S#5

MARTIN MARIETTA ENERGY SYSTEMS LIBRARIES
3 4456 0361501 4

253.

CENTRAL RESEARCH LIBRARY
DOCUMENT COLLECTION

ORNL-2955
UC-4 - Chemistry-General

ADSORPTION OF XENON AND ARGON ON GRAPHITE

M. C. Cannon
W. T. Ward
G. M. Watson
W. R. Grimes

CENTRAL RESEARCH LIBRARY
DOCUMENT COLLECTION
LIBRARY LOAN COPY
DO NOT TRANSFER TO ANOTHER PERSON
If you wish someone else to see this document, send in name with document and the library will arrange a loan.

OAK RIDGE NATIONAL LABORATORY
operated by
UNION CARBIDE CORPORATION
for the
U.S. ATOMIC ENERGY COMMISSION

Printed in USA. Price $0.75. Available from the

Office of Technical Services
Department of Commerce
Washington 25, D.C.

LEGAL NOTICE

This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission:

A. Makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or

B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method, or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission, or employee of such contractor, to the extent that such employee or contractor of the Commission, or employee of such contractor prepares, disseminates, or provides access to, any information pursuant to his employment or contract with the Commission, or his employment with such contractor.

ORNL-2955
UC-4 – Chemistry-General
TID-4500 (15th ed.)

Contract No. W-7405-eng-26

REACTOR CHEMISTRY DIVISION

ADSORPTION OF XENON AND ARGON ON GRAPHITE

M. C. Cannon G. M. Watson
W. T. Ward W. R. Grimes

DATE ISSUED

NOV 21 1960

OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee
operated by
UNION CARBIDE CORPORATION
for the
U.S. ATOMIC ENERGY COMMISSION

MARTIN MARIETTA ENERGY SYSTEMS LIBRARIES
3 4456 0361501 4

CONTENTS

Abstract..... 1

Introduction..... 1

Objectives..... 2

Literature Survey..... 2

Experimental..... 3

Results..... 7

Comparison with Charcoal Data..... 10

Heat of Adsorption..... 11

Extrapolation to Reactor Temperatures..... 13

Conclusions..... 16

Appendix A Comparison of Calculated and Analyzed Percentage of Xenon in Standard Mixtures..... 18

Appendix B Comparison of Mass Spectrometric Analyses with Analyses by Gas Chromatography..... 19

Appendix C Precision of Mass Spectrometric Xenon Analyses..... 20

ADSORPTION OF XENON AND ARGON ON GRAPHITE

M. C. Cannon W. T. Ward G. M. Watson W. R. Grimes

ABSTRACT

Adsorption isotherms for xenon on AGOT-grade graphite, having a surface area of 0.64 m^2/g, were determined at -79, 0, 20, 30, and 80°C in order to determine whether the presence of helium affects the adsorption behavior of xenon. The isotherms obtained from xenon-helium mixtures were essentially the same as those obtained using pure xenon gas. The calculated heats of adsorption for xenon range between 3500 and 3700 cal/mole and approximate the heat of vaporization of 3270 cal/mole reported in the literature. The volume of xenon adsorbed (cm^3 at STP) per gram of graphite, a, vs xenon partial pressure, P (mm Hg), may be expressed by the equation $a = bp^{0.8}$. The values of b are 2.14×10^{-4} and 6.33×10^{-5} at 0 and 80°C respectively. Extrapolation of the measurements to higher temperatures gives values of b of 6.5×10^{-6} and 4.1×10^{-6} at 500 and 750°C respectively.

Adsorption isotherms for argon were determined at -83 and 0°C and can be expressed by the same equation indicated above. At -83 and at 0°C b has values of 1.00×10^{-4} and 1.60×10^{-5} respectively.

INTRODUCTION

One of the problems inherent in reactor design is that of removing the high-cross-section fission products. This is particularly important in breeder reactors such as the molten-salt reactors and liquid-metal-fuel reactors currently under consideration.[1,2] One of the more objectionable fission-product poisons is xenon, and a knowledge of the adsorption characteristics of xenon on reactor-grade graphites is important in designing a xenon-removal process. One such proposed process

---

[1] H. G. MacPherson, Molten-Salt Breeder Reactors, ORNL CF-59-12-64 (Dec. 22, 1959).

[2] J. A. Lane, H. G. MacPherson, and F. Maslan (eds.), Fluid Fuel Reactors, Addison-Wesley, Reading, Mass., 1958.

involves sweeping out the xenon with a purge of helium gas. The experimental program conducted as a part of this study includes a comparison of the adsorption of xenon from helium-xenon mixtures with that from the pure gas.

Objectives

The objectives of this study may be listed as follows:

1. to make a survey of the literature for adsorption data for noble gases on graphites or charcoals,
2. to obtain experimental data to compare the adsorption of xenon from a helium-xenon mixture with that from pure xenon on graphite,
3. to ascertain if a correlation exists between the adsorption of xenon on graphite and on various charcoals as reported in the literature,
4. to attempt to predict by extrapolation the approximate amount of xenon adsorption to be expected at reactor temperatures from the data obtained at considerably lower temperatures (-79 to +80°C) where more accurate data could be obtained.

Literature Survey

A search of the literature yielded no information on the graphite-xenon system. Several investigations concerning adsorption of krypton on powdered graphite and adsorption of helium, argon, krypton, and xenon on charcoals at temperatures below 0°C have been reported.[3,4,5] The data in most of these reports were of relatively little value for the present purpose since they were generally obtained at temperatures below 0°C, and temperature-dependence studies were not carried out.

Difficulty is encountered in extrapolating the data in the literature to fit graphite even when one assumes that the attractive forces causing adsorption on charcoal may be of the same magnitude as those for graphite.

---

[3]R. A. Lad and T. F. Young, The Adsorption of Xenon on Charcoals at Room Temperature, CC-3106 (Aug. 1, 1945).

[4]R. A. McNees, private communication (to be published), ORNL; HRP Quar. Prog. Rep. Jan. 31, 1958, ORNL-2493, p 157.

[5]K. Peters and K. Weil, Z. physik. Chem. A148, 1 (1930).

Most of the investigators gave no data on the surface area or surface characteristics of the adsorbent. The surface areas of charcoals generally range from 300 to 3000 m^2/g but only a rough dependence of adsorption on the surface area is observed.

There are some data available on the surface area of bulk graphite.[6] It is known that the surface area, and hence, presumably, the adsorption characteristics of graphite, may be changed by oxidation of the surface. This would occur when graphite is heated at 400°C or above to remove the adsorbed gases. The oxygen content of the desorbed gases is always very low, while CO_2 and CO are present in greater abundances, indicating surface disruption when the oxygen is removed. The density of graphite measured by weighing in helium shows an apparent increase after oxidation of the graphite; it is likely that some pores are opened by oxidation of graphite crystallites which blocked them, and become accessible to the small helium atom.[6] These same investigators found that the surface area measured by the B.E.T. method, with either argon or nitrogen, after outgassing at 370°C, had increased to 135% of the value obtained after outgassing at room temperature; another 6% increase was observed after outgassing at 800°C.

The surface area of bulk graphite is usually 0.5–1.5 m^2/g, but this area is increased considerably by grinding. Roberts[6] found that graphite dust of 40–70 mesh had a surface area of 2.33 m^2/g; the same sample after grinding to less than 200 mesh had a surface area of 8.1 m^2/g.

A comparison of the adsorption determined for xenon on AGOT-grade graphite with that reported by Lad and Young[3] on charcoals appears later in this report.

EXPERIMENTAL

All experimental tests run in this study were carried out on AGOT-grade graphite. AGOT was selected because its relatively high porosity portended greater adsorption than that expected for more highly impermeable grades; more material adsorbed would result in more accurate measurements. The two graphite samples utilized in the two types of measurements outlined below were cut from the same AGOT block to help ensure

[6]L. E. J. Roberts, E. A. Harper, and C. T. Small, The Microstructure of Graphite, AERE C/R-882 (May 1952).

uniformity. Both were pretreated by heating to 960°C under vacuum for 16 hr to remove adsorbed gases.

Two types of adsorption measurements were made. In the first type the equilibrium gas consisted of the pure gas. The method consisted essentially in admitting a measured quantity of xenon (or argon) into the container holding the previously evacuated and desorbed graphite specimen, and measuring the resulting equilibrium pressure. Two isotherms (0 and 80°C) were determined for xenon by this method with measurements at ten equilibrium pressures on each. Isotherms at 0 and -83°C for argon were also determined[7] by this method.

The equilibrium gas in the second type of measurement (performed by the authors in this laboratory) consisted of xenon-helium mixtures in which the xenon was the minor constituent (0.5 to 9.5 mole %). The method consisted in circulating the xenon-helium gas mixture through the graphite, which was enclosed in a gastight, close-fitting Inconel vessel. This was done by providing a 1/4-in. hole, threaded at the top, down most of the length of the graphite cylinder, into which was screwed a fitting and tube leading to the circulation pump. The gas mixture was pumped into the vessel around the outside of the graphite and flowed through the graphite to the inner channel, where it was led back to the pump for recycling. The pressure drop across the graphite cylinder was kept as low as possible and was usually about 2 cm above the static pressure (with the pump off) on the outside and 1.0 cm below on the inside of the graphite. Adsorption pressures were assumed to be equal to the static pressure.

After the gas was circulated for 10–15 min, the pump was stopped and the mixture allowed to equilibrate for about 45 min. The process was repeated over a 4- to 5-hr period. No data were acquired to show the minimum adsorption time necessary, but several investigators found that 15 to 30 min was entirely adequate to ensure the establishment of equilibrium in the adsorption of gases. However, because of the relatively large

---

[7]All these measurements using the pure gas as equilibrium gas, along with surface-area measurements by the B.E.T. method, were made at the Barrier Testing Laboratory at the Oak Ridge Gaseous Diffusion Plant under the supervision of P. G. Dake and E. A. Woy.

bulk (600 g) of the graphite a considerably longer period of equilibration time was allowed.

It was presumed that after equilibrium had been reached the composition of the gas in the dead space of the graphite (that is, in equilibrium with the graphite surface) was the same as the gas in the pump and lines leading to it. By means of adequately located valves, the adsorption chamber could be closed off and samples of the gas in the pump and lines taken for analysis. Such samples are referred to as the "equilibrium gas." The pump and lines were then evacuated and the graphite sample heated to 600°C to desorb the xenon. The desorbed xenon thus enriched the gas which was still confined in the dead space and in the pores of the graphite, and, after mixing by cycling, this "desorbed gas" mixture was sampled for analysis.

The volume of the dead space in the adsorption vessel was determined by evacuating and then filling with helium under known conditions. From the analyses of the equilibrium gas and the desorbed gas, and knowing the dead volume, the amount of adsorbed xenon could be determined.

Figure 1 is a line drawing showing the essential parts of the adsorption apparatus. It was possible to prepare and store a standard gas mixture in the gasometer, G. The mixture could be transferred to the adsorption vessel, A, by means of the glass manifold, which also held the gas sampling bulbs, S. A circulating pump, P, could, with the proper manipulation of needle valves, be used to mix the gases during preparation of a standard gas mixture or could be used to force the gas mixture through the graphite in the adsorption vessel.

Standard gas mixtures were prepared by evacuating the gasometer and the line leading to it from the gas supply. Xenon was admitted until the approximate pressure desired was obtained, and the pressure was read on an open-end mercury manometer. The gasometer stopcock was closed and the gas line again evacuated. Helium was next admitted until a total pressure of nearly 1 atm was reached, and this pressure was also read on the manometer. Care was taken to minimize the diffusion of xenon out of the gasometer by maintaining a positive helium pressure while it was added to the gasometer. Assuming the ideal gas laws to hold, the fraction of xenon was calculated by dividing its pressure by the total pressure. The gases

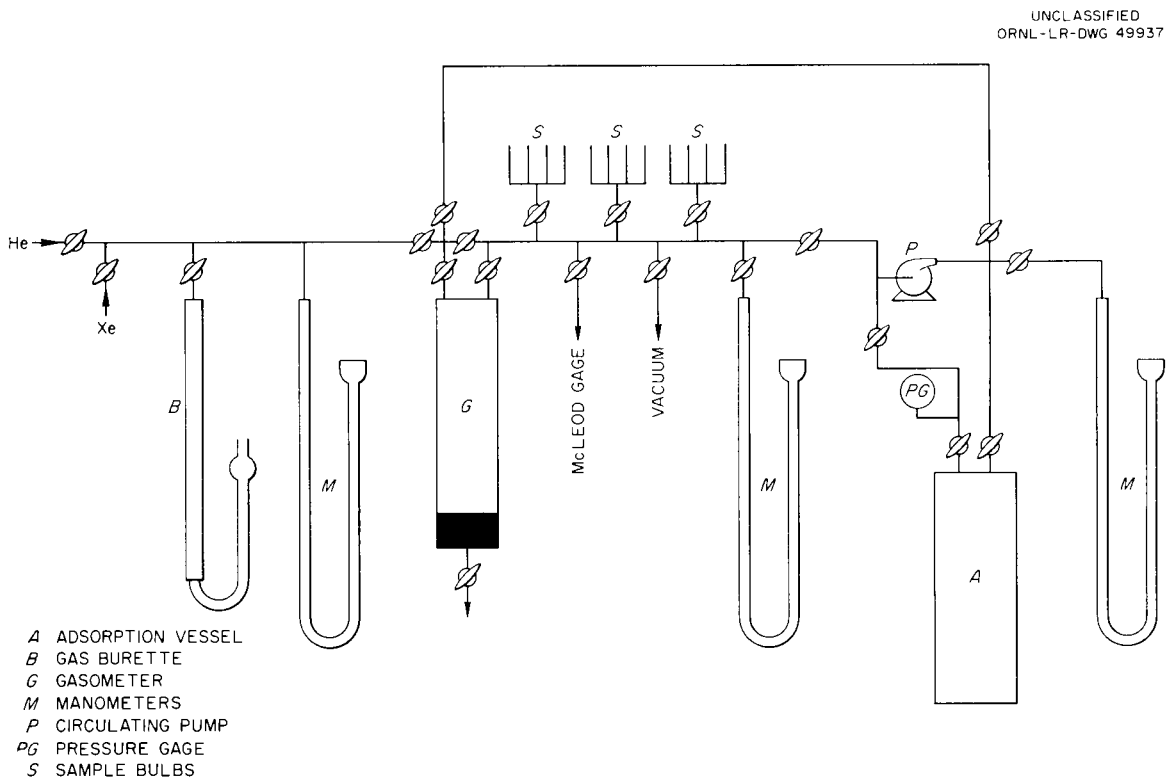

Fig. 1. Adsorption Apparatus.

could be allowed to mix by standing, or the gasometer could be opened to the evacuated manifold and pump for forced mixing. It was difficult to read the manometer to better than 1 mm at each end. With a partial pressure of xenon of about 75 mm, this could cause an error of up to ±2% in calculating the composition of the gas mixture.

Samples of the standard gas mixtures were submitted to the Mass Spectrometer Laboratory along with samples from the experiments and served as checks on the analytical procedure. Reasonably good agreement between the calculated and the analyzed values was found, as shown in Appendix A. A few samples were analyzed by gas chromatography. A comparison of results obtained by the two analytical methods is shown in Appendix B. Appendix C gives an indication of the amount of variation in the mass spectrometric analyses on supposedly identical samples.

The calculations of the adsorption by this second method were made with two assumptions: (1) that helium adsorption was negligible[3,6] at these temperatures, and (2) that xenon adsorption would be negligible at

the desorption temperature of 600°C. Extrapolation of the data (discussed later in the report) indicates that this second assumption is not entirely valid. A xenon partial pressure in the desorbed gas of from 7 to 70 mm Hg existed during the 600°C desorption period, which (based on Fig. 8) required corrections of the values as first calculated amounting to from 5 to 7% for the 80°C points, about 2-1/2% at 0°C, and less than 1% for the -79°C data.

RESULTS

The adsorption isotherms at 0 and 80°C obtained by using pure xenon as the equilibrium gas are shown as the solid lines and points in Fig. 2.

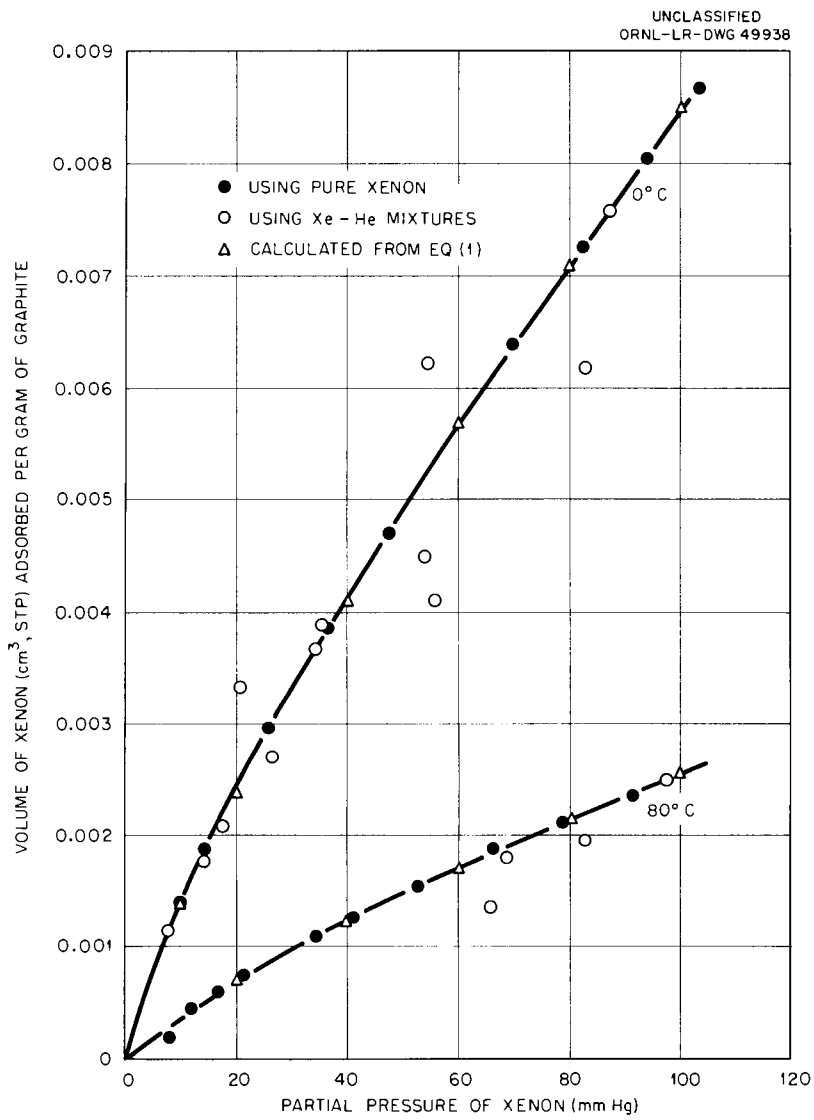

Fig. 2. Comparison of Two Xenon Isotherms Each Determined by Two Methods.

The isotherms obtained at these same temperatures using xenon-helium mixtures as the equilibrium gas are shown as open circles. Although the data obtained by the latter method are considerably more scattered, it appears that essentially the same results are obtained by the two methods. In other words, the presence of the relatively large proportion of helium has a negligible effect on the adsorption of xenon. Xenon isotherms at five different temperatures are shown in Fig. 3. Argon isotherms on the same AGOT sample are shown in Fig. 4.

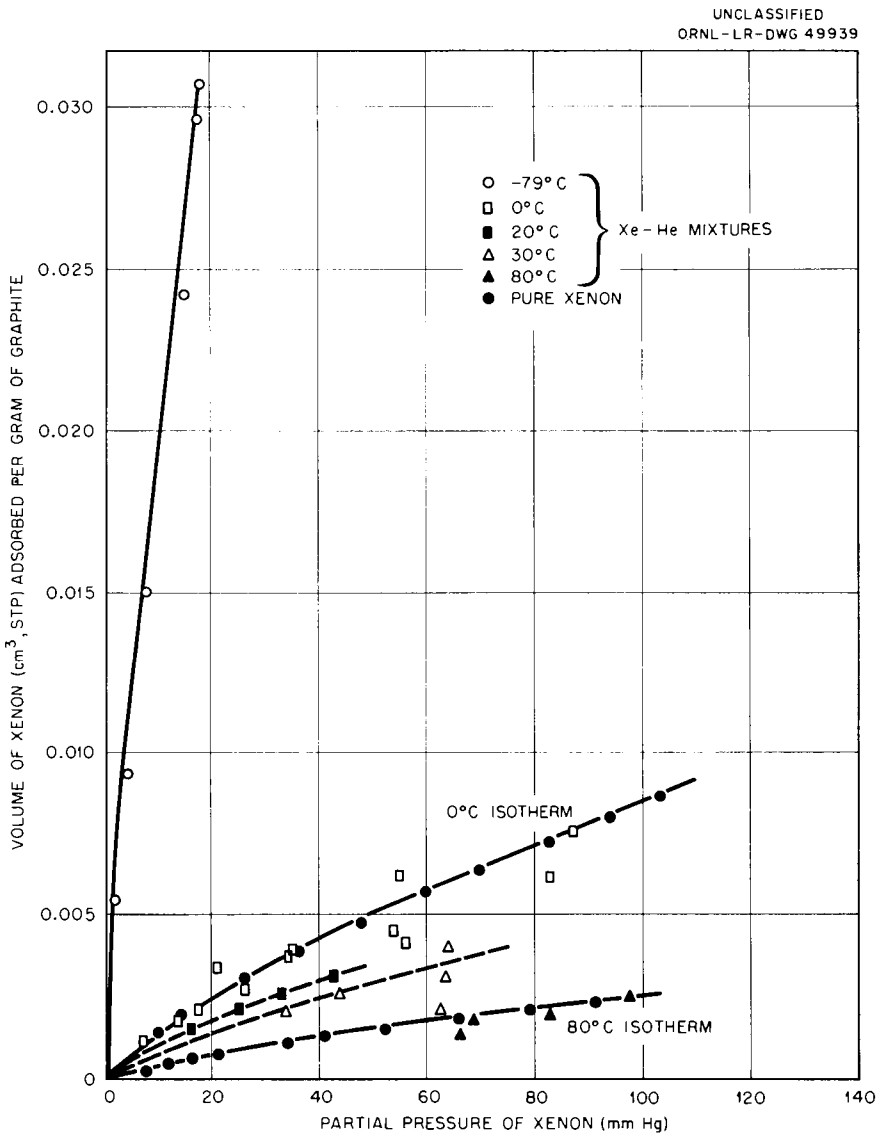

Fig. 3. Adsorption of Xenon on AGOT-Grade Graphite at Various Temperatures.

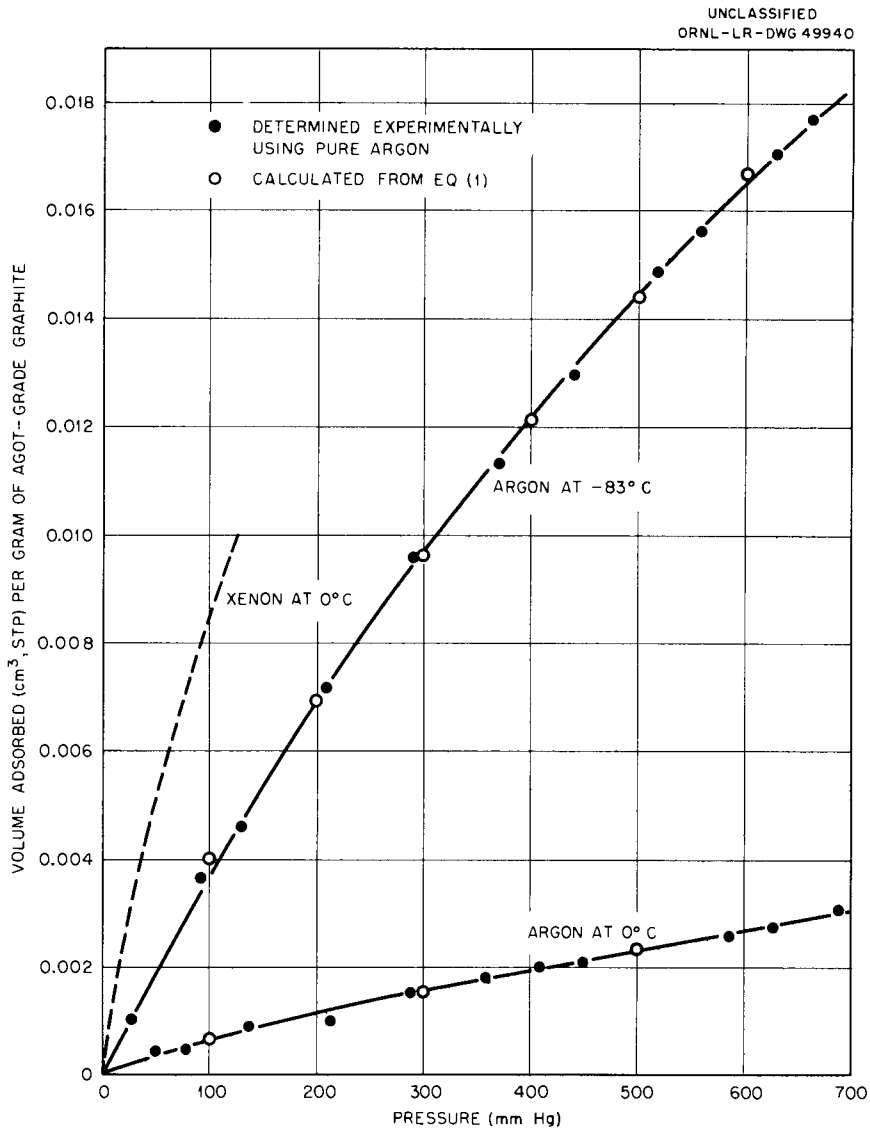

Fig. 4. Argon Isotherms on AGOT Graphite.

An analysis of these isotherms shows that they obey the Freundlich-type equation

$$a = bp^{0.8} \quad , \tag{1}$$

where a is the volume adsorbed (cm^3, STP, per gram of graphite), and p is the equilibrium pressure in millimeters of mercury. The 0.8-power pressure dependence applies to both xenon and argon as shown in Figs. 2 and 4. Values of b calculated for both gases at two temperatures each are shown in Table 1.

Table 1. Value of b in Freundlich Equation $a = bp^{0.8}$, as Applied to Xenon and Argon on AGOT-Grade Graphite

Gas	-83°C	0°C	+80°C
Argon	1.00×10^{-4}	1.60×10^{-5}	
Xenon		2.14×10^{-4}	6.33×10^{-5}

Comparison with Charcoal Data

The search of the literature revealed some data on the adsorption of xenon on charcoals,[8-10] but none were found on the adsorption of xenon on graphite. The effective surface area of charcoals usually varies from 300 to 3000 m^2/g while that for graphite runs from 0.5 to 1.5 m^2/g, so that a comparison of the two adsorbent media should be made on an area rather than a weight basis. Most of the charcoal data in the literature contained no surface-area measurements. However, Lad and Young[8] obtained data on the adsorption of xenon on seven different types of charcoals, together with surface-area and density data. A comparison of the 25°C isotherm[11] for the AGOT graphite with those reported by Lad and Young for the seven types of charcoal (both on a surface-area basis) are shown in Fig. 5, and a similar comparison at 0°C is shown in Fig. 6. The seven charcoals are identified in Table 2. The amount of adsorption exhibited on the various charcoals varied from the highest to the lowest by a factor of approximately 16. Thus it would be difficult to predict the amount of adsorption on graphite from charcoal data, even though the isotherms on AGOT graphite fell within the range of those found on various charcoals and the pressure dependence in the Freundlich equation in both cases is to the 0.8 power.

---

[8]R. A. Lad and T. F. Young, The Adsorption of Xenon on Charcoals at Room Temperature, CC-3106 (Aug. 1, 1945).

[9]R. A. McNees, private communication (to be published), ORNL; HRP Quar. Prog. Rep. Jan. 31, 1958, ORNL-2493, p 157.

[10]K. Peters and K. Weil, Z. physik. Chem. A148, 1 (1930).

[11]Interpolated from experimentally determined isotherms shown in Figs. 2 and 3.

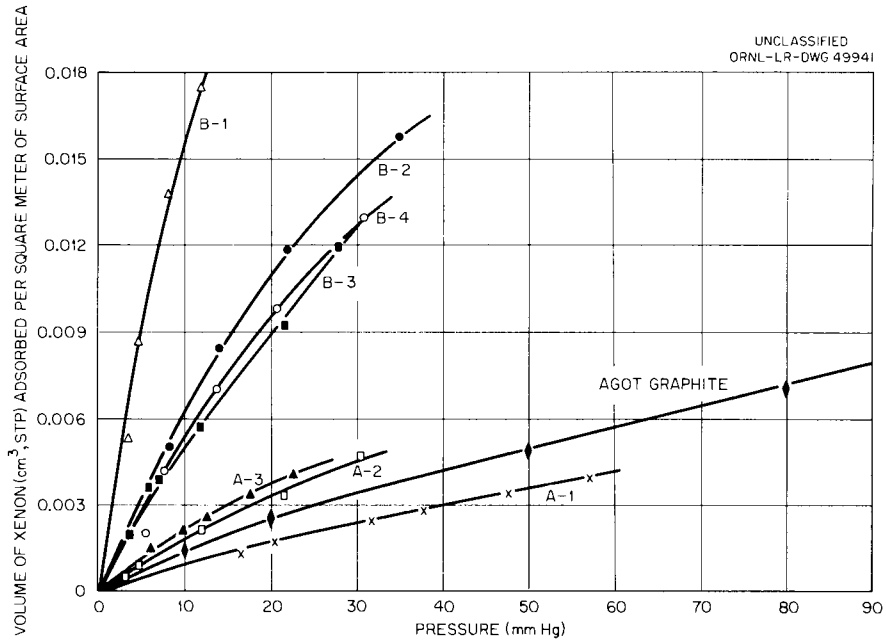

Fig. 5. Xenon Isotherms at 25°C for Charcoals (Lad and Young[8]) Compared to AGOT Graphite.

Heat of Adsorption

The adsorption isotherms may be used to calculate the heat of adsorption. The heat of adsorption, generally speaking, will be found to vary with the amount of gas adsorbed, particularly at pressures where the surface is not completely covered with gas molecules. Heats of adsorption are therefore calculated for particular volumes of adsorbed gas.

The heat of adsorption can be calculated from any two isotherms using the integrated form of the Clausius-Clapeyron equation:

$$\Delta H = 2.303R \frac{\log P_2 - \log P_1}{(1/T_2) - (1/T_1)} , \qquad (2)$$

or it can be obtained from the slope of the isosteres (log p vs 1/T). Three such isosteres are shown in Fig. 7. Because the isotherms obtained using pure xenon at 0 and 80°C are probably more accurate than the others, the isosteres are drawn as straight lines through these points. Points from the -79°C isotherms are also shown.

Heats of adsorption calculated by Eq. (2) from the 0 and 80°C data for five different adsorbed volumes are given in Table 3. The values of

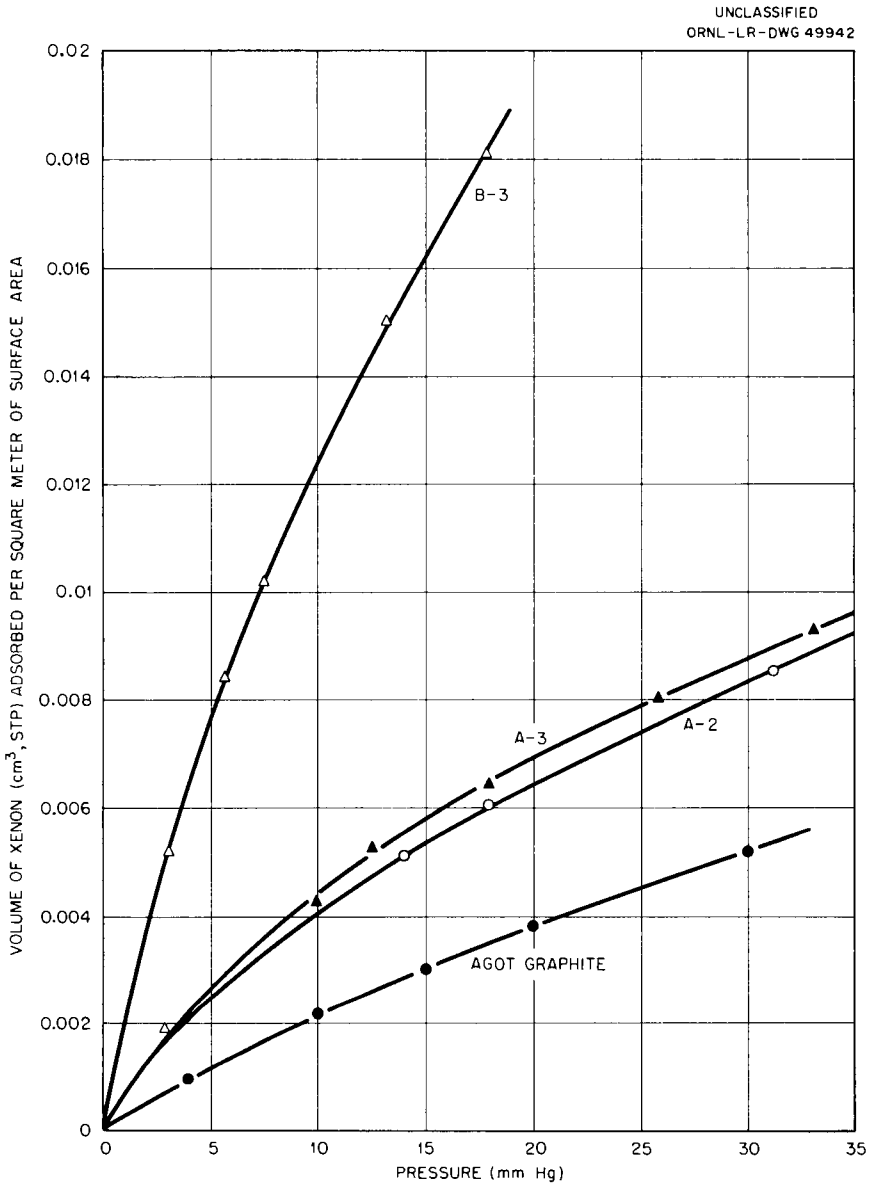

Fig. 6. Xenon Isotherms (0°C) on Charcoals (Lad and Young[8]) Compared to AGOT Graphite.

Table 2. Properties of the Charcoals Used by Lad and Young* and of AGOT-Grade Graphite

Charcoal	Apparent Density (g/cm^3)	Area (m^2/g)	Preparation
A-1	0.31	2800	Made from wood flour; activated with $ZnCl_2$
A-2	0.35	2400	Made from wood flour; activated with $ZnCl_2$
A-3	0.35	2400	Made from wood flour; activated with $ZnCl_2$
B-1	0.69	400	Made from coal; activated with steam
B-2	0.56	660	Made from coal; activated with steam
B-3	0.51	663	Made from coal; activated with steam
B-4	0.56	600	Made from coal; activated with steam
AGOT-grade graphite		0.64**	

*R. A. Lad and T. F. Young, The Adsorption of Xenon on Charcoals at Room Temperature, CC-3106 (Aug. 1, 1945).

**Measured at the Barrier Testing Laboratory at ORGDP.

3500–3700 cal/mole are fairly close to the heat of vaporization of xenon, which is reported by Peters and Weil[10] as 3270 cal/mole.

This agreement, plus the fact that the adsorption process appears to be completely reversible (as evidenced by the agreement between the two experimental methods), indicates that the adsorption of xenon on graphite may be classified as physical adsorption rather than chemisorption.

Extrapolation to Reactor Temperatures

In order to estimate the amount of xenon adsorption to be expected at reactor temperatures, a straight-line extrapolation of the isosteres

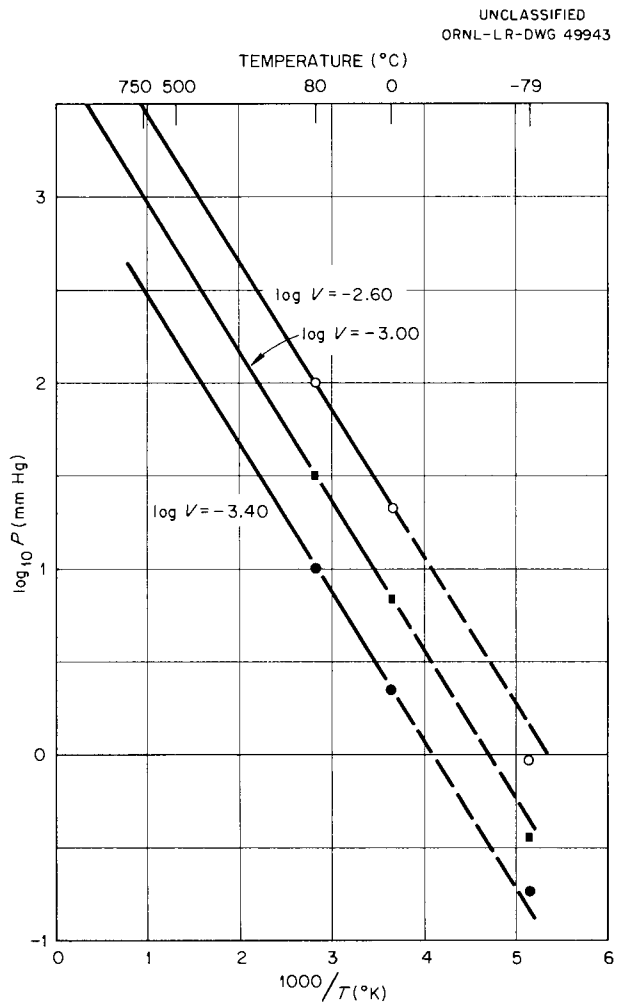

Fig. 7. Adsorption Isosteres Extrapolated to 750°C.

Table 3. Heat of Adsorption of Xenon on AGOT-Grade Graphite Calculated from 0 and 80°C Isotherms

Volume Adsorbed (cm^3, STP, per gram of graphite)	Heat of Adsorption (cal/mole)
0.0005	3530
0.0010	3630
0.0015	3660
0.0020	3700
0.0025	3710

to 750°C was made in Fig. 7. Log plots of isotherms at 500 and 750°C obtained from this extrapolation are shown in Fig. 8, along with the 0 and 80°C isotherms. The value of b in Eq. (1) can be obtained from the intercepts of these log plots. Thus for 500 and 750°C the values of b are 6.5×10^{-6} and 4.1×10^{-6} respectively. An extrapolation may also be made on a log plot of the isobars (Fig. 9).

It would appear from these curves that at temperatures of 500 to 750°C the adsorption of xenon on AGOT graphite would be less than 1×10^{-5} cm^3 (STP) per gram at a xenon partial pressure of 1 mm Hg and approximately 3×10^{-5} cm^3/g at 10 mm Hg. At 1 atm approximately 1×10^{-3} cm^3 (STP) would adsorb at these temperatures. The length of the extrapolation should be kept in mind when considering the validity of these values.

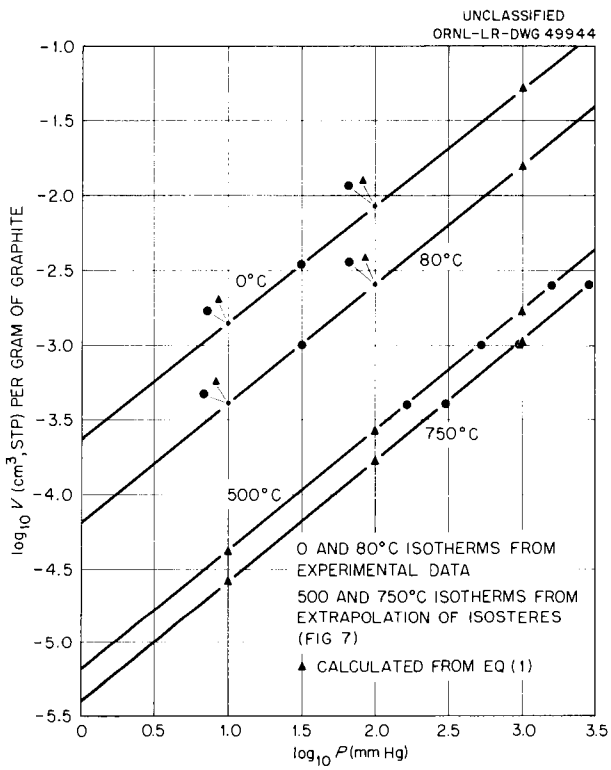

Fig. 8. Xenon Isotherms on AGOT Graphite.

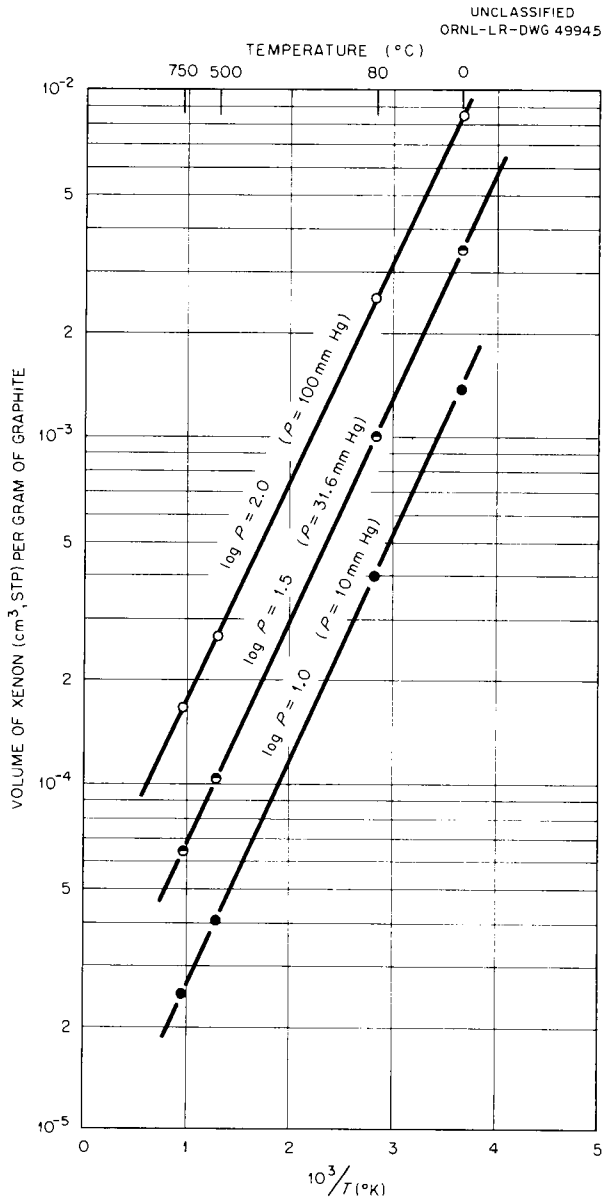

Fig. 9. Adsorption Isobars Extrapolated to 750°C.

CONCLUSIONS

The following conclusions were reached as a result of this study:

1. The presence of relatively large proportions of helium has a negligible effect on the observed adsorption of xenon at temperatures above 0°C.

2. The adsorption isotherms for both xenon and argon on AGOT graphite over the range studied and for xenon on various charcoals at room

temperature as reported in the literature may all be expressed by means of Freundlich's equation showing 0.8-power pressure dependence.

3. The temperature dependence of the adsorption behavior of xenon shows a heat of adsorption of about 3500 cal/mole, which is close to the published heat of condensation. This is an indication that the adsorption is physical.

4. The data for adsorption of xenon on various types of charcoal as reported in the literature exhibit too great a spread (more than an order of magnitude) to be useful in predicting the adsorption of xenon on graphite.

ACKNOWLEDGMENTS

The authors wish to thank P. G. Dake and E. A. Woy of the Barrier Testing Laboratory at the Oak Ridge Gaseous Diffusion Plant for the surface area and adsorption measurements made at that laboratory.

The assistance of W. D. Harman and his associates, who were responible for the mass-spectrometric analysis of the many samples, is gratefully acknowledged.

Appendix A

Comparison of Calculated and Analyzed Percentage of Xenon in Standard Mixtures

Calculated*	Mass Spectrometric Analyses (Average)
9.67	9.76
9.69	9.34
4.50	4.68
4.71	4.83
9.91	9.67
9.77	9.78

*From mixing of known volumes of xenon and helium.

Appendix B

Comparison of Mass Spectrometric Analyses with Analyses by Gas Chromatography

Sample No.	Mass Spectrometric		By Gas Chromatography	
	Number of Determinations	Average Value and Average Deviation	Number of Determinations	Average Value and Average Deviation
SA-8	6	10.68 ± 0.07*	2	10.73 ± 0.06*
SA-19	5	9.51 ± 0.07*	2	9.57 ± 0.04*
18X-6	5	8.92 ± 0.19	1	9.65
18X-12	5	8.78 ± 0.23	1	9.95
19X-6	5	7.21 ± 0.09	2	8.05 ± 0.04
19X-12	4	9.25 ± 0.04	2	11.10 ± 0.27
22X-6	4	7.00 ± 0.04	2	7.15 ± 0.11
22X-12	5	9.53 ± 0.04	4	9.81 ± 0.28
23X-12	5	8.91 ± 0.06	2	8.28 ± 0.10
33X-12	5	4.25 ± 0.03	2	4.39 ± 0.29
SX-72	10	9.78 ± 0.12	2	8.52 ± 0.05

*The first two samples were analyzed for argon in helium, the remainder for xenon in helium.

Appendix C

Precision of Mass Spectrometric Xenon Analyses*

Run No.	Number of Analyses Discarded	Number of Analyses Included in Average	Average Mole % Xenon and Average Deviation
Stand. 1	0	10	9.76 ± 0.10
12-a**	0	6	2.31 ± 0.08
12-b**	0	6	12.19 ± 0.08
13-a	0	6	2.28 ± 0.08
13-b	0	6	12.02 ± 0.12
14-a	0	6	2.00 ± 0.12
14-b	0	6	10.14 ± 0.08
15-a	0	6	7.48 ± 0.06
15-b	0	6	9.35 ± 0.11
16-a	0	6	8.50 ± 0.19
16-b	0	6	10.01 ± 0.16
Stand. 2	1	9	9.34 ± 0.15
17-a	0	5	8.34 ± 0.06
17-b	2	3	9.42 ± 0.11
18-a	0	5	8.92 ± 0.19
18-b	0	5	8.78 ± 0.23
19-a	0	5	7.21 ± 0.09
19-b	1	4	9.25 ± 0.04
20-a	2	4	8.81 ± 0.14
20-b	1	4	9.55 ± 0.20
21-a	0	5	7.52 ± 0.06
21-b	0	6	9.42 ± 0.10
22-a	1	4	7.00 ± 0.04
22-b	0	5	9.53 ± 0.04
23-a	0	6	6.27 ± 0.09
23-b	0	5	8.91 ± 0.06
Stand. 3	1	11	4.68 ± 0.10
24-a	0	6	3.05 ± 0.22
24-b	1	5	4.70 ± 0.04
25-a	0	6	3.41 ± 0.07
25-b	0	6	4.96 ± 0.17
26-a	0	6	3.55 ± 0.19
26-b	0	6	4.85 ± 0.10
28-a	2	4	3.37 ± 0.03
28-b	1	5	5.30 ± 0.02
Stand. 4	2	10	4.83 ± 0.12
29-a	0	6	0.88 ± 0.04
29-b	0	5	5.53 ± 0.09
30-a	0	6	0.56 ± 0.06
30-b	1	4	5.16 ± 0.06
31-a	0	6	0.66 ± 0.06
31-b	0	6	4.53 ± 0.03

Appendix C (continued)

Run No.	Number of Analyses Discarded	Number of Analyses Included in Average	Average Mole % Xenon and Average Deviation
32-a	1	5	3.35 ± 0.07
32-b	0	6	4.42 ± 0.08
33-a	0	5	3.13 ± 0.11
33-b	0	5	4.25 ± 0.03
34-a	1	5	3.66 ± 0.09
34-b	0	6	4.67 ± 0.06
35-a	0	6	3.48 ± 0.13
35-b	0	6	4.51 ± 0.08
Stand. 5	1	10	9.67 ± 0.14
36-a	1	5	7.63 ± 0.06
36-b	0	6	10.53 ± 0.08
37-a	1	5	8.25 ± 0.10
37-b	1	5	10.66 ± 0.16
38-a	0	5	7.29 ± 0.30
38-b	0	6	10.00 ± 0.30
39-a	1	5	8.57 ± 0.07
39-b	2	4	10.50 ± 0.09
40-a	2	4	8.66 ± 0.08
40-b	1	5	10.64 ± 0.15
41-a	1	5	8.21 ± 0.25
41-b	1	5	10.01 ± 0.16
42-a	1	5	7.08 ± 0.17
42-b	0	5	9.01 ± 1.15
Stand. 6	1	10	9.78 ± 0.11
43-a	0	6	9.30 ± 0.18
43-b	1	5	10.29 ± 0.08
44-a	1	5	9.27 ± 0.07
44-b	1	5	10.18 ± 0.07
45-a	0	6	9.12 ± 0.09
45-b	0	6	10.11 ± 0.05
Total	35	410	Over-all av. dev. = ± 0.12

*Some of the variation in the reported values might possibly be due to imperfect mixing of the gas before sampling or to air leakage.

**a – equilibrium gas samples; b – desorbed gas samples.

ORNL-2955
UC-4 — Chemistry-General
TID-4500 (15th ed.)

INTERNAL DISTRIBUTION

1. C. E. Center
2. A. M. Weinberg
3. L. B. Emlet (K-25)
4. J. P. Murray (Y-12)
5. J. A. Swartout
6. G. E. Boyd
7. R. A. Charpie
8. W. H. Jordan
9. A. H. Snell
10. C. E. Winters
11. R. B. Briggs
12. J. A. Lane
13. H. G. MacPherson
14. S. C. Lind
15. P. R. Bell
16. D. S. Billington
17. E. P. Blizard
18. C. J. Borkowski
19. J. A. Cox
20. F. L. Culler
21. J. L. Fowler
22. J. H. Frye, Jr.
23. J. M. Googin (Y-12)
24. J. H. Gillette
25. W. R. Grimes
26. A. Hollaender
27. A. S. Householder
28. M. T. Kelley
29. T. A. Lincoln
30. R. S. Livingston
31. K. Z. Morgan
32. M. L. Nelson
33. H. E. Seagren
34. E. D. Shipley
35. E. H. Taylor
36. C. P. Keim
37. R. S. Cockreham
38. P. M. Reyling
39. M. J. Skinner
40. G. C. Williams
41. A. L. Boch
42. E. G. Bohlmann
43. M. A. Bredig
44. F. R. Bruce
45. J. E. Cunningham
46. J. H. Crawford, Jr.
47. A. P. Fraas
48. C. S. Harrill
49. R. N. Lyon
50. W. D. Manly
51. H. F. McDuffie
52. A. J. Miller
53. L. G. Alexander
54. C. D. Susano
55. C. F. Baes
56. C. J. Barton
57. M. Blander
58. F. F. Blankenship
59. W. E. Browning
60. S. Cantor
61. D. R. Cuneo
62. R. B. Evans
63. H. Insley
64. E. V. Jones
65. G. W. Keilholtz
66. M. J. Kelly
67. K. B. Brown
68. W. L. Marshall
69. R. E. Moore
70. G. I. Cathers
71. R. F. Newton
72. L. G. Overholser
73. W. T. Rainey
74. J. H. Shaffer
75. M. D. Silverman
76. B. A. Soldano
77. R. A. Strehlow
78. R. E. Thoma
79-128. G. M. Watson
129. W. T. Ward
130. J. S. Drury
131. E. E. Hoffman
132. B. W. Kinyon
133. R. B. Lindauer
134. A. Taboada
135. G. M. Adamson
136. S. E. Beall
137. A. M. Billings
138. S. E. Bolt
139. J. R. Brown

140. W. D. Burch
141. R. H. Chapman
142. R. D. Cheverton
143. H. C. Claiborne
144. E. L. Compere
145. J. S. Culver
146. D. G. Davis
147. R. J. Davis
148. J. L. English
149. D. E. Ferguson
150. C. H. Gabbard
151. W. R. Gall
152. R. S. Greeley
153. J. C. Griess
154. P. A. Haas
155. P. H. Harley
156. P. N. Haubenreich
157. J. W. Hill
158. E. C. Hise
159. G. H. Jenks
160. D. T. Jones
161. P. R. Kasten
162. N. A. Krohn
163. C. G. Lawson
164. W. H. Lewis
165. R. A. Lorenz
166. M. I. Lundin
167. J. P. McBride
168. H. A. McLain
169. R. A. McNees
170. J. R. McWherter
171. C. S. Morgan
172. R. L. Moore
173. L. F. Parsly, Jr.
174. R. L. Pearson
175. F. N. Peebles
176. M. L. Picklesimer
177. S. A. Reed
178. D. M. Richardson
179. R. C. Robertson
180. H. C. Savage
181. C. H. Secoy
182. C. L. Segaser
183. I. Spiewak
184. D. G. Thomas
185. M. Tobias
186. D. S. Toomb
187. W. E. Unger
188. R. Van Winkle
189. K. W. West
190. F. C. Zapp
191. J. W. Allen
192. M. Bender
193. W. F. Boudreau
194. E. J. Breeding
195. T. E. Cole
196. J. H. Coobs
197. J. A. Conlin
198. W. B. Cottrell
199. H. N. Culver
200. J. H. DeVan
201. L. M. Doney
202. D. A. Douglas
203. L. C. Emerson
204. E. P. Epler
205. H. L. Falkenberry
206. J. Foster
207. G. A. Garrett (K-25)
208. B. L. Greenstreet
209. E. Guth
210. R. F. Hibbs (Y-12)
211. M. R. Hill
212. H. W. Hoffman
213. P. R. Kasten
214. J. J. Keyes
215. R. B. Korsmeyer
216. S. A. Levin (K-25)
217. E. R. Mann
218. H. C. McCurdy
219. W. B. McDonald
220. F. R. McQuilkin
221. H. J. Metz
222. F. H. Neill
223. P. Patriarca
224. F. S. Patton (Y-12)
225. A. M. Perry
226. D. Phillips
227. G. Samuels
228. H. W. Savage
229. A. W. Savolainen
230. O. Sisman
231. E. Storto
232. R. D. Stulting
233. D. B. Trauger
234. E. Von Halle (K-25)
235. C. S. Walker
236. J. L. Wantland
237. J. C. White
238. E. A. Wick
239. J. Zasler
240. P. H. Emmett (consultant)
241. H. Eyring (consultant)
242. D. G. Hill (consultant)

243. C. E. Larson (consultant)
244. W. O. Milligan (consultant)
245. J. E. Ricci (consultant)
246. G. T. Seaborg (consultant)
247. E. P. Wigner (consultant)
248. L. Brewer (consultant)
249. F. Daniels (consultant)
250. F. T. Miles (consultant)
251. Biology Library
252. Health Physics Library
253-254. Central Research Library
255-274. Laboratory Records Department
275. Laboratory Records, ORNL R.C.
276. Reactor Experimental Eng. Library
277. ORNL Y-12 Technical Library

EXTERNAL DISTRIBUTION

278-283. M. C. Cannon, Utah State University
284. Division of Research and Development, AEC, Washington
285. Division of Research and Development, AEC, ORO
286. Division of Reactor Development, AEC, Washington
287. Division of Reactor Development, AEC, ORO
288-844. Given distribution as shown in TID-4500 (15th ed.) under Chemistry-General category (75 copies – OTS)