Lomonosov Moscow State Univ.). Zhur. Anal. Khim. 14, 411-16(1959) July-Aug.

Selenenoyl-2-acetone is much more suitable for the extraction of thorium from water solutions than acetylacetone widely used for this purpose. The stability constants of thorium selenenoyl-2-acetonates and the distribution constant of the extracted complex in the $CHCl_3-H_2O$ system, have higher values than those of the acetylacetonate complexes. (auth)

**8829**

THE DETERMINATION OF THE CHARGE OF SOME INORGANIC THORIUM COMPLEXES WITH THE ION EXCHANGE METHOD. K. F. Schulz and M. J. Herak (Yugoslav Academy of Sciences and Arts and Inst. Ruder Bošković, Zagreb, Croatia). Croat. Chem. Acta 29, No. 1, 49-52(1957).

The charges of complex thorium chloride ions in solutions with NaCl, HCl, LiCl, KCl, $MgCl_2$, and $CaCl_2$ have been determined by means of an ion exchange technique. (T.R.H.)

# THORIUM 1.39

## OTHER REACTIONS AND PROPERTIES 1.39.04

### COMPLEX FORMATION 1.39.04.02

**4303**

THORIUM COMPLEX OF 2,7-DINITROSO-1,8-DIHYDROXYNAPHTHALENE-3,6-DISULPHONIC ACID. III. COMPLEXOMETRIC DETERMINATION OF THORIUM WITH ETHYLENEDIAMINETETRAACETIC ACID. Sachindra Kumar Datta (Darjeeling Government Coll., India). Anal. Chim. Acta 16, 115-20(1957) Feb.

Thorium forms a pinkish-violet colored complex with dinitrosochromotropic acid, which has been used as an indicator in the titrimetric determination of Th with EDTA. The method is based on the fact that this colored complex is less stable than the Th-EDTA complex and breaks down after a bulk of Th has reacted with EDTA; this marks the end-point, which is the change from pinkish-violet to red. As little as 3.1 mg of Th present in 50 ml volume of solution may be accurately determined within a pH range from 2.2 to 3.5. The study of interferences revealed that quite a number of elements do not interfere; iron may be masked with ascorbic acid. Thorium may be determined by the same method, after separating it from many interfering ions by precipitating it with o-anisilic acid. (auth)

**6409** A/CONF.15/P/2136

**CARBONATE COMPLEX THORIUM COMPOUNDS. I. I. Cherniayev, V. A. Golovnia, and A. K. Molodkin (Academy of Sciences, U.S.S.R.). 23p.**

**The conditions are specified for which sodium pentacarbothoriates are formed. A unity of views is established on thorium coördinating number for a complex carbonate anion of this type. This required studying of the character and strength of linked water in hydrated forms of pentacarbothoriates and carrying out chemical and physiochemical research on pentacarbothoriate type compounds. (W.D.M.)**

**2637**

**PHYSICO-CHEMICAL STUDIES ON THE COMPLEX FORMATION BETWEEN THORIUM ION AND OXALATE ION. PART II. THERMOMETRIC AND CRYOSCOPIC TITRATIONS. Monisha Bose and D. M. Chowdhury (Univ. Coll. of Science, Calcutta). J. Indian Chem. Soc. 32, 673-8(1955) Oct.**

**The existance of different thoro-oxalates in solution has been corroborated by thermometric and cryoscopic titrations with thorium nitrate-potassium oxalate systems. (auth)**

**6240**

THERMOLYSIS OF THORIUM PRECIPITATES. SALTS OF ORGANIC ACIDS. Wesley W. Wendlandt (Texas Technological Coll., Lubbock). Anal. Chem. 29, 800-2(1957) May.

The thermal decomposition of the Th precipitates with stearic, pyrogallic, m-hydroxybenzoic, m-cresoxyacetic, benzoic, 2,4-dichlorophenoxyacetic, phenylacetic, cinnamic, and o-aminobenzoic acids, and mercaptothiazole were studied on the thermobalance. In general, the precipitates decomposed at fairly low temperatures. The least stable began to lose weight at 35° C, while the most stable exhibited no weight loss below 285° C. The oxide levels were obtained in the temperature range from 450° to 675° C. (auth)

**9236**

INVESTIGATION OF COMPLEX COMPOUNDS OF THORIUM WITH AMINOPOLYCARBONIC ACIDS BY MEANS OF HIGH FREQUENCY TITRATION. D. I. Ryabchikov and B. K. Belyaeva (Vernadskiĭ Moscow Inst. of Geochemistry and Analytical Chemistry). Zhur. Analit. Khim. 12, 166-75(1957) Mar.–Apr. (In Russian)

The preparative high-frequency titration methods used in the investigation showed that thorium forms complex compounds $(NH_4)_2ThX_2 \cdot 4H_2O$ with nitrilotriacetic acid and $(NH_4)_2ThUr_2 \cdot 4H_2O$ with uramyldiacetic acid pH 8.2 when the molar ratio of Th to addendum is 1:2. Thorium forms complex compounds $NH_4(Th\gamma OH) \cdot 4H_2O$ with ethylenediaminetetraacetic acid at pH 7.0 and $NH_4[Th(CH_2)_4OH] \cdot 5H_2O$ with 1.2 diaminocyclohexanetetraacetic acid at pH 8.0 when the molar ratio of thorium to addendum is 1:1. (tr-auth)

### GENERAL 1.39.04.03

**12516** UCRL-8703

California. Univ., Berkeley. Lawrence Radiation Lab. THE RADIOCHEMISTRY OF THORIUM. E. K. Hyde. Apr. 1959. 86p. Contract W-7405-eng-48. $15.30(ph), $5.40(mf) OTS.

Inorganic, analytical, and radiochemistry of thorium is reviewed. A table of thorium isotopes is given. The features of thorium chemistry of interest to radiochemists include metallic thorium, soluble and insoluble salts and coprecipitation characteristics, complex ions, chelate complexes, extraction of the TTA complex of thorium into organic solvents, and ion exchange behavior. A collection of detailed radiochemical procedures for thorium is given. (J.E.D.)

# THORIUM 1.39

## OTHER REACTIONS AND PROPERTIES 1.39.04

### GENERAL 1.39.04.03

THORIUM AND THORIUM COMPOUNDS. D. I. Ryabchikov and E. K. Gol'braikh. Uspekhi Khim. 28, 408-35(1959) Apr. (In Russian)

A detailed review is given on thorium and thorium compounds. Preparation, properties, and uses are discussed. 288 references. (R.V.J.)

**10612** NLCO-727
National Lead Co. of Ohio, Cincinnati.
THORIUM—A LITERATURE SEARCH. Earl W. Mautz. Mar. 18, 1958. 19p. Contract AT(30-1)-1156. $0.75 (OTS).

A literature search on "Thorium" from Chemical Abstracts, Volume 1, (1907) through Volume 27 (1933) is presented, exclusive of references to medical, radiochemical, mineralogical, analytical and spectrochemical headings. (auth)

THE PRODUCTION AND CONSUMPTION OF THORIUM. G. E. Kaplan, Yu. I. Zarembo, and T. A. Uspenskaya. Atomnaya Energ. 5, 147-54(1958). (In Russian)

A review is given of the production methods and consumption of thorium. (R.V.J.)

**4480**
THORIUM'S ROLE IN ATOMIC POWER. John P. Howe (North American Aviation, Inc., Canoga Park, Calif.). Metal Progress 71, No. 2, 97-103(1957) Feb.

This paper was presented at the conference on Th held at the last Metal Congress and Exposition. The nuclear reactions of Th, the production of $U^{233}$ in the CETR, SGR, and LMFR, properties of Th and its alloys, preparation of slurries, refining of spent elements, and the cost of fuel are discussed. (W.L.H.)

THORIUM PRODUCTION TECHNOLOGY. F. L. Cuthbert. Reading, Mass., Addison-Wesley Publishing Company, Inc., 1958. 312p. $6.50.

The first and second chapters contain background information on uses and physical and chemical properties of thorium metal and compounds. The third chapter is concerned with thorium-bearing ores and their concentration. Succeeding chapters describe the various steps for extracting and purifying the ore and reducing it to the metal and methods for casting and fabricating the metal. Other chapters are concerned with the health and safety aspects of thorium production and with the chemical and physical methods of testing thorium. (W.L.H.)

**1525** TID-3309
Technical Information Service Extension, AEC.
THORIUM: A BIBLIOGRAPHY OF UNCLASSIFIED REPORT LITERATURE. Oct. 1956. 13p. $0.20(OTS).

This bibliography contains 74 references to unclassified reports covering all aspects of Th except production of Th metal. A report number index is provided. (auth)

**1369** BMI-1052
Battelle Memorial Inst., Columbus, Ohio.
THE ELECTRICAL RESISTANCE OF THORIUM THROUGH THE ALLOTROPIC TRANSITION. Herbert W. Deem and Robert A. Winn. Nov. 18, 1955. 10p. Contract W-7405-eng-92.

The electrical resistance-temperature curve of Th exhibits a reversible inflection at about 1400°C corresponding with the allotropic transition in this vicinity. Resistance data indicate that such impurities as C, $N_2$, and $O_2$ raise the transformation temperature. (auth)

URANIUM AND THORIUM. L. Grainger. London, George Newnes Limited, 1958. 209p.

The technology of uranium and thorium from their occurrence and extraction, through their chemical and physical properties, to their uses in the atomic energy industry is described. (W.L.H.)

**11171** IGR-R/R-303
United Kingdom Atomic Energy Authority. Industrial Group H. Q., Risley, Lancs, England.
THORIUM DATA MANUAL. E. L. Francis, comp. 1958. 29p. $1.33(BIS).

This manual is a compilation of data on the physical, mechanical, chemical, and irradiation properties of Th. (W.L.H.)

**1429**
THORIUM. ITS PROPERTIES AND CHARACTERISTICS. I. P. Bell (Culcheth Labs., U.K.A.E.A.I.G.). Nuclear Eng. 2, 418-22(1957) Oct.

The physical, mechanical, and chemical properties of Th are presented. Also its compatibility with other materials is considered. (W.L.H.)

# THORIUM 1.39

## OTHER REACTIONS AND PROPERTIES 1.39.04

### FLUORIDES 1.39.04.04

**8722**

THE PREPARATION OF THORIUM OXIDE AND THORIUM FLUORIDE FROM THORIUM NITRATE. Ray W. Fisher (Iowa State Coll., Ames). pp. 149-54 in "Progress in Nuclear Energy. Series III. Process Chemistry. Volume 2."

Methods are reviewed for converting thorium nitrate to purified thorium fluoride. The nitrate is converted to an oxalate by precipitation from an aqueous acid solution. The oxalate is ignited to thorium oxide and the oxide reacted with anhydrous hydrogen fluoride to yield the fluoride. Specific process conditions are given for each step. Alternative less-favored methods are also discussed. (auth)

**4389**

PREPARATION OF URANIUM AND THORIUM TETRAFLUORIDES. A. Cacciari, R. De Leone, C. Fizzotti, and M. Gabaglio (CISE laboratories, Milano). Energia nucleare (Milan) 3, 462-70(1956) Dec.

Less conventional processes for preparation of anhydrous $UF_4$ and $ThF_4$ are described. Difluorodichloromethane was used as the fluorinating agent both for $UO_2$ and $ThO_2$. Flow sheets and pilot plants for this process are shown. Thorium fluoride can also be produced by a wet process with ammonium fluoride or bifluoride and subsequent transformation into the anhydrous salt with a difluorodichloromethane atmosphere. (auth)

**12666** NAA-SR-1925

Atomics International Div., North American Aviation, Inc., Canoga Park, Calif.

BASIC CHEMISTRY OF HIGH TEMPERATURE INORGANIC SYSTEMS. Semiannual Progress Report [for] July–December 1956. S. J. Yosim and T. A. Milne. July 15, 1957. 49p. Contract AT-11-1-GEN-8. $0.45(OTS).

The vapor pressure determination of solid $ThF_4$ has been completed. The corrected vapor pressure of solid $ThF_4$ from 1055 to 1297°K is: Log P(atm) = – 16,860/T°K + 9.107. Experiments to determine the heat of formation of $ThF_4$ by studying the reaction of $ThF_4$ with $SiO_2$ are described. A kinetic study of the thermal decomposition of $Th(NO_3)_4$ has been initiated. The results of the $Bi-BiCl_3$ solubility experiments indicate the possibility that the consolute temperature exists at about 775°C. The solubility of Cd in $CdCl_2$ increases with increasing temperature to a value of 24 mole per cent at 963°C. The solubility studies of $Hg-Hg_2Cl_2$ are also under way. Vapor pressure experiments on bismuth trichloride dissolved in bismuth indicated large positive deviations from Raoult's law. Two series of cryoscopic experiments are described: one in which $HgCl_2$ is the solvent, and one in which molten Bi is the solvent. In order to gain information on the species in molten salts, a study of the transport number in fused salts has begun. A new program has been initiated to examine the nature of ceramics at high temperatures. Knudsen and Langmuir vaporization studies are under way on $La_2O_3$, BeO, and ZrC. The electron density distribution of BeO is being determined by three-dimensional x-ray-diffraction measurements. Also, an experimental program is under way to seek principles to guide the search for new and superior refractories. (For preceding period see NAA-SR-1797.) (auth)

### OXIDES 1.39.04.05

**51** AERE-R/R-2578

United Kingdom Atomic Energy Authority. Research Group. Atomic Energy Research Establishment, Harwell, Berks, England.

THE THERMAL CONDUCTIVITY OF AQUEOUS THORIA SUSPENSIONS. F. A. Johnson. June 1958. 31p. $0.81(BIS).

Experiments were carried out to determine the thermal conductivity of suspensions of thoria in ordinary water at temperatures in the range 0 to 100°C and at concentrations between 0 and 20% by volume. Three other systems, of similar concentration, were also investigated at 30°C. On the basis of these measurements and on similar work by other investigators, expressions are suggested for the calculation of slurry conductivity from the conductivities of the constituent substances together with the volume concentration of solids. (auth)

**4427**

PROPERTIES OF THORIUM OXIDE CERAMICS. C. E. Curtis and J. R. Johnson (Oak Ridge National Lab., Tenn.). J. Am. Ceram. Soc. 40, 63-8(1957) Feb.

Data are included concerning the strength, density, and porosity that may be expected of thoria ceramics formed by dry-pressing and isostatic pressing and fired at 1400, 1600, and 1800°C. (W.L.H.)

**5669**

THE EFFECT OF NEUTRON IRRADIATION ON THE SURFACE ELECTRICAL PROPERTIES OF THORIA. D. J. O'Connor (Atomic Energy Research Establishment, Harwell, Didcot, Berks.). Chem. Indust. No. 45, 1348-50(1956) Nov.

# THORIUM 1.39

## OTHER REACTIONS AND PROPERTIES 1.39.04

### OXIDES 1.39.04.05

**6190** AECU-4612
Utah. Univ., Salt Lake City. Inst. of Metals and Explosives Research.
THE SURFACE CHEMISTRY OF THORIA. Progress Report [for] February 1, 1959 to January 31, 1960. Harold R. Bradford, Chong S. Cho, Charles H. Hausenfleck, Ralph M. Horton, Frederic Megerth, David A. Reese, Russell A. Schalow, Lowell G. Tensmeyer, and Milton E. Wadsworth. Jan. 1, 1960. 9p. For [Oak Ridge National Lab.]. Contract W-7405-eng-26, Subcontract No. 1075. OTS.

The use of chloroplatinic acid to platinize the thoria surface produced a much more active catalyst than did the metal. The addition of colloidal silica in excess of 0.42 g per g thoria produced an apparently stable catalyst as did thoria with a platinum surface coverage of 0.34 g (no silica present). The effects of slurrying, refiring, and oxygen–hydrogen pretreatment are reported. The surface adsorption and reactivity of the oxides of Cr and Mo and $Na_2SO_4$ with thoria under hydrothermal conditions are reported. Chromium oxide shows no reactivity up to 48 hrs and 290°C. Molybdenum oxide shows no reaction up to 24 hrs, while between 24 and 48 hrs at 290°C extremely slow reaction takes place. Surface adsorption of sulfates takes place up to 290°C. Infrared studies indicate the adsorbed species on the surface as the bisulfate ion. The preparation of thoria for infrared studies on the surface adsorption of hydroxyl groups is described. The kinetics of silica transfer from colloidal silica to the thoria surface are discussed. (For preceding period see AECU-4345.) (C.J.G.)

**11727** CF-56-2-110
Oak Ridge National Lab., Tenn.
COMPARISON OF VARIOUS THORIUM OXIDES. R. B. Gallaher and A. S. Kitzes. Feb. 6, 1956. Decl. Mar. 16, 1957. 8p. Contract [W-7405-eng-26]. $1.80(ph OTS); $1.80(mf OTS)

The effect of pumping on the properties of $ThO_2$ slurries was investigated. Properties evaluated include particle degradation, the thermal stability of crystallites, corrosive and abrasive effects on stainless steel, and general handling characteristics. (C.H.)

**10837** CF-56-1-109
Oak Ridge National Lab., Tenn.
ADSORPTION OF $H_2O$ BY $ThO_2$ AT HIGH TEMPERATURES. D. M. Richardson. Jan. 20, 1956. 10p. Contract [W-7405-eng-26]. $1.80(ph OTS); $1.80(mf OTS).

Adsorption studies were made to determine the existence of a stable hydrate of $ThO_2$. The classical volumetric method was chosen for the studies. Resulting adsorption data are shown graphically. (B.J.H.)

**12411** TID-7521(Pt. 1(Del.)(p.3-12))
[Sylvania Electric Products Inc., Bayside, N. Y.]
DIRECT REDUCTION OF THORIUM OXIDE. R. B. Holden and N. Fuhrman. p.3-11 [of] PAPERS FOR THORIUM–URANIUM-233 INFORMATION MEETING HELD AT WILMINGTON, AUGUST 3, 1955. 10p.

A brief review of the status of the production of thorium powder from thorium oxide by calcium reduction is presented. The process is now conducted routinely on a scale which produces seven to eight pounds of powder per reduction. (W.L.H.)

**8823** LA-1934
Los Alamos Scientific Lab., N. Mex.
THE PREPARATION OF HIGH-PURITY THORIUM OXIDE. Robert N. Roberts. July 1955. 22p. Contract W-7405-eng-36. $0.25(OTS).

Thorium oxide prepared by the method described has the requisite quality—purity, homogeneity, and reproducibility—for use as the matrix material of spectrochemical standards. The method has been developed and tested to the point where it is considered a reliable routine operation. Essentially, the method consists of the purification of aqueous solutions of thorium salts of the best grade available by more or less standard precipitation techniques, the thorium being retained in solution where necessary through the formation of a soluble complex. Thorium is recovered as the pure oxalate by a double precipitation from homogeneous solution. The final step, the ignition of the oxalate to the oxide, is concerned primarily with preventing the addition of impurities rather than with effecting further purification. (auth)

**2668** CF-55-8-87
Oak Ridge National Lab., Tenn.
AN ESTIMATE OF THE HEAT PRODUCTION RATE IN THE THORIUM OXIDE SLURRY BLANKET OF THE HRT. D. G. Thomas. Aug. 5, 1955. Decl. Apr. 13, 1956. 8p. Contract W-7405-eng-26. $1.80(ph OTS); $1.80(mf OTS).

# THORIUM 1.39

## OTHER REACTIONS AND PROPERTIES 1.39.04

### OXIDES 1.39.04.05

Union Carbide Nuclear Co. Y-12 Plant, Oak Ridge, Tenn. LITERATURE SEARCH ON SELECTED PROPERTIES OF THORIUM OXIDE. Francis Sachs. Feb. 22, 1952. Decl. with deletions July 29, 1952. 21p. (AECD-3423; Y-847).

This bibliography contains 42 selected references on the preparation, dissolution, precipitants, and radiation effects on $ThO_2$.

**2896** AERE-C/M-224

Gt. Brit. Atomic Energy Research Establishment, Harwell, Berks, England.

PRELIMINARY INVESTIGATIONS IN THORIA SLURRIES. J. K. Dawson, K. Alcock, and A. R. Chilton. Oct. 24, 1954. 11p. (RCTC/P-30).

The preparations of $ThO_2$ and $ThO_2$ slurries and their properties are discussed. (T.R.H.)

# TIN 1.40

**4746**

4

DECAY OF $Sn^{125}$ (9.7-DAY AND 9.4-MINUTE). S. B. Burson, J. M. LeBlanc, and D. W. Martin (Argonne National Lab., Lemont, Ill.). Phys. Rev. 105, 625-33 (1957) Jan. 15.

The $\beta$ and $\gamma$ radiations of the 9.7-day and 9.4-minute radioactive decays of $Sn^{125}$ have been studied by scintillation methods using multichannel coincidence spectrometers. Sources were prepared by thermal-neutron irradiation of metallic tin foil enriched in $Sn^{124}$, followed by chemical purification. In the 9.7-day activity, seven $\gamma$ rays of energies 0.342, 0.468, 0.811, 0.904, 1.068, 1.41, and 1.97 Mev are observed. Their intensities, expressed in percent of the total decay to excited states, are 9, 10, 20, 18, 73, 3, and 24 respectively. The presence of four $\beta$-ray components is deduced; their energies are 2.35, 1.28, 0.47, and 0.38 Mev, with log ft values of 8.9, 9.8, 7.9, and 7.7 respectively. There is a possible weak fifth component of 0.94 Mev with log ft about 10.4. The coincidence data define a decay scheme involving excited states in $Sb^{125}$ at 1.07, 1.41, 1.88, and 1.97 Mev, with the strong (~95%) 2.35-Mev $\beta$ ray proceeding directly to the ground state. All these excited states surely have spins of at least $^9/_2$, and all probably have positive parity. In the 9.4-minute decay, four $\gamma$ rays of 0.326, 0.64, 1.07, and 1.39 Mev are observed. Their intensities, expressed in percent of the total decay, are 99.7, 0.3, 0.3, and 1.9 respectively. The first and last are coincident, and define an excited level at 1.72 Mev. The principal $\beta$ component of 2.05 Mev proceeds to the intermediate level at 0.326 Mev. The $\beta$ component to the 1.72-Mev level has therefore an energy of 0.66 Mev and log ft of 5.8, so the level has a low spin and probably positive parity. The two weak $\gamma$ rays are also found to be in coincidence, with an energy sum of 1.72 Mev. The intermediate state of this cascade could be at either 1.07 or 0.64 Mev. Since it must be of fairly low spin, it apparently cannot be identical with the 1.07-Mev level observed in the 9.7-day decay. (auth)

**17573**

GAMMA RADIATION FROM THE DECAY OF $^{113}Sn$. R. K. Girgis and R. Van Lieshout (Instituut voor kernphysisch Onderzoek, Amsterdam). Physica 24, 672-82 (1958) Aug.

The gamma radiation accompanying the decay of 118 day $Sn^{113}$ was studied with scintillation detectors, using kicksorters. The relative intensities of the 393 kev and the 257 kev gamma ray were found to be 100 : (3.0 ± 0.3). Chemical separations show that the 257 kev radiation belongs to $Sn^{113}$ and not to its 1.75 hour $In^{113}$ daughter. There is some evidence for a weak transition of 605 ± 10 kev. Remarks about the decay scheme are added. (auth)

**72**

THE HYDROLYSIS OF TIN(IV) IN SULFURIC ACID. C. H. Brubaker, Jr. (Michigan State Coll., East Lansing). J. Am. Chem. Soc. 77, 5265-8(1955) Oct. 20.

The hydrolysis of $Sn^{4+}$ in dilute $H_2SO_4$ solutions was studied by the technique of diluting stable acid solutions until solid, hydrous stannic oxide formed in equilibrium with the solution. When reasonable estimates of activity coefficients are taken into account the data demand that the species present in the solutions be sulfato tin(IV) sulfate, $(SnSO_4)(SO_4)$, in contrast to the $Sn^{4+}$ ion which is indicated on the basis of concentration equilibrium considerations. The data indicate that the following takes place: $SnO_2(aq.) + 2H_2SO_4 \overset{K}{=} (SnSO_4)^{++} + (SO_4)^{=} + 2H_2O$. Taking into account the best estimates of the mean activity coefficients which are available, we find, at 30°, $K = 5 \times 10^{-2}$ and, at 18°, $K = 2.8 \times 10^{-2}$. (auth)

# TIN 1.40

A STUDY OF THE KINETICS OF THE REACTION BETWEEN TIN(II) AND CERIUM(IV) IN AQUEOUS SULFURIC ACID SOLUTIONS. Carl H. Brubaker, Jr. and Anita Jeanne Court (Michigan State Univ. of Agriculture and Applied Science, East Lansing). J. Am. Chem. Soc. 78, 5530-3(1956) Nov. 5.

The kinetics of the reaction between tin($2^+$) and cerium($4^+$) in aqueous $H_2SO_4$ was studied in the temperature range from 0 to 25°. Three types of reaction were observed corresponding to low sulfate ion and Sn($4^+$) concentration, high sulfate ion and Sn($4^+$) concentrations, and the presence of colloidal Sn($4^+$) in the solutions. Only the first type seems subject to interpretation and appears to represent the stepwise oxidation of Sn($2^+$) by the tris-sulfatocerate(IV) ion. (auth)

THE HALF LIFE OF $Sn^{127}$. H. Carminatti, I. Fraenz, R. Radicella, and J. Rodriguez (Comisión Nacional de la Energía Atómica, Buenos Aires). Z. Naturforsch. 11a, 119-20(1956) May. (In German)

# TITANIUM 1.41

See also, under PLANTS AND EQUIPMENT,

MATERIALS (CONSTRUCTION) Titanium (5.14.09)

## CHEMISTRY 1.41.01

**5756** AD-107820
Baylor Univ., Waco, Tex.
THE ELECTROCHEMISTRY OF LOW VALENCES OF TITANIUM. Quarterly Progress Report for June 1, 1956 to September 1, 1956. Thomas C. Franklin, Haig Verne Seklemian, and Ronald Poe. Sept. 1, 1956. 28p. Contract AF 33(616)-3331.

Experiments with titanium in organic solvents are described. Divalent Ti has not been demonstrated, but current-voltage curves for Ti dissolution in several organic solvents were obtained. A gas-phase synthesis of $Ti^{2+}$ shows promise. (T.R.H.)

Argonne National Lab., Lemont, Ill.
THE FLUORINATION OF METALLIC TITANIUM. M. J. Steindler, D. V. Steidl, and R. K. Steunenberg. June 1959. 6p. Contract W-31-109-eng-38. $0.50 (OTS).

Metallic titanium was fluorinated by elemental fluorine at 100, 200, and 300°C and at partial pressures of fluorine of 0.25, 0.50, 0.75, and 1.0 atmosphere. The effect of flow rates was studied briefly. The activation energy for the reaction is approximately 25.6 kcal/mole. (auth)

**5204**
SEPARATION AND DETERMINATION OF TITANIUM IN STAINLESS STEELS. M. N. Nadkarni, G. G. Nair, and Ch. Venkateswarlu (Atomic Energy Establishment, Bombay). Anal. Chim. Acta 21, 511-14(1959) Dec. (In English)

Titanium is separated from titanium-bearing stainless steels by coprecipitation with zirconium as phosphate from 2 to 3 N acid solutions after removal of iron by ether extraction. It is spectrophotometrically determined by the hydrogen peroxide method in the presence of oxalic acid, with an accuracy better than ±0.02%. V, Fe, Cr, Ni, Al, Cu, Mo, W, Nb, and Ta do not interfere. (auth)

**13735**
REACTIONS OF TITANIUM WITH ELEMENTS OF PERIODIC SYSTEM. I. I. Kornilov. Zhur. Neorg. Khim. 3, 360-5(1958) Feb. (In Russian)

Chemical interactions of titanium were divided into four groups: the elements which do not react with titanium, such as Ba, Ca, Cs, Fr, K, Li, Mg, Na, Ra, Rb, and Sr, and inert gases Ar, Kr, Ne, Rn and Xe; the elements which form chemical complexes with ionic and covalent bonds, such as At, Br, Cl, F, I, O, Po, S, Se, and Te; the elements which form metallic bond complexes and limited solid solutions, such as Ag, Al, As, Au, B, Be, Bi, C, Cd, Co, Cu, Fe, Ga, Ge, H, Hg, In, Ir, Mn, N, Ni, Os, P, Pb, Pd, Pt, Re, Rh, Ru, Sb, Si, Sn, Tc, Tl, W, and Zr; and the elements which form continuous solid solutions in β phase, such as Cr, Hf, Mo, Nb, Sc, Ta, V, U, and Zr. (R.V.J.)

# TITANIUM 1.41

## CHEMISTRY 1.41.01

**16968**

**AN X-RAY STUDY OF TITANIUM TRIBROMIDE. Robert F. Rolsten and Harry H. Sisler (Ohio State Univ., Columbus). J. Phys. Chem. 62, 1024(1958) Aug.**

**That titanium tribromide crystallizes in two forms, platelet and needle. Only the platelet form was considered in detail. Preliminary work with the needle form indicates the crystal to be hexagonal although different from the platelet form. The x-ray diffraction data for the platelet form of $TiBr_3$ can be indexed with the unit rhombohedral cell being $a_0 = 7.26_3$ A and alpha = 52°48′. An x-ray density of 4.24 g $cc^{-1}$ was calculated with two formula weights per unit cell. The space group is $C_{3i}^2-R_3$ and the structure is a layer lattice. The powder diffraction patterns for platelet $TiCl_3$ and platelet $TiBr_3$ have been compared. The observed spacings for the two compounds are slightly different as evidenced from the reported cell constants. Even so, the two compounds can be considered to be isostructural, since the spacings with corresponding Miller indices are in excellent intensity accordance. (auth)**

EXTRACTION OF CUPFERRONATES OF NIOBIUM, TANTALUM, AND TITANIUM. I. P. Alimarin and I. M. Gibalo (Lomonosov Moscow State Univ.). Doklady Akad. Nauk. S.S.S.R. 109, 1137-9(1956) Aug. 21. (In Russian)

A method is offered for segregation of Ti from materials containing Nb, Ta, and Ti. A satisfactory result was obtained of Ti segregation from the solution of $Nb_2O_5 + Ta_2O_5$, with various ratios of Ti, by extraction of cupferronates with the isoamyl alcohol pH5. The segregation was checked by $H_2O_2$ and by radioactive isotopes $Nb^{95}$ and $Ta^{182}$ with activity of 2000 to 3000 imp/min per 1 ml. (R.V.J.)

STUDIES OF CHLORINATION REACTIONS OF TITANIUM OXIDE. A. N. Zelikman and T. Segarchanu. (Moscow Inst. of Non Ferrous Metals and Gold). Zhur. Obshchei Khim. 26, 625-9(1956) Mar. (In Russian)

It is shown that in contrast to the $TiO_2$ reaction, the TiO chlorinates with considerable speed at 300° temperature, and at 400 to 700° the chlorination maximum reaches 50%. The chlorination reaction is as follows: $2TiO + 2\ Cl_2 = TiCl + TiO_2$. In presence of carbon at 500°, TiO chlorinates much faster than $TiO_2$ under the same conditions. (R.V.J.)

**5299** WADC-TR-58-349
Baylor Univ., Waco, Tex.
THE CHEMISTRY OF THE LOWER VALENCES OF TITANIUM. Thomas C. Franklin and Haig Verne Seklemian. Aug. 1958. 63p. Contract AF33(616)-3331. (AD-155694).

A study was conducted to identify and characterize the lower valence states of titanium (normally tetravalent), with a particular view to establishing whether divalent compounds do in fact have stable existence. Several methods for the preparation of divalent titanium were investigated: disproportionation of titanium tetrabromide, reduction of titanium tetrachloride, dissolution of the metal in aqueous and anhydrous acids, and the anodic dissolution of the acid in various nonaqueous solvents. These techniques failed to produce identifiable quantities of divalent compounds. Solubility and reaction studies were made by extracting commercial "titanium dichloride" with a number of typical solvents. This substance is insoluble in nonpolar liquids; in polar solvents, or those containing labile hydrogen atoms, slow reactions appear to accompany dissolution. With water, reaction is immediate and hydrogen is evolved. Absorption spectra of these solutions give peaks characteristic of tri- and tetravalent titanium. No other peaks are observed. It is concluded that divalent titanium does not exist to any appreciable extent in solution, and that much of the literature on alleged divalent compounds is probably describing a corresponding trivalent substance. Electrochemical experiments, using both dissolution and deposition techniques, confirm the observation that the lowest stable valence of titanium in solution is three. Divalent titanium appears to be so powerful a reducing agent that oxidation by ordinary solvents proceeds preferentially to any further electrochemical reduction, defeating attempts to plate the metal from media other than fused salts. The thin black deposits obtained in electroplating experiments from a variety of solvents (presumed to be titanium metal by some previous workers) are not elemental titanium, as established by x-ray diffraction and by chemical tests; the exact composition is undetermined and is probably variable. (auth)

# TITANIUM 1.41

## CHEMISTRY 1.41.01

THE STANDARD POTENTIAL OF TITANIUM. Shun-ichi Satoh and Koshin Yamane. J. Sci. Research Inst. (Tokyo) 50, 43-50(1956) Mar.

The theoretical value of the standard potential of Ti is 1.30 v; an experimental value obtained for the standard potential of Ti in $Ti_2(SO_4)_3$ solution is 0.355 v. The discrepancy between the calculated and observed values is attributed to the irreversible nature of the Ti electrode. The calculated value is accepted as the standard potential. (C.W.H.)

**2014**

PREPARATION OF TITANIUM TETRACHLORIDE OF HIGH PURITY. W. Stanley Clabaugh, Robert T. Leslie, and Raleigh Gilchrist. J. Research Natl. Bur. Standards 55, 261-4(1955) Nov.

A procedure is described for the preparation of $TiCl_4$ of high purity. Procedures are also given for determining the purity of $TiCl_4$ by cryoscopic, spectrochemical, and infrared absorption measurements. The triple-point temperature of pure $TiCl_4$ was found to be 249.045°K, with an estimated uncertainty of ±0.010°K. (auth)

**603**

PRODUCTION AND PURIFICATION OF $TiCl_4$. L. W. Rowe and W. R. Opie (National Lead Co., South Amboy, N. J.). J. Metals 7, 1189-93(1955) Nov.

A brief history of $TiCl_4$ production and purification is given. Chlorinator feed materials for the production of $TiCl_4$ are classified. The thermodynamics and kinetics of $TiCl_4$ production by chlorination of $TiO_2$ are discussed. Problems encountered in the chlorination and purification steps are outlined in detail. (auth)

**4527**

STRUCTURAL ASPECTS OF THE HYDROLYSIS OF TITANIUM TETRAETHOXIDE. D. C. Bradley, R. Gaze, and W. Wardlaw (Birkbeck Coll., London). J. Chem. Soc. 3977-82(1955) Nov.

The hydrolysis of titanium tetraethoxide in $C_2H_5OH$ has been studied by an ebulliometric technique. The molecular complexities of the titanium oxide ethoxides produced by hydrolysis have been explained in terms of a structural theory based on the assumption that titanium exhibits the coordination number 6 in these compounds. (auth)

**1311**

ON OXIDES OF TITANIUM. N. P. Bogoroditskiĭ, I. E. Zelenkova, V. G. Prokhvatilov, and I. D. Fridberg. Doklady Akad. Nauk S.S.S.R. 104, 543-5(1955) Oct. 1. (In Russian)

Experiments were set up to determine the possible synthesis of sphene-type combination for the silicotitanates $MeO-SiO_2-TiO_2$, and for the aluminotitanates of Mendeleev's second group elements $MeO-Al_2O_3-TiO_2$, where Me = Ca, Ba, Mg, Fe, Na, Ni and Zn. (R.V.J.)

**13005**

STUDIES ON THE LOWER OXIDES OF TITANIUM. A. David Pearson (Massachusetts Inst. of Tech., Cambridge). Phys. and Chem. Solids 5, 316-27(1958).

Pure TiO is face-centered cubic above ~950°C. The structure of samples annealed below this temperature is complex, consisting of two or possibly three phases not in equilibrium. Impurities and excess of oxygen stabilize the face-centered cubic form at room temperature. The electrical resistivity of TiO (prepared by melting) is $2.81 \times 10^{-4}$ Ω cm at room temperature, and increases with temperature between −162 and 362°C. The thermoelectric emf of TiO is of the same order of magnitude as that of metals. The measured density is less than the x-ray density, indicating that 14.6% of the lattice positions are unoccupied. The properties suggest that the TiO-phase oxides may be considered solid solutions of oxygen in titanium. X-ray investigations indicate that $Ti_3O_4$ probably does not exist. The trigonal unit cell of $Ti_2O_3$ between room temperature and 350°C is confirmed. The lattice parameters change rapidly between 160 and 200°C, corresponding to the rapid increase in magnetic susceptibility. $Ti_2O_3$ is antiferromagnetic; $\chi_m = 1.09 \times 10^{-6}$ cgs units at 20°C. The thermal activation energy of electrical conduction of $Ti_2O_3$ in the room-temperature region is about half of the observed optical activation energy. The material is p-type semiconductor at room temperature. (auth)

## METALLURGY 1.41.02

Knolls Atomic Power Lab., Schenectady, N. Y.
TITANIUM-BORON SYSTEMS: A LITERATURE SURVEY. Janet M. Cisar. Aug. 15, 1955. 22p. Contract W-31-109-Eng-52. (KAPL-M-JMC-2).

Extracts from 5 reports dealing with the effect of boron addition to titanium and titanium alloys are given. 26 additional annotated references are included.

# TITANIUM 1.41

## METALLURGY 1.41.02

**190** DMIC-Memo-1
Battelle Memorial Inst. Defense Metals Information Center, Columbus, Ohio.
THERMAL PROPERTIES OF TITANIUM AND TITANIUM ALLOYS. J. W. Holladay. Aug. 25, 1958. 23p.
Available data from the files of the Defense Metals Information Center on the thermal properties of titanium and titanium alloys are presented. The properties covered are thermal conductivity, thermal expansion, heat capacity, thermal diffusivity, and emissivity. Methods are given for estimating values for these properties when experimental data are not available. (auth)

**2709**
PASSIVITY OF TITANIUM IN HYDROCHLORIC ACID SOLUTION. Rikuro Ōtsuka. J. Sci. Research Inst. (Tokyo) 51, 73-4(1957) June.
Titanium hydride formed on the surface of titanium in hydrochloric acid solution shows passivation. Protecting effect of the hydride against the acid is due to its passivity. (auth)

**8958**
TWIN INTERSECTIONS IN TITANIUM. F. D. Rosi (RCA Labs., Princeton, N. J.). Acta Met. 5, 337-9(1957) June.

**3159**
RADIOACTIVITY OF $Ti^{44}$. J. R. Huizenga and J. Wing (Argonne National Lab., Lemont, Ill.). Phys. Rev. 106, 90-2(1957) Apr. 1.
$Ti^{44}$ has been produced by the $Sc^{45}(d,3n)Ti^{44}$ reaction. The radiations of $Ti^{44}$ were studied with gamma-scintillation spectrometers alone and in coincidence. A decay scheme is suggested in which $Ti^{44}$ electron captures predominantly to a 144-kev level in $Sc^{44}$ which in turn de-excites by two gamma rays in cascade. A $Ti^{44}$ half life of approximately $10^3$ years is deduced. (auth)

**1883** TML-39(Suppl.)
Battelle Memorial Inst. Titanium Metallurgical Lab., Columbus, Ohio.
PHYSICAL-PROPERTY DATA FOR TITANIUM AND TITANIUM ALLOYS. Nov. 16, 1956. 11p. Contract [AF 18(600)-1375].
A literature survey of the physical properties of Ti and Ti alloys is presented. (J.E.D.)

**2741**
STATUS OF TITANIUM FABRICATION AND USE. J. H. Garrett (U. S. Dept. of Defense, Washington, D. C.). J. Metals 8, 30-5(1956) Jan.

ON THE PREPARATION OF CERMETS WITH CrB, $TiB_2$, AND WB. I. I. Iskol'dskiĭ and L. P. Bogorodskaya. Zhur. Priklad. Khim. 30, 177-85(1957) Feb. (In Russian)
Experiments to produce cermets with CrB, $TiB_2$, and WB cemented by Co, Ni, or Fe showed negative results; the attempts to prove that CrB and $TiB_2$ chemically combine and form solid solutions with W carbides and W borides, also, were unsuccessful. However, it has been revealed that Fe, Ni, Co, and W combine with the borides of metals and form a new triple boron-metal system. The system CrB-Fe, CrB-Ni, CrB-Co, CrB-W and the $TiB_2$-Fe, $TiB_2$-Ni, $TiB_2$-Co, and $TiB_2$-W were studied and new phases observed. (R.V.J.)

**5783**
DETERMINATION OF TITANIUM IN PLUTONIUM-TITANIUM ALLOYS. Karl S. Bergstresser (Los Alamos Scientific Lab., N. Mex.). Anal. Chem. 29, 532-4(1957) April.
Titanium in Pu-Ti alloys can be determined by adding $H_2O_2$ to a perchloric acid solution of the sample. A colored solution with Ti and a precipitate of Pu are formed simultaneously. The insoluble plutonium peroxide is removed by centrifuging before the titanium peroxy complex is measured colorimetrically. The method is applicable from 0.1 to 1.0% titanium. A standard deviation of 2 $\gamma$ is observed for samples containing from 50 to 500 $\gamma$ of Ti and 50 mg. of Pu. Thorium does not interfere, but U and Nb do. (auth)

**2738**
PHYSICAL AND X-RAY STUDY OF THE DISILICIDES OF TITANIUM, ZIRCONIUM, AND HAFNIUM. Perry G. Cotter, J. A. Kohn, and R. A. Potter (Bureau of Mines, Norris, Tenn.). J. Am. Ceram. Soc. 39, 11-12(1956) Jan.
A method of preparing the disilicides of titanium, zirconium, and hafnium is outlined. Unit-cell dimensions, density, Knoop microhardness numbers, chemical analyses, and solubility in various reagents are given for the three compounds. It is concluded that these disilicides have no value as industrial hard materials. (auth)

**2740**
THE PRESENT STATUS OF TITANIUM DEVELOPMENT. D. J. McPherson (Armour Research Foundation, Chicago). J. Metals 8, 23-30(1956) Jan.
A general discussion of the status of Ti development is presented covering the alloy development, heat treatment, production quality, large scale handling and processing and sponge preparation. (J.E.D.)

# TITANIUM 1.41

## METALLURGY 1.41.02

**2729** TML-27
Battelle Memorial Inst., Columbus, Ohio. Titanium Metallurgical Lab.
EFFECT OF HYDROGEN ON THE PROPERTIES OF TITANIUM AND TITANIUM ALLOYS. G. A. Lenning and R. I. Jaffee. Dec. 27, 1955. 111p. Contract AF 18(600)-1375.

The effect of hydrogen on mechanical properties of titanium materials is somewhat unique in that two fundamentally different types of embrittlement have been observed. The first type of embrittlement has been shown to be a classical transition behavior in which the precipitation of the brittle hydride phase increases the sensitivity to high testing speeds and notches. The second type of embrittlement has been shown to occur through a strain-aging mechanism. This embrittlement becomes most severe at slow testing speeds and low temperatures. (auth)

**5342** NYO-7257
Carnegie Inst. of Tech., Pittsburgh. Lab. for Magnetics Research.
RESEARCH ON PROPERTIES OF RARE METALS. Final Report. J. E. Goldman. SUPPLEMENT I. THE HALL EFFECT IN TITANIUM, VANADIUM, CHROMIUM AND MANGANESE. Simon Foner. SUPPLEMENT 2. THE HALL EFFECT IN ZIRCONIUM AND HAFNIUM. Simon Foner. SUPPLEMENT 3. DEVELOPMENT OF CALORIMETRIC TECHNIQUES LEADING TO MEASUREMENTS ON ZIRCONIUM. George L. Guthrie. Aug. 31, 1956. 37p. Contract AT(30-1)-1596. $0.30(OTS).

The Hall effect in Ti, V, Cr and Mn was measured at room temperature with fields up to 30 kilo-oersteds. The Hall constant was positive for all of these elements. The effect is extremely small in Ti and apparently sensitive to small amounts of impurities. The results for these transition elements indicate that electrical conduction is predominantly due to hole conduction. Measurements of the Hall effect in Zr and Hf at room temperature show that the Hall constants are $+ 12.6 \times 10^{-13}$ v-cm/amp-gauss and $- 0.16 \times 10^{-13}$ v-cm/amp-gauss, respectively. The results indicate that there is an appreciable contribution of hole conduction to the electrical conductivity. (auth)

**2728** TML-25
Battelle Memorial Inst. Titanium Metallurgical Lab., Columbus, Ohio.
BETA TRANSFORMATION IN TITANIUM ALLOYS. F. C. Holden and R. I. Jaffee. Dec. 5, 1955. 137p. Contract AF-18(600)-1375.

A survey has been made of the literature on the four types of beta transformation encountered in alpha-beta Ti alloys. The present state of knowledge regarding the mechanism and reaction kinetics of these transformations has been summarized in the text and a considerable amount of experimental data are included in the appendixes. The relationships existing between these transformations and the problems of heat treatment and thermal stability of Ti alloys are discussed. (auth)

**1753**
THE LANTHANUM-TITANIUM-OXYGEN SYSTEM. Michael Kestigian and Roland Ward (Univ. of Connecticut, Storrs). J. Am. Chem. Soc. 77, 6199-6200(1955) Dec. 5.

The preparation and crystal structure of the lanthanum titanium oxide, $La_{(\frac{2}{3}+x)}TiO_3$, where x has values from 0 to $\frac{1}{3}$, are described. The oxide has a deformed Perovskite structure and is analogous to the sodium tungsten bronzes. (C.W.H.)

Refer also to abstracts 1745 and 1755.

**1389** TML-21
Battelle Memorial Inst. Titanium Metallurgical Lab., Columbus, Ohio.
THE DIFFUSION OF INTERSTITIAL AND SUBSTITUTIONAL ELEMENTS IN TITANIUM. J. E. Reynolds and R. I. Jaffee. Oct. 24, 1955. 22p. Contract AF18(600)-1375.

The self-diffusion of titanium has not been determined, but the activation energy for this process has been estimated to be 77,000 cal/mol. Diffusion data are available for carbon, oxygen, nitrogen, and hydrogen in alpha titanium and beta titanium. Additional interstitial diffusion data have been obtained in an air-contamination study of three commercial titanium alloys. Data on substitutional diffusion are meager, but some information is available on chromium, molybdenum, iron, and zirconium diffusion in titanium. Lack of systematic studies in this category may severely limit progress in the interpretation of solid-state reactions in titanium alloy development. The theoretical and practical uses of diffusion data in general are reviewed. (auth)

# TITANIUM 1.41

## METALLURGY 1.41.02

**1388** TML-20

Battelle Memorial Inst. Titanium Metallurgical Lab., Columbus, Ohio.

THE EFFECTS OF CARBON, OXYGEN, AND NITROGEN ON THE MECHANICAL PROPERTIES OF TITANIUM AND TITANIUM ALLOYS. H. R. Ogden and R. I. Jaffee. Oct. 19, 1955. 99p. Contract AF18(600)-1375.

The effects of the alpha solute interstitials C, O, and N on the mechanical properties of titanium alloys are reviewed. These interstitial elements strengthen titanium, although this effect is lost at elevated temperatures. At room temperatures the interstitials have little effect on tensile ductility, but at subzero temperatures they promote embrittlement. They also have a deleterious effect on toughness, notch sensitivity, weld ductility, machinability, and bend ductility. The strengthening effect of either individual or combined interstitials can be grouped in terms of an oxygen equivalent. It has been found that 0.1% nitrogen is approximately equivalent to 0.2% oxygen or 0.3% carbon. Thus, the oxygen equivalent becomes oxygen equivalent = $\%O + 2 \times \%N + \frac{2}{3} \times \%C$. The oxygen equivalent is related to hardness as follows: $Bhn = 40 + 310 \sqrt{\text{oxygen equivalent}}$. (auth)

**1374** NP-5825

Air Materiel Command, Wright-Patterson AFB, Ohio and Battelle Memorial Inst. Titanium Metallurgical Lab., Columbus, Ohio.

TITANIUM AND TITANIUM ALLOYS PROGRAMS. Book 1. [1955]. 43p.

**1375** NP-5826

Air Materiel Command, Wright-Patterson AFB, Ohio and Battelle Memorial Inst. Titanium Metallurgical Lab., Columbus, Ohio.

TITANIUM AND TITANIUM ALLOYS PROGRAMS. Book 2. [1955]. 97p.

**1376** NP-5827

Air Materiel Command, Wright-Patterson AFB, Ohio and Battelle Memorial Inst. Titanium Metallurgical Lab., Columbus, Ohio.

TITANIUM AND TITANIUM ALLOYS PROGRAMS. Book 3. [1955]. 80p.

**1387** TML-19

Battelle Memorial Inst. Titanium Metallurgical Lab., Columbus, Ohio.

A GENERAL SUMMARY OF THE PHYSICAL METALLURGY OF TITANIUM ALLOYS. R. I. Jaffee. Oct. 18, 1955. 81p. Contract AF 18(600)-1375.

A short summary of the extensive literature on titanium-alloy physical metallurgy is reported. It covers alloying elements and alloy types, and describes the general effects of interstitials. The mechanical properties of annealed alloys and the dependence of properties on structure are described. The second half of the report is devoted to heat treatment and thermal stability of alpha-beta and beta alloys. A short section on future trends in alloy development is presented. (auth)

**1408**

ULTRAVIOLET MICROSCOPIC INVESTIGATION OF TITANIUM, NIOBIUM, AND CARBON ALLOY STRUCTURES. V. P. Elyutin, M. L. Bernshteĭn, and Yu. A. Pavlov. (Moscow Inst. of Steel). Doklady Akad. Nauk S.S.S.R. 104, 546-8 (1955) Oct. 1. (In Russian)

The structures and properties of titanium–niobium alloy samples, melted in vacuum furnaces of graphite were studied. The content of niobium varied from 1.5 to 88.4%; content of carbon was within 0.7 to 0.9%. The samples were tempered in a vacuum at 1000°C. Ultraviolet microscopic studies determined the phase character of some multicomponent systems occurring in some samples. (R.V.J.)

**1377** NP-5828

Air Materiel Command, Wright-Patterson AFB, Ohio and Battelle Memorial Inst. Titanium Metallurgical Lab., Columbus, Ohio.

TITANIUM AND TITANIUM ALLOYS PROGRAMS. Book 4. [1955]. 129p.

**1378** NP-5829

Air Materiel Command, Wright-Patterson AFB, Ohio and Battelle Memorial Inst. Titanium Metallurgical Lab., Columbus, Ohio.

TITANIUM AND TITANIUM ALLOYS PROGRAMS. Book 5. [1955]. 77p.

# TRANSURANICS (GENERAL) 1.42

THE FIRST ISOLATIONS OF THE TRANSURANIUM ELEMENTS—A HISTORICAL SURVEY. J. C. Wallmann (Univ. of California, Berkeley). J. Chem. Educ. 36, 340-3(1959) July.

The history of the isolation which included purification of the element from contaminants and measurement of the property of the element is given for plutonium, neptunium, americium, curium, berkelium, and californium. (C.J.G.)

**14264** ✓ UCRL-8615

California. Univ., Berkeley. Lawrence Radiation Lab. THE DISCOVERY OF THE TRANSURANIUM ELEMENTS: THEIR HISTORY AND A PRESENTATION OF THE DIFFERENT METHODS USED IN THEIR DISCOVERY. Stanley G. Thompson. Apr. 1959. 23p. Contract W-7405-eng-48. $4.80(ph), $2.70(mf) OTS.

The ten transuranium elements discovered since 1940 are discussed in chronological order. The discoverer, the history, and methods used are given for each element. Future developments in the discovery and preparation of transuranic elements are discussed. (A.C.)

**12477** ✓ UCRL-8683

California. Univ., Berkeley. Lawrence Radiation Lab. RECENT RESEARCH ON TRANSPLUTONIUM ELEMENTS. Stanley G. Thompson. [Mar. 1959]. 18p. Contract W-7405-eng-48. $3.30(ph), $2.40(mf) OTS.

Presented at Mendeleev Chemistry Conference, Moscow, March 1959.

Work which is being done on very heavy elements at the Lawrence Radiation Laboratory is described. The subject matter is presented in three broad classifications including production of isotopes, their chemical properties, and studies of nuclear properties. The elements which are discussed include Bk, Am, Cm, and Cf. (J.R.D.)

RECENT WORK ON THE SYNTHESIS OF ELEMENT 102. V. I. Goldanskii. Priroda 48, No. 1, 118-21 (1959) Jan. (In Russian)

The Moscow group's scheme for synthesis of element-102 is compared to the experimental scheme carried out by California and Stockholm scientific groups. The $\alpha$-particle spectra observed in the Moscow experiments are shown. (R.V.J.)

**12478** ✓ UCRL-8714

California. Univ., Berkeley. Lawrence Radiation Lab. TECHNIQUES USED FOR THE PRODUCTION AND IDENTIFICATION OF THE TRANSPLUTONIUM ELEMENTS. Albert Ghiorso. [Mar. 1959]. 21p. Contract W-7405-eng-48. $4.80(ph), $2.70(mf) OTS.

Presented at Mendeleev Chemistry Conference, Moscow, March 1959.

A study was made of the production and identification of the transplutonium elements with atomic number greater than 94. A detailed discussion is presented of the identification of elements 101 and 102 and the possible applications of these methods to elements beyond. A brief review of the discovery of all of the transplutonium elements is given to show the gradual change in experimental techniques. (J.E.D.)

**10391** HW-58596

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

TRANS-PLUTONIUM ISOTOPE BUILDUP BY NEUTRON IRRADIATION OF PLUTONIUM. F. P. Brauer and Helen H. Burley. Dec. 15, 1958. 47p. Contract W-31-109-Eng-52. $1.25(OTS).

Graphs suitable for estimating the plutonium and trans-plutonium isotopic content of irradiated plutonium reactor fuel of various initial isotopic compositions are presented. The curves were computed for a neutron flux of $5 \times 10^{13}$ n/cm$^2$/sec and for irradiation times up to ten years. (auth)

**12329** ✓

ATTEMPTS TO CONFIRM THE EXISTENCE OF THE 10-MINUTE ISOTOPE OF 102. A. Ghiorso, T. Sikkeland, J. R. Walton, and G. T. Seaborg (Univ. of California, Berkeley). Phys. Rev. Letters 1, 17-18(1958) July 1.

Fields et al. (Phys. Rev. 107, 1460(1957)) reported an isotope of element 102 with an $\alpha$ activity having an energy of 8.5 ± 0.1 Mev and a half life of ~10 min. Attempts to confirm the results of this experiment are reported. It is concluded that the activity found cannot be ascribed to element 102. (L.T.W.)

# TRANSURANICS (GENERAL) 1.42

**4394**

ION-EXCHANGE BEHAVIOR OF MENDELEVIUM. R. C. Gatti, L. Phillips, T. Sikkeland, M. L. Muga, and S. G. Thompson (Univ. of California, Berkeley). J. Inorg. & Nuclear Chem. 11, 251-3(1959) Oct.

The elution position of mendelevium from cation-exchange resin columns was determined relative to the peaks of actinide and lathanide elements. A separation factor (relative to curium) for mendelevium by ammonium $\alpha$-hydroxyisobutyrate eluant was determined to be 0.050 ± 0.005. (C.J.G.)

EXPERIMENTS ON THE PRODUCTION OF THE 102d ELEMENT. G. N. Flerov, S. M. Polikanov, et al. Doklady Akad. Nauk S.S.S.R. 120, 73-5(1958) May 1. (In Russian)

Isotopes of $Pu^{239}$ and $Pu^{241}$ were bombarded by oxygen ions. Ions formed from special source were accelerated to 102 Mev on a 150 cm cyclotron. Energy variations were not over 3%; the ion current was 0.2 to 0.4 $\mu$a. The method and scheme for recording $\alpha$ decay are described. The energy spectra of $\beta$ particles emitted from decayed products in reactions $Pu^{239,241} + O^{16}$ are plotted. Alpha particles with energies < 8.5 Mev are emitted by isotopes $102^{251}$, $102^{252}$, and $102^{253}$ formed by reactions $Pu^{239}(O^{16}, 4n)102^{251}$, $Pu^{241}(O^{16}, 4-6n)102^{251-253}$. Eighteen $\alpha$ particles with energies > 8.5 Mev were recorded in bombardment of $Pu^{241}$ and 8 in case of $Pu^{239}$. The reaction cross sections were $2 \times 10^{-32}$ and $5 \times 10^{-33}$ $cm^2$, respectively. It was shown that the method used in the experiment can be applied to recording short life $\alpha$ active reaction products with very small yield (cross sections $10^{-32}$ to $10^{-33}$ $cm^2$). (R.V.J.)

PREPARATION OF TRANS-URANIUM ELEMENTS. H. A. C. McKay (Atomic Energy Research Establishment, Harwell). Nature 180, 1010-12(1957) Nov. 16.

The history of the various methods of producing transuranic elements through No is reviewed briefly. The limitations and advantages of neutron irradiation of U, thermonuclear explosions reactions, and heavy-ion bombardment processes are discussed. (M.H.R.)

**2031** ORNL-61?
Oak Ridge National Lab., Tenn.
THE PRODUCTION OF TRANSURANIC ISOTOPES IN THE MTR. H. E. Goeller. Mar. 15, 1950. Decl. Mar. 19, 1957, 34p. Contract W-7405-eng-26. $0.40(OTS).

The production of transuranic isotopes from the irradiation of $U^{235}$ fuel assemblies in the MTR has been recalculated on the basis of a 12 day irradiation at a power level of 30,000 kw for a loading of 3.2 kg of $U^{235}$. (auth)

APPLICATIONS OF RESEARCH REACTORS FOR ISOTOPE PRODUCTION AND TRANSURANIUM RESEARCH. A. H. W. Aten, Jr. Presented at the European Atomic Energy Society Symposium on Research Reactors and their Applications, Noordwijk, Netherlands, Sept. 10-14, 1957. 5p.

The requirements for radioisotopes are reviewed, and the possibilities for production of presently unobtainable or scarce isotopes are discussed. Topics considered are $Co^{60}$, $P^{33}$, double neutron capture, and transuranic buildup. (W.D.M.)

REVIEW OF THE JOINT AECL-KAPL STUDIES OF THE TRANSURANIC ELEMENTS. J.P. Butler, T.A. Eastwood, H.G. Jackson (Chalk River, Canada); T.L. Collins, M.E. Jones, F.M. Rourke, R.P. Schuman (Knolls Atomic Power Lab.). KAPL 1781, July 2, 1957.

A joint nuclear study was made of the transuranium elements produced by long-term irradiation of plutonium in the Materials Testing Reactor. This study is reviewed under the following headings - Introduction, Chemical separations, Counting techniques and mass analysis, Results - $E^{254}$, $Cf^{253}$, $Cf^{252}$, $Cf^{251}$, $Cf^{250}$, $Cf^{249}$, $Bk^{249}$, $Cm^{249}$, $Cm^{248}$, $Cm^{247}$, $Cm^{246}$, $Cm^{245}$, $Cm^{244}$, $Cm^{243}$, $Pu^{244}$, $Pu^{242}$, $Pu^{240}$, $Pu^{238}$ - Correlation of data and Conclusions. Bibliography 40 references.

**13065**

DISCOVERY OF THE ELEMENT 102. S. S. Rodin. Nauka i Zhizn No. 12, 47(1957). (In Russian)

In July, 1957. the discovery of element 102 was announced by a group of Swedish scientists. The new element was obtained by bringing particles of curium (element 96) into contact with carbon ions, accelerated in a cyclotron. The new element has the mass 253 and is extremely unstable. Its half-life is from 10 to 12 minutes, emitting alpha particles with an energy of 8.5 Mev. (TCO)

THE TRANSURANIUM ELEMENTS. P. Graf (Wurenlingen, Switzerland). Chimia 11, 57-70, 1957.

Review, with 217 references.

# TRANSURANICS (GENERAL) 1.42

THE CHEMISTRY OF THE ACTINIDE ELEMENTS.
Joseph J. Katz and Glenn T. Seaborg. London, Methuen and Co., Ltd., 1957. 520p.

The actinide elements are treated thoroughly, including important literature citations up to 1956. Sections on Ac, Th, U, Pa, Np, Pu, Am, Cu, and transcurium elements are presented which give information on history, isotopes, occurrence and isolation, properties, compounds, and properties of compounds. A final summarizing and correlating section is given. Data on atomic weights, x-ray energies, and nuclear spins of the actinide nuclides are appended. (T.R.H.)

**10119**
THE CHLORIDE COMPLEXES OF TRIVALENT PLUTONIUM, AMERICIUM, AND CURIUM. M. Ward and G. A. Welch (U. K. Atomic Energy Authority, Sellafield, Cumb., England). J. Inorg. and Nuclear Chem. 2, 395-402(1956) July.

The dissociation constants of the monochloride complexes of $Pu^{3+}$, have been found to be identical in dilute HCl solutions, with a value of 0.068 corrected to zero ionic strength. In concentrated hydrochloric-acid solutions the relative complexing power has been shown to be Pu ≫ Am > Cr. This result has been discussed with reference to a theory of f-orbital hybridization in the actinides. (auth)

Refer also to abstracts 10304, 10566, and 10669.

**3275** HW-41025
Hanford Atomic Products Operation, Richland, Wash.
ELECTRODEPOSITION OF THE ACTINIDE ELEMENTS.
R. Ko. Jan. 23, 1956. 10p. Contract W-31-109-Eng-52. $1.80(ph OTS); $1.80(mf OTS).

Thorium, U, Np, Pu, Am, and Cr have been deposited at metal cathodes by the electrolytic formation of base. The electrolyses have been made in various acid solutions containing ammonium formate. The presence of formate reduces hydrogen ion formation at the anode and makes the quantitative precipitation of the metal hydroxides at the cathode possible. (auth)

**2831** TID-5002
[Manhattan District, Oak Ridge, Tenn.].
TRANSURANIC ELEMENTS: ANALYTICAL CHEMISTRY.
Paul L. Kirk and C. J. Rodden. [1947?]. TIS issuance date Nov. 1954. Decl. July 23, 1956. 57p.

A detailed discussion is presented of the analytical procedures and equipment devised for the determination of Pu under all conditions and in many mixtures. Indications of variations encountered with transuranic elements other than Pu and their effects on analytical determination are given. (J.E.D.)

**10914** CF-55-11-151
Oak Ridge National Lab., Tenn.
SURVEY OF SOME RECENT DATA ON TRANSURANICS.
J. O. Blomeke and J. Halperin. Nov. 22, 1955. Decl. Apr. 4, 1956. 12p. Contract W-7405-eng-26. $3.30(ph OTS); $2.40(mf OTS).

Most recent cross section data for transuranic isotopes are compiled, primarily for use in a computer study of transuranic buildup in reactor fuels. (T.R.H.)

MAN-MADE ELEMENTS. Atoms for Peace Digest 2, 20, pp. 5-6, 1957.

Summary of a lecture by Dr. G. T. Seaborg at University of California.

**5575**
TRANSURANIC ELEMENTS. A. K. Lavrukhina. Priroda 44, 13-20(1955) Dec. (In Russian).

A general review of available data on uranium elements and their analogy to rare element properties are discussed. The 5-f shell actinide hypothesis and the magnetic susceptibility of actinides and lanthanides are analyzed. (R.V.J.)

# URANIUM 1.43

## ANALYTICAL SEPARATION 1.43.01

**13216** ✓ GAT-283
Goodyear Atomic Corp., Portsmouth, Ohio.
ANALYSIS OF URANIUM SOLUTIONS USING ANION EXCHANGE IN NITRATE MEDIA. O. A. Vita, C. F. Trivisonno, and C. W. Phipps. Apr. 28, 1959. 14p. Contract AT(33-2)-1. $0.50(OTS).

A method for the separation of milligram quantities of uranium from gross quantities of other elements in a nitrate medium has been developed. In conjunction with basic peroxide colorimetric determination, this is a reliable procedure for the analysis of many samples which cannot otherwise be handled conveniently. Essentially the procedure consists of adsorption of the uranium from a concentrated aluminum or nickel nitrate solution on an anion-exchange resin, elimination of the impurities and the adsorption solution by washing with saturated sodium nitrate solution, elution of the uranium with dilute nitric acid, and determination of the uranium by the basic peroxide colorimetric method. Results indicate that a limit of error of 1.9 percent per determination and a bias of $-0.04 \pm 0.60$ percent at the 95-percent confidence level can be achieved. (auth)

APPLICATION OF ION EXCHANGE TO THE COLORIMETRIC DETERMINATION OF TRACE AMOUNTS OF URANIUM USING DIBENZOYLMETHANE. H. J. Seim, R. J. Morris, and R. G. Pastorino (Univ. of Nevada, Reno). Anal. Chem. 31, 957-8(1959) May.

A method for ion exchange separation and colorimetric determination of uranium is reported. The uranium, complexed with dibenzoylmethane in 80% alcohol, is determined colorimetrically at 400 mμ. This method has been routinely applied to a large number of low-grade uranium samples. (auth)

ANALYTICAL PROPERTIES OF $NH_4F \cdot UF_4$. E. P. Nikolaeva. Vestnik Moskov. Univ., Ser. Mat. Mekhan. Astron. Fiz. i Khim. 13, No. 4, 193-6(1958). (In Russian)

The effects of acidity, concentration of the precipitator, and other factors on the completeness of U(IV) precipitation by ammonium fluoride were investigated. It is shown that it is possible to use ammonium fluoride for determining small quantities of U (0.5 to 2 mg) in V, Mo, and Fe, when their concentration does not exceed 10, 15, and 50 mg, respectively, in 10 ml of solution.

DETERMINATION OF URANIUM WITH THE USE OF POTASSIUM IODATE. E. S. Przhevalskii, E. R. Nikolaeva and N. I. Udaltsova (Lomonosov Moscow State Univ.). Zhur. Anal. Khim. 13, 567-9(1958) Sept.-Oct. (In Russian)

Conditions were established for precipitating tetravalent uranium iodate of constant composition according to the formula $U(IO_3)_4$. The iodate method is suitable for the gravimetric and titrimetric determination of uranium. The influence of some elements on the accuracy of determination was studied. The possibility was established for the determination of uranium in the presence of aluminum. Iron must be separated beforehand. (tr-auth)

THE USE OF RADIOACTIVE ISOTOPES IN STUDYING THE SPATIAL DISTRIBUTION OF ELEMENTS IN DIRECT CURRENT ARC PLASMA DURING SPECTROCHEMICAL DETERMINATION OF IMPURITIES IN URANIUM. E. E. Vainshtein and Yu I. Belyaev (Vernadskii Inst. of Geochemistry and Analytical Chemistry, Moscow). Zhur. Anal. Khim. 13, 388-95(1958) July-Aug. (In Russian)

Active isotope distribution in the plasma was recorded in gamma rays by means of a pin-hole camera (camera-obscura) made of lead. The spatial distribution in the d-c arc plasma of atoms of various elements was proved to be different and to depend on volatility of elements. The causes of the effect of the carrier on the sensitivity of spectrochemical determination of impurities in uranium were ascertained. A symmetrical dome-like distribution of the atoms in the space of the arc, with a sharp maximum in the center is characteristic of the carrier, irrespective of the method of carrier introduction into the analytical gap of the arc. The carrier affects only the distribution of the elements in analytical gap of the source and brings about forced concentration of impurities in the central region of plasma in accordance with carriers distribution. The effect of the carrier is not of a selective nature. It may be considerably less when large amounts of elements with a spatial atom distribution differing from that of the carrier are present in the sample. (tr-auth)

**2280**
ANALYTICAL CHEMISTRY OF THE ACTINIDES. P. I. Palei. Zhur. Analst. Khim. 12, 647-64(1957) Sept-Oct. (In Russian)

A review is given of the chemical method for separation and determination of the actinides, mainly those used and developed in U.S.S.R. (R.V.J.)

# URANIUM 1.43

## ANALYTICAL SEPARATION 1.43.01

**5203** ✓

SEPARATIONS INVOLVING SULPHIDES. XI. SEPARATION OF ALUMINIUM OR URANIUM FROM SOME ELEMENTS FORMING THIOSALTS. I. K. Taimni and S. N. Tandon (Univ. of Allahabad, India). Anal. Chim. Acta 21, 502-04 (1959) Dec. (In English)

A 2 N sodium sulfide can be used to separate arsenic, antimony, tellurium, selenium, molybdenum, mercury, gold, platinum, or rhenium from aluminum or uranium. (auth)

GRAVIMETRIC DETERMINATION OF URANIUM WITH THE USE OF CUPFERRON FOR ITS SEPARATION. S. V. Elinson and V. A. Oleznyuk. Zhur. Anal. Khim. 13, 95-9 (1958) Jan.–Feb. (In Russian)

The method is based on the separation of admixtures with cupferron and precipitation of tetravalent uranium with the same reagent after reduction with sodium hyposulfite. The method has been tested on pure uranium, artificial mixtures with accompanying uranium admixtures, as well as on ores and headings with various concentrations of uranium. The method can be used for the precision analysis of ores and headings containing more than 5 % of uranium in plant laboratories. One determination takes 4 to 5 hrs. Four samples can be analyzed simultaneously. The mean quadratic error of determination is estimated to be ±0.3 % relative for samples containing 50 % and ±1.2 % for samples containing 5 to 10 % of uranium. (tr-auth)

**2235** GAT-L-421

Goodyear Atomic Corp., Portsmouth, Ohio.

ION EXCHANGE IN URANIUM ANALYSIS–A LITERATURE SURVEY. C. F. Trivisonno. Nov. 1, 1957. 17p. $3.30 (ph OTS); $2.40(mf OTS).

A literature survey was made on applications of ion exchange in uranium analysis. Topics covered include the absorption of U, the elution of U, and application of ion exchange resins in U analysis. 27 references. (C.H.)

**13001** IDO-14243

American Cyanamid Co. Atomic Energy Div., Idaho Falls, Idaho.

PURIFICATION OF ENRICHED URANIUM PRODUCT FOR USE AS AN ANALYTICAL STANDARD. Investigation Order No. 144. G. K. Cederberg. May 1, 1953. Decl. Apr. 10, 1957. 7p. Contract AT(10-1)-177. $1.80(ph OTS); $1.80(mf OTS).

The purification of enriched uranium (about 90% $U^{235}$) by extracting with 30% TBP, stripping with $H_2O$, and precipitating as $UO_4$ is described. (C.W.H.)

SEPARATION OF URANIUM AND VANADIUM. Yu. V. Morachevskii, A. I. Belyaeva, and L. V. Ivanova (Zhdanov Leningrad State Univ.). Zhur. Anal. Khim. 13, 570-5(1958) Sept.-Oct. (In Russian)

It was shown that the difficulty in the analytical separation of uranium (VI) from vanadium (V) lies in the formation of stable uranovanadium complexes. Three uranovanadic acids and their ammonium salts were isolated. The solubility of the salts was determined. (tr-auth)

**16226** TID-7555(p.24-42)

New Brunswick Area Office, AEC.

ANALYSIS OF URANIUM AND ITS COMPOUNDS. C. J. Rodden. p.24-42 [of] FIRST CONFERENCE — ANALYTICAL CHEMISTRY IN NUCLEAR REACTOR TECHNOLOGY, NOVEMBER 4-6, 1957, GATLINBURG, TENNESSEE. 19p.

Methods are described for the determination of uranium and other major constituents of ores, process materials and uranium alloys and compounds, and for the determination of minor impurities which are present in uranium metal, alloys and compounds. Dissolution procedures for different types of materials, methods for the separation of interferences, limits of detection, and range of applicability are discussed. In addition to an outline of the general principles in the determination of uranium, specific topics considered include: Isotope analysis; determination of elements which absorb neutrons strongly; spectrographic procedures; separation of rare earth elements by ion-exchange; methods for the determination of carbon, nitrogen, oxygen, hydrogen and silicon in uranium metal; methods for the estimation of molybdenum, nickel, chromium, manganese, tungsten, vanadium, silicon, sulfur, and phosphate in $UO_3$, $UF_4$, and, in some cases, in other compounds of uranium; fluoride in $UF_4$; impurities in $UF_6$ by the freezing point method; and standard materials. 32 references. (auth)

DETERMINATION OF URANIUM IN IRON. L. Kosta. "J. Stefan" Inst. Repts. (Ljubljana) 2, 7-8(1955) May.

A method has been devised for the determination of very small concentrations of uranium in iron and iron-base alloys based on the elimination of iron, chromium, and other constituents on the mercury cathode and subsequent extraction of uranium with ethylacetate. By this procedure over 95% uranium has been recovered at a concentration level of $10^{-4}$ to $10^{-3}$ %. (auth)

# URANIUM 1.43

## ANALYTICAL SEPARATION 1.43.01

**3346** K-1106

Carbide and Carbon Chemicals Co. K-25 Plant, Oak Ridge, Tenn.

THE USE OF THE HIGH CURRENT MERCURY CATHODE IN URANIUM DETERMINATION. J. Gurney, T. W. Bartlett, E. D. Marshall, and R. H. Lafferty, Jr. Feb. 26, 1954. Decl. Nov. 30, 1955. 28p. Contract W-7405-Eng-26. $0.25(OTS).

Electrolysis with a Hg cathode operating at 20 amp has been tested as a method for the rapid purification of U solutions prior to volumetric determination of the U. This high current Hg cathode is much faster than the conventional type Hg cathode, and no further chemical purification is necessary prior to volumetric determination as is the case with solvent extraction. Statistically, no difference in precision could be shown in the volumetric determination of U in pure $UO_2SO_4$ solutions with no electrolysis and in $UO_2SO_4$ solutions containing Fe, Ni, and Cu which had been purified by electrolysis at 20 amp for 45 min. Deposition rates of Fe, Cu, and Ni into the Hg cathode were studied while controlling such variables as concentration, temperature, stirring, acidity, and anion concentration. (auth)

**4368**

SEPARATION OF URANIUM FROM VANADIUM BY ION EXCHANGE: WITH SPECIAL REFERENCE TO THE DETERMINATION OF SMALL AMOUNTS OF URANIUM. T. K. S. Murthy (Atomic Energy Establishment, Bombay, India). Anal. Chim. Acta 16, 25-8(1957) Jan.

An ion exchange method has been worked out for the separation of milligram quantities of U from large amounts of V. A solution containing V and U and excess $Na_2CO_3$ is passed through a column filled with an anion exchanger in the chloride form. All the U and part of the V are adsorbed by the resin. The adsorbed V is first eluted with 10% $Na_2CO_3$ solution leaving U in the column. U is then eluted with NaCl and estimated colorimetrically. (auth)

**104** ERI-2228-9-F

Michigan. Univ., Ann Arbor. Engineering Research Inst. ISOLATION AND DETERMINATION OF SUBMICROGRAM QUANTITIES OF THE HEAVY ELEMENTS FROM GROSS FISSION PRODUCTS. Final Report [for] February 15, 1954 to August 14, 1955. Philip J. Elying and Charles L. Rulfs. Nov. 1955. 15p. Contract AF19(604)-1026. (AFCRC-TR-55-172; AD-86566).

The analytical chemistry of U is reviewed and the results of a search for a simple, fast, method for small amounts of U in fission products are given. (TBH)

**6260**

SPECTROPHOTOMETRIC DETERMINATION OF URANIUM WITH THIOCYANATE IN BUTYL CELLOSOLVE-METHYL ISOBUTYL KETONE-WATER MEDIUM. Oscar A. Nietzel and Michael A. De Sesa (National Lead Co., Winchester, Mass.). Anal. Chem. 29, 756-9(1957) May.

A spectrophotometric method for the determination of U in ores and leach liquors consists of separation of U from interfering ions by extraction into methyl isobutyl ketone, using $Al(NO_3)_3$ as a salting agent, followed by development of the color in a portion of the extract with a solution of $NH_4CNS$ in a butyl Cellosolve-water solvent. The yellow uranyl thiocyanate complex forms immediately, and the color is stable for at least 48 hours. The optimum range of U concentration at 375 mμ is from 0.4 to 2.0 mg. of $U_3O_8$ in the sample aliquot. The coefficient of variation of absorbance measurements on standard solutions at 375 mμ was 0.34%. Titanium is the only serious interference, but procedures are given which make it possible to analyze samples containing as much as 5 mg of Ti in the sample aliquot. (auth)

# URANIUM 1.43

## BURNUP AND YIELD 1.43.02

See also, under SURVEYS (GENERAL),

FUEL CYCLE (7.03).

**16499**

CALCULATION OF THE ACCUMULATIVE YIELDS IN THE FISSION OF URANIUM. Horacio E. Bosch and Sara M. Abecasis (Comisión Nacional de Energia Atómica, [Buenos Aires] and Universidad Nacional, Buenos Aires). Publs. com. nacl. energia atomica (Buenos Aires) Informe No. 4, 24p. (1959). (In Spanish)

A general method is given for the activity of a given nuclide obtained from uranium fission and the calculation of the accumulative yields of the nuclide. The numerical value is obtained by simple resolution of a system of equations. Some examples are given. (J.S.R.)

THE QUANTITATIVE DETERMINATION OF FISSION AND NUCLEAR REACTION PRODUCTS. C. E. Crouthamel, Robert Heinrich, and Christopher Gatrousis (Argonne National Lab., Lemont, Ill.). Talanta 1, 396-407(1958) Nov.

Definitions are given to the terms "per cent atom burn-up" and "per cent atoms consumed" as applied to nuclear fuel analysis at the Argonne National Laboratory. The radiochemical and analytical methods which have been adapted and developed especially for this type of analysis are discussed. The analysis of nuclear reaction products by paper chromatographic methods and scintillation spectrometry is emphasized and demonstrated. (auth)

URANIUM-235 FISSION-PRODUCT PRODUCTION AS A FUNCTION OF THE THERMAL NEUTRON FLUX, IRRADIATION TIME, AND DECAY TIME. II. SUMMATIONS OF INDIVIDUAL CHAINS, ELEMENTS, AND THE RARE-GAS AND RARE-EARTH GROUPS. VOLUMES 1 AND 2. J. O. Blomeke and Mary F. Todd. (ORNL-2127(Pt. II)(Vol. 1)), Dec. 19, 1957. 363p. and (ORNL-2127(Pt. II)(Vol. 2)), June 10, 1958. 365p.

The following properties, per initial atom of $U^{235}$, are tabulated for each fission-product chain with mass number 72 to 161: activity, gamma power, total power, poisoning, and gamma disintegrations per second with energies up to 1.70 Mev.

URANIUM-235 FISSION-PRODUCT PRODUCTION AS A FUNCTION OF THERMAL NEUTRON FLUX, IRRADIATION TIME, AND DECAY TIME. I. ATOMIC CONCENTRATIONS AND GROSS TOTALS. J. O. Blomeke and Mary F. Todd. Aug. 19, 1957. (Issued in two volumes: Vol. 1, 216p. and Vol. 2, 220p). (ORNL-2127(Pt. 1)(Vols. 1 and 2))

Levels of fission products resulting from thermal fission of $U^{235}$ in reactor fuels were computed over a wide range of reactor operating conditions and decay times. Values for approximately 300 fission products are presented in graphical form together with gross totals of their activities, radiation powers, and thermal neutron poisoning. The $\gamma$ spectrum is further broken into four groups of specified energy ranges, which are suitable for use in shielding design. Tabulations of these properties are arranged as to chain or mass number, element, and as to the rare-gas and rare-earth groups. The calculations assume constant replenishment of $U^{235}$, constant reactor power operation, and no fission-product separations during irradiation.

Heavy Isotope Buildup in Core of $U^{233}$ Breeder, R.W. Stounghton, J. Halperin. J Nuclear Energy 4, 3, Mar 1957, p 279-92.

Buildup of uranium isotopes with time difference depending on starting fuel and isotope composition of continuously added make-up fuel; total uranium concentration was found to approach slowly equilibrium value of 2.6 to 3.5 times starting value, depending on composition of make-up fuel.

THE BUILDUP OF HEAVY ISOTOPES DURING THERMAL NEUTRON IRRADIATION OF URANIUM REACTOR FUELS. J. O. Blomeke. Jan. 11, 1957. 62p. (ORNL-2126)

Curves suitable for predicting the buildup of heavy isotopes in U reactor fuel of any likely initial isotopic composition are presented. The curves were computed for seven values of thermal neutron flux between $10^{12}$ and $10^{15}$ $n/cm^2/sec$, assuming constant flux, and extended to flux-times of $3 \times 10^{21}$ $n/cm^2$.

# URANIUM 1.43

## BURNUP AND YIELD 1.43.02

**9481** ✓

BURNUP OF FISSIONABLE MATERIAL AND PLUTONIUM PRODUCTION IN URANIUM THERMAL REACTORS. G. Quilico. Energia nucleare (Milan) 4, 115-27(1957) Apr. (In Italian)

On the basis of energetic considerations, a system of differential equations has been developed which characterizes the isotopic composition of irradiated nuclear fuel in a uranium thermal reactor, directly with regard to the power developed per unit of fuel. Considering separately the capture of resonance neutrons and that, in the thermal area, by U-238, the solution of the system is developed for given initial values of the conversion factor and of the enrichment degree of the fuel. It is then shown how practically identical results, as far as numerical calculation is concerned, can be reached with much more simple expressions obtained by adopting some simplifying hypotheses. Diagrams of isotopic composition are given together with other diagrams connected with the power developed separately by the fission of isotopes, calculated by means of elaborated formulas. (auth)

**8191** ✓ ORO-162

Emory Univ., Ga.

BOMBARDMENT ENERGY AND FISSION PRODUCT YIELD PATTERN: PROTONS ON Th-232, U-233, AND Th-230. William H. Jones. [1956]. 20p. Contract [AT(40-1)-1399]. $0.20(OTS).

Experimental methods are summarized. Yields of fission products are tabulated and graphed relative to that of $Mo^{99}$. (M.H.R.)

**3890** ✓ ORNL-1783

Oak Ridge National Lab., Tenn.

NUCLEAR PROPERTIES OF $U^{235}$ FISSION PRODUCTS. J. O. Blomeke, comp. Nov. 2, 1955. 60p. Contract W-7405-eng-26. $0.40(OTS).

Tables are presented that list the $U^{235}$ fission-product decay chains and the current best single values of their fission yields and cross sections. The fission products are also tabulated according to decreasing order of half life, thermal-neutron capture cross section, gamma energy, and beta energy. (auth)

### MEASURING INSTRUMENTS AND TECHNIQUES

**12515** ✓ MTR-L-231

Phillips Petroleum Co. Atomic Energy Div., Idaho Falls, Idaho.

GAMMA RAY SCANNING OF SPENT FUEL ASSEMBLIES. Thomas J. Parmley. Oct. 22, 1953. Decl. Mar. 7, 1957. 14p. Contract AT(10-1)-205. $3.30(ph OTS); $2.40(mf OTS).

Equipment was built for determining the amount of $U^{235}$ fissioned in fuel assemblies after the assemblies had been in the MTR and then released into a canal of water. These determinations give the $U^{235}$ burn-up. (F.S.)

**7840** ✓ LWS-24612

California Research and Development Co., Livermore, Calif.

FAST REACTOR POISONING BY FISSION PRODUCTS. C. C. Old. Oct. 24, 1952. Decl. Feb. 26, 1957. 8p. (CRD-R-1). $3.30(ph OTS); $2.40(mf OTS).

Estimates are made of fast reactor poisoning by fission products. Data are included on the neutron absorption and production of fission products in reactors. (B.J.H.)

**9845** ✓ NAA-SR-Memo-20

North American Aviation, Inc., Downey, Calif.

CONVERSION OF IRRADIATION UNITS FOR THERMAL, NATURAL URANIUM REACTORS. R. Loftness. Oct. 13, 1950. Decl. Mar. 11, 1957. 7p. Contract AT-11-1-gen-8. $1.80(ph OTS); $1.80(mf OTS).

A chart and a table are presented for thermal natural uranium reactors, to inter-convert the irradiation units of percent burnup, Mwd/t integrated neutron flux, and the ratio of $U^{235}$ atoms fissioned to total uranium atoms. (auth)

## FISSION PRODUCTS, ISOTOPES, AND DECAY 1.43.03

### GENERAL 1.43.03.01

**8697** ✓✓

FISSION-PRODUCT YIELDS FROM U, Th and Pu. Seymour Katcoff (Brookhaven National Lab., Upton, N. Y.). Nucleonics 16, No. 4, 78-85(1958) Apr.

Graphs and tabulations of the fission yields of $U^{235}$, $U^{233}$, $Pu^{239}$, $Th^{232}$, and $U^{238}$ and the decay chains and yields of $U^{235}$ are given. (J.S.R.)

# URANIUM 1.43

## FISSION PRODUCTS, ISOTOPES, AND DECAY 1.43.03

### GENERAL 1.43.03.01

**21495**
TRITIUM AS A PRODUCT OF FISSION. E. L. Albenesius (E. I. du Pont de Nemours and Co., Aiken, S. C.). Phys. Rev. Letters 3, 274-5(1959) Sept. 15.
Experiments are described which indicate that the triton is a previously unrecognized fission product. Tritium was shown to be present in a ratio of one triton per $(1-2) \times 10^4$ fissions in samples of irradiated natural and enriched uranium and in an irradiated mixture of transuranium isotopes. The Li content of the sample was proven not to be the source of the tritium. (W.D.M.)

Armed Forces Special Weapons Project, Washington, D. C.
GAMMA SPECTRA OF URANIUM-235 FISSION PRODUCTS AT VARIOUS TIMES AFTER FISSION. P. J. Dolan. Mar. 5, 1959. 82p.
Calculated gamma spectra produced by uranium-235 fission are tabulated for various times after fission. Similar tabulations are given omitting certain volatiles and portions of their daughter products. (auth)

**12936**
COMPOSITION OF PRODUCTS FORMED BY THERMAL NEUTRON FISSION OF $^{235}U$. III. ISOTOPIC COMPOSITION AND ATOMIC WEIGHT OF THE FISSION PRODUCT ELEMENTS. Jan Prawitz (Research Inst. of National Defence, Sundbyberg, Sweden and Univ. of Stockholm). Acta Chem. Scand. 13, 163-73(1959).
The isotopic composition and atomic weight of the fission product elements were calculated for seven different irradiation times between one day and two years, two cooling times, 100 and 3000 days, and three thermal neutron fluxes $10^{12}$, $10^{13}$, and $10^{14}$ n $cm^{-2}$ $sec^{-1}$. Some applications of the difference in composition between the natural and fission product elements are discussed. (auth)

**4705**
REACTOR PHYSICS. 9. James F. Hill (Reactor School, Harwell). Nuclear Power 2, No. 10, 67-70(1957) Feb.
Some of the changes which take place in a reactor during operation are reviewed. These include the buildup of fission product poisons, temperature, density, and pressure effects, and changes in the content of fissionable material. (B.J.H.)

**16853** LAMS-2226
Los Alamos Scientific Lab., N. Mex.
ON THE PRODUCTION OF HEAVY URANIUM ISOTOPES IN A VERY HIGH DENSITY FAST NEUTRON FLUX. Joseph J. Devaney, Albert G. Petschek, and Mary Tsingou Menzel. May 1958. 17p. Contract W-7405-Eng-36. $0.75(OTS).
An estimate of the probability of multiple capture of neutrons by $U^{238}$ in times short compared to $\beta$-decay lifetimes and to spontaneous fission lifetimes as, for example, in a thermonuclear explosion is discussed. It is assumed that the requisite very high density neutron flux is present. How far successive capture can go is sought. The pertinent cross sections are estimated and appropriate differential equations are set up and solved. Estimates are given in the form of graphs. (T.R.H.)

**10974** AERE-T/M-159
United Kingdom Atomic Energy Authority. Research Group. Atomic Energy Research Establishment, Harwell, Berks, England.
CALCULATION OF FISSION PRODUCT ACCUMULATION. E. G. H. Crouch. Mar. 1958. 13p. $0.45(BIS).
The program "Other Poisons" Calculation, written for the Ferranti Mark I computer at Aldermaston, computes the total poisoning in a reactor at required times for given reactor conditions and given fission-product chains. Poisoning for each fission-product chain can be printed out if required. (auth)

**10229**
THE FISSION OF URANIUM AND PROTACTINIUM AT HIGH EXCITATION ENERGIES. V. P. Shamov (Radium Inst., Academy of Sciences, USSR). Soviet Phys. JETP 6, 268-73(1958) Feb.
This paper was previously abstracted from the original language and appears in NSA, Vol. 12, as abstract No. 3402.

ON THE URANIUM NUCLEI COMPLEX FISSION PRODUCED BY 14 Mev NEUTRONS. N. A. Perfilov and Z. I. Solov'eva. Atomnaya Energ. 5, 175-6(1958). (In Russian)
Uranium complex fission, with long-range $\alpha$-particle emission, by 14-Mev neutron irradiation was studied.

# URANIUM 1.43

## FISSION PRODUCTS, ISOTOPES, AND DECAY 1.43.03

### GENERAL 1.43.03.01

**11592** BNL-407
Brookhaven National Lab., Upton, N. Y.
ACCUMULATION OF FISSION PRODUCTS FROM $U^{235}$.
A. K. Booth and D. Schweitzer. July 1956. 10p.
$0.15(OTS).

A relatively simple and direct method is presented for estimating the amounts (or concentrations) of the fission products of $U^{235}$ as a function of: power level, flux, time of operation, and burn-up. Tables are given for the build-up in one hour, the times required to reach one % burn-up, and the equilibrium values for fission products based on a one-megawatt reactor operating at a flux of $10^{14}$ neutrons/$cm^2$/sec. The fission product concentrations for a 500-Mw reactor with a flux of $10^{15}$ neutrons/$cm^2$/sec which has been operated for 10,000 hr have also been tabulated. To obtain concentrations, 100 tons total inventory of Bi was assumed. (auth)

**10494** AERE-C/M-278
Gt. Brit. Atomic Energy Research Establishment, Harwell, Berks, England.
MATHEMATICS OF FISSION PRODUCT FORMATION IN REACTORS WITH CIRCULATING FUEL. C. J. L. Lock. May 1956. 18p.

In reactors with circulating fuel the fuel is exposed to intermittent radiation. Formulae are presented enabling the calculation of the amount of any fission product after any time of reactor operation under varying conditions. Formulae are also presented to enable calculation of the amount of fission product gases present in the reactor assuming various efficiencies of removal. (auth)

**14324** AERE-HP/M-100
United Kingdom Atomic Energy Authority. Research Group. Atomic Energy Research Establishment, Harwell, Berks, England.
CALCULATION OF FISSION PRODUCT ACTIVITIES IN IRRADIATED THORIUM AND URANIUM. D. V. Booker. Oct. 31, 1955. 19p.

A method is given for calculating gross fission product activity in thorium irradiated to produce $U^{235}$. Also, presented are methods of calculating the activity of single and gross fission product activity in irradiated natural uranium. Specimen calculations are included. The aim is to present the available data in a convenient form for the assessment of health physics problems arising in the handling of irradiated samples. (auth)

**7811** CF-56-2-87
Oak Ridge National Lab., Tenn.
PREDICTED BEHAVIOR OF FISSION PRODUCTS IN THE HRT. D. E. Ferguson, R. E. Leuze, and R. A. McNees. Feb. 16, 1956. Decl. Feb. 14, 1957. 28p. Contract [W-7405-eng-26]. $0.35(OTS).

The results of a study made to predict the behavior of fission products in the HRT are presented. Specifically, the amount of rare gases escaping to the atmosphere and accumulated in the carbon beds, the rate of accumulation of the daughters of Xe and Kr in the off-gas system, and the concentration of all non-gaseous fission products in the reactor fuel solution including iodine were estimated. In addition, the predicted accumulation of insoluble fission and corrosion products in various components of the fuel system are discussed. In most cases insufficient data are available to make firm estimates, and the results reported here should be considered very tentative until such data are available. (auth)

**3118** WAPD-P-564
[Westinghouse Electric Corp. Atomic Power Div., Pittsburgh.]
THE EFFECT OF BURNABLE POISONS ON THE REGENERATION FACTOR, $\eta$, FOR SLIGHTLY ENRICHED URANIUM METAL. W. R. Clancey. Nov. 1, 1954. Decl. Oct. 30, 1958. 24p. $4.80(ph OTS); $2.70(mf OTS).

The principle variation in reactivity is due to the variation of the regenerative factor, $\eta$, the variation of the other factors being small by comparison. By studying the variations in $\eta$ for slightly enriched U metal, results are obtained that are generally applicable to reactors using this fuel, since $\eta$ depends only on the fuel material. The results presented show that it is possible to reduce the total variation in $\eta$ by using a burnable poison in the fuel material. However, there is usually a sacrifice in lifetime or enrichment cost that must be weighed against the easing of the control problem. The calculations are based on a modification of data obtained for a flux of neutrons with a Maxwellian average temperature of 537°F. The effects of Pu buildup and fission product poisons are explicitly included. A further discussion of the methods and assumptions used in the calculations is given. It is shown that the addition of two burnable poisons to fuel offers only a small improvement over the single poison results. (M.H.R.)

# URANIUM 1.43

## FISSION PRODUCTS, ISOTOPES, AND DECAY 1.43.03

### GENERAL 1.43.03.01

**6090** ✓ NRDC-22
Gt. Brit. Atomic Energy Research Establishment, Harwell, Berks, England.
THE DEPENDENCE OF THE RATIO $Pu^{240}-Pu^{239}$ ATOMS IN A NATURAL URANIUM REACTOR ON THE CAPTURE CROSS-SECTION OF $Np^{239}$ AND THE THERMAL NEUTRON FLUX. J. F. Hill. Mar. 10, 1953. 6p.

For a natural U reactor the increase in the ratio $Pu^{240}/Pu^{239}$ atoms over its value when the $Np^{239}$ capture cross section is assumed negligibly small is found as a function of the assumed $Np^{239}$ cross section and the thermal flux. Assuming a capture cross section of 7000 b and a thermal neutron dose of $10^{20}$ neutrons per $cm^2$, this ratio is increased by about 12%, a factor of 2 and a factor of 10 respectively in a thermal flux of $10^{12}$, $10^{13}$ and $10^{14}$ neutrons/$cm^2$/sec. It is also shown that, after the $Np^{240}$ has come into equilibrium, this increase is almost exactly proportional to the thermal flux and to the $Np^{239}$ cross section up to irradiations of about 600 Mwd/T. (auth)

**11491** ORNL-2127(Pt. 1(Vols. 1 and 2))
Oak Ridge National Lab., Tenn.
URANIUM-235 FISSION-PRODUCT PRODUCTION AS A FUNCTION OF THERMAL NEUTRON FLUX, IRRADIATION TIME, AND DECAY TIME. I. ATOMIC CONCENTRATIONS AND GROSS TOTALS. J. O. Blomeke and Mary F. Todd. Aug. 19, 1957. (Issued in two volumes: Vol. 1, 216p. and Vol. 2, 220p). Contract W-7405-eng-26. $1.75(OTS).

Levels of fission products resulting from thermal fission of $U^{235}$ in reactor fuels were computed over a wide range of reactor operating conditions and decay times. Values for approximately 300 fission products are presented in graphical form together with gross totals of their activities, radiation powers, and thermal neutron poisoning. The $\gamma$ spectrum is further broken into four groups of specified energy ranges, which are suitable for use in shielding design. Tabulations of these properties are arranged as to chain or mass number, element, and as to the rare-gas and rare-earth groups. The calculations assume constant replenishment of $U^{235}$, constant reactor power operation, and no fission-product separations during irradiation. (auth)

**7382** ✓ BNL-3201
Brookhaven National Lab., Upton, N. Y.
THE SPONTANEOUS NEUTRON YIELD OF NATURAL URANIUM. Serial Report No. 7 on Startup Experiments. R. S. Margulies. Sept. 4, 1951. Decl. Nov. 7, 1955. 10p. $1.80(ph OTS); $1.80(mf OTS).

A mathematical formulation for the spontaneous neutron yield of natural uranium was made. This formulation was compared with experimental data, and the results were graphed. (M.H.R.)

**3442** USNRDL-TR-187
Naval Radiological Defense Lab., San Francisco.
GAMMA DECAY OF FISSION PRODUCTS FROM THE SLOW-NEUTRON FISSION OF $U^{235}$. C. F. Miller. July 11 1957. 131p. Project NS-081-001.

Photon energy radiation rates and photon emission rates from the fission products produced by slow-neutron bombardment of $U^{235}$ are computed, using nuclear decay scheme data and the results of new computations for the gross activity in terms of disintegration rate. The computed rates were used to determine, as a function of time after fission, the mean photon energy per disintegration, and the number of beta rays per photon. Curves showing photon energy radiation rates, photon emission rates, and beta rates for a time range of about 46 min to about 300 years after fission are presented. The relative percent contributions of the fission product elements to the photon energy radiation rate for the same time range are listed and plotted. A comparison is made of activity and the computed photon energy radiation rates for 1 hr to 3 years after fission. A comparison is also made of the number of fissions and neutron capture/fission ratio for neutron bombarded samples of $U^{235}$ and of $U^{235}$ + $U^{238}$ as determined by the decay curve analyses and by radiochemical analyses. The computed decay curves for $10^4$ fissions from slow-neutron fission of $U^{235}$ using the USNRDL 4-pi Ionization Chamber is presented. (auth)

**2238** ✓ AEC-tr-2363
A CASE OF FISSION OF A URANIUM NUCLEUS INTO FOUR FRAGMENTS OF COMPARABLE MASS. Yu. S. Ivanov. Translated by V. N. Rimsky-Korsakoff from Doklady Akad. Nauk. S.S.S.R. 104, 40-3, 1955.

An event, which is interpreted as the fission of a U nucleus into four heavy fragments, was observed in a U-loaded photographic plate which had been exposed to a photon beam. A microphotograph of the event is shown. (B.J.H.)

# URANIUM 1.43

## FISSION PRODUCTS, ISOTOPES, AND DECAY 1.43.03

### GENERAL 1.43.03.01

**2187** CF-50-5-29
[Oak Ridge National Lab., Tenn.]
FISSION PRODUCT ACTIVITY OF X SLUGS. J. A. Lane. May 2, 1950. Decl. Feb. 15, 1957. 6p. Contract [W-7405-eng-26]. $1.80(ph OTS); $1.80(mf OTS).
Fission product activity measurements of MTR slugs were made for design data for discharge chute shielding and channel water depth. (T.R.H.)

**3439** AERE-C/M-324
Gt. Brit. Atomic Energy Research Establishment, Harwell, Berks, England.
$U^{235}$ THERMAL FISSION PRODUCT ACTIVITIES AND EMISSION POWERS PLOTTED AGAINST IRRADIATION AND DECAY TIMES. E. A. C. Crouch. July 1957. 10p.
The $\beta$ and $\gamma$ activities and emission powers of the total fission products of $U^{235}$ have been plotted against times of irradiation and decay in the range 1 to 1000 days. (auth)

**6445** ✓ A/CONF.15/P/1119
THE CARRIER-FREE SEPARATION OF UZ FROM 100 Kg URANYL NITRATE. J. van R. Smit, M. Peisach, and F. W. E. Strelow (South African Council for Scientific and Industrial Research, Pretoria). 11p.
The carrier-free separation of the UX complex from 100 kg $UO_2(NO_3)_2$ and the subsequent milking off of the 6.7-hour UZ activity in a re-investigation of the decay scheme of the UX complex are described. (W.L.H.)

### $U^{232}$ 1.43.03.02

**13530** ✓ DP-279
Du Pont de Nemours (E. I.) & Co. Savannah River Lab., Augusta, Ga.
FORMATION OF U-232 DURING THE IRRADIATION OF THORIUM. Daniel S. St. John and Edward C. Toops. Apr. 1958. 19p. Contract AT(07-2)-1. $0.75(OTS).
The formation of $U^{232}$ by (n,2n) reactions in pile-irradiated thorium is discussed. For thorium irradiated in a heterogeneous reactor, the total $U^{232}$ formed is produced by fast neutrons from two sources: (a) those which originate in the surrounding fuel elements, and (b) those produced by the fissioning of $U^{233}$ in the thorium itself. A Monte Carlo calculation is used to estimate the effective (n,2n) flux in heavy water or graphite surrounding a point source of fission neutrons. The results for the point source are integrated to give the effect of a line source or, approximately, a fuel rod. (auth)

**13529** ✓ CF-58-7-122
Oak Ridge National Lab., Tenn.
BUILDUP AND DECAY FACTORS FOR MEMBERS OF THE U-232 DECAY CHAIN. E. D. Arnold. July 31, 1958. 8p. Contract [W-7405-eng-26]. $1.80(ph OTS); $1.80(mf OTS).
Activity ratios for the important members of the $U^{232}$ chain are presented in tabular form. These ratios are presented for initially pure $U^{232}$, initially pure $Th^{228}$, and initially pure $Ra^{224}$. (auth)

### $U^{233}$ 1.43.03.03

THE SPECIFIC $\alpha$-ACTIVITY AND HALF-LIFE OF $U^{233}$. Ya. P. Dokuchayev and I. S. Osipov. Atomnaya Energ. 6, 73(1959) Jan. (In Russian)
The specific $\alpha$ activity of $U^{233}$ was determined for five uranium specimens with isotopic content (in wt. %): $U^{232} \sim 4 \times 10^{-3}$; $U^{233}$, 93.28 to 95.24; $U^{234}$, 2.25 to 2.36(±0.07); $U^{235}$, < 0.1; and $U^{238}$, 2.46 to 4.38(±0.07). The $\alpha$ activity of the specimens indicated 20,940 $\alpha$-decay/min per microgram $U^{233}$. Considering that all specimens had ~0.05 wt. % of practically inactive (in comparison to $U^{233}$) $U^{235}$ isotope, the $U^{233}$ specific $\alpha$ activity is 20,950 ± 100 $\alpha$ decay/min per $\mu$g. (R.V.J.)

**12507** ✓ LRL-109
California Research and Development Co. Livermore Research Lab., Livermore, Calif.
SOME ASPECTS OF THE PRODUCTION OF URANIUM-233 BY THE IRRADIATION OF THORIUM-232 WITH THERMAL NEUTRONS. T. E. Hicks and W. H. McVey. Mar. 1954. Decl. Feb. 27, 1957. 21p. Contract AT(11-1)-74. $0.25(OTS).
Within a system for the production of $U^{233}$ by thermal neutron irradiation of $Th^{232}$, the relative importance of fission and capture on $U^{233}$ production and production of neutrons from $U^{233}$ fission is studied. The maximum concentration of $U^{233}$ in $Th^{232}$, where the rate of $U^{233}$ destruction equals production, is found to be 11,500 grams per metric ton. Thirty percent neutron loss is found to be the point at which the ratio of productive $U^{233}$ atoms to neutrons entering the lattice stops increasing with $U^{233}$ concentration and starts decreasing. $U^{233}$ concentrations less than 2000 grams per metric ton are found to have little effect on the production lattice efficiency. (auth)

# URANIUM 1.43

## FISSION PRODUCTS, ISOTOPES, AND DECAY 1.43.03

### $U^{233}$ 1.43.03.03

**11493**✓ TID-5223
Argonne National Lab., Lemont, Ill.
PRODUCTION AND SEPARATION OF $U^{233}$. Collected Papers. Leonard I. Katzin, ed. 1952. Decl. with deletions Jan. 11, 1957. (Issued in two parts: TID-5223(Pt. 1), 420p. and TID-5223(Pt. 2), 323p.) $3.25(OTS).

This is a deleted version of NNES-IV-17B.

The assembled record of the significant work relating to $U^{233}$ done on the Manhattan Project up to July 1945 is presented. About 80 papers are presented. The papers included are: A new Fissionable Isotope of U: $U^{233}$; Determination of the Half Life of $U^{233}$; Radiation Spectrum of the Transition of $U^{233}$ to $Th^{229}$; The (4n + 1) Radioactive Series: Decay products of $U^{233}$; Fast Neutron Fission of $U^{233}$, $Pa^{231}$, and $Pu^{239}$; Abundance of $U^{238}$ in samples of $U^{233}$; Spontaneous-Fission Rate of $U^{234}$; Further Search for Spontaneous Fission in $U^{234}$; Test for Slow-Neutron Fission of $U^{234}$; New Isotopes of Pa and U: $Pa^{232}$ and $U^{232}$; Neutron Absorption and Production by $U^{233}$; Eta for $U^{233}$; Volatilization of Pa from Th in a stream of HF; A $MnO_2$ Procedure for Isolation and Concentration of Pa from Irradiated Th Compounds; Isolation of U without Carrier from Th Metal Bombarded with Deuterons; Feasibility of Separating $U^{233}$ from Th and $Pa^{233}$ by Solvent Extraction; Removal of U from Th by Means of a Semi-Continuous Solvent Extractor; Some General Solvent Extraction Considerations; Theoretical Consideration of Ether Extraction of $UO_2(NO_3)_2$ from Aqueous Solutions Containing Various Metal Nitrate Salting Agents; Influence of Various Nitrates on Diethyl Ether Extraction of Low Concentrations of U from Th; Solvent Extraction of $U^{233}$ from Highly Radioactive Material; A Remotely Controlled Laboratory Scale Apparatus; A Laboratory Metering Pump; Isolation of the First Milligram Quantities of $U^{233}$; A Continuous-Batch Solvent Extraction Apparatus; Study of $ThO_2$ Slurries; Analysis of Ore Residues for Pa and Th; Extraction of Pa from Carbonate Insoluble Residues of U Ores: I. Isolation and Purification of Pa Using HF, II. "Gel Procedure" for Isolation of Pa, III. $MnO_2$ Procedure; Half Life of $Pa^{231}$; Solubility of Pa in Common Acids; Chemistry of Pa: I. Some Observations on Solvent Extraction of Pa, II. Analysis of Ore Residues for Pa; Dissolution of Th and $ThO_2$ in $HNO_3$–HF and $HNO_3$–$(NH_4)_2SiF_6$ Mixtures; A study of the Peroxides of Th; A study of Thorium Peroxide Sulfate; Note on Electrolysis of $ThCl_4$ from Fused Salts; Note on Methods of Purification and Analysis of Anhydrous $ThCl_4$; A Physical Study of the Th–$H_2$ System; Complex Ions Formed by Th and Fe with Fluoride in Acid Solution; Preparation of Binary Compounds of Th from Th Metal; Precipitation of $Th(C_2O_4)_2$ from $HNO_3$ Solutions; Note on the Effect of HCl Concentration on Heat of Solution of $ThCl_4$; Precipitation of $Th(NO_3$ $Th(C_2O_4)_2$; A Method of Recovering Th from Slag; Preparation of Anhydrous $ThF_4$ for Metal Production; Production of Th by Metallothermic Reduction of $ThF_4$; Casting of Th and Some Properties of the Cast Metal; A Pilot Plant for Purification of $Th(NO_3)_4$ by Countercurrent Extraction; Extraction Purification of $Th(NO_3)_4$; Thermal Neutron Fission Cross Section of $Th^{229}$; The Protactinium Radioactive Series; Thermal Neutron Capture Cross Section of $Th^{230}$ by Measurement of $Th^{231}$; Thermal Neutron Fission Properties of $Pa^{233}$; Determination of Thermal Neutron Capture Cross Section of $Pa^{233}$; A New Isotope: $Pa^{229}$; Determination of Half Life of $Th^{230}$; Products of Deuteron and He ion Bombardments of $Pa^{231}$; Thermal Neutron Fission Properties of $Th^{228}$, $U^{232}$, $Pa^{231}$, $Th^{232}$, and $Th^{230}$; Counting Efficiency of a Mica-Window G-M Tube for 0.3 Mev $\gamma$-rays; Gamma-Ray Emission by $U^{235}$; Thermal Neutron Capture Cross Section of $Pa^{231}$; A Simple Electronic Device for Measurement of Short Half Lives; The Half Life of $Rn^{218}$; Half Life of $Th^{227}$; Thermal Neutron Fission Properties of $Th^{227}$: Half Life of $Pa^{232}$; Study of Radiation Characteristics of 6.8d $U^{237}$; Yield of 6.8d $U^{237}$ in Cyclotron and Pile; Determination of $Th^{234}$ Activity (II); Gamma Radiation of $U^{235}(Th^{231})$; Radiations of $Pa^{232}$; Report on Radiations of $Th^{231}$; and Upper Limit to Absorption Cross Section of $U^{236}$. (T.R.H.)

**9440**✓ AERE-NP/R-2140
Gt. Brit. Atomic Energy Research Establishment, Harwell, Berks, England.
TABLE OF CONSISTENT NUCLEAR DATA FOR $U^{233}$, $U^{235}$, AND $Pu^{239}$ FOR 2200 M/SEC NEUTRON. P. A. Egelstaff, K. W. Morton, and J. E. Sanders. Dec. 1955. 11p.

Five quantities relating to the behavior of fissile isotopes are tabulated for $U^{233}$, $U^{235}$, and $Pu^{239}$. These quantities are the average number of neutrons emitted per fission, the average number of neutrons emitted per neutron absorbed, $\sigma_a$, the absorption cross section, $\sigma_f$ the fission cross section and the ratio $(\sigma_a - \sigma_f)/\sigma_f$. (M.H.R.)

# URANIUM 1.43

## FISSION PRODUCTS, ISOTOPES, AND DECAY 1.43.03

### $U^{233}$ 1.43.03.03

**2860**

4

PHOTONEUTRONS FROM $U^{233}$ AND $Pu^{239}$ FISSION PRODUCTS IN HEAVY WATER. S. Bernstein, J. K. Leslie, C. R. McKinney, and H. K. Jackson (Oak Ridge National Lab., Tenn.). J. Appl. Phys. 27, 23-4(1956) Jan.

The yield of photoneutrons from $U^{235}$, $U^{233}$, and $Pu^{239}$ fission products in heavy water were compared. The number of photoneutrons per delayed neutron was found to be approximately the same for all three, in spite of the previously known large variations in the relative numbers of delayed neutrons from these isotopes. (auth)

**4762** AERE-R/M-98

Gt. Brit. Atomic Energy Research Establishment, Harwell, Berks, England.

THE BUILD-UP OF URANIUM ISOTOPES BY IRRADIATION OF U-233. W. G. Davey. Oct. 1956. 9p. (LMFS/P-6).

The buildup of higher isotopes by neutron irradiation of $U^{233}$ is analyzed using 2200 meter/sec neutron cross sections. (B.J.H.)

**8141** TNCC(US)-17

Brookhaven National Lab., Upton, N. Y.

BASIS OF U.S. BEST VALUES FOR CROSS SECTIONS OF $U^{233}$, $U^{235}$, AND $Pu^{239}$. D. J. Hughes, R. S. Carter, and R. B. Schwartz. [1957]. 5p. $1.80(ph OTS); $1.80(mf OTS).

The manner in which the U.S. best values were obtained from the many experimental results during the last decade is described. (M.H.R.)

**11357** AERE-NP/R-2104

Gt. Brit. Atomic Energy Research Establishment, Harwell, Berks, England.

THE HARWELL VALUES OF THE 2,200 m/sec NEUTRON DATA FOR $U^{233}$, $U^{235}$ AND $Pu^{239}$. P. A. Egelstaff, ed. Mar. 18, 1957. 9p.

THE FISSION CROSS-SECTION OF $U^{233}$ AND THE TOTAL EFFECTIVE CROSS-SECTIONS OF As, V, Ta, AND Bi. V. V. Vladimirskii, A. A. Panov, et al. Atomnaya Energ. 5, 69-70(1958). (In Russian)

The fission cross sections and total cross sections of As, Bi, Ta, and V were measured with a neutron spectrometer with a mechanical chopper. The resonance parameters for $U^{233}$ and As are tabulated. (R.V.J.)

### $U^{234}$ 1.43.03.04

**5538**

THE ENERGY OF ALPHA PARTICLES FROM $U^{234}$, $U^{238}$, AND $Th^{232}$. B. G. Harvey, H. G. Jackson, T. A. Eastwood, and G. C. Hanna (Atomic Energy of Canada Ltd., Chalk River, Ontario). Can. J. Phys. 35, 258-70(1957) March.

The $\alpha$-particle energies of $U^{234}$, $U^{238}$, and $Th^{232}$ were measured with a grid ionization chamber. The electronic equipment was designed to provide low noise, high resolution, and good long term stability. $Ra^{226}$, $Em^{222}$, $Po^{218}$, $Po^{214}$ and $Po^{210}$ were used as energy standards. An investigation was made of the corrections to the measurements due to variation in pulse rise-time, source thickness, and imperfact shielding of the collector by the grid. It was found that the experimentally observed resolution was satisfactorily accounted for by the combination of these factors and the noise and ionization straggling. Alpha particle pulse heights were measured in terms of the output of a precision pulse generator. The corrected pulse heights were related to the energies of the standard sources by a two-parameter least squares calculation; the standard deviation was never greater than 5 kev. On extrapolating to zero ionization the line so obtained intercepted the energy axis at 83 kev. The $\alpha$-particle energies deduced using this line were: $U^{234}$ 4.768 ± 0.003, $U^{238}$ 4.195 ± 0.005, $Th^{232}$ 4.007 ± 0.005 Mev. (auth)

**13532** UCRL-8215

California. Univ., Berkeley. Radiation Lab.

THE CROSS-SECTION OF THE REACTION $U^{234}(\alpha,4n)Pu^{234}$. Glen E. Gordon. Mar. 1958. 10p. Contract W-7405-eng-48. $0.50(OTS).

The cross section of the reaction $U^{234}(\alpha,4n)Pu^{234}$ was determined by the recoil technique, using the reaction $Pu^{239}(\alpha,3n)Cm^{240}$ to monitor the beam and to determine the recoil efficiency. The maximum in the cross section occurs at 42.6 Mev, where it is 0.98 ± 0.15 mb. (auth)

# URANIUM 1.43

## FISSION PRODUCTS, ISOTOPES, AND DECAY 1.43.03

### $U^{235}$ 1.43.03.05

**4777** AERE-R-3033
United Kingdom Atomic Energy Authority. Research Group. Atomic Energy Research Establishment, Harwell, Berks, England.
ENERGY RELEASE FROM FISSION PRODUCT DECAY. I. J. MacBean. Sept. 1959. 16p. BIS.
The average power emitted as gamma or beta radiation from $U^{235}$ thermal fission products is calculated as a function of time after fission. Previous work on the subject is surveyed and compared with the present results. (W.D.M.)

**4776** AERE-M-494
United Kingdom Atomic Energy Authority. Research Group. Atomic Energy Research Establishment, Harwell, Berks, England.
THE DECAY ENERGY OF THE FISSION PRODUCTS OF $U^{235}$. I. J. MacBean. Sept. 1959. 15p. BIS.
The information on the average power emitted as gamma or beta radiation from the fission products formed in thermal fission of $U^{235}$, as functions of the time after fission is reviewed. Data and calculations are taken from the sources considered to be best at the present time, and some new calculations were made. The total delayed gamma energy is estimated to be 7.0 ± 1 Mev/fission. Graphs of the functions and their integrals are presented in the report by MacBean. A revised estimate of the average total disintegration energy of all fission products has been based on the recent semi-empirical estimates by Hay and Newton of the fission-fragment masses. The result, which is 21.15 ± 0.35 Mev/fission, is surprisingly close to the much earlier estimate by Way and Wigner. (auth)

**22635** NAA-SR-Memo-4126
Atomics International Div., North American Aviation, Inc., Canoga Park, Calif.
ENERGY RELEASE FROM THE DECAY OF FISSION PRODUCTS. P. Speigler. July 31, 1959. 10p. $1.80(ph), $1.80(mf) OTS.
The beta-ray energy release, gamma-ray energy release, and gamma-ray energy spectrum were calculated as a function of time after shutdown for fission products due to thermal neutron fission of $U^{235}$. Calculations were carried out for reactor operating times of 100 hours, 1000 hours, and for an infinite operating time. Only the results for infinite operating time are given since it is possible to obtain from them the results for any finite operating time. (auth)

**2956** APEX-530
General Electric Co. Aircraft Nuclear Propulsion Dept., Cincinnati.
URANIUM-235 FISSION PRODUCT ACTIVITY AND ENERGY AS A FUNCTION OF DECAY TIME FOR A SPECIFIC IRRADIATION TIME AND THERMAL FLUX. C. B Magee. Apr. 1959. 21p. Contract AF33(600)-38062 and AT(11-1)-171. OTS.
The activity and beta minus power of the individual radioactive fission products are given as a function of cooling time up to about 30 hr for an irradiation time and thermal neutron flux that approximate conditions in a one-week irradiation in the Low Intensity Test Reactor (LITR). The recent compilation of Blomeke and Todd was used for the most part to obtain concentrations of individual nuclides. Totals of activity and $\beta^-$ power have been obtained from the values for the individual fission products, and these totals are compared in graphical form to similar totals given by Blomeke and Todd. Comparison is made also to totals of total power and gamma power given by Blomeke and Todd and to a modified Way-Wigner expression which is reported to represent either the $\gamma$ or $\beta^-$ power within a factor of 2 for cooling times from 10 seconds to 100 days. For cooling times beyond 30 hours the total quantities of Blomeke and Todd are compared to the same Way-Wigner expression. Some conclusions based on these comparisons are given at the end of Part II. (auth)

**3003**
FISSION PARAMETERS FOR $U^{235}$. George J. Safford and William W. Havens, Jr. (Columbia Univ., New York). Nucleonics 17, No. 11, 134-8; 205-6(1959) Nov.
A re-examination of all measurements of fission parameters of U-235 in the energy region in which instrumental resolution was not a problem was performed. From experiments, references, and theoretical calculations the following best values were obtained: total cross section, $\sigma_t = 694 \pm 1.3$b; scattering cross section, $\sigma_s = 15 \pm 2$b; absorption cross section, $\sigma_a = 679 \pm 3$b; fission cross section, $\sigma_f = 580 \pm 12$b; capture cross section, $\sigma_c = 99 \pm 13$b; average number of neutrons emitted per neutron absorbed in the fuel nuclide, $\eta = 2.07 \pm 0.02$; number of neutrons emitted per fission, $\nu = 2.43 \pm 0.02$; and the capture-to-fission ratio, $\alpha = 0.172 \pm 0.010$. The errors involved in the experimental values are discussed. (C.J.G.)

# URANIUM 1.43

## FISSION PRODUCTS, ISOTOPES, AND DECAY 1.43.03

### $U^{235}$ 1.43.03.05

**351** NARF-58-37T
Convair, Fort Worth, Tex.
CALCULATED GAMMA RAY SPECTRA FROM $U^{235}$ FISSION PRODUCTS. John F. Scoles. Aug. 29, 1958. 149p. Project No. 6(1-9964). Contract AF33(600)-32054. (FZK-9-132).

The gamma rays from fission products remaining in a reactor after operation are usually the most important contributors to the dose from a shutdown reactor or spent fuel assembly. To improve the accuracy of shielding calculations, the spectra of these gamma rays were calculated for various combinations of reactor operation time and time after shutdown. A literature survey was performed to obtain $U^{235}$ thermal fission yields and decay information. These data were used in a digital computer program to obtain the gamma ray energy in each of 28 energy groups. The results obtained are substantially more accurate than previous calculations of the same type. The improvement was obtained primarily by using more recently available nuclear data, by extending the length of the decay chains considered, and by a finer division of energy groups.

THE YIELDS OF THE CHEMICAL ELEMENTS IN THERMAL NEUTRON FISSION OF U-235. Mark T. Robinson and Joseph F. Krause (Oak Ridge National Lab., Tenn.). Nuclear Sci. and Eng. 1, 216-21(1956) July.

The yields of most of the chemical elements occurring in thermal neutron fission of $U^{235}$ have been calculated from available data on mass yields, radioactive half lives, and decay schemes of fission product nuclides. The results of the computations are presented graphically. (auth)

**5841** CEA-tr-A-599
DURÉE DE VIE ET SCHÉMA DE DÉSINTÉGRATION $^{235}U$. (Lifetime and Decay Scheme of $U^{235}$). E. Wurger, K. P. Meyer, and P. Huber. Translated into French from Helv. Phys. Acta 30, 157-82(1957). 39p.

An exact value of the $U^{235}$ decay constant is needed for accurate age determinations of U ores. A method is described for obtaining this value which involves a $\gamma-\alpha$ coincidence study of the $U^{235}$ decay scheme and a measurement of the ratio of $\alpha$ activity of $U^{235}$ and $U^{238}$ to $U^{234}$ in natural U. The apparatus and technique for these studies are described. The average value found for the ratio of intensities was $0.04776 \pm 0.00094$. The period calculated from this is $6.84 \pm 0.15 \times 10^8$ yr. (T.R.H.)

**14193**
NUCLEAR-CHARGE DISTRIBUTION IN FISSION: CUMULATIVE YIELDS OF SHORT-LIVED KRYPTON AND XENON ISOTOPES FROM THERMAL-NEUTRON FISSION OF $^{235}U$. Arthur C. Wahl (Washington Univ., St. Louis and Los Alamos Scientific Lab., N. Mex.). J. Inorg. & Nuclear Chem. 6, 263-77(1958) July.

Experiments are described in which use was made of the very large emanating powers of barium stearate and uranyl stearate for determination of cumulative yields for a number of krypton and xenon isotopes formed in the thermal-neutron fission of $U^{235}$. The results, expressed as the fraction of the total chain yield, are: $Kr^{89}$, $0.960 \pm 0.004$; $Kr^{90}$, $0.86 \pm 0.02$; $Kr^{91}$, $0.59 \pm 0.01$; $Kr^{92}$, $0.31 \pm 0.01$; $Xe^{139}$, $0.82 \pm 0.02$; $Xe^{140}$, $0.59 \pm 0.01$; $Xe^{141}$, $0.21 \pm 0.02$; $Xe^{143}$, $(8.5 \pm 0.5) \times 10^{-3}$; $Xe^{144}$, $(1.1 \pm 0.1) \times 10^{-3}$. These data along with previously reported independent-yield data are used for construction of an empirical curve of the most probable primary charge ($Z_P$) vs. mass number. In the regions where shell edges are absent the curve is about equidistant for complementary mass numbers from the most stable charge ($Z_A$) lines for light and heavy fragments as proposed in the postulate of equal-charge displacement; in the regions where shell edges are present the $Z_P$ curve makes a smooth continuous transition. The $Z_P$ curve tends to approach and remain close to the 50-proton shell edge. (auth)

**4594** AERE-R-2941
United Kingdom Atomic Energy Authority. Research Group. Atomic Energy Research Establishment, Harwell, Berks, England.
THE URANIUM SPECTRUM BETWEEN 3500 Å AND 5500 Å WITH ASSOCIATED ISOTOPIC SHIFTS. E. W. T. Richards and M. D. Crew. Sept. 1959. 205p. BIS.

Experiments are described which were carried out in an attempt to increase the fundamental knowledge of the U spectrum and because of the growing tendency to perform isotopic abundance measurements by means of emission spectroscopy. Information is given as to the wavelengths and relative strengths of the spectral lines in the region chosen and the isotopic shifts. The experiments were limited to the isotopes $U^{235}$ and $U^{238}$. The 21 ft spectrograph at Harwell was used as a photographic instrument. (W.D.M.)

# URANIUM 1.43

## FISSION PRODUCTS, ISOTOPES, AND DECAY 1.43.03

### $U^{235}$ 1.43.03.05

**14387** √
COMPOSITION OF PRODUCTS FORMED BY THERMAL NEUTRON FISSION OF $^{235}U$. II. CHEMICAL COMPOSITION OF STABLE AND RADIOACTIVE FISSION PRODUCTS. Jan Prawitz and Jan Rydberg (Research Inst. of National Defence, Sundbyberg, Sweden). Acta Chem. Scand. 12, 377-98(1958).

The chemical composition of stable and radioactive fission products has been calculated for seven different irradiation times between 1 day and 2 years, and for three different neutron fluxes, $10^{12}$, $10^{13}$, and $10^{14}$ n/cm sec. The results are given in the form of curves showing the $\beta$ activity and mole fraction of each element as a function of cooling time from 1 day up to about 15 years. The calculations are based on nuclear data published before July 1957. (auth)

**14188** ✓
COMPOSITION OF PRODUCTS FORMED BY THERMAL NEUTRON FISSION OF $^{235}U$. I. COMPILATION OF NUCLEAR DATA OF THE FISSION PRODUCTS. Jan Prawitz and Jan Rydberg (Research Inst. of National Defence, Sundbyberg, Sweden). Acta Chem. Scand. 12, 369-76(1958).

An extensive compilation is made of the data up to July 1957 for the fission yields, decay schemes, half lives, and thermal neutron cross sections of the $U^{235}$ fission products. (auth)

**12857** ✓
SHORT LIVED FISSION PRODUCT GAMMA RADIATION. W. Zobel and T.*A. Love (Oak Ridge National Lab., Tenn.). pp. 25-33 in "The Shorter-Term Biological Hazards of a Fallout Field." Gordon M. Dunning and John A. Hilcken, eds. Washington, Atomic Energy Commission—Department of Defense, 1958. 236p. Available from U. S. Government Printing Office for $1.75.

Samples of $U^{235}$ varying from 2 to 32 mg in size were sent pneumatically into a graphite reactor and removed after times ranging from 0.7 to about 64 seconds. The energy spectrum and time behavior of the gross fission-product gamma-ray mixtures was measured at short times, starting about 1 second after fission. Data are presented graphically. (C.H.)

**12895** ORNL-2127(Pt. II(Vols. 1 and 2))
Oak Ridge National Lab., Tenn.
URANIUM-235 FISSION-PRODUCT PRODUCTION AS A FUNCTION OF THE THERMAL NEUTRON FLUX, IRRADIATION TIME, AND DECAY TIME. II. SUMMATIONS OF INDIVIDUAL CHAINS, ELEMENTS, AND THE RARE-GAS AND RARE-EARTH GROUPS. VOLUMES 1 AND 2. J. O. Blomeke and Mary F. Todd. (Vol. 1, Dec. 19, 1957. 363p. and Vol. 2, June 10, 1958. 365p.). Contract W-7405-eng-26. (Vol. 1, $6.50(OTS) and Vol. 2, $5.00(OTS)).

These two volumes were issued separately, but are cataloged as a unit.

The following properties, per initial atom of $U^{235}$, are tabulated for each fission-product chain with mass number 72 to 161: activity, gamma power, total power, poisoning, and gamma disintegrations per second with energies up to 1.70 Mev. (M.H.R.)

**13531** ✓ UCRL-5208
California. Univ., Livermore. Radiation Lab.
TABLES OF TWO $U^{235}$ FISSION SPECTRA. R. J. Howerton, J. Bengston, and S. J. French. Oct. 1957. 5p. Contract W-7405-eng-48. $0.50(OTS).

The $U^{235}$ fission spectrum is tabulated as a function of energy for two analytic representations. The table contains the distribution functions, their first derivatives, and their first integrals up to 10 Mev. (auth)

ISOMERIC STATE OF URANIUM-235. Frank Asaro and I. Perlman (Univ. of California, Berkeley). Phys. Rev. 107, 318-19(1957) July 1.

An isomeric state decaying by emission of very soft electrons was found by collecting recoils from the $\alpha$ decay of $Pu^{239}$ and counting the $U^{235m}$ in a windowless proportional counter. Results indicate a half life of 26.5 ± 0.2 min and electron energy < 1 kev. (M.H.R.)

THE MASS DISTRIBUTION OF FRAGMENTS RESULTING FROM THE FISSION OF $U^{235}$, $U^{238}$, AND $Pu^{238}$ INDUCED BY 14.6 Mev NEUTRONS. A. N. Protopopov, G. M. Tolmachev, et al. Atomnaya Energ. 5, 130-4 (1958). (In Russian)

Methods and results of measurements are presented of the relative yields of fragments formed in $U^{235}$, $U^{238}$, and $Pu^{238}$ fission by 14.6-Mev neutrons. Fragment mass distribution curves are plotted. Peculiarities of certain distributions are discussed. (tr-auth)

# URANIUM 1.43

## FISSION PRODUCTS, ISOTOPES, AND DECAY 1.43.03

### $U^{235}$ 1.43.03.05

RESONANCE FISSION OF $U^{235}$. C. I. Browne (Los Alamos Scientific Lab., N. Mex.). Phys. Rev. 107, 325(1957) July 1.

Fission-product activity ratios produced by thermal-neutron fission of $U^{235}$ are compared with the ratios produced in the neutron fission of $U^{235}$ in a slowing down, or dE/E, spectrum. Ratios are compared to those of $Mo^{98}$.

27-MINUTE ISOMER OF $U^{235}$. J. R. Huizenga, C. L. Rao, and D. W. Engelkemeir (Argonne National Lab., Lemont, Ill.). Phys. Rev. 107, 319-20(1957) July 1.

Low-energy excited states of $U^{235}$ and sample separation methods are given. Least-squares analyses of decay curves give a half life of 26.6 ± 0.3 min for the $U^{235}$ isomer. Absorption experiments with $U^{235m}$ samples prepared by a recoil technique on thin films serve to show that the electrons are of very low energy, ≲2 kev. (M.H.R.)

**12933** UCRL-3877

California. Univ., Berkeley. Radiation Lab.

NUCLEAR DECAY SCHEMES IN THE ACTINIUM FAMILY (thesis). Richard C. Pilger, Jr. July 1957. 133p. Contract W-7405-eng-48. $21.30(ph OTS); $6.90(mf OTS).

With magnetic alpha-particle and electron high-resolution spectrographs and scintillation gamma-ray spectrometers, a study was made of the nuclear decay of a number of members of the actinium family—$U^{235}$, $Th^{227}$, $Ra^{223}$, $Rn^{219}$, $Po^{215}$, and $Bi^{211}$. Decay schemes are presented for each of these nuclides, together with such correlations as are possible with present theoretical nuclear models. The decay scheme of $U^{235}$ and a portion of that of $Th^{227}$ are interpretable in terms of the collective model and a spheroidal deformation; the decay schemes of $Po^{215}$ and $Bi^{211}$ display spherical shell-model characteristics; however, the intermediate nuclides present complexities not well understood. (auth)

**5030**

THE DECAY SCHEME OF URANIUM 235. Sven A. E. Johansson. Arkiv Fysik 10, No. 2, 97-108(1956).

The γ radiation from enriched $U^{235}$ has been investigated by means of a coincidence scintillation spectrometer. Gamma rays were found at 74, 110, 184, 200, 289, and 382 kev. The coincidence relations between the γ rays were investigated in detail. These measurements lead to a decay scheme which is in good agreement with the α spectrum. The possibility to interpret the level scheme as a system of rotational bands is discussed. (auth)

**6183**

ON THE DEPENDENCE UPON ENERGY OF THE FISSION PRODUCT POISONING OF $U^{235}$. U. L. Businaro, S. Gallone, and D. Morgan. J. Nuclear Energy 4, 319-25 (1957) Mar.

A calculation is made of the energy dependence of the average cross section of the fission products of $U^{235}$. Two methods are used. One is based on the average over many resonances of cross sections and uses low-energy data on average widths and spacings: the other applies the "continum theory" formulae normalized on experimental cross sections at 1 Mev. (auth)

**7500** TID-7531(Pt. 2)(Del.)(p.53-69)

Atomics International Div., North American Aviation, Inc., Canoga Park, Calif.

TESTING OF NUCLEAR FUELS BY THE DANGER COEFFICIENT METHOD. M. E. Remley and B. A. Engholm. p.53-69 [of] MODERN APPROACHES TO ISOTOPIC ANALYSIS OF URANIUM. A Conference Held at Chicago, February 5-7, 1957. 17p.

Reactors operating at essentially zero power can be used as sensitive non-destructive test instruments for quality control and isotopic assay determinations of nuclear fuels. Use of a zero-power water boiler for this type of testing has been investigated in a series of experiments performed with the Water Boiler Neutron Source at Atomics International. Uranium cylinders, 3.875 inches in length by 0.500, 0.600, and 0.750 inch in diameter, with enrichments in U-235 of 0.491, 0.711, 0.902, 1.399, and 2.778 weight per cent have been compared by the danger coefficient method. This method with the water boiler will detect U-235 enrichment differences of $9 \times 10^{-4}$ weight per cent for samples enriched to one per cent in U-235 and differences of $2.8 \times 10^{-3}$ weight per cent in samples of three per cent enrichment. A suggested procedure for the application of the method to the routine testing of fuel material is outlined. (auth)

ON THE ENERGY SPECTRUM OF γ RAYS EMITTED FROM $U^{235}$ FISSION PRODUCTS. E. Germagnoli and L. Mongini (Laboratori CISE, Milan). Energia nucleare (Milan) 3, 32-8(1956) Feb. 15. (In Italian).

The energy spectrum of γ rays emitted from fission products has been examined by means of a single crystal γ spectrometer over in interval of about 20 months after the irradiation of uranium. As long as isotopes whose half-life is longer than 5 days are considered, a satisfactory agreement has been found between the measured energies and intensities of γ lines and the expected ones. (auth)

# URANIUM 1.43

## FISSION PRODUCTS, ISOTOPES, AND DECAY 1.43.03

### $U^{235}$ 1.43.03.05

**9525** ✓

HALF LIFE AND DECAY SCHEME OF $U^{235}$. E. Wurger, K. P. Meyer, and P. Huber. Helv. Phys. Acta 30, No. 2-3, 157-82(1957). (In German)

The half life of $U^{235}$ with respect to alpha decay was measured by comparison of its alpha activity with the $U^{238}$ and $U^{234}$ activities of a source of natural uranium. As only one alpha group of the $U^{235}$ alpha spectrum can be measured without interference from the other uranium isotopes, some knowledge of the $U^{235}$ decay scheme is necessary for the calculation of its half life. Consequently the decay scheme of $U^{235}$, proposed by Ghiorso, has been tested and verified in a scintillation spectrometer by $\alpha-\gamma$ coincidences. Furthermore the conversion of the two $\gamma$ rays has been measured. The value of $6.84 \pm 0.15 \times 10^8$ years found for the half life of $U^{235}$ is in agreement with the value of $7.13 \pm 0.16 \times 10^8$ years found by absolute activity measurement. (auth)

**378** AEC-tr-3061

YIELD OF FISSION PRODUCTS OF $U^{235}$ IN THE RARE EARTH REGION. V. K. Gorshkov, R. N. Ivanov, G. N. Kukavadeze, and I. A. Reformatskii. Translated from Atomnaya Energ. III, 11-14(1957). 12p.

A description is given of results of measurements of the yields of the fission product of $U^{235}$ using the integral mass spectrographic method, which makes it possible to simultaneously determine the concentration of several elements in their mixtures. Using the integral mass spectrographic method, measurements of the yields of $La^{139}$, $Pr^{141}$, $Pm^{147}$, and $Pm^{149}$ are given for the first time. From these data the absorption cross sections for $Pm^{147}$ and $Sm^{147}$ are calculated, and the lower absorption cross section boundary for $Sm^{149}$ is given. (auth)

THE TOTAL $\gamma$-ACTIVITY OF U-235 FISSION PRODUCTS. V. N. Sakharov and A. I. Malofeyev. Atomnaya Energiya 3, No. 10, 334-5(1957).

The $\gamma$ activity of $U^{235}$ fission products is compared with the $\gamma$ activity of a simultaneously irradiated $Na^{23}$ target by means of a $\gamma$ counting tube which is equally sensitive within a wide $\gamma$ energy range. Irradiation took place in the Russian $D_2O$ reactor. The order of magnitude Q(t) (summated activity) is calculated. (TCO)

**8982** ✓ USNRDL-456

Naval Radiological Defense Lab., San Francisco.

CALCULATED ACTIVITIES AND ABUNDANCES OF $U^{235}$ FISSION PRODUCTS. R. C. Bolles and N. E. Ballou. Aug. 30, 1956. 260p.

This is a revised edition of ADC-65.

Computed disintegration rates and numbers of atoms (abundances) of each fission product radionuclide at various times after simultaneous slow neutron fission of 10,000 atoms of $U^{235}$ are presented. These results are based on fission yields from two different theories of independent fission yields. The computations treat both known and unknown fission product radionuclides. Half lives and yields of the latter were estimated. The disintegration rate, the number of active and of inactive atoms, the total number of atoms, and the percentage contribution to total activity and to total number of atoms are presented for each element and for each chemical group of elements. The disintegration rate of the total fission product mixture according to each independent yield theory is also presented. (auth)

FISSION NEUTRON SPECTRUM OF $U^{235}$. L. Cranberg, G. Frye, N. Nereson, and L. Rosen (Los Alamos Scientific Lab., N. Mex.). Phys. Rev. 103, 662-70(1956) Aug. 1.

The neutron spectrum associated with the fission of $U^{235}$ induced by slow neutrons has been remeasured from 0.18 to 12 Mev. Two different experimental techniques were employed in this measurement: (1) the time-of-flight method covering the energy range from 0.18 to 2.7 Mev, and (2) the photographic plate method encompassing the energy range from 0.35 to 12 Mev. The combined results of these measurements fit the relation, $N(E) = Ke^{-E/0.965} \sinh[(2.29E)^{1/2}]$, where N(E) is the neutron flux, E is the neutron energy in Mev and K is a constant. The simpler expression, $N(E) = KE^{1/2}e^{-0.775E}$, also fits the data well for neutron energies below 9 Mev. (auth)

**1581** ✓

THE ABSOLUTE FISSION YIELDS OF TWENTY-EIGHT MASS CHAINS IN THE THERMAL NEUTRON FISSION OF $U^{235}$. J. A. Petruska, H. G. Thode, and R. H. Tomlinson (McMaster Univ., Hamilton, Ont., Canada). Can. J. Phys. 33, 693-706(1955) Nov.

Twenty-eight absolute fission yields totalling 78% of the heavy and 16% of the light fragments have been determined using the mass spectrometer and isotope dilution techniques. The precision of the values obtained is in most cases better than 2%, and the absolute accuracy is estimated to be about 3%. Fine structure in the mass-yield curve is discussed in terms of structural preference and various chain branching mechanisms. (auth)

# URANIUM 1.43

## FISSION PRODUCTS, ISOTOPES, AND DECAY 1.43.03

### $U^{235}$ 1.43.03.05

**2197**

THE γ-RAY SPECTRUM OF FISSION PRODUCTS FROM SLOW NEUTRON IRRADIATION OF URANIUM-235. D. H. Peirson (Atomic Energy Research Establishment, Harwell, Berks, England). Brit. J. Appl. Phys. 6, 444-9(1955) Dec.

The fission products from $U^{235}$, irradiated by slow neutrons, have been analyzed by a two-crystal γ-ray scintillation spectrometer. The spectrum between 1 day and 70 days after irradiation has been recorded. The gross spectrum varies with time and consists of 2 groups of lines around 0.2 and 0.7 Mev, with a single line at 1.58 Mev as the only important component above 1 Mev. By measurement of energy and decay rates, 17 activities due to fission products of high yield are identified during the period of analysis. The spectrometer is described and its use as an analytical tool in other applications indicated. (auth)

**2859**

YIELD OF PHOTONEUTRONS FROM $U^{235}$ FISSION PRODUCTS IN BERYLLIUM AND DEUTERIUM. S. Bernstein, W. K. Ergen, F. L. Talbott, J. K. Leslie, and C. P. Stanford (Oak Ridge National Lab., Tenn.). J. Appl. Phys. 27, 18-22(1956) Jan.

The yield of photoneutrons from a sample of $U^{235}$ fission products at the center of a 9-in. diameter Be sphere was measured. Samples of $U^{235}$ were exposed to neutrons in the reactor for periods of 15 min, 6 hr, and 74 hr. The photoneutrons created by the fission product gamma rays acting upon the Be nuclei were observed from 0.3 sec to about 4 weeks after the end of the exposure. Curves showing the photoneutron yield as a function of time, relative to the delayed neutron yield, are given for these exposure and observation times. The attempt was made to account for the observed yields from Be in this experiment, and the yield from $D_2O$ observed in an earlier experiment, in terms of known fission product gamma emitters. (auth)

**10976** IDO-16269

Phillips Petroleum Co. Atomic Energy Div., Idaho Falls, Idaho.

ENERGY DEPENDENCY OF η FOR $U^{235}$ IN THE REGION 0.04 – 1.0 EV. J. R. Smith and E. H. Magleby. Nov. 21, 1955. 7p. Contract AT(10-1)-205. (PTR-19). $1.80(ph OTS); $1.80(mf OTS).

Measurements have been made of the energy dependence of η, the number of fission neutrons emitted per neutron absorbed, for $U^{235}$ in the energy region 0.04 to 1.0 ev. Two 5-in. Hornyak buttons on DuMont 6364 photomultiplier tubes count fission neutrons from a target of $U^{235}$ placed between them in the Bragg beam of the MTR crystal spectrometer. A sample changer moves the target into and out of the beam, enabling a single thin $BF_3$ counter behind the target to serve as both flux monitor and transmission detector. The data are normalized to the Brookhaven slow chopper results, which were normalized to the thermal value of η = 2.08. Below 0.1 ev η is essentially flat. Above 0.1 ev it falls to a value of 1.95 for the 0.3 ev resonance, then rises to a peak of about 2.2 between 0.5 and 1.0 ev. In the neighborhood of 1 ev η decreases as the 1.12 ev resonance is approached. (auth)

**9787** ANL-5283

Argonne National Lab., Lemont, Ill.

THE REGENERATION FACTOR AS A FUNCTION OF TIME IN A $Th^{232}$–$U^{235}$ THERMAL REACTOR. J. C. Carter. Sept. 1954. Decl. Feb. 12, 1957. 24p. Contract W-31-109-Eng-38. $0.25(OTS).

A theoretical investigation of the variation of the regeneration factor η in a $Th^{232}$-$U^{235}$ thermal reactor was made. The abundances of the significant isotopes in the thorium-uranium cycle have been derived as a function of irradiation time at constant reactor power. The change in η as a function of irradiation time at constant power was calculated for combinations of enrichment and resonance escape probability considered likely to exist in a thermal reactor. The effect upon η of the absorption cross section of $_{91}Pa^{233}$ and of the fission products has been shown. (auth)

### $U^{236}$ 1.43.03.05

**9184**

THE ACTIVATION CROSS-SECTION OF $U^{236}$. B. V. Efimov and Y. I. Mityaev. J. Nuclear Energy 5, No. 1, 158-9(1957).

The value of 24.6 ± 6b was found for the radiative capture cross section of $U^{236}$. (M.H.R.)

# URANIUM 1.43

## FISSION PRODUCTS, ISOTOPES, AND DECAY 1.43.03

### $U^{238}$ 1.43.03.07

**5834** ✓ DASA-525
Defense Atomic Support Agency, Washington, D. C.
CALCULATED ABUNDANCES AND ACTIVITIES OF THE PRODUCTS OF HIGH ENERGY NEUTRON FISSION OF URANIUM-238. P. J. Dolan. May 7, 1959. 123p.

Calculated abundances and activities of each fission product radionuclide as well as the activity of the total fission product mixture at various times after simultaneous high-energy neutron fission of 10,000 atoms of $U^{238}$ are presented in tabular form. The percentage contribution to the total activity of each fission product radionuclide and the disintegration rate of the total fission product mixture are presented graphically. (auth)

**5835** ✓ DASA-526
Defense Atomic Support Agency, Washington, D. C.
GAMMA SPECTRA OF URANIUM-238 FISSION PRODUCTS AT VARIOUS TIMES AFTER FISSION. P. J. Dolan. May 7, 1959. 58p.

Calculated gamma spectra produced by 14-Mev fission of $U^{238}$ are tabulated for various times after fission. Similar tabulations are given omitting certain volatiles and portions of their daughter products. The tabulated data are also presented in graphical form. (auth)

**3030**
NUMBER OF PROMPT NEUTRONS EMITTED PER THORIUM-232 FISSION. A. B. Smith, R. G. Nobles, and S. A. Cox (Argonne National Lab., Lemont, Ill.). Phys. Rev. 115, 1242-3(1959) Sept. 1.

The number of prompt neutrons emitted per $Th^{232}$ fission [$\nu_{Th232}$] is compared to the number emitted per $U^{238}$ fission [$\nu_{U^{238}}$]. At a bombarding neutron energy of 1.4 Mev the ratio $\nu_{Th\,238}/\nu_{U^{238}} = 0.98 \pm 0.08$. (auth)

**5884** ✓
THE RATE OF EMISSION OF SPONTANEOUS FISSION NEUTRONS BY NATURAL URANIUM. D. J. Littler (Atomic Energy Research Establishment, Harwell, Berks, Eng.). Reactor Sci. 11, 34(1959) Nov.

Corrections are made on the value of the spontaneous fission neutron yield of natural uranium reported by D. J. Littler (Proc. Phys. Soc. A65, 203'1952)). The corrected value is $(1.52 \pm 0.05) \times 10^{-2}$ n/sec/g. (C.J.G.)

**5880** ✓
MEASUREMENT OF THE SPONTANEOUS FISSION NEUTRON YIELD OF NATURAL URANIUM. A. W. Waltner and B. E. Leonard (North Carolina State Coll., Raleigh). Reactor Sci. 11, 1-7(1959) Nov.

A measurement of the spontaneous fission neutron yield of natural uranium was made by the activation of approximately 1500 l. of $KMnO_4$ solution in a sub-critical assembly containing over 5000 lb of natural uranium. By filtering a large volume of this solution, sufficient manganese activity is removed as $MnO_2$ by the Szilard-Chalmers effect to provide an accuracy of 1.5% in the result. However, since the total efficiency of $MnO_2$ extraction process was not known to this high degree of accuracy, comparison of the activation by Pu-Be sources of known strength superimposed over the uranium was made. This provided the spontaneous fission neutron yield of natural uranium in terms of the Pu-Be source calibration. A value of $(1.532 \pm 0.061) \times 10^{-2}$/sec per g was obtained. (auth)

**16857**
THE DISTRIBUTION OF SPONTANEOUS FISSION EVENTS IN $U^{238}$ OVER FRAGMENT ENERGY. B. S. Kovrigin and K. A. Petrzhak. Atomnaya Energ. 4, 547-54(1958) June. (in Russian)

Records were made of 780 spontaneous fission events of $U^{238}$ and 4500 events of $U^{235}$ fission by slow neutrons. The data were used for plotting the statistical distribution of the events over the fragment energy. The following curves were developed for both fission events: the energy spectra for all fragments and separately for the light and heavy fragments; the distribution of events by the total kinetic energy for both fragments of the nucleus; distribution of fission fragments by masses; the dependence of the total mean kinetic energy of light and heavy fragments on their total kinetic energy. Results for both isotopes show great resemblance. It was revealed that the total kinetic energy of the two fragments in $U^{238}$ spontaneous fission is about 4 Mev less than that for $U^{235}$ thermal fission. (tr-auth)

**12090** ✓
STUDY OF THE RADIOACTIVITY OF URANIUM USING PHOTONUCLEAR EMULSIONS. J. Catalá and J. Casanova. Anales real soc. españ. fís. y quím. (Madrid) A54, 93-100(1958) Mar.-Apr.

The radioactivity of natural uranium was studied using the photographic method. Some plates loaded with silk wires were soaked in uranium salts, and a theory to justify the existence of short-range alpha tracks is given. (auth)

# URANIUM 1.43

## FISSION PRODUCTS, ISOTOPES, AND DECAY 1.43.03

### $U^{238}$ 1.43.03.07

**15179** A/CONF.15/P/643
Naval Radiological Defense Lab., San Francisco.
RADIOCHEMICAL STUDIES OF THE FAST NEUTRON FISSION OF $U^{235}$ AND $U^{238}$. L. R. Bunney, E. M. Scadden, J. O. Abriam, and N. E. Ballou. 7p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Radiochemical studies of the fast neutron fission of $U^{235}$ and $U^{238}$ have been made in the mass region beyond mass 143 with two neutron energy distributions. These studies provide measurements of the relative fission yields of several chains in the rare earth group in fission of $U^{235}$ and $U^{238}$ caused by neutrons with an energy distribution very close to unmoderated fission neutrons and by neutrons with an energy distribution peaked at 8 Mev. The increased contribution of very asymmetric modes of fission as the energy of the compound nucleus is increased is clearly shown by the results. In the fission of $U^{238}$ the yield at mass 161 is increased 2.9 times at the higher neutron energy. No previous measurements have been published on radiochemical studies of the fission of $U^{238}$ at these neutron energies beyond mass 144 except at mass 156 for the lower neutron energy. (auth)

**4763** UCRL-4735
California. Univ., Livermore. Radiation Lab.
THERMAL-NEUTRON-CAPTURE GAMMA-RAY SPECTRUM FROM $U^{238}$. R. W. Kenney and J. T. Mattingly. Oct. 30, 1956. 13p. Contract W-7405-eng-48. $0.20 (OTS).

The prompt $\gamma$-ray spectrum initiated by thermal neutron capture in $U^{238}$ was measured by observing the photon spectrum from a target of $U^{238}$ placed in the Water Boiler Neutron Source thermal neutron beam. The photon detector was a three-crystal scintillation spectrometer of conventional design. Three gamma-ray lines were identified. Their energies and their production cross sections were found to be, 4.0, 5.9, and 7.5 Mev and 1.3, 0.2, and 0.1 barns respectively. The spectral shape corresponds to class 2-b of Mittelman, and is typical of heavy elements. (auth)

**6184**
LOW-LYING LEVELS IN $U^{238}$ EXCITED BY INELASTIC NEUTRON SCATTERING. Robert C. Allen (Los Alamos Scientific Lab., N. Mex.). Phys. Rev. 105, 1796-8(1957) Mar. 15.

Analysis of neutrons inelastically scattered by $U^{238}$ indicates that the first two excited states in $U^{238}$ are at 50 ± 20 kev and 140 ± 25 kev. The inelastic collision cross sections, the total inelastic scattering cross sections, and the partial inelastic scattering cross sections for the excitation of these levels are presented for neutron energies of 150, 250, and 500 kev. (auth)

**6547**
PHOTONEUTRON EMISSION FROM $Th^{232}$, $U^{233}$, $U^{238}$, AND $Pu^{239}$. L. Katz, K. G. McNeill, M. LeBlanc, and F. Brown (Univ. of Saskatchewan, Saskatoon, Sask. and Atomic Energy of Canada Ltd., Chalk River, Ont.). Can. J. Phys. 35, 470-6(1957) Apr.

Measurements have been made of the numbers of neutrons emitted by the fissile materials $Th^{232}$, $U^{233}$, $U^{238}$, and $Pu^{239}$ under irradiation by betatron x rays of various energies up to 23 Mev. Yield curves and corresponding cross section curves are given for these nuclides. At low x-ray energies it is found that the yield curves differ from those found with non-fissile heavy elements, corresponding to the fact that even at zero x-ray energy the fissile materials suffer (spontaneous) fission. (auth)

EFFECTIVE REACTOR CROSS SECTIONS IN MTR FUEL ASSEMBLIES. J. Halperin and J. O. Blomeke (Oak Ridge National Lab., Tenn.) and D. A. Mrkvicka (Argonne National Lab., Chicago). Nuclear Sci. and Eng. 3, 395-402(1958) Apr.

Analyses of uranium, neptunium, and plutonium isotopes have been carried out on dissolved MTR fuel elements. Effective reactor cross sections computed from these measurements are in good agreement with differential cross-section measurements. In particular, effective cross-section values were found for $U^{236}$ and $U^{238}$ of 34 barns and 23 barns, respectively. (auth)

# URANIUM 1.43

## FISSION PRODUCTS, ISOTOPES, AND DECAY 1.43.03

### $U^{238}$ 1.43.03.07

**12089** ✓ LA-2144
Los Alamos Scientific Lab., N. Mex.
$U^{238}$ CROSS SECTIONS AND THEIR TEMPERATURE DEPENDENCE. Joseph J. Devaney and Bertha G. Fagan. July 1957. Revised Mar. 1958. 109p. Contract W-7405-eng-36. $2.50(OTS).

A Breit-Wigner analysis of $U^{238}$ is folded into a Maxwell velocity distribution to obtain total, scattering, and radiative capture cross sections vs. neutron energy from 0.025 to 419 ev and for $U^{238}$ temperatures of 0.0253 to 500 ev. (auth)

INVESTIGATION OF THE ISOTOPE EFFECT IN THE URANIUM SPECTRUM. A. R. Striganov and L. A. Korostyleva. Soviet Phys. JETP 2, 277-89(1956) Mar. (In English). Zhur. Eksptl.' i Teoret. Fiz. 29, 393-405 (1955) Oct. (In Russian)

The isotope shift in the spectrum of uranium has been measured for 346 lines among the components of the isotopes $U^{238}$ and $U^{235}$. The regularities obtained in the isotope shift have been employed for the extension of the classification of the uranium spectrum and for the establishment of the isotope shift in several terms of U I and U II. Starting from the shift of the terms $5f^47s^6I_{9/2}$ and $5f^37s^2\ ^4I_{9/2}$, it is found that the lowest electron configuration of U II is $5f^47_1$. (auth)

**8935** CF-55-9-168(Rev.)
Oak Ridge National Lab., Tenn.
THE CALCULATION OF NEUTRON RADIATIVE CROSS-SECTIONS OF NUCLEI. Lawrence Dresner. Nov. 3, 1955. 8p. Contract [W-7405-eng-26]. $1.80(ph OTS); $1.80(mf OTS).

The derivation of the Wigner equation for the radiative capture cross-section was reviewed and its relation to an exact expression was examined, and the exact expression was compared with the experimental radiative capture cross section for $U^{238}$. (F.S.)

## FLUORIDES 1.43.04

### $UF_4$ 1.43.04.01

**15099** ✓
THE FLUORIDES OF URANIUM. III. KINETIC STUDIES OF THE FLUORINATION OF URANIUM TETRAFLUORIDE BY FLUORINE. V. Y. Labaton and K. D. B. Johnson (United Kingdom Atomic Energy Authority, Capenhurst Works, Chester, Eng.). J. Inorg. & Nuclear Chem. 10, 74-85(1959) Apr.

The reaction between uranium tetrafluoride and fluorine was studied between 265 and 348°C by following the change in weight of the solid phase, using a spring balance. Formation of uranium hexafluoride at the solid surface is accompanied by migration of fluorine ions into the $UF_4$ lattice. The rate of production $UF_6$ is in agreement with the kinetics expected for reaction between a gas and a solid at a continuously diminishing spherical interface. The rate of reaction depends on the temperature; no reaction is detectable below 220°C. Within the limits of experimental accuracy the Arrhenius equation relates the reaction-rate constant and the temperature of reaction: the activation energies determined for three preparations of $UF_4$ were 15.5, 19.1, and 19.9 kcal per mole. A linear relationship is shown to exist between the reaction rate and partial pressure of fluorine, but within the range examined the reaction rate is not affected by the velocity of gaseous reactant past the solid. The rate of $UF_6$ production is dependent on an "effective" surface area of $UF_4$, rather than the surface area determined by gaseous adsorption. (auth)

SINTERING AND HOT PRESSING OF URANIUM TETRAFLUORIDE. E. Barnes and P. Murray (Atomic Energy Research Establishment, Harwell, Berks, Eng.). J. Am. Soc. 41. 246-8(1958) July.

The basic sintering and hot-pressing conditions have been established for $UF_4$. Either sintering of cold compacted material in argon or direct hot pressing in graphite dies can be used satisfactorily to obtain high-bulk-density compacts. Vacuum sintering is ruled out because of the volatility of the $UF_4$. The occurrence of black localized areas in both sintered and hot-pressed material is attributed to the internal distortion of fluorine atoms into lattice voids resulting in the formation of strained areas. (auth)

# URANIUM 1.43

## FLUORIDES 1.43.04

### $UF_4$ 1.43.04.01

**15100**

THE FLUORIDES OF URANIUM. IV. KINETIC STUDIES OF THE FLUORINATION OF URANIUM TETRAFLUORIDE BY CHLORINE TRIFLUORIDE. V. Y. Labaton (United Kingdom Atomic Energy Authority, Capenhurst Works, Chester, Eng.). J. Inorg. & Nuclear Chem. 10, 86-93(1959) Apr.

The reaction between uranium tetrafluoride and chlorine trifluoride was studied between 17 and 193°C using the same basic technique as was used in an investigation of the uranium tetrafluoride-fluorine reaction. This consists essentially of following the change in weight of the solid phase using a spring balance. The mechanism and kinetics of reaction were shown to be substantially the same for chlorine trifluoride as fluorine. The reaction rate passes through a maximum at 105°C, falls to a minimum at 148°C and then rises again. An explanation of this unusual behavior is suggested. In the regions 17 to 58°C and 156 to 194°C, within the limits of experimental accuracy, the Arrhenius equation relates the reaction-rate constant and the temperature of reaction; the activation energies determined for uranium tetrafluoride prepared by hydrofluorination were 5.6 and 3.4 kcal per mole, respectively. A linear relationship is shown to exist near ambient temperature between the reaction rate and partial pressure of chlorine trifluoride. In the velocity range examined, gas velocity had no effect on the reaction rate. (auth)

**184**

THE REACTION OF URANIUM TETRAFLUORIDE WITH CALCIUM SULFATE. Mark T. Robinson (Oak Ridge National Lab., Tenn.). J. Am. Chem. Soc. 79, 5418-19 (1957) Oct. 20.

Uranium tetrafluoride has been observed to react readily with calcium sulfate at temperatures above 630°C, forming $CaF_2$, $U_3O_8$, $SO_2$, and $SO_3$. (auth)

NEW METHOD FOR THE PRODUCTION OF URANIUM TETRAFLUORIDE. (to United Kingdom Atomic Energy Authority). German Patent DAS 1033 647. Atompraxis 4, 477(1958). (In German)

**18858** AECU-4244

Los Alamos Scientific Lab., N. Mex.

THE AQUEOUS SOLUBILITY OF $UF_4$. Albert W. Savage, Jr., and James C. Browne. [1958?]. 9p. Contract [W-7405-eng-36]. $1.80(ph), $1.80(mf) OTS.

The solubility of $2UF_4 \cdot 5H_2O$ was measured at 25°C as a function of added fluoride in mixtures of hydrofluoric and perchloric acids at a constant strength of 0.12 M. Evidence was found for the existence in solution of the species $UF_5^-$, $UF_4 \cdot$, and $UF_3^+$. (auth)

**7570** BMI-1103

Battelle Memorial Inst., Columbus, Ohio.

DIFFERENTIAL THERMAL ANALYSIS OF URANIUM TETRAFLUORIDE–URANIUM DIOXIDE MIXTURES. Robert A. Ewing and Arthur E. Bearse. June 28, 1956. Decl. Feb. 20, 1957. 22p. Contract W-7405-eng-92. $0.35(OTS).

Approximate melting points have been determined for 5 samples of $UF_4$ representing incompletely converted $UO_2$ and covering the range from about 2 to 20 wt.% $UO_2$, using the method of differential thermal analysis. The results indicate that melting temperatures are in the range of 910 to 940°C. No significant correlation between melting point and $UO_2$ content was observed, possibly because of eutectic formation. Similar results were obtained on synthetic mixtures of $UF_4$ containing from 10 to 40 wt.% $UO_2$. (auth)

**266**

THE PHOTOLYTIC SEPARATION OF URANIUM FROM ALUMINIUM AND THORIUM, CERIUM AND LANTHANUM. K. Singh, Balaram Sahoo, and D. Patnaik (Ravenshaw College, Cuttack, India). Proc. Indian Acad. Sci., Sec. A 50, 129-31(1959) Aug.

The photolytic process of isolating the hydrated uranium complex $NH_4F \cdot UF_4 \cdot H_2O$ was applied to the separation of uranium from aluminum and a mixture of thorium, cerium, and lanthanum. Sunlight was used as the source of energy for the photolysis. It is reported that 100% pure uranium is obtained, with a recovery of 99% pure uranium ~~is obtained with a recovery of 99%~~ from aluminum and 93 to 95% from thorium, cerium, and lanthanum. (C.J.G.)

# URANIUM 1.43

## FLUORIDES 1.43.04

### $UF_4$ 1.43.04.01

**7574** CF-56-6-125
Oak Ridge National Lab., Tenn.
DEHYDRATION OF URANIUM TETRAFLUORIDE HYDRATE. L. L. Annas. June 22, 1956. Decl. Feb. 14, 1957. 7p. Contract [W-7405-eng-26]. $0.25(OTS).

Results indicate that $UF_4 \cdot {}^3/_4\ H_2O$ can be successfully dehydrated continuously and batchwise in a dry $N_2$ atmosphere at elevated temperatures. (T.R.H.)

**13029** ✓ HW-35814
General Electric Co. Hanford Atomic Products Operation, Richland, Wash.
PRECIPITATION OF URANIUM AMMONIUM FLUORIDE FROM UNH SOLUTIONS AS AN INTERMEDIATE IN THE PREPARATION OF URANIUM TETRAFLUORIDE. W. B. Tolley. Feb. 1, 1955. Decl. Feb. 23, 1957. 11p. Contract W-31-109-Eng-52. $0.25(OTS).

Uranyl solutions can be reduced with ferrous ions in the presence of fluoride, precipitating a uranium (IV) fluoride. $UF_4$ prepared in this manner is difficult to filter and wash and generally is not suitable as an intermediate. Dehydration can only be accomplished in a HF atmosphere at elevated temperatures, thereby incorporating the difficulties experienced in the hydrofluorination process. However, $U(NO_3)_2$ solutions reduced in the presence of $(NH_4)_2F_2$ or $NH_4F$ yield a double salt, $UF_4(NH_4F)$, fluoride, which exhibits excellent precipitate characteristics. This compound can be decomposed at 375°C to $UF_4$ and volatile $NH_4F$. The $NH_4F$ is easily trapped and can be recycled for subsequent precipitations. $UF_4$ prepared by precipitation from $U(NO_3)_2$ solutions has been reduced in an hermetically sealed bomb by reaction with Ca. Reduction yields of approximately 80% were realized on a 20-gm. scale. During reduction the co-precipitated Fe is concentrated in the U. (auth)

**11140** ✓ RDB(C)/TN-60
Gt. Brit. Culcheth Labs., Culcheth, Lancs, England.
THE REACTION OF $UF_4$ WITH $UF_6$. J. S. Broadley and P. B. Longton. Mar. 1, 1954. 13p. (DDC/P-68).

As part of an investigation into the corrosion of metals by $UF_6$ the system $UF_4(s)-UF_6(g)$ has been studied under closely defined experimental conditions. The formation of the intermediate fluorides $U_4F_{17}$, $U_2F_9$ and $\beta UF_5$ was found to be stepwise, each stage proceeding at a well defined reaction-initiation temperature. The properties of the intermediate fluorides obtained were compared with previous findings, and were identified by x-ray-diffraction analysis. (auth)

**13032** LA-1860
Los Alamos Scientific Lab., N. Mex.
EFFECTS OF CERTAIN VARIABLES UPON THE REACTIONS FOR PREPARATION, BY THE DRY METHOD, OF $UF_4$ FROM $U_3O_8$. R. W. Kewish and O. E. Fry. Nov. 4, 1954. Decl. May 2, 1957. 22p. Contract W-7405-eng-36. $0.30(OTS).

The effects of certain process variables on the production of $UF_4$ from $U_3O_8$ have been studied. It was found that the initial step (reduction of $U_3O_8$ to $UO_2$ by $H_2$) is complete in a few minutes at an elevated temperature. The rate of conversion was shown to be temperature dependent. An optimum temperature was determined for the conversion of $UO_2$ to $UF_4$ by HF. Changes resulting from the present study and yielding an increased efficiency in the production process are described. (auth)

**10848** ✓ K-849
Carbide and Carbon Chemicals Co. K-25 Plant, Oak Ridge, Tenn.
REACTIONS OF GASEOUS CHLORINE TRIFLUORIDE WITH URANIUM TETRAFLUORIDE. W. Davis, Jr. and R. L. Jarry. Dec. 18, 1953. Decl. Feb. 26, 1957. 38p. Contract W-7405-eng-26. $0.40(OTS).

The reaction of gaseous chlorine trifluoride with uranium tetrafluoride has been studied at 40, 60, and 80°C and at initial chlorine trifluoride pressures of 5 to 50 cm. Under these conditions the initial value of the mole ratio $(ClF_3)/(UF_4)$ varied from 2 to 20. To a first approximation the stoichiometry is given by equation 1 and the rate of conversion by equation 6, where t is the time, k a constant, z the number of moles of uranium hexafluoride formed from $x_0$ moles of uranium tetrafluoride: (1) $UF_4 + 0.9\ ClF_3 \rightarrow UF_6 + 0.7\ ClF + 0.1\ Cl_2$; and (6) $1 - z/x_0 = e^{-kt}$. Within the pressure range studied the reaction is essentially independent of the chlorine trifluoride pressure. Average values of k at 40, 60, and 80°C are 0.551, 0.584, and 0.800 per hour, corresponding to 43%, 45%, and 55% conversion of unreacted solid per hour. The effect of temperature on the reaction is thus small. Uranium pentafluoride has been found in solid residues, indicating the reaction occurs, at least partially, by the sequence $UF_4 \rightarrow UF_5 \rightarrow UF_6$. (auth)

# URANIUM 1.43

## FLUORIDES 1.43.04

### $UF_4$ 1.43.04.01

**13867** LA-472
[Los Alamos Scientific Lab., N. Mex.]
PREPARATION OF URANIUM METAL BY THE BOMB METHOD. R. D. Baker, B. R. Hayward, C. Hull, H. Raich, and A. R. Weiss. June 25, 1946. Decl. Dec. 2, 1957. 49p. Contract [W-7405-eng-36]. $7.80 (ph OTS); $3.30(mf OTS).

A detailed description of methods of preparation of uranium by bomb reduction of $UF_4$ is presented. Developmental work for all scales of reduction is given, and it is pointed out that the larger-scale reduction techniques are in use for production of $U^{235}$ metal. (auth)

**10792** K-410
Carbide and Carbon Chemicals Corp. K-25 Plant, Oak Ridge, Tenn.
THERMAL DECOMPOSITION OF THE COMPOUND URANIUM TETRAFLUORIDE–AMMONIUM FLUORIDE. H. A. Bernhardt, R. A. Gustison, and J. C. Posey. June 1, 1949. Decl. Oct. 17, 1955. 10p. Contract [W-7405-eng-26]. (KLO-104). $1.80(ph OTS); $1.80(mf OTS).

When $UF_4$ is precipitated from a solution containing $NH_4F$, the precipitate contains slightly more than one mole of $NH_4F$ per mole of $UF_4$. The thermal decomposition in vacuo of this additional compound was studied over the temperature range 151 to 385°C. At a temperature of 375°C, the decomposition may be carried practically to completion in 100 minutes.

**10853** MCW-218
Mallinckrodt Chemical Works, St. Louis.
DETERIORATION OF URANIUM TETRAFLUORIDE DURING STORAGE IN STEEL DRUMS. Carl W. Kuhlman. Sept. 14, 1949. Decl. Feb. 26, 1957. 3p. Contract [W-14-108-Eng-8]. $1.80(ph OTS); $1.80(mf OTS).

A lot of Plant 4 green salt was stored for 1½ years and assayed periodically. Nonsignificant or only slightly significant change in assay was observed during this period. (D.E.B.)

**2570** Y-42
Carbide and Carbon Chemicals Corp. Y-12 Plant, Oak Ridge, Tenn.
THE VAPOR PRESSURE OF URANIUM TETRAFLUORIDE. K. O. Johnsson. Oct. 20, 1947. Decl. Dec. 7, 1955. 19p. Contract [W-7405-eng-26]. $3.30(ph OTS); $2.40(mf OTS).

The vapor pressure of $UF_4$ has been measured in the temperature range 850 to 1000°C. The method is a static one, using the pressure of an inert gas balanced against the pressure of vaporous and solid $UF_4$ in equilibrium. The $UF_4$ vapor is separated from the gas, whose pressure is measured with common type gauges, by means of a thin monel diaphragm. (auth)

**8826** AECD-4235
Carbide and Carbon Chemicals Co. K-25 Plant, Oak Ridge, Tenn.
HYDROLYSIS OF URANIUM TETRA-FLUORIDE. Harvey A. Bernhardt. Jan. 10, 1953. Decl. Feb. 8, 1956. 4p. Contract [W-7405-eng-26]. (KLI-1918). $1.80(ph OTS); $1.80(mf OTS).

A direct determination of the equilibrium constant of the reaction $UF_4 + 2H_2O \rightleftharpoons UO_2 + 4HF$ was made in the temperature range 200 to 500°C. The results are summarized and expressed graphically. (auth)

**6533** A/CONF.15/P/1668
STUDIES ON THE PREPARATION OF PURE URANIUM TETRAFLUORIDE FROM CRUDE SODIUM DIURANATE. V. V. Dadape and N. S. Krishna Prasad (Atomic Energy Establishment, Trombay, India). 24p.

Crude sodium diuranate is converted to crude uranyl nitrate, the pH of the solution is adjusted to < 3.0, and ammonium fluoride is added. The precipitated insoluble fluorides are filtered off, and the filtrate containing the complex fluorides of uranium and iron is treated with hydrogen peroxide and the pH adjusted to 6.5 to 7.0. At this pH the iron remains in solution. The precipitated ammonium uranium peroxyfluoride is filtered, washed, dried, and heated in a current of Freon-12 at 450 to 500°C to give uranium tetrafluoride. The preparation of the peroxy complex, the optimum conditions for the reaction between the peroxy complex and freon-12, and the nature and purity of the uranium tetrafluoride formed are described. (auth)

# URANIUM 1.43

## FLUORIDES 1.43.04

### $UF_6$ 1.43.04.02

**19605** ✓ GAT-265
Goodyear Atomic Corp., Portsmouth, Ohio.
THE REACTION OF URANIUM DIOXIDE WITH URANIUM HEXAFLUORIDE. G. A. Rampy. June 5, 1959. 30p. Contract AT(33-2)-1. $1.00(OTS).

The reaction of uranium dioxide with uranium hexafluoride in a quasi-static system has been investigated in the temperature range 25 to 500°C. Although the products of the reaction at 500°C are uranyl fluoride and uranium tetrafluoride, the data indicate that the reaction mechanism is extremely complex, involving little-known uranium compounds. While these compounds have not been identified or isolated, their presence is deduced from visual observations, weight change and wet chemical and isotopic analyses. A mechanism for the reaction has been proposed which is in agreement with the observed data. This mechanism is not intended as a rigorous representation of the reaction, but rather as an illustration of the experimental results. The reaction of uranium dioxide with uranium hexafluoride apparently proceeds through the formation of a pentavalent oxyfluoride which subsequently undergoes further reaction with the hexafluoride, forming another unstable pentavalent oxyfluoride. (auth)

KINETICS OF THE REACTION BETWEEN URANIUM HEXAFLUORIDE AND SODIUM FLUORIDE. II. SODIUM FLUORIDE PELLETS AND CRUSHED PELLETS. F. E. Massoth and W. E. Hensel, Jr. (Goodyear Atomic Corp., Portsmouth, Ohio). J. Phys. Chem. 63, 697-702(1959) May.

A study of the kinetics of the reaction between uranium hexafluoride and sodium fluoride pellets and crushed pellets has been made over the temperature range 25 to 68°. Derivation of the logarithmic and parabolic laws for gas-solid reaction, involving a cubic particle, is presented. The reaction appears to proceed initially by a logarithmic mechanism and then by a parabolic mechanism. A blocking effect is advanced to explain the incomplete reaction with sodium fluoride pellets. A physical picture of the various steps of the reaction mechanism for the sodium fluoride–uranium hexafluoride reaction is presented. (auth)

PROCESS FOR PRODUCTION OF URANIUM HEXAFLUORIDE. (to United Kingdom Atomic Energy Authority)(U.S.A.). British Patent 794,023. Nuclear Eng. 3, 510(1958) Nov.

Uranium hexafluoride is produced by the reaction, at elevated temperature, of anhydrous uranyl fluoride with elemental fluorine. (W.D.M.)

SEPARATION OF URANIUM HEXAFLUORIDE FROM ORGANIC FLUORO COMPOUNDS. W. F. Libby (to U. S. Atomic Energy Commission). U. S. Patent 2,855,271. Oct. 7, 1958.

A method is presented for removing perfluoroörganic compounds such as $C_7F_{16}$ from $UF_6$. The physical and chemical properties of the perfluoro compounds are such as to render their removal from $UF_6$ difficult by conventional techniques. The mixture containing $UF_6$ and the perfluoro compounds is pyrolyzed in an inert container at high temperature and pressure. The properties of the products obtained by pyrolysis differ from the properties of $UF_6$ to a sufficient degree to render their separation possible by ordinary methods.

**10519**
THE FLUORIDES OF URANIUM. I. LIQUID-VAPOUR EQUILIBRIA IN THE SYSTEMS URANIUM HEXAFLUORIDE–CHLORINE TRIFLUORIDE AND URANIUM HEXAFLUORIDE–BROMINE PENTAFLUORIDE. J. F. Ellis and K. D. B. Johnson (United Kingdom Atomic Energy Authority, Industrial Group, Capenhurst Works, Chester, Eng.). J. Inorg. & Nuclear Chem. 6, 194–8 (1958) June.

The system uranium hexafluoride–chlorine trifluoride exhibits complete miscibility in the liquid phase at 67°C but partial miscibility at 75°C over a limited composition range. No azeotropes exist in this system. The system uranium hexafluoride–bromine pentafluoride exhibits complete miscibility over the range 68 to 80°C and has a single maximum vapor pressure azeotrope at a composition corresponding to a mole fraction of 0.1 of uranium hexafluoride, approximately. (auth)

**10495** AERE-C/M-300
Gt. Brit. Atomic Energy Research Establishment, Harwell, Berks, England.
THE REACTION BETWEEN URANIUM HEXAFLUORIDE AND SULPHURIC ACID. D. Davies. Feb. 1957. 6p.

A preliminary investigation of the hydrolysis of uranium hexafluoride by concentrated sulfuric acid has been made. The reaction proceeds smoothly to give a precipitate of $U^{VI}$ sulfate with only slight reduction to $U^{IV}$. (auth)

# URANIUM 1.43

## FLUORIDES 1.43.04

### $UF_6$ 1.43.04.02

**10520**
THE FLUORIDES OF URANIUM. II. DISTILLATION OF MIXTURES OF CORROSIVE VOLATILE FLUORIDES INCLUDING URANIUM HEXAFLUORIDE. J. F. Ellis, L. H. Brooks, and K. D. B. Johnson (United Kingdom Atomic Energy Authority, Industrial Group, Capenhurst Works, Chester, Eng.). J. Inorg. & Nuclear Chem. 6, 199-206(1958) June.

Distillation of binary systems has shown that uranium hexafluoride is completely separable from chlorine trifluoride and bromine trifluoride, but forms azeotropes with hydrogen fluoride and bromine pentafluoride. At pressures above atmospheric, uranium hexafluoride and bromine interdistil without separation. Hydrogen fluoride forms azeotropes with bromine, bromine trifluoride, bromine pentafluoride and chlorine trifluoride. A distillation method has been evolved for purifying uranium hexafluoride from a ternary mixture with chlorine trifluoride and hydrogen fluoride. (auth)

**12341** ✓
SOLID-LIQUID EQUILIBRIA OF THE SYSTEM URANIUM HEXAFLUORIDE–CHLORINE TRIFLUORIDE. W. S. Wendolkowski and E. J. Barber (Union Carbide Nuclear Co., Oak Ridge, Tenn.). J. Phys. Chem. 62, 750-2(1958) June.

The solid-liquid equilibria of the $UF_6-ClF_3$ system were investigated in the entire range of compositions from 0 to 100 mole % $UF_6$. The techniques of Skau were used but modified to ensure equilibrium during the melting and freezing cycles. (J.R.D.)

**9771** ✓
KINETICS OF THE REACTION BETWEEN SODIUM FLUORIDE AND URANIUM HEXAFLUORIDE. I. SODIUM FLUORIDE POWDER. F. E. Massoth and W. E. Hensel, Jr. (Goodyear Atomic Corp., Portsmouth, Ohio). J. Phys. Chem. 62, 479-81(1958) Apr.

The reaction of uranium hexafluoride with sodium fluoride has been found to give a solid addition compound of the formula $UF_6 \cdot 3NaF$. The kinetics of this reaction have been studied at a constant pressure, by weight-change method. The reaction is reversible at higher temperature but dissociation can be safely ignored below 100°C. (J.R.D.)

**86** GAT-213
Goodyear Atomic Corp., Portsmouth, Ohio.
FREEZING POINT DETERMINATIONS OF THE URANIUM HEXAFLUORIDE–HYDROGEN FLUORIDE SYSTEM. H. L. Bullard, A. S. Ostroski, and W. S. Stringham. Oct. 8, 1957. 14p. Contract AT(33-2)-1. $0.50(OTS).

A more efficient and time-conserving method for the production analysis of small amounts of HF in $UF_6$ is presented. The apparatus includes automatic controlling-recording equipment and thermistors. The amount of HF as an impurity is determined by measuring the depression in the $UF_6$ freezing point. The use of calibration curves is necessary to correct for the variation of gaseous volume above the liquid level. (auth)

**2849** K-722(Add. I)
Oak Ridge Gaseous Diffusion Plant, Tenn.
VAPOR PRESSURE TABLES FOR LIQUID URANIUM HEXAFLUORIDE. A. A. Brooks and P. Wood. Nov. 21, 1957. 7p. Contract W-7405-eng-26. $0.50(OTS).

Tabular values of the saturated vapor pressure of liquid uranium hexafluoride and the derivative of the vapor pressure with respect to temperature are presented. (auth)

**18912** ✓ RISLEY-8092-D
Gt. Brit. Capenhurst Works, Capenhurst, Ches., England.
LIQUID-VAPOUR EQUILIBRIA IN BINARY SYSTEMS INVOLVING URANIUM HEXAFLUORIDE AND SOME HALOGEN FLUORIDES. J. F. Ellis. May 1954. 13p.

Liquid-vapor equilibria in the system $UF_6-ClF_3$ at 67°C and (in part) 84°C have been investigated. Complete miscibility is exhibited at the lower temperature over the whole composition range and at the higher temperature up to 0.565 mol. fraction Hex. Mixtures with smaller quantities of Hex than this were not studied at the higher temperature due to the high pressure hazard. Liquid vapor equilibria in the system $UF_6-BrF_5$ at 68 and 80°C were investigated. The components are completely miscible and the results indicate the formation of an azeotrope of maximum total vapor pressure of approximate composition 0.1 mol. fraction Hex. An attempt has been made to study liquid-vapor equilibria in the system $UF_6-BrF_3$ at 82°C. The incomplete results obtained indicate that it should be possible to separate these compounds by simple distillation. (auth)

# URANIUM 1.43

## FLUORIDES 1.43.04

### $UF_6$ 1.43.04.02

**1109** K-1298
Oak Ridge Gaseous Diffusion Plant, Tenn.
VAPOR PRESSURE MEASUREMENTS FOR THE SYSTEM: URANIUM HEXAFLUORIDE–CHLORINE TRIFLUORIDE. W. C. Kuykendall. Nov. 20, 1956. Decl. Sept. 8, 1957. 11p. Contract W-7405-eng-26. $3.30 (ph OTS); $2.40(mf OTS).

Vapor pressures for the system uranium hexafluoride–chlorine trifluoride at approximately 76, 83, and 92°C over the entire composition range are reported. Vapor pressure and gross composition data indicate that the system exhibits complete miscibility. At 75°C vapor pressures of 128 and 32 psia were observed at compositions of 0 and 1.0 mole fraction uranium hexafluoride, respectively. The smooth curve within these limits shows a maximum positive deviation from a Raoult's law relationship of approximately 13 pounds occurring at 0.4 mole fraction uranium hexafluoride.

REMOVAL OF SOME VOLATILE IMPURITIES FROM URANIUM HEXAFLUORIDE. Whitney H. Mears, Robert V. Townend, Robert D. Broadley, A. D. Turissini, and Richard F. Stahl (Allied Chemical Corp., Morristown, N. J.). Ind. Eng. Chem. 50, 1771-3(1958)

**11979** RDB(R)/TN-17
Gt. Brit. Div. of Atomic Energy (Production), Risley, Lancs, England.
THE PHYSICAL PROPERTIES OF $UF_6$. J. E. Mann. Nov. 16, 1953. 15p. (DDC/P-31).

Values of the physical properties of $UF_6$ are to be found in various reports and data sheets not all of which are readily available or in agreement. The present collection aims to provide, in a convenient form, acceptable values of the most commonly used properties in both c.g.s. and f.p.s. units. (auth)

**2378** AECD-4236
Carbide and Carbon Chemicals Div. [K-25 Plant], Oak Ridge, Tenn.
THE PREPARATION AND SOME PROPERTIES OF A URANIUM HEXAFLUORIDE–SODIUM FLUORIDE COMPLEX. Charles A. Horton, Warren W. Harris, John T. Barr, and J. C. Posey. Nov. 30, 1950. Decl. Feb. 9, 1956. 6p. Contract [W-7405-eng-26]. (KLI-753). $1.80 (ph OTS); $1.80(mf OTS).

**3575** Y-409
Carbide and Carbon Chemicals Corp. Y-12 Plant, Oak Ridge, Tenn.
DIRECT REDUCTION OF URANIUM HEXAFLUORIDE TO METALLIC URANIUM. D. E. Carpenter, C. P. Johnston, and C. D. Susano. May 16, 1949. Decl. Dec. 8, 1955. 5p. Contract W-7405-eng-26. $1.80(ph OTS); $1.80 (mf OTS).

Exploratory tests are reported which indicate the feasibility of a one-step reduction process for the preparation of uranium metal from the hexafluoride by the action of calcium metal and iodine. (auth)

**1909** A-4003
Harshaw Chemical Co., Cleveland, Ohio.
THE MANUFACTURE OF URANIUM HEXAFLUORIDE. OPERATING MANUAL. G. C. Whitaker. Oct. 22, 1946. Decl. Mar. 11, 1957. 221p. $51.50(ph OTS); $11.10(mf OTS).

A manual is presented that explains the mechanics of plant operation and gives details of plant design for the preparation of $UF_6$ in commercial quantities. (W.L.H.)

**2362** A-732
Columbia Univ., New York. Div. of War Research.
VISCOSITY OF LIQUID $UF_6$ AT 70°C. A. D. Kirshenbaum. June 10, 1943. Decl. Dec. 8, 1955. 5p. Contract W-7405-eng-50. (1-R128). $1.80(ph OTS); $1.80(mf OTS).

A modified Ostwald viscosimeter was employed in measurements of the viscosity of liquid $UF_6$ at 70°C. The absolute viscosity of $UF_6$ was determined to be a little less than twice that of water, and the kinematic viscosity of water was determined to be a little greater than twice that of $UF_6$. (C.H.)

**2357** -456
National Bureau of Standards, [Washington, D. C.]
DENSITY OF SOLID HEX [$UF_6$] NEAR THE TRIPLE POINT, AND THE EXPANSIVITY OF THE LIQUID FROM THE TRIPLE POINT TO 92°C. Martin T. Wechsler and Harold J. Hoge. Feb. 25, 1943. Decl. Dec. 8, 1955. 4p. $1.80(ph OTS); $1.80(mf OTS).

# URANIUM 1.43

## FLUORIDES 1.43.04

### $UF_6$ 1.43.04.02

**15921** AECU-4177
Kellex Corp., New York.
THE CHEMISTRY OF THE REACTION OF URANIUM HEXAFLUORIDE WITH ACTIVATED CARBON. T. P. Wilson, S. C. Schuman, and E. L. Simons. [194?]. Decl. June 10, 1959. 29p. (KZ-5585). $4.80(ph), $2.70(mf) OTS.

The effects of temperature, time and other variables on the rate and extent of reaction between $UF_6$ and various types, grades and particle sizes of commercial activated carbon have been studied experimentally. It is shown that both hydrolysis and reduction of the $UF_6$ occur, the latter more slowly than the former. Reduction leads to the formation of a mixture of fluorocarbons ranging from $CF_4$ to a wax-like material volatile only above 250°C. There is also evidence for the adsorption of $UF_6$ on an undetermined substrate. (auth)

### OTHER FLUORIDES 1.43.04.03

**6229**
THE EFFECT OF FLUORIDE ION ON THE CO-ORDINATION OF URANIUM(IV) BY ETHYLENEDIAMINE TETRAACETIC ACID. T. D. Smith (Royal Coll. of Science and Tech., Glasgow). J. Inorg. & Nuclear Chem. 11, 314-19 (1959) Dec.

The effect of fluoride ion upon uranium(IV) solutions containing ethylenediamine tetraacetic acid is explained in terms of the participation of the $UF^{3+}$ ion in co-ordination. The stability constant of this ion with ethylenediamine tetraacetic acid was measured and its value used to estimate thermodynamic quantities associated with the formation of the complex fluoride. The general co-ordinating tendency of $UF^{3+}$ ion is discussed and compared with other systems of a similar nature. (auth)

**15100**
THE FLUORIDES OF URANIUM. IV. KINETIC STUDIES OF THE FLUORINATION OF URANIUM TETRAFLUORIDE BY CHLORINE TRIFLUORIDE. V. Y. Labaton (United Kingdom Atomic Energy Authority, Capenhurst Works, Chester, Eng.). J. Inorg. & Nuclear Chem. 10, 86-93(1959) Apr.

The reaction between uranium tetrafluoride and chlorine trifluoride was studied between 17 and 193°C using the same basic technique as was used in an investigation of the uranium tetrafluoride-fluorine reaction. This consists essentially of following the change in weight of the solid phase using a spring balance. The mechanism and kinetics of reaction were shown to be substantially the same for chlorine trifluoride as fluorine. The reaction rate passes through a maximum at 105°C, falls to a minimum at 148°C and then rises again. An explanation of this unusual behavior is suggested. In the regions 17 to 58°C and 156 to 194°C, within the limits of experimental accuracy, the Arrhenius equation relates the reaction-rate constant and the temperature of reaction; the activation energies determined for uranium tetrafluoride prepared by hydrofluorination were 5.6 and 3.4 kcal per mole, respectively. A linear relationship is shown to exist near ambient temperature between the reaction rate and partial pressure of chlorine trifluoride. In the velocity range examined, gas velocity had no effect on the reaction rate. (auth)

**13234** SCS-R-392
United Kingdom Atomic Energy Authority. Industrial Group. Springfields Works, Springfields, Lancs, England.
PYROHYDROLYSIS OF FLUORIDES AND FLUORIDE MIXTURES. H. Mason and J. D. Rushmere. Apr. 20, 1955. 25p. (ARDC/P-84).

A study was made of some of the more important factors governing the pyrohydrolysis of metal fluorides, e.g., temperature, steam rate, and weight of sample. As working materials the fluorides of calcium, magnesium, uranium(IV), and uranium(III) were used, these being considered to be the principal fluorides likely to be present in uranium tetrafluoride reduction slags. It was shown that in mixtures containing fluorides of widely different stabilities, e.g., magnesium–uranium(IV), selective pyrohydrolysis of the constituents is possible by a careful control of temperature. (auth)

# URANIUM 1.43

## FLUORIDES 1.43.04

### OTHER FLUORIDES 1.43.04.03

ELECTRODIALYTIC CONVERSION OF URANYL NITRATE TO URANIC FLUORIDE SALTS. Wallace W. Schulz, Erwin W. Neuvar, Jimmy L. Carroll, and Raymond E. Burns (General Electric Co., Richland, Wash.). Ind. Eng. Chem. 50, 1768-70(1958) Dec.

An electrodialytic process for alkali metal and ammonium uranium(IV) double fluorides is described. Essential features of the process, together with pertinent developmental data and a chemical flowsheet, are discussed. This electrodialytic process can be operated on a continuous basis at 80 to 85% current efficiency and involves fewer steps than the conventional method. A simple schematic of the process is shown. (J.H.M.)

**11499**

METHOD FOR CONVERTING URANIUM AMMONIUM PHOSPHATE TO URANYL FLUORIDE. S. Bernstein and H. A. Bernhardt (to U. S. Atomic Energy Commission). U. S. Patent 2,795,479. June 11, 1957.

A method for converting $UO_2NH_3PO_4$ to $UO_2F_2$ is given. This conversion is effected by heating the $UO_2NH_3PO_4$ within a narrow temperature range, preferably at about 450°C, until it is converted into $UO_2HPO_4$, and then contacting the resulting $UO_2HPO_4$ with HF at a temperature, of about 500°C until it is converted into the desired $UO_2F_2$. (auth)

**7160** ANL-5441

Argonne National Lab., Lemont, Ill.

THE BEHAVIOR OF URANIUM, THORIUM, AND OTHER SELECTED MATERIALS IN BROMINE TRIFLUORIDE, BROMINE PENTAFLUORIDE, CHLORINE TRIFLUORIDE, AND FLUORINE AT ELEVATED TEMPERATURES. Lawrence Stein and Richard C. Vogel. May 1955. 20p. Contract W-31-109-eng-38. $0.20(OTS).

The reactivity of uranium, thorium, aluminum, copper, iron, magnesium, zirconium, and Fluorothene with bromine trifluoride, bromine pentafluoride, chlorine trifluoride, and fluorine was investigated at temperatures ranging from 25 to 410°C. The reactivity of platinum with bromine trifluoride was also studied. (auth)

## METALLURGY 1.43.05

### ALLOYS 1.43.05.01

**22501**

**IMPROVEMENTS IN OR RELATING TO CASTING OF METAL SURFACES. Alan Blainey and Michael Lesney Noakes (to United Kingdom Atomic Energy Authority). British Patent 820,614. Sept. 23, 1959.**

Grogan (to U. S. Atomic Energy Commission). U. S. Patent 2,886,430. May 12, 1959.

**This patent relates to high purity uranium alloys characterized by improved stability to thermal cycling and low thermal neutron absorption. The high purity uranium alloy contains less than 0.1 per cent by weight in total amount of any ore or more of the elements such as aluminum, silicon, phosphorous, tin, lead, bismuth, niobium, and zinc.**

URANIUM AND ITS ALLOYS. G. Ya. Sergeev and V. V. Titova. Atomnaya Energ. 6, 253-60(1959) Mar. (In Russian)

The physico-mechanical properties of uranium and its alloys are reviewed on the basis of data presented at the Second Geneva Conference. Radiation effects on uranium, especially gas swelling, are discussed. The $\alpha$ and $\gamma$ phases of uranium and other fission alloys are described. The temperature maxima of uranium-base solid fuel elements are analyzed. Data are given from metallographic investigations. (tr-auth)

URANIUM – PART II, ALLOYS AND COMPOUNDS, 1936-1958. CTR-366. Washington, Office of Technical Services, 1958. 14p. $0.10.

This catalog of technical reports on uranium alloys and compounds is the result of research conducted for the Army, Navy, Air Force, Atomic Energy Commission and other U. S. Government Agencies. Other reports are German documents captured by the Allies during World War II. (J.E.D.)

**188**

URANIUM AND ITS ALLOYS. R. W. Nichols ~~(Culcheth Labs., U.K.A.E.A.I.G.)~~. Nuclear Eng. 2, 355-64(1957) ~~Sept.~~

The mechanical, physical, chemical, and metallurgical properties of U are given in tabular and graphic form. Selected values for these properties are given, and the effects of radiation, thermal cycling, fabrication history and alloy additions are discussed. ~~(T.R.M.)~~

# URANIUM 1.43

## METALLURGY 1.43.05

### ALLOYS 1.43.05.01

**17225**

**A REVIEW PAPER ON THE CONSTITUTION OF URANIUM–MOLYBDENUM ALLOYS. A. J. Carrea ~~(National Commission of Atomic Energy, Buenos Aires)~~ and D. R. F. West and J. G. Ball ~~(Imperial Coll., London)~~. J. Nuclear Energy 7, 189–98(1958) ~~Sept.~~**

**Reports of investigations of the constitution of uranium–molybdenum alloys are summarized and differences between the proposed equilibrium diagrams are discussed. It is apparent that the differences are due partly to the difficulty of establishing equilibrium in the solid state transformations. A compiled equilibrium diagram is shown. (auth**

THE $\gamma$ PHASE IN URANIUM ALLOYS. R. G. Loasby ~~(Univ. of Nottingham, Eng.)~~ Proc. Phys. Soc. (London) 72, 425-8(1958) ~~Sept.~~

Electrical resistivity and magnetic susceptibility properties of two alloys based on $\gamma$-uranium are described and interpreted in terms of a theoretical structure derived from x-ray work. The implication of the earlier work, that uranium in the $\gamma$ form is characterized by only four electrons per atom (as opposed to six for the $\alpha$ and $\beta$ forms), is supported by the results. (auth)

**21200** NP-7902

**Sylvania-Corning Nuclear Corp., Bayside, N. Y. BIBLIOGRAPHY ON URANIUM ALLOYS WITH BINARY PHASE DIAGRAMS AND SELECTED DATA ON PROPERTIES. Helen C. Friedemann and Henry H. Hausner. [1959]. 70p.**

**Available from Sylvania-Corning Nuclear Corp. $1.00.**

**This bibliography contains 470 references on U alloys. Also included are U binary phase diagrams and data on U alloys. (W.L.H.)**

THE FIRST FERRO-URANIUM MADE IN AMERICA. Clarence T. Patterson ~~(Solvay Process Co., Syracuse, N. Y.)~~. Metal Progress 71, No. 6, 85-9(1957) ~~June~~

A history of the research, production, and uses of ferro-uranium in the U. S. is given. (W.L.H.)

PRE-IRRADIATION TESTS ON U–Si ALLOYS. L. M. Howe and L. G. Bell. May 1958. 41p. (AECL-646) ~~$1.00(AECL)~~.

Pre-irradiation tests of hardness, density, electrical resistivity, and corrosion resistance as well as metallographic and x-ray examinations were undertaken on Si–U core material, which had been co-extruded in Zircaloy-2, in order that the effect of irradiation on alloys in the epsilon range could be assessed. In addition, a study of the epsilonization of arc-melted material was undertaken in order to gain familiarity with the epsilonization process and to obtain information on the corrosion behavior of epsilonized material. Sheathed Si–U samples in the epsilonized and de-epsilonized conditions were irradiated in the X-2 loop, with a water temperature of 275°C. The samples were examined after 250 Mwd/t and show no dimensional change. (auth)

METAL STUDIES ON Pu, U AND THEIR ALLOYS. A. A. Bochvar, S. T. Konobeevskii, et al. Atomnaya Energ. 5, 5-23(1958). (In Russian)

A review is given of metallographic studies of nuclear fuels of Pu, U, and their alloys made in U.S.S.R. in connection with nuclear energy development. Descriptions are given of Pu properties and regularities in its interactions with other elements according to their position on the periodic table. Some properties and the behavior of U in thermal cycling and irradiation are discussed in relation to alloying and thermal and mechanical treatment. The methods of U treatment by pressure are investigated. Effects of neutron bombardment on the structure and properties of metals and their alloys are also analyzed. ~~(tr-auth)~~.

HEATS OF FORMATION OF $UAl_2$, $UAl_3$, AND $UAl_4$. M. I. Ivanov, V. A. Tumbakov, and N. S. Podolskaya. Atomnaya Energ. 5, 166-70(1958). (In Russian)

The intermetallic compounds $UAl_2$, $UAl_3$, and $UAl_4$ were prepared by interdiffusion of heated aluminum and dispersed uranium, obtained by disintegration of hydride, followed by crushing and repeated heating of the powder. The x-ray-diffraction analysis showed a single-phase structure. Judging by the expelled hydrogen in the dissolution of the preparations and the initial components of specially selected solvent (mixture of HCl, $H_3PO_4$, $Na_2SiF_6$, $H_2PtCl_6$, and $CuSO_4 \cdot 5\,H_2O$), it was found that the composition of preparations was $UAl_{1.997}$, $UAl_{2.994}$, and $UAl_{3.997}$. The heats of formation ($-\Delta H^\circ_{298}$) of $UAl_2$, $UAl_3$, and $UAl_4$ are 22.3 ± 2.4, 25.2 ± 2.2, and 31.2 ± 3.1 kcal/mole, respectively. (tr-auth)

# URANIUM 1.43

## METALLURGY 1.43.05

### ALLOYS 1.43.05.01

**14819** A/CONF.15/P/706
Atomics International Div., North American Aviation Inc., Canoga Park, Calif.
STUDY OF THE THORIUM–URANIUM ALLOY SYSTEM. G. G. Bentle. 13p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The thorium–uranium phase diagram has been determined from 0 to 20 wt. % uranium. A new high-temperature region in the phase diagram is proposed. The data were obtained from resistivity and lattice parameter measurements. Metallography indicates that uranium has a slight solubility in thorium, that is, about 1% at room temperature. The excess uranium occurs as a finely divided second phase in arc-melted alloys. The fine particles coalesce when the alloys are held at 600°C for several months, a thermal treatment which might be encountered in the operation of a nuclear power reactor. Mechanical property measurements indicate that thorium is strengthened at room temperature and at 500°C by adding uranium; three or four percent uranium added to thorium increases the strength of thorium about 50% at the respective temperatures. The thermal conductivity for several alloys was calculated as a function of temperature, using resistivity data and the Weidemann-Franz relation. The thermal conductivity of thorium was found to increase approximately linearly from 0.090 at 100°C to 0.110 cal/cm/°C/sec at 1100°C. (auth)

THE URANIUM–SILICON EPSILON PHASE. S. Isserow (Nuclear Metals, Inc., Cambridge. Mass.). J. Metals 9, 1236-9(1957) Oct.

The properties of the U–Si ε phase have been investigated, with emphasis on the means of obtaining material resistant to corrosion in water. Evidence is presented that the corrosion resistance depends on the absence of phases other than ε and that the desired ε phase has a silicon content in the range of 3.9 to 4.0 wt. % rather than the 3.78 wt. % of stoichiometric $U_3Si$. It was necessary to develop an analytical method to overcome the apparently low silicon content found in this system under certain conditions. Attempts to fabricate this alloy were devoted primarily to coextrusion with Zircaloy-2. Extrusion constants are reported. (auth)

**6588**
URANIUM ALLOYS. E. W. Colbeck (to U. K. Atomic Energy Authority). British Patent 766,060. Nuclear Eng. 2, 172(1957) Apr.

The corrosion resistance of U metal can be markedly improved by including in the metal from 0.2% to 10%, preferably 1% to 6%, of its weight of Mo. Uranium metal and Mo are melted together, in the desired proportions, out of contact with air, under a flux or in vacua in a thoria crucible at 1,150°C to 1,400°C. The alloys may be subjected to an annealing treatment. No substantial competitive neutron absorption is introduced into the U metal by the Mo. (auth)

**9545**
HEAT TREATED URANIUM ALLOY AND METHOD OF PREPARING SAME. D. W. White, Jr. (to U. S. Atomic Energy Commission). U. S. Patent 2,780,072. Apr. 16, 1957.

A process is given for obtaining U alloys which are dimensionally stable when subjected to nuclear irradiation. This is accomplished by adding to the U from 0.1 to 10 at. % Cr, heating the alloy so obtained to a temperature above the alpha-beta transformation temperature and then quenching the alloy to alpha-phase and holding the alloy at this temperature until transformation to alpha phase crystals is complete. (auth)

**6589**
URANIUM ALLOYS. E. W. Colbeck (to U. K. Atomic Energy Authority). British Patent 766,061. Nuclear Eng. 2, 172(1957) Apr.

The alloy includes 0.1% to 5% of its weight of Mo and 0.1% to 5% of its weight of Si. The alloys are prepared and may also be annealed in order to relieve stresses. In addition to the higher resistance to corrosion, the tensile strength of these alloys is greater than that of U, especially when annealed. (auth)

**6413**
THE ELECTRONIC STRUCTURE OF PALLADIUM–URANIUM ALLOYS. J. A. Catterall (National Physical Lab.). Phil. Mag. (8) 2, 491-8(1957) Apr.

The measured effects of uranium upon the paramagnetic susceptibility, electrical resistivity, thermoelectric power, and lattice parameter of palladium are discussed, and an interpretation of the results in terms of a solvent and solute band is suggested. (auth)

# URANIUM 1.43

## METALLURGY 1.43.05

### ALLOYS 1.43.05.01

**8926** ✓ WASH-701
Division of Research, AEC.
URANIUM ALLOY NEWSLETTER. E. Epremian, ed.
Feb. 1957. Decl. Mar. 13, 1957. 38p. $0.40(OTS).

A tentative phase diagram is given of the U rich U–Ru alloy. Results of investigations on the corrosion behavior of irradiated U–Si systems are tabulated. Corrosion tests were also made on U–Zr alloys. Results are also given of the aqueous corrosion of U–Zr–Ta alloys at 290°C. Isothermal transformation kinetics of the $\gamma$ phase of U–Nb and U–Nb–X alloys were investigated, and diagrams are included. Data are included on the effect of temperature and various Zr melting stocks on the corrosion behavior of Zr–U alloys in high-temperature water. The physical properties of U–Al alloys are tabulated. Data are also included on the solidification of U–Nb alloys and the $M_s$ temperature of U–Nb alloys. (B.J.H.)

**6718** ANL-5672
Argonne National Lab., Lemont, Ill.
AQUEOUS CORROSION OF URANIUM AND URANIUM–6 w/o ZIRCONIUM ALLOY. Work performed: 1953–54. W. E. Ruther and W. B. Seefeldt. Jan. 9, 1957. 15p. Contract W-31-109-eng-38. $0.20(OTS).

The corrosion rates of U subjected to heat treatments of 600°, 720°, 800° and 1000°C asymptotically approached the lower corrosion rate of high purity U. Experiments in which hydrogen was deliberately added to heat-treated samples showed no correlation between corrosion rate and the hydrogen content. At a flow velocity of about 20 ft/sec of distilled water, U–Zr alloy corroded at low, but increasing, rates at 60° and 90°C. The water was saturated with a $N_2$–4 7 mol % $O_2$ mixture. The protective oxide film formed on initial immersion became less adherent and lost its interference colors after 30 days at 90°C. At 60°C this change of protective film occurred only at edges and corners. The increasing corrosion rate with time made it impossible to assign any single value for a corrosion rate. Little or no effect of the water flow rate was indicated by comparison of results with the previously reported behavior in static water. (auth)

Division of Research, AEC. (WASH-298)
URANIUM ALLOY NEWSLETTER. Edward Epremian, ed. Sept. 1956. Decl. with deletions Mar. 5, 1957. 36p. $6.30(ph OTS); $3.00(mf OTS).

The status of research on the properties and preparation of various U alloys is summarized. (C.H.)

**11841** ✓ NP-7384
[Japan. Atomic Energy Research Inst., Tokyo.]
SEVERAL PROPERTIES OF METALLIC URANIUM. [Report] No. 1. 1957. 61p.

Various properties of uranium are reviewed including melting and casting, processing, cladding, physical metallurgy, radiation damage, corrosion, and general alloying properties. (W.D.M.)

**4765** WAPD-TM-22
Westinghouse Electric Corp. Bettis Plant, Pittsburgh.
THEORY OF LOCAL ATOMIC DISPLACEMENTS IN SOLID SOLUTIONS OF URANIUM ALLOYS. R. B. Roof, Jr. Dec. 14, 1956. 15p. Contract AT-11-1-GEN-14. $0.20(OTS).

A local static displacement in solid binary solutions occurring within a distance of one atom from the ideal lattice and completely independent of the thermal effects was determined, based on the measurements of the Bragg intensities. The measured intensities were corrected for multiplicity, Lorentz and polarization effects, and a set of structure factors on an arbitrary scale were calculated. Values of $\ln(F_c/F_o)$ were plotted against $\sin^2\theta/\lambda^2$ and the best straight line through the experimental points has been derived by the method of least squares. Applications of theory to solid solutions of U alloys are discussed. (R.V.J.)

**271** AERE-M/M-107(Del.)
Gt. Brit. Atomic Energy Research Establishment, Harwell, Berks, England.
SOME OBSERVATIONS ON URANIUM-RICH URANIUM RUTHENIUM ALLOYS. J. R. Murray and S. J. Lloyd. Jan. 1956. 9p.

The solidus and liquidus depressions in U-rich U–Ru alloys are approximately 5 and 1°C for 0.1 at.% Ru addition, respectively. A eutectic occurs at 900°C and 18 at.% Ru between U and an intermetallic compound of unknown composition. The $\alpha \rightarrow \beta$ and $\beta \rightarrow \gamma$ transformation temperatures in U are lowered by additions of Ru, but in alloys containing up to 20 at.% Ru sharp arrests can be detected at heating and cooling rates of $1\frac{1}{2}$°C/min. The solubility of Ru in $\gamma$ uranium is approximately 10 at.% at 900°C, the solubility in $\alpha$ uranium being considerably lower. (auth)

# URANIUM 1.43

## METALLURGY 1.43.05

### ALLOYS 1.43.05.01

**2091** ✓ HW-38982
Hanford Atomic Products Operation, Richland, Wash.
THE DIFFUSION OF URANIUM INTO ALUMINUM. T. K. Bierlein and D. R. Green. Oct. 6, 1955. 23p. Contract W-31-109-Eng-52.

The maximum penetration of uranium into aluminum in the temperature range 200 to 390°C (392 to 734°F) has been investigated. The maximum values for the penetration coefficient $K_T$, determined from the realtionship $K_T = x^2/t$, are 0,075, 0.50, and $6.1 \times 10^{-6}$ inches$^2$/hour at temperatures of 200, 250, and 390°C (392, 482, and 734°F), respectively; the corresponding activation energy is 14,300 calories per mole. The utility of cathodically vacuum etching specimens to obtain clean metal surfaces prior to the diffusion anneal is demonstrated. Couples prepared in the temperature range investigated, 200 to 390°C (392 to 734°F), fracture by the application of tension between the aluminum and the adjacent $UAl_3$ diffusion zone interface. Subsequent measurement of the maximum $UAl_3$ peak heights above the initial uranium-aluminum interface assures a maximum value of penetration coefficient. The investigation provides a necessary basis for interpreting the effect of irradiation on the diffusion rates of uranium into aluminum. (auth)

**13818** ✓ WAPD-MM-287
[Westinghouse Electric Corp. Atomic Power Div., Pittsburgh.]
RESUMÉ OF URANIUM ALLOY DATA. B. Lustman. Feb. 19, 1954. Decl. Mar. 22, 1957. 25p. $0.35(OTS).

Additional data on uranium alloys which have been compiled are summarized. Of greatest significance probably are the results of preliminary irradiation tests on the U–Mo alloys and the results of cathodic treatment of clad and unclad samples of U–Mo alloys. Irradiation of an 11.5% Mo–U alloy to approximately 3000 Mdw/t burn-up revealed no change in the general corrosion resistance of the alloy on subsequent corrosion testing but a marked decrease in the time for discontinuous failure. Cathodic treatment of unclad U–Mo alloys in boiling water revealed formation of uranium hydride needles in the alloy matrix. The time for discontinuous failure of samples thus treated on subsequent high-temperature corrosion testing is drastically reduced over that of untreated samples. Cathodic treatment of "defected" clad samples, however, revealed no pick-up of hydrogen in the form of hydride needles. (auth)

**13820** ✓ WAPD-PMM-15
Westinghouse Electric Corp. Atomic Energy Div., Pittsburgh.
RESUME' OF URANIUM ALLOY DATA–VIII. B. Lustman, Feb. 25, 1955. Decl. Mar. 20, 1957. 83p. $13.80(ph OTS); $4.80(mf OTS).

The effects of melting, extrusion temperature, homogenization, and other variables on the corrosion properties of U–Mo were studied. The corrosion resistance of U–Mo–Pt, U–Mo–Nb, U–Mo–X (where X is Cr, Ti, or V), and U–Zr–Nb to high-temperature water and the irradiation behavior of U–Mo and U–Si were investigated. Work continued on the preparation, powder metallurgy, and irradiation testing of $UO_2$. (C.W.H.)

**11664** WAPD-MM-491
[Westinghouse Electric Corp. Atomic Power Div., Pittsburgh.]
RESUMÉ OF URANIUM ALLOY DATA—VI. B. Lustman. Jan. 3, 1955. Decl. Feb. 1, 1957. 54p. $0.50(OTS).

Data are summarized on the corrosion of U–Mo alloy in 343°C $H_2O$, the corrosion of U–Mo–Pt alloys in 650°F $H_2O$, the corrosion life of unclad U–Mo–Nb alloys in 650°F $H_2O$, the corrosion behavior of U–Mo–X alloys in 650°F $H_2O$, the corrosion life of zircaloy-clad U alloys, dimensional changes in irradiated U–Si alloy specimens, and hardness changes in U–Mo alloys during corrosion testing. Macroscopic observations of $UO_2$ powders and compacts are also shown. (W.L.H.)

**10871** ✓ WAPD-FE-434
Westinghouse Electric Corp. Atomic Power Div., Pittsburgh.
PRELIMINARY LITERATURE SURVEY [ON] URANIUM–SILICON ALLOYS. K. M. Goldman. Aug. 20, 1954. Decl. Mar. 6, 1957. 10p. $1.80(ph OTS); $1.80(mf OTS).

A survey of the mechanical properties, constitution diagrams, heat treatment, melting and fabrication characteristics, and powder metallurgical techniques of Si–U systems is presented. (J.E.D.)

**5223** ✓ WAPD-T-208
Westinghouse Electric Corp. Atomic Power Div., Pittsburgh.
THE CRYSTAL STRUCTURE OF $U_2Mo$. E. K. Halteman. Sept. 1955. 10p. $1.80(ph OTS); $1.80(mf OTS).

The crystal structure of the gamma prime phase in the U–Mo system has been determined to be the C11b $MoSi_2$ type. The unit cell is tetragonal and the space group $D_{4h}^{17}$–I4/mmm. The lattice parameters are $a_0 = 3.427$A, $c_0 = 9.834$A, $c/a = 2.871$. The gamma phase is an ordered state of the body-centered cubic gamma phase. (auth)

# URANIUM 1.43

## METALLURGY 1.43.05

### ALLOYS 1.43.05.01

**6767** ✓ A/CONF.15/P/49
**HIGH TEMPERATURE PROPERTIES OF URANIUM AND ITS ALLOYS.** A. B. McIntosh and T. J. Heal (United Kingdom Atomic Energy Authority, Culcheth, Lances, Eng.). 48p.

Data are presented on the mechanical and physical properties of high-purity and normal uranium and for a range of dilute uranium alloys at temperatures up to 700°C. The results of thermal conductivity and thermal expansion determinations for a range of alloys are discussed, and some results on the latent heat of fusion and volume change on melting are presented. Results of dilute alloy creep tests are reported and correlated with thermal cycling data and resistance to swelling under irradiation. (J.R.D.)

**9793** BMI-1023
Battelle Memorial Inst., Columbus, Ohio.
PHASE RELATIONS IN THE URANIUM–ZIRCONIUM–OXYGEN SYSTEMS INVOLVING ZIRCONIUM AND URANIUM DIOXIDE. Henry A. Saller, Frank A. Rough, Joseph M. Fackelmann, Arthur A. Bauer, and J. Robert Doig. July 28, 1955. Decl. Apr. 11, 1956. 30p. Contract W-7405-eng-92. $0.25(OTS).

Tentative isothermal sections of a part of the U–Zr–O system have been determined for 1000, 1300, and 2000°F. Uranium dioxide and zirconium solid solutions coexist in equilibrium at each of these temperatures. Alpha Zr in equilibrium with uranium dioxide contains about 28 a/o O, but very little U. Little Zr is soluble directly in $UO_2$, but extensive solubility exists between $UO_2$ and $ZrO_2$.

**9786** AECD-4008
National Bureau of Standards, Washington, D. C.
THE URANIUM–ZIRCONIUM [BINARY SYSTEM]. Metallurgy Division Final Report. R. W. Buzzard, R. B. Liss, and D. P. Fickle. [nd]. Decl. Jan. 11, 1956. 13p. (NBS-D-116). $3.30(ph OTS); $2.40(mf OTS)

The phase diagram for the U–Zr system within the range 0 to 43 at. % Zr was developed by thermal, metallographic and x-ray techniques. The general form of the diagram appeared to agree with that proposed by Udy. The solubility of Zr in α-Uranium was low, being approximately 2 at. % at room temperature, rising to 6 at. % at 685°C. The β-γ transition was lowered to 685°C at 18.5 at. %. Two horizontals were observed in the system, one at 685°C and the other at 610°C. Above 685°C a continuous solid solution between beta-Zr and U existed. (auth)

### GENERAL 1.43.05.02

**1436** JEN-46
Spain. Junta de Energia Nuclear, Madrid.
CONTROL TERMOGRAVIMETRICO DE PRODUCTOS INTERMEDIOS DE LA METALURGIA DEL URANIO. (Thermogravimetric Control of Intermediate Products in the Metallurgy of Uranium). L. Gascó Sánchez and R. Fernández Cellini. 1959. 14p.

The thermal decomposition of some intermediate compounds in the metallurgy of uranium such as uranium peroxide, ammonium uranate, ammonium uranium pentafluoride, uranium tetrafluoride, and $UO_2$, were studied using Chevenard's thermobalance. Some data on the pyrolysis of synthetic mixtures of intermediate compounds which may appear during the industrial processing are given. Thermogravimetric methods of control are suggested for use in uranium metallurgy. (tr-auth)

PROCESSING AND PROPERTIES OF URANIUM. G. Schneider. Metall 13, 625-30(1959) July. (In German)

The chemical, physical, and mechanical properties which are essential for the machining and application of uranium are described. 28 references. (J.S.R.)

**15095** ✓
AQUEOUS URANIUM CORROSION AT 100°C. J. B. Schroeder, D. A. Vaughan, and C. M. Schwartz (Battelle Memorial Inst., Columbus). J. Electrochem. Soc. 106, 486-9(1959) June.

The mechanism of aqueous uranium corrosion was studied using weight loss and hydrogen evolution measurements. Microscopic x-ray diffraction and chemical analyses were made of the corrosion product. The results indicate that uranium corrodes by forming an oxide of the type $UO_{2+x}$. The lack of chemical balance reported by earlier workers is explained by the existence of metallic uranium in the oxide layer. (auth)

**17034**
THE DOUBLE FLUORIDES OF TETRAVALENT URANIUM IN THE METALLURGY OF URANIUM. G. Imarisio and R. Sesini (CISE, Milan). Energia nucleare (Milan) 5, 522-6(1958) Aug. (In Italian)

A review is made of the several methods involved in the production of uranium fluorides which are suitable for reduction to uranium metal. The fluoride reduction appears to be a convenient way for obtaining uranium metal. Uranium tetrafluorides and uranium–alkaline metals or alkaline earth metal fluorides were found to be the most suitable compounds to be employed for this purpose. (tr-auth)

# URANIUM 1.43

## METALLURGY 1.43.05

### GENERAL 1.43.05.02

URANIUM SELENIDE $U_3Se_5$. Parviz Khodadad. Compt. rend. 247, 1205-6(1958) Oct. 20. (In French)

The selenides $USe_3$, $U_\alpha Se_2$, $U_\beta Se_2$, and $U_\gamma Se_2$ when heated between 700 and 1200°C either in a current of hydrogen or under vacuum give a selenide of the formula $U_3Se_5$. Some physical and chemical characteristics of the compound were studied. (tr-auth)

PREPARATION OF METALLIC URANIUM. J. Maly, V. Machacek, J. Kutzendorfer, V. Kourim, and V. Jerabek (Inst. of Nuclear Physics, Prague). Jaderna Energie 4, No. 1, 9-18(1958) Jan. (In Czech.)

Experiments on laboratory preparation of metallic uranium are reviewed, and the method most suitable to Czechoslovakian economics is presented. The chosen process consisted of the extraction of concentrated solutions of $UO_2(NO_3)_2 \cdot 6H_2O$ with ethyl ether and re-extraction with water. Uranium is then precipitated as $UO_4 \cdot 2H_2O$ and burned to $UO_3$, which is in turn reduced by hydrogen to $UO_2$ and changed by a dry process (over $NH_4UF_5$) to $UF_4$. With the aid of very pure Ca in a crucible lined with pure $CaF_2$ the $UF_4$ undergoes calcinothermic reduction to uranium metal. (tr-auth)

PROBLEMS OF CHEMISTS IN THE PRODUCTION OF URANIUM AND THORIUM. G. Wirths (Deutsche Gold- und Silber-Scheideanstalt, Wolfgang bei Hanau). Acta Phys. Austriaca 11, 471-84(1958). (In German)

After an introductory discussion of the purity requirement, the technical procedures for the production of metallic reactor grade uranium and thorium are explained and discussed. (tr-auth)

**5703** NP-6238

Penn-Texas Corp., New York.

BIBLIOGRAPHY ON THE PHYSICAL METALLURGY OF URANIUM. [Period covered] 1953–1956. Helen C. Friedemann, comp. Mar. 1957. 30p.

**4694** CEA-693

**France. Commissariat à l'Énergie Atomique, Paris.**

**COMPORTEMENT MÉCANIQUE DE L'URANIUM. (Mechanical Behaviour of Uranium.) J. Bernard and G. Coureau. 1957. 22p.**

**The principal mechanical properties of uranium at 20 to 400°C are presented. (auth)**

COMPARATIVE STUDY OF THE ALLOTROPIC TRANSFORMATIONS IN IRON AND URANIUM. P. Lehr and J. P. Langeron. pp. 47-56 in "Symposium on Special Metallurgy held at Saclay June 27-28, 1957." 130p. (In French)

The $\alpha \rightleftharpoons \beta$ phase change of uranium presents a certain number of analogies with the $\alpha \rightleftharpoons \gamma$ transformation of iron. For uranium as for iron, these transformations appear to be effected by processes of germination and growth. There seems to be no crystallographic relation of orientation between the $\alpha$ and $\beta$ phase in uranium. The allotropic transformations of both metals are accompanied by a relative volume variation of the order of 1%. It results in the creation of internal stresses which are relatively important during the formation of germs and their development. It was shown that these stresses entail a true plastic deformation of the metal during the transformation. (tr-auth)

**15184** A/CONF.15/P/1855

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

METALLOGRAPHIC STUDIES OF URANIUM. T. K. Bierlein and B. Mastel. 17p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The desirability of understanding and predicting the behavior of metallic uranium reactor fuel material as a function of various reactor parameters has warranted a study of the microstructure of non-irradiated and irradiated uranium. Since the metallography of irradiated uranium is difficult and subject to questionable interpretation three different approaches have been used: (1) statistical comparison of the microstructure of non-irradiated uranium with that revealed in irradiated uranium specimens which have been subjected to a standardized sectioning, grinding, polishing, and etching procedure; (2) point to point comparison of non-irradiated areas in metallographic specimens of uranium with the same identical area on the specimen after irradiation; (3) statistical comparison of the fracture surface of notched-bar impact specimens of non-irradiated uranium with that of irradiated uranium specimens. The experimental techniques which include etching by ion bombardment, replication of either flat or rough surfaces, and subsequent optical and electron microscope preparation of the replicas are described. The metallographic data and its interpretation are presented. (auth)

# URANIUM 1.43

## METALLURGY 1.43.05

### GENERAL 1.43.05.02

**173** AERE-M/M-156
Gt. Brit. Atomic Energy Research Establishment, Harwell, Berks, England.
INCLUSIONS IN URANIUM METAL. K. E. G. Meredith and M. B. Waldron. May 1957. 18p.

The available evidence on the occurrence and identity of inclusions due to C, O, N, H, Fe, Si, and Al in U is reviewed in conjunction with observations. Apparently divergent views on interpretation can be reconciled by postulating that absolutely pure UO, UN, or UC do not exist in normal U metal, but that due to their isomorphism they occur as a complex designated U(O.C.N.). Oxygen, C, or N can predominate in U(O.C.N.) depending on the composition and thermal history of the metal. Although a broad basis has been established for the identification of inclusions in U, precise details of the composition is not always possible of either U(O.C.N.) or the differentiation of the precipitates formed by the U–Fe, U–Si, and U–Al compounds. Uranium hydride and $CaF_2$ or $MgF_2$ can be identified with fair certainty when in sufficient quantity. (auth)

**4394** NYO-7543
Tufts Univ., Medford, Mass.
HIGH TEMPERATURE DISSOCIATION PRESSURE STUDIES OF THE URANIUM–HYDROGEN SYSTEM. Period Covered: March 17, 1955 to December 31, 1956. George G. Libowitz and Thomas R. P. Gibb, Jr. Dec. 31, 1956. 23p. Contract AT(30-1)-1355. $4.80(ph OTS); $2.70 (mf OTS).

Pressure-composition isotherms were obtained for the U–$H_2$ system over the temperature range 450 to 650°C at pressures up to 65 atm. in a stainless steel apparatus designed for high temperature high pressure measurements. The effect of thermal gradients on the shapes of the isotherms is discussed. The experimentally determined plateau pressures are compared with values extrapolated from low temperature studies of Spedding and Flotow and Abraham. A value of −30.3 kcal/mole was obtained for the heat of formation of $UH_3$ from the dissociation pressure data. (auth)

**2223** HW-42532
Hanford Atomic Products Operation, Richland, Wash.
METALLOGRAPHY OF IRRADIATED URANIUM. James R. Morgan. Mar. 30, 1956. Decl. May 1, 1958. 19p. Contract W-31-109-Eng-52. $3.30(ph OTS); $2.40(mf OTS).

**1147**
DEFORMATION MECHANISMS OF ALPHA-URANIUM SINGLE CRYSTALS. L. T. Lloyd and H. N. Chiswik (Argonne National Lab., Lemont, Ill.). J. Metals 7, 1206-14(1955) Nov.

The operative deformation elements in α-uranium single crystals under compression at room temperature have been determined as a function of the compression directions. The deformation mechanisms noted may be arranged with respect to their frequency of occurrence and ease of operation in the following order: 1–(010)-[100] slip, 2–{130} twinning, 3–{~172} twinning, and 4–under special conditions of stress application, kinking, cross-slip, {~176} twinning, and {011} slip. The composition planes of the {172} and {176} systems were found to be irrational. Crossslip was shown to be associated with the major (010) slip system, coupled with localized interaction of slip on the (001) planes. The mechanism of kinking was found to be similar to that observed in other metals in that it occurred chiefly when the compression direction was nearly parallel to the principal slip direction [100] and was associated with a lattice rotation about an axis contained in the slip plane and normal to the slip direction: the [001] in the uranium lattice. The resolved critical shear stress for slip on the (010)-[100] system was found to be 0.34 kg per $mm^2$. In a single test it was shown that under compression in suitable directions twinning on the {130} also occurs at 600°C. (auth)

**2731** NAA-SR-Memo-4269
Atomics International Div., North American Aviation, Inc., Canoga Park, Calif.
THE HIGH TEMPERATURE CHEMICAL REACTIVITIES OF THE URANIUM CARBIDES. Louis Silverman. Aug. 19, 1959. 17p. OTS.

The reactions of uranium carbides with elements and compounds are briefly discussed. Phase diagrams of the C–U system are presented. The irradiation properties of uranium carbides are also discussed. (W.L.H.)

SUCCESSFUL DETERMINATION OF PHASE DIAGRAMS OF METAL SYSTEMS. Ye. O. (O. Ye.). Atomnaya Energiya 3, No. 8, 174-5(1957).

A meeting was held in Moscow from May 17 to May 21, 1957, to discuss problems connected with phase diagrams. The alloys of beryllium, niobium, zirconium, uranium, and plutonium were emphasized. (J.S.R.)

# URANIUM 1.43

## METALLURGY 1.43.05

### GENERAL 1.43.05.02

**3428** TID-7523(Pt. 1)
Metallurgy Development Advisory Committee, AEC.
TECHNICAL PAPERS OF THE TENTH METALLOGRAPHIC GROUP MEETING HELD AT KNOLLS ATOMIC POWER LABORATORY, OCTOBER 24, 1955. H. P. Roth, comp. 100p. $0.70(OTS).

The papers presented are: A Macroetch for U; Castomold—A Self-curing Plastic for Mounting Specimens; New Etching Methods for Th; Inclusion Counting Methods for U; Microhardness Evaluation of Alpha Hot-Rolled U Rod for Drawing; Metallographic Determination of U–Nb Phase Diagram Up To 10% Nb; Metallography of Epsilon Phase in the U–Zr System; A Preliminary Report on the U–C System; Metallography for the Geneva Reactor Fuel Elements; Techniques for the Preparation of $UO_2$ Compacts for Microscopic Examination; Microstructure of Some Irradiated Nonfissionable Metals; Techniques for the Metallography of High Purity Al; Cooperative Program on Identification of Inclusions in U. (T.R.H.)

**1649** ✓
ON THE EXPANSION BEHAVIOR OF SINGLE CRYSTALS OF α URANIUM. Pierre Lehr and Jean-Paul Langeron. Compt. rend. 241, 1130-3(1955) Oct. 24. (In French)

The expansion behavior of uranium monocrystals was studied as a function of their orientation, and values of linear expansion coefficients along the three principal crystal axes were determined. (tr-auth)

**10226** ✓ RDB(S)/TM-3245
United Kingdom Atomic Energy Authority. Industrial Group. Springfields Works, Springfields, Lancs, England.
THE PHYSICAL METALLURGY OF URANIUM: 3RD REVIEW–A MICROGRAPHIC STUDY OF INCLUSIONS IN URANIUM. M. D. Jepson, W. A. Pollock, and G. Slattery. [1955]. 13p.

The metallographic examination of a large number of samples of uranium made at Springfields has revealed the existence of at least six distinct types of inclusion. While the composition of the inclusions has not been established with certainty, it is believed that they include uranium dioxide, uranium monocarbide, uranium monocarbide in association with uranium oxide or nitride, intermetallic compounds of uranium with iron, silicon, or aluminum, and calcium fluoride slag. (auth)

**13099** ✓ TID-5256(Rev.)
[Metallurgy Development Advisory Committee, AEC].
URANIUM INCLUSIONS—TECHNICAL PAPERS OF NINTH METALLOGRAPHIC GROUP MEETING OCTOBER 27, 1954, [AT BATTELLE MEMORIAL INSTITUTE]. H. P. Roth, comp. Apr. 26, 1955. Decl. Mar. 1, 1957. 113p. $0.70(OTS).

Results of studies of the inclusions in U and its alloys are reported. The development of an ultrasonic drill for the extraction of inclusions in U is described. Inclusions in U due to $N_2$ and $H_2$ are identified. Metallographic examinations for the identification of inclusions were made on U–Fe and U–Si alloys and reject commercial slugs. (C.W.H.)

✓ **12429** NYO-3800
Metal Hydrides Inc. Chemical Research Lab., Beverly, Mass.
SECOND ANNUAL REPORT ON THE PREPARATION OF URANIUM HYDRIDE. Period Covered: July 1, 1953 through June 30, 1954. Sidney Johnson. Aug. 20, 1954. Decl. Feb. 26, 1957. 37p. Contract AT(30-1)-1350. $0.40(OTS).

Uranium metal of density 18.55 g/cm$^3$, or greater than 97% of the theoretical value, has been prepared by hot-pressing $UH_3$ powder obtained from the direct reduction of $UO_2$ with $CaH_2$, and leaching the resulting furnace product with aqueous acid. Massive metal of better quality could not be produced by the process employed because of the interaction between the $UH_3$ and the aqueous leaching media. Although the initial reaction rate of $UH_3$ with methanol is smaller by an order of magnitude than the reaction rate of $UH_3$ with $H_2O$, methanolic HCl did not prove to be satisfactory leaching medium. Optimum furnacing conditions for the reduction have been determined. Analytical methods for evaluating $UH_3$ powders were perfected during the course of the investigation. These methods include: (1) direct determination of $O_2$ in U and $UH_3$ by reaction with $BrF_3$; (2) densities of U pellets produced by a small scale hot-pressing technique from $UH_3$ powders; and (3) U oxide assays by dissolution of $UH_3$ in a measured excess of $Ce(HSO_4)_4$ solution. (auth)

**2665** ✓ MND-2081
Martin Co. Nuclear Div., Baltimore.
LITERATURE SURVEY ON URANIUM MONOCARBIDE. J. L. Kane. July 15, 1959. 20p. OTS.

A literature survey is presented covering only the unclassified literature on uranium monocarbide, which is considered the only thermodynamically stable specie at room temperature. (auth)

# URANIUM 1.43

## METALLURGY 1.43.05

### GENERAL 1.43.05.02

**12482** LRL-135(Rev.)
California Research and Development Co. Livermore Research Lab., Livermore, Calif.
FEASIBILITY OF FABRICATING URANIUM SPHERES BY POWDER METALLURGICAL TECHNIQUES. C. H. Bean and H. T. Campion. May 1954. Decl. Mar. 12, 1957. 15p. $0.30(OTS).

A system of fabricating ½-inch-diameter uranium spheres by powder metallurgy techniques was developed. Initial tests indicate that spheres produced by this method will exceed 95% of theoretical density and will possess good dimensional tolerances. (auth)

**17313** TID-2502(Del.)(p.7-26)
Sylvania Electric Products Inc. Metallurgical Labs., Bayside, N. Y.
THE APPLICATION OF POWDER METALLURGY TO PROBLEMS INVOLVING BERYLLIUM, ZIRCONIUM, AND URANIUM. B. H. Alexander, H. H. Hausner, and W. E. Kingston. p.7-26 [of] NUCLEAR SCIENCE AND TECHNOLOGY. (EXTRACTS FROM REACTOR SCIENCE AND TECHNOLOGY. VOL. 1, ISSUES 1 TO 3, APRIL–DECEMBER 1951). 20p. (SEP-51(X)).

The advantages of powder metallurgy in certain applications are discussed, and the methods that have been developed for making, pressing, and sintering powders of uranium, beryllium, and zirconium are outlined. Special applications of these methods in the production of fuel elements, in the control of grain size

KRISTALLOKHIMIYA PROSTEYSHIKH SOYEDINENIY URANA, TORIYA, PLUTONIYA I NEPTUNIYA. (Crystal Chemistry of Simple Compounds of Uranium, Thorium, Plutonium, and Neptunium.) Yevgenii Sergeyevich Makarov. Moscow, Izd-vo AN SSSR, 1958. 141p.

A compilation is presented of the published data up to 1957 on the crystal chemistry of simple compounds of the actinide elements. An introductory chapter discusses some problems of general crystal chemistry. The crystal structure of polymorphous modifications of thorium, uranium, neptunium, and plutonium is described, and then the crystal structure of simple compounds with non-metals and metals is reported. The atomic radii of actinides in crystals are considered. The final chapter is a discussion of the dual chemical nature of thorium, uranium, neptunium, and plutonium. 117 references. (TCO-J.S.R.)

**7258** CT-2960
Iowa State Coll., Ames.
THE URANIUM-MERCURY SYSTEM. D. H. Ahmann, R. R. Baldwin, and A. S. Wilson. Oct. 27, 1945. Decl. Dec. 15, 1955. 21p. Contract W-7405-eng-82. $0.25(OTS).

The U–Hg system has been studied by thermal analysis, vapor pressure-temperature curves and x-ray diffraction. Three compounds exist; $UHg_4$ which decomposes at 360°C to $UHg_3$ and Hg(v), $UHg_3$ which goes to $UHg_2$ and Hg(v) at 390°C, and $UHg_2$ which breaks down into U + Hg(v) at 460°C. There appears to be some solubility of U in Hg(l) and of Hg in U but no mutual solubility between the compounds. Because of the pyrophoric nature of the amalgams, all work was done under vacuum or an inert atmosphere. $UHg_2$ has a hexagonal structure, a = 4.77 Å and c = 3.21 Å with a calculated density of 15.29 g/cc. $UHg_3$ has a hexagonal c.p. structure, a = 3.30 and c = 4.86 with calculated density of 14.88 g/cc. The structure of $UHg_4$ has not been determined. (auth)

**3407** BMI-66
Battelle Memorial Inst., Columbus, Ohio.
GRAIN SIZE CHART OF URANIUM. H. A. Saller, R. F. Dickerson, and G. E. Lind. June 1, 1951. Decl. Nov. 30, 1955. 14p. Contract W-7405-eng-92.

A grain size chart containing photographs of typical U structures for grain diameters of 0.009 to 0.118 mm was prepared. All structures were photographed using both polarized light and bright field illumination. (J.E.D.)

**6813** A/CONF.15/P/1470
THE POWDER METALLURGY OF URANIUM.
H. Lloyd and J. Williams (Atomic Energy Research Establishment, Harwell, Berks, Eng.). 38p.

The powder metallurgy of uranium was developed in the United Kingdom concurrently with casting as a fabrication technique for the production of uranium fuel rods. Attention was concentrated almost exclusively upon the consolidation of powder produced by calcium reduction of uranium dioxide. This type of uranium powder was considerably more stable in air than that produced by the hydriding of massive uranium. The handling of powder in elaborate glove-box systems containing inert atmospheres was therefore not necessary for the investigations described. The calcium-reduced powder consistently contained over 90 wt. % of material of particle size below 300 B.S.S. mesh (~60 microns). A typical particle size distribution for this powder fraction and a typical chemical analysis are given. The spheroidal nature of the –300 mesh particles is illustrated. (auth)

# URANIUM 1.43

## METALLURGY 1.43.05

### GENERAL 1.43.05.02

**16858**
RECRYSTALLIZATION IN URANIUM CAUSED BY THERMAL CYCLING. A. A. Bochvar, G. I. Tomson, and N. T. Chebotarev. Atomnaya Energ. 4, 555-6(1958) June. (In Russian)

Recrystallization which results in crushed initial microstructure was observed as the result of cyclic thermal treatment at temperatures of 100 to 550°C for 50 sec in quenched and tempered $\gamma$ phases and in cast uranium not subjected to additional deformation. Recrystallization starts at the points with the most distorted crystalline lattice. (tr-auth)

**6786** A/CONF.15/P/964
SOME PROPERTIES OF URANIUM MONOCARBIDE. A. Boettcher and G. Schneider (Degussa, Frankfurt a. M.). 6p.

The properties of UC that are essential for its application as a nuclear fuel are discussed. Various methods for producing UC are discussed along with the composition of the resulting product. Mechanical, thermal, electrical, and corrosion properties are briefly discussed. The reaction of UC with other metals is discussed at length. (W.L.H.)

**8931**
THE URANIUM–LEAD SYSTEM. Robert J. Teitel (Brookhaven National Lab., Upton, N. Y.). J. Inst. Metals 85, 409-12(1957) May.

In order to confirm the conclusions concerning the liquid immiscibility in the lead–uranium system reached in an earlier paper, the experiments on which these conclusions were founded are described in greater detail. New data on the solubility of uranium in lead, obtained by a filtration technique, and on the crystal structure of UPb, obtained by neutron diffraction, are also presented. UPb has a body-centered tetragonal cell with c/a = 0.961, a = 11.04 A., and contains 48 atoms. The density is estimated to be 13.7 g./c.c. A discrepancy between the values for the cell size of $UPb_3$, as determined by Frost and Maskrey and by the present author, is discussed. According to present work, a = 4.791 A. and the density = 12.98 g./c.c. (auth)

**8946** ANL-5700(Pt. B)
Argonne National Lab., Lemont, Ill.
THE ELECTRICAL CONDUCTIVITY OF URANIUM. Karl F. Smith. Apr. 1957. 25p. Contract W-31-109-eng-38. $0.25(OTS).

Second in a monograph series on "The Physical Metallurgy of Uranium," sponsored by the Metallurgy Div., ANL.

The data on electrical conductivity of U, including the British work on purity, a study of transition temperature effects, and other more unusual points, like the effects of annealing temperature, cycling growth, preferred orientation, and hydrostatic pressure are presented. Comments in the literature on superconductivity of U are also covered. The reason for classing as minor the effects of preferred orientation is that the electrical-thermal relations apparently may not be valid for different crystallographic directions and so cannot as yet be used to determine thermal data. The monograph is primarily intended as a critical review of data to be used for further research on U, and completeness has been striven for only in the one respect of published data on U. A brief résumé of basic theory not intended to be complete, is included along with some schematic description of apparatus and experimental techniques. Electrical measurements, not being so difficult or so demanding in experimental technique, usually have an earlier history than thermal measurements of a given substance. The spread of data from various observers occurs over a much narrower band than the thermal data, even if observations be limited to U of nominal purity. The best and most representative data at the present time are shown for resistivity and translated to conductivity. (auth)

**9899** HW-34868 C 8
Hanford Atomic Products Operation, Richland, Wash.
MECHANICAL AND PHYSICAL PROPERTIES OF URANIUM. Chapter 8 of NUCLEAR METALLURGY LECTURES. R. E. Hueschen. May 10, 1955. Decl. Mar. 13, 1957. 32p. Contract [W-31-109-Eng-52]. $0.35(OTS).

The physical properties such as density, thermal and electrical conductivity, and thermal expansion and the mechanical properties such as tensile and elastic behavior, fatigue, hardness, shear strength, creep, and impact for pre-irradiated U are given. (F.S.)

# URANIUM 1.43

## OTHER REACTIONS AND PROPERTIES 1.43.06

**189**

NUCLEAR ENGINEERING DATA SHEET. NO. 1. URANIUM. Nuclear Eng. 2, 364a-5(1957) Sept.

The mechanical, chemical, physical, nuclear and metallurgical properties of uranium are summarized and presented in graphic and tabular form. (T.R.H.)

## CHLORIDES 1.43.06.01

**16024**

PRODUCTION OF URANIUM HALIDES. U. K. Atomic Energy Authority (U.S.A.). British Patent 803,258. Nuclear Eng. 4, 284(1959) June.

Uranium tetrafluoride is prepared from the oxide $U_3O_8$ by maintaining the oxide in particle form in fluidized suspension at elevated temperature in hydrogen to convert it to uranium dioxide. Uranium tetrahalide is then produced by the interaction of a gaseous hydrogen halide and the uranium dioxide at elevated temperature maintained in fluidized suspension in the hydrogen halide.

**8884**

THE HEAT OF SOLUTION OF URANIUM TETRACHLORIDE AND THE HYDROLYSIS OF THE URANIUM(IV) ION. J. A. Hearne and A. G. White (A.E.R.E., Harwell, Didcot, Berks). J. Chem. Soc. 2081-5(1957) May.

Measurements have been made of the heat of solution of anhydrous $UCl_4$ in aqueous HCl–LiCl mixtures at constant ionic strength. The variation of the heat of solution with HCl concentration is in apparent disagreement with current views on the $U^{4+}$ and an explanation is offered in terms of the effect of the electrolyte in the solvent on the solvation energy of $UCl_4$. (auth)

**8089**

PROCESS FOR PRODUCING URANIUM PENTACHLORIDE. A. D. Webb and H. P. Kyle (to U. S. Atomic Energy Commission). U. S. Patent No. 2,743,158, Apr. 24, 1956. $UCl_5$

Uranium ~~pentafluoride~~ can be prepared by passing a stream of $UCl_4$ particles through a stream of $Cl_2$ in a tubular reaction vessel. A portion of the reaction tube is heated to 550°C and here the $UCl_5$ is formed and volatilizes immediately. The $Cl_2$ stream sweeps the $UCl_5$ on into a cooler portion of the tube and the $UCl_5$ vapor condenses and is separated from and purified of free $Cl_2$. (auth)

**132**

THE INTERACTION OF URANYL CHLORIDE WITH HYDRAZINE, AMMONIA AND AMINES. I. Kalnins and G. Gibson (Illinois Inst. of Tech., Chicago). J. Inorg. & Nuclear Chem. 11, 115-23(1959) Sept.

Solid systems of composition $UO_2Cl_2 \cdot 4N_2H_4$, $UO_2Cl_2 \cdot 3NH_3$, and $UO_2Cl_2 \cdot 2-3RHN_2$ (R = $CH_3$, $C_2H_5$, $C_3H_7$, and $C_4H_9$) were prepared. Of these only $UO_2Cl_2 \cdot 3NH_3$ is stable up to 200°C. The $UO_2Cl_2-RNH_2$ systems underwent a slow redox reaction giving $UO_2$, ligand hydrochloride and polymeric materials as the solid products. The polymeric materials containing carbon, nitrogen, and hydrogen appeared to be primarily polymers of alkylamine, produced from the corresponding amine by dehydrogenation. In $UO_2Cl_2$–n- and i-butylamine systems the amine also seems to be involved in the polymerization. In the $UO_2Cl_2$–t-butylamine redox reaction, isobutylene and a branched hexane or hexene were identified in the volatile products. The only oxidation products in the $UO_2Cl_2-N_2H_4$ system were noncondensable gases ($N_2$ and $H_2$). Aqueous 10 M hydrazine was found to reduce solid $UO_2Cl_2$, but not $UO_3$, to solid $UO_2$ at room temperature. (auth)

## HYDROLYSIS 1.43.06.02

**10098**

THE MECHANISM OF THORIUM IV AND URANIUM IV HYDROLYSIS. Sirkka Hietanen (Royal Inst. of Tech., Stockholm, Sweden). Rec. trav. chim. 75, 711-15(1956) June.

The hydrolysis of $Th^{4+}$ and $U^{4+}$ were studied in perchlorate media by electrometric titrations. The pH was measured, and can be deduced from the equilibrium data that a series of complexes are formed. (W.L.H.)

**1769**

HEAT OF HYDROLYSIS OF URANIUM(IV) IN PERCHLORIC ACID SOLUTIONS. R. H. Betts (Atomic Energy of Canada Ltd., Chalk River, Ont.). Can. J. Chem. 33, 1775-9(1955) Dec.

Using spectrophotometric techniques, the heat of hydrolysis of $U^{4+}$ in aqueous $HClO_4$ solutions has been determined to be 10.7 ± kcal/mol and the entropy of association of $U^{4+}$ with hydroxyl ion estimated to be +52 eu. (C.W.H.)

# URANIUM 1.43

## OTHER REACTIONS AND PROPERTIES 1.43.06

### HYDROLYSIS 1.43.06.02

**4395**

STUDIES ON THE HYDROLYSIS OF METAL IONS. 17. THE HYDROLYSIS OF THE URANIUM(IV) ION, $U^{4+}$. Sirkka Hietanen (Royal Inst. of Tech., Stockholm). Acta Chem. Scand. 10, No. 10, 1531-46(1956).

The hydrolysis of $U^{4+}$ has been studied in a 3M (sodium) perchlorate medium at 25°C by two series of electrometric titrations; in one, $[H^+] = h$ was measured with glass or hydrogen electrodes, in the other, $b = [U^{4+}]$ was measured with a Pt–Pd redox electrode. after the addition of $UO_2^{2+}$. The data could be explained, assuming the mononuclear reaction $U^{4+} + H_2O \rightleftharpoons UOH^{3+} + H^+$, equilibrium constant $\beta_1$, and a polynuclear "core + links" reaction, according to hypothesis IIIa: $(n + 1)U^{4+} + 3\,n\,H_2O \rightleftharpoons U((OH)_3U)_n^{4+n} + 3\,n\,H^+$, equilibrium constant $k_n = k_0k^n$. The best agreement was found with $\log \beta_1 = -2.00 \pm 0.1$, $\log k_0 = -1.2 \pm 0.3$, $\log k = -3.4 \pm 0.1$. By analogy with $Th^{4+}$ and considering the crystal structure of $U(OH)_2SO_4$ it seems plausible that the complexes are chain-like, of formula $U(^{O}_{OH}U)_n^{4+n}$. (auth)

### IRRADIATION EFFECTS 1.43.06.03

**13869**

RADIATION OXIDATION OF QUADRIVALENT URANIUM SOLUTIONS. V. G. Firsov and B. V. Ershler. Atomnaya Energ. 4, 343-8(1958) Apr. (In Russian)

Equations describing the dependence of G (G = 2 to 4 kev/100 ev) on $U^{4+}$ and expressions for the rate constants of H + OH, H + H, and $U^{4+}$ + OH were derived. The yield of G is reduced with the increase of $U^{4+}$ concentrations. This results from the reduction of $U^{4+}$ by H radicals. Studies were made of the mechanisms of $UO_2^{2+}$ inhibition of oxidation processes in $U^{4+}$. Equations for the rate constant of $UO_2^{2+}$ + H, and H + H, and for reactions $UO_2^{2+}$ + OH, H + OH, and H + H were calculated. An equation was derived describing the dependence of G on $U^{4+}$ and $UP_2^{2+}$, which is in good agreement with the experimental data for a wide range of concentrations. (tr-auth)

**9445** TID-7546(p.591-615)

[General Electric Co.] Hanford Atomic Products Operation, Richland, Wash.

IRRADIATION EFFECTS IN URANIUM. S. H. Bush. p.591-615 [of] FUEL ELEMENTS CONFERENCE, PARIS, NOVEMBER 18-23, 1957. 25p. (HW-51444).

A review of pertinent physical metallurgical properties of irradiated uranium is presented. Included under mechanical properties are hardness, bend, and tensile data. In the case of tensile properties the variables considered are burn-up, irradiation temperature, $U^{235}$ content, composition (to 3 wt. % alloy), postirradiation annealing, and tensile testing temperature. Drastic reductions in ductility occur at burnups as low as 0.02 at. %. Recovery of damage is limited on postirradiation annealing. Changes in such physical properties as density, thermal conductivity, electrical resistivity, and modulus of elasticity are reported. Thermal conductivity decreases 10 to 15% at nominal burnups. The effect of irradiation on the microstructure of uranium is reported. Macroscopic, optical and electron microscopic, and fractographic results are presented. Precipitation, microcracking, and microbrittleness were detected. Solid-state studies, including recrystallization and solid and noble-gas diffusion, are reported. No direct evidence of a change in diffusion due to irradiation has been obtained. Structural changes were observed by means of x-ray diffraction; line broadening, line asymmetry, and some line shift were observed. Dimensional instability of uranium is discussed; typical results and possible mechanisms advanced to explain these results are reported. The impact of these changes in physical metallurgical properties on the behavior of uranium fuel elements is discussed. (auth)

**9733**

CHEMICAL EFFECTS IN FISSION PRODUCT RECOIL. II. THE DECOMPOSITION OF URANYL IODATE. D. Hall (Atomic Energy Research Establishment, Harwell, Berks, Eng.). J. Inorg. and Nuclear Chem. 6, 3-11(1958) Feb.

Under pile irradiation uranyl iodate decomposes, elementary iodine being formed. The amount of decomposition is proportional to the number of fissions that occur; the G factor is 5.8 iodine atoms per 100 ev of recoil energy absorbed. A constant proportion (14 per cent) of the $I^{131}$ formed in fission is extracted with the reduced iodine, irrespective of the extent of decomposition. This is interpreted as the result of the chemical reaction involving the primary fission fragment and its surroundings. (auth)

# URANIUM 1.43

## OTHER REACTIONS AND PROPERTIES 1.43.06

### IRRADIATION EFFECTS 1.43.06.03

A PROPOSED EXPLANATION OF IRRADIATION GROWTH OF URANIUM. Ryukiti R. Hasiguti, Hideo Sakairi, and Tetuya Sugai (Univ. of Tokyo). J. Phys. Soc. Japan 13, 1233-4(1958) Oct.

It is observed that irradiation growth does not occur at low temperatures and at temperatures of 500°C. This is explained by the facts that diffusion and precipitation become slow at lower temperatures and that twinning does not take place at high temperatures. (auth)

**11196** ✓

THE EFFECTS OF PILE IRRADIATION ON $U_3Si$. Presented at Nuclear Engineering and Science Conference, held at Chicago, March 17 to 21, 1958. Preprint 18, Session 8. M. L. Bleiberg and L. J. Jones (Westinghouse Electric Corp., Pittsburgh). New York, American Institute of Chemical Engineers, 1958. 31p.

Specimens of U-3.8 wt.% Si alloy, heat treated to produce the epsilon intermetallic compound ($U_3Si$), were irradiated in the Materials Testing Reactor to a maximum exposure of 0.104 at.% burnup and at a maximum in-pile temperature of less than 250°C. The irradiation produced large changes in hardness, density, electrical resistivity, and mode of corrosion in 650°F water. The microstructure of the samples appeared unchanged, but no x-ray diffraction lines were observed after the irradiation. These results were tentatively explained on the basis of a neutron-induced disordering reaction. (auth)

**4740** CF-57-1-119

Oak Ridge National Lab., Tenn.

REACTOR IRRADIATION OF THORIUM AND URANIUM OXIDE SLURRIES. N. A. Krohn and J. P. McBride. Jan. 29, 1957. 18p. Contract [W-7405-eng-26]. $3.30(ph OTS); $2.40(mf OTS).

Thorium and thorium–uranium oxide slurries were irradiated in the Low Intensity Test Reactor (LITR) at temperatures up to 300°C in small stirred autoclaves. Stirring was accomplished by means of an electromagnetically operated plunger. Stirrer operation was monitored using an oscilloscope. Relative slurry viscosities were determined both in and out-of-pile using calibration curves of apparent viscosity versus stirrer rise time. Post-irradiation examination of selected slurries indicated no gross changes occurred in the particulate properties. (auth)

**15177** A/CONF.15/P/615

Knolls Atomic Power Lab., Schenectady, N. Y.

IRRADIATION EFFECTS IN $UO_2$. W. K. Barney. 11p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The physical, chemical, and mechanical properties of $UO_2$ that are important in describing irradiation effects are presented. The various types of $UO_2$ containing elements studied are discussed along with their relative merits and performances. The irradiation behavior of $UO_2$ in elements receiving burnups as great as 50% is discussed. Included are such effects as plasticity, fission gas agglomerations and release, sintering, growth or swelling as a function of burnup and crystal structure. An attempt is made to explain these observed irradiation effects based on the $UO_2$ structure and properties. The advantages and limitations of $UO_2$ are presented as supported by the irradiation data. (auth)

**8825** ✓ KAPL-1836

Knolls Atomic Power Lab., Schenectady, N. Y.

METALLOGRAPHY OF IRRADIATED $UO_2$-CONTAINING FUEL ELEMENTS. W. K. Barney and B. D. Wemple. Jan. 15, 1958. 40p. Contract W-31-109-Eng-52. $1.50 (OTS).

A description of hot laboratory metallography and techniques of operation are presented. These facilities and techniques provided a means of examining fuel elements that contain $UO_2$ after irradiation to high burnups. Some unusual irradiation characteristics of $UO_2$ were observed, and each effect is discussed. A complete explanation of the causes of such effects has not yet been obtained. (auth)

**8905** ✓ CF-58-4-25

Oak Ridge National Lab., Tenn.

TABLE OF CURRENT VALUES FOR THE DISTRIBUTION OF ENERGY RELEASED BY THE FISSION OF $U^{235}$ INDUCED BY THERMAL NEUTRONS. [PART] II. F. C. Maienschein. Apr. 7, 1958. 3p. Contract [W-7405-eng-26]. $1.80(ph OTS); $1.80(mf OTS).

**9446** TID-7546(p.616-716)

[Westinghouse Electric Corp.] Bettis Plant, Pittsburgh.

EFFECTS OF IRRADIATION ON BULK URANIUM DIOXIDE. J. D. Eichenberg, P. W. Frank, T. J. Kisiel, B. Lustman, and K. H. Vogel. p.616-716 [of] FUEL ELEMENTS CONFERENCE, PARIS, NOVEMBER 18-23, 1957. 101p.

This is a revised version of WAPD-183.

# URANIUM 1.43

## OTHER REACTIONS AND PROPERTIES 1.43.06

### IRRADIATION EFFECTS 1.43.06.03

**14656** A/CONF 15/P/522
Oak Ridge Gaseous Diffusion Plant, Tenn.
RADIATION EFFECTS OF ALPHA PARTICLES ON URANIUM HEXAFLUORIDE. H. A. Bernhardt, W. Davis, Jr., and C. H. Shiflett. 19p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Alpha irradiation of uranium hexafluoride results in the formation of fluorine and intermediate, solid uranium fluorides; these products react with each other, apparently by a radiation-induced process, to reform uranium hexafluoride. The number of molecules of uranium hexafluoride decomposed, excluding recombination, per 100 ev of energy absorbed, G , is approximately 1 in the temperature range 21 to 87°C. Irradiation of a mixture of fluorine and uranium hexafluoride in a vessel containing uranium fluorides substantiates the postulated mechanism. At fluorine pressures of 50 to 100 mm Hg, there is an increase, rather than a decrease, in uranium hexafluoride pressure. Rates of both decomposition and recombination processes appear to depend only on the rates of radiation energy absorption. Equations formulated to describe the combined decomposition and reformation reactions can be used to calculate equilibrium concentrations of uranium hexafluoride and fluorine when the intensity of the radiation source is defined. The effects of three diluent gases, helium, nitrogen, and oxygen, were studied in an attempt to find possible electron transfer processes. (auth)

**13705** WAPD-PMM-404(Del.)
Westinghouse Electric Corp. Atomic Power Div., Pittsburgh.
MINUTES OF URANIUM OXIDE PANEL MEETING. J. Glatter and R. C. Koch. Oct. 18, 1955. Decl. with deletions Mar. 5, 1957. 9p. $1.80(ph OTS); $1.80(mf OTS).

Irradiation tests on $UO_2$ and $UO_2$–ceramic systems are reported and discussed. (T.R.H.)

**9900** KAPL-1044
Knolls Atomic Power Lab., Schenectady, N. Y.
THE DIMENSIONAL STABILITY OF URANIUM SINGLE CRYSTALS AND POLYCRYSTALS DURING IRRADIATION AND THERMAL CYCLING. A. M. Turkalo. Feb. 8, 1954. Decl. Feb. 25, 1957. 15p. Contract W-31-109-Eng-52. $0.25(OTS).

**12622** BMI-986
Battelle Memorial Inst., Columbus, Ohio.
EFFECT OF RADIATION ON THE THERMAL CONDUCTIVITY OF URANIUM – 1.6 w/o ZIRCONIUM. H. W. Deem, M. Pobereskin, E. C. Lusk, C. F. Lucks, and G. D. Calkins. Mar. 16, 1955. Decl. Feb. 28, 1957. 20p. Supported by Atomic Power Development Associates through Contract W-7405-eng-92. $0.30(OTS).

Thermal-conductivity measurements were made with the heatwave method on the uranium-1.6 w/o zirconium alloy at a burnup of 0.21 and 0.75 a/o. On the basis of an interpolated thermal-conductivity value of 0.063 cal/(sec)(cm)(C) for the unirradiated alloy, the reduction in thermal conductivity for 0.21 and 0.75 a/o burnup was 8 and 9.5%, respectively. (auth)

**11105** ANL-5664
Argonne National Lab., Lemont, Ill.
EFFECTS OF IRRADIATION ON POWDER COMPACTS OF URANIUM AND SOME URANIUM-BASE ALLOYS. Final Report [for] Metallurgy Program 6.1.23. J. H. Kittel and S. H. Paine. June 1957. 42p. Contract W-31-109-eng-38. $1.25(OTS).

Results are given from irradiation experiments on powder compacts prepared from U, $UH_4$, and the following alloys: U–1.0, 1.4, 2.0, 2.5, and 3.5 wt. % Mo; U–1.6 wt. % Nb; and U–0.42 wt. % Si. The methods by which the compacts were prepared included end-pressing, side-pressing, hot-rolling, and hot-swaging. When subjected to irradiation, the uranium compacts invariably shortened in the pressing direction, whereas the compacts prepared from uranium hydride elongated in the pressing direction. The alloy compacts elongated in the direction of pressing, rolling, or swaging. The surface smoothness of the irradiated Mo alloy compacts improved with increasing Mo content, although dimensional stability tended to decrease. The irradiated Nb alloy showed comparatively good surface smoothness and dimensional stability, but the Si alloy specimens were badly roughened and elongated. Both the unalloyed and the alloyed compacts decreased in density under irradiation, and the rate of density decrease was found to depend strongly on the irradiation temperature. (auth)

# URANIUM 1.43

## OTHER REACTIONS AND PROPERTIES 1.43.06

### IRRADIATION EFFECTS 1.43.06.03

**13633** ✓ AERE-M/R-741
Gt. Brit. Atomic Energy Research Establishment, Harwell, Berks, England.
EFFECT OF IRRADIATION ON THE HARDNESS OF ALPHA-URANIUM. P. E. Madsen. July 1951. Decl. Jan. 11, 1956. 15p.

Further irradiations of samples from the original uranium used in earlier work show that at a flux of $10^{11}$ neutrons/cm$^2$/sec cold-worked uranium softens and annealed uranium hardens Both worked and annealed specimens from fresh uranium sheet show a drop in hardness on the first irradiation in a flux of $10^{11}$ neutrons/cm$^2$/sec. Further irradiation causes the hardness of the worked specimens to vary within a band of 14 Brinell, while the annealed specimens show a significant though slight hardening with time. This behavior was compared with the effect of annealing unirradiated material at 150°C from which it is concluded that the behavior of uranium under irradiation cannot be entirely explained by the heating effect produced by irradiation. Annealing experiments show that the hardness induced by irradiation is stable at 150°C but can be removed at 220°C. The results are consistent with the view that the hardness changes in uranium on irradiation are the net effect of the competing processes, hardening by atom disturbance from normal sites and thermal recovery. (auth)

**22091**
RADIATION PROCESSES IN SOLUTIONS OF TETRAVALENT URANIUM. V. G. Firsev and B. V. Ershler. p.53-6 of "Radiation Chemistry of Aqueous Solutions (Inorganic and Organic Systems)."

It was shown that the oxidation of $U^{IV}$ solutions under the action of $\gamma$ radiation is effected by the OH radical and $H_2O_2$. The molecular ion $H_2^+$ does not participate in this process. When the $U^{IV}$ concentration is reduced the oxidation yield decreases as a result of the recombination of H and OH radicals. An equation was deduced giving the relation of $G_{U^{VI}}$ to $[U^{IV}]$ and including the ratio of the rate constants of the three reactions: $U^{IV}$ + OH, H + OH, H + H. A mechanism is proposed for the retardation of $U^{IV}$ oxidation by $UO_2^{2+}$ ions. An hypothesis is put forward on the possibility of the reaction $UO_2^{2+}$ + OH. Kinetic equations based on this mechanism were given which agree with the experimental data. (auth)

**1975** ✓ KAPL-1158
Knolls Atomic Power Lab., Schenectady, N. Y.
X-RAY DIFFRACTION EFFECTS TO BE EXPECTED FROM IRRADIATED URANIUM. W. M. Cashin and C. W. Tucker, Jr. Aug. 13, 1954. ~~Decl. Oct. 6, 1955.~~ 13p. Contract W-31-109-Eng-52.

The expected x-ray effects in irradiated uranium are compared with effects in ionic, covalent, and metallic crystals. The unique changes due to fission product formation are discussed. Some criteria for the suitability of experimental techniques in the study of damage are presented. (auth)

**6792** ✓ A/CONF.15/P/1158
ETUDE SUR L'URANIUM IRRADIE. (Study on Irradiated Uranium.) J. Bloch, J. P. Mustelier, P. Bussy, and J. Blin (Commissariat à l'Énergie Atomique, Paris). 31p.

Recrystallization and hardness in uranium irradiated at 220 Mwd/t were studied during successive annealings by following the evolution of micrographies. Some measurements of density were also made. It was observed that the initial state of the irradiated metal and its restoration differed little from cold-worked metal. Recrystallization was not observed by heating beyond the $\alpha$ phase. It is necessary to pass the $\beta$ region to observe it. The effect of very weak irradiations (integrated flux of $10^{16}$ nvt) on uranium was studied by measurements of the hardness. Hardness does not increase linearly with the flux, but there is a period of incubation which represents the time necessary for the saturation of the dislocations. (J.S.R.)

### ORGANIC 1.43.06.04

COMPOSITION AND APPARENT INSTABILITY CONSTANT OF URANYL 1-HYDROXY-2-NAPHTHOATE CHELATE. S. C. Tripathi and Satya Prakash (Allahabad Univ., India). J. Indian Chem. Soc. 36, 19-22(1959) Jan.

The complex formation of uranyl with monosodium 1-hydroxy-2-naphthoate as a chelating agent was studied and its composition determined by Job's method of continuous variation. The complex is formed at pH 4.8 and contains uranyl and 1-hydroxy-2-naphthoate in 1:1 ratio, the color of the complex being deep red. It was suggested that in the complex formation the hydroxyl hydrogen of the naphthoate is displaced and oxygen atoms of carboxyl and hydroxyl groups share to form the complex. (auth)

# URANIUM 1.43

## OTHER REACTIONS AND PROPERTIES 1.43.06

### ORGANIC 1.43.06.04

**15103**

THE CHEMISTRY OF URANYL NITRATE–HYDROXIDE–UREA SYSTEMS. P. S. Gentile, L. H. Talley, and T. J. Collopy (National Lead Co. of Ohio, Cincinnati). J. Inorg. & Nuclear Chem. 10, 110-13(1959) Apr.

The reaction mechanism was determined for addition of ammonium hydroxide or sodium hydroxide to a solution of uranyl nitrate and urea. Evidence is presented to show that nitrouranic acid [$UO_2(NO_3)OH$] and hydrated uranic acid ($H_2UO_4.H_2O$) are intermediate compounds. Finally, a discussion of the relationship of these intermediates to the chemistry of uranates is presented. (auth)

THE CHEMISTRY OF URANYL ACETYLACETONE COMPLEX. Alan E. Comyns, Bryan M. Gatehouse, and Eric Wait (Atomic Energy Research Establishment, Harwell, Berks, Eng. and University Coll., London). J. Chem. Soc. 4655-65(1958) Dec.

Three crystalline modifications of uranyl acetylacetone monohydrate have been prepared and their unit-cell parameters, infrared spectra, visible spectra, and magnetic susceptibilities studied. Crystalline solvates of uranyl acetylacetone have also been prepared with ethanol, dioxan, acetylacetone, and acetophenone. The visible and ultraviolet spectra of solutions of anhydrous uranyl acetylacetone in ethanol and in benzene are presented; the compound is dimeric in benzene at 80°. The electrical conductivities of aqueous solutions of uranyl acetylacetone have been measured: at 0.2° the solutions are relatively stable and the equivalent conductivity is approximately unity at $10^{-4}$M; at 25° the solutions are rapidly hydrolyzed with deposition of $UO_3.2H_2O$. (auth)

FURTHER STUDIES OF THE URANYL COMPLEX OF TRIOSE-REDUCTONE. J. Hojman, V. Dražić and A. Muk. Bull. Inst. Nuclear Sci. "Boris Kidrich" (Belgrade) 8, 23-30(1958) Mar.

The spectrophotometric and polarographic determination of uranyl ion as reductone complex was investigated. For the concentration ranges $1.8 \times 10^{-5}$ to $1.0 \times 10^{-4}$ g/ml $I_d/C$ is constant. The thermodynamic dissociation constant of reductone was determined at 15°, 25°, and 33°C. The apparent dissociation constant of uranyl reductone complex was determined at $\mu = 0.1$ and a temperature of 25°C. (auth)

INVESTIGATIONS ON THE CO-ORDINATIVE POWER OF URANYL. PART III. INFRARED SPECTRA OF SOME COMPLEXES WITH $\beta$-DIKETONES. L. Sacconi, G. Caroti, and P. Paoletti (The University, Palermo, Italy). J. Chem. Soc. 4257-64(1958) Dec.

Infrared absorption spectra have been obtained for a number of uranyl complexes with acetylacetone, benzoylacetone, and dibenzoylmethane, crystallized with water, ammonia, or pyridine and in the anhydrous state. Despite the complexity of the spectra the two $\nu_1$ and $\nu_3$ frequencies assigned to the bent form of the uranyl group have been observed for some of such compounds. In the anhydrous complexes of benzoylacetone and dibenzoylmethane such frequencies are shifted and altered in intensity probably owing to the modified crystal field of the "surroundings" of uranyl. The frequencies and the features of the absorption bands of water indicate different types of hydrogen bonding and confirm the existence of co-ordinate bonds between uranium and water molecules in the hydrated complexes. The H–N stretching vibrations of the ammonia appear to be shifted to lower frequencies, a feature regarded as characteristic of nitrogen-to-metal bonds. (auth)

A REACTION BETWEEN mesoINOSITOL AND URANYL ACETATE. P. Meredith and H. G. Sammons (Univ. of Birmingham, Eng.). Analyst 83, 686(1958) Dec.

A reaction has been observed between mesoinositol and uranyl acetate solutions which may provide the basis for a method of detection on paper chromatograms and for determination in solution after chromatographic separation from other polyols. (W.L.H.)

**9770**

COMPLEX FORMATION OF URANYL ION WITH o-CRESOTIC ACID: POTENTIOMETRIC, COLORIMETRIC AND CONDUCTOMETRIC STUDY. S. C. Tripathi and Satya Prakash (Univ. of Allahabad, India). J. Indian Chem. Soc. 35, 119-24(1958) Feb.

Like salicylic acid, o-cresotic acid also forms a complex with uranyl ion. The formation of a red-colored complex containing uranyl and o-cresotate in 1:1 molar ratio at about pH 4.5 is demonstrated by the inflection, break, and maximum in colorimeter reading at one equivalent of alkali in all the potentiometric, conductometric, and colorimetric titration curves of different mixtures of uranyl nitrate and monosodium o-cresotate. (auth)

# URANIUM 1.43

## OTHER REACTIONS AND PROPERTIES 1.43.06

### ORGANIC 1.43.06.04

**17037**

THE INTERACTION OF URANIUM TETRACHLORIDE WITH HYDRAZINE, AMMONIA AND AMINES. Ilmars Kalnins and George Gibson (Illinois Inst. of Tech., Chicago). J. Inorg. & Nuclear Chem. 7, 55-65(1958) Aug.-Sept.

Equilibrium vapor-pressure studies at 35 to 55°C of the systems $UCl_4-\underline{m}\ RNH_2$ (R = H, $CH_3$, $C_2H_5$, $\underline{n}$-$C_3H_7$) in the range of $\underline{m}$ = 2 to 5 revealed a univariant behavior indicating a solid solution of $UCl_4$ in the corresponding ligand. At $\underline{m}$ = 4 the ligand pressure increases very rapidly with further increase in the ligand composition indicating the approach of a saturation limit. Evidence obtained from x-ray and thermal desorption studies indicates the existence of addition compounds of the stoichelometry: $UCl_4 \cdot 2NH_3$, $UCl_4 \cdot 2CH_3NH_2$, $UCl_4 \cdot C_2H_5NH_2$, $UCl_2 \cdot 2C_2H_5NH_2$, and $UCl_4 \cdot \underline{n}$-$C_3H_7NH_2$. The addition compounds $UCl_4 \cdot 6N_2H_4$ and $UO_2 \cdot N_2H_4$ also seem to exist although the latter was not isolated. All of the above-mentioned systems appear to be stable indefinitely when stored in sealed ampules. They react, however, with water vapor and oxygen to give either $UO_2$ or $UO_2Cl_2$ and ligand hydrochloride as the solid products. The enthalpy, free energy and enthropy of formation in $UCl_4$-amine systems were found to increase with increasing alkyl chain length. The values of these thermodynamic quantities at a given composition, however, depend on the history of preparation of the initial solid phase. A considerable improvement of the $UCl_4$ x-ray powder diagram was observed after some gaseous amine was added to the solid $UCl_4$ at room temperature to form a second, solid $UCl_4$-$RNH_2$ phase. The infra-red spectrum of $UCl_4 \cdot 4\underline{n}$-$C_3H_7NH_2$ differs from the spectra of its components by having some additional absorption peaks. Since not enough is known at present concerning characteristic U-N absorption frequencies no specific assignment of peaks was made. (auth)

**98**

**REACTION OF URANIUM WITH FERRON (7-IODINE-8-HYDROXYQUINOLINE-5-SULFONIC ACID). V. A. Mikhailov. Zhur. Anal. Khim. 13, 494-5(1958) July-Aug. (In Russian)**

**A color reaction of uranium with ferron is described. A mechanism of the reaction is suggested on the basis of absorption curves comparison. (tr-auth)**

**13878**

STUDIES IN THE CHEMISTRY OF URANIUM- AND THORIUM-OXALATES. A. A. Grinberg. G. I. Petrzhak, and L. I. Evteev. Zhur. Neorg. Khim. 3, 204-11(1958). (In Russian)

On the basis of physical-chemical studies, the coördinate structure of the compound $K_4[U(C_2O_4)_4] \cdot 5H_2O$ was determined. Its behavior in water solution was studied. A comparative investigation was made of the physical and chemical properties of the hexahydrate of thorium and uranium oxalates. The conductivity, pH, and solubility were studied. It was shown that the uranium oxalate has more strongly acidic properties than the thorium oxalate. (J.S.R.)

ORGANIC COMPOUNDS OF URANIUM. VII. URANYL ALKOXIDES AND DITHIOCARBAMATES. R. G. Jones, E. Bindschadler, G. A. Martin, Jr., J. R. Thirtle, and H. Gilman (Iowa State Coll., Ames). J. Am. Chem. Soc. 79, 4921-2(1957) Sept. 20.

Several uranyl dialkyldithiocarbamates, uranyl ethoxide, and a compound thought to be uranyl t-butoxide are described. (auth)

**8385** KAPL-M-LJK-1

Knolls Atomic Power Lab., Schenectady, N. Y.
INVESTIGATION OF THE STRUCTURE OF AMMONIUM URANYL CUPFERRATE $NH_4[UO_2(C_6H_5N_2O_2)_3]$. L. J. Katz. Sept. 1957. 6p. Contract W-31-109-Eng-52. $1.80(ph OTS); $1.80(mf OTS).

The ammonium uranyl cupferrate group has been shown to be primitive cubic with four molecules per unit cell, the locations of the carbon, nitrogen, and oxygen atoms in this structure were investigated. (J.R.D.)

**9272**

SPECTROPHOTOMETRIC STUDY OF THE URANYL COMPLEX OF REDUCTONE. Jolanda M. Hojman. Bull. Inst. Nuclear Sci. "Boris Kidrich" (Belgrade) 7, 17-24(1957) Mar.

It was found that reductone gives a reddish-brown colored complex with uranyl ion, similar to 1-ascorbic acid and dihydroxymaleic acid. The complex is stable in weak acid and neutral medium. Its color obeys Beer's law which makes possible the colorimetric determination of the concentration of the uranyl ion as the reductone complex. The effect of reductone on the absorption curve of the uranyl ion in various molar ratios was investigated. The stoichiometric composition of the complex was determined by Job's method. (auth)

# URANIUM 1.43

## OTHER REACTIONS AND PROPERTIES 1.43.06

### ORGANIC 1.43.06.04

**4397**

QUINQUEVALENT COMPOUNDS OF URANIUM. I. ALKOXIDES AND COMPLEX CHLORIDES. D. C. Bradley, B. N. Chakravarti, and A. K. Chatterjee (Birkbeck Coll., London). J. Inorg. and Nuclear Chem. 3, 367-9(1957) Jan.

The new complex, $(C_5H_6N)_2UOCl_5$ (I), was obtained from reactions involving $UCl_5$, $SOCl_2$, alcoholic hydrogen chloride, and pyridine. Reaction of (I) with alcohol and ammonia afforded a novel method of preparing uranium penta-alkoxides $U(OR)_5$ by disproportionation of the oxide-alkoxides initially formed. The new compound, $UOCl_3$,EtOH(II), was isolated from the reaction involving $UCl_5$,$SOCl_2$ and very dry ethyl alcohol, and this explains the formation. (auth)

**1331**

ABSORPTION SPECTRA OF THE COMPLEXES OF URANIUM (VI) WITH SOME β-DIKETONES. H. I. Feinstein (U. S. Geological Survey, Washington). Microchem. J. 1, 237-44(1957).

The absorption spectra of the complexes of $U^{6+}$ with four β-diketones were determined under various conditions of pH, concentration of uranium, and alcohol concentration. Under optimum conditions, the maximum molar absorptivity (31,200) is obtained using 2-furoyltrifluoroacetone. This compares with about 4,000 and 19,000 for the thiocyanate and dibenzoylmethane complexes, respectively. (auth)

**11144**

QUINQUEVALENT COMPOUNDS OF URANIUM. II. URANIUM PENTA-n-ALKOXIDES. D. C. Bradley and A. K. Chatterjee (Birkbeck Coll., London). J. Inorg. and Nuclear Chem. 4, 279-82(1957).

The quinquevalent uranium compounds $U(OR)_5$, where R = Me, Et, $Pr^n$, $Bu^n$, and $Am^n$, have been prepared and their molecular weights have been determined ebullioscopically in benzene. Boiling points were determined under reduced pressure. These results are discussed from the structural viewpoint, and it is proposed that uranium penta-alkoxides may involve uranium in co-ordination numbers of 6 and 8. The uranium penta-alkoxides are compared with the corresponding derivatives of niobium and tantalum. (auth)

ORGANIC COMPOUNDS OF URANIUM. III. URANIUM(V) ETHOXIDE. R. G. Jones, E. Bindschadler, G. Karmas, F. A. Yoeman, and H. Gilman (Iowa State Coll., Ames). J. Am. Chem. Soc. 78, 4287-8(1956) Sept. 5.

Uranium(IV) ethoxide, a dark-brown, thermally stable, distillable liquid, was prepared by several methods. Its physical properties and some of its reactions are described. (auth)

**11145**

SOME COMPLEX CHLORIDES OF URANIUM TETRACHLORIDE AND THORIUM TETRACHLORIDE. John R. Ferraro (Argonne National Lab., Lemont, Ill.). J. Inorg. and Nuclear Chem. 4, 283-6(1957).

The preparation of the five anhydrous complex chlorides $[(CH_3)_4N]_2UCl_6$, $[(C_2H_5)_4N]_2UCl_6$, $Cs_2UCl_6$, $[(CH_3)_4N]_2ThCl_6$, and $Cs_2ThCl_6$ is described. The results of powder x-ray-diffraction studies of these compounds are given, and the possibility of hydrates existing for the thorium complexes is discussed. (auth)

**11160**

ORGANIC COMPOUNDS OF URANIUM. II. URANIUM(IV) AMIDES, ALKOXIDES AND MERCAPTIDES. R. G. Jones, G. Karmas, G. A. Martin, Jr., and H. Gilman (Iowa State Coll., Ames). J. Am. Chem. Soc. 78, 4285-6(1956) Sept. 5.

Uranium(IV) diethylamide, a green, low melting, distillable compound, was prepared from $UCl_4$ and $LiN(C_2H_5)_2$. Uranium(IV) ethyl and n-butylmercaptides were prepared from $U[N(C_2H_5)_2]_4$ and the corresponding mercaptans. These light green solids were pyrophoric. Uranium(IV) methoxide and ethoxide were obtained from reactions of the alcohols with $U[N(C_2H_5)_2]_4$. They were light green solids, readily decomposed by air or moisture. (auth)

ORGANIC COMPOUNDS OF URANIUM. IV. URANIUM(V) ALKOXIDES. R. G. Jones, E. Bindschadler, G. Karmas, G. A. Martin, Jr., J. R. Thirtle, F. A. Yoeman, and H. Gilman (Iowa State Coll., Ames). J. Am. Chem. Soc. 78, 4289-90(1956) Sept. 5.

A number of $U^{5+}$ alkoxides were prepared by several methods, the most important of which was the exchange reaction $U(OC_2H_5)_5 + 5ROH \rightarrow U(OR)_5 + 5C_2H_5OH$. (auth)

**6386** √ A/CONF.15/P/1596

REDUCTOMETRIC DETERMINATION OF METALS IN NON-AQUEOUS MEDIA. J. Minczewski, S. Kołyga, and L. Wódkiewicz (Polish Academy of Sciences, Warsaw). 8p.

Chromous acetate in dioxane solution was used as a reducing agent in non-aqueous media. The method was applied for the determination of uranyl nitrate in a solution of ethyl alcohol and for the determination of copper and vanadium after extraction with chloroform solution of 8-hydroxyquinoline. Good reproducibility and accuracy were obtained in concentrations of about 0.2 mg/ml. (W.D.M.)

# URANIUM 1.43

## OTHER REACTIONS AND PROPERTIES 1.43.06

### ORGANIC 1.43.06.04

**6411** A/CONF 15/P/2138
ON THE STRUCTURE OF COMPLEX URANYL COMPOUNDS. I. I. Chernyaev, V. A. Golovnya, et al. (U.S.S.R.). 43p.

A number of complex uranyl compounds containing homogeneous cyclic addends were studied. The existence of three genetic families of complex uranyl compounds was shown. Complex uranyl compounds with heterogeneous cyclic substitutes were synthesized and studied on the basis of the displacing capacity of the addends under investigation. Mixed oxalate complex uranyl compounds containing noncyclic addends were synthesized and studied, such as ureate, acetate, and thiocyanate groups. The investigations conducted showed that uranyl ion, in the compounds studied has the coördination number six. The analyzed addends forming a cycle according to the power of their reciprocal displacing capacity are aligned in series. Carbonate uranyl compounds are the only exceptions from L. A. Chugayev's rule of cycles in the chemistry of complex compounds, exceptions which are caused by the nature of both the formation of complexes and of the addends. (auth)

**2312** BMI-JDS-146
Battelle Memorial Inst., Columbus, Ohio.
ORGANIC PRECIPITANTS AND COMPLEXING AGENTS FOR URANIUM. A. E. Bearse, E. J. Kahler, G. W. Kinzer, G. A. Lutz, and R. H. Poirier. Oct. 10, 1948. Decl. Mar. 5, 1956. 27p. Contract AT-30-1-gen-202. $0.25(OTS).

The precipitation of U from acidic phosphate solutions by long-chain amines, complexing and solvent extraction studies, precipitation of U from buffered solutions with arsonic acids, the reduction of U in $Na_2CO_3$ solutions, and preparation of reagents are reported. (J.E.D.)

**751**
URANIUM(III) CUPFERRATE. Charles L. Rulfs and Philip J. Elving (Univ. of Michigan, Ann Arbor). J. Am. Chem. Soc. 77, 5502-3(1955) Nov. 5.

Polarographic studies indicate the existence of a very stable ether-soluble uranium (III) cupferrate. (C.W.H.)

**6385** A/CONF.15/P/1594
STUDIES ON THE CHEMISTRY OF SESQUIVALENT AND QUADRIVALENT URANIUM IN ORGANIC SOLVENTS. B. Jezowska-Trzebiatowska, A. Bartecki, M. Chmtelowska, H. Przywarska, T. Mikulski, K. Bukietynska, and W. Kakołowicz (Polish Academy of Sciences, Wrocław, Poland). 27p.

An attempt was made to tackle the problem of the electron structure and molecular state in various solvents of the uranyl and tetravalent uranium compounds from various aspects to obtain further data relative to the electron structure manifested by their complex forming properties and oxidation-reduction reactions. The structure of the uranyl ion is studied by observing the behavior of uranyl nitrate in organic solvents. The absorption spectra method was used in the investigations. (W.D.M.)

**9246**
ORGANIC COMPOUNDS OF URANIUM. I. 1,3-DICARBONYL CHELATES. H. Gilman, R. G. Jones, E. Bindschadler, D. Blume, G. Karmas, G. A. Martin, Jr., J. F. Nobis, J. R. Thirtle, H. L. Yale, and F. A. Yoeman (Iowa State Coll., Ames). J. Am. Chem. Soc. 78, 2790-2(1956) June 20.

**10123**
THE REACTION OF URANYL ION WITH XANTHATES AND DIETHYLDITHIOCARBAMATE. Ralph A. Zingaro (Texas A & M, College Station and Oak Ridge National Lab., Tenn.). J. Am. Chem. Soc. 78, 3568-70(1956) Aug. 5.

In the presence of potassium ion, some xanthates and diethyldithiocarbamate have been found to form precipitates corresponding to the formula $KUO_2X_3$, where X is the xanthate or diethyldithiocarbamate radical. On the basis of spectrophotometric data, a double salt structure of the type $UO_2X_2 \cdot K_2UO_2X_4$ is indicated for the diethyldithiocarbamate complex. (auth)

### OXIDATION 1.43.06.05

**4140**
COPPER SALT CATALYSIS OF THE AIR OXIDATION OF REDUCED URANIUM COMPOUNDS IN CARBONATE–BICARBONATE SOLUTIONS. Warren E. Clifford (Arthur D. Little, Inc., San Francisco, Calif.). J. Am. Chem. Soc. 80, 245(1958) Jan.

It was found that Cu salts, especially in the presence of $NH_3$, catalyze the air oxidation and dissolution of reduced U compounds in carbonate–bicarbonate solutions in the carbonate leaching of U ores. (W.L.H.)

# URANIUM 1.43

## OTHER REACTIONS AND PROPERTIES 1.43.06

### OXIDATION 1.43.06.05

**6289**

RADIOCHEMICAL INVESTIGATION ON URANIUM. II. OXIDATION OF URANIUM SULFATE BY $\alpha$ RAYS; EFFECT OF HIGH URANIUM CONCENTRATION AND OF THE NATURE OF THE ANION. M. Haissinsky and M. Duflo (Laboratoire Curie, Paris). J. chim. phys. 56, 955-66(1959) Nov.-Dec. (In French)

The oxidation yield of uranous sulfate ($U^{4+}$) in acid solution by polonium $\alpha$ rays in the absence of air decreases at first with the increase of concentration and then remains constant. It is confirmed that the presence of hexavalent uranium in high concentration also causes a decrease in the oxidation yield of $U^{4+}$ by $\gamma$ rays, but this effect was not observed with $\alpha$ rays. This is in agreement with the hypothesis formulated by Russian writers on the transitory reduction of $UO_2^{2+}$ by H atoms. The irradiation of uranous sulfate by $\alpha$ rays in the presence of air gives very high oxidation yields, lower however, than those obtained with $\gamma$ rays. The oxidation yields with $\alpha$ rays vary with the intensity according to a $I^{-1/2}$ law. This leads to a reaction mechanism essentially analogous to that which has been proposed for chain reaction propagated by electron transfer between $UO_2^+$ and $O_2$. To this mechanism is added the oxidation of $U^{4+}$ by $H_2O_2$ and its reduction by the electrons in the $\alpha$ trajectories, followed by the reoxidation of $U^{3+}$ by oxygen. $U^-$ ions are oxidation inhibitors of the $U^{4+}$ both in the presence and absence of air. Oxidation in perchloric solution is complicated by the superposition of oxidation reactions by the products from the direct effect of radiation on $UO_4^-$ with radical reactions. (tr-auth)

**9268** IGR-TN/W-517

Gt. Brit. Windscale Works, Sellafield, Cumb., England. THE OXIDATION OF URANIUM IN ARGON CONTAINING TRACES OF OXYGEN. D. Shaw and P. Hindmarch. Apr. 1957. 11p.

The rates of oxidation of U in A containing up to 50 ppm $O_2$ at temperatures up to 900°C have been investigated. The $O_2$ content of the A was measured using an electrolytic cell method. The rates of oxidation in A containing up to 10 ppm $O_2$ were considerably less, proportionally, than the rates obtaining at 30 and 50 ppm $O_2$. The rates of oxidation at 600 and 900°C were similar, but at 300°C the rate was appreciably less. The results indicated that the initial rate of oxidation is slow but increases to become linear with time after the oxide thickness exceeds a certain value. (auth)

EXCHANGE REACTION BETWEEN URANIUM IONS IN A HYDROCHLORIC ACID SOLUTION. Presented at International Conference on Radioisotopes in Scientific Research held Sept. 9-20, 1957 at Paris. No. UNESCO/NS/RIC/39. Elizabeth Rona. London, Pergamon Press, Ltd., 1957. 7p. (In French)

Exchange reactions with heavy isotopes have received increased attention in recent years. Several theories have been advanced to explain the paths through which electron transfer can occur. There are but very few heavy element systems which will lend themselves for the experimental tests of these problems. The exchange between uranium ions in hydrochloric acid solution, however, proceeds with measurable speed. The following two systems were studied: (1) $U^{+4} + U^*O_2^{+2} = U^{*+4} + UO_2^{+2}$ and (2) $UO^{+2} + U^*O_2^{+2} = U^*O^{+2} + UO_2^{+2}$. Experimental data show that the rate of exchange is first order with respect to $UO_2^{+2}$ concentration in (1) and (2) and second order in respect to $U^{+4}$ in (1) and $UO^{+2}$ in (2). It is –3 order with respect to pH in (1) and –3.7 in (2). The rate of exchange is considerably faster for (2) than for (1). The mechanism proposed for (1) and (2) is naturally somewhat different, but in both an activated complex ion is postulated with an oxygen bridge between the two uranium ions. The energy of activation of reaction (2) is lower. The entropy of activation is less positive than for (1). A hypothesis is advanced to account for these results. [The ion with asterisk is labelled with $U^{233}$.] (auth)

### REDUCTION 1.43.06.06

**11507**

METHOD OF REDUCING HEAVY METAL TETRAHALIDES. J. J. Katz (to U. S. Atomic Energy Commission). U. S. Patent 2,797,142. June 25, 1957.

A process is given for the reduction of uranium tetrahalides other than the tetrafluoride. These uranium tetrahalides can be reduced by treating an ether solution of the uranium tetrahalide with an alkali metal aluminum hydride. The reaction will occur at room temperature, and will even take place at temperatures as low as –80°C. The alkali metal aluminum hydride added to the ether solution may be incorporated as such or may be formed in situ. In the latter case, an aluminum halide is added to the ether solution of uranium tetrahalide, and the resultant solution is contacted with alkali metal hydride. (auth)

**9249**

THE REDUCTION OF URANIUM(VI) BY IRON(II) IN PHOSPHORIC ACID SOLUTION. C. F. Baes, Jr. (Oak Ridge National Lab., Tenn.). J. Phys. Chem. 60, 805-6(1956) June.

# URANIUM 1.43

## OTHER REACTIONS AND PROPERTIES 1.43.06

### REDUCTION 1.43.06.06

**9745** NYO-3797
Metal Hydrides Inc., Beverly, Mass.
FIFTH QUARTERLY REPORT ON THE REDUCTION OF URANIUM OXIDES. Period Covered: October 1, 1953 through December 31, 1953. Sidney Johnson. Feb. 8, 1954. Decl. Mar. 29, 1957. 16p. Contract AT(30-1)-1350. $0.25(OTS).

The development of evaluation techniques for more precise determination of the purity of $UH_3$ powders, and their suitability for powder metallurgical processes, was concluded. The evaluation procedures now available are: (1) densities of hot-pressed U pellets processed from $UH_3$ powder; (2) direct $O_2$ determinations by the reaction of $UH_3$ powders with $BrF_3$; and (3) U oxide assays by dissolution of $UH_3$ in a measured excess of Ce acid sulfate solution. Utilization of these methods now makes it possible for the first time to evaluate the reductive processes with sufficient accuracy to determine optimum conditions for the variables involved. New furnacing equipment of increased capacity has been placed in operation during this period, and several reduction runs to produce well over one pound of $UH_3$ have been successfully furnaced. (auth)

**15953** RDB(C)/TN-3
Gt. Brit. Culcheth Labs., Culcheth, Lancs, England.
A THERMODYNAMIC STUDY OF THE REDUCTION OF URANIUM HALIDES. W. G. O'Driscoll and G. H. Chalder. Apr. 28, 1952. 18p.

The possibility of reducing halides by various metallic reducing agents was studied from a thermodynamic point of view. The changes in free energy for the various reductions were examined and an assessment made of those processes which might prove more efficient than the present reduction of uranium tetrafluoride by either calcium or magnesium. Sodium offers favorable theoretical possibilities as a reductant for $UF_4$, $UF_6$, or the corresponding chlorides. The hexafluoride and hexachloride offer possibilities as a suitable basic material for any reduction process. Disproportionation of either $UF_3$ or $UCl_3$ as a cyclic process should also be examined. (auth)

**7302** A/CONF.15/P/485
REDUCTION OF URANIUM FROM CARBONATE SOLUTIONS WITH HYDROGEN USING $UO_2$ AS CATALYST. Bela Bunji and Blagoje Zogović (Inst. for Tech. of Mineral Raw Materials, Belgrade). 11p.

$UO_2$ obtained from carbonate solutions by reduction with hydrogen and a nickel wire was used as catalyst for the reduction of uranium with hydrogen. The analysis of $UO_2$ used is presented. The reduction rate depends on the surface of the catalyst, but not on the concentration of uranium in the solution. The influence of the concentration of $Na_2CO_3$, $NaHCO_3$, and $Na_2SO_4$ at constant reduction conditions was examined. In the same reduction conditions, when the catalyst is absent, separation of $UO_2$ does not happen. By staying in the open air, $UO_2$ oxidizes partially, and this process is accompanied by a decomposition of the carbonate solutions. This can be avoided by preliminary activation of the catalyst, which does not change its catalytic properties. $UO_2$ separated by reduction of the solution was also used as catalyst for further reduction. The reduction effect is 99%. (auth)

**7180** AECD-4101
Massachusetts Inst. of Tech., Watertown, Mass. Mineral Engineering Lab.
ELECTROLYTIC REDUCTION OF URANYL AND FERRIC SULFATE SOLUTIONS. Wilfred Freyberger. May 12, 1950. Decl. Dec. 15, 1955. 14p. Contract W-7405-eng-85. (MITG-A95). $0.20(OTS).

The current efficiency of reduction of $UO_2^{2+}$ decreases with increasing pH between the values of pH 0.1 and 2.6. Ferric-ion reduction shows no appreciable change in this same range. The current efficiency for reduction of $Fe^{3+}$ and $UO_2^{2+}$ varies almost inversely with increasing current density in the range of 0.5 to 9 amp/ft$^2$. Increasing the concentration of $UO_2^{2+}$ by a factor of 50 increases the current efficiency 60 fold. Increasing the $Fe^{3+}$ concentration by a factor of 50 increases the current efficiency 10 fold. Mechanical agitation is helpful; the current efficiency doubles with mechanical agitation of 150 rpm. and more than doubles at 500 rpm. Ferric ion at an initial concentration of 2 g/l is reduced at a rate directly proportional to the concentration; uranyl ion at 0.1 g/l is reduced more slowly. The reduction of $Fe^{3+}$ is enhanced by the presence of $UO_2^{2+}$. (auth)

# URANIUM 1.43

## OTHER REACTIONS AND PROPERTIES 1.43.06

### REDUCTION 1.43.06.06

**12438** Y-519

Carbide and Carbon Chemicals Corp. Y-12 Plant, Oak Ridge, Tenn.

THE BEHAVIOR OF RUTHENIUM AND PHOSPHORUS IN THE REDUCTION OF URANIUM TETRAFLUORIDE TO METAL. F. L. Daley and D. W. Kuhn. Nov. 16, 1949. Decl. Mar. 6, 1957. 12p. Contract W-7405-eng-26. $1.80(ph OTS); $1.80(mf OTS).

By the use of Ru tracer, it was shown that in the reduction of $UF_4$ to U metal, approximately 95% of the Ru initially present in the $UF_4$ was carried over into the metal. Uranium tetrafluoride containing up to 1.4% P was reduced to U metal. Approximately one-seventh of the P was carried over into the metal. (auth)

**17036**

REACTION OF HYDROGEN WITH URANIUM. W. M. Albrecht and M. W. Mallett (Battelle Memorial Inst., Columbus, Ohio). J. Electrochem. Soc. 105, 610-11 (1958) Oct.

An addendum is presented to report BMI-982, in which the kinetics of the reaction to produce constant compositions of $UH_x$ is discussed. (J.E.D.)

### URANYLS (INORGANIC) 1.43.06.07

INFRARED ABSORPTION SPECTRA OF URANYL HALOGENIDE ANHYDRIDES. Jacques Prigent. Compt. rend. 247 1737-9(1958) Nov. 17. (In French)

The preparation of anhydrous uranyl chloride and bromide and the determination of the infrared absorption spectra of samples carefully shielded from the air show that the anhydrous uranyl ion is linear. This conclusion agrees with that from x-ray-diffraction work. The results explain previous contradictions. (tr-auth)

**13337**

PREPARATION AND PROPERTIES OF LANTHANUM URANYL CARBONATE. Maurice Bachelet and Henri Gueniffey (Faculté des Sciences, Caen, France). Bull. soc. chim. France No. 2, 333-6(1959) Feb. (In French)

Lanthanum uranyl carbonate was prepared by mixing sodium uranyl carbonate solutions with lanthanum nitrate solutions. The reaction was studied by measuring the electric conductivity and the pH. The thermal decomposition of the product obtained was also studied. (tr-auth)

IMPROVEMENTS IN OR RELATING TO METHOD FOR PREPARING METAL SALT SOLUTIONS. Thomas Victor Healy (to United Kingdom Atomic Energy Authority). British Patent 814,568. June 10, 1959.

Uranyl nitrate in dilute $HNO_3$ can be converted completely to sulfate by adding $H_2SO_4$ equivalent to the $UO_2(NO_3)_2$ and boiling with formaldehyde. (T.R.H.)

**9772**

SYSTEMATICS IN THE VIBRATIONAL SPECTRA OF URANYL COMPLEXES. Llewellyn H. Jones (Los Alamos Scientific Lab., N. Mex.). Spectrochim. Acta 10, 395-403(1958) Feb.

The calculation of U–O bond force constants for uranyl complexes from their infrared absorption spectra is discussed. The maximum error involved in treating the uranyl group as free $UO_2^{2+}$ for calculation of the U–O force constant is estimated to be less than 3 per cent. Approximate anharmonicity constants for general use for the uranyl vibrations are given. The application of Badger's rule relating U–O force constant to U–O bond distance is discussed. (auth)

**8885**

HYDROLYSIS OF THE URANYL ION. J. A. Hearne and A. G. White (A.E.R.E., Harwell). J. Chem. Soc. 2168-74 (1957) May.

The pH of uranyl perchlorate solutions has been measured over a wide concentration range at various temperatures and ionic strengths. The results can be explained in terms of two hydrolytic reactions, leading respectively to the formation of the monomeric $UO_2 \cdot OH^+$ and the dimeric $UO_2 \cdot UO_3^{2+}$ ion, $\Delta H$ for formation of the former being considerably larger than for the latter. The effect of complex formation with anions is discussed and a new method of detecting perchlorate-complex formation is suggested. (auth)

**2377**

PREPARATION OF URANYL CARBONATE. J. Čejka. Collection Czechoslov. Chem. Communs. 24, 3180-81 (1959) Sept. (In German)

A $UO_2(NO_3)_2 \cdot 6H_2O$ solution was reacted with ethanol to produce $U_3O_8 \cdot xH_2O$. This was then heated in air and $CO_2$ to produce $UO_2CO_3$ which analyzed 86.18% $UO_3$ and 12.53% $CO_2$. (T.R.H.)

THE LENGTH OF THE URANYL ION IN URANYL CARBONATE. Don T. Cromer and Paul E. Harper (Los Alamos Scientific Lab., N. Mex.). Acta Cryst. 8, 847-8(1955) Dec.

**4736**

# URANIUM 1.43

## OTHER REACTIONS AND PROPERTIES 1.43.06

### URANYLS (INORGANIC) 1.43.06.07

**5289**

A SYNTHETIC URANYL SILICATE HYDRATE. William L. Marshall and James S. Gill (Oak Ridge National Lab., Tenn.) J. Am. Chem. Soc. 79, 1300-1(1957) March 20.

A uranyl silicate hydrate was prepared by the reaction of an aqueous $UO_2F_2$ solution with silica at 300°. The chemical analysis of this yellow crystalline solid indicated the probable composition to be either $(UO_2)_2SiO_4 \cdot 3H_2O$ or $(UO_2)_3Si_2O_7 \cdot 3H_2O$. The compound is virtually insoluble in HCl, $HNO_3$ or $H_2SO_4$. It is thermally stable to approximately 400°. (auth)

**6327** BMI-1110

Battelle Memorial Inst., Columbus, Ohio.

THERMAL DECOMPOSITION OF URANYL NITRATE HEXAHYDRATE. J. Robert Bridge, Carl W. Melton, Charles M. Schwartz, and Dale A. Vaughan. July 12, 1956. 20p. Contract W-7405-eng-92. $0.25(OTS).

The pyrolytic decomposition of uranyl nitrate hexahydrate in the absence of the decomposition gases has been investigated at low and atmospheric pressures. X-ray diffraction and chemical analyses were made of the decomposition products at several temperatures from 25° to 250°C. At temperatures below 190°C, the amount of water evolved from uranyl nitrate hexahydrate is pressure dependent. The nitrate approaches the anhydrous state on heating to 190°C at either low or atmospheric pressure. Nitrogen evolution occurs mainly above 190°C. X-ray diffraction examination of partially decomposed $UO_3(NO_3)_2 \cdot 6H_2O$ revealed nitrate phases not previously reported; these appear to be nearly anhydrous. Amorphous $UO_3$ is formed as an end product when the decomposition gases are removed from the vessel and not permitted to remain in contact with the decomposition product. If, however, the gases (in particular water vapor) are allowed to react with the decomposition product, Mallinckrodt-type $UO_3$ is produced. Diffraction data for four nitrates and two types of $UO_3$, prepared in the course of the decomposition studies, are given. (auth)

**13692** CF-56-5-114

Oak Ridge National Lab., Tenn.

A STUDY OF DILUTE SOLUTIONS IN THE SYSTEM, $UO_2SO_4-CuSO_4-NiSO_4-H_2SO_4-H_2O$. F. E. Clark, J. S. Gill, R. Slusher, and C. H. Secoy. May 17, 1956. Decl. Mar. 13, 1957. 6p. Contract [W-7405-eng-26.] $1.80(ph OTS); $1.80(mf OTS).

Studies carried out on the system $UO_2SO_4$ (0.04m)–$CuSO_4$ (0 to 0.04m)–$CuSO_4$ (0 to 0.04m)–$NiSO_4$ (0 to 0.04m)–$H_2SO_4$ (0.01 to 0.03m)–$H_2O$ indicated that solid or liquid phases separated at temperatures ranging from 200 to 400°C. (C.W.H.)

SOME OBSERVATIONS ON RUTHERFORDINE. Joan R. Clark and C. L. Christ (U. S. Geological Survey, Washington). Am. Mineralogist 41, 844-50(1956).

The optical properties of rutherfordine, $UO_2CO_3$, have been redetermined on sizeable crystals and the relations among the indices of refraction, the morphology, and the crystal structure have been examined. Rutherfordine is orthorhombic, biaxial positive, with $\alpha$ = 1.715, $\beta$ = 1.730, $\gamma$ = 1.795, 2V = 53° (calc.); X = b, Y = c, (elongation), Z = a. The crystal structure of $UO_2CO_3$ consists of layers of carbonate groups parallel to (010) with linear $(O-U-O)^{+2}$ ions normal to the layers. The indices $\beta$ and $\gamma$ correspond to vibration directions parallel to layers; the unexpectedly large difference in value between $\beta$ and $\gamma$ is ascribed to the optical anisotropy of the uranium-oxygen bonding in the layer. Indexed x-ray powder data are given. (auth)

**12342**

SOLUBILITY PRODUCTS OF URANYL ARSENATES. V. G. Chukhlantsev and A. K. Sharova (Kiev State Univ.). Zhur. Neorg. Khim. 1, No. 1, 36-41(1956). (Translated from Referat. Zhur. Khim. No. 2, 1957, Abstract No. 3747.)

By the isothermal method data were secured at 20° on the solubility of uranyl arsenates $UO_2MAsO_4$ (M = H, $NH_4$, K, Li, and Na) in dilute solutions of nitric and sulfuric acid. By utilizing previously derived equations, a determination was made of the solubility products of the arsenates $[UO_2^{2+}]\,[M^+]\,[AsO_4^{3-}]$, which are (at 20°): $1.71 \times 10^{-24}$ (M = $NH_4$), $2.52 \times 10^{-23}$ (M = K), $1.35 \times 10^{-22}$ (M = Na), $1.52 \times 10^{-19}$ (M = Li), and $3.17 \times 10^{-11}$ for $[UO_2^{2+}]\,[HAsO_4^{2-}]$.

# URANIUM 1.43

## OTHER REACTIONS AND PROPERTIES 1.43.06

### URANYLS (INORGANIC) 1.43.06.07

**11658** ✓ IDO-14246
American Cyanamid Co. Atomic Energy Div., Idaho Falls, Idaho.
DENSITIES AND BOILING POINTS OF URANYL NITRATE-NITRIC ACID SOLUTIONS. R. H. Perkins. May 6, 1953. Decl. Mar. 14, 1957. 14p. Contract AT-(10-1)-177. $3.30(ph OTS); $2.40(mf OTS).

The boiling points at 635 mm mercury pressure and the densities at 91°C were determined for a series of solutions containing 0.75, 1.5 and 2.0 molar $UO_2(NO_3)_2$ and 0, 2 and 5% $HNO_3$. The densities of these solutions change by about 0.030 g/ml for a 0.1 molar change in $UO_2(NO_3)_2$ concentration at the boiling point, while the boiling temperature changes 0.2 to 0.5°C for the same change in U concentration. Since variations in barometric pressure may cause the boiling points to change by as much as 1.6°C, it appears that a temperature measuring device offers disadvantages as a primary controller for the intercycle evaporators, but could operate an upper limit cut off for the prevention of over concentration. (auth)

**2684** ✓ MLM-729
Mound Lab., Miamisburg, Ohio.
THE pH MEASUREMENT OF URANYL SULFATE SOLUTIONS FROM 25° TO 60°C. Edward Orban. Aug. 1, 1952. Decl. Oct. 13, 1955. 12p. Contract AT-33-1-GEN-53. (Deleted version: AECD-3583.)

The pH of uranyl sulfate solutions has been measured from 25 to 60°C over a concentration range from 0.0006 to 3.9 molal. At 25°C the pH changes from 4.12 for the lowest concentration to 0.55 at the highest concentration, while at 60°C the change is from 3.97 to −0.12 for the same concentrations, respectively. (auth)

**10788** CF-52-3-253
Oak Ridge National Lab., Tenn.
PHYSICAL PROPERTIES OF URANYL SULFATE SOLUTIONS AT ATMOSPHERIC PRESSURE. J. D. Roarty, S. I. Kaplan, W. D. Powers, and R. F. Redmond. Mar. 10, 1952. Decl. Feb. 4, 1956. 16p. Contract [W-7405-eng-26]. $3.30(ph OTS); $2.40(mf OTS).

The surface tension, viscosity, density, and heat capacity of uranyl sulfate solutions were measured in a temperature range of approximately 0 to 100°C at atmospheric pressure. Solutions of uranyl sulfate in concentrations of 100, 200, and 400 g. U/l. solution were investigated in both light and heavy water. (auth)

**11660** K-444
Carbide and Carbon Chemicals Corp. K-25 Lab. Div., Oak Ridge, Tenn.
SPRAY DECOMPOSITION OF URANYL NITRATE SOLUTIONS TO URANIUM TRIOXIDE. A. L. Allen, H. A. Bernhardt, S. Bernstein, R. H. Harrison, E. W. Powell. July 15, 1949. Decl. Feb. 25, 1957. 18p. Contract [W-7405-eng-26]. (KLO-124). $3.30(ph OTS); $2.40(mf OTS).

A method employing the thermal decomposition of atomized $UO_2(NO_3)_2$ solutions has been developed for the preparation of a more reactive $UO_3$ which is suitable for subsequent conversion to $UF_4$. The submicron diameter $UO_3$ produced has a very high surface area and is continuously prepared in a completely closed system. A glass cloth filter is used to remove entrained U oxide dust particles, and a water scrubber is employed to recover the gaseous $UO_2(NO_3)_2$ decomposition products as $HNO_3$. (auth)

**12416** ✓ CF-51-11-66
[Oak Ridge National Lab., Tenn.]
DENITRATION OF URANYL NITRATE. Quarterly Report for Period August 10–November 10, 1951. V. J. Reilly. Nov. 13, 1951. Decl. Feb. 16, 1957. 5p. Contract [W-7405-eng-26]. $0.20(OTS).

Uranyl nitrate solution was concentrated prior to denitration by removal of water only. The composition during boildown where vapors of the azeotropic composition come off is at 85% $UO_2(NO_3)_2$ and 4.1% $HNO_3$. The freezing and boiling points for compositions near the end of boildown were determined. The freezing point rises much more rapidly than the boiling point. At 85% $UO_2(NO_3)_2$ and 4.1% $HNO_3$ the solution is metastable. Vapor-liquid equilibria were obtained for compositions near the end of boildown. From these data the number of theoretical plates for removal of water was obtained. (auth)

THE SPACE GROUP AND SOME DATA ON THE CRYSTAL STRUCTURE OF URANYL NITRATE HEXAHYDRATE $UO_2(NO_3)_2.6H_2O$. K. Sasvari (Academy of Sciences of Hungary). Acta Geol. Acad. Sci. Hung. 4, No. 3-4, 467-8(1957). (Translated from Referat. Zhur. Khim. No. 4, 1958, Abstract No. 10397)

The results of a preliminary x-ray study of the crystalline structure of $UO_2(NO_3)_2.6H_2O$ (I) are reported. The accuracy of earlier determined lattice parameters (Amer. Chem. Soc. 46, 1615(1924)) was confirmed by the study, and the space group of I $C_{2v}^{12}$ in the aspect $A2_1ma$ (presence of the piezoelectric effect) was established. The intensity analysis showed that the z coordinates of U atoms and of a part of the O atoms are near to $\frac{1}{8}$.

# URANIUM 1.43

## OXIDES 1.43.07

### GENERAL 1.43.07.01

**7081** A/CONF.15/P/26
THE ACTINIDE OXIDES. L. E. J. Roberts, M. H. Rand, L. E. Russell, and A. J. Walter (Atomic Energy Research Establishment, Harwell, Berks, Eng.) and A. G. Adwick (United Kingdom Atomic Energy Authority, [Risley, Lancs, Eng.]). 16p.

Some chemical properties of the actinide oxides and of solid solutions of these oxides with each other and with other oxides are reviewed. The subjects chosen are relevant to the use of $UO_2$ and $PuO_2$ as reactor fuels, either as ceramics or in dispersed systems such as cermets and slurries. Equilibrium pressures of oxygen over the $UO_2-U_4O_9-U_3O_8$ composition range were directly determined at high temperatures. These results are used to calculate the oxygen pressures below which the cubic $UO_2-U_4O_9$ phases are stable at various temperatures. The rate of oxidation within this composition range can be approximately calculated from diffusion coefficients for interstitial oxygen determined at low temperatures. The process of phase division into the two cubic phases, $UO_2$ and $U_4O_9$, that occurs on temperature cycling is accompanied by particle division. The cubic $UO_2$ structure can be stabilized at higher oxygen pressures by making solid solutions with other 4-valent oxides such as $ThO_2$ and $ZrO_2$; excess oxygen can be incorporated interstitially in all such structures. Equilibria between $UO_2$-$ThO_2$ solid solutions and oxygen have been measured over a wide range of pressure, temperature, and composition. The degree of oxidation under given conditions diminishes as the uranium content decreases, mainly because the heat of solution of oxygen in the lattice decreases. Uranium dioxide forms a number of anomalous solid solutions with trivalent and divalent oxides and the stability of the fluorite structure is such that extensive solid solutions can be formed between $UO_2$ and oxides such as MgO and $Al_2O_3$, which do not dissolve appreciably in stoichiometric $UO_2$, if sufficient oxygen is present to complete the $MO_2$ structure. The diffusion of oxygen through such structures containing U and anion vacancies seems anomalously rapid as compared to oxygen diffusion through $ThO_2$ containing anion vacancies. From such studies, certain predictions can be made about the behavior of solid solutions containing $PuO_2$ and $NpO_2$, which cannot be easily oxidized in the pure state. Some forms of $PuO_2$ can be oxidized as far as $PuO_{2.1}$ but $NpO_2$ has not been oxidized beyond $NpO_{2.01}$ despite the stability of $Np_3O_8$ at low temperatures. $UO_2$ and $ThO_2$ form solid solutions with $NpO_2$ and $PuO_2$. Preliminary results on the preparation, stability, and oxidation of these solid solutions are recorded, together with some data on anomalous solid solutions containing the transuranic elements. (auth)

HEAT OF OXIDATION OF URANIUM OXIDES. Aurelio Burdese and Fedele Abbattista (Istituto di chimica generale e applicata e di metallurgia del Politecnico, Turin). Ricerca sci. 28, 163-8(1958) Aug. (In Italian)

By means of the direct determination of the heat of dissolution of uranium oxides in nitric solution, the heats of the following oxidation reactions were determined: $UO_2 \rightarrow \frac{1}{4} U_4O_9 \rightarrow \frac{1}{3} U_3O_8 \rightarrow UO_3$. The values found for $-\Delta H$(kcal/g atom of U) were 12.6, 14.9, and 7.6, respectively. (tr-auth)

HIGH-TEMPERATURE HEAT CONDUCTIVITY OF SOME METAL OXIDES. John C. Jamieson and A. W. Lawson (Univ. of Chicago.). J. Appl. Phys. 29. 1313-14(1958) Sept.

A reanalysis of data on the thermal conductivity of certain metal oxides has shown that the deviation from a $T^{-1}$ law may be fitted to a law exponential in $T^{-1}$. Thus the deviations may be ascribed to the flow of excitons. The contribution to the thermal conductivity from radiative transfer is shown to be too small to fit the observed deviations. (auth)

**7899** CF-51-10-133
Oak Ridge National Lab., Tenn.
THE OXIDES OF URANIUM. J. M. Fulmer. Oct. 16, 1951. Decl. Feb. 14, 1957. 30p. [Contract W-7405-eng-26]. $0.35(OTS).

**22035**
**ON THE CATALYTIC PROPERTIES OF URANIUM OXIDES. A. Krause and P. Poszwinski. Roczniki Chem. 30, 29-38(1956). (Translated from Referat. Zhur. Khim. No. 23, 1958, Abstract No. 76744.)**

**The oxides of U were investigated as redox catalysts and their specific and selective action has been confirmed.**

# URANIUM 1.43

## OXIDES 1.43.07

### GENERAL 1.43.07.01

**10506** ✓ NP-6722
[Westinghouse Electric Corp. Research Labs., East Pittsburgh, Penna.]
OXYGEN DISSOCIATION PRESSURES OVER URANIUM OXIDES. Scientific Paper 100FF942-P1. P. E. Blackburn. Jan. 15, 1957. 31p.

Oxygen dissociation pressures over the uranium oxides, $UO_{2.0}$ to $UO_{2.6}$, were measured between 950 and 1150°C by the Knudsen effusion method. In this temperature and composition range there are three stable uranium oxides: $UO_2$ in which the solubility of oxygen increases with temperature, $U_4O_9$ which exists up to 1167°C with a narrow homogeneity range, and $U_5O_{13}$ in which oxygen dissolves. A phase diagram of the uranium–oxygen system was constructed, thermodynamic values were derived and the accommodation coefficient of oxygen on $U_4O_9$ was estimated to be 0.027. (auth)

**1770**
KINETICS OF THE OXIDATION OF URANIUM (IV) BY IRON (III) IN AQUEOUS SOLUTIONS OF PERCHLORIC ACID. R. H. Betts (Atomic Energy of Canada, Ltd., Chalk River, Ont.). Can. J. Chem. 33, 1780-91(1955) Dec.

The kinetics of oxidation of $U^{4+}$ by $Fe^{3+}$ in aqueous solutions of perchloric acid have been investigated at four temperatures between 3.1 and 24.8°C. For the conditions $(H^+)$ = 0.1–1.0 M, ionic strength = 1.02, $(Fe^{3+}) = 10^{-4}-10^{-5}$ M, and $(U^{4+}) = 10^{-4}-10^{-5}$ M, the observed rate law is $d(Fe^{2+})/dt = -2d(U^{4+})/dt = 2(U^{4+})(Fe^{3+})\ [K'(H^+) + K''/(H^+)^2 + (K_1 + K_2)(H^+) + K_1K_2]$ mol/liter/sec. $K_1$ and $K_2$ are the first hydrolysis constants for $Fe^{3+}$ and $U^{4+}$, respectively, and K′ and K″ are pseudo rate constants. At 24.8°C., K′ = 2.98 sec.$^{-1}$, and K″ = 10.6 mol liter$^{-1}$ sec.$^{-1}$. The corresponding temperature coefficients are ΔH′ = 22.5 kcal./mol and ΔH″ = 24.2 kcal./mol. The kinetics of the process are consistent with a mechanism which involves, as a rate-controlling step, electron transfer between hydrolyzed ions. (auth)

**15955** ✓ RDB(C)/TN-41
Gt. Brit. Culcheth Labs., Culcheth, Lancs, England.
THE SYSTEM URANIUM–OXYGEN: A CRITICAL REVIEW OF THE LITERATURE. K. Q. Bagley and D. S. Oliver. May 7, 1953. 32p.

The literature pertaining to the phase relations, kinetics, and thermodynamic data of the oxygen–uranium system is critically reviewed. Recommendations for further work on this system are presented. (auth)

### $UO_2$ – Properties 1.43.07.02.01

**14499** ✓ AECU-4142
Gladding, McBean and Co., Inc., Los Angeles.
BIBLIOGRAPHY ON URANIUM DIOXIDE. (284 References). Henry H. Hausner, comp. Mar. 1959. 28p. Contract [AT(04-3)-249]. $4.80(ph), $2.70(mf) OTS.

A bibliography of 284 references to AEC reports, U. S. patents, and the periodical literature of the world is presented. (T.R.H.)

**16924** CRMet-788
Atomic Energy of Canada Ltd. Chalk River Project, Chalk River, Ont.
THE COHESIVE ENERGY OF URANIUM DIOXIDE AND THORIUM DIOXIDE. B. G. Childs. Aug. 1958. 26p. (AECL-680). $0.50(AECL).

Theoretical values have been calculated of the heats of formation of uranium dioxide and thorium dioxide on the assumption that the atomic binding forces in these solids are predominantly ionic in character. The good agreement found between the theoretical and observed values shows that the ionic model may, with care, be used in calculating the energies of defects in the uranium and thorium dioxide crystal structures. (auth)

**12891** ✓ AERE-M/R-2526
United Kingdom Atomic Energy Authority. Research Group. Atomic Energy Research Establishment, Harwell, Berks, England.
THERMAL CONDUCTIVITY OF $UO_2$. R. Scott. Mar. 1958. 13p.

An experimental measurement of the thermal conductivity of stoichiometric $UO_2$ of 96% theoretical density, over the range 800 to 1150°C, is described. The results are considered in conjunction with previous measurements, and it is concluded that the expression $K = \frac{10}{T + 400}$ cal (cm sec °C)$^{-1}$, where T is the temperature in °C, represents the thermal conductivity of $UO_2$ of theoretical density. Irradiation data for $UO_2$ are not inconsistent with the value $K = \frac{8D}{T + 400}$. The behavior of $UO_2$ cylindrical rods under thermal stress is considered, and it is shown that a temperature difference in excess of 150°C between the surface and axis will cause cracking. (auth)

# URANIUM 1.43

## OXIDES 1.43.07

### $UO_2$ – Properties 1.43.07.02.01

**10222** CRL-51(Rev.)
Atomic Energy of Canada Ltd. Chalk River Project, Chalk River, Ont.
URANIUM DIOXIDE–A PROMISING NUCLEAR FUEL. A Metallurgy Seminar Presented at the University of Toronto, January 24, 1958 and at McMaster University, March 6, 1958. O. J. C. Runnalls. Jan. 1958. 35p. (AECL-553(Rev.)). $1.00(AECL).

Canada's need for power is dealt with briefly. Experience with U metal in the NRX Reactor in relatively cold water and experiments with hot water which indicate that U metal is unsatisfactory for water-cooled power reactors are discussed. Information is presented to support the contention that Zr alloy clad $UO_2$ will meet the required specifications of corrosion resistance, irradiation stability, and economic fabrication costs. Photographs illustrating variations in corrosion behavior, radiation effects, and fabrication techniques for U and $UO_2$ are given. (M.H.R.)

**10568** KAPL-1918
Knolls Atomic Power Lab., Schenectady, N. Y.
PROPERTIES OF URANIA–CERIA BODIES FOR NUCLEAR FUEL APPLICATION. G. L. Ploetz, A. T. Muccigrosso, and C. W. Krystyniak. Jan. 1958. 23p. Contract W-31-109-Eng-52. $0.75(OTS).

Several compositions within the $UO_2$–$CeO_2$ system were studied for possible application as ceramic fuel in nuclear reactors. The properties of interest reported include density, porosity, modulus of rupture, thermal expansion, thermal conductivity, corrosion resistance to water, and microstructure. It was found that higher strength bodies resulted by air firing $U_3O_8$–$CeO_2$ mixtures into a single-phase solid solution rather than by hydrogen firing $UO_2$–$CeO_2$ mixtures into a single-phase solid solution. The preferred setting material for sintering low density urania–ceria bodies is BeO. For high-density bodies fired at temperatures above 1600°C, rhodium is a satisfactory refractory setting material. (auth)

**10679** CRFD-762
Atomic Energy of Canada Ltd. Chalk River Project, Chalk River, Ont.
A LITERATURE SURVEY ON THE MEASUREMENT OF THERMAL CONDUCTIVITY OF SEVERAL SOLIDS INCLUDING URANIUM DIOXIDE. A. M. Ross. Mar. 1958. 42p. (AECL-585). $1.00(AECL).

A literature search has been made on the measurement of thermal conductivity in order to choose a suitable method for small sintered samples of uranium dioxide at various temperatures. The method must be readily adaptable for remotely controlled measurements on neutron-irradiated samples in a hot-cell facility. The various methods for measuring thermal conductivity at ambient and elevated temperatures have been classified into six steady-state heat flow groups and one transient-state heat flow group. The principle of the method of each group is outlined, and a review of pertinent work in the literature is given. As a result of the survey it is suggested that a comparative heat flow apparatus be developed for measurements on uranium dioxide in vacuum at temperatures up to 1400°C. The comparative heat flow method presently being used should be improved in accuracy and developed for remotely controlled measurements on irradiated samples. A transient-state heat flow comparative method should also be examined. A summary of the published thermal conductivity values for powdered and sintered uranium dioxide is given. An index has been made to provide a source of thermal conductivity data for the many materials covered in the survey. (auth)

**8384** KAPL-1702
Knolls Atomic Power Lab., Schenectady, N. Y.
THE THERMAL STABILITY OF URANIUM DIOXIDE. L. G. Wisnyi and S. W. Pijanowski. Nov. 1, 1957. 20p. Contract W-31-109-Eng-52. $0.75(OTS).

The melting point of uranium dioxide was determined in hydrogen, helium, and argon to be 2760 ± 30°C. From lattice constant measurements, it was concluded that in all cases the melted material was uranium dioxide, and not a lower oxide. From the results obtained during thermal analysis experiments in a vacuum, the accepted cubic form was established as the only stable phase of uranium dioxide up to 2500°C. (auth)

# URANIUM 1.43

## $UO_2$ – Properties 1.43.07.02.01

Westinghouse Electric Corp. Bettis Plant, Pittsburgh. PROPERTIES OF $UO_2$. J. Belle and B. Lustman. Sept. 1957. 140p. Contract AT-11-1-GEN-14. (WAPD-184).

Information on the out-of-pile properties of $UO_2$ is reviewed. It is divided into the following topics: Introduction; Physical characteristics of $UO_2$ preparations; Sintering characteristics of $UO_2$; Physical properties of $UO_2$; The System $UO_2$-$U_3O_8$; Stability of $UO_2$ in water; Self-diffusion kinetics; and Conclusions. 73 references to report and published literature are given.

**12000** WAPD-TM-73

Westinghouse Electric Corp. Bettis Plant, Pittsburgh. RÉSUMÉ OF URANIUM OXIDE DATA—X. J. Belle and L. J. Jones. Aug. 15, 1957. 81p. Contract AT-11-1-GEN-14. $12.30(ph OTS); $4.50(mf OTS).

The preparation and characterization of $UO_2$ powders and the effects of ball-milling and steam on the sintering of $UO_2$ are discussed. Investigations of $UO_2$ stability in water, $UO_2-O_2$ equilibrium and kinetics, $O_2$ diffusion in $UO_2$, and the inert gas fission products of $UO_2$ are also reported. In the $UO_2$ irradiation program, fusion and grain growth in $UO_2$ and the effect of high burnup on PWR blanket rods were studied. Reports of studies conducted at KAPL on sintering binary $UO_2$ mixtures with $CeO_2$, $ZrO_2$, $Nb_2O_5$, and $PuO_2$ and studies at BMI on the effect of structure and $N_2$ content on $UO_3$ prepared from various sources are presented. A paper on the irradiation of swage-compacted $UO_2$ fuel rods is included. (For preceding period see WAPD-TM-44.) (T.R.H.)

**8382** ✓ AECU-3674

Westinghouse Electric Corp. Research Labs., [East] Pittsburgh, Penna.

OXIDATION OF URANIUM DIOXIDE. Research Report No. 100FF942-R2(Revised). Paul E. Blackburn, Joseph Weissbart, and Earl A. Gulbransen. Aug. 2, 1957. 22p. For [Westinghouse Electric Corp.] Bettis Plant. $4.80 (ph OTS); $1.70(mf OTS).

The results of kinetic, x-ray, and density studies of the $UO_2$ oxidation products indicate that $UO_2$ oxidizes by the immediate formation of a surface $\gamma$-tetragonal $U_3O_7$ phase. This process is controlled by the diffusion of oxygen through the second phase. Analysis of the $\alpha-UO_2$ lattice parameters demonstrates that the solubility of oxygen in $UO_2$ below 300°C is less than one atom percent per mole of $UO_2$. The stability of $U_3O_7$ and the interpretation of other authors' results are discussed. (auth)

HEAT OF ADSORPTION OF OXYGEN ON URANIUM DIOXIDE AT -183°C. I. F. Ferguson and J. D. M. McConnell (Atomic Energy Research Establishment, Harwell, Didcot, Berkshire). Proc. Roy. Soc. (London) A241, 67-79(1957) July 23.

A number of specimens of $UO_2$ have been prepared and studied in a nonadiabatic nonisothermal calorimeter at −183°C. Uptake of $O_2$ by the oxide is rapid. Incremental addition of $O_2$ has yielded differential heats of adsorption which decrease on all specimens as the surface becomes covered. The initial heat of adsorption is 55 ± 2 kcal/mole. The rate of evolution of heat becomes increasingly slow for successive increments of $O_2$ adsorbed. This slow process takes place after the disappearance of all the $O_2$ from the gas phase and must therefore be a reaction in or on the oxide. It is discussed in terms of a slow change to the chemisorbed state of $O_2$ molecules rapidly adsorbed initially in the physical state. (auth)

# URANIUM 1.43

## $UO_2$ – Properties 1.43.07.02.01

**10050**
KINETIC STUDY OF THE OXIDATION OF URANIUM DIOXIDE. S. Aronson, R. B. Roof, Jr., and J. Belle (Westinghouse Electric Corp., Pittsburgh). J. Chem. Phys. 27, 137-44(1957) July.

Oxidation of $UO_2$ to $U_3O_8$ in dry air and oxygen at temperatures of 160 to 350°C proceeds by a two-step reaction. In the first step the tetragonal oxide of composition $UO_{2.34 \pm 0.03}$ is formed. In the second step this tetragonal phase is converted to orthorhombic $U_3O_8$. The rate controlling process in the first stage is the diffusion of oxygen through the uranium dioxide lattice. The value found for the diffusion coefficient D is $D = 5.5 \times 10^{-3} \exp[-(26,300 \pm 1500)/RT]$, where the activation energy is 26.3 ± 1.5 kcal/mole. The second stage of the reaction proceeds by a process of nucleation and growth. (auth)

**6909** WAPD-MRP-66
Westinghouse Electric Corp. Bettis Plant, Pittsburgh.
PRESSURIZED WATER REACTOR (PWR) PROJECT TECHNICAL PROGRESS REPORT FOR THE PERIOD DECEMBER 24, 1956 TO FEBRUARY 23, 1957. 77p. Contract AT-11-1-GEN-14. $0.45(OTS).

Additional studies were undertaken to establish the degree of reactor and plant safety. Construction progress is reviewed. Performance and corrosion tests on reactor and reactor system components were continued. The status of core component fabrication is given. Developments in core component handling, assembly, and instrumentation planning are reviewed. Fuel rod, blanket plate, and control rod fabrication and inspection experience is summarized. Weld penetration and contamination problems observed following subassembly fabrication were resolved by revisions in fabrication parameters. Basic investigations of metallurgical problems with U-base alloys and fuel cladding alloys were continued. Available information on in-pile tests of $UO_2$ fuel element sections is given. Further studies were made of the chemical and metallurgical properties of $UO_2$. Progress in computer coding for flux, reactivity, and life-time calculations is summarized. (For preceding period see WAPD-MRP-65.) (D.E.B.)

**6713** TID-7530(Pt. 1)
Oak Ridge National Lab., Tenn.
CERAMIC INFORMATION MEETING HELD AT OAK RIDGE NATIONAL LABORATORY ON OCTOBER 1, 2, AND 3, 1956. Apr. 1957. 165p. $1.00(OTS).

Thermodynamic calculations for the behavior of fission products in a high-temperature carbide pile are presented. A survey on the thermodynamic stability of a number of refractory oxides is presented. Methods for determination of melting points of $UO_2$ and other refractories are presented. The characteristics of sinterable BeO powders was determined quantitatively. The radiation stability of some ceramic materials is described. The oxidation of SiC in air at temperatures up to 2300°C is discussed. An experimental technique for fabricating high density fuel elements by high temperature (> 2000°C) flame techniques is described. A study to find means of producing a dense $ThO_2$ body with good thermal shock resistance and adequate mechanical strength is presented. Preliminary irradiation studies on $ThO_2-UO_2$ fuel bodies are presented. (W.L.H.)

**6006** MT-33
National Research Council of Canada. National Research Labs., Ottawa.
AN INVESTIGATION OF THE WETTABILITY OF URANIUM DIOXIDE BY BISMUTH AND BISMUTH ALLOYS. P. G. Hill and E. H. Dudgeon. Dec. 19, 1956. 24p.

An examination has been made of the factors involved in the wetting of solids by liquid metals. It indicates that the wetting of $UO_2$ by liquid Bi might be considerably improved by the addition of small quantities of alkali metals to the Bi. Experiments indicate that the addition of 5 to 10% by weight of Na is required to produce sufficient wetting of $UO_2$ to allow formation of a $Bi-UO_2$ slurry. (auth)

# URANIUM 1.43

## $UO_2$ – Properties 1.43.07.02.01

**12773** BMI-1094(Del.)
Battelle Memorial Inst., Columbus, Ohio.
PROGRESS RELATING TO CIVILIAN APPLICATIONS DURING MAY 1956. Russell W. Dayton and Clyde R. Tipton, Jr. June 1, 1956. Decl. with deletions Feb. 13, 1957. 86p. Contract W-7405-Eng-92. $13.80(ph OTS); $4.80(mf OTS).

Studies were continued on the following: elevated-temperature properties of Al–U alloys; phase equilibria in Th–U alloys; radiation damage to graphite; extrusion cladding of flat fuel plates; metallographic evaluation of dingot–U tubes; preparation and reduction of $UO_3$; electric properties of $UO_2$; corrosion of stainless steel alloys by plant liquors; development of graphite, BeO, and $MoSi_2$ as fuel-element matrix material; high-temperature properties of Mo–U alloys; uranium corrosion; phase studies, heat treatment, and corrosion of U–Zr alloys; corrosion of Zr-base alloys by $H_2O$ and steam; heat treatment of Zr alloys; Zr–$UO_2$ reactions at high temperatures; coating of stainless steel with Mo; preparation and properties of U compounds; oxidation of Nb and Nb alloys; water–zircaloy reactions; and thermal fracture and corrosion resistance of $UO_2$–ceramic systems. (C.W.H.)

**9901** ORNL-2011
Oak Ridge National Lab., Tenn.
THE TECHNOLOGY OF URANIUM DIOXIDE—A REACTOR MATERIAL. J. R. Johnson, L. M. Doney, S. D. Fulkerson, A. J. Taylor, J. M. Warde, and G. D. White. Feb. 21, 1956. ~~Decl.~~ Mar. 2, 1957. 34p. $0.40(OTS).

Interest in the use of $UO_2$ as a reactor fuel resulted in a detailed study of its chemical and physical properties. The crystalline structure, thermal properties, oxidation behavior, chemical activity, methods of preparation and analysis, and susceptibility to radiation have been investigated. Results are reported. (D.E.B.)

**4578**
THE OXIDES OF URANIUM. PART VII. THE OXIDATION OF URANIUM DIOXIDE. J. S. Anderson, L. E. J. Roberts, and E. A. Harper (Atomic Energy Research Establishment, Harwell, Berks, England). J. Chem. Soc., 3946-59(1955) Nov.

Uranium dioxide is oxidized by two distinct processes in the temperature ranges −130 to 50°C and 130 to 180°C though in each case $O_2$ is absorbed into interstitial positions in the lattice. Between −130 and 50°C, the $O_2$ absorbed increases as the logarithm of the time; the same law is followed at the same temperatures by solid solutions of $UO_2$ and $ThO_2$. The oxidation virtually ceases at temperatures below 50° at a composition which depends upon the surface area of the $UO_2$. Between 130 and 180°C the kinetic law followed is characteristic of a diffusion-controlled process but both the rate of reaction and, to some degree, the composition of the oxide finally formed depend upon the pressure. The reaction with $NO_2$ is much faster than the reaction with $O_2$ (auth)

**11802** ORNL-1904
Oak Ridge National Lab., Tenn.
AQUEOUS URANIUM SLURRY STUDIES. J. O. Blomeke. Oct. 20, 1955. Decl. Jan. 17, 1957. 65p. Contract W-7405-eng-26. $10.80(ph OTS); $3.90(mf OTS).

The possible use of aqueous uranium oxide slurries as reactor fuels has been investigated. It was found that $U^{6+}$ was the most stable valence state in such slurry fuels. Several methods for the preparation of $U_2O \cdot H_2O$ are described. The crystal structure of $UO_3 \cdot H_2O$ was examined. Slurries of $UO_3 \cdot H_2O$ were tested for thermal stability, radiation stability, and corrosive properties. (C.W.H.)

**2363** Y-823
Oak Ridge National Lab., Y-12 Area, Tenn.
URANIUM CHEMISTRY OF RAW MATERIALS SECTION PROGRESS REPORT [FOR] JULY 1, 1951 TO SEPTEMBER 30, 1951. Oct. 30, 1951. Decl. May 29, 1956. 58p. Contract W-7405-eng-26. $9.30(ph OTS); $3.60(mf OTS).

Studies were continued on the physical properties of $UO_2CO_3$–$CO_3^{2-}$ systems, ionic analysis of $(UO_2)_3(PO_4)_2$ solutions, solvent extraction of $UO_2^{2+}$, and sorption of U on ion exchange resins. The recovery of U from Bartow Clay, high-lime carnotite ores, and Marysvale-type ores, and the recovery of V from carnotites were investigated. (C.W.H.)

# URANIUM 1.43

## $UO_2$ – Properties 1.43.07.02.01

**9682** MCW-213
Mallinckrodt Chemical Works, St. Louis.
"INHIBITION" OF THE OXIDATION OF LOW-TEMPERATURE URANIUM DIOXIDE. Carl W. Kuhlman, Jr. Aug. 23, 1949. Decl. Feb. 26, 1957. 4p. $0.20(OTS).

Uranium dioxide prepared by the reduction of $UO_3$ at low temperature was found to be very reactive toward HF. In the preparation of $UO_2$ for use in the $UF_4$ pilot plant, difficulty was experienced in obtaining a product of high $UO_2$ assay due to the extremely rapid rate of oxidation by air of the freshly reduced dioxide. An account of attempts to find a method of "inhibiting" this oxidation reaction without disturbing the rate of the subsequent fluorination is given. HF treatment was found to inhibit oxidation quite well; $NH_3$, $N_2$, $CCl_4$, ethyl alcohol, and toluene were less successful. (auth)

**13222** NYO-5224
Mallinckrodt Chemical Works, St. Louis.
THE OXIDATION OF $UO_2$ IN AIR AND UNDER CONDITIONS OF STORAGE. J. Stevenson and J. Boyd. Apr. 1, 1948. Decl. Mar. 7, 1957. 27p. $0.35(OTS).

Varying oxidation losses of up to 2 to 3% $UO_2$ was observed during storage of $UO_2$ but they have been considered abnormal, probably the product of unusual variations in storage conditions. Since long term storage of $UO_2$ has been proposed it is essential to know the rate and extent of oxidation of $UO_2$ under current storage conditions. Some knowledge of the oxidation mechanism would be desirable. To obtain this knowledge, a study of the variables affecting the rate and extent of oxidation of $UO_2$ was conducted. Under current storage conditions oxidation losses reach at least 1% $UO_2$ in about two months. Further losses probably depend on the rate of diffusion of air into the container and occur relatively slowly. Under optimum storage and handling conditions no more than 0.4% $UO_2$ loss would be incurred. These conditions require transfer of the $UO_2$ to an air tight container within two hours after exposure to air and at a temperature of 25°C or less. The initial rate of oxidation of $UO_2$ is probably determined by the rate of the chemical reaction. This rate diminishes rapidly to a constant value suggesting that gas diffusion or solid rearrangement may be controlling the rate of oxidation. The rate and extent of oxidation of $UO_2$ are functions of: surface of $UO_2$, temperature, time, concentration of oxygen in the oxidizing atmosphere, and history of the $UO_2$. (J.E.D.)

**2369** A-1241
Columbia Univ., New York. Div. of War Research.
THE OXIDATION OF URANIUM OXIDE–WATER SLURRIES BY HYDROGEN PEROXIDE. Clyde A. Hutchison, James S. Smith, and Ashton M. Lyon. Feb. 15, 1944. Decl. Jan. 16, 1956. 39p. Contract W-7405-eng-50. (100K-R-591). $9.30(ph OTS); $3.60(mf OTS).

**17933** AEC-tr-3374
THE ELECTRICAL CONDUCTIVITY OF URANIUM OXIDES. Karl Hauffe. Translated for Los Alamos Scientific Lab., N. Mex. from Z. physik. Chem. 48B, 124-30(1941). 6p.

The electrical conductivity of $UO_2$ and $U_3O_8$ was measured in the temperature range 800 to 1000°C barostatically, applying varying oxygen pressures. In the pressure range utilized the electrical conductivity is in both cases independent of the oxygen pressure. The energy increment $\Delta E$ of the $U_3O_8$ phase electrical conductivity was calculated to be 5 kcal in the 700 to 900°C temperature range. (auth)

**13877**
A KINETIC STUDY OF THE DISSOLUTION OF $UO_2$ IN CARBONATE SOLUTION. Ray L. Pearson and Milton E. Wadsworth (Univ. of Utah, Salt Lake City). Trans. Met. Soc. AIME 212, 294-300(1958) June.

Sintered $UO_2$ samples were leached in carbonate solutions of various concentrations. A pressurized system was used so that it was possible to investigate the kinetics of the reaction to 200°C with oxygen overpressures as high as 800 psi. The surface active species in solution appears to be the undissociated acid $H_2CO_3$. Competitive adsorption between oxygen and $H_2CO_3$ occurs at the $UO_2$ surface resulting in an over-all rate decrease at high concentrations of $H_2CO_3$. Oxygen splits between two surface active sites and the slow step of the surface reactions involves a rearrangement or diffusion of oxygen on the mineral surface. (auth)

# URANIUM 1.43

## $UO_2$ – Properties 1.43.07.02.01

**6876** A/CONF.15/P/1474
ELECTRICAL CONDUCTIVITY OF URANIUM OXIDES. M. J. Brabers (Joint Establishment for Nuclear Energy Research, Kjeller, Norway). 5p.

Electrical conductivities of sintered uranium oxides in the composition range from O/U = 2.00 to O/U = 2.15 have been measured in argon atmosphere and in the temperature range from 20 to 1000°C. Conductivities have been determined from measurement of the potential drops in the specimen and a calibrated resistor in series with it. (auth)

**7044** A/CONF.15/P/141
THERMAL CONDUCTIVITY OF $UO_2$. K. Berg, J. E. Flinta, and L. Seltorp (AB Atomenergi, Stockholm). 9p.

The heat transfer coefficient of $UO_2$ and its dependence on the thermal load, and on the neutron irradiation was investigated. $UO_2$ of different densities produced by various methods was used. Thermal load was produced by electrical heating. The neutron irradiation was done in the research reactor R1. (auth)

**8328** CEA-363
~~France. Commissariat à L'Énergie Atomique, Paris.~~
CONTRIBUTION A L'ETUDE CRISTALLOGRAPHIQUE DU SYSTEME URANIUM–OXYGENE (theses). (Contribution to the Crystallographic Study of the Oxygen–Uranium System (thesis). Pierre Perio. 1955. 111p.

A detailed study was made of the properties of the crystallographic species between U and $UO_3$. Remarks concerning the low-temperature oxidation kinetics of $UO_2$ are also included. (B.J.H.)

**3185** NBS-C-568
National Bureau of Standards, Washington, D. C.
HIGH-TEMPERATURE REACTIONS OF URANIUM DIOXIDE WITH VARIOUS METAL OXIDES. S. M. Lang, F. P. Knudsen, C. L. Fillmore, and R. S. Roth. Feb. 20. 1956. 34p. $0.20(GPO).

The high-temperature reactions of $UO_2$ with 15 metal oxides are described. The systems are discussed in groups according to the cation valence of the second oxide; the divalent oxides BeO, MgO, CaO, SrO, BaO, and CuO; the trivalent oxides $Al_2O_3$, $Y_2O_3$, and $Nd_2O_3$; the tetravalent oxides $SiO_2$, $ZrO_2$, $SnO_2$, $CeO_2$, and $ThO_2$; and the pentavalent oxide $V_2O_5$. A brief review is presented for the relations in the U–O system, particularly in the region of $UO_2$. Detailed descriptions of the equipment and the procedures used are included. (auth)

# URANIUM 1.43

## $UO_2$ – Preparation 1.43.07.02.02

**6249**

PREPARATION OF HIGH DENSITY $UO_2$. J. M. Googin (to U. S. Atomic Energy Commission). U. S. Patent 2,906,598. Sept. 29, 1959.

A method is presented for the preparation of high-density $UO_2$ from $UF_6$. In accordance with the invention, $UF_6$ is reacted with water and concentrated ammonium hydroxide is added to the resulting aqueous solution of $UO_2F_2$. The resulting precipitate is calcined to $U_3O_8$ and the $U_3O_8$ is reduced to $UO_2$ with a gaseous mixture comprised of carbon monoxide and carbon dioxide at a temperature of from 1600 to 1900°C.

**6247** ✓

METHOD FOR PREPARATION OF $UO_2$ PARTICLES. J. R. Johnson and A. J. Taylor (to U. S. Atomic Energy Commission). U. S. Patent 2,905,528. Sept. 22, 1959.

A method is described for the preparation of high-density $UO_2$ particles within the size range of 40 to 100 microns. In accordance with the invention $UO_2$ particles are autoclaved with an aqueous solution of uranyl ions. The resulting crystals are reduced to $UO_2$ and the $UO_2$ is heated to at least 1000°C to effect densification. The resulting $UO_2$ particles are screened, and oversize particles are crushed and screened to recover the particles within the desired size range.

**11386** ✓ CRCE-716

Atomic Energy of Canada Ltd. Chalk River Project, Chalk River, Ont.

PREPARATION OF URANIUM DIOXIDE FOR USE IN CERAMIC FUELS. PART III. AMMONIUM DIURANATE REDUCTION STUDIES. A. R. Bancroft and L. C. Watson. May 1958. 27p. (AECL-586). $1.00(AECL).

Uranium dioxide can be prepared by the reduction of ammonium diuranate with hydrogen at elevated temperatures. The results of a study made to define the effects of the reduction conditions on the sintered density of the uranium dioxide compacts are described. Seven variables which might be expected to affect the properties of the uranium dioxide were investigated using ammonium diuranate samples of three different qualities simultaneously for all tests. (auth)

$UO_2$–$PuO_2$ SOLID SOLUTIONS. Robert N. R. Mulford and F. H. Ellinger (Los Alamos Scientific Lab., N. Mex.). J. Am. Chem. Soc. 80, 2023(1958) Apr. 20.

An X-ray-diffraction investigation has been made of the solid phase relationships in the $UO_2$–$PuO_2$ system. The results show that a continuous solid solution exists, and that the lattice parameter varies essentially linearly with composition. A slight negative deviation from linearity may exist. (auth)

THE WARM PRESSING (800°C.) OF $UO_2$ AND $UO_2$–METAL MIXTURES. R. Scott and J. Williams (Atomic Energy Research Establishment, Harwell, Berks, Eng.). Trans. Brit. Ceram. Soc. 57, 199-209(1958) Apr.

Fine non-stoicheiometric $UO_2$ powders can be compacted to at least 90% theoretical density at 800°C under 10 t/in$^2$ pressure. The addition of powders of iron, tungsten, tantalum, uranium, and magnesium inhibits densification. The effect is considered to be due to the removal of oxygen in excess of the stoicheiometric amount from the $UO_2$. Possible mechanisms of densification are discussed. (auth)

MECHANISM OF ELECTROCHEMICAL REACTIONS ON A MERCURY CATHODE IN URANIUM SALT SOLUTIONS. G. S. Tyurikov, K. I. Rosental, and V. I. Veselovskii (Karpov Inst. of Physical Chemistry, Moscow). Zhur. Fiz. Khim. 32, 1490-8(1958). (In Russian)

Results are presented of polarographic studies on the mechanism of electrochemical reactions occurring in uranium salt solutions, using a dropping mercury electrode. Data are produced on exchange current measurements of the reactions: $UO_2^{2+} + \bar{e} \rightleftharpoons UO_2^{+}$ and $UO^{2+} + \bar{e} \rightleftharpoons UO^{+}$ on a stationary mercury electrode polarized by weak alternating currents. The main factors determining the character and rate of the electrochemical process taking place in acid solutions of uranium salts where hydrolysis has as yet not taken place were shown to be the laws governing the disproportionation of uranium and the related stability and steady state concentration, changing within wide limits. Measurement of the exchange currents of the electrodic reactions $UO_2^{2+} + \bar{e} \rightleftharpoons UO^{+}_2$ and $UO^{2+} + \bar{e} \rightleftharpoons UO^{+}$ yielded a value of 5 to 10 ma/cm$^2$. The dependence of the exchange current of these reactions on the potential and $H^+$ ion concentration follows from the slow discharge theory. (tr-auth)

# URANIUM 1.43

## $UO_2$ – Preparation 1.43.07.02.02

**9434** TID-7546 (p.369-83)
Mallinckrodt Chemical Works, St. Louis.
PREPARATION AND PROPERTIES OF URANIUM DIOXIDE POWDER. C. D. Harrington. p.369-83 [of] FUEL ELEMENTS CONFERENCE, PARIS, NOVEMBER 18-23, 1957. 15p.

The physical properties of $UO_2$ powder are discussed in relation to their importance in fuel-element application. Various methods of commercial preparation of the dioxide are described with particular emphasis on the two methods which have had the widest application in the actual production of the material for fuel-element raw material. Data are presented showing the relation between method of manufacture and properties of interest. (auth)

**9436** TID-7546 (p.402-13)
Aktiebolaget Atomenergi, Stockholm.
SINTERING OF URANIUM DIOXIDE. R. Kiessling and U. Runfors. p.402-13 [of] FUEL ELEMENTS CONFERENCE, PARIS, NOVEMBER 18-23, 1957. 12p.

The qualifications for sintered compacts of $UO_2$ used as simple fuel elements for subcritical assemblies are listed, along with additional problems which need to be solved. Figures illustrating the influence of shape and size of agglomerates on the properties of the sintered product are shown. Some general conclusions from the work done are drawn. (M.H.R.)

**168**
EXCHANGE REACTION BETWEEN URANIUM IONS IN A HYDROCHLORIC ACID SOLUTION. Presented at International Conference on Radioisotopes in Scientific Research held Sept. 9-20, 1957 at Paris. No. UNESCO/NS/RIC/39. Elizabeth Rona. London, Pergamon Press, Ltd., 1957. 7p. (In French)

Exchange reactions with heavy isotopes have received increased attention in recent years. Several theories have been advanced to explain the paths through which electron transfer can occur. There are but very few heavy element systems which will lend themselves for the experimental tests of these problems. The exchange between uranium ions in hydrochloric acid solution, however, proceeds with measurable speed. The following two systems were studied: (1) $U^{+4} + U^*O_2^{+2} = U^{*+4} + UO_2^{+2}$ and (2) $UO^{+2} + U^*O_2^{+2} = U^*O^{+2} + UO_2^{+2}$. Experimental data show that the rate of exchange is first order with respect to $UO_2^{+2}$ concentration in (1) and (2) and second order in respect to $U^{+4}$ in (1) and $UO^{+2}$ in (2). It is –3 order with respect to pH in (1) and –3.7 in (2). The rate of exchange is considerably faster for (2) than for (1). The mechanism proposed for (1) and (2) is naturally somewhat different, but in both an activated complex ion is postulated with an oxygen bridge between the two uranium ions. The energy of activation of reaction (2) is lower. The entropy of activation is less positive than for (1). A hypothesis is advanced to account for these results. [The ion with asterisk is labelled with $U^{233}$.] (auth)

# URANIUM 1.43

## $UO_2$ – Preparation 1.43.07.02.02

**7740** AECU-3660
Utah. Univ., Salt Lake City. Inst. for the Study of Rate Processes.
KINETICS OF DISSOLUTION OF $UO_2$ IN SULFURIC ACID. Technical Report No. XXVIII. Theron L. Mackay and Milton E. Wadsworth. Sept. 15, 1957. 44p. Project No. 1. Contract AT(11-1)-82. $7.80(ph OTS); $3.30(mf OTS).

The leaching of $UO_2$ in sulfuric acid solutions was investigated and the rate of leaching was measured by determining the concentration of $UO_2^{++}$ in solution as a function of time. The rate was determined as a function of the agitation of the solution, acid concentration, and overpressure of oxygen. A mechanism was postulated that satisfied the experimental observations. The leaching of uranium was found to be linear over the range of time under all the conditions investigated, and the rate was observed to be directly proportional to the partial pressure of oxygen. The rate at various concentrations of ions was determined to be a function of the concentration of $H^+$ ions. Evidences are presented that a $UO_2$ site on the surface of $UO_2$ reacts with a molecule of water to form a hydroxyl complex which in turn can dissociate similar to an acid. The rate determining step was found to be the reaction between an oxygen molecule and a hydroxyl complex of uranium on the surface of $UO_2$. Calculations of the energy of activation for the over-all process using the arrhenius equation was found to be 18 kcal/mole. With this value it was estimated that one site for every 10 to 20 surface sites was active. (auth)

**8845** ✓
PARTICLE SIZE DETERMINATION BY RADIOACTIVATION. Bernard M. Abraham, Howard E. Flotow, and Roger D. Carlson (Argonne National Lab., Lemont, Ill.). Anal. Chem. 29, 1058-60(1957) July.

A rapid and reliable sedimentation method has been developed for determination of particle size of $UO_2$ powders in NaK alloy. Powder is first activated by neutron bombardment. Resultant activity that radiates from a thin lamina of suspension is a measure of weight of material in lamina. Method can be used for any radioactive powder in any fluid. (auth)

**9101** ✓ HW-49567
General Electric Co. Hanford Atomic Products Operation, Richland, Wash.
CORE TEMPERATURES OF SWAGED $UO_2$ FUEL ELEMENTS. W. E. Roake. Apr. 5, 1957. 9p. Contract [W-31-109-Eng-52]. $1.80(ph OTS); $1.80(mf OTS).

The method for compaction of $UO_2$ powders by swaging in a restraining tube is described. The core temperatures to be expected are calculated. (T.R.H.)

**6311** KAPL-1743
Knolls Atomic Power Lab., Schenectady, N. Y.
THE PARTICLE SIZE OF SOME URANIUM DIOXIDE SAMPLES. F. D. Leipziger. Mar. 8, 1957. 18p. Contract W-31-109-Eng-52. $0.20(OTS).

Surface area measurements by the BET $N_2$ adsorption method were made on four different $UO_2$ samples. The particle size of the $UO_2$ was calculated from these measurements and compared with particle size measurements determined by studying x-ray line broadening and settling velocity, and measurements by electron microscopy. (auth)

**5825** BMI-1175
Battelle Memorial Inst., Columbus, Ohio.
EXPERIMENTS ON THE PREPARATION OF $UO_{2-x}$ AND UO. Dale A. Vaughan, Carl W. Melton, and Arnold F. Gerds. Mar. 6, 1957. 12p. Contract W-7405-eng-92. $0.15(OTS).

Reactions designed to reduce the $O_2$ content of $UO_2$ below stoichiometric composition are described. No evidence was found for the existence of substoichiometric $UO_2$. The reaction of metal with $UO_{2+x}$ yields a phase described in the literature as uranium monoxide, UO. However, the reaction proceeds at a low rate and the reaction products are contaminated with a large amount of $UO_2$. The reaction of UC with $UO_2$ is described: this reaction is capable of producing a single-phase material of composition $UC_xO_{1-x}$ ($x \cong 0.5$) by heating in vacuum at 1600 to 1800°C. (autb)

# URANIUM 1.43

## $UO_2$ – Preparation 1.43.07.02.02

PRODUCTION OF ESPECIALLY PURE $U^{233}$ AND $U^{235}$ POWDERS. Z. G. Atomnaya Energiya 3, 270-1(1957).

A reaction apparatus is described by means of which 200 to 350 g batches of $UO_2$ powder can be obtained. The exact technological operation is given step by step. Because of the high $\alpha$ activity of $U^{235}$ and $U^{233}$ all operations must be carried out in closed rooms which are accessible only from the outside. A scheme for this operation is given. (TCO)

**4451** CF-56-8-135
Oak Ridge National Lab., Tenn.
THE REACTION OF $UO_2$ WITH ALUMINUM. M. L. Picklesimer. Aug. 7, 1956. 27p. Contract [W-7405-eng-26]. $4.80(ph OTS); $2.70(mf OTS).

The reaction of $UO_2$ with Al was investigated by reacting compacts of powder blends of 50 wt. % Al and 50 wt. % $UO_2$, the latter being made by two different processes which produced oxides of differing physical characteristics. The compacts were held for various times at 615°C in evacuated quartz capsules. The reaction curves for the compacts of the two different oxides were determined by residue analyses performed by successive chemical leaching operations on reacted compacts. The reaction products, $UAl_3$ and $UAl_4$, were identified by x-ray diffraction, and $Al_2O_3$ by spectrographic analysis. The conclusions reached were that the reaction is not stoichiometric, at least in the earlier stages of the reaction, that the reaction cannot be suppressed but can be slowed sufficiently by quality control of the oxide to permit successful fabrication of fuel plates, and that the primary cause of the major portion of the growth of fuel plates and compacts observed was due to the release of $H_2$ which had been adsorbed by the oxide during its preparation. A probable mechanism for the reaction is proposed but not conclusively proven. The mechanism involves the production of $U_3O_8$ as an intermediate product of the reaction. A quick study of the possible direct substitutes for the $UO_2$ powder, UC, $UC_2$, $U_3Si$, and $U_3Si_2$, showed that all except $UC_2$ reacted with the Al matrix. Completely successful fuel plates were fabricated from 50 wt. % $UC_2$ and 50 wt. % Al powder blends, and were tested at a temperature and for time at temperature conditions much more severe than will be encountered in practice. $UC_2$ powder can be made easily from the pure elements by arc melting and then grinding to powder in an inert atmosphere. (auth)

**2221** ANL-5053
Argonne National Lab., Lemont, Ill.
THE FABRICATION AND PHYSICAL PROPERTIES OF URANIA BODIES. Work completed: August 1954. W. A. Lambertson and J. H. Handwerk. Feb. 1956. 48p. Contract W-31-109-eng-38. $0.50(OTS).

The fabrication methods employed in forming urania bodies are reviewed. The density of urania appeared to increase with a decrease in the particle size of urania used, and with an increase in firing time and temperature. The melting point of urania was redetermined, and found to be 2880 ± 20°C. The thermal expansion of urania was found to be linear up to 950°C and the average thermal expansion from room temperature to 950°C was found to be $10 \times 10^{-6}$ cm/cm/°C. The thermal conductivity is reported to be 0.016 cal/sec/cm/°C at 100°C, and the hardness was found to be approximately 6 to 7 on Moh's scale. The specific resistance was found to be 315 ohm-centimeters at room temperature, and the modulus of rupture was found to be approximately 26,200 psi. Specimens were corroded in water, hydrogen peroxide solutions, and NaK eutectic alloy. The urania was found to be resistant to corrosion in water up to 315°C, and to dilute hydrogen peroxide solutions. Specimens of high density urania heated slowly in NaK alloy to 600°C were found to be in good condition after 72 hours. This would indicate that urania is resistant to corrosion by NaK alloy. Specimens dropped in NaK alloy at 400°C were found to fracture, which would indicate that urania is susceptible to thermal shock. Specimens irradiated to low burnups showed cracking, presumably due to the thermal gradients existing in the specimens during irradiation. The phase systems $UO_2-O$, $UO_2-Al_2O_3$, $UO_2-Nd_2O_3$, $UO_2-ZrO_2$, $UO_2-ThO_2$, $UO_2-MgO$, and $U_3O_8-MgO$ are reviewed. (auth)

# URANIUM 1.43

## $UO_2$ – Preparation 1.43.07.02.02

**7898** BMI-1009
Battelle Memorial Inst., Columbus, Ohio.
CERAMIC INVESTIGATIONS OF $UO_2$. Adrian G. Allison and Winston H. Duckworth. June 16, 1955. Decl. Feb. 13, 1957. 32p. Contract W-7405-eng-92. $0.35(OTS).

A $UO_2$ powder with unusually good sinterability was prepared from MCW $UO_3$ by milling it for 4 hr in 0.02N $H_2SO_4$ or in distilled water and then reducing it to $UO_2$ in water-saturated $H_2$ at temperatures of 930 to 1110°F. Compacts of these powders, pressed at 20,000 psi and sintered at 2800°F for 1 hr in $H_2$, had bulk densities of 10.75 to 10.93 g per $cm^3$. As-received MCW $UO_2$ powder was made free flowing by mechanical agglomeration, using camphor as a temporary binder. The agglomerated powders had good pressing characteristics, and the treatment did not appear to affect the sintering behavior or the resistance of sintered compacts to corrosion by 650°F water or 750°F steam. Twelve simulated fuel elements were made for in-pile tests. Plus 325-mesh MCW $UO_2$ was hydrostatically pressed into core rods at 100,000 psi and sintered in $H_2$ at 3750°F. Bulk densities of the cores varied from 9.71 to 9.96 g per $cm.^3$ The sintered $UO_2$ cores were ground to the desired diameter and length, and were clad in Zircaloy-2 tubes by an arc-welding process. Preliminary investigation indicated ceramic extrusion to be a satisfactory method for fabricating $UO_2$ fuel-element cores, providing that the $UO_2$ powder used is a readily sinterable type. Using such a powder and a quantity of organic plasticizer that introduced less than 0.2 w/o ash, extrusions $^3/_{16}$ in. in diameter had bulk densities of from 9.85 to 10.65 g per $cm^3$ after sintering at 3000°F in $H_2$ for 1 hr. The bulk density of compacts made of MCW $UO_2$ pressed at 100,000 psi and sintered in $H_2$ at 3200°F was increased from 9.50 to 10.38 g per $cm^3$ by milling the as-received $UO_2$ to a maximum particle size of 5 $\mu$ in a rubber-lined mill, using U balls. Small lots, up to 3000 g, of $UO_2$ were fused in an electric-arc furnace using a W-tipped electrode with a water-cooled Cu crucible and a protective atmosphere of pure A. About 5 w/o of the $UO_2$ was deposited on the cool walls of the furnace by vaporization during the melting operation. About 2000 ppm of W was picked up by the $UO_2$ during the fusion. Compacts having a sintered bulk density of 10.03 g per $cm^3$ were made by milling the fused oxide to an average particle size of 7.1 $\mu$, hydrostatically pressing at 100,000 psi, and sintering for 2 hr in $H_2$ at 3750°F. Between 0.1 and 1 w/o of Zr was picked up during milling of the fused $UO_2$, using a rubber-lined mill and Zircaloy-2 balls. (auth)

**13702** NYO-3796
Metal Hydrides Inc., Beverly, Mass.
REDUCTION OF URANIUM OXIDES. QUARTERLY REPORT NO. 4. Sidney Johnson. Oct. 19, 1953. ~~Decl. Feb. 27, 1957.~~ 14p. Contract AT(30-1)-1350. $0.25(OTS).

Means of reduction of uranium oxides to uranium hydride powder were further studied. On the basis of previous experience, emphasis was upon the reduction of $UO_2$ by $CaH_2$, which not only has given some of the best results, but also is considered to be the reaction most readily adaptable to a continuous process. Three methods of evaluation which are considered the most promising are being pursued. These are: (1) a U assay method whereby the $UH_3$ powder is dissolved directly in a measured excess of $CeSO_4$; (2) the density of U metal prepared by hot-pressing $UH_3$ powder; and (3) a direct determination of oxygen by displacing this element with $BrF_3$. In addition, the A. E. C. New Brunswick Laboratories agreed to do a limited number of oxygen determinations by the vacuum fusion technique on U metal produced in this laboratory. It is certain that one or more of these methods will be suitable for a complete evaluation of $UH_3$ powder. (auth)

**9768** RDB(C)/TM-142
Gt. Brit. Culcheth Labs., Culcheth, Ches., England.
MAGNESIUM REDUCTION OF URANIUM DIOXIDE. INFLUENCE OF MAGNESIUM PRESSURE ON FREE ENERGY OF REACTION. W. G. O'Driscoll. Jan. 16, 1953. Decl. Apr. 18, 1958. 8p.

The variations of the vapor pressure of Mg with the free energy of the reaction of $UO_2$ with Mg have been calculated over the range 0.01 to 30 atm. An analysis of these data indicates that it is thermodynamically possible to obtain maximum reaction temperatures in excess of the melting point of U (1130°C) when a Mg vapor pressure of at least 1 atm. is maintained during the reaction. (J.E.D.)

# URANIUM 1.43

## $UO_2$ – Preparation 1.43.07.02.02

12428 NYO-3793
Metal Hydrides, Inc. Chemical Research Lab., Beverly, Mass.
SECOND QUARTERLY REPORT ON THE REDUCTIONS OF URANIUM OXIDES. Robert W. Bragdon. Jan. 10, 1953. Decl. Mar. 28, 1957. 15p. Contract AT(30-1)-1350. $3.30(ph OTS); $2.40(mf OTS).

The progress on a program designed to evaluate methods of preparing uranium hydride from the various oxides of uranium is presented. The current portion of the investigation is concerned with the reduction of $UO_2$, $UO_3$, and $U_3O_8$ with calcium hydride in an atmosphere of $H_2$, and three such reductions are described. Chemical analyses of the products indicate that the reductions are incomplete under the specific conditions employed in these three runs. These conditions are the simplest and are not those which can be considered optimum. An apparently satisfactory standard laboratory leach method for the removal of the by-products has been evaluated, using a synthetic furnace product, and this method is currently being employed in the isolation of actual products. The evaluation of these products was seriously hindered by the difficulty in obtaining a sufficiently pure argon atmosphere for the dry box. The passage of tank argon over titanium sponge at 850 to 900°C has effectively solved this problem. (auth)

13069 AERE-M/R-1049
Gt. Brit. Atomic Energy Research Establishment, Harwell, Berks, England.
THE PRODUCTION OF URANIUM POWDER BY THE URANIUM DIOXIDE–MAGNESIUM ROUTE. R. G. Bellamy and J. H. Buddery. Oct. 28, 1952. Decl. July 24, 1958. 32p.

The uranium dioxide–magnesium route has been investigated as a method of obtaining uranium metal. Conditions have been determined for the production of non-pyrophoric, substantially oxide-free powder of acceptable particle shape and size by heating uranium dioxide with magnesium and a flux (preferably magnesium chloride) in a line-lined, heat resisting steel vessel out of contact with air; crushing the resulting reaction cake; and leaching with either nitric or acetic acids. Conditions for washing, drying, and if necessary waxing the powder for subsequent fabrication stages are described. (auth)

13707 Y-876(Del.)
Carbide and Carbon Chemicals Co. Y-12 Plant, Oak Ridge, Tenn.
DEVELOPMENT OF HIGH DENSITY URANIUM DIOXIDE POWDERS. Harvey T. Kite and David W. Smith. May 28, 1952. Decl. with deletions May 7, 1957. 17p. Contract W-7405-eng-26. $3.30(ph OTS); $2.40(mf OTS).

Various procedures for the preparation of $UO_2$ powders are reviewed. Blending of various sieve sizes of $UO_2$ and coprecipitation of U with magnesia are also reported. (L.T.W.)

17332 TID-2502(Del.)(p.243-5)
Ames Lab., Ames, Iowa.
A TECHNIQUE FOR PRODUCING FINE-PARTICLE THORIUM OXIDE AND URANIUM OXIDE. Robert S. Hansen and Robert E. Minturn. p.243-5 [of] NUCLEAR SCIENCE AND TECHNOLOGY. (EXTRACTS FROM REACTOR SCIENCE AND TECHNOLOGY. VOL. 1, ISSUES 1 TO 3, APRIL–DECEMBER 1951.) 3p. (ISC-145).

Oxides of U and Th with particles averaging less than 75 mμ in diameter have been prepared by combustion of atomized solutions of the corresponding nitrates in organic solvents (chiefly acetone). Using these procedures, yields ~25% of theoretical maximum were obtained. An x-ray powder photograph of the U oxide indicates it to be about 70% $U_3O_8$. (auth)

12379 M-333(Pt. IV)
Linde Air Products Co., New York.
CONSTRUCTION, PROCESS AND OPERATION REPORT. STEP III. Oct. 1, 1946. Decl. June 10, 1957. 108p. Contract W-7401-ENG-14. $16.80(ph OTS); $5.70(mf OTS).

The specifications and description of the Ceramic Plant, Step III unit for conversion of $UO_2$ to $UF_4$ are given. The process and operation procedures are included. (T.R.H.)

# URANIUM 1.43

## $UO_2$ – Preparation 1.43.07.02.02

**6351** ✓ A/CONF.15/P/552
THE PREPARATION OF URANIUM DIOXIDE FUEL FOR A SUSPENSION REACTOR. M. E. A. Hermans (Reactor Centrum Nederland, Arnhem, The Netherlands). 13p.

By using a controlled precipitation from a homogeneous solution, it is possible to produce an ammonium diuranate which, after reduction in hydrogen at 1100°C and subsequent sintering in a hydrogen–water vapor atmosphere at 1700°C, results in a uranium dioxide powder with a specific surface smaller than 0.1 $m^2/g$ and with a favorable particle size distribution. (auth)

**6788** A/CONF.15/P/1097
URANIUM ALLOY POWDERS BY DIRECT REDUCTION OF OXIDES. R. H. Myers and R. G. Robins (New South Wales Univ. of Tech., Kensington, N.S.W., Australia). 15p.

A process is outlined for the production of uranium alloy powders by co-reduction of mixtures of uranium oxide and alloy element oxides. The reduction of mechanical mixtures of the oxides of uranium and alloy element with calcium in a sealed reaction vessel is shown to produce powder with a variation in particle composition, although of consistent composition over various size fractions. The particular alloy systems which are considered are uranium–nickel, uranium–chromium, uranium–molybdenum, and uranium–niobium. The uranium–molybdenum and uranium–niobium powders are single phase (metastable gamma), which is of consequence in the production of dimensionally stable nuclear fuels. Potential applications of some of these alloys are discussed. (auth)

**6526** A/CONF.15/P/1417
SELF-REDUCTION OF AMMONIUM DIURANATE TO URANIUM DIOXIDE. Jovino D. Pedregal and Roberto R. Solano (Junta de Energia Nuclear, Madrid). 10p.

The method is designed to transform ammonium diuranate into uranium dioxide without having to use any other agent as a reducer. It rests on the fact that this reduction can be achieved by the hydrogen produced by the dissociation of the ammonia released from the diuranate when heated. The final total reaction is $(NH_4)_2U_2O_7 \rightarrow 2UO_2 + N_2 + \frac{5}{3} H_2 + \frac{1}{3} O_2 + \frac{7}{3} H_2O$. By observing the quantity of $NH_3$ produced and consumed in the reaction, it is deduced that there is a 33.3% excess over and above the theoretical quantity required.

STEPS IN PREPARING URANIUM DIOXIDE FOR FUEL ELEMENTS. H.H. Hausner (Penn-Texas Corp., New York) and R.G. Mills (General Electric Co., San Jose, Calif.). Nucleonics 15, 7, 94-103 (1957)July.

# URANIUM 1.43

$UO_3$ 1.43.07.03

**6246** ✓
PREPARATION OF URANIUM TRIOXIDE. J. S. Buckingham (to U. S. Atomic Energy Commission). U. S. Patent 2,903,334. Sept. 8, 1959.

The production of uranium trioxide from aqueous solutions of uranyl nitrate is discussed. The uranium trioxide is produced by adding sulfur or a sulfur-containing compound, such as thiourea, sulfamic acid, sulfuric acid, and ammonium sulfate, to the uranyl solution in an amount of about 0.5% by weight of the uranyl nitrate hexahydrate, evaporating the solution to dryness, and calcining the dry residue. The trioxide obtained by this method furnished a dioxide with a considerably higher reactivity with hydrogen fluoride than a trioxide prepared without the sulfur additive.

PROCESSES FOR PRODUCING URANIUM TRIOXIDE. (to U. K. Atomic Energy Authority (U.S.A.)). British Patent 787,742. Nuclear Eng. 3, 272(1958) June.

Treatment of uranium tetraoxide slurries or suspensions with aqueous ammonium hydroxide gives a material which upon heating yields a uranium trioxide capable of rapid and complete reaction with carbon tetrachloride.

**15104** ✓
SOME EVIDENCE FOR THE PRESENCE OF URANIC ACID IN URANIUM TRIOXIDE–WATER SYSTEMS. P. S. Gentile, L. H. Talley, and T. J. Collopy (National Lead Co. of Ohio, Cincinnati). J. Inorg. & Nuclear Chem. 10, 114-16(1959) Apr.

The hydrates, $UO_3.2H_2O$, $UO_3.0.8H_2O$, and $UO_3.0.5H_2O$ were shown to react with the organic base, urea, to form urea uranate $H_2UO_4.2CO(NH_2)_2$. The formation of this salt provides evidence that these "hydrates" constitute a series of acids whose relationship may be expressed as follows: $H_2UO_4.H_2O \xrightarrow{100°C} H_2UO_4 \xrightarrow{160°C} H_2U_2O_7$ (pyrouranic acid). Attempts to characterize the "hydrate" $UO_3.0.8H_2O$ were unsuccessful; instead the presence of a mixture of $H_2UO_4$ and $H_2U_2O_7$ was indicated. (auth)

**7383** ✓ KAPL-1668
Knolls Atomic Power Lab., Schenectady, N. Y.
ELECTROWINNING OF URANIUM FROM ITS OXIDES. II. A PRELIMINARY ENGINEERING EVALUATION. L. W. Niedrach and A. C. Schafer. Apr. 3, 1957. 32p. Contract W-31-109-Eng-52. $0.25(OTS).

A preliminary estimate was made of the cost of reducing $UO_3$ to metal by an electro-reduction method similar to the Hall process for Al. Based upon a production rate of 10 tons of metal per day operating costs of $0.332/lb of U were found. Amortization of plant facilities in five years will add $0.195/lb to this cost. If a 25% profit before taxes is desired an additional $0.129 must be added. The total plant investment is $7,850,000. (auth)

**12317** BMI-1088(Del.)
Battelle Memorial Inst., Columbus, Ohio.
PROGRESS RELATING TO CIVILIAN APPLICATIONS DURING APRIL 1956. Russell W. Dayton and Clyde R. Tipton, Jr. May 1, 1956. Decl. with deletions Feb. 13, 1957. 82p. Contract W-7405-eng-92. $12.30(ph OTS); $4.50(mf OTS).

Development of Materials for Hanford Reactors. Hot-hardness and grain size studies of U–Al and U–Zr alloys for slugs are reported. Other studies on the creep properties of annealed and cold-worked Zircaloy-2 and cladding with Zr are described. Developments for Al-Clad Fuel Elements. Inclusions in and mechanical properties of dingot-U tubes were investigated. Plant Assistance to MCW. The studies reported are: comparison of thermal activities of $UO_3$ from three sources; decomposition of $UO_3$ in air; electrical conductivity of $UO_2$; and corrosion of Ti and stainless steel. Development of a salt bath for U heat treatment continued. General Fuel Element Development. The bend strength and crystal size of sintered BeO compacts was studied along with surface areas of $Be(OH)_2$ vs. density of BeO made from it. The mechanical properties of U–Cr and U–Cr–Mo and the hardness of fissium alloys were investigated. Studies of Zr–U Alloys. The corrosion, radiation stability and heat treatment of Zr–U alloys were investigated. Corrosion Studies of Zr. The mechanism of corrosion of Zr is discussed, and a comparison of the reaction rates of $H_2$ and $H_2O$ vapor with several Zr alloys at 400°C was made. Reactor Materials Development. The investigations reported are: Zr heat treatment; and kinetics of the Zr–$UO_2$ reaction. Physical Metallurgy. Studies were made of the quenching and aging of U–Ti alloys, air-oxidation rates for Nb alloys, and uranium reactions with hydrogen. Developmental Studies for the PWR. Some emissivity measurements on Zircaloy-2 and reaction rates of Zircaloy-2 with steam are given. Data from corrosion tests of $UO_2$ fuel element bodies in 750°F steam and from thermal fracture tests of $UO_2$–BeO bodies are presented and discussed. (T.R.H.)

# URANIUM 1.43

## $UO_2$ 1.43.07.03

OXIDATION OF URANOSIC OXIDE TO URANIUM TRIOXIDE WITH NITRIC ACID VAPOR. Edward R. Flook, et al (to U. S. Atomic Energy Commission). U. S. Patent 2,735,745, February 21, 1956.

Uranosic oxide ($U_3O_8$) is oxidized to $UO_3$ by heating uranosic oxide at a temperature between 400 to 500°C in the presence of $HNO_3$ vapor for a suitable period of time and then cooling the reactants to below 400°C while maintaining $HNO_3$ vapor in the system until the reactants are cooled below 400°C. (auth)

**501**

A CUBIC FORM OF URANIUM TRIOXIDE. E. Wait (Atomic Energy Research Establishment, Harwell, Berks, England). J. Inorg. and Nuclear Chem. 1, 309-12(1955) Oct.

The crystal structure of a uranium oxide phase of composition $UO_{2.82}$ has been determined by x-ray-powder-diffraction techniques using a Guinier-type focusing camera. The unit cell is cubic with a = 4.138 ± 0.005 kX. A uranium atom is located at (000) and oxygens at (½00), (0½0), and (00½) with some anion vacancies. The compound is isostructural with $ReO_3$. The U–O bond length is 2.073 A. (auth)

**12437** WAPD-PMM-197

Westinghouse Electric Corp. Atomic Power Div., Pittsburgh.

RESUME' OF URANIUM OXIDE DATA–III. Z. M. Shapiro. Sept. 19, 1955. Decl. Mar. 5, 1957. 57p. $13.80(ph OTS); $4.80(mf OTS).

Investigations into preparation and properties of $UO_2$ powders are summarized. Preparation methods discussed included: $H_2$ reduction of $UO_3$, $UH_3$ methods, and precipitation. Sintering and fabrication of $UO_2$ were studied along with chemical properties, physical properties, radiation effects, and mechanical properties. Appendices are included on surface area and density measurements on $UO_2$ powders and microscopy of $UO_2$ powders. (T.R.H.)

**6309** AERE-C/R-1703

Gt. Brit. Atomic Energy Research Establishment, Harwell, Berks, England.

SOME ASPECTS OF THE SYSTEM $UO_3$–$H_2O$. J. K. Dawson, E. Wait, K. Alcock, and D. R. Chilton. Sept. 14, 1955. Decl. Jan. 21, 1957. 28p. (RCTC/P-52).

Uranium trioxide in contact with water at about 180°C gives an orthorhombic hydrate, $UO_3$, 0.8 $H_2O$, with the cell dimensions a = 10.23 ± 0.01 A, b = 6.89 ± 0.01 A, c = 4.28 ± 0.01 A. These dimensions appear to vary slightly with deviation of the $H_2O$ content from 0.8 mole per U atom. Between 200 to 280°C another phase appears, $UO_3$, 1.0 $H_2O$, also orthorhombic with cell dimensions a = 5.638 ± 0.005 A, b = 6.273 ± 0.005 A, c = 9.925 ± 0.005 A, space group Pbca. The hemi-hydrate, $UO_3$, 0.5 $H_2O$, is stable in water above 280°C. A further phase, probably triclinic, was observed when the $UO_3$ was heated in water at 230°C in contact with glass, probably due to a relatively high pH. Some of the properties of these hydrates are described, together with observations on the preparation of pure anhydrous $UO_3$ from $UO_2(NO_3)_2$. Possible applications of aqueous slurries of $UO_3$ hydrate to homogeneous reactors are discussed. (auth)

# URANIUM 1.43

## $UO_3$ 1.43.07.03

**13087** KAPL-1380(Del.)
Knolls Atomic Power Lab., Schenectady, N. Y.
PREPARATION OF SPHERICAL URANIUM POWDER BY REDUCTION OF URANIUM TRIOXIDE WITH CALCIUM. A. P. Beard and F. K. Heumann. July 22, 1955. Decl. with deletions Feb. 25, 1957. 39p. Contract W-31-109-eng-52. $0.40(OTS).

The reduction of $UO_3$ with Ca metal in a bomb, at elevated temperatures, provides an excellent method for making spherical U particles. The yields of metal are high (90 to 95%) and ~50% of the pellets are larger than 325 mesh (43 microns). Spherical U particles are of interest for use in a long-lived fuel element, consisting of such particles dispersed homogeneously in a matrix of a ductile, nonfissionable metal or alloy. (auth)

**13026** CF-54-6-60
Oak Ridge National Lab., Tenn.
DENITRATION OF URANYL NITRATE HYDRATE. J. E. Moore. June 9, 1954. ~~Decl. Apr. 2, 1957~~. 5p. Contract [W-7405-eng-26]. $1.80(ph OTS); $1.80(mf OTS).

The possibility of using spray calciners and moving-bed shaft reactors for $UO_2(NO_3)_2$ denitration to produce $UO_3$ has been investigated. Both methods appear feasible, but further developmental work is necessary. (D.E.B.)

**9675** HW-26531
Hanford Works, Richland, Wash.
PRODUCTION OF $UO_3$ BY CALCINATION OF URANYL PEROXIDE. R. L. Moore and R. A. Watts, Jr. Dec. 10, 1952. ~~Decl. Feb. 28, 1957~~. 3p. Contract [W-31-109-Eng-52]. $1.80(ph OTS); $1.80(mf OTS).

**13701** NYO-1466
Harshaw Chemical Co., Cleveland.
THE REACTIVITY OF URANIUM OXIDES DECEMBER 31, 1951. Karl S. Willson. Feb. 15, 1952. ~~Decl. Feb. 27, 1957~~. 22p. Contract W-7405-eng-276. $0.35(OTS).

The occasional poor conversions in the reduction of $UO_3$ to $UO_2$ and the hydrofluorination of $UO_2$ to $UF_4$ was studied. Results of experiments indicate that this variable chemical activity may be due in part to different crystalline forms of $UO_3$ as a result of variations in the denitrating operation. (M.H.R.)

**9752** AECD-4006
Tennessee Eastman Corp., Oak Ridge, Tenn.
THE REDUCTION OF URANIUM TRIOXIDE BY ETHYL ALCOHOL. B. M. Haines and V. P. Calkins. Nov. 18, 1946. Decl. Jan. 5, 1956. 15p. Contract W-7401-eng-23. (H-8.385.9). $3.30(ph OTS); $2.40(mf OTS).

The effect of temperature upon the rate of reduction of $UO_3$ by ethyl alcohol was investigated, and a comparison of the reactivity of the dioxide produced at various temperatures was made. The per cent of C in the end product has been studied with respect to both temperature of reduction and length of exposure to alcohol. Optimum conditions for the reduction have been suggested. (auth)

**12433** NYO-5189
Mallinckrodt Chemical Works, St. Louis.
THE LOSS ON IGNITION TEST FOR PURIFIED URANIUM TRIOXIDE. R. W. Bragdon, C. L. French, and G. L. Martin. July 1946. Decl. Mar. 16, 1957. 13p. $3.30(ph OTS); $2.40(mf OTS).

The difficulty experienced in obtaining satisfactory agreement of loss on ignition results between plant batches and finished lots of $UO_3$ was attributed to the hygroscopicity of the sample. The loss on ignition test for uranium trioxide was investigated, and it was found that the temperature of the ignition (250°C) was too low to drive off all the nitrate and water. A graph of temperature vs. loss on ignition was made, and several other temperature ranges were considered. An ignition at 525°C seemed promising but gave low results. The low results may be caused by failure to bring the samples to constant weight and may in small part be due to residual nitrate content. An ignition at 800°C for twenty minutes, which converts the sample to $U_3O_8$, was found to be the best method of analysis for loss on ignition of $UO_3$. A limit of 1.8% loss on ignition (basis of U metal) for the 800°C test is recommended as best correlating with the limit of 0.3% for the previous test at 250°C. (auth)

# URANIUM 1.43

## $UO_3$ 1.43.07.03

**13034** MCW-7
Mallinckrodt Chemical Works, St. Louis.
REDUCTION OF URANIUM TRIOXIDE TO THE DIOXIDE WITH VARIOUS GASES. R. W. Shearer. Apr. 1, 1946. Decl. Feb. 26, 1957. 47p. Contract W-7405-eng-1. $0.45(OTS).

A study of five gases as reducing agents in the reduction of $UO_3$ to $UO_2$ indicated that general conditions for use included a high temperature (about 1500°F) and about a 100% excess of gas flowing over the trioxide in a properly designed furnace box. Cracked ammonia gas was the most economical, most readily available, and most easily usable of the gases considered. Hydrogen was efficient but more costly than cracked ammonia. Hydrogen gas saturated with water vapor could be used. Anhydrous ammonia gas was required in greater quantity than cracked ammonia. Artificial and natural gas reduced the $UO_3$, but heavy deposits of carbon were formed which might flake and contaminate the product. (J.E.D.)

## $UO_4$ 1.43.07.04

**20929**
EVIDENCE FOR THE EXISTENCE OF PEROXYURANIC ACID. R. E. DeMarco, D. E. Richards, T. J. Collopy, and R. C. Abbott (National Lead Co. of Ohio, Cincinnati). J. Am. Chem. Soc. 81, 4167-9(1959) Aug. 20.

Uranium trioxide was treated with aqueous hydrogen peroxide to form a hydrated uranium peroxide compound identical to that precipitated from aqueous uranyl nitrate solution by the addition of hydrogen peroxide. The stoichiometric compound, $UO_4 \cdot 2H_2O$, was shown to react with alcoholic potassium hydroxide to form hydrated monobasic ($KHUO_5 \cdot xH_2O$) and dibasic ($K_2UO_5 \cdot xH_2O$) potassium salts. A hydrated peroxyuranic acid structure ($H_2UO_5 \cdot H_2O$) was concluded to best represent a compound of the stoichiometry $UO_4 \cdot 2H_2O$. This structure was supported by the infrared absorption spectrum and reactions with a strong base of the uranium peroxide compound. (auth)

**13872**
A STUDY OF PRECIPITATION OF HEXAVALENT URANIUM HYDROXIDE. S. A. Brusilovskii (Inst. of Geology, Petrography, Mineralogy, and Geochemistry, Academy of Sciences, USSR). Doklady Akad. Nauk S.S.S.R. 120, 305-8(1958) May 11. (In Russian)

Conditions for the precipitation of hexavalent uranium hydroxide were studied, and the relation between the pH magnitudes at which the precipitation of the hydroxide begins and initial solubility and concentration of metal ions in the solution was determined. The curves of potentiometric titration of $UO_2(ClO_4)_2$ with sodium hydroxide were plotted. (R.V.J.)

THE THERMAL DECOMPOSITION OF URANIUM PEROXIDE, $UO_4 \cdot 2H_2O$. James E. Boggs and Munzier El-Chehabi (Univ. of Texas, Austin). J. Am. Chem. Soc. 79, 4258-60(1957) Aug. 20.

$UO_4 \cdot 2H_2O$ decomposes slowly in the temperature range 90 to 195° to form a different peroxide, $U_2O_7$. The rate of this reaction has been followed and the properties of $U_2O_7$, which has not been isolated previously, have been investigated. (auth)

METHOD FOR IMPROVED PRECIPITATION OF URANIUM PEROXIDE. A. J. Miller, B. M. Pitt and P. F. Grieger (to U. S. Atomic Energy Commission). U. S. Patent 2,780,515. February 5, 1957.

An improved method for the recovery of $UO_4$ from dilute aqueous solutions containing Fe is presented. The presence of $Fe^{3+}$ in such solutions makes difficult the precipitation of $UO_4$ with $H_2O_2$. The $Fe^{3+}$ catalytically decomposes the $H_2O_2$ precipitant, and also co-precipitates with the U, thus affecting the products' purity. The addition of malonate ion to the solutions, before the precipitation step, complexes the $Fe^{3+}$ and prevents its decomposing the $H_2O_2$ and its precipitation with the U. The malonate is added as malonic acid and the pH of the solution is maintained between 1 and 3. (auth)

# URANIUM 1.43

## $UO_4$ 1.43.07.04

**3223**
PURIFICATION OF URANIUM PEROXIDE. Clarence L. Richardson et al (to U. S. Atomic Energy Commission). U. S. Patent 2,764,470. Sept. 25, 1956.

Uranium peroxide, as manufactured, sometimes contains objectionable amounts of fluoride impurities. This fluoride may be removed by agitating the $UO_4$ with aqueous $HNO_3$ or $H_2SO_4$ of controlled concentration, the acid dissolving most of the fluoride and but little of the $UO_4$. An acid solution having a pH of from 0.1 to 2.0 may be employed, the more concentrated solutions in this range effecting a greater degree of purification and a greater dissolution of the $UO_4$. Recovery of the small amount of $UO_4$ dissolved in this manner, may be made by neutralizing the acid leach solution with alkali, thus causing precipitation of the $UO_4$. This material is, of course, contaminated with fluorides and may be added to the feed for the first, or fluoride removing, step. (auth)

**1768** AEC-tr-2361
A CONTRIBUTION TO THE STUDY OF THE PEROXIDES OF URANIUM AND MOLYBDENUM. Gabriel Tridot. Translated from Ann. chim. (Paris) 12, 225-54(1955). 36p.

This report is a thesis submitted to Univ. of Paris.

Infrared spectra of uranyl salts and hydrated oxides of $U^{6+}$ are reported. The formation and chemical properties of uranyl peruranate, $(UO_2)_2UO_6$, are described. (C.W.H.)

**13689** A-2576
Du Pont de Nemours (E. L) & Co. Jackson Lab., Wilmington, Del.
CHAMBERS WORKS PROCESS FOR THE MANUFACTURE OF PERURANIC ACID. G. M. Richardson. Nov. 15, 1944. Decl. Mar. 18, 1957. 7p. (BP-13). $1.80(ph OTS); $1.80 (mf OTS).

Directions are given for precipitating peruranic acid by means of hydrogen peroxide from uranyl sulfate solutions which have been clarified by filtration. (F.S.)

## $U_3O_8$ 1.43.07.05

**3556** AECU-3924
Michigan. Univ., Ann Arbor and Oslo. Univ.
LOW TEMPERATURE HEAT CAPACITY AND THERMODYNAMIC FUNCTIONS OF TRIURANIUM OCTOXIDE. Edgar F. Westrum, Jr. and Fredrik Grønvold. [1958]. 16p. $3.30(ph OTS); $2.40(mf OTS).

The heat capacity of $U_3O_8$ was measured over the range 5 to 350°K. In addition, the enthalpy, entropy, and free energy increments were computed by numerical integration, using graphically interpolated values of heat capacity. The heat capacity determinations are listed in tables and the heat capacity versus temperature values are presented graphically. (J.R.D.)

**14739** A/CONF.15/P/1548
Argonne National Lab., Lemont, Ill.
THE URANIUM-OXYGEN SYSTEM: $U_3O_8$ TO $UO_3$. Henry R. Hoekstra and Stanley Siegel. 8p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Results of investigations on the uranium-oxygen system and on several related binary oxide systems are presented. A survey of recent publications is included in order to present a complete picture of current work in this field. Studies of the structure of $U_4O_9$ indicate that the oxide may not crystallize in the simple fluorite lattice which has been generally accepted for this compound. The $U_3O_8$ phase has a relatively narrow composition range below which it converts to a larger orthorhombic cell whose composition range extends from $UO_{2.56}$ to $UO_{2.65}$. The preparation and some properties of four crystalline modifications of $UO_3$ are described as well as methods for interconversion of structural types. Studies of $UO_3$ hydrates under various conditions of temperature and pressure are included. Alkali metal uranate systems were investigated at elevated temperatures, and their methods of preparation are described. The preparation of zinc and lead uranates and their thermal stability are discussed. (J.E.D.)

# URANIUM 1.43

## $U_3O_8$ 1.43.07.05

**16856**

THE STRUCTURE OF $U_3O_8$ DETERMINED BY NEUTRON DIFFRACTION. Arne F. Andresen (Joint Establishment for Nuclear Energy Research, Kjeller, Norway). Acta Cryst. 11, 612-14(1958) Sept.

Neutron diffraction diagrams of the orthorhombic form of $U_3O_8$ show that the structure previously assumed on the basis of x-ray data must be in error. A modified unit cell is derived in which two of the uranium atoms are surrounded by a distorted octahedron of six oxygen atoms at distances of $U_1-O_2$ = 2.07 A and $U_1-O_4$ = 2.18 A. The other four are surrounded by seven oxygen atoms at distances $U_2-O_3$ = 2.07 A, $U_2-O_1$ = 2.21 A, $U_2-O_4'$ = 2.17 A, and $U_2-O_4''$ = 2.42 A. The symmetry conforms with the orthorhombic space group $D_2^8-C222$. (auth)

INVESTIGATIONS ON THE $U_3O_8$-$ZrO_2$-$O_2$ AND $U_3O_8$-$TiO_2$-$O_2$ SYSTEMS BY THE EMANATION METHOD. Presented at the International Conference on Radioisotopes in Scientific Research Sept. 9-20, 1957 at Paris. No. UNESCO/NS/RIC/198. G. Wolf, L. Ochs, and F. Strassman. London, Pergamon Press, Ltd., 1957. 10p.

RdTh is incorporated into $U_3O_8$, $ZrO_2$, and $TiO_2$ after which the individual components or the mixtures of $U_3O_8-ZrO_2$, and $U_3O_8-TiO_2$ are slowly heated to 1400°C in an oxygen stream. The escaping thoron is fed through an ionization chamber where the activity is continuously measured in a vibrating reed electrometer and registered on an automatic recorder. The heated mixtures are examined by x-ray methods in order to verify a reaction between the components. In both systems the emanation curves of the components were altered. In the $U_3O_8-TiO_2$ system both chemical and x-ray methods showed the formation of a compound $TiO_2 \cdot UO_3$. However in the system $U_3O_8-ZrO_2$ no change in the x-ray pattern could be noticed. Therefore the study of emanation curves seems to be a sensitive method for verification of reactions in the solid state. (auth)

**2047**

HIGH-TEMPERATURE X-RAY STUDY OF URANIUM OXIDES IN THE $UO_2-U_3O_8$ REGION. Fredrik Grønvold (Universitetet i Oslo, Blindern, Norway). J. Inorg. and Nuclear Chem. 1, 357-70(1955) Dec.

Uranium oxides in the $UO_2-U_3O_8$ range have been studied by the x-ray powder method at temperatures between 20 and 969°C after annealing at 1000°C. The following phases were found: $UO_{2+x}$ with no detectable range of homogeneity at room temperature, $UO_{2.25}$ or $U_4O_9$ with a narrow range, and $U_3O_{8-x}$ with a range between $UO_{2.62}$ and $UO_{2.667}$. (auth)

Refer also to abstract 2074.

**13068** AERE-M/R-632

Gt. Brit. Atomic Energy Research Establishment, Harwell, Berks, England.

DIFFERENTIAL THERMAL ANALYSIS OF THE URANIUM OXIDES. P. Murray and R. W. Thackray. Jan. 1951. Decl. July 24, 1958. 15p.

Characteristic exothermic peaks related to the chemical and phase changes occurring on oxidation of $UO_2$ are obtained by differential thermal analysis. From these curves, quantitative estimation of $UO_2$ in oxide mixtures is possible. The shapes of the peaks confirm the conclusions of Anderson and Alberman that the initial oxidation from $UO_2$ to $UO_{2.3}$ is diffusion-controlled, whereas nucleation via the breakdown of $UO_{2.3}$ into $UO_2$ and $U_3O_8$ is the rate determining step in the main oxidation to $U_3O_8$. It is suggested that the large volume change arising from the breakdown of $UO_{2.3}$ results in the disruption of the matrix and the exposure of fresh surfaces, thus allowing wing rapid oxidation of the $UO_2$ to $U_3O_8$. It is found that non-stoichiometric oxides in the range $UO_2-U_3O_8$ are more susceptible to oxidation than Mallinckrodt $UO_2$. This is attributed to the presence of spatial imperfections or lattice defects arising from the interstitial incorporation into the lattice of oxygen atoms in excess of the stoichiometric composition $UO_2$. (auth)

# URANIUM 1.43

## $U_3O_8$ 1.43.07.05

**6406** ✓ A/CONF.15/P/2099
K RESHENIYU STRUKTURY $U_3O_8$. (A Contribution to The Solution of the Structure of $U_3O_8$). B. Chodura and J. Malý (Czechoslovakja). 23p.

The structure of $U_3O_8$ is discussed. Three cells alternate in the structure of $U_3O_8$—one orthorhombic and two monocline ones, which are close to being orthorhombic, as was determined by the x-ray method for a rotating monocrystal. This arrangement explains also the superstructure with a three-fold parameter a = 11.90 kX, which was found on all photographs taken around axes a, b and c. A slight double periodicity in the direction of axis c (c = 8.27 kX) was observed on the photographs taken around axis c. A probable explanation of the structure is given and the most probable group is derived. (auth)

## $U_4O_9$ 1.43.07.06

**10506** NP-6722
[Westinghouse Electric Corp. Research Labs., East Pittsburgh, Penna.]
OXYGEN DISSOCIATION PRESSURES OVER URANIUM OXIDES. Scientific Paper 100FF942-P1. P. E. Blackburn. Jan. 15, 1957. 31p.

Oxygen dissociation pressures over the uranium oxides, $UO_{2.0}$ to $UO_{2.6}$, were measured between 950 and 1150°C by the Knudsen effusion method. In this temperature and composition range there are three stable uranium oxides: $UO_2$ in which the solubility of oxygen increases with temperature, $U_4O_9$ which exists up to 1167°C with a narrow homogeneity range, and $U_5O_{13}$ in which oxygen dissolves. A phase diagram of the uranium–oxygen system was constructed, thermodynamic values were derived and the accommodation coefficient of oxygen on $U_4O_9$ was estimated to be 0.027. (auth)

**10120** ANL-5603
Argonne National Lab., Lemont, Ill.
THE HEAT CAPACITY AND THERMODYNAMIC FUNCTIONS OF TETRAURANIUM NONOXIDE FROM 5 TO 310°K. Darrell W. Osborne, Edgar F. Westrum, Jr., and Harold R. Lohr. Aug. 1956. 6p. Contract W-31-109-eng-38. $0.15(OTS).

The heat capacity of $U_4O_9$ was measured from 5 to 310°K; from these data the entropy, enthalpy, and free energy function were calculated. At 298.16°K, the values of Cp, $S^\circ$, $(H^\circ - H_0^\circ)/T$, and $(F^\circ - H_0^\circ)/T$ are 70.11 ± 0.07, 80.29 ± 0.08, 40.69 ± 0.04, and 39.60 ± 0.04 cal $deg^{-1}$ $mole^{-1}$, respectively. In contrast to the behavior of $UO_2$, there is no anomaly in the heat capacity of $U_4O_9$ in the temperature range investigated. (auth)

**7765** WAPD-BT-10(p.96-100)
Westinghouse Electric Corp. Bettis Plant, Pittsburgh.
DENSITIES OF URANIUM OXIDE IN THE REGION $UO_2$–$U_4O_9$. J. C. Clayton and S. Aronson. p.96-100 [of] BETTIS TECHNICAL REVIEW. REACTOR METALLURGY. 5p.

Mallinckrodt PWR Core 1 $UO_2$ powder samples were oxidized to various compositions up to $U_4O_9$ and were homogenized at temperatures of 200, 350, and 700°C. X-ray diffraction and density measurements were made. The $U_4O_9$ phase did not appear in samples of composition lower than $UO_{2.10}$; the density increased linearly with degree of oxidation. (auth)

# XENON 1.44

**18206** AECU-4247
Los Alamos Scientific Lab. N. Mex.
STATE PROPERTIES OF LIQUID AND SOLID XENON: A BIBLIOGRAPHY. Soliska R. Harris and Helen S. Stearns, comps. Oct. 17, 1957. 14p. Contract [W-7405-eng-36]. (D-BIB-14). $3.30(ph), $2.40(mf) OTS.

This bibliography consists of 59 references covering a period from 1926 to Sept. 1957. The sources consulted were Chemical Abstracts, Nuclear Science Abstracts, and Los Alamos Report Library Subject Catalog. The bibliography is arranged alphabetically by author. (J.E.D.)

**13637**
THE DIFFUSION OF FISSION XENON IN URANIUM OXIDE. Fred Felix (Institut für Kernforschung, Berlin). Nukleonik 1, 66-7(1958) July. (In German)

Measurements were made of the diffusion of fission xenon in uranium oxide in the form of thin layers, powders, and tablets. The preparations were irradiated in a neutron flux of approximately $10^{11}$ neutrons/cm$^2$ sec for various lengths of time. The xenon content of the oxide samples was determined as a function of temperature. It was shown that the xenon is independent of the sample form and quite dependent on the temperature. (J.S.R.)

**9679**
THE SOLUBILITY OF XENON IN SOME HYDROCARBONS. H. Lawrence Clever (Duke Univ., Durham, N. C.). J. Phys. Chem. 62, 375-6(1958) Mar.

The solubility of xenon has been determined at a total pressure of one atmosphere and temperature of 16, 25, 34.5, and 43°C in benzene, cyclohexane, n-hexane, isooctane, and n-dodecane. (auth)

**13494** WAPD-RM-182(Del.)
Westinghouse Electric Corp. Atomic Power Div., Pittsburgh.
XENON AND SAMARIUM CONCENTRATIONS PRODUCED BY VARIOUS FLUX PROGRAMS. H. J. Kirk. June 1953. Decl. with deletions Mar. 7, 1957. 70p. Contract AT-11-1-GEN-14. $12.30(ph OTS); $4.50(mf OTS).

The effect of time variations of the flux on the $Xe^{135}$ and $Sm^{149}$ concentrations in a reactor is discussed in this paper. The large increase in poison concentration following a reduction of flux is given as a function of time for various initial and final values of the flux. Graphs are provided from which the maximum xenon and samarium concentrations following a reduction of flux from any initial to any final value can be determined. For the special case of reduction to zero flux the effect of various initial conditions on the resulting xenon concentration is shown as a function of time. The reactivity required for criticality is given as a function of xenon concentration, samarium concentration, and reactor constants. Also, the effect of the spacial dependence of poison concentration on reactivity calculations is briefly discussed. The problem of maintaining criticality during the shutdown of a reactor which cannot override maximum poison concentration is investigated. The poison concentration produced by periodic time variations in the flux is determined as a function of time for various frequencies and amplitudes of oscillation. Also, the variation in poison concentration produced by an arbitrary flux problem is discussed briefly. Appendix I enables solution of the more general problem, that of xenon and samarium buildup from arbitrary initial concentrations. Appendix II discusses the problem of the time variations of poison concentrations produced by an increase of the flux level. (auth)

**12050**
THE RATIO OF XENON TO KRYPTON IN $U^{235}$ FISSION. A. T. Blades, W. H. Fleming, and H. G. Thode (McMaster Univ., Hamilton, Ont., Canada). Can. J. Chem. 34, 233-7 (1956) Mar.

The ratio of the yield of $Kr^{86}$ to the yield of $Xe^{134}$ in $U^{235}$ fission is 0.257 ± .005 determined by isotope dilution techniques. The corresponding yield ratio of total xenon to total krypton in the thermal neutron fission of $U^{235}$ is 5.52 ± .10. (auth)

THE RELATIVE YIELDS OF THE ISOTOPES OF XENON IN PLUTONIUM FISSION. W. H. Fleming and H. G. Thode (McMaster Univ., Hamilton, Ont., Canada). Can. J. Chem. 34, 193-200(1956) Mar.

The relative fission yields of 5 isotopes of Xe in $Pu^{239}$ fission have been determined. Fine structure, similar to that observed in $U^{238}$ fission but smaller, occurs in Pu fission in the xenon mass range. The yield of the 133 mass chain has been determined at xenon in order to permit the normalization of the relative xenon yields to the relative cesium yields. (auth)

# XENON 1.44

11453 ✓

IONIZATION FOLLOWING INTERNAL CONVERSION IN XENON. Frances Pleasonton and A. H. Snell (Oak Ridge National Lab., Tenn.). Proc. Roy. Soc. (London) A241, 141-52(1957) Aug. 7.

The predominant internal conversion accompanying the decay of 12-day $Xe^{131m}$ from its metastable nuclear level to its stable ground state usually leaves the atoms in states of high multiple ionization, even though only a single primary electron vacancy is created in the initial process. The differential charge spectrum of the ions has been measured by the methods of magnetic analysis. Only 0.62 ± 0.08% of the decays leave the atom singly charged. The most probable state of ionization is 8, following 21.06 ± 0.21% of the nuclear transitions, and corresponding to the depopulation of the outer electron shell. Thereafter the probability of occurrence decreases toward the higher charges, twenty electrons being thrown off in 0.003 ± 0.002% of the decays, which presently is about as far as the sensitivity of the spectrometer carries the spectrum. The mechanism of this multiple ionization is discussed in terms of successive Auger events. An analysis of the intensity of the singly charged ions in particular suggests that they result predominantly from a combination of direct internal conversion in the outer shell of the atom and of K-shell conversion followed by the (1s–5p) x-ray transition. The upper limit thereby set for the 5p shell conversion coefficient is 0.28, and the upper limit for the intensity of the (1s–5p) line is 0.011 in a total K-series intensity of 1. (auth)

ON THE DECAY OF XENON 133. S. Jha, H. G. Devare, M. Narayana Rao, and R. M. Singru (Tata Inst. of Fundamental Research, Bombay). Nuovo cimento (10) 11, 788-92(1959) Mar. 16.

The $\gamma$-rays from $Xe^{133}$ were studied in a scintillation spectrometer. The $\gamma$-rays have the energy of 80, 160, 300, and 380 kev with the relative intensity 1, $1.4 \cdot 10^{-2}$, $8.4 \cdot 10^{-4}$, and $4.3 \cdot 10^{-4}$. By studying the 80 kev $\gamma$-rays in coincidence, the relative intensity of the cascade and the cross-over transition from the 160 kev state was found. Taking this into account, the log ft values for the $\beta$-transition to the 80, 160, and 380 kev states were calculated to be 5.6, 7, and 5.7, respectively. (auth)

RADIATIONS OF $Xe^{127}$. R. N. Forrest and H. T. Easterday (Univ. of Oregon, Eugene). Phys. Rev. 112, 950-4(1958) Nov. 1.

The radiations of $Xe^{127}$ were examined. The energies of previously observed gamma rays were found to be 58 ± 1, 146 ± 0.5, 173.0 ± 0.5, 204.5 ± 0.5, and 377.5 ± 0.5 kev. Conversion electron intensities relative to gamma-ray intensities and internal conversion coefficients were measured. The experiment indicates that electron capture to the ground state is suppressed. Spin and parity assignments are proposed for the 204- and 377-kev excited states of $I^{127}$. (auth)

CHARGE SPECTROMETRY FOR $Xe^{133}$-$Cs^{133}$. Arthur H. Snell and Frances Pleasonton (Oak Ridge National Lab., Tenn.). Phys. Rev. 111, 1338-43(1958) Sept. 1.

The distribution in charge of the product atoms of the radioactive decay $Xe^{133}$-$Cs^{133}$ was examined under magnetic analysis. The relative intensities are found to be as follows, expressed in percent of the decay events, and going, respectively, from charge 1 through charge 23: 34.1, 3.74, 2.27, 2.15, 2.99, 4.27, 6.14, 9.5, 12.3, 9.0, 6.06, 3.32, 1.76, 1.06, 0.66, 0.32, 0.13, 0.050, 0.014, 0.0075, 0.0027, 0.0013, and 0.0005. In interpreting this charge spectrum, the initial part (charges 1 through 4) is attributed mainly to atoms that escape internal conversion, and the subsequent rise to a maximum at charge 9 and decrease to charge 23 is attributed to atoms that suffer internal conversion. The ratio of the intensities of the two parts of the distribution gives a total internal conversion coefficient for the K, L, and M shells of 1.4, in rough agreement with work of others. Comparison is made with the charge spectrum arising from internal conversion in $Xe^{131m}$-$Xe^{131}$, which had previously been measured in the same apparatus. From the low-charge end of the spectrum, the probabilities of electron loss as a result of the beta decay alone are derived as follows: no-electron loss, 0.8; 1-electron loss, 0.08; 2-electron loss, 0.04; 3-electron loss, 0.03. The high-charge side of the spectrum shows a shallow dip in the region of charges 12, 13, and 14, and beyond that point there is relatively more intensity in $Xe^{133}$-$Cs^{133}$ than there is in $Xe^{133m}$-$Xe^{131}$ The difference in shape probably results both from the higher K/(L + M) conversion ratio of $Xe^{133}$-$Cs^{133}$ as compared with $Xe^{131m}$-$Xe^{131}$, and from the fact that the beta emission in $Xe^{133}$-$Cs^{133}$ introduces electron loss by shake-off. The dip at charges 12, 13, and 14 suggests an underlying structure in the total distribution, comprising subspectra associated with the individual electron shells in which the vacancy cascades originate. (auth)

# YTTRIUM 1.45

SOLUBILITY OF YTTRIUM OXALATE. A. M. Feibush, Keith Rowley, and Louis Gordon (Brookhaven National Lab., Upton, N. Y. and Syracuse Univ., N. Y.). Anal. Chem. 30, 1610-12(1958) Oct.

The solubility product of yttrium oxalate and the dissociation constants of the yttrium oxalate complexes have been measured by the method developed by Crouthamel and Martin. The solubility product was determined to be $5.34 \times 10^{-29}$. The complex ions detected were: $Y(C_2O_4)^+$, $K_1 \cong 3 \times 10^{-7}$; $Y(C_2O_4)_2^-$, $K_2 \cong 8 \times 10^{-11}$; and $Y(C_2O_4)_3^{---}$, $K_3 \cong 3.4 \times 10^{-12}$. (auth)

**13808**

THE APPLICATION OF ION EXCHANGE IN THE INVESTIGATION OF THE STATE OF THE SUBSTANCE IN SOLUTION. IV. THE INVESTIGATION OF THE COMPLEX-FORMATION OF YTTRIUM WITH LACTIC ACID BY MEANS OF THE METHOD OF "ABSORPTION-CURVES." V. I. Paramonova, A. N. Mosevich, and A. I. Subbotina. Zhur. Neorg. Khim. 3, 88-94(1958). (In Russian)

The formation of yttrium complexes with lactic acids was studied by adsorption of the complex on cation resins. A tracer technique was used. (J.S.R.)

THE HEAT OF COMBUSTION OF YTTRIUM. Elmer J. Huber, Jr., Earl L. Head, and Charles E. Holley, Jr. (Los Alamos Scientific Lab., N. Mex.). J. Phys. Chem. 61, 497-8(1957) Apr.

**1780**

THE CRYSTAL STRUCTURE OF YTTRIUM NITRIDE. Charles P. Kempter, N. H. Krikorian, and Joseph C. McGuire (Los Alamos Scientific Lab., N. Mex.). J. Phys. Chem. 61, 1237-8(1957).

Yttrium nitride was prepared by converting Y metal to $YH_2$ and then to YN. The polycrystalline YN was examined by x-ray diffraction, using both photographic and diffractometric methods. Yttrium nitride has space group $O_h^5$-Fm3m (NaCl structure-type) and 4 (YN) per unit cell. The lattice constant is 4.877 ± 0.006 A at 23°, and the calculated density is 5.89 ± 0.02 g/cm$^3$ at 23°; the pycnometric density was found to be 5.60 ± 0.05 g/cm$^3$ at 20°. The melting point of YN is ≥2670° in the presence of one atmosphere of N. (auth)

**2262**

THE THERMAL DECOMPOSITION OF YTTRIUM, SCANDIUM, AND SOME RARE-EARTH CHLORIDE HYDRATES Wesley W. Wendlandt (Texas Tech. Coll., Lubbock). J. Inorg. and Nuclear Chem. 5, 118-22(1957).

The thermal decomposition of Y, Sc, La, Ce, Pr, Nd, Sm, and Gd chloride hydrates was studied on the thermobalance. The salts began to lose water of hydration in the 55 to 110°C temperature range. Horizontal weight levels were found in the decomposition curves which corresponded to the 1-hydrate, metal oxychloride, and in some cases the metal oxide. The thermal decomposition product, in all cases except scandium and cerium, was the metal oxychloride. The minimum temperature limits for the metal oxychlorides ranged from 445 to 680°C. (auth)

**10075** ISC-744

Ames Lab., Ames, Iowa.

PREPARATION OF YTTRIUM METAL BY REDUCTION OI YTTERIUM TRIFLUORIDE WITH CALCIUM. O. N. Carlson, F. A. Schmidt, and F. H. Spedding. July 17, 1956. 22p. Contract W-7405-eng-82. $0.25(OTS).

The preparation of Y metal by the reduction of $YF_3$ with Ca is described. Alternate methods employing the formation of low melting Y–Zn or Y–Mg intermediate alloy are evaluated and data on chemical and microscopic purity of the resulting metal are presented. (auth)

**8429**

NEW BORIDES OF YTTRIUM. I. Binders (Schwarzkopf Development Corp., Yonkers, N. Y.). Powder Met. Bull. 7, 74-5(1956) Apr.

No borides with a B content greater than $YB_6$ have been found in a study of yttrium borides. Two borides with tetragonal-type structure were prepared. $YB_4$ has lattice parameters a = 7.09, c = 4.01A and $YB_x$ has a = 3.78, c = 3.55A, x is believed to be 3. A hexagonal unit similar to the diboride structures of transition metals with a = 3.78, c = 4.40A is being studied. (F.S.)

# ZIRCONIUM 1.46

## DECAY 1.46.01

**12503** ✓ CF-56-7-61
Oak Ridge National Lab., Tenn.
ZIRCONIUM-95 AS A FISSION MONITOR. W. A. Brooksbank, Jr. July 17, 1956. Decl. Mar. 13, 1957. 4p. Contract [W-7405-eng-26.] $1.80(ph OTS); $1.80 (mf OTS).

A study is reported to determine the feasibility of using $Zr^{95}$ (instead of $Cs^{137}$) as a fission monitor. Two samples of enriched uranium were irradiated and allowed to decay for 10 d before analysis. $Cs^{137}$ and $Zr^{95}$ were separated, counted, and the fission values obtained were compared. (T.T.W.)

NEUTRON CROSS SECTIONS FOR ZIRCONIUM. Janet B. Guernsey and Clark Goodman (Massachusetts Inst. of Tech., Cambridge). Phys. Rev. 101, 294-7(1956) Jan. 1.

The inelastic neutron cross section for the excitation of the 930-kev level in zirconium has been measured as a function of neutron energy between 0.9 and 2.2 Mev. The de-excitation gamma radiation has been observed with a single-crystal NaI(Tl) spectrometer. Isotopic assignment of the observed level is still uncertain. The total cross section for zirconium has been measured for neutrons with energies between 0.7 and 1.2 Mev, using a hydrogen recoil counter in a good-geometry transmission experiment. Some correlation between inelastic and total cross sections has been observed. (auth)

## METALLURGY 1.46.02

See also, under PLANTS AND EQUIPMENT,

MATERIALS (CONSTRUCTION)--Zirconium (5.14.10).

**20172** ✓ NP-7843
Foote Mineral Co., Berwyn, Penna.
REPORT ON ZIRCONIUM METAL POWDER. G. W. Mao and M. M. Morris. [1959]. For Catalyst Research Corp.

A literature survey on the theoretical and technological aspects of zirconium metal powder has been completed. This report summarizes the methods for preparation, physical and chemical properties, safety control, chemical analysis, and available thermodynamic data on the oxidation and kinetics of some common gases reactions with zirconium. Literature on the fabrication of zirconium powder is not discussed. The bibliography is attached. (auth)

PROPERTIES AND PROCESSING OF ZIRCONIUM AND ZIRCONIUM ALLOYS. K. Anderko (Metallgesellschaft A.G., Frankfurt am Main) and E. G. Hess (Vereinigte Deutsche Metallwerke A.G., Duisburg, Ger.). Metall 13, 638-43(1959) July. (In German)

A brief review is given of the chemical, physical, and mechanical properties of zirconium, Zircaloy-2, and zirconium–niobium alloy. The reaction of the metals and alloys with atmospheric gases and hydrogen is described. The conditions for heat and cold working are discussed. Heat treatment of the metal and alloys is also considered. 11 references. (J.S.R.)

**15372** ✓ WAPD-ZH-17
Westinghouse Electric Corp. Bettis Plant, Pittsburgh.
ZIRCONIUM HIGHLIGHTS. May 1959. 21p. $3.30(ph), $2.40(mf) OTS.

The following reports on the technology of zirconium are presented: hardness of Zircaloy-2 with varying oxygen, hydrogen in zirconium, habit plane for hydride precipitation in zirconium and uranium–zirconium, effect of iron contamination on the corrosion resistance of Zircaloy-2, and effects of rocking and drawing reductions on grain size of Zircaloy-2 tubing. (J.E.D.)

**13554** ✓ WAPD-ZH-16
Westinghouse Electric Corp., Bettis Plant, Pittsburgh.
ZIRCONIUM HIGHLIGHTS. Apr. 1959. 33p. Contract AT-11-1-GEN-14. $6.30(ph), $3.00(mf) OTS.

The March 1958 and June 1958 issues of Zirconium Highlights reported the effects of heat treatment on the mechanical and corrosion properties of Zircaloy-2. Corrosion data were included for Zircaloy-2 specimens tested for 14 days in 750°F, 1500 psi steam after heat treatment in the alpha or beta phase followed by an air cool or furnace cool. The results of the 14-day corrosion test showed that all of the alpha-treated and beta-treated, air cooled materials were equivalent in weight gain to material tested in the as-received condition (hot rolled at 1550°F, annealed 1550°F for 15 min). The results of this test also showed that the beta-treated furnace-cooled specimens had weight gains almost twice those of the other specimens. The corrosion tests were extended for a total of 140 days. The resulting corrosion data and final results of the tests are presented in this article. (auth)

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**203** KAPL-M-AEB-3
Knolls Atomic Power Lab., Schenectady, N. Y.
ATTEMPT AT IDENTIFICATION OF SECOND PHASE IN ZIRCALOY-3 BY THE MICROEMISSION X-RAY SPECTROGRAPH. A. E. Bibb. Aug. 1958. 11p. Contract W-31-109-Eng-52. $1.80(ph OTS); $1.80(mf OTS).

An investigation was conducted to identify the globular second phase observed in various Zircaloy metallographic specimens. This second phase was observed in both Zircaloy-2 and -3 and does not appear to be a function of the tin content of the alloy. (auth)

**9660** ✓ AGC-AF-39
Aerojet-General Corp., Azusa, Calif.
REACTION OF ZIRCALOY-2 WITH WATER AND WITH URANYL SULFATE FUEL SOLUTION. Monthly Progress Report No. 4 [for] October 1 through October 31, 1957. Nov. 27, 1957. 9p. For Oak Ridge National Lab. Contract [W-7405-eng-26], Subcontract No. 1089. (AGC-L3501-01-4). $1.80(ph OTS); $1.80(mf OTS).

The following conclusions were reached, based on a qualitative analysis of these data: there is no appreciable difference between uranyl sulfate fuel solution and water as an oxidant for molten Zircaloy-2 droplets; the reaction of molten Zircaloy-2 with aqueous solutions is not self-sustaining when the droplets are larger than 20 $\mu$ and when there is an excess of the aqueous solution; minor alloying additions in zirconium-base alloys do not materially affect the extent of the reaction under the conditions of these tests; the data provide additional evidence to support earlier conclusions that the zirconium–water reaction is a process involving chemisorption of oxygen molecules on the surface of the metal. The fact that the addition of small amounts of electrolytes to the water has only a second-order effect on the reaction rate is consistent with this conclusion. (auth)

**4825** BMI-1232
Battelle Memorial Inst., Columbus, Ohio.
PROGRESS RELATING TO CIVILIAN APPLICATIONS DURING OCTOBER 1957. Russell W. Dayton and Clyde R. Tipton, Jr. Nov. 1, 1957. Decl. Dec. 6, 1957. 58p. Contract W-7405-eng-92. $1.50(OTS).

The creep properties of annealed Zircaloy-2, Zircaloy-3, and 15% cold-worked Zircaloy-2 at elevated temperatures were determined. The metallurgical bond formed between electropolished U and Zr cladding by hydrostatic pressing is being evaluated. Oxidation data are given for Nb and Nb alloys in dry air at various temperatures. A study of the phase relationships which occur between the delta phases of the U–Zr and U–Mo systems is nearly complete. The solid-solid reactions of some uranium nitrates and carbides at 1800°C are given. The creep properties of Ta at 1200°F in a helium atmosphere were investigated. (For preceding period see BMI-1226.) (W.L.H.)

**12729** ✓
PHASE RELATIONSHIPS IN THE SYSTEM ZIRCONIA–THORIA. Pol Duwez and Eugene Loh (California Inst. of Tech., Pasadena and Stanford Research Inst., Menlo Park, Calif.). J. Am. Ceram. Soc. 40, 321-4(1957) Sept.

The phase relationships in the system zirconia–thoria were investigated by x-ray diffraction and dilatometric methods. The specimens were melted in air at the focus of a solar furnace. The existence of a cubic calcium fluoride-type solid solution was established for thoria concentrations above 17.5 mole %. However, this solid solution is stable only at high temperature, and, after prolonged heating at 2000°C and at 1350°C, it decomposes into tetragonal zirconia (which during subsequent cooling undergoes the unavoidable tetragonal-monoclinic inversion) and a thoria-rich phase containing at least 99 mole % thoria. (auth)

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**11509**
PRODUCTION OF ZIRCONIUM. F. H. Spedding et al. (to U. S. Atomic Energy Commission). U. S. Patent 2,797,160. June 25, 1957.

A process for the production of Zr or Zr-base alloys from $ZrF_4$ is given. This is accomplished by preparing a mixture of $ZrF_4$ and a reducing metal and heating this mixture in a closed reactor. Alkali metals and alkaline earth metals are suitable as reducing agents, and in particular Mg and Ca have been found to yield satisfactory results. A booster material, such as $I_2$ or S, is added to the reaction mixture, or an alloying metal in the form of a compound which functions as a booster may be added so that with this one compound the dual purpose of furnishing heat and the alloying metal is attained. (auth)

**11201** KAPL-M-RLM-12
Knolls Atomic Power Lab., Schenectady, N. Y.
TENSILE PROPERTIES AND METALLOGRAPHIC STUDY OF ZIRCALOY 3 STRIP. R. L. Mehan. June 13, 1957. 56p. Contract W-31-109-Eng-52. $9.30(ph OTS); $3.60 (mf OTS).

Room-temperature tensile tests and metallographic examination were performed on zircaloy-3 strip of two different thicknesses, 0.065 and 0.185 in., from eleven different ingots. Pronounced anisotropic effects were found, increasing with the smaller thickness. No noticeable effect of microstructure on tensile properties was found. Tabulations and statistical reductions of the data are presented. (auth)

**13108** SC-4122
Clevite Research Center, Cleveland.
PROPERTIES OF LEAD TITANATE ZIRCONATE CERAMICS. Technical Report No. 3 [for] February 1, 1956 to January 31, 1957. Don Berlincourt. May 15, 1957. 101p. Project No. 30135. For Sandia Corp. $7.80(ph OTS); $3.30(mf OTS).

Research done by the Clevite Research Center for Sandia Corporation on solid solutions of lead titanate and lead zirconate is reported. This research was expanded to include lead titanate zirconate modified by off-valency additions. Effects of these additions on the properties of lead titanate zirconate are discussed in this report. (auth)

**5898**
OXIDATION OF ZIRCONIUM BETWEEN 400° AND 800°C. Earl A. Gulbersen and Kenneth F. Andrew (Westinghouse Electric Corp., Pittsburgh). J. of Metals 9, 394-400(1957) Apr.

The vacuum microbalance method is used to study the oxidation reaction for two surface preparations over the temperature range of 400 to 800°C. The results fit in well with the authors previous work at temperatures of 200 to 425°C and with the work of other groups at higher temperatures. An analysis of the rate data shows that the cubic rate law fits the experimental data best for the abraded specimens. However, the parabolic rate law can be fitted to the data if an initial deviation is disregarded. With chemically polished specimens, a good fit is obtained with the parabolic rate law. The parabolic rate law constant A gives two straight lines when plotted as log A vs 1/T. For the temperature range of 200 to 525°C an energy of activation of 18,200 cal per mol is calculated while a value of 28,600 cal per mol is calculated for the temperature range of 525 to 750°C. The results of this work bring together the previously determined high-temperature oxidation studies of Cubicciotti with the early low-temperature studies of Gulbransen and Andrew. (auth)

ZIRCONIUM TERNARY ALLOYS. L. L. Marsh, Jr. and W. Chubb (to U. S. Atomic Energy Commission). U. S. Patent 2,784,084. March 5, 1957.

A group of Zr–Nb ternary alloys are described which contain from 1% to 5% by weight of Nb and from 0.1% to 2% by weight of either Al, Mo or V. These alloys have low neutron capture cross sections, together with superior tensile characteristics at high temperatures and desirable ductility. Mentioned as outstanding in possessing these properties is the specific alloy containing 1.5% Nb and 1.0% Al, with the balance being Zr. (auth)

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**6432**

RECRYSTALLIZATION DIAGRAM OF IODIDE ZIRCONIUM. E. M. Savitskiĭ and V. F. Terekhova. (Baĭkov Inst. of Metallurgy, Acad. of Sciences U.S.S.R.). Doklady Akad. Nauk S.S.S.R. 112, 276-8(1957) Jan. 11. (In Russian)

A crystallization diagram has been constructed for the bars of iodide zirconium (99.7 Zr) prepared by cold rolling with 50% compression followed by 1 hr annealing at 600°. Deformation of these specimens was followed by cold compression from 2.5 to 90% at 10% intervals with 1 hr annealing at 500, 550, 600, 700, 800, 900, 1000, and 1200°. Annealing of the cold-rolled specimens considerably affected the size and shape of the grain. Specimens annealed in the Zr $\alpha$-modification range (up to 800°) had even polyedric structure; the annealing in the $\beta$ range (900 to 1200°) caused a sharp increase of the grain and change of the form. Roentgengrams, microstructures, table of hardness and the recrystallization diagram are presented. (R.V.J.)

**6910**

THE PHYSICO-CHEMICAL AND ELECTRICAL PROPERTIES OF THE $TiO_2-ZrO_2$ SYSTEM. Ya. M. Ksendzov and V. G. Prokhvatilov. Zhur. Tekh. Khim. 31, 320-7(1957) Feb. (In Russian)

Investigations revealed that the $ZrTiO_4$ compound, and solid solutions of rutile and ZrO were formed at the boundaries of the $TiO_2-ZrO_2$ system. At 400°C the solid solution of rutile was found between 11 and 12 mole % of $ZrO_2$, while tetragonal ZrO was present at ~15% $TiO_2$. With the increase of temperature, the solid solution boundaries shifted towards higher solute concentrations. The electrical properties of the $TiO_2-ZrO_2$ system were studied. For the compound $ZrTiO_4$, the value of $\epsilon$ was 39, and the temperature coefficient was $110 \times 10^{-6}$. (tr-auth)

**10674**

ZIRCONIUM. METALLURGY OF THE RARER METALS. 2. Second Edition. G. L. Miller. New York, Academic Press, Inc., 1957. 569p.

The methods for the production of Zr metal are divided into three sections, each occupied by one chapter. The various melting techniques employed in the metallurgy of Zr are described in detail. The properties of the metal are detailed, and a chapter is devoted to the reactions of Zr with the common gases. The outstanding property of Zr—its resistance to chemical corrosion—is discussed at length. The fabrication and mechanical properties of various Zr alloys are discussed in detail. (W.L.H.)

**13150**

PREPARATION, PROPERTIES, AND UTILIZATION OF ZIRCONIUM. Khershkovich. An. Rom.-Sov. chim. 11 No. 2, 145-75(1957). (Translated from Referat. Zhur. Khim. No. 1, 1958, Abstract No. 658.)

ON URANIUM—ZIRCONIUM ALLOYS. G. Z. (Z. G.). Atomnaya Energiya 3, No. 8, 176-7(1957).

It was found as the result of research work recently carried out that the $\epsilon$ phase is constant up to 610°C. Between $\beta$ Zr and $\gamma$ U there is the eutectic reaction

$\beta Zr(\gamma U) \xrightleftharpoons{593°C} \alpha Zr + \epsilon$. Above 610° the $\epsilon$ phase is decomposed: $\epsilon \xrightleftharpoons{607°C} \beta Zr + \alpha U$. An investigation of the U—Zr—O system gave the following result: the solubility of O in the $\epsilon$ phase is less than 0.05%, and in the case of a higher O content of the $\epsilon$ phase it exists together with $\alpha$ U and $\alpha$ Zr. If U is alloyed with crystalline Zr (O content 0.005%), then this alloy behaves differently than it would have done if zirconium sponge (O content 0.1%) had been used. (TCO)

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**184** BM-IC-7830
Bureau of Mines, Albany, Oreg.
BIBLIOGRAPHY OF ZIRCONIUM. Eleanor Abshire. June 1956. 219p.
Supplement to BM-IC-7771.
A bibliography covering the current technical literature relating to the metallurgy of zirconium is presented. The material is divided into two sections—literature and patents. The bibliography contains 844 literature references and 62 patent references. Each section is arranged alphabetically by author, and a subject index is included. (J.E.D.)

**11182** ✓ AEC-tr-3014
SOME PHYSICOCHEMICAL PROPERTIES OF ALLOYS OF ZIRCONIUM WITH CARBON. G. V. Samsonov and N. S. Rozinova. Translated from Izvest. Sektora Fiz. Khim. Anal. Inst. Obshchei Neorg. Khim. Akad. Nauk S.S.S.R. 27, 126-32(1956) 9p.

THE δ PHASE FOUND IN THE U-Zr ALLOYS. Melvin H. Muelier (Argonne National Lab., Lemont, Ill.). Acta Cryst. 8, 849-50(1955) Dec.

**526** ✓
Technical Information Service Extension, AEC.
ZIRCONIUM: A BIBLIOGRAPHY OF UNCLASSIFIED REPORT LITERATURE. Hugh E. Voress and Thomas W. Scott, comps. Sept. 1955. 41p. (TID-3010(Suppl. 2)).
This supplement contains 228 annotated references to unclassified reports on Zr which were available for review at the Technical Information Service Extension from March 15, 1953 to September 20, 1955. Author, subject, and report number indexes are included.

**2533** WAPD-FE-954
Westinghouse Electric Corp. Atomic Power Div., Pittsburgh.
ZIRCALOY-2 HOT BEND TESTS PERFORMED BY THE YOUNGSTOWN WELDING AND ENGINEERING CO. W. L. Frankhouser. Aug. 10, 1955. Changed from OFFICIAL USE ONLY Oct. 3, 1956. 27p. $4.80(ph OTS); $2.70(mf OTS).
Six-inch long angle shapes were hot formed from Zircaloy-2 strip by the subject company. The work had to be heated between 720 and 865°F to make 1/8-in. radius bends (~3/4t) in cold dies. This range of temperature included Zircaloy-2 material taken from two ingots and with three variations in metallurgical processing. By preheating the dies to 750°F for one group of samples, it was possible to reduce the furnace preheat 130°F below that required for cold die forming. Heating the work entirely with the dies was proven possible but not advisable. Temperature gradients established through cooling of the samples at their edges necessitated raising the temperatures to a higher level than that needed when the die and work were heated separately. (auth)

**6736** BM-IC-7771
Bureau of Mines.
BIBLIOGRAPHY OF ZIRCONIUM. Eleanor Abshire. June 1955. 284p.
This bibliography is the result of a cooperative project undertaken by the Bureau of Ships and the Bureau of Mines to accumulate literature published to date on Zr and Hf and to establish an information center on these metals for the use of any interested research organization or library. The bibliography, which will be supplemented as additional information is accumulated, consists of references, with abstracts, to pertinent literature on the subject published from 1907 to date. (auth)

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**13822** ✓ WAPD-T-46
Westinghouse Electric Corp. Atomic Power Div., Pittsburgh.
MECHANICAL PROPERTIES AND MICROSTRUCTURE OF ANNEALED ZIRCONIUM. W. L. Mudge, Jr. June 10, 1953. ~~Decl. Mar. 7, 1957.~~ 25p. Contract AT-11-1-GEN-14. $4.80(ph OTS); $2.70(mf OTS).

The mechanical properties of unalloyed Zr are shown to vary markedly depending on the state of anneal of the metal. Hardness is used as an index of annealing condition. Precautions to be taken in obtaining reproducible hardness values in Zr are outlined. In addition, the appendix contains a hardness conversion table for Zr base alloys. This covers the hardness range from approximately 60 to 250 DPH (20 to 100 $R_B$). (auth)

**2924** BMI-780(Del.)
Battelle Memorial Inst., Columbus, Ohio.
MECHANICAL PROPERTIES OF IODIDE ZIRCONIUM ALLOYS. A. D. Schwope and W. Chubb. Nov. 1, 1952. Decl. with deletions May 7, 1957. 21p. $4.80(ph OTS); $2.70(mf OTS).

The tensile properties, hot hardness, impact strength, and corrosion resistance of some arc-melted iodide Zr alloys were determined. The alloys investigated include binary alloys of Zr containing zero to 5% Sn and zero to 0.14% N and ternary alloys of Zr containing Sn and N, Sn and U, and U and Be. (auth)

**6821** ✓ A/CONF.15/P/2046
**STRUCTURE AND PROPERTIES OF ZIRCONIUM ALLOYS. O. S. Ivanov and V. K. Grigorovich (U.S.S.R.). 34p.**

**The following properties of binary zirconium alloys were investigated; microstructure, hardness, tensile properties at 20 and 500°C, creep resistance to bending and extention, and corrosion resistance in water at 350 to 400°C. The ternary alloys Cr-Nb-Zr, Cr-Sn-Zr, Mo-Nb-Zr, and Mo-Sn-Zr were also studied. The methods of sampling, heat treatment, and test technique were the same as were used for the binary alloys.**

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Technical Information Service Extension, AEC.
ZIRCONIUM: A BIBLIOGRAPHY OF UNCLASSIFIED REPORT LITERATURE. July 1956. 41p. (TID-3304).

This bibliography contains 225 annotated references to unclassified reports on zirconium. References are included to reports written prior to September 1955. Author, subject, and report number indexes are provided.

**9127**
ZIRCONIA REACTIONS IN BINARY OXIDE SYSTEMS. Robert S. Roth (National Bureau of Standards, Washington, D. C.). J. Am Ceram. Soc. 39, 196(1956) May.

**147**
THE COMPOSITION AND STABILITY OF THE SULFATE COMPLEX OF ZIRCONIUM. V. F. Saksin. Nauch. Doklady Vysshel Shkoly. Khim. i Khim. Tekhnol., No. 1, 75-9(1959).

It is known from publications that anion complexes of zirconium as well as positively charged complexes, e.g., $[ZrO(H_2O)(OH)]^+$ may be formed in a solution of sulfuric acid. In the present paper the formation of positive zirconyl complexes with an excess of $ZrO^{2+}$-ions is investigated. 1) The solubility of $BaSO_4$ in zirconyl nitrate at 20° and the composition of the bottom phase were investigated. 2) Zirconyl nitrate was titrated with a 0.05 molar $Na_2SO_4$ solution and the precipitate was analyzed. 3) The pH in this titration lye was measured; the pH was determined in solutions to which 0.2-n $HNO_3$ was added until the precipitate dissolved. 4) The solubility of $BaSO_4$ in $KNO_3$ solutions and $KNO_3$ solutions acidified with $HNO_3$ was investigated in order to investigate salt effects. The solubility of barium sulfate in zirconyl nitrate can neither be explained by salt effects nor by the influence of the free acid formed in the hydrolysis of zirconyl nitrate. It is a matter of formation of zirconyl complex salts which takes place according to the following equations: (1) $BaSO_4 + ZrO^{2+} + nH_2O \rightleftharpoons [(ZrO(SO_4)H_2O)_n]^0 + Ba^{2+}$ and (2) $BaSO_4 + 2ZrO^{2+} \rightleftharpoons [(ZrO_2)SO_4]^{2+} + Ba^{2+}$ Since a $ZrO^{2+}$ excess was used, the dissolution of barium sulfate had to take place mainly according to equation 2. The tiration showed also that the precipitate dissolved in the zirconyl nitrate excess. A dissolution of the precipi-

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tate in free nitric acid does not occur before a high acid concentration is attained. The complex ion has the formula $[(ZrO_2)SO_4]^{2+}$. With lower concentrations of zirconyl nitrate other complexes appear, e.g., the neutral $[ZrO(SO_4)(H_2O)_n]^0$. With still lower concentrations of zirconyl nitrate complex formation stops and zirconium is found in the bottom phase. The formation of anion complexes of the type $[Zr(SO_4)]^{4-2n}$ was not found. The absence of these complexes was indicated by the rapid decrease of the solubility of barium nitrate in zirconyl nitrate after the addition of nitric acid. Nitric acid suppresses the hydrolysis of zirconyl nitrate; tetravalent Zr ions are formed which obviously do not form complexes with $SO_4^{2-}$ ions and therefore cannot dissolve barium sulfate. The computed instability constant $K_n = 1.88 \times 10^{-9}$ maintained its value independent of the experimental conditions. A slight decrease of the value with a very low zirconyl nitrate concentration seems to be due to the formation of the neutral complex according to equation 1. (TCO)

THE STRUCTURES OF $ZrGe_2$, $HfSi_2$, AND $HfGe_2$. J. F. Smith and D. M. Bailey (Iowa State Coll., Ames). Acta Cryst. 10, 341-2(1957) Apr.

**1492** ✓

THE SELF-CONSISTENT FIELD FOR $Zr^{4+}$. S. L. Altmann (Mathematical Inst., Oxford). Proc. Phys. Soc. (London) A68, 987-93(1955) Nov. 1.

A fairly general program for the computation of atomic self-consistent fields without exchange has been prepared for the Manchester University electronic computer. Results obtained for the $Zr^{4+}$ ion are given. (auth)

Bureau of Mines.

BIBLIOGRAPHY OF ZIRCONIUM. Eleanor Abshire. June 1955. 284p. (BM-IC-7771).

This bibliography consists of references, with abstracts, to pertinent literature on zirconium published from 1907 to June 1955. Reference sources are as follows: *ASM Metals Review; ASTIA Index; AEC (Oak Ridge) TID Index; Battelle Technical Review; Bibliography of Technical Reports; British Abstracts; Chemical Abstracts; Crerar Metal Abstracts; Current List of Medical Literature; Education Index; Engineering Index; Industrial Arts Index; Nuclear Science Abstracts; Quarterly Cumulative Index Medicus;* and *Readers' Guide*. The material is divided into two sections, 969 literature references and 645 references to patents.

**13736**

PREPARATION OF ZIRCONIUM HYDROXIDE. I. V. Tananev and M. Ya. Bokmel'der. Zhur. Neorg. Khim. 3, 1273-80(1958) June. (In Russian)

The solubility method, pH measurements, electric conductivity, and visual precipitation methods were used in studies of the formation of zirconium hydroxide in the reaction of zirconium sulfate and oxychloride dilute solutions with nitric acid. Three stages were observed in the reaction of zirconium sulfate with alkali: first the basic salt $3Zr(SO_4)_2 \cdot Zr(OH)_4$ forms, then the basic salt $(ZrO \cdot OH)SO_4$ precipitates, which reacts with alkali to form zirconium hydroxide. The

METHOD AND APPARATUS FOR OBTAINING DUCTILE TITANIUM OR ZIRCONIUM. K. M. Hill (to Peter Spence and Sons, Ltd.). British Patent 768,124. Nuclear Eng. 2, 266(1957) June.

Halide reduction is normally carried out in two separate stages. In the second stage the contaminating halide and unreacting reducing metal are removed by leaching with liquid $NH_3$ or acid or by distilling in vacuo. In both methods contamination risks are present affecting the purity and hardness of the Ti or Zr. The new apparatus enables the reaction and subsequent distillation to be carried out as a single operation allowing unobstructed path distillation to take place from the evaporating surface to the condensing surface. It is built up, in general, of a reaction vessel, an inverted condensing vessel mounted on the reaction vessel, with temperature control and evacuating means and with inverting means for the reaction and condensing vessels so as to enable interchange of their relative positions. (auth)

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KINETICS OF THE REDUCTION OF $ZrI_4$ VAPORS BY METALLIC ZIRCONIUM. F. I. Busol (Khar'kov Inst. of Physics and Tech.). Zhur. Fiz. Khim. 33, 799-807 (1959) Apr. (In Russian)

A method is described for determining the kinetics of formation of the lower zirconium iodides on interaction of the tetraiodide with metallic zirconium. The method is based on continuously following the changes (decreases) in vapor pressure of the $ZrI_4$ vapors as they are being reduced to the little volatile lower iodides. It was found that at zirconium temperatures of 300 to 530°C and tetraiodide pressures 10 to 250 mm Hg the $ZrI_4$ molecules are reduced mainly to $ZrI_3$. The reaction takes place on the metal surface with the formation of a strong $ZrI_3$ film. Evidently under these conditions zirconium diiodide does not form. For a given temperature of the zirconium the rate of growth of the triiodide layer with time obeys a parabolic law, the constant of the parabolic law depending exponentially on the temperature. For the activation energy of the process which determines the rate of the reaction studied the value $Q \approx 21$ kcal/mole. Such a process is evidently diffusion of the atoms or ions of zirconium through the $ZrI_3$ layer. (auth)

**4393**

PREPARATION OF $Nb^{95}$-FREE $Zr^{95}$ BY TTA EXTRACTION. H. L. Scherff and G. Herrmann (Universität, Mainz). J. Inorg. & Nuclear Chem. 11, 247-8(1959) Oct. (In German)

The conditions for the extraction of $Zr^{95}$ from a mixture of $Zr^{95}$ and $Nb^{95}$ with TTA (thenoyltrifluoroacetone) and back extraction with HCl was investigated. The distribution coefficient was determined in 0.10 and 0.05 M TTA in benzol and 0.05 M TTA in xylol as a function of increasing HCl concentration. The results showed a sharp increase in the distribution coefficient with HCl concentration over about 6 N. The cause of the increased distribution coefficient was attributed to an ion exchange mechanism resulting in the preferential formation of a negatively charged ZrCl complex. The method, previously suggested, of preparing a stock solution of $Zr^{95}$ in TTA–benzol, storing it in $HNO_3$ or HCl, and extracting the $Zr^{95}$ as needed by multiple washing with 2 N HCl. With increasing age of the stock solution, the extraction time is increased and the method is not suitable for the preparation of pure $Zr^{95}$. (J.S.R.)

**5167** PGR-16(S)

United Kingdom Atomic Energy Authority. Production Group. Chemical Services Dept., Springfields, Lancs, England.

ANALYTICAL METHODS FOR THE ABSORPTIOMETRIC DETERMINATION OF IRON IN ZIRCALOY 2. Aug. 28, 1959. 7p. BIS.

The sample is dissolved in hydrofluoric acid. The fluoride is complexed with boric acid and zirconium with ammonium citrate. The iron is complexed with thioglycolic acid and determined absorptiometrically in ammoniacal solution. (auth)

**5784**

SEPARATION AND DETERMINATION OF MICROGRAM QUANTITIES OF ZIRCONIUM. Clark E. Bricker and Glenn R. Waterbury (Los Alamos Scientific Lab., N. Mex.). Anal. Chem. 29, 558-62(1957) April.

The recommended procedure has been applied to the analysis of samples of Pu alloys and to solutions containing a wide variety of metallic ions. Its reproducibility with multiplicate samples is within 3% in all analyses where 15 or more $\gamma$ of Zr are present. Even though a single analysis may require 4 to 5 hours, 12 analyses can be performed simultaneously in about 6 hours. (auth)

**6360** A/CONF.15/P/1306

**L'ACIDE FLAVIANIQUE, UN RÉACTIF SÉLECTIF DU ZIRCONIUM. (A Radiochemical Method of Determination and Separation of Zr with Flavianic Acid). Tiberiu Născuţiu (Inst. de Physique Atomique, Bucharest). 8p.**

**The behavior of 50 ions in flavianic acid (1-oxy-2, 4-dinitro-7-naphthalene sulfonic acid) was studied, and it was found that in 5 to 7.5 M HCl only Zr and Hf precipitate. A series of experiments made to determine Zr in the presence of Be, Cu, Co, Ni, U, and the rare earths showed that none of these elements interferred with the determination. The method for the gravimetric determination of Zr is given. (J.S.R.)**

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**2503** COO-110
Graham, Crowley and Associates, Inc., Jenkintown, Penna.
ELECTRODEPOSITION OF ZIRCONIUM. Progress Report No. 4 Covering Period August 1, 1952 to October 31, 1952. Changed from OFFICIAL USE ONLY June 22, 1956. 44p. Project No. J-132. Contract AT(11-1)-173. $7.80 (ph OTS); $3.30(mf OTS).

A literature review of ternary electrolyte systems of the "Plotnikov type" has shown that many metals, including Al and four of the alkali metals, have been electrodeposited from such systems. In general, these systems are comprised of a halide of the metal whose deposition is desired together with either an alkali metal halide or an Al halide in an organic constituent such as benzene, nitrobenzene, toluene, ethylbromide, or ethylenebromide. Solubility and conductivity studies of $ZrCl_4$ with aluminum chloride, bromide, or iodide in nitrobenzene and with aluminum chloride in para-xylene have been carried out. These studies have strongly suggested that comparable conductive complexes are formed with $Z_2Cl_4$. A closed Pyrex glass electrolysis system was designed and built so that all the electrolyte components could be volatilized in anhydrous form directly into the electrolysis chamber in an atmosphere of dry nitrogen. The following three systems have been electrolyzed under these conditions: zirconium tetrachloride—aluminum chloride—para-xylene; zirconium tetrachloride—aluminum chloride—nitrobenzene, and zirconium tetrachloride—aluminum iodide—nitrobenzene. No weighable cathode deposits were obtained with the first two systems. Hard black cathode deposits which proved to contain Zr but no Al were obtained when the third system was electrolyzed. Gas evolution tests, however, failed to establish that metallic Zr was present. (auth)

**2502** COO-107
Graham, Crowley and Associates, Inc., Jenkintown, Penna.
ELECTRODEPOSITION OF ZIRCONIUM. Progress Report No. 3 Covering Period May 1, 1952 to July 31, 1952. Changed from OFFICIAL USE ONLY June 22, 1956. 29p. Project No. J-132. Contract AT(11-1)-173. $4.80(ph OTS); $2.70(mf OTS).

A number of organic liquids having relatively nonlabile H atoms were studied as possible solvents for $ZrCl_4$. Acetic anhydride and propionitrile were found to dissolve appreciable amounts of $ZrCl_4$ and form solutions which were sufficiently conductive for electrolysis. Solutions of $ZrCl_4$ in acetic anhydride, propionitrile and tetrahydrofuran were electrolyzed with Pt cathodes and Zr anodes over a range of cathode current densities. No weighable cathode deposits were obtained although, when the cathodes were analyzed qualitatively, trace tests indicating the presence of Zr in some form were obtained. Studies involving the possible electrodeposition of Zr metal from ternary systems of the Plotnikov type have been initiated. These systems, in general, are comprised of a halide of the metal whose deposition is desired together with either an alkali metal halide or an Al halide in an organic constituent, such as, nitrobenzene, benzene, toluene, ethylbromide or ethylenebromide. Two of Plotnikov's electrolyses considered as representative of simple and difficult electrodepositions, Cu and K have been reproduced in our laboratory. To date, three conductive ternary systems of the above type containing a Zr halide as one of the constituents have been found and electrolyzed. No metallic deposits have been obtained from these. The systematic study of other ternary systems containing a Zr halide is now in progress. (auth)

**91** NP-7943
Pennsalt Chemicals Corp., Wyndmoor, Penna.
THE COMPOSITION AND PROPERTIES OF ZIRKLOR Technical Report No. 7. F. L. Scott, H. Q. Smith, and I. Mockrin. Sept. 10, 1959. 8p. Contract Nonr-2687(00).

"Zirklor" (ZrCl) was prepared by the electrolysis of $ZrCl_4$ in a fused salt bath. The properties claimed for Zirklor, which was obtained as black flakes: good lubricating power, thermoplasticity, and stability to 1000°C. The chemical reactivity of Zirklor was studied. (W.L.H.)

# ZIRCONIUM 1.46

## OTHER REACTIONS AND PROPERTIES 1.46.03

**7432** ✓ Y-574
Oak Ridge National Lab., Y-12 Area, Oak Ridge, Tenn.
CHLORINATION OF PURIFIED ZIRCONIUM OXIDE. L. P. Twichell. Mar. 10, 1950. Decl. Feb. 7, 1957. 17p. Contract W-7405-Eng-26. $3.30(ph OTS); $2.40(mf OTS).

A series of experiments was made to study various methods of chlorination of $ZrO_2$. Several types of liquid phase reactions were tried without success. Chlorination of the oxide and added C by means of $Cl_2$ gas at high temperature gave incomplete conversion under the conditions studied. Reaction of oxide with $CCl_4$ vapor at 500°C gave essentially complete conversion to product of required purity. This was accomplished in a reactor and a condenser both made of nickel to simulate conditions in the large chlorinators available. The reaction was considerably more rapid at 550 to 600°C but the resultant product was highly contaminated with Ni. Studies were also made of the corrosion of Ni and other metals, types of condensers, and degree of ignition necessary in starting oxide. Cost estimates indicate that the oxide could be chlorinated by this method for $0.51 per pound of contained Zr metal. (auth)

**10919** ✓
CHLORINATION OF ZIRCONIUM DIOXIDE BY GASEOUS CHLORINE IN THE PRESENCE OF SOLID CARBON. B. D. Vasilenko and A. N. Vol'skii. Sbornik Nauch. Trudov Moskov. Inst. Tsvetnoĭ Met. i Zolota No. 27, 119-35(1957). (Translated from Referat. Zhur. Met. No. 8, 1958, p. 70.)

A study is made of the relationship between the rate of chlorination of briquets of a mixture of $ZrO_2$ and soot on the one hand and a series of factors and the composition of the gas phase in chlorination on the other. It is established that in this process the C may oxidize to $CO_2$ or to CO, the latter of which acts to reduce the $ZrO_2$. The rate of chlorination in the presence of CO is almost fifty per cent less than with solid C at the same $Cl_2$ consumption. When the briquets are chlorinated with solid C, the $CO/CO_2$ ratio in the gas phase rises with increasing temperature, attaining a value of 5 at 1000°C and a $ZrO_2$:C molecular ratio of 1:2. Three regions of dependence of chlorination rate upon temperature are noted: A kinetic interval up to 520°, an intermediate from 520 to 700°, and a diffusive at >700°. Mathematical expressions for the relationship between the chlorination rate and the partial pressure of the $Cl_2$ and the rate of flow of the $Cl_2$ are presented. The temperature of the chlorination process is 700°.

**3336** ✓ AECD-3708
Battelle Memorial Inst., Columbus, Ohio.
VAPOR PRESSURES OF BERYLLIUM FLUORIDE AND ZIRCONIUM FLUORIDE. K. A. Sense, M. J. Snyder, and J. W. Clegg. July 13, 1953. Decl. with deletions Nov. 22, 1955. 13p. Contract W-7405-eng-92. $0.15(OTS).

The vapor pressures of $BeF_2$ and $ZrF_4$ were measured over the temperature ranges 746 to 968°C and 689 to 825°C, respectively, using the transpiration method. The respective extrapolated boiling points are shown to be 1159°C and 902°C. The melting point of $BeF_2$ is about 803°C. (auth)

**8240**
THE HYDRATES OF ZIRCONIUM TETRAFLUORIDE. R. W. M. D'Eye, J. P. Burden, and E. A. Harper (Atomic Energy Research Establishment, Harwell, Berks, England). J. Inorg. and Nuclear Chem. 2, 192-5(1956) Mar.

A mono- and a trihydrate of $ZrF_4$ have been identified from x-ray diffraction and chemical studies. The monohydrate is body-centred tetragonal with a = 7.70 ± 0.01kX and c = 11.63 ± 0.01kX and 8 molecules per unit cell. The trihydrate degrades to the monohydrate at 100°C in air, and at room temperature in vacuo. The monohydrate when heated in air at 250°C degrades to the oxide and/or oxyfluoride, and in vacuo decomposes to an unidentified substance. (auth)

# ZIRCONIUM 1.46

## OTHER REACTIONS AND PROPERTIES 1.46.03

**7089** ✓ NP-6307
Brussels. Centre D'Etudes Pour Les Applications de l'Energie Nucleaire.
PREPARATION DU FLUORURE DE ZIRCONIUM ANHYDRE PUR. (Preparation of Pure Anhydrous Zirconium Fluoride). C. Decroly, D. Tytgat, and J. Gerard. Aug. 1, 1956. 21p. (R-1259).

The preparation of pure, anhydrous $ZrF_4$ with HF on a large scale in the laboratory is described. The raw material used for separation is pure $ZrO_2$. The fluorinating agent used was $NH_4F.HF$. The $(NH_4)_2ZrF_6$ was changed to $ZrF_4$ by firing at 500°C in a vacuum. The $ZrF_4$ was purified by vacuum sublimation at 700°C. The equipment used for the vacuum sublimation is described. The yield of the conversion of oxide to sublimed fluoride was about 95%. (Tr-T.R.H.)

**11294** IDC-14442
Phillips Petroleum Co. Atomic Energy Div., Idaho Falls, Idaho.
THE SOLUBILITY OF ZIRCONIUM TETRAFLUORIDE IN NITRIC ACID FROM 0 TO 80°C. A. G. Chapman and C. M. Slansky. Apr. 30, 1958. 17p. Contract AT(10-1)-205. $0.75(OTS).

The solubility of zirconium tetrafluoride in concentrations of nitric acid from 1 to 16M and at temperatures from 0 to 80°C was determined. At least three solid species of zirconium fluoride as determined by x-ray diffraction and chemical analysis were observed to be in equilibrium with nitric acid through these ranges of concentration and temperature: zirconium tetrafluoride monohydrate, $ZrF_4 \cdot H_2O$ or $ZrOF_2 \cdot 2HF$, is the stable solid phase in equilibrium with nitric acid greater than about 8 molar through the entire measured temperature range and in nitric acid concentrations above 4 molar at temperatures above 50 to 60°C; zirconium tetrafluoride trihydrate, $ZrF_4 \cdot 3H_2O$, at acid concentrations below about 6M and temperatures below about 50 to 60°C; and a solid having unidentified x-ray-diffraction pattern and chemical composition of approximately 3 moles of fluoride to 1 mole of zirconium in nitric acid of less than 4M and at temperatures above about 50 to 60°C. The solubility of zirconium tetrafluoride in nitric acid expressed as grams $ZrO_2$ per liter ranges from about 0.5 grams per liter at 0°C in 16M acid to approximately 215 g/l at 80°C in 1M acid. (auth)

**14311** ✓
THE DIFFERENT VARIETIES OF ZIRCONIUM TETRAFLUORIDE. André Chrétien and Bernard Gaudreau. Compt. rend. 248, 2878-9(1959) May 20. (In French)

The preparation and properties of two crystalline varieties and one amorphous variety of zirconium tetrafluoride are presented. (tr-auth)

**6119** Y-769
Oak Ridge National Lab., Y-12 Area, Tenn.
PREPARATION OF ZIRCONIUM TETRAFLUORIDE. Progress Report No. II. Joe L. Williams. Feb. 15, 1951. ~~Decl. Jan. 27, 1956~~. 13p. Contract W-7405-eng-26. $3.30(ph OTS); $2.40(mf OTS).

Studies on the preparation of $ZrF_4$ by hydrofluorination of the oxide, followed by vacuum sublimation, have been considerably extended since publication of the preceding progress report. Reaction rates have been determined and equipment design has been improved. Some properties of the high quality product are discussed. (auth)

**16937**
THE ELECTROCHEMICAL BEHAVIOR OF ZIRCONIUM IN SULFURIC ACID. N. A. Balashova and B. N. Kabanov (Inst. of Electrical Chemistry, Academy of Sciences, USSR). Doklady Akad. Nauk S.S.S.R. 121, 126-8(1958) July 1. (In Russian)

The cathode and anode polarization behavior of zirconium in 1N $H_2SO_4$ and zirconium potential variations with delayed time in air, in sulfuric acid, and in bare electrode were investigated. (R.V.J.)

# ZIRCONIUM 1.46

## OTHER REACTIONS AND PROPERTIES 1.46.03

INVESTIGATIONS ON THE $U_3O_8$-$ZrO_2$-$O_2$ AND $U_3O_8$-$TiO_2$-$O_2$ SYSTEMS BY THE EMANATION METHOD. Presented at the International Conference on Radioisotopes in Scientific Research Sept. 9-20, 1957 at Paris. No. UNESCO/NS/RIC/198. G. Wolf, L. Ochs, and F. Strassman. London, Pergamon Press, Ltd., 1957. 10p.

RdTh is incorporated into $U_3O_8$, $ZrO_2$, and $TiO_2$ after which the individual components or the mixtures of $U_3O_8$–$ZrO_2$, and $U_3O_8$–$TiO_2$ are slowly heated to 1400°C in an oxygen stream. The escaping thoron is fed through an ionization chamber where the activity is continuously measured in a vibrating reed electrometer and registered on an automatic recorder. The heated mixtures are examined by x-ray methods in order to verify a reaction between the components. In both systems the emanation curves of the components were altered. In the $U_3O_8$–$TiO_2$ system both chemical and x-ray methods showed the formation of a compound $TiO_2 \cdot UO_3$. However in the system $U_3O_8$–$ZrO_2$ no change in the x-ray pattern could be noticed. Therefore the study of emanation curves seems to be a sensitive method for verification of reactions in the solid state. (auth)