Molten Salts: Volume 5, Part 2. Additional Single and Multi-Component Salt Systems. Electrical Conductance, Density, Viscosity and Surface Tension Data

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Molten Salts: Volume 5, Part 2. Additional Single and Multi-Component Salt Systems. Electrical Conductance, Density, Viscosity and Surface Tension Data

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Evaluated data for the four properties, density, surface tension, viscosity, and electrical conductance are reported for salt systems in which both the anionic and cationic species may differ. This contrasts with the systems in the preceding publications in this series in which the anionic species were, in general, the same in the binary mixtures. The results are reported in equation form, with brief tables of numerical values. A cross index by salt system was compiled and is included for ease of accessing the data tables.

Key words: density, electrical conductance, fused salts, molten salts, phase diagrams, surface tension, viscosity.

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1. Introduction

In the present work, the critical evaluations of the published data for the properties: density, surface tension, electrical conductance, and viscosity have been extended to additional multicomponent systems as follows:

- 134 binary mixtures with a halide salt as a component of the system
- 39 binary mixtures with an oxide, but not a halide, as a component of the system
- 59 binary systems with neither an oxide nor a halide as a component of the system

These are reported in three sections, A, B and C, respectively. Within each section the systems have been classified using the position in the periodic table of the central atom in the anion, and with oxygenated anions considered first, fluorocomplexes second, and other anions third, viz:

$BO_3^- > CO_3^{-2} > NO_3^-$, $NO_2^- > PO_4^{-3}$, $PO_3^- > SO_4^{-2} > ClO_4^-$, $ClO_3^- > BF_4^- > AlF_6^{-3}$, SiF_6^{-2}, TiF_6^{-2}, $ZrF_6^{-2} > C_2^{-2} > S^{-2}$, Te^{-2} > other.

For the preceding publications in this series see: [1–9][1] and table 1. In the present work, the critical data evaluations have been extended to include the most complex systems, namely, binary systems that may include differing cations and differing anions.

For each system, the results are reported 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 is treated separately.

[1]Numbers in brackets refer to literature references.

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: 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 (1980)	Binary mixtures: mixed anions other than nitrates, nitrites, halides	[8]
Vol. 5 Pt. 2	Additional systems	[9]

2. Symbols and Units

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

TABLE 2. Fundamental constants[1]

Symbol	Name	Values[2]
N_A	Avogadro constant	$6.022045\ (31) \times 10^{23}$ mol^{-1}
F	Faraday constant	$9.648456\ (27) \times 10^4$ mol^{-1}
e	Electron charge	$1.6027892\ (46) \times 10^{-19}$C
R	Gas constant	8.31441 (26) J K^{-1} mol^{-1}
		1.98719 (6) cal K^{-1} mol^{-1}

[1]Fundamental constants from: CODATA Bulletin No. 11 (Dec. 1973).
[2]In each case the digits in the parentheses following a numerical value represent the standard deviation of that value in the decimal places indicated for its final digits.

TABLE 3. Symbols and units

Symbol	Physical quantity	Units
A	Pre-exponential factor	as in text
C	Concentration	mol%; equiv. %
E	Energy of activation	cal mol^{-1}; cal $equiv^{-1}$
t	Temperature (Celsius)	°C
T	Temperature (Absolute)	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:
1mN s m^{-2} = 1 cp = 1 mPa s
1mN m^{-1} = 1 dyn cm^{-1}
4.184 J mol^{-1} = 1 cal mol^{-1}

3. Practical Aspects

Practical aspects of molten salts containment (materials) and designs of experimental assemblies for measurements of electrical conductivity, viscosity, density, and surface tension have been reviewed in the preceding parts of this series (see: table 4).

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

Techniques	Aspects reviewed and references
γ	Various possible methods and % applications: This series, Vol. 2, Part 2 [2]
$\kappa, \rho, \eta, \gamma$	Descriptions of experimental assemblies: This series, Vol. 3 [3]
$\kappa, \rho, \eta, \gamma$	Practical aspects of studies with molten fluorides: This series, Vol. 4, Part 1 [4]
$\kappa, \rho, \eta, \gamma$	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]
$\kappa, \rho, \eta, \gamma$	Recent advances: This series, Vol. 5, Part 1 [8]

In the present communication, thus, attention is directed to some recent advances in the area of calibration-quality reference data and molten salt standards. A project in this area was initiated at RPI in 1973, with participating laboratories in Czechoslovakia, DDR-Germany, Japan, Norway, Poland, Rumania, and the USA. The results, specifically for density, surface tension, electrical conductance and viscosity, have recently been reported in detail [10,11,12] and the present remarks will be limited to the salient accomplishments, and the recommendations advanced.

KNO_3 (m. 335°C ± 2°C) and NaCl (m. 800°C ± 2°C) were selected as reference materials to bracket the temperature range 350°–1050°C, i. e., for measurements with moderately high and high melting molten systems, respectively. These two salts are readily dried since they are not strongly hydrated. Samples of the reference materials were supplied from the MSDC-RPI; the critical evaluations of these "round-robin" measurements were part of the project at the MSDC-RPI.

The upgraded recommendations based on the accomplishments of this project are summarized in table 5, as equations, together with the temperature ranges, and accuracy estimates.

Relative to the best value estimates advanced earlier, the following should be noted.

Density

KNO_3: The 1968 NSRDS recommendations [1] are gently shifted to lower values by ~0.25%.

NaCl: The 1968 NSRDS recommendations [1] are supported within the limits of accuracy of the experimental techniques.

Surface tension

KNO_3: The 1969 NSRDS recommendations [2] receive firm support.

NaCl: While no change in the 1969 NSRDS recommendations [2] appears necessary, the accuracy limits of the data set are revised to ±1.5% (estimated earlier as ~±0.1% [2]).

Electrical conductance

KNO_3: The NSRDS recommendations, were advanced in 1968, and were revised and updated in 1972. The 1972 NSRDS data set are supported within the experimental limits of accuracy (~±0.5%).

NaCl: The 1968 NSRDS recommendations [1] are superseded. While the 1968 data base and the new results are virtually in exact agreement in the range from the melting point (800°C) to ~ 850°C, the earlier conductance values are too high above 850°C, the departure reaching ~3.5% at the upper temperature limit of the new data base (~1020°C).

Viscosity

KNO_3: The 1968 NSRDS recommendations [1] are shifted gently to ~1% higher values.

NaCl: The 1968 NSRDS recommendations [1] are shifted to markedly lower values; the deviation being largest (~30%) in the lower limits of measurements (~810°C), and decreasing with increasing temperatures (to ~10% at ~1050°C).

Relative to the practical aspects of such measurements a number of significant questions were addressed through this project; some of the results may be briefly summarized as follows.

TABLE 5. Molten salts standards: calibration – quality data sets

System	Equation	Temp. range (K)	Accuracy
Density (g cm^{-3})			
KNO_3	$\rho = 2.3063 - 0.7235 \times 10^{-3}T$	620 – 730	$\sim\pm0.25$ %
NaCl	$\rho = 2.1389 - 0.5426 \times 10^{-3}T$	1080 – 1300	$\sim\pm1.0$ %
Surface Tension (mN m^{-1})			
KNO_3	$\gamma = 154.715 - 71.7080 \times 10^{-3}T$	620 – 760	$\sim\pm0.5$ %
NaCl	$\gamma = 191.1600 - 71.8800 \times 10^{-3}T$	1080 – 1240	$\sim\pm1.5$ %
Electrical Conductance (ohm^{-1} cm^{-1})			
KNO_3	$\kappa = -2.1250 + 5.7332 \times 10^{-3}T - 2.0301 \times 10^{-6}T^2$	615 – 790	$\sim\pm0.5$
NaCl	$\kappa = -5.6241 + 13.9640\times10^{-3}T - 5.0245\times10^{-6}T^2$	1080 – 1250	$\sim\pm1.0$
Viscosity (mN s m^{-2})			
KNO_3	$\eta = 29.7085 - 71.1208 \times 10^{-3}T + 44.7023 \times 10^{-6}T^2$	615 – 760	$\sim\pm2.0$%
NaCl	$\eta = 89.272 \times 10^{-3} \exp(5248.5/RT)$	1080 – 1210	$\sim\pm0.2$ %

Trace impurities:

Some measurements with Reagent-Grade KNO_3 and NaCl were undertaken to investigate the effects of trace additives. Using the properties of viscosity and electrical conductance as the sensing techniques for impurity effects comparisons with Standards-Quality and Reagent Grade samples were undertaken.

It is apparent that the trace impurities in Reagent-Grade KNO_3 and NaCl do not alter the measured properties significantly. The influences of trace amounts of moisture, and metal oxides, were not investigated.

Comparison of capillary viscometer designs and techniques:

A comparison of the various capillary viscometer designs used for molten salt measurements was undertaken as part of this project. For details, see: [10–12].

Comparison of torsional viscometer designs and techniques:

Torsion wire:

The Kestin alloy (92% Pt, 8% tungsten) has superior qualities and is recommended for the torsion wire of the damped oscillational (torsion) viscosity technique. For details, see: [10–12].

Immersed oscillational shape:

The accuracy limits of the torsional technique with an immersed sphere are $\sim\pm3.0$%, largely due to the tolerance limits imposed in working with soft metals when machining spherical shapes. The accuracy limits of the torsional technique can be narrowed significantly (to ~0.2%) if a cylinder is adopted for the immersed shape. For details, see: [10–12].

Neglect of the surface tension correction with the partially filled cylindrical shape will contribute to significant errors. For details, see: [12,13].

Measurement techniques:

For additional insights gained on the accuracy of measurement techniques for density, surface tension, and electrical conductance, see: [10].

As a result of these measurements, one has a set of reference points for value judgements in critical data evaluation studies, particularly relative to accuracy estimates, and for comparisons of numerical values for these four physical properties. These were used throughout our present work in firming up the recommended data sets advanced herewith (see: Section 8. Numerical Data by Systems).

4. Statistical Analysis

The recommended data values were selected on the basis of our estimates of precision and accuracy of the data in the literature.

All calculations were made on the digital computer facilities at Rensselaer Polytechnic Institute. The data of each recommended study were fitted by a one-dimensional analysis, using the method of least squares, to establish the variation of the physical quantities with temperature at the experimental compositions.

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

This was defined by

$$s = \sqrt{\frac{\sum^{n} (Z_e - Z)^2}{n - q}}$$

where Z_e = the experimental value at each temperature, Z = 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 fitting equation. The standard error of estimate was computed from the residuals in the least squares routine.

If 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.

A Percent Departure criterion has been used to compare additional results with the values being recommended. The Percent Departure is defined as:

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

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" are calculated from statistically derived equations since the results have to be interpolated to common temperatures and common compositions.

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 data points, the nature of the concentration dependence and the temperature dependence of the particular physical property. The precision is defined here as the standard error expressed as a percent value. Assuming a normal distribution, about 68% of the data points lie within this estimate of precision, 95% within twice this value, and approximately 99% within three times this 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 inter-comparisons with results from the same and/or different laboratories. The accuracy estimates are more subjective than the estimates of precision.

6. Phase Diagrams

The lower temperature limits of the molten state are most conveniently gained by inspection of the phase diagrams of the multi-component systems. Phase diagrams, accordingly, are included for ease of reference. The compilations used as sources included International Critical Tables [14], Landolt-Bornstein [15], Clark [16], Robertson [17], Thoma [18], Voskresenskaya [19], Sinistri et al. [20], Shaffer [21], Franzosini [22], Toropov et al. [23], and Levin et al. [24]. The primary research literature was searched for diagrams relative to systems not covered in the above compilations. The phase diagrams were not further critically evaluated since, as already noted, the primary intent of these in the present work was ease of reference relative to the lower temperature limits of the molten states of the systems, i. e., the melting-crystallization temperatures.

7. Presentation of Physical Properties Data

Two types of tables are used to present the 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
- comparisons with the NSRDS recommendations

Footnotes to these tables call attention to information of unusual importance (technique,experimental uncertainty, etc.). A recommended reference is always indicated by a bold typeface 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 in bold typeface.

(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.

The physical properties tables in each section are preceded by a data-status table for the systems in that sub-section of the compilation.

8. Numerical Data by Systems

Section A: Systems Containing a Halide

Halide - tetraborate

TABLE 6. Data Status

System	Phase Diagram	Electrical Conductance	Density	Viscosity	Surface Tension
CaF_2–$Na_2B_4O_7$			X		X
KF–$Na_2B_4O_7$			X		X
NaF–$Na_2B_4O_7$	X	X	X		X
ZrF_4–$Na_2B_4O_7$			X		X
KCl–$Na_2B_4O_7$			X		X
LiCl–$Na_2B_4O_7$			X		X
NaCl–$Na_2B_4O_7$		X			

CaF_2 - $Na_2B_4O_7$

Melt preparation and purification

Yakobashvili, et al. [25] used reagent grade salts to prepare the melts.

TABLE 7. Density studies: CaF_2 - $Na_2B_4O_7$

Investigations critically examined			
Ref.	Mol % $Na_2B_4O_7$	Temp. range (K)	Comments
25	54–85	1223	alundum crucibles and capillary tubes; purified Ar; experimental uncertainty ~±5%.

TABLE 8. CaF_2 - $Na_2B_4O_7$: Density (g cm^{-3})

Mol percent $Na_2B_4O_7$	1223 K
80	2.125
70	2.119
60	2.123

Composition-dependent equation

$$\rho = 2.344 - 0.650 \times 10^{-2}C + 0.47 \times 10^{-4}C^2$$

[C = Mol % $Na_2B_4O_7$]

The above equation is based on the graphical data of Yakobashvili, Oparin, Lyudvig, and Danil'chenko (maximum bubble pressure method [25]. The density of CaF_2–$Na_2B_4O_7$ as reported appears to be virtually independent of composition at 1223 K.

TABLE 9. Surface tension studies: CaF_2 - $Na_2B_4O_7$

Investigations critically examined			
Ref.	Mol % $Na_2B_4O_7$	Temp. range (K)	Comments
25	54–85	1223	alundum crucibles and capillary tubes; purified Ar; experimental uncertainty ~±5%

TABLE 10. CaF_2–$Na_2B_4O_7$: Surface tension (dyn cm^{-1})

Mol percent $Na_2B_4O_7$	1223 K
85	245
75	243
65	237
55	229

Composition-dependent equation

$$\gamma = 126.7 + 2.725C - 1.57 \times 10^{-2}C^2$$

[C = Mol % $Na_2B_4O_7$]

These values are based on the data of Yakobashvili, Oparin, Lyudvig, and Danil'chenko (maximum bubble pressure method); data in graphical form; precision not estimated [25].

$KF - Na_2B_4O_7$

Melt Preparation and Purification

Yakobashvili, et al. [25,26] used reagent grade salts to prepare the melts.

TABLE 11. Density studies: $KF - Na_2B_4O_7$

Investigations critically examined			
Ref.	Mol % $Na_2B_4O_7$	Temp. range (K)	Comments
26	40–100	1223	alundum crucibles and capillary tubes; purified Ar; experimental uncertainty $\sim \pm 5\%$.
25	33–81	1223	as for [26]

TABLE 12. $KF - Na_2B_4O_7$: Density (g cm^{-3})

Mol percent $Na_2B_4O_7$	1223 K
100	2.07
90	2.01
80	1.98
70	1.98
60	1.99
50	2.04
40	2.10

Composition-dependent equation

$$\rho = 2.609 - 1.756 \times 10^{-2}C + 1.216 \times 10^{-4}C^2$$

[C = Mol % $Na_2B_4O_7$]

Standard error of estimate = 3.98%

These values are based on the data of Oparin and Yakobashvili (maximum bubble pressure method). [26].

TABLE 13. Surface tension studies: $KF - Na_2B_4O_7$

Investigations critically examined			
Ref.	Mol % $Na_2B_4O_7$	Temp. range (K)	Comments
26	40–100	1223	alundum crucible and capillary tube; purified Ar; experimental uncertainty $\sim \pm 5\%$.
25	33–81	1223	as for [26]

TABLE 14. $KF - Na_2B_4O_7$: Surface tension (dyn cm^{-1})

Mol percent $Na_2B_4O_7$	1223 K
100	234
90	208
80	185
70	166
60	152
50	141
40	135

Composition-dependent equation

$$\gamma = 150.2 - 119.3 \times 10^{-2}C + 203.3 \times 10^{-4}C^2$$

[C = Mol % $Na_2B_4O_7$]

Standard error of estimate = 2.39%

These values are based on the data of Oparin and Yakobashvili (maximum bubble pressure method) [26]. The two values for the surface tension of $Na_2B_4O_7$ at 1223 K [25,26] are in close agreement ($< \pm 0.5\%$).

$NaF - Na_2B_4O_7$

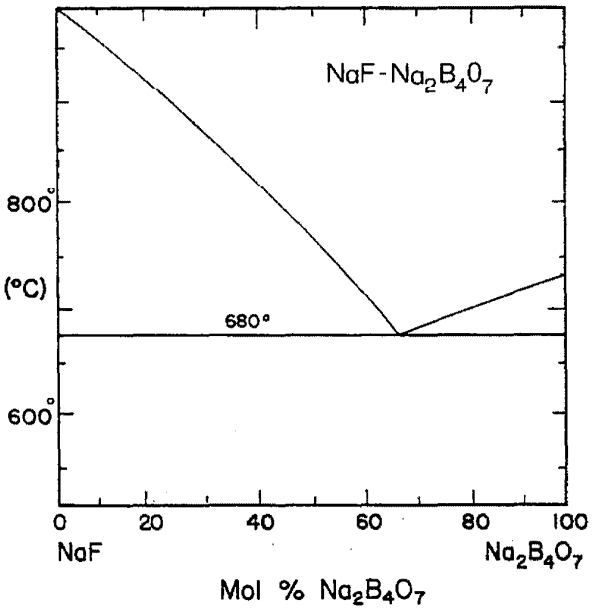

FIGURE 1. Phase diagram for $NaF - Na_2B_4O_7$.

Data from: A. G. Bergman, and I. N. Nikonova, Zhur. Obshchei Khim., **12**, 449 (1942).

Melt Preparation and Purification

Stalhane [27] and Yakobashvili, et al. [25] used reagent grade salts to prepare the melts.

TABLE 15. Electrical conductance studies: $NaF - Na_2B_4O_7$

Investigations critically examined			
Ref.	Mol % $Na_2B_4O_7$	Temp. range (K)	Comments
27	37–100	1020–1130	Pt electrodes

TABLE 16. $NaF - Na_2B_4O_7$: Specific conductance ($ohm^{-1}\ cm^{-1}$)

T(K)	Mol percent $Na_2B_4O_7$			
	91.5	72.6	57.0	37.6
1020	0.20	0.29		
1050	0.24	0.34		
1080	0.29	0.40	0.57	0.96
1110	0.35	0.48	0.68	1.11
1130	0.40	0.54	0.74	1.22

Temperature-dependent equations

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

Mol % $Na_2B_4O_7$	a	$b \times 10^3$	$c \times 10^6$	standard error of estimate
100	4.533	-9.768	5.388	1.10
91.5	4.476	-9.624	5.323	0.97
72.6	7.252	-15.095	8.105	1.11
57.0	-3.099	3.400		*
37.6	-4.660	5.200		*

These values are based on the data of Stalhane (classical ac method) [27]. *Insufficient data for estimate.

TABLE 17. Density studies: $NaF - Na_2B_4O_7$

Investigations critically examined

Ref.	Mol % $Na_2B_4O_7$	Temp. range (K)	Comments
25	38–74	1223	alundum crucible and capillary tube; purified Ar; experimental uncertainty $\sim \pm 5\%$

TABLE 18. $NaF - Na_2B_4O_7$: Density (g cm^{-3})

Mol percent $Na_2B_4O_7$	1223 K
70	2.21
60	2.21
50	2.22
40	2.22

Composition-dependent equation

$\rho = 2.272 - 0.188 \times 10^{-2}C + 0.150 \times 10^{-4}C^2$

[C = Mol % $Na_2B_4O_7$]

Standard error of estimate = 0.7%

The above equation is based on the graphical data of Yakobashvili, Oparin, Lyudvig, and Danil'chenko (maximum bubble pressure method) [25].

TABLE 19. Surface tension studies: $NaF - Na_2B_4O_7$

Investigations critically examined

Ref.	Mol % $Na_2B_4O_7$	Temp. range (K)	Comments
25	38–76	1223	alundum crucible and capillary tube; purified Ar; experimental uncertainty $\sim \pm 5\%$

TABLE 20. $NaF - Na_2B_4O_7$: Surface tension (dyn cm^{-1})

Mol percent $Na_2B_4O_7$	1223 K
75	229
70	228
60	226
50	223
40	220

Composition-dependent equation

$\gamma = 203.11 + 51.82 \times 10^{-2}C - 22.83 \times 10^{-4}C^2$

[C = Mol % $Na_2B_4O_7$]

Standard error of estimate = 0.5%

These values are based on the data of Yakobashvili, Lyudvig, Oparin, and Danil'chenko (maximum bubble pressure method); data in graphical form [25]. In the table (above) the values at 75 and 70 mol % are those from the graphical interpolation; the curve-fitting equation (above) fails in this composition range, i.e., values ~4–5% higher are predicted.

$ZrF_4 - Na_2B_4O_7$

Melt Preparation and Purification

Yakobashvili et al. [25] used reagent grade salts to prepare the melts.

TABLE 21. Density studies: $ZrF_4 - Na_2B_4O_7$

Investigations critically examined

Ref.	Mol % $Na_2B_4O_7$	Temp. range (K)	Comments
25	72–93	1223	alundum crucible and capillary tube; purified Ar; experimental uncertainty $\sim \pm 5\%$

TABLE 22. $ZrF_4 - Na_2B_4O_7$: Density (g cm^{-3})

Mol percent $Na_2B_4O_7$	1223 K
90	2.07
80	2.09
70	2.19

Composition-dependent equation

$\rho = 5.191 - 7.118 \times 10^{-2}C + 4.05 \times 10^{-4}C^2$

[C = Mol % $Na_2B_4O_7$]

Standard error of estimate = 0.7%

These values are based on the data of Yakobashvili, Oparin, Lyudvig, and Danil'chenko; (maximum bubble pressure method); data in graphical form [25].

TABLE 23. Surface tension studies: ZrF_4 - $Na_2B_4O_7$

Investigations critically examined			
Ref.	Mol % $Na_2B_4O_7$	Temp. range (K)	Comments
25	72–93	1223	alundum crucible and capillary tube; purified Ar; experimental uncertainty $\sim\pm5\%$

TABLE 24. ZrF_4 - $Na_2B_4O_7$: Surface tension (dyn cm^{-1})

Mol percent $Na_2B_4O_7$	1223 K
90	240
80	247
70	240

Composition-dependent equation

$\gamma = -222.3 + 11.710C - 7.30 \times 10^{-2}C^2$

[C = Mol % $Na_2B_4O_7$]

Standard error of estimate = 0.9%

These values are based on the data of Yakobashvili, Oparin, Lyudvig, and Danil'chenko (maximum bubble pressure method) [25].

TABLE 26. KCl - $Na_2B_4O_7$: Density (g cm^{-3})

Mol percent $Na_2B_4O_7$	1223 K
100	2.06
90	2.15
80	2.24
70	2.33
60	2.42
50	2.51
40	2.60
30	2.69

Composition-dependent equation

$\rho = 2.961 - 0.902 \times 10^{-2}C$

[C = Mol % $Na_2B_4O_7$]

Standard error of estimate = 2.40%

These values are based on the data of Oparin and Yakobashvili (maximum bubble pressure method) [26].

TABLE 27. Surface tension studies: KCl - $Na_2B_4O_7$

Investigations critically examined			
Ref.	Mol % $Na_2B_4O_7$	Temp. range (K)	Comments
26	30–100	1223	alundum crucible and capillary tube; purified Ar; experimental uncertainty $\sim\pm5\%$.
25	39–81	1223	as for [26]

KCl - $Na_2B_4O_7$

Melt Preparation and Purification

Yakobashvili, et al. [25,26] used reagent grade salts to prepare the melts.

TABLE 25. Density studies: KCl - $Na_2B_4O_7$

Investigations critically examined			
Ref.	Mol % $Na_2B_4O_7$	Temp. range (K)	Comments
26	30–100	1223	alundum crucible and capillary tube;purified Ar; experimental uncertainty $\sim\pm5\%$.
25	33–81	1223	as for [26]

TABLE 28. KCl - $Na_2B_4O_7$: Surface tension (dyn cm^{-1})

Mol percent $Na_2B_4O_7$	1223 K
100	227
90	195
80	169
70	149
60	135
50	126
40	124
30	128

Composition-dependent equation

$\gamma = 176.5 - 2.508C + 30.15 \times 10^{-3}C^2$

[C = Mol % $Na_2B_4O_7$]

Standard error of estimate = 2.52%

These values are based on the data of Oparin and Yakobashvili (maximum bubble pressure method) [26]. The value predicted for 100% $Na_2B_4O_7$ from the above equation is $\sim$1% low [cf. Table 10].

LiCl - $Na_2B_4O_7$

Melt Preparation and Purification

Yakobashvili, et al. [25, 26] used reagent grade salts to prepare the melts.

TABLE 29. Density studies: LiCl - $Na_2B_4O_7$

Investigations critically examined			
Ref.	Mol % $Na_2B_4O_7$	Temp. range (K)	Comments
26	40–100	1223	alundum crucible and capillary tube; purified Ar; experimental uncertainty ~±5%.
25	32–76		as for [26]

TABLE 30. LiCl - $Na_2B_4O_7$: Density (g cm^{-3})

Mol percent $Na_2B_4O_7$	1223 K
100	2.06
90	2.08
80	2.10
70	2.11
60	2.12
50	2.12
40	2.12

Composition-dependent equation

$$\rho = 2.069 + 0.221 \times 10^{-2}C - 0.231 \times 10^{-4}C^2$$

[C = Mol % $Na_2B_4O_7$]

Standard error of estimate = 0.13%

These values are based on the data of Oparin and Yakobashvili (maximum bubble pressure method) [26].

TABLE 31. Surface tension studies: LiCl - $Na_2B_4O_7$

Investigations critically examined			
Ref.	Mol % $Na_2B_4O_7$	Temp. range (K)	Comments
26	40–100	1223	alundum crucible and capillary tube; purified Ar; experimental uncertainty ~±5%
25	32–76		as for [26]

TABLE 32. LiCl - $Na_2B_4O_7$: Surface tension (dyn cm^{-1})

Mol percent $Na_2B_4O_7$	1223 K
100	231
90	222
80	205
70	184
60	166
50	155
40	156

Composition-dependent equation

$$\gamma = 392.7 - 12.29C + 19.44 \times 10^{-2}C^2 - 8.77 \times 10^{-4}C^3$$

[C = Mol % $Na_2B_4O_7$]

Standard error of estimate = 1.61%

These values are based on the data of Oparin and Yakobashvili (maximum bubble pressure method) [26]. The value for 100% $Na_2B_4O_7$ from the above equation agrees with that in Table 10 within the limits of experimental error (i.e., ±0.5%).

NaCl - $Na_2B_4O_7$

Melt Preparation and Purification

Stalhane [27] used reagent grade salts to prepare the melts.

TABLE 33. Electrical conductance studies: NaCl - $Na_2B_4O_7$

Investigations critically examined			
Ref.	Mol % $Na_2B_4O_7$	Temp. range (K)	Comments
27	50–100	1023–1123	Pt electrodes

TABLE 34. NaCl - $Na_2B_4O_7$: Specific conductance (ohm^{-1} cm^{-1})

T(K)	Mol percent $Na_2B_4O_7$			
	92.5	76.5	60.8	50.7
1020	0.20	0.33		
1080	0.32	0.44	0.67	0.86
1100	0.37	0.50	0.74	0.95
1130	0.44	0.60	0.86	1.09

Temperature-dependent equations

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

Mol % $Na_2B_4O_7$	a	$b \times 10^3$	$c \times 10^6$	standard error of estimate
100	4.533	-9.768	5.390	1.1%
92.5	0.968	-3.33	2.53	0.4%
76.5	10.417	-21.02	10.91	1.4%
60.8	-3.438	3.80		*
50.7	-4.106	4.60		*

These values are based on the data of Stalhane (classical ac method) [27]. *Insufficient data for estimate.

Halide - Carbonate

TABLE 35. Data Status

System	Phase Diagram	Electrical Conductance	Density	Viscosity	Surface Tension
$KF-Li_2CO_3$			X		
$LiF-K_2CO_3$			X		
$KCl-K_2CO_3$	X		X		
$-Li_2CO_3$	X		X		
$-Na_2CO_3$	X		X		
$LiCl-K_2CO_3$	X		X		
$-Li_2CO_3$	X		X	X	X
$NaCl-K_2CO_3$	X		X		
$-Na_2CO_3$	X	X	X		

$KF - Li_2CO_3$

Phase diagram: Prisyazhnyi and Zvagol'skaya [28] cite the work of N. N. Volkov and T. F. Shvab, Izv. Fiz.-Khim. n.-i. in-ta pri Irkutskom gosuniversitete, **2**, 55 (1953) for the phase diagram; copy of the latter could not be retrieved via conventional interlibrary loan channels.

Melt Preparation and Purification

Prisyazhnyi and Zvagol'skaya [28] recrystallized potassium fluoride from double distilled water and then fused it in a platinum crucible. Lithium carbonate was prepared from lithium hydroxide and ammonium carbonate. The carbonate was then dried in an atmosphere of CO_2 at 600°C. All mixtures were prepared in a dry box.

TABLE 36. Density studies: $KF - Li_2CO_3$

Investigations critically examined			
Ref.	Equiv% Li_2CO_3	Temp. range (K)	Comments
28	0–90	1123–1223	gold bob suspended on Pt thread; Pt crucible

TABLE 37. $KF - Li_2CO_3$: Density (g cm^{-3})

T(K)	Equiv. percent Li_2CO_3			
	90	60	40	10
1140	1.823	1.843	1.860	1.884
1220	1.799	1.813	1.820	1.840

Temperature-dependent equations

$$\rho = a + bT$$

Equiv. % Li_2CO_3	a	$-b \times 10^3$
90	2.164	0.299
70	2.221	0.344
60	2.266	0.371
50	2.387	0.473
40	2.432	0.502
10	2.524	0.561
0	2.664	0.669

The above equations are based on those reported by Prisyazhnyi and Zvagol'skaya; temperature limits not cited; precisions not estimated (Archimedean technique) [28]. The values calculated from the above equation for KF (i.e. 0% Li_2CO_3) are virtually in exact agreement with the recommended data base, i.e. ~0.3% [1].

$LiF - K_2CO_3$

Phase diagram: Prisyazhnyi and Zvagol'skaya [28] cite the work of N. N. Volkov and T. F. Shvab, Izv. Fiz.-Khim. n.-i. in-ta pri Irkutskom gosuniversitete, **2**, 55 (1953) for the phase diagram; copy of the latter could not be retrieved via conventional interlibrary loan channels.

Melt Preparation and Purification

Prisyazhnyi and Zvagol'skaya [28] recrystallized lithium fluoride from double distilled water and then fused it in a platinum crucible. Reagent grade potassium carbonate was recrystallized from double distilled water. All mixtures were prepared in a dry box.

TABLE 38. Density studies: LiF – K_2CO_3

Investigations critically examined

Ref.	Equiv% K_2CO_3	Temp. range (K)	Comments
28	0–90	1123–1223	gold bob suspended on Pt thread; Pt crucible.

TABLE 39. LiF – K_2CO_3: Density (g cm^{-3})

T(K)	Equiv. percent K_2CO_3			
	90	60	40	20
1140	1.856	1.847	1.831	1.809
1220	1.816	1.807	1.790	1.771

Temperature dependent equations

$$\rho = a + bT$$

Equiv. % K_2CO_3	a	$-b \times 10^3$
90	2.425	0.499
80	2.434	0.507
70	2.448	0.523
60	2.417	0.500
50	2.411	0.493
40	2.423	0.519
30	2.328	0.448
20	2.352	0.476
0	2.294	0.441

The above equations are based on those reported by Prisyazhnyi and Zvagol'skaya; temperature limits not cited; precisions not estimated (Archimedean technique) [28]. For 60, 70, and 80 equiv. % K_2CO_3, the density equations in [28] are incorrect, the calculated values are uniformly ~20% too low. The equation parameters (above) for these three compositions were calculated in the present work [9]. The calculated densities from these are in close accord with the experimental data (~0.5%). The values above for pure LiF (i.e. 0% K_2CO_3) are virtually in exact accord with the recommended data base (i.e. ~0.3%) [1].

KCl – K_2CO_3

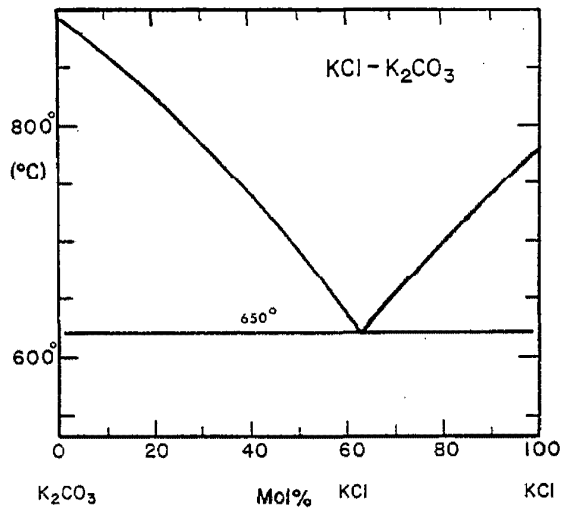

FIGURE 2. Phase diagram for KCl – K_2CO_3.

The system KCl–K_2CO_3 is seen in Fig. 3 as one side of the field of the reciprocal salt system: K, Li/Cl, CO_3.

Data from: M. Amadori, Atti realli accad. Lincei. Sez. II, **224**, 372 (1913); V. P. Radishchev, Zhur. O. Khim. **3**, 852 (1933); P. N. Volkov and A. G. Bergman, Dokl. Akad. Nauk SSSR, **27**, 967 (1940); **35**, 50 (1943).

Melt Preparation and Purification

Polyakov and Berul [29] used reagent grade salts for the preparation of the melts.

TABLE 40. Density studies: KCl – K_2CO_3

Investigations critically examined

Ref.	Mol % K_2CO_3	Temp. range (K)	Comments
29	5–81	973–1173	Pt ball; Pt crucible; calibration; molten KNO_3.
30	0–85	–	–

TABLE 41. KCl - K_2CO_3: Density (g cm^{-3})

T(K)	Mol percent K_2CO_3				
	80.8	51.9	32.3	21.0	5.3
970			1.767		
1050			1.730	1.660	
1090		1.811	1.712	1.645	
1150	1.883	1.784	1.684	1.622	1.534
1170	1.878				

Temperature-dependent equations

$\rho = a + bT$

Mol % K_2CO_3	a	$-b \times 10^3$	standard error of estimate
80.8	2.1593	0.2406	*
65.0	2.3173	0.4202	*
51.9	2.3085	0.4560	0.01%
41.5	2.2794	0.4714	0.02%
32.3	2.2178	0.4643	0.15%
23.5	2.2319	0.5128	0.02%
21.0	2.0633	0.3838	0.06%
10.4	2.1600	0.5200	0.00%
5.3	2.1319	0.5199	*

These values are based on the data of Polyakov and Berul (Archimedean technique). *Insufficient data for estimate. [29].

Melt Preparation and Purification

Prisyazhnyi and Zvagol'skaya [28] recrystallized reagent grade potassium chloride from double distilled water. Lithium carbonate was prepared from lithium hydroxide and ammonium carbonate (both chemically pure). The carbonate was then dried in a current of CO_2 at 600°. All mixtures were prepared in a dry box, and all measurements were in a dry CO_2 atmosphere.

TABLE 42. Density studies: KCl - Li_2CO_3

Investigations critically examined			
Ref.	Equiv% Li_2CO_3	Temp. range (K)	Comments
28	0-90	998-1073	gold bob suspended on Pt thread; alundum crucible.

KCl - Li_2CO_3

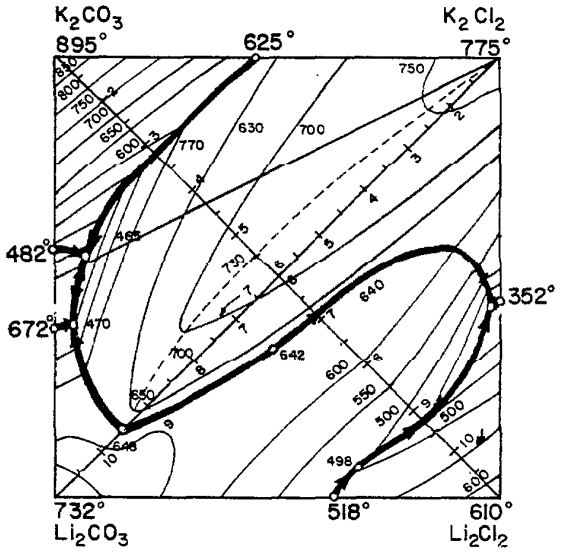

FIGURE 3. Phase diagram for KCl-Li_2CO_3. The system KCl-Li_2CO_3 is a diagonal in the field of the reciprocal salt system: K, Li/Cl, CO_3.

Data from: N. N. Volkov and M. N. Zakhvalinskii, Izv. Fiz.-Khim. n.-i. in-ta pri Irkutskom gosuniversitete, 4, 107 (1959).

TABLE 43. KCl - Li_2CO_3: Density (g cm^{-3})

T(K)	Equiv. percent Li_2CO_3			
	90	60	30	10
1020	1.783	1.669	1.597	1.551
1070	1.766	1.653	1.572	1.525

Temperature-dependent equations

$\rho = a + bT$

Equiv. % Li_2CO_3	a	$-b \times 10^3$
90	2.127	0.337
80	2.146	0.390
60	1.993	0.318
50	2.104	0.447
40	2.050	0.427
30	2.109	0.502
20	2.090	0.509
10	2.089	0.527
0	2.100	0.550

The above equations are based on those reported by Prisyazhnyi and Zvagol'skaya; temperature limits not cited; precisions not estimated; (Archimedean technique) [28]. The values for KCl (0% Li_2CO_3) are virtually in exact agreement with the recommended KCl density data base (<0.5%) [1].

KCl - Na_2CO_3

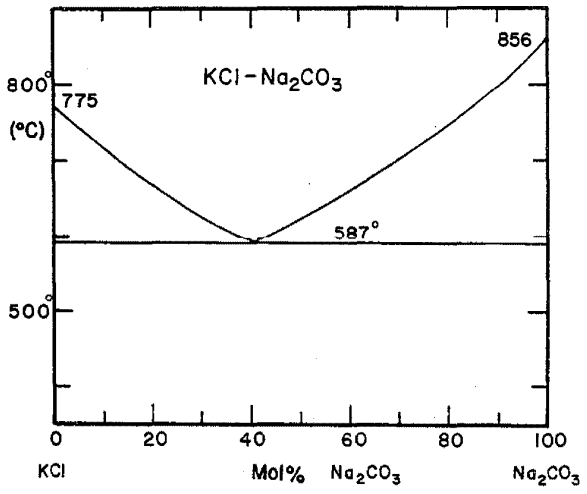

FIGURE 4. Phase diagram for KCl - Na_2CO_3.

Data from: Tomo-o Sato, Kinzoku, **10**, 453 (1933). See also N. N. Volkov, and A. G. Bergman, Dokl. Akad. Nauk. SSSR, **35**, 50 (1942)

Melt Preparation and Purification

Polyakov and Berul [29] used reagent grade salts for the preparation of the melts. No information on melt preparation was given in the study by Markov [31].

TABLE 44. Density studies: KCl - Na_2CO_3

Investigations critically examined			
Ref.	Mol % Na_2CO_3	Temp. range (K)	Comments
29	0-81.8	923-1148	Pt ball and crucible; calibration; molten KNO_3.
31	0-100	1098	

TABLE 45. KCl - Na_2CO_3: Density (g cm^{-3})

T(K)	Mol percent Na_2CO_3				
	81.8	53.8	33.3	14.3	5.3
920			1.802		
980		1.875	1.776	1.687	
1040		1.851	1.750	1.659	1.587
1100	1.941	1.828	1.723	1.631	1.554
1150	1.920	1.808	1.701	1.607	1.527

Temperature-dependent equations

$$\rho = a + bT$$

Mol % Na_2CO_3	a	$-b \times 10^3$	standard error of estimate
81.8	2.4029	0.4198	0.02%
66.7	2.3318	0.4086	0.03%
53.8	2.2639	0.3967	0.02%
42.9	2.2206	0.4067	0.03%
33.3	2.2066	0.4395	0.03%
22.2	2.1828	0.4614	0.02%
14.3	2.1473	0.4695	0.02%
11.1	2.1619	0.5199	0.00%
5.3	2.1573	0.5481	0.02%

These values are based on the data of Polyakov and Berul (Archimedean technique) [29]. The density values for pure KCl reported in the work (above) are uniformly lower (~2 to 3%) than the recommended data for KCl [1].

LiCl - K_2CO_3

Phase diagram: see Fig. 3

The system LiCl-K_2CO_3 is a diagonal cross section of the reciprocal salt system Li, K/CO_3, Cl.

Melt Preparation and Purification

Prisyazhnyi and Zvagol'skaya [28] dehydrated LiCl using a stream of dry HCl through the molten salt; the HCl was expelled using a dry argon sweep. The potassium carbonate was a chemically pure grade, and was further recrystallized from distilled water. All measurements were in a dry carbon dioxide atmosphere.

TABLE 46. Density studies: LiCl - K_2CO_3

Investigations critically examined			
Ref.	Equiv% K_2CO_3	Temp. range (K)	Comments
28	0-90	1023-1073	Archimedean technique; gold bob (42g); alundum crucible; temp. Pt-Rh thermocouple; dry CO_2 atmosphere

TABLE 47. LiCl – K_2CO_3: Density (g cm^{-3})

T(K)	Equiv. percent K_2CO_3			
	90	60	30	10
1030	1.893	1.697	1.561	1.470
1070	1.874	1.680	1.544	1.452

Temperature-dependent equations

$\rho = a + bT$

Equiv. % K_2CO_3	a	$-b \times 10^3$
90	2.392	0.484
80	2.315	0.466
70	2.149	0.373
60	2.143	0.433
50	2.033	0.384
40	1.945	0.343
30	1.988	0.415
20	1.987	0.451
10	1.935	0.451
0	1.881	0.434

The above equations are based on those reported by Prisyazhnyi and Zvagol'skaya; temperature limits not cited; precisions not estimated. (Archimedean technique) [28]. The values for pure LiCl (0% K_2CO_3) are virtually in exact agreement with the recommended data base (<0.3%) [1].

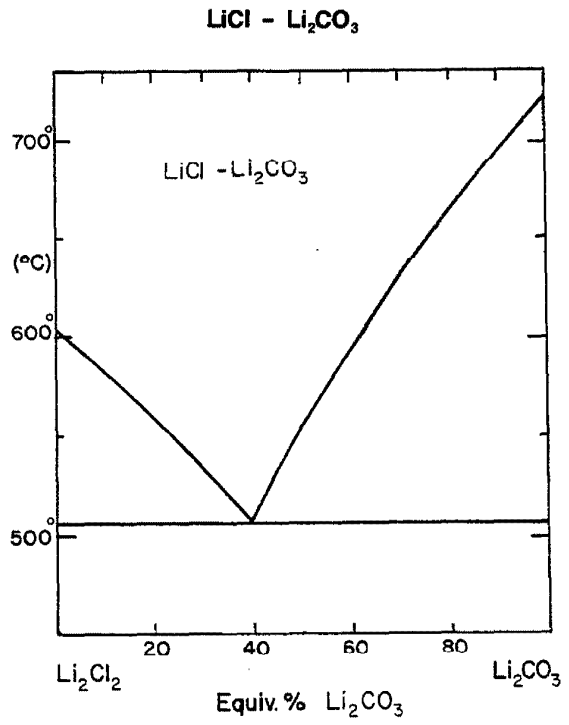

FIGURE 5. Phase diagram for LiCl – Li_2CO_3.

Data from: Metalloy Corporation, Minneapolis, Minn. (1944); cited in E. Levin, et al., "Phase Diagrams for Ceramists", Amer. Ceramic Soc. (publ.), Columbus, Ohio (1964;1969).

Melt Preparation and Purification

Bockris et al. [32] used reagent grade lithium chloride and lithium carbonate. The lithium chloride was dried in a slow flow of dry argon under a pressure of 0.1–0.2 torr. The drying temperature was gradually increased from room temperature to about 450°C in intervals of 60°C over 30 hours. Lithium carbonate was treated in the same way, but using CO_2 instead of argon. The dried salts were stored under argon and the melts were prepared in a dry box in a gold– palladium crucible.

TABLE 48. Density studies: LiCl – Li_2CO_3

Investigations critically examined			
Ref.	Mol % Li_2CO_3	Temp. range (K)	Comments
32	10–71	810–1045	quartz cell; gold–palladium alloy plate; calibration: benzene, toluene, CCl_4

TABLE 49. LiCl – Li_2CO_3: Density (g cm^{-3})

T(K)	Mol percent Li_2CO_3			
	71	40	25.2	10
850			1.633	1.553
910		1.668	1.611	1.527
970	1.740	1.646	1.589	1.501
1030	1.716	1.624	1.568	1.475

Temperature-dependent equations

$\rho = a + bT$

Mol % Li_2CO_3	a	$-b \times 10^3$	standard error of estimate
71	2.1244	0.3965	0.23%
50	2.0530	0.4058	0.14%
40	2.0020	0.3672	0.10%
30	1.9523	0.3498	0.07%
25.2	1.9420	0.3635	0.08%
20	1.9157	0.3895	0.07%
10	1.9199	0.4316	0.07%

These values are based on the data of Bockris, Calandra and Solomons (Archimedean technique). [32]. The density technique [32] was cross checked with molten KNO_3; the results are in exact agreement with the recommended density data base for KNO_3 [10].

TABLE 50. Viscosity studies: LiCl – Li_2CO_3

Investigations critically examined

Ref.	Mol % Li_2CO_3	Temp. range (K)	Comments
32	10–70	825–1026	gold plate and quartz spring; modified Delmar stopcock; calibration: benzene, toluene, CCl_4.

TABLE 51. LiCl – Li_2CO_3: Viscosity (cp)

T(K)	Mol percent Li_2CO_3			
	70	40	20	10
840			3.10	
880		4.34	2.65	1.91
920		3.67	2.28	1.70
960		3.15	1.99	1.52
1000	4.66	2.78	1.79	1.37
1020	4.30	2.64	1.71	1.30

Temperature-dependent equations

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

Mol % Li_2CO_3	a	$-b \times 10^3$	$c \times 10^6$	standard error of estimate
70	37.102	46.43	13.99	0.14%
50	62.693	107.99	48.62	0.88%
40	56.106	99.09	45.76	0.91%
30	55.866	103.68	50.07	1.55%
20	30.955	54.13	24.96	0.66%
15	18.585	29.83	12.74	0.49%
10	13.528	20.82	8.66	0.71%

These values are based on the data of Bockris, Calandra and Solomons (linear-oscillating plate method) [32]. The extrapolated values for LiCl in the work above are in agreement with the recommended data base for LiCl [1]; recent work by Brockner, Torklep and Oye shows that the viscosities for LiCl cited in [1] are uniformly too high (~4%) [235].

TABLE 52. Surface tension studies: LiCl – Li_2CO_3

Investigations critically examined

Ref.	Mol % Li_2CO_3	Temp. range (K)	Comments
32	10–70	810–1049	Au–Pd plate; calibration: molten KNO_3, $NaNO_3$.

TABLE 53. LiCl – Li_2CO_3: Surface tension (dyn cm^{-1})

T(K)	Mol percent Li_2CO_3			
	70	50	40	20
830				147.7
890			162.5	144.3
930		171.2	160.7	142.1
970	191.3	168.3	158.8	139.9
1030	189.1	163.8		136.5
1050	188.3			

Temperature-dependent equations

$$\gamma = a + bT$$

Mol % Li_2CO_3	a	$-b \times 10^3$	standard error of estimate
70	227.57	37.37	0.05%
50	240.39	74.37	0.12%
40	204.04	46.63	0.06%
30	203.44	55.11	0.27%
20	194.04	55.85	0.25%
10	195.57	63.12	0.29%

These values are based on the data of Bockris, Calandra, and Solomons (detachment technique) [32]. The estimated limits of accuracy are ~±1%.

NaCl – K_2CO_3

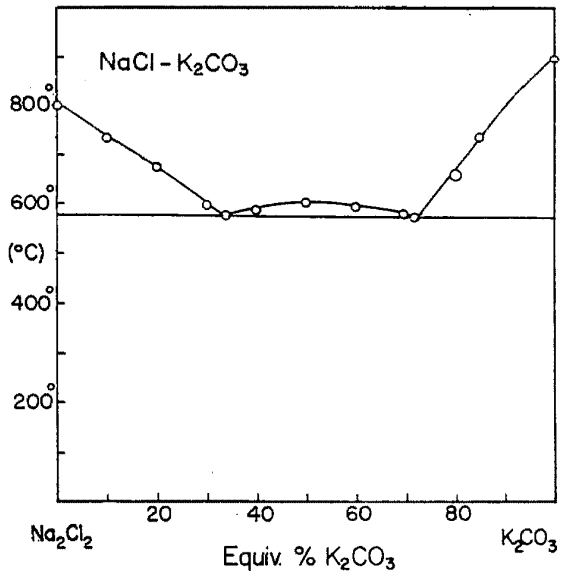

FIGURE 6. Phase diagram for NaCl – K_2CO_3.

Data from: V. P. Radishchev, Zhur. O. Khim, 3, 852 (1933).

Melt Preparation and Purification

Polyakov and Berul [29] used reagent grade salts for the preparation of the melts. No information on melt preparation was given in the study by Markov [31].

TABLE 54. Density studies: NaCl - K_2CO_3

Investigations critically examined			
Ref.	Mol % K_2CO_3	Temp. range (K)	Comments
29	9.6–68	898–1148	Pt ball and crucible; calibration, molten KNO_3
31	0–100	1098	no information

TABLE 55. NaCl - K_2CO_3: Density (g cm^{-3})

T(K)	Mol percent K_2CO_3				
	66.7	42.9	33.3	25.0	11.1
920		1.840	1.799	1.768	
960		1.823	1.783	1.749	
1000	1.902	1.806	1.766	1.731	1.666
1060	1.873	1.781	1.741	1.703	1.635
1120		1.755	1.716	1.676	1.604
1150		1.742	1.704	1.662	1.589

Temperature-dependent equations

$$\rho = a + bT$$

Mol % K_2CO_3	a	$-b \times 10^3$	standard error of estimate
66.7	2.3815	0.4800	0.19%
53.8	2.3094	0.4531	0.04%
42.9	2.2292	0.4233	0.02%
37.9	2.0997	0.3166	0.05%
33.3	2.1813	0.4152	0.11%
29.0	2.2026	0.4577	0.09%
25.0	2.1911	0.4601	0.11%
17.6	2.1099	0.4266	0.02%
11.1	2.1786	0.5128	0.02%

These values are based on the data of Polyakov and Berul (Archimedean technique) [29].

NaCl - Na_2CO_3

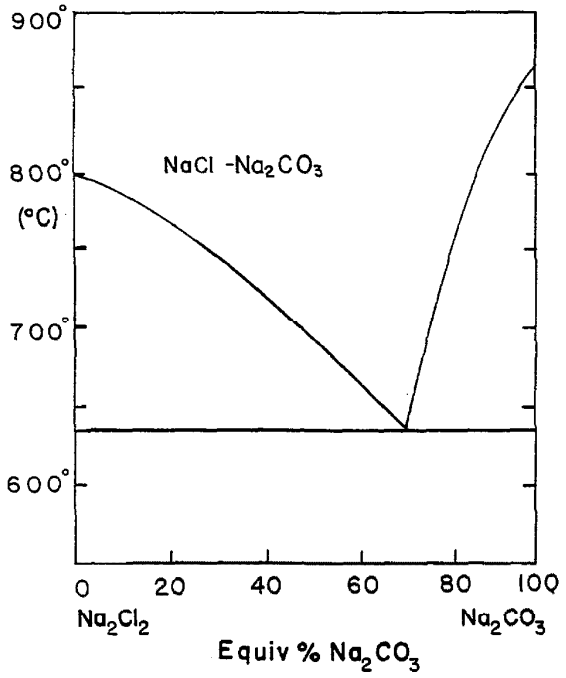

FIGURE 7. Phase diagram for NaCl - Na_2CO_3.

Data from: P. Niggli, Z. Anorg. U. allgem. Chem. **106**, 136 (1919).

Melt Preparation and Purification

Ryschkewitsch [33] used reagent grade salts for the preparation of the melts. The sodium chloride was recrystallized from distilled water. The sodium carbonate was dried in an atmosphere of CO_2.

TABLE 56. Electrical conductance studies: NaCl - Na_2CO_3

Investigations critically examined			
Ref.	Mol % Na_2CO_3	Temp. range (K)	Comments
33	20–100	913–1323	quartz cell; Pt electrodes; calibration: aq KCl, sat NaCl, molten KNO_3; estimated uncertainty ~1%.

TABLE 57. NaCl – Na_2CO_3: Specific conductance (ohm^{-1} cm^{-1})

T(K)	Mol percent Na_2CO_3	
	33.3	20
930	1.74	
990	2.23	2.43
1110	2.90	3.04
1210	3.13	3.41
1310	3.10	3.65

Temperature-dependent equations

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

Mol % Na_2CO_3	$-a$	$b \times 10^3$	$-c \times 10^6$	standard error of estimate
100	83.035	137.821	54.191	7.43%
33.3	18.599	34.876	13.98	4.28%
20	9.413	18.132	6.23	3.19%

These values are based on the data of Ryschkewitsch (classical ac method) [[33]. The values reported in [[33] for molten Na_2CO_3 are uniformly lower (~10%) than the recommended conductance data base for Na_2CO_3 [1].

TABLE 58. Density studies: NaCl – Na_2CO_3

Investigations critically examined

Ref.	Mol % Na_2CO_3	Temp. range (K)	Comments
29	0–81.8	973–1148	Pt ball and crucible calibration: molten KNO_3

TABLE 59. NaCl – Na_2CO_3: Density (g cm^{-3})

T(K)	Mol percent Na_2CO_3				
	81.8	53.8	37.9	25.0	11.1
1000		1.889	1.825		
1060		1.869	1.804	1.731	
1100	1.947	1.856	1.789	1.716	1.645
1150	1.928	1.839	1.772	1.698	1.619

Temperature-dependent equations

$$\rho = a + bT$$

Mol % Na_2CO_3	a	$-b \times 10^3$	standard error of estimate
81.8	2.3645	0.3800	0.01%
66.7	2.2831	0.3440	0.01%
53.8	2.2172	0.3286	0.01%
42.9	2.1485	0.3085	0.03%
37.9	2.1823	0.3571	0.04%
33.3	2.2411	0.4367	0.06%
29.0	2.2051	0.4228	0.02%
25.0	2.1209	0.3679	0.07%
17.6	2.0025	0.2999	0.09%
11.1	2.2168	0.5198	0.00%
0	1.8564	0.3202	0.08%

These values are based on the data of Polyakov and Berul (Archimedean technique) [29]. The densities reported for NaCl in a related study [28] are ~2% lower than the values from the recommended data base for NaCl [1,10].

Halides - Nitrate

TABLE 60. Data Status

System	Phase Diagram	Electrical Conductance	Density	Viscosity	Surface Tension
$NaF-NaNO_3$	X				X
$AgCl-AgNO_3$	X	X	X		
$BaCl_2-NaNO_3$	X	X			
$CoCl_2-KNO_3$		X			
$HgCl_2-TlNO_3$	X	X	X	X	
$KCl-KNO_3$	X	X	X		
$-LiNO_3$			X		
$-NH_4NO_3$	X		X	X	
$-NaNO_3$					X
$LiCl-KNO_3$			X		
$-LiNO_3$	X	X	X		
$-NaNO_3$		X			
$NaCl-NaNO_3$	X	X	X	X	X
$PbCl_2-NaNO_3$		X			
$TlCl-KNO_3$	X	X			
$-NaNO_3$	X	X			
$AgBr-AgNO_3$	X	X			
$CoBr_2-KNO_3$		X	X		
$HgBr_2-AgNO_3$	X	X		X	
$-Hg(NO_3)_2$		X			
$KBr-KNO_3$	X	X	X		
$TlBr-KNO_3$		X			
$AgI-AgNO_3$	X	X	X	X	
HgI_2-AgNO_3	X	X	X	X	
$-TlNO_3$	X	X			
$NaI-NaNO_3$	X				X

$NaF-NaNO_3$

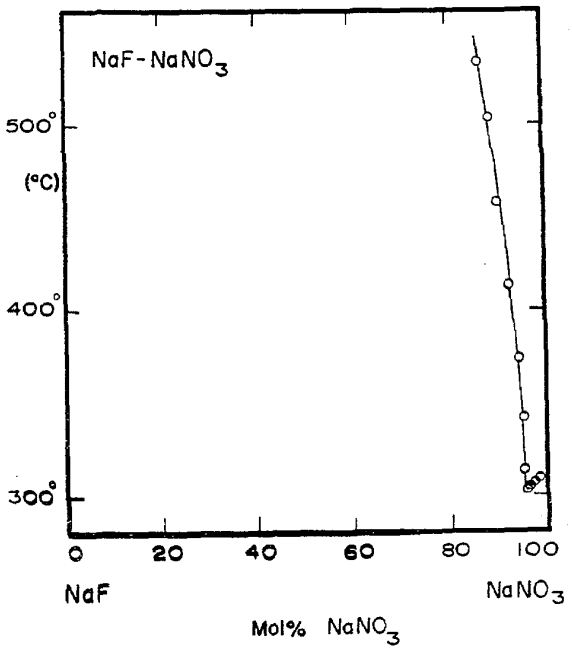

FIGURE 8. Phase diagram for $NaF - NaNO_3$.

Data from: R. N. Nyankovskaya and A. G. Bergman, Izv. Sekt. Fiz. Khim. Analiza, 21, 250(1952).

Melt Preparation and Purification

Semenchenko and Shikhobalova [34] used reagent grade materials. No other information on melt preparation was given.

TABLE 61. Surface tension studies: $NaF - NaNO_3$

Investigations critically examined			
Ref.	Mol % $NaNO_3$	Temp. range (K)	Comments
34	90-100	833	Pyrex capillary, estimated uncertainty, 0.5 - 2%; calibration: pure $NaNO_3$

TABLE 62. $NaF - NaNO_3$: Surface tension (dyn cm^{-1})

T(K)	Mol percent $NaNO_3$
	90
833	108.27

A single data point only (above) was reported by Semenchenko and Shikhobalova (maximum bubble pressure method). [34]

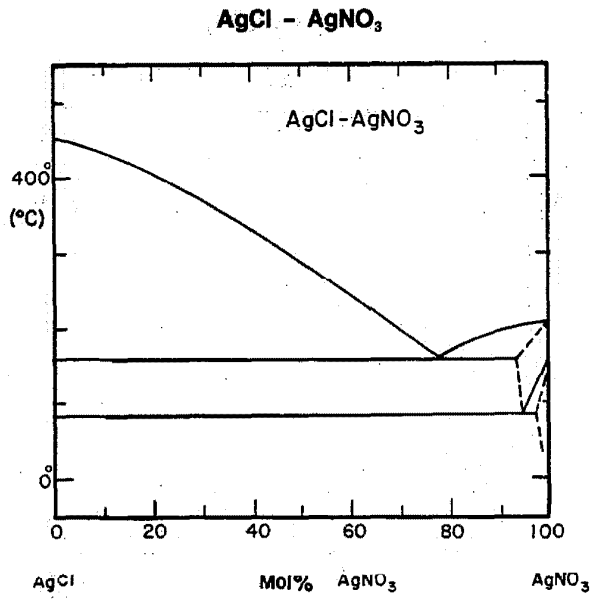

FIGURE 9. Phase diagram for $AgCl - AgNO_3$.

Data from: G. Scarpa, Atti reale accad. Lincei, Sez. II, 22, 457(1913).

Melt Preparation and Purification

Spooner and Wetmore [35] used reagent grade silver nitrate recrystallized three times from conductivity water. The crystals were dried by first gentle heating followed by fusion. The silver chloride was prepared by diluting a saturated solution of silver nitrate 30:1 with water and then adding dilute hydrochloric acid in 5% excess. The precipitate was washed 15 times with water and dried, first by suction and then by slow heating well below the melting point. All work with the silver salts was in a semi-darkened laboratory.

Townsend and Duby [36] prepared the melts from reagent grade salts which were fused under a partial vacuum and filtered through medium porosity fritted glass filters. Chemical analyses were used to confirm the compositions of the melts.

Bizouard [37] used Merck reagent grade $AgNO_3$. The AgCl was prepared in the laboratory immediately prior to use.

TABLE 63. Electrical conductance studies: $AgCl - AgNO_3$

Investigations critically examined

Ref.	Mol % $AgNO_3$	Temp. range (K)	Comments
37	0–100	573–823	Pyrex and silica cells; Pt electrodes; calibration: 1*N* KCl (aq), NaCl(sat'd), H_2SO_4
35	0–100	483–603	Pyrex and silica dip-type cells; frequency: 2200Hz; Pt disk electrodes; temp. gradients determined; calibration: 1*D* KCl solns; corrections made for thermal expansion.

TABLE 64. $AgCl - AgNO_3$: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent $AgNO_3$				
	81.5	80	60	40	20
580	1.087	1.087	1.204		
640	1.323	1.323	1.459	1.739	2.327
700	1.529	1.531	1.683	1.971	2.592
760	1.705	1.710	1.877	2.180	2.827
820	1.852	1.860	2.040	2.366	3.033

Temperature-dependent equations

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

Mol % $AgNO_3$	$-a$	$b \times 10^3$	$-c \times 10^6$	standard error of estimate
100	3.0977	10.3687	5.4283	0.27%
81.5	2.7317	8.9847	4.1400	0.16%
80	2.69075	8.8389	4.0110	0.19%
60	2.83295	9.4191	4.2395	0.20%
40	2.1612	8.1267	3.1770	0.07%
20	2.2970	9.8052	4.0305	0.20%
0	3.0685	14.6225	7.1410	0.03%

These values are based on the data of Bizouard (potentiometric ac method) [37]. The values for $AgNO_3$ (above) are in exact agreement with the recommended data base [3]; for AgCl, the values above are consistently lower ~1% than the recommended data base [1].
For specific conductivity data at some additional compositions: (mol % $AgNO_3$), 55.85, 66.30, 77.13, 82.13, 85.52, 89.51, and at 480–620 K, see: Spooner and Wetmore [35].

TABLE 65. Density studies: AgCl – $AgNO_3$

Investigations critically examined			
Ref.	Mol % $AgNO_3$	Temp. range (K)	Comments
35	55.9–100	583–603	Ag bob; Pt wire suspension; calibration: H_2O; corrections for thermal expansion
36	57.2–100	457–600	two bob gravimetric method; lead weighted Vycor bobs; Pt suspension wire experimental uncertainty ±0.001 (gm cm^{-3})

Density data of the above two studies are in agreement to ~±0.5%.

TABLE 66. AgCl – $AgNO_3$: Density (g cm^{-3})

T(K)	Mol percent $AgNO_3$				
	94.3	83.9	76.8	65.5	57.2
460		4.125	4.179		
500	3.983	4.078	4.133	4.239	
540	3.938	4.032	4.088	4.195	4.270
580	3.893	3.985	4.043	4.151	4.225
600		3.962			

Temperature-dependent equations

$$\rho = a + bT$$

Mol % $AgNO_3$	a	$-b \times 10^3$
100	4.5218	1.1434
94.3	4.5514	1.1360
83.9	4.6599	1.1631
76.8	4.7017	1.1365
65.5	4.7896	1.1007
57.2	4.8674	1.1070

These values are based on the data of Townsend and Duby (two bob gravimetric method); data in equation form; precisions not estimated [36]. The values of $AgNO_3$ (above) are in exact agreement with the recommended density data base for $AgNO_3$ [3].

For densities at some additional compositions: (mol % $AgNO_3$): 55.85, 66.30, 77.13, 82.13, 85.52, 89.51, and at 580–600 K, see: Spooner and Wetmore [35].

$BaCl_2$ – $NaNO_3$

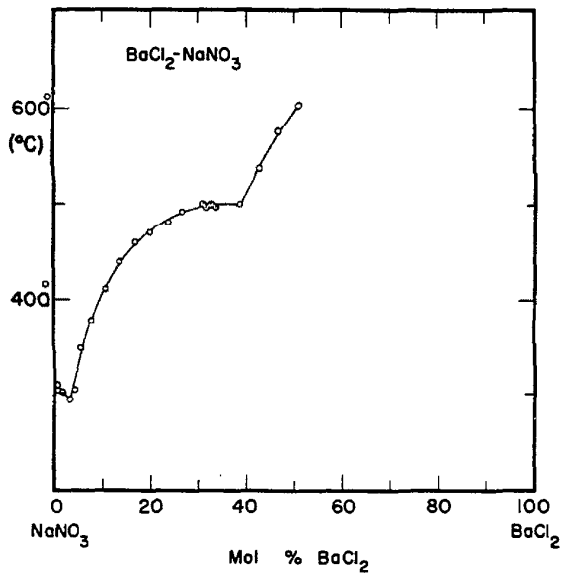

FIGURE 10. Phase diagram for $BaCl_2$ – $NaNO_3$.

Data from: E. I. Esperanskaya, Dokl. Akad. Nauk SSSR, **40**, 28 (1943).

Melt Preparation and Purification

No information on melt preparation was given in the study by Bogorodskavo [38].

TABLE 67. Electrical conductance studies: $BaCl_2$ – $NaNO_3$

Investigations critically examined			
Ref.	Mol % $BaCl_2$	Temp. range (K)	Comments
38	0–9	626–635	Pt disk electrodes; heavy wall capillary

TABLE 68. $BaCl_2$ – $NaNO_3$: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent $BaCl_2$			
	9.121	6.138	1.979	1.169
620	1.015	1.061	1.094	1.111
630	1.059	1.100	1.136	1.151
640				1.192

Temperature-dependent equations

$\kappa = a + bT$

Mol % $BaCl_2$	$-a$	$b \times 10^3$	standard error of estimate
9.121	1.7062	4.3886	0.20%
6.138	1.3394	3.8720	0.03%
1.979	1.5356	4.2407	0.03%
1.169	1.4019	4.0527	0.13%

These values are based on the data of Bogorodskavo (classical ac method) [38].

$CoCl_2$ - KNO_3

Melt Preparation and Purification

Reagent grade salts were used (further oven-dried before measurements [39]).

TABLE 69. Electrical conductance studies: $CoCl_2$ – KNO_3

Investigations critically examined			
Ref.	Mol % KNO_3	Temp. range (K)	Comments
39	99.973–100	673–698	Investigations limited to small additions of $CoCl_2$

TABLE 70. $CoCl_2$ – KNO_3: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent KNO_3			
	99.997	99.995	99.986	99.973
670	0.792	0.791	0.799	0.797
680	0.823	0.822	0.827	0.825
690	0.854	0.853	0.854	0.852
700	0.885	0.885	0.882	0.880

Temperature-dependent equations

$\kappa = a + bT$

Mol % KNO_3	$-a$	$b \times 10^3$	standard error of estimate
99.997	1.2921	3.1104	0.893%
99.995	1.2927	3.1104	0.896%
99.986	1.0551	2.7674	0.004%
99.973	1.0571	2.7674	0.004%

These values are based on the data of Papaioannou (Temple Univ., Philadelphia, PA., Ph. D. Thesis, 1964) (Archimedean technique) as cited in Clark [40]. Comparisons of the results reported for 100% KNO_3 in the work above with the recommended conductivity data base for KNO_3 [10], shows that the results may be as much as 5% low at 700 K; at the lower temperature limit (670 K), the agreement appears excellent (~0.5%).

$HgCl_2$ - $TlNO_3$

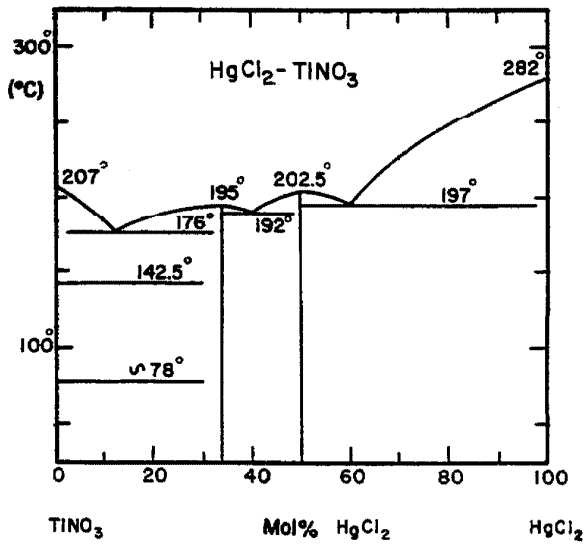

FIGURE 11. Phase diagram for $HgCl_2$ – $TlNO_3$.

Data from: A. G. Bergman, Z. Anorg. Allgem. Chem., 157, 89(1926).

Melt Preparation and Purification

Janz, Timidei and Dampier [41] recrystallized reagent grade $TlNO_3$ from aqueous solutions and dried it at reduced pressure in a vacuum oven, first at 25°C for 24 hours and finally at 110°C for 12 hours. The purified sample was stored in a desiccator over $MgClO_4$. The compositions of the mixtures were gained by gravimetric precipitation of TlI with KI. All mixtures were analyzed after the measurements owing to the small, but inevitable, loss of $HgCl_2$ through sublimation during the filtration. Some NO_2 evolution was noted above the solidified mixtures and experiments were undertaken to estimate the possible errors introduced through this. Bergman and Chagin [42] recrystallized $TlNO_3$ twice from analytical grade material. The mercuric chloride was recrystallized and sublimed.

TABLE 71. Electrical conductance studies: $HgCl_2 - TlNO_3$

Investigations critically examined			
Ref.	Mol % $TlNO_3$	Temp. range (K)	Comments
42	25–100	473–548	modified Biltz electrode; calibration: molten KNO_3; frequency: 1000Hz.
41	50–100	455–555	Pt disk electrodes; frequency correction for polarization effects; calibration: 1*D* KCl soln; correction for thermal expansion

TABLE 72. $HgCl_2 - TlNO_3$: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent $TlNO_3$				
	90	80	70	60	50
460	0.231	0.177	0.136	0.108	0.096
510	0.342	0.277	0.229	0.188	0.148
550	0.438	0.365	0.307	0.259	0.217

Temperature-dependent equations

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

Mol % $TlNO_3$	$-a$	$b \times 10^3$	$c \times 10^6$
100	0.9058	2.609	
90	0.3384	0.347	1.935
80	0.2734	0.060	2.000
70	0.4388	0.708	1.179
60	0.1064	−0.544	2.197
50	−1.3399	−6.092	7.363

These values are based on the data of Janz, Timidei and Dampier; (classical ac method); [41]. The experimental compositions correspond to: 95.2, 90.7, 86.1, 81.6, 75.0, 70.1, 65.1, 60.7, and 55.0 mol % $TlNO_3$ respectively. The precisions of the measurements were respectively: 0.2, 1.2, 0.3, 4.3, 1.2, 1.3, 2.3, 0.3, 0.4, and 0.3 mol %. For 100% $TlNO_3$ (above) the data are from Timidei and Janz (classical ac method) [236]. This had been advanced earlier in this series [1] as the recommended data set for this salt.

A comparison of the specific conductance data [41] with the results of Bergman and Chagin [42], shows that the latter conductivities are consistently higher (~2 to ~10%). This is understood if it is noted that the earlier investigators [42] used an open conductance cell assembly; the higher conductances thus can be attributed to a change in composition of the mixture through the sublimation of $HgCl_2$.

TABLE 73. Density studies: $HgCl_2 - TlNO_3$

Investigations critically examined			
Ref.	Mol % $TlNO_3$	Temp. range (K)	Comments
41	50–100	455–555	Ar atmosphere in glass dilatometer.

TABLE 74. $HgCl_2 - TlNO_3$: Density (g cm^{-3})

T(K)	Mol percent $TlNO_3$				
	90	80	70	60	50
460	4.941	4.941	4.941	4.941	4.941
490	4.885	4.885	4.885	4.885	4.884
550	4.772	4.772	4.772	4.772	4.771

Temperature-dependent equations

$$\rho = a + bT$$

Mol percent $TlNO_3$	a	$-b \times 10^3$
100	5.808	1.882
90	5.807	1.882
80	5.807	1.882
70	5.807	1.882
60	5.807	1.882
50	5.807	1.882

These values are based on the data of Janz, Timidei and Dampier; (dilatometric method); [41]. For the exact experimental compositions investigated, see: specific conductance (above). The precisions of the density measurements throughout this series were better than ~0.12%. The results for 100% $TlNO_3$ are based on the work of Timidei and Janz (dilatometric method) [236], and were advanced elsewhere as the recommended data base for this salt [1].

TABLE 75. Viscosity studies: $HgCl_2 - TlNO_3$

Investigations critically examined

Ref.	Mol % $TlNO_3$	Temp. range (K)	Comments
41	50–100	455–555	calibration: n-hexane, H_2O; glass viscometer.

TABLE 76. $HgCl_2 - TlNO_3$: Viscosity (cp)

T(K)	Mol percent $TlNO_3$				
	90	80	70	60	50
460	5.47	6.39	7.47	8.54	9.68
520	3.30	3.62	3.97	4.37	4.82
560	2.50	2.65	2.81	3.03	3.29

Temperature-dependent equations

$$\eta = A \exp [E/RT]$$

Mol percent $TlNO_3$	$A \times 10^3$	E
100	83.99	3660
90	67.58	4017
80	45.72	4516
70	31.48	4999
60	25.73	5306.2
50	22.92	5526

These values are based on the data of Janz, Timidei and Dampier; (capillary method); [41]. The exact experimental compositions investigated were: (mol % $TlNO_3$), 96.1, 95.2, 90.0, 85.0, 80.0, 75.6, 70.0, 65.3, 60.7, 55.9, and 52.2. The precisions of the viscosity measurements were, respectively: 0.3, 0.4, 2.0, 1.4, 0.9, 1.7, 1.8, 1.5, 1.2, 1.5. The results for 100% $TlNO_3$ are those of Timidei and Janz (capillary method) [236] , and were advanced elsewhere as the recommended data set [1].

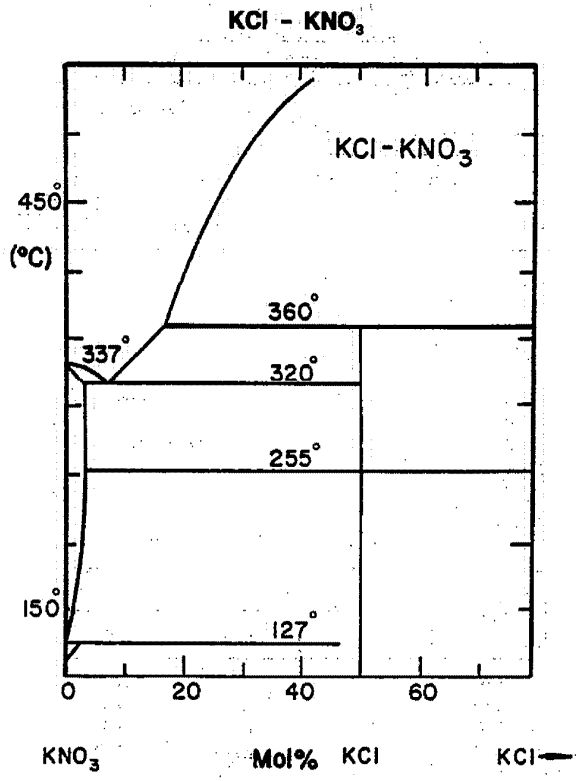

FIGURE 12. Phase diagram for KCl - KNO_3.

Data from: A. G. Bergman, V. P. Radishchev, I. N. Nikonova, V. N. Sveshnikova, Z. B. Shternina, and M. A. Yatsuk, Izv. Sektora, Fiz.-Khim. Analiza, Inst. Obshch. Neorgan. Khim., Akad. Nauk SSSR, 15, 161(1947).

Melt Preparation and Purification

Kirillov and Voronin [43] used reagent grade materials. Smith and Petersen [44] recrystallized reagent grade KNO_3 , partially dried it in an air oven, and then completed the drying by heating through the melting point under vacuum. The KCl was recrystallized reagent grade material. The preparation of the mixtures and other handling of the purified compounds was carried out in a nitrogen-filled box.

Electrical conductance: the specific conductance of this system has been investigated for the mixtures containing up to 15 mol % KCl and in the temperature range: 654–748 K. The information reported is insufficient to recover numerical values. For specific conductivity value judgements; see [43].

TABLE 77. Density studies: KCl - KNO_3

Investigations critically examined			
Ref.	Mol % KCl	Temp. range (K)	Comments
44	0–30	619–906	Pt bicone; Pt suspension wire; correction for thermal expansion of Pt.

TABLE 78. KCl - KNO_3: Density (g cm^{-3})

T(K)	Mol percent KCl		
	29.8	20.5	8.7
620			1.848
710		1.779	1.782
770	1.731	1.736	1.739
800	1.711	1.715	1.717
830	1.690	1.694	
890	1.650		

Temperature-dependent equations

$\rho = a + bT$

Mol percent KCl	a	$-b \times 10^3$
29.8	2.2547	0.6799
20.5	2.2844	0.7118
8.7	2.2998	0.7280
0	2.3100	0.7330

These values are based on the data of Smith and Petersen; (Archimedean technique); data in equation form; precisions not estimated [44]. The results for KNO_3 (0% KCl) are virtually in exact accord (~0.1%) with the recommended density data base for KNO_3 [10].

KCl - $LiNO_3$

Melt Preparation and Purification

For the method used by Smith and Petersen [44] see KCl - KNO_3.

Density: No data; for density equations of ternary mixtures see [44].

KCl - NH_4NO_3

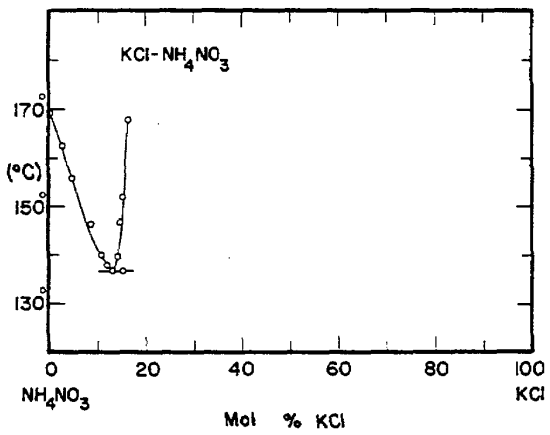

FIGURE 13. Phase diagram for KCl - NH_4NO_3.

Data from: E. Ph. Perman and H. L. Saunders, J. Chem. Soc., **123**, 841(1923).

Melt Preparation and Purification

Booth and Vinyard [45] used reagent grade salts which were dried at 110°C.

TABLE 79. Density studies: KCl - NH_4NO_3

Investigations critically examined			
Ref.	Mol % NH_4NO_3	Temp. range (K)	Comments
45	85–96	413–453	"Veridia" precision tubing used for dilatometer; calibration: Hg

TABLE 80. KCl - NH_4NO_3: Density (g cm^{-3})

T(K)	Mol percent NH_4NO_3			
	95.7	91.5	87.2	85.1
410			1.500	
430	1.456	1.472	1.486	1.494
450	1.441	1.456	1.472	1.480

Temperature-dependent equations

$\rho = a + bT$

Mol % NH_4NO_3	a	$-b \times 10^3$	standard error of estimate
95.7	1.7796	0.7516	0.05%
91.5	1.8124	0.7924	0.06%
87.2	1.7908	0.7084	0.09%
85.1	1.7860	0.6792	0.05%

These values are based on the data of Booth and Vinyard (dilatometric method) [45].

TABLE 81. Viscosity studies: KCl - NH_4NO_3

Investigations critically examined			
Ref.	Mol % NH_4NO_3	Temp. range (K)	Comments
45	85–95	418–448	Ostwald U-tube viscometer; calibration: silicone fluid

TABLE 82. KCl - NH_4NO_3: Viscosity (cp)

T(K)	Mol percent NH_4NO_3		
	94.6	89.3	85.1
420		7.40	
430	5.64	6.61	7.39
450	4.75	5.55	6.30

Temperature-dependent equations

$$\eta = a + bT + cT^2 + dT^3$$

Mol % NH_4NO_3	a	$b \times 10^3$	$-c \times 10^6$	$d \times 10^9$	standard error of estimate
94.6	35.897	-45.47	168.46	257.11	0.95%
89.3	97.813	-112.49	791.34	1301.56	0.54%
85.1	22.052	109.08	608.05	639.68	1.39%

These values are based on the data of Booth and Vinyard (capillary method) [45].

KCl - $NaNO_3$

Melt Preparation and Purification

Semenchenko and Shikhobalova [34] used reagent grade salts. No other information on melt preparation was given.

TABLE 83. Surface tension studies: KCl - $NaNO_3$

Investigations critically examined			
Ref.	Mol % $NaNO_3$	Temp. range (K)	Comments
34	70–100	743	see: NaF–$NaNO_3$

TABLE 84. KCl - $NaNO_3$: Surface tension (dyn cm^{-1})

T(K)	Mol percent $NaNO_3$		
	100	90	70
743	110.4	109.1	109.1

The above values are the sole data points reported by Semenchenko and Shikhobalova [34]; insufficient data for precision estimates. The value reported for 100% $NaNO_3$ at 743 K is virtually in exact agreement (i.e., ~0.25%) with the recommended surface tension data base for $NaNO_3$ [2].

LiCl - KNO_3

Melt Preparation and Purification

For the method used by Smith and Petersen [44]: see KCl - KNO_3

Density: No data; for density equations of ternary mixtures see [44].

LiCl - $LiNO_3$

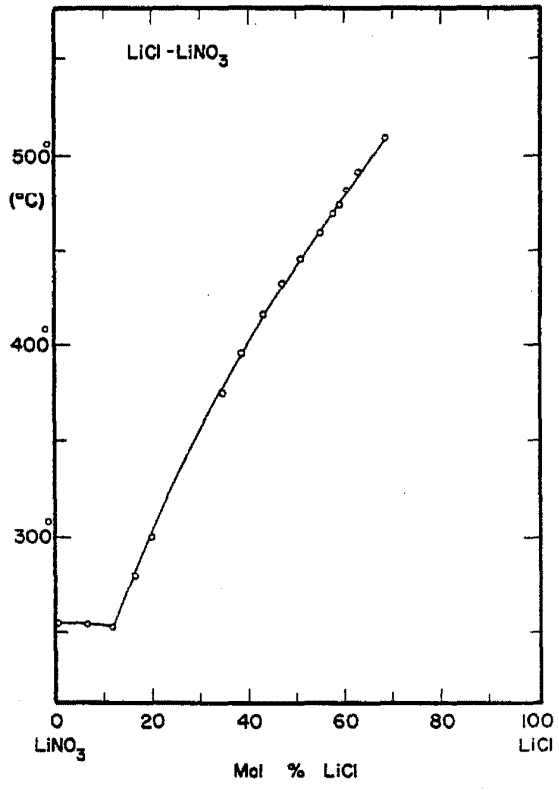

FIGURE 14. Phase diagram for LiCl - $LiNO_3$.

Data from: V. P. Blidin, Izv. Sekt. Fiz.-Khim. Anal. 13, 291(1940).

Melt Preparation and Purification

For the methods used by Kirillov and Voronin [43] and Smith and Petersen [44]: see KCl - KNO_3.

Electrical conductance: The specific conductance of this system has been investigated for the mixtures containing up to 15 mol % LiCl and in the temperature range 548–633 K. The reported information is insufficient to recover numerical values for specific conductivity value judgements; see [43].

TABLE 85. Density studies: LiCl - $LiNO_3$

Investigations critically examined			
Ref.	Mol % $LiNO_3$	Temp. range (K)	Comments
44	70–100	551–778	see KCl - KNO_3

TABLE 86. LiCl - $LiNO_3$: Density (g cm^{-3})

T(K)	Mol percent $LiNO_3$		
	90	79.9	70
550	1.76		
610	1.73	1.72	
670	1.70	1.69	1.68
700	1.68	1.67	1.67
760		1.64	1.63

Temperature-dependent equations

$\rho = a + bT$

Mol percent $LiNO_3$	a	$-b \times 10^3$
100	2.074	0.556
90	2.058	0.537
79.9	2.050	0.538
70	2.032	0.524

These values are based on the data of Smith and Petersen; (Archimedean technique); data in equation form; precisions not estimated [44]. The results for pure $LiNO_3$ are in exact accord with the recommended density data base for $LiNO_3$ [1].

LiCl - $NaNO_3$

Melt Preparation and Purification

No information on melt preparation was given in the study by Bogorodskavo [38].

TABLE 87. Electrical conductance studies: LiCl - $NaNO_3$

Investigations critically examined			
Ref.	Mol % $NaNO_3$	Temp. range (K)	Comments
38	97.4	621–636	see: $BaCl_2$-$NaNO_3$

TABLE 88. LiCl – $NaNO_3$: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent $NaNO_3$
	97.40
620	1.139
630	1.181

Temperature-dependent equation

$\kappa = -1.4761 + 4.218 \times 10^{-3}T$

Standard error of estimate = 0.19%

These values are based on the data of Bogorodskavo (classical ac method) [38].

NaCl - $NaNO_3$

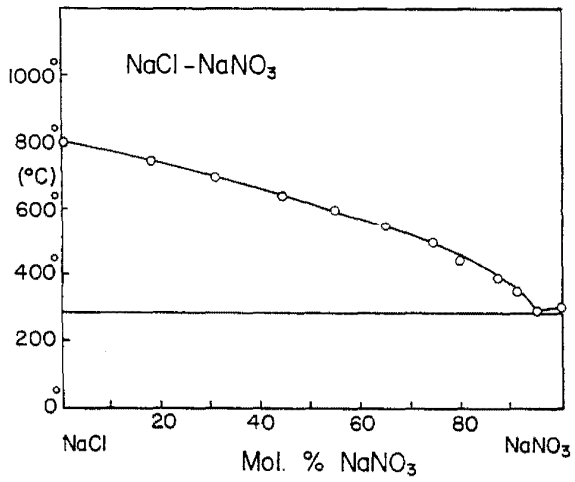

FIGURE 15. Phase diagram for NaCl - $NaNO_3$.

Data from: Blidin, V. P., Izv. Sekt. Fiz.-Khim. Anal., Inst. Obshch. Neorg. Khim., Akad. Nauk SSSR, 13, 296(1940).

Melt Preparation and Purification

For the method used by Kirillov and Voronin [43] see KCl-KNO_3. Vereshchetina and Luzhnaya [46] used reagent grade salts which were recrystallized twice from conductance water. Semenchenko and Shikhobalova [34] used reagent grade salts. No other information was given.

TABLE 89. Electrical conductance studies: NaCl - $NaNO_3$

Investigations critically examined			
Ref.	Mol % $NaNO_3$	Temp. range (K)	Comments
43	85–100	634–746	Pyrex cell; Pt electrodes
46	87–100	598–723	Pt electrodes

TABLE 90. NaCl – $NaNO_3$: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent $NaNO_3$				
	96.04	94.04	91.99	90.03	87.71
600	1.092	1.062	1.054		
620	1.180	1.163	1.162	1.164	
660	1.355	1.354	1.354	1.353	1.373
700	1.529	1.529	1.515	1.521	1.530
720		1.610	1.583	1.597	1.595

Temperature-dependent equations

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

Mol % $NaNO_3$	$-a$	$b \times 10^3$	$-c \times 10^6$	standard error of estimate
100	1.3658	4.081	-	0.33%
98.93	4.4397	13.524	0.7167	0.17%
97.93	4.1582	12.430	0.6164	0.34%
96.90	5.7807	17.713	1.0400	0.20%
96.04	1.5290	4.369		0.70%
95.66	5.4532	16.567	9.441	0.32%
94.85	4.7768	14.479	7.814	0.32%
94.04	3.8245	11.125	4.968	0.31%
92.95	5.5991	17.152	9.972	0.40%
91.99	5.8169	17.317	9.776	0.40%
90.8	4.2843	12.616	6.222	0.46%
90.03	4.4719	13.189	6.611	0.18%
89.0	6.1456	17.816	9.801	0.25%
87.71	6.4546	19.330	11.319	0.19%
86.8	10.3688	30.168	18.828	0.23%

These values are based on the data of Vereshchetina and Luzhnaya (classical ac method) [46]. The values of $NaNO_3$ (above) are in good agreement with the recommended data base [1]; at the higher temperature limit (~0.4%) and at the lower temperature limit (~2.3%).

TABLE 91. Density studies: NaCl – $NaNO_3$

Investigations critically examined			
Ref.	Mol % $NaNO_3$	Temp. range (K)	Comments
46	86–100	623–723	no details given

TABLE 92. NaCl – $NaNO_3$: Density (g cm^{-3})

T(K)	Mol percent $NaNO_3$				
	98.0	96.0	94.0	92.0	88.08
(620)	1.881	1.881	1.881	1.878	
660	1.852	1.851	1.852	1.848	1.849
720	1.808	1.806	1.809	1.804	1.805

Values at 620K were gained by extrapolation.

Temperature-dependent equations

$$\rho = a + bT$$

Mol % $NaNO_3$	a	$-b \times 10^3$	standard error of estimate
100	2.3389	0.7360	0.02%
99.03	2.3156	0.7017	0.01%
98.0	2.3331	0.7292	0.02%
96.91	2.3240	0.7154	0.03%
96.0	2.3405	0.7418	0.01%
95.0	2.3330	0.7303	0.01%
94.0	2.3313	0.7257	0.02%
93.02	2.3368	0.7384	0.01%
92.0	2.3333	0.7348	0.02%
90.10	2.3277	0.7258	0.02%
88.08	2.3352	0.7361	0.01%
86.1	2.3207	0.7200	0.00%

These values are based on the data of Vereshchetina and Luzhnaya (technique not cited; probably Archimedean technique) [46]. The values calculated from the above equation for $NaNO_3$ are virtually in exact agreement with the recommended data base, i.e., ~0.3% [1].

TABLE 93. Viscosity studies: NaCl – $NaNO_3$

Investigations critically examined			
Ref.	Mol % $NaNO_3$	Temp. range (K)	Comments
46	86–100	583–723	Pt ball; steel wire suspension enclosed in glass

TABLE 94. NaCl – $NaNO_3$: Viscosity (cp)

T(K)	Mol percent $NaNO_3$			
	98.0	94.0	90.0	86.0
(580)	3.23	3.67		
620	2.62	2.90	3.03	
660	2.17	2.37	2.23	
680	1.99	2.19	2.02	2.32
720	1.75	2.01	1.96	2.17

Values at 580K were gained by extrapolation.

Temperature-dependent equations

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

Mol % $NaNO_3$	a	$-b \times 10^3$	$c \times 10^6$	standard error of estimate
100	27.683	67.92	43.96	1.13%
98.0	28.173	69.17	45.10	1.00%
96.0	29.517	73.41	48.72	0.86%
94.0	41.733	108.95	74.70	2.65%
92.0	141.203	403.00	291.37	13.07%
90.0	79.141	219.29	155.69	4.26%
88.0	146.176	402.26	280.04	3.73%
86.0	65.613	177.47	124.10	1.02%

These values are based on the data of Vereshchetina and Luzhnaya (damped oscillational method) [46]. The viscosity values for 100% $NaNO_3$ calculated from the equation (above) are lower than the recommended data for $NaNO_3$ [1] (0 to ~2%).

TABLE 95. Surface tension studies: NaCl – $NaNO_3$

Investigations critically examined

Ref.	Mol % $NaNO_3$	Temp. range (K)	Comments
34	90	743	see: NaF – $NaNO_3$

TABLE 96. NaCl – $NaNO_3$: Surface tension (dyn cm^{-1})

T(K)	Mol percent $NaNO_3$
	90
743	110.1

A single data point only (above) was reported by Semenchenko and Shikhobalova (maximum bubble pressure method) [34].

$PbCl_2$ – $NaNO_3$

Melt Preparation and Purification

No information on melt preparation was given in the study by Bogorodskavo [38].

TABLE 97. Electrical conductance studies: $PbCl_2$ – $NaNO_3$

Investigations critically examined

Ref.	Mol % $NaNO_3$	Temp. range (K)	Comments
38	92–100	620–636	see: $BaCl_2$–$NaNO_3$

TABLE 98. $PbCl_2$ – $NaNO_3$: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent $NaNO_3$		
	96.914	92.979	91.992
620	1.101	1.073	1.069
630	1.140	1.107	1.098
640	1.178		

Temperature-dependent equations

$$\kappa = a + bT$$

Mol % $NaNO_3$	$-a$	$b \times 10^3$	standard error of estimate
96.914	1.3016	3.8751	0.03%
92.979	1.0314	3.3947	0.03%
91.992	0.7029	2.8582	0.05%

These values are based on the data of Bogorodskavo (classical ac method) [38].

TlCl – KNO_3

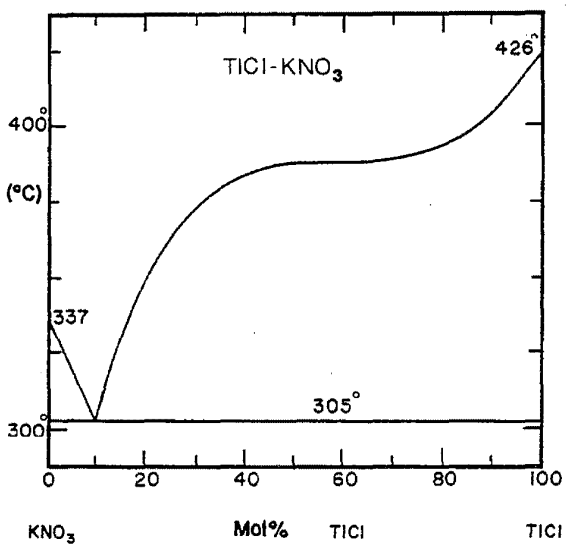

FIGURE 16. Phase diagram for TlCl – KNO_3.

Data from: R. N. Nyankovskaya, Izv. Sekt. Fiz.-Khim. Anal., Inst. Obshch. Neorg. Khim., Akad. Nauk SSSR, 11, 268(1938).

Melt Preparation and Purification

No information was available on melt preparation and purification in reference [47] and in experimental references cited therein.

TABLE 99. Electrical conductance studies: TlCl - KNO_3

Investigations critically examined			
Ref.	Mol % KNO_3	Temp. range (K)	Comments
47	0–100	703	Pyrex U-shaped cells; cylindrical Pt electrodes.

TABLE 100. TlCl - KNO_3: Specific conductance ($ohm^{-1}cm^{-1}$)

Mol percent KNO_3	703 K
100	0.906
90	0.88
60	0.85
30	0.92
10	1.02
0	1.084

Composition-dependent equation

$$\kappa = 1.084 - 0.708 \times 10^{-2}C + 0.53 \times 10^{-4}C^2$$

[C = Mol % KNO_3]

These values are based on the data of Prisyazhnyi and Zvagol'skaya (classical ac method); data in graphical form; precisions not estimated [47]. The conductivities reported for pure KNO_3 and TlCl, respectively, are virtually in exact agreement with the recommended data bases for KNO_3 [1,10] and TlCl [1].

Melt Preparation and Purification

For the method used by Zvagol'skaya and Prisyazhnyi [47] see TlCl - KNO_3

TABLE 101. Electrical conductance studies: TlCl - $NaNO_3$

Investigations critically examined			
Ref.	Mol % $NaNO_3$	Temp. range (K)	Comments
47	0–100	703	see TlCl - KNO_3

TABLE 102. TlCl - $NaNO_3$: Specific conductance ($ohm^{-1}cm^{-1}$)

Mol percent $NaNO_3$	703 K
100	1.46
90	1.35
60	1.11
30	1.03
10	1.06
0	1.11

Composition-dependent equation

$$\kappa = 1.109 - 0.545 \times 10^{-2}C + 0.90 \times 10^{-4}C^2$$

[C — Mol % $NaNO_3$]

These values are based on the data of Prisyazhnyi and Zvagol'skaya (classical ac method); data in graphical form; precisions not estimated [47]. Comparison of the conductivities (above) for 100% $NaNO_3$ and 100% TlCl, respectively, with the recommended data bases shows that the values from [47] are ~4% and ~1% high [1].

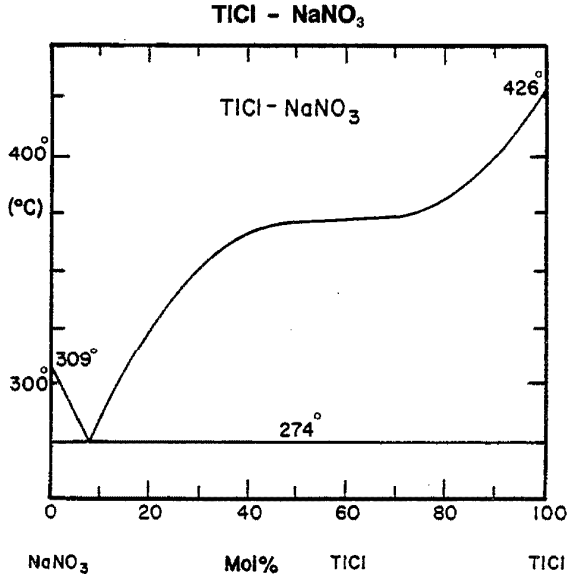

FIGURE 17. Phase diagram for TlCl - $NaNO_3$.

Data from: R. N. Nyankovskaya, Izv. Sekt. Fiz.-Khim. Anal., Inst. Obshch. Neorg. Khim., Akad. Nauk SSSR, **11**, 268(1938).

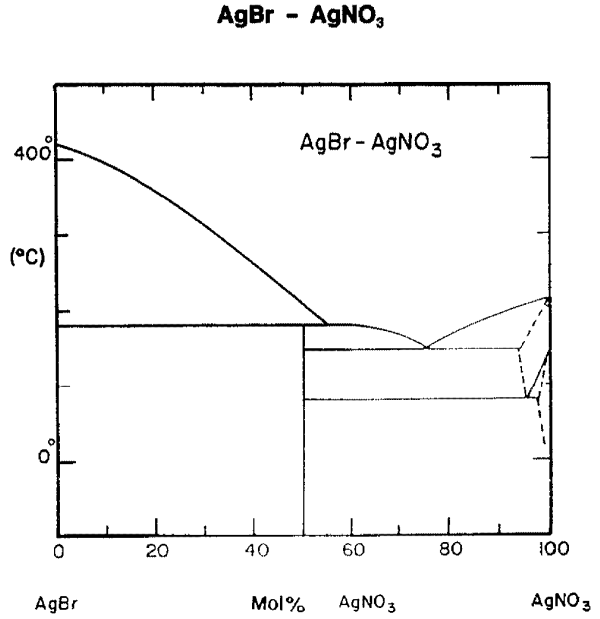

FIGURE 18. Phase diagram for AgBr - $AgNO_3$.

Data from: G. Scarpa, Atti reale accad., Lincei, Sez. II, **22**, 458(1913).

Melt Preparation and Purification

For the method of melt preparation used by Bizouard [37], see: AgCl - $AgNO_3$.

TABLE 103. Electrical conductance studies: AgBr - $AgNO_3$

Investigations critically examined			
Ref.	Mol % $AgNO_3$	Temp. range (K)	Comments
37	0-100	573-823	see AgCl-$AgNO_3$

TABLE 104. AgBr - $AgNO_3$: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent $AgNO_3$				
	80	76	60	40	20
570	1.046	1.069	1.163	1.367	
630	1.288	1.309	1.393	1.603	2.000
710	1.554	1.574	1.656	1.876	2.282
810	1.793	1.817	1.916	2.152	2.535

Temperature-dependent equations

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

Mol % $AgNO_3$	$-a$	$b \times 10^3$	$-c \times 10^6$	standard error of estimate
100	3.0977	10.3688	5.4284	0.27%
80	3.1033	10.2105	5.1431	0.14%
76	2.9673	9.8673	4.8891	*
60	2.4106	8.4728	3.8663	0.89%
40	2.1865	8.3194	3.6578	0.41%
20	2.7117	10.9812	5.5599	0.01%
0	-0.114	5.3227	2.0189	0.07%

These values are based on the data of Bizouard (potentiometric ac method) [37]. *Data for 76 mol % $AgNO_3$ from Clark [40] citing Bizouard [37]; interpolated values; precision not estimated. The conductivities calculated from the above equations for pure AgBr (0% $AgNO_3$) and pure $AgNO_3$ are virtually in exact agreement with the recommended data base for AgBr [1] and $AgNO_3$ [1,3] (to ~1-2%).

$CoBr_2$ - KNO_3

Melt Preparation and Purification

Papaioannou and Harrington [39] used reagent grade salts which were oven-dried.

TABLE 105. Electrical conductance studies: $CoBr_2$ - KNO_3

Investigations critically examined			
Ref.	Mol % KNO_3	Temp. range (K)	Comments
39	99.973-99.997	673-698	cell (one arm of capillary tubing and the other a long piece of Pt foil); calibration: 1 *D* KCl soln.

TABLE 106. $CoBr_2$ - KNO_3: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent KNO_3			
	99.997	99.995	99.986	99.973
670	0.800	0.799	0.799	0.798
680	0.828	0.827	0.826	0.825
690	0.856	0.855	0.854	0.852

Temperature-dependent equations

$\kappa = a + bT$

Mol percent KNO_3	$-a$	$b \times 10^3$
99.997	1.0744	2.7980
99.995	1.0748	2.7970
99.986	1.0483	2.7570
99.973	1.0227	2.7170

These values are based on the data of Papaioannou and Harrington (classical ac method); data in equation form; precisions not estimated [39].

TABLE 107. Density studies: $CoBr_2$ KNO_3

Investigations critically examined			
Ref.	Mol % KNO_3	Temp. range (K)	Comments
39	99.973-99.997	673-698	Archimedean technique; measurements limited to dilute range

TABLE 108. $CoBr_2$ - KNO_3: Density (g cm^{-3})

T(K)	Mol percent KNO_3			
	99.997	99.995	99.986	99.973
670	1.826	1.826	1.827	1.828
680	1.818	1.818	1.819	1.820
700	1.803	1.803	1.804	1.805

Temperature-dependent equations

$$\rho = a + bT$$

Mol percent KNO_3	a	$-b \times 10^3$
99.997	2.3284	0.7502
99.995	2.3284	0.7502
99.986	2.3294	0.7502
99.973	2.3311	0.7512

These values are based on the data of Papaioannou and Harrington (Archimedean technique;); data in equation form; precisions not estimated [39].

$HgBr_2$ - $AgNO_3$

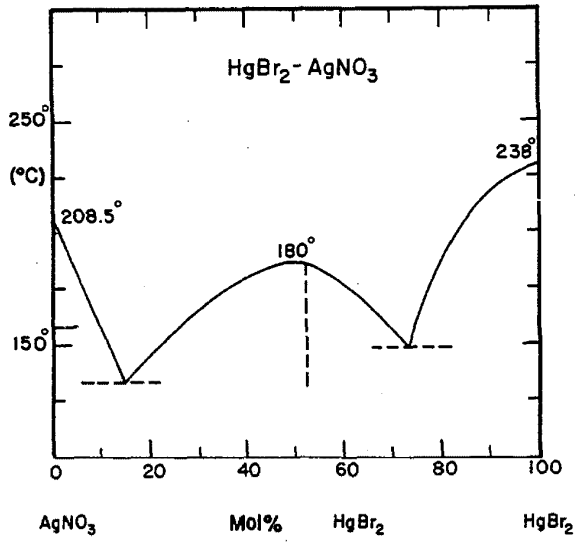

FIGURE 19. Phase diagram for $HgBr_2$ - $AgNO_3$.

Data from: A. G. Bergman, Z. Anorg. Allgem. Chem. **157**, 102(1926).

Melt Preparation and Purification

Jander and Brodersen [48] purified the $HgBr_2$ by sublimation. No information was given on silver nitrate.

TABLE 109. Electrical conductance studies: $HgBr_2$ - $AgNO_3$

Investigations critically examined

Ref.	Mol percent $AgNO_3$	Temp. Range (K)	Comments
48	dilute solution range: ($AgNO_3$ in $HgBr_2$ as solvent)	515	see: $HgBr_2$-HgO

Jander and Brodersen [48] reported the results in units of equivalent conductance; density data were not reported and, hence, the specific conductance cannot be calculated.

TABLE 110. Viscosity studies: $HgBr_2$ - $AgNO_3$

Investigations critically examined

Ref.	Mol % $AgNO_3$	Temp. range (K)	Comments
48	0.19-6.75	528-548	Jena glass capillary viscometer; calibration: Hg; N_2 atmosphere

TABLE 111. $HgBr_2$ - $AgNO_3$: Viscosity (cp)

T(K)	Mol percent $AgNO_3$			
	6.75	4.38	1.01	0.19
530	2.74	2.46	2.18	2.22
540	2.51	2.33	2.11	2.10
550	2.25	2.20	2.04	2.01

Temperature-dependent equations

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

Mol % $AgNO_3$	a	$-b \times 10^3$	$c \times 10^6$	standard error of estimate
6.75	-43.613	-195.43	-203.73	2.69%
4.38	12.966	26.65	12.88	0.21%
1.01	15.643	43.34	33.83	0.55%
0.19	63.328	216.04	190.09	1.68%

These values are based on the data of Jander and Brodersen (capillary method) [48].

$HgBr_2$ - $Hg(NO_3)_2$

Melt Preparation and Purification

Jander and Brodersen [48] purified the $HgBr_2$ by sublimation. No information was given on mercuric nitrate.

TABLE 112. Electrical conductance studies: $HgBr_2$ - $Hg(NO_3)_2$

Investigations critically examined			
Ref.	Mol percent $AgNO_3$	Temp. Range (K)	Comments
	$Hg(NO_3)_2$	(K)	
48	dilute solution range: $(Hg(NO_3)_2$ in $HgBr_2$ as solvent)	515	see: $HgBr_2$-Hg_0

Jander and Brodersen [48] reported the results in units of equivalent conductance; density data were not reported and, hence, the specific conductance cannot be calculated.

KBr - KNO_3

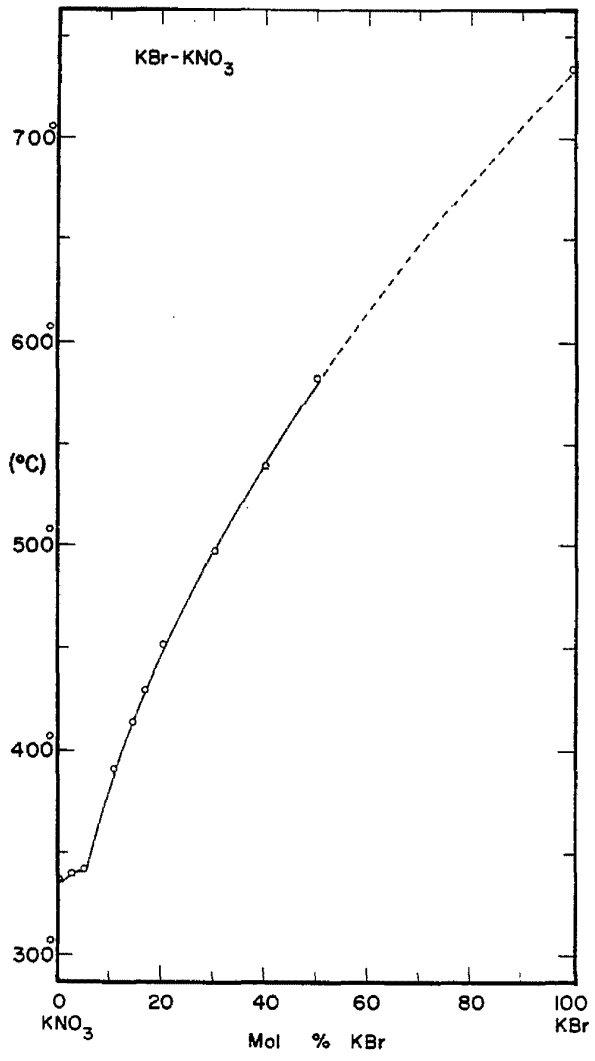

FIGURE 20. Phase diagram for KBr - KNO_3.
Data from: A. D. Rostovskii, Zh. R. Fiz. Khim. O. 61, 89(1929)

Melt Preparation and Purification

Bloom et al. [49] used reagent grade salts. The mixtures were made by weighing the dry constituents which had previously been fused and allowing them to cool in desiccators. Standard methods of analysis were used to determine melt compositions.

TABLE 113. Electrical conductance studies: KBr - KNO_3

Investigations critically examined			
Ref.	Mol % KNO_3	Temp. range (K)	Comments
49	0-100	650-1050	glass cell; Pt electrode calibration: 1 *N* KCl; correction for thermal expansion

TABLE 114. KBr - KNO_3: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent KNO_3		
	85	66.7	50
660	0.764	0.757	
760	1.034	1.015	
780	1.088	1.067	1.056
880	1.358	1.325	1.322

Temperature-dependent equations

$$\kappa = a + bT$$

Mol percent KNO_3	$-a$	$b \times 10^3$
100	1.1404	2.8988
85	1.0162	2.6979
66.7	0.9454	2.5799
50	1.0124	2.6520
33.3	0.63645	2.2320
0	0.8443	2.4398

These values are based on the data of Bloom, Knaggs, Molloy, and Welch (classical ac method); data in equation form; precisions not estimated [49]. Conductance values as calculated from the above equations for 100% KNO_3 and 100% KBr (0% KNO_3) agree to within 1-2% of the recommended data bases for KNO_3 [1,3] (~1-2%) and KBr [1] (0.3%).

TABLE 115. Density studies: KBr - KNO_3

Investigations critically examined			
Ref.	Mol % KNO_3	Temp. range (K)	Comments
49	0-100	648-1048	10% Rh-Pt sinker; correction for thermal expansion; estimated accuracy ±0.1%

TABLE 116. KBr – KNO_3: Density (g cm^{-3})

T(K)	Mol percent KNO_3		
	85	66.7	50
650	1.917	2.011	
740	1.853	1.946	
770	1.831	1.924	2.028
860	1.767	1.858	1.958

Temperature-dependent equations

$$\rho = a + bT$$

Mol percent KNO_3	a	$-b \times 10^4$
100	2.3151	0.7290
85	2.3811	0.7141
66.7	2.4836	0.7270
50	2.6277	0.7788
33.3	2.6755	0.7301
15	2.8536	0.8008
0	2.9400	0.7922

These values are based on the data of Bloom, Knaggs, Molloy and Welch (Archimedean technique;); data in equation form; precisions not estimated [49]. The density values as calculated from the above equations for 100% pure KNO_3 and 100% KBr (0% KNO_3) are in exact agreement with the recommended data base [1] for these pure salts (<0.8%).

TlBr – KNO_3

Melt Preparation and Purification

Ichikawa [50] purified reagent grade TlBr by vacuum distillation. Reagent grade KNO_3 was dried at 110°C for at least 12 hours.

TABLE 117. Electrical conductance studies: TlBr – KNO_3

Investigations critically examined			
Ref.	Mol % KNO_3	Temp. range (K)	Comments
50	0–100	823	Pyrex cell; Pt electrodes

TABLE 118. TlBr – KNO_3: Specific conductance ($ohm^{-1}cm^{-1}$)

Mol percent TlBr	823 K
100	1.03
90	1.00
60	0.98
30	1.06
10	1.19*
0	1.21*

Composition-dependent equation

$$\kappa = 1.2289 - 0.733 \times 10^{-2}C + 0.53 \times 10^{-4}C^2$$

[C = Mol % TlBr]

These values are based on the data of Ichikawa (classical ac method) [50]. The above equation was derived by interpolating graphical data in [50]; the equation expresses the results from 20–100 mol % TlBr with an accuracy of ~±2%. The lower concentration range (0–10 mol % TlBr) cannot be expressed by this simple quadratic; the values, marked by asterisks, are those directly interpolated from the graph. Inspection of the reported experimental points shows an accuracy of ~±13%. The conductivities as reported above are in close agreement with the recommended data base for pure TlBr [1] and pure KNO_3 (0.8%) [10] at 823 K.

AgI – $AgNO_3$

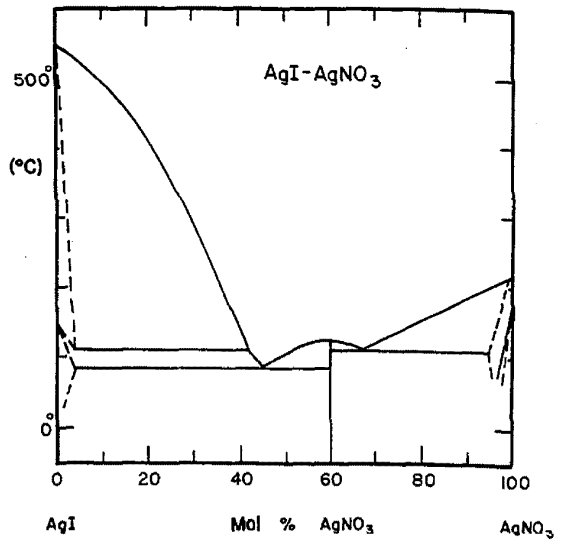

FIGURE 21. Phase diagram for AgI – $AgNO_3$.
Data from: G. Scarpa, Atti reale accad. Lincei, Sez. II, 22, 459(1913).

Melt Preparation and Purification

No information on melt preparation is given in the study by Luzhnaya et al. [51]. Bokhovkin [52] recrystallized the reagent grade salts followed by fusion.

TABLE 119. Electrical conductance studies: AgI - $AgNO_3$

Investigations critically examined

Ref.	Mol % $AgNO_3$	Temp. range (K)	Comments
53, 54			review articles
51			review article
52	55-100	398-573	Pyrex cell; modified Biltz electrodes; calibration: molten KNO_3

TABLE 120. AgI - $AgNO_3$: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent $AgNO_3$				
	80.6	70.2	64.7	60.0	55.1
400	0.319	0.384	0.428	0.463	0.517
460	0.578	0.636	0.684	0.712	0.775
520	0.817	0.868	0.917	0.939	1.004
560	0.965	1.012	1.059	1.077	1.139

Temperature-dependent equations

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

Mol % $AgNO_3$	$-a$	$b \times 10^3$	$-c \times 10^6$	standard error of estimate
100	4.5862	16.2900	11.4382	0.14%
92.6	2.0023	6.5039	2.2669	0.58%
84.7	1.8206	6.1075	2.0909	0.37%
80.6	1.9388	6.7880	2.8616	0.36%
78.9	1.6810	5.7616	1.8789	0.68%
76.3	1.6437	5.5784	1.6211	0.40%
73.7	1.8611	6.6586	2.8111	0.61%
72.0	1.7861	6.4668	2.6740	0.54%
70.2	1.8261	6.6657	2.8538	0.88%
67.5	1.8367	6.9405	3.3122	2.57%
64.7	1.8962	7.1390	3.3239	0.55%
61.9	1.8060	6.9239	3.1402	0.94%
60.0	1.7762	6.8551	3.1419	1.01%
58.0	1.9867	7.9181	4.2647	0.69%
55.1	1.9867	7.9480	4.2249	0.91%

These values are based on the data of Bokhovkin (classical ac method) [52]. The conductivity values as calculated from the above equation for 100% $AgNO_3$ are 35% higher than the recommended data base for pure $AgNO_3$ [3].

TABLE 121. Density studies: AgI - $AgNO_3$

Investigations critically examined

Ref.	Mol % $AgNO_3$	Temp. range (K)	Comments
52	48-100	423-498	Pt float
51			review article

TABLE 122. AgI - $AgNO_3$: Density (g cm^{-3})

T(K)	Mol percent $AgNO_3$				
	84.7	76.3	67.5	58.0	48.0
420	4.420	4.642	4.832	5.019	5.195
440	4.405	4.616	4.797	4.981	5.143
460	4.376	4.576	4.754	4.937	5.091
480	4.334	4.523	4.704	4.886	5.039
500	4.278	4.458	4.646	4.829	4.987

Temperature-dependent equations

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

Mol % $AgNO_3$	a	$b \times 10^3$	$-c \times 10^6$	standard error of estimate
92.6	5.2239	-2.2402		0.00%
84.7	1.6316	13.7144	16.844	0.08%
80.6	3.2270	7.7214	10.900	0.04%
76.3	2.1570	12.8285	16.455	0.10%
72.0	2.4272	11.9652	15.423	0.15%
67.5	3.7652	6.6228	9.724	0.04%
62.8	3.6366	7.6315	10.866	0.02%
58.0	4.2884	5.1957	8.231	0.04%
53.0	4.7999	3.2944	6.094	0.03%
48.0	6.2888	-2.6041		0.77%

These values are based on the data of Bokhovkin (Archimedean technique;) [52]. Bokhovkin reported a single density data point for 100% $AgNO_3$ at 498 K (3.954 g cm^{-3}) which is in exact agreement with the recommended data base for pure $AgNO_3$, at this temperature [3].

TABLE 123. Viscosity studies: AgI - $AgNO_3$

Investigations critically examined

Ref.	Mol % $AgNO_3$	Temp. range (K)	Comments
51			review article
52	48-100	398-498	capillary viscometer: calibration: alpha-naphthol

TABLE 124. AgI - $AgNO_3$: Viscosity (cp)

T(K)	Mol percent $AgNO_3$				
	84.7	76.3	67.5	58.0	48.0
400		16.31	19.07	22.41	29.15
420	9.68	12.54	14.84	17.22	21.67
460	6.93	7.61	9.27	10.39	12.28
500	5.65	6.16	7.57	8.29	10.29

Temperature-dependent equations

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

Mol % $AgNO_3$	a	$b \times 10^3$	$c \times 10^6$	standard error of estimate
92.6	15.082	20.00		0.00%
84.7	126.322	468.75	454.81	1.00%
80.6	229.683	896.09	898.61	7.17%
79.3	232.528	904.45	904.13	6.81%
76.3	273.714	1077.13	1084.03	6.51%
74.2	296.167	1177.07	1196.25	11.06%
72.0	264.187	1042.14	1055.75	8.72%
67.5	306.505	1201.41	1207.07	4.24%
62.8	337.182	1322.39	1330.27	5.49%
60.0	355.937	1393.98	1397.51	3.97%
58.0	374.522	1471.59	1478.25	4.45%
56.1	689.650	2842.83	2966.73	20.10%
53.1	307.862	1189.35	1185.18	4.97%
48.0	568.063	2274.20	2317.32	7.61%

These values are based on the data of Bokhovkin (oscillational method) [52]. Bokhovkin [52] reported a single value for the viscosity of 100% $AgNO_3$ at 498 K (4.56 cp). This is ~2% lower than that of the recommended data base for pure $AgNO_3$ at this temperature [1].

HgI_2 - $AgNO_3$

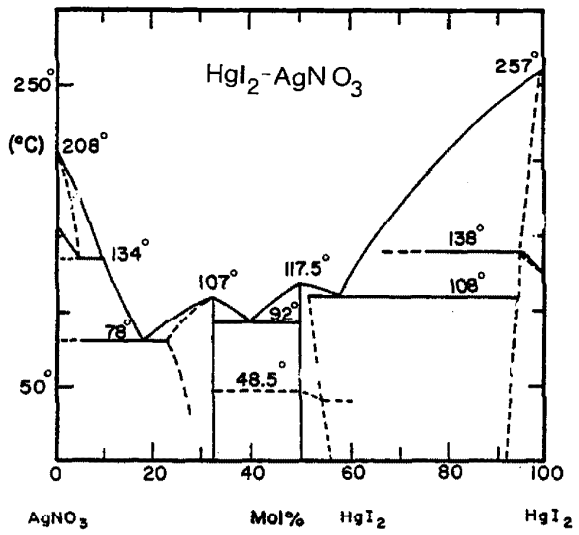

FIGURE 22. Phase diagram for HgI_2 - $AgNO_3$.

Data from: A. G. Bergman. Z. Anorg. Allgem. Chem. 157. 97(1926).

Melt Preparation and Purification

No information on melt preparation and purification was given in the study by Polyakov [55] or Luzhnaya, et al. [51]. Bergman [42] recrystallized $AgNO_3$ twice from analytical grade material. The HgI_2 was prepared from recrystallized $HgCl_2$ and KI and was then re-sublimed. All materials were carefully dried and stored over H_2SO_4.

TABLE 125. Electrical conductance studies: HgI_2 - $AgNO_3$

Investigations critically examined			
Ref.	Mol % $AgNO_3$	Temp. range (K)	Comments
42	0-100	400-550	modified Biltz electrodes; calibration: molten KNO_3; frequency 1000 Hz
51	-	-	review article
55	0-100	350-470	Pyrex cells

TABLE 126. HgI_2 - $AgNO_3$: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent $AgNO_3$			
	80	60	40	20
400	0.156	0.104	0.081	
460	0.343	0.240	0.210	
480	0.405	0.286	0.252	0.301
540	0.593	0.422	0.381	0.406

Temperature-dependent equations

$$\kappa = a + bT$$

Mol % $AgNO_3$	$-a$	$b \times 10^5$	standard error of estimate
100	1.5101	4.4808	0.07%
95	1.1607	3.6321	0.07%
90	1.0307	3.2263	0.09%
86	1.0670	3.1943	0.16%
85	1.0725	3.1800	0.23%
83	1.0963	3.1857	0.15%
80	1.0922	3.1200	0.00%
76	1.0962	3.0800	0.19%
73	1.0287	2.8800	0.00%
70	0.9924	2.7586	0.22%
69	0.9565	2.6543	0.70%
68	0.9003	2.4915	0.50%
67	0.8319	2.3600	0.17%
65	0.7738	2.2729	0.98%
62	0.8008	2.2886	0.12%
60	0.8045	2.2714	0.22%
57	0.8106	2.2514	0.28%
55	0.8192	2.2543	0.24%
52	0.8228	2.2472	0.29%
50	0.8256	2.2486	0.25%
49	0.8206	2.2300	0.55%
47.5	0.8184	2.2243	0.42%
46	0.8155	2.2129	0.16%
45	0.8155	2.2129	0.16%
42	0.7914	2.1657	0.46%
40	0.7762	2.1429	0.43%
37.5	0.7589	2.1043	0.30%
35	0.8161	2.2172	0.47%
30	0.7150	2.0400	0.28%
25	0.6668	1.9800	0.21%
20	0.5402	1.7520	0.15%
15	0.3455	1.3600	0.00%
10	0.4574	1.4803	0.00%

These values are based on the data of Bergman and Chagin (classical ac method) [42]. The conductivity of 100% $AgNO_3$ as calculated from the above equation is virtually in exact agreement (~0.7%) with the recommended data base for pure $AgNO_3$ [3]. The results reported by Polyakov [55] are in accord with the data of Bergman and Chagin (above) to ±5%.

TABLE 127. Density studies: HgI_2 - $AgNO_3$

Investigations critically examined

Ref.	Mol % $AgNO_3$	Temp. range (K)	Comments
55	30–100	373–513	Pt bob; calibration: molten KNO_3

TABLE 128. HgI_2 - $AgNO_3$: Density ($g\ cm^{-3}$)

T(K)	Mol percent $AgNO_3$				
	70	60	50	40	30
370	5.050		5.439		
390	5.023	5.192	5.410	5.565	
430	4.968	5.135	5.352	5.507	5.580
510	4.857	5.020	5.236	5.390	5.450

Temperature-dependent equations

$$\rho = a + bT$$

Mol % $AgNO_3$	a	$-b \times 10^3$	standard error of estimate
100	4.6292	1.2472	0.04%
85	5.2677	1.2576	0.04%
75	5.4362	1.3286	0.02%
70	5.5599	1.3774	0.01%
67.5	5.6330	1.4464	0.04%
62.5	5.6960	1.3931	0.03%
60	5.7501	1.4308	0.02%
55	5.8670	1.3937	0.02%
52.5	5.9126	1.3627	0.03%
50	5.9756	1.4503	0.03%
47.5	6.0299	1.3533	0.01%
45	6.0709	1.4002	0.03%
42.5	6.1269	1.4532	0.02%
40	6.1357	1.4630	0.04%
37.5	6.1413	1.4434	0.01%
35	6.1625	1.4549	0.02%
30	6.2743	1.6153	0.03%

These values are based on the data of Polyakov (Archimedean technique;) [55]. The density of 100% $AgNO_3$ as calculated from the above equation is uniformly higher (~1.3%) than the recommended data base for pure $AgNO_3$ [3].

TABLE 129. Viscosity studies: HgI_2 - $AgNO_3$

Investigations critically examined

Ref.	Mol % $AgNO_3$	Temp. range (K)	Comments
55	22.5–77.5	363–473	Pyrex Ostwald viscometer

TABLE 130. HgI_2 - $AgNO_3$: Viscosity (cp)

T(K)	Mol percent $AgNO_3$				
	65	60	55	32.5	30
380		20.89		27.62	
390	17.69	15.14		19.88	
400	13.23	11.15	13.92	14.54	
430	6.00	4.86	5.88	6.21	6.25
470	2.45	1.89	2.21	2.37	2.34

Temperature-dependent equations

$\eta = A \exp [E/RT]$

Mol % $AgNO_3$	$A \times 10^4$	E	standard error of estimate
*65	1.6009	8999.6	5.35%
60	0.7443	9472.8	5.86%
55	0.6060	9812.5	10.18%
32.5	0.7362	9692.2	8.33%
30	0.6094	9859.5	4.46%

These values are based on the data of Polyakov (oscillational method) [55].

*The quadratic equation,

$$\eta = 492.15 - 2.086T + 2.221 \times 10^{-3}T^2,$$

gives a better precison at 65 mol% $AgNO_3$ (~2.23%). Results were reported for 22.5-77.5 mol% $AgNO_3$; for the compositions not included in Table 130 (above), the accuracy limits were 10-35%; for experimental data and additional details see [55].

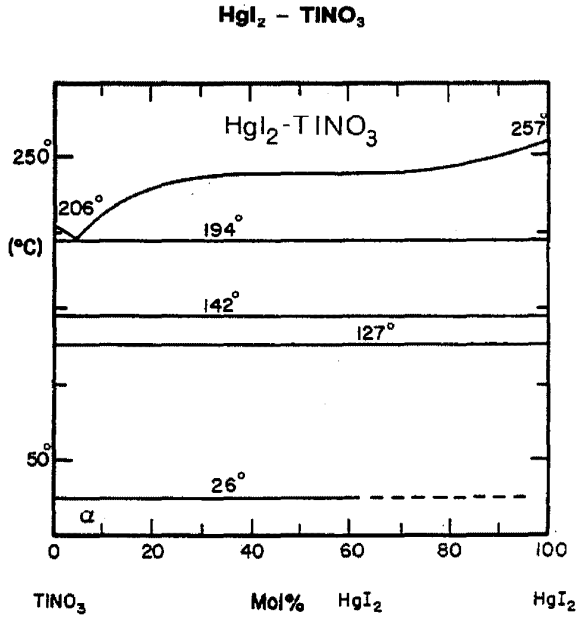

FIGURE 23. Phase diagram for HgI_2 - $TlNO_3$.

Data from: A. P. Palkin, Zh. Obshch. Khim. 2(1), 44 (1932) See also: A. G. Bergman, Z. Anorg. Allgem. Chem. 157, 89(1926).

Melt Preparation and Purification

For the method of melt preparation used by Bergman [42], see $AgNO_3$ - HgI_2. The $TlNO_3$ was recrystallized twice starting with analytical grade material.

TABLE 131. Electrical conductance studies: HgI_2 - $TlNO_3$

Investigations critically examined

Ref.	Mol % $TlNO_3$	Temp. range (K)	Comments
42	0-100	478-573	see: $AgNO_3$-HgI_2

TABLE 132. HgI_2 - $TlNO_3$: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent $TlNO_3$				
	90	70	50	30	10
500	0.326				
520	0.367	0.231	0.150	0.140	
550	0.429	0.279	0.186	0.160	0.144
570	0.470	0.311	0.210	0.174	0.149

Temperature-dependent equations

$\kappa = a + bT$

Mol % $TlNO_3$	a	$b \times 10^3$	standard error of estimate
100	-0.7796	2.400	0.00%
95	-0.7412	2.228	0.07%
90	-0.7085	2.068	0.08%
80	-0.6712	1.860	0.08%
70	-0.6010	1.600	0.00%
60	-0.6006	1.480	0.27%
50	-0.4744	1.200	0.63%
40	-0.3978	1.020	0.18%
30	-0.2141	0.680	0.37%
20	-0.1616	0.580	0.18%
10	0.0124	0.240	0.00%
8	-0.0434	0.320	0.00%
5	0.0941	0.040	0.00%
3	0.1409	-0.080	0.00%
0	0.0853	-0.100	0.00%

These values are based on the data of Bergman and Chagin (classical ac method) [42]. The conductivities as calculated from the above equations for 100% $TlNO_3$ and 100% HgI_2 (0% $TlNO_3$) are 7% and 5% higher than the recommended data bases for pure $TlNO_3$ and pure HgI_2, respectively [1].

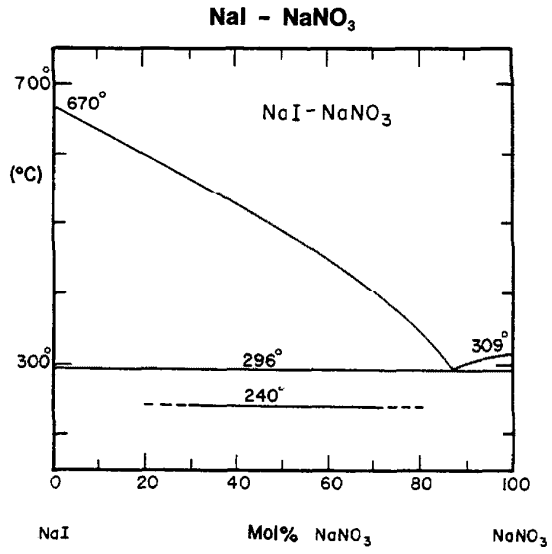

FIGURE 24. Phase diagram for NaI – $NaNO_3$.

Data from: F. I. Vasenin and A. G. Bergman, Izv. Sekt. Fiz.-Khim. Analiza, Inst. Obshch. Neorg. Khim., Akad. Nauk. SSSR, **11**, 172(1938).

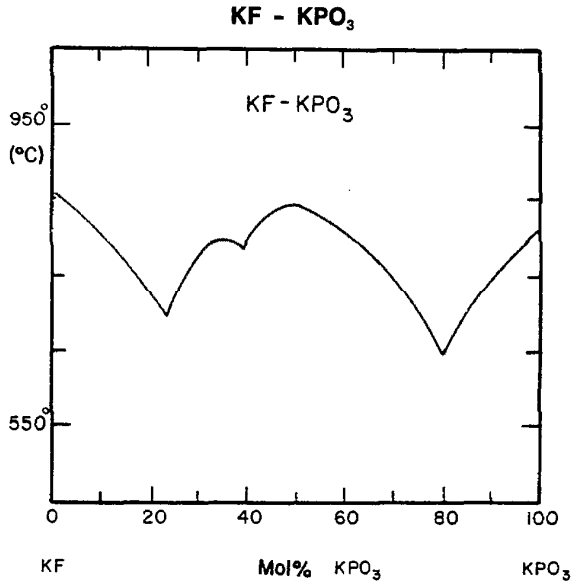

FIGURE 25. Phase diagram for KF – KPO_3.

Data from: V. P. Kochergin,Z. A. Shevrina, and I. V Madirosova, Izv. Akad. Nauk. SSSR, Neorg. Mater., **4**, 436 (1968).

Melt Preparation and Purification

Semenchenko [34] used reagent grade materials. No other information was provided.

TABLE 133. Surface tension studies: NaI – $NaNO_3$

Investigations critically examined

Ref.	Mol % $NaNO_3$	Temp. range (K)	Comments
34	90–100	585	see: NaF – $NaNO_3$

TABLE 134. NaI – $NaNO_3$: Surface tension (dyn cm^{-1})

T(K)	Mol percent $NaNO_3$
	90
585	119.1

A single data point only (above) was reported by Semenchenko and Shikhobalova (maximum bubble pressure method) [34].

Melt Preparation and Purification

Kochergin et al. [56] prepared the melts from reagent grade salts. The potassium metaphosphate was synthesized from the primary phosphate.

TABLE 136. Viscosity studies: KF – KPO_3

Investigations critically examined

Ref.	Mol % KPO_3	Temp. range (K)	Comments
56	10–100	1173	Effects of added Fe_2O_3 were also studied.

Halide - Meta/Ortho/Pyrophosphate

TABLE 135. Data Status

System	Phase Diagram	Electrical Conductance	Density	Viscosity	Surface Tension
KF-KPO_3	X			X	
LiF-$LiPO_3$	X			X	
NaF-$NaPO_3$	X			X	
KCl-KPO_3	X	X		X	
-K_3PO_4	X	X			
-$K_4P_2O_7$	X	X			
NaCl-$NaPO_3$	X	X		X	
-$Na_4P_2O_7$	X	X	X		

TABLE 137. KF - KPO_3: Viscosity (cp)

T(K)	Mol percent KPO_3
	80
1173	200

A single data point only (above) was reported by Kochergin, Shevrina, and Mardirosova (oscillational method) [56]. Kochergin et al. also investigated the influence of ferric oxide (Fe_2O_3), as an additive, on the viscosity of the above system at 1173 K (2.49–20.0 wt% Fe_2O_3).

TABLE 139. LiF - $LiPO_3$: Viscosity (cp)

T(K)	Mol percent $LiPO_3$
	20
1173	150

A single data point only (above) was reported by Kochergin, Shevrina, and Mardirosova (oscillational method) [56]. Kochergin et al. also investigated the influence of ferric oxide (Fe_2O_3), as an additive, on the viscosity of the above system at 1173 K (2.49 - 9.08 wt% Fe_2O_3).

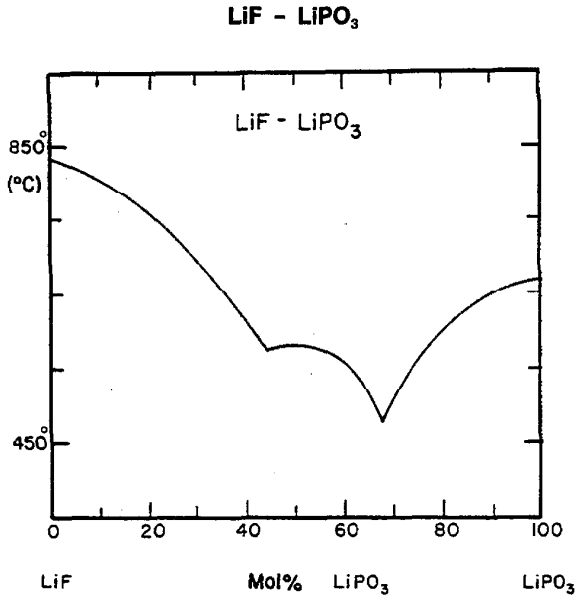

FIGURE 26. Phase diagram for LiF - $LiPO_3$.
Data from: V. P. Kochergin, Z. A. Shevrina, and I. V. Mardirosova, Izv. Akad. Nauk. SSSR, Neorg. Mater. 4, 436 (1968).

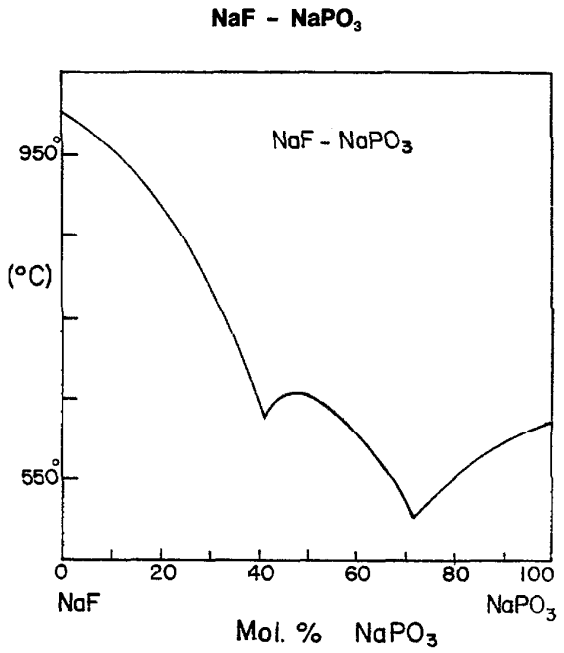

FIGURE 27. Phase diagram for NaF - $NaPO_3$.
Data from: V. P. Kochergin, Z. A. Shevrina, and I. V. Mardirosova, Izv. Akad. Nauk. SSSR, Neorg. Mater., 4, 436(1968).

Melt Preparation and Purification

Kochergin et al. [56] prepared the melts from reagent grade salts. Lithium metaphosphate was synthesized from lithium carbonate and phosphoric acid.

TABLE 138. Viscosity studies: LiF - $LiPO_3$

Investigations critically examined			
Ref.	Mol % $LiPO_3$	Temp. range (K)	Comments
56	20–100	1173	Effects of added Fe_2O_3 were also studied.

Melt Preparation and Purification

For the method of melt preparation used by Kochergin et al. [56] see KF - KPO_3.

TABLE 140. Viscosity studies: NaF - $NaPO_3$

Investigations critically examined			
Ref.	Mol % $NaPO_3$	Temp. range (K)	Comments
56	20–100	1173	-

TABLE 141. NaF - $NaPO_3$: Viscosity (cp)

Mol percent $NaPO_3$	1173 K
100	431.7
79.4	148.8
59.1	51.8
39.7	14.5
20.0	9.8

The above values were interpolated from the graphical data points reported by Kochergin, Shevrina, and Mardirosova (oscillational method) [56]; these data could not be fit to a simple equation.

KCl - KPO_3

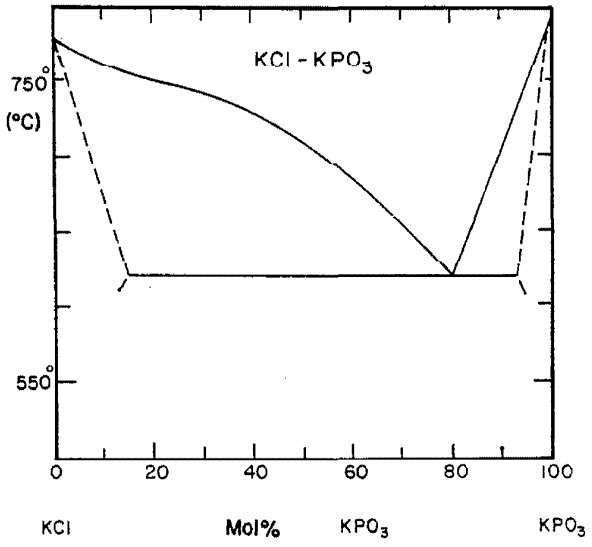

FIGURE 28. Phase diagram for KCl - KPO_3.
Data from: M. Amadori, Atti reale accad. Lincei, Sez. II, 21, 184(1912).

Melt Preparation and Purification

Kochergin et al. [56] used reagent grade salts to prepare the melts. The potassium metaphosphate was synthesized from the primary phosphate.

TABLE 142. Electrical conductance studies: KCl - KPO_3

Investigations critically examined			
Ref.	Mol % KPO_3	Temp. range (K)	Comments
56	0–100	1123	Mo electrodes; calibration: molten KCl, NaCl; N_2 atmosphere.

TABLE 143. KCl - KPO_3: Specific conductance ($ohm^{-1}cm^{-1}$)

Mol percent KPO_3	1123 K
100	1.23
90	1.34
60	1.65
30	1.97
10	2.18
0	2.28

Composition-dependent equation
$\kappa = 2.280 - 0.0105C$
[C = Mol% KPO_3]
standard error of estimate = 3.70%

These values are based on the data of Kochergin, Shevrina, and Mardirosova (classical ac method) [56]. Results are also reported for the effect of 8 wt% ferric oxide (Fe_2O_3) as additive to the above system. For KPO_3, specific conductance at 1123 K from the recommended data base [8] is 0.71; for KCl, similarly [1], 2.36.

TABLE 144. Viscosity studies: KCl - KPO_3

Investigations critically examined			
Ref.	Mol % KPO_3	Temp. range (K)	Comments
56	40–100	1173	-

TABLE 145. KCl - KPO_3: Viscosity (cp)

Mol percent KPO_3	1123 K
40	15
60	65
80	185
100	220

The above values are reported by Kochergin, Shevrina, and Mardirosova (oscillational method) [56]. Results are also reported for the effect of 8 wt% ferric oxide (Fe_2O_3) as additive to the above system.

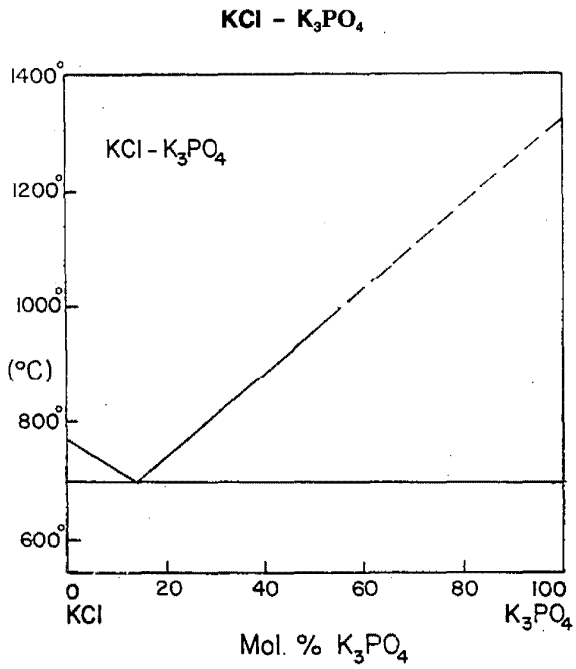

FIGURE 29. Phase diagram for KCl - K_3PO_4.

Data from: M. Amadori, Atti reale accad. Lincei Sez. II, **21**, 187(1912).

Melt Preparation and Purification

For the method of melt preparation used by Kochergin et al. [56] see KF - KPO_3

TABLE 146. Electrical conductance studies: KCl - K_3PO_4

Investigations critically examined

Ref.	Mol % K_3PO_4	Temp. range (K)	Comments
56	0–30	1123	Mo electrodes; calibration: molten KCl, NaCl; N_2 atmosphere

TABLE 147. KCl - K_3PO_4: Specific conductance ($ohm^{-1}cm^{-1}$)

Mol percent K_3PO_4	1123 K
30	1.15
20	1.37
10	1.74
0	2.28

Composition-dependent equation

$\kappa = 2.275 - 6.12 \times 10^{-2}C + 7.91 \times 10^{-4}C^2$

[C = Mol% K_3PO_4]

These values are based on the data of Kochergin, Shevrina, and Mardirosova (classical ac method); data in graphical form; precision not estimated [56]. For KCl, the specific conductance at 1123 K from the recommended data base [1], is 2.36 ohm^{-1} cm^{-1}.

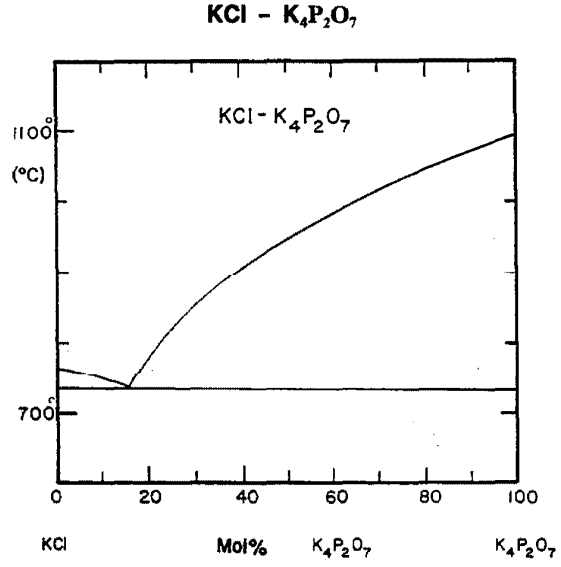

FIGURE 30. Phase diagram for KCl - $K_4P_2O_7$.

Data from: M. Amadori, Atti reale accad. Lincei, Sez. II, **21**, 186(1912).

Melt Preparation and Purification

For the method of melt preparation used by Kochergin et al. [56] see KF - KPO_3.

TABLE 148. Electrical conductance studies: KCl - $K_4P_2O_7$

Investigations critically examined

Ref.	Mol % $K_4P_2O_7$	Temp. range (K)	Comments
56	0–30	1123	Mo electrodes; calibration: molten KCl, NaCl; N_2 atmosphere

TABLE 149. KCl - $K_4P_2O_7$: Specific conductance ($ohm^{-1}cm^{-1}$)

Mol percent $K_4P_2O_7$	1123 K
30	0.95
20	0.95
10	1.35
5	1.70
0	2.16

Composition-dependent equation

$\kappa = 2.160 - 10.13 \times 10^{-2}C + 20.30 \times 10^{-4}C^2$ (1123 K)

[C = Mol% $K_4P_2O_7$]

These values are based on the data of Kochergin, Shevrina, and Mardirosova (classical ac method); data in graphical form; precision not estimated [56]. For KCl, the specific conductance at 1123 K from the recommended data base [1] is 2.36 ohm^{-1} cm^{-1}.

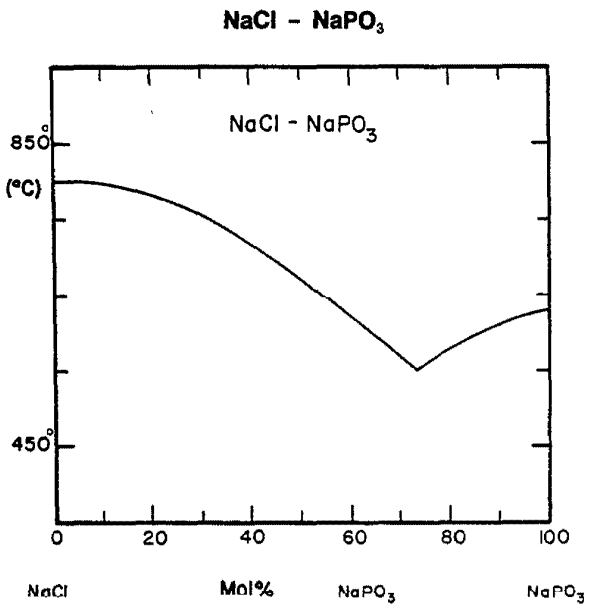

FIGURE 31. Phase diagram for NaCl - $NaPO_3$.

Data from: V. P. Kochergin, Z. A. Shevrina, I. V. Mardirosova, Izv. Akad. Nauk. SSSR, Neorg. Mater, **4**, 436(1968).

Melt Preparation and Purification

For the method of melt preparation used by Kochergin et al. [**56**] see KF - KPO_3. Bergman et al. [57] used reagent grade salts.

TABLE 150. Electrical conductance studies: NaCl - $NaPO_3$

Investigations critically examined

Ref.	Mol % $NaPO_3$	Temp. range (K)	Comments
56	0–100	1123	Mo electrodes; calibration: molten KCl, NaCl; N_2 atmosphere

TABLE 151. NaCl - $NaPO_3$: Specific conductance ($ohm^{-1}cm^{-1}$)

Mol percent $NaPO_3$	1123 K
100	1.23
90	1.49
70	2.01
50	2.52
30	3.04
10	3.55
0	3.81

Composition-dependent equation

$\kappa = 3.8119 - 2.580 \times 10^{-2}C$ (1123 K)

[C = Mol% $NaPO_3$]

These values are based on the data of Kochergin, Shevrina and Mardirosova (classical ac method); data in graphical form; precision not estimated **[56]**. For NaCl, the specific conductance at 1123 K from the recommended data base [10], is 3.72 ohm^{-1} cm^{-1}; for $NaPO_3$, similarly [8], 0.91 $ohm^{-1}cm^{-1}$.

TABLE 152. Viscosity studies: NaCl - $NaPO_3$

Investigations critically examined

Ref.	Mol % $NaPO_3$	Temp. range (K)	Comments
56	20–100	1173	effects of added Fe_2O_3 also studied. Estimated experimental uncertainty 2–4%; calibration: water, water–glycerine
57	0–100	1173	

TABLE 153. NaCl - $NaPO_3$: Viscosity (cp)

T(K)	Mol percent $NaPO_3$
	80
1173	240

A single data point only (above) was reported by Kochergin, Shevrina, and Mardirosova (oscillational method) [**56**]. Kochergin et al. also investigated the influence of ferric oxide (Fe_2O_3), as an additive, on the viscosity of the above system at 1173 K (2.49 - 20.0 wt% Fe_2O_3).

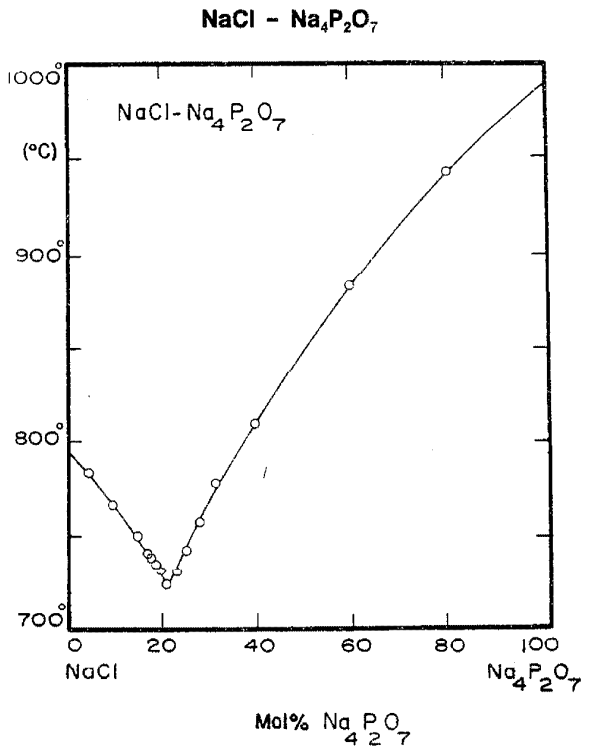

FIGURE 32. Phase diagram for NaCl – $Na_4P_2O_7$.

Data from: S.I. Sklyarenko and J.E. Krauze, Zh. Fiz. Khim. **10**, 449(1937).

Melt and Preparation and Purification

Sklyarenko et al. [58] used reagent grade sodium chloride. The $Na_4P_2O_7$ was prepared from pure Na_2HPO_4 by heating it at 450–550°C. The components were fused together after mixing. After experiments had been completed the mixtures were analyzed for phosphate content (<0.3–0.5% change).

TABLE 154. Electrical conductance studies: NaCl – $Na_4P_2O_7$

Investigations critically examined			
Ref.	Mol % $Na_4P_2O_7$	Temp. range (K)	Comments
58	0–100	1073–1343	quartz cell; capillary electrodes; calibration: molten KNO_3

TABLE 155. NaCl – $Na_4P_2O_7$: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent $Na_4P_2O_7$			
	79.7	60.2	31.6	19.1
1070			2.06	2.37
1150			2.36	2.66
1230		2.29	2.66	2.95
1270	2.34	2.50	2.81	3.09
1320	2.39	2.74	3.00	3.27

Temperature-dependent equations

$$\kappa = a + bT$$

Mol % $Na_4P_2O_7$	$-a$	$b \times 10^3$	standard error of estimate
100	3.001	4.116	0.17%
79.7	3.811	4.847	0.06%
60.2	3.856	5.000	0.00%
39.7	3.092	4.600	0.24%
31.6	1.965	3.760	0.16%
19.1	1.483	3.600	0.00%
9.9	1.084	3.600	0.00%
4.5	–0.278	2.660	0.20%
0	–1.549	1.891	0.07%

These values are based on the data of Sklyarenko and Krauze (classical ac method) [58]. For NaCl, at 1080 K and 1250 K, the specific conductances from the recommended data base [10] are, respectively, 3.597 and 3.980 ohm^{-1} cm^{-1} (cf. 3.59 and 3.91, respectively [58]).

TABLE 156. Density studies: NaCl – $Na_4P_2O_7$

Investigations critically examined			
Ref.	Mol % $Na_4P_2O_7$	Temp. range (K)	Comments
58	0–100	1073–1373	Pt sphere and crucible

TABLE 157. NaCl - $Na_4P_2O_7$: Density (g cm^{-3})

T(K)	Mol percent $Na_4P_2O_7$			
	80.3	49.8	31.6	20.0
1070			2.001	1.897
1150			1.968	1.861
1170		2.073	1.960	1.852
1230	2.165	2.050	1.935	1.826
1310	2.134	2.021	1.902	1.790
1370	2.110	1.999	1.877	1.763

Temperature-dependent equations

$$\rho = a + bT$$

Mol % $Na_4P_2O_7$	a	$-b \times 10^3$	standard error of estimate
100	2.5876	0.3201	0.00%
80.3	2.6498	0.3941	0.01%
64.7	2.5775	0.3720	0.03%
49.8	2.5031	0.3680	0.03%
31.6	2.4443	0.4143	0.17%
20.0	2.3712	0.4436	0.06%
0	2.1320	0.5429	0.09%

These are values based on the data of Skylarenko and Krauze (Archimedean technique) [58]. For NaCl at 1080 K and 1290 K, the densities from the recommended data base are, respectively, 1.553 and 1.439 g cm^{-3} (cf. 1.55 and 1.43, respectively [58]).

$BaCl_2$ - Li_2SO_4

Melt and Preparation and Purification

No information is available on melt preparation and purification in reference [59], or in experimental references cited therein.

TABLE 159. Surface tension studies: $BaCl_2$ - Li_2SO_4

Investigations critically examined			
Ref.	Mol % Li_2SO_4	Temp. range (K)	Comments
59	0-100	1273-13	see: NaI-Na_2SO_4

Halide - Sulfate

TABLE 158. Data Status

System	Phase Diagram	Electrical Conductance	Density	Viscosity	Surface Tension
$BaCl_2$-Li_2SO_4					X
CsCl-Cs_2SO_4	X				X
-Li_2SO_4					X
KCl-K_2SO_4	X		X		X
-Li_2SO_4	X				X
-Na_2SO_4	X	X			
-$ZnSO_4$	X	X	X		
NaCl-K_2SO_4	X	X			
-Li_2SO_4	X	X		X	X
-Na_2SO_4	X				X
-KCl-Na_2SO_4		X			
-Na_2SO_4-K_2SO_4		X			
RbCl-Li_2SO_4					X
-K_2SO_4					X
-Na_2SO_4					X
-Rb_2SO_4					X
TlCl-$ZnSO_4$	X	X	X		
CsBr-$ZnSO_4$	X	X			
$HgBr_2$-$HgSO_4$	X	X			
-$TlSO_4$	X	X			
KBr-Na_2SO_4					X
-$ZnSO_4$	X	X	X		
NaBr-K_2SO_4					X
KI-Na_2SO_4					X
-$ZnSO_4$	X	X			
NaI-Na_2SO_4					X

TABLE 160. $BaCl_2$–Li_2SO_4: Surface tension (dyn cm^{-1})

Mol percent Li_2SO_4	1273 K	1323 K
100	215	208
90	193	186
60	161	156
30	163	161
10	171	169
0	174	171

Composition-dependent equations

$\gamma = a + bC + cC^2 + dC^3$

[C = Mol% Li_2SO_4]

T(K)	a	$-b \times 10^2$	$-c \times 10^4$	$d \times 10^6$	standard error of estimate
1273	174.1	30.61	69.26	140.9	2.77%
1323	170.9	9.98	134.31	181.8	4.10%

These values are based on the data of Semenchenko and Shikhobalova (maximum bubble pressure method) [59]. For $BaCl_2$ (0% Li_2SO_4), at 1273 K and 1323 K, the surface tension values from the recommended data base [2] are, respectively, 163 and 159 dyn cm^{-1}.

$CsCl - Cs_2SO_4$

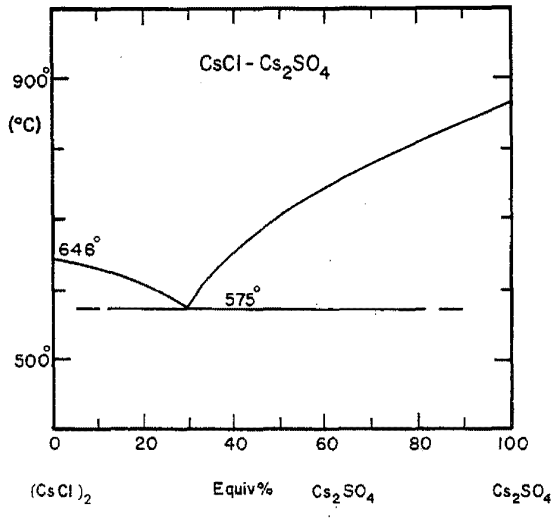

FIGURE 33. Phase diagram for $CsCl - Cs_2SO_4$.

Data from: O. S. Dombrovskaya, Zh. Obshch. Khim., 3(8), 1019 (1933).

Melt and Preparation and Purification

Bertozzi and Soldani [60] used reagent grade salts. No other information was given.

TABLE 161. Surface tension studies: $CsCl - Cs_2SO_4$

Investigations critically examined

Ref.	Mol % Cs_2SO_4	Temp. range (K)	Comments
60	0–100	950–1473	see:NaCl-Na_2SO_4

TABLE 162. $CsCl - Cs_2SO_4$: Surface tension (dyn cm^{-1})

T(K)	Mol percent Cs_2SO_4	
	50	75
1060	102.9	114.9
1100	100.1	112.1
1200	93.2	105.2
1450	80.0	88.0

Temperature-dependent equations

$\gamma = a + bT$

Mol percent Cs_2SO_4	a	$-b \times 10^3$
100	193.3	62.0
75	188.0	69.0
50	176.0	69.0
0	159.2	74.0

These equations are based on those reported by Bertozzi and Soldani (Wilhelmy slide plate method) [60]. The results for pure CsCl are in close agreement with the recommended data base, i.e., $< 1.5\%$, while for pure Cs_2SO_4, the values fall $\sim 3\%$ above the recommended data set [2].

$CsCl - Li_2SO_4$

Melt and Preparation and Purification

For the method of melt preparation used by Semenchenko and Shikhobalova [59, 61], see: RbCl - Na_2SO_4.

TABLE 163. Surface tension studies: $CsCl - Li_2SO_4$

Investigations critically examined

Ref.	Mol % Li_2SO_4	Temp. range (K)	Comments
59, 61	0–100	1173–1373	see: NaI- Na_2SO_4

TABLE 164. $CsCl - Li_2SO_4$: Surface tension (dyn cm^{-1})

T(K)	Mol percent Li_2SO_4				
	98.5	98	97	90	50
1170	201	193	189	164	102
1260	196	190	186	160	92
1290	195	188	184	159	
1350	191	184	179	155	

Temperature-dependent equations

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

Mol % Li_2SO_4	a	$b \times 10^3$	$-c \times 10^6$	standard error of estimate
100	-73.00	523.9	230.9	0.13%
99.75	93.40	229.3	113.6	0.07%
99.50	133.40	164.0	87.2	0.19%
99.00	-59.00	463.3	203.2	0.26%
98.50	274.00	-67.2	-4.4	0.26%
98.00	-63.10	454.4	201.2	0.55%
97.00	-67.30	454.4	201.2	0.20%
90.00	82.46	171.5	87.0	0.09%
50.00	1102.60	-1547.0	-591.5	0.45%
0	-4.93	199.8	114.5	0.25%

These values are based on the data of Semenchenko and Shikhobalova (maximum bubble pressure method) [59]. The results for pure CsCl (0% Li_2SO_4) are virtually in exact agreement with the recommended data base, i.e., ~0.3 to 0.7% [2]; for 100% Li_2SO_4 the results are ~1-2% higher than the recommended data base for pure Li_2SO_4 [2].

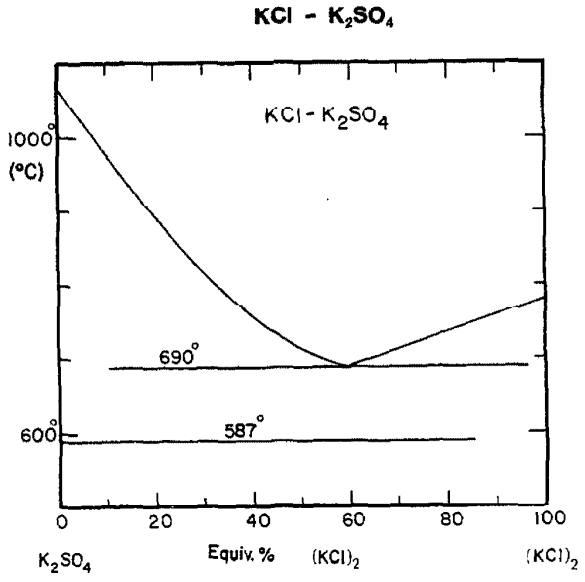

FIGURE 34. Phase diagram for $KCl - K_2SO_4$.

Data from: E. Janecke, Z. physik. Chem., 64, 343 (1908).

Melt and Preparation and Purification

Neithamer and Peake [62] used reagent grade KCl and dried it for 16 hours at 600°C. Reagent grade K_2SO_4 was dried for 24 hours at 900°C. The mixtures were blended for 5 minutes. Bertozzi and Soldani [60] used reagent grade salts. No other information was given. Semenchenko and Shikhobalova [61] used C.P. grade salts which were recrystallized twice.

TABLE 165. Density studies: $KCl - K_2SO_4$

Investigations critically examined

Ref.	Mol % K_2SO_4	Temp. range (K)	Comments
62	0-100	1064-1411	Pt bob and suspension wire

TABLE 166. $KCl - K_2SO_4$: Density (g cm^{-3})

T(K)	Mol percent K_2SO_4				
	80.2	69.4	45.0	32.4	15.3
1090				1.732	1.599
1120			1.783	1.713	1.580
1150			1.766	1.695	1.562
1180			1.749		1.544
1240		1.821			
1270		1.807			
1300	1.828	1.792			
1330	1.813	1.778			
1360	1.799				

Temperature-dependent equations

$$\rho = a + bT$$

Mol % K_2SO_4	a	$-b \times 10^3$	standard error of estimate
100	2.4761	0.4519	0.06%
80.2	2.4495	0.4784	0.05%
69.4	2.4145	0.4785	0.16%
55.2	2.4994	0.5991	0.04%
45.0	2.4194	0.5680	0.05%
43.1	2.4453	0.5989	0.04%
32.4	2.4057	0.6183	0.05%
22.3	2.3420	0.6234	0.04%
15.3	2.2536	0.6010	0.04%
0	2.0865	0.5476	0.09%

These values are based on the data of Neithamer and Peake (Archimedean method) [62]. The results for KCl (0% K_2SO_4) agree with the recommended data base to <1% [1]; for pure K_2SO_4, the results are virtually in exact agreement with the recommended data base [1].

TABLE 167. Surface tension studies: KCl – K_2SO_4

Investigations critically examined			
Ref.	Mol % K_2SO_4	Temp. range (K)	Comments
62	0–100	1090–1373	90% Pt – 10% Rh capillary; porcelain crucible; dry N_2 atmosphere; calibration: molten $NaNO_3$, KNO_3
61	90–100	1343	see: NaI – Na_2SO_4
60	0–100	mp–1473	see: NaCl – Na_2SO_4

TABLE 168. KCl – K_2SO_4: Surface tension (dyn cm^{-1})

T(K)	Mol percent K_2SO_4			
	79.2	60.2	35.4	15.3
1090			112.7	99.2
1170			107.3	93.4
1190		123.1		
1210		121.7		
1250		118.7		
1270	127.1			
1310	124.6			

Temperature-dependent equations

$$\gamma = a + bT$$

Mol % K_2SO_4	a	$-b \times 10^3$	standard error of estimate
100	244.41	75.95	0.08%
79.2	205.85	62.04	0.18%
69.9	198.28	61.46	0.23%
60.2	212.03	74.69	0.33%
44.7	196.07	72.21	0.11%
35.4	186.22	67.43	0.18%
21.3	186.88	74.54	0.44%
15.3	177.50	71.87	0.19%
0	169.44	68.64	0.30%

These values are based on the data of Neithamer and Peake (maximum bubble pressure method) [62]. The results for 100% K_2SO_4 are in exact accord with the recommended data base for pure K_2SO_4 [2]; for 100% KCl (0% K_2SO_4), the results are uniformly lower (~2–3%) than those of the recommended data base for pure KCl [2].

KCl – Li_2SO_4

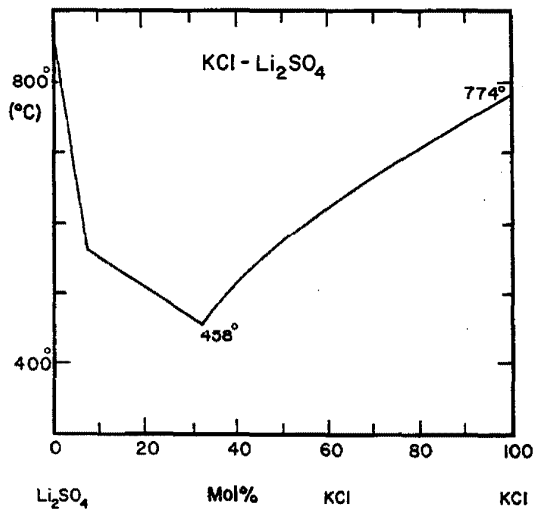

FIGURE 35. Phase diagram for KCl – Li_2SO_4.

Data from: E. K. Akopov and A. G. Bergman, J. Inorg. Chem., 2(2), 241 (1957).

Melt and Preparation and Purification

For the method of melt preparation used by Semenchenko and Shikhobalova [61, 59], see: RbCl-Na_2SO_4.

TABLE 169. Surface tension studies: KCl – Li_2SO_4

Investigations critically examined			
Ref.	Mol % Li_2SO_4	Temp. range (K)	Comments
61, 59	0–100	1173–1373	see: NaI–Na_2SO_4

TABLE 170. $KCl - Li_2SO_4$: Surface tension (dyn cm^{-1})

T(K)	Mol percent Li_2SO_4				
	90	65	45	25	5
1170	182	145	123	109	96
1250	178	143	119	103	92
1330	175	138	113	96	84
1370	173	135	110	93	79

Temperature-dependent equations

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

Mol % Li_2SO_4	a	$b \times 10^3$	$-c \times 10^6$	standard error of estimate
100	-73.0	523.9	230.9	0.13%
99	66.3	290.2	143.0	0.10%
98	12.0	371.6	172.6	0.29%
97	-386.3	975.5	405.1	0.37%
95	201.85	61.8	55.7	0.73%
90	234.7	-46.0	-0.8	0.29%
65	-113.2	454.9	199.9	0.51%
60	-22.1	309.6	145.9	0.41%
55	-9.9	292.1	143.8	0.15%
50	17.7	229.7	115.4	0.60%
45	61.5	153.6	86.2	0.55%
40	52.7	158.3	88.1	0.35%
25	114.9	62.3	57.4	0.19%
10	-39.0	285.5	144.3	0.61%
5	-216.6	571.1	259.6	0.62%
0	-235.7	583.0	259.6	0.77%

These values are based on the data of Semenchenko and Shikhobalova (maximum bubble pressure method) [59]. Comparison of the above data with the recommended data base for Li_2SO_4 and KCl [2] shows close agreement at 1170 K (~0.3% and 0.9%, respectively), at higher temperatures, e.g., 1250 K, the results in [59] for Li_2SO_4 and KCl appear high (i.e., 1% and 2.5%, respectively).

$KCl - Na_2SO_4$

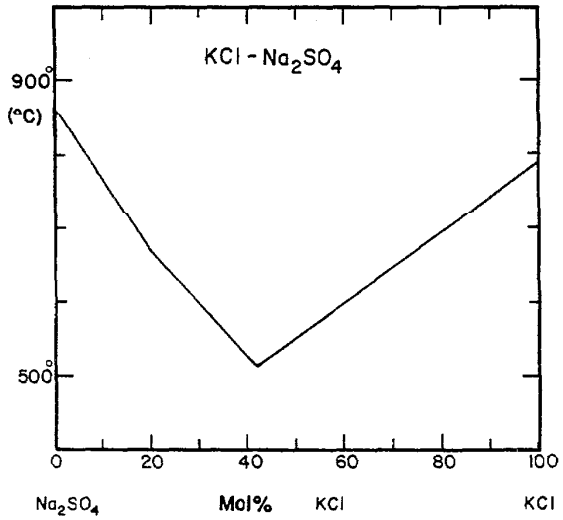

FIGURE 36. Phase diagram for $KCl - Na_2SO_4$.

Data from: I. T. Gul'din and A. V. Buzhinskaya, Zh. Prikl. Khim. 38(4), 778 (1965).

Melt and Preparation and Purification

For the method of melt preparation used by Gul'din and Buzhinskaya [63], see: $NaCl-K_2SO_4$.

TABLE 171. Electrical conductance studies: $KCl - Na_2SO_4$

Investigations critically examined

Ref.	Equiv. % Na_2SO_4	Temp. range (K)	Comments
63	10–90	923–1073	alumina crucibles used for fusion

TABLE 172. $KCl - Na_2SO_4$: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Equiv. percent Na_2SO_4				
	80	69	59	49	19
920				1.278	
960				1.487	
980	1.884	1.866	1.728	1.573	1.468
1060	2.100	2.097	1.967	1.792	1.720

Temperature-dependent equations

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

Equiv. % Na_2SO_4	a	$b \times 10^3$	$c \times 10^6$
80	14.8683	-27.996	15.048
69	0.9666	2.890	
59	4.9550	-9.096	5.922
49	-17.4151	34.768	-15.705
39	-3.4924	6.684	-1.672
19	-5.8679	11.499	-4.095

These values are based on the data of Gul'din and Buzhinskaya; data in graphical form; precisions not estimated (classical ac method) [63]. The compositions in Table 172 are calculated for the system as $(KCl)_2-Na_2SO_4$, i.e., equiv. %.

KCl - $ZnSO_4$

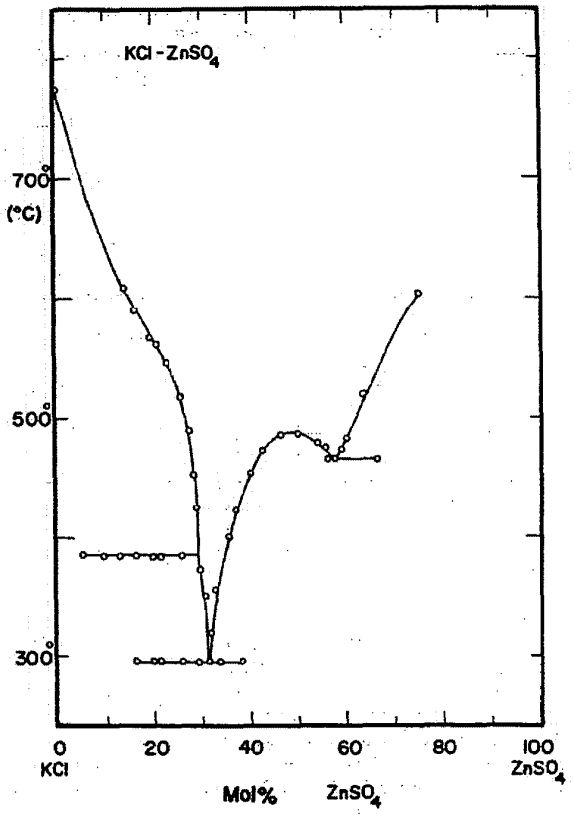

FIGURE 37. Phase diagram for KCl – $ZnSO_4$.

Data from: N. P. Luzhnaya and I. P. Vereshchetina, Zh. Prikl. Khim., 22, 952 (1949).

TABLE 174. KCl – $ZnSO_4$: Specific conductance (ohm^{-1}cm^{-1})

T(K)	Equiv. percent $ZnSO_4$				
	74.44	65.31	55.04	44.94	41.11
750	0.094	0.149	0.231	0.293	0.361
780	0.125	0.199	0.282	0.350	0.426
800	0.144	0.228	0.313	0.385	0.466
820	0.163	0.252	0.342	0.417	0.503

Temperature-dependent equations

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

Equiv. % $ZnSO_4$	$-a$	$b \times 10^3$	$-c \times 10^6$	standard error of estimate
79.82	0.6172	0.9199		0.00%
74.44	1.3218	2.7208	1.1105	0.41%
69.78	3.5829	8.3470	4.5260	0.94%
68.87	3.1242	7.0238	3.5743	0.67%
67.54	4.7317	11.0419	6.0910	1.65%
66.68	2.0959	4.3343	1.8510	1.04%
65.31	3.9442	9.1063	4.8641	0.67%
64.37	4.7340	11.1269	6.1298	0.93%
62.00	2.0437	4.4738	1.9844	1.13%
58.17	2.5250	5.5921	2.5893	0.37%
55.04	2.7391	6.1295	2.8931	0.55%
51.78	2.7414	6.1640	2.8896	0.95%
49.29	3.7561	8.7469	4.4750	0.85%
47.92	3.0932	6.9709	3.2479	0.53%
47.21	4.5192	10.7469	5.7479	0.53%
44.94	2.9584	6.6764	3.1216	0.58%
43.13	3.4003	7.6123	3.5059	0.41%
41.11	3.1284	7.0496	3.1962	0.25%

These values are based on the data of Vereshchetina and Luzhnyaya (classical ac method) [64]. The compositions in Table 174 are calculated for the system $(KCl)_2$–$ZnSO_4$, i.e., equiv. %.

Melt and Preparation and Purification

Vereshchetina and Luzhnaya [64, 65] used reagent grade materials. The potassium chloride was recrystallized twice. The zinc sulfate was dehydrated and ignited carefully at 500°C.

TABLE 173. Electrical conductance studies: KCl – $ZnSO_4$

Investigations critically examined

Ref.	Equiv. % $ZnSO_4$	Temp. range (K)	Comments
64	41.11–79.82	748–823	quartz or Mo cells; Pt electrodes; temp. variation < 1%
65			see: [64]

TABLE 175. Density studies: KCl – $ZnSO_4$

Investigations critically examined

Ref.	Equiv. % $ZnSO_4$	Temp. range (K)	Comments
65	41.89–75.26	748–823	Pt float; calibration: molten KNO_3, $NaNO_3$
64			see [65]

TABLE 176. KCl – $ZnSO_4$: Density (g cm^{-3})

T(K)	Equiv. percent $ZnSO_4$				
	75.26	65	50.94	43.59	41.89
750	2.695	2.536	2.271	2.176	2.156
790	2.676	2.512	2.249	2.148	2.130
820	2.648	2.484	2.225	2.127	2.109

Temperature-dependent equations

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

Equiv. % $ZnSO_4$	a	$b \times 10^3$	$-c \times 10^6$	standard error of estimate
75.26	-0.6222	9.0764	6.2048	0.11%
71.71	5.2308	-6.2319	-3.6584	0.22%
69.27	4.9839	-5.5023	-3.0617	0.19%
68.28	5.0276	-5.6840	-3.1900	0.09%
66.77	2.9978	-0.6040		0.13%
65.00	0.2331	6.5701	4.6654	0.06%
59.85	0.4534	5.5985	3.9782	0.21%
55.00	3.3873	-2.0602	-0.8733	0.05%
50.94	0.6673	4.6978	3.4127	0.14%
45.39	2.6747	-0.6440		0.09%
43.59	2.7105	-0.7121		0.08%
42.82	2.6616	0.6521		0.01%
41.89	1.9617	1.1094	1.1339	0.05%

These values are based on the data of Vereshchetina and Luzhnaya (Archimedean technique) [65]. The compositions in Table 176 are calculated for the system $(KCl)_2$–$ZnSO_4$, i.e., equiv. %.

NaCl – K_2SO_4

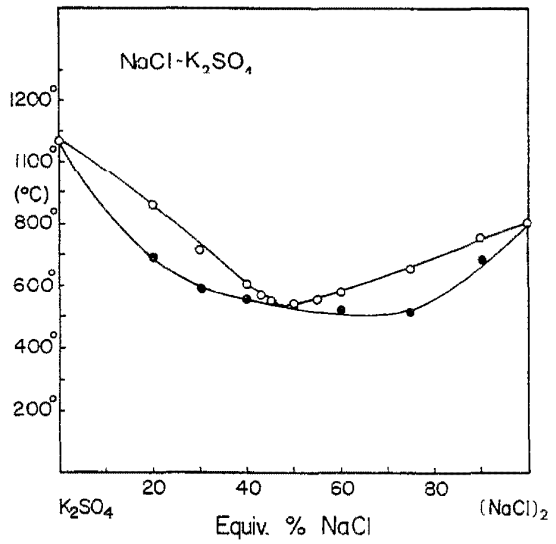

FIGURE 38. Phase diagram for NaCl – K_2SO_4.

Data from: E. Janecke, Z. phys. Chem. **64**, 343 (1908); Z. Anorg. Chem. **261**, 213 (1950).

Melt and Preparation and Purification

Gul'din and Buzhinskaya [63] used reagent grade salts, which were recrystallized twice from distilled water.

TABLE 177. Electrical conductance studies: NaCl – K_2SO_4

Investigations critically examined

Ref.	Equiv. % K_2SO_4	Temp. range (K)	Comments
63	40–80	923–1023	alumina crucibles used for fusion

TABLE 178. NaCl – K_2SO_4 : Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Equiv. percent K_2SO_4		
	61	51	42
920	1.691	1.416	1.364
960	1.827	1.513	1.409
1020	2.032	1.719	1.577

Temperature-dependent equations

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

Equiv. % K_2SO_4	a	$-b \times 10^3$	$c \times 10^6$
61	-1.4465	-3.410	
51	7.8716	16.080	9.851
42	15.0579	30.231	16.681

These values are based on the data of Gul'din and Buzhinskaya (classical ac method); data in graphical form; precisions not estimated [63]. The compositions in Table 178 are calculated for the system as $(NaCl)_2$–K_2SO_4, i.e., equiv. %.

NaCl – Li_2SO_4

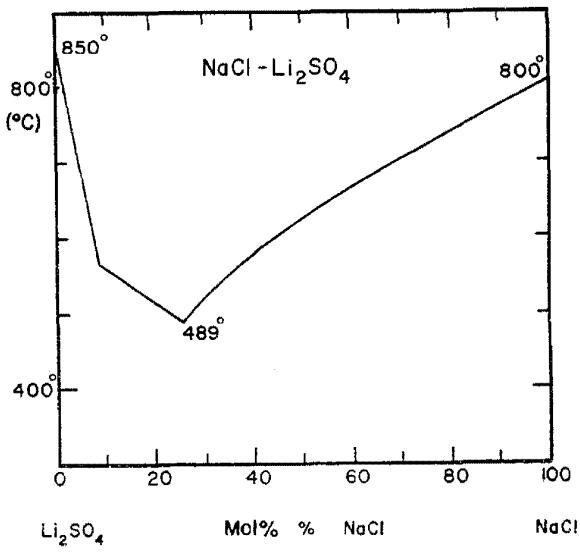

FIGURE 39. Phase diagram for NaCl – Li_2SO_4.

Data from: E. K. Akopov and A. G. Bergman, Russ. J. Inorg. Chem., 2, 243 (1957).

Melt and Preparation and Purification

For the method of melt preparation used by Semenchenko and Shikhobalova [61, 59], see: RbCl–Na_2SO_4.

TABLE 179. Surface tension studies: NaCl – Li_2SO_4

Investigations critically examined			
Ref.	Mol % Li_2SO_4	Temp. range (K)	Comments
61, 59	0–100	1173–1373	see: NaI–Na_2SO_4

TABLE 180. NaCl – Li_2SO_4: Surface tension (dyn cm^{-1})

T(K)	Mol percent Li_2SO_4				
	99	90	70	50	25
1170	214	199	168	148	131
1250	210	195	165	144	127
1350	203	188	158	136	118
1370	201	187	157	134	116

Temperature-dependent equations

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

Mol % Li_2SO_4	a	$b \times 10^3$	$-c \times 10^6$	standard error of estimate
100	-73.0	523.9	230.9	0.13%
99	61.9	296.9	142.5	0.09%
98.5	241.2	10.3	30.0	0.13%
98	249.1	1.3	28.0	0.13%
97.5	-539.4	1210.6	491.9	0.65%
90	84.6	231.2	114.3	0.50%
70	98.2	160.2	85.7	0.51%
50	-50.1	374.8	175.5	0.32%
25	-12.7	290.2	143.0	0.16%
0	-40.2	295.4	143.5	0.53%

These values are based on the data of Semenchenko and Shikhobalova (maximum bubble pressure method) [59]. The results for Li_2SO_4 and NaCl are 1–2% and 2–3% higher than the recommended data bases for pure Li_2SO_4 and pure NaCl, respectively [2, 10].

NaCl – Na_2SO_4

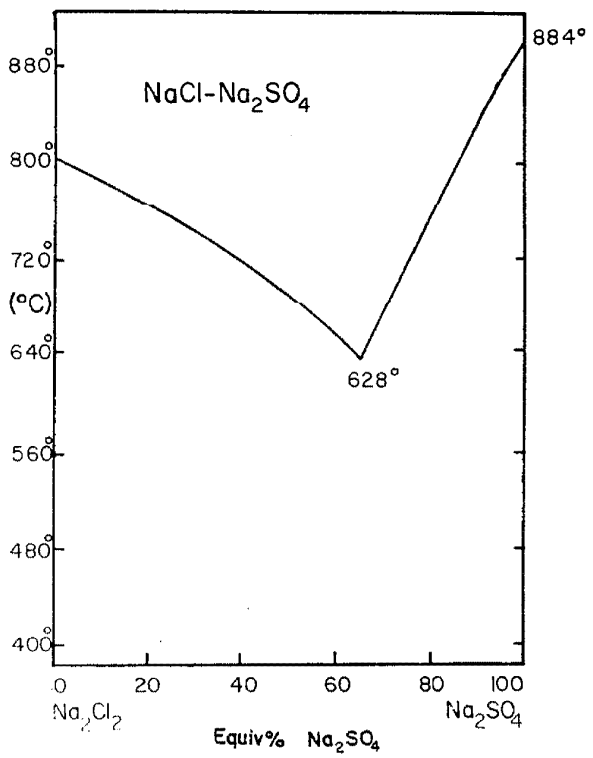

FIGURE 40. Phase diagram for NaCl – Na_2SO_4.

Data from: A. P. Palkin, Trud. Voron. Gosudar. Univ. Sbor. Rabot. Khim. Fak., 17, 3 (1950).

Melt and Preparation and Purification

Bertozzi and Soldani [60] used reagent grade salts. No other information was given. Gul'din and Buzhinskaya [63] used reagent grade salts which were recrystallized twice from distilled water. Bergman et al. [57] and semenchenko and Shikhobalova [61] used C. P. Grade salts. In [61] these were twice recrystallized.

TABLE 181. Electrical conductance studies: NaCl – Na_2SO_4

Investigations critically examined			
Ref.	Equiv. % Na_2SO_4	Temp. range (K)	Comments
63	10–90	1023, 1073	Pt electrodes. Measurements were extended to include a limited series of ternary sulfate–chloride systems see Tables 188–191

TABLE 182. $NaCl - Na_2SO_4$: Specific conductance ($ohm^{-1}cm^{-1}$)

Equiv. percent Na_2SO_4	1023 K	1073 K
84.1		3.332
74.3		3.195
65.2	2.877	
54.9	2.795	
34.6	2.395	
33.7		2.573
23.5	2.173	
12.0		2.086

The above values were interpolated from the graphical data of Gul'din and Buzhinskaya (classical ac method) [63]. The compositions in Table 182 are calculated for the system as $(NaCl)_2$–Na_2SO_4, i.e., equiv. %.

TABLE 183. Viscosity studies: $NaCl - Na_2SO_4$

Investigations critically examined

Ref.	Mol % Na_2SO_4	Temp. range (K)	Comments
57	0–100	1173	calibration: H_2O, molten salts; estimated experimental uncertainty, 2–4%

TABLE 184. $NaCl - Na_2SO_4$: Viscosity (cp)

Mol percent Na_2SO_4	1173 K
100	5.74
90	4.31
60	2.05
30	1.55
0	1.17

Composition-dependent equation

$$\eta = 1.169 + 2.943 \times 10^{-2}C - 8.586 \times 10^{-4}C^2 + 10.21 \times 10^{-6}C^3$$

[C = Mol % Na_2SO_4]

These values are based on the data of Bergman, Gasanaliev, Trunin, and Kolesnikov (oscillational method); data in graphical form; precision not estimated [57]. For Na_2SO_4, the recommended data base value for the viscosity at 1173 K is 10.75 cp [8]; for NaCl, similarly 0.85 cp [10].

TABLE 185. Surface tension studies: $NaCl - Na_2SO_4$

Investigations critically examined

Ref.	Mol % Na_2SO_4	Temp. range (K)	Comments
61	90–100	1173	see: NaI–Na_2SO_4
60	0–100	up to 1473	Pt crucible; sintered alumina metal parts

TABLE 186. $NaCl - Na_2SO_4$: Surface tension (dyn cm^{-1})

Mol percent Na_2SO_4	1173 K
100	190
99	189
98	188
97	187
96	185
90	178

Composition-dependent equation

$$\gamma = 69.65 + 1.205C$$

[C = Mol % Na_2SO_4]

standard error of estimate — 0.79%

These values are based on the data of Semenchenko and Shikhobalova (maximum bubble pressure method) [61]. For Na_2SO_4, the recommended data base value for the surface tension at 1173 K is 194.5 dyn cm^{-1} [2].

TABLE 187. $NaCl - Na_2SO_4$: Surface tension (dyn cm^{-1})

T(K)	Mol percent Na_2SO_4		
	75	50	25
980		159.2	
1000	178.4	157.8	
1025	176.7	156.1	136.6
1470	145.5	124.9	105.4

Temperature dependent equations

$$\gamma = a + bT$$

Mol percent Na_2SO_4	a	$-b \times 10^3$
100	269.0	66
75	248.4	70
50	227.8	70
25	208.3	70
0	197.3	74

These values are based on the data of Bertozzi and Soldani (Wilhelmy slide technique); data in equation form; precisions not estimated [60]. The results for 100% Na_2SO_4 and 100% NaCl (0% Na_2SO_4) differ by ±3% from the recommended data bases for pure Na_2SO_4 [2] and pure NaCl [10].

NaCl - KCl - Na_2SO_4

For investigations critically examined, see Table 181.

The molar ratios for NaCl and KCl are indicated in the composition column headings of the tables that follow. This ratio was held constant, in the ternary mixtures.

TABLE 188. $NaCl - KCl - Na_2SO_4$
Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent Na_2SO_4 in NaCl (74.8 mol %), KCl (25.2 mol %)	
	39	34
920	1.783	1.672
980	1.994	1.920
1020	2.135	2.071
1060		2.210

Temperature-dependent equations
$\kappa = a + bT + cT^2$

Mol % Na_2SO_4	$-a$	$b \times 10^3$	$-c \times 10^6$
39	1.4557	3.5200	
34	5.4327	11.0915	3.662

These values are based on the data of Gul'din and Buzhinskaya (classical ac method); data in graphical form; precision not estimated [63].

TABLE 189. $NaCl - KCl - Na_2SO_4$
Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent Na_2SO_4 in NaCl (58 mol %), KCl (42 mol %)		
	49	39	29
920	1.769	1.696	1.598
980	1.967	1.881	1.821
1020	2.099	2.016	1.969

Temperature-dependent equations
$\kappa = a + bT + cT^2$

Mol % Na_2SO_4	a	$b \times 10^3$	$c \times 10^6$
49	-1.2666	3.3000	
39	1.3355	-2.1352	2.747
29	-1.8248	3.7199	

These values are based on the data of Gul'din and Buzhinskaya (classical ac method); data in graphical form; precisions not estimated [63].

TABLE 190. $NaCl - KCl - Na_2SO_4$
Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent Na_2SO_4 in NaCl (35.3 mol %), KCl (64.7 mol %)			
	80	59	39	29
870		1.632	1.234	1.209
930	1.960	1.783	1.425	1.348
990	2.162	1.933	1.581	1.486
1010	2.208	1.983	1.625	1.532

Temperature-dependent equations
$\kappa = a + bT + cT^2$

Mol % Na_2SO_4	$-a$	$b \times 10^3$	$-c \times 10^6$
80	3.8099	29.7145	13.718
59	0.5479	2.5059	
39	5.4475	11.8900	4.839
29	0.7968	2.3059	

These values are based on the data of Gul'din and Buzhinskaya (classical ac method); data in graphical form; precisions not estimated [63].

$NaCl - Na_2SO_4 - K_2SO_4$

TABLE 191. $NaCl - Na_2SO_4 - K_2SO_4$
Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Equiv. percent NaCl in Na_2SO_4 (30 mol %), K_2SO_4 (70 mol %)		
	57	48	36
920	1.354	1.625	1.811
960	1.507	1.716	1.975
1000	1.659	1.869	2.125
1020	1.735	1.967	2.195

Temperature-dependent equations
$\kappa = a + bT + cT^2$

Equiv. % NaCl	a	$b \times 10^3$	$c \times 10^6$
57	-2.1511	3.8100	
48	16.2957	-33.4202	18.993
36	-5.3565	11.3559	-3.874

These values are based on the data of Gul'din and Buzhinskaya (classical ac method); data in graphical form; precisions not estimated [63].

$RbCl - Li_2SO_4$

Melt and Preparation and Purification

For the method of melt preparation used by Semenchenko and Shikhobalova [61], see: $RbCl-Na_2SO_4$.

TABLE 192. Surface tension studies: RbCl – Li_2SO_4

Investigations critically examined			
Ref.	Mol % Li_2SO_4	Temp. range (K)	Comments
59, 61	0–100	1173–1373	see: NaI–Na_2SO_4

TABLE 193. RbCl – Li_2SO_4: Surface tension (dyn cm^{-1})

T(K)	Mol percent Li_2SO_4				
	90	80	70	60	40
1170	179	155	140	127	106
1260	175	150	135	121	98
1320	171	147	131	117	94
1350	170	146		115	93

Temperature-dependent equations

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

Mol % Li_2SO_4	a	$b \times 10^3$	$-c \times 10^6$	standard error of estimate
100	-73.0	523.9	230.9	0.13%
99.75	151.7	153.6	86.2	0.19%
99.5	240.6	6.5	28.5	0.14%
99.25	210.2	53.6	46.6	0.01%
99	-216.2	750.2	331.2	0.07%
98.5	129.5	165.4	86.2	0.19%
98	126.3	165.4	86.2	0.33%
97	252.9	-50.0		0.14%
90	150.5	93.1	58.5	0.11%
80	402.1	-345.8	-115.4	0.26%
70	210.4	-60.0		0.00%
60	199.1	-62.0		0.35%
40	371.1	-361.9	-115.4	0.66%
0	276.2	-233.8	-58.8	0.26%

These values are based on the data of Semenchenko and Shikhobalova (maximum bubble pressure method) [59]. The results for Li_2SO_4 are ~1.5% higher than the recommended data base for pure Li_2SO_4 [2]; the values for RbCl are in exact accord with the recommended data base for pure RbCl [2].

RbCl - K_2SO_4

Melt and Preparation and Purification

For the method of melt preparation used by Semenchenko and Shikhobalova [61], see: RbCl–Na_2SO_4.

TABLE 194. Surface tension studies: RbCl – K_2SO_4

Investigations critically examined			
Ref.	Mol % K_2SO_4	Temp. range (K)	Comments
61	90–100	1348	see: NaI–Na_2SO_4

TABLE 195. RbCl – K_2SO_4: Surface tension (dyn cm^{-1})

Mol percent K_2SO_4	1348 K
100	143
99	142
98	141
97	140
96	140
95	138.8
90	135

Composition-dependent equation

$$\gamma = 59.3 + 0.837C$$

[C = Mol % K_2SO_4]

standard error of estimate = 0.58%

These values are based on the data of Semenchenko and Shikhobalova (maximum bubble pressure method) [61]. For K_2SO_4, the recommended value of the surface tension at 1348 K is 142 dyn cm^{-1} [2].

RbCl - Na_2SO_4

Melt and Preparation and Purification

Semenchenko and Shikhobalova [61] used C.P. grade salts twice recrystallized.

TABLE 196. Surface tension studies: RbCl – Na_2SO_4

Investigations critically examined			
Ref.	Mol % Na_2SO_4	Temp. range (K)	Comments
61	90–100	1323	see: NaI–Na_2SO_4

TABLE 197. RbCl – Na_2SO_4: Surface tension (dyn cm^{-1})

Mol percent Na_2SO_4	1323 K
100	178
99	176
98	175
97	173
96	171
95	170
90	161

Composition-dependent equation

$$\gamma = 6.2 + 1.72C$$

[C = Mol % Na_2SO_4]

Standard error of estimate = 1.50%

These values are based on the data of Semenchenko and Shikhobalova (maximum bubble pressure method) [61]. For Na_2SO_4, the recommended value of the surface tension is 185.8 dyn cm^{-1} [2].

RbCl - Rb_2SO_4

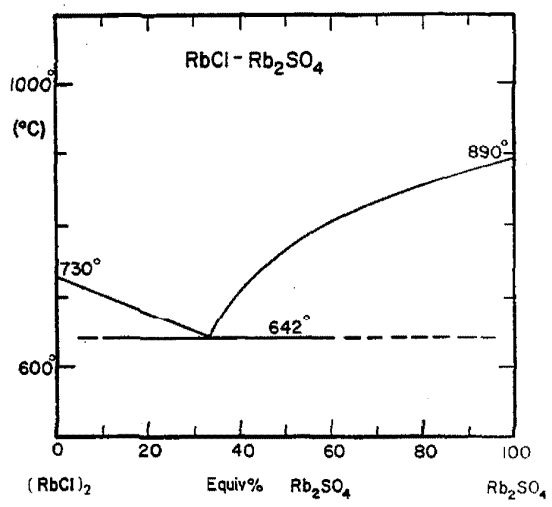

FIGURE 41. Phase diagram for RbCl - Rb_2SO_4.

Data from: O. S. Dombrovskaya, Zh. Obshch. Khim., 3(8), 1022(1933).

Melt and Preparation and Purification

Bertozzi and Soldani [60] used reagent grade salts. No other information was given.

TABLE 198. Surface tension studies: RbCl - Rb_2SO_4

Investigations critically examined			
Ref.	Mol % Rb_2SO_4	Temp. range (K)	Comments
60	50	1023-1273	Pt crucible; sintered alumina metal parts

TABLE 199. RbCl - Rb_2SO_4: Surface tension (dyn cm^{-1})

T(K)	Mol percent Rb_2SO_4
	50
1040	117.8
1100	113.6
1190	107.3
1250	103.1
1270	101.7

Temperature-dependent equation

$$\gamma = 190.6 - 0.070T$$

These values are based on the data of Bertozzi and Soldani; (Wilhelmy slide plate technique); results in equation form; precision not estimated [60].

TlCl - $ZnSO_4$

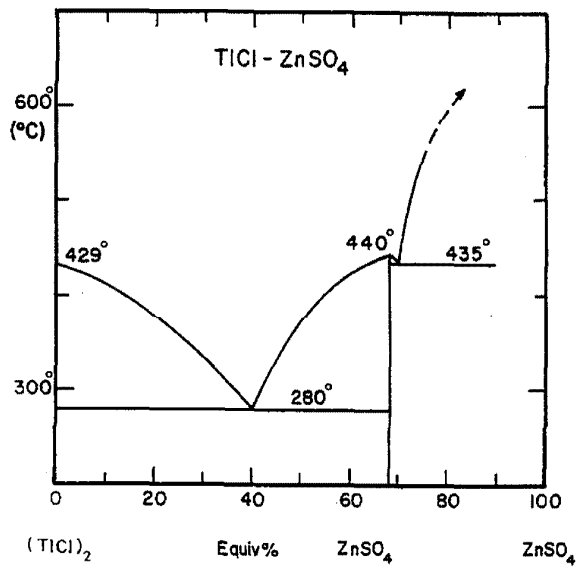

FIGURE 42. Phase diagram for TlCl - $ZnSO_4$.

Data from: N.P. Luzhnaya and I.P. Vereshchetina, Izv. Sektora Fiz. Khim. Analiza, Inst. Obshch. Neorgan. Khim., Akad. Nauk SSSR, 27, 285(1956).

Melt and Preparation and Purification

Vereshchetina and Luzhnaya [65] used reagent grade salts. No other information was given.

TABLE 200. Electrical conductance studies: TlCl - $ZnSO_4$

Investigations critically examined			
Ref.	Equiv.% $ZnSO_4$	Temp. range (K)	Comments
65	30-70	753-823	Pt electrodes

TABLE 201. TlCl - $ZnSO_4$: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Equiv. percent $ZnSO_4$				
	73	68	50	41	36
720	0.086	0.113	0.294	0.442	0.525
780	0.147	0.206	0.400	0.570	0.660
820	0.185	0.246	0.461	0.642	0.732

Temperature-dependent equations

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

Equiv. % $ZnSO_4$	$-a$	$b \times 10^3$	$-c \times 10^6$
73	1.1196	2.2687	0.826
68	4.2361	10.1780	5.747
50	2.3237	5.3645	2.401
41	2.9640	7.1266	3.328
36	3.7561	9.3489	4.727

These values are based on the data of Vereshchetina and Luzhnaya; (classical ac method); data in graphical form; precisions not estimated [65]. The compositions in Table 201 are calculated for the system as Tl_2Cl_2 - $ZnSO_4$; i.e., as equiv. %.

TABLE 202. Density studies: TlCl - $ZnSO_4$

Investigations critically examined			
Ref.	Equiv.% $ZnSO_4$	Temp. range (K)	Comments
65	50–70.7	723–773	Pt float and wire; calibration: molten KNO_3, $NaNO_3$

TABLE 203. TlCl - $ZnSO_4$: Density (g cm^{-3})

T(K)	Equiv. percent $ZnSO_4$				
	70.66	68.28	63.12	56.9	50
720		4.150	4.281	4.425	
740		4.129	4.261	4.403	
750	4.090	4.118	4.251	4.393	4.545
770	4.078	4.098	4.231	4.378	4.517

Temperature-dependent equations

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

Equiv. % $ZnSO_4$	a	$-b \times 10^3$	$c \times 10^6$	standard error of estimate
70.66	4.5411	0.6016		0.00%
68.28	4.8983	1.0398		0.01%
66.58	3.7183	-2.0478	-1.9168	0.05%
65.48	3.1417	-3.7556	-3.1251	0.02%
63.12	5.0014	1.0008		0.03%
56.90	8.3506	9.6740	5.8634	0.00%
50.00	5.6258	1.4406		0.00%

These values are based on the data of Vereshchetina and Luzhnaya (Archimedean technique) [65]. The compositions in Table 203 are calculated for the system $(TlCl)_2$-$ZnSO_4$; i.e., as equiv. %.

CsBr - $ZnSO_4$

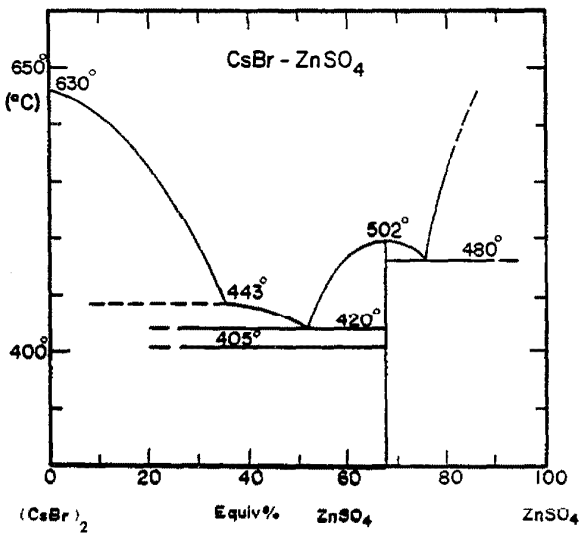

FIGURE 43. Phase diagram for CsBr - $ZnSO_4$.

Data from: N.D. Luzhnaya and I.P. Vereshchetina. Izv. Sektora Fiz. Khim. Analiza, Inst. Obshch. Neorgan. Khim. Akad. Nauk SSSR, 27, 292(1956).

Melt Preparation and Purification

Luzhnaya et al. [51] used reagent grade salts. No other information was given.

TABLE 204. Electrical conductance studies: CsBr - $ZnSO_4$

Investigations critically examined			
Ref.	Equiv. % $ZnSO_4$	Temp. range (K)	Comments
51	40–80	873–1123	Pt electrodes

TABLE 205. $CsBr - ZnSO_4$: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Equiv. percent $ZnSO_4$				
	78.5	73.0	70.0	50.0	36.0
780	0.031	0.074	0.051	0.162	0.235
800	0.040	0.084	0.063	0.181	0.259
820	0.050	0.094	0.074	0.199	0.283

Temperature-dependent equations

$$\kappa = a + bT$$

Equiv. % $ZnSO_4$	$-a$	$b \times 10^3$
78.5	0.3478	0.485
76.0	0.3081	0.440
73.0	0.3131	0.496
70.0	0.4151	0.597
65.8	0.4111	0.616
60.0	0.5960	0.885
50.0	0.5659	0.933
40.0	0.9459	1.473
36.0	0.6953	1.193

These values are based on the data of Luzhnaya, Evseeva and Vereshchetina (classical ac method); data in graphical form; precisions not estimated [51]. The compositions in Table 205 are calculated for the system $(CsBr)_2$–$ZnSO_4$; i.e., as equiv. %.

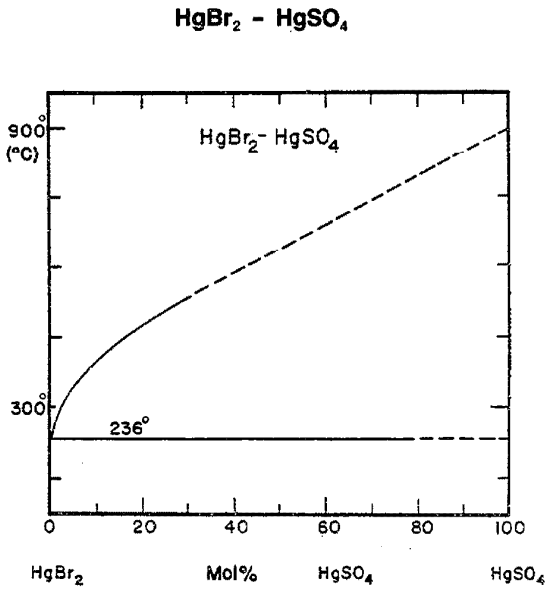

FIGURE 44. Phase diagram for $HgBr_2 - HgSO_4$.

Data from: M. Paic, Compt. Rend., **191**, 1338(1930).

Melt Preparation and Purification

Jander and Brodersen [48] purified $HgBr_2$ by sublimation. The $HgSO_4$ was reagent grade.

TABLE 206. Electrical conductance studies: $HgBr_2 - HgSO_4$

Ref.	Mol percent $HgSO_4$	Temp. Range (K)	Comments
48	dilute solution range: ($HgSO_4$ in $HgBr_2$ as solvent)	515	see: $HgBr_2$–HgO

Electrical conductance: $HgBr_2 - HgSO_4$. Jander and Brodersen [48] reported the results in units of equivalent conductance; density data were not reported and the specific conductivities, thus, cannot be calculated.

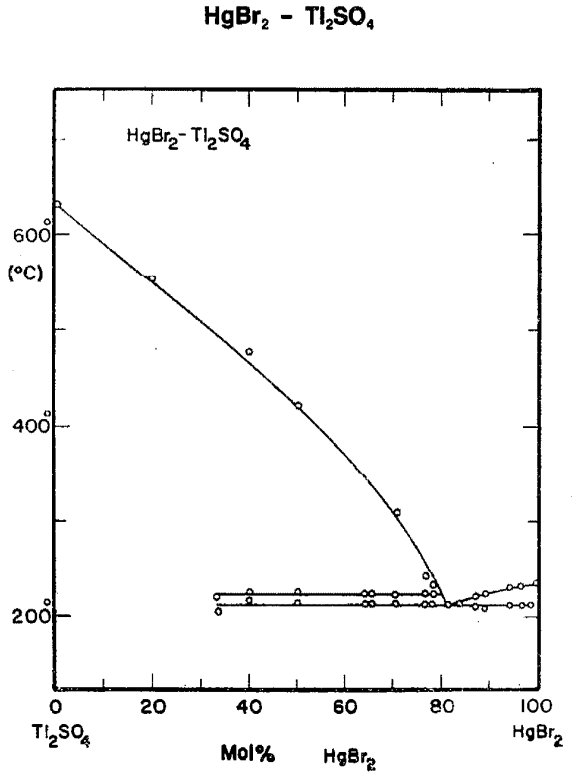

FIGURE 45. Phase diagram for $HgBr_2 - Tl_2SO_4$.

Data from: N.K. Voskresenskaya, Zh. Fiz. Khim. Obshch., **61** (1), 84(1929).

Melt Preparation and Purification

Jander and Brodersen [48] purified the $HgBr_2$ by sublimation. The Tl_2SO_4 was reagent grade.

TABLE 207. Electrical conductance studies: $HgBr_2 - Tl_2SO_4$

Ref.	Mol percent Tl_2SO_4	Temp. Range (K)	Comments
48	dilute solution range: (Tl_2SO_4 in $HgBr_2$ as solvent)	515	see: $HgBr_2$–HgO

Electrical conductance: $HgBr_2 - Tl_2SO_4$. Jander and Brodersen [48] reported the results in units of equivalent conductance; density data were not reported and the specific conductivities, thus, cannot be calculated.

KBr - Na_2SO_4

Melt Preparation and Purification

Semenchenko and Shikhobalova [34] used reagent grade materials. No other information was given.

TABLE 208. Surface tension studies: KBr - Na_2SO_4

Investigations critically examined

Ref.	Mol % Na_2SO_4	Temp. range (K)	Comments
67	50–100	1173	see: NaF–$NaNO_3$
66			isotherms; review article

TABLE 209. KBr - Na_2SO_4: Surface tension (dyn cm^{-1})

Mol percent Na_2SO_4	1173 K
100	190.8
95	180.7
75	145.3
50	112.0

Composition-dependent equation

$$\gamma = 81.60 + 0.122C + 0.97 \times 10^{-2}C^2$$

[C = Mol % NaS_2O_4]

Standard error of estimate = 2.83%

These values are based on the data of Semenchenko and Shikhobalova (maximum bubble pressure method) [67]. For Na_2SO_4, the recommended value of the surface tension at 1173 K is 194.5 dyn cm^{-1} [2].

KBr - $ZnSO_4$

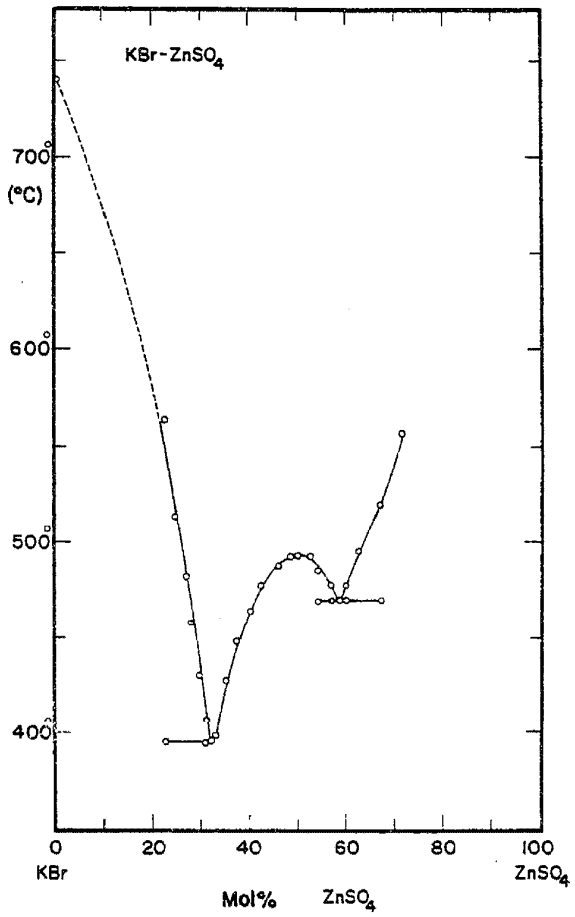

FIGURE 46. Phase diagram for KBr - $ZnSO_4$.

Data from: N.P. Luzhnaya and I.P. Vereshchetina, Izv. Sekt., Fiz. Khim. Anal. Inst. Obshch. Neorg. Khim. Akad. Nauk SSSR, **24**, 192(1954).

Melt Preparation and Purification

Vereshchetina and Luzhnaya [64, **65**] used reagent grade salts. The potassium bromide was recrystallized twice. The zinc sulfate was dehydrated and ignited carefully at 500°C. All measurements were carried out in a current of dry CO_2.

TABLE 210. Electrical conductance studies: KBr - $ZnSO_4$

Investigations critically examined

Ref.	Equiv.% $ZnSO_4$	Temp. range (K)	Comments
65	35–73	748–823	quartz or Mo cell; Pt electrodes
64	21–57		quartz or Mo cell; Pt electrodes

TABLE 211. KBr - $ZnSO_4$: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Equiv. percent $ZnSO_4$				
	54.92	50	44.9	39.56	35.09
750	0.175	0.211	0.249	0.278	0.346
770	0.207	0.243	0.287	0.320	0.403
790	0.237	0.275	0.326	0.362	0.460
820	0.281	0.324	0.383	0.424	0.545

Temperature-dependent equations

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

Equiv. % $ZnSO_4$	$-a$	$b \times 10^3$	$c \times 10^6$	standard error of estimate
72.71	-1.9033	-5.3798	3.9688	1.16%
71.62	1.2458	2.5605	-0.9777	0.65%
69.00	0.7321	1.1399		0.16%
67.64	0.7228	1.1199		0.00%
66.62	0.7514	1.1399		0.91%
65.50	3.3434	7.9709	-4.4801	1.84%
65.00	1.7275	3.6642	-1.6191	0.98%
63.90	4.8501	1.1366	-6.3567	2.62%
62.18	0.7980	1.2198		0.16%
60.00	0.7585	1.1879		0.83%
59.37	-0.0906	-1.0618	1.4900	0.90%
54.92	1.9810	4.1108	-1.6490	0.29%
50.00	1.0010	1.6158		0.10%
47.72	1.0975	1.7638		0.17%
44.90	1.1817	1.9079		0.28%
39.56	1.2844	2.0838		1.02%
35.09	1.7807	2.8358		0.28%

These values are based on the data of Luzhnaya and Vereshchetina (classical ac method)[65]. The compositions in Table 211 are calculated for the system $(KBr)_2$-$ZnSO_4$; i.e., as equiv. %.

TABLE 212. Density studies: KBr - $ZnSO_4$

Investigations critically examined

Ref.	Equiv.% $ZnSO_4$	Temp. range (K)	Comments
65	40 74	773 823	Pt float and wire, calibration: molten $NaNO_3$,KNO_3
64			see [65]
51			review article

TABLE 213. KBr - $ZnSO_4$: Density (g cm^{-3})

T(K)	Equiv. percent $ZnSO_4$				
	73.62	68.09	54.58	50.12	40
770	2.862	2.805	2.709	2.686	2.601
790	2.853	2.797	2.689	2.665	2.581
810	2.843	2.788	2.674	2.656	2.566
820	2.838	2.783	2.669	2.656	2.561

Temperature-dependent equations

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

Equiv. % $ZnSO_4$	a	$-b \times 10^5$	$c \times 10^6$	standard error of estimate
73.62	3.2322	0.4805		0.02%
68.09	3.1447	0.4406		0.12%
66.60	3.1641	0.4996		0.01%
54.58	7.1155	10.3484	6.0067	0.02%
50.12	12.1673	23.3031	14.2724	0.09%
45.52	10.4957	19.1144	11.5857	0.09%
40.00	7.0075	10.3484	6.0067	0.02%

These values are based on the data of Vereshchetina and Luzhnaya (Archimedean technique) [65]. The compositions in Table 213 are calculated for the system $(KBr)_2$-$ZnSO_4$; i.e., as equiv. %.

NaBr - K_2SO_4

Melt Preparation and Purification

Sokolova and Voskresenskaya [68] used reagent grade salts recrystallized three times from distilled water, dried at 250°C and stored in a desiccator over P_2O_5.

TABLE 214. Surface tension studies: NaBr - K_2SO_4

Investigations critically examined

Ref.	Mol % K_2SO_4	Temp. range (K)	Comments
68	0-100	1100-1350	Pt capillary
66	0-100	1123	isotherms; review article

TABLE 215. NaBr – K_2SO_4: Surface tension (dyn cm^{-1})

T(K)	Mol percent K_2SO_4				
	80	70	60	50	35
1010					107.6
1070					103.1
1100				111.4	101.2
1160				108.1	97.9
1190			110.5	106.5	96.5
1220			108.7	104.8	95.4
1250		115.0	106.7		
1280	118.3	113.7	104.5		
1340	116.4				

Temperature-dependent equations

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

Mol % K_2SO_4	a	$-b \times 10^3$	$c \times 10^6$	standard error of estimate
100	251.07	85.02		0.48%
95	215.28	63.53		0.00%
85	237.61	84.94		0.09%
80	416.20	426.10	151.04	0.17%
70	169.06	43.27		0.04%
60	0.44	-240.28	-124.23	0.39%
50	171.95	55.02		0.28%
35	298.25	296.80	106.96	0.43%
20	170.73	65.58		0.50%
0	186.89	80.91		0.74%

These values are based on the data of Sokolova and Voskresenskaya (maximum bubble pressure method) [68]. The results for 100% K_2SO_4 are 4% high compared to the recommended data base [2]; 100% NaBr (0% K_2SO_4) is in exact accord with the recommended data base [2].

KI - Na_2SO_4

Melt Preparation and Purification

Semenchenko and Shikhobalova [34] used reagent grade materials. No other information was given.

TABLE 216. Surface tension studies: KI – Na_2SO_4

Investigations critically examined			
Ref.	Mol % Na_2SO_4	Temp. range (K)	Comments
34	50–100	1173	see: NaF–$NaNO_3$

TABLE 217. KI – Na_2SO_4: Surface tension (dyn cm^{-1})

Mol percent Na_2SO_4	1173 K
100	193.8
98	186.3
95	175.7
90	160.1
75	126.4
50	101.0

Composition-dependent equation

$$\gamma = 72.69 + 1.3093C - 2.873 \times 10^{-2}C^2 + 2.775 \times 10^{-4}C^3$$

[C = Mol % Na_2SO_4]

Standard error of estimate = 1.51%

These values are based on the data of Semenchenko and Shikhobalova (maximum bubble pressure method) [34]. For Na_2SO_4, the recommended value of the surface tension at 1173 K is 194.5 dyn cm^{-1} [2].

KI - $ZnSO_4$

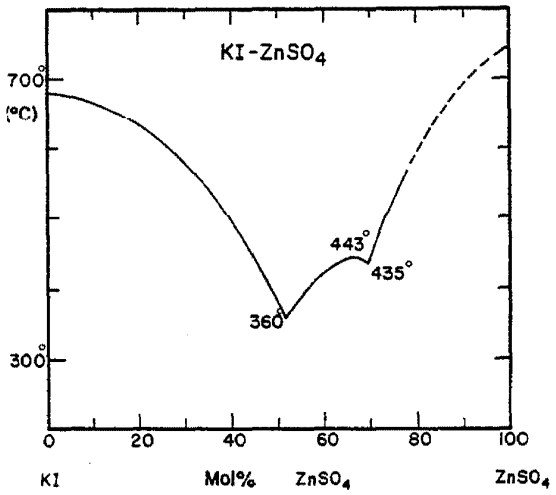

FIGURE 47. Phase diagram for KI – $ZnSO_4$.

Data from: N.P. Luzhnaya and I.P. Vereshchetina, Izv. Sekt. Fiz. Khim. Anal. Inst. Obshch., Neorg. Khim. Akad. Nauk SSSR, 24, 192(1954).

Melt Preparation and Purification

Luzhnaya and Vereshchetina [64] used either analytical grade or C.P. grade materials. The potassium iodide was recrystallized twice. The zinc sulfate was dehydrated and ignited carefully at 500°C. All measurements were made in a current of dry CO_2.

TABLE 218. Electrical conductance studies: KI – $ZnSO_4$

Investigations critically examined			
Ref.	Equiv.% $ZnSO_4$	Temp. range (K)	Comments
64	50–70	713–753	quartz or Mo cell; Pt electrodes; temperature variation less than 1%

TABLE 219. KI – $ZnSO_4$: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Equiv. percent $ZnSO_4$				
	63	60.36	57.5	54.91	50
710	0.105	0.118	0.122	0.145	0.200
730	0.129	0.145	0.151	0.173	0.235
750	0.152	0.172	0.181	0.200	0.270

Temperature-dependent equations

$\kappa = a + bT$

Equiv. % $ZnSO_4$	$-a$	$b \times 10^3$	standard error of estimate
63.00	0.7294	1.1754	1.09%
60.36	0.8411	1.3504	0.01%
57.50	0.9257	1.4755	0.56%
54.91	0.8314	1.3754	0.49%
52.58	1.0054	1.6505	0.28%
50.00	1.0430	1.7505	0.48%

These values are based on the data of Luzhnaya and Vereshchetina (classical ac method) [64]. Results were also reported for 69.65, 68, 66.53, 65.99, 65.34 and 64.07 Mol % $ZnSO_4$ but the data-sets are insufficient for temperature-dependence study. The compositions in Table 219 are calculated for the system $(KI)_2$ – $ZnSO_4$; i.e., as equiv. %.

NaI – Na_2SO_4

Melt Preparation and Purification

Semenchenko and Shikhobalova [61] used C.P. grade salts which were recrystallized twice.

TABLE 220. Surface tension studies: NaI – Na_2SO_4

Investigations critically examined			
Ref.	Mol % Na_2SO_4	Temp. range (K)	Comments
61	90–100	1173	Pt capillary; Pt crucible; estimated uncertainty, 1%; correction for immersion of capillary

TABLE 221. NaI – Na_2SO_4: Surface tension (dyn cm^{-1})

Mol percent Na_2SO_4	1173 K
100	168
99.75	167
98.00	162
95.00	154
90.00	140

Composition-dependent equation

$\gamma = -107.8 + 2.756C$

[C = Mol % Na_2SO_4]

Standard error of estimate = 0.98%

These values are based on the data of Semenchenko and Shikhobalova (maximum bubble pressure method) [61]. For Na_2SO_4, the recommended value of the surface tension at 1173 K is 194.5 dyn cm^{-1} [2].

Halide – Perchlorate

TABLE 222. Data Status

System	Phase Diagram	Electrical Conductance	Density	Viscosity	Surface Tension
LiCl–$LiClO_4$		X			
$HgBr_2$–$(CH_3)_4NClO_4$		X		X	

LiCl - $LiClO_4$

Melt Preparation and Purification

Brovkina and Sergeeva [69] dehydrated C. P. grade salts before use. The residual water was determined by Karl Fischer polarographically. The melts were analyzed for possible hydrolysis products and decomposition of $LiClO_4$.

TABLE 223. Electrical conductance studies: LiCl - $LiClO_4$

Investigations critically examined			
Ref.	Mol % $LiClO_4$	Temp. range (K)	Comments
69	80–100	533–593	Pyrex cell; Pt electrodes; calibration: molten KNO_3

Specific conductance: No data. Brovkina and Sergeeva [69] have reported specific conductance data for this system. The article, deposited at VINITI (No. 5147-72), was unavailable for inclusion in this volume.

$HgBr_2$-$(CH_3)_4NClO_4$

Melt Preparation and Purification

Jander and Brodersen [48] purified the $HgBr_2$ by sublimation. The tetramethylammonium perchlorate was reagent grade.

TABLE 224. Electrical conductance studies: $HgBr_2$-$(CH_3)_4NClO_4$

Investigations critically examined			
Ref.	Mol percent $(CH_3)_4NClO_4$	Temp. range (K)	Comments
48	dilute solution range: $(CH_3)_4NClO_4$ in $HgBr_2$ as solvent)	515	see: $HgBr_2$-HgO

Electrical Conductance: $HgBr_2$-$(CH_3)_4NClO_4$. Jander and Brodersen [48] reported the results in units of equivalent conductance; density data were not reported and the specific conductivities, thus, cannot be calculated.

TABLE 225. Viscosity studies: $HgBr_2$-$(CH_3)_4NClO_4$

Investigations critically examined			
Ref.	Mol % $(CH_3)_4NClO_4$	Temp. range (K)	Comments
48	0.02–0.52	515–548	see: $HgBr_2$-$AgNO_3$

TABLE 226. $HgBr_2$-$(CH_3)_4NClO_4$: Viscosity (cp)

T(K)	Mol percent $(CH_3)_4NClO_4$		
	0.52	0.10	0.02
520	2.05	2.13	2.14
540	1.52	1.66	1.67
550	1.43	1.61	1.63

Temperature-dependent equations

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

Mol % $(CH_3)_4NClO_4$	a	$-b \times 10^3$	$c \times 10^6$	standard error of estimate
0.52	187.606	674.81	611.48	3.56%
0.10	187.975	679.16	618.77	3.51%
0.02	194.953	705.28	643.25	3.22%

These values are based on the data of Jander and Brodersen (capillary technique) [48].

Halide - Tetrafluoroaluminate, - Tetrafluoroborate

TABLE 227. Data Status

System	Phase Diagram	Electrical Conductance	Density	Viscosity	Surface Tension
NaF-$NaAlF_4$			X		
KF-KBF_4	X	X			
NaF-$NaBF_4$	X	X	X	X	X

NaF - $NaAlF_4$

Melt Preparation and Purification

No information on melt preparation was given in the study by Vetyukov [70].

TABLE 228. Density studies: NaF - $NaAlF_4$

Investigations critically examined			
Ref.	Mol % $NaAlF_4$	Temp. range (K)	Comments
70	0–100	not given	calculated values

Density: No data; for graphical data of equivalent volume of NaF–$NaAlF_4$, see: [70].

KF - KBF_4

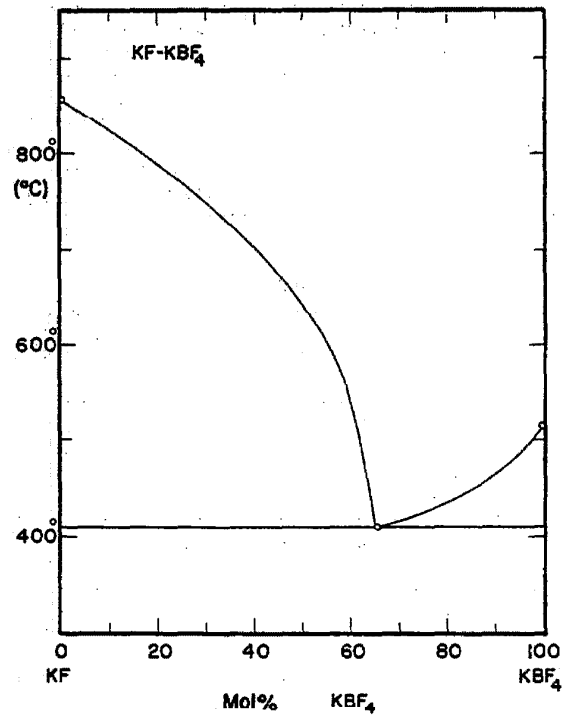

FIGURE 48. Phase diagram for KF - KBF_4.
Data from: V. G. Selivanov and V. V. Stender, Russ. J. Inorg. Chem., 4, 934 (1959).

TABLE 229. Electrical conductance studies: KF - KBF_4

Investigations critically examined			
Ref.	Mol percent KBF_4	Temp. range (K)	Comments
71	23.53–80.59	723–1073	see: NaF–$NaBF_4$
72			review article

TABLE 230. KF - KBF_4: Specific conductance (ohm $^{-1}$cm $^{-1}$)

T(K)	Mol percent KBF_4				
	81	65	41	32	17
723	0.281	0.519			
823	0.915	1.215			
923	3.601	4.209	2.255		
973	6.801	7.292	5.303	3.291	
1073	12.703	13.01	11.495	9.912	5.001

These values are based on the data of Selivanov and Stender (classical ac method) [71]. Winterhager and Werner [173] have reported data for the temperature-dependence of the conductance of KBF_4 (m.p., 803 K); viz., 818–925 K; $\kappa = -0.3011 + 1.6750 \times 10^{-3}T$ (precision limits, $\sim \pm 1.1\%$).

NaF - $NaBF_4$

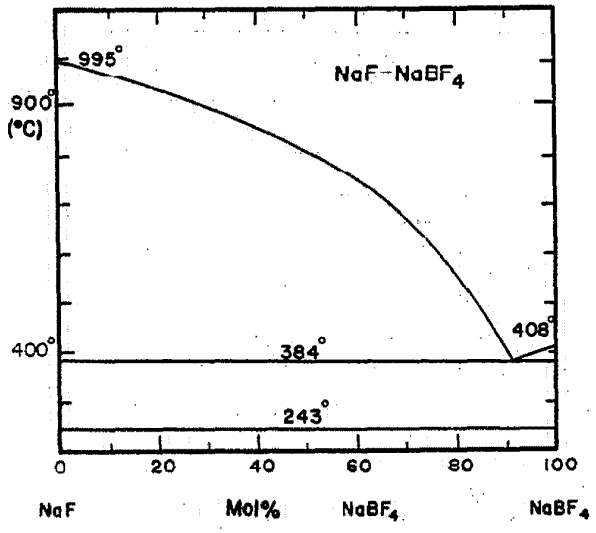

FIGURE 49. Phase diagram for NaF - $NaBF_4$.

Data from: W. R. Grimes, Nucl. Appl. Technol. 8, 137 (1970).

Melt Preparation and Purification

No information on melt preparation was given in the study by Selivanov and Stender [71].

Melt Preparation and Purification

Cantor and Gilpatrick [73] purified $NaBF_4$ by passing a mixture of BF_3, HF and helium through molten $NaBF_4$ at

425°C. The product was stored in a glass bottle after grinding. The oxygen content of the material was 200 ppm. No information on melt preparation was given in the study by Selivanov and Stender [71].

TABLE 231. Electrical conductance studies: $NaF - NaBF_4$

Investigations critically examined

Ref.	Mol percent $NaBF_4$	Temp. range (K)	Comments
74	92	658	no information
71	20.32–77.49	723–1073	Pt electrodes; calibration: borax and 62% $CaCl_2$–38% NaCl melt; graphite beaker
72			review article

TABLE 232. $NaF - NaBF_4$: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent $NaBF_4$				
	77.49	60.47	47.16	36.45	27.66
720	2.540	1.996	1.459	0.856	
880	7.139	6.773	6.194	4.498	3.200
1000	11.526	11.633	11.342	9.727	6.424
1040	13.166	13.497	13.363	11.946	9.074

Temperature–dependent equations

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

Mol % $NaBF_4$	a	$-b \times 10^3$	$c \times 10^6$	standard error of estimate
77.49	−0.4814	15.888	27.895	3.93%
60.47	4.6094	31.025	38.049	2.77%
47.16	10.2821	46.491	47.551	1.21%
36.45	31.5719	96.186	74.341	6.65%
27.66	196.0954	435.740	246.069	8.77%

These values are based on the data of Selivanov and Stender (classical ac method) [71]. Results were also reported for 20.32 mol% $NaBF_4$, but with insufficient data for accurate expression in equation form.

TABLE 233. Density studies: $NaF - NaBF_4$

Investigations critically examined

Ref.	Mol % $NaBF_4$	Temp. range (K)	Comments
73	92	673–863	calculated from molar volumes using additivity equation
76	92	727,894	review article
77			review article

TABLE 234. $NaF - NaBF_4$: Density (g cm^{-3})

T(K)	Mol percent $NaBF_4$
	92
670	1.970
730	1.927
790	1.884
850	1.842

Temperature dependent equation

$$\rho = a + bT$$

Mol % $NaBF_4$	a	$b \times 10^3$
92	2.446	−0.711

These values are based on the data of Cantor; data in equation form; precision not estimated [73].

TABLE 235. Viscosity studies: $NaF - NaBF_4$

Investigations critically examined

Ref.	Mol % $NaBF_4$	Temp. range (K)	Comments
73	92	799–906	calculated values
76	–	727,894	review article
75	92	800–900	estimated value

TABLE 236. $NaF - NaBF_4$: Viscosity (cp)

T(K)	Mol percent $NaBF_4$
	92
690	2.26
750	1.74
790	1.49
810	1.39

Temperature–dependent equation

$$\eta = A \exp [E/RT]$$

Mol % $NaBF_4$	A	E
92	0.0872	4460

These values are based on the data of Cantor; data in equation form; precision not estimated [73].

TABLE 237. Surface tension studies: $NaF - NaBF_4$

Investigations critically examined

Ref.	Mol % $NaBF_4$	Temp. range (K)	Comments
74	92	800–900	estimated uncertainty: ±30%

TABLE 238. $NaF - NaBF_4$: Surface tension ($dyn\ cm^{-1}$)

T(K)	Mol percent $NaBF_4$
	92
670	100
730	95
790	91
850	86

Temperature-dependent equation

$$\gamma = 150 - 0.075\ T$$

These values are based on the data of Cantor (maximum bubble pressure method); data in equation form; precision not estimated [74].

Halide-Hexafluoroaluminate, -Hexafluorosilicate, -Hexafluorotitanate, -Hexafluorozirconate

TABLE 239. Data Status

System	Phase Diagram	Electrical Conductance	Density	Viscosity	Surface Tension
AlF_3-Na_3AlF_6	X	X	X	X	
BaF_2-Na_3AlF_6	X		X		
BeF_2-Na_3AlF_6	X	X	X		
CaF_2-Na_3AlF_6	X	X	X	X	
KF-K_2SiF_6	X	X			
-K_2ZrF_6	X	X	X	X	X
LiF-Na_3AlF_6	X	X	X	X	
MgF_2-Na_3AlF_6	X	X	X	X	
NaF-Na_3AlF_6	X	X	X	X	
-Na_2ZrF_6			X		
$BaCl_2$-Na_3AlF_6		X	X	X	
-BaF_2-Na_3AlF_6		X			
KCl-K_2ZrF_6	X	X	X	X	X
NaCl-K_2TiF_6	X	X		X	
-K_2ZrF_6	X	X	X	X	X
-Na_3AlF_6	X	X	X	X	
-Na_2TiF_6		X	X		
-Na_2ZrF_6			X		

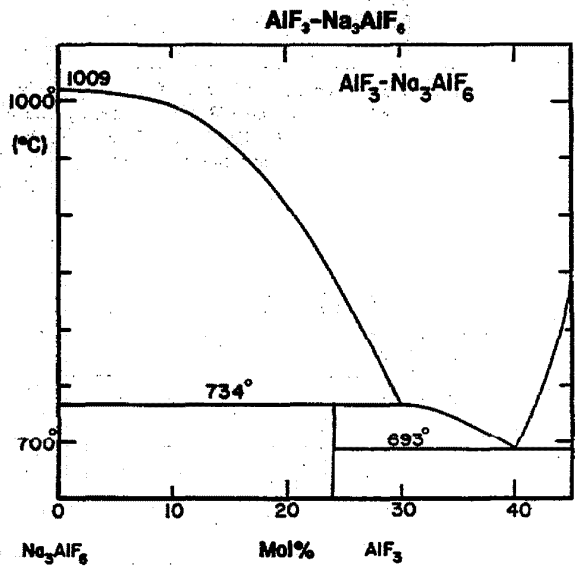

FIGURE 50. Phase diagram for AlF_3-Na_3AlF_6.

Data from: N.W.F. Phillips, R.H. Singleton, and E.A. Hollingshead, J. Electrochem. Soc., 102(12), 690(1955).

Melt Preparation and Purification

Edwards et al. [78] used distilled aluminum fluoride. The sodium fluoride was reagent grade. The materials were ignited at 600°C in a platinum crucible before weighing. Spectrographic analysis of cryolite showed only K and Li as impurities at 0.1 to 0.01%.

No information on melt preparation was given in the study by Batslavik and Belyaev [79]. Chu and Belyaev [80] used synthetic cryolite. The melting point of the cryolite was given as 1002°C . Vayna [81, 82, 83] used natural cryolite. Nishihara et al [84] obtained cryolite from the Light Metal Corporation and used commercial grade AlF_3.

TABLE 240. Electrical conductance studies: AlF_3–Na_3AlF_6

Investigations critically examined

Ref.	Mol % Na_3AlF_6	Temp. range (K)	Comments
83	69.38–100	1273	Pt crucible and electrodes; calibration: 15% NaCl aq. (18°C); frequency: 1000Hz.
85			Review article
78	82.1–100	1273	Pt electrodes; frequency range: 600–4000Hz.
72			Review article
79	70–100	1343	Pt cell
80	70–100	1273	Pt crucible and electrodes

TABLE 241. AlF_3–Na_3AlF_6: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent Na_3AlF_6	
	88.4	82.1
1270	2.672	2.595
1300	2.739	2.655
1330	2.806	2.716
1350	2.851	2.757

Temperature-dependent equations

$$\kappa = a + bT$$

Mol % Na_3AlF_6	a	$b \times 10^3$	standard error of estimate
100	-0.4680	2.5623	0.13%
88.4	-0.1692	2.2372	0.14%
82.1	0.0231	2.0248	0.06%

These values are based on the data of Edwards, Taylor, Cosgrove and Russell (classical ac method) [78]. The values for 100% Na_3AlF_6 are in exact agreement with the recommended data base [8].

TABLE 242. Density studies: AlF_3–Na_3AlF_6

Investigations critically examined

Ref.	Mol % Na_3AlF_6	Temp. range (K)	Comments
80	70–100	1273	Pt float; calibration: molten NaCl, KCl
81	70–100	1273	Pt bob and suspension wire; calibration: H_2O (20°C); graphite crucible for melting cryolite.
84	71.8–100	1303–1343	Pt bob

TABLE 243. AlF_3–Na_3AlF_6: Density (g cm^{-3})

T(K)	Mol percent Na_3AlF_6			
	91.7	84.3	76.5	71.8
1300	2.064	2.052	2.037	2.026
1320	2.046	2.034	2.019	2.007
1340	2.028	2.015	2.000	1.989

Temperature-dependent equations

$$\rho = a + bT$$

Mol % Na_3AlF_6	a	$-b \times 10^3$	standard error of estimate
100	3.3070	0.9515	0.00%
91.7	3.2349	0.9008	0.00%
84.3	3.2549	0.9253	0.01%
76.5	3.2415	0.9265	0.01%
71.8	3.2294	0.9259	0.01%

These values are based on the data of Nishihara, Matsumara, Komatsu and Noguchi (Archimedean technique) [84]. The density values calculated from the equation (above) for 100% Na_3AlF_6 are virtually in exact agreement (<0.5%) with the recommended data base [4].

TABLE 244. Viscosity studies: AlF_3–Na_3AlF_6

Investigations critically examined

Ref.	Mol % Na_3AlF_6	Temp. range (K)	Comments
84	71.8–100	1343–1373	Pt disk and crucible; temperature control, ±5°C
82	70–100	1273	graphite crucible; calibration: glycerine solutions (20°C); stainless steel rotor

TABLE 245. AlF_3–Na_3AlF_6: Viscosity (cp)

T(K)	Mol percent Na_3AlF_6			
	91.7	84.3	76.5	71.8
1300	1.25	1.23	1.20	1.16
1320	1.20	1.18	1.15	1.12
1340	1.15	1.13	1.10	1.07

Temperature-dependent equations

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

Mol % Na_3AlF_6	a	$-b \times 10^3$	$-c \times 10^6$	standard error of estimate
100	2.617	0.112	0.714	0.02%
91.7	4.215	2.066	0.164	0.68%
84.3	3.821	1.500	0.378	0.69%
76.5	3.555	1.143	0.513	0.70%
71.8	4.432	2.770	-0.196	1.11%

These values are based on the data of Nishihara, Matsamura, Komatsu and Noguchi [84]. Vayna [82] reported additional data for 78.26 Mol % Na_3AlF_6 and 69.39 Mol % Na_3AlF_6 in graphical form. For pure Na_3AlF_6, at 1300 K and 1340 K, the viscosities from the recommended data base [8] are 2.16 and 1.87 cp, respectively.

BaF_2–Na_3AlF_6

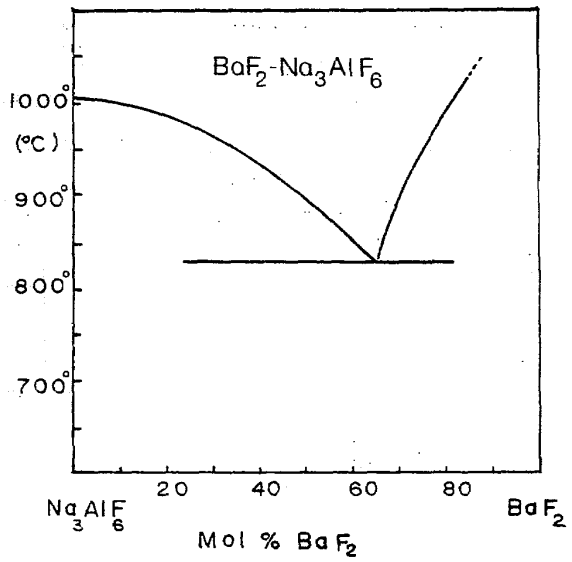

FIGURE 51. Phase diagram for BaF_2–Na_3AlF_6.

Data from: V. M. Guskov, Elekt. Rafiniro[illegible] Alyuminiya, Metall., Moscow, 1945.

Melt Preparation and Purification

Abramov and Kozunov [86] purified NaF by sublimation. All other materials were reagent grade. Kameyama and Naka [87] gave no details on melt preparation. Kuvakin and Klyakin [88] used C.P. grade NaF and Pure grade AlF_3 and BaF_2. These materials were purified by igniting with a mixture of NH_4F. The cryolite was synthesized by fusing NaF and AlF_3 in the mole ratio of 3:1.

TABLE 246. Density studies: BaF_2–Na_3AlF_6

Investigations critically examined			
Ref.	Mol % Na_3AlF_6	Temp. range (K)	Comments
86	57.2–100	1193–1450	Pt bob
87	24.9–100	1325–1395	Pt bob suspended from fine Pt wire; calibration: molten KCl

TABLE 247. BaF_2–Na_3AlF_6: Density (g cm^{-3})

T(K)	Mol percent Na_3AlF_6		
	87.1	72.9	57.2
1190	2.661		3.402
1230	2.627	3.059	3.379
1290	2.577	2.890	3.348
1390	2.493	2.898	3.306
1450	2.443		

Temperature-dependent equations

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

Mol % Na_3AlF_6	a	$-b \times 10^3$	$c \times 10^6$	standard error of estimate
100	3.3191	0.9513		0.11%
87.1	3.6575	0.8376		0.18%
72.9	35.1341	48.2619	18.0362	1.30%
57.2	4.9104	1.9390	0.5645	0.12%

These values are based on the data of Abramov and Kozunov (Archimedean technique) [86]. Kameyama and Naka [87] reported data for the additional compositions (mol % Na_3AlF_6) 75.0%, 45.6%, 33.4% and 24.9% (buoyancy method). The density values for Na_3AlF_6 are virtually in exact agreement (<0.3%) with the recommended data base [43].

BeF_2 - Na_3AlF_6

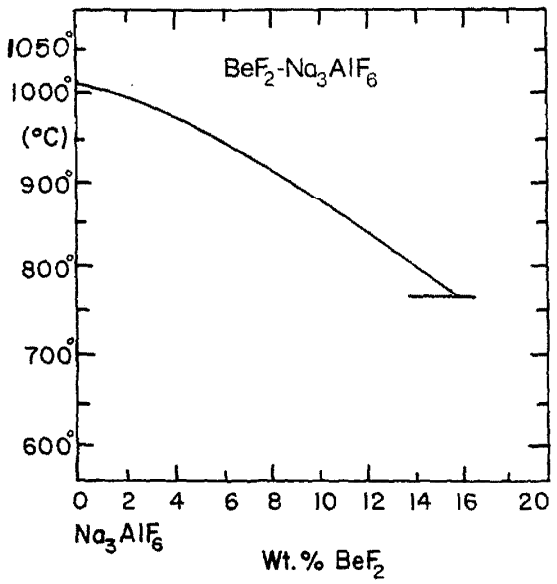

FIGURE 52. Phase diagram for BeF_2 - Na_3AlF_6.

Data from: I. A. Chu and A. I. Belyaev, Izv. Vyssh. Ucheb. Zaved., Tsvet. Metall. 2, 69 (1959).

Melt Preparation and Purification

Chu and Belyaev [80] used synthetic cryolite. The melting point of cryolite was given as 1002°C. Twenty grams of the mixture was melted in a Pt crucible. No other information was given.

TABLE 248. Electrical conductance studies: BeF_2 - Na_3AlF_6

Investigations critically examined			
Ref.	Mol % Na_3AlF_6	Temp. range (K)	Comments
80	55-100	1273	see: AlF_3-Na_3AlF_6

TABLE 249. BeF_2 - Na_3AlF_6: Specific conductance (ohm^{-1}cm^{-1})

Mol percent Na_3AlF_6	1273 K
100	2.77
80	2.52
70	2.39
60	2.26
55	2.20

Composition-dependent equation

$$\kappa = 1.495 + 1.277 \times 10^{-2}C$$

[C = Mol % Na_3AlF_6]

These values are based on the data of Chu and Belyaev (classical ac method) [80] as cited in Clark [40]; data in graphical form; precision not estimated. For Na_3AlF_6, the conductance at 1273 K from the recommended data base [8] is 2.80.

TABLE 250. Density studies: BeF_2 - Na_3AlF_6

Investigations critically examined			
Ref.	Mol % Na_3AlF_6	Temp. range (K)	Comments
80	55-100	1273	Pt bob; calibration: molten NaCl, KCl

TABLE 251. BeF_2 - Na_3AlF_6: Density (g cm^{-3})

Mol percent Na_3AlF_6	1273 K
100	2.088
95	2.085
80	2.058
60	1.982
55	1.956

Composition-dependent equation

$$\rho = 1.4759 + 1.192 \times 10^{-2}C - 0.58 \times 10^{-4}C^2$$

[C = Mol % Na_3AlF_6]

These values are based on the data of Chu and Belyaev (Archimedean technique); data in graphical form; precision not estimated [80]. For Na_3AlF_6, the recommended value of the density at 1273 K is 2.102 g cm^{-3} [4].

CaF_2 - Na_3AlF_6

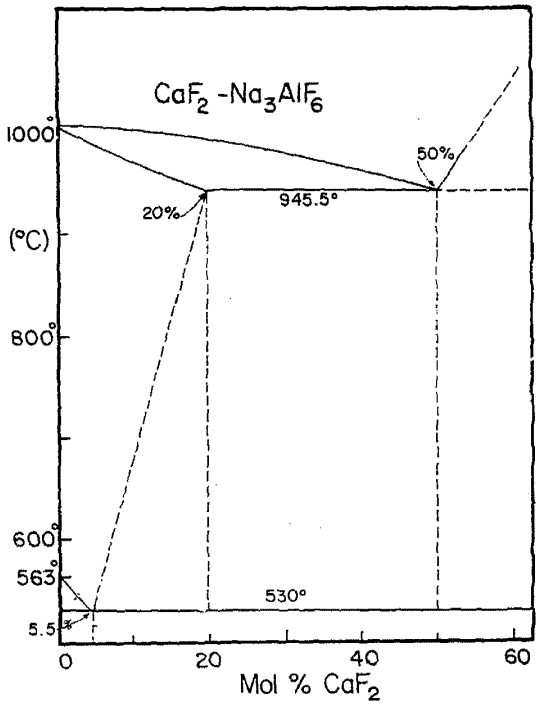

FIGURE 53. Phase diagram for CaF_2 - Na_3AlF_6.

Data from: M. Verdan and R. Monnier, Rev. Int. Hautes Temp. Refract., 9(2), 205 (1972).

Melt Preparation and Purification

Yim and Feinleib [89] used reagent grade CaF_2 and NaF. The pure salts and mixtures were fused at a temperature of about 50°C above the melting point. The melts were cooled and crushed. Analysis indicated little or no composition change. No information on melt preparation was given in the study by Pearson and Waddington [90]. Edwards et al. [78] used hand-picked crystals of pure Greenland cryolite which was then crushed to 20 mesh and any associated particles of galena were removed. Taniuchi [91] used reagent grade materials. The CaF_2 was of ultra pure quality. The salts were dried before use for more than 24 hours at 110°C. Abramov and Kozunov [86] used reagent grade materials and purified the NaF by sublimation. Votava and Matiasovsky [92, 93] used single crystal calcium fluoride and hand-picked Greenland natural cryolite. The fluorine content was determined by a pyrohydrolytic method. Before melting, the Na_3AlF_6 was calcined at 600°C for 3 hours. Vayna [81, 82, 83] used natural cryolite. Nishihara et al. [84] obtained cryolite from the Light Metal Corporation (Japan) and used commercial grade CaF_2.

TABLE 252. Electrical conductance studies: CaF_2 - Na_3AlF_6

Investigations critically examined

Ref.	Mol % Na_3AlF_6	Temp. range (K)	Comments
89	92	1243–1303	Boron nitride cell; Inconel electrodes
83	85–100	1273	see: AlF_3–Na_3AlF_6
90	25–100	1273	electrode reaction study
72			review article
78	67.7–100	1273–1353	Pt electrodes; frequency range: 600–4000 Hz.
91	45–100	1273	Pt crucible; frequency range: 1–20 Hz.
85			review article

TABLE 253. CaF_2 - Na_3AlF_6: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent Na_3AlF_6		
	87.7	77.0	67.7
1270	2.728	2.672	2.649
1300	2.809	2.754	2.730
1330	2.889	2.835	2.810
1350	2.943	2.889	2.864

Temperature-dependent equations

$$\kappa = a + bT$$

Mol % Na_3AlF_6	$-a$	$b \times 10^3$	standard error of estimate
100	0.3506	2.4747	0.06%
87.7	0.6853	2.6877	0.09%
77.0	0.7725	2.7124	0.05%
67.7	0.7643	2.6877	0.03%

These values are based on the data of Edwards, Taylor, Cosgrove and Russell (classical ac method) [78]. The conductance values for pure Na_3AlF_6 are in exact agreement with the recommended data base [8].

TABLE 254. Density studies: CaF_2 - Na_3AlF_6

Investigations critically examined

Ref.	Mol % Na_3AlF_6	Temp. range (K)	Comments
94	74.6–100	1258–1273	
81	75–100	1273	Pt bob; calibration: H_2O (20°C); correction for thermal expansion
86	53.5–87.1	1203–1448	Pt bob
95			review article
78	35.8–100	1260–1372	Pt sinker
84	80–100	1303–1343	Pt bob

TABLE 255. CaF_2 - Na_3AlF_6: Density (g cm^{-3})

T(K)	Mol percent Na_3AlF_6				
	87.6	77.0	67.8	59.8	35.8
1260	2.133	2.169		2.231	
1280	2.116	2.151	2.181	2.214	2.326
1300	2.098	2.134	2.164	2.197	2.309
1320	2.080	2.117	2.147	2.180	2.292
1340	2.062	2.099	2.129	2.163	2.275
1360			2.112	2.147	2.259

Temperature-dependent equations

$\rho = a + bT$

Mol percent Na_3AlF_6	a	$b \times 10^3$
100	3.288	0.937
87.6	3.256	0.891
77.0	3.265	0.870
67.8	3.295	0.870
59.8	3.289	0.840
35.8	3.402	0.841

These values are based on the data of Edwards, Taylor, Cosgrove and Russell (Archimedean technique); data in equation form; precisions not estimated [78]. The density values as calculated from the equation (above) for pure Na_3AlF_6 are virtually in exact accord (<0.4%) with the recommended data base [4].

TABLE 256. Viscosity studies: CaF_2 - Na_3AlF_6

Investigations critically examined

Ref.	Mol % Na_3AlF_6	Temp. range (K)	Comments
92	40-100	1273-1323	Mo torsion wire; Pt sphere
84	77-100	1303-1343	Pt disk and crucible
82	85-100	1273	see: AlF_3-Na_3AlF_6
93		1273	see: Al_2O_3-Na_3AlF_6

TABLE 257. CaF_2 - Na_3AlF_6: Viscosity (cp)

T(K)	Mol percent Na_3AlF_6		
	93.6	87.6	77.0
1300	1.31	1.34	1.36
1320	1.26	1.27	1.29
1340	1.20	1.21	1.22

Temperature-dependent equations

$\eta = a + bT$

Mol % Na_3AlF_6	a	$-b \times 10^3$	standard error of estimate
100	3.543	1.751	0.21%
93.6	4.891	2.752	0.69%
87.6	5.567	3.253	1.14%
77.0	5.912	3.503	0.90%

These values are based on the data of Nishihara, Matsumura, Komatsu and Noguchi (oscillational method) [84]. For Na_3AlF_6, at 1300 and 1340 K, the viscosities tabulated in the recommended data base [8] are 2.16 and 1.87 cp respectively.

KF - K_2SiF_6

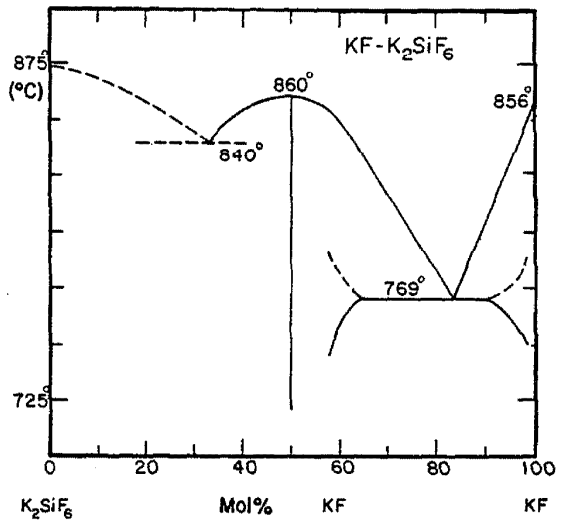

FIGURE 54. Phase diagram for KF - K_2SiF_6.

Data from: V. M. Moshnenko, Yu. K. Delimarskii, and R. V. Chernov, Russ. J. Inorg. Chem. 20(4), 595 (1975).

Melt Preparation and Purification

Delimarskii et al. [96] used chemically pure grade KF. It was recrystallized, dried and remelted before use. Pure grade K_2SiF_6 was recrystallized in a specially built apparatus and the salt was then dried at 200-300°C.

TABLE 258. Electrical conductance studies: KF - K_2SiF_6

Investigations critically examined

Ref.	Mol % K_2SiF_6	Temp. range (K)	Comments
96	52.3	1000-1100	quartz test tube cells; Pt electrodes and crucible; calibration: molten KCl; frequency range: 2-20 KHz.

TABLE 259. KF - K_2SiF_6: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent K_2SiF_6
	52.3
1100	1.48
1130	1.54
1160	1.60
1170	1.63

Temperature-dependent equation

$\kappa = -0.830 + 2.099 \times 10^{-3}T$

These values are based on the data of Delimarskii, Golov and Chernov (classical ac method); data in graphical form; precision not estimated [96].

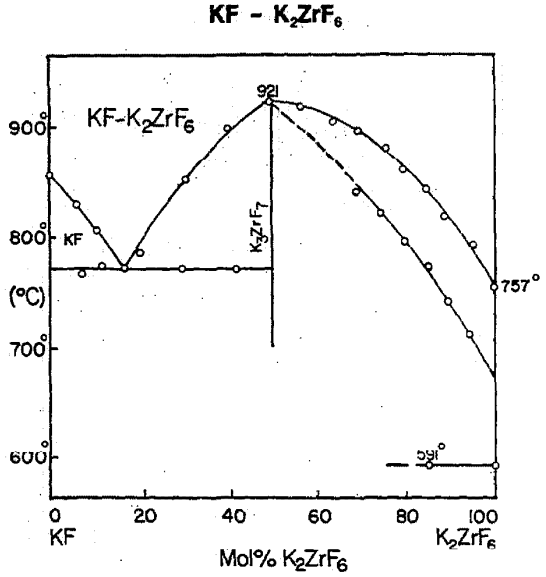

FIGURE 55. Phase diagram for KF - K_2ZrF_6.

Data from: I. N. Sheiko, R. V. Chernov and V. S. Kikhno, Ukr. Khim. Zhur. 27, 469 (1961).

Melt Preparation and Purification

Sheiko et al. [97, 98] used reagent grade KF. The K_2ZrF_6 contained a small amount of hafnium. The salt was recrystallized twice and dried under vacuum at 150°C

TABLE 260. Electrical conductance studies: KF - K_2ZrF_6

Investigations critically examined

Ref.	Mol % K_2ZrF_6	Temp. range (K)	Comments
97	0–100	1233	Pt electrodes

TABLE 261. KF - K_2ZrF_6: Specific conductance ($ohm^{-1}cm^{-1}$)

Mol percent K_2ZrF_6	1233 K
100	2.558
90	2.692
70	3.090
50	3.662
30	4.409
10	5.331
0	5.857

Composition-dependent equation

$$\kappa = 5.8571 - 5.481 \times 10^{-2}C + 2.182 \times 10^{-4}C^2$$

[C = Mol % K_2ZrF_6]

Standard error of estimate = 1.59%

These values are based on the data of Sheiko (classical ac method) [97]. For KF (0% K_2ZrF_6), the recommended value of the conductance at 1233 K is 4.836 ohm^{-1} cm^{-1} respectively.

TABLE 262. Density studies: KF - K_2ZrF_6

Investigations critically examined

Ref.	Mol % K_2ZrF_6	Temp. range (K)	Comments
97	0–100	1233	Pt sphere

TABLE 263. KF - K_2ZrF_6: Density (g cm^{-3})

Mol percent K_2ZrF_6	1233 K	1173 K
100	2.185	2.235
70	2.187	2.250
50	2.141	2.203
30	2.055	2.109
0	1.855	1.833

Composition-dependent equations

$$\rho = a + bC + cC^2$$

[C = Mol % K_2ZrF_6]

T(K)	a	$b \times 10^2$	$-c \times 10^4$	standard error of estimate
1233	1.8545	0.814	0.484	1.53%
1173	1.8830	0.927	0.575	1.80%

These values are based on the data of Sheiko [97] and Sheiko, Bandur and Grechina [99] (Archimedean method). For KF (0% K_2ZrF_6), at 1173 K and 1233 K, the densities from the recommended data base [1] are, respectively, 1.882 and 1.843.

TABLE 264. Viscosity studies: KF - K_2ZrF_6

Investigations critically examined

Ref.	Mol % K_2ZrF_6	Temp. range (K)	Comments
97	0–100	1253	Pt sphere

TABLE 265. KF - K_2ZrF_6: Viscosity (cp)

Mol percent K_2ZrF_6	1253 K
100	2.264
70	2.206
50	2.095
30	1.927
0	1.566

Composition-dependent equation

$$\eta = 1.5659 + 0.01419C - 0.7214 \times 10^{-4}C^2$$

[C = Mol % K_2ZrF_6]

Standard error of estimate = 1.31%

These values are based on the data of Sheiko (oscillational method) [97].

TABLE 266. Surface tension studies: KF - K_2ZrF_6

Investigations critically examined

Ref.	Mol % K_2ZrF_6	Temp. range (K)	Comments
97	0–100	1233	Ar atmosphere

TABLE 267. KF - K_2ZrF_6: Surface tension (dyn cm^{-1})

Mol percent K_2ZrF_6	1233 K
100	95.2
70	102.2
50	112.6
30	124.1
0	136.3

Composition-dependent equation

$$\gamma = 136.3 - 0.2136C - 0.8420 \times 10^{-2}C^2 + 0.6447 \times 10^{-4}C^3$$

[C = Mol % K_2ZrF_6]

Standard error of estimate = 2.01%

These values are based on the data of Sheiko (maximum bubble pressure method) [97]. For KF (0% K_2ZrF_6), the recommended data base value of the surface tension at 1233 K is 135.1 dyn cm^{-1} [2].

LiF - Na_3AlF_6

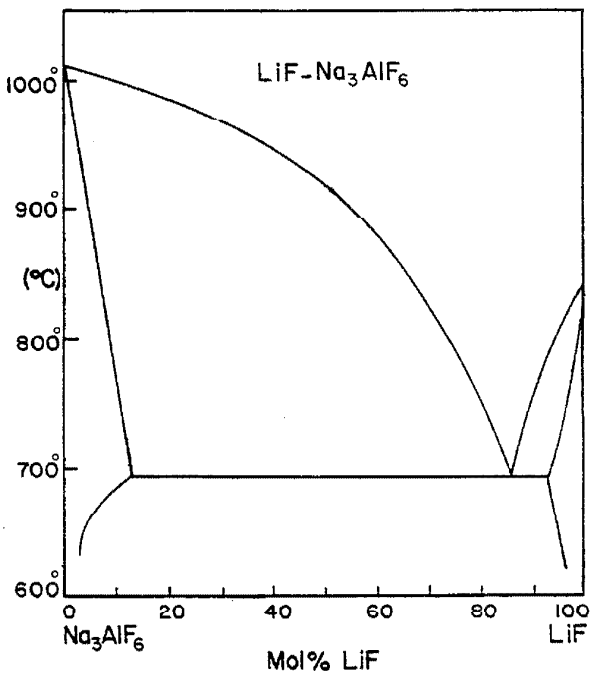

FIGURE 56. Phase diagram for LiF - Na_3AlF_6.

Data from: P. A. Foster, Jr., "The Phase Diagram of the Na_3AlF_6 - LiF System", Unpublished data, AlCOA, Pa. (1968); cited in "Applications of Phase Diagrams in Metallurgy and Ceramics" 2 Vols. (G. C. Carter, ed.) NBS Sp. Publ. 496, March 1978, Washington, D. C.

Melt Preparation and Purification

Matiasovsky et al. [100, 93, **92**, **101**] used hand-picked Greenland cryolite with a melting point of 1006°C±20°C. Reagent grade LiF was used. For the method of melt preparation used by Chu and Belyaev [80], see: BeF_2-Na_3AlF_6.

TABLE 268. Electrical conductance studies: LiF - Na_3AlF_6

Investigations critically examined

Ref.	Mol % Na_3AlF_6	Temp. range (K)	Comments
102			review article
101, 100, 103	0–100	1073–1323	Pt disk electrodes and Pt crucible; calibration: molten Na_3AlF_6; experimental uncertainty ~±2%
80	0–15	1273	Pt electrodes and crucible; calibration molten Na_3AlF_6

TABLE 269. LiF - Na_3AlF_6: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent Na_3AlF_6				
	75.0	43.8	25.0	18.2	7.7
1070			3.19		
1130			3.44	4.05	5.75
1220		3.10	3.81	4.35	6.09
1280	3.01	3.26	4.06	4.55	6.32
1310	3.07	3.34	4.18	4.65	6.43
1370	3.19	3.51			

Temperature-dependent equations

$$\kappa = a + bT$$

Mol percent Na_3AlF_6	a	$b \times 10^3$
100	-0.375	2.50
75	0.454	2.00
57.2	0.579	2.00
43.8	-0.193	2.70
33.3	-2.536	5.00
25.0	-1.239	4.14
18.2	0.323	3.30
12.5	0.879	3.50
7.7	1.452	3.80
3.6	5.722	1.20
0	6.184	2.00

These values are based on the data of Danek, Malinovsky and Matiasovsky (classical ac method) [**101**]; as cited in Clark; data in graphical form; precisions not estimated [40]. The conductance values for Na_3AlF_6 calculated from the equations (above) are virtually in exact agreement (<1.0%) with the recommended data base [8]; for LiF (0% Na_3AlF_6), the values are 1-5% low compared with the recommended data base [1].

TABLE 270. Density studies: LiF – Na_3AlF_6

Investigations critically examined			
Ref.	Mol % Na_3AlF_6	Temp. range (K)	Comments
80	85–100	1273	Pt sinker; calibration: molten NaCl, KCl
104	0–100	1223–1423	Pt sinker

TABLE 271. LiF – Na_3AlF_6: Density (g cm^{-3})

T(K)	Mol percent Na_3AlF_6			
	80	60	40	20
1220	2.139	2.117	2.088	2.026
1250	2.113	2.093	2.073	2.005
1300	2.071	2.053	2.028	1.969
1320	2.054	2.036	2.013	1.995

Temperature-dependent equations

$$\rho = a + bT$$

Mol % Na_3AlF_6	a	$-b \times 10^3$	standard error of estimate
100	3.2732	0.9199	0.00%
80	3.1758	0.8502	0.05%
60	3.0951	0.8020	0.00%
40	2.9929	0.7421	0.00%
30	2.9439	0.7201	0.00%
20	2.8927	0.7102	0.01%
10	2.6020	0.5540	0.00%
0	2.3289	0.4681	0.00%

These values are based on the data of Matiasovsky (method not cited) (private communication) [**104**]. The density values for Na_3AlF_6 and LiF (0% Na_3AlF_6) as calculated from the equations (above) are in exact agreement with the recommended data bases for pure Na_3AlF_6 [4] and pure LiF [1].

TABLE 272. Viscosity studies: LiF – Na_3AlF_6

Investigations critically examined			
Ref.	Mol % Na_3AlF_6	Temp. range (K)	Comments
105			review article
92, 93	0–46.1	1173–1323	Mo torsion wire; Pt sphere

TABLE 273. LiF – Na_3AlF_6: Viscosity (cp)

T(K)	Mol percent Na_3AlF_6			
	46.1	24.3	12.5	5.1
1180	2.10	1.78	1.75	1.89
1200	1.88	1.56	1.60	1.76
1300	1.09	0.89	0.97	1.22
1320	1.01	0.84	0.87	1.13

Temperature-dependent equations

$$\eta = a + bT + cT^2 + dT^3$$

Mol % Na_3AlF_6	a	$-b \times 10^3$	$-c \times 10^6$	$d \times 10^9$
46.1	31.626	18.936	21.44	13.80
24.3	33.064	19.207	25.13	16.05
12.5	13.837	6.307	9.00	4.80
5.1	12.552	5.670	7.83	4.22
0	24.610	32.984	-11.74	

These values are based on the data of Votava and Matiasovsky (oscillational method); data in graphical form; precisions not estimated [**92**].

MgF_2 – Na_3AlF_6

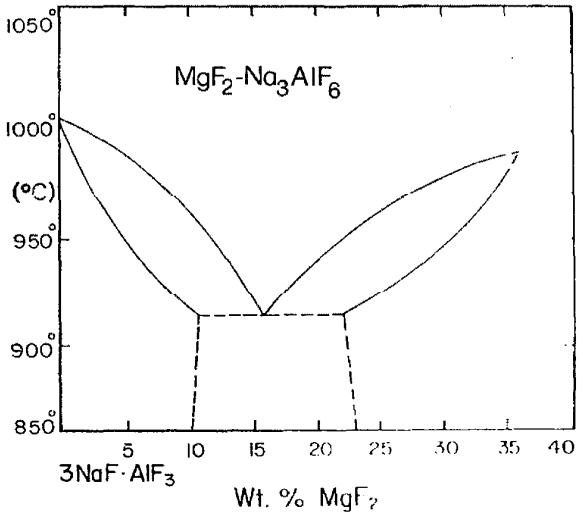

FIGURE 57. Phase diagram for MgF_2 – Na_3AlF_6.

Data from: A. M. Romanovski and Ya. K. Berent, Legkie Metal., **6**, 34 (1935).; E. Batslavik and A. I. Belyaev, Zhur. Neorg. Khim., **3**, 1045 (1958).

Melt Preparation and Purification

No information on melt preparation was given in the study by Batslavik and Belyaev [79]. Abramov et al. [**106**] fused reagent grade MgF_2 for one hour at at 1000–1100°C before use. Votava and Matiasovsky [**92, 93**] used hand picked Greenland natural cryolite and determined the fluorine content by a pyrohydrolytic method. Single crystal MgF_2 was used.

TABLE 274. Electrical conductance studies: MgF_2 - Na_3AlF_6

Investigations critically examined

Ref.	Mol % Na_3AlF_6	Temp. range (K)	Comments
79	85-100 (wt %)	1353	Pt cell
72			review article
106	5.92-100	1273-1423	Pt electrodes and crucible; calibration: molten Na_3AlF_6

TABLE 275. MgF_2 - Na_3AlF_6: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent Na_3AlF_6			
	94.0	62.7	50.6	5.9
1270	2.47	2.37	2.31	2.15
1310	2.54	2.44	2.38	2.23
1350	2.61	2.51	2.45	2.31
1390	2.68	2.58	2.52	2.40
1410	2.72	2.61	2.56	2.44

Temperature-dependent equations

$$\kappa = a + bT$$

Mol % Na_3AlF_6	a	$b \times 10^3$	standard error of estimate
100	0.434	1.643	0.11%
94.0	0.218	1.771	0.12%
62.7	0.172	1.729	0.12%
50.6	0.021	1.800	0.11%
5.9	0.446	2.044	0.13%

These values are based on the data of Abramov, Kostyukov and Narolviki (classical ac method) [**106**]. The density values for Na_3AlF_6 as calculated from the equations (above) are ~10% low compared to the recommended data base [8].

TABLE 276. Density studies: MgF_2 - Na_3AlF_6

Investigations critically examined

Ref.	Mol % Na_3AlF_6	Temp. range (K)	Comments
79	74-100	1273	Pt float

TABLE 277. MgF_2 - Na_3AlF_6: Density (g cm^{-3})

Mol percent Na_3AlF_6	1273 K
100	2.10
90	2.11
85	2.12
80	2.13
75	2.14

Composition-dependent equation

$$\rho = 2.270 - 0.174 \times 10^{-2}C$$

[C = Mol % Na_3AlF_6]

These values are based on the data of Batslavik and Belyaev (Archimedean technique); data in graphical form; precisions not estimated [**79**]. The density value for Na_3AlF_6 at 1273 K from the recommended data base [4] is 2.10 g cm^{-3}.

TABLE 278. Viscosity studies: MgF_2 - Na_3AlF_6

Investigations critically examined

Ref.	Mol % Na_3AlF_6	Temp. range (K)	Comments
92	75-100 (wt %)	1273-1323	Mo torsion wire; Pt sphere
93		1273	see: Al_2O_3-Na_3AlF_6

TABLE 279. MgF_2 - Na_3AlF_6: Viscosity (cp)

Mol percent Na_3AlF_6	1273 K	1323 K
100	2.79	2.34
90	2.82	2.33
80	3.00	2.47
70	3.35	2.75
60	3.87	3.17
50	4.55	3.74

Composition-dependent equation

$$\eta = a + bC + cC^2$$

[C = Mol % Na_3AlF_6]

T(K)	a	$-b \times 10^2$	$c \times 10^4$
1273	10.394	15.786	8.185
1323	8.752	13.623	7.209

These values are based on the data of Votava and Matiasovsky (oscillational method); data in graphical form; precisions not estimated [**92**]. For Na_3AlF_6 the viscosities from the recommended data base [8] are, respectively, 2.39 and 1.99 g cm^{-3} at 1273 K.

NaF - Na_3AlF_6

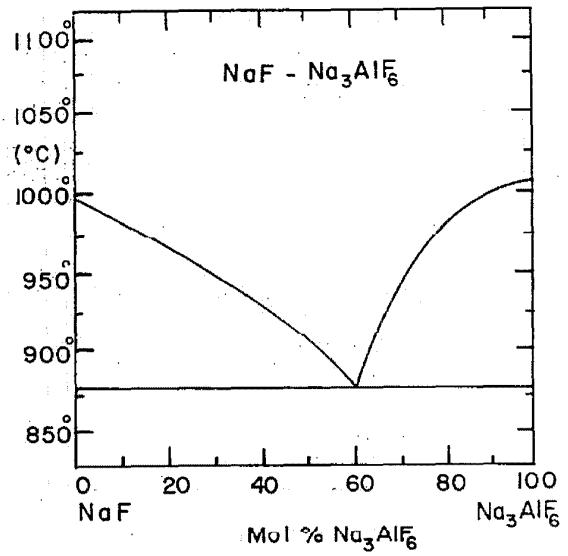

FIGURE 58. Phase diagram for NaF - Na_3AlF_6.

Data from: N.W.F. Phillips, R.H. Singleton, and E.A. Hollingshead, J. Electrochem. Soc., **102**, 690 (1955); M. Rolin and M. Ray, Bull. Soc. Chim. Fr. P. 2785 (1966).

TABLE 281. NaF - Na_3AlF_6: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent Na_3AlF_6		
	64.3	50.0	23.1
1270	3.115	3.181	3.845
1300	3.195	3.263	3.950
1340	3.300	3.373	4.090
1350	3.326	3.400	4.125

Temperature-dependent equations

$$\kappa = a + bT$$

Mol % Na_3AlF_6	$-a$	$b \times 10^3$	standard error of estimate
100	0.3506	2.4747	0.06%
64.3	0.2343	2.6376	0.10%
50.0	0.2953	2.7374	0.04%
23.1	0.5997	3.4998	0.04%
0	1.4021	5.4376	0.09%

These values are based on the data of Edwards, Taylor, Cosgrove and Russell (classical ac method) [78]. The conductance values for Na_3AlF_6 as calculated from the equations (above) are in exact agreement with the recommended data base [8]; for NaF (0% Na_3AlF_6), the values are 10–15% high compared to the recommended data base [1].

Melt Preparation and Purification

Edwards et al. [78] used hand-picked crystals of pure Greenland cryolite which was crushed to 20 mesh. Any associated particles of galena were removed. Reagent grade NaF was employed in this study. No information on melt preparation was given in the study by Pearson and Waddington [90]. Vayna [81, **82**, 83] used natural cryolite.

TABLE 280. Electrical conductance studies: NaF - Na_3AlF_6

Investigations critically examined

Ref.	Mol % Na_3AlF_6	Temp. range (K)	Comments
83	85–100	1273	Pt electrodes and crucible; calibration: 15% NaCl (18°C); frequency: 1000 Hz; temp. control ±5°C
72			review article
78	0–100	1273–1353	Pt electrodes and crucible; frequency range: 600–4000 Hz
85			review article

TABLE 282. Density studies: NaF - Na_3AlF_6

Investigations critically examined

Ref.	Mol % Na_3AlF_6	Temp. range (K)	Comments
81	85–100	1273	see: CaF_2–Na_3AlF_6
78	0–100	1220–1353	Pt sinker
90	0–100	1273–1373	electrode reaction study

TABLE 283. NaF - Na_3AlF_6: Density (g cm^{-3})

T(K)	Mol percent Na_3AlF_6				
	79	64	53	44	23
1220					2.119
1260			2.118	2.116	2.088
1280	2.095	2.097	2.100	2.098	2.072
1340	2.038	2.042	2.046	2.044	2.024

Temperature-dependent equations

$\rho = a + bT$

Mol percent Na_3AlF_6	a	$-b \times 10^3$
100	3.288	0.937
79	3.311	0.950
64	3.275	0.920
53	3.265	0.910
44	3.263	0.910
23	3.083	0.790
0	2.733	0.610

These values are based on the data of Edwards, Taylor, Cosgrove and Russell (Archimedean technique); data in equation form; precisions not estimated [78]. The density values for Na_3AlF_6 and NaF (0% Na_3AlF_6) as calculated from the equations (above) are virtually in exact agreement with the recommended data bases for pure Na_3AlF_6 [8] and pure NaF [4].

TABLE 284. Viscosity studies: NaF - Na_3AlF_6

Investigations critically examined

Ref.	Mol % Na_3AlF_6	Temp. range (K)	Comments
82	85-100	1273	see: AlF_3-Na_3AlF_6

TABLE 285. NaF - Na_3AlF_6: Viscosity (cp)

T(K)	Mol percent Na_3AlF_6	
	90	85
1240		5.60
1250	6.27	5.36
1270	6.00	4.90
1290	5.72	4.43
1300		4.20

Temperature-dependent equations

$\eta = a + bT$

Mol percent Na_3AlF_6	a	$-b \times 10^3$
90	23.459	13.75
85	34.576	23.37

These values are based on the data of Vayna (torsional method); data in graphical form; precisions not estimated [82].

NaF - Na_2ZrF_6

Melt Preparation and Purification

Sheiko et al. [107] used analytical grade NaF, after drying and remelting. The sodium fluorozirconate was prepared by an exchange reaction between K_2ZrF_6 and NaCl. The product was washed with water to remove chlorides, dried in vacuum at 150°C and then fused.

TABLE 286. Density studies: NaF - Na_2ZrF_6

Investigations critically examined

Ref.	Mol % Na_2ZrF_6	Temp. range (K)	Comments
107	0-80	1023-1273	Pt bob and beaker; pure Ar atmosphere

TABLE 287. NaF - Na_2ZrF_6: Density (g cm^{-3})

T(K)	Mol percent Na_2ZrF_6			
	80	60	40	20
1070	2.649	2.669	2.657	2.568
1130	2.597	2.615	2.603	2.520
1210	2.528	2.544	2.530	2.457
1270	2.477	2.491	2.475	2.410

Temperature-dependent equations

$\rho = a + bT$

Mol percent Na_2ZrF_6	a	$-b \times 10^3$
80	3.569	0.86
60	3.621	0.89
40	3.631	0.91
20	3.413	0.79
0	2.645	0.56

These values are based on the data of Sheiko (Archimedean technique); data in equation form; precisions not estimated [107]. The density values from the equations (above) for NaF (0% Na_2ZrF_6) are virtually in exact agreement with the recommended data base [4] for pure NaF; i.e., <0.7%.

$BaCl_2$ - Na_3AlF_6

Melt Preparation and Purification

Matiasovsky and Danek [108] used hand-picked natural Greenland cryolite (m.p. 1006±1°C). The fluorine content was determined by a pyrohydrolitic method. Barium chloride was reagent grade and was dehydrated by vacuum calcination at 200°C for 2 hours. Abramov [109] used reagent grade material. No other information was provided. Zuca et al. [110] used reagent grade $BaCl_2$ and NaF. The cryolite was prepared by

fusing the reagent grade NaF and AlF_3, which were previously dried at 400°C. The $BaCl_2$ was recrystallized from distilled water, dried for 24 hours at 150°C and melted before mixing, while dry HCl or Ar was bubbled through the melt. For the method of melt preparation used by Kuvakin and Klyakin [88] see: BaF_2–Na_3AlF_6. The $BaCl_2$ was ignited with NH_4Cl and purified by fusion.

TABLE 288. Electrical conductance studies: $BaCl_2$ - Na_3AlF_6

Investigations critically examined			
Ref.	Mol % Na_3AlF_6	Temp. range (K)	Comments
88	0–100	1273–1373	Pt beaker; Pt wire electrodes; calibration: molten NaCl, KCl, NaF
108	0–100	1223–1393	Pt disk electrodes and crucible; calibration: molten cryolite; experimental uncertainty estimated as ±2%.

TABLE 289. $BaCl_2$ - Na_3AlF_6: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent Na_3AlF_6				
	98.0	89.9	79.9	59.8	39.8
1220					1.983
1240			2.267		2.053
1260	2.670	2.469	2.315	2.221	2.123
1320	2.842	2.563	2.459	2.401	2.334
1340	2.899	2.594	2.507		
1360	2.956		2.555		
1380	3.013		2.603		

Temperature-dependent equations

$\kappa = a + bT$

Mol % Na_3AlF_6	a	$b \times 10^3$	standard error of estimate
100	-0.3776	2.5000	0.30%
98.0	-0.9377	2.8631	0.26%
95.0	1.2920	1.0478	0.29%
89.9	0.4867	1.3729	0.17%
79.9	-0.7008	2.3937	0.65%
59.8	-1.5534	2.9966	0.34%
39.8	-2.3047	3.5143	1.12%
0	-1.8827	3.1820	1.24%

These values are based on the data of Matiasovsky and Danek (classical ac method) [108]. For cryolite, the results in [108] are virtually in exact agreement [i.e., ~0.3%] with the recommended cryolite conductivity data base [4,8]. The results for $BaCl_2$ (0% Na_3AlF_6) are ~30% higher than the recommented data set [1].

TABLE 290. Density studies: $BaCl_2$ - Na_3AlF_6

Investigations critically examined			
Ref.	Mol % Na_3AlF_6	Temp. range (K)	Comments
109	25–75	1053–1393	hollow Pt float

TABLE 291. $BaCl_2$ - Na_3AlF_6: Density (g cm^{-3})

T(K)	Mol percent Na_3AlF_6		
	75	50	25
1050		2.588	
1140		2.506	2.813
1200	2.284	2.452	2.764
1320	2.175	2.343	2.667
1380	2.121	2.289	2.618

Temperature-dependent equations

$\rho = a + bT$

Mol % Na_3AlF_6	a	$-b \times 10^3$	standard error of estimate
75	3.3688	0.9043	0.07%
50	3.5384	0.9053	0.16%
25	3.7392	0.8124	0.12%

These values are based on the data of Abramov (Archimedean technique) [109]. Zuca et al. [110] reported data for the above system (40 mol % Na_3AlF_6) with NaCl (2–8 mol%) and LiF (1–7 mol%) added as solutes. At 1000°C, the values for the densities [109], and in the recommended data set are, respectively: $BaCl_2$, 3.146 [109]; 3.148 [1]; Na_3AlF_6, 2.054 [109]; 2.099 [4].

TABLE 292. Viscosity studies: $BaCl_2$ - Na_3AlF_6

Investigations critically examined			
Ref.	Mol % Na_3AlF_6	Temp. range (K)	Comments
110	40	1326–1421	estimated accuracy ±3%; measurements made in heating and cooling

TABLE 293. $BaCl_2$ - Na_3AlF_6: Viscosity (cp)

T(K)	Mol percent Na_3AlF_6
	40
1050	4.25
1080	3.62
1100	3.27
1130	2.83

Temperature-dependent equation

$\eta = 0.01360 \exp(11985/RT)$

These values are based on the data of Zuca, Costin and Olteanu (oscillational method); data in equation form; precisions not estimated [110]. Results are also reported for the effect of added NaCl (2–8 mol%) and added LiF (3–7 mol%).

$BaCl_2$ - BaF_2 - Na_3AlF_6

Melt Preparation and Purification

For the method of melt preparation used by Kuvakin and Klyakin [88] see: BaF_2 - Na_3Alf_6 and $BaCl_2$ - Na_3AlF_6. In all of the compositions in the ternary system, the ratio of $BaCl_2$ to BaF_2 was held as an equimolar ratio.

TABLE 294. Electrical conductance studies: $BaCl_2$ - BaF_2 - Na_3AlF_6

Investigations critically examined

Ref.	Mol % Na_3AlF_6	Temp. range (K)	Comments
88	0-100	1273-1373	$BaCl_2/BaF_2$ ratio was fixed at equimolar over the whole composition range

TABLE 295. $BaCl_2$ - BaF_2 - Na_3AlF_6: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent Na_3AlF_6			
	80	60	40	20
1270	2.633	2.491	2.166	1.861
1280	2.669	2.530	2.205	1.899
1290	2.705	2.569	2.245	1.936
1300	2.741	2.608	2.284	1.973
1310	2.778	2.647	2.324	2.011
1320	2.814	2.686	2.363	2.048
1330	2.850	2.725	2.403	2.085
1340	2.886	2.764	2.442	2.123
1350	2.992	2.803	2.481	2.160
1360	2.959	2.842	2.521	2.197
1370	2.995	2.881	2.560	2.234

Temperature-dependent equations

$$\kappa = a + bT$$

Mol percent Na_3AlF_6	$-a$	$b \times 10^3$
100	1.9204	3.6903
80	1.9657	3.6207
60	2.4580	3.8967
40	2.8472	3.9471
20	2.8766	3.7314
0	3.4466	3.8462

These values are based on the data of Kuvakin and Klyakin (classical ac method); data in equation form; precisions not estimated [88]. For Na_3AlF_6, the values in [88] are ~1% higher than the recommended Na_3AlF_6 conductance data [4,8].

KCl - K_2ZrF_6

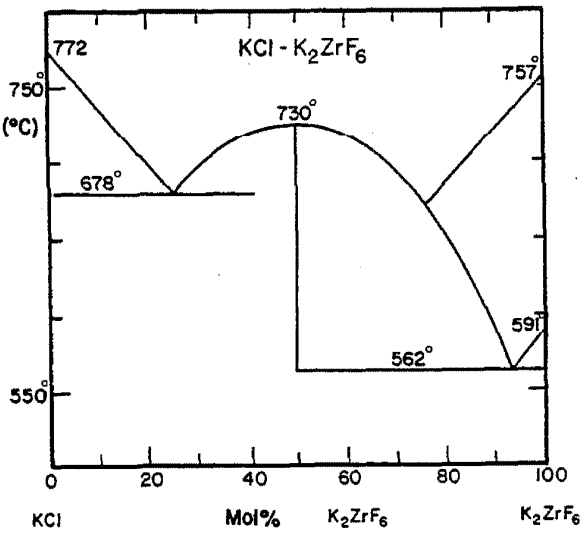

FIGURE 59. Phase diagram for KCl - K_2ZrF_6.

Data from: I. N. Sheiko, R. V. Chernov, and V. S. Kikhno, Ukrain. Khim. Zhur. 27, 469(1961).

Melt Preparation and Purification

Kurmaev [111] recrystallized K_2ZrF_6 twice from distilled water and dried it at 150°C. Sheiko [97] used analytical grade materials. The K_2ZrF_6 contained a small amount of hafnium and was recrystallized twice from distilled water.

TABLE 296. Electrical conductance studies: KCl - K_2ZrF_6

Investigations critically examined

Ref.	Mol % K_2ZrF_6	Temp. range (K)	Comments
97	0-100	1173	Pt electrodes

TABLE 297. KCl – K_2ZrF_6: Specific conductance ($ohm^{-1}cm^{-1}$)

Mol percent K_2ZrF_6	1173 K
100	2.29
90	2.32
70	2.37
50	2.40
30	2.42
10	2.41
0	2.40

Composition-dependent equation

$\kappa = 2.400 + 0.125 \times 10^{-2}C - 0.24 \times 10^{-4}C^2$

[C = Mol % K_2ZrF_6]

Standard error of estimate = 1.27%

These values are based on the data of Sheiko (classical ac method) [97]. The recommended data base value of the conductance of KCl at 1173 K is 2.466 ohm^{-1} cm^{-1} [1]. Results for K_2ZrF_6 (100%) have not been reported prior to [97].

TABLE 298. Density studies: KCl – K_2ZrF_6

Investigations critically examined

Ref.	Mol % K_2ZrF_6	Temp. range (K)	Comments
97	0–100	1073	
99	0–100	1173	Pt sphere

TABLE 299. KCl – K_2ZrF_6: Density (g cm^{-3})

Mol percent K_2ZrF_6	1173 K	1073 K
100	2.250	2.425
90	2.238	2.347
60	2.113	2.111
30	1.853	1.876
10	1.606	1.719
0	1.460	1.640

Composition-dependent equations

$\rho = a + bC + cC^2$

[C = Mol % K_2ZrF_6]

T(K)	a	$b \times 10^2$	$-c \times 10^4$	standard error of estimate
1173	1.4604	1.533	0.743	0.89%
1073	1.6401	0.785		3.44%

These values are based on the data of Sheiko (Archimedean technique) [97] and Sheiko, Bandu and Grechina (Archimedean technique) [99]. The recommended values of the density for KCl at 1073 and 1173 K are, respectively, 1.451 and 1.510 ohm^{-1} cm^{-1} [1]. Results for the density of K_2ZrF_6 (100%) have not been reported prior to [97,99].

TABLE 300. Viscosity studies: KCl – K_2ZrF_6

Investigations critically examined

Ref.	Mol percent K_2ZrF_6	Temp. range (K)	Comments
112	0–100	1073–1173	Pt sphere
111	56.94–100	1073–1173	no information
97	0–100	1073–1173	Pt sphere

TABLE 301. KCl – K_2ZrF_6: Viscosity (cp)

T(K)	Mol percent K_2ZrF_6				
	90	70	50	30	10
1070	3.00	2.85	2.62	2.09	1.69
1100	2.80	2.62	2.36	1.88	1.40
1150	2.47	2.25	1.98	1.59	1.17
1170	2.33	2.11	1.86	1.50	1.17

Temperature-dependent equations

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

Mol % K_2ZrF_6	a	$-b \times 10^3$	$c \times 10^6$	standard error of estimate
100	2.561	6.8183	-5.929	0.00%
90	9.050	4.6991	-0.8909	0.09%
80	8.150	3.0906	1.696	0.02%
70	15.480	15.855	3.808	0.15%
60	33.566	48.5505	18.451	0.39%
50	33.408	48.117	18.080	0.38%
40	26.623	37.209	13.580	0.37%
30	27.179	40.576	15.480	0.41%
20	4.005	14.746	8.701	0.09%
10	86.953	147.80	63.658	1.90%
0	18.056	26.644	10.254	0.43%

These values are based on the data of Sheiko (oscillational method) [97]. The viscosities for KCl (0% K_2ZrF_6) in [97], above, are high by comparison with the recommended KCl data set [1], i.e., 1070 K, ~2%; 1170 K, 12%. A recent re-investigation of the viscosity of KCl by Brockner, Torklep and Oye [238] has shown that the recommended data set [1] is uniformly 7% too high in this temperature range. Results for the viscosity of K_2ZrF_6 (100%) have not been reported prior to [97].

TABLE 302. Surface tension studies: KCl – K_2ZrF_6

Investigations critically examined

Ref.	Mol % K_2ZrF_6	Temp. range (K)	Comments
97	0–100	1073–1173	Ar atmosphere

TABLE 303. KCl - K_2ZrF_6: Surface tension (dyn cm^{-1})

T(K)	Mol percent K_2ZrF_6				
	90	70	50	30	10
1070	104.9	103.4	100.9	99.4	97.9
1100	102.5	100.9	98.3	96.9	95.3
1150	98.4	96.8	94.1	92.7	91.1
1170	96.7	95.2	92.5	91.0	89.5

Temperature–dependent equations

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

Mol % K_2ZrF_6	a	$-b \times 10^3$	$c \times 10^6$	standard error of estimate
100	193.01	81.00		0.03%
90	147.44	1.42	-35.87	0.01%
80	193.00	83.01		0.03%
70	191.11	82.01		0.00%
60	190.76	83.00		0.03%
50	190.76	84.01		0.00%
40	188.87	83.01		0.03%
30	189.25	84.00		0.00%
20	271.73	232.37	56.78	0.06%
10	259.26	211.56	56.78	0.04%
0	212.95	139.86	28.87	0.02%

These values are based on the data of Sheiko (maximum bubble pressure method) [97].

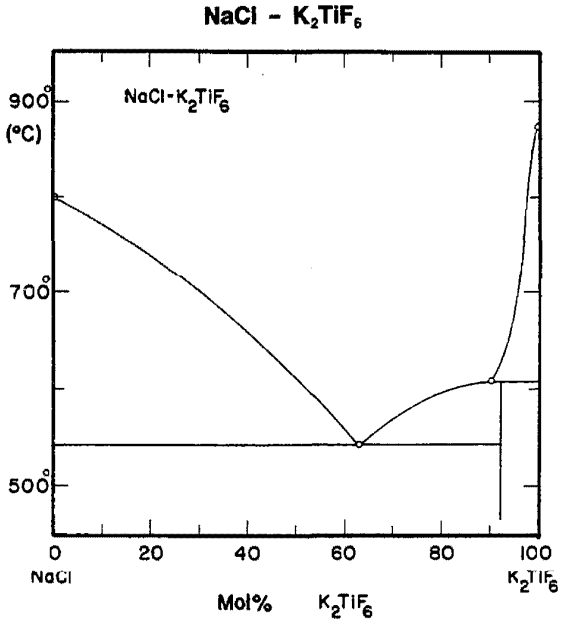

FIGURE 60. Phase diagram for NaCl - K_2TiF_6.
Data from: K. Aoya, K. Hasegawa, and Y. Miyazawa, Denki Kagaku, 27, 117(1959).

Melt Preparation and Purification

No information is available on melt preparation and purification in reference [113], or in experimental references cited therein.

TABLE 304. Electrical conductance studies: NaCl - K_2TiF_6

Investigations critically examined

Ref.	Mol % K_2TiF_6	Temp. range (K)	Comments
113	2–100	853–1173	Pt crucible and electrodes; calibration: molten NaCl, $NaNO_3$; frequency: 10,000Hz; estimated experimental uncertainty 1.5–2%

TABLE 305. NaCl - K_2TiF_6: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent K_2TiF_6			
	82.2	57.8	36.2	19.6
820			2.10	
850		1.52	2.23	
880	1.27	1.67	2.35	
910	1.61	1.82	2.45	2.91
1000	2.41	2.20	2.71	3.00
1170	2.96	2.67	2.94	3.17

Temperature dependent equations

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

Mol % K_2TiF_6	a	$b \times 10^3$	$c \times 10^6$	standard error of estimate
100	-9.7339	11.241		4.62%
82.2	-26.2135	50.309	-21.685	9.89%
68.7	-15.643	30.219	-12.356	9.69%
57.8	-7.057	14.796	-5.5413	6.32%
49.3	0.358	1.9296		3.01%
42.2	0.3918	2.0598		3.25%
36.2	-5.6627	14.403	-6.026	3.79%
31.1	-0.05587	2.8157		5.35%
26.8	-0.3165	3.0768		7.63%
19.6	1.9689	1.0294		4.17%
14.0	1.6993	1.6065		0.98%
9.5	1.4578	1.8523		0.83%
5.7	0.9254	2.3541		0.84%
2.6	-0.5458	3.720		0.75%

These values are based on the data of Kolomitskii and Ponomarev (classical ac method) [113]. Measurements were not extended to NaCl (0% K_2TiF_6) but calibration of the conductance cell with molten NaCl was reported; the accuracy limits thus were $\sim \pm 1.5\%$; results for K_2TiF_6 (100%) have not been reported prior to [113].

TABLE 306. Viscosity studies: NaCl - K_2TiF_6

Investigations critically examined

Ref.	Mol % K_2TiF_6	Temp. range (K)	Comments
113	27–100	823–1173	no information

TABLE 307. $NaCl - K_2TiF_6$: Viscosity (cp)

T(K)	Mol percent K_2TiF_6		
	69	49	27
850			4.76
940	6.31	4.48	3.37
1000	5.27	3.63	2.70
1120	3.39	2.39	1.97
1170	2.68	2.05	1.90

Temperature-dependent equations

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

Mol % K_2TiF_6	a	$-b \times 10^3$	$c \times 10^6$	standard error of estimate
100	*	*	*	19.5%
69	31.617	35.853	9.505	2.34%
49	37.166	54.226	20.694	3.05%
27	40.398	65.900	28.205	7.61%

These values are based on the data of Kolomitskii and Ponomarev [113]. For K_2TiF_6 (100%) the temperature-dependence is best expressed by an exponential fit, $\eta = 1.891 \times 10^{-5} \exp(27826/RT)$. Measurements were not extended to NaCl (0% K_2TiF_6). Results for K_2TiF_6 have not been reported prior to [113].

NaCl - K_2ZrF_6

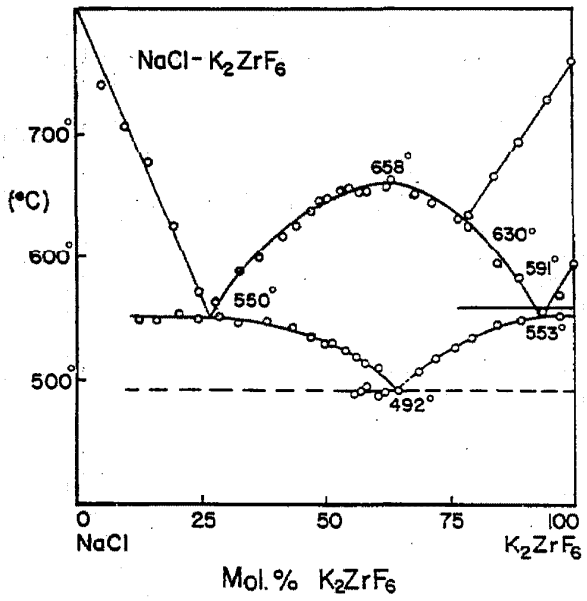

FIGURE 61. Phase diagram for $NaCl - K_2ZrF_6$.

Data from: I. N. Sheiko, R. V. Chernov, and V. S. Kikhno, Ukr. Khim. Zhur. 27, 469(1961).

Melt Preparation and Purification

Sheiko [97] used reagent grade materials. The K_2ZrF_6 contained a small amount of hafnium. The salt was recrystallized twice and dried under vacuum at 150°C.

TABLE 308. Electrical conductance studies: $NaCl - K_2ZrF_6$

Investigations critically examined

Ref.	Mol % K_2ZrF_6	Temp. range (K)	Comments
97	0–100	1173	Pt electrodes

TABLE 309. $NaCl - K_2ZrF_6$: Specific conductance ($ohm^{-1}cm^{-1}$)

Mol percent K_2ZrF_6	1173 K
100	2.38
90	2.38
70	2.47
50	2.68
30	3.02
10	3.47
0	3.75

Composition-dependent equation

$$\kappa = 3.748 - 2.898 \times 10^{-2}C + 1.53 \times 10^{-4}C^2$$

[C = Mol % K_2ZrF_6]

Standard error of estimate = 1.89%

These values are based on the data of Sheiko (classical ac method) [97]. At 1173 K, the recommended data base value of the conductance of NaCl (0% K_2ZrF_6) is 3.84 ohm^{-1} cm^{-1} [1,10]. Comparison of the result for K_2ZrF_6 (0% NaCl) with the value in Table 297, shows about the same accuracy limits (~±3%).

TABLE 310. Density studies: $NaCl - K_2ZrF_6$

Investigations critically examined

Ref.	Mol % K_2ZrF_6	Temp. range (K)	Comments
97	0–100	1173	Pt sinker

TABLE 311. $NaCl - K_2ZrF_6$: Density ($g\ cm^{-3}$)

Mol percent K_2ZrF_6	1173 K
100	2.238
90	2.243
70	2.205
50	2.098
30	1.924
10	1.682
0	1.535

Composition-dependent equation

$$\rho = 1.5354 + 1.551 \times 10^{-2}C - 0.85 \times 10^{-4}C^2$$

[C = Mol % K_2ZrF_6]

Standard error of estimate = 1.28%

These values are based on the data of Sheiko (Archimedean technique) [97]. From the recommended data set for NaCl [1,10] the density of NaCl at 1173 K is 1.503. For K_2ZrF_6 (0% NaCl), comparison of the result (above) with that in Table 299, shows that the reproducibility was ~0.5%.

TABLE 312. Viscosity studies: NaCl – K_2ZrF_6

Investigations critically examined			
Ref.	Mol % K_2ZrF_6	Temp. range (K)	Comments
97	0–100	1073–1173	Pt sphere

TABLE 313. NaCl – K_2ZrF_6: Viscosity (cp)

T(K)	Mol percent K_2ZrF_6				
	90	70	50	30	10
1070	3.01	2.92	2.72	2.33	1.80
1100	2.88	2.73	2.50	2.19	1.68
1150	2.55	2.37	2.16	1.92	1.49
1170	2.38	2.21	2.03	1.80	1.41

Temperature-dependent equations

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

Mol % K_2ZrF_6	a	$b \times 10^3$	$c \times 10^6$	standard error of estimate
100	-3.635	17.872	-10.849	0.06%
90	-27.740	60.785	-29.952	0.29%
80	-23.601	54.134	-27.393	0.26%
70	3.056	17.119	-10.782	0.06%
60	21.667	-26.908	8.728	0.23%
50	18.053	-21.186	6.404	0.21%
40	-59.619	116.215	-54.360	0.73%
30	-2.758	13.999	-8.636	0.06%
20	-19.423	42.678	-21.091	0.33%
10	9.836	-10.786	3.065	0.14%
0	20.193	28.631	10.520	0.39%

These values are based on the data of Sheiko (oscillational method) [97]. For K_2ZrF_6 (0% NaCl) the results above check with the values from the same study but for the system KCl–K_2ZrF_6 (see: Table 301). Comparison of NaCl (0% K_2ZrF_6) with the recommended NaCl viscosity data set [10], shows that the results (above) are uniformly ~15–20% too high.

TABLE 314. Surface tension studies: NaCl – K_2ZrF_6

Investigations critically examined			
Ref.	Mol % K_2ZrF_6	Temp. range (K)	Comments
97	0–100	1123–1223	Ar atmosphere

TABLE 315. NaCl – K_2ZrF_6: Surface tension (dyn cm^{-1})

T(K)	Mol percent K_2ZrF_6				
	90	70	50	30	10
1120	103.5	105.1	107.3	108.9	110.9
1150	100.9	102.4	104.8	106.3	108.3
1200	96.5	98.0	100.5	102.0	104.1
1220	94.8	96.2	98.8	100.2	102.4

Temperature-dependent equations

$$\gamma = a + bT$$

Mol % K_2ZrF_6	a	$-b \times 10^3$	standard error of estimate
100	191.9	80.0	0.00%
90	200.9	87.0	0.03%
80	200.67	86.01	0.06%
70	204.75	89.0	0.03%
60	202.26	86.0	0.06%
50	202.56	85.01	0.03%
40	203.26	85.0	0.03%
30	206.37	87.0	0.08%
20	204.16	84.01	0.00%
10	206.06	85.0	0.03%
0	191.50	72.0	0.00%

These values are based on the data of Sheiko (maximum bubble pressure method) [97]. For NaCl (0% K_2ZrF_6), the results (above) check with the recommented data set [2,10] to ~±0.3%. The results for K_2ZrF_6 (0% NaCl) are in exact agreement with the values for the system KCl–K_2ZrF_6 (see: Table 303); both are from the same study [97].

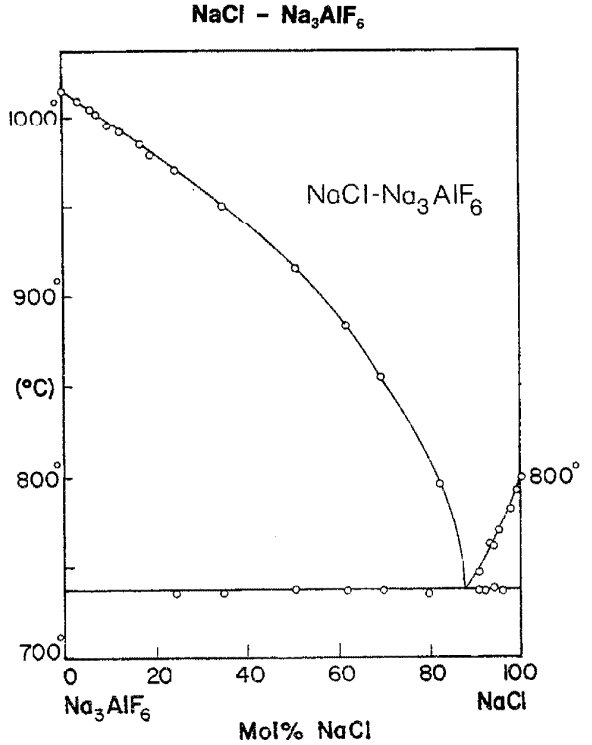

FIGURE 62. Phase diagram for NaCl – Na_3AlF_6.

Data from: J. L. Holm, Dr. techn. Thesis, The University of Trondheim, NTH, Trondheim, 1971.

Melt Preparation and Purification

Matiasovsky et al. [114, 108, 93, 92] used hand-picked natural Greenland cryolite (m.p, 1006±1°C). The fluoride content was determined by a pyrohydrolytic method. The NaCl used was reagent grade. Kuvakin and Kusakin [115] prepared cryolite by remelting NaF and AlF_3. The molar ratio was checked by X-ray analysis and by a hot titration method. The AlF_3 was purified by sublimation of the technical product. The NaCl was C. P. grade and was recrystallized twice.

TABLE 316. Electrical conductance studies: NaCl - Na_3AlF_6

Investigations critically examined

Ref.	Mol % Na_3AlF_6	Temp. range (K)	Comments
105	0–100	1273	calculated data
102			estimation equations
115	0–100	1073–1323	Pt vessel and platinized Pt electrodes; frequency: 4000–4500 Hz; calibration: 0.1*N* KCl (18°C); correction for expansion of Pt
108, 114	0–100	1183–1373	Pt disk electrodes and crucible; calibration: molten cryolite; estimated uncertainty, ±2%

TABLE 317. NaCl - Na_3AlF_6: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent Na_3AlF_6			
	84.2	52.6	21.8	2.9
1180				3.80
1200			3.06	3.83
1240		2.87	3.13	3.89
1280	2.88	2.96	3.20	3.94
1320	2.98	3.06	3.28	4.00
1340	3.02	3.11		
1360	3.07			

Temperature-dependent equations

$$\kappa = a + bT$$

Mol % Na_3AlF_6	a	$b \times 10^3$	standard error of estimate
100	-0.378	2.500	0.30%
84.2	-0.115	2.341	0.26%
71.5	-0.320	2.534	0.32%
61.2	-0.125	2.411	0.24%
52.6	-0.134	2.419	0.29%
39.4	0.094	2.263	0.34%
29.5	0.543	1.976	0.23%
21.8	0.956	1.757	0.22%
15.8	1.485	1.438	0.23%
10.7	1.675	1.456	0.23%
6.5	1.662	1.613	0.31%
2.9	2.114	1.430	0.14%
0	1.424	2.129	0.35%

These values are based on the data of Matiasovsky and Danek (classical ac method) [108]. For Na_3AlF_6 (0% NaCl) the results above are in exact accord with the recommended data set for cryolite [4,8]; NaCl (0% Na_3AlF_6) with the recommended data set [10], shows that results (above) are uniformly 2.5% too high.

TABLE 318. Density studies: NaCl - Na_3AlF_6

Investigations critically examined

Ref.	Mol % Na_3AlF_6	Temp. range (K)	Comments
114	50–100	1273	Pt–Rh sinker

TABLE 319. NaCl - Na_3AlF_6: Density (g cm^{-3})

Mol percent Na_3AlF_6	1273 K
100	2.10
90	2.05
70	1.96
50	1.90

Composition-dependent equation

$$\rho = 1.874 - 0.141 \times 10^{-2}C + 0.37 \times 10^{-4}C^2$$

[C = Mol % Na_3AlF_6]

These values are based on the data of Matiasovsky and Malinovsky (Archimedean technique); data in graphical form; precisions not estimated [114]. The value for Na_3AlF_6 (0% NaCl) is in exact accord with the recommended density data set for molten cyrolite [4].

TABLE 320. Viscosity studies: NaCl - Na_3AlF_6

Investigations critically examined

Ref.	Mol % Na_3AlF_6	Temp. range (K)	Comments
105	0-100	1273	calculated values
92	3-70	1123-1323	Mo torsion wire, Pt sphere
93	0-100	1273	see: Al_2O_3-Na_3AlF_6

TABLE 321. NaCl - Na_3AlF_6: Viscosity (cp)

T(K)	Mol percent Na_3AlF_6			
	71.5	39.4	21.8	6.5
1120				1.75
1180		2.08	1.46	1.28
1240	2.63	1.88	1.32	0.95
1300	2.12	1.54	1.13	0.74

Temperature-dependent equations

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

Mol % Na_3AlF_6	a	$b \times 10^3$	$c \times 10^6$
71.5	-77.996	135.23	-56.62
52.7	25.366	-30.84	9.87
39.4	-22.766	44.24	-19.65
29.5	-0.403	7.03	-4.41
21.8	-3.293	10.19	-5.22
15.7	-6.758	16.21	-7.91
10.7	69.271	-105.81	40.87
6.5	34.009	-48.76	17.82
3.0	24.490	-34.92	12.78

These values are based on the data of Votava and Matiasovsky (oscillational method); data in graphical form; precisions not estimated [92]. For NaCl, inspection of the limited graphical results in [92], shows that the values are high relative to the recommended NaCl data set [10], i.e., @ 1123 K, ~35%, @ 1173 K, ~15%. Similarly, the viscosity data for Na_3AlF_6 (0% NaCl) are about 20% high relative to the recommended Na_3AlF_6 data set [4]. For a discussion of probable error sources, see [10].

NaCl - Na_2TiF_6

Melt Preparation and Purification

Milov et al. [116] used reagent grade materials. No other information was given.

TABLE 322. Electrical conductance studies: NaCl - Na_2TiF_6

Investigations critically examined

Ref.	Mol percent Na_2TiF_6	Temp. range (K)	Comments
116	3.03-100	973-1173	Pt electrodes; frequency: 10,000Hz

TABLE 323. NaCl - Na_2TiF_6: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent Na_2TiF_6				
	71.67	52.93	39.62	29.67	10.75
1000	1.59	1.93	2.13	2.55	
1020	1.63	1.99	2.19	2.65	3.37
1100	1.80	2.24	2.44	3.03	3.82
1120	1.84	2.30	2.50		3.93
1140	1.89				

Temperature-dependent equations

$$\kappa = a + bT$$

Mol % Na_2TiF_6	$-a$	$b \times 10^3$
100	3.018	4.829
84.21	-0.006	1.343
71.67	0.525	2.114
61.44	1.246	2.872
52.93	1.205	3.132
45.75	1.721	3.680
39.62	0.943	3.075
34.30	1.942	4.229
29.67	2.251	4.800
21.95	1.761	4.600
10.75	2.344	5.601
6.57	2.507	5.920
3.03	0.430	4.240

These values are based on the data of Milov, Baitenev, and Ponomarev (classical ac method) [116] and as cited in Clark [40]; data from graphical study; precisions not estimated. Measurements were not extended in [116] to NaCl (0% Na_2TiF_6) and comparisons with the recommended NaCl data set is not possible; results for Na_2TiF_6 (0% NaCl) have not been reported before.

TABLE 324. Density studies: NaCl - Na_2TiF_6

Investigations critically examined

Ref.	Mol % Na_2TiF_6	Temp. range (K)	Comments
116	30-100	973-1123	Pt sphere

TABLE 325. NaCl - Na_2TiF_6: Density (g cm^{-3})

T(K)	Mol percent Na_2TiF_6			
	95	80	65	50
970		2.19	2.04	1.91
1010		2.15	2.00	1.88
1030	2.26	2.13	1.98	1.86
1110	2.20	2.06	1.92	1.80

Temperature-dependent equations

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

Mol % Na_2TiF_6	a	$b \times 10^3$	$c \times 10^6$
100	1.195	2.681	-1.58
95	-1.325	7.419	-3.82
90	3.143	-0.888	
85	2.486	0.319	-0.59
80	3.854	-2.390	0.69
75	2.486	0.319	-0.59
70	2.358	0.186	-0.48
65	3.908	-2.897	1.00
60	2.808	-0.838	
50	3.060	-1.517	0.34
40	2.906	-1.100	
30	0.153	3.471	-1.88

These values are based on the data of Milov, Baitenev, and Ponomarev (Archimedean technique) [116]; data interpolated from graphical isotherms; precisions not estimated. Data for 0 - 25 mol % Na_2TiF_6 were also included in the isotherms, but with insufficient data points for temperature-dependence evaluations. For NaCl, at 1123 K, the density values in the above investigation [116], and from the recommended data set [10] are, 1.51 and 1.53, respectively. No previous results have been reported for Na_2TiF_6 (0% NaCl).

NaCl - Na_2ZrF_6

Melt Preparation and Purification

For the method of melt preparation used by Sheiko et al. [107] see: NaF - Na_2ZrF_6. The NaCl was reagent grade and was recrystallized.

TABLE 326. Density studies: NaCl - Na_2ZrF_6

Investigations critically examined

Ref.	Mol % Na_2ZrF_6	Temp. range (K)	Comments
107	0-100	1173	see: NaF-Na_2ZrF_6

TABLE 327. NaCl - Na_2ZrF_6: Density (g cm^{-3})

Mol percent Na_2ZrF_6	1173 K
100	2.524
90	2.411
70	2.142
50	1.907
30	1.708
10	1.545
0	1.486

Composition-dependent equation

$\rho = 1.4759 + 0.643 \times 10^{-2}C + 0.44 \times 10^{-4}C^2$

[C = Mol % Na_2ZrF_6]

Standard error of estimate = 1.06%

These values are based on the data of Sheiko, Derks and Pozdnyakov (Archimedean technique) [107]. In addition to the above values, results are reported as a series of temperature-dependent density equations. For NaCl, a comparison with the recommended density data set [10], shows that the value in the table (above) is ~1% low. Data for Na_2ZrF_6 have not been reported previously.

Halide - Oxide

TABLE 328. Data Status

System	Phase Diagram	Electrical Conductance	Density	Viscosity	Surface Tension
CaF_2-Al_2O_3	X	X	X	X	X
-BaO		X	X		X
-CaO	X	X	X	X	X
-MgO	X	X	X	X	X
-SiO_2	X		X		X
-TiO_2	X	X	X	X	X
-V_2O_5		X	X	X	X
-ZrO_2		X	X		X
NaF-Al_2O_3				X	
-B_2O_3	X		X	X	
-CaO				X	
PbF_2-PbO	X			X	
$CaCl_2$-CaO	X		X		
$MgCl_2$-MgO		X			
NaCl-B_2O_3				X	
-Na_2O	X		X		X
$HgBr_2$-HgO		X			

CaF_2 – Al_2O_3

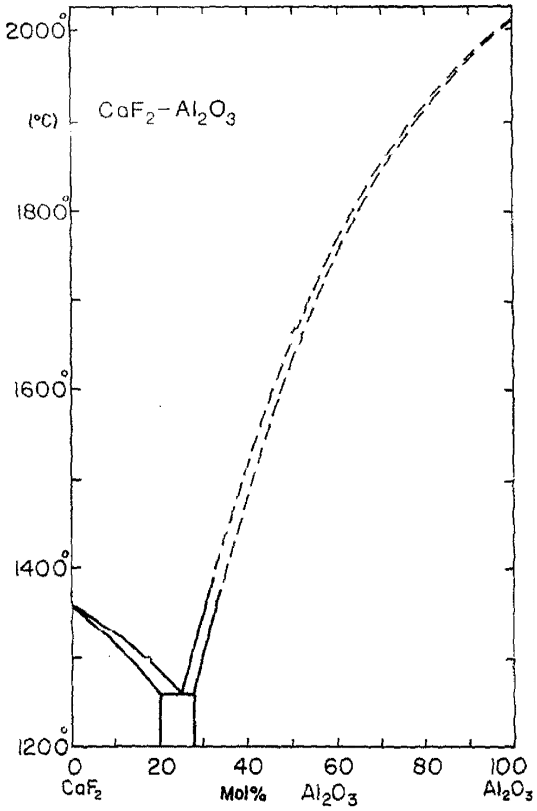

FIGURE 63. Phase diagram for CaF_2 – Al_2O_3.

Data from: P. Pascal, Z. Electrochem. **19**, 611 (1913).

Melt Preparation and Purification

Mitchell and Cameron [117] used ultra pure CaF_2 dried at 300°C and prefused under Ar in a molybdenum-lined graphite crucible. The alumina was recrystallized 2mm grain (99.95% Al_2O_3). Stepanov and Lopaev [118] melted chemically pure components in a graphite crucible. No information on melt preparation was given in the study by Nikitin [119]. Evseev and Filippov [120] used reagent grade materials and performed all measurements in a stream of dry argon. To remove air bubbles the melt was maintained at 1700–1800°C for at least 30 min. Voronov and Nikitin [121] used reagent grade materials and fused them for 3 hours at 1000°C. Zhmojdin and Moldavskii [122] prepared samples by the addition of chemically pure oxides to the initial slag. The oxides were added immediately prior to measurements.

TABLE 329. Electrical conductance studies: CaF_2 – Al_2O_3

Investigations critically examined

Ref.	Mol % Al_2O_3	Temp. range (K)	Comments
117	0–25	1723–1973	concentric cell; molybdenum lined graphite crucible; temperature control, ±5°C; calibration: NaCl(aq), molten NaCl, KCl; frequency: 0.8–20 KHz
123	0–23.5	1873–2073	Mo crucibles
120	37.6 (wt %)	1700–2073	Mo cell; W electrodes; calibration: 0.1*N* KCl soln; frequency: 0.5–5 KHz; experimental uncertainty, ±6%

TABLE 330. CaF_2 – Al_2O_3: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent Al_2O_3			
	24.7	16.1	7.8	3.9
1720	1.20	2.24	2.96	3.95
1840	1.57	2.50	3.27	4.26
1960	2.22	2.93	3.80	4.87

Temperature-dependent equations

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

Mol % Al_2O_3	a	$-b \times 10^3$	$c \times 10^6$
24.7	25.920	30.711	9.50
16.1	17.373	19.068	5.97
7.8	22.187	24.042	7.48
3.9	32.190	34.186	10.33
0	25.008	23.931	7.481

These values are based on the data of Mitchell and Cameron (classical ac method); data in graphical form; precisions not estimated [117]. From the conductance cell calibrations (molten NaCl and KCl) the accuracy limits are ~±3%. Values for CaF_2 have not been reported earlier in the NSRDS series. The values above for CaF_2 (0% Al_2O_3) agree with [120,123] at the higher temperatures; in the lower temperature range, the values are significantly greater than in [120,123]. This is probably because in [117], the purity of CaF_2 was higher (less oxides), and because melt/crucible reactions were minimized. The conductance-dependence for CaF_2 in [117] may also be expressed as: $\kappa = 18.168 \exp(-3859/RT)$, within 0 1.2%.

TABLE 331. Density studies: $CaF_2 - Al_2O_3$

Investigations critically examined

Ref.	Mol % Al_2O_3	Temp. range (K)	Comments
121	0–25	1873	Mo crucible; Ar atmosphere
118	0–24.7	1670–1730	Mo capillary tube; N_2 atmosphere; graphite crucible
124	0–25	1673–1973	Mo bob; tungsten wire suspension; Mo lined crucible; temp. control, ±10°C
123	0–30	1873	Mo capillary tube; Ar atmosphere
125	0–24.6	1673–1773	Mo bob; graphite crucible

TABLE 332. $CaF_2 - Al_2O_3$: Density (g cm^{-3})

T(K)	Mol percent Al_2O_3		
	24.7	16.1	7.8
1670	2.93	2.85	2.75
1700	2.91	2.82	2.72
1730	2.88	2.79	2.69

Temperature-dependent equations

$$\rho = a + bT$$

Mol % Al_2O_3	a	$-b \times 10^3$
24.7	4.571	0.980
16.1	4.564	1.024
7.8	4.415	1.000

These values are based on the data of Stepanov and Lopaev at 1673 and 1723 K; precisions not estimated (maximum bubble pressure method) [118]. Extrapolation of the temperature limits to 1670 and 1730 assumed linearity. A single data point, 2.52, was reported for CaF_2 (0% Al_2O_3) at 1723 K; this is to be compared with 2.51 (from the recommended data base [1]).

TABLE 333. Viscosity studies: $CaF_2 - Al_2O_3$

Investigations critically examined

Ref.	Mol % Al_2O_3	Temp. range (K)	Comments
122	7–45	1473–1873	Mo spindle head; estimated error, ±10%

TABLE 334. $CaF_2 - Al_2O_3$: Viscosity (cp)

Mol % Al_2O_3	1673 K	1773 K	1873 K
43.4			1.0
40.4			0.8
38.5			0.6
33.8		4.0	0.4
29.2		3.0	
28.3			0.3
24.7	2.0	2.0	0.2
18.6	1.5		
16.1		1.5	
7.8		1.0	

The above values were interpolated from the graphical data of Zhmojdin and Moldavskii (oscillational method) [122] for the system $CaO-Al_2O_3-CaF_2$. Results for the ternary were also reported therein at 1573 K.

TABLE 335. Surface tension studies: $CaF_2 - Al_2O_3$

Investigations critically examined

Ref.	Mol % Al_2O_3	Temp. range (K)	Comments
121	0–25	1873	Mo capillary; Ar atmosphere
123	0–35	1873	Mo capillary; Ar atmosphere
125	0–24.6	1673–1773	graphite crucible
119	0–30	1470–1550	no information given on cell materials.

TABLE 336. $CaF_2 - Al_2O_3$: Surface tension (dyn cm^{-1})

Mol percent Al_2O_3	1873 K
35	239
30	242
20	247
10	251
5	254
0	256

Composition-dependent equation

$$\gamma = 256.2 - 0.485C$$

[C = Mol % Al_2O_3]

Standard error of estimate = 0.77%

These values are based on the data of Evseev (maximum bubble pressure method) [123]. Limits of accuracy, ~±4%.

$CaF_2 - BaO$

Melt Preparation and Purification

No information on melt preparation was given in the study by Evseev et al. [123, 126].

TABLE 337. Electrical conductance studies: CaF_2 - BaO

Investigations critically examined			
Ref.	Mol % BaO	Temp. range (K)	Comments
123	10.48	1673–1973	Mo crucible

TABLE 338. CaF_2 - BaO: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent BaO
	10.48
1700	5.09
1820	6.31
1940	7.18

Temperature-dependent equation

$$\kappa = -49.49 + 52.61 \times 10^{-3}T - 12.06 \times 10^{-6}T^2$$

These values are based on the data of Evseev (classical ac method); data in graphical form; precisions not estimated **[123]**. See also: comments following Table 330.

TABLE 339. Density studies: CaF_2 - BaO

Investigations critically examined			
Ref.	Mol % BaO	Temp. range (K)	Comments
126	10.45	1823–1873	Mo capillary; purified Ar atmosphere

TABLE 340. CaF_2 - BaO: Density ($g\ cm^{-3}$)

Mol percent BaO	1823–1873 K
18.65	2.66

The single data point (above) was reported by Evseev and Filippov (maximum bubble pressure method) **[126]**. Limits of accuracy, ±4%.

TABLE 341. Surface tension studies: CaF_2 - BaO

Investigations critically examined			
Ref.	Mol % BaO	Temp. range (K)	Comments
126	10.45	1823–1873	Mo capillary; purified Ar atmosphere

TABLE 342. CaF_2 - BaO: Surface tension ($dyn\ cm^{-1}$)

Mol percent BaO	1823–1873 K
18.65	258.0

The single data point (above) was reported by Evseev and Filippov (maximum bubble pressure method) **[126]**.

CaF_2 - CaO

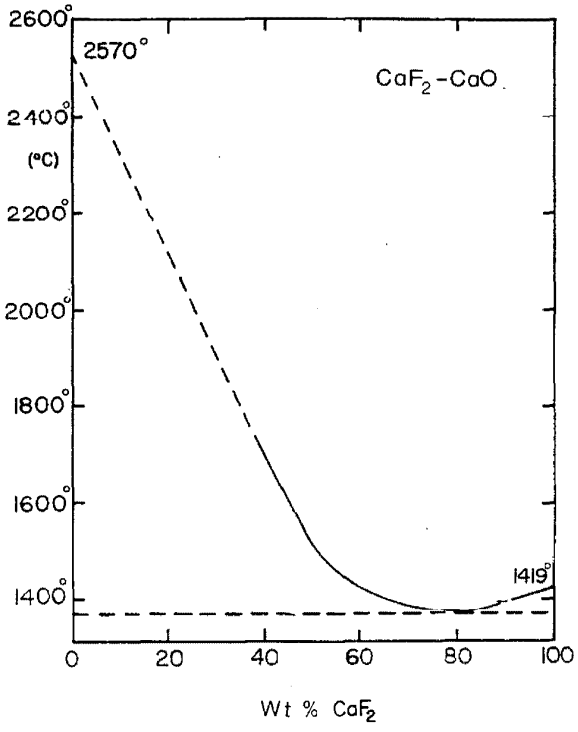

FIGURE 64. Phase diagram for CaF_2 - CaO.

Data from: J. Mukerji, J. Am. Ceram. Soc. **48**(4), 210 (1965).

Melt Preparation and Purification

Mitchell and Cameron [117] and Mitchell and Joshi [124] used ultra pure CaF_2, dried it at 300°C and then prefused it under argon in a molybdenum-lined graphite crucible. The calcium oxide was recrystallized 2mm grain. Stepanov and Lopaev [118] prepared samples by melting reagent grade materials in a graphite crucible. No information on melt preparation was given in the study by Yakobashvili and Frumin [125], Evseev [123] and Nikitin et al. [119]. Voronov and Nikitin [121] used reagent grade materials and fused them for 3 hours at 1000°C. Daak [127] used A. R. grade salts. All experiments were carried out under a purified nitrogen atmosphere. Zhmojdin et al. [122] used chemically pure oxides.

TABLE 343. Electrical conductance studies: CaF_2 - CaO

Investigations critically examined

Ref.	Mol % CaO	Temp. range (K)	Comments
117	0–54	1723–1973	see: CaF_2–Al_2O_3
123	35.8	1673–1923	Mo crucibles
127	0–14	1773–1818	Mo electrodes; calibration: 0.1 *N* KCl; graphite crucibles

TABLE 344. CaF_2 - CaO: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent CaO				
	53.3	37.4	19.7	6.8	3.4
1720	3.27	4.08	4.41	4.73	5.30
1840	3.92	4.77	5.13	5.42	5.83
1960	4.97	6.16	6.45	6.56	6.69

Temperature-dependent equations

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

Mol % CaO	a	$-b \times 10^3$	$c \times 10^6$
53.3	38.797	44.992	14.15
37.4	72.088	81.851	24.60
19.7	59.668	67.785	20.73
6.8	43.243	48.706	15.30
3.4	34.475	36.932	11.61

These values are based on the data of Mitchell and Cameron (classical ac method); data in graphical form; precisions not estimated [117]. For the results for CaF_2 (0% CaO) from this work [117], see Table 330, and comments thereafter.

TABLE 345. Density studies: CaF_2 - CaO

Investigations critically examined

Ref.	Mol % CaO	Temp. range (K)	Comments
121	0–49	1873	Mo capillary; Ar atmosphere
125	0–48	1673–1773	graphite crucible
127	0–9.6	1818	graphite crucible; Mo bob
118	0–50	1723	Mo capillary tube; graphite crucible
124	0–37.3	1673–2023	Mo bob; tungsten wire; Mo lined crucible; temperature control, ±10°C; estimated uncertainty, ±0.2%

TABLE 346. CaF_2 - CaO: Density (g cm^{-3})

T(K)	Mol percent CaO		
	37.4	25.8	13.4
1770			2.58
1840		2.59	2.57
1890	2.62	2.58	2.56
1950	2.61	2.57	2.54
2010	2.60	2.56	

Temperature dependent equations

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

Mol % CaO	a	$b \times 10^4$	$c \times 10^6$
37.4	3.761	1.039	0.23
25.8	2.874	0.155	
13.4	2.969	0.219	
0	4.046	1.379	

These values are based on the data of Mitchell and Joshi (Archimedean technique); data in graphical form; precisions not estimated [124]. For CaF_2 (0% CaO) the results fall ~2.4% above the recommended data set [1].

TABLE 347. Viscosity studies: CaF_2 - CaO

Investigations critically examined

Ref.	Mol % CaO	Temp. range (K)	Comments
122	35–50	1473–1873	see: CaF_2–Al_2O_3

TABLE 348. CaF_2 – CaO: Viscosity (poise)

Mol percent CaO	1873 K
48.1	1.5
45.0	1.0
43.9	0.8
43.4	0.6
42.8	0.4
41.8	0.3
37.8	0.2

The above values were interpolated from the graphical data of Zhmojdin and Moldavskii (oscillational method) [122] for the system $CaO–Al_2O_3–CaF_2$. Results for this ternary system were also reported therein at 1573 K, 1673 K and 1773 K.

TABLE 349. Surface tension studies: CaF_2 – CaO

Investigations critically examined			
Ref.	Mol % CaO	Temp. range (K)	Comments
121	0–45	1873	Mo capillary; Ar atmosphere
125	0–48	1673–1773	alloy steel rods; graphite crucible
119	0–35	1470–1550	electrocapillary method

TABLE 350. CaF_2 – CaO: Surface tension (dyn cm^{-1})

Mol percent CaO	T(K)	γ
48.0	1773	440
37.5	1773	430
30.7	1753	420
14.5	1723	410

These values are the data-set reported by Yakobashvili and Frumin (drop-weight technique) [125]. Accuracy limits, ~±3%. A single measurement of the surface tension of CaF_2 (0% CaO) is reported in [125], i.e.: at 1673 K, 400 dyn cm^{-1}. For related studies, see [119,126]. In [119], the surface tension over the temperature range of 1750–1825 K for CaF_2 is reported to have a value of 280 dyn cm^{-1} and this increases to a value of 315, for 33 mol % CaO as additive. There is insufficient information to resolve the factors leading to the greatly differing results in these two studies.

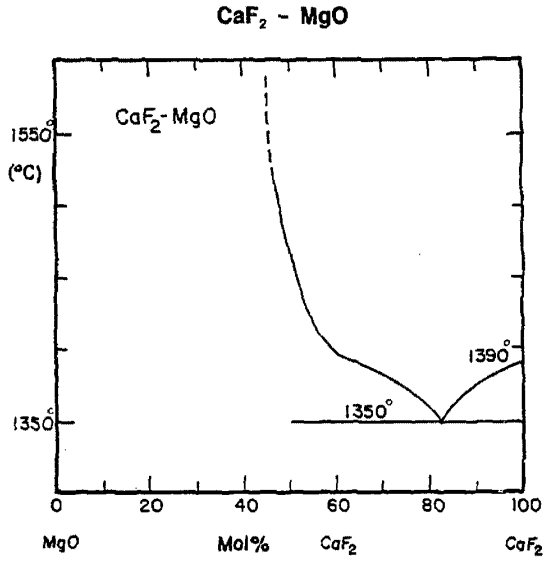

FIGURE 65. Phase diagram for CaF_2 – MgO.

Data from: D. D. Budnikov and S. G. Tresvyatskii, Ukr. Khim. Zhur., **19**, 555 (1953).

Melt Preparation and Purification

Yakobashvili and Frumin [125] and Evseev [123] prepared samples by melting chemically pure components in a graphite crucible. Goncharev et al. [128] used analytical grade MgO and pure grade CaF_2.

TABLE 351. Electrical conductance studies: CaF_2 – MgO

Investigations critically examined			
Ref.	Mol % MgO	Temp. range (K)	Comments
123	31.2	1673–2000	Mo crucible
128	9–33	1673–1873	Mo crucible and electrodes; calibration: 0.1 *N* KCl; Ar atmosphere; frequency: 1000 Hz; estimated accuracy, ±6%

TABLE 352. CaF_2 – MgO: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent MgO
	31.2
1670	4.31
1790	5.28
1910	6.44
1950	6.87

Temperature-dependent equation

$$\kappa = 11.369 - 15.676 \times 10^{-3}T + 6.857 \times 10^{-6}T^2$$

These values are based on the data of Evseev (classical ac method); data in graphical form; precisions not estimated [123]. For CaF_2 (0% MgO) the conductance at 1973 K is 6.81 in [123]. This is to be compared with the value of 6.80 at the same temperature calculations from the work of Mitchell and Cameron [117]. See also: Table 330.

TABLE 353. Density studies: CaF_2 – MgO

Investigations critically examined

Ref.	Mol % MgO	Temp. range (K)	Comments
125	0–32.7	1673–1773	Mo weight
128	9.0	1670–1820	alundum capillary and crucible; calibration: H_2O, molten salts; quartz-lined graphite furnace; Ar atmosphere

TABLE 354. CaF_2 – MgO: Density ($g\ cm^{-3}$)

T(K)	Mol percent MgO
	9.0
1680	2.59
1740	2.47
1800	2.34
1820	2.30

Temperature-dependent equation

$$\rho = 6.034 - 2.05 \times 10^{-3}T$$

These values are based on the data of Goncharev, Manakov and Kovalev (maximum bubble pressure method); data in graphical form; precisions not estimated [128].

TABLE 355. Viscosity studies: CaF_2 – MgO

Investigations critically examined

Ref.	Mol % MgO	Temp. range (K)	Comments
128	33	1447–1621	no information

TABLE 356. CaF_2 – MgO: Viscosity (poise)

T(K)	Mol percent MgO
	33
1447	2.01
1475	0.71
1505	0.56
1564	0.41
1621	0.34

The above values were interpolated from the graphical data of Goncharev, Manakov, and Kovalev (oscillational method) [128].

TABLE 357. Surface tension studies: CaF_2 – MgO

Investigations critically examined

Ref.	Mol % MgO	Temp. range (K)	Comments
125	0–32.7	1673–1773	alloy steel rods, cleaned in acetone and CCl_4
128	9–18	1570–1870	as for density

TABLE 358. CaF_2 – MgO: Surface tension ($dyn\ cm^{-1}$)

T(K)	Mol percent MgO	
	18	9
1570	283	282
1630	280	277
1720	274	270
1870	265	258

Temperature-dependent equations

$$\gamma = a + bT$$

Mol percent MgO	a	$-b \times 10^3$
18	381.4	62.4
9	405.7	79.1

These values are based on the data of Goncharev, Manakov and Kovalev (maximum bubble pressure method); data in graphical form; precisions not estimated [128].

CaF_2 - SiO_2

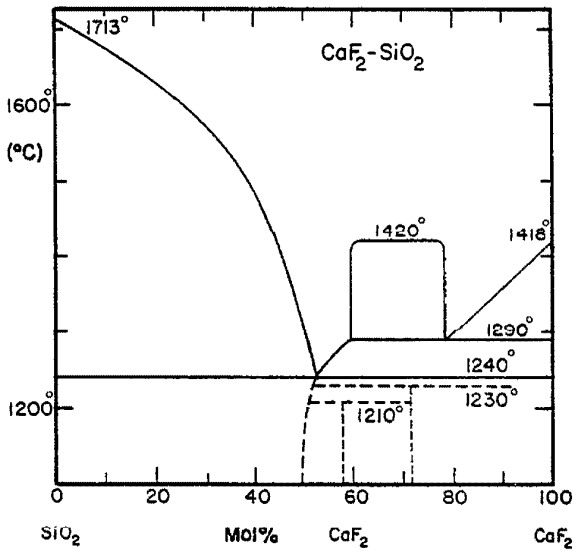

FIGURE 66. Phase diagram for CaF_2 - SiO_2.

Data from: L. Hillert, Acta Chem. Scand. **18**, 2411 (1964).

Melt Preparation and Purification

Yakobashvili and Frumin [**125**] prepared samples by melting the chemically pure components in a graphite crucible. Nikitin et al. [119] gave no information on melt preparation.

TABLE 359. Density studies: CaF_2 - SiO_2

Investigations critically examined			
Ref.	Mol % SiO_2	Temp. range (K)	Comments
125	0–35.7	1673–1823	Mo weight

TABLE 360. CaF_2 - SiO_2: Density (g cm^{-3})

Mol percent SiO_2	T(K)	γ
35.7	1823	2.18
24.6	1793	2.3
12.7	1773	2.2

These values are the data-set reported by Yakobashvili and Frumin (Archimedean technique) [**125**]. At 1673 K, the density values for CaF_2 (0% SiO_2) are: 2.40 [**125**]; 2.52 [1], i.e., the reported value is ~5% low relative to the recommended data set.

TABLE 361. Surface tension studies: CaF_2 - SiO_2

Investigations critically examined			
Ref.	Mol % SiO_2	Temp. range (K)	Comments
125	0–35.7	1673–1823	alloy steel rods cleaned in acetone and CCl_4
119	14	1743–1823	–

TABLE 362. CaF_2 - SiO_2: Surface tension (dyn cm^{-1})

Mol percent SiO_2	T(K)	γ
35.7	1823	350
24.6	1793	360
12.7	1773	390

These values are the data set reported by Yakobashvili and Frumin [**125**]. In a closely related study [119], a value of 285 dyn cm^{-1} is reported for CaF_2 containing 16.6 mol % SiO_2 at ~1750–1825 K. There is insufficient information given to resolve the factors leading to these markedly differing results. (cf.: CaF_2–CaO, Table 349 and comments).

CaF_2 - TiO_2

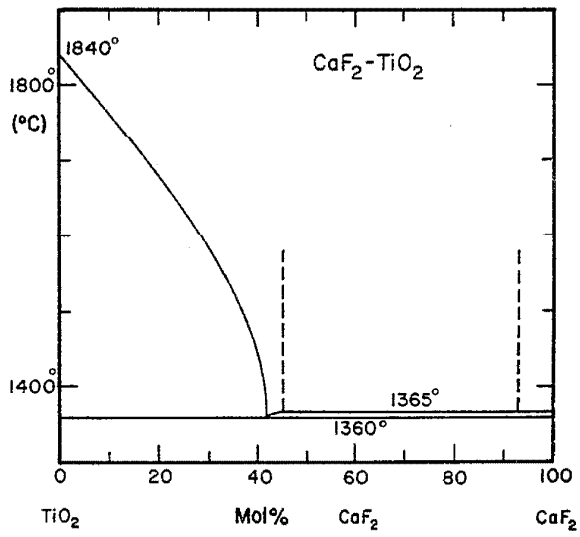

FIGURE 67. Phase diagram for CaF_2 - TiO_2.

Data from: L. Hillert, Act Chem. Scand. **19**(6), 1516 (1965).

Melt Preparation and Purification

Yakobashvili and Frumin [**125**] prepared samples by melting the chemically pure components in a graphite crucible. No information on melt preparation was given in the study by Evseev et al. [123]. Goncharev [**128**] used analytical grade salts.

TABLE 363. Electrical conductance studies: $CaF_2 - TiO_2$

Investigations critically examined

Ref.	Mol % TiO_2	Temp. range (K)	Comments
123	19.6	1720–1970	Mo crucible
128	5–20	1470–1870	see: CaF_2–MgO

TABLE 364. $CaF_2 - TiO_2$: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent TiO_2	
	20	5
1470	2.59	2.42
1670	5.08	5.13
1870	5.09	4.91

Temperature-dependent equations

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

Mol % TiO_2	$-a$	$b \times 10^3$	$-c \times 10^6$
20	92.214	110.266	31.14
5	107.518	128.660	36.65

These values are based on the data of Goncharev, Manakov, and Kovalev (classical ac method); data in graphical form; precisions not estimated [**128**].

TABLE 365. Density studies: $CaF_2 - TiO_2$

Investigations critically examined

Ref.	Mol % TiO_2	Temp. range (K)	Comments
125	0–29.4	1673–1833	Mo weight
128	5–20	1673–1800	see: CaF_2–MgO

TABLE 366. $CaF_2 - TiO_2$: Density (g cm^{-3})

T(K)	Mol percent TiO_2	
	20	5
1680	2.73	2.72
1740	2.63	2.62
1800	2.53	2.53

Temperature-dependent equations

$\rho = a + bT$

Mol percent TiO_2	a	$-b \times 10^3$
20	5.540	1.670
5	5.398	1.595

These values are based on the data of Goncharev, Manakov, and Kovalev (maximum bubble pressure method); data in graphical form; precisions not estimated [**128**]. A density value of 2.54 at ~1800 K for CaF_2 containing 9.8 mol % TiO_2, is reported by Yakobashvili and Frumin (Archimedean technique) [125]. The results are virtually in exact accord.

TABLE 367. Viscosity studies: $CaF_2 - TiO_2$

Investigations critically examined

Ref.	Mol % TiO_2	Temp. range (K)	Comments
128	5	1570–1773	see: CaF_2–MgO

TABLE 368. $CaF_2 - TiO_2$: Viscosity (cp)

T(K)	Mol percent TiO_2
	5
1570	2.75
1591	1.10
1621	0.56
1651	0.41
1683	0.33
1716	0.30
1746	0.30
1773	0.30

The above values were interpolated from the graphical data of Goncharev, Manakov and Kovalev (oscillational method) [**128**].

TABLE 369. Surface tension studies: $CaF_2 - TiO_2$

Investigations critically examined

Ref.	Mol % TiO_2	Temp. range (K)	Comments
128	5–20	1570–1870	see: CaF_2–MgO
125	0–29.4	1673–1833	alloy steel rod cleaned with acetone and CCl_4

TABLE 370. $CaF_2 - TiO_2$: Surface tension (dyn cm^{-1})

Mol percent TiO_2	T(K)	γ
29.4	1833	360
19.5	1833	380
9.8	1793	390

These values are the data set reported by Yakobashvili and Frumin (drop weight method) [**125**]. The value for CaF_2 (0% TiO_2) at 1673 K is reported in this study, as 400 dyn cm^{-1}. This differs markedly from the result in a closely related study, namely, 280 dyn cm^{-1} [119]. The information in these two studies is insufficient to resolve the error source(s) leading to these two very different values.

$CaF_2 - V_2O_5$

Melt Preparation and Purification

Goncharev et al. [**128**] used Pure grade CaF_2 and analytical grade V_2O_5. No other information was given.

TABLE 371. Electrical conductance studies: $CaF_2 - V_2O_5$

Investigations critically examined

Ref.	Mol % V_2O_{25}	Temp. range (K)	Comments
128	2–7	1470–1870	see: CaF_2–MgO

TABLE 372. $CaF_2 - V_2O_5$: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent V_2O_5	
	7	2
1470		1.74
1560		3.08
1590		3.92
1680	9.65	7.20
1800	9.91	7.79
1870	10.06	7.61

Temperature-dependent equations

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

Mol % V_2O_5	a	b x 10^3	c x 10^6	T range (K)
7	5.981	2.181		1670–1870
2	−119.657	141.38	−39.21	1600–1870
2	224.209	−307.98	106.56	1470–1590

These values are based on the data of Goncharov, Manakov, and Kovalev (classical ac method); data in graphical form; precisions not estimated [**128**].

TABLE 373. Density studies: $CaF_2 - V_2O_5$

Investigations critically examined

Ref.	Mol % V_2O_5	Temp. range (K)	Comments
128	2–7	1670–1820	see: CaF_2–MgO

TABLE 374. $CaF_2 - V_2O_5$: Density (g cm^{-3})

T(K)	Mol percent V_2O_5	
	7	2
1690	2.88	
1730	2.76	2.50
1770	2.63	2.34
1810	2.49	2.18

Temperature-dependent equations

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

Mol % V_2O_5	a	b x 10^3	c x 10^6
7	4.048	1.71	−1.42
2	9.563	−4.08	

These values are based on the data of Goncharev, Manakov, and Kovalev (maximum bubble pressure method); data in graphical form; precisions not estimated [**128**]. See: Table 366 for checks of results from a closely related study [125].

TABLE 375. Viscosity studies: $CaF_2 - V_2O_5$

Investigations critically examined

Ref.	Mol % V_2O_5	Temp. range (K)	Comments
128	2.2	1530–1775	see: CaF_2–MgO

TABLE 376. $CaF_2 - V_2O_5$: Viscosity (poise)

T(K)	Mol percent V_2O_5
	2.2
1532	2.90
1562	0.91
1652	0.31
1713	0.26
1744	0.23
1773	0.22

The above values were interpolated from the graphical data of Goncharev, Manakov, and Kovalev (oscillational method) [**128**].

TABLE 377. Surface tension studies: $CaF_2 - V_2O_5$

Investigations critically examined

Ref.	Mol % V_2O_5	Temp. range (K)	Comments
128	2–7	1570–1870	see: CaF_2–MgO

TABLE 378. $CaF_2 - V_2O_5$: Surface tension (dyn cm^{-1})

T(K)	Mol percent V_2O_5	
	7	2
1570	287	
1690	238	270
1750	232	249
1870		227

Temperature-dependent equations

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

Mol % V_2O_5	a	$-b$ x 10^3	c x 10^6
7	5566.0	6101.1	1744.5
2	3461.5	3380.3	882.6

These values are based on the data of Goncharev, Manakov, and Kovalev (drop weight method); data in graphical form; precisions not estimated [**128**].

CaF_2 - ZrO_2

Melt Preparation and Purification

Yakobashvili and Frumin [**125**] prepared samples by melting the chemically pure components in a graphite crucible. Evseev et al. [**123**] gave no information on melt preparation. Goncharev et al. [128] used pure grade materials.

TABLE 379. Electrical conductance studies: $CaF_2 - ZrO_2$

Investigations critically examined

Ref.	Mol % ZrO_2	Temp. range (K)	Comments
123	10.2	1670–2020	Mo crucible

TABLE 380. $CaF_2 - ZrO_2$: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent ZrO_2
	10.13
1670	3.15
1830	4.78
1960	5.77
1990	5.96

Temperature-dependent equation

$\kappa = -40.908 + 41.134 \times 10^{-3}T - 8.835 \times 10^{-6}T^2$

These values are based on the data of Evseev; data in graphical form; precisions not estimated (classical ac method) [123]

TABLE 381. Density studies: $CaF_2 - ZrO_2$

Investigations critically examined

Ref.	Mol % ZrO_2	Temp. range (K)	Comments
125	0–21.4	1673–1813	Mo weight
126	15	1673–1973	Mo capillary

TABLE 382. $CaF_2 - ZrO_2$: Density ($g\ cm^{-3}$)

Mol percent ZrO_2	T(K)	ρ
21.4	1813	3.42
13.7	1793	3.00
6.5	1753	2.70

These values are the data set reported by Yakobashvili and Frumin (Archimedean technique) [125]. The densities of a series of CaF_2 containing slags have also been investigated by Evseev and Filippova [126]; for the above system; the density value, reported for the composition 10 mol% ZrO_2 and the temperature range 1823–1873 K, is: 2.65 gm cm^{-3}, i.e., the agreement appears all that can be expected.

TABLE 383. Surface tension studies: $CaF_2 - ZrO_2$

Investigations critically examined

Ref.	Mol % ZrO_2	Temp. range (K)	Comments
125	0–21.4	1673–1813	alloy steel rod cleaned with acetone and CCl_4
126	15.1	1823–1873	Mo capillary; no corrosion observed

TABLE 384. $CaF_2 - ZrO_2$: Surface tension ($dyn\ cm^{-1}$)

Mol percent ZrO_2	T(K)	γ
21.4	1813	380
13.7	1793	390
6.5	1753	400

These values are the data set reported by Yakobashvili and Frumin (drop-weight technique) [125].

The surface tensions of a series of CaF_2 containing slags have also been investigated by Evseev and Filippova (maximum bubble pressure method) [126]. For the above system the surface tension value reported for the composition 10 mol% ZrO_2 and the temperature range 1823–1873 K, is 267 dyn cm^{-1}. A somewhat similar trend is noted for CaF_2 (0% ZrO_2) at 1673 K in [125] and [119] e.g., 400, and 280 dyn cm^{-1}, respectively. The information in these publications [119,125,126] is insufficient to resolve the factors contributing to these very differing values.

$NaF - Al_2O_3$

Melt Preparation and Purification

No information on melt preparation was given in the study by Balyabin et al. [129].

TABLE 385. Viscosity studies: $NaF - Al_2O_3$

Investigations critically examined

Ref.	Mol % Al_2O_3	Temp. range (K)	Comments
129	10–40	1673	tungsten wire and rod; alundum crucible; calibration: solns. of castor oil in butanol; experimental error given as ~±7%

TABLE 386. $NaF - Al_2O_3$: Viscosity (cp)

Mol percent Al_2O_3	1673 K
40	420
30	304
20	180
10	49

Composition-dependent equation

$\eta = -89.9 + 14.27C - 0.038C^2$

[C = Mol % Al_2O_3]

Insufficient data for estimate of standard error.

These values are based on the data of Balyabin, Ovakimyan and Stepanov (electromagnetic method) [129]. Accuracy limits, ~±10%.

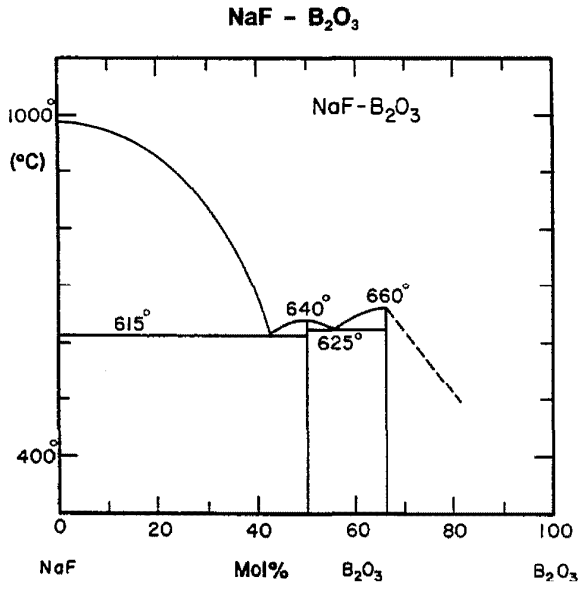

FIGURE 68. Phase diagram for $NaF - B_2O_3$.

Data from: V. N. Pavlikov, V. A. Yurchenko, E. S. Lugovskaya, N. L. Korbanova, and S. G. Tresvyatskii, Russ. J. Inorg. Chem. **19**(6), 869 (1974).

Melt Preparation and Purification

Kruh and Stern [**130**] used reagent grade B_2O_3 and heated it to 900°C in a stainless steel beaker to remove residual water. After adding the sodium fluoride, the mixture was stirred thoroughly and then allowed to stand so that air bubbles might escape.

TABLE 387. Density studies: $NaF - B_2O_3$

Investigations critically examined			
Ref.	Mol % B_2O_3	Temp. range (K)	Comments
130	88–100	873–1073	Au sphere; corrections made for thermal expansion and for the effect of the surface tension on the expansion wire.

TABLE 388. $NaF - B_2O_3$: Density (g cm^{-3})

T(K)	Mol percent B_2O_3		
	97.31	92.35	87.6
870	1.621	1.711	1.783
950	1.604	1.691	1.759
1030	1.588	1.670	1.734
1070	1.580	1.660	1.721

Temperature-dependent equations

$$\rho = a + bT$$

Mol percent B_2O_3	a	$-b \times 10^3$
97.31	1.799	0.205
92.35	1.933	0.255
87.6	2.053	0.310

These values are based on the data of Kruh and Stern (buoyancy method) precisions not estimated [**130**]. Accuracy limits, $\sim\pm0.5\%$. Density data for B_2O_3 (0% NaF) in [**130**] agree with the data set of Shartsis, Capps, and Spinner (NBS) [242] to $\sim\pm0.5\%$. The temperature range (~850–1100 K) falls below that of the recommended data set advanced earlier in this series [1], but extrapolation of the latter gives the results: at 1073 K, 1.551 [1]; 1.548 [**130**]; i.e., the results are in very close agreement.

TABLE 389. Viscosity studies: $NaF - B_2O_3$

Investigations critically examined			
Ref.	Mol % B_2O_3	Temp. range (K)	Comments
130	80–100	883–973	stainless steel container

TABLE 390. $NaF - B_2O_3$: Viscosity (poise)

T(K)	Mol percent B_2O_3			
	97.3	93.6	87.9	81.1
870	1900	1400	2700	3500
930	640	460	600	760
990	250	170	160	200
1010	190	120	110	130

Temperature-dependent equations

$$\eta = A \exp [E/RT]$$

Mol % B_2O_3	A	E	standard error of estimate
97.3	1.2175×10^{-4}	28604	6.60%
93.6	3.0380×10^{-5}	30561	10.18%
87.9	2.2615×10^{-7}	40098	12.13%
81.1	2.0269×10^{-7}	40734	60.53%

These values are based on the data of Kruh and Stern (damped rotational method) [**130**]. Accuracy limits, $\sim\pm5\%$. For B_2O_3 (0% NaF) the temperature range for the measurements [**130**] lies below that of the recommended data set [1]; comparison with the work of Shartsis et al. (NBS) [242] at 850–1100 K shows that the two data sets are in close accord.

NaF - CaO

Melt Preparation and Purification

No information on melt preparation was given in the study by Balyabin et al. [129].

TABLE 391. Viscosity studies: NaF - CaO

Investigations critically examined

Ref.	Mol % CaO	Temp. range (K)	Comments
129	15-55	1673	see: $NaF-Al_2O_3$

TABLE 392. NaF - CaO: Viscosity (cp)

Mol percent CaO	1673 K
55	137
35	83
15	24

Composition-dependent equation

$$\eta = -25.2 + 3.38C - 0.8 \times 10^{-2}C^2$$

[C = Mol % CaO]

These values are based on the data of Balyabin, Ovakimyan and Stepanov (electromagnetic method) [129]. Insufficient data for precision estimate, accuracy limits, $\sim \pm 10\%$.

PbF_2 - PbO

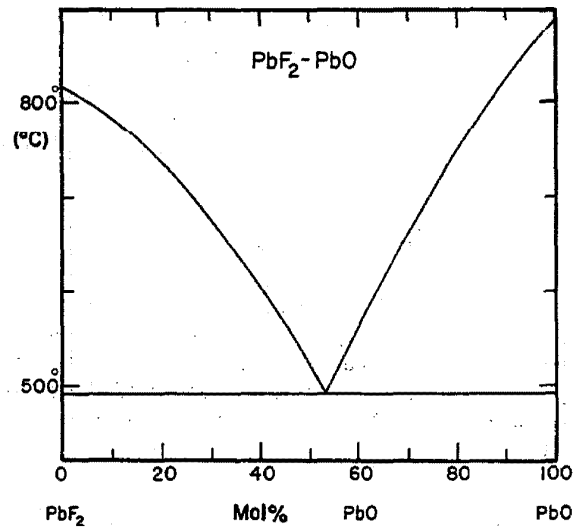

FIGURE 69. Phase diagram for PbF_2 - PbO.

Data from: C. Sandonnini, Atti reale accad. sci., Torino, 22(1), 959 (1914).

Melt Preparation and Purification

Oliver [131] used reagent grade lead monoxide and ultra pure PbF_2.

TABLE 393. Viscosity studies: PbF_2 - PbO

Investigations critically examined

Ref.	Mol % PbO	Temp. range (K)	Comments
131	52	880-1250	Pt crucible and bob; samples were analyzed chemically; calibration: NaCl

TABLE 394. PbF_2 - PbO Viscosity (cp)

T(K)	Mol percent PbO
	52
880	580
1000	379
1120	283
1200	278

Composition-dependent equation

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

Mol % PbO	a	$-b \times 10^3$	$c \times 10^6$
52	5254	8515	3640

These values are based on the data of Oliver (rotational method); data in graphical form; precisions not estimated [131]. Accuracy limits, $\sim \pm 20\%$.

$CaCl_2$ - CaO

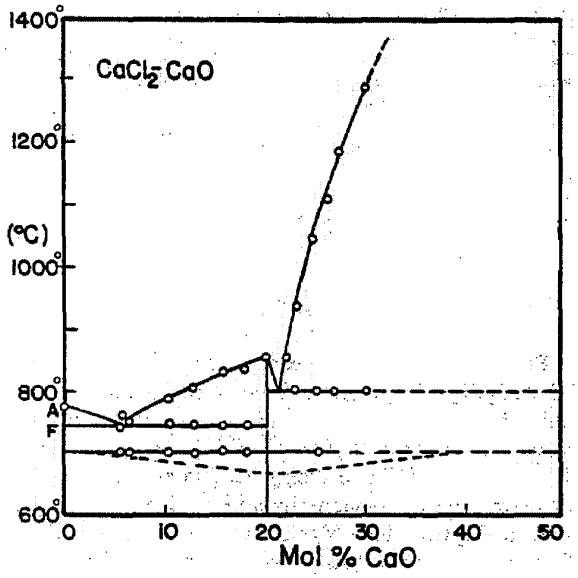

FIGURE 70. Phase diagram for $CaCl_2$ - CaO.

Data from: B. Neumann, C. Kroger and H. Juttner, Z. Elektrochem., 41, 725 (1935).

Melt Preparation and Purification

Arndt and Loewenstein [132] dried Kahlbaum high purity salts by heating in Pt crucibles.

TABLE 395. Density studies: $CaCl_2$ - CaO

Investigations critically examined			
Ref.	Mol % CaO	Temp. range (K)	Comments
132	1.15–8.9	1070–1260	Pt float *crucible*

TABLE 396. $CaCl_2$ - CaO Density (g cm^{-3})

T(K)	Mol percent CaO		
	8.90	4.90	1.15
1070		2.089	
1100	2.109	2.076	2.046
1130	2.095	2.063	2.033
1190	2.068	2.036	
1250	2.040		

Temperature-dependent equations

$\rho = a + bT$

Mol % CaO	a	$-b \times 10^3$	standard error of estimate
8.90	2.6143	0.4593	0.02%
4.90	2.5615	0.4414	0.05%
1.15	2.5025	0.4151	*

*Insufficient data for estimate.

These values are based on the data of Arndt and Loewenstein (Archimedean technique) [132]. The density data for $CaCl_2$ (0% CaO) is ~1% higher than the recommended data set [1].

Limited electrical conductance results for the system $CaCl_2$–CaO are also reported in [132]. *Insufficient data for estimate.

$MgCl_2$ - MgO

Melt Preparation and Purification

Potter et al. [133] used reagent grade magnesium oxide. The $MgCl_2$ was prepared from purified anhydrous lead chloride. A slight excess of magnesium metal was added to the lead chloride in a bomb. The bomb was rotated for 1.5 hours at 725°C and then placed in an upright position to permit the lead–magnesium alloy to separate from the molten $MgCl_2$. The $MgCl_2$ was at least 99.7% pure. Spectrographic analysis indicated no alkali and alkaline earth metals Fe, Al, Cu, or B. Silicon and Pb were present in amounts less than 0.002%. The mixtures were melted in a porcelain crucible and then poured into the cell.

TABLE 397. Electrical conductance studies: $MgCl_2$ - MgO

Investigations critically examined			
Ref.	Mol % MgO	Temp. range (K)	Comments
133	1.8	1000–1240	fused silica cell; Pt electrodes; calibration: saturated NaCl

TABLE 398. $MgCl_2$ - MgO: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent MgO
	1.8
1000	1.027
1080	1.180
1160	1.332
1240	1.485

Temperature-dependent equation

$\kappa = a + bT$

Mol % MgO	a	$b \times 10^3$	standard error of estimate
1.8	-0.8793	1.9066	0.39%

These values are based on the data of Potter, St. Clair and Huber (classical ac method) [133]. Accuracy limits, ~±2%.

$NaCl - B_2O_3$

Melt Preparation and Purification

Kruh and Stern [130] used reagent grade boric oxide. The oxide was placed in a stainless steel beaker and heated to 900°C to remove residual water. After adding the sodium chloride, the mixture was stirred thoroughly and then allowed to stand so that air bubbles might escape.

TABLE 399. Viscosity studies: NaCl - B_2O_3

Investigations critically examined			
Ref.	Mol % B_2O_3	Temp. range (K)	Comments
130	98–100	873–1023	stainless steel container

TABLE 400. NaCl - B_2O_3: Viscosity (poise)

T(K)	Mol percent B_2O_3	
	99	98
870	2100	2000
930	880	790
990	410	340
1020	290	240

Temperature-dependent equations

$\eta = A \exp [E/RT]$

Mol % B_2O_3	$A \times 10^3$	E	standard error of estimate
99	3.2406	23130	12.08%
98	0.8572	25381	8.73%

These values are based on the data of Kruh and Stern (damped rotational method) [130]. Accuracy limits $\sim \pm 5\%$. For comparison of esults for B_2O_3, see Table 390 (comments).

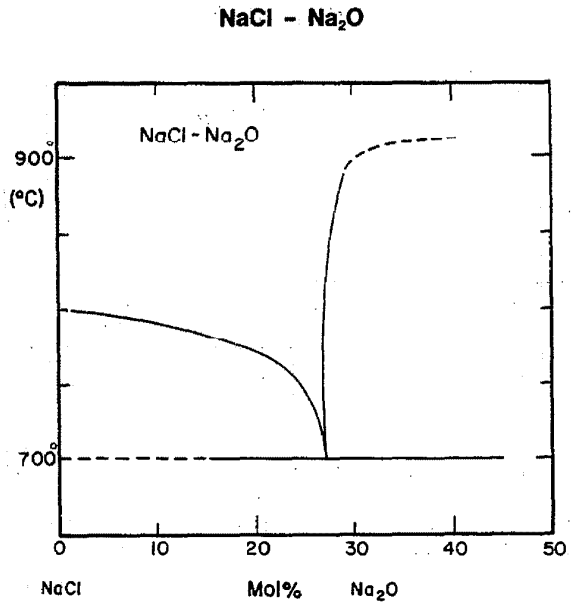

FIGURE 71. Phase diagram for NaCl - Na_2O.

Data from: W. Fischer and H. Abendroth, Z. anorg. u allgem. chem., 308, 103 (1961).

Melt Preparation and Purification

Volodin and Gorbunova [134] used reagent grade sodium chloride which was recrystallized twice from distilled water. The sodium oxide was obtained by reacting pure metallic sodium with reagent grade sodium hydroxide. Mixtures were prepared under an atmosphere of pure argon. The mixtures were evacuated and slowly heated to melting.

TABLE 401. Density studies: NaCl - Na_2O

Investigations critically examined			
Ref.	Mol % Na_2O	Temp. range (K)	Comments
134	0.1–0.9	1193	correction made for immersion depth and thermal expansion of capillary; calibration: molten NaCl

TABLE 402. NaCl - Na_2O Density (g cm^{-3})

Mol percent Na_2O	1193 K
0.9	1.534
0.8	1.540
0.7	1.534
0.6	1.519
0.5	1.500
0.4	1.481
0.3	1.467
0.2	1.461
0.1	1.468

Composition-dependent equation

$\rho = 1.493 - 0.346C + 1.074C^2 - 0.710C^3$

[C = Mol % Na_2O]

These values are based on the data of Volodin and Gorbunova (maximum bubble pressure method) data in graphical form [134]. The value for the density of NaCl at 1193 K calculated from the the above equation is in close agreement ($\sim \pm 1\%$) with the recommended density data base for NaCl [10].

TABLE 403. Surface tension studies: NaCl - Na_2O

Investigations critically examined			
Ref.	Mol % Na_2O	Temp. range (K)	Comments
134	0.1–0.72	1193–1263	correction made for immersion depth and thermal expansion of capillary; calibration: molten NaCl

TABLE 404. NaCl - Na_2O: Surface tension (dyn cm^{-1})

T(K)	Mol percent Na_2O				
	0.72	0.48	0.35	0.20	0.10
1190	130.0	116.3	57.4	91.7	100.5
1230	125.3	112.8	53.6	88.6	97.9
1270	120.6	109.2	49.7	85.4	95.3

Temperature-dependent equations

$$\gamma = a + bT$$

Mol percent Na_2O	a	$-b \times 10^3$
0.72	269.8	117.5
0.48	222.6	89.3
0.35	171.9	96.2
0.20	186.4	79.5
0.10	178.1	65.2
0.0	225.0	98.1

These values are based on the data of Volodin and Gorbunova (maximum bubble pressure method); data in equation form; precisions not estimated [134]. The results for NaCl (0% Na_2O) are in close accord ($\sim \pm 2\%$) with the recommended NaCl surface tension data set [10].

$HgBr_2$ - HgO

Melt Preparation and Purification

Jander and Brodersen [48] purified the $HgBr_2$ by sublimation. No information was given on the preparation of HgO.

TABLE 405. Electrical conductance studies: $HgBr_2$ - HgO

Investigations critically examined			
Ref.	Mol % HgO	Temp. range (K)	Comments
48	dilute solution range: HgO in $HgBr_2$ as solvent	515	Pt-Ir electrodes; Duran glass cell; calibration: 0.1 N KCl

Electrical conductance: Jander and Brodersen [48] reported the results in units of equivalent conductance; density data were not reported and the specific conductances cannot be calculated.

Halide - Sulfide, - Selenide, - Telluride

TABLE 406. Data Status

System	Phase Diagram	Electrical Conductance	Density	Viscosity	Surface Tension
$AgCl-Ag_2S$	X	X	X		
$-Ag_2Se$	X		X		
$-Ag_2Te$	X		X		
$CuCl-Cu_2S$	X	X	X		
$FeCl_2$-FeS	X	X	X		
$PbCl_2$-PbS	X	X	X		
$AgBr-Ag_2Te$			X		
$HgBr_2$-HgS		X			
-HgSe		X			
-HgTe		X			
$AgI-Ag_2S$			X		
$-Ag_2Te$			X		

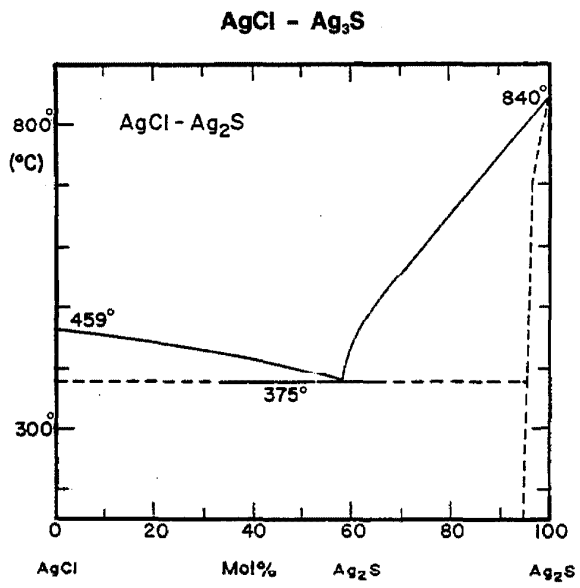

FIGURE 72. Phase diagram for AgCl – Ag_2S.

Data from: G. G. Urazov and M. A. Sokolova, Izv. Sekt. Fiz. Khim. Analiza, Inst. Obshch. Neorg. Khim., Akad. Nauk SSSR, **14**, 319 (1941); G. G. Urazov and L. A. Chelidze, ibid., **13**, 264 (1940).

TABLE 408. AgCl – Ag_2S: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent Ag_2S			
	89.94	47.83	40.00	20.00
730				3.0
850			8.8	3.5
910		17.5	14.2	3.8
970		21.8	16.6	4.2
1030	255.7	25.5		
1050	219.8	31.1		

Temperature-dependent equations

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

Mol % Ag_2S	a	$b \times 10^3$	$c \times 10^6$
89.94	966.9	-1040.7	340.0
77.2	1551.73	-2375.9	1000.4
47.83	-119.12	224.0	-81.2
40.0	-403.93	854.09	-433.6
35.0	25.55	-67.14	49.9
30.0	10.76	-26.35	21.3
20.0	2.24	-1.92	4.0
10.0	4.00	-4.18	4.3
5.0	0.40	4.0	
0.0	-1.58	10.70	-4.51

These values are based on the data of Bell and Flengas (classical ac method) [135], as cited in Clark [40]; data in graphical form; precisions not estimated. The results for AgCl (0% Ag_2S) have been advanced elsewhere in this series as the recommended data set [1]; accuracy limits, $\sim \pm 1.5\%$.

Melt Preparation and Purification

Bell and Flengas [135] prepared silver sulfide by precipitation from a boiling aqueous solution of reagent grade silver nitrate and sodium sulfide. The precipitate was thoroughly washed with distilled water and dried at 120°C. The product was further purified by treatment in a dry mixture of hydrogen sulfide and hydrogen at about 700°C. Small amounts of excess sulfur were then removed from this product by heating to about 150°C under vacuum. The product was analyzed by titration for silver with thiocyanate. The silver chloride was anhydrous reagent grade and was further dried under vacuum at 300°C. Blachnik and Alberts [136] used high purity AgCl. The Ag_2S was prepared by fusing together high purity Ag (99.99%) and sulfur which had been sublimed twice.

TABLE 407. Electrical conductance studies: AgCl – Ag_2S

Investigations critically examined			
Ref.	Mol % Ag_2S	Temp. range (K)	Comments
135	0–90	733–1193	silica cell; Pt electrodes

TABLE 409. Density studies: AgCl – Ag_2S

Investigations critically examined			
Ref.	Mol % Ag_2S	Temp. range (K)	Comments
135	0–98	770–1233	sinker made by sealing tungsten rod in silica glass tubing under vacuum; surface tension effects and volume of stem correction were negligible; Ar atmosphere.
136	0–100	773–1273	quartz dilatometer; tested with pure silver halides

TABLE 410. $AgCl - Ag_2S$: Density (g cm^{-3})

T(K)	Mol percent Ag_2S				
	85.50	65.59	39.14	30.01	5.70
770			5.66	5.48	4.99
970	6.43	6.07	5.51	5.33	4.82
1050	6.39	6.03	5.45	5.27	4.75
1210	6.31	5.96			

Temperature-dependent equations

$$\rho = a + bT$$

Mol percent Ag_2S	a	$-b \times 10^3$
97.98	9.4488	2.5997
85.50	6.9369	0.5199
78.31	6.8323	0.5500
65.59	6.5069	0.4500
53.44	6.5301	0.6701
39.14	6.2184	0.7300
32.30	6.1120	0.7399
30.01	6.0549	0.7501
20.37	6.0687	0.8700
5.70	5.6412	0.8500
0.0	5.5045	0.8698

These values are based on the data of Bell and Flengas (Archimedean technique); data in equation form; precisions not estimated [135]. The results for AgCl (0% Ag_2S) have been advanced elsewhere in this series as the recommended data set [1]; accuracy limits, $\sim \pm 0.5\%$.

AgCl - Ag_2Se

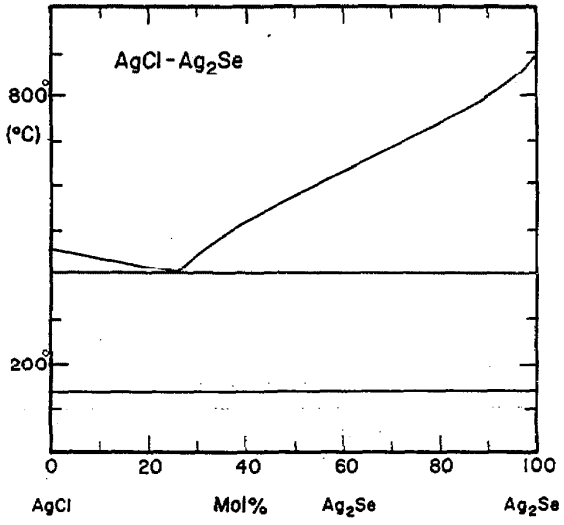

FIGURE 73. Phase diagram for AgCl - Ag_2Se.

Data from: R. Blachnik and G. Kudermann, Z. Naturforsch., 28b, 1 (1973).

Melt Preparation and Purification

Blachnik and Alberts [136] used high purity AgCl. The Ag_2Se was prepared by fusing the stoichiometric quantities of pure Ag (99.99%) and Se (99.999%) in a quartz ampoule. The mixtures were evacuated at 1000°C.

TABLE 411. Density studies: AgCl - Ag_2Se

Investigations critically examined

Ref.	Mol % Ag_2Se	Temp. range (K)	Comments
136	0–100	773–1273	see: AgCl–Ag_2S

TABLE 412. AgCl - Ag_2Se: Density (g cm^{-3})

T(K)	Mol percent Ag_2Se			
	70	50	40	10
970		6.17	5.90	5.02
1090	6.55	6.09	5.80	4.88
1210	6.49	6.00	5.70	4.75
1250	6.47	5.98	5.66	4.71

Temperature-dependent equations

$$\rho = a + bT$$

Mol percent Ag_2Se	a	$-b \times 10^3$
100	8.4199	0.9746
70	7.1012	0.5093
60	7.0975	0.6825
50	6.8537	0.7022
40	6.6984	0.8273
30	6.4121	0.8427
10	6.0941	1.1108
0	5.4719	0.8854

These values are based on the data of Blachnik and Alberts (dilatometric method); results in equation form; precisions not estimated [136]. For AgCl (0% Ag_2Se) the density data fall $\sim 1\%$ below the recommended values [1].

AgCl - Ag_2Te

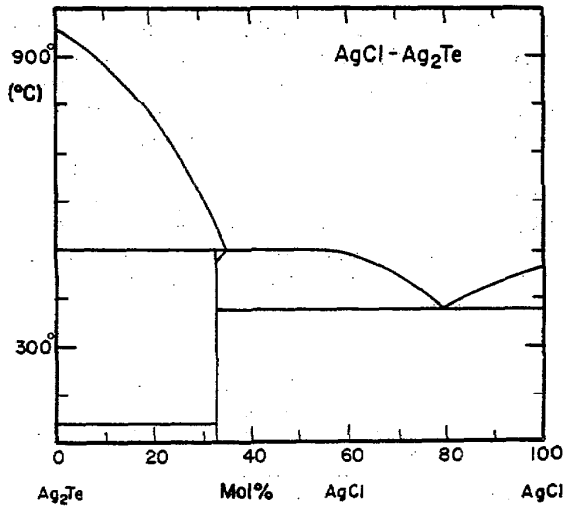

FIGURE 74. Phase diagram for AgCl - Ag_2Te.

Data from: Z. Bontschewa-Mladenowa, N. Abramov, and D. Rajkowa, Z. Anorg. allgem. Chem. 402, 306 (1973).

Melt Preparation and Purification

Blachnik and Alberts [136] used high purity silver chloride. The Ag_2Te was prepared by fusing the stoichiometric quantities of pure Ag (99.99%) and Te (99.999%) in a quartz ampoule. The mixtures were evacuated at 1000°C. Bontschewa Mladenowa et al. [137] prepared Ag_2Te by direct high temperature synthesis. The starting materials were refined silver (99.99%) and USSR tellurium, purified by two vacuum distillations. The AgCl was prepared by precipitation using silver nitrate and hydrochloric acid under subdued light.

TABLE 413. Density studies: AgCl – Ag_2Te

Investigations critically examined

Ref.	Mol % Ag_2Te	Temp. range (K)	Comments
137	0–100	770–1200	no details given
136	0–100	773–1273	see: AgCl–Ag_2S

TABLE 414. AgCl – Ag_2Te: Density (g cm^{-3})

T(K)	Mol percent Ag_2Te				
	85.00	67.00	40.00	25.00	10.00
770				5.77	5.20
850			6.20	5.70	5.13
970		6.84	6.10	5.60	5.04
1090	7.19	6.74	6.00	5.49	4.94
1250	7.07	6.61	5.86	5.35	4.82

Temperature-dependent equations

$$\rho = a + bT$$

Mol percent Ag_2Te	a	$-b \times 10^3$
100	8.4178	0.8125
85.00	8.0119	0.7577
77.50	7.9781	0.8807
67.00	7.6632	0.8465
55.00	7.4291	0.8967
40.00	6.9222	0.8465
32.50	6.6613	0.8281
25.00	6.4556	0.8868
17.50	6.2636	0.9538
10.00	5.8137	0.7993
7.36	5.8350	0.9400
3.04	5.5677	0.8638
0.0	5.4719	0.8854

These values are based on the data of Blachnik and Alberts (dilatometric method); data in equation form; precisions not estimated [136]. For AgCl (0% Ag_2Te) the density data values fall ~1% below the recommended data set [1].

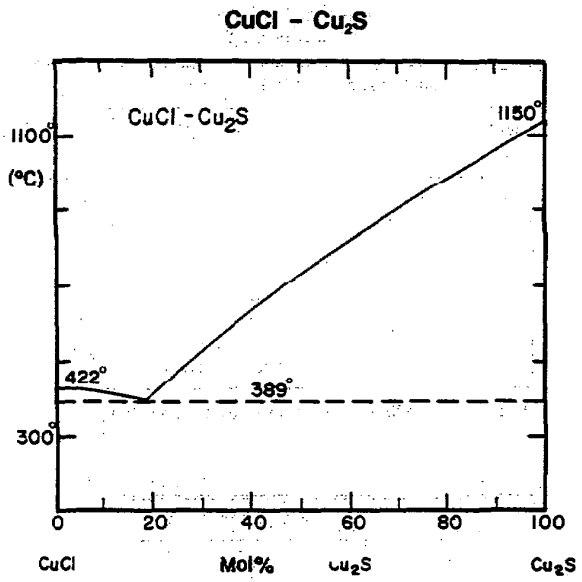

FIGURE 75. Phase diagram for CuCl – Cu_2S.

Data from: G. G. Urazov and L. A. Chelidze, Izv. Sektora Fiz.-Khim. Analiza, Inst. Obshch. Neorg. Khim., Akad. Nauk SSSR, 13, 266 (1940).

Melt Preparation and Purification

Garbee and Flengas [138] prepared anhydrous CuCl from an aqueous solution of cupric chloride by reduction with sulfurous acid. The precipitated CuCl was washed with anhydrous alcohol and was dehydrated by treatment under vacuum for several hours, followed by melting and sublimation in a stream of dry hydrogen chloride gas. Chemical analysis of the product indicated a purity of better than 99.7% by weight. Pure Cu_2S was prepared by direct reaction between stoichiometric amounts of hydrogen-reduced copper metal powder and sulfur which had been previously purified by sublimation. The reactants were charged to quartz ampoules which were then flame sealed under vacuum. The reaction was completed by heating at about 600°C for at least three days. Samples were prepared in a dry box filled with purified argon gas.

Yang et al. [139] prepared samples from the reagent grade salts by prefusing in a graphite crucible under a helium atmosphere. After measurements, the samples were analyzed for copper, sulfur and chlorine.

TABLE 415. Electrical conductance studies: CuCl - Cu_2S

Investigations critically examined

Ref.	Mol % Cu_2S	Temp. range (K)	Comments
139	60–100	1373–1700*	silica cell; graphite electrodes; alundum crucible
138	0–66	773–1273	quartz capillary cell; Ar atmosphere; calibration: 1*D* KCl; frequency: 3000 Hz

*Data above 1470 K were obtained by extrapolation.

TABLE 416. CuCl - Cu_2S: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent Cu_2S				
	65.2	36.0	26.0	19.2	9.3
770					3.29
890				3.48	3.47
970			3.73	3.72	3.48
1090		4.32	4.11	4.02	
1170	7.38	4.86	4.30	4.17	
1250	9.76	5.34	4.44		

Temperature-dependent equations

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

Mol % Cu_2S	*a*	*b* x 10^3	*c* x 10^6	standard error of estimate
65.2	-27.492	29.801		0.00%
50.6	-5.271	8.900		0.00%
36.0	-7.683	15.069	-3.72	0.04%
30.4	6.083	-5.721	3.65	0.03%
26.7	-17.137	34.340	-13.61	0.11%
26.0	-3.544	11.360	-3.98	0.60%
19.2	-1.597	8.151	-2.75	0.37%
16.2	1.640	2.080		0.15%
12.5	2.230	0.967	0.51	0.00%
9.3	-1.904	11.365	-5.99	0.00%
7.7	-6.287	18.806	-8.76	1.36%
3.5	-0.532	7.725	-3.43	0.16%
0.0	0.106	6.709	-2.89	0.37%

These values are based on the data of Garbee and Flengas (classical ac method) [**138**]. For CuCl (0% Cu_2S) the conductance data and the recommended data set [1] agree to within ±1.5%. Specific conductivity data for Cu_2S (0% CuCl) is also reported in [**138**] in the temperature range 1400–1470 K. The values are ~35% lower and less temperature dependent than the results by Yang, Pound, and Derge [243], and ~40% higher than those reported by Knacke and Strese [244].

TABLE 417. Density studies: CuCl - Cu_2S

Investigations critically examined

Ref.	Mol % Cu_2S	Temp. range (K)	Comments
138	0–70	684–1423	sinker made of tungsten rod in quartz glass; Ar atmosphere; correction made for condensation of salt on suspension wire

TABLE 418. CuCl - Cu_2S: Density (g cm^{-3})

T(K)	Mol percent Cu_2S				
	69.4	55.0	36.7	21.0	9.7
700					4.00
900				4.10	3.83
940				4.07	3.80
1060				3.966	
1180		4.41	4.21		
1260		4.38	4.17		
1300		4.37			
1340	4.55				
1420	4.52				

Temperature-dependent equations

$$\rho = a + bT$$

Mol percent Cu_2S	*a*	-*b* x 10^3
69.4	5.0206	0.3535
55.0	4.8082	0.3397
44.9	4.8889	0.5032
36.7	4.8723	0.5594
33.2	4.7148	0.4793
25.4	4.7106	0.6015
21.0	4.8453	0.8293
17.5	4.6461	0.8146
13.6	4.6601	0.7200
9.7	4.5956	0.8495
6.6	4.5128	0.8201
5.8	4.4748	0.8309
4.8	3.8300	0.0837
3.6	4.4484	0.8462
0.0	4.2995	0.7930

These values are based on the data of Garbee and Flengas (Archimedean technique); data in equation form; precisions not estimated [**138**]. For CuCl (0% Cu_2S), the density values agree with the recommended data set [1] to within ±0.5%.

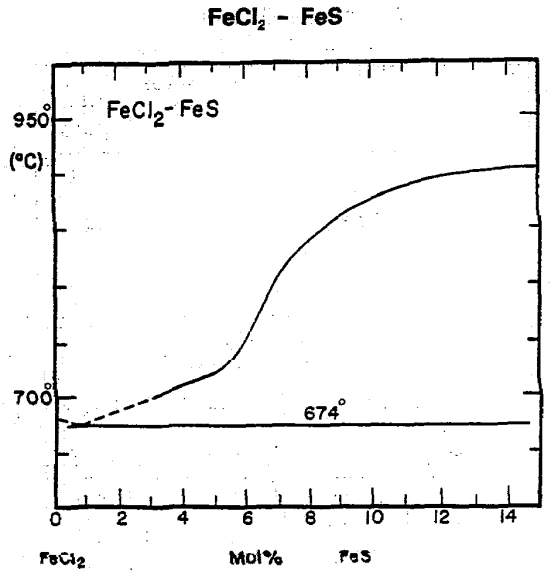

FIGURE 76. Phase diagram for $FeCl_2$ - FeS.

Data from: A. K. Garbee and S. N. Flengas, J. Electrochem. Soc. 119(5), 631 (1972).

Melt Preparation and Purification

Garbee and Flengas [138] prepared anhydrous $FeCl_2$ from reagent grade hydrated $FeCl_2$ which had been dried in a vacuum oven at 110°C for several days. The partly dehydrated solid was finely ground in a dry box filled with purified argon and then treated with dry HCl gas at about 500°C. The chemical analysis of the product corresponded to a 99.7% $FeCl_2$ content.

Stoichiometric FeS was prepared by reacting equivalent quantities of hydrogen reduced iron metal powder with sublimed sulfur in double-wall glass ampoules which were sealed under vacuum. After the initial violent reaction had subsided, the reaction cell was transferred to a furnace and heated to 600°C for a period of six days. The chemical analysis of the reaction product indicated an FeS composition between $FeS_{1.00}$ and $FeS_{1.01}$. Samples were handled in a dry box filled with purified argon gas.

TABLE 419. Electrical conductance studies: $FeCl_2$ - FeS

Investigations critically examined			
Ref.	Mol % FeS	Temp. range (K)	Comments
138	0–16	1000–1198	quartz capillary cell; Ar atmosphere; calibration: 1D KCl; frequency: 3000Hz

TABLE 420. $FeCl_2$ - FeS: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent FeS			
	15.53	14.41	9.26	4.86
1000	1.68	1.54	1.44	1.41
1090	2.00	1.84	1.60	1.58
1180	2.37	2.23	1.78	1.76

Temperature-dependent equations

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

Mol % FeS	a	$b \times 10^3$	$c \times 10^6$
15.53	1.376	-2.697	3.00
14.41	5.309	-10.221	6.45
9.26	0.486	0.173	0.78
4.86	-0.178	1.299	0.29
0.0	0.875	2.529	-0.28

These values are based on the data of Garbee and Flengas (classical ac method); data in graphical form; precisions not estimated [138]. The standard deviation for the $FeCl_2$ conductivities was ~0.4%. Accuracy limits, ~±1%. Other data for this system are not available.

TABLE 421. Density studies: $FeCl_2$ - FeS

Investigations critically examined			
Ref.	Mol % FeS	Temp. range (K)	Comments
138	0–9	958–1157	see: $CuCl-Cu_2S$

TABLE 422. $FeCl_2$ - FeS: Density (g cm^{-3})

T(K)	Mol percent FeS	
	8.4	5.4
1000		2.331
1100	2.282	2.275
1120	2.271	2.264
1140		2.253

Temperature-dependent equations

$$\rho = a + bT$$

Mol percent FeS	a	$-b \times 10^3$
8.4	2.8950	0.5573
5.4	2.8908	0.5594
0.0	2.8754	0.5550

These values are based on the data of Garbee and Flengas (Archimedean technique); data in equation form; precisions not estimated [138]. Accuracy limits, ~±0.5%.

$PbCl_2$ - PbS

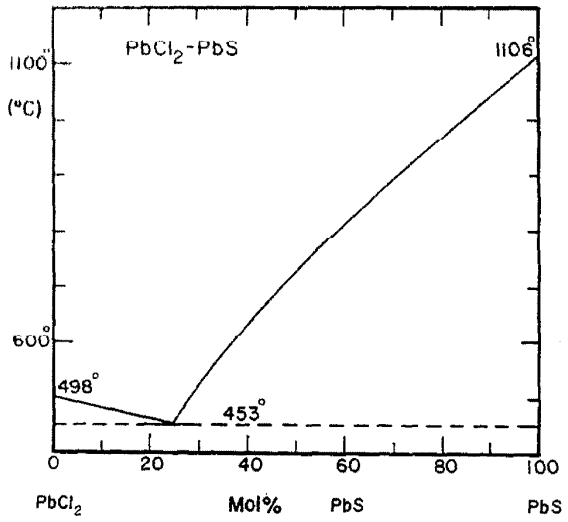

FIGURE 77. Phase diagram for $PbCl_2$ - PbS.

Data from: G. G. Urazov and M. A. Sokolova, Izv. Sektora, Fiz.-Khim. Analiza, Inst. Obshch. Neorg. Khim., Akad. Nauk SSSR, **14**, 318 (1941).

Melt Preparation and Purification

Bell and Flengas [**140**] prepared lead sulfide by the direct reaction of stoichiometric amounts of zone-refined hydrogen-reduced lead and distilled sulfur in sealed evacuated quartz capsules. Reagent grade lead chloride was heated under vacuum for several days, melted, and then filtered through a fritted Pyrex disk by applying an argon pressure to the upper compartment of the tube containing the melt. The tube was allowed to cool slowly, and translucent crystals from the outside of the tube were taken for use.

TABLE 423. Electrical conductance studies: $PbCl_2$ - PbS

Investigations critically examined			
Ref.	Mol % PbS	Temp. range (K)	Comments
140	0–46	773–1193	graphite electrodes; for high sulfide concentrations (melts unstable) silica ground joints were placed about 2 ins. above the capillary; calibration: 1*D* KCl

TABLE 424. $PbCl_2$ - PbS: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent PbS		
	46.00	32.71	16.03
770			1.19
850		0.94	1.23
970	0.85	1.00	1.28
1050	0.89	1.03	
1130	0.92	1.06	
1170	0.93		

Temperature-dependent equations

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

Mol % PbS	a	$b \times 10^3$	$-c \times 10^6$
46.00	0.283	0.732	0.15
44.61	0.289	0.741	0.15
39.32	0.337	0.758	0.17
35.94	0.373	0.769	0.18
32.71	0.402	0.804	0.20
26.89	0.488	0.842	0.22
25.20	0.502	0.865	0.23
18.64	0.609	0.896	0.26
16.03	0.620	0.972	0.30
10.58	0.715	0.966	0.30
2.79	0.877	0.965	0.30
0.0	0.846	11.520	0.41

These values are based on the data of Bell and Flengas (classical ac method); data in equation form; precisions not estimated [**140**]. The data for $PbCl_2$ (0% PbS) and the recommended data set [1] agree to within ±1%.

TABLE 425. Density studies: $PbCl_2$ - PbS

Investigations critically examined			
Ref.	Mol % PbS	Temp. range (K)	Comments
140	0–100	763–1473	see: $CuCl-Cu_2S$

TABLE 426. $PbCl_2$ – PbS: Density (g cm^{-3})

T(K)	Mol percent PbS			
	70.54	50.00	34.35	14.97
760				5.180
920				4.931
960			5.107	
1080		5.244	4.978	
1160		5.163		
1200	5.551	5.123		
1320	5.423			

Temperature-dependent equations

$\rho = a + bT$

Mol percent PbS	a	$-b \times 10^3$
100.0	6.991	0.54
70.54	6.823	1.06
50.00	6.335	1.01
34.35	6.134	1.07
14.97	6.366	1.56
0.00	5.395	1.50

These values are based on the data of Bell and Flengas (Archimedean technique); data in equation form; precisions not estimated [140]. The results for $PbCl_2$ (0% PbS) and the recommended data base [1] agree to within $\sim \pm 0.5\%$.

$AgBr - Ag_2Te$

Melt Preparation and Purification

Blachnik and Alberts [136] used high purity AgBr. For the method of preparation of Ag_2Te, see: AgCl–Ag_2Te.

TABLE 427. Density studies: AgBr – Ag_2Te

Investigations critically examined			
Ref.	Mol % Ag_2Te	Temp. range (K)	Comments
136	0–100	723–1273	see: AgCl–Ag_2S

TABLE 428. AgBr – Ag_2Te: Density (g cm^{-3})

T(K)	Mol percent Ag_2Te				
	80	68	50	30	10
780				6.227	5.628
940			6.593	6.077	5.498
1020		6.891	6.525	6.002	5.433
1140	7.069	6.785	6.422	5.890	5.335
1260	6.976	6.679	6.319	5.777	5.238

Temperature-dependent equations

$\rho = a + bT$

Mol percent Ag_2Te	a	$-b \times 10^3$
100	9.0430	0.8086
80	7.9529	0.7757
68	7.7926	0.8840
50	7.3999	0.8582
30	6.9582	0.9374
10	6.2609	0.8119
0	6.3212	1.0875

These values are based on the data of Blacknik and Alberts (dilatometric method); data in equation form; precisions not estimated [136]. The results for AgBr (0% Ag_2Te) and the recommended data set [1] agree to within $\sim \pm 0.5\%$.

$HgBr_2 - HgS$

Melt Preparation and Purification

Jander and Brodersen [48] purified the $HgBr_2$ by sublimation. No information was given on the preparation of HgS.

TABLE 429. Electrical conductance studies: $HgBr_2$ – HgS

Investigations critically examined			
Ref.	Mol % HgS	Temp. range (K)	Comments
48	dilute solution range: HgS in $HgBr_2$ as solvent	515	see: $HgBr_2$–HgO

Electrical conductance: $HgBr_2$–HgS. Jander and Brodersen [48] reported the results in units of equivalent conductance; density data were not reported and specific conductance cannot be calculated.

$HgBr_2 - HgSe$

Melt Preparation and Purification

Jander and Brodersen [48] purified the $HgBr_2$ by sublimation. No information was given on the preparation of HgSe.

TABLE 430. Electrical conductance studies: $HgBr_2$ - HgSe

Investigations critically examined			
Ref.	Mol % HgSe	Temp. range (K)	Comments
48	dilute solution range: HgSe in $HgBr_2$ as solvent	515	see: $HgBr_2$-HgO

Electrical conductance: $HgBr_2$HgSe. Jander and Brodersen [48] reported the results in units of equivalent conductance; density data were not reported and specific conductance cannot be calculated.

$HgBr_2$ - HgTe

Melt Preparation and Purification

Jander and Brodersen [48] purified the $HgBr_2$ by sublimation. No information was given on the preparation of HgTe.

TABLE 431. Electrical conductance studies: $HgBr_2$ - HgTe

Investigations critically examined			
Ref.	Mol % HgTe	Temp. range (K)	Comments
48	dilute solution range: HgTe in $HgBr_2$ as solvent	515	see: $HgBr_2$-HgO

Electrical conductance: $HgBr_2$-HgTe. Jander and Brodersen [48] reported the results in units of equivalent conductance; density data were not reported and specific conductance cannot be calculated.

AgI - Ag_2S

Melt Preparation and Purification

Blachnik and Alberts [136] used high purity AgI. For the method used to prepare Ag_2S, see: AgCl - Ag_2S.

TABLE 432. Density studies: AgI - Ag_2S

Investigations critically examined			
Ref.	Mol % Ag_2S	Temp. range (K)	Comments
136	0-100	873-1273	see: AgCl-Ag_2S

TABLE 433. AgI - Ag_2S: Density (g cm^{-3})

T(K)	Mol percent Ag_2S				
	80	65	50	30	15
970					5.631
1050				5.729	5.567
1090			5.980	5.692	5.535
1130	6.375	6.187	5.952	5.655	5.503
1250	6.259	6.047	5.868	5.544	5.406

Temperature-dependent equations

$$\rho = a + bT$$

Mol percent Ag_2S	a	$-b \times 10^3$
100	7.5350	0.9149
80	7.4651	0.9646
65	7.5082	1.1690
50	6.7416	0.6987
40	6.7956	0.8549
30	6.7032	0.9274
15	6.4086	0.8018
0	6.4109	1.0175

These values are based on the data of Blachnik and Alberts (dilatometric method); data in equation form; precisions not estimated [136]. The densities for AgI (0% Ag_2S) and the recommended AgI density data set [1] agree to within $\sim \pm 0.3\%$.

AgI - Ag_2Te

Melt Preparation and Purification

For the method used by Blachnik and Alberts [136] see: AgI-Ag_2S and AgCl-Ag_2Te.

TABLE 434. Density studies: AgI - Ag_2Te

Investigations critically examined			
Ref.	Mol % AgI	Temp. range (K)	Comments
136	0-100	873-1273	see: AgCl-Ag_2S

TABLE 435. AgI – Ag_2Te: Density (g cm^{-3})

T(K)	Mol percent Ag_2Te				
	80	60	30	20	10
920					5.750
1000				5.869	5.668
1040			6.136	5.836	5.627
1080			6.101	5.803	5.586
1120	7.085	6.654	6.065	5.770	5.544
1240	7.001	6.568	5.958	5.672	5.421

Temperature-dependent equations

$$\rho = a + bT$$

Mol percent AgTe	a	$-b \times 10^3$
100	8.4178	0.8125
80	7.8607	0.6930
60	7.4642	0.7231
50	7.4962	0.9192
30	7.0626	0.8905
20	6.6858	0.8173
10	6.6967	1.0289
0	6.4109	1.0175

These values are based on the data of Blachnik and Alberts (dilatometric method); data in equation form; precisions not estimated [136]. The densities of AgI (0% Ag_2Te) and the recommended AgI density data set agree to within ~±0.3%.

Halide - Other

TABLE 436. Data Status

System	Phase Diagram	Electrical Conductance	Density	Viscosity	Surface Tension
BaF_2–$CaSiO_3$					X
CaF_2–$CaSiO_3$	X	X	X		X
KF–$CaSiO_3$					X
LiF–$CaSiO_3$					X
MgF_2–$CaSiO_3$					X
NaF–$CaSiO_3$					X
$CaCl_2$–$CaMoO_4$			X		
LiCl–$CaCrO_4$		X			
–KCl–$CaCrO_4$		X			
NaCl–NaOH	X		X	X	
NaBr–Na_2CrO_4	X	X	X		

BaF_2 - $CaSiO_3$

Melt Preparation and Purification

Ejima and Shimoji [141] used reagent grade materials (99.9% purity BaF_2, 98.5% for CaO) and transparent quartz powder (99.8 % purity). Samples of the desired composition were made by pre-melting mixtures for thirty minutes in a purified argon stream followed by quenching the melt.

TABLE 437. Surface tension studies: BaF_2 - $CaSiO_3$

Investigations critically examined

Ref.	Mol % $CaSiO_3$	Temp. range (K)	Comments
141	85–100	1823	Pt crucible; Pt–10% Rh capillary; analysis ±0.5% for fluoride composition in melt after quenching

TABLE 438. BaF_2 - $CaSiO_3$: Surface tension (dyn cm^{-1})

Mol percent $CaSiO_3$	1823 K
100	485
98	458
94	410
90	369
86	334

Composition-dependent equation

$\gamma = 1221.0 - 28.37C + 0.210C^2$

[C = Mol % $CaSiO_3$]

These values are based on the data of Ejima and Shimoji (maximum bubble pressure method); data in graphical form; precisions not estimated [141]. Accuracy limits, $-\pm 1.5\%$. For $CaSiO_3$ (0% BaF_2), the surface tension is higher than those of the other workers; at 1823 K, the deviations are as follows: Popel and Esin [245], ~2%; Cooper and Kitchener [246], ~8%; Ono et al., [247], ~13; and King [248], ~18%.

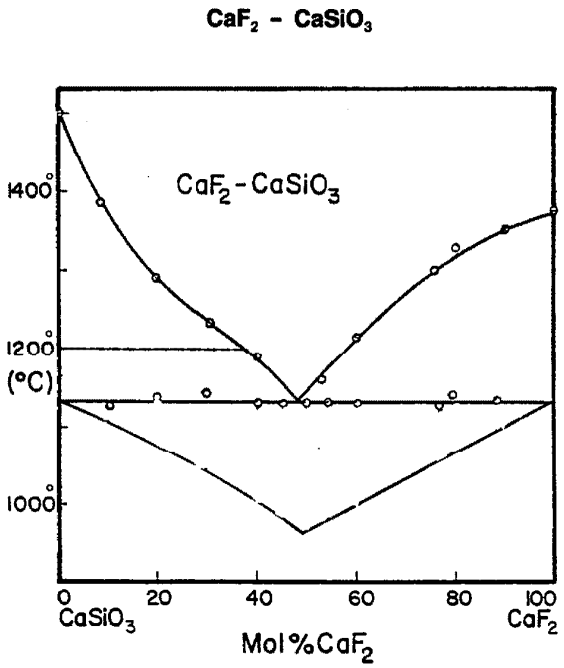

FIGURE 78. Phase diagram for CaF_2 - $CaSiO_3$.

Data from: D. Karandeeff, Z. Anorg. Chem. 68, 188 (1910).

Melt Preparation and Purification

For the method of melt preparation used by Ejima and Shimoji [141] see: BaF_2 - $CaSiO_3$. No details given in [142].

TABLE 439. Electrical conductance studies: CaF_2 - $CaSiO_3$

Investigations critically examined			
Ref.	Mol % $CaSiO_3$	Temp. range (K)	Comments
142	0–100	1748–1833	No details given

Specific conductance: Starkova, Starkov, and Sryvalin [142] give the following observations: the variation of electrical conductivity with concentration and temperature is stated to indicate the absence of abrupt structural changes up to ~20 mol % metasilicate at 1748 K, and ~30 mol % at 1833 K. Further increases in the metasilicate proportion produces sharp changes in the temperature dependence slope of the electrical conductivity; results not reported numerically or graphically.

TABLE 440. Density studies: CaF_2 - $CaSiO_3$

Investigations critically examined			
Ref.	Mol % $CaSiO_3$	Temp. range (K)	Comments
141	85–100	1823	calculated values
142	0–100	1748–1833	no details given

TABLE 441. CaF_2 - $CaSiO_3$: Density (g cm^{-3})

Mol percent $CaSiO_3$	1823 K
100	1.67
95	1.65
90	1.62
85	1.59

Composition-dependent equation

$\rho = 1.100 + 0.574 \times 10^{-2}C$

[C = Mol % $CaSiO_3$]

These values are based on the data of Ejima and Shimoji (maximum bubble pressure method); data in graphical form; precisions not estimated [141]. Accuracy limits, $\sim\pm 2\%$.

TABLE 442. Surface tension studies: CaF_2 - $CaSiO_3$

Investigations critically examined			
Ref.	Mol % $CaSiO_3$	Temp. range (K)	Comments
141	88–100	1823	Pt crucible; Pt-10% Rh capillary; analysis ±0.5% for fluoride composition in melt after quenching

TABLE 443. CaF_2 - $CaSiO_3$: Surface tension (dyn cm^{-1})

Mol percent $CaSiO_3$	1823 K
100	485
98	464
94	429
90	401
88	389

Composition-dependent equation

$$\gamma = 1560.2 - 31.962C + 0.212C^2$$

[C = Mol % $CaSiO_3$]

These values are based on the data of Ejima and Shimoji (maximum bubble pressure method); data in graphical form; precisions not estimated [141]. Accuracy limits, $\sim\pm1.5\%$. See also: Table 437 and comments.

KF - $CaSiO_3$

Melt Preparation and Purification

For the method of melt preparation used by Ejima and Shimoji [141] see: BaF_2 - $CaSiO_3$.

TABLE 444. Surface tension studies: KF - $CaSiO_3$

Investigations critically examined

Ref.	Mol % $CaSiO_3$	Temp. range (K)	Comments
141	85-100	1823	Pt crucible; Pt-10% Rh capillary; analysis $\pm0.5\%$ for fluoride composition in melt after quenching.

TABLE 445. KF - $CaSiO_3$: Surface tension (dyn cm^{-1})

Mol percent $CaSiO_3$	1823 K
100	485*
95	369
90	315
85	277

Composition-dependent equation

$$\gamma = 1978 - 46.24C + 0.3085C^2$$

[C = Mol % $CaSiO_3$]

These values are based on the data of Ejima and Shimoji (maximum bubble pressure method); data in graphical form; precisions not estimated [141]. Accuracy limits, $\sim\pm1.5\%$. See also: Table 437 and comments.

*The value for 100% $CaSiO_3$ in Table 445 (above) is from the graphical interpolation; the value from the curvefitting equation is 439.

LiF - $CaSiO_3$

Melt Preparation and Purification

For the method of melt preparation used by Ejima and Shimoji [141] see: BaF_2 - $CaSiO_3$.

TABLE 446. Surface tension studies: LiF - $CaSiO_3$

Investigations critically examined

Ref.	Mol % $CaSiO_3$	Temp. range (K)	Comments
141	83-100	1823	Pt crucible; Pt-10% Rh capillary; analysis $\pm0.5\%$ for fluoride composition *in melt after quenching.*

TABLE 447. LiF - $CaSiO_3$: Surface tension (dyn cm^{-1})

Mol percent $CaSiO_3$	1823 K
95	454
90	424
85	395

Composition-dependent equation

$$\gamma = 43.61 + 2.554C + 18.59 \times 10^{-3}C^2$$

[C = Mol % $CaSiO_3$]

These values are based on the data of Ejima and Shimoji (maximum bubble pressure method); data in graphical form; precisions not estimated [141]. Accuracy limits, $\sim\pm1.5\%$. See also: Table 437 and comments.

MgF_2 - $CaSiO_3$

Melt Preparation and Purification

For the method of melt preparation used by Ejima and Shimoji [141] see: BaF_2 - $CaSiO_3$.

TABLE 448. Surface tension studies: MgF_2 - $CaSiO_3$

Investigations critically examined

Ref.	Mol % $CaSiO_3$	Temp. range (K)	Comments
141	85-100	1823	Pt crucible; Pt-10% Rh capillary; analysis $\pm0.5\%$ for fluoride composition in melt after quenching

TABLE 449. MgF_2 - $CaSiO_3$: Surface tension (dyn cm^{-1})

Mol percent $CaSiO_3$	1823 K
100	485
95	460
90	427
85	386

Composition-dependent equation
$\gamma = -1634.1 + 38.38C - 0.172C^2$
$[C$ = Mol % $CaSiO_3]$

These values are based on the data of Ejima and Shimoji (maximum bubble pressure method); data in graphical form; precisions not estimated [141]. Accuracy limits, $\sim\pm1.5\%$. See also: Table 437 and comments.

NaF - $CaSiO_3$

Melt Preparation and Purification

For the method of melt preparation used by Ejima and Shimoji [141] see: BaF_2 - $CaSiO_3$.

TABLE 450. Surface tension studies: NaF - $CaSiO_3$

Investigations critically examined			
Ref.	Mol % $CaSiO_3$	Temp. range (K)	Comments
141	80–100	1823	Pt crucible; Pt–10% Rh capillary; analysis ±0.5% for fluoride composition in melt after quenching

TABLE 451. NaF - $CaSiO_3$: Surface tension (dyn cm^{-1})

Mol percent $CaSiO_3$	1823 K
100	485
95	434
90	389
85	350
80	320

Composition-dependent equation
$\gamma = 836.9 - 18.32C + 0.1482C^2$
$[C$ = Mol % $CaSiO_3]$

These values are based on the data of Ejima and Shimoji (maximum bubble pressure method); data in graphical form; precisions not estimated [141]. Accuracy limits, $\sim\pm1.5\%$. See also: Table 437 and comments.

$CaCl_2$ - $CaMoO_4$

Melt Preparation and Purification

Khlebnikov and Nadolskii [143] prepared the samples by placing 50-60 g of the $CaCl_2$ - $CaMoO_4$ mixture in a platinum crucible and heating it in an electric furnace. After fusion the mixture was stirred to dissolve the $CaMoO_4$.

TABLE 452. Density studies: $CaCl_2$ - $CaMoO_4$

Investigations critically examined			
Ref.	Mol % $CaMoO_4$	Temp. range (K)	Comments
143	1.6–9.7	1073	Pt float; temperature controlled to ±3°C.

TABLE 453. $CaCl_2$ - $CaMoO_4$: Density (g cm^{-3})

Mol percent $CaMoO_4$	1073 K
9.0	2.185
6.0	2.132
3.0	2.079
2.0	2.061
0.0	2.026

Composition-dependent equation
$\rho = 2.0257 + 0.01774C$
$[C$ = Mol % $CaMoO_4]$
Standard error of estimate = 0.30%

These values are based on the data of Khlebnikov and Nadolskii (Archimedean technique) [143]. The result for $CaCl_2$ (0% $CaMoO_4$) falls 2% below the value from the recommended data set [1].

LiCl - $CaCrO_4$

Melt Preparation and Purification

Clark and Goldsmith [144] used reagent grade lithium chloride which was vacuum dried for 16 hours at 120°C. The $CaCrO_4$ was prepared from reagent grade $CaCl_2$ and K_2CrO_4. All work was conducted in a controlled atmosphere dry room.

TABLE 454. Electrical conductance studies: LiCl - $CaCrO_4$

Investigations critically examined			
Ref.	Mol % $CaCrO_4$	Temp. range (K)	Comments
144	6.36	863–973	magnesia dip-type cell; cylindrical Pt electrodes; porcelain crucible; calibration: LiCl–KCl eutectic; estimated experimental uncertainty: ±2%

TABLE 455. LiCl - $CaCrO_4$: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent $CaCrO_4$
	6.36
860	2.11
900	2.20
940	2.31
970	2.41

Temperature-dependent equation

$\kappa = 5.657 - 10.161 \times 10^{-3}T + 7.02 \times 10^{-6}T^2$

Standard error of estimate = 0.39%

These values are based on the data of Clark (classical ac method) [144]. Accuracy limits, $\sim \pm 2\%$. The LiCl conductance data, measured as a calibration cross check, agreed with the recommended data base [5] to within $\pm$ 1%.

LiCl - KCl - $CaCrO_4$

Melt Preparation and Purification

Clark and Goldsmith [144] used reagent grade LiCl and KCl which was vacuum dried for 16 hours at 120°C. Water, oxide, hydroxyl ions and heavy metal impurities were removed from the mixture. The $CaCrO_4$ was prepared from reagent grade $CaCl_2$ and K_2CrO_4.

TABLE 456. Electrical conductance studies: LiCl - KCl - $CaCrO_4$

Investigations critically examined			
Ref.	Mol. percent LiCl-KCl-$CaCrO_4$	Temp. range (K)	Comments
144	81.3 7.7 11.0 73.7 19.0 7.3 52.8 36.6 10.6 44.2 47.6 8.2 33.6 57.3 9.1	763–973	see: LiCl-$CaCrO_4$

TABLE 457. LiCl - KCl - $CaCrO_4$: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent $CaCrO_4$				
	11.0	10.6	9.1	8.2	7.3
760				0.459	0.426
820	0.920	0.407	0.308	0.632	0.533
910	1.118	0.529	0.468	0.861	0.716
970	1.263	0.617	0.596	0.993	0.852

Temperature-dependent equations

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

Mol % $CaCrO_4$	a	$-b \times 10^3$	$c \times 10^6$	standard error of estimate
11.0	0.1816	0.2687	1.426	0.32%
10.6	-0.0275	0.2071	0.899	1.85%
9.1	0.6052	2.2930	2.354	0.25%
8.2	-3.1603	-6.5009	-2.288	1.44%
7.3	0.1038	0.8318	1.653	1.08%

These values are based on the data of Clark (classical ac method) [144]. Accuracy limits, $\sim \pm 2\%$. For calibration cross-check comparison, see: Table 453 and comments.

NaCl - NaOH

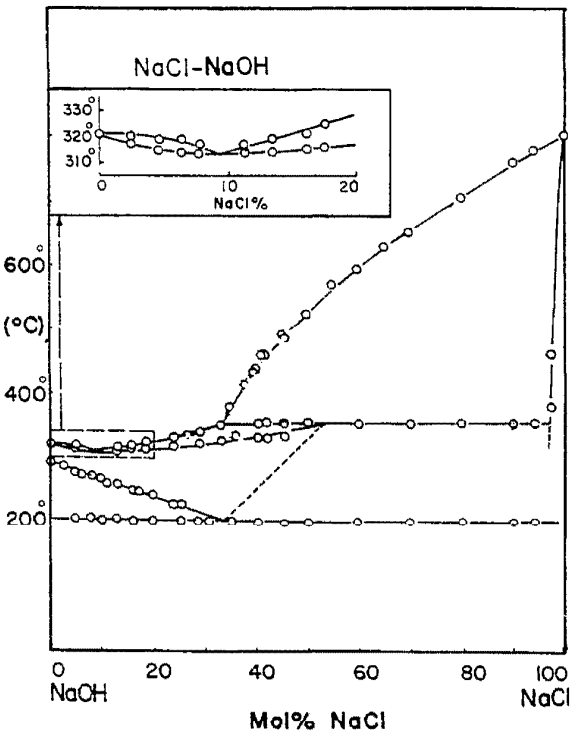

FIGURE 79. Phase diagram for NaCl - NaOH.

Data from: R. Cohen-adad, C. Ruby, and M. J. Pichon, Compt. Rend. **260**, 2200 (1965).

Melt Preparation and Purification

Lasek [**145**] used high purity sodium hydroxide. Samples were analyzed for Na_2CO_3 content gravimetrically.

TABLE 458. Density studies: NaCl - NaOH

Investigations critically examined

Ref.	Mol % NaOH	Temp. range (K)	Comments
145	80–95	693	steel sphere; calibration: molten KNO_3

TABLE 459. NaCl - NaOH: Density (g cm^{-3})

Mol percent NaOH	693 K
100	1.737
95	1.737
90	1.737
85	1.737
80	1.737

These values are based on the data of Lasek (Archimedean technique) [**145**]. The density value for NaOH (100%) at 693 K from the recommended data base [1] is 1.736, i.e., the values are in essential agreement.

TABLE 460. Viscosity studies: NaCl - NaOH

Investigations critically examined

Ref.	Mol % NaOH	Temp. range (K)	Comments
145	80–95	693	calibration: sucrose solution

TABLE 461. NaCl - NaOH: Viscosity (cp)

Mol percent NaOH	693 K
100	2.30
95	2.43
90	2.55
85	2.65
80	2.74

Composition-dependent equation

$$\eta = 2.3173 + 2.722 \times 10^{-2}C - 0.2742 \times 10^{-3}C^2$$

[C = Mol % NaOH]

Standard error of estimate = 0.34%

These values are based on the data of Lasek (torsional method) [**145**]. The viscosity value for NaOH (0% NaCl) at 693 K from the recommended data base [1] is 2.51 cp, i.e., the observed [145] falls within the estimated accuracy limits (±5%).

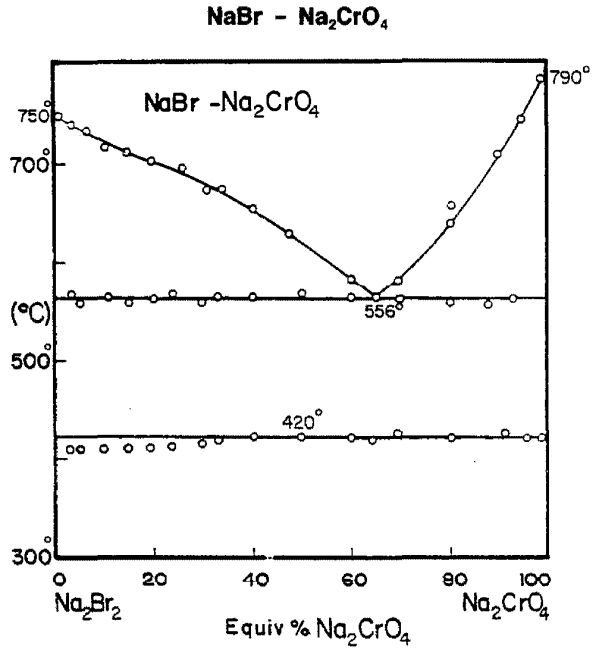

FIGURE 80. Phase diagram for NaBr – Na_2CrO_4.

Data from: G. A. Bukhalova, Z. N. Topshinoeva, V. G. Akhtyrskii, and V. I. Snezhkov, Russ. J. Inorg. Chem. 19(2), 282 (1974).

TABLE 463. NaBr – Na_2CrO_4: Specific conductance ($ohm^{-1}cm^{-1}$)

Mol percent Na_2CrO_4	1033 K	1073 K	1113 K
100		2.01	2.19
90		2.14	2.31
70	2.22	2.39	2.55
50	2.41	2.61	2.78
30	2.68	2.83	2.98
10	3.06	3.02	3.17
0	3.08	3.12	3.26

Composition-dependent equation

$$\kappa = a + bC + cC^2$$

[C = Mol % Na_2CrO_4]

T(K)	a	$-b \times 10^2$	$c \times 10^4$
1033	3.280	2.343	1.19
1073	3.116	0.905	-0.20
1113	3.261	0.863	-0.21

These values are based on the data of Bukhalova, Topshinoeva, Akhtyrskii, and Snezhkov (classical ac method); data in graphical form; precisions not estimated [146]. The results for NaBr (0% Na_2CrO_4) are ~ 3% higher than the recommended data set [1]. no previous results for Na_2CrO_4 (0% NaBr) have been reported.

TABLE 464. Density studies: NaBr – Na_2CrO_4

Investigations critically examined

Ref.	Mol % Na_2CrO_4	Temp. range (K)	Comments
146	0–100	1033–1113	Pt ball

Melt Preparation and Purification

Bukhalova et al. [146] used reagent grade salts to prepare the melt.

TABLE 462. Electrical conductance studies: NaBr – Na_2CrO_4

Investigations critically examined

Ref.	Mol % Na_2CrO_4	Temp. range (K)	Comments
146	0–100	1033–1113	quartz U-type cell; calibration: molten KCl.

TABLE 465. NaBr – Na_2CrO_4: Density (g cm^{-3})

Mol percent Na_2CrO_4	1033 K	1073 K	1113 K
100	2.33	2.30	2.26
90	2.34	2.31	2.28
50	2.35	2.32	2.29
10	2.28	2.26	2.24
0	2.25	2.24	2.22

Composition-dependent equation

$$\rho = a + bC + cC^2$$

[C = Mol % Na_2CrO_4]

T(K)	a	$b \times 10^2$	$-c \times 10^4$
1033	2.253	0.3044	0.23
1073	2.238	0.262	0.20
1113	2.215	0.252	0.20

These values are based on the data of Bukhalova, Topshinoeva, Akhtyrskii and Snezhkov (Archimedean technique); data in graphical form; precisions not estimated [146]. The results for NaBr (0% Na_2CrO_4) fall ~ 2% below the recommended data set [1].

Section B: Systems Containing An Oxide

TABLE 466. Data Status

System	Phase Diagram	Electrical Conductance	Density	Viscosity	Surface Tension
Al_2O_3–K_3AlF_6	X	X			
–Li_3AlF_6			X		
–Li_2CO_3					X
–Na_3AlF_6	X	X	X	X	X
–Na_3AlF_6–SiO_2	X	X	X		
B_2O_3–Cs_2CO_3				X	
–$K_2B_4O_7$				X	
–K_2CO_3				X	
–Li_2CO_3				X	X
–Na_3AlF_6				X	
–$Na_2B_4O_7$			X	X	X
–Na_2CO_3				X	
–$NaPO_3$		X		X	
–Rb_2CO_3				X	
Bi_2O_3–$K_2B_4O_7$			X		
–KPO_3			X		
–$Na_2B_4O_7$			X		
–$NaPO_3$			X		
CaO–CaC_2				X	
–SiO_2			X		
Fe_2O_3–CaC_2				X	
–Li_2CO_3					X
K_2O–$Zn(PO_3)_2$	X		X		X
Li_2O–Li_2CO_3					X
MoO_3–K_2MoO_4	X	X	X		X
–Li_2MoO_4		X	X		X
–Na_2MoO_4		X	X		X
Na_2O–$Zn(PO_3)_2$	X		X		X
NiO–$K_2B_4O_7$			X	X	
–KPO_3			X	X	
–$Na_2B_4O_7$			X		
–$NaPO_3$			X		
PbO–$K_2B_4O_7$			X		
–KPO_3			X		
–$Na_2B_4O_7$			X		
–$NaPO_3$			X		
–$PbMoO_4$		X	X		X
Sb_2O_3–$CaSb_2O_4$		X			
–$CaSb_2O_6$		X			
–$Ca_4Sb_8O_{23}$		X			
SiO_2–CaC_2				X	
–Li_2CO_3					X
–Na_3AlF_6		X	X		
Ta_2O_5–K_2TaF_7		X			
TiO_2–K_2TiF_6		X			
–Na_2TiF_6			X		
Tl_2O_3–Li_2CO_3					X
V_2O_5–KVO_3		X	X	X	X
–$NaVO_3$	X	X	X	X	
WO_3–KPO_3		X	X		
–K_2WO_4		X	X		X
–Li_2WO_4		X	X		X
–$Na_2B_4O_7$	X	X	X	X	X
–$NaPO_3$		X	X		
–$Na_4P_2O_7$		X	X	X	X
–Na_2WO_4		X	X		X
ZnO–KPO_3	X		X		X
–$NaPO_3$			X		X
–$Zn(PO_3)_2$					X

Al_2O_3 - K_3AlF_6

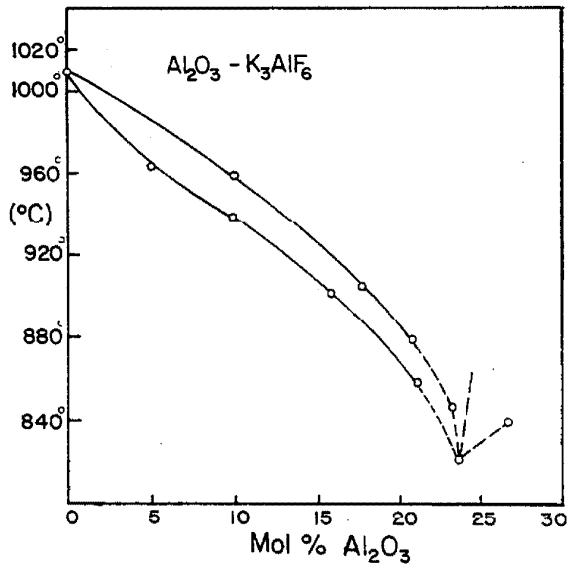

FIGURE 81. Phase diagram for Al_2O_3 - K_3AlF_6.

Data from: A. I. Belyaev, M. B. Rappaport, and L. A. Firsanova, Elektrometallurgia Alyuminia, Metallurgizdat, Moscow, 1953.

Melt Preparation and Purification

Batashev and Zhurin [147] used reagent grade KF, AlF_3 and Al_2O_3. The salts were dried in a Pt beaker and dehydrated in a furnace at a temperature of 880–900°C. The AlF_3 was purified by sublimation.

TABLE 467. Electrical conductance studies: Al_2O_3 - K_3AlF_6

Investigations critically examined

Ref.	Mol percent K_3AlF_6	Temp. range (K)	Comments
147	69.11–88.24	1233–1323	Pt electrodes and crucible; calibration: molten KCl

TABLE 468. Al_2O_3 - K_3AlF_6: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent K_3AlF_6		
	88	78	69
1230			2.00
1250		2.19	2.05
1270	2.37	2.26	2.11
1300	2.50	2.36	2.21
1320	2.59	2.42	2.29

Temperature–dependent equations

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

Mol % K_3AlF_6	$-a$	$b \times 10^3$	$c \times 10^6$	standard error of estimate
100	13.859	13.006		0.00%
88	3.199	4.386		0.24%
78	1.872	3.253		0.44%
69	-6.273	-9.731	5.084	0.83%

These values are based on the data of Batashev and Zhurin (classical ac method) [147]. The values for K_3AlF_6 (0% Al_2O_3) are ~35% higher than the recommended data set [4], and the values reported elsewhere by Markov and Prisyazhnyi [249]. The values for KF in [147] are ~8% higher than the recommended KF data set [1]. The accuracy limits assigned to the latter set are ~±12%.

Al_2O_3 - Li_3AlF_6

Melt Preparation and Purification

No information on melt preparation and purification in references [104].

TABLE 469. Density studies: Al_2O_3 - Li_3AlF_6

Investigations critically examined

Ref.	Mol % Li_3AlF_6	Temp. range (K)	Comments
104	94–100	1223–1323	Pt sinker

TABLE 470. Al_2O_3 - Li_3AlF_6: Density (g cm^{-3})

T(K)	Mol percent Li_3AlF_6	
	97	94
1220	2.014	2.007
1260	1.981	1.975
1300	1.947	1.943
1320	1.930	1.928

Temperature-dependent equations

$\rho = a + bT$

Mol % Li_3AlF_6	a	$b \times 10^3$	standard error of estimate
100	3.0475	0.8400	0.00%
97	3.0466	0.8460	0.00%
94	2.9730	0.7920	0.00%

These values are based on the data of Matiasovsky (Archimedean technique) [104]. The density data for Li_3AlF_6 (0% Al_2O_3), advanced elsewhere as the recommended data set [4], are from the same laboratory.

Al_2O_3 - Li_2CO_3

Melt Preparation and Purification

Moiseev and Stepanov [148] used reagent grade salts to prepare the melts. The lithium carbonate was heated in a CO_2 atmosphere at 500–600°C for several hours and then stored in a desiccator.

TABLE 471. Surface tension studies: Al_2O_3 - Li_2CO_3

Investigations critically examined

Ref.	Mol % Li_2CO_3	Temp. range (K)	Comments
148	93–100	1038	Pt capillary; dry N_2 and CO_2 atmosphere

TABLE 472. Al_2O_3 - Li_2CO_3: Surface tension (dyn cm^{-1})

Mol percent Li_2CO_3	1038 K
100	242
99	247
97	256
95	257
93	249

Composition-dependent equation

$\gamma = -8753.7 + 188.04C - 0.981C^2$

[C = Mol % Li_2CO_3]

These values are based on the data of Moiseev and Stepanov (maximum bubble pressure method); data in graphical form; precisions not estimated [148]. The value for Li_2CO_3 (0% Al_2O_3) at 1038 K and that from the recommended data set [2] are in exact accord.

Al_2O_3 - Na_3AlF_6

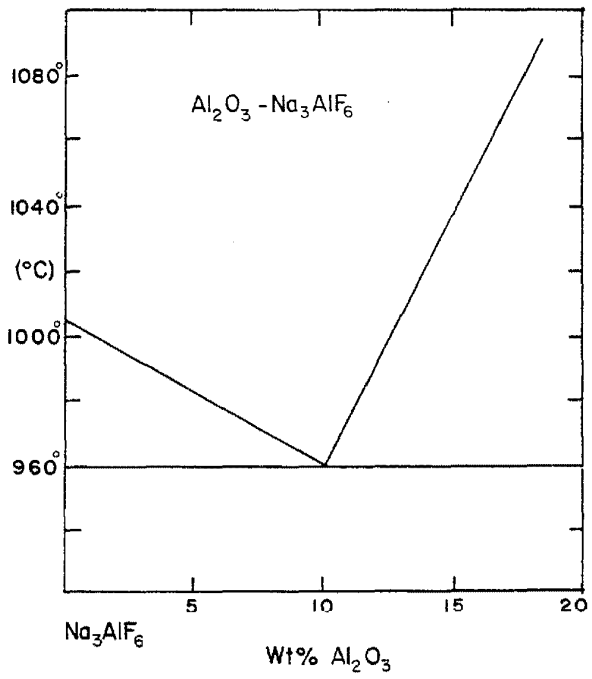

FIGURE 82. Phase diagram for Al_2O_3 - Na_3AlF_6.

Data from: P. A. Foster, Jr., J. Electrochem. Soc. 106 (11), 971 (1959); J. Am. Ceram. Soc. 43(2), 66 (1960).

Melt Preparation and Purification

Yim and Feinleib [89] used reagent grade NaF and reduction grade Al_2O_3. The cryolite was from natural hand-picked crystals obtained from the Pennsylvania Salt Mfg. Company. Melts were fused in a graphite crucible before each determination. The chilled melt was pulverized, thoroughly mixed, and sampled. The cryolite-based melts were analyzed by pyrotitration. No information on melt preparation was given in the study by Pearson and Waddington [90]. Matiasovsky and Malinovsky [114, 104] dried reagent grade Al_2O_3 at 1200°C. Cryolite was prepared by fusing the stoichiometric quantities of pure NaF and AlF_3. Edwards et al. [78] used hand-picked crystals of pure Greenland cryolite which were crushed to 20 mesh. Any associated particles of galena were removed. The alumina was high purity Alcoa A-14, containing less than 0.2% water. For the method used by Votava and Matiasovsky [92, 93] see references [114] and [104]. Bloom and Burrows [149] used high purity natural cryolite (99.6% Na_3AlF_6) and analytical reagent grade alumina. Mixtures were prepared by weighing stoichiometric amounts of the carefully dried components. Vayna [81, 82, 83] used natural cryolite and high grade alumina which was at least 99% pure. Kazantsev et al. [150] used C. P. grade materials. The Al_2O_3 was purified by heating a mixture of Al_2O_3 and Al in a vacuum at 1500–1700 °C. Nishihara et al. [84] obtained

cryolite and alumina from the Light Metal Corporation (Japan). Arndt and Kalass [151] gave no information on the preparation of materials. Batashev [152] purified dehydrated aluminum fluoride by sublimation. All materials were obtained from Kahlbaum. Grjotheim et al. [153] used hand selected natural Greenland cryolite (m.p. 1006 °C) and chromatographic quality Al_2O_3.

TABLE 474. Al_2O_3 – Na_3AlF_6: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent Na_3AlF_6	
	90.3	82.8
1270	2.55	2.32
1310	2.63	2.40
1340	2.69	2.46
1350	2.71	2.48

Temperature–dependent equations

$$\kappa = a + bT$$

Mol % Na_3AlF_6	$-a$	$b \times 10^3$	standard error of estimate
90.3	0.1215	2.0999	0.07%
82.8	0.2027	1.9876	0.06%

These values are based on the data of Edwards, Taylor, Cosgrove and Russell (classical ac method) [78]. The results of Arndt and Kalass [151] are uniformly ~15% lower, while those of Batashev [152], are ~20% higher than the values above. The composition range was extended to 73 and 66 mol % Na_3AlF_6 by Batashev [152] and Arndt and Kalass [151], respectively. For updated recommendations on the specific conductance of molten cryolite, see [8].

TABLE 473. Electrical conductance studies: Al_2O_3 – Na_3AlF_6

Investigations critically examined

Ref.	Mol % Na_3AlF_6	Temp. range (K)	Comments
151	80–100	1173–1313	porcelain cell; Pt electrodes and crucible; calibration: 0.1 *N* KCl
152	85–100	1328–1323	Pt electrodes and crucible; calibration: 0.1 *D* KCl
102			estimation methods
89	85–100	1253–1323	boron nitride cell;
83	85–100	1273	2 Pt concentric crucibles; Pt electrodes; calibration: 15% aq. NaCl(18°C); frequency: 1000Hz.
85			review article
90			electrode reaction study
114			Pt electrodes; frequency: 5 Hz.
153	85–100	1273	Pt electrodes; frequency: 18 KHz; calibration: molten cryolite
78	82.8–100	1273–1353	hemispherical Pt electrodes; frequency range: 600–4000 Hz
154			textbook

TABLE 475. Density studies: Al_2O_3 – Na_3AlF_6

Investigations critically examined

Ref.	Mol % Na_3AlF_6	Temp. range (K)	Comments
155			review
81	85–100	1250–1303	Pt float; calibration: H_2O (20°C); correction for thermal expansion; graphite crucibles for melting cryolite
95			review
94	76–100	1208–1268	quartz float
114	70–100	1273	Pt–Rh sinker
84		1303–1343	Pt bob
104, 193	76–100	1273–1323	Pt sinker
153	85–100	1273	Pt–10% Rh sinker suspended on a Pt wire; calibration: molten NaCl
78	75–100	1249–1366	Pt sinker

TABLE 476. Al_2O_3 – Na_3AlF_6: Density (g cm^{-3})

T(K)	Mol percent Na_3AlF_6				
	97	94	88	82	76
1270	2.090	2.081	2.063	2.049	2.038
1300	2.063	2.054	2.038	2.025	2.016
1320	2.045	2.036	2.021	2.008	2.001

Temperature-dependent equations
$\rho = a + bT$

Mol % Na_3AlF_6	a	$-b \times 10^3$	standard error of estimate
97	3.2522	0.9148	0.02%
94	3.2120	0.8906	0.01%
88	3.1458	0.8523	0.00%
82	3.0736	0.8070	0.03%
76	2.9674	0.7320	0.00%

These values are based on the data of Matiasovsky (Archimedean technique) [104,114,193] and Edwards et al. [78]. The density data of Vetyukov et al. [155] and Nishihara et al. [84] are virtually in exact agreement with the values above (1%).

TABLE 477. Viscosity studies: Al_2O_3 – Na_3AlF_6

Investigations critically examined

Ref.	Mol % Na_3AlF_6	Temp. range (K)	Comments
155	70–100	1240–1380	review
92		1273–1323	Mo torsion wire; Pt sphere
82	85–100	1263–1323	graphite crucibles; calibration: glycerine solutions (20°C); stainless steel rotor.
84	85–100	1303–1353	Pt disk and crucible
93	75–100	1273–1323	Pt rod fused to Pt/Ir rod; Mo wire support; Pt crucible; Ar atmosphere; temp. control, ±1°C.
194	75–100	1253–1323	damped oscillational technique; Pt sphere
195	78–100	1240–1380	damped oscillational technique; Pt cylinder

TABLE 478. Al_2O_3 – Na_3AlF_6: Viscosity (cp)

T(K)	Mol percent Na_3AlF_6				
	92.1	84.8	78.1	76.0	70.0
1240			3.750		
1250		2.975			
1280	2.390	2.659	3.195	3.823	
1300	2.226	2.469	2.958	3.538	4.940
1360	1.816	2.004	2.426	2.837	3.945
1380	1.707			2.656	3.676
1400				2.503	3.438
1460				2.215	2.915
1480					2.803

Temperature-dependent equations
$\eta = a + bT + cT^2 + dT^3$

Mol % Na_3AlF_6	a	$b \times 10^3$	$c \times 10^6$	$d \times 10^9$	standard error of estimate
92.1	29.469	-25.460	-3.146	5.084	0.01%
84.8	34.586	-28.144	-6.754	7.226	0.27%
78.1	22.929	23.010	-62.294	25.213	0.32%
76.0	44.972	-27.689	-20.475	13.275	2.62%
70.0	95.998	-121.143	39.307		1.65%

The values from 78–100 mol% Na_3AlF_6 are based on the data of Torklep and Oye [195] and for the range 70–76 mol% Na_3AlF_6, on Abramov et al. [155] (both oscillational techniques). The results of Abramov et al. [155], Matiasovsky and Votava [92,93], and Desclaux and Rolin [194] are uniformly higher than those of Torklep and Oye [195], e.g. at 5 mol% Al_2O_3 and 1300 K, ~12%, ~15%, and ~25%, respectively. The values of Nishihara et al. [84], by contrast, are uniformly lower, e.g. at 5 mol% and 1300 K, ~50% lower. For updated recommendations for the viscosity of molten cryolite, see [8]; for evaluation of viscosity measurement techniques, see [10].

TABLE 479. Surface tension studies: Al_2O_3 – Na_3AlF_6

Investigations critically examined

Ref.	Mol % Na_3AlF_6	Temp. range (K)	Comments
156	75–100	1325–1329	Pt plate; inert atmosphere
150	75–100	1293–1333	stainless steel capillary; Ar atmosphere; correction for thermal expansion and depth of immersion; estimated uncertainty 5%
149	73–100	1273	Pt–10% Rh capillary; dry Ar atmosphere
155			review

TABLE 480. Al_2O_3 – Na_3AlF_6: Surface tension (dyn cm^{-1})

T(K)	Mol percent Na_3AlF_6		
	91	81	73
1270	132	127	133
1300	129	123	129
1330	126	120	125
1350	124	117	123

Temperature-dependent equations

$$\gamma = a + bT$$

Mol percent Na_3AlF_6	a	$-b \times 10^3$
100	297.02	128.04
91	257.76	99.02
81	272.76	115.04
73	298.29	130.06

These values are based on the data of Bloom and Burrows (maximum bubble pressure method), data in equation form, precisions not estimated [**149**]. Accuracy limits, $\sim \pm 1.5\%$. The data set for Na_3AlF_6 (0% Al_2O_3) have been advanced as the recommended surface tension data base [2].

Al_2O_3-Na_3AlF_6-SiO_2

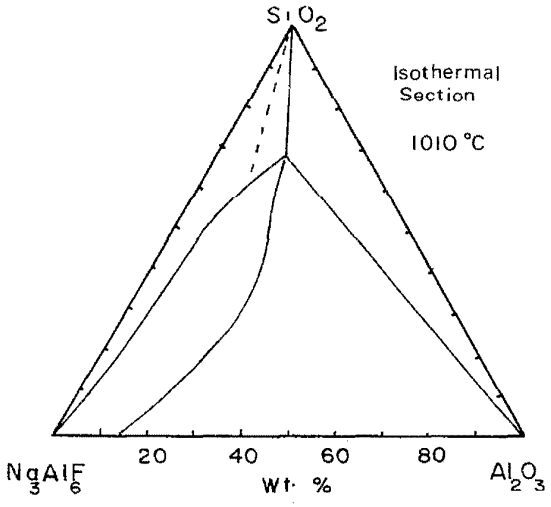

FIGURE 83. Phase diagram for Al_2O_3 – Na_3AlF_6 – SiO_2.

Data from: D. F. Weill and W. J. Fyfe, J. Electrochem. Soc., **111**, 582 (1964).

Melt Preparation and Purification

For the method of melt preparation and purification of Grjotheim et al. [**153**], see Al_2O_3–Na_3AlF_6.

TABLE 481. Electrical conductance studies: Al_2O_3 – Na_3AlF_6 – SiO_2

Investigations critically examined

Ref.	Wt% Al_2O_3	Wt% SiO_2	Temp. range (K)	Comments
153	0–12	0–6	1273	see Al_2O_3–Na_3AlF_6

0

TABLE 482. Al_2O_3 – Na_3AlF_6 – SiO_2: Specific conductance ($ohm^{-1}cm^{-1}$)

Wt % Al_2O_3	Wt % SiO_2 (1273 K)			
	0	2	4	6
0	2.80	2.63	2.57	2.50
3	2.68	2.57	2.49	2.42
6	2.53	2.41	2.31	2.26
9	2.38	2.28	2.23	2.18
12	2.22	2.18	2.15	2.10

The above values are reported by Grjotheim, Matiasovsky, Fellner and Silny (classical ac method) [**153**]. The value for Na_3AlF_6 (0% Al_2O_3, 0% SiO_2) is virtually in close agreement (i.e., $\pm 0.5\%$) with the recommended data set [8].

TABLE 483. Density studies: Al_2O_3 – Na_3AlF_6 – SiO_2

Investigations critically examined

Ref.	Wt% Al_2O_3	Wt% SiO_2	Temp. range (K)	Comments
153	0–12	0–6	1273	see Al_2O_3–Na_3AlF_6

TABLE 484. Al_2O_3 – Na_3AlF_6 – SiO_2: Density (g cm^{-3})

Wt % Al_2O_3	Wt % SiO_2 (1273 K)			
	0	2	4	6
0	2.102	2.100	2.099	2.098
3	2.078	2.084	2.087	2.088
6	2.061	2.071	2.078	2.083
9	2.048	2.060	2.070	2.075
12	2.038	2.051	2.060	–

The above values are reported by Grjotheim, Matiasovsky, Fellner and Silny (Archimedean technique) [**153**]. The value for Na_3AlF_6 (0% Al_2O_3, 0% SiO_2) and that from the recommended data set [4] are essentially in exact agreement [i.e., $\sim < \pm 0.2\%$].

B_2O_3 – Cs_2CO_3

Melt Preparation and Purification

Kruh and Stern [**130**] used reagent grade boric oxide, heated to 900° to remove residual water. When the Cs_2CO_3 was added, the mixture was stirred thoroughly and then allowed to stand so that air bubbles might escape.

TABLE 485. Viscosity studies: B_2O_3 - Cs_2CO_3

Investigations critically examined			
Ref.	Mol % Cs_2CO_3	Temp. range (K)	Comments
130	0–3	873–1023	stainless steel beaker; estimated uncertainty; ±30 poise

TABLE 486. B_2O_3 - Cs_2CO_3: Viscosity (poise)

T(K)	Mol percent Cs_2CO_3	
	3.0	1.0
873	1000	1400
973	180	300
1023	140	200

The above values are reported by Kruh and Stern (rotational technique) **[130]**. Accuracy limits, ~±5%. For B_2O_3 viscosity see Table 390 and comments.

B_2O_3 - $K_2B_4O_7$

Melt Preparation and Purification

Leont'eva **[157]** prepared boric oxide from C.R. grade boric anhydride.

TABLE 487. Viscosity studies: B_2O_3 - $K_2B_4O_7$

Investigations critically examined			
Ref.	Mol % $K_2B_4O_7$	Temp. range (K)	Comments
157	0–5.2	1023–1373	no information

TABLE 488. B_2O_3 - $K_2B_4O_7$: Viscosity (poise)

T(K)	Mol percent $K_2B_4O_7$	
	5.2	3.2
1080	151.1	223.1
1160	100.5	146.3
1220	75.4	110.3
1300	59.0	
1320	58.0	

Temperature-dependent equations

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

Mol % $K_2B_4O_7$	a	$-b \times 10^3$	$c \times 10^6$	standard error of estimate
5.2	2750.31	4058.25	1529.24	4.6%
3.2	4490.73	6736.44	2578.65	1.4%
0	exponential equation			7.6%

These values are based on the data of Leont'eva (oscillational method) **[157]**. For B_2O_3 (0% $K_2B_4O_7$) the viscosity data are expressed by the exponential equation: $\eta = 0.521 \exp(13850/RT)$. The results for B_2O_3 appear ~40–50% higher than the values from the recommended data set [1], if the equations are extrapolated to an overlapping temperature range.

B_2O_3 - K_2CO_3

Melt Preparation and Purification

For the method of melt preparation used by Kruh and Stern **[130]** see: B_2O_3–Cs_2CO_3.

TABLE 489. Viscosity studies: B_2O_3 - K_2CO_3

Investigations critically examined			
Ref.	Mol % K_2CO_3	Temp. range (K)	Comments
130	0–6	873–1023	see: B_2O_3–Cs_2CO_3

TABLE 490. B_2O_3 - K_2CO_3: Viscosity (poise)

T(K)	Mol percent K_2CO_3		
	6.0	3.0	1.0
873	1600	1000	1300
973	160	160	280
1023	96	96	180

The above values are reported by Kruh and Stern (rotational technique) **[130]**. Accuracy limits, ~±5%. For B_2O_3 viscosity see Table 390 and comments.

B_2O_3 - Li_2CO_3

Melt Preparation and Purification

For the method of melt preparation used by Kruh and Stern **[130]** see: B_2O_3–Cs_2CO_3. Moiseev and Stepanov **[148]** used reagent grade materials. No further information was given.

TABLE 491. Viscosity studies: B_2O_3 - Li_2CO_3

Investigations critically examined			
Ref.	Mol % Li_2CO_3	Temp. range (K)	Comments
130	0–6	873–1023	see: B_2O_3–Cs_2CO_3

TABLE 492. B_2O_3 - Li_2CO_3: Viscosity (poise)

T(K)	Mol percent Li_2CO_3		
	6.0	3.0	1.0
873	1500		1680
973	170	240	320
1023	80	120	160

The above values are reported by Kruh and Stern (rotational technique) **[130]**. Accuracy limits, ~±5%. For B_2O_3 viscosity see Table 390 and comments.

TABLE 493. Surface tension studies: B_2O_3 - Li_2CO_3

Investigations critically examined

Ref.	Mol % Li_2CO_3	Temp. range (K)	Comments
148	92–100	1038	Pt capillary; Ar atmosphere

TABLE 494. B_2O_3 - Li_2CO_3: Surface tension (dyn cm^{-1})

Mol percent Li_2CO_3	1038 K
100	243
95	259
90	253

Composition-dependent equation

$$\gamma = 242.56 + 2.68C - 10.42 \times 10^{-2}C^2$$

[C = Mol % Li_2CO_3]

These values are based on the data of Moiseev and Stepanov (maximum bubble pressure method); data in graphical form; precisions not estimated **[148]**. For Li_2CO_3 the result is in exact agreement with the recommended data base [2].

B_2O_3 - Na_3AlF_6

Melt Preparation and Purification

For the method of melt preparation used by Kruh and Stern **[130]** see: B_2O_3–Cs_2CO_3.

TABLE 495. Viscosity studies: B_2O_3 - Na_3AlF_6

Investigations critically examined

Ref.	Mol % Na_3AlF_6	Temp. range (K)	Comments
130	0–3.2	873–1023	see: B_2O_3–Cs_2CO_3

TABLE 496. B_2O_3 - Na_3AlF_6: Viscosity (poise)

T(K)	Mol percent Na_3AlF_6	
	3.2	1.6
873	480	1080
973	100	240
1023	72	140

The above values are reported by Kruh and Stern (rotational technique) **[130]**. Accuracy limits, ~±5%. For B_2O_3 (0% Na_3AlF_6) see Table 390 and comments.

B_2O_3 - $Na_2B_4O_7$

Melt Preparation and Purification

Yakobashvili et al. **[26, 25]** and Volarovich and Tolstoi **[158]** used reagent grade materials for the preparation of the melts. For the method used by Kruh and Stern [130] to prepare boric oxide, see: B_2O_3–Cs_2CO_3. No information on melt preparation was given in the study by Frumin et al. **[159]**. Leont'eva [157] prepared boric oxide from C.P. grade boric acid. To remove bubbles from the melt it was held at 1000°C for 2 hours.

TABLE 497. Density studies: B_2O_3 - $Na_2B_4O_7$

Investigations critically examined

Ref.	Mol % $Na_2B_4O_7$	Temp. range (K)	Comments
26	57–100	1223	Pt capillary; dry Ar atmosphere; alundum crucible

TABLE 498. B_2O_3 - $Na_2B_4O_7$: Density (g cm^{-3})

Mol percent $Na_2B_4O_7$	1223 K
100	2.06
90	2.08
80	2.10
70	2.12
60	2.12

Composition-dependent equation

$$\rho \quad 1.946 + 0.573 \times 10^{-2}C - 0.47 \times 10^{-4}C^2$$

[C = Mol % $Na_2B_4O_7$]

Standard error of estimate = 0.64%

These values are based on the data of Oparin and Yakobashvili (modified maximum bubble pressure method) **[26]**. Accuracy limits, ~±2%. The value for $Na_2B_4O_7$ (0% B_2O_3) has been advanced as recommended data [8].

TABLE 499. Viscosity studies: B_2O_3 - $Na_2B_4O_7$

Investigations critically examined

Ref.	Mol % $Na_2B_4O_7$	Temp. range (K)	Comments
157	0–8	1023–1273	see: B_2O_3–$K_2B_4O_7$
130	0–3	873–1023	see: B_2O_3–Cs_2CO_3
159	25.7–100	923–1323	estimated uncertainty, ±2%; pendulum viscometer
158	0–100	923–1023	Pt crucible

TABLE 500. B_2O_3 – $Na_2B_4O_7$: Viscosity (poise)

Mol % $Na_2B_4O_7$	923 K	948 K	973 K	1023 K
100.0	2180	649	225	49
76.1	6090	1740	598	111
49.6	14800	4320	1450	254
45.2	13800	4230	1490	272
40.1	9880	3060	1090	206
35.1	8890	2910	1090	217
33.7	12700	4020	1470	279
32.8	8710	2680	975	211
22.4	5240	1920	816	212
7.9	793	468	289	130
0.0	1510	1130	868	542

The above values are reported by Volarovich and Tolstoi (rotating cylinder method) [**158**]. These values cannot be expressed as simple equations. Other results for $Na_2B_4O_7$ (100%) have not been published. The results for B_2O_3 (% $Na_2B_4O_7$) are ~40–50% higher than the results of Kruh and Stern [130] and Shartsis et al. [242]; see also Table 390 and comments.

TABLE 501. Surface tension studies: B_2O_3 – $Na_2B_4O_7$

Investigations critically examined

Ref.	Mol % $Na_2B_4O_7$	Temp. range (K)	Comments
26	57–100	1223	Pt capillary; dry Ar atmosphere
25	43.5–100	1223	corundum capillary; Ar atmosphere
159	20–100	1023,1223	estimated uncertainty, ±5%

TABLE 502. B_2O_3 – $Na_2B_4O_7$: Surface tension (dyn cm^{-1})

Mol percent $Na_2B_4O_7$	1023 K	1223 K
100	242	232
80	229	219
50	208	200
30	195	187

Composition-dependent equations

$\gamma = a + bC$

[C = Mol % $Na_2B_4O_7$]

T(K)	a	$b \times 10^3$
1023	174.5	675
1223	167.0	650

These values are based on the data of Frumin and Yakobashvili (maximum bubble pressure method); data in equation form; precisions not estimated [**159**]. The result at 1223 K for $Na_2B_4O_7$ agrees with the recommended data [8] to within 1%.

B_2O_3 – Na_2CO_3

Melt Preparation and Purification

For the method of melt preparation used by Kruh and Stern [**130**] see: B_2O_3–Cs_2CO_3.

TABLE 503. Viscosity studies: B_2O_3 – Na_2CO_3

Investigations critically examined

Ref.	Mol % Na_2CO_3	Temp. range (K)	Comments
130	0–6	873–1023	see: B_2O_3–Cs_2CO_3

TABLE 504. B_2O_3 – Na_2CO_3: Viscosity (poise)

T(K)	Mol percent Na_2CO_3		
	6.0	3.0	1.0
873	1700	1650	1750
973	280	280	280
1023	180	150	180

The above values are reported by Kruh and Stern (rotational technique) [**130**]. Accuracy limits, ~±5%. For B_2O_3 (0% Na_2CO_3) see Table 390 and comments.

B_2O_3 – $NaPO_3$

Melt Preparation and Purification

Arndt [160, **161**] used pure grade materials. No other information was given.

TABLE 505. Electrical conductance studies: B_2O_3 – $NaPO_3$

Investigations critically examined

Ref.	Mol % $NaPO_3$	Temp. range (K)	Comments
161, 250	3.5–100	923–1323	porcelain U-tube cell, Pt electrodes

TABLE 506. B_2O_3 - $NaPO_3$: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent $NaPO_3$	
	40.6	3.5
1020	0.058	
1080	0.095	0.0006
1140	0.140	0.0011
1220	0.214	0.0019

Temperature-dependent equations
$\kappa = a + bT + cT^2$

Mol % $NaPO_3$	a	$-b \times 10^3$	$c \times 10^6$	standard error of estimate
100.00	-1.8829	-2.5000		0.00%
40.6	0.7649	1.9274	1.210	3.84%
3.5	0.00116	0.00902	0.0079	0.02%

These values are based on the data of Arndt (classical ac method) [161]. For $NaPO_3$ (0% B_2O_3) the results agree with the recommended data set [8] to within ~±5%, at 1100 K, the two are in exact agreement.

TABLE 507. Viscosity studies: B_2O_3 - $NaPO_3$

Investigations critically examined

Ref.	Mol % $NaPO_3$	Temp. range (K)	Comments
161, 160	3.5-100	923-1388	falling weight; Pt float and crucible; calibration: castor oil

TABLE 508. B_2O_3 - $NaPO_3$: Viscosity (poise)

T(K)	Mol percent $NaPO_3$	
	40.6	3.5
1070	25.1	100.2
1130	8.7	64.7
1190	2.7	42.5
1220	3.6	36.4

Composition-dependent equations
$\eta = a + bT + cT^2$

Mol % $NaPO_3$	a	$-b \times 10^{-3}$	$c \times 10^{-6}$	standard error of estimate
100.0	28.7	501.77	220.0	16.7%
40.6	2066.73	3455.70	1446.4	17.1%
3.5	2976.93	4673.70	1855.3	0.2%

These values are based on the data of Arndt (falling body technique) [161]. The results for $NaPO_3$ (100%) have been advanced earlier in this series as a recommended data base [1].

B_2O_3 - Rb_2CO_3

Melt Preparation and Purification

For the method of melt preparation used by Kruh and Stern [130] see: B_2O_3-Cs_2CO_3.

TABLE 509. Viscosity studies: B_2O_3 - Rb_2CO_3

Investigations critically examined

Ref.	Mol % Rb_2CO_3	Temp. range (K)	Comments
130	0-3	873-1023	see: B_2O_3 Cs_2CO_3

TABLE 510. B_2O_3 - Rb_2CO_3: Viscosity (poise)

T(K)	Mol percent Rb_2CO_3	
	3.0	1.0
873	840	920
973	140	240
1023	80	160

The above values are reported by Kruh and Stern (rotational technique) [130]. Accuracy limits, ~±5%. For B_2O_3 (0% Rb_2CO_3) see Table 390 and comments.

Bi_2O_3 - $K_2B_4O_7$

Melt Preparation and Purification

No information on melt preparation was given in the study by Kochergin et al. [162].

TABLE 511. Density studies: Bi_2O_3 - $K_2B_4O_7$

Investigations critically examined

Ref.	Mol percent $K_2B_4O_7$	Temp. range (K)	Comments
162	95-100	1123	Pt sphere; calibration: toluene

TABLE 512. Bi_2O_3 - $K_2B_4O_7$: Density (g cm^{-3})

Mol percent $K_2B_4O_7$	1123 K
100	1.997
97.4	2.191
96.9	2.282
95.8	2.377

Composition-dependent equation
$\rho = 11.070 - 9.082 \times 10^{-2}C$
[C = Mol % $K_2B_4O_7$]
Standard error of estimate = 1.0%

The above values are reported by Kochergin, Baldina, and Kareva (Archimedean technique) [162]. Precision ~0.2%. The data point for $K_2B_4O_7$ (0% Bi_2O_3) has been advanced elsewhere in this series as recommended data [8]. Accuracy, ~±5%.

Bi_2O_3 - KPO_3

Melt Preparation and Purification

No information on melt preparation was given in the study by Kochergin et al. [162].

TABLE 513. Density studies: Bi_2O_3 - KPO_3

Investigations critically examined			
Ref.	Mol percent KPO_3	Temp. range (K)	Comments
162	97-100	1123	Pt sphere; calibration: toluene

TABLE 514. Bi_2O_3 - KPO_3: Density (g cm^{-3})

Mol percent KPO_3	1123 K
100	2.185
99.2	2.442
98.4	2.714
97.3	3.028

Composition-dependent equation

$\rho = 33.054 - 30.86 \times 10^{-2}C$

[C = Mol % KPO_3]

Standard error of estimate = 1.0%

The above values are reported by Kochergin, Baldina, and Kareva (Archimedean technique) [162]. Precision ~0.2%. The value for KPO_3 (0% Bi_2O_3) appears to be 5% too high relative to the recommended data set [8].

Bi_2O_3 - $Na_2B_4O_7$

Melt Preparation and Purification

No information on melt preparation was given in the study by Kochergin et al. [162].

TABLE 515. Density studies: Bi_2O_3 - $Na_2B_4O_7$

Investigations critically examined			
Ref.	Mol percent $Na_2B_4O_7$	Temp. range (K)	Comments
162	96-100	1123	Pt sphere; calibration: toluene

TABLE 516. Bi_2O_3 - $Na_2B_4O_7$: Density (g cm^{-3})

Mol percent $Na_2B_4O_7$	1123 K
100	2.094
99.1	2.200
98.2	2.329
96.3	2.558

Composition-dependent equation

$\rho = 14.969 - 12.875 \times 10^{-2}C$

[C = Mol % $Na_2B_4O_7$]

Standard error of estimate = 0.3%

The above values are reported by Kochergin, Baldina, and Kareva (Archimedean technique) [162]. Precision, ~2%. The data point for $Na_2B_4O_7$ (0% Bi_2O_3) has been recommended earlier in this series [8] as a reference point. Accuracy, ~±5%.

Bi_2O_3 - $NaPO_3$

Melt Preparation and Purification

No information on melt preparation was given in the study by Kochergin at al. [162].

TABLE 517. Density studies: Bi_2O_3 - $NaPO_3$

Investigations critically examined			
Ref.	Mol percent $NaPO_3$	Temp. range (K)	Comments
162	96-100	1123	Pt sphere; calibration: toluene

TABLE 518. Bi_2O_3 - $NaPO_3$: Density (g cm^{-3})

Mol percent $NaPO_3$	1123 K
100	2.086
98.9	2.452
97.6	2.803
96.3	3.415

Composition-dependent equation

$\rho = 37.169 - 3.5115C$

[C = Mol % $NaPO_3$]

Standard error of estimate = 3%

The above values are reported by Kochergin, Baldina, and Kareva (Archimedean technique) [162].

CaO - CaC_2

Melt Preparation and Purification

No information on melt preparation was given in the study by Emons et al. [163] or by Hellmold et al. [164].

TABLE 519. Viscosity studies: CaO – CaC_2

Investigations critically examined			
Ref.	Mol % CaC_2	Temp. range (K)	Comments
163, **164**	73	2050–2490	carbon inner cylinder; graphite crucible.

TABLE 520. CaO – CaC_2: Viscosity (poise)

T(K)	Mol percent CaC_2
	73
2190	7.26
2280	4.32
2400	2.62
2490	3.10

Temperature-dependent equation

$$\eta = 291.112 - 128.903 \times 10^{-3}T - 41.496 \times 10^{-6}T^2 + 18.80 \times 10^{-9}T^3$$

Standard error of estimate = 14.87%

These values are based on the graphical data of Hellmold, Horlbeck, and Woerh (oscillational method) [**164**]. The CaC_2 contained ~10 wt % impurities (C, ~8.4%; SiO_2, ~3.6%; Fe_2O_3, ~1.4%).

$CaO - SiO_2$

Melt Preparation and Purification

No information on melt preparation was given in the study by Ejima and Shimoji [**141**].

TABLE 521. Density studies: CaO – SiO_2

Investigations critically examined			
Ref.	Mol % SiO_2	Temp. range (K)	Comments
141	45–60	1873	no information given

TABLE 522. CaO – SiO_2: Density (g cm^{-3})

Mol percent SiO_2	1873 K
60	0.44
50	0.88
45	1.23

Composition-dependent equation

$$\rho = 8.224 - 23.22 \times 10^{-2}C + 17.08 \times 10^{-4}C^2$$

These values are based on the data of Ejima and Shimoji (maximum bubble pressure method); data in graphical form; precisions not estimated [**141**]. Accuracy limits, ~±2%.

$Fe_2O_3 - CaC_2$

Melt Preparation and Purification

No information on melt preparation was given in the study by Hellmold et al. [**164**]

TABLE 523. Viscosity studies: Fe_2O_3 – CaC_2

Investigations critically examined			
Ref.	Mol % CaC_2	Temp. range (K)	Comments
164	95.5–100	2273	carbon inner cylinder; graphite crucible.

Viscosity: No data; for a graphical study of the effect on viscosity of varying Fe_2O_3 in the system CaC_2–CaO–SiO_2–Fe_2O_3, see [**164**].

$Fe_2O_3 - Li_2CO_3$

Melt Preparation and Purification

Moiseev and Stepanov [**148**] used very pure Li_2CO_3 and analytically pure Fe_2O_3. The salts were heated in a CO_2 atmosphere at 500–600°C for several hours and then stored in a desiccator.

TABLE 524. Surface tension studies: Fe_2O_3 – Li_2CO_3

Investigations critically examined			
Ref.	Mol % Li_2CO_3	Temp. range (K)	Comments
148	92–100	1038	Pt capillary; dry CO_2 and air atmosphere.

TABLE 525. Fe_2O_3 – Li_2CO_3: Surface tension (dyn cm^{-1})

Mol percent Li_2CO_3	1038 K
100	240.4
98	240.4
94	240.3
92	240.2

Composition-dependent equation

$$\gamma = 238.0 + 2.40 \times 10^{-2}C$$

[C = Mol % Li_2CO_3]

These values are based on the data of Moiseev and Stepanov (maximum bubble pressure method); data in graphical form; precisions not estimated [**148**]. At 1038 K, the surface tension for Li_2CO_3 given in the recommended data base [2] is 242.4 dyn cm^{-1}.

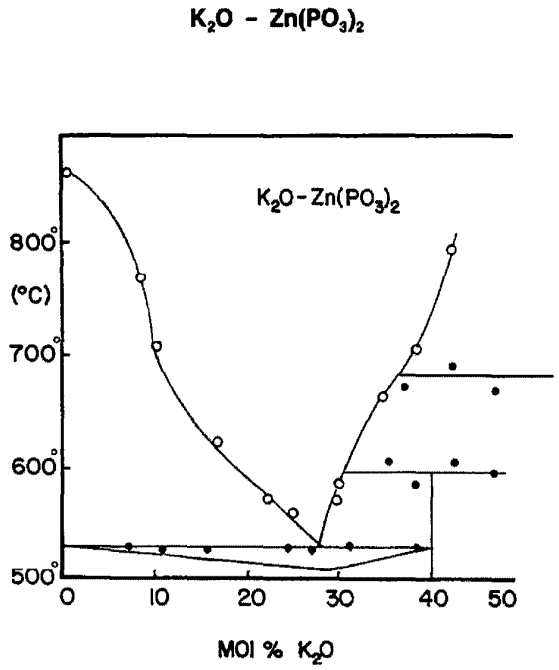

FIGURE 84. Phase diagram for K_2O - $Zn(PO_3)_2$.

Data from: E. L. Krivovyazov, N. K. Voskresenskaya, K. K. Palkina, Zh. Neorg. Mat. 5(6), 898 (1969).

Melt Preparation and Purification

No information on melt preparation was given in the study by Eliseeva [165], or in the study by Krivovyazov and Voskresenskaya [166].

TABLE 526. Density studies: K_2O - $Zn(PO_3)_2$

Investigations critically examined

Ref.	Mol percent $Zn(PO_3)_2$	Temp. range (K)	Comments
166	56.6-88.4	1085-1378	no information

TABLE 527. K_2O - $Zn(PO_3)_2$: Density (g cm^{-3})

T(K)	Mol percent $Zn(PO_3)_2$		
	88.4	74.2	56.6
1080		2.742	
1110	2.762	2.734	2.632
1200	2.744	2.710	2.602
1290	2.727	2.686	2.572
1350	2.716	2.670	2.552
1380	2.710		

Temperature-dependent equations

$$\rho = a + bT$$

Mol percent $Zn(PO_3)_2$	a	$-b \times 10^3$
88.4	2.9737	0.1911
74.2	3.0305	0.2671
56.6	3.0019	0.3330

These values are based on the data of Krivovyazov and Voskresenskaya (Archimedean technique); data in equation form; precisions not estimated [166]. Accuracy limits, $\sim \pm 1\%$.

TABLE 528. Surface tension studies: K_2O - $Zn(PO_3)_2$

Investigations critically examined

Ref.	Mol % $Zn(PO_3)_2$	Temp. range (K)	Comments
165	50-100	1233-1373	no information
166	52-92.7	1119-1383	no information

TABLE 529. K_2O - $Zn(PO_3)_2$: Surface tension (dyn cm^{-1})

T(K)	Mol percent $Zn(PO_3)_2$			
	92.7	74.4	61.9	52
1120			180.0	
1180		174.1	177.3	
1240	176.3	171.6	174.6	184.1
1360	175.8	166.6	169.2	178.8

Temperature-dependent equations

$$\gamma = a + bT$$

Mol % $Zn(PO_3)_2$	a	$-b \times 10^3$	standard error of estimate
92.7	181.9	4.5	0.00%
74.4	223.7	42.0	0.00%
61.9	230.8	45.3	0.00%
52	239.0	44.3	0.00%

These values are based on the data of Krivovyazov and Voskresenskaya (maximum bubble pressure method) [166]. Accuracy limits, $\sim \pm 2\%$.

Li_2O - Li_2CO_3

Melt Preparation and Purification

Moiseev and Stepanov [148] used very pure Li_2CO_3 and analytically pure Li_2O. The salts were heated in a CO_2 atmosphere at 500–600°C for several hours and then stored in a desiccator.

TABLE 530. Surface tension studies: Li_2O – Li_2CO_3

Investigations critically examined

Ref.	Mol % Li_2CO_3	Temp. range (K)	Comments
148	60–100	1038	Pt capillary; dry CO_2 and air atmosphere.

TABLE 531. Li_2O – Li_2CO_3: Surface tension (dyn cm^{-1})

Mol percent Li_2CO_3	1038 K
100	244.3
90	244
80	252
70	256
60	245

Composition-dependent equation

$$\gamma = -809.2 + 39.98C - 49.19 \times 10^{-2}C^2 + 19.74 \times 10^{-4}C^3$$

[C = Mol % Li_2CO_3]

These values are based on the data of Moiseev and Stepanov (maximum bubble pressure method); data in graphical form; precisions not estimated [148]. At 1038 K, for Li_2CO_3 the surface tension in the recommended data base [2] is 242.4 dyn cm^{-1}.

MoO_3 - K_2MoO_4

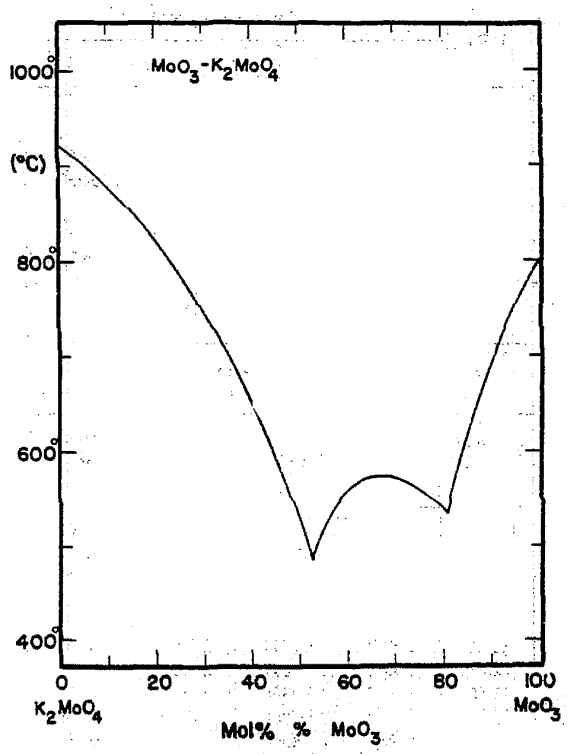

FIGURE 85. Phase diagram for MoO_3 – K_2MoO_4.

Data from: K. B. Morris and D. L. Robinson, J. Phys. Chem. 68, 1194 (1964).

Melt Preparation and Purification

All salts used by Morris and Robinson [167] were reagent quality anhydrous powders. Gossink and Stevels [168] used reagent grade materials. In order to determine whether the compositions of the samples had changed after preparation and measuring, some samples were analyzed gravimetrically for their trioxide contents.

TABLE 532. Electrical conductance studies: MoO_3 - K_2MoO_4

Investigations critically examined

Ref.	Mol % K_2MoO_4	Temp. range (K)	Comments
167	0–100	856–1270	quartz cell; Pt disk electrodes; frequency: 2000Hz

TABLE 533. MoO_3 – K_2MoO_4: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent K_2MoO_4				
	85.87	69.87	47.56	31.46	18.65
860			0.332		
890			0.390		0.361
950			0.478	0.517	0.480
980			0.508	0.576	0.537
1040				0.681	0.645
1070					0.697
1100		0.885			
1160	1.009	0.983			
1190	1.054	1.024			
1250	1.166				

Temperature-dependent equations

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

Mol % K_2MoO_4	$-a$	$b \times 10^3$	$-c \times 10^6$	standard error of estimate
100	0.3930	1.3393		0.4%
85.87	-4.9906	-8.2350	-4.1405	0.6%
69.87	4.5880	8.1525	2.8879	0.3%
47.56	5.2526	10.9081	5.1324	0.4%
39.80	2.3126	4.2016	1.3117	0.5%
31.46	3.5754	6.5811	2.3931	0.4%
22.65	3.4563	6.2097	2.1630	0.6%
18.65	2.2092	3.7366	0.9536	0.6%
11.37	7.8471	14.4396	6.0546	0.3%
0	-0.1437	0.4960		0.3%

These values are based on the data of Morris and Robinson (classical ac method) [167]. Accuracy, ~±1.5%. The values for K_2MoO_4 (0% MoO_3) have been advanced elsewhere as the recommended data base [8]. For MoO_3, the values in the above study are ~20% lower than the recommended data [1].

TABLE 535. MoO_3 – K_2MoO_4: Density (g cm^{-3})

T(K)	Mol percent K_2MoO_4				
	85.87	69.87	39.80	31.46	18.65
910			2.982		3.237
970			2.920	3.003	3.169
1000			2.889	2.970	3.138
1030			2.856	2.935	
1060		2.605		2.899	
1090		2.580			
1120	2.476	2.557			
1210	2.445	2.498			
1240	2.422				

Temperature-dependent equations

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

Mol % K_2MoO_4	a	$-b \times 10^3$	$c \times 10^6$	standard error of estimate
100	3.1339	0.5425		0.01%
85.87	-1.9831	-7.9911	-3.5798	0.12%
69.87	4.4907	2.7142	0.8819	0.03%
47.56	4.9075	3.5709	1.3674	0.14%
39.80	3.6209	0.3988	-0.3335	0.04%
31.46	3.2137	-0.6392	-0.8833	0.06%
22.65	4.3202	1.3910	0.1287	0.06%
18.65	5.0724	2.8518	0.9173	0.05%
11.37	6.1619	4.5517	1.5732	0.11%
0	4.8704	1.5135		0.20%

These values are based on the data of Morris and Robinson (Archimedean technique) [167]. Accuracy limits, ~±1%. The values for K_2MoO_4 (0% MoO_3) are uniformly higher (~5%) than the recommended data base [1,8].

TABLE 534. Density studies: MoO_3 – K_2MoO_4

Investigations critically examined

Ref.	Mol % K_2MoO_4	Temp. range (K)	Comments
167	0–100	847–1251	Pt bob; Pt-Rh wire; surface tension correction negligible.

TABLE 536. Surface tension studies: MoO_3 – K_2MoO_4

Investigations critically examined

Ref.	Mol % K_2MoO_4	Temp. range (K)	Comments
168	25–100	1044–1386	Pt ring and dish

TABLE 537. MoO_3 - K_2MoO_4: Surface tension (dyn cm^{-1})

T(K)	Mol percent K_2MoO_4				
	81	61	50	42	25
1040			112.3		
1100			108.2	107.0	
1130			106.1	104.9	98.1
1190	122.5	111.0	102.0	100.7	94.1
1340	114.0	100.6	91.7	90.2	84.1
1370	112.3	98.6		88.1	

Temperature-dependent equations

$$\gamma = a + bT$$

Mol percent K_2MoO_4	a	$-b \times 10^3$
100	217.38	64.25
81	189.74	56.54
61	192.97	68.90
50	183.90	68.84
42	183.77	69.83
25	173.42	66.63

These values are based on the data of Gossink and Stevels (ring detachment method); data in equation form; precisions not estimated [168]. Accuracy limits, ~±2%. The values for K_2MoO_4 (0% MoO_3) are uniformly lower (~7–8%) than the recommended values [2].

MoO_3 - Li_2MoO_4

Melt Preparation and Purification

For the method of melt preparation used by Morris and Robinson [167] see: MoO_3–K_2MoO_4.

TABLE 538. Electrical conductance studies: MoO_3 - Li_2MoO_4

Investigations critically examined

Ref.	Mol % Li_2MoO_4	Temp. range (K)	Comments
167	0–100	1041–1271	see: MoO_3–K_2MoO_4

TABLE 539. MoO_3 - Li_2MoO_4: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent Li_2MoO_4			
	85.84	65.23	41.18	16.03
1040			1.209	
1060			1.283	0.809
1080	2.186		1.350	0.871
1120	2.372	1.521	1.468	0.969
1160	2.538	1.619	1.563	1.036
1180	2.614	1.666	1.601	1.057
1220		1.756		

Temperature-dependent equations

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

Mol % Li_2MoO_4	$-a$	$b \times 10^3$	$-c \times 10^6$	standard error of estimate
100	79.9132	-148.53		1.38%
85.84	10.2842	18.2030	6.1631	0.42%
77.88	29.5189	54.3689	23.3504	0.48%
65.23	3.2139	5.9551	1.5423	0.31%
52.51	1.3338	2.6750		0.63%
41.18	10.6330	18.9532	7.2755	0.88%
27.56	1.2893	2.1890		0.89%
16.03	13.9794	24.6273	10.0716	1.29%
0	-0.1437	0.4960		0.28%

These values are based on the data of Morris and Robinson (classical ac method) [167]. Accuracy, ~±2%. The recommended data base values for Li_2MoO_4 (% MoO_3) previously advanced [1] fall uniformly ~80–140% lower than the data set in the above study. For comments on MoO_3, see Table 533.

TABLE 540. Density studies: MoO_3 - Li_2MoO_4

Investigations critically examined

Ref.	Mol % Li_2MoO_4	Temp. range (K)	Comments
167	0–100	1028–1261	see: MoO_3–K_2MoO_4

TABLE 541. MoO_3 - Li_2MoO_4: Density (g cm^{-3})

T(K)	Mol percent Li_2MoO_4			
	85.84	65.23	41.18	16.03
1030			3.155	
1050			3.137	3.256
1070		3.015	3.120	3.236
1110	2.907	2.990	3.088	3.197
1190	2.864	2.941	3.029	3.124
1210		2.928	3.016	

Temperature-dependent equations

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

Mol % Li_2MoO_4	a	$-b \times 10^3$	$c \times 10^6$	standard error of estimate
100	3.9660	1.4877		0.05%
85.84	3.4971	0.5316		0.03%
77.88	3.6172	0.5923		0.03%
65.23	3.6775	0.6193		0.02%
52.51	-0.8651	-7.1893	-3.3271	0.28%
41.18	4.7806	2.2620	0.6639	0.05%
27.56	4.5485	1.6136	0.3425	0.06%
16.03	4.9692	2.2349	0.5748	0.03%
0	4.8550	1.5002		0.20%

These values are based on the data of Morris and Robinson (Archimedean technique) [167]. The data for Li_2MoO_4 (0% MoO_3) from this study have been advanced elsewhere as the recommended data set [8].

TABLE 542. Surface tension studies: MoO_3 - Li_2MoO_4

Investigations critically examined

Ref.	Mol % Li_2MoO_4	Temp. range (K)	Comments
168	30-100	917-1301	Pt ring and dish

TABLE 543. MoO_3 - Li_2MoO_4: Surface tension (dyn cm^{-1})

T(K)	Mol percent Li_2MoO_4			
	80	60	40	30
920			144.1	
980		159.9	140.2	
1040	177.9	156.3	136.3	
1070	176.3	154.6	134.3	118.4
1220	168.3	145.8	124.6	109.6
1250	166.7	144.0	122.7	
1280		142.2		

Temperature-dependent equations

$$\gamma = a + bT$$

Mol percent Li_2MoO_4	a	$-b \times 10^2$
100	276.08	57.86
80	233.47	53.42
60	217.46	58.77
40	203.77	64.88
30	180.95	58.49

These values are based on the data of Gossink and Stevels (ring detachment method); data in equation form; precisions not estimated [168]. Accuracy limits, $\sim \pm 2\%$. The values for Li_2MoO_4 (0% MoO_3) are $\sim 5\%$ low relative to the recommended data set [8].

MoO_3 - Na_2MoO_4

Melt Preparation and Purification

Morris and Robinson [169] used reagent grade molybdenum trioxide and sodium molybdate dihydrate. Both salts were dried and dehydrated by heating in an air oven at 180°C and then were used without further treatment.

TABLE 544. Electrical conductance studies: MoO_3 - Na_2MoO_4

Investigations critically examined

Ref.	Mol % Na_2MoO_4	Temp. range (K)	Comments
169	0-100	913-1323	Vycor or quartz cells; Pt disk electrodes; calibration: molten NaCl, satd. NaCl, satd. KCl; frequency: 1000Hz.

TABLE 545. MoO_3 – Na_2MoO_4: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent Na_2MoO_4				
	90	66	50	30	12
930		0.942	0.776	0.676	
990		1.129	0.956	0.865	0.651
1050	1.270	1.325	1.136	1.047	0.725
1080	1.356	1.426	1.226	1.134	0.762
1200	1.700				
1230	1.786				

Temperature-dependent equations

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

Mol % Na_2MoO_4	$-a$	$b \times 10^3$	$c \times 10^6$	standard error of estimate
100	2.0118	3.1993		0.32%
90	1.7362	2.8635		0.67%
80	2.0147	3.2011		0.15%
72	2.6602	3.8274		0.44%
66	0.7871	0.6794	1.2684	0.67%
50	2.0155	3.0018		0.92%
40	-4.8568	-10.6490	6.7021	2.17%
30	3.2432	5.2158	-1.0765	0.84%
22	2.5100	3.3461		0.54%
12	0.5725	1.2357		0.91%
9.8	1.8670	2.5835		0.94%
0	-0.2244	-0.8131	1.3003	0.08%

These values are based on the data of Morris, Cook, Sykes, and Templeman (classical ac method) [169]. The values for Na_2MoO_4 and MoO_3 in the above study have been advanced elsewhere as a recommended data set [1].

TABLE 546. Density studies: MoO_3 – Na_2MoO_4

Investigations critically examined

Ref.	Mol % Na_2MoO_4	Temp. range (K)	Comments
169	0–72	934–1182	Tungsten sinker encased in opaque quartz; B&S gauge No.24 Pt wire.

TABLE 547. MoO_3 – Na_2MoO_4: Density (g cm^{-3})

T(K)	Mol percent Na_2MoO_4				
	72	66	40	30	12
940			3.12	3.22	
960		2.95	3.09	3.20	
980	2.79	2.92	3.07	3.17	
1000	2.79	2.89	3.04	3.15	3.16
1100	2.79	2.82	2.96	3.03	3.08

Temperature-dependent equations

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

Mol % $NaMoO_4$	a	$-b \times 10^3$	$c \times 10^6$	standard error of estimate
72	2.790			0.00%
66	8.329	9.724	4.29	0.08%
40	7.559	7.896	3.38	0.04%
30	4.362	1.212		0.01%
22	4.165	1.007		0.04%
12	4.028	0.865		0.06%
9.8	-6.431	18.11949	-8.61	0.07%
0	4.5226	1.3049		0.01%

These values are based on the data of Morris, Cook, Sykes, and Templeman (Archimedean technique) [169]. The values for Na_2MoO_4 (0% MoO_3) in the above study were advanced elsewhere as a recommended data set [1].

TABLE 548. Surface tension studies: MoO_3 – Na_2MoO_4

Investigations critically examined

Ref.	Mol % Na_2MoO_4	Temp. range (K)	Comments
168	20–100	931–1294	Pt ring and dish

TABLE 549. MoO_3 – Na_2MoO_4: Surface tension (dyn cm^{-1})

T(K)	Mol percent Na_2MoO_4				
	80	60	40	30	20
930		155.7			
960		153.6			
990	169.2	151.5	132.1		
1020	167.1	149.4	129.9		
1050	165.1	147.4	127.7	117.2	103.3
1230	152.8	134.9	114.4	105.0	91.5
1260					89.5

Temperature-dependent equations

$\gamma = a + bT$

Mol percent Na_2MoO_4	a	$-b \times 10^3$
100	259.71	66.58
80	236.78	68.27
60	219.95	69.13
40	205.18	73.82
30	187.80	67.28
20	172.42	65.79

These values are based on the data of Gossink and Stevels (ring detachment method); data in equation form; precisions not estimated [168]. For Na_2MoO_4 (0% MoO_3) the values above are ~7% lower than the recommended data set [2].

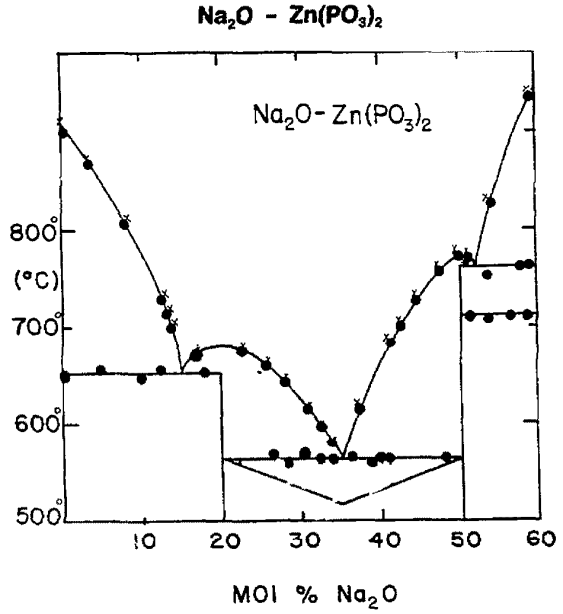

FIGURE 86. Phase diagram for Na_2O – $Zn(PO_3)_2$.

Data from: E. L. Krivovyazov, N. K. Voskresenskaya, K. K. Palkina, Zh. Neorg. Mat., Inorg. Mat. 5(6), 898 (1969).

Melt Preparation and Purification

For the method of melt preparation used by Krivovyazov et al. [166], see: K_2O–$Zn(PO_3)_2$.

TABLE 550. Density studies: Na_2O – $Zn(PO_3)_2$

Investigations critically examined

Ref.	Mol percent $Zn(PO_3)_2$	Temp. range (K)	Comments
166	41.2–95.4	1125–1375	see: K_2O–$Zn(PO_3)_2$

TABLE 551. Na_2O – $Zn(PO_3)_2$: Density (g cm^{-3})

T(K)	Mol percent $Zn(PO_3)_2$			
	95.4	86.1	63.2	41.2
1120		2.789	2.771	
1180	2.786	2.778	2.753	
1240	2.778	2.767	2.735	2.667
1300	2.771	2.755	2.717	2.645
1360	2.763	2.744		2.624

Temperature-dependent equations

$\rho = a + bT$

Mol percent $Zn(PO_3)_2$	a	$-b \times 10^3$
95.4	2.9330	0.1247
86.1	3.0024	0.1902
63.2	3.1084	0.3104
41.2	3.1100	0.3576

These values are based on the data of Krivovyazov and Voskresenskaya (Archimedean technique); data in equation form; precisions not estimated [166]. The results for $Zn(PO_3)_2$ from the same laboratory in an earlier study have been advanced as a recommended data set [8].

TABLE 552. Surface tension studies: Na_2O – $Zn(PO_3)_2$

Investigations critically examined

Ref.	Mol percent $Zn(PO_3)_2$	Temp. range (K)	Comments
166	42.1–90.6	1177–1439	see: K_2O–$Zn(PO_3)_2$
165	graphical		see: [166]

TABLE 553. $Na_2O - Zn(PO_3)_2$: Surface tension (dyn cm^{-1})

T(K)	Mol percent $Zn(PO_3)_2$			
	90.6	73	59.7	42.1
1170			214.8	
1200	190.7	198.8	213.9	
1290	189.4	196.1	211.3	248.2
1350	188.5	194.3	209.5	245.4
1380	188.0	193.4		244.0
1440	187.1			

Temperature-dependent equations

$\gamma = a + bT$

Mol percent $Zn(PO_3)_2$	a	$-b \times 10^3$
90.6	208.45	14.8
73	235.31	30.4
59.7	249.33	29.5
42.1	308.18	46.5

These values are based on the data of Krivovyazov and Voskresenskaya (maximum bubble pressure method); data in equation form; precisions not estimated [166]. For $Zn(PO_3)_2$, the results from an earlier study in the same laboratory were advanced as a recommended data set [8].

$NiO - K_2B_4O_7$

Melt Preparation and Purification

Kochergin et al. [162, 170] used analytical grade NiO.

TABLE 554. Density studies: $NiO - K_2B_4O_7$

Investigations critically examined

Ref.	Mol percent $K_2B_4O_7$	Temp. range (K)	Comments
162	82-100	1123	Pt sphere; calibration: toluene

TABLE 555. $NiO - K_2B_4O_7$: Density (g cm^{-3})

Mol percent $K_2B_4O_7$	1123 K
100	1.997
95.0	2.005
85.9	2.013
81.7	2.019

Concentration-dependent equation

$\rho = 2.112 - 0.114 \times 10^{-2}C$

[C = Mol % $K_2B_4O_7$]

Standard error or estimate = 0.1%

The above values are reported by Kochergin, Baldina, and Kareva (Archimedean technique) [162]. Precision, ~2%. For comments on $K_2B_4O_7$, see Table 512 and following.

TABLE 556. Viscosity studies: $NiO - K_2B_4O_7$

Investigations critically examined

Ref.	Mol % $K_2B_4O_7$	Temp. range (K)	Comments
170	96-99	1123,1173	scc: $NiO-KPO_3$

TABLE 557. $NiO - K_2B_4O_7$: Viscosity (cp)

Mol percent $K_2B_4O_7$	1123 K	1173 K
99	5.0	3.6
98	5.9	4.4
97	6.8	5.2
96	7.7	6.1

Composition-dependent equation

$\eta = a + bC$

[C = Mol % $K_2B_4O_7$]

T(K)	a	$-b \times 10^2$
1123	92.26	88.12
1173	85.54	82.79

These values are based on the data of Kochergin, Baldina, Vinyaskaya, and Pavlova (oscillational method); data in graphical form; precisions not estimated [170].

$NiO - KPO_3$

Melt Preparation and Purification

Kochergin et al. [162, 170] used analytical grade NiO. The potassium metaphosphate was prepared by dehydration of KH_2PO_4 at 850°C.

TABLE 558. Density studies: $NiO - KPO_3$

Investigations critically examined

Ref.	Mol percent KPO_3	Temp. range (K)	Comments
162	92-100	1123	Pt sphere; calibration: toluene

TABLE 559. $NiO - KPO_3$: Density (g cm^{-3})

Mol percent KPO_3	1123 K
100	2.086
97.4	2.133
94.9	2.142
92.3	2.156

Concentration dependent equation

$\rho = 2.955 - 0.859 \times 10^{-2}C$

[C = Mol % KPO_3]

Standard error of estimate = 0.1%

The above values are reported by Kochergin, Baldina, and Kareva (Archimedean technique) [162]. Precision, ~2%. For comments on KPO_3, see Table 514 and following.

TABLE 560. Viscosity studies: NiO - KPO_3

Investigations critically examined

Ref.	Mol % KPO_3	Temp. range (K)	Comments
170	80–100	1123,1173	no information

TABLE 561. NiO - KPO_3: Viscosity (poise)

Mol percent KPO_3	1123 K	1173 K
100	2.75	1.59
95	5.18	3.78
90	5.43	4.19
85	4.61	3.41
80	3.80	2.83

These values interpolated, from the graphical data of Kochergin, Baldina, Vinyaskaya, and Pavlova (oscillational method) **[170]**, could not be fitted with simple equations.

NiO - $Na_2B_4O_7$

Melt Preparation and Purification

Kochergin et al. **[162]** used analytical grade NiO. No other information was given.

TABLE 562. Density studies: NiO - $Na_2B_4O_7$

Investigations critically examined

Ref.	Mol percent $Na_2B_4O_7$	Temp. range (K)	Comments
162	81–100	1123	Pt sphere; calibration: toluene

TABLE 563. NiO - $Na_2B_4O_7$: Density (g cm^{-3})

Mol percent $Na_2B_4O_7$	1123 K
100	2.095
94.8	2.102
84.9	2.113
81.0	2.129

Composition dependent equation

$$\rho = 2.2770 - 0.1829 \times 10^{-2}C$$

[C = Mol % $Na_2B_4O_7$]

Standard error of estimate = 0.1%

The above values are reported by Kochergin, Baldina, and Kareva (Archimedean technique) **[162]**. Precision, ~2%. For comments on $Na_2B_4O_7$, see Table 516 and following.

NiO - $NaPO_3$

Melt Preparation and Purification

For the method of melt preparation used by Kochergin et al. **[162]**, see: NiO–KPO_3.

TABLE 564. Density studies: NiO - $NaPO_3$

Investigations critically examined

Ref.	Mol percent $NaPO_3$	Temp. range (K)	Comments
162	88–100	1113	Pt sphere; calibration: toluene

TABLE 565. NiO - $NaPO_3$: Density (g cm^{-3})

Mol percent $NaPO_3$	1123 K
100	2.442
97.2	2.493
93.2	2.573
88.9	2.653

Concentration-dependent equation

$$\rho = 90.549 - 185.07 \times 10^{-2}C + 96.93 \times 10^{-4}C^2$$

[C = Mol % $NaPO_3$]

Standard error of estimate = 1.5%

The above values are reported by Kochergin, Baldina, and Kareva (Archimedean technique) **[162]**. Precision, ~2%. For comments on $NaPO_3$, see Table 518 and following.

PbO - $K_2B_4O_7$

Melt Preparation and Purification

No information on melt preparation was given in the study by Kochergin et al. **[162]**.

TABLE 566. Density studies: PbO - $K_2B_4O_7$

Investigations critically examined

Ref.	Mol percent $K_2B_4O_7$	Temp. range (K)	Comments
162	85–100	1123	Pt sphere; calibration: toluene

TABLE 567. PbO – $K_2B_4O_7$: Density (g cm^{-3})

Mol percent $K_2B_4O_7$	1123 K
100	1.997
94.8	2.085
89.6	2.178
84.4	2.271

Concentration-dependent equation

$\rho = 3.757 - 1.769 \times 10^{-2}C$

[C = Mol % $K_2B_4O_7$]

Standard error of estimate = 0.1%

The above values are reported by Kochergin, Baldina, and Kareva (Archimedean technique) [162]. Precision, ~2%. For comments on $K_2B_4O_7$, see Table 512 and following.

PbO – KPO_3

Melt Preparation and Purification

No information on melt preparation was given in the study by Kochergin et al. [162].

TABLE 568. Density studies: PbO – KPO_3

Investigations critically examined

Ref.	Mol percent KPO_3	Temp. range (K)	Comments
162	91–100	1123	Pt sphere; calibration: toluene

TABLE 569. PbO – KPO_3: Density (g cm^{-3})

Mol percent KPO_3	1123 K
99.5	2.135
97.3	2.282
94.5	2.473
91.5	2.675

Concentration-dependent equation

$\rho = 8.839 - 6.740 \times 10^{-2}C$

[C = Mol % KPO_3]

Standard error of estimate = 0.1%

The above values are reported by Kochergin, Baldina, and Kareva (Archimedean technique) [162]. Precision, ~2%. For comments on KPO_3, see Table 514 and following.

PbO – $Na_2B_4O_7$

Melt Preparation and Purification

No information on melt preparation was given in the study by Kochergin et al. [162].

TABLE 570. Density studies: PbO – $Na_2B_4O_7$

Investigations critically examined

Ref.	Mol percent $Na_2B_4O_7$	Temp. range (K)	Comments
162	86–100	1123	Pt sphere; calibration: toluene

TABLE 571. PbO – $Na_2B_4O_7$: Density (g cm^{-3})

Mol percent $Na_2B_4O_7$	1123 K
100	2.095
95.5	2.184
90.9	2.280
86.3	2.369

Concentration-dependent equation

$\rho = 4.100 - 2.2006 \times 10^{-2}C$

[C = Mol % $Na_2B_4O_7$]

Standard error of estimate = 0.1%

The above values are reported by Kochergin, Baldina, and Kareva (Archimedean technique) [162]. Precision, ~0.2%; see Table 512.

PbO – $NaPO_3$

Melt Preparation and Purification

No information on melt preparation was given in the study by Kochergin et al. [162].

TABLE 572. Density studies: PbO – $NaPO_3$

Investigations critically examined

Ref.	Mol percent $NaPO_3$	Temp. range (K)	Comments
162	95–100	1123	Pt sphere; calibration: toluene

TABLE 573. PbO – $NaPO_3$: Density (g cm^{-3})

Mol percent $NaPO_3$	1123 K
99.54	2.224
97.65	2.383
96.68	2.455
95.17	2.574

Concentration-dependence equation

$\rho = 10.200 - 8.011 \times 10^{-2}C$

[C = Mol % $NaPO_3$]

Standard error of estimate = 0.2%

The above values are reported by Kochergin, Baldina, and Kareva (Archimedean technique) [162]. Precision, ~2%. For comments on $NaPO_3$, see Table 518 and following.

PbO - $PbMoO_4$

Melt Preparation and Purification

No information on melt preparation was given in the study by Morris and Mazumder [171].

TABLE 576. Density studies: PbO - $PbMoO_4$

Investigations critically examined

Ref.	Mol % $PbMoO_4$	Temp. range (K)	Comments
171	0–100	1141–1466	Pt bob; Pt–Rh wire

TABLE 574. Electrical conductance studies: PbO - $PbMoO_4$

Investigations critically examined

Ref.	Mol % $PbMoO_4$	Temp. range (K)	Comments
171	0–100	1129–1473	alumina cell and crucibles; calibration: 0.1*N* and 1.0N KCl.

TABLE 575. PbO - $PbMoO_4$: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent $PbMoO_4$				
	80	60	40	12	5
1130				0.917	
1230				1.382	
1270		0.843	0.936		
1290		0.887	0.994		1.414
1350		1.017	1.170		1.749
1370	0.933		1.228		1.860
1390	0.965				1.971
1450	1.062				

Temperature-dependent equations

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

Mol % $PbMoO_4$	$-a$	$b \times 10^3$	$c \times 10^6$
100	1.2141	1.5516	
80	1.2724	1.6097	
60	1.9083	2.1666	
40	2.7743	2.9215	
12	-4.4507	-10.2643	6.3164
5	5.7681	5.5679	
0	5.1646	5.2499	

These values are based on the data of Morris and Mazumder (classical ac method); data in equation form; precisions not estimated [171]. The values for PbO (0% $PbMoO_4$) are about 50% lower than an earlier study [1]; for $PbMoO_4$ (0% PbO), the results agree with the recommended data base [8] to ~0.5%.

TABLE 577. PbO - $PbMoO_4$: Density (g cm^{-3})

T(K)	Mol percent $PbMoO_4$				
	80	60	40	12	5
1140				7.079	
1220				6.966	
1240				6.938	
1260		5.780			
1280		5.769	6.133		7.111
1340	5.409	5.736	6.088		7.067
1360	5.397	5.725	6.073		7.052
1460	5.339				

Temperature-dependent equations

$\rho = a + bT$

Mol percent $PbMoO_4$	a	$-b \times 10^3$
100	5.1386	0.0405
80	6.1828	0.5777
60	6.4802	0.5556
40	7.0844	0.7436
12	8.6857	1.4098
5	8.0493	0.7331
0	9.4831	1.3384

These values are based on the data of Morris and Mazumder (Archimedean technique); data in equation form; precisions not estimated [171]. The values for $PbMoO_4$ (0% PbO) agree with the recommended data set [8] to within ±1%.

TABLE 578. Surface tension studies: PbO - $PbMoO_4$

Investigations critically examined

Ref.	Mol % $PbMoO_4$	Temp. range (K)	Comments
232	0–100	1140–1489	no information given

TABLE 579. PbO - $PbMoO_4$: Surface tension (dyn cm^{-1})

T(K)	Mol percent $PbMoO_4$				
	80	60	40	12	5
1140				136.8	
1220				134.2	
1240		149.0			
1280		147.2	163.7		
1300		146.9	162.2		137.5
1360	145.3	141.1	159.1		134.7
1400	143.4				132.9
1440	141.6				

Temperature-dependent equations
$\gamma = a + bT$

Mol percent $PbMoO_4$	a	$-b \times 10^3$
100	257.94	80.51
80	209.68	47.3
60	198.00	39.5
40	238.05	58.1
12	174.14	32.7
5	196.6	45.5
0	244.26	69.5

These values are based on the data of Mazumder and Morris (pin-detachment technique); data in equation form; precisions not estimated [232]. Accuracy limits, $\sim \pm 1.5\%$. The values for $PbMoO_4$ in the above study are $\sim 10\%$ lower than the earlier data set from the same laboratory [2]. Because of more precise instrumentation and techniques, the values in this study [232] are recommended as more accurate. Note: In [232] the arithmetical sign of the b coefficient is incorrect.

Sb_2O_3 - $CaSb_2O_4$

Melt Preparation and Purification

Zenaidi, Renaud and Josien [172] pulverized the mixture into a fine powder to avoid oxidation. All procedures were carried out in an atmosphere of pure argon.

TABLE 580. Electrical conductance studies: Sb_2O_3 - $CaSb_2O_4$

Investigations critically examined			
Ref.	Mol % $CaSb_2O_4$	Temp. range (K)	Comments
172	0–15	1033	silica cell: Pt electrodes

TABLE 581. Sb_2O_3 - $CaSb_2O_4$: Specific conductance ($ohm^{-1}cm^{-1}$)

Mol percent $Ca_2Sb_2O_4$	1033 K
15	0.036
10	0.059
5	0.061
0	0.044

Composition-dependent equation
$\kappa = 0.0443 + 0.5402 \times 10^{-2}C - 0.397 \times 10^{-3}C^2$
[C = Mol % $CaSb_2O_4$]

These values are based on the data of Zenaidi, Renaud and Josien (classical ac method); data in graphical form; precision not estimated [172]. The recommended data base value for the specific conductance of Sb_2O_3 (extrapolated from 1110 to 1033 K) is 0.011 ohm^{-1} cm^{-1} [1].

Sb_2O_3 - $CaSb_2O_6$

Melt Preparation and Purification

For the method of melt preparation used by Zenaidi et al. [172], see: Sb_2O_3–$CaSb_2O_4$.

TABLE 582. Electrical conductance studies: Sb_2O_3 - $CaSb_2O_6$

Investigations critically examined			
Ref.	Mol % $CaSb_2O_6$	Temp. range (K)	Comments
172	0–15	1033	see: Sb_2O_3–$CaSb_2O_4$

TABLE 583. Sb_2O_3 - $CaSb_2O_6$: Specific conductance ($ohm^{-1}cm^{-1}$)

Mol percent $CaSb_2O_6$	1033 K
15	0.032
10	0.036
5	0.040
0	0.044

Composition-dependent equation
$\kappa = 0.0446 - 0.8227 \times 10^{-3}C$
[C = Mol % $CaSb_2O_6$]

These values are based on the data of Zenaidi, Renaud and Josien (classical ac method); data in graphical form; precision not estimated [172]. For comments on the value for Sb_2O_3, see Table 581 and following.

Sb_2O_3 - $Ca_4Sb_8O_{23}$

Melt Preparation and Purification

For the method of melt preparation used by Zenaidi et al. [172], see: Sb_2O_3–$CaSb_2O_4$.

TABLE 584. Electrical conductance studies: Sb_2O_3 - $Ca_4Sb_8O_{23}$

Investigations critically examined			
Ref.	Mol % $Ca_4Sb_8O_{23}$	Temp. range (K)	Comments
172	0–15	1033	see: Sb_2O_3–$CaSb_2O_4$

TABLE 585. Sb_2O_3 - $Ca_4Sb_8O_{23}$: Specific conductance ($ohm^{-1}cm^{-1}$)

Mol percent $Ca_4Sb_8O_{23}$	1033 K
15	0.039
10	0.046
5	0.050
0	0.044

Composition-dependent equation

$$\kappa = 0.0500 + 0.2871 \times 10^{-3}C - 0.689 \times 10^{-4}C^2$$

[C = Mol % $Ca_4Sb_8O_{23}$]

These values are based on the data of Zenaidi, Renaud and Josien (classical ac method); data in graphical form; precision not estimated [**172**]. For comments on the value of Sb_2O_3, see Table 581 and following.

SiO_2 - CaC_2

Melt Preparation and Purification

No information on melt preparation and purification was given in the study by Hellmold et al. [**164**], or in experimental references cited therein.

TABLE 586. Viscosity studies: SiO_2 - CaC_2

Investigations critically examined			
Ref.	Mol % CaC_2	Temp. range (K)	Comments
164	93–100	2343	graphite cylinder

Viscosity: No data; for a graphical illustration of the effect on viscosity of varying SiO_2 in the system CaC_2–CaO–SiO_2–Fe_2O_3, see [**164**].

SiO_2 - Li_2CO_3

Melt Preparation and Purification

Moiseev and Stepanov [**148**] used reagent grade salts. No other information was given.

TABLE 587. Surface tension studies: SiO_2 - Li_2CO_3

Investigations critically examined			
Ref.	Mol % Li_2CO_3	Temp. range (K)	Comments
148	85–100	1038	Pt capillary; dry Ar atmosphere

TABLE 588. SiO_2 - Li_2CO_3: Surface tension (dyn cm^{-1})

Mol percent Li_2CO_3	1038 K
100	242
95	252
90	257
85	255

Composition-dependent equation

$$\gamma = -790.5 + 23.55C - 13.24 \times 10^{-2}C^2$$

[C = Mol % Li_2CO_3]

These values are based on the data of Moiseev and Stepanov (maximum bubble pressure method); data in graphical form; precision not estimated [**148**]. For Li_2CO_3 (100%), the value is in exact agreement with the recommended data set [2].

SiO_2 - Na_3AlF_6

Melt Preparation and Purification

Grjotheim et al. [**153**] used hand-picked natural Greenland cryolite (m.p. 1006°C). The fluoride content was determined by analysis.

TABLE 589. Electrical conductance studies: SiO_2 - Na_3AlF_6

Investigations critically examined			
Ref.	Mol % Na_3AlF_6	Temp. range (K)	Comments
153	80–100	1273	Pt electrodes; calibration: molten cryolite; frequency: 18 KHz.

TABLE 590. SiO_2 - Na_3AlF_6: Specific conductance ($ohm^{-1}cm^{-1}$)

Mol percent Na_3AlF_6	1273 K
100	2.80
95	2.68
90	2.59
85	2.53
80	2.49

Composition-dependent equation

$$\kappa = 5.756 - 8.525 \times 10^{-2}C + 5.56 \times 10^{-4}C^2$$

[C = Mol % Na_3AlF_6]

Standard error of estimate = 0.64%

These values are based on the data of Grjotheim, Matiasovsky, Fellner, and Silny (classical ac method) [**153**]. The specific conductance of Na_3AlF_6 (100%) extrapolated from the recommended data base to 1273 K, is 2.794 ohm^{-1} cm^{-1} [8]. For conductance data on the ternary system Al_2O_3–Na_3AlF_6–SiO_2, see Table 482.

TABLE 591. Density studies: SiO_2 – Na_3AlF_6

Investigations critically examined			
Ref.	Mol % Na_3AlF_6	Temp. range (K)	Comments
153	80–100	1273	Pt–10% Rh bob; Pt wire suspension; calibration: molten NaCl; estimated accuracy, ±0.5%

TABLE 592. SiO_2 – Na_3AlF_6: Density (g cm^{-3})

Mol percent Na_3AlF_6	1273 K
100	2.102
95	2.101
90	2.100
85	2.099
80	2.097

Composition-dependent equation

$$\rho = 2.0802 + 0.0216 \times 10^{-2}C$$

[C = Mol % Na_3AlF_6]

Standard error of estimate = 0.02%

These values are based on the data of Grjotheim, Matiasovsky, Fellner, and Silny (Archimedean technique) **[153]**. The value for Na_3AlF_6 (100%) is in exact accord with the recommended data set [4]. For density data on the ternary system Al_2O_3–Na_3AlF_6–SiO_2, see Table 484.

Ta_2O_5 – K_2TaF_7

Melt Preparation and Purification

Winterhager and Werner **[173]** prepared the melts from carefully dried reagent grade salts.

TABLE 593. Electrical conductance studies: Ta_2O_5 – K_2TaF_7

Investigations critically examined			
Ref.	Mol % K_2TaF_7	Temp. range (K)	Comments
173	80–100	1073,1173	Pt electrodes

TABLE 594. Ta_2O_5 – K_2TaF_7: Specific conductance (ohm^{-1}cm^{-1})

Mol percent K_2TaF_7	1073 K	1173 K
100	0.92	1.06
95	0.90	1.03
90	0.86	0.99
85	0.80	0.93
80	0.72	0.85

Composition-dependent equations

$$\kappa = a + bC + cC^2$$

[C = Mol % K_2TaF_7]

T(K)	$-a$	$b \times 10^2$	$-c \times 10^4$
1073	3.228	8.045	3.89
1173	3.529	9.036	4.46

These values are based on the data of Winterhager and Werner (classical ac method); data in graphical form; precisions not estimated **[173]**. Accuracy limits, ~±2%. Data for the temperature dependence of conductance for K_2TaF_7 (100%) are reported in **[173]**. For the temperature range 1020 – 1160 K, the conductance may be expressed by: $\kappa = -17.956 + 32.81 \times 10^{-3}T - 14.185 \times 10^{-6}T^2$, (precision limits, ~±2.7%). For comparison, the results for Na_2TaF_7 (100%) in the same work **[173]** are: 873 – 1087 K; $\kappa = -24.859 + 47.561 \times 10^{-3}T - 21.370 \times 10^{-6}T^2$ (precision limits, ~±2%).

TiO_2 – K_2TiF_6

Melt Preparation and Purification

For the method of melt preparation used by Winterhager and Werner **[173]** see: Ta_2O_5–K_2TaF_7.

TABLE 595. Electrical conductance studies: TiO_2 – K_2TiF_6

Investigations critically examined			
Ref.	Mol % K_2TiF_6	Temp. range (K)	Comments
173	60–100	1143,1193	Pt electrodes

TABLE 596. TiO_2 - K_2TiF_6: Specific conductance ($ohm^{-1}cm^{-1}$)

Mol percent K_2TiF_6	1143 K	1193 K
100	1.40	1.50
90	1.32	1.43
80	1.26	1.36
70	1.21	1.31
60	1.17	1.27

Composition-dependent equations

$\kappa = a + bC + cC^2$

[C = Mol % K_2TiF_6]

T(K)	a	$b \times 10^2$	$c \times 10^4$
1143	1.320	0.751	0.84
1193	1.304	0.448	0.65

These values are based on the data of Winterhager and Werner (classical ac method); data in graphical form; precisions not estimated [173]. Accuracy limits, ~±2%. Data for the temperature-dependence of conductance for K_2TiF_6 (100%) are reported in [173]; for 1116 - 1249 K, the conductance may be expressed by: $\kappa = -0.8143 + 1.9370 \times 10^{-3}T$ (precision limits, ~±0.2%).

TiO_2 - Na_2TiF_6

Melt Preparation and Purification

Milov et al. [116] used reagent grade salts. No other information was given.

TABLE 597. Density studies: TiO_2 - Na_2TiF_6

Investigations critically examined			
Ref.	Mol % Na_2TiF_6	Temp. range (K)	Comments
116	63.5	1098–1213	Pt sphere and suspension wire

TABLE 598. TiO_2 - Na_2TiF_6: Density (g cm^{-3})

T(K)	Mol percent Na_2TiF_6
	63.5
1100	2.349
1140	2.318
1180	2.287
1200	2.272

Temperature-dependent equation

$\rho = 3.2057 - 0.7785 \times 10^{-3}T$

Standard error of estimate = 0.05%

These values are based on the data of Milov, Baitenev and Ponomarev (Archimedean technique) [116]. Accuracy limits, ~±1.5%.

Tl_2O_3 - Li_2CO_3

Melt Preparation and Purification

For the method of melt preparation used by Moiseev and Stepanov [148], see: SiO_2–Li_2CO_3.

TABLE 599. Surface tension studies: Tl_2O_3 - Li_2CO_3

Investigations critically examined			
Ref.	Mol % Li_2CO_3	Temp. range (K)	Comments
148	97–100	1038	see: SiO_2-Li_2CO_3

TABLE 600. Tl_2O_3 - Li_2CO_3: Surface tension (dyn cm^{-1})

Mol percent Li_2CO_3	1038 K
100	242
99	228
98	220
97	212

Composition-dependent equation

$\gamma = -588.3 + 8.250C$

[C = Mol % Li_2CO_3]

These values are based on the data of Moiseev and Stepanov (maximum bubble pressure method); data in graphical form; precision not estimated [148]. See Table 588 and following, for comments on value for Li_2CO_3 (100%).

V_2O_5 - KVO_3

Melt Preparation and Purification

Makarevich et al. [174] used C.P. grade V_2O_5 and analytical grade KVO_3. The N_2 used to provide the inert atmosphere was carefully purified to remove traces of O_2 and moisture by passing it through concentrated sulfuric acid and P_2O_5, and then through a tube containing metallic Mg and Ti, heated to 800°C. Allersma et al. [175] used (Fisher) A.R. grade V_2O_5 (tm, 668°C; $V_2O_{4.9}$); all melting was carried out in platinum crucibles in air. After the melt was held for 3 hrs in air at 800°C, and permitted to crystallize, 0.02% Pt was found to be present in the V_2O_5 crystals. Pantony and Vasu [176] started with (Johnson and Matthey) "High Purity" V_2O_5 (99.99%), and an oxygen atmosphere to minimize dissociation of the melts.

TABLE 601. Electrical conductance studies: V_2O_5 – KVO_3

Investigations critically examined

Ref.	Mol % KVO_3	Temp. range (K)	Comments
177	0–50	833–1250	quartz cells
175	0	950–1200	Pt crucible; Pt electrodes (calibr. 0.01 and 0.1 *N* KCl)
176	0	965–1215	Pt crucible; Pt electrodes; oxygen atmosphere (calibr. 0.01 M KCl; molten KCl)

Deviations from previous NSRDS recommendations [1]

Ref.	V_2O_5 Mol %	Min. departure	Max. departure
177	100	~–10% (1237 K)	~75% (1140 K)
175	100	results do not overlap in *T* range	
176	100	~180% (1215 K)	~200% (1128 K)

The results of Pantony and Vasu [176] differ markedly from the previous NSRDS recommendations [1,178] and from the results of [177,175]. Pantony attributes this to the high purity of the V_2O_5 used in their study, to the absence of contamination by silica, alumina or zirconia, and to the use of an ambient oxygen atmosphere to repress dissociation: $V_2O_5 = 2VO_2 + 1/2\ O_2$.

TABLE 602. V_2O_5 – KVO_3: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent KVO_3				
	50.0	44.6	40.4	24.4	9.4
835	0.31	0.27	0.23		
910	0.42	0.38	0.33	0.19	0.09
1000	0.55	0.51	0.45	0.28	0.15
1250	0.85	0.81	0.71	0.55	0.34

Temperature-dependent equations

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

Mol % KVO_3	$-a$	$b \times 10^3$	$-c \times 10^6$
50.0	1.320	2.408	0.54
44.6	1.364	2.389	0.52
40.4	1.368	2.424	0.61
32.2	1.587	2.711	0.76
24.4	0.797	1.080	
18.0	0.675	0.897	
9.4	0.244	0.116	–0.28

These values are based on the data of Musikhin, Chernyaev, Makarevich, and Koz'minykh; (classical ac technique; quartz cells); data in graphical form; precisions not estimated [177].

TABLE 603. Density studies: V_2O_5 – KVO_3

Investigations critically examined

Ref.	Mol % KVO_3	Temp. range (K)	Comments
174	0–100	mp–1273	max. bubble method; N_2 atmosphere; calibration: molten KNO_3, NaCl
176	0	975–1140	Archimedean technique; Au–Pt bob; Pt crucible; oxygen atmosphere

The density data for molten V_2O_5 in an ambient oxygen atmosphere are presented graphically in [176]; the densities vary non-linearly with temperature.

TABLE 604. V_2O_5 – KVO_3: Density (g cm^{-3})

T(K)	Mol percent KVO_3			
	89.0	65.8	36.0	19.0
750	2.439			
850	2.409	2.450		
950	2.380	2.422	2.433	2.442
1150	2.321	2.366	2.382	2.390
1250	2.292	2.337		2.364
1275		2.330		2.358

Temperature-dependent equations

$$\rho = a + bT$$

Mol percent KVO_3	*a*	$-b \times 10^3$
100	2.515	0.222
89.0	2.658	0.293
80.6	2.694	0.302
65.8	2.691	0.283
51.7	2.682	0.267
36.0	2.676	0.256
19.0	2.689	0.260
0	2.690	0.267

These values are based on the data of Makarevich, Koz'minykh and Ketov (maximum bubble pressure method); data in equation form; precisions not estimated [174]. At 973 K, for V_2O_5 (0% KVO_3), the values for the density under N_2 and O_2 atmospheres are respectively: 2.43 [174] and 2.27 [176].

TABLE 605. Viscosity studies: V_2O_5 - KVO_3

Investigations critically examined			
Ref.	Mol % KVO_3	Temp. range (K)	Comments
177	0–50	833–1250	Pt blade attached to vertically supported rod
176	0	940–1150	rate of displacement of suspended Au–Pt bob
179	0	923–1173	damped oscillation technique; Pt–Ir sphere

The viscosity results for V_2O_5 [176] as a function of temperature are illustrated graphically. The viscosities were for V_2O_5 in an ambient oxygen atmosphere (to repress the dissociation: $V_2O_5 = 2VO_2 + 1/2\ O_2$). The values are uniformly lower than in [177, 179]; the difference changing from ~30% at ~1000 K to ~300% at ~1100 K [177], and ~70% at ~1000 K to ~260% at ~1140 K [179].

TABLE 606. V_2O_5 - KVO_3: Viscosity (cp)

T(K)	Mol percent KVO_3		
	50.0	18.0	9.4
910	72.0	58.5	51.3
1000	53.3	44.6	38.9
1250	28.9	26.8	

Temperature-dependent equations

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

Mol % KVO_3	a	$-b \times 10^3$	$c \times 10^6$
50.0	553.73	822.39	322.0
32.2	insufficient data for equation		
18.0	422.83	623.86	245.6
9.4	455.62	723.20	306.5

These values are based on the data of Musikhin, Chernyaev, Makarevich and Koz'minykh (rate of displacement of sinking Au–Pt bob); data in graphical form; precisions not estimated [177]. The values for V_2O_5 (0% KVO_3) at 1111 K from [177] and [176] are, respectively, 26 and 30 cp (the measurements in [176] were in oxygen).

TABLE 607. Surface tension studies: V_2O_5 - KVO_3

Investigations critically examined			
Ref.	Mol % KVO_3	Temp. range (K)	Comments
174	0–100	733–1273	max. bubble method; N_2 atmosphere; calibration: molten KNO_3, NaCl

TABLE 608. V_2O_5 - KVO_3: Surface tension (dyn cm^{-1})

T(K)	Mol percent KVO_3			
	89.0	65.8	36.0	19.0
750	131.7			
850	128.7	106.7		
950	125.7	104.3	94.9	91.5
1150	119.7	99.5	91.4	88.7
1250	116.7	97.0		87.4
1275		96.4		87.0

Temperature-dependent equations

$$\gamma = a + bT$$

Mol percent KVO_3	a	$-b \times 10^3$
100	179.4	33.3
89.0	154.2	30.0
80.6	142.3	28.1
65.8	127.4	24.3
51.7	120.3	21.0
36.0	111.4	17.4
19.0	104.5	13.7
0	100.5	11.8

These values are based on the data of Makarevich, Koz'minykh and Ketov (maximum bubble pressure method); data in equation form, precision not estimated [174].

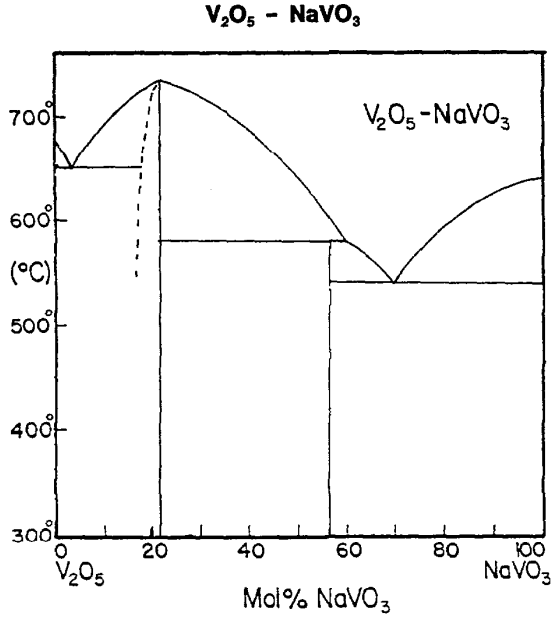

FIGURE 87. Phase diagram for V_2O_5 - $NaVO_3$.

Data from: V. Danek, J. Balajka, and K. Matiasovsky, Chem. Zvesti, 27(6), 748 (1973).

Melt Preparation and Purification

Danek et al. [179] prepared V_2O_5 by the thermal decomposition of reagent grade NH_4VO_3 and Na_2CO_3.

The samples were previously heated for 2 hrs. at 700–750°C and, after cooling, were remelted in order to remove the last traces of CO_2. Allersma et al. [175] used (Fisher) A.R. grade V_2O_5 (m.p., 668°C; $V_2O_{4.9}$); all melting was carried out in platinum crucibles in air. After the melt was held for 3 hrs in air at 800°C, and permitted to crystallize, 0.02% Pt was found to be present in the V_2O_5 crystals. Pantony and Vasu [176] started with (Johnson and Matthey) "High Purity" V_2O_5 (99.99%), and an oxygen atmosphere to minimize dissociation of the melts. The sodium metavanadate–V_2O_5 melts [176] were similarly prepared in Pt crucibles under oxygen.

TABLE 609. Electrical conductance studies: V_2O_5 - $NaVO_3$

Investigations critically examined

Ref.	Mol % $NaVO_3$	Temp. range (K)	Comments
179	0–100	923–1173	Pt crucible and Pt disk electrodes
175	0	950–1200	Pt crucible; Pt electrodes (calib. 0.01 and 0.1 N KCl)
176	0–28.5	998–1098	Pt crucible; Pt electrodes; oxygen atmosphere (calib. 0.01 *M* KCl; molten KCl)

Deviations from previous NSRDS recommendations [1]

Ref.	V_2O_5 Mol %	Min. departure	Max. departure
179	100	85% (1200 K)	300% (1140 K)
175	100	results do not overlap in T range	
176	100	~180% (1215 K)	~200% (1128 K)

The results of Pantony and Vasu [176] differ markedly from the previous NSRDS recommendations [1,178] and from the results of [179,175]. Pantony attributes this to the high purity of the V_2O_5 used in their study, to the absence of contamination by silica, alumina or zirconia, and to the use of an ambient oxygen atmosphere to repress dissociation:

$$V_2O_5 = 2VO_2 + 1/2\ O_2.$$

TABLE 610. V_2O_5 - $NaVO_3$: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent $NaVO_3$				
	78.3	56.9	33	17.7	9.8
920	0.86	0.55			
980	0.98	0.69	0.89		0.47
1040	1.10	0.82	1.08	1.06	0.59
1100	1.21	0.95	1.31	1.29	0.74
1130	1.26	1.01	1.44	1.42	0.83
1160	1.31	1.07	1.58	1.56	0.93

Temperature-dependent equations

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

Mol % $NaVO_3$	a	$b \times 10^3$	$c \times 10^6$
100	-4.123	8.406	-2.66
78.3	-2.207	4.471	-1.24
56.9	-2.709	4.624	-1.18
49.8	1.876	-3.717	2.57
33.0	3.634	-8.392	5.71
21.0	5.380	-11.948	7.52
17.7	3.364	-7.880	5.45
9.8	3.358	-7.572	4.72
0	-1.193	1.398	

These values are based on the data of Danek, Votava, Matiasovsky and Balajka (classical ac method); data in graphical form; precisions not estimated [179].

TABLE 611. V_2O_5 - $NaVO_3$: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent $NaVO_3$				
	28.5	20.0	15.5	9.9	1.0
1000	0.71	0.52	0.47	0.36	0.18
1050	0.92	0.70	0.62	0.51	0.28
1100	1.16	0.90	0.80	0.71	0.42

Temperature-dependent equations

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

Mol percent $NaVO_3$	A	E
28.5	162.18	10800
23.8	204.17	11700
20.0	208.93	11900
15.5	186.21	11900
9.9	588.84	14700
6.6	1621.81	17200
3.0	data does not fit given equation	
1.0	2290.87	18800

These values are based on the data of Pantony and Vasu (classical ac method; ambient oxygen atmosphere); [176].

TABLE 612. Density studies: V_2O_5 - $NaVO_3$

Investigations critically examined

Ref.	Mol % $NaVO_3$	Temp. range (K)	Comments
179	0–100	923–1173	Pt sphere
176	0	975–1140	Archimedean technique; Au–Pt bob; Pt crucible; oxygen atmosphere

The density data for molten V_2O_5 in an ambient oxygen atmosphere are presented graphically in [176]; the densities vary non-linearly with temperature.

TABLE 613. V_2O_5 - $NaVO_3$: Density (g cm^{-3})

T(K)	Mol percent $NaVO_3$			
	80	60	40	20
920	2.43	2.45		
980	2.40	2.42	2.46	
1040	2.38	2.40	2.43	2.40
1100	2.35	2.38	2.40	2.39
1160	2.33	2.35	2.38	2.37

Temperature-dependent equations

$$\rho = a + bT$$

Mol percent $NaVO_3$	a	$-b \times 10^3$
100	2.766	0.332
80	2.810	0.414
60	2.822	0.406
40	2.896	0.448
20	2.650	0.240
0	2.856	0.450

These values are based on the data of Danek, Votava, Matiasovsky and Balajka (Archimedean technique); data in graphical form; precisions not estimated; ambient atmosphere not specified in article; [179].

TABLE 614. Viscosity studies: V_2O_5 - $NaVO_3$

Investigations critically examined

Ref.	Mol % $NaVO_3$	Temp. range (K)	Comments
179	0–100	923–1173	Pt 10% Ir torsion pendulum; Mo suspension wire.
176	0	940–1150	rate of displacement of suspended Au–Pt bob
177	0–50	833–1250	Pt blade attached to vertically supported rod

The viscosity results for V_2O_5 [176] as a function of temperature are illustrated graphically. The viscosities were for V_2O_5 in an ambient oxygen atmosphere (to repress the dissociation : $V_2O_5 = 2VO_2 + 1/2\ O_2$). The values are uniformly lower than in [177, 179]; the difference changing from ~30% at ~1000 K to ~260% 300% at ~1100 K [177], and ~70% at ~1000 K to ~260% at ~1140 K [179].

TABLE 615. V_2O_5 - $NaVO_3$: Viscosity (cp)

T(K)	Mol percent Na_2VO_3				
	80	57	32	20	10
920	85	26			
980	62	19	34		58
1040	43	15	23	51	45
1100	29	12	17	38	35
1160	19	10	14	31	29

Temperature-dependent equations

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

Mol % $NaVO_3$	a	$-b \times 10^3$	$c \times 10^6$
100	1116.6	1709.2	667
80	1025.8	1612.8	642
57	346.7	573.1	244
32	761.2	1277.6	546
20	1185.8	1919.2	796
10	777.1	1213.6	490
0	678.7	1031.9	402

These values are based on the data of Danek, Votava, Matiasovsky and Balajka (oscillational method); data in graphical form; precisions not estimated; ambient atmosphere not specified in article; [179].

WO_3 - KPO_3

Melt Preparation and Purification

Shurdumov et al. [180, 181] used recrystallized, analytical grade KPO_3 and C. P. grade WO_3.

TABLE 616. Electrical conductance studies: WO_3 - KPO_3

Investigations critically examined

Ref.	Mol % KPO_3	Temp. range (K)	Comments
180	50–100	973–1223	see: WO_3–$Na_2B_4O_7$

TABLE 617. WO_3 - KPO_3: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent KPO_3				
	90	80	70	60	50
1020		0.301	0.153	0.078	
1080	0.262	0.413	0.269	0.165	0.062
1100	0.377	0.447	0.307	0.194	0.094
1200	0.664	0.599	0.485	0.338	0.253
1220	0.665	0.625	0.519	0.367	0.285

Temperature–dependent equations

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

Mol % KPO_3	$-a$	$b \times 10^3$	$-c \times 10^6$	standard error of estimate
100	-1.898	-4.2036	-2.7061	0.11%
95	-8.1470	-14.6589	-7.0329	0.58%
90	34.3521	57.8761	23.9131	7.32%
85	3.7771	5.8974	1.8755	1.81%
80	3.5642	5.6026	1.7778	1.34%
75	5.9710	9.5829	3.4499	0.50%
70	2.6771	3.5682	0.7777	2.26%
65	-0.8145	-2.2905	-1.6256	1.90%
60	1.3956	1.4450		7.47%
55	1.2453	1.2812		2.42%
50	1.6529	1.5881		10.24%

These values are based on the data of Shurdumov, Semenchenko and Shurdumov (classical ac method) [180]. The values for KPO_3 (100%) are 6–10% lower than the recommended data set [8].

TABLE 618. Density studies: WO_3 - KPO_3

Investigations critically examined

Ref.	Mol % KPO_3	Temp. range (K)	Comments
181	45–100	973–1223	Pt float

TABLE 619. WO_3 - KPO_3: Density (g cm^{-3})

T(K)	Mol percent KPO_3				
	90	80	70	60	50
1070	2.353	2.664	2.962	3.346	3.655
1130	2.323	2.618	2.911	3.281	3.596
1190	2.292	2.577	2.866	3.216	3.538
1210	2.281	2.565	2.853	3.195	3.519

Temperature–dependent equations

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

Mol % KPO_3	a	$-b \times 10^3$	$c \times 10^6$	standard error of estimate
100	1.6532	-1.1022	-0.6594	0.00%
95	1.3668	-2.0659	-1.1469	0.04%
90	2.9043	0.5149		0.13%
85	4.1647	2.4157	0.8064	0.13%
80	4.4755	2.5658	0.8155	0.04%
75	4.5324	2.4111	0.7773	0.03%
70	4.9337	2.7876	0.8826	0.08%
65	4.2282	0.9913		0.04%
60	4.4975	1.0766		0.01%
55	4.8299	1.2197		0.04%
50	4.6981	0.9749		0.11%

These values are based on the data of Shurdumov, Semenchenko and Shurdumov. (Archimedean technique) [181]. The values for KPO_3 (100%) are in agreement with the recommended data set [8], ($\sim \pm 1\%$).

WO_3 - K_2WO_4

Melt Preparation and Purification

Morris and Robinson [182] used reagent grade anhydrous chemicals. Gossink and Stevels [168] used carefully dried reagent grade salts. Gravimetric analysis was performed to check for composition changes.

TABLE 620. Electrical conductance studies: WO_3 - K_2WO_4

Investigations critically examined

Ref.	Mol % K_2WO_4	Temp. range (K)	Comments
182	30–100	947–1302	fused quartz cell; frequency: 2000Hz; Pt–Rh crucible for samples

TABLE 621. $WO_3 - K_2WO_4$: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent K_2WO_4			
	90	70	59.42	29.88
940			0.347	
1060		0.700	0.608	
1090		0.793	0.662	
1180	0.828	1.006		0.548
1210	1.032	1.054		0.597
1270	1.210			0.695
1300	1.184			

Temperature-dependent equations

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

Mol % K_2WoO_4	$-a$	$b \times 10^3$	$-c \times 10^6$
100	1.0052	1.815	0.31
90	68.0643	108.690	42.633
80.11	12.2562	19.9645	7.297
70	9.9849	16.8371	6.375
59.42	4.3395	7.4716	2.645
50.18	1.3939	1.7922	
42.13	4.4680	7.0114	2.273
29.88	1.3809	1.6346	

These values are based on the data of Morris and Robinson (classical ac method); data in equation form; precisions not estimated [182]. The values for K_2WO_4 (0% WO_3) are ~1.5% higher than the recommended data set [8].

TABLE 622. Density studies: $WO_3 - K_2WO_4$

Investigations critically examined			
Ref.	Mol % K_2WO_4	Temp. range (K)	Comments
182	30–100	928–1302	Pt bob; Pt–Rh suspension wire

TABLE 623. $WO_3 - K_2WO_4$: Density (g cm^{-3})

T(K)	Mol percent K_2WO_4				
	89.55	70	59.42	42.13	30
950			4.052		
1040			3.932	4.321	
1070		3.723	3.892	4.276	
1100		3.692	3.852	4.230	
1160		3.631		4.139	
1190	3.302			4.093	4.465
1250	3.252				4.372
1280	3.226				

Temperature dependent equations

$\rho = a + bT$

Mol percent K_2WO_4	a	$-b \times 10^3$
100	4.043	0.7268
89.55	4.3080	0.8452
80.11	4.4919	0.9071
70	4.8095	1.0156
59.42	5.3195	1.3339
50.18	5.7594	1.5622
42.13	5.9017	1.5197
30	6.3152	1.5546

These values are based on the data of Morris and Robinson (Archimedean technique); data in equation form; precisions not estimated [182]. The values for K_2WO_4 (100%) are in essential agreement with the recommended data set [1] (~±0.1%).

TABLE 624. Surface tension studies: $WO_3 - K_2WO_4$

Investigations critically examined			
Ref.	Mol % K_2WO_4	Temp. range (K)	Comments
168	45–100	1013–1348	Pt ring and Pt dish; calibration: molten NaCl

TABLE 625. WO_3 - K_2WO_4: Surface tension (dyn cm^{-1})

T(K)	Mol percent K_2WO_4			
	80	65	55	45
1010				140.9
1040		143.2		138.2
1070		140.5	139.8	135.6
1130	140.4	135.2	134.1	130.2
1220	133.2	127.3	125.5	122.2
1250	130.8		122.7	
1280	128.4			

Temperature-dependent equations

$\gamma = a + bT$

Mol percent K_2WO_4	a	$-b \times 10^3$
100	213.54	59.45
80	230.43	79.71
65	234.71	88.03
55	241.79	95.31
45	231.12	89.32

These values are based on the data of Gossink and Stevels (ring detachment method); data in equation form; precisions not estimated [168]. The values for K_2WO_4 (100%) have been advanced earlier in this series as the recommended data set [8].

WO_3 - Li_2WO_4

Melt Preparation and Purification

For the method of melt preparation used by Morris and Robinson [182] see: WO_3-K_2WO_4.

TABLE 626. Electrical conductance studies: WO_3 - Li_2WO_4

Investigations critically examined

Ref.	Mol % Li_2WO_4	Temp. range (K)	Comments
182	45-100	989-1225	see: WO_3-K_2WO_4

TABLE 627. WO_3 - Li_2WO_4: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent Li_2WO_4				
	88.86	79.51	69.92	59.98	44.95
990		1.418			
1020	1.535	1.589	1.310		
1050	1.690	1.752	1.440	1.608	
1080	1.836	1.906	1.569	1.779	1.098
1170	2.212	2.316		2.190	1.447
1200				2.293	1.539

Temperature-dependent equations

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

Mol % Li_2WO_4	$-a$	$b \times 10^3$	$-c \times 10^6$
100	13.8311	24.5407	9.255
88.86	9.7959	16.8528	5.632
79.51	9.1064	15.4039	4.822
69.92	3.1062	4.3292	
59.98	15.1180	25.8677	9.465
49.99	2.9336	3.8949	
44.95	11.7666	19.3287	6.867

These values are based on the data of Morris and Robinson (classical ac method); data in equation form; precisions not estimated [182]. The values for Li_2WO_4 (100%) were advanced earlier in this series as a recommended data set [8].

TABLE 628. Density studies: WO_3 - Li_2WO_4

Investigations critically examined

Ref.	Mol % Li_2WO_4	Temp. range (K)	Comments
182	45-100	987-1241	see: WO_3-K_2WO_4

TABLE 629. WO_3 - Li_2WO_4: Density (g cm^{-3})

T(K)	Mol percent Li_2WO_4				
	88.86	79.51	69.92	59.98	49.99
980		4.581			
1010	4.389	4.552	4.708		
1040	4.363	4.522	4.674	4.857	5.049
1190	4.236	4.373	4.508	4.678	4.848
1220	4.210			4.643	4.808
1250				4.607	

Temperature-dependent equations

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

Mol percent Li_2WO_4	a	$-b \times 10^3$
100	5.1265	0.8062
88.86	5.2485	0.8511
79.51	5.5530	0.9916
69.92	5.8312	1.1122
59.98	6.0950	1.1906
49.99	6.4441	1.3413
44.95	6.2894	1.1628

These values are based on the data of Morris and Robinson (Archimedean technique); data in equation form; precisions not estimated [182]. The values for Li_2WO_4 (100%) were advanced earlier in this series as a recommended data set [8].

TABLE 630. Surface tension studies: WO_3 - Li_2WO_4

Investigations critically examined

Ref.	Mol % Li_2WO_4	Temp. range (K)	Comments
168	50–100	1000–1283	see: WO_3–K_2WO_4

TABLE 631. WO_3 - Li_2WO_4: Surface tension (dyn cm $^{-1}$)

T(K)	Mol percent Li_2WO_4	
	70	*50*
1000	207.9	
1120	198.8	198.8
1200	192.7	192.7
1240	189.6	

Temperature-dependent equations

$\gamma = a + bT$

Mol percent Li_2WO_4	a	$-b \times 10^3$
100	279.48	55.56
70	284.19	76.28
50	284.40	76.41

These values are based on the data of Gossink and Stevels (ring detachment method); data in equation form; precisions not estimated [**168**]. The values for Li_2WO_4 (100%) were advanced earlier in this series as a recommended data set [8].

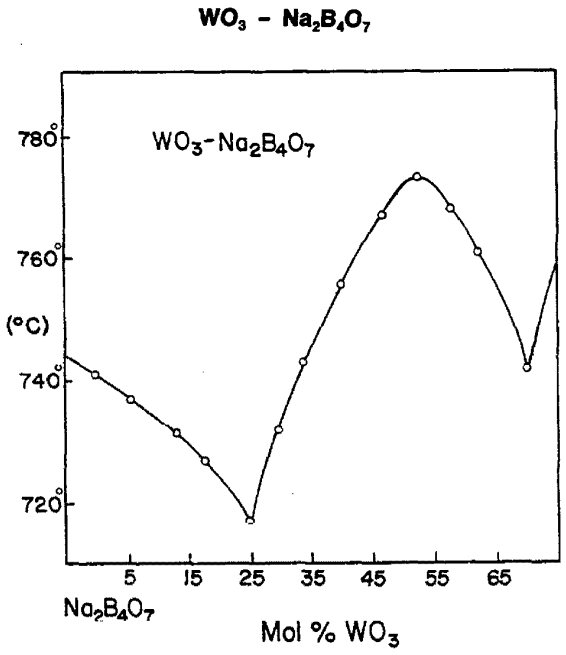

FIGURE 88. Phase diagram for WO_3 - $Na_2B_4O_7$.

Data from: B. K. Shurdumov, G. K. Shurdumov and D. P. Semchenko, Khim. Tekhnol. Molybdena, Wolframa, **1**, 282 (1971).

Melt Preparation and Purification

Shurdumov et al. [183, 184, 185, **186**] recrystallized analytical grade sodium tetraborate. The tetraborate was dehydrated completely at 400–450°C. The tungsten trioxide was especially pure grade.

TABLE 632. Electrical conductance studies: WO_3 - $Na_2B_4O_7$

Investigations critically examined

Ref.	Mol % $Na_2B_4O_7$	Temp. range (K)	Comments
184	50–100	1023–1273	Pt electrodes; corundum crucibles; frequency: 1000Hz; calibration: 0.1 *N* KCl; measurements at two immersions

TABLE 633. WO_3 - $Na_2B_4O_7$: Specific conductance (ohm^{-1}cm^{-1})

T(K)	Mol percent $Na_2B_4O_7$				
	98.3	90	84.8	71	56.3
1070	0.237	0.210	0.225	0.237	0.237
1150	0.346	0.309	0.311	0.335	0.333
1250	0.483	0.467	0.477	0.511	0.525
1270	0.510	0.503	0.518	0.554	0.574

Temperature-dependent equations

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

Mol % $Na_2B_4O_7$	a	$-b \times 10^3$	$c \times 10^6$	standard error of estimate
100	0.3759	1.4115	1.193	1.44%
98.3	-1.2271	-1.3681		2.15%
96.4	-1.2301	-1.3761		4.32%
94.4	-1.1766	-1.3220		4.97%
92.3	-1.2854	-1.4041		4.57%
90	1.1747	2.8987	1.866	1.71%
87.5	0.8559	2.3731	1.657	3.46%
84.8	3.0818	6.1580	3.260	2.90%
81.8	2.9654	5.9877	3.201	3.54%
79	3.2064	6.5156	3.466	5.62%
75	-1.3639	-1.4601		8.14%
71	2.5231	5.2732	2.931	5.76%
66.7	-1.4285	-1.5501		6.23%
61.8	1.4723	3.5551	2.221	4.10%
56.3	3.9102	7.7447	4.030	3.25%
50	-1.7518	-1.8441		9.27%

These values are based on the data of Shurdumov, Semenchenko and Shurdumov (classical ac method) [**184**]. Comparison with the conductance results for molten NaCl fixes the accuracy limits to $\sim \pm 2\%$.

TABLE 634. Density studies: WO_3 – $Na_2B_4O_7$

Investigations critically examined			
Ref.	Mol % $Na_2B_4O_7$	Temp. range (K)	Comments
183	56.3–100	1073–1273	Pt float

TABLE 635. WO_3 – $Na_2B_4O_7$: Density (g cm^{-3})

T(K)	Mol percent $Na_2B_4O_7$			
	90	81.8	71	61.8
1070	2.191	2.313	2.506	2.699
1150	2.149	2.280	2.458	2.668
1250	2.106	2.233	2.403	2.617
1270	2.099	2.222	2.392	2.606

Temperature-dependent equations

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

Mol % $Na_2B_4O_7$	a	b x 10^3	$-c$ x 10^6	standard error of estimate
100.0	1.2375	1.7811	0.9313	0.00%
98.3	1.8291	0.7798	0.5009	0.00%
96.4	2.1411	0.2674	0.2832	0.00%
94.4	2.1445	0.3097	0.3072	0.01%
92.3	1.8739	0.8727	0.5697	0.00%
90	3.4075	-1.7078	-0.5335	0.02%
87.5	2.2612	0.3127	0.3283	0.00%
84.8	2.2419	0.4394	0.3903	0.01%
81.8	2.3236	0.3603	0.3464	0.00%
78.5	3.1314	-0.8730	-0.2054	0.01%
75	2.5660	0.1820	0.2896	0.00%
71	3.5499	-1.3177	-0.3199	0.01%
66.7	9.7834	-11.2754	-4.3525	0.07%
61.8	2.2501	1.1643	0.6963	0.00%
56.3	2.9253	0.2587	0.3421	0.01%

These values are based on the data of Shurdumov, Shurdumov and Semenchenko (Archimedean technique) **[183]**. Accuracy limits, $\sim\pm1\%$. The values for $Na_2B_4O_7$ (100%) agree with the recommended data to $\sim\pm1.5\%$ [1]. The results in [183] represent a more complete study.

TABLE 636. Viscosity studies: WO_3 – $Na_2B_4O_7$

Investigations critically examined			
Ref.	Mol % $Na_2B_4O_7$	Temp. range (K)	Comments
185	56.3–100	1123–1373	electro-vibrating rod viscometer; calibration: castor oil in butyl alcohol, rosin in castor oil; estimated uncertainty: ±1.5%

TABLE 637. WO_3 – $Na_2B_4O_7$: Viscosity (poise)

T(K)	Mol percent $Na_2B_4O_7$			
	90	81.8	75	61.8
1123	11.40	11.90	13.40	13.70
1173	5.61	6.1	7.75	8.55
1223	2.67	3.12	3.87	4.44
1273	1.85	2.40	2.80	3.26
1323	1.11	1.37	1.47	2.02
1373	0.69	0.83	0.70	0.97

The above values are reported by Shurdumov, Shurdumov, Semenchenko and Barokova (oscillational method) **[185]**. The data as reported cannot be fitted to a simple equation. Values reported for $Na_2B_4O_7$ (100%) were: 1123 K, 10.60; 1173 K, 5.80; 1223 K, 2.66; 1273 K, 2.00; 1323 K, 1.20; 1373 K, 0.41; results were also reported for compositions (mol % $Na_2B_4O_7$): 96.4, 92.3, 87.5, 84.8, 76.6, 71, 66.7, and 56.3 **[185]**.

TABLE 638. Surface tension studies: WO_3 – $Na_2B_4O_7$

Investigations critically examined			
Ref.	Mol % $Na_2B_4O_7$	Temp. range (K)	Comments
186	56.3–100	1073–1373	see: WO_3–$Na_4P_2O_7$

TABLE 639. WO_3 – $Na_2B_4O_7$: Surface tension (dyn cm^{-1})

T(K)	Mol percent $Na_2B_4O_7$				
	96.4	90	81.8	66.7	56.3
1070	225.9	217.8	215.7	205.8	185.5
1160	215.7	208.7	202.2	189.2	178.2
1250	205.5	199.7	191.3	177.2	170.0
1340	195.3	190.6	183.0	169.8	160.7
1370	191.9	187.6	180.8	168.4	157.4

Temperature-dependent equations

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

Mol % $Na_2B_4O_7$	a	$-b$ x 10^3	c x 10^6	standard error of estimate
100	364.06	124.01		0.53%
96.4	347.26	113.39		0.35%
92.3	279.21	8.47	-42.13	0.25%
90	325.29	100.47		0.30%
87.5	544.65	463.72	147.80	0.60%
81.8	576.31	509.34	161.08	0.46%
75	654.89	43.36	211.91	0.38%
66.7	754.15	815.26	282.98	0.39%
61.8	306.12	106.46		0.46%
56.3	197.70	-52.86	-60.031	0.37%

These values are based on the data of Shurdumov, Shardanova and Shurdumov (maximum bubble pressure method) **[186]**. Comparison with the previously reported data point at 1223 K [8], shows that the present results are ~8% higher. The present work **[186]** is the more complete study.

WO_3 - $NaPO_3$

Melt Preparation and Purification

Shurdumov et al. [180, 181] used recrystallized, analytical grade $NaPO_3$ and C.P. grade WO_3.

TABLE 640. Electrical conductance studies: WO_3 - $NaPO_3$

Investigations critically examined

Ref.	Mol % $NaPO_3$	Temp. range (K)	Comments
180	40–100	973–1223	see: WO_3–$Na_2B_4O_7$

TABLE 641. WO_3 - $NaPO_3$: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent $NaPO_3$				
	80	70	60	50	40
970	0.402				
1030	0.422	0.144			
1120	0.622	0.488	0.285		
1180	0.871	0.716	0.585	0.345	0.238
1210	0.029	0.831	0.654	0.485	0.321

Temperature-dependent equations

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

Mol % $NaPO_3$	a	$b \times 10^3$	$c \times 10^6$	standard error of estimate
100	0.7660	-3.1542	3.0162	2.07%
95	0.4422	-2.3912	2.5155	1.73%
90	0.7855	-3.2576	2.9094	1.66%
85	8.7926	-18.2117	9.7273	6.99%
80	12.8033	-25.1263	12.7235	6.20%
75	-3.8540	3.9478		3.47%
70	-3.7868	3.8163		7.63%
65	-39.1151	63.4548	-25.2052	2.31%
60	-45.0448	74.1376	-30.0580	3.05%
55	-3.9693	3.7566		0.00%
50	-5.1906	4.6909		0.00%
45	-4.1625	3.8507		0.00%
40	-3.0173	2.7585		0.01%

These values are based on the data of Shurdumov, Semenchenko and Shurdumov (classical ac method) [180].

TABLE 642. Density studies: WO_3 - $NaPO_3$

Investigations critically examined

Ref.	Mol % $NaPO_3$	Temp. range (K)	Comments
181	45–100	973–1273	Pt float

TABLE 643. WO_3 - $NaPO_3$: Density (g cm^{-3})

T(K)	Mol percent $NaPO_3$				
	94	77	68	58	49
970	2.365				
1090	2.321	2.893			
1120	2.308	2.874	3.244		
1180	2.278	2.834	3.194	3.608	3.910
1270	2.228	2.768	3.120	3.516	3.808

Temperature-dependent equations

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

Mol % $NaPO_3$	a	$-b \times 10^3$	$-c \times 10^6$	standard error of estimate
100	2.6237	0.4155		0.05%
94	2.2204	-0.6132	0.4781	0.09%
91	2.9523	0.4771		0.03%
87	2.7340	-0.2634	0.3436	0.14%
82	2.9645	-0.0197	0.2855	0.10%
77	3.0114	-0.3936	0.4610	0.05%
73	3.8531	0.7121		0.31%
68	4.1682	0.8256		0.11%
63	4.4870	0.9151		0.07%
58	4.8118	1.0201		0.00%
54	4.0977	-0.5010	0.6898	0.04%
49	5.2370	1.1250		0.02%
45	10.3526	9.1469	-3.2711	0.07%

These values are based on the data of Shurdumov, Semenchenko and Shurdumov (Archimedean technique) [181].

WO_3 - $Na_4P_2O_7$

Melt Preparation and Purification

Shurdumov et al. [187, 188, 189, 186] used analytical grade sodium pyrophosphate twice recrystallized. The pyrophosphate was completely dehydrated at 86°C. The WO_3 was Pure grade, used without further treatment.

TABLE 644. Electrical conductance studies: WO_3 - $Na_4P_2O_7$

Investigations critically examined

Ref.	Mol % $Na_4P_2O_7$	Temp. range (K)	Comments
188	27–100	1073–1373	see: WO_3–$Na_2B_4O_7$

TABLE 645. WO_3 – $Na_4P_2O_7$: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent $Na_4P_2O_7$			
	89.5	64.8	50	34
1070			0.592	0.489
1190		1.038	0.828	0.616
1280	1.537	1.211	0.981	0.711
1340	1.667	1.283	1.072	0.774
1370	1.733	1.306	1.114	0.806

Temperature–dependent equations

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

Mol % $Na_4P_2O_7$	$-a$	$b \times 10^3$	$-c \times 10^6$	standard error of estimate
96.5	1.9717	2.9203		0.34%
92.5	1.5603	2.5003		0.30%
89.5	1.2539	2.1801		0.25%
85.72	1.0229	1.9501		0.24%
82	0.8106	1.7201		0.20%
77.8	6.9148	11.3015	3.7829	0.57%
73.5	6.6181	10.9148	3.6825	0.58%
69.3	0.8314	1.6100		1.46%
64.8	8.6708	13.9515	4.8680	1.00%
60	8.0079	12.7241	4.3381	0.63%
55.2	4.0944	6.2547	1.7246	3.15%
50	3.0880	4.7669	1.2408	1.91%
45	2.2935	3.8572	1.1069	2.02%
40	0.5349	0.9964		2.46%
34	0.6388	1.0543		2.57%
27	-3.2518	-5.2343	2.4829	1.14%

These values are based on the data of Shurdumov, Semenchenko and Shurdumov (classical ac method) [188].

TABLE 646. Density studies: WO_3 – $Na_4P_2O_7$

Investigations critically examined

Ref.	Mol % $Na_4P_2O_7$	Temp. range (K)	Comments
189	34–100	1073–1373	Pt float; corundum crucible

TABLE 647. WO_3 – $Na_4P_2O_7$: Density (g cm^{-3})

T(K)	Mol percent $Na_4P_2O_7$				
	96.5	82	65	50	34
1080				3.022	3.511
1170			2.805	2.950	3.410
1260			2.758	2.888	3.345
1290	2.170	2.361	2.736	2.870	
1370	2.147	2.323	2.664	2.827	

Temperature–dependent equations

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

Mol % $Na_4P_2O_7$	a	$-b \times 10^3$	$c \times 10^6$	standard error of estimate
100	2.5477	0.3102		0.16%
96.5	2.5378	0.2852		0.06%
92.5	2.7069	0.3791		0.11%
89.5	2.7378	0.3741		0.01%
86	3.9347	1.2302		1.13%
82	2.9631	0.4670		0.02%
78	3.1333	0.5341		0.10%
73.5	1.5612	-2.0024	-0.9722	0.10%
70	2.3313	-0.9855	-0.6032	0.12%
65	1.0246	-3.4233	-1.6253	0.22%
60	3.7814	0.7641		0.13%
55	14.2938	17.3810	6.5621	2.10%
50	4.6818	2.2166	0.6296	0.19%
45	3.8695	0.6418		0.32%
40	5.4561	3.0045	0.9579	0.36%
34	7.4792	6.0340	2.1850	0.11%

These values are based on the data of Shurdumov, Shurdumov and Semenchenko (Archimedean technique) [189].

TABLE 648. Viscosity studies: WO_3 – $Na_4P_2O_7$

Investigations critically examined

Ref.	Mol % $Na_4P_2O_7$	Temp. range (K)	Comments
187	40–100	1073–1373	see: WO_3–$Na_2B_4O_7$

TABLE 649. WO_3 – $Na_4P_2O_7$: Viscosity (cp)

T(K)	Mol percent $Na_4P_2O_7$				
	92.5	85.8	69.3	50	40
1070			1.01	1.39	1.79
1250			0.45	0.41	0.56
1280	0.59	0.51	0.38	0.33	0.45
1370	0.40	0.34	0.24	0.19	0.28

Temperature-dependent equations

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

Mol % $Na_4P_2O_7$	a	$-b \times 10^3$	$c \times 10^6$	standard error of estimate
78	15.730	21.576	7.525	1.63%
69.3	10.817	14.338	4.833	1.44%
50	23.211	33.204	11.973	6.61%
45	27.577	39.807	14.485	10.50%
40	29.280	41.809	15.064	8.33%

$\eta = A \exp[E/RT]$

Mol % $Na_4P_2O_7$	$A \times 10^3$	E	standard error of estimate
100	2.9506	13836	0.10%
92.5	1.3230	15527	1.08%
85.8	1.1919	15423	0.19%
60	0.2600	18233	5.84%
55.2	0.1724	19553	8.08%

These values are based on the data of Shurdumov, Semenchenko and Shurdumov (Archimedean technique) [187].

TABLE 650. Surface tension studies: WO_3 – $Na_4P_2O_7$

Investigations critically examined

Ref.	Mol % $Na_4P_2O_7$	Temp. range (K)	Comments
186	34–100	1073–1373	calibration: molten KNO_3, $NaNO_3$, NaCl; estimated uncertainty ±1.5%; corundum crucible

TABLE 651. WO_3 – $Na_4P_2O_7$: Surface tension (dyn cm^{-1})

T(K)	Mol percent $Na_4P_2O_7$			
	85.72	69.3	50	34
1120			205.7	188.6
1270	228.6	212.6	189.1	173.2
1360	215.5	203.5	181.7	164.0

Temperature-dependent equations

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

Mol % $Na_4P_2O_7$	a	$-b \times 10^3$	$c \times 10^6$	standard error of estimate
100	389.56	110.01		0.35%
92.5	380.40	113.01		0.16%
85.72	414.07	146.01		0.34%
77.8	-349.23	-974.80	-415.28	0.36%
69.3	340.58	100.81		0.11%
60	689.93	683.24	233.81	0.41%
55.2	326.81	104.24		0.41%
50	498.99	395.15	118.98	0.39%
45	469.73	336.22	88.49	0.10%
40	321.46	110.81		0.58%
34	303.37	102.46		0.30%

These values are based on the data of Shurdumov, Shardanova and Shurdumov (maximum bubble pressure method) [186].

WO_3 – Na_2WO_4

Melt Preparation and Purification

For the method of melt preparation used by Morris and Robinson [182] and by Gossink and Stevels [168], see: WO_3–K_2WO_4.

TABLE 652. Electrical conductance studies: WO_3 – Na_2WO_4

Investigations critically examined

Ref.	Mol % Na_2WO_4	Temp. range (K)	Comments
182	40–100	926–1196	see: WO_3–K_2WO_4.

TABLE 653. $WO_3 - Na_2WO_4$: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent Na_2WO_4				
	89.67	79.46	59.60	49.99	40
920		0.948			
980	0.754	1.290			
1010	0.847	1.444	0.749		
1040	0.936	1.586	0.881	0.736	
1070	1.020	1.716	0.997	0.836	0.657
1100	1.100		1.096	0.928	0.747
1130	1.176		1.178	1.013	0.831
1160				1.090	0.910
1190					0.983

Temperature-dependent equations

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

Mol % Na_2WO_4	$-a$	$b \times 10^3$	$-c \times 10^6$
100	2.1370	3.1262	0.04
89.67	4.7265	8.0002	2.4574
79.46	10.1381	18.0145	6.4825
69.41	6.4018	10.7643	3.4004
59.60	13.4613	23.4455	9.2832
49.99	7.4984	12.3678	4.2793
44.98	8.7824	13.8746	4.5428
40	6.1977	9.7207	3.0978

These values are based on the data of Morris and Robinson (classical ac method); data in equation form; precisions not estimated [182]. The values for Na_2WO_4 (100%) are in essential agreement with the recommended data set at ~1050 K; with increasing temperature, the values in [182] rise above the recommended values [1]. The present study [182] is more complete than the earlier study which had been advanced elsewhere as the recommended data base [1].

TABLE 654. Density studies: $WO_3 - Na_2WO_4$

Investigations critically examined

Ref.	Mol % Na_2WO_4	Temp. range (K)	Comments
182	40–100	927–1199	see: WO_3–K_2WO_4

TABLE 655. $WO_3 - Na_2WO_4$: Density (g cm^{-3})

T(K)	Mol percent Na_2WO_4			
	89.67	69.41	49.99	40
980	3.970	4.366		
1040	3.973	4.292	4.689	
1070	3.974	4.255	4.642	4.829
1130	3.977	4.182	4.548	4.743
1160			4.502	4.700
1190				4.658

Temperature-dependent equations

$\rho = a + bT$

Mol percent Na_2WO_4	a	$-b \times 10^3$
100	4.7676	-0.9069
89.67	3.9198	-0.0508
79.46	5.3025	1.1166
69.41	5.5676	1.2264
59.60	4.4079	-0.0307
49.99	6.3080	1.5571
44.98	6.0475	1.2294
40	6.3526	1.4243

These values are based on the data of Morris and Robinson (Archimedean technique); data in equation form; precisions not estimated [182]. The results for Na_2WO_4 (100%) are in close accord with the recommended data set [1] (~±0.5%).

TABLE 656. $WO_3 - Na_2WO_4$ Surface tension studies:

Investigations critically examined

Ref.	Mol % Na_2WO_4	Temp. range (K)	Comments
168	40–100	1039–1283	see: WO_3–K_2WO_4

TABLE 657. $WO_3 - Na_2WO_4$: Surface tension (dyn cm^{-1})

T(K)	Mol percent Na_2WO_4				
	80	70	60	55	40
1040	189.3				
1070	186.5	182.2			
1100	183.7	178.7	171.8	168.1	
1130	181.0	175.2	169.0	165.1	157.6
1220	172.6	164.9	160.4	156.2	149.7
1250	169.8	161.4		153.2	147.1
1280					144.4

Temperature-dependent equations

$\gamma = a + bT$

Mol percent Na_2WO_4	a	$-b \times 10^3$
100	262.98	66.03
80	286.18	93.12
70	305.58	115.35
60	275.92	94.66
55	276.73	98.80
40	256.70	87.72

These values are based on the data of Gossink and Stevels (ring detachment method); data in equation form; precisions not estimated [168]. The values for Na_2WO_4 (100%) fall uniformly below (~2.6%) the recommended data set [2].

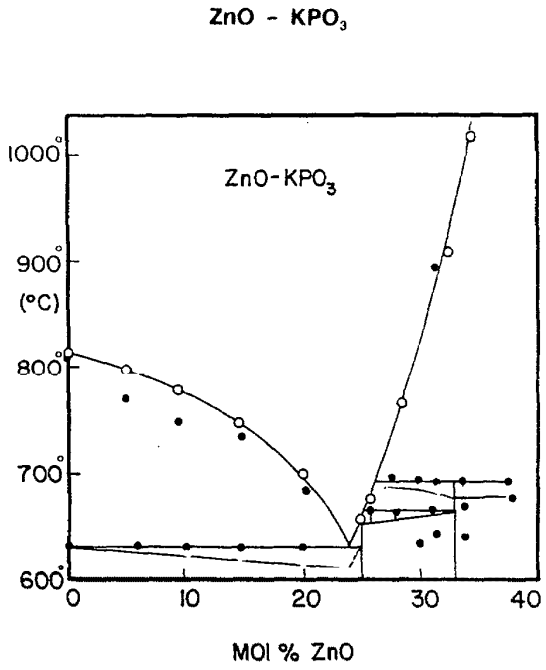

FIGURE 89. Phase diagram for ZnO - KPO_3.

Data from: E. L. Krivovyazov, N. K. Voskresenskaya and K. K. Palkina, Zh. Neorg. Mat., 5(6), 898 (1969).

Melt Preparation and Purification

For the method of melt preparation used by Krivovyazov and Voskresenskaya [166], see: ZnO–$NaPO_3$.

TABLE 658. Density studies: ZnO - KPO_3

Investigations critically examined			
Ref.	Mol % KPO_3	Temp. range (K)	Comments
166	74.2–90.4	1086–1379	see: ZnO–$NaPO_3$

TABLE 659. ZnO - KPO_3: Density (g cm^{-3})

T(K)	Mol percent KPO_3		
	90.4	77.9	74.2
1080		2.446	
1110	2.217	2.435	
1140	2.205	2.425	2.486
1260	2.157	2.382	2.443
1320	2.133	2.360	2.421
1350		2.349	2.410
1380		2.338	

Temperature-dependent equations

$$\rho = a + bT$$

Mol percent KPO_3	a	$-b \times 10^3$
90.4	2.6613	0.4000
77.9	2.8343	0.3593
74.2	2.8940	0.3582

These values are based on the data of Krivovyazov and Voskresenskaya (Archimedean technique); data in equation form; precisions not estimated [166].

TABLE 660. Surface tension studies: ZnO - KPO_3

Investigations critically examined			
Ref.	Mol % KPO_3	Temp. range (K)	Comments
166	72.3–89.6	1057–1379	see: ZnO–$Zn(PO_3)_2$

TABLE 661. ZnO - KPO_3: Surface tension (dyn cm^{-1})

T(K)	Mol percent KPO_3		
	89.6	77.9	72.3
1050		176	
1080	153	174	
1200	148	170	181
1320	142	165	176
1350	141		175
1380			174

Temperature-dependent equations

$$\gamma = a + bT$$

Mol percent KPO_3	a	$-b \times 10^3$
89.6	204.2	47.1
77.9	218.2	40.5
72.3	231.6	41.9

These values are based on the data of Krivovyazov and Voskresenskaya (maximum bubble pressure method); data in equation form; precisions not estimated [166].

$ZnO - NaPO_3$

Melt Preparation and Purification

Krivovyazov and Voskresenskaya [166] prepared the metaphosphate by decomposition of the monomono-orthophosphate in a platinum crucible.

TABLE 662. Density studies: $ZnO - NaPO_3$

Investigations critically examined			
Ref.	Mol % $NaPO_3$	Temp. range (K)	Comments
166	65.2–87.2	1083–1361	Pt ball; calibration: molten KNO_3.

TABLE 663. $ZnO - NaPO_3$: Density (g cm^{-3})

T(K)	Mol percent $NaPO_3$		
	87.2	73.8	65.2
1080	2.368		
1140	2.345	2.585	
1260	2.303	2.543	2.715
1350	2.270	2.512	2.684

Temperature-dependent equations

$\rho = a + bT$

Mol percent $NaPO_3$	a	$-b \times 10^3$
87.2	2.7616	0.3643
73.8	2.9778	0.3449
65.2	3.1487	0.3439

These values are based on the data of Krivovyazov and Voskresenskaya (Archimedean technique); data in equation form; precisions not estimated [166].

TABLE 664. Surface tension studies: $ZnO - NaPO_3$

Investigations critically examined			
Ref.	Mol % $NaPO_3$	Temp. range (K)	Comments
166	65.2–87.2	1073–1373	see: $ZnO–Zn(PO_3)_2$

TABLE 665. $ZnO - NaPO_3$: Surface tension (dyn cm^{-1})

T(K)	Mol percent $NaPO_3$		
	87.2	73.8	65.2
970	196		
1060	193		
1090	191	215	
1210	187	211	
1270	184	209	231
1360	180	206	227

Temperature-dependent equations

$\gamma = a + bT$

Mol percent $NaPO_3$	a	$-b \times 10^3$
87.2	236.5	41.3
73.8	250.3	32.3
65.2	283.1	41.0

These values are based on the data of Krivovyazov and Voskresenskaya (maximum bubble pressure method); data in equation form; precisions not estimated [166].

$ZnO - Zn(PO_3)_2$

Melt Preparation and Purification

Krivovyazov and Voskresenskaya [190] prepared zinc metaphosphate from analytical grade orthophosphoric acid and analytical grade zinc oxide. The synthesis was carried out in a Pt vessel. The salt was analyzed for phosphorus and zinc using standard procedures. To verify the thermal stability of the $Zn(PO_3)_2$, the melt was kept above 1000°C for 11 hours. Analysis showed no change in the composition.

TABLE 666. Surface tension studies: $ZnO - Zn(PO_3)_2$

Investigations critically examined			
Ref.	Mol % $Zn(PO_3)_2$	Temp. range (K)	Comments
190	33.3–75.2	1268–1460	Pt–Rh capillary; calibration: H_2O; correction for thermal expansion; Ar atmosphere.

TABLE 667. $ZnO - Zn(PO_3)_2$: Surface tension (dyn cm^{-1})

T(K)	Mol percent $Zn(PO_3)_2$				
	75.2	60.2	50	42.9	33.3
1270	212.8				
1290	213.2	225.9			
1350	214.5	227.3	239.9	257.7	
1370	214.9	227.7	240.1	257.8	314.6
1450		229.6	240.7	258.0	314.0

Temperature-dependent equations

$$\gamma = a + bT$$

Mol percent $Zn(PO_3)_2$	a	$b \times 10^3$
75.2	185.2	21.7
60.2	196.1	23.1
50	229.5	7.7
42.9	254.2	2.6
37.6	274.7	6.9
33.3	323.6	-6.6

These values are based on the data of Krivovyazov and Voskresenskaya (maximum bubble pressure method); data in equation form; precisions not estimated [190].

Section C: Other Binary Systems

Meta - Tetraborate - Other

TABLE 668. Data Status

System	Phase Diagram	Electrical Conductance	Density	Viscosity	Surface Tension
KBO_2–KPO_3			X	X	
$NaBO_2$–$NaPO_3$			X	X	
$Na_2B_4O_7$–K_2ZrF_6				X	X

KBO_2 - KPO_3

Melt Preparation and Purification

For the method of melt preparation used by Kochergin et al. [191], see: $NaBO_2$–$NaPO_3$.

TABLE 669. Density studies: KBO_2 - KPO_3

Investigations critically examined			
Ref.	Mol % KPO_3	Temp. range (K)	Comments
191	10–100	1123–1223	Pt ball; calibration: molten KNO_3

TABLE 670. KBO_2 – KPO_3: Density (g cm^{-3})

T(K)	Mol percent KPO_3				
	92.8	77.1	59.0	38.2	26.5
1123	2.09	2.10	2.07	2.01	1.97
1173	2.11	2.12	2.10	2.04	2.00
1223	2.13	2.14	2.12	2.07	2.03

Temperature-dependent equations

$$\rho = a + bT$$

Mol percent KPO_3	a	$b \times 10^3$
100	8.967	-5.621
96.8	single data point = 2.08g cm^{-3}	
92.8	1.690	0.360
85.2	1.725	0.340
77.1	1.711	0.350
68.4	1.702	0.350
59.0	1.537	0.480
49.0	1.425	0.550
38.2	1.421	0.530
26.5	1.356	0.550
10.5	1.288	0.560

These values are based on the data of Kochergin, Khanzhina and Zlodeeva (Archimedean technique); data in graphical form; precisions not estimated [**191**]. The recommended data base [8] gives the following values for KPO_3 at 1173 and 1223 K, respectively: 2.07 and 2.05 g cm^{-3}; the corresponding values from [**191**] are: 2.57 and 2.09 g cm^{-3}.

TABLE 671. Viscosity studies: KBO_2 – KPO_3

Investigations critically examined

Ref.	Mol % KPO_3	Temp. range (K)	Comments
191	0–100	1073–1223	-

TABLE 672. KBO_2 – KPO_3: Viscosity (poise)

T(K)	Mol percent KPO_3				
	87.4	79.8	69.7	55.0	39.3
1080	3.71	3.35	4.27	6.63	5.78
1140	2.51	2.19	2.66	3.48	3.27
1200	1.63	1.34	1.74	1.95	1.96
1220	1.40	1.13	1.52	1.63	1.67

Temperature-dependent equations

$$\eta = A \exp [E/RT]$$

Mol % KPO_3	$A \times 10^3$	E	standard error of estimate
94.2	0.9428	17912	2.08%
87.4	see footnote		
79.8	see footnote		
69.7	0.5307	19298	0.68%
55.0	0.0330	26204	1.17%
49.9	0.0117	28658	3.26%
39.3	0.1186	23164	4.44%

These values are based on the data of Kochergin, Khanzhina and Zlodeeva (oscillational method); data in graphical form; precisions not estimated [**191**]. The data for 87.4 mol% KPO_3 and 79.8 mol% KPO_3 are expressed more accurately by the quadratic equations:

(87.4%) $\eta = 80.434 - 119.314 \times 10^{-3}T + 44.70 \times 10^{-6}T^2$

(79.8%) $\eta = 76.922 - 114.355 \times 10^{-3}T + 42.81 \times 10^{-6}T^2$

$NaBO_2$ – $NaPO_3$

Melt Preparation and Purification

Volarovich and Tolstoi [**158**] used reagent grade materials to prepare the melts. No other information was given. Kochergin et al. [**191**] prepared the metaphosphate from C.P. grade NaH_2PO_4 and used pure grade $NaBO_2.H_2O$. The dehydrated salts were fused in corundum crucibles at 950°C. The mixtures were fused and then stored in capped tubes for 2 hours at 950°C.

TABLE 673. Density studies: $NaBO_2$ – $NaPO_3$

Investigations critically examined

Ref.	Mol % $NaPO_3$	Temp. range (K)	Comments
191	0–69	1123–1223	see: KBO_2–KPO_3

TABLE 674. $NaBO_2$ - $NaPO_3$: Density (g cm^{-3})

T(K)	Mol percent $NaPO_3$				
	69.0	50.2	38.5	26.2	15.9
1120	2.120	2.146	2.176	2.214	2.233
1160	2.144	2.172	2.197	2.227	2.245
1200	2.164	2.190	2.213	2.241	2.256
1220	2.172	2.196	2.219	2.247	2.262

Temperature-dependent equations

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

Mol % $NaPO_3$	a	$b \times 10^3$	$c \times 10^6$
69.0	-0.0827	3.2881	-1.180
50.2	-2.1269	6.8602	-2.719
38.5	-0.3536	3.9281	-1.491
26.2	1.8445	0.3300	
18.5	1.8580	0.3299	
15.9	1.9083	0.2899	
2.6	14.1611	-20.5040	8.781
0.6	7.5345	-9.3061	4.039

These values are based on the data of Kochergin, Khanzhina and Zlodeeva (Archimedean technique); data in graphical form; precisions not estimated [191].

TABLE 675. Viscosity studies: $NaBO_2$ - $NaPO_3$

Investigations critically examined

Ref.	Mol % $NaPO_3$	Temp. range (K)	Comments
158	0-100	723-1158	calibration: aq. glycerine- sugar sol'n.; Pt cylinder: accuracy estimated as 3-4%
191	0-100	1073-1223	see: KBO_2-KPO_3

TABLE 676. $NaBO_2$ - $NaPO_3$: Viscosity (poise)

T(K)	Mol percent $NaPO_3$			
	80	60	40	20
1080	10.91			
1120	6.74	9.25	11.46	9.31
1160	4.05	6.30	10.09	6.42
1200	2.82	4.58	8.06	5.07
1220	2.75	4.18	6.79	4.97

Temperature-dependent equations

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

Mol % $NaPO_3$	a	$b \times 10^3$	$c \times 10^6$
80	677.348	-1111.792	458.07
60	593.855	-954.600	386.28
40	-222.884	444.198	-209.79
20	715.359	-1169.267	481.13

These values are based on the data of Kochergin, Khanzhina and Zlodeeva (oscillational method); data in graphical form; precisions not estimated [191].

$Na_2B_4O_7$ - K_2ZrF_6

Melt Preparation and Purification

Frumin and Yakobashvili [159] used *reagent grade* materials. No other information was given.

TABLE 677. Viscosity studies: $Na_2B_4O_7$ - K_2ZrF_6

Investigations critically examined

Ref.	Mol % K_2ZrF_6	Temp. range (K)	Comments
159	0-12.91	1053-1223	pendulum viscometer

TABLE 678. $Na_2B_4O_7$ - K_2ZrF_6: Viscosity (poise)

T(K)	Mol percent K_2ZrF_6				
	12.9	8.5	5.8	3.2	1.3
1050	22.10	25.19	32.90	21.23	31.33
1110	9.40	9.99	11.67	9.30	10.69
1200	3.06	2.97	2.99	3.15	2.61
1220	2.44	2.32	2.27	2.53	1.96

Temperature-dependent equations

$$\eta = A \exp[E/RT]$$

Mol percent K_2ZrF_6	$A \times 10^6$	E
12.9	3.0055	32989
8.5	0.9402	35687
5.8	0.1537	40023
4.5	0.1168	40783
3.2	4.9892	31848
2.4	0.0543	42439
1.3	0.0716	41515
0	0.1270	39518

These values are based on the data of Frumin and Yakobashvili (pendulum viscometer); data in graphical form; precisions not estimated [159].

TABLE 679. Surface tension studies: $Na_2B_4O_7$ - K_2ZrF_6

Investigations critically examined

Ref.	Mol % K_2ZrF_6	Temp. range (K)	Comments
159	0-9	1023-1223	corundum capillary; Ar atmosphere; estimated experimental uncertainty, ±5%

TABLE 680. $Na_2B_4O_7$ - K_2ZrF_6: Surface tension (dyn cm^{-1})

T(K)	Mol percent K_2ZrF_6				
	8.8	7.2	5.8	4.3	2.9
1020	225	224	226	228	229
1080	222	221	222	225	226
1140	218	218	219	222	223
1200	214	214	215	218	221

Temperature-dependent equations

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

Mol % K_2ZrF_6	a	$b \times 10^3$	$c \times 10^6$
8.8	200.3	92.0	-66.9
7.2	266.7	-32.5	-9.3
5.8	248.6	6.0	-28.1
4.3	140.1	205.5	-117.4
2.9	301.6	-91.5	20.0
1.4	220.6	69.9	-54.6
0	302.9	-67.2	7.3

These values are based on the data of Frumin and Yakobashvili (maximum bubble pressure method); data in graphical form; precisions not estimated [159]. For $Na_2B_4O_7$ (0% K_2ZrF_6) the surface tension values at 1223 K listed in the recommended data base [8] and those of [159] are 230 and 232 dyn cm^{-1} respectively.

Carbonate - Other

TABLE 681. Data Status

System	Phase Diagram	Electrical Conductance	Density	Viscosity	Surface Tension
Na_2CO_3-NaOH	X	X	X	X	
-NaOH-CaO		X	X	X	
-NaOH-NaCl	X	X	X	X	
-NaOH-Na_2SiO_3		X	X	X	
K_2CO_3-KOH	X	X	X	X	
-KOH-CaO		X	X	X	
-KOH-KCl		X	X	X	
-KOH-K_2SiO_3		X	X	X	
-Li_2SO_4	X	X	X		
Li_2CO_3-K_2SO_4	X	X	X		X
-LiOH					X

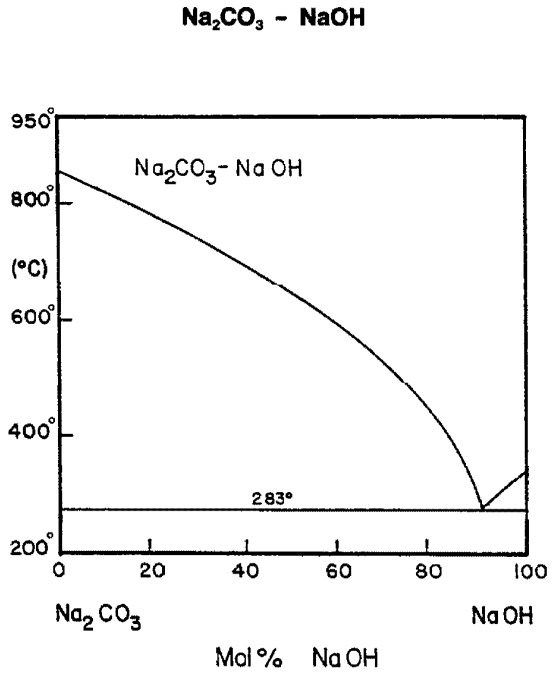

FIGURE 90. Phase diagram for Na_2CO_3 – NaOH.

Data from: A. D. Pelton, et al. "*Calculation of Thermodynamic Equilibria in the Carbonate Fuel Cell*", Topical Report Feb.(1980), (US DOE Contract DE-AC_{02}79ET_{15416}); Proj. CDT-P_{501}, L'Ecole Polytechnique Montreal.

Melt Preparation and Purification

Lasek [145] used high purity salts to prepare the melts. The sodium carbonate content of the melts was analyzed gravimetrically. Arndt and Ploetz [192] used pure sodium hydroxide (stored in sealed tubes prior to use).

TABLE 682. Electrical conductance studies: Na_2CO_3 – NaOH

Investigations critically examined			
Ref.	Mol % NaOH	Temp. range (K)	Comments
192	91.4–100	593–746	Ag crucible and electrodes; calibration: H_2O, molten KNO_3.

TABLE 683. Na_2CO_3 – NaOH: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent NaOH				
	99.4	98.3	96.0	93.8	91.4
590		1.79			
610	2.01	1.94			
630	2.18	2.10	1.69	1.56	1.46
710	2.86	2.73	2.26	2.12	2.01
730	3.03				

Temperature-dependent equations

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

Mol % NaOH	$-a$	$b \times 10^3$	$c \times 10^6$	standard error of estimate
100	2.286	6.625	1.96	0.01%
99.4	3.144	8.453		0.67%
98.3	2.836	7.837		0.09%
98.1	5.099	14.039	–4.63	0.06%
96.0	1.099	1.977	3.88	0.01%
93.8	1.101	1.769	3.89	0.01%
91.4	2.943	7.173	–0.28	0.03%

These values are based on the data of Arndt and Ploetz (classical ac method) [192]. The values calculated from the above equation for NaOH are in essential agreement with the recommended data base [1].

TABLE 684. Density studies: Na_2CO_3 – NaOH

Investigations critically examined			
Ref.	Mol % NaOH	Temp. range (K)	Comments
192	90.6–100	593–723	Ag bob and suspension wire
145	86–100	693	steel ball; correction for thermal expansion; calibration: molten KNO_3

TABLE 685. Na_2CO_3 - NaOH: Density (g cm^{-3})

T(K)	Mol percent NaOH			
	97.9	96.4	92.8	90.6
600	1.803	1.813	1.845	1.861
660	1.773	1.784	1.816	1.831
720	1.743	1.755	1.786	1.800

Temperature-dependent equations

$\rho = a + bT$

Mol % NaOH	a	$-b \times 10^3$	standard error of estimate
100	2.0782	0.4929	0.02%
98.1	2.1073	0.5100	0.05%
97.9	2.1026	0.5000	0.00%
96.4	2.1037	0.4837	0.01%
96.0	2.1112	0.4901	0.02%
93.8	2.1357	0.5001	0.00%
92.8	2.1411	0.4928	0.02%
91.4	2.1607	0.5100	0.02%
90.6	2.1648	0.5061	0.02%

These values are based on the data of Arndt and Ploetz (Archimedean technique) [192]. The values from the above equation for NaOH are in essential agreement with the recommended data base [1].

TABLE 686. Viscosity studies: Na_2CO_3 - NaOH

Investigations critically examined

Ref.	Mol % NaOH	Temp. range (K)	Comments
192	92.1-100	623-823	Ag cylinder converging into a Ag capillary; Ag crucible; calibration: molten KNO_3
145	86-100	693	calibration: molten KNO_3; estimated error, 2%

TABLE 687. Na_2CO_3 - NaOH: Viscosity (cp)

T(K)	Mol percent NaOH	
	98.2	92.1
630	3.76	3.67
750	1.98	1.91
820	1.49	1.42

Temperature-dependent equations

$\eta = A \exp(E/RT)$

Mol % NaOH	$A \times 10^2$	E	standard error of estimate
100	7.212	4936	
98.2	6.858	5013	4.50%
92.1	6.099	5130	1.66%

These values are based on the data of Arndt and Ploetz (capillary technique) [192]. The values calculated from the above equation for NaOH are in essential agreement with the recommended data base [1].

Na_2CO_3 - NaOH - CaO

Melt Preparation and Purification

Arndt and Ploetz [192] used pure sodium hydroxide (stored in sealed tubes prior to use).

TABLE 688. Electrical conductance studies: Na_2CO_3 - NaOH - CaO

Investigations critically examined

Ref.	Mol % CaO	Temp. range (K)	Comments
192	1.6	773-873	see: Na_2CO_3-NaOH

TABLE 689. Na_2CO_3 - NaOH - CaO: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent
	Na_2CO_3 2.1 NaOH 96.3 CaO 1.6
780	3.00
820	3.23
860	3.46

Temperature-dependent equations

$\kappa = -1.524 + 5.800 \times 10^{-3} T$

Standard error of estimate = 0.00%

These values are based on the data of Arndt and Ploetz (classical ac method) [192].

TABLE 690. Density studies: Na_2CO_3 - NaOH - CaO

Investigations critically examined			
Ref.	Mol % CaO	Temp. range (K)	Comments
192	1.6	773–873	see: Na_2CO_3–NaOH

TABLE 691. Na_2CO_3 - NaOH - CaO: Density (g cm^{-3})

T(K)	Mol percent Na_2CO_3 2.1 NaOH 96.3 CaO 1.6
780	1.717
820	1.697
860	1.677
870	1.672

Temperature-dependent equations

$\rho = 2.107 - 0.5001 \times 10^{-3}T$

These values are based on the data of Arndt and Ploetz (Archimedean technique) [192].

TABLE 692. Viscosity studies: Na_2CO_3 - NaOH - CaO

Investigations critically examined			
Ref.	Mol % CaO	Temp. range (K)	Comments
192	1.4	723–823	see: Na_2CO_3–NaOH

TABLE 693. Na_2CO_3 - NaOH - CaO: Viscosity (cp)

T(K)	Mol percent Na_2CO_3 1.6 NaOH 97.0 CaO 1.4
730	2.09
760	1.80
800	1.57
820	1.51

Temperature-dependent equations

$\eta = 36.438 - 83.23 \times 10^{-3}T + 49.55 \times 10^{-6}T^2$

Standard error of estimate = 0.66%

These values are based on the data of Arndt and Ploetz (capillary technique) [192].

Na_2CO_3 - NaOH - NaCl

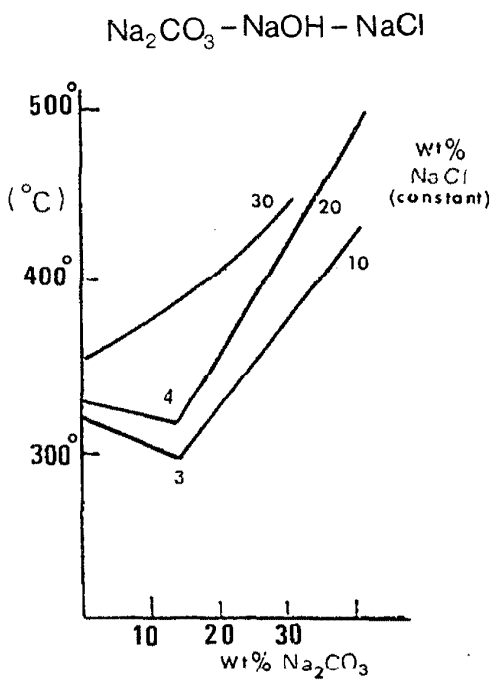

FIGURE 91. Phase diagram for Na_2CO_3 - NaOH - NaCl.

Three solubility isotherms for Na_2CO_3 in NaOH–NaCl are shown.

Data from: M. F. Lantratov and A. F. Alabyshev, *J. Appl. Chem.*, USSR, **32**, 66 (1959).

Melt Preparation and Purification

Arndt and Ploetz [192] used pure sodium hydroxide (stored in sealed tubes prior to use).

TABLE 694. Electrical conductance studies: Na_2CO_3 - NaOH - NaCl

Investigations critically examined			
Ref.	Mol % NaCl	Temp. range (K)	Comments
192	0–10	593–723	see: Na_2CO_3–NaOH

TABLE 695. Na_2CO_3 - NaOH - NaCl: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol % [Na_2CO_3: NaOH: NaCl]				
	1.7 88.3 10.0	1.7 91.0 7.3	1.7 92.2 6.1	1.7 94.7 3.6	1.7 96.4 1.9
600	1.32		1.43		1.68
620	1.44		1.55	1.70	1.84
640	1.56	1.64	1.67	1.83	1.99
680	1.79	1.89	1.92	2.11	2.29
720	2.03	2.13	2.17	2.38	2.58

Temperature-dependent equations

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

wt % Na_2CO_3 = 4.3 (constant)

Mol % NaCl	Mol % NaOH	-a	b x 10^3	-c x 10^6	standard error of estimate
10.0	88.3	2.2572	5.959		0.32%
7.3	91.0	4.387	12.33	4.556	0.06%
6.1	92.2	1.855	4.903	-0.9567	0.09%
3.8	94.5	2.5753	6.867		0.16%
3.6	94.7	2.5175	6.800		0.00%
1.9	96.4	4.573	12.83	4.021	0.05%

These values are based on the data of Arndt and Ploetz (classical ac method) [192].

TABLE 696. Na_2CO_3 - NaOH - NaCl: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol % [NaCl: Na_2CO_3: NaOH]				
	2.0 0.6 97.4	2.0 1.6 96.4	2.1 3.9 94.0	2.1 5.0 92.9	2.3 10.5 87.2
600	1.89	1.70	1.51	1.42	1.24
640	2.23	2.01	1.80	1.69	1.50
680	2.57	2.32	2.09	1.97	1.76
720	2.90	2.64	2.37	2.26	2.03

Temperature-dependent equations

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

wt % NaCl = 2.8 (constant)

Mol % NaOH	Mol % Na_2CO_3	-a	b x 10^3	c x 10^6	standard error of estimate
97.4	0.6	3.1583	8.418	-0.733	0.23%
96.4	1.6	3.3221	8.802	0.3871	0.07%
96.1	1.9	2.6057	6.878	0.996	0.03%
94.3	3.6	2.3416	5.8515	-1.775	0.08%
94.0	3.9	3.5452	9.491	1.855	0.02%
92.9	5.0	1.9708	4.535	1.216	0.22%
87.2	10.5	2.1640	4.948		0.13%

These values are based on the data of Arndt and Ploetz (classical ac method) [192].

TABLE 697. Density studies: Na_2CO_3 - NaOH - NaCl

Investigations critically examined

Ref.	Mol % NaCl	Temp. range (K)	Comments
192	2.0-10.2	593-723	see: Na_2CO_3-NaOH

TABLE 698. Na_2CO_3 - NaOH - NaCl: Density (g cm^{-3})

T(K)	Mol % [Na_2CO_3:NaOH:NaCl]		
	1.7 88.1 10.2	1.7 93.1 5.2	1.6 96.4 2.0
600	1.802	1.797	1.799
660	1.770	1.766	1.769
700	1.749	1.745	1.749
720	1.738	1.735	1.739

Temperature-dependent equations

$\rho = a + bT$

wt % Na_2CO_3 = 4.2 (constant)

Mol percent NaCl	Mol percent NaOH	a	-b x 10^3	standard error of estimate
10.2	88.1	2.1212	0.5316	0.01%
7.3	91.1	2.1112	0.5200	0.00%
5.2	93.1	2.1065	0.5163	0.01%
3.6	94.8	2.1101	0.5201	0.00%
2.0	96.4	2.0986	0.5000	0.00%

These values are based on the data of Arndt and Ploetz (Archimedean technique) [192].

TABLE 699. Viscosity studies: Na_2CO_3 - NaOH - NaCl

Investigations critically examined

Ref.	Mol % NaCl	Temp. range (K)	Comments
192	2.0-7.9	623-823	see: Na_2CO_3-NaOH

TABLE 700. Na_2CO_3 - NaOH - NaCl: Viscosity (cp)

T(K)	Mol % [Na_2CO_3:NaOH:NaCl]	
	1.6 90.5 7.9	1.6 96.4 2.0
630	3.81	3.70
680	2.61	2.69
760	1.78	1.78
780		1.67
820		1.57

Temperature-dependent equations

$\eta = a + bT + cT^2 + dT^3$

Wt % Na_2CO_3 = 4.0 (constant)

Mol % NaCl	Mol % NaOH	a	-b x 10^3	c x 10^6	-d x 10^9	standard error of estimate
7.9	90.5	63.570	160.56	104.29		1.99%
2.0	96.4	67.004	202.93	203.96	65.61	3.35%

These values are based on the data of Arndt and Ploetz (capillary technique) [192].

TABLE 702. Na_2CO_3 - NaOH - Na_2SiO_3: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol % [Na_2CO_3:NaOH:Na_2SiO_3]	
	1.8 93.8 4.4	1.8 96.1 2.1
780	2.62	2.89
820	2.88	3.18
860	3.13	3.45
870	3.19	3.52

Temperature-dependent equations

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

wt % Na_2CO_3 = 4.4 (constant)

Mol % Na_2SiO_3	Mol % NaOH	-a	b x 10^3	-c x 10^6	standard error of estimate
4.4	93.8	3.256	8.654	1.43	0.04%
2.1	96.1	4.672	12.124	3.11	0.18%

These values are based on the data of Arndt and Ploetz (classical ac method) [192].

TABLE 703. Density studies: Na_2CO_3 - NaOH - Na_2SiO_3

Investigations critically examined

Ref.	Mol % Na_2SiO_3	Temp. range (K)	Comments
192	1.8; 3.6	773-873	see: Na_2CO_3-NaOH

Na_2CO_3 - NaOH - Na_2SiO_3

Melt Preparation and Purification

Arndt and Ploetz [192] used pure sodium hydroxide and kept it in sealed tubes prior to use.

TABLE 701. Electrical conductance studies: Na_2CO_3 - NaOH - Na_2SiO_3

Investigations critically examined

Ref.	Mol % Na_2SiO_3	Temp. range (K)	Comments
192	2.1; 4.4	773-873	see: Na_2CO_3-NaOH

TABLE 704. Na_2CO_3 - NaOH - Na_2SiO_3: Density (g cm^{-3})

T(K)	Mol % [Na_2CO_3:NaOH:Na_2SiO_3]	
	1.8 94.6 3.6	1.7 96.5 1.8
780	1.762	1.731
820	1.739	1.709
860	1.717	1.687
870	1.711	1.682

Temperature-dependent equations

$\rho = a + bT$

wt % Na_2CO_3 = 4.2 (constant)

Mol % Na_2SiO_3	Mol % NaOH	a	-b x 10^3	standard error of estimate
3.6	94.6	2.1983	0.5600	0.03%
1.8	96.5	2.1605	0.5501	0.02%

These values are based on the data of Arndt and Ploetz (Archimedean technique) [192].

TABLE 705. Viscosity studies: Na_2CO_3 - NaOH - Na_2SiO_3

Investigations critically examined

Ref.	Mol % Na_2SiO_3	Temp. range (K)	Comments
192	4.7	723–823	see: Na_2CO_3–NaOH

TABLE 706. Na_2CO_3 - NaOH - Na_2SiO_3: Viscosity (cp)

T(K)	Mol percent Na_2CO_3 1.7 NaOH 93.6 Na_2SiO_3 4.7
730	2.09
740	1.99
780	1.68
820	1.47

Temperature-dependent equation

$$\eta = 28.841 - 63.15 \times 10^{-3}T + 36.31 \times 10^{-6}T^2$$

Standard error of estimate = 0.51 %

These values are based on the data of Arndt and Ploetz (capillary technique) [192].

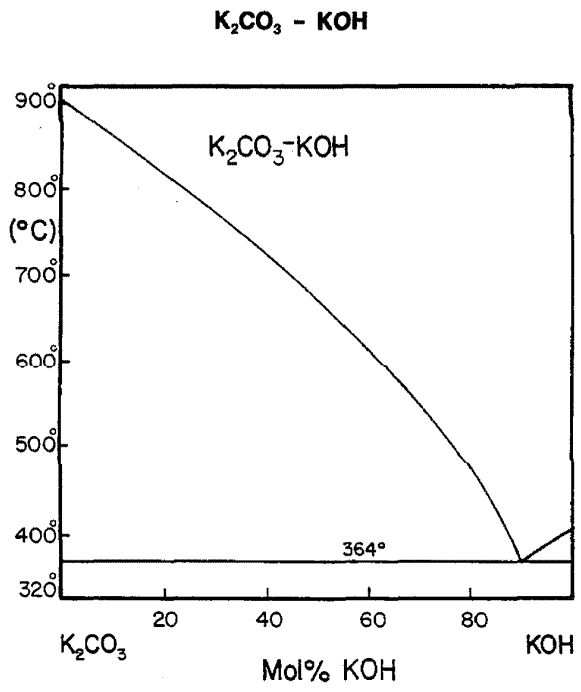

FIGURE 92. Phase diagram for K_2CO_3 - KOH.

Data from: A. D. Pelton, et al. "*Calculation of Thermodynamic Equilibria in the Carbonate Fuel Cell*", Topical Report Feb.(1980), (US DOE Contract $DE\text{-}AC_{02}79ET_{15416}$); Proj. $CDT\text{-}P_{501}$, L'Ecole Polytechnique Montreal.

Melt Preparation and Purification

Arndt and Ploetz [192] used high purity salts. The potassium hydroxide was stored in sealed tubes until required for use.

TABLE 707. Electrical conductance studies: K_2CO_3 - KOH

Investigations critically examined

Ref.	Mol % KOH	Temp. range (K)	Comments
192	91.52–100	673–873	see: Na_2CO_3–NaOH

TABLE 708. K_2CO_3 - KOH: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent KOH			
	97.9	97.5	96.0	91.5
680	2.32	2.21	2.11	1.94
740	2.67	2.56	2.45	2.29
800	3.02	2.91	2.80	2.64
860	3.36	3.25	3.14	2.98

Temperature-dependent equations

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

Mol % KOH	$-a$	$b \times 10^3$	$c \times 10^6$	standard error of estimate
100	1.427	5.860		0.09%
98.3	0.786	3.828	1.15	0.05%
97.9	1.624	5.800		0.00%
97.5	1.734	5.800		0.00%
96.0	1.811	5.760		0.12%
95.7	1.814	5.740		0.10%
93.3	1.354	4.327	0.89	0.06%
91.5	2.004	5.800		0.00%

These values are based on the data of Arndt and Ploetz (classical ac method) [192]. The values calculated from the above equation for KOH are in close agreement with the recommended data base [1].

TABLE 709. Density studies: K_2CO_3 - KOH

Investigations critically examined

Ref.	Mol % KOH	Temp. range (K)	Comments
192	91.4–100	673–823	see: Na_2CO_3–NaOH

TABLE 710. K_2CO_3 - KOH: Density (g cm^{-3})

T(K)	Mol percent KOH			
	98.3	97.2	95.5	91.4
680	1.730	1.747	1.756	1.796
740	1.702	1.720	1.730	1.767
800	1.675	1.693	1.703	1.738
820	1.666	1.683	1.694	1.728

Temperature-dependent equations

$\rho = a + bT$

Mol % KOH	a	$-b \times 10^3$	standard error of estimate
100	2.0132	0.4400	0.00%
98.3	2.0414	0.4580	0.03%
97.9	2.0382	0.4460	0.02%
97.2	2.0541	0.4520	0.00%
95.7	2.0696	0.4600	0.00%
95.5	2.0552	0.4400	0.00%
93.3	2.1043	0.4780	0.02%
91.4	2.1268	0.4860	0.02%

These values are based on the data of Arndt and Ploetz (Archimedean technique) [192]. The values calculated from the above equation for KOH are in exact agreement with the recommended data base [1].

TABLE 711. Viscosity studies: K_2CO_3 - KOH

Investigations critically examined

Ref.	Mol % KOH	Temp. range (K)	Comments
192	93.2–100	673–873	see: Na_2CO_3–NaOH

TABLE 712. K_2CO_3 - KOH: Viscosity (cp)

T(K)	Mol percent KOH	
	98.0	93.2
680	2.13	2.13
740	1.45	1.53
800	1.10	1.11
860	0.88	0.86

Temperature-dependent equations

$\eta = a + bT + cT^2 + dT^3$

Mol % KOH	a	$-b \times 10^3$	$c \times 10^6$	$-d \times 10^9$	standard error of estimate
100	22.256	46.830	25.50		1.51%
98.0	100.723	352.000	418.16	167.27	2.59%
93.2	21.001	44.121	24.07		1.45%

These values are based on the data of Arndt and Ploetz (capillary technique) [192]. The values calculated from the above equation for KOH are in exact agreement with the recommended data base [1].

K_2CO_3 - KOH - CaO

Melt Preparation and Purification

Arndt and Ploetz [192] used pure potassium hydroxide (stored in sealed tubes until required for use).

TABLE 713. Electrical conductance studies: K_2CO_3 - KOH - CaO

Investigations critically examined

Ref.	Mol % CaO	Temp. range (K)	Comments
192	5.1; 10.2	673–873	see: Na_2CO_3–NaOH

TABLE 714. K_2CO_3 - KOH - CaO: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol % [K_2CO_3:KOH:CaO]	
	1.7 88.1 10.2	1.7 93.2 5.1
680	1.71	2.00
740	1.94	2.25
800	2.17	2.50
860	2.40	2.77

Temperature-dependent equations

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

wt % K_2CO_3 = 4.0 (constant)

Mol % CaO	Mol % KOH	$-a$	$b \times 10^3$	$c \times 10^6$	standard error of estimate
10.2	88.1	0.854	3.763	0.02	0.01%
5.1	93.2	0.243	2.527	1.13	0.16%

These values are based on the data of Arndt and Ploetz (classical ac method) [192].

TABLE 715. Density studies: K_2CO_3 - KOH - CaO

Investigations critically examined

Ref.	Mol % CaO	Temp. range (K)	Comments
192	5.1; 8.5	673–873	see: Na_2CO_3–NaOH

TABLE 716. K_2CO_3 - KOH - CaO: Density (g cm^{-3})

T(K)	Mol % [K_2CO_3:KOH:CaO]	
	1.9 89.5 8.5	1.9 92.9 5.1
680	1.774	1.758
740	1.747	1.731
800	1.720	1.703
860	1.693	1.676

Temperature-dependent equations

$\rho = a + bT$

wt % K_2CO_3 = 4.0 (constant)

Mol % CaO	Mol % KOH	a	$-b \times 10^3$	standard error of estimate
8.5	89.5	2.0801	0.450	0.02%
5.1	92.9	2.0681	0.456	0.03%

These values are based on the data of Arndt and Ploetz (Archimedean technique) [192].

TABLE 717. Viscosity studies: K_2CO_3 - KOH - CaO

Investigations critically examined

Ref.	Mol % CaO	Temp. range (K)	Comments
192	7.6	673–873	see: Na_2CO_3–NaOH

TABLE 718. K_2CO_3 - KOH - CaO: Viscosity (cp)

T(K)	Mol percent KOH 2.0 K_2CO_3 90.4 CaO 7.6
680	2.16
740	1.52
800	1.08
860	0.85

Temperature-dependent equation

$\eta = 24.024 - 51.799 \times 10^{-3}T + 28.895 \times 10^{-6}T^2$

Standard error of estimate = 2.78%

These values are based on the data of Arndt and Ploetz (capillary technique) [192].

K_2CO_3 - KOH - KCl

Melt Preparation and Purification

Arndt and Ploetz [192] used pure potassium hydroxide (stored in sealed tubes until required for use).

TABLE 719. Electrical conductance studies: K_2CO_3 - KOH - KCl

Investigations critically examined

Ref.	Mol % KCl	Temp. range (K)	Comments
192	1.3–12.4	673–873	see: Na_2CO_3–NaOH

TABLE 720. K_2CO_3 - KOH - KCl: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol % [K_2CO_3:KOH:KCl]			
	1.7 85.8 12.4	1.7 90.0 8.3	1.7 94.3 4.0	1.7 97.1 1.3
680	1.56	1.72	1.89	2.21
740	1.87	2.02	2.21	2.53
800	2.17	2.33	2.54	2.86
860	2.47	2.65	2.88	3.18

Temperature-dependent equations

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

wt % K_2CO_3 = 4.0 (constant)

Mol % KCl	Mol % KOH	a	$b \times 10^3$	$c \times 10^6$	standard error of estimate
12.4	85.8	1.7044	4.607	0.293	0.14%
12.0	86.3	1.7175	4.589	0.305	0.14%
8.3	90.0	1.2877	3.820	0.879	0.18%
7.9	90.4	1.3111	3.855	0.857	0.18%
4.0	94.3	1.6747	5.032	0.303	0.12%
3.9	94.4	2.2363	6.686	-0.845	0.16%
1.3	97.1	1.4556	5.376	0.016	0.00%

These values are based on the data of Arndt and Ploetz (classical ac method) [192].

TABLE 721. Density studies: K_2CO_3 - KOH - KCl

Investigations critically examined

Ref.	Mol percent KCl	Temp. range (K)	Comments
192	3.8–9.0	673–873	see: Na_2CO_3–NaOH

TABLE 722. K_2CO_3 - KOH - KCl: Density (g cm^{-3})

T(K)	Mol % [K_2CO_3:KOH:KCl]			
	1.7 89.3 9.0	1.7 90.4 7.9	1.7 94.4 3.9	1.7 94.5 3.8
680	1.736	1.735	1.732	1.733
740	1.708	1.707	1.704	1.705
800	1.681	1.680	1.677	1.678
860		1.653	1.650	

Temperature-dependent equations

$\rho = a + bT$

wt % K_2CO_3 = 4.0 (constant)

Mol % KCl	Mol % KOH	a	$-b \times 10^3$	standard error of estimate
9.0	89.3	2.0444	0.454	0.02%
7.9	90.4	2.0434	0.454	0.02%
3.9	94.4	2.0404	0.454	0.02%
3.8	94.5	2.0456	0.460	0.00%

These values are based on the data of Arndt and Ploetz (Archimedean technique) [192].

TABLE 723. Viscosity studies: K_2CO_3 - KOH - KCl

Investigations critically examined

Ref.	Mol % KCl	Temp. range (K)	Comments
192	8.9	673–873	see: Na_2CO_3–NaOH

TABLE 724. K_2CO_3 - KOH - KCl: Viscosity (cp)

T(K)	Mol percent K_2CO_3 2.1 KOH 89.0 KCl 8.9
680	2.12
740	1.49
800	1.13
860	0.90

Temperature-dependent equation

$\eta = 72.032 - 0.24228T + 0.2790 \times 10^{-3}T^2 - 0.10867 \times 10^{-6}T^3$

Standard error of estimate = 2.03%

These values are based on the data of Arndt and Ploetz (capillary technique) [192].

K_2CO_3 - KOH - K_2SiO_3

Melt Preparation and Purification

Arndt and Ploetz [192] used pure potassium hydroxide (stored in sealed tubes until required for use).

TABLE 725. Electrical conductance studies: K_2CO_3 - KOH - K_2SiO_3

Investigations critically examined

Ref.	Mol % K_2SiO_3	Temp. range (K)	Comments
192	1.9–6.2	773–873	see: Na_2CO_3–NaOH

TABLE 726. K_2CO_3 - KOH - K_2SiO_3: Specific conductance (ohm^{-1}cm^{-1})

T(K)	Mol % [K_2CO_3:KOH:K_2SiO_3]		
	1.8 92.0 6.2	1.8 94.2 4.0	1.7 96.4 1.9
780	2.35	2.53	2.70
800	2.44	2.63	2.81
830	2.58	2.77	2.97
870	2.76	2.96	3.18

Temperature-dependent equations

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

Mol % K_2SiO_3	Mol % KOH	$-a$	$b \times 10^3$	$-c \times 10^6$	standard error of estimate
6.2	92.0	2.285	7.247	1.669	0.03%
4.0	94.2	3.440	10.213	3.288	0.05%
1.9	96.4	4.902	13.750	5.133	0.06%

These values are based on the data of Arndt and Ploetz (classical ac method) [192].

TABLE 727. Density studies: K_2CO_3 - KOH - K_2SiO_3

Investigations critically examined

Ref.	Mol percent K_2SiO_3	Temp. range (K)	Comments
192	1.9; 4.0	773–873	see: Na_2CO_3–NaOH

TABLE 728. K_2CO_3 - KOH - K_2SiO_3: Density (g cm^{-3})

T(K)	Mol % [K_2CO_3:KOH:K_2SiO_3]	
	1.9 94.1 4.0	1.9 96.2 1.9
780	1.747	1.717
800	1.737	1.708
830	1.723	1.694
860	1.709	1.679
870	1.704	1.675

Temperature-dependent equations

$\rho = a + bT$

wt % K_2CO_3 = 4.3 (constant)

Mol % K_2SiO_3	Mol % KOH	a	$-b \times 10^3$	standard error of estimate
4.0	94.1	2.1214	0.4800	0.03%
1.9	96.2	2.0836	0.4700	0.02%

These values are based on the data of Arndt and Ploetz (Archimedean technique) [192].

TABLE 729. Viscosity studies: K_2CO_3 - KOH - K_2SiO_3

Investigations critically examined

Ref.	Mol % K_2SiO_3	Temp. range (K)	Comments
192	1.1	723-873	see: Na_2CO_3-NaOH

TABLE 730. K_2CO_3 - KOH - K_2SiO_3: Viscosity (cp)

T(K)	Mol percent
	KOH 96.8 K_2CO_3 2.0 K_2SiO_3 1.1
730	1.56
790	1.18
850	0.92
870	0.86

Temperature-dependent equation

$\eta = 16.869 - 34.352 \times 10^{-3}T + 18.337 \times 10^{-6}T^2$

Standard error of estimate = 1.12%

These values are based on the data of Arndt and Ploetz (capillary technique) [192].

K_2CO_3 - Li_2SO_4

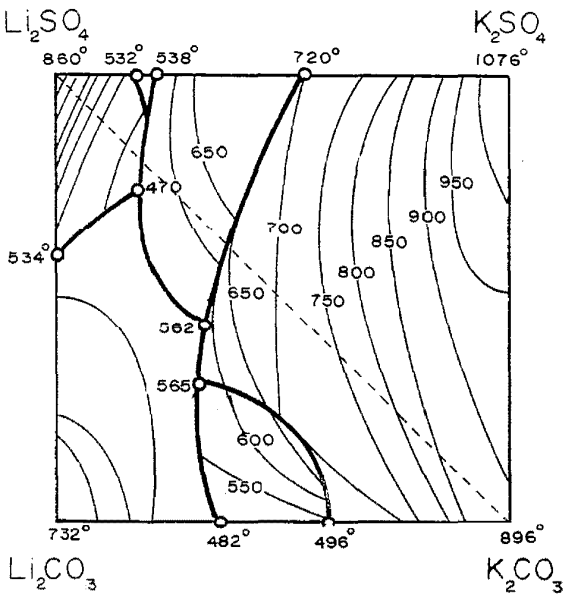

FIGURE 93. Phase diagram for K_2CO_3 - Li_2SO_4.

The system K_2CO_3-Li_2SO_4 is shown as a diagonal in the field of the reciprocal salt system $K,Li/CO_3,SO_4$.

Data from: L. F. Volkova, Izv. Fiz Khim., n.-i. in-ta pri Irkutskom gosuniv. 4, 115 (1959).

Melt Preparation and Purification

Prisyazhnyi and Zvagol'skaya [28] used reagent grade potassium carbonate and lithium sulfate and recrystallized them from distilled water. The K_2CO_3 was dried in a current of CO_2 at 600°C. All salts were prefused in a CO_2 atmosphere. Markov et al. [196] used reagent grade salts and handled the K_2CO_3 in an atmosphere of dry CO_2.

TABLE 731. Electrical conductance studies: K_2CO_3 - Li_2SO_4

Investigations critically examined

Ref.	Mol % Li_2SO_4	Temp. range (K)	Comments
196	0-100	1173	Au electrodes; sintered carborundum cell

TABLE 732. K_2CO_3 - Li_2SO_4: Specific conductance ($ohm^{-1}cm^{-1}$)

Mol percent Li_2SO_4	1173 K
90	1.70
60	1.08
30	0.86
10	0.94

Composition-dependent equation

$$\kappa = 1.049 - 1.314 \times 10^{-2}C + 2.265 \times 10^{-4}C^2$$

[C = Mol % Li_2SO_4]

Specific conductance, calculated from equivalent conductance data (interpolated from Markov et al. (classical ac method) [196]) and density data equations (from Prisyazhnyi and Zvagol'skaya (Archimedean technique) [28]).

TABLE 733. Density studies: K_2CO_3 - Li_2SO_4

Investigations critically examined

Ref.	Mol % Li_2SO_4	Temp. range (K)	Comments
28	0–100	1070–1170	Au bob; Pt thread; dry CO_2 atmosphere

TABLE 734. K_2CO_3 - Li_2SO_4: Density (g cm^{-3})

T(K)	Mol percent Li_2SO_4			
	80	60	40	20
860	2.064			
940	2.032	2.007		
1020	1.999	1.974	1.954	
1100	1.966	1.940	1.920	1.925
1220	1.917	1.889	1.869	1.869

Temperature-dependent equations

$$\rho = a + bT$$

Mol percent Li_2SO_4	a	$-b \times 10^3$
100	2.636	0.565
80	2.416	0.409
60	2.405	0.423
40	2.390	0.427
20	2.442	0.470
0	2.359	0.400

These values are based on the data of Prisyazhnyi and Zvagol'skaya (Archimedean technique); data in equation form; precisions not estimated [28]. The values calculated from the equations (above) for Li_2SO_4 and K_2CO_3 are in close agreement with the recommended data base, i.e., <0.7% [1].

Li_2CO_3 - K_2SO_4

Phase diagram: see Figure 93 The system Li_2CO_3-K_2SO_4 is shown in Figure 93 as a diagonal in the field of the reciprocal salt system K,Li/CO_3,SO_4

Data from: L. F. Volkova, Izv. Fiz Khim., n.-i. in-ta pri Irkutskom gosuniv. **4**, 115 (1959).

Melt Preparation and Purification

For the method of melt preparation used by Markov et al. [196], see: K_2CO_3-Li_2SO_4. Prisyazhnyi and Zvagol'skaya [28] used reagent grade potassium sulfate recrystallized from distilled water. Lithium carbonate was prepared from lithium hydroxide and ammonium carbonate. The salt was then dried in a current of CO_2 at 600°C. All mixtures were prepared in a dry box under a CO_2 atmosphere.

TABLE 735. Electrical conductance studies: Li_2CO_3 - K_2SO_4

Investigations critically examined

Ref.	Mol % K_2SO_4	Temp. range (K)	Comments
196	0–100	1173	see: K_2CO_3-Li_2SO_4

TABLE 736. Li_2CO_3 - K_2SO_4: Specific conductance ($ohm^{-1}cm^{-1}$)

Mol percent K_2SO_4	1173 K
80	0.83
60	0.84
40	1.01
20	1.53
10	2.00

Composition-dependent equation

$$\kappa = 2.640 - 7.332 \times 10^{-2}C + 9.919 \times 10^{-4}C^2 - 4.470 \times 10^{-6}C^3$$

[C = Mol % K_2SO_4]

The specific conductance values were calculated from equivalent conductance data interpolated from Markov et al. (classical ac method) [196], and density data equations from Prisyazhnyi and Zvagol'skaya (Archimedean technique) [28].

TABLE 737. Density studies: Li_2CO_3 - K_2SO_4

Investigations critically examined

Ref.	Mol % K_2SO_4	Temp. range (K)	Comments
28	0–100	not cited	see: K_2CO_3-Li_2SO_4

TABLE 738. Li_2CO_3 - K_2SO_4: Density (g cm^{-3})

T(K)	Mol percent K_2SO_4			
	80	60	40	20
870	2.063	2.044		
1030	1.998	1.978	1.944	
1190	1.933	1.911	1.873	1.819
1310	1.885	1.861	1.819	1.770
1370	1.861	1.836	1.793	1.746

Temperature-dependent equations

$\rho = a + bT$

Mol percent K_2SO_4	a	$-b \times 10^3$
100	2.614	0.552
80	2.414	0.404
60	2.405	0.415
40	2.401	0.444
20	2.301	0.405
0	2.131	0.306

These values are based on the data of Prisyazhnyi and Zvagol'skaya (Archimedean technique); data in equation form; precisions not estimated [28]. The values for Li_2CO_3 and K_2SO_4 in [28] are in close agreement with those of the recommended data base, i.e., ~0.5% [1].

Li_2CO_3 - LiOH

Melt Preparation and Purification

Moiseev and Stepanov [148] prepared the melts from reagent grade materials. The lithium carbonate was heated in a CO_2 atmosphere at 500–600°C for several hours and then stored in a desiccator.

TABLE 739. Surface tension studies: Li_2CO_3 - LiOH

Investigations critically examined

Ref.	Mol % LiOH	Temp. range (K)	Comments
148	0–30	1038	Pt capillary

TABLE 740. Li_2CO_3 - LiOH: Surface tension (dyn cm^{-1})

Mol percent LiOH	1038 K
30	223
20	230
10	237
0	242

Composition-dependent equation

$\gamma = 242.5 - 49.32 \times 10^{-2}C - 54.15 \times 10^{-4}C^2$

[C = Mol % LiOH]

These values are based on the data of Moiseev and Stepanov (maximum bubble pressure method); data in graphical form; precisions not estimated [148]. The values for Li_2CO_3 (0% LiOH) are in close agreement with the reference data base, $\sim <0.5\%$ [2].

Nitrate/nitrite - Other

TABLE 741. Data Status

System	Phase Diagram	Electrical Conductance	Density	Viscosity	Surface Tension
KNO_3-$KClO_4$	X	X	X	X	
-$K_2Cr_2O_7$	X	X			
-K_2MoO_4	X		X		
-KOH	X		X		
-K_2WO_4			X		
-$LiClO_4$	X	X	X	X	
-$NaClO_4$		X	X	X	
-$Na_2Cr_2O_7$			X		
$LiNO_3$-$AgClO_3$		X	X		
-$KClO_4$	X	X	X	X	
-$LiClO_3$		X	X	X	X
-$LiClO_4$	X	X	X	X	
-LiOH	X	X	X		
-$NaClO_4$	X	X	X	X	
NH_4NO_3-$NH_4H_2PO_4$			X	X	
$NaNO_3$-$KC_2H_3O_2$					X
-$KC_3H_5O_2$					X
-$K_2Cr_2O_7$	X		X		
-$KClO_4$		X	X	X	
-$LiClO_4$	X	X	X	X	
-$NaClO_3$	X	X	X	X	X
-$NaClO_4$	X	X	X		
-Na_2MoO_4	X	X	X		
-NaOH	X		X		
-Na_2SO_4	X	X			
-Na_2WO_4	X	X	X		
KNO_2-K_2MoO_4	X		X		
-K_2WO_4			X		
$NaNO_2$-Na_2MoO_4	X	X	X		
-Na_2WO_4	X	X	X		

KNO_3 - $KClO_4$

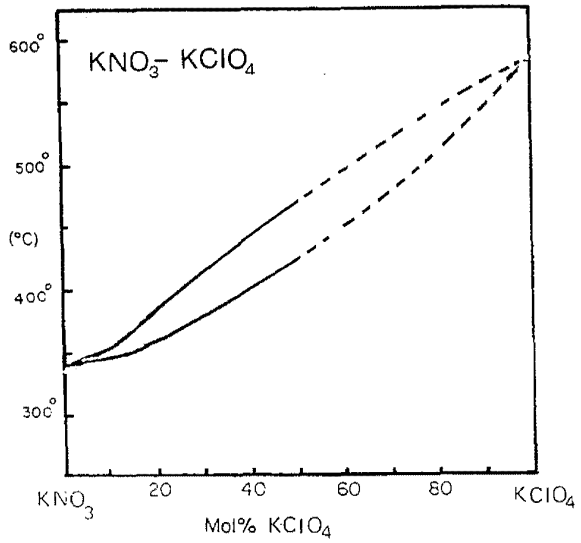

FIGURE 94. Phase diagram for KNO_3 - $KClO_4$.

The system KNO_3-$KClO_4$ is shown also as one side of the reciprocal salt system K,Li/NO_3,ClO_4 in Figure 98. Data from: I. A. Brovkina, and S. I. Selivanova, Deposited document VINITI No. 2877-71 (Moscow, 1971).

Melt Preparation and Purification

Brovkina and Selivanova [198] and Farmakovskaya et al. [**199**] used "extra pure"-grade starting materials. The salts were recrystallized and dried under vacuum.

TABLE 742. Electrical conductance studies: KNO_3 - $KClO_4$

Investigations critically examined			
Ref.	Mol % $KClO_4$	Temp. range (K)	Comments
199	0–50	610–877	
198	0–25	not cited	Pyrex cell; Pt electrodes; calibration: molten KNO_3.

TABLE 743. KNO_3 – $KClO_4$: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent $KClO_4$				
	50	30	15	10	5
620				0.61	0.63
650			0.68	0.70	0.72
700		0.79	0.83	0.85	0.87
750		0.93			
800	1.07				
875	1.25				

Composition-dependent equations

$\kappa = a + bT$

Mol percent $KClO_4$	$-a$	$b \times 10^3$
50	0.927	2.49
40	1.030	2.61
30	1.114	2.72
20	1.179	2.84
15	1.203	2.90
10	1.222	2.96
5	1.234	3.01
0	1.235	3.05

These values are based on the data of Brovkina and Selivanova (classical ac method); data in equation form; precisions not estimated [198]. The results for pure KNO_3 are ~0.5–1% higher than the recommended conductance data base for KNO_3 [10].

TABLE 744. Density studies: KNO_3 – $KClO_4$

Investigations critically examined

Ref.	Mol % $KClO_4$	Temp. range (K)	Comments
200	0–30	610–693	Pt ball

TABLE 745. KNO_3 – $KClO_4$: Density (g cm^{-3})

T(K)	Mol percent $KClO_4$		
	30	15	5
610			1.864
630		1.868	1.851
670		1.838	1.824
680	1.838		
690	1.830		

Temperature-dependent equations

$\rho = a + bT$

Mol percent $KClO_4$	a	$-b \times 10^3$
30	2.334	0.73
15	2.340	0.75
5	2.273	0.67
0	2.313	0.735

These values are based on the data of Brovkina, Selivanova and Farmakovskaya (Archimedean technique); data in equation form; precisions not estimated [200]. The densities for KNO_3 (0% $KClO_4$) are in essential agreement with the recommended density data base for KNO_3 [10].

TABLE 746. Viscosity studies: KNO_3 – $KClO_4$

Investigations critically examined

Ref.	Mol % $KClO_4$	Temp. range (K)	Comments
199	0–40	673	discussion article
201	0–30	610–720	damped oscillations of a spherical pendulum

TABLE 747. KNO_3 – $KClO_4$: Viscosity (cp)

T(K)	Mol percent $KClO_4$		
	30	15	5
630			2.63
650		2.46	2.35
690	2.04	2.00	1.92
710	1.86	1.83	
720	1.78		

Temperature-dependent equations

$\eta = A \exp[E/RT]$

Mol percent $KClO_4$	$A \times 10^2$	E
30	7.096	4607.3
15	7.263	4549.2
5	7.079	4526.6
0	7.088	4515.6

These values are based on the data of Farmakovskaya and Brovkina (damped oscillation); data in equation form; precisions not estimated [201]. The viscosity results for KNO_3 (0% $KClO_4$) and the recommended data base [10] are in very close agreement (~±0.5%).

KNO_3 – $K_2Cr_2O_7$

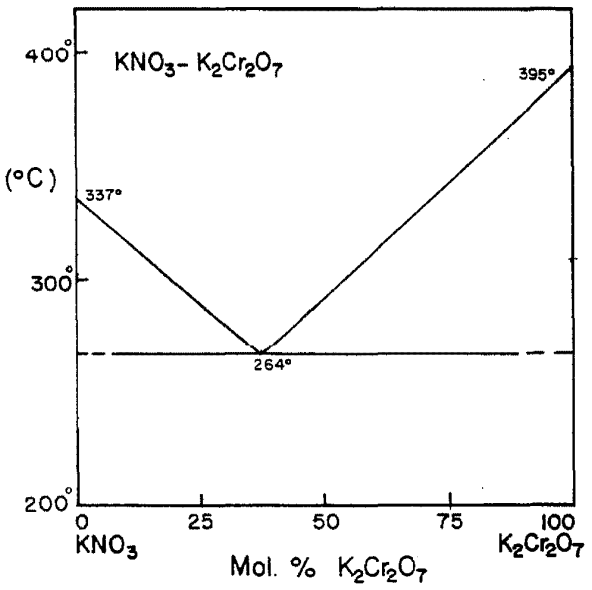

FIGURE 95. Phase diagram for KNO_3 – $K_2Cr_2O_7$.

Data from: A. P. Palkin and I. M. Bokhovkin, Tr. Voronezhsk. Gos. Univ. 9(3), 10 (1937).

Melt Preparation and Purification

Belyaev [202] used C.P. grade materials. Both of the salts were recrystallized twice.

TABLE 748. Electrical conductance studies: $KNO_3 - K_2Cr_2O_7$

Investigations critically examined			
Ref.	Mol % $K_2Cr_2O_7$	Temp. range (K)	Comments
202	0–100	623–748	Pyrex cell; Pt electrodes; frequency: 500–1000 Hz; calibration: molten KNO_3

TABLE 749. $KNO_3 - K_2Cr_2O_7$: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent $K_2Cr_2O_7$				
	85	70	55	40	25
620		0.164	0.205	0.256	0.368
680	0.227	0.274	0.332	0.395	0.519
720	0.299	0.353	0.417	0.488	0.620
740	0.335	0.394	0.459	0.534	0.670

Temperature-dependent equations

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

Mol % $K_2Cr_2O_7$	$-a$	$b \times 10^3$	$c \times 10^6$	standard error of estimate
100	1.1462	1.9999		0.00%
95	1.8028	3.7729	−1.2053	0.39%
90	−0.5801	−2.8404	3.3776	1.20%
85	0.9966	1.7999		0.00%
80	0.2064	−0.4870	1.6809	0.72%
75	1.0066	1.8600		0.47%
70	0.4370	0.1808	1.2724	0.31%
65	1.0663	2.0000		0.00%
60	1.1342	2.1326		0.38%
55	1.1085	2.1189		0.56%
50	1.2753	2.4057		0.54%
45	1.2556	2.4000		0.00%
40	1.1824	2.3200		0.40%
35	1.1946	2.3829		0.43%
30	1.2313	2.5371		0.46%
25	1.1906	2.5143		0.72%
20	6.2312	17.5686	−11.0615	6.35%
15	0.2633	−0.1390	2.1265	0.41%
10	0.6794	1.1839	1.1985	0.40%
0	3.2255	8.4485	−3.8200	0.67%

These values are based on the data of Belyaev (classical ac method) [202]. In [202], Table 4, the compositions are incorrectly labelled; the compositions should be given as Mol % $K_2Cr_2O_7$. The results for pure KNO_3 and $K_2Cr_2O_7$ in [202] are ~10% and ~6% lower, respectively, than the recommended conductance data bases for these two salts [1,10].

$KNO_3 - K_2MoO_4$

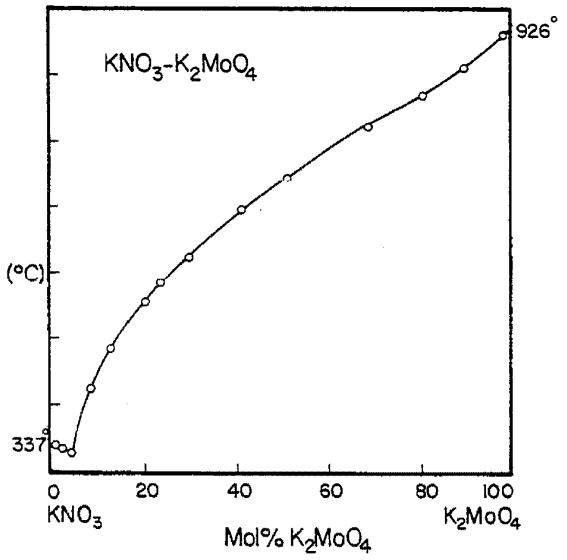

FIGURE 96. Phase diagram for $KNO_3 - K_2MoO_4$.

Data from: G. K. Shurdumov and T. N. Khokonova, Russ. J. Inorg. Chem., 15(3), 429 (1970).

Melt Preparation and Purification

Khokhonova et al. [203] prepared the potassium nitrate from analytical grade K_2CO_3 and C.P. grade HNO_3. The salt was recrystallized twice from distilled water. The potassium molybdate was prepared by fusing together analytical grade K_2CO_3 and C.P. grade molybdenum oxide.

TABLE 750. Density studies: $KNO_3 - K_2MoO_4$

Investigations critically examined			
Ref.	Mol % K_2MoO_4	Temp. range (K)	Comments
203	0–20	623–1023	Au bob suspended with Pt wire.

TABLE 751. KNO_3 - K_2MoO_4: Density (g cm^{-3})

T(K)	Mol percent K_2MoO_4			
	20	16	8	4
620				1.907
680			1.926	1.865
770		1.959	1.853	1.801
830	1.964	1.923	1.808	1.759
860	1.940	1.903	1.786	1.738
920	1.894	1.861	1.745	
950	1.872	1.838		

Temperature-dependent equations

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

Mol % K_2MoO_4	a	-b x 10^3	c x 10^6
20	2.9596	1.5788	0.457
16	2.0556	-0.3193	-0.577
12	2.4800	0.7470	
8	2.6730	1.3554	0.377
4	2.3437	0.7044	
2	2.3064	0.6899	
0	1.3424	-2.0389	-1.985

These values are based on the data of Khokhonova, Shurdumov and Protsenko (Archimedean technique); data in graphical form; precisions not estimated [203]. The results for pure KNO_3 in [203] are virtually in close accord (~ <0.5%) with the recommended density data base for KNO_3 [10].

KNO_3 - KOH

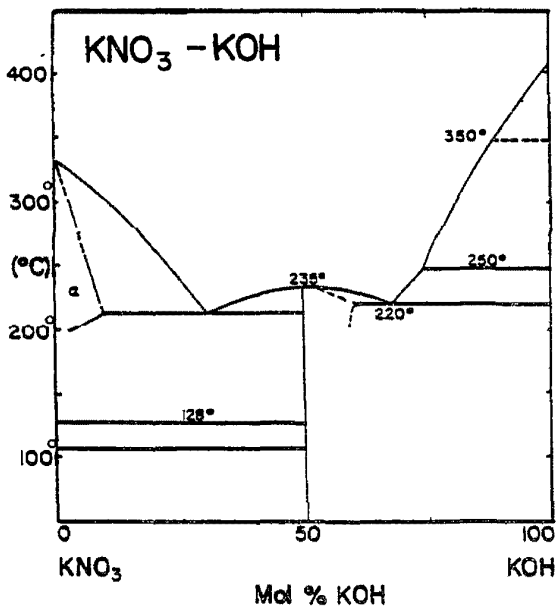

FIGURE 97. Phase diagram for KNO_3 - KOH.

Data from: N. A. Reshetnikov and N. I. Vilutis. Zhur. Neorg. Khim., 3, 177 (1958).

Melt Preparation and Purification

Very little information on melt preparation and purifaction by Kruglov and Kochergin [204]; KNO_3 (m. pt. 333°C) was recrystallized and dried before use; KOH (m. pt. 402°C) was dehydrated from the fluid (molten) state. The concentration of the carbonate in the KOH was less than 0.2–0.3%.

TABLE 752. Density studies: KNO_3 - KOH

Investigations critically examined			
Ref.	Mol % KOH	Temp. range (K)	Comments
204	0–100	513–823	Archimedean technique; Pt sphere; CO_2-free and moisture-free air atmosphere

TABLE 753. KNO_3–KOH Density (g cm^{-3})

T(K)	Mol percent KOH				
	90	66.5	50	31	10
520		1.700	1.718	1.802	
610		1.725	1.697	1.756	1.840
700	1.700	1.680	1.676	1.710	1.783
760	1.666	1.650	1.662	1.679	1.745

Temperature-dependent equations

$$\rho = a + bT$$

Mol % KOH	a	-b x 10^3	T range (K)
100	2.009	0.432	683–823
90	2.088	0.555	683–773
75	2.053	0.525	563–773
66.5	2.031	0.501	513–773
55	2.075	0.580	513–773
50	1.838	0.231	513–773
45	2.047	0.520	513–773
31	2.067	0.510	513–773
20	1.999	0.309	563–773
10	2.228	0.636	593–773
0	2.134	0.703	623–773

These values are based on the data of Kruglov, Kochergin and Poluyanova (Archimedean technique); data in equation form; precisions not estimated [204]. For KOH the results are in excellent agreement with the recommended data base [1], whereas for KNO_3, the results are uniformly lower than the recommended data base (~ 10%) [10].

KNO_3 - K_2WO_4

Melt Preparation and Purification

For the method of melt preparation and purification used by Khokhonova et al. [203], see: KNO_3–K_2MoO_4.

TABLE 754. Density studies: $KNO_3 - K_2WO_4$

Investigations critically examined

Ref.	Mol % K_2WO_4	Temp. range (K)	Comments
203	0–20	623–973	see: KNO_3–K_2MoO_4

TABLE 755. $KNO_3 - K_2WO_4$: Density (g cm^{-3})

T(K)	Mol percent K_2WO_4				
	20	16	10	6	2
620	1.885	1.984			
740	1.808	1.907	2.016		
770	1.788	1.888	1.998	2.167	
830	1.747	1.853	1.962	2.129	2.250
860	1.727	1.836	1.943	2.110	2.232
920			1.907	2.075	2.195
950				2.058	2.177

Temperature-dependent equations

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

Mol % K_2WO_4	a	$-b \times 10^3$	$-c \times 10^6$
20	2.7554	0.6087	
18	2.8767	1.0353	0.250
16	2.7988	0.9965	0.228
14	2.2130	-0.2206	-0.463
12	2.6189	0.8320	0.131
10	2.4629	0.6040	
8	2.3234	0.3823	-0.142
6	2.4865	0.9461	0.220
4	2.3157	0.6251	
2	2.2315	0.4869	-0.116
0	2.2516	0.6625	

These values are based on the data of Khokhonova, Shurdumov and Protsenko (Archimedean technique); data in graphical form; precisions not estimated [**203**]. For pure KNO_3 (0% K_2WO_4) the results in [**203**] are ~0.5% lower than the recommended density data base for KNO_3 [10].

KNO_3 - $LiClO_4$

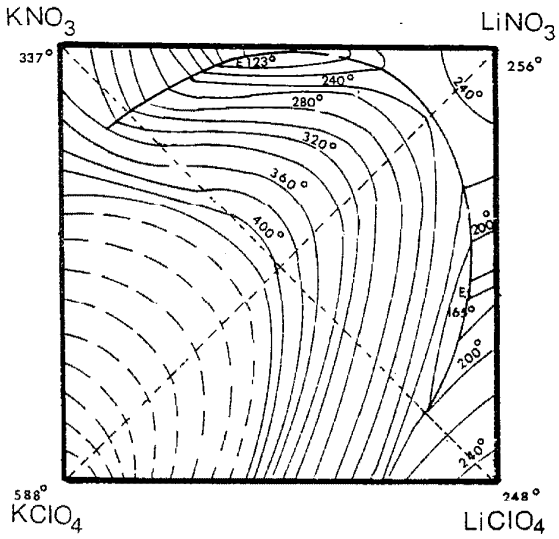

FIGURE 98. Phase diagram for $KNO_3 - LiClO_4$.

Data from: I. A. Brovkina, and S. I. Selivanova, Deposited Document VINITI No 2877-71 (Moscow, 1971). The KNO_3–$LiClO_4$ system is shown as a diagonal in the field of the quaternary reciprocal salt system: KNO_3, $LiNO_3$, $KClO_4$, $LiClO_4$.

Melt Preparation and Purification

Farmakovskaya et al. [199, **205**] used extra pure grade starting materials. The salts were recrystallized and dried under vacuum.

TABLE 756. Electrical conductance studies: $KNO_3 - LiClO_4$

Investigations critically examined

Ref.	Mol % $LiClO_4$	Temp. range (K)	Comments
205, 199, 197	0–100	500–700	Pyrex cell; Pt electrodes; calibration: molten KNO_3

TABLE 757. KNO_3 - $LiClO_4$: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent $LiClO_4$				
	84	70	50	30	15
500	0.480				
580	0.762	0.571			0.471
660	1.076	0.837		0.629	0.690
680	1.159	0.903	0.763	0.683	0.745
700			0.824	0.736	

Temperature-dependent equations

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

Mol % $LiClO_4$	$-a$	$b \times 10^3$	$c \times 10^6$
100	1.6447	4.5356	
84	0.5834	0.9153	2.4227
70	1.3563	3.3226	
50	1.3081	3.0452	
30	1.1503	2.6953	
15	1.1170	2.7375	
0	1.1833	3.0069	

These values are based on the data of Brovkina, Farmakovskaya and Khokhlov (classical ac method); data in equation form; precisions not estimated [205]. For pure KNO_3 and $LiClO_4$, the results in [205] are ~3% higher, and ~1% lower, respectively, than the recommended conductance data bases for KNO_3 [10] and $LiClO_4$ [8].

TABLE 758. Density studies: KNO_3 - $LiClO_4$

Investigations critically examined

Ref.	Mol % $LiClO_4$	Temp. range (K)	Comments
205	0-100	473-713	Pt ball

TABLE 759. KNO_3 - $LiClO_4$: Density (g cm^{-3})

T(K)	Mol percent $LiClO_4$				
	84	70	50	30	15
480	2.038				
580	1.971	1.947			1.885
660	1.918	1.894		1.839	1.825
680	1.904	1.881	1.864	1.824	1.810
700			1.848	1.809	

Temperature-dependent equations

$$\rho = a + bT$$

Mol percent $LiClO_4$	a	$-b \times 10^3$
100	2.3185	0.5772
84	2.3581	0.6673
70	2.3283	0.6574
50	2.4075	0.7998
30	2.3339	0.7503
15	2.3199	0.7501
0	2.3089	0.7295

These values are based on the data of Brovkina, Farmakovskaya and Khokhlov (Archimedean technique); data in equation form; precisions not estimated [205]. For pure KNO_3 and $LiClO_4$, the results in [205] are virtually in exact accord (i.e., <0.1%) with the recommended density data bases for KNO_3 [10], and $LiClO_4$ [1].

TABLE 760. Viscosity studies: KNO_3 - $LiClO_4$

Investigations critically examined

Ref.	Mol % $LiClO_4$	Temp. range (K)	Comments
205, 199	0-100	500-720	spherical Pt bob

TABLE 761. KNO_3 – $LiClO_4$: Viscosity (cp)

T(K)	Mol percent $LiClO_4$				
	84	70	50	30	15
500	10.50				
580	5.37	4.74			
660	3.23	2.89		2.66	
680	2.90	2.60	2.51	2.39	2.25
700	2.62	2.36	2.27	2.17	2.04
720			2.06		1.86

Temperature-dependent equations

$\rho = A \exp [E/RT]$

Mol percent $LiClO_4$	$A \times 10^2$	E
100	9.436	4666
84	8.119	4831
70	8.096	4690
50	7.456	4750
30	7.664	4650
15	7.643	4570
0	7.088	4516

These values are based on the data of Brovkina, Farmakovskaya and Khokhlov (oscillational method); data in equation form; precisions not estimated [205]. The results for pure $LiClO_4$ in [205] (above) have been advanced elsewhere in this series as the recommended viscosity data base for $LiClO_4$ [8]. For KNO_3, the results in [205] agree with the recommended viscosity data base for KNO_3 to within 0.5% [10].

KNO_3 – $NaClO_4$

Melt Preparation and Purification

Brovkina et al. [205] used extra pure grade materials. The salts were recrystallized and dried under vacuum.

TABLE 762. Electrical conductance studies: KNO_3 – $NaClO_4$

Investigations critically examined

Ref.	Mol % $NaClO_4$	Temp. range (K)	Comments
205	0–64	600–720	see: KNO_3–$LiClO_4$

TABLE 763. KNO_3 – $NaClO_4$: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent $NaClO_4$			
	64	55	30	14
600				0.592
630			0.632	0.678
650			0.685	0.735
670	0.860	0.814	0.739	0.793
690	0.921	0.874	0.792	0.850
700	0.952	0.904		
710	0.982	0.934		

Temperature-dependent equations

$\kappa = a + bT$

Mol percent $NaClO_4$	$-a$	$b \times 10^3$
64	1.1775	3.0415
55	1.1901	2.9917
30	1.0550	2.6772
14	1.1304	2.8703
0	1.1833	3.0069

These values are based on the data of Brovkina, Farmakovskaya and Khokhlov (classical ac method); data in equation form; precisions not estimated [205]. The results for pure KNO_3 (0% $NaClO_4$) in [205] are ~3% higher than the recommended conductance data for KNO_3 [10].

TABLE 764. Density studies: KNO_3 – $NaClO_4$

Investigations critically examined

Ref.	Mol % $NaClO_4$	Temp. range (K)	Comments
205	0–64	593–713	see: KNO_3–$LiClO_4$

TABLE 765. KNO_3 – $NaClO_4$: Density (g cm^{-3})

T(K)	Mol percent $NaClO_4$			
	64	50	30	14
590				1.902
630			1.902	1.872
670	1.935	1.910	1.870	1.842
690	1.918	1.893	1.854	1.827
700	1.909	1.885		
710	1.901	1.877		

Temperature-dependent equations

$\rho = a + bT$

Mol percent $NaClO_4$	a	$-b \times 10^3$
64	2.5045	0.8501
50	2.4589	0.8198
30	2.4060	0.8005
14	2.3448	0.7503
0	2.3089	0.7295

These values are based on the data of Brovkina, Farmakovskaya and Khokhlov (Archimedean technique); data in equation form; precisions not estimated [205]. For pure KNO_3 (0% $NaClO_4$) the density equation [205] and the recommended density data base [10] are virtually in exact agreement.

TABLE 766. Viscosity studies: KNO_3 – $NaClO_4$

Investigations critically examined			
Ref.	Mol % $NaClO_4$	Temp. range (K)	Comments
205, 201	0–64	600–720	see: KNO_3–$LiClO_4$

TABLE 767. KNO_3 – $NaClO_4$: Viscosity (cp)

T(K)	Mol percent $NaClO_4$			
	64	50	30	14
600				3.24
640			2.72	2.56
680	2.47	2.33	2.20	2.08
700	2.24	2.11	2.00	1.89
710	2.13	2.02	1.91	

Temperature–dependent equations

$\eta = A \exp [E/RT]$

Mol percent $NaClO_4$	$A \times 10^2$	E
64	7.918	4648
50	7.667	4614
30	7.574	4553
14	7.391	4507
0	7.088	4516

These values are based on the data of Brovkina, Farmakovskaya and Khokhlov (oscillational method); data in equation form; precisions not estimated [**205**]. The results in [**205**] for KNO_3 are in close agreement with the recommended data base set (<0.5%) [10].

KNO_3 - $Na_2Cr_2O_7$

Melt Preparation and Purification

Markov and Prisyazhnyi [**206**] recrystallized reagent grade salts twice from distilled water.

TABLE 768. Density studies: KNO_3 – $Na_2Cr_2O_7$

Investigations critically examined			
Ref.	Mol % $Na_2Cr_2O_7$	Temp. range (K)	Comments
206	0–100	693	quartz sphere filled with Mo

TABLE 769. KNO_3 – $Na_2Cr_2O_7$ Density (g cm^{-3})

Mol percent $Na_2Cr_2O_7$	693 K
100	2.39
90	2.34
70	2.22
50	2.10
30	1.98
10	1.87
0	1.81

Composition–dependent equation

$\rho = 1.8094 + 0.5853 \times 10^{-2} C$

[C = Mol % $Na_2Cr_2O_7$]

These values are based on the data of Markov and Prisyazhnyi (Archimedean technique); data in graphical form; precisions not estimated [**206**]. The value for 100% $Na_2Cr_2O_7$ (above) has been advanced elsewhere in this series as the sole density reference point for Na_2CrO_7 [8]. For KNO_3, the above density result is virtually in exact accord with the recommended data set [10].

$LiNO_3$ - $AgClO_3$

Melt Preparation and Purification

Goodwin and Mailey [**207, 208**] used reagent grade salts. No other information was given.

TABLE 770. Electrical conductance studies: $LiNO_3$ – $AgClO_3$

Investigations critically examined			
Ref.	Mol % $AgClO_3$	Temp. range (K)	Comments
207, 208	50	484–513	quartz cell; Pt electrodes; calibration: 1N H_2SO_4

TABLE 771. $LiNO_3$ – $AgClO_3$: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent $AgClO_3$
	50
480	0.386
490	0.423
500	0.461
510	0.498

Temperature–dependent equation

$\kappa = -1.4177 + 0.3757 \times 10^{-2} T$

Standard error of estimate = 2.24%

These values are based on the data of Goodwin and Mailey (classical ac method) [207].

TABLE 772. Density studies: $LiNO_3$ - $AgClO_3$

Investigations critically examined			
Ref.	Mol % $AgClO_3$	Temp. range (K)	Comments
207, 208	50	483–523	fused quartz sinker or Pt sinker

TABLE 773. $LiNO_3$ - $AgClO_3$: Density (g cm^{-3})

T(K)	Mol percent $AgClO_3$
	50
480	2.971
500	2.950
520	2.928

Temperature-dependent equation

$\rho = 3.4849 - 0.10703 \times 10^{-2}T$

Standard error of estimate = 0.01%

These values are based on the data of Goodwin and Mailey (Archimedean technique) [207].

$LiNO_3$ - $KClO_4$

Phase diagram: see: Fig. 98 The system $LiNO_3$–$KClO_4$ is shown as a diagonal in the field of the quaternary reciprocal salt system: KNO_3, $LiNO_3$, $KClO_4$, $LiClO_4$.

Melt Preparation and Purification

Brovkina et al. [205] used extra pure grade materials. The salts were recrystallized and dried under vacuum.

TABLE 774. Electrical conductance studies: $LiNO_3$ - $KClO_4$

Investigations critically examined			
Ref.	Mol % $KClO_4$	Temp. range (K)	Comments
205, 197	0–50	508–693	see: KNO_3–$LiClO_4$

TABLE 775. $LiNO_3$ - $KClO_4$: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent $KClO_4$				
	50	40	25	14	5
520				0.580	
540				0.661	0.805
580			0.679	0.831	1.015
660	0.693	0.799	1.000	1.200	1.436
680	0.753	0.867	1.080	1.298	1.541

Temperature-dependent equations

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

Mol % $KClO_4$	$-a$	$b \times 10^3$	$c \times 10^6$
50	1.3028	3.0235	
40	1.4711	3.4391	
25	1.6484	4.0124	
14	0.6523	0.7526	3.1113
5	2.0320	5.2541	
0	1.0902	1.9855	3.1530

These values are based on the data of Brovkina, Farmakovskaya and Khokhlov (classical ac method); data in equation form; precisions not estimated [205]. For $LiNO_3$ (0% $KClO_4$) the results in [205] are ~2% higher than the recommended conductance data base for $LiNO_3$ [1].

TABLE 776. Density studies: $LiNO_3$ - $KClO_4$

Investigations critically examined			
Ref.	Mol % $KClO_4$	Temp. range (K)	Comments
205	0–45	508–693	see: KNO_3–$LiClO_4$

TABLE 777. $LiNO_3$ - $KClO_4$: Density (g cm^{-3})

T(K)	Mol percent $KClO_4$			
	45	25	14	5
520			1.835	
540			1.824	1.806
580		1.837	1.802	1.781
660	1.849	1.786	1.756	1.730
680	1.835	1.773	1.745	1.718

Temperature-dependent equations

$\rho = a + bT$

Mol percent $KClO_4$	a	$-b \times 10^3$
45	2.3113	0.7002
25	2.2076	0.6384
14	2.1287	0.5641
5	2.1467	0.6308
0	1.9892	0.4137

These values are based on the data of Brovkina, Farmakovskaya and Khokhlov (Archimedean technique); data in equation form; precisions not estimated [205]. For pure $LiNO_3$ (i.e., 0% $KClO_4$) the results in [205] are about 0.4% higher than the recommended density data base [1].

TABLE 778. Viscosity studies: $LiNO_3$ - $KClO_4$

Investigations critically examined

Ref.	Mol % $KClO_4$	Temp. range (K)	Comments
205	0–60	520–700	see: KNO_3-$LiClO_4$

TABLE 779. $LiNO_3$ - $KClO_4$: Viscosity (cp)

T(K)	Mol percent $KClO_4$			
	60	45	25	14
520				6.54
560			4.97	4.78
600		3.99	3.77	3.64
660	2.85	2.78	2.65	2.58
680	2.56	2.50	2.39	2.33
700	2.32	2.26	2.17	

Temperature-dependent equations

$\eta = A \exp [E/RT]$

Mol percent $KClO_4$	$A \times 10^2$	E
60	7.318	4805
45	7.425	4750
25	7.949	4601
14	8.076	4541
0	8.070	4508

These values are based on the data of Brovkina, Farmakovskaya and Khokhlov (Archimedean technique); data in equation form; precisions not estimated [205]. In a re-investigation of $LiNO_3$, Janz, Lurie and Gardner (capillary technique) [241], have shown that the recommended viscosity data base advanced elsewhere in this series [1], should be superseded by: $\eta = 70.567 - 20.188 \times 10^{-2}T + 14.976 \times 10^{-6}T^2$ (for 540–650 K; accuracy limits, $\sim \pm 2\%$). The results for $LiNO_3$ in [205] above are in close agreement with this recommendation ($\sim$ 4% higher).

$LiNO_3$ - $LiClO_3$

Melt Preparation and Purification

Campbell et al. [209, 210, 211, 212] prepared lithium chlorate from equimolar proportions of barium chlorate and lithium sulfate. The precipitated barium sulfate was filtered off and the clear solution titrated alternately with solutions of lithium sulfate and of barium chlorate until all excess over stoichiometric proportions was removed. The solution was then concentrated by vacuum distillation at about 60°C. When the solution had attained a concentration of about 90% lithium chlorate, it was cooled in an ice bath, and crystals separated out. The crystals were dried over H_2SO_4 from 2–3 weeks. Final drying of the salt was performed under vacuum. Because of the hydroscopic nature of lithium chlorate, all measurements were conducted in a moisture-free atmosphere. The lithium nitrate (reagent grade) was further dried before use.

TABLE 780. Electrical conductance studies: $LiNO_3$ - $LiClO_3$

Investigations critically examined

Ref.	Mol % $LiClO_3$	Temp. range (K)	Comments
209	70–100	404–446	Pyrex cell; Pt electrodes; frequency range: 500–10,000 Hz; calibration: aq. KCl

TABLE 781. $LiNO_3$ - $LiClO_3$: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent $LiClO_3$				
	84.4	81.9	79.4	74.5	70
400		0.105	0.105		
410	0.134	0.132	0.134	0.135	
420	0.163	0.160	0.163	0.165	0.162
440	0.211	0.219	0.221	0.227	0.232

Temperature-dependent equations

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

Mol % $LiClO_3$	$-a$	$b \times 10^3$	$c \times 10^6$	standard error of estimate
100	0.9547	2.6391		1.12%
84.4	1.0572	2.9045		0.82%
81.9	-0.0646	-2.3967	6.2463	0.35%
79.4	1.0558	2.9022		0.80%
74.5	0.0995	-1.7479	5.6589	0.73%
70	1.3111	3.5074		1.67%

These values are based on the data of Campbell and Williams (classical ac method) [209]. The results for $LiClO_3$ (above) have been advanced elsewhere in this series [1] as the recommended conductance data base.

TABLE 782. Density studies: $LiNO_3$ - $LiClO_3$

Investigations critically examined

Ref.	Mol % $LiClO_3$	Temp. range (K)	Comments
210	70–100	408–435	Pyrex dilatometer; calibration: Hg

TABLE 783. $LiNO_3$ - $LiClO_3$: Density (g cm^{-3})

T(K)	Mol percent $LiClO_3$			
	89.2	82.9	77.3	70.8
410	2.078	2.070	2.061	2.053
420	2.070	2.062	2.053	2.045
430	2.062	2.054	2.045	2.038
440	2.055			

Temperature-dependent equations

$\rho = a + bT$

Mol % $LiClO_3$	a	$-b \times 10^3$	standard error of estimate
100	2.4461	0.8828	0.01%
89.2	2.3922	0.7671	0.00%
82.9	2.3990	0.8018	0.01%
77.3	2.3745	0.7657	0.01%
70.8	2.3553	0.7379	0.00%

These values are based on the data of Campbell and Nagarajan (dilatometric method) [210]. The results for $LiClO_3$ (above) are in virtual agreement (~0.05%) with the recommended density data base for $LiClO_3$ [1].

TABLE 784. Viscosity studies: $LiNO_3$ - $LiClO_3$

Investigations critically examined

Ref.	Mol % $LiClO_3$	Temp. range (K)	Comments
211	70–100	400–450	Pyrex Ostwald viscometer; calibration: H_2O; estimated accuracy, +1%

TABLE 785. $LiNO_3$ - $LiClO_3$: Viscosity (cp)

T(K)	Mol percent $LiClO_3$				
	97	91.8	86.9	79.4	74
400	0.43	0.52	0.56	0.60	0.63
420	0.26	0.31	0.34	0.36	0.38
440	0.17	0.20	0.22	0.23	0.24
450	0.14	0.16	0.17	0.19	0.19

Temperature-dependent equations

$\eta = A \exp [E/RT]$

Mol percent $LiClO_3$	$A \times 10^4$	E
100	0.1982	7812
97	0.1811	8004
91.8	0.1201	8482
86.9	0.1444	8402
79.4	0.1848	8254
74	0.1620	8399

These values are based on the data of Campbell and Nagarajan (capillary technique); data in equation form; precisions not estimated [211]. For $LiClO_3$, the results (above) are in close accord (~±2%) with the recommended viscosity data base [1].

TABLE 786. Surface tension studies: $LiNO_3$ - $LiClO_3$

Investigations critically examined

Ref.	Mol % $LiClO_3$	Temp. range (K)	Comments
212	79–100	403–441	glass capillary; calibration: H_2O

TABLE 787. $LiNO_3$ - $LiClO_3$: Surface tension (dyn cm^{-1})

T(K)	Mol percent $LiClO_3$			
	96.8	92.5	82.8	78.7
400				92.84
410	88.59	89.70	91.68	92.24
430	87.65	88.58	90.80	91.03
440				90.42

Temperature-dependent equations

$\gamma = a + bT$

Mol % $LiClO_3$	a	$-b \times 10^3$	standard error of estimate
96.8	107.76	46.76	0.17%
92.5	112.70	56.09	0.11%
82.8	109.66	43.86	0.11%
78.7	117.06	60.54	0.10%

These values are based on the data of Campbell and Williams (capillary rise technique) [212].

$LiNO_3$ - $LiClO_4$

Phase diagram: See: Fig. 98

The $LiNO_3$-$LiClO_4$ system is shown as one side of the quaternary reciprocal salt system: KNO_3, $LiNO_3$, $KClO_4$, $LiClO_4$. Inspection shows it to be a continuous series of solid solutions with a minimum at ~165°C and ~40 mol % $LiNO_3$.

Melt Preparation and Purification

Brovkina et al. [213, 199] used reagent grade salts. The salts were held at 300°C for 8–10 hours under a pressure of 0.1–0.2 mm Hg. Powdered titanium iodide was added to the sample of the molten dehydrated salt to check for complete water removal. Petersen et al. [214] recrystallized reagent grade $LiNO_3$ and partially dried it in an air oven. The drying was completed by slowly heating through the melting point under a vacuum of about 10 microns.

TABLE 788. Electrical conductance studies: $LiNO_3$ - $LiClO_4$

Investigations critically examined

Ref.	Mol % $LiClO_4$	Temp. range (K)	Comments
213	0–100	473–653	Pyrex cell; Pt electrodes; calibration: molten KNO_3
199	0–100	673	isotherms from **[213]**.

TABLE 789. $LiNO_3$ - $LiClO_4$: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent $LiClO_4$				
	90	75	45	30	15
480			0.488		
500		0.590	0.583	0.593	
520	0.709	0.682	0.677	0.692	0.723
580	0.974	0.958	0.961	0.991	1.040
640	1.238	1.233	1.245	1.290	1.356

Temperature-dependent equations

$$\kappa = a + bT$$

Mol % $LiClO_4$	$-a$	$b \times 10^3$	standard error of estimate
100	1.5991	4.4553	0.14%
95	1.6044	4.4643	0.18%
90	1.5846	4.4107	0.15%
85	1.6200	4.4553	0.14%
80	1.6189	4.4523	0.13%
75	1.7080	4.5958	0.16%
70	1.6646	4.5250	0.19%
60	1.7447	4.6394	0.17%
55	1.6915	4.5485	0.18%
50	1.7331	4.6242	0.21%
45	1.7815	4.7288	0.19%
40	1.8033	4.7708	0.20%
35	1.8106	4.7875	0.15%
30	1.8971	4.9792	0.23%
25	1.9725	5.1219	0.17%
20	2.0929	5.3541	0.14%
15	2.0191	5.2737	0.19%
10	2.0497	5.3571	0.14%
5	2.0744	5.4553	0.13%
0	2.1827	5.7053	0.12%

These values are based on the data of Brovkina (classical ac method) **[213]**. For the end members, the results are ~1.5% and ~8% lower, respectively, than the values from the recommended conductance data bases for $LiClO_4$ [8] and $LiNO_3$ [1].

TABLE 790. Density studies: $LiNO_3$ - $LiClO_4$

Investigations critically examined

Ref.	Mol % $LiClO_4$	Temp. range (K)	Comments
214	0–100	471–693	Pt bicone suspended on a Pt wire; correction for thermal expansion; fused silica tube; calibration: molten KNO_3
200	0–100	444–673	Pt ball

TABLE 791. $LiNO_3$ - $LiClO_4$: Density (g cm^{-3})

T(K)	Mol percent $LiClO_4$		
	75	46.5	25
480		1.958	
500	1.991	1.945	
520	1.979	1.933	1.863
600	1.928	1.882	1.815
620		1.870	1.802

Temperature-dependent equations

$$\rho = a + bT$$

Mol percent $LiClO_4$	a	$-b \times 10^3$
100	2.3371	0.6119
75	2.3058	0.6291
46.5	2.2598	0.6290
25	2.1807	0.6101
0	2.0739	0.5561

These values are based on the data of Petersen, Ewing and Smith (Archimedean technique); data in equation form; precisions not estimated **[214]**. The results for $LiClO_4$ (above) have been advanced elsewhere in this series [1] as the recommended density data bases. For $LiNO_3$, the results are in very close agreement with the recommended density data base [1].

TABLE 792. Viscosity studies: $LiNO_3$ - $LiClO_4$

Investigations critically examined

Ref.	Mol % $LiClO_4$	Temp. range (K)	Comments
199	0–100	673	isotherms, discussion article
201	0–100	470–700	see: KNO_3–$KClO_4$

TABLE 793. $LiNO_3$ - $LiClO_4$: Viscosity (cp)

T(K)	Mol percent $LiClO_4$				
	90	70	55	30	10
470			11.89		
490		10.19	9.70		
510	8.90	8.43	8.05	7.51	
530	7.48	7.08	6.77	6.31	
550	6.37	6.02	5.76	5.38	5.10
630	3.71	3.48	3.36	3.13	3.00
690	2.69	2.51	2.43	2.27	2.19
700				2.16	2.09

Temperature-dependent equations

$\eta = A \exp [E/RT]$

Mol percent $LiClO_4$	$A \times 10^2$	E
100	9.438	4665.1
90	9.068	4647.7
70	8.138	4702.8
55	8.188	4649.4
30	7.617	4652.4
10	7.891	4555.5
0	8.072	4507.8

These values are based on the data of Farmakovskaya and Brovkina (damped oscillation); data in equation form; precisions not estimated [201]. The results for $LiClO_4$ (above) have been advanced elsewhere in this series [8] as the recommended viscosity data base for the salt. A comparison of the results for $LiNO_3$ with the recommended viscosity data base as given following Table 779.

$LiNO_3$ - LiOH

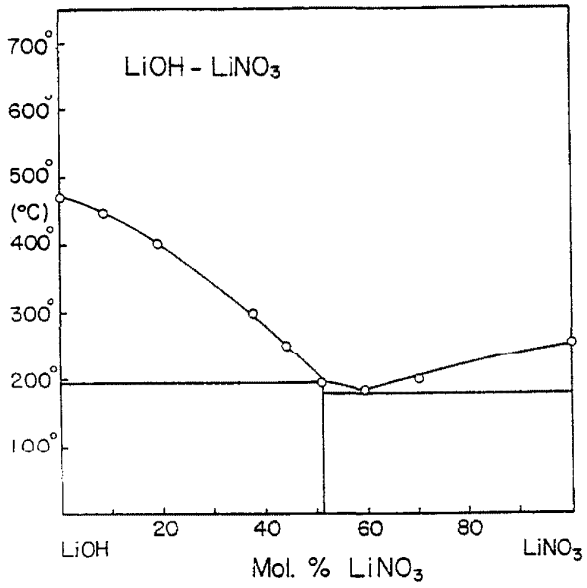

FIGURE 99. Phase diagram for $LiNO_3$ - LiOH.

Data from: G. G. Drogenov, Dokl. Akad. Nauk SSSR, 78, 699 (1951); *ibid* 89, 305 (1953).

Melt Preparation and Purification

Very little information reported for melt preparation and purification by Kruglov and Kochergin [204, 234]; $LiNO_3$ (m. pt. 254°C) was recrystallized and dried before use; LiOH (m. pt. 472°C) was dehydrated from the fluid (molten) state. The concentration of the LiOH was less than 0.2–0.3%. Campbell and Williams [209] further dried reagent grade lithium nitrate before use. All mixtures were made up in a drybox.

TABLE 794. Electrical conductance studies: $LiNO_3$ - LiOH

Investigations critically examined

Ref.	Mol % LiOH	Temp. range (K)	Comments
209	7.6	405–451	see: $LiNO_3$–$LiClO_3$

TABLE 795. $LiNO_3$ - LiOH: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent LiOH
	7.6
410	0.116
420	0.138
430	0.162
440	0.188

Temperature-dependent equation

$\kappa = 0.4421 - 3.7749 \times 10^{-3}T + 7.2653 \times 10^{-6}T^2$

Standard error of estimate = 0.97%

These values are based on the data of Campbell and Williams (classical ac method) [209].

TABLE 796. Density studies: $LiNO_3$ - LiOH

Investigations critically examined

Ref.	Mol % LiOH	Temp. range (K)	Comments
209	0–7.6	405–451	see: $LiNO_3$–$LiClO_3$
204	0–100	483–823	Archimedean technique; Pt sphere; CO_2-free and moisture-free air atmosphere

TABLE 797. $LiNO_3$ - LiOH: Density (g cm^{-3})

T(K)	Mol percent LiOH
	7.6
410	2.037
420	2.029
430	2.021
440	2.013

Temperature-dependent equation

$\rho = 2.3681 - 0.8065 \times 10^{-3}T$

Standard error of estimate = 0.01%

These values are based on the data of Campbell and Williams (dilatometric method) [209].

TABLE 798. Additional $LiNO_3$ - LiOH Compositions: Density (g cm^{-3})

T(K)	Mol percent LiOH			
	73	43	40.5	20
480		1.694	1.687	
510		1.678	1.675	1.750
630	1.427	1.616	1.629	1.685
690	1.405	1.585	1.606	1.652

Temperature-dependent equations

$\rho = a + bT$

Mol % LiOH	a	$-b \times 10^3$	T range (K)
100	1.718	0.457	748–823
90	1.524	0.151	693–723
80	1.691	0.310	653–693
73	1.662	0.373	613–693
65	1.878	0.504	573–693
53	1.919	0.515	523–693
45	1.929	0.495	483–693
43	1.943	0.519	483–693
40.5	1.870	0.382	483–693
30	1.993	0.521	483–693
20	2.026	0.542	503–693
0	2.028	0.521	533–693

These values are based on the data of Kruglov, Kochergin, and Polyanova (Archimedean technique); data in equation form; precisions not estimated [204]. Comparisons of the results (above) for $LiNO_3$ with the values reported earlier in this series, show that the densities are in close agreement (~1%) with the recommended data base [1]; densities for LiOH have not been reported previous to [204].

$LiNO_3$ - $NaClO_4$

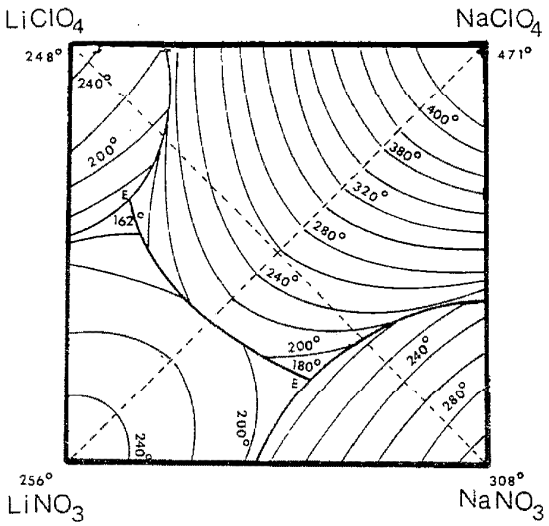

FIGURE 100. Phase diagram for $LiNO_3$ - $NaClO_4$.

Data from: I. A. Brovkina, S. I. Selivanova and A. A. Farmakovskaya, deposited document VINITI No. 2723-71 (Moscow, 1971).

The $LiNO_3$-$NaClO_4$ system is shown as a diagonal in the field of the quaternary reciprocal salt system: $LiNO_3$, $NaNO_3$, $LiClO_4$, $NaClO_4$. Inspection shows the binary to be a continuous series of solid solutions.

Melt Preparation and Purification

Brovkina et al. [205] used extra pure grade materials. The salts were recrystallized and dried under vacuum.

TABLE 799. Electrical conductance studies: $LiNO_3$ - $NaClO_4$

Investigations critically examined			
Ref.	Mol % $NaClO_4$	Temp. range (K)	Comments
205, 215	0–70	500–700	see: KNO_3–$LiClO_4$

TABLE 800. $LiNO_3$ - $NaClO_4$: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent $NaClO_4$				
	70	50	33	20	10
500			0.495	0.546	
520			0.572	0.632	0.711
540		0.571	0.653	0.721	0.808
620	0.858	0.892	1.008	1.106	1.219
680	1.100	1.157	1.306	1.426	1.551

Temperature-dependent equations

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

Mol % $NaClO_4$	$-a$	$b \times 10^3$	$c \times 10^6$
70	1.6493	4.0434	
50	0.6141	0.6123	2.9297
33	0.4328	-0.0974	3.9043
20	0.6408	0.5257	3.6967
10	1.0125	1.8337	2.8470
0	1.0908	1.9855	3.1530

These values are based on the data of Brovkina, Farmakovskaya and Khokhlov (classical ac method); data in equation form; precisions not estimated [205]. For $LiNO_3$, the above results are ~2% higher than the recommended conductance data base for $LiNO_3$ [1].

TABLE 801. Density studies: $LiNO_3$ - $NaClO_4$

Investigations critically examined			
Ref.	Mol % $NaClO_4$	Temp. range (K)	Comments
205	0–70	483–683	see: KNO_3–$LiClO_4$

TABLE 802. $LiNO_3$ – $NaClO_4$: Density (g cm^{-3})

T(K)	Mol percent $NaClO_4$				
	70	50	33	20	10
480			1.934		
500			1.922	1.866	
520			1.911	1.854	1.825
540		1.964	1.899	1.842	1.813
620	1.988	1.916	1.853	1.795	1.764
680	1.946	1.880	1.818	1.760	1.727

Temperature-dependent equations

$$\rho = a + bT$$

Mol percent $NaClO_4$	a	$-b \times 10^3$
70	2.4197	0.6963
50	2.2906	0.6041
33	2.2107	0.5772
20	2.1599	0.5881
10	2.1470	0.6183
0	1.9892	0.4237

These values are based on the data of Brovkina, Farmakovskaya and Khokhlov (Archimedean technique); data in equation form; precisions not estimated [205]. For $LiNO_3$, the above results are virtually in exact accord (~0.3%) with the recommended density data base [1].

TABLE 803. Viscosity studies: $LiNO_3$ – $NaClO_4$

Investigations critically examined

Ref.	Mol % $NaClO_4$	Temp. range (K)	Comments
205	0–70	500–710	see: KNO_3–$LiClO_4$

TABLE 804. $LiNO_3$ – $NaClO_4$: Viscosity (cp)

T(K)	Mol percent $NaClO_4$			
	70	55	33	10
500			7.63	
540		5.53	5.50	5.34
660	2.74	2.68	2.61	2.53
680	2.50	2.44	2.37	2.29

Temperature-dependent equations

$$\eta = A \exp[E/RT]$$

Mol percent $NaClO_4$	$A \times 10^2$	E
70	11.160	4200
55	10.340	4271
33	9.914	4390
10	8.760	4410
0	8.070	4508

These values are based on the data of Brovkina, Farmakovskaya and Khokhlov (oscillational method); data in equation form; precisions not estimated [205]. For the recommended viscosity data base for $LiNO_3$, see comments following Table 779; the above results are ~4% higher than the recommended data set.

NH_4NO_3 – $NH_4H_2PO_4$

Melt Preparation and Purification

Booth and Vinyard [45] used reagent grade chemicals which were dried at 110°C.

TABLE 805. Density studies: NH_4NO_3 – $NH_4H_2PO_4$

Investigations critically examined

Ref.	Mol percent $NH_4H_2PO_4$	Temp. range (K)	Comments
45	3.5–51.1	413–449	"Veridia" tube dilatometer; calibration: Hg

TABLE 806. NH_4NO_3 – $NH_4H_2PO_4$: Density (g cm^{-3})

T(K)	Mol percent $NH_4H_2PO_4$				
	51.1	41.0	33.9	18.8	10.9
420				1.495	1.472
440	1.567	1.543	1.525	1.482	1.458
450	1.564	1.539	1.520	1.476	1.452

Temperature-dependent equations

$$\rho = a + bT$$

Mol % $NH_4H_2PO_4$	a	$-b \times 10^3$	standard error of estimate
51.1	1.7002	0.3024	0.02%
41.0	1.7216	0.4053	0.00%
33.9	1.7278	0.4612	0.02%
27.3	1.7327	0.5141	0.02%
18.8	1.7495	0.6069	0.04%
10.9	1.7629	0.6920	0.03%
7.2	1.7815	0.7611	0.02%
3.5	1.7695	0.7611	0.02%

These values are based on the data of Booth and Vinyard (dilatometric method) [45].

TABLE 807. Viscosity studies: NH_4NO_3 – $NH_4H_2PO_4$

Investigations critically examined

Ref.	Mol percent $NH_4H_2PO_4$	Temp. range (K)	Comments
45	3.5–51.07	403–453	glass viscometer; calibration: silicone fluid

TABLE 808. NH_4NO_3 - $NH_4H_2PO_4$: Viscosity (cp)

T(K)	Mol percent $NH_4H_2PO_4$				
	51.1	41.0	33.9	18.8	10.9
420				10.8	7.71
440	26.5	18.8	14.4	8.58	6.29
450	22.4	16.2	12.6	7.72	5.72

Temperature-dependent equations

$\eta = A \exp [E/RT]$

Mol % $NH_4H_2PO_4$	A	E	standard error of estimate
51.1	0.01235	6709	0.52%
41.0	0.02255	5879	0.07%
33.9	0.03360	5300	0.10%
27.3	0.03181	5138	1.43%
18.8	0.07306	4167	0.39%
10.9	0.08893	3724	0.84%
7.2	0.08488	3658	0.53%
3.5	0.1867	2875	0.54%

These values are based on the data of Booth and Vinyard (capillary technique) [45].

$NaNO_3$ - $KC_2H_3O_2$

Melt Preparation and Purification

Semenchenko and Shikhobalova [34] used reagent grade salts. No other information was given.

TABLE 809. Surface tension studies: $NaNO_3$ - $KC_2H_3O_2$

Investigations critically examined

Ref.	Mol % $KC_2H_3O_2$	Temp. range (K)	Comments
34	0–50, and 100	588	see: NaF–$NaNO_3$

TABLE 810. $NaNO_3$ - $KC_2H_3O_2$: Surface tension (dyn cm^{-1})

Mol percent $KC_2H_3O_2$	588 K
100	42.0
50	51.5
25	62.7
10	83.6
5	94.9
2	106.4
1	110.4

These are the experimental data reported by Semenchenko and Shikhobalova (maximum bubble pressure method) [34].

$NaNO_3$ - $KC_3H_5O_2$

Melt Preparation and Purification

Semenchenko and Shikhobalova [34] used reagent grade salts. No other information was given.

TABLE 811. Surface tension studies: $NaNO_3$ - $KC_3H_5O_2$

Investigations critically examined

Ref.	Mol % $KC_3H_5O_2$	Temp. range (K)	Comments
34	0–50, and 100	588	see: NaF–$NaNO_3$

TABLE 812. $NaNO_3$ - $KC_3H_5O_2$: Surface tension (dyn cm^{-1})

Mol percent $KC_3H_5O_2$	588 K
100	25.6
50	35.7
25	41.7
10	54.8
5	70.3
2	86.1
1	97.86

These are the experimental data reported by Semenchenko and Shikhobalova (maximum bubble pressure method) [34].

$NaNO_3$ - $K_2Cr_2O_7$

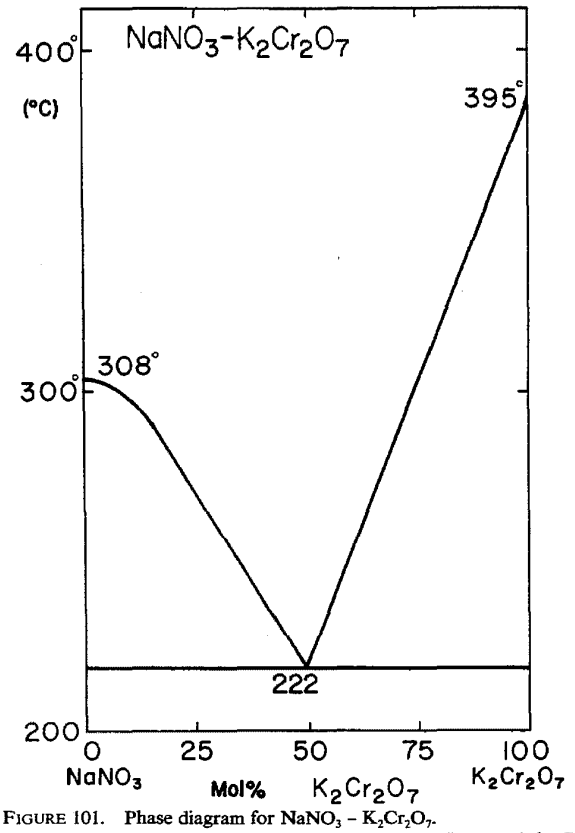

FIGURE 101. Phase diagram for $NaNO_3$ - $K_2Cr_2O_7$.
Data from: A. D. Palkin and I. M. Bokhovkin, Tr. Voronezhsk. Gos. Univ., 9(3), 10 (1937).

Melt Preparation and Purification

Markov and Prisyazhnyi [206] recrystallized reagent grade salts from distilled water.

TABLE 813. Density studies: $NaNO_3$ – $K_2Cr_2O_7$

Investigations critically examined			
Ref.	Mol % $K_2Cr_2O_7$	Temp. range (K)	Comments
206	0–100	693	quartz sphere; calibration H_2O

TABLE 814. $NaNO_3$ – $K_2Cr_2O_7$: Density (g cm^{-3})

Mol percent $K_2Cr_2O_7$	693 K
100	2.30
90	2.26
60	2.13
30	1.99
10	1.91
0	1.86

Composition–dependent equation

$\rho = 1.8612 + 0.4422 \times 10^{-2}C$

[C = Mol % $K_2Cr_2O_7$]

These values are based on the data of Markov and Prisyazhnyi (Archimedean technique); data in graphical form; precision not estimated [206]. The densities at 693 K for $K_2Cr_2O_7$ and $NaNO_3$ from the recommended data bases [1] are, respectively, 2.27 and (1.83). The latter is an extrapolated value.

$NaNO_3$ – $KClO_4$

Melt Preparation and Purification

Brovkina et al. [205] used extra pure grade materials. The salts were recrystallized and dried under vacuum.

TABLE 815. Electrical conductance studies: $NaNO_3$ – $KClO_4$

Investigations critically examined			
Ref.	Mol % $KClO_4$	Temp. range (K)	Comments
205	0–40	533–683	see: KNO_3–$LiClO_4$

TABLE 816. $NaNO_3$ – $KClO_4$: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent $KClO_4$		
	40	22	10
540		0.599	
560		0.672	0.763
640	0.772	0.965	1.086
680	0.899	1.112	1.247

Temperature–dependent equations

$\kappa = a + bT$

Mol percent $KClO_4$	$-a$	$b \times 10^3$
40	1.2636	3.1799
22	1.3782	3.6619
10	1.4932	4.0297
0	1.4911	4.2486

These values are based on the data of Brovkina, Farmakovskaya and Khokholov (classical ac method); data in equation form; precisions not estimated [205]. The results for $NaNO_3$ are virtually in exact agreement (<0.1%) with the recommended conductance data base [1].

TABLE 817. Density studies: $NaNO_3$ – $KClO_4$

Investigations critically examined			
Ref.	Mol % $KClO_4$	Temp. range (K)	Comments
205	0–40	533–693	see: KNO_3–$LiClO_4$

TABLE 818. $NaNO_3$ – $KClO_4$: Density (g cm^{-3})

T(K)	Mol percent $KClO_4$		
	40	22	10
540		1.969	
560		1.956	1.933
640	1.919	1.902	1.879
680	1.889	1.875	1.852

Temperature–dependent equations

$\rho = a + bT$

Mol percent $KClO_4$	a	$-b \times 10^3$
40	2.3974	0.7478
22	2.3322	0.6720
10	2.3093	0.6719
0	2.3206	0.7151

These values are based on the data of Brovkina, Farmakovskaya and Khokhlov (Archimedean technique); data in equation form; precisions not estimated [205]. The results for $NaNO_3$ are essentially in exact agreement (<0.1%) with the recommended density data base [1].

TABLE 819. Viscosity studies: $NaNO_3$ - $KClO_4$

Investigations critically examined			
Ref.	Mol % $KClO_4$	Temp. range (K)	Comments
205	0–50	540–710	see: KNO_3–$LiClO_4$

TABLE 820. $NaNO_3$ - $KClO_4$: Viscosity (cp)

T(K)	Mol percent $KClO_4$			
	50	40	22	10
540		5.29	4.71	
580		3.97	3.59	3.29
600	3.66	3.49	3.18	2.93
660	2.58	2.49	2.30	2.14
700	2.11	2.05	1.91	1.80

Temperature-dependent equations

$\eta = A \exp [E/RT]$

Mol percent $KClO_4$	$A \times 10^2$	E
50	7.757	4595
40	8.346	4452
22	9.095	4236
10	9.615	4072
0	8.070	4508

These values are based on the data of Brovkina, Farmakovskaya and Khokhlov (oscillational method); data in equation form; precisions not estimated **[205]**. The results for $NaNO_3$ are 20–30% higher than the recommended viscosity data base [1].

$NaNO_3$ - $LiClO_4$

Phase diagram: See Fig. 100. The $NaNO_3$–$LiClO_4$ system is shown as a diagonal in the field of the quaternary reciprocal salt system; $LiNO_3$, $NaNO_3$, $LiClO_4$, $NaClO_4$.

Melt Preparation and Purification

Brovkina et al. **[205]** used extra pure grade materials. The salts were recrystallized and dried under vacuum.

TABLE 821. Electrical conductance studies: $NaNO_3$ - $LiClO_4$

Investigations critically examined			
Ref.	Mol % $LiClO_4$	Temp. range (K)	Comments
205, 215	0–100	473–693	see: KNO_3–$LiClO_4$

TABLE 822. $NaNO_3$ - $LiClO_4$: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent $LiClO_4$				
	90	78	60	28	10
480		0.488		0.409	
520	0.736	0.649		0.552	
540	0.835	0.734	0.644	0.628	
560	0.935	0.821	0.733	0.706	0.804
600	1.133	1.003	0.912	0.870	0.979
640	1.332	1.195	1.091	1.044	1.154
680	1.531	1.397	1.269	1.228	1.329

Temperature-dependent equations

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

Mol % $LiClO_4$	$-a$	$b \times 10^3$	$c \times 10^6$
100	1.9358	5.3385	
90	1.8464	4.9662	
78	0.6427	0.8082	3.2230
60	1.7708	4.4710	
28	0.5060	0.3623	3.2175
10	1.6495	4.3805	
0	1.4911	4.2486	

These values are based on the data of Brovkina, Farmakovskaya and Khokhlov (classical ac method), data in equation form; precisions not estimated **[205]**. For $NaNO_3$, the results are in exact agreement with the recommended data base [1], whereas the results for $LiClO_4$ are uniformly ~15% higher than the recommended conductance data base for this salt [8].

TABLE 823. Density studies: $NaNO_3$ - $LiClO_4$

Investigations critically examined			
Ref.	Mol % $LiClO_4$	Temp. range (K)	Comments
205	0–100	473–693	see: KNO_3–$LiClO_4$

TABLE 824. $NaNO_3$ - $LiClO_4$: Density (g cm^{-3})

T(K)	Mol percent $LiClO_4$				
	90	78	60	28	10
470		2.039			
500		2.019		1.960	
530	2.005	2.000	1.980	1.941	
560	1.987	1.980	1.960	1.922	1.917
680	1.916	1.903	1.882	1.847	1.834

Temperature-dependent equations

$$\rho = a + bT$$

Mol percent $LiClO_4$	a	$-b \times 10^3$
100	2.3185	0.5772
90	2.3192	0.5931
78	2.3439	0.6490
60	2.3276	0.6560
28	2.2753	0.6305
10	2.3028	0.6890
0	2.3206	0.7151

These values are based on the data of Brovkina, Farmakovskaya and Khokhlov (Archimedean technique); data in equation form; precisions not estimated [205]. The results for $LiClO_4$ and $NaNO_3$ are virtually in exact accord (~ <0.1%) with the respective recommended data bases [1].

TABLE 825. Viscosity studies: $NaNO_3$ - $LiClO_4$

Investigations critically examined

Ref.	Mol % $LiClO_4$	Temp. range (K)	Comments
205	0–100	500–710	see: KNO_3–$LiClO_4$

TABLE 826. $NaNO_3$ - $LiClO_4$: Viscosity (cp)

T(K)	Mol percent $LiClO_4$				
	90	78	60	28	10
500		8.30		6.77	
520	7.57	7.01		5.75	
540	6.44	5.99	5.69	4.94	
580	4.83	4.53	4.31	3.77	3.36
680	2.72	2.59	2.49	2.21	1.98
700			2.27	2.02	1.81

Temperature-dependent equations

$$\eta = A \exp [E/RT]$$

Mol percent $LiClO_4$	$A \times 10^2$	E
100	9.436	4666
90	9.817	4490
78	10.21	4370
60	10.16	4320
28	9.824	4205
10	9.091	4160
0	9.139	4037

These values are based on the data of Brovkina, Farmakovskaya and Khokhlov (oscillational method); data in equation form; precisions not estimated [205]. The results for $LiClO_4$ have been advanced elsewhere in this series [8] as the recommended viscosity data base for this salt; for $NaNO_3$, the results are in close agreement (~2%) with the recommended data base [1].

$NaNO_3$ - $NaClO_3$

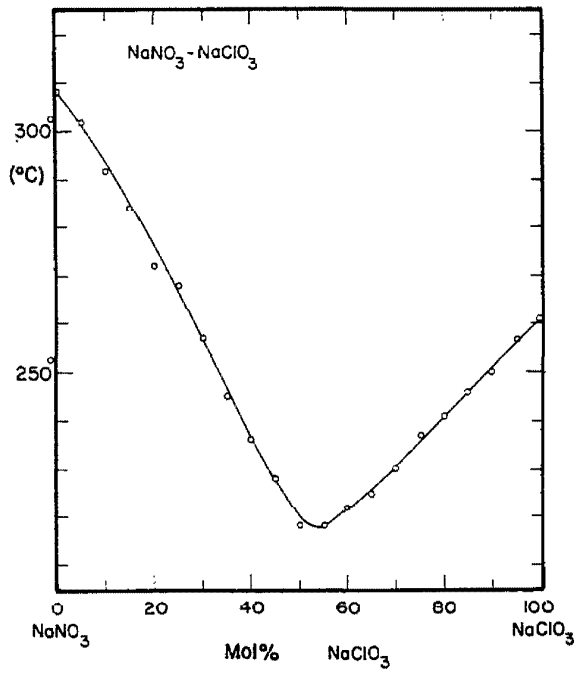

FIGURE 102. Phase diagram for $NaNO_3$ - $NaClO_3$.

Data from: F. P. Platonov, Dokl. Nauchn. Konf. Mosk. Sel'sko. Akad. Timir. 1, 72 (1948).

Melt Preparation and Purification

Campbell and Van der Kouwe [216] used reagent grade salts exhaustively dried 130°C.

TABLE 827. Electrical conductance studies: $NaNO_3$ - $NaClO_3$

Investigations critically examined

Ref.	Mol % $NaClO_3$	Temp. range (K)	Comments
217, 216	38–100	514–587	see: $LiNO_3$–$LiClO_3$

TABLE 828. $NaNO_3$ – $NaClO_3$: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent $NaClO_3$		
	72.7	51.5	38.9
520	0.340	0.414	0.450
540	0.414	0.490	0.533
550	0.451	0.528	0.575
560	0.488		

Temperature-dependent equations

$$\kappa = a + bT$$

Mol % $NaClO_3$	$-a$	$b \times 10^3$	standard error of estimate
100	1.3799	3.1717	0.15%
72.7	1.5860	3.7038	0.18%
51.5	1.5462	3.7704	0.29%
38.9	1.7092	4.1530	0.15%

These values are based on the data of Van der Kouwe (classical ac method) [217]. The results for $NaClO_3$ have been advanced elsewhere in this series as the recommended data set for this salt [8].

TABLE 829. Density studies: $NaNO_3$ – $NaClO_3$

Investigations critically examined

Ref.	Mol % $NaClO_3$	Temp. range (K)	Comments
218, 217	38–100	511–561	see: $LiNO_3$–$LiClO_3$

TABLE 830. $NaNO_3$ – $NaClO_3$: Density (g cm^{-3})

T(K)	Mol percent $NaClO_3$		
	72.7	51.5	38.9
510	2.087	2.057	
520	2.079	2.048	2.027
540	2.061	2.031	2.010
560	2.043	2.013	1.993

Temperature-dependent equations

$$\rho = a + bT$$

Mol % $NaClO_3$	a	$-b \times 10^3$	standard error of estimate
100	2.5747	0.8827	0.01%
72.7	2.5362	0.8800	0.02%
51.5	2.5097	0.8871	0.02%
38.9	2.4798	0.8700	0.01%

These values are based on the data of Van der Kouwe (dilatometric method) [217]. The results for $NaClO_3$ have been advanced elsewhere in this series as the recommended data set for this salt [8].

TABLE 831. Viscosity studies: $NaNO_3$ – $NaClO_3$

Investigations critically examined

Ref.	Mol % $NaClO_3$	Temp. range (K)	Comments
218, 217	38–100	511–561	see: $LiNO_3$–$LiClO_3$

TABLE 832. $NaNO_3$ – $NaClO_3$: Viscosity (cp)

T(K)	Mol percent $NaClO_3$		
	72.7	51.5	38.9
510	8.61	7.65	
520	7.67	6.84	6.24
530	6.86	6.15	5.66
540	6.16	5.55	5.16
550	5.55	5.03	4.71
560	5.02	4.57	4.32

Temperature-dependent equations

$$\eta = A \exp [E/RT]$$

Mol % $NaClO_3$	$A \times 10^2$	E	standard error of estimate
100	2.439	6001.3	0.29%
72.7	2.054	6119.9	0.32%
51.5	2.385	5848.0	0.62%
38.9	3.660	5309.3	0.28%

These values are based on the data of Van der Kouwe (capillary technique) [217]. The results for $NaClO_3$ have been advanced elsewhere in this series as the recommended data set for this salt [8].

TABLE 833. Surface tension studies: $NaNO_3$ – $NaClO_3$

Investigations critically examined

Ref.	Mol % $NaClO_3$	Temp. range (K)	Comments
218, 217	38–100	510–559	see: $LiNO_3$–$LiClO_3$

TABLE 834. $NaNO_3$ – $NaClO_3$: Surface tension (dyn cm^{-1})

T(K)	Mol percent $NaClO_3$		
	72.7	51.5	38.9
510		103.39	
520	97.65	102.76	105.91
550	95.67	100.86	104.05
560		100.22	

Temperature-dependent equations

$\gamma = a + bT$

Mol % $NaClO_3$	a	$-b \times 10^3$	standard error of estimate
100	130.49	73.91	0.05%
72.7	131.94	65.94	0.06%
51.5	135.72	63.39	0.05%
38.9	138.13	61.97	0.04%

These values are based on the data of Van der Kouwe (capillary rise technique) [217]. The results for $NaClO_3$ have been advanced elsewhere in this series as the recommended data set for this salt [8].

$NaNO_3$ - $NaClO_4$

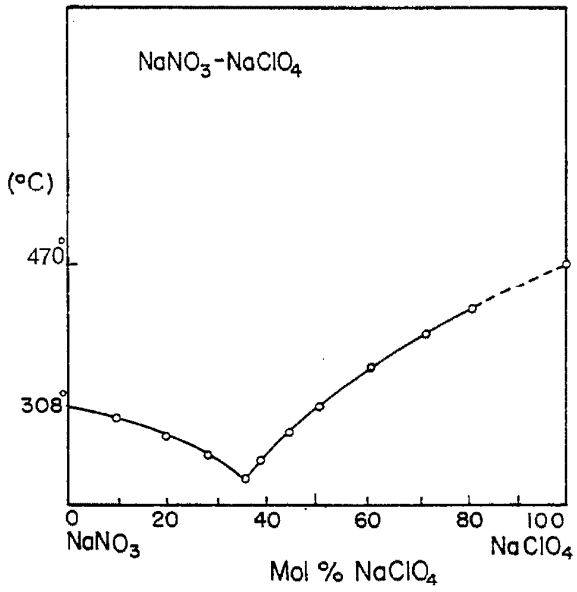

FIGURE 103. Phase diagram for $NaNO_3$ – $NaClO_4$.

Data from: I. A. Brovkina, S. I. Selivanova and A. A. Farmakovskaya, Russ. J. Inorg. Chem. 16(1), 133 (1971).

Melt Preparation and Purification

Farmakovskaya et al. [199] used extra pure grade materials. The salts were recrystallized and dried under vacuum.

TABLE 835. Electrical conductance studies: $NaNO_3$ – $NaClO_4$

Investigations critically examined

Ref.	Mol % $NaClO_4$	Temp. range (K)	Comments
199	0–60	673	discussion article
198			complete paper deposited with VINITI

TABLE 836. $NaNO_3$ – $NaClO_4$: Specific conductance ($ohm^{-1}cm^{-1}$)

Mol percent $NaClO_4$	673 K
60	1.14
40	1.17
20	1.24
10	1.28

Composition-dependent equation

$\kappa = 1.341 - 0.612 \times 10^{-2}C + 0.456 \times 10^{-4}C^2$

[C = Mol % $NaClO_4$]

The specific conductance values (above) were calculated from molar conductance data interpolated from Farmakovskaya et al. [199] and density data from Brovkina et al. [200].

TABLE 837. Density studies: $NaNO_3$ – $NaClO_4$

Investigations critically examined

Ref.	Mol % $NaClO_4$	Temp. range (K)	Comments
200	0–70	500–673	Pt ball

TABLE 838. $NaNO_3$ – $NaClO_4$: Density (g cm^{-3})

T(K)	Mol percent $NaClO_4$				
	70	45	38.5	20	10
500			2.041		
540		2.032	2.014	1.968	
580		2.004	1.987	1.942	1.926
660	1.987	1.949	1.933	1.892	1.874
670	1.980	1.942	1.926	1.885	1.868

Temperature-dependent equations

$\rho = a + bT$

Mol percent $NaClO_4$	a	$-b \times 10^3$
70	2.464	0.723
45	2.405	0.691
38.5	2.376	0.671
20	2.310	0.634
10	2.303	0.650
0	2.310	0.700

These values are based on the data of Brovkina, Selivanova and Farmakovskaya (Archimedean technique); data in equation form; precisions not estimated [200]. For $NaNO_3$, the results, above, and the recommended data base [1] are in exact accord.

TABLE 839. Viscosity studies: $NaNO_3$ – $NaClO_4$

Investigations critically examined

Ref.	Mol % $NaClO_4$	Temp. range (K)	Comments
199	0–60	673	discussion article
201	0–70	530–710	see: KNO_3–$KClO_4$
217	38.9–100	510–560	

TABLE 840. $NaNO_3$ – $NaClO_4$: Viscosity (cp)

T(K)	Mol percent $NaClO_4$				
	70	45	38.5	20	10
530			4.93		
570		3.86	3.72	3.54	
590		3.40	3.28	3.13	2.98
670	2.45	2.20	2.14	2.06	1.98
700	2.14	1.92	1.87	1.80	1.73

Temperature-dependent equations

$\eta = A \exp [E/RT]$

Mol percent $NaClO_4$	$A \times 10^2$	E
70	9.587	4317.2
45	8.937	4265.5
38.5	9.085	4206.0
20	9.332	4118.7
10	9.425	4051.2
0	9.151	4035.6

These values are based on the data of Farmakovskaya and Brovkina (damped oscillation); data in equation form; precisions not estimated [201]. For $NaNO_3$ the results (above) are in close accord (~2%) with the recommended viscosity data set for this salt [1].

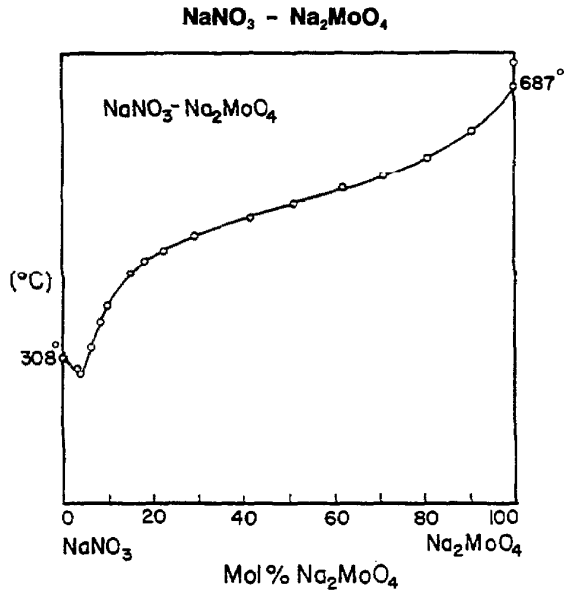

FIGURE 104. Phase diagram for $NaNO_3$ – $NaMoO_4$.

Data from: G. K. Shurdumov and T. N. Khokhonova, Russ. J. Inorg Chem., **15**(3), 429 (1970).

Melt Preparation and Purification

For the method of melt preparation used by Khokhonova et al. [219], see: KNO_3–K_2MoO_4.

TABLE 841. Electrical conductance studies: $NaNO_3$ – Na_2MoO_4

Investigations critically examined

Ref.	Mol % Na_2MoO_4	Temp. range (K)	Comments
220	0–100	573–1073	no information given
221			

TABLE 842. $NaNO_3$ – Na_2MoO_4: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent Na_2MoO_4				
	70	50	20	8	3.2
620				0.97	1.07
780			1.23	1.51	1.65
820		1.03	1.38	1.65	
860		1.16	1.53	1.79	
900	1.12	1.29	1.67		
940	1.24	1.43	1.82		
980	1.37	1.56			
1020	1.49	1.70			

Temperature-dependent equations

$\kappa = a + bT$

Mol percent Na_2MoO_4	$-a$	$b \times 10^3$
100	2.122	3.319
70	1.718	3.148
50	1.722	3.352
20	1.636	3.679
8	1.137	3.399
3.2	1.185	3.633
0	1.157	3.766

These values are based on the data of Khokhonova, Shurdumov and Protsenko (classical ac method); data in graphical form; precisions not estimated [220, 221]. For $NaMoO_4$ and $NaNO_3$, the results are in close accord (~1%, and ~2%, respectively) with the recommended conductance data sets for these two salts [1].

TABLE 843. Density studies: $NaNO_3$ - Na_2MoO_4

Investigations critically examined			
Ref.	Mol % Na_2MoO_4	Temp. range (K)	Comments
219	0–100	640–1100	Au bob suspended from Pt wire.

TABLE 844. $NaNO_3$ - Na_2MoO_4: Density (g cm^{-3})

T(K)	Mol percent Na_2MoO_4			
	80	60	40	20
730				2.17
810			2.41	2.13
850		2.61	2.39	2.10
890	2.76	2.59	2.37	2.08
930	2.74	2.57	2.35	2.06
970	2.72	2.55	2.33	
1050	2.68	2.50	2.29	
1090	2.66	2.48		

Temperature-dependent equations

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

Mol % Na_2MoO_4	a	$-b \times 10^3$	$c \times 10^6$
100	2.900	-0.412	-0.49
90	3.413	0.632	
80	3.229	0.519	
70	2.830	-0.116	-0.32
60	2.918	0.216	-0.17
50	3.054	0.754	0.13
40	2.693	0.257	-0.12
30	2.750	0.566	
25	2.840	0.977	0.25
20	2.637	0.715	0.10
15	2.526	0.579	
10	2.437	0.568	
4	2.384	0.639	
0	2.400	0.976	0.25

These values are based on the data of Khokhonova, Shurdumov and Protsenko (Archimedean technique); data in graphical form; precisions not estimated [219]. For Na_2MoO_4 and $NaNO_3$, the results are in close accord (~2% and 1% respectively) with the recommended data sets for these two salts [1].

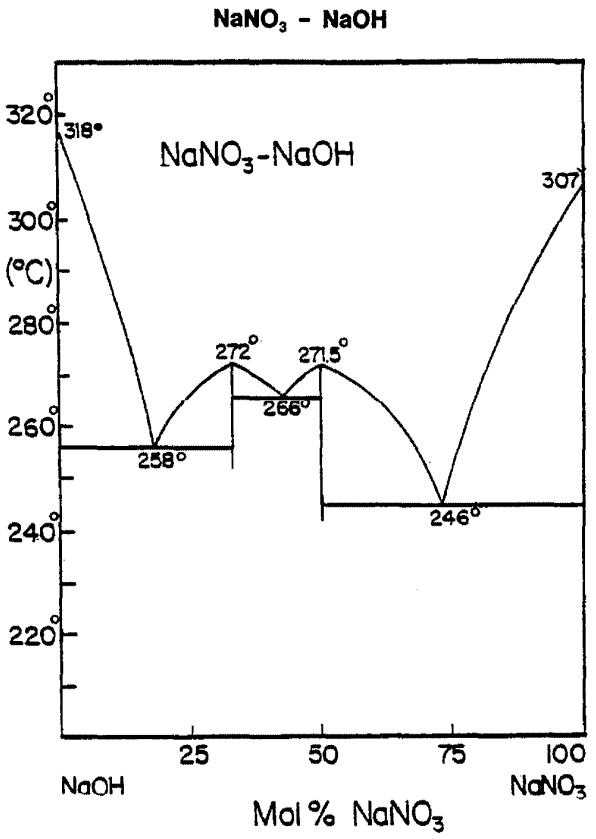

FIGURE 105. Phase diagram for $NaNO_3$ - NaOH.

Data from: A. G. Bergman, and N. A. Reshetnikov, Izv. Sekt. Fiz. Khim. Anal. Inst. Obshch. Neorg. Khim. Akad. Nauk SSSR, **25**, 212 (1954).

Melt Preparation and Purification

Kruglov and Polyanova [234] gave the following information: $NaNO_3$ (m.p. 308°C) was recrystallized and dried under vacuum at 100°C; NaOH (m.p. 318°C) was dehydrated for a prolonged time in the molten state under vacuum. The carbonate concentration in the hydroxide was <0.2%.

TABLE 845. Density studies: $NaNO_3$ - NaOH

Investigations critically examined			
Ref.	Mol % NaOH	Temp. range (K)	Comments
204, 234	0–100	553–823	Archimedean technique; Pt sphere; CO_2-free and moisture-free air.

TABLE 846. $NaNO_3$ - NaOH Density (g cm^{-3})

T(K)	Mol percent NaOH				
	82	66	50	28	10
560	1.785	1.755	1.823	1.846	
590	1.767	1.741	1.802	1.828	1.873
680	1.714	1.697	1.742	1.774	1.813
740	1.679	1.668	1.701	1.738	1.773

Temperature dependent equations

$\rho = a + bT$

Mol % NaOH	a	$-b \times 10^3$	T range (K)
100	2.159	0.604	598–823
90	2.187	0.673	573–753
82	2.115	0.589	553–753
75	1.972	0.418	553–753
66	2.028	0.487	553–753
63	2.176	0.688	553–753
55	2.111	0.562	553–753
50	2.200	0.674	553–753
40	2.183	0.605	553–753
28	2.182	0.600	553–753
10	2.268	0.669	573–753
0	2.116	0.729	583–753

These values are based on the data of Kruglov, Kochergin, and Poluyanova (Archimedean technique); data in equation form; precisions not estimated [204.234]. Comparisons of the data for NaOH and $NaNO_3$ with the values recommended in this series, show that the results above for $NaNO_3$ are uniformly lower (~10%) than the recommended data base [1]; the results for NaOH (above), by contrast, are virtually in exact agreement with the recommended data base [1].

$NaNO_3$ - Na_2SO_4

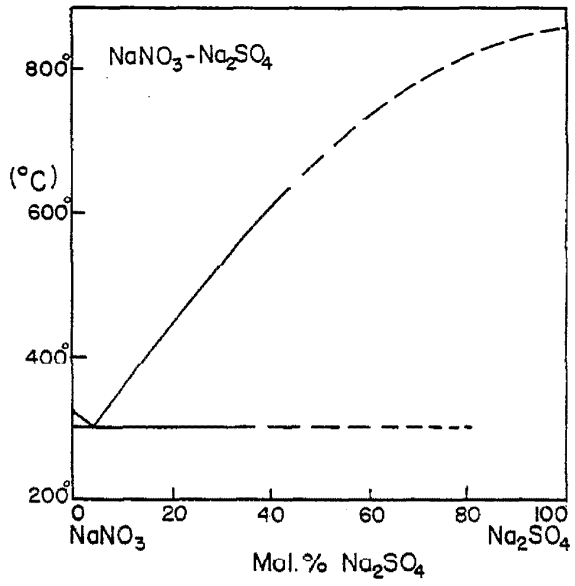

FIGURE 106. Phase diagram for $NaNO_3$ - Na_2SO_4.

Data from: M. Amadori, Atti reale accad. Lincei, Sez. II, 22, 334 (1913).

Melt Preparation and Purification

No information on melt preparation was given in the study by Bogorodskavo [38].

TABLE 847. Electrical conductance studies: $NaNO_3$ - Na_2SO_4

Investigations critically examined

Ref.	Mol % Na_2SO_4	Temp. range (K)	Comments
38	1.03–4.78	621–636	Pt disk electrodes; heavy wall capillary cells

TABLE 848. $NaNO_3$ - Na_2SO_4: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent Na_2SO_4		
	4.78	2.86	1.03
620	1.034	1.074	1.109
630	1.080	1.115	1.150
640	1.126	1.158	1.190

Temperature-dependent equations

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

Mol % Na_2SO_4	$-a$	$b \times 10^3$	$c \times 10^6$	standard error of estimate
4.78	1.8280	4.6157		0.04%
2.86	0.0612	-0.4622	3.6978	0.04%
1.03	1.3836	4.0211		0.04%

These values are based on the data of Bogorodskavo (classical ac method) [38].

$NaNO_3$ - Na_2WO_4

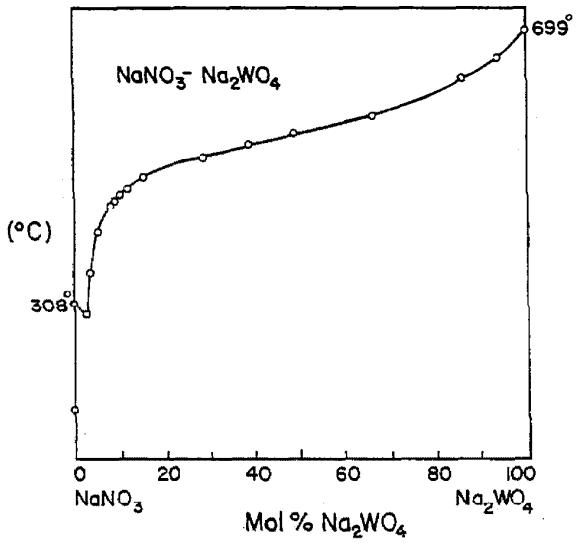

FIGURE 107. Phase diagram for $NaNO_3$ - Na_2WO_4.

Data from: G. K. Shurdumov and T. N. Khokhlonova, Russ. J. Inorg. Chem., 15(3), 429 (1970).

Melt Preparation and Purification

Khokhonova et al. [220] used C.P. grade sodium tungstate twice recrystallized and dried carefully. A melting point of 698.0±0.3°C was reported and the tungstate content was given as 78.01%. The $NaNO_3$ was recrystallized from reagent grade material and dried under vacuum.

TABLE 849. Electrical conductance studies: $NaNO_3$ - Na_2WO_4

Investigations critically examined			
Ref.	Mol % Na_2WO_4	Temp. range (K)	Comments
220	0 100	760–1100	no information given

TABLE 850. $NaNO_3$ - Na_2WO_4: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent Na_2WO_4		
	70	50	8
780			1.50
870		1.24	1.90
930	1.13	1.43	
1020	1.47	1.74	
1050	1.58		

Temperature-dependent equations

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

Mol % Na_2WO_4	$-a$	$b \times 10^3$	$c \times 10^6$
100	0.255	-0.022	1.26
70	2.364	3.756	
50	-0.113	-0.404	1.96
20	1.765	3.898	
8	2.004	4.489	
3	3.163	9.093	3.68
0	1.216	3.835	

These values are based on the data of Khokhonova, Shurdumov and Protsenko (classical ac method); data in graphical form; precisions not estimated [220]. The results for Na_2WO_4 and $NaNO_3$ are in close agreement (~2% and ~1%, respectively) with the recommended data sets for these two salts [1].

TABLE 851. Density studies: $NaNO_3$ - Na_2WO_4

Investigations critically examined			
Ref.	Mol % Na_2WO_4	Temp. range (K)	Comments
220, 221	0–100	780–1123	Au sphere suspended by a Pt wire; estimated uncertainty, 0.3–0.5%

TABLE 852. $NaNO_3$ - Na_2WO_4: Density (g cm^{-3})

T(K)	Mol percent Na_2WO_4			
	80	60	40	20
790				2.43
830			3.00	2.40
870		3.47	2.97	2.48
950	3.84	3.42	2.92	2.33
1070	3.75	3.34	2.85	
1110	3.72	3.31		

Temperature-dependent equations

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

Mol % Na_2WO_4	a	$-b \times 10^3$	$-c \times 10^6$
100	5.828	2.920	-1.06
90	4.729	0.814	
80	4.534	0.734	
70	4.296	0.705	
60	3.813	0.199	0.23
50	4.051	1.182	-0.28
40	3.532	0.642	
30	3.141	0.397	0.14
25	3.062	0.608	
20	2.565	-0.187	0.46
15	2.626	0.307	0.19
10	2.237	-0.195	0.48
5	2.772	1.481	-0.55
2	2.357	0.628	
0	2.484	1.102	

These values are based on the data of Khokhonova, Shurdumov and Protsenko (Archimedean technique); data in graphical form; precisions not estimated [220, 221]. For Na_2WO_4, the results are ~6% higher than the recommended data set [1]; for $NaNO_3$, the agreement with the recommended data set [1] is better (~1.5%).

KNO_2 - K_2MoO_4

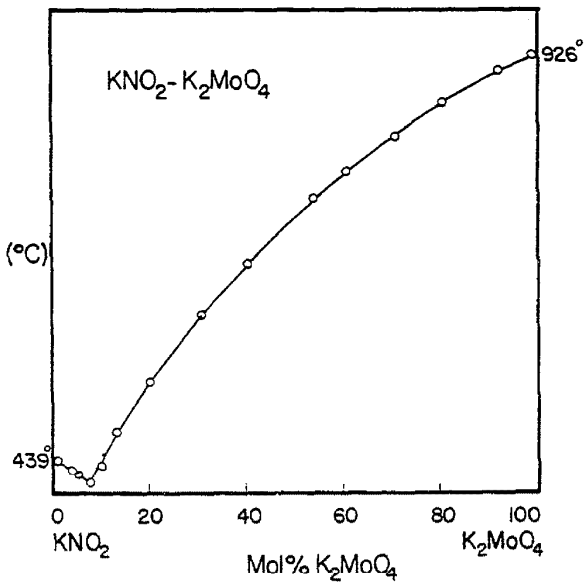

FIGURE 108. Phase diagram for KNO_2 - K_2MoO_4.

Data from: G. K. Shurdunov and T. N. Khokhonova, Russ. J. Inorg. Chem., 15(3),429(1970).

Melt Preparation and Purification

For the method of melt preparation used by Khokhonova et al. [203], see: $KNO_3 - K_2MoO_4$.

TABLE 853. Density studies: $KNO_2 - K_2MoO_4$

Investigations critically examined			
Ref.	Mol % K_2MoO_4	Temp. range (K)	Comments
203	0–20	723–1100	see: KNO_3–K_2MoO_4

TABLE 854. $KNO_2 - K_2MoO_4$: Density (g cm^{-3})

T(K)	Mol percent K_2MoO_4			
	20	14	8	4
720			1.812	1.742
780		1.873	1.775	1.709
810		1.851	1.756	1.693
840	1.921	1.829	1.738	1.676
900	1.873	1.786	1.701	1.643
960	1.825	1.742	1.664	
990	1.801	1.721		
1020	1.777	1.699		

Temperature–dependent equations

$\rho = a + bT$

Mol percent K_2MoO_4	a	$-b \times 10^3$
20	2.5949	0.8020
18	2.5531	0.7888
14	2.4371	0.7236
10	2.3083	0.6432
8	2.2564	0.6173
6	2.1966	0.5847
4	2.1357	0.5470
0	2.0239	0.4824

These values are based on the data of Khokhonova, Shurdumov and Protsenko (Archimedean technique); data in graphical form; precisions not estimated [203]. In the range of overlapping temperatures (700–750 K) the results for KNO_3 (above) and the recommended data set for this salt differ by ~1%.

$KNO_2 - K_2WO_4$

Melt Preparation and Purification

For the method of melt preparation used by Khokhonova et al. [203], see: $KNO_3 - K_2MoO_4$.

TABLE 855. Density studies: $KNO_2 - K_2WO_4$

Investigations critically examined			
Ref.	Mol % K_2WO_4	Temp. range (K)	Comments
203	0–20	723–1100	Au bob suspended from Pt wire.

TABLE 856. $KNO_2 - K_2WO_4$: Density (g cm^{-3})

T(K)	Mol percent K_2WO_4			
	20	16	8	4
720			1.903	1.791
840		2.057	1.834	1.726
900	2.131	2.016	1.799	1.693
930	2.108	1.996	1.782	
1020	2.038	1.934	1.730	

Temperature–dependent equations

$\rho = a + bT$

Mol percent K_2WO_4	a	$-b \times 10^3$
20	2.8301	0.7767
18	2.6902	0.6851
16	2.6331	0.6854
14	2.5639	0.6690
12	2.4647	0.6194
8	2.3195	0.5780
6	2.2565	0.5683
4	2.1814	0.5427
0	1.9811	0.4354

These values are based on the data of Khokhonova, Shurdumov and Protsenko (Archimedean technique); data in graphical form; precisions not estimated [203]. In the range of overlapping temperatures (700–750 K), the results for KNO_2 (above) and the recommended data set [1] differ by ~1%.

$NaNO_2 - Na_2MoO_4$

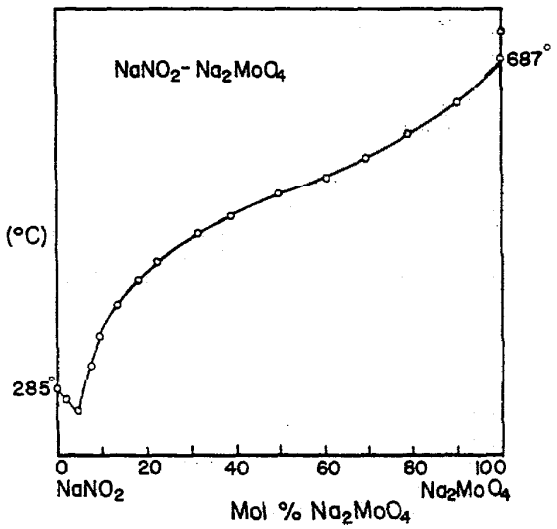

FIGURE 109. Phase diagram for $NaNO_2 - Na_2MoO_4$.

Data from: G. K. Shurdumov and T. N. Khokhonova, Russ. J. Inorg. Chem., 15(3), 429 (1970).

Melt Preparation and Purification

For the method of melt preparation used by Khokhonova et al. [219], see: $KNO_3 - K_2MoO_4$.

TABLE 857. Electrical conductance studies: $NaNO_2 - Na_2MoO_4$

Investigations critically examined			
Ref.	Mol % Na_2MoO_4	Temp. range (K)	Comments
220	0–100	590–1170	no information given

TABLE 858. $NaNO_2 - Na_2MoO_4$: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent Na_2MoO_4				
	70	50	20	8	3.2
590					1.42
630				1.46	1.60
750			1.43	1.95	2.16
790			1.59	2.11	
870	1.07	1.27	1.89	2.44	
910	1.21	1.39	2.04		
990	1.48	1.65			
1030	1.61				

Temperature-dependent equations

$\kappa = a + bT$

Mol percent Na_2MoO_4	$-a$	$b \times 10^3$
100	2.127	3.320
70	1.838	3.348
50	1.506	3.186
20	1.415	3.799
8	1.127	4.101
3.2	1.317	4.633
0	1.420	4.982

These values are based on the data of Khokhonova, Shurdumov and Protsenko (classical ac method); data in graphical form; precisions not estimated [220]. For Na_2MoO_4 the results are ~2% higher than the recommended data set [1]; for $NaNO_2$ the results are ~4% higher [1].

TABLE 859. Density studies: $NaNO_2 - Na_2MoO_4$

Investigations critically examined			
Ref.	Mol % Na_2MoO_4	Temp. range (K)	Comments
219	0–100	620–1120	see: $NaNO_3$–Na_2MoO_4

TABLE 860. $NaNO_2 - Na_2MoO_4$: Density (g cm^{-3})

T(K)	Mol percent Na_2MoO_4			
	80	60	40	20
760				2.11
800				2.09
840			2.36	2.07
880		2.55	2.34	2.05
920	2.71	2.53	2.32	2.03
960	2.69	2.51	2.30	2.01
1040	2.65	2.47	2.26	
1120	2.61	2.44		

Temperature-dependent equations

$\rho = a + bT$

Mol percent Na_2MoO_4	a	$-b \times 10^3$
100	3.439	0.617
90	3.230	0.480
80	3.153	0.484
70	3.041	0.457
60	2.952	0.460
50	2.870	0.476
40	2.767	0.487
30	2.658	0.506
25	2.601	0.530
20	2.517	0.532
16	2.446	0.533
12	2.383	0.547
8	2.301	0.531
3.5	2.187	0.503
0	2.022	0.393

These values are based on the data of Khokhonova, Shurdumov and Protsenko (Archimedean technique); data in graphical form; precisions not estimated [219]. For Na_2MoO_4, the results differ from the recommended data set [1] by ~2% (higher); for $NaNO_2$ the results differ by ~1% (higher).

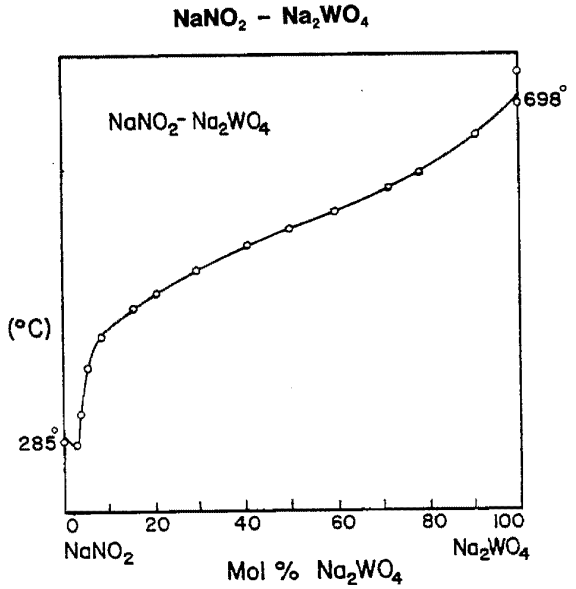

FIGURE 110. Phase diagram for $NaNO_2 - Na_2WO_4$.

Data from: G. K. Shurdumov and T. N. Khokhonova, Russ. J. Inorg. Chem., || (3), 429 (1970).

Melt Preparation and Purification

For the method of melt preparation used by Khokhonova et al. [220], see: $NaNO_3$-Na_2WO_4.

TABLE 861. Electrical conductance studies: $NaNO_2$ - Na_2WO_4

Investigations critically examined			
Ref.	Mol % Na_2WO_4	Temp. range (K)	Comments
220	0–100	620–1170	no information given

TABLE 862. $NaNO_2$ - Na_2WO_4: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent Na_2WO_4			
	70	50	20	8
740				1.74
780			1.39	1.90
860		1.26	1.76	2.22
900		1.41	1.93	
940	1.12	1.55	2.10	
1020	1.40	1.84		

Temperature-dependent equations

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

Mol % Na_2WO_4	$-a$	$b \times 10^3$	$-c \times 10^6$
100	0.2254	-0.0218	-1.26
70	2.175	3.501	
50	1.817	3.583	
20	3.535	7.888	2.01
8	1.217	3.992	
3	2.281	7.814	2.59
0	2.665	8.611	2.63

These values are based on the data of Khokhonova, Shurdumov and Protsenko (classical ac method); data in graphical form, precisions not estimated [220]. The results for Na_2WO_4 are ~6% higher than the recommended data set [1]; for $NaNO_2$ the results are ~2% higher than the recommended data set [1].

TABLE 863. Density studies: $NaNO_2$ - Na_2WO_4

Investigations critically examined			
Ref.	Mol % Na_2WO_4	Temp. range (K)	Comments
221	0–100	620–1120	see: $NaNO_3$-Na_2WO_4

TABLE 864. $NaNO_2$ - Na_2WO_4: Density (g cm^{-3})

T(K)	Mol percent Na_2WO_4			
	80	60	40	20
750				2.46
790				2.43
830			2.96	2.41
870		3.41	2.94	2.38
910	3.77	3.39	2.93	2.36
1070	3.70	3.31	2.86	
1110	3.68	3.29		

Temperature-dependent equations

$$\rho = a + bT$$

Mol percent Na_2WO_4	a	$-b \times 10^3$
100	4.487	0.533
90	4.242	0.371
80	4.147	0.417
70	3.999	0.463
60	3.858	0.510
50	3.570	0.452
40	3.327	0.440
30	3.167	0.565
25	3.062	0.612
20	2.911	0.607
16	2.895	0.740
12	2.690	0.674
8	2.480	0.727
2	2.218	0.548
0	2.038	0.424

These values are based on the data of Khokhonova, Shurdumov and Protsenko (Archimedean technique), data in graphical form, precisions not estimated [221]. For Na_2WO_4, the results are ~2% higher than the recommended data set [1]; for $NaNO_2$, the correspondence is closer (~0.8%) [1].

Metaphosphate - Other

TABLE 865. Data Status

System	Phase Diagram	Electrical Conductance	Density	Viscosity	Surface Tension
KPO_3–K_3PO_4			X		
–$K_4P_2O_7$			X		
$LiPO_3$–Li_3PO_4			X		
–$Li_4P_2O_7$			X		
$NaPO_3$–Li_2SO_4			X		X
–$Na_2B_4O_7$				X	
–Na_3PO_4			X		
–$Na_4P_2O_7$	X	X	X	X	X
–Na_2SO_4			X	X	X
–Rb_2SO_4			X		X
–UO_2SO_4			X		X
$Na_4P_2O_7$–Na_2SO_4				X	

KPO_3 - K_3PO_4

Melt Preparation and Purification

Kochergin and Khanzhina [222] used reagent grade materials. No other information was given.

TABLE 866. Density studies: KPO_3 - K_3PO_4

Investigations critically examined

Ref.	Mol % K_3PO_4	Temp. range (K)	Comments
222	0–25.5	1023–1173	-

TABLE 867. KPO_3 - K_3PO_4: Density (g cm^{-3})

T(K)	Mol percent K_3PO_4				
	25.5	20	15	11	6
1020			2.161	2.175	2.153
1080	2.179	2.163	2.146	2.148	2.125
1140	2.152	2.145	2.127	2.128	2.100
1160	2.145	2.139	2.120	2.124	2.093

Temperature-dependent equations

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

Mol % K_3PO_4	a	$b \times 10^3$	$c \times 10^6$
25.5	4.3712	-3.5303	1.389
22.5	4.2122	-3.2756	1.285
20	1.9854	0.6044	-0.407
18	3.2153	-1.5805	0.350
15	1.8393	0.8512	-0.525
11	3.8433	-2.7492	1.092
9	2.9461	-1.0934	0.323
6	3.0867	-1.3442	0.420
3	2.0918	0.4381	-0.382
0	1.4349	1.6179	-0.925

These values are based on the data of Kochergin and Khanzhina (Archimedean technique); data in graphical form; precisions not estimated [222]. The densities above for pure KPO_3 [222] are in close accord (~0.5%) with the recommended density data base [8].

KPO_3 - $K_4P_2O_7$

Melt Preparation and Purification

Kochergin and Khanzhina [222] used reagent grade materials. No other information was given.

TABLE 868. Density studies: KPO_3 - $K_4P_2O_7$

Investigations critically examined

Ref.	Mol % $K_4P_2O_7$	Temp. range (K)	Comments
222	0–30	1073–1223	-

TABLE 869. KPO_3 - $K_4P_2O_7$: Density (g cm^{-3})

T(K)	Mol percent $K_4P_2O_7$				
	29.7	24.8	20.0	15.0	9.8
1070	2.165	2.163	2.155	2.147	2.142
1130	2.148	2.143	2.135	2.128	2.125
1210	2.126	2.117	2.107	2.102	2.102
1220	2.123	2.113	2.104	2.099	2.099

Temperature-dependent equations

$$\rho = a + bT$$

Mol percent $K_4P_2O_7$	a	$-b \times 10^3$
29.7	2.4645	0.2801
24.8	2.5136	0.3281
20.0	2.5189	0.3401
15.0	2.4847	0.3160
9.8	2.4435	0.2820
5.0	2.4514	0.2961
0	2.6338	0.4822

These values are based on the data of Kochergin and Khanzhina (Archimedean technique); data in graphical form; precisions not estimated [222]. The densities for pure KPO_3 (above) are in close accord with the recommended density data base [8].

$LiPO_3$ - Li_3PO_4

Melt Preparation and Purification

Kochergin and Khanzhina [222] used reagent grade materials. No other information was given.

TABLE 870. Density studies: $LiPO_3$ - Li_3PO_4

Investigations critically examined			
Ref.	Mol % Li_3PO_4	Temp. range (K)	Comments
222	0–30	1073,1173	-

TABLE 871. $LiPO_3$ - Li_3PO_4: Density (g cm^{-3})

Mol percent Li_3PO_4	1073 K	1173 K
30		2.145
20	2.167	2.142
10	2.161	2.135

Composition-dependent equations

$\rho = a + bC + cC^2$

[C = Mol % Li_3PO_4]

T(K)	a	b x 10^3	$-c$ x 10^6
1073	2.1418	2.6104	68.149
1173	2.1230	1.4524	23.944

These values are based on the data of Kochergin and Khanzhina (Archimedean technique); data in graphical form; precisions not estimated [222].

$LiPO_3$ - $Li_4P_2O_7$

Melt Preparation and Purification

Kochergin and Khanzhina [222] used reagent grade materials. No other information was given.

TABLE 872. Density studies: $LiPO_3$ - $Li_4P_2O_7$

Investigations critically examined			
Ref.	Mol % $Li_4P_2O_7$	Temp. range (K)	Comments
222	0–34.3	1023–1243	-

TABLE 873. $LiPO_3$ - $Li_4P_2O_7$: Density (g cm^{-3})

T(K)	Mol percent $Li_4P_2O_7$			
	34.3	24.4	15.0	9.5
1020	2.176	2.170		
1080	2.157	2.157	2.150	2.150
1120	2.145	2.148	2.139	2.139
1180	2.126		2.122	2.122
1240	2.107		2.105	2.105

Temperature-dependent equations

$\rho = a + bT$

Mol percent $Li_4P_2O_7$	a	$-b$ x 10^3
34.3	2.4990	0.3165
24.4	2.3941	0.2200
15.0	2.4579	0.2849
9.5	2.4537	0.2812
0	2.2432	0.1102

These values are based on the data of Kochergin and Khanzhina (Archimedean technique); data in graphical form; precisions not estimated [222]. The densities for pure $LiPO_3$ (above) are uniformly higher (~5–10%) than the recommended density data base [8].

$NaPO_3$ - Li_2SO_4

Melt Preparation and Purification

Owens and Mayer [223] prepared the melts from reagent grade materials. The lithium sulfate was prepared by dehydrating $Li_2SO_4.H_2O$ in a muffle furnace at 400°C. The $NaPO_3$ was prepared 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 874. Density studies: $NaPO_3$ - Li_2SO_4

Investigations critically examined			
Ref.	Mol % Li_2SO_4	Temp. range (K)	Comments
223	0–50	763–973	Pt conical-shaped bob

TABLE 875. $NaPO_3$ - Li_2SO_4: Density (g cm^{-3})

T(K)	Mol percent Li_2SO_4		
	50	35	10
760	2.229	2.262	
800	2.213	2.244	2.289
840		2.226	2.271
860			2.262
940			2.226
960			2.217

Temperature-dependent equations

$\rho = a + bT$

Mol percent Li_2SO_4	a	$-b \times 10^3$
50	2.547	0.418
35	2.606	0.452
10	2.647	0.448
0	2.691	0.459

These values are based on the data of Owens and Mayer (Archimedean technique); data in equation form; precisions not estimated [223]. The densities for 100% $NaPO_3$ (above) were advanced elsewhere in this series as the recommended data set [8].

TABLE 876. Surface tension studies: $NaPO_3$ - Li_2SO_4

Investigations critically examined

Ref.	Mol % Li_2SO_4	Temp. range (K)	Comments
223	0-10	773-1103	Pt-iridium ring with Pt counterweight on torsion arm; correction for thermal expansion

TABLE 877. $NaPO_3$ - Li_2SO_4: Surface tension (dyn cm^{-1})

T(K)	Mol percent Li_2SO_4
	10
780	197.3
800	196.6
900	193.1
980	190.3

Temperature-dependent equations

$\gamma = a + bT$

Mol percent Li_2SO_4	a	$-b \times 10^3$
10	224.8	35.2
0	228.7	39.8

These values are based on the data of Owens and Mayer (ring detachment method); data in equation form; precisions not estimated [223]. The surface tension values for $NaPO_3$ (0% Li_2SO_4) have been advanced elsewhere in this series [8] as the recommended data base.

$NaPO_3$ - $Na_2B_4O_7$

Melt Preparation and Purification

Bergman et al. [57] used reagent grade salts to prepare the melts. No other information was given.

TABLE 878. Viscosity studies: $NaPO_3$ - $Na_2B_4O_7$

Investigations critically examined

Ref.	Equiv. % $NaPO_3$	Temp. range (K)	Comments
57	0-100	1223	calibration: water; estimated uncertainty: 2 - 4%

TABLE 879. $NaPO_3$ - $Na_2B_4O_7$: Viscosity (cp)

Equiv. percent $NaPO_3$	1223 K
100	119.4
90	92.3
70	151.5
40	213.5
10	173.8
0	170.7

Composition-dependent equations

$\eta = a + bC + cC^2 + dC^3$

[C = Equiv. % $NaPO_3$]

Equiv. % $NaPO_3$	a	$b \times 10^2$	$c \times 10^4$	$d \times 10^6$
0-50	170.73	5.184	251.3	
50-100	-449.38	3755.0	-6359.0	3172.8

These values are based on the data of Bergman, Gasanaliev, Trunin and Kolesnikov (oscillational method); data in graphical form; precisions not estimated [57]. At 50 equiv. %, a sharp inflexion is reported in the viscosity-composition isotherm. For $NaPO_3$, the value above is virtually in exact agreement with results of the recommended data set extrapolated to 1223 K [1].

$NaPO_3$ - Na_3PO_4

Melt Preparation and Purification

Kochergin and Khanzhina [222] used reagent grade salts. No other information was given.

TABLE 880. Density studies: $NaPO_3$ - Na_3PO_4

Investigations critically examined

Ref.	Mol % Na_3PO_4	Temp. range (K)	Comments
222	0-25	973-1123	-

TABLE 881. $NaPO_3$ – Na_3PO_4: Density (g cm^{-3})

T(K)	Mol percent Na_3PO_4			
	20	15	10	5
980	2.268	2.259	2.246	2.257
1000	2.263	2.252	2.238	2.252
1060	2.245	2.231	2.217	2.233
1120	2.219	2.210	2.198	2.212

Temperature-dependent equations

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

Mol % Na_3PO_4	a	$b \times 10^3$	$c \times 10^6$
25	1.6762	1.4503	-0.835
20	1.5503	1.6773	-0.964
15	2.6063	-0.3540	
10	2.9748	-1.0946	0.358
7.5	3.2937	-1.7035	0.654
5	2.0451	0.6888	-0.482
2.5	2.5785	-0.3401	
0	2.5806	-0.3641	

These values are based on the data of Kochergin and Khanzhina (Archimedean technique); data in graphical form; precisions not estimated [222]. For pure $NaPO_3$ (i.e., 0 mol% Na_3PO_4) the density results are in close agreement (~0.5%) with the recommended $NaPO_3$ density data base [8].

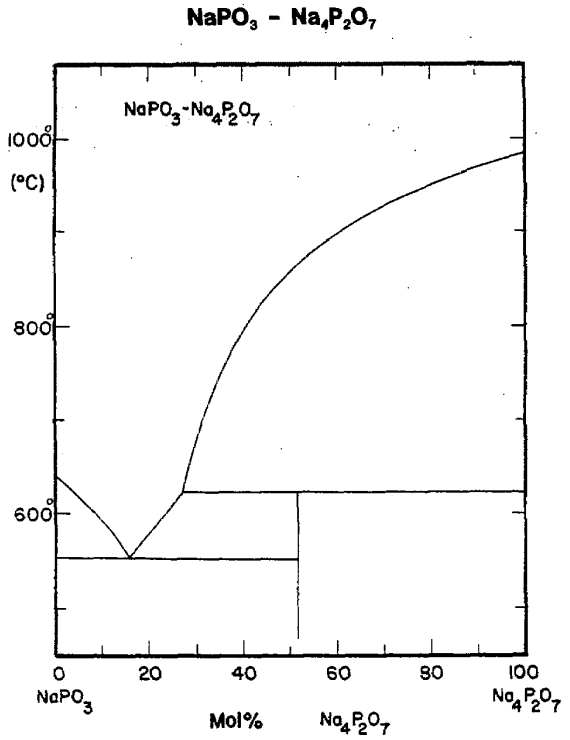

FIGURE 111. Phase diagram for $NaPO_3$ – $Na_4P_2O_7$.

Data from: N. Parravano and G. Calcagni, Z. anorg. Chem. 65, 1 (1910).

Melt Preparation and Purification

Hubble and Copeland [224] used reagent grade $NaPO_3$ and $Na_4P_2O_{7.10}H_2O$. The $Na_4P_2O_{7.10}H_2O$ was dehydrated as completely as possible by heating in a porcelain dish for about 2 hours. This sample as well as the $NaPO_3$ was oven-dried at 130°C for an additional 72 hours. The samples were cooled in a Drierite desiccator before being used. Kochergin and Khanzhina [222] used reagent grade materials. No further details were given. No information on melt preparation was given in the study by Postnikov et al. [225].

TABLE 882. Electrical conductance studies: $NaPO_3$ – $Na_4P_2O_7$

Investigations critically examined

Ref.	Mol ratio Na_2O/P_2O_5	Temp. range (K)	Comments
224	1.16–1.48	833–1140	Vycor cell; calibration: molten $NaNO_3$

In [224], the sodium polyphosphate melt compositions were expressed as Na_2O/P_2O_5 ratios; for the ratio $Na_2O/P_2O_5 = 2.0$, the composition is $Na_4P_2O_7$.

TABLE 883. Specific conductance ($ohm^{-1}cm^{-1}$): $NaPO_3$ – $Na_4P_2O_7$

T(K)	Na_2O/P_2O_5 (mol ratio)			
	1.16	1.28	1.45	1.48
840		0.372		
900	0.532	0.547	0.616	
980	0.788	0.808	0.909	
1000		0.878	0.988	1.029
1080		1.179	1.329	1.403
1100			1.420	1.504
1140				1.715

Temperature-dependent equations

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

Mol ratio Na_2O/P_2O_5	a	$-b \times 10^3$	$c \times 10^6$	standard error of estimate
1.16	0.3576	2.567	3.068	0.28%
1.28	-0.1757	1.4587	2.5124	0.36%
1.45	-0.0598	1.927	2.975	0.40%
1.48	0.3882	3.0964	3.737	0.25%

These values are based on the data of Hubble and Copeland (classical ac method) [224].

TABLE 884. Density studies: $NaPO_3$ – $Na_4P_2O_7$

Investigations critically examined

Ref.	Mol % $Na_4P_2O_7$	Temp. range (K)	Comments
222	0–30	993–1123	-

TABLE 885. $NaPO_3$ - $Na_4P_2O_7$: Density (g cm^{-3})

T(K)	Mol percent $Na_4P_2O_7$		
	30	20	10
1000	2.289	2.260	2.266
1040	2.274	2.245	2.251
1080	2.260	2.230	2.237
1120	2.247	2.215	2.222

Temperature-dependent equations

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

Mol % $Na_4P_2O_7$	a	$-b \times 10^3$	$c \times 10^6$
30	3.0166	1.0677	0.340
25	2.6349	0.3683	
20	2.6324	0.3723	
15	2.6075	0.3480	
10	2.6293	0.3633	
5	4.7304	4.3247	1.856
0	3.7700	2.5699	1.022

These values are based on the data of Kochergin and Khanzhina (Archimedean technique); data in graphical form; precisions not estimated [222]. The density results for $NaPO_3$ (i.e., 0% $Na_4P_2O_7$) agree closely (~0.5%) with the recommended $NaPO_3$ density data base [8].

TABLE 886. Viscosity studies: $NaPO_3$ - $Na_4P_2O_7$

Investigations critically examined

Ref.	Mol % $Na_4P_2O_7$	Temp. range (K)	Comments
225	0-100	870-1370	immersed Pt sphere

TABLE 887. $NaPO_3$ - $Na_4P_2O_7$: Viscosity (poise)

T(K)	Mol percent $Na_4P_2O_7$				
	53.5	27.7	20.4	14.1	4.1
870			3.36		
950			2.21	2.39	
990			1.74	1.90	4.01
1110		0.66	0.78	0.86	1.74
1230	0.38	0.42			
1270	0.34	0.38			
1310	0.31				

Temperature-dependent equations

$$\eta = a + bT + cT^2 + dT^3$$

Mol % $Na_4P_2O_7$	a	$-b \times 10^3$	$c \times 10^6$	$-d \times 10^9$	standard error of estimate
100	2.454	2.777	0.86		3.01%
68.5	0.648	0.244	-0.05		0.42%
53.5	4.299	5.388	1.79		0.48%
36.5	7.534	10.248	3.62		1.70%
27.7	12.682	18.765	7.15		3.44%
23.9	80.774	197.222	162.12	44.60	14.09%
20.4	34.731	55.926	22.83		14.36%
14.1	34.319	54.239	21.71		14.03%
11.3	not analyzed - typographical error in paper				
6.3	79.683	126.553	50.81		9.31%
4.1	141.654	299.149	209.46	48.21	4.52%
0	exponential equation (see below)				2.46%

These values are based on the data of Postnikov, Frenkel and Melnikov (rotational method) [225]. For pure $NaPO_3$ (i.e., 0% $Na_4P_2O_7$), the temperature-dependent equation is $\eta = 1.6063 \times 10^{-3} \exp(16222/RT)$ for 1010-1290 K. Comparison of the viscosities in the region of temperature overlap, shows that the results in [225] are ~6% higher than the recommended $NaPO_3$ viscosity data base [8]. Viscosity results for pure $Na_4P_2O_7$ have also been reported by Collis, Van Wazer, and Metcalf, over the same temperature range (1300-1350 K), (rotational method) [237]. The data sets from these two investigations of $Na_2P_4O_7$ are virtually in exact accord (~±0.5%).

TABLE 888. Surface tension studies: $NaPO_3$ - $Na_4P_2O_7$

Investigations critically examined

Ref.	Mol ratio Na_2O/P_2O_5	Temp. range (K)	Comments
226	1.16-1.48	833-1140	see remarks after Table 839

TABLE 889. $NaPO_3 - Na_4P_2O_7$: Surface tension (dyn cm^{-1})

T(K)	Na_2O/P_2O_5 (mol ratio)			
	1.16	1.28	1.45	1.48
850		215.4		
910	205.0	213.1	224.7	
970	202.7	210.8	222.4	
1000		209.7	221.3	223.3
1060		207.4	219.0	221.0
1090			217.8	219.9
1120				218.7
1140				218.0

Temperature-dependent equations

$\gamma = a + bT$

Mol ratio Na_2O/P_2O_5	a	$-b \times 10^3$	standard error of estimate
1.16	239.5	37.93	0.01%
1.28	247.6	37.89	0.01%
1.45	259.2	37.95	0.01%
1.48	261.1	37.84	0.01%

The surface tension data for molten sodium phosphate were extended from the metaphosphate to pyrophosphate composition using the ring detachment technique and special platinum equipment, by Callis, Van Wazer, and Metcalf [238]. The accuracies in the experimental measurements [238] were cited as $\sim \pm 0.8\%$. A composition-dependent and temperature-dependent equation, advanced in [237], was used by Hubble and Copeland [226] to calculate the surface tensions reported in Table 830

$NaPO_3 - Na_2SO_4$

Melt Preparation and Purification

Owens and Mayer [223] used reagent grade materials. The $NaPO_3$ was prepared 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%. The Na_2SO_4 was used without further treatment. Bergman et al. [57] used reagent grade salts. No other information was given.

TABLE 890. Density studies: $NaPO_3 - Na_2SO_4$

Investigations critically examined

Ref.	Mol % Na_2SO_4	Temp. range (K)	Comments
223	0–25	803–1083	Pt conical shaped bob; correction for thermal expansion of Pt.

TABLE 891. $NaPO_3 - Na_2SO_4$: Density (g cm^{-3})

T(K)	Mol percent Na_2SO_4				
	25	12.5	8	4	2
800				2.324	
830			2.303	2.309	
860			2.289	2.295	2.295
890		2.267	2.275	2.281	2.280
950	2.230	2.240	2.247	2.251	2.252
1070	2.175	2.185	2.190	2.192	2.195

Temperature-dependent equations

$\rho = a + bT$

Mol percent Na_2SO_4	a	$-b \times 10^3$
25	2.662	0.455
12.5	2.674	0.457
8	2.696	0.473
4	2.716	0.490
2	2.705	0.477
1	2.693	0.465
0	2.6906	0.459

These values are based on the data of Owens and Mayer (Archimedean technique); data in equation form; precisions not estimated [223]. The density results for pure $NaPO_3$ (above) have been advanced earlier, in this series, as the recommended data set [8].

TABLE 892. Viscosity studies: $NaPO_3 - Na_2SO_4$

Investigations critically examined

Ref.	Equiv. % Na_2SO_4	Temp. range (K)	Comments
57	0–100	1173	estimated uncertainty: 2–4%

TABLE 893. $NaPO_3 - Na_2SO_4$: Viscosity (cp)

Equiv. percent Na_2SO_4	1173 K
100	7.62
90.5	5.71
80.2	3.81
72.2	2.38
60.9	5.24
51.0	6.67
39.4	11.91
29.6	18.10
19.8	30.95
10.1	71.91
0	(180.2)

These values were interpolated from the graphical data of Bergman, Gasanaliev, Trunin and Kolesnikov (oscillational method) [57]. The data could not be fitted to a simple equation. For Na_2SO_4, the viscosity measurements reported by Tanutrov et al. (oscillational method) [238], are given by: $\eta = 14.8 \times 10^{-2} \exp(9990/RT)$ for 1240–1460 K (accuracy estimate: $\sim \pm 25\%$). The value at 1173 K (above table) agrees with the results of Tanutrov within these error limits. The value for $NaPO_3$ (182.0) appears to be an extrapolated value; from the recommended data base for $NaPO_3$ [1], the viscosity at 1173 K is 126 (±30) cp.

TABLE 894. Surface tension studies: $NaPO_3$ - Na_2SO_4

Investigations critically examined			
Ref.	Mol % Na_2SO_4	Temp. range (K)	Comments
223	0–25	883–1143	Pt–iridium ring modified with Pt counterweight in torsion arm; correction for thermal expansion of Pt.

TABLE 895. $NaPO_3$ - Na_2SO_4: Surface tension (dyn cm^{-1})

T(K)	Mol percent Na_2SO_4		
	25	12.5	1
880			194.0
910		199.3	192.9
940	201.6	197.7	191.7
1030	196.3	192.9	188.1
1060	194.6		
1120	191.1		

Temperature-dependent equations

$\gamma = a + bT$

Mol percent Na_2SO_4	a	$-b \times 10^3$
25	256.17	58.1
12.5	247.9	53.4
1	228.8	39.5
0	228.7	39.8

These values are based on the data of Owens and Mayer (ring detachment method); data in equation form; precisions not estimated [223]. The results for pure $NaPO_3$, (i.e., 0% Na_2SO_4) have been advanced elsewhere in this series as the recommended surface tension data set for $NaPO_3$ [2].

$NaPO_3$ - Rb_2SO_4

Melt Preparation and Purification

For the method used by Owens and Mayer [223] to prepare $NaPO_3$, see: $NaPO_3$–Na_2SO_4. The Rb_2SO_4 was reagent grade and used without further purification.

TABLE 896. Density studies: $NaPO_3$ - Rb_2SO_4

Investigations critically examined			
Ref.	Mol % Rb_2SO_4	Temp. range (K)	Comments
223	0–25	773–1073	see: $NaPO_3$–Na_2SO_4

TABLE 897. $NaPO_3$ - Rb_2SO_4: Density (g cm^{-3})

T(K)	Mol percent Rb_2SO_4	
	25	12.5
780	2.560	2.461
870	2.512	2.417
960	2.464	2.373
1050	2.417	2.330

Temperature-dependent equations

$\rho = a + bT$

Mol percent Rb_2SO_4	a	$-b \times 10^3$
25	2.973	0.530
12.5	2.840	0.486
0	2.6906	0.4592

These values are based on the data of Owens and Mayer (Archimedean technique); data in equation form; precisions not estimated [223]. The results above for 100% $NaPO_3$ (0% Rb_2SO_4) have been advanced elsewhere in this series as the recommended density data base for $NaPO_3$ [8].

TABLE 898. Surface tension studies: $NaPO_3$ - Rb_2SO_4

Investigations critically examined			
Ref.	Mol % Rb_2SO_4	Temp. range (K)	Comments
223	0–25	793–1083	see: $NaPO_3$–Li_2SO_4

TABLE 899. $NaPO_3$ - Rb_2SO_4: Surface tension (dyn cm^{-1})

T(K)	Mol percent Rb_2SO_4	
	25	12.5
810	166.1	
870	162.9	173.2
960	158.1	168.9
1050	153.4	164.7
1080		163.3

Temperature-dependent equations

$\gamma = a + bT$

Mol percent Rb_2SO_4	a	$-b \times 10^3$
25	209.0	53.0
12.5	214.05	47.0
0	228.7	39.8

These values are based on the data of Owens and Mayer (ring detachment method); data in equation form; precisions not estimated [223]. The results for $NaPO_3$ (0% Rb_2SO_4) have been advanced elsewhere in this series [8] as the recommended surface tension data base for $NaPO_3$.

$NaPO_3$ - UO_2SO_4

Melt Preparation and Purification

For the method used by Owens and Mayer [223] to prepare $NaPO_3$, see: $NaPO_3$–Na_2SO_4. The UO_2SO_4 was prepared by dehydrating reagent grade $UO_2SO_4.3H_2O$ in a muffle furnace at 400°C.

TABLE 900. Density studies: $NaPO_3$ - UO_2SO_4

Investigations critically examined

Ref.	Mol % UO_2SO_4	Temp. range (K)	Comments
223	0–12.5	803–1023	see: $NaPO_3$–Na_2SO_4

TABLE 901. $NaPO_3$ - UO_2SO_4: Density (g cm^{-3})

T(K)	Mol percent UO_2SO_4				
	12.5	10	7	3	2
800				2.436	
830			2.580	2.421	2.372
860	2.775	2.671	2.565	2.407	2.358
950	2.727	2.625	2.520	2.362	2.318
980	2.711		2.505	2.347	2.305
1010	2.695		2.490	2.332	2.291

Temperature-dependent equations

$\rho = a + bT$

Mol percent UO_2SO_4	a	$-b \times 10^3$
12.5	3.234	0.534
10	3.105	0.505
7	2.997	0.502
3	2.832	0.495
2	2.745	0.449
1	2.705	0.447
0	2.6906	0.4592

These values are based on the data of Owens and Mayer (Archimedean technique); data in equation form; precisions not estimated [223]. The results above for $NaPO_3$ (0% UO_2SO_4) have been advanced elsewhere in this series [8] as the recommended data base for $NaPO_3$.

TABLE 902. Surface tension studies: $NaPO_3$ - UO_2SO_4

Investigations critically examined

Ref.	Mol % UO_2SO_4	Temp. range (K)	Comments
223	0–12.5	933–1103	see: $NaPO_3$–Li_2SO_4

TABLE 903. $NaPO_3$ - UO_2SO_4: Surface tension (dyn cm^{-1})

T(K)	Mol percent UO_2SO_4
	12.5
930	212.1
970	204.8
1010	197.6
1030	194.0

Temperature dependent equations

Mol percent UO_2SO_4	a	$-b \times 10^3$
12.5	380.4	181.0
0	228.7	39.8

These values are based on the data of Owens and Mayer (ring detachment method); data in equation form; precisions not estimated [223]. The results above for $NaPO_3$ (0% UO_2SO_4) have been advanced elsewhere in this series as the recommended surface tension data base for $NaPO_3$ [8].

$Na_4P_2O_7$ - Na_2SO_4

Melt Preparation and Purification

Bergman et al. [57] used reagent grade materials. No other information was given.

TABLE 904. Viscosity studies: $Na_4P_2O_7$ - Na_2SO_4

Investigations critically examined

Ref.	Equiv. % Na_2SO_4	Temp. range (K)	Comments
57	30–100	1273	estimated uncertainty; 2–4%

TABLE 905. $Na_4P_2O_7$ - Na_2SO_4: Viscosity (cp)

Equiv. percent Na_2SO_4	1273 K
100	5.0
90	5.9
80	7.1
70	8.4
60	9.4
50	11.7
30	15.6

Composition-dependent equation

$\eta = 22.987 - 27.32 \times 10^{-2}C + 9.30 \times 10^{-4}C^2$

[C = Equiv. % Na_2SO_4]

These values are based on the data of Bergman, Gasanaliev, Trunin and Kolesnikov (oscillational method); data in graphical form; precision not estimated [57]. The viscosity value for 100% Na_2SO_4 (above) appears low from the data of Tanutrov et al. [239], the value at 1273 K is 7.75 (±2) cp. (see also: comments following Table 893, this work).

Sulfate - Other

TABLE 906. Data Status

System	Phase Diagram	Electrical Conductance	Density	Viscosity	Surface Tension
K_2SO_4-K_2WO_4	X	X			
Li_2SO_4-K_2WO_4		X			

K_2SO_4 - K_2WO_4

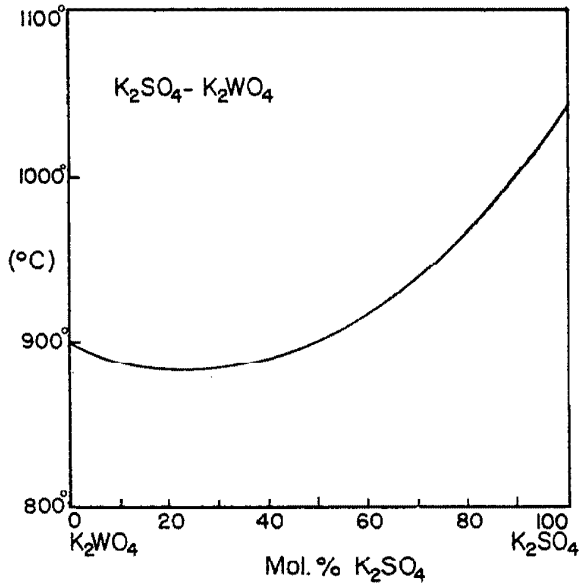

FIGURE 112. Phase diagram for K_2SO_4 - K_2WO_4.

Data from: M. Amadori, Atti reale accad. Lincei, Sez. I, 22, 610 (1913).

Melt Preparation and Purification

Kvist and Trolle [227] further dried reagent grade salts before use.

TABLE 907. Electrical conductance studies: K_2SO_4 - K_2WO_4

Investigations critically examined

Ref.	Mol % K_2WO_4	Temp. range (K)	Comments
227	50	1202–1265	quartz cell; Pt electrodes; frequency: 1–10Hz.

TABLE 908. K_2SO_4 - K_2WO_4: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent K_2WO_4
	50
1200	1.337
1220	1.381
1240	1.424
1260	1.468

Temperature-dependent equation

$\kappa = -1.2876 + 0.2187 \times 10^{-2}T$

Standard error of estimate = 0.20%

These values are based on the data of Kvist and Trolle (classical ac method) [227].

Li_2SO_4 - K_2WO_4

Melt Preparation and Purification

Kvist and Trolle [227] further dried reagent grade salts before use.

TABLE 909. Electrical conductance studies: Li_2SO_4 - K_2WO_4

Investigations critically examined

Ref.	Mol % K_2WO_4	Temp. range (K)	Comments
227	50	1083–1246	see: K_2SO_4-K_2WO_4

TABLE 910. Li_2SO_4 - K_2WO_4: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent K_2WO_4
	50
(1080)	1.054
1140	1.227
1200	1.389
1240	1.490

The data were extrapolated to 1080 K.

Temperature-dependent equation

$\kappa = -4.2017 + 0.67306 \times 10^{-2}T - 0.17265 \times 10^{-5}T^2$

Standard error of estimate = 0.20%

These values are based on the data of Kvist and Trolle (classical ac method) [227].

Li_2SO_4 - Li_2WO_4

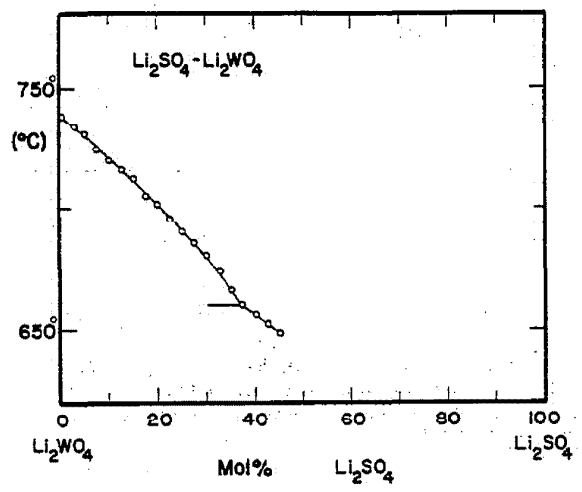

FIGURE 113. Phase diagram for Li_2SO_4 - Li_2WO_4.

Data from: A. G. Bergman, A. I. Kislova, and V. I. Posypaiko, Zh. Osbshch. Khim. **24**, 1722, (1954).

Melt Preparation and Purification

Kvist and Trolle [227] further dried reagent grade salts before use.

TABLE 911. Electrical conductance studies: Li_2SO_4 - Li_2WO_4

Investigations critically examined

Ref.	Mol % Li_2WO_4	Temp. range (K)	Comments
227	50	919–1180	see: K_2SO_4–K_2WO_4

TABLE 912. Li_2SO_4 - Li_2WO_4: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent Li_2WO_4
	50
920	1.721
1010	2.237
1100	2.703
1180	3.074

Temperature-dependent equation

$\kappa = -6.4555 + 0.01176T - 0.3122 \times 10^{-5}T^2$

Standard error of estimate = 0.13%

These values are based on the data of Kvist and Trolle [227] and Kvist [228] (classical ac method).

Perchlorate/Chlorate - Other

TABLE 913. Data Status

System	Phase Diagram	Electrical Conductance	Density	Viscosity	Surface Tension
$LiClO_3$-LiOH		X	X		

$LiClO_3$ - LiOH

Melt Preparation and Purification

Campbell and Williams [209] prepared the lithium chlorate by mixing equimolar proportions of barium chlorate and lithium sulfate. The precipitated barium sulfate was filtered off and the clear solution titrated alternately with solutions of lithium sulfate and of barium chlorate until all excess over stoichiometric proportions was removed. The solution was then concentrated by vacuum distillation at about 60°. When the solution had attained a concentration of lithium chlorate of about 90%, it was cooled in an ice bath until crystals of lithium chlorate separated out. The crystals were removed by filtration and stored over sulfuric acid for 2–3 weeks. When the salt was sufficiently dry it was ground to a fine powder in a dry box. Final drying was carried out under vacuum.

Reagent grade lithium hydroxide was dried before use. The mixture of lithium chlorate and lithium hydroxide was made up in a dry box, melted and filtered through a coarse filter and then transferred to the cell.

TABLE 914. Electrical conductance studies: $LiClO_3$ - LiOH

Investigations critically examined

Ref.	Mol % LiOH	Temp. range (K)	Comments
209	0–7.6	403–443	Pyrex cell; Pt electrodes; frequency range: 1–10 KHz; calibration: aq. KCl.

TABLE 915. $LiClO_3$ - LiOH: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent LiOH
	7.6
410	0.116
420	0.138
430	0.162
440	0.188

Temperature-dependent equations

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

Mol % LiOH	a	$-b \times 10^3$	$c \times 10^6$
7.6	0.4421	3.775	7.265
0	-0.9548	-2.639	

Standard error of estimate = 0.97%

These values are based on the data of Campbell and Williams (classical ac method) [209]. The results for $LiClO_3$ (0% LiOH) have been advanced elsewhere in this series as the recommended conductance data base for $LiClO_3$ [1].

TABLE 916. Density studies: $LiClO_3$ - LiOH

Investigations critically examined

Ref.	Mol % LiOH	Temp. range (K)	Comments
209	0-7.6	403-443	Pyrex dilatometer; calibration: Hg

TABLE 917. $LiClO_3$ - LiOH: Density ($g\ cm^{-3}$)

T(K)	Mol percent LiOH
	7.6
410	2.037
420	2.029
430	2.021
440	2.013

Temperature-dependent equations

$\rho = a + bT$

Mol percent LiOH	a	$-b \times 10^3$
7.6	2.3681	0.8065
0	2.3936	0.7570

Standard error of estimate = 0.01%

These values are based on the data of Campbell and Williams (dilatometric method) [209]. The results for $LiClO_3$ (0% LiOH) have been advanced elsewhere in this series [1] as the recommended density data base for $LiClO_3$.

Miscellaneous

TABLE 918. Data Status

System	Phase Diagram	Electrical Conductance	Density	Viscosity	Surface Tension
$KCHO_2$-$KC_2H_3O_2$		X			
Na_3AsO_4-NaOH				X	
Na_3SbO_4-NaOH				X	
$Na_2Si_2O_5$-$PbSiO_3$				X	
LiF-BeF_2-ThF_4			X	X	
-ZrF_4			X		
-ZrF_4-UF_4			X		

$KCHO_2$ - $KC_2H_3O_2$

Melt Preparation and Purification

Leonesi et al. [229] used reagent grade salts which were dried carefully under vacuum at 120°C.

TABLE 919. Electrical conductance studies: $KCHO_2$ - $KC_2H_3O_2$

Investigations critically examined

Ref.	Mol % $KC_2H_3O_2$	Temp. range (K)	Comments
229	0-100	580-600	Pyrex cell: Pt electrodes; frequency: 2000 Hz; calibration: molten $NaNO_3$, KNO_3

TABLE 920. $KCHO_2 - KC_2H_3O_2$: Specific conductance ($ohm^{-1}cm^{-1}$)

T(K)	Mol percent $KC_2H_3O_2$			
	50	25	13	7
580	0.304	0.384	0.433	0.463
590	0.326	0.410	0.460	0.491
600	0.349	0.435	0.487	0.519

Temperature-dependent equations

$\kappa = a + bT$

Mol % $KC_2H_3O_2$	$-a$	$b \times 10^3$	standard error of estimate
100	0.8487	1.800	0.00%
50	1.0005	2.249	0.09%
25	1.0944	2.549	0.07%
13	1.1326	2.699	0.00%
7	1.1603	2.799	0.00%
0	1.2087	2.949	0.05%

These values are based on the data of Leonesi, Berchiesi and Cingolani (classical ac method) [229].

Na_3AsO_4 - NaOH

Melt Preparation and Purification

Urazov et al. [230] used reagent grade salts as starting materials. The sodium hydroxide was first fused in the outer cylinder of the viscometer before adding the sodium arsenate. Chemical analysis of the melts was undertaken.

TABLE 921. Viscosity studies: Na_3AsO_4 - NaOH

Investigations critically examined

Ref.	Mol % NaOH	Temp. range (K)	Comments
230	31.0–60.9	650–770	two concentric cylinders with hemispherical bases

TABLE 922. Na_3AsO_4 - NaOH: Viscosity (cp)

T(K)	Mol percent NaOH	
	48.9	39.4
650	8.54	
730	2.04	13.48
750	1.86	7.85
770		4.69

For two compositions, single data points, only, were reported, i.e.: 60.9 mol % NaOH (1.44 P, 653 K); 31.0 mol % NaOH (6.03 P, 773 K).

Temperature-dependent equations

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

Mol % NaOH	a	$-b \times 10^3$	$c \times 10^6$	standard error of estimate
48.9	403.845	1077.35	721.83	15.56%
39.4	1916.538	4870.05	3100.17	0.56%

These values are based on the data of Urazov, Lovchikov and Lipshits (oscillational method) [230].

Na_3SbO_4 - NaOH

Melt Preparation and Purification

For the method of melt preparation used by Urazov et al. [230], see: Na_3AsO_4–NaOH.

TABLE 923. Viscosity studies: Na_3SbO_4 - NaOH

Investigations critically examined

Ref.	Mol % NaOH	Temp. range (K)	Comments
230	46–68	650–750	see: Na_3AsO_4–NaOH

TABLE 924. Na_3SbO_4 - NaOH: Viscosity (cp)

T(K)	Mol percent NaOH				
	68	62	56	50	46
650	10.3	15.8	23.5	32.6	37.1
700	8.5	12.7	19.2	27.5	32.6
740	6.0	9.3	14.5	22.1	27.3
750	5.2	8.3	13.1	20.5	25.7

Temperature-dependent equations

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

Mol % NaOH	$-a$	$b \times 10^3$	$-c \times 10^6$	standard error of estimate
68	104.15	372.5	302.3	1.03%
62	57.15	274.5	249.6	0.54%
56	85.00	401.4	360.7	2.39%
50	84.28	440.2	400.6	1.96%
46	129.07	575.8	492.6	1.04%

These values are based on the data of Urazov, Lovchikov and Lipshits (oscillational method) [230].

$Na_2Si_2O_5$ - $PbSiO_3$

Melt Preparation and Purification

No information on melt preparation was given in the study by Trifonov [231].

TABLE 925. Viscosity studies: $Na_2Si_2O_5$ - $PbSiO_3$

Investigations critically examined

Ref.	Mol % $PbSiO_3$	Temp. range (K)	Comments
231	0-100	663-1163	-

TABLE 926. $Na_2Si_2O_5$ - $PbSiO_3$: Viscosity (cp)

T(K)	Mol percent $PbSiO_3$			
	80	60	40	20
390 800	The results of the measurements by Pospelov and Evstropev [233] are cited in the review by Trifonov [231] in the form of a log η vs. composition graph. The information given therein is insufficient for critical analysis. The publication of Pospelov and Evstropev [233] could not be retrieved through normal interlibrary loan channels.			

LiF - BeF_2 - ThF_4

Melt Preparation and Purification

Cantor [74] purified LiF by recrystallizing from slowly cooled melts. Thorium tetrafluoride was recrystallized in a graphite crucible by slowly heating the commercial, anhydrous product to melting under a He atmosphere. The BeF_2 was purified by sublimation.

TABLE 927. Density studies: LiF - BeF_2 - ThF_4

Investigations critically examined

Ref.	Mol percent LiF:BeF_2:ThF_4	Temp. range (K)	Comments
74	as in Table 928	800-1010	Pt bob, melt contained in cylindrical Ni vessel; calibration: H_2O

TABLE 928. LiF - BeF_2 - ThF_4: Density (g cm^{-3})

T(K)	Mol percent LiF:BeF_2:ThF_4		
	70.1:23.9:6.0	70.0:18.0:12.0	70.0:15.0:15.0
800		3.400	
830	2.738	3.376	3.651
980	2.637	3.255	3.508
1010		3.230	3.480

Temperature-dependent equations

$\rho = a + bT$

Mol percent LiF:BeF_2:ThF_4	a	$-b \times 10^3$
70.1:23.9:6.0	3.295	0.671
70.0:18.0:12.0	4.044	0.805
70.0:15.0:15.0	4.439	0.950

These values are based on the data of Cantor (dilatometric method); data in equation form; precisions not estimated [74].

TABLE 929. Viscosity studies: LiF - BeF_2 - ThF_4

Investigations critically examined

Ref.	Mol percent LiF:BeF_2:ThF_4	Temp. range (K)	Comments
74	as in Table 930	800-1010	Inconel rotating spindle; calibration: H_2O

TABLE 930. LiF - BeF_2 - ThF_4: Viscosity (cp)

T(K)	Mol percent LiF:BeF_2:ThF_4	
	72.7:15.7:11.6	70.1:23.9:6.0
800		15.74
840	14.18	12.13
900	10.25	8.57
920	9.29	
940	8.45	

Temperature-dependent equations

$\eta = A \exp [E/RT]$

Mol percent LiF:BeF_2:ThF_4	A	E
72.7:15.7:11.6	0.10910	8125
70.1:23.9:6.0	0.06625	8697

These values are based on the data of Cantor (oscillational method); data in equation form; precisions not estimated [74].

LiF - BeF_2 - ZrF_4

Melt Preparation and Purification

For the method of melt preparation used by Cantor [74], see: LiF-BeF_2-ThF_4. The ZrF_4 was sublimed and dried under vacuum.

TABLE 931. Density studies: $LiF - BeF_2 - ZrF_4$

Investigations critically examined

Ref.	Mol percent $LiF:BeF_2:ZrF_4$	Temp. range (K)	Comments
74	64.7:30.1:5.2	720–960	see: $LiF–BeF_2–ThF_4$

TABLE 932. $LiF - BeF_2 - ZrF_4$: Density (g cm^{-3})

T(K)	Mol percent $LiF:BeF_2:ZrF_4$
	64.7:30.1:5.2
720	2.281
810	2.229
900	2.177
960	2.142

Temperature-dependent equation

$\rho = 2.697 - 0.578 \times 10^{-3}T$

These values are based on the data of Cantor (dilatometric method); data in equation form; precisions not estimated [74].

$LiF - BeF_2 - ZrF_4 - UF_4$

Melt Preparation and Purification

For the method of melt preparation used by Cantor [74] see: $LiF–BeF_2–ThF_4$. The ZrF_4 was sublimed and dried under vacuum.

TABLE 933. Density studies: $LiF - BeF_2 - ZrF_4 - UF_4$

Investigations critically examined

Ref.	Mol percent $LiF:BeF_2:ZrF_4:UF_4$	Temp. range (K)	Comments
74	64.79:29.96:4.99:0.26	790–1030	see: $LiF\ BeF_2\ ThF_4$

TABLE 934. $LiF - BeF_2 - ZrF_4 - UF_4$: Density (g cm^{-3})

T(K)	Mol percent $LiF:BeF_2:ZrF_4:UF_4$
	64.79:29.96:4.99:0.26
790	2.243
850	2.209
910	2.176
1000	2.125
1030	2.108

Temperature-dependent equation

$\rho = 2.687 - 0.562 \times 10^{-3}T$

These values are based on the data of Cantor (dilatometric method); data in equation form; precisions not estimated [74].

9. Salt Systems: Cross Index

In the following table, the letters in parentheses refer to the section in the manuscript where information on the system is to be found.

Salt	*Systems*	
AgBr	(A)	$-AgNO_3$; $-Ag_2Te$;
AgCl	(A)	$-AgNO_3$; $-Ag_2S$; $-Ag_2Se$; $-Ag_2Te$
$AgClO_3$	(C)	$LiNO_3$–
AgI	(A)	$-AgNO_3$; $-Ag_2S$; $-Ag_2Te$
$AgNO_3$	(A)	AgCl–; AgBr–; $HgBr_2$–; AgI–; HgI_2–
Ag_2S	(A)	AgCl–; AgI–
Ag_2Se	(A)	AgCl–
Ag_2Te	(A)	AgCl–; AgBr–; AgI–
AlF_3	(A)	$-Na_3AlF_6$
Al_2O_3	(A)	CaF_2–; NaF–
	(B)	$-K_3AlF_6$; $-Li_3AlF_6$; $-Li_2CO_3$; $-Na_3AlF_6$ $-Na_3AlF_6–SiO_2$
$BaCl_2$	(A)	$-NaNO_3$; $-Li_2SO_4$; $-Na_3AlF_6$; $-Na_3AlF_6$ BaF_2
BaF_2	(A)	$-CaSiO_3$; $-Na_3AlF_6$; BaCl–Na_3AlF_6–
BaO	(A)	CaF_2–
BeF_2	(A)	$-Na_3AlF_6$
	(C)	$LiF–ThF_4$; $LiF–ZrF_4$; $LiF–ZrF_4–UF_4$
Bi_2O_3	(B)	$-K_2B_4O_7$; $-KPO_3$; $-Na_2B_4O_7$; $-NaPO_3$
B_2O_3	(A)	NaCl–; NaF–
	(B)	$-Cs_2CO_3$; $-K_2B_4O_7$; $-K_2CO_3$; $-Li_2CO_3$; $-Na_3AlF_6$; $-Na_2B_4O_7$; $-Na_2CO_3$; $-NaPO_3$; $-Rb_2CO_3$
CaC_2	(B)	CaO–; Fe_2O_3–; SiO_2–
$CaCl_2$	(A)	$-CaMoO_4$; $-CaO$;
$CaCrO_4$	(A)	LiCl–; LiCl–KCl–
CaF_2	(A)	$-Al_2O_3$; $-BaO$; $-CaO$; $-CaSiO_3$; $-MgO$; $-Na_3AlF_6$; $-Na_2B_4O_7$; $-SiO_2$; $-TiO_2$; $-V_2O_5$; $-ZrO_2$
$CaMoO_4$	(A)	$CaCl_2$–
CaO	(A)	$CaCl_2$–; CaF_2–; NaF–
	(B)	$-CaC_2$; $-SiO_2$
	(C)	Na_2CO_3–NaOH–
$CaSb_2O_4$	(B)	Sb_2O_3–
$CaSb_2O_6$	(B)	Sb_2O_3–
$Ca_4Sb_6O_{23}$	(B)	Sb_2O_3–
$CaSiO_3$	(A)	BaF_2–; CaF_2–; KF–; LiF–; MgF_2–; NaF–
$(CH_3)_4NClO_4$	(A)	$HgBr_2$–
$CoBr_2$	(A)	$-KNO_3$
$CoCl_2$	(A)	$-KNO_3$
CsBr	(A)	$-ZnSO_4$
CsCl	(A)	$-Cs_2SO_4$; $-Li_2SO_4$
Cs_2CO_3	(B)	B_2O_3–
Cs_2SO_4	(A)	CsCl–
CuCl	(A)	$-Cu_2S$
Cu_2S	(A)	CuCl–
$FeCl_2$	(A)	–FeS
Fe_2O_3	(B)	$-CaC_2$; $-Li_2CO_3$
FeS	(A)	$FeCl_2$–
$HgBr_2$	(A)	$-AgNO_3$; $-(CH_3)_4NClO_4$; –HgO; $-Hg(NO_3)_2$; –HgS; –HgSe; $-HgSO_4$; –HgTe; $-Tl_2SO_4$;
$HgCl_2$	(A)	$-TlNO_3$
HgI_2	(A)	$-AgNO_3$; $-TlNO_3$
$Hg(NO_3)_2$	(A)	$HgBr_2$–
HgO	(A)	$HgBr_2$–
HgS	(A)	$HgBr_2$–
$HgSO_4$	(A)	$HgBr_2$–
HgSe	(A)	$HgBr_2$–
HgTe	(A)	$HgBr_2$–
K_3AlF_6	(B)	Al_2O_3–
KBF_4	(A)	KF–
KBO_2	(C)	$-KPO_3$

Salt	*Systems*	
$K_2B_4O_7$	(B)	B_2O_3–; Bi_2O_3–; NiO–; PbO–
KBr	(A)	–KNO_3; –Na_2SO_4; –$ZnSO_4$
$KCHO_2$	(C)	–$KC_2H_3O_2$
$KC_2H_3O_2$	(C)	$KCHO_2$–; $NaNO_3$–;
$KC_3H_5O_2$	(C)	$NaNO_3$–
KCl	(A)	–K_2CO_3; –KNO_3; –KPO_3; –K_3PO_4; –$K_4P_2O_7$; –K_2SO_4; –$Na_2B_4O_7$; –K_2ZrF_6; –Li_2CO_3; –$LiNO_3$; –Li_2SO_4; –Na_2CO_3; –$NaNO_3$; –Na_2SO_4; –NH_4NO_3; –$ZnSO_4$ NaCl–Na_2SO_4; LiCl–$CaCrO_4$
$KClO_4$	(C)	KNO_3–; $LiNO_3$–; $NaNO_3$–
K_2CO_3	(A)	KCl–; LiF–; NaCl–; LiCl–
	(B)	B_2O_3–
	(C)	–KOH; –Li_2SO_4; –KOH–CaO; –KOH–KCl; –KOH–K_2SiO_3
$K_2Cr_2O_7$	(C)	KNO_3–; $NaNO_3$–
KF	(A)	–$CaSiO_3$; –KBF_4; –KPO_3; –K_2SiF_6; –K_2ZrF_6; –Li_2CO_3; –$Na_2B_4O_7$
KI	(A)	–Na_2SO_4; –$ZnSO_4$
K_2MoO_4	(B)	MoO_3–
	(C)	KNO_3–; KNO_2–
KNO_2	(C)	–K_2MoO_4; –K_2WO_4
KNO_3	(A)	$CoBr_2$–; KBr–; KCl–; LiCl–; TlBr–; TlCl–; $CoCl_2$–
	(C)	–$KClO_4$; –$K_2Cr_2O_7$; –K_2MoO_4; –KOH; –K_2WO_4; –$LiClO_4$; –$NaClO_4$; –$Na_2Cr_2O_7$;
K_2O	(B)	–$Zn(PO_3)_2$
KOH	(C)	K_2CO_3–;KNO_3–; K_2CO_3–CaO; K_2CO_3–KCl; K_2CO_3–K_2SiO_3
KPO_3	(A)	KCl–; KF–
	(B)	Bi_2O_3–; NiO–; PbO–; WO_3–; ZnO–
	(C)	KBO_2–; –K_3PO_4; –$K_4P_2O_7$;
K_3PO_4	(A)	KCl–
	(C)	KPO_3–
$K_4P_2O_7$	(A)	KCl–
	(C)	KPO_3–
K_2SiF_6	(A)	KF–
K_2SO_4	(A)	KCl–; NaBr–; NaCl–; NaCl–Na_2SO_4–; RbCl–
	(C)	–K_2WO_4; Li_2CO_3–
K_2TaF_7	(B)	Ta_2O_5–
K_2TiF_6	(A)	NaCl–
	(B)	TiO_2–
KVO_3	(B)	V_2O_5–
K_2WO_4	(B)	WO_3–
	(C)	KNO_3–; KNO_2–; K_2SO_4–; Li_2SO_4–
K_2ZrF_6	(A)	KCl–; KF–; NaCl–
	(C)	$Na_2B_4O_7$–
Li_3AlF_6	(B)	Al_2O_3–
LiCl	(A)	–Li_2CO_3; –$CaCrO_4$; –K_2CO_3; –$LiClO_4$; –$LiNO_3$; –$Na_2B_4O_7$; –KNO_3; –KCl–$CaCrO_4$ $NaNO_3$
$LiClO_3$	(C)	$LiNO_3$–; LiOH–
$LiClO_4$	(A)	LiCl–
	(C)	KNO_3–; $LiNO_3$–; $NaNO_3$–
Li_2CO_3	(A)	KCl–; KF–; LiCl–
	(B)	Al_2O_3–; B_2O_3–; Fe_2O_3–; Li_2O–; SiO_2–; Tl_2O_3–
	(C)	–K_2SO_4; –LiOH
LiF	(A)	–$CaSiO_3$; –K_2CO_3; –$LiPO_3$; –Na_3AlF_6
	(C)	–BeF_2–ThF$_4$; –BeF_2–ZrF_4; –BeF_2–ZrF_4 UF_4
Li_2MoO_4	(B)	MoO_3–
$LiNO_3$	(A)	KCl–; LiCl–
	(C)	–$AgClO_3$; –$KClO_4$; –$LiClO_3$; –$LiClO_4$; –LiOH; –$NaClO_4$
Li_2O	(B)	–Li_2CO_3
LiOH	(C)	Li_2CO_3–; $LiClO_3$–; $LiNO_3$–
$LiPO_3$	(A)	LiF–
	(C)	–Li_3PO_4; –$Li_4P_2O_7$

Salt	*Systems*	
Li_3PO_4	(C)	$LiPO_3$–
$Li_4P_2O_7$	(C)	$LiPO_3$–
Li_2SO_4	(A)	$BaCl_2$–; CsCl–; KCl–; NaCl–; RbCl–
	(C)	K_2CO_3–; –K_2WO_4; –Li_2WO_4; $NaPO_3$–
Li_2WO_4	(B)	WO_3–
	(C)	Li_2SO_4–
$MgCl_2$	(A)	–MgO
MgF_2	(A)	–$CaSiO_3$; –Na_3AlF_6
MgO	(A)	CaF_2–; $MgCl_2$–
MoO_3	(B)	–K_2MoO_4; –Li_2MoO_4; –Na_2MoO_4
$NaAlF_4$	(A)	NaF–
Na_3AlF_6	(A)	AlF_3–; $BaCl_2$–; $BaCl_2$–BaF_2; BaF_2–; BeF_2–; CaF_2–; LiF–; MgF_2–; NaCl–; NaF–
	(B)	Al_2O_3–; Al_2O_3–SiO_2; B_2O_3–; SiO_2–
Na_3AsO_4	(C)	–NaOH
$NaBF_4$	(A)	NaF–
$NaBO_2$	(C)	–$NaPO_3$
$Na_2B_4O_7$	(A)	CaF_2–; KCl–; KF–; LiCl–; NaCl–; NaF–; ZrF_4–
	(B)	B_2O_3–; Bi_2O_3–; NiO–; PbO–; WO_3–
	(C)	–K_2ZrF_6; $NaPO_3$–
NaBr	(A)	–K_2SO_4; –Na_2CrO_4
NaCl	(A)	–B_2O_3; –K_2CO_3; –K_2SO_4; –K_2TiF_6; –K_2ZrF_6; –Li_2SO_4; –Na_3AlF_6; –$Na_2B_4O_7$ –Na_2CO_3; –$NaNO_3$; –Na_2O; –NaOH; –$NaPO_3$; –$Na_4P_2O_7$; –Na_2SO_4; –Na_2TiF_6; –Na_2ZrF_6; –Na_2SO_4–K_2SO_4; –KCl–Na_2SO_4 Na_2CO_3–NaOH
$NaClO_3$	(C)	$NaNO_3$–
$NaClO_4$	(C)	KNO_3–; $LiNO_3$–; $NaNO_3$–
Na_2CO_3	(A)	KCl–; NaCl–
	(B)	B_2O_3–;
	(C)	–NaOH; –NaOH–CaO; –NaOH–NaCl; –NaOH–Na_2SiO_3;
Na_2CrO_4	(A)	NaBr–
$Na_2Cr_2O_7$	(C)	KNO_3–
NaF	(A)	–Al_2O_3; B_2O_3; –CaO; –$CaSiO_3$; –$NaAlF_4$ –Na_3AlF_6; –$NaBF_4$; –$Na_2B_4O_7$; –$NaNO_3$; –$NaPO_3$; –Na_2ZrF_6;
NaI	(A)	–$NaNO_3$; –Na_2SO_4
Na_2MoO_4	(B)	MoO_3–
	(C)	$NaNO_3$–; $NaNO_2$–
$NaNO_2$	(C)	–Na_2MoO_4; –Na_2WO_4
$NaNO_3$	(A)	$BaCl_2$–; KCl–; LiCl–; NaCl–; NaF–; NaI–; $PbCl_2$–; TlCl–
	(C)	–$KC_2H_3O_2$; –$KC_3H_5O_2$; –$KClO_4$; –$K_2Cr_2O_7$ –$LiClO_4$, –$NaClO_3$, –$NaClO_4$, –Na_2MoO_4 –NaOH; –Na_2WO_4; –Na_2SO_4;
Na_2O	(A)	NaCl–
	(B)	–$Zn(PO_3)_2$
NaOH	(A)	NaCl–
	(C)	Na_3AsO_4–; Na_2CO_3–; Na_2CO_3–NaCl; Na_2CO_3–CaO; Na_2CO_3–Na_2SiO_3; $NaNO_2$–; Na_3SbO_4–
$NaPO_3$	(A)	NaCl–; NaF–
	(B)	B_2O_3–; Bi_2O_3–; $NaBO_2$–; NiO–; PbO–; WO_3–; ZnO–
	(C)	–Li_2SO_4; –$Na_2B_4O_7$; –Na_3PO_4; –$Na_4P_2O_7$ –Na_2SO_4; –Rb_2SO_4; –UO_2SO_4
Na_3PO_4	(C)	$NaPO_3$–
$Na_4P_2O_7$	(A)	NaCl–
	(B)	WO_3–
	(C)	$NaPO_3$–; –Na_2SO_4
Na_3SbO_4	(C)	–NaOH
Na_2SO_4	(A)	KBr–; KCl–; KI–; NaCl–; NaI–; RbCl–; NaCl–K_2SO_4; NaCl–KCl–
	(C)	$NaNO_3$–; $NaPO_3$–; $Na_4P_2O_7$–
Na_2SiO_3	(C)	Na_2CO_3–NaOH
$Na_2Si_2O_5$	(C)	–$PbSiO_3$

Salt	*Systems*	
Na_2TiF_6	(A)	NaCl–
	(B)	TiO_2–
$NaVO_3$	(B)	V_2O_5–
Na_2WO_4	(B)	WO_3–
	(C)	$NaNO_3$–; $NaNO_2$–
Na_2ZrF_6	(A)	NaCl–; NaF–
NH_4NO_3	(A)	KCl–
	(C)	–$(NH_4)H_2PO_4$
$(NH_4)H_2PO_4$	(C)	–NH_4NO_3
NiO	(B)	–$K_2B_4O_7$; –KPO_3; –$Na_2B_4O_7$; –$NaPO_3$
$PbCl_2$	(A)	–$NaNO_3$; –PbS
PbF_2	(A)	–PbO
$PbMoO_4$	(B)	PbO–
PbO	(A)	PbF_2–
	(B)	–$K_2B_4O_7$; –KPO_3; –$Na_2B_4O_7$; –$NaPO_3$; –$PbMoO_4$
PbS	(A)	$PbCl_2$–
$PbSiO_3$	(C)	$Na_2Si_2O_5$–
RbCl	(A)	–K_2SO_4; –Li_2SO_4; –Na_2SO_4; –Rb_2SO_4
Rb_2CO_3	(B)	B_2O_3–
Rb_2SO_4	(A)	RbCl–
	(C)	$NaPO_3$–
Sb_2O_3	(B)	–$CaSb_2O_4$; –$CaSb_2O_6$; –$Ca_4Sb_6O_{23}$
SiO_2	(A)	CaF_2–
	(B)	Al_2O_3–Na_3AlF_6–; –CaC_2; CaO–; –Li_2CO_3 –Na_3AlF_6
Ta_2O_5	(B)	–K_2TaF_7
ThF_4	(C)	LiF–BeF_2–
TiO_2	(A)	CaF_2–
	(B)	–K_2TiF_6; –Na_2TiF_6
TlBr	(A)	–KNO_3
TlCl	(A)	–KNO_3; –$NaNO_3$; –$ZnSO_4$
$TlNO_3$	(A)	$HgCl_2$–; HgI_2–
Tl_2O_3	(B)	–Li_2CO_3
Tl_2SO_4	(A)	$HgBr_2$–
UF_4	(C)	LiF–BeF_2–ZrF_4–
UO_2SO_4	(C)	$NaPO_3$–
V_2O_5	(A)	CaF_2–
	(B)	–KVO_3; –$NaVO_3$
WO_3	(B)	–KPO_3; –K_2WO_4; –Li_2WO_4; –$Na_2B_4O_7$; –$NaPO_3$; –$Na_4P_2O_7$; –Na_2WO_4
ZnO	(B)	–KPO_3; –$NaPO_3$; –$Zn(PO_3)_2$
$Zn(PO_3)_2$	(B)	K_2O–; Na_2O–; ZnO–
$ZnSO_4$	(A)	CsBr–; KBr–; KCl–; KI–; TlCl–
ZrF_4	(A)	–$Na_2B_4O_7$
	(C)	LiF–BeF_2–; LiF–BeF_2–UF_4
ZrO_2	(A)	CaF_2–

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