Molten Salts: Volume 5, Part 1

Additional Single and Multi-Component Salt Systems. Electrical Conductance, Density, Viscosity, and Surface Tension Data

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Data on the electrical conductance, density, viscosity, and surface tension of more than ninety additional multi-component salt systems have been systematically collected and evaluated. Resultes are given for mixtures over a range of compositions and temperatures. Values of the above properties for some sixty single salt systems are also reported.

Key words: Carbonates; density; electrical conductance; hexafluoraluminates; metaphosphates; molybdates; molten salts; sulfates; sulfides; surface tension; tungstates; viscosity.

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1. Introduction

The published data for the four physical properties: electrical conductance, density, viscosity, and surface tension for molten mixtures have been reviewed and critically assessed, and the results of this work, together with value judgements are reported herewith. For earlier publications and forthcoming issues in this series see [1–7][1] and table 1. In addition to the assessment of the multi component salt systems, a review of data for single salts was undertaken as an update to the recommendations advanced in 1968 and 1969, and the results of this work are also reported.

Within each anion family, the mixtures are arranged in alphabetical order by cations according to chemical symbol. The presentation of the material is organized as follows: some observations concerning melt preparation and purification are given together with a temperature-liquidus phase diagram. This is followed by a tabular presentation of the investigations critically examined, including temperature and composition ranges, and comments on cell materials and calibrations. Table(s) of recommended numerical values over the experimental temperature and composition ranges complete the presentation. Each of the four properties are treated separately. General summary tables giving a total overview of the number of investigations and application of techniques are provided at the end of the manuscript.

TABLE 1. NSRDS Molten salts data series (For single salts and their binary mixtures relative to the data for electrical conductance, viscosity, density and surface tension)

Molten Salts	NSRDS Recommendations	Ref.
Vol. 1 (1968)	Single salts (κ,η ρ)	[1]
Vol. 2 (1969)	Single salts (γ)	[2]
Vol. 3 (1972)	Binary mixtures: nitrates, nitrites	[3]
Vol. 4, Pt. 1 (1974)	Binary mixtures of fluorides	[4]
Vol. 4, Pt. 2 (1976)	Binary mixtures chlorides	[5]
Vol. 4, Pt. 3 (1977)	Binary mixtures: bromides, iodides	[6]
Vol. 4, Pt. 4 (1979)	Binary mixtures: mixed halides	[7]
Vol. 5, Pt. 1	Binary mixtures: mixed anions other than nitrates, nitrites, halides	[8]
Vol. 5, Pt. 2	Additional systems	[9]

TABLE 2. Fundamental constants [a]

Symbol	Name	Values[b]
N	Avogadro constant	$6.022045\ (31) \times 10^{23}\ mol^{-1}$
F	Faraday constant	$9.648456\ (27) \times 10^{4}\ mol^{-1}$
e	Electron charge	$1.6021892\ (46) \times 10^{-19}\ C$
R	Gas constant	$8.3143 \pm 0.0012\ J\ K^{-1}\ mol^{-1}$
		$1.98716 \pm 0.00029\ cal\ K^{-1}\ mol^{-1}$

[a] Fundamental constants from: CODATA Bulletin No. 11 (Dec. 1973).

[b] In each case the digits in parentheses following a numerical value represent the standard deviation of that value in the decimal places indicated for its final digits.

2. Symbols and Units

The fundamental constants, symbols, and units are in tables 2 and 3, respectively.

3. Experimental Methods

Practical aspects of molten salts containment (materials) and designs of experimental assemblies for measurements of

[1] Numbers in brackets indicate literature references.

TABLE 3. Symbols and units

Symbol	Physical quantity	Units
A	Pre-exponential factor	as in text
C	Concentration	mol %
E	Energy of activation	cal mol^{-1}
t	Temperature	°C
T	Temperature	K
X	Mol fraction	dimensionless
γ	Surface tension	dyn cm^{-1}
η	Viscosity	cp or poise
κ	Electrical conductance	ohm^{-1} cm^{-1}
ρ	Density	g cm^{-3}

For conversion between SI and other units:
1 mN s m^{-2} = 1 cp = 1 mPa s
1 mN m^{-1} = 1 dyn cm^{-1}
4.184 J mol^{-1} = 1 cal mol^{-1}

TABLE 4. Experimental techniques reviewed in NSRDS molten salts data series

Techniques	*Aspects reviewed and references*
γ	Various possible methods and % applications: This series, Vol. 2, Part 2 [2]
κ, ρ, η, γ	Descriptions of experimental assemblies: This series, Vol. 3 [3]
κ, ρ, η, γ	Practical aspects of studies with molten fluorides: This series, Vol. 4, Part 1 [4]
κ, ρ, η, γ	Conductance: possible errors in measurements. Viscosity: comparison of oscillational and capillary techniques: This series, Vol. 4, Part 2 [5]
κ	Calibration techniques in molten salts conductivity measurements: This series, Vol. 4, Part 3 [6]

electrical conductivity, viscosity, density, and surface tension have been reviewed in the preceding parts of this series. A summary is given in table 4. Additional studies, particularly with reference to the question of value judgements (limits of accuracy), together with recent advances in techniques are reported herewith. In table 5, an analysis of the use of the various techniques in the studies of the systems in this volume is given.

TABLE 5. Percent application of techniques for molten salt systems in this volume

Method	Percent application
Specific conductance	
Classical ac	99%
Other	1%
Density	
Archimedean	49%
Pycnometric, dilatometric	22%
Bubble Pressure	16%
Hydrostatic weighing	13%
Viscosity	
Capillary	16%
Oscillational	84%
Surface tension	
Maximum bubble pressure	38%
Pin detachment	32%
Wilhelmy slide plate	20%
Cylinder method	10%

Density

For low-melting salt systems a confining volume dilatometric technique utilizing mercury as indicator liquid has been described by Coker, Wunderlich, and Janz [10]. The technique is particularly well suited for studies of premelting transitions, and volume changes during fusions. For volatile systems, such as mercuric halides and aluminum halide containing systems, sealed dilatometric techniques, and Archimedean "float" techniques have been used to determine densities [11–13]. For recent advances, the contributions of King et al. (aluminum halides, and mixtures) [14–17] and Andreasen, Bjerrum, and Foverskov (highly colored melts) [18] are of note. The latter system utilizes a design in which the quartz floats are weighted with a ferromagnetic material so that a windowless furnace can be used; the observations are made electrically; the technique can be applied as a dynamic method rather than as the conventional "static-type" density measurements.

Densities may be derived from the maximum bubble pressure technique, (surface tension), utilizing the linear relationship between the maximum rise (manometer) and the depth of the bubble orifice (capillary tip). Recent measurements by Ejima with this technique [19], shows results in close agreement with those of the classical Archimedean immersion technique. In the moderately high temperature range (350–550 °C), accuracy limits of ±0.5% can be assigned to this technique; this is to be compared with ±0.2% for the Archimedean technique. Approximately 90% of the molten salts density studies have been with Archimedean and dilatometric measurement methods.

Surface Tension

Of the various techniques, the maximum bubble pressure method has seen widest application for molten salts surface tension determinations. More than 80% of the measurements have been made by the maximum bubble method. This method is capable of precise results at high temperature; the theory and practice have been reviewed in detail by Tripp and Dahl [20–21]. It should be noted that the mathematical theory and experimental measurements are in accord for slow bubble rates, i.e., ~5 bubbles per minute. For accuracy and reproducibility careful attention should be paid to the tip of the capillary. The end must be flat and exactly perpendicular to the axis of the bore; the latter must be accurately circular, and also the edge (of the latter) should be very sharp. For a recent example of the technique in practice, see Nissen and

Carlsten [22]. The accuracy limits of this technique are estimated to be about ±1%.

Of the remaining methods (approx seven) the detachment techniques (viz. the Wilhelmy slide plate and the flat-pin) have seen widest use. It is estimated that these techniques are capable of surface tension data to an accuracy of ±1.5%. In recent measurements by Zuca and Terzi [23], it has been shown that surface tensions calculated by the pin detachment equations of Janz and Lorenz [24] and Lillebuen [25] are basically in agreement. The results from the Lillebuen equation appear very sensitive to the accuracy to which the pin radius is known.

Electrical Conductance

The problem of polarization errors in conductance measurements has been re-examined with ambient temperature electrolytes by Tomkins, Janz, and Andalaft [26]. It is shown that the uncorrected values for specific conductance may be as much as 0.7% to 1.2% too low if the measurements are limited to 3 KHz and 10 KHz frequencies. These errors may be compounded with improperly designed cells and/or faulty ac impedance bridge techniques. With single crystal quality MgO capillary at 800–1000 °C, Lorenz and Janz [27] found that the polarization correction was less than 1% relative to the values of 1 KHz. With molten NaCl and quartz capillary dipping cell techniques, recent measurements completed by Ejima (with corrections for the polarization error by extrapolation to infinite frequency) and Emons (limited to 20 KHz) are virtually in exact agreement [28, 29].

These results are in accord with the results reported by Ketelaar and Maenaut [30] using the air-thermostated closed U shaped quartz capillary conductance cells; this indicates that the quartz dipping cell may be used with satisfactory results in this temperature range (800–1000 °C) if care is taken to correct for polarization errors. The estimated limits of accuracy at these high temperatures are ~±1%.

Two additional points of technique should be noted. The first is that in some molten salts studies it is sometimes observed that the "cell-constant" is not constant. This cell calibration anomaly was investigated for ambient temperature electrolytes by Jones and Bollinger in 1929–1931 [31]; it was shown that the anomaly is indicative of improperly designed conductance cells and was termed by them as the "Parker Effect". Apparently this earlier investigation has been overlooked and this error source is thus being repeated in some of the more recent studies (above). The second concerns the Jones and Bradshaw KCl conductance values (generally accepted as standard reference points for cell calibrations) which are widely cited in textbooks and reference books [32, 33]. It is of concern that a recent textbook cites the composition of the 1 demal KCl standard as 74.1352 g rather than the correct value, i.e., 71.1352 g [34]. This is unfortunate and may lead to errors in post-1970 conductance measurements.

Conductance cell calibration techniques have recently been assessed by Janz and Tomkins [33], and were summarized in a preceding volume in this series [35].

As noted earlier in this series [36], the 1968 NSRDS conductance values for NaCl are, apparently, in error at temperatures above 850 °C.

Viscosity

The torsional pendulum technique (logarithmic damped oscillation of an immersed body or a liquid-filled shape) is possibly the most widely used technique in molten salts viscometry, especially at highest temperatures.

At moderately high temperatures where the containment problems are less severe, the capillary technique has seen widest application.

With reference to the former there have been significant theoretical and practical advances in the past decade, and these may be briefly summarized as follows. Grouvel [37] has shown that for very precise measurements with the oscillating hollow cylinder (cup), the mathematical first order equations (to the solution of the theory of this technique) are adequate for the calculation of viscosities. This is under exact and precise experimental conditions for which the effects of secondary flow have been successfully eliminated. The effects of the latter (secondary flow) can be large, and lead to apparent viscosities that are too high. Thus the relatively large departure of the earlier NaCl and KCl viscosities relative to the more recent values from Trondheim (i.e., 20–40%) [38, 39, 40] can undoubtedly be attributed to such secondary flow effects. There is a need for a set of molten salts viscosity data, preferably with uncertainties of ±2% or less, that would serve as calibration standards for cross-checks in this temperature range (600–1000 °C). As noted elsewhere, such work is in progress [4]. Under conditions of no secondary flow, Grouvel has shown that the working equations of Roscoe [42] and Beckwith and Newell [43] are capable of viscosity values to an accuracy of ±1.0%; the equations advanced by others (Shidvovskii; Hopkins and Toye; Reeves and Janz) are much less exact. Ejima [44] has called attention to an error in working equations of Roscoe, as derived by Thresh [45] for the cylindrical techniques; the cofficient of the 2nd term in the series expansion is 3/2 (and not 1/2 as reported by Thresh). Attention has already been directed to the merits of the "Kestin" alloy as the torsion wire for viscometry [40]. This alloy (Pt–8% W) has a low internal friction and highly stable elastic constant (considerations which are important in minimizing errors due to nonideality of such wires in periodic torsional applications).

In addition to the preceding, a critical error analysis of the experimental technique has been completed by Vasu, Wesson, and Borcan [46]. Under conditions with no secondary flow effects, the result is that the accuracy of the torsional technique (with immersed sphere as the oscillating shape) is apparently limited to ±2–3% in accuracy. The practical factor that determines these limits is the accuracy to which the immersed shape can be machined to "sphericity"; thus for a sphere of 1.022 cm radius (a size generally used), an uncertainty of ±0.004 cm imposes the preceding accuracy limits. With noble metals, the tolerances for machining are approx. ±0.004 cm, largely due to the inherent softness of these

metals. These investigators [46] also propose a new computational method for the calculation of viscosity data (based on the simultaneous solution of two Verschaffelt equations). This approach is shown to be superior to the more conventional method (requiring experiment period measurements) since simplication of the experimental assembly is possible (to a design minimizing conditions for secondary flow effects).

The significant publications by Øye et al. [39,233] should also be noted. A detailed description is given for a torsional viscometer assembly having an ancillary microprocessor coupled for computer-assisted "online" viscosity calculations. The limits of accuracy for routine measurements are estimated as ±1.0%. With additional care, ±0.2% accuracy has been attained.

With reference to the capillary technique, two designs of closed-type capillary viscometers have been reported [47, 48] that appear especially suited for accurate viscosity measurements [±1.0%] at moderately high temperatures (up to 500°C). Routine extension of the capillary technique to the higher temperature range (>500°C) has not yet been achieved. It is to be noted, however, that van Os and Ketelaar [47] and Zuca and Borcan [49] have completed limited measurements for molten KCl and NaCl, respectively, with the capillary technique [i.e., at temperatures >800°C]. The results are in close agreement with those of the Trondheim school with the torsional pendulum, and are firm support for the accuracy of the new values for NaCl. Apparently the Trondheim design has minimized secondary flow effects in the torsional technique so that accurate viscosities are now possible in the higher temperature range (>800°C).

At more moderate temperatures (~400–500°C), the recent measurements of molten KNO_3 viscosities by Zuca and Borcan are of note [49]. In these both the classical capillary and the torsional (sphere) techniques were found to be in excellent agreement (within the limits of accuracy of the torsional technique, i.e., ±2–3 %). The very simple oscillation sphere design used by the Bucharest group [see 46] thus appears capable of quite precise and accurate viscosity measurements.

4. Statistical Analysis Data

The recommended data values were selected from our estimates of precision and uncertainty of the data surveyed in the literature. The Percent Departure is defined as:

$$\text{Percent Departure} = \frac{\text{"compared valued"}-\text{"tabulated value"}}{\text{"tabulated value"}} \times 100.$$

Here "compared value" and "tabulated value" refer to the literature value and the value recommended in the present work. Both the "compared value" and the "tabulated value" were calculated from statistically derived equations since the results had to be interpolated to common temperatures and common compositions. Where the data sets from two or more studies were merged to provide the data base for the recommended values (either to extend the temperature range, or to fix the confidence level) this has been noted in the data tables. Unless otherwise indicated, all values were recalculated to the Kelvin temperature scale and are thus reported.

All calculations were made on the digital computer facilities at Rensselaer Polytechnic Institute. The data set of the recommended study was recalculated by a one-dimensional analysis, using the method of least squares, to establish the physical quantities with temperature at the experimental compositions. If the data base was sufficient, calculations using a two-dimensional analysis, with a stepwise multiple regression routine were undertaken. In this way a physical property-temperature-composition matrix was developed. A result of this analysis is that it enables intercomparisons of property values at either common temperatures or at common compositions.

One-Dimensional Analysis

The criterion for choosing the equation of best fit in the one-dimensional analysis was the standard error of estimate. This was defined by

$$s = \left[\frac{\sum_{n} (\gamma_e - \gamma)^2}{n - q}\right]^{1/2}$$

where γ_e = the experimental value at each temperature, γ = the value calculated from the least squares equation at the same temperature, n = the number of experimental data points, and q = the number of coefficients in the least squares equation (2 for linear, 3 for quadratic). The standard error of estimate was computed from the residuals in the least-squares routine.

Two-Dimensional Analysis

The computer programs consisted of the four routines, STPRG, CORRE, LOC, and MSTR; the latter two are storage routines which have no effect on the accuracy of the results. In addition a subroutine STOUT was used to print the results of each regression step and the subroutine MATRIX, for printing a matrix of numerical values from the thus derived equation.

The abbreviated Doolittle method was used to select the variables entering the regression and for calculation of coefficients. The independent variable included in each step of analysis was selected by computing the reduction of sums of squares of each variable. The variable causing the largest reduction was added to the equation and deleted from the table of sums of squares. The coefficients, intercept, and statistical parameters for the new equation were computed and printed. This procedure was repeated until the maximum proportion of sums of squares to the total reduced was less than a limit set by the programmer.

The independent variables used in the initial selection were chosen from a generalized procedure, which generated 30 combinations of input variables using powers, reciprocals, logarithmic and exponential quantities. It was found that the procedure consistently selected the equation $(T + C)^3$, so that the working program used nine independent variables. After the final equation was produced, it was transferred to the MATRIX routine, which recalculates values at rounded com-

positions and temperatures, within specified boundary conditions. In the presentation of the matrix, due cognizance is taken of the experimental range of investigation and of the phase relationships for the system so that values are always "interpolated" rather than "extrapolated". The final step in the procedure involves the residual analysis (giving the deviations of the original values from those computed for the "best-fit" equations).

In the programs used (vide infra), a summary of significant parameters is printed by the computer at each step in the regression analysis. These are: the sum of the squares reduced, S_i; the ratio S_i/D where D is defined below; and the cumulative sum of these variables, S_{cum} and P_{cum}. These quantities give an indication of the effect of each variable in the final equation. The programmer's limit on P was always in the range $0.0001 < P_{cum} < 0.001$.

The standard error in the estimated y values adjusted for degrees of freedom, is then given by:

$$S = \left[\frac{D - S_{cum}}{n - q - l}\right]^{1/2}$$

where $D = \Sigma(y_j - y)^2$, y_j = experimental values, y = average of all experimental values, and q = the number of independent variables in the equations.

An F value analysis of variance was used to determine if a particular model was acceptable. Tables of F values indicate that values greater than 2.0 are acceptable for the routine used here. In all cases values of F were greater than 1000. The F value is defined as:

$$F = \frac{S_{cum}/q}{(D - S_{cum})/(n - q - 1)}$$

where S_{cum}, q, D, and n are defined above.

5. Value Judgements

Precision

Estimates of precision were based on standard error of estimate analysis. The standard error of estimate is the end result of a statistical analysis of the numerical data, and the statistical analysis depends on various factors, such as the number of the data points, the nature of the concentration dependence and the temperature dependence of the particular physical property. The precision is the standard error expressed as a percent value. As a general guide, about 60% of the results lie within the estimate of precision, 95% within three times the value. Where the preceding approach was not possible, we refer to the published error estimates of the original authors.

Accuracy

Accuracy estimates were based on assessments of experimental details including method of measurements, techniques, analytical characterization of chemicals, and intercomparisons with results from the same and/or different laboratories. The accuracy estimates are more subjective than the estimates of precision.

6. Phase Diagrams

Phase diagrams, when known, are reported with the multicomponent systems.

The diagrams are not advanced as critically evaluated recommendations but are included for reference relative to values for eutectic compositions, and the temperature-composition boundary conditions for the liquidus-solidus phase transitions.

Source references are cited with each phase diagram. A partial list of some of the more useful compilations of phase diagrams would include International Critical Tables [50], Landolt-Bornstein [51], Clark [52], Robertson [53], Thoma [54], Voskresenskaya [55], Sinistri et al. [56], Shaffer [57], Toropev et al. [59], Franzosini et al. [58] and Levin et al. [60].

7. Physical Property Tables

Two types of tables are used to present information relative to the physical properties.

(a) Tables of investigations critically re-examined. In such tables, the results are given with respect to:

- the investigations critically re-examined
- composition and temperature ranges
- a summary of experimental details such as cell material and calibration-method
- comparison with the NSRDS recommendations

The notation (g) indicates the data were presented graphically. Otherwise it may be assumed that the data were reported in numerical or equation form. Footnotes to these tables call attention to information of unusual importance (technique, experimental uncertainty, etc.). A recommended reference is always indicated by an underscored reference number. In situations where the composition-temperature-physical property data base was developed from more than one publication, all references used to develop the recommended values are underscored.

(b) Tables of numerical values. Each table of values either contains the equation from which the values were calculated with the statistical parameters associated with it, or it has a footnote stating how the values were obtained. The coefficients of the equations are cited to more significant figures than justified by the accuracy so that the equations may be used to gain values within the limits of precision. If the tabulated values are listed in brackets, this indicates these are of less reliability.

When the experimental results were published in graphical form only, the graphs were digitized, and the values reported herewith were obtained by statistical analysis of the thus derived numerical data bases.

8. General Summary Tables

The series of general summary tables give additional information, such as total number of investigations, recommended references, experimental techniques, and literature references.

9. *Single Salts*

Sections 9.1 and 9.2 update the recommendations for single salt melts given in NSRDS-NBS-15 [1] and NSRDS-NBS-28 [2]. The discussions for each single salt recommendation and the numerical values together with the temperature-dependent equations are given in sections 9.3 and 9.5. Additional studies not included in NSRDS-NBS-15 [1] and NSRDS-NBS-28 [2] are summarized in sections 9.4 and 9.6.

9.1 *New Recommendations*

One component salt systems which are being examined here for the first time are listed in table 6.

9.2 *Carbonate Salts*

Single carbonate salts for which a new recommendation is reported are discussed in this section with respect to experimental techniques, references, temperature ranges, percent departure values, and melt preparation and purification. Numerical values are given for each property at rounded temperatures together with the temperature-dependent equations.

TABLE 6. New recommendations

Compound	Number of investigations			
	Specific Conductance	Density	Viscosity	Surface tension
Cs_2CO_3				1
Rb_2CO_3				1
$AgClO_3$	2	1		
$NaClO_3$	3	2	2	
$Na_2Cr_2O_7$		1		
Na_3AlF_6	1		1	
$AgPO_3$				1
$Ba(PO_3)_2$	2	1		
$Ca(PO_3)_2$	1			
$Cd(PO_3)_2$	1	1		1
$Co(PO_3)_2$		1		
$CsPO_3$	1	1		
KPO_3	2	7	2	
$LiPO_3$	1	3		
$Mg(PO_3)_2$				1
$NaPO_3$	3	11		
$RbPO_3$	1			
$Sr(PO_3)_2$	1			
$Zn(PO_3)_2$	2	1		3
$Bi_2(MoO_4)_3$	1	1		
K_2MoO_4	3		1	
Li_2MoO_4		2	1	3

TABLE 6. New recommendations CONTINUED.

Compound	Number of investigations			
	Specific Conductance	Density	Viscosity	Surface tension
Na_2MoO_4			1	
$PbMoO_4$	1	1		
$LiClO_4$	2		1	
Li_2SO_4	5			
Na_2SO_4			1	
Tl_2SO_4	1	1		
$ZnSO_4$		1		
Co_4S_3		2	2	
Cu_2S		3	2	
FeS		3	3	
Na_2S_4		2		2
Na_2S_5		2		2
Ni_3S_2		2	2	
Tl_2S	2	1	1	
K_2S-S(K_2S_x)	1			
Na_2S-S(Na_2S_x)	1	1	1	1
$K_2B_4O_7$		1		
$Na_2B_4O_7$		2		2
$CsBF_4$		1		
KBF_4		1	2	
$LiBF_4$		1		
$NaBF_4$	1	2	2	1
$RbBF_4$		1		
$Bi_2(WO_4)_3$	2	2		
K_2WO_4	4		1	
Li_2WO_4	4	4	1	2
Na_2WO_4			1	
$PbWO_4$	2	2		1
$NaVO_3$	1	1		

Cs_2CO_3

Melt Preparation and Purification

For a description of Moiseev and Stepanov's method of melt preparation, refer to Cs_2CO_3-Li_2CO_3 [190]. No experimental details were given in [61].

TABLE 7. Surface tension studies: Cs_2CO_3

Investigations critically examined		
Ref.	Temp. range (K)	Comments
61	1093-1223	Refer: Cs_2CO_3-Li_2CO_3

TABLE 8. Cs_2CO_3: Surface tension (dyn cm^{-1})

$\gamma = 213.5 - 73.1 \cdot 10^{-3} T$

T(K)	γ
1100	133.1
1120	131.6
1140	130.1
1160	128.7
1180	127.2
1200	125.8
1220	124.3

These values are based on the data of Moiseev and Stepanov (maximum bubble pressure) [61].

Rb_2CO_3

Melt Preparation and Purification

For a description of Moiseev and Stepanov's method of melt preparation, refer to Cs_2CO_3-Li_2CO_3 [190], this volume. No experimental details were given in [61].

TABLE 9. Surface tension studies: Rb_2CO_3

Investigations critically examined		
Ref.	Temp. range (K)	Comments
61	1156-1231	Refer: Cs_2CO_3-Li_2CO_3

TABLE 10. Rb_2CO_3: Surface tension (dyn cm^{-1})

$\gamma = 266.4 - 104.2 \cdot 10^{-3} T$

T(K)	γ
1160	145.53
1165	145.01
1170	144.49
1175	143.97
1180	143.44
1185	142.92
1190	142.40
1195	141.88
1200	141.36
1205	140.84
1210	140.32
1215	139.80
1220	139.28
1225	138.75
1230	138.23

These values are based on the data of Moiseev and Stepanov (maximum bubble pressure) [61].

9.3 *Additional Studies: Carbonates*

The following tables summarize information relative to additional studies for single carbonate salt melts that have been reported since the publication of NSRDS-NBS-15 [1] and NSRDS-NBS-28 [2]. The information included in this summary table indicates the authors, reference and maximum and minimum percent departure of the various studies relative to the previously recommended values.

TABLE 11. Deviations from NSRDS recommendations: K_2CO_3

Reference	Authors	Min. departure	Max. departure
Conductance (NSRDS reference data base: Janz and Lorenz (1961), [1], p. 23)			
62	Karpachev, Pal'guev, Vorob'ev (1961)	graphical	
63	Spedding (1973)	0.01% (1185 K)	-0.33% (1275 K)
64	Matiasovsky, Danek, Lillebuen (1972)	-0.17% (1275 K)	-0.18% (1195 K)
65	Karpachev, Vorob'ev (1960)	graphical	
66	Markov, Polishchuk (1973)	graphical	
Density (NSRDS reference data base: Janz and Lorenz (1961), [1], p. 24)			
62	Karpachev, Pal'guev, Vorob'ev (1961)	outside temp. range of data base	
67	Spedding (1970)	0.01% (1250 K)	0.05% (1180 K)
68	Markov, Prisyazhnyii (1963)	graphical	
Surface tension (NSRDS reference data base: Janz and Lorenz, (1961) [2], p. 67)			
61	Moiseev, Stepanov (1971)	-0.09% (1245 K)	-0.25% (1180 K)
69	Moiseev, Stepanov (1964)	-0.09% (1245 K)	-0.25% (1180 K)

TABLE 12. Deviations from NSRDS recommendations: Li_2CO_3

Reference	Authors	Min. departure	Max. departure
Conductance (NSRDS reference data base: Janz and Lorenz (1961), [1] p. 23)			
62	Vorob'ev, Pal'guev, Karpachev (1961)	graphical	
63	Spedding (1973)	0.06% (1115 K)	0.40% (1055 K)
66	Markov, Polishchuk (1973)	graphical	
Density (NSRDS reference data base: Janz and Lorenz (1961), [1] p. 23)			
62	Vorob'ev, Pal'guev, Karpachev (1961)	-1.11% (1073 K)	-2.69% (1023 K)
67	Spedding (1970)	0.00% (1085 K)	0.12% (1015 K)

TABLE 13. Deviations from NSRDS recommendations: Na_2CO_3

Reference	Authors	Min. departure	Max. departure
Conductance (NSRDS reference data base: Janz and Lorenz (1961), [1] p. 23)			
62	Karpachev, Pal'guev, Vorob'ev (1961)	graphical	
65	Karpachev, Vorob'ev (1960)	graphical	
63	Spedding (1973)	-0.00% (1220 K)	-0.17% (1145 K)
70	Ryschkewitzsch (1933)	-9.97% (1148 K)	-15.39% (1233 K)
71	Djordjevic, Hills (1968)	outside range of data base	
64	Matiasovsky, Danek, Lillebuen (1972)	-1.28% (1175 K)	-1.40% (1235 K)
Density (NSRDS reference data base: Janz and Lorenz (1961), [1] p. 23)			
62	Karpachev, Pal'guev, Vorob'ev (1961)	-0.31% (1148 K)	-0.36% (1173 K)
67	Spedding (1970)	0.00% (1205 K)	-0.07% (1145 K)
68	Markov, Prisyazhnyii (1963)	graphical	
Surface tension (NSRDS reference data base: Janz and Lorenz (1961), [2] p.67)			
61	Moiseev, Stepanov (1971)	-0.47% (1160 K)	-1.54% (1260 K)

9.4 *Chlorate Salts*

Single chlorate salts for which a new recommendation is reported are discussed in this section in the same manner as single carbonate salts were discussed in section 9.2.

$AgClO_3$

Melt Preparation and Purification

Goodwin and Mailey [72,73] used reagent grade silver chlorate.

TABLE 14. Electrical conductance studies: $AgClO_3$

Investigations critically examined		
Ref.	Temp. range (K)	Comments
72	470-513	quartz cell; calibr. H_2SO_4
73	473-523(g)	as for [72]

TABLE 15. Density studies: $AgClO_3$

Investigations critically examined		
Ref.	Temp. range (K)	Comments
73	483-523	fused quartz sinker; Pt ball

TABLE 16. $AgClO_3$: Specific conductance ($ohm^{-1}cm^{-1}$)

$\kappa = -1.1171 + 3.0414 \cdot 10^{-3}T$

Standard error of est. = 0.41%

T(K)	κ
475	0.328
480	0.343
485	0.358
490	0.373
495	0.388
500	0.404
505	0.419
510	0.434

These values are based on the data of Goodwin and Mailey (classical ac technique) [72].

TABLE 17. $AgClO_3$: Density (g cm^{-3})

$\rho = 8.9502 - 0.01056 T$

Standard error of estimate = 0.04%

T (K)	ρ
478	3.902
479	3.891
480	3.881
481	3.870
482	3.859
483	3.849
484	3.838
485	3.828

These values have been interpolated from the graphical data of Goodwin and Mailey (Archimedean method) [73].

$NaClO_3$

Melt Preparation and Purification

Campbell and Van der Kouwe [74,75] used reagent grade sodium chlorate without further purification, except for drying at 130°C.

Schamm and Todheide [151] used E. Merck, 99% $NaClO_3$ and carefully dried it under vacuum at 150°C for 15 hours prior to placement in the evacuated cell. All measurements were made under an argon atmosphere.

TABLE 18. Electrical conductance studies: $NaClO_3$

Investigations critically examined

Ref.	Temp. range (K)	Comments
74	540-555	Pyrex cap. cell; Pt electr.
75	540-555	as for [74]
76	543-643 (g)	Pt electr. cap. cell; ∿500-1000 cm^{-1}

TABLE 19. Density studies: $NaClO_3$

Investigations critically examined

Ref.	Temp. range (K)	Comments
74	536.7-558	Pyrex densitom.; calib. H_2O, dibutylph.
77	536.7-558	as for [74]

TABLE 20. $NaClO_3$: Specific conductance ($ohm^{-1}cm^{-1}$)

$\kappa = -1.3791 + 3.1702 \cdot 10^{-3}T$

Standard error of est. = 0.15%

T(K)	κ
540	0.333
545	0.349
550	0.364
555	0.380

These values are based on the data of Campbell and Van der Kouwe (classical ac technique) [74, 75].

TABLE 21. $NaClO_3$: Density (g cm^{-3})

$\rho = 2.5728 - 0.87933 \cdot 10^{-3} T$

Standard error of est. = 0.01%

T(K)	ρ
540	2.098
545	2.094
550	2.089
555	2.085

These values are based on the data of Campbell and Van der Kouwe (dilatometric technique) [74, 77].

TABLE 22. Viscosity studies: $NaClO_3$

Investigations critically examined

Ref.	Temp. range (K)	Comments
74	534-559	Pyrex capillary calibr. H_2O
77	535-559	as for [74]

TABLE 23. $NaClO_3$: Viscosity (cp)

$\eta = 31.1980 + 152.12 \times 10^{-3} T - 382.614 \times 10^{-6} T^2 - 534.010 \times 10^{-9} T^3 + 1044.97 \times 10^{-2} T^4$

Standard error of est. = 0.26%

T(K)	η
535	6.908
540	6.544
545	6.208
550	5.903
555	5.629

These values are based on the data of Campbell and Van der Kouwe (capillary technique) [74, 77].

9.5 *Additional Studies: Chlorates*

The following tables summarize information relative to additional studies for single chlorate salt melts that have been reported since the publication of NSRDS-NBS-28 [2].

9.6 *Dichromate Salts*

Single dichromate salts for which a new recommendation is reported are discussed in this section in the same manner as single salts were discussed in section 9.2.

$Na_2Cr_2O_7$

Melt Preparation and Purification

Markov and Prisyazhnyi [82] used reagent grade dichromate.

9.7 *Additional Studies: Dichromate Salts*

The following tables summarize information relative to additional studies for single dichromate salts that have been reported since the publication of NSRDS-NBS-15 [1] and NSRDS-NBS-28 [2].

TABLE 24. Deviations from NSRDS recommendations: $LiClO_3$

Reference	Authors	Min. departure	Max. departure
Electrical conductance (NSRDS reference data base: Campbell, Williams (1962), [1] p. 37			
78	Campbell, Williams (1964)	0.28% (411 K)	-1.73% (418 K)
Density (NSRDS reference data base: Campbell, Williams (1964), [1] p. 37			
79	Campbell, Nagarajan (1965)	0.01% (421 K)	-0.09% (431 K)
Viscosity (NSRDS reference data base: Campbell, Williams (1964), [1] p. 37			
80	Campbell, Nagarajan (1964)	0.10% (430 K)	-5.8% (450 K)
81	Moynihan (1967)	-0.47% (408 K)	-0.47% (408 K)

TABLE 25. Density studies: $Na_2Cr_2O_7$

Investigations critically examined		
Ref.	Temp. range (K)	Comments
82	693	quartz sphere; calibr.: dist. water

TABLE 26. $Na_2Cr_2O_7$: Density ($g.cm^{-3}$)

T(K)	ρ
693	2.38

The value has been interpolated from the graphical data of Markov and Prisyazhnyi (Archimedean method) [82].

TABLE 27. Deviations from NSRDS recommendations: $K_2Cr_2O_7$

Reference	Authors	Min. departure	Max.departure
Density (NSRDS reference data base: Jaeger (1917) [1] p. 36)			
82	Markov, Prisyazhnyi (1963)	graphical	

9.8 *Hexafluoroaluminate Salts*

Single hexafluoroaluminate salts for which a new recommendation is reported are discussed in this section in the same manner as single carbonate salts were discussed in section 9.2.

Na_3AlF_6 - *Cryolite*

A summary of the recommendations advanced for the electrical conductance, density, viscosity and surface tension in an earlier volume in this series is given in Table 28.

9.9 *Additional Studies: Hexafluoroaluminates*

The following tables summarize information relative to additional studies for single hexafluoroaluminate salt melts that have been reported since the publication of NSRDS-NBS-15 [1] and NSRDS-NBS-28 [2].

TABLE 28. Recommended studies for Na_3AlF_6 - cryolite

Ref. and Authors	Property	Temperature-dependent equation
Edwards et al. [4, p. 20]	κ[a]	$\kappa = -0.038597 + 0.20205 .10^{-2}T + 0.16701 .10^{-6}T^2$
Matiasovsky et al. [4, p. 21]	ρ	$\rho = 3.2733 - 9.20.10^{-4}T$
Abramov [4, p. 22]	η[b]	$\eta = 1.736.10^{-2}e^{12893/RT}$
Bloom, Burrows [4, p. 23]	γ	$\gamma = 297.0 - 12.8.10^{-2}T$

[a] The experimental data reported in [4] have been reanalyzed to generate a temperature dependent equation and the values are given in Table 29.

[b] Superseded by the data of Tørklep and Øye [232]. See updated recommendations advanced in Table 30.

TABLE 29. Na_3AlF_6: Specific conductance ($ohm^{-1}cm^{-1}$)

$\kappa = -0.038597 + 0.20205 \cdot 10^{-2}T + 0.16701 \cdot 10^{-6}T^2$

Standard error of estimate = 0.68%

T (K)	κ
1280	2.821
1290	2.846
1300	2.870
1310	2.895
1320	2.920
1330	2.944
1340	2.969
1350	2.994
1360	3.018
1370	3.043

These values are based on the data of Edwards et al. (classical ac technique) [95]. Recent work by Matiasovsky [231] is in accord with these recommended values with percent deviations of: min, 0.22% (1353K) and max. 0.53% (1303K).

TABLE 30. Na_3AlF_6: Viscosity (cp)

$\eta = 0.017924 e^{12380.27/RT}$

Standard error of estimate = 0.17%

T (K)	η
1290	2.244
1300	2.162
1310	2.085
1320	2.011
1330	1.941
1340	1.874
1350	1.811
1360	1.750
1370	1.693
1380	1.638
1390	1.585

These values are based on the data of Tørklep and Øye (oscillating cylinder) [232].

TABLE 31. Deviations from NSRDS recommendations: Li_3AlF_6

Reference	Authors	Min. departure	Max. departure
Viscosity (NSRDS reference data base: Vetyukov, Sipriya (1962), [4] p. 16			
102	Votava, Matiasovsky (1973)	graphical	

TABLE 32. Deviations from NSRDS recommendations: Na_3AlF_6

Ref.	Authors	Min. departure	Max. departure
Density (NSRDS reference data base: Matiasovsky (1970), [4] p.21)			
94	Taniuchi (1973)	-0.10% (1273 K)	-0.10% (1273 K)
86	Grjotheim, Matiasovsky (1971)	0.00% (1273 K)	0.00% (1273 K)
103	Abramov (1936)	0.18% (1328 K)	-0.85% (1363 K)
97	Ian'an, Belyaev (1959)	-0.34% (1323 K)	-0.38% (1273 K)
Viscosity (NSRDS reference data base: Tørklep, Øye (1979) [this volume])			
102, 104	Matiasovsky, Votava (1972)	graphical	

9.10 *Metaphosphate Salts*

Single metaphosphate salts for which a new recommendation is reported are discussed in this section in the same manner as single carbonate salts were discussed in section 9.2.

$AgPO_3$

Melt Preparation and Purification

Sokolova, Markina, Soklakov and Voskresenskaya [105] prepared $AgPO_3$ by the thermal decomposition of the dihydrogen phosphate.

$Ba(PO_3)_2$

Melt Preparation and Purification

Zuca et al. [106] prepared $Ba(PO_3)_2$ by dehydration of the commercial monosubstituted orthophosphate.

$Ca(PO_3)_2$

Melt Preparation and Purification

Sokolova, et al. [107] prepared calcium metaphosphate by the dehydration of monosubstituted calcium orthophosphate.

TABLE 33. Surface tension studies: $AgPO_3$

Investigations critically examined		
Ref.	Temp. range (K)	Comments
105	758-775	Pt capillary

TABLE 34. $AgPO_3$: Surface tension ($dyn \cdot cm^{-1}$)

$\gamma = 137.18 + 71.642 \cdot 10^{-3} T$

Standard error of est. = 0.72%

T(K)	γ
760	191.6
765	192.0
770	192.4
775	192.7

These values are based on the data of Sokolova, Markina, Soklakov and Voskresenskaya (maximum bubble pressure) [105].

TABLE 35. Electrical conductance studies: $Ba(PO_3)_2$

Investigations critically examined

Ref.	Temp. range (K)	Comments
106	1223-1349	Pt cell, electr. and crucible
107	1163-1248	as for [106]

Deviations from NSRDS recommendations(this volume)

Ref.	Min. departure	Max. departure
107	-2.97% (1224 K)	-6.13% (1248K)

Table 36. $Ba(PO_3)_2$: Specific conductance ($ohm^{-1}cm^{-1}$)

$\kappa = -0.4917 + 0.4308 \cdot 10^{-3}T$

Standard error of est.= 3.97%

T(K)	κ
1230	0.0382
1240	0.0425
1250	0.0468
1260	0.0511
1270	0.0554
1280	0.0597
1290	0.0640
1300	0.0683
1310	0.0726
1320	0.0770
1330	0.0813
1340	0.0856

These values are based on the work of Zuca, Sokolova, Gagescu and Olteanu (classical ac technique) [106].

TABLE 37. Density studies: $Ba(PO_3)_2$

Investigations critically examined

Ref.	Temp. range (K)	Comments
106	1163-1246	Pt sinker

TABLE 38. $Ba(PO_3)_2$: Density (g cm^{-3})

$\rho = 3.7366 - 0.4921 \cdot 10^{-3}T$

Standard error of est.= 0.2%

T(K)	ρ
1170	3.161
1180	3.156
1190	3.151
1200	3.146
1210	3.141
1220	3.136
1230	3.131
1240	3.126

These values are based on the work of Zuca, Sokolova, Gagescu and Olteanu (Pt sinker method) [106].

TABLE 39. Electrical conductance studies: $Ca(PO_3)_2$

Investigations critically examined

Ref.	Temp. range (K)	Comments
107	1255-1331	Pt cell; calibr.: NaCl, KCl

$Cd(PO_3)_2$

Melt Preparation and Purification

Zuca et al. [106] and Sokolova et al. [107] prepared $Cd(PO_3)_2$ by dehydration of the commercial monosubstituted orthophosphate.

$Co(PO_3)_2$

Melt Preparation and Purification

Krivovyazov et al. [109] prepared the cobalt metaphosphate from reagent grade cobalt carbonate and orthophosphoric acid. The product was analyzed by x-ray diffractometry and differential thermal analysis.

TABLE 40. $Ca(PO_3)_2$: Specific conductance ($ohm^{-1}cm^{-1}$)

$\kappa = 1.6188 - 2.8327 \cdot 10^{-3}T + 1.246 \cdot 10^{-6}T^2$

T(K)	κ
1255	0.0262
1260	0.0277
1265	0.0293
1270	0.0309
1275	0.0326
1280	0.0344
1285	0.0362
1290	0.0381
1295	0.0400
1300	0.0420
1305	0.0441
1310	0.0462
1315	0.0484
1320	0.0507
1325	0.0530
1330	0.0554

These values are based on the work of Sokolova, Markina and Sokolov (classical ac technique) [107].

$CsPO_3$

Melt Preparation and Purification

Sokolova et al. [107] and Krivovyazov et al. [109] used metaphosphates which were prepared by the dehydration of commercial monosubstituted orthophosphates.

KPO_3

Melt Preparation and Purification

Zuca et al. [106] prepared KPO_3 by the dehydration of the commercial monosubstituted orthophosphate. Kochergin [110] used reagent grade orthophosphates to prepare the metaphosphate.

TABLE 41. Electrical conductance studies: $Cd(PO_3)_2$

Investigations critically examined

Ref.	Temp. range (K)	Comments
107	1183-1277	Pt cell; calibr. molten NaCl, KCl.

TABLE 42. $Cd(PO_3)_2$: Specific conductance ($ohm^{-1}cm^{-1}$)

$\kappa = 0.6567 - 1.4316 \cdot 10^{-3}T + 0.768 \cdot 10^{-6}T^2$

T(K)	κ
1190	0.0407
1200	0.0447
1210	0.0489
1220	0.0532
1230	0.0577
1240	0.0624
1250	0.0672
1260	0.0722
1270	0.0773

These values are based on the work of Sokolova, Markina and Sokolov (classical ac technique) [107].

TABLE 43. Density studies: $Cd(PO_3)_2$

Investigations critically examined

Ref.	Temp. range (K)	Comments
106	1197-1262	Pt sinker

$LiPO_3$

Melt Preparation and Purification

Zuca et al. [106] prepared $LiPO_3$ by dehydration of the commercial monosubstituted orthophosphate. Boyer, Fray and Meadowcroft [118] prepared $LiPO_3$ by reacting lithium carbonate in varying amounts of monobasic ammonium phosphate. The mixture was dehydrated in a Pt crucible for several hours at 900° before measurements.

TABLE 44. $Cd(PO_3)_2$: Density studies (g cm^{-3})

$\rho = 3.4974 - 0.1865 \cdot 10^{-3} T$

Standard error of est. = 0.1%

T(K)	ρ
1200	3.274
1205	3.273
1210	3.272
1215	3.271
1220	3.270
1225	3.269
1230	3.268
1235	3.267
1240	3.266
1245	3.265
1250	3.264
1255	3.263
1260	3.262

These values are based on the work of Zuca, Sokolova, Gagescu and Olteanu (Pt sinker method) [106].

TABLE 45. Surface tension studies: $Cd(PO_3)_2$

Investigations critically examined

Ref.	Temp. range (K)	Comments
108	1174-1263	Pt-Rh capillary

TABLE 47. Density studies: $Co(PO_3)_2$

Investigations critically examined

Ref.	Temp. range (K)	Comments
109	1393-1473	Pt - 10% Rh sinker

TABLE 46. $Cd(PO_3)_2$: Surface tension (dyn cm^{-1})

$\gamma = 190.824 + 12.0 \cdot 10^{-3} T$

T(K)	γ
1170	204.86
1180	204.98
1190	205.10
1200	205.22
1210	205.34
1220	205.46
1230	205.58
1240	205.70
1250	205.82
1260	205.94
1270	206.06

These values are based on the work of Sokolova (maximum bubble pressure) [108]. The temperature coefficient is very small; values of γ in the above temperature range could be expressed as 205.5 ± 0.6 dyn cm^{-1}; the uncertainty of these measurements was given as ±1%.

TABLE 48. $Co(PO_3)_2$: Density (g·cm^{-3})

$\rho = 2.9505 - 0.1341 \cdot 10^{-3} T$

T(K)	ρ
1395	2.763
1400	2.763
1405	2.762
1410	2.761
1415	2.761
1420	2.760
1425	2.759
1430	2.759
1435	2.758
1440	2.757
1445	2.757
1450	2.756
1455	2.755
1460	2.755
1465	2.754
1470	2.753

TABLE 49. Electrical conductance studies: $CsPO_3$

Investigations critically examined

Ref.	Temp. range (K)	Comments
107	1015-1203	Pt cell; calibr. NaCl, KCl

TABLE 50. $CsPO_3$: Specific conductance ($ohm^{-1}cm^{-1}$)

$\kappa = 0.057 - 0.577 \cdot 10^{-3}T + 0.813 \cdot 10^{-6}T^2$

T(K)	κ
1020	0.314
1030	0.325
1040	0.336
1050	0.347
1060	0.359
1070	0.370
1080	0.382
1090	0.394
1100	0.406
1110	0.418
1120	0.431
1130	0.443
1140	0.456
1150	0.469
1160	0.482
1170	0.495
1180	0.508
1190	0.522
1200	0.535

These values are based on the data of Sokolova, Lazarev, Markina, Rybakova and Sokolova (classical ac technique) [107].

TABLE 51. Density studies: $CsPO_3$

Investigations critically examined

Ref.	Temp. range (K)	Comments
109	1063-1398	Pt - 10% Rh sinker

TABLE 52. $CsPO_3$: Density (g cm^{-3})

$\rho = 3.8253 - 0.7320 \cdot 10^{-3}T$

T(K)	ρ
1070	3.042
1090	3.027
1110	3.013
1130	2.998
1150	2.984
1170	2.969
1190	2.954
1210	2.940
1230	2.925
1250	2.910
1270	2.896
1290	2.881

These values are based on the work of Krivovyazo, Dzhurinskii, Rachimbekova and Voskresenskaya (Archimedean technique) [109].

TABLE 53. Electrical conductance studies: KPO_3

Investigations critically examined

Ref.	Temp. range (K)	Comments
106	1155-1226	Pt cell and electr.
107	1173	Mo electr.; calibr. molten KCl, NaCl

TABLE 54. KPO_3: Specific conductance ($ohm^{-1}cm^{-1}$)

$\kappa = -0.8738 + 1.4094 \cdot 10^{-3}T$

Standard error of est. = 0.78%

T(K)	κ
1155	0.754
1160	0.761
1165	0.768
1170	0.775
1175	0.782
1180	0.789
1185	0.796
1190	0.803
1195	0.810
1200	0.817
1205	0.825
1210	0.832
1215	0.839
1220	0.846
1225	0.853

These values are based on the data of Zuca, Sokolova, Gagescu and Olteanu (classical ac technique) [106].

TABLE 55. Density studies: KPO_3

Investigations critically examined

Ref.	Temp. range (K)	Comments
111	1170-1470	Pt sinker
112	1261,1363,1468	Pt sinker
113	1148-1383	Pt sphere; calibr.: KNO_3
114	1142-1347	
115	1123,1173,1223(g)	
116	1123	
117	1023-1223(g)	

Deviations from NSRDS recommendations

Ref.	Min. deviation	Max. deviation
112	0.01%(1468 K)	0.04%(1261 K)
113	-0.00%(1155 K)	0.35%(1380 K)

TABLE 56. KPO_3: Density ($g \cdot cm^{-3}$)

$\rho = 2.5680 - 0.42725 \cdot 10^{-3}T$

Standard error of est. = 0.09%

T(K)	ρ
1170	2.068
1190	2.060
1210	2.051
1230	2.043
1250	2.034
1270	2.025
1290	2.017
1310	2.008
1330	2.000
1350	1.991
1370	1.983
1390	1.974
1410	1.966
1430	1.957
1450	1.949
1470	1.940

These values are based on the data of Jaeger (Archimedean method) [111].

TABLE 57. Viscosity studies: KPO_3

Investigations critically examined

Ref.	Temp. range (K)	Comments
110	1073	
115	1073-1223(g)	

TABLE 58. KPO_3: Viscosity (poise)

T(K)	η
1173	2.20

The above value is the sole data point reported by Kochergin, Mardirosova and Shevrina (oscillational method) [110].

TABLE 59. Electrical conductance studies: $LiPO_3$

Investigations critically examined		
Ref.	Temp. range (K)	Comments
106	1106-1275	Pt cell and electrodes

TABLE 60. $LiPO_3$: Specific conductance ($ohm^{-1}cm^{-1}$)

$\kappa = -1.8978 + 2.7249 \cdot 10^{-3}T$

Standard error of est. = 1.1%

T(K)	κ
1110	1.127
1120	1.154
1130	1.181
1140	1.209
1150	1.236
1160	1.263
1170	1.290
1180	1.318
1190	1.344
1200	1.372
1210	1.400
1220	1.427
1230	1.454
1240	1.481
1250	1.508
1260	1.536
1270	1.563

These values are based on the data of Zuca, Sokolova, Gagescu and Olteanu (classical ac technique) [106].

TABLE 61. Density studies: $LiPO_3$

Investigations critically examined		
Ref.	Temp range (K)	Comments
106	1097-1193	Pt sinker
118	960-1212	Pt-10% Rh cap.
117	1023-1243(g)	

Deviations from NSRDS recommendations		
Ref.	Min. deviation	Max. deviation
118	7.76% (1118 K)	7.76% (1118K)

TABLE 62. $LiPO_3$: Density ($g \cdot cm^{-3}$)

$\rho = 2.5755 - 0.5273 \cdot 10^{-3}T$

T(K)	ρ
1100	1.995
1110	1.990
1120	1.985
1130	1.980
1140	1.974
1150	1.969
1160	1.964
1170	1.959
1180	1.953
1190	1.948

These values are based on the data of Zuca, Sokolova, Gagescu and Olteanu (Archimedean method) [106].

$Mg(PO_3)_2$

Melt Preparation and Purification

Sokolova et al. [119] used $Mg(H_2PO_4)_2$ $2H_2O$ to prepare the magnesium metaphosphates. The starting material was obtained from MgO and H_3PO_4. The dihydrate was dehydrated by slowly heating it in a platinum vessel with constant stirring. The starting materials and products were analyzed for magnesium content by titration with Trilon B using a borate buffer and for phosphorus by precipitation with quinoline molybdate.

TABLE 63. Surface tension studies: $Mg(PO_3)_2$

Investigations critically examined

Ref.	Temp. range (K)	Comments
119	1428-1504	Pt-Rh capillary

TABLE 64. $Mg(PO_3)_2$: Surface tension (dyn cm^{-1})

$\gamma = 279.992 - 36.6 \cdot 10^{-3} T$

T(K)	γ
1430	227.6
1440	227.2
1450	226.9
1460	226.5
1470	226.1
1480	225.8
1490	225.4
1500	225.0

These values are based on the data of Sokolova, Krivoviazov and Kojtel'tsev (maximum bubble pressure method) [119]. The uncertainty of these measurements is estimated as ±2%.

$NaPO_3$

Melt Preparation and Purification

Zuca et al. [106] prepared $NaPO_3$ by dehydration of the commercial monosubstituted orthophosphate. Boyer, Fray and Meadowcroft [118] obtained $NaPO_3$ by dehydration of the appropriate mixtures of the mono and dibasic phosphates. Williams, Bradbury and Maddocks [120] prepared $NaPO_3$ by heating reagent grade sodium dihydrogen phosphate in a muffle furnace for about 7 hours at a temperature of 900-950°C. The melt was then quenched and the resulting glass was crushed and stored in a desiccator. Owens and Mayer [121] obtained $NaPO_3$ by heating reagent grade NaH_2PO_4 at 520°C for 1 week. Analysis of the product by the zinc oxide method indicated a water content of less than 0.2 wt%.

TABLE 65. Electrical conductance studies: $NaPO_3$

Investigations critically examined

Ref.	Temp. range (K)	Comments
106	1092-1302	Pt cell and electr.
122	923-1173	
107	933-1173	

Deviations from NSRDS recommendations (this volume)

Ref.	Min. deviation	Max. diviation
122	1.52% (1123 K)	4.39% (1173 K)
107	2.54% (1095 K)	3.47% (1165 K)

TABLE 66. $NaPO_3$: Specific conductance ($ohm^{-1}cm^{-1}$)

$\kappa = -1.2176 + 1.8953 \cdot 10^{-3} T$

Standard error of est. = 0.91%

T(K)	κ
1100	0.867
1120	0.905
1140	0.943
1160	0.981
1180	1.019
1200	1.057
1220	1.095
1240	1.133
1260	1.170
1280	1.208
1300	1.246

These values are based on the work of Zuca, Sokolova, Gagescu and Olteanu (classical ac technique) [106].

TABLE 67. Density studies: $NaPO_3$

Investigations critically examined

Ref.	Temp. range (K)	Comments
121	923-1113	Pt cruc.; Pt bob
112	1183,1280	
113	1033-1308	Pt sphere; calibr. molten KNO_3
118	992-1240	Pt-10% Rh cap.
120	1123-1273(g)	Pt-10% Rh sinker; Pt cruc.
123	952-1223	Pt bob,
111	1100-1790	
114	1138-1307	
115	1123-1223(g)	
116	1123	
117	973-1123(g)	

Deviations from NSRDS recommendations

Ref.	Min. deviation	Max. deviation
113	0.06%(1035 K)	0.32% (1110 K)
118	0.67%(992 K)	0.86% (1066 K)
123	-0.52%(1043 K)	-0.77% (952 K)
111	-0.20%(1100 K)	-0.20% (1100 K)

TABLE 68. $NaPO_3$: Density ($g \cdot cm^{-3}$)

$\rho = 2.6903 - 0.459 \cdot 10^{-3} T$

Standard error of est.= 0.002

T(K)	ρ
930	2.263
940	2.259
950	2.254
960	2.250
970	2.245
980	2.241
990	2.236
1000	2.231
1010	2.227
1020	2.222
1030	2.218
1040	2.213
1050	2.208
1060	2.204
1070	2.199
1080	2.195
1090	2.190
1100	2.185

These values are based on the data of Owens and Mayer (Archimedean method) [121].

$RbPO_3$

Melt Preparation and Purification

Sokolova et al. [107] prepared rubidium metaphosphate by dehydration of commercial monosubstituted rubidium orthophosphate.

TABLE 69. Electrical conductance studies: $RbPO_3$

Investigations critically examined

Ref.	Temp. range (K)	Comments
107	1118-1233	Pt cell

$Sr(PO_3)_2$

Melt Preparation and Purification

Sokolova et al. [107] prepared strontium metaphosphate by dehydration of commercial monosubstituted strontium orthophosphate.

TABLE 70. $RbPO_3$: Specific conductance ($ohm^{-1}cm^{-1}$)

$\kappa = -1.018 + 1.292 \cdot 10^{-3}T + 0.20 \cdot 10^{-6}T^2$

T(K)	κ
1120	0.680
1130	0.697
1140	0.715
1150	0.732
1160	0.750
1170	0.767
1180	0.785
1190	0.803
1200	0.820
1210	0.838
1220	0.856
1230	0.874

These values are based on the data of Sokolova, Lazarov, Markina and Ribakova (classical ac method) [107].

TABLE 71. Electrical conductances studies: $Sr(PO_3)_2$

Investigations critically examined

Ref.	Temp. range (K)	Comments
107	1255-1343	Pt cell

TABLE 72. $Sr(PO_3)_2$: Specific conductance ($ohm^{-1}cm^{-1}$)

$\kappa = 0.784 - 1.563 \cdot 10^{-3}T + 0.769 \cdot 10^{-6}T^2$

T(K)	κ
1260	0.0355
1270	0.0393
1280	0.0433
1290	0.0474
1300	0.0517
1310	0.0562
1320	0.0607
1330	0.0655
1340	0.0704

$Zn(PO_3)_2$

Melt Preparation and Purification

Zuca et al. [106] prepared $Zn(PO_3)_2$ by dehydration of the commercial monosubstituted orthophosphate. Sokolova and Voskresenskaya [124] obtained $Zn(PO_3)_2$ from reagent grade orthophosphoric acid and zinc oxide. The synthesis was carried out in platinum.

TABLE 73. Electrical conductance studies: $Zn(PO_3)_2$

Investigations critically examined

Ref.	Temp. range (K)	Comments
106	1362-1423	Pt cell and electrodes
107	1178-1331	

TABLE 74. $Zn(PO_3)_2$: Specific conductance ($ohm^{-1}cm^{-1}$)

$\kappa = -0.238 + 0.194 \cdot 10^{-3}T$

T(K)	κ
1365	0.0268
1370	0.0278
1375	0.0288
1380	0.0297
1385	0.0307
1390	0.0317
1395	0.0326
1400	0.0336
1405	0.0346
1410	0.0355
1415	0.0365
1420	0.0375

These values are based on the data of Zuca, Sokolova, Gagescu and Olteanu (classical ac technique) [106].

TABLE 75. Density studies: $Zn(PO_3)_2$

Investigations critically examined

Ref.	Temp. range (K)	Comments
113	1178-1398	Pt ball

TABLE 76. $Zn(PO_3)_2$: Density ($g \cdot cm^{-3}$)

$\rho = 2.8817 - 0.0767 \cdot 10^{-3} T$

T(K)	ρ
1180	2.791
1200	2.790
1220	2.788
1240	2.787
1260	2.785
1280	2.784
1300	2.782
1320	2.780
1340	2.779
1360	2.777
1380	2.776

These values are based on the data of Krivovyazov and Voskresenskaya (Archimedean method) [113].

TABLE 77. Surface tension studies: $Zn(PO_3)_2$

Investigations critically examined

Ref.	Temp. range (K)	Comments
124	1244-1466	
125	1073 1303 1373	
126	1173 1373	

TABLE 78. $Zn(PO_3)_2$: Surface tension (dyn cm^{-1})

$\gamma = 196.576 + 0.019533 \cdot 10^{-3} T$

Standard error of est. = 0.48%

T(K)	γ
1250	199.02
1260	199.04
1270	199.06
1280	199.08
1290	199.10
1300	199.12
1310	199.14
1320	199.16
1330	199.17
1340	199.19
1350	199.21
1360	199.23
1370	199.25
1380	199.27
1390	199.29
1400	199.31
1410	199.33
1420	199.35

These values are based on the data of Krivovyazov, Sokolova and Voskresenskaya (maximum bubble pressure) [124].

9.11 *Additional Studies: Metaphosphates*

The following tables summarize information relative to studies for metaphosphate salt melts since the publication of NSRDS-NBS-15 [1] and NSRDS-NBS-28 [2].

TABLE 79. Deviations from NSRDS recommendations: $Ca(PO_3)_2$

Reference	Authors	Min. deviation	Max. deviation
Surface tension (NSRDS reference data base: Sokolova, Voskresenskaya (1963), [2] p. 72)			
127	Nijjhar, Williams (1968)	0.68% (1380 K)	1.35% (1280 K)

TABLE 80. Deviations from NSRDS recommendations: KPO_3

Reference	Authors	Min. deviation	Max. deviation
Surface tension (NSRDS reference data base: Sokolova, Voskresenskaya (1963) [2], p. 71)			
114	Krivovyazov, Voskresenskaya (1969)	graphical	
128	Nijjhar, Williams (1966)	graphical	
127	Nijjhar, Williams (1968)	1.83% (1355 K)	2.89% (1135 K)

TABLE 81. Deviations from NSRDS recommendations: $LiPO_3$

Reference	Authors	Min. deviation	Max. deviation
Surface tension (NSRDS reference data base: Sokolova, Voskresenskaya (1963) [2] p. 71)			
118	Boyer, Fray, Meadowcroft (1967)	11.20% (1118 K)	11.56% (1212 K)
127	Nijjhar, Williams (1968)	1.96% (1345 K)	2.18% (1050 K)

TABLE 82. Deviations from NSRDS recommendations: $NaPO_3$

Reference	Authors	Min. deviation	Max. deviation
Viscosity (NSRDS reference data base: Arndt (1907), [1], p. 36)			
115	Kochergin, Khanzhina (1973)	graphical	
129	Volarovich, Tolstoi (1934)	outside temp. range of data base	
Surface tension (NSRDS reference data base: Owens, Mayer (1964), [2], p. 71)			
118	Boyd, Fray, Meadowcroft (1967)	-0.17% (1240 K)	2.02% (1189 K)
114	Krivovyazov, Voskresenskaya (1969)	graphical	
130	Sokolova, Krivovyazov, Voskresenskaya (1966)	-2.35% (990 K)	-3.85% (1250 K)
128	Nijjhar, Williams (1966)	graphical	

9.12 *Molybdate Studies*

New recommendations are reported here for single molybdates (cf.: sec. 9.2).

$Bi_2(MoO_4)_3$

Melt Preparation and Purification

Morris, McNair and Koops [131] used reagent grade bismuth molybdate with drying at 200°C for 1 hr.

K_2MoO_4

Melt Preparation and Purification

Morris and Robinson [132] used reagent grade potassium molybdate. Brown [133] used reagent grade salt and dried it for 6 hours at 225°C in an Ar atmosphere. Gossink and Stevels [134] prepared potassium molybdate from reagent grade potassium carbonate and molybdenum trioxide by reacting them (molten) in a platinum dish at 950-1000°C for 2 hours.

Li_2MoO_4

Melt Preparation and Purification

Morris and Robinson [132] used reagent grade lithium molybdate. Brown [133] used reagent grade salt and dried it for 6 hours at 225°C in an Ar atmosphere. Gossink and Stevels [134] prepared lithium molybdate from reagent grade lithium carbonate and molybdenum oxide by reacting these (molten) in a platinum dish at 950-1000°C for 2 hours.

Na_2MoO_4

Melt Preparation and Purification

Gossink and Stevels [134] prepared sodium molybdate from reagent grade sodium carbonate and molybdenum oxide by reacting these (molten) in a platinum dish at 1000°C for 2 hours.

$PbMoO_4$

Melt Preparation and Purification

Morris et al. [131] used reagent grade lead molybdate with drying for 2 hours at 200°C.

TABLE 83. Electrical conductance stu

$Bi_2(MoO_4)_3$

Investigations critically examined

Ref.	Temp. range (K)	Comments
131	980-1120	quartz dip cell Pt-Rh alloy cruc. calibr.: 0.1 D KCl

TABLE 84. $Bi_2(MoO_4)_3$: Specific conductance ($ohm^{-1}cm^{-1}$)

$\kappa = 1.82951 - 4.7284 \cdot 10^{-3}T + 3.2018 \cdot 10^{-6}T^2$

Standard error of est. = 0.90%

T(K)	κ
980	0.270
990	0.286
1000	0.303
1010	0.320
1020	0.338
1030	0.356
1040	0.375
1050	0.395
1060	0.415
1070	0.436
1080	0.457
1090	0.480
1100	0.502
1110	0.526
1120	0.550

These values are based on the data of Morris, McNair and Koops (classical ac technqiue) [131].

TABLE 85. Density studies: $Bi_2(MoO_4)_3$

Investigations critically examined

Ref.	Temp. range (K)	Comments
131	954-1034	platinum bob

TABLE 86. $Bi_2(MoO_4)_3$: Density (g cm^{-3})

$\rho = 6.2457 - 1.0779 \cdot 10^{-3}T$

Standard error of est. = 0.07%

T(K)	ρ
955	5.216
960	5.211
965	5.206
970	5.200
975	5.195
980	5.189
985	5.184
990	5.179
995	5.173
1000	5.168
1005	5.162
1010	5.157
1015	5.152
1020	5.146
1025	5.141
1030	5.136

These values are based on the data of Morris, McNair and Koops (Archimedean method) [131].

TABLE 87. Electrical conductance studies: K_2MoO_4

Investigations critically examined

Ref.	Temp. range (K)	Comments
133, 135	1281-1207	fused quartz cap. cell
132	1204-1271	fused quartz dip cell

Deviations from NSRDS recommendations (this vol.)

Ref.	Min. deviation	Max. deviation
133	-0.62% (1248 K)	-2.26% (1207 K)

TABLE 88. K_2MoO_4: Specific conductance($ohm^{-1}cm^{-1}$)

$\kappa = -13.1412 + 22.0142 \cdot 10^{-3}T - 8.37773 \cdot 10^{-6}T^2$

Standard error of est. = 0.85%

T(K)	κ
1205	1.221
1210	1.230
1215	1.239
1220	1.247
1225	1.254
1230	1.262
1235	1.269
1240	1.275
1245	1.281
1250	1.286
1255	1.292
1260	1.296
1265	1.301
1270	1.305

These values are based on the data of Morris and Robinson (classical ac technique) [132].

TABLE 89. Viscosity studies: K_2MoO_4

Investigations critically examined

Ref.	Temp. range (K)	Comments
134	1211-1287	tungsten torsion wire; Au-Pd alloy crucible

TABLE 90. Density studies: Li_2MoO_4

Investigations critically examined

Ref.	Temp. range (K)	Comments
133	1034-1154	Pt bob
132	1054-1236	Pt bob

Deviations from NSRDS recommended values

Ref.	Min. deviation	Max. deviation
133	-2.37% (1065 K)	-2.73% (1188 K)

TABLE 91. K_2MoO_4: Viscosity (cp)

$\eta = -58.392 + 100.82 \cdot 10^{-3}T - 41.8244 \cdot 10^{-6}T^2$

Standard error of est. 1.21%

T(K)	η
1215	2.37
1220	2.36
1225	2.36
1230	2.35
1235	2.34
1240	2.32
1245	2.31
1250	2.29
1255	2.27
1260	2.25
1265	2.22
1270	2.20
1275	2.17
1280	2.14
1285	2.11

These values are based on the data of Gossink and Stevels (oscillating hollow cylinder method) [134].

TABLE 92. Li_2MoO_4: Density (g cm^{-3})

$\rho = 3.87074 - 1.32077 \cdot 10^{-3}T + 0.36824 \cdot 10^{-6}T^2$

Standard error of est. = 0.05%

T(K)	ρ
1060	2.885
1070	2.879
1080	2.874
1090	2.869
1100	2.864
1110	2.858
1120	2.853
1130	2.849
1140	2.844
1150	2.839
1160	2.834
1170	2.830
1180	2.825
1190	2.821
1200	2.816
1210	2.812
1220	2.808
1230	2.803

These values are based on the data of Morris and Robinson (Archimedean method) [132].

TABLE 93. Viscosity studies: Li_2MoO_4

Investigations critically examined

Ref.	Temp. range (K)	Comments
134	996-1209	tungsten torsion wire; Au-Pd crucible

TABLE 94. Surface tension studies: Li_2MoO_4

Investigations critically examined

Ref.	Temp. range (K)	Comments
133	1034-1194	platinum bob; calibration: carbon tetrachloride; benzene; methanol
136	1034-1194	platinum bob
136	1103-1308	platinum ring; calibration: water, benzene

Deviations from NSRDS recommended values

Ref.	Min. deviation	Max. deviation
137	-3.45% (1190 K)	-7.69% (1040 K)

TABLE 95. Li_2MoO_4: Viscosity (cp)

$\eta = 43.5856 - 52.556 \cdot 10^{-3}T + 16.378 \cdot 10^{-6}T^2$

Standard error of est. = 0.72%

T(K)	η
1000	7.40
1010	7.21
1020	7.01
1030	6.82
1040	6.64
1050	6.45
1060	6.27
1070	6.10
1080	5.92
1090	5.75
1100	5.59
1110	5.42
1120	5.26
1130	5.11
1140	4.95
1150	4.80
1160	4.66
1170	4.51
1180	4.37
1190	4.23
1200	4.10

These values are based on the data of Gossink and Stevels (oscillating hollow cylinder method) [134].

TABLE 96. Li_2MoO_4: Surface tension (dyn cm^{-1})

$\gamma = 278.9389 + 30.983 \cdot 10^{-3}T - 71.450 \cdot 10^{-6}T^2$

Standard error of est. = 0.06%

T(K)	γ
1040	233.9
1050	232.7
1060	231.5
1070	230.3
1080	229.1
1090	227.8
1100	226.6
1110	225.3
1120	224.0
1130	222.7
1140	221.4
1150	220.1
1160	218.7
1170	218.1
1180	216.0
1190	214.6

These values are based on the data of Morris and Brown (pin detachment method) [133].

TABLE 97. Viscosity studies: Na_2MoO_4

Investigations critically examined

Ref.	Temp. range (K)	Comments
134	1029-1199	tungsten torsion wire; Au-Pd alloy crucible

TABLE 98. Electrical conductance studies: $PbMoO_4$

Investigations critically examined

Ref.	Temp. range (K)	Comments
131	1370-1390	quartz dip type cell; Pt-Rh alloy crucible

TABLE 99. Na_2MoO_4: Viscosity (cp)

$\eta = 82.414 - 130.657 \cdot 10^{-3}T + 53.819 \cdot 10^{-6}T^2$

Standard error of est. = 0.22%

T(K)	η
1030	4.93
1040	4.74
1050	4.56
1060	4.38
1070	4.22
1080	4.07
1090	3.94
1100	3.81
1110	3.69
1120	3.58
1130	3.49
1140	3.40
1150	3.33
1160	3.27
1170	3.21
1180	3.17
1190	3.14

These values are based on the data of Gossink and Stevels (oscillating hollow cylinder method) [134].

TABLE 100. $PbMoO_4$: Specific conductance ($ohm^{-1}cm^{-1}$)

$\kappa = -0.77025 + 1.2454 \cdot 10^{-3}T$

Standard error of est. = 0.09%

T(K)	κ
1370	0.936
1375	0.942
1380	0.949
1385	0.955
1390	0.961

These values are based on the data of Morris, McNair and Koops (classical ac technique) [131].

TABLE 101. Density studies: $PbMoO_4$

Investigations critically examined

Ref.	Temp. range (K)	Comments
131	1347-1401	platinum bob

TABLE 102. $PbMoO_4$: Density ($g \cdot cm^{-3}$)

$\rho = 6.14778 - 0.6770 \cdot 10^{-3}T$

Standard error of est. = 0.01%

T(K)	ρ
1350	5.234
1355	5.230
1360	5.227
1365	5.224
1370	5.220
1375	5.217
1380	5.213
1385	5.210
1390	5.207
1395	5.203
1400	5.200

These values are based on the data of Morris, McNair and Koops (Archimedean method) [131].

9.13 *Additional Studies: Molybdates*

The following tables summarize information relative to studies since the publication of NSRDS-NBS-15 [1] and NSRDS-NBS-28 [2].

TABLE 103. Deviations from NSRDS recommendations: K_2MoO_4

Reference	Authors	Min. departure	Max. departure
Density (NSRDS reference data base: Jaeger (1917), [1] p. 35)			
133, 135	Brown (1970)	-0.06% (1333 K)	-0.77 % (1245 K)
132	Morris, Robinson (1964)	5.22% (1255 K)	5.27% (1261 K)
Surface tension (NSRDS reference data base: Jaeger (1917), [2] p. 74)			
133, 136	Brown (1970)	1.64% (1284 K)	3.66% (1218 K)
137	Gossink, Stevels (1971)	-7.20% (1240 K)	-8.26% (1370 K)

TABLE 104. Deviations from NSRDS recommendations: Li_2MoO_4

Reference	Authors	Min. departure	Max. departure
Electrical conductance (NSRDS reference data base: Kvist, Lunden (1965), [1] p. 35			
133	Brown (1970)	25.63% (1125 K)	29.09% (1018 K)
132	Morris, Robinson (1964)	85.28% (1063 K)	136.51% (1212 K)

TABLE 105. Deviations from NSRDS recommendations: Na_2MoO_4

Reference	Authors	Min. departure	Max. departure
Density (NSRDS reference data base: Jaeger and Kapma (1920), [1] p. 35)			
133, 135	Brown (1970)	-2.37% (1146 K)	-2.44% (1124 K)
Surface tension (NSRDS reference data base: Jaeger (1917), [2] p. 74)			
133, 136	Brown (1970)	-1.17% (1167 K)	-1.86% (999.8 K)
137	Gossink, Stevels (1971)	-6.72% (1280 K)	-7.44% (1105 K)

9.14 *Perchlorate Salts*

Perchlorates, for which new recommendations are reported, are in this section (cf.: carbonates, sec. 9.2).

$LiClO_4$

Melt Preparation and Purification

Brovkina, Krotov and Selivanova [138] and Brovkina, Farmakovskaya, and Khokhlov [139] heated reagent grade lithium perchlorate at 300°C for 8-10 hours under vacuo (0.1-0.2 mm press.). For details of the method used by Allulli and Palazzeschi [140], refer to $CsClO_4$-$LiClO_4$.

TABLE 106. Electrical conductance studies: $LiClO_4$

Investigations critically examined

Ref.	Temp. range (K)	Comments
140	550-620	Pyrex cell;
138	533-653	Pyrex cell; calibr. KNO_3

Deviations from NSRDS recommended values (this vol

Ref.	Min. deviation	Max. deviation
138	-1.02% (553 K)	-2.26% (633 K)

TABLE 107. $LiClO_4$: Specific conductance ($ohm^{-1}cm^{-1}$)

$\kappa = -1.8656 + 5.2286 \cdot 10^{-3}T - 0.49754 \cdot 10^{-6}T^2$

T(K)	κ
550	0.860
560	0.906
570	0.953
580	1.000
590	1.046
600	1.093
610	1.139
620	1.185

These values are based on the work of Allulli and Palazzeschi (classical ac technique) [140].

TABLE 108. Viscosity studies: $LiClO_4$

Investigations critically examined

Ref.	Temp. range (K)	Comments
139	813-973	spherical Pt bob

TABLE 109. $LiClO_4$: Viscosity (cp)

$\eta = Ae^{E_a/RT}$

$A = 9.436 \cdot 10^{-2}$; $E_a = 4.665 \cdot 10^3$ cal mol^{-1}

T(K)	η
540	7.29
550	6.74
560	6.24
570	5.80
580	5.40
590	5.04
600	4.72
610	4.43
620	4.16
630	3.92
640	3.69
650	3.49
660	3.31
670	3.13
680	2.98
690	2.83
700	2.70

These values are based on the data of Brovkina, Farmakovskaya and Khokhlov (torsional oscillation method) [139].

9.15 *Additional Studies: Perchlorates*

The following table summarizes information relative to studies since the publication of NSRDS-NBS-15 [1] and NSRDS-NBS-28 [2].

TABLE 110. Deviations from NSRDS recommendations: $LiClO_4$

Reference	Authors	Min. departure	Max. departure
Density (NSRDS reference data base: Peterson, Ewing, Smith (1961), [1] p. 37			
139	Brovkina, Farmakovskaya, Khokhlov (1974)	0.00% (535 K)	0.21% (650 K)
140, 141	Allulli, Palazzeschi (1972)	-0.01% (625 K)	0.28% (545 K)

9.16 *Sulfate Salts*

Sulfates, for which new recommendations are advanced, are discussed in this section (cf.: sec. 9.2).

Li_2SO_4

Melt Preparation and Purification

For Kvist's method of melt preparation and some details of his experimental method, refer to Ag_2SO_4-Li_2SO_4 [142] [this volume].

Na_2SO_4

Melt Preparation and Purification

For Moiseev's method of melt preparation, refer to $CaSO_4$-Na_2SO_4 [145] [this volume].

Tl_2SO_4

Melt Preparation and Purification

For Kvist's method of melt preparation, refer to Ag_2SO_4-Li_2SO_4 [146] [this volume].

$ZnSO_4$

Melt Preparation and Purification

For Kvist's method of melt preparation, refer to Ag_2SO_4-Li_2SO_4 [146]. Zinc sulfate melts are thermally unstable. The equations for the conductivity and density of pure $ZnSO_4$ melts were obtained by Kvist by extrapolation of the data for Li_2SO_4-$ZnSO_4$ and Na_2SO_4-$ZnSO_4$ molten mixtures. These are stable up to about 80 mol % $ZnSO_4$. An analysis of Kvist's data for the binary mixtures is given under Li_2SO_4-$ZnSO_4$ and Na_2SO_4-$ZnSO_4$ [147] [this volume].

TABLE 111. Electrical conductance studies: Li_2SO_4

Investigations critically examined		
Ref.	Temp. range (K)	Comments
142	1140-1203	Quartz capillary cell; frequency range: 1000-10,000 Hz.
143	1140-1250	Al_2O_3 cell
144	840-1125	
76	898-1193	
66	1173	

TABLE 112. Li_2SO_4: Specific conductance ($ohm^{-1}cm^{-1}$)

$\kappa = -0.19539 \cdot 10^2 + 35.410 \cdot 10^{-3}T - 12.795 \cdot 10^{-6}T^2$

Standard error of est. = 0.09%

T(K)	κ
1140	4.200
1145	4.231
1150	4.261
1155	4.291
1160	4.320
1165	4.348
1170	4.376
1175	4.403
1180	4.429
1185	4.455
1190	4.480
1195	4.504
1200	4.528

These values are based on the data of Kvist (classical ac technique) [142] and supersede the recommendations advanced in [1].

TABLE 113. Viscosity studies : Na_2SO_4

Investigations critically examined		
Ref.	Temp. range (K)	Comments
145	1243-1473	alumina rod; calibr. CCl_4, H_2SO_4 and Hg

TABLE 114. Na_2SO_4: Viscosity (cp)

$\eta = 0.148\ e^{9990/RT}$

T(K)	η
1240	8.53
1250	8.26
1260	8.00
1270	7.76
1280	7.52
1290	7.29
1300	7.08
1310	6.87
1320	6.68
1330	6.49
1340	6.31
1350	6.13
1360	5.97
1370	5.81
1380	5.66
1390	5.51
1400	5.37
1410	5.23
1420	5.10
1430	4.98
1440	4.86
1450	4.74
1460	4.63
1470	4.53

These values based on the data of Tanutrov, Kosteneskii, Moiseev and Okunev (oscillational technique) [145]. The data were reported in equation form; no error estimate given.

TABLE 115. Electrical conductance studies: Tl_2SO_4

Investigations critically examined		
Ref.	Temp. range (K)	Comments
146	925-1004	quartz capillary cell; bright Pt electrodes

TABLE 116. Tl_2SO_4: Specific conductance ($ohm^{-1}cm^{-1}$)

$\kappa = -84.069 \cdot 10^{-2} + 1.9169 \cdot 10^{-3}\ T$

Standard error of est. = 0.12%

T(K)	κ
925	0.932
930	0.942
935	0.952
940	0.961
945	0.971
950	0.980
955	0.990
960	1.000
965	1.009
970	1.019
975	1.028
980	1.038
985	1.048
990	1.057
995	1.067
1000	1.076

These values are based on the data of Kvist and Schroeder (classical ac technique) [146].

TABLE 117. Density studies: Tl_2SO_4

Ref.	Temp. range (K)	Comments
146	953-1216	platinum bob

TABLE 118. Tl_2SO_4: Density (g cm^{-3})

$\rho = 7.3441 - 2.3155 \cdot 10^{-3}T + 0.4694 \cdot 10^{-6}T^2$

Standard error of est. = 0.06%

T(K)	ρ
960	5.554
980	5.526
1000	5.498
1020	5.471
1040	5.444
1060	5.417
1080	5.391
1100	5.365
1120	5.340
1140	5.315
1160	5.290
1180	5.266
1200	5.242

These values are based on the data of Kvist and Schroeder (Archimedean method) [146].

TABLE 119. Density studies: $ZnSO_4$

Investigations critically examined

Ref.	Temp. range (K)	Comments
147	873-1273	platinum bob

TABLE 120. $ZnSO_4$: Density (g cm^{-3})

$\rho = 3.591 - 0.470 \cdot 10^{-3}T$

T(K)	ρ
880	3.177
900	3.168
920	3.159
940	3.149
960	3.140
980	3.130
1000	3.121
1020	3.112
1040	3.102
1060	3.093
1080	3.083
1100	3.074
1120	3.065
1140	3.055
1160	3.046
1180	3.036
1200	3.027
1220	3.018
1240	3.008
1260	2.999

These values are based on the data of Kvist and Schroeder (extrapolated values) [147].

9.17 *Additional Studies: Sulfates*

The following tables summarize information relative to studies for single sulfates since the publication of NSRDS-NBS-15 [1] and NSRDS-NBS-28 [2].

TABLE 121. Deviations from NSRDS recommendations: Ag_2SO_4

Reference	Authors	Min. departure	Max. departure
Conductance (NSRDS reference data base: Kvist (1967), [1] p. 33)			
148	Polishchuk, Shurkhal (1972)	graphical	

TABLE 122. Deviations from NSRDS recommendations: Cs_2SO_4

Reference	Authors	Min. departure	Max. departure
Conductance (NSRDS reference data base: Kvist (1967), [1] p. 32)			
144	Polishchuk, Shurkhal, Romashchenko (1973)	graphical	
Density (NSRDS reference data base: Jaeger (1917), [1] p. 32)			
112	Kvist (1967)	-5.14% (1313 K)	-15.53% (1493 K)
Surface tension (NSRDS reference data base: Jaeger (1917), [2], p. 73)			
149	Bertozzi, Soldani (1967)	9.88% (1320 K)	15.08% (1470 K)

TABLE 123. Deviations from NSRDS recommendations: K_2SO_4

Reference	Authors	Min. departure	Max. departure
Conductance (NSRDS reference data base: Kvist (1967), [1] p. 32)			
64	Matiasovsky, Danek, Lillebuen (1972)	1.79% (1355 K)	1.86% (1350 K)
144	Polishchuk, Shurkhal, Romashchenko (1973)	graphical	
66	Markov, Polishchuk, Zvagolskaya (1973)	graphical	
Density (NSRDS reference data base: Neithamer, Peake (1961), [1] p. 32)			
112	Jaeger, Kahn (1916)	0.88% (1375 K)	
146	Kvist, Schroeder (1968)	0.18% (1404 K)	0.24% (1353 K)
Surface tension (NSRDS reference data base: Neithamer, Peake (1961), [2] p. 73)			
150	Semenchenko, Shikhobalova (1947)	outside temp. range data base	
149	Bertozzi, Soldani (1967)	0.14% (1360 K)	1.10% (1470 K)

TABLE 124. Deviations from NSRDS recommendations: Li_2SO_4

Reference	Authors	Min. departure	Max. departure
Density (NSRDS reference data base: Jaeger (1917) [1] p. 32)			
147	Josefson, Kvist (1970)	-0.91% (1165 K)	-1.07% (1220 K)
146	Kvist, Schroeder (1968)	0.02% (1232 K)	0.15% (1209 K)
151	Kvist (1967)	0.03% (1183 K)	0.41% (1231 K)

TABLE 125. Deviations from NSRDS recommendations: Na_2SO_4

Reference	Authors	Min. departure	Max. departure
Conductance (NSRDS reference data base: Kvist (1967), [1] p. 32)			
64	Matiasovsky, Danek, Lillebuen (1972)	-0.04% (1190 K)	-0.20% (1230 K)
144	Polishchuk, Shurkhal, Romashchenko (1973)	graphical	
152	Josefson, Kvist (1969)	-0.15% (1232 K)	0.17% (1192 K)
Density (NSRDS reference data base: Jaeger (1917), [1] p. 32)			
147	Josefson, Kvist (1970)	0.32% (1265 K)	0.57% (1350 K)
146	Kvist, Schroeder (1968)	0.34% (1269 K)	0.48% (1320 K)
145	Tanutrov, Kostenetskii, Moiseev (1971)	-0.65% (1350 K)	-1.30% (1265 K)
Surface tension (NSRDS reference data base: Jaeger (1917), [2] p.73)			
145	Tanutrov, Kostenetskii, Moiseev (1971)	-1.00% (1265 K)	-2.83% (1350 K)
153	Semenchenko, Shikhobalova (1947)	outside temp. range of data base	
150	Semenchenko, Shikhobalova (1947)	-1.51% (1323 K)	
149	Bertozzi, Soldani (1967)	-10.57% (1220 K)	-12.68% (1350 K)

TABLE 126. Deviations from NSRDS recommendations: Rb_2SO_4

Reference	Authors	Min. departure	Max. departure
Conductance (NSRDS reference data base: Kvist (1967), [1] p. 32)			
144	Polishchuk, Shurkhal, Romashchenko (1973)	graphical	
Surface tension (NSRDS reference data base: Jaeger (1917), [2] p. 73)			
149	Bertozzi, Soldani (1967)	-3.25% (1490 K)	-9.05 % (1820 K)

9.18 *Sulfide Salts and Polysulfides*

New recommendations for single sulfide salts and polysulfides are in this section (cf. sec. 9.2).

Co_4S_3

Melt Preparation and Purification

No information on melt preparation or purification was given in the studies by Dobrovinskii, Esin, Barmin et al. [154, 155, 156].

Cu_2S

Melt Preparation and Purification

No information on melt preparation or purification was given in the studies by Dobrovinskii, Esin, Barmin et al. [154, 155, 157].

FeS

Melt Preparation and Purification

No information on melt preparation or purification was given in the studies by Dobrovinskii, Barmin, Esin et al. [154, 155].

Na_2S_4

Melt Preparation and Purification

Oei [158, 159] prepared sodium tetrasulfide by reacting stoichiometric amounts of sodium and sulfur under dry toluene.

Na_2S_5

Melt Preparation and Purification

Oei [158, 159] prepared sodium pentasulfide from stoichiometric amounts of sodium and sulfur, reacted under dry toluene.

Ni_3S_2

Melt Preparation and Purification

No information on melt preparation and purification was given in the studies by Dobrovinskii, Barmin, Esin et al., [154, 155].

Tl_2S

Melt Preparation and Purification

Nakamura, Matsumura and Shimoji [160] prepared Tl_2S in the molten state under vacuo in sealed ampoules by carefully reacting stoichiometric amounts of the constituent elements.

K_2S - Sulfur (K_2S_x)

Melt Preparation and Purification

For the method used by Cleaver et al. [164] see Na_2S-sulfur (Na_2S_x).

TABLE 127. Density studies: Co_4S_3

Investigations critically examined

Ref.	Temp. range (K)	Comments
154	1523-1773	quartz capillary
155	1473-1773	quartz capillary

TABLE 128. Co_4S_3: Density ($g \cdot cm^{-3}$)

T(K)	ρ
1523-1773	4.3

The above single value is from the data of Dobrovinskii, Esin and Barmin (maximum bubble pressure method) [154].

TABLE 129. Viscosity studies: Co_4S_3

Investigations critically examined		
Ref.	Temp. range (K)	Comments
154	1523,1773	corundum crucible
155	1473,1773	corundum crucible

TABLE 130. Co_4S_3: Viscosity (cp)

T (K)	η
1523	2.15
1773	1.65

The above values are from the data of Dobrovinskii, Esin and Barmin (oscillational method) [154]

TABLE 131. Density studies: Cu_2S

Investigations critically examined		
Ref.	Temp. range (K)	Comments
154	1523-1773	quartz capillary
155	1473-1773	quartz capillary
157	graphical	

TABLE 132. Cu_2S: Density (g cm^{-3})

T (K)	ρ
1523-1773	5.4

The above value is the single value reported by Dobrovinskii, Esin and Barmin (maximum bubble pressure) [154].

TABLE 133. Viscosity studies: Cu_2S

Investigations critically examined		
Ref.	Temp. range (K)	Comments
154	1523, 1773	corundum crucible
155	1473, 1773	corundum crucible

TABLE 134. Cu_2S: Viscosity(cp)

T(K)	η
1523	4.0
1773	2.75

The above values are from the data of Dobrovinskii Barmin and Esin (oscillational method) [154].

TABLE 135. Density studies: FeS

Investigations critically examined		
Ref.	Temp. range (K)	Comments
154	1523-1773	quartz capillary
155	1473-1773	quartz capillary
157	graphical	

TABLE 136. FeS: Density (g cm^{-3})

T (K)	ρ
1523-1773	3.7

The above value is the sole data point reported by Dobrovinskii, Barmin and Esin (maximum bubble pressure) [154].

TABLE 137. Viscosity studies: FeS

Investigations critically examined		
Ref.	Temp. range (K)	Comments
154	1523,1773	corundum crucible
156	1523,1773	as for [154]
155	1473, 1773	as for [154]

TABLE 138. FeS: Viscosity (cp)

T (K)	η
1523	3.4
1773	2.45

These above values are from the data of Dobrovinskii, Barmin and Esin (oscillational technique) [154].

TABLE 139. Density studies: Na_2S_4

Investigations critically examined

Ref.	Temp. range (K)	Comments
158, 159	623-723	pycnometer

TABLE 140. Na_2S_4: Density ($g \cdot cm^{-3}$)

$\rho = 2.7631 - 0.14900 \cdot 10^{-2} T$

Standard error of estimate = 0.77%

T (K)	ρ	T (K)	ρ
625	1.832	675	1.757
630	1.824	680	1.750
635	1.817	685	1.743
640	1.810	690	1.735
645	1.802	695	1.728
650	1.795	700	1.720
655	1.787	705	1.713
660	1.780	710	1.705
665	1.772	715	1.698
670	1.765	720	1.690

These values are based on the data of Oei (pycnometric method) [158, 159]. The uncertainty in the values is estimated to be ± 3%.

TABLE 141. Surface tension studies: Na_2S_4

Investigations critically examined

Ref.	Temp. range (K)	Comments
158, 159	623-713	quartz plate

TABLE 142. Density studies: Na_2S_5

Investigations critically examined

Ref.	Temp. range (K)	Comments
158, 159	623-723	pycnometer

TABLE 143. Na_2S_4. Surface tension (dyn cm^{-1})

$\gamma = 177.24 - 0.065571 T$

Standard error of estimate = 0.58%

T (K)	γ	T (K)	γ
625	136.3	670	133.3
630	135.9	675	133.0
635	135.6	680	132.7
640	135.3	685	132.3
645	135.0	690	132.0
650	134.6	695	131.7
655	134.3	700	131.3
660	134.0	705	131.0
665	133.6	710	130.7

These values are based on the data of Oei (Wilhelmy slide plate method) [158, 159]. The uncertainty in the values is estimated to be ± 3%.

TABLE 144. Na_2S_5: Density ($g \cdot cm^{-3}$)

$\rho = 2.2890 - 0.84995 \cdot 10^{-3} T$

Standard error of estimate = 0.55%

T (K)	ρ	T (K)	ρ
625	1.758	675	1.715
630	1.754	680	1.711
635	1.749	685	1.707
640	1.745	690	1.703
645	1.741	695	1.698
650	1.737	700	1.694
655	1.732	705	1.690
660	1.728	710	1.686
665	1.724	715	1.681
670	1.720	720	1.677

These values are based on the data of Oei (pycnometric method) [158, 159]. The uncertainty in the values is estimated to be ± 3%.

TABLE 145. Surface tension studies: Na_2S_5

Investigations critically examined

Ref.	Temp. range (K)	Comments
158, 159	633-703	quartz plate

TABLE 146. Na_2S_5: Surface tension (dyn cm^{-1})

$\gamma = 184.87 - 0.101353\ T$

Standard error of estimate = 0.49%

T (K)	γ
635	120.5
640	120.0
645	119.5
650	119.0
655	118.5
660	118.0
665	117.5
670	117.0
675	116.5
680	116.0
685	115.5
690	114.9
695	114.4
700	113.9

These values are based on the data of Oei (Wilhelmy slide plate method) [158, 159]. The uncertainty in the values is estimated to be ± 3%

TABLE 147. Density studies: Ni_3S_2

Investigations critically examined

Ref.	Temp. range (K)	Comments
154	1523-1773	quartz capillary
155	1473-1773	quartz capillary

TABLE 148. Ni_3S_2: Density ($g \cdot cm^{-3}$)

T(K)	ρ
1523-1773	5.25

The above value is the sole data point reported by Dobrovinskii, Barmin and Esin (maximum bubble pressure method) [154].

TABLE 149. Viscosity studies: Ni_2S_3

Ref.	Temp. range (K)	Comments
154	1523,1773	corundum crucible
155	1473,1773	corundum crucible

TABLE 150. Ni_3S_2: Viscosity (cp)

T(K)	η
1523	3.50
1773	2.55

These above values are the results of Dobrovinskii Esin and Barmin (oscillational technique) [154].

TABLE 151. Electrical conductance studies: Tl_2S

Investigations critically examined

Ref.	Temp. range (K)	Comments
160	723-873	graphite electrodes
161	773-1173	

TABLE 152. Tl_2S: Specific conductance ($ohm^{-1}cm^{-1}$)

$\kappa = -17.387 + 0.223995\ T - 0.498804 \cdot 10^{-3}T^2 + 0.313565 \cdot 10^{-6}T^3$

Standard error of estimate = 0.91%

T (K)	κ	T (K)	κ
730	2.30	830	4.19
740	2.29	840	4.66
750	2.32	850	5.19
760	2.39	860	5.78
770	2.50	870	6.43
780	2.66	880	7.14
790	2.86	890	7.92
800	3.12	900	8.77
810	3.42	910	9.68
820	3.78		

These values have been interpolated from the graphical data of Nakamura, Matsumura and Shimoji (dc and ac four probe methods) [160].

TABLE 153. Density studies: Tl_2S

Investigations criticlaly examined

Ref.	Temp. range (K)	Comments
162	783-1073	

TABLE 154. Tl_2S: Density ($g \cdot cm^{-3}$)

$\rho = 20.0235 - 25.4630 \cdot 10^{-3}T + 12.662 \cdot 10^{-6}T^2$

Standard error of est. = 0.86%

T(K)	ρ
790	7.810
810	7.706
830	7.612
850	7.529
870	7.455
890	7.391
910	7.338
930	7.295
950	7.261
970	7.238
990	7.225
1010	7.223
1030	7.230
1050	7.248
1070	7.275

These values are based on data of Abdusalyamova and Salohakhina [162].

TABLE 155. Viscosity studies: Tl_2S

Investigations critically examined

Ref.	Temp. range (K)	Comments
162	783-1073	

TABLE 156. Electrical conductance studies

Investigations critically examined

Ref.	Composition	Temp. range	Comments
164	K_2S_3	571-695	carbon electrodes calibr.: 1 D KCl
	$K_2S_{3.4}$	486-674	
	K_2S_4	473-678	
	K_2S_5	524-674	
	K_2S_6	524-678	

TABLE 157. Tl_2S: Viscosity (poise)

$\eta = 0.28651 + 0.53134 \cdot 10^{-3}T + 0.25806 \cdot 10^{-6}T^2$

Standard error of estimate = 5.1%

T (K)	η	T (K)	η
790	0.027	940	0.015
800	0.026	950	0.014
810	0.025	960	0.014
820	0.024	970	0.013
830	0.023	980	0.013
840	0.022	990	0.013
850	0.021	1000	0.013
860	0.020	1010	0.013
870	0.019	1020	0.013
880	0.018	1030	0.013
890	0.018	1040	0.013
900	0.017	1050	0.013
910	0.016	1060	0.013
920	0.016		
930	0.015		

TABLE 158. K_2S_3: Specific conductance ($ohm^{-1}cm^{-1}$)

$\kappa = 5.438\ e^{-1490/R(T-343)}$

Standard error of estimate = 1.04%

T (K)	κ
570	0.199
580	0.229
590	0.260
600	0.293
610	0.327
620	0.362
630	0.398
640	0.435
650	0.472
660	0.510
670	0.548
680	0.587
690	0.626

TABLE 159. $K_2S_{3.4}$: Specific conductance ($ohm^{-1}cm^{-1}$)

$\kappa = 6.260\ e^{-1777/R(T\ -306)}$

Standard error of estimate = 0.70%

T (K)	κ
490	0.048
500	0.062
510	0.078
520	0.095
530	0.115
540	0.136
550	0.159
560	0.184
570	0.211
580	0.238
590	0.267
600	0.298
610	0.329
620	0.362
630	0.395
640	0.429
650	0.464
660	0.499
670	0.535

These values are based on the data of Cleaver, Davies and Hames (classical ac technique) [164].

TABLE 160. K_2S_4: Specific conductance ($ohm^{-1}cm^{-1}$)

$\kappa = 3.014\ e^{-1295/R(T\ -341)}$

Standard error of estimate = 1.09%

T (K)	κ
470	0.019
480	0.028
490	0.038
500	0.050
510	0.063
520	0.079
530	0.096
540	0.114
550	0.133
560	0.153
570	0.175
580	0.197
590	0.220
600	0.243
610	0.267
620	0.291
630	0.316
640	0.340
650	0.365
660	0.390
670	0.415
680	0.440

These values are based on the data of Cleaver, Davies and Hames (classical ac technique) [164].

TABLE 161. K_2S_5: Specific conductance ($ohm^{-1}cm^{-1}$)

$\kappa = 2.427\ e^{-1245/R(T - 354)}$

Standard error of estimate = 0.71%

T (K)	κ
520	0.055
530	0.069
540	0.083
550	0.099
560	0.115
570	0.133
580	0.151
590	0.170
600	0.190
610	0.210
620	0.230
630	0.250
640	0.271
650	0.292
660	0.313
670	0.334

These values are based on the data of Cleaver, Davies and Hames (classical ac technique) [164].

TABLE 162. K_2S_6: Specific conductance ($ohm^{-1}cm^{-1}$)

$\kappa = 1.099\ e^{-798.3/R(T - 393)}$

Standard error of estimate = 1.48%

T (K)	κ
520	0.046
530	0.058
540	0.071
550	0.085
560	0.099
570	0.113
580	0.128
590	0.143
600	0.157
610	0.172
620	0.187
630	0.201
640	0.216
650	0.230
660	0.243
670	0.257
680	0.270
690	0.284

These values are based on the data of Cleaver, Davies and Hames (classical ac technique) [164].

9.19 *Additional Studies: Sulfides*

The following tables summarize information relative to studies since the publication of NSRDS-NBS-15 [1] and NSRDS-NBS-28 [2].

TABLE 163. Deviations from NSRDS recommendations: Ag_2S

Reference	Authors	Min. departure	Max. departure
Electrical conductance (NSRDS reference data base: Velikanov (1960), [1] p 31)			
165	Velikanov, Eichis (1972)	graphical	

TABLE 164. Deviations from NSRDS recommendations: Bi_2S_3

Reference	Authors	Min. departure	Max. departure
Electrical conductance (NSRDS reference data base: Velikanov (1958), [1]p. 31)			
166	Mustyatsa, Velikanov, Gudzenko (1970)	graphical	
167	Velikanov, Mustyatsa (1972)	graphical	

TABLE 165. Deviations from NSRDS recommendations: Cu_2S

Reference	Authors	Min. deviation	Max. deviation
Electrical conductance (NSRDS reference data base: Velikanov (1970), [1], p. 31)			
168	Delmaire, Brusq, Marion (1970)	graphical	
227	Pound, Derge, Osuch (1955)	11.82% (1400 K)	16.42% (1470 K)
226	Barmin, Dobrovinski, Esin (1970)	2.21% (1530 K)	33.22% (1470 K)
Surface tension (NSRDS reference data base: Boni, Derge (1956), [2] p. 59)			
157	Vaisburd, Yakovleva (1968)	graphical	

TABLE 166. Deviations from NSRDS recommendations: FeS

Reference	Authors	Min. deviation	Max. deviation
Electrical conductance (NSRDS reference data base: Velikanov (1960), [1] p. 30)			
169	Kurochkin, Potapova Onaev (1972)	-2.39% (1473 K)	-2.39% (1473 K)
227	Pound, Derge, Osuch (1955)	3.10% (1460 K)	5.30% (1500 K)
226	Barmin, Dobrovinski, Esin (1970)	15.21% (1464 K)	16.48% (1485 K)

TABLE 168. Deviations from NSRDS recommendations: Sb_2S_3

Reference	Authors	Min. deviation	Max. deviation
Electrical conductance (NSRDS reference data base: Velikanov (1960), [1] p 31)			
171	Velikanov, Mustyatsa, Delimarskii (1971)	graphical	
170	Delimarskii, Velikanov (1958)	7.14% (948 K)	11.18% (1048 K)
Density (NSRDS reference data base: Velikanov (1960), [1] p 31)			
172	Glazov, Glagoleva, Eugen'ev (1969)	graphical	

9.20 *Tetraborate Salts*

New recommendations for tetraborates are discussed in this section (cf. carbonates, sec. 9.2).

$K_2B_4O_7$

Melt Preparation and Purification

Kochergin, Baldina and Kareva [116] used reagent grade salt.

$Na_2B_4O_7$

Melt Preparation and Purification

Kochergin, Baldina and Kareva [116] and Oparin and Yakobashvilii [173] used reagent grade salt.

TABLE 169. Density studies: $K_2B_4O_7$

Investigations critically examined

Ref.	Temp. range (K)	Comments
116	1123	Pt sphere

TABLE 170. $K_2B_4O_7$: Density ($g \cdot cm^{-3}$)

T(K)	ρ
1123	1.997

This value is the sole data point of Kochergin, Baldina and Kareva (Archimedean method) [116].

TABLE 171. Density studies: $Na_2B_4O_7$

Investigations critically examined

Ref.	Temp. range (K)	Comments
116	1123	Pt sphere
173	1223	corrundum cap.

TABLE 172. $Na_2B_4O_7$: Density ($g \cdot cm^{-3}$)

T(K)	ρ
1123	2.095
1223	2.06

These values are from (a): Kochergin, Boldina and Kareva (Archimedean method) [116] and (b): Oparin and Yakobashvilii (maximum bubble pressure) [173].

TABLE 173. Surface tension studies: $Na_2B_4O_7$

Investigations critically examined

Ref.	Temp. range (K)	Comments
173	1223	corrundum cap Ar atmosphere
174	1023-1223(g)	as for [173]

TABLE 174. $Na_2B_4O_7$: Surface tension ($dyn \cdot cm^{-1}$)

T(K)	γ
1223	230

This values is from the data of Oparin and Yakobashvilii (modified maximum bubble pressure) [173].

9.21 *Tetrafluoroborate Salts*

New recommendations for tetrafluoroborates are discussed in this section (cf. sec. 9.2).

$CsBF_4$

Melt Preparation and Purification

Cantor, McDermott and Gilpatrick [175] prepared $CsBF_4$ by the reactions:

$$H_3BO_3(s) + 4HF\ (48\%\ aq) = HBF_4(aq) + 3H_2O\ (\ell)$$

$$CsF(aq) + HBF_4(aq) = CsBF_4(s) + HF(aq)$$

The precipitated fluoroborate salt was washed with cold water, and dried at 100°C in an oven. Reagent grade CsF was the starting material.

KBF_4

Melt Preparation and Purification

Cantor [175, 176, 177] prepared pure KBF_4 by reacting aqueous solutions of previously purified $NaBF_4$ and reagent grade KCl. The precipitated KBF_4, after several washings with water, was vacuum dried in a desiccator and then oven-dried overnight at 100°C.

$LiBF_4$

Melt Preparation and Purification

Cantor, McDermott and Gilpatrick [175] used $LiBF_4$ obtained from the Foote Mineral Company without further purification. All transfers were made in a dry box with helium atmosphere.

$NaBF_4$

Melt Preparation and Purification

Cantor et al. [175, 176, 177, 179] prepared $NaBF_4$ by dissolving the commercial salt [Harshaw Chemical Company] in water, filtering and recrystallization from a hot (90°) dilute HF solution. The crystals were dried first in a vacuum desiccator and then in an oven at 100°C.

$RbBF_4$

Melt Preparation and Purification

Cantor, McDermott and Gilpatrick [175] prepared the salt by the following reactions:

$$H_3BO_3(s) + 4HF\ (48\%\ aq) = HBF_4(aq) + 3H_2O(\ell)$$

$$RbF(aq) + HBF_4(aq) = RbBF_4(s) + HF(aq)$$

The precipitated fluoroborate salt was washed with cold water and over-dried at 100°C.

TABLE 175. Density studies: $CsBF_4$

Investigations critically examined

Ref.	Temp. range (K)	Comments
175	833-990	Ni dilatometer

TABLE 176. Density studies: KBF_4

Investigations critically examined

Ref.	Temp. range (K)	Comments
175	858-954	Ni dilatometer

TABLE 177. $CsBF_4$: Density $g \cdot cm^{-3}$

$\rho = 3.4770 - 1.19 \cdot 10^{-3} T$

T(K)	ρ
840	2.477
850	2.466
860	2.454
870	2.442
880	2.430
890	2.418
900	2.406
910	2.394
920	2.382
930	2.370
940	2.358
950	2.347
960	2.335
970	2.323
980	2.311
990	2.299

These values are based on the data of Cantor et al. (dilatometric method) [175]. The data were reported in the form of a temperature dependent equation; no error estimate given.

TABLE 178. KBF_4: Density $(g \cdot cm^{-3})$

$\rho = 2.4506 - 0.815 \cdot 10^{-3} T$

T(K)	ρ
890	1.725
900	1.717
910	1.709
920	1.701
930	1.693
940	1.685
950	1.676
960	1.668
970	1.660
980	1.652
990	1.644

These values are based on the data of Cantor et al. (dilatometric method) [175]. The data were reported in the form of a temperature dependent equation; no error estimate given.

TABLE 179. Viscosity studies: KBF_4

Investigations critically examined

Ref.	Temp. range (K)	Comments
177	857-954	sealed cylindrical cup; torsion wire suspension
178	858-954	as for [177]

Deviations from NSRDS recommendations

Ref.	Min. deviation	Max. deviation
176 (sample 1)	1.64% (858 K)	-3.13% (898 K)
176 (sample 2)	-0.01% (875 K)	4.76% (914 K)

TABLE 180. KBF_4: Viscosity (cp)

$\eta = 0.0946 \exp (4530.36/RT)$

T(K)	η
860	1.34
870	1.30
880	1.26
890	1.22
900	1.19
910	1.15
920	1.12
930	1.09
940	1.07
950	1.04

These values are based on the data of Cantor et al. (oscillating cup) [177]. The data were reported in the form of a temperature dependent equation; no error estimate given.

TABLE 181. Density studies: $LiBF_4$

Investigations critically examined

Ref.	Temp. range (K)	Comments
175	583-676	Ni dilatometer

TABLE 182. $LiBF_4$: Density ($g \cdot cm^{-3}$)

$\rho = 2.13310 - 0.458 \cdot 10^{-3} T$

T (K)	ρ
590	1.863
600	1.858
610	1.854
620	1.849
630	1.845
640	1.840
650	1.835
660	1.831
670	1.826

These values are based on the data of Cantor et al. (dilatometric technique) [175]. The data were reported in the form of a temperature dependent equation ; no error estimate given.

TABLE 183. Electrical conductance studies: $NaBF_4$

Investigations critically examined

Ref.	Temp. range (K)	Comments
179	700-780	corrundum cruc. Pt electrodes

TABLE 184. $NaBF_4$: Specific conductance ($ohm^{-1} cm^{-1}$)

$\kappa = -0.09019 + 2.6 \cdot 10^{-3} T$

T(K)	κ
700	1.730
710	1.756
720	1.782
730	1.808
740	1.834
750	1.860
760	1.886
770	1.912
780	1.938

These values are from the data of Cantor et al. (estimated from KBF_4, NaI and KI) [179]. The data were reported in the form of a temperature dependent equation; the accuracy limits are ±20%.

TABLE 185. Density studies: $NaBF_4$

Investigations critically examined

Ref.	Temp. range (K)	Comments
175	689-827	Ni dilatometer
176	699-786	Ni dilatometer

Deviations from NSRDS recommendations (this vol)

Ref.	Min. deviation	Max. deviation
176	0.09% (700 K)	0.14% (785 K)

TABLE 186. $NaBF_4$: Density ($g \cdot cm^{-3}$)

$\rho = 2.4681 - 0.751 \cdot 10^{-3} T$

T(K)	ρ
690	1.950
700	1.942
710	1.935
720	1.927
730	1.920
740	1.912
750	1.905
760	1.897
770	1.890
780	1.882
790	1.875
800	1.867
810	1.860
820	1.852

These values are based on the data of Cantor et al. (dilatometric technique) [175]. The data were reported in the form of a temperature dependent equation; error limits not given.

TABLE 187. Viscosity studies: $NaBF_4$

Investigations critically examined

Ref.	Temp. range (K)	Comments
176	699-786	sealed cylindr. cup
177	692-786	as for [176]

Deviations from NSRDS recommendations (this vol)

Ref.	Min. deviation	Max. deviation
180	9.21% (780 K)	19.94% (700 K)

TABLE 188. $NaBF_4$: Viscosity (cp)

$\eta = 0.0832 \exp (4689.3 / RT)$

T (K)	η
700	2.42
710	2.31
720	2.20
730	2.10
740	2.01
750	1.93
760	1.85
770	1.78
780	1.71

These values are based on the data of Cantor et al. (oscillating cup method) [177]. The data were reported in the form of a temperature dependent equation; no error estimate given.

TABLE 189. Surface tension studies: $NaBF_4$

Investigations critically examined

Ref.	Temp. range (K)	Comments
179	700-785	

TABLE 190. $NaBF_4$: Surface tension ($dyn \cdot cm^{-1}$)

$\gamma = 140.48 - 75.0 \cdot 10^{-3} T$

T(K)	γ
700	88.0
710	87.2
720	86.5
730	85.7
740	85.0
750	84.2
760	83.5
770	82.7
780	82.0

These values are based on the data of Cantor et al. (estimated from the surface tension data for NaI) [179]. The data were reported in the form of a temperature dependent equation; accuracy limits, approx. ±25%.

TABLE 191. Density studies: $RbBF_4$

Investigations critically examined

Ref.	Temp. range (K)	Comments
175	864-998	Ni dilatometer

TABLE 192. $RbBF_4$: Density ($g \cdot cm^{-3}$)

$\rho = 3.07907 - 1.04 \cdot 10^{-3} T$

T	ρ
870	2.174
880	2.164
890	2.153
900	2.143
910	2.133
920	2.122
930	2.112
940	2.101
950	2.091
960	2.081
970	2.070
980	2.060
990	2.049

9.22 *Additional Studies: Thiocyanates*

The following table summarizes information relative to studies for thiocyanates since the publication of NSRDS-NBS-15 [1] and NSRDS-NBS-28 [2].

9.23 *Tungstate Salts*

New recommendations for tungstates are discussed in this section (cf. sec. 9.2).

$Bi_2(WO_4)_3$

Melt Preparation and Purification

Brown [133, 182] used reagent grade bismuth tungstate and dried the salt for 6 hours at 225°C, in an Ar atmosphere. The dried salt was stored in a desiccator until ready for use.

K_2WO_4

Melt Preparation and Purification

Kvist [183] and Brown and Morris [182] used reagent grade potassium tungstate without further purification. The salt was dried for several hours at about 200°C and stored in a desiccator before use. Gossink and Stevels [134] prepared the tungstate from reagent grade K_2CO_3 and tungsten trioxide by reacting them in platinum at 950-1000° for 2 hours.

Li_2WO_4

Melt Preparation and Purification

Brown [133, 182], Kvist [185] and Morris and Brown [13047] used reagent grade lithium tungstate without further purification. The salt was dried for several hours at about 200°C. Gossink and Stevels [137] prepared lithium tungstate from reagent grade lithium carbonate and tungsten trioxide by reacting them in the molten state in a Pt dish for 2 hours at 950-1000°C.

Na_2WO_4

Melt Preparation and Purification

Gossink and Stevels [134] prepared sodium tungstate from reagent grade sodium carbonate and tungsten trioxide by reacting them molten in platinum at 950-1000°C for 2 hours.

$PbWO_4$

Melt Preparation and Purification

Brown [133, 182] used reagent grade lead tungstate and dried it for 6 hours at 225°C in an Ar atmosphere. The salt was stored in a desiccator until ready for use.

TABLE 193. Deviations from NSRDS recommendations: KSCN

Reference	Authors	Min. departure	Max. departure
Electrical conductance (NSRDS reference data base: Plester, Rogers, Ubbelohde (1956)[1] p 35)			
181	Dulieu, Claes (1973)	0.56% (502 K)	6.01% (453 K)
Density (NSRDS reference data base: Frame, Rhodes, Ubbelohde (1959)[1] p. 35)			
181	Dulieu, Claes	0.00% (473 K)	0.63% (502 K)

TABLE 194. Electrical conductance studies: $Bi_2(WO_4)_3$

Investigations critically re-examined

Ref.	Temp. range (K)	Comments
133, 182	1160-1275	fused quartz cell; cal : 1 D KCl

TABLE 195. $Bi_2(WO_4)_3$: Specific conductance ($ohm^{-1}cm^{-1}$)

$\kappa = -4.2192 + 5.5585 \cdot 10^{-3}T - 1.3365 \cdot 10^{-6}T^2$

Standard error of est = 0.44%

T(K)	κ
1160	0.430
1170	0.455
1180	0.479
1190	0.503
1200	0.526
1210	0.550
1220	0.573
1230	0.596
1240	0.618
1250	0.640
1260	0.663
1270	0.684

These values are based on the data of Brown and Morris (classical ac technique) [133,182].

TABLE 196. Density studies: $Bi_2(WO_4)_3$

Investigations critically examined

Ref.	Temp. range (K)	Comments
133, 182	1145-1275	platinum bob; Pt-Rh suspension wire; calibration: methanol, carbon tetrachloride, benzene.

TABLE 197. $Bi_2(WO_4)_3$: Density ($g\ cm^{-3}$)

$\rho = 10.5556 - 4.7001 \cdot 10^{-3}T + 1.4179 \cdot 10^{-6}T^2$

Standard error of est = 0.03%

T(K)	ρ
1150	7.026
1160	7.012
1170	6.998
1180	6.984
1190	6.971
1200	6.957
1210	6.945
1220	6.932
1230	6.920
1240	6.908
1250	6.896
1260	6.885
1270	6.874

These values are based on the data of Brown and Morris (Archimedean method) [133,182].

TABLE 198. Surface tension studies: $Bi_2(WO_4)_3$

Investigations critically examined

Ref.	Temp. range (K)	Comments
182	1145-1273	platinum bob; Pt-Rh wire; cal.: methanol, benzene, carbon tetrachloride

TABLE 199. $Bi_2(WO_4)_3$: Surface tension (dyn cm^{-1})

$\gamma = 328.816 - 99.729 \cdot 10^{-3} T$

Standard error of est. = 0.01%

T(K)	γ
1150	214.13
1160	213.13
1170	212.13
1180	211.14
1190	210.14
1200	209.14
1210	208.14
1220	207.15
1230	206.15
1240	205.15
1250	204.15
1260	203.16
1270	202.16

These values are based on the data of Brown (detachment method) [182].

TABLE 200. Electrical conductance studies: K_2WO_4

Investigations critically examined

Ref.	Temp. range (K)	Comments
183	1206-1309	quartz capillary cell; bright Pt electrodes; calibration 1.0 N KCl
184	1219-1297	fused quartz dip type cell
133, 182	1249-1302	fused quartz cap.

Deviations from NSRDS recommendations

Ref.	Min, deviation	Max. deviation
184	-5.11% (1260 K)	-5.83% (1220 K)
133	-0.17% (1301 K)	-2.57% (1248 K)

TABLE 201. K_2WO_4: Specific conductance ($ohm^{-1}cm^{-1}$)

$\kappa = -5.3874 + 8.697 \cdot 10^{-3}T - 2.7120 \cdot 10^{-6}T^2$

Standard error of est. = 0.16%

T(K)	κ
1210	1.166
1220	1.187
1230	1.208
1240	1.228
1250	1.247
1260	1.266
1270	1.284
1280	1.302
1290	1.320
1300	1.336

These values are based on the data of Kvist (classical ac technique) [183].

TABLE 202. Viscosity studies: K_2WO_4

Investigations critically examined

Ref.	Temp. range (K)	Comments
134	1235,1255	tungsten torsion wire; Au-Pd alloy crucible

TABLE 203. K_2WO_4: Viscosity (cp)

T(K)	η
1235	2.57
1255	2.43

These values are from the data of Gossink and Stevels (oscillating hollow cylinder) [134].

TABLE 204. Electrical conductance studies: Li_2WO_4

Investigations critically re-examined

Ref.	Temp. range (K)	Comments
185	1010-1083	quartz cap. bright Pt electrodes; cal.: 1.0 N KCl
184	1035-1176	fused quartz dip cell
182 133	1070-1170	fused quartz cap. cell

Deviations from NSRDS recommendations (this vol)

Ref.	Min. deviation	Max deviation
185	-9.28% (1150 K)	-11.40% (1090 K)
184	-9.67% (1130 K)	-13.20% (1040 K)

TABLE 205. Density studies: Li_2WO_4

Ref.	Temp. range (K)	Comments
184	1037-1174	platinum bob;
133 182	1040-1190	platinum bob; calibr methanol, carbon tetrachloride, benzene
137	1098-1265	platinum bob

Deviation from NSRDS recommended values

Ref.	Min. deviation	Max. deviation
184	1.09% (1170 K)	1.13% (1085 K)
137	-0.30% (1100 K)	-0.51% (1190 K)

TABLE 206. Li_2WO_4: Specific conductance ($ohm^{-1}cm^{-1}$)

$\kappa = -2.2926 + 4.0675 \cdot 10^{-3}T$

Standard error of est. = 0.14%

T(K)	κ
1085	2.121
1090	2.141
1095	2.161
1100	2.182
1105	2.202
1110	2.222
1115	2.243
1120	2.263
1125	2.283
1130	2.304
1135	2.324
1140	2.344
1145	2.365
1150	2.385

TABLE 207. Li_2WO_4: Density ($g\ cm^{-3}$)

$\rho = 5.3361 - 1.2911 \cdot 10^{-3}T + 0.22835 \cdot 10^{-6}T^2$

Standard error of est. = 0.01%

T(K)	ρ
1050	4.232
1060	4.224
1070	4.216
1080	4.208
1090	4.200
1100	4.192
1110	4.184
1120	4.177
1130	4.169
1140	4.161
1150	4.153
1160	4.146
1170	4.138
1180	4.131
1190	4.123

TABLE 208. Viscosity studies: Li_2WO_4

Investigations critically examined		
Ref.	Temp. range (K)	Comments
134	1126, 1164, 1215	tungsten wire; Au-Pd crucible

TABLE 209. Li_2WO_4: Viscosity (cp)

T (K)	η
1126	8.13
1164	6.42
1215	5.27

These values are from the work of Gossink and Stevels (oscillating hollow cylinder method [134]

TABLE 210. Surface tension studies: Li_2WO_4

Investigations critically examined		
Ref.	Temp. range (K)	Comments
133	1030-1235	platinum bob; calibration: methanol, carbon tetrachloride, benzene
137	1073-1283	platinum ring

Deviations from NSRDS recommended values		
Ref.	Min. deviation	Max. deviation
137	-3.18% (1235 K)	-5.01% (1075 K)

TABLE 211. Viscosity studies: Na_2WO_4

Investigations critically examined		
Ref.	Temp. range (K)	Comments
134	1045-1258	tungsten wire; Au-Pd crucible

TABLE 212. Li_2WO_4: Surface tension (dyn cm^{-1})

$\gamma = 322.590 - 84.855 \cdot 10^{-3}T$

Standard error of est. = 0.03%

T(K)	γ
1040	234.3
1060	232.6
1080	230.9
1100	229.2
1120	227.5
1140	225.8
1160	224.1
1180	222.4
1200	220.7
1220	219.0

These values are based on the data of Morris and Brown (pin detachment method) [133].

TABLE 213. Na_2WO_4: Viscosity (cp)

$\eta = 69.2751 - 95.897 \cdot 10^{-3}T + 34.477 \cdot 10^{-6}T^2$

Standard error of est. = 2.90%

T(K)	η
1050	6.59
1070	6.14
1090	5.71
1110	5.31
1130	4.94
1150	4.59
1170	4.27
1190	3.98
1210	3.72
1230	3.48
1250	3.27

These values are based on the data of Gossink and Stevels (oscillating hollow cylinder method [134].

TABLE 214. Electrical conductance studies: $PbWO_4$

Investigations critically examined		
Ref.	Temp. range (K)	Comments
133,182	1407-1503	quartz capillary

TABLE 215. $PbWO_4$: Specific conductance ($ohm^{-1}cm^{-1}$)

$\kappa = -4.4419 + 5.8640 \cdot 10^{-3}T - 1.5002 \cdot 10^{-6}T^2$

Standard error of est. = 0.18%

T(K)	κ
1410	0.844
1420	0.860
1430	0.876
1440	0.891
1450	0.907
1460	0.922
1470	0.936
1480	0.951
1490	0.965
1500	0.979

TABLE 216. Density studies: $PbWO_4$

Investigations critically examined		
Ref.	Temp. range (K)	Comments
133,182	1425-1504	platinum bob; calibration: methanol, CCl_4, benzene

TABLE 217. Surface tension studies: $PbWO_4$

Investigations critically examined		
Ref.	Temp. range (K)	Comments
133	1413-1504	platinum bob calibr. methanol, CCl_4, benzene

TABLE 218. $PbWO_4$: Density ($g\ cm^{-3}$)

$\rho = 7.8450 - 0.9525 \cdot 10^{-3}T$

Standard error of est. = 0.01%

T(K)	ρ
1430	6.483
1435	6.478
1440	6.473
1445	6.469
1450	6.464
1455	6.459
1460	6.454
1465	6.450
1470	6.445
1475	6.440
1480	6.435
1485	6.431
1490	6.426
1495	6.421
1500	6.416

These values are based on the data of Brown and Morris (Archimedean method) [133,182].

TABLE 219. $PbWO_4$: Surface tension ($dyn\ cm^{-1}$)

$\gamma = 279.367 - 78.360 \cdot 10^{-3}\ T$

Standard error of est. = 0.06%

T(K)	γ
1420	168.1
1430	167.3
1440	166.5
1450	165.7
1460	164.9
1470	164.1
1480	163.3
1490	162.6
1500	161.8

These values are based on the data of Brown (detachment method) [133].

9.24 *Additional Studies: Tungstates*

The following tables summarize information relative to studies since the publication of NSRDS-NBS-15 [1] and NSRDS-NBS-28 [2].

TABLE 220. Deviations from NSRDS recommendations: K_2WO_4

Reference	Authors	Min. departure	Max. departure
Density (NSRDS reference data base: Jaeger (1917), [1] p. 35)			
184	Morris,Robinson (1964)	0.11% (1250 K)	0.33% (1325 K)
133, 182	Brown, Morris (1970)	-0.20% (1301 K)	-0.28% (1260 K)
137	Gossink, Stevels (1971)	0.38% (1250 K)	1.12% (1325 K)
Surface tension (NSRDS reference data base: Jaeger (1917), [2] p. 74)			
133	Brown (1970)	0.15% (1287 K)	1.23% (1260 K)
137	Gossink, Stevels (1971)	-8.13% (1340 K)	-10.32% (1240 K)

TABLE 221. Deviations from NSRDS recommendations: Na_2WO_4

Reference	Authors	Min. departure	Max. departure
Conductance (NSRDS reference data base: Jaeger, Kapma (1920), [1] p. 35)			
184	Morris, Robinson (1964)	-0.06% (1050 K)	-7.64% (980 K)
133,182	Brown, Morris (1971)	0.48% (1040 K)	6.00% (1146 K)
186	Khokonova,Shurdumov, Protsenko (1973)	graphical	
Density (NSRDS reference data base: Jaeger, Kapma (1920), [1] p. 35)			
133, 182	Brown,Morris (1971)	0.01% (1123 K)	0.25% (1039 K)
184	Morris, Robinson (1964)	0.34% (1150 K)	0.78% (990 K)
137	Gossink, Stevels (1971)	0.01% (1055 K)	-0.58% (1230 K)
187	Khokonova,Shurdumov, Protsenko (1972)	3.66% (975 K)	4.22% (1170 K)
Surface tension (NSRDS reference data base: Jaeger (1917), [2] p. 74)			
182	Brown (1970)	-0.62% (1179 K)	-1.52% (1013 K)
137	Gossink,Stevels (1971)	-2.61% (1045 K)	-2.66% (1200 K)

9.25 *Vanadate Salts*

New recommendations for single vanadates are discussed in this section (cf. sec. 9.2).

$NaVO_3$

Melt Preparation and Purification

Dubois, Richard and Millet [188] used reagent grade $NaVO_3 \cdot 4H_2O$ and dried the salt at 250-300°C under an Ar atmosphere.

TABLE 222. Density studies: $NaVO_3$

Investigations critically examined

Ref.	Temp. range (K)	Comments
188	973-1273	

TABLE 223. $NaVO_3$: Density ($g \cdot cm^{-3}$)

$\rho = 2.864 - 0.44 \cdot 10^{-3} T$

T(K)	ρ
980	2.433
1000	2.424
1020	2.415
1040	2.406
1060	2.398
1080	2.389
1100	2.380
1120	2.371
1140	2.362
1160	2.354
1180	2.345
1200	2.336
1220	2.327
1240	2.318
1260	2.310

These values are based on the data of Dubois, Richard and Millet (dilatometric technique) [188]. The data were reported in the form of a temperature dependent equation; no error estimate given.

TABLE 224. Electrical conductance studies

$NaVO_3$

Investigations critically examined

Ref.	Temp. range (K)	Comments
188	923-1293	

TABLE 225. $NaVO_3$: Specific conductance ($ohm^{-1} cm^{-1}$)

$\kappa = 10.797 \exp(-3810/RT)$

T(K)	κ
940	1.404
960	1.465
980	1.526
1000	1.587
1020	1.648
1040	1.708
1060	1.769
1080	1.829
1100	1.889
1120	1.949
1140	2.008
1160	2.067
1180	2.126
1200	2.184
1220	2.242
1240	2.300
1260	2.357
1280	2.414

These values are based on the data of Dubois, Richard and Millet (classical ac technique) [188]. The data were reported in the form of a temperature dependent equation; no error estimate given.

10 Binary Mixtures

10.1 *Acetate-Acetate Systems*

This section contains the studies tables and the numerical tables for the physical properties of acetate-acetate melts. Also included are summaries of the methods used for melt preparation and purification and, where possible, temperature-liquidus phase diagrams.

$CsC_2H_3O_2$-$NaC_2H_3O_2$

Melt Preparation and Purification

Leonesi, Cingolani and Berchiesi [189] used reagent grade salts, carefully dried under vacuum.

$NaC_2H_3O_2$-$RbC_2H_3O_2$

Melt Preparation and Purification

For the method of melt preparation used by Leonesi et al. [189] refer $Cs_2C_3H_2O$ - $NaC_2H_3O_2$.

TABLE 226. Electrical conductance studies

$CsC_2H_3O_2$-$NaC_2H_3O_2$

Investigations critically examined

Ref.	Mol % $NaC_2H_3O_2$	Temp. range (K)	Comments
189	0-100	550-630	Pyrex cap. cell

TABLE 227. Density studies: $CsC_2H_3O_2$-$NaC_2H_3O_2$

Investigations critically examined

Ref.	Mol % $NaC_2H_3O_2$	Temp. range (K)	Comments
189	0-100	600-620	Pyrex vessels; calibration: $NaNO_3$

TABLE 228. $CsC_2H_3O_2$-$NaC_2H_3O_2$: Specific conductance ($ohm^{-1}cm^{-1}$)

Mol percent $NaC_2H_3O_2$

T(K)	100	75	50	20	0
550					0.168
560		0.131	0.139		0.182
570		0.144	0.152	0.176	0.197
580		0.158	0.165	0.189	0.211
590		0.171	0.177	0.202	0.225
600		0.184	0.190	0.215	0.239
610	0.196	0.197	0.203	0.229	0.253
620	0.210	0.211	0.215	0.242	0.268
630	0.224	0.224			

temperature-dependent equations

$\kappa = a + bT$

Mol % $NaC_2H_3O_2$	-a	$b \cdot 10^3$
0	0.6129	1.420
20	0.5802	1.326
50	0.5708	1.268
75	0.6091	1.322
100	0.6449	1.379

TABLE 229. $CsC_2H_3O_2$-$NaC_2H_3O_2$: Density ($g \cdot cm^{-3}$)

Mol percent $NaC_2H_3O_2$

T(K)	100	75	50	20	0
600				2.129	
610	1.260	1.567	1.841	2.122	2.294
620	1.253	1.562	1.835	2.116	2.285

temperature-dependent equations

$\rho = a + bT$

Mol % $NaC_2H_3O_2$	a	$-b \cdot 10^3$	standard error of est.
0	2.843	0.90	0.006
20	2.519	0.65	0.007
50	2.207	0.60	0.004
75	1.872	0.50	0.004
100	1.687	0.76	0.005

TABLE 230. Electrical conductance studies

$NaC_2H_3O_2$-$RbC_2H_3O_2$

Investigations critically examined

ef.	Mol % $RbC_2H_3O_2$	Temp. range (K)	Comments
]	0-100	550-620	Pyrex cap. cell

LE 231. $NaC_2H_3O_2$-$RbC_2H_3O_2$: Specific conductance ($ohm^{-1}cm^{-1}$)

Mol percent $RbC_2H_2O_2$

T(K)	100	75	50	25	0
550	0.139		0.118	0.113	
560	0.155	0.141	0.134	0.128	
570	0.171	0.157	0.149	0.142	
580	0.187	0.173	0.164	0.157	
590	0.204	0.188	0.179	0.171	
600	0.220	0.204	0.194	0.186	0.183
610	0.236	0.220	0.210	0.201	0.196
620	0.252	0.236		0.215	0.210

temperature-dependent equations

$\kappa = a + bT$

ol % $RbC_2H_3O_2$	- a	b · 10^3
0	0.6449	1.379
25	0.6876	1.456
50	0.7177	1.520
75	0.7397	1.573
100	0.7517	1.619

BLE 232. Density studies: $NaC_2H_3O_2$-$RbC_2H_3O_2$

Investigations critically examined

ef.	Mol % $RbC_2H_3O_2$	Temp. range (K)	Comments
89	0-100	570-620	Pyrex cell calibration: $NaNO_3$

TABLE 233. $NaC_2H_3O_2$-$RbC_2H_3O_2$: Density ($g \cdot cm^{-3}$)

Mol percent $RbC_2H_3O_2$

T(K)	100	75	50	25	0
570	1.961				
580	1.951				
590	1.941	1.784	1.622	1.444	
600	1.932	1.775	1.614	1.437	
610	1.923	1.767	1.606	1.430	1.260
620	1.913	1.759	1.597	1.422	1.253

$\rho = a + bT$

Mol % $RbC_2H_3O_2$	a	-b · 10^3	standard error of est.
0	1.687	0.95	0.005
25	1.874	0.83	0.009
50	2.111	0.83	0.011
75	2.273	0.73	0.011
100	2.502	0.70	0.018

These values are based on the data of Leonesi, Cingolani and Berchiese (dilatometric method) [189].

10.2 *Carbonate-Carbonate Systems*

This section contains the studies tables and the numerical tables for the physical properties of carbonate-carbonate melts. Also included are, where possible, temperature-liquidus phase diagrams.

Cs_2CO_3-Li_2CO_3

Melt Preparation and Purification

Moissev and Stepanov [190] used chemically pure salts. The salts were initially fused under a CO_2 atmosphere while bubbling CO_2 through the melt, then allowed to solidify and stored in a desiccator. Mixtures were dried at 500-600°C. The atmosphere above the melts was dry CO_2, or a (dry) mixture of CO_2 and O_2, or dry air.

K_2CO_3-Li_2CO_3

Melt Preparation and Purification

Ward and Janz [191] used Fisher Certified reagents (purity 99.98%) dried to constant weight at 400°C under an atmosphere of pure dry CO_2.

Spedding [63, 67] used analytical grade lithium, sodium and potassium carbonates dried at 120°C to constant weight and kept in a desiccator prior to weighing of the salts. This mixture was pre-melted in a furnace under a CO_2 atmosphere care being taken to ensure that no bubbles were formed in the melt. The melt was solidified and stored in a desiccator until used for the measurements.

Vorob'ev et al. [62, 192] used reagent grade salts remelted in an atmosphere of CO_2,

Moiseev and Stepanov [692 used reagent grade salts dried in a stream of CO_2 at temperatures up to 500°C for 5-6 hours and stored in a desiccator before use.

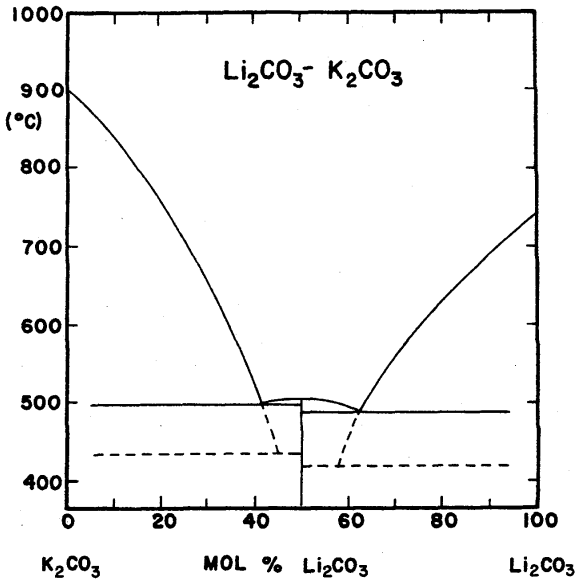


FIGURE 1. Phase diagram for K_2CO_3-Li_2CO_3.

Data from: G. J. Janz and M. R. Lorenz, J. Chem. Eng. Data 6, 321 (1961); W. Eitel and W. Skaliks Z. Anorg. Allgm. Chem. 183, 263 (1929).

K_2CO_3-Na_2CO_3

Melt Preparation and Purification

For the methods of melt preparation of Janz et al. [191, 195], Spedding [63, 67], Karparchev and Vorob'ev [62, 192] and Moiseev and Stepanov [69], refer to K_2CO_3-Li_2CO_3; Moiseev and Stepanov, refer also to Cs_2CO_3-Li_2CO_3.

Li_2CO_3-Na_2CO_3

Melt Preparation and Purification

For the methods of melt preparation of Ward and Janz [191], Spedding [63, 67], Moiseev and Stepanov [69] and Vorob'ev et al. [62, 192], see K_2CO_3-Na_2CO_3.

Li_2CO_3-Na_2CO_3-K_2CO_3

Melt Preparation and Purification

Janz et al. [198, 199] used Fisher reagent grade alkali metal carbonates (99.98% purity) which were dried to constant weight at 400°C under an atmosphere of pure dry CO_2. The eutectic melts were prepared in a gold-palladium crucible under CO_2.

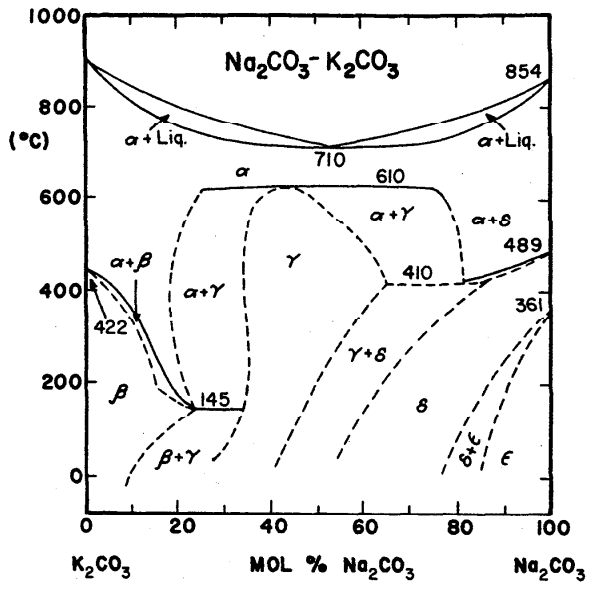


FIGURE 2. Phase diagram for K_2CO_3-Na_2CO_3.

Data from: A. Reisman, J. Amer. Chem. Soc. 81, 810 (1959).

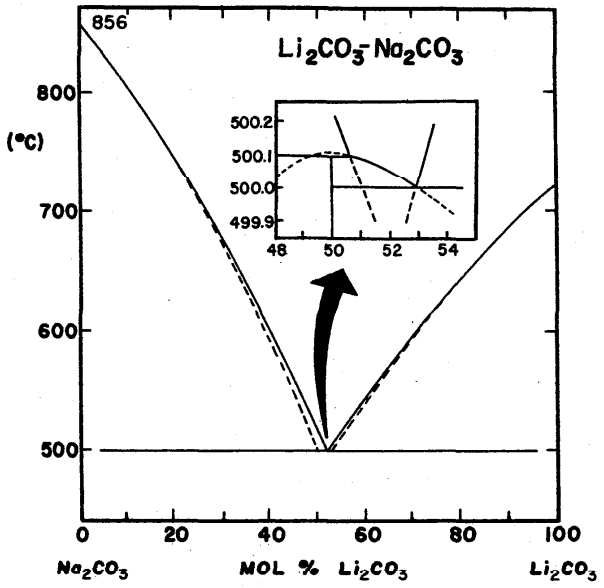


FIGURE 3. Phase diagram for Li_2CO_3-Na_2CO_3.

Data from: E. J. Cairns and D. I. McDonald, Nature 194, 441 (1962); G. J. Janz and M. R. Lorenz, J. Chem. Eng. Data 6, 321 (1961).

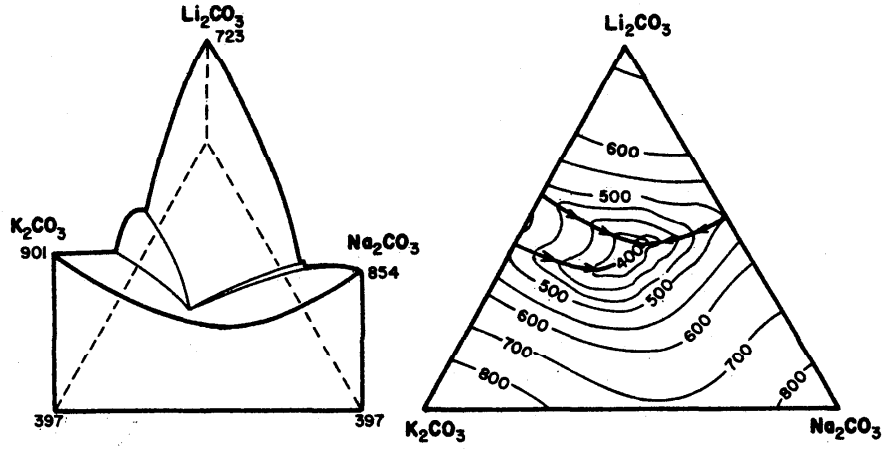


FIGURE 4. Phase diagram for K_2CO_3-Li_2CO_3-Na_2CO_3.

Data from: G. J. Janz and M. R. Lorenz, J. Chem. Eng. Data 6, 321 (1961); M. Rolin and J. M. Recapet, Bull. Soc. Chim. France 2504 (1964).

TABLE 234. Surface tension studies

Cs_2CO_3-Li_2CO_3

Investigations critically examined

Ref.	Mol % Cs_2CO_3	Temp. range (K)	Comments
190	0-3.5	1038	Pt capillary

Considerable oxidation of the capillary occurred. Above 610°C, Cs_2CO_3 decomposes in air. At the temperature of this experiment (765 °C), decomposition of some of molten carbonate mixtures with formation of the respective oxides appear probable [190].

TABLE 235. Cs_2CO_3-Li_2CO_3: Surface tension (dyn cm^{-1})

Mol % Cs_2CO_3	1038 K
0	242
3.5	213

These values have been interpolated from the graphical data of Moiseev and Stepanov (maximum bubble pressure) [190].

TABLE 236. Electrical conductance studies: K_2CO_3-Li_2CO_3

Investigations critically examined

Ref.	Mol % Li_2CO_3	Temp. range (K)	Comments
63	0-100	973-1280	MgO capillary cell; Au-Pd crucible; calibration: aq. KCl, molten KCl and KNO_3; frequency range: 2000-40,000 Hz
62	0-100(g)	773-1173	
191	42.7	847-1147	as for 63, except frequency range 1000-20,000 Hz.
193	50	873-1173	

Deviations from NSRDS recommendations ([1] p. 23 and this volume)

Ref.	Mol % Li_2CO_3	Min. departure	Max. departure
63	100	0.06% (1115 K)	0.40% (1055 K)
63	0	-0.01% (1185 K)	-0.33% (1275 K)
191	42.7	10.71% (1147 K)	-2.48% (1280 K)

A conductance bridge designed for high precision performance, comparable to the Jones bridge was used in [63].

TABLE 237. Density studies: K_2CO_3-Li_2CO_3

Investigations critically examined

Ref.	Mol % Li_2CO_3	Temp. range (K)	Comments
67	0-100	843-1254	Au-Pd crucible and density bob
62	0-100	823-1173	Ag sphere suspended on Pt filament
191	42.7	842-1083	Au-Pd crucible and density bob; calibration: trimethylpentane, benzene, toluene, CCl_4, molten KNO_3

Deviations from NSRDS recommendations ([1] p. 23 and this volume)

Ref.	Mol % Li_2CO_3	Min. departure	Max. departure
62	10	0.07% (1173 K)	0.12% (1148 K)
	20	0.01% (923 K)	0.33% (1173 K)
	30	0.63% (923 K)	0.73% (1173 K)
	40	0.83% (823 K)	1.51% (1173 K)
	50	0.14% (823 K)	0.86% (1173 K)
	60	0.32% (923 K)	0.93% (1173 K)
	70	0.44% (973 K)	0.93% (1173 K)
	80	-0.27% (973 K)	0.99% (1173 K)
	90	0.16% (1023 K)	0.54% (1173 K)
	100	0.12% (1173 K)	0.13% (1023 K)
191	42.7	0.03% (940 K)	0.79% (877 K)
67	0	0.01% (1250 K)	0.05% (1180 K)
	100	-0.00% (1220 K)	-0.17% (1145 K)

ABLE 238. Viscosity studies: K_2CO_3-Li_2CO_3

Investigations critically examined

f.	Mol % Li_2CO_3	Temp. range (K)	Comments
2	0-100(g)	973-1173	corundum crucible containing melt;

TABLE 239. Surface tension studies

K_2CO_3-Li_2CO_3

Investigations critically examined

Ref.	Mol % Li_2CO_3	Temp. range (K)	Comments
69	0-100	800-1310	Pt cap.
191	42.7	842-1083	Au-Pd pen calibr.: CCl_4, trimethylpentane, benzene, KNO_3

Deviations from NSRDS recommendations ([2])

Ref.	Mol % Li_2CO_3	Min. departure	Max. departure
69	0	0.03% (1190 K)	0.15% (1250 K)
	100	0.42% (1030 K)	0.58% (1120 K)

TABLE 240. K_2CO_3-Li_2CO_3

Specific conductance ($ohm^{-1}cm^{-1}$)

	Mol Percent Li_2CO_3				
T (K)	60	50	42.7	40	30
980					1.557
1000	1.969			1.648	1.625
1020	2.053	1.766	1.728	1.719	1.694
1040	2.137	1.840	1.800	1.791	1.762
1060	2.221	1.915	1.872	1.863	1.831
1080	2.306	1.989	1.945	1.936	1.899
1100	2.390	2.063	2.017	2.008	1.968
1120	2.474	2.138	2.090	2.080	2.036
1140	2.558	2.212	2.162	2.152	2.104
1160	2.642	2.286	2.235	2.224	2.172
1180	2.726	2.360	2.307	2.296	2.240
1200	2.809	2.434	2.379		
1220	2.893	2.507	2.450		
1240					
1260					
1280					

temperature-dependent equations

$\kappa = A \exp(-E/RT)$

Mol % Li_2CO_3	A $ohm^{-1}cm^{-1}$	E cal mol^{-1}	Temp. range (K)
0	10.52	3830	1178-1281
10	10.85	3840	996-1136
20	11.41	3890	972-1165
30	13.32	4180	973-1193
40	14.49	4320	1003-1197
42.7	14.56	4320	1013-1223
50	14.96	4330	1013-1222
60	16.63	4240	993-1227
70	20.27	4180	1001-1239
80	23.37	4110	1034-1246
90	26.46	4030	1133-1260
100	29.22	3940	1013-1153

These values are based on the data of Spedding (classical ac technique) [63]. The uncertainty limits are estimated to be ±2.5%.

TABLE 241. K_2CO_3-Li_2CO_3

Density ($g\ cm^{-3}$)

	Mol Percent Li_2CO_3					
T(K)	62	60	50	42.7	40	30
850	1.967					
870	1.958		1.964			
890	1.949	1.953	1.955	1.960	1.977	
910	1.940	1.944	1.946	1.950	1.968	
930	1.931	1.934	1.937	1.941	1.958	
950	1.922	1.925	1.928	1.932	1.949	1.966
970	1.913	1.916	1.919	1.923	1.940	1.957
990	1.904	1.907	1.910	1.913	1.931	1.947
1010	1.895	1.898	1.901	1.904	1.922	1.938
1030	1.886	1.889	1.891	1.895	1.913	1.928
1050	1.877	1.880	1.882	1.886	1.904	1.918
1070	1.868	1.870	1.873	1.876	1.895	1.909
1090	1.859	1.861	1.864	1.867	1.886	1.899
1110	1.850	1.852	1.855	1.858	1.877	1.890
1130	1.840	1.843	1.846	1.849	1.868	1.880
1150	1.831	1.834		1.839	1.859	1.871
1170	1.822			1.830		1.861
1190	1.813			1.821		
1210	1.804					
1230						
1250						

temperature-dependent equations

$\rho = a + bT$

Mol % Li_2CO_3	a	$-b \cdot 10^3$	Temp. range (K)
0	2.4295	0.4543	1190-1250
10	2.4094	0.4422	1130-1250
20	2.3942	0.4385	1050-1250
30	2.4184	0.4761	950-1170
40	2.3795	0.4527	890-1150
42.7	2.3711	0.4623	890-1190
50	2.3599	0.4548	870-1150
60	2.3593	0.4569	890-1150
62	2.3526	0.4532	850-1210
70	2.3251	0.4390	970-1150
80	2.2966	0.4264	990-1170
90	2.2687	0.4180	1010-1170
100	2.2365	0.4041	1030-1130

These values are based on the data of Spedding (Archimedean method) [67]. The uncertainty limits are estimated to be ±0.5%.

TABLE 242. K_2CO_3-Li_2CO_3: Viscosity (cp)

	Mol Percent Li_2CO_3					
T(K)	30	40	50	60	70	75
980	4.97	5.08	5.23	5.51	5.81	6.00
990	4.79	4.89	5.04	5.30	5.59	5.77
1000	4.62	4.71	4.85	5.10	5.37	5.55
1010	4.45	4.54	4.67	4.90	5.17	5.34
1020	4.29	4.37	4.50	4.72	4.97	5.14
1030	4.14	4.20	4.33	4.54	4.78	4.94
1040	3.99	4.05	4.17	4.37	4.61	4.76
1050	3.85	3.90	4.02	4.20	4.44	4.58
1060	3.72	3.76	3.87	4.05	4.27	4.42
1070	3.59	3.62	3.73	3.90	4.12	4.26
1080	3.47	3.50	3.60	3.76	3.98	4.11
1090	3.35	3.37	3.47	3.63	3.84	3.97
1100	3.24	3.26	3.35	3.51	3.72	3.84
1110	3.14	3.15	3.24	3.39	3.60	3.72
1120	3.04	3.05	3.13	3.28	3.49	3.61
1130	2.96	2.96	3.03	3.18	3.39	3.50
1140	2.87	2.87	2.94	3.09	3.30	3.41
1150	2.80	2.79	2.85	3.00	3.21	3.32
1160	2.73	2.72	2.77	2.93	3.14	3.25
1170	2.66	2.65	2.70	2.86	3.07	3.18

temperature-dependent equations

$\eta = a + bT + cT^2$

ol % i_2CO_3	a	$-b.10^3$	$c.10^6$	Temp. range (K)	Standard error of est.
10	10.776	6.80		1123-1173	
20	50.590	75.76	29.80	1023-1173	0.4%
30	53.599	81.00	32.02	973-1173	0.4%
40	56.671	86.01	34.05	973-1173	0.6%
50	56.353	84.67	33.17	973-1173	0.7%
60	64.086	98.16	39.17	973-1173	0.5%
70	69.752	107.85	43.47	973-1173	0.5%
75	72.031	111.38	44.90	973-1173	0.6%
80	75.469	117.19	47.47	973-1173	1.0%
85	70.975	107.85	42.89	973-1173	0.5%
90	79.076	121.36	48.66	1023-1173	0.5%
95	16.121	5.749	-3.958	1023-1173	4.5%
100	9.621	-6.993	-9.960	1023-1173	4.1%

These values are based on the data of [192]. The uncertainty in the values is estimated to be ±10% (torsional pendulum method).

TABLE 243. K_2CO_3-Li_2CO_3

Surface tension: (dyn cm^{-1})

	Mol percent Li_2CO_3				
T(K)	90	70	50	42.7	30
800			198.0		
820			197.2		
840		206.7	196.4	219.3	
860		206.1	195.6	216.8	
880		205.5	194.8	214.3	
900		204.9	194.0	211.8	
920		204.3	193.3	208.0	
940		203.7	192.5	206.8	187.4
960		203.1	191.7	204.3	186.3
980	220.7	202.6	190.9	201.8	185.1
1000	220.0	202.0	190.1	199.3	183.9
1020	219.4	201.4	189.3	196.8	182.8
1040	218.7	200.8	188.5	194.3	181.6
1060	218.0	200.2	187.7	191.8	180.5
1080	217.3	199.6	186.9	189.3	179.3
1100	216.7	199.1	186.1		178.1
1120	216.0	198.5	185.4		177.0
1140	215.3	197.9	184.6		175.8
1160	214.7	197.3	183.8		174.7

temperature-dependent equations

$\gamma = a + bT$

Mol % Li_2CO_3	a	$- b \cdot 10^3$	Temp. range (K)	Standard error of est.
0	241.07	61.4	1173-1308	0.41%
10	262.93	76.9	1114-1173	0.12%
30	241.94	58.0	931-1173	0.83%
50	229.59	39.5	800-1172	0.68%
70	231.18	29.2	842-1173	0.25%
90	253.42	33.4	965-1172	0.62%
100	281.50	36.6	1023-1173	0.46%
42.7	324.09	124.8	1004-1155	0.80%

These values are based on the data of [69] and [191] (maximum bubble pressure, pin detachment). The uncertainty limits are ±3%.

TABLE 244. K_2CO_3-Na_2CO_3

Electrical conductance studies

Investigations critically examined

Ref.	Mol % Na_2CO_3	Temp. range (K)	Comments
63	0-100	1043-1281	see K_2CO_3-Li_2CO_3.
65	0-100	973-1273	see K_2CO_3-Li_2CO_3.
191	58	1046-1160	see K_2CO_3-Li_2CO_3.

Deviations from NSRDS recommendations [1]

Ref.	Mol % Na_2CO_3	Min. departure	Max departure
63	0	0.01% (1185 K)	-0.33% (1275 K)
	100	-0.00% (1220 K)	-0.17% (1145 K)
191	58	-1.88% (1157 K)	-4.72% (1046 K)

TABLE 245. Viscosity studies: K_2CO_3-Na_2CO_3

Investigations critically examined

Ref.	Mol % Na_2CO_3	Temp. range (K)	Comments
192	0-100	1023-1173	refer K_2CO_3-Li_2CO_3

TABLE 246. Density studies: K_2CO_3-Na_2CO_3

Investigations critically examined

Ref.	Mol % Na_2CO_3	Temp. range (K)	Comments
67	0-100	1003-1260	see K_2CO_3-Li_2CO_3.
195	0-100	1000-1283	see K_2CO_3-Li_2CO_3.
191	58	1000-1163	as for [195].
196	0-100	1048-1173	Pt wire and sphere

Deviations from NSRDS recommendations ([1] and this volume)

Ref.	Mol % Na_2CO_3	Min. departure	Max. departure
195	0	-0.01% (1224 K)	-0.08% (1196 K)
	25	0.00% (1114.K)	-1.28% (1084 K)
	50	-0.03% (1115 K)	0.19% (1022 K)
	75	-0.18% (1123 K)	-0.28% (1178 K)
	100	-0.00% (1184 K)	-0.13% (1223 K)
191	58	-0.46% (1067 K)	-1.05% (1118 K)
196	20	1.57% (1123 K)	1.83% (1173 K)
	30	1.53% (1148 K)	1.79% (1173 K)
	40	1.42% (1073 K)	1.58% (1148 K)
	50	1.09% (1048 K)	1.32% (1148 K)
	60	1.20% (1148 K)	4.92% (1048 K)
	70	1.34% (1098 K)	6.15% (1048 K)
	80	0.71% (1098 K)	1.06% (1148 K)
67	0	0.01% (1250 K)	0.05% (1180 K)
	100	0.00% (1205 K)	-0.07% (1145 K)

TABLE 247. K_2CO_3-Na_2CO_3: Density (g cm^{-3})

	Mol Percent Na_2CO_3				
T(K)	70	60	58	50	30
1000				1.997	
1010				1.992	
1020				1.988	
1030				1.983	
1040		1.986		1.979	
1050		1.982	1.979	1.975	
1060		1.977	1.974	1.970	
1070	1.978	1.973	1.970	1.966	
1080	1.974	1.968	1.965	1.961	1.952
1090	1.969	1.964	1.961	1.957	1.947
1100	1.965	1.959	1.957	1.953	1.943
1110	1.960	1.955	1.952	1.948	1.938
1120	1.956	1.950	1.948	1.944	1.934
1130	1.952	1.946	1.943	1.939	1.930
1140	1.947	1.941	1.939	1.935	1.925
1150	1.943	1.937	1.935	1.931	1.921
1160	1.938	1.932	1.930	1.926	1.917
1170	1.934	1.928	1.926	1.922	1.912
1180	1.929	1.923	1.921	1.918	1.908
1190	1.925	1.919	1.917	1.913	1.903
1200	1.921	1.915	1.913	1.909	1.809
1210	1.916	1.910	1.908	1.904	1.895
1220	1.912	1.906	1.904	1.900	1.890
1230	1.907	1.901	1.899	1.896	1.886
1240	1.903		1.895		1.882
1250					1.877
1260					1.873

temperature-dependent equations

$\rho = a + bT$

Mol % Na_2CO_3	a	$-b \cdot 10^3$	Temp. range (K)
0	2.4295	0.4543	1190-1260
10	2.4179	0.4419	1180-1260
20	2.4130	0.4329	1140-1260
25	2.4243	0.4405	1070-1260
30	2.4240	0.4375	1070-1260
40	2.4278	0.4366	1020-1240
50	2.4359	0.4393	1000-1230
58	2.4413	0.4406	1050-1240
60	2.4506	0.4467	1040-1230
70	2.4509	0.4419	1070-1240
75	2.4614	0.4465	1090-1240
80	2.4723	2.4520	1070-1230
90	2.4864	0.4581	1120-1240
100	2.4532	0.4267	1140-1240

TABLE 248. K_2CO_3-Na_2CO_3

Specific conductance ($ohm^{-1}cm^{-1}$)

	Mol Percent Na_2CO_3				
T(K)	70	60	58	50	40
1040			1.866	1.848	
1060			1.934	1.915	1.886
1080	2.134	2.022	2.002	1.982	1.951
1100	2.206	2.092	2.069	2.049	2.016
1120	2.278	2.161	2.136	2.114	2.081
1140	2.349	2.230	2.203	2.181	2.145
1160	2.420	2.299	2.270	2.247	2.209
1180	2.491	2.367	2.336	2.312	2.273
1200	2.561	2.435	2.402	2.377	2.336
1220	2.631	2.503	2.467	2.442	2.399
1240					2.461
1260					
1280					

temperature-dependent equations

$\kappa = A \exp(-E/RT)$

Mol % Na_2CO_3	A $ohm^{-1}cm^{-1}$	E cal mol^{-1}	Temp. range (K)
0	10.52	3830	1178-1281
10	10.85	3850	1157-1250
20	11.32	3880	1148-1258
30	11.49	3870	1076-1237
40	11.79	3860	1047-1246
50	12.20	3900	1044-1230
58	12.38	3910	1043-1226
60	12.98	3990	1073-1230
70	13.20	3910	1071-1222
80	13.65	3800	1086-1236
90	13.95	3700	1143-1254
100	14.12	3590	1145-1238

These values are based on [63] (classical ac method). The uncertainty limits are ±2.5%.

TABLE 249. Surface tension studies: K_2CO_3-Na_2CO_3

Investigations critically examined

Ref.	Mol % Na CO	Temp. range (K)	Comments
191, 195	0-100	1000-1278	refer K_2CO_3-Li_2CO_3
197	25,50, 75	1000-1193	Pt capillary and crucible
69	0-100	1000-1263	refer K_2CO_3-Li_2CO_3.

Deviations from NSRDS recommendations ([2] p. 67 and this volume)

Ref.	Mol % Na_2CO_3	Min. departure	Max. departure
191	0	0.14% (1189 K)	0.40% (1221 K)
	100	0.01% (1279 K)	-0.12% (1230 K)
197	25	0.10% (1100 K)	0.55% (1140 K)
	50	0.00% (1140 K)	-0.04% (1170 K)
	75	-0.03% (1050 K)	-0.08% (1170 K)
69	0	0.03% (1190 K)	0.15% (1250 K)
	50	0.03% (1020 K)	0.90% (1170 K)
	100	-0.32% (1150 K)	-1.72% (1280 K)

A technique for simultaneous measurement of surface tension and density was used, uncertainty limits, ±0.5% [191,195].

TABLE 250. K_2CO_3-Na_2CO_3: Viscosity (cp)

	Mol Percent Na_2CO_3			
T (K)	70	60	50	30
1020	5.259	5.166	5.002	4.786
1030	5.099	5.011	4.860	4.640
1040	4.944	4.862	4.722	4.499
1050	4.794	4.718	4.589	4.364
1060	4.650	4.579	4.460	4.235
1070	4.510	4.446	4.334	4.111
1080	4.376	4.317	4.213	3.994
1090	4.248	4.193	4.096	3.882
1100	4.124	4.075	3.983	3.776
1110	4.006	3.961	3.875	3.676
1120	3.893	3.853	3.770	3.582
1130	3.785	3.750	3.670	3.493
1140	3.682	3.652	3.573	3.410
1150	3.585	3.558	3.481	3.333
1160	3.492	3.476	3.393	3.262
1170	3.405	3.388	3.309	3.197
1180	3.324	3.310	3.229	3.138

temperature-dependent equations

$\eta = a + bT + cT^2$

Mol % Na_2CO_3	$a.10^{-2}$	-b	$c.10^4$	Standard error of est.
30	0.50254	0.07420	0.290447	0.34%
40	0.40580	0.056193	0.207621	0.42%
50	0.41092	0.056393	0.205979	0.20%
60	0.47626	0.067586	0.254493	0.23%
70	0.49057	0.069600	0.261388	0.41%
80	0.45980	0.063680	0.233244	0.15%

The values are from [192] (oscillating sphere). The uncertainty limits are estimated as ±20%.

TABLE 251. K_2CO_3-Na_2CO_3

Surface tension (dyn cm^{-1})

	Mol Percent Na_2CO_3			
T(K)	75	58	50	25
1000		211.8	191.2	
1020		210.4	190.0	
1040		209.0	188.7	
1060	197.8	207.6	187.4	
1080	196.6	206.0	186.2	180.1
1100	195.4	204.5	184.9	177.9
1120	194.3	202.8	183.7	176.1
1140	193.1	201.1	192.5	174.7
1160	191.9		181.3	173.7
1180	190.8			173.1
1200	189.6			172.8
1220				
1240				
1260				
1280				

temperature-dependent equations

$\gamma = a + bT + cT^2$

Mol % Na_2CO_3	a	$-b \cdot 10^3$	$c \cdot 10^6$	Standard error of estimate
0	243.908	63.714		0.15%
25	866.024	1152.236	478.79	1.31%
50	272.280	97.203	16.16	0.04%
58	202.781	83.556	-74.57	0.18%
75	259.582	58.333		0.09%
100	304.552	109.714	24.49	0.06%

These values are based on [191] [194] and [195]. The uncertainty limits are ±0.5% (pin detachment method).

TABLE 252. Electrical conductance studies: Li_2CO_3-Na_2CO_3

Investigations critically examined

Ref.	Mol % Na_2CO_3	Temp. range (K)	Comments
63	0-100	913-1234	refer K_2CO_3-Li_2CO_3
62	0-100	773-1173	refer K_2CO_3-Li_2CO_3
191	46.7	843-1162	refer K_2CO_3-Li_2CO_3
193	50	873-1173	

Deviations from NSRDS recommendation ([1] p. 23 and this volume)

Ref.	Mol % Na_2CO_3	Min. departure	Max. departure
63	0	0.06% (1115 K)	0.40% (1055 K)
	100	-0.00% (1220 K)	-0.17% (1145 K)
191	46.7	-0.01% (1039 K)	-3.63% (933 K)

TABLE 253. Li_2CO_3-Na_2CO_3

Specific conductance ($ohm^{-1}cm^{-1}$)

	Mol Percent Na_2CO_3				
T(K)	60	50	46.7	40	30
920			2.274		
940		2.354	2.384		2.727
960		2.462	2.494	2.602	2.851
980		2.571	2.604	2.717	2.976
1000	2.596	2.679	2.715	2.832	3.101
1020	2.698	2.788	2.826	2.948	3.226
1040	2.801	2.897	2.936	3.063	3.350
1060	2.904	3.005	3.047	3.179	3.475
1080	3.006	3.114	3.157	3.294	3.599
1100	3.108	3.222	3.268	3.409	3.723
1120	3.210	3.330	3.378	3.523	3.847
1140	3.311	3.437	3.487	3.638	3.970
1160	3.412	3.544	3.596	3.752	4.093
1180	3.512	3.651	3.705	3.865	4.215
1200	3.612	3.757	3.813	3.978	4.337
1220	3.711		3.921		
1240	3.810				

TABLE 253 - CONTINUED

Li_2CO_3-Na_2CO_3: Specific conductance

Temperature-dependent equations

$$\kappa = A \exp(-E/RT)$$

Mol % Na_2CO_3	A ($ohm^{-1}cm^{-1}$)	E ($cal\ mol^{-1}$)	Temp. Range (K)
0	29.22	3940	1013-1153
10	28.00	3980	1007-1201
20	25.05	3930	973-1196
30	23.21	4000	973-1196
40	21.74	4050	953-1253
46.7	20.84	4050	913-1220
50	20.36	4030	933-1212
60	18.85	3940	983-1239
70	17.29	3820	983-1234
80	15.88	3710	1013-1224
90	14.71	3620	1077-1232
100	14.12	3590	1145-1238

These values are based on the data of Spedding (classical ac technique) [63]. The uncertainty limits are estimated to be ±25%.

TABLE 254. Density studies: Li_2CO_3-Na_2CO_3

Investigations critically examined

Ref.	Mol % Na_2CO_3	Temp. range (K)	Comments
67	0-100	815-1246	refer K_2CO_3-Li_2CO_3
62	0-100	823-1173	refer K_2CO_3-Li_2CO_3
191	46.7	863-1023	refer K_2CO_3-Li_2CO_3

Deviations from NSRDS recommendation ([1] p. 23

Ref.	Mol % Na_2CO_3	Min. departure	Max. departure
67	0	0.00% (1085 K)	0.12% (1023 K)
	100	0.00% (1205 K)	-0.07% (1145 K)
62	0	-1.11% (1073 K)	-2.69% (1023 K)
	10	0.59% (973 K)	1.34% (1173 K)
	20	0.04% ((923 K)	0.66% (1173 K)
	30	0.01% (1148 K)	-0.92% (873 K)
	40	0.05% (1023 K)	1.52% (1148 K)
	50	0.43% (823 K)	0.93% (1173 K)
	60	0.89% (873 K)	1.43% (1173 K)
	70	0.49% (973 K)	1.21% (1123 K)
	80	-0.34% (1173 K)	-0.61% (1023 K)
	90	-0.53% (1148 K)	-1.38% (1023 K)
	100	-0.31% (1148 K)	-0.36% (1173 K)
191	46.7	0.50% (1021 K)	1.24% (863.8 K)

TABLE 255. Li_2CO_3-Na_2CO_3: Density (g cm^{-3})

	Mol Percent Na_2CO_3				
T(K)	60	50	46.7	40	30
820			2.003		
840			1.995		
860			1.986		
880	1.990		1.978		
900	1.982	1.971	1.969		
920	1.973	1.962	1.960	1.957	
940	1.965	1.954	1.952	1.948	1.936
960	1.956	1.945	1.943	1.939	1.927
980	1.948	1.937	1.934	1.931	1.918
1000	1.939	1.928	1.926	1.922	1.910
1020	1.931	1.920	1.917	1.913	1.901
1040	1.922	1.911	1.908	1.905	1.892
1060	1.914	1.903	1.900	1.896	1.883
1080	1.905	1.894	1.891	1.887	1.875
1100	1.896	1.886	1.882	1.879	1.866
1120	1.888	1.877	1.874	1.870	1.857
1140	1.879	1.869	1.865	1.861	1.848
1160	1.871	1.860	1.856	1.853	1.840
1180	1.862	1.852	1.848	1.844	1.831
1200					1.822
1220					
1240					

Temperature-dependent equations

$$\rho = a + bT$$

Mol % Na_2CO_3	a	$-b \cdot 10^3$	Temp. Range (K)
0	2.2365	0.4041	1020 - 1120
10	2.2435	0.3991	980 - 1200
20	2.2885	0.4120	960 - 1220
30	2.3474	0.4378	940 - 1220
40	2.3557	0.4337	920 - 1180
46.7	2.3581	0.4325	820 - 1180
50	2.3532	0.4249	900 - 1180
60	2.3653	0.4262	880 - 1180
70	2.3890	0.4230	960 - 1180
80	2.4461	0.4437	1060 - 1220
90	2.4443	0.4301	1120 - 1220
100	2.4532	0.4267	1140 - 1240

These values are based on the work of Spedding (Archimedean method) [67]. The uncertainty limits are estimated to be ±0.5%.

TABLE 256. Viscosity studies: Li_2CO_3-Na_2CO_3

Investigations critically examined

Ref.	Mol % Na_2CO_3	Temp. range (K)	Comments
192	0-100	973-1173	refer K_2CO_3-Li_2CO_3.

TABLE 257. Surface tension studies: Li_2CO_3-Na_2CO_3

Investigations critically examined

Ref.	Mol % Na_2CO_3	Temp. range (K)	Comments
69	0-100	822-1263	see K_2CO_3-Li_2CO_3.
191	46.7	863-1022	see K_2CO_3-Li_2CO_3.

Deviations from NSRDS recommendations ([2]

Ref.	Mol % Na_2CO_3	Min. departure	Max. departure
69	0	0.42% (1030 K)	0.58% (1120 K)
	100	-0.32% (1150 K)	-1.72% (1280 K)

TABLE 258. Electrical conductance studies

Li_2CO_3-Na_2CO_3-K_2CO_3

Investigations critically examined

Ref.	Li_2CO_3-Na_2CO_3-K_2CO_3			Comments
		Mol % Li_2CO_3	Mol % Na_2CO_3	
[198]	eutectic	43.5	31.5	twin MgO capillary cells; frequency: 1-20 KHz.
[193]	A	50	33.3	Al cell; Pt electrodes; frequency: 1000 Hz
	B	40	30	
	C	33.3	33.3	

TABLE 259. Li_2CO_3-Na_2CO_3: Viscosity (cp)

	Mol Percent Na_2CO_3				
T (K)	70	60	50	40	30
970	6.291	6.417	6.581	6.738	6.841
980	6.066	6.188	6.345	6.490	6.588
990	5.849	5.967	6.117	6.251	6.344
1000	5.639	5.753	5.898	6.021	6.109
1010	5.438	5.548	5.686	5.799	5.884
1020	5.245	5.350	5.482	5.586	5.667
1030	5.060	5.161	5.287	5.382	5.459
1040	4.882	4.979	5.099	5.187	5.260
1050	4.712	4.806	4.920	5.000	5.071
1060	4.551	4.640	4.748	4.822	4.890
1070	4.397	4.482	4.585	4.653	4.718
1080	4.251	4.333	4.429	4.492	4.556
1090	4.113	4.191	4.282	4.341	4.402
1100	3.983	4.057	4.142	4.198	4.257
1110	3.861	3.932	4.011	4.063	4.122
1120	3.747	3.814	3.888	3.938	3.995
1130	3.640	3.704	3.773	3.821	3.878
1140	3.542	3.602	3.665	3.713	3.769
1150	3.452	3.509	3.566	3.613	3.670
1160	3.369	3.423	3.475	3.523	3.579
1170	3.295	3.345	3.392	3.441	3.498
1180	3.228	3.275	3.317	3.368	3.425

temperature-dependent equations

$\eta = a + bT + cT^2$

Mol % Na_2CO_3	a	-b	$c.10^4$	Standard error of est.
0	59.7518	0.08390	0.31057	0.21%
10	66.6495	0.09802	0.37840	0.17%
20	76.2127	0.11652	0.46535	0.37%
30	74.2392	0.11323	0.45101	0.46%
40	72.2827	0.10992	0.43663	0.18%
50	67.6519	0.10193	0.40184	0.27%
60	66.5557	0.10066	0.39859	0.35%
70	65.7512	0.09970	0.39588	0.53%
80	53.6576	0.07791	0.29816	0.25%
90	50.5268	0.07280	0.27828	0.31%

These values are from [192] (oscillating sphere method).

TABLE 260. Li_2CO_3-Na_2CO_3

Surface tension (dyn cm^{-1})

	Mol percent Na_2CO_3					
T(K)	90	70	50	46.7	30	10
830			246.2	249.9		
850			244.7	248.4		
870			243.2	246.9		
890			241.7	245.3		
910			240.2	243.8	243.1	
930			238.7	242.3	241.9	
950			237.2	240.7	240.7	
970		232.2	235.7	239.2	239.5	
990		230.7	234.2	237.7	238.3	241.3
1010		229.1	232.8	236.1	237.1	240.3
1030		227.6	231.3		235.9	239.4
1050		226.0	229.8		234.7	238.4
1070		224.4	228.3		233.5	237.4
1090	217.9	222.9	226.8		232.3	236.5
1110	216.8	221.3	225.3		231.1	235.5
1130	215.7	219.8	223.8		229.8	234.5
1150	214.6	218.2	222.3		228.6	233.6
1170	213.4	216.7	220.8		227.4	232.6
1190			219.3			

temperature-dependent equations

$\gamma = a + bT$

L % $_2CO_3$	a	$- b \cdot 10^3$	Standard error of estimate
90	292.2	72.0	0.3%
70	279.3	56.3	0.5%
50	307.8	77.9	0.8%
46.7	308.0	74.5	0.6%
30	313.5	76.6	0.7%
10	298.1	60.4	0.4%
0	289.0	48.2	0.1%
	281.5	36.6	0.4%

These values are based on the data of [69]. The uncertainty limits are estimated to be ±1.5%.

TABLE 261. Density studies: Li_2CO_3-Na_2CO_3-K_2CO_3

Investigations critically examined

Ref.	Composition (eutectic)	Temp. range (K)	Comments
198	43.5 mol % Li_2CO_3, 31.5 mol % Na_2CO_3, 25.0 mol % K_2CO_3	680-1060	Au-Pd cruc and bob

TABLE 262. Li_2CO_3-Na_2CO_3-K_2CO_3: Specific conductance ($ohm^{-1}cm^{-1}$)

	Mixtures			
T(K)	Eutectic	A	B	C
670	0.3269			
700	0.4146			
730	0.5157			
760	0.6305			
790	0.7591			
820	0.9017			
850	1.0581	1.16	0.95	0.94
880	1.2282	1.30	1.08	1.09
910	1.4117	1.46	1.25	1.22
940	1.6082	1.62	1.39	1.34
970	1.8174	1.78	1.53	1.47
1000	2.0387	1.95	1.68	1.61
1030		2.13	1.83	1.75
1060		2.31	1.99	1.89
1090		2.50	2.15	2.03
1120		2.69	2.31	2.18

temperature-dependent equations

$\kappa = A \exp(-E/RT)$

Mixture	A ($ohm^{-1}cm^{-1}$)	E (cal mol^{-1})	Std. error of est.
Eutectic	83.819	7385	0.5%
A	38.236	5910	1.7%
B	32.777	5904	2.0%
C	27.208	5619	1.3%

See Table 260 for compositions of mixtures.

These values are based on the data of Ward and Janz (eutectic) (classical ac technique) [198] and Noda and Tamura (mixtures) (classical ac technique) [193]. The estimated uncertainty limits are ±2% for the eutectic and ±4% for the other mixtures.

TABLE 263. Viscosity studies: Li_2CO_3-Na_2CO_3-K_2CO_3

Investigations critically examined

Ref.	Composition (eutectic)	Temp. range (K)	Comments
199	43.5 mol % Li_2CO_3 31.5 mol % Na_2CO_3 25.0 mol % K_2CO_3	760-870	Au-Pd viscom cal·toluene chloroform, KNO_3

TABLE 264. Surface tension studies

Li_2CO_3-Na_2CO_3-K_2CO_3

Investigations critically examined

Ref.	Composition	Temp. range (K)	Comments
198	43.5 mol % Li_2CO_3 31.5 mol % Na_2CO_3 25.0 mol % K_2CO_3	740-1050	Au-Pd cruc. and bob.

TABLE 265. Li_2CO_3-Na_2CO_3-K_2CO_3 (eutectic): Density (g cm^{-3})

T(K)	ρ	T(K)	ρ
680	2.142	880	2.034
700	2.132	900	2.023
720	2.121	920	2.012
740	2.110	940	2.001
760	2.099	960	1.990
780	2.088	980	1.979
800	2.077	1000	1.968
820	2.066	1020	1.957
840	2.055	1040	1.947
860	2.044	1060	1.936

temperature-dependent equation

$\rho = 2.5128 - 0.5440 \times 10^{-3} T$

These values are based on the data of Ward and Janz (Archimedean technique) [198]. The uncertainty limits are estimated to be ±1%.

TABLE 266. Li_2CO_3-Na_2CO_3-K_2CO_3 (eutectic)

Viscosity (cp)

T(K)	η	T(K)	η
760	5.402	820	3.223
770	4.929	830	2.978
780	4.507	840	2.758
790	4.132	850	2.558
800	3.795	860	2.377
810	3.494	870	2.213

temperature-dependent equation

$\eta = 4.64 \times 10^{-3} \exp(10{,}661/RT)$

These values are based on the data of Janz and Saegusa (oscillating cylinder method) [199]. The uncertainty limits are estimated to be ±10%.

TABLE 267. Li_2CO_3-Na_2CO_3-K_2CO_3 : (eutectic)

Surface tension (dyn.cm^{-1})

T(K)	γ	T(K)	γ	T(K)	γ
740	235.7	850	228.0	960	220.4
750	235.0	860	227.4	970	219.7
760	234.3	870	226.7	980	219.0
770	233.6	880	226.0	990	218.3
780	232.9	890	225.3	1000	217.6
790	232.2	900	224.6	1010	216.9
800	231.5	910	223.9	1020	216.2
810	230.8	920	223.2	1030	215.5
820	230.1	930	222.5	1040	214.9
830	229.4	940	221.8	1050	214.2
840	228.7	950	221.1		

temperature-dependent equation

$\gamma = 287.07 - 69.44 \times 10^{-3} T$

These values are based on the data of Ward and Janz (pin detachment method) [198]. The uncertainty limits are estimated to be ±0.5%.

10.3 *Hexafluoroaluminate-Hexafluoroaluminate Systems*

This section contains the studies tables d the numerical tables for the physical operties of hexafluoroaluminate-hexafluoroıminate melts. Also included are summaries the methods used for melt preparation and rification and, where possible, tempera-re-liquidus phase diagrams.

Cs_3AlF_6-K_3AlF_6

Melt Preparation and Purification

Bukhalova and Mal'tsev [200] used reagent ade salts without further purification.

Cs_3AlF_6-Li_3AlF_6

Melt Preparation and Purification

Mal'tsev [201] used reagent grade terials without further purification.

The density data in Table 280 may cxpressed by a three variable power series ıation:

$$\rho = a + bT + cC + dC^2 + eT^3 + fC^3 + gTC + hTC^2 + iCT^2,$$

ere a = 8.88112, $b\cdot10^3$ = -6.99244, $c\cdot10^2$ = .11444, $d\cdot10^4$ = 2.38057, $e\cdot10^2$ = 14.4564, 10^7 = -7.68609, $g\cdot10^5$ = 2.05553, $h\cdot10^7$ = .27952, $i\cdot10^9$ = -2.78453. The units of ıcentration, C, and temperature, T, are l % (Li_3AlF_6) and degrees Kelvin, respec-rely. The standard error of estimate is 77%, and the maximum percent departure is 47% (at 100 mol % Li_3AlF_6 and 1073K).

Cs_3AlF_6-Na_3AlF_6

Melt Preparation and Purification

For the method of melt preparation used Bukhalova and Mal'tsev [200] see Cs_3AlF_6-AlF_6.

K_3AlF_6-Li_3AlF_6

Melt Preparation and Purification

For the method of melt preparation used Mal'tsev and Bukhlova [201] see Cs_3AlF_6-AlF_6.

K_3AlF_6-Na_3AlF_6

Melt Preparation and Purification

Bukhalova and Mal'tsev [200] used reagent de materials without further purification. ashev [84] removed iron particles magne-ally from ground cryolite.

Li_3AlF_6-Na_3AlF_6

Melt Preparation and Purification

Matiasovsky, et al. [89, 102, 104, 202, 203, 204, 205] used single crystal quality lithium and sodium fluorides and prepared pure aluminum fluoride by sublimation. Mashovets and Petrov [91] used reagent grade salts. Yim and Feinleib [85] used reagent grade salts and naturally occurring cryolite, and analyzed the melts by thermometric titration. Vetyukov and Sipriya [206] used reagent grade salts.

Li_3AlF_6-Rb_3AlF_6

Melt Preparation and Purification

For the method of melt preparation used by Mal'tsev and Bukhalova [201] see Cs_3AlF_6-Li_3AlF_6.

The density data of the Li_3AlF_6-Rb_3AlF_6 system (Table 287) may also be expressed by the three-variable equation:

$$\rho = a + bT + cC + dC^2 + eC^3 + fTC$$

where a = 3.36574, $b\cdot10^3$ = -1.12482, $c\cdot10^3$ = 8.47703, $d\cdot10^5$ = -4.26499, $e\cdot10^7$ = 2.80101, $f\cdot10^6$ = -1.35873; standard error of estimate of 0.02%; maximum percent departure of 2.7% at 10 mol % Rb_3AlF_6 and 1173 K. The units of concentration, C, and temperature, T, are mol % (Rb_3AlF_6) and degrees kelvin, respectively.

Na_3AlF_6-Rb_3AlF_6

Melt Preparation and Purification

For the method of melt preparation used by Bukhalova and Mal'tsev [200] see Cs_3AlF_6-K_3AlF_6.

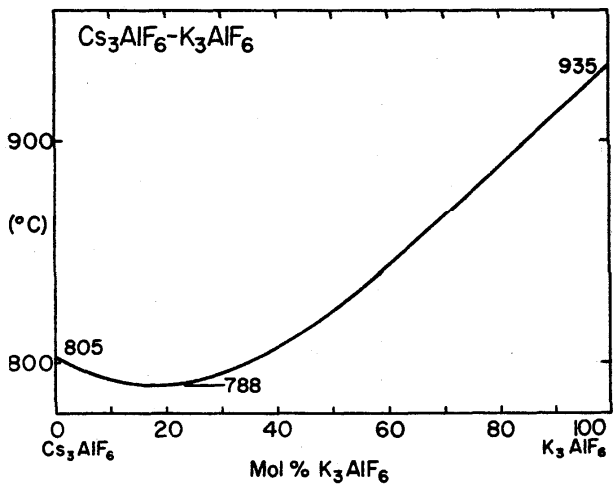


FIGURE 5. Phase diagram for Cs_3AlF_6-K_3AlF_6. Data from: G. A. Bukhalova and V. T. Mal'tsev, Russ. J. Inorg. Chem. 11, 215 (1966).

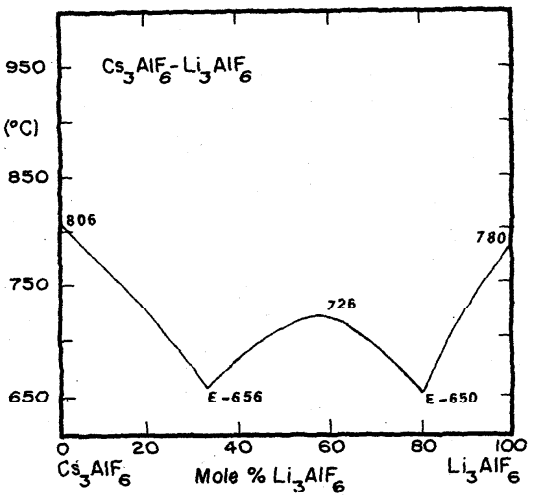


FIGURE 6. Phase diagram for Cs_3AlF_6-Li_3AlF_6

Data from: V. T. Mal'tsev and G. A. Bukalova, J. Appl. Chem. (USSR) 40, 521 (1967).

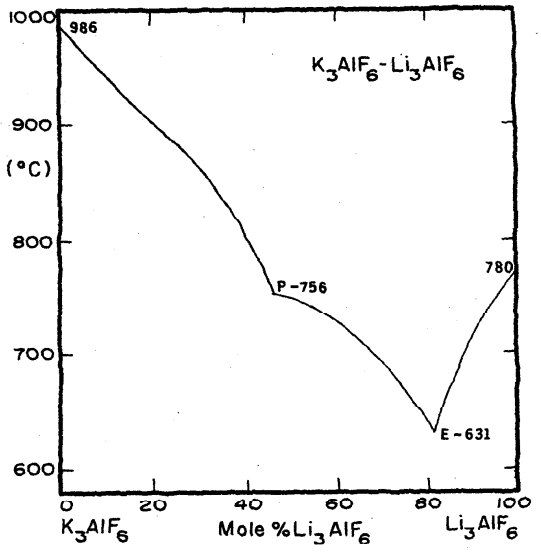


FIGURE 8. Phase diagram for K_3AlF_6-Li_3AlF_6

Data from: V. T. Mal'tsev and G. A. Bukalova, J. Appl. Chem. (USSR) 40, 521 (1967).

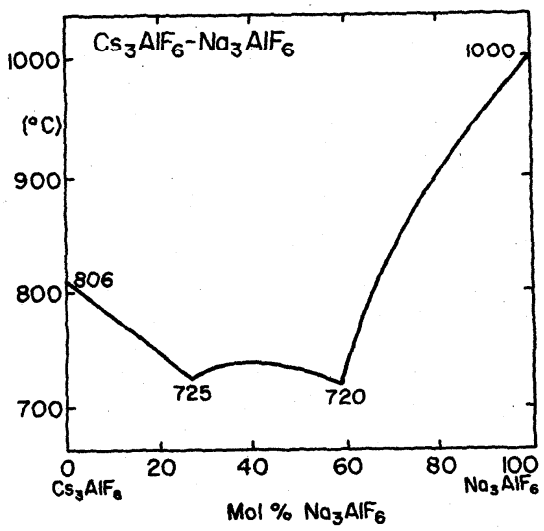


FIGURE 7. Phase diagram for Cs_3AlF_6-Na_3AlF_6

Data from: G. A. Bukhalova and V. T. Mal'tsev Russ. J. Inorg. Chem. 11, 215 (1966).

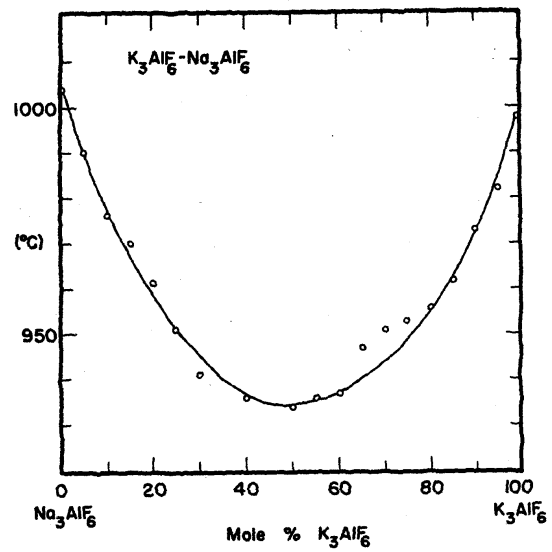


FIGURE 9. Phase diagram for K_3AlF_6-Na_3AlF_6.

Data from: A. I. Belyaev and Ya. E. Studentsov, Legkie Metallyi 3, 15 (1936).

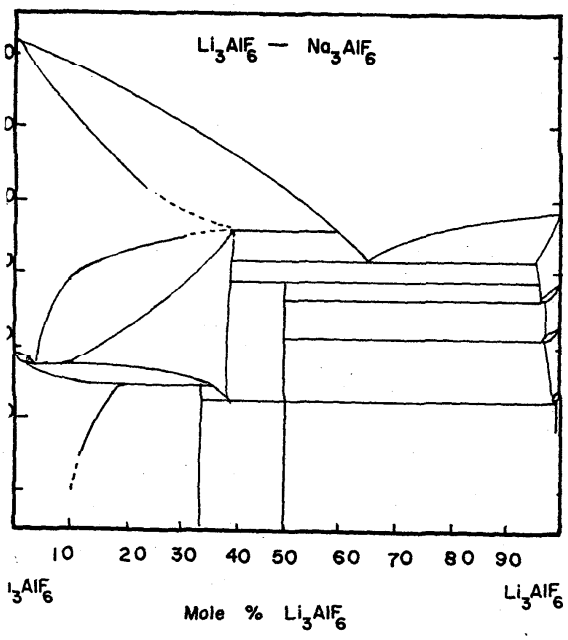


FIGURE 10. Phase diagram for Li_3AlF_6-Na_3AlF_6.

Data from: J. L. Holm and R. L. Holm, Acta Chemica Scand. 24, 2535 (1970); D. P. Stinton and J. J. Brown, J. Amer. Ceram. Soc. 58, 257 (1975).

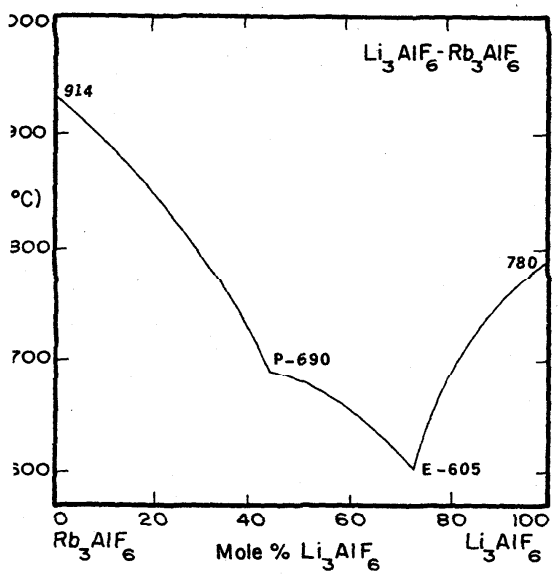


FIGURE 11. Phase diagram for Li_3AlF_6-Rb_3AlF_6

Data from: V. T. Mal'tsev and G. A. Bukalova, J. Appl. Chem. (USSR) 40, 521 (1967).

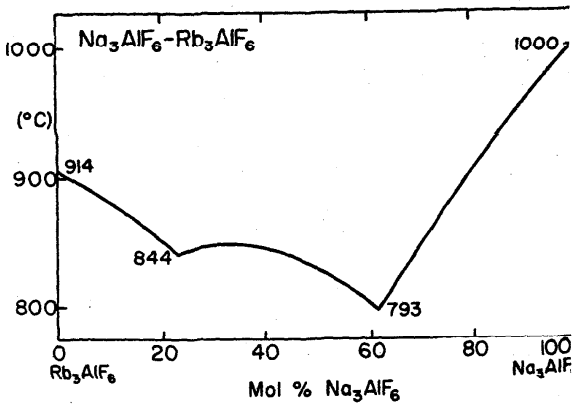


FIGURE 12. Phase diagram for Na_3AlF_6-Rb_3AlF_6.

Data from: G. A. Bukhalova and V. T. Mal'tsev, Russ. J. Inorg. Chem. 11, 215 (1966).

TABLE 268. Density studies: Cs_3AlF_6-K_3AlF_6

Investigations critically examined

Ref.	Mol. % K_3AlF_6	Temp. range (K)	Comments
200	0-100	1223, 1273	Pt sphere and wire; calibration: molten NaCl, KCl, NaF.

TABLE 269. Density studies: Cs_3AlF_6-Li_3AlF_6

Investigations critically examined

Ref.	Mol % Li_3AlF_6	Temp. range (K)	Comments
201	10-100	1023-1223	Pt sphere and wire; calibr.: molten NaCl, KCl

TABLE 270. Density Studies: Cs_3AlF_6-Na_3AlF_6

Investigations critically examined

Ref.	Mol % Na_3AlF_6	Temp. range (K)	Comments
200	0-100	1123;1173;1223;1273	see Cs_3AlF_6-K_3AlF_6

TABLE 271. Density studies: K_3AlF_6-Li_3AlF_6

Investigations critically examined

Ref.	Mol % Li_3AlF_6	Temp. range (K)	Comments
201	0-100	1223, 1273, 1323	see Cs_3AlF_6-Li_3AlF_6

TABLE 272. Electrical conductance studies K_3AlF_6-Na_3AlF_6

Investigations critically examined

Ref.	Mol % Na_3AlF_6	Temp. range (K)	Comments
84	0-100	1223-1323	Pt electrodes; calibr. 1 D KCl

TABLE 273. Density studies: K_3AlF_6-Na_3AlF_6

Investigations critically examined

Ref.	Mol % Na_3AlF_6	Temp. range (K)	Comments
200	0-100	1223, 1273	see Cs_3AlF_6-K_3AlF_6

TABLE 274. Density studies: Li_3AlF_6-Na_3AlF_6

Investigations critically examined

Ref.	Mol % Na_3AlF_6	Temp. range (K)	Comments
205	0-100	1223,1273,1323	
91	0-100 50	1273 1035-1209	Pt float; Pt crucible
206	0-100	1173,1273,1373	as for [91]
202	0-100	1223-1323	platinum sphere; calibr.: KCl, NaCl

TABLE 275. Electrical conductance studies Li_3AlF_6-Na_3AlF_6

Investigations critically examined

Ref.	Mol % Na_3AlF_6	Comments
89	0-100(g)	Pt disk electrodes; Pt crucible; calibration: molten Na_3AlF_6; frequency: 5000-20,000 Hz
204	0-95	as for [89]
83	0-100	
91	0-100(g)	Pt electrodes; calibration 0.1 N KCl, 30% H_2SO_4
85	40(g)	boron nitride dip-type cell; calibration: molten KCl
203	0-100(g)	as for [89]

TABLE 276. Viscosity studies: Li_3AlF_6-Na_3AlF_6

Investigations critically examined

Ref.	Mol % Na_3AlF_6	Temp. range (K)	Comments
206	16.1-100	1178-1450	Pt sphere
104	0-100(g)	1273	
102	0-100(g)	1223;1273 1323	Mo torsion wire; Pt sphere

TABLE 277 Density studies: Li_3AlF_6-Rb_3AlF_6

Investigations critically examined

Ref.	Mol % Rb_3AlF_6	Temp. range (K)	Comments
201	0-90	1073-1273	see Cs_3AlF_6-Li_3AlF_6

TABLE 278. Density studies: Na_3AlF_6-Rb_3AlF_6

Investigations critically examined

Ref.	Mol % Rb_3AlF_6	Temp. range (K)	Comments
200	0-100	1173;1223; 1273;1323	see Cs_3AlF_6-K_3AlF_6

TABLE 279. Cs_3AlF_6-K_3AlF_6: Density (g cm^{-3})

	Mol percent K_3AlF_6				
T (K)	70	50	30	20	10
1220	2.272	2.462	2.625	2.729	2.820
1230	2.260	2.449	2.608	2.713	2.803
1240	2.248	2.435	2.592	2.698	2.787
1250	2.236	2.422	2.575	2.683	2.770
1260	2.224	2.408	2.559	2.668	2.754
1270	2.213	2.395	2.542	2.653	2.737
1280	2.201	2.382	2.525	2.637	2.720

temperature-dependent equations

$\rho = a + bT$

Mol% K_3AlF_6	a	$-b.10^2$	Standard error of est.
0	4.2775	0.1140	0.00%
10	4.8453	0.1660	0.00%
20	4.5833	0.1520	0.00%
30	4.6503	0.1660	0.00%
40	4.2196	0.1400	0.00%
50	4.0966	0.1339	0.00%
60	3.8498	0.1240	0.00%
70	3.7117	0.1180	0.00%
80	3.2090	0.0919	0.00%
90	3.3613	0.1100	0.00%

These values are based on [200] (hydrostatic weighing method).

TABLE 280. Cs_3AlF_6-Li_3AlF_6: Density ($g \cdot cm^{-3}$)

	Mol. Percent Li_3AlF_6				
T(K)	80	70	60	40	30
1030	2.520	2.597	2.685	2.856	2.960
1040	2.504	2.580	2.668	2.839	2.940
1050	2.487	2.565	2.651	2.822	2.920
1060	2.471	2.550	2.634	2.806	2.901
1070	2.456	2.535	2.618	2.790	2.883
1080	2.440	2.522	2.602	2.774	2.865
1090	2.426	2.509	2.587	2.759	2.848
1100	2.411	2.497	2.573	2.745	2.831
1110	2.398	2.485	2.559	2.731	2.816
1120	2.385	2.475	2.546	2.718	2.801
1130	2.373	2.465	2.534	2.706	2.788
1140	2.362	2.456	2.522	2.695	2.775
1150	2.351	2.447	2.512	2.684	2.764
1160	2.342	2.439	2.503	2.675	2.753
1170	2.334	2.432	2.494	2.667	2.745
1180	2.327	2.426	2.487	2.660	2.737
1190	2.321	2.420	2.481	2.654	2.731
1200	2.317	2.416	2.476	2.649	2.727
1210	2.314	2.411	2.473	2.646	2.724
1220	2.312	2.408	2.471	2.644	2.722

temperature-dependent equations

$\rho = a + bT + cT^2 + dT^3$

Mol % Li_3AlF_6	a	$b \cdot 10^3$	$c \cdot 10^6$	$d \cdot 10^9$	Standard error of estimate
10	14.1847	-18.492	7.575		0.45%
20	-7.6434	35.398	-36.813	12.147	0.55%
30	-6.7556	34.044	-36.675	12.408	0.45%
40	-6.9531	32.967	-34.616	11.509	0.49%
50	9.6051	-11.221	4.461		0.53%
60	-5.6841	29.155	-31.255	10.521	0.54%
70	8.1696	-9.140	3.621		0.47%
80	-8.8366	36.984	-38.093	12.515	0.53%
90	-10.2352	41.718	-43.308	14.296	0.70%
100	3.4144	-1.318	0.123		0.01%

These values are based on the data of [201] (Archimedean technique).

TABLE 281. Cs_3AlF_6-Na_3AlF_6: Density ($g.cm^{-3}$)

	Mol percent $NaAl_3F_6$					
T (K)	70	60	50	40	30	20
1120		2.660	2.736	2.813	2.870	2.931
1130		2.646	2.722	2.799	2.856	2.916
1140		2.633	2.708	2.784	2.842	2.901
1150		2.619	2.694	2.770	2.827	2.886
1160		2.605	2.680	2.755	2.813	2.871
1170	2.432	2.591	2.666	2.741	2.798	2.856
1180	2.422	2.577	2.651	2.727	2.784	2.842
1190	2.413	2.564	2.637	2.712	2.770	2.827
1200	2.403	2.550	2.623	2.698	2.755	2.812
1210	2.394	2.536	2.609	2.684	2.741	2.797
1220	2.384	2.522	2.595	2.669	2.726	2.782
1230	2.374	2.508	2.580	2.655	2.712	2.768
1240	2.365	2.495	2.566	2.640	2.698	2.753
1250	2.355	2.481	2.552	2.626	2.683	2.738
1260	2.346	2.467	2.538	2.612	2.669	2.723
1270	2.336	2.453	2.524	2.597	2.654	2.708
1280	2.326	2.439	2.510	2.583	2.640	2.694

temperature-dependent equations

$\rho = a + bT$

Mol % Na_3AlF_6	a	$-b.10^2$	Standard error of est.
0	4.7792	0.15342	0.01%
10	4.9399	0.17221	0.32%
20	4.5882	0.14801	0.34%
30	4.4832	0.14401	0.00%
40	4.4236	0.14381	0.02%
50	4.3246	0.14181	0.04%
60	4.2059	0.13802	0.00%
70	3.5550	0.09599	0.07%
80	3.7310	0.11398	0.00%

These values are based on the data of [200] (hydrostatic weighing method).

TABLE 282. K_3AlF_6-Li_3AlF_6: Density ($g.cm^{-3}$)

	Mol percent K_3AlF_6				
T (K)	90	85	80	70	60
1220		1.870	1.865	1.871	1.874
1240		1.852	1.852	1.854	1.858
1260		1.833	1.838	1.837	1.842
1280	1.828	1.815	1.825	1.820	1.826
1300	1.807	1.796	1.811	1.803	1.810
1320	1.785	1.777	1.797	1.787	1.794
1330	1.774	1.768	1.791	1.778	1.786

	Mol percent K_3AlF_6				
T(K)	50	40	30	20	10
1220	1.893	1.911	1.928	1.943	1.969
1240	1.873	1.892	1.908	1.924	1.950
1260	1.853	1.873	1.889	1.906	1.931
1280	1.833	1.853	1.870	1.888	1.912
1300	1.814	1.834	1.850	1.870	1.893
1320	1.794	1.815	1.831	1.852	1.874
1330	1.784	1.805	1.821	1.843	1.864

temperature-dependent equations

$\rho = a + bT$

Mol % Li_3AlF_6	a	$-b.10^3$	Standard error of est.
0	3.2346	1.0199	0.03%
10	3.1278	0.9500	0.02%
20	3.0528	0.9100	0.08%
30	3.1111	0.9700	0.02%
40	3.0822	0.9601	0.00%
50	3.1006	0.9900	0.02%
60	2.8505	0.8000	0.09%
70	2.8953	0.8400	0.00%
80	2.6951	0.6801	0.35%
85	3.0049	0.9300	0.05%
90	3.2104	1.0796	0.00%
100	2.7698	0.7398	0.00%

These values are based on the hydrostatic weighing method) [201].

TABLE 283. K_3AlF_6-Na_3AlF_6

Specific conductance ($ohm^{-1}cm^{-1}$)

	Mol percent Na_3AlF_6					
(K)	100	83.11	64.85	45.06	23.52	0
220			2.144			
230			2.218			
240		2.618	2.294	1.964	1.425	
250		2.689	2.371	2.037	1.593	
260		2.764	2.450	2.113	1.749	
270	3.200	2.842	2.530	2.192	1.893	1.814
280	3.266	2.925	2.611	2.275	2.025	1.891
290	3.334	3.012	2.693	2.360	2.145	1.971
300	3.405	3.102	2.777	2.448	2.252	2.054
310	3.479	3.197	2.862	2.539	2.348	2.140
320	3.556	3.295	2.948	2.633	2.432	2.229
330	3.636	3.397	3.035	2.730	2.503	2.322

temperature-dependent equations

$\kappa = a + bT + cT^2$

% AlF_6	a	-b	$c.10^4$	Standard error of est.
0	16.8979	0.03130	0.1529	1.62%
23.52	-112.8901	-0.1669	-0.6030	3.49%
45.06	15.9277	0.02968	0.1486	0.51%
83.11	24.3597	0.04195	0.1969	0.68%
100	17.0540	0.02825	0.1366	0.76%

$\kappa = Ae^{-E/RT}$

Mol % Na_3AlF_6	A	E	Standard error of est.
0	143.640	10192.8	1.13%

These values are based on [84] (classical ac technique).

TABLE 284. K_3AlF_6-Na_3AlF_6: Density ($g \cdot cm^{-3}$)

	Mol percent Na_3AlF_6				
T (K)	80	70	60	50	40
1220	2.046	2.020	1.906	1.975	1.945
1230	2.027	2.001	1.905	1.958	1.929
1240	2.008	1.982	1.904	1.940	1.913
1250	1.990	1.963	1.903	1.923	1.897
1260	1.971	1.944	1.902	1.905	1.881
1270	1.953	1.926	1.901	1.887	1.865
1280	1.934	1.907	1.900	1.870	1.849

temperature-dependent equations

$\rho = a + bT$

Mol % Na_3AlF_6	a	$-b.10^2$	Standard error of est
20	3.9891	0.1700	0.00%
30	3.8102	0.1539	0.00%
40	3.8968	0.1600	0.00%
50	4.1221	0.1759	0.00%
60	2.0283	0.0100	0.00%
70	4.3133	0.1880	0.00%
80	4.3144	0.1859	0.00%
90	4.2618	0.1806	0.00%

These values are based on [200] (hydrostatic weighing method).

TABLE 285 Li_3AlF_6-Na_3AlF_6

Specific conductance (ohm^{-1} cm^{-1})

	Mol percent Na_3AlF_6				
T(K)	60	55	45	37.5	30
1180	2.579	2.710	2.638	2.869	2.782
1190	2.635	2.754	2.709	2.924	2.850
1200	2.689	2.798	2.777	2.976	2.914
1210	2.740	2.840	2.841	3.025	2.976
1220	2.788	2.881	2.901	3.072	3.034
1230	2.833	2.920	2.957	3.116	3.089
1240	2.876	2.958	3.009	3.158	3.141
1250	2.916	2.995	3.058	3.197	3.190
1260	2.954	3.031	3.102	3.233	3.236
1270	2.989	3.065	3.143	3.267	3.279
1280	3.021	3.098	3.180	3.299	3.318
1290	3.051	3.129	3.213	3.327	3.355
1300	3.078	3.159	3.242	3.353	3.388
1310	3.102	3.188	3.267	3.377	3.418
1320	3.124	3.216	3.288	3.398	3.446
1330	3.142	3.242	3.306	3.416	3.470
1340	3.159	3.267	3.319	3.432	3.491
1350	3.172	3.290	3.329	3.445	3.508
1360	3.183	3.313	3.335	3.455	3.523
1370	3.192	3.334	3.337	3.463	3.535

temperature dependent equations

$\kappa = a + bT + cT^2$

Mol % Na_3AlF_6	-a	$b \cdot 10^3$	$-c \cdot 10^6$
0	13.6429	24.8144	8.65
10	13.2057	23.4011	7.93
20	10.7779	19.4480	6.48
30	27.0143	43.5885	15.54
37.5	21.8029	36.2249	12.98
45	32.9393	52.9475	19.32
55	11.8841	20.1909	6.63
60	22.7109	37.1143	13.29
65	12.2374	20.8431	6.98
70	31.1122	49.9422	18.19
75	27.6289	44.1483	15.84
80	31.6170	50.9352	18.71
85	12.0852	20.5070	6.89
90	0.5043	3.0278	0.32
95	22.4769	36.0150	12.68

These values are based on the data of Danek, Novak and Malinovsky (classical ac technique) [204].

TABLE 286. Li_3AlF_6-Na_3AlF_6: Density

	Mol percent Na_3AlF_6					
T(K)	100	90	80	70	60	50
1230					2.079	2.068
1240				2.087	2.070	2.059
1250			2.089	2.078	2.061	2.050
1260		2.096	2.080	2.068	2.052	2.040
1270		2.087	2.071	2.059	2.043	2.031
1280	2.096	2.078	2.062	2.050	2.034	2.022
1290	2.086	2.069	2.052	2.040	2.025	2.013
1300	2.077	2.060	2.043	2.031	2.016	2.004
1310	2.068	2.051	2.034	2.022	2.007	1.995
1320	2.059	2.042	2.025	2.012	1.998	1.986

	Mol percent Na_3AlF_6				
T(K)	40	30	20	10	0
1230	2.058	2.047	2.037	2.026	2.014
1240	2.049	2.037	2.028	2.017	2.006
1250	2.040	2.028	2.020	2.009	1.997
1260	2.031	2.019	2.010	2.000	1.989
1270	2.022	2.010	2.001	1.991	1.981
1280	2.013	2.001	1.992	1.982	1.972
1290	2.004	1.991	1.983	1.973	1.964
1300	1.995	1.982	1.974	1.964	1.955
1310	1.985	1.973	1.964	1.955	1.947
1320	1.976	1.964	1.955	1.946	1.939

temperature-dependent equations

$\rho = a + bT$

Mol % Na_3AlF_6	a	$-b \cdot 10^3$
0	3.0474	0.84
10	3.1211	0.89
20	3.1565	0.91
30	3.1782	0.92
40	3.1775	0.91
50	3.1870	0.91
60	3.1858	0.90
70	3.2400	0.93
80	3.2392	0.92
90	3.2303	0.90
100	3.2732	0.92

These values are based on the data of Malinovsky, Paucirova and Matiasovsky (Archimedean method) [202].

BLE 287. Li_3AlF_6-Rb_3AlF_6: Density (g · cm^{-3})

	Mol percent Rb_3AlF_6					
(K)	70	60	50	40	30	20
30	2.536	2.480	2.421	2.375	2.346	2.280
00	2.522	2.466	2.409	2.363	2.335	2.268
90	2.507	2.452	2.397	2.351	2.323	2.257
80	2.493	2.439	2.385	2.339	2.311	2.245
70	2.480	2.425	2.372	2.326	2.299	2.233
60	2.467	2.412	2.360	2.314	2.287	2.221
50	2.454	2.400	2.348	2.302	2.275	2.210
40	2.441	2.387	2.336	2.289	2.263	2.198
30	2.428	2.375	2.323	2.277	2.251	2.186
20	2.416	2.363	2.311	2.264	2.239	2.174
10	2.405	2.352	2.299	2.251	2.227	2.163
00	2.393	2.340	2.286	2.239	2.215	2.151
90	2.382	2.329	2.274	2.226	2.191	2.139
80	2.371	2.319	2.262	2.213	2.191	2.127
70	2.360	2.308	2.249	2.200	2.178	2.116
60	2.350	2.298	2.237	2.187	2.166	2.104
50	2.340	2.289	2.224	2.174	2.154	2.092
40	2.330	2.279	2.212	2.161	2.141	2.080
30	2.321	2.270	2.199	2.148	2.129	2.069
20	2.312	2.261	2.187	2.135	2.117	2.057

temperature-dependent equations

$\rho = a + bT + cT^2$

ol % $_3AlF_6$	a	$-b \cdot 10^3$	$c \cdot 10^6$	Standard error of estimate
0	3.3613	1.2290	0.0865172	0.02%
0	3.4793	1.1700		0.01%
0	3.5479	1.1740		0.05%
0	3.4165	0.8058	-0.1714	0.03%
0	3.3486	0.5918	-0.2864	0.05%
0	3.5899	0.9549	-0.1180	0.02%
0	5.7585	4.6348	1.4809	0.20%
0	5.8675	4.7040	1.4994	0.21%
0	7.5309	7.3855	2.6163	0.16%

These values are based on the data of [201] (Archimedean method).

TABLE 288. Li_3AlF_6-Na_3AlF_6: Viscosity (cP)

	Mol percent Na_3AlF_6			
T(K)	100	75.5	53.6	16.1
1180				2.71
1190				2.62
1200				2.53
1210			2.73	2.45
1220		2.72	2.61	2.37
1230		2.63	2.50	2.29
1240		2.54	2.39	2.21
1250		2.45	2.29	2.13
1260		2.36	2.19	2.06
1270		2.28	2.10	1.99
1280		2.20	2.02	1.92
1290		2.13	1.93	1.86
1300		2.05	1.86	1.79
1310		1.98	1.79	1.73
1320	2.19	1.91	1.73	1.68
1330	2.10	1.85	1.67	1.62
1340	2.01	1.79	1.61	1.57
1350	1.93	1.73	1.57	1.51
1360	1.86	1.67		1.47
1370	1.79	1.62		1.42
1380	1.73	1.57		1.38
1390	1.67	1.52		1.33
1400	1.62	1.48		1.29
1410	1.58			
1420	1.55			
1430	1.52			

temperature-dependent equations

$\eta = a + bT + cT^2$

Mol % Na_3AlF_6	a	$-b \cdot 10^3$	$c \cdot 10^6$	Std. error of est.
16.1	29.665	36.678	11.722	0.44%
53.6	57.890	78.975	27.596	2.17%
75.5	36.230	45.402	14.700	3.15%
100	70.606	94.024	31.965	0.14%

These values are based on the data of Vetyikov and Sipriya (torsional pendulum method) [206].

TABLE 289. Na_3AlF_6-Rb_3AlF_6: Density ($g \cdot cm^{-3}$)

	Mol percent Rb_3AlF_6				
T (K)	80	70	60	40	30
1170		2.470	2.459	2.361	2.306
1180		2.459	2.446	2.350	2.296
1190		2.448	2.434	2.339	2.286
1200		2.436	2.421	2.328	2.276
1210		2.425	2.409	2.316	2.266
1220	2.444	2.413	2.396	2.305	2.257
1230	2.432	2.402	2.384	2.294	2.247
1240	2.420	2.390	2.371	2.283	2.237
1250	2.409	2.379	2.359	2.272	2.227
1260	2.397	2.368	2.346	2.260	2.217
1270	2.385	2.356	2.334	2.249	2.207
1280	2.373	2.345	2.321	2.238	2.197
1290	2.361	2.333	2.308	2.227	2.187
1300	2.350	2.322	2.296	2.215	2.177
1310	2.338	2.311	2.283	2.204	2.167
1320	2.326	2.299	2.271	2.193	2.158
1330	2.314	2.288	2.258	2.182	2.148

temperature-dependent equations

$\kappa = a + bT$

Mol % Rb_3AlF_6	a	$-b.10^2$	Standard error of est.
0	3.0470	0.07800	0.00%
10	3.3125	0.09399	0.22%
20			
30	3.4642	0.09899	0.05%
40	3.6738	0.1121	0.06%
50	3.8558	0.1235	0.05%
60	3.9234	0.1251	0.14%
70	3.8063	0.1141	0.09%
80	3.8835	0.1180	0.02%
90	3.9682	0.1220	0.00%
100	4.1844	0.1360	0.00%

These values are based on the data of [200] (hydrostatic weighing method).

10.4 *Metaphosphate-Metaphosphate Systems*

This section contains the studies tables and the numerical tables for the physical properties of metaphosphate-metaphosphate melts. Also included are summaries of the methods used for melt preparation and purification and, when available, temperature-liquidus phase diagrams.

$Ba(PO_3)_2$-KPO_3

Melt Preparation and Purification

Voskresenskaya et al. [130, 114] prepared metaphosphates by decomposition of the mono-orthophosphates in a platinum crucible. The general reaction for the decomposition is:

$$MH_2PO_4(s) \triangleq MPO_3(s) + H_2O(g)$$

For additional information, refer to KPO_3-$Zn(PO_3)_2$.

$Ca(PO_3)_2$-$NaPO_3$

Melt Preparation and Purification

Nijjhar and Williams [127] prepared sodium and potassium metaphosphates by decomposition of reagent grade dihydrogen phosphate at 1100° C. Calcium metaphosphate was prepared by heating calcium carbonate intimately mixed with ammonium dihydrogen phosphate at 1200°C for half hour. The reaction is:

$$CaCO_3 + 2NH_4H_2PO_4 \rightarrow Ca(HPO_3)_2 + (NH_4)_2CO_3 + 2H_2O$$

The ammonium carbonate volatilizes. The metaphosphates were analyzed for phosphorus after each run. For Voskresenskaya's method of preparing metaphosphates, refer to $Ba(PO_3)_2$-KPO_3.

KPO_3-$LiPO_3$

Melt Preparation and Purification

For Nijjhar and Williams' [127] method of preparing metaphosphates, refer to $Ca(PO_3)_2$. The phosphorus content of the salts was determined before and after each run.

The surface tension data for these mixtures (Table 301) may also be expressed by the three-variable equation:

$$\gamma = a + bT + cC + dC^2 + eC^3 + fTC$$

where $a = 218.89595$, $b \cdot 10^2 = -6.15782$, $c \cdot 10^2 = 26.9192$, $d \cdot 10^3 = -5.56371$, $e \cdot 10^5 = 3.61392$, $f \cdot 10^6 = 3.03440$; maximum departure, 1.1% at 1418 K and 100 mol % $LiPO_3$; standard error of estimate, 0.40%. The units of concentration, C, and temperature, T, are mol % ($LiPO_3$) and degrees kelvin, respectively.

KPO_3-$NaPO_3$

Melt Preparation and Purification

Refer to $Ca(PO_3)_2$-$NaPO_3$ for Nijjhar and lliams' [127] method of preparing meta-)sphates.

The surface tension data for KPO_3-$NaPO_3$ ible 302) may also be expressed by the ree-variable equation:

$$= a + bT + cC^2 + dC^3 + eTC^2 + fCT^2,$$

ere a = 220.55698, $b \cdot 10^2$ = -6.28769, $c \cdot 10^3$= 26411, $d \cdot 10^5$ = 1.00452, $e \cdot 10^6$ = 1.33072, 10^7 = 1.13009; maximum departure, 0.55% 1420 K and 49.95 mol % $NaPO_3$. The units concentration, C, and temperature, T, e mol % ($NaPO_3$) and degrees kelvin, respec-rely.

KPO_3-$Zn(PO_3)_2$

Melt Preparation and Purification

For Voskresenskayas' et al. [114] gener- method of preparing metaphosphates refer $Ba(PO_3)_2$-KPO_3. Zinc metaphosphate was tained by reacting reagent grade orthophos-)ric acid and zinc oxide to form the ortho-)sphate which was then fused and tempered a water-cooled platinum cup. The result-g glassy compound was stored in a desiccator. ter hydrolysis in a solution of HCl, the lt was analyzed for phosphorus by precipi-tion as magnesium ammonium phosphate and r zinc by precipitation as zinc ammonium)sphate. The orthophosphate was then composed to metaphosphate in the usual nner. To insure that all the orthophosphate d decomposed the melt was kept above 100°C r 11 hours.

$LiPO_3$-$NaPO_3$

Melt Preparation and Purification

For Nijjhar and Williams' [127] method melt preparation refer to $Ca(PO_3)_2$-$NaPO_3$. e $Ba(PO_3)_2$-KPO_3 for Voskresenskaya's thod of metaphosphate preparation.

The data in Table 306 for $LiPO_3$-$NaPO_3$ xtures may also be expressed as a three-riable equation:

$$= a + bT + cC + dC^2 + eT^3 + fC^3 + gTC + iCT^2 + hTC^2$$

iere a = 189.19498, $b \cdot 10^2$ = 1.20091, c = .34339, $d \cdot 10^3$ = -3.50222, $e \cdot 10^9$ = 7.99302, 10^6 = 5.23609, $g \cdot 10^3$ = -1.94445, $h \cdot 10^6$ = .74123, $i \cdot 10^7$ = 5.85018; maximum departure 0.59% at 1423 K and 100 mol % $NaPO_3$. The nits of concentration, C, and temperature, , are mol % ($NaPO_3$) and degrees kelvin, espectively.

$NaPO_3$-$Zn(PO_3)_2$

Melt Preparation and Purification

Refer to KPO_3-$Zn(PO_3)_2$ and $Ba(PO_3)_2$-KPO_3 for Voskresenskaya's [114] method of prepar-ation of metaphosphates.

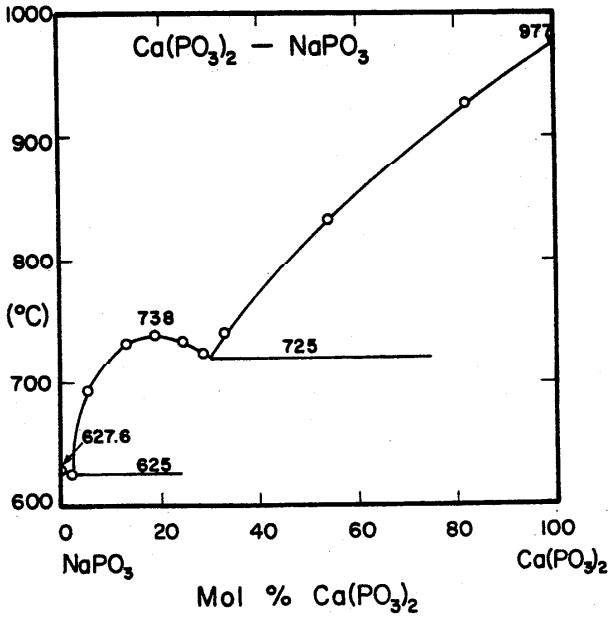


FIGURE 13. Phase diagram for $Ca(PO_3)_2$-$NaPO_3$.

Data from: G. W. Morey, J. Amer. Chem. Soc. 74, 5783 (1952).

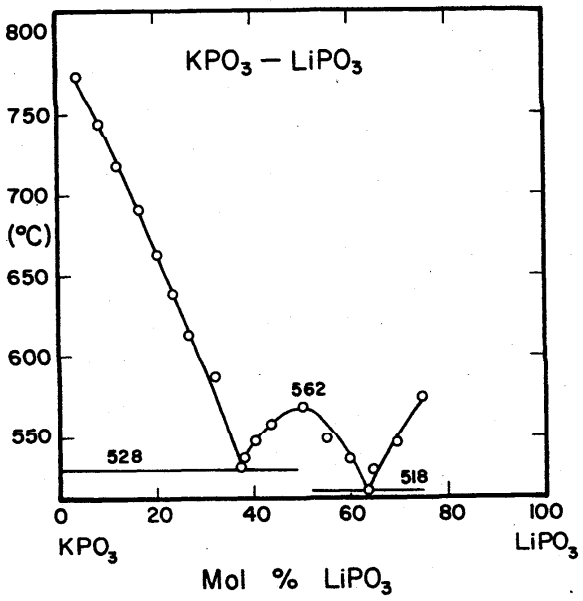


FIGURE 14. Phase diagram for KPO_3-$LiPO_3$.

Data from: A. G. Bergman and M. L. Shalakhovich, Zhur. Obshch. Khim. 23, 1075 (1953).

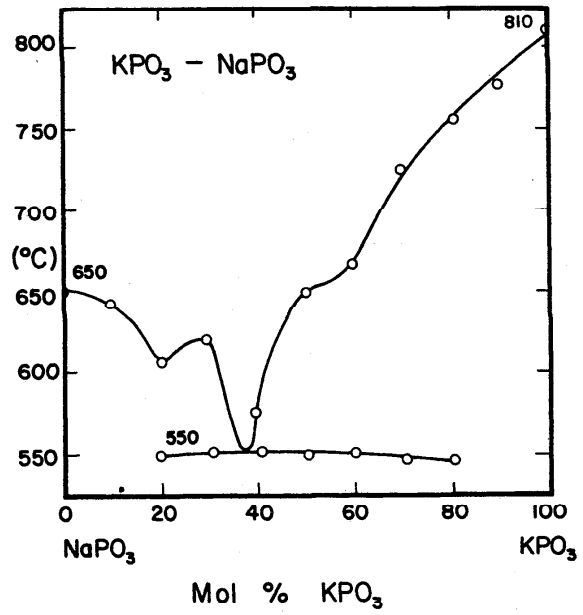


FIGURE 15. Phase diagram for KPO_3-$NaPO_3$.

Data from: G. Tammann and A. Ruppelt, Z. Anorg. Allg. Chem. 197, 65 (1911).

TABLE 290. Surface tension studies: $Ba(PO_3)_2$-KPO_3

Investigations critically examined

Ref.	Mol % KPO_3	Temp. range (K)	Comments
130	0-100	1180-1355	Pt-Rh capillary; calibration: H_2O, NaCl

Reference [130] is the NSRDS recommended data base for the surface tension of $Ba(PO_3)_2$ and KPO_3 [2].

TABLE 291. Surface tension studies: $Ca(PO_3)_2$-$NaPO_3$

Investigations critically examined

Ref.	Mol % $NaPO_3$	Temp. range (K)	Comments
127	0-100	1078-1423	Pt-10% Rh cylinder, calibr.: toluene, benzene, CCl_4
130	0-100	946-1400	refer: $Ba(PO_3)_2$-KPO_3

TABLE 292. Surface tension studies: KPO_3-$LiPO_3$

Investigations critically examined

Ref.	Mol % $LiPO_3$	Temp. range (K)	Comments
127	0-100	978-1428	refer: $Ca(PO_3)_2$-$NaPO_3$

TABLE 293. Surface tension studies: KPO_3-$NaPO_3$

Investigations critically examined

Ref.	Mol % $NaPO_3$	Temp. range (K)	Comments
127, 128	0-100	980-1420	refer: $Ca(PO_3)_2$-$NaPO_3$

TABLE 294. Density studies: KPO_3-$Zn(PO_3)_2$

Investigations critically examined

Ref.	Mol % $Zn(PO_3)_2$	Temp. range (K)	Comments
114	0-100	1047-1417	Pt ball; calibr.: KNO_3

TABLE 295. Surface tension studies: KPO_3-$Zn(PO_3)_2$

Investigations critically examined

Ref.	Mol % $Zn(PO_3)_2$	Temp. range (K)	Comments
114 125	0-100	1072-1466	Capillary; calibr.: NaCl; H_2O

TABLE 296. Surface tension studies: $LiPO_3$-$NaPO_3$

Investigations critically examined

Ref.	Mol % $NaPO_3$	Temp. range (K)	Comments
127	0-100	1023-1428	refer: $Ca(PO_3)_2$-$NaPO_3$
130	0-100	990-1346	refer: $Ba(PO_3)_2$-KPO_3

TABLE 297. Density studies: $NaPO_3$-$Zn(PO_3)_2$

Investigations critically examined

ef.	Mol % $Zn(PO_3)_2$	Temp. range (K)	Comments
14	0-100	1073-1382	Pt sphere; calibration: molten KNO_3

TABLE 298. Surface tension studies: $NaPO_3$-$Zn(PO_3)_2$

Investigations critically examined

Ref.	Mol % $Zn(PO_3)_2$	Temp. range (K)	Comments
114	0-100	1070-1466	capillary; calibr.: H_2O, NaCl

TABLE 299. $Ba(PO_3)_2$-KPO_3

Surface tension (dyn cm^{-1})

	Mol percent KPO_3				
T(K)	65	49	32.8	27.6	13.9
1180	155.9	167.5		179.9	196.9
1190	155.5	167.1		179.7	196.3
1200	155.1	166.6	177.9	179.4	195.8
1210	154.7	166.2	177.4	179.1	195.2
1220	154.2	165.7	177.0	178.9	194.6
1230	153.8	165.3	176.5	178.6	194.1
1240	153.4	164.9	176.0	178.4	193.5
1250	153.0	164.4	175.5	178.1	192.9
1260	152.6	164.0	175.0	177.8	192.3
1270	152.2	163.5	174.6	177.6	191.8
1280	151.8	163.1	174.1	177.3	191.2
1290		162.7	173.6		190.6
1300		162.2	173.1		190.1
1310			172.6		
1320					
1330					
1340					

temperature-dependent equations

$\gamma = a + bT$

Mol % KPO_3	a	$- b \cdot 10^3$
0	244.73	17.7
5	222.49	13.9
13.9	264.04	56.9
27.6	210.72	26.1
32.8	235.51	48.0
49	219.41	44.0
65	203.53	40.4
75	220.54	55.8
90.8	174.68	27.4
100	208.38	55.6

These values are based on the data of [130] (maximum bubble pressure).

TABLE 300. $Ca(PO_3)_2$-$NaPO_3$: Surface tension (dyn cm^{-1})

	Mol percent $NaPO_3$					
T(K)	100	94.72	88.88	82.34	74.99	66.68
1080	184.3	185.3	187.0	188.3	190.1	192.4
1100	183.3	184.3	186.0	187.3	189.2	191.6
1120	182.4	183.4	185.1	186.4	188.3	190.7
1140	181.4	182.4	184.1	185.4	187.4	189.9
1160	180.4	181.5	183.1	184.5	186.5	189.1
1180	179.4	180.6	182.1	183.5	185.5	188.2
1200	178.5	179.6	181.2	182.6	184.6	187.4
1220	177.5	178.7	180.2	181.6	183.7	186.5
1240	176.5	177.8	179.2	180.7	182.8	185.7
1260	175.5	176.8	178.2	179.7	181.9	184.9
1280	174.6	175.9	177.3	178.8	181.0	184.0
1300	173.6	174.9	176.3	177.8	180.1	183.2
1320	172.6	174.0	175.3	176.9	179.2	182.3
1340	171.6	173.1	174.3	175.9	178.3	181.5
1360	170.7	172.1	173.4	175.0	177.3	180.7
1380	169.7	171.2	172.4	174.0	176.4	179.8
1400	168.7	170.3	171.4	173.1	175.5	179.0
1420	167.7	169.3	170.4	172.1	174.6	178.1

temperature-dependent equations

$\gamma = a + bT$

Mol % $NaPO_3$	a	$-b \cdot 10^3$
0	266.35	26.2
18.19	255.36	33.2
33.34	253.53	40.4
46.11	254.46	47.1
57.04	236.42	45.5
66.68	237.77	42.0
74.99	239.35	45.6
82.34	239.57	47.5
88.88	239.60	48.7
94.72	235.91	46.9
100	237.02	48.8

These values are based on the data of [127] (cylinder method).

TABLE 301. KPO_3-$LiPO_3$ Surface tension (dyn cm^{-1})

	Mol percent $LiPO_3$					
T(K)	70.02	59.95	50.10	40.02	31.09	19.81
1030	175.1	171.3	167.9	164.5	161.9	159.3
1050	174.1	170.2	166.9	163.5	160.8	158.2
1070	173.1	169.2	165.8	162.4	159.6	157.0
1090	172.1	168.1	164.7	161.3	158.5	155.8
1110	171.1	167.1	163.6	160.3	157.4	154.6
1130	170.1	166.0	162.5	159.2	156.3	153.4
1150	169.1	165.0	161.5	158.2	155.1	152.3
1170	168.1	163.9	160.4	157.1	154.0	151.1
1190	167.1	162.9	159.3	156.0	152.9	149.9
1210	166.1	161.8	158.2	155.0	151.8	148.7
1230	165.1	160.8	157.1	153.9	150.6	147.5
1250	164.1	159.7	156.1	152.8	149.5	146.4
1270	163.1	158.7	155.0	151.8	148.4	145.2
1290	162.1	157.6	153.9	150.7	147.3	144.0
1310	161.1	156.6	152.8	149.6	146.1	142.8
1330	160.0	155.5	151.7	148.6	145.0	141.6
1350	159.0	154.5	150.7	147.5	143.9	140.5
1370	158.0	153.4	149.6	146.4	142.7	139.3
1390	157.0	152.4	148.5	145.4	141.6	138.1
1410	156.0	151.3	147.4	144.3	140.5	136.9

temperature-dependent equations

$\gamma = a + bT$

Mol % $LiPO_3$	a	$-b \cdot 10^3$
0	221.672	63.6
10.13	220.307	60.8
19.81	220.115	59.0
31.09	219.878	56.3
40.02	219.331	53.2
50.10	223.550	54.0
59.95	225.467	52.6
70.02	226.812	50.2
79.98	228.583	46.8
89.88	227.071	39.8
100	218.282	24.1

These values are based on the data of [127]. (cylinder method).

TABLE 302. KPO_3-$NaPO_3$

Surface tension (dyn cm^{-1})

	Mol percent $NaPO_3$					
T(K)	89.94	80.03	70.11	60.18	49.95	39.97
980	183.3	178.3	174.3	171.3	168.5	165.4
000	182.3	177.3	173.3	170.3	167.4	164.3
020	181.4	176.4	172.3	169.2	166.2	163.3
040	180.4	175.4	171.3	168.2	165.1	162.2
060	179.4	174.4	170.3	167.1	164.0	161.1
080	178.4	173.4	169.3	166.1	162.9	160.1
100	177.4	172.4	168.3	165.0	161.8	159.0
120	176.4	171.4	167.3	164.0	160.7	157.9
140	175.5	170.5	166.3	162.9	159.6	156.9
160	174.5	169.5	165.3	161.9	158.5	155.8
180	173.5	168.5	164.3	160.8	157.4	154.8
200	172.5	167.5	163.3	159.8	156.3	153.7
220	171.5	166.5	162.3	158.7	155.1	152.6
240	170.5	165.5	161.4	157.6	154.0	151.6
260	169.5	164.5	160.4	156.6	152.9	150.5
280	168.6	163.6	159.4	155.5	151.8	149.4
300	167.6	162.6	158.4	154.5	150.7	148.4
320	166.6	161.6	157.4	153.4	149.6	147.3
340	165.6	160.6	156.4	152.4	148.5	146.2
360	164.6	159.6	155.4	151.3	147.4	145.2
380	163.6	158.6	154.4	150.3	146.3	144.1
400	162.7	157.7	153.4	149.2	145.2	143.1
420	161.7	156.7	152.4	148.2	144.0	142.0

temperature-dependent equations

$\gamma = a + bT$

Mol % $NaPO_3$	a	$-b \cdot 10^3$
0	221.67	63.6
9.94	217.85	59.5
21.18	218.17	57.7
29.91	216.00	54.2
39.97	217.53	53.2
49.95	222.85	55.5
60.18	222.99	52.7
70.11	223.10	49.8
80.03	226.53	49.2
89.94	231.53	49.2
100	237.02	48.8

hese values are based on the data of [127] cylinder method).

TABLE 303. KPO_3-$Zn(PO_3)_2$: Density ($g \cdot cm^{-3}$)

	Mol percent $Zn(PO_3)_2$					
T(K)	100	87.8	71.7	52.3	24.3	14
1050					2.323	
1070					2.315	
1090			2.652	2.537	2.308	2.223
1110			2.647	2.531	2.300	2.216
1130			2.642	2.525	2.293	2.208
1150			2.638	2.519	2.286	2.200
1170		2.724	2.633	2.513	2.278	2.193
1190	2.790	2.721	2.628	2.508	2.271	2.185
1210	2.789	2.718	2.624	2.502	2.263	2.177
1230	2.787	2.715	2.619	2.496	2.256	2.170
1250	2.786	2.712	2.615	2.490	2.249	2.162
1270	2.784	2.709	2.610	2.484	2.241	2.155
1290	2.783	2.706	2.605	2.479	2.234	2.147
1310	2.781	2.703	2.601	2.473	2.226	2.139
1330	2.780	2.700	2.596	2.467	2.219	2.132
1350	2.778	2.697	2.592	2.461	2.212	2.124
1370	2.777	2.694	2.587	2.455		2.117
1390	2.775					
1410	2.774					

temperature-dependent equations

$\rho = a + bT$

Mol % $Zn(PO_3)_2$	a	$-b \cdot 10^3$
0	2.5292	0.3963
14	2.6382	0.3808
24.3	2.7106	0.3696
52.3	2.8520	0.2895
71.7	2.9030	0.2307
87.8	2.9028	0.1525
100	2.8817	0.0767

These values are based on the data of [114] (Archimedean method).

TABLE 304. KPO_3-$Zn(PO_3)_2$

Surface tension (dyn cm^{-1})

	Mol percent $Zn(PO_3)_2$				
T(K)	69.9	55.9	38.8	29.5	21.9
1080			145.4	146.8	
1100		151.8	144.6	145.9	
1120		151.2	143.8	144.9	
1140	144.5	150.6	142.9	144.0	143.0
1160	143.8	149.9	142.1	143.0	142.2
1180	143.0	149.3	141.3	142.1	141.4
1200	142.3	148.7	140.4	142.2	140.6
1220	141.5	148.1	139.6	140.2	139.8
1240	140.8	147.4	138.8	139.3	138.9
1260	148.9	146.8	137.9	138.3	138.1
1280	139.3	146.2	137.1	137.4	137.3
1300	138.6	145.6	136.3	136.4	136.5
1320	137.9	144.9	135.5	135.5	135.7
1340		144.3	134.6	134.5	

temperature-dependent equations

$\gamma = a + bT$

Mol % $Zn(PO_3)_2$	a	$-b \cdot 10^3$
0	208.38	55.6
5.5	206.01	53.5
14.8	191.90	42.5
21.9	189.16	40.5
29.5	197.79	47.2
38.8	190.36	41.6
55.9	186.24	31.3
69.9	186.30	3.67
81.9	171.14	4.20
91.7	175.60	4.00
100	198.02	-1.00

These values are based on the data of [114] (maximum bubble pressure method).

TABLE 305. $NaPO_3$-$Zn(PO_3)_2$: Density ($g \cdot cm^{-3}$)

	Mol percent $Zn(PO_3)_2$					
T(K)	100	81.1	62.5	57.5	41.8	21.3
1080				2.632	2.537	2.389
1100		2.734	2.695	2.627	2.531	2.382
1120		2.731	2.692	2.622	2.525	2.375
1140		2.728	2.688	2.617	2.519	2.368
1160		2.725	2.684	2.612	2.513	2.361
1180		2.721	2.680	2.607	2.507	2.354
1200	2.790	2.718	2.677	2.602	2.502	2.347
1220	2.788	2.715	2.673	2.597	2.496	2.340
1240	2.787	2.712	2.669	2.592	2.490	2.333
1260	2.785	2.708	2.665	2.587	2.484	2.326
1280	2.784	2.705	2.662	2.582	2.478	2.319
1300	2.782	2.702	2.658	2.578	2.472	2.312
1320	2.780	2.699	2.654	2.573	2.466	2.305
1340	2.779	2.695	2.650	2.568	2.460	2.298
1360	2.777	2.692	2.646	2.563	2.454	
1380	2.776		2.643			
1400	2.774					

temperature-dependent equations

$\rho = a + bT$

Mol % $Zn(PO_3)_2$	a	$-b \cdot 10^3$
0	2.6124	0.382
21.3	2.7648	0.348
41.8	2.8575	0.296
57.5	2.8970	0.245
62.5	2.9024	0.188
81.1	2.9131	0.162
100	2.8817	0.076

These values are based on the data of [114] (Archimedean method).

TABLE 306. $LiPO_3$-$NaPO_3$

Surface tension (dyn cm^{-1})

	Mol percent $NaPO_3$				
T(K)	79.98	69.99	59.99	49.94	39.92
1030	187.6	188.4	188.8	189.7	190.2
1050	186.7	187.5	187.9	188.9	189.4
1070	185.7	186.5	187.0	188.0	188.6
1090	184.8	185.6	186.1	187.1	187.8
1110	183.9	184.7	185.2	186.2	187.0
1130	182.9	183.8	184.4	185.4	186.3
1150	182.0	182.9	183.5	184.5	185.5
1170	181.0	182.0	182.6	183.6	184.7
1190	180.1	181.1	181.7	182.7	183.9
1210	179.2	180.2	180.8	181.9	183.1
1230	178.2	179.3	179.9	181.0	182.3
1250	177.3	178.4	179.0	180.1	181.5
1270	176.3	177.4	178.1	179.2	180.7
1290	175.4	176.5	177.3	178.4	179.9
1310	174.5	175.6	176.4	177.5	179.1
1330	173.5	174.7	175.5	176.6	178.4
1350	172.6	173.8	174.6	175.8	177.6
1370	171.7	172.9	173.7	174.9	176.8
1390	170.7	172.0	172.8	174.0	176.0
1410	169.8	171.1	171.9	173.1	175.2

temperature-dependent equations

$\gamma = a + bT$

Mol % $NaPO_3$	a	$-b \cdot 10^3$
0	218.28	24.1
10	224.04	30.2
20.08	227.94	34.2
28.79	228.19	35.5
39.92	230.88	39.5
49.94	234.73	43.7
59.99	234.52	44.4
69.99	235.22	45.5
79.98	235.91	46.9
89.94	237.12	48.4
100	237.02	48.8

These values are based on the data of [127] (cylinder method).

TABLE 307. $NaPO_3$-$Zn(PO_3)_2$

Surface tension (dyn cm^{-1})

	Mol percent $Zn(PO_3)_2$				
T(K)	64.2	51.8	40.9	31.3	21.6
990					
1010					
1030					
1050					
1070					
1090				171.0	172.1
1110			169.8	170.3	171.5
1130		168.0	169.3	169.6	170.8
1150		167.5	168.9	169.0	170.2
1170	172.0	167.1	168.4	168.3	169.6
1190	171.7	166.7	167.9	167.6	169.0
1210	171.4	166.2	167.4	166.9	168.4
1230	171.1	165.8	166.9	166.3	167.7
1250	170.8	165.3	166.5	165.6	167.1
1270	170.4	164.9	166.0	164.9	166.5
1290	170.1	164.4	165.5	164.2	165.9
1310	169.8	164.0	165.0	163.6	165.3
1330	169.5	163.5			
1350	169.2	163.1			

temperature-dependent equations

$\gamma = a + bT$

Mol % $Zn(PO_3)_2$	a	$-b \cdot 10^3$
0	233.53	49.20
4.5	220.68	39.50
10.2	216.54	37.50
21.6	205.86	31.00
31.3	207.83	33.80
40.9	196.58	24.10
51.8	193.19	22.30
64.2	189.87	15.30
82.9	196.87	14.20
100	198.02	1.00

These values are based on the data of [114] (maximum bubble pressure).

10.5 *Molybdate-Molybdate Systems*

This section contains the studies tables and the numerical tables for the physical properties of molybdate-molybdate melts. Included also are summaries of the methods used for melt preparation and purification and, where possible, temperature-liquidus phase diagrams.

$Bi_2(MoO_4)_3$-$PbMoO_4$

Melt Preparation and Purification

Morris, McNair and Koops [131] used reagent grade materials, which were heated almost to sintering, cooled and then crushed to a fine powder. The salts were then dried at 200°C for an hour.

K_2MoO_4-Li_2MoO_4

Melt Preparation and Purification

Brown [133] and Brown and Morris [135, 136] used reagent grade salts and dried them in a vacuum for 6 hours at 225°C. The salts were stored in a desiccator until ready for use.

Li_2MoO_4-Na_2MoO_4

Melt Preparation and Purification

For the method of melt preparation used by Brown [133] and Brown and Morris [135, 135] refer to the system K_2MoO_4-Li_2MoO_4.

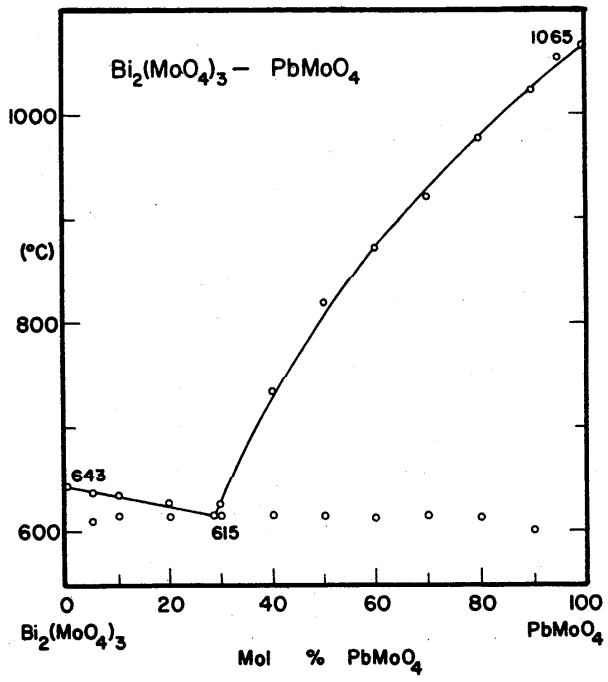


FIGURE 16. Phase diagram for $Bi_2(MoO_4)_3$-$PbMoO_4$.

Data from: F. Zambonini, Gazz. Chim. Ital. 50, II, 128 (1920).

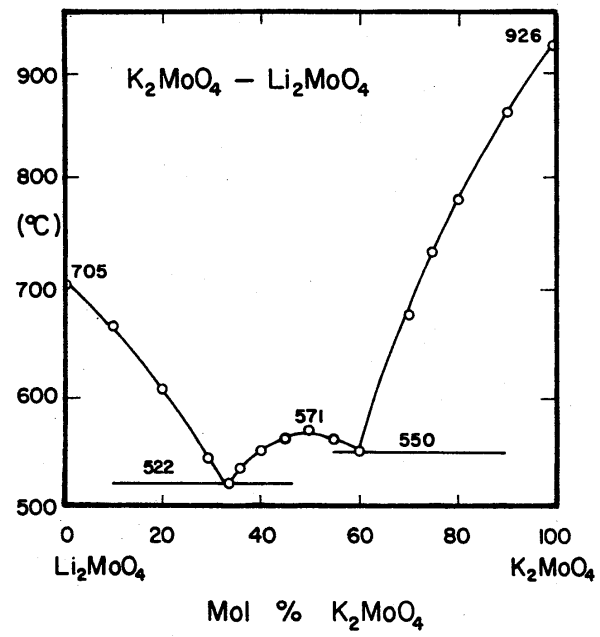


FIGURE 17. Phase diagram for K_2MoO_4-Li_2MoO_4.

Data from: F. Hoermann, Z. Anorg. Allg. Chem. 177, 145 (1928).

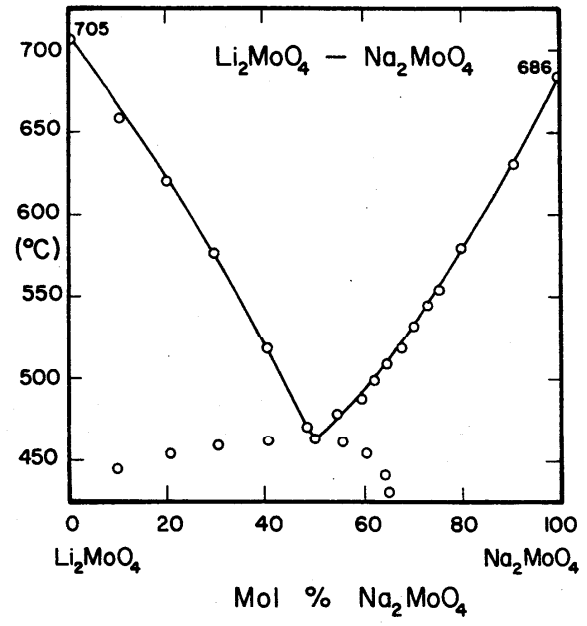


FIGURE 18. Phase diagram for Li_2MoO_4-Na_2MoO_4.

Data from: F. Hoermann, Z. Anorg. Allg. Chem. 177, 145 (1928).

TABLE 308. Electrical conductance studies: $Bi_2(MoO_4)_3$-$PbMoO_4$

Investigations critically examined

Ref.	Mol % $PbMoO_4$	Temp. range (K)	Comments
131	0-100	976-1390	cap. dip cell calibr.: 1 D KCl

TABLE 309. Surface tension studies: $Bi_2(MoO_4)_3$-$PbMoO_4$

Investigations critically examined

Ref.	Mol %	Temp. range (K)	Comments
131	0-100	953-1397	detachment

TABLE 310. Density studies: $Bi_2(MoO_4)_3$-$PbMoO_4$

Investigations critically examined

Ref.	Mol % $PbMoO_4$	Temp. range (K)	Comments
131	0-100	953-1401	Pt bob

TABLE 311. Electrical conductance studies: K_2MoO_4-Li_2MoO_4

Investigations critically examined

Ref.	Mol % Li_2MoO_4	Temp. range (K)	Comments
133, 135	0-100	884-1280	quartz dip cell; calibr.: 1 D KCl

Deviation from NSRDS recommendations ([1] p. 34)

Ref.	Mol % Li_2MoO_4	Min. departure	Max. departure
133	100	25.63% (1125 K)	29.09% (1018 K)

TABLE 312. Density studies: K_2MoO_4-Li_2MoO_4

Investigations critically examined

Ref.	Mol % Li_2MoO_4	Temp. range (K)	Comments
133, 135	0-100	858-1337	Pt bob; corrections made for volume and surface tension effects

Deviations from NSRDS recommendations ([1] p. 35)

Ref.	Mol % Li_2MoO_4	Min departure	Max. departure
133, 135	0	-0.06% (1333 K)	-0.77% (1245 K)

TABLE 313. Surface tension studies: K_2MoO_4-Li_2MoO_4

Investigations critically examined

Ref.	Mol % Li_2MoO_4	Temp. range (K)	Comments
133, 136	0-100	820-1284	Pt-Rh crucible

Deviations from NSRDS recommendations ([2] p. 74)

Ref.	Mol % Li_2MoO_4	Min. departure	Max. departure
133, 136	0	1.64% (1284 K)	3.66% (1218 K)

TABLE 314. Electrical conductance studies: Li_2MoO_4-Na_2MoO_4

Investigations critically examined

Ref.	Mol % Na_2MoO_4	Temp. range	Comments
133, 135	0-100	805-1132	refer K_2MoO_4-Li_2MoO_4

Deviations from NSRDS recommendations [[1] p. 35]

Ref.	Mol % Na_2MoO_4	Min. departure	Max. departure
133, 135	0	25.63% (1125 K)	29.09% (1018 K)
	100	0.00% (1130 K)	0.00% (1130 K)

TABLE 315. Density studies: Li_2MoO_4-Na_2MoO_4

Investigations critically examined

Ref.	Mol % Na_2MoO_4	Temp. range	Comments
133, 135	0-100	800-1200	refer: K_2MoO_4-Li_2MoO_4

Deviations from NSRDS recommendations ([1] p. 35)

Ref.	Mol % Na_2MoO_4	Min. departure	Max. departure
133, 135	100	-2.37% (1146 K)	-2.44% (1124 K)

TABLE 316. Surface tension studies: Li_2MoO_4-Na_2MoO_4

Investigations critically examined

Ref.	Mol % Na_2MoO_4	Temp. range (K)	Comments
133, 136	0-100	763-1194	refer: K_2MoO_4-Li_2MoO_4

Deviations from NSRDS recommendations ([2] p. 74)

Ref.	Mol % Na_2MoO_4	Min. departure	Max. departure
133, 136	100	-1.17% (1167 K)	-1.86% (999.8 K)

TABLE 317. $Bi_2(MoO_4)_3$-$PbMoO_4$

Specific conductance ($ohm^{-1}cm^{-1}$)

	Mol percent $PbMoO_4$				
T(K)	60	37.8	28.5	21.3	10
980				0.244	
1000			0.322	0.285	0.300
1020			0.371	0.325	0.338
1040			0.416	0.364	0.379
1060		0.402		0.403	0.421
1080		0.445			
1100		0.488			
1120					
1140					
1160					
1180	0.719				
1200	0.763				
1220	0.806				
1240	0.850				

temperature dependent equations

$$\kappa = a + bT + cT^2$$

Mol % $PbMoO_4$	a	b · 10^3	c · 10^6	Standard error of estimate
0	1.8252	-4.7203	3.1979	0.90%
10	1.0309	-3.3346	2.6033	0.13%
21.3	-2.6782	3.9050	-0.9419	0.44%
28.5	-7.9224	13.9280	-5.6831	0.48%
37.8	-1.8794	2.1521		0.57%
60	-1.8628	2.1879		0.11%
80.4	-1.6974	2.0118		0.12%
100	-0.7738	1.2480		0.10%

These values are based on the data of [131] (classical ac technique).

BLE 318. $Bi_2(MoO_4)_3$-$PbMoO_4$: Density (g cm^{-3})

	Mol percent $PbMoO_4$					
(K)	60.0	37.8	28.5	21.3	10	0
0						5.222
0				5.221		5.200
0				5.199		5.179
0				5.179		5.157
0			5.184	5.158	5.148	5.136
0			5.160	5.139	5.126	
0		5.164		5.119	5.104	
0		5.138		5.100		
0		5.113		5.082		
0	5.135					
0	5.132					
0	5.126					
0	5.117					
0	5.106					
0	5.092					

temperature-dependent equations

$\rho = a + bT + cT^2$

% $PbMoO_4$	a	b · 10^3	c · 10^6	Standard error of estimate
0	6.2457	-1.0779		0.07%
0	6.2892	-1.1079		0.02%
1.3	6.8124	-2.2088	0.5853	0.03%
8.5	6.4205	-1.2010		0.02%
7.8	6.5207	-1.2682		0.03%
0.0	0.6415	8.0244	-3.5825	0.04%
0.4	4.0300	2.3873	-1.2010	0.02%
0	6.1477	0.6770		0.01%

These values are based on the data of [131] (Archimedean method).

TABLE 319. $Bi_2(MoO_4)_3$-$PbMoO_4$

Surface tension (dyn cm^{-1})

	Mol percent $PbMoO_4$					
T (K)	80.4	60	37.8	28.5	21.3	10
960					163.2	
980				169.2	161.7	
1000				168.1	160.1	164.8
1020			162.7	166.7	158.6	162.8
1040			162.0	164.9	157.0	161.1
1060			160.7	162.8	155.4	159.7
1080			158.7			158.7
1100			156.1			
1120						
1140						
1160						
1180		159.1				
1200		157.7				
1220		156.2				
1240						
1260						
1280						
1300	156.8					
1320	155.4					

temperature-dependent equations

$\gamma = a + bT + cT^2 + dT^3$

Mol % $PbMoO_4$	a	b	c · 10^3	d · 10^9	Standard error of est.
0	-853.69	2.132	-1.119		0.19%
10	652.59	-0.868	0.381		0.21%
21.3	237.97	-0.077			0.15%
28.5	0.9643	0.234	0.096	-163.9	0.04%
37.8	659.70	1.631	-0.808		0.42%
60.0	244.05	-0.072			0.33%
80.4	252.36	-0.073			0.23%
100	254.92	-0.065			

These values are based on the data of [131] (detachment technique).

TABLE 320. K_2MoO_4-Li_2MoO_4

Specific conductance ($ohm^{-1}cm^{-1}$)

	Mol percent Li_2MoO_4					
T(K)	80.1	67	60.7	50	46.6	40
870		0.579				0.416
890		0.630	0.470	0.472		0.452
910		0.681	0.522	0.518	0.415	0.490
930	0.837	0.733	0.575	0.564	0.461	0.530
950	0.891	0.784	0.627	0.610	0.507	0.571
970	0.944	0.836	0.679	0.655	0.553	0.612
990	0.996	0.887	0.731	0.699	0.599	0.652
1010	1.046	0.938	0.783	0.741	0.646	0.691
1030	1.094	0.990	0.835	0.781	0.693	0.728
1050	1.141	1.041		0.819	0.740	0.762
1070	1.186	1.093		0.853		0.792
1090	1.229					
1110	1.269					
1130	1.308					

temperature-dependent equations

$$\kappa = a + bT + cT^2 + dT^3$$

Mol % Li_2MoO_4	a	$b \cdot 10^3$	$c \cdot 10^6$	$d \cdot 10^9$	Standard error of estimate
0	4.7293	-1.025	-6.699	4.248	0.52%
20.1	-2.8671	5.008	-1.449		0.52%
40	11.2726	-37.818	41.891	-14.674	1.30%
46.6	-1.3240	1.555	0.391		0.17%
50	6.7266	-24.695	29.255	-10.566	1.06%
60.7	-2.0566	3.036	-0.223		0.19%
67	-1.6565	2.569			1.02%
80.1	-1.6458	0.996	3.506	-1.835	0.32%
100	-7.8636	14.297	-4.044		0.26%

These values are based on the data of [133,135] (classical ac technique).

TABLE 321. K_2MoO_4-Li_2MoO_4: Density ($g\ cm^{-3}$)

	Mol percent Li_2MoO_4					
T(K)	80.1	67	60.7	50	46.6	40
860						2.652
880						2.639
900		2.732			2.657	2.626
920		2.719	2.678		2.642	2.614
940		2.707	2.666	2.641	2.628	2.601
960	2.752	2.694	2.655	2.628	2.614	2.589
980	2.744	2.682	2.644	2.616	2.600	2.576
1000	2.735	2.670	2.632	2.604	2.586	2.564
1020	2.724	2.658	2.621	2.591	2.572	2.552
1040	2.713	2.647	2.610	2.579	2.558	2.540
1060	2.701	2.635	2.598	2.567		2.527
1080	2.689	2.624	2.587	2.555		2.515
1100	2.676					
1120	2.664					
1140	2.653					
1160	2.642					
1180						
1200						

temperature-dependent equations

$$\rho = a + bT + cT^2 + dT^3$$

Mol % Li_2MoO_4	a	$-b \cdot 10^3$	$c \cdot 10^6$	$d \cdot 10^9$	Standard error of estimate
0	2.8854	0.4531			0.07%
20.1	3.3761	1.1428	0.2569		0.03%
40	3.2574	0.7726	0.0790		0.02%
46.6	3.2911	0.7051			0.00%
50	3.3236	0.8275	0.1074		0.02%
60.7	3.1998	0.5676			1.4 %
67	3.4677	1.0008	0.2031		0.02%
80.1	-3.8751	-19.3572	-18.391	5.6443	0.04%
100	3.8075	1.2827	0.3271		0.03%

These values are based on the data of [133] [135] (Archimedean method).

TABLE 322. K_2MoO_4-Li_2MoO_4: Surface tension (dyn cm^{-1})

	Mol percent Li_2MoO_4				
T(K)	80.1	67	50	40	20.1
820		184.9			
840		183.5		176.7	
860		182.2	179.5	175.4	
880		180.8	178.2	174.1	
900		179.4	176.9	172.8	
920		178.0	175.6	171.5	
940	187.8	176.7	174.2	170.3	
960	186.4	175.3	172.9	169.1	
980	184.9	173.9	171.6	168.0	
1000	183.5	172.5	170.2	166.8	
1020	182.0	171.1	168.9	165.7	
1040	180.5	169.7	167.6	164.7	
1060	179.1		166.3	163.7	
1080	177.6				155.7
1100	176.2				154.2
1120	174.7				152.6
1140	173.3				151.1
1160	171.8				149.5
1180					148.0

temperature-dependent equations

$\gamma = a + bT + cT^2$

% MoO_4	a	$- b \cdot 10^3$	$c \cdot 10^6$	Standard error of estimate
0	760.97	873.30	308.58	0.19%
0.1	239.22	77.32		0.04%
0	262.69	136.30	40.43	0.11%
0	236.63	66.39		0.09%
7	241.46	68.96		0.38%
0.1	256.28	72.83		0.11%
0	288.51	+13.37	-63.40	0.06%

se values are based on the data of [133] [136] tachment technique).

TABLE 323. Li_2MoO_4-Na_2MoO_4: Density (g · cm^{-3})

	Mol percent Na_2MoO_4				
T(K)	80	62	55	48	25
800				2.890	
820		2.865		2.880	
840		2.853	2.866	2.869	
860		2.842	2.854	2.857	
880	2.819	2.831	2.843	2.846	
900	2.806	2.820	2.831	2.835	2.850
920	2.793	2.808	2.819	2.824	2.839
940	2.780	2.797	2.807	2.812	2.827
960	2.767	2.785	2.795	2.801	2.816
980	2.754	2.773	2.783	2.790	2.804
1000	2.741	2.761	2.771	2.780	2.793
1020	2.728	2.749	2.760		2.781
1040	2.715	2.736	2.748		2.770
1060	2.702		2.736		2.759
1080	2.690		2.724		2.747
1100	2.677				
1120	2.665				
1140					
1160					
1180					
1200					

temperature-dependent equations

$\rho = a + bT + cT^2 + dT^3$

Mol. % Na_2MoO_4	a	$- b \cdot 10^3$	$c \cdot 10^6$	$d \cdot 10^9$	Standard error of estimate
0	3.8075	1.2827	0.3271		0.03%
25	3.3665	0.5735			0.01%
48	2.6972	-1.5994	-2.4185	0.9014	0.01%
55	3.3803	0.6272	0.0181		0.01%
62	3.9063	2.5699	2.3145	-0.8897	0.02%
80	3.4743	0.8221	0.08842		0.02%
100	3.3016	0.5936			0.04%

These values are based on the data of [133] [135] (Archimedean method).

TABLE 324. Li_2MoO_4-Na_2MoO_4

Specific conductance ($ohm^{-1}cm^{-1}$)

	Mol. percent Na_2MoO_4				
T(K)	80	62	55	48	25
810			0.691	0.718	
830		0.759	0.767	0.796	
850		0.837	0.844	0.874	
870		0.914	0.920	0.952	
890	0.897	0.991	0.996	1.030	
910	0.967	1.067	1.073	1.108	
930	1.038	1.142	1.149	1.186	
950	1.108	1.216	1.226	1.264	
970	1.178	1.289	1.302	1.342	1.532
990	1.249	1.362	1.379	1.420	1.617
1010	1.319	1.432			1.698
1030	1.390	1.502			1.774
1050	1.460	1.570			1.846
1070		1.636			
1090		1.701			

temperature-dependent equations

$$\kappa = a + bT + cT^2 + dT^3$$

Mol. % Na_2MoO_4	- a	b · 10^3	c · 10^6	- d · 10^9	Standard error of estimate
0	7.8636	14.297	-4.044		0.26%
25	-5.0132	-23.179	32.240	12.416	0.43%
48	2.4429	3.902			0.25%
55	2.4050	3.821			0.40%
62	1.2728	0.728	5.923	2.525	0.12%
80	2.2342	3.518			0.35%
100	2.0086	3.236			0.26%

These values are based on the data of [133] [135] (classical ac technique).

TABLE 325. Li_2MoO_4-Na_2MoO_4

Surface tension ($dyn\ cm^{-1}$)

	Mol percent Na_2MoO_4				
T(K)	80	62	55	48	25
770		231.5			
790		229.9			
810		228.3		241.3	
830		226.7	231.6	239.0	
850		225.0	229.9	236.8	
870	219.9	223.3	228.1	234.6	
890	218.2	221.6	226.4	232.4	239.7
910	216.5	219.9	224.6	230.3	237.8
930	214.8	218.2	222.8	228.2	235.9
950	213.1	216.6	221.0	226.2	233.8
970	211.4		219.1	224.2	231.6
990	209.7		217.2	222.2	229.4
1010	208.1				227.1
1030	206.4				224.9
1050	204.7				222.6
1070	203.0				220.5

temperature-dependent equations

$$\gamma = a + bT + cT^2 + dT^3$$

Mol % Na_2MoO_4	a	b · 10^3	- c · 10^6	d · 10^9	Standard error of estimate
0	278.93	30.98	71.45		0.06%
25	-286.87	1753.95	1849.58	610.7	0.09%
48	361.49	-183.343	-43.07		0.09%
55	283.63	-40.028	27.31		0.04%
62	129.08	489.744	654.54	248.3	0.03%
80	293.22	-84.326			0.12%
100	303.70	-109.572	-12.97		0.01%

These values are based on the data of [133] [136] (detachment technique).

10.6 *Perchlorate-Perchlorate Systems*

This section contains the studies tables and the numerical tables for the physical properties of perchlorate-perchlorate melts. Included also are summaries of the methods used for melt preparation and purification and, where possible, temperature-liquidus phase diagrams.

$CsClO_4$-$LiClO_4$

Melt Preparation and Purification

Alluli [140, 207] used reagent grade salts. All the mixtures were carefully dried under a vacuum of 10^{-2} torr after melting. The molar ratio of the mixtures was determined using atomic absorption spectroscopy.

$KClO_4$-$LiClO_4$

Melt Preparation and Purification

Refer to $CsClO_4$-$LiClO_4$ for the method of melt preparation used by Alluli and Palazzeschi [140]. Refer to $LiClO_4$-$NaClO_4$ for observations on the method used by Brovkina et al. [209, 210, 211].

$LiClO_4$-$NaClO_4$

Melt Preparation and Purification

Refer to $CsClO_4$-$LiClO_4$ for the method of melt preparation used by Alluli [207]. Brovkina et al. [209, 210, 211] analyzed the melt for thermal decomposition products (chloride, chlorate). The reagent grade salts were vacuum dried.

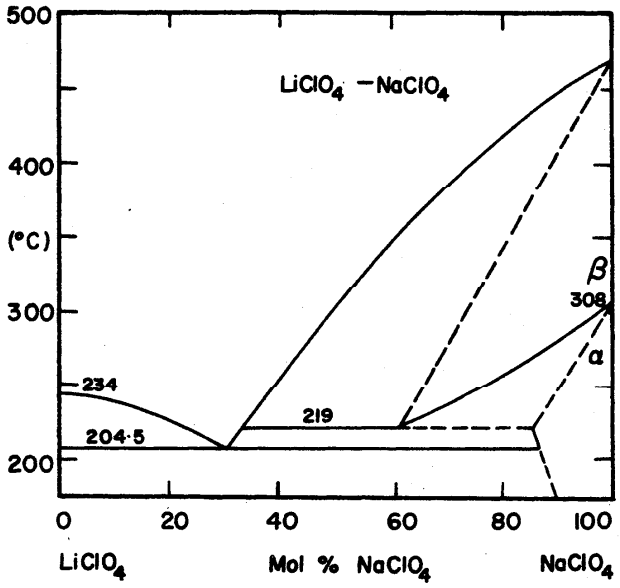


FIGURE 19. Phase diagram for $LiClO_4$-$NaClO_4$.

Data from: I. A. Zakharova, V. G. Markova, and A. A. Zinovdev, Zhur. Neorg. Khim. 5, 914 (1960); Russ. J. Inorg. Chem. 5, 441 (1960).

TABLE 326. Electrical conductance studies

$CsClO_4$-$LiClO_4$

Investigations critically examined

Ref.	Mol % $LiClO_4$	Temp. range (K)	Comments
141, 207, 208	75-100	525-800	Pyrex cell; calibr.: 1 N KCl

Refs. [141,207,208] are the NSRDS recommended studies for the specific conductance of pure $LiClO_4$.

TABLE 327. Density studies: $CsClO_4$-$LiClO_4$

Investigations critically examined

Ref.	Mol % $LiClO_4$	Temp. range (K)	Comments
141, 207, 208	75-100	502-635	Pyrex cell; calibr.: Hg, KNO_3

TABLE 328. Electrical conductance studies

$KClO_4$-$LiClO_4$

Investigations critically examined

Ref.	Mol % $LiClO_4$	Temp. range (K)	Comments
140, 141, 207, 209	65-100	493-643	refer: $CsClO_4$-$LiClO_4$
212	75-100		

Ref. [140] is the NSRDS recommended study for pure $LiClO_4$.

TABLE 329. Density studies: $KClO_4$-$LiClO_4$

Investigations critically examined

Ref.	Mol. % $LiClO_4$	Temp. range (K)	Comments
140	65-100	493-643	refer: $CsClO_4$-$LiClO_4$
213		673	

Refer to $LiClO_4$: density (this volume) for % deviations.

Table 330. Electrical conductance studies

$LiClO_4$-$NaClO_4$

Investigations critically examined

Ref.	Mol % $NaClO_4$	Temp. range (K)	Comments
140,207	0-50	503-643	refer: $CsClO_4$-$LiClO_4$
209,210	0-50	513-673	decomp. above 70 mol % $NaClO_4$
214	0-70(g)	573-653	cap. cell; 110-120 cm^{-1}

Ref. [207, 140] are the NSRDS recommended studies for $NaClO_4$.

TABLE 331. Density studies: $LiClO_4$-$NaClO_4$

Investigations critically examined

Ref.	Mol. % $NaClO_4$	Temp. range (K)	Comments
207	0-54.5	493-633	refer: $CsClO_4$-$LiClO_4$
215	0-100		

Refer to $LiClO_4$: density for % deviations.

TABLE 332. Viscosity studies: $LiClO_4$-$NaClO_4$

Investigations critically examined

The viscosity of $LiClO_4$-$NaClO_4$ melts was investigated by Farmakovskaya and Brovkina [216] by an oscillational technique. The temperature variation was found to be of the type: $\log \eta = A + B/T$. No data were reported in [216]; the original article is deposited with the All-Union Institute of Scientific and Technical Information (VINITI).

TABLE 333. $CsClO_4$-$LiClO_4$: Specific conductance

($ohm^{-1} cm^{-1}$)

	Mol. percent $LiClO_4$		
T(K)	95	85	75
550	0.761	0.590	0.440
560	0.802	0.622	0.466
570	0.844	0.654	0.493
580	0.887	0.687	0.521
590	0.931	0.720	0.549
600	0.975	0.754	0.578
610	1.019	0.788	0.607
620	1.064	0.823	0.636
630	1.110	0.857	
640		0.893	

temperature-dependent equations

$$\kappa = a + bT + cT^2$$

Mol % $LiClO_4$	a	$b \cdot 10^3$	$c \cdot 10^6$	Standard error of estimate	Temp. range (K)
95	-1.7708	4.4864	-0.1071	0.20%	544-808
85	-1.6186	4.5755	-1.0285	0.15%	541-647
75	-0.8169	1.8250	0.8333	0.35%	525-616

These values are based on the data of Allulli (classical ac technique) [207]

TABLE 334. $CsClO_4$-$LiClO_4$: Density (g cm^{-3})

	Mol. percent $LiClO_4$		
T(K)	95	85	75
510			2.321
520			2.312
530			2.303
540			2.294
550	2.015	2.187	2.285
560	2.028	2.178	2.276
570	2.037	2.170	2.268
580	2.041	2.161	2.259
590	2.041	2.153	2.250
600	2.038	2.144	2.241
610	2.029	2.136	
620	2.017	2.127	
630		2.119	

temperature-dependent equations

$$\rho = a + bT + cT^2$$

Mol % $LiClO_4$	a	$b \cdot 10^3$	$c \cdot 10^6$	Standard error of estimate
75	2.8761	- 1.255	0.330	0.03%
85	2.6513	- 0.845		0.03%
95	-5.1702	24.625	-21.021	0.41%

These values are based on the data of [207] (dilatometric technique).

TABLE 335. $KClO_4$-$LiClO_4$

Specific conductance (ohm^{-1}cm^{-1})

	Mol percent $LiClO_4$			
T(K)	95	85	75	65
500			0.454	
510			0.488	
520		0.599	0.523	
530	0.723	0.639	0.558	
540	0.769	0.680	0.593	
550	0.815	0.721	0.628	0.538
560	0.861	0.761	0.663	0.570
570	0.906	0.802	0.698	0.603
580	0.951	0.843	0.733	0.635
590	0.995	0.884	0.768	0.667
600	1.039	0.924	0.803	0.699
610	1.082	0.965	0.838	0.731
620	1.125		0.873	0.763
630	1.168		0.907	0.795
640			0.942	

temperature-dependent equations

$$\kappa = a + bT + cT^2 + dT^3$$

Mol % $LiClO_4$	- a	$b \cdot 10^3$	$c \cdot 10^6$	$d \cdot 10^9$	Standard error of estimate
65	1.2292	3.2137			0.15%
75	0.3965	1.3197	8.5792	- 5.078	0.06%
85	1.5187	4.0717			3.09%
95	2.3995	7.1014	-2.2832		0.07%
100	1.8656	5.2286	-0.4975		0.09%

These values are based on [140, 141] (classical ac technique)

TABLE 336. $KClO_4$-$LiClO_4$: Density (g cm^{-3})

	Mol percent $LiClO_4$			
T(K)	95	85	75	65
500			2.060	
510			2.052	
520	2.024	2.035	2.045	
530	2.017	2.028	2.037	
540	2.010	2.020	2.029	2.038
550	2.003	2.012	2.021	2.030
560	1.997	2.005	2.013	2.022
570	1.989	1.997	2.005	2.013
580	1.983	1.990	1.998	2.005
590	1.976	1.982	1.990	1.997
600	1.970	1.975	1.982	1.988
610	1.963	1.968	1.974	1.980
620	1.956	1.960	1.966	1.971
630				1.963

temperature-dependent equations

$\rho = a + bT = cT^2$

Mol % $LiClO_4$	a	$-b \cdot 10^3$	$c \cdot 10^6$	Standard error of estimate
65	2.4913	0.8387		0.02%
75	2.4510	0.7817		0.11%
85	2.4784	0.9381	0.1646	0.02%
95	2.3743	0.6745		0.14%
100	2.6677	1.6838	0.8686	0.11%

These values are based on the data of [140] (dilatometric technique)

TABLE 337. $LiClO_4$-$NaClO_4$: Density (g cm^{-3})

	Mol percent $NaClO_4$				
T(K)	54.5	42	27	6.3	0
500			2.078		
510			2.071		
520			2.064	2.053	
530			2.057	2.045	
540			2.050	2.036	
550		2.046	2.043	2.028	2.006
560	2.055	2.039	2.036	2.020	1.999
570	2.048	2.033	2.029	2.011	1.992
580	2.041	2.027	2.022	2.003	1.985
590	2.034	2.021	2.015	1.995	1.978
600	2.027	2.014	2.008	1.986	1.971
610	2.021	2.008	2.001	1.978	1.965
620	2.014	2.002	1.994		1.958
630	2.007				1.951

temperature-dependent equations

$\rho = a + bT$

Mol % $NaClO_4$	a	$-b \cdot 10^3$
0	2.3812	0.6830
6.3	2.4863	0.8333
27	2.4289	0.7018
42	2.3894	0.6250
54.5	2.4364	0.6818

These values are based on the data of Allulli (dilatometric method) [207].

TABLE 338. $LiClO_4$-$NaClO_4$

Specific conductance ($ohm^{-1}cm^{-1}$)

	Mol percent $NaClO_4$				
T(K)	50.3	41	32	12	10.7
510					0.632
520					0.677
530			0.654	0.701	0.722
540			0.696	0.745	0.768
550			0.737	0.789	0.813
560		0.775	0.779	0.833	0.858
570		0.814	0.821	0.877	0.904
580		0.854	0.862	0.921	0.949
590	0.861	0.893	0.904	0.965	0.994
600	0.901	0.932	0.946	1.009	1.040
610	0.942	0.972	0.987	1.053	1.085
620	0.982	1.011	1.029	1.096	1.131
630	1.023	1.050	1.070	1.140	
640	1.063	1.089		1.184	

temperature-dependent equations

$\kappa = a + bT$

Mol. % $NaClO_4$	- a	$b \cdot 10^3$
0	1.6988	4.6512
10.7	1.6822	4.5367
12	1.6260	4.3910
32	1.5514	4.1617
41	1.4257	3.9300
50.3	1.5287	4.0503

These values are based on the data of [207] (classical ac technique).

10.7 *Sulfate-Sulfate Systems*

This section contains the studies tables and the numerical tables for the physical properties of sulfate-sulfate melts. Also included are summaries of the methods used for melt preparation and purification and, where possible, temperature-liquidus phase diagrams.

Ag_2SO_4-Li_2SO_4

Melt Preparation and Purification

Kvist [151, 217] used reagent grade salts without further purification. The salts were dried overnight at 180°C before use.

$BaSO_4$-Li_2SO_4

Melt Preparation and Purification

For Kvist's [143, 218, 219] method of melt preparation, refer to Ag_2SO_4-Li_2SO_4.

$CaSO_4$-Na_2SO_4

Melt Preparation and Purification

Moiseev, et al. [145] used chemically pure, anhydrous Na_2SO_4 and $CaSO_4$. All measurements were carried out under an oxidizing atmosphere. Because of the corrosive nature of molten sulfates, all parts of the apparatus which came into contact with the melts were made of sintered alumina. For further information of Moiseev's methods of melt preparation, refer to Cs_2CO_3-Li_2CO_3.

The surface tension data for $CaSO_4$-Na_2SO_4 (Table 383) may also be expressed as a three-variable equation:

$$\gamma = a + bT + cC + dC^2 + eC^3 + fTC^2 + gCT^2$$

where $a = 360.627$, $b \cdot 10^2 = 10.5161$, $c \cdot 10^2 = 82.1528$, $d \cdot 10^4 = 3.16218$, $e \cdot 10^5 = 3.98141$, $f \cdot 10^6 = -3.53318$ and $g = 2.62251$; a standard error of estimate, 0.24%; maximum departure 0.38% at 1470 K and 90 mol % Na_2SO_4. The units of concentration, C, and temperature, T, are mol % (Na_2SO_4) and degrees kelvin, respectively.

$CdSO_4$-Li_2SO_4

Melt Preparation and Purification

For Kvist's [218] method of melt preparation, refer to Ag_2SO_4-Li_2SO_4.

Cs_2SO_4-K_2SO_4

Melt Preparation and Purification

For Kvist's [217] method of melt purification, refer to Ag_2SO_4-Li_2SO_4.

Bertozzi and Soldani [149] used carefully dried reagent grade salts without further purification.

Cs_2SO_4-Li_2SO_4

Melt Preparation and Purification

For Kvist's [217] method of melt preparation, refer to Ag_2SO_4-Li_2SO_4.

Cs_2SO_4-Na_2SO_4

Melt Preparation and Purification

For Kvist's [217] and Bertozzi's [149] methods of melt preparation, refer to Ag_2SO_4-Li_2SO_4 and Cs_2SO_4-K_2SO_4, respectively.

Cs_2SO_4-Rb_2SO_4

Melt Preparation and Purification

For Kvist's [217] and Bertozzi's [149] methods of melt preparation refer to Ag_2SO_4-Li_2SO_4 and Cs_2SO_4-K_2SO_4, respectively.

Cs_2SO_4-Tl_2SO_4

Melt Preparation and Purification

For Kvist's [146] method of melt preparation, see Ag_2SO_4-Li_2SO_4.

K_2SO_4-Li_2SO_4

Melt Preparation and Purification

For Kvist's [218, 219] method of melt preparation refer to Ag_2SO_4-Li_2SO_4.

James and Liu [220] used recrystalized salts partially dried in an air oven, and then more completely dried by heating slowly through the melting point under a vacuum of ∿10μ. The preparation of mixtures and the handling of the purified compounds were carried out in a dry box under high-purity nitrogen.

K_2SO_4-Na_2SO_4

Melt Preparation and Purification

For Kvist's [146, 217] and Bertozzi's [149] method of melt preparation, refer to Ag_2SO_4-Li_2SO_4 and Cs_2SO_4-K_2SO_4, respectively,

K_2SO_4-Rb_2SO_4

Melt Preparation and Purification

For Kvist's [217] and Bertozzi's [149] methods of melt preparation, refer to Ag_2SO_4-Li_2SO_4 and Cs_2SO_4-K_2SO_4, respectively.

K_2SO_4-Tl_2SO_4

Melt Preparation and Purification

For Kvist's [146] method of melt preparation, refer to Ag_2SO_4-Li_2SO_4.

K_2SO_4-$ZnSO_4$

Melt Preparation and Purification

Vereshchetina and Luzhnaya [22] used chemically pure salts.

Li_2SO_4-$MgSO_4$

Melt Preparation and Purification

For Kvist's [218, 219] method of melt preparation, refer to Ag_2SO_4-Li_2SO_4.

Li_2SO_4-Na_2SO_4

Melt Preparation and Purification

Kvist's [218, 219] method of melt preparation is described under Ag_2SO_4-Li_2SO_4.

Li_2SO_4-Rb_2SO_4

Melt Preparation and Purification

For Kvist's [217, 219] method of melt preparation, see Ag_2SO_4-Li_2SO_4.

Li_2SO_4-Tl_2SO_4

Melt Preparation and Purification

For Kvist's [146] method of melt preparation, refer to Ag_2SO_4-Li_2SO_4.

Li_2SO_4-$ZnSO_4$

Melt Preparation and Purification

For Kvist's [147] method of melt preparation, see Ag_2SO_4-Li_2SO_4.

Na_2SO_4-Rb_2SO_4

Melt Preparation and Purification

For Kvist's [217] and Bertozzi's [149] ethods of melt preparation, refer to Ag_2SO_4-$i_2SO_4$and Cs_4SO_4-K_2SO_4, respectively.

Na_2SO_4-Tl_2SO_4

Melt Preparation and Purification

Refer to Ag_2SO_4-Li_2SO_4 for Kvist's [146] ethod of melt preparation.

Na_2SO_4-$ZnSO_4$

Melt Preparation and Purification

Refer to Ag_2SO_4-Li_2SO_4 for Kvist's [147] ethod of melt preparation.

Rb_2SO_4-Tl_2SO_4

Melt Preparation and Purification

Refer to Ag_2SO_4-Li_2SO_4 for Kvist's [146] ethod of melt preparation.

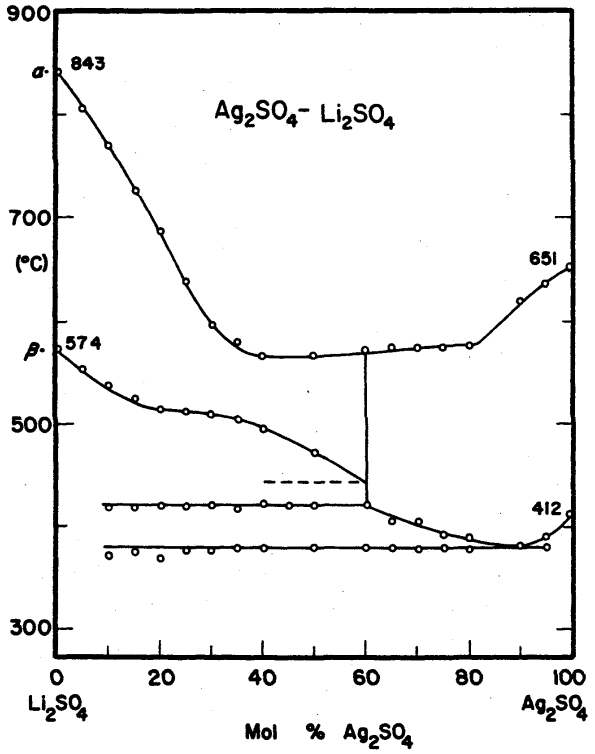


FIGURE 20. Phase diagram for Ag_2SO_4-Li_2SO_4.

Data from: R. Nacken, Neues Jahrb. Mineral. Geol Palaontal., Beil. Band, 24, 1 (1907).

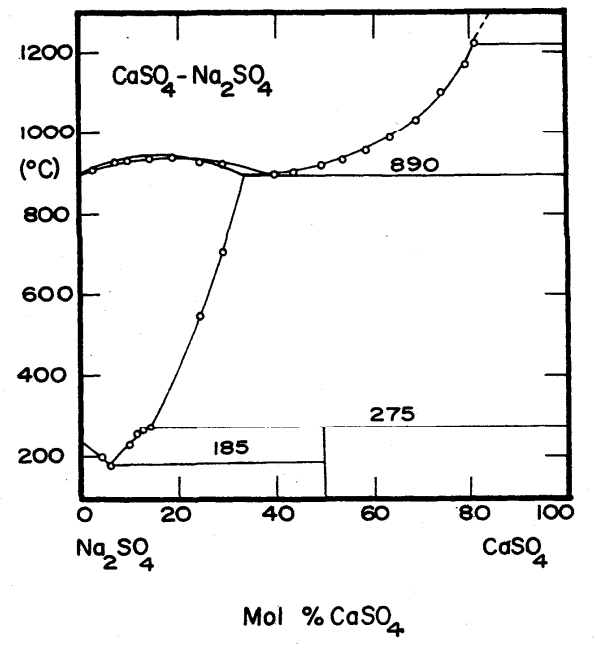


FIGURE 21. Phase diagram for $CaSO_4$-Na_2SO_4.

Data from: L. N. Komissarova, V. E. Plyushchev, and S. B. Stepina, Tr. Moskovskogo Institute Tonkoi Khim. Tekhnal. 5, 3 (1955).

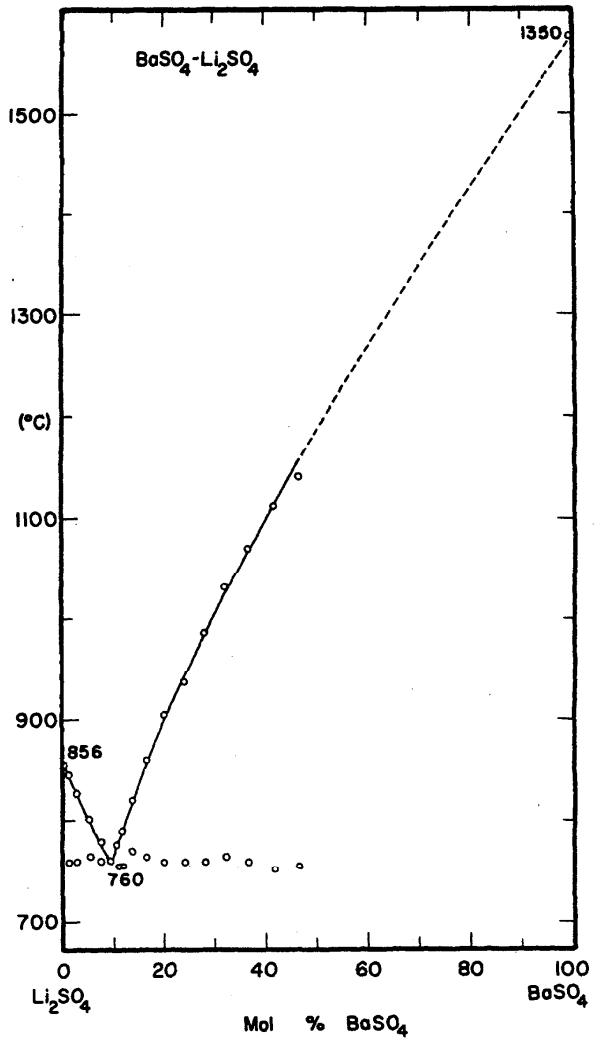


FIGURE 22. Phase diagram for $BaSO_4$-Li_2SO_4.

Data from: G. Calcagni and D. Marotta, Atti della Reale Accad. dei Lincei (5), 21, II, 93 (1912); G. Calcagni, Gazz. Chim. Ital. 42 (II), 688 (1912).

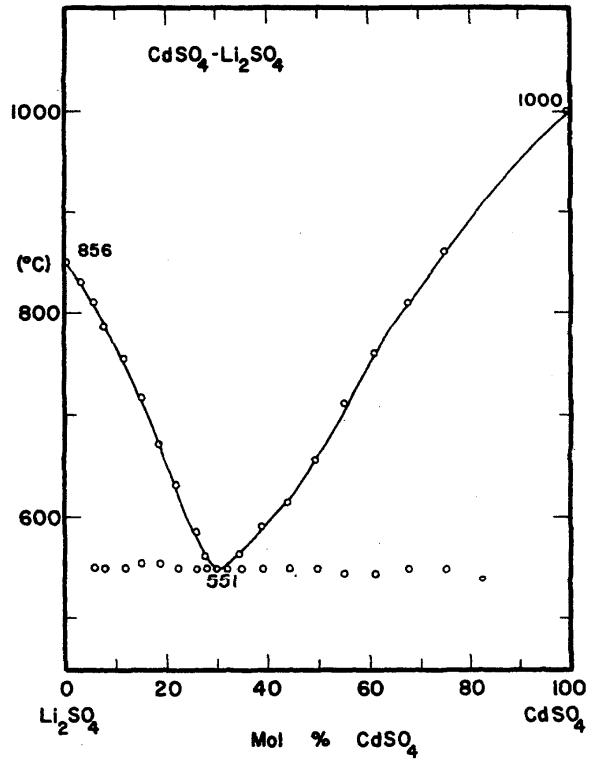


FIGURE 23. Phase diagram for $CdSO_4$-Li_2SO_4.

Data from: G. Calcagni and D. Marotta, Atti della Reale Accad. dei Lincei (5), 22, II, 373 (1913).

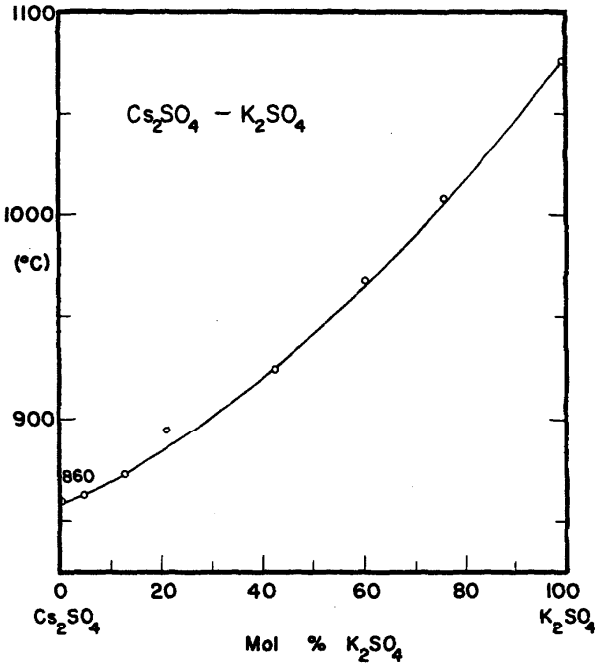


FIGURE 24. Phase diagram for Cs_2SO_4-K_2SO_4.

Data from: O. S. Dombrovskaya, Zhur. Obshch. Khim. 3, 1017 (1933).

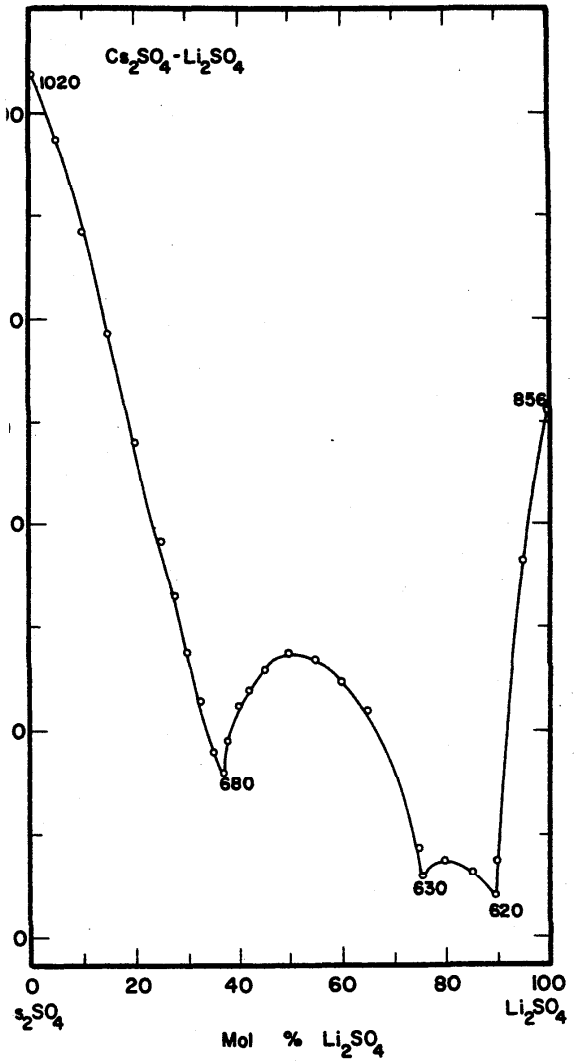


FIGURE 25. Phase diagram for Cs_2SO_4-Li_2SO_4.

a from: E. P. Dergunov, Zhur. Fiz. Khim. 25, (1951).

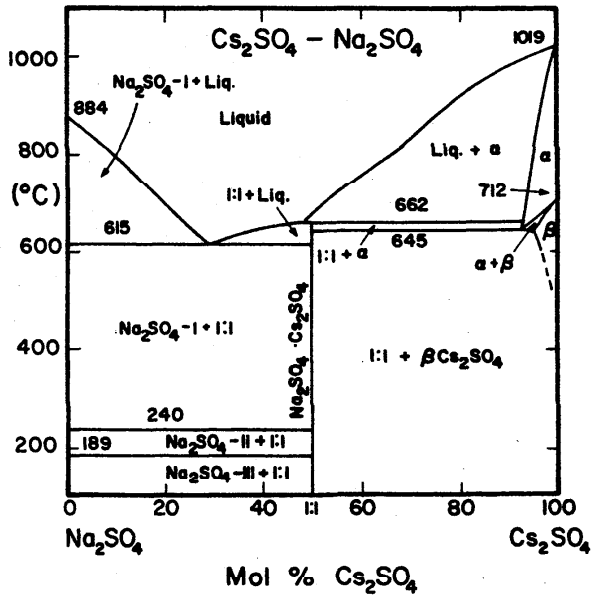


FIGURE 26. Phase diagram for Cs_2SO_4-Na_2SO_4.

Data from: V. E. Plyushchev, R. G. Samuseva, and I. F. Paletaev, Zh. Neorg. Khim. 7, 860 (1962); Russ. J. Inorg. Chem. 7, 445 (1962).

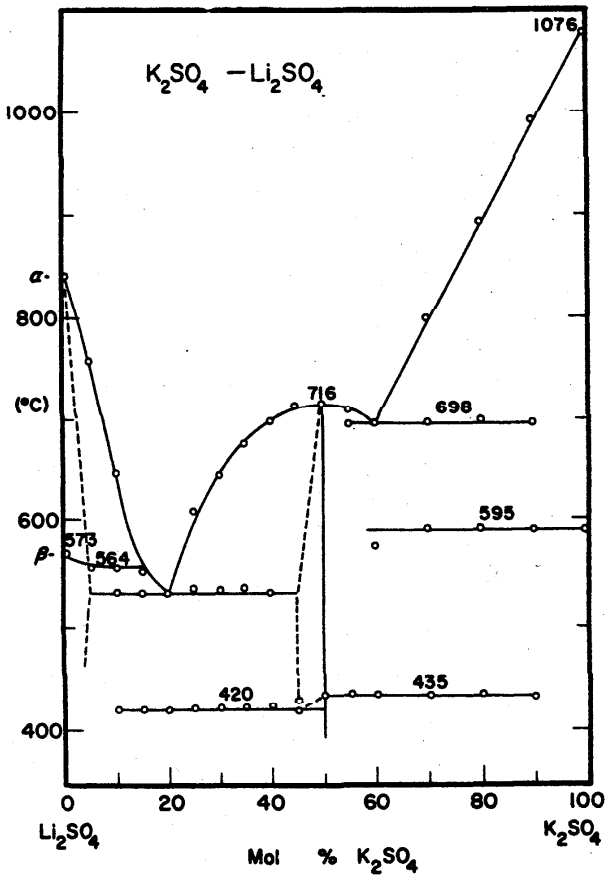


FIGURE 27. Phase diagram for K_2SO_4-Li_2SO_4.

Data from: R. Nacken, News Jahrb. Mineral., Geol., Palaontol., Beil. Band 24, 1 (1907).

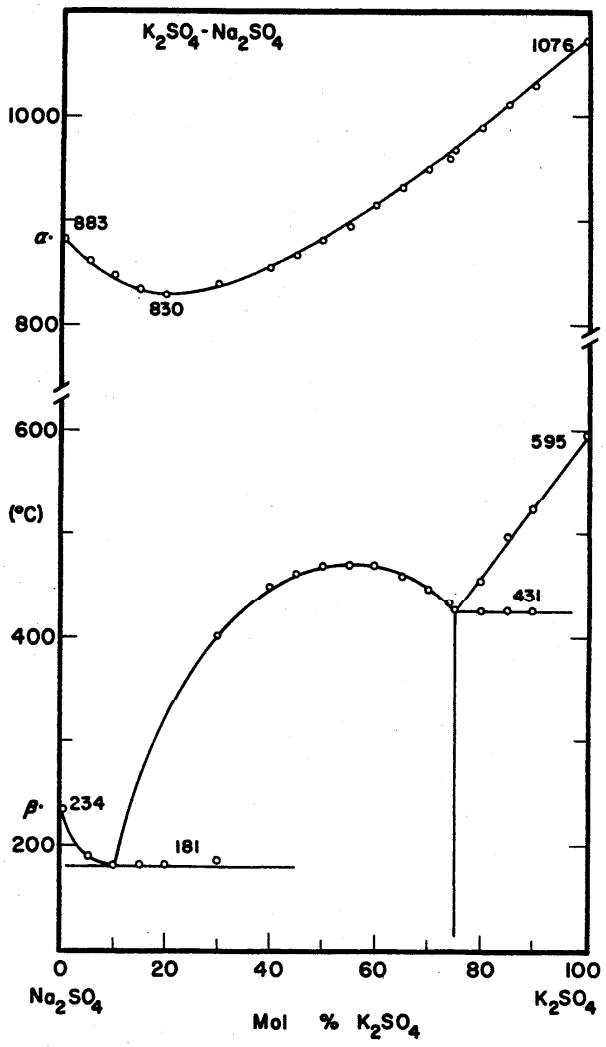


FIGURE 28. Phase diagram for K_2SO_4-Na_2SO_4.

Data from: R. Nacken, News Jahrb. Mineral., Geol., Palaontol., Beil. Band 24, 1 (1907).

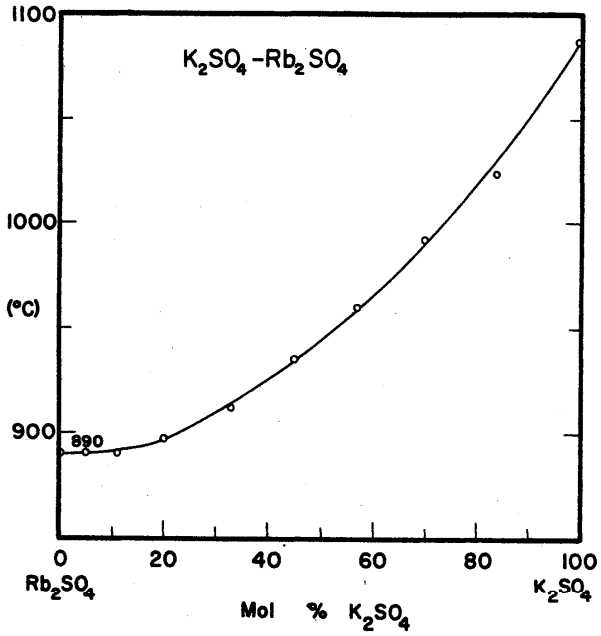


FIGURE 29. Phase diagram for K_2SO_4-Rb_2SO_4.

Data from: O. S. Dombrovskaya, Zhur. Obsch. Khim. 3, 1017 (1933).

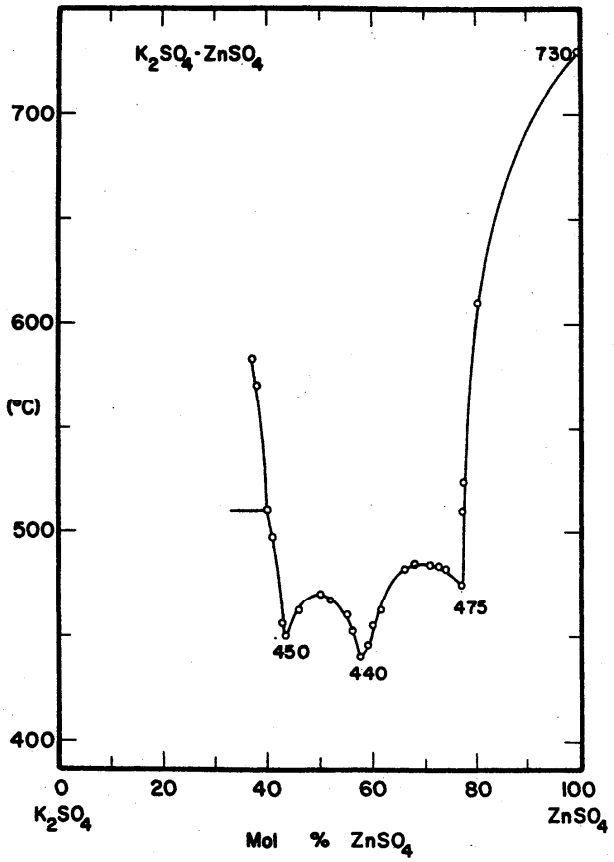
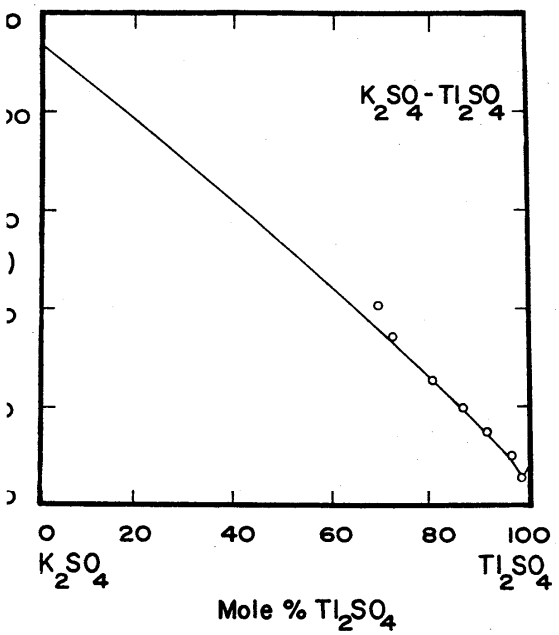


FIGURE 30. Phase diagram for K_2SO_4-$ZnSO_4$.

Data from: N. N. Evseeva and A. G. Bergman, Izv. Sektora Fiz.-Khim. Anal. 24, 162 (1954).



IGURE 31. Phase diagram for K_2SO_4-Tl_2SO_4.

ta from: O. S. Dombrovskaya, Izv. Sektora z.-Khim. Anal. 11, 189 (1938).

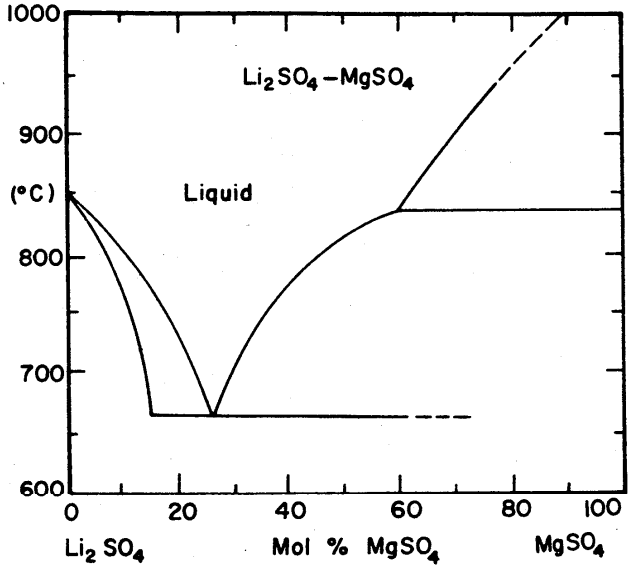


FIGURE 33. Phase diagram for Li_2SO_4-$MgSO_4$.

Data from: R. G. Rea, J. Amer. Ceram. Soc. 21, 100 (1938).

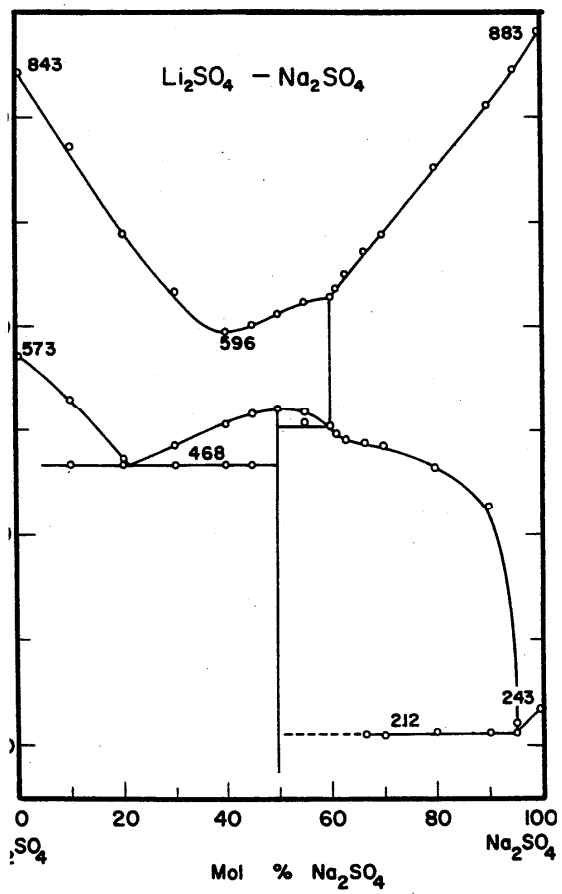


FIGURE 32. Phase diagram for Li_2SO_4-Na_2SO_4.

ta from: R. Nacken, News Jahrb. Mineral., ol., Palaontal, Beil. Band 24, 1 (1907).

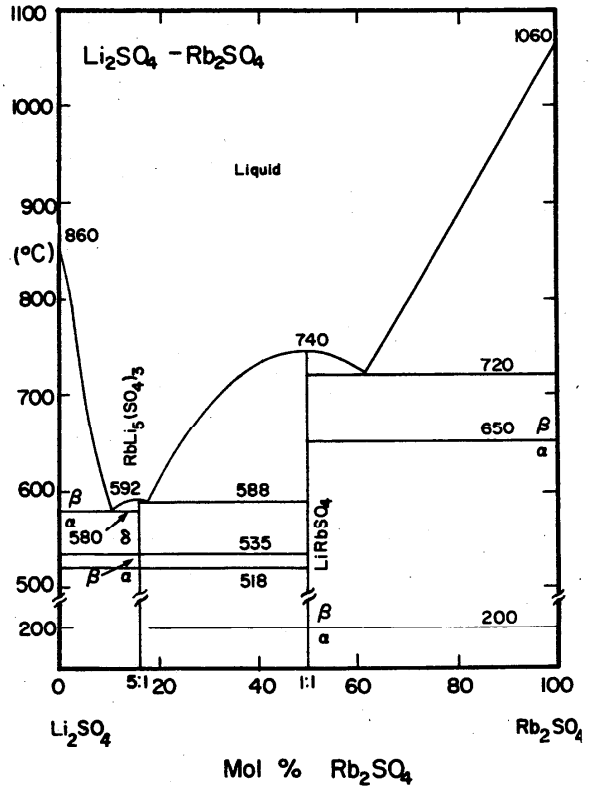


FIGURE 34. Phase diagram for Li_2SO_4-Rb_2SO_4.

Data from: I. S. Rassonskaya and N. K. Semendyaeva, Zh. Neorg. Khim. 11, 1123 (1966); Russ. J. Inorg. Chem. 11 608 (1966).

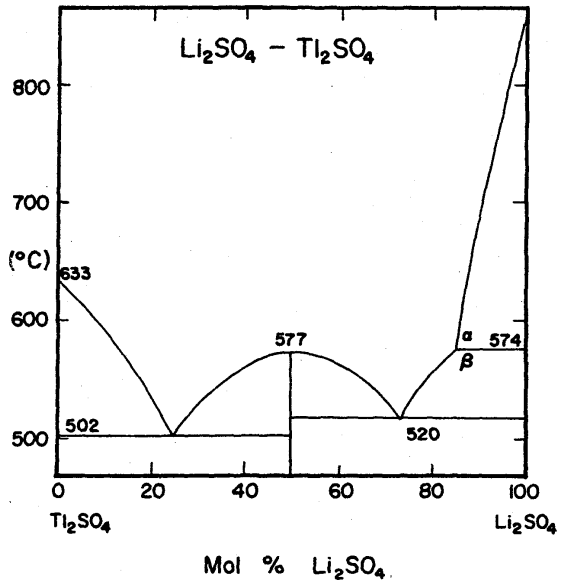


FIGURE 35. Phase diagram for Li_2SO_4-Tl_2SO_4.

Data from: A. G. Bergman and M. L. Shalakhovich, Zh. Obshch. Khim. 25, 451 (1955); J. Gen. Chem. USSR 25, 423 (1955).

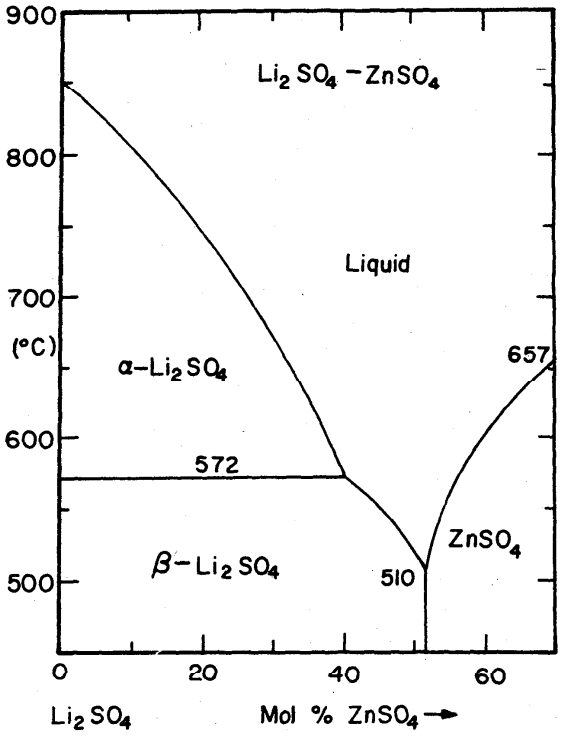


FIGURE 36. Phase diagram for Li_2SO_4-$SnSO_4$.

Data from: N. N. Evseeva and A. G. Bergman, Zhur Obshch. Khim. 21, 1763 (1951).

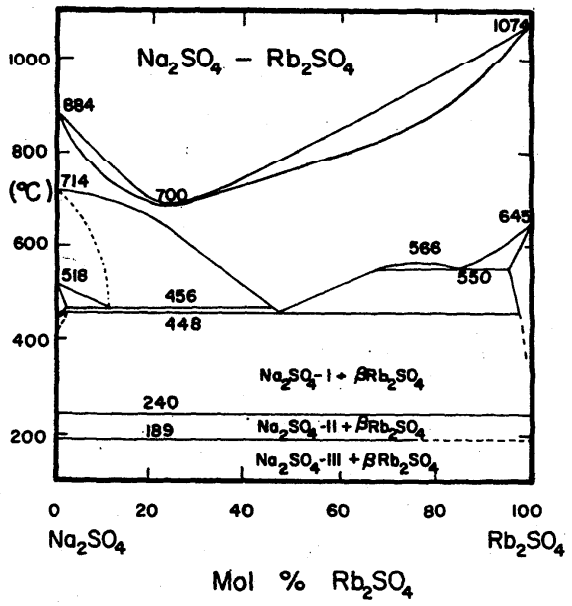


FIGURE 37. Phase diagram for Na_2SO_4-Rb_2SO_4.

Data from: V. E. Plyushchev, R. G. Samuseva, and I. F. Paletaev, Zh. Neorg. Khim. 7, 860 (1962); Russ. J. Inorg. Chem. 7, 445 (1962).

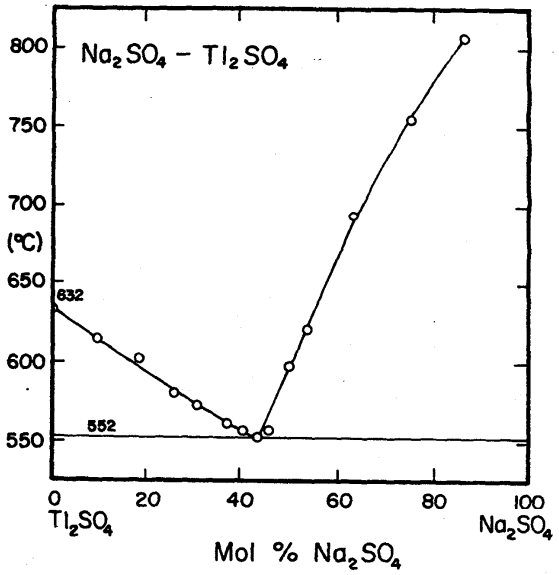


FIGURE 38. Phase diagram for Na_2SO_4-Tl_2SO_4.

Data from: A. P. Palkin, Tr. Voronezhsk, Gosudarstv. Univ., 17, Sbornik Ralist Khim. Fakult. 3 (1950).

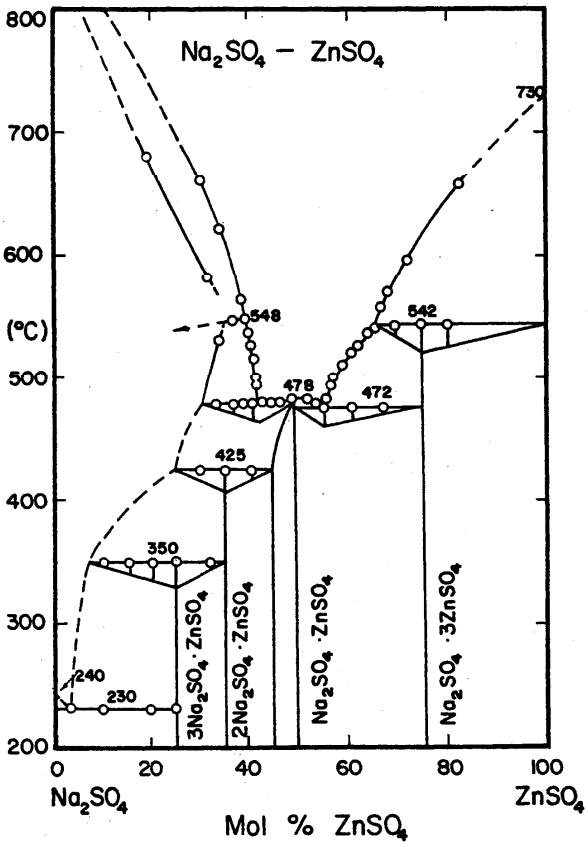


FIGURE 39. Phase diagram for Na_2SO_4-$ZnSO_4$.

ata from: N. N. Evseeva and A. G. Bergman, Izv. ektor Fiziko-Khim. Anal. 21, 208 (1952); N. N. vseeva, Izv. Sektor Fiziko-Khim. Anal. 22, 1962 1953).

TABLE 339. Electrical conductance studies

Ag_2SO_4-Li_2SO_4

Investigations critically examined

Ref.	Mol % Li_2SO_4	Temp. range (K)	Comments
143, 151 217	0-82.5	850-1050	quartz cap. cell; Pt electrodes; calibr.: 1.0 N KCl

Ref. [143] and [151] are the NSRDS recommended data bases for the electrical conductivity of Ag_2SO_4 and Li_2SO_4 melts, respectively [1]. It was observed that Vycor glass, but not quartz, was attacked by these sulphates. Cell constant $\sim 450\ cm^{-1}$.

TABLE 340. Density studies: Ag_2SO_4-Li_2SO_4

Investigations critically examined

Ref.	Mol % Li_2SO_4	Temp. range (K)	Comments
151, 217	0;50;100	890-1011	Au-10% bob; calibr.: benzene, toluene, CCl_4, KNO_3

Ref. [151] is the NSRDS recommended study for the density of pure molten Ag_2SO_4 (Kvist) [1]. No corrosion of the bob was noted after approx. 50 hrs in molten Li_2SO_4; however in molten Ag_2SO_4, the bob was slightly discolored and a small weight change was observed. The NSRDS data base for the density of pure Li_2SO_4 melts is a merge of the data of (1) Jaeger and (2) Kvist [194].

TABLE 341. Electrical conductance studies

$BaSO_4$-Li_2SO_4

Investiations critically examined

Ref.	Li_2SO_4	Temp. range (K)	Comments
143 218 219	94-100	1101-1232	refer: Ag_2SO_4-Li_2SO_4

Ref. [143] (Kvist) is the NSRDS recommended data base for the electrical conductivity of molten Li_2SO_4 [1].

TABLE 342. Density studies: $CaSO_4$-Na_2SO_4

Investigations critically examined

Ref.	Mol % Na_2SO_4	Temp. range (K)	Comments
145	40-100	1233-1473	Al_2O_3 cruc. Ar. atmos.

Deviations from NSRDS recommendations ([1] p. 32)

Ref.	Mol % Na_2SO_4	Min. departure	Max. departure
145	100	-0.65% (1350 K)	-1.30% (1265 K)

TABLE 343. Viscosity studies: $CaSO_4$-Na_2SO_4

Investigations critically examined

Ref.	Mol % Na_2SO_4	Temp. range (K)	Comments
145	40-100	1233-1473	alumina rod; calibr.: CCl_4, H_2SO_4 and Hg.

Ref. [145] is the NSRDS recommended data base for the viscosity of molten Na_2SO_4.

TABLE 344. Surface tension studies: $CaSO_4$-Na_2SO_4

Investigations critically examined

Ref.	Mol % Na_2SO_4	Temp. range (K)	Comments
145	40-100	1243-1473	refer: $CaSO_4$-Na_2SO_4; density

Deviations from NSRDS recommendations ([2] p. 73)

Ref.	Mol % Na_2SO_4	Min. departure	Max. departure
145	100	-1.00% (1265%)	2.83 % (1350 K)

TABLE 345. Electrical conductance studies $CdSO_4$-Li_2SO_4

Investigations critically examined

Ref.	Mol % Li_2SO_4	Temp. range (K)	Comments
143 218	96.08,100	1114-1203	refer Ag_2SO_4-Li_2SO_4

Reference [143] is the NSRDS data base for the electrical conductivity of pure Li_2SO_4 [1], and [this volume].

TABLE 346. Electrical conductance studies Cs_2SO_4-K_2SO_4

Investigations critically examined

Ref.	Mol % K_2SO_4	Temp. range (K)	Comments
217	0;50	1215-1275	refer Ag_2SO_4-Li_2SO_4

Reference [217] is the NSRDS recommended data base [1] (for the electrical conductivity of molten Cs_2SO_4 (Kvist).

TABLE 347. Surface tension studies Cs_2SO_4-K_2SO_4

Investigations critically examined

Ref.	Mol % K_2SO_4	Temp. range (K)	Comments
149	0-100	1210-1470	Pt plate, Pt cruc.

Deviations from NSRDS recommendations ([2] p. 73)

Ref.	Mol % K_2SO_4	Min. departure	Max. departure
149	0	9.88% (1320 K)	15.08% (1470 K)
	100	0.14% (1360 K)	1.10% (1470 K)

All metal parts within the furnace were replaced with sintered alumina; the crucible was enclosed in a cylindrical alumina cell to allow rapid equilibration between the liquid and its vapor; estimated precision: ~1%.

TABLE 348. Electrical conductance studies

Cs_2SO_4-Li_2SO_4

Investigations critically examined

Ref.	Mol % Li_2SO_4	Temp. range (K)	Comments
217	0,50, 95.11,98	1037-1274	refer: Ag_2SO_4-Li_2SO_4.

Reference [217] is the NSRDS data base for the electrical conductance of pure Cs_2SO_4. Refer: Li_2SO_4 (single salt), this volume; for an analysis of Kvist's data on the conductivity of Li_2SO_4 melts.

TABLE 349. Electrical conductance studies

Cs_2SO_4-Na_2SO_4

Investigations critically examined

Ref.	Mol % Na_2SO_4	Temp. range (K)	Comments
217	0,50,100	956-1179	refer: Ag_2SO_4-Li_2SO_4

Reference [217] is the NSRDS data base for the electrical conductance of both Cs_2SO_4 and Na_2SO_4.

TABLE 350. Surface tension studies

Cs_2SO_4-Na_2SO_4

Investigations critically examined

Ref.	Mol % Na_2SO_4	Temp. range (K)	Comments
149	0-100	903-373	refer: Cs_2SO_4-K_2SO_4.

viations from NSRDS recommendations ([2], p. 73)

ef.	Mol % Na_2SO_4	Min. departure	Max. departure
49	0	1.17% (1300 K)	2.04% (1360 K)
	100	1.10% (1240 K)	3.33% (1360 K)

TABLE 351. Electrical conductance studies

Cs_2SO_4-Rb_2SO_4

Investigations critically examined

Ref.	Mol % Rb_2SO_4	Temp. range (K)	Comments
217	0;50;100	1285-1420	refer: Ag_2SO_4-Li_2SO_4.

Reference [217] is the NSRDS recommended study for the electrical conductance for both Cs_2SO_4 and Rb_2SO_4 [1].

TABLE 352. Surface tension studies

Cs_2SO_4-Rb_2SO_4

Investigations critically examined

Ref.	Mol % Rb_2SO_4	Temp. range (K)	Comments
149	0,50,100	1285-1420	refer: Cs_2SO_4-K_2SO_4.

)eviations from NSRDS recommendations ([2] p. 73)

Ref.	Mol % Rb_2SO_4	Min. departure	Max. departure
149	0	9.88% (1320 K)	15.08% (1470 K)
	100	-3.25% (1490 K)	-9.05% (1820 K)

TABLE 353. Electrical conductance studies

Cs_2SO_4-Tl_2SO_4

Investigations critically examined

Ref.	Mol % Tl_2SO_4	Temp. range (K)	Comments
146	50;100	1071-1218	refer: Ag_2SO_4-Li_2SO_4

Reference [146] is the NSRDS recommended study for the electrical conductance of both Cs_2SO_4 and Tl_2SO_4.

TABLE 354. Electrical conductance studies: K_2SO_4-Li_2SO_4

Investigations critically examined

Ref.	Mol % Li_2SO_4	Temp. range (K)	Comments
218, 219, 221	0-100	826-1360	refer: Ag_2SO_4-Li_2SO_4

Kvist's data [218,219] were used for the NSRDS recommendations for both K_2SO_4 and Li_2SO_4 [1, and this volume].

TABLE 355. Density studies: K_2SO_4-Li_2SO_4

Investigations critically examined

Ref.	Mol % Li_2SO_4	Temp. range (K)	Comments
146	0,50,100	1062-1420	refer: Ag_2SO_4-Li_2SO_4.
220	80 (eutc.)	853-1023	Pt bob; N_2 atmos.

TABLE 356. Electrical conductance studies K_2SO_4-Na_2SO_4

Investigations critically examined

Ref.	Mol % Na_2SO_4	Temp. range (K)	Comments
217	50	1182;1193	refer: Ag_2SO_4-Li_2SO_4.

Kvist's data were selected for the NSRDS recommendations for both K_2SO_4 and Na_2SO_4 [1].

TABLE 357. Density studies: K_2SO_4-Na_2SO_4

Investigations critically examined

Ref.	Mol % Na_2SO_4	Temp. range (K)	Comments
146	50,100	1204-1360	refer Ag_2SO_4-Li_2SO_4.

Deviations from NSRDS recommendations ([1] p. 32)

Ref.	Mol % Na_2SO_4	Min. departure	Max. departure
146	100	0.34% (1269 K)	0.48% (1320 K)

TABLE 358. Surface tension studies: K_2SO_4-Na_2SO_4

Investigations critically examined

Ref.	Mol % Na_2SO_4	Temp. range (K)	Comments
149	0-100	1100-1470	refer: Cs_2SO_4-Na_2SO_4

Deviations from NSRDS recommendations [2]

Ref.	Mol % Na_2SO_4	Min. departure	Max. departure
149	0	0.14% (1360 K)	1.10% (1470 K)
	100	-10.57% (1220 K)	-12.68% (1350 K)

TABLE 359. Electrical conductance studies K_2SO_4-Rb_2SO_4

Investigations critically examined

Ref.	Mol % Rb_2SO_4	Temp. range (K)	Comments
217	50	1337-1382	refer: Ag_2SO_4-Li_2SO_4.

Kvist's data [217] were selected for the NSRDS recommendations for both K_2SO_4 and Rb_2SO_4 [1].

TABLE 360. Surface tension studies: K_2SO_4-Rb_2SO_4

Investigations critically examined

ef.	Mol % Rb_2SO_4	Temp. range (K)	Comments
49	0-100	1170-1470	refer to Cs_2SO_4-K_2SO_4

)eviations from NSRDS recommendations ([2] p. 73)

ef.	Mol % Rb_2SO_4	Min. departure	Max. departure
49	0	0.14% (1360 K)	1.10% (1470 K)
	100	-3.25% (1490 K)	-9.05% (1820 K)

TABLE 361. Electrical conductance studies

K_2SO_4-Tl_2SO_4

Investigations critically examined

Ref.	Mol % Tl_2SO_4	Temp. range (K)	Comments
146	50	1101-1205	refer: Ag_2SO_4-Li_2SO_4.

Reference [146] is the recommended study for the electrical conductance of both K_2SO_4 and Tl_2SO_4 [this volume].

TABLE 362 Electrical conductance studies

K_2SO_4-$ZnSO_4$

Investigations critically examined

Ref.	Mol % $ZnSO_4$	Temp. range (K)	Comments
222	40-75	723-898	quartz cell

TABLE 363. Density studies: K_2SO_4-$ZnSO_4$

Investigations critically examined

Ref.	Mol % $ZnSO_4$	Temp. range (K)	Comments
222	43-75	773-823	Pt sphere; calibr.: KNO_3, $NaNO_3$

TABLE 364. Electrical conductance studies

Li_2SO_4-$MgSO_4$

Investigations critically examined

Ref.	Mol % $MgSO_4$	Temp. range (K)	Comments
218, 219	4	1112-1223	refer: Ag_2SO_4-Li_2SO_4

TABLE 365. Electrical conductance studies

Li_2SO_4-Na_2SO_4

Investigations critically examined

Ref.	Mol % Na_2SO_4	Temp. range (K)	Comments
152,217 218,219	0-100	901-1338	refer: Ag_2SO_4-Li_2SO_4

Ref. [217] is also the data base for the NSRDS recommendations for both Na_2SO_4 and Li_2SO_4 [1] and [this volume]. Kvist notes that Na|Li||SO_4 mixtures were more aggressive to quartz than either salt alone.

TABLE 366. Density studies: Li_2SO_4-Na_2SO_4

Investigations critically examined

Ref.	Mol % Na_2SO_4	Temp. range (K)	Comments
146	50	1010-1235	refer: Ag_2SO_4-Li_2SO_4

TABLE 367. Electrical conductance studies

Li_2SO_4-Rb_2SO_4

Investigations critically examined

Ref.	Mol % Rb_2SO_4	Temp. range (K)	Comments
217,218, 219	0-100	699-1390	refer: Ag_2SO_4-Li_2SO_4.

Ref. [217,218,219] are also the data bases for the NSRDS recommendations for the electrical conductivity of Li_2SO_4 and Rb_2SO_4 [1].

TABLE 368. Electrical conductance studies

Li_2SO_4-Tl_2SO_4

Investigations critically examined

Ref.	Mol % Tl_2SO_4	Temp. range (K)	Comments
146	50	1037-1195	refer: Ag_2SO_4-Li_2SO_4.

TABLE 369. Density studies: Li_2SO_4-Tl_2SO_4

Investigations critically examined

Ref.	Mol % Tl_2SO_4	Temp. range (K)	Comments
146	50	1048-1279	refer to: Ag_2SO_4-Li_2SO_4.

TABLE 370 Electrical conductance studies

Li_2SO_4-$ZnSO_4$

Investigations critically examined

Ref.	Mol % $ZnSO_4$	Temp. range (K)	Comments
147	0-100	777-1146	refer to Ag_2SO_4-Li_2SO_4.

Mixtures up to 80 mol % $ZnSO_4$ are thermally stable (Kvist).

TABLE 371. Density studies: Li_2SO_4-$ZnSO_4$

Investigations critically examined

Ref.	Mol % $ZnSO_4$	Temp. range (K)	Comments
147	50	863-963	refer: Ag_2SO_4-Li_2SO_4.

See $ZnSO_4$ [this volume] for further information.

TABLE 372. Electrical conductance studies

Na_2SO_4-Rb_2SO_4

Ref.	Mol % Rb_2SO_4	Temp. range (K)	Comments
217	0,50, 100	1114-1261	refer: Ag_2SO_4-Li_2SO_4.

TABLE 373. Surface tension studies

Na_2SO_4-Rb_2SO_4

Investigations critically examined

Ref.	Mol % Rb_2SO_4	Temp. range (K)	Comments
149	0-100	980-1460	refer Cs_2SO_4-K_2SO_4

Deviations from NSRDS recommendations ([2], p. 73)

Ref.	Mol % Rb_2SO_4	Min. departure	Max. departure
149	0	-10.57% (1220 K)	-12.68% (1350 K)
	100	-3.25% (1490 K)	-9.05% (1820 K)

TABLE 374. Electrical conductance studies

Na_2SO_4-Tl_2SO_4

Investigations critically examined

Ref.	Mol % Tl_2SO_4	Temp. range (K)	Comments
146	50-100	1061-1210	refer: Ag_2SO_4-Li_2SO_4.

TABLE 375. Electrical conductance studies

Na_2SO_4-$ZnSO_4$

Investigations critically examined

f.	Mol % $ZnSO_4$	Temp. range (K)	Comments
7	0-75	842-1232	refer: Ag_2SO_4-Li_2SO_4.

Na_2SO_4-$ZnSO_4$ mixtures up to 80 mol % $ZnSO_4$ are hermally stable (Kvist) [147].

TABLE 376. Density studies: Na_2SO_4-$ZnSO_4$

Investigations critically examined

Ref.	Mol % $ZnSO_4$	Temp. range (K)	Comments
147	50	842-1232	see: Ag_2SO_4-Li_2SO_4.

TABLE 377. Electrical conductance studies

Rb_2SO_4-Tl_2SO_4

Investigations critically examined

:.	Mol % Tl_2SO_4	Temp. range (K)	Comments
6	0;50; 100	925-1190	refer: Ag_2SO_4-Li_2SO_4.

st's data [146] were selected for the NSRDS ommendations for both Tl_2SO_4 and Rb_2SO_4 [1].

TABLE 378. Ag_2SO_4-Li_2SO_4

Specific conductance ($ohm^{-1}cm^{-1}$)

	Mol percent Li_2SO_4					
T(K)	60	50	40	20	10	0
850			1.375			
860		1.462	1.422	1.433		
870	1.556	1.509	1.469	1.473		
880	1.606	1.556	1.516	1.513		
890	1.656	1.602	1.561	1.552		
900	1.705	1.648	1.606	1.591	1.597	
910	1.754	1.693	1.650	1.630	1.630	
920	1.803	1.738	1.693	1.668	1.663	
930	1.852	1.782	1.736	1.706	1.696	
940	1.901	1.825	1.778	1.743	1.729	1.705
950	1.949	1.868	1.819	1.780	1.762	1.733
960	1.998	1.911	1.859	1.816	1.795	1.761
970	2.046	1.953	1.899	1.852	1.828	1.787
980	2.094	1.995	1.938	1.888	1.861	1.814
990	2.142	2.036	1.976	1.923	1.894	1.840
1000	2.189	2.076	2.013	1.958	1.927	1.865
1010	2.237	2.116	2.050		1.961	1.890
1020	2.284	2.156	2.086		1.994	1.914
1030	2.331					
1040	2.378					
1050	2.425					

temperature-dependent equations

$\kappa = a + bT + cT^2$

Mol % Li_2SO_4	-a	b · 10^3	-c · 10^6	Standard error of estimate
0	3.3166	7.8584	2.6767	0.08%
10	1.3813	3.3087	-	0.09%
20	3.6335	7.7302	2.1387	0.17%
40	5.3479	11.012	3.6515	0.21%
50	4.5077	9.1373	2.5533	0.20%
60	3.4537	6.5305	0.8873	0.25%

These values are based on the data of [151,217] (classical ac technique).

TABLE 379. Ag_2SO_4-Li_2SO_4: Density (g cm^{-3})

	Mol percent Li_2SO_4		
T(K)	100	50	0
890		3.605	
910		3.599	
930		3.588	
950		3.572	4.809
970		3.550	4.787
990		3.522	4.765
1010		3.489	4.743
1030			4.721
1050			4.700
1070			
1090			
1110			
1130			
1150	1.998		
1170	1.990		
1190	1.983		
1210	1.977		
1230	1.971		

temperature-dependent equations

$\rho = a + bT + cT^2$

Mol % Li_2SO_4	a	b · 10^3	-c · 10^6	Standard error of estimate
0	5.8436	-1.0895		0.08%
50	-1.7245	12.1141	6.8836	0.22%
100	2.5798	0.5767	1.9509	0.07%

These values are based on the data of [76,217] (Archimedean method)

TABLE 380. $BaSO_4$-Li_2SO_4

Specific conductance (ohm^{-1}cm^{-1})

	Mol percent Li_2SO_4				
T(K)	100	99	97.5	96.08	94
1100				3.731	3.609
1110				3.782	3.648
1120				3.834	3.687
1130				3.885	3.726
1140	3.915	4.171		3.936	3.765
1150	3.966	4.222	4.102	3.988	3.804
1160	4.014	4.274	4.152	4.039	3.844
1170	4.058	4.325	4.202	4.091	3.883
1180	4.099	4.377	4.252	4.142	3.922
1190	4.136	4.428	4.302	4.193	3.961
1200	4.170	4.480	4.352		4.000
1210		4.531	4.402		4.039
1220		4.583	4.452		4.078

temperature-dependent equations

$\kappa = a + bT + cT^2$

Mol % Li_2SO_4	-a	b · 10^3	c · 10^6	Standard error of estimate
94	0.6868	3.9055		0.010
96.08	1.9230	5.1399		0.003
97.5	1.6477	4.9997		0.008
99	1.6957	5.1462		0.004
100	24.544	44.630	-17.251	0.008

These values are based on the data of [218,219] (classical ac technique)

TABLE 381. $CaSO_4$-Na_4SO_4: Density (g cm^{-3})

	Mol percent Na_2SO_4				
T (K)	90	80	70	60	50
240	2.055	2.113	2.162	2.205	2.122
250	2.052	2.108	2.158	2.201	2.116
260	2.048	2.104	2.153	2.196	2.111
270	2.044	2.100	2.149	2.191	2.105
280	2.041	2.096	2.145	2.187	2.100
290	2.037	2.092	2.140	2.182	2.094
300	2.033	2.088	2.136	2.178	2.089
310	2.030	2.084	2.132	2.173	2.083
320	2.026	2.079	2.127	2.169	2.078
330	2.022	2.075	2.123	2.164	2.072
340	2.019	2.071	2.119	2.160	2.067
350	2.015	2.067	2.115	2.155	2.061
360	2.011	2.063	2.110	2.151	2.056
370	2.008	2.059	2.106	2.146	2.050
380	2.004	2.055	2.102	2.142	2.044
390	2.000	2.051	2.097	2.138	2.039
400	1.997	2.046	2.093	2.133	2.033
410	1.993	2.042	2.089	2.129	2.028
420	1.989	2.038	2.084	2.124	2.022
430	1.986	2.034	2.080	2.120	2.017
440	1.982	2.030	2.076	2.115	2.011
450	1.978	2.026	2.072	2.111	2.006
460	1.975	2.022	2.067	2.106	2.000
470	1.971	2.017	2.063	2.102	1.995

temperature-dependent equations

$\rho = a + bT$

Mol % Na_2SO_4	a	$-b \cdot 10^3$
40	2.823	0.440
45	2.816	0.446
50	2.808	0.553
60	2.763	0.450
70	2.695	0.430
80	2.625	0.413
90	2.510	0.366
100	2.405	0.327

ese values are based on the data of [145] aximum bubble pressure).

TABLE 382. $CaSO_4$-Na_2SO_4: Viscosity (cp)

	Mol percent Na_2SO_4				
T (K)	90	80	70	60	45
1240	12.54	14.20	19.29	24.95	23.18
1250	12.00	13.49	18.36	24.08	22.47
1260	11.48	12.83	17.49	23.25	21.79
1270	11.00	12.21	16.68	22.46	21.15
1280	10.54	11.63	15.91	21.71	20.53
1290	10.11	11.09	15.19	20.99	19.94
1300	9.70	10.57	14.51	20.31	19.38
1310	9.32	10.09	13.88	19.66	18.84
1320	8.95	9.64	13.28	19.04	18.32
1330	8.61	9.22	12.71	18.45	17.83
1340	8.28	8.82	12.18	17.89	17.35
1350	7.97	8.44	11.68	17.35	16.89
1360	7.67	8.08	11.20	16.84	16.46
1370	7.40	7.75	10.75	16.34	16.04
1380	7.13	7.43	10.32	15.87	15.64
1390	6.88	7.13	9.92	15.42	15.25
1400	6.64	6.85	9.54	14.99	14.88
1410	6.41	6.58	9.18	14.57	14.52
1420	6.19	6.32	8.83	14.18	14.17
1430	5.99	6.08	8.51	13.80	13.84
1440	5.79	5.85	8.20	13.43	13.52
1450	5.60	5.63	7.90	13.08	13.21
1460	5.42	5.43	7.62	12.74	12.92
1470	5.25	5.23	7.36	12.42	12.63

temperature-dependent equations

$\eta = Ae^{E/RT}$

Mol % Na_2SO_4	$A \cdot 10^2$	E (cal mol^{-1})
45	47.86	9560
60	28.84	10990
70	4.07	15180
80	2.40	15730
90	4.79	13720
100	14.80	9990

These values are based on the data of [145] (oscillational technique).

TABLE 383. $CaSO_4$-Na_2SO_4: Surface tension(dyn cm^{-1})

	Mol percent Na_2SO_4				
T(K)	90	80	70	60	50
1240	188.55	190.88	194.71	198.62	203.57
1250	187.83	190.18	193.99	197.89	202.81
1260	187.10	189.47	193.27	197.16	202.05
1270	186.38	188.77	192.55	196.43	201.29
1280	185.66	188.07	191.83	195.70	200.53
1290	184.94	187.36	191.11	194.98	199.77
1300	184.22	186.66	190.40	194.25	199.01
1310	183.50	185.96	189.68	193.52	198.25
1320	182.78	185.26	188.96	192.79	197.49
1330	182.06	184.55	188.24	192.06	196.73
1340	181.34	183.85	187.52	191.33	195.97
1350	180.62	183.15	186.80	190.61	195.21
1360	179.90	182.45	186.08	189.88	194.44
1370	179.18	181.74	185.37	189.15	193.68
1380	178.46	181.04	184.65	188.42	192.92
1390	177.74	180.34	183.93	187.69	192.16
1400	177.02	179.63	183.21	186.97	191.40
1410	176.30	178.93	182.49	186.24	190.64
1420	175.57	178.23	181.77	185.51	189.88
1430	174.85	177.53	181.05	184.78	189.12
1440	174.13	176.83	180.34	184.05	188.36
1450	173.41	176.12	179.62	183.33	187.60
1460	172.69	175.42	178.90	182.60	186.84

temperature-dependent equations

$\gamma = a + bT$

Mol % Na_2SO_4	a	$-b \cdot 10^3$
40	317.5	86.64
45	306.5	80.50
50	297.9	76.07
60	288.9	72.81
70	283.8	71.85
80	278.0	70.26
90	277.9	72.06
100	273.1	69.12

These values are based on the data of [145] (maximum bubble pressure).

TABLE 384. $CdSO_4$-Li_2SO_4

Specific conductance ($ohm^{-1}cm^{-1}$)

	Mol percent Li_2SO_4	
T (K)	100	96.08
1120		4.016
1130		4.069
1140	3.915	4.122
1150	3.966	4.175
1160	4.014	4.228
1170	4.058	4.281
1180	4.099	
1190	4.136	
1200	4.170	

temperature-dependent equation

$\rho = a + bT + cT^2$

Mol % Li_2SO_4	$-a$	$b \cdot 10^3$	$c \cdot 10^6$	Standard error of estimate
96.08	1.9275	5.3065		0.009
100	24.544	44.630	-17.251	0.008

These values are based on the data of [218] (classical ac technique).

TABLE 385. Cs_2SO_4-K_2SO_4

Specific conductance ($ohm^{-1}cm^{-1}$)

Mol percent K_2SO_4			
T(K)	50	T(K)	0
1220	1.197	1290	1.117
1225	1.204	1295	1.123
1230	1.211	1300	1.129
1235	1.219	1305	1.135
1240	1.227	1310	1.141
1245	1.235	1315	1.147
1250	1.243	1320	1.153
1255	1.252	1325	1.160
1260	1.261	1330	1.166
1265	1.270	1335	1.172
1270	1.280	1340	1.178

temperature-dependent equations

$\rho = a + bT + cT^2 + dT^3$

l % SO_4	a	b · 10^3	c · 10^6	d · 10^9	Standard error of estimate
0	-0.4683	1.2285			0.27%
50	2.6982	-0.3033	- 3.6835	2.3960	0.25%

hese values are based on the data of [217] classical ac technique).

TABLE 386. Cs_2SO_4-K_2SO_4

Surface tension (dyn cm^{-1})

Mol percent K_2SO_4					
T (K)	100	75	50	25	0
1210			130.8	124.3	
1220			130.1	123.6	
1230			129.4	122.9	
1240			128.8	122.2	
1250			128.1	121.6	
1260		135.5	127.4	120.9	
1270		134.9	126.8	120.2	
1280		134.2	126.1	119.5	
1290		133.5	125.4	118.8	
1300		132.9	124.8	118.1	112.7
1310		132.2	124.1	117.4	112.1
1320		131.6	123.4	116.7	111.5
1330		130.9	122.7	116.0	110.8
1340		130.2	122.1	115.3	110.2
1350		129.6	121.4	114.7	109.6
1360	141.3	128.9	120.7	114.0	109.0
1370	140.7	128.3	120.1	113.3	108.4
1380	140.0	127.6	119.4	112.6	107.7
1390	139.4	126.9	118.7	111.9	107.1
1400	138.7	126.3	118.1	111.2	106.5
1410	138.1	125.6	117.4	110.5	105.9
1420	137.4	125.0	116.7	109.8	105.3
1430	136.8	124.3	116.0	109.1	104.6
1440	136.1	123.6	115.4	108.4	104.0
1450	135.5	123.0	114.7	107.8	103.4
1460	134.8	122.3	114.0	107.1	102.8

temperature-dependent equations

$\gamma = a + bT$

Mol % K_2SO_4	a	- b · 10^3
0	193.33	6.20
25	207.84	6.90
50	211.90	6.70
75	218.72	6.60
100	229.75	6.50

These values are based on the data of [149] (Wilhelmy slide plate).

TABLE 387. Cs_2SO_4-Li_2SO_4

Specific conductance ($ohm^{-1}cm^{-1}$)

	Mol percent Li_2SO_4				
T(K)	100	98	95.11	50	0
1040			2.814		
1050			2.865	0.720	
1060			2.916	0.741	
1070			2.967	0.763	
1080			3.018	0.784	
1090			3.069	0.805	
1100		3.551	3.119	0.826	
1110		3.606	3.170	0.847	
1120		3.662	3.221	0.868	
1130		3.717	3.272	0.890	
1140	3.915	3.772		0.911	
1150	3.966	3.828		0.932	
1160	4.014	3.883		0.953	
1170	4.058	3.938		0.973	
1180	4.099			0.994	
1190	4.136			1.015	
1200	4.170			1.036	
1210				1.056	
1220				1.077	
1230				1.098	
1240				1.118	
1250				1.139	
1260				1.159	
1270				1.180	
1280					
1290					1.117
1300					1.129
1310					1.141
1320					1.153
1330					1.666

temperature-dependent equations

$\kappa = a + bT + cT^2$

Mol % Li_2SO_4	-a	b · 10^3	-c · 10^6	Standard error of estimate
0	4.6835	1.2285		0.27%
50	1.7970	2.6518	0.2427	0.23%
95.11	2.472	5.0831		0.20%
98	2.538	5.5353		0.25%
100	24.544	44.630	17.251	0.20%

These values are based on the data of [217] (classical ac technique).

TABLE 388. Cs_2SO_4-Na_2SO_4: Specific conductance ($ohm^{-1}cm^{-1}$)

	Mol percent Na_2SO_4		
T(K)	100	50	0
960		0.600	
980		0.643	
1000		0.685	
1020		0.728	
1040		0.770	
1060		0.812	
1080		0.853	
1100		0.894	
1120		0.935	
1140		0.976	
1180			
1200	2.396		
1220	2.460		
1240			
1260			
1280			
1300			1.129
1320			1.153
1330			1.166

temperature-dependent equations

$\kappa = a + bT + cT^2$

Mol % Na_2SO_4	-a	b · 10^3	-c · 10^6	Standard error of estimate
0	4.6835	1.2285		0.27%
50	1.7898	2.8256	0.3503	0.25%
100	1.4269	3.1861		0.20%

These values are based on the data of [217] (classical ac technique).

TABLE 389. Cs_2SO_4-Na_2SO_4: Surface tension (dyn cm^{-1})

	Mol Percent Na_2SO_4				
T(K)	100	75	50	25	0
900		148.6			
920		147.2			
940		145.7	155.2		
960		144.3	153.7		
980		142.8	152.2		
1000		141.3	150.7		
1020		139.9	149.2		
1040		138.4	147.8		
1060		137.0	146.3		
1080		135.5	144.8		
1100		134.0	143.3		
1120		132.6	141.8		
1140		131.1	140.4	153.2	
1160	192.5	129.7	138.9	151.9	
1180	191.1	128.2	137.4	150.5	
1200	189.8	126.7	135.9	149.2	
1220	188.5	125.3	134.4	147.9	
1240	187.2	123.8	133.0	146.6	
1260	185.9	122.4	131.5	145.3	
1280	184.5	120.9	130.0	143.9	
1300	183.2	119.4	128.5	142.6	112.7
1320	181.9	118.0	127.0	141.3	111.5
1340	180.6	116.5	125.6	140.0	110.3
1360	179.3	115.1	124.1	138.7	109.0

temperature-dependent equations

$\gamma = a + bT$

Mol % Na_2SO_4	a	$-b \cdot 10^3$
0	193.33	62.0
25	228.42	66.0
50	224.71	74.0
75	214.33	73.0
100	269.02	66.0

These values are based on the data of [149] (Wilhelmy slide plate).

TABLE 390. Cs_2SO_4-Rb_2SO_4: Specific conductance ($ohm^{-1}cm^{-1}$)

	Mol percent Rb_2SO_4		
T(K)	100	50	0
1290			1.117
1300			1.129
1310			1.141
1320			1.153
1330		1.183	1.166
1340	1.401	1.197	
1350	1.417	1.210	
1360	1.432	1.223	
1370	1.447	1.236	
1380	1.463	1.248	
1390	1.478	1.260	
1400		1.271	
1410		1.283	
1420		1.293	

temperature-dependent equations

$\kappa = a + bT + cT^2$

Mol % Rb_2SO_4	-a	$b \cdot 10^3$	$-c \cdot 10^6$	Standard error of estimate
0	4.6835	1.2285		0.27%
50	3.8027	6.1125	1.7772	0.15%
100	6.6573	1.5424		0.12%

These values are based on the data of Kvist (classical ac technique [217].

TABLE 391. Cs_2SO_4-Tl_2SO_4: Specific conductance ($ohm^{-1}cm^{-1}$)

	Mol percent Tl_2SO_4
T(K)	50
1070	0.990
1090	1.021
1110	1.052
1130	1.084
1150	1.117
1170	1.150
1190	1.184
1210	1.218

TABLE 391. Cs_2SO_4-Tl_2SO_4: Specific conductance - CONTINUED

temperature-dependent equations

$\kappa = a + bT + cT^2$

Mol % Tl_2SO_4	a	$b \cdot 10^3$	$c \cdot 10^6$	Std. error of est.
50	0.1159	0.0922	0.6767	0.25%

These values are based on the data of Kvist and Schroeder (classical ac technique) [146].

TABLE 392. Cs_2SO_4-Rb_2SO_4: Surface tension (dyn cm^{-1})

	Mol percent Rb_2SO_4		
T(K)	100	50	0
1290			113.3
1300			112.7
1310			112.1
1320			111.5
1330		117.7	110.8
1340	127.4	117.0	110.2
1350	126.8	116.4	109.6
1360	126.2	115.7	
1370	125.6	115.1	
1380	125.0	114.4	
1390	124.4	113.7	
1400	123.8	113.1	
1410		112.4	
1420		111.8	

temperature-dependent equations

$\gamma = a + bT$

Mol % Rb_2SO_4	a	$-b \cdot 10^3$
0	193.33	62.0
50	205.52	66.0
100	207.89	60.0

These values are based on the work of Bertozzi and Soldani (Wilhelmy slide plate) [149]. The values at 0% and 100% Rb_2SO_4 are included for comparison with the NSRDS data recommended values [2].

TABLE 393. K_2SO_4-Li_2SO_4

Specific conductance ($ohm^{-1}cm^{-1}$) with > 95 mole percent Li_2SO_4

	Mol percent Li_2SO_4					
T (K)	95.11	97.0	99.0	99.25	99.5	99.75
1040	3.170					
1050	3.223					
1060	3.277					
1070	3.330					
1080	3.384					
1090	3.437					
1100	3.491					
1110	3.545	3.723				
1120	3.598	3.776		4.022		
1130	3.652	3.829		4.075		
1140	3.705	3.883		4.129		
1150	3.759	3.936	4.184	4.182		
1160	3.812	3.989	4.235	4.236	4.256	4.290
1170	3.866	4.043	4.286	4.289	4.308	4.342
1180	3.919	4.096	4.337	4.343	4.360	4.393
1190			4.388	4.397	4.412	4.445
1200			4.439	4.450	4.464	4.497
1210			4.490	4.504	4.516	4.549
1220				4.557	4.568	4.601

temperature-dependent equations

$\kappa = a + bT$

Mol % Li_2SO_4	- a	$b \cdot 10^3$	Standard error of estimate
99.75	1.733	5.1919	0.001
99.50	1.7818	5.2048	0.003
99.25	1.9771	5.3560	0.005
99.00	1.6864	5.1046	0.005
97.00	2.1928	5.3295	0.004
95.11	2.3972	5.3530	0.007

These values are based on the data of [218,219] (classical ac technique).

TABLE 394. K_2SO_4-Li_2SO_4

Specific conductance ($ohm^{-1}cm^{-1}$)

with 20-80 mole percent K_2SO_4

	Mol percent K_2SO_4				
)	80.00	60.00	40.00	25.00	20.00
0				0.800	
0				0.921	
0				1.037	1.193
0				1.147	1.296
0				1.253	1.397
0				1.355	1.498
0				1.453	1.597
0				1.547	1.695
0		0.989	1.230	1.638	1.791
0		1.055	1.308	1.727	1.886
0		1.119	1.385	1.813	1.979
0		1.184	1.462	1.897	2.071
0		1.247	1.539	1.980	2.160
0		1.310	1.614	2.062	2.248
0		1.373	1.689	2.143	2.334
0		1.435	1.763	2.224	2.418
0		1.496	1.837	2.305	2.500
0				2.386	
0				2.468	
0	1.583				
0	1.607				

temperature-dependent equation

$\kappa = a + bT + cT^2 + dT^3$

₺ ₄	-a	$b \cdot 10^3$	$-c \cdot 10^6$	$-d \cdot 10^9$	Standard error of estimate
)	3.3627	3.9615	-2.7605	1.5680	0.20%
)	14.446	35.919	28.076	-8.2412	0.50%
)	3.5117	5.5556	0.8142		0.15%
)	2.9996	4.6972	0.7082		0.13%
)	1.3908	2.4373			0.03%

ese values are based on the data of [221] lassical ac technique).

TABLE 395. K_2SO_4-Li_2SO_4: Density (g cm^{-3})

	Mol percent Li_2SO_4	
T(K)	80	50
860	2.105	
880	2.096	
900	2.088	
920	2.080	
940	2.072	
960	2.064	
980	2.056	
1000	2.048	
1020	2.039	
1040		
1060		
1080		2.001
1100		1.992
1120		1.983
1140		1.975
1160		1.966
1180		1.957
1200		1.949
1220		1.940
1240		1.931
1260		1.923
1280		1.914
1300		1.906
1320		1.897

temperature-dependent equations

$\rho = a + bT + cT^2 + dT^3$

Mol % Li_2SO_4	a	$-b \cdot 10^3$	$c \cdot 10^6$	$-d \cdot 10^9$	Standard error of estimate
50	3.2959	2.4987	1.7126	.4717	0.03%
80	2.455	0.407			0.02%

These values are based on the data of [146]-[220] (Archimedean method).

TABLE 396. K_2SO_4-Na_2SO_4: Density (g cm^{-3})

	Mol percent Na_2SO_4	
T(K)	100	50
1180	2.059	
1200	2.051	
1220	2.042	1.977
1240	2.034	1.968
1260	2.025	1.959
1280	2.017	1.950
1300	2.008	1.941
1320	2.000	1.932
1340		1.924
1360		1.916

temperature-dependent equations

$$\rho = a + bT + cT^2$$

Mol % Na_2SO_4	a	$-b \cdot 10^3$	$c \cdot 10^6$	Std, error of est.	Temp. range (K)
50	2.9813	1.1703	0.2846	0.02%	1204-1360
100	2.5608	0.4249		0.05%	1176-1320

These values are based on the data of Kvist and Schroeder (Archimedean method [146]. The values for 100% Na_2SO_4 are included for comparison with the NSRDS recommendations for Na_2SO_4 [1].

TABLE 397. K_2SO_4-Na_2SO_4: Surface tension (dyn cm^{-1})

	Mol percent Na_2SO_4				
T(K)	100	75	50	25	0
1100		164.7			
1120		163.4			
1140		162.1			
1160	192.5	160.8			
1180	191.1	159.4			
1200	189.8	158.1	164.3		
1220	188.5	156.8	162.9		
1240	187.2	155.5	161.5	170.7	
1260	185.9	154.2	160.2	169.4	
1280	184.5	152.8	158.8	168.2	
1300	183.2	151.5	157.4	166.9	
1320	181.9	150.2	156.0	165.6	
1340	180.6	148.9	154.6	164.4	
1360	179.3	147.6	153.3	163.1	141.4
1380	177.9	146.2	151.9	161.9	140.1
1400	176.6	144.9	150.5	160.6	138.8
1420	175.3	143.6	149.1	159.3	137.5
1440	173.9	142.3	147.7	158.1	136.2
1460	172.7	141.0	146.4	156.8	134.9

temperature-dependent equations

$$\gamma = a + bT$$

Mol % Na_2SO_4	a	$-b \cdot 10^3$
0	229.8	65.0
25	248.8	63.0
50	247.1	69.0
75	237.3	66.0
100	269.0	66.0

These values are based on the data of Bertozzi and Soldani (Wilhelmy slide plate method) [149]. For 100% and 0% Na_2SO_4, cf. NSRDS recommendations [2].

TABLE 398. K_2SO_4-Na_2SO_4: Specific conductance ($ohm^{-1}cm^{-1}$)

Mol percent Na_2SO_4	
T (K)	50
1182.7	1.666
1193.4	1.698

Above as reported by Kvist [217] (classical ac technique).

TABLE 399. K_2SO_4-Rb_2SO_4: Specific conductance ($ohm^{-1}cm^{-1}$)

$\kappa = 0.3973069 + 0.1068092 \cdot 10^{-3}T + 0.5880921 \cdot 10^{-6}T^2$

standard error of estimate = 0.10%

Mol % Rb_2SO_4	
T (K)	50
1340	1.596
1345	1.605
1350	1.613
1355	1.622
1360	1.630
1365	1.639
1370	1.647
1375	1.656
1380	1.665

Above are from the data of Kvist (classical ac technique) [217].

TABLE 400. K_2SO_4-Rb_2SO_4: Surface tension ($dyn\ cm^{-1}$)

	Mol percent Rb_2SO_4			
T(K)	100	75	50	0
1170	137.7			
1190	136.5	148.1		
1210	135.3	146.8		
1230	134.1	145.5	141.4	
1250	132.9	144.1	140.1	
1270	131.7	142.8	138.7	
1290	130.5	141.5	137.4	
1310	129.3	140.2	136.0	
1330	128.1	138.9	134.7	
1350	126.9	137.5	133.4	142.0
1370	125.7	136.2	132.0	140.7
1390	124.5	134.9	130.7	139.4
1410	123.3	133.6	129.3	138.1
1430	122.1	132.3	128.0	136.8
1450	120.9	130.9	126.7	135.5
1470	119.7	129.6	125.3	134.2

temperature-dependent equations

$\gamma = a + bT$

Mol % Rb_2SO_4	a	$-b.10^3$
0	229.76	65.0
50	223.80	67.0
75	226.63	66.0
100	207.89	60.0

These values are based on the data of Bertozzi and Soldani (Wilhelmy slide plate) [149]. The values at 0% and 100% Rb_2SO_4 are given here for comparison with the NSRDS recommendations [2].

TABLE 401. K_2SO_4-Tl_2SO_4: Specific conductance ($ohm^{-1}cm^{-1}$)

	Mol percent Tl_2SO_4
T(K)	50
1100	1.254
1110	1.273
1120	1.292
1130	1.312
1140	1.331
1150	1.350
1160	1.369
1170	1.388
1180	1.408
1190	1.427
1200	1.446

temperature-dependent equations

$\kappa = a + bT$

Mol % Tl_2SO_4	-a	$b \cdot 10^3$	Std. error of est.
50	0.8578	1.9198	0.17%

These values are based on the data of Kvist and Schroeder (classical ac technique) [146].

TABLE 402. K_2SO_4-$ZnSO_4$: Specific conductance ($ohm^{-1}cm^{-1}$)

	Mol percent $ZnSO_4$					
T(K)	80	75	70	60	50	43
723				0.06	0.05	0.09
748		0.02	0.02	0.07	0.06	0.11
773	0.04		0.04	0.08	0.07	0.13
798	0.04		0.06	0.10	0.10	0.16
823	0.05		0.08	0.13	0.13	0.19

These values have been interpolated from the graphical data of Vereshchetina and Luzhnaya (classical ac technique) [222].

TABLE 403. K_2SO_4-$ZnSO_4$: Density (g cm^{-3})

	Mol percent $ZnSO_4$					
T (K)	74.87	70.29	66.00	66.57	64.99	60.43
770			2.752	2.748	2.729	2.681
780			2.747	2.740	2.721	2.673
790			2.742	2.731	2.714	2.665
800	2.830	2.765	2.737	2.722	2.707	2.657
810	2.822	2.762	2.733	2.714	2.700	2.650
820	2.814	2.758	2.728	2.705	2.693	2.642
830	2.807	2.755	2.723	2.697	2.685	2.634

	Mol percent $ZnSO_4$				
T (K)	55.42	51.99	50.00	48.26	43.00
770	2.622	2.594	2.560	2.546	2.510
780	2.616	2.587	2.555	2.540	2.505
790	2.611	2.580	2.551	2.534	2.501
800	2.605	2.573	2.546	2.528	2.496
810	2.599	2.565	2.541	2.522	2.491
820	2.594	2.558	2.536	2.516	2.486
830	2.588	2.551	2.531	2.510	2.481

temperature-dependent equations

$\kappa = a + bT$

Mol % $ZnSO_4$	a	$b \cdot 10^3$	Std. error of est.
43.00	2.8797	0.4800	0.02%
48.26	3.0074	0.6000	0.09%
50.00	2.9297	0.4800	0.03%
51.99	3.1488	0.7203	0.00%
55.42	3.0530	0.5601	0.07%
60.43	3.2815	0.7800	0.10%
64.99	3.2828	0.7199	0.11%
66.57	3.4110	0.8605	0.33%
66.00	3.1214	0.4800	0.04%
70.29	3.0528	0.3595	0.00%
74.87	3.4372	0.7596	0.00%

These values are based on the data of [222] (Archimedean method)

: 404. Li_2SO_4-$MgSO_4$: Specific conductance ($ohm^{-1}cm^{-1}$)

Mol percent $MgSO_4$	
T(K)	4.0
1110	3.884
1120	3.942
1130	3.999
1140	4.057
1150	4.114
1160	4.172
1170	4.229
1180	4.287
1190	4.345
1200	4.402
1210	4.460
1220	4.517

temperature-dependent equations

$\kappa = a + bT$

$MgSO_4$	- a	b · 10	Standard error of estimate
)	2.5067	5.757	0.011

values are based on the data of Kvist (clas-ac technique) [218,219].

TABLE 405. Li_2SO_4-Na_2SO_4: Density (g cm^{-3})

Mol percent Na_2SO_4	
T(K)	50
1010	2.097
1030	2.088
1050	2.080
1070	2.071
1090	2.063
1110	2.054
1130	2.045
1150	2.036
1170	2.026
1190	2.017
1210	2.007
1230	1.997

temperature-dependent equations

$\rho = a + bT + cT^2$

Mol % Na_2SO_4	a	b · 10^6	c · 10^9	Std. error of est.
50	2.2987	5.119	-203.3	0.03%

These values are based on the data of Kvist and Schroeder (Archimedean method) [146].

TABLE 406. Li_2SO_4-Na_2SO_4: Specific conductance ($ohm^{-1}cm^{-1}$)

	Mol percent Na_2SO_4												
T(K)	0	2.0	4.89	10	20	30	40	50	60	70	80	90	100
900							1.651						
920							1.763	1.638	1.491				
940						2.017	1.872	1.741	1.588				
960						2.128	1.979	1.841	1.683				
980						2.236	2.083	1.939	1.776				
1000					2.549	2.342	2.185	2.036	1.867	2.353			
1020					2.660	2.446	2.285	2.130	1.956	2.459			
1040					2.769	2.548	2.382	2.223	2.043	2.563	1.905		
1060					2.877	2.647		2.314	2.128	2.664	1.984		
1080					2.982	2.745			2.211	2.763	2.062		
1100				3.530	3.085	2.840			2.292	2.859	2.138	2.143	
1120			3.808	3.636	3.186	2.933			2.372	2.953	2.212	2.217	
1140	3.915	4.143	3.910	3.739	3.286	3.024			2.450	3.044	2.285	2.289	
1160	4.014	4.252	4.012	3.841	3.383	3.113			2.527	3.133	2.356	2.359	2.261
1180	4.099	4.361	4.113	3.940	3.478					3.219	2.424	2.427	2.327
1200	4.170			4.037	3.571					3.302	2.491	2.493	2.392
1220				4.132						3.383	2.557	2.556	2.455
1240				4.225						3.461	2.620	2.618	2.515
1260				4.315						3.537	2.681		2.573
1280				4.403							2.741		2.629
1300				4.489							2.799		2.683
1320											2.855		2.735
1340											2.910		2.785

temperature-dependent equations

$$\kappa = a + bT + cT^2 + dT^3$$

Mol % Na_2SO_4	-a	b · 10^3	-c · 10^6	d · 10^9	Standard error of estimate	Temp. range (K)
0	24.544	44.630	17.251		0.05%	1136-1204
2.0	2.0644	5.4453			0.03%	1140-1190
4.89	1.8962	5.0930			0.05%	1116-1182
10	5.7385	11.496	2.7917		0.24%	1296-1305
20	5.5588	10.604	2.4963		0.29%	990-1213
30	5.6152	10.663	2.7058		0.12%	923-1178
40	5.8915	11.118	3.0424		0.21%	901-1056
50	5.1261	9.5471	2.3852		0.21%	909-1068
60	6.5347	13.742	6.7677	1.4268	0.24%	915-1155
70	6.2156	11.755	3.1864		0.30%	995-1272
80	4.7349	8.7392	2.2645		0.21%	1038-1338
90	5.1469	9.4942	2.6067		0.42%	1100-1253
100	5.2337	9.5320	2.6477		0.31%	1153-1342

These values are based on the data of Kvist (classical ac technique) [152,217,218,219].

TABLE 407. Li_2SO_4-Rb_2SO_4

Specific conductance ($ohm^{-1}cm^{-1}$)

	Mol percent Rb_2SO_4				
T(K)	50	6.51	2.0	1.0	0
970		2.300			
980		2.353			
990		2.406			
1000		2.458			
1010		2.511			
1020		2.564			
1030		2.616			
1040		2.669			
1050	0.919	2.722			
1060	0.947	2.774			
1070	0.975	2.827			
1080	1.002	2.880			
1090	1.029	2.932	3.659		
1100	1.055	2.985	3.712		
1110	1.081	3.038	3.765		
1120	1.106	3.090	3.818		
1130	1.130		3.871	4.029	
1140	1.155		3.925	4.081	3.915
1150	1.179		3.978	4.134	3.966
1160	1.202		4.031	4.186	4.014
1170	1.225			4.239	4.058
1180	1.247			4.291	4.099
1190	1.269			4.343	4.136
1200	1.290			4.396	4.170
1210	1.311			4.448	
1220				4.500	

temperature-dependent equations

$\kappa = a + bT + cT^2$

Mol % Rb_2SO_4	- a	b $\cdot 10^3$	-c $\cdot 10^6$	Standard error of estimate
0	24.544	44.63	1.725	0.15%
1.0	1.8872	5.235		0.12%
2.0	2.1271	5.308		0.15%
6.51	2.8076	5.266		0.13%
50.0	4.6804	7.834	2.382	0.18%

These values are based on the data of [217,218,219] (classical ac technique).

TABLE 408. Li_2SO_4-Tl_2SO_4: Specific conductance ($ohm^{-1}cm^{-1}$)

	Mol percent Tl_2SO_4
T(K)	50
1040	1.197
1050	1.226
1060	1.254
1070	1.283
1080	1.311
1090	1.339
1100	1.366
1110	1.393
1120	1.420
1130	1.447
1140	1.473
1150	1.499
1160	1.525
1170	1.550
1180	1.575
1190	1.600
1200	1.624

temperature-dependent equations

$\kappa = a + bT + cT^2$

Mol % Tl_2SO_4	a	b $\cdot 10^3$	c $\cdot 10^6$	Std. error of est.
50	-3.4940	6.1034	-1.5318	0.15%

These values are based on the data of Kvist and Schroeder (classical ac technique) [146].

TABLE 409. Li_2SO_4-Tl_2SO_4: Density (g cm^{-3})

	Mol percent Tl_2SO_4	
T(K)	100	50
950	5.568	
970	5.540	
990	5.512	
1010	5.484	
1030	5.457	
1050	5.431	4.166
1070	5.404	4.148
1090	5.378	4.130
1110	5.352	4.112
1130	5.327	4.094
1150	5.302	4.075
1170	5.278	4.056
1190	5.254	4.038
1210	5.230	4.019
1230		3.999
1250		3.980
1270		3.961

temperature-dependent equations

$\rho = a + bT + cT^2$

Mol % Tl_2SO_4	a	$-b \cdot 10^3$	$c \cdot 10^6$	Std. error of est.
50	4.9071	0.5156	-0.1807	0.03%
100	7.3441	2.3155	0.4694	0.06%

These values are based on the data of Kvist and Schroeder (Archimedean method) [146].

TABLE 410. Li_2SO_4-$ZnSO_4$

Specific conductance ($ohm^{-1}cm^{-1}$)

	Mol percent $ZnSO_4$				
T(K)	75	67	50	33	25
780			0.521		
800			0.568		
820			0.615		
840			0.661		
860			0.706	1.237	
880			0.750	1.324	
900			0.793	1.412	
920			0.835	1.499	
940		0.614	0.877	1.587	1.917
960		0.653	0.917	1.675	2.025
980			0.957	1.762	2.129
1000				1.850	2.232
1020	0.676			1.938	2.331
1040	0.723			2.025	
1060	0.773			2.113	
1080	0.827				
1100	0.884				
1120	0.946				
1140	1.011				

temperature-dependent equations

$\kappa = a + bT + cT^2 + dT^3$

Mol % $ZnSO_4$	-a	b $\cdot 10^2$	c $\cdot 10^6$	d $\cdot 10^9$	Standard error of estimate
25	6.3511	1.2133	-3.5511		0.19%
33	2.5310	0.4380			0.57%
50	2.0017	0.4073	-1.0763		0.39%
67	11.441	1.1652	13.554	13.092	0.42%
75	-3.2160	-0.7211	4.6291		1.88%

These values are based on the data of [147] (classical ac method).

BLE 411. Li_2SO_4-$ZnSO_4$: Density (g cm^{-3})

Mol percent $ZnSO_4$	
T(K)	50
870	2.629
880	2.625
890	2.621
900	2.616
910	2.612
920	2.608
930	2.604
940	2.599
950	2.595
960	2.591

temperature-dependent equation

$\rho = a + bT$

l % $ZnSO_4$	a	b · 10^3	Standard error of estimate
50	2.9984	-0.4245	0.02%

se values are based on the data of Josefson and st (Archimedean method) [147].

TABLE 412. Na_2SO_4-Rb_2SO_4: Specific conductance ($ohm^{-1}cm^{-1}$)

Mol percent Rb_2SO_4	
T(K)	κ
1110	1.170
1120	1.179
1130	1.189
1140	1.200
1150	1.212
1160	1.225
1170	1.239
1180	1.255
1190	1.271
1200	1.289
1210	1.308
1220	1.328
1230	1.349
1240	1.371
1250	1.394
1260	1.418

temperature-dependent equation

$\kappa = a + bT + cT^2$

Mol % Rb_2SO_4	a	b · 10^2	c · 10^6	Std. error of est.
50	7.0607	-1.1440	5.5259	2.37%

These values are based on the data of Kvist (classical ac technique) [217].

TABLE 413. Na_2SO_4-Rb_2SO_4: Surface tension ($dyn\ cm^{-1}$)

	Mol percent Rb_2SO_4			
T(K)	100	50	25	0
980			179.5	
1000			178.1	
1020			176.8	
1040			175.5	
1060			174.2	
1080		159.0	172.9	
1100		157.6	171.5	
1120		156.3	170.2	
1140		155.0	168.9	
1160		153.7	167.6	192.5
1180		152.4	166.3	191.2
1200		151.0	164.9	189.8
1220		149.7	163.6	188.5
1240		148.4	162.3	187.2
1260		147.1	161.0	185.9
1280		145.8	159.7	184.6
1300		144.4	158.3	183.2
1320		143.1	157.0	181.9
1340		141.8	155.7	180.6
1360	127.9	140.5	154.4	179.3
1380	126.7	139.2	153.1	178.0
1400	125.5	137.8	151.7	176.6
1420	124.3	136.5	150.4	175.3
1440	123.1	135.2	149.1	174.0
1460	121.9	133.9	147.8	172.7

temperature-dependent equations

$\gamma = a + bT$

Mol % Rb_2SO_4	a	$-b \cdot 10^3$
0	269.03	66.0
25	244.13	66.0
50	230.23	66.0
100	209.53	66.0

These values are based on the data of Bertozzi and Soldani (Wilhelmy slide plate) [149]. For the NSRDS recommendations at 0% and 100% Rb_2SO_4 see [2]

TABLE 414. Na_2SO_4-Tl_2SO_4: Specific conductance ($ohm^{-1}cm^{-1}$)

	Mol percent Tl_2SO_4
T(K)	50
1060	1.234
1070	1.257
1080	1.279
1090	1.301
1100	1.322
1110	1.344
1120	1.365
1130	1.387
1140	1.408
1150	1.428
1160	1.449
1170	1.469
1180	1.490
1190	1.510
1200	1.530
1210	1.549

temperature-dependent equations

$\kappa = a + bT + cT^2$

Mol % Tl_2SO_4	a	$b \cdot 10^3$	$c \cdot 10^6$	Std. error of est.
50	-2.2011	4.2403	-0.9428	0.17%

The values are based on the data of Kvist and Schroeder (classical ac technique) [146].

TABLE 415. Na_2SO_4-$ZnSO_4$

Specific conductance ($ohm^{-1}cm^{-1}$)

	Mol percent $ZnSO_4$				
T(K)	75	67	50	33	25
840		0.221			
860		0.251	0.383		
880		0.281	0.422		
900	0.282	0.312	0.462		
920	0.314	0.343	0.503		
940	0.346	0.375	0.546	0.823	
960	0.378	0.408	0.589	0.880	
980	0.411		0.634	0.937	
.000			0.679	0.995	
.020			0.726	1.052	
.040			0.774	1.109	1.245
.060				1.167	1.308
.080				1.224	1.370
.100					1.431
120					1.490

temperature-dependent equations

$\kappa = a + bT + cT^2$

Mol % $ZnSO_4$	-a	$b \cdot 10^3$	$c \cdot 10^6$	Standard error of estimate
25	3.2908	5.5669	-1.158	0.12%
33	1.8746	2.8693		0.72%
50	0.2782	- 0.3907	1.348	0.20%
67	0.5410	0.3372	0.678	0.15%
75	0.6868	0.5858	0.545	0.16%

These values are based on the data of [147] (classical ac technique).

TABLE 416. Na_2SO_4-$ZnSO_4$: Density (g cm^{-3})

Mol percent $ZnSO_4$	
T(K)	50
820	2.660
830	2.653
840	2.648
850	2.643
860	2.639
870	2.636
880	2.633
890	2.631
900	2.630
910	2.629

temperature-dependent equation

$\rho = a + bT + cT^2$

Mol % $ZnSO_4$	a	$b \cdot 10^3$	$c \cdot 10^6$	Standard error of estimate
50	5.6779	- 6.6933	3.6739	0.92%

These values are based on the data of Josefson and Kvist (Archimedean method) [147].

TABLE 417. Rb_2SO_4-Tl_2SO_4: Specific conductance ($ohm^{-1}cm^{-1}$)

Mol percent Tl_2SO_4	
T(K)	50
1120	1.149
1130	1.167
1140	1.185
1150	1.204
1160	1.222
1170	1.240
1180	1.259
1190	1.277

temperature-dependent equations

$\kappa = a + bT$

Mol % Tl_2SO_4	-a	$b \cdot 10^3$	Standard error of estimate
50	0.9055	1.8341	0.31%

These values are based on the data of Kvist and Schroeder (classical ac technique) [146]

10.8 *Sulfide-Sulfide Systems*

This sections contains the studies tables and the numerical tables for the physical properties of sulfide-sulfide melts. Also included are summaries of the methods used for melt preparation and purification and, where possible, temperature-liquidus phase diagrams.

Ag_2S-Na_2S

Melt Preparation and Purification

Eichis, Sokalova and Velikanov [223] prepared anhydrous Na_2S by a multi-stage drying of the crystal hydrate. Silver sulfide was prepared by fusion of pure grades of silver and sulfur.

As_2S_3-K_2S

Melt Preparation and Purification

Mustyatsa, Velikanov and Novik [224] prepared arsenic sulfide by reacting elemental arsenic and sulfur in a quartz ampoule and Ar atmosphere. Potassium sulfide was prepared by the dehydration of $K_2S \cdot 5H_2O$ in a vacuum dry box, followed by annealing in a crucible furnace with an Ar atmosphere at temperatures below 500°C.

As_2S_3-Na_2S

Melt Preparation and Purification

For the method of melt preparation of arsenic sulfide used by Mustyatsa and Velikanov [225] see As_2S_3-K_2S. The sodium sulfide was produced by dehydrating commercial analytical grade $Na_2S \cdot 9H_2O$ initially during a gradual heating in a vacuum chamber above P_2O_5 and then in a crucible in vacuum at 400°C.

Bi_2S_3-K_2S

Melt Preparation and Purification

Mustyatsa, Velikanov and Gudzenko [166] prepared bismuth sulfide from elemental bismuth and sulfur by heating in quartz ampoules. Potassium sulfide was prepared by the dehydration of $K_2S \cdot H_2O$ in a vacuum dry box, followed by annealing in a crucible furnace in an atmosphere of Ar.

Co_4S_3-Cu_2S

Melt Preparation and Purification

Barmin, Esin and Dobrovinskii [155, 226] prepared the sulfides by reacting the corresponding metal powder with elemental sulfur.

Co_4S_3-FeS

Melt Preparation and Purification

For the method of melt preparation used by Barmin et al. [154, 226] see: Co_4S_3-Cu_2S.

Co_4S_3-Ni_3S_2

Melt Preparation and Purification

For the method of melt preparation used by Barmin et al. [156, 226] see Co_4S_3-Cu_2S.

Cu_2S-FeS

Melt Preparation and Purification

Pound, Derge and Osuch [227] prefused chemically pure Cu_2S powder and commercial grade FeS under an atmosphere of He. Barmin, Esin and Dobrovinskii [154, 155, 226] prepared the sulfides by reacting the corresponding metal powder with elemental sulfur carefully mixed pure Cu_2S and FeS in a quartz tube and sealed them under Ar.

Cu_2S-Ni_3S_2

Melt Preparation and Purification

For the method of melt preparation used by Barmin et al. [155, 226] see Co_4S_3-Cu_2S.

FeS-Ni_3S_2

Melt Preparation and Purification

For the method of melt preparation used by Barmin et al. [154, 156, 226] see Co_4S_3-Cu_2S.

GeS_2-K_2S

Melt Preparation and Purification

No information on melt preparation was given in the study by Malinovskii, Shevchuk and Velikanov [228].

K_2S-SnS

Melt Preparation and Purification

No information on melt preparation was given in the study by Malinovskii, Shevchuk and Velikanov [228].

K_2S - Sulfur (K_2S_x)

Melt Preparation and Purification

For the method used by Cleaver t al.[163, 164]see Na_2S-sulfur (Na_2S_x). r *numerical data, see sec. 9.18* .

Na_2S-PbS

Melt Preparation and Purification

No information on melt preparation was ı in the study by Velikanov, Shevchuk Malinovskii [229].

Na_2S-Sulfur (Na_2S_x)

Melt Preparation and Purification

Cleaver at al. [163, 164] prepared the sulfides by either a conventional method g sodium and sulfur or H_2S, or by con- led discharge of a sodium sulfur cell, ting with pure sulfur in the cathode artment.

In the conventional method dry toluene, ne or mesitylene were used as solvents. sodium was added to the boiling solvent reflux condenser. Sulfur was added in l quantities over a period of two hours ugh the condenser. The polysulfide was ected, washed with hot toluene, freed solvent by evacuation for 24 hours at C and finally melted and filtered.

In the method employing H_2S, sodium was olved in absolute ethanol under an atmos- e of dry N_2 and refluxed. H_2S was bub- l through the resulting sodium ethoxide tion, giving a precipitate of sodium osulfide. Sulfur was then added and the tion was refluxed for two hours. Alcohol distilled off until the residual volume 50 cm^3. The solid product was collected washed with hot absolute ethanol.

The preparation of the polysulfides us- the sodium-sulfur cell involved reducing ighed quantity of sulfur at a carbon trode with an equivalent amount of Na^+ ring the melt through the β-alumina. The sulfides produced by this method were from suspended matter, and formed clear ow or amber glasses on cooling to room erature.

Na_2S-Sb_2S_3

Melt Preparation and Purification

Velikanov, Mustyatsa and Delimarskii [171] prepared the melts by fusing spectrally pure Na_2S and Sb_2S_3.

Na_2S-Tl_2S

Melt Preparation and Purification

Velikanov, Shevchuk and Posukh [161] prepared Tl_2S by melting the metal and sulfur in quartz ampoules in an atmosphere of argon. The Na_2S was prepared from multigraded dehydrated crystal.

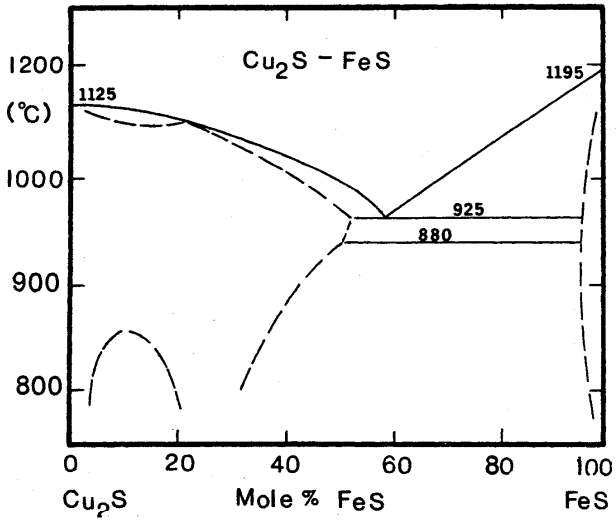


FIGURE 40. Phase diagram for Cu_2S-FeS

Data from: N. I. Kopylov and S. S. Novoselov, Zh. Neorgan. Khim. 9 [8], 1919 (1964); Russ. J. Inorg. Chem. (Eng.) 1039 (1964).

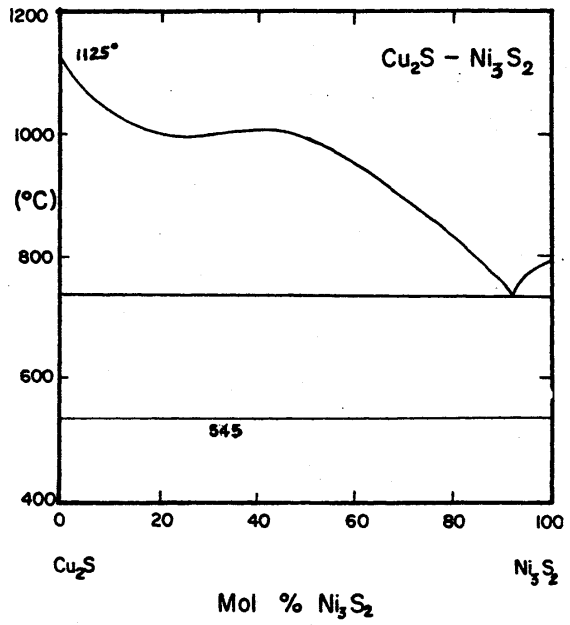


FIGURE 41. Phase diagram for Cu_2S-Ni_3S_2.

Data from: K. Friedrich, Z. Metall. U. Erzberghau 1, 164 (1914).

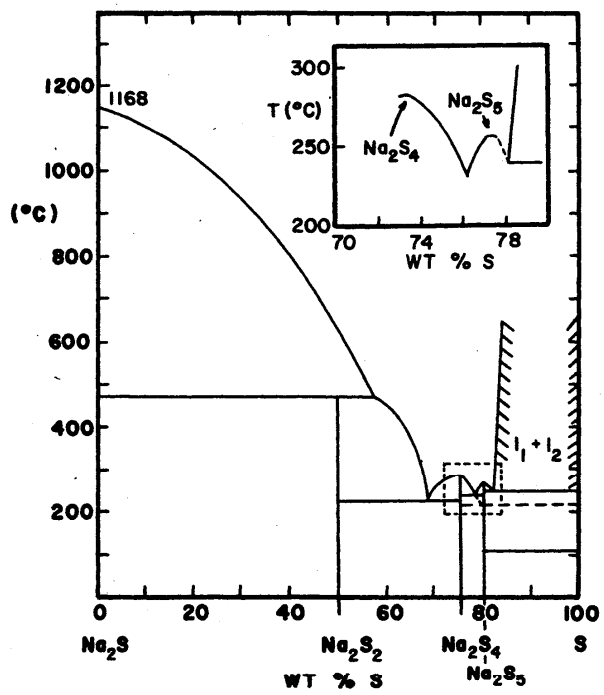


FIGURE 42. Phase diagram for Na_2S-S.

Data from: E. Rosen and R. Tegman, Acta Chem. Scand. 23, 3329 (1971); Chimica Scripta 2, 221 (1972).

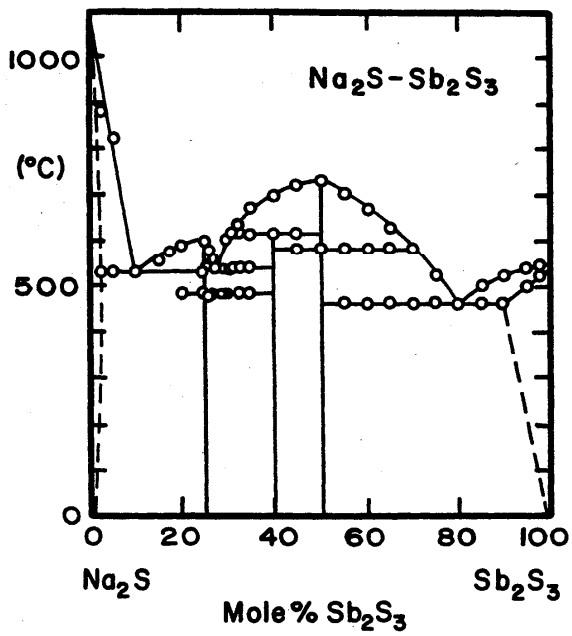


FIGURE 43. Phase diagram for Na_2S-Sb_2S_3.

Data from: S. I. Berul, V. B. Lazerev, and A. V. Salov, Russ. J. Inorg. Chem. 16, 1779 (1971).

TABLE 418. Electrical conductance studies

Ag_2S-Na_2S

Investigations critically examined

.	Mol % Na_2S	Temp. range (K)	Comments
;	30-80(g)	962-1245	Ar atmos.

TABLE 419. Electrical conductance studies

As_2S_3-K_2S

Investigations critically examined

f.	Mol % K_2S	Temp. range (K)	Comments
4	10-70(g)	673-973	quartz cap. graphite electrodes

TABLE 420. Electrical conductance studies

As_2S_3-Na_2S

Investigations critically examined

ef.	Mol % Na_2S	Temp. range (K)	Comments
25	0-90(g)	723-923	quartz cap. graphite electrodes

TABLE 421. Electrical conductance studies

Bi_2S_3-K_2S

Investigations critically examined

	Mol % K_2S	Temp. range (K)	Comments
	0-70	973-1242	quartz cap. graphite electrodes

TABLE 422. Electrical conductance studies

Co_4S_3-Cu_2S

Investigations critically examined

Ref.	Mol % Cu_2S	Temp. range (K)	Comments
226	0-100	1473-1773	quartz cap. cell

TABLE 423. Density studies: Co_4S_3-Cu_2S

Investigations critically examined

Ref.	Mol % Cu_2S	Temp. range (K)	Comments
155	0-100	1473-1773	quartz cap. He atmos.

TABLE 424. Viscosity studies: Co_4S_3-Cu_2S

Investigations critically examined

Ref.	Mol % Cu_2S	Temp. range (K)	Comments
155	0-100	1473-1773	corundum cruc. calibr.: Cu,Ni,Co,Fe

TABLE 425. Electrical conductance studies

Co_4S_3-FeS

Investigations critically examined

Ref.	Mol % FeS	Temp. range (K)	Comments
226	0-100	1773	see: Co_4S_3-Cu_2S

TABLE 426. Density studies: Co_4S_3-FeS

Investigations critically examined

Ref.	Mol % FeS	Temp. range (K)	Comments
154,156	0.100	1523	see: Co_4S_3-Cu_2S

TABLE 427. Viscosity studies: Co_4S_3-FeS

Investigations critically examined

Ref.	Mol % FeS	Temp. range (K)	Comments
154,156	0-100	1523-1773	see: Co_4S_3-Cu_2S

TABLE 428. Electrical conductance studies: Co_4S_3-Ni_3S_2

Investigations critically examined

Ref.	Mol % Ni_3S_2	Temp. range (K)	Comments
226	0-100	1773	see: Co_4S_3-Cu_2S

TABLE 429. Density studies: Co_4S_3-Ni_3S_2

Investigations critically examined

Ref.	Mol % Ni_3S_2	Temp. range (K)	Comments
156	0-100	1523	see Co_4S_3-Cu_2S

TABLE 430. Viscosity studies: Co_4S_3-Ni_3S_2

Investigations critically examined

Ref.	Mol % Ni_3S_2	Temp. range (K)	Comments
156	0-100	1523-1773	see Co_4S_3-Cu_2S

TABLE 431. Electrical conductance studies: Cu_2S-FeS

Investigations critically examined

Ref.	Mol % FeS	Temp. range (K)	Comments
169	10-100	973-1473	quartz cap. calibr.: Sn
227	0-100(g)	1273-1673	alundum cruc. graph. electr. calibr.: H_2SO_4
226	0-100	1473-1773	quartz cap.

The study by Kurochkin et al [169] extends the measurements down to 973 K in the region of temperature overlap (1473K), the Kurochkin results fall about 15% lower than the Pound [227] and the Barmin [226] results. The results in the Kurochkin study cannot be expressed satisfactorily in equation format owing to the sharp inflexions at certain compositions. The data of Barmin et al. [226] covers the same composition range as Pound, Derge, and Osuch but with some additional compositions. The results are about 10% higher than the study by Pound et al. For comparison, the data of Barmin et al [226] are summarized in equation form in Table 463.

TABLE 432. Density studies: Cu_2S-FeS

Investigations critically examined

Ref.	Mol % FeS	Temp. range (K)	Comments
154,155	0-100	1523	see: Co_4S_3-Cu_2S

TABLE 433. Viscosity studies: Cu_2S-FeS

Investigations critically examined

Ref.	Mol % FeS	Temp. range (K)	Comments
154,155	0-100	1473, 1773	corundum; crucible; He atm.

TABLE 434. Electrical conductance studies

Cu_2S-Ni_3S_2

Investigations critically examined

Ref.	Mol % Ni_3S_2	Temp. range (K)	Comments
226	0-100	1473-1773	See: Co_4S_3-Cu_2S

TABLE 435. Density studies: Cu_2S-Ni_3S_2

Investigations critically examined

Ref.	Mol % Ni_3S_2	Temp. range (K)	Comments
155	0-100	1473	See: Co_4S_3-Cu_2S

TABLE 436. Viscosity studies: Cu_2S-Ni_3S_2

Investigations critically examined

Ref.	Mol % Ni_3S_2	Temp. range (K)	Comments
155	0-100	1473,1773	See: Co_4S_3-Cu_2S

TABLE 437. Electrical conductance studies

FeS-Ni_3S

Investigations critically examined

ef.	Mol % Ni_3S_2	Temp. range (K)	Comments
26	0-100	1773	See: Co_4S_3-Cu_2S

TABLE 438. Density studies: FeS-Ni_3S_2

Investigations critically examined

Ref.	Mol % Ni_3S_2	Temp. range (K)	Comments
54,156	0-100	1523	See: Co_4S_3-Cu_2S

TABLE 439. Viscosity studies: FeS-Ni_3S_2

Investigations critically examined

Ref.	Mol % Ni_3S_2	Temp. range (K)	Comments
154,156	0-100	1523; 1773	See: Co_4S_3-Cu_2S

TABLE 440. Electrical conductance studies:

GeS_2-K_2S

Investigations critically examined

Ref.	Mol % K_2S	Temp. range (K)	Comments
228	16-62(g)	873-1123	

TABLE 441. Electrical conductance studies:

K_2S-SnS

Investigations critically examined

Ref.	Mol % SnS	Temp. range (K)	Comments
228	40-90	923-1223	

TABLE 442. Electrical conductance studies:

Na_2S-PbS

Investigations critically examined

Ref.	Mol % PbS	Temp. range (K)	Comments
229	30-92.7	873-1483	quartz cap.; Ar atmos.

TABLE 443. Electrical conductance studies: Na_2S_x

Investigations critically examined

Ref.	Comp.	Temp. range (K)	Comments
164	$Na_2S_{2.1}$	728-840	carbon electrodes; calibr.: 1 D KCl
	$Na_2S_{2.9}$	642-698	
	$Na_2S_{3.0}$	582-693	
	$Na_2S_{3.2}$	458-694	
	$Na_2S_{3.8}$	428-694	
	$Na_2S_{4.2}$	456-671	
	$Na_2S_{5.1}$	477-681	

TABLE 444. Density studies: Na_2S_x

Investigations critically examined

Ref.	Comp.	Temp. range (K)	Comments
163	Na_2S_3	590-683	max. bubble pressure; N_2 atmos.
	$Na_2S_{3.3}$	576-689	
	$Na_2S_{3.7}$	563-669	
	$Na_2S_{4.4}$	571-680	
	$Na_2S_{4.8}$	573-683	

TABLE 445. Viscosity studies: Na_2S_x

Investigations critically examined

Ref.	Comp.	Temp. range (K)	Comments
163	$Na_2S_{3.1}$	577-653	N_2 atmos.
	$Na_2S_{3.3}$	589-647	
	$Na_2S_{3.6}$	558-646	
	$Na_2S_{3.9}$	533-652	
	$Na_2S_{4.1}$	587-641	
	$Na_2S_{4.3}$	572-675	
	$Na_2S_{4.7}$	557-654	
	$Na_2S_{5.2}$	620-648	

TABLE 446. Surface tension studies: Na_2S_x

Investigations critically examined

Ref.	Comp.	Temp. range (K)	Comments
163	$Na_2S_{3.0}$	583-691	calibr.: H_2O, glycol, $NaNO_3$
	$Na_2S_{3.1}$	588-673	
	$Na_2S_{3.3}$	586-671	
	$Na_2S_{3.6}$	589-677	
	$Na_2S_{3.9}$	539-676	
	$Na_2S_{4.1}$	556-641	
	$Na_2S_{4.3}$	602-676	
	$Na_2S_{4.7}$	562-671	
	$Na_2S_{4.8}$	625-688	
	$Na_2S_{5.2}$	616-661	

TABLE 447. Electrical conductance studies Na_2S-Sb_2S_3

Investigations critically examined

Ref.	Mol % Sb_2S_3	Temp. range (K)	Comments
171	0-100	923-1333	quartz cap.

TABLE 448. Electrical conductance studies Na_2S-Tl_2S

Investigations critically examined

Ref.	Mol % Tl_2S	Temp. range (K)	Comments
161	0-100	773-1173	quartz cap. graphite electrodes; Ar atmos.

TABLE 449. Ag_2S-Na_2S: Specific conductance ($ohm^{-1}cm^{-1}$)

	Mol percent Na_2S					
T (K)	80	70	60	50	40	30
960	2.333	2.099	2.213	2.487	3.000	3.633
980	2.437	2.225	2.313	2.580	3.039	3.764
1000	2.543	2.349	2.414	2.677	3.102	3.954
1020	2.650	2.472	2.517	2.779	3.190	4.205
1040	2.760	2.593	2.623	2.885	3.302	4.514
1060	2.871	2.713	2.730	2.994	3.438	4.883
1080	2.984	2.831	2.840	3.108	3.598	5.312
1100	3.099	2.948	2.952	3.227	3.783	5.801
1120	3.216	3.063	3.066	3.349	3.992	6.349
1140	3.334	3.177	3.182	3.475	4.225	6.957
1160	3.455	3.289	3.300	3.606	4.483	7.624
1180	3.577	3.400	3.421	3.741	4.764	8.351
1200	3.701	3.509	3.543	3.879	5.070	9.138
1220	3.827	3.617	3.668	4.022	5.401	9.984
1240	3.954	3.724	3.795	4.170	5.755	1.089
1250	4.019	3.776	3.859	4.245	5.942	1.137

temperature-dependent equations

$$\kappa = a + bT + cT^2$$

Mol % Na_2S	a	$-b \cdot 10^2$	$c \cdot 10^4$	standard error of est.
30	67.4668	13.8037	0.7452	8.52%
40	29.6725	5.6913	0.3034	3.28%
50	2.8840	0.5387	0.0518	2.00%
60	-0.0375	0.0212	0.0266	1.05%
70	-5.6925	0.9908	-0.0186	0.84%
80	-0.5414	0.08286	0.0225	1.98%

These values have been interpolated from the graphical data of Eichis, Sokolova and Velikanov (classical ac technique) [223].

TABLE 450. As_2S_3-K_2S: Specific conductance ($ohm^{-1}cm^{-1}$)

Mol percent K_2S

T (K)	70	60	50	40	30	20	10
670			0.023	0.014	0.013	0.014	0.005
690			0.041	0.032	0.027	0.023	0.008
710			0.061	0.053	0.044	0.033	0.012
730		0.007	0.084	0.076	0.064	0.045	0.018
750		0.026	0.109	0.102	0.086	0.060	0.024
770	0.010	0.051	0.136	0.129	0.110	0.077	0.032
790	0.012	0.083	0.166	0.159	0.138	0.097	0.040
810	0.017	0.120	0.198	0.192	0.167	0.118	0.050
830	0.023	0.160	0.233	0.226	0.200	0.142	0.061
850	0.032	0.204	0.270	0.263	0.235	0.168	0.073
870	0.044	0.248	0.309	0.302	0.272	0.196	0.086
890	0.057	0.291	0.350	0.344	0.312	0.227	0.101
910	0.073	0.333	0.394	0.388	0.355	0.260	0.116
930	0.091	0.371	0.441	0.434	0.400	0.295	0.133
950	0.112	0.404	0.489	0.483	0.447	0.332	0.151
970	0.135	0.430	0.541	0.534	0.498	0.372	0.170
980	0.147	0.439	0.567	0.560	0.524	0.392	0.180

temperature-dependent equations

$$\kappa = a + bT + cT^2 + dT^3 + eT^4$$

Mol % K_2S	a	$-b \cdot 10^2$	$c \cdot 10^5$	$d \cdot 10^7$	$-e \cdot 10^{10}$	standard error of est.
10	0.5679	0.1798	0.1431			7.25%
20	1.046	0.3425	0.2814			3.94%
30	1.006	0.3624	0.3195			3.07%
40	0.7444	0.3039	0.2909			2.46%
50	0.7889	0.3124	0.2957			6.40%
60	8.2757	2.0714	0.0355	0.3123	0.1799	8.21%
70	1.6660	0.4352	0.2859			8.54%

These values have been interpolated from the graphical data of Mustyatsa, Velikanov and Novik (classical ac technique) [224].

TABLE 451. As_2S_3-Na_2S: Specific conductance ($ohm^{-1}cm^{-1}$)

	Mol percent Na_2S								
T (K)	90	80	70	60	50	40	30	20	10
730						0.136	0.088	0.057	0.024
750						0.176	0.122	0.075	0.034
770				0.426	0.289	0.218	0.156	0.096	0.045
790				0.486	0.343	0.262	0.192	0.118	0.058
810				0.547	0.397	0.306	0.228	0.142	0.072
830	1.282	1.098	0.868	0.609	0.453	0.352	0.265	0.168	0.087
850	1.366	1.204	0.937	0.673	0.510	0.399	0.303	0.196	0.104
870	1.461	1.305	1.007	0.737	0.568	0.448	0.341	0.225	0.121
890	1.567	1.402	1.079	0.803	0.627	0.498	0.380	0.257	0.140
910	1.683	1.493	1.153	0.869	0.688	0.549	0.419	0.290	0.160
930	1.809	1.580	1.229	0.937	0.749	0.602	0.460	0.326	0.182
950	1.946	1.662	1.306	1.006	0.812	0.655	0.501	0.363	0.204
970	2.093	1.739	1.384	1.077	0.875	0.711	0.542	0.402	0.228

temperature-dependent equations

$\kappa = a + bT + cT^2$

Mol % Na_2S	-a	$-b \cdot 10^2$	$c \cdot 10^5$	standard error of est.
10	-0.5119	0.1812	0.1567	3.98%
20	-0.6723	0.2559	0.2351	1.10%
30	0.6876	-0.0435	0.0858	3.60%
40	0.4498	0.0396	0.1642	1.25%
50	0.8989	-0.0440	0.1431	1.59%
60	1.0098	-0.0764	0.1429	1.23%
70	0.5603	-0.0037	0.2028	1.14%
80	7.5068	-1.5323	-0.5970	2.20%
90	-6.9703	1.7674	1.3037	1.08%

These values have been interpolated from the graphical data of Mustyatsa and Velikanov (classical ac technique) [225].

TABLE 452. Bi_2S_3-K_2S

Specific conductance ($ohm^{-1}cm^{-1}$)

	Mol percent K_2S				
T(K)	69.44	60	49.44	40	30.60
1023			0.0121	0.0203	
1073		0.0077	0.0148	0.0233	
1123	0.0060	0.0104	0.0181	0.0290	0.0405
1173	0.0082	0.0132	0.0219	0.0351	0.0466
1223	0.0110	0.0164	0.0258	0.0384	0.0564

	Mol percent K_2S			
T(K)	29.44	20.7	10	0
1023	0.0290	0.0356	0.0438	0.0510
1073	0.0345	0.0422	0.0510	0.0597
1123		0.0515	0.0641	0.0773
1173		0.0608	0.0762	0.0932
1223		0.0668	0.0833	0.1019

These values have been interpolated from [166] (classical ac technique).

TABLE 453. Co_4S_3-Cu_2S

Specific conductance ($ohm^{-1}cm^{-1}$)

	Mol percent Cu_2S			
T (K)	94.92	89.30	82.9	75.8
1470	443.84	693.95	1850.0	2938.5
1510	462.51	802.36	1877.5	2973.5
1550	484.45	898.39	1906.0	3009.3
1590	509.65	982.02	1935.5	3046.1
1630	538.11	105.33	1966.1	3083.7
1670	569.83	111.21	1997.6	3122.3
1710	604.82	115.86	2030.1	3161.7
1750	643.07	119.26	2063.7	3202.1
1770	663.42	120.50	2080.8	3222.6

	Mol percent Cu_2S		
T (K)	47.1	34.2	18.9
1470	5618.0	6329.1	6329.2
1530	5618.0	6329.1	6288.5
1570	4618.0	6329.1	6258.0
1610	5618.0	6329.1	6224.8
1650	5618.0	6329.1	6189.0
1690	5618.0	6329.1	6150.5
1730	5618.0	6329.1	6109.2
1770	5618.0	6329.1	6065.3

temperature-dependent equations

$\kappa = a + bT + cT^2$

Mol % Cu_2S	a	-b	$c \cdot 10^2$	Std. err. of est.
0	22541.45	20.2890	0.5444	1.76%
18.9	5436.44	-1.8420	-0.0839	1.10%
34.2	6329.1			
47.1	5618.0			
58	5696.84	1.7681	0.0791	0.08%
67.6	2995.02	-0.2164	0.0148	0.01%
75.8	2277.79	-0.0363	0.0281	0.01%
82.9	1532.40	0.2435	0.0312	0.01%
89.3	-11885.08	-14.2490	-0.0038	3.45%
94.92	2020.83	2.5716	0.1019	0.25%
100	260.482	0.3099	0.0132	0.22%

These values are based on [226] (ac technique).

TABLE 454. Co_4S_3-Cu_2S: Density ($g \cdot cm^{-3}$)

T = 1473 K

Mol % Cu_2S	ρ
100	5.45
90	5.38
80	5.30
70	5.22
60	5.12
50	5.00
40	4.89
30	4.74
20	4.59
10	4.43
0	4.26

composition-dependent equation

$$\rho = 4.2632 + 1.7759\ C - 0.59319\ C^2$$

[C = Mol % Cu_2S]

standard error of estimate = 0.32%

ıese values are based on the data of Barmin, Esin ıd Dobrovinskii (maximum bubble pressure method) .55]. Within the limits of the experimental :chnique (±5%) the experimental data may be ex-·essed by the above equation.

TABLE 455. Co_4S_3-Cu_2S: Viscosity (cp)

Mol % Cu_2S	1473 (K)	1773 (K)
100	4.27	2.74
90	3.83	2.59
80	3.43	2.42
70	3.07	2.23
60	2.76	2.05
50	2.50	1.88
40	2.31	1.74
30	2.18	1.64
20	2.12	1.58
10	2.14	1.59
0	2.24	1.67

TABLE 455. Co_4S_3-Cu_2S: Viscosity - CONTINUED

composition-dependent equations

$$\eta = a + bC + cC^2 + dC^3 \quad [C = \text{Mol \% } Cu_2S]$$

T (K)	a	-b	c	-d
1473	2.2434	1.4679	4.4565	0.9624287
1773	1.6744	0.1241	4.3305	2.020684

These values are based on the data of Barmin, Esin and Dobrovinskii (logarithmic damping of corundum crucible) [155]. At 1437 K, the experimental values for 70, 30 and 0 mol % Cu_2S are respectively 2.95, 2.10 and 2.30. With the exception of these three compositions, the results may be expressed by the equations above, with standard error of estimates of 3.1% and 1.9% respectively at 1473 K and 1773 K.

TABLE 456. Co_4S_3-FeS: Specific conductance ($ohm^{-1}cm^{-1}$)

T = 1773 (K)

Mol % FeS	κ
100	1432.50
90	2103.50
80	2615.37
70	2991.01
60	3253.33
50	3425.22
40	3529.60
30	3589.35
20	3627.39
10	3666.62
0	3729.93

composition-dependent equation

$$\kappa = 3729.92 - 829.886\ C + 2349.4\ C^2 - 3817.00\ C^3 \quad [C = \text{Mol \% FeS}]$$

standard error of estimate = 1.16%

These values are based on the data of Barmin, Esin and Dobrovinskii (classical ac technique) [226].

TABLE 457. Co_4S_3-FeS: Density ($g \cdot cm^{-3}$)

T = 1523 (K)

Mol % Co_4S_3	ρ
100	3.76
90	4.25
80	4.59
70	4.82
60	4.94
50	4.97
40	4.92
30	4.81
20	4.66
10	4.48
0	4.29

composition-dependent equation

$\rho = 4.2885 + 1.93754\ C + 0.130478\ C^2 - 2.59386\ C^3$ [C = Mol % FeS]

standard error of estimate = 0.86%

These values are based on the data of Dobrovinskii, Esin and Barmin (maximum bubble pressure method) [154] [156]. Between the composition range 62-49 mol % Co_4S_3, the density appears to pass through a sharp maximum.

TABLE 458. Co_4S_3-FeS: Viscosity (cp)

Mol % FeS	1523 (K)	1773 (K)
100	3.37	2.44
90	2.84	2.09
80	2.44	1.83
70	2.16	1.66
60	1.99	1.55
50	1.90	1.50
40	1.87	1.50
30	1.92	1.53
20	1.99	1.57
10	2.07	1.62
0	2.16	1.65

TABLE 458. Co_4S_3-FeS: Viscosity - CONTINUED

composition-dependent equations

$\eta = a + bC + cC^2 + dC^3$ [C = Mol % FeS]

T (K)	a	-b	-c	d
1523	2.1561	0.7825	0.8846	2.8815
1773	1.6546	0.2856	1.1259	2.1963

These values are based on the data of Dobrovinskii Esin and Barmin (logarithmic damping of corundum crucible) [154] [156]. The precisions of the composition-dependent equations are 1.7% and 1.4% respectively at 1523 K and 1773 K.

TABLE 459. Co_4S_3-Ni_3S_2: Specific conductance ($ohm^{-1}cm^{-1}$)

T = 1773 (K)

Mol % Ni_3S_2	κ
100	3856.38
90	3764.61
80	3696.28
70	3648.91
60	3619.99
50	3607.06
40	3607.63
30	3619.20
20	3639.30
10	3665.43
0	3695.11

composition-dependent equation

$\kappa = 3695.114 - 306.292\ C + 53.240\ C^2 + 414.320\ C^3$ [C = Mol % Ni_3S_2]

standard error of estimate = 0.29%

These values are based on the data of Barmin, Esin and Dobrovinskii (classical ac technique) [226].

TABLE 460. Co_4S_3-Ni_3S_2: Density ($g \cdot cm^{-3}$)

T = 1523 (K)

Mol % Ni_3S_2	ρ
100	5.18
90	5.30
80	5.37
70	5.40
60	5.37
50	5.30
40	5.18
30	5.02
20	4.82
10	4.58
0	4.30

composition-dependent equation

$$\rho = 4.29993 + 3.0004\ C - 1.89039\ C^2 - 0.229239\ C^3 \quad [C = \text{Mol \% } Ni_3S_2]$$

standard error of estimate = 0.42%

se values are based on the data of Dobrovinskii n and Barmin (maximum bubble pressure method) 6].

TABLE 461. Co_4S_3-Ni_3S_2: Viscosity (cp)

Mol % Ni_3S_2	1523 (K)	1773 (K)
100	3.50	2.55
90	2.86	2.39
80	2.48	2.22
70	2.24	2.04
60	2.07	1.87
50	1.92	1.72
40	1.78	1.61
30	1.66	1.53
20	1.62	1.50
10	1.74	1.54
0	2.15	1.64

composition-dependent equations

$$\eta = a + bC + cC^2 + dC^3 + eC^4 \quad [C = \text{Mol \% } Ni_3S_2]$$

T (K)	a	b	c	d	e
1523	2.147	5.953	21.673	28.264	13.896
1773	1.643	1.480	4.188	1.805	

These values are based on the data of Dobrovinskii, Esin and Barmin (logarithmic damping of corundum crucible) [156]. The precision of the above equations are 1.3% and 1.0% at 1523 K and 1773 K, respectively.

TABLE 462. Cu_2S-FeS: Specific conductance ($ohm^{-1}cm^{-1}$)

	Mol percent FeS						
T(K)	100	84.4	77.1	64.1	49.4	37.6	0
1270				397.4			
1290				415.8			
1310				432.7			
1330				448.1	286.4	202.0	
1350				462.1	311.7	223.9	
1370		917.5	809.9	474.6	334.0	244.6	41.9
1390		922.1	810.7	485.6	353.6	264.0	49.8
1410		924.2	811.6	495.2	370.7	282.2	57.4
1430	1562.4	927.4	812.4	503.3	385.6	299.0	64.8
1450	1557.6	930.3	813.2	509.9	398.4	314.6	72.0
1470	1552.7	933.0	814.0	515.1	409.5	328.9	79.0
1490	1547.8	935.5	814.8	518.8	419.0	341.8	85.7
1510	1542.9	937.9	815.6	521.0	427.2	353.5	92.3
1530	1537.9	940.0	816.4	521.8	434.3	364.0	98.6
1550	1532.8	942.0	817.1	521.1	440.5	373.1	104.7
1570	1527.7	943.8	817.9	518.9	446.1	381.0	110.6
1590	1522.6	945.3	818.6	515.3	451.4	387.5	116.3
1610	1517.4	946.7	819.4	510.2	456.5	392.8	121.8
1630	1512.1	947.9	820.1		461.6	396.9	127.0
1650	1506.8	949.0	820.8		467.1	399.6	132.1
1670	1501.4	949.8	821.5		473.2	401.0	136.9
1690	1496.0	950.4	822.2				141.5
1710	1490.6	950.9	822.9				145.9
1730	1485.1	951.1	823.6				150.1
1750	1479.5	951.2	824.2				154.0
1770	1473.9	951.0	824.9				157.8

temperature-dependent equations

$$\kappa = a + bT + cT^2 + dT^3$$

Mol % FeS	-a	b	$-c.10^3$	$d.10^5$	Standard error of est.
0	1007.56	1.1348	0.2691		6.57%
37.6	4137.65	5.3951	1.6031		1.70%
49.4	19976.18	37.7281	23.3773	0.4861	1.05%
64.1	3771.60	5.6104	1.8328		0.85%
77.1	-727.34	0.0777	0.0128		0.00%
84.4	-225.70	0.8307	0.2378		0.00%
100	-1770.17	-0.0524	0.0649		0.00%

These values are based on the data of Pound, Derge and Osuch (classical ac method) [227].

TABLE 463. Cu_2S-FeS: Specific conductance

temperature-dependent equations for the Barmin study [226]

$\kappa = a + bT + cT^2$

Mol % FeS	a	-b	$c.10^3$	Standard error of est.
0	265.60	0.3163	0.1342	0.19%
16.8	359.32	0.4295	0.1750	0.10%
31.2				
43.6	244.45	0.1165	0.0763	0.01%
54.8	633.00	0.5384	0.2117	0.80%
61.5	91.92	-0.2429	-0.0365	0.24%
73.1	353.30	-0.0251	0.0249	0.00%
81.0	588.2			
88.0	1513.45	0.7711	0.1890	0.11%
94.4	2950.80	1.7164	0.3476	0.04%
100	6561.66	5.2202	1.3128	0.81%

The results of Barmin et al. [226] are about 10% higher than those of the study by Pound [TABLE 462].

TABLE 464. Cu_2S-FeS: Density ($g \cdot cm^{-3}$)

T = 1523 (K)

Mol % FeS	ρ
100	3.73
90	3.87
80	4.01
70	4.16
60	4.31
50	4.47
40	4.64
30	4.81
20	4.98
10	5.16
0	5.35

composition-dependent equation

$\rho = 5.351048 - 1.89789\ C + 27971\ C^2$

[C = Mol % FeS]

standard error of estimate = 0.85%

TABLE 465. Cu_2S-FeS: Viscosity (cp)

Mol % FeS	1473 (K)	1773 (K)
100	3.71	2.37
90	2.99	2.25
80	2.57	2.12
70	2.36	2.00
60	2.28	1.90
50	2.27	1.84
40	2.34	1.83
30	2.49	1.90
20	2.80	2.06
10	3.36	2.32
0	4.28	2.71

composition-dependent equations

$\eta = a + bC + cC^2 + dC^3 + eC^4$ [C = Mol % FeS]

T(K)	a	-b	c	-d	e
1473	4.275	11.53	26.15	29.24	14.05
1773	2.71	4.57	7.06	2.83	

These values are based on the data of Barmin, Esin and Dobrovinskii [154,155].

TABLE 466. Cu_2S-Ni_3S_2: Specific conductance ($ohm^{-1}cm^{-1}$)

Mol percent Ni_3S_2

T (K)	100	85.5	72.5	60.6	50	39.8
1470	9970.6	10000	9090.9	7692.3	6087.1	3029.0
1510	7805.4	10000	9090.9	7692.3	6160.0	3047.4
1550	6074.8	10000	9090.9	7692.3	6227.2	3066.0
1590	4778.8	10000	9090.9	7692.3	6288.7	3084.9
1630	3917.4	10000	9090.9	7692.3	6344.5	3104.0
1670	3490.6	10000	9090.9	7692.3	6394.6	3123.5
1710	3498.3	10000	9090.9	7692.3	6438.9	3143.1
1750	3940.7	10000	9090.9	7692.3	6477.6	3163.1
1770	4324.8	10000	9090.9	7692.3	6494.8	3173.2

Mol percent Ni_3S_2

T (K)	30.7	22.1	14.2	6.85	0
1470	1871.8	1018.2	740.0	343.6	897.3
1530	1355.2	1039.9	756.6	360.0	954.7
1570	1303.2	1054.9	768.2	370.8	997.3
1610	1485.3	1070.3	780.2	381.7	104.3
1650	1901.3	1086.1	792.6	392.6	109.3
1690	2551.2	1102.4	805.5	403.4	114.6
1730	3435.1	1119.1	818.7	414.3	120.2
1770	4553.1	1136.3	832.3	425.1	126.2

temperature-dependent equations

$\kappa = a + bT + cT^2$

Mol % Ni_3S_2	a	-b	$c.10^3$	standard error of est.
0	192.08	0.2283	0.1080	0.10%
6.85	-66.07	-0.2844	-0.0039	0.33%
14.2	616.63	0.1020	0.1265	0.01%
22.1	789.32	0.0417	0.1343	0.34%
30.7	178968.0	227.9502	73.1133	27.88%
39.8	2538.9	-0.2112	0.0830	0.00%
50.0	-547.4	-7.1331	-1.7822	0.21%
60.6	7692.3			
72.5	9090.9			
82.5	10000.0			
100.0	390995.5	458.8387	0.1358	20.50%

These values are based on the data of Barmin, Esin and Dobrovinskii (classical ac technique) [226].

TABLE 467. Cu_2S-Ni_3S_2: Density ($g \cdot cm^{-3}$)

T = 1473 (K)

Mol % Ni_3S_2	ρ
100	5.28
90	5.35
80	5.39
70	5.41
60	5.42
50	5.41
40	5.40
30	5.39
20	5.39
10	5.39
0	5.41

composition-dependent equation

$$\rho = 5.41259 - 0.30592\ C + 1.04885\ C^2 - 0.874043\ C^3$$

standard error of estimate = 0.45%

These values are based on the data of Barmin, Esin and Dobrovinskii (maximum bubble pressure method) [155].

TABLE 468. Cu_2S-Ni_3S_2: Viscosity (cp)

Mol % Ni_3S_2	1473 (K)	1773 (K)
100	4.11	2.54
90	3.27	2.16
80	2.68	1.92
70	2.31	1.79
60	2.14	1.76
50	2.15	1.82
40	2.32	1.94
30	2.63	2.11
20	3.07	2.31
10	3.60	2.52
0	4.22	2.73

TABLE 468. Cu_2S-Ni_3S_2: Viscosity - CONTINUED

composition-dependent equations

$\eta = a + bC + cC^2 + dC^3$ [C = Mol % Ni_3S_2]

T(K)	a	-b	c	d
1473	4.219	6.4936	3.045	3.336
1773	2.733	2.0414	-0.990	2.835

The precisions of these two equations are 3.6% and 1.0% at 1473 K and 1773 K respectively. These values are based on the data of Barmin, Esin and Dobrovinskii (oscillational technique) [155]. The experimental value at 90 mol % Ni_3S_2 = 1.95 at 1473 K appears to be an error.

TABLE 469. FeS-Ni_3S_2: Specific conductance ($ohm^{-1}cm^{-1}$)

T = 1773 (K)

Mol % FeS	κ
1.00	1368.9
0.90	1875.8
0.80	2325.2
0.70	2717.0
0.60	3051.2
0.50	3328.0
0.40	3547.2
0.30	3708.9
0.20	3813.1
0.10	3859.8
0.0	3848.9

composition-dependent equation

$$\kappa = 3848.889 + 0.39629\ x10^3C - 0.28762\ x10^4C^2$$

[C = mol % FeS]

standard error of estimate = 1.54%

These values are from the data of Barmin, Esin and Dobrovinskii (classical ac technique) [226].

TABLE 470. FeS-Ni_3S_2: Density ($g \cdot cm^{-3}$)

T = 1523 (K)

Mol % Ni_3S_2	ρ
100	3.68
90	3.92
80	4.14
70	4.34
60	4.52
50	4.68
40	4.82
30	4.95
20	5.05
10	5.14
0	5.21

composition-dependent equation

$$\rho = 5.21070 - 0.59255\ C - 0.934720\ C^2$$

[C = Mol % Ni_3S_2]

standard error of estimate = 0.29%

These values are from the data of Dobrovinskii, Esin and Barmin (maximum bubble pressure method) [154,156].

TABLE 471. FeS-Ni_3S_2: Viscosity (cp)

Mol % Ni_3S_2	1523 (K)	1773 (K)
100	3.40	2.45
90	3.24	2.38
80	3.05	2.29
70	2.86	2.20
60	2.70	2.11
50	2.59	2.05
40	2.55	2.03
30	2.61	2.07
20	2.79	2.17
10	3.11	2.36
0	3.61	2.66

temperature-dependent equations

$$\eta = a + bC + cC^2 + dC^3$$

T(K)	a	b	c	d
1523	3.605	-5.872	9.676	-4.009
1773	2.659	-3.505	5.875	-2.582

These values are from the data of Dobrovinskii, Esin and Barmin (oscillational technique) [154,156]. The precision of the equations are 1.2% and 1.3% at 1523 K and 1773 K, respectively.

TABLE 472. GeS_2-K_2S

Specific conductance ($ohm^{-1}cm^{-1}$)

	Mol percent K_2S				
(K)	55	50	40	30	16.6
380		0.493	0.199	6.102	0.021
390		0.537	0.213	0.115	0.027
900		0.582	0.227	0.128	0.032
910		0.626	0.242	0.141	0.038
920	0.451	0.669	0.256	0.154	0.044
930	0.487	0.712	0.270	0.166	0.051
940	0.522	0.755	0.285	0.179	0.058
950	0.557	0.798	0.299	0.192	0.065
960	0.591	0.840	0.313	0.205	0.073
970	0.625	0.881	0.328	0.218	0.081
980	0.657	0.923	0.342	0.231	0.090
990	0.689	0.963	0.356	0.244	0.098
000	0.721	1.004	0.371	0.257	0.108
010	0.751	1.044	0.385	0.270	0.117
020	0.781	1.084	0.399	0.283	0.127
030	0.810	1.123	0.414	0.296	0.137
040	0.839	1.162	0.428	0.309	0.148
050	0.867	1.201	0.442	0.322	0.159
060	0.894	1.239	0.457	0.335	0.170
070	0.921	1.277	0.471	0.348	0.182
080	0.946	1.314	0.485	0.361	0.194
090	0.972	1.352	0.500	0.374	0.207
100	0.996	1.388	0.514	0.387	0.220
110	1.020	1.425	0.528	0.400	0.233
120	1.043	1.461	0.543	0.413	0.247

temperature-dependent equations

$\kappa = a + bT + cT^2$

l % $_2S$	-a	$b \cdot 10^2$	$c \cdot 10^5$	Standard error of est.
.6	-1.0053	-0.2733	0.1835	10.37%
0	1.0381	0.1295		4.23%
0	1.0621	0.1432		0.90%
0	4.9285	0.7831	-0.1898	1.47%
5	5.8109	0.9965	-0.3433	0.61%
.79	3.0702	0.4725	-0.1185	1.15%

ese values have been interpolated from the aphical data of Malinovskii, Shevchuk and likanov (classical ac technique) [228].

TABLE 473. K_2S-SnS

Specific conductance ($ohm^{-1}cm^{-1}$)

	Mol percent SnS			
T (K)	90	80	70	60
920				0.468
940				0.518
960				0.567
980				0.615
1000				0.662
1020	1.662	0.817	0.720	0.708
1040	1.923	0.903	0.786	0.753
1060	2.203	0.991	0.849	0.796
1080	2.502	1.083	0.910	0.838
1100	2.821	1.177	0.967	0.879
1120	3.158	1.275	1.022	0.919
1140	3.515	1.376	1.074	0.958
1160	3.891	1.481	1.123	0.995
1180	4.286	1.588	1.170	1.031
1200	4.700	1.699	1.213	1.066
1220	5.133	1.813	1.254	1.100
1230	5.357	1.871	1.274	1.117

temperature-dependent equations

$\kappa = a + bT + cT^2$

Mol % SnS	-a	$b \cdot 10^2$	$-c \cdot 10^5$	Standard error of est.
40	9.5377	1.5212	0.4991	0.01%
50	3.3083	0.5720	0.1729	0.57%
60	3.1363	0.5281	0.1482	1.92%
70	6.3608	1.0512	0.3500	0.00%
80	-0.6947	-0.3939	-0.3980	0.01%
90	-13.7267	-3.6228	-2.3922	0.02%

These values have been interpolated from [228] (classical ac technique).

TABLE 474. Na_2S-PbS

Specific conductance ($ohm^{-1}cm^{-1}$)

	Mol percent PbS					
T(K)	76.8	70	63.4	57	45.6	40
870			1.31			
890			1.39			
910			1.47			
930			1.54			1.59
950			1.62			1.64
970			1.71			1.71
990			1.80			1.79
1010			1.90			1.88
1030			2.01			1.99
1050			2.13			2.11
1070			2.27	2.13		2.24
1090			2.43	2.33	2.10	2.39
1110			2.62	2.56	2.19	2.55
1130			2.81	2.80	2.29	2.72
1150			3.04	3.06	2.42	
1170			3.30	3.34	2.56	
1190			3.58		2.71	
1210			3.90		2.88	
1230			4.25		3.07	
1250		9.08	4.64			
1270		1.01	5.07			
1290	20.81	1.12	5.54			
1310	22.97	1.25	6.05			

temperature-dependent equations

$$\kappa = a + bT + cT^2 + dT^3$$

Mol % PbS	a	-b	$c \cdot 10^4$	$d \cdot 10^7$	Standard error of est.
30	14.1545	0.02927	0.1695		4.43%
40	14.1545	0.02927	0.1695		4.43%
45.6	22.2497	0.04101	0.2067		1.21%
57	18.3195	0.04003	0.2327		1.40%
63.4	-38.2096	-0.12305	-1.3092	0.4792	3.30%
70	260.9044	0.44761	1.9693		1.24%
76.8	-78.4490	-0.04644	0.2364		0.03%
92.7	-1660.207	-2.28229	-7.2090		1.39%

These values have been interpolated from [229], for (40,30) mol % PbS are the same.

TABLE 475. Na_2S_x: Specific conductance ($ohm^{-1}cm^{-1}$)

Sodium polysulfide

T(K)	$Na_2S_{2.9}$	$Na_2S_{3.0}$	$Na_2S_{3.2}$	$Na_2S_{3.8}$	$Na_2S_{4.2}$	$Na_2S_{5.1}$
430				0.0044		
440				0.0084		
460			0.0311	0.0227	0.0123	
480			0.0640	0.0476	0.0301	0.0215
500			0.1114	0.0843	0.0589	0.0440
520			0.1724	0.1328	0.0993	0.0767
540			0.2455	0.1923	0.1506	0.1192
560			0.3288	0.2614	0.2118	0.1708
580			0.4202	0.3386	0.2812	0.2302
600		0.5613	0.5179	0.4224	0.3574	0.2963
620		0.6679	0.6202	0.5114	0.4390	0.3675
640		0.7771	0.7256	0.6043	0.5245	0.4428
680	1.001	0.9990	0.9412	0.7975		0.6014
690	1.060	1.055	0.9954	0.8467		

temperature-dependent equations

$$\kappa = A \exp [-E_\kappa/R(T-T_o)]$$

Melt	Wt % S	Temp. range (K)	A ($ohm^{-1}cm^{-1}$)	E cal mol^{-1}	T_o (K)	Standard error of estimate
$Na_2S_{2.1}$	60.0	728-840	5.4770	736.1	499	1.3%
$Na_2S_{2.9}$	66.1	642-698	3.8590	595.4	458	0.9%
$Na_2S_{3.0}$	67.5	582-693	7.0407	1362	329	0.5%
$Na_2S_{3.2}$	70.1	458-694	7.0650	1402	330	1.0%
$Na_2S_{3.8}$	72.3	428-694	7.0860	1541	325	0.7%
$Na_2S_{4.2}$	74.8	456-671	6.2783	1475	341	1.4%
$Na_2S_{5.1}$	77.8	477-681	5.7935	1513	344	1.0%

These values are based on the data of [164] (Wayne-Kerr ac technique).

TABLE 476. Na_2S_x: Density $g.cm^{-3}$

Sodium polysulfides

T(K)	$Na_2S_{3.0}$	$Na_2S_{3.3}$	$Na_2S_{3.7}$	$Na_2S_{4.4}$	$Na_2S_{4.8}$
570			1.9426		
590		1.9089	1.9317	1.8756	1.8834
610	1.8818	1.8929	1.9208	1.8622	1.8691
630	1.8705	1.8770	1.9099	1.8489	1.8547
650	1.8592	1.8610	1.8990	1.8356	1.8404
680	1.8422	1.8370		1.8156	1.8190

temperature-dependent equations

$$\rho = a + bT$$

Melt	Wt % S	Temp. range (K)	a	$-b \times 10^3$	Standard error of estimate
$Na_2S_{3.0}$	67.6	590-683	2.2270	0.5658	0.18%
$Na_2S_{3.3}$	69.7	576-689	2.3802	0.7989	0.40%
$Na_2S_{3.7}$	72.0	563-669	2.2538	0.5459	0.13%
$Na_2S_{4.4}$	75.4	571-680	2.2687	0.6664	0.26%
$Na_2S_{4.8}$	77.0	573-683	2.3056	0.7156	0.27%

These values are based on the data of [163] (modified dilatometric technique).

TABLE 477. Na_2S_x: Viscosity (cp)

Sodium polysulfides

T(K)	$Na_2S_{3.1}$	$Na_2S_{3.3}$	$Na_2S_{3.6}$	$Na_2S_{3.9}$	$Na_2S_{4.1}$	$Na_2S_{4.3}$	$Na_2S_{4.7}$	$Na_2S_{5.2}$
540				75.03				
560			50.43	48.02			59.38	
580	33.76		34.84	32.96		36.39	38.53	
600	24.87	25.53	25.50	23.91	25.39	25.32	26.85	
620	19.12	19.67	19.51	18.12	19.13	18.76	19.75	19.37
660						11.77		
670						10.70		

temperature-dependent equations

$$\eta = A \exp[E_\eta/R(T-T_o)]$$

Melt	Wt % S	Temp. range (K)	A (cp)	E_η (cal mol^{-1})	T_o (K)	Standard error of estimate
$Na_2S_{3.1}$	68.4	577-653	0.5624	2018	332	0.5%
$Na_2S_{3.3}$	70.0	589-647	0.3370	2683	288	0.1%
$Na_2S_{3.6}$	71.7	558-646	0.6193	1906	342	0.2%
$Na_2S_{3.9}$	73.1	533-652	0.4046	2221	326	0.8%
$Na_2S_{4.1}$	74.0	587-641	0.4070	2234	328	0.2%
$Na_2S_{4.3}$	75.1	572-675	0.8071	1438	390	0.4%
$Na_2S_{4.7}$	76.8	557-654	0.4684	1963	356	0.6%
$Na_2S_{5.2}$	78.5	620-648	1.7411	742.1	465	0.3%

These values are based on the data of Cleaver and Davies (modified capillary method) [163].

TABLE 478. Na_2S_x: Surface tension (dyn cm^{-1})

Sodium polysulfides

T(K)	$Na_2S_{3.0}$	$Na_2S_{3.1}$	$Na_2S_{3.3}$	$Na_2S_{3.6}$	$Na_2S_{3.9}$	$Na_2S_{4.1}$	$Na_2S_{4.3}$	$Na_2S_{4.7}$	$Na_2S_{4.8}$	$Na_2S_{5.2}$
550					133.86					
580					132.79	129.38		128.64		
610	173.19	164.12	151.98	141.29	131.71	127.64	127.20	126.52		
640	171.37	160.53	150.03	140.27	130.63	125.90	125.18	124.39	124.37	113.78
670	169.55	156.94	148.09	139.26	129.55		123.16	122.23	121.63	

temperature-dependent equations

$$\gamma = a + bT$$

Melt	Wt % S	Temp. range (K)	a	$-b \times 10^3$	Standard error of estimate
$Na_2S_{3.0}$	67.7	583-691	210.22	60.70	0.4%
$Na_2S_{3.1}$	68.5	588-673	237.21	119.8	0.4%
$Na_2S_{3.3}$	69.7	586-671	191.61	64.96	0.3%
$Na_2S_{3.6}$	71.5	589-677	162.00	33.95	0.2%
$Na_2S_{3.9}$	72.4	539-676	153.62	35.92	0.2%
$Na_2S_{4.1}$	74.0	556-641	163.08	58.09	0.4%
$Na_2S_{4.3}$	75.1	602-676	168.25	67.29	1.0%
$Na_2S_{4.7}$	76.3	562-671	169.80	71.00	0.5%
$Na_2S_{4.8}$	76.8	625-688	182.95	91.53	1.2%
$Na_2S_{5.2}$	78.4	616-661	138.74	39.01	0.4%

These values are based on the data of Cleaver and Davies (maximum bubble pressure method) [163].

TABLE 479. Na_2S-Sb_2S_3: Specific conductance ($ohm^{-1}cm^{-1}$)

Mol percent Sb_2S_3

(K)	100	84.8	83	70.4	55.2	41.1	35	28.5	20	13.5	0
920	0.396	0.531	0.543	0.812	1.031	1.029	1.071	1.289	1.303	1.506	
960	0.592	0.723	0.724	0.848	1.106	1.165	1.220	1.420	1.491	1.755	
000	0.857	0.961	0.945	0.925	1.196	1.291	1.376	1.558	1.677	1.994	
040	1.205	1.250	1.207	1.068	1.314	1.416	1.537	1.703	1.862	2.223	
080	1.652	1.594	1.514	1.299	1.472	1.547	1.704	1.854	2.048	2.443	
120	2.215	1.997	1.869	1.642	1.683	1.695	1.877	2.011	2.234	2.655	
160	3.261	2.654	2.360	2.121	1.957	1.868	2.054	2.174	2.422	2.859	
200	5.380	4.039	3.294	2.759	2.308	2.074	2.237	2.341	2.613	3.056	
240	7.458	5.516	3.960	3.580	2.747	2.323	2.425	2.512	2.807	3.246	3.777
280	14.926	9.187	6.929	4.608	3.287	2.624	2.618	2.686	3.005	3.429	4.072
320	31.549	16.479	14.159	5.866	3.940	2.985	2.816	2.864	3.209	3.608	4.517

temperature-dependent equations

$$\kappa = a + bT + cT^2 + dT^3$$

$$\kappa = Ae^{-Ea/RT}$$

l % $_2S_3$	Temp. Range	a	b	$c \cdot 10^3$	$d \cdot 10^5$	A	E_a	Standard error of est.
0	920-1320	15.95090	0.01395	-0.05074	0.002546			0.29%
3.5	920-1320	-8.375	0.01641	-0.007561	0.000152			2.9%
0.0	920-1320	-5.504	0.01200	-0.007099	0.000227			1.9%
8.5	920-1320	1.479	-0.00474	0.006179	-0.000135			2.3%
5.0	920-1320	-0.390	-0.00081	0.002958	-0.000038			2.2%
1.1	920-1320	6.751	-0.01370	0.008203				5.1%
5.2	920-1320	19.747	-0.03923	0.020263				7.0%
0.4	920-1320	42.716	-0.08541	0.043506				11.3%
3.0	920-1120					551.777	12657.5	13.4%
	1130-1210	193.509	-0.34664	0.156772				2.5%
	1220-1330	445.935	0.42307	-1.563553	0.07539			8.3%
4.8	920-1120					886.913	13566.6	19.8%
	1130-1210	238.644	-0.43358	0.178401				1.4%
	1220-1330	361.025	0.35188	-0.130033	0.06333			2.6%
0	920-1120					6067.88	17615.2	22.9%
	1130-1210	421.808	-0.76079	0.344811				7.6%
	1220-1330	929.671	0.92108	-0.334737	0.16167			3.5%

These values have been interpolated from the graphical data of Velikanov, Mustyatsa and Delimarskii (classical ac technique) [171].

TABLE 480. Na_2S-Tl_2S: Specific conductance ($ohm^{-1}cm^{-1}$)

	Mol % Tl_2S								
T(K)	100	90	80	70	60	50	40	30	20
770	4.273	2.126	1.447	1.211	0.969	0.872			
790	4.673	2.630	1.857	1.410	1.351	1.053			
810	5.234	3.187	2.307	1.647	1.703	1.254			
830	5.945	3.798	2.797	1.922	2.030	1.475			
850	6.795	4.462	3.328	2.235	2.339	1.717			
870	7.771	5.180	3.898	2.587	2.636	1.978	1.285	1.139	0.886
890	8.862	5.952	4.509	2.976	2.929	2.260	1.700	1.143	1.012
910	10.056	6.778	5.160	3.404	3.224	2.562	2.055	1.191	1.142
930	11.341	7.657	5.851	3.869	3.526	2.883	2.364	1.282	1.278
950	12.707	8.590	6.582	4.373	3.844	3.226	2.638	1.411	1.418
970	14.139	9.577	7.353	4.915	4.182	3.588	2.889	1.578	1.564
990	15.628	10.617	8.164	5.495	4.548	3.970	3.129	1.778	1.715
1010	17.161	11.711	9.016	6.113	4.949	4.373	3.368	2.009	1.870
1030	18.727	12.859	9.908	6.769	5.390	4.796	3.620	2.269	2.031
1050	20.313	14.061	1.084	7.463	5.878	5.239	3.896	2.554	2.197
1070	21.909	15.316	1.181	8.196	6.420	5.702	4.208	2.863	2.367
1090	23.501	16.625	1.282	8.966	7.023	6.185	4.567	3.191	2.543
1110	25.079	17.987	1.388	9.775	7.692	6.689	4.986	3.536	2.724
1130	26.631	19.404	1.497	10.621	8.435	7.212	5.475	3.896	2.909
1150	28.144	20.874	1.610	11.506	9.257	7.756	6.048	4.268	3.100
1170	29.608	22.397	1.728	12.429	1.017	8.320	6.715	4.650	3.296

temperature-dependent equations

$$\kappa = a + bT + cT^2 + dT^3$$

Mol % Tl_2S	a	$-b \cdot 10^2$	$c \cdot 10^5$	$d \cdot 10^6$	Standard error of est.
20	0.2793	0.4756	0.6269		0.72%
30	24.0567	5.4785	3.2651		6.09%
40	13.7228	3.7723	2.7107		9.12%
50	9.2416	3.0276	2.5203		3.60%
60	-104.179	-33.3605	-36.0450	0.1357	6.61%
70	22.5204	6.4344	4.7622		1.79%
80	16.2011	5.7812	5.0196		1.75%
90	23.5724	7.9534	6.7119		1.42%
100	232.8014	75.4622	78.3328	-0.2451	2.11%

These values have been interpolated from the graphical data of Posukh , Shevchuk and Velikanov(classical ac technique [161].

10.9. *Thiocyanate-Thiocyanate Systems*

This section contains the studies tables the numerical tables for the physical perties of thiocyanate-thiocyanate melts. luded also are summaries of the methods l for melt preparation and purification , where possible, temperature-liquidus se diagrams.

$AgSCN-(C_3H_7)_4NSCN$

Melt Preparation and Purification

Kowalski [230] prepared the tetra-n-ylammonium thiocyanate by ion exchange tetra-n-pentylammonium iodide in 95% nol using Amberlite IRA-400 exchange ate-hexane mixture at 70°C until a melt-point of 50.0-50.5°C was achieved.

$Cd(SCH)_2-(C_3H_7)_4NSCN$

Melt Preparation and Purification

For the method of melt preparation used owalski [230] refer to $AgSCN-(C_3H_7)_4NSCN$.

$CuSCN-(C_3H_7)_4NSCN$

Melt Preparation and Purification

For the method of melt preparation of a-n-pentylammonium thiocyanate used by lski [230] refer to $AgSCN-(C_3H_7)_4NSCN$.

Reagent grade cuprous thiocyanate was d at 100°C to remove surface moisture stored under vacuum.

TABLE 481. Viscosity studies

$AgSCN-(C_3H_7)_4NSCN$

Investigations critically examined

	Mol % $(C_3H_7)_4NSCN$	Temp. range (K)	Comments
	59-98	333-373	cap. visc.

TABLE 482. Viscosity studies

$Cd(SCN)_2-(C_3H_7)_4NSCN$

Investigations critically examined

Ref.	Mol % $(C_3H_7)_4NSCN$	Temp. range (K)	Comments
230	79-99	333-373	cap. visc.

TABLE 483. Electrical conductance studies

$CuSCN-(C_3H_7)_4NSCN$

Investigations critically examined

Ref.	Mol % $(C_3H_7)_4NSCN$	Temp. range	Comments
230	49-100	325-373	cap. cell

TABLE 484. Density studies

$CuSCN-(C_3H_7)_4NSCN$

Investigations critically examined

Ref.	Mol % $(C_3H_7)_4NSCN$	Temp. range (K)	Comments
230	49-100	325-373	pyrex dilat.

TABLE 485. Viscosity studies

$CuSCN-(C_3H_7)_4NSCN$

Investigations critically examined

Ref.	Mol % $(C_3H_7)_4NSCN$	Temp. range (K)	Comments
230	50-100	333-373	cap. visc.

TABLE 486. $AgSCN-(C_3H_7)_4NSCN$: Viscosity (poise)

	Mol percent $(C_3H_7)_4NSCN$			
T (K)	96.6	84.9	73.2	58.4
330	2.380	2.883	3.588	5.095
340	1.595	1.922	2.381	3.291
350	1.006	1.204	1.479	1.962
360	0.615	0.729	0.883	1.108
370	0.421	0.497	0.593	0.729
380	0.423	0.507	0.608	0.825

temperature-dependent equations

$\eta = a + bT + cT^2$

Mol % $(C_3H_7)_4NSCN$	a	-b	$c \cdot 10^2$	Standard error of est.
58.4	331.030	1.7712	0.2374	8.71%
73.2	214.823	1.1442	0.1527	6.25%
84.9	170.736	0.9091	0.1213	6.58%
96.6	138.870	0.7388	0.09854	5.98%

These values are from the data of Kowalski (capillary viscometer) [230]

TABLE 487. $Cd(SCN)_2-(C_3H_7)_4NSCN$: Viscosity (poise)

	Mol percent $(C_3H_7)_4NSCN$			
T (K)	98.2	95.3	84.9	78.9
330	2.485	3.046	4.688	5.943
340	1.664	2.000	2.852	3.723
350	1.049	1.225	1.570	2.112
360	0.640	0.722	0.841	1.111
370	0.437	0.490	0.667	0.718

temperature-dependent equations

$\eta = a + bT + cT^2$

Mol % $(C_3H_7)_4NSCN$	a	-b	$c \cdot 10^2$	Standard error of est.
78.9	420.945	2.2627	0.3045	11.22%
84.9	375.942	2.0387	0.2768	10.74%
95.3	189.971	1.0146	0.1358	7.94%
98.2	145.373	0.7735	0.1031	6.54%

These values are from the data of Kowalski (capillary viscometer) [230].

TABLE 488. CuSCN-$(C_3H_7)_4NSCN$: Specific conductance ($ohm^{-1}cm^{-1}$) x 10^3

	Mol percent $(C_3H_7)_4NSCN$								
T(K)	100	93	81.9	74.6	69.3	62.1	56.1	50	48.3
330	0.390	0.280	0.129	0.080	0.055	0.046	0.051	0.106	
340	0.672	0.509	0.294	0.152	0.110	0.095	0.106	0.105	
350	1.055	0.821	0.519	0.294	0.228	0.211	0.236	0.194	0.153
360	1.538	1.215	0.805	0.510	0.415	0.396	0.443	0.374	0.344
370	2.122	1.693	1.152	0.804	0.673	0.655	0.734	0.643	0.577

temperature-dependent equations

$\kappa = a + bT + cT^2 + dT^3$

Mol % $(C_3H_7)_4NSCN$	a	-b	$c \cdot 10^3$	$d \cdot 10^6$	Standard error of est.
48.3	20.8383	0.1350	0.2170		5.45%
50	50.5942	0.3014	0.4498		1.99%
56.1	11.9647	-0.0030	-0.3524	0.7088	6.84%
62.1	10.6935	-0.0026	-0.3149	0.6332	6.98%
69.3	10.2745	-0.00240	-0.3031	0.6122	5.78%
74.6	10.9844	-0.00236	-0.3262	0.6635	4.47%
81.9	28.7377	0.18682	0.3034		16.59%
93	39.0848	0.25397	0.4132		3.43%
100	47.4312	0.30831	0.5023		3.33%

These values are from the work of Kowalski (classical ac technique) [230].

TABLE 489. CuSCN-$(C_3H_7)_4NSCN$: Density($g \cdot cm^{-3}$)

	Mol percent $(C_3H_7)_4NSCN$								
T(K)	100	93	81.9	74.6	69.3	62.1	56.1	50	48.3
325	0.904	0.918	0.946	0.968	0.988	1.017	1.047		
340	0.896	0.910	0.938	0.959	0.979	1.008	1.037		
355	0.887	0.902	0.930	0.951	0.971	0.999	1.028	1.063	1.075
360	0.885	0.899	0.927	0.949	0.968	0.996	1.025	1.060	1.071
370	0.879	0.894	0.921	0.943	0.962	0.990	1.019	1.054	1.065

temperature-dependent equations

$\rho = a + bT$

Mol % $(C_3H_7)_4NSCN$	a	$-b \cdot 10^3$
48.3	1.2973	0.6277
50.0	1.2923	0.6450
56.1	1.2494	0.6237
62.1	1.2076	0.5871
69.3	1.1711	0.5642
74.6	1.1434	0.5411
81.9	1.1216	0.5412
93	1.0965	0.5481
100	1.0790	0.5397

These values are based on the data of Kowalski (dilatometric technique) [230].

TABLE 490. CuSCN-$(C_3H_7)_4NSCN$: Viscosity (poise)

Mol percent $(C_3H_7)_4NSCN$

T (K)	100	93	81.9	74.6	69.3	62.1	56.1	50
330	2.379	3.294	6.320	10.683	15.633	19.698		
340	1.483	1.996	3.586	5.707	7.983	9.709		
350	0.950	1.244	2.101	3.160	4.236	4.983	4.920	6.525
360	0.623	0.796	1.268	1.808	2.329	2.654	2.735	3.542
370	0.419	0.522	0.787	1.066	1.322	1.462	1.570	1.988
380	0.287	0.350	0.501	0.647	0.773	0.832	0.928	1.150

temperature-dependent equations

$$\eta = Ae^{E/RT}$$

Mol % $(C_3H_7)_4NSCN$	$A.10^8$	$E \cdot 10^{-5}$ (cal mol^{-1})	Standard error of est.
50.0	0.1842	0.1529	1.01%
56.1	0.3272	0.1469	1.43%
62.1	0.0704	0.1577	11.42%
69.3	0.1863	0.1498	8.81%
74.6	0.5911	0.1397	7.33%
81.9	2.6990	0.1263	5.64%
93.0	13.1219	0.1117	3.60%
100.0	24.8274	0.1054	3.55%

These values are based on the data of Kowalski (capillary viscometer) [203].

10.10 *Tungstate-Tungstate Systems*

This section contains the studies tables the numerical tables for the physical erties of tungstate-tungstate melts. uded also are summaries of the methods for melt preparation and purification where possible, temperature-liquidus e diagrams.

$Bi_2(WO_4)_3$-$PbWO_4$

Melt Preparation and Purification

Brown and Morris [182] and Brown [133] reagent grade salts and dried them in an sphere of argon gas for 6 hours at 225°C. salts were stored in a desiccator until y for use.

K_2WO_4-Li_2SO_4

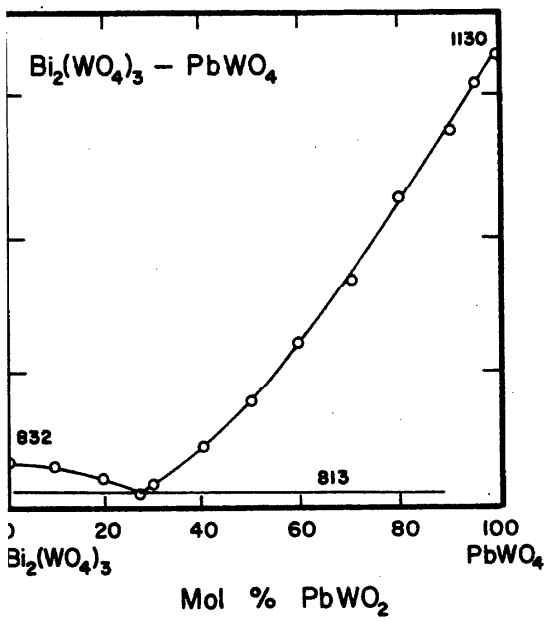
Melt Preparation and Purification

Kvist and Trolle [183] used reagent grade s without further purification. For the od of melt preparation used by Brown and is [182] and Brown [133] refer to $WO_4)_3$-$PbWO_4$.

Li_2WO_4-Na_2WO_4

Melt Preparation and Purification

For the method of melt preparation used own and Morris [182] and Brown [133] to $Bi_2(WO_4)_3$-$PbWO_4$.



URE 44. Phase diagram for $Bi_2(WO_4)_3$-$PbWO_4$.

from: F. Zambonini, Gazz. Chim. Ital. 50 128 (1920).

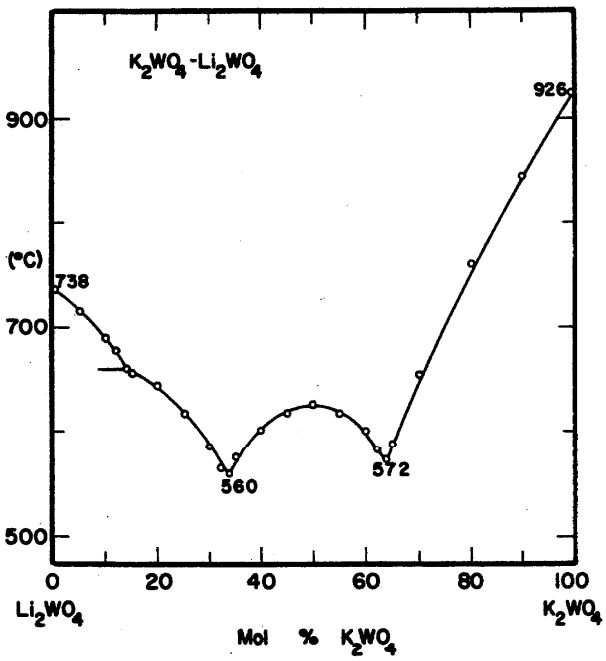


FIGURE 45. Phase diagram for K_2WO_4-Li_2WO_4.

Data from: A. G. Bergman and A. N. Kislova, Zhur. Fiz. Khim. 28, 1480 (1954).

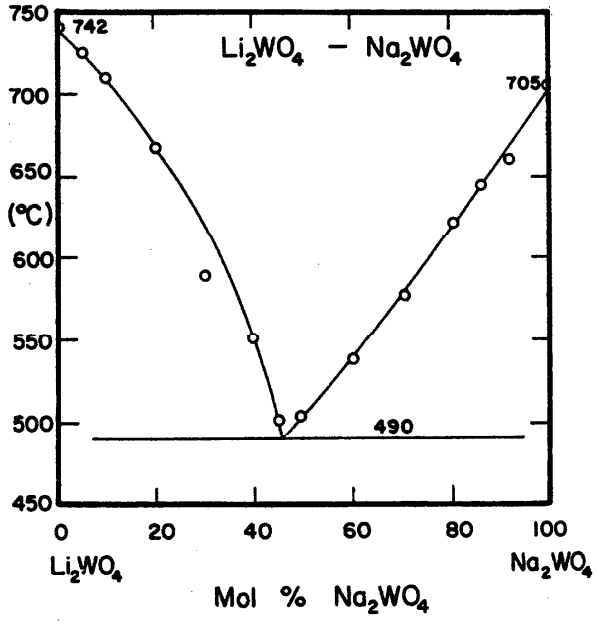


Figure 46. Phase diagram for Li_2WO_4-Na_2WO_4.

Data from: J. A. M. vanLiempt, Z. Anorg. Allg. Chem. 143, 285 (1925).

TABLE 491. Electrical conductance studies: $Bi_2(WO_4)_3$-$PbWO_4$

Investigations critically examined

Ref.	Mol % $PbWO_4$	Temp. range (K)	Comments
133 182	0-100	1122 - 1503	quartz dip cell

TABLE 492. Density studies: $Bi_2(WO_4)_3$-$PbWO_4$

Investigations critically examined

Ref.	Mol % $PbWO_4$	Temp. range (K)	Comments
133 182	0-100	1143-1504	Pt bob; Pt-Rh crucible

TABLE 493. Surface tension studies: $Bi_2(WO_4)_3$-$PbWO_4$

Investigations critically examined

Ref.	Mol % $PbWO_4$	Temp. range (K)	Comments
133	0-100	1123-1504	Pt bob

TABLE 494. Electrical conductance studies: K_2WO_4-Li_2WO_4

Investigations critically examined

Ref.	Mol % Li_2WO_4	Temp. range (K)	Comments
183	50	964-1191	quartz cap. cell; calibr. in KCl
133 182	0-100	900-1300	refer: $Bi_2(WO_4)_3$-$PbWO_4$

(Deviations from NSRDS recommendations (this vol.)

Ref.	Mol % Li_2WO_4	Min. departure	Max. departure
133 182	0	-0.17% (1301K)	-2.57% (1248K)
183	50	17.64% (1069K)	20.21% (964K)

TABLE 495. Density studies: K_2WO_4-Li_2WO_4

Investigations critically examined

Ref.	Mol % Li_2WO_4	Temp. range (K)	Comments
133 182	0-100	928-1301	refer: $Bi_2(WO_4)_3$-$PbWO_4$

Deviations from NSRDS recommendations ([1] p. 35)

Ref.	Mol % Li_2WO_4	Min. departure	Max. departure
133 182	0	-0.20% (1301K)	-0.28% (1260K)

TABLE 496. Surface tension studies: K_2WO_4-Li_2WO_4

Investigations critically examined

Ref.	Mol % Li_2WO_4	Temp. range (K)	Comments
133	0-100	867-1287	Pt bob

Deviations from NSRDS recommendations ([2] p. 74)

Ref.	Mol % Li_2WO_4	Min. departure	Max. departure
133	0	0.15% (1287K)	1.23% (1260K)

TABLE 497. Electrical conductance studies: Li_2WO_4-Na_2WO_4

Investigations critically examined

Ref.	Mol % Na_2WO_4	Temp. range (K)	Comments
133 182	0-100	812-1150	refer: $Bi_2(WO_4)_3$-$PbWO_4$

Deviations from NSRDS recommendations ([1] p. 35)

Ref.	Mol % Na_2WO_4	Min. departure	Max. departure
133 182	100	0.48% (1040K)	6.00% (1146K)

TABLE 498. Density studies: Li_2WO_4-Na_2WO_4

Investigations critically examined

Ref.	Mol % Na_2WO_4	Temp. range (K)	Comments
133 182	0-100	804-1190	refer: $Bi_2(WO_4)_3$-$PbWO_4$

Deviations from NSRDS recommendations ([1] p. 35)

Ref.	Mol % Na_2WO_4	Min. departure	Max. departure
133 182	100	0.01% (1123K)	0.25% (1039K)

The density data may also be expressed as a three-variable equation:

$$\rho = a + bT + cC + dC^2 + eT^3 + fC^3 + gTC^2 + hCT^2$$

where $a = 5.36309$, $b \cdot 10^3 = -1.16184$, $c \cdot 10^3 = -8.98957$, $d \cdot 10^4 = 1.04293$, $e \cdot 10^{11} = 8.09416$, $f \cdot 10^7 = -1.74506$, $g \cdot 10^8 = -6.81738$, $h \cdot 10^9 = 2.84594$; standard error of estimate, 0.21%; maximum percent departure, 0.53% at 85 mol % Na_2WO_4 and 943 K. The units of concentration, C, and temperature, T, are mol % (Na_2WO_4) and degrees kelvin, respectively.

TABLE 499. Surface tension studies: Li_2WO_4-Na_2WO_4

Investigations critically examined

Ref.	Mol % Na_2WO_4	Temp. range (K)	Comments
133	0-100	779-1235	Pt bob

Deviations from NSRDS recommendations ([2] p. 74)

Ref.	Mol % Na_2WO_4	Min. departure	Max. departure
133	100	-0.62% (1179K)	-1.52% (1013K)

The surface tension data may also be expressed as a three-variable equation:

$$\gamma = a + bT + cC^2 + dC^3 + eTC + fTC^2 + gCT^2$$

where $a = 310.07739$, $b \cdot 10^2 = -7.40021$, $c \cdot 10^3 = 5.56492$, $d \cdot 10^5 = -6.16041$, $e \cdot 10^3 = -1.10517$, $f \cdot 10^6 = 3.66590$, $g \cdot 10^7 = 4.27887$; standard error of estimate, 0.67%; maximum percent departure, 1.4% at 70 mol % Na_2WO_4 and 900 K. The units of concentration, C, and temperature, T, are mol % (Na_2WO_4) and degrees kelvin, respectively.

TABLE 500. $Bi_2(WO_4)_3$-$PbWO_4$: Specific conductance ($ohm^{-1}cm^{-1}$)

	Mol percent $PbWO_4$						
T(K)	100	80	60	40	27	20	0
1130					0.380	0.356	
1150				0.433	0.424	0.408	
1170				0.476	0.469	0.457	0.454
1190				0.519	0.513	0.504	0.503
1210				0.561		0.548	0.550
1230			0.593	0.602		0.589	0.596
1250			0.637	0.643			0.640
1270			0.680	0.683			0.684
1290			0.723				
1310		0.703					
1330		0.738					
1350		0.775					
1370		0.813					
1390		0.852					
1410	0.844						
1430	0.875						
1450	0.905						
1470	0.936						
1490	0.966						

temperature-dependent equations

$$\kappa = a + bT + cT^2 + dT^3$$

Mol % $PbWO_4$	$-a$	$b \cdot 10^3$	$c \cdot 10^6$	$-d \cdot 10^9$	Standard error of estimate
0	4.2371	5.5880	-1.3487		0.43%
20	6.8021	10.0138	-3.2557		0.61%
27	1.5284	0.5028	1.6332	0.5163	0.14%
40	3.0529	3.8909	-0.74741		0.27%
60	2.0713	2.1664			0.17%
80	-1.5495	-3.0048	1.8006		0.12%
100	1.3023	1.5225			0.19%

These values are based on the data of Brown and Morris [182] and Brown [133] (classical ac technique).

TABLE 501. $Bi_2(WO_4)_3$-$PbWO_4$: Density (g cm^{-3})

	Mol percent $PbWO_4$						
T (K)	100	80	60	40	27	20	0
1130						6.999	
1150				6.919		6.955	7.026
1170				6.891	6.994	6.918	6.998
1190				6.863	6.965	6.889	6.971
1210				6.835	6.936	6.867	6.945
1230				6.806	6.907	6.852	6.920
1250			6.783	6.777	6.878	6.845	6.896
1270			6.755	6.748			6.873
1290			6.728				
1310			6.702				
1330							
1350		6.605					
1370		6.582					
1390		6.559					
1410							
1430	6.484						
1450	6.463						
1470	6.444						
1490	6.426						

temperature-dependent equations

$$\rho = a + bT + cT^2 + dT^3$$

Mol % $PbWO_4$	a	b · 10^3	c · 10^6	d · 10^9	Standard error of estimate
0	10.3226	-4.3141	1.2583		0.03%
20	21.2967	-22.934	9.0984		0.25%
27	8.5352	-1.1846	-0.1132		0.00%
40	7.2656	1.2807	-1.8216	0.3873	0.01%
60	9.2677	-2.5918	0.4832		0.01%
80	8.1532	-1.1469			0.00%
100	8.1000	0.9833	-3.0018	1.0655	0.01%

These values are based on the data of Brown and Morris [182] and Brown [133] (Archimedean method).

The density data may also be expressed as a three-variable equation: $\rho = a + bT + cC + dT^3 + eTC^2$, where a = 8.84094, $b \cdot 10^3$ = -1.69370, $c \cdot 10^3$ = -2.31064, $d \cdot 10^{11}$ = 8.55740, $e \cdot 10^9$ = 3.46709; standard error of estimate, 0.41%; maximum departure, 0.84% at 27 mol % $PbWO_4$ and 1158 K. The units of concentration, C, and temperature, T, are mol % ($PbWO_4$) and degrees kelvin, respectively.

TABLE 502. $Bi_2(WO_4)_3$-$PbWO_4$: Surface tension (dyn cm^{-1})

	Mol percent $PbWO_4$						
T (K)	100	80	70	40	27	20	0
1130					196.4		
1150				203.2	194.9	203.8	214.1
1170				200.7	193.3	201.5	212.1
1190				198.3	191.8	199.2	210.1
1210			194.0	196.0	190.2	196.8	208.1
1230			191.9	193.6	188.6	194.5	206.2
1250			189.8	191.2	187.0	192.1	204.2
1270			187.7			189.8	202.2
1290			185.6				
1310							
1330		182.0					
1350		180.1					
1370		178.3					
1390		176.5					
1410							
1430	167.4						
1450	166.0						
1470	164.4						
1490	162.6						

temperature-dependent equations

$$\gamma = a + bT + cT^2 + dT^3$$

Mol % $PbWO_4$	a	$-b \cdot 10^3$	$-c \cdot 10^6$	$d \cdot 10^9$	Standard error of estimate
0	328.815	99.72			0.01%
20	338.208	116.85			0.05%
27	256.931	30.76	20.16		0.03%
40	605.836	777.16	-543.61	-149.82	0.01%
70	321.041	105.03			0.02%
80	314.166	21.86	119.84	46.289	0.02%
100	-250.373	-648.04	248.90		0.20%

These values are based on the data of Brown (pin detachment method) [133].

These values are based on the data of Brown (pin detachment method) [133]. The surface tension data may also be expressed as a three-variable equation: $\gamma = a + bC + cT^2 + dC^2 + eT^3 + fC^3 + gTC$, where $a = 313.80127$, $b = -1.56585$, $c \cdot 10^4 = -1.08045$, $d \cdot 10^2 = 1.51941$, $e \cdot 10^8 = 2.66195$, $f \cdot 10^4 = -1.04449$, $g \cdot 10^4 = 7.36886$; standard error of estimate, 2.37%; maximum departure, 4.6% at 0% $PbWO_4$ and 1207 K. The units of concentration, C, and temperature, T, are mol % ($PbWO_4$) and degrees kelvin, respectively.

TABLE 503. K_2WO_4-Li_2WO_4: Specific conductance ($ohm^{-1}cm^{-1}$)

Mol percent Li_2WO_4											
)	100	90	80.1	70	60	50	45.6	40	32	20	0
)				0.325							
)				0.374							
)				0.424				0.390			
)				0.475		0.449	0.409	0.424			
)				0.527	0.393	0.494	0.426	0.455			
)				0.579	0.429	0.539	0.442	0.483			
)				0.632	0.465	0.583	0.458	0.509			
)		1.041			0.501	0.628	0.473	0.530	0.613		
)		1.118	0.884			0.673	0.487	0.550	0.660		
)		1.198	0.956					0.566	0.706	0.584	
)	2.182	1.279	1.030						0.749	0.643	
)	2.263	1.362	1.106						0.792	0.702	
)	2.345								0.832	0.761	
)									0.871	0.820	
)									0.908		
)									0.943		
)											
)											
)											1.243
)											1.295
)											1.335

temperature-dependent equations

$$\kappa = a + bT + cT^2 + dT^3$$

Mol % Li_2WO_4	- a	b · 10^3	c · 10^6	- d · 10^9	Standard error of estimate
0	14.64877	13.4610	6.3655	5.5864	0.18%
20	2.60447	2.9522			0.70%
32	4.18502	6.8216	-2.1234		0.67%
40	4.47439	8.5812	-3.6240		1.06%
45.6	0.32851	-0.3001	2.106791	1.0356	0.77%
50	1.70311	2.2417			0.15%
60	1.36912	1.7981			0.21%
70	1.20906	0.9460	0.8422		0.80%
80.1	-0.34733	-2.5186	2.8535		0.42%
90	0.41117	-1.0259	2.3291		0.16%
100	2.29695	4.0716			0.13%

These values are based on the work of Brown and Morris [182] and Brown [133] (classical ac technique).

TABLE 504. K_2WO_4-Li_2WO_4: Density (g cm^{-3})

	Mol percent Li_2WO_4										
T(K)	100	90	80.1	70	60	50	45.6	40	32	20	0
930				3.968							
950			4.049	3.952	3.790						
970			4.032	3.937	3.775		3.640				
990			4.014	3.923	3.761	3.702	3.627	3.648			
1010			3.997	3.906	3.746	3.686	3.614	3.596	3.534		
1030		4.119	3.980	3.891	3.731	3.669	3.601	3.556	3.518		
1050	4.232	4.103	3.963	3.876	3.716	3.653	3.588	3.528	3.503		
1070	4.216	4.088	3.945	3.861	3.701	3.636		3.511	3.487		
1090	4.200	4.073	3.928	3.845		3.620		3.506	3.472	3.385	
1110	4.184	4.058	3.911	3.830				3.513	3.456	3.369	
1130	4.169	4.042						3.531	3.440	3.353	
1150	4.153	4.027							3.425	3.337	
1170	4.138	4.012							3.409	3.321	
1190									3.394	3.305	
1210											3.136
1230											3.121
1250											3.106
1270											3.091
1290											

temperature-dependent equations

$$\rho = a + bT + cT^2$$

Mol % Li_2WO_4	a	$-b \cdot 10^3$	$c \cdot 10^6$	Standard error of estimate
0	5.0446	2.3146	0.6204	0.02%
20	4.2567	0.8001		0.00%
32	4.3225	0.7806		0.01%
40	20.9043	31.9699	14.6864	1.89%
45.6	4.3841	0.8741	0.1102	0.00%
50	4.5201	0.8259		0.01%
60	4.4983	0.7452		0.00%
70	4.6792	0.7651		0.02%
80.1	4.8683	0.8627		0.00%
90	4.9048	0.7633		0.01%
100	5.3332	1.2861	0.2262	0.01%

These values are based on the data of Brown [133] and Brown and Morris [182] (Archimedean method).

TABLE 505. K_2WO_4-Li_2WO_4: Surface tension (dyn cm^{-1})

	Mol percent Li_2WO_4									
T(K)	100	90	80.1	70	60	50	45.6	40	20	0
870				206.8						
890				204.6						
910				202.5						
930			209.4	200.3				181.7		
950			207.5	198.1	194.4	190.3	188.2	180.0		
970			205.6	195.9	192.5	188.1	186.3	178.3		
990		215.3	203.8	193.8	190.6	186.0	184.3	176.6		
1010		213.8	201.9	191.6	188.7	183.9	182.4	174.8		
1030	235.2	212.3	200.0		186.8	181.8	180.5	173.0		
1050	233.5	210.8	198.1		184.8	179.7	178.6	171.1	169.9	
1070	231.8	209.3	196.2		182.8	177.7	176.6	169.2	168.0	
1090	230.1	207.8	194.3		180.7			167.2	166.1	
1110	228.4	206.3	192.4						164.2	
1130	226.7	204.8	190.5						162.5	
1150	225.0	203.3							160.8	
1170	223.3	201.8							159.1	
1190	221.6									
1210	219.9									
1230	218.2									158.2
1250										156.2
1270										153.8

temperature-dependent equations

$$\gamma = a + bT + cT^2$$

Mol % Li_2WO_4	a	$-b \cdot 10^3$	$-c \cdot 10^6$	Standard error of estimate
0	-482.983	-1133.236	497.522	0.30%
20	349.129	243.239	-69.075	0.06%
40	210.765	-19.016	54.086	0.03%
45.6	279.705	96.334		0.03%
50	333.096	190.310	-42.119	0.07%
60	252.294	28.982	33.634	0.08%
70	301.364	108.686		0.05%
80.1	289.057	78.804	7.421	0.03%
90	289.918	75.360		0.03%
100	322.588	84.853		0.03%

These values are based on the data of Brown (pin detachment method) [133].

TABLE 506. Li_2WO_4-Na_2WO_4: Specific conductance ($ohm^{-1}cm^{-1}$)

	Mol percent Na_2WO_4							
T(K)	100	85	70	60	47.4	30	15	0
820					0.540			
840				0.582	0.604			
860				0.631	0.668			
880			0.704	0.683	0.732			
900			0.767	0.738	0.797			
920		0.745	0.830	0.796	0.863	0.986		
940		0.825	0.893	0.857	0.928	1.032		
960		0.901	0.955	0.922	0.995	1.083		
980	0.962	0.975	1.017	0.989	1.061	1.138	1.504	
1000	1.019	1.045	1.079	1.059		1.198	1.561	
1020	1.075	1.112	1.140	1.133		1.262	1.619	
1040	1.131	1.176	1.201			1.332	1.677	
1060	1.187	1.238	1.261			1.406	1.734	
1080	1.242	1.296	1.321			1.484	1.792	
1100	1.297						1.849	2.182
1120	1.352						1.907	2.263
1140	1.406							2.345

temperature-dependent equations

$$\kappa = a + bT + cT^2$$

Mol % Na_2WO_4	- a	$b \cdot 10^3$	$c \cdot 10^6$	Standard error of estimate
0	2.2969	4.0716		0.13%
15	1.3206	2.8818		1.92%
30	-3.9171	-8.5518	5.8325	1.34%
47.4	1.7102	2.3176	0.5207	0.36%
60	-1.2901	-4.0595	3.8288	3.5%
70	2.4235	3.9358	-0.4336	3.9%
85	6.2059	11.0609	-3.8101	1.69%
100	2.3323	3.8654	-0.5144	0.11%

These values are based on the data of Brown and Morris [182] and Brown [133] (classical ac technique).

TABLE 507. Li_2WO_4-Na_2WO_4: Density ($g \cdot cm^{-3}$)

	Mol percent Na_2WO_4							
T(K)	100	85	70	60	47.4	30	15	0
810					4.220			
830					4.202			
850				4.135	4.185			
870				4.117	4.167			
890				4.099	4.150			
910			4.038	4.081	4.132			
930			4.021	4.063	4.115	4.192		
950		3.982	4.004	4.045	4.097	4.174		
970		3.962	3.987	4.027	4.080	4.157		
990	3.856	3.942	3.970	4.009	4.062	4.140		
1010	3.837	3.921	3.953	3.991		4.122	4.186	
1030	3.819	3.901	3.936	3.972		4.105	4.170	
1050	3.801	3.881	3.919			4.088	4.155	4.232
1070	3.782					4.070	4.139	4.216
1090	3.764					4.053	4.123	4.200
1110	3.746						4.108	4.184
1130	3.728						4.092	4.169
1150							4.077	4.153
1170								4.138
1190								4.123

temperature-dependent equations

$$\rho = a + bT + cT^2 + dT^3$$

Mol % Na_2WO_4	a	$-b \cdot 10^3$	$c \cdot 10^6$	$d \cdot 10^9$	Standard error of estimate
0	5.4505	1.4966	0.3204		0.01%
15	3.9345	-2.1639	-2.7738	0.8691	0.01%
30	5.0509	0.9726	0.0525		0.01%
47.4	4.9286	0.8754			0.01%
60	5.8905	4.0656	3.3662	-1.1914	0.01%
70	4.8794	0.9920	0.0740		0.01%
85	4.9456	1.0140			0.00%
100	4.8482	1.0810	0.0793		0.01%

These values are based on the data of Brown and Morris [182] and Brown [133] (Archimedean method).

TABLE 508. Li_2WO_4-Na_2WO_4: Surface tension (dyn cm^{-1})

	Mol percent Na_2WO_4							
T (K)	100	85	70	60	47.4	30	15	0
780					237.3			
800					235.6			
820				229.7	233.9			
840				228.3	232.2			
860				226.9	230.4			
880				225.5	228.7			
900			217.8	224.2	227.0	228.8		
920			216.4	222.8	225.3	227.5		
940			215.1	221.5	223.5	226.2		
960		212.1	213.7	220.3	221.8	224.9		
980	200.0	210.4	212.4	219.0	220.0	223.6		
1000	198.8	208.7	211.0	217.8	218.2	222.3	226.7	
1020	197.7	206.9	209.6	216.6		221.1	225.4	
1040	196.6	205.1	208.3			219.9	224.0	234.3
1060	195.5	203.1	206.9			218.6	222.7	232.6
1080	194.4		205.6			217.4	221.3	231.0
1100	193.3						220.0	229.3
1120	192.2						218.7	227.6
1140	191.1						217.3	225.9
1160	190.0						216.0	224.2
1180	188.9							222.5
1200								220.8
1220								219.1

temperature-dependent equations

$$\gamma = a + bT + cT^2$$

Mol % Na_2WO_4	a	$-b \cdot 10^3$	$c \cdot 10^6$	Standard error of estimate
0	322.588	84.8530		0.03%
15	293.860	67.1567		0.05%
30	300.478	93.5938	15.4489	0.01%
47.4	297.868	70.7870	-8.8584	0.02%
60	305.224	113.6183	26.1653	0.04%
70	278.635	67.6386		0.12%
85	199.954	-104.9994	96.2294	0.03%
100	254.095	55.2521		0.03%

These values are based on the work of Brown (pin detachment method) [133].

General Summary Tables

The following series of tables presents, first, for each of the four properties, κ, ρ, η, γ, the binary systems for which a recommendation has been advanced in this study, the technique used in the recommended reference and the authors of the recommended reference, and, second, an over-view of the recommendations advanced in this study for binary melts.

TABLE 509. Specific conductance

A: Classical ac technique

B: Classical dc technqiue

C: ac four probe method

D: dc four probe method

System	Investigations critically examined	Total examined	Technique of recommended reference	Authors of recommended reference
$C_2H_3O_2$-$NaC_2H_3O_2$	189	1	A	Leonesi, Cingolani and Berchiesi
$C_2H_3O_2$-$RbC_2H_3O_2$	189	1	A	Leonesi, Cingolani and Berchiesi
CO_3-Li_2CO_3	63, 62, 191, 193	4	A	Spedding
CO_3-Na_2CO_3	63, 65, 191	3	A	Spedding
$_2CO_3$-Na_2CO_3	63, 62, 191, 193	4	A	Spedding
$_2CO_3$-Na_2CO_3-K_2CO_3	193, 198	2	A	193, Joad 198, Ward and Janz
AlF_6-Na_3AlF_6	84	1	A	Batashev
$_3AlF_6$-Na_3AlF_6	204, 83, 85, 89, 91, 203	6	A	Danek, Novak and Malinovsky
$_2(MoO_4)_3$-$PbMoO_4$	131	1	A	Morris McNair and Koops
MoO_4-Li_2MoO_4	133, 135	2	A	Brown and Morris
$_2MoO_4$-Na_2MoO_4	133, 135	2	A	Brown and Morris
ClO_4-$LiClO_4$	141, 207, 208	3	A	Allulli
lO_4-$LiClO_4$	140, 141, 207, 209, 212	5	A	Allulli
ClO_4-$NaClO_4$	140, 207, 209, 210, 214	5	A	Allulli
$_2SO_4$-Li_2SO_4	151, 217	2	A	Kvist
SO_4-Li_2SO_4	218, 219	2	A	Kvist
SO_4-Li_2SO_4	143, 218	2	A	Kvist
$_2SO_4$-K_2SO_4	217	1	A	Kvist
$_2SO_4$-Li_2SO_4	217	1	A	Kvist
$_2SO_4$-Na_2SO_4	217	1	A	Kvist
$_2SO_4$-Rb_2SO_4	217	1	A	Kvist
$_2SO_4$-Tl_2SO_4	146	1	A	Kvist and Schroeder
$_2SO_4$-Li_2SO_4	218, 219, 221	3	A	Kvist
$_2SO_4$-Na_2SO_4	217	1	A	Kvist
$_2SO_4$-Rb_2SO_4	217	1	A	Kvist
$_2SO_4$-Tl_2SO_4	146	1	A	Kvist and Schroeder
$_2SO_4$-$ZnSO_4$	222	1	A	Vereshchetina and Luzhnaya
$_2SO_4$-$MgSO_4$	218, 219	2	A	Kvist
$_2SO_4$-Na_2SO_4	152, 217, 218, 219	4	A	Kvist
$_2SO_4$-Rb_2SO_4	217, 218, 219	3	A	Kvist
$_2SO_4$-Tl_2SO_4	146	1	A	Kvist and Schroeder
$_2SO_4$-$ZnSO_4$	147	1	A	Josefson and Kvist
$_2SO_4$-Rb_2SO_4	217	1	A	Kvist
$_2SO_4$-Tl_2SO_4	146	1	A	Kvist and Schroeder

TABLE 509, Specific conductance-CONTINUED

System	Investigations critically examined	Total examined	Technique of recommended reference	Authors of recommended reference
Na_2SO_4-$ZnSO_4$	147	1	A	Josefson and Kvist
Rb_2SO_4-Tl_2SO_4	146	1	A	Kvist and Schroeder
Ag_2S-Na_2S	223	1	A	Eichis, Sokolova and Velikanov
Ag_2S-K_2S	224	1	A	Mustyatsa, Velikanov and Novik
As_2S_3-Na_2S	225	1	A	Mustyatsa and Velikanov
Bi_2S_3-K_2S	166	1	A	Mustyatsa, Velikanov and Gudzenko
Co_4S_3-Cu_2S	226	1	A	Barmin, Esin and Dobrovinskii
Co_4S_3-FeS	226	1	A	Barmin, Esin and Dobrovinskii
Co_4S_3-Ni_3S_2	226	1	A	Barmin, Esin and Dobrovinskii
Cu_2S-FeS	169, 227, 226	3	A	Pound, Derge and Osuch
Cu_2S-Ni_3S_2	226	1	A	Barmin, Esin and Dobrovinskii
FeS-Ni_3S_2	226	1	A	Barmin, Esin and Dobrovinskii
GeS_2-K_2S	228	1	A	Malinovsky, Shevchuk and Velikanov
K_2S-SnS	228	1	A	Malinovsky, Shevchuk and Velikanov
Na_2S-PbS	229	1	A	Malinovsky, Shevchuk and Velikanov
Na_2S-Sb_2S_3	171	1	A	Velikanov, Mustyatsa and Delimarskii
Na_2S-Tl_2S	161	1	A	Velikanov, Shevchuk and Posukh
$Bi_2(WO_4)_3$-$PbWO_4$	133, 182	2	A	133, Brown 182, Brown and Morris
K_2WO_4-Li_2WO_4	133, 182, 183	3	A	133, Brown 182, Brown and Morris
Li_2WO_4-Na_2WO_4	133, 182	2	A	133, Brown 182, Brown and Morris

TABLE 510. Density

A: Archimedean method
B: Dilatometric method
C: Maximum bubble pressure method
D: Method of hydrostatic weighing

System	Investigations critically examined	Total examined	Technique of recommended reference	Authors of recommended reference
$CsC_2H_3O_2$-$NaC_2H_3O_2$	189	1	B	Leonesi, Cingolani and Berchiesi
$NaC_2H_3O_2$-$RbC_2H_3O_2$	189	1	B	Leonesi, Cingolani and Berchiesi
K_2CO_3-Li_2CO_3	67, 62, 191	3	A	Spedding
K_2CO_3-Na_2CO_3	67, 191, 195, 196	4	A	Spedding
Li_2CO_3-Na_2CO_3	67, 62, 191	3	A	Spedding

TABLE 510. CONTINUED. Density

System	Investigations critically examined	Total examined	Technique of recommended reference	Authors of recommended reference
$_3$-Na_2CO_3-K_2CO_3	198	1	A	Ward and Janz
F_6-K_3AlF_6	200	1	D	Bukhalova and Mal'tsev
F_6-Li_3AlF_6	201	1	D	Mal'tsev
F_6-Na_3AlF_6	200	1	D	Bukhalova and Mal'tsev
$_6$-Li_3AlF_6	201	1	D	Mal'tsev
$_6$-Na_3AlF_6	200	1	D	Bukhalova and Mal'tsev
F_6-Na_3AlF_6	202, 91, 205, 206	4	D	Malinovsky, Paucirova and Matiasovsky
F_6-Rb_3AlF_6	201	1	D	Mal'tsev
F_6-Rb_3AlF_6	200	1	D	Bukhalova and Mal'tsev
$oO_4)_3$-$PbMoO_4$	131	1	A	Morris, McNair and Koops
$_4$-Li_2MoO_4	133, 135	2	A	133, Brown 135, Brown and Morris
O_4-Na_2MoO_4	133, 135	2	A	133, Brown 135, Brown and Morris
$_4$-$LiClO_4$	140, 141, 207	3	B	Allulli
-$LiClO_4$	140, 213	2	B	Allulli
$_4$-$NaClO_4$	207, 215	2	B	Allulli
$Zn(PO_3)_2$	114	1	A	Krivovyazov and Voskresenskaya
-$Zn(PO_3)_2$	114	1	A	Krivovyazov and Voskresenskaya
$_4$-Li_2SO_4	151, 217	2	A	Kvist
-Na_2SO_4	145	1	C	Tanutrov, Kosteneski, Moiseev and Okunev
-Li_2SO_4	146, 220	2	A	146, Kvist and Schroeder 220, James and Liu
-Na_2SO_4	146	1	A	Kvist and Schroeder
-$ZnSO_4$	222	1	A	Vereshchetina and Luzhnaya
$_4$-Na_2SO_4	146	1	A	Kvist and Schroeder
$_4$-Tl_2SO_4	146	1	A	Kvist and Schroeder
$_4$-$ZnSO_4$	147	1	A	Josefson and Kvist
$_4$-$ZnSO_4$	147	1	A	Josefson and Kvist
-Cu_2S	155	1	C	Barmin, Esin and Dobrovinskii
-FeS	154, 156	2	C	Barmin, Esin and Dobrovinskii
-Ni_3S_2	156	1	C	Barmin, Esin and Dobrovinskii
FeS	154, 155	2	C	Barmin, Esin and Dobrovinskii
Ni_3S_2	155	1	C	Barmin, Esin and Dobrovinskii
$_3S_2$	154, 156	2	C	Barmin, Esin and Dobrovinskii
-$(C_3H_7)_4NSCN$	230	1	B	Kowalski
$_4)_3$-$PbWO_4$	133, 182	2	A	133, Brown 182, Brown and Morris
-Li_2WO_4	133, 182	2	A	133. Brown 182, Brown and Morris
$_4$-Na_2WO_4	133, 182	2	A	133, Brown 182, Brown and Morris

TABLE 511. Viscosity

A: capillary technique
B: oscillational method

System	Investigations critically examined	Total examined	Technique of recommended reference	Authors of recommended reference
K_2CO_3-Li_2CO_3	192	1	B	Vorob'ev, Pal'guev and Karpachev
K_2CO_3-Na_2CO_3	192	1	B	Vorob'ev, Pal'guev and Karpachev
Li_2CO_3-Na_2CO_3	192	1	B	Vorob'ev, Pal'guev and Karpachev
Li_2CO_3-Na_2CO_3-K_2CO_3	199	1	B	Janz and Saegusa
Li_3AlF_6-Na_3AlF_6	206, 102, 104	3	B	Vetyukov and Sipriya
$LiClO_4$-$NaClO_4$	216	1	B	Farmakovskaya and Brovkina
$CaSO_4$-Na_2SO_4	145	1	B	Tanutrov, Kosteneskii, Moiseev and Okunev
Co_4S_3-Cu_2S	155	1	B	Barmin, Esin and Dobrovinskii
Co_4S_3-FeS	154, 156	2	B	Barmin, Esin and Dobrovinskii
Co_4S_3-Ni_3S_2	156	1	B	Barmin, Esin and Dobrovinskii
Cu_2S-FeS	154, 155	2	B	Barmin, Esin and Dobrovinskii
Cu_2S-Ni_2S_3	155	1	B	Barmin, Esin and Dobrovinskii

TABLE 512. Surface tension

A: Wilhelmy slide plate method
B: Pin detachment method
C: Maximum bubble pressure method
D: Cylinder method
E: Break weight method

System	Investigations critically examined	Total examined	Technique of recommended reference	Authors of recommended reference
Cs_2CO_3-Li_2CO_3	190	1	C	Moiseev and Stepanov
K_2CO_3-Li_2CO_3	69, 191	2	B,C	69 Moiseev and Stepanov 191, Ward and Janz
K_2CO_3-Na_2CO_3	191, 195, 69, 197	4	B	191, Ward and Janz 195, Janz and Lorenz
Li_2CO_3-Na_2CO_3	69, 191	2	C	Moiseev and Stepanov
Li_2CO_3-Na_2CO_3-K_2CO_3	198	1	B	Ward and Janz
$Bi(MoO_4)_3$-$PbMoO_4$	131	1	E	Morris, McNair and Koops
K_2MoO_4-Li_2MoO_4	133, 136	2	E	133, Brown 136, Brown and Morris
Li_2MoO_4-Na_2MoO_4	133, 136	2	E	133, Brown 136, Brown and Morris
$Ba(PO_3)_2$-KPO_3	130	1	C	Sokolova, Krivovyazov and Voskresenskaya
$Ca(PO_3)_2$-$NaPO_3$	127, 130	2	D	Nijjhar and Williams
KPO_3-$LiPO_3$	127	1	D	Nijjhar and Williams
KPO_3-$NaPO_3$	127, 128	2	D	Nijjhar and Williams
KPO_3-$Zn(PO_3)_2$	114	1	C	Krivovyazov and Voskresenskaya
$LiPO_3$-$NaPO_3$	127, 130	2	D	Nijjhar and Williams

TABLE 512. CONTINUED. Surface tension

System	Investigations critically examined	Total examined	Technique of recommended reference	Authors of recommended reference
PO_3-$Zn(PO_3)_2$	114	1	C	Krivovyazov and Voskresenskaya
SO_4-Na_2SO_4	145	1	C	Tanutrov, Kosteneskii, Moiseev and Okunev
$_2SO_4$-K_2SO_4	149	1	A	Bertozzi and Soldani
$_2SO_4$-Na_2SO_4	149	1	A	Bertozzi and Soldani
$_2SO_4$-Rb_2SO_4	149	1	A	Bertozzi and Soldani
SO_4-Na_2SO_4	149	1	A	Bertozzi and Soldani
SO_4-Rb_2SO_4	149	1	A	Bertozzi and Soldani
$_2SO_4$-Rb_2SO_4	149	1	A	Bertozzi and Soldani
$_2(WO_4)_3$-$PbWO_4$	133	1	B	Brown
WO_4-Li_2WO_4	133	1	B	Brown
$_2WO_4$-Na_2WO_4	133	1	B	Brown

TABLE 513. Recommendations

System	Recommended reference			
	κ	ρ	η	γ
$CsC_2H_3O_2$-$NaC_2H_3O_2$	189	189		
$NaC_2H_3O_2$-$RbC_2H_3O_2$	189	189		
Cs_2CO_3-Li_2CO_3				190
K_2CO_3-Li_2CO_3	63	67	192	69,191
K_2CO_3-Na_2CO_3	63	67	192	191,195
Li_2CO_3-Na_2CO_3	63	67	192	69
Li_2CO_3-Na_2CO_3-K_2CO_3	193	198	199	198
Cs_3AlF_6-K_3AlF_6		200		
Cs_3AlF_6-Li_3AlF_6		201		
Cs_3AlF_6-Na_3AlF_6		200		
K_3AlF_6-Li_3AlF_6		201		
K_3AlF_6-Na_3AlF_6		200		
Li_3AlF_6-Na_3AlF_6	204	202	206	
Li_3AlF_6-Rb_3AlF_6		201		
Na_3AlF_6-Rb_3AlF_6		200		
$Bi_2(MoO_4)_3$-$PbMoO_4$	131	131		131
K_2MoO_4-Li_2MoO_4	133,135	133,135		133,136
Li_2MoO_4-Na_2MoO_4	133,135	133,135		133,136
$CsClO_4$-$LiClO_4$	141,207,208	140,141		
$KClO_4$-$LiClO_4$	140,141,207	140		
$LiClO_4$-$NaClO_4$	140,207	207	216	
$Ba(PO_3)_2$-$NaPO_3$				130
$Ca(PO_3)_2$-$NaPO_3$				127
KPO_3-$LiPO_3$				127

TABLE 513. Recommendations CONTINUED

System	Recommended reference			
	κ	ρ	η	γ
KPO_3-$NaPO_3$				127
KPO_3-$Zn(PO_3)_2$		114		114
$LiPO_3$-$NaPO_3$				127
$NaPO_3$-$Zn(PO_3)_2$		114		114
Ag_2SO_4-Li_2SO_4	151,217	151,217		
$BaSO_4$-Li_2SO_4	218,219			
$CaSO_4$-Na_2SO_4		145	145	145
$CdSO_4$-Li_2SO_4	143,218			
Cs_2SO_4-K_2SO_4	217			149
Cs_2SO_4-Li_2SO_4	217			
Cs_2SO_4-Na_2SO_4	217			149
Cs_2SO_4-Rb_2SO_4	217			149
Cs_2SO_4-Tl_2SO_4	146			
K_2SO_4-Li_2SO_4	218,219	146,220		
K_2SO_4-Na_2SO_4	217	145		149
K_2SO_4-Rb_2SO_4	217			149
K_2SO_4-Tl_2SO_4	146			
K_2SO_4-$ZnSO_4$	222	222		
Li_2SO_4-$MgSO_4$	218,219			
Li_2SO_4-Na_2SO_4	152,217	146		
Li_2SO_4-Rb_2SO_4	217,218			
Li_2SO_4-Tl_2SO_4	146	146		
Li_2SO_4-$ZnSO_4$	147	147		
Na_2SO_4-Rb_2SO_4	217			149

TABLE 513. Recommendations-CONTINUED

System	Recommended reference			
	κ	ρ	η	γ
Na_2SO_4-Tl_2SO_4	146			
Na_2SO_4-$ZnSO_4$	147	147		
Rb_2SO_4-Tl_2SO_4	146			
Ag_2S-Na_2S	223			
Ag_2S-K_2S	224			
As_2S_3-Na_2S	225			
Bi_2S_3-K_2S	166			
Co_4S_3-Cu_2S	226	155	155	
Co_4S_3-FeS	226	154,156	154,156	
Co_4S_3-Ni_3S_2	226	156	156	
Cu_2S-FeS	169,227	154,155	154,155	
Cu_2S-Ni_3S_2	226	155	155	
FeS-Ni_3S_2	226	154,156	154,156	
GeS_2-K_2S	228			
K_2S-SnS	228			
Na_2S-PbS	229			
Na_2S-Sb_2S_3	171			
Na_2S-Tl_2S	161			
AgSCN-$(C_3H_7)_4NSCN$			154,156	
$Cd(SCN)_2$-$(C_3H_7)_4NSCN$			230	
$Cu(SCN)_2$-$(C_3H_7)_4NSCN$			230	
CuSCN-$(C_3H_7)_4NSCN$		133,182	230	
$Bi_2(WO_4)_3$-$PbWO_4$	133,182	133,182		133
K_2WO_4-Li_2WO_4	133,182	133,182		133
Li_2WO_4-Na_2WO_4	133,182	133,182		133

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