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DENSITIES OF SOME MOLTEN SALT MIXTURES CONTAINING NITRATES

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ORNL-2762

Contract No. W-7405-eng-26

METALLURGY DIVISION

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DATE ISSUED

AUG 6 1959

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G. Pedro Smith, Guy F. Petersen, and William M. Ewing

Values of the densities of molten salt mixtures have been determined as needed for the computation of molar extinction coefficients from absorption spectra. Constants in the density function measured during the past eighteen months are reported here. A report of experimental details and estimates of limiting errors will be published upon completion of a full statistical analysis of the data.

Experimental

Densities were obtained with a high precision apparatus operating on the principle of determining the buoyancy of a platinum bicone immersed in the fused salt and suspended by means of a fine platinum wire from one arm of an analytical balance. The molten salts were appropriately purified and were measured under an inert atmosphere. Careful consideration was given to the measurement and control of temperature, to the elimination of thermal and compositional gradients, and to errors arising from decomposition and volatilization of the salts.

Results

The results of the density measurements are reported in the accompanying tables in terms of the constants a and b of the conventional density function

$$\rho = a - bt$$

where ρ is density in g/cm^3, t is the temperature in °C, and a and b are constants for a fixed composition. The data were fitted to this equation by the method of least squares. The adequacy of fitting is indicated in the tables by standard deviation (Stand. Dev.) between the measured density values and those computed from the least-squares equation. In several instances, determinations were made at only one or two temperatures. For these the density is listed in the "a" column and the corresponding temperature in the "Temp. Range" column.

It is to be noted that the standard deviation is only a measure of linearity for these data and is by no means a measure of over-all accuracy or reliability. The reliability of these data varies considerably. Thus, the values for the KNO_3–$LiNO_3$ binary system are based on repeated determinations at many temperatures each while the values for the KNO_3–$Zn(NO_3)_2$ binary system represent single determinations at single temperatures. Intermediate to these extremes are the 30 mole % $Ca(NO_3)_2$-70 mole % KNO_3 mixture for which determinations were made at eleven temperatures and the 30 mole % $Sr(NO_3)_2$-70 mole % KNO_3 mixture for which determinations were made at only four temperatures. Following complete statistical evaluation of the data, it is probable that the number of significant figures will be decreased for a number of compositions.

In several instances the temperature range is given as exceeding 500°C. For these instances it is likely that decomposition occurred. However, this was not reflected in a deviation of the higher temperature values from linearity.

Table I lists our values for the pure, alkali nitrates (except $RbNO_3$). These are in substantial agreement with older, precision determinations. In particular, the constants for $NaNO_3$ were very carefully checked and found to lie intermediate to previous precision determinations which were already in substantial agreement.

The unit of concentration for binary mixtures (Tables II and III) is mole fraction based on gram-formula weights for the formulae as written. The unit of concentration for reciprocal systems (Table IV) is the ionic fraction based on the gram-formula weights of the ions taken to be K^+, Li^+, NO_3^-, and Cl^- for the KNO_3–$LiCl$ reciprocal system and K^+, Cd^{++}, NO_3^-, and Cl^- for the KNO_3–$CdCl_2$ reciprocal system.

TABLE I

PURE ALKALI NITRATES

Nitrate	a	b	Stand. Dev.	Temp. Range
	g/cm^3	$g/cm^3/°C \times 10^3$	$g/cm^3 \times 10^4$	°C
$LiNO_3$	1.9221	0.5557	6	276 – 420
$NaNO_3$	2.1248	0.7010	5	320 – 452
KNO_3	2.1101	0.7329	8	346 – 505
$CsNO_3$	3.2784	1.1353	4	429 – 553

TABLE II

BINARY SYSTEMS - MIXED CATIONS

Comp.	a	b	Stand. Dev.	Temp. Range
Mole Fraction	g/cm^3	$g/cm^3/°C$ x 10^3	g/cm^3 x 10^4	°C
		KNO_3–$LiNO_3$ System		
$LiNO_3$				
0.107	2.1017	0.7352	3	318 – 452
0.245	2.0830	0.7290	6	294 – 425
0.375	2.0553	0.6964	4	306 – 454
0.500	2.0334	0.6827	7	275 – 473
0.625	2.0100	0.6572	4	328 – 476
0.680	1.9965	0.6376	9	219 – 445
0.801	1.9742	0.6233	2	264 – 350
0.876	1.9540	0.5988	4	257 – 403
		KNO_3–$Sr(NO_3)_2$ System		
$Sr(NO_3)_2$				
0.10	2.2175	0.7401	5	361 – 501
0.20	2.3162	0.7373	14	348 – 497
0.30	2.4025	0.7210	2	421 – 452
		KNO_3–$Ba(NO_3)_2$ System		
$Ba(NO_3)_2$				
0.10	2.3047	0.7727	3	324 – 520
0.20	2.4749	0.7946	8	377 – 518
0.30	2.6289	0.8048	4	438 – 517

(continued)

TABLE II (continued)

Comp.	a	b	Stand. Dev.	Temp. Range
Mole Fraction	g/cm^3	$g/cm^3/°C \times 10^3$	$g/cm^3 \times 10^4$	°C
		KNO_3–$Ca(NO_3)_2$ System		
$Ca(NO_3)_2$				
0.10	2.1319	0.7093	3	396 – 469
0.20	2.1715	0.7348	11	296 – 470
0.30	2.1924	0.7129	5	231 – 449
		KNO_3–$Zn(NO_3)_2$ System		
$Zn(NO_3)_2$				
0.20	2.064	-----		247.5
0.40	2.142	-----		205.8
		KNO_3–$Cd(NO_3)_2$ System		
$Cd(NO_3)_2$				
0.33	2.419	-----		223.5
0.55	2.710	-----		201.0
	2.690	-----		221.8

TABLE III

BINARY SYSTEMS - MIXED ANIONS

Comp.	a	b	Stand. Dev.	Temp. Range
Mole Fraction	g/cm^3	$g/cm^3/°C \times 10^3$	$g/cm^3 \times 10^4$	°C
		KNO_3–KCl System		
KCl				
0.087	2.1013	0.7275	7	349 – 540
0.205	2.0898	0.7120	12	429 – 580
0.298	2.0691	0.6804	14	485 – 633
		$LiNO_3$–LiCl System		
LiCl				
0.100	1.9113	0.5374	4	278 – 446
0.201	1.9026	0.5380	2	340 – 497
0.305	1.8891	0.5240	3	378 – 497
		$LiNO_3$–$LiClO_4$ System		
$LiClO_4$				
0.75	2.1342	0.6293	4	225 – 336
0.54	2.0883	0.6292	4	198 – 347
0.25	2.0144	0.6102	4	240 – 357

TABLE IV

RECIPROCAL SYSTEMS

Comp.		a	b	Stand. Dev.	Temp. Range
Cation Fract.	Anion Fract	g/cm^3	$g/cm^3/°C \times 10^3$	$g/cm^3 \times 10^4$	°C
		KNO_3–LiCl Reciprocal System			
K^+	NO_3^-				
0.25	0.50	1.9191	0.5568	4	350 – 398
0.25	0.75	1.9654	0.6179	2	296 – 376
0.41	0.25	1.9108	0.5509	30	302 – 473
0.41	0.50	1.9509	0.5773	11	253 – 450
0.41	0.75	1.9985	0.6497	4	300 – 449
0.75	0.75	1.799 1.781	------ ------		366.9 395.8
		KNO_3–$CdCl_2$ Reciprocal System			
Cd^{++}	Cl^-				
0.30	0.40	2.6627	1.0597	7	266 – 297
0.42	0.21	2.542	------		236.8
0.51	0.10	2.670 2.628			205.1 246.6

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