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Molten Salts: Volume 4, Part 2, Chlorides and Mixtures

Electrical Conductance, Density, Viscosity, and Surface Tension Data

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Data on the electrical conductance, density, viscosity, and surface tension of chloride mixtures have been systematically collected and evaluated. Results are given for 124 binary mixtures over a range of compositions and temperatures. Values of the above properties for the single salts have been updated in accord with previously advanced recommendations.

Key words: Chlorides; data compilation; density; electrical conductance; molten salt mixtures; standard reference data; surface tension; viscosity.

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1. Introduction

The published data for the four physical properties: electrical conductance, density, viscosity, and surface tension for molten mixtures of chlorides—chlorides have been reviewed and critically assessed, and the results of this work, together with value judgments are reported herewith. This publication is Part 2 of Volume 4: Binary Mixtures of Halides. For earlier publications in this series see [1,2,3,4][1]. In addition to the assessment of the binary chlorides, a review of the data for single salt chloride melts was undertaken as an update to the recommendations advanced in 1968 and 1969, and the results of this work are also reported.

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

[1]Numbers in brackets refer to literature references in section 8.

2. Symbols and Units

The symbols and units[2] for the four physical properties in this compilation are:

κ = specific conductance ($ohm^{-1}cm^{-1}$)
ρ = density ($g\ cm^{-3}$)
η = viscosity (cp)
γ = surface tension ($dyn\ cm^{-1}$).[3]

In addition:

E = activation energy ($cal\ mol^{-1}$)
Λ = equivalent conductance ($ohm^{-1}\ cm^2\ equiv^{-1}$)
C = concentration (mol %)
R = gas constant = 1.98717 $cal\ mol^{-1}\ deg^{-1}$
T = temperature in kelvins, defined on the thermodynamic scale by assigning 273.16 K to the triple point of water (freezing point, 273.15 K = 0°C).

[2]For conversion to the SI system:

$$1\ ohm^{-1}cm^{-1} = 1 \times 10^2\Omega^{-1}m^{-1}$$
$$1\ g\ cm^{-3} = 1 \times 10^3 K\ g\ cm^{-3}$$
$$1\ cp = 1 \times 10^{-3} N\ s\ m^{-2}$$
$$1\ dyn\ cm^{-1} = 1 \times 10^{-3} N\ m^{-1}$$
$$1\ cal\ mol^{-1} = 4.184\ J\ mol^{-1}.$$

[3]When γ is treated as a free energy per unit area, it is given the unit, erg cm^{-3}; this is dimensionally identical to dyn cm^{-1}.

3. Experimental Methods

The principles and practice of experimental measurements of electrical conductance, density, viscosity, and surface tension have been reported in the preceding volumes [2, 3, 4] as well as more specific remarks of utility relative to molten nitrates and molten fluorides. See also [222] and [305] for some additional comments. These principles and procedures are generally applicable to work with molten chlorides if due care is taken in the selection of materials for containment of the melts; chlorides are less "aggressive" than fluorides and the material problems are, accordingly, less severe. Pyrex, Vycor, quartz, and platinum have been widely used in contact with molten chlorides; useful summary tables on containment and corrosion are given elsewhere by Janz[4], and the theoretical principles have been discussed by Littlewood[5]. Information on melt purification, containment, and experimental techniques, as reported for the various binary chloride-chloride mixtures, has been summarized and this is given elsewhere in this work. The remarks in this section are limited to some points for attention when precision and accuracy are important considerations to the measurements.[6]

3.1. Electrical Conductance

A study of the experimental methods used for molten salt conductivities has been reported by Ketelaar and Maenaut[7], with particular attention to possible errors. The results may be summarized as follows.

The various conductance cell designs may be grouped into 3 principle design types: (i) the U-shaped capillary design, open only to the two electrodes and in which the molten salt is entirely contained within the cell; (ii) the dip-type capillary design, consisting of a single capillary, or "twin" capillaries immersed in the molten salt, with the result that the external surfaces of the cell are also in contact with the melt; and (iii) the non-capillary type cells having plane electrodes or hemispherical electrodes immersed in the molten salt. With the former two types, high cell constants can be attained with the result that the conventional high-precision AC conductance bridge techniques are readily applicable; with the latter, high cell constants cannot be achieved so that special techniques suitable for very low resistance measurements must be used, e.g. such as the Kelvin double bridge.

The conductance recommendations advanced for the alkali halides as single salt melts in the first volume in this series [1], were based on the work of Van Artsdalen and coworkers, in which versions of the dip-type capillary cells were used. The possibility of parasitic conductance through the cell walls exists in this design. Although the conductivity of quartz glass is negligible at temperatures as high as 1000 °C, this may no longer hold true when the quartz surfaces are in direct contact with the molten salt. The diffusion effect of alkali ions of smaller ionic radii (e.g., Li^+, Na^+) from the melt into the quartz may be sufficiently significant at the higher temperatures (800-1000 °C) to constitute a parasitic conductance, with the result that observed values will be too high. The electrical conductance of molten sodium chloride has thus been reinvestigated by Ketelaar and Maenaut, with special attention to possible errors due to this factor. The parasitic conductance of the walls, for cells of the dip-type, was measured in the temperature range of 800-1000 °C, using molten NaCl and high precision ac conductance techniques. A redetermination of the conductivity of molten NaCl with the U-shaped capillary cell design was undertaken and these results together with an overview of the total input for NaCl are given below.

A graphical comparison of the percent departures of the data of various investigators with the NSRDS recommended data base is shown in figure 1. Values of both the specific conductance and the equivalent conductance at rounded temperatures from the investigations of Van Artsdalen and Yaffe [1] and Ketelaar and Maenaut [309] are given in table 1.

TABLE 1. Comparison of specific conductance (κ) and equivalent conductance (Λ) values at rounded temperatures for NaCl from the investigations for Van Artsdalen and Yaffe [1] and Ketelaar and Maenaut [309]

	κ (ohm^{-1} cm^{-1})		Λ (ohm^{-1} cm^2 equiv^{-1})	
T	Van Artsdalen	Ketelaaer	Van Artsdalen	Ketelaaer
1080	3.596		135.4	
1090	3.629		137.1	
1100	3.660	3.689	138.8	140.0
1110	3.692	3.715	140.4	141.3
1120	3.723	3.740	142.1	142.7
1130	3.753	3.764	143.8	144.1
1140	3.783	3.787	145.4	145.4
1150	3.813	3.810	147.1	146.8
1160	3.842	3.831	148.8	148.1
1170	3.870	3.852	150.4	149.4
1180	3.898	3.872	152.1	150.7
1190	3.926	3.891	153.7	152.0
1200	3.954	3.910	155.3	153.3
1210	3.980	3.927	157.0	154.6
1220	4.007	3.944	158.6	155.9
1230	4.033	3.960	160.2	157.1
1240	4.058	3.975	161.8	158.4
1250	4.083	3.990	163.4	159.6
1260	4.108	4.003	165.0	160.8
1270	4.132	4.016	166.6	162.0
1280	4.156	4.028	168.2	163.2
1290	4.179	4.039	169.8	164.4

Temperature-dependent equations

$\kappa_{\text{Van Artsdalen}}{}^{a} = -2.4975 + 8.0431 \cdot 10^{-3}T - 2.2227 \cdot 10^{-6}T^2$

$\Lambda_{\text{Van Artsdalen}}{}^{a} = 544.6 \exp(-2990/RT)$

$\kappa_{\text{Ketelaar}} = -4.0896 + 0.11528 \cdot 10^{-3}T - 4.0534 \cdot 10^{-6}T^2$

standard error of estimate = 0.27%

$\Lambda_{\text{Ketelaar}} = 417.7 \exp(-2390/RT)$

standard error of estimate = 0.30%

[a]From reference [1].

[4]G. J. Janz; Molten Salts Handbook; Sec. V.B. p. 388-405; Academic Press, N.Y. (1969).

[5]R. Littlewood, in "Corrosion", R. Schrier ed., Vol. 2, Chap. 9. MacMillan (Pergamon) N.Y. (1963).

[6]The commercial sources of certain materials are identified in this article in order to specify adequately the experimental procedure. Such identification does not in any case imply recommendation or endorsement of the material by the National Bureau of Standards.

[7]J. A. A. Ketelaar and P. P. E. Maenaut; Electrochimica Acta, 17, 2195 (1972).

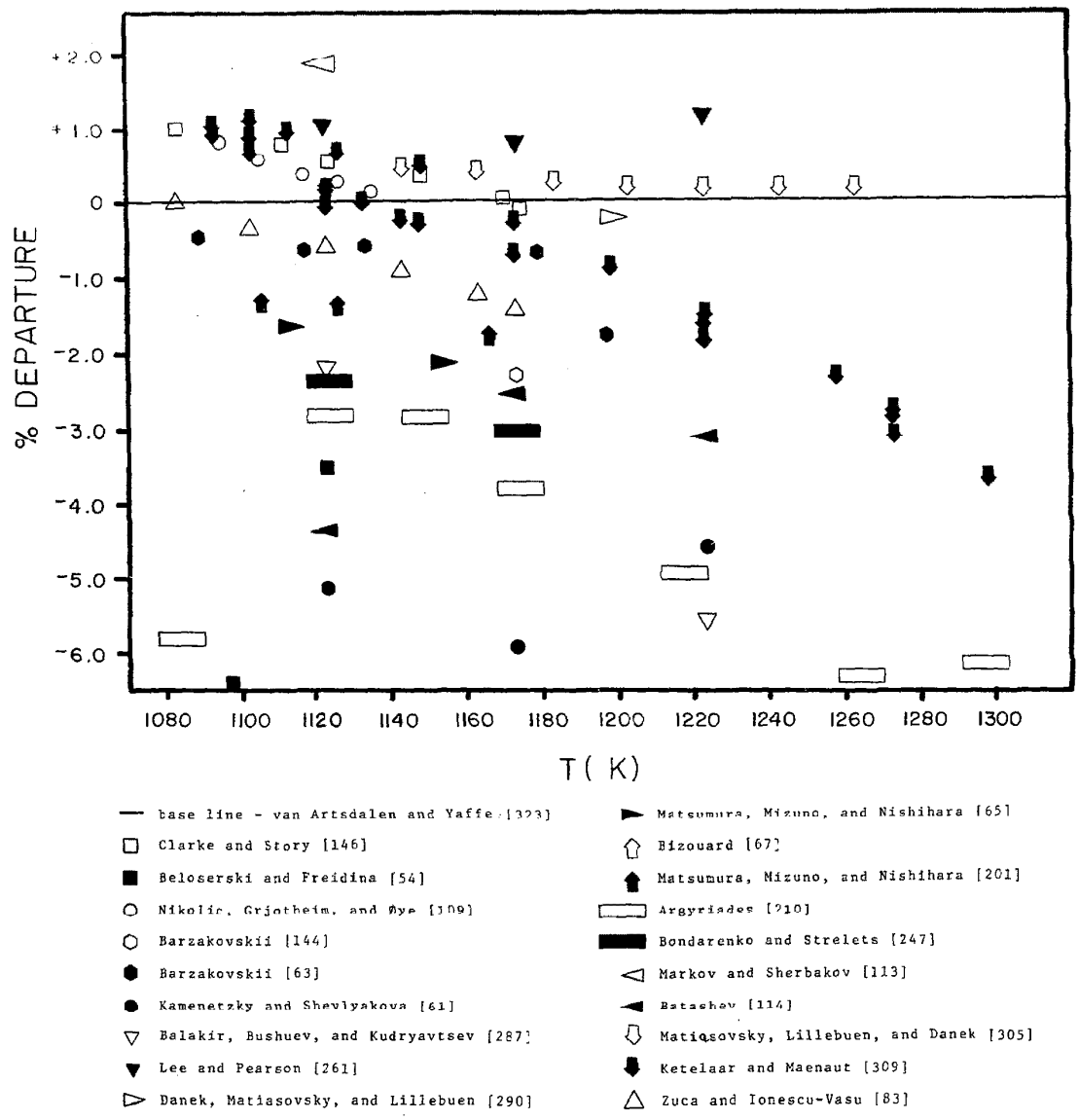


FIGURE 1. Comparison of percent departure of the data of various investigators with the van Artsdalen specific conductance data for NaCl.

Inspection shows that the techniques are in agreement (±1.0%) for temperatures from 800 °C to ~930 °C; at higher temperatures, the dip-type results are uniformly higher (maximum percent departure, —3.35%, 1020 °C). The parasitic conductance effect is thus a significant factor, and due cognizance of this is important for measurements where highest accuracy is an important consideration. If dip-type cells are used, the parasitic conductance effect may be corrected for by undertaking additional measurements with an assembly in which the capillaries of the conductance cells have been flame-sealed; the effect may also be diminished by a double walled capillary, in which the two surfaces are separated by an air layer. The alternate is to avoid this through the use of the U-shaped capillary design, air thermostatted, and in which the molten salt is entirely contained within the conductance cell.

Inspection of the updates for RbCl and CsCl, show quite similar deviations when the van Artsdalen results are compared with results from other laboratories and this appears as additional support for the preceding viewpoints. It is apparent that unless due care is taken to eliminate the conductance parasitics, measurements of the electrical conductivity of such molten salts at temperatures above 850 °C should be viewed with caution.

3.2. Density

Some five techniques have been used for the density determinations of mixtures of molten chlorides: (i) Archi-

medean method, (ii) dilatometry, (iii) a flotation technique, (iv) pycnometry, and (v) the bubble pressure principle. The principles of the three most widely used techniques have been reviewed elsewhere [3]. The flotation method, used by Boston [90, 110] for alkali-halide-$AlCl_3$ mixtures, is a recent innovation, well suited for moderately low melting systems and capable of good precision and accuracy.

3.3. Viscosity

The problem of selected molten salts as calibrating fluids for molten salt viscometers may be summarized as follows.

The viscosity of molten KNO_3 has been investigated some 13 times since the studies of Kalmus and Lorenz in 1907, and at least 8 times in the past decade (with both capillary and oscillational techniques). A statistical treatment of the values falling within the limits 1.0-1.5% agreement, gives the following results [353]:

KNO_3 (temp. range, 630-750 K)
(110 data points, 13 investigations)

Power series equation:

$$\eta = 28.404 - 0.06752062T + 0.4220783 \times 10^{-4}T^2$$
(standard error of estimate $= 2.05 \times 10^{-2}$)

and the derived viscosities at rounded temperatures are:

T (K)	620	630	640	650	660	670	680	690
KNO_3 (cp)	2.76	2.62	2.48	2.35	2.23	2.11	2.01	1.91

T (K)	700	710	720	730	740	750	760
KNO_3 (cp)	1.82	1.74	1.67	1.61	1.55	1.51	1.47

The preceding results are thus based on the results of some 13 studies independently undertaken at various laboratories using either the capillary or the damped oscillational viscosity techniques. An accuracy of better than ±1.5% may be assigned to the values thus established, and within these limits, the results appear suitable for cross-checks of viscometer calibrations at moderately high temperatures.

At somewhat higher temperatures, i.e. molten alkali metal halides, (900–1300 K) the data are insufficiently well established to enable recommendations to be developed from the viewpoints of calibration quality data. The situation may be summarized as follows. Viscosity values that have been established by two differing viscosity techniques (e.g., the capillary and damped oscillational techniques) are non-existant for the alkali halides, and indeed for any halides in this temperature range. Potassium chloride would appear a suitable candidate for this in view of its availability, ease of purification, and high temperature stability. Of the 7 data sets known for KCl, all are from the damped oscillational viscosity technique. A statistical least-squares analysis of the data falling within the limits of ±1.5% agreement gives the results:

KCl (temp. range, 1060–1200 K)
(5 investigations, 23 data points)

$$\eta = 12.838 - 0.18646 \times 10^{-1}T + 0.71861 \times 10^{-5}T^2$$
(stand. error of estimate, 9.90×10^{-3} (1.01%)

The viscosities at rounded temperatures thus derived are:

T (K)	1060	1070	1080	1090	1100
KCl (cp)	1.138	1.105	1.073	1.042	1.013

T (K)	1110	1120	1130	1140	1150
KCl (cp)	0.986	0.960	0.935	0.911	0.890

T (K)	1160	1170	1180	1190	1200
KCl (cp)	0.869	0.850	0.832	0.816	0.802

Two data sets fall far outside these limits, the 1964 results of Nishihara et al.[8] (20–24% departure; uniformly positive), and the 1970 results of Grjotheim et al.[9] (−7 to −10% departure; uniformly negative). In the application of the oscillational technique, it appears insufficient to cross-check the calibration with molten KNO_3 if the subsequent measurements are at much higher temperatures (as for the molten halides) since the temperature gradients of the torsion wire will differ, and this may be the source of changes in the torsional constants.[10] Attention is also directed to the recent results for CsCl by Zuca[11] and given elsewhere in this work; the data show uniformly large positive departures (as much as 20%) from the previously reported data (all by the oscillational technique). In light of these recent results from the Trondheim and Bucharest schools[9, 11], the estimates of accuracy for viscosity data for the molten halides, which rests on the oscillational technique, must be accepted with reservations. It thus appears that if this technique is to be used with a reasonable confidence factor in the temperature range of 900–1300 K, cross-check measurements with calibration quality data overlapping this temperature range is important. Studies, such as reported for molten KNO_3, in which the viscosity results are established by two differing techniques would be a first step to resolving this dilemma.

3.4. Surface Tension

The surface tension techniques have been reviewed elsewhere [2], and it is sufficient to note that, next to the maximum bubble pressure technique, the pin method[12]

[8] K. Nishihara, Y. Matsumura, and M. Mizuno; J. Chem. Soc. Japan **85**, 404 (1967).

[9] D. Dumas, K. Grjotheim, B. Högdahl, and H. W. Oye; Acta Chem. Scand. **24**, 510 (1970).

[10] Attention is directed to the work of Kestin and colleagues concerning experimental investigations of the internal friction of thin platinum-alloy wires at low frequencies. The results of these studies show that an alloy of 92% Pt and 8% W is especially suitable as a torsion wire, in view of its low internal friction and stable elastic constant. In the work of Kestin et al. a wire of 0.051 cm. diam. and 51 cm length was used, after a heat treatment (980K) to relieve stresses. See J. Kestin and J. M. Moszynski; Brown University Report AF891/11, July 1958; AFOSR 7N-58-752; ASTIA Doc. No. 201, 516; see also R. S. Marvin, J. Res. Nat. Bur. Stand; **75A**, 535 A(71).

[11] S. Zuca, private communication to G. J. Janz (1973).

[12] G. J. Janz and M. R. Lorenz; Rev. Sci. Instr. **31**, 18 (1960).

(rod with flat circular endface) and the Wilhelmy method[13] (rod with flat rectangular endface) have been used most widely. Based on a theoretical analysis of the above two detachment methods, Lillebuen[14] recommends the following method for calculating the surface tension from the experimental quantity, ΔW_{max}, the detachment force.

The Pin Method: The surface tension is given by:

$$\gamma = \left(\frac{\Delta W_{max}}{2\pi r}\right)\left(\frac{\pi r_r}{V_r}\right), \quad (1)$$

where V_r is the largest reduced volume of liquid that can be held above the surface by the pin before detachment, and r_r is the reduced pin radius. The quantity $(\pi r_r/V_r)$ is thus equivalent to a measure of the deviation from the simple intuitive relation advanced earlier elsewhere [2]. The calculation of this term is possible from a knowledge of r, ρ, and ΔW_{max}, and the equation:

$$\left(\frac{\pi r_r}{V_r}\right) = 0.992 + 2.564 \times 10^{-6}/(r_r^3/V_r) - 6.605(r_r^3/V_r) + 73.25(r_r^3/V_r)^2 - 454.0(r_r^3/V_r), \quad (2)$$

where the quantity:

$$\left(\frac{r_r^3}{V_r}\right) = \frac{r^3}{(\Delta W_{max}/g\rho)}, \quad (3)$$

can be gained from a knowledge of the pin radius (r), the density (ρ), the gravitational constant (g) and the measured detachment force. Without due cognizance of this correction term, the calculated surface tensions may be as much as 10% higher than the results gained by the other techniques (e.g. maximum bubble pressure).

The Wilhelmy Method: The results of the theoretical analysis show that the surface tension is given by:

$$\gamma = \Delta W_{max}/(L+B), \quad (4)$$

where L and B are sides of the flat endface of the rectangular rod, having $L>>>B$. Consequently the density of the liquid need not be known. The only approximation in the above equation is that edge effects are negligible.

3.5. Percent Application of Methods

Experimental methods for studying transport properties of molten chloride melts were cited in sections 3.1–3.4. The summaries in table A indicate the application of "frequency of use" of these techniques. The percent application is defined as the number of investigations employing a particular method relative to the total number of reported studies for that property.

TABLE A.

Method	Percent application
Specific conductance	
Classical ac	99.6
Paper electrophoresis	0.4
Density	
Archimedean	76.5
Dilatometric	8.5
Flotation	2.0
Pycnometric	8.5
Bubble pressure	4.5
Viscosity	
Capillary	38
Oscillating body	62
Surface tension	
Maximum bubble pressure	63
Wilhelmy slide plate	13
Pin detachment	24

3.6. Melt Preparation and Purification

Most chlorides are commercially available, either in technical or analytical pure grades, so that synthetic procedures are avoided. Emphasis is given here to details of salt purification.

The following procedures have been adopted: recrystallization, sublimation, and vacuum distillation. The salts are mostly dehydrated in a Pt-crucible under vacuum at elevated temperatures with an inert atmosphere.

Mixtures are prepared by fusion of the required amounts of the pure components under an inert gas atmosphere. The composition and purity are usually checked using standard spectrochemical and gravimetric procedures.

Detailed procedures, including handling and transfer, for each salt or mixture are discussed in sections 5.1 and 6.1, respectively.

4. Treatment of Data

4.1. Statistical Analysis

The statistical analysis was performed on the computer facilities (IBM 360, PDP 15 and G.E. Mark II Time Sharing Unit) at Rensselaer Polytechnic Institute.

The density, specific conductance, viscosity, and surface tension values were recalculated by a one-dimensional analysis, using the method of least squares to establish equations indicating the variations of the physical quantities with temperature at the experimental composition. For density and surface tension results, where five or more experimental compositions and temperatures or temperature-dependent equations were reported, the values were recalculated by a two-dimensional analysis, using a stepwise multiple regression routine. In this way a physical property-temperature-composition matrix was developed.

[13] G. Bertozzi, J. Phys. Chem. 69, 2606 (1965).
[14] B. Lillebuen; Acta. Chem. Scand. 24, 3287 (1970).

Tabulated values given in brackets indicate that they have been statistically derived from an insufficient number of data points.

(a). One-Dimensional Analysis

The criterion for choosing the equation of best fit in the one-dimensional analysis is the standard error of estimate computed from the residuals and defined by

$$s = \sqrt{\frac{\sum^{n}(\gamma_e - \gamma_c)^2}{n - q}},$$

where γ_e = the experimental value at each temperature, γ_c = the value calculated from the least squares equation at the same temperature as γ_e, n = the number of experimental data points, and q = the number of coefficients in the least squares equation (2 for linear, 3 for quadratic).

(b). Two-Dimensional Analysis

Computer Programs Used

Programs from the IBM Scientific Subroutine Package[15] were used with the IBM 360/50 computer facility at Rensselaer. The routines consist of STPRG, CORRE, LOC, and MSTR, the latter two being storage routines which have no effect on the accuracy of the results. In addition the subroutine STOUT is used to print the results of each regression step and the subroutine MATRIX is used for printing a matrix of the final equation.

Statistical Procedure

The abbreviated Doolittle method[16] was used to select the variables entering the regression and for calculation of coefficients. The independent variable included in each step of the analysis was selected by computing the reduction of sums of squares of each variable. The variable causing the largest reduction was added to the equation and deleted from the table of sums of squares. The coefficients, intercept and statistical parameters for the new equation were computed and printed. This procedure was repeated until the maximum proportion of sums of squares to the total reduced was less than a limit set by the programmer. The independent variables used in the initial selection were chosen from a generalized procedure, which generated 30 combinations of the input variables using powers, reciprocals, logarithmic and exponential quantities. It was found that the procedure consistently selected the equation $(T + C)^3$, so that the working program used nine independent variables. After the final equation has been produced, it is transferred to the MATRIX routine, which recalculates values at rounded compositions and temperatures, within specified boundary conditions. In the presentation of the matrix, due cognizance is taken of the experimental range of the investigation and of the phase relationships for the system so that values are always "interpolated" rather than "extrapolated". The final step in the procedure involves the residual analysis, where the deviations of the original values from those computed from the "best" equations are given.

Statistical Parameters

For each step in the regression analysis a summary of significant statistical parameters is given. First the sums of squares reduced (S_i), the proportion of S_i/D, where D is defined below, given by P, the cumulative S_i given by S_{cum} and the cumulative proportion given by (P_{cum}) are listed. These quantities give an indication of the effect of each variable in the final equation. The programmers limit on P was always in the range $0.0001 \leq P \leq 0.001$.

Standard Error of Estimate

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

$$s.e. = \sqrt{\frac{D - S_{cum}}{n - q - 1}},$$

where

$$D = \sum_{j=1}^{n} (y_j - \bar{y})^2,$$

y_j = experimental values
$\bar{y}$ = average of all experimental values
q = the number of independent variables in the equations

As a general guide, about 68% of the results lie within the standard error of estimate, 95% within twice this value and approximately 99 percent within three times the value[17]. The standard error of estimate has been reported as a percent in this study. Where this information was reported in the literature as standard deviations, the preceding approach was not possible and we refer to the published error estimates of the original authors.

F Value for Analysis of Variance

This value is used to determine if a particular model is acceptable.[18] Tables of F values indicate that values greater than 2.0 are acceptable for the routine used here. In all cases values of F were greater than 500 and in most cases greater than 1000. The F value is defined as:

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

where S_{cum}, q, D, and n were defined earlier.

[15] System 360 Scientific Subroutine Package Programmers Manual; IBM H20-0205-3. 1969.

[16] C. A. Bennet and N. L. Franklin, Statistical Analysis in Chemistry and the Chemical Industry (John Wiley and Sons, 1954).

[17] I. D. Sterling and S. V. Pollack, Introduction to Statistical Data Processing (Prentice-Hall, 1968).

[18] H. Smith and N. R. Draper, Applied Regression Analysis (John Wiley and Sons, 1968).

4.2 Percent Departure

The percent departure has been used to compare the results of different investigations with either previous [1,2] or current recommendations and has been later considered when evaluating a study for possible recommendation.

The percent departure is defined by:

$$\text{Percent departure} = \frac{\text{"compared value"} - \text{"recommended value"} \cdot 100}{\text{"recommended value"}}$$

The "compared values" refer to the numerical data given in the discussed study and are compared to the "recommended values" given in NSRDS–NBS15 [1] or NSRDS–NBS–28 [2], or the present work.

The experimental values, when available, were used as the "compared values", otherwise the "compared values" and the "recommended values" were calculated from statistically derived equations at common temperatures and compositions.

The percent departure is given in discussion section 5.3 for single salts and 6.1 for binary mixtures.

4.3 Value Judgments

The recommendations advanced in this work are based on three criteria: (a) type and quantity of experimental data available, (b) experimental method used and (c) an error analysis of the reported results. The principles followed in selecting the most reliable data are outlined for each case.

(a) Studies reporting either numerical data, results derived from statistically generated equations or data in the form of temperature dependent equations were preferred over graphical results. For the case where two sets of results were reported for the same system, one graphical and the other numerical, the graphical results could be preferred if these were based on a more extensive composition and temperature range, when other criteria were of equal merit.

(b) The experimental aspects as discussed in section 3 were examined for each system when a recommendation has been advanced. Of primary importance was the cognizance of an investigator with respect to improvements and limitations on standard measuring techniques together with an examination of the errors leading to uncertainties in the measured transport properties. Attention was given to the preparation, purification, stability and analysis of single and mixed chloride melts as discussed in section 3.3. The reliability of the measuring technique and melt preparation and purification procedures as determined from results on standard calibration materials was considered important in the ultimate value of the data reported.

(c) The statistical parameters and percent departures as discussed in section 4.1 and 4.2, respectively, were considered. For systems where investigations had similar quantity and quality of data, the results with superior statistical parameters were selected.

For some systems more than one reference may have been used to generate the recommendations. This was to extend the recommendations to the widest possible ranges of temperature/composition.

4.4. Physical Properties

Physical properties of molten chlorides and their mixtures have been analyzed and summarized in tabular form with respect to: experimental methods employed, composition and temperature ranges studied, and percent departures of numerical data from current or previous recommendations.

For each system the property table reports the following:

- the references critically re-examined
- a summary of experimental details such as cell material and calibration method
- the calculated percent departures.

A recommended reference is always indicated by a bold-faced reference number in square brackets. The first section of the table summarizes all investigations carried out for the relevant physical property with corresponding composition and temperature ranges. Data were reported in numerical or equation form except for graphical presentations, where the notation (g) is used.

In the second part, the minimum and maximum percent departures are listed for the different investigations at comparable compositions and temperatures in relation to previous recommendations [1,2] or the present work. Remarks concerning the accuracy, the reproducibility, and the form of the numerical data are included. Further comments highlight information of unusual importance (technique, experimental uncertainty, etc.) with respect to the particular property and system studied. In situations where the composition-temperature-physical property base rests on more than one investigation, all references used to develop the value judgments are listed in bold face.

4.5. Numerical Tables

The specific conductance, density, viscosity, and surface tension values were computed for each system for the experimental compositions at rounded temperatures using the corresponding "best" equation for the same temperature range for which the investigation was carried out. These values are given in the numerical tables which immediately follow the discussion tables for each property of each system. Also given are the temperature-dependent equation(s), the standard error of estimate (or the standard deviation) and a statement giving the recommended reference and experimental technique. For density and surface tension the values were also calculated using a two-dimensional statistical analysis where sufficient data (more than five compositions and temperatures) were given. The matrices produced by the two-dimensional analysis are reported in tabular form at rounded temperatures and compositions. The two-dimensional equation, maximum percent departure and standard error of estimate are also included in these tables. Original values are given

in cases where investigations reported only limited data or the one- or two-dimensional analysis was unsuccessful. In some 47 cases, the experimental results were reported in graphical form. In these cases, the graphs have been interpolated, and the results given in tabular form together with a statement giving the recommended reference and the number of significant figures to which interpolation could be carried out. Numerical tables are presented only for the recommended studies.

4.6. Phase Diagrams

Phase diagrams for each system, are included in section 6.1 when available. It should be understood that the temperature-liquidus phase diagrams included in this work are not advanced as critically evaluated recommendations, but serve the useful purpose of reporting values for a eutectic composition.

The liquidus curves were also used as guidelines for imposing the boundary conditions for generating the matrix, in order to avoid producing values in the solid phase.

References for each phase diagram are given with the diagram.

4.7 General Summary Tables

Summary tables are given in section 5.4 (single salts) and section 6.2 (binary mixtures) to summarize specific information such as total number of investigations, recommended references, experimental techniques used and literature references.

5. Single Salts

Sections 5.1 and 5.2 update the recommendations for single salt melts given in NSRDS–NBS–15 [1] and NSRDS–NBS–28 [2]. The discussions for each single salt recommendation and the numerical values together with the temperature dependent equations are given in section 5.3. Additional studies for chloride salts not included in NSRDS–NBS–15 [1] and NSRDS–NBS–28 [2] are summarized in section 5.4.

5.1. New Recommendations

Single chloride salts which do not appear in NSRDS–NBS–15 [1] and NSRDS–NBS–28 [2] are listed in table B. The discussions, numerical values and temperature dependent equations for the new recommendations are given in section 5.3.

TABLE B.

Compound	Number of investigations			
	Electrical conductance	Density	Viscosity	Surface tension
$DyCl_3$	2	2	1	
$GdCl_3$	2	2		
$LaCl_3$				1
$NbCl_5$		2		
$NdCl_3$		1		
$NiCl_2$		1		
$PrCl_3$		1		
$SbCl_3$	2	1	2	
$SmCl_3$	1			
$SnCl_4$				1
$TaCl_5$		1		
$TiCl_4$		3		2
TlCl			1	
UCl_3	3	2		
UCl_4		4		3
$ZrCl_4$		1	1	1

5.2. Revised Recommendations

The recommendations for single chloride melts given in NSRDS–NBS–15 [1] and NSRDS–NBS–28 [2] have been updated relative to new investigations and the revised recommendations are listed in table C. The discussions, numerical values, and temperature-dependent equations for the revised recommendations are given in section 5.3.

TABLE C.

Compound	Property
$BaCl_2$	viscosity
$CaCl_2$	viscosity, surface tension
CsCl	viscosity
$HgCl_2$	viscosity
KCl	surface tension
$LaCl_3$	electrical conductance
$MgCl_2$	viscosity
$SrCl_2$	viscosity
$ThCl_4$	density
UCl_4	electrical conductance
$ZnCl_2$	electrical conductance, density

5.3. Discussions and Numerical Values

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

$AlCl_3$

Melt Preparation and Purification

Aluminum, having a purity of 99.5%, was reacted with dry HCl gas and sublimed without residue into the conductivity cell in a CO_2 atmosphere [347].

"Baker Analyzed" aluminum chloride was purified by repetitive sublimation in a stream of argon. Approximately 500 grams of $AlCl_3$ was loaded into one end of a 55-mm (o.d.) Pyrex tube approximately 60 cm long. Over a period of about 8 h, the tube was passed through a furnace maintained at about 200 °C. The final sublimate, which was collected in a water-cooled receiving tube, was transferred into a glove box having a nitrogen atmosphere. The white $AlCl_3$ powder was quickly transferred into the density tubes, which were then stoppered and removed from the box for weighing and sealing under vacuum [**348**].

Aluminum chloride was synthesized by passing HCl gas over aluminum turnings, having a purity of 99.99%, in a Jena glass apparatus at 500 °C. During the reaction, the product sublimed into a cooled flask. After reaction it was again sublimed under a stream of nitrogen into another vessel which was sealed off under vacuum. The $AlCl_3$ was then transferred by sublimation into the cells for viscosity measurements [**349**].

TABLE 2. Electrical conductance studies: $AlCl_3$

Investigations critically examined			
Ref.	Temp. range (T)	Cell material	Calibration
347	473–518	Glass with platinized disc electrodes	
16	437–473	Mo glass	$NaNO_3$ (molten); KCl (aqueous)
51	437–473		

Deviations from NSRDS recommendation		
Ref.	Min. departure	Max. departure
16	0.0% (473.2 K)	
51	2.95% (473.2 K)	

TABLE 3. $AlCl_3$: Specific conductance (ohm^{-1} cm^{-1})

$$\kappa = 7.0270 \cdot 10^{-6} - 3.6646 \cdot 10^{-8}T + 4.8623 \cdot 10^{-11}T^2$$

Standard error of estimate: 1.70%

T	κ ($\times 10^7$)	T	κ ($\times 10^7$)
475	5.906	500	8.596
480	6.395	505	9.207
485	6.909	510	9.842
490	7.447	515	10.500
495	8.009		

These values are based on the work of Biltz and Vöigt (classical ac technique) [**347**].

TABLE 4. Density studies: $AlCl_3$

Investigations critically re-examined			
Ref.	Temp. range (T)	Cell material	Calibration
348	462–569	Pyrex	H_2O
90	475–494	Quartz	H_2O
347	463–503	Glass	
157	463–553	Mo glass	Hg

Deviations from previous NSRDS recommendation: [1, p. 11]				
Ref.	Min. departure		Max. departure	
348	0.0%	(504 K)	5.05%	(474 K)
90	−1.66%	(490 K)	−3.41%	(480 K)
347	2.58%	(503 K)	5.79%	(483 K)
157	−1.27%	(530 K)	3.42%	(476 K)

TABLE 5. $AlCl_3$: Density (g cm^{-3})

$$\rho = 2.18725 - 5.4045 \cdot 10^{-4}T - 1.13544 \cdot 10^{-5}T^2 + 3.04126 \cdot 10^{-8}T^3$$

Standard error of estimate: (0.15%)

T	ρ	T	ρ
465	1.287	515	1.169
470	1.277	520	1.155
475	1.266	525	1.142
480	1.256	530	1.127
485	1.243	535	1.113
490	1.231	540	1.098
495	1.219	545	1.082
500	1.207	550	1.066
505	1.195	555	1.050
510	1.182	560	1.033

These values, based on the work of King and Seegmiller (dilatometric technique [**348**], supersede the previous NSRDS recommendations [1].

TABLE 6. Viscosity studies: $AlCl_3$

Investigations critically re-examined			
Ref.	Temp. range (T)	Cell material	Calibration
349	465–493	Jena glass	CH_3I, C_2H_5I, CCl_4
291	462–549		

Deviations from previous NSRDS recommendations: [1, p. 11]		
Ref.	Min. departure	Max. departure
349	−1.48% (468.5 K)	−8.63% (493 K)

TABLE 7. $AlCl_3$: Viscosity (cp)

$$\eta = 1.71471 \cdot \exp(4943.8/RT)$$

Standard error of estimate: 1.05%

T	η
470	0.341
475	0.323
480	0.306
485	0.290
490	0.275

These values, based on the work of Kleinschmidt (hollow sphere torsion technique) [**349**], supersede the previous NSRDS recommendations [1].

$BaCl_2$

Melt Preparation and Purification

Barium chloride was purified by double recrystallization from distilled water, drying at 150 °C for 24 hours, and melting to remove hydrolysis products according to the following scheme: the chloride was slowly heated to its melting point either under dry argon or under vacuum. Carbon tetrachloride vapor was bubbled through the molten salt during the heating period, and for an additional fifteen minutes. The purified salt was stored in pellet form under liquid carbon tetrachloride and checked for alkalinity with phenolphthalein. Subsequent handling of the salt was performed in a dry box [**282**].

TABLE 8. Viscosity studies: $BaCl_2$

Investigations critically re-examined			
Ref.	Temp. range (T)	Cell material	Calibration
282	1245–1340	Pt sphere and rod	$NaNO_3$, KCl melts
174	1240–1290		
151	1249–1358		
24	1273		

Deviations from previous NSRDS recommendations: [1, p. 51]		
Ref.	Min. departure	Max. departure
282	−9.15% (1310 K)	−18.05% (1270 K)
174	−21.87% (1290 K)	−25.81% (1270 K)
151	−9.098% (1309 K)	−18.79% (1275 K)
24		13.33% (1273 K)

TABLE 9. $BaCl_2$: Viscosity (cp)

$$\eta = 94.4198 - 1.2920\,T + 9.5505 \cdot 10^{-5}T^2$$

Standard error of estimate: 1.47%

T	η	T	η
1250	4.02	1300	3.36
1260	3.87	1310	3.25
1270	3.73	1320	3.16
1280	3.59	1330	3.07
1290	3.47	1340	3.00

These values, based on the work of Zuca and Costin (oscillating sphere method) [**282**], supersede the previous NSRDS recommendations [1].

$CaCl_2$

Melt Preparation and Purification

Calcium chloride was purified by double recrystallization from distilled water, drying at 150 °C for 24 hours, and melting to remove hydrolysis products according to the following scheme: the chloride was slowly heated to its melting point either under dry argon or under vacuum. Carbon tetrachloride vapor was bubbled through the molten salt during the heating period and for an additional fifteen minutes. The purified salt was stored in pellet form under liquid carbon tetrachloride and checked for alkalinity with phenolphthalein. Subsequent handling of the salt was performed in a dry box [**282**].

TABLE 10. Viscosity studies: $CaCl_2$

Investigations critically re-examined			
Ref.	Temp. range (T)	Cell material	Calibration
282	1060–1220		
24	1075–1270		
34	1075–1150	Pt sphere and rod	$NaNO_3$ melt
144[a]	1075–1270		

Deviations from previous NSRDS recommendations: [1, p. 50]		
Ref.	Min. departure	Max. departure
282	0.86% (1057 K)	38.36% (1221 K)
24	61.9% (1073 K)	125.3% (1273 K)
34	39.86% (1073 K)	71.2% (1148 K)

[a]Data taken from reference 24.

TABLE 11. $CaCl_2$: Viscosity (cp)

$\eta = 3.7206 - 5.3247 \cdot 10^{-2}T + 2.0141 \cdot 10^{-5}T^2$

Standard error of estimate: 1.07%

T	η	T	η
1060	3.40	1150	2.61
1070	3.29	1160	2.54
1080	3.19	1170	2.48
1090	3.10	1180	2.42
1100	3.01	1190	2.37
1110	2.92	1200	2.31
1120	2.84	1210	2.27
1130	2.76	1220	2.22
1140	2.68		

These values, based on the work of Zuca and Costin (oscillating sphere technique) [**282**], supersede the previous NSRDS recommendations [1].

TABLE 12. Surface tension studies: $CaCl_2$

Investigations critically re-examined		
Ref.	Temp. range	Cell material
253	1085–1190	Pt rod
250	1080–1270	
236[a]	1085–1190	

Deviations from previous NSRDS recommendations: [2, p. 60]		
Ref.	Min. departure	Max. departure
253	1.13% (1085.46 K)	3.32% (1192.66 K)
250	1.33% (1073.15 K)	6.79% (1273.16 K)

[a]Data taken from reference **253**.

TABLE 13. $CaCl_2$: Surface tension (dyn cm^{-1})

$\gamma = 1.9567 \cdot 10^2 - 4.5411 \cdot 10^{-2}T$

Standard error of estimate: 0.02%

T	γ	T	γ
1090	146.17	1150	143.45
1100	145.72	1160	142.99
1110	145.26	1170	142.54
1120	144.81	1180	142.09
1130	144.36	1190	141.63
1140	143.90		

These values, based on the work of Lillebuen (rod detachment method) [**253**], supersede the previous NSRDS recommendations [2].

CsCl

Melt Preparation and Purification

Zuca [**314**] used both Merck suprapure and reagent grade CsCl to investigate the effects of salt purity on the viscosity values. The individual sets of data were within ±3% agreement with those obtained using CsCl prepared from cesium perchlorate so that the question of impurities was ruled out. During the course of these investigations it was found that the addition of 1% $CaCl_2$ to pure CsCl increased the viscosity by about 6%.

TABLE 14. Viscosity studies: CsCl

Investigations critically re-examined		
Ref.	Temp. range (T)	Cell material
314	950–1086	Pt sphere
280	950	
82, 174	930–1030	

Deviations from previous NSRDS recommendations: [1, p. 6]		
Ref.	Min. departure	Max. departure
280	3.9% (950 K)	
82, 174	0% (960 K)	−3.0% (1030 K)
314[a]	19.8% (968 K)	24.5% (1066 K)
314[a]	19.55% (960 K)	20.23% (1080 K)
314[a]	19.04% (950 K)	21.62% (1080 K)

[a]Three separate investigations were made by Zuca. For further discussions concerning the relatively large percent departures commonly obtained for viscosity data, reference should be made to section 3.3.

TABLE 15. Deviations from the updated NSRDS recommendations (see Table 16): CsCl

Ref.	Min. departure	Max. departure
82, 174	−14.6% (930 K)	−20.58% (1030 K)
280	−13.05% (949 K)	
315	−6.47% (963 K)	−32.2% (1064 K)
316	−15.11% (927 K)	−18.39% (1092 K)
314[a]	0.07% (1081 K)	2.42% (1065 K)
314[b]	0.10% (952 K)	−2.63% (1074 K)
314[c]	0.07% (1081 K)	1.68% (968 K)

[a,b,c]Represent the three separate investigations of Zuca.

TABLE 16. CsCl: Viscosity (cp)

$$\eta = 6.30528 + 0.25804 \cdot 10^{-3}T - 0.12063 \cdot 10^{-4}T^2$$

Standard error of estimate: 0.98%

T	η	T	η
950	1.468	1020	1.202
955	1.446	1025	1.186
960	1.426	1030	1.171
965	1.405	1035	1.156
970	1.384	1040	1.141
975	1.364	1045	1.127
980	1.345	1050	1.114
985	1.325	1055	1.101
990	1.307	1060	1.088
995	1.288	1065	1.076
1000	1.270	1070	1.064
1005	1.253	1075	1.053
1010	1.235	1080	1.042
1015	1.219	1085	1.031

These values, based on an averaged equation generated from three investigations of Zuca [**314**] (oscillating sphere technique), supersede the previous NSRDS recommendations [1]. The uncertainty of the new values is estimated to be ±3%.

$DyCl_3$

Melt Preparation and Purification

Irisawa, Mochinaga, and Kuroda prepared $DyCl_3$ by heating the rare-earth oxide (99.9% purity, American Potash and Chem. Co.) with ammonium chloride at about 350 °C under vacuum [**285**].

TABLE 17. Electrical conductance, density, and viscosity studies: $DyCl_3$

Investigations critically re-examined			
Property	Ref.	Temp. range (T)	Comments
κ	**265**	950–1010	
	312	1060–1270	
	190	1073, 1173	graphical
ρ	**285**	965–1270	silica dilatometer; calibrated with molten NaCl, KCl
η	**311**	1205–1272	Ostwald viscometer; quartz

Deviations from NSRDS recommendations			
Property	Ref.	Min. deviation	Max. deviation
κ (from averaged equation)	**312**	−0.05% (1238 K)	−3.06% (1058 K)
	265	−0.97% (952 K)	2.18% (977 K)

TABLE 18. $DyCl_3$: Specific conductance (ohm^{-1} cm^{-1}), density (g cm^{-3}), and viscosity (cp)

$\kappa = 1.7723 - 7.1242 \cdot 10^{-3}T + 8.7014 \cdot 10^{-6}T^2 - 2.8983 \cdot 10^{-9}T^3$
Standard error of estimate: 1.12%
$\rho = 4.2668 - 0.6821 \cdot 10^{-3}T$
Standard error of estimate: 1.37%
$\eta = 46.764 + 2.253 \cdot 10^{-3}T - 8.651 \cdot 10^{-5}T^2 + 4.515 \cdot 10^{-8}T^3$

T	κ	ρ	η
960	0.388		
980	0.419	3.5975	
1000	0.451	3.5839	
1020	0.483	3.5702	
1040	0.514	3.5566	
1060	0.545	3.5429	
1080	0.576	3.5293	
1100	0.607	3.5156	
1120	0.636	3.5020	
1140	0.665	3.4884	
1160	0.693	3.4747	
1180	0.719	3.4611	
1200	0.745	3.4474	
1220	0.769	3.4338	2.736
1240	0.791	3.4201	2.624
1260	0.812	3.4065	2.576

The updated values for specific conductance and the new recommendations for density and viscosity are given in table 18. The data bases for these are, specific conductance: an averaged equation generated from the work of Cho and Kuroda [**312**], and Dworkin, Bronstein and Bredig [**265**] (classical ac technique); density: Irisawa, Mochinaga and Kuroda (dilatometric technique) [**285**]; viscosity: Cho and Kuroda (Ostwald viscometer) [**311**].

$GdCl_3$

Melt Preparation and Purification

Irisawa, Mochinaga, and Kuroda prepared $GdCl_3$ by heating the rare-earth oxide (99.9% purity, American Potash and Chem. Co.) with ammonium chloride at about 350 °C under vacuum [**285**].

TABLE 19. Electrical conductance, density, and viscosity studies: $GdCl_3$

Investigations critically re-examined			
Property	Ref.	Temp. range (T)	Comments
κ	**265**	900–980	
	312	1020–1264	
	190	1073	graphical
ρ	**285**	935–1280	silica dilatometer; calibrated with molten NaCl, KCl
η	**311**	1070–1240	Ostwald viscometer; quartz

Deviations from NSRDS recommendations			
Property	Ref.	Min. deviation	Max. deviation
κ (from averaged equation)	**312**	0.00% (1213 K)	−3.07% (1081 K)
	265	−1.42% (922 K)	4.56% (971 K)

TABLE 20. $GdCl_3$: Specific conductance (ohm^{-1} cm^{-1}), density (g cm^{-3}), and viscosity (cp)

$\kappa = 5.5955 - 1.6528 \cdot 10^{-2}T + 1.6171 \cdot 10^{-5}T^{-2} - 4.7074 \cdot 10^{-9}T^3$
Standard error of estimate: 1.21%
$\rho = 4.1491 - 0.67139 \cdot 10^{-3}T$

T	κ	ρ	η[a]
920	0.411		
940	0.438	3.5180	
960	0.467	3.5046	
980	0.498	3.4912	
1000	0.531	3.4777	
1020	0.565	3.4643	
1040	0.602	3.4509	
1060	0.639	3.4374	
1080	0.677	3.4240	2.4
1100	0.716	3.4106	2.2
1120	0.755	3.3972	2.1
1140	0.795	3.3837	1.9
1160	0.835	3.3703	1.8
1180	0.874	3.3569	1.8
1200	0.913	3.3435	1.7
1220	0.952	3.3300	1.7
1240	0.990	3.3166	1.6
1260		3.3032	
1280		3.2897	

[a]Values were interpolated to two significant figures from the graphical presentation.

The updated values for specific conductance and the new recommendations for density and viscosity are given in table 20. The data bases for these are, specific conductance: an averaged equation generated from the work of Cho and Kuroda [**312**] and Dworkin, Bronstein and Bredig [**265**] (classical ac technique); density: Irisawa, Mochinaga and Kuroda (dilatometric technique) [**285**]; viscosity: Cho and Kuroda (Ostwald viscometer) [**311**].

$HgCl_2$

Melt Preparation and Purification

Janz et al., resublimed $HgCl_2$ (Fisher, Certified reagent grade) three times through medium porosity filter discs [**107**].

TABLE 21. Viscosity studies: $HgCl_2$

Investigations critically re-examined			
Ref.	Temp. range (T)	Cell material	Calibration
107	550–568	Quartz viscometer	N-hexane (Cannon Viscosity Standard No. N-4-66-1), N-decane (Cannon Viscosity Standard No. N-1.0-66-1)

Deviations from previous NSRDS recommendations: [1, p. 58]		
Ref.	Min. departure	Max. departure
107	−8.93% (550 K)	−18.18% (568.5 K)

TABLE 22. $HgCl_2$: Viscosity (cp)

$$\eta = 22.97074 - 4.100932 \cdot 10^{-2}T - 3.75155 \cdot 10^{-5}T^2 + 7.5274 \cdot 10^{-8}T^3$$

Standard error of estimate: 0.61%

T	η	T	η
550	1.59	560	1.45
552	1.56	562	1.43
554	1.53	564	1.41
556	1.51	566	1.38
558	1.48	568	1.36

These values, based on the work of Timidei, Lederman and Janz (modified Ostwald viscometer) [**107**], supersede the previous NSRDS recommendations [1].

Hg_2Cl_2

TABLE 23. Electrical conductance studies: Hg_2Cl_2

Investigations critically re-examined	
Ref.	Temp. range (T)
121	80–1060

Deviations from previous NSRDS recommendation: [1, p. 11]		
Ref.	Min. departure	Max. departure
121	−5.82% (822.2 K)	−7.29% (808.2 K)

TABLE 24. Hg_2Cl_2: Specific conductance (ohm^{-1} cm^{-1})

$$\kappa = -0.980099 + 1.74861 \cdot 10^{-3}T + 7.75868 \cdot 10^{-7}T^2$$

Standard error of estimate: 0.59%

T	κ	T	κ
800	0.915	940	1.349
820	0.975	960	1.414
840	1.036	980	1.479
860	1.097	1000	1.544
880	1.159	1020	1.611
900	1.222	1040	1.678
920	1.285	1060	1.745

These values, based on the work of Grantham (ac technique) [**121**], supersede the previous NSRDS recommendations [1].

KCl

TABLE 25. Surface tension studies: KCl

Investigations critically re-examined			
Ref.	Temp. range (T)	Cell material	Calibration
255	1043–1273		
257	1073–1173	Pt	Molten LiCl, NaCl
258	1073–1273		
24	1073		
245	800–950 (g)		
246	800–850 (g)		
244	850 (g)		
254	800–900 (g)		
232	830–920	90%Pt-10% Rh alloy porcelain crucible	
241	730–930	90%Pt-10% Rh alloy graphite crucible	
237	828–918	90%Pt-10% Rh alloy alumina crucible	
252	800–900 (g)	Pt	
178	1073–1193		

Deviations from previous NSRDS recommendations: [2, p. 58]		
Ref.	Min. departure	Max. departure
255	−1.54% (1243 K)	−2.07% (1053 K)
257	−2.67% (1181 K)	−3.04% (1072 K)
258	−0.48% (1273 K)	−1.82% (1073 K)
24	−2.73% (1073 K)	

TABLE 26. Deviations from the updated NSRDS recommendations (see table 27): KCl

Ref.	Min. departure	Max. departure
255	−0.20% (1273 K)	−0.70% (1073 K)
257	0.15% (1173 K)	0.96% (1073 K)
258	0.02% (1170 K)	0.75% (1270 K)
237	1.17% (1070 K)	1.26% (1170 K)
24	−1.50% (1073 K)	
250	17.57% (1073 K)	
178	−0.01% (1143 K)	−1.01% (1263 K)
224	−0.19% (1273 K)	−0.73% (1073 K)
259	−0.13% (1109 K)	−0.44% (1113 K)
241	3.63% (1073 K)	4.78% (1273 K)
227	1.16% (1173 K)	3.30% (1223 K)
232	−0.70% (1192 K)	−1.64% (1142 K)

TABLE 27. KCl: Surface tension (dyn cm^{-1})

$\gamma = 179.1168 - 0.76026 \times 10^{-1}T$

Standard error of estimate: 0.26%

T	γ	T	γ
1080	97.01	1190	88.65
1090	96.25	1200	87.89
1100	95.49	1210	87.13
1110	94.73	1220	86.37
1120	93.97	1230	85.61
1130	93.21	1240	84.84
1140	92.45	1250	84.08
1150	91.69	1260	83.32
1160	90.93	1270	82.56
1170	90.17	1280	81.80
1180	89.41		

These values are based on an averaged equation generated from the investigations of Ellis and Freeman [**255**] Mizuno and Matsumura [**257**], Grjotheim, Holm, Lillebuen and Øye [**258**], Lehman [**237**], Smirnov and Stepanov [**178**], Bloom, Davis and James [**224**], Jaeger [**259**] and Peake and Bothwell [**232**]. These values supersede the previous NSRDS recommendations [2]. All of these investigators used the maximum bubble pressure method except Grjotheim et al. who used the pin detachment method.

$LaCl_3$

Melt Preparation and Purification

Lanthanum trichloride was prepared [**154,279**] as discussed under the $LaCl_2$-$LaCl_3$ system. In [**262**] the $LaCl_3$ was crystallized from solutions of the oxides in hydrochloric acid, dehydrated by purging with dry HCl gas and slowly heated to 400 °C under reduced pressure. The salt was then sublimed under vacuum. The final product contained less than 0.5% of other rare-earth ions. Cho and Kuroda [**220**] used the method discussed under the KCl-UCl_3 system.

TABLE 28. Electrical conductance studies: $LaCl_3$

Investigations critically re-examined			
Ref.	Temp. range (T)	Cell Material	Calibration
279	1173–1273		
154	1143–1223	Alundum crucible and Mo wire electrodes	LiCl, KCl
220	1165–1300		
186	1185–1195 (g)		

Deviations from previous NSRDS recommendations:[a] [1, p. 8]		
Ref.	Min. departure	Max. departure
279	−8.98% (1170 K)	−10.83% (1230 K)
154	−15.87% (1140 K)	−16.92% (1190 K)
220	−20.77% (1273 K)	−23.44% (1173 K)
262	−14.42% (1223 K)	−14.79% (1198 K)

[a]The positive deviations (~8.0% to 25.0%) of the previously recommended data base of van Artsdalen and Yaffe [1] may be attributed to parasitic conductance effects. (See section 3.)

TABLE 29. Deviations from the updated NSRDS recommendations: $LaCl_3$ (see table 30)

Ref.	Min. departure	Max. departure
279	6.39% (1284 K)	8.42% (1173 K)
154	−0.17% (1223 K)	−0.72% (1173 K)
220	−5.93% (1273 K)	−0.61% (1173 K)
262	1.87% (1198 K)	2.24% (1223 K)

TABLE 30. $LaCl_3$: Specific conductance ($ohm^{-1}\ cm^{-1}$)

$$\kappa = -8.1470 + 0.1353 \cdot 10^{-1}T - 0.4638 \cdot 10^{-5}T^2$$

Standard error of estimate: 0.30%

T	κ	T	κ
1170	1.335	1230	1.479
1180	1.362	1240	1.500
1190	1.387	1250	1.520
1200	1.411	1260	1.539
1210	1.435	1270	1.557
1220	1.458		

These values are based on an averaged equation generated from the investigations of Smirnov et al. [**279**], Smirnov and Khokhlov [**154**], Cho and Kuroda [**220**], and Dworkin, Bronstein and Bredig [**262**]; they supersede the previous NSRDS recommendations [1].

TABLE 31. Surface tension studies: $LaCl_3$

Investigations critically re-examined	
Ref.	Temp. range (T)
177, 248	1073–1273

TABLE 32. $LaCl_3$: Surface tension (dyn cm^{-1})

$\gamma = 199.0 - 0.0541\ T$			
T	γ	T	γ
1080	140.57	1190	134.62
1090	140.03	1200	134.08
1100	139.49	1210	133.54
1110	138.95	1220	133.00
1120	138.41	1230	132.46
1130	137.87	1240	131.92
1140	137.33	1250	131.38
1150	136.79	1260	130.83
1160	136.24	1270	130.29
1170	135.70	1280	129.75
1180	135.16		

These values are based on the work of Smirnov and Stepanov (maximum bubble pressure) [**177, 248**].

$MgCl_2$

Melt Preparation and Purification

$MgCl_2$ was prepared by treatment with HCl [**277**]. Polarographic analysis did not yield any detectable amount of water.

TABLE 33. Viscosity studies: $MgCl_2$

Investigations critically re-examined			
Ref.	Temp. range (T)	Cell material	Calibration
151	1000–1150	Pt sphere	$NaNO_3$, KCl melts
277	1045–1120	Pt-10% Ir sphere and rod	H_2O and KNO_3

Deviations from previous NSRDS recommendations: [1, p. 6]		
Ref.	Min. departure	Max. departure
151	−55.5% (1003 K)	−57.2% (1105 K)
277	−56.46% (1118 K)	−58.07% (1014 K)

TABLE 34. Deviations from the updated NSRDS recommendations: $MgCl_2$ (see table 35)

Ref.	Min. departure	Max. departure
151	0.58% (1143 K)	3.57% (1003 K)
277	0.14% (1118 K)	−2.61% (1014 K)

TABLE 35. $MgCl_2$: Viscosity (cp)

$\eta = 14.903 - 0.2039 \cdot 10^{-1}T + 0.7625 \cdot 10^{-5}T^2$
Standard error of estimate: 2.29%

T	η	T	η
1000	2.14	1080	1.78
1010	2.09	1090	1.74
1020	2.04	1100	1.70
1030	1.99	1110	1.67
1040	1.95	1120	1.63
1050	1.90	1130	1.60
1060	1.86	1140	1.57
1070	1.82		

These values are based on an averaged equation generated from the investigations of Bondarenko and Strehlets (oscillating sphere) [**151**] and Dumas, Grjotheim and Øye (oscillating sphere) [**277**]. These values supersede the previous NSRDS recommendations [1]. The uncertainty of the new recommendations is estimated to be about 2.0 percent.

$NbCl_5$

Melt Preparation and Purification

The $NbCl_5$ used by Johnson and Cubicciotti [292] was commercially obtained and then sublimed in a stream of the gas saturated with $SOCl_2$ to convert the oxychloride to chloride. The product was analyzed and yielded 34.31% Nb, compared to 34.39% calculated for $NbCl_5$ and was stored in sealed Pyrex ampoules fitted with break seals. $NbCl_5$ was sublimed into a quartz manifold by using an evacuated manifold assembly and crushing the break seal of the ampoule. The pure $NbCl_5$ was distilled into quartz tubes under its own vapor pressure, sealed off and stored.

$NbCl_5$ was purified by distillation and the purest fraction was used in ref. [217].

TABLE 36. Density studies: $NbCl_5$

Investigations critically re-examined			
Ref.	Temp. range (T)	Cell materials[a]	Calibration
292	485–800	quartz float	water
217	601–806		

Deviations from NSRDS recommendations:		
Ref.	Min. departure	Max. departure
292	0.0% (619 K)	−27.3% (803 K)

[a]The densities of the floats used in [292] were determined from their weights in air and in water.

TABLE 37. $NbCl_5$: Density (g cm^{-3})

$\rho = 4.3718 - 6.5712 \cdot 10^{-3}T + 3.6767 \cdot 10^{-6}T^2$
Standard error of estimate: 0.09% (485–600 K)
$\rho = -3.9066 + 1.9019 \cdot 10^{-2}T - 1.6146 \cdot 10^{-5}T^2$
Standard error of estimate: 1.75% (600–800 K)

T	ρ	T	ρ
490	2.035	650	1.634
500	2.005	660	1.613
510	1.977	670	1.588
520	1.949	680	1.560
530	1.922	690	1.529
540	1.895	700	1.495
550	1.870	710	1.458
560	1.845	720	1.417
570	1.821	730	1.373
580	1.797	740	1.326
590	1.775	750	1.276
600	1.753	760	1.222
610	1.687	770	1.165
620	1.679	780	1.105
630	1.667	790	1.042
640	1.652	800	0.975

These values are based on the work of Johnson and Cubicciotti (flotation method) [292].

$NdCl_3$

Melt Preparation and Purification

The $NdCl_3$ used in [285] was prepared as discussed under $PrCl_3$.

TABLE 38. Density and viscosity studies: $NdCl_3$

Investigations critically re-examined			
Property	Ref.	Temp. range (T)	Comments
ρ	**285**	1082–1272	silica cell; calibrated with molten NaCl, KCl
η	**311**	1160–1240	

TABLE 39. $NdCl_3$: Density (g cm^{-3}) and viscosity (cp)

$\rho = 4.2642 - 9.3014 \cdot 10^{-4}T$
Standard error of estimate: 0.28%
$\eta = 41.2037 - 2.2755 \cdot 10^{-2}T - 4.0865 \cdot 10^{-5}T^2 + 2.7019 \cdot 10^{-8}T^3$

T	ρ	η
1090	3.250	
1100	3.241	
1110	3.232	
1120	3.222	
1130	3.213	
1140	3.204	
1150	3.195	
1160	3.185	1.994
1170	3.176	1.914
1180	3.167	1.845
1190	3.157	1.788
1200	3.148	1.741
1210	3.139	1.706
1220	3.129	1.681
1230	3.120	1.669
1240	3.111	1.659
1250	3.102	
1260	3.092	
1270	3.083	

The values for density and viscosity are given in table 39. The data bases for these are, density: Mochinaga, Cho and Kuroda (dilatometric technique) [**285**]; viscosity: Cho and Kuroda (Ostwald viscometer) [**311**].

$NiCl_2$

Melt Preparation and Purification

Galka et al. [**269**] used analytical grade $NiCl_2 \cdot 6H_2O$ as starting material. The chloride was dehydrated by heating at about 970 K in a stream of gaseous HCl for 4 to 5 h and then transferred into the absorption cell. The cell content was degassed and dehydrated for 24 h at 373 K under high vacuum. After degassing, the cells were filled with pure helium so that its pressure at the measurement temperature was about 1.5 atm.

TABLE 40. Density studies: $NiCl_2$

Investigations critically re-examined

Ref.	Temp. range (T)
269[a]	1288–1331

[a]The absorption of γ-radiation by molten $NiCl_2$ was measured in cells made out of quartz tubes with parallel quartz windows. The absorption cell containing $NiCl_2$ was placed in a special furnace which provided a continuous mixing of the melt by rocking. A scintillation counter with an electronic detecting system was employed to measure the γ-radiation of the isotope ^{241}Am used as a radiation source.

TABLE 41. $NiCl_2$: Density (g cm^{-3})

$\rho = 3.4994 - 6.6044 \cdot 10^{-4}T$
Standard error of estimate: 0.44%

T	ρ	T	ρ
1290	2.648	1315	2.631
1295	2.644	1320	2.628
1300	2.641	1325	2.634
1305	2.638	1330	2.621
1310	2.634		

These values are based on the work of Galka et al. (γ-ray absorption method) [**269**].

$PrCl_3$

Melt Preparation and Purification

The $PrCl_3$ used by Cho et al. [**285**] was prepared by heating a mixture of oxide and ammonium chloride at about 350 °C in a vacuum. The rare-earth oxide used as starting material was 99.9% pure.

TABLE 42. Density and viscosity studies: $PrCl_3$

Investigations critically re-examined

Property	Ref.	Temp. range (T)	Comments
η	**285**	1102–1257	silica cell; calibrated with molten NaCl, KCl
ρ	**311**	1130–1240	

TABLE 43. $PrCl_3$: Density (g cm^{-3}) and viscosity (cp)

$\rho = 4.0120 - 7.4165 \cdot 10^{-4}T$
Standard error of estimate: 0.15%
$\eta = 16.0130 - 2.2994 \cdot 10^{-3}T - 2.03843 \cdot 10^{-5}T^2$

T	ρ	η
1120	3.181	
1130	3.174	2.54
1140	3.167	2.46
1150	3.159	2.38
1160	3.152	2.31
1170	3.144	2.24
1180	3.137	2.17
1190	3.129	2.11
1200	3.122	2.05
1210	3.115	1.99
1220	3.107	1.94
1230	3.100	1.89
1240	3.092	1.84
1250	3.085	1.80

The values for density and viscosity are given in table 43. The data bases for these are, density: Mochinaga, Cho and Kuroda (dilatometric technique) [**285**]; viscosity: Cho and Kuroda (Ostwald viscometer) [**311**].

$SbCl_3$

Melt Preparation and Purification

The $SbCl_3$ used in [46] was prepared as discussed under the system $SbCl_3$-$SbCl_5$.

TABLE 44. Electrical conductance, density and viscosity studies: $SbCl_3$

Investigations critically re-examined			
Property	Ref.	Temp. range (T)	Comments
κ	46	333, 343, 353	graphical
	304	373–423	
ρ	46	323–353	
η	46	323–353	
	40	373	

TABLE 45. $SbCl_3$: Specific conductance (ohm^{-1} cm^{-1}), density (g cm^{-3}), and viscosity (cp)

$\rho = 3.4755 - 2.2931 \cdot 10^{-3}T$
Standard error of estimate: 0.03%

T	κ[a]	ρ	η[a]
323			3.90
325		2.730	
330		2.719	
333	0.000149		3.18
335		2.707	
340		2.696	
343	0.000174		2.63
345		2.684	
350		2.673	
353	0.000227		2.16

[a]Due to limited data the experimental values are given.

The values for specific conductance, density and viscosity are given in table 45. The data bases for these are, specific conductance: Usanovich (classical ac technique) [46]; density: Usanovich (pycnometric method) [46]; viscosity: Usanovich (capillary technique) [46].

$SbCl_5$

Melt Preparation and Purification

The $SbCl_5$ was prepared by passing dry Cl_2 gas over powdered antimony. The salt was dried under vacuum and sealed in glass ampoules. [46]

TABLE 46. Density and viscosity studies: $SbCl_5$

Investigations critically re-examined		
Property	Ref.	Temp. range (T)
ρ	46	325–350
η	46	325–350

TABLE 47. $SbCl_5$: Density (g cm^{-3}) and viscosity (cp)

$\rho = 2.8922 - 1.869 \times 10^{-3}T$
Standard error of estimate: 0.09%
$\eta = 5.62101 - 0.0129998T$
Standard error of estimate: 0.00%

T	ρ	η
325	2.2848	1.40
330	2.2755	1.33
335	2.2661	1.27
340	2.2568	1.20
345	2.2474	1.14
350	2.2381	1.07

The values for density and viscosity are given in table 47. The data bases for these are, density: Usanovich, Sumarokova and Beketov (pycnometric method) [46]; viscosity: Usanovich, Sumarokova and Beketov (capillary method) [46].

$SmCl_3$

Melt Preparation and Purification

Reference [190] is discussed under the system KCl-$NdCl_3$.

TABLE 48. Electrical conductance studies: $SmCl_3$

Investigations critically re-examined			
Ref.	Temp. range (T)	Cell Material	Calibration
190	1073	Quartz capillary cell; Pt electrodes; freq. range: 100,000-250,000 Hz	Molten NaCl, KCl, CsCl

TABLE 49. $SmCl_3$: Specific conductance ($ohm^{-1}cm^{-1}$)

T	κ[a]
1073.2	0.84

[a] Interpolated value.

These values are based on the work of Forthmann and Schneider (classical ac technique) [190]. The relative error of the measured conductance values was reported to be ±1%.

$SnCl_4$

Melt Preparation and Purification

Pugachevich et al. [306] used the purest fractions of $SnCl_4$, purified by rectification in an efficient column.

TABLE 50. Surface tension studies: $SnCl_4$

Investigations critically re-examined	
Ref.	Temp. range (T)
306[a]	293-383

[a] Pugachevich et al. reported a maximum error of 0.2% in measuring the surface tension. An improved gas apparatus was described where it was not necessary to take into account the depth of immersion of the calibrated tube in the test liquid, the height of the capillary rise, or the change in the level of the liquid.

TABLE 51. $SnCl_4$: Surface tension (dyn cm^{-1})

$\gamma = 61.0028 - 1.1368 \cdot 10^{-1} T$
Standard error of estimate: 0.25%

T	γ	T	γ
295	27.47	340	22.35
300	26.90	345	21.78
305	26.33	350	21.21
310	25.76	355	20.65
315	25.19	360	20.08
320	24.63	365	19.51
325	24.06	370	18.94
330	23.49	375	18.37
335	22.92	380	17.80

These values are based on the work of Pugachevich et al. (maximum bubble pressure method) [**306**].

$SrCl_2$

Melt Preparation and Purification

Zuca and Costin [**282**] used p.a. reagent $SrCl_2$ recrystallized twice from distilled water and dried for 24 h at 150 °C. The salt contained in a silica cell was slowly heated to the melting point, alternatively under vacuum or dry argon gas saturated with CCl_4 vapors.

Strontium chloride was checked for alkalinity with phenolphthalein.

TABLE 52. Viscosity studies: $SrCl_2$

Investigations critically re-examined		
Ref.	Temp. range (T)	Comments
282[a]	1154-1246	Cell material: Pt sphere and suspension wire; method checked with benzene and aniline

Deviations from previous NSRDS recommendations: [1, p. 7]		
Ref.	Min. departure	Max. departure
282	11.3% (1154 K)	52.6% (1232 K)

[a] The large deviation among the viscosity data available for $SrCl_2$ indicate additional measurements are necessary to clarify the present disagreement. The work by Zuca et al. [**282, 319**] is recommended.

TABLE 53. $SrCl_2$: Viscosity (cp)

$\eta = 90.6109 - 1.3440 \cdot 10^{-1} T + 5.1455 \cdot 10^{-5} T^2$
Standard error of estimate: 0.94%

T	η	T	η
1155	4.03	1205	3.38
1160	3.95	1210	3.33
1165	3.87	1215	3.28
1170	3.80	1220	3.23
1175	3.73	1225	3.19
1180	3.67	1230	3.15
1185	3.61	1235	3.11
1190	3.54	1240	3.08
1195	3.49	1245	3.04
1200	3.43		

These values, based on the work of Zuca and Costin (oscillating sphere method) [**282**], supersede the previous NSRDS recommendations [1].

$TaCl_5$

Melt Preparation and Purification

The $TaCl_5$ was purified by distillation [**217**].

TABLE 54. Density studies: $TaCl_5$

Investigations critically re-examined	
Ref.	Temp. range (T)
217	600–770

TABLE 55. $TaCl_5$: Density (g cm^{-3})

$\rho = 31.5417 - 0.1452T + 0.2436 \cdot 10^{-3}T^2 - 0.1384 \cdot 10^{-6}T^3$

Standard error of estimate: 3.8%

T	ρ	T	ρ
600	2.289	690	1.892
610	2.147	700	1.877
620	2.043	710	1.842
630	1.972	720	1.782
640	1.928	730	1.688
650	1.905	740	1.553
660	1.896	750	1.369
670	1.895	760	1.129
680	1.896	770	0.823

These values are based on the work of Nisel'son, Pustil'nik and Sokolova (pycnometric technique) [**217**].

$ThCl_4$

Melt Preparation and Purification

See $NaCl$-$ThCl_4$ [81, **200**] for discussion of preparative aspects.

TABLE 56. Density studies: $ThCl_4$

Investigations critically re-examined		
Ref.	Temp. range (T)	Cell material
81	1045–1173	
200	1045–1123	Pt-bob and suspension wire

Deviations from previous NSRDS recommendations: [1, p. 9]		
Ref.	Min. departure	Max. departure
200	2.2% (1120 K)	3.4% (1090 K)
81	2.2% (1120 K)	3.4% (1090 K)

TABLE 57. $ThCl_4$: Density (g cm^{-3})

$\rho = 4.823 - 1.4 \cdot 10^{-3}T$

T	ρ
1050	3.352
1060	3.339
1070	3.325
1080	3.311
1090	3.297
1100	3.283
1110	3.269
1120	3.254

These values, based on the work of Oyamada, Yoshida, and Kuroda (Archimedean method) [**200**], supersede the previous NSRDS recommendations [1].

$TiCl_4$

Melt Preparation and Purification

$TiCl_4$ in reference [**307**] was purified by fractionation on efficient sieve-plate columns. The chemical and spectroscopic analysis showed an impurity content of less than 10^{-3} to 10^{-4}%.

Toropov [48] used $TiCl_4$, purified by fractional distillation. $TiCl_4$ used in [**213**] was purified by repeated fractional distillations. The melting point of $TiCl_4$ in reference [**214**] was found to be 135.6 °C.

TABLE 58. Density and surface tension studies: $TiCl_4$

Investigations critically re-examined			
Property	Ref.	Temp. range (T)	Comments
ρ	213	301–406	sealed quartz pycnometer, calibrated with H_2O; relative error estimated as 5×10^{-2}%
	214	253–293	calibration with Hg
	48	293, 313, 333	
	346	340, 360, 375, 393	
	221	255–381	
γ	**307**	282–408	absolute error less than 0.02 dyn cm^{-1}; comparison of capillary rise and maximum bubble pressure methods given
	266	273–373	

Deviations from NSRDS recommendations			
Property	Ref.	Min. deviation	Max. deviation
ρ	48	0.2% (333 K)	0.5% (313 K)
γ	266	−2.3% (239 K)	−3.1% (373 K)

TABLE 59. $TiCl_4$: Density (g cm^{-3}) and surface tension (dyn cm^{-1})

$\rho = 2.1808 - 1.3581 \cdot 10^{-3}T - 6.3489 \cdot 10^{-7}T^2$
Standard error of estimate: 0.01%
Temp. range: 260–290 K, [214]
$\rho = 2.1488 - 1.2226 \cdot 10^{-3}T - 7.3676 \cdot 10^{-7}T^2$ (g cm^{-3})
Standard error of estimate: 0.04%
Temp. range: 300–410 K, [213]
$\gamma = 78.0149 - 1.7791 \cdot 10^{-1}T + 8.9548 \cdot 10^{-5}T^2$
Standard error of estimate: 0.15%

T	ρ	γ
260	1.7847	
270	1.7678	
280	1.7507	
290	1.7335	33.95
300	1.7157	32.70
310	1.6989	31.47
320	1.6821	30.25
330	1.6651	29.06
340	1.6479	27.88
350	1.6306	26.72
360	1.6131	25.57
370	1.5955	24.45
380	1.5778	23.34
390	1.5599	22.25
400	1.5418	21.18
410	1.5236	

The values for density and surface tension are given in table 59. The data bases for these are, density: Niselson and Tret'yakova, 300–410 K, [213] and Sackmann and Arnold, 260–290 K [214] (pycnometric method); surface tension: Pugachevich (maximum bubble pressure) [307].

TlCl

Melt Preparation and Purification

P.A. Thallium (I) chloride in reference [140] was dried in the quartz apparatus for 6 hours at 10^{-3} Torr and 350 °C.

The salt was distilled under vacuum into a quartz cylinder previously washed with pure dry nitrogen and sealed off. Thallium (I) chloride was stored protected from light. The maximum error was reported to be between 2 and 3 %.

TABLE 60. Viscosity studies: TlCl

Investigations critically re-examined

Ref.	Temp. range (T)	Calibration	Cell material
140	733–1053	CCl_4, methyl iodide, n-hexane, ether, ethyl bromide at room temperature	Quartz cylinder containing the melt suspended on a W wire
303	732–1053		

TABLE 61. TlCl: Viscosity (cp)

$\eta = 0.173 \cdot \exp(3400/RT)$

T	η	T	η
740	1.747	900	1.158
760	1.644	920	1.111
780	1.552	940	1.068
800	1.469	960	1.028
820	1.399	980	0.992
840	1.327	1000	0.958
860	1.265	1020	0.926
880	1.209	1040	0.897

These values are based on the work of Grothe (oscillating hollow cylinder method) [140].

UCl_3

Melt Preparation and Purification

Forthmann et al. [190] used UO_2, preheated in a pure hydrogen atmosphere at 900 °C as starting material. The oxide contained in a quartz boat was heated in an argon atmosphere saturated with CCl_4 at 500–600 °C. The UCl_4 was distilled immediately into the quartz apparatus at 700–800 °C. Dry hydrogen was passed through the melt at 600 °C and the temperature was increased until the measured conductance remained constant at 850 °C. UCl_3 was analyzed by a gravimetric method and by titration with $K_2Cr_2O_7$. The references [135, **189**, **190**] are discussed under the system KCl-UCl_3.

TABLE 62. Electrical conductance and density studies: UCl_3

Investigations critically re-examined

Property	Ref.	Temp. range (T)	Comments
κ	**190**	1123	Quartz cell, Pt electrodes, calibration with molten NaCl, KCl, CsCl
	135	1123	graphical
	189	1113–1213	graphical
ρ	**189**	1219–1303	Quartz cell; calibration with molten NaCl, KCl
	135		graphical

TABLE 63. UCl_3: Specific conductance (ohm^{-1} cm^{-1}) and density (g cm^{-3})

$\rho = 13.652 - 7.943 \cdot 10^{-3}T$

For specific conductance only one value was reported:

$\kappa = 1.07$ at 1123 K

T	ρ	T	ρ
1220	3.962	1265	3.604
1225	3.922	1270	3.564
1230	3.882	1275	3.525
1235	3.842	1280	3.485
1240	3.803	1285	3.445
1245	3.763	1290	3.406
1250	3.723	1295	3.366
1255	3.683	1300	3.326
1260	3.644		

The values for specific conductance and density are given in table 63. The data bases for these are, specific conductance: Forthmann and Schneider (classical ac technique) [**190**]; density: Mochinaga (pycnometric method) [**189**].

UCl_4

Melt Preparation and Purification

Kuroda and Suzuki [52] prepared UCl_4 by the reaction between carbon, chlorine and urano-uranic oxide at about 850 °C. The urano-uranic oxide was obtained from uranyl nitrate which had been previously purified with tributylphosphate, sodium nitrate and kerosene.

Bogacz and Ziolek [**179**] used UCl_4 prepared from uranyl oxalate by hydrogen reduction at 400 °C to UO_2 and then chlorination at 440 °C with CCl_4 in a stream of previously purified nitrogen. The composition of the obtained UCl_4 was found to vary between $UCl_{3.9}$ and $UCl_{4.01}$. The salt was kept in sealed ampoules filled with dry argon.

Desyatnik et al. [**212**] prepared the UCl_4 by chlorination of UO_2 with CCl_4. The product was twice recrystallized and the melting point of UCl_4 was found to be 587±2 °C.

The preparation of UCl_4 in reference [52] is discussed under the system KCl-UCl_4.

TABLE 64. Electrical conductance, density and surface tension studies: UCl_4

Investigations critically re-examined

Property	Ref.	Temp. range (T)	Comments
κ	**179**	872–1001	Quartz cell; Pt electrodes; calibration with molten KNO_3, $NaNO_3$ and KCl; experimental error was within 0.5%
	52	873–943	Quartz cell; Pt electrodes; calibration with aqueous KCl
ρ	**179**	876–949	Pt sinker and suspension wire; measurement error of 0.1 to 0.2%
	276	863–1273	
	52	873–1023	Quartz cell
γ	**212**	878–973	Pt crucible
	276	863–1273	
	179	883–933	Coaxial quartz capillary tubes; calibration with water; benzene, CCl_4, molten $NaNO_3$ and KNO_3

Deviations from NSRDS recommendations:
[1, p. 9 for κ, otherwise this volume]

Property	Ref.	Min. deviation	Max. deviation
κ	**179**	−1.8% (880 K)	−4.5% (890 K)
	52	−1.9% (873 K)	−6.0% (883 K)
ρ	276	11.0% (948 K)	11.1% (913 K)
	52	−1.6% (923 K)	−2.0% (873 K)
γ	179	−3.9% (883 K)	3.8% (933 K)

TABLE 65. UCl_4: Specific conductance (ohm^{-1} cm^{-1}); density (g cm^{-3}) and surface tension (dyn cm^{-1})

$\kappa = -2.2782 + 4.6911 \cdot 10^{-3}T - 1.8260 \cdot 10^{-6}T^2$
Standard deviation: 0.0002
$\rho = 5.2508 - 1.9455 \cdot 10^{-3}T$
Standard deviation: 0.0006
$\gamma = 204.95 - 1.8500 \cdot 10^{-1}T$
Standard deviation: 0.02

T	κ	ρ	γ
870		3.558	
880	0.436	3.539	42.15
890	0.451	3.519	40.30
900	0.465	3.500	38.45
910	0.479	3.480	36.60
920	0.492	3.461	34.75
930	0.505	3.441	32.90
940	0.518	3.422	31.05
950	0.530		29.20
960	0.542		27.35
970	0.559		
980	0.565		
990	0.576		
1000	0.587		

The updated values for specific conductance and the new recommendations for density and surface tension are given in table 65. The data bases for these are, specific conductance: Bogacz and Ziolek (classical ac technique) [**179**]; density: Bogacz and Ziolek (Archimedean method) [**179**]; surface tension: Desyatnik (maximum bubble pressure method) [**212**].

$ZnCl_2$

Melt Preparation and Purification

The melt preparation and purification described in the following references are discussed under the binary systems given in section 6.

Ref.	Systems
93	$CdCl_2$-$ZnCl_2$
91	CsCl -$ZnCl_2$
108	CsCl -$ZnCl_2$
199	CsCl -$ZnCl_2$
194	CsCl -$ZnCl_2$
195	CsCl -$ZnCl_2$
197	CsCl -$ZnCl_2$
274	CsCl -$ZnCl_2$
78	KCl -$ZnCl_2$

TABLE 66. Electrical conductance studies: $ZnCl_2$

Investigations critically re examined

Ref.	Temp. range (T)	Cell materials	Calibration
286[a]	733–913		
297	589–673 (g)		
296	589–673 (g)		
274	589–851	Capillary silica cells; Pt electrodes; freq. range: 500–100,000 Hz [**274**], [108], [197]	0.1 and 1.0 demal KCl solutions at 25° C [**274**], [108], [197]
108	589–851		
197[b]	589–851		

Deviations from previous NSRDS recommendations: [1, p. 10]

Ref.	Min. departure	Max. departure
286	0.04% (913 K)	2.7% (823 K)
274	−1.1% (851 K)	−40% (621 K)

[a]Data from [1].
[b]Data from [108].

For a statistical satisfactory fit two equations were generated to cover the temperature range of reference [**274**] with standard errors of estimate of $9.93 \cdot 10^{-5}$ (588.9 to 672.6 K) and $9.62 \cdot 10^{-4}$ (684.2 to 851.4 K). The method used by Bloom and Weeks [**274**] is identical to the one discussed under the systems KCl-NaCl and NaCl-$ZnCl_2$ for the references [108, 197].

TABLE 67. $ZnCl_2$: Specific conductance (ohm^{-1} cm^{-1})

$\kappa = 4.68133 - 1.4586 \cdot 10^{-3}T + 8.8563 \cdot 10^{-7}T^2 + 4.1656 \cdot 10^{-10}T^3$
Standard error of estimate: 2.45% (590–673 K)
$\kappa = 1.0297 - 2.2729 \cdot 10^{-3}T - 2.9677 \cdot 10^{-7}T^2 + 2.1377 \cdot 10^{-9}T^3$
Standard error of estimate: 1.12% (673–851 K)

T	κ	T	κ
590	0.00140	730	0.04395
600	0.00178	740	0.05151
610	0.00248	750	0.05995
620	0.00352	760	0.06930
630	0.00488	770	0.07956
640	0.00658	780	0.09075
650	0.00862	790	0.1029
660	0.01100	800	0.1160
670	0.01372	810	0.1300
680	0.01908	820	0.1451
690	0.02238	830	0.1611
700	0.02650	840	0.1781
710	0.03146	850	0.1962
720	0.03727		

These values, based on the work of Bloom and Weeks (classical ac technique) [**274**], supersede the previous NSRDS recommendations [1].

TABLE 68. Density studies: $ZnCl_2$

Investigations critically re-examined			
Ref.	Temp. range (T)	Cell material	Calibration
128[a]	623–763		
199[b,c]	588–873	Silica	water
91[c]	620–868	Sealed silica cell	
108[c]	587–835	Silica	water
78	637–934	Pt bob	
93	623–763	Quartz ball containing W for weight	water and CCl_4
194	696–749	Quartz float (weighted with W); Pt suspension wire	water
195	623–723	as for 194	
193	873, 973		

Deviations from previous NSRDS recommendations: [1, p. 10]

Ref.	Min. departure	Max. departure
78	−0.86% (660 K)	−1.1% (800 K)
91	0.0% (630 K)	−0.5% (800 K)
93	0.0% (680 K)	−0.2% (760 K)
108	−0.1% (683 K)	0.4% (600 K)
193	−0.2% (873 K)	
194	−0.02% (733 K)	−0.2% (696 K)
195	0.04% (660 K)	−0.1% (720 K)

[a]Data from [93].

[b]Data from [**108**].

[c]References [91, **108**, 199] are discussed under the system CsCl-$ZnCl_2$. A statistical analysis of the experimental data in [**108**] resulted in a satisfactory linear equation over the whole temperature range, as reported for the system CsCl-$ZnCl_2$. A slightly better fitted equation is given in table 69.

TABLE 69. $ZnCl_2$: Density (g cm^{-3})

$$\rho = 3.0183 - 1.0536 \cdot 10^{-3}T + 3.7641 \cdot 10^{-7}T^2$$

Standard error of estimate: 0.05%

T	ρ	T	ρ
590	2.528	720	2.455
600	2.522	730	2.450
610	2.516	740	2.445
620	2.510	750	2.440
630	2.504	760	2.435
640	2.498	770	2.430
650	2.492	780	2.426
660	2.487	790	2.421
670	2.481	800	2.416
680	2.476	810	2.412
690	2.471	820	2.407
700	2.465	830	2.403
710	2.460		

These values, based on the work of Weeks [**108**] (pycnometric method), supersede the previous NSRDS recommendations [1].

$ZrCl_4$

Melt Preparation and Purification

Nisel'son [**268**] used the purest fractions of $ZrCl_4$, fractionated in a packed metallic column. The content of metallic impurities was less than 0.01%.

$ZrCl_4$ in reference [**264**] was prepared by chlorination of Zr in a quartz tube under dry argon to prevent oxidation, followed by resublimation. The product was stored in sealed ampoules.

TABLE 70. Density, viscosity and surface tension studies: $ZrCl_4$

Investigations critically re-examined			
Property	Ref.	Temp. range (T)	Comments
ρ	**264**	707–770	Mo glass cell; correction applied for thermal expansion of the glass
η	**268**	710–760	Borosilicate glass cell; calibration with water and CCl_4; estimated error less than 1%
γ	**268**	716–761	Borosilicate glass

TABLE 71. $ZrCl_4$: Density (g cm^{-3}), viscosity (cp) and surface tension (dyn cm^{-1})

$$\rho = -22.3517 + 7.2020 \cdot 10^{-2}T - 5.3886 \cdot 10^{-5}T^2$$
Standard error of estimate: 1.07%
$$\eta = 11.0518 - 2.4817 \cdot 10^{-2}T + 1.3787 \cdot 10^{-5}T^2$$
Standard error of estimate: 4.44%
$$\gamma = 304.3602 - 7.0955 \cdot 10^{-1}T + 4.0916 \cdot 10^{-4}T^2$$
Standard error of estimate: 3.11%

T	ρ	η	γ
710	1.62	0.381	
715	1.60	0.356	6.20
720	1.57	0.330	5.59
725	1.54	0.306	5.00
730	1.51	0.282	4.43
735	1.47	0.259	3.88
740	1.44	0.237	3.35
745	1.40	0.215	2.84
750	1.35	0.194	2.35
755	1.31	0.174	1.88
760	1.26	0.154	1.43
765	1.21		

The data bases for these are. density: Nisel'son and Sokolova (pycnometric method) [**264**]; viscosity: Nisel'son (capillary technique) [**268**]; surface tension: Nisel'son (capillary rise method) [**268**].

5.4. Additional Studies

The following table summarizes information relative to additional studies for single salt melts that have been reported since the publication of NSRDS–NBS–15 [1] and NSRDS–NBS–28 [2]. This information does not include new systems or cases where a revised recommendation has been introduced; such cases are discussed in detail in earlier sections. The information included in this summary table indicates the authors, reference and maximum and minimum percent departure of the various studies relative to the previously recommended values.

TABLE 72. Deviations from NSRDS recommended values: AgCl

Reference	Authors	Min. departure	Max. departure
Conductance (NSRDS reference data base Bell, Flengas (1964), [1], p. 10)			
288	Sakai (1954)	−0.40% (727.56 K)	−4.91% (880.56 K)
12	Sandonnini (1920)	−8.60% (773.16 K)	
58	Markov, Prisyazhnyi (1962)	graphical	
67, 169	Bizouard (1961)	−0.76% (973.16 K)	−1.08% (873.16 K)
124	Markov (1965)	graphical	
131	Protsenko, Shatskaya (1967)	graphical	
Density (NSRDS reference data base Bell, Flengas (1964), [1], p. 10)			
26	Boardman, Dorman, Heymann (1949)	0.63% (750 K)	1.05% (900 K)
124	Markov, Prisyazhnyi (1965)	graphical	
181	Markov, Prisyazhnyi (1963)	graphical	
Viscosity (NSRDS reference data base Harrap, Heymann (1955), [1], p. 10)			
136	Harrap, Heymann (1951)	0.24% (773.2 K)	
Surface tension (NSRDS reference data base Boardman, Palmer, Heymann (1955), [2], p. 59			
242	Sternberg, Terzi (1972)	−2.30% (700 K)	−2.70% (480 K)

TABLE 73. Deviations from previous NSRDS recommendations: $BaCl_2$

Reference	Authors	Min. departure	Max. departure
Conductance (NSRDS reference data base Bockris, et al. (1966), [1], p. 7)			
20	Alabyshev, Kulakorskaya (1946)	graphical	
63	Barzakovskii (1940)	5.48% (1245.16 K)	−7.18% (1357.16 K)
120	Kochinashvili, Barzakovskii (1957)	−6.04% (1273.16 K)	−6.10% (1323.16 K)
155*	Smirnov, Khokhlov (1969)	0.01% (1260 K)	1.57% (1360 K)
151	Bondarenko, Strelets (1965)	graphical	
182	Taniuchi (1970)	graphical	
210	Argyriades (1954)	−1.70% (1236.16 K)	−4.73% (1343.16 K)
339	Kuvakin, Evstifeev, Ispolin, Talanova (1973)	−12.4% (1273 K)	
Density (NSRDS reference data base Van Artsdalen, Yaffe (1956), [1], p. 7)			
24	Barzakovskii (1940)		−1.40% (1273 K)
79	Smirnov, Puzanova, Stepanov (1969)	−1.91% (1240 K)	2.22% (1270 K)
105	Bukhilova, Yagub'yan (1968)	graphical	
150	Reding (1965)		
152	Yagub'yan, Bukhalova (1968)	graphical	
167	Bondarenko, Strelets (1962)		0.23% (1273.16 K)
89	Bukhilova, Yagub'yan (1965)	6.28% (1360 K)	6.46% (1240 K)
22	Abramov (1936)	0.0% (1240 K)	0.13% (1360 K)
Surface Tension (NSRDS reference data base Peake, Bothwell (1954), [2], p. 60)			
167	Bondarenko, Strelets (1962)		
250	Barzakovskii (1940)		0.78% (1173.16 K)
244	Bertozzi (1964)	graphical	21.2% (1273 K)

*Data presented graphically in 209.

TABLE 74. Deviations from previous NSRDS recommendations: $BeCl_2$

Reference	Authors	Min. departure	Max. departure
Conductance (NSRDS reference data base Delimarskii, Shieko, Feshchenko (1955), [1], p. 6)			
297	Markov, Polishchuk (1965)	graphical	

TABLE 75. Deviations from previous NSRDS recommendations: $BiCl_3$

Reference	Authors	Min. departure	Max. departure
Conductance (NSRDS reference data base Grantham (1965), [1], p. 13)			
281, 324	Ichikawa, Shimoji (1966)	graphical	
283	Bertram, Lambrecht, Wiebe (1970)	graphical	
302, 278	Grantham, Yosim (1963)	graphical	
275	Darnell, McCollum, Yosim (1969)	−0.5% (660 K)	29.4% (550 K)
Density (NSRDS reference data base Voigt, Biltz (1924), [1], p. 13)			
90	Boston (1968)	−0.12% (700 K)	−0.22% (780 K)

TABLE 76. Deviations from previous NSRDS recommendations: $CaCl_2$

Reference	Authors	Min. departure	Max. departure
Conductance (NSRDS reference data base Brockris, et al., (1960), [1], p. 7)			
299	Emons, Richter (1965)	graphical	
297	Markov, Polishchuk (1965)	graphical	
120	Kochinashvilli, Barzakovskii (1957)	−9.35% (1173.16 K)	−10.84% (1123.16 K)
12	Sandonnini (1920)	−5.02% (1123.16 K)	−7.24% (1223.16 K)
109	Grjotheim, Nikolic, Øye (1970)	−1.54% (1093.66 K)	−3.73% (1173.46 K)
94	Markov, Prisyazhnyi (1965)	graphical	
160	Mulcahy, Heymann (1943)	graphical	
170	Emons, Brautigam, Vogt (1970)	graphical	
44	Luzhnaya, Evseeva, Vereshchetina (1956)	graphical	
144	Barzakovskii (1940)	−4.57% (1073.16 K)	−8.96% (1173.16 K)
146	Story, Clarke (1957)	−0.13% (1124.46 K)	−0.36% (1075.66 K)
5	Arndt, Gessler (1908)	−9.29% (1123.16 K)	−11.43% (1273.16 K)
210	Argyriades (1954)	0.38% (1138.16 K)	−2.55% (1243.16 K)

TABLE 76. Deviations from previous NSRDS recommendations: $CaCl_2$—Continued

Reference	Authors	Min. departure	Max. departure
	Density (NSRDS reference data base Van Artsdalen, Yaffe (1956) [1], p. 7)		
6	Arndt, Gessler (1908)	−0.92% (1273.16 K)	−1.05% (1123.16 K)
202	Markov, Prisyazhnyi (1970)	7.16% (1060 K)	7.32% (1120 K)
17	Fuseya, Ouchi (1949)	0.56% (1123.16 K)	0.59% (1073.16 K)
34	Vereshchetina (1954)	−1.10% (1073.16 K)	−1.15% (1123.16 K)
144	Barzakovskii (1940)	1.12% (1060 K)	1.66% (1230 K)
94	Markov, Prisyazhnyi (1965)	graphical	
95	Maurit (1966)	graphical	
44	Luzhnaya, Evseeva, Vereshchetina (1956)	graphical	
12	Sandonnini (1920)	−0.76% (1073.16 K)	−1.06% (1173.16 K)
28	Pavlenko (1949)	−0.70% (1157.16 K)	−0.10% (1073.16 K)
130	Lillebuen (1966)	−0.01% (1065.56 K)	0.12% (1142.16 K)
133	Grjotheim, Holm, Øye (1971)		0.00% (1073.16 K)
30	Potter, St. Clair, Huber (1952)	−0.73% (1091.2 K)	−0.78% (1148.2 K)

TABLE 77. Deviations from previous NSRDS recommendations: $CdCl_2$

Reference	Authors	Min. departure	Max. departure
	Conductance (NSRDS reference data base Bockris, et al., (1960) [1], p. 11)		
288	Sakai (1954)	−0.12% (930.46 K)	2.17% (850.56 K)
293	Hills, Djordwic (1968)		0.03% (873.16 K)
301	Grantham (1966)	0.03% (885.16 K)	3.55% (843.16 K)
116	Sakai (1954)	0.59% (908.16 K)	2.29% (868.16 K)
283	Bertram, Lambrecht, Wiebe (1970)	graphical	
297	Markov, Polishchuk (1965)	graphical	
160	Mulcahy, Heymann (1943)	graphical	
94	Markov, Prisyazhnyi (1965)	graphical	
117	Sakai, Hayashi (1953)	graphical	
338	Suski, Stachowicz (1972)	2.2% (903.5 K)	2.2% (1009 K)
	Density (NSRDS reference data base Bloom, et al., (1953), and Boardman, (1949), [1], p. 11)		
204	Il'yasov, Barsegov (1970)	graphical	
193	Lantratov, Shevlyakova (1963)	−0.65% (973.16 K)	−2.13% (873.16 K)
94	Markov, Prisyazhnyi (1965)	graphical	
103	Bloom, Boyd, Laver (1966)	−0.02% (1000 K)	−0.05% (1070 K)
93	Markov, Prisyazhnyi (1968)	−0.01% (970 K)	−0.48% (870 K)
78	Ellis (1967)	0.02% (990 K)	0.10% (850 K)
184	Ellis (1959)	−0.02% (987.16 K)	−0.15% (895.16 K)
	Viscosity (NSRDS reference data base Bloom, Harrap, Heymann, (1948) [1], p. 11)		
36	Harrap, Heymann (1955)	0.04% (923.15 K)	0.75% (873.15 K)
136	Harrap, Heymann (1951)		1.19% (873.15 K)
	Surface tension (NSRDS reference data base Ellis, (1958) [2], p. 61)		
234	Boardman, Palmer, Heymann (1955)	graphical	
255	Ellis, Freeman (1965)	0.10% (859.00 K)	1.30% (924.00 K)
143	Ellis, Smith (1958)	graphical	
235	Ellis, Smith, Wilcox, Crook (1961)	0.10% (859.00 K)	1.30% (924.00 K)

TABLE 78. Deviations from previous NSRDS recommendations: $CeCl_3$

Reference	Authors	Min. departure	Max. departure
	Conductance (NSRDS reference data base Bronstein, Dworkin, Bredig, (1962) [1], p. 8)		
289	Smirnov, Lbov (1966)	18.33% (1120 K)	23.23% (1210 K)
	Density (NSRDS reference data base Senderoff, (1960) [1], p. 8)		
106	Smirnov, Lbov (1966)	0.01% (1100 K)	0.01% (1170 K)

TABLE 79. Deviations from previous NSRDS recommendations: CsCl

Reference	Authors	Min. departure	Max. departure
Conductance[a] (NSRDS reference data base Van Artsdalen and Yaffe, (1956) [1], p. 6)			
166[b]	Smirnov, Khoklov (1969)	−0.23% (1010 K)	−7.48% (940 K)
141	Zuca, Olteanu (1968)	−0.88% (993.15 K)	−9.95% (1103.15 K)
124	Markov, Prisyazhnyi (1965)	graphical	
59	Chernov, Delimarskii (1961)	graphical	
158	Bogacz, Ziolek (1967)	1.31% (940 K)	3.23% (990 K)
104	Smirnov, Khoklov, Puzanova (1966)	graphical	
98	Zuca, Olteanu (1970)	−0.55% (1010 K)	−7.48% (948 K)
142	Bloom (1963)	graphical	
71	Fedorov, Petrov (1967)	graphical	
186	Von Forthmann, Vogel, Schneider (1969)	graphical	
Density (NSRDS reference data base Van Artsdalen, (1956) [1], p. 6)			
280	Vasu (1969)		0.00% (950 K)
284	Jaeger, Kahn (1916)	0.01% (940 K)	0.05% (1010 K)
294	Murgulescu, Zuca (1962)	−0.00% (945.16 K)	−0.08% (1110.16 K)
75	Smirnov, Stepanov, Khokhlov (1966)	−0.38% (960 K)	−1.14% (1070 K)
79	Smirnov, Puzanova, Stepanov (1969)	0.12% (970 K)	−1.26% (1170 K)
98	Zuca, Olteanu (1970)	−0.30% (1090 K)	−0.39% (940 K)
103	Bloom, Boyd, Laver, Wong (1966)	0.26% (1110 K)	0.46% (970 K)
130	Lillibuen (1966)	0.01% (1020 K)	−0.14% (940 K)
133	Grjotheim, Holm, Øye (1971)		0.09% (1073.16 K)
141	Zuca, Olteanu (1969)	−0.29% (1090 K)	−0.38% (940 K)
158	Bogacz, Ziolek (1970)	−0.56% (990 K)	−0.58% (940 K)
177	Smirnov, Stepanov (1969)		1.22% (1123.16 K)
202	Markov, Prisyazhnyi, Prikhod'ko (1970)	−0.06% (940 K)	−0.16% (1000 K)
124	Markov (1965)	graphical	
142	Bloom (1963)	graphical	
152	Bukhalova, Gagub'yan (1968)	graphical	
181	Markov, Prisyazhnyi (1963)	graphical	
205	Prisyazhnyi, Bryzgailo (1966)	graphical	
Surface tension (NSRDS data reference base Jaeger, (1917) [2], p. 58)			
244	Morachevski (1967)	graphical	
252	Smirnov, Stepanov (1968)	−0.10% (993.16 K)	−1.10% (933.16 K)
253, 258	Lillebuen (1969)	−0.05% (1013.16 K)	−1.40% (933.16 K)

[a]The results of Smirnov (1966), Smirnov (1969) and Zuca (1968) are in agreement within ±1% at temperatures up to 1020 K, but at higher temperatures the Van Artsdalen data fall uniformly above with a maximum percent departure ~8% at ~1160 K.
[b]Reported graphically in 209.

TABLE 80. Deviations from previous NSRDS recommendations: $ErCl_3$

Reference	Authors	Min. departure	Max. departure
Conductance (NSRDS reference data base Dworkin, Bronstein, Bredig, (1963) [1], p. 9)			
190	Forthmann, Schneider (1969)	graphical	

TABLE 81. Deviations from previous NSRDS recommendations: $HgCl_2$

Reference	Authors	Min. departure	Max. departure
Conductance (NSRDS reference data base Grantham, Yosim, (1966) [1], p. 11)			
313	Cleaver, Smedley (1970)	graphical	
295	Darnell, McCollum (1971)	data: Λ at elevated pressures	
278	Grantham, Yosim (1967)	graphical	
76	Bergman, Chagin (1940)		1.92% (573.16 K)
15, 123	Belyaev (1940)	graphical	
Density (NSRDS reference data base Janz, McIntyre, (1962) [1], p. 11)			
310[a]	Johnson, Silva, Cubiciotti (1965)	−0.17% (596.8 K)	−0.38% (568.8 K)

[a]See also [1], ref. 127.

TABLE 82. Deviations from previous NSRDS recommendations: KCl

Reference	Authors	Min. departure	Max. departure
	Conductance (NSRDS reference data base Van Artsdalen and Yaffe, (1955), [1], p. 5)		
290	Lillebuen, Danek (1970)	graphical	
94	Markov, Volkov, Prisyazhnyi (1965)	graphical	
109	Grjotheim, Nikolic, Øye (1970)	0.09% (1149.95 K)	0.05% (1123.55 K)
160	Mulcahy (1943)	graphical	
171	Emons, Brautigam, Vogt (1970)	graphical	
98	Zuca, Olteanu (1970)	−0.13% (1200 K)	−0.27% (1060 K)
287	Balakir, Bushnev (1968)	9.51% (1073.15 K)	17.71% (1213.15 K)
270	Kuraev, Voleinii, Shabdenov (1972)	−5.76% (1223.15 K)	−7.58% (1123.15 K)
305	Lillebuen, Danek (1972)	0.11% (1150 K)	1.75% (1070 K)
186	Vogel, Schneider (1969)	graphical	
190	Von Forthmann, Scheider (1969)	graphical	
65	Matsumura, Mizuno, Nishihara (1966)	0.13% (1073.15 K)	0.24% (1113.15 K)
183	Kawamura (1969)	graphical	
96	Ukshe, Kachina-Pullo (1966)	−0.02% (1170.15 K)	−0.20% (1126.15 K)
113	Sherbakov, Markov (1939)	−1.21% (1073.15 K)	−1.66% (1073.15 K)
114	Botashev (1935)	4.15% (1073.15 K)	11.94% (1173.15 K)
145	Karpachev, Stromberg (1934)	−0.37% (1123.15 K)	−1.21% (1073.15 K)
72	Murgulescu, Zuca (1959)	0.01% (1123.15 K)	0.04% (1073.15 K)
218	Markov, Tarasenko (1958)	graphical	
97	Sundheim (1957)	0.04% (1073.15 K)	
142	Bloom (1963)	graphical	
71	Fedorov, Petrov (1967)	graphical	
55	Delimarskii, Chernov (1960)	0.13% (1073.15 K)	
59	Delimarskii, Chernov (1961)	graphical	
61	Kamenetskii, Scheoylajakova (1962)	0.50% (1223.15 K)	−5.04% (1123.15 K)
58	Markov, Prisyazhnyii (1962)	graphical	
67	Bizouard (1961)	−0.01% (1073.15 K)	
124	Markov, Prisyazhnyii (1965)	graphical	
95	Doucet, Michel (1960)	−0.01% (1073.15 K)	
83	Zuca, Ionescu-Vasu (1967)	0.25% (1060 K)	−0.5% (1200 K)
201	Matsumura, Mizuno, Nishihara (1967)	−0.01% (1086.15 K)	0.18% (1126.15 K)
56	Markov, Prisyazhnyii (1962)	graphical	
273	Janz, Lorenz (1960)	−0.10% (1107.55 K)	−2.79% (1125.35 K)
210	Argyriades (1954)	3.62% (1128.15 K)	4.31% (1176.15 K)
	Density (NSRDS reference data base Van Artsdalen, Yaffe, (1955) [1], p. 5)		
28	Pavlenko (1949)	−0.90% (1145.15 K)	−1.15% (1071.15 K)
130	Lillebuen (1961)	0.20% (1123.15 K)	0.32% (1073.15 K)
133	Grjotheim, Holm, Øye (1970)	0.32% (1073.15 K)	
98	Zuca, Olteanu (1969)	0.00% (1090 K)	0.21% (1210 K)
178	Smirnov, Stepanov (1969) [a]	−0.08% (1170 K)	−0.10% (1070 K)
228	Neithammer, Peake (1961)	−0.37% (1222.15 K)	−0.85% (1089.15 K)
284	Saeger, Kahn (1916)	−0.24% (1110.15 K)	3.83% (1058.15 K)
27	Von Grothe (1949)	−0.00% (1173.15 K)	0.45% (1073.15 K)
89	Bukhalova, Yagub'yan (1965) [b]	−0.13% (1060 K)	−0.39% (1270 K)
150	Reding (1965)	−0.25% (1070 K)	0.32% (1220 K)
83	Zuca, Ionescu-Vasu (1967)	0.00% (1103 K)	−0.23% (953 K)
62	Treadwell, Cohen (1939)	−1.07% (1073.15 K)	
145	Karpachev, Stromberg (1934)	−1.67% (1073 K)	
72	Murgulescu, Zuca (1959)	0.12% (1073.15 K)	
24	Barzakovskii (1940)	−0.28% (1173.15 K)	−4.05% (1073.15 K)
143	Ellis, Smith (1958)	0.00% (1250 K)	
181 [c]	Markov, Prisyazhnyii (1963)	−0.21% (1073.15 K)	
53	Murgulescu, Zuca (1965)	0.01% (1093 K)	0.02% (1203 K)
194	Markov, Bolkov (1967)	−0.16% (1111.45 K)	−0.18% (1142.15 K)
189	Mochinaga, Kuroda (1969)	1.29% (1070 K)	2.43% (1270 K)
219	Buckle, Tsaoussoglou (1972)	1.07% (1060 K)	1.86% (1220 K)
171	Emons, Brautigam, Vogt (1970)	graphical	
87	Yamate, Takeuchi (1960)	graphical	
193	Lantratov, Shevlyakova (1963)	graphical	
100	Matsumura, Mizuno, Nishihara (1966)	graphical	

TABLE 82. Deviations from previous NSRDS recommendations: KCl—Continued

Reference	Authors	Min. departure	Max. departure
	Viscosity (NSRDS reference data base Murgulescu, Zuca, (1961)[d] [1], p. 5)		
277	Dumas, Grjotheim (1970)	−7.11% (1136.15 K)	−10.28% (1080.15 K)
24	Barzakovskii (1940)	3.39% (1073.15 K)	5.70% (1173.15 K)
66	Bondarenko (1966)	0.43% (1113.15 K)	11.47% (1151.15 K)
53	Murgulescu, Zuca (1965)	0.35% (1073.15 K)	1.46% (1113.15 K)
100	Matsumura (1964)	20.58% (1063.16 K)	23.50% (1108.15 K)
88	Bondarenko (1969)	0.09% (1151.15 K)	9.59% (1106.00 K)
29	Ogawa (1949)	graphical	
201	Matsumura, Mizuno, Nishihara (1967)	graphical	

[a]See [106] for graphical analysis.
[b]See [152] and [105] for graphical analysis of this data.
[c]See [94], [124], [162] and [205] for additional information.
[d]See also S. Zuca and R. Borcan; Rev. Roum. Chim., **15**, 1681 (1970). In light of these additional studies the uncertainty estimate reported in Molten Salts Vol. 1 should be revised to ±1.5% for the lower temperature limits to a somewhat larger uncertainty i.e. ±5% at the higher temperatures.

TABLE 83. Deviations from previous NSRDS recommendations: $LaCl_3$

Reference	Authors	Min. departure	Max. departure
	Density (NSRDS reference data base Van Artsdalen, Yaffe, (1956) [1], p. 8)		
177	Smirnov, Stepanov (1969)	−0.56% (1260 K)	−1.35% (1140 K)
	Viscosity[a] (NSRDS reference data base Smirnov, Khokhlov and Stepanov (1966) [1], p. 8)		
173	Smirnov and Khokhlov (1970)	0.18% (1240 K)	3.35% (1190 K)

[a]The uncertainty estimate reported in ref. 1 should be increased to 3%.

TABLE 84. Deviations from previous NSRDS recommendations: LiCl

Reference	Authors	Min. departure	Max. departure
	Conductance (NSRDS reference data base Van Artsdalen and Yaffe (1955) [1], p. 4)		
47	Duke, Bissell (1964)	1.18% (986.15 K)	2.81% (982.55 K)
287	Balakir, Bushnev (1968)	−3.01% (1023 K)	
67	Bizouard (1961)	−0.08% (973.15 K)	−0.20% (923.15 K)
179	Bogacz, Ziolek (1970)	−0.69% (925 K)	−0.82% (895 K)
155	Smirnov, Khokhlov (1969)	Equation given; outside temperature range of data base	
65	Matsumura, Mizuno (1966)	−0.36% (1023 K)	1.28% (1073 K)
210	Aragyiades, (1954)	−5.28% (1076 K)	−6.97% (1163 K)
191	Danielyan, Belyaev (1965)	Single data point; outside temperature range of data base	
183	Kawamura (1969)	graphical	
73	Fedorov, Petrov (1967)	graphical	
171	Emons, Brautgam, Vogt (1970)	graphical	
94	Markov, Prisyazhnyi, Volkov (1965)	graphical	
	Density (NSRDS reference data base Van Artsdalen, Yaffe (1955) [1], p. 4)		
284	Jaeger, Kahn (1916)	−0.34% (899.15 K)	−0.37% (956.15 K)
294	Murgulescu, Zuca (1962)[b]	−0.25% (1062.15 K)	−0.71% (1014.15 K)
130	Lillebuen (1961)	0.16% (902.6 K)	0.73% (1059.6 K)
133	Grjotheim, et al. (1971)	T out of range of data base	
179	Bogacz, Ziolek (1970)	0.26% (910 K)	0.32% (920 K)
202	Markov, et al. (1969)	0.01% (910 K)	0.01% (1050 K)
75	Smirnov, et al. (1966)	0.00% (950 K)	−0.10% (1060 K)
176	Smirnov, Stepanov (1970)	−0.22% (1123 K)	

TABLE 84. Deviations from previous NSRDS recommendations: LiCl—Continued

Reference	Authors	Min. departure	Max. departure
	Density (NSRDS reference data base Van Artsdalen, Yaffe (1955) [1], p. 4)		
194	Markov, Bolkov (1966)	−0.26% (927.65 K)	−0.44% (896.35 K)
191	Danielyan, Belayev (1963)	−0.01% (970 K)	−0.13% (890 K)
196	Chesnokov, Strelets (1970)	graphical	
171	Emons, Brautigam, Vogt (1970)	graphical	
100	Matsumura, Mizuno, Nishihara (1966)	graphical	
	Viscosity[c] (NSRDS reference data base Murgulescu, Zuca (1963)[d] [1], p. 4)		
88	Bondarenko (1964)	−1.04% (911 K)	9.78% (917 K)
82	Smirnov, Khokhlov (1967)	−0.60% (1060 K)	−4.65% (930 K)
23	Karpachev, Stromberg, Padachinova (1935)	−2.39% (973 K)	−8.41% (1073 K)
86	Nishihara, Matsumura, Asaki (1964)	7.42% (947 K)	15.66% (917 K)
294	Murgulescu, Zuca (1962)	−0.11% (1007.45 K)	−1.24% (958.15 K)
	Surface tension (NSRDS reference data base Ellis (1961) [2], p. 55)		
252	Smirnov, Stepanov (1968)	5.65% (1133 K)	9.64% (893 K)
257	Mizuno (1968)	4.43% (1188 K)	7.06% (887 K)
179	Bogacz, Ziolek (1970)	11.76% (920 K)	14.32% (880 K)
258	Grjotheim, Holm, Lillebuen (1971)	0.31% (893 K)	−2.24% (1143 K)

[a]The fact that the new results are consistently lower would support the suggestion that there may be a conductance short through the cell walls occurring in some of those studies clustering at the higher values. Until experiments are repeated using an air thermostatted bath in a sealed capillary cell it is difficult to resolve this problem unambiguously (refer to section 3.1).

[b]See also S. Zuca and R. Borcan; Rev. Roum. Chim., **15**, 1681 (1970).

[c]In light of the new investigations the uncertainty estimate reported in Molten Salts Vol. 1 should be revised to ±3%.

[d]See also S. Zuca and R. Borcan; Rev. Roum. Chim., **15**, 1681 (1970).

TABLE 85. Deviations from previous NSRDS recommendations: $MgCl_2$

Reference	Authors	Min. departure	Max. departure
	Conductance (NSRDS reference data base Bockris, et al. (1960) [1], p. 6)		
109	Grjotheim, Nickolic, Øye (1970)	−0.18% (1082 K)	−0.37% (1220 K)
114	Batashov (1935)	−3.96% (1023 K)	−5.50% (1123 K)
117	Sakai, Hayashi (1953)	0.66% (1023 K)	0.79% (973 K)
151	Bondarenko, Strelets (1965)	graphical	
167	Bondarenko, Strelets (1962)	−0.25% (1073 K)	−5.32% (1173 K)
30	Potter, Huber, St. Clair (1952)	−0.55% (999 K)	−2.21% (1242 K)
94	Markov, Prisyazhnyii (1965)	graphical	
96	Ukshe, Kachina (1966)	2.25% (1074 K)	2.42% (1103 K)
	Density (NSRDS reference data base Ellis, Smith (1958) [1], p. 6)		
196	Chesnokov (1970)	graphical	
30	Potter, Huber, St. Clair (1952)	0.41% (1240 K)	0.62% (1000 K)
130, 133	Lillebuen (1969)	0.37% (1000 K)	0.60% (1240 K)
102	Grothe (1962)	graphical	
150	Reding (1965)	0.77% (1000 K)	0.87% (1240 K)
95	Marit (1966)	0.0% (1145 K)	−2.26% (1240 K)
62	Treadwell, Cohen (1939)	−0.19% (998 K)	0.30% (1073 K)
	Surface tension (NSRDS reference data base[a] Desyatnikov (1956) [2], p. 59)		
236	Grjotheim, Holm, et al. (1972)	−4.82% (1203.16 K)	−6.56% (993.16 K)
167	Bondarenko, Strehlets (1962)	1.50% (993.16 K)	1.55% (1203.16 K)
241	Reding (1966)	7.76% (1203.16 K)	9.40% (993.16 K)
223	Zezyanov, Il'ichev (1960)	0.76% (1073.16 K)	

[a]The uncertainty of the recommended data base is estimated to be ±2%.

TABLE 86. Deviations from previous NSRDS recommendations: NaCl[a]

Reference	Authors	Min. departure	Max. departure
	Electrical conductance (NSRDS reference data base Van Artsdalen, Yaffe (1955) [1], p. 4)		
309	Ketelaar, Maenaut (1972)	−0.01% (1133 K)	−3.11% (1273 K)
54	Beloserski, Freidina (1941)	−3.54% (1123 K)	−6.42% (1098 K)
109	Nikolic, Grjotheim, Øye (1970)	0.11% (1136 K)	0.80% (1095 K)
63	Barzakovskii (1940)	−0.44% (1089 K)	−1.79% (1197 K)
61	Kamenetzky, Shevlyakova (1962)	−4.61% (1223 K)	−5.91% (1173 K)
287	Balakir, Bushuev, Kudryavtsev (1968)	−2.20% (1123 K)	−5.61% (1223 K)
261	Lee, Pearson (1945)	0.79% (1173 K)	1.12% (1223 K)
290	Danek, Matiasovsky, Lillebuen (1971)	0.22% (1198 K)	
65	Matsumura, Mizuno, Nishihara (1966)	−1.66% (1113 K)	−2.14% (1153 K)
67	Bizouard (1961)	0.18% (1123 K)	
201	Matsumura, Mizuno, Nishihara (1967)	−1.35% (1106 K)	−1.80% (1166 K)
210	Argyriades (1954)	−2.84% (1148 K)	−6.31% (1263 K)
247	Bondarenko, Strelets (1962)	−2.34% (1123 K)	−3.07% (1173 K)
113	Markov, Sherbakov (1939)	1.82% (1123 K)	
114	Batashev (1935)	−2.56% (1173 K)	−4.35% (1123 K)
305	Matiasovsky, Lillebuen, Danek (1972)	0.17% (1243 K)	0.50% (1123 K)
146	Clarke, Story (1957)	−0.12% (1170 K)	0.99% (1083 K)
83	Zuca, Vasu (1967)	0.01% (1083 K)	−1.42% (1173 K)
	Density (NSRDS reference data base Van Artsdalen, Yaffe (1955) [1], p. 4)		
152	Yaguby'an, Bukhalova (1968)	graphical	
171	Emons, Brautigam, Vogt (1970)	graphical	
34	Vereshchetina, Luzhnaya (1954)	−1.29% (1098.16 K)	−1.46% (1123.16 K)
133	Grjotheim, Lillebuen, Holm (1971)	0.22% (1073.16 K)	
12	Sandonnini (1920)	−1.13% (1123.16 K)	
196	Chesnokov (1970)	graphical	
294	Zuca, Murgulescu (1962)	−0.61% (1085.86 K)	−1.68% (1165.46 K)
284	Jaeger, Kahn (1916)	−0.73% (1127.16 K)	−1.36% (1098.16 K)
16	Fuseya, Ouchi (1913)	−0.35% (1123.16 K)	−0.48% (1073.16 K)
98	Zuca, Olteanu (1970)	0.21% (1090 K)	0.29% (1180 K)
89	Bukhalova, Yagub'yan (1965)	3.00% (1080 K)	4.46% (1270 K)
144	Barzakovskii (1940)	0.84% (1080 K)	1.68% (1270 K)
44	Luzhnaya, Evseeva (1956)	graphical	
162	Markov, Prisyazhnyi (1963)	graphical	
130	Lillebuen, Herty, Frear (1961)	0.24% (1090 K)	0.27% (1130 K)
156	Sheiko, Perks, Pozdnyokov (1965)	−2.89% (1080 K)	−4.55% (1290 K)
83	Zuca, Ionescu-Vasu (1967)	−1.01% (1080 K)	−1.17% (1200 K)
200	Yamada, Yoshida, Kunoda (1969)	−1.23% (1170 K)	−1.36% (1080 K)
17	Fuseya, Ouchi (1949)	−0.46% (1085 K)	−0.47% (1080 K)
	Viscosity[b] (NSRDS reference data base Murgulescu and Zuca (1963) [1], p. 4)		
151	Bondarenko, Strelets (1965)	−5.65% (1234 K)	−15.93% (1088 K)
24	Barzakovskii (1940)	0.32% (1173 K)	−11.36% (1273 K)
34	Vereshchetina, Luzhnaya (1954)	2.65% (1153 K)	7.91% (1123 K)
53	Murgulescu, Zuca (1965)	0.32% (1153 K)	−1.82% (1093 K)
201	Matsumura, Mizuno, Nishihara (1967)	2.82% (1113 K)	−6.62% (1083 K)
277	Dumas, Grjotheim, Hogdahl, Øye (1970)	−18.27% (1175 K)	−31.45% (1087 K)
320	Moynihan (1967)	0.27% (1074 K)	
	Surface tension[c] (NSRDS reference data base Sokolova, Voskresenskaya (1962) [2], p. 57)		
242	Sternberg, Terzi (1972)	0.0% (1123.0 K)	2.2% (1243.2 K)
250	Barzakovskii (1940)	0.0% (1273 K)	0.6% (1094.1 K)
257	Mizuno, Matsumura, Tenako (1968)	0.0% (1075.6 K)	0.3% (1094.1 K)
308	Lutzow, Holm (1971)	−1.8% (1083.2 K)	−2.3% (1243.2 K)
258	Grjotheim, Holm, Lillebuen (1971)	1.86% (1083.1 K)	1.90% (1245.1 K)
254	Dahl, Duke (1957)	1.23% (1147.1 K)	3.02% (1099.1 K)

[a]For further discussion of the electrical conductance of NaCl see section 3.1.

[b]Additional studies are needed in order to establish a revised recommendation for this system (see section 3.3).

[c]In light of the new data, the uncertainty estimate reported in Molten Salts Vol. 2 should be revised to ±1%. On examination of the total number of investigations, it is seen that there is a cluster of results within close agreement, falling outside this limit and in which the detachment method is in agreement with the maximum bubble pressure method again within the limits of ±1%. When additional results are available the reference base may have to be adjusted to somewhat higher values.

TABLE 87. Deviations from previous NSRDS recommendations: $NdCl_3$

Reference	Authors	Min. departure	Max. departure
	Conductance (NSRDS reference data base Voigt, Biltz (1924) [1], p. 9)		
186	Von Forthmann, Vogel, Schneider (1969)	graphical	
312	Cho, Kuroda (1972)	17.95% (1170 K)	25.81% (1050 K)

TABLE 88. Deviations from previous NSRDS recommendations: $PbCl_2$

Reference	Authors	Min. departure	Max. departure
	Conductance (NSRDS reference data base Lantratov, Moiseeva (1960) [1]), p. 13)		
210	Agyriades (1954)	*T* out of range of data base	
13	Tarasova (1947)	—0.08% (793.15 K)	—0.98 (773.15 K)
131	Protsenko (1967)	graphical	
94	Markov, Prisyazhnyii (1965)	graphical	
117	Sakai, Hayashi (1955)	graphical	
49	Bloom, Macky (1970)	—0.43% (873.15 K)	0.52% (823.15 K)
142	Bloom (1963)	graphical	
185	Easteal, Hodge (1969)	—1.30% (890 K)	—1.65% (810 K)
98	Barzakovskii (1940)	—0.63% (773.15 K)	—0.95% (873.15 K)
12	Sandonnini (1920)	1.22% (773.15 K)	
17	Markov, Tarasenko (1958)	graphical	
	Density (NSRDS reference data base Boardman, Dorman, Heymann (1949) [1], p. 13)		
94	Markov, Prisyazhnyi (1965)	graphical	
103	Bloom, Boyd, Wong (1966)	—0.06% (910.00 K)	
142	Bloom (1963)	graphical	
195	Markov, et al. (1968)	0.05% (870 K)	0.11% (970 K)
193	Lantratov, et al. (1963)	graphical	
101	Hersh, Kleppa (1964)	graphical	
	Surface tension (NSRDS reference data base Duke, Dahl (1957) [2], p. 61)		
234	Boardman, Palmer, Heymann (1954)	graphical	
250	Barzakovskii (1940)	3.63% (773.15 K)	

TABLE 89. Deviations from previous NSRDS recommendations: $PrCl_3$

Reference	Authors	Min. departure	Max. departure
	Conductance (NSRDS reference data base Voigt, Biltz (1924) [1], p. 8)		
190	Von Forthmann, Vogel, Schneider (1969)	graphical	
312	Cho, Kuroda (1972)	0.37% (1220 K)	11.88% (1120 K)

TABLE 90. Deviations from previous NSRDS recommendations: RbCl

Reference	Authors	Min. departure	Max. departure
	Conductance[a] (NSRDS reference data base Van Artsdalen, Yaffe (1956) [1], p. 6)		
171	Emons, Brautigam (1970)	graphical	
300	Fuller, Reilly (1967)	graphical	
98	Zuca, Olteanu (1970)	—1.66% (1070 K)	—2.21% (1090 K)
59	Chernov, Delimarskii (1961)	graphical	
158	Bogacz, Ziolek (1970)	—0.25% (1010 K)	—1.22% (1040 K)
124	Markov, Prisyazhnyii (1965)	graphical	
57	Markov, Prisyazhnyii (1962)	graphical	
141	Zuca, Olteanu (1968)	0.02% (1070 K)	—0.57% (1090 K)
71	Fedorov, Chernov (1967)	graphical	
	Density (NSRDS reference data base Van Artsdalen, Yaffe (1956) [1], p. 6)		
130	Lillebuen (1961)	0.04% (1004 K)	0.14% (1112 K)
103	Bloom, Boyd, Laver (1966)	0.10% (1000 K)	0.41% (1200 K)
158	Bogacz, Ziolek (1970)	—0.08% (1010 K)	—0.13% (1030 K)
133	Grjotheim (1971)	0.04% (1004 K)	0.14% (1112 K)
141	Zuca, Olteanu (1968)	0.0% (1100 K)	0.14% (1140 K)
98	Zuca, Olteanu (1970)	—0.02% (1080 K)	0.15% (1200 K)
142	Bloom (1963)	graphical	
171	Emons, Brautigam, Vogt (1970)	graphical	

TABLE 90. Deviations from previous NSRDS recommendations: RbCl—Continued

Reference	Authors	Min. departure	Max. departure
Density (NSRDS reference data base Van Artsdalen, Yaffe (1956) [1], p. 6)—Continued			
124	Markov, Prisyazhnyii (1965)	graphical	
181	Markov, Prisyazhnyii (1963)	graphical	
280	Vasu (1969)	0.0% (1010 K)	

*The results reported by Zuca (1968, 1970) and Bogacz (1970) are in accord with the Van Artsdalen data base to ±1.0% up to 1100 K, but at higher temperatures the Zuca data fall uniformly below, the maximum percent departure being ~3% at ~1190 K.

TABLE 91. Deviations from previous NSRDS recommendations: $SnCl_2$

Reference	Authors	Min. departure	Max. departure
Conductance (NSRDS reference data base Grantham, Yosim (1966) [1], p. 12)			
119	Rafalskii (1960)	−0.80% (623.15 K)	1.37% (573.15 K)
288	Sakai (1954)	−0.55% (662.3 K)	−8.10% (591.9 K)
Density (NSRDS reference data base Jaeger (1917) [1], p. 12)			
128	Prikhod'ko (1970)	0.85% (600 K)	0.91% (550 K)

TABLE 92. Deviations from previous NSRDS recommendations: $SnCl_4$

Reference	Authors	Min. departure	Max. departure
Density (NSRDS reference data base Pugachevick, Nisel'son (1963) [1], p. 13)			
48	Toropov (1956)	−0.17% (333 K)	
Viscosity (NSRDS reference data base Pugachevick, Nisel'son (1963) [1], p. 13)			
48	Toropov (1956)	1.22% (313.15 K)	8.97% (293.15 K)

TABLE 93. Deviations from previous NSRDS recommendations: $SrCl_2$

Reference	Authors	Min. departure	Max. departure
Conductance (NSRDS reference data base Bockris et al. (1960) [1], p. 7)			
5	Arndt, Gessler (1908)	−5.47% (1173.15 K)	−8.97% (1323.15 K)
297	Markov, Polishchuk (1965)	graphical	
298	Dworkin, Bronstein, Bredig (1966)	−2.13% (1173.15 K)	
Surface tension (NSRDS reference data base Ellis (1958) [2], p. 65)			
244	Bertozzi (1966)	graphical	

TABLE 94. Deviations from previous NSRDS recommendations: $ThCl_4$

Reference	Authors	Min. departure	Max. departure
Conductance (NSRDS reference data base Voigt, Biltz (1924) [1], p. 9)			
81	Yoshida, Ogamada, Kuroda (1968)	0.0% (1090 K)	−4.83% (1150 K)

TABLE 95. Deviations from previous NSRDS recommendations: $TiCl_4$

Reference	Authors	Min. departure	Max. departure
Viscosity (NSRDS reference data base Toropov (1952) [1], p. 9)			
221	Sagawa (1933)	−4.72% (293.15 K)	−5.94% (298.15 K)
346	Ruban, Isaeva (1966)	outside temperature range of data base	

TABLE 96. Deviations from previous NSRDS recommendations: TlCl

Reference	Authors	Min. departure	Max. departure
Conductance (NSRDS reference data base Grantham, Yosim (1966) [1], p. 12)			
131	Protsenko, Shatskaya (1967)	graphical	
70	Belyaev (1953)	−0.23% (723.16 K)	2.28% (743.16 K)
68	Lantratov, Moiseeva (1961)	−0.09% (723.16 K)	−2.5% (743.16 K)
14	Protsenko, Popovskaya (1961)	2.00% (753.16 K)	3.09% (743.16 K)
12	Sandonnini (1920)	0.48% (873.16 K)	10.0% (773.16 K)
Density (NSRDS reference data base Klemm (1926) [1], p.12)			
195	Markov, Prisyazhnyii (1968)	0.0% (780 K)	−0.12% (720 K)
204	Ilyasov, Barsegov (1970)	graphical	
219	Buckle, Tsaoussoglou (1972)	T out of range of data base	

6. Binary Mixtures

6.1. Discussions and Numerical Values

This section comprises a discussion of the investigated transport properties featuring references, composition and temperature ranges, percent departure values, and experimental techniques. The melt preparation and purification section summarizes the procedures used in each investigation. Numerical tables of physical properties at rounded or experimental compositions and temperatures, together with temperature and composition-dependent equations, are given for the recommended studies. Phase diagrams for the binary mixtures are reported as an aid to the user.

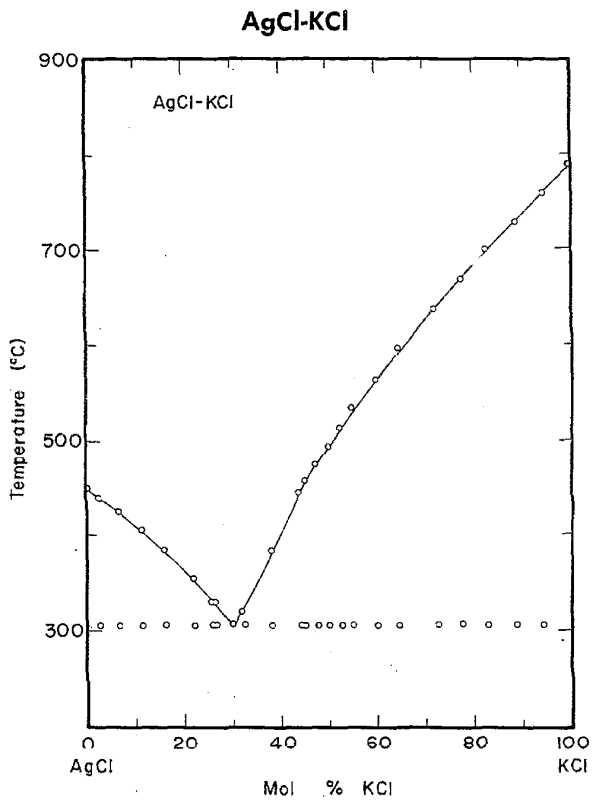


FIGURE 2. Temperature-composition phase diagram for AgCl-KCl.

S. F. Zhemchuzhnyi, Zhrfkho, clast' Khimicheskaya, Vol. 38: 1052 (report), 1135 1966; Izv. Politekhnicheskogo Instituta, Vol. 6: 443, 1906; S. F. Zemczuzng, Z. anorg. Chem., **57**, 267 (1908).

Melt Preparation and Purification

Boardman et. al. [26] and Harrap and Heymann [35] used analytical reagent potassium chloride and prepared silver chloride from A. R. silver nitrate and hydrochloric acid. After fusion of the silver chloride to a transparent solid, small amounts of reduced silver could be detected if present. Mixtures were analyzed by leaching out the soluble salt with warm water or by dissolving the melt in concentrated ammonia followed by precipitation of the silver chloride with nitric acid. Although photo-decomposition of the mixtures showed little effect on the resulting measurements, all operations were carried out in subdued light.

Boardman et. al. [234] used salts that were either of A.R. purity or prepared from reagents of this purity and recrystallized.

TABLE 97. Electrical conductance studies: AgCl-KCl

Investigations critically re-examined			
Ref.	KCl Mol %	Temp. range (T)	Comment
35	0–65.7	673–973	Cell material: B.T.H.-C14 glass; Pt electrode; freq. range ~ 3000 Hz; calibration: 1N KCl solution
218	eutectic	860–1180	

Deviations from previous NSRDS recommendations: [1, p. 10]			
Ref.	KCl Mol %	Min. departure	Max. departure
35	0	−2.4% (978 K)	−2.6% (873 K)

TABLE 98. AgCl-KCl: Specific conductance (ohm^{-1} cm^{-1})

	Mol percent KCl				
T	65.7	53.2	42.3	20.9	0.0
680				2.333	
690				2.374	
700				2.415	
710				2.456	
720				2.495	
730			1.764	2.534	3.731
740			1.802	2.572	3.770
750			1.840	2.608	3.809
760			1.876	2.645	3.846
770			1.913	2.680	3.883
780			1.948	2.714	3.919
790			1.983	2.748	3.954
800			2.017	2.781	3.988
810			2.051	2.813	4.022
820			2.084	2.844	4.055
830		1.866	2.116	2.874	4.086
840		1.899	2.148	2.904	4.118
850		1.931	2.179	2.933	4.148
860		1.964	2.209	2.961	4.178
870		1.995	2.239	2.988	4.206
880		2.027	2.268	3.014	4.234
890		2.059	2.297	3.039	4.261
900		2.090	2.324	3.064	4.288
910		2.121	2.352	3.088	4.313
920		2.152	2.378	3.111	4.338
930	[2.010]	2.183	2.404	3.133	4.362
940	[2.046]	2.214	2.429	3.154	4.385
950	[2.082]	2.244	2.454	3.175	4.408
960	[2.118]	2.274	2.478	3.194	4.429
970	[2.153]	2.304	2.501	3.213	4.450

Temperature-dependent equations

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

Mol % KCl	a	$b \cdot 10^3$	$c \cdot 10^6$	Stand. error of est.
0.0	1.2820	9.7014	−3.9922	0.10%
20.9	−2.4446	9.8210	−4.1116	0.20%
42.3	−2.7417	8.5052	−3.1959	0.19%
53.2	−1.5240	4.9048	−0.9880	0.02%
65.7	[−2.7535]	[6.6100]	[−1.6000]	0.00%

These values are based on the work of Harrap and Heymann (classical ac technique) **[35]**.

TABLE 99. Density studies: AgCl-KCl

Investigations critically re-examined

Ref.	KCl Mol %	Temp. range (T)	Cell material	Calibration
26	0, 19.4, 32.0, 52.2	658–1018	Silica glass dilatometer	Molten $AgNO_3$

Deviations from previous NSRDS recommendations: [1, p. 10]

Ref.	KCl Mol %	Min. departure	Max. departure
26	0	−0.82% (760 K)	−1.0% (900 K)

Comment: Boardman et al. **[26]** applied corrections for the shape of the meniscus, buoyancy and expansion of the silica dilatometer. The authors state that the method cannot be used above 700–750 °C due to chemical attack on the silica glass. A maximum error of ±0.30% in the density values was reported.

TABLE 100. AgCl-KCl: Density (g cm^{-3})

	Mol percent KCl			
T	52.2	32.0	19.4	0
660		3.630		
680		3.611		
700		3.591		
720		3.572	4.039	
740		3.553	4.020	
760		3.534	4.001	4.804
780		3.515	3.912	4.786
800		3.495	3.963	4.767
820		3.476	3.944	4.748
840	2.787	3.457	3.925	4.729
860	2.770	3.438	3.906	4.710
880	2.752	3.419	3.887	4.692
900	2.734	3.399	3.868	4.673
920	2.717		3.849	
940	2.699		3.830	
960	2.682			
980	2.664			
1000	2.646			

Temperature-dependent equations

$\rho = a + bT$

Mol % KCl	a	$b \cdot 10^3$
0	5.519	−0.94
19.4	4.723	0.95
32.0	4.263	−0.96
52.2	3.526	−0.88

These values are based on the work of Boadman et al. (dilatometric method) **[26]**.

TABLE 101. Viscosity studies: AgCl-KCl

Investigations critically re-examined

Ref.	KCl Mol %	Temp. range (T)	Cell material	Calibration
[35]	0–61.9	673–973	B.T.H.-C14 glass	Molten KNO_3

Comment: Viscosity values for pure silver chloride in reference **[35]** are those recommended in [1].

TABLE 102. AgCl-KCl: Viscosity (cp)

	Mol percent KCl				
T	61.9	55.1	32.1	19.4	0.0
680			3.01		
690			2.88		
700			2.77		
710			2.66		
720			2.55		
730			2.46	2.42	2.30
740			2.37	2.35	2.24
750			2.28	2.28	2.19
760			2.20	2.21	2.14
770			2.13	2.15	2.09
780			2.06	2.08	2.04
790			1.99	2.02	2.00
800			1.93	1.97	1.95
810			1.87	1.91	1.91
820			1.82	1.86	1.87
830		1.82	1.76	1.81	1.82
840		1.77	1.71	1.76	1.78
850		1.72	1.66	1.72	1.75
860		1.68	1.62	1.67	1.71
870		1.63	1.58	1.63	1.67
880	[1.61]	1.58	1.54	1.59	1.64
890	[1.57]	1.54	1.50	1.55	1.61
900	[1.53]	1.50	1.46	1.52	1.57
910	[1.49]	1.46	1.42	1.48	1.55
920	[1.45]	1.42	1.39	1.45	1.52
930	[1.41]	1.38	1.36	1.41	1.49
940	[1.38]	1.35	1.33	1.38	1.47
950	[1.34]	1.31	1.30	1.35	1.45
960	[1.31]	1.28	1.27	1.32	1.42
970	[1.29]	1.25	1.24	1.29	1.41

Temperature-dependent equations

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

$$\eta = A \cdot \exp\,(E/RT)$$

Mol % KCl	a	$b \cdot 10^2$	$c \cdot 10^5$	$d \cdot 10^9$	$A \cdot 10^1$	E (cal mol^{-1})	Stand. error of est.
0.0	6.4257	−0.2698	−0.8623	6.2580			0.12%
19.4	22.7942	−5.7017	5.1895	−16.4588			0.31%
32.1					1.556	4003	0.85%
55.1	4.7309	0.4686	−1.7793	9.5504			0.30%
61.9	[−94.8174]	[32.6001]	[−36.3272]	[133.3306]			0.00%

These values are based on the work of Harrap and Heymann (capillary method) [**35**].

TABLE 103. Surface tension studies: AgCl-KCl

Investigations critically re-examined				
Ref.	KCl Mol %	Temp. range (T)	Cell material	Calibration
234	0–100 (g)	873, 973	Capillaries of B.T.H.-C46 glass	Water

Comment: Surface tension values for pure KCl in reference [**234**] were obtained by extrapolation. Capillary calibration was performed after each series of measurements. Reported uncertainty in results was ±1%.

TABLE 104. AgCl-KCl: Surface tension (dyn cm^{-1})

Mol % KCl	873 K	973 K
0	169	164
10	148	143
20	138	131
30	131	124
40	125	117
50	120	112
60	116	109
70	114	106
80	113	104
90	111	103
100	109	102

These values have been interpolated to three significant figures from the graphical presentation of Boardman, Palmer and Heymann (maximum bubble pressure method) [**234**].

AgCl-PbCl₂

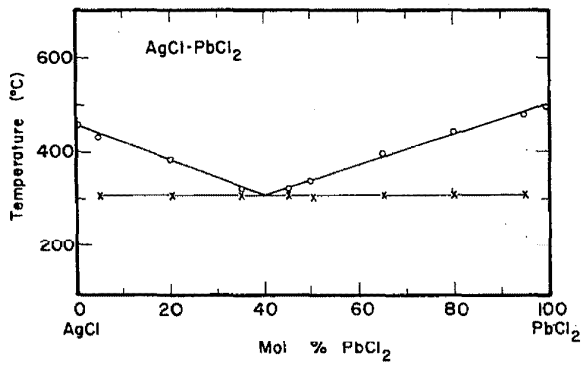


FIGURE 3. Temperature-composition phase diagram for AgCl-PbCl₂.

K. Treis, Neues Jahrb. Mineral., Geol. Paleontol., ABH. **37**, 766–818 (1914).

Melt Preparation and Purification

Harrap and Heymann [**35**] and Boardman et al. [**26**] used analytical reagent grade salts and analyzed the mixtures by dissolving the soluble salts in hot water. Protsenko and Shatskaya [131] prepared the chloride salts using the nitrates and hydrochloric acid as starting materials. The salts were dehydrated under vacuum at a temperature of 160 °C.

Boardman et al. [**234**] used salts that were either of A.R. purity or prepared from reagents of this purity and recrystallized.

TABLE 105. Electrical conductance studies: AgCl-PbCl₂

Investigations critically re-examined

Ref.	$PbCl_2$ Mol %	Temp. range (T)	Comments
35	0–100	625–973	Cell material: B.T.H.-C14 glass; Pt electrodes; freq. range: ~ 3000 Hz; calibration: 1N KCl solution
60	0–100 (g)		
131	0–100 (g)	593–773	Calibration: molten KNO_3
218	eutectic (g)	860–1180	

Deviations from previous NSRDS recommendations: [1, pp. 10, 13]

Ref.	$PbCl_2$ Mol %	Min. departure	Max. departure
35	100	−0.24% (923 K)	−0.42% (873 K)
35	0	−2.4% (978 K)	−2.6% (873 K)

TABLE 106. AgCl-PbCl₂: Specific conductance (ohm^{-1} cm^{-1})

	Mol percent $PbCl_2$					
T	100.0	80.3	59.8	40.2	13.8	0.0
640				1.478		
660				1.595		
680			1.317	1.708	2.662	
700			1.428	1.817	2.765	
720			1.535	1.923	2.863	
740		1.413	1.641	2.025	2.957	3.770
760		1.519	1.743	2.124	3.046	3.846
780	1.469	1.623	1.843	2.219	3.131	3.919
800	1.572	1.724	1.941	2.310	3.211	3.988
820	1.672	1.823	2.036	2.398	3.288	4.055
840	1.768	1.920	2.128	2.482	3.359	4.118
860	1.862	2.015	2.217	2.563	3.426	4.177
880	1.952	2.107	2.304	2.639	3.489	4.234
900	2.039	2.197	2.389	2.713	3.548	4.288
920	2.123	2.284	2.470	2.782	3.602	4.338
940	2.204	2.369		2.848	3.651	4.385
960	2.282	2.452		2.911	3.697	4.429

Temperature-dependent equations

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

Mol % $PbCl_2$	a	$b \cdot 10^3$	$c \cdot 10^6$	Stand. error of est.
0.0	−1.2873	9.7951	−4.0009	0.12%
13.8	−3.4571	12.7549	−5.5241	0.25%
40.2	−4.1630	11.7052	−4.5173	0.29%
59.8	−3.9942	10.0327	−3.2676	0.36%
80.3	−4.1558	9.6828	−2.9161	0.23%
100.0	−5.0026	11.3675	−3.9370	0.28%

These values are based on the work of Harrap and Heymann (classical ac technique [**35**].

TABLE 107. Density studies: AgCl-PbCl₂

Investigations critically re-examined

Ref.	$PbCl_2$ Mol %	Temp. range (T)	Cell material	Calibration
26	0–100	653–983	Silica glass	Molten $AgNO_3$

Deviations from previous NSRDS recommendations: [1, p. 10]

Ref.	$PbCl_2$ Mol %	Min. departure	Max. departure
26	0	−0.82% (760 K)	−1.0% (900 K)

Comment: Boardman [**26**] applied corrections for the shape of the meniscus, buoyancy and expansion of the silica dilatometer. The authors report a maximum error in their density values of ±0.10%.

A two dimensional regression analysis was successfully applied to the data of [**26**]. Density values for pure lead chloride in reference [**26**] are those recommended in [1].

TABLE 108. $AgCl\text{-}PbCl_2$: Density (g cm^{-3})

	Mol percent $PbCl_2$											
T	100	90	80	70	60	50	40	30	20	10	0	40.5
675							5.007					5.008
690						5.009	4.988					4.989
705						4.990	4.970	4.946				4.971
720					4.986	4.970	4.951	4.928				4.952
735					4.966	4.951	4.932	4.911				4.933
750					4.946	4.931	4.914	4.893				4.915
765				4.936	4.925	4.912	4.895	4.875	4.853	4.827	4.799	4.896
780				4.915	4.905	4.892	4.876	4.858	4.836	4.812	4.785	4.877
795	4.906	4.905	4.901	4.894	4.885	4.873	4.858	4.840	4.820	4.797	4.772	4.859
810	4.885	4.884	4.880	4.873	4.865	4.853	4.839	4.823	4.804	4.782	4.758	4.840
825	4.863	4.862	4.859	4.853	4.844	4.834	4.821	4.805	4.787	4.767	4.744	4.821
840	4.842	4.841	4.837	4.832	4.824	4.814	4.802	4.788	4.771	4.752	4.731	4.803
855	4.820	4.819	4.816	4.811	4.804	4.795	4.783	4.770	4.755	4.737	4.717	4.784
870	4.799	4.798	4.795	4.790	4.784	4.775	4.765	4.752	4.738	4.722	4.704	4.765
885	4.777	4.777	4.774	4.770	4.763	4.756	4.746	4.735	4.722	4.707	4.690	4.747
900	4.756	4.755	4.753	4.749	4.743	4.736	4.727	4.717	4.705	4.692	4.677	4.728
915	4.734	4.734	4.732	4.728	4.723	4.717	4.709	4.700	4.689			4.709
930	4.713	4.712	4.710	4.707	4.703	4.697	4.690	4.682	4.673			4.691
945	4.691	4.691	4.689	4.686	4.683	4.678	4.672	4.664				4.672
960	4.670	4.669	4.668			4.658	4.653	4.647				4.653
975	4.648	4.648										

Two-dimensional equation and statistical parameters

$$\rho = a + bT + cC^2 + dTC^2$$

a	$b \cdot 10^3$	$c \cdot 10^5$	$d \cdot 10^8$	Max. percent departure	Stand. error of est.
6.04622	−1.43371	−5.58698	5.33057	−0.27% (789.2 K, 0 mol % AgCl)	0.08%

These values are based on the work of Boardman et al. (dilatometric method) [**26**]. C = mol % AgCl.

TABLE 109. $AgCl\text{-}PbCl_2$: Density (g cm^{-3})

	Mol percent $PbCl_2$							
T	100	80.6	70.9	61.1	53.4	42.6	20.3	0
660						5.032		
670						5.020		
680						5.007		
690						4.995		
700						4.982		
710						4.969	4.915	
720				4.983	4.971	4.957	4.904	
730				4.970	4.959	4.944	4.894	
740				4.956	4.946	4.932	4.883	
750			4.957	4.943	4.933	4.919	4.872	
760			4.943	4.930	4.920	4.906	4.861	4.804
770			4.929	4.916	4.907	4.894	4.850	4.795
780			4.914	4.903	4.895	4.881	4.840	4.786
790	4.927		4.900	4.889	4.882	4.869	4.829	4.776
800	4.912	4.896	4.886	4.876	4.869	4.856	4.818	4.767
810	4.897	4.882	4.872	4.863	4.856	4.843	4.807	4.757
820	4.882	4.867	4.858	4.849	4.843	4.831	4.796	4.748
830	4.867	4.852	4.843	4.836	4.831	4.818	4.786	4.739
840	4.852	4.838	4.829	4.822	4.818	4.806	4.775	4.729
850	4.837	4.824	4.815	4.809	4.805	4.793	4.764	4.720
860	4.822	4.809	4.801	4.796	4.792	4.780	4.753	4.710
870	4.807	4.795	4.787	4.782	4.779	4.768	4.742	4.701
880	4.792	4.780	4.772	4.769	4.767	4.755	4.732	4.692
890	4.777	4.766	4.758	4.755	4.754	4.743	4.721	4.682
900	4.762	4.751	4.744	4.742	4.741	4.730	4.710	4.673
910	4.747	4.737	4.730	4.729	4.728	4.717	4.699	
920	4.732	4.722	4.716	4.715	4.715	4.705	4.688	
930	4.717	4.708	4.701	4.702	4.703	4.692	4.678	
940	4.702	4.693	4.687	4.688	4.690	4.680		

TABLE 109. $AgCl\text{-}PbCl_2$: Density (g cm^{-3})—Continued

	Mol percent $PbCl_2$							
T	100	80.6	70.9	61.1	53.4	42.6	20.3	0
950	4.687	4.679	4.673		4.677	4.667		
960	4.672	4.664				4.654		
970	4.657	4.649				4.642		
980	4.642							

Temperature-dependent equations

$$\rho = a + bT$$

Mol % $PbCl_2$	a	$b \cdot 10^3$
0	5.519	−0.94
20.3	5.682	−1.08
42.6	5.864	−1.26
53.4	5.893	−1.28
61.1	5.948	−1.34
70.9	6.022	−1.42
80.6	6.056	−1.45
100	6.112	−1.50

These values are based on the work of Boardman et al. (dilatometric method) [**26**].

TABLE 110. Viscosity studies: $AgCl\text{-}PbCl_2$

Investigations critically re-examined				
Ref.	$PbCl_2$ Mol %	Temp. range (T)	Cell material	Calibration
35	0–100	623–973	B.T.H. C14 glass	Molten KNO_3

Comment: Viscosity values for pure silver and lead chloride in [**35**] are those recommended in [1].

TABLE 111. AgCl-$PbCl_2$: Viscosity (cp)

	Mol percent $PbCl_2$					
T	100.0	82.6	62.0	39.2	19.8	0.0
640				5.77		
660				5.14		
680				4.58	3.45	
700				4.10	3.20	
720				3.69	2.98	
740			4.16	3.34	2.77	2.24
760			3.72	3.05	2.58	2.13
780	4.41	3.98	3.34	2.80	2.41	2.03
800	3.98	3.60	3.03	2.60	2.26	1.94
820	3.60	3.26	2.77	2.44	2.12	1.85
840	3.25	2.96	2.56	2.31	2.00	1.78
860	2.94	2.71	2.39	2.20	1.90	1.70
880	2.67	2.49	2.26	2.11	1.82	1.64
900	2.44	2.32	2.14	2.03	1.75	1.58
920	2.24	2.18	2.05	1.95	1.70	1.53
940	2.07	2.08	1.96	1.87	1.67	1.48
960	1.94	2.01	1.87	1.79	1.65	1.43

Temperature-dependent equations

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

$$\eta = A \cdot \exp\ (E/RT)$$

Mol % $PbCl_2$	a	$b \cdot 10^2$	$c \cdot 10^5$	$d \cdot 10^9$	$A \cdot 10$	E (cal mol^{-1})	Stand. error of est.
0.0					3.128	2897	0.85%
19.8	25.4141	−5.4678	3.7119	−6.1965			0.44%
39.2	108.1142	−34.0837	36.8787	−134.5024			3.34%
62.0	142.2340	−43.8257	46.0808	−163.1201			1.87%
82.6	64.3575	−14.8354	10.8596	−22.6128			1.18%
100.0	55.5502	−11.4857	7.0618	−9.5258			0.44%

These values are based on the work of Harrap and Heymann (capillary method) [35].

TABLE 112. Surface tension studies: AgCl-$PbCl_2$

Investigations critically re-examined		
Ref.	$PbCl_2$ Mol %	Temp. range (T)
234	0–100 (g)	773, 873

Comment: A brief discussion of reference [234] is given under the system AgCl-KCl.

TABLE 113. AgCl-$PbCl_2$: Surface tension (dyn cm^{-1})

Mol % $PbCl_2$	773 K	873 K
0	175	171
10	166	161
20	159	153
30	154	146
40	149	141
50	146	137
60	143	134
70	141	132
80	139	130
90	138	128
100	137	127

These values have been interpolated to three significant figures from the graphical presentation of Boardman, Palmer and Heymann (maximum bubble pressure method) [234].

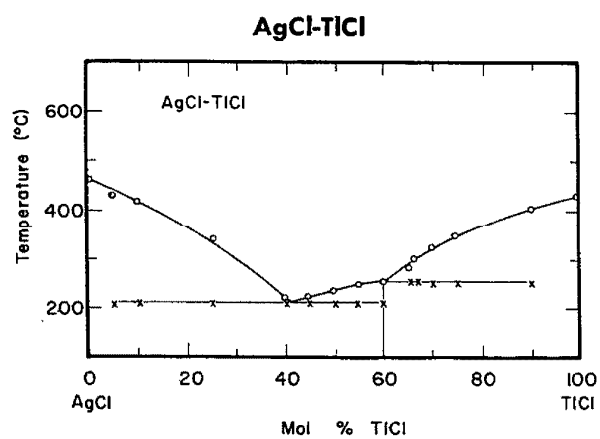


FIGURE 4. Temperature-composition phase diagram for AgCl-TlCl.

Carlo Sandonnini, Gazz. Chim. Ital., **44**, I, 290–386 (1914).

Melt Preparation and Purification

Protsenko and Shatskaya [131] prepared the chloride salts from the corresponding nitrates and hydrochloric acid. They were dried under vacuum at a pressure of 5 torr and at a temperature of 160 °C.

TABLE 114. Electrical conductance studies: AgCl-TlCl

Investigations critically re-examined			
Ref.	TlCl Mol %	Temp. range (T)	Comments
12	0, 15.3, 30, 50, 70, 100	773–973	Cell material: silica and quartz U-tubes; Pt electrodes; calibration: 1N KCl solution
131	0–100 (g)	517–773	Pt electrodes; calibration: molten KNO_3

Deviations from previous NSRDS recommendations: [1, pp. 10, 12]			
Ref.	TlCl Mol %	Min. departure	Max. departure
12	100	−9.64% (773 K)	
12	0	−8.52% (773 K)	

TABLE 115. AgCl-TlCl: Specific conductance (ohm^{-1} cm^{-1})

	Mol percent TlCl					
T	100.00	70.00	50.00	30.00	15.30	0.00
773.2	1.215	1.470	1.771	2.260	2.925	3.653
873.2	1.702					
973.2	1.951					

Comment: Due to limited data the experimental values are given. These values are based on the work of Sandonnini (classical ac technique) [**12**].

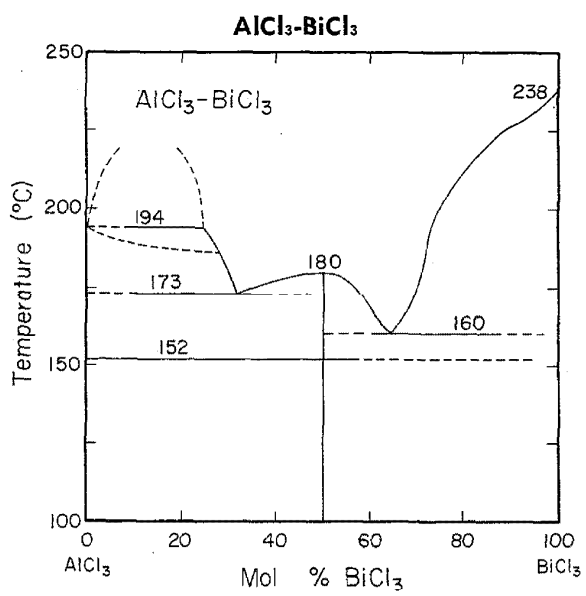


FIGURE 5. Temperature-composition phase diagram for $AlCl_3$-$BiCl_3$.

B. J. Korshurov, N. I. Kaloev, L.A. Niselson and O. R. Gavrilov, Zh. Neorg. Khim., **13**, 1956 (1968).

Melt Preparation and Purification

The aluminum chloride [**90**] was prepared from high purity aluminum metal and hydrogen chloride gas. The latter was produced by allowing NaCl to react with H_2SO_4, after which the gas was then deoxidized by passage over copper at 350 °C and dehydrated over $Mg(ClO_4)_2$. The aluminum metal was placed in a pure Al_2O_3 boat in a quartz tube at a temperature slightly above its melting point of 660 °C. The vaporized aluminum chloride was passed through a sintered disk prior to condensation.

The bismuth chloride was formed from the reaction of zone-refined, 99.9999% bismuth metal with chlorine gas followed by several distillations.

TABLE 116. Density studies: $AlCl_3$–$BiCl_3$

Investigations critically re-examined				
Ref.	$BiCl_3$ Mol %	Temp. range (T)	Cell material	Calibration[a]
90	0, 40, 65, 80, 100	440–752	Quartz float	Water

Deviations from previous NSRDS recommendations: [1, pp. 11, 13]			
Ref.	$BiCl_3$ Mol %	Min. departure	Max. departure
90	100	0.14% (700 K)	0.21% (740 K)
90	0	2.2% (490 K)	3.6% (480 K)

[a]The float method [**90**] involves measuring the temperature at which quartz floats of known density neither fall nor rise in the liquid under study. Platinum wire was sealed into floats for cases where the liquid density was greater than that of quartz. Boston reported that the standard deviations for the least squares fit varied from 0.8×10^{-3} g cm^{-3} to 3.8×10^{-3} g cm^{-3} for 0.0 and 35.0 mol % $AlCl_3$, respectively.

TABLE 117. $AlCl_3$-$BiCl_3$: Density (g cm^{-3})

	Mol percent $BiCl_3$				
T	100.0	80.0	65.0	40.0	0.0
450				2.499	
460				2.484	
470			3.090	2.470	
480		3.444	3.073	2.456	1.253
490		3.425	3.056	2.441	1.229
500		3.406	3.039	2.427	
510		3.387	3.022	2.413	
520		3.368	3.005	2.398	
530		3.349	3.988	2.384	
540		3.330	2.971	2.370	
550		3.311	2.954	2.356	
560			2.936		
570			2.919		
580			2.902		
590			2.885		
600			2.868		
610			2.851		
620			2.834		
630			2.817		
640			2.800		
650			2.783		
660			2.765		
670			2.748		
680					
690	3.491				

TABLE 117. $AlCl_3$-$BiCl_3$: Density (g cm^{-3})—Continued

	Mol percent $BiCl_3$				
T	100.0	80.0	65.0	40.0	0.0
700	3.468				
710	3.445				
720	3.423				
730	3.400				
740	3.378				
750	3.355				

Temperature-dependent equations

$\rho = a + bT$

Mol % $BiCl_3$	a	$b \cdot 10^3$
0.0	2.371	−2.33
40.0	3.142	−1.43
65.0	3.894	−1.71
80.0	4.356	−1.90
100.0	5.050	−2.26

These values are based on the work of Boston (flotation method) [90].

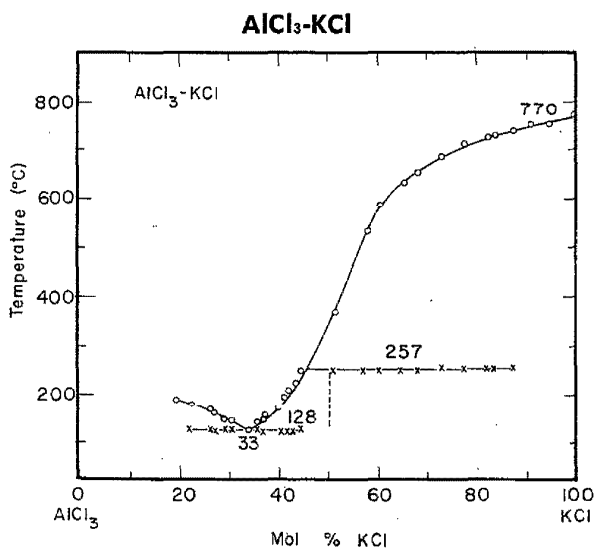


FIGURE 6. Temperature-composition phase diagram for $AlCl_3$-KCl.

V. I. Shvartsman, Zapiski Inst. Khim. Akad. Nauk U.S.S.R., 7, [1], 3–9 (1940).

Melt Preparation and Purification

Moss [112] used CP reagent grade potassium chloride which was dried by fusion before use; the preparation of aluminum chloride is described under the $AlCl_3$-LiCl system.

Morrey and Carter [92] used Baker and Adamson "special reagent grade" and CP "reagent anhydrous grade" for KCl and $AlCl_3$, respectively. The KCl was dried by passing first chlorine then dry argon through the melt, after which it was stored in a drybox prior to use. The $AlCl_3$ was sublimed at about 170 °C under a pressure of about 15 mm of dry argon. The $AlCl_3$-KCl mixtures when melted often produced a black, carbonaceous precipitate which was thought to result from the decomposition of organic impurities. However, clear solutions were obtained after digesting the precipitate at 500 °C followed by filtration through a fine quartz frit.

Yamaguti and Sisido's [42] purification of $AlCl_3$ is described for the $AlCl_3$-LiCl system.

Øye and Gruen [134] prepared their $AlCl_3$ from analytical grade aluminum wire and dry hydrogen chloride gas. In order to avoid traces of moisture their quartz reaction vessel was outgassed at 600 °C under a pressure of less than 10^{-5} mm for several hours.

The preparation of pure $AlCl_3$ described by Boston et al. [175] is discussed under the system $AlCl_3$-$BiCl_3$. Reagent grade KCl was purified by bubbling first HCl and then argon gas through the melt, followed by filtration of the molten salt through a pyrex fritted disk. The $AlCl_3$-KCl mixtures were prepared by weighing the salts into conductivity cells in a dry box under high purity argon.

TABLE 118. Electrical conductance studies: $AlCl_3$-KCl

Investigations critically re-examined			
Ref.	KCl Mol %	Temp. range (T)	Comments
27	51.7, 60.7 63.8 (g)	773–1073	Cell material: quartz; Pt electrodes; calibration: molten KNO_3 and $NaNO_3$
42	19.4–49.3	468–578	Cell material: glass; Pt electrodes; freq: 8000 Hz; calibration: 1N KCl solution
102	53–65 (g)	973	Cell material: quartz; Pt electrodes; calibration: molten KNO_3 and $NaNO_3$
112	25, 30, 35, 40	448–498	Cell material: silica; Pt electrodes
115	29.2, 31.2 32.1, 37.1	410–550	Cell material: Pyrex; freq. range: ~600–900 Hz; calibration: 1N KCl solution
175[a]	20–87 (g)	453–1353	Cell material: quartz; W electrodes; calibration: redistilled Hg and standard KCl solutions; freq. range: 1000–5000 Hz

[a]Boston et al. [175] used a conductivity cell designed for measurements involving very volatile melts. The tungsten electrodes were found to be inert to $AlCl_3$-KCl mixtures even at temperatures of 1000 °C. In the case of one mixture (70 mole % $AlCl_3$), an external pressure was applied to the conductivity cell to prevent cell rupture.

TABLE 119. $AlCl_3$-KCl: Specific conductance (ohm^{-1} cm^{-1})

	Mol percent KCl					
T	49.35	39.45	30.75	28.80	19.75	19.4
470				0.1544	0.1056	0.1044
480		0.2122	0.1746	0.1660	0.1123	0.1111
490		0.2276	0.1867	0.1775	0.1191	0.1180
500		0.2430	0.1988	0.1889	0.1258	0.1249
510		0.2584	0.2110	0.2002	0.1325	0.1320
520		0.2738	0.2234	0.2114	0.1393	0.1391
530	0.3623	0.2892	0.2358	0.2225	0.1460	0.1464
540	0.3842	0.3046	0.2483	0.2335	0.1527	0.1538
550	0.4061	0.3200	0.2609		0.1595	0.1613
560	0.4280	0.3354	0.2736		0.1662	
570	0.4499		0.2864			

Temperature-dependent equations

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

Mol % KCl	a	$b \cdot 10^3$	$c \cdot 10^6$	Stand. error of est.
19.4	−0.0842	0.1364	0.5637	0.50%
19.75	−0.2107	0.6730	0	0.74%
28.80	−0.4986	1.6155	−0.4008	0.21%
30.75	−0.2948	0.7560	0.4625	0.52%
39.45	−0.5271	1.5402	0	1.18%
49.35	−0.7979	2.1891	0	0.74%

These values are based on the work of Yamaguti and Sisido (classical ac technique) [**42**]. The values in table 120, which cover a wider temperature and composition range, have been interpolated to three significant figures from the graphical presentation of Boston et al. [**175**].

TABLE 120. $AlCl_3$-KCl: Specific conductance (ohm^{-1} cm^{-1})

Mol % KCl	873 K	973 K	1073 K	1173 K	1273 K
0	<0.1				
10	0.23				
20	0.43				
30	0.63				
40	0.83	0.87	0.93		
50	0.93	1.00	1.08	1.13	1.17
60	0.78	0.91	0.97	1.07	1.13
70	0.82	0.95	1.05	1.15	1.23
80	0.95	1.13	1.25	1.37	1.46
90	1.20	1.43	1.64	1.75	2.25
100	1.73	1.94	2.24	2.43	2.67

These values have been interpolated to a maximum of three significant figures from the graphical presentation of Boston et al. (classical ac technique) [**175**].

TABLE 121. Density studies: $AlCl_3$-KCl

Investigations critically re-examined			
Ref.	KCl Mol %	Temp. range (T)	Comments
27	25, 51.8 64.9, 100	773–1073	Cell material: glass dilatometer; calibration: eutectic mixture of KCl and LiCl
42	50	532–623	Cell material: glass dilatometer
92	20.0, 33.3, 50.3, 66.7	461–1051	Cell material: quartz float; calibration: water
112	25, 30, 35, 40	448–498	Cell material: glass dilatometer; calibration: purified Hg
134	40.6, 50.0	573	
188	33–42	423–558	Cell material: Pt oval vessel and Pt suspension wire, melt contained in Pyrex cylinder; calibration: water

TABLE 122. $AlCl_3$-KCl: Density (g cm^{-3})

	Mol percent KCl			
T	66.66	50.03	33.33	20.00
480				1.543
500			1.594	1.523
520			1.578	1.503
540			1.562	1.483
560			1.547	
580			1.531	
600			1.515	
620			1.499	
640			1.483	
660			1.468	
680			1.452	
700			1.436	
720			1.420	
740		1.466	1.404	
760		1.452	1.389	
780		1.439	1.373	
800		1.426		
820		1.413		
840		1.399		
860		1.386		
880		1.373		
900		1.360		
920		1.346		
940		1.333		
960	1.388	1.320		
980	1.376	1.307		
1000	1.363	1.293		
1020	1.351	1.280		
1040	1.339	1.267		

Temperature-dependent equations

$$\rho = a + bT$$

Mol % KCl	a	$b \cdot 10^3$	Stand. error of est.
20.00	2.0252	−1.0038	0.11%
33.33	1.9889	−0.7901	0.14%
50.03	1.9556	−0.6622	0.05%
66.66	1.9734	−0.6101	0.02%

These values are based on the work of Carter and Morrey (flotation method) [**92**].

$AlCl_3$-LiCl

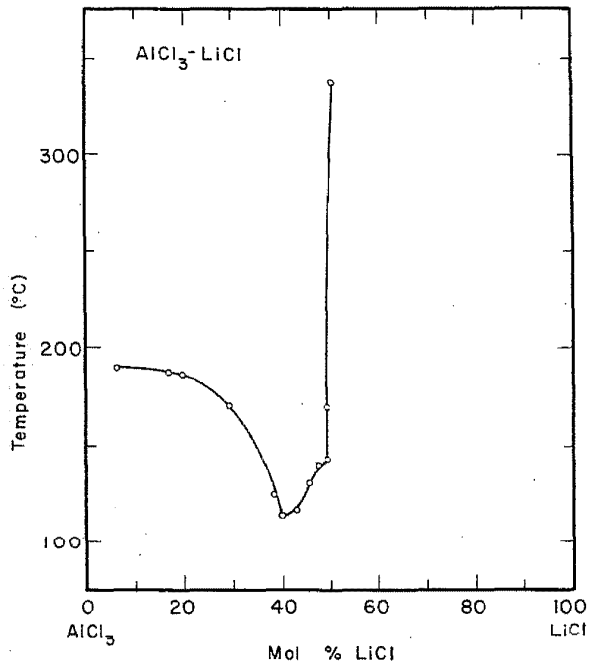


FIGURE 7. Temperature-composition phase diagram for $AlCl_3$-LiCl.

J. Kendal, E. D. Crittenden, and H. K. Miller, J. Amer. Chem. Soc., **45**, 963 (1923).

Melt Preparation and Purification

Moss [**112**] used C.P. reagent grade lithium chloride and Fisher "Certified Reagent" aluminum chloride as starting materials. The LiCl was dried by fusion and subsequently ground to a fine powder in a dry box. The $AlCl_3$ was distilled from a mixture of $AlCl_3$ and NaCl, after which it was stored in a dry box.

Yamaguti and Sisido [42] purified their aluminum chloride by heating a mixture of $AlCl_3$, NaCl and aluminum powder first to 100 °C to remove moisture and then to higher temperatures to sublime the $AlCl_3$. Cool dry air was introduced through $CaCl_2$ and P_2O_5 to the sublimed vapor, and the anhydrous $AlCl_3$ was collected as a white powder.

TABLE 123. Electrical conductance studies: $AlCl_3$-LiCl

Investigations critically re-examined			
Ref.	LiCl Mol %	Temp. range (T)	Comments
42	50	523	Cell material: glass; Pt electrodes; freq. range: ~8000 Hz; calibration: 1N KCl solution
102	67–95 (g)	973	Cell material: quartz; Pt electrodes; calibration: molten KNO_3 and $NaNO_3$
112	25, 30, 35, 40, 45	448–498	Cell material: silica; Pt electrodes

TABLE 124. $AlCl_3$-LiCl: Specific conductance (ohm^{-1} cm^{-1})

	Mol percent LiCl				
T	45.0	40.0	35.0	30.0	25.0
448.2	0.271	0.220	0.173	0.132	0.103
473.2	0.317	0.258	0.203	0.153	0.118
498.2	0.362	0.296	0.230	0.174	0.133

These values are based on the work of Moss (classical ac technique) [**112**]. Due to limited data, experimental results are given.

TABLE 125. Density studies: $AlCl_3$-LiCl

Investigations critically re-examined			
Ref.	LiCl Mol %	Temp. range (T)	Comments
42	50	523–623	Cell material: glass dilatometer
112	25, 30, 35, 40, 45	448–498	Cell material: glass dilatometer; calibration: purified mercury

TABLE 126. $AlCl_3$-LiCl: Density (g cm^{-3})

	Mol percent LiCl				
T	45.0	40.0	35.0	30.0	25.0
450	1.617	1.614	1.611	1.609	1.599
455	1.613	1.610	1.606	1.605	1.595
460	1.610	1.606	1.602	1.600	1.591
465	1.607	1.602	1.598	1.596	1.587
470	1.603	1.598	1.594	1.591	1.583
475	1.600	1.594	1.590	1.587	1.579
480	1.596	1.590	1.585	1.582	1.575
485	1.593	1.586	1.581	1.578	1.571
490	1.590	1.582	1.577	1.573	1.567
495	1.586	1.578	1.573	1.569	1.563

Temperature-dependent equations

$$\rho = a + bT$$

Mol % LiCl	a	$b \cdot 10^3$	Stand. error of est.
25.0	1.9589	−0.8000	0.04%
30.0	2.0142	−0.9000	0.02%
35.0	1.9885	−0.8400	0.00%
40.0	1.9742	−0.7999	0.07%
45.0	1.9228	−0.6800	0.00%

These values are based on the work of Moss (pycnometric method) [**112**].

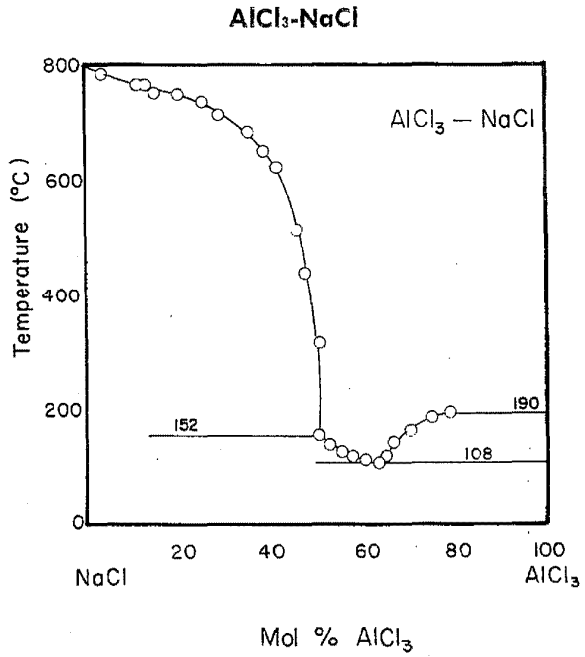


FIGURE 8. Temperature-composition phase diagram for $AlCl_3$-NaCl.

V. I. Shvartsman, Zapysky Instytutu Khimiyi U.S.S.R., Vol. 7:1 1940; abbreviated version: Zh. Fiz. Khim., Vol. 14:253, 1940.

Melt Preparation and Purification

Kryagova [16, **32**, 45, 157] prepared $AlCl_3$ by two methods: (a) distillation of impure technical $AlCl_3$, and (b) chlorination of metallic aluminum shavings. Industrial grade $AlCl_3$ was placed in a test tube containing Al filings, sealed and heated to about 5–10 °C above the fusion temperature. The test tube was shaken gently and kept at 200 °C for several hours, after which any iron impurities present settled to the bottom of the tube. With the test tube partially removed from the furnace, the snow-white crystals of $AlCl_3$ condensed on the cold surface. Multiple distillations were sometimes necessary to remove final traces of iron. The second method involved reacting Al shavings or powder with a dry stream of Cl_2 or HCl gas at 650–700 °C. The yellow powder obtained was purified by the distillation method described above.

Plotnikov [51] used pure, commercial materials and purification involved recrystallization of the NaCl and sublimation of $AlCl_3$ over hot Al filings in an atmosphere of CO_2. Qualitative analysis showed the absence of Ca, Mn, Fe and sulfates.

Boston [**110**] used reagent grade sodium chloride which was purified by passing first argon then anhydrous HCl through the melt at 300 °C in a quartz apparatus. The salt was then filtered through a fine fritted disk into narrow glass tubes which were later sealed off under vacuum. Boston's [**110**] preparation of $AlCl_3$ is given under the $AlCl_3$-$BiCl_3$ system.

Moss [112] used CP reagent grade NaCl which was dried by fusion and stored in a dry box. The preparation of $AlCl_3$ for references [112], [42] and [**50**] is given under the $AlCl_3$-LiCl system.

Howie and Macmillan [164] used analytical grade NaCl which was oven dried at 550 °C for 6 hours and stored in a desiccator. Commercial grade $AlCl_3$ was sublimed.

Yamaguchi and Sisido [**50**] mixed pulverized $AlCl_3$ with 5% NaCl and Al powder. After drying at 100 °C the mixture was strongly heated and the sublimed vapor was cooled with dry air. Some impurities remained after sublimation since the molten $AlCl_3$-NaCl appeared grayish in color.

TABLE 127. Electrical conductance studies: $AlCl_3$-NaCl

Investigations critically re-examined			
Ref.	NaCl Mol %	Temp. range (T)	Comments
16	0, 32.6–49.7	463–543	Cell material: Mo glass; Pt electrodes; calibration: 1N KCl and KI solutions and molten KNO_3
50	18.9–50.0	418–545	Cell material: glass tube; Pt electrodes; freq. range: 8000 Hz; calibration: 1N KCl solutions
51	0, 30.4, 41.8	397–573	
112	20.0–47.5	448–498	Cell material: silica glass; Pt electrodes
115	29.9–47.7	401–475	Cell material: Pyrex glass; freq. range 600–900 Hz; calibration: 1N KCl solutions
164	28.7–49.4	428–468	Cell material: Pyrex glass; Pt electrodes; calibration: 1N KCl solutions

Comparison with NSRDS recommendations [this volume]

Ref.	NaCl Mol %	Min. departure	Max. departure
112	30.9	13.7% (498 K)	
115	30.9	−11.5% (465 K)	−13.3% (443 K)
164	30.9	− 4.3% (443 K)	− 9.4% (453 K)
164	42.2	− 0.65% (459 K)	
164	49.2	− 6.1% (463 K)	

Comment: Yamaguti and Sisido [**50**] reported an error of less than 1% for their conductance measurements. Howie and MacMillan [164] gave ±1% for reproducibility of results. In the latter reference the apparatus was designed to both minimize evaporation of $AlCl_3$ and also allow for slight losses when changes in melt composition were desired.

TABLE 128. $AlCl_3$-NaCl: Specific conductance (ohm^{-1} cm^{-1})

	Mol percent NaCl						
T	50.0	49.2	42.2	31.0	30.9	19.4	18.9
420				0.160			
430				0.167			
440				0.176			
450				0.186	0.197		
460	0.462	0.453	0.309	0.197	0.211		
470	0.490	0.477	0.329	0.208	0.224		
480	0.517	0.501	0.348	0.221	0.238	0.121	0.119
490	0.544	0.525	0.368	0.234	0.252	0.127	0.126
500	0.572	0.549	0.387	0.249		0.133	0.132
510	0.599	0.573	0.406	0.264		0.140	0.139
520	0.626	0.598	0.426				
530	0.654	0.622	0.445				
540	0.681	0.646	0.465				

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

Comp. Mol. % NaCl	a	$b \cdot 10^3$	$c \cdot 10^6$	Stand. error of est.
18.9	−0.2067	0.6780	0	0.63%
19.4	−0.1839	0.6342	0	0.87%
30.9	−0.4258	1.3836	0	0.69%
31.0	0.6993	−3.3027	4.8037	2.07%
42.2	−0.5852	1.9443	0	0.95%
49.2	−0.6548	2.4082	0	1.32%
50.0	−0.7966	2.7366	0	0.52%

These values are based on the work of Sisido and Yamaguti (classical ac technique) **[50]**.

TABLE 129. Density studies: $AlCl_3$-NaCl

Investigations critically re-examined

Ref.	NaCl Mol %	Temp. range (T)	Comments
16	40.6, 49.7	463–543	Cell material: Mo glass dilatometer; calibration: purified mercury
42	50	455–620	Cell material: glass dilatometer
110	0, 27, 38.2, 48	397–610	Cell material: quartz float; calibration: water
112	20.0–47.5	448–498	Cell material: glass dilatometer; calibration: purified mercury
157	0, 32.6–49.8	463–553	Cell material: Mo glass dilatometer; calibration: purified mercury
188	37–50	423–558	Cell material: Pt bob with Pt suspension wire, Pyrex sample container; calibration: water
317[a]	25–50	360–620	

Comparison with NSRDS recommendations [1, p. 11 and this volume]

Ref.	NaCl Mol %	Min. departure	Max. departure
157	48	1.7% (473 K)	2.7% (533 K)
110	0	2.2% (490 K)	3.6% (480 K)
157	0	2.8% (550 K)	6.6% (480 K)

[a]This investigation has recently been reported as a private communication.

Comment: The higher results of Yamaguti [42] and Kryagova [157] compared to Boston's **[110]** data could be explained by loss of $AlCl_3$ either through vaporization or by reaction with adsorbed water. The recently reported data by King et al. [317] covers the composition range of 50–75 mol % $AlCl_3$ from the melting points up to 620 K. The results are reported in the form of an empirical equation which expresses the density as a function of composition and temperature with an overall standard deviation of ±0.003 g cm^{-3}. For the relatively narrow temperature and composition ranges where comparisons are possible, it was found that Boston's values were generally greater (2.2 to 3.6%), while those of Midorikawa [188] were somewhat less (−0.2 to −1.0%).

TABLE 130. $AlCl_3$-NaCl: Density (g cm^{-3})

	Mol percent NaCl			
T	48.0	38.2	27.0	0.0
400	1.733			
410	1.724			
420	1.716			
430	1.708			
440	1.699	1.653		
450	1.691	1.644		
460	1.682	1.635	1.588	
470	1.674	1.627	1.579	
480	1.666	1.618	1.570	1.252
490	1.657	1.609	1.561	1.229
500	1.649	1.601	1.551	
510	1.641	1.592	1.542	
520	1.632	1.583	1.533	
530	1.624	1.575	1.524	
540	1.615	1.566	1.515	
550	1.607		1.505	
560	1.598		1.496	
570			1.487	
580			1.478	
590			1.469	
600			1.459	
610			1.450	

Temperature-dependent equations
$\rho = a + bT$

Mol % NaCl	a	$b \cdot 10^3$	Stand. deviation
0.0	2.371	−2.330	0.0017
27.0	2.011	−0.920	0.0011
38.2	2.034	−0.866	0.0007
48.0	2.068	−0.838	0.0008

These values are based on the work of Boston (flotation method) **[110]**.

TABLE 131. Viscosity studies: $AlCl_3$-NaCl

Investigations critically re-examined

Ref.	NaCl Mol %	Temp. range (T)
32	34.5–49.8	473–573

Comment: Kryagova **[32]** calibrated his viscometer with water at 20 °C and also with several alkali nitrates. The viscometer was sealed to prevent adsorption of moisture and the loss of volatile components.

TABLE 132. $AlCl_3$-NaCl: Viscosity (cp)

	Mol percent NaCl							
T	49.8	49.3	48.2	43.6	40.6	39.1	34.8	34.5
480	2.65	[2.44]	[2.37]	[2.44]	2.84	2.96	3.11	
490	2.47	[2.26]	[2.21]	[2.27]	2.65	2.77	2.89	
500	2.32	[2.11]	[2.06]	[2.11]	2.47	2.60	2.70	[2.82]
510	2.17	[1.97]	[1.92]	[1.96]	2.31	2.45	2.53	[2.63]
520	2.04	[1.85]	[1.79]	[1.83]	2.17	2.31	2.38	[2.46]
530	1.93	[1.74]	[1.67]	[1.71]	2.04	2.18	2.24	[2.31]
540	1.82	[1.64]	[1.57]	[1.61]	1.93	2.07	2.11	[2.18]
550	1.72				1.82	1.96	2.00	[2.06]
560	1.63				1.73	1.87	1.89	[1.96]
570	1.55				1.64	1.78	1.80	[1.87]

Temperature-dependent equations

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

$$\eta = A \cdot \exp\,(E/RT)$$

Mol % NaCl	a	$b \cdot 10^1$	$c \cdot 10^4$	$d \cdot 10^7$	$A \cdot 10^2$	E (cal mol^{-1})	Stand. error of est.
34.5	[65.0389]	[−2.8254]	[4.2285]	[−2.1333]			0.00%
34.8					9.684	3308	0.55%
39.1					11.804	3073	0.37%
40.6					8 639	3332	0.52%
43.6	[−15.7630]	[1.6688]	[−4.2227]	[3.2000]			0.00%
48.2	[−31.2541]	[2.5481]	[−5.8970]	[4.2667]			0.00%
49.3	[99.3197]	[−5.0765]	[8.9312]	[−5.3333]	8.993	3227	0.00%
49.8							0.26%

These values are based on the work of Kryagova (capillary method) [32].

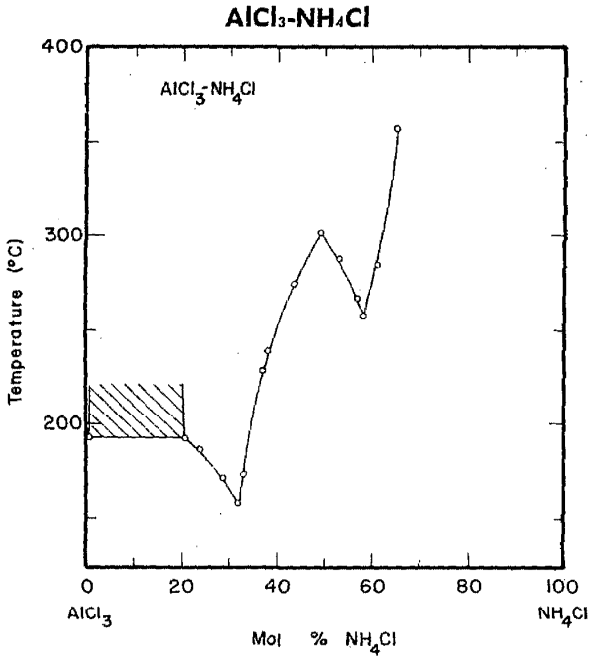


FIGURE 9. Temperature-composition phase diagram for $AlCl_3$-NH_4Cl.

J. Kendall, E. D. Crittenden and H. K. Miller, J. Amer. Chem. Soc., **45**, 963 (1923).

Melt Preparation and Purification

Yamaguti and Sisido's [42] preparation of $AlCl_3$ described under the $AlCl_3$-LiCl system.

TABLE 133. Electrical conductance studies: $AlCl_3$-NH_4Cl

Investigations critically re-examined			
Ref.	NH_4Cl Mol %	Temp. range (T)	Comments
42	20.2, 29.1, 42.9, 50.1	467–582	Cell material: glass; Pt electrodes; freq. range: 800 Hz; calibration: 1N KCl solution

TABLE 134. $AlCl_3$-NH_4Cl: Specific conductance (ohm^{-1} cm^{-1})

Mol percent NH_4Cl				
T	50.10	42.90	29.10	20.25
470			0.163	0.112
480			0.176	0.120
490			0.189	0.128
500			0.201	0.136
510			0.214	0.144
520			0.226	0.152
530			0.239	0.161
540		0.348	0.251	0.169
550		0.368	0.264	0.177
560		0.387	0.277	0.185
570	0.471		0.289	
580	0.501			

Temperature-dependent equations

$\kappa = a + bT$

Mol % NH_4Cl	a	$b \cdot 10^3$	Stand. error of est.
20.25	−0.2700	0.8123	0.94%
29.10	−0.4281	1.2583	0.99%
42.90	−0.6940	1.9304	0.78%
50.10	−1.2669	3.0486	0.34%

These values are based on the work of Yamaguti and Sisido (classical ac technique) [42].

TABLE 135. Density studies: $AlCl_3$-NH_4Cl

Investigations critically re-examined			
Ref.	NH_4Cl Mol %	Temp. range (T)	Comment
42	50	556–627	Cell material: glass dilatometer

TABLE 136. $AlCl_3$-NH_4Cl: Density (g cm^{-3})

Mol percent NH_4Cl	
T	50.0
556.2	1.470
557.2	1.475
584.2	1.445
588.2	1.440
597.2	1.425
627.2	1.420

These values are based on the work of Yamaguti and Sisido (dilatometric method) [42]. Due to limited data, the experimental results are given.

$AlCl_3$-RbCl

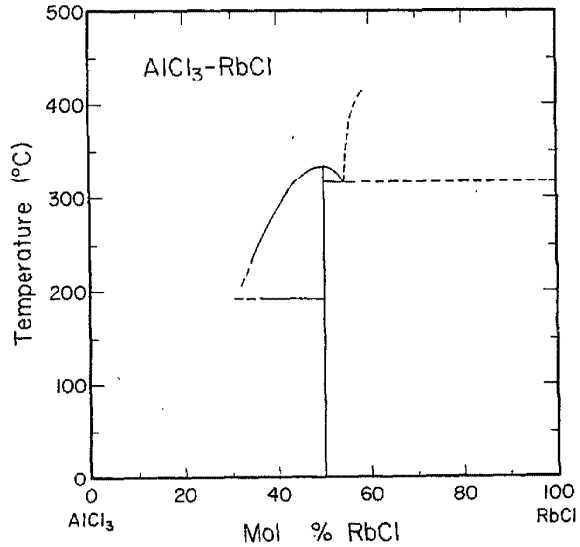


FIGURE 10. Temperature-composition phase diagram for $AlCl_3$-RbCl.

G. Boef, H. B. Slot, R. A. W. Leenwen, H. Wesels and J. W. van Spronson, Z. anorg. allgem. Chem., **353**, 93 (1967).

Melt Preparation and Purification

Moss [112] used CP reagent grade rubidium chloride which was dried in a muffle furnace and then stored in a dry box. His preparation of $AlCl_3$ is described under the $AlCl_3$-LiCl system.

TABLE 137. Electrical conductance studies: $AlCl_3$-RbCl

Investigations critically re-examined			
Ref.	RbCl Mol %	Temp. range (T)	Comments
112	25, 30	448–498	Cell material: silica; Pt electrodes

TABLE 138. $AlCl_3$-RbCl: Specific conductance (ohm^{-1} cm^{-1})

Mol percent RbCl		
T	30.0	25.0
448.2	0.098	0.090
473.2	0.121	0.108
498.2	0.146	0.128

These values are based on the work of Moss (classical ac technique) [112]. Due to limited data, the experimental results are given.

TABLE 139. Density studies: $AlCl_3$-RbCl

Investigations critically re-examined				
Ref.	RbCl Mol %	Temp. range (T)	Cell material	Calibration
112	25.0, 30.0	448–498	Glass dilatometer	Purified mercury

TABLE 140. $AlCl_3$-RbCl: Density (g cm^{-3})

Mol percent RbCl		
T	30.0	25.0
450	1.822	1.798
455	1.817	1.793
460	1.812	1.788
465	1.807	1.783
470	1.802	1.778
475	1.798	1.773
480	1.793	1.768
485	1.788	1.763
490	1.783	1.758
495	1.778	1.753

Temperature-dependent equations

$\rho = a + bT$

Mol % RbCl	a	$b \cdot 10^3$	Stand. error of est.
25.0	2.2482	−1.00	0.00%
30.0	2.2536	−0.96	0.03%

These values are based on the work of Moss (dilatometric method) [**112**].

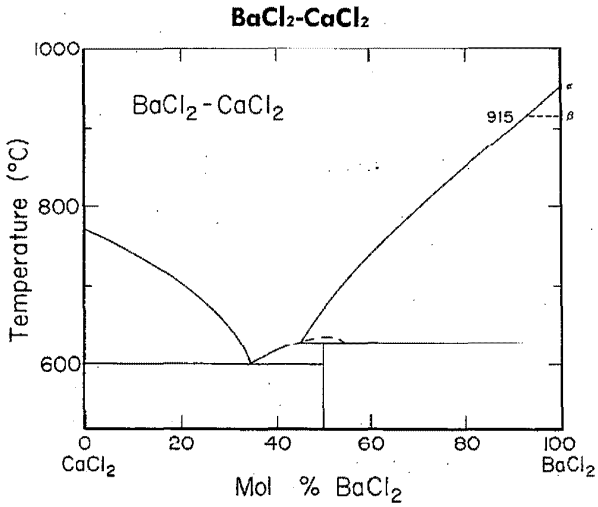


FIGURE 11. Temperature-composition phase diagram for $BaCl_2$-$CaCl_2$.

P. D. Budinkov, Pl. Volodin and S. G. Tresvyatskii, Ukraine. Khim. Zhur., **22**, 293 (1956).

Melt Preparation and Purification

Lantratov and Moiseeva [74] used chemically pure grade barium and calcium chlorides. To remove traces of oxides and water, $BaCl_2$ was heated in a current of dry HCl at 500–800 °C. Calcium chloride was purified by passing HCl gas through the melt for several hours.

Alabyshev and Kulakovskaya [20] used chemically "anhydrous" salt and purified them by an unspecified method.

Lantratov [**229**] used c.p. grade $BaCl_2$ and $CaCl_2$ which were dried and fused under a flow of HCl gas (30–60 minutes). The salts were desiccated until used.

TABLE 141. Electrical conductance studies: $BaCl_2$-$CaCl_2$

Investigations critically re-examined

Ref.	$CaCl_2$ Mol %	Temp. range (T)	Comments
20	75	921, 939, 979	Cell material: quartz; freq. range: 1000 Hz; calibration: 30% H_2SO_4 solution
74	60, 75, 87.5	932–1073	Cell material: quartz; Pt electrodes; freq. range: 1000–3000 Hz; calibration: molten KNO_3, $NaNO_3$ and NaCl
120	0–100	973–1573	Cell material: quartz; freq. range: 500–20,000 Hz: calibration: KCl solutions

Comparison with NSRDS recommendations [1, p. 7, and this volume]

Ref.	$CaCl_2$ Mol %	Min. departure	Max. departure
120	100	9.4% (1173 K)	10.8% (1223 K)
74	60	0.0% (1023 K)	4.5% (973 K)
120	0	6.0% (1273 K)	6.0% (1323 K)

Comment: Lantratov and Moiseeva [**74**] noted that their quartz cells were attacked by the melts; consequently the vessels were boiled in concentrated HCl and washed with hot distilled water between consecutive measurements.

From isotherms of specific conductance versus mole % $BaCl_2$, Lantratov and Moiseeva [74] concluded that their data at 60, 75, and 87.5 mol % $CaCl_2$ was in satisfactory agreement with the results of Barzakovskii and Kochinashvili [**120**].

TABLE 142. $BaCl_2$-$CaCl_2$: Specific conductance (ohm^{-1} cm^{-1})

	Mol percent $CaCl_2$										
T	100	90	80	70	60	50	40	30	20	10	0
980			1.50	1.45	1.40						
1000			1.57	1.51	1.47						
1020			1.63	1.58	1.53						
1040		1.74	1.70	1.65	1.60	1.54					
1060		1.81	1.77	1.71	1.67	1.61					
1080	1.94	1.89	1.84	1.78	1.74	1.68	1.64				
1100	2.02	1.96	1.91	1.85	1.81	1.75	1.71				
1120	2.10	2.03	1.97	1.92	1.87	1.82	1.77				
1140	2.18	2.10	2.04	1.98	1.94	1.89	1.84	1.80			
1160	2.26	2.17	2.11	2.05	2.01	1.95	1.90	1.86			
1180	2.33	2.24	2.18	2.12	2.07	2.02	1.97	1.92	1.85		
1200	2.40	2.31	2.24	2.18	2.14	2.08	2.03	1.98	1.92		
1220	2.47	2.38	2.31	2.25	2.20	2.15	2.09	2.04	1.99		
1240	2.54	2.45	2.38	2.32	2.27	2.21	2.16	2.10	2.05	2.01	
1260	2.61	2.51	2.45	2.38	2.33	2.28	2.22	2.16	2.12	2.07	
1280	2.67	2.58	2.52	2.45	2.39	2.34	2.28	2.22	2.18	2.13	2.07
1300	2.73	2.64	2.58	2.52	2.45	2.40	2.34	2.28	2.24	2.18	2.13
1320	2.79	2.71	2.65	2.58	2.52	2.46	2.41	2.35	2.30	2.24	2.19
1340	2.85	2.77	2.72	2.65	2.58	2.52	2.47	2.41	2.35	2.30	2.24
1360	2.90	2.83	2.79	2.72	2.64	2.58	2.53	2.47	2.41	2.36	2.30
1380											2.35
1400											2.40
1420											2.45
1440											2.49
1440											2.53
1460											2.57
1480											2.61
1500											2.65
1520											2.69
1540											2.72

Temperature-dependent equations

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

Mol % $CaCl_2$	a	$b \cdot 10^3$	$c \cdot 10^6$	Stand. error of est.
0	−5.8435	9.3706	−2.4887	0.78%
10	−1.6386	2.9400	0	0.66%
20	−5.4488	8.8668	−2.2729	0.60%
30	−1.6903	3.0571	0	0.68%
40	−2.4699	4.3216	−0.4761	0.45%
50	−3.1879	5.5379	−0.9539	0.72%
60	−2.6071	4.6708	−0.5981	0.73%
70	−1.8346	3.3476	0	0.62%
80	−1.8254	3.3909	0	0.64%
90	−3.3773	6.0568	−1.0969	0.72%
100	−5.8425	10.1868	−2.7630	0.41%

These values are based on the work of Barzakovskii and Kochinashvili (classical ac technique) [**120**].

TABLE 143. Surface tension studies: $BaCl_2$-$CaCl_2$

Investigations critically re-examined			
Ref.	$CaCl_2$ Mol %	Temp. range (T)	Comments
229	60, 75, 100	873–1140	Cell material: Pt and stainless steel capillaries, Pt crucible; calibration: capillary diameter determined microscopically, checked using molten KNO_3 and $NaNO_3$

Deviations from previous NSRDS recommendations [2, p. 60]			
Ref.	$CaCl_2$ Mol %	Min. departure	Max. departure
229	100	0.21% (1093 K)	1.2% (1173 K)

Comment: Lantratov [**229**] reported reproducibility in surface tension measurements of ±0.1%. Glass or quartz vessels could not be used due to corrosive attack of the melts.

TABLE 144. $BaCl_2$-$CaCl_2$: Surface tension (dyn cm^{-1})

	Mol % $CaCl_2$		
T	100	75.0	60
880			166.31
890			165.81
900			165.31
910			164.81
920			164.31
930		159.98	163.81
940		159.51	163.30
950		159.04	162.80
960		158.57	162.30
970		158.10	161.80
980		157.63	161.30
990		157.16	160.80
1000		156.69	160.30
1010		156.22	159.80
1020		155.75	159.29
1030		155.28	158.79
1040		154.81	158.29
1050		154.34	157.79
1060	146.36	153.87	157.29
1070	145.80	153.40	156.79
1080	145.24		
1090	144.68		
1100	144.12		
1110	143.56		
1120	143.00		
1130	142.44		
1140	141.88		

Temperature-dependent equations

$$\gamma = a + bT$$

Mol % $CaCl_2$	a	$b \cdot 10^2$	Stand. error of est.
60	210.42	−5.01	0.002%
75.0	203.69	−4.70	0.000%
100	205.83	−5.61	

These values are based on the work of Lantratov (maximum bubble pressure method) [**229**].

$BaCl_2$-$CdCl_2$

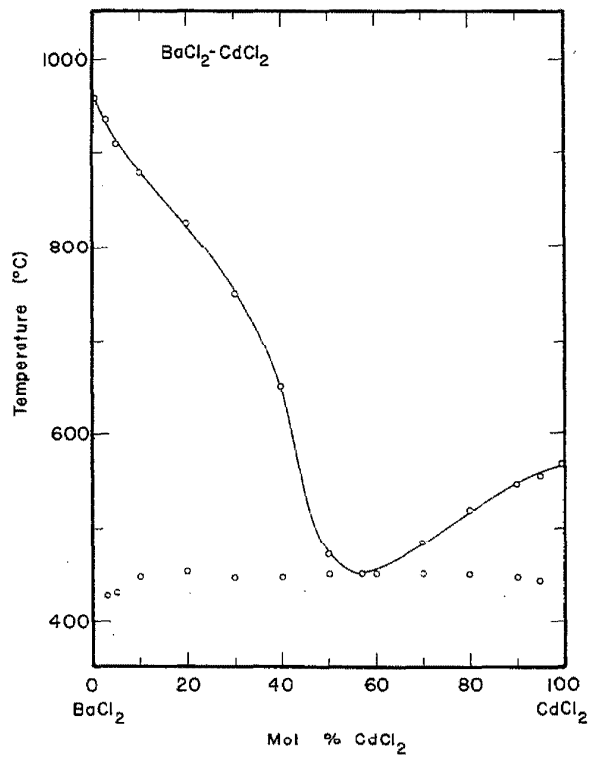


FIGURE 12. Temperature-composition phase diagram for $BaCl_2$-$CdCl_2$.

C. Sandonnini, Attidella Reale Accad. dei Lincei, (5), 20, II, 646. 1911.

Melt Preparation and Purification

Boardman, Dorman, and Heymann [**26**] report that their salts were either of analytical grade purity or were prepared from pure reagents and recrystallized. Cadmium chloride, from pure electrolytic cadmium (Electrolytic Zinc Co., Tasmania), was dried with increasing temperatures until molten, and finally dry HCl was passed through the melt. Analysis for cadmium was performed using the electro-analytical method.

TABLE 145. Density studies: $BaCl_2$-$CdCl_2$

Investigations critically re-examined				
Ref.	$CdCl_2$ Mol %	Temp. range (T)	Cell material	Calibration
26[a]	45.8, 64.0, 82.9, 100	853–998	Silica glass dilatometer	Molten $AgNO_3$
165	50	673–973		

[a]Boardman et al. [**26**] applied corrections for the shape of the meniscus, buoyancy and expansion of the silica glass. In general the dilatometer method could not be used above 700–750 °C because of chemical attack on the silica glass. Values for pure $CdCl_2$ are those recommended in [1].

TABLE 146. $BaCl_2$-$CdCl_2$: Density (g cm^{-3})

	Mol percent $CdCl_2$			
T	100	82.9	64.0	45.8
860	3.377		3.492	
870	3.368	3.441	3.483	
880	3.360	3.432	3.474	3.486
890	3.351	3.422	3.464	3.477
900	3.343	3.413	3.455	3.467
910	3.335	3.404	3.446	3.457
920	3.326	3.394	3.436	3.448
930	3.318	3.385	3.427	3.438
940	3.309	3.376	3.418	3.429
950	3.301	3.367	3.409	3.419
960	3.293	3.357	3.399	3.409
970	3.284	3.348	3.390	
980	3.276			
990	3.267			

Temperature-dependent equations

$$\rho = a + bT$$

Mol % $CdCl_2$	a	$b \cdot 10^3$
45.8	4.331	−0.96
64.0	4.292	−0.93
82.9	4.250	−0.93
100	4.099	−0.84

These values are based on the work of Boardman et al. (dilatometric method) [**26**].

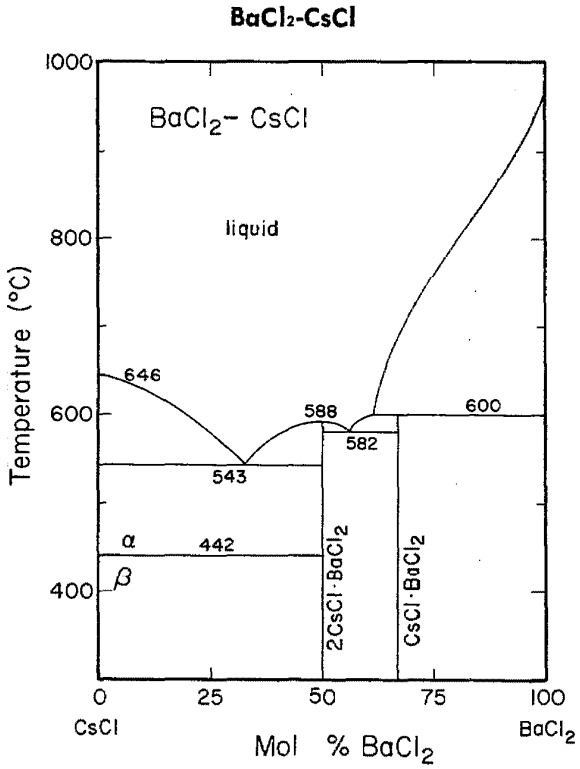


FIGURE 13. Temperature-composition phase diagram for $BaCl_2$-CsCl.

Z. A. Mateiko, E. S. Yagub'yon, and G. A. Bukhalova, Zh. Neorgan. Khim., **11**, [10], 2405 (1966); Russ. J. Inorg. Chem. (English Transl.) **12**, 91 (1966).

Melt Preparation and Purification

Smirnov et al. [**79**] used "chemically pure" $BaCl_2$ and "pure" CsCl which were recrystallized from distilled water.

Smirnov and Khokhlov [**174**] purified their salts by double recrystallization, followed by drying under vacuum and finally melting the salts in an argon atmosphere.

Smirnov and Stepanov [**225**] used salts purified by triple recrystallization from doubly distilled water.

TABLE 147. Electrical conductance studies: $BaCl_2$-CsCl

Investigations critically re-examined			
Ref.	CsCl Mol %	Temp. range (T)	Comments
166	0–100	1063–1298	Cell material: alundum crucible in a sealed quartz tube; Mo electrodes; freq. range: 50,000 Hz; calibration: molten LiCl, KCl
209[a]	0–100 (g)	1240	Cell material and calibration: as for **166**

Deviations from previous NSRDS recommendations: [1, pp. 6, 7]			
Ref.	CsCl Mol %	Min. departure	Max. departure
166	100	−5.12% (1090 K)	−8.21% (1170 K)
166	0	−0.79% (1300 K)	−0.18% (1270 K)

[a]Equivalent conductance reported.

TABLE 148. $BaCl_2$-CsCl: Specific conductance (ohm^{-1} cm^{-1})

	Mol percent CsCl										
T	100	90.96	82.37	73.40	67.0	60.35	50.95	45.0	36.0	10.0	0
1070		1.402	1.330	1.239	1.161	1.119	1.080	1.107	1.124		
1080		1.418	1.348	1.256	1.184	1.142	1.104	1.132	1.150		
1090	1.533	1.434	1.365	1.272	1.206	1.166	1.129	1.156	1.175		
1100	1.551	1.451	1.383	1.289	1.229	1.189	1.152	1.180	1.201		
1110	1.569	1.467	1.400	1.306	1.251	1.211	1.176	1.204	1.226		
1120	1.587	1.483	1.418	1.323	1.272	1.233	1.199	1.227	1.250		
1130	1.606	1.500	1.435	1.340	1.293	1.255	1.221	1.250	1.275		
1140	1.624	1.516	1.452	1.358	1.314	1.276	1.243	1.273	1.299		
1150	1.642	1.533	1.470	1.357	1.334	1.297	1.265	1.295	1.323		
1160	1.660	1.550	1.487	1.393	1.354	1.317	1.286	1.317	1.346		
1170	1.678	1.566	1.505	1.411	1.373	1.337	1.307	1.338	1.370	1.679	
1180	1.696	1.583	1.522	1.430	1.392	1.356	1.327	1.359	1.393	1.707	
1190	1.714	1.600	1.540	1.448	1.411	1.375	1.347	1.380	1.415	1.734	
1200	1.732	1.617	1.557	1.467	1.429	1.394	1.366	1.401	1.437	1.762	
1210	1.751	1.634	1.575	1.486	1.447	1.412	1.385	1.421	1.459	1.790	
1220	1.769	1.651	1.592	1.505	1.464	1.429	1.404	1.440	1.481	1.818	
1230	1.787	1.668	1.610	1.524	1.482	1.447	1.422	1.460	1.502	1.845	
1240	1.804	1.685	1.627	1.544	1.498	1.463	1.439	1.479	1.523	1.873	2.068
1250		1.702	1.645	1.564	1.514	1.480	1.456	1.497	1.544	1.901	2.098
1260		1.720	1.662	1.584	1.530	1.496	1.473	1.515	1.565	1.928	2.128
1270		1.737	1.679	1.604	1.546	1.511	1.489	1.533	1.585	1.956	2.158
1280		1.755	1.697	1.624	1.561	1.526	1.505	1.551	1.605	1.984	2.189
1290											2.220

Temperature-dependent equations

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

Mol % CsCl	a	$b \cdot 10^3$	$c \cdot 10^6$	Standard deviation
0	0.750	−0.838	1.533	±0.008
10.0	−1.563	2.771	0	±0.005
36.0	−3.443	5.921	−1.545	±0.003
45.0	−3.667	6.425	−1.835	±0.003
50.95	−4.144	7.269	−2.231	±0.002
60.35	−3.955	7.084	−2.189	±0.002
67.0	−3.630	6.628	−2.010	±0.002
73.40	0.670	−0.555	1.016	±0.007
82.37	−0.538	1.746	0	±0.005
90.96	0.059	0.901	0.331	±0.006
100	−0.442	1.812	0	±0.003

These values are based on the work of Smirnov and Khokhlov (classical ac technique) [166].

TABLE 149. Density studies: $BaCl_2$-CsCl

Investigations critically re-examined				
Ref.	CsCl Mol %	Temp. range (T)	Cell material	Calibration
79	0–100	973–1273	Pt ball	Molten KNO_3 and KCl
152	0–100 (g)	1273	Pt sphere	

Deviations from previous NSRDS recommendations: [1, pp. 6, 7]			
Ref.	CsCl Mol %	Min. departure	Max. departure
79	100	1.1% (980 K)	1.3% (1170 K)
79	0	−1.9% (1240 K)	−2.2% (1270 K)

TABLE 150. $BaCl_2$-CsCl: Density (g cm^{-3})

	Mol percent CsCl										
T	100	88.58	75.68	66.98	56.25	46.63	35.17	27.59	24.72	15.23	0
980	2.754	2.775	2.834	2.909	2.982	3.041	3.119	3.166	3.181	3.242	3.367
990	2.744	2.764	2.823	2.899	2.972	3.032	3.109	3.156	3.172	3.233	3.357
1000	2.733	2.753	2.812	2.889	2.962	3.022	3.099	3.146	3.163	3.224	3.347
1010	2.723	2.742	2.801	2.879	2.952	3.012	3.089	3.137	3.154	3.215	3.337
1020	2.712	2.731	2.791	2.869	2.942	3.003	3.079	3.127	3.144	3.206	3.328
1030	2.702	2.720	2.780	2.859	2.932	2.993	3.069	3.117	3.135	3.197	3.318
1040	2.692	2.709	2.769	2.849	2.922	2.984	3.059	3.108	3.126	3.187	3.308
1050	2.681	2.697	2.758	2.839	2.912	2.974	3.048	3.098	3.117	3.178	3.298
1060	2.670	2.686	2.748	2.829	2.902	2.964	3.038	3.088	3.108	3.169	3.288
1070	2.660	2.675	2.737	2.819	2.892	2.955	3.028	3.078	3.099	3.160	3.278
1080	2.650	2.664	2.726	2.809	2.882	2.945	3.018	3.069	3.090	3.151	3.268
1090	2.639	2.653	2.716	2.799	2.872	2.936	3.008	3.059	3.081	3.142	3.259
1100	2.629	2.642	2.705	2.789	2.863	2.926	2.998	3.049	3.072	3.133	3.249
1110	2.618	2.631	2.694	2.779	2.853	2.916	2.988	3.040	3.063	3.123	3.239
1120	2.608	2.620	2.683	2.769	2.843	2.907	2.977	3.030	3.053	3.114	3.229
1130	2.597	2.609	2.673	2.759	2.833	2.897	2.967	3.020	3.044	3.105	3.219
1140	2.587	2.598	2.662	2.749	2.823	2.888	2.957	3.011	3.035	3.096	3.209
1150	2.576	2.587	2.651	2.739	2.813	2.878	2.947	3.001	3.026	3.087	3.200
1160	2.566	2.576	2.640	2.729	2.803	2.868	2.937	2.991	3.017	3.078	3.190
1170	2.555	2.565	2.630	2.719	2.793	2.859	2.927	2.982	3.008	3.069	3.180
1180	2.545	2.554	2.619	2.709	2.783	2.849	2.917	2.972	2.999	3.059	3.170
1190	2.534	2.543	2.608	2.699	2.773	2.840	2.906	2.962	2.990	3.050	3.160
1200	2.524	2.532	2.598	2.689	2.763	2.830	2.896	2.952	2.981	3.041	3.150
1210	2.513	2.520	2.587	2.679	2.753	2.820	2.886	2.943	2.972	3.032	3.140
1220	2.503	2.509	2.576	2.669	2.743	2.811	2.876	2.933	2.962	3.023	3.131
1230	2.493	2.498	2.565	2.659	2.733	2.801	2.866	2.923	2.953	3.014	3.121
1240	2.482	2.487	2.555	2.650	2.723	2.792	2.856	2.914	2.944	3.005	3.111
1250	2.472	2.476	2.544	2.640	2.713	2.782	2.846	2.904	2.935	2.995	3.101
1260	2.461	2.465	2.533	2.630	2.703	2.772	2.835	2.894	2.926	2.986	3.091
1270	2.451	2.454	2.522	2.620	2.694	2.763	2.825	2.885	2.917	2.977	3.081

Temperature-dependent equations

$$\rho = a + bT$$

Mol % CsCl	a	$b \cdot 10^3$
0	4.3316	−0.9844
15.23	4.1382	−0.9142
24.72	4.0725	−0.9099
27.59	4.1154	−0.9691
35.17	4.1136	−1.0144
46.63	3.9816	−0.9597
56.25	3.9558	−0.9939
66.98	3.8866	−0.9976
75.68	3.8851	−1.0730
88.58	3.8593	−1.1065
100	3.7808	−1.0474

These values are based on the work of Smirnov et al. (Archimedean method) [79].

TABLE 151. Viscosity studies: $BaCl_2$-CsCl

Investigations critically re-examined				
Ref.	CsCl Mol %	Temp. range (T)	Cell material	Calibration
174	0–100	930–1290	Pt ball	Molten Cs and Li chlorides

Deviations from previous NSRDS recommendations: [1, pp. 6, 7]			
Ref.	CsCl Mol %	Min. departure	Max. departure
174	100	0.91% (960 K)	1.6% (940 K)
174	0	−22.0% (1290 K)	−26.1% (1270 K)

TABLE 152. $BaCl_2$-CsCl: Viscosity (cp)

	Mol percent CsCl									
T	100	88.58	75.68	66.98	56.25	46.63	35.17	24.72	15.22	0
930	1.349									
940	1.296									
950	1.248									
960	1.202									
970	1.159									
980	1.118									
990	1.079									
1000	1.043		1.966	2.606						
1010	1.008		1.909	2.513						
1020	0.095		1.856	2.425						
1030	0.944		1.805	2.342	2.896	3.683				
1040			1.756	2.263	2.788	3.530				
1050			1.710	2.188	2.686	3.387				
1060			1.665	2.117	2.589	3.253				
1070		1.191	1.623	2.049	2.498	3.126				
1080		1.168	1.582	1.985	2.412	3.006				
1090		1.145	1.543	1.924	2.330	2.893				
1100		1.123	1.506	1.866	2.252	2.780	3.511			
1110		1.102	1.470	1.811	2.178	2.684	3.359			
1120		1.082	1.436	1.758	2.108	2.589	3.216			
1130		1.062	1.403	1.708	2.041	2.498	3.082	3.420		
1140		1.043	1.371	1.660	1.978	2.412	2.956	3.280		
1150		1.025	1.341	1.614	1.917	2.330	2.837	3.148		
1160		1.008	1.312	1.570	1.860	2.253	2.724	3.024		
1170		0.991	1.284	1.528	1.805	2.179	2.618	2.906		
1180		0.974	1.257	1.488	1.752	2.109	2.518	2.795	3.591	
1190		0.958	1.231	1.450	1.702	2.042	2.423	2.690	3.448	
1200		0.943	1.206		1.654	1.978	2.333	2.591	3.312	
1210		0.928	1.182				2.248	2.497	3.184	
1220		0.914	1.159				2.167	2.407	3.063	
1230		0.900	1.136				2.091	2.322	2.948	
1240		0.886	1.115				2.018	2.242	2.839	3.811
1250		0.873						2.166	2.736	3.671
1260								2.093	2.639	3.538
1270								2.024	2.546	3.413
1280								1.958	2.458	3.293
1290								1.895	2.374	3.180

Temperature-dependent equations

$$\eta = A \cdot \exp\,(E/RT)$$

Mol % CsCl	$A \cdot 10^2$	E (cal mol^{-1})	Standard deviation
0	3.570	11507	±0.018
15.22	2.799	11382	±0.008
24.72	2.928	10689	±0.009
35.17	2.607	10716	±0.007
46.63	4.584	8977	±0.006
56.25	5.559	8090	±0.008
66.98	6.616	7299	±0.006
75.68	10.483	5824	±0.007
88.58	13.769	4588	±0.008
100	3.448	6774	±0.008

These values are based on the work of Smirnov and Khokhlov (oscillating sphere method) [174].

TABLE 153. Surface tension studies: $BaCl_2$-CsCl

Investigations critically re-examined				
Ref.	CsCl Mol %	Temp. range (T)	Cell material	Calibration
225	0-100	1070-1263	Ceramic capillary	Measurements on pure salts
244	0-100 (g)	1123		

Deviations from previous NSRDS recommendations: [2, pp. 58, 60]

Ref.	CsCl Mol %	Min. departure	Max. departure
225	100	—0.0% (933 K)	0.24% (1013 K)
225	0	2.8% (990 K)	4.4% (1040 K)

Comment: Calculations in reference [**225**] were corrected for the depth of immersion and for the thermal expansion of the capillary. Least squares linear fit to the surface tension results gave a mean deviation of ±0.1 dyne cm^{-1}. The data in reference [244] was stated as reproducible to 0.5%.

TABLE 154. $BaCl_2$–CsCl: Surface tension (dyn cm^{-1})

	Mol percent CsCl										
T	100	90	80	70	60	50	40	30	20	10	0
940	89.75										
960	88.19										
980	86.62										
1000	85.05										
1020	83.48										
1040	81.91										
1060	80.35										
1080		79.0	79.2	80.2							
1100		77.5	77.7	78.8		84.9					
1120		75.9	76.2	77.3	79.2	83.6	89.8				
1140		74.4	74.7	75.9	77.8	82.3	88.5	95.3			
1160		72.8	73.2	74.5	76.4	80.9	87.3	94.1			
1180		71.3	71.7	73.0	75.0	79.6	86.0	92.9			
1200		69.7	70.2	71.6	73.6	78.3	84.7	91.7	109.8		
1220		68.2	68.8	70.2	72.2	77.0	83.4	90.4	108.7	127.3	
1240		66.6	67.3	68.7	70.9	75.6	82.1	89.2	107.5	126.5	
1260		65.1	65.8	67.3	69.5	74.3	80.9	88.0	106.3	125.6	168.1
1280				65.9				86.8	105.1	124.7	167.3
1300									104.0	123.9	166.6
1320										123.0	165.8
1340											165.0
1360											164.3

Temperature-dependent equations

$$\gamma = a + bT$$

Mol % CsCl	a	$b \cdot 10^2$
0	216.1	—3.81
10	179.4	—4.27
20	179.9	—5.84
30	165.1	—6.12
40	161.5	—6.40
50	157.6	—6.61
60	157.4	—6.98
70	157.4	—7.15
80	159.4	—7.43
90	162.6	—7.74
100	163.46	—7.841

These values are based on the work of the work of Smirnov and Stepanov (maximum bubble pressure method) [**225**].

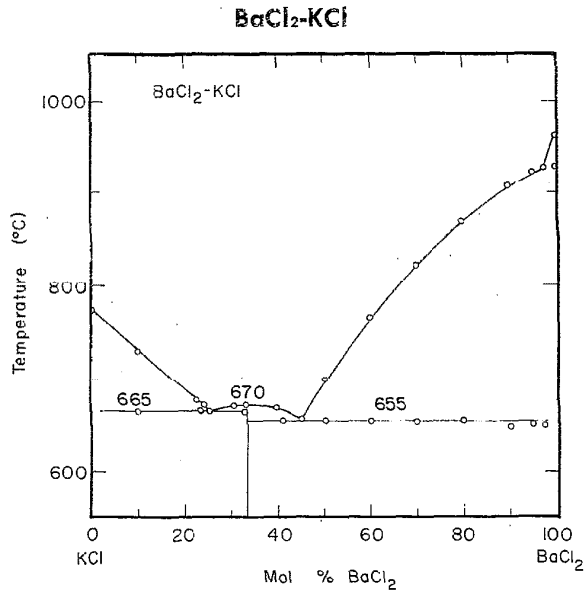


FIGURE 14. Temperature-composition phase diagram for $BaCl_2$-KCl. T. Sato, Kinzoku no Kenkyu, **10**, 383 (1933).

Melt Preparation and Purification

Peake and Bothwell [**232, 33**] used Baker and Adamson reagent grade and Merck and Co. reagent grade potassium chloride and barium chloride dihydrate, respectively. To obtain anhydrous materials the KCl was heated for ten hours at 600° in a muffle furnace while the $BaCl_2 \cdot 2H_2O$ was first heated in a porcelain casserole for 24 hours on a hot-plate and then for 10 hours at 800 °C in a muffle furnace. Analysis of the melts consisted in determining the barium content by weighing as the carbonate.

Reding [241] used Baker and Adamson reagent grade KCl which was dried under vacuum for 12 hours or longer. Baker and Adamson reagent grade $BaCl_2 \cdot 2H_2O$ was dehydrated by heating under vacuum for 12 hours at 200 °C and then for 5 hours at 500 °C. The dried salts were stored in sealed Mason jars that had been previously flushed with argon and dried.

TABLE 155. Density studies: $BaCl_2$–KCl

Investigations critically re-examined		
Ref.	KCl Mol %	Temp. range (T)
33[a]	0–100	1054–1286
89[c]	0–100	
152	0–100 (g)	1273
150[b]	0–100 (g)	1073

Deviations from previous NSRDS recommendations: [1, pp. 5, 11]			
Ref.	KCl Mol %	Min. departure	Max. departure
33	100	−0.59% (1065 K)	−0.82% (1161 K)
33	0	−0.86% (1267 K)	−0.89% (1286 K)

[a] Peake and Bothwell [**33**] took suitable precautions to avoid condensation of salt vapors on their suspension wire and incorporated a technique for accurate location of the surface of the melt, resulting in reproducible depths of immersion of the platinum sinker. The authors report a probable error in density measurements on the pure salts of less than ±0.2% and an error of less than ±0.3% on density of mixtures.

[b] Data from ref. [**33**].

[c] Graphical except for pure salts.

TABLE 156. $BaCl_2$–KCl: Density (g cm^{-3})

	Mol percent KCl											
T	100	91.6	86.9	75.6	70.2	66.7	66.4	54.3	50.5	36.7	20.9	0
1060									2.487			
1070	1.503	1.693	1.766	2.051		2.226	2.220	2.422	2.481			
1080	1.497	1.685	1.761	2.045	2.120	2.208	2.213	2.414	2.475			
1090	1.491	1.678	1.756	2.039	2.113	2.192	2.206	2.407	2.468			
1100	1.485	1.671	1.751	2.032	2.106	2.177	2.199	2.399	2.462	2.731		
1110	1.479	1.663	1.746	2.026	2.099	2.164	2.192	2.391	2.456	2.725		
1120	1.472	1.656	1.742	2.020	2.092	2.153	2.185	2.384	2.449	2.718		
1130	1.466	1.648	1.737	2.014	2.085	2.143	2.178	2.376	2.443	2.712		
1140	1.460	1.641	1.732	2.008	2.079	2.134	2.171	2.368	2.436	2.705		
1150	1.454	1.633	1.727	2.002	2.072	2.128	2.164	2.361	2.430	2.699		
1160	1.448	1.626	1.723	1.995	2.065	2.122	2.157			2.692	2.922	
1170					2.058					2.686	2.915	
1180										2.679	2.908	
1190											2.901	
1200											2.893	
1210											2.886	
1220												
1230												
1240												
1250												3.136
1260												3.129
1270												3.122
1280												3.115

Temperature-dependent equations

$$\rho = a + bT$$

Mol % KCl	a	$b \cdot 10^3$	$c \cdot 10^6$	Stand. error of est.
0	3.9881	−0.6819	0	0.02%
20.9	3.7621	−0.7240	0	0.05%
36.7	3.4446	−0.6486	0	0.04%
50.5	3.1602	−0.6349	0	0.07%
54.3	3.2396	−0.7643	0	0.04%
66.4	2.9626	−0.6944	0	0.17%
66.7	13.2921	−18.8213	7.9243	0.29%
70.2	2.8580	−0.6838	0	0.06%
75.6	2.7114	−0.6173	0	0.06%
86.9	2.2758	−0.4769	0	0.18%
91.6	2.4850	−0.7405	0	0.21%
100	2.1559	−0.6103	0	0.08%

These values are based on the work of Peake and Bothwell (Archimedean method) [33].

TABLE 157. Surface tension studies: $BaCl_2$-KCl

Investigations critically re-examined

Ref.	KCl Mol %	Temp. range (T)	Comments
232	0–100	1077–1314	Cell material: Pt–10%Rh capillary and porcelain crucible; calibration: liquids of known surface tension; diameter of capillary measured with microscope
241	25–100	1023–1198	Cell material: Pt–10%Rh capillary and graphite crucible; diameter of capillary measured with microscope
244	0–100 (g)	1123	

Comparison with NSRDS recommendations [2, p. 58 and this volume]

Ref.	KCl Mol %	Min. departure	Max. departure
232	100	−2.2% (1117 K)	−2.9% (1142 K)
241	100	2.3% (1073 K)	
241	40	5.0% (1165 K)	5.2% (1103 K)

TABLE 158. $BaCl_2$-KCl: Surface tension (dyn cm^{-1})

	Mol percent KCl												
T	100.0	96.1	91.6	86.5	75.6	70.6	66.0	62.7	57.7	52.3	37.7	17.9	0.0
1080							112.1						
1090			99.2		108.1	109.4	111.6						
1100		96.1	98.6	100.9	107.5	108.9	111.0	112.7	115.3	118.9			
1110	93.5	95.3	98.0	100.2	106.8	108.4	110.4	112.0	114.9	118.4			
1120	92.8	94.6	97.4	99.5	106.2	107.8	109.8	111.4	114.4	117.8			
1130	92.1	93.8	96.9	98.8	105.5	107.3	109.2	110.7	113.9	117.3	129.4		
1140	91.4	93.1	96.3	98.1	104.8	106.8	108.6	110.0	113.4	116.8	128.6		
1150	90.7	92.3	95.7	97.4	104.2	106.3	108.0	109.4	112.9	116.3	127.7		
1160	90.0	91.6	95.1	96.7	103.5	105.8	107.4	108.7	112.4	115.7	126.9		
1170	89.3	90.8				105.2			111.9		126.1		
1180	88.6										125.2	143.8	
1190	87.9										124.4	143.0	
1200											123.5	142.2	
1210											122.7	141.5	
1220											121.8	140.7	
1230											121.0	139.9	
1240												139.2	
1250												138.4	
1260												137.7	163.5
1270													162.8
1280													162.0
1290													161.2
1300													160.4
1310													159.6

Temperature-dependent equations

$$\gamma = a + bT$$

Mol % KCl	a	$b \cdot 10^2$	Stand. error of est.
0.0	262.9968	−7.8938	0.17%
17.9	233.9472	−7.6421	0.26%
37.7	224.6250	−8.4254	0.80%
52.3	176.1607	−5.2083	0.54%
57.7	168.9015	−4.8698	0.27%
62.7	186.0652	−6.6690	0.28%
66.0	175.6408	−5.8798	0.24%
70.6	166.1773	−5.2091	0.27%
75.6	180.4021	−6.6294	0.32%
86.5	178.0157	−7.0131	0.46%
91.6	163.2767	−5.8786	0.46%
96.1	178.7136	−7.5125	0.40%
100.0	171.1364	−6.9911	0.25%

These values are based on the work of Bothwell and Peake (maximum bubble pressure method) [232].

$BaCl_2$-$LaCl_3$

Melt Preparation and Purification

Smirnov and Khoklov [172] and Smirnov and Stepanov [168] used "pure" barium chloride which was twice recrystallized, dried at reduced pressure, and remelted in an atmosphere of pure argon. The preparation of pure $LaCl_3$ is described under the system $LaCl_2$-$LaCl_3$.

TABLE 159. Electrical conductance studies: $BaCl_2$-$LaCl_3$

Investigations critically re-examined			
Ref.	$LaCl_3$ Mol %	Temp. range (T)	Comments
172	13.69–90.0	1131–1306	Pt electrodes; freq. range: 50,000 Hz; calibration: molten $CaCl_2$

TABLE 160. $BaCl_2$-$LaCl_3$: Specific conductance ($ohm^{-1}cm^{-1}$)

	Mol percent $LaCl_3$							
T	100	90.0	75.0	60.0	45.0	30.0	13.69	0.0
1140	1.248	1.271	1.282					
1150	1.273	1.297	1.310		1.350			
1160	1.299	1.324	1.338	1.353	1.381			
1170	1.325	1.351	1.366	1.384	1.412			
1180	1.350	1.378	1.394	1.415	1.443			
1190	1.376	1.404	1.423	1.445	1.474	1.510		
1200	1.402	1.431	1.451	1.476	1.505	1.542		
1210	1.427	1.458	1.479	1.507	1.536	1.573		
1220	1.453	1.485	1.507	1.538	1.567	1.605		
1230		1.511	1.535	1.568	1.598	1.637		
1240		1.538	1.564	1.599	1.628	1.669		2.069
1250		1.565	1.592	1.630	1.659	1.701	1.856	2.099
1260		1.592	1.620	1.660	1.690	1.733	1.886	2.129
1270		1.618	1.648	1.691	1.721	1.765	1.917	2.159
1280					1.752	1.797	1.948	2.190
1290							1.979	2.221
1300							2.009	

Temperature-dependent equations

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

Mol % $LaCl_3$	a	$b \cdot 10^3$	$c \cdot 10^6$	Standard deviation
0.0	0.750	−0.838	1.533	0.008
13.69	−1.989	3.076	0	0.003
30.0	−2.287	3.190	0	0.001
45.0	−2.202	3.089	0	0.001
60.0	−2.209	3.071	0	0.003
75.0	−1.931	2.818	0	0.002
90.0	−1.780	2.676	0	0.004
100	−1.673	2.562	0	0.002

These values are based on the work of the work of Smirnov and Khokhlov (classical ac technique) [172].

TABLE 161. Density studies: $BaCl_2$-$LaCl_3$

Investigations critically re-examined			
Ref.	$LaCl_3$ Mol %	Temp. range (T)	Comments
168[a]	14–90	1067–1321	Cell material: Mo capillary tube; calibration: molten NaCl

[a] Smirnov and Stepanov [168] report a root-mean-square deviation for their density measurements of 0.004 g cm^{-3}.

TABLE 162. $BaCl_2$-$LaCl_3$: Density (g cm^{-3})

	Mol percent $LaCl_3$									
T	90	80	70	60	50	40	30	20	10	0
1080		3.217	3.229			3.141	3.131	3.117	3.101	3.082
1090		3.213	3.225							
1100		3.209	3.221	3.229						
1110	3.188	3.205	3.217	3.225						
1120	3.184	3.201	3.213	3.220	3.223					
1130	3.180	3.197	3.209	3.216	3.219					
1140	3.176	3.193	3.205	3.212	3.214					
1150	3.172	3.189	3.201	3.207	3.209					
1160	3.168	3.185	3.196	3.203	3.204	3.207				
1170	3.164	3.181	3.192	3.198	3.199	3.202				
1180	3.159	3.176	3.187	3.193	3.194	3.197				
1190	3.155	3.172	3.183	3.188	3.189	3.192				
1200	3.151	3.167	3.178	3.184	3.184	3.186				
1210	3.146	3.163	3.173	3.179	3.179	3.181	3.173			
1220	3.142	3.158	3.169	3.174	3.174	3.175	3.168			
1230	3.137	3.153	3.164	3.169	3.168	3.170	3.162			
1240	3.132	3.149	3.159	3.163	3.163	3.164	3.156	3.144		
1250	3.127	3.144	3.154	3.158	3.158	3.158	3.149	3.137		
1260	3.123	3.139	3.149	3.153	3.152	3.152	3.143	3.131		
1270			3.143	3.148	3.146	3.146	3.137	3.124	3.108	3.090

Two-dimensional equation and statistical parameters

$$\rho = a + bC + cT^3 + dC^3 + eTC^2$$

a	$b \cdot 10^5$	$c \cdot 10^{10}$	$d \cdot 10^5$	$e \cdot 10^8$	Max. percent departure	Stand. error of est.
3.30441	2.65931	−1.02422	9.26544	−2.92357	−0.22% (1269.2 K, 50 mol % $BaCl_2$)	0.08%

These values are based on the work of Smirnov and Stepanov (modified maximum bubble pressure method) [**168**, 79]. C = mol % $BaCl_2$.

TABLE 163. $BaCl_2$-$LaCl_3$:Density (g cm^{-3})

	Mol percent $LaCl_3$							
T	90	75	60	50	45	30	14	0
1070		3.231						
1080		3.227						
1090		3.222						
1100		3.217	3.226	3.232				
1110	3.193	3.213	3.222	3.228				
1120	3.189	3.208	3.218	3.223				
1130	3.184	3.203	3.213	3.219				
1140	3.179	3.198	3.209	3.214	3.212			
1150	3.174	3.194	3.205	3.209	3.207			
1160	3.169	3.189	3.200	3.205	3.202			
1170	3.164	3.184	3.196	3.200	3.196			
1180	3.159	3.180	3.192	3.195	3.191			
1190	3.154	3.175	3.187	3.191	3.186			
1200	3.150	3.170	3.183	3.186	3.181	3.175		
1210	3.145	3.166	3.178	3.181	3.176	3.169		
1220	3.140	3.161	3.174	3.177	3.171	3.162		
1230	3.135	3.156	3.170	3.172	3.166	3.156		
1240	3.130	3.152	3.165	3.167	3.161	3.150		
1250	3.125	3.147	3.161	3.163	3.156	3.143	3.123	3.101
1260	3.120	3.142	3.157	3.158	3.151	3.137	3.115	3.091
1270			3.152	3.153	3.146	3.130	3.106	3.081
1280			3.148			3.124	3.098	
1290						3.118	3.090	
1300							3.082	
1310							3.073	
1320							3.065	

Temperature-dependent equations

$$\rho = a + bT$$

Mol % $LaCl_3$	a	$b \cdot 10^4$
0	4.3316	−9.844
14	4.158	−8.28
30	3.942	−6.39
45	3.785	−5.03
50	3.744	−4.65
60	3.706	−4.36
75	3.732	−4.68
90	3.734	−4.87

These values are based on the work of Smirnov and Stepanov (modified maximum bubble pressure method) [168].

TABLE 164. Surface tension studies: $BaCl_2$-$LaCl_3$

Investigations critically re-examined				
Ref.	$LaCl_3$ Mol %	Temp. range (T)	Cell material	Calibration
168[a]	14–90	1067–1321	Mo capillary tube	Molten NaCl

[a]Smirnov and Stepanov [168] report a root-mean-square deviation in their surface tension measurements of 0.1 dyne cm^{-1}.

TABLE 165. $BaCl_2$-$LaCl_3$: Surface tension (dyn cm^{-1})

	Mol percent $LaCl_3$							
T	90	80	70	60	50	40	30	20
1085		134.9	139.6					
1100		134.1	138.8	143.8				
1115	128.9	133.3	138.1	143.0	148.1			
1130	128.1	132.6	137.3	142.3	147.4			
1145	127.3	131.8	136.5	141.5	146.7			
1160	126.5	131.0	135.8	140.8	146.0	151.3		
1175	125.7	130.2	135.0	140.1	145.3	150.6		
1190	124.9	129.4	134.2	139.3	144.5	149.9		
1205	124.1	128.6	133.5	138.6	143.8	149.2	154.6	
1220	123.3	127.9	132.7	137.8	143.1	148.5	153.9	
1235	122.6	127.1	131.9	137.1	142.4	147.8	153.3	158.8
1250	121.8	126.3	131.2	136.3	141.7	147.1	152.6	158.1
1265			130.4	135.6	140.9	146.4	152.0	157.5
1280						145.7	151.3	156.9
1295								156.3

Two-dimensional equation and statistical parameters

$$\gamma = a + bT + cC + dC^3 + eTC^2$$

a	$b \cdot 10^2$	$c \cdot 10^1$	$d \cdot 10^5$	$e \cdot 10^6$	Max. percent departure	Stand. error of est.
183.65417	−5.28164	3.90870	−1.15911	1.89752	−0.23% (1067.2 K, 25.0 mol % $BaCl_2$	0.12%

These values are based on the work of Smirnov and Stepanov (maximum bubble pressure method) [168]. C = mol % $BaCl_2$.

TABLE 166. $BaCl_2$-$LaCl_3$: Surface tension (dyn cm^{-1})

	Mol percent $LaCl_3$						
T	90	75	60	50	45	30	14
1070		138.3					
1080		137.8					
1090		137.3					
1100		136.7	143.7	148.6			
1110	129.0	136.2	143.2	148.2			
1120	128.5	135.7	142.7	147.7			
1130	128.0	135.2	142.2	147.2			
1140	127.4	134.6	141.7	146.7	149.6		
1150	126.9	134.1	141.2	146.3	149.1		
1160	126.4	133.6	140.7	145.8	148.7		
1170	125.9	133.1	140.2	145.3	148.2		
1180	125.3	132.5	139.7	144.8	147.7		
1190	124.8	132.0	139.2	144.4	147.3		
1200	124.3	131.5	138.7	143.9	146.8	154.9	
1210	123.8	131.0	138.3	143.4	146.3	154.5	
1220	123.2	130.4	137.8	142.9	145.9	154.1	
1230	122.7	129.9	137.3	142.5	145.4	153.7	
1240	122.2	129.4	136.8	142.0	144.9	153.2	
1250	121.7	128.9	136.3	141.5	144.5	152.8	161.3
1260	121.1	128.3	135.8	141.0	144.0	152.4	161.0
1270			135.3	140.6	143.5	152.0	160.6
1280			134.8			151.6	160.2
1290						151.2	159.8
1300							159.5
1310							159.1
1320							158.7

Temperature-dependent equations
$\gamma = a + bT$

Mol % $LaCl_3$	a	$b \cdot 10^2$
14	208.2	−3.75
30	205.2	−4.19
45	202.6	−4.65
50	201.0	−4.76
60	197.9	−4.93
75	194.6	−5.26
90	187.4	−5.26

These values are based on the work of Smirnov and Stepanov (maximum bubble pressure method) [168].

$BaCl_2$-LiCl

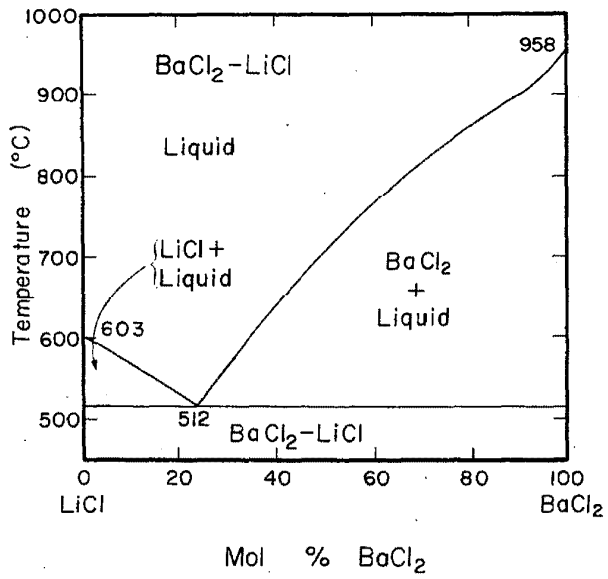


FIGURE 15. Temperature-composition phase diagram for $BaCl_2$-LiCl.

A. G. Bergman and E. I. Banshlen, Izv. Sekt. Fiz. Khim. Anal. Inst. Obshch. Neorg. Khim., Akad. Nauk. S.S.S.R., **23**, 201 (1953).

Melt Preparation and Purification

Smirnov et al. [**251,126**] and Smirnov and Khokhlov [**155**] used "chemically pure" salts. $BaCl_2$ was recrystallized three times from doubly distilled water; their purification of LiCl is described under the CsCl-LiCl system.

Barium and lithium chloride in reference [**173**] were twice recrystallized from distilled water and dried under vacuum and stored in an argon atmosphere.

TABLE 167. Electrical conductance studies: $BaCl_2$-LiCl

Investigations critically re-examined			
Ref.	LiCl Mol %	Temp. range (T)	Comments
155	0–100	1073–1273	Cell material: alundum crucible (containing melt) in a sealed quartz tube; Mo electrodes; freq. range: 10,000 Hz; calibration: molten LiCl and KCl

Deviations from previous NSRDS recommendations: [1, p. 7]			
Ref.	LiCl Mol %	Min. departure	Max. departure
155	0	0.0% (1260 K)	0.53% (1240 K)

TABLE 168. $BaCl_2$-LiCl: Specific conductance ($ohm^{-1}\ cm^{-1}$)

	Mol percent LiCl							
T	100	77.6	64.4	52.4	35.0	21.6	10.5	0.0
1080	6.640	4.386	3.593	2.952	2.325			
1090	6.679	4.450	3.653	3.011	2.383			
1100	6.716	4.515	3.713	3.071	2.440			
1110	6.753	4.579	3.773	3.132	2.498			
1120	6.789	4.643	3.835	3.194	2.556			
1130	6.824	4.707	3.897	3.258	2.613			
1140	6.858	4.771	3.961	3.323	2.671	2.190		
1150	6.891	4.835	4.025	3.389	2.728	2.242		
1160	6.923	4.900	4.090	3.456	2.786	2.294		
1170	6.954	4.964	4.155	3.525	2.844	2.346		
1180	6.984	5.028	4.222	3.594	2.901	2.398	2.070	
1190	7.014	5.092	4.289	3.665	2.959	2.450	2.109	
1200	7.043	5.156	4.358	3.738	3.017	2.501	2.148	
1210	7.070	5.220	4.427	3.811	3.074	2.553	2.187	
1220	7.097	5.285	4.497	3.886	3.132	2.605	2.226	
1230	7.123	5.349	4.567	3.961	3.189	2.657	2.266	
1240	7.148	5.413	4.639	4.038	3.247	2.709	2.305	2.118
1250	7.172	5.477	4.711	4.117	3.305	2.761	2.344	2.133
1260	7.195	5.541	4.784	4.196	3.362	2.813	2.383	2.149
1270	7.217	5.605	4.858	4.277	3.420	2.864	2.422	2.164

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

Mol % LiCl	a	$b \cdot 10^3$	$c \cdot 10^6$
0.0	0.217	1.533	0
10.5	−2.545	3.911	0
21.6	−3.723	5.187	0
35.0	−3.899	5.763	0
52.4	3.746	−7.291	6.070
64.4	2.064	−3.041	4.127
77.6	−2.543	6.416	0
100	−2.885	13.738	−4.554

These values are based on the work of Khokhlov and Smirnov (classical ac technique) [155].

TABLE 169. Density studies: $BaCl_2$-LiCl

Investigations critically re-examined			
Ref.	LiCl Mol %	Temp. range (T)	Cell material
126	15.0–89.8	875–1220	Mo or Pt capillary tube Pt float
152	0–100 (g)	1273	

Comment: Smirnov et al. [126] using the maximum gas bubble pressure method were able to measure both the density and the surface tension of the melts in the same apparatus. They report a standard deviation for the density measurements on all the mixtures of $\pm 0.008\ g\ cm^{-3}$.

TABLE 170. $BaCl_2$-LiCl: Density ($g\ cm^{-3}$)

	Mol percent LiCl							
T	100.0	89.8	75.0	60.6	46.7	32.3	15.0	0.0
880	1.504	1.959						
890	1.500	1.950						
900	1.495	1.942						
910	1.491	1.934		2.663				
920	1.486	1.925		2.654				
930	1.482	1.917		2.646				
940	1.477	1.909		2.638				
950	1.473	1.901	2.317	2.629				
960	1.469	1.892	2.309	2.621				
970	1.464	1.884	2.301	2.612				
980	1.460	1.876	2.293	2.604				
990	1.455	1.867	2.285	2.595	2.803			
1000	1.451	1.859	2.277	2.587	2.794			
1010	1.446	1.851	2.269	2.579	2.785			
1020	1.442	1.842	2.261	2.570	2.775			
1030	1.437	1.834	2.253	2.562	2.766			
1040	1.433	1.826	2.245	2.553	2.756			
1050	1.428	1.818	2.237	2.545	2.747			
1060	1.424	1.809	2.229	2.536	2.738			
1070	1.419	1.801	2.222	2.528		2.936		
1080						2.927		
1090						2.919		
1100						2.910		
1110						2.901		
1120						2.892		
1130						2.884		
1140						2.875		
1150						2.866		
1160						2.858	3.049	
1170							3.041	
1180							3.033	
1190							3.025	
1200							3.017	
1210							3.009	
1220							3.001	
1230								
1240								3.111
1250								3.101
1260								3.091
1270								3.081

Temperature-dependent equations

$\rho = a + bT$

Mol % LiCl	a	$b \cdot 10^4$
0	4.3316	−9.844
15.0	3.977	−8.00
32.3	3.868	−8.71
46.7	3.735	−9.41
60.6	3.430	−8.43
75.0	3.069	−7.92
89.8	2.689	−8.30
100.0	1.8965	−4.458

These values are based on the work of Smirnov et al. (modified maximum bubble pressure method) [126].

TABLE 171. Viscosity studies: $BaCl_2$-LiCl

Investigations critically re-examined			
Ref.	LiCl Mol %	Temp. range (T)	Comments
173	15–89.8	1010–1290	Cell material: Mo sphere, steel suspension wire; Pt or Mo crucible containing melt in quartz tube; calibration: organic liquids and fused NaCl used to check reliability of apparatus

Comment: A brief discussion of the experimental approach of Smirnov and Khokhlov [**173**] is given under the CsCl-$LaCl_3$ system.

TABLE 172. $BaCl_2$-LiCl: Viscosity (cp)

	Mol percent LiCl						
T	89.8	75.0	60.6	46.7	32.0	15.0	0
1010	1.33		2.11				
1020	1.30	1.54	2.07				
1030	1.28	1.52	2.03				
1040	1.26	1.49	1.99				
1050	1.23	1.46	1.95				
1060	1.21	1.44	1.92				
1070	1.19	1.41	1.88	2.81			
1080	1.17	1.39	1.85	2.74			
1090	1.15	1.37	1.82	2.67			
1100	1.13	1.35	1.79	2.60			
1110	1.12	1.33	1.76	2.54			
1120	1.10	1.31	1.73	2.48			
1130	1.08	1.29	1.70	2.43	3.13		
1140	1.07	1.27	1.67	2.37	3.06		
1150	1.05	1.25	1.65	2.32	2.99		
1160	1.03	1.23	1.62	2.27	2.92	3.82	
1170		1.21	1.60	2.22	2.85	3.71	
1180				2.17	2.79	3.61	
1190				2.13	2.73	3.51	
1200				2.09	2.67	3.41	
1210				2.04	2.61	3.32	
1220				2.00	2.56	3.24	
1230					2.51	3.16	
1240					2.46		3.81
1250					2.41		3.67
1260							3.54
1270							3.41
1280							3.29
1290							3.18

Temperature-dependent equations

$$\eta = A \cdot \exp\,(E/RT)$$

Mol % LiCl	$A \cdot 10^2$	E (cal mol^{-1})	Standard deviation
0.0	3.570	11507	0.018
15.0	13.508	7701	0.03
32.0	20.147	6161	0.03
46.7	18.155	5821	0.04
60.6	25.252	4469	0.03
75.0	23.561	3810	0.02
89.8	18.963	3909	0.02

These values are based on the work of Smirnov and Khokhlov (oscillating pendulum method) [**173**].

TABLE 173. Surface tension studies: $BaCl_2$-LiCl

Investigations critically re-examined			
Ref.	LiCl Mol %	Temp. range (T)	Comments
251	15.0–89.8	1073	Cell material: Mo capillary, melt contained in Pt crucible: calibration: molten NaCl

TABLE 174. $BaCl_2$-LiCl: Surface tension (dyn cm^{-1})

	Mol percent LiCl							
T	100	89.8	75.0	60.6	46.7	32.3	15.0	0
880	141.87	145.89						
900	140.21	144.29						
920	138.56	142.69		153.10				
940	136.90	141.09		151.75				
960	135.24	139.50	139.37	150.40				
980	133.58	137.90	137.78	149.05				

TABLE 174. $BaCl_2$-LiCl: Surface tension (dyn cm^{-1})—Continued

	Mol percent LiCl							
T	100	89.8	75.0	60.6	46.7	32.3	15.0	0
1000	131.92	136.30	136.20	147.70	152.80			
1020	130.26	134.70	134.62	146.35	151.64			
1040	128.60	133.10	133.03	145.00	150.47			
1060	126.94	131.51	131.45	143.65	149.31			
1080						157.48		
1100						156.42		
1120						155.36		
1140						154.31		
1160						153.25	164.40	
1180							163.50	
1200							162.60	
1220							161.70	
1260								168.09
1280								167.33
1300								166.57
1320								165.81
1340								165.05
1360								164.28

Temperature-dependent equation

$$\gamma = a + bT$$

Mol % LiCl	a	$b \cdot 10^2$	Standard deviation
0	216.1	−3.81	
15.0	216.6	−4.50	0.3
32.3	214.5	−5.28	0.1
46.7	211.0	−5.82	0.2
60.6	215.2	−6.75	0.2
75.0	215.4	−7.92	0.1
89.8	216.2	−7.99	0.2
100	214.86	−8.294	

These values are based on the work of Smirnov et al. (maximum bubble pressure method) [**251**]. The temperature ranges were assumed to be the same as given for the density data in [**251**].

$BaCl_2$-$MgCl_2$

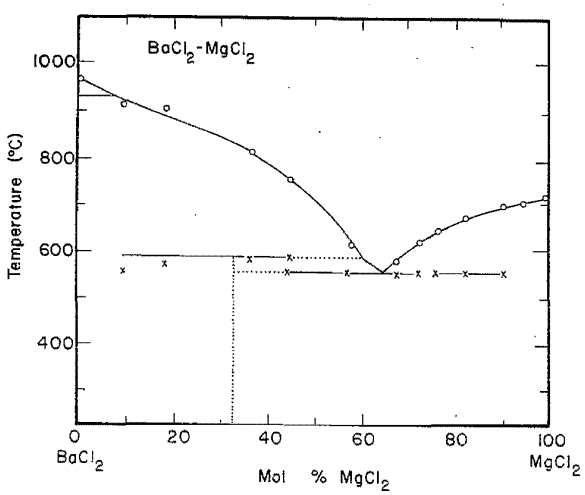


FIGURE 16. Temperature-composition phase diagram for $BaCl_2$-$MgCl_2$.

C. Sandonnini, Atti della Reak. Acad. dei Lincei, (5), **21**, 11, 634 (1912).

Melt Preparation and Purification

Huber et al. [**30**] used C.P. analytical grade barium chloride and prepared magnesium chloride from purified $PbCl_2$. A slight excess of magnesium metal was added to the $PbCl_2$ in a bomb which was rotated for 90 minutes at 725 °C and subsequently placed in an upright position to permit the lead-magnesium alloy to separate from the molten $MgCl_2$. Analysis of the $MgCl_2$ indicated the melt to be at least 99.7% pure.

Reding [150, **241**] dried Baker and Adamson reagent grade $BaCl_2 \cdot 2H_2O$ under vacuum for 12 hours at 200 °C and then for 5 hours at 500 °C. The $MgCl_2$, obtained from the core of anhydrous $MgCl_2$ cakes (purchased from titanium and zirconium dealers), was given the same drying treatment as $BaCl_2$.

TABLE 175. Electrical conductance studies: $BaCl_2$-$MgCl_2$

Investigations critically re-examined			
Ref.	$MgCl_2$ Mol %	Temp. range (T)	Comments
30	0–100	998–1354	Cell material: silica; Pt electrodes; freq. range: 1000 Hz; calibration: saturated NaCl solution
151[a]	0–60 (g)	1073	
167	35.4–100	973–1173	

Deviations from previous NSRDS recommendations: [1, pp. 6, 7]			
Ref.	$MgCl_2$ Mol %	Min. departure	Max. departure
30	100	−0.26% (1242 K)	−1.72% (1064 K)
167	100	−0.25% (1073 K)	−5.4% (1173 K)
30	0	−5.0% (1273 K)	−6.9% (1351 K)

[a]Equivalent conductance vs. % composition was given in graphical form.

Comment: Brief remarks concerning reference [**30**] are given under the system $CaCl_2$-KCl.

TABLE 176. $BaCl_2$-$MgCl_2$: Specific conductance (ohm^{-1} cm^{-1})

	Mol % $MgCl_2$				
T	100	68.6	44.4	35.5	0
1000	1.03				
1020	1.07				
1040	1.10	1.63			
1060	1.14	1.67			
1080	1.18	1.72			
1100	1.22	1.76			
1120	1.26	1.81			
1140	1.29	1.85	1.75		
1160	1.33	1.89	1.80		
1180	1.37	1.93	1.84	1.80	
1200	1.41	1.97	1.88	1.85	
1220	1.45	2.01	1.93	1.90	
1240	1.49	2.04	1.97	1.95	
1260		2.08	2.01	2.00	2.02
1280		2.11	2.05	2.05	2.08
1300		2.15	2.10	2.09	2.14
1320		2.18	2.14	2.14	2.20
1340		2.21	2.18		2.25

Temperature-dependent equations

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

Mol % $MgCl_2$	a	$b \cdot 10^3$	$c \cdot 10^6$	Stand. error of est.
0	−9.4111	14.8879	−4.6173	0.28%
35.5	−1.0464	2.4160	0	0.81%
44.4	−0.6872	2.1417	0	1.27%
68.6	−2.3019	5.2045	−1.3706	0.24%
100	−0.8790	1.9065	0	0.39%

These values are based on the work of Huber, Potter and St. Clair (classical ac technique) [**30**].

TABLE 177. Density studies: $BaCl_2$-$MgCl_2$

Investigations critically re-examined			
Ref.	$MgCl_2$ Mol %	Temp. range (T)	Comments
30	0–100	977–1323	Cell material: solid and hollow fused-silica balls containing tungsten powder
150	19.6–100	1023–1198	Cell material: Tungsten sinker and Pt suspension wire (melt contained in stainless steel crucible); calibration: water and CCl_4
167[a]	0–95.2	1073, 1023	

Comparisons with NSRDS recommendations [1, pp. 6, 7 and this volume]			
Ref.	$MgCl_2$ Mol %	Max. departure	Min. departure
30	100	0.49% (1060 K)	0.66% (1020 K)
150	100	0.84% (1040 K)	0.86% (1160 K)
167	95.2	−1.4% (1073 K)	
30	69.1	1.7% (1073 K)	
167	69.1	−0.04% (1073 K)	
167	19.6	−0.33% (1173 K)	
30	0	−3.7% (1260 K)	−3.9% (1280 K)
167	0	0.22% (1273 K)	

[a]Density values for the 19.6 and 0 mol % mixtures were reported at temperatures of 1173 K and 1273 K, respectively.

Comments: Reding [**150**] applied corrections for the surface tension of the melt and for the variation of the volume of the sinker with temperature. To prevent salt vapors from condensing on the suspension wire during a run, argon gas was passed through a guide tube that surrounded the wire.

TABLE 178. $BaCl_2$-$MgCl_2$: Density (g cm^{-3})

	Mol % $MgCl_2$					
T	100.0	95.2	86.8	68.6	42.2	19.6
1030	1.679	1.801	1.977	2.351	2.797	3.105
1040	1.676	1.797	1.973	2.344	2.789	3.097
1050	1.673	1.793	1.968	2.338	2.782	3.090
1060	1.670	1.790	1.963	2.331	2.774	3.083
1070	1.667	1.786	1.958	2.325	2.767	3.076
1080	1.664	1.783	1.954	2.319	2.750	3.069
1090	1.661	1.779	1.949	2.312	2.752	3.062
1100	1.658	1.775	1.944	2.306	2.744	3.055
1110	1.655	1.772	1.940	2.299	2.737	3.048
1120	1.652	1.768	1.935	2.293	2.729	3.041
1130	1.649	1.765	1.930	2.287	2.722	3.034
1140	1.646	1.761	1.926	2.280	2.714	3.026
1150	1.643	1.757	1.921	2.274	2.707	3.019
1160	1.640	1.754	1.916	2.267	2.699	3.012
1170	1.637	1.750	1.911	2.261	2.692	3.005
1180	1.634	1.747	1.907	2.255	2.684	2.998
1190	1.631	1.743	1.902	2.248	2.677	2.991

Temperature-dependent equations

$$\rho = a + bT$$

Mol % $MgCl_2$	a	$b \cdot 10^4$
19.6	3.836	−7.1
42.2	3.569	−7.5
68.6	3.010	−6.4
86.8	2.461	−4.7
95.2	2.171	−3.6
100.0	1.988	−3.0

These values are based on the work of Reding (Archimedean method) [**150**].

TABLE 179. Viscosity studies: $BaCl_2$-$MgCl_2$

Investigations critically re-examined

Ref.	$MgCl_2$ Mol %	Temp. range (T)	Comments
151	0–100[a]	973–1358	Cell material: Pt sphere and Pt crucible; calibration: method tested on molten $NaNO_3$, KCl and with solutions of water, nitrobenzene and aniline

Deviations from previous NSRDS recommendations [1, p. 7]

Ref.	$MgCl_2$ Mol %	Min. departure	Max. departure
151	0	−9.1% (1309 K)	−20.9% (1270 K)

[a]Graphical except for pure salts.

Comment: Corrections were applied for the volume expansion of the platinum sphere and for the friction in air of those parts of the suspension system projecting from the melt. The precision of the viscosity measurements was reported to be ±5% [**151**].

TABLE 180. $BaCl_2$-$MgCl_2$: Viscosity (cp)

	Mol % $MgCl_2$	
T	100	0
1010	2.15	
1030	2.04	
1050	1.93	
1070	1.84	
1090	1.75	
1110	1.67	
1130	1.60	
1250		3.92
1270		3.65
1290		3.43
1310		3.24
1330		3.09
1350		2.98

Temperature-dependent equations

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

$$\eta = A \cdot \exp\,(E/RT)$$

Mol % $MgCl_2$	a	$b \cdot 10^2$	$c \cdot 10^5$	$d \cdot 10^8$	$A \cdot 10^1$	E (cal mol^{-1})	Stand. error of est.
0	59.5251	−4.9023	−1.7083	1.65			1.62%
100					1.317	5607	1.32%

These values are based on the work of Bondarenko and Strelets (oscillating sphere method) [**151**].

TABLE 181. $BaCl_2$-$MgCl_2$: Viscosity (cp)

Mol % $BaCl_2$	973 K	1023 K	1073 K
0		2.03	1.83
10	2.43	2.03	1.81
20	2.60	2.15	1.95
30	2.94	2.43	2.15
40	3.46	2.84	2.47
50	4.57	3.50	2.87
60		4.53	3.56

These values have been interpolated to three significant figures from the graphical presentation of Bondarenko and Strelets (oscillating sphere method) [**151**].

TABLE 182. Surface tension studies: $BaCl_2$-$MgCl_2$

Investigations critically re-examined			
Ref.	$MgCl_2$ Mol %	Temp. range (T)	Comments
241	25–100	1023–1198	Cell material: Pt-10%Rh capillary and graphite crucible; calibration: capillary diameter measured microscopically
167	0–100	973–1273	

Deviations from previous NSRDS recommendations [2, pp. 59, 60]			
Ref.	$MgCl_2$ Mol %	Min. departure	Max. departure
241	100	7.9% (1193 K)	9.0% (1033 K)
167	100	1.5% (1073 K)	
167	0	−0.25% (1273 K)	

Comment: Bondarenko and Strelets [**167**] reported surface tension values at 800 °C and isotherms at 750 °C but gave no exact temperature range for the mixtures studied.

TABLE 183. $BaCl_2$-$MgCl_2$: Surface tension (dyn cm^{-1})

	Mol % $MgCl_2$				
T	100.0	80.0	60.0	40.0	25.0
1030	72.5	85.4	101.9	122.0	145.4
1040	72.4	85.0	101.5	121.6	144.7
1050	72.2	84.7	101.1	121.2	144.0
1060	72.0	84.3	100.7	120.7	143.3
1070	71.9	84.0	100.3	120.3	142.6
1080	71.7	83.6	99.9	119.9	141.9
1090	71.6	83.3	99.5	119.5	141.2
1100	71.4	82.9	99.1	119.1	140.5
1110	71.2	82.6	98.7	118.7	139.8
1120	71.1	82.2	98.3	118.3	139.1
1130	70.9	81.9	97.9	117.9	138.4
1140	70.8	81.5	97.5	117.5	137.7
1150	70.6	81.2	97.1	117.1	137.0
1160	70.4	80.8	96.7	116.6	136.3
1170	70.3	80.5	96.3	116.2	135.6
1180	70.1	80.1	95.9	115.8	134.9
1190	70.0	79.8	95.5	115.4	134.2

Temperature-dependent equations

$$\gamma = a + bT$$

Mol % $MgCl_2$	a	$b \cdot 10^2$
25.0	217.5	−7.0
40.0	164.2	−4.1
60.0	143.1	−4.0
80.0	121.4	−3.5
100.0	89.0	−1.6

These values are based on the work of Reding (maximum bubble pressure method) [**241**].

$BaCl_2$-NaCl

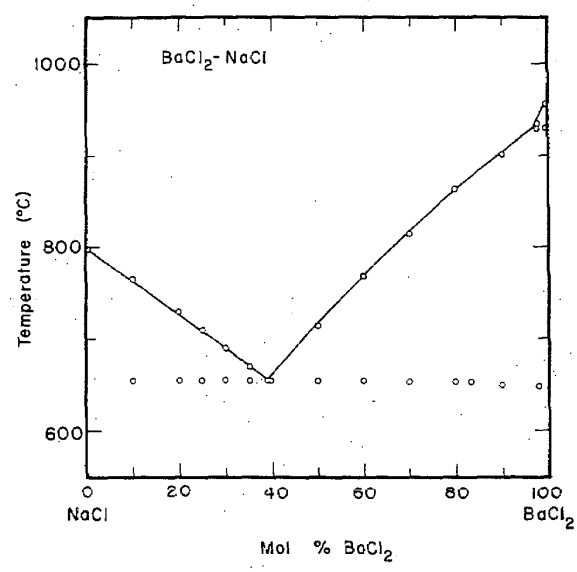


FIGURE 17. Temperature-composition phase diagram for $BaCl_2$-NaCl.

H. Gemsky, Neues Jahrb. Mineral., Geol., Paläontol., Beil. Band., **36**, 513 (1913); J. Chem. Soc. (Lond.), **106**, 51 (1913).

Melt Preparation and Purification

Vereshchetina and Luzhnaya [34] used "reagent grade" salts which were twice recrystallized from water. Lantratov and Moiseeva [74] used reagent grade materials without further purification. To remove traces of oxides and water $BaCl_2$ was heated in a current of HCl at 500–800 °C and NaCl was fused in an atmosphere of HCl. Mixtures were prepared by fusion of weighed quantities of the salts in the measurement cell. Thoroughly dried HCl gas was passed through the molten mixtures prior to experimental measurements.

Sokolova and Voskresenskaya [**233**] used "chemically pure" salts, recrystallized three times, dried at 250 °C and stored over P_2O_5. Barzakovskii [**63**] kept the molten recrystallized salts in a porcelain crucible under dry HCl gas for 2–3 hours prior to use. Alabyshev and Kulakovskaya [20] used "chemically anhydrous" salts which were purified by an unspecified method.

TABLE 184. Electrical conductance studies: $BaCl_2$-NaCl

Investigations critically re-examined

Ref.	NaCl Mol %	Temp. range (T)	Comments
20[a]	0–100 (g)	1073–1373	
24[a]	0–100	1073, 1173, 1273	
34[b]	40.0–100.0	953–1113	Cell material: quartz; calibration: molten KCl at 800 °C
44[a]	40–100 (g)	953–1113	
63	0–100	944–1407	Cell material: Pt; Pt electrodes; freq. range: 300–1000 Hz; calibration: 1N KCl and 30% H_2SO_4 solution
74[c]	40–100 (g)	1023–1113	
151[d]	47–100 (g)	1073	Cell material: quartz; calibration: 30% H_2SO_4 solution
167	47–100	1023–1173	Cell material and calibration: as for 151

Comparisons with NSRDS recommendations [1, pp. 4, 7 and this volume]

Ref.	NaCl Mol %	Min. departure	Max. departure
34	100	−2.4% (1113 K)	−2.8% (1073 K)
24	100	−2.7% (1173 K)	−3.1% (1273 K)
63	100	−0.4% (1089 K)	−3.1% (1273 K)
167	100	−2.3% (1123 K)	−3.1% (1173 K)
34	64.6	0.6% (953 K)	−8.3% (1113 K)
24	0		−5.9% (1273 K)
63	0	−5.5% (1245 K)	−7.2% (1357 K)

[a] Data from reference [**63**].
[b] Vereshchetina and Luzhnaya [34] found their quartz conductance vessels to be attacked by the melt at high temperatures.
[c] Data from reference [34].
[d] Data from reference [167].

TABLE 185. $BaCl_2$-NaCl: Specific conductance (ohm^{-1} cm^{-1})

	Mol percent NaCl							
T	100	87	76.05	64.6	52	32.5	16.5	0
960				1.78				
980				1.87				
1000				1.96				
1020			2.39	2.05	1.83			
1040			2.45	2.13	1.91			
1060			2.51	2.21	1.98			
1080		2.86	2.57	2.29	2.05			
1100	3.64	2.92	2.63	2.36	2.12			
1120	3.71	2.98	2.68	2.43	2.19			
1140	3.76	3.03	2.73	2.50	2.26			
1160	3.81	3.09	2.78	2.56	2.32	2.17		
1180	3.86	3.14	2.83	2.62	2.38	2.25		
1200		3.19	2.88	2.67	2.44	2.33	2.02	
1220		3.23	2.92	2.73	2.50	2.40	2.09	
1240		3.28	2.97	2.78	2.56	2.47	2.16	
1260		3.32	3.01	2.82	2.61	2.53	2.23	2.01
1280		3.36	3.05	2.86	2.66	2.59	2.29	2.08
1300		3.40	3.08	2.90	2.71	2.64	2.35	2.14
1320		3.43				2.69	2.41	2.18
1340		3.47				2.73	2.46	2.23
1360		3.50					2.52	2.26
1380		3.53					2.57	
1400							2.61	

Temperature-dependent equations

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

Mol % NaCl	a	$b \cdot 10^2$	$c \cdot 10^6$	Stand. error of est.
0	−18.4596	2.9011	−10.1297	2.47%
16.5	− 7.5250	1.2250	− 3.5782	0.65%
32.5	−11.2053	1.8833	− 6.2943	0.83%
52	− 4.6329	0.8854	− 2.4643	0.40%
64.6	− 0.6683	1.2884	− 4.2384	0.62%
76.05	− 3.3793	0.8140	− 2.4368	1.33%
87	− 3.7821	0.9225	− 2.8480	0.31%
100	−10.9807	2.3203	− 9.0085	0.36%

These values are based on the work of the work of Barzakovskii (classical ac technique) [**63**].

TABLE 186. Density studies: $BaCl_2$-NaCl

Investigations critically re-examined

Ref.	NaCl Mol %	Temp. range (T)
22[a]	0, 16	1238–1378
24	0, 35, 50, 65, 80, 100	1073, 1173, 1273
34	40.0–100	981–1129
44[b]	40–75 (graphical)	998–1073
89[a]	0–100 (graphical for mixtures)	973–1273
152[c]	40–100 (graphical)	1073

Deviations from previous NSRDS recommendations [1, pp. 4, 7]

Ref.	NaCl Mol %	Min. departure	Max. departure
34	100	−1.4% (1095 K)	−1.5% (1123 K)
24	100	−0.33% (1173 K)	−1.7% (1273 K)
22	0	0.02% (1243 K)	−0.19% (1323 K)
24	0		−1.4% (1273 K)

[a] A platinum sphere was used as a float in the investigations [22, 89]. Bukhalova and Yagub'yan [89] do not report a temperature range for the single salt density equations.
[b] Data from reference [**34**].
[c] Data from reference [89].

TABLE 187. $BaCl_2$-NaCl: Density (g cm^{-3})

	Mol percent NaCl															
T	100	89.0	82.0	81	75.0	74	71.5	68.0	67	64.5	61.0	60	57.5	54.0	47.0	40.0
990									2.384			2.518				
1000					2.203		2.287	2.349	2.376	2.417	2.490	2.509	2.552	2.615		
1010					2.198		2.280	2.342	2.368	2.408	2.482	2.499	2.544	2.604		
1020					2.194		2.272	2.336	2.360	2.399	2.474	2.490	2.537	2.592		
1030					2.189		2.265	2.330	2.352	2.390	2.466	2.481	2.529	2.580		
1040					2.184		2.258	2.323	2.343	2.381	2.458	2.472	2.522	2.569		
1050		[1.829]	[1.992]		2.180		2.251	2.317	2.335	2.373	2.450	2.463	2.514	2.557	2.647	2.753
1060		[1.826]	[1.989]	2.019	2.175	2.188	2.244	2.310	2.327	2.364	2.442	2.454	2.507	2.546	2.637	2.745
1070		[1.823]	[1.987]	2.013	2.170	2.184	2.236	2.304	2.319	2.355	2.435	2.445	2.500	2.534	2.628	2.736
1080	1.535			2.007		2.181			2.311			2.436		2.522	2.618	2.728
1090	1.528			2.002		2.177			2.303			2.426		2.511	2.608	2.719
1100	1.522			1.996		2.173			2.294			2.417		2.499	2.599	2.711
1110	1.515			1.990		2.170			2.286					2.487	2.589	2.703
1120	1.509			1.984										2.476	2.580	2.694

Temperature-dependent equations

$$\rho = a + bT$$

Mol % NaCl	a	$b \cdot 10^3$	Stand. error of est.
40.0	3.6349	−0.8399	0.15%
47.0	3.6532	−0.9586	0.19%
54.0	3.7799	−1.1645	0.12%
57.5	3.2956	−0.7440	0.01%
60	3.4208	−0.9123	0.09%
61.0	3.2735	−0.7840	0.01%
64.5	3.3008	−0.8840	0.02%
67	3.1909	−0.8150	0.06%
68.0	2.9889	−0.6400	0.00%
71.5	3.0067	−0.7200	0.00%
74	2.5799	−0.3698	0.01%
75.0	2.6709	−0.4680	0.01%
81	2.6378	−0.5837	0.09%
82.0	[2.2436]	[−0.2400]	0.00%
89.0	[2.1654]	[−0.3200]	0.00%
100	2.2259	−0.640	0.00%

These values are based on the work of Vereshchetina and Luzhnaya (Archimedean method) [34].

TABLE 188. Viscosity studies: $BaCl_2$-NaCl

Investigations critically re-examined			
Ref.	NaCl Mol %	Temp. range (T)	Comments
24	0, 25, 50, 75, 90, 100	1073, 1173, 1273	
34[a]	40–100	998–1148	Cell material: Pt sphere with Pt suspension rod enclosed in a glass tube; calibration: method tested using molten $NaNO_3$
151[a]	0–100[b]	973–1358	Cell material: Pt sphere, Pt crucible; calibration: water, nitrobenzene, aniline at room temperature; KCl and $NaNO_3$ at high temperature

TABLE 188. Viscosity studies: $BaCl_2$-NaCl—Continued

Deviations from previous NSRDS recommendations: [1, pp. 4, 7]			
Ref.	NaCl Mol %	Min. departure	Max. departure
34	100	5.3% (1148 K)	6.3% (1098 K)
24	100		0.3% (1173 K)
151	100	−6.3% (1231 K)	−16.0% (1128 K)
24	0		13.0% (1273 K)
151	0	−9.1% (1309 K)	−20.9% (1270 K)

[a] Vereshchetina and Luzhnaya [34] and Bondarenko and Strelets [151] applied corrections for the volume expansion of platinum and to the decrement of the damped oscillation of the suspended system in air. The accuracy of the viscosity determination was checked by measuring the viscosity of molten $NaNO_3$; the obtained data agreed to ±2% with literature values.

[b] Mixtures reported graphically.

TABLE 189. $BaCl_2$-NaCl: Viscosity (cp)

	Mol percent NaCl							
T	100	81	74	67	60	54	47	40
1000			3.18	3.38	3.98	4.51		
1010			3.04	3.25	3.81	4.28		
1020			2.92	3.13	3.65	4.06		
1030		2.58	2.80	3.02	3.49	3.87	4.05	
1040		2.47	2.69	3.92	3.35	3.68	3.87	
1050		2.37	2.58	2.82	3.22	3.51	3.71	3.81
1060		2.28	2.49	2.73	3.10	3.36	3.56	3.68
1070		2.20	2.40	2.66	2.99	3.23	3.43	3.56
1080		2.12	2.32	2.59	2.90	3.11	3.30	3.45
1090		2.04	2.25	2.53	2.81	3.00	3.19	3.35
1100	1.42	1.98	2.19	2.48	2.74	2.92	3.10	3.27
1110	1.36	1.92	2.14	2.44	2.68	2.85	3.02	3.20
1120	1.30	1.86	2.10	2.40	2.64	2.80	2.96	3.15
1130	1.25	1.82	2.08	2.38	2.60	2.77	2.91	3.10
1140	1.20	1.78	2.04	2.37	2.58	2.75	2.88	3.08

Temperature-dependent equations

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

$$\eta = A \cdot \exp\,(E/RT)$$

Mol % NaCl	a	$b \cdot 10^2$	$c \cdot 10^5$	$d \cdot 10^8$	Stand. error of est.
40	45.2315	− 2.5851	− 5.0127	3.5409	0.88%
47	−27.5715	18.5037	−25.2516	9.9680	1.52%
54	48.0262	− 1.2149	− 8.2738	5.1366	1.91%
60	36.8416	− 1.1175	− 5.8275	3.6593	1.31%
67	32.6395	− 2.1266	− 3.1961	2.3969	0.62%
74	34.6255	− 2.7972	− 2.4482	2.1007	1.04%
81	33.1327	− 3.5723	− 0.6575	1.2093	0.68%

Comment: For 100 mol % NaCl, $A = 1.134 \times 10^{-2}$, $E = 10553$ cal mol^{-1}; standard error of estimate = 1.58%.

These values are based on the work of Vereshchetina and Luznaya (oscillating sphere method) [34].

TABLE 190. Surface tension studies: $BaCl_2$-NaCl

Investigations critically re-examined

Ref.	NaCl Mol %	Temp. range (T)	Comments
167	0–100	1073	
233[a]	0–100	1075–1273	Cell material: Pt-Rh capillary (melt container); calibration: capillary diameter determined with microscope, checked with measurements on water and molten NaCl
244	0–100 (g)	1075–1175	
250	0, 10, 20, 50, 65, 80, 90, 100	1173, 1273	

Comparisons with NSRDS recommendations:
[2, pp. 57, 60 and this volume]

Ref.	NaCl Mol %	Min. departure	Max. departure
250	100		0.2% (1173 K)
250	80		0.4% (1173 K)
250	50		4.4% (1173 K)
233	0	2.4% (1239 K)	3.2% (1273 K)
250	0		5.2% (1273 K)

[a]Sokolova and Voskresenskaya [233] corrected for the depth of immersion and thermal expansion of the capillary. The temperature variation of the surface tension of mixtures containing large quantities of NaCl was not investigated above 900 °C due to compositional changes arising from evaporation of NaCl. The experimental error reported was within ±1%.

TABLE 191. $BaCl_2$-NaCl: Surface tension (dyn cm^{-1})

	Mol percent NaCl							
T	100	80	70	50	40	30	20	0
1080	113.5	122.0	126.5	132.7				
1090	112.8	121.3	126.0	132.1				
1100	112.1	120.7	125.6	131.5				
1110	111.4	120.0	125.1	130.9	145.3			
1120	110.7	119.4	124.6	130.3	144.7			
1130	109.9	118.8	124.1	129.7	144.1			
1140	109.2	118.1	123.7	129.1	143.5			
1150	108.5	117.5	123.2	128.5	142.9			
1160	107.8	116.8	122.7	127.9	142.3			
1170	107.1	116.2	122.2	127.3	141.7	149.3		
1180	106.3	115.6	121.7	126.7	141.2	148.8		
1190	105.6		121.3	126.1	140.6	148.3	156.1	
1200	104.9				140.0	147.7	155.5	
1210	104.2				139.4	147.2	154.7	
1220	103.5				138.8	146.5	154.1	
1230	102.7				138.2	146.0	153.5	
1240	102.0				137.6			169.1
1250								168.7
1260								168.3
1270								167.6

Temperature-dependent equations

$\gamma = a + bT$

Mol % NaCl	a	$b \cdot 10^2$	Stand. error of est.
0	214.2	−3.6	0.12%
20	235.4	−6.7	0.20%
30	213.8	−5.5	0.14%
40	210.7	−5.9	0.23%
50	197.1	−6.0	0.10%
70	178.3	−4.8	0.10%
80	191.3	−6.4	0.20%
100	191.2	−7.2	0.18%

These values are based on the work of Sokolova and Voskresenskaya (maximum bubble pressure method) [233].

$BaCl_2$-$PbCl_2$

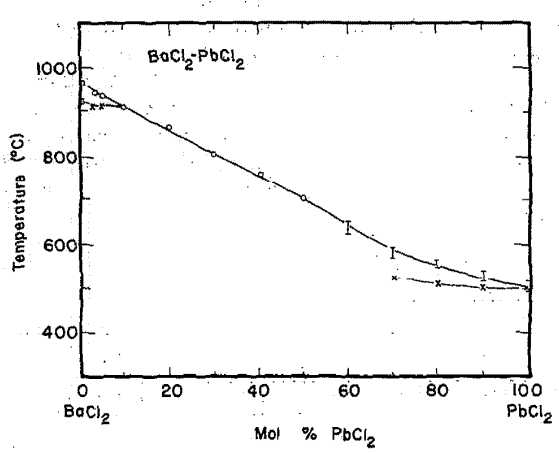


FIGURE 18. Temperature-composition phase diagram for $BaCl_2$-$PbCl_2$.

F. Hoffman, Neues Jahrb. Min. Abt., Beil Bd., **55**, 149 (1926).

E. I. Banashek, Izvest. Sektora Fiz.-Khim. Anal Akad. Nauk, S.S.S.R., **20**, 109 (1950). Translation Monthly R-4044 (1958).

S. D. Gromakov, Zhur. Fiz-Khim., **24**, 641 (1950).

Melt Preparation and Purification

Boardman et al. [26] used analytical reagent purity salts and their mixtures were analyzed for total chloride.

Lantratov and Alabyshev [165] used "chemically pure" grade barium and lead chloride. The salts were recrystallized from their hydrochloric acid solutions and traces of oxide and water were removed by heating the salts in a current of dry HCl at 500–800 °C.

TABLE 192. Density studies: $BaCl_2$-$PbCl_2$

Investigations critically re-examined

Ref.	$PbCl_2$ Mol %	Temp. range (T)	Cell material	Calibration
9	0–100	795–1013	Pt bob	Water (17 °C)
26	69.4–100	789–983	Silica dilatometer	Molten $AgNO_3$
165	40	873–973		

Comparisons with NSRDS recommendations: [1, p. 13 and this volume]

Ref.	$PbCl_2$ Mol %	Min. departure	Max. departure
9	100	−0.76% (940 K)	−0.90% (800 K)
9	100	−0.72% (950 K)	−0.90% (800 K)

Comment: Boardman et al. [26] have stated that the Archimedean method of determining densities may give values which are too low when the salt is somewhat volatile, due to condensation on the suspension wire.

The density values of ref. [26] for pure $PbCl_2$ are those recommended in NSRDS-1.

TABLE 193. $BaCl_2$-$PbCl_2$: Density (g cm^{-3})

	Mol percent $PbCl_2$			
T	100	86.2	80.3	69.4
790	4.927			
800	4.912			
810	4.897			
820	4.882			
830	4.867			
840	4.852	4.665		
850	4.837	4.651	4.572	
860	4.822	4.638	4.558	
870	4.807	4.624	4.544	
880	4.792	4.611	4.531	
890	4.777	4.597	4.517	
900	4.762	4.584	4.504	
910	4.747	4.570	4.490	
920	4.732	4.557	4.476	
930	4.717	4.543	4.463	
940	4.702	4.530	4.449	4.309
950	4.687	4.516	4.436	4.297
960	4.672	4.503	4.422	4.284
970	4.657	4.489		4.271
980	4.642			4.258

Temperature-dependent equations

$\rho = a + bT$

Mol % $PbCl_2$	a	$b \cdot 10^3$
100	6.112	−1.50
86.2	5.799	−1.35
80.3	5.720	−1.36
69.4	5.503	−1.27

These values are based on the work of Boardman et al. (dilatometric method) [26].

$BaCl_2$-RbCl

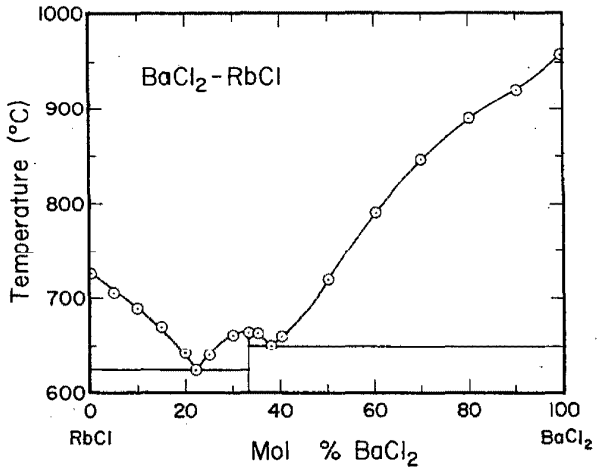


FIGURE 19. Temperature-composition phase diagram for $BaCl_2$-RbCl.

S. D. Gromakov, Zh. Fiz. Khim., **24**, 641 (1950).

Melt Preparation and Purification

In their surface tension studies, Bertozzi and Soldani [**244**] used carefully dried Merck and B.D.H. salts of analytical purity without further purification.

TABLE 194. Surface tension studies: $BaCl_2$-RbCl

Investigations critically re-examined		
Ref.	RbCl Mol %	Temp. range (T)
[244]ᵃ	0–100 (g)	1123

ᵃThese authors report a reproducibility of 0.5% in their surface tension measurements.

TABLE 195. $BaCl_2$-RbCl: Surface tension (dyn cm^{-1})

Mol % RbCl	1123 K	Mol % RbCl	1123 K
0	06	60	116
10	91	70	124
20	95	80	136
30	100	90	155
40	105	100	184
50	110		

These values have been interpolated to three significant figures from the graphical presentation of Bertozzi and Soldani (Wilhelmy slide plate method) [**244**].

$BaCl_2$-$ZnCl_2$

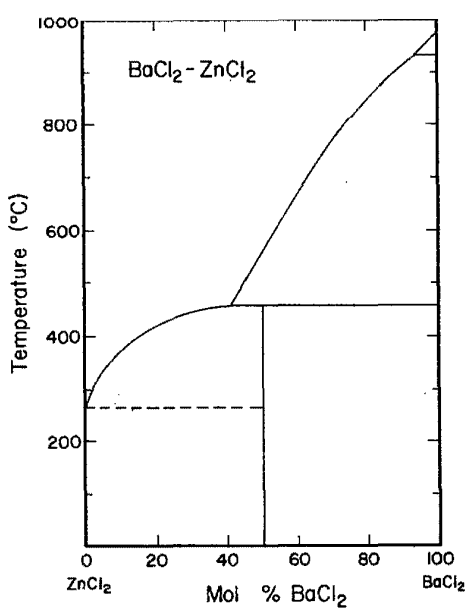


FIGURE 20. Temperature-composition phase diagram for $BaCl_2$-$ZnCl_2$.

Carlo Sandonnini, Gazz. chim, ital., **44 I**, 353 (1914).

Melt Preparation and Purification

Lantratov and Alabyshev [**165**] used "chemically pure" barium chloride and "anhydrous" zinc chloride (Schering Co.). The barium chloride was recrystallized from hydrochloric acid and traces of oxide and water were removed by heating the salt in a current of dry HCl at 500–800 °C. Traces of moisture were removed from $ZnCl_2$ by fusing the salt at 400 °C in the presence of metallic zinc for 2–3 hours; after which the molten $ZnCl_2$ was decanted off and a stream of dry HCl was passed through it for several hours.

TABLE 196. Density studies: $BaCl_2$-$ZnCl_2$

Investigations critically re-examined		
Ref.	$ZnCl_2$ Mol %	Temp. range (T)
165	40	873–973

TABLE 197. $BaCl_2$-$ZnCl_2$: Density (g cm^{-3})

Mol percent $ZnCl_2$	
T	50
880	3.024
890	3.017
900	3.010
910	3.004
920	2.997
930	2.991
940	2.984
950	2.978
960	2.971
970	2.964

Temperature-dependent equations

$\rho = a + bT$

Mol % $ZnCl_2$	a	$b \cdot 10^3$
50	3.6008	−0.656

These values are based on the work of Alabyshev and Lantratov (Archimedean method) [165].

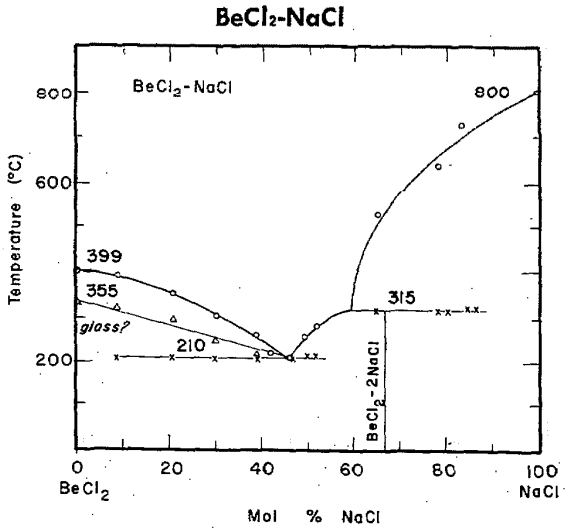


FIGURE 21. Temperature-composition phase diagram for $BeCl_2$-NaCl.

E. Furby and K. L. Wilkinson, J. Inorg. and Nuclear Chem., 14, 123 (1960).

Melt Preparation and Purification

Delimarskii et al. [69] prepared their beryllium chloride from the pure metal which was chlorinated in a quartz tube contained in an electric furnace. The $BeCl_2$ was then fractionally distilled in a stream of hydrogen and the pure snow-white crystals were stored in sealed test-tubes. The pure preparation contained 0.0004% Al, and 0.004% of the remaining metals: Fe, Cu, Ni, Zn, Cd etc. "Chemically pure" grade sodium chloride was recrystallized from doubly-distilled water, dried and finally heated in a muffle furnace.

TABLE 198. Electrical conductance studies: $BeCl_2$-NaCl

Investigations critically re-examined			
Ref.	NaCl Mol %	Temp. range (T)	Comment
69	21.52–69.56	533–793	Cell material: quartz; Pt electrodes; freq. range: 6000 Hz; calibration: molten KNO_3

Comment: Delimarskii et al. [69] tested the reliability of their ac conductance bridge and cell by measuring the electrical conductance of fused sodium nitrate at various temperatures. They compared their values with those of Goodwin and Mailey, and Jager and Kapma and found departures of 0.30% (763 K) to 1.65% (623 K) and 0.00% (763 K) to −0.88% (673 K), respectively.

TABLE 199. $BeCl_2$-NaCl: Specific conductance (ohm^{-1} cm^{-1})

	Mol percent NaCl														
T	69.56	68.05	64.91	62.23	61.57	58.47	56.81	55.14	49.26	48.37	45.08	43.83	42.32	35.9	21.52
540									0.446	0.434	0.324				
550									0.491	0.478	0.363				
560							0.613	0.588	0.536	0.521	0.401	0.436	0.347		
570							0.663	0.638	0.579	0.564	0.439	0.479	0.386		
580						0.718	0.710	0.686	0.622	0.605	0.475	0.521	0.425		
590						0.765	0.756	0.732	0.664	0.646	0.511	0.562	0.463		
600						0.811	0.800	0.777	0.705	0.686	0.547	0.602	0.501	0.391	
610						0.855	0.842	0.820	0.746	0.726	0.581	0.640	0.538	0.415	
620				0.775	0.816	0.898	0.883	0.862	0.785	0.764	0.615	0.678	0.576	0.439	
630				0.821	0.856	0.939	0.921	0.902	0.825	0.802	0.648	0.714	0.612	0.464	
640			0.882	0.866	0.896	0.979	0.958	0.941	0.863	0.839	0.681	0.749	0.649	0.488	
650			0.926	0.908	0.935	1.018	0.993	0.978	0.901	0.875	0.712	0.782	0.684	0.513	
660			0.968	0.949	0.972	1.055	1.026	1.014	0.937	0.910	0.743	0.815	0.720	0.537	
670			1.009	0.988	1.009	1.091	1.058	1.048	0.974	0.945	0.773	0.847	0.755	0.562	
680			1.048	1.025	1.044	1.126	1.087	1.081	1.009	0.978	0.803	0.877		0.586	0.204
690			1.085	1.060	1.079	1.159	1.115	1.112	1.044	1.011	0.832	0.906		0.610	0.223
700			1.121	1.093	1.112	1.191	1.141	1.142	1.078	1.043	0.860			0.635	0.242
710			1.155	1.124	1.145	1.221	1.165	1.171	1.111	1.075	0.887			0.659	0.261
720		1.167	1.187	1.154	1.176	1.250	1.188	1.197	1.144	1.105	0.914				0.280
730		1.204	1.218	1.181	1.206	1.278	1.208	1.223	1.175	1.135	0.940				0.299
740	1.261	1.240	1.247	1.207	1.235	1.304	1.227	1.247	1.206	1.164	0.965				0.318
750	1.288	1.274	1.274	1.231	1.263	1.329	1.244	1.269	1.237	1.192	0.989				0.337
760	1.315	1.306	1.300	1.253	1.291	1.352				1.219	1.013				
770	1.343	1.336	1.324	1.273	1.317	1.374				1.246	1.036				
780	1.371														
790	1.400														

Temperature-dependent equations

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

Mol % NaCl	a	$b \cdot 10^3$	$c \cdot 10^6$	Stand. error of est.
21.52	−1.0883	1.9000	0	0.42%
35.9	−1.0753	2.4429	0	0.73%
42.32	−2.4793	6.1653	−1.9971	1.16%
43.83	−3.8265	10.8574	−5.7950	0.89%
45.08	−2.0458	7.0177	−3.6060	0.98%
48.37	−3.1356	8.7679	−3.9971	0.63%
49.26	−3.0648	8.4736	−3.6509	0.75%
55.14	−4.5671	13.4067	−7.5007	0.57%
56.81	−5.0195	15.0920	−8.9877	0.74%
58.47	−4.3739	12.7887	−6.9134	0.33%
61.57	−3.7502	10.6043	−5.2258	0.39%
62.23	−5.7221	16.2448	−9.2991	0.86%
64.91	−5.4067	15.1636	−8.3406	0.38%
68.05	−6.0628	16.2559	−8.6323	0.19%
69.56	1.0804	−2.1374	3.2183	0.18%

These values are based on the work of Delimarskii et al. (classical ac technique) [69].

$BiCl_3$-$GaCl_3$

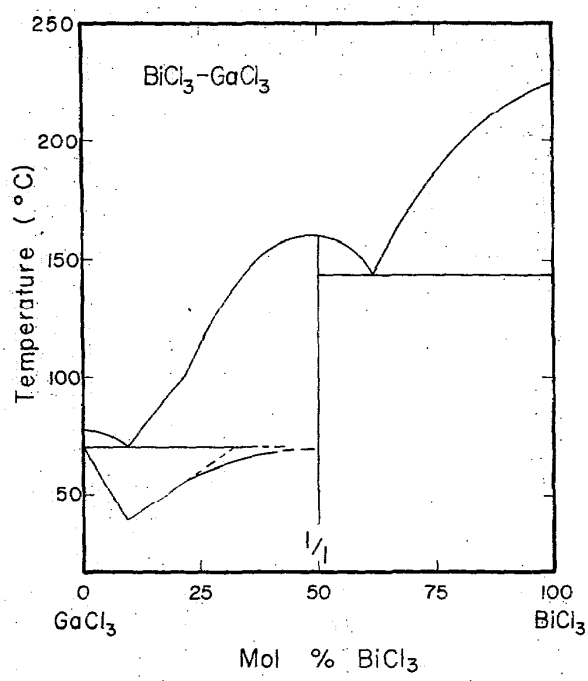


FIGURE 22. Temperature-composition phase diagram for $BiCl_3$-$GaCl_3$.

J. C. Couturier, Compt. Rend., **264**, 1378 (1967).

Melt Preparation and Purification

Couturier [64] prepared the bismuth and gallium chlorides from the pure metals and chlorine gas. The reaction of bismuth metal with chlorine gas was carried out in a specially designed quartz apparatus; the resulting $BiCl_3$ was sublimed under nitrogen in a quartz tube. Gallium was purified by bubbling Cl_2 through the molten liquid, followed by a distillation under CO_2 and a vacuum distillation. Analysis consisted of EDTA titrations for the metals and a potentiometric titration for total chloride using $AgNO_3$.

TABLE 200. Electrical conductance studies: $BiCl_3$-$GaCl_3$

Investigations critically re-examined		
Ref.	$GaCl_3$ Mol %	Temp. range (T)
64	15–85 (g)	456.2, 509.2, 521.2

Comment: Couturier [64] reported a precision of 1% in his conductance measurements.

TABLE 201. $BiCl_3$-$GaCl_3$: Specific conductance (ohm^{-1} cm^{-1})

Mol % $BiCl_3$	456 K	509 K	521 K
0	0.016		
10	0.042	0.024	
20	0.048	0.060	
30	0.056	0.068	
40	0.066	0.078	0.092
50		0.096	0.112
60		0.122	0.144
70		0.156	0.184
80		0.200	0.230
90		0.248	0.276
100		0.308	0.332

These values have been interpolated to three significant figures from the graphical presentation of Couturier (classical ac technique) [64].

$CaCl_2$-CsCl

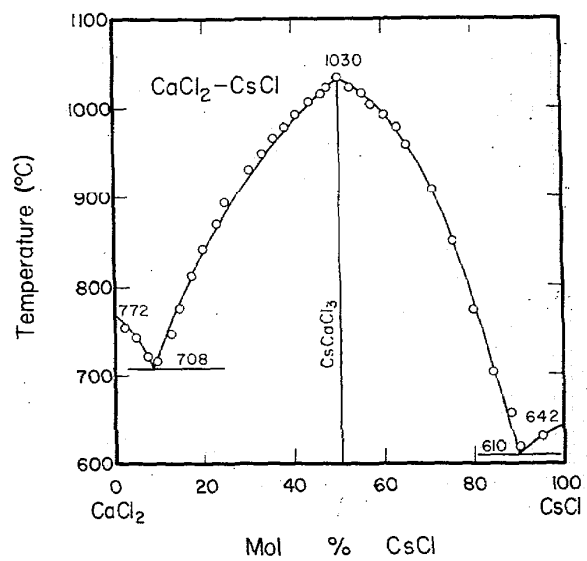


FIGURE 23. Temperature-composition phase diagram for $CaCl_2$-CsCl.

E. P. Dergurov and A. G. Bergman, Dokl. Akad. Nauk. S.S.S.R., **75**, 815 (1950)

Melt Preparation and Purification

Lehman [237] initially dehydrated "Baker Analyzed Reagent" $CaCl_2 \cdot 2H_2O$ at 130 °C for 2–3 days and then dried the anhydrous salt for 2 days at a temperature slightly below the melting point. The system was periodically flushed with HCl to remove water vapor produced. The temperature was then raised above the melting point and HCl was replaced with dry N_2. Cesium chloride (Fairmont Chemical Company) was first dried at 150 °C and then, in preparation of mixtures, was dried in a HCl furnace following the same procedure used for drying $CaCl_2$. EDTA titrations were carried out for Ca analysis.

TABLE 202. Density studies: $CaCl_2$-CsCl

Investigations critically re-examined			
Ref.	CsCl Mol %	Temp. range (T)	Comments
237	0–100	1035–1327	Cell material: Pt–10%Rh capillary, alumina crucible as melt container; diameter of capillary measured microscopically; calibration: molten KCl
330	0–100	1173–1223	

Deviations from previous NSRDS recommendations: [1, pp. 6, 7]			
Ref.	CsCl Mol %	Min. departure	Max. departure
237	100	−0.03% (1035 K)	−3.5% (1156 K)
237	0	0.12% (1109 K)	7.5% (1069 K)

Comment: Lehman reported a standard deviation of less than ±1% (±0.4 to ±0.7% for majority of results) for density.

TABLE 203. $CaCl_2$-CsCl: Density (g cm^{-3})

	Mol percent CsCl									
T	100.0	87.8	75.0	58.8	51.2	38.4	29.2	19.3	13.1	0.0
1040	2.66	2.60								
1050	2.64	2.59								
1060	2.63	2.58								
1070	2.61	2.57							2.13	2.16
1080	2.59	2.55							2.12	2.15
1090	2.58	2.54							2.11	2.13
1100	2.56	2.53							2.11	2.12
1110	2.54	2.52							2.10	2.10
1120	2.53	2.51	2.39						2.10	2.09
1130	2.51	2.50	2.40						2.09	2.07
1140	2.49		2.40						2.08	2.05
1150	2.48		2.41						2.08	2.04
1160			2.42						2.07	2.02
1170			2.42						2.06	2.01
1180									2.06	1.99
1190								2.09	2.05	
1200								2.09	2.04	
1210								2.09	2.04	
1220								2.09	2.03	
1230								2.08		
1240								2.08		
1250							2.13	2.08		
1260							2.12	2.08		
1270				2.26			2.11	2.07		
1280				2.26			2.10	2.07		
1290				2.27		2.17	2.09	2.07		
1300				2.27		2.16	2.08			
1310				2.27		2.15	2.07			
1320				2.27		2.13				
1330				2.27	2.27					

Temperature-dependent equations

$$\rho = a + bT$$

Mol % CsCl	a	$b \cdot 10^3$	Stand. error of est.
0.0	3.8131	−1.5428	1.96%
13.10	2.8162	−0.6441	1.06%
19.30	2.3585	−0.2236	0.78%
29.20	3.2884	−0.9285	0.30%
38.40	3.8335	−1.2887	2.91%
51.20	−1.6372	2.9656	0.58%
58.80	2.2372	0.0213	2.66%
75.00	1.6350	0.6731	1.07%
87.80	3.8243	−1.1758	0.59%
100.00	4.3740	−1.6505	0.50%

These values are based on the work of Lehman (modified maximum bubble pressure method) [237].

TABLE 204. Surface tension studies: $CaCl_2$-CsCl

Investigations critically re-examined			
Ref.	CsCl Mol %	Temp. range (T)	Comments
237	0–100	1035–1327	Cell material: Pt–10%Rh capillary, alumina crucible as melt container; diameter of capillary measured microscopically; calibration: molten KCl

TABLE 204. Surface tension studies: $CaCl_2$-CsCl—Continued

Deviations from previous NSRDS recommendations: [2, pp. 58, 60]			
Ref.	CsCl Mol %	Min. departure	Max. departure
237	100	−1.6% (1100 K)	−2.8% (1035 K)
237	0	2.1% (1069 K)	3.5% (1109 K)

Comment: A maximum probable error of ±0.6% in surface tension values was reported by Lehman.

TABLE 205. $CaCl_2$-CsCl: Surface tension (dyn cm^{-1})

	Mol percent CsCl									
T	100.0	87.8	75.0	58.8	51.2	38.4	29.2	19.3	13.1	0.0
1040	80.14	85.31								
1050	79.53	84.51								
1060	78.93	83.91								
1070	78.32	83.21							119.94	149.05
1080	77.71	82.50							119.52	148.78
1090	77.10	81.80							119.09	148.51
1100	76.50	81.10							118.67	148.24
1110	75.89	80.40							118.25	147.97
1120	75.28	79.70	82.58						117.82	147.70
1130	74.68	79.00	81.66						117.40	147.42
1140	74.07		80.74						116.97	147.15
1150	73.46		79.82						116.55	146.88
1160			78.90						116.13	146.61
1170			77.98						115.70	146.34
1180									115.28	146.07
1190								108.03	114.86	
1200								107.48	114.43	
1210								106.93	114.01	
1220								106.38	113.58	
1230								105.83		
1240								105.28		
1250							95.92	104.73		
1260							95.36	104.18		
1270				77.44			94.79	103.63		
1280				76.48			94.23	103.08		
1290				75.52		86.95	93.67	102.53		
1300				74.56		86.29	93.11			
1310				73.60		85.62	92.55			
1320				72.64		84.96				
1330				71.68	75.62					

Temperature-dependent equations

$$\gamma = a + bT$$

Mol % CsCl	a	$b \cdot 10^2$	Stand. error of est.
0.0	178.1292	−2.7173	0.27%
13.1	165.2924	−4.2384	0.11%
19.3	173.5487	−5.5056	0.20%
29.2	166.0696	−5.6122	0.67%
38.4	172.5632	−6.6366	0.16%
51.2	312.9067	−17.8409	0.36%
58.8	199.2852	−9.5940	0.49%
75.0	185.7609	−9.2123	1.39%
87.8	158.2487	−7.0134	0.85%
100.0	143.3111	−6.0740	0.91%

These values are based on the work of Lehman (maximum bubble pressure method) [**237**].

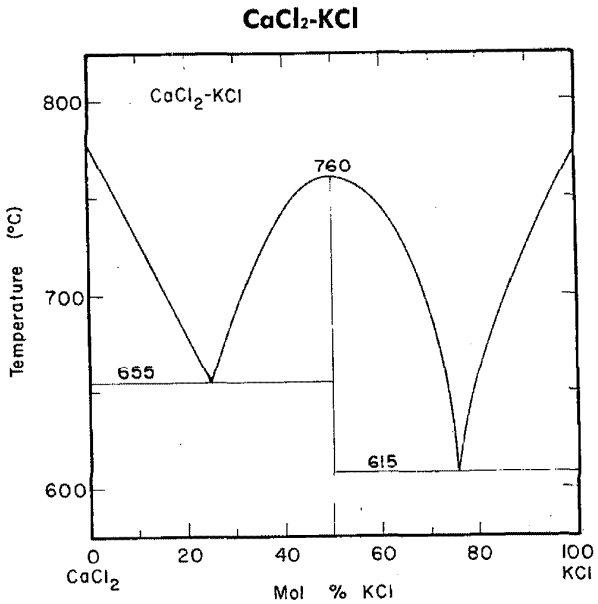


FIGURE 24. Temperature-composition phase diagram for $CaCl_2$-KCl.

T. Sato and T. Amano, Kinzoku-no-Kenkyu, **11**, 549 (1934).

Melt Preparation and Purification

Huber et al. [30] used C.P. analytical grade chloride salts. The mixtures were melted in a porcelain crucible and transferred to an electrolytic cell; after each set of measurements an analysis of the mixture was performed.

Pavlenko [28] prepared anhydrous $CaCl_2$ by baking and dehydrating the hexahydrate salt; "chemically pure" grade KCl was recrystallized and baked.

Lillebuen [**130**] and Grjotheim et al. [133] used KCl (Baker, p.a.) and $CaCl_2 \cdot 2H_2O$ (Merck, p.a.) as starting materials. The KCl was heated at 500 °C under moderate vacuum to remove moisture. $CaCl_2 \cdot 2H_2O$ was dehydrated by heating to 400 °C under an atmosphere of dry HCl gas. When necessary the melt was filtered through a quartz frit into a quartz tube in order to remove solid oxide impurities. The salts were kept in a dry box and all subsequent work was carried out under an inert gas atmosphere. Chloride analysis was performed by titrating with silver nitrate.

Grjotheim et al. [**109**] used analytical grade quality $CaCl_2 \cdot 2H_2O$ and KCl as starting materials. Purification of KCl initially involved drying at 300 °C and then melting under vacuum. The salt was slowly recrystallized from the melt and only clear crystals were used. The dihydrate salt of calcium chloride was dried at a temperature of 50–70 °C under a vacuum of 10^{-1} mm and with a flow rate of 4 l/min of HCl gas passing over the salt. The temperature was then gradually increased to 400 °C. After cooling the $CaCl_2$ in an atmosphere of dry argon the salt was transferred to a filtration vessel in a dry box. Dry HCl gas was then bubbled through the molten salt for a period of two hours, followed by dry argon and finally the apparatus was evacuated causing the melt to filter through the quartz frit. Samples were sealed off and stored in a dry box until used. The drying process for $CaCl_2$ took less than two days.

Lehman's [**237**] purification of $CaCl_2$ is given under the system $CaCl_2$-CsCl. "Baker Analyzed Reagent" KCl was dried at 600 °C for 12 hours and later stored in a desiccator containing Drierite.

TABLE 206. Electrical conductance studies: $CaCl_2$-KCl

Investigations critically re-examined			
Ref.	KCl Mol %	Temp. range (T)	Comments
12	0–100	1073, 1123, 1173, 1223	Cell material: quartz or silica U-tube; Pt electrodes; calibration: 1N KCl solution
30	0–100	973–1223	Pt electrodes; freq. range: 1000 Hz; calibration: saturated NaCl solution
109	0, 20, 40 60, 70, 100	973–1174	Cell material: Al_2O_3 tube in a quartz tube container; Pt electrodes; freq. range: 2000–20,000 Hz; calibration: 1N KCl solution and saturated NaCl solution
94[a]	0–100	1073	
160[a]	0–100	1073	
171	0, 30, 50 70, 100 (g)	~973–1173	Cell material: quartz; Mo electrodes; freq. range: 20,000 Hz
218	eutectic (g)	1182–1384	
331	0–100 (g)	973–1273	

Comparisons with previous NSRDS recommendations: [1, pp. 5, 7 and this volume]

Ref.	KCl Mol %	Min. departure	Max. departure
12	100	2.7% (1173 K)	3.4% (1073 K)
30	100	0.21% (1126 K)	−2.8% (1042 K)
109	*100*	*0.08% (1150 K)*	*−0.59% (1124 K)*
12	100	3.7% (1076 K)	
30	100	0.4% (1123 K)	
12	0	−5.1% (1123 K)	−6.2% (1173 K)
30	0	−8.8% (1109 K)	−11.5% (1223 K)
109	0	−0.94% (1073 K)	−3.8% (1174 K)
12	0	−2.4% (1173 K)	
30	0	−6.5% (1125 K)	−6.7% (1111 K)

[a]Data (equivalent conductance) from [12].

Comment: The conductivity cell of Grjotheim et al. [**109**] consisted of an Al_2O_3 tube, which carried the platinum electrodes, and a quartz tube containing the salt mixture. The apparatus was placed inside a second outer quartz tube which could be evacuated to a pressure of 10^{-5} mm Hg. Experiments were performed by melting the dried mixtures under vacuum and filtering them through a quartz frit into the inner quartz containing tube. After evacuation to 10^{-4} to 10^{-5} mm Hg, the cell was filled with dry nitrogen at 0.5 atm and placed in a furnace ("general purpose laboratory furnace"). When the salt had melted the Al_2O_3 tube, containing the electrodes, was lowered into the melt and measurements were taken. Resistance changes over the frequency range 2 to 20 kHz amounted to about

8% and extrapolations to infinite frequency were approximately 3–5%. Based on the scattering and uncertainties in the determination of the cell constant the authors estimate a standard deviation for their data of ≤1.5%.

Huber et al. [30] report an accuracy of 1.0% in their bridge measurements and Emons et al. [171] claim 0.5–0.6% reproducibility in the temperature interval 500–1000 °C.

TABLE 207. $CaCl_2$-KCl: Specific conductance (ohm^{-1} cm^{-1})

	Mol percent KCl					
T	100	80	60	40	20	0
1000		1.446				
1010		1.478		1.249		
1020		1.509		1.280		
1030		1.541		1.311		
1040		1.572		1.342		
1050		1.604		1.374		
1060					1.592	
1070					1.626	
1080	2.245		1.463		1.660	
1090	2.270		1.490		1.694	
1100	2.294		1.517		1.728	2.192
1110	2.319		1.545			2.228
1120	2.344					2.265
1130	2.368					2.302
1140	2.393					2.339
1150						2.376
1160						2.413
1170						2.449

Temperature-dependent equations

$\kappa = a + bT$

Mol % KCl	a	$b \cdot 10^3$	Stand. error of est.
0	−1.8599	3.6831	0.19%
20	−2.0217	3.4089	0.14%
40	−1.8903	3.1085	0.24%
60	−1.4617	2.7083	0.21%
80	−1.7129	3.1590	0.23%
100	−0.4161	2.4642	0.18%

These values are based on the work of Grjotheim et al. (classical ac technique) [109].

TABLE 208. Density studies: $CaCl_2$-KCl

Investigations critically re-examined

Ref.	KCl Mol %	Temp. range (T)	Comments
12	0–100	1073, 1173	Cell material: Pt cylinder, Pt wire
28	0–100	1063–1167	Cell material: Pt sphere, Pt wire; calibration: molten KNO_3, NaCl, LiCl
94[a]	0–100 (g)	1073	
130	0–100	1057–1179	Cell material: Pt–10%Rh sinker, Pt–10%Rh suspension wire; calibration: water
133[c]	0–100	1073	Cell material: Pt–10%Rh sinker, Pt–10%Rh suspension wire; calibration: water

TABLE 208. Density studies: $CaCl_2$-KCl—Continued

Investigations critically re-examined

Ref.	KCl Mol %	Temp. range (T)	Comments
163[b]	49.6	1013	Cell material: Pt sphere, Pt wire
171	0, 30, 50, 70, 100	~923–1173	Cell material: Mo bob
237	0–100	1066–1193	Cell material: Pt–10%Rh capillary, melt contained in alumina crucible; calibration: diameter of capillary measured with microscope; calibration: molten KCl
330	0–100	1073	

Comparisons with previous NSRDS recommendations: [1, pp. 5, 7 and this volume]

Ref.	KCl Mol %	Min. departure	Max. departure
133	100	0.33% (1073 K)	
237	100	−0.93% (1101 K)	−2.20% (1191 K)
12	100	−1.3% (1073 K)	
28	100	−1.3% (1096 K)	−1.4% (1073 K)
12	50	0.12% (1173 K)	0.50% (1073 K)
28	50	−0.22% (1073 K)	0.35% (1173 K)
163	50	−1.2% (1073 K)	
12	0	−1.07% (1123 K)	
28	0	−0.69% (1157 K)	−0.87% (1111 K)
130	0	0.0% (1066 K)	0.10% (1142 K)
133	0	−0.05% (1073 K)	
237	0	0.12% (1109 K)	7.5% (1069 K)
12	0	−0.72% (1073 K)	−1.0% (1123 K)
28	0	−0.73% (1123 K)	−0.96% (1073 K)
12	100	−0.99% (1073 K)	−1.24% (1173 K)
28	100	−0.89% (1167 K)	−1.12% (1071 K)
130	100	0.20% (1123 K)	0.33% (1073 K)

[a]Data from reference [130].

[b]Data from reference [27].

[c]Graphical except for pure salts; data from reference [130].

Comment: Lillebuen [130] and Grjotheim et al. [133] used an apparatus similar to the one described by Janz and Lorenz (Rev. Sci. Instr., **31**, 18, 1960) in which a pin of known dimensions was fixed to the lower end of an Archimedean density bob, thus permitting simultaneous measurements of surface tension and density. Experiments were carried out in an atmosphere of dry nitrogen gas, after evacuating the apparatus to about 10^{-4} mm Hg. Corrections were applied for the buoyancy of the sinker in air or N_2 and for the surface tension effect on the suspension wire. Density measurements were reproducible to within ±0.3% and total corrections on the observed densities were between 0.3 to 0.4%.

Emons et al. [126] report reproducibilities in their density values of 0.2 to 0.5% in the temperature range 500–1000 °C.

Brief comments regarding the work of Lehman are given under the system $CaCl_2$-CsCl.

TABLE 209. $CaCl_2$-KCl: Density (g cm^{-3})

	Mole percent KCl											
T	100	90	80	70	60	50	40	30	20	10	0	76.0
1060		1.582										
1070		1.577									2.073	
1080	1.511	1.571	1.627			1.783	1.834	1.888			2.069	1.648
1090	1.505	1.565	1.621	1.675	1.726	1.778	1.830	1.883	1.940	2.000	2.065	1.643
1100	1.499	1.559	1.616	1.669	1.721	1.773	1.825	1.879	1.935	1.996	2.062	1.637
1110	1.493	1.553	1.610	1.664	1.716	1.768	1.820	1.874	1.931	1.992	2.058	1.632
1120	1.486	1.547	1.604	1.658	1.711	1.763	1.815	1.870	1.927	1.988	2.054	1.626
1130		1.541	1.598	1.652	1.705	1.757	1.810	1.865	1.922	1.983	2.048	1.620
1140		1.534	1.592	1.646	1.699	1.752	1.805	1.860	1.918	1.979	2.044	1.614
1150			1.586	1.640	1.694	1.747	1.800	1.855	1.913	1.975		1.608
1160			1.579	1.634	1.688	1.741	1.795	1.850	1.908	1.970		1.602
1170			1.573	1.628	1.682	1.735	1.790	1.845	1.903			1.595

Two-dimensional equation and statistical parameters

$$\rho = a + bC + cC^2 + dT^3 + eC^3 + fCT^2$$

a	$b \cdot 10^3$	$c \cdot 10^5$	$d \cdot 10^{10}$	$e \cdot 10^7$	$f \cdot 10^9$	Max. percent departure	Stand. error of est.
1.72672	4.92335	−2.48640	−1.71243	1.85373	1.10524	0.30% (1084.2 K. 77.7 mol % $CaCl_2$)	0.09%

These values are based on the work of Lillebuen (Archimedean method) [**130**]. C = mol % $CaCl_2$.

TABLE 210. $CaCl_2$-KCl: Density (g cm^{-3})

	Mol percent KCl							
T	100	92.8	83.8	71.8	49.9	31.9	22.3	0
1060		1.567						
1070		1.561	1.612					2.073
1080	1.511	1.555	1.606		1.786	1.878		2.069
1090	1.505	1.549	1.600	1.663	1.780	1.874	1.923	2.065
1100	1.498	1.542	1.594	1.657	1.774	1.869	1.919	2.061
1110	1.492	1.536	1.588	1.652	1.769	1.864	1.915	2.057
1120	1.486	1.530	1.582	1.646	1.763	1.859	1.911	2.053
1130		1.524	1.576	1.641	1.757	1.854	1.907	2.049
1140			1.570	1.635	1.752	1.849	1.903	2.045
1150			1.564	1.630	1.746	1.844	1.899	
1160			1.558	1.624	1.741	1.839	1.895	
1170			1.552	1.619	1.735	1.834	1.891	

Temperature-dependent equations

$$\rho = a + bT$$

Mol % KCl	a	$b \cdot 10^4$	Stand. error of est.
0	2.4968	−3.9594	0.05%
22.3	2.3534	−3.9512	0.14%
31.9	2.4067	−4.8912	0.01%
49.9	2.3934	−5.6284	0.01%
71.8	2.2650	−5.5242	0.03%
83.8	2.2540	−6.0024	0.05%
92.8	2.2231	−6.1878	0.03%
100	2.1866	−6.2556	0.01%

These values are based on the work of Lillebuen (Archimedean method) [**130**].

TABLE 211. Surface tension studies: $CaCl_2$-KCl

Investigations critically re-examined			
Ref.	KCl Mol %	Temp, range (T)	Comments
237	0–100	1066–1193	Cell material: Pt-10%Rh capillary, melt contained in alumina crucible; calibration: molten KCl
253	0–100	1048–1192	Cell material: density sinker and rod for surface tension measurements were made from Pt-10%Rh alloy; calibration: measurements on pure salts
258[a]	0–100	1073	Cell material and calibration: as for **253**
223	0–100	1073	Cell material: quartz capillaries of 0.8–1.44 mm diameter: calibration: pure molten salts

Comparisons with previous NSRDS recommendations: [2, pp. 58, 60 and this volume]

Ref.	KCl Mol %	Min. departure	Max. departure
237	100	0.0% (1127 K)	−0.9% (1165 K)
253	100	1.8% (1089 K, 1092 K, 1112 K)	3.5% (1109 K)
237	0	2.1% (1069 K)	
253	0	−1.1% (1085 K)	
223	100	1.07% (1073 K)	
223	0	−0.86% (1073 K)	
223	100	−0.73% (1073 K)	
223	0	0.24% (1073 K)	

[a] Graphical except for pure salts.

Comment: Lillebuen [**253**] reports a reproducibility for surface tension measurements of ±1%.

Brief remarks concerning reference [237] are to be found under the system $CaCl_2$-CsCl.

TABLE 212. $CaCl_2$-KCl: Surface tension (dyn cm^{-1})

	Mol percent KCl									
T	100.0	92.8	83.6	57.8	44.7	44.5	31.9	22.6	9.8	0.0
1050				110.4				124.9		
1060				109.7				124.3		
1070		98.5	101.4	109.0		114.8	120.5	123.8		
1080		97.8	100.7	108.3	112.8	114.2	119.9	123.2	132.4	
1090	95.8	97.2	99.9	107.6	112.2	113.6	119.3	122.7	131.9	146.2
1100	95.0	96.5	99.2	106.9	111.5	112.9	118.7	122.1	131.4	145.7
1110	94.3	95.8	98.4	106.1	110.9	112.3	118.1	121.6	130.9	145.3
1120	93.6	95.1	97.6	105.4	110.2	111.7	117.5	121.0	130.4	144.8
1130	92.8	94.5	96.9	104.7	109.6	111.0	116.9	120.4	129.9	144.4
1140	92.1	93.8	96.1	104.0	109.0	110.4	116.3	119.9	129.4	143.9
1150	91.4		95.4			109.7	115.7	119.3	128.9	143.5
1160						109.1	115.1	118.8	128.4	143.0
1170						108.5	114.6	118.2	127.9	142.5
1180										142.0
1190										141.6

Temperature-dependent equations

$$\gamma = a + bT$$

Mol % KCl	a	$b \cdot 10^2$	Stand. error of est.
0.0	195.6276	−4.5373	0.03%
9.8	186.2582	−4.9863	0.03%
22.6	183.4629	−5.5781	0.11%
31.9	183.5472	−5.8969	0.09%
44.5	182.7049	−6.3444	0.05%
44.7	181.3611	−6.3498	0.05%
57.8	185.4227	−7.1422	0.01%
83.6	182.5108	−7.5773	0.07%
92.8	170.6846	−6.7448	0.09%
100.0	175.5216	−7.3168	0.06%

These values are based on the work of Lillebuen (pin detachment method) [253].

$CaCl_2$-LiCl

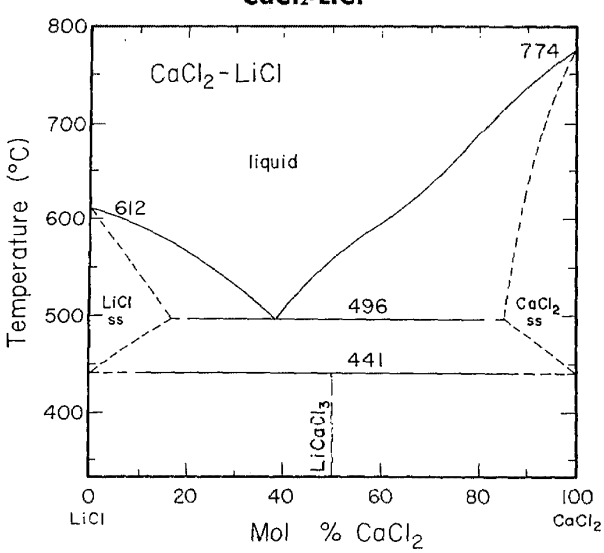


FIGURE 25. Temperature-composition phase diagram for $CaCl_2$-LiCl.

G. Grube and W. Rüdel, Z. Anorg. Allgem. Chem., **133**, 381 (1924).

Melt Preparation and Purification

Grjotheim et al. [258] used Baker analytical reagent grade LiCl. Purification of $CaCl_2$ is described under the system $CaCl_2$-KCl.

TABLE 213. Electrical conductance studies: $CaCl_2$-LiCl

Investigations critically re-examined			
Ref.	LiCl Mol %	Temp. range (T)	Comments
171, 331[a]	0, 30, 50 70, 100 (g)	~923–1173	Cell material: quartz; Mo electrodes; freq. range: 20,000 Hz

[a]Emons et al. [171, 331] report a reproducibility in their specific conductance values of 0.5 to 0.6% in the temperature range 500–1000 °C. Their conductance apparatus was similar to the one described by Story and Clarke [146].

TABLE 214. $CaCl_2$-LiCl: Specific conductance (ohm^{-1} cm^{-1})

Mol % $CaCl_2$	1073 K	Mol % $CaCl_2$	1073 K
0	6.60	60	2.85
10	5.68	70	2.56
20	4.92	80	2.38
30	4.25	90	2.21
40	3.71	100	2.13
50	3.23		

These values have been interpolated to three significant figures from the graphical presentation of Emons et al. (classical ac technique) [171, 331].

TABLE 215. Density studies: $CaCl_2$-LiCl

Investigations critically re-examined		
Ref.	LiCl Mol %	Temp. range (T)
171[a]	0, 30, 50, 70, 100	~923–1173

[a]Emons et al. [171] measured density by the hydrostatic weighing method using a molybdenum bob and reported a reproducibility of 0.2–0.5% in the temperature interval 500–1000 °C.

TABLE 216. $CaCl_2$-LiCl: Density (g cm^{-3})

Mol % $CaCl_2$	0	30	50	70	100
923 K	1.49	1.76	1.91	1.99	
948 K	1.48	1.75	1.90	1.98	
973 K	1.47	1.74	1.89	1.97	
998 K	1.46	1.73	1.88	1.96	
1023 K	1.44	1.73	1.87	1.96	
1048 K	1.43	1.72	1.86	1.95	
1073 K	1.42	1.71	1.85	1.95	2.07
1098 K	1.41	1.70	1.84	1.94	2.07
1123 K	1.40	1.69	1.83	1.93	2.06
1148 K	1.39	1.68	1.82	1.92	2.06
1173 K	1.38	1.67	1.80	1.91	2.06

These values have been interpolated to three significant figures from the graphical presentation of Emons et al. (Archimedean method) [171].

TABLE 217. Surface tension studies: $CaCl_2$-LiCl

Investigations critically re-examined			
Ref.	NaCl Mol %	Temp. range (T)	Comments
258	0–100[a]	1073	Cell material: density sinker and rod for surface tension measurements were made from Pt–10%Rh alloy, melt contained in Pt crucible; calibration: pure salts

Deviations from previous NSRDS recommendations: [2, p. 60]			
Ref.	NaCl Mol %	Min. departure	Max. departure
258	0	1.02% (1073 K)	

[a]Mixtures reported graphically.

Comment: Grjotheim et al. [258] reported a reproducibility for surface tension measurements of ±1%.

TABLE 218. $CaCl_2$-LiCl: Surface tension (dyn cm^{-1})

Mol % $CaCl_2$	1073 K	Mol % $CaCl_2$	1073 K
0	116.5	60	133.3
10	119.0	70	136.3
20	121.8	80	139.7
30	124.7	90	143.0
40	127.4	100	146.5
50	130.3		

These values have been interpolated to four significant figures from the graphical presentation of Grjotheim et al. (pin detachment method) [258].

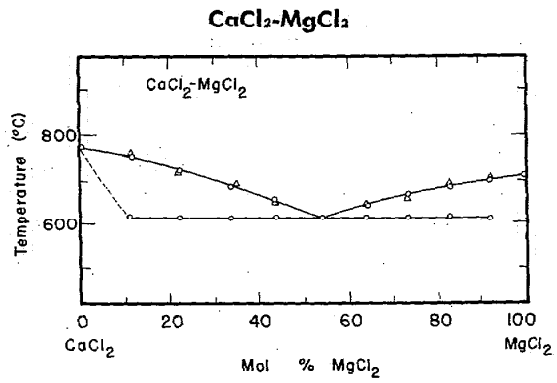


FIGURE 26. Temperature-composition phase diagram for $CaCl_2$-$MgCl_2$.

1) O. Menge, Z. Anorg. Chem., **72**, 162 (1911).

2) A. I. Ivanoc, Sbornik Statei Obshchei Khim., Akad. Nauk S.S.S.R., **1**, 754 (1953).

3) K. Mariasovsky, Chem. Zvesti., **13**, 69 (1959).

Melt Preparation and Purification

Huber et al. [30] used C.P. analytical grade $CaCl_2$ and prepared $MgCl_2$ from purified anhydrous $PbCl_2$. A slight excess of magnesium metal was added to $PbCl_2$ in a bomb which was rotated for 1½ hours at 725 °C. Analysis showed the $MgCl_2$ to be at least 99.7% pure. The pure weighed salts were melted in a porcelain crucible and then transferred to the electrolytic cell. After completing a series of measurements the mixture was analyzed.

Lillebuen [**130**] and Grjotheim's et al. [133] preparation of pure $CaCl_2$ is described under the system $CaCl_2$-KCl. Anhydrous $MgCl_2$ was prepared from the hexahydrate salt ($MgCl_2 \cdot 6H_2O$, min. 99.0% $MgCl_2 \cdot 6H_2O$, analytical reagent grade, Baker, U.S.A.) by heating the salt overnight at 100 °C under moderate vacuum. The temperature was then raised to 400 °C and the sample was further dried at this temperature for several hours while a stream of dry HCl was passed through the salt to prevent any hydrolysis. Final purification consisted in bubbling HCl gas through the molten salt with subsequent filtration through fritted silica filters. The purity of the anhydrous $MgCl_2$ was checked in several ways: (1) molten $MgCl_2$ was examined for purity in color and for the presence of solid white particles of MgO, (2) the solubility of the salt was tested in water and the presence of the insoluble salt, MgO, was checked, and (3) the Mg and Cl content was determined by EDTA and $AgNO_3$ titrations, respectively. Analysis showed less than 1% contamination of $MgCl_2$ by MgO and MgOHCl; the dehydrated $CaCl_2$ did not contain detectable amounts of the same impurities.

The preparation of anhydrous $CaCl_2$ by Grjotheim et al. [**105**] is discussed under the $CaCl_2$-KCl system. Analytical grade quality $MgCl_2 \cdot 6H_2O$ was dehydrated in essentially the same manner except that the process took approximately 4–5 days instead of two days as was the case with $CaCl_2$. Initially 500 grams of $MgCl_2 \cdot 6H_2O$ was dried at a temperature of 50–70 °C under a vacuum of 10^{-1} mm for a minimum of two days. The temperature was then gradually raised to 400 °C over a one day period and the sample was again heated at this temperature for 4–5 hours under a flow of dry HCl of about 6 l/min. After the salt was cooled in a dry Ar atmosphere it was transferred into a filtration vessel in a dry-box. The $MgCl_2$ was heated to its melting point (714 °C) over a 6–7 hour period. HCl gas was bubbled through the melt for two hours after the temperature had reached 800 °C. Final steps consisted in flushing the melt with dry argon, evacuating and filtering the melt through a quartz frit and finally sealing the vessal under vacuum. Titration with HCl showed 0.01 weight % MgO content in the $MgCl_2$. A dc polarogram was taken on the melt using the method of Laitinen et al. (J. A. Laitinen, W. Ferguson, and R. J. Osteryoung, J. Electrochem. Soc., **104**, 516, 1957) and water was not detected.

TABLE 219. Electrical conductance studies: $CaCl_2$-$MgCl_2$

Investigations critically re-examined

Ref.	$MgCl_2$ Mol %	Temp. range (T)	Comment
30	0, 26.65, 41.60, 62.59	1002–1193	Cell material: silica; Pt electrodes; freq. range: 1000 Hz; calibration: saturated NaCl solution
109	0, 20, 40 60, 80, 100	977–1173	Cell material: Al_2O_3 tube in a quartz container; Pt electrodes; freq. range: 2000 20,000 Hz; calibration: 1N KCl solution and saturated NaCl solution

Deviations from previous NSRDS recommendations: [1, p. 7 and this volume]

Ref.	$MgCl_2$ Mol %	Min. departure	Max. departure
109	100	0.36% (1038 K)	1.83% (1082 K)
30	0	−8.8% (1109 K)	−11.5% (1223 K)
109	0	−0.94% (1073 K)	−3.8% (1174 K)
30	0	−6.5% (1125 K)	−6.7% (1111 K)

Comment: Comments regarding references [30] and [**109**] are noted under the system $CaCl_2$-KCl.

TABLE 220. $CaCl_2$-$MgCl_2$: Specific conductance (ohm^{-1} cm^{-1})

	Mol percent $MgCl_2$					
T	100	80	60	40	20	0
980			1.678			
990			1.711			
1000		1.503	1.744	1.805		
1010		1.527	1.776	1.836		
1020	1.073	1.550	1.809	1.869		
1030	1.097	1.575	1.842	1.903		
1040	1.121	1.600	1.875	1.939		
1050	1.145	1.626		1.976	2.034	
1060	1.169				2.084	
1070	1.192				2.135	
1080	1.216				2.185	
1090					2.235	
1100						2.192
1110						2.228
1120						2.264
1130						2.300
1140						2.337
1150						2.375
1160						2.412
1170						2.451

Temperature-dependent equations

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

Mol % $MgCl_2$	a	$b \cdot 10^3$	$c \cdot 10^6$	Stand. error of est.
0	0.9270	−1.2350	2.1685	0.16%
20	−3.2418	5.0248	0	0.28%
40	5.3906	−10.2624	6.6765	0.11%
60	−1.5310	3.2746	0	0.24%
80	2.5710	−4.4139	3.3464	0.12%
100	−1.3646	2.3899	0	0.01%

These values are based on the work of Grjotheim et al. (classical ac technique) [**109**].

TABLE 221. Density studies: $CaCl_2$-$MgCl_2$

Investigations critically re-examined

Ref.	$MgCl_2$ Mol %	Temp. range (T)	Comments
30	0–100	996–1180	Cell material: silica ball (hollow and solid), W suspension wire; calibration: water
95	0, 36.6, 53.9 69.8, 100	1048–1148	Cell material: quartz cylinder, Pt suspension wire; calibration: water
130	0–100	1017–1182	Cell material: Pt–10%Rh sinker and suspension wire; calibration: water
133[a]	0–100 (g)	1073	Cell material and calibration: as for **130**
202	0–100 (g)	1073	

Deviations from previous NSRDS recommendations: [1, pp. 6, 7 and this volume]

Ref.	$MgCl_2$ Mol %	Min. departure	Max. departure
30	100	0.49% (1160 K)	0.66% (1020 K)
95	100	0.0% (1148 K)	1.1% (1048 K)
130	100	0.30% (1017 K)	0.50% (1099 K)
133	100	0.50% (1073 K)	
30	100	0.12% (1073 K)	0.18% (1048 K)
95	100	0.06% (1098 K)	0.66% (1048 K)
30	0	−0.72% (1055 K)	−0.78% (1148 K)
95	0	−1.1% (1073 K)	−1.4% (1148 K)
130	0	0.0% (1066 K)	0.10% (1142 K)
133	0	−0.05% (1073 K)	
30	0	−0.82% (1073 K)	
95	0	−1.06% (1073 K)	

Comment: Lillebuen [**130**] and Grjotheim et al. [133] used an apparatus similar to the one described by Janz and Lorenz (Rev. Sci. Instr., **31**, 18, 1960) in which a pin of known dimensions was fixed to the lower end of an Archimedean density bob, thus permitting simultaneous measurements of surface tension and density. Corrections were applied for the effect of surface tension and for expansion of the suspension wire. Density measurements were reproducible to within ±0.3% and total corrections on the observed densities were between 0.3 to 0.4%.

Maurits [95] reports an error of 0.4 to 0.6% in density measurements depending upon the melt composition. The author's method was verified by measurements on the pure molten salts: KCl, NaCl, $MgCl_2$, and $CaCl_2$.

[a]Data from reference [**130**].

TABLE 222. $CaCl_2$-$MgCl_2$: Density (g cm^{-3})

	Mol percent $MgCl_2$							
T	100.0	80.6	59.9	40.9	34.6	32.1	13.3	0.0
1020	1.674							
1030	1.671							
1040	1.668							
1050	1.666							
1060	1.663	2.016						
1070	1.660	2.012	1.942					2.073
1080	1.658	2.007	1.938					2.069
1090	1.655	2.003	1.933	1.867		1.807	1.732	2.065
1100		1.999	1.929	1.863	1.831	1.803	1.729	2.061
1110		1.994	1.925	1.858	1.827	1.799	1.725	2.057
1120		1.990	1.921	1.854	1.823	1.795	1.721	2.053
1130		1.985	1.917	1.849	1.819	1.791	1.718	2.049
1140				1.844	1.815	1.787	1.714	2.045
1150				1.840	1.811	1.783	1.710	
1160				1.835	1.007	1.779	1.706	
1170					1.803	1.775		
1180					1.799			

Temperature-dependent equations
$\rho = a + bT$

Mol % $MgCl_2$	a	$b \cdot 10^3$	Stand. of est. error
0.0	2.4986	−0.3976	0.05%
13.3	2.1352	−0.3697	0.03%
32.1	2.2379	−0.3955	0.05%
34.6	2.2680	−0.3977	0.01%
40.9	2.3656	−0.4571	0.02%
59.9	2.3796	−0.4093	0.05%
80.6	2.4864	−0.4436	0.01%
100.0	1.9497	−0.2705	0.03%

These values are based on the work of Lillebuen (Archimedean method) [**130**].

TABLE 223. Surface tension studies: $CaCl_2$-$MgCl_2$

Investigations critically re-examined

Ref.	$MgCl_2$ Mol %	Temp. range (T)	Comment
253	0–100	1002–1193	Cell material: density sinker and rod for surface tension measurements was made from Pt–10%Rh alloy; calibration: measurements on pure salts
258	0–100[a]	1073	Cell material and calibration: as for **253**
223	0–100	1073	Cell material: quartz capillaries of 0.8–1.4 mm diameter; calibration: measurements on pure salts

Deviations from previous NSRDS recommendations: [1, pp. 59, 60 and this volume]

Ref.	$MgCl_2$ Mol %	Min. departure	Max. departure
253	100	−5.9% (1073 K)	−6.7% (1002 K)
253	0	−1.1% (1085 K)	
223	100	1.3% (1073 K)	
223	100	4.2% (1073 K)	

[a]Graphical except for pure components.

Comment: Lillebuen [**253**] and Grjotheim et al. [258] reported a reproducibility for surface tension measurements of ±1%. Temperature coefficients for surface tension of mixtures were given in [258] without stating definite temperature limits.

TABLE 224. $CaCl_2$-$MgCl_2$: Surface tension (dyn cm^{-1})

	Mol percent $MgCl_2$											
T	100	90	80	70	60	50	40	30	20	10	0	53
1010	62.3											
1020	62.3											
1030	62.3											
1040	62.3											
1050	62.2											
1060	62.2											
1070	62.2	66.8										
1080	62.2	66.8										
1090	62.1	66.7	72.2	78.5	85.6	93.6	102.4	112.0	122.5	133.8	145.9	91.1
1100	62.1	66.7	72.1	78.4	85.5	93.4	102.2	111.7	122.2	133.4	145.5	90.9
1110	62.1	66.6	72.1	78.3	85.3	93.2	101.9	111.5	121.9	133.1	145.1	90.8
1120	62.0	66.6	72.0	78.2	85.2	93.1	101.7	111.2	121.5	132.7	144.7	90.6
1130	62.0	66.6	71.9	78.1	85.1	92.9	101.5	111.0	121.2	132.3	144.2	90.5
1140	62.0	66.5	71.8	78.0	85.0	92.7	101.3	110.7	120.9	132.0	143.8	90.3
1150	62.0	66.5	71.8	77.9	84.8	92.6	101.1	110.5	120.6	131.6	143.4	90.2
1160	61.9	66.4	71.7	77.8	84.7	92.4	100.9	110.2	120.3	131.2	142.9	90.0
1170				77.7	84.6	92.2	100.7	109.9	120.0	130.8	142.5	89.8
1180											142.1	89.7
1190											141.6	

TABLE 224. $CaCl_2$-$MgCl_2$: Surface tension (dyn cm^{-1})—Continued

Two-dimensional equation and statistical parameters

$$\gamma = a + bC + cC^2 + dT^3 + eTC^2 + fCT^2$$

a	$b \cdot 10^1$	$c \cdot 10^8$	$d \cdot 10^{10}$	$e \cdot 10^6$	$f \cdot 10^8$	Max. departure	Stand. error of est.
63.14053	5.00268	6.03065	−7.02398	−2.43231	−6.82139	−0.85% (117.5 K, 65.4 mol % $CaCl_2$)	0.43%

These values are based on the work of Lillebuen (pin detachment method) **[253]**. C = mol % $CaCl_2$.

TABLE 225. $CaCl_2$-$MgCl_2$: Surface tension (dyn cm^{-1})

	Mole percent $MgCl_2$							
T	100.0	86.7	83.4	65.4	53.0	34.6	15.2	0.0
1010	62.2							
1020	62.2							
1030	62.2							
1040	62.1							
1050	62.1							
1060	62.1							
1070	62.1							
1080	62.0		70.8				127.4	
1090	62.0	68.6	70.7		90.7	107.9	127.1	146.2
1100	62.0	68.5	70.6	81.3	90.5	107.7	126.8	145.7
1110	61.9	68.5	70.5	81.2	90.4	107.6	126.5	145.3
1120	61.9	68.4	70.5	81.1	90.2	107.4	126.2	144.8
1130	61.9	68.3	70.4	81.0	90.1	107.2	125.9	144.4
1140	61.8	68.3	70.3	81.0	89.9	107.0	125.6	143.9
1150	61.8	68.2	70.2	80.8	89.8	106.8	125.3	143.4
1160	61.8	68.1		80.7	89.6	106.6	125.0	143.0
1170		68.1		80.6	89.5	106.4	124.7	142.5
1180				80.4				142.1
1190								141.6

Temperature-dependent equations

$$\gamma = a + bT$$

Mol % $MgCl_2$	a	$b \cdot 10^2$	Stand. error of est.
0.0	195.6276	−4.5373	0.03%
15.2	160.5346	−3.0646	0.01%
34.6	128.3171	−1.8706	0.06%
53.0	106.8475	−1.4831	0.11%
65.4	93.4904	−1.1054	0.05%
83.4	79.0134	−0.7645	0.00%
86.7	75.8703	−0.6668	0.09%
100.0	65.3426	−0.3073	0.09%

These values are based on the work of Lillebuen (pin detachment method) **[253]**.

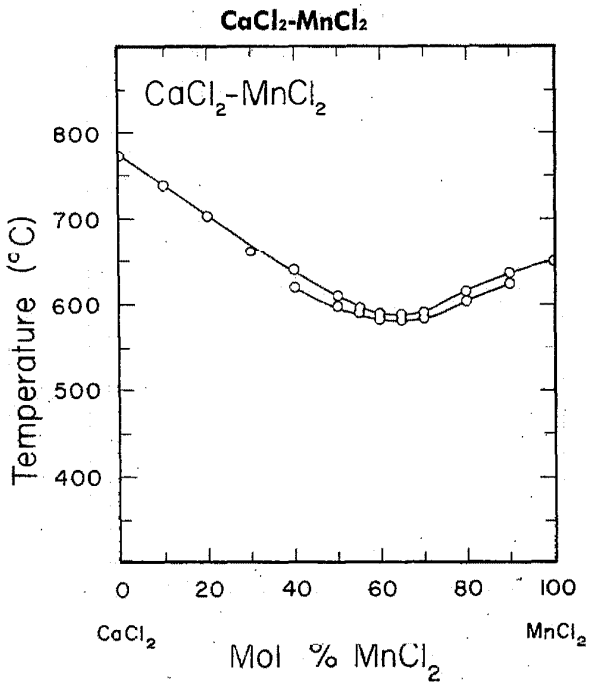


FIGURE 27. Temperature-composition phase diagram for $CaCl_2$-$MnCl_2$.

C. Sandonnini, Atti della Reale Accad. dei Lincei, (5), **20**, II 496 (1911).

TABLE 226. Density studies: $CaCl_2$-$MnCl_2$

Investigations critically re-examined			
Ref.	$MnCl_2$ Mol %	Temp. range (T)	Comments
202	20–100	873–1050	Cell material: quartz ball containing W for weight; calibration: water and carbon tetrachloride

Deviations from previous NSRDS recommendations: [1, p. 9]			
Ref.	$MnCl_2$ Mol %	Min. departure	Max. departure
202	100	0.04% (960 K)	−0.43% (1020 K)

TABLE 227. $CaCl_2$-$MnCl_2$: Density (g cm^{-3})

	Mol percent $MnCl_2$							
T	100	80	70	60	50	40	30	20
880						2.287		
890						2.280		
900						2.273		
910						2.266		
920					2.320	2.260		
930		2.370		2.327	2.313	2.253		
940	2.350	2.364		2.322	2.307	2.246		
950	2.344	2.358	2.332	2.316	2.300	2.239		
960	2.338	2.351	2.326	2.310	2.294	2.232	2.233	
970	2.331	2.345	2.320	2.305	2.287	2.225	2.227	
980	2.325	2.339	2.314	2.299	2.281	2.219	2.220	
990	2.319	2.332	2.308	2.294	2.274	2.212	2.214	2.176
1000	2.313	2.326	2.302	2.288	2.268	2.205	2.208	2.170
1010	2.307	2.319	2.296	2.282	2.262	2.198	2.201	2.165
1020	2.301	2.313	2.289	2.277	2.255	2.191	2.195	2.159
1030							2.189	2.154
1040								2.148
1050								2.143

Temperature-dependent equations

$$\rho = a + bT$$

Mol % $MnCl_2$	a	$b \cdot 10^4$
20	2.720	−5.50
30	2.840	−6.32
40	2.889	−6.84
50	2.916	−6.48
60	2.848	−5.60
70	2.916	−6.14
80	2.962	−6.36
100	2.928	−6.15

These values are based on the work of Markov et al. (Archimedean method) [**202**].

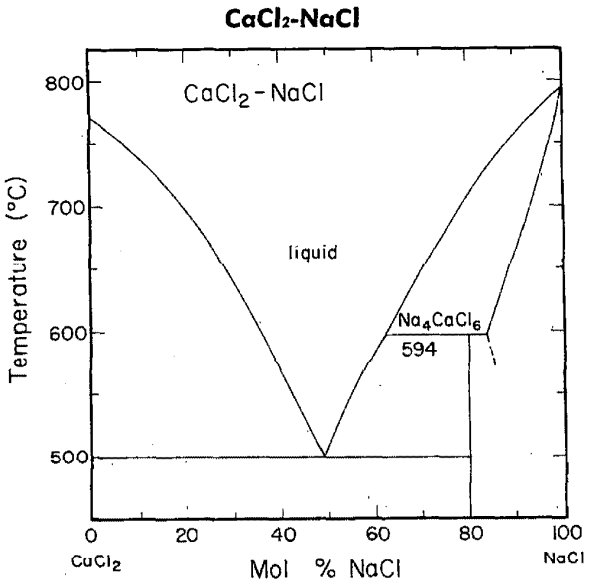


FIGURE 28. Temperature-composition phase diagram for $CaCl_2$-NaCl.

A. Seltveit and A. Flood, Acta Chem. Scand., **12** [5] 1036 (1958).

Melt Preparation and Purification

Fuseya and Ouchi [17] used reagent grade NaCl and c.p. grade $CaCl_2$ as starting materials. The NaCl was purified by passing HCl gas through its saturated solution and drying the resulting crystals at 800 °C. $CaCl_2 \cdot H_2O$ was recrystallized several times from water and then fused in a porcelain dish to remove water of crystallization. Any CaO formed during melting was converted to $CaCl_2$ by bubbling HCl gas through the molten salt. Anhydrous $CaCl_2$ was stored at 300 °C. Mixtures were heated in an atmosphere of HCl and dried.

Alabyshev and Kulakovskaya [20] used chemically anhydrous salts which were later purified by an unspecified method.

Ryschkewitsh [21] treated $CaCl_2$ with HCl gas and passed nitrogen gas through the conductivity cell during measurements.

Barzakovskii [24, 63, 144] used "chemically pure" salts. The melts were heated in a porcelain crucible in an atmosphere of dry HCl gas for 2–3 hours.

Calcium chloride was purified by Vereshchetina and Luzhnaya [**34**] by fusion in a HCl atmosphere. Before mixtures were prepared, calculated weights of the salts were again treated with HCl to remove any traces of CaO.

Lantratov and Moiseeva [74] used "chemically pure" salts. Traces of oxides and water were removed by passing HCl through the melt and again through the molten mixtures prior to measurements.

Kochergin [129] used "chemically pure" grade salts as starting materials. Sodium chloride was recrystallized twice followed by heating at 500 °C and molten $CaCl_2$ was dehydrated in a current of HCl gas. Melt conductivities were measured in an atmosphere of argon where initially the $CaCl_2$-NaCl mixtures were dehydrated in a vacuum for 3 hours.

Zolotarev and Egerev [139] recrystallized their analytical grade reagents from water and bubbled HCl gas through the molten mixtures before measurements.

Story and Clarke [**146**] used reagent grade materials which were melted and bubbled with HCl for ½ hour to decrease the CaO content to less than 0.1%. The salts were cooled and pulverized in a dry box. Mixtures were chemically analyzed.

The preparations of pure $CaCl_2$ and NaCl by Grjotheim et al. [109, 133] and Lillebuen [**130**] are given under the systems $CaCl_2$-KCl and $MgCl_2$-NaCl, respectively.

Lantratov [**229**] used C.P. grade NaCl and $CaCl_2$. The salts were dried and remelted in an atmosphere of dry HCl.

TABLE 228. Electrical conductance studies: $CaCl_2$-NaCl

Investigations critically re-examined			
Ref.	NaCl Mol %	Temp. range (T)	Comments
12	0–100	1123, 1223	Cell material; quartz vessel or silica U-tube; Pt electrodes; calibration: 1N KCl
20	30, 50	795–959	Cell material: quartz vessel; freq. range: 1000 Hz; calibration: 30% sulfuric acid at 18 °C
21	0, 33.3, 50, 65.4, 66.6, 100[a]	898–1283	Cell material: Pt crucible; Pt electrodes; freq. range: ~6000 Hz; calibration: sulfuric acid solution, saturated NaCl solution and molten KNO_3
24	0–100	1073, 1173, 1273	Cell material: quartz vessel; Pt electrodes; freq. range: 20–2000 Hz; calibration: KCl solutions
34	0–100	973–1113	Cell material: quartz vessel; calibration: molten KNO_3
44[b]	0–100 (g)	873–1113	
63	0–100	816–1365	Cell material: Pt vessel; Pt electrodes; freq. range: 300–1000 Hz; calibration: KCl solutions and 30% sulfuric acid solution

TABLE 228. Electrical conductance studies: $CaCl_2$-NaCl—Continued

Investigations critically re-examined

Ref.	NaCl Mol %	Temp. range (T)	Comments
74	30, 50, 70	923–1073	Cell material: quartz vessel; Pt electrodes; freq. range: 1000–3000 Hz; calibration: molten KNO_3, $NaNO_3$, and NaCl
109	0–100	968–1189	Cell material: Al_2O_3 tube in a quartz tube container; Pt electrodes; freq. range: 2000–20,000 Hz; calibration: 1N KCl and saturated NaCl solution
129	54[c]	798–873	Cell material: quartz vessel; freq. range: 1000–6000 Hz; calibration: molten KCl and KNO_3
139	50	923–1023	Cell material: quartz vessel; Pt electrodes; freq. range: 1000 Hz
144	0–100	873–1173	Cell material: Pt vessel; Pt electrodes; freq. range: 300–1000 Hz; calibration: KCl solutions and 30% sulfuric acid solution
146	0–100	829–1174	Cell material: quartz vessel; electrodes: Ni wires or chromel strips; freq. range: 1000–40,000 Hz (measurements at 5000 Hz); calibration: 1N KCl solution
331	0–100 (g)	923–1273	
171	0–100 (g)	948–1173	Cell material: quartz vessel; electrodes: Mo wires; freq. range: 20,000 Hz
192	37.6 (g)	830–1330	

Comparisons with NSRDS recommendations: [1, pp. 4, 7 and this volume]

Ref.	NaCl Mol %	Min. departure	Max. departure
12	100	−3.0% (1223 K)	− 4.2% (1123 K)
24	100	0.0% (1073 K)	− 3.4% (1273 K)
34	100	−2.4% (1113 K)	− 2.8% (1073 K)
63	100	−0.4% (1089 K)	− 3.1% (1273 K)
109	100	0.29% (1126 K)	0.79% (1095 K)
144	100	0.0% (1073 K)	− 2.3% (1173 K)
146	100	0.03% (1171 K)	0.53% (1130 K)
21	33.3	−8.8% (963 K)	
109	100	−0.30% (1130 K)	
24	100	−2.1% (1173 K)	
34	100	−3.2% (1111 K)	
12	0	−7.2% (1233 K)	
24	0	−4.7% (1073 K)	−10.0% (1273 K)
34	0	−0.8% (1113 K)	− 1.4% (1073 K)
63	0	−3.7% (1073 K)	− 9.8% (1173 K)
109	0	0.29% (1126 K)	0.79% (1095 K)
144	0	−4.7% (1073 K)	− 9.0% (1173 K)
146	0	−0.08% (1124 K)	− 0.33% (1076 K)
12	0	−5.1% (1123 K)	
24	0	−4.2% (1075 K)	
34	0	−1.4% (1075 K)	
109	0	−3.0% (1124 K)	

[a]Graphical for pure salts.
[b]Data from reference [34].
[c]Eutectic—graphical.

Comment: Lantratov and Moiseeva [74] noted that their quartz cells were attacked by the melts; consequently the vessels were boiled in concentrated HCl and washed with hot distilled water between consecutive measurements. Story and Clarke [146] report that attack by molten $CaCl_2$ on their cell was minimal; purification of $CaCl_2$ (0.1% CaO) and flushing the conductance cell with inert gas prevented any appreciable formation of calcium orthosilicate. Chromel strips were used as electrodes since electrodes constructed of nickel eventually became brittle presumably due to small amounts of oxygen entering the cell during sample changes.

Kochergin et al. [129] reported conductivity values on air measured melts as well as measurements on vacuum dried melts. The increased conductivity of melts in air was interpreted as being due to hydrogen-containing compounds present in the molten mixture.

Comments regarding reference [109] are discussed under the system $CaCl_2$-KCl.

TABLE 229. $CaCl_2$-NaCl: Specific conductance (ohm^{-1} cm^{-1})

	Mol % NaCl					
T	100	88.5	73.6	51.8	33.3	0
830				1.183		
840				1.230		
850				1.277		
860				1.323		
870				1.369		
880				1.415		
890				1.460		
900				1.505		
910				1.550		
920				1.594		
930				1.638		
940				1.682		
950				1.725		
960				1.768		
970				1.811	[1.660]	
980			[2.219]	1.853	[1.704]	
990			[2.259]	1.895	[1.747]	
1000			[2.298]	1.936	[1.790]	
1010			[2.337]	1.977	[1.833]	
1020			[2.376]	2.018	[1.876]	
1030			[2.414]	2.058	[1.919]	
1040			[2.451]	2.098	[1.961]	
1050			[2.488]	2.138	[2.003]	
1060		[3.046]	[2.525]	2.177	[2.045]	
1070		[3.072]	[2.561]	2.216	[2.087]	
1080		[3.098]	[2.597]	2.255		[2.141]
1090	3.663					[2.187]
1100	3.692					[2.233]
1110	3.720					[2.278]
1120	3.748					[2.324]
1130	3.774					
1140	3.800					
1150	3.824					
1160	3.847					
1170	3.870					

Temperature-dependent equations

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

Mol % NaCl	a	$b \cdot 10^3$	$c \cdot 10^7$	Stand. error of est.
0	[−2.8166]	[4.5902]	0	0.00%
33.3	[−3.4536]	[6.1849]	[−9.4099]	0.00%
51.8	−3.9865	7.7171	−17.9443	0.07%
73.6	[−3.9759]	[8.6268]	[−23.5295]	0.00%
88.5	[0.2981]	[2.5926]	0	0.00%
100	−5.3960	13.6391	−48.8857	0.04%

These values are based on the work of Story and Clarke (classical ac technique) [146].

TABLE 230. Density studies: $CaCl_2$-NaCl

Investigations critically re-examined

Ref.	NaCl Mol %	Temp. range (T)	Comments
12	0–100	1073–1173	Cell material: Pt cylinder and suspension wire
17	0–100	823–1173	Cell material: Pt bob (Pt crucible containing melt); calibration: molten NaCl
24	0–100	1073, 1273	
34	0–100 0–100 (g)	907–1123 907–1123	
129	54[a]	798–1173	Cell material: Pt sphere and suspension wire
130	0–100	1036–1173	Cell material: Pt-10%Rh sinker and suspension wire; calibration: water
133	0–100[b]	1073	Cell material: Pt-10%Rh sinker and suspension wire; calibration: water
144	0–100	1073	
163	23.6, 41.2, 80.0	1073	Cell material: Pt sphere and suspension wire
171	0–100 (g)	923–1173	Cell material: Mo bob
330	0–100	1073	

Comparison with NSRDS recommendation: [1, pp. 4, 7 and this volume]

Ref.	NaCl Mol %	Min. departure	Max. departure
12	100	−1.11% (1123 K)	
17	100	−0.20% (1173 K)	−0.45% (1073 K)
24	100	−0.58% (1073 K)	−1.66% (1273 K)
34	100	−1.30% (1098 K)	−1.44% (1123 K)
130	100	0.39% (1088 K)	0.53% (1149 K)
144	100	0.77% (1073 K)	
12	100	−1.85% (1173 K)	
17	100	−0.73% (1173 K)	
24	100	−0.86% (1173 K)	
34	100	−1.9% (1126 K)	
144	100	2.25% (1073 K)	
12	85	−0.43% (1123 K)	
17	20	0.0% (1073, 1123 K)	
34	20	−0.76% (1123 K)	
12	0	−1.07% (1123 K)	
17	0	0.54% (1123 K)	0.58% (1073 K)
24	0	−1.16% (1073 K)	−1.76% (1273 K)
34	0	−1.06% (1048 K)	−1.17% (1123 K)
130	0	0.0% (1066 K)	0.10% (1142 K)
144	0	−1.16% (1073 K)	
12	0	−1.0% (1123 K)	
17	0	0.63% (1073, 1123 K)	
24	0	−1.1% (1073 K)	
34	0	−1.2% (1065 K)	

[a]Eutectic—graphical.
[b]Graphical except for pure salts.
Comment: Remarks concerning references **[130]** and [133] are given under the system $LiCl$-$MgCl_2$.

TABLE 231. $CaCl_2$-NaCl: Density (g cm^{-3})

	Mol % NaCl											
T	100	90	80	70	60	50	40	30	20	10	0	48
1060									1.994			
1070						1.844			1.989	2.033	2.075	
1080					1.787	1.839	1.890	1.938	1.984	2.029	2.071	1.849
1090	1.551	1.612	1.670	1.727	1.782	1.834	1.885	1.933	1.980	2.024	2.066	1.845
1100	1.546	1.607	1.666	1.722	1.777	1.830	1.880	1.929	1.975	2.019	2.061	1.840
1110	1.541	1.602	1.661	1.718	1.772	1.825	1.875	1.924	1.970	2.014	2.056	1.835
1120	1.536	1.597	1.656	1.713	1.768	1.820	1.871	1.919	1.965	2.009	2.052	1.830
1130	1.532	1.593	1.651	1.708	1.763	1.816	1.866	1.914	1.961	2.005	2.047	1.826
1140	1.527	1.588	1.647	1.704	1.758	1.811	1.861	1.910			2.042	1.821
1150	1.522	1.583	1.642			1.806	1.857	1.905				1.816
1160	1.517	1.578				1.801	1.852	1.900				1.812
1170	1.512	1.574										

Two-dimensional equation and statistical parameters

$$\rho = a + bT + cC + dC^2$$

a	$b \cdot 10^4$	$c \cdot 10^3$	$d \cdot 10^5$	Max. percent departure	Stand. error of est.
2.06606	−4.72915	6.20063	−1.04771	0.38% (1090.1 K, 15.0 mol % $CaCl_2$)	0.18%

These values are based on the work of Lillebuen (Archimedean method) [130]. C = mol % $CaCl_2$.

TABLE 232. $CaCl_2$-NaCl: Density (g cm^{-3})

	Mol % NaCl							
T	100	85.0	67.5	49.1	35.9	22.5	19.8	0
1040							2.003	
1050							1.998	
1060				1.855			1.994	
1070				1.850			1.990	2.073
1080				1.845	1.913	1.972	1.985	2.069
1090	1.555	1.635	1.742	1.840	1.908	1.967	1.981	2.065
1100	1.549	1.630	1.738	1.835	1.903	1.963	1.976	2.061
1110	1.544	1.626	1.734	1.830	1.897	1.958	1.972	2.057
1120	1.539	1.621	1.730	1.825	1.892	1.954	1.967	2.053
1130	1.533	1.617	1.726	1.820	1.887	1.949		2.049
1140	1.528	1.612	1.722	1.815	1.881	1.945		2.045
1150	1.523	1.608	1.718	1.810	1.876	1.940		
1160	1.517	1.603		1.805	1.871	1.935		
1170	1.512	1.599			1.865	1.931		

Temperature-dependent equations

$$\rho = a + bT$$

Mol % NaCl	a	$b \cdot 10^4$	Stand. error of est.
0	2.4986	−3.976	0.05%
19.8	2.4651	−4.444	0.03%
22.5	2.4637	−4.554	0.02%
35.9	2.4925	−5.367	0.18%
49.1	2.3800	−4.955	0.02%
67.5	2.1791	−4.006	0.01%
85.0	2.1305	−4.546	0.01%
100	2.1319	−5.297	0.04%

These values are based on the work of Lillebuen (Archimedean method) [130].

TABLE 233. Viscosity studies: $CaCl_2$-NaCl

Investigations critically re-examined

Ref.	NaCl Mol %	Temp. range (T)	Comments
24	0–100	1073, 1173, 1273	
34	0–100	923–1148	Cell material: Pt sphere, Pt suspension rod enclosed in a glass tube; calibration: method tested using molten $NaNO_3$
144	0–100	873–1273	

Comparisons with NSRDS recommendations: [1, pp. 4, 7 and this volume]

Ref.	NaCl Mol %	Min. departure	Max. departure
24	100	0.4% (1173 K)	
34	100	5.5% (1148 K)	6.8% (1098 K)
144	100	0.4% (1173 K)	
24	90	−14.5% (1073 K)	
144	90	−14.5% (1073 K)	
24	70	7.9% (1073 K)	
144	70	7.9% (1073 K)	−9.1% (973 K)
144	60	9.1% (973 K)	18.7% (1073 K)
24	50	16.3% (1073 K)	
144	50	8.9% (973 K)	16.3% (1073 K)
144	40	13.5% (973 K)	14.2% (1073 K)
24	20	6.6% (1073 K)	
144	20	6.6% (1073 K)	
144	10	− 1.7% (1073 K)	
24	0	61.8% (1073 K)	124.5% (1173 K)
34	0	39.8% (1073 K)	70.7% (1148 K)
144	0	61.8% (1073 K)	124.5% (1173 K)
24	0	15.8% (1073 K)	
144	0	15.8% (1073 K)	

Comment: Vereshchetina and Luzhnaya [34] measured viscosities by the method of damped oscillations and corrected for the damping decrement of the Pt ball and of the system (excluding Pt ball) in air. The accuracy of the system was checked by viscosity measurements on molten $NaNO_3$ and their results agreed to ±2% with literature values.

TABLE 234. $CaCl_2$-NaCl: Viscosity (cp)

	Mol % NaCl									
T	100	90	80	70	60	50	40	20	10	0
930					4.00	4.43	4.73			
940					3.88	4.31	4.62			
950					3.77	4.19	4.50			
960					3.66	4.08	4.39			
970					3.55	3.97	4.28			
980				3.42	3.45	3.86	4.18	5.37		
990				3.30	3.35	3.76	4.07	5.20		
1000			3.05	3.18	3.25	3.66	3.97	5.03		
1010			2.91	3.06	3.15	3.56	3.87	4.88		
1020			2.77	2.95	3.06	3.47	3.78	4.73		
1030			2.64	2.84	2.97	3.38	3.69	4.59	5.13	4.88
1040			2.51	2.73	2.88	3.29	3.60	4.46	4.98	4.71
1050		2.20	2.39	2.62	2.80	3.20	3.51	4.34	4.84	4.55
1060		2.08	2.28	2.52	2.72	3.12	3.43	4.22	4.71	4.40
1070		1.97	2.17	2.42	2.64	3.04	3.35	4.12	4.59	4.25
1080		1.86	2.07	2.32	2.56	2.96	3.28	4.03	4.47	4.12
1090		1.76	1.97	2.23	2.49	2.89	3.21	3.94	4.37	4.00
1100	[1.41]	1.67	1.88	2.14	2.43	2.82	3.14	3.87	4.27	3.89
1110	[1.37]	1.59	1.80	2.05	2.37	2.74	3.08	3.81	4.19	3.79
1120	[1.32]	1.51	1.72	1.96	2.31	2.68	3.02	3.75	4.11	3.70
1130	[1.26]	1.44	1.65	1.88	2.25	2.61	2.96	3.71	4.05	3.61
1140	[1.20]	1.38	1.59	1.80	2.20	2.54	2.91	3.68	3.99	3.54

Temperature-dependent equations

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

Mol % NaCl	a	$b \cdot 10^2$	$c \cdot 10^5$	$d \cdot 10^9$	Stand. error of est.
0	69.3492	−10.3644	3.5858	3.8776	0.73%
10	20.1917	2.8465	−8.3002	39.9729	0.34%
20	30.0118	−0.1588	−5.5677	32.2866	0.41%
40	12.1701	0.9805	−3.4259	16.2560	0.67%
50	44.5576	−8.7561	6.2253	−15.5917	0.65%
60	10.4758	1.2168	−3.6226	16.8297	0.68%
70	19.1369	−1.1116	−1.3786	8.9463	0.58%
80	33.3003	−3.3357	−0.9395	12.5058	0.69%
90	30.9838	−2.2958	−2.2975	17.8387	0.64%
100	[−22.9126]	[4.8514]	[−2.4000]	0	

These values are based on the work of Vereshchetina and Luzhnaya (oscillating sphere method) [**34**].

TABLE 235. Surface tension studies: $CaCl_2$-NaCl

Investigations critically re-examined

Ref.	NaCl Mol %	Temp. range (T)	Comments
229	0–100	823–1148	Cell material: Pt and stainless steel capillaries; Pt crucible; calibration: microscope used to find capillary diameter, checked using fused KNO_3, $NaNO_3$
250	0–100	1073, 1173, 1273	
253	0–100	1075–1193	Cell material: density sinker and rod for surface tension measurements was made from Pt-10%Rh; calibration: measurements on pure salts
258	0–100[a]	1073	Cell material and calibration: as for 253

TABLE 235. Surface tension studies: $CaCl_2$-NaCl—Continued

Comparisons with NSRDS recommendations [2, pp. 57, 60 and this volume]

Ref.	NaCl Mol %	Min. departure	Max. departure
229	100	0.0% (1143 K)	0.35% (1083 K)
250	100	0.19% (1173 K)	
253	100	1.7% (1169 K)	2.0% (1118 K)
250	90	0.17% (1073 K)	
250	70	2.9% (1073 K)	
250	50	2.6% (1073 K)	
250	20	1.6% (1073 K)	
229	0	0.21% (1093 K)	1.2% (1173 K)
250	0	1.3% (1073 K)	
253	0	−1.1% (1085 K)	

[a]Graphical except for pure components.

Comment: Lantratov [**229**] and Lillebuen [253] reported reproducibilities in surface tension measurements of ±0.1% and ±1.0%, respectively.

TABLE 236. $CaCl_2$-NaCl: Surface tension (dyn cm^{-1})

	Mol % NaCl											
T	100	90	80	70	60	50	40	35	30	23.72	20	0
830						139.20	143.40					
840						138.54	142.67					
850						137.88	141.93					
860						137.22	141.19					
870						136.56	140.46					
880					134.90	135.89	139.72	141.07				
890					134.15	135.23	138.99	140.41				
900					133.39	134.57	138.25	139.74				
910					132.64	133.91	137.51	139.07				
920					131.88	133.25	136.78	138.41				
930					131.13	132.58	136.04	137.74	139.47			
940					130.37	131.92	135.31	137.08	138.77			
950				127.94	129.62	131.26	134.57	136.41	138.07			
960				127.12	128.86	130.60	133.83	135.74	137.37			
970				126.29	128.11	129.94	133.10	135.08	136.67	140.14		
980				125.47	127.35	129.27	132.36	134.41	135.97	139.40	142.78	
990				124.64	126.60	128.61	131.63	133.75	135.27	138.66	141.95	
1000				123.82	125.84	127.95	130.89	133.08	134.57	137.92	141.11	
1010				123.00	125.09	127.29	130.15	132.41	133.87	137.18	140.27	149.17
1020			120.48	122.17	124.33	126.63	129.42	131.75	133.17	136.44	139.44	148.61
1030			119.63	121.35	123.58	125.96	128.68	131.08	132.47	135.70	138.60	148.05
1040			118.79	120.52	122.82	125.30	127.95	130.42	131.77	134.96	137.76	147.49
1050			117.95	119.70	122.07	124.64	127.21	129.75	131.07	134.22	136.93	146.93
1060			117.11	118.88	121.31	123.98	126.47	129.08	130.37	133.48	136.09	146.36
1070		115.14	116.27	118.05	120.56	123.32	125.74	128.42	129.67	132.74	135.25	145.80
1080	113.90	114.35	115.42	117.23	119.80				128.97	132.00	134.41	145.24
1090	113.12	113.56	114.58	116.40						131.26	133.58	144.68
1100	112.34	112.77	113.74	115.58						130.52		144.12
1110	111.56	111.98	112.90	114.76								143.56
1120	110.78	111.19	112.06									143.00
1130	110.00	110.40										142.44
1140												141.88

Temperature-dependent equations

$\gamma = a + bT$

Mol % NaCl	a	$b \cdot 10^2$
0	205.83	−5.61
20	224.81	−8.37
23.72	211.92	−7.40
30	204.57	−7.00
35	199.68	−6.66
40	204.49	−7.36
50	194.15	−6.62
60	201.34	−7.55
70	206.22	8.24
80	206.36	−8.42
90	199.67	−7.90
100	198.14	−7.80

These values are based on the work of Lantratov (maximum bubble pressure method) [229].

$CaCl_2$-RbCl

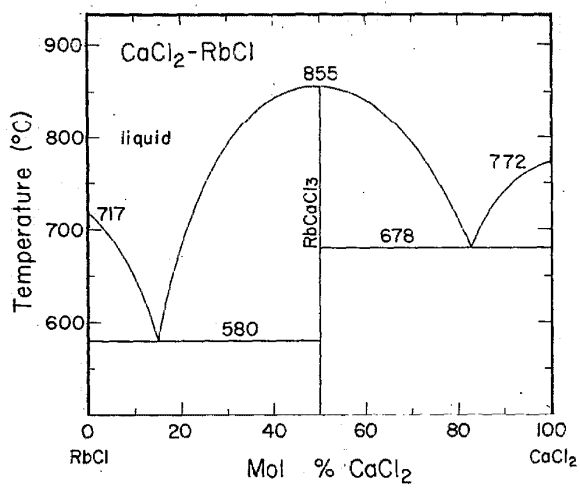


FIGURE 29. Temperature-composition phase diagram for $CaCl_2$-RbCl.

I. V. Shakhano and V. E. Plyuslchev, Zh. Neorgan. Khim,. **5** [5], 1172 (1960).

Melt Preparation and Purification

Grjotheim et al. [**258**] used "analytical reagent grade" RbCl (Merck). Purification of $CaCl_2$ is described under the system $CaCl_2$-KCl.

TABLE 237. Electrical conductance studies: $CaCl_2$-RbCl

	Investigations critically re-examined		
Ref.	RbCl Mol %	Temp. range (T)	Comments
171, 331[a]	0, 30, 50, 70, 100 (g)	~1023–1173	Cell material: quartz; Mo electrodes; freq. range: 20,000 Hz

[a]Emons et al. [**171**], [**331**] report reproducibilities in their conductance measurements of 0.5–0.6% in the temperature interval 500–1000 °C.

TABLE 238. $CaCl_2$-RbCl: Specific conductance (ohm^{-1} cm^{-1})

Mol % $CaCl_2$	1073 K	1173 K
0	1.78	2.00
10	1.54	1.78
20	1.36	1.60
30		1.49
40		1.40
50		1.38
60		1.40
70	1.38	1.54
80	1.54	1.76
90	1.80	2.05
100	2.10	2.42

These values have been interpolated to three significant figures from the graphical presentation of Emons et al. (classical ac technique) [**171, 331**].

TABLE 239. Density studies: $CaCl_2$-RbCl

Investigations critically re-examined		
Ref.	RbCl Mol %	Temp. range (T)
171[a]	0, 30, 50, 70, 100 (g)	~1023–1173

[a]Emons et al. [**171**] using a molybdenum bob for density measurements, report reproducibilities of 0.2–0.5% in the temperature interval 500–1000 °C.

TABLE 240. $CaCl_2$-RbCl: Density (g cm^{-3})

Mol % RbCl	1023 K	1048 K	1073 K	1098 K	1123 K	1148 K	1173 K
0			2.07	2.06	2.05	2.03	2.02
30			2.10	2.08	2.06	2.04	2.02
50						2.05	2.03
70			2.12	2.10	2.07	2.05	2.03
100	2.22	2.20	2.18	2.15	2.13	2.11	2.09

These values have been interpolated to three significant figures from the graphical presentation of Emons et al. (Archimedean method) [**171**].

TABLE 241. Surface tension studies: $CaCl_2$-RbCl

Investigations critically re-examined			
Ref.	RbCl Mol %	Temp. range (T)	Comments
258[a]	0–100[b]	1073	Cell material: density sinker and rod for surface tension measurements Pt–10%Rh alloy, melt contained in Pt crucible; calibration: pure salts

TABLE 241. Surface tension studies: $CaCl_2$-RbCl—Continued

Deviations from previous NSRDS recommendations: [2, pp. 58, 60]			
Ref.	RbCl Mol %	Min. departure	Max. departure
258	100	−3.06% (1073 K)	
258	0	1.02% (1073 K)	

[a]Grjotheim et al. [**258**] reported a reproducibility for surface tension measurements of ±1%. These authors stated that most of the values for the above system were found by extrapolation from higher temperatures.

[b]Mixtures reported graphically.

TABLE 242. $CaCl_2$-RbCl: Surface tension (dyn cm^{-1})[1]

Mol % $CaCl_2$	1073 K	Mol % $CaCl_2$	1073 K
0	88.5	60	107.8
10	88.8	70	114.4
20	90.6	80	122.6
30	93.3	90	132.0
40	97.4	100	147.5
50	102.6		

These values have been interpolated to three significant figures from the graphical presentation of Grjotheim et al. (pin detachment method) [258].

$CaCl_2$-$SrCl_2$

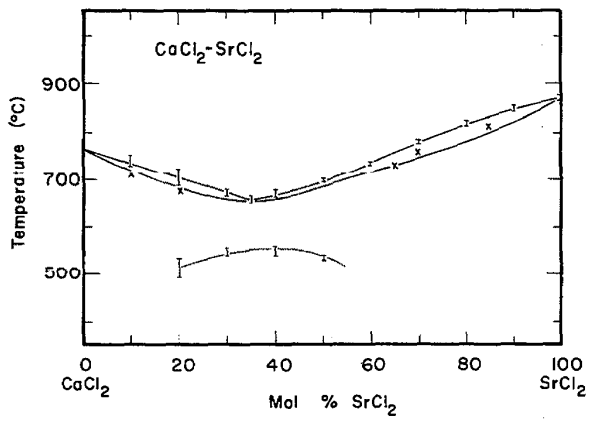


FIGURE 30. Temperature-composition phase diagram for $CaCl_2$-$SrCl_2$.

C. Sandonnini, Att. accad. Lincei, **20, II**, 497 (1911).

W. Schaefer, Neues Jahbr. Min. Geol., **I**, 15 (1914).

G. R. Bukhalove and A. G. Bergman, Zhur. Ob. Khim., **22**, 23 (1952).

TABLE 243. Electrical conductance studies: $CaCl_2$-$SrCl_2$

Investigations critically re-examined			
Ref.	$SrCl_2$ Mol %	Temp. range (T)	Comments
5	0, 41.2, 100	1173–1323	Cell material: porcelain tube; Pt electrodes; calibration: 1N KCl solutions

Deviations from previous NSRDS recommendations: [1, p. 7]			
Ref.	$SrCl_2$ Mol %	Min. departure	Max. departure
5	100	−5.0% (1173 K)	− 9.0% (1323 K)
5	0	−9.4% (1173 K)	−14.0% (1323 K)

TABLE 244. $CaCl_2$-$SrCl_2$: Specific conductance (ohm^{-1} cm^{-1})

	Mol percent $SrCl_2$		
T	100	41.2	0
1180	2.00	2.20	2.35
1190	2.03	2.23	2.39
1200	2.07	2.26	2.42
1210	2.10	2.29	2.46
1220	2.13	2.33	2.50
1230	2.16	2.36	2.53
1240	2.19	2.39	2.56
1250	2.22	2.41	2.59
1260	2.25	2.44	2.62
1270	2.28	2.47	2.65
1280	2.31	2.49	2.67
1290	2.34	2.52	2.69
1300	2.37	2.54	2.72
1310	2.39	2.56	2.74
1320	2.42	2.58	2.76

Temperature-dependent equations

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

Mol % $SrCl_2$	a	$b \cdot 10^3$	$c \cdot 10^6$	Stand. error of est.
0	−13.6775	23.0978	−8.0667	0.24%
41.2	−8.9176	15.3675	−5.0422	0.20%
100	−4.6696	8.0333	−2.0162	0.003%

These values are based on the work of Arndt and Gessler (classical ac technique) [5].

TABLE 245. Density studies: $CaCl_2$-$SrCl_2$

Investigations critically re-examined		
Ref.	$SrCl_2$ Mol %	Temp. range (T)
6[a]	0, 41.2, 100	1123–1323

Deviations from previous NSRDS recommendations: [1, p. 7]			
Ref.	$SrCl_2$ Mol %	Min. departure	Max. departure
6	100	0.00% (1323 K)	−0.74% (1173 K)
6	0	−0.98% (1123 K)	+1.00% (1223 K)

[a]Arndt and Gessler [6] used a density bob and suspension wire of platinum in their measurements.

TABLE 246. $CaCl_2$-$SrCl_2$: Density[a] (g cm^{-3})

	Mol percent $SrCl_2$		
T	100	41.2	0
1123.2			2.03
1173.2	2.69	2.33	2.01
1223.2	2.67	2.30	1.99
1273.2	2.645	2.28	1.97
1323.2	2.62	2.24	

[a]Due to limited data the experimental values are given.

These values are based on the work of Arndt and Gessler (Archimedean method) [6].

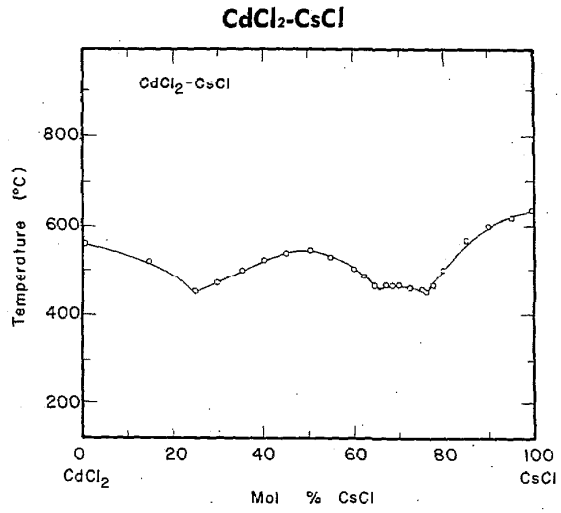


FIGURE 31. Temperature-composition phase diagram for $CdCl_2$-CsCl.

E. P. Deigurov, Doklad. Adad. Nauk. S.S.S.R., **64**, 517–20 (1949).

Melt Preparation and Purification

Bloom et al. [**103**] used Koch-Light CsCl (99.9%) without further purification. Pure $CdCl_2$ was prepared from high purity cadmium metal (99.9%; Electrolytic Zinc Co. of Australia Ltd.) and chlorine gas. Oxygen-free nitrogen and chlorine gas, dried by bubbling through sulfuric acid and through a tube containing $MgClO_4$ and glass wool, was introduced into a glass distilling flask containing 150–200 grams of cadmium metal. After air was displaced from the closed system, the reaction flask was heated slowly to melt the cadmium. Initial stages of the reaction produced a dark red solution (probably Cd_2Cl_2); the reaction was assumed complete when the melt formed a light yellow color and no further color changes occurred. Under strong heating, nitrogen was then passed through the melt to remove final traces of chlorine gas. Prior to use, the pale yellow melt was finally filtered through sintered silica. Analysis of the $CdCl_2$ for Cd (electrolytically) and chloride (gravimetrically) showed that the purity of the product was better than 99.98%.

TABLE 247. Electrical conductance studies: $CdCl_2$-CsCl

Investigations critically re-examined		
Ref.	CsCl Mol %	Temp. range (T)
132	50	823, 873

Comment: Kwak and Ketelaar [**132**] measured the ionic mobilities of Cl, Cd, and Cs ions using a radiotracer-electrophoresis method. The equivalent conductance of the equimolar mixture was calculated from the ionic mobilities.

TABLE 248. $CdCl_2$-CsCl: Equivalent conductance (ohm^{-1} cm^2 $equiv^{-1}$)

	Mol % CsCl
T	50
823.2	30.0
873.2	33.8

These values (equivalent conductances of the equimolar mixture) are based on the work of Kwak and Ketelaar (paper electrophoresis method) [**132**].

TABLE 249. Density studies: $CdCl_2$-CsCl

Investigations critically re-examined			
Ref.	CsCl Mol %	Temp. range (T)	Comments
103	0–100	873–1113	Cell material: sinker of Pt-10%Rh alloy; Pt wire; calibration: water

Deviations from previous NSRDS recommendations: [1, p. 6]			
Ref.	CsCl Mol %	Min. departure	Max. departure
103	100	−0.23% (1100 K)	−0.44% (980 K)

Comment: Bloom et al. [**103**] corrected for salt condensation on the wire, upthrust due to surface tension and the buoyancy of the sinker in air. The corrections were usually between 0.1 and 0.2%. Reported standard deviations in the density measurements were between 0.6×10^{-3} g cm^{-3} (69.8 mol % CsCl) and 2.1×10^{-3} g cm^{-3} (38.9 mol % CsCl).

TABLE 250. $CdCl_2$-CsCl: Density (g cm^{-3})

	Mol % CsCl							
T	100.0	86.8	69.8	53.3	38.9	25.7	17.6	0.0
880							3.231	
890							3.220	
900						3.135	3.210	
910						3.124	3.199	
920		2.831	2.837		3.018	3.114	3.189	3.323
930		2.821	2.828		3.008	3.103	3.178	3.315
940		2.811	2.818	2.882	2.998	3.093	3.168	3.307
950		2.800	2.809	2.872	2.988	3.082	3.157	3.299
960		2.790	2.799	2.862	2.977	3.072	3.146	3.291
970		2.780	2.790	2.852	2.967	3.061	3.136	3.283
980	2.714	2.770	2.780	2.842	2.957	3.051	3.125	3.275
990	2.704	2.759	2.771	2.832	2.947	3.040	3.115	3.267
1000	2.694	2.749	2.761	2.822	2.937	3.030	3.104	3.257
1010	2.684	2.738	2.752	2.812	2.927	3.019	3.094	3.251
1020	2.673	2.728	2.742	2.802	2.917	3.009	2.083	3.243
1030	2.663	2.717	2.733	2.792	2.907	2.998	3.073	3.233
1040	2.653	2.707	2.724	2.782	2.897	2.988	3.062	3.227
1050	2.643	2.697	2.714	2.772	2.886	2.977	3.052	3.219
1060	2.632	2.686	2.705	2.762	2.876	2.967	3.041	3.211
1070	2.622	2.676	2.695	2.752	2.866	2.956	3.030	3.203
1080	2.612	2.666			2.856		3.020	
1090	2.602	2.655			2.846			
1100	2.592							
1110	2.581							

Temperature-dependent equations

$\rho = a + bT$

Mol % CsCl	a	$b \cdot 10^3$	Stand. deviation
0.0	4.059	−0.800	
17.6	4.156	−1.052	0.0008
25.7	4.083	−1.053	0.0010
38.9	3.949	−1.012	0.0021
53.3	3.824	−1.002	0.0008
69.8	3.707	−0.946	0.0006
86.8	3.783	−1.034	0.0009
100.0	3.718	−1.024	0.0010

These values are based on the work of Bloom et al. (Archimedean method) [**103**].

$CdCl_2$-KCl

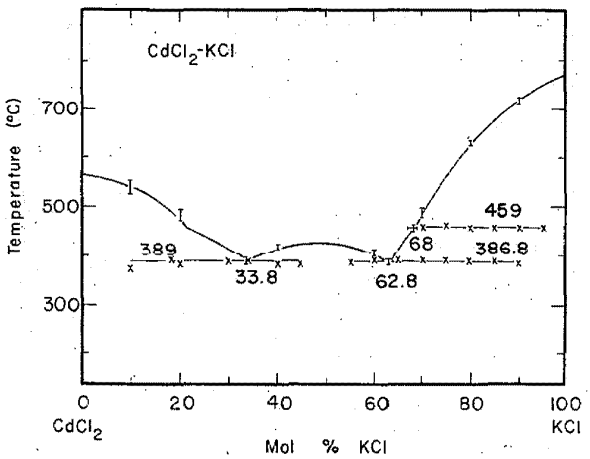


FIGURE 32. Temperature-composition phase diagram for $CdCl_2$-KCl.

Herman Brand, Neues Jahr. Min. Geol., **32**, 627–700 (1911).

E. P. Dergunov, Doklady Akad. Nauk S.S.S.R., **64**, 517–20 (1949).

Melt Preparation and Purification

Tarasova [13] dehydrated $CdCl_2$ in an atmosphere of HCl gas for a period of 6 hours. The pure $CdCl_2$ had a melting point of 568 °C. Analysis for total chloride was performed by the Volhard method and cadmium was weighed as its oxide.

Bloom and Heymann [**25**] used A.R. purity KCl and purified $CdCl_2$ (Electrolytic Zinc Co., Tasmania) by dehydration followed by fusion in a dry HCl atmosphere. Standard methods were employed for analysis; the electroanalytical method was used for cadmium.

The preparation of pure $CdCl_2$ by Boardman et al. [**26**] is discussed under the $BaCl_2$-$CdCl_2$ system. Potassium chloride was analytical reagent purity.

Bronstein and Bredig [147] used chemically reagent grade salts which were predried for several days and finally dehydrated under vacuum. Drying was executed at temperatures up to 50 degrees below the melting points and until a pressure of 20 microns was obtained.

Reagent grade $CdCl_2$ used in reference [180] was vacuum dried at 200 °C for two days and KCl was oven dried at 200 °C overnight.

TABLE 251. Electrical conductance studies: $CdCl_2$-KCl

Investigations critically re-examined

Ref.	KCl Mol %	Temp. range (T)	Comments:
12	0–100	1073, 1173	Cell material: quartz vessel or silica U-tube; Pt electrodes; calibration 1N KCl solutions
13	17.8–52.1	713–773	Cell material: Pyrex glass; Pt electrodes
14	25–72	713–813	Calibration: molten KNO_3
25	0–100[a]	843–993	Cell material: Supremax glass; Pt electrodes; freq. range: ~3000 Hz; calibration: molten $PbCl_2$ and 1N KCl solutions
116	0–78.7	823–998	
132	50 (g)	723–813	
147	35–72 (g)	633–873	Cell material: Al_2O_3; freq. range: 500–10,000 Hz; calibration: 1 demal KCl solution
160[b]	0–100 (g)	1073	

Comparisons with NSRDS recommendations:
[I, pp. 5, 11 and this volume]

Ref.	KCl Mol %	Min. departure	Max. departure
12	100	2.7% (1173 K)	3.4% (1073 K)
116	54	−0.57% (998 K)	−1.69% (873 K)
12	0	−5.0% (1073 K)	−7.6% (1173 K)
25	0	0.0% (918 K)	0.27% (963 K)
116	0	0.64% (908 K)	2.32% (868 K)

[a]100% values were extrapolated.

[b]Data (equivalent conductivities) from reference [12].

Comment: Tarasova [13] tested the reliability of the apparatus with measurements on molten $NaNO_3$ and $CdCl_2$. Experimental results for $CdCl_2$ were close to literature values while those for $NaNO_3$ were about 1% higher.

Comments regarding reference [**25**] are given under the $CdCl_2$-KCl system.

TABLE 252. $CdCl_2$-KCl: Specific conductance (ohm^{-1} cm^{-1})

	Mol percent KCl													
T	83.9	79.6	74.8	69.2	66.5	59.2	54.0	49.4	39.4	32.4	29.0	20.3	9.5	0
850				1.164	1.167	1.200	1.247	1.321	1.447	1.514	1.540	1.627	1.736	1.880
860				1.189	1.194	1.225	1.271	1.346	1.473	1.542	1.569	1.659	1.768	1.909
870				1.213	1.220	1.250	1.294	1.370	1.499	1.570	1.598	1.691	1.800	1.937
880			1.278	1.238	1.246	1.275	1.317	1.394	1.525	1.598	1.626	1.722	1.831	1.965
890			1.306	1.262	1.272	1.300	1.340	1.417	1.550	1.626	1.655	1.752	1.862	1.993
900			1.332	1.287	1.297	1.324	1.363	1.440	1.575	1.653	1.683	1.783	1.892	2.020
910			1.359	1.311	1.322	1.347	1.387	1.463	1.600	1.679	1.710	1.812	1.922	2.047
920		[1.290]	1.385	1.336	1.347	1.371	1.410	1.485	1.625	1.705	1.737	1.841	1.951	2.074
930		[1.368]	1.411	1.361	1.371	1.394	1.433	1.507	1.649	1.731	1.764	1.870	1.980	2.100
940		[1.437]	1.437	1.385	1.395	1.417	1.456	1.529	1.673	1.757	1.791	1.898	2.008	2.126
950		[1.495]	1.462	1.410	1.419	1.439	1.480	1.550	1.696	1.782	1.817	1.926	2.036	2.152
960		[1.544]	1.487	1.434	1.442	1.461	1.503	1.571	1.719	1.806	1.843	1.953	2.063	2.177
970	[1.438]	[1.582]	1.512	1.459	1.466	1.483	1.526	1.592	1.742	1.831	1.869	1.979	2.089	2.202
980	[1.552]	[1.611]	1.537	1.483	1.488	1.505	1.549	1.612	1.765	1.855	1.894	2.005	2.116	2.227
990	[1.666]	[1.630]	1.561	1.506	1.511	1.526	1.573	1.631	1.787	1.878	1.919	2.031	2.141	2.251

Temperature-dependent equations

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

Mol % KCl	a	$b \cdot 10^3$	$c \cdot 10^6$	Stand. error of est.
0	−1.8198	5.8171	−1.7225	0.12%
9.5	−2.9381	7.7335	−2.6294	0.12%
20.3	−2.9336	7.4930	−2.5032	0.11%
29.0	−2.1492	5.7421	−1.6496	0.14%
32.4	−2.2999	6.1049	−1.9038	0.06%
39.4	−1.9636	5.3671	−1.5943	0.06%
49.4	−2.0954	5.5694	−1.8230	0.07%
54.0	−0.7277	2.3235	0	0.06%
59.2	−2.1210	5.2626	−1.5946	0.08%
66.5	−2.1757	5.2027	−1.4936	0.08%
69.2	−0.9225	2.4549	0	0.27%
74.8	−2.2754	5.3478	−1.4878	0.05%
79.6	[−48.1099]	[99.0823]	[−49.3333]	0.00%
83.9	[−9.5874]	[11.3667]	0	0.00%

These values are based on the work of Bloom and Heymann (classical ac technique) [25].

TABLE 253. Density studies: $CdCl_2$-KCl

Investigations critically re-examined

Ref.	KCl Mol %	Temp. range (T)	Cell material	Calibration
9	0, 33.3, 66.6	873–1073	Pt bob, Pt wire	Water (17 °C)
26	0–75.2	773–1023	Silica dilatometer	Molten $AgNO_3$
122	20, 40, 60, 80	871–993	Quartz bob, Pt wire	
165	50	773, 873, 973		
193	0–90	873, 973		
206	33.3–66.7	753	Pt sphere, Pt wire	

Comparison with NSRDS recommendations: [1, p. 11 and this volume]

Ref.	KCl Mol %	Min. departure	Max. departure
122	60	0.30% (871 K)	0.58% (924 K)
193	60	1.7 % (873 K)	1.8 % (973 K)
9	0	−0.50% (1070 K)	−1.3 % (870 K)
193	0	−0.51% (873 K)	−0.64% (973 K)

Comments: Boardman et al. [26] applied corrections for the shape of the meniscus, buoyancy and expansion of the silica glass. In general the method was not successful above 700–750 °C due to chemical attack on the silica glass. Values for pure $CdCl_2$ are those recommended in NSRDS–NBS–15 [1]. The authors report a maximum error of ±0.2% in the density values for mixtures.

TABLE 254. $CdCl_2$-KCl: Density (g cm^{-3})

	Mol percent KCl				
T	75.2	60.0	40.8	16.9	0
740		2.408	2.735		
750		2.400	2.725		
760		2.392	2.716		
770		2.384	2.706		
780		2.375	2.697		
790		2.367	2.687		
800		2.359	2.678		
810		2.351	2.668	3.109	
820		2.343	2.659	3.100	
830		2.334	2.649	3.090	
840		2.326	2.640	3.081	
850		2.318	2.630	3.071	
860		2.310	2.621	3.061	3.377
870		2.302	2.611	3.052	3.368
880	2.058	2.293	2.602	3.042	3.360
890	2.051	2.285	2.592	3.033	3.351
900	2.044	2.277	2.583	3.023	3.343
910	2.037	2.269	2.573	3.013	3.335
920	2.030	2.261	2.564	3.004	3.326
930	2.022	2.252	2.554	2.994	3.318
940	2.015	2.244	2.545	2.985	3.309
950	2.008	2.236	2.535	2.975	3.301
960	2.001			2.965	3.293
970	1.994			2.956	3.284
980	1.986				3.276
990	1.979				3.267
1000	1.972				
1010	1.965				
1020	1.958				

Temperature-dependent equations

$$\rho = a + bT$$

Mol % KCl	a	$b \cdot 10^4$
0	4.099	−8.4
16.9	3.887	−9.6
40.8	3.438	−9.5
60.0	3.015	−8.2
75.2	2.692	−7.2

These values are based on the work of Boardman et al. (dilatometric method) [26].

TABLE 255. Viscosity studies: $CdCl_2$-KCl

Investigations critically re-examined

Ref.	KCl Mol %	Temp. range (T)	Cell material	Calibration
36	0–78.4	723–973	B.T.H. C-14 glass viscometer	Molten KNO_3
180	33.7–50.7	682–1127	Glass viscometer with upper reservoir and capillary made of Pt alloys	
206	33.3–66.7	753	Glass Ostwald viscometer	

Comparison with NSRDS recommendations: [1, p. 5 and this volume]

Ref.	KCl Mol %	Min. departure	Max. departure
180	50	1.5% (723 K)	4.2% (923 K)
180	34.6	5.7% (723 K)	6.8% (873 K)
36	0	0.0% (948 K)	0.87% (873 K)

Comments: To overcome corrosion problems, Ellis [180] limited his viscosity measurements to temperatures not exceeding 650 °C.

TABLE 256. $CdCl_2$-KCl: Viscosity (cp)

	Mol percent KCl								
T	78.4	73.9	62.5	54.4	49.9	48.9	34.4	23.5	0.0
730			3.18	3.19	3.20	3.24	3.68		
740			3.01	3.02	3.04	3.08	3.49		
750			2.86	2.87	2.88	2.92	3.32		
760			2.73	2.73	2.74	2.78	3.15		
770			2.60	2.60	2.61	2.65	3.00		
780			2.48	2.48	2.49	2.53	2.86	3.08	
790			2.37	2.37	2.37	2.42	2.73	2.95	
800			2.26	2.26	2.27	2.32	2.61	2.83	
810			2.17	2.16	2.17	2.22	2.50	2.72	
820			2.07	2.07	2.07	2.13	2.39	2.61	
830		[2.06]	1.99	1.99	1.99	2.04	2.29	2.51	
840		[1.98]	1.91	1.91	1.91	1.96	2.20	2.42	
850		[1.90]	1.84	1.83	1.83	1.88	2.12	2.33	
860		[1.83]	1.77	1.76	1.76	1.81	2.03	2.25	
870		[1.76]	1.70	1.70	1.69	1.75	1.96	2.17	
880	1.71	[1.70]	1.64	1.63	1.63	1.68	1.89	2.09	2.27
890	1.65	[1.64]	1.58	1.57	1.57	1.62	1.82	2.02	2.21
900	1.59	[1.58]	1.53	1.52	1.52	1.57	1.75	1.96	2.15
910	1.53	[1.53]	1.47	1.47	1.46	1.52	1.69	1.90	2.10
920	1.47	[1.47]	1.42	1.42	1.41	1.47	1.64	1.84	2.05
930	1.42	[1.43]	1.38	1.37	1.37	1.42	1.58	1.78	2.01
940	1.37	[1.38]	1.33	1.33	1.32	1.37	1.53	1.73	1.96
950	1.33	[1.34]	1.29	1.29	1.28	1.33	1.48	1.68	1.92
960	1.28	[1.29]	1.25	1.25	1.24	1.29	1.44	1.63	1.88
970	1.24	[1.25]	1.22	1.21	1.20	1.25	1.39	1.58	1.84

Temperature-dependent equations

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

$$\eta = A \cdot \exp\,(E/RT)$$

Mol % KCl	a	$b \cdot 10^1$	$c \cdot 10^4$	$d \cdot 10^8$	$A \cdot 10^2$	E (cal mol^{-1})	Stand. error of est.
0.0					23.837	3937	0.53%
23.5					10.266	5272	0.32%
34.4					7.274	5692	1.66%
48.9					6.977	5567	0.85%
49.9					6.124	5740	1.60%
54.4					6.313	5689	1.16%
62.5					6.544	5632	1.57%
73.9	[58.1443]	[−1.6339]	[1.5971]	[−5.3333]			0.00%
78.4					5.392	6049	0.17%

These values are based on the work of Harrap and Heymann (capillary method) [36].

TABLE 257. Surface tension studies: $CdCl_2$-KCl

Investigations critically re-examined				
Ref.	KCl Mol %	Temp. range (T)	Cell material	Calibration
234	0–100 (g)	873, 973	B.T.H.–C46 glass capillary, melt contained in tube of B.T.H.–C14 glass	Water
255[a]	0–100 (g)	773, 873, 973		

[a]Data taken from reference [234].

Comment: The authors [234] report a maximum error of ±1% in their surface tension measurements. Calibration of the capillary was reproducible to better than 0.3% and measurements in the molten salts were reproducible to 0.2%.

TABLE 258. $CdCl_2$-KCl: Surface tension (dyn cm^{-1})

Mol % $CdCl_2$	873 K	973 K
0	110.	102.
10	104.	97.0
20	99.5	92.8
30	95.5	89.5
40	92.8	86.9
50	91.0	85.2
60	90.5	84.6
70	90.0	84.4
80	88.4	84.2
90	85.8	83.0
100	82.5	80.5

These values have been interpolated from the graphical presentation of Boardman et al. (maximum bubble pressure method) [**234**].

$CdCl_2$-LiCl

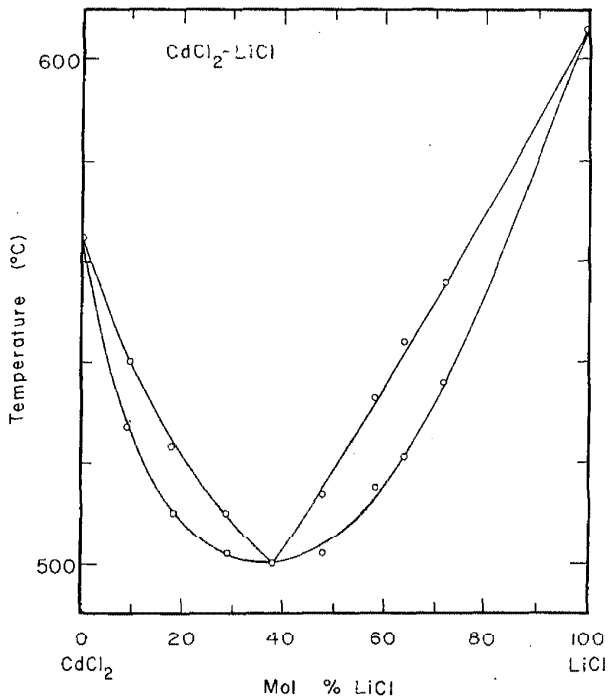


FIGURE 33. Temperature-composition phase diagram for $CdCl_2$-LiCl.

S. D. Gromakov, Zh. Fiz. Khim., **24**, 641 (1950).

Melt Preparation and Purification

Bloom et al. [**31**] used salts of A.R. purity or prepared to a purity of at least 99.8%. Cadmium chloride was made by reacting pure cadmium metal (99.96%; Electrolytic Zinc Co. of Australia Ltd.) with a stream of dry HCl gas. The mixtures were made by weighing the dry salts which had been previously fused and allowed to cool in desiccators. Standard methods of analysis were used and the electro-analytical method was used for cadmium.

TABLE 259. Electrical conductance studies: $CdCl_2$-LiCl

Investigations critically re-examined			
Ref.	LiCl Mol %	Temp. range (T)	Comments
31[a]	0–100	797–1023	Cell material: capillary cells of silica or B.T.H. #37 glass; Pt electrodes; freq. range: 100–10,000 Hz; 1N KCl solutions

Deviations from previous NSRDS recommendations: [1, pp. 4, 11]			
Ref.	LiCl Mol %	Min. departure	Max. departure
31	100	1.7% (1010 K)	2.3% (910 K)
31	0	−0.10% (920 K)	0.79% (1000 K)

[a]Bloom et al. [**31**] used a dipping type conductivity cell with one platinum electrode enclosed in a capillary tube and the other electrode outside. Conductivity through the glass wall of the capillary tube was found to be negligible when compared to that of the melt. Overall accuracy of the measurements was estimated at ±0.5%.

TABLE 260. $CdCl_2$-LiCl: Specific conductance (ohm^{-1} cm^{-1})

	Mol percent LiCl				
T	100	75.0	50.0	25.0	0
800				2.18	
810			2.69	2.22	
820			2.74	2.26	
830			2.78	2.30	
840			2.82	2.33	
850		3.78	2.87	2.37	
860		3.83	2.91	2.41	1.91
870		3.88	2.95	2.44	1.94
880		3.92	2.99	2.48	1.97
890		3.97	3.04	2.52	1.99
900	5.96	4.02	3.08	2.55	2.02
910	6.01	4.06	3.12	2.59	2.05
920	6.05	4.11	3.16	2.63	2.08
930	6.10	4.15	3.20	2.66	2.10
940	6.15	4.20	3.24	2.70	2.13
950	6.20	4.24	3.28	2.73	2.16
960	6.24	4.28	3.32	2.77	2.18
970	6.29	4.33	3.36	2.80	2.21
980	6.33	4.37	3.40	2.83	2.24
990	6.38	4.41	3.44	2.87	2.26
1000	6.42	4.45	3.47	2.90	2.29
1010	6.46	4.50	3.51	2.93	2.31
1020	6.50	4.54	3.55	2.97	2.34

Temperature-dependent equations

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

Mol % LiCl	A	E (cal mol^{-1})
0	6.92	2200
25.0	9.09	2270
50.0	10.3	2160
75.0	11.3	1850
100	12.6	1340

These values are based on the work of Bloom et al. (classical ac technique) [**31**].

TABLE 261. Density studies: $CdCl_2$-LiCl

Investigations critically re-examined		
Ref.	LiCl Mol %	Temp. range (T)
31[a]	0–100	797–1023
165	58.2	773– 973
193	0–90	873, 973

Comparisons with NSRDS recommendations: [1, pp. 4, 11 and this volume]

Ref.	LiCl Mol %	Min. departure	Max. departure
31	100	0.00% (970 K)	−0.20% (910 K)
193	50	−1.17% (873 K)	−1.21% (973 K)
193	0	−0.51% (873 K)	−0.64% (973 K)

[a]Bloom et al. [**31**] used a sinker and suspension wire of 10% Rh–Pt for their density determinations. Precautions were taken to prevent air bubbles from clinging to the sinker, and corrections were made for thermal expansion of the silica glass. Accuracy was reported to be within ±0.1%.

The density values for pure cadmium chloride [**31**] are those reported in NSRDS–NBS–15 [1].

TABLE 262. $CdCl_2$-LiCl: Density (g cm^{-3})

	Mol percent LiCl				
T	100	75.0	50.0	25.0	0
800				3.158	
810			2.792	3.150	
820			2.783	3.142	
830			2.775	3.133	
840			2.766	3.125	
850		2.240	2.758	3.117	
860		2.234	2.749	3.109	3.370
870		2.228	2.741	3.100	3.362
880		2.222	2.732	3.092	3.354
890		2.216	2.724	3.084	3.346
900	1.491	2.211	2.715	3.076	3.338
910	1.487	2.205	2.707	3.067	3.330
920	1.484	2.199	2.699	3.059	3.322
930	1.480	2.193	2.690	3.051	3.314
940	1.476	2.188	2.682	3.043	3.306
950	1.472	2.182	2.673	3.034	3.298
960	1.468	2.176	2.665	3.026	3.290
970	1.464	2.170	2.656	3.018	3.282
980	1.461	2.165	2.648	3.010	3.274
990	1.567	2.159	2.639	3.001	3.266
1000	1.453	2.153	2.631	2.993	3.250
1010	1.449	2.147	2.623	2.985	3.250
1020	1.445	2.141	2.614	2.977	3.242

Temperature-dependent equations
$\rho = a + bT$

Mol % LiCl	a	$b \cdot 10^4$
0	4.058	−8.00
25.0	3.818	−8.25
50.0	3.476	−8.45
75.0	2.730	−5.77
100	1.835	−3.82

These values are based on the work of Bloom et al. (Archimedean method) [**31**].

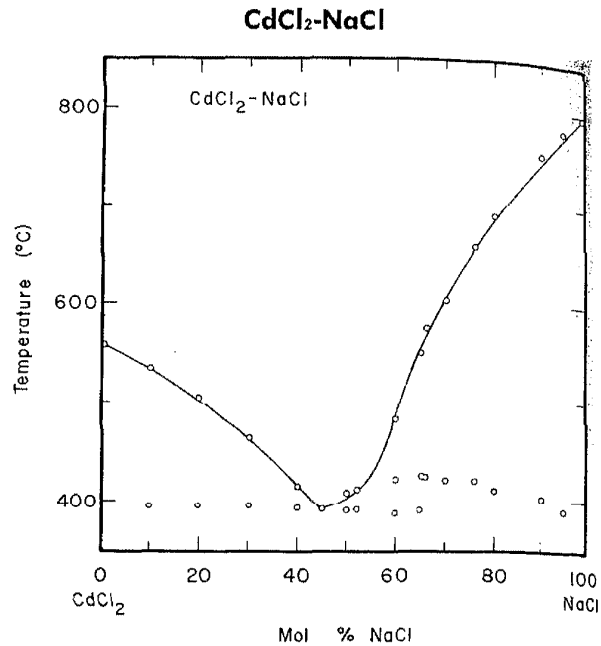


FIGURE 34. Temperature-composition phase diagram for $CdCl_2$-NaCl.

H. Brand, Neues Jahrb. Mineral., Geol., Pälaontd Beil. Band, **32**, 627 (1911).

Melt Preparation and Purification

Sodium chloride used in references [**234, 25, 26, 36**] was of A.R. purity. Cadmium chloride was made from pure electrolytic cadmium (Electrolytic Zinc Co., Tasmania), dehydrated and subsequently fused while a stream of HCl gas was passed through the melt to remove products of hydrolysis. The method used by Bloom et al. [103] described under the $CdCl_2$-CsCl system for the preparation of pure $CdCl_2$ is probably superior to the earlier methods used [**25, 26, 36**].

TABLE 263. Electrical conductance studies: $CdCl_2$-NaCl

Investigations critically re-examined			
Ref.	NaCl Mol %	Temp. range (T)	Comments
25[a]	0–100[b]	823–973	Cell material: Supremax glass; Pt electrodes; freq. range: ~3000 Hz; calibration: molten $PbCl_2$ and N KCl solutions
132	50	823, 873	

Deviations from previous NSRDS recommendations: [1, p. 11]

Ref.	NaCl Mol %	Min. departure	Max. departure
25	0	0.0% (918 K)	0.27% (963 K)

[a]Bloom and Heymann [**25**] used a dipping type conductivity cell in which one Pt electrode was enclosed in a capillary tube and the other electrode was outside. Conductivity through the glass wall of the capillary tube was found to be negligible compared with that of the melt. Using a Wien bridge, resistance measurements were made to within 0.1 to 0.2%. The cell constant did not change appreciably (0.3%) during prolonged use of a capillary.

[b]Mixtures reported graphically.

TABLE 264. $CdCl_2$-NaCl: Specific conductance (ohm^{-1} cm^{-1})

Mol % NaCl	823 K	873 K	923 K	973 K
0	1.82	1.94	2.00	2.24
10	1.86	2.00	2.17	2.32
20	1.87	2.04	2.21	2.36
30	1.90	2.08	2.25	2.38
40	1.92	2.10	2.28	2.40
50	1.94	2.12	2.29	2.40
60	1.96[a]	2.14	2.31	2.44
70	2.06[a]	2.20	2.35	2.54
80	2.24[a]	2.38[a]	2.50[a]	2.70
90	2.57[a]	2.66[a]	2.78[a]	2.97[a]
100	2.97	3.06	3.21	3.29

[a]Extrapolated values.

These values have been interpolated to three significant figures from the graphical presentation of Bloom and Heymann (classical ac technique) [25].

TABLE 265. Density studies: $CdCl_2$-NaCl

Investigations critically re-examined

Ref.	NaCl Mol %	Temp. range (T)	Comments
26[a]	0–65.7	773–998	Cell material: silica glass dilatometer; calibration: molten $AgNO_3$
165	50	773–973	
193	0–90	873, 973	

Deviations from previous NSRDS recommendations: [1, p. 11]

Ref.	NaCl Mol %	Min. departure	Max. departure
193	0	−0.51% (873 K)	−0.64% (973 K)

[a]Boardman et al. [26] applied corrections for the shape of the meniscus, buoyancy and expansion of the silica dilatometer. The authors state that the method cannot be used above 700–750 °C due to chemical attack on the silica glass. A maximum error of ±0.20% in the density values was reported. The density values for pure cadmium chloride in ref. [26] are those recommended in NSRDS–NBS–15.

TABLE 266. $CdCl_2$-NaCl: Density (g cm^{-3})

	Mol percent NaCl					
T	65.7	55.7	44.5	35.2	22.2	0
780		2.654				
790		2.646				
800		2.637				
810		2.628				
820		2.620		2.974		
830		2.611		2.964		
840		2.603		2.953		
850		2.594	2.784	2.943		
860	2.418	2.585	2.775	2.933	3.120	3.377
870	2.409	2.577	2.766	2.922	3.111	3.369
880	2.401	2.568	2.757	2.912	3.101	3.360
890	2.393	2.560	2.747	2.901	3.092	3.352
900	2.385	2.551	2.738	2.891	3.082	3.343
910	2.377	2.542	2.729	2.881	3.073	3.335
920	2.368	2.534	2.720	2.870	3.063	3.327
930	2.360	2.525	2.711	2.860	3.054	3.318
940	2.352	2.517	2.701	2.849	3.044	3.310
950	2.344	2.508	2.692	2.839	3.035	3.301
960	2.336	2.499			3.025	3.293
970					3.016	3.285
980						3.276
990						3.268

Temperature-dependent equations

$$\rho = a + bT$$

Mol % NaCl	a	$b \cdot 10^4$
0	4.099	− 8.4
22.2	3.937	− 9.5
35.2	3.827	−10.4
44.5	3.566	− 9.2
55.7	3.325	− 8.6
65.7	3.123	− 8.2

These values are based on the work of Boardman et al. (dilatometric method) [26].

TABLE 267. $CdCl_2$-NaCl: Density (g cm^{-3})

	Mol percent NaCl							
T	60	50	40	30	20	10	0	45
800	2.560	2.734						
810	2.553	2.727						
820	2.545	2.719						
830	2.538	2.712	2.877					
840	2.530	2.704	2.869	3.023				
850	2.522	2.696	2.861	3.015	3.156			2.780
860	2.513	2.688	2.853	3.007	3.148	3.274	3.384	2.771
870	2.505	2.679	2.844	2.998	3.139	3.265	3.375	2.763
880	2.496	2.670	2.835	2.989	3.130	3.257	3.366	2.754
890	2.487	2.662	2.827	2.981	3.122	3.248	3.358	2.745
900	2.478	2.652	2.818	2.971	3.113	3.239	3.348	2.736
910	2.469	2.643	2.808	2.962	3.103	3.230	3.339	2.727
920	2.460	2.634	2.799	2.953	3.094	3.220	3.330	2.718
930	2.450	2.624	2.789	2.943	3.084	3.210	3.320	2.708
940	2.440	2.614	2.779	2.933	3.074	3.201	3.310	2.698
950	2.430	2.604	2.769	2.923	3.064	3.190	3.300	2.688
960	2.420			2.913	3.054	3.180	3.290	
970					3.043	3.170	3.279	
980						3.159	3.269	
990							3.258	

Two-dimensional equation and statistical parameters

$$\rho = a + bC + cT^3 + dC^3$$

a	$b \cdot 10^2$	$c \cdot 10^{10}$	$d \cdot 10^7$	Max. percent departure	Stand. error of est.
2.00068	1.93015	−3.76995	−3.07505	0.40% (960.0 K, 34.3 mol % $CdCl_2$)	0.18%

These values are based on the work of Boardman et al. (dilatometric method) [**26**]. C = mol % $CdCl_2$.

TABLE 268. Viscosity studies: $CdCl_2$-NaCl

Investigations critically re-examined

Ref.	NaCl Mol %	Temp. range (T)	Cell materials	Calibration
36	0–72.8	723–973	B.T.H.–C14 glass viscometer	Molten KNO_3

Deviations from previous NSRDS recommendations: [1, p. 11]

Ref.	NaCl Mol %	Min. departure	Max. departure
36	0	0.0% (948 K)	0.87% (873 K)

TABLE 269. $CdCl_2$-NaCl: Viscosity (cp)

	Mol percent NaCl					
T	72.8	50.0	45.5	40.0	25.5	0.0
730		3.38	3.43	3.56		
740		3.21	3.25	3.38		
750		3.05	3.09	3.22		
760		2.90	2.93	3.06		
770		2.76	2.79	2.92		
780		2.63	2.66	2.78	2.89	
790		2.51	2.54	2.65	2.77	
800		2.39	2.43	2.53	2.66	
810		2.29	2.32	2.42	2.56	
820		2.19	2.22	2.31	2.46	
830		2.09	2.13	2.21	2.37	
840		2.01	2.04	2.12	2.28	
850		1.93	1.96	2.04	2.20	
860		1.85	1.89	1.96	2.12	
870		1.78	1.82	1.89	2.05	
880		1.72	1.75	1.82	1.98	[2.27]
890		1.66	1.69	1.76	1.92	[2.21]
900		1.61	1.63	1.70	1.86	[2.15]
910		1.56	1.57	1.65	1.80	[2.10]
920		1.51	1.52	1.60	1.74	[2.04]
930	1.55	1.47	1.47	1.55	1.69	[2.00]
940	1.50	1.43	1.42	1.51	1.64	[1.95]
950	1.46	1.39	1.37	1.47	1.60	[1.91]
960	1.42	1.35	1.33	1.44	1.55	[1.88]
970	1.38	1.32	1.29	1.41	1.51	[1.84]

Temperature-dependent equations

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

$$\eta = A \cdot \exp\,(E/RT)$$

Mol % NaCl	a	$b \cdot 10^1$	$c \cdot 10^4$	$d \cdot 10^8$	$A \cdot 10^1$	E (cal mol^{-1})	Stand. error of est.
0.0	[20.0982]	[−0.3434]	[0.1600]	[0.000004]			0.00%
25.5					1.045	5146	0.55%
40.0	64.3414	−1.7725	1.6798	−5.3747			1.03%
45.5					0.659	5733	1.42%
50.0	66.7594	−1.8845	1.8328	−6.0360			1.27%
72.8					0.980	5096	0.47%

These values are based on the work of Harrap and Heymann (capillary method) [36].

TABLE 270. Surface tension studies: $CdCl_2$-NaCl

Investigations critically re-examined		
Ref.	NaCl Mol %	Temp. range (T)
234[a]	0–100 (g)	973, 1073

[a]Data were presented in graphical form. The value for 100% NaCl at 700 °C was obtained by extrapolation. The capillary was drawn from British-Thomson-Houston C46 glass tubing, and the calibration was performed with tap water. After each series of measurements on a particular mixture, the capillary was recalibrated. The maximum uncertainty was given by the authors [234] as ±1%.

TABLE 271. $CdCl_2$-NaCl: Surface tension (dyn cm^{-1})

Mol % NaCl	973 K	1073 K
0	82.4	79.2
10	84.3	80.7
20	86.2	81.7
30	88.0	83.4
40	91.6	85.9
50	94.9	88.6
60	99.4	92.1
70	104.	96.4
80	110.	102.
90	117.	108.
100	125.	116.

These values have been interpolated to three significant figures from the graphical presentation of Boardman, Palmer, and Heymann (maximum bubble pressure method) [234].

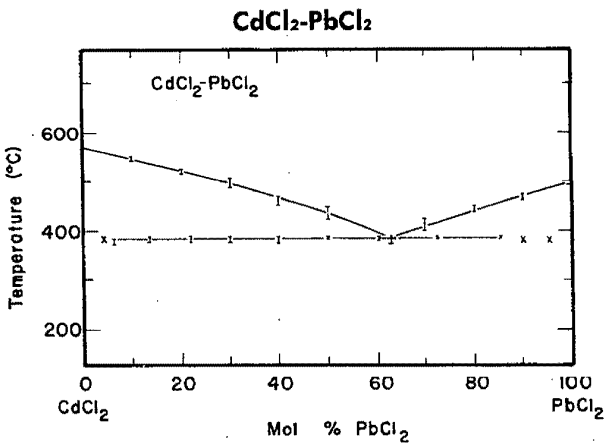


FIGURE 35. Temperature-composition phase diagram for $CdCl_2$-$PbCl_2$.

G. Hermann, Z. anorg. Chem., **71**, 257–302 (1911).

C. Sandonnini, Atti. Acad. Lincei, **21**, **1**, 208 13 (1912).

Melt Preparation and Purification

The preparation of pure $CdCl_2$ in references [**234, 25, 26, 36**] is discussed under the system $CdCl_2$-NaCl.

References [**25, 26, 36**] do not give any particular details concerning the preparation of pure $PbCl_2$, but indicate that salts were of analytical grade purity or prepared from reagents of analytical grade purity and recrystallized. Mixtures were analyzed for total chloride and lead was determined gravimetrically as the chromate or sulfate salt.

TABLE 272. Electrical conductance studies: $CdCl_2$-$PbCl_2$

Investigations critically re-examined			
Ref.	$PbCl_2$ Mol %	Temp. range (T)	Comments
13[a]	39.7–100	733–793	Cell material: Pyrex; Pt electrodes; calibration: molten $Ca(NO_3)_2$
25[b]	0–100[c]	803–973	Cell material: Supremax glass; Pt electrodes; freq. range: ~3000 Hz; calibration: molten $PbCl_2$ and 1N KCl solutions
94[d]	0–100 (g)	873	
117	0–100 (g)	813–963	Cell material: quartz; Pt electrodes
218	eutectic (g)	940–1180	

Deviations from previous NSRDS recommendations: [1, p. 13]			
Ref.	$PbCl_2$ Mol %	Min. departure	Max. departure
13	100	0.13% (793 K)	
25	100	0.0% (833 K)	−0.52% (873 K)

[a]Tarasova [**13**] tested the experimental arrangement and procedure by conductivity measurements on molten $NaNO_3$ and $CdCl_2$. The author reports that values for $NaNO_3$ were about 1% higher than literature values and results for $CdCl_2$ were close to those of Tubandt and Lorenz (Z. Phys. Chem., **87**, 543, 1914).

[b]Bloom and Heymann [25], using a Wien bridge, report that resistance measurements were made to within 0.1 to 0.2%. The cell constant was found to change little (0.3%) during prolonged use of any one capillary.

[c]Mixtures reported graphically.

[d]Graphical data of equivalent conductance versus % composition was given.

TABLE 273. $CdCl_2$-$PbCl_2$: Specific conductance (ohm^{-1} cm^{-1})

	Mol percent $PbCl_2$					
T	100	85.6	72.5	61.8	49.7	39.7
735			1.433	1.488	1.459	
740			1.459	1.520	1.482	
745			1.487	1.552	1.505	
750			1.516	1.584	1.530	
755		[1.477]	1.545	1.616	1.556	[1.519]
760		[1.508]	1.576	1.648	1.582	[1.546]
765		[1.540]	1.608	1.680	1.610	[1.574]
770		[1.575]	1.641	1.712	1.639	[1.603]
775	[1.450]	[1.611]	1.676	1.744	1.669	[1.633]
780	[1.479]	[1.650]	1.711	1.776	1.700	[1.664]
785	[1.507]	[1.690]	1.747	1.808	1.732	[1.696]
790	[1.536]	[1.732]	1.785	1.840	1.765	[1.728]

Temperature-dependent equations

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

Mol % $PbCl_2$	a	$b \cdot 10^2$	$c \cdot 10^5$	Stand. error of est.
39.7	[8.9396]	[−2.4928]	[2.000]	0.00%
49.7	9.6082	−2.6580	2.1079	0.23%
61.8	−3.2083	0.6390	0	0.36%
72.5	9.3389	−2.6719	2.1717	0.61%
85.6	[18.3339]	[−5.0640]	[3.750]	0.00%
100.0	[−2.9672]	[5.700]	0	0.00%

These values are based on the work of Tarasova (classical ac technique) [**13**].

TABLE 274. Density studies: $CdCl_2$-$PbCl_2$

Investigations critically re-examined			
Ref.	$PbCl_2$ Mol %	Temp. range (T)	Comments
26[a]	0–100	753–998	Cell material: silica glass dilatometer; calibration: molten $AgNO_3$
94[b]	0–100 (g)	873	
206	50–80	753	Cell material: Pt sphere and Pt wire

[a]Boardman et al. [26] applied corrections for the shape of the meniscus, buoyancy and expansion of the silica dilatometer. The authors remark that the method cannot be used above 700–750 °C due to chemical attack on the silica glass. A maximum error of ±0.20% in the density values was reported. The density values for pure $CdCl_2$ and $PbCl_2$ were those recommended in NSRDS–NBS–15 [1].

[b]Data from reference [26].

TABLE 275. $CdCl_2$-$PbCl_2$: Density (g cm^{-3})

	Mol percent $PbCl_2$											
T	100	90	80	70	60	50	40	30	20	10	0	61.6
760					4.441							4.464
770				4.567	4.426	4.282						4.449
780				4.552	4.412	4.267						4.434
790	4.930			4.537	4.397	4.253						4.420
800	4.914			4.522	4.382	4.238	4.089					4.405
810	4.899			4.508	4.368	4.223	4.076			3.603		4.391
820	4.884			4.493	4.354	4.210	4.062	3.909	3.752	3.590		4.376
830	4.869	4.743	4.613	4.479	4.340	4.196	4.048	3.896	3.739	3.578		4.362
840	4.854	4.728	4.599	4.465	4.326	4.183	4.035	3.883	3.727	3.566		4.348
850	4.839	4.714	4.584	4.451	4.312	4.170	4.022	3.871	3.715	3.554		4.335
860	4.823	4.699	4.570	4.437	4.299	4.157	4.010	3.859	3.703	3.543	3.378	4.321
870	4.808	4.684	4.556	4.423	4.286	4.144	3.997	3.847	3.691	3.532	3.367	4.308
880	4.793	4.670	4.542	4.409	4.272	4.131	3.985	3.835	3.680	3.521	3.357	4.295
890	4.778	4.655	4.528	4.396	4.259	4.119	3.973	3.824	3.670	3.511	3.348	4.282
900	4.763	4.640	4.514	4.382	4.247	4.106	3.962	3.813	3.659	3.501	3.339	4.269
910	4.748	4.626	4.500	4.369	4.234	4.094	3.950	3.802	3.649	3.492	3.330	4.256
920	4.732	4.611	4.486	4.356	4.222	4.083	3.939	3.792	3.639	3.483	3.321	4.243
930	4.717	4.597	4.472	4.343	4.209	4.071	3.929	3.782	3.630	3.474	3.314	4.231
940	4.702	4.583	4.459	4.330	4.197	4.060	3.918	3.772	3.621	3.466	3.306	4.219
950	4.687	4.568	4.445	4.317	4.185	4.049	3.908	3.762	3.612	3.458	3.299	4.207
960	4.672					4.038	3.898	3.753		3.450	3.292	4.195
970	4.657										3.286	
980	4.641										3.280	
990											3.275	

Two-dimensional equation and statistical parameters

$$\rho = a + bT + cC^2 + dTC + eCT^2$$

a	$b \cdot 10^3$	$c \cdot 10^5$	$d \cdot 10^5$	$e \cdot 10^8$	Max. percent departure	Stand. error of est.
6.12822	−1.51722	−2.23281	−3.28610	2.16864	0.36% (788.2 K 58.2 mol % $CdCl_2$)	0.13%

These values are based on the work of Boardman et al. (dilatometric method) [26]. C = mol % $CdCl_2$.

TABLE 276. $CdCl_2$-$PbCl_2$: Density (g cm^{-3})

	Mol percent $PbCl_2$					
T	100	79.4	67.2	41.8	20.1	0
760			4.545			
770			4.531			
780			4.518			
790	4.927		4.504	4.116		
800	4.912		4.490	4.104		
810	4.897		4.476	4.093		
820	4.882	4.620	4.462	4.081	3.747	
830	4.867	4.606	4.448	4.069	3.737	
840	4.852	4.592	4.434	4.057	3.727	
850	4.837	4.577	4.420	4.045	3.717	
860	4.822	4.563	4.406	4.034	3.706	3.377
870	4.807	4.549	4.392	4.022	3.696	3.369
880	4.792	4.534	4.378	4.010	3.686	3.360
890	4.777	4.520	4.365	3.998	3.676	3.352
900	4.762	4.506	4.351	3.986	3.666	3.343
910	4.747	4.491	4.337	3.975	3.655	3.335
920	4.732	4.477	4.323	3.963	3.645	3.327
930	4.717	4.463	4.309	3.951	3.635	3.318
940	4.702	4.449	4.295	3.939	3.625	3.310
950	4.687	4.434	4.281	3.927	3.615	3.301
960	4.672			3.916		3.293
970	4.657			3.904		3.285
980	4.642					3.276
990						3.268

Temperature-dependent equations

$$\rho = a + bT$$

Mol % $PbCl_2$	a	$b \cdot 10^4$
0	4.099	− 8.4
20.1	4.584	−10.2
41.8	5.048	−11.8
67.2	5.602	−13.9
79.4	5.793	−14.3
100	6.112	−15.0

These values are based on the work of Boardman et al. (dilatometric method) [26].

TABLE 277. Viscosity studies: $CdCl_2$-$PbCl_2$

Investigations critically re-examined		
Ref.	$PbCl_2$ Mol %	Temp. range (T)
36[a]	0–100	713–853
206	50–80	753

Deviations from previous NSRDS recommendations: [1, pp. 11, 13]			
Ref.	$PbCl_2$ Mol %	Min. departure	Max. departure
36	100	−4.0% (953 K)	−16.6% (873 K)
36	0	0.0% (948 K)	0.87% (873 K)

[a]Harrap and Heymann [36] measured viscosities using a capillary viscometer constructed from B.T.H.—C14 glass and calibrated with molten potassium nitrate.

TABLE 278. $CdCl_2$-$PbCl_2$: Viscosity (cp)

	Mol percent $PbCl_2$					
T	100	74.9	64.2	51.8	25.4	0
720			5.31			
730			4.97			
740			4.65			
750			4.36			
760		4.54	4.10	3.99		
770		4.31	3.86	3.80		
780		4.08	3.64	3.62		
790		3.87	3.45	3.44		
800	4.02	3.67	3.27	3.28		
810	3.80	3.49	3.12	3.13		
820	3.61	3.31	2.98	2.98		
830	3.43	3.15	2.85	2.84		
840	3.26	3.00	2.74	2.71	[2.57]	
850	3.10	2.86	2.64	2.60	[2.47]	
860	2.95	2.73	2.55	2.48	[2.37]	
870	2.82	2.61	2.47	2.38	[2.29]	
880	2.69	2.50	2.39	2.29	[2.21]	2.27
890	2.57	2.41	2.32	2.21	[2.14]	2.21
900	2.46	2.32	2.26	2.13	[2.07]	2.15
910	2.36	2.25	2.19	2.06	[2.02]	2.10
920	2.26	2.19	2.13	2.00	[1.97]	2.05
930	2.17	2.13	2.06	1.95	[1.92]	2.00
940	2.08	2.09	1.99	1.91	[1.89]	1.96
950	2.00	2.06	1.92	1.88	[1.86]	1.91

Temperature-dependent equations

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

$$\eta = A \cdot \exp\ (E/RT)$$

Mol % $PbCl_2$	a	$b \cdot 10$	$c \cdot 10^4$	$d \cdot 10^8$	$A \cdot 10^2$	E (cal mol^{-1})	Stand. error of est.
0.0					22.47	4041	0.24%
25.4	[55.1409]	[−1.3302]	[1.0572]	[−2.6042]			
51.8	49.6580	−1.0583	0.6711	−0.9114			1.28%
64.2	214.700	−6.8724	7.4766	−27.3707			8.76%
74.9	71.2361	−1.6607	1.2262	−2.5744			1.82%
100.0					4.915	6999	1.37%

TABLE 279. Surface tension studies: $CdCl_2$-$PbCl_2$

Investigations critically re-examined		
Ref.	$PbCl_2$ Mol %	Temp. range (T)
234[a]	0–100 (g)	873, 973

[a]Data were presented in graphical form. The capillary was drawn from British-Thomson-Houston C46 glass tubing, and the calibration was preformed with tap water. After each series of measurements on a particular mixture, the capillary was recalibrated. The maximum uncertainty was given by the authors [**234**] as ±1%.

TABLE 280. $CdCl_2$-$PbCl_2$: Surface tension (dyn cm^{-1})

Mol % $PbCl_2$	873 K	973 K
0	83.4	81.2
10	86.8	84.3
20	90.7	87.5
30	94.0	90.5
40	98.7	94.0
50	103.0	97.5
60	107.0	101.0
70	112.0	104.5
80	116.5	108.5
90	122.0	112.7
100	127.5	117.0

These values have been interpolated to three significant figures from the graphical presentation of Boardman, Palmer, and Heymann (maximum bubble pressure method) [**234**].

$CdCl_2$-RbCl

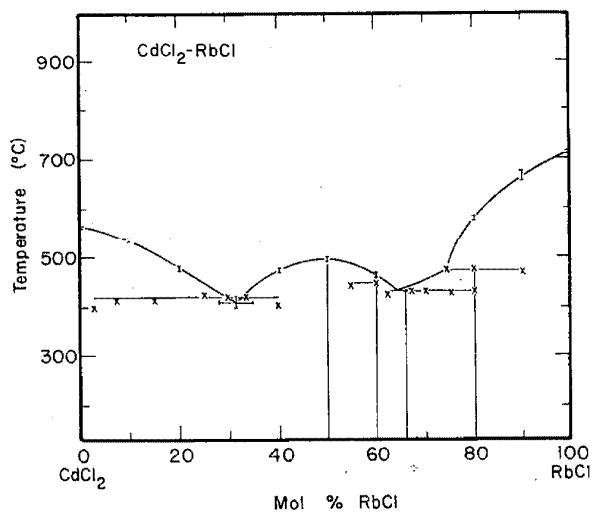


FIGURE 36. Temperature-composition phase diagram for $CdCl_2$-RbCl.

F. Hofmann, Neues Jahrb. Min. Abt., **55**, 149–62 (1926–7).

B. P. Dergunov, Doklady Akad. Nauk. U.S.S.R., **64**, 516–20 (1949).

Melt Preparation and Purification

Preparation of pure $CdCl_2$ described by Bloom et al. [**103**] is discussed under the system $CdCl_2$-CsCl. Koch-Light RbCl was used without further purification. Standard methods of analysis were used for the pure materials as well as the molten mixtures.

TABLE 281. Density studies: $CdCl_2$-RbCl

Investigations critically re-examined				
Ref.	RbCl Mol %	Temp. range (T)	Cell material	Calibration
103	0–100	857–1198	Sinker of 10% Rh-Pt, Pt suspension wire	Water

Deviations from previous NSRDS recommendations: [1, p. 6]			
Ref.	RbCl Mol %	Min. departure	Max. departure
103	100	0.10% (100 K)	0.41% (1198 K)

TABLE 282. $CdCl_2$-RbCl: Density (g cm^{-3})

	Mol percent RbCl							
T	100.0	89.7	77.4	62.3	51.2	39.9	25.6	0.0
860						2.901		
875					2.747	2.887		
890					2.734	2.872	3.081	
905				2.595	2.720	2.857	3.067	
920				2.582	2.707	2.842	3.053	3.323
935			2.443	2.569	2.693	2.827	3.039	3.311
950			2.430	2.557	2.680	2.812	3.025	3.299
965			2.418	2.544	2.667	2.797	3.011	3.287
980			2.405	2.531	2.653	2.783	2.997	3.275
995	2.244		2.392	2.518	2.640	2.768	2.983	3.263
1010	2.231	2.321	2.379	2.505	2.627	2.753	2.969	3.251
1025	2.219	2.309	2.366	2.493	2.613	2.738	2.955	3.239
1040	2.206	2.296	2.353		2.600	2.723	2.941	3.227
1055	2.193	2.283	2.341		2.587		2.926	3.215
1070	2.180	2.271	2.328				2.912	3.203
1085	2.167	2.258	2.315					
1100	2.155	2.245						
1115	2.142	2.233						
1130	2.129	2.220						
1145	2.116	2.207						
1160	2.103	2.194						
1175	2.091	2.182						

Temperature-dependent equations

$$\rho = a + bT$$

Mol % RbCl	a	$b \cdot 10^3$	Stand. deviation
0.0	4.059	−0.800	
25.6	3.915	−0.937	0.0006
39.9	3.754	−0.991	0.0006
51.2	3.526	−0.890	0.0009
62.3	3.367	−0.853	0.0006
77.4	3.243	−0.855	0.0006
89.7	3.177	−0.847	0.0006
100.0	3.092	−0.852	0.0007

These values are based on the work of Bloom et al. (Archimedean method) [**103**].

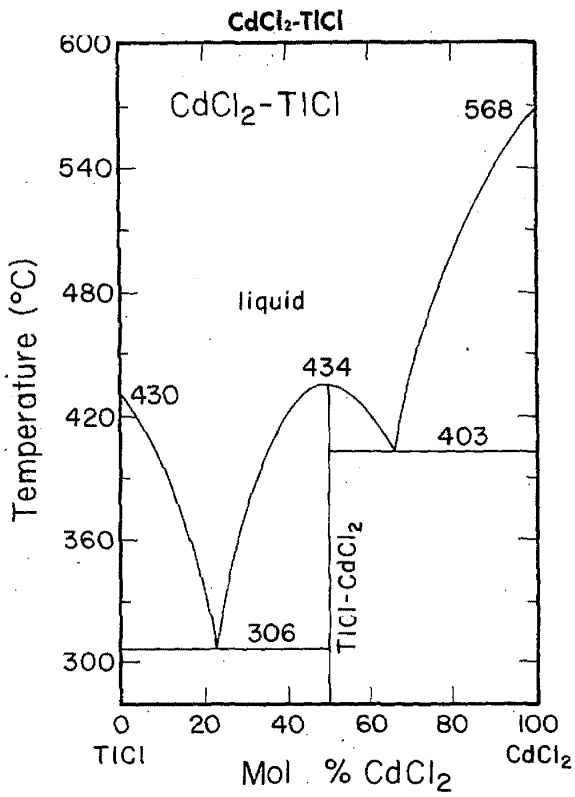


FIGURE 37. Temperature-composition phase diagram for $CdCl_2$-TlCl.

A. P. Polkin and I. P. Palyura, Zh. Neorgan. Khim., 4, [11], 253 (1959).

TABLE 283. Electrical conductance studies: $CdCl_2$-TlCl

Investigations critically re-examined			
Ref.	TlCl Mol %	Temp. range (T)	Comments
12	0–100	873, 973	Cell material: silica and quartz U-tubes; Pt electrodes; calibration: 1N KCl
14	35–100	733–773	Cell material: glass cell; Pt electrodes; freq. range: 1200 Hz; calibration: molten KNO_3
70	20 110	733–783	Cell material: Pyrex cell; Pt electrodes; calibration: 0.1N and 0.01N NaCl solutions

Comparison with NSRDS recommendations [1, p 12 and this volume]

Ref.	TlCl Mol %	Min. departure	Max. departure
12	100	0.47% (873 K)	− 2.5% (973 K)
14	100	2.0% (756 K)	2.2% (773 K)
70	100	0.22% (773 K)	1.9% (733 K)
70	100	−0.33% (733 K)	− 2.5% (773 K)
70	70	4.8% (733 K)	9.0% (773 K)
70	60	0.0% (733 K)	2.8% (773 K)
70	57.5	−0.9% (753 K)	3.2% (773 K)
70	55	−0.88% (773 K)	− 2.7% (733 K)
70	52.5	−2.8% (763 K)	− 4.0% (743 K)
70	50	−6.2% (773 K)	− 7.6% (733 K)
70	45	−5.8% (773 K)	−12.0% (733 K)
70	40	−0.41% (773 K)	− 7.7% (733 K)

TABLE 284. $CdCl_2$-TlCl: Specific conductance ($ohm^{-1}\ cm^{-1}$)

	Mol percent TlCl											
T	100	75	70	65	60	57.5	55	52.5	50	45	40	35
735	1.237	1.046	1.030	1.018	1.016	1.023	1.032	1.039	1.055	1.082	1.096	1.126
740	1.254	1.060	1.044	1.032	1.030	1.037	1.046	1.054	1.071	1.096	1.112	1.142
745	1.272	1.074	1.059	1.046	1.044	1.051	1.060	1.068	1.086	1.110	1.128	1.158
750	1.290	1.088	1.073	1.059	1.058	1.065	1.074	1.083	1.102	1.124	1.145	1.174
755	1.309	1.103	1.088	1.073	1.072	1.079	1.088	1.097	1.117	1.139	1.161	1.190
760	1.328	1.117	1.102	1.087	1.086	1.093	1.103	1.112	1.132	1.155	1.178	1.206
765	1.348	1.132	1.117	1.101	1.100	1.107	1.117	1.126	1.148	1.171	1.194	1.222
770	1.368	1.146	1.131	1.114	1.114	1.121	1.131	1.141	1.163	1.188	1.210	1.238

Temperature-dependent equations

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

Mol % TlCl	$a \cdot 10^1$	$b \cdot 10^4$	$c \cdot 10^6$	Stand. error of est.
35	− 2.5790	6.0841	1.7336	0.02%
40	−13.153	32.800	0	0.11%
45	60.754	−161.62	12.746	0.09%
50	−12.085	30.800	0	0.04%
52.5	−10.922	29.000	0	0.00%
55	−10.633	28.501	0	0.04%
57.5	−10.348	28.000	0	0.04%
60	−10.646	28.300	0	0.05%
65	−10.031	27.500	0	0.03%
70	−10.866	28.800	0	0.08%
75	6.5343	−16.910	3.0277	0.04%
100	27.778	−76.773	7.5924	0.07%

These values are based on the work of Protsenko and Popovskaya (classical ac technique) [14].

TABLE 285. Density studies: $CdCl_2$-TlCl

Investigations critically re-examined				
Ref.	TlCl Mol %	Temp. range (T)	Cell material	Calibration
195	0–100	673–968	Quartz float (W core), Pt suspension wire	Distilled water
204	0–100 (g)	873	Pt float	

Deviations from previous NSRDS recommendations: [1, pp. 11, 12]			
Ref.	TlCl Mol %	Min. departure	Max. departure
195	100	0.00% (780 K)	−0.12% (720 K)
195	0	0.00% (960 K)	0.06% (890 K)

TABLE 286. $CdCl_2$-TlCl: Density (g cm^{-3})

Mol percent TlCl												
T	100	90	80	70	60	50	40	30	20	10	0	78
680			5.083									
690		5.364	5.067	4.816								5.013
700		5.348	5.051	4.801								4.998
710		5.331	5.035	4.786	4.572		4.207					4.982
720		5.314	5.019	4.770	4.558	4.370	4.196					4.965
730	5.652	5.297	5.002	4.754	4.543	4.357	4.184	4.014				4.949
740	5.634	5.280	4.985	4.738	4.528	4.343	4.172	4.004				4.932
750	5.617	5.262	4.968	4.722	4.513	4.329	4.160	3.994				4.915
760	5.599	5.245	4.951	4.706	4.498	4.315	4.148	3.983				4.898
770	5.580	5.227	4.933	4.689	4.482	4.301	4.135	3.973				4.881
780	5.562							3.962				
790									3.785			
800									3.776			
810									3.767			
820									3.758			
830												
840										3.567		
850										3.559		
860										3.551		
870										3.543		
880										3.535	3.347	
890											3.342	
900											3.336	
910											3.330	
920											3.324	
930											3.317	
940											3.310	
950											3.303	
960											3.296	

Two-dimensional equation and statistical parameters

$$\rho = a + bC + cT^2 + dC^2 + eC^3 + fTC^2$$

a	$b \cdot 10^2$	$c \cdot 10^6$	$d \cdot 10^4$	$e \cdot 10^6$	$f \cdot 10^7$	Max. percent departure	Stand. error of est.
6.28372	−3.87720	−1.18610	2.39428	−1.89636	1.54676	0.43% (814.2 K, 80 mol % $CdCl_2$)	0.23%

These values are based on the work of Markov et al. (Archimedean method) [**195**]. C = mol % $CdCl_2$.

TABLE 287. $CdCl_2$-TlCl: Density

Mol percent TlCl										
T	100	90	80	70	60	50	40	30	20	0
680			5.089							
690		5.346	5.072	4.822						
700		5.328	5.054	4.806			4.228			
710		5.311	5.037	4.790	4.572		4.214			

TABLE 287. $CdCl_2$-TlCl: Density—Continued

	Mol percent TlCl									
T	100	90	80	70	60	50	40	30	20	0
720		5.294	5.020	4.774	4.558	4.377	4.200			
730	5.664	5.276	5.003	4.758	4.544	4.363	4.187	4.014		
740	5.647	5.259	4.986	4.742	4.529	4.349	4.173	4.002		
750	5.630	5.241	4.968	4.726	4.515	4.335	4.160	3.989		
760	5.613	5.224	4.951	4.710	4.500	4.321	4.146	3.977		
770	5.596	5.207	4.934	4.694	4.486	4.307	4.132	3.964		
780	5.580							3.952		
790									3.774	
800									3.763	
810									3.752	
820									3.740	
830										
840										
850										
860										
870										
880										3.358
890										3.350
900										3.341
910										3.333
920										3.325
930										3.316
940										3.308
950										3.299
960										3.291

Temperature-dependent equations

$\rho = a + bT$

Mol % TlCl	a	$b \cdot 10^4$
0	4.098	− 8.40
20	4.661	−11.22
30	4.922	−12.43
40	5.180	−13.60
50	5.398	−14.18
60	5.593	−14.37
70	5.931	−16.07
80	6.259	−17.21
90	6.548	−17.42
100	6.892	−16.82

These values are based on the work of Markov et al. (Archimedean method) [195].

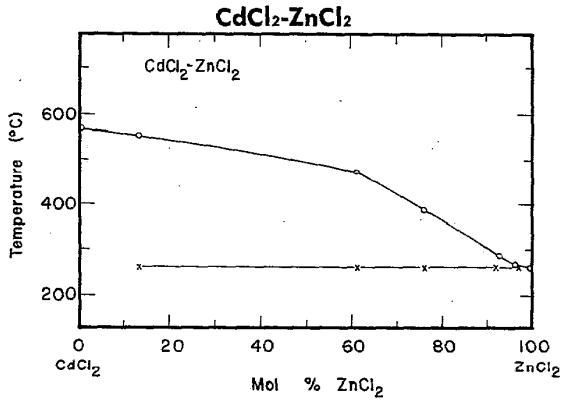


FIGURE 38. Temperature-composition phase diagram for $CdCl_2$-$ZnCl_2$.

G. Herrmann, Z. anorg. Chem., 71, 257–302 (1911).

Melt Preparation and Purification

Markov et al. [93] used "analytical" grade cadmium and zinc chloride, which were further purified by recrystallization and dehydration with anhydrous hydrogen chloride. Hydrogen chloride gas was removed from the melt with dry argon. Zinc chloride was distilled from a quartz retort into ampoules. The salt mixtures were weighed and prepared in a dry chamber, and were transferred to the quartz floats under an atmosphere of dry argon.

TABLE 288. Density studies: $CdCl_2$-$ZnCl_2$

Investigations critically re-examined

Ref.	$ZnCl_2$ Mol %	Temp. range (T)	Cell material	Calibration
93	0–100	628–968	Quartz ball (containing tungsten for weight)	Water and carbon tetrachloride

Deviations from previous NSRDS recommendations: [1, pp. 10, 11]

Ref.	$ZnCl_2$ Mol %	Min. departure	Max. departure
93	100	0.0% (680 K)	−0.24% (760 K)
93	0	1.32% (920 K)	1.37% (880 K)

Comment: Markov et al. [**93**] made no corrections for the expansion of the quartz float since the errors involved were considerably less than the accuracy of the density measurements (±0.2%). The volume of the floats was checked after each experiment.

TABLE 289. $CdCl_2$-$ZnCl_2$: Density (g cm^{-3})

	Mol percent $ZnCl_2$											
T	100	90	80	70	60	50	40	30	20	10	0	92
630	2.502											
645	2.496											
660	2.489	2.587										2.567
675	2.481	2.580										2.560
690	2.474	2.572										2.553
705	2.467	2.565	2.663									2.545
720	2.459	2.557	2.655									2.538
735	2.451	2.549	2.647	2.746								2.530
750	2.443	2.541	2.640	2.738								2.522
765		2.533	2.631	2.730								2.514
780		2.525	2.623	2.721	2.819							2.506
795		2.517	2.615	2.713	2.811							
810		2.508	2.606	2.704	2.802	2.900						
825		2.499	2.598	2.696	2.794	2.892						
840		2.491	2.589	2.687	2.785	2.883						
855					2.776	2.874	2.972	3.070				
870					2.767	2.865	2.963	3.061	3.159	3.257		
885					2.757	2.855	2.953	3.051	3.149	3.247	3.346	
900							2.944	3.042	3.140	3.238	3.336	
915							2.934	3.032	3.130	3.228	3.326	
930											3.316	
945											3.306	
960											3.296	

Two-dimensional equation and statistical parameters

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

a	$b \cdot 10^3$	$c \cdot 10^7$	Max. percent departure	Stand. error of est.
2.64349	9.80560	−3.55640	−0.34% (843.2 K, 10 mol % $CdCl_2$)	0.11%

These values are based on the work of Markov et al. (Archimedean method) [**193**].

TABLE 290. $CdCl_2$-$ZnCl_2$: Density (g cm^{-3})

	Mol percent $ZnCl_2$										
T	100	90	82	70	60	50	40	30	20	10	0
630	2.503										
640	2.498										
650	2.493	2.593									
660	2.488	2.588									
670	2.483	2.583									
680	2.478	2.578									
690	2.473	2.573									
700	2.468	2.568	2.643								
710	2.463	2.563	2.638								
720	2.458	2.558	2.633								
730	2.453	2.553	2.628	2.745							
740	2.448	2.548	2.623	2.739							
750	2.443	2.543	2.618	2.734							
760	2.438	2.539	2.613	2.729							
770		2.534	2.608	2.723							
780		2.529	2.603	2.718	2.818						
790		2.524	2.597	2.713	2.812						
800		2.519	2.592	2.707	2.807	2.908					
810		2.514	2.587	2.702	2.801	2.902					
820		2.509	2.582	2.696	2.795	2.896					
830		2.504	2.577	2.691	2.790	2.890					
840		2.499	2.572	2.686	2.784	2.884					
850					2.778	2.878	2.972	3.073			
860					2.772	2.872	2.965	3.067	3.165	3.269	
870					2.767	2.866	2.959	3.060	3.158	3.261	
880					2.761	2.860	2.953	3.053	3.151	3.254	3.358
890					2.755		2.946	3.047	3.144	3.246	3.350
900							2.940	3.040	3.137	3.238	3.341
910							2.933	3.033	3.129	3.231	3.333
920							2.927	3.027	3.122	3.223	3.325
930											3.316
940											3.308
950											3.299
960											3.291

Temperature-dependent equations

$\rho = a + bT$

Mol % $ZnCl_2$	a	$b \cdot 10^4$
0	4.098	−8.40
10	3.920	−7.57
20	3.785	−7.20
30	3.643	−6.70
40	3.516	−6.40
50	3.388	−6.00
60	3.263	−5.70
70	3.135	−5.35
80	2.997	−5.06
90	2.916	−4.96
100	2.822	−5.06

These values are based on the work of Markov et al. (Archimedean method) [93].

$CeCl_3$-KCl

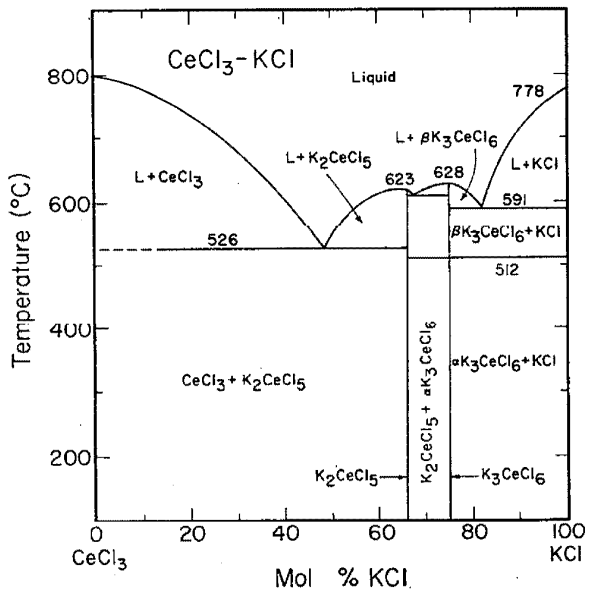


FIGURE 39. Temperature-composition phase diagram for $CeCl_3$-KCl.

Ir-Chzhu Sun and I. S. Mordzov, Zhur. Neorg. Khim., 3, 1916 (1958).

Melt Preparation and Purification

Smirnov and Lbov [**106**] used "chemically pure" recrystallized KCl. The $CeCl_3$ was dehydrated by heating with an excess of NH_4Cl at reduced pressure. The temperature was gradually increased until the salt melted and NH_4Cl vapors ceased to appear.

TABLE 291. Density studies: $CeCl_3$-KCl

Investigations critically re-examined			
Ref.	KCl Mol %	Temp. range (T)	Comments
106[a]	0–100[b]	1073–1173	Cell material: tungsten float; calibration: molten KCl

Deviations from previous NSRDS recommendations: [1, p. 8]			
Ref.	KCl Mol %	Min. departure	Max. departure
106	0	0.0% (1100 K)	−0.16% (1160 K)

[a]Smirnov and Lbov [**106**] checked the reliability of their method by density measurements on molten NaCl in the temperature range of interest. The values obtained agreed to ±1% with the literature data of Yaffe and Van Artsdalen (J. Phys. Chem., **60**, 1125, 1956). The authors report an accuracy of ±0.002 g cm^{-3} in the density values for their mixtures.

[b]Data at 100 mol % KCl reported graphically.

TABLE 292. $CeCl_3$-KCl: Density (g cm^{-3})

	Mol percent KCl							
T	90	80	75	60	45	30	15	0
1075	1.827	2.117	2.246	2.476	2.677	2.878	3.064	3.261
1080	1.823	2.113	2.242	2.472	2.673	2.873	3.059	3.256
1085	1.820	2.110	2.238	2.468	2.669	2.869	3.055	3.251
1090	1.816	2.106	2.235	2.465	2.665	2.864	3.050	3.246
1095	1.813	2.103	2.231	2.461	2.661	2.860	3.046	3.241
1100	1.810	2.099	2.227	2.457	2.658	2.856	3.041	3.236
1105	1.806	2.096	2.223	2.453	2.654	2.851	3.037	3.231
1110	1.803	2.092	2.220	2.449	2.650	2.847	3.033	3.226
1115	1.799	2.089	2.216	2.445	2.646	2.842	3.028	3.221
1120	1.796	2.085	2.212	2.441	2.642	2.838	3.024	3.216
1125	1.792	2.082	2.208	2.438	2.638	2.833	3.019	3.211
1130	1.789	2.078	2.204	2.434	2.634	2.829	3.015	3.206
1135	1.785	2.075	2.201	2.430	2.630	2.825	3.010	3.201
1140	1.782	2.071	2.197	2.426	2.626	2.820	3.006	3.196
1145	1.778	2.068	2.193	2.422	2.622	2.816	3.002	3.191
1150	1.775	2.064	2.189	2.418	2.618	2.811	2.997	3.186
1155	1.771	2.061	2.185	2.414	2.614	2.807	2.993	3.181
1160	1.768	2.057	2.182	2.410	2.610	2.802	2.988	3.176
1165	1.764	2.054	2.178	2.407	2.606	2.798	2.984	3.171
1170	1.761	2.050	2.174	2.403	2.603	2.794	2.979	3.166

Temperature-dependent equations

$$\rho = a + bT$$

Mol % KCl	a	$b \cdot 10^3$
0	4.336	−1.000
15	4.016	−0.886
30	3.829	−0.885
45	3.521	−0.785
60	3.306	−0.772
75	3.062	−0.759
80	2.868	−0.699
90	2.574	−0.695

These values are based on the work of Smirnov and Lbov (Archimedean method) [**106**].

CsCl-GaCl₃

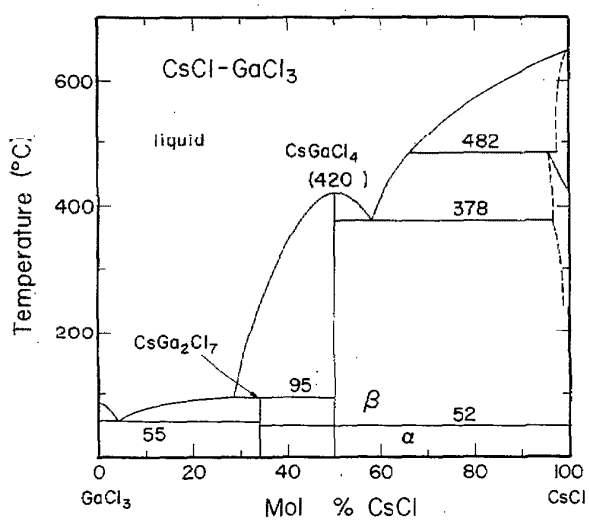


FIGURE 40. Temperature-composition phase diagram for $CsCl-GaCl_3$.

P. I. Fedrov and V. V. Tsimbalist, Zh. Neorgan. Khim., 9, [7], 1676 (1964); Russ. J. Inorgan. Chem. (English Translation), 910 (1964).

TABLE 293. Electrical conductance studies: $CsCl-GaCl_3$

Investigations critically re-examined			
Ref.	$GaCl_3$ Mol %	Temp. range (T)	Comments
80[a]	10–98 (g)	373–973	Cell material: quartz or Pyrex, depending on temperature range; calibration: molten KCl, 0.1N and 1.0N KCl solutions

[a]Arbekov and Petrov [**80**] reported a 2% accuracy in their measurements and found differences of up to 5% in calibrating their cell depending upon the solution used.

TABLE 294. $CsCl-GaCl_3$: Specific conductance ($ohm^{-1}\ cm^{-1}$)

Mol % $GaCl_3$	373 K	473 K	573 K	673 K	773 K	873 K	973 K
10							1.00
20						0.67	0.78
30						0.53	0.64
40					0.41	0.50	0.60
50				0.33	0.43	0.54	0.67
60				0.32	0.43	0.54	0.65
70			0.20	0.29	0.40	0.50	
80	0.04	0.09	0.16	0.23	0.34		
90	0.03	0.05	0.10	0.16			
100	<0.01	<0.01					

These values have been interpolated to two significant figures from the graphical presentation of Arbekov and Petrov (classical ac technique) [**80**].

CsCl-KCl

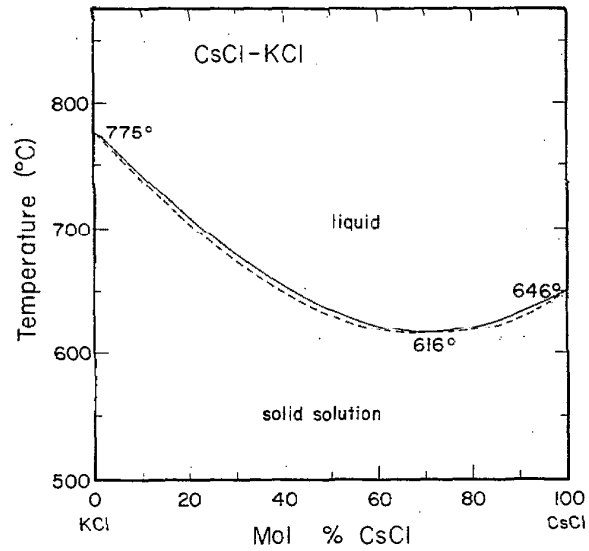


FIGURE 41. Temperature-composition phase diagram for CsCl-KCl.

O. S. Dombrovkaya, Zh. Obshch. Khim., 3 [8], 1019 (1933).

Melt Preparation and Purification

Salts used in reference [**98**] were Merck p.a. reagents and were purified by the procedure described under the system CsCl-LiCl.

TABLE 295. Electrical conductance studies: CsCl-KCl

Investigations critically re-examined			
Ref.	KCl Mol %	Temp. range (T)	Comments
98[a]	0, 25, 50, 75, 100	943–1193	Cell material: quartz or silica glass capillary cell; Pt electrodes; freq. range: 1000–7000 Hz; calibration: 0.1M and 1.0M KCl solutions
218	eutectic (g)	890–1273	

Deviations from previous NSRDS recommendations: [I, pp. 5, 6]			
Ref.	KCl Mol %	Min. departure	Max. departure
98	100	0.04% (1180 K)	−0.31% (1080 K)
98	0	0.68% (940 K)	−8.10% (1090 K)

[a]Zuca and Olteanu [**98**] report, in addition to experimental specific conductivities, Arrhenius equations (equivalent conductance as a function of temperature) with standard deviations for E_λ, the activation energy, in the range: 1.0×10^{-2} Kcal mol^{-1} (0 mole % KCl, $E_\lambda = 4.0$ Kcal mol^{-1}) to 2.9×10^{-2} Kcal mol^{-1} (75 mole % KCl, $E_\lambda = 3.69$ Kcal mol^{-1}).

TABLE 296. CsCl-KCl: Specific conductance (ohm^{-1} cm^{-1})

	Mol percent KCl				
T	100	75	50	25	0
950					1.197
960					1.219
970					1.241
980					1.262
990					1.284
1000					1.305
1010					1.326
1020					1.346
1030			1.623		1.367
1040			1.644		1.387
1050			1.666		1.407
1060	2.198	1.895	1.687		1.427
1070	2.223	1.919	1.708	1.569	1.447
1080	2.249	1.943	1.730	1.588	1.466
1090	2.273	1.966	1.751	1.607	1.485
1100	2.298	1.989	1.772	1.626	
1110	2.322	2.011	1.793	1.644	
1120	2.346	2.033	1.815	1.663	
1130	2.369	2.054	1.836	1.682	
1140	2.392	2.075	1.857	1.701	
1150	2.415	2.095	1.879	1.720	
1160	2.437	2.115			
1170	2.459				
1180	2.480				
1190	2.501				

Temperature-dependent equations

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

Mol % KCl	a	$b \cdot 10^3$	$c \cdot 10^6$	Stand. error of est.
0	−1.9170	4.3411	−1.1192	0.02%
25	−0.4635	1.8990	0	0.10%
50	−0.5701	2.1293	0	0.13%
75	−3.4350	7.6141	−2.4396	0.09%
100	−2.9614	7.1219	−2.1277	0.02%

These values are based on the work of Zuca and Olteanu (classical ac technique) [98].

TABLE 297. Density studies: CsCl-KCl

Investigations critically re-examined

Ref.	KCl Mol %	Temp. range (T)	Comments
98[a]	0, 25, 50, 75, 100	933–1213	Cell material: Pt ball; calibration: water

Deviations from previous NSRDS recommendations: [1, pp. 5, 6]

Ref.	KCl Mol %	Min. departure	Max. departure
98	100	0.01% (1100 K)	0.18% (1200 K)
98	0	0.30% (1040 K)	0.36% (960 K)

[a]Density results in reference [98] were reported as linear temperature dependent equations with standard deviations in the range: 2×10^{-4} g cm^{-3} (0 mol % KCl) to 8×10^{-4} g cm^{-3} (100 mol % KCl).

TABLE 298. CsCl-KCl: Density (g cm^{-3})

	Mol percent KCl										
T	100	90	80	70	60	50	40	30	20	10	0
940											2.782
950										2.672	2.771
960									2.559	2.662	2.760
970								2.443	2.549	2.651	2.748
980								2.434	2.539	2.640	2.737
990							2.315	2.425	2.529	2.630	2.726
1000						2.193	2.306	2.415	2.520	2.619	2.714
1010					2.067	2.185	2.298	2.406	2.510	2.609	2.703
1020				1.938	2.060	2.177	2.289	2.397	2.500	2.598	2.692
1030				1.931	2.052	2.168	2.280	2.387	2.490	2.587	2.680
1040			1.798	1.924	2.044	2.160	2.271	2.378	2.480	2.577	2.669
1050		1.661	1.791	1.916	2.037	2.152	2.263	2.369	2.470	2.566	2.657
1060	1.520	1.655	1.784	1.909	2.029	2.144	2.254	2.359	2.459	2.555	2.646
1070	1.514	1.648	1.778	1.902	2.021	2.136	2.245	2.350	2.449	2.544	2.634
1080	1.508	1.642	1.771	1.895	2.013	2.127	2.236	2.340	2.439	2.533	2.622
1090	1.502	1.636	1.764	1.887	2.006	2.119	2.227	2.331	2.429	2.522	2.611
1100	1.496	1.629	1.757	1.880	1.998	2.111	2.219	2.321	2.419	2.512	
1110	1.490	1.623	1.750	1.873	1.990	2.102	2.210	2.312	2.409	2.502	
1120	1.484	1.616	1.744	1.866	1.982	2.094	2.201	2.302	2.399		
1130	1.478	1.610	1.737	1.858	1.975	2.086	2.192	2.293	2.388		
1140	1.472	1.604	1.730	1.851	1.967	2.077	2.183	2.283			

TABLE 298. CsCl-KCl: Density (g cm^{-3})—Continued

	Mol percent KCl										
T	100	90	80	70	60	50	40	30	20	10	0
1150	1.466	1.597	1.723								
1160											
1170											
1180	1.448	1.578									
1190	1.442										
1200	1.436										
1210	1.429										

Two-dimensional equation and statistical parameters

$$\rho = a + bT + cC + dTC^2 + eCT^2$$

a	$b \cdot 10^4$	$c \cdot 10^2$	$d \cdot 10^8$	$e \cdot 10^9$	Max. percent departure	Stand. error of est.
2.16370	−6.06810	1.53705	−2.29426	−1.50186	0.36% (993.2 K, 50 mol % KCl)	−0.16%

These values are based on the work of Zuca and Olteanu (Archimedean method) [98]. C = mol % CsCl.

TABLE 299. CsCl-KCl: Density (g cm^{-3})

	Mol percent KCl				
T	100	75	50	25	0
940					2.779
950					2.768
960					2.757
970				2.497	2.746
980				2.487	2.736
990				2.477	2.725
1000			2.200	2.467	2.714
1010			2.192	2.457	2.703
1020			2.183	2.447	2.692
1030		1.870	2.174	2.437	2.681
1040		1.862	2.165	2.427	2.670
1050		1.855	2.156	2.417	2.660
1060	1.517	1.847	2.147	2.408	2.649
1070	1.512	1.839	2.139	2.398	2.638
1080	1.506	1.832	2.130	2.388	2.627
1090	1.500	1.824	2.121	2.378	2.616
1100	1.495	1.816	2.112	2.368	
1110	1.489	1.809	2.103	2.358	
1120	1.484	1.801	2.094	2.348	
1130	1.478	1.793	2.085	2.338	
1140	1.472	1.786	2.077	2.328	
1150	1.467				
1160	1.461				
1170	1.456				
1180	1.450				
1190	1.445				
1200	1.439				
1210	1.433				

Temperature-dependent equations

$$\rho = a + bT$$

Mol % KCl	a	$b \cdot 10^3$	Stand. dev.
100	3.7987	−1.0849	0.0008
75	3.4567	−0.9898	0.0007
50	3.0844	−0.8840	0.0006
25	2.6582	−0.7654	0.0006
0	2.1089	−0.5583	0.0002

These values are based on the work of Zuca and Olteanu (Archimedean method) [98].

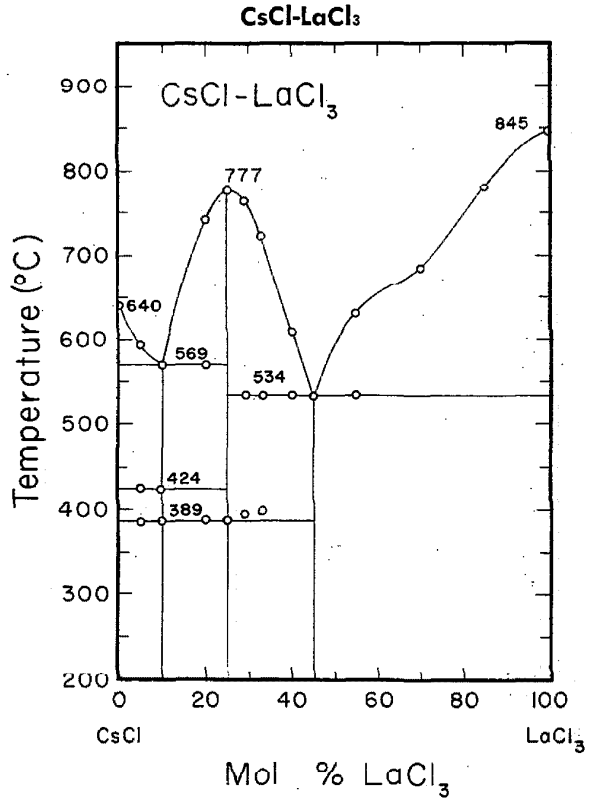


FIGURE 42. Temperature-composition phase diagram for CsCl-LaCl$_3$.

S. In-Chzhu and I. S. Morozov, Zhur. Neorg. Khim., 3, 1914 (1958).

Melt Preparation and Purification

Smirnov and Khokhlov [154] and Smirnov and Stepanov [177] used "pure" CsCl which was recrystal-

lized from distilled water. The preparation of pure $LaCl_3$ is described under the system $LaCl_2$-$LaCl_3$.

Smirnov and Khokhlov [173] used CsCl which was recrystallized twice from distilled water and dried under vacuum in an argon atmosphere. Lanthanum trichloride was prepared from the hexahydrate salt by drying with NH_4Cl, followed by fusion under argon.

Smirnov and Stepanov [177] used recrystallized CsCl and their preparation of pure $LaCl_3$ is described under the system $LaCl_2$-$LaCl_3$.

The preparation of pure $LaCl_3$ in reference [186] is described under the system KCl-$NdCl_3$.

TABLE 300. Electrical conductance studies: CsCl-$LaCl_3$

Investigations critically re-examined

Ref.	$LaCl_3$ Mol %	Temp. range (T)	Comments
154	10.3–100	1073–1223	Cell material: alundum crucible inside sealed quartz tube; electrodes: Mo wire; freq. range: 50,000 Hz; calibration: molten KCl
186[a]	0–100 (g)	1195	Cell material: quartz capillary cell; Pt electrodes; freq. range: 100,000–250,000 Hz; calibration: molten CsCl, NaCl, KCl
209[a]	0–100 (g)	1120	

Deviations from previous NSRDS recommendations: [1, p. 8]

Ref.	$LaCl_3$ Mol %	Min. departure	Max. departure
154	100	−15.5% (1140 K)	−16.7% (1220 K)

[a]Equivalent conductivities were reported.

Comment: Smirnov and Khokhlov [**154**] reported their results in the form of linear temperature dependent equations ($\kappa = a + bt$) with standard deviations in the range: 2×10^{-3} ohm^{-1} cm^{-1} (100 mol % $LaCl_3$) to 4×10^{-3} ohm^{-1} cm^{-1} (10.3 mol % $LaCl_3$)

TABLE 301. CsCl-$LaCl_3$: Specific conductance (ohm^{-1} cm^{-1})

	Mol % $LaCl_3$										
T	100	90.0	80.0	70.0	61.45	51.40	41.35	30.76	20.48	10.30	0
1080		1.029	0.923	0.847	0.801	0.772	0.764	0.802	0.954	1.181	
1090		1.057	0.950	0.870	0.821	0.788	0.788	0.817	0.971	1.196	1.533
1100		1.086	0.977	0.894	0.841	0.805	0.792	0.832	0.987	1.212	1.551
1110		1.114	1.003	0.917	0.861	0.822	0.807	0.847	1.004	1.228	1.569
1120		1.142	1.030	0.940	0.882	0.838	0.821	0.862	1.020	1.244	1.587
1130		1.170	1.057	0.963	0.902	0.855	0.835	0.876	1.037	1.259	1.606
1140	1.248	1.199	1.084	0.987	0.922	0.872	0.849	0.891	1.053	1.275	1.624
1150	1.273	1.227	1.110	1.010	0.942	0.888	0.863	0.906	1.070	1.291	1.642
1160	1.299	1.255	1.137	1.033	0.962	0.905	0.877	0.921	1.086	1.307	1.660
1170	1.325	1.283	1.164	1.057	0.982	0.921	0.892	0.936	1.103	1.322	1.678
1180	1.350	1.312	1.191	1.080	1.002	0.938	0.906	0.951	1.119	1.338	1.696
1190	1.376	1.340	1.217	1.103	1.022	0.955	0.920	0.965	1.136	1.354	1.714
1200	1.402	1.368	1.244	1.127	1.043	0.971	0.934	0.980	1.152	1.370	1.732
1210	1.427	1.396	1.271	1.150	1.063	0.988	0.948	0.995	1.169	1.385	1.751
1220	1.453	1.425	1.298	1.173	1.083	1.005	0.963	1.010	1.185	1.401	1.769
1230											1.787
1240											1.805

Temperature-dependent equations

$\kappa = a + bT$

Mol % $LaCl_3$	a	$b \cdot 10^3$	Standard deviation
0	−0.442	1.812	0.003
10.30	−0.520	1.575	0.004
20.48	−0.827	1.649	0.002
30.76	−0.802	1.485	0.002
41.35	−0.767	1.418	0.003
51.40	−1.023	1.662	0.002
61.45	−1.373	2.013	0.003
70.0	−1.668	2.329	0.003
80.0	−1.966	2.675	0.003
90.0	−2.022	2.825	0.003
100	−1.673	2.562	0.002

These values are based on the work of Smirnov and Khokhlov (classical ac technique) [**154**].

TABLE 302. Density studies: $CsCl-LaCl_3$

Investigations critically re-examined			
Ref.	$LaCl_3$ Mol %	Temp. range (T)	Comments
177	0–94.9	1010–1233	Cell material: Mo or Pt capillary tube and crucible

Deviations from previous NSRDS recommendations: [1, p. 6]			
Ref.	$LaCl_3$ Mol %	Min. departure	Max. departure
177	0	1.24% (1123 K)	

Comment: Smirnov and Stepanov [177] report their density data in the form of linear temperature dependent equations with standard deviations of ± 0.002 g cm^{-3}.

TABLE 303. $CsCl-LaCl_3$: Density (g cm^{-3})

	Mol % $LaCl_3$										
T	90	80	70	60	50	40	30	20	10	0	45
920										2.812	
930										2.803	
940										2.794	
950										2.785	
960										2.776	
970										2.766	
980										2.757	
990									2.773	2.747	
1000									2.764	2.738	
1010									2.754	2.728	
1020								2.768	2.744	2.718	
1030								2.758	2.734	2.708	
1040								2.748	2.723	2.698	
1050							2.765	2.738	2.713	2.688	
1060							2.755	2.728	2.703	2.677	
1070				2.857	2.812	2.775	2.744	2.717	2.692	2.667	2.793
1080				2.849	2.803	2.766	2.734	2.707	2.682		2.784
1090			2.897	2.840	2.794	2.756	2.724	2.696	2.671		2.774
1100			2.889	2.832	2.785	2.746	2.714	2.686	2.660		2.764
1110			2.882	2.823	2.775	2.736	2.703	2.675	2.649		2.755
1120			2.874	2.815	2.766	2.726	2.693	2.664	2.638		2.745
1130		2.940	2.867	2.806	2.757	2.716	2.682	2.653	2.627		2.735
1140	3.023	2.933	2.859	2.798	2.747	2.706	2.672	2.642	2.616		2.726
1150	3.018	2.927	2.851	2.789	2.738	2.696	2.661	2.631	2.605		2.716
1160	3.012	2.920	2.844	2.780	2.728	2.686	2.650	2.620	2.594		2.706
1170	3.007	2.914	2.836	2.772	2.719	2.675	2.639				2.696
1180	3.002	2.908	2.828			2.665					
1190	2.997	2.901									
1200	2.992	2.895									
1210	2.987	2.888									
1220	2.982	2.881									

Two-dimensional equation and statistical parameters

$$\rho = a + bT + cC^2 + dTC + eTC^2 + fCT^2$$

a	$b \cdot 10^4$	$c \cdot 10^7$	$d \cdot 10^6$	$e \cdot 10^8$	$f \cdot 10^9$	Max. percent departure	Stand. error of est.
3.53260	−3.54243	−3.30822	−4.28269	8.30068	−5.11690	−0.46% (873.2 K, 100 mol % CsCl)	0.17%

These values are based on the work of Smirnov and Stepanov (modified maximum bubble pressure method) [177]. C = mol % CsCl.

TABLE 304. $CsCl\text{-}LaCl_3$: Density (g cm^{-3})

	Mol % $LaCl_3$								
T	94.9	89.7	78.0	65.0	52.3	39.8	26.5	12.7	0
920									2.817
930									2.807
940									2.796
950									2.786
960									2.775
970									2.765
980									2.754
990									2.744
1000									2.733
1010									2.723
1020								2.747	2.712
1030								2.737	2.702
1040								2.726	2.692
1050							2.752	2.716	2.681
1060						2.780	2.743	2.706	2.671
1070						2.772	2.733	2.696	2.660
1080				2.867		2.763	2.724	2.686	
1090				2.859	2.802	2.754	2.714	2.676	
1100				2.852	2.794	2.745	2.705	2.666	
1110				2.844	2.786	2.737	2.695	2.655	
1120				2.837	2.777	2.728	2.686	2.645	
1130			2.923	2.829	2.769	2.719	2.677	2.635	
1140	3.080	2.023	2.916	2.822	2.761	2.710	2.667	2.625	
1150	3.074	3.016	2.909	2.814	2.752	2.702	2.658	2.615	
1160	3.069	3.010	2.903	2.807	2.744	2.693	2.648	2.605	
1170	3.063	3.004	2.896	2.799	2.736	2.684			
1180	3.058	2.997	2.889			2.675			
1190	3.052	2.991	2.882						
1200	3.047	2.984	2.875						
1210	3.041		2.868						
1220	3.036		2.862						
1230	3.030								

Temperature-dependent equations

$$\rho = a + bT$$

Mol % $LaCl_3$	a	$b \cdot 10^4$
0	3.7808	−10.474
12.7	3.782	−10.15
26.5	3.740	− 9.41
39.8	3.708	− 8.75
52.3	3.707	− 8.30
65.0	3.679	− 7.52
78.0	3.696	− 6.84
89.7	3.750	− 6.38
94.9	3.707	− 5.50

These values are based on the work of Smirnov and Stepanov (modified maximum bubble pressure method) [177].

TABLE 305. Viscosity studies: $CsCl\text{-}LaCl_3$

Investigations critically re-examined			
Ref.	$LaCl_3$ Mol %	Temp. range (T)	Comments
173	12.7–100	1055–1245	Cell material: Mo sphere, steel suspension wire, melt contained in a Pt or Mo crucible; calibration: method tested by measurements on organic liquids and fused NaCl
209	0–100 (g)	1120	

TABLE 305. Viscosity studies: $CsCl\text{-}LaCl_3$—Continued

Deviations from previous NSRDS recommendations: [1, p. 8]			
Ref.	$LaCl_3$ Mol %	Min. departure	Max. departure
173	100	−0.59% (1190 K)	−3.4% (1240 K)

Comment: Measurements in reference [173] were made after a quartz tube, containing the crucible and molten mixture, was evacuated and filled with pure helium. After temperature equilibration, the decrement of the amplitude and the period of oscillation of the Mo sphere in the melt were measured. Viscosity data was fitted to equations of the type, $\log \eta = A + B/T$.

TABLE 306. $CsCl\text{-}LaCl_3$: Viscosity (cp)

	Mol % $LaCl_3$								
T	100.0	89.7	78.0	65.0	52.3	39.8	26.5	12.7	0
930									1.35
940									1.30
950									1.25
960									1.20
970									1.16
980									1.12
990									1.08
1000									1.04
1010									1.01
1020									0.98
1030									0.94
1060				4.54		2.73		0.43	
1070			5.53	4.33	3.43	2.64	2.04	0.42	
1080			5.27	4.14	3.29	2.54	1.98	0.41	
1090			5.03	3.97	3.16	2.46	1.92	0.40	
1100			4.80	3.80	3.04	2.37	1.86	0.39	
1110			4.58	3.64	2.92	2.29	1.80	0.38	
1120			4.38	3.49	2.81	2.22	1.75	0.37	
1130			4.19	3.35	2.71	2.15	1.69	0.36	
1140		5.13	4.01	3.22	2.61	2.08	1.64	0.36	
1150	6.35	4.87	3.84	3.10	2.51	2.02	1.60	0.35	
1160	6.00	4.63	3.69	2.98	2.43	1.95	1.55	0.34	
1170	5.68	4.41	3.54	2.87	2.34	1.90			
1180	5.38	4.20	3.40	2.76	2.26				
1190	5.11	4.00	3.26						
1200	4.85	3.82	3.14						
1210	4.61	3.65	3.02						
1220	4.38		2.91						
1230	4.17								
1240	3.97								

Temperature-dependent equations

$$\eta = A \cdot \exp\,(E/RT)$$

Mol % $LaCl_3$	$A \cdot 10^2$	E (cal mol^{-1})	Standard deviation
0	3.448	6774	0.008
12.7	2.944	5646	0.02
26.5	5.943	7522	0.01
39.8	5.585	8194	0.01
52.3	4.018	9452	0.02
65.0	3.436	10285	0.02
78.0	2.951	11127	0.01
89.7	1.403	13369	0.03
100.0	0.984	14783	0.02

These values are based on the work of Smirnov and Khokhlov (oscillating sphere method) [173].

TABLE 307. Surface tension studies: $CsCl\text{-}LaCl_3$

Investigations critically re-examined		
Ref.	$LaCl_3$ Mol %	Temp. range (T)
177	12.7–100	1010–1233

Comment: Smirnov and Stepanov [177] reported a standard deviation of ±0.1 dynes cm^{-1} for their surface tension results.

TABLE 308. $CsCl\text{-}LaCl_3$: Surface tension (dyn cm^{-1})

	Mol % $LaCl_3$									
T	100	94.9	89.7	78.0	65.0	52.3	39.8	26.5	12.7	0
920										91.32
930										90.54
940										89.75
950										88.97
960										88.19
970										87.40
980										86.62
990										85.83
1000										85.05
1010										84.27
1020									83.78	83.48
1030									83.02	82.70
1040									82.26	81.91
1050								82.49	81.50	81.13
1060							82.57	81.75	80.73	80.35
1070							81.85	81.01	79.97	79.56
1080					87.39		81.12	80.26	79.21	
1090					86.72	82.92	80.40	79.52	78.45	
1100					86.06	82.20	79.68	78.78	77.69	
1110					85.40	81.48	78.96	78.04	76.93	
1120					84.73	80.76	78.24	77.30	76.17	
1130				91.08	84.07	80.04	77.51	76.55	75.41	
1140		109.42	101.60	90.45	83.40	79.32	76.79	75.81	74.65	
1150		108.86	101.00	89.83	82.74	78.60	76.07	75.07	73.89	
1160		108.30	100.39	89.20	82.08	77.88	75.35	74.33	73.12	
1170	117.76	107.75	99.78	88.58	81.41	77.16	74.63			
1180	116.44	107.19	99.17	87.95			73.90			
1190	115.12	106.64	98.57	87.33						
1200	113.80	106.08	97.96	86.70						
1210	112.48	105.52		86.08						
1220	111.16	104.97		85.45						
1230	109.84	104.41								
1240	108.52									
1250	107.20									
1260	105.88									

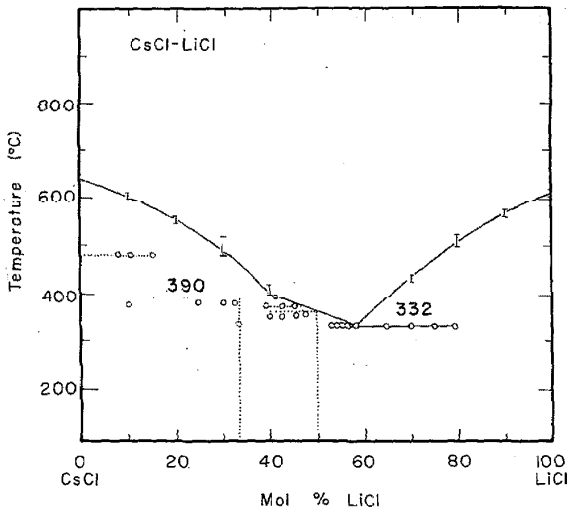
Temperature-dependent equations

$$\gamma = a + bT$$

Mol % $LaCl_3$	a	$b \cdot 10^2$
0	163.46	− 7.841
12.7	161.4	− 7.61
26.5	160.4	− 7.42
39.8	159.1	− 7.22
52.3	161.4	− 7.20
65.0	159.1	− 6.64
78.0	161.7	− 6.25
89.7	170.8	− 6.07
94.9	172.8	− 5.56
100	272.2	−13.2

These values are based on the work of Smirnov and Stepanov (maximum bubble pressure method) [177].

CsCl-LiCl



GURE 43. Temperature-composition phase diagram for CsCl-LiCl.

E. Korreng, Z. Anorg. Chem., **91**, 194 (1915).

T. W. Richards and W. B. Meldrum, J. Am. Chem. Soc., **39**, 1816 (1947).

E. P. Dergunov, Zhur. Fiz. Khim., **25**, 584 (1951).

Melt Preparation and Purification

Zuca and Olteanu [11] used Merck p.a. reagents recrystallized and pre-dried for 24 hours at 150 °C. The halides were purified by the method of Gruen and McBeth (J. Inorg. Chem., **9**, 290, 1959). The individual salts were heated close to the melting point, first in vacuum and then in an argon atmosphere. The temperature was then increased beyond the melting point and dry HCl gas was bubbled through the melt. The salts were tested for neutrality with phenolphthalein, both before and after each experiment.

Smirnov et al. [**75, 104**] purified their LiCl according to the method recommended by Laitinen (J. Electrochem. Soc., **104**, 516, 1957). This initially involved drying the LiCl under vacuum at 0.1 to 0.2 mm Hg for 6 hours. The salt was then ground to a fine powder in a clean closed jar; after which it was fused under an atmosphere of dry HCl gas followed by a stream of pure, dry argon.

Smirnov and Khokhlov [**82**] used "pure" and "chemically pure" CsCl and LiCl, respectively. The salts were twice recrystallized from doubly distilled water, dried at low pressure, and remelted in an argon atmosphere.

Salts used in reference [252] were "chemically pure" grade. Lithium chloride was purified by the method of Laitinen (see above) and cesium chloride was recrystallized several times.

TABLE 309. Electrical conductance studies: CsCl-LiCl

Investigations critically re-examined

Ref.	LiCl Mol %	Temp. range (T)	Comments
11[a]	50	918–1121	Cell material: alundum glass capillary cell; Pt electrodes; freq. range: 1000–7000 Hz; calibration: 1.0M and 0.1M KCl solutions
104	0–100	608–1073	Cell material: alundum crucible in sealed quartz tube; Mo wire electrodes; freq. range: 10,000 Hz; calibration: molten LiCl and KCl

Deviations from previous NSRDS recommendations: [1, pp. 4, 6]

Ref.	LiCl Mol %	Min. departure	Max. departure
104	100	−0.06% (1030 K)	−0.18% (930 K)
104	0	−0.26% (940 K)	−5.7% (1060 K)

[a]Zuca and Olteanu [11] report a precision of ±0.1% in their resistance measurements. Zuca reported a 20% difference between her results and those of Smirnov et al. [**104**] for the equimolar mixture.

TABLE 310. CsCl-LiCl: Specific conductance (ohm^{-1} cm^{-1})

	Mol percent LiCl						
T	100	80	58	46	30	20	0
610			0.784				
630			0.859				
650			0.934	0.448			
670			1.009	0.544			
690			1.084	0.639			
710			1.159	0.730			
730			1.234	0.820			
750			1.309	0.909	0.721		
770			1.384	0.996	0.785		
790			1.459	1.081	0.847		
810			1.534	1.164	0.910		
830		2.764	1.609	1.245	0.972	0.953	
850		2.864	1.684	1.325	1.033	1.003	
870		2.965	1.759	1.402	1.094	1.053	
890	5.735	3.066	1.834	1.478	1.154	1.103	
910	5.845	3.167	1.909	1.552	1.214	1.153	
930	5.953	3.267	1.984	1.624	1.273	1.202	1.141
950	6.056	3.368	2.059	1.695	1.332	1.252	1.187
970	6.156	3.469	2.134	1.763	1.390	1.302	1.234
990	6.252	3.570	2.209	1.830	1.448	1.352	1.281
1010	6.345	3.670	2.285	1.895	1.506	1.402	1.327
1030	6.434		2.360	1.958	1.562	1.452	1.374
1050	6.519		2.435	2.020	1.619	1.502	1.421
1070	6.601		2.510	2.079	1.674	1.552	1.467

Temperature-dependent equations

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

Mol % LiCl	a	$b \cdot 10^3$	$c \cdot 10^6$
0	−1.029	2.333	0
20	−1.117	2.494	0
30	−2.022	4.133	−0.634
46	−3.654	7.785	−2.268
58	−1.505	3.752	0
80	−1.418	5.038	0
100	−2.885	13.738	−4.554

These values are based on the work of Smirnov et al. (classical ac technique) [**104**].

TABLE 311. Density studies: CsCl-LiCl

Investigations critically re-examined			
Ref.	LiCl Mol %	Temp. range (T)	Comments
11[a]	50	913–1123	Cell material: Pt ball; calibration: water
75[a]	0–100	843–1083	Cell material: Pt ball; calibration: molten KNO_3 and KCl
328	0–80 (g)	1073	

Deviations from previous NSRDS recommendations: [1, pp. 4, 6]			
Ref.	LiCl Mol %	Min. departure	Max. departure
75	100	0.0% (940 K)	−0.08% (1040 K)
75	0	1.01% (940 K)	1.17% (1060 K)

[a]Zuca and Olteanu [11] report a precision of 0.1% in their density measurements, while Smirnov et al. [75] state an experimental error of 0.0005 g cm^{-3}. In both studies measurements were carried out in an atmosphere of dry argon to avoid hydrolysis of LiCl.

TABLE 312. CsCl-LiCl: Density (g cm^{-3})

	Mol percent LiCl									
T	100	98.27	82.67	70	55	47	40	25	10	0
880	1.504	1.546	1.864	2.104	2.333	2.427	2.506	2.656	2.775	
890	1.500	1.542	1.858	2.097	2.324	2.417	2.496	2.647	2.765	
900	1.495	1.537	1.852	2.090	2.315	2.408	2.487	2.637	2.754	
910	1.491	1.532	1.845	2.082	2.307	2.399	2.477	2.627	2.744	
920	1.486	1.528	1.839	2.075	2.298	2.390	2.468	2.617	2.733	2.817
930	1.482	1.523	1.833	2.068	2.289	2.380	2.458	2.608	2.723	2.807
940	1.477	1.518	1.827	2.060	2.281	2.371	2.449	2.598	2.712	2.796
950	1.473	1.514	1.820	2.053	2.272	2.362	2.440	2.588	2.702	2.786
960	1.469	1.509	1.814	2.046	2.263	2.353	2.430	2.578	2.692	2.775
970	1.464	1.504	1.808	2.039	2.255	2.343	2.421	2.569	2.681	2.765
980	1.460	1.500	1.801	2.031	2.246	2.334	2.411	2.559	2.671	2.754
990	1.455	1.495	1.795	2.024	2.237	2.325	2.402	2.549	2.660	2.744
1000	1.451	1.490	1.789	2.017	2.229	2.316	2.393	2.539	2.650	2.733
1010	1.446	1.486	1.783	2.009	2.220	2.306	2.383	2.530	2.639	2.723
1020	1.442	1.481	1.776	2.002	2.111	2.297	2.374	2.520	2.629	2.712
1030	1.437	1.476	1.770	1.995	2.202	2.288	2.364	2.510	2.618	2.702
1040	1.433	1.472	1.764	1.987	2.194	2.278	2.355	2.500	2.608	2.692
1050	1.428	1.467	1.757	1.980	2.185	2.269	2.345	2.491	2.597	2.681
1060	1.424	1.462	1.751	1.973	2.176	2.260	2.336	2.481	2.587	2.671
1070	1.419	1.458	1.745	1.965	2.168	2.251	2.327	2.471	2.576	2.660

Temperature-dependent equations

$$\rho = a + bT$$

Mol % LiCl	a	$b \cdot 10^3$
0	3.7808	−1.0474
10	3.6970	−1.0474
25	3.5147	−0.9754
40	3.3352	−0.9427
47	3.2408	−0.9253
55	3.0975	−0.8690
70	2.7470	−0.7304
82.67	2.4174	−0.6285
98.27	1.9574	−0.4672
100	1.8965	−0.4458

These values are based on the work of Smirnov et al. (Archimedean method) [75].

TABLE 313. Viscosity studies: CsCl-LiCl

Investigations critically re-examined			
Ref.	LiCl Mol %	Temp. range (T)	Comments
82	0–100	830–1070	Cell material: Pt ball; calibration: method tested by measurements on molten CsCl and LiCl

Deviations from previous NSRDS recommendations: [1, pp. 4, 6]			
Ref.	LiCl Mol %	Min. departure	Max. departure
82	100	−4.7% (940 K)	
82	0	0.0% (940 K)	−3.0% (1020 K)

TABLE 314. CsCl-LiCl: Viscosity (cp)

	Mol percent LiCl								
T	100	70	55	40	30	25	20	10	0
830						2.03			
840		1.66	1.83			1.93			
850		1.60	1.75			1.85			
860		1.53	1.67			1.77			
870		1.48	1.60		1.70	1.69			
880		1.42	1.54		1.63	1.62			
890		1.37	1.48		1.57	1.55	1.56		
900		1.33	1.42		1.50	1.49	1.50		
910		1.28	1.37		1.45	1.43	1.44	1.53	
920		1.24	1.32	1.39	1.39	1.38	1.39	1.48	
930	1.40	1.20	1.27	1.33	1.34	1.33	1.34	1.43	1.33
940	1.35	1.16	1.22	1.28	1.29	1.28	1.30	1.38	1.28
950	1.30	1.13	1.18	1.23	1.25	1.23	1.25	1.34	1.23
960	1.25	1.09	1.14	1.19	1.20	1.19	1.21	1.29	1.19
970	1.21	1.06	1.10	1.15	1.16	1.15	1.17	1.25	1.14
980	1.17	1.03	1.07	1.11	1.12	1.11	1.13	1.21	1.10
990	1.13	1.00	1.03	1.07	1.09	1.07	1.10	1.18	1.07
1000	1.10	0.97	1.00	1.03	1.05	1.04	1.07	1.14	1.03
1010	1.06	0.94	0.97	1.00	1.02	1.01	1.03	1.11	1.00
1020	1.03	0.92	0.94	0.96	0.99	0.98	1.00	1.08	0.96
1030	1.00	0.89	0.91		0.96	0.95	0.97	1.05	0.93
1040	0.97	0.87	0.89		0.93	0.92	0.95	1.02	
1050	0.94	0.85	0.86		0.90	0.89	0.92	0.99	
1060	0.92		0.84		0.88	0.86	0.90	0.97	
1070								0.94	

Temperature-dependent equations

$$\eta = A \cdot \exp\,(E/RT)$$

Mol % LiCl	$A \cdot 10^2$	E (cal mol^{-1})	Mean quadratic scatter
0	3.4478	6750	0.008
10	5.9260	5880	0.015
20	4.9971	6080	0.010
25	4.0057	6470	0.006
30	4.1733	6410	0.010
40	3.4348	6760	0.008
55	4.2181	6290	0.004
70	5.8263	5590	0.014
100	4.4257	6380	0.018

These values are based on the work of Smirnov and Khokhlov (oscillating sphere method) [**82**].

TABLE 315. Surface tension studies: CsCl-LiCl

Investigations critically re-examined			
Ref.	LiCl Mol %	Temp. range (T)	Comments
252	0–100	873–1073	Cell material: ceramic capillary; calibration: measurements on pure salts

Deviations from previous NSRDS recommendations: [2, pp. 57, 58]			
Ref.	LiCl Mol %	Min. departure	Max. departure
252	100	6.8% (1073 K)	8.7% (893 K)
252	0	−1.1% (933 K)	0.24% (1013 K)

TABLE 316. CsCl-LiCl: Surface tension (dyn cm^{-1})

	Mol percent LiCl								
T	100	98.27	82.67	70	55	40	25	10	0
880	141.87	127.55	105.46	100.04	97.50	95.20	94.54	93.81	
890	141.04	126.75	104.66	99.28	96.73	94.44	93.77	93.09	
900	140.21	125.95	103.86	98.53	95.96	93.68	93.01	92.36	
910	139.39	125.15	103.05	97.77	95.18	92.92	92.24	91.63	
920	138.56	124.35	102.25	97.01	94.41	92.16	91.48	90.90	91.32
930	137.73	123.55	101.45	96.26	93.64	91.40	90.71	90.18	90.54
940	136.90	122.75	100.65	95.50	92.87	90.64	89.94	89.45	89.76
950	136.07	121.95	99.84	94.74	92.09	89.87	89.18	88.72	88.97
960	135.24	121.14	99.04	93.99	91.32	89.11	88.41	88.00	88.19
970	134.41	120.34	98.24	93.23	90.55	88.35	87.65	87.27	87.40
980	133.58	119.54	97.44	92.47	89.78	87.59	86.88	86.54	86.62
990	132.75	118.74	96.63	91.72	89.00	86.83	86.12	85.82	85.83
1000	131.92	117.94	95.83	90.96	88.23	86.07	85.35	85.09	85.05
1010	131.09	117.14	95.03	90.20	87.46	85.31	84.58	84.36	84.27
1020	130.26	116.34	94.23	89.45	86.69	84.55	83.82	83.64	83.48
1030	129.43	115.54	93.42	88.69	85.91	83.79	83.05	82.91	82.70
1040	128.60	114.74	92.62	87.93	85.14	83.03	82.29	82.18	81.91
1050	127.77	113.94	91.82	87.18	84.37	82.27	81.52	81.46	81.13
1060	126.94	113.13	91.01	86.42	83.59	81.51	80.76	80.73	80.35
1070	126.11	112.33	90.21	85.66	82.82	80.74	79.99	80.00	79.56

Temperature-dependent equations

$$\gamma = a + bT$$

Mol % LiCl	a	$b \cdot 10^2$
0	163.46	−7.841
10	157.77	−7.268
25	161.91	−7.656
40	162.15	−7.608
55	165.50	−7.727
70	166.62	−7.566
82.67	176.10	−8.027
98.27	198.04	−8.010
100	214.86	−8.294

These values are based on the work of Smirnov and Stepanov (maximum bubble pressure method) [**252**].

CsCl-MgCl₂

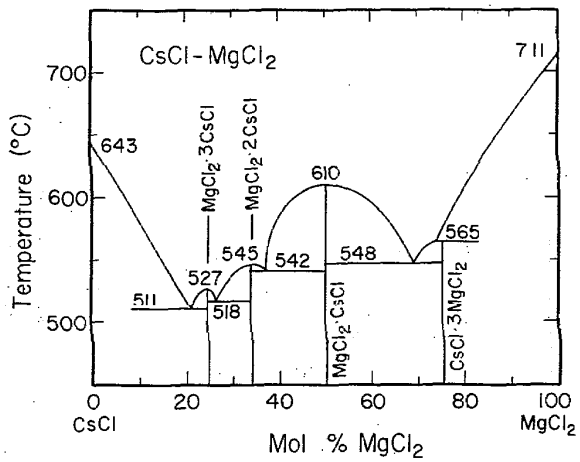


FIGURE 44. Temperature-composition phase diagram for $CsCl-MgCl_2$.

B. E. Markov and I. D. Panchenko. Zhur. Obshei. Khim., **25**, 2042 (1955).

Melt Preparation and Purification

Grjotheim et al. [**130,133**] dehydrated p.a. grade CsCl (Hopkins and Williams Ltd., Eng.) by heating the salt to 400 °C in an atmosphere of dry HCl gas. The preparation of pure $MgCl_2$ is described under the system $CaCl_2$-$MgCl_2$.

TABLE 318. $CsCl-MgCl_2$: Density (g cm^{-3})

	Mol percent $MgCl_2$				
T	100.0	34.5	33.3	30.7	0.0
950				2.308	2.762
960				2.300	2.751
970				2.293	2.740
980		2.246	2.270	2.286	2.728
990		2.239	2.262	2.278	2.717
1000		2.232	2.255	2.271	2.706
1010		2.225	2.247	2.264	2.695
1020	1.674	2.217	2.239	2.256	2.683
1030	1.671	2.210	2.231	2.249	2.672
1040	1.668	2.203	2.224	2.242	2.661
1050	1.666	2.196	2.216	2.235	2.650
1060	1.663	2.188	2.208	2.227	2.638
1070	1.660	2.181	2.200	2.220	2.627
1080	1.658		2.192		
1090	1.655				

Temperature-dependent equations

$\rho = a + bT$

Mol % $MgCl_2$	a	$b \cdot 10^4$	Stand. error of est.
0.0	3.829	−11.234	0.03%
30.7	3.001	−7.300	0.00%
33.3	3.032	−7.777	0.07%
34.5	2.954	−7.220	0.04%
100.0	1.950	−2.705	0.03%

These values are based on the work of Grjotheim, et al. (Archimedean method) [**130, 133**].

TABLE 317. Density studies: $CsCl-MgCl_2$

Investigations critically re-examined			
Ref.	$MgCl_2$ Mol %	Temp. range (T)	Comments
130, 133[a]	0, 30.7, 33.3, 34.5, 100	943–1099	Cell material: Pt–10%Rh sinker and Pt–10%Rh suspension wire; calibration: water

Deviations from previous NSRDS recommendations: [1, p. 6]			
Ref.	$MgCl_2$ Mol %	Min. departure	Max. departure
130	100	0.30% (1017 K)	0.50% (1099 K)
133	100	0.50% (1073 K)	
130	0	0.0% (1018 K)	0.22% (943 K)
133	0	−0.08% (1073 K)	

[a]Grjotheim et al. [**130, 133**] used an apparatus similar to the one described by Janz and Lorenz (Rev. Sci. Instr., **31**, 18, 1960) in which a pin of known dimensions was fixed to the lower end of an Archimedean density bob, thus permitting simultaneous measurements of both surface tension and density. Corrections were applied for the effect of surface tension and for expansion of the suspension wire. Density measurements were reproducible to within ±0.3% and total corrections on the observed densities were between 0.3 to 0.4%.

TABLE 319. Surface tension studies: $CsCl-MgCl_2$

Investigations critically re-examined			
Ref.	$MgCl_2$ Mol %	Temp. range (T)	Comments
253, 258[a]	0, 30.7, 33.3	942–1169	Cell material: density sinker and rod for surface tension measurements was made from Pt–10%Rh alloy; calibration: measurements on pure salts.

Deviations from previous NSRDS recommendations: [2, pp. 58, 59]			
Ref.	$MgCl_2$ Mol %	Min. departure	Max. departure
253	100	−5.9% (1073 K)	−6.7% (1002 K)
253	0	−0.01% (1023 K)	0.9% (942 K)

[a]Grjotheim, et al. [**253, 258**] reported a reproducibility of ±1% for surface tension measurements.

TABLE 320. $CsCl-MgCl_2$: Surface tension (dyn cm^{-1})

	Mol percent $MgCl_2$			
T	100.0	33.3	30.7	0.0
950			74.5	89.0
960			73.9	88.2
970			73.4	87.5
980		71.3	72.8	86.7
990		70.8	72.3	85.9
1000		70.4	71.8	85.2
1010	62.2	70.0	71.2	84.4
1020	62.2	69.5	70.7	83.6
1030	62.2	69.1	70.2	82.8
1040	62.1	68.6	69.6	82.1
1050	62.1	68.2	69.1	81.3
1060	62.1	67.8	68.6	80.5
1070	62.1	67.3	68.0	79.8
1080	62.0	66.9		
1090	62.0			
1100	62.0			
1110	61.9			
1120	61.9			
1130	61.9			
1140	61.9			
1150	61.8			
1160	61.8			

Temperature-dependent equations

$\gamma = a + bT$

Mol % $MgCl_2$	a	$b \cdot 10^2$	Stand. error of est.
0.0	162.0726	−7.6919	0.06%
30.7	125.1754	−5.3395	0.19%
33.3	114.4065	−4.4016	0.18%
100.0	65.3426	−0.3073	0.09%

These values are based on the work of Grjotheim (pin detachment method) **[253, 258]**.

$CsCl-MnCl_2$

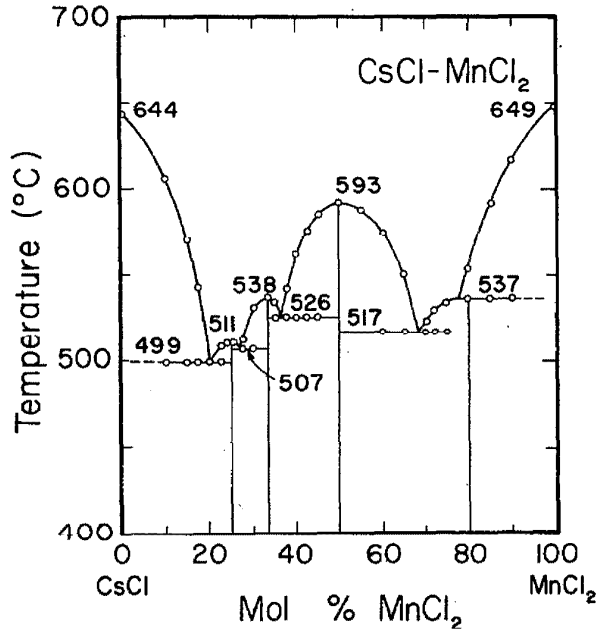


FIGURE 45. Temperature-composition diagram for $CsCl-MnCl_2$.

B. F. Markov and R. V. Chernov, Ukr. Khim. Zh., **24**, 139 (1958).

TABLE 321. Density studies: $CsCl-MnCl_2$

Investigations critically re-examined			
Ref.	$MnCl_2$ Mol %	Temp. range (T)	Comments
202	0–100	813–1023	Cell material: quartz ball containing tungsten for weight; calibration: water and CCl_4

Deviations from previous NSRDS recommendations: [1, pp. 6, 9]

Ref.	$MnCl_2$ Mol %	Min. departure	Max. departure
202	100	0.04% (960 K)	−0.43% (1020 K)
202	0	0.07% (940 K)	0.15% (1000 K)

TABLE 322. $CsCl-MnCl_2$: Density (g cm^{-3})

	Mol % $MnCl_2$										
T	100	90	80	70	60	50	40	30	20	10	0
820									2.714		
830									2.704		
840									2.695		
850									2.686		
860								2.587	2.677		
870								2.580	2.667		
880				2.492	2.494		2.522	2.572	2.658		
890				2.484	2.486		2.514	2.564	2.649		
900				2.476	2.478	2.489	2.506	2.556	2.640		
910		2.442	2.464	2.468	2.470	2.480	2.499	2.548	2.630		
920		2.436	2.456	2.460	2.462	2.472	2.491	2.540	2.621		
930		2.430	2.448	2.452	2.454	2.464	2.483	2.532	2.612		2.780
940	2.350	2.424	2.441	2.444	2.446	2.455	2.476	2.524	2.603	2.684	2.770
950	2.344	2.418	2.433	2.435	2.437	2.447	2.468	2.516	2.593	2.674	2.760
960	2.338	2.413	2.425	2.427	2.429	2.438	2.460	2.508	2.584	2.665	2.749
970	2.331	2.407	2.417	2.419	2.421	2.430	2.452	2.500	2.575	2.655	2.739
980	2.325									2.646	2.729
990	2.319									2.636	2.719
1000	2.313									2.627	
1010	2.307										
1020	2.301										

Temperature-dependent equations

$\rho = a + bT$

Mol % $MnCl_2$	a	$b \cdot 10^4$
0	3.731	−10.23
10	3.576	−9.49
20	3.473	−9.26
30	3.271	−7.95
40	3.202	−7.73
50	3.240	−8.35
60	3.212	−8.15
70	3.204	−8.09
80	3.167	−7.73
90	2.969	−5.80
100	2.928	−6.15

These values are based on the work of Markov et al. (Archimedean method) [202].

CsCl-NaCl

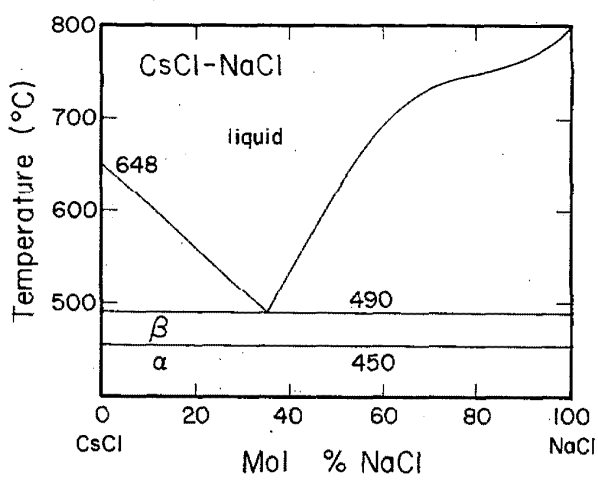


FIGURE 46. Temperature-composition phase diagram for CsCl-NaCl.

R. G. Samuseva and V. E. Plyvshchev. Zh. Neorgan. Khim., 6 [9], 2139 (1961); Russ. J. Inorg. Chem. (English Transl.), 1093 (1961).

Melt Preparation and Purification

The preparation of the pure halides by Zuca and Olteanu [98] is discussed under the CsCl-LiCl system. Dry argon gas was bubbled through the molten mixtures to eliminate small traces of HCl.

TABLE 323. Electrical conductance studies: CsCl-NaCl

Investigations critically re-examined			
Ref.	NaCl Mol %	Temp. range (T)	Comments
98	0, 25, 50 75, 100	933–1178	Cell material: quartz or silica glass capillary cell; Pt electrodes; freq. range: 1000–7000 Hz; calibration: 1.0M and 0.1M KCl solutions
218	eutectic (g)	1054–1384	

Deviations from previous NSRDS recommendations: [1, pp. 4, 6]			
Ref.	NaCl Mol %	Min. departure	Max. departure
98	100	−0.11% (1090 K)	−1.40% (1170 K)
98	0	0.68% (940 K)	−8.10% (1090 K)

Comment: Zuca and Olteanu [98] report, in addition to experimental specific conductivities, Arrehenius equations (equivalent conductance as a function of temperature) with standard deviations for $E\lambda$, the activation energy, in the range: 4×10^{-3} Kcal mol^{-1} (50 mol % NaCl, $E\lambda = 3.65$) to 15×10^{-3} Kcal mol^{-1} (100 mol % NaCl, $E\lambda = 2.53$).

TABLE 324. CsCl-NaCl: Specific conductance (ohm^{-1} cm^{-1})

	Mol % NaCl				
T	100	75	50	25	0
950					1.197
960					1.219
970					1.241
980					1.262
990					1.284
1000					1.305
1010					1.326
1020					1.346
1030					1.367
1040					1.387
1050		2.195	1.777	1.537	1.407
1060		2.220	1.799	1.556	1.427
1070		2.244	1.821	1.575	1.447
1080		2.268	1.843	1.594	1.466
1090	3.626	2.290	1.864	1.613	1.485
1100	3.652	2.312	1.885	1.632	
1110	3.677	2.334	1.905	1.651	
1120	3.702	2.534	1.926	1.670	
1130	3.726	2.374	1.945	1.689	
1140	3.749	2.392	1.965	1.708	
1150	3.773		1.984	1.727	
1160	3.795				
1170	3.817				

Temperature-dependent equations

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

Mol % NaCl	a	$b \cdot 10^3$	$c \cdot 10^6$	Stand. error of est.
0	−1.9170	4.3411	−1.1192	0.02%
25	−0.4547	1.8967	0	0.10%
50	−2.3101	5.5562	−1.5843	0.06%
75	−4.9137	10.9827	−4.0123	0.10%
100	−2.4204	8.4918	−2.7014	0.01%

These values are based on the work of Olteanu and Zuca (classical ac technique) [98].

TABLE 325. Density studies: CsCl-NaCl

Investigations critically re-examined			
Ref.	NaCl Mol %	Temp. range (T)	Comments
98	0, 25, 50 75, 100	933–1178 1073	Cell material: Pt ball; calibration: water
328	40–60 (g)		

Deviations from previous NSRDS recommendations: [1, pp. 4, 6]			
Ref.	NaCl Mol %	Min. departure	Max. departure
98	100	−0.06% (1090 K)	−0.13% (1170 K)
98	0	0.30% (1040 K)	0.36% (960 K)

Comment: Density results in reference [98] were reported as linear equations with standard deviations in the range: 2×10^{-4} g cm^{-3} (100 mol % NaCl) to 10.0×10^{-4} g cm^{-3} (50 mol % NaCl).

TABLE 326. CsCl-NaCl: Density (g cm^{-3})

	Mol % NaCl				
T	100	75	50	25	0
940					2.779
950					2.768
960					2.757
970					2.746
980					2.736
990					2.725
1000				2.510	2.714
1010			2.269	2.500	2.703
1020			2.260	2.490	2.692
1030		1.968	2.250	2.480	2.681
1040		1.961	2.241	2.471	2.670
1050		1.953	2.231	2.461	2.660
1060		1.945	2.222	2.451	2.649
1070		1.938	2.213	2.441	2.638
1080		1.930	2.203	2.431	2.627
1090	1.546	1.922	2.194	2.421	2.616
1100	1.540	1.915	2.184	2.411	
1110	1.535	1.907	2.175	2.402	
1120	1.529	1.900	2.165	2.392	
1130	1.524	1.892	2.156	2.382	
1140	1.518	1.884	2.147	2.372	
1150	1.513				
1160	1.508				
1170	1.502				

Temperature-dependent equations

$$\rho = a + bT$$

Mol % NaCl	a	$b \cdot 10^3$	Stand. dev.
0	3.7987	−1.0849	0.0008
25	3.4953	−0.9853	0.0009
50	3.2194	−0.9410	0.0010
75	2.7526	−0.7616	0.0009
100	2.1390	−0.5444	0.0002

These values are based on the work of Olteanu and Zuca (Archimedean method) [98].

TABLE 327. Surface tension studies: CsCl-NaCl

Investigations critically re-examined		
Ref.	Mol % NaCl	Temp. range (T)
243	0, 25, 50, 75, 100	~873–1173

Deviations from previous NSRDS recommendations: [2, pp. 57, 58]

Ref.	NaCl Mol %	Min. departure	Max. departure
243	100	3.4% (1083 K)	3.5% (1183 K)
243	0	0.46% (973 K)	0.0% (1013 K)

Comment: Reference **[243]** contained only graphical data in the form of surface tension—composition isotherms at 888 °C for the mixtures reported. Numerical data given here was obtained through a private communication. Bertozzi reported a reproducibility for his data of ±0.5%.

TABLE 328. CsCl-NaCl: Surface tension (dyn cm^{-1})

	Mol % NaCl				
T	100	75	50	25	0
820				101.8	
840				100.4	
860			103.7	98.9	
880			102.3	97.4	
900			100.9	95.9	
920			99.5	94.4	
940			98.1	93.0	
960			96.7	91.5	
980			95.3	90.0	86.7
1000		102.0	93.9	88.5	85.2
1020		100.7	92.5	87.0	83.7
1040		99.3	91.1	85.6	82.3
1060		97.8	89.7	84.1	80.8
1080		96.3	88.3	82.6	79.3
1100	115.9	94.8	86.9	81.1	77.8
1120	114.4	93.3	85.5	79.6	
1140	113.0	91.9	84.1	78.2	

Temperature-dependent equations

$$\gamma = a + bT$$

Mol % NaCl	a	$b \cdot 10^2$
0	159.2	−7.4
25	162.5	−7.4
50	163.9	−7.0
75	176.2	−7.4
100	197.3	−7.4

These values are based on the work of Bertozzi (Wilhelmy slide plate method) **[243]**.

CsCl-PbCl$_2$

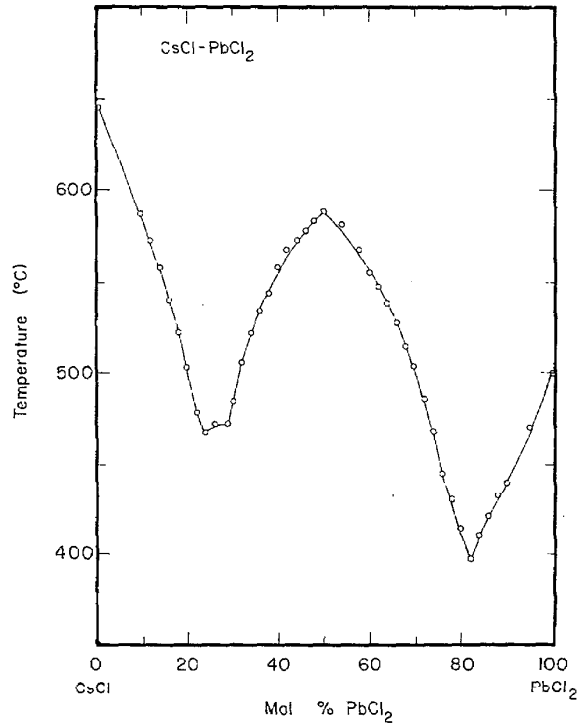


FIGURE 47. Temperature-composition phase diagram for CsCl-PbCl$_2$.

S. D. Gromakov, Zh. Fiz. Khim., **24**, 641 (1950).

Melt Preparation and Purification

Koch-Light CsCl was used by Bloom et al. **[103]** without further purification, and PbCl$_2$ was prepared from HCl and A.R. grade Pb(NO$_3$)$_2$ and recrystallized. Standard methods of analysis were used for pure materials as well as mixtures.

The preparation of pure salts by Dahl and Duke **[258]** is given under the system LiCl-PbCl$_2$.

TABLE 329. Electrical conductance studies: CsCl-PbCl$_2$

Investigations critically re-examined			
Ref.	PbCl$_2$ Mol %	Temp. range (T)	Comments
49	26.4–100	727–1073	Cell material: silica; Pt electrodes; freq. range: 1000 Hz; calibration: 1N KCl solutions
142[a]	0–100 (g)	993	

Deviations from previous NSRDS recommendations: [1, p. 13]

Ref.	PbCl$_2$ Mol %	Min. departure	Max. departure
49	100	0.05% (930 K)	0.06% (830 K)

[a]Data taken from [49].

Comment: Bloom and Macky **[49]** claimed an overall accuracy in their conductance measurements of ±0.5%.

TABLE 330. $CsCl-PbCl_2$: Specific conductance (ohm^{-1} cm^{-1})

	Mol percent $PbCl_2$					
T	100.0	82.8	61.5	44.3	33.4	26.4
730		1.045				
740		1.084				
750		1.123				
760		1.161				
770		1.199				
780		1.237			0.440	0.480
790		1.274			0.470	0.508
800		1.311			0.500	0.535
810		1.348			0.529	0.563
820		1.384			0.559	0.590
830	1.737	1.421			0.589	0.617
840	1.780	1.457			0.619	0.645
850	1.823	1.492			0.649	0.672
860	1.865	1.528			0.679	0.699
870	1.908	1.562			0.709	0.726
880	1.950	1.597	1.255	0.883	0.739	0.754
890	1.991	1.632	1.280	0.911	0.769	0.781
900	2.033	1.666	1.305	0.938	0.798	0.808
910	2.074	1.699	1.331	0.967	0.828	0.835
920	2.115	1.733	1.356	0.996	0.858	0.862
930	2.156	1.766	1.382	1.025	0.888	0.889
940	2.196	1.799	1.407	1.055	0.918	0.916
950	2.236	1.831	1.433	1.086	0.948	0.943
960	2.276	1.863	1.459	1.116	0.978	0.970
970	2.315	1.895	1.484	1.148	1.008	0.997
980	2.354	1.927	1.510	1.180	1.038	1.023
990	2.393	1.958	1.536	1.212	1.068	1.050
1000	2.432	1.989	1.562	1.245	1.097	1.077
1010	2.470	2.020	1.588	1.278	1.127	1.104
1020	2.508	2.050	1.614	1.312	1.157	1.130
1030	2.546	2.080	1.640	1.346	1.187	1.157
1040	2.583	2.110	1.666	1.381	1.217	1.184
1050	2.621	2.140	1.692	1.461	1.247	1.210
1060	2.658	2.169	1.719	1.452	1.277	1.237
1070	2.694	2.198	1.745	1.488	1.307	1.263

Temperature-dependent equations

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

Mol % $PbCl_2$	$a \cdot 10^1$	$b \cdot 10^3$	$c \cdot 10^7$	Stand. error of est.
26.4	−17.757	3.0330	− 1.8036	0.23%
33.4	−18.918	2.9893	0	0.30%
44.3	3.7353	−1.5622	24.333	0.52%
61.5	− 7.5039	2.0295	2.8284	0.07%
82.8	−26.223	6.1380	−15.264	0.40%
100.0	−28.404	6.6977	−14.256	0.32%

These values are based on the work of Bloom and Macky (classical ac technique) [**49**].

TABLE 331. Density studies: $CsCl-PbCl_2$

Investigations critically re-examined

Ref.	$PbCl_2$ Mol %	Temp. range (T)	Cell material	Calibration
103	0–100	903–1113	Sinker of 10% Rh-Pt	Water
142[a]	0–100	993		

Deviations from previous NSRDS recommendations: [1, p. 13, 6]

Ref.	$PbCl_2$ Mol %	Min. departure	Max. departure
103	100	−0.04% (920 K)	−0.02% (960 K)
103	0	−0.23% (1100 K)	−0.44% (980 K)

[a]Data from [**103**].

Comment: The experimental technique of Bloom et al. [**103**] is discussed under the system $CdCl_2$-CsCl.

TABLE 332. $CsCl-PbCl_2$: Density (g cm^{-3})

	Mol percent $PbCl_2$						
T	100.0	76.4	54.8	35.0	25.9	16.8	0.0
910		4.165					
920	4.730	4.151					
930	4.715	4.137				3.703	
940	4.701	4.124		3.321	3.187	3.061	
950	4.686	4.110	3.649	3.309	3.175	3.049	
960	4.671	4.096	3.636	3.297	3.163	3.036	
970	4.656	4.082	3.623	3.285	3.151	3.024	
980	4.642	4.068	3.609	3.273	3.139	3.012	2.714
990	4.627	4.054	3.596	3.261	3.126	2.999	2.704
1000	4.612	4.041	3.583	3.249	3.114	2.987	2.694
1010	4.597	4.027	3.569	3.237	3.102	2.975	2.684
1020	4.582	4.013	3.556	3.224	3.090	2.962	2.673
1030	4.568	3.999	3.542	3.212	3.077	2.950	2.663
1040	4.553	3.985	3.529	3.200	3.065		2.653
1050	4.538	3.972	3.516	3.188	3.053		2.643
1060	4.523	3.958	3.502	3.176	3.041		2.632
1070		3.944	3.489	3.164	3.028		2.622
1080							2.612
1090							2.602
1100							2.591
1110							2.581

Temperature-dependent equations

$\rho = a + bT$

Mol % $PbCl_2$	a	$b \cdot 10^3$	Stand. deviation
0.0	3.718	−1.024	0.001
16.8	4.217	−1.230	0.001
25.9	4.337	−1.223	0.001
35.0	4.459	−1.210	0.002
54.8	4.921	−1.338	0.001
76.4	5.423	−1.382	0.002
100.0	6.089	−1.477	0.002

These values are based on the work of Bloom et al. (Archimedean method) [**103**].

TABLE 333. Surface tension studies: $CsCl-PbCl_2$

Investigations critically re-examined			
Ref.	$PbCl_2$ Mol %	Temp. range (T)	Comments
238	25.89–100	734–903	Cell material: Pt-10%Rh capillary, melt contained in Pt crucible; calibration: benzene
254	25.89–100	734–903	Cell material and calibration: as for **238**

Comment: Remarks concerning reference [**238**] are given under the system $LiCl-PbCl_2$.

TABLE 334. $CsCl-PbCl_2$: Surface tension (dyn cm^{-1})

	Mol percent $PbCl_2$						
T	100.00	81.90	81.77	63.03	50.50	40.11	25.89
740		119.5					
750		118.5					
760		117.5					
770		116.5	116.2				
780		115.5	115.3				101.9
790		114.5	114.3				101.1
800	134.3	113.5	113.3				100.2
810	133.0	112.5	112.3				99.4
820	131.8	111.5	111.3				98.6
830	130.5	110.5	110.3				97.7
840	129.3	109.6	109.3				96.9
850		108.6	108.3				96.1
860			107.3	98.4			95.2
870				97.1			94.4
880				95.8		92.1	93.6
890				94.6		91.1	92.7
900					90.6	90.2	91.9

Temperature-dependent equations

$$\gamma = a + bT$$

Mol % $PbCl_2$	a	$b \cdot 10^1$	Stand. error of est.
25.89	166.8733	−0.8329	0.44%
40.11	173.7146	−0.9278	0.19%
50.50	540.5747	−5.0000	0.40%
63.03	206.0883	−1.2528	0.61%
81.77	192.6446	−0.9922	0.15%
81.90	192.7038	−0.9900	0.27%
100.00	233.6772	−1.2428	0.49%

These values are based on the work of Dahl and Duke (maximum bubble pressure method) [**238**].

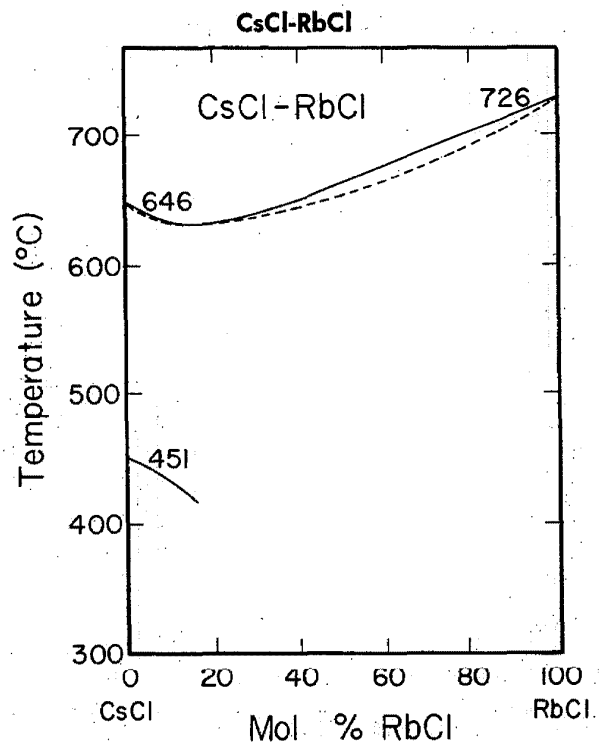


FIGURE 48. Temperature-composition phase diagram for CsCl-RbCl.

S. Zhemhuzhnui and F. Rambach, Z. Anorg. Chem., **65**, 417 (1910).

Melt Preparation and Purification

Salts used in reference [**98**] were Merck p.a. reagents and were purified by the procedure described under the CsCl-LiCl system.

TABLE 335. Electrical conductance studies: CsCl-RbCl

Investigations critically re-examined			
Ref.	RbCl Mol %	Temp. range (T)	Comments
98	0, 25, 50, 75, 100	933–1223	Cell material: quartz or silica glass capillary cell; Pt electrodes; freq. range: 1000–7000 Hz; calibration: 1.0M and 0.1M KCl solutions

Deviations from previous NSRDS recommendations [1, p. 6]			
Ref.	RbCl Mol %	Min. departure	Max. departure
98	100	0.12% (1010 K)	−4.4% (1200 K)
98	0	0.68% (940 K)	−8.1% (1090 K)

Comment: Zuca and Olteanu [**98**] report, in addition to experimental specific conductivities, Arrehenius equations (equivalent conductance as a function of temperature) with standard deviations for E_λ, the activation energy, in the range: 1×10^{-2} Kcal mol^{-1} (0 mol % RbCl, $E_\lambda = 4.00$ Kcal mol^{-1}) to 5.5×10^{-2} Kcal mol^{-1} (25 mol % RbCl, $E_\lambda = 3.87$ Kcal mol^{-1}).

TABLE 336. CsCl-RbCl: Specific conductance (ohm^{-1} cm^{-1})

	Mol percent RbCl				
T	100	75	50	25	0
950					1.197
960					1.219
970					1.241
980					1.262
990					1.284
1000					1.305
1010					1.326
1020	1.574				1.346
1030	1.596		1.449		1.367
1040	1.618		1.469		1.387
1050	1.640	1.556	1.488		1.407
1060	1.662	1.576	1.508	1.460	1.427
1070	1.683	1.596	1.527	1.478	1.447
1080	1.704	1.616	1.546	1.495	1.466
1090	1.725	1.636	1.565	1.513	1.485
1100	1.745	1.656	1.583	1.531	
1110	1.766	1.675	1.602	1.548	
1120	1.785	1.694	1.620	1.566	
1130	1.805	1.713	1.638	1.584	
1140	1.824	1.731	1.656	1.601	
1150	1.843	1.750	1.674	1.619	
1160	1.862	1.768	1.692		
1170	1.880				
1180	1.899				
1190	1.916				

Temperature-dependent equations

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

Mol % RbCl	a	$b \cdot 10^3$	$c \cdot 10^6$	Stand. error of est.
0	−1.9170	4.3411	−1.1192	0.02%
25	−0.4128	1.7667	0	0.12%
50	−1.4354	3.6305	−0.8057	0.15%
75	−1.9403	4.5965	−1.2069	0.07%
100	−2.3072	5.3381	−1.5035	0.02%

These values are based on the work of Zuca and Olteanu (classical ac technique) [98].

TABLE 337. Density studies: CsCl-RbCl

Investigations critically re-examined

Ref.	RbCl Mol %	Temp. range (T)	Comments
98	0, 25, 50, 75, 100	933–1233	Cell material: Pt ball; calibration: water

Deviations from previous NSRDS recommendations: [1, p. 6]

Ref.	RbCl Mol %	Min. departure	Max. departure
98	100	−0.02% (1080 K)	0.15% (1200 K)
98	0	0.30% (1040 K)	0.36% (960 K)

Comment: Density results in reference [98] were reported as linear temperature dependent equations with standard deviations in the range: 7×10^{-4} g cm^{-3} (50 mol % RbCl) to 9×10^{-4} g cm^{-3} (25 and 100 mol % RbCl).

TABLE 338. CsCl-RbCl: Density (g cm^{-3})

	Mol percent RbCl											
T	100	90	80	70	60	50	40	30	20	10	0	11.5
940											2.780	
950											2.769	
960										2.711	2.758	2.704
970									2.654	2.700	2.747	2.693
980								2.596	2.643	2.690	2.736	2.683
990							2.538	2.586	2.633	2.679	2.725	2.672
1000						2.481	2.528	2.576	2.622	2.668	2.714	2.661
1010					2.423	2.471	2.518	2.565	2.612	2.658	2.703	2.651
1020	2.218			2.366	2.414	2.461	2.508	2.555	2.601	2.647	2.692	2.640
1030	2.210	2.259	2.309	2.356	2.404	2.452	2.499	2.545	2.591	2.636	2.681	2.629
1040	2.201	2.250	2.299	2.347	2.395	2.442	2.489	2.535	2.580	2.625	2.670	2.619
1050	2.193	2.242	2.290	2.338	2.385	2.432	2.479	2.524	2.570	2.615	2.659	2.608
1060	2.184	2.233	2.281	2.329	2.376	2.422	2.469	2.514	2.559	2.604	2.648	2.597
1070	2.176	2.224	2.272	2.319	2.366	2.413	2.459	2.504	2.549	2.593	2.637	2.587
1080	2.167	2.215	2.263	2.310	2.357	2.403	2.449	2.494	2.538	2.583	2.626	2.576
1090	2.159	2.206	2.254	2.301	2.347	2.393	2.439	2.484	2.528	2.572	2.615	2.565
1100	2.150	2.198	2.245	2.292	2.338	2.383	2.429	2.473	2.517	2.561		2.555
1110	2.141	2.189	2.236	2.282	2.328	2.374	2.419	2.463	2.507	2.550		2.544
1120	2.133	2.180	2.227	2.273	2.319	2.364	2.409	2.453	2.497			
1130	2.124	2.171	2.218	2.264	2.309	2.354	2.399	2.443	2.486			
1140	2.116	2.162	2.209	2.254	2.300	2.344	2.389	2.432				
1150	2.107	2.154	2.200	2.245	2.290	2.335	2.379					
1160	2.099	2.145	2.191									
1170	2.090	2.136										
1180	2.082	2.128										
1190	2.073	2.119										
1200	2.064											
1210	2.056											
1220	2.047											
1230	2.039											

Two-dimensional equation and statistical parameters

$$\rho = a + bT + cC + dC^2 + eTC$$

a	$b \cdot 10^4$	$c \cdot 10^3$	$d \cdot 10^6$	$e \cdot 10^6$	Max. percent departure	Stand. error of est.
3.09092	−8.55390	7.42126	−2.49024	−2.38944	0.07% (1163.2 K, 50 mol % CsCl)	0.03%

These values are based on the work of Zuca and Olteanu (Archimedean method) [98]. C = mol % CsCl.

TABLE 339. CsCl-RbCl: Density (g cm^{-3})

	Mol percent RbCl				
T	100	75	50	25	0
940					2.779
950					2.768
960					2.757
970					2.746
980				2.619	2.736
990				2.609	2.725
1000			2.482	2.599	2.714
1010			2.472	2.588	2.703
1020	2.218		2.462	2.578	2.692
1030	2.209	2.333	2.452	2.568	2.681
1040	2.201	2.324	2.442	2.557	2.670
1050	2.192	2.315	2.432	2.547	2.660
1060	2.184	2.305	2.422	2.537	2.649
1070	2.175	2.296	2.413	2.526	2.638
1080	2.167	2.287	2.403	2.516	2.627
1090	2.158	2.278	2.393	2.506	2.616
1100	2.150	2.269	2.383	2.495	
1110	2.141	2.260	2.373	2.485	
1120	2.133	2.251	2.363	2.475	
1130	2.124	2.242	2.353	2.464	
1140	2.116	2.232	2.343	2.454	
1150	2.107	2.223	2.333		
1160	2.099		2.323		
1170	2.090				
1180	2.082				
1190	2.073				
1200	2.065				
1210	2.056				
1220	2.048				
1230	2.039				

Temperature-dependent equations

$$\rho = a + bT$$

Mol % RbCl	a	$b \cdot 10^3$	Stand. dev.
0	3.7987	−1.0849	0.0008
25	3.6314	1.0327	0.0009
50	3.4729	−0.9910	0.0007
75	3.2733	−0.9131	0.0008
100	3.0863	−0.8514	0.0009

These values are based on the work of Zuca and Olteanu (Archimedean method) [98].

CsCl-ScCl$_3$

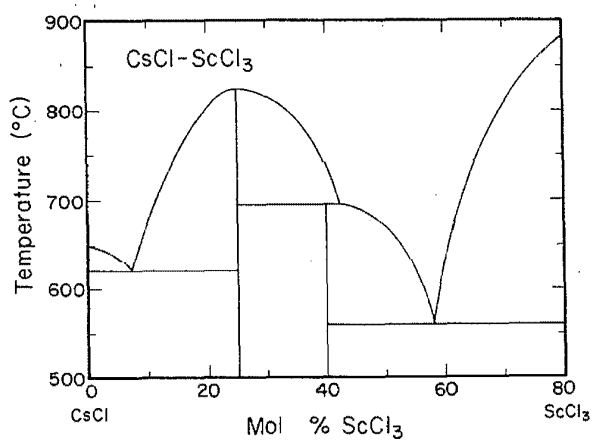


FIGURE 49. Temperature-composition phase diagram for CsCl-ScCl$_3$.

N. Ya. Feda-ou and E. S. Petiov, Izv. Sib. Otd. Akad. Nauk. S.S.S.R. Ser. Khim Nauk, I, 57 (1967).

Melt Preparation and Purification

Details concerning the preparation of pure ScCl$_3$ by Fedorov and Petrov [71] are discussed under the LiCl-ScCl$_3$ system. No specific information was reported for cesium chloride.

TABLE 340. Electrical conductance studies: CsCl-ScCl$_3$

Investigations critically re-examined			
Ref.	ScCl$_3$ Mol %	Temp. range (T)	Comments
71	0–61.7 (g)	893–1233	Cell material: sealed quartz vessels; Mo wire electrodes; calibration: 1N KCl solution

Comment: A brief discussion of the experimental procedure used by Federov and Petrov [71] is given under the LiCl-ScCl$_3$ system.

TABLE 341. CsCl-ScCl₃: Specific conductance (ohm^{-1} cm^{-1})

Mol % $ScCl_3$	893 K	913 K	933 K	953 K	973 K	993 K	1013 K	1033 K	1053 K
0			1.15	1.21	1.24	1.26	1.32	1.36	1.40
10						0.95	0.97	1.02	1.05
20									
30									
40							0.48	0.53	0.54
50			0.38	0.42	0.46	0.48	0.50	0.52	0.54
60	0.31	0.34	0.37	0.39	0.42	0.44	0.46	0.47	0.50
70									

Mol % $ScCl_3$	1073 K	1093 K	1113 K	1133 K	1153 K	1173 K	1193 K	1213 K	1233 K
0	1.44	1.47	1.50	1.52	1.56	1.58	1.62	1.64	1.67
10	1.10	1.13	1.16	1.18	1.21	1.25	1.28	1.32	1.34
20	0.82	0.86	0.87	0.92	0.96	0.98	1.00	1.02	1.05
30	0.64[a]	0.69	0.74	0.74	0.78	0.80	0.82	0.85	
40	0.56	0.59	0.62	0.64	0.66	0.68	0.70	0.72	0.74
50	0.56	0.58	0.60	0.62	0.63	0.64	0.66	0.68	0.68
60	0.52	0.54	0.56	0.58	0.60	0.62	0.63	0.65	0.65
70			0.47	0.50	0.52	0.54	0.55	0.57	0.60

[a]Interpolated value. These values have been interpolated to a maximum of three significant figures from the graphical presentation of Federov and Petrov (classical ac technique) [71].

CsCl-SrCl₂

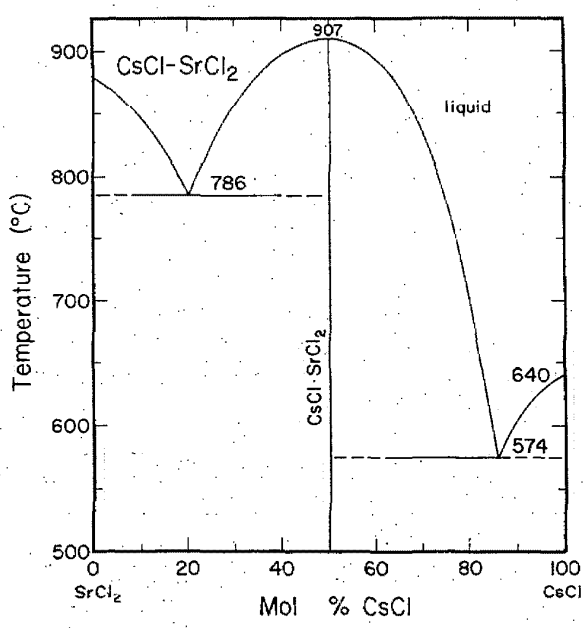


FIGURE 50. Temperature-composition phase diagram for CsCl-SrCl₂.

E. P. Dergurov and A. C. Bergman, Dokl. Akad. Nauk. S.S.S.R., 75, [6], 817 (1950).

Melt Preparation and Purification

In their surface tension studies, Bertozzi and Soldani [244] used carefully dried Merck and B. D. H. salts of analytical purity without further purification.

TABLE 342. Surface tension studies: CsCl-SrCl₂

Investigations critically re-examined		
Ref.	$SrCl_2$ Mol %	Temp. range (T)
244[a]	0–100 (g)	1123

[a]Surface tension results in reference [244] were reported to be reproducible to 0.5%.

TABLE 343. CsCl-SrCl₂: Surface tension (dyn cm^{-1})

Mol % $SrCl_2$	1123 K	Mol % $SrCl_2$	1123 K
0	75	60	102
10	79	70	110
20	84	80	123
30	88	90	141
40	93	100	172
50	97		

These values have been interpolated to three significant figures from the graphical presentation of Bertozzi and Soldani (Wilhelmy slide plate method) [244].

CsCl-TiCl₃

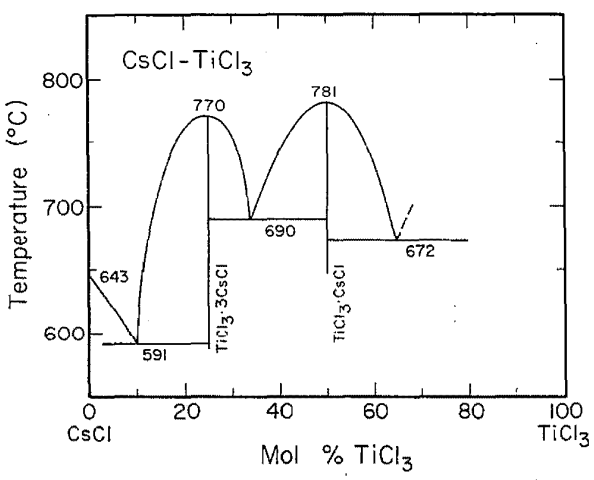


FIGURE 51. Temperature-composition phase diagram for CsCl-$TiCl_3$.

B. F. Markov and R. V. Chernov, Ukrain. Khim. Zhur., **25**, 283 (1959).

TABLE 344. Electrical conductance studies: CsCl-$TiCl_3$

Investigations critically re-examined			
Ref.	$TiCl_3$ Mol %	Temp. range (T)	Comments
59	0–53 (g)	1073	Cell material: quartz; Pt electrodes; freq. range: 1400 Hz

TABLE 345. CsCl-$TiCl_3$: Specific conductance (ohm^{-1} cm^{-1})

Mol % $TiCl_3$	1073 K
0	1.45
10	1.09
20	0.92
30	0.82
40	0.70
50	0.68

These values have been interpolated to three significant figures from the graphical presentation of Delimarskii and Chernov (classical ac technique) **[59]**.

CsCl-UCl_4

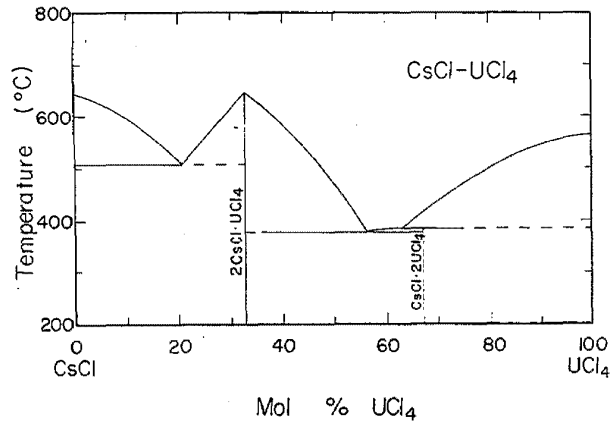


FIGURE 52. Temperature-composition phase diagram for CsCl-UCl_4.

C. J. Barton, A. B. Wilkelson, and W. R. Grimes, Oakridge National Laboratory, Phase Diagrams of Nuclear Reactor Materials, R. F. T. Thoma ed., ORNL-2548, p. 137 (1959).

Melt Preparation and Purification

Bogacz and Ziolek **[158]** dehydrated CsCl (obtained from Soyuzkhimexport) by melting the salt in a quartz tube under a constant flow of dry HCl for a 30 minute period. The melt was allowed to solidify on a quartz evaporating dish under a strong stream of HCl. The purified salt was then crushed and stored in a desiccator over P_2O_5 or in sealed ampoules. Uranium (IV) chloride was prepared from uranyl oxalate by hydrogen reduction at 400 °C to uranium dioxide followed by chlorination at 440 °C with CCl_4 vapors in a stream of purified nitrogen. The composition of the product varied from $UCl_{3.9}$ to $UCl_{4.01}$. The purified salt was kept in sealed ampoules filled with dry argon.

TABLE 346. Electrical conductance studies: CsCl-UCl_4

Investigations critically re-examined			
Ref.	UCl_4 Mol %	Temp. range (T)	Comments
158	0–100	660–1001	Cell material: quartz tube; Pt electrodes; freq. range: 5,000–10,000 Hz, measurements at 10,000 Hz; calibration: KCl solutions and fused KNO_3, $NaNO_3$ and KCl

Deviations from previous NSRDS recommendations: [1, pp. 6, 9]			
Ref.	UCl_4 Mol %	Min. departure	Max. departure
158	100	1.2% (870 K)	−4.4% (890 K)
158	0	−1.3% (940 K)	−3.1% (990 K)

Comment: Bogacz and Ziolek **[158]** report their conductance results in the form of equations of the type $\kappa = a + bt + ct^2$ with standard deviations in the range 0.0×10^{-4} ohm^{-1} cm^{-1} (31.13 mol % UCl_4) to 7.0×10^{-4} ohm^{-1} cm^{-1} (64.08 mol % UCl_4). The overall error in the conductivity measurements did not exceed 0.5%.

TABLE 347. $CsCl\text{-}UCl_4$: Specific conductance ($ohm^{-1}\ cm^{-1}$)

	Mol percent UCl_4																										
T	100.00	92.58	83.35	79.29	77.20	69.17	65.52	64.08	62.44	58.86	56.25	49.04	43.89	38.86	33.65	33.04	31.13	30.43	27.00	24.06	21.28	19.45	13.83	7.35	3.26	1.02	0.00
670								0.141	0.148																		
680								0.154	0.160																		
690							0.170	0.167	0.172																		
700							0.184	0.179	0.184																		
710							0.197	0.191	0.196																		
720							0.210	0.204	0.207																		
730							0.223	0.216	0.219																		
740							0.235	0.227	0.230																		
750							0.248	0.239	0.241																		
760						0.265	0.260	0.251	0.252			0.229															
770						0.277	0.272	0.262	0.263			0.240															
780						0.290	0.283	0.273	0.274			0.250															
790						0.302	0.295	0.285	0.285		0.279	0.261															
800						0.313	0.306	0.295	0.295		0.290	0.271															
810						0.325	0.317	0.305	0.305		0.300	0.281										0.418					
820					0.354	0.336	0.327	0.317	0.316		0.310	0.291	0.293								0.408	0.434					
830			0.365		0.368	0.347	0.338	0.328	0.326		0.320	0.301	0.303								0.423	0.449					
840			0.379		0.381	0.357	0.348	0.338	0.336	0.335	0.330	0.311	0.313							0.416	0.437	0.464					
850		0.392	0.393		0.393	0.368	0.358	0.348	0.346	0.345	0.339	0.321	0.322							0.430	0.451	0.479	0.569				
860		0.407	0.406	0.398	0.405	0.378	0.368	0.358	0.355	0.354	0.349	0.331	0.332							0.444	0.465	0.494	0.586				
870		0.421	0.418	0.410	0.417	0.388	0.377	0.368	0.365	0.363	0.358	0.340	0.341							0.457	0.479	0.509	0.604				
880	0.436	0.434	0.431	0.421	0.428	0.398	0.387	0.378	0.374	0.372	0.367	0.349	0.351	0.364					0.442	0.471	0.493	0.524	0.621				
890	0.451	0.447	0.442	0.432	0.439	0.407	0.396	0.388	0.384	0.381	0.376	0.359	0.360	0.374					0.454	0.484	0.506	0.538	0.638				
900	0.465	0.460	0.453	0.443	0.449	0.416	0.404	0.397	0.393	0.390	0.385	0.368	0.369	0.384					0.466	0.497	0.519	0.552	0.655	0.816			
910	0.479	0.472	0.464	0.454	0.459	0.425	0.413	0.407	0.402	0.399	0.394	0.377	0.378	0.394					0.478	0.510	0.532	0.567	0.672	0.835			
920	0.492	0.484	0.474	0.464	0.469	0.434	0.421	0.416	0.411	0.407	0.403	0.386	0.387	0.403					0.489	0.522	0.545	0.580	0.688	0.855	0.991	1.065	
930	0.505	0.495	0.483	0.473	0.478	0.442	0.429	0.425	0.420	0.416	0.411	0.395	0.396	0.413				0.471	0.501	0.535	0.557	0.594	0.705	0.875	1.014	1.090	1.128
940	0.518		0.492			0.450	0.437	0.436	0.428	0.424	0.419	0.404	0.405	0.422			0.469	0.482	0.512	0.547	0.570	0.608	0.721		1.035	1.117	1.152
950	0.530		0.500					0.443	0.437	0.432		0.412	0.414	0.431			0.479	0.492	0.524	0.559			0.737		1.057		1.176
960	0.542									0.439		0.421	0.422	0.440	0.473	0.473	0.489	0.502	0.535	0.571							1.202
970	0.554													0.449	0.482	0.486		0.511									1.228
980	0.565														0.492	0.497											1.255
990	0.576														0.501	0.506											
1000	0.587																										

TABLE 347. $CsCl-UCl_4$: Specific conductance ($ohm^{-1}\ cm^{-1}$)—Continued

Temperature-dependent equations $\kappa = a + bT + cT^2$				
Mol % UCl_4	a	$b \cdot 10^3$	$c \cdot 10^7$	Stand. deviation
0.00	2.9957	−6.3226	46.395	0.0005
1.02	13.7417	−29.8048	174.198	0.0003
3.26	−3.8451	8.2454	−32.482	0.0003
7.35	−0.7589	1.5389	2.342	0.0002
13.83	−1.4400	2.9736	−7.178	0.0001
19.45	−1.4068	2.9349	−8.422	0.0001
21.28	−1.4799	3.1354	−10.159	0.0002
24.06	−1.3083	2.7199	−7.937	0.0001
27.00	−1.2033	2.5200	−7.392	0.0002
30.43	−2.7700	5.8537	−25.474	0.0002
31.13	−0.9636	2.0305	−5.384	0.0000
33.04	−10.8375	22.1369	−107.871	0.0003
33.65	−2.1522	4.4807	−18.193	0.0001
38.86	−1.0835	2.2748	−7.161	0.0001
43.89	−0.7890	1.6591	−4.138	0.0001
49.04	−0.9181	1.9459	−5.744	0.0001
56.25	−0.9869	2.1639	−7.104	0.0002
58.86	−1.0665	2365.8989	−8.304	0.0003
62.44	−0.9636	2.1025	−6.614	0.0003
64.08	−1.0450	2.2606	−7.312	0.0007
65.52	−1.3451	3.0240	−12.003	0.0001
69.17	−1.4164	3.1693	−12.591	0.0005
77.20	−2.1097	4.6609	−20.194	0.0002
79.29	−1.9297	4.2145	−17.533	0.0002
83.35	−2.5714	5.6454	−25.388	0.0004
92.58	−2.5156	5.3743	−22.980	0.0002
100.00	−2.2782	4.6911	−18.260	0.0002

These values are based on the work of Bogacz and Ziolek (classical ac technique) [158].

TABLE 348. Density studies: $CsCl-UCl_4$

Investigations critically re-examined			
Ref.	UCl_4 Mol %	Temp. range (T)	Cell material
158	0–100	660–1004	Pt ball and suspension wire inside quartz tube

Deviations from previous NSRDS recommendations: [1, p. 6]			
Ref.	UCl_4 Mol %	Min. departure	Max. departure
158	0	0.54% (950 K)	0.59% (980 K)

Comment: Density data in reference [158] were reported in the form of linear temperature dependent equations with standard deviations in the range: 0.0×10^{-4} g cm^{-3} (33.04 and 33.65 mol % UCl_4) to 15.0×10^{-4} g cm^{-3} (64.08 mol % UCl_4). The total error in density measurements did not exceed 0.2%.

TABLE 349. $CsCl-UCl_4$: Density (g cm^{-3})

	Mol percent UCl_4													
T	100.00	92.58	83.35	79.29	77.20	69.19	65.52	64.08	62.44	58.86	56.25	49.04	43.89	38.86
680									3.574					
690									3.558					
700							3.570		3.542					
710							3.554		3.526					
720							3.538	3.463	3.510					
730							3.522	3.449	3.494					
740							3.505	3.435	3.478					
750							3.489	3.421	3.462					
760							3.473	3.407	3.446			3.290		
770							3.457	3.392	3.430			3.278		
780							3.441	3.378	3.414			3.266		
790							3.425	3.364	3.398		3.343	3.254		
800							3.409	3.350	3.382		3.329	3.242		
810							3.393	3.336	3.366		3.316	3.230		
820							3.377	3.322	3.350		3.302	3.218	3.173	
830							3.361	3.308	3.335		3.288	3.206	3.163	
840							3.345	3.294	3.319		3.275	3.194	3.152	
850							3.328	3.279	3.303		3.261	3.183	3.141	
860		3.423		3.385			3.312	3.265	3.287		3.247	3.171	3.131	
870	3.558	3.410		3.371			3.296	3.251	3.271		3.234	3.159	3.120	
880	3.539	3.397		3.358	3.329	3.303	3.280	3.237	3.255	3.230	3.220	3.147	3.109	3.072
890	3.519	3.385		3.344	3.315	3.288	3.264	3.223	3.239	3.216	3.206	3.135	3.099	3.062
900	3.500	3.372	3.254	3.330	3.301	3.273	3.248	3.209	3.223	3.203	3.193	3.123	3.088	3.052
910	3.480	3.359	3.241	3.316	3.287	3.258	3.232	3.195	3.207	3.189	3.179	3.111	3.077	3.043
920	3.461	3.346	3.227	3.303	3.273	3.243	3.216	3.180	3.191	3.175	3.166	3.099	3.066	3.033
930	3.441	3.333	3.214	3.289		3.228	3.200	3.166	3.175	3.161	3.152	3.087	3.056	3.023
940	3.422	3.320	3.201			3.213	3.184	3.152	3.159	3.148	3.138	3.075	3.045	3.014
950		3.307	3.187			3.198		3.138	3.143			3.063	3.034	3.004
960												3.051	3.024	2.994
970														2.985

TABLE 349. CsCl-UCl_4: Density (g cm^{-3})—Continued

	Mol percent UCl_4												
T	33.65	33.04	31.13	30.43	27.00	24.06	21.28	19.45	13.83	7.35	3.26	1.02	0.00
800								3.073					
810								3.062					
820							3.061	3.051					
830							3.050	3.040					
840						3.048	3.039	3.030					
850						3.039	3.028	3.019	2.986				
860						3.029	3.017	3.008	2.975				
870						3.019	3.007	2.997	2.964				
880					3.017	3.010	2.996	2.987	2.953				
890					3.010	3.000	2.985	2.976	2.942				
900					3.003	2.990	2.974	2.965	2.931	2.889			
910	2.974				2.996	2.980	2.963	2.954	2.920	2.878			
920	2.969				2.989	2.971	2.953	2.944	2.909	2.868	2.833		
930	2.964			2.985	2.982	2.961	2.942	2.933	2.897	2.857	2.822	2.801	2.795
940	2.959		2.964	2.975	2.975	2.951	2.931	2.922	2.886		2.812	2.792	2.784
950	2.954		2.956	2.966	2.968	2.942	2.920		2.875		2.801	2.783	2.773
960	2.949		2.947	2.957		2.932						2.773	2.763
970	2.944	2.941		2.948								2.764	2.752
980		2.935										2.755	2.741
990												2.746	
1000												2.736	

Temperature-dependent equations

$$\rho = a + bT$$

Mol % UCl_4	a	$b \cdot 10^4$	Stand. deviation
0.0	3.8047	−10.855	0.0001
1.02	3.6670	−9.308	0.0004
3.26	3.7852	−10.355	0.0006
7.35	3.8520	−10.701	0.0003
13.83	3.9309	−11.113	0.0004
19.45	3.9316	−10.378	0.0003
21.28	3.9463	−10.801	0.0004
24.06	3.8629	−9.697	0.0007
27.00	3.6417	−7.094	0.0004
30.43	3.8441	−9.241	0.0007
31.13	3.7666	−8.536	0.0004
33.04	3.5297	−6.065	0.0000
33.65	3.4249	−4.955	0.0000
38.86	3.9243	−9.688	0.0004
43.89	4.0492	−10.682	0.0005
49.04	4.1955	−11.917	0.0004
56.25	4.4225	−13.663	0.0004
58.86	4.4402	−13.752	0.0005
62.44	4.6601	−15.971	0.0013
64.08	4.4808	−14.134	0.0015
65.52	4.6966	−16.096	0.0011
69.19	4.6211	−14.976	0.0002
77.20	4.5521	−13.904	0.0006
79.29	4.5678	−13.751	0.0003
83.35	4.4601	−13.398	0.0005
92.58	4.5279	−12.847	0.0007
100.00	5.2508	−19.455	0.0006

These values are based on the work of Bogacz and Ziolek (Archimedean method) [158].

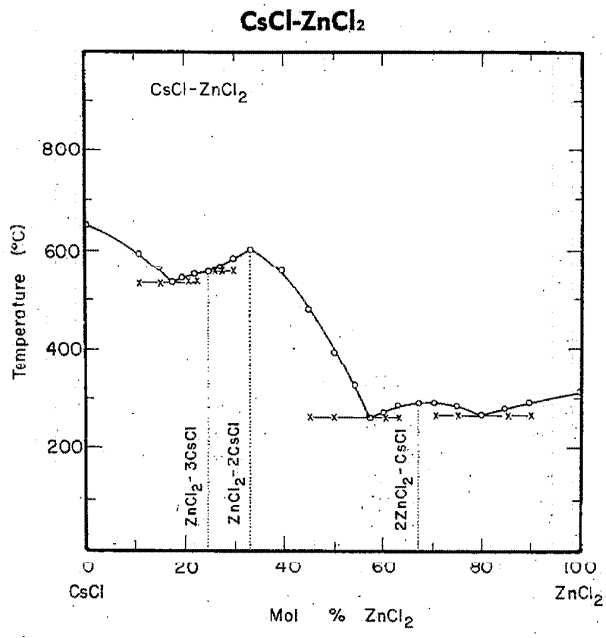


FIGURE 53. Temperature-composition phase diagram for $CsCl-ZnCl_2$.

B. R. Markov, I. D. Panchonko, and T. G. Mostenko, Ukrain. Khim. Zhur., **22**, 287–91 (1956).

Melt Preparation and Purification

Smith and Smith [91] used CsCl (99.9%) which was recrystallized from water, solvent extracted and vacuum dried. Further purification involved passing pure HCl gas through the melt followed by nitrogen gas. Zinc chloride was prepared from high grade Zn metal and pure HCl and then distilled. Weighings were made in a vacuum-type dry box under nitrogen atmosphere.

Koch-Light CsCl used by Weeks [**108**] and Bloom and Weeks [**197,198**] was dried at 400 °C for three hours. May and Baker (R) $ZnCl_2$ was heated under vacuum for several hours and then fused. Chlorine gas was passed through the melt for 15–30 minutes, after which it was transferred to a silica apparatus and distilled at 600 °C. Solutions were analyzed for Zn^{2+} and Cl^- ions using disodium ethylenediaminetetracetic acid and silver nitrate (dichlorofluorescein indicator), respectively.

Markov and Bolkov [194] used $ZnCl_2$ which was twice recrystallized from water, dried, subjected to a flow of HCl gas and finally distilled and sealed into ampoules. CsCl was recrystallized and dried.

TABLE 350. Electrical conductance studies: $CsCl-ZnCl_2$

Investigations critically re-examined			
Ref.	$ZnCl_2$ Mol %	Temp. range (T)	Comments
108, 197[a]	58.1–100	522–882	Cell material: silica glass; Pt electrodes; freq. range: 0.5–50,000 Hz, measurements at 5000 Hz; calibration: 0.1 and 1.0 Demal KCl solutions at 25 °C

Deviations from previous NSRDS recommendations: [1, p. 10]			
Ref.	$ZnCl_2$ Mol %	Min. departure	Max. departure
108, 197[a]	100	−3.0% (830 K)	−53.0% (627 K)

[a]Weeks [**108**] reports an overall accuracy in conductance measurements of 0.5% and 0.3% for pure zinc chloride and for mixtures, respectively. The cell constant changed by 0.1–0.2% during a run. Weeks [**108**] reported experimental specific conductivities and Bloom and Weeks [**197**] gave equivalent conductances in the form of the Adam-Gibbs equation ($\Lambda = A \exp(-B/T \ln (T/T_0))$).

TABLE 351. CsCl-$ZnCl_2$: Specific conductance (ohm^{-1} cm^{-1})

	Mol percent $ZnCl_2$						
T	100.00	97.17	93.84	84.90	79.70	67.94	58.08
530							0.06754
550					0.05364	0.08252	0.09248
570				0.04580	0.07269	0.1083	0.1192
590		0.008815	0.01962	0.06198	0.09427	0.1360	0.1475
610	0.002514	0.01274	0.0279	0.08101	0.1182	0.1654	0.1773
630	0.004740	0.01892	0.03861	0.1027	0.1444	0.1962	0.2082
650	0.008460	0.02749	0.05181	0.1269	0.1726	0.2284	0.2403
670	0.01399	0.03856	0.06752	0.1535	0.2028	0.2617	0.2732
690	0.02163	0.05225	0.8580	0.1823	0.2347	0.2961	0.3069
710	0.03171	0.06869	0.1067	0.2131	0.2682	0.3312	0.3410
730	0.04454	0.08798	0.1302	0.2458	0.3032	0.3669	0.3755
750	0.06042	0.1103	0.1564	0.2801	0.3395	0.4031	0.4102
770	0.07968	0.1356	0.1853	0.3160	0.3769	0.4396	0.4449
790	0.1026	0.1642	0.2170	0.3533	0.4154	0.4761	0.4794
810	0.1296	0.1961	0.2515	0.3918	0.4546	0.5126	0.5135
830	0.1608	0.2315	0.2889	0.4313	0.4946	0.5488	0.5471
850	0.1967	0.2705	0.3291	0.4718	0.5351	0.5846	0.5800
870		0.3132	0.3723	0.5129	0.5759	0.6198	0.6120

Temperature-dependent equations

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

Mol % $ZnCl_2$	$a \cdot 10^1$	$b \cdot 10^3$	$c \cdot 10^6$	$d \cdot 10^9$	Stand. error of est.
58.08	6.7241	−4.5267	8.3585	−3.7187	0.25%
67.94	7.7826	−4.8809	8.5913	−3.6672	0.15%
79.70	11.1048	−5.6959	8.6185	−3.1928	0.22%
84.90	14.7698	−6.8603	9.5679	−3.3976	3.36%
93.84	6.7834	−2.2889	1.4825	0.8552	0.38%
97.17	3.4730	−0.4230	−1.7232	2.4876	1.13%
100.00	−9.7574	5.5534	−10.4507	6.5176	1.30%

These values are based on the work of Bloom and Weeks (classical ac technique) [**108, 197**].

TABLE 352. Density studies: CsCl-$ZnCl_2$

Investigations critically re examined			
Ref.	$ZnCl_2$ Mol %	Temp. range (T)	Comments
91[a]	10–100	583–1068	Cell material: Pt bi-cone and Pt suspension wire (Archimedean method), silica cell (float method)
108, 199[b]	58.1–100	530–850	Cell material: silica pycnometer; calibration: water
194	0–100	695–975	Cell material: quartz sphere (weighted with W), Pt suspension wire; calibration: water

Deviations from previous NSRDS recommendations: [1, pp. 6, 10]			
Ref.	$ZnCl_2$ Mol %	Min. departure	Max. departure
91	100	0.0% (630 K)	0.45% (800 K)
108, 199	100	−0.08% (683 K)	0.40% (600 K)
194	100	−0.02% (733 K)	−0.16% (696 K)
194	0	−0.03% (939 K)	−0.04% (975 K)

[a]Due to the hygroscopic nature and volatility of $ZnCl_2$, Smith and Smith [91] used the floatation method for density measurements on pure $ZnCl_2$ and also for the 97 mole % $ZnCl_2$ mixture. Results from the buoyancy and float methods were in agreement to within 0.1% for pure $ZnCl_2$ and 0.7% for the 97 mole % mixture. A correction was applied for the thermal expansion of the platinum sinker; however no corrections were made for surface tension force since the authors concluded that errors due to salt condensation were smaller than the precision of the measurements. Linear temperature dependent equations were reported with standard deviations in the range 0.1×10^{-2} g cm^{-3} (99 mole % Zn Cl_2) to 7.8×10^{-2} g cm^{-3} (95 mole % $ZnCl_2$).

[b]Weeks [**108**] and Bloom and Weeks [**199**] reported an overall accuracy in density measurements of 0.05% to 0.1%. Calibration of the pycnometers after experiments showed reproducibility of 0.01%. Weeks [**108**] reported experimental density values while Bloom and Weeks [**199**] gave results in the form of linear temperature dependent equations with standard deviations in the range: 0.33×10^{-3} g cm^{-3} (91.2 mole % $ZnCl_2$) to 2.31×10^{-3} g cm^{-3} (71.4 mole % $ZnCl_2$).

TABLE 353. $CsCl\text{-}ZnCl_2$: Density (g cm^{-3})

	Mol percent $ZnCl_2$								
T	100.00	99.38	98.62	95.13	91.22	85.20	71.40	61.20	58.10
540									2.813
560							2.730		2.794
580				2.571	2.599	2.642	2.713	2.739	2.776
600	2.520	2.529	2.533	2.559	2.586	2.627	2.696	2.722	2.758
620	2.509	2.518	2.522	2.547	2.573	2.613	2.679	2.704	2.739
640	2.499	2.507	2.511	2.535	2.560	2.598	2.661	2.686	2.721
660	2.488	2.497	2.500	2.524	2.547	2.584	2.644	2.668	2.703
680	2.478	2.486	2.490	2.512	2.534	2.569	2.627	2.651	2.684
700	2.467	2.475	2.479	2.500	2.521	2.554	2.610	2.633	2.666
720	2.456	2.464	2.468	2.488	2.509	2.540	2.593	2.615	2.647
740	2.446	2.454	2.457	2.476	2.496	2.525	2.575	2.598	2.629
760	2.435	2.443	2.446	2.464	2.483	2.511	2.558	2.580	2.611
780	2.425	2.432		2.452		2.496	2.541	2.562	2.592
800	2.414			2.440		2.482	2.524	2.544	2.574
820	2.403			2.428		2.467	2.507	2.527	2.555
840				2.416		2.453	2.490	2.509	2.537
860				2.405		2.438	2.472	2.491	2.519
880							2.455		

Temperature-dependent equations

$$\rho = a + bT$$

Mol % $ZnCl_2$	a	$b \cdot 10^4$	Stand. error of est.
58.10	3.3095	−9.1970	0.03%
61.20	3.2531	−8.8586	0.03%
71.40	3.2111	−8.5904	0.09%
85.20	3.0642	−7.2818	0.05%
91.22	2.9745	−6.4724	0.01%
95.13	2.9160	−5.9476	0.04%
98.62	2.8575	−5.4123	0.06%
99.38	2.8516	−5.3800	0.08%
100.00	2.8375	−5.2926	0.09%

These values are based on the work of Bloom and Weeks (pycnometric method) [**108, 199**].

CuCl-KCl

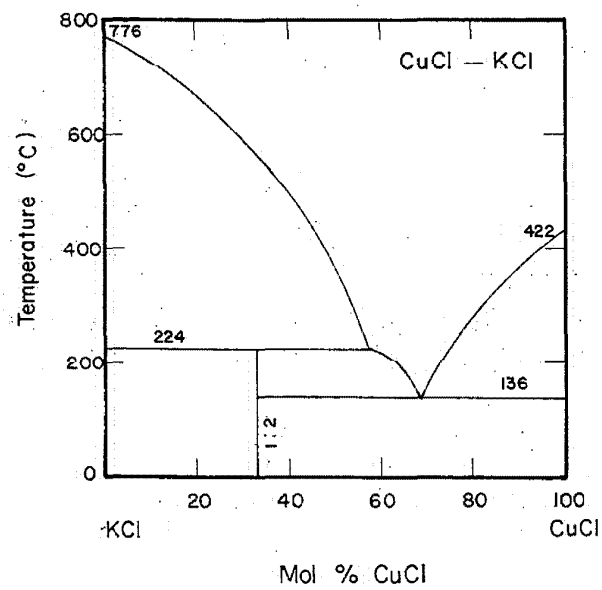


FIGURE 54. Temperature-composition phase diagram for CuCl-KCl.

Carlo Sandonnini, Gazz. Chim. ital., **44I**, 307 (1914).

Melt Preparation and Purification

Sackur [**18**] used KCl which had been previously fused and pulverized. The CuCl was obtained by precipitation and then dried.

Kanazawa and Sakai [**116**] used purified material supplied by either Ishizu Chem. Co. (Japan) or Merck. The salts were dehydrated by heating in vacuum.

TABLE 354. Electrical conductance studies: CuCl-KCl

Investigations critically re-examined			
Ref.	KCl Mol %	Temp. range (T)	Comments
116	0–79.4	698–903	Cell material: quartz cell; Pt electrodes; freq. range: 1000 Hz; calibration: 1N KCl solution

Deviations from previous NSRDS recommendations: [1, p. 9]			
Ref.	KCl Mol %	Min. departure	Max. departure
116	0	−3.5% (903 K)	−5.2% (763 K)

TABLE 355. CuCl-KCl: Specific conductance (ohm^{-1} cm^{-1})

	Mol percent KCl								
T	79.4	71.1	64.9	59.5	49.7	40.8	29.6	17.9	0
700			1.95	2.10	2.03	2.35	2.64	2.91	3.26
710			1.97	2.10	2.08	2.38	2.66	2.94	3.29
720			1.98	2.10	2.12	2.42	2.70	2.96	3.32
730			1.99	2.11	2.17	2.46	2.72	2.99	3.34
740			2.01	2.12	2.21	2.49	2.75	3.01	3.37
750			2.03	2.13	2.25	2.52	2.78	3.04	3.40
760			2.04	2.14	2.29	2.56	2.81	3.06	3.42
770		1.93	2.06	2.16	2.33	2.59	2.83	3.08	3.45
780		1.96	2.08	2.17	2.36	2.62	2.86	3.11	3.48
790		2.00	2.10	2.19	2.40	2.65	2.88	3.13	3.50
800		2.03	2.12	2.21	2.43	2.68	2.91	3.16	3.52
810		2.07	2.15	2.23	2.46	2.70	2.93	3.18	3.54
820		2.11	2.17	2.25	2.49	2.73	2.95	3.20	3.56
830		2.14	2.20	2.28	2.51	2.75	2.98	3.23	3.58
840		2.18	2.22	2.30	2.54	2.78	3.00	3.25	3.60
850		2.22	2.25	2.33	2.56	2.80	3.02	3.28	3.62
860	[2.17]	2.25	2.28	2.36	2.58	2.82	3.04	3.30	3.64
870	[2.21]	2.29	2.31	2.39	2.60	2.84	3.06	3.32	3.66
880	[2.26]	2.32	2.34	2.42	2.62	2.86	3.08	3.35	3.68
890	[2.30]	2.36	2.37	2.46	2.64	2.88	3.10	3.37	3.69
900	[2.34]	2.40	2.41	2.49	2.65	2.90	3.12	3.40	3.71

Temperature-dependent equations

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

Mol % KCl	a	$b \cdot 10^3$	$c \cdot 10^6$	Stand. error of est.
0.0	−0.7844	8.5196	−3.9207	0.18%
17.9	1.2251	2.4135	0	1.29%
29.6	−1.0888	7.5901	−3.2428	0.35%
40.8	−2.7408	10.764	−4.9926	0.52%
49.7	−5.7136	17.258	−8.8502	3.14%
59.5	6.2012	−11.971	8.7241	1.02%
64.9	3.8262	−6.5115	5.4819	1.30%
71.1	−0.8606	3.6194	0	0.82%
79.4	[−1.4746]	[4.240]	0	0.00%

These values are based on the work of Kanazawa and Sakai (classical ac technique) [116].

TABLE 356. Density studies: CuCl-KCl

Investigations critically re-examined			
Ref.	KCl Mol %	Temp. range (T)	Comments
18	91.1–97.5	1073	Cell material: Density bob of Pt-Au alloy; calibration: molten KCl

TABLE 357. CuCl-KCl: Density (g cm^{-3})

	Mol percent KCl			
T	100	97.5	94.6	91.1
1073.2	1.506	1.548	1.586	1.624

These values are based on the work of Sackur (Archimedean method) [18]. Due to limited data, the experimental results are given.

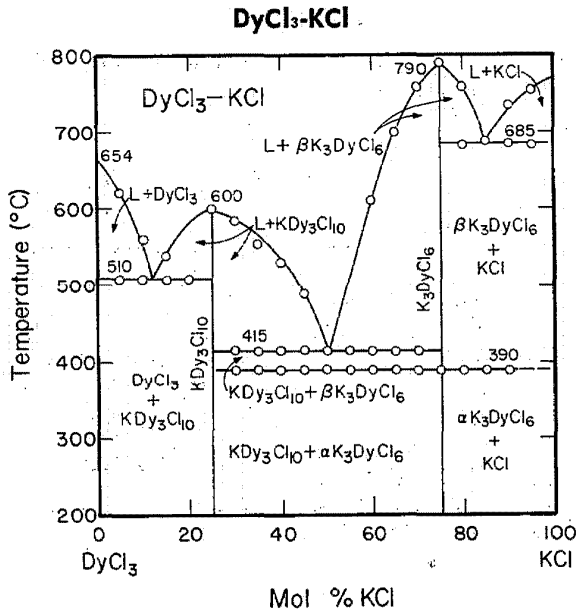


FIGURE 55. Temperature-composition phase diagram for $DyCl_3$-KCl.

B. G. Korshunov, and D. V. Drobot, Russ. J. Inorg. Chem., **10**, 508 (1965).

Melt Preparation and Purification

Dysprosium trichloride was prepared and analyzed as described under the system KCl-$NdCl_3$.

TABLE 358. Electrical conductance studies: $DyCl_3$-KCl

Investigations critically re-examined			
Ref.	KCl Mol %	Temp. range (T)	Comments
190[a]	0–100 (g)	1073, 1173	Cell material: quartz capillary cell; Pt electrodes; freq. range: 100,000–250,000 Hz; calibration: molten CsCl, KCl, NaCl

[a]Equivalent conductivities were reported.

Comment: Experimental details are briefly discussed under the system KCl-$NdCl_3$.

TABLE 359. $DyCl_3$-KCl: Molar conductance (ohm^{-1} cm^2 mol^{-1})

Mol % KCl	1073 K	Mol % KCl	1073 K
0	45.6	50	56.0
10	50.9	60	57.5
20	53.6	70	62.0
30	55.0	80	71.0
40	55.7	90[a]	86.6

[a]Extrapolated value.

These values have been interpolated to three significant figures from the graphical presentation of Forthmann and Schneider (classical ac technique) [**190**].

$DyCl_3$-NaCl

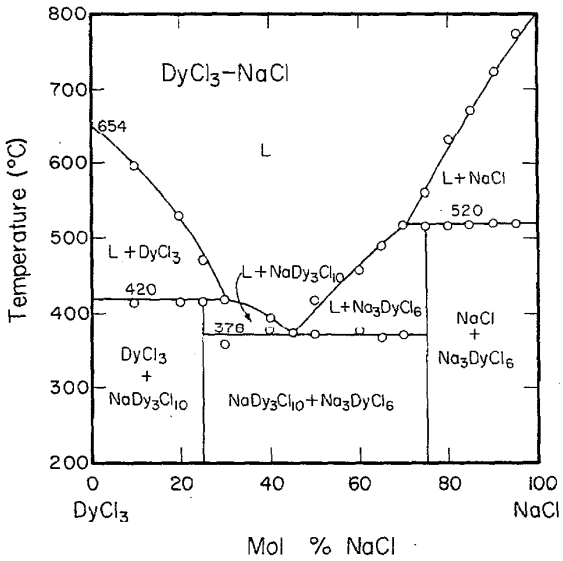


FIGURE 56. Temperature-composition phase diagram for $DyCl_3$-NaCl.

B. G. Korshvnov and D. V. Droboy, Zh. Neorgan. Khim., **10** [4], 939 (1965); Russ. J. Inorg. Chem. (English Transl.), 509 (1965).

Melt Preparation and Purification

Dysprosium trichloride was prepared and analyzed as described under the system KCl-$NdCl_3$.

TABLE 360. Electrical conductance studies: $DyCl_3$-NaCl

Investigations critically re-examined			
Ref.	NaCl Mol %	Temp. range (T)	Comments
190[a]	0–100 (g)	1073, 1173	Cell material: quartz capillary cell; Pt electrodes; freq. range: 100,000–250,000 Hz; calibration: molten CsCl, KCl, NaCl

[a]Equivalent conductivities were reported.

Comment: Experimental details are briefly discussed under the system KCl-$NdCl_3$.

TABLE 361. $DyCl_3$-NaCl: Molar conductance (ohm^{-1} cm^2 mol^{-1})

Mol % NaCl	1073 K	Mol % NaCl	1073 K
0	46.6	60	83.2
10	51.6	70	90.3
20	59.5	80	100.
30	67.0	90[a]	115.
40	72.4	100	135.
50	77.4		

[a]Extrapolated value.

These values have been interpolated to three significant figures from the graphical presentation of Forthmann and Schneider (classical ac technique) [**190**].

$ErCl_3$-KCl

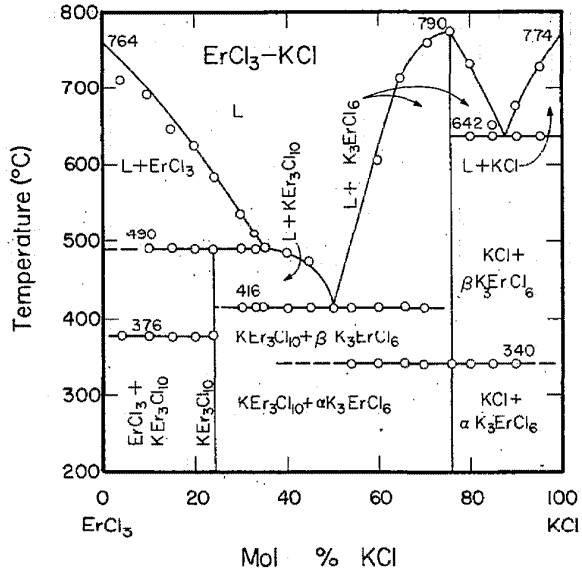


FIGURE 57. Temperature-composition phase diagram for $ErCl_3$-KCl.

B. G. Korshurov, D. V. Drobot, I. E. Galchenko and Z. N. Shevtsona, Russ. J. Inorg. Chem., **11**, 223 (1966).

Melt Preparation and Purification

Erbium trichloride was prepared and analyzed as described under the system KCl-$NdCl_3$.

TABLE 362. Electrical conductance studies: $ErCl_3$-KCl

Investigations critically re-examined			
Ref.	KCl Mol %	Temp. range (T)	Comments
190[a]	0–100 (g)	1073	Cell material: quartz capillary cell; Pt electrodes; freq. range 100,000–250,000 Hz; calibration: molten CsCl, KCl, NaCl

[a]Equivalent conductance reported.

Comment: Experimental details are briefly discussed under the system KCl-$NdCl_3$.

TABLE 363. $ErCl_3$-KCl: Molar conductance (ohm^{-1} cm^2 mol^{-1})

Mol % KCl	1073 K	Mol % KCl	1073 K
0	36.7	50	56.0
10	43.3	60	58.9
20	48.3	70	63.3
30	51.3	80	72.5
40	54.0	90	90.7

These values have been interpolated to three significant figures from the graphical presentation of Forthmann and Schneider (classical ac technique) [**190**].

$GaCl_3$-$HgCl_2$

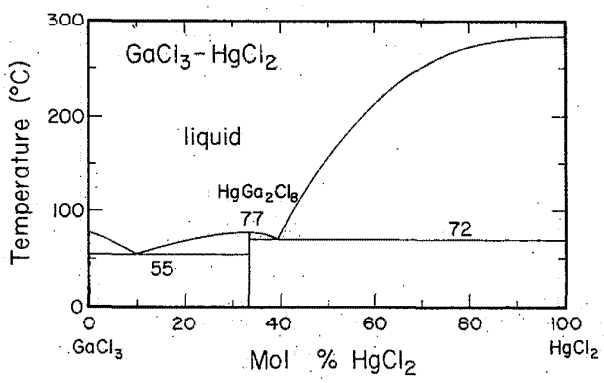


FIGURE 58. Temperature-composition phase diagram for $GaCl_3$-$HgCl_2$.

P. I. Fedorov, V. V. Tsimbalist, and Liu Kuo-Yüan, Zh. Neorgan. Khim., **9** [7], 1681 (1964).

Melt Preparation and Purification

The preparation of pure $GaCl_3$ by Chretien and Couturier [**148**] is discussed under the system $GaCl_3$-KCl. No information was given regarding the preparation of $HgCl_2$.

TABLE 364. Electrical conductance studies: $GaCl_3$-$HgCl_2$

Investigations critically re-examined		
Ref.	$HgCl_2$ Mol %	Temp. range (T)
148	~3.4–17.4 (g)	353

TABLE 365. $GaCl_3$-$HgCl_2$: Specific conductance (ohm^{-1} cm^{-1})

Mol % $HgCl_2$	353 K
2.5	0.0020
5.0	0.0040
7.5	0.0064
10.0	0.0088
12.5	0.0090
15.0	0.0091

These values have been interpolated to two significant figures from the graphical presentation of Chretien and Couturier (classical ac technique) [**148**].

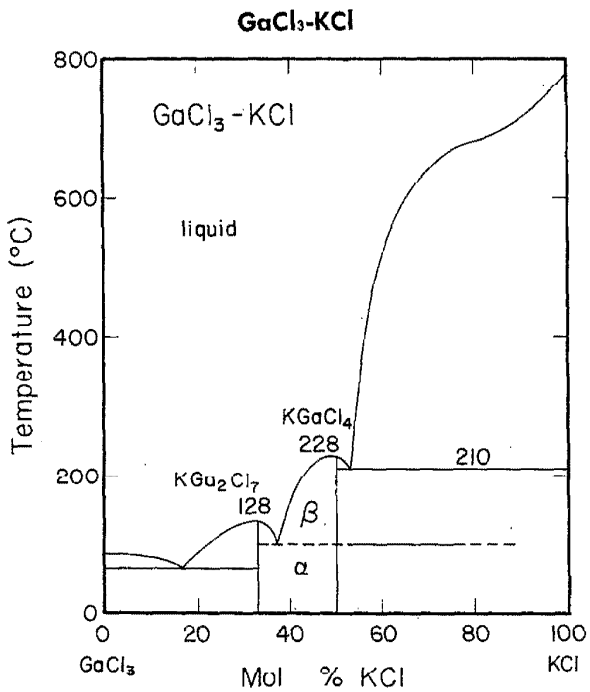


FIGURE 59. Temperature-composition phase diagram for $GaCl_3$-KCl.

P. I. Fedorov and V. V. Tsimbalist, Zh. Neorgan. Khim., **9** [7] 1676 (1964).

Melt Preparation and Purification

Chretien and Coutourier [148] prepared $GaCl_3$ by direct synthesis from gallium metal and Cl_2 gas. The distilled product (which contained some $GaCl_2$) was then fused under N_2 or CO_2 and gaseous Cl_2 was bubbled through the melt. Pure $GaCl_3$ was then obtained by distillation. The product was pure white $GaCl_3$ of high purity. Analysis was by complexometric titration using EDTA (for Ga) and potentiometric titration with $AgNO_3$ (for Cl). Care was taken to keep the apparatus, in which the measurements were made, dry.

TABLE 366. Electrical conductance studies: $GaCl_3$-KCl

Investigations critically re-examined			
Ref.	KCl Mol %	Temp. range (T)	Comments
80	~8–75 (g)	873–973	Cell material: quartz or Pyrex depending on temperature range; calibration: molten KCl and 0.1N and 1.0N KCl solutions
148[a]	~5.2–23.0 (g)	353	Pt electrodes; freq. range: 1000 Hz

[a]Compositions reported in terms of moles of KCl per 1000 g of $GaCl_3$.

Comment: Arbekov and Petrov **[80]** reported a 2% accuracy in their measurements and found differences of up to 5% in calibrating their cells depending upon the solution used.

TABLE 367. $GaCl_3$-KCl: Specific conductance (ohm^{-1} cm^{-1})

Mol % $GaCl_3$	373 K	473 K	573 K	673 K	773 K	873 K	973 K
30							0.951
40						0.804	0.944
50				0.644	0.865	1.086	1.324
60			0.340	0.531	0.718	0.925	
70		0.169	0.316	0.507			
80	0.047	0.133	0.246				
90	0.029	0.074	0.143				

These values have been interpolated to three significant figures from the graphical presentation of Arbekov and Petrov (classical ac technique) **[80]**.

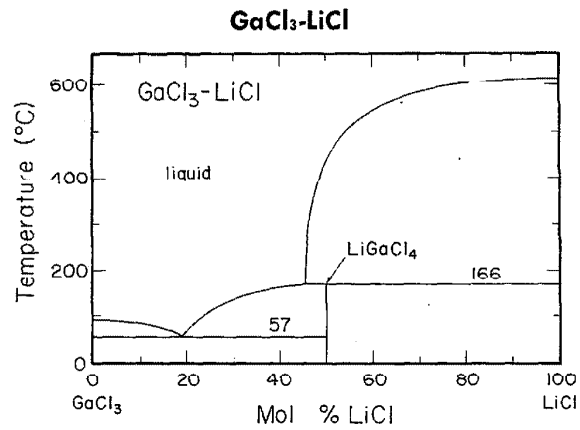


FIGURE 60. Temperature-composition phase diagram for $GaCl_3$-LiCl.

P. I. Fedorov and V. V. Tsimbalist, Zh. Neorgan. Khim., **9** [7], 1676 (1964); Russ. J. Inorg. Chem. (English Transl.), 909 (1964).

TABLE 368. Electrical conductance studies: $GaCl_3$-LiCl

Investigations critically re-examined			
Ref.	LiCl Mol %	Temp. range (T)	Comments
138, 80	8–80 (g)	373–873	Cell material: Pyrex or quartz depending on temperature range; calibration: molten KCl and 0.1N and 1.0N KCl solutions

TABLE 369. $GaCl_3$-LiCl: Specific conductance (ohm^{-1} cm^{-1})

Mol % $GaCl_3$	373 K	473 K	573 K	673 K	773 K	873 K
30						1.19
40				0.76	0.90	1.06
50		0.28	0.45	0.60		
60		0.18	0.31			
70	0.06	0.16				
80	0.04	0.10				
90	0.02	0.06				

These values have been interpolated to two significant figures from the graphical presentation of Arbekov and Petrov (classical ac technique) **[138, 80]**.

$GaCl_3$-NaCl

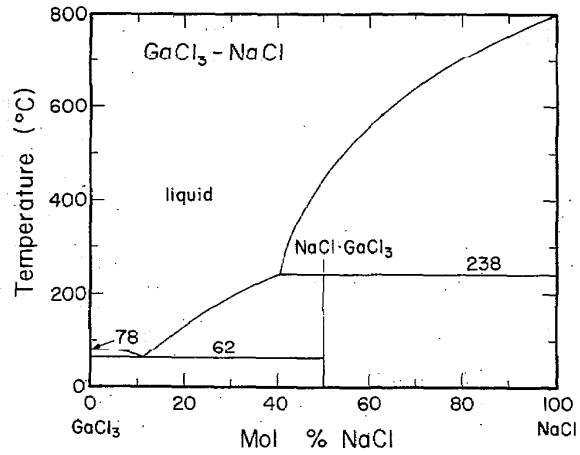


FIGURE 61. Temperature-composition phase diagram for $GaCl_3$-NaCl.

P. I. Fedorov and V. M. Yakunina, Zh. Neorgan. Khim., 8 [9], 2103 (1963).

Melt Preparation and Purification

A brief outline of Chretien and Coutourier's [148] preparation of $GaCl_3$ is to be found under the system $GaCl_3$-KCl.

TABLE 370. Electrical conductance studies: $GaCl_3$-NaCl

Investigations critically re-examined			
Ref.	LiCl Mol %	Temp. range (T)	Comments
138	~8–80 (g)	373–1073	Cell material: quartz or Pyrex depending on temperature range; calibration: molten KCl and 0.1N and 1.0N KCl solutions
148[a]	~5.2–16.2 (g)	353	Pt electrodes; freq. range: 1000 Hz

[a]Compositions were reported in terms of moles of NaCl per 1000 g $GaCl_3$.

TABLE 371. $GaCl_3$-NaCl: Specific conductance (ohm^{-1} cm^{-1})

Mol % $GaCl_3$	373 K	473 K	573 K	673 K	773 K	883 K	993 K	1073 K
20								1.56
30								1.30
40					0.95[a]	1.10[a]	1.22	1.32
50		0.45	0.68	0.85	1.02			
60		0.30	0.45					
70		0.20						
80	0.07	0.15						
90	0.02	0.06						

These values have been interpolated to three significant figures from the graphical presentation of Arbekov and Petrov (classical ac technique) [138].

[a]Extrapolated value.

$GaCl_3$-RbCl

TABLE 372. Electrical conductance studies: $GaCl_3$-RbCl

Investigations critically re-examined			
Ref.	RbCl Mol %	Temp. range (T)	Comments
80[a]	~2–90 (g)	373–973	Cell material: Pyrex or quartz depending on temperature range; calibration: molten KCl, and 0.1 and 1.0N KCl solutions

[a]Arbekov and Petrov [80] reported a 2% accuracy in their measurements and found differences of up to 5% in calibrating their cells depending upon the solution used.

TABLE 373. $GaCl_3$-RbCl: Specific conductance (ohm^{-1} cm^{-1})

RbCl Mol %	373 K	473 K	573 K	673 K	773 K	873 K	973 K
10							1.04
20							0.83
30							0.72
40					0.49	0.60	0.71
50				0.51	0.67	0.85	1.02
60				0.48	0.61	0.75	
70		0.16	0.29	0.41	0.55		
80	0.03	0.11	0.22				
90	<0.02	0.06					
100	<0.01	<0.01					

These values have been interpolated to two significant figures from the graphical presentation of Arbekov and Petrov (classical ac technique) [80].

$GaCl_3$-$SbCl_3$

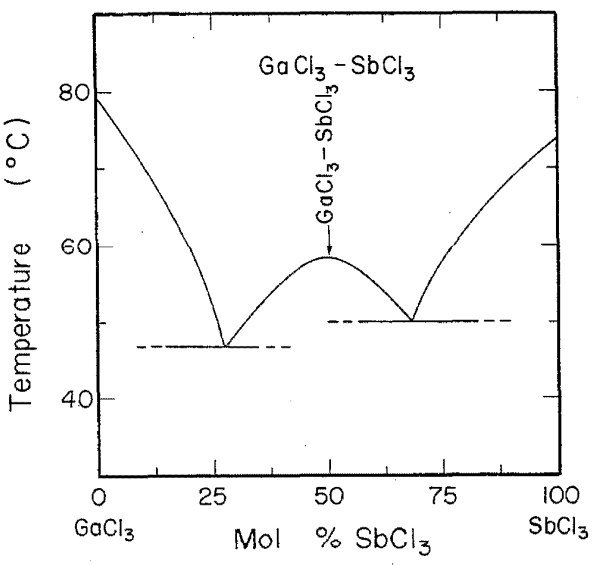


FIGURE 62. Temperature-composition phase diagram for $GaCl_3$-$SbCl_3$.

A. Chrefien, J. C. Couturier, Rev Chim. Minérale, **2**, 487 (1965).

Melt Preparation and Purification

Chretien and Coutourier's [148] preparation of pure $GaCl_3$ is discussed under the $GaCl_3$-KCl system. No details were given for the preparation of $SbCl_3$.

TABLE 374. Electrical conductance studies: $GaCl_3$-$SbCl_3$

Investigations critically re-examined		
Ref.	$SbCl_3$ Mol %	Temp. range (T)
148	~10–95 (g)	353, 363, 373

TABLE 375. $GaCl_3$-$SbCl_3$: Specific conductance (ohm^{-1} cm^{-1})

Mol % $SbCl_3$	353 K	363 K	373 K
0	<0.0005		
10	0.006		
20	0.010		
30	0.017		
40	0.023		
50	0.029		
60	0.034	0.040	0.046
70	0.036	0.042	0.047
80	0.032	0.036	0.040
90	0.017	0.020	0.022

These values have been interpolated to two significant figures from the graphical presentation of Chretien and Couturier (classical ac technique) [148].

$GdCl_3$-KCl

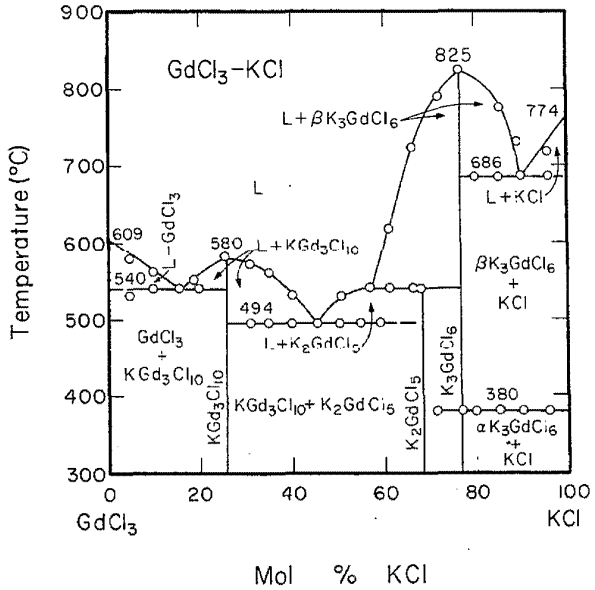


FIGURE 63. Temperature-composition phase diagram for $GdCl_3$-KCl.

D. G. Korshunov and D. V. Drobot, Russ. J. Inorg. Chem., **10**, 508 (1965).

Melt Preparation and Purification

Gadolinium trichloride was prepared and analyzed as described under the system KCl-$NdCl_3$.

TABLE 376. Electrical conductance studies: $GdCl_3$-KCl

Investigations critically re-examined			
Ref.	KCl Mol %	Temp. range (T)	Comments
190[a]	0–100 (g)	1073	Cell material: quartz capillary cell; Pt electrodes; freq. range: 100,000–250,000 Hz; calibration: molten CsCl, KCl, NaCl

[a]Equivalent conductivities were reported.

Comment: Experimental details are briefly discussed under the system KCl-$NdCl_3$.

TABLE 377. $GdCl_3$-KCl: Molar conductance (ohm^{-1} cm^2 mol^{-1})

Mol % KCl	1073 K	Mol % KCl	1073 K
0	56.4	60	61.2
10	58.2	70	63.8
20	59.8	80	72.6
30	60.5	90	89.7[a]
40	60.8	100	109.[a]
50	60.8		

[a]Extrapolated value.

These values have been interpolated to three significant figures from the graphical presentation of Forthmann and Schneider (classical ac technique) [190].

$GdCl_3$-NaCl

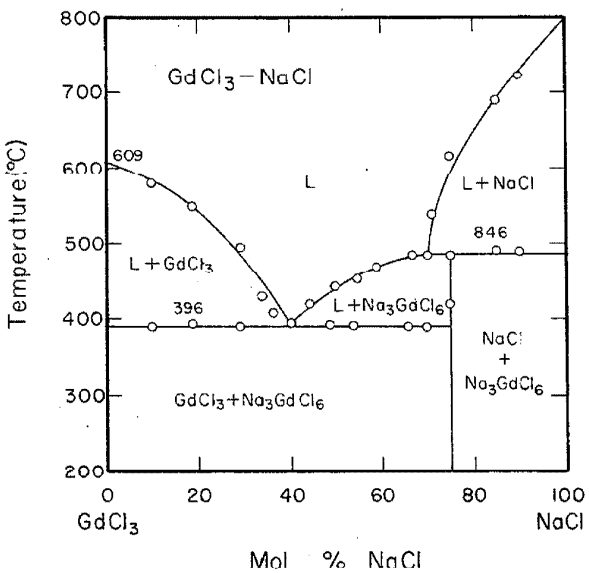


FIGURE 64. Temperature-composition phase diagram for $GdCl_3$-NaCl.

B. G. Korshunon and D. V. Drobot, Russ. J. Inorg. Chem., **10**, 508 (1965).

Melt Preparation and Purification

Gadolinium trichloride was prepared and analyzed as described under the system KCl-$NdCl_3$.

TABLE 378. Electrical conductance studies: $GdCl_3$-NaCl

	Investigations critically re-examined		
Ref.	NaCl Mol %	Temp. range (T)	Comments
190[a]	0–100 (g)	1073	Cell material: quartz capillary cell; Pt electrodes; freq. range: 100,000–250,000 Hz; calibration: molten CsCl, KCl, NaCl

[a]Equivalent conductivities were reported.

Comment: Experimental details are briefly discussed under the system KCl-$NdCl_3$.

TABLE 379. $GdCl_3$-NaCl: Molar conductance (ohm^{-1} cm^2 mol^{-1})

Mol % NaCl	1073 K	Mol % NaCl	1073 K
0	57.4	60	90.9
10	64.7	70	94.6
20	72.2	80	104.
30	78.0	90	118.
40	84.6	100	136.[a]
50	87.4		

[a]Extrapolated value.

These values have been interpolated to three significant figures from the graphical presentation of Forthmann and Schneider (classical ac technique) [190].

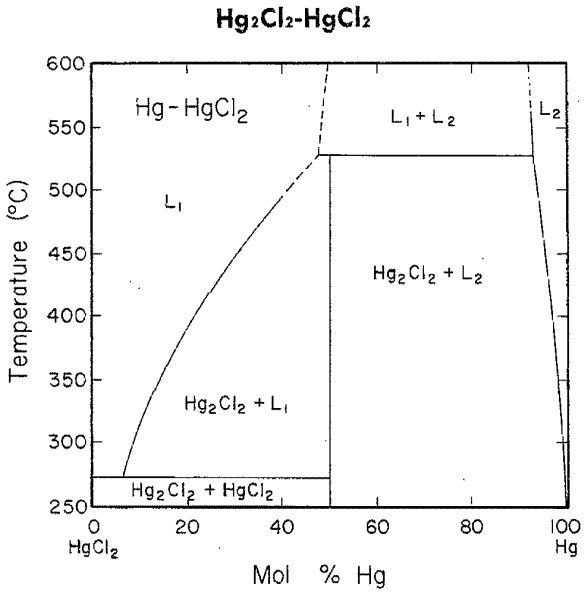


FIGURE 65. Temperature-composition phase diagram for Hg_2Cl_2-$HgCl_2$.

S. J. Yosim and S. W. Mayer, J. Phys. Chem., **64**, 707 (1960).

Melt Preparation and Purification

Grantham [**121**] purified reagent-grade $HgCl_2$ by distillation under a partial pressure of oxygen (oxidation of any Hg_2Cl_2). The $HgCl_2$ was added to the cell in an inert-atmosphere dry box and sufficient triply distilled mercury was introduced to obtain the desired compositions.

TABLE 380. Electrical conductance studies: Hg_2Cl_2-$HgCl_2$

Investigations critically re-examined			
Ref.	$HgCl_2$ Mol %	Temp. range (T)	Comments
121	0.0–94.7	540–1073	Cell material: quartz; W electrodes; calibration: redistilled Hg and KCl solutions

Deviations from previous NSRDS recommendations: [1, p. 11]			
Ref.	$HgCl_2$ Mol %	Min. departure	Max. departure
121	0	−5.8% (822 K)	−8.2% (800 K)

Comment: The data reported by Grantham [**121**] was the average of several experiments made in a quartz apparatus with various cell constants. The values obtained agreed to within 1%. The cell was constructed for the purpose of measuring electrical conductivities of molten salts to temperatures of 900 °C and vapor pressure of 118 atmospheres.

TABLE 381. Hg_2Cl_2-$HgCl_2$: Specific conductance (ohm^{-1} cm^{-1})

	Mol percent $HgCl_2$					
T	94.7	88.9	74.8	57.2	33.3	0.0
540	0.00038					
560	0.00050					
580	0.00061					
600	0.00072					
620	0.00083	0.0052				
640	0.00093	0.0063				
660	0.00103	0.0072				
680	0.00113	0.0080				
700	0.00122	0.0088	0.095			
720		0.0094	0.106			
740		0.0100	0.116			
760		0.0105	0.125	0.397		
780		0.0109	0.132	0.425	0.716	
800		0.0112	0.137	0.451	0.779	0.92
820		0.0114	0.142	0.475	0.836	0.98
840		0.0115	0.145	0.497	0.887	1.04
860			0.147	0.517	0.932	1.10
880			0.147			1.16
900			0.146			1.22
920			0.144			1.29
940			0.141			1.35
960						1.41
980						1.48
1000						1.54
1020						1.61
1040						1.68
1060						1.75

Temperature-dependent equations

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

Mol % $HgCl_2$	a	$b \cdot 10^8$	$c \cdot 10^6$	Stand. error of est.
0.0	−0.9795	1.7470	0.7767	0.55%
33.3	−6.2331	14.5385	−7.2170	1.79%
57.2	−2.0389	4.9750	−2.3285	0.38%
74.8	−1.1293	2.9109	−1.6594	0.97%
88.9	−0.0719	0.1953	−0.1144	2.44%
94.7	−0.0038	0.0097	−0.0036	2.26%

These values are based on the work of Grantham (classical ac technique) [**121**].

$HgCl_2$-NH_4Cl

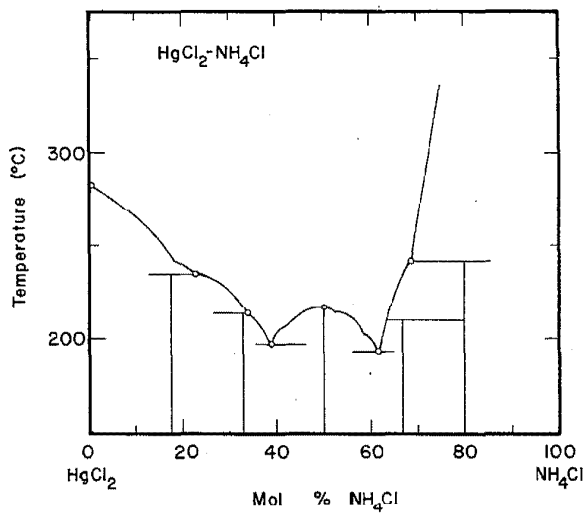


FIGURE 66. Temperature-composition phase diagram for $HgCl_2$-NH_4Cl.

N. Belyaev and K. E. Mironov, Zhur. Obshchei Khim., **22**, 1488 (1952).

TABLE 382. Electrical conductance studies: $HgCl_2$-NH_4Cl

Investigations critically re-examined			
Ref.	NH_4Cl Mol %	Temp. range (T)	Comments
15	~0–73 (g)	523, 573	Cell material and calibration: as for **123**
123	0–70.6	498–573	Cell material: Pyrex; Pt electrodes; calibration: 0.1N and 0.01N NaCl solutions

TABLE 383. $HgCl_2$-NH_4Cl: Specific conductance (ohm^{-1} cm^{-1})

	Mol percent NH_4Cl																								
T	70.6	67.8	65.0	62.0	58.2	55.8	53.8	51.5	50.0	49.7	47.3	45.2	43.2	37.6	33.4	30.0	28.0	27.0	22.0	21.5	17.0	15.9	10.0	5.1	0*
500			0.642	0.691	0.720	0.717		0.726	0.719	0.608	0.476	0.630	0.615	0.630	0.558	0.441	0.515	0.666							
510			0.710	0.759	0.794	0.797		0.817	0.778	0.695	0.576	0.699	0.692	0.701	0.614	0.495	0.576	0.716							
520			0.773	0.820	0.862	0.870		0.899	0.837	0.777	0.672	0.765	0.766	0.768	0.670	0.546	0.635	0.764							
530	[0.897]	[0.748]	0.831	0.873	0.923	0.936		0.972	0.896	0.853	0.764	0.829	0.839	0.830	0.723	0.596	0.690	0.810	[0.667]	[0.561]	[0.419]	[0.310]	[0.222]		
540	[0.923]	[0.810]	0.883	0.920	0.978	0.995		1.036	0.955	0.923	0.852	0.890	0.910	0.888	0.776	0.643	0.742	0.854	[0.695]	[0.596]	[0.456]	[0.350]	[0.227]		
550	[0.953]	[0.864]	0.931	0.959	1.027	1.046	[1.053]	1.090	1.013	0.987	0.936	0.949	0.979	0.941	0.827	0.689	0.791	0.896	[0.723]	[0.631]	[0.493]	[0.390]	[0.232]	[0.092]	
560	[0.978]	[0.911]	0.973	0.992	1.069	1.090	[1.089]	1.136	1.072	1.044	1.017	1.005	1.046	0.990	0.876	0.733	0.837	0.936	[0.752]	[0.666]	[0.529]	[0.433]	[0.236]	[0.100]	
570	[1.003]	[0.949]	1.011	1.017	1.105	1.128	[1.126]	1.172	1.131	1.096	1.093	1.059	1.112	1.034	0.925	0.774	0.879	0.974	[0.781]	[0.700]	[0.565]	[0.477]	[0.241]	[0.108]	0.00012

Temperature-dependent equations

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

Mol % NH_4Cl	a	$b \cdot 10^3$	$c \cdot 10^6$	Stand. error of est.
5.1	[— 0.3705]	[0.8400]	0	
10.0	[— 2.6159]	[1.3371]	[— 0.8000]	
15.9	[0.2772]	[—3.7541]	[7.2000]	
17.0	[— 1.7608]	[4.5371]	[— 0.8000]	
21.5	[— 1.7636]	[5.2342]	[— 1.6000]	
22.0	[— 0.3581]	[1.0858]	[1.6000]	
27.0	— 4.4557	15.3785	—10.2693	0.04%
28.0	— 6.7151	22.5722	—16.2257	0.46%
30.0	— 4.6388	14.9001	— 9.4793	0.20%
33.4	— 4.0838	12.8281	— 7.0899	0.13%
37.6	— 8.5729	29.4857	—22.1596	0.22%
43.2	5.6267	17.2120	— 9.4568	0.36%
45.2	— 5.9212	19.2235	—12.2416	0.20%
47.3	— 9.4519	29.5406	—19.3697	0.22%
49.7	—11.4560	39.1703	—30.0863	0.05%
50.0	— 2.2228	5.8840	0	6.89%
51.5	—15.4435	55.1178	—45.5572	0.46%
53.8	[— 0.9714]	[3.6800]	0	
55.8	—12.4897	44.4325	—36.0394	0.25%
58.2	— 11.1690	39.8133	—32.0716	0.48%
62.0	—11.7939	42.7950	—35.6498	0.03%
65.0	— 9.2110	32.3724	—25.3318	0.26%
67.8	[—13.5138]	[47.2618]	[— 38.4000]	
70.6	[— 2.6740]	[10.5541]	[— 7.2000]	

*The only experimental value is reported.

These values are based on the work of Belyaev and Mirnov (classical ac technique) [**123**].

KCl-$LaCl_3$

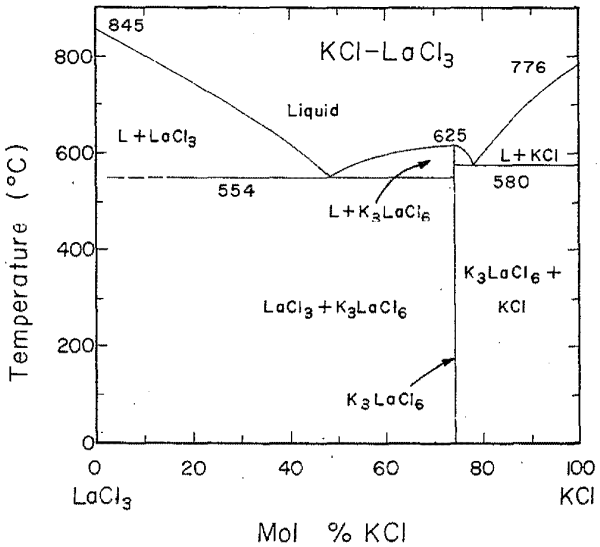


FIGURE 67. Temperature-composition phase diagram for KCl-$LaCl_3$.

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Melt Preparation and Purification

The preparation of $LaCl_3$ by Forthmann et al. [186] is described under the system KCl-$NdCl_3$. Cho and Kuroda [**220**] used commercial lanthanum nitrate as a starting material and reacted this with oxalic acid to produce lanthanum oxalate. This was then decomposed at 900–1000 °C. Anhydrous $LaCl_3$ was then obtained by vacuum heating a mixture of pure La_2O_3 and NH_4Cl at 350 °C for one hour. The yield exceeded 90%. In order to remove unreacted La_2O_3, LaOCl and NH_4Cl the product was fused at 950 °C, evacuated for 2 hours and then the upper layer was removed and stored under an atmosphere of Ar.

TABLE 384. Electrical conductance studies: KCl-$LaCl_3$

Investigations critically re-examined			
Ref.	$LaCl_3$ Mol %	Temp. range (T)	Comments
220	0–100	1057–1310	Cell material: quartz capillary cell; Pt electrodes; calibration: molten NaCl, KCl, CsCl
186	0–100 (g)	1190	Cell material: quartz capillary cell; Pt electrodes; freq. range: 100,000–250,000 Hz; calibration: molten NaCl, KCl, CsCl

TABLE 385. KCl-$LaCl_3$: Specific conductance (ohm^{-1} cm^{-1})

	Mol percent $LaCl_3$									
T	100	84.5	69.9	59.3	50.3	38.3	24.9	13.9	5.2	0
1050						0.935				
1060						0.958	0.980			
1070						0.981	1.003	1.053		2.016
1080					1.232	1.003	1.027	1.076	1.448	2.046
1090			1.057		1.259	1.026	1.050	1.099	1.466	2.074
1100			1.088	1.060	1.285	1.049	1.072	1.121	1.484	2.100
1110			1.118	1.087	1.311	1.072	1.095	1.142	1.502	2.125
1120			1.146	1.113	1.338	1.094	1.117	1.163	1.520	2.148
1130			1.174	1.139	1.364	1.117	1.139	1.183	1.538	2.170
1140			1.201	1.165	1.390	1.139	1.161	1.203	1.555	2.189
1150			1.227	1.189	1.415	1.161	1.182	1.222	1.572	2.207
1160		1.167	1.253	1.214	1.441	1.183	1.204	1.241	1.589	2.224
1170	1.219	1.193	1.277	1.238	1.467	1.206	1.225	1.259	1.606	2.238
1180	1.244	1.218	1.300	1.262	1.492	1.228	1.246	1.276	1.622	2.251
1190	1.270	1.244	1.323	1.285	1.518	1.250	1.266	1.293	1.638	2.263
1200	1.294	1.269	1.345	1.307	1.543	1.271	1.286	1.310	1.654	2.273
1210	1.319	1.294	1.365	1.329	1.568	1.293	1.307	1.325	1.669	
1220	1.343	1.319					1.326	1.341	1.685	
1230	1.368	1.343						1.355	1.700	
1240	1.391	1.368								
1250	1.415	1.392								
1260	1.438	1.417								
1270	1.461									
1280	1.484									
1290	1.507									
1300	1.529									

Temperature-dependent equations

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

Mol % $LaCl_3$	a	$b \cdot 10^3$	$c \cdot 10^6$
0	−5.7416	16.408	−8.374
5.2	−0.8456	3.820	−1.212
13.9	−2.5990	6.828	−2.817
24.9	−1.6079	4.222	−1.186
38.3	−1.1009	2.934	−0.404
50.3	−1.2162	3.422	−0.480
59.3	−2.7239	6.456	−2.273
69.9	−4.4667	10.423	−4.481
84.5	−1.7387	3.976	−0.789
100.0	−2.1376	4.930	−1.324

These values are based on the work of Cho and Kuroda (classical ac technique) [**220**].

TABLE 386. Density studies: KCl-$LaCl_3$

Investigations critically re-examined

Ref.	$LaCl_3$ Mol %	Temp. range (T)	Cell material
178	0–88	1075–1170	Mo or Pt capillary tube and crucible
220	0–100	1040–1270	

Comparison with NSRDS recommendations: [1, p. 5 and this volume]

Ref.	$LaCl_3$ Mol %	Min. departure	Max. departure
178	0	−0.07% (1123 K)	
220	50	3.51% (1260 K)	6.46% (1040 K)
220	25	−0.84% (1130 K)	−1.21% (1250 K)

Comment: Density results in reference [**178**] were reported in the form of linear temperature dependent equations with standard deviations of ±0.002 g cm^{-3}.

TABLE 387. KCl-$LaCl_3$: Density (g cm^{-3})

	Mol percent $LaCl_3$									
T	80	70	60	50	40	30	20	10	0	53
1075	2.876	2.737	2.600	2.459	2.309	2.144	1.958	1.746	1.503	2.502
1080	2.874	2.734	2.597	2.456	2.306	2.141	1.955	1.744	1.500	2.499
1085	2.871	2.731	2.594	2.453	2.303	2.137	1.952	1.741	1.498	2.496
1090	2.868	2.729	2.591	2.450	2.299	2.134	1.949	1.738	1.495	2.493
1095	2.866	2.726	2.588	2.446	2.296	2.131	1.946	1.735	1.493	2.489
1100	2.863	2.723	2.585	2.443	2.293	2.128	1.943	1.732	1.490	2.486
1105	2.860	2.720	2.581	2.440	2.290	2.125	1.940	1.729	1.488	2.483
1110	2.858	2.717	2.578	2.437	2.286	2.122	1.937	1.727	1.485	2.480
1115	2.855	2.714	2.575	2.433	2.283	2.118	1.934	1.724	1.483	2.477
1120	2.852	2.711	2.572	2.430	2.280	2.115	1.931	1.721	1.481	2.473
1125	2.850	2.708	2.569	2.427	2.277	2.112	1.928	1.719	1.478	2.470
1130	2.847	2.705	2.566	2.424	2.274	2.109	1.925	1.716	1.476	2.467
1135	2.844	2.702	2.563	2.421	2.270	2.106	1.922	1.713	1.474	2.464
1140	2.842	2.699	2.560	2.418	2.267	2.103	1.919	1.711	1.472	2.461
1145	2.839	2.696	2.557	2.415	2.264	2.100	1.917	1.708	1.469	2.458
1150	2.837	2.694	2.554	2.411	2.261	2.097	1.914	1.706	1.467	2.455
1155	2.834	2.691	2.551	2.408	2.258	2.094	1.911	1.703	1.465	2.452
1160	2.831	2.688	2.548	2.405	2.255	2.091	1.908	1.701	1.463	2.449
1165	2.829	2.685	2.545	2.402	2.252	2.088	1.905	1.698	1.461	2.446
1170	2.826	2.682	2.542	2.399	2.249	2.085	1.903	1.696	1.459	2.442

Two-dimensional equation and statistical parameters

$$\rho = a + bT + cC^3 + dTC + eTC^2 + fCT^2$$

a	$b \cdot 10^4$	$c \cdot 10^7$	$d \cdot 10^5$	$e \cdot 10^8$	$f \cdot 10^9$	Max. percent departure	Stand. error of est.
3.58192	—3.72058	—9.31284	—2.11294	8.63911	5.14737	0.45% (1173.2 K, 100 mol % KCl)	0.08%

These values are based on the work of Smirnov and Stepanov (modified maximum bubble pressure technique) **[178]**. C = mol % KCl.

TABLE 388. KCl-$LaCl_3$: Density (g cm^{-3})

	Mol percent $LaCl_3$							
T	88	75	62	50	37	25	12	0
1075	2.997	2.806	2.624	2.456	2.259	2.053	1.791	1.508
1080	2.995	2.803	2.621	2.453	2.256	2.050	1.788	1.505
1085	2.992	2.801	2.618	2.450	2.253	2.047	1.785	1.502
1090	2.989	2.798	2.615	2.447	2.250	2.045	1.782	1.499
1095	2.986	2.795	2.612	2.444	2.247	2.042	1.780	1.496
1100	2.983	2.792	2.610	2.441	2.245	2.039	1.777	1.493
1105	2.980	2.790	2.607	2.439	2.242	2.036	1.774	1.490
1110	2.978	2.787	2.604	2.436	2.239	2.033	1.771	1.487
1115	2.975	2.784	2.601	2.433	2.236	2.030	1.768	1.484
1120	2.972	2.781	2.599	2.430	2.233	2.027	1.765	1.482
1125	2.969	2.779	2.596	2.427	2.230	2.025	1.763	1.479
1130	2.966	2.776	2.593	2.424	2.227	2.022	1.760	1.476
1135	2.963	2.773	2.590	2.422	2.224	2.019	1.757	1.473
1140	2.960	2.770	2.588	2.419	2.222	2.016	1.754	1.470
1145	2.958	2.768	2.585	2.416	2.219	2.013	1.751	1.467
1150	2.955	2.765	2.582	2.413	2.216	2.010	1.749	1.464
1155	2.952	2.762	2.579	2.410	2.213	2.007	1.746	1.461
1160	2.949	2.759	2.577	2.407	2.210	2.005	1.743	1.458
1165	2.946	2.757	2.574	2.405	2.207	2.002	1.740	1.455
1170	2.943	2.754	2.571	2.402	2.204	1.999	1.737	1.453

Temperature-dependent equations

$\rho = a + bT$

Mol % $LaCl_3$	a	$b \cdot 10^4$
0	2.130	−5.79
12	2.396	−5.63
25	2.667	−5.71
37	2.877	−5.75
50	3.064	−5.66
62	3.218	−5.53
75	3.394	−5.47
88	3.608	−5.68

These values are based on the work of Smirnov and Stepanov (modified maximum bubble pressure technique) **[178]**.

TABLE 389. Surface tension studies: KCl-$LaCl_3$

Investigations critically re-examined

Ref.	$LaCl_3$ Mol %	Temp. range (T)	Comments
178	0–88	1080–1260	Cell material: Mo or Pt capillary and crucible enclosed in a sealed quartz tube; calibration: apparatus tested by measurements on molten NaCl (825–1010 °C)

Deviations from previous NSRDS recommendations: [2, p. 58]

Ref.	$LaCl_3$ Mol %	Min. departure	Max. departure
178	0	−0.81% (1073 K)	−1.42% (1173 K)

TABLE 390. KCl-$LaCl_3$: Surface tension (dyn cm^{-1})

	Mol percent $LaCl_3$								
T	100	88	75	62	50	37	25	12	0
1080		118.25	111.81	107.12	103.85	101.22	99.52	97.86	97.47
1085		117.96	111.48	106.79	103.50	100.87	99.17	97.50	97.05
1090		117.67	111.16	106.45	103.15	100.51	98.81	97.13	96.64
1095		117.38	110.84	106.12	102.79	100.16	98.46	96.77	96.23
1100		117.09	110.51	105.78	102.44	99.80	98.10	96.40	95.81
1105		116.80	110.19	105.44	102.09	99.45	97.75	96.04	95.40
1110		116.51	109.86	105.11	101.73	99.09	97.39	95.67	94.98
1115		116.22	109.54	104.77	101.38	98.74	97.04	95.31	94.57
1120		115.93	109.21	104.44	101.03	98.38	96.68	94.94	94.15
1125		115.64	108.89	104.10	100.68	98.03	96.33	94.58	93.74
1130		115.35	108.56	103.76	100.32	97.67	95.97	94.21	93.32
1135		115.06	108.24	103.43	99.97	97.32	95.62	93.85	92.91
1140		114.77	107.91	103.09	99.62	96.96	95.26	93.48	92.49
1145		114.48	107.59	102.76	99.26	96.61	94.91	93.12	92.08
1150		114.19	107.27	102.42	98.91	96.25	94.55	92.75	91.67
1155		113.90	106.94	102.08	98.56	95.90	94.20	92.39	91.25
1160		113.60	106.62	101.75	98.20	95.54	93.84	92.02	90.84
1165		113.31	106.29	101.41	97.85	95.19	93.49	91.66	90.42
1170	117.76	113.02	105.97	101.08	97.50	94.83	93.13	91.29	90.01
1180	116.44								
1190	115.12								
1200	113.80								
1210	112.48								
1220	111.16								
1230	109.84								
1240	108.52								
1250	107.20								
1260	105.88								

Temperature-dependent equations

$$\gamma = a + bT$$

Mol % $LaCl_3$	a	$b \cdot 10^2$
0	187.0	− 8.29
12	176.7	− 7.30
25	176.2	− 7.10
37	177.9	− 7.10
50	180.1	− 7.06
62	179.7	− 6.72
75	181.9	− 6.49
88	181.0	− 5.81
100	272.2	−13.2

These values are based on the work of Smirnov and Stepanov (maximum bubble pressure method) [178]. The temperature range from 1080 to 1170 K was assumed.

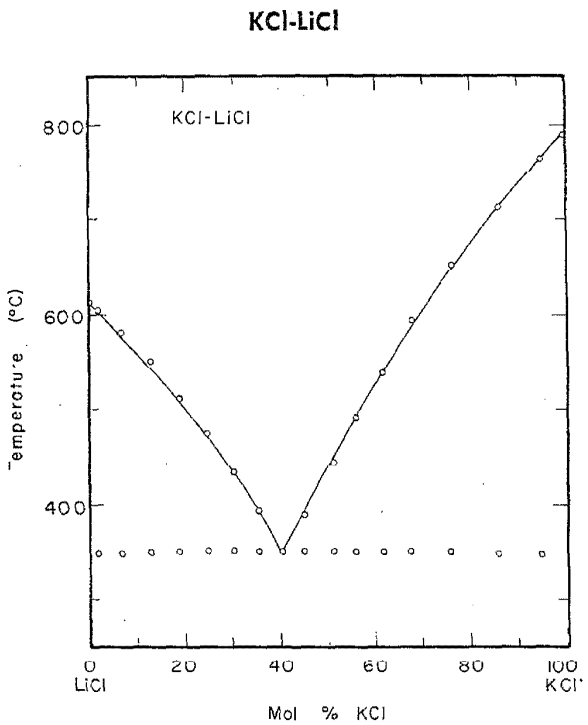

FIGURE 68. Temperature composition phase diagram for KCl-LiCl.

S. Zhemchuzhngi and F. Rambath, Izv. Spb. Politekhnicheskogo Institute, **12**, 349 (1909); Zh. Russ. Fiz.-Khim. Ova Chast Fiz. **41**, 1785 (1909); S. Zemezuzny and F. Rambach, Z. Anorg. Chem., **65**, 403 (1910).

Melt Preparation and Purification

Karpachev et al. [23] dehydrated the chloride salts in an electric oven. The dried mixture was analyzed for total chloride with $AgNO_3$.

Van Artsdalen and Yaffe [**37**] used analytical grade materials which were dehydrated by fusion under an atmosphere of hydrogen or argon gas. The melts were then cooled to room temperature, crushed and stored in a dry atmosphere. Mixtures were placed in a platinum-rhodium crucible and gradually heated in an inert atmosphere to a temperature slightly above the melting point. Hydrolysis was checked for after each experiment and composition analysis consisted of total chloride by precipitation as silver chloride.

Duke and Bissell [47] dehydrated Baker "analyzed" LiCl and KCl at 450 °C for 36 hours in a vacuum apparatus.

Janz et al. [84] used Fisher "reagent grade" materials which were dried in an all glass vacuum-transfer system. The salts were placed in vials and evacuated to 10^{-6} mm pressure at room temperature or at 100 °C; a dry argon or nitrogen "flush" was used to hasten water removal. The LiCl and KCl dried using this procedure gave pH readings of 7.1 and 6.6, respectively for their aqueous solutions. The eutectic mixture was prepared, placed in the conductance cell and evacuated at 300 °C overnight.

The preparation of pure salts by Sakai and Suzuki [127] is described under the LiCl-NaCl system.

Ellis [187] used reagent-grade alkali metal halides which were dried at 200 °C overnight. The LiCl-KCl eutectic mixture was prepared by ball-milling the dry salts together, fusing them under vacuum over a 72 hour period and passing anhydrous HCl through the melt for two hours. Before using, the gray colored product was filtered producing a colorless melt and a white solid on solidification.

Nissen and Carlsten [**230,231**] used reagent grade materials, which were carefully vacuum dried before use. The appropriate composition was made up by accurately weighing the dried salts directly into the container. After melting, the salts were further purified by use of chlorine and hydrogen chloride gas. All weighing and other manipulations were performed in an atmosphere containing less than 100 ppm of water. Each sample was analyzed by atomic absorption after the measurement to determine the exact composition.

TABLE 392. Electrical conductance studies: KCl-LiCl

Investigations critically re-examined

Ref.	LiCl Mol %	Temp. range (T)	Comments
23	0–100	873–1213	Cell material: quartz; Pt electrodes; calibration: molten $CdCl_2$
37[a]	0–100	668–1201	Cell material: quartz; Pt electrodes; freq. range: 2000–20,000 Hz; calibration: 1.0 Demal KCl solution
47[b]	0–100	703–1157	Cell material: silica; Ag/AgCl electrodes; calibration: 1.0 Demal KCl solution
60	0–100 (g)		
65	0–100	823–1153	Cell material: alumina (U-shaped tube); Pt electrodes; freq. range: 800 Hz; calibration: molten KCl
84	58	633–673	Cell material: Pyrex; Pt electrodes; freq. range: 750–5000 Hz; calibration: KCl solutions
94[c]	0–100 (g)	1073	
102	15–88 (g)	973	
127	58.5 (g)	673–1023	Cell material: Vycor glass; Pt electrodes; freq. range: 1000 Hz; calibration: 1.0 Demal KCl solution
159[d]		873–1073	Cell material: quartz
183[c]	0–100 (g)	1073	
192	20 (g)	970–1200	
216	0–100 (g)	1073	
218	eutectic (g)	1182–1390	

Comparison with NSRDS recommendations: [1, pp. 4, 5 and this volume]

Ref.	LiCl Mol %	Min. departure	Max. departure
23	100	−0.44% (1123 K)	−3.1% (1053 K)
47	100	2.2% (1019 K)	2.6% (900 K)
65	100	−0.31% (1023 K)	−1.2% (1073 K)
47	81.8	3.5% (813 K)	4.4% (953 K)
65	81.8	−4.9% (873 K)	
23	70	5.8% (981 K)	6.0% (775 K)
65	58.8	−0.05% (793 K)	−0.6% (713 K)
84	58.8	4.3% (663 K)	
47	40	−0.95% (893 K)	−1.2% (953 K)
65	40	−0.8% (973 K)	−2.8% (923 K)
23	20	3.9% (1038 K)	
47	20	0.08% (1033 K)	0.33% (1093 K)
65	20	0.9% (1023 K)	1.7% (1073 K)
23	0	−2.3% (1053 K)	−5.1% (1213 K)
47	0	−0.04% (1110 K)	−0.74% (1157 K)

[a]Resistance measurements made by Van Artsdalen and Yaffe [37] in the range 2000 to 20,000 Hz were found to vary less than 0.5%. Recalibration of the quartz dip-type capillary cells showed changes of less than 0.3% and an average change of 0.1% in the cell constants. Measurements on melts which showed evidence of hydrolysis were discarded. Experimental conductance data was reported together with temperature dependent equations of the form: $\kappa = a + bt + ct^2$, with standard deviations in the range 1×10^{-3} ohm^{-1} cm^{-1} (70.4 mol % LiCl) to 8×10^{-3} ohm^{-1} cm^{-1} (100 mol % LiCl).

[b]Duke and Bissell [47] reported no observable attack of the melts on their Vycor cells and found changes of only 0.04% in the cell constant of these cells after an eight hour period of contact with the melts.

[c]Data from reference [37].

[d]Composition of mixture was not reported in reference [159].

TABLE 393. KCl-LiCl: Specific conductance (ohm^{-1} cm^{-1})

T	Mol percent LiCl 100	81.77	70.36	58.80	40.45	19.96	0
670				1.227			
690				1.360			
710				1.490			
730			1.976	1.615			
750			2.133	1.737			
770			2.280	1.854			
790			2.416	1.967			
810		3.150	2.541	2.076			
830		3.271	2.656	2.181			
850		3.386	2.760	2.281			
870		3.495	2.854		1.890		
890		3.599			1.992		
910	5.819				2.087		
930	5.940				2.177		
950	6.054				2.260		
970	6.161				2.337		
990	6.261				2.408	2.109	
1010	6.353				2.472	2.176	
1030	6.439					2.239	
1050	6.517					2.298	
1070						2.354	2.225
1090						2.406	2.279
1110						2.454	2.329
1130							2.376
1150							2.420
1170							2.460
1190							2.497

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

Mol % LiCl	a	$b \cdot 10^2$	$c \cdot 10^6$	Stand. error of est.
0	−5.5231	1.1714	−4.1800	0.19%
19.96	−5.9678	1.2866	−4.7560	0.17%
40.45	−8.5932	1.8845	−7.8109	0.24%
58.80	−5.6492	1.3732	−5.1788	0.18%
70.36	−11.0108	2.7461	−13.2471	0.49%
81.77	−6.7217	1.8182	−7.4002	0.09%
100	−7.3766	2.2747	−9.0623	0.35%

These values are based on the work of Van Artsdalen and Yaffe (classical ac technique) [37].

TABLE 394. Density studies: KCl-LiCl

Investigations critically re-examined			
Ref.	LiCl Mol %	Temp. range (T)	Cell material
23	20–80	950–1156	
37[a]	0–100	668–1212	Pt bob, Pt–Rh suspension wire
100[b]	0–100 (g)	1063	Pt sinker
149[c]	0–100	873–1173	
215[d]	0–100 (g)	1063	

Comparisons with NSRDS recommendations: [1, pp. 4, 5 and this volume]

Ref.	LiCl Mol %	Min. departure	Max. departure
149	100	−0.27% (910 K)	−0.28% (1050 K)
23	40	1.3% (921 K)	
149	40	0.02% (953 K)	0.09% (1013 K)
23	20	0.48% (1126 K)	
149	20	−0.26% (963 K)	−0.27% (1073 K)
149	0	−0.03% (1080 K)	0.12% (1160 K)

[a]Van Artsdalen and Yaffe [37] corrected for the expansion of the platinum density bob with temperature. Experimental density data were reported as well as linear temperature dependent equations with standard deviations in the range 1×10^{-4} g cm^{-3} (100, 70.4, 81.8 mol % LiCl) to 4×10^{-4} g cm^{-3} (40.4 mol % LiCl).

[b]Data from reference [37].

[c]Zuca and Borcan [149] report their density results in the form of linear temperature dependent equations with standard deviations in the range: 2×10^{-4} g cm^{-3} (0 mol % LiCl) to 5×10^{-4} g cm^{-3} (40 and 60 mol % LiCl).

[d]Data from reference [264].

TABLE 395. KCl-LiCl: Density (g cm^{-3})

	Mol percent LiCl											
T	100	90	80	70	60	50	40	30	20	10	0	59.5
720					1.646							
740				1.622	1.636							1.636
760			1.598	1.612	1.625							1.626
780			1.588	1.602	1.615	1.627						1.615
800			1.578	1.591	1.604	1.616						1.605
820		1.552	1.568	1.581	1.594	1.605						1.594
840		1.542	1.558	1.571	1.583	1.595						1.584
860		1.533	1.548	1.562	1.573	1.584	1.595					1.574
880		1.523	1.539			1.574	1.584					1.564
900	1.496	1.514				1.563	1.573	1.583				
920	1.487	1.505				1.553	1.562	1.572				
940	1.478	1.496				1.543	1.552	1.561				
960	1.469						1.541	1.550				
980	1.460						1.531	1.539	1.548			
1000	1.451						1.521	1.528	1.536			
1020	1.443							1.518	1.525	1.534		
1040	1.434							1.507	1.514	1.522		
1060								1.497	1.503	1.510	1.520	
1080									1.492	1.499	1.507	
1100									1.481	1.487	1.495	
1120									1.471	1.476	1.483	
1140										1.465	1.471	
1160										1.454	1.459	
1180											1.447	
1200											1.436	

Two-dimensional equation and statistical parameters

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

a	$b \cdot 10^4$	$c \cdot 10^3$	$d \cdot 10^{11}$	$e \cdot 10^7$	$f \cdot 10^6$	Max. percent departure	Stand. error of est.
1.98715	−5.89069	2.02443	5.31098	1.21294	−2.16826	0.36% (1019.2 K, 59.55 mol % KCl)	0.13%

These values are based on the work of Van Artsdalen and Yaffe (Archimedean method) [37]. C = mol % LiCl.

TABLE 396. KCl-LiCl: Density (g cm^{-3})

T	Mol percent LiCl 100	81.77	70.36	58.80	40.45	19.96	0
680				1.670			
700				1.660			
720				1.649			
740			1.619	1.639			
760			1.609	1.628			
780			1.599	1.618			
800			1.589	1.607			
820		1.568	1.578	1.597			
840		1.558	1.568	1.586			
860		1.548	1.558	1.576	1.594		
880		1.539			1.583		
900	1.495	1.529			1.572		
920	1.486	1.519			1.560		
940	1.477				1.549		
960	1.469				1.538		
980	1.460				1.527	1.551	
1000	1.451				1.516	1.540	
1020	1.443					1.528	
1040	1.434					1.516	
1060						1.505	1.518
1080						1.493	1.506
1100						1.482	1.495
1120						1.470	1.483
1140							1.471
1160							1.460
1180							1.448
1200							1.436

Temperature-dependent equations
$\rho = a + bT$

Mol % LiCl	a	$b \cdot 10^4$	Stand. error of est.
0	2.1376	−5.8445	0.03%
19.96	2.1172	−5.7764	0.02%
40.45	2.0768	−5.6120	0.03%
58.80	2.0286	−5.2676	0.01%
70.36	1.9945	−5.0738	0.01%
81.77	1.9689	−4.8908	0.01%
100	1.8832	−4.3182	0.01%

These values are based on the work of Van Artsdalen and Yaffe (Archimedean method) [37].

TABLE 397. Viscosity studies: KCl-LiCl

Investigations critically re-examined

Ref.	LiCl Mol %	Temp. range (T)	Comments
23	0–100	673–1123	
86	0–100	836–1087	Cell material: Pt disc
88	0–100	911–1187	Cell material: Pt sphere; calibration: water, nitrobenzene, aniline, molten $NaNO_3$ and KCl
100	0–100	1015–1123	Cell material: Pt disc; calibration: H_2SO_4 solutions and molten KCl
149[a]	0–100	892–1156	Cell material: Pt sphere and Pt suspension wire
187	60	~645–833	Cell material: viscometer with an outer container consisting of a Ni can and a Vycor glass liner, Pt–10%Rh wire probes
215	0–100	1015–1123	
216	0–100 (g)	1073	
327[b]	0–100 (g)	670–800	

Comparison with NSRDS recommendations:
[1, pp. 4, 5 and this volume]

Ref.	LiCl Mol %	Min. departure	Max. departure
23	100	−2.4% (973 K)	−8.0% (1073 K)
86	100	7.3% (947 K)	15.6% (917 K)
88	100	−1.2% (911 K)	9.6% (1023 K)
100	100	21.5% (1015 K)	34.5% (1083 K)
149	100	0.8% (972 K)	5.2% (1043 K)
23	100	3.3% (973 K)	15.6% (1073 K)
86	100	9.1% (1013 K)	27.7% (890 K)
88	100	5.6% (1023 K)	6.1% (948 K)
100	100	18.2% (1015 K)	23.5% (1063 K)
23	60	0.88% (973 K)	−14.3% (1073 K)
23	50	0.85% (973 K)	17.6% (923 K)
23	40	−2.8% (923 K)	−8.3% (1023 K)
86	40	−8.7% (999 K)	
100	40	30.9% (1063 K)	
23	20	−5.2% (973 K)	−14.7% (1073 K)
86	20	−4.3% (1021 K)	
100	20	21.0% (1063 K)	
23	0	2.1% (1123 K)	
86	0	−1.9% (1087 K)	
88	0	−1.1% (1051 K)	
100	0	24.3% (1108 K)	
23	0	−1.8% (1073 K)	9.5% (1173 K)
86	0	0.10% (1087 K)	−2.2% (1056 K)
88	0	0.0% (1151 K)	9.1% (1106 K)
100	0	23.5% (1108 K)	59.3% (1063 K)
149	0	0.9% (1085 K)	2.2% (1156 K)

[a]Zuca and Borcan [149] report numerical data along with Arrhenius equations with standard deviations for E_λ, the activation energy in the range: 1.2×10^{-2} Kcal mol^{-1} (60 mol % LiCl, $E_\lambda = 4.94$ Kcal mol^{-1}) to 6.4×10^{-2} Kcal mol^{-1} (100 mol % LiCl, $E_\lambda = 6.20$ Kcal mol^{-1}). The authors state an overall experimental error of ±1.0% in their viscosity measurements.

[b]Data from reference [100].

TABLE 398. KCl-LiCl: Viscosity (cp)

	Mol percent LiCl							
T	100	80	60	50	40	30	20	0
890			1.46					
900	1.60		1.42					
910	1.54	1.40	1.38					
920	1.49	1.36	1.33		1.45	1.47		
930	1.43	1.32	1.29	1.35	1.40	1.42		
940	1.38	1.28	1.25	1.31	1.36	1.38		
950	1.33	1.24	1.22	1.27	1.32	1.34		
960	1.29	1.21	1.18	1.23	1.28	1.31		
970	1.24	1.18	1.15	1.20	1.24	1.27	1.36	
980	1.20	1.15	1.12	1.17	1.21	1.24	1.32	
990	1.17	1.12	1.09	1.13	1.18	1.20	1.28	
1000	1.13	1.09	1.06	1.10	1.14	1.17	1.24	
1010	1.10	1.06	1.03	1.08	1.11	1.14	1.21	
1020	1.07	1.04	1.01	1.05	1.09	1.12	1.18	
1030	1.05	1.01	0.99	1.02	1.06	1.09	1.14	
1040	1.02	0.99	0.97	1.00	1.03	1.06	1.11	
1050	1.01	0.97	0.95	0.97	1.01	1.04	1.09	
1060	0.99	0.95	0.93	0.95	0.98	1.01	1.06	
1070	0.98	0.93	0.92	0.93	0.96	0.99	1.03	
1080						0.97	1.01	
1090								1.04
1100								1.01
1110								0.99
1120								0.96
1130								0.94
1140								0.92
1150								0.89

Temperature-dependent equations

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

$$\eta = A \cdot \exp\,(E/RT)$$

Mol % LiCl	a	$b \cdot 10^2$	$c \cdot 10^6$	$d \cdot 10^9$	$A \cdot 10^2$	E (cal mol^{-1})	Stand. error of est.
0	13.5546	−2.0050	7.8613	0			0.76%
20					7.037	5707	0.69%
30					9.019	5097	1.69%
40					7.793	5337	1.01%
50					7.860	5249	1.09%
60	8.5113	−0.7401	−4.8633	4.8121			0.59%
80					8.893	4980	0.98%
100	10.0147	−0.5158	−13.0241	9.2997			1.36%

These values are based on the work of Zuca and Borcan (oscillating sphere method) [**149**].

TABLE 399. Surface tension studies: KCl-LiCl

Investigations critically re-examined			
Ref.	LiCl Mol %	Temp. range (T)	Comments
230, 231[a]	10–90	660–1083	Cell material: capillary tip fabricated from pure gold; calibration: KNO_3 and $NaNO_3$
257	0–100	923–1173	Cell material: Pt capillary; calibration: radius of capillary determined from measurements on molten LiCl, NaCl and KCl

Comparison with NSRDS recommendations: [2, pp. 57, 58 and this volume]

Ref.	LiCl Mol %	Min. departure	Max. departure
257	100	2.9% (1073 K)	3.2% (923 K)
257	0	−0.30% (1073 K)	−1.1% (1173 K)
257	40	3.16% (700 K)	5.36% (850 K)

[a]Nissen and Carlsten [**230, 231**] indicate that careful attention should be paid to the capillary tip, in particular that the bore should be as accurately round as possible, the end flat and perpendicular to the axis of the capillary and the end of the orifice should be very sharp. A Lietz Ortholux microscope was used to check the condition and diameter of the orifice. All measurements were corrected for thermal expansion of the orifice. The level of the vapor-liquid interface was determined by measuring the resistance between the capillary and a gold-sheathed thermocouple placed in the melt as the tip was slowly lowered by means of an adjustment screw attached to the micrometer head. The temperature of the melt was maintained constant within ±0.5 °C. The vertical temperature gradient through the sample was less than 1 °C. The experimental error assessed by Nissen and Carlsten was ±0.2 dyn/cm.

TABLE 400. KCl-LiCl: Surface tension (dyn cm^{-1})

	Mol percent KCl									
T	90	80	70	60	50	40	30	20	10	58.0
700				132.2						131.9
720				130.6						130.3
740				129.0						128.7
760			128.7	127.4	126.2					127.0
780			127.2	125.8	124.6					125.4
800			125.7	124.2	123.0					123.7
820			124.1	122.6	121.3					122.1
840			122.6	121.0	119.7					120.4
860			121.0	119.4	118.0	117.0				118.8
880	124.0	121.6	119.5	117.7	116.3	115.3				
900	122.6	120.1	117.9	116.1	114.7	113.6				
920	121.3	118.6	116.4	114.5	113.0	111.9				
940	119.9	117.2	114.8	112.9	111.4	110.2				
960	118.6	115.7	113.3	111.3	109.7	108.5	107.8			
980	117.2	114.2	111.7		108.0	106.8	106.1	105.9		
1000	115.8	112.7				105.1	104.4	104.2		
1020	114.5	111.8				103.4	102.7	102.5		
1040	113.1	109.8					101.0	100.8		
1060	111.7						99.3	99.2	99.5	

TABLE 400. KCl-LiCl: Surface tension (dyn cm^{-1})—Continued

Two-dimensional equation and statistical parameters

$\gamma = a + bT + cC + dT^2 + eC^2 + fTC + gTC^2$

a	$b \cdot 10^2$	$c \cdot 10$	$d \cdot 10^6$	$e \cdot 10^3$	$f \cdot 10^4$	$g \cdot 10^6$	Max. percent departure	Stand. error of est.
177.43373	−5.43167	3.40743	−3.73703	−3.19922	−7.20291	5.57068	0.76% 876.15 K; 21.0 mol % KCl	0.37%

These values are based on the work of Nissen and Carlsten (maximum bubble pressure method) [**230**, **231**]. C = mol % KCl.

TABLE 401. KCl-LiCl: Surface tension (dyn cm^{-1})

	Mol percent LiCl									
T	90	79	69	58	50	40	30	22	15	10
660				135.22						
680				133.57						
700				131.92						
720				130.28						
740				128.63						
760				126.98						
780			127.30	125.33	124.31					
800			125.74	123.69	122.70					
820			124.17	122.04	121.08					
840		123.88	122.61	120.39	119.46					
860		122.46	121.04	118.75	117.85					
880	123.96	121.04	119.47	117.10	116.23	115.09				
900	122.61	119.62		115.45	114.61	113.40				
920	121.26	118.20		113.81	113.00	111.71	110.97			
940	119.90	116.78			111.38	110.02	109.23			
960	118.56	115.36			109.77	108.33	107.49			
980	117.20	113.94			108.15	106.64	105.75	106.40		
1000	115.85	112.52			106.53	104.95	104.01	104.57		
1020	114.50	111.10			104.92	103.25	102.28	102.73	102.95	
1040	113.15						100.54	100.90	101.25	101.03
1060	111.80						98.80	99.07	99.56	99.37
1080									97.86	97.71
1100									96.16	96.04

Temperature-dependent equations at experimental compositions

$\gamma = a + bT$

Mol % LiCl	a	$b \cdot 10^2$	Stand. error of est.
10	187.4541	−8.30993	0.139
15	189.5651	−8.49146	0.086
22	196.2269	−9.16605	0.213
30	190.9364	−8.69217	0.240
40	189.4704	−8.45251	0.269
50	187.3435	−8.08096	0.245
58	189.5657	−8.23478	0.877
69	188.3650	−7.82852	0.280
79	183.5300	−7.10111	0.460
90	183.3852	−6.75324	0.236

These values are based on the work of Nissen and Carlsten (maximum bubble pressure method) [**230**, **231**].

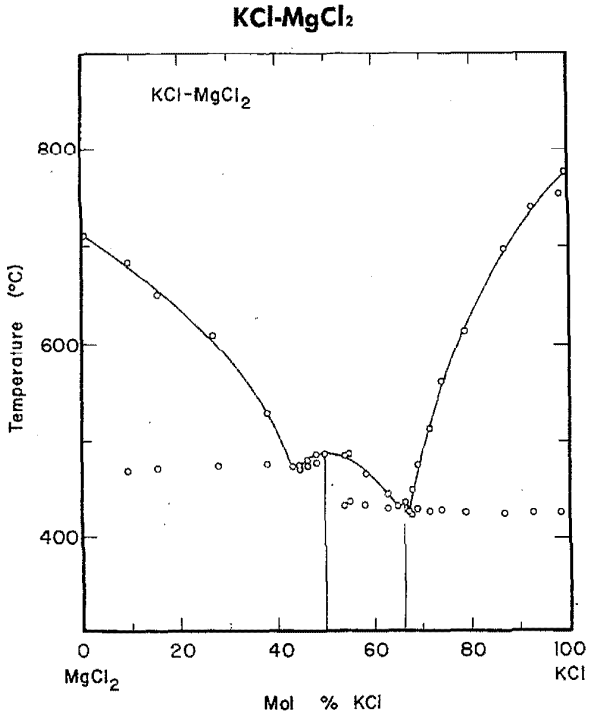

FIGURE 69. Temperature-composition phase diagram for $KCl-MgCl_2$.

O. Menge, Z. Anorg.-Allg. Chem., **72**, 162 (1911).

Melt Preparation and Purification

The methods of Huber et al. [30] for the preparation of pure $MgCl_2$ and KCl are given under $CaCl_2$-$MgCl_2$ and $CaCl_2$-KCl, respectively.

Treadwell and Cohen [62] prepared pure $MgCl_2$ by reacting MgO with KCl.

Ukshe and Kachina-Pullo [96] used "chemically pure" grade KCl and $MgCl_2$. The salts were dried by initially heating with ammonium chloride followed by fusion in a stream of dry argon. Prior to actual measurements argon was bubbled through the melt for one hour.

Bathshov [114] used "chemically pure" salts and dehydrated the $MgCl_2$ by heating the $MgCl_2 \cdot 6H_2O$ and NH_4Cl in a HCl atmosphere. Analysis of the $MgCl_2$ indicated approximately 0.2–0.3% MgO.

Sherbakov and Markov [113] used "chemically pure" KCl and $MgCl_2$ which were recrystallized twice and then heated at 500 °C for 1–2 hours. Magnesium chloride was dehydrated using NH_4Cl. Following each experiment the melt was analyzed for $MgCl_2$; MgO content was found to be less than 0.2%.

Sakai and Hayashi [**117**] used "high purity" $MgCl_2$ (99.95%; Nippon Sodo Co., Takaoka Corp.). Purification involved the initial loading of the salt into a sample reservoir of the conductance cell. The salt was covered with a layer of diphenylamine and dry CO_2 was passed over the salt for one hour. The diphenylamine was melted to cover the entire sample and then evaporated by evacuating the cell for 30 minutes at 200 °C. After melting the $MgCl_2$ under chlorine gas, the salt was transferred to the capillary compartment of the cell by proper tilting of the heating furnace. No formation of the oxychloride was detected in the above process.

Lillebuen [**130**] and Grjotheim et al. [**133**] used Baker "analytical reagent" grade KCl which was dried at about 500 °C under moderate vacuum (0.1–0.01 Torr). The preparation of pure $MgCl_2$ is described under the system $CaCl_2$-$MgCl_2$.

Stromberg et al. [145] recrystallized KCl and $MgCl_2 \cdot 6H_2O$ several times from water and dehydrated the mixture which contained NH_4Cl.

Reding [150, 241] used Baker and Adamson "reagent grade" KCl. The $MgCl_2$ was obtained from the core of anhydrous magnesium chloride cakes purchased from titanium and zirconium producers. The KCl was dried under vacuum at 400 °C for 12 hours and $MgCl_2$ was dehydrated by heating for 12 hours at 200 °C followed by further drying at 500 °C for 5 hours. Only $MgCl_2$ containing <1% MgO and >99% $MgCl_2$ was used for actual preparation.

Arndt and Kunze [153] used pure salts without further purification. When mixtures were melted, NH_4Cl was added to avoid decomposition of the $MgCl_2$. However, some decomposition was still observed during measurements.

Desyatnikov [**245**] used "chemically pure" KCl and $MgCl_2$. The SO_4^{2-} and Fe^{2+} impurities in the salts did not exceed 0.005%. The MgO content in the anhydrous $MgCl_2$ was 0.2–0.4%. Dehydration of the $MgCl_2$ involved passing a stream of dry HCl gas through the melt for 6–8 hours, after which CO_2 was bubbled through for 20–30 minutes to displace the HCl.

TABLE 402. Electrical conductance studies: $KCl-MgCl_2$

Investigations critically re-examined			
Ref.	$MgCl_2$ Mol %	Temp. range (T)	Comments
30	0–87.9	947–1236	Cell material: silica; Pt electrodes; freq. range: 1000 Hz; calibration: saturated NaCl
94[a]	0–100 (g)	1073	
96	0–100	1035–1170	Cell material: quartz; Pt electrodes; freq. range: 1000–20,000 Hz; calibration: molten KCl
102	19–75 (g)	973	Cell material: quartz; Pt electrodes; calibration: molten KNO_3 and $NaNO_3$

TABLE 402. Electrical conductance studies: $KCl\text{-}MgCl_2$—Continued

Investigations critically re-examined

Ref.	$MgCl_2$ Mol %	Temp. range (T)	Comments
109	0, 20, 40 60, 80, 100	986–1150	Cell material: Al_2O_3 tube in a quartz tube container; Pt electrodes; freq. range: 2000–20,000 Hz; calibration: saturated NaCl solution and 1N KCl solution
113	0–76.42	953–1093	Cell material: quartz; Pt electrodes; calibration: H_2SO_4 solutions
114	0–100	923–1123	Cell material: Pt cylinder; electrodes: Pt dish; calibration: molten NaCl
117	18.5–100	723–1023	Cell material: quartz; Pt electrodes
145	0–100	773–1123	Cell material: quartz; calibration: molten $CdCl_2$
153	50	843–1053	Cell material: porcelain; Pt electrodes
159	one mixture (g)	073–1073	Cell material: quartz
216	0–100 (g)	1073	

Comparisons with NSRDS recommendations:
[1, pp. 5, 6 and this volume]

Ref.	$MgCl_2$ Mol %	Min. departure	Max. departure
96	100	2.3% (1074 K)	2.4% (1130 K)
109	100	0.36% (1038 K)	1.83% (1082 K)
114	100	−3.7% (1023 K)	−5.5% (1123 K)
117	100	0.65% (1023 K)	0.81% (973 K)
145	100	0.0% (1073 K)	−2.1% (1023 K)
109	100	−0.92% (1023 K)	
114	100	4.6% (1023 K)	
145	100	−2.8% (1023 K)	
113	58.8	0.76% (1023 K)	1.7% (973 K)
30	52	7.5% (973 K)	
145	52	0.42% (973 K)	6.0% (823 K)
109	40	0.23% (1023 K)	
114	34	24.8% (923 K)	27.1% (1023 K)
30	18.5	13.4% (1023 K)	
30	0	0.21% (1126 K)	−2.8% (1042 K)
96	0	0.0% (1170 K)	−0.33% (1137 K)
109	0	0.08% (1150 K)	−0.59% (1124 K)
113	0	−1.65% (1073 K)	
114	0	4.0% (1073 K)	7.6% (1123 K)
145	0	−0.40% (1123 K)	−1.2% (1073 K)

[a]Data from reference [113].

Comments: Huber et al. [30] claim an accuracy of 0.5% in their bridge measurements when calibrated against standard resistors and report that routine accuracy was about 1%.

The conductivity cell used in reference [96] was constructed in such a way as to reduce errors arising from electrical conductance through the quartz walls of the vessel. Resistance measurements in the frequency range 3000 to 15,000 cps varied by about 1–1.5%.

Comments concerning reference [109] are given under the $CaCl_2$-KCl system.

TABLE 403. $KCl\text{-}MgCl_2$: Specific conductance ($ohm^{-1}\ cm^{-1}$)

	Mol percent $MgCl_2$													
T	100.0	84.0	72.1	58.8	52.0	48.8	45.5	39.9	37.0	34.0	31.8	24.5	22.0	18.5
830				0.885	0.856	0.889	0.890	0.871	0.866	0.862	0.871	0.866	0.847	
840				0.907	0.883	0.910	0.912	0.894	0.890	0.887	0.896	0.897	0.883	
850				0.929	0.910	0.932	0.934	0.917	0.914	0.911	0.920	0.927	0.918	
860				0.951	0.937	0.954	0.956	0.940	0.938	0.935	0.945	0.957	0.952	
870				0.973	0.964	0.975	0.977	0.963	0.962	0.959	0.969	0.986	0.985	
880			0.981	0.995	0.990	0.997	0.999	0.986	0.986	0.984	0.993	1.015	1.018	1.027
890			1.001	1.017	1.015	1.019	1.021	1.009	1.010	1.008	1.018	1.043	1.049	1.064
900			1.021	1.039	1.040	1.040	1.043	1.032	1.034	1.032	1.042	1.071	1.080	1.099
910			1.041	1.061	1.065	1.062	1.065	1.055	1.058	1.057	1.066	1.098	1.110	1.132
920			1.062	1.082	1.089	1.083	1.087	1.079	1.082	1.081	1.090	1.125	1.139	1.165
930		[1.035]	1.082	1.104	1.113	1.105	1.109	1.102	1.106	1.105	1.114	1.151	1.167	1.195
940		[1.054]	1.103	1.126	1.137	1.127	1.130	1.125	1.130	1.130	1.138	1.177	1.194	1.225
950		[1.073]	1.123	1.148	1.160	1.148	1.152	1.149	1.154	1.154	1.162	1.203	1.220	1.253
960		[1.092]	1.144	1.169	1.182	1.170	1.174	1.172	1.178	1.178	1.186	1.228	1.246	1.280
970		[1.112]	1.164	1.191	1.204	1.191	1.196	1.196	1.202	1.203	1.210	1.252	1.270	1.305
980	[1.007]	[1.131]	1.185	1.213	1.226	1.213	1.218	1.219	1.226	1.227	1.234	1.276	1.294	1.329
990	[1.026]	[1.151]	1.206	1.234	1.247	1.235	1.240	1.243	1.250	1.252	1.257	1.300	1.317	1.351
1000	[1.045]	[1.172]	1.226	1.256	1.268	1.256	1.261	1.266	1.274	1.276	1.281	1.323	1.338	1.372
1010	[1.065]	[1.192]	1.247	1.278	1.288	1.278	1.283	1.290	1.298	1.301	1.304	1.346	1.359	1.392
1020	[1.084]	[1.212]	1.268	1.299	1.308	1.299	1.305	1.314	1.322	1.325	1.328	1.368	1.380	1.410

Temperature-dependent equations

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

Mol % $MgCl_2$)	a	$b \cdot 10^3$	$c \cdot 10^6$	Stand. error of est.
18.5	−7.6274	15.9584	−6.9587	0.04%
22.0	−5.2200	10.9753	−4.4169	0.08%
24.5	−3.2951	6.9439	−2.3255	0.58%
31.8	−1.3943	2.9933	−0.3181	0.10%
34.0	−1.0872	2.2795	0.0837	0.04%
37.0	−1.1279	2.4020	0	0.05%
39.9	−0.8689	1.9071	0.2279	0.14%
45.5	−0.9227	2.1840	0	0.48%
48.8	−0.9039	2.1600	0	0.21%
52.0	−2.9434	6.3630	−2.1518	0.70%
58.8	−1.0490	2.4504	−0.1454	0.06%
72.1	−0.5571	1.4860	0.2974	0.07%
84.0	[0.1479]	[0.0236]	[1.0000]	0.00%
100.0	[−0.8745]	[1.9200]	0	0.00%

These values are based on the work of Sakai and Hayashi (classical ac technique) [117].

TABLE 404. Density studies: KCl-$MgCl_2$

Investigations critically re-examined

Ref.	$MgCl_2$ Mol %	Temp. range (T)	Comments
30	0–100	973–1193	Cell material: solid and hollow fused silica balls (containing tungsten powder); calibration: water
39	19.15–70.31	773–1023	Cell material: Pt sphere
62	0–100	823–1073	Cell material: quartz bob, Supremax glass tube
102	0–100 (g)	973	Cell material: Supremax glass dilatometer; calibration: eutectic mixture of KCl and LiCl
130	0–100	1017–1174	Cell material: Pt–10%Rh sinker and suspension wire; calibration: water
133	0–100[a]	973	Cell material and calibration: as for **130**
145	0–87.4	923–1073	Cell material: Pt sphere; calibration: water
150	0–100	1073	Cell material: tungsten sinker and Pt suspension wire; calibration: CCl_4 and water
153	50	845–1053	Cell material: Pt bob, Pt crucible
211, 267	0–100	810–1333	

Comparisons with NSRDS recommendations: [1, pp. 5, 6 and this volume]

Ref.	$MgCl_2$ Mol %	Min. departure	Max. departure
30	100	0.49% (1140 K)	0.80% (1160 K)
62	100	0.18% (998 K)	−0.30% (1073 K)
130	100	0.30% (1017 K)	0.50% (1099 K)
133	100	0.50% (1073 K)	
150	100	0.85% (1073 K)	
30	100	0.12% (1073 K)	0.18% (1048 K)
62	100	−0.78% (1073 K)	
150	100	0.24% (1073 K)	
150	53.5	−0.82% (1073 K)	
62	49.7	−1.0% (1073 K)	
62	42.2	−1.3% (1073 K)	
62	25.0	−0.73% (1073 K)	
30	0	−0.86% (1073 K)	
62	0	−1.4% (1073 K)	
145	0	−2.0% (1073 K)	
150	0	−0.07% (1073 K)	
30	0	−0.49% (1198 K)	−0.55% (1156 K)
62	0	−1.1% (1073 K)	
130	0	0.20% (1123 K)	0.33% (1073 K)
133	0	0.33% (1073 K)	
145	0	−1.6% (1023 K)	−1.7% (1073 K)
150	0	0.26% (1073 K)	

[a]Graphical except for pure components.

Comments: A brief discussion of some pertinent experimental aspects in references [**130**] and [133] is given under the system LiCl-$MgCl_2$.

Karpachev and Stromberg [39] analyzed their mixtures after density measurements and found water and MgO contents in the range 0.1–4.24 wt % and 0.13–0.54 wt %, respectively.

Redding [150] corrected for the effect of surface tension of the melt on the weight of the platinum sinker and attempted to avoid salt condensation on the suspension wire by passing Ar through a guide tube surrounding the Pt wire. The Ar gas was purified by passing it through a bed of Ti sponge maintained at 1400 °F.

TABLE 405. KCl-$MgCl_2$: Density (g cm^{-3})

	Mol percent $MgCl_2$													
T	100.0	90.0	77.4	67.5	66.3	61.7	53.5	50.3	42.2	32.8	25.0	12.0	6.6	0.0
1020	1.674													
1030	1.671								1.567	1.530				
1040	1.668								1.562	1.525				
1050	1.666				1.625				1.556	1.521	1.520		1.525	
1060	1.663	1.667	1.652	1.621	1.620	1.603	1.585		1.550	1.516	1.515		1.519	
1070	1.660	1.663	1.647	1.615	1.615	1.597	1.580		1.545	1.512	1.510		1.513	
1080	1.658	1.659	1.642	1.609	1.609	1.592	1.574	1.557	1.539	1.507	1.504	1.501	1.507	1.511
1090	1.655	1.655	1.636	1.603	1.604	1.586	1.568	1.552	1.534	1.503	1.499	1.495	1.502	1.505
1100		1.651	1.631	1.597	1.599	1.580	1.562	1.547	1.528	1.498	1.494	1.489	1.496	1.499
1110		1.647	1.625	1.591	1.594	1.575	1.557	1.542	1.523	1.493	1.488	1.483	1.490	1.492
1120			1.620	1.585	1.589	1.569	1.551	1.537	1.517	1.489	1.483	1.477	1.484	1.486
1130			1.615	1.579		1.564	1.545	1.532	1.512	1.484		1.471	1.478	
1140				1.573		1.558		1.527	1.506	1.480		1.465	1.472	
1150				1.567				1.522		1.475				
1160				1.561				1.516						
1170								1.511						

Temperature-dependent equations

$$\rho = a + bT$$

Mol % $MgCl_2$	a	$b \cdot 10^4$	Stand. error of est.
0.0	2.1819	−6.2126	0.01%
6.6	2.1380	−5.8395	0.04%
12.0	2.1561	−6.0618	0.04%
25.0	2.0796	−5.3272	0.02%
32.8	2.0007	−4.5709	0.03%
42.2	2.1387	−5.5501	0.02%
50.3	2.0998	−5.0287	0.05%
53.5	2.1900	−5.7054	0.05%
61.7	2.1923	−5.5627	0.01%
66.3	2.1587	−5.0863	0.04%
67.5	2.2582	−6.0077	0.02%
77.4	2.2238	−5.3922	0.01%
90.0	2.0844	−3.9367	0.01%
100.0	1.9497	−2.7050	0.03%

These values are based on the work of Lillebuen (Archimedean method) **[130]**.

TABLE 406. Viscosity studies: KCl-$MgCl_2$

Investigations critically re-examined			
Ref.	$MgCl_2$ Mol %	Temp. range (T)	Comments
39	11.19–56.60	773–1023	Cell material: Pt sphere; calibration: molten KNO_3, $PbCl_2$, $K_2Cr_2O_7$
41	8.00	1002–1125	Cell material: Pt ball
45	25–58 (g)	823–923	
66	0–100	891–1189	Cell material: Pt ball; calibration: water, nitrobenzene, aniline, molten $NaNO_3$ and KCl
207	11.19–56.60	773–1023	Cell material and calibration: as for 39
216	0–100 (g)	1073	
226	0–100	914–1205	

TABLE 406. Viscosity studies: KCl-$MgCl_2$—Continued

Comparison with NSRDS recommendations: [1, p. 5 and this volume]			
Ref.	$MgCl_2$ Mol %	Min. departure	Max. departure
66	0	1.0% (1113 K)	11.4% (1151 K)
39	34.4	−4.8% (923 K)	
207	34.4	−4.0% (923 K)	
226	0	9.2% (1129 K)	13.1% (1150 K)
226	100		129.1% (1125 K)
226	49.02	77.8% (1125 K)	118.1% (1040 K)

Comment: Bondarenko **[66]** reported a precision of ±3% in the viscosity of salt mixtures in the temperature range 700–900 °C.

TABLE 407. $KCl-MgCl_2$: Viscosity (cp)

Mol % $MgCl_2$

T	100	54.0	49.9	43.9	34.3	32.4	25.1	16.4	8.0	0
900				1.65		1.70	1.48			
910				1.60	1.53	1.67	1.44			
920				1.55	1.49	1.64	1.40			
930				1.50	1.46	1.61	1.36			
940				1.45	1.42	1.58	1.33			
950				1.41	1.38	1.54	1.30			
960				1.36	1.35	1.51	1.26	1.31		
970		1.40		1.32	1.32	1.48	1.23	1.28		
980		1.37	[1.36]	1.29	1.28	1.44	1.20	1.24		
990		1.35	[1.33]	1.25	1.25	1.40	1.18	1.21		
1000		1.32	[1.29]	1.22	1.23	1.36	1.15	1.18		
1010	2.15	1.29	[1.26]	1.18	1.20	1.32	1.12	1.15		
1020	2.09	1.27	[1.24]	1.15	1.17	1.28	1.10	1.12		
1030	2.04	1.24	[1.22]	1.12	1.15	1.24	1.08	1.09	1.18	
1040	1.98	1.22	[1.20]	1.09	1.12		1.05	1.07	1.13	
1050	1.93	1.20	[1.18]	1.07	1.10		1.03	1.04	1.09	
1060	1.89	1.18	[1.16]		1.08		1.01	1.02	1.05	
1070	1.84		[1.14]		1.06		0.99	1.01	1.01	1.14
1080	1.79		[1.12]		1.04		0.97	0.99	0.98	1.11
1090	1.75		[1.11]		1.03			0.97	0.95	1.08
1100	1.71		[1.09]					0.96	0.93	1.05
1110	1.67		[1.07]					0.95	0.92	1.02
1120	1.63		[1.05]						0.91	1.00
1130	1.60		[1.03]						0.90	0.97
1140	1.56		[1.01]						0.90	0.95
1150			[0.98]						0.90	0.92
1160									0.91	0.90
1170									0.93	0.88
1180									0.95	0.85

Temperature-dependent equations

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

$$\eta = A \cdot \exp\,(E/RT)$$

Mol % $MgCl_2$	a	$b \cdot 10^2$	$c \cdot 10^5$	$d \cdot 10^9$	$A \cdot 10^2$	E (cal mol^{-1})	Stand. error of est.
0					5.315	6522	5.75%
8.0	22.7430	−2.8083	−0.1331	8.0324			2.81%
16.4	8.0331	0.5430	0.6629	5.2014			1.25%
25.1					11.894	4508	3.57%
32.4	9.3463	−2.2533	2.5006	−10.4550			2.06%
34.3	12.0513	−2.0180	1.0689	−1.3348			0.38%
43.9					7.757	5469	2.47%
49.9	[94.1729]	[−25.5548]	[23.5470]	[−72.8022]			
54.0					17.399	4025	4.36%
100					13.173	5605	1.33%

These values are based on the work of Bondarenko (oscillating sphere method) [66].

TABLE 408. Surface tension studies: $KCl-MgCl_2$

Investigations critically re-examined

Ref.	$MgCl_2$ Mol %	Temp. range (T)	Comments
241	0–100	1023–1198	Cell material: Pt–10%Rh capillary and graphite crucible; calibration: diameter of capillary measured with microscope
245	0–100	973–1223	Cell material: Pt capillary and quartz beaker containing melt; calibration: diameter of capillary measured with microscope, water, alcohol
246	0–90.3 (g)	998–1098	
253	0–100	1002–1169	Cell material: density sinker and rod for surface tension measurements was made from Pt–10%Rh alloy; calibration: measurements on pure salts
226	0–100	820–1283	

Comparison with NSRDS recommendation:
[2, pp. 58, 59 and this volume]

Ref.	$MgCl_2$ Mol %	Min. departure	Max. departure
241	100	7.9% (1193 K)	9.0% (1033 K)
253	100	−5.9% (800 K)	−6.7% (729 K)
241	90	13.3% (1173 K)	14.2% (1023 K)
253	80	−1.5% (1065 K)	−2.0% (1123 K)
253	60	0.53% (1063 K)	2.2% (1129 K)
241	50	3.2% (1173 K)	5.5% (1023 K)
253	40	−0.25% (1033 K)	−2.1% (1142 K)
253	30	0.85% (1059 K)	−0.89% (1125 K)
241	10	4.7% (1173 K)	7.6% (1023 K)
241	0	2.3% (1073 K)	
245	0	−2.5% (1223 K)	−2.6% (1073 K)
253	0	−1.7% (1089 K)	−1.8% (1112 K)

Comment: Desynatnikov [**245**] reported that his surface tension measurements were reproducible to an accuracy of 0.8%. Results on the pure salts agreed with literature values obtained by other methods. Values for pure $MgCl_2$ were those recommended in NSRDS–NBS–28 [2].

Lillebuen [253] reports a reproducibility for surface tension measurements of ±1%.

TABLE 409. $KCl-MgCl_2$: Surface tension (dyn cm^{-1})

T	Mol % $MgCl_2$ 100	90	80	70	60	50	40	30	20	10	0
980		70.6	74.2	77.2	79.1	80.9	82.1	86.0	90.9		
990		70.4	74.0	76.8	78.7	80.4	81.7	85.5	90.3		
1000	66.7	70.2	73.7	76.5	78.3	80.0	81.3	85.0	89.7		
1010	66.6	70.0	73.4	76.2	77.9	79.6	80.9	84.5	89.1		
1020	66.5	69.8	73.2	76.8	77.5	79.1	80.5	84.0	88.5	93.1	
1030	66.4	69.6	72.9	75.5	77.2	78.7	80.2	83.6	88.0	92.4	
1040	66.3	69.4	72.6	75.2	76.8	78.3	79.8	83.1	87.4	91.8	
1050	66.2	69.2	72.4	74.9	76.4	77.9	79.4	82.6	86.8	91.1	
1060	66.1	68.9	72.1	74.5	76.0	77.4	79.0	82.1	86.2	90.4	
1070	66.0	68.7	71.8	74.2	75.6	77.0	78.6	81.6	85.6	89.8	
1080	65.9	68.5	71.5	73.9	75.3	76.6	78.3	81.2	85.1	89.1	95.80
1090	65.8	68.3	71.3	73.5	74.9	76.1	77.9	80.7	84.5	88.5	95.05
1100	65.7	68.1	71.0	73.2	74.5	75.7	77.5	80.2	83.9	87.8	94.30
1110	65.6	67.9	70.7	72.9	74.1	75.3	77.1	79.7	83.3	87.1	93.55

TABLE 409. KCl-$MgCl_2$: Surface tension (dyn cm^{-1})—Continued

	Mol % $MgCl_2$										
T	100	90	80	70	60	50	40	30	20	10	0
1120	65.5	67.7	70.5	72.5	73.7	74.8	76.7	79.2	82.7	86.5	92.80
1130	65.4	67.5	70.2	72.2	73.4	74.4	76.4	78.8	82.2	85.8	92.05
1140	65.3	67.3	69.9	71.9	73.0	74.0	76.0	78.3	81.6	85.2	91.30
1150	65.2	67.1	69.7	71.6	72.6	73.6	75.6	77.8	81.0	84.5	90.55
1160	65.1	66.8	69.4	71.2	72.2	73.1	75.2	77.3	80.4	83.8	89.80
1170	65.0	66.6	69.1	70.9	71.8	72.7	74.8	76.8	79.8	83.2	89.05
1180	64.9										88.30
1190											87.55
1200											86.80
1210											86.05
1220											85.30

Temperature-dependent equations

$\gamma = a + bT$

Mol % $MgCl_2$	a	$b \cdot 10^2$
0	176.8	−7.5
10	160.4	−6.6
20	147.7	−5.8
30	133.0	−4.8
40	119.3	−3.8
50	123.0	−4.3
60	116.3	−3.8
70	109.5	−3.3
80	100.7	−2.7
90	91.2	−2.1
100	76.7	−1.0

These values are based on the work of Desyatnikov (maximum bubble pressure method) [245].

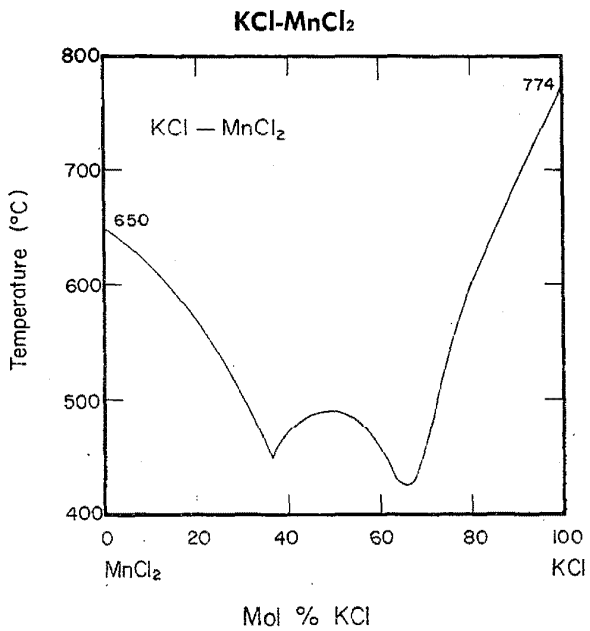

FIGURE 70. Temperature-composition phase diagram for KCl-$MnCl_2$.

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Melt Preparation and Purification

Murgulescu and Zuca [**72**] used pure salts without further purification. Analysis for manganese and chloride were performed using the volumetric and Volhard methods respectively. The salts were stored in a desiccator over concentrated sulfuric acid.

TABLE 410. Electrical conductance studies: KCl-$MnCl_2$

Investigations critically re-examined			
Ref.	$MnCl_2$ Mol %	Temp. range (T)	Comments
72	0–100	773–1123	Cell material: quartz vessel; Pt electrodes; freq. range: 1000–7000 Hz; calibration: 0.1M and 1.0M KCl solutions

Deviations from previous NSRDS recommendations: [1, p. 5]			
Ref.	$MnCl_2$ Mol %	Min. departure	Max. departure
72	0	0.04% (1123 K)	0.09% (1073 K)

Comment: Values for the conductance of pure $MnCl_2$ reported by Murgulescu and Zuca [**72**] were recommended in NSRDS–NBS–15 [1].

TABLE 411. KCl-$MnCl_2$: Specific conductance (ohm^{-1} cm^{-1})

	Mol percent $MnCl_2$											
T	100	80	70	65	55	50	45	35	30	25	20	0
780				0.92	0.94	0.87	0.82	0.86	0.89			
800				0.98	0.99	0.92	0.88	0.91	0.95			
820				1.04	1.03	0.97	0.93	0.97	1.00			
840			1.09	1.09	1.08	1.02	0.98	1.02	1.06	1.09		
860			1.15	1.14	1.13	1.07	1.03	1.07	1.11	1.15		
880		1.22	1.20	1.20	1.17	1.11	1.08	1.12	1.15	1.20		
900		1.27	1.25	1.24	1.21	1.16	1.13	1.17	1.20	1.25		
920		1.32	1.30	1.29	1.25	1.20	1.18	1.21	1.25	1.30		
940	1.504	1.37	1.35	1.34	1.30	1.24	1.22	1.26	1.29	1.34	1.30	
960	1.536	1.42	1.40	1.38	1.33	1.29	1.26	1.30	1.34	1.39	1.35	
980	1.568	1.46	1.44	1.42	1.37	1.32	1.30	1.34	1.38	1.44	1.41	
1000	1.602	1.50	1.48	1.46	1.41	1.36	1.34	1.38	1.42	1.48	1.46	
1020	1.637	1.55	1.52	1.50	1.44	1.40	1.38	1.42	1.46	1.52	1.51	
1040	1.674	1.59	1.56	1.54	1.47	1.44	1.42	1.46	1.50	1.56	1.57	
1060	1.712	1.63	1.59	1.57	1.51	1.47	1.45	1.49	1.54	1.60	1.62	
1080	1.752	1.66	1.63	1.61	1.54	1.50	1.48	1.53	1.57	1.64	1.68	[2.254]
1100	1.793	1.70	1.66	1.64	1.57	1.54	1.52	1.56	1.61	1.67	1.73	[2.303]
1120	1.835	1.73	1.69	1.67	1.59	1.57	1.55	1.59	1.64	1.71	1.78	[2.351]

Temperature-dependent equations

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

Mol % $MnCl_2$	a	$b \cdot 10^3$	$c \cdot 10^6$	Stand. error of est.
0	[−0.3591]	[2.4200]	0	0.00%
20	−1.2134	2.6740	0	1.38%
25	−2.4456	5.7267	−1.8027	0.39%
30	−2.2945	5.4090	−1.6923	0.74%
35	−2.4924	5.7863	−1.9113	0.54%
45	−2.5998	5.9536	−2.0113	0.41%
50	−2.1120	5.0603	−1.5851	0.39%
55	−2.0710	5.1917	−1.7136	0.33%
65	−2.7158	6.3909	−2.2113	0.57%
70	−3.0991	7.1222	−2.5406	0.44%
80	−2.5122	5.8926	−1.8757	0.36%
100	1.5853	−1.6987	1.7155	0.05%

These values are based on the work of Murgulescu and Zuca (classical ac technique) [72].

TABLE 412. Density studies: KCl-$MnCl_2$

Investigations critically re-examined				
Ref.	$MnCl_2$ Mol %	Temp. range (T)	Cell material	Calibration
72	0–100	773–1123	Pt bob	Water

Deviations from previous NSRDS recommendations: [1, p. 5]			
Ref.	$MnCl_2$ Mol %	Min. departure	Max. departure
72	0	0.07% (1123 K)	0.13% (1073 K)

Comment: Density values for pure $MnCl_2$ reported by Murgulescu and Zuca [72] were those recommended in NSRDS–NBS–15 [1].

TABLE 413. $KCl\text{-}MnCl_2$: Density ($g.cm^{-3}$)

	Mol percent $MnCl_2$											
T	100	80	70	65	55	50	45	35	30	25	20	0
780				2.206	2.106	2.059	2.009	1.939	1.894			
800				2.196	2.095	2.048	1.998	1.927	1.882			
820				2.185	2.084	2.037	1.987	1.914	1.870			
840			2.216	2.174	2.073	2.026	1.975	1.902	1.857	1.815		
860			2.206	2.164	2.061	2.015	1.964	1.889	1.845	1.803		
880		2.333	2.197	2.153	2.050	2.004	1.953	1.876	1.833	1.790		
900		2.320	2.188	2.143	2.039	1.993	1.942	1.864	1.820	1.777		
920		2.307	2.179	2.132	2.027	1.982	1.931	1.851	1.808	1.764		
940	2.346	2.295	2.169	2.122	2.016	1.971	1.919	1.839	1.796	1.751	1.725	
960	2.337	2.282	2.160	2.111	2.005	1.960	1.908	1.826	1.784	1.738	1.712	
980	2.328	2.270	2.151	2.100	1.994	1.949	1.897	1.813	1.771	1.726	1.699	
1000	2.319	2.257	2.142	2.090	1.982	1.938	1.886	1.801	1.759	1.713	1.685	
1020	2.311	2.245	2.132	2.079	1.971	1.927	1.875	1.788	1.747	1.700	1.672	
1040	2.302	2.232	2.123	2.069	1.960	1.916	1.863	1.776	1.735	1.687	1.659	
1060	2.293	2.220	2.114	2.058	1.948	1.905	1.852	1.763	1.722	1.674	1.646	
1080	2.284	2.207	2.105	2.048	1.937	1.894	1.841	1.750	1.710	1.662	1.633	[1.508]
1100	2.276	2.195	2.095	2.037	1.926	1.883	1.830	1.738	1.698	1.649	1.620	[1.495]
1120	2.267	2.182	2.086	2.027	1.915	1.872	1.819	1.725	1.686	1.636	1.607	[1.482]

Temperature-dependent equations

$$\rho = a + bT$$

Mol % $MnCl_2$	a	$b \cdot 10^3$	Stand. error of est.
0	[2.1988]	[−0.6400]	
20	2.3414	−0.6560	0.02%
25	2.3542	−0.6414	0.18%
30	2.3727	−0.6136	0.07%
35	2.4305	−0.6298	0.04%
45	2.4457	−0.5600	0.17%
50	2.4889	−0.5507	0.11%
55	2.5466	−0.5643	0.06%
65	2.6180	−0.5281	0.01%
70	2.6045	−0.4629	0.05%
80	2.8831	−0.6257	0.02%
100	2.7574	−0.4380	0.02%

These values are based on the work of Murgulescu and Zuca (Archimedean method) [72].

KCl-NaCl

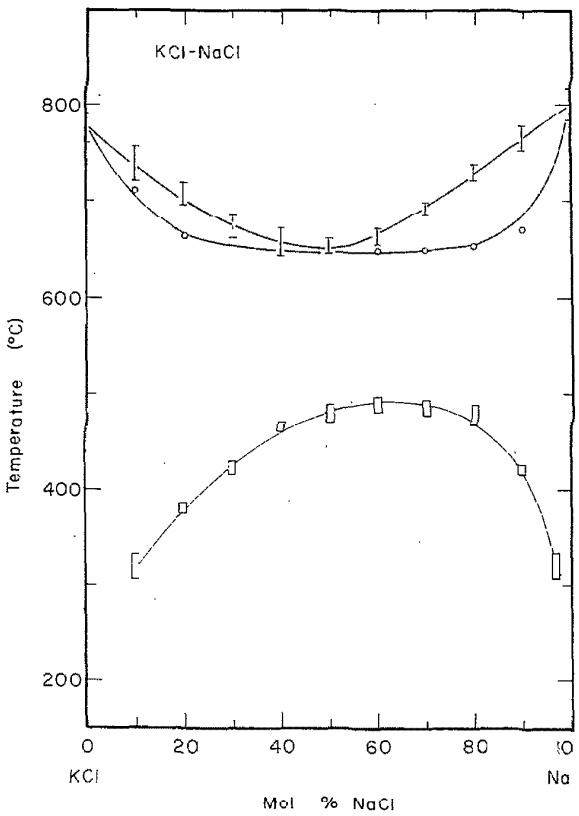

FIGURE 71. Temperature-composition phase diagram for KCl-NaCl.

E. Scheil and H. Stadelmaien, Z. Metallkd., **43**, 227 (1952).

Melt Preparation and Purification

Van Artsdalen and Yaffe's [**37**] procedure for salt purification is discussed under the KCl-LiCl system.

Barzakovskii [24] used "chemically pure" salts which *were heated in a porcelain crucible under a dry atmosphere* of HCl for 2–3 hours.

Markova and Sherbakov [113] used "chemically pure" salts, recrystallized twice from water and heated to a temperature of 500 °C for 1–2 hours.

Murgulescu and Zuca [**53**] dried Merck "reagent grade" salts by heating at 150°C followed by melting in an atmosphere of dry HCl.

Reagent grade alkali metal halide salts used by Ellis [78, 143] were dried at 200 °C overnight. Mixtures were prepared by combining the dry salts, in the proper molar ratio, and mixing them in a ball mill for about 16 hours.

"Chemically pure" *salts were used by Maurit [95]* and were dehydrated in a current of dry HCl gas.

The preparation of pure NaCl and KCl by Sakai and Suzuki [127] is discussed under the system KCl-LiCl.

Desynatnikov [**245**] used "chemically pure" salts which were dried by passing a stream of dry HCl gas through the melt for 6–8 hours and then bubbling CO_2 for 20–30 minutes to displace the HCl.

TABLE 414. Electrical conductance studies: KCl-NaCl

Investigations critically examined			
Ref.	NaCl Mol %	Temp. range (T)	Comments
5	0, 50, 100	1073–1223	Cell material: porcelain tube; Pt electrodes; calibration: 1N KCl solution
12	*0–100*	*1123*	*Cell material: silica and* quartz U-tube; Pt electrodes; calibration: 1N KCl solution
21	20, 50, 80, 90	933–1033	Cell material: quartz vessel or Pt crucible for corrosive melts; Pt electrodes; freq. range: ~6000 Hz; calibration: sulfuric acid solution, saturated NaCl solution and molten KNO_3
24	0–100	1123	Cell material: quartz vessel; Pt electrodes; freq. range: ~20–2000 Hz; calibration: KCl solutions
37	0–100	936–1294	Cell material: quartz dip type capillary cell; Pt electrodes; freq. range: 2000–20,000 Hz; calibration: 1 demal KCl solution
60	0–100 (g)		
65	0–100	1033–1153	Cell material: alumina U-tube; Pt electrodes; freq. range: ~800 Hz; calibration: molten KCl
97[a]	0–100	936–1294	
102	*34–72 (g)*	*973*	
113	0–100	953–1093	Cell material: quartz vessel; Pt electrodes; calibration: sulfuric acid solutions
114	0, 20, 50 80, 100	1073–1173	Cell material: Pt cylinder; Pt disc electrodes; calibration: molten KCl
127	50 (g)	923–1023	Cell material: Vycor glass; Pt disc electrodes; freq. range: 1000 Hz
160[a]	0–100 (g)	1123	
161	*80 (g)*	*1073–1173*	
192	50 (g)	950–1090	
203	~25–65 (g)	1023	
208[b]			Cell material: quartz vessel; Pt electrodes; calibration: molten KCl

TABLE 414. Electrical conductance studies: KCl-NaCl—Continued

Comparison with NSRDS recommendations:
[1, pp. 4, 5 and this volume]

Ref.	NaCl Mol %	Min. departure	Max. departure
5	100	−4.7% (1223 K)	−6.2% (1123 K)
12	100	−3.0% (1223 K)	−4.2% (1123 K)
24	100	0.0% (1073 K)	−3.4% (1273 K)
65	100	−1.6% (1113 K)	−2.1% (1153 K)
113	100	1.9% (1123 K)	
114	100	−2.6% (1173 K)	−4.3% (1123 K)
21	20.04	12.5% (1063 K)	16.4% (1088 K)
65	20.04	0.41% (1113 K)	
5	0	−2.2% (1073 K)	−2.5% (1123 K)
12	0	2.7% (1173 K)	3.4% (1073 K)
24	0	2.5% (1123 K)	
114	0	4.0% (1073 K)	7.6% (1123 K)
113	0	−1.6% (1073 K)	

[a]Data in references [97] and [160] were from [37] and [12], respectively.

[b]No data reported.

Comments: Van Artsdalen and Yaffe [37] report experimental specific conductivity values as well as equations of the form: $k = a + bt + ct^2$ with standard deviations in the range 2×10^{-3} ohm^{-1} cm^{-1} (51.23 and 84.77 mol % NaCl) to 6×10^{-3} ohm^{-1} cm^{-1} (100 mol % NaCl).

TABLE 415. KCl-NaCl: Specific conductance (ohm^{-1} cm^{-1})

	Mol percent NaCl							
T	100.00	84.77	72.94	65.15	51.23	41.00	20.40	0.00
940					2.231			
950					2.265			
960					2.298	2.162		
970				2.518	2.331	2.200		
980				2.552	2.363	2.237		
990				2.586	2.395	2.273		
1000			2.736	2.620	2.426	2.309		
1010			2.770	2.652	2.457	2.343	2.169	
1020			2.804	2.685	2.487	2.376	2.196	
1030			2.837	2.717	2.517	2.408	2.223	
1040		3.125	2.870	2.748	2.546	2.439	2.250	
1050		3.154	2.901	2.779	2.575	2.469	2.276	
1060		3.184	2.933	2.809	2.603	2.498	2.302	2.197
1070		3.214	2.963	2.839	2.630	2.526	2.327	2.225
1080	3.599	3.243	2.993	2.869	2.657	2.553	2.352	2.252
1090	3.631	3.272	3.022	2.898	2.684	2.579	2.377	2.279
1000	3.662	3.300	3.051	2.926	2.710	2.604	2.401	2.304
1110	3.693	3.329	3.079	2.954	2.735	2.628	2.424	2.329
1120	3.724	3.357	3.106	2.981	2.760	2.651	2.447	2.353
1130	3.754	3.385	3.133	3.008	2.784	2.673	2.470	2.376
1140	3.783	3.412	3.158	3.035	2.808	2.694	2.492	2.398
1150	3.813	3.440	3.184	3.061	2.831	2.714	2.514	2.420
1160	3.842	3.467	3.208	3.086	2.854	2.732	2.535	2.440
1170	3.870	3.494	3.232	3.111	2.876	2.750	2.556	2.460
1180	3.898	3.520	3.255	3.136	2.898	2.767	2.576	2.479
1190	3.926	3.547	3.278	3.159			2.596	2.497
1200	3.953	3.573	3.300	3.183			2.615	
1210	3.980			3.206				
1220	4.006							
1230	4.032							
1240	4.058							
1250	4.083							
1260	4.107							
1270	4.132							
1280	4.155							
1290	4.179							

TABLE 415. KCl-NaCl: Specific conductance (ohm^{-1} cm^{-1})—Continued

Temperature-dependent equations $\kappa = a + bT + cT^2$				
Mol % NaCl	a	$b \cdot 10^2$	$c \cdot 10^5$	Stand. error of est.
0.00	−5.5231	1.1714	−0.4180	0.19%
20.40	−2.9567	0.7368	−0.2270	0.29%
41.00	−6.3093	1.3765	−0.5147	0.22%
51.23	−3.3119	0.8380	−0.2641	0.40%
65.15	−3.1690	0.8265	−0.2477	0.19%
72.94	−4.0668	1.0120	−0.3317	0.30%
84.77	−1.3797	0.5656	−0.1274	0.24%
100.00	−2.3356	0.7783	−0.2118	0.22%

These values are based on the work of Van Artsdalen and Yaffe (classical ac technique) [37].

TABLE 416. Density studies: KCl-NaCl

Investigations critically re-examined			
Ref.	NaCl Mol %	Temp. range (T)	Comments
12	0–100	1123, 1173	Cell material: Pt cylinder, Pt suspension wire
24	0–100	1073, 1173	
37	0–100	943–1300	Cell material: Pt bob, Pt–Rh suspension wire
78	0–77.5	1059–1330	Cell material: Pt bob, Pt chain
87	0–100 (g)	1073	Cell material: Pt sphere, Pt suspension wire; calibration: water
89	0–100[a]	1073, 1173	Cell material: Pt sphere
95	0, 13.7, 100[a]	1048–1213	Cell material: Pt hollow cylinder, Pt suspension wire; calibration: water
215	0–100 (g)	1063	
267, 211	0–100	930–1130	
328	30–60 (g)	1073	

Deviations from previous NSRDS recommendations: [1, pp. 4, 5]			
Ref.	NaCl Mol %	Min. departure	Max. departure
12	100	−1.1% (1123 K)	
24	100	−0.33% (1173 K)	−1.7% (1273 K)
89	100	−2.9% (1080 K)	−3.6% (1180 K)
12	0	−0.99% (1073 K)	−1.2% (1173 K)
24	0	−0.33% (1173 K)	−1.7% (1273 K)
89	0	−0.13% (1080 K)	−0.27% (1160 K)

[a]Graphical except for pure components.

Comments: Van Artsdalen and Yaffe [37] report experimental density data together with linear temperature dependent equations with standard deviations in the range: 1×10^{-4} g cm^{-3} (51.23 mol % NaCl) to 7×10^{-3} g cm^{-3} (100 mol % NaCl).

TABLE 417. KCl-NaCl: Density (g cm^{-3})

Mol percent NaCl												
T	100	90	80	70	60	50	40	30	20	10	0	50
960						1.588	1.583					1.588
970					1.587	1.582	1.578	1.574				1.582
980					1.582	1.576	1.572	1.568				1.576
990				1.582	1.576	1.571	1.566	1.563	1.560			1.571

TABLE 417. KCl-NaCl: Density (g cm^{-3})—Continued

	Mol percent NaCl											
T	100	90	80	70	60	50	40	30	20	10	0	50
1000				1.576	1.570	1.565	1.560	1.557	1.554			1.565
1010				1.571	1.565	1.559	1.555	1.551	1.549			1.559
1020			1.572	1.565	1.559	1.554	1.549	1.545	1.543	1.542		1.554
1030			1.566	1.560	1.554	1.548	1.543	1.540	1.537	1.536		1.548
1040			1.561	1.554	1.548	1.542	1.538	1.534	1.531	1.530		1.542
1050			1.555	1.549	1.542	1.537	1.532	1.528	1.526	1.524		1.537
1060			1.550	1.543	1.537	1.531	1.526	1.522	1.520	1.518	1.519	1.531
1070		1.552	1.544	1.537	1.531	1.525	1.520	1.517	1.514	1.513	1.513	1.525
1080	1.554	1.546	1.539	1.532	1.525	1.520	1.515	1.511	1.508	1.507	1.507	1.520
1090	1.548	1.541	1.533	1.526	1.520	1.514	1.509	1.505	1.502	1.501	1.501	1.514
1100	1.543	1.535	1.528	1.521	1.514	1.508	1.503	1.499	1.497	1.495	1.495	1.508
1110	1.537	1.530	1.522	1.515	1.509	1.503	1.498	1.494	1.491	1.489	1.489	1.503
1120	1.532	1.524	1.517	1.510	1.503	1.497	1.492	1.488	1.485	1.484	1.484	1.497
1130	1.526	1.519	1.511	1.504	1.497	1.491	1.486	1.482	1.479	1.478	1.478	1.491
1140	1.521	1.513	1.506	1.498	1.492	1.486	1.481	1.477	1.474	1.472	1.472	1.486
1150	1.515	1.508	1.500	1.493	1.486	1.480	1.475	1.471	1.468	1.466	1.466	1.480
1160	1.510	1.502	1.495	1.487	1.481	1.475	1.469	1.465	1.462	1.461	1.460	
1170	1.504	1.497	1.489	1.482	1.475	1.469	1.464	1.460	1.456	1.455	1.455	
1180	1.499	1.491	1.483					1.454	1.451	1.449	1.449	
1190	1.493	1.486							1.445	1.443	1.443	
1200	1.488	1.480							1.439	1.438	1.437	
1220	1.477											
1240	1.466											
1260	1.455											
1280	1.444											
1300	1.433											

Two-dimensional equation and statistical parameters

$$\rho = a + bT + cC^3 + dTC + eCT^2$$

a	$b \cdot 10^4$	$c \cdot 10^8$	$d \cdot 10^7$	$e \cdot 10^{10}$	Max. percent departure	Stand. error of est.
2.14250	−5.45436	2.79726	−9.89901	2.78444	−0.26% (1127.3 K; 0.0 mol % KCl)	0.11%

These values are based on the work of Van Artsdalen and Yaffe (Archimedean method) [37]. C — mol % KCl.

TABLE 418. KCl-NaCl: Density (g cm^{-3})

	Mol percent NaCl							
T	100	84.77	72.94	65.15	51.23	41.00	20.75	0
945					1.595			
960					1.586	1.582		
975					1.578	1.574		
990			1.584	1.582	1.569	1.565		
1005			1.576	1.574	1.561	1.557	1.554	
1020			1.567	1.565	1.552	1.548	1.545	
1035			1.559	1.557	1.544	1.539	1.536	
1050			1.550	1.548	1.535	1.531	1.527	
1065		1.550	1.542	1.540	1.527	1.522	1.519	1.515
1080	1.553	1.542	1.534	1.532	1.518	1.513	1.510	1.506
1095	1.545	1.534	1.525	1.523	1.510	1.505	1.501	1.498
1110	1.537	1.525	1.517	1.515	1.501	1.496	1.493	1.489
1125	1.528	1.517	1.509	1.507	1.493	1.488	1.484	1.480
1140	1.520	1.509	1.500	1.498	1.484	1.479	1.475	1.471
1155	1.512	1.500	1.492	1.490	1.475	1.470	1.466	1.463
1170	1.504	1.492	1.483	1.482	1.467	1.462	1.458	1.454
1185	1.496	1.484	1.475	1.473			1.449	1.445
1200	1.488						1.440	1.436
1215	1.480							
1230	1.472							
1245	1.464							
1260	1.455							
1275	1.447							
1290	1.439							

Temperature-dependent equations

$$\rho = a + bT$$

Mol % NaCl	a	$b \cdot 10^4$	Stand. error of est.
0	2.1376	−5.8445	0.03%
20.75	2.1377	−5.8127	0.01%
41.00	2.1342	−5.7477	0.02%
51.23	2.1314	−5.6793	0.01%
65.15	2.1338	−5.5749	0.01%
72.94	2.1374	−5.5900	0.02%
84.77	2.1400	−5.5381	0.02%
100	2.1365	−5.4052	0.05%

These values are based on the work of Van Artsdalen and Yaffe (Archimedean method) [37].

TABLE 419. Viscosity studies: KCl-NaCl

Investigations critically re-examined

Ref.	NaCl Mol %	Temp. range (T)	Comments
24	0, 50, 75, 100	1073, 1173, 1273	
29	0–100 (g)	1103, 1123, 1173	Cell material: Ni sphere, Ni wire; calibration: water and molten NaCl
53	0–100	993–1173	Cell material: Pt sphere, Pt suspension wire; calibration: water, nitrobenzene, aniline, molten $NaNO_3$ and KNO_3
66	0, 29.8, 56.0, 79.3	988–1187	Cell material: Pt ball; calibration: water, nitrobenzene, aniline, molten $NaNO_3$ and KNO_3
86[a]	0–100	992–1118	Cell material: Pt disc, stainless steel suspension wire; Pt sample vessel; calibration: sulfuric acid solutions
100[a]	0–100	992–1118	Cell material: Pt disc, stainless steel suspension wire, Pt sample vessel; calibration: sulfuric acid solutions and molten KCl
215[a]	0–100	992–1118	
226	0–100	930–1270	

Comparisons with NSRDS recommendations: [1, p. 4 and this volume]

Ref.	NaCl Mol %	Min. departure	Max. departure
24	100	0.3% (1173 K)	
53	100	−0.32% (1153 K)	−1.8% (1093 K)
86, 100	100	−14.5% (1102 K)	−17.1% (1118 K)
86, 100	84.8	−27.9% (1043 K)	
86, 100	72.9	−26.0% (1037 K)	
86, 100	65.2	−20.0% (993 K)	
86, 100	51.2	−18.8% (1033 K)	
86, 100	41.0	−9.2% (993 K)	
86, 100	20.8	−9.6% (1063 K)	

[a]References [86], [100], and [215] contain the same experimental data.

TABLE 420. KCl-NaCl: Viscosity (cp)

	Mol percent NaCl							
T	100	84.77	72.90	65.15	51.23	41.00	20.75	0
1000			1.777	1.668	1.580	1.502		
1010			1.702	1.605	1.519	1.450		
1020			1.631	1.545	1.460	1.400	1.331	
1030			1.565	1.486	1.404	1.351	1.285	
1040		1.557	1.502	1.430	1.351	1.305	1.241	
1050		1.498	1.443	1.376	1.300	1.260	1.199	
1060		1.441	1.387	1.324	1.252	1.217	1.158	1.154
1070		1.387	1.335	1.274	1.206	1.175	1.119	1.116
1080		1.335	1.285	1.226	1.162	1.136	1.082	1.080
1090		1.285	1.238	1.181	1.121	1.098	1.047	1.046
1100	1.307	1.239	1.194	1.139	1.083	1.062	1.014	1.014
1110	1.258	1.195	1.152	1.098	1.047	1.028	0.983	0.984
1120	1.211	1.153	1.112	1.060	1.014	0.996	0.954	0.957
1130	1.167	1.114	1.074	1.024	0.984	0.966	0.926	0.931
1140	1.125	1.078	1.038	0.990	0.956	0.937	0.900	0.908
1150	1.086	1.044	1.004	0.959	0.930	0.911	0.877	0.887
1160	1.048	1.013	0.972	0.931	0.907	0.887	0.855	0.869
1170	1.012	0.985	0.941	0.904	0.887	0.864	0.835	0.853

Temperature-dependent equations

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

$$\eta = A \cdot \exp\,(E/RT)$$

Mol % NaCl	a	$b \cdot 10^2$	$c \cdot 10^6$	$d \cdot 10^9$	$A \cdot 10^2$	E (cal mol^{-1})	Stand. error of est.
0	1.7091	1.5846	−27.7213	11.5836			0.57%
20.75	14.1361	−1.9076	5.0784	1.2900			0.29%
41.00	11.6454	−1.1612	− 1.9476	3.4160			0.55%
51.23	18.3576	−2.5649	7.1721	1.6990			0.61%
65.15	16.2796	−2.0228	3.0276	2.5895			0.38%
72.90					2.231	8699	0.60%
84.77	15.2401	−1.4962	− 3.3789	4.9174			0.25%
100					1.821	9341	0.47%

These values are based on the work of Murgulescu and Zuca (oscillating sphere method) **[53]**.

TABLE 421. Surface tension studies: KCl-NaCl

Investigations critically re-examined			
Ref.	NaCl Mol %	Temp. range (T)	Comments
243	0, 50, 65, 100	998–1183	
245	0–100	1073–1223	Cell material: Pt capillary and quartz beaker containing melt; calibration: diameter of capillary measured with microscope, water, alcohol
250	0–100	1073, 1173, 1273	
254	0–100	970–1210	Cell material: 90%Pt-Rh capillary, melt in Pt crucible; calibration: benzene
257	40, 60, 100	973–1182	Cell material: Pt capillary; calibration: radius of capillary obtained from measurements of pure molten LiCl, NaCl, and KCl
143	50	995–1293	
226	0–100	990–1370	

TABLE 421. Surface tension studies: KCl-NaCl—Continued

Comparison with NSRDS recommendations [2. pp. 57, 58 and this volume]			
Ref.	NaCl Mol %	Min. departure	Max. departure
243	100	3.4% (1083 K)	3.5% (1183 K)
245	100	0.18% (1123 K)	0.58% (1223 K)
250	100	0.19% (1173 K)	
254	100	2.3% (1175 K)	3.0% (1099 K)
257	100	3.1% (1173 K)	3.8% (1103 K)
254	60	3.4% (1098 K)	3.5% (1095 K)
257	60	4.2% (1123 K)	5.1% (1023 K)
243	50	3.5% (1073 K)	3.9% (1173 K)
143	50	3.3% (950 K)	4.2% (800 K)
254	40	3.0% (1099 K)	3.7% (1071 K)
257	40	3.8% (1073 K)	4.2% (1023 K)
243	0	0.81% (1073 K)	1.2% (1173 K)
245	0	−2.5% (1223 K)	−2.6% (1073 K)
250	0	−2.7% (1073 K)	

Comment: Reference [243] contained only graphical data in the form of surface tension—composition isotherms at 800 °C for the mixtures reported. Numerical data given here was obtained through a private communication. Bertozzi reported a reproducibility of ±0.5% for his surface tension measurements.

Desynatnikov **[245]** reported a reproducibility of 0.8%. Results on the pure salts agreed with literature values obtained by other methods. Values for pure $MgCl_2$ were those recommended in [2].

Dahl and Duke [254] reported a total error in surface tension data for mixtures of less than ±1%.

TABLE 422. KCl-NaCl: Surface tension (dyn cm^{-1})

	Mol percent NaCl											
T	100	90	80	70	60	50	40	30	20	10	0	50
980			114.0	111.7	109.8	108.3	107.1	106.1	105.2			
990			113.3	111.0	109.1	107.6	106.4	105.3	104.5			107.6
1000	119.0	115.5	112.6	110.3	108.4	106.9	105.6	104.6	103.7	102.9		106.9
1010	118.3	114.8	111.9	109.6	107.7	106.1	104.9	103.9	103.0	102.2		106.1
1020	117.6	114.1	111.2	108.9	107.0	105.4	104.2	103.1	102.3	101.4		105.4
1030	116.9	113.4	110.5	108.2	106.3	104.7	103.5	102.4	101.5	100.7		104.7
1040	116.3	112.8	109.9	107.5	105.6	104.0	102.7	101.7	100.8	99.9		104.0
1050	115.6	112.1	109.2	106.8	104.8	103.3	102.0	100.9	100.0	99.2		103.3
1060	114.9	111.4	108.5	106.1	104.1	102.6	101.3	100.2	99.3	98.4		102.6
1070	114.2	110.7	107.8	105.4	103.4	101.8	100.5	99.5	98.5	97.7		101.8
1080	113.5	110.0	107.1	104.7	102.7	101.1	99.8	98.7	97.8	96.9	96.0	101.1
1090	112.9	109.3	106.4	104.0	102.0	100.4	99.1	98.0	97.0	96.2	95.2	100.4
1100	112.2	108.6	105.7	103.3	101.3	99.7	98.4	97.3	96.3	95.4	94.5	99.7
1110	111.5	108.0	105.0	102.6	100.6	99.0	97.6	96.5	95.6	94.6	93.7	99.0
1120	110.8	107.3	104.3	101.9	99.9	98.2	96.9	95.8	94.8	93.9	93.0	98.2
1130	110.2	106.6	103.6	101.2	99.1	97.5	95.2	95.0	94.1	93.1	92.2	97.5
1140	109.5	105.9	102.9	100.4	98.4	96.8	95.4	94.3	93.3	92.4	91.4	96.8
1150	108.8	105.2	102.2	99.7	97.7	96.1	94.7	93.6	92.6	91.6	90.6	96.1
1160	108.1	104.5	101.5	99.0	97.0	95.3	94.0	92.8	91.8	90.9	89.9	95.3
1170	107.4	103.8	100.8	98.3	96.3	94.6	93.2	92.0	91.0	90.1	89.1	94.6
1180	106.8										88.3	

Two-dimensional equation and statistical parameters

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

a	$b \cdot 10^2$	$c \cdot 10^1$	$d \cdot 10^3$	$e \cdot 10^5$	$f \cdot 10^8$	$g \cdot 10^8$	Max. percent departure	Stand. error of est.
186.76500	−6.77993	−3.41591	3.42500	−1.28519	−3.15694	−3.79717	−0.46% (1170.0 K, 50 mol % KCl)	0.20%

These values are based on the work of Desyatnikov (maximum bubble pressure method) [245]. C = mol % KCl.

TABLE 423. KCl-NaCl: Surface tension (dyn cm^{-1})

	Mol percent NaCl								
T	100	90	75	60	50	40	25	10	0
980		116.9	112.6	109.8	108.7	106.7	105.5	104.6	
990		116.2	111.9	109.1	108.0	106.0	104.7	103.9	
1000	119.0	115.5	111.2	108.4	107.3	105.3	104.0	103.1	
1010	118.3	114.8	110.5	107.7	106.6	104.6	103.3	102.4	
1020	117.6	114.1	109.8	107.0	105.9	103.9	102.5	101.6	
1030	117.0	113.5	109.1	106.2	105.1	103.1	101.8	100.9	
1040	116.3	112.8	108.4	105.5	104.4	102.4	101.0	100.1	
1050	115.6	112.1	107.7	104.8	103.7	101.7	100.3	99.4	
1060	114.9	111.4	107.0	104.1	103.0	101.0	99.6	98.6	
1070	114.2	110.7	106.3	103.4	102.3	100.3	98.8	97.9	
1080	113.6	110.1	105.6	102.6	101.5	99.5	98.1	97.1	95.8
1090	112.9	109.4	104.9	101.9	100.8	98.8	97.3	96.4	95.1
1100	112.2	108.7	104.2	101.2	100.1	98.1	96.6	95.6	94.3
1110	111.5	108.0	103.5	100.5	99.4	97.4	95.9	94.9	93.6
1120	110.8	107.3	102.8	99.8	98.7	96.7	95.1	94.1	92.8
1130	110.2	106.7	102.1	99.0	97.9	95.9	94.4	93.4	92.1
1140	109.5	106.0	101.4	98.3	97.2	95.2	93.6	92.6	91.3
1150	108.8	105.3	100.7	97.6	95.5	94.5	92.9	91.9	90.6
1160	108.1	104.6	100.0	96.9	95.8	93.8	92.2	91.1	89.8
1170	107.4	103.9	99.3	96.2	95.1	93.1	91.4	90.4	89.1
1180	106.8								88.3
1190	106.1								87.6
1200	105.4								86.8
1210	104.7								86.1
1220	104.0								85.3

TABLE 423. KCl-NaCl: Surface tension (dyn cm^{-1})—Continued

Temperature-dependent equations. $\gamma = a + bT$		
Mol % NaCl	a	$b \cdot 10^2$
0	176.8	−7.5
10	178.1	−7.5
25	178.0	−7.4
40	177.3	−7.2
50	179.3	−7.2
60	180.4	−7.2
75	181.2	−7.0
90	183.5	−6.8
100	187.0	−6.8

These values are based on the work of Desyatnikov (maximum bubble pressure method) [245].

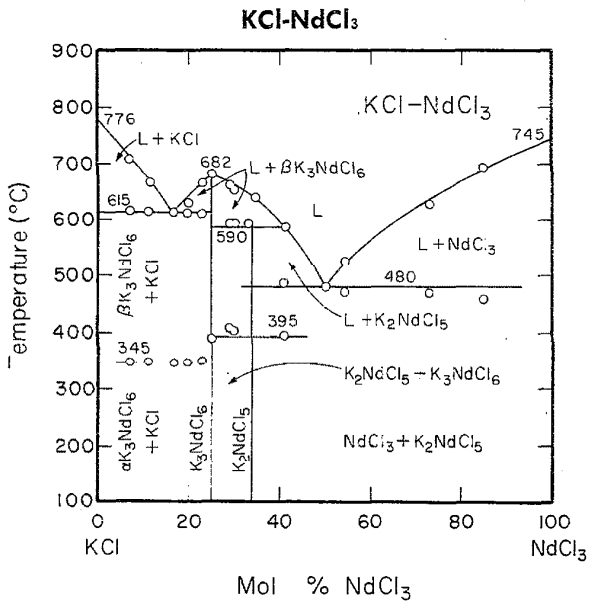

FIGURE 72. Temperature-composition phase diagram for KCl-$NdCl_3$.

In-chzhu Sun and I. S. Morozov, Russ. J. Inorg. Chem., U.S.S.R., 3, 1914 (1958).

Melt Preparation and Purification

Neodymium trichloride and the other lanthanide trichlorides used by Forthmann and Schneider [186, 190] were prepared by adding excess NH_4Cl to the rare earth oxide (purity >99.8%) at 280 °C for 12–15 hours. Excess NH_4Cl was sublimed under vacuum at 300–400 °C and the rare earth chloride was melted under an argon atmosphere. Analysis of the melts were performed using EDTA titrations for the rare earth metals. Differences between calculated and titrated values were less than 1%.

TABLE 424. Electrical conductance studies: KCl-$NdCl_3$

Investigations critically re-examined			
Ref.	$NdCl_3$ Mol %	Temp. range (T)	Comments
186, 190[a]	0–100 (g)	1073, 1173[b]	Cell material: quartz capillary cell; Pt electrodes; freq. range: 100,000-250,000 Hz; calibration: molten NaCl, KCl, and CsCl

[a]Forthmann et al. [186, 190] initially filled their quartz conductance cells with $NdCl_3$ under Ar flow; the pure $LaCl_3$ was melted and HCl gas was passed through the melt until the conductance was constant. Compositions were varied by adding the solid alkali chloride.

[b]Data reported at 1073 K only in reference [186].

TABLE 425. KCl-$NdCl_3$: Molar conductance (ohm^{-1} cm^2 mol^{-1})

Mol % KCl	1073 K
0	73.3
10	69.3
20	66.8
30	65.7
40	65.0
50	65.2
60	66.0
70	68.2
80	74.5
90	90.0
100	110.0

These values were interpolated to three significant figures from the graphical presentation of Forthmann and Schneider (classical ac technique) [186, 190].

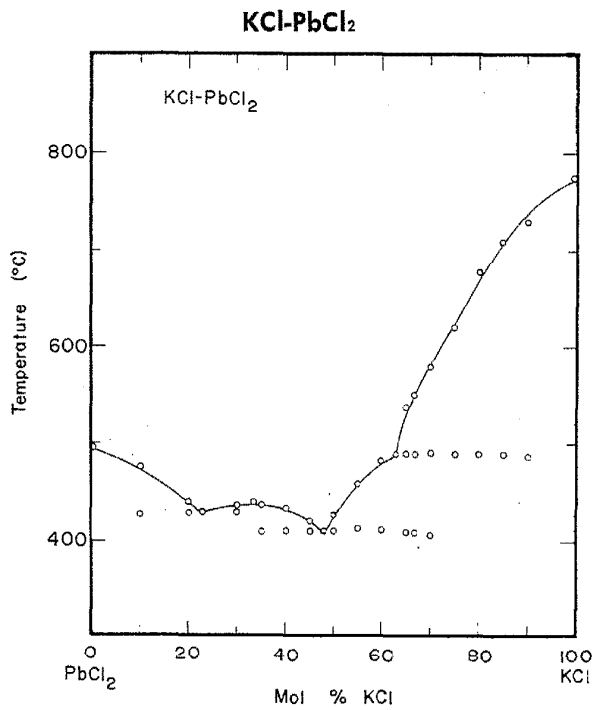

FIGURE 73. Temperature-composition phase diagram for $KCl-PbCl_2$.

K. Treis, Neues Jahrb. Mineral., Geol., Paläontol., Beil. Band, **37**, 766 (1914).

Melt Preparation and Purification

Tarasova [13] used salts of domestic production. Lead chloride was recrystallized from water and stored in black, opaque paper. The melting point of the pure $PbCl_2$ was 500 °C.

Bloom and Heymann [25] and Boardman et al. [**26**] used analytical reagent salts which were checked by analysis.

"Chemically pure" salts used by Lantratov and Moiseeva [**43**] were recrystallized from their hydrochloric acid solutions and dried in a stream of HCl.

Easteal and Hodge [158] prepared $PbCl_2$ from May and Baker Ltd. "Analar" $Pb(NO_3)_2$ and HCl, and was purified by crystallization from a dilute hydrochloric acid solution followed by filtration of the molten salt, under nitrogen, through a porous silica frit. Pure KCl was precipitated from a cold saturated solution of the "Analar" salt with dry HCl. Mixtures were analyzed before and after each experiment by conversion of the samples to nitrates and titrating with sodium molybdate using Solochrome Red B as the indicator.

Boardman et al. [234] used salts that were either of A.R. purity or prepared from reagents of this purity and recrystallized.

Dahl and Duke [**238, 254**] used "Baker Analyzed" reagent grade materials. Lead chloride was fused, crushed and stored in a drying oven at 110 °C and KCl was dried and used without further purification.

TABLE 426. Electrical conductance studies: $KCl-PbCl_2$

Investigations critically re-examined			
Ref.	$PbCl_2$ Mol %	Temp. range (T)	Comments
13	65–100	733–793	Cell material: Pyrex; Pt electrodes; calibration: molten $Ca(NO_3)_2$
25[a]	0–100[b]	833–993	Cell material: Supremax glass; Pt electrodes; freq. range: 3000 Hz; calibration: 1.0 N KCl solution and molten $PbCl_2$
43[c]	10–100	698–1073	Cell material: silica capillary cell, Pt electrodes; freq. range: 1000–3000 Hz; calibration: 30% H_2SO_4 solution, molten KNO_3, $NaNO_3$, $PbCl_2$ and KCl
116	17.1–91.5	813–993	
118	50–80 (g)	733–793	
142[d]	0–100 (g)	993	
185[e]	20.1–100	693–1213	Cell material: U-shaped quartz capillary cell; Pt electrodes; freq. range. 1000 Hz; calibration: 1.0 Demal KCl solution
325	25–100 (g)	800–1000	

Comparison with NSRDS recommendations [1, p. 13 and this volume]

Ref.	$PbCl_2$ Mol %	Min. departure	Max. departure
13	100	−1.4% (793 K)	
25	100	0.0% (833 K)	−0.52% (873 K)
185	100	0.06% (823 K)	0.22% (848 K)
13	80	−13.4% (773 K)	
25	80	−1.8% (973 K)	
25	70	−0.86% (973 K)	−1.2% (873 K)
13	67	−12.1% (773 K)	
116	41.6	−1.9% (973 K)	
25	18	−1.7% (873 K)	

[a]Bloom and Heymann [25] periodically checked the cell constant of their capillary conductance cell and found no appreciable change (less than 0.3%) even over long periods of continued use.

[b]0% values were extrapolated.

[c]Lantratov and Moiseeva [**43**] claimed an accuracy of ±0.2–0.3% in their conductivity measurements. The values for pure $PbCl_2$ were those recommended in NSRDS–NBS–15 [1].

[d]Data from reference [25].

[e]Easteal and Hodge [185] reported an overall accuracy in their conductance measurements of ±0.4%.

TABLE 427. $KCl\text{-}PbCl_2$: Specific conductance ($ohm^{-1}\ cm^{-1}$)

	Mol percent $PbCl_2$														
T	100	90	85	81.93	80	77	67	60	50	41.67	30	25	20	15	10
700			1.050	1.019	1.048	1.048	0.977	0.908							
720			1.143	1.108	1.132	1.130	1.051	0.988							
740			1.234	1.195	1.214	1.210	1.123	1.066	0.998						
760			1.325	1.282	1.295	1.289	1.195	1.142	1.064						
780	1.454	1.464	1.414	1.367	1.375	1.366	1.266	1.216	1.129	1.080	1.058	1.095	1.125		
800	1.566	1.551	1.502	1.452	1.454	1.441	1.336	1.287	1.193	1.139	1.110	1.142	1.171		
820	1.673	1.638	1.589	1.535	1.531	1.515	1.405	1.357	1.257	1.199	1.164	1.191	1.219		
840	1.774	1.725	1.675	1.617	1.608	1.588	1.474	1.424	1.319	1.258	1.219	1.243	1.270		
860	1.870	1.812	1.759	1.697	1.683	1.659	1.541	1.489	1.381	1.318	1.276	1.296	1.324		
880	1.960	1.899	1.842	1.777	1.757	1.728	1.608	1.552	1.443	1.377	1.334	1.351	1.380		
900	2.045	1.986	1.924	1.855	1.829	1.796	1.674	1.613	1.503	1.437	1.393	1.407	1.438		
920	2.125	2.073	2.005	1.933	1.901	1.862	1.739	1.671	1.562	1.496	1.453	1.466	1.500		
940			2.085	2.009	1.971	1.927	1.803	1.728	1.621	1.556	1.515	1.527	1.563		
960							1.866		1.679	1.615	1.578	1.590	1.630	1.679	
980										1.674	1.643	1.654		1.728	1.829
1000														1.777	1.877
1020														1.826	1.925
1040														1.875	1.973
1060														1.924	2.021

Temperature-dependent equations

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

Mol % $PbCl_2$	a	$b \cdot 10^3$	$c \cdot 10^6$	Stand. error of est.
10	−0.5220	2.3994	0	0.89%
15	−0.6742	2.4507	0	1.56%
20	1.3527	−2.8048	3.2223	0.46%
25	0.7253	−1.3756	2.3707	0.43%
30	0.0797	−0.0758	1.7052	0.39%
41.67	−1.2380	2.9718	0	0.19%
50	−2.0076	4.8037	−1.0035	0.29%
60	−3.2334	7.7796	−2.6612	1.60%
67	−2.1243	5.1692	−1.0544	0.55%
77	−2.7663	6.7806	−1.9017	0.50%
80	−2.6378	6.3218	−1.5092	0.62%
81.93	−2.8316	6.5241	−1.4624	0.49%
85	−2.9686	6.8045	−1.5201	1.98%
90	−1.9349	4.3570	0	0.80%
100	−7.1379	16.2944	−6.7679	0.53%

These values are based on the work of Lantratov and Moiseeva (classical ac technique) [43].

TABLE 428. Density studies: KCl-$PbCl_2$

Investigations critically re-examined			
Ref.	$PbCl_2$ Mol %	Temp. range (T)	Comments
9	16.7–100	773–1173	Cell material: Pt bob, Pt wire; calibration: water (17 °C)
26[a]	47.4, 63.8, 82.1, 100	763–973	Cell material: silica dilatometer; calibration: molten $AgNO_3$
142[b]	0–100	993	
165	50		
193	20–100	873, 973	
206	42.9–81.8	753	Cell material: Pt sphere, Pt wire
325	20–100 (g)	973, 1023	

Deviations from previous NSRDS recommendations: [1, p. 13]

Ref.	$PbCl_2$ Mol %	Min. departure	Max. departure
9	100	−0.73% (960 K)	−0.90% (000 K)
193	100	0.23% (873 K)	

[a]Density values in reference [**26**] for pure components were those recommended in NSRDS–NBS–15 [1].

A maximum error of ±0.6% was reported for density results on mixtures. The volume of the dilatometers was checked after each experiment and no significant changes were found.

[b]Data from reference [**26**].

TABLE 429. KCl-$PbCl_2$: Density (g cm^{-3})

	Mol percent $PbCl_2$			
T	100	82.1	63.8	47.4
770				3.399
780				3.387
790	4.927			3.376
800	4.912			3.365
810	4.897			3.353
820	4.882			3.342
030	4.867			3.331
840	4.852	4.340		3.320
850	4.837	4.326		3.308
860	4.822	4.312	3.762	3.297
870	4.807	4.298	3.749	3.286
880	4.792	4.283	3.736	3.274
890	4.777	4.269	3.724	3.263
900	4.762	4.255	3.711	3.252
910	4.747	4.241	3.698	3.240
920	4.732	4.227	3.685	3.229
930	4.717	4.212	3.672	3.218
940	4.702	4.198	3.660	3.207
950	4.687	4.184	3.647	3.195
960	4.672	4.170		
970	4.657	4.156		

Temperature-dependent equations

$$\rho = a + bT$$

Mol % $PbCl_2$	a	$b \cdot 10^3$
47.4	4.269	−1.13
63.8	4.863	−1.28
82.1	5.533	−1.42
100	6.112	−1.50

These values are based on the work of Boardman, et al. (dilatometric method) [**26**].

TABLE 430. Viscosity studies: KCl-$PbCl_2$

Investigations critically re-examined		
Ref.	$PbCl_2$ Mol %	Temp. range (T)
36	25.9–100	723–973
206	42.9–81.8	753

The glass viscometers used in reference [**36**] were calibrated using molten KNO_3. Viscosity values for pure $PbCl_2$ were those recommended in NSRDS–NBS–15

TABLE 431. KCl-$PbCl_2$: Viscosity (cp)

	Mol percent $PbCl_2$										
T	100.0	82.9	73.4	66.4	54.3	51.9	49.7	48.9	43.5	33.4	25.9
730		5.27	4.74	4.42	4.30	4.35	4.20	4.36			
740		4.96	4.47	4.17	4.05	4.11	3.96	4.12			
750		4.67	4.21	3.94	3.82	3.88	3.74	3.89			
760		4.40	3.98	3.73	3.60	3.66	3.54	3.67			
770		4.15	3.76	3.53	3.41	3.46	3.35	3.47			
780	4.44	3.91	3.56	3.35	3.23	3.27	3.17	3.29	3.26		
790	4.20	3.69	3.38	3.18	3.06	3.10	3.01	3.11	3.10		
800	3.98	3.48	3.21	3.03	2.91	2.93	2.87	2.95	2.94		
810	3.77	3.30	3.05	2.89	2.77	2.78	2.73	2.80	2.80		
820	3.58	3.12	2.90	2.75	2.63	2.64	2.60	2.66	2.66		
830	3.41	2.96	2.77	2.63	2.51	2.51	2.48	2.53	2.53	2.56	
840	3.24	2.81	2.64	2.51	2.39	2.39	2.37	2.41	2.41	2.46	
850	3.09	2.67	2.52	2.40	2.29	2.27	2.27	2.29	2.30	2.36	
860	2.95	2.54	2.41	2.30	2.19	2.17	2.17	2.19	2.19	2.26	
870	2.82	2.43	2.31	2.20	2.09	2.08	2.08	2.10	2.09	2.17	

TABLE 431. KCl-$PbCl_2$: Viscosity (cp)—Continued

	Mol percent $PbCl_2$										
T	100.0	82.9	73.4	66.4	54.3	51.9	49.7	48.9	43.5	33.4	25.9
880	2.69	2.32	2.21	2.12	2.01	1.99	1.99	2.01	2.00	2.09	
890	2.58	2.23	2.12	2.03	1.93	1.91	1.92	1.93	1.91	2.01	
900	2.47	2.14	2.04	1.95	1.85	1.84	1.84	1.86	1.83	1.93	
910	2.37	2.06	1.96	1.88	1.78	1.77	1.77	1.80	1.76	1.85	
920	2.27	1.98	1.88	1.81	1.71	1.71	1.70	1.74	1.70	1.78	
930	2.18	1.92	1.81	1.74	1.64	1.66	1.64	1.68	1.64	1.72	1.76
940	2.10	1.85	1.75	1.68	1.58	1.61	1.58	1.63	1.58	1.65	1.70
950	2.02	1.80	1.68	1.62	1.53	1.56	1.53	1.58	1.53	1.60	1.63
960	1.94	1.74	1.63	1.57	1.47	1.52	1.47	1.54	1.49	1.54	1.57
970	1.87	1.69	1.57	1.52	1.42	1.48	1.43	1.50	1.46	1.49	1.51

Temperature-dependent equations

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

$$\eta = A \cdot \exp\,(E/RT)$$

Mol % $PbCl_2$	a	$b \cdot 10^2$	$c \cdot 10^5$	$d \cdot 10^8$	$A \cdot 10^2$	E (cal mol^{-1})	Stand. error of est.
25.9					4.191	6911	0.91%
33.4	25.8532	−4.6389	2.2943	−1.0429			0.31%
43.5	49.6217	−11.4175	85.1646	19.2230			0.79%
48.9	98.2580	−27.9981	27.2824	−89.7130			1.35%
49.7					5.321	6337	1.31%
51.9	97.0965	−27.5332	26.6724	−87.1132			1.31%
54.3					4.929	6481	0.91%
66.4					5.837	6278	0.70%
73.4					5.424	6486	1.15%
82.9	130.0077	−37.5111	36.9363	−122.7078			1.45%
100.0					5.415	6830	1.56%

These values are based on the work of Harrap and Heymann (capillary method) [36].

TABLE 432. Surface tension studies: KCl-$PbCl_2$

Investigations critically re-examined			
Ref.	$PbCl_2$ Mol %	Temp. range (T)	Comments
234[a]	0–100 (g)	773, 873	Cell material: capillary and salt containing tube of BTH–C46 glass: calibration: water
238, 254[a]	31.77–100	768–899	Cell material: Pt–10% Rh capillary, melt contained in Pt crucible; calibration: benzene

[a] Remarks concerning references [234] and [238] were given under the system AgCl-KCl and LiCl-$PbCl_2$, respectively.

TABLE 433. KCl-$PbCl_2$: Surface tension (dyn cm^{-1})

	Mol percent $PbCl_2$						
T	100.00	75.68	64.12	49.13	48.85	36.86	31.77
765					115.9		
770		121.2		115.5	115.3		
775			117.4	115.0	114.8		
780			116.9	114.5	114.3		
785			116.4	113.9	113.8		
790			115.9	113.4	113.2		
795	134.9		115.4	112.9	112.7		
800	134.3		114.9	112.4	112.2		
805	133.6		114.4	111.9	111.6		
810	133.0		113.9	111.4	111.1		
815	132.4		113.4	110.9	110.6		
820	131.8		113.0	110.4	110.1		
825	131.1		112.5		109.5		
830	130.5		112.0			110.0	
835	129.9		111.5			109.6	
840	129.3		111.0			109.2	
845	128.7		110.5			108.8	
850						108.3	
855						107.9	
860						107.5	
865						107.0	
870						106.6	106.0
875							105.6
880							105.3
885							104.9
890							104.5
895							104.2

Temperature-dependent equations

$$\gamma = a + bT$$

Mol % $PbCl_2$	a	$b \cdot 10^2$	Stand. error of est.
31.77	169.9381	− 7.3489	0.12%
36.86	180.9981	− 8.5499	0.35%
48.85	196.6602	−10.5613	0.37%
49.13	193.1133	−10.0855	0.28%
64.12	198.7382	− 9.8527	0.08%
75.68	201.4260	−10.4167	0.01%
100.00	233.6772	−12.4284	0.49%

These values are based on the work of Dahl and Duke (maximum bubble pressure method) [238, 254].

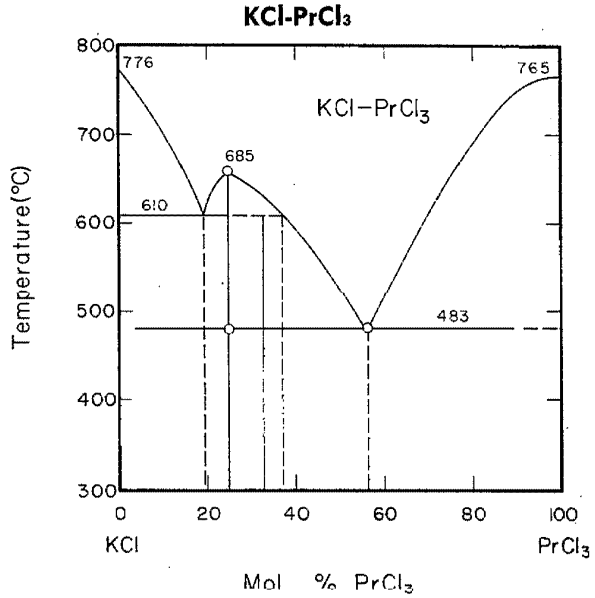

FIGURE 74. Temperature-composition phase diagram for KCl-$PrCl_3$.

Z. N. Shentova, E. N. Karzina, and B. G. Korshunov, Russ. J. Inorg. Chem., 7, 1348 (1962).

Melt Preparation and Purification

Praseodymium trichloride was prepared and analyzed as discussed under the system KCl-$NdCl_3$.

TABLE 434. Electrical conductance studies: KCl-$PrCl_3$

Investigations critically re-examined			
Ref.	$PrCl_3$ Mol %	Temp. range (T)	Comments
190[a]	0–100 (g)	1073	Cell material: quartz capillary cell; Pt electrodes; freq. range: 100,000–250,000 Hz; calibration: molten CsCl, KCl, NaCl

[a]Equivalent conductivities were reported.

Comment: Experimental details are briefly discussed under the system KCl-$NdCl_3$.

TABLE 435. KCl-$PrCl_3$: Molar conductance (ohm^{-1} cm^2 mol^{-1})

Mol % KCl	1073 K	Mol % KCl	1073 K
0	77.3	60	67.3
10	73.4	70	68.0
20	70.7	80	75.5
30	68.7	90	92.6[a]
40	67.9	100	112.0[a]
50	67.3		

[a]Extrapolated values.

These values have been interpolated to three significant figures from the graphical presentation of Forthmann and Schneider (classical ac technique) [190].

KCl-RbCl

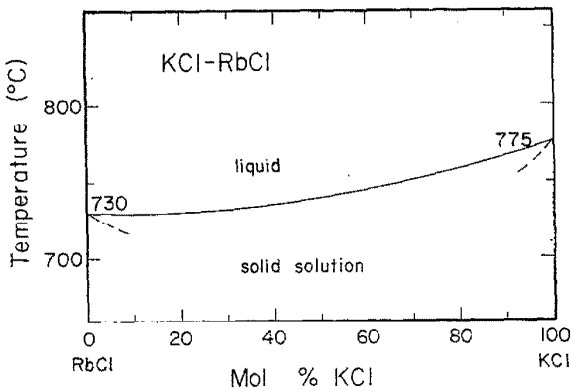

FIGURE 75. Temperature-composition phase diagram for KCl-RbCl.

O. S. Dombrovskaya, Zh. Obshch. Khim., 3 [8], 1022 (1922).

Melt Preparation and Purification

Salts used in reference [98] were Merck p.a. reagents and were purified by the procedure described under the system CsCl-LiCl.

TABLE 436. Electrical conductance studies: KCl-RbCl

Investigations critically re-examined			
Ref.	RbCl Mol %	Temp. range (T)	Comments
98	0, 25, 50, 75, 100	1013–1233	Cell material: quartz or silica glass capillary cell; Pt electrodes; freq. range: 1000–7000 Hz; calibration: 0.1M and 1.0M KCl solutions

Deviations from previous NSRDS recommendations: [1, p. 5, 6]			
Ref.	RbCl Mol %	Min. departure	Max. departure
98	100	0.12% (1010 K)	−4.4% (1200 K)
98	0	0.04% (1180 K)	−0.31% (1080 K)

Comment: Zuca and Olteanu [98] report, in addition to experimental specific conductivities, Arrhenius equations (equivalent conductances as a function of temperature) with standard deviations for E_λ, the activation energy, in the range: 1.2×10^{-2} Kcal mol^{-1} (0 mol % RbCl, $E_\lambda = 3.44$ Kcal mol^{-1}) to 3.7×10^{-2} Kcal mol^{-1} (75 mol % RbCl, $E_\lambda = 3.71$ Kcal mol^{-1}).

TABLE 437. KCl-RbCl: Specific conductance (ohm^{-1} cm^{-1})

	Mol % RbCl				
T	100	75	50	25	0
1020	1.574				
1030	1.596				
1040	1.618				
1050	1.640				
1060	1.662	1.756			2.198
1070	1.683	1.776	1.903	2.042	2.223
1080	1.704	1.797	1.926	2.066	2.249
1090	1.725	1.817	1.949	2.090	2.273
1100	1.745	1.838	1.971	2.114	2.298
1110	1.766	1.859	1.993	2.137	2.322
1120	1.785	1.881	2.015	2.160	2.346
1130	1.805	1.903	2.036	2.182	2.369
1140	1.824	1.925	2.057	2.204	2.392
1150	1.843		2.077	2.225	2.415
1160	1.862		2.097	2.246	2.437
1170	1.880		2.116	2.267	2.459
1180	1.899		2.136	2.287	2.480
1190	1.916		2.154		2.501

Temperature-dependent equations

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

Mol % RbCl	a	$b \cdot 10^3$	$c \cdot 10^6$	Stand. error of est.
0	−2.9614	7.1219	−2.1277	0.02%
25	−3.0441	7.0423	−2.1393	0.10%
50	−3.0678	6.9368	−2.1418	0.13%
75	1.3252	−1.1682	1.4859	0.07%
100	−2.3072	5.3381	−1.5035	0.02%

These values are based on the work of Zuca and Olteanu (classical ac technique) [98].

TABLE 438. Density studies: KCl-RbCl

Investigations critically re-examined			
Ref.	RbCl Mol %	Temp. range (T)	Comments
98	0, 25, 50, 75, 100	1013–1233	Cell material: Pt ball; calibration: water
328	30–70 (g)	1073	

Comparisons with NSRDS recommendations: [1, pp. 5, 6]			
Ref.	RbCl Mol %	Min. departure	Max. departure
98	100	−0.02% (1080 K)	0.15% (1200 K)
98	0	0.01% (1100 K)	0.18% (1200 K)

Comment: Density results in reference [98] were reported as linear temperature dependent equations with standard deviations in the range: 2×10^{-4} grams/cm^3 (0 mol % RbCl) to 10×10^{-4} grams/cm^3 (50 mol % RbCl).

TABLE 439. KCl-RbCl: Density (g cm^{-3})

	Mol % RbCl				
T	100	75	50	25	0
1020	2.218				
1030	2.209	2.057			
1040	2.201	2.048			
1050	2.192	2.040			
1060	2.184	2.032	1.863	1.700	1.517
1070	2.175	2.024	1.856	1.693	1.512
1080	2.167	2.015	1.849	1.686	1.506
1090	2.158	2.007	1.842	1.680	1.500
1100	1.150	1.999	1.834	1.673	1.495
1110	2.141	1.991	1.827	1.666	1.489
1120	2.133	1.982	1.820	1.660	1.484
1130	2.124	1.974	1.812	1.653	1.478
1140	2.116	1.966	1.805	1.646	1.472
1150	2.107	1.958	1.798	1.640	1.467
1160	2.099		1.791	1.633	1.461
1170	2.090		1.783	1.626	1.456
1180	2.082			1.620	1.450
1190	2.073			1.613	1.445
1200	2.065				1.439
1210	2.056				1.433
1220	2.048				
1230	2.039				

Temperature-dependent equations

$\rho = a + bT$

Mol % RbCl	a	$b \cdot 10^3$	Stand. Dev.
0	2.1089	−0.5583	0.0002
25	2.4094	−0.6694	0.0005
50	2.6333	−0.7264	0.0010
75	2.9062	−0.8249	0.0006
100	3.0863	−0.8514	0.0009

These values are based on the work of Zuca and Olteanu (Archimedean method) [98].

KCl-SbCl$_3$

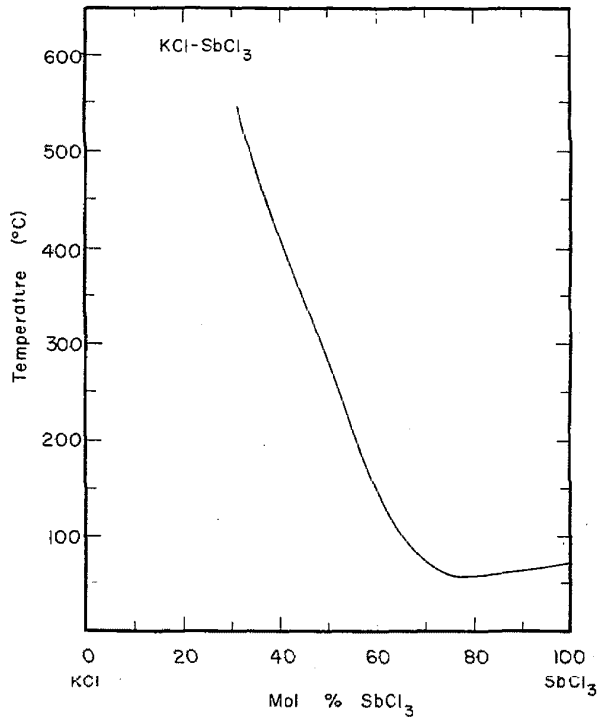

FIGURE 76. Temperature-composition phase diagram for KCl-SbCl$_3$.

J. Kendall, E. D. Crittenden, and H. K. Miller, J. Am. Chem. Soc., **45**, 963–96 (1923).

Melt Preparation and Purification

Stromberg [**40**] prepared SbCl$_3$ by reacting chlorine gas with metallic antimony and purified the resulting salt by sublimation into a sealed vessel. Potassium chloride was purified by recrystallization.

TABLE 440. Viscosity studies: KCl-SbCl$_3$

Investigations critically re-examined		
Ref.	KCl[a] Conc.	Temp. range (T)
40	0–1.91 M	373

[a]Compositions were reported in terms of moles of KCl per liter of solution.

TABLE 441. KCl-$SbCl_3$: Viscosity (cp)

moles KCl/liter solution	η at 373.2 K	moles KCl/liter solution	η at 373.2 K
0.000	1.710	0.128	1.902
0.009	1.721	0.168	1.950
0.0153	1.730	0.242	2.054
0.0232	1.741	0.352	2.22
0.0314	1.758	0.513	2.48
0.0403	1.765	0.744	2.91
0.0505	1.787	1.23	3.96
0.0706	1.814	1.91	6.39
0.0990	1.862		

These values are based on the work of Stromberg (capillary method) [**40**]. Due to limited data, the experimental results are given.

KCl-$ScCl_3$

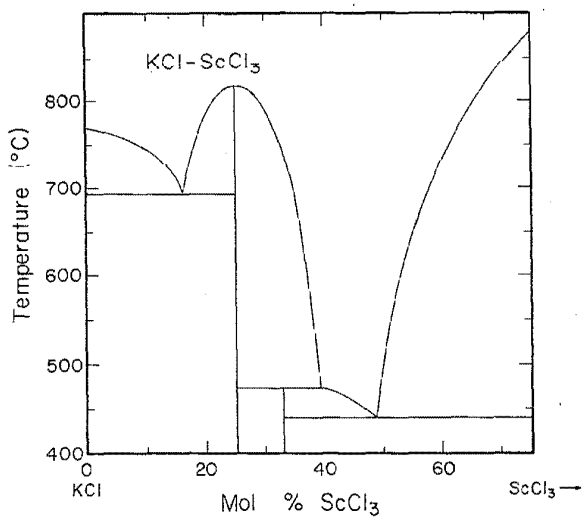

FIGURE 77. Temperature-composition phase diagram for KCl-$ScCl_3$.

J. Kendall, E. D. Crittenden, and H. K. Miller, J. Am. Chem. Soc., **45**, 963–96 (1923).

N. Ya. Fedorov and E. S. Petrov, Izv. Sib. Otd. Akad. Naur S.S.S.R., Ser Khim Nauk, **1**, 57 (1967)

Melt Preparation and Purification

The preparation of pure $ScCl_3$ by Fedorov and Petrov [**71**] is discussed under the LiCl $ScCl_3$ system. No information was given with regard to potassium chloride.

TABLE 442. Electrical conductance studies: KCl-$ScCl_3$

Investigations critically re-examined			
Ref.	$ScCl_3$ Mol %	Temp. range (T)	Comments
71	0–73 (g)	913–1233	Cell material: sealed quartz vessels; Mo wire electrodes; calibration: 1N KCl solution[a]

[a]A brief discussion of the experimental procedure used by Fedorov and Petrov [**71**] is given under the LiCl-$ScCl_3$ system.

TABLE 443. KCl-$ScCl_3$: Specific conductance (ohm^{-1} cm^{-1})

Mol % $ScCl_3$	913 K	953 K	993 K	1033 K	1073 K	1113 K	1153 K	1193 K	1233 K
0					2.18	2.24	2.36	2.42	2.52
10				1.84	2.00	2.09	2.18	2.27	2.38
20					1.68	1.78	1.88	1.98	2.10
30						1.42	1.56	1.68	1.74
40					1.36	1.43	1.51	1.58	1.65
50	0.78	0.91	1.00	1.08	1.16	1.26	1.36	1.42	1.50
60						1.18	1.24	1.30	1.36
70							1.18	1.24	1.30

These values have been interpolated to three significant figures from the graphical presentation of Fedorov and Petrov (classical ac chnique) [**71**].

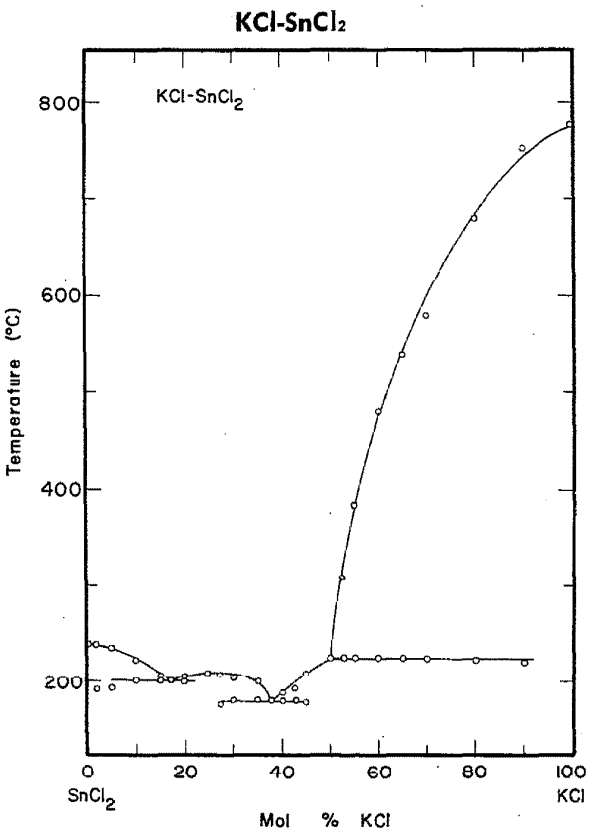

FIGURE 78. Temperature-composition phase diagram for KCl-$SnCl_2$.

G. Rack, Cbl. Mineral., Geol., Paläontol., 374 (1913).

Melt Preparation and Purification

Rafalskii [**119**] used chemically pure $SnCl_2 \cdot 2H_2O$ as starting material. The salt was recrystallized and dehydrated in a stream of HCl gas and finally sealed into glass ampoules. Chemically pure KCl was dried at high temperatures.

TABLE 444. Electrical conductance studies: KCl-$SnCl_2$

Investigations critically re-examined			
Ref.	$SnCl_2$ Mol %	Temp. range (T)	Comments
119	45–100	573, 623	Cell material: glass (outside) and quartz (inside) capillary cell; Pt electrodes; freq. range: 1400 Hz; calibration: 30% sulfuric acid solution at 25 °C

Deviations from previous NSRDS recommendations: [1, p. 12]			
Ref.	$SnCl_2$ Mol %	Min. departure	Max. departure
119	100	—0.71% (623 K)	1.46% (573 K)

TABLE 445. KCl-$SnCl_2$: Specific conductance (ohm^{-1} cm^{-1})

	Mol percent $SnCl_2$												
T	100	95	90	85	80	75	70	65	60	55	50	48	45
573.2	1.115	1.100	1.079	1.040	0.995	0.935	0.865	0.798	0.688	0.553	0.472	0.515	
623.2	1.388	1.388	1.331	1.260	1.215	1.160	1.060	1.000	0.871	0.713	0.645	0.677	0.702

These values are based on the work of Rafalskii (classical ac technique) [**119**]. Due to limited data, the experimental values are given.

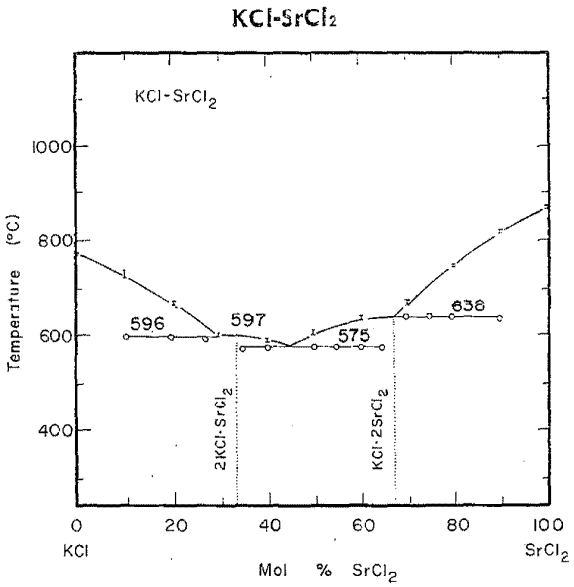

FIGURE 79. Temperature-composition phase diagram for $KCl-SrCl_2$.

E. Vortisch, Jahrb. Min. Beil. Bd, **38**, 185 (1914).

E. P. Dergunov and Dergman, Doklady, Adad. Nauk. S.S.S.R., **75**, 815 (1950).

Melt Preparation and Purification

Reagent-grade alkali metal halides, oven dried at 200 °C overnight, were used by Ellis and Smith [**143, 17**]. Dehydration of $SrCl_2 \cdot 6H_2O$ involved heating the salt under vacuum (0.3 mm Hg) at temperatures up to 300 °C for a period of 48 to 72 hours.

TABLE 446. Density studies: $KCl-SrCl_2$

Investigations critically re-examined		
Ref.	$SrCl_2$ Mol %	Temp. range (T)
143[a]	0, 20, 40, 60, 80	1074–1329
325	0–100 (g)	1023, 1123

Deviations from previous NSRDS recommendations: [1, p. 5]			
Ref.	$SrCl_2$ Mol %	Min. departure	Max. departure
143	0	−0.51% (1319 K)	−1.16% (1153 K)

[a]Ellis and Smith [**143**] used a platinum bob and chain together with an analytical balance for their density measurements. Salt condensation on the suspension system was reduced by a slow flow of inert gas.

TABLE 447. $KCl-SrCl_2$: Density (g cm^{-3})

	Mol percent $SrCl_2$					
T	100	80	60	40	20	0
1080					1.714	
1090		2.518	2.307		1.707	
1100		2.513	2.301	2.040	1.700	1.477
1110		2.507	2.294	2.035	1.694	1.472
1120		2.502	2.288	2.029	1.687	1.466
1130		2.496	2.281	2.024	1.680	1.460
1140		2.490	2.275	2.018	1.674	1.454
1150	2.712	2.485	2.268	2.013	1.667	1.448
1160	2.707	2.479	2.262	2.008	1.661	1.443
1170	2.701	2.474	2.255	2.002	1.654	1.437
1180	2.696	2.468	2.248	1.997	1.647	1.431
1190	2.691	2.463	2.242	1.991	1.641	1.426
1200	2.686	2.457	2.235	1.986	1.634	1.420
1210	2.681	2.452	2.229	1.980	1.627	1.415
1220	2.675	2.446	2.222	1.975	1.621	1.410
1230	2.670	2.441	2.216	1.970	1.614	1.404
1240	2.665	2.435	2.209	1.964		1.399
1250	2.660	2.430	2.202	1.959		1.394
1260	2.655	2.424	2.196	1.953		1.389
1270	2.649	2.418	2.189			1.384
1280	2.644					1.379
1290	2.639					1.374
1300						1.369
1310						1.364
1320						1.359

Temperature-dependent equations

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

Mol % $SrCl_2$	a	$b \cdot 10^4$	$c \cdot 10^7$	Stand. error of est.
0	2.4614	−11.9158	2.7012	0.22%
20	2.4294	−6.6273	0	0.20%
40	2.6376	−5.4315	0	0.07%
60	3.0230	−6.5642	0	0.17%
80	3.1221	−5.5402	0	0.07%
100	3.3110	−5.2104	0	0.09%

These values are based on the work of Ellis and Smith (Archimedean method) [**143**].

TABLE 448. Surface tension studies: $KCl-SrCl_2$

Investigations critically re-examined		
Ref.	$SrCl_2$ Mol %	Temp. range (T)
143[a]	20, 40, 60, 80	1000–1315
244[a]	0–100 (g)	1123

[a]Ellis [**143**] reported an accuracy of ±1.5 dynes cm^{-1} in his surface tension data while Bertozzi and Soldani [244] reported that results were reproducible to within 0.5%.

TABLE 449. KCl-$SrCl_2$: Surface tension (dyn cm^{-1})

	Mol percent $SrCl_2$					
T	100	80	60	40	20	0
1010			134.30	120.12	114.70	
1020			133.59	119.46	113.91	
1030		142.55	132.88	118.80	113.13	
1040		141.88	132.17	118.14	112.34	
1050		141.22	131.46	117.48	111.55	
1060		140.56	130.74	116.81	110.76	
1070		139.89	130.03	116.15	109.98	
1080		139.23	129.32	115.49	109.19	97.21
1090		138.56	128.61	114.83	108.40	96.37
1100		137.90	127.90	114.17	107.61	95.54
1110		137.24	127.19	113.51	106.82	94.70
1120		136.57	126.48	112.85	106.04	93.86
1130		135.91	125.77	112.19	105.25	93.03
1140		135.25	125.06	111.53	104.46	92.19
1150		134.58	124.34	110.87	103.67	91.35
1160	167.87	133.92	123.63	110.21	102.89	90.52
1170	167.39	133.25	122.92	109.54	102.10	89.68
1180	166.91	132.59	122.21	108.88	101.31	88.84
1190	166.43	131.93	121.50	108.22	100.52	88.01
1200	165.94	131.26	120.79	107.56	99.74	87.17
1210	165.46	130.60	120.08	106.90	98.95	86.33
1220	164.98	129.94	119.37	106.24	98.16	85.50
1230	164.49	129.27	118.66	105.58	97.37	84.66
1240	164.01	128.61	117.94	104.92	96.59	83.82
1250	163.53	127.95	117.23	104.26	95.80	82.99
1260	163.04	127.28	116.52	103.60	95.01	82.15
1270		126.62	115.81	102.94	94.22	81.31
1280		125.95	115.10	102.27	93.44	80.48
1290		125.29	114.39	101.61	92.65	79.64
1300		124.63	113.68	100.95	91.86	
1310					91.07	

Temperature-dependent equations

$\gamma = a + bT$

Mol % $SrCl_2$	a	$b \cdot 10^2$	Stand. error of est.
0	187.57	−8.37	0.87%
20	194.25	−7.88	0.89%
40	186.87	−6.61	0.53%
60	206.12	−7.11	1.11%
80	210.90	−6.64	0.54%
100	223.94	−4.83	0.32%

These values are based on work of Ellis (maximum bubble pressure method) [143].

KCl-$TiCl_3$

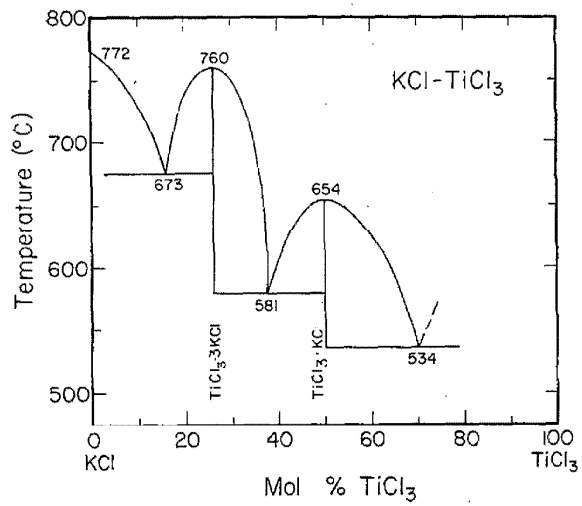

FIGURE 80. Temperature-composition diagram for KCl-$TiCl_3$.

B. F. Markov and R. V. Chernov, Ukrain. Khim. Zhur., **25**, 281 (1959).

Melt Preparation and Purification

Kamenetskii and Shevlyakova [61] used "chemically pure" KCl and $TiCl_3$ and indicate no additional purification.

TABLE 450. Electrical conductance studies: KCl-$TiCl_3$

Investigations critically re-examined			
Ref.	$TiCl_3$ Mol %	Temp. range (T)	Comments
55[a]	~0–60	1073	Cell material: quartz; Pt electrodes; freq. range: 1400 Hz
59	~0–60 (g)	1073	Cell material: quartz; Pt electrodes; freq. range: 1400 Hz
61[a,b]	~0–36	1073–1223	Cell material: quartz; Mo and W electrodes; freq. range: 1150 Hz; calibration: 0.02N KCl solution

Comparison with NSRDS recommendations: [1, p. 4 and this volume]

Ref.	$TiCl_3$ Mol %	Min. departure	Max. departure
55	0	0.0% (1073 K)	
61	0	−3.4% (1123 K)	−4.1% (1173 K)
61	0	−3.6% (1073 K)	

[a]Data presented graphically except for pure KCl.

[b]Electrical resistances in reference [61] were measured to within 0.01 ohms with an accuracy of ±1%. Repeated calibrations showed that the cell constant varied no more than 1%.

TABLE 451. KCl-$TiCl_3$: Specific conductance (ohm^{-1} cm^{-1})

Mol % $TiCl_3$	1073 K
0	2.3
10	1.8
20	1.5
30	1.4
40	1.2
50	1.2

These values were interpolated to two significant figures from the graphical presentation of Delimarskii and Chernov (classical ac technique) [55].

KCl-UCl_3

Melt Preparation and Purification

Mochinaga [137, 189] prepared UCl_3 by first hydrogenating metallic uranium at 220–230 °C followed by chlorination using HCl gas at 270–300 °C. Excess HCl was removed by evacuation below a temperature of 150 °C. Due to the hygroscopic nature of UCl_3 and the ease of oxidation, all measurements were made in an apparatus that was filled with argon which was previously purified by passage over a titanium sponge layer heated at 1000 °C.

TABLE 452. Electrical conductance studies: KCl-UCl_3

Investigations critically re-examined		
Ref.	UCl_3 Mol %	Temp. range (T)
137	5.0–50.4	864–1235
189[a]	5–50 (g)	1023, 1223

[a]Equivalent conductivities were reported.

TABLE 453. KCl-UCl_3: Specific conductance (ohm^{-1} cm^{-1})

	Mol percent UCl_3					
T	50.4	40.1	28.8	25.0	18.9	5.0
870	0.48					
880	0.50					
890	0.52					
900	0.55					
910	0.57				1.00	
920	0.59				1.03	
930	0.61	0.70			1.05	
940	0.63	0.72			1.07	
950	0.65	0.75		0.91	1.10	
960	0.67	0.77		0.94	1.12	
970	0.69	0.79	0.96	0.96	1.14	
980	0.71	0.81	0.98	0.98	1.16	
990	0.73	0.82	1.00	1.00	1.18	
1000	0.75	0.84	1.02	1.02	1.20	
1010	0.77	0.86	1.04	1.04	1.22	
1020	0.79	0.88	1.06	1.06	1.24	
1030	0.80	0.90	1.08	1.07	1.26	
1040	0.82	0.91	1.09	1.09	1.28	
1050	0.84	0.93	1.11	1.10	1.30	
1060	0.86	0.95	1.13	1.12	1.32	1.81
1070	0.87	0.96	1.14			1.84
1080	0.89	0.98	1.16			1.87
1090	0.90	0.99	1.17			1.89
1100	0.92	1.01	1.18			1.92
1110		1.02	1.19			1.94
1120		1.04				1.96
1130		1.05				1.98
1140		1.06				2.00
1150		1.08				2.01
1160		1.09				2.03
1170		1.10				2.04
1180		1.11				2.05
1190		1.12				2.06
1200						2.07
1210						2.08
1220						2.08
1230						2.09

Temperature-dependent equations

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

Mol % UCl_3	a	$b \cdot 10^3$	$c \cdot 10^6$
5.0	−10.297	19.873	−7.972
18.9	− 2.422	5.199	−1.575
25.0	− 6.728	13.586	−5.836
28.8	− 4.395	8.890	−3.473
40.1	− 2.963	5.764	−1.959
50.4	− 2.649	4.928	−1.530

These values are based on the work of Mochinaga et al. (classical ac technique) [137].

TABLE 454. Density studies: KCl-UCl_3

Investigations critically re-examined			
Ref.	UCl_3 Mol %	Temp. range (T)	Comments
189	0–100	1073–1304	Cell material: quartz pycnometer; calibration: molten NaCl, KCl

Deviations from previous NSRDS recommendations: [1, p. 5]			
Ref.	UCl_3 Mol %	Min. departure	Max. departure
189	0	−2.5% (1200 K)	−2.9% (1070 K)

TABLE 455. KCl-UCl_3: Density (g cm^{-3})

	Mol percent UCl_3							
T	100	74.5	67.5	37.1	25.6	11.7	2.4	0
1090				2.765				1.458
1100				2.753				1.453
1110				2.741				1.447
1120				2.729				1.442
1130				2.716		1.968		1.437
1140				2.704		1.960		1.431
1150				2.692		1.953		1.426
1160				2.680		1.945		1.421
1170				2.667		1.937	1.636	1.416
1180			3.470	2.655		1.929	1.631	1.410
1190			3.428	2.643		1.921	1.625	1.405
1200			3.386	2.631		1.913	1.620	1.400
1210			3.344	2.618		1.906	1.615	1.394
1220	3.962	3.474	3.303	2.606		1.898	1.609	1.389
1230	3.882	3.432	3.261	2.594	2.280	1.890	1.604	1.384
1240	3.803	3.389	3.219	2.582	2.266	1.882	1.599	1.379
1250	3.723	3.346	3.177	2.569	2.252	1.874	1.593	1.373
1260	3.644	3.303	3.135	2.557	2.239	1.867		1.368
1270	3.564		3.093	2.545	2.225	1.859		1.363
1280	3.485			2.533	2.211			1.357
1290	3.406							1.352
1300	3.326							

Temperature-dependent equations

$$\rho = a + bT$$

Mol % UCl_3	a	$b \cdot 10^4$
0	2.0343	— 5.288
2.4	2.255	— 5.288
11.7	2.852	— 7.818
25.6	3.981	—13.827
37.1	4.099	—12.240
67.5	8.405	—41.819
74.5	8.700	—42.835
100	13.652	—79.430

These values are based on the work of Moohinaga et al. (pycnometric method) [**109**].

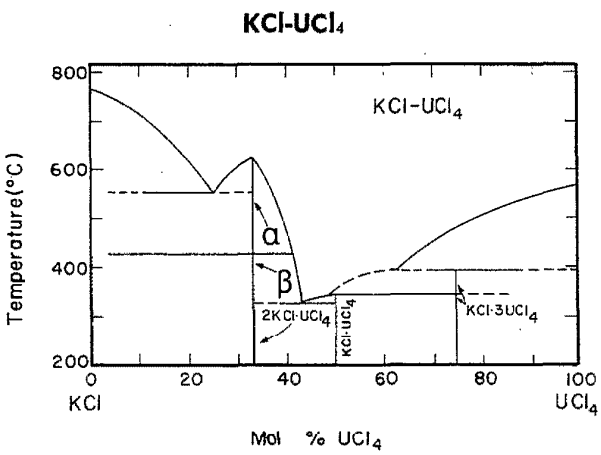

FIGURE 81. Temperature-composition phase diagram for KCl-UCl_4.

C. J. Barton, A. B. Wilkerson, T. N. McVay, R. J. Sheil, and W. R. Grimes. Oak Ridge National Laboratory, Phase Diagrams of Nuclear Reactor Materials, R. E. Thoma, ed., ORNL-2548, p. 135 (1959).

Melt Preparation and Purification

Kuroda and Suzuki [52] prepared UCl_4 by the reaction of carbon and chlorine with urano-uranic oxide at 850 °C. The urano-uranic oxide was obtained from uranyl nitrate, which was previously purified with tributylphosphate, sodium nitrate and kerosene.

Bogacz and Ziolek [**158**] prepared and purified KCl and UCl_4 using the procedure described under the system CsCl-UCl_4.

Desyatnik et al. [**212**] used recrystallized KCl, dried in a vacuum for 1 hour at 770 °C. UCl_4 was prepared by chlorination of UO_2 with CCl_4. The product was twice recrystallized and the melting point of UCl_4 was found to be 587 ± 2 °C.

TABLE 456. Electrical conductance studies: KCl-UCl_4

Investigations critically re-examined			
Ref.	UCl_4 Mol %	Temp. range (T)	Comments
52	19.0–100[a]	723–1023	Cell material: quartz U-tube; Pt electrodes; freq. range: 1000 Hz; calibration: 1N KCl solution
158	45.62–100	793–1001	Cell material: quartz U-tube; Pt electrodes; freq. range: 5,000–10,000 Hz (measurements at 10,000 Hz); calibration: KCl solutions and fused KNO_3, $NaNO_3$, and KCl

TABLE 456. Electrical conductance studies: KCl-UCl_4—Continued

Deviations from previous NSRDS recommendations: [1, p. 9]			
Ref.	UCl_4 Mol %	Min. departure	Max. departure
52	100	−2.1% (873 K)	−6.0% (883 K)
158	100	1.2% (870 K)	−4.4% (890 K)

[a]Graphical except for pure UCl_4.

Comment: Kuroda and Suzuki [52] carried out conductivity measurements in an argon atmosphere since UCl_4 is hygroscopic and reacts with oxygen.

Bogacz and Ziolek [**158**] report their conductance results in the form of equations of the type $\kappa = a + bt + ct^2$ with the standard deviations in the range 0.0×10^{-4} ohm^{-1} cm^{-1} (95.53 mol % UCl_4) to 3.0×10^{-4} ohm^{-1} cm^{-1} (64.35 mol % UCl_4). The overall error in the conductivity measurements did not exceed 0.5%.

TABLE 457. KCl-UCl_4: Specific conductance (ohm^{-1} cm^{-1})

	Mol % UCl_4							
T	100.00	95.53	90.34	83.26	74.24	64.35	53.70	45.62
800					0.431			
810					0.448			
820					0.464			
830					0.479	0.521		
840				0.452	0.495	0.535	0.573	
850			0.433	0.467	0.510	0.548	0.588	0.626
860			0.449	0.482	0.524	0.562	0.602	0.640
870		0.437	0.464	0.497	0.538	0.575	0.616	0.655
880	0.436	0.451	0.478	0.512	0.552	0.587	0.630	0.669
890	0.451	0.465	0.492	0.526	0.566	0.600	0.644	0.683
900	0.465		0.505		0.579	0.613	0.657	0.697
910	0.478		0.517		0.592	0.625	0.669	0.711
920	0.492						0.682	0.724
930	0.505							0.737
940	0.518							
950	0.530							
960	0.542							
970	0.554							
980	0.565							
990	0.576							
1000	0.587							

Temperature-dependent equations

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

Mol % UCl_4	a	$b \cdot 10^3$	$c \cdot 10^6$	Stand. dev.
45.62	−1.4352	3.3652	−1.1068	0.0001
53.70	−1.8769	4.3403	−1.6948	0.0002
64.35	−1.2444	2.8824	−0.9099	0.0003
74.24	−2.0232	4.4852	−1.7711	0.0001
83.26	−1.7850	3.7868	−1.3376	0.0002
90.34	−3.7786	8.2786	−3.9105	0.0002
95.53	−3.9647	8.6262	−4.1001	0.0000
100.00	−2.2782	4.6911	−1.8260	0.0002

These values are based on the work of Bogacz and Ziolek (classical ac technique) [**158**].

TABLE 458. Density studies: KCl-UCl_4

Investigations critically re-examined			
Ref.	UCl_4 Mol %	Temp. range (T)	Comments
158	45.62–100	793–949	Cell material: Pt ball and suspension wire inside quartz tube

Comment: Density data in reference [**158**] were reported in the form of linear temperature dependent equations with standard deviations in the range: 1.0×10^{-4} g cm^{-3} (45.62 mol % UCl_4) to 40.0×10^{-4} g cm^{-3} (95.53 mol % UCl_4). The total error in density measurements did not exceed 0.2%.

TABLE 459. KCl-UCl_4: Density (g cm^{-3})

	Mol % UCl_4							
T	100.0	95.53	90.34	83.26	74.24	64.35	53.70	45.62
800					3.384			
810					3.370	3.188		
820					3.355	3.174		
830					3.340	3.161		
840				3.425	3.326	3.148	2.996	
850				3.411	3.311	3.135	2.986	2.841
860		3.522	3.475	3.398	3.296	3.122	2.975	2.831
870	3.558	3.503	3.461	3.384	3.281	3.109	2.964	2.822
880	3.539	3.485	3.447	3.370	3.267	3.096	2.953	2.812
890	3.519	3.466	3.433	3.357	3.252	3.083	2.943	2.802
900	3.500		3.419			3.070	2.932	2.793
910	3.480		3.405			3.056	2.921	2.783
920	3.461						2.911	2.773
930	3.441							2.764
940	3.422							

Temperature-dependent equations

$$\rho = a + bT$$

Mol % UCl_4	a	$b \cdot 10^4$	Stand. dev.
45.62	3.6615	−9.654	0.0001
53.70	3.8979	−10.732	0.0004
64.35	4.2492	−13.107	0.0003
74.24	4.5627	−14.728	0.0005
83.26	4.5715	−13.649	0.0009
90.34	4.6922	−14.150	0.0002
95.53	5.1147	−18.524	0.0040
100.00	5.2508	−19.455	0.0006

These values are based on the work of Bogacz and Ziolek (Archimedean method) [**158**].

TABLE 460. Surface tension studies: KCl-UCl_4

Investigations critically re-examined			
Ref.	UCl_4 Mol %	Temp. range (T)	Comments
212	0–100	863–1173	Cell material: Pt crucible

Deviations from previous NSRDS recommendations: [2, p. 50]			
Ref.	UCl_4 Mol %	Min. departure	Max. departure
212	0	−0.21% (1073 K)	−0.36% (1173 K)

TABLE 461. KCl-UCl_4: Surface tension (dyn cm^{-1})

	Mol % KCl							
T	100.00	97.33	96.00	73.68	64.31	56.04	39.33	0
870				65.85				
880				65.72		50.73		42.15
890				65.58		50.25	47.56	40.30
900				65.45		49.77	46.94	38.45
910				65.31		49.29	46.32	36.60
920				65.18		48.81	45.70	34.75
930				65.04	51.69	48.33	45.08	32.90
940				64.91	51.60	47.85	44.47	31.05
950				64.77	51.51	47.36	43.84	29.20
960				64.64	51.43	46.88	43.21	27.35
970				64.51	51.34	46.40	42.59	
980				64.37	51.25	45.92	41.97	
990				64.24	51.17	45.44		
1000				64.10	51.08			
1010				63.97	50.99			
1020			67.98	63.83				
1030			67.31	63.70				
1040			66.64	63.56				
1050		71.68	65.96	63.43				
1060		70.79	65.29					
1070		69.90	64.62					
1080	98.05	69.01	63.94					
1090	97.27	68.13	63.27					
1100	96.49		62.60					
1110	95.71		61.93					
1120	94.93		61.25					
1130	94.14		60.58					
1140	93.36		59.91					
1150	92.58		59.23					
1160	91.80							
1170	91.02							

Temperature-dependent equations

$$\gamma = a + bT$$

Mol % KCl	a	$b \cdot 10^2$	Stand. deviation
0	204.95	−18.500	0.02
39.33	102.83	−6.210	0.01
56.04	93.04	−4.808	0.01
64.31	59.73	−0.865	0.02
73.68	77.59	−1.349	0.01
96.00	136.65	−6.732	0.03
97.33	164.82	−8.871	0.02
100.00	182.51	−7.820	0.02

These values are based on the work of Desyatnik et al. (maximum bubble pressure method) [212].

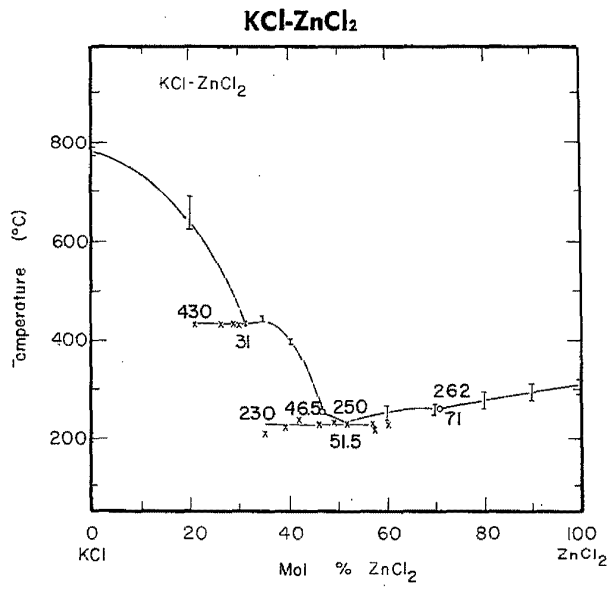

FIGURE 82. Temperature-composition phase diagram for KCl-$ZnCl_2$.

I. N. Nikonova, S. P. Paulenko and A. G. Bergman, Dokl. Akad. Nauk. S.S.S.R., Ser. Khim., 391–400 (1941).

Ya. A. Ugal and Y. A. Shatillo, Zhur. Fiz. Khim., **23**, 744–54 (1949).

F. Duko and R. A. Fleming, J. Electrochem. Soc., **104**, 251–4 (1957).

Melt Preparation and Purification

Pavlenko [28] prepared $ZnCl_2$ by dissolving electrolytic zinc metal in chemically pure, concentrated hydrochloric acid. The $ZnCl_2$ was dehydrated by heating the material in a test tube with a current of dry HCl passing through the melt. The anhydrous product was transferred to a platinum cup, crushed and finally stored in weighing bottles.

Duke and Fleming [38] used Baker and Adamson reagent grade crystalline KCl. "Bakers Analyzed broken lump" $ZnCl_2$ was fused in a Pyrex test tube in a furnace at about 400 °C. Predetermined quantities of the two chloride salts were mixed and fused while a stream of HCl gas was passed through the melt. Mixtures were analyzed for Zn^{2+} by the method of Loomis (T. C. Loomis, Ph.D. thesis, Iowa State College Library, Ames, Iowa, 1953). Specially designed conductivity cells were used so that HCl gas could be passed through the melt contained in the cell and thus convert any ZnO formed by hydrolysis back to the chloride.

Weeks [**108**] and Bloom and Weeks [197, 199] used B.D.H. KCl without further purification except for vacuum drying at 400 °C for three hours. The purification of $ZnCl_2$ is described under the system CsCl-$ZnCl_2$.

Ellis et al. [240,78] dried KCl in an oven for 16 hours at 150 °C to 220 °C. Zinc chloride was pre-dried by heating at 300 °C under vacuum for a period of 48 to 72 hours. The salt was then transferred to a Vycor flask under a vacuum of 25 microns or better, and fused. Nitrogen followed by HCl gas was then bubbled through the melt for several hours and, after the melt was cooled in an atmosphere of HCl, the flask was flushed thoroughly with N_2 gas. The anhydrous salt was transferred to a Mason jar for storage.

TABLE 462. Electrical conductance studies: KCl-$ZnCl_2$

Investigations critically re-examined			
Ref.	$ZnCl_2$ Mol %	Temp. range (T)	Comments
38[a]	21–100	748–923	Cell material: Pyrex glass; Pt electrodes; freq. range: 1000 Hz
108	36.8–100	510–890	Cell material: silica glass; Pt electrodes; freq. range: 500–50,000 Hz; calibration: 0.1 and 1.0 demal KCl solutions
197[a]	36.8–100	510–890	Cell material and calibration: as for 108

Deviations from previous NSRDS recommendations: [1, p. 10]			
Ref.	$ZnCl_2$ Mol %	Min. departure	Max. departure
108	100	−3.0% (830 K)	−53.0% (627 K)

[a]Equivalent conductivities were reported.

Comment: Weeks [**108**] reported a decrease in cell resistance of 0.1% from 0.5–100 KHz for molten $ZnCl_2$ and for mixtures with the alkali chlorides. It was suggested by Weeks that the large differences in conductivities for pure $ZnCl_2$ between [**108**] and Bockris et al. (NSRDS–NBS–15) [1] have been due in part to the large frequency extrapolation (~5%) used in the latter case. Weeks [**108**] reported experimental specific conductivities and Bloom and Weeks [197] gave equivalent conductances in the form of Adam-Gibbs equations $\Lambda = A \exp(-B/T \ln(T/T_0))$.

Overall accuracy in the recommended values was reported to be 0.5% and 0.3% for pure zinc chloride and for mixtures, respectively.

TABLE 463. $KCl-ZnCl_2$: Specific conductance ($ohm^{-1}\ cm^{-1}$)

	Mol percent $ZnCl_2$							
T	100.00	94.28	91.02	79.20	66.20	53.00	45.90	36.80
510						0.08876		
530					0.09720	0.1275		
550					0.1339	0.1692	0.1708	
570					0.1734	0.2136	0.2201	
590		0.009732	0.02176	0.1075	0.2155	0.2602	0.2704	
610	0.002514	0.01781	0.03007	0.1391	0.2597	0.3089	0.3215	
630	0.004740	0.02771	0.04181	0.1729	0.3060	0.3592	0.3733	
650	0.008460	0.03951	0.05699	0.2088	0.3539	0.4109	0.4255	
670	0.01399	0.05334	0.07561	0.2467	0.4031	0.4636	0.4779	
690	0.02163	0.06928	0.09766	0.2865	0.4534	0.5170	0.5305	
710	0.03171	0.08745	0.1231	0.3280	0.5044	0.5707	0.5830	0.5927
730	0.04454	0.1079	0.1521	0.3712	0.5559	0.6244	0.6352	0.6446
750	0.06042	0.1309	0.1844	0.4159	0.6076	0.6779	0.6871	
770	0.07968	0.1563	0.2202	0.4620	0.6592	0.7307	0.7383	
790	0.1026	0.1844	0.2595	0.5094	0.7104	0.7826	0.7889	
810	0.1296	0.2152	0.3021	0.5580	0.7608	0.8332	0.8385	
830	0.1608	0.2488	0.3482	0.6076	0.8103	0.8822	0.8869	
850	0.1967	0.2854	0.3978	0.6582	0.8585	0.9293	0.9342	
870		0.3250	0.4507	0.7097		0.9741	0.9800	
890		0.3678						

Temperature-dependent equations

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

Mol % $ZnCl_2$	a	$b \cdot 10^3$	$c \cdot 10^6$	$d \cdot 10^9$	Stand. error of est.
36.80	−1.2500	2.5953	0	0	0.13%
45.90	−0.1469	−2.3679	7.3232	−3.5778	0.41%
53.00	1.1202	−7.6752	14.5618	−6.8193	0.40%
66.20	1.1729	−7.5411	13.6490	−6.1321	0.19%
79.20	0.7195	−4.4323	7.1719	−2.4026	1.32%
91.02	1.3224	−4.7385	4.2950	0	2.55%
94.28	0.1026	0.0675	−1.6401	2.1337	3.69%
100.00	−0.9757	5.5534	−10.4507	6.5176	1.30%

These values are based on the data of Weeks (classical ac technique) [**108**].

TABLE 464. Density studies: $KCl-ZnCl_2$

Investigations critically re-examined			
Ref.	$ZnCl_2$ Mol %	Temp. range (T)	Comments
28	0–100	593–835	Cell material: Pt sphere, Pt suspension wire; calibration: molten KNO_3, LiCl and NaCl
38	18.9–100	715–988	Cell material: Pt sinker
78	0–100	573–1330	Cell material: Pt bob
108	38.4–100	506–881	Cell material: silica pycnometer; calibration: water
165	50	773–973	
187	40.1, 60.9, 80.3, 90.0, 96.9	590–1057	
193	20–100	873, 973	
194	38.4–100	506–881	
199	0–100 (g)	873	Cell material: silica pycnometer: calibration: water
240			Cell material: Mo capillary (max. bubble pressure method); calibration: tin/p-terphenyl

TABLE 464. Density studies: $KCl-ZnCl_2$—Continued

Comparisons with NSRDS recommendations:
[1, pp. 5, 10 and this volume]

Ref.	$ZnCl_2$ Mol %	Min. departure	Max. departure
28	100	0.0% (669 K)	−0.04% (728 K)
38	100	−0.08% (723 K)	−0.63% (910 K)
78	100	−0.76% (660 K)	−1.07% (800 K)
108	100	−0.08% (683 K)	0.40% (600 K)
199	100	−0.21% (873 K)	
28	100	0.12% (781 K)	0.20% (718 K)
28	65	−0.04% (710 K)	−0.22% (617 K)
28	0	−0.89% (1167 K)	−1.12% (1071 K)
78	0	−1.04% (1200 K)	−1.33% (1090 K)

Comment: Density measurements in references [**108**, 199] were corrected for thermal expansion of the silica pycnometers and the total correction was 0.05–0.1%. The overall accuracy was reported to be between 0.05% and 0.1%. Weeks [**108**] reported experimental density values while Bloom and Weeks [199] gave results in the form of linear temperature dependent equations with standard deviations in the range: 0.37×10^{-3} g cm^{-3} (72.4 mol % $ZnCl_2$) to 3.47×10^{-5} g cm^{-3} (95.4 mol % $ZnCl_2$).

TABLE 465. $KCl-ZnCl_2$: Density (g cm^{-3})

	Mol percent $ZnCl_2$											
T	100.00	97.52	95.43	93.70	90.46	83.70	72.40	65.20	57.80	53.90	47.40	38.40
520									2.333	2.299		
540									2.319	2.284	2.231	
560							2.406	2.360	2.304	2.270	2.217	
580			2.515			2.455	2.392	2.345	2.290	2.255	2.204	
600	2.520	2.511	2.504	2.489	2.470	2.443	2.378	2.331	2.275	2.241	2.190	
620	2.509	2.500	2.492	2.478	2.459	2.430	2.364	2.317	2.261	2.227	2.176	
640	2.499	2.489	2.481	2.467	2.448	2.417	2.350	2.302	2.247	2.212	2.162	
660	2.488	2.478	2.470	2.456	2.437	2.405	2.336	2.288	2.232	2.198	2.148	
680	2.478	2.466	2.459	2.445	2.425	2.392	2.322	2.274	2.218	2.183	2.134	
700	2.467	2.455	2.448	2.434	2.414	2.379	2.308	2.259	2.203	2.169	2.120	
720	2.456	2.444	2.436	2.423	2.403	2.366	2.294	2.245	2.188	2.155	2.106	2.034
740	2.446	2.433	2.425	2.412	2.392	2.354	2.280	2.231	2.174	2.140	2.092	2.021
760	2.435	2.422	2.414	2.401	2.380		2.267	2.216	2.160	2.126	2.078	2.008
780	2.425		2.403		2.369		2.253	2.202	2.145	2.111	2.064	1.994
800	2.414		2.391				2.239	2.187	2.131	2.097	2.050	1.981
820	2.403		2.380				2.225	2.173	2.116	2.083	2.036	1.968
840			2.369				2.211	2.159	2.102	2.068	2.022	1.955
860			2.358				2.197	2.144	2.087	2.054	2.008	1.942
880								2.130	2.073			

Temperature-dependent equations

$$\rho = a + bT$$

Mol % $ZnCl_2$)	a	$b \cdot 10^3$	Stand. error of est.
38.40	2.5092	−0.6600	0.03%
47.40	2.6084	−0.6982	0.03%
53.90	2.6727	−0.7197	0.05%
57.80	2.7097	−0.7239	0.05%
65.20	2.7610	−0.7169	0.03%
72.40	2.7976	−0.6989	0.02%
83.70	2.8246	−0.6364	0.02%
90.46	2.8079	−0.5627	0.04%
93.70	2.8164	−0.5465	0.05%
95.43	2.8401	−0.5608	0.14%
97.52	2.8440	−0.5552	0.05%
100.00	2.8375	−0.5293	0.09%

These values are based on the work of Weeks (pycnometric method) [**108**].

TABLE 466. Surface tension studies: $KCl-ZnCl_2$

Investigations critically re-examined			
Ref.	Mol % $ZnCl_2$	Temp. range (T)	Comments
187	40.1–100	573–1073	Cell material: Capillary of 89%Pt–11%Ru alloy; melt contained in Pt crucible; calibration: capillary diameter measured with microscope
318	12.2–89.5	650–1158	

Comparison with NSRDS recommendations [this volume]			
Ref.	Mol % $ZnCl_2$	Min. departure	Max. departure
318	0	−1.1% (1148 K)	−2.44% (1158 K)
318	100	−20.27% (848 K)	−23.19% (948 K)

TABLE 467. $KCl-ZnCl_2$: Surface tension (dyn cm^{-1})

	Mol percent $ZnCl_2$						
T	100.0	96.9	93.3	86.6	80.3	60.9	40.1
560						81.2	
580	59.3			58.2		80.6	
600	58.5	57.3		58.3	62.9	79.9	
620	57.7	57.1		58.3	62.9	79.3	
640	57.0	56.9		58.3	62.8	78.6	100.2
660	56.3	56.7	55.3	58.3	62.7	77.9	99.1
680	55.7	56.5	55.7	58.3	62.5	77.1	98.0
700	55.1	56.2	56.0	58.2	62.3	76.4	96.9
720	54.5	56.0	56.3	58.1	62.1	75.6	95.8
740	54.0	55.8	56.4	58.0	61.8	74.8	94.6
760	53.6	55.5	56.4	57.8	61.5	74.0	93.4
780	53.2	55.2	56.4	57.7	61.1	73.2	92.3
800	52.8	55.0	56.2	57.5	60.7	72.4	91.1
820	52.5	54.7	56.0	57.2	60.1	71.5	89.9
840	52.3	54.4	55.7	57.0	59.7	70.6	88.7
860	52.0	54.1	55.2	56.7	59.1	69.8	87.4
880	51.9	53.8	54.7	56.4	58.5	68.8	86.2
900	51.7	53.5	54.1	56.1	57.9	67.9	84.9
920	51.7	53.1	53.4	55.7	57.2	67.0	83.7
940	51.6	52.8	52.6	55.4	56.5	66.0	82.4
960	51.6		51.7	55.0	55.7	65.0	81.1
980	51.7		50.7		54.9	64.0	79.8
1000			49.6		54.0	63.0	78.4
1020						61.9	77.1
1040							75.8

Temperature-dependent equations

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

Mol % $ZnCl_2$	a	$b \cdot 10^2$	$c \cdot 10^5$	Stand. error of est.
40.1	128.3456	−3.3339	−1.6569	0.77%
60.9	91.3691	−0.5041	−2.3374	1.16%
80.3	43.2450	6.5717	−5.4958	0.73%
86.6	45.5907	4.0180	−3.1594	0.91%
93.3	−11.3582	17.8578	−11.7600	1.18%
96.9	58.7231	0.4508	−1.1502	0.79%
100.0	103.5767	−11.0131	5.8369	3.13%

These values are based on the work of Ellis (maximum bubble pressure method) [**187**].

$LaCl_2$-$LaCl_3$

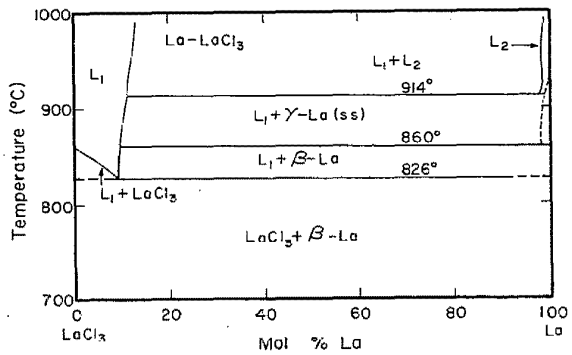

FIGURE 83. Temperature-composition phase diagram for $LaCl_2$-$LaCl_3$.

F. S. Keneshea and H. Cubiccio, J. Chem. Eng. Data, **6**, 507 (1961).

Melt Preparation and Purification

Pure lanthanum trichloride was prepared by Smirnov et al. [**111, 99**] by dissolution of analytical grade lanthanum oxide in analytical grade hydrochloric acid. After the solution was concentrated with an excess of NH_4Cl, the temperature was gradually raised to 600 °C and the salt was then melted in a quartz tube under vacuum. Analysis showed 56.59% La^{+3} and 42.91% Cl^- (purity of the salt 99.93% with respect to La and 98% with respect to Cl). Equilibrium mixtures of lanthanum and its di- and trichlorides (containing ≃86 mol % $LaCl_2$ and 14 mol % $LaCl_3$) were prepared before each experiment in a molybdenum crucible by reduction of the molten $LaCl_3$ with an excess of metal at 1000 °C in an atmosphere of dry argon or helium.

TABLE 468. Density studies: $LaCl_2$-$LaCl_3$

Investigations critically re-examined		
Ref.	$LaCl_3$ Mol %	Temp. range (T)
111	14	1158–1328

TABLE 469. $LaCl_2$-$LaCl_3$: Density (g cm^{-3})

Mol percent $LaCl_3$		Mol percent $LaCl_3$	
T	14	T	14
1160	3.763	1250	3.686
1170	3.755	1260	3.677
1180	3.746	1270	3.669
1190	3.738	1280	3.660
1200	3.729	1290	3.652
1210	3.720	1300	3.643
1220	3.712	1310	3.634
1230	3.703	1320	3.626
1240	3.695		

Temperature-dependent equations

$$\rho = a + bT$$

Mol % $LaCl_3$	a	$b \cdot 10^3$
14	4.761	−0.860

These values are based on the work of Smirnov et al. (Archimedean method) [**111**].

TABLE 470. Viscosity studies: $LaCl_2$-$LaCl_3$

Investigations critically re-examined			
Ref.	$LaCl_3$ Mol %	Temp. range (T)	Comments
99	14, 100	1150–1265	Cell material: Mo sphere, steel suspension wire, crucible containing salt was placed in a quartz tube; calibration: organic liquids and fused NaCl used to check reliability of apparatus

TABLE 471. $LaCl_2$-$LaCl_3$: Viscosity (cp)

Mol percent $LaCl_3$		
T	100	14
1150		3.09
1160		2.93
1170		2.79
1180		2.65
1190	5.14	2.52
1200	4.91	2.40
1210	4.69	2.29
1220	4.49	2.19
1230	4.29	2.09
1240	4.11	1.99
1250	3.94	1.91
1260	3.78	1.82

Temperature-dependent equations
$\eta = A \cdot \exp(E/RT)$

Mol % $LaCl_3$	$A \cdot 10^2$	E (cal mol^{-1})
14	0.733	13806
100	2.061	13049

These values are based on the work of Smirnov et al. (oscillating sphere method) [99].

TABLE 472. Surface tension studies: $LaCl_2$-$LaCl_3$

Investigations critically re-examined			
Ref.	$LaCl_3$ Mol %	Temp. range (T)	Comments
248[a]	14, 100	1165–1334	Cell material: Mo crucible and capillary; calibration: apparatus tested using molten NaCl

[a]Smirnov et al. [248] reported that the only material found to be stable in contact with a molten $LaCl_2$-$LaCl_3$ mixture was molybdenum.

TABLE 473. $LaCl_2$-$LaCl_3$: Surface tension (dyn cm^{-1})

Mol percent $LaCl_3$		
T	100	14
1170	118.1	
1180	116.8	
1190	115.5	
1200	114.3	
1210	113.0	
1220	111.8	
1230	110.5	
1240	109.2	120.4
1250	108.0	119.5
1260	106.7	118.5
1270		117.6
1280		116.6
1290		115.6
1300		114.7
1310		113.7
1320		112.8
1330		111.8

Temperature-dependent equations
$\gamma = a + bT$

Mol % $LaCl_3$	a	$b \cdot 10^2$	Stand. error of est.
14	239.7	−9.615	0.10%
100	265.8	−12.628	0.17%

These values are based on the work of Smirnov et al. (maximum bubble pressure method) [248].

$LaCl_3$-LiCl

Melt Preparation and Purification

The preparation of pure LiCl by Smirnov and Stepanov [176] is discussed under the CsCl-LiCl system. Lanthanum trichloride was prepared [154,176] as discussed under the $LaCl_2$-$LaCl_3$ system.

Smirnov and Khokhlov [173] purified their LiCl by double recrystallization from distilled water followed by drying in a low-pressure argon atmosphere. The hexahydrate salt of $LaCl_3$ was dried with NH_4Cl and fused in an argon atmosphere. The pure salts were stored over P_2O_5 in a desiccator.

TABLE 474. Electrical conductance studies: $LaCl_3$-LiCl

Investigations critically re-examined			
Ref.	LiCl Mol %	Temp. range (T)	Comments
154	0–89.96	1073–1223	Cell material: Alundum crucible inside sealed quartz tube; electrodes: Mo wire; freq. range: 50,000 Hz; calibration: molten KCl

Deviations from previous NSRDS recommendations: [1, p. 8]			
Ref.	LiCl Mol %	Min. departure	Max. departure
154	0	−15.5% (1140 K)	−16.7% (1220 K)

Comment: Smirnov and Khokhlov [154] report their results in the form of linear temperature dependent equations with standard deviations in the range: 2×10^{-3} ohm^{-1} cm^{-1} (0 mol % LiCl) to 14×10^{-3} ohm^{-1} cm^{-1} (70.37 mol % LiCl).

TABLE 475. $LaCl_3$-LiCl: Specific conductance (ohm^{-1} cm^{-1})

	Mol % LiCl								
T	100	89.96	79.94	70.37	60.00	46.98	34.99	19.97	0
1080	6.640	4.666	3.736	3.093	2.598	2.056	1.688	1.391	
1090	6.679	4.707	3.767	3.124	2.629	2.089	1.720	1.424	
1100	6.716	4.747	3.798	3.155	2.656	2.122	1.753	1.457	
1110	6.753	4.788	3.829	3.186	2.684	2.155	1.786	1.491	
1120	6.789	4.829	3.860	3.218	2.713	2.188	1.818	1.524	
1130	6.824	4.870	3.891	3.249	2.741	2.221	1.851	1.557	
1140	6.858	4.911	3.922	3.280	2.770	2.254	1.883	1.590	1.248
1150	6.890	4.951	3.953	3.312	2.799	2.287	1.916	1.624	1.273
1160	6.923	4.992	3.985	3.343	2.827	2.320	1.949	1.657	1.299
1170	6.954	5.033	4.016	3.374	2.856	2.353	1.981	1.690	1.325
1180	6.985	5.074	4.047	3.405	2.884	2.385	2.014	1.724	1.350
1190	7.014	5.115	4.078	3.437	2.913	2.418	2.047	1.757	1.376
1200	7.043	5.155	4.109	3.468	2.942	2.451	2.079	1.790	1.402
1210	7.070	5.196	4.140	3.499	2.970	2.484	2.112	1.824	1.427
1220	7.097	5.237	4.171	3.531	2.999	2.517	2.144	1.857	1.453
1230	7.123								
1240	7.148								
1250	7.172								
1260	7.195								
1270	7.217								

Temperature-dependent equations

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

Mol % LiCl	a	$b \cdot 10^5$	$c \cdot 10^9$	Standard deviation
0	−1.673	2.562	0	0.002
19.97	−2.206	3.330	0	0.006
34.99	−1.835	3.262	0	0.010
46.98	−1.497	3.290	0	0.007
60.00	−0.492	2.861	0	0.004
70.37	−0.287	3.129	0	0.014
79.94	−0.374	3.113	0	0.009
89.96	−0.259	4.080	0	0.009
100	−2.885	13.738	−4.554	0.008

These values are based on the work of Smirnov and Khokhlov (classical ac technique) [**154**].

TABLE 476. Density studies: $LaCl_3$-LiCl

Investigations critically re-examined			
Ref.	LiCl Mol %	Temp. range (T)	Comments
176	11.4–100	1073–1173	Cell material: Mo or Pt capillary tube and crucible

Comment: Smirnov and Stepanov report their density data in the form of linear temperature dependent equations with standard deviations of ±0.002 g cm^{-3} [**176**].

TABLE 477. $LaCl_3$-LiCl: Density (g cm^{-3})

	Mol % LiCl							
T	100	87.7	75.8	63.2	50.7	38.8	25.0	11.4
880	1.504							
900	1.495							
920	1.486							
940	1.477							
960	1.469							
980	1.460							
1000	1.451							
1020	1.442							
1040	1.433							
1060	1.424							
1080		1.881	2.208	2.468	2.669	2.823	2.975	3.104
1090		1.876	2.203	2.464	2.664	2.818	2.970	3.099
1100		1.872	2.198	2.459	2.659	2.813	2.965	3.093
1110		1.867	2.194	2.454	2.655	2.808	2.959	3.087
1120		1.862	2.189	2.450	2.650	2.803	2.954	3.082
1130		1.858	2.185	2.445	2.645	2.798	2.949	3.076
1140		1.853	2.180	2.440	2.640	2.793	2.944	3.070
1150		1.849	2.176	2.435	2.636	2.788	2.939	3.065
1160		1.844	2.171	2.431	2.631	2.783	2.933	3.059
1170		1.839	2.167	2.426	2.626	2.776	2.928	3.054

Temperature-dependent equations

$\rho = a + bT$

Mol % LiCl	a	$b \cdot 10^4$
11.4	3.710	−5.61
25.0	3.540	−5.23
38.8	3.372	−5.08
50.7	3.174	−4.68
63.2	2.976	−4.70
75.8	2.699	−4.55
87.7	2.381	−4.63
100	1.8965	−4.458

These values are based on the work of Smirnov and Stepanov (modified maximum bubble pressure method) [**176**]. The temperature range for density data over the concentration range 11.4 to 87.7 mol % LiCl was assumed to be the same as that reported for the surface tension data in reference [**176**].

TABLE 478. Viscosity studies: $LaCl_3$-LiCl

Investigations critically re-examined

Ref.	LiCl Mol %	Temp. range (T)	Comments
173	0, 25.0, 50.7, 75.8	1160–1245	Cell material: Mo sphere, steel suspension wire, melt contained in a Pt or Mo crucible; calibration: method tested by measurements on organic liquids and fused NaCl

Deviations from previous NSRDS recommendations: [1, p. 8]

Ref.	LiCl Mol %	Min. departure	Max. departure
173	0	−0.59% (1190 K)	−3.40% (1240 K)

Comment: Experimental details concerning reference [**173**] are discussed under the $CsCl$-$LaCl_3$ system.

TABLE 479. $LaCl_3$-LiCl: Viscosity (cp)

	Mol % LiCl			
T	75.8	50.7	25.0	0.0
1060	2.14	3.53		
1070	2.07	3.40	5.58	
1080	2.00	3.28	5.33	
1090	1.94	3.16	5.09	
1100	1.88	3.05	4.87	
1110	1.83	2.95	4.67	
1120	1.78	2.85	4.47	
1130	1.73	2.76	4.29	
1140	1.68	2.67	4.12	
1150	1.63	2.58	3.96	6.35
1160	1.59	2.50	3.80	6.00
1170	1.55	2.42	3.66	5.68
1180	1.51	2.35	3.52	5.38
1190				5.11
1200				4.85
1210				4.61
1220				4.38
1230				4.17
1240				3.97

Temperature-dependent equations

$\eta = A \cdot \exp(E/RT)$

Mol % LiCl	$A \cdot 10^2$	E (cal/mol)	Stand. Deviation
0.0	0.984	14782	0.02
25.0	4.046	10473	0.02
50.7	6.486	8418	0.02
75.8	6.887	7233	0.03

These values are based on the work of Smirnov and Khokhlov (oscillating sphere method) [**173**].

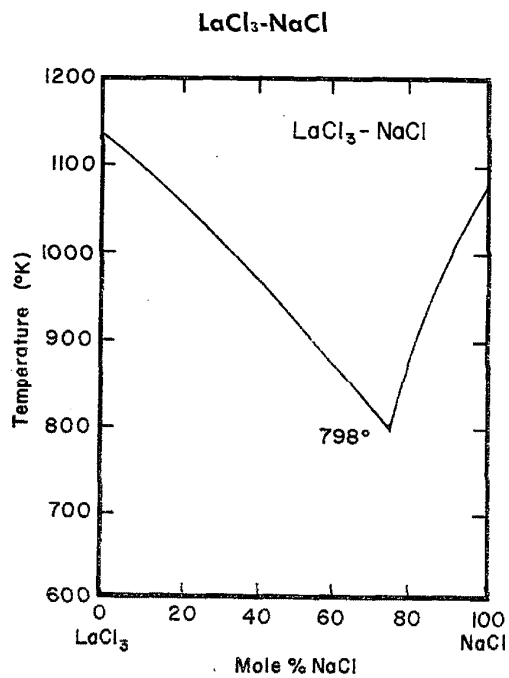

FIGURE 84. Temperature-composition phase diagram for $LaCl_3$-NaCl.

G. I. Novikov and A. K. Baev, Izv. Akad. Nauk S.S.S.R., **22**, 116 (1961).

Melt Preparation and Purification

The preparation of $LaCl_3$ by Forthmann et al. [186] is described under the system KCl-$NdCl_3$, while that used by Cho and Kuroda [**220**] is described under the system KCl-$LaCl_3$.

TABLE 480. Electrical conductance studies: $LaCl_3$-NaCl

Investigations critically re-examined			
Ref.	NaCl Mol %	Temp. range (T)	Comments
186	0–100 (g)	1185	Cell material: quartz capillary cell; Pt electrodes; freq. range: 100,000–250,000 Hz; calibration: molten NaCl, KCl and CsCl
220	15–100	1060–1260	Cell material: quartz capillary cell; Pt electrodes; calibration: molten KCl

TABLE 481. $LaCl_3$-NaCl: Specific conductance (ohm^{-1} cm^{-1})

	Mol percent NaCl							
T	100	86.83	79.13	66.70	54.89	44.98	29.78	15.14
1070					1.260			
1080					1.291			
1090		2.012			1.321			
1100		2.036			1.351			
1110		2.059	1.558	1.312	1.379			
1120	3.404	2.082	1.587	1.346	1.407			
1130	3.417	2.104	1.616	1.379	1.435			
1140	3.431	2.126	1.644	1.411	1.461	1.188		
1150	3.446	2.148	1.670	1.442	1.487	1.228		
1160	3.461	2.168	1.696	1.472	1.511	1.264		1.114
1170	3.478	2.188	1.720	1.501	1.535	1.296	0.811	1.170
1180	3.495	2.208	1.743	1.528	1.559	1.325	0.827	1.196
1190	3.514	2.227	1.765	1.555	1.581	1.351	0.844	1.222
1200	3.533	2.246	1.786	1.580	1.603	1.373	0.861	1.247
1210		2.264	1.806	1.605		1.391	0.877	1.273
1220		2.281	1.825	1.628		1.406	0.894	1.298
1230								1.324
1240								1.349
1250								1.374
1260								1.399

Temperature-dependent equations

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

Mol % NaCl	a	$b \cdot 10^3$	$c \cdot 10^6$
15.14	− 1.5372	3.453	− 0.484
29.78	− 0.8995	2.139	− 0.259
44.98	−15.9240	35.321	−17.974
54.89	− 3.7242	9.364	− 3.902
66.70	− 5.3039	12.352	− 5.313
79.13	− 4.8636	12.310	− 5.541
86.83	− 1.7952	6.892	− 2.732
100.00	5.5935	−6.419	4.527

These values are based on the work of Cho and Kuroda (classical ac technique) [**220**].

TABLE 482. Density studies: $LaCl_3$-NaCl

Investigations critically re-examined			
Ref.	NaCl Mol %	Temp. range (T)	Comments
220	15–100	1090–1280	Cell material: quartz vessel; calibration: molten KCl

TABLE 483. $LaCl_3$-NaCl: Density (g cm^{-3})

	Mol percent NaCl								
T	100	95.01	86.83	79.13	66.70	54.89	44.98	29.78	15.14
1090				2.098					
1100				2.092					
1110		1.666		2.086					
1120		1.661		2.081			2.635		
1130		1.656		2.075			2.629		3.035
1140	1.520	1.650		2.069		2.490	2.623	2.883	3.028
1150	1.515	1.645		2.064		2.483	2.617	2.877	3.021
1160	1.510	1.640		2.058	2.350	2.476	2.611	2.871	3.014
1170	1.505	1.634		2.052	2.343	2.469	2.606	2.864	3.007
1180	1.500	1.629	1.832	2.047	2.336	2.463	2.600	2.858	3.001
1190	1.495	1.624	1.825	2.041	2.330	2.456	2.594	2.852	2.994
1200	1.490	1.619	1.817	2.035	2.323	2.449	2.588	2.845	2.987
1210	1.485	1.613	1.809	2.030	2.316	2.442	2.582	2.839	2.980
1220	1.481	1.608	1.801	2.024	2.310	2.436	2.577	2.833	2.974
1230	1.476	1.603	1.793	2.018	2.303	2.429	2.571		2.967
1240	1.471	1.597	1.785	2.013	2.296	2.422	2.565		2.960
1250	1.466	1.592	1.777	2.007	2.290	2.416	2.559		2.953
1260		1.587	1.769	2.001	2.283		2.553		2.946
1270		1.582	1.761		2.277				

Temperature-dependent equations

$\rho = a + bT$

Mol % NaCl	a	$b \cdot 10^3$
15.14	3.6154	−0.6779
29.78	3.4319	−0.6330
44.98	3.1250	−0.5792
54.89	3.0733	−0.6734
66.70	2.9382	−0.6638
79.13	2.5623	−0.5687
86.83	2.5542	−0.7959
95.01	2.1079	−0.5280
100.00	1.9517	−0.4977

These values are based on the work of Cho and Kuroda (dilatometric method) [**220**].

$LaCl_3$-RbCl

Melt Preparation and Purification

The preparation of $LaCl_3$ by Forthmann et al. [186] is described under the system KCl-$NdCl_3$.

TABLE 484. Electrical conductance studies: $LaCl_3$-RbCl

Investigations critically re-examined			
Ref.	RbCl Mol %	Temp. range (T)	Comments
186[a,b]	0–100 (g)	1195	Cell material: quartz capillary cell; Pt electrodes; freq. range: 100,000–250,000 Hz; calibration: molten NaCl, KCl and CsCl

[a]Equivalent conductivities were reported.
[b]Refer to system KCl-$NdCl_3$.

TABLE 485. $LaCl_3$-RbCl: Molar conductance (ohm^{-1} cm^2 mol^{-1})

Mol % $LaCl_3$	1195 K	Mol % $LaCl_3$	1195 K
0	122.	60	80.0
10	112.	70	81.7
20	102.	80	88.3
30	93.2	90	105.
40	86.3	100	126.
50	82.0		

These values were interpolated to three significant figures from the graphical presentation of Forthmann, Vogel and Schneider (classical ac technique) [186].

LiCl-$MgCl_2$

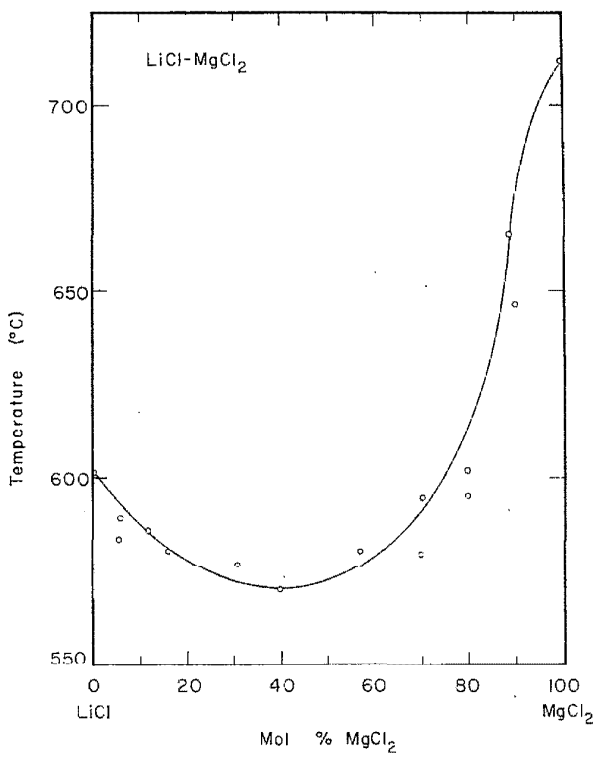

FIGURE 85. Temperature-composition phase diagram for LiCl-$MgCl_2$.

C. Sandonnini, Atti della Reale Accad. dei Lincei, (5), 22, I; 629 (1913).

Melt Preparation and Purification

Matsushima and Ito [77] purified the chloride salts by introducing 400–600 grams of sample into a quartz vessel followed by drying in vacuum for 12 hours at 150 °C, 3 hours at 400 °C and a final drying at a temperature slightly above the melting point. The molten salt was swept, first with dry HCl gas for 2 hours, then argon for 30 minutes followed by evacuation for 30 minutes. Samples were sealed under argon in quartz tubes. Magnesium chloride and lithium chloride, purified by the above procedure, were mixed in a desired composition and further purified in an identical manner.

Lillebuen [130] and Grjotheim [133] used Baker p.a. LiCl (min. 99.8%) which was dried by slowly heating to 400 °C under an inert gas atmosphere. The preparation of pure $MgCl_2$ is described under the system $CaCl_2$-$MgCl_2$.

TABLE 486. Electrical conductance studies: LiCl-$MgCl_2$

Investigations critically re-examined			
Ref.	$MgCl_2$ Mol %	Temp. range (T)	Comments
77[a]	4.7–40	898–1148	Cell material: Pyrex capillary cell; Pt electrodes; freq. range: 1000–20,000 Hz; calibration: molten KCl

[a]Matsushima and Ito [77] found a change of ±0.03% in the cell constant of their conductivity cell before and after each experiment. The effect of temperature on the cell constant (≃1000–2000 cm^{-1}) was about ±0.15% in the temperature range 1063–1173 K and the change due to frequency was ±0.03% in the range 1000–20,000 Hz.

TABLE 487. LiCl-$MgCl_2$: Specific conductance (ohm^{-1} cm^{-1})

	Mol percent $MgCl_2$					
T	40.0	30.0	20.0	16.0	10.0	4.7
910	2.87	3.28	4.04	4.37	4.90	5.47
920	2.90	3.32	4.08	4.42	4.95	5.52
930	2.94	3.36	4.13	4.46	5.00	5.57
940	2.98	3.40	4.17	4.51	5.05	5.62
950	3.01	3.43	4.21	4.55	5.10	5.67
960	3.05	3.47	4.26	4.59	5.14	5.72
970	3.08	3.51	4.30	4.63	5.19	5.77
980	3.11	3.54	4.34	4.67	5.23	5.81
990	3.14	3.58	4.38	4.71	5.27	5.86
1000	3.18	3.61	4.41	4.75	5.31	5.90
1010	3.21	3.65	4.45	4.79	5.35	5.94
1020	3.24	3.68	4.49	4.83	5.39	5.98
1030	3.26	3.71	4.52	4.86	5.43	6.02
1040	3.29	3.74	4.55	4.90	5.46	6.06
1050	3.32	3.77	4.59	4.93	5.50	6.10
1060	3.35	3.80	4.62	4.96	5.53	6.13
1070	3.37	3.83	4.65	4.99	5.56	6.17
1080	3.40	3.85	4.68	5.02	5.60	6.20
1090	3.42	3.88	4.71	5.05	5.63	6.23
1100	3.45	3.91	4.73	5.08	5.65	6.26
1110	3.47	3.93	4.76	5.10	5.68	6.29
1120	3.49	3.95	4.78	5.13	5.71	6.31
1130	3.51	3.98	4.81	5.15	5.73	6.34

Temperature-dependent equations

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

Mol % $MgCl_2$	a	$b \cdot 10^3$	$c \cdot 10^6$
4.7	−5.000	17.572	−6.67
10.0	−4.811	16.234	−6.11
16.0	−4.374	14.466	−5.34
20.0	−4.712	14.526	−5.40
30.0	−4.007	11.879	−4.26
40.0	−3.717	10.692	−3.80

These values are based on the work of Matsushima and Ito (classical ac technique) [**77**].

TABLE 488. Density studies: LiCl-$MgCl_2$

Investigations critically re-examined			
Ref.	$MgCl_2$ Mol %	Temp. range (T)	Comments
77[a]	4.7–40	898–1148	Cell material: quartz bob and quartz vessel containing melt
130[b]	0–100	902–1125	Cell material: Pt-10%Rh sinker and Pt-10%Rh suspension wire; calibration: water
133[b,c,d]	0–100	1073	Cell material and calibration: as for **130**
196	0–100 (g)	918–1183	Cell material: Pt sphere; calibration: molten NaCl

Deviations from previous NSRDS recommendations: [1, pp. 4, 6]

Ref.	$MgCl_2$ Mol %	Min. departure	Max. departure
130	100	0.30% (1017 K)	0.49% (1099 K)
130	0	0.41% (933 K)	0.62% (1015 K)

[a]Matsushima and Ito [77] noted that no corrosion of their quartz bob or vessel occurred providing the salts had been thoroughly purified.

[b]Lillebuen [**130**] and Grjotheim et al. [133] used an apparatus similar to the one described by Janz and Lorenz (Rev. Sci. Instr., **31**, 18, 1960) in which a pin of known dimensions was fixed to the lower end of an Archimedean density bob, thus permitting simultaneous measurement of surface tension and density. Corrections were applied for the effect of surface tension and for expansion of the suspension wire. Density measurements were reproducible to within ±0.3% and total corrections on the observed densities were between 0.3 to 0.4%.

[c]Mixtures reported graphically.

[d]Data from reference [**130**].

TABLE 489. LiCl-$MgCl_2$: Density (g cm^{-3})

	Mol percent $MgCl_2$							
T	100	77.4	56.4	45.4	30.8	18.0	5.7	0.0
910								1.495
920								1.491
930								1.487
940								1.483
950								1.479
960								1.475
970		1.705						1.471
980		1.701	1.669	1.637		1.550		1.467
990		1.696	1.664	1.632		1.545		1.463
1000		1.692	1.659	1.627		1.540		1.459
1010		1.687	1.654	1.623		1.535		1.455
1020	1.674	1.683	1.649	1.618	1.577	1.530		1.451
1030	1.671	1.679	1.644	1.614	1.572	1.525	1.494	1.447
1040	1.668		1.639	1.609	1.566	1.520	1.485	1.443
1050	1.666		1.634	1.604	1.561	1.515	1.477	1.439
1060	1.663		1.629	1.600	1.555	1.510	1.468	
1070	1.660		1.624	1.595	1.550	1.505	1.459	
1080	1.658			1.590	1.544	1.500	1.450	
1090	1.655				1.539		1.441	
1100					1.533		1.432	
1110					1.528		1.423	
1120					1.522		1.414	

TABLE 489. $LiCl-MgCl_2$: Density (g cm^{-3})—Continued

Temperature-dependent equations $\rho = a + bT$			
Mol % $MgCl_2$	a	$b \cdot 10^4$	Stand. error of est.
0.0	1.8561	−3.9698	0.13%
5.7	2.4116	−8.9056	0.05%
18.0	2.0351	−4.9534	0.02%
30.8	2.1408	−5.5248	0.02%
45.4	2.0892	−4.6178	0.04%
56.4	2.1623	−5.0348	0.04%
77.4	2.1334	−4.4146	0.02%
100.0	1.9483	−2.6917	0.03%

These values are based on the work of Lillebuen (Archimedean method) [130].

TABLE 490. Viscosity studies: $LiCl-MgCl_2$

Investigations critically re-examined		
Ref.	$MgCl_2$ Mol %	Temp. range (T)
88	0–100	933–1143

Deviations from previous NSRDS recommendations: [1, p. 4]			
Ref.	$MgCl_2$ Mol %	Min. departure	Max. departure
88	0	−1.2% (911 K)	9.6% (1023 K)

TABLE 491. $LiCl-MgCl_2$: Viscosity (cp)

	Mol percent $MgCl_2$											
T	100	71.6	50.9	40.0	30.8	22.9	19.3	16.0	10.0	7.3	4.7	0
920										1.42		1.52
930				1.65						1.39	1.33	1.47
940		2.04		1.61	1.50	1.55	1.46	1.47		1.36	1.32	1.42
950		1.98		1.58	1.47	1.50	1.42	1.41		1.34	1.30	1.38
960		1.92	1.63	1.54	1.45	1.45	1.38	1.36	1.30	1.31	1.28	1.34
970		1.87	1.58	1.50	1.42	1.41	1.35	1.32	1.29	1.27	1.25	1.30
980		1.82	1.53	1.47	1.40	1.37	1.31	1.28	1.28	1.24	1.22	1.26
990		1.76	1.49	1.43	1.37	1.34	1.27	1.25	1.26	1.20	1.19	1.23
1000		1.71	1.45	1.39	1.34	1.31	1.24	1.23	1.23	1.17	1.15	1.20
1010	2.16	1.67	1.41	1.36	1.32	1.28	1.20	1.20	1.19	1.13		1.17
1020	2.10			1.32		1.26	1.16	1.19	1.15			1.14
1030	2.04			1.29					1.10			
1040	1.98											
1050	1.93											
1060	1.88											
1070	1.83											
1090	1.79											
1100	1.75											
1110	1.71											
1120	1.67											
1130	1.63											
1140	1.60											

TABLE 491. $LiCl-MgCl_2$: Viscosity (cp)—Continued

Temperature-dependent equations $\eta = a + bT + cT^2$				
Mol % $MgCl_2$	a	$b \cdot 10^2$	$c \cdot 10^5$	Stand. error of est.
0	18.0426	−3.0698	1.3850	0.41%
4.7	−18.5918	4.3588	−2.3921	0.23%
7.3	− 2.7743	1.1627	−0.7685	0.60%
10.0	−33.0602	7.1770	−3.7482	1.95%
16.0	30.3873	−5.5918	2.6756	2.44%
19.3	4.9416	−0.3706	0	2.19%
22.9	24.4338	−4.3455	2.0328	2.24%
30.8	3.9577	−0.2614	0	0.61%
40.0	5.0241	−0.3630	0	2.40%
50.9	25.0771	−4.3473	1.9841	0.82%
71.6	13.5675	−1.8764	0.6911	0.63%
100	21.5293	−3.3172	1.2864	1.21%

These values are based on the work of Bondarenko (oscillating sphere method) [88].

TABLE 492. Surface tension studies: $LiCl-MgCl_2$

Investigations critically re-examined			
Ref.	$MgCl_2$ Mol %	Temp. range (T)	Comments
253[a]	0–100	903–1169	Cell material: density sinker and rod for surface tension measurements was made from Pt-10%Rh alloy, pin made from Pt; calibration: measurements on pure salts
258[b]	0–100	1073	As for **253**

Deviations from previous NSRDS recommendations [2, pp. 57, 59]			
Ref.	$MgCl_2$ Mol %	Min. departure	Max. departure
253	100	−5.9% (1073 K)	−6.7% (1002 K)
253	0	−1.2% (902 K)	−2.8% (1059 K)

[a]Lillebuen [253] reports a reproducibility for surface tension measurements of ±1%.

[b]Mixtures reported graphically.

TABLE 493. $LiCl-MgCl_2$: Surface tension (dyn cm^{-1})

	Mol percent $MgCl_2$								
T	100.0	73.5	56.4	53.1	45.4	36.2	18.0	17.2	0.0
910									125.8
920						94.1			125.1
930						93.8			124.4
940				84.5		93.4			123.7
950		73.4		84.3		93.0		105.1	123.0
960		73.3		84.0		92.7		104.6	122.3
970		73.2	79.9	83.7		92.3		104.1	121.6
980		73.0	79.7	83.5	86.1	92.0		103.6	120.9
990		72.9	79.4	83.2	85.8	91.6	102.4	103.2	120.2
1000		72.8	79.2	82.9	85.6	91.2	101.9	102.7	119.5
1010	62.2	72.6	78.9	82.7	85.3	90.9	101.4	102.2	118.9
1020	62.2	72.5	78.6	82.4	85.1	90.5	101.0	101.7	118.2
1030	62.2	72.4	78.4	82.1	84.8		100.5	101.2	117.5
1040	62.2	72.4	78.1	81.9	84.6		100.0	100.7	116.8
1050	62.1	72.1	77.9		84.3				116.1
1060	62.1	72.0	77.6		84.1				
1070	62.1		77.3		83.8				
1080	62.0		77.1		83.6				
1090	62.0								

TABLE 493. LiCl-$MgCl_2$: Surface tension (dyn cm^{-1})—Continued

	Mol percent $MgCl_2$								
T	100.0	73.5	56.4	53.1	45.4	36.2	18.0	17.2	0.0
1100	62.0								
1110	61.9								
1120	61.9								
1130	61.9								
1140	61.8								
1150	61.8								
1160	61.8								

Temperature-dependent equations

$$\gamma = a + bT$$

Mol % $MgCl_2$	a	$b \cdot 10^2$	Stand. error of est.
0.0	189.2378	−6.9694	0.07%
17.2	152.5166	−4.9870	0.09%
18.0	149.7022	−4.7791	0.03%
36.2	127.1996	−3.5963	0.07%
45.4	110.3943	−2.4826	0.12%
53.1	109.3989	−2.6473	0.04%
56.4	105.1314	−2.5978	0.11%
73.5	86.0789	−1.3302	0.08%
100.0	65.3426	−0.3073	0.09%

These values are based on the work of Lillebuen (pin detachment method) [253].

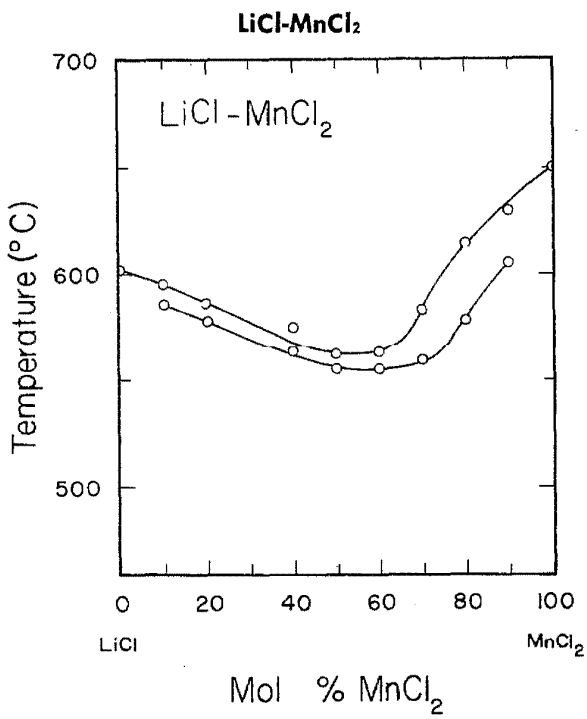

FIGURE 86. Temperature-composition phase diagram for LiCl-$MnCl_2$.

C. Sandonnini and G. Scarpa, Atti della Reale Accad. dei Lincei, (5), 22, 11, 163 (1913).

TABLE 494. Density studies: LiCl-$MnCl_2$

Investigations critically re-examined			
Ref.	$MnCl_2$ Mol %	Temp. range (T)	Comments
202	0–100	929–1123	Cell material: quartz ball containing tungsten for weight; calibration: water and CCl_4

Deviations from previous NSRDS recommendations: [1, p. 9]			
Ref.	$MnCl_2$ Mol %	Min. departure	Max. departure
202	100	0.04% (960 K)	−0.43% (1020 K)

TABLE 495. LiCl-$MnCl_2$: Density (g cm^{-3})

	Mol percent $MnCl_2$											
T	100	90	80	70	60	50	40	30	20	10	0	52
940	2.348		2.245	2.188	2.123			1.867	1.754			2.065
950	2.342	2.292	2.240	2.182	2.118	2.045	1.960	1.863	1.749			2.060
960	2.337	2.287	2.234	2.177	2.113	2.040	1.956	1.858	1.745	1.614		2.055
970	2.331	2.281	2.229	2.172	2.108	2.035	1.951	1.854	1.741	1.610		2.050
980	2.325	2.276	2.223	2.167	2.103	2.030	1.946	1.849	1.736	1.606		2.046
990	2.319	2.270	2.218	2.161	2.098	2.025	1.942	1.844	1.732	1.602		2.041
1000	2.313	2.264	2.213	2.156	2.093	2.020	1.937	1.840	1.727	1.597		2.036
1010	2.308	2.259	2.207	2.151	2.088	2.016	1.932	1.835	1.723	1.593		2.031
1020	2.302	2.253	2.202	2.146	2.083	2.011	1.927	1.831	1.719	1.589		2.026
1030		2.248	2.196							1.585		
1040		2.242								1.581		
1050												
1060											1.424	
1070											1.420	
1080											1.416	
1090											1.412	
1100											1.408	
1110											1.405	
1120											1.401	

Two-dimensional equation and statistical parameters

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

a	$b \cdot 10^4$	$c \cdot 10^3$	$d \cdot 10^6$	$e \cdot 10^7$	$f \cdot 10^{10}$	Max. percent departure	Stand. error of est.
2.88953	−5.76071	−5.73125	−2.24036	−3.57931	8.76495	−0.25% (1019.2 K, 30 mol % LiCl)	0.13%

These values are based on the work of Markov et al. (Archimedean method) [**202**]. C = mol % LiCl.

TABLE 496. LiCl-$MnCl_2$: Density (g cm^{-3})

	Mol percent $MnCl_2$							
T	100	90	80	70	60	40	20	0
930				2.195				
940	2.350		2.243	2.190	2.119		1.754	
950	2.344	2.292	2.238	2.185	2.114	1.962	1.749	
960	2.338	2.287	2.233	2.181	2.109	1.957	1.745	
970	2.331	2.281	2.228	2.176	2.104	1.952	1.740	
980	2.325	2.275	2.223	2.171	2.099	1.948	1.736	
990	2.319	2.269	2.218	2.166	2.094	1.943	1.731	
1000	2.313	2.263	2.213	2.161	2.089	1.938	1.727	
1010	2.307	2.258	2.208	2.156	2.085	1.934	1.722	
1020	2.301	2.252	2.203	2.151	2.080	1.929	1.718	
1030		2.246						
1040		2.240						
1050								
1060							1.425	
1070							1.421	
1080							1.417	
1090							1.412	
1100							1.408	
1110							1.404	
1120							1.399	

TABLE 496. $LiCl-MnCl_2$: Density (g cm^{-3})—Continued

Temperature-dependent equations $\rho = a + bT$		
Comp. mol % $MnCl_2$	a	$b \cdot 10^4$
0	1.884	—4.33
20	2.177	—4.50
40	2.404	—4.66
60	2.574	—4.85
70	2.651	—4.90
80	2.713	5.00
90	2.843	—5.80
100	2.928	—6.15

These values are based on the work of Markov et al. (Archimedean method) [**202**].

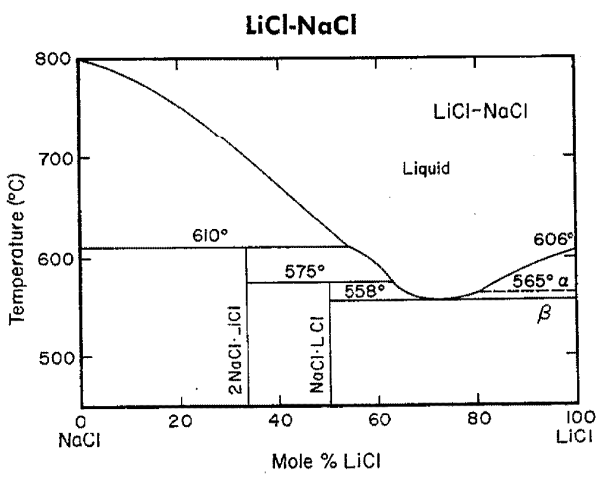

FIGURE 87. Temperature-composition phase diagram for LiCl-NaCl.

A. K. Akopov and A. G. Bergman, Zh. Neorgan. Khim., **11** [7], 1751 (1966); Russ. J. Inorg. Chem. (English Transl.) 937 (1966); A. S. Arabadzhan and A. G. Bergman, Zh. Neorgan. Khim., **7** [9], 2262 (1962); Russ. J. Inorg. Chem. (English Transl.) 1153 (1962).

TABLE 497. Electrical conductance studies: LiCl-NaCl

Investigations critically re-examined			
Ref	LiCl Mol%	Temp range (T)	Comments
11	50	912–1130	Cell material: quartz or silica glass capillary cell; Pt electrodes; freq. range: 1000–7000 Hz; calibration: 0.1M and 1M KCl solutions
127	50 (g)	923–1023	Cell material: Vycor glass; Pt electrodes; freq. range: 500–10,000 Hz, measurements at 1000 Hz; calibration: 1 demal KCl solution

Comment: Zuca and Olteanu [**11**] report a precision of ±0.1% in their resistance measurements.

Melt Preparation and Purification

The purification of NaCl and LiCl by Zuca and Olteanu [**11**] is described under the system CsCl-LiCl.

Sakai and Suzuki [127] studied the electrical conductance of melts composed of Nb_3Cl_8 and various alkali halides. The melt was prepared by mixing Nb_3Cl_8 with sodium chloride and lithium chloride in a Vycor glass tube under argon. The molten mixture was quickly cooled to room temperature and was crushed into suitable sizes in an argon glove box.

TABLE 498. LiCl-NaCl: Specific conductance ($ohm^{-1}cm^{-1}$)

Mol percent NaCl		
T	100	50
920		4.009
930		4.052
940		4.094
950		4.135
960		4.175
970		4.215
980		4.253
990		4.290
1000		4.327
1010		4.362
1020		4.397
1030		4.430
1040		4.463
1050		4.494
1060		4.525
1070		4.555
1080		4.584
1090	3.626	4.612
1100	3.652	4.639
1110	3.677	4.665
1120	3.702	4.630
1130	3.726	4.714
1140	3.749	
1150	3.773	
1160	3.795	
1170	3.817	

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

Mol % NaCl	a	$b \cdot 10^3$	$c \cdot 10^6$	Stand. error of est.
50	−3.9723	13.0062	−4.7073	0.18%
100	−2.4204	8.4918	−2.7014	0.01%

These values are based on the work of Zuca and Olteanu (classical ac technique) [11]. The data for NaCl were reported as equivalent conductance in the form of an Arrhenius equation [98].

TABLE 499. Density studies: LiCl-NaCl

Investigations critically re-examined			
Ref.	NaCl Mol %	Temp. range (T)	Comments
11	50	893–1123	Cell material: Pt ball; calibration: water
196	0–100 (g)	918–1183	Cell material: Pt sphere; calibration: molten NaCl
328	0–100 (g)	1073	

Comment: Zuca and Olteanu [11] report their density results for the equimolecular mixture in terms of a linear temperature dependent equation with a standard deviation of 6×10^{-4} g cm^{-3}. The precision of the density measurements was 0.1%. Experiments were carried out in an atmosphere of dry argon to avoid hydrolysis of LiCl.

TABLE 500. LiCl-NaCl: Density (g cm^{-3})

Mol percent NaCl			
T	100	50	0
880			1.4987
890			1.4944
900		1.5749	1.4902
910		1.5700	1.4860
920		1.5652	1.4817
930		1.5603	1.4775
940		1.5555	1.4733
950		1.5506	1.4690
960		1.5457	1.4648
970		1.5409	1.4605
980		1.5360	1.4563
990		1.5312	1.4520
1000		1.5263	1.4478
1010		1.5214	1.4436
1020		1.5166	1.4393
1030		1.5117	1.4351
1040		1.5069	1.4308
1050		1.5020	1.4266
1060		1.4972	1.4223
1070		1.4923	1.4181
1080		1.4874	
1090	1.5456	1.4826	
1100	1.5402	1.4777	
1110	1.5348	1.4729	
1120	1.5293	1.4680	
1130	1.5239		
1140	1.5184		
1150	1.5130		
1160	1.5075		
1170	1.5021		
1180	1.4966		
1190	1.4912		
1200	1.4858		
1210	1.4803		
1220	1.4749		

Temperature-dependent equations
$\rho = a + bT$

Mol % NaCl	a	$b \cdot 10^4$	Stand. deviation
0	1.8721	−4.243	0.0003
50	2.0121	−4.858	0.0006
100	2.1390	−5.444	0.0002

These values are based on the work of Zuca and Olteanu (Archimedean method) [11].

TABLE 501. Surface tension studies: LiCl-NaCl

Investigations critically re-examined			
Ref.	NaCl Mol %	Temp. range (T)	Comments
257	0–100	923–1173	Cell material: Pt capillary; calibration: radius of capillary determined from measurements on molten LiCl, NaCl, and KCl

Deviations from previous NSRDS recommendation [2, p. 57]

Ref.	NaCl Mol %	Min. departure	Max. departure
257	100	3.1% (1173 K)	3.8% (1103 K)
257	0	2.9% (1073 K)	3.2% (923 K)

TABLE 502. LiCl-NaCl: Surface tension (dyn cm^{-1})

	Mol Percent NaCl				
T	100	60	40	20	0
930					130.2
940					129.6
950					129.0
960					128.3
970					127.7
980		125.0	126.2	127.0	127.1
990		124.2	125.4	126.2	126.5
1000		123.5	124.6	125.4	125.9
1010		122.7	123.8	124.6	125.3
1020		122.0	123.0	123.7	124.6
1030		121.3	122.2	122.9	124.0
1040		120.5	121.4	122.1	123.4
1050		119.8	120.7	121.3	122.8
1060		119.1	119.9	120.5	122.2
1070		118.3	119.1	119.7	121.6
1080		117.6	118.3	118.9	120.9
1090		116.8	117.5	118.1	120.3
1100		116.1	116.7	117.3	119.7
1110	115.4	115.4	115.9		119.1
1120	114.6	114.6	115.1		118.5
1130	113.7	113.9	114.3		
1140	112.9	113.2	113.5		
1150	112.1	112.4	112.8		
1160	111.2	111.7	112.0		
1170	110.4	110.9	111.2		

Temperature-dependent equations

$\gamma = a + bT$

Mol % NaCl	a	$b \cdot 10^2$	Stand. error of est.
0	187.6507	−6.1781	0.04%
20	206.0480	−8.0691	0.20%
40	203.5707	−7.8974	0.12%
60	197.2639	−7.3786	0.45%
100	209.0422	−8.4345	0.01%

These values are based on the work of Mizuno et al. (maximum bubble pressure method) [**257**].

LiCl-PbCl$_2$

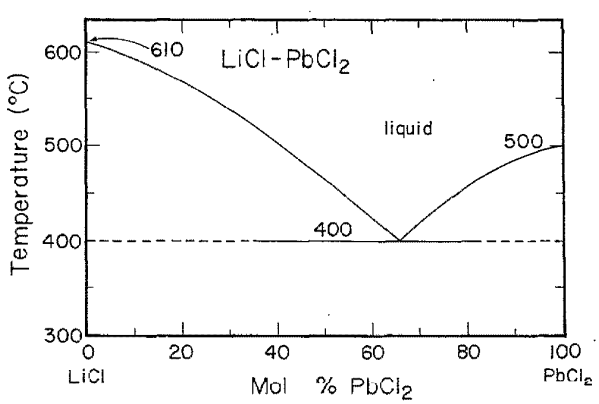

FIGURE 88. Temperature-composition phase diagram for LiCl-PbCl$_2$.

S. P. Geomakov and L. M. Gromakov, Zh. Fiz. Khim., **29** [9], 747 (1955).

Melt Preparation and Purification

Dahl and Duke [**238**] used "Baker Analyzed" reagent materials which were fused at temperatures just above their melting points, crushed and stored in a drying oven at 110 °C. Volatilization of PbCl$_2$ was reduced during the preparation of mixtures by placing LiCl on top of PbCl$_2$ in a platinum crucible which was covered with a platinum foil.

The PbCl$_2$ was filtered and weighed and the filtrate was titrated for Pb^{2+} with the disodium salt of 1,2-cyclohexanediaminetetraacetic acid.

TABLE 503. Density studies: LiCl-PbCl$_2$

Investigations critically re-examined		
Ref.	PbCl$_2$ Mol %	Temp. range (T)
165	42.8	673 973
193	20–100	873, 973

Deviations from previous NSRDS recommendations: [1, p. 13]			
Ref.	PbCl$_2$ Mol %	Min. departure	Max. departure
193	100	0.23% (873 K)	

TABLE 504. LiCl-$PbCl_2$: Density (g cm^{-3})

	Mol percent $PbCl_2$							
T	100	90	80	70	60	50	40	30
873.2	4.813	4.632	4.431	4.203	3.962	3.697	3.391	
973.2	4.675	4.482	4.286	4.071	3.836	3.569	3.276	2.937

These values are based on the work of Lantratov and Shevlyakova (Archimedean method) [**193**]. Due to limited data, the experimental values are given.

TABLE 505. Surface tension studies: LiCl-$PbCl_2$

Investigations critically re-examined

Ref.	$PbCl_2$ Mol %	Temp. range (T)	Cell material	Calibration
238	26.37–100	711–873	Pt–10% Rh capillary, melt contained in Pt crucible	Benzene
254	0–100	711–983		

Deviations from previous NSRDS recommendations: [2, p. 57]

Ref.	$PbCl_2$ Mol %	Min. departure	Max. departure
254	0	0.61% (955 K)	1.34% (935 K)

Comment: Dahl and Duke [**238**, 254] applied corrections for the thermal expansion of the capillary tube. Reported deviations of experimentally measured surface tension values from literature data were less than 0.5%. The surface tension data for pure lead chloride was that recommended in NSRDS-NBS-28 [2].

TABLE 506. LiCl-$PbCl_2$: Surface tension (dyn cm^{-1})

	Mol percent $PbCl_2$						
T	100	69.90	64.25	50.61	49.63	31.26	26.37
775		133.4	134.4	133.4	132.5		
780		133.0	133.8	132.9	132.1		
785		132.5	133.2	132.4	131.7		
790		132.1	132.6	131.9	131.3		
795	134.9	131.6	132.0	131.4	130.9		
800	134.3	131.2	131.4	130.9	130.5		
805	133.6	130.8	130.8	130.4	130.1		
810	133.0	130.3	130.2	129.9	129.7	129.0	
815	132.4	129.9	129.6	129.4	129.3	128.5	
820	131.8	129.5	129.1	128.9	128.9	128.0	
825	131.1	129.0	128.5	128.5	128.5		
830	130.5	128.6	127.9	128.0	128.1		
835	129.9	128.2	127.3	127.5	127.7		
840	129.3	127.7	126.7	127.0	127.3		
845	128.7	127.3	126.1	126.5	126.9		
850		126.9					125.7
855		126.4					125.2
860		126.0					124.8
865		125.6					124.3
870		125.1					123.9

Temperature-dependent equations

$$\gamma = a + bT$$

Mol %$PbCl_2$	a	$b \cdot 10^2$	Stand error of est.
26.37	200.9088	−8.8542	0.72%
31.26	211.7828	−10.2165	0.45%
49.63	194.0891	−7.9463	0.54%
50.61	209.6978	−9.8480	0.17%
64.25	226.3552	−11.8665	0.17%
69.90	200.8931	−8.7107	0.35%
100.0	233.6772	−12.4284	0.49%

These values are based on the work of Dahl and Duke (maximum bubble pressure method) [**238**].

LiCl-RbCl

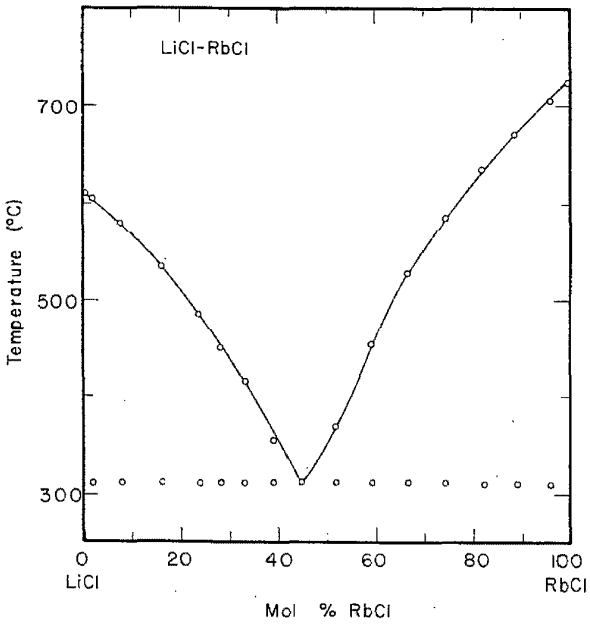

FIGURE 89. Temperature-composition phase diagram for LiCl-RbCl.

S. Zemczuzny and F. Rambach, Z. Anorg. Chem., **65**, 403 (1910).

Melt Preparation and Purification

The purification procedures described by Zuca and Olteanu [11] are discussed under the system CsCl-LiCl.

TABLE 507. Electrical conductance studies: LiCl-RbCl

Investigations critically re-examined			
Ref.	RbCl Mol %	Temp. range (T)	Comments
11	50	904–1135	Cell material: quartz or silica glass capillary cell; Pt electrodes; freq. range: 1000–7000 Hz; calibration: 0.1M and 1M KCl solutions

Comment: Zuca and Olteanu [11] report a precision of ±0.1% in their resistance measurements.

TABLE 508. LiCl-RbCl: Specific conductance (ohm^{-1} cm^{-1})

	Mol percent RbCl	
T	100	50
910		1.745
920		1.780
930		1.814
940		1.848
950		1.882
960		1.915
970		1.948
980		1.981
990		2.013
1000		2.045
1010		2.077
1020	1.574	2.108
1030	1.596	2.139
1040	1.618	2.170
1050	1.640	2.200
1060	1.662	2.230
1070	1.683	2.260
1080	1.704	2.289
1090	1.725	2.318
1100	1.746	2.346
1110	1.766	2.375
1120	1.785	2.403
1130	1.805	2.430
1140	1.824	
1150	1.843	
1160	1.862	
1170	1.880	
1180	1.899	
1190	1.916	

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

Comp. Mol % RbCl	a	$b \cdot 10^3$	$c \cdot 10^6$	Stand. error of est.
50	−2.8227	6.5525	−1.6847	0.98%
100	−2.3072	5.3381	−1.5035	0.02%

These values are based on the work of Zuca and Olteanu (classical ac technique) [11].

TABLE 509. Density studies: LiCl-RbCl

Investigations critically re-examined			
Ref.	RbCl Mol %	Temp. range (T)	Comments
11	50	888–1128	Cell material: Pt ball; calibration: water
328	0–100 (g)	1073	

Comment: Zuca and Olteanu [11] report their density results for the equimolecular mixture in terms of a linear temperature dependent equation with a standard deviation of 8×10^{-4} g cm^{-3}. The precision of the density measurements was 0.1%. Experiments were carried out in an atmosphere of dry argon to avoid hydrolysis of LiCl.

TABLE 510. LiCl-RbCl: Density (g cm^{-3})

	Mol percent RbCl		
T	100	50	0
880			1.4987
890		2.0261	1.4945
900		2.0187	1.4902
910		2.0114	1.4860
920		2.0040	1.4817
930		1.9966	1.4775
940		1.9892	1.4733
950		1.9818	1.4690
960		1.9744	1.4648
970		1.9671	1.4605
980		1.9597	1.4563
990		1.9523	1.4520
1000		1.9449	1.4478
1010		1.9375	1.4436
1020	2.2179	1.9301	1.4393
1030	2.2094	1.9228	1.4351
1040	2.2008	1.9154	1.4308
1050	2.1923	1.9080	1.4266
1060	2.1838	1.9006	1.4223
1070	2.1753	1.8932	1.4181
1080	2.1668	1.8858	
1090	2.1583	1.8784	
1100	2.1498	1.8711	
1110	2.1413	1.8637	
1120	2.1327	1.8563	
1130	2.1242		
1140	2.1157		
1150	2.1072		
1160	2.0987		
1170	2.0902		
1180	2.0817		
1190	2.0731		

Temperature-dependent equations

$$\rho = a + bT$$

Mol % RbCl	a	$b \cdot 10^4$	Stand. deviation
0	1.8721	−4.243	0.0003
50	2.6833	−7.384	0.0008
100	3.0863	−8.514	0.0009

These values are based on the work of Zuca and Olteanu (Archimedean method) [**11**].

TABLE 511. Surface tension studies: LiCl-RbCl

Investigations critically re-examined		
Ref.	RbCl Mol %	Temp. range (T)
256	0–100	1073

Deviations from previous NSRDS recommendations: [2, pp. 55, 58]

Ref.	RbCl Mol %	Min. departure	Max. departure
256	0	5.15% (1073 K)	
256	100	0.27% (1073 K)	

Comment: An error of ±1 dyn cm^{-1} in the surface tension values was reported.

TABLE 512. LiCl-RbCl: Surface tension (dyn cm^{-1})

	Mol percent RbCl							
T	100	10.00	5.00	3.00	2.00	1.00	0.50	0
1023.2	96	113	118	119	121	122	124	127

These values are based on the work of Semenchencko and Shikobalova (maximum bubble pressure method) [**256**]. Due to limited data, the experimental values are given.

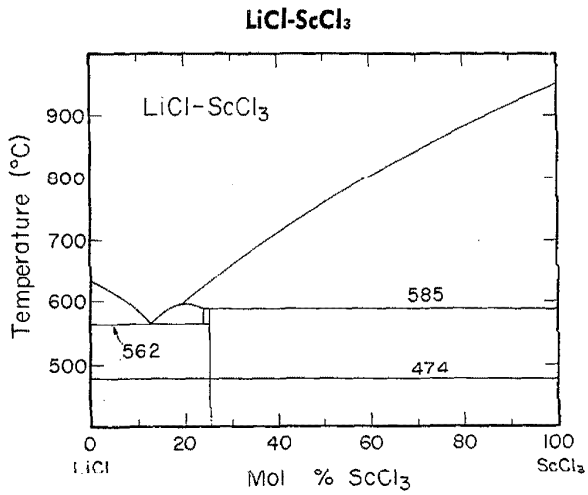

FIGURE 90. Temperature-composition phase diagram for LiCl-$ScCl_3$.

N. Ya. Fedorov and E. S. Petrov, Izv. Sib. Otd. Akad. Nauk, S.S.S.R., Ser. Khim. Nauk, 1, 48 (1967).

Melt Preparation and Purification

Petrov and Fedorov [**73**] prepared anhydrous $ScCl_3$ by chlorination of Mark 0S–99 scandium oxide using gaseous chlorine in the presence of a reducing agent. The $ScCl_3$ was sublimed in a current of chlorine. Anhydrous LiCl was prepared by the method of Raynor (Ber. Busengeselschaft, Phys. Chem., **67**, 360, 1963). The procedure essentially involved first heating the salt in an evacuated vessel at 95 °C for 24 hours to remove as much adsorbed moisture as possible. The temperature was then raised to 200 °C and the flask evacuated for a further 24 hours. This was followed by fusion in the presence of HCl gas and subsequent removal of dissolved gas by purging with dry nitrogen.

TABLE 513. Electrical conductance studies: LiCl-$ScCl_3$

Investigations critically re-examined			
Ref.	$ScCl_3$ Mol %	Temp. range (T)	Comments
73	0–72.6 (g)	373–1233	Cell material: quartz; Mo wire electrodes; calibration: 1N KCl solution

Comment: Due to the high volatility of $ScCl_3$ at high temperatures and the hygroscopicity of the starting materials, Fedorov and Petrov [73] measured the conductivity in sealed quartz vessels. The salts were loaded into the cell in a dry box and then fused, and mixed by transferring the mixture from one arm of the cell to the other until a uniform composition was attained. Reproducibility of experiments in the same cell was about 1%, and the overall accuracy of measurement was about 3%.

TABLE 514. LiCl-$ScCl_3$: Specific conductance (ohm^{-1} cm^{-1})

Mol % $ScCl_3$	933 K	993 K	1053 K	1113 K	1173 K	1233 K
0	6.11	6.30	6.55	6.74	6.86	6.99
10	3.77	4.02	4.34	4.59	4.80	5.07
20	2.78	3.01	3.30	3.49	3.65	3.84
30		2.45		2.56	2.67	2.78
40				1.80	1.89	1.96
50					1.20	1.52
60					0.97	1.27
70						1.03

These values have been interpolated to three significant figures from the graphical presentation of Fedorov and Petrov (classical ac technique) [73].

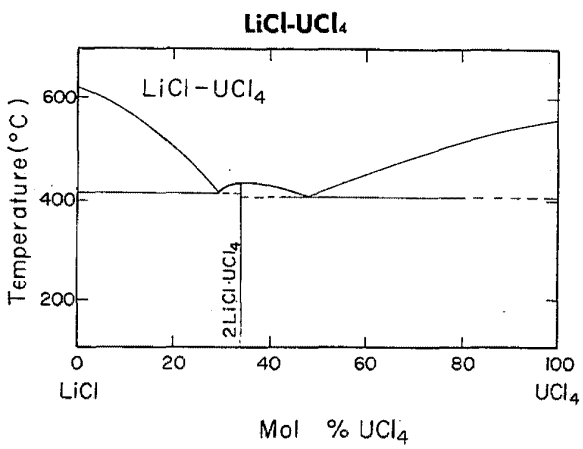

FIGURE 91. Temperature-composition phase diagram for LiCl-UCl_4.

C. J. Barton, R. J. Sheil and W. R. Grimes, Oak Ridge National Laboratory, Phase Diagrams of Nuclear Reactor Materials, R. E. Thoma, ed., ORNL-2548, p. 132 (1959).

Melt Preparation and Purification

Bogacz and Ziolek [179] used LiCl of BDH Analar grade as starting material. The salt was melted in a quartz tube for 30 minutes under a stream of dry HCl gas, and then transferred to a quartz evaporating dish. The salt was crushed and stored in a desiccator over P_2O_5 or kept in sealed ampoules. Uranium (IV) chloride was prepared from uranyl oxalate by hydrogen reduction at 400 °C to uranium dioxide, and then chlorinated at 440 °C using CCl_4 vapors contained in a stream of purified nitrogen. The purified salt was kept in sealed ampoules filled with dry argon.

Mixtures were prepared directly in the measuring cell in an argon atmosphere purified from moisture and oxygen. Even small traces of oxygen would result in chlorine evolution which reacted with the platinum components. Argon gas of 99.9% purity was further purified by passing it through a column filled with BTS catalyst, through a wash of aluminum and calcium amalgam and finally through a 80 cm. column of P_2O_5.

TABLE 515. Electrical conductance studies: LiCl-UCl_4

Investigations critically re-examined			
Ref.	UCl_4 Mol %	Temp. range (T)	Comments
179	0–100	703–1001	Cell material: quartz; Pt electrodes; freq. range: 5,000–10,000 Hz, measurements at 10,000 Hz; calibration: KCl solutions, fused KNO_3, $NaNO_3$, and KCl

Deviations from previous NSRDS recommendations: [1, pp. 4, 9]			
Ref.	UCl_4 Mol %	Min. departure	Max. departure
179	100	−0.91% (920 K)	−0.94% (910 K)
179	0	−1.8% (880 K)	−4.4% (890 K)

Comment: Bogacz and Ziolek [179] used the same quartz vessel for measurements of electrical conductance, density and surface tension. No frequency effect on the measured electrical resistance of the melts was found over the frequency range 5000 to 10,000 Hz. The overall error in conductivity measurement was reported at 0.5% or less.

TABLE 516. $LiCl-UCl_4$: Specific conductance ($ohm^{-1}\ cm^{-1}$)

	Mol percent UCl_4																					
T	100.00	85.24	78.44	75.30	67.78	61.96	55.58	53.60	47.16	43.39	41.64	38.92	33.29	31.22	27.79	20.44	16.01	10.97	8.90	8.31	3.79	0.0
710															1.483							
720															1.518							
730														1.459	1.553							
740														1.489	1.586							
750														1.519	1.620							
760							0.863							1.548	1.652							
770							0.884						1.555	1.576	1.684							
780							0.906						1.582	1.604	1.715							
790							0.927						1.609	1.631	1.746	2.022						
800					0.717		0.948				1.398		1.634	1.657	1.776	2.058						
810					0.737		0.968				1.423		1.658	1.682	1.806	2.093						
820					0.757	0.887	0.988	1.126	1.280		1.446		1.682	1.707	1.834	2.127	2.351					
830			0.595		0.775	0.907	1.008	1.148	1.302	1.431	1.469		1.704	1.731	1.863	2.160	2.387					
840			0.614		0.793	0.926	1.027	1.169	1.323	1.452	1.491	1.574	1.726	1.754	1.890	2.193	2.423					
850		0.535	0.632	0.674	0.811	0.944	1.046	1.189	1.343	1.473	1.512	1.595	1.747	1.776	1.917	2.224	2.457	3.008				
860		0.551	0.649	0.691	0.827	0.963	1.065	1.209	1.362	1.494	1.532	1.614	1.766	1.798	1.943	2.254	2.491	3.050	3.300	3.344		
870		0.566	0.665	0.707	0.843	0.980	1.083	1.228	1.381	1.514	1.552	1.634	1.785	1.819	1.969	2.284	2.525	3.088	3.338	3.384		
880	0.436	0.579	0.681	0.722	0.858	0.997	1.100	1.246	1.398		1.571	1.653	1.803	1.840	1.994	2.312	2.558	3.125	3.374	3.423	4.591	
890	0.451		0.696	0.737	0.872	1.014	1.118	1.264	1.415		1.589	1.672		1.859		2.340	2.590	3.158	3.408	3.462	4.636	5.700
900	0.465		0.710	0.751	0.886	1.030	1.135	1.282	1.431		1.606	1.690							3.440	3.500	4.679	5.754
910	0.479		0.724	0.765	0.899	1.045		1.298				1.709										5.808
920	0.492		0.736		0.911	1.060		1.315														5.863
930	0.505							1.330														
940	0.518							1.345														
950	0.530																					
960	0.542																					
970	0.554																					
980	0.565																					
990	0.576																					
1000	0.587																					

TABLE 516. LiCl-UCl_4: Specific conductance (ohm^{-1} cm^{-1})—Continued

Temperature-dependent equations $\kappa = a + bT + cT^2$				
Mol % UCl_4	a	$b \cdot 10^3$	$c \cdot 10^6$	Standard deviation
0.0	3.5985	−0.6244	3.3543	0.0018
3.79	−1.2113	8.7335	−2.4315	0.0002
8.31	−2.9183	10.5152	−3.7601	0.0002
8.90	−7.6414	21.5428	−10.2563	0.0012
10.97	−10.3904	27.2422	−13.5049	0.0008
16.01	−2.7227	8.7474	−3.1215	0.0005
20.44	−3.7492	10.9723	−4.6413	0.0003
27.79	−2.5870	7.9337	−3.0998	0.0002
31.22	−2.6963	8.3072	−3.5825	0.0002
33.29	−3.3389	9.9446	−4.6607	0.0010
38.92	−1.2908	4.7910	−1.6429	0.0003
41.64	−3.0185	8.5830	−3.8274	0.0002
43.39	−1.7917	5.6049	−2.0749	0.0002
47.16	−3.4994	9.4199	−4.3800	0.0007
53.60	−2.6089	6.9385	−2.9064	0.0002
55.58	−1.8947	5.0491	−1.8699	0.0015
61.96	−2.4925	6.2480	−2.5936	0.0002
67.78	−3.2406	7.8471	−3.6247	0.0009
75.30	−2.7934	6.4795	−2.8233	0.0003
78.44	−3.3512	7.6311	−3.4652	0.0003
85.24	−5.5651	12.6925	−6.4888	
100.00	−2.2782	4.6911	−1.8260	0.00025

These values are based on the work of Bogacz and Ziolek (classical ac technique) [179].

TABLE 517. Density studies: LiCl-UCl_4

Investigations critically re-examined		
Ref.	UCl_4 Mol %	Temp. range (T)
179	0–100	703–949

Deviations from previous NSRDS recommendations: [1, p. 4]			
Ref.	UCl_4 Mol %	Min. departure	Max. departure
179	0	0.25% (910 K)	0.50% (950 K)

Comment: Densities in reference [179] were determined by the Archimedean method using a 7.5 gram platinum ball suspended from a platinum wire of 0.08 mm diameter. The error in measurements was reported to be 0.1–0.2%. The density values for pure UCl_4 in reference [179] are about 2% higher than those of Kuroda and Suzuki [52] (KCl-UCl_4).

TABLE 518. $LiCl\cdot UCl_4$: Density (g cm^{-3})

	Mol percent UCl_4																		
T	100.00	85.24	78.44	75.30	61.96	53.60	47.16	43.39	41.64	38.92	31.22	27.79	20.44	16.01	8.90	8.31	5.66	3.79	0.00
710												2.894							
720											2.961	2.884							
730											2.951	2.875							
740											2.941	2.866							
750											2.931	2.857							
760											2.921	2.847							
770											2.911	2.838							
780											2.901	2.829							
790											2.891	2.819	2.637						
800										3.031	2.881	2.810	2.628						
810									3.061	3.020	2.871	2.801	2.620						
820					3.320	3.212	3.141		3.050	3.009	2.861	2.792	2.611	2.462					
830			3.455		3.307	3.202	3.129		3.039	2.998	2.851	2.782	2.603	2.454					
840			3.440		3.295	3.192	3.117	3.058	3.028	2.987	2.841	2.773	2.594	2.446					
850		3.500	3.425	3.414	3.283	3.182	3.105	3.048	3.018	2.976	2.831	2.764	2.586	2.438					
860		3.483	3.410	3.398	3.270	3.172	3.093	3.038	3.007	2.965	2.821	2.754	2.578	2.430	2.113	2.030			
870	3.558	3.466	3.395	3.383	3.258	3.162	3.082	3.028	2.996	2.954	2.811	2.745	2.569	2.421	2.103	2.022			
880	3.539	3.449	3.380	3.367	3.245	3.153	3.070	3.019	2.985	2.943	2.801	2.736	2.561	2.413	2.094	2.014	1.878	1.777	
890	3.519		3.365	3.351	3.233	3.142	3.058	3.009	2.975	2.932	2.791		2.552		2.084	2.005	1.870	1.772	1.501
900	3.500		3.350	3.335	3.220	3.133	3.046	2.999	2.964	2.921					2.075	1.997	1.862		1.498
910	3.480			3.319	3.208	3.123		2.990		2.910							1.854		1.494
920	3.461				3.195	3.113		2.980											1.491
930	3.441					3.103													
940	3.422					3.093													

Temperature-dependent equations

$\rho = a + bT$

Mol % LiCl	a	$b \cdot 10^3$	Standard deviation
0.00	1.8102	−0.3472	0.0001
3.79	2.2016	−0.4830	0.0003
5.66	2.5977	−0.8176	0.0002
8.31	2.7263	−0.8100	0.0002
8.90	2.9249	−0.9446	0.0006
16.01	3.1352	−0.8205	0.0001
20.44	3.3023	−0.8427	0.0001
27.79	3.5531	−0.9287	0.0003
31.22	3.6801	−0.9990	0.0003
38.92	3.9101	−1.0990	0.0003
41.64	3.9311	−1.0748	0.0003
43.39	3.8728	−0.9706	0.0005
47.16	4.1104	−1.1826	0.0004
53.60	4.0213	−0.9872	0.0005
61.96	4.3400	−1.2441	0.0002
75.30	4.7589	−1.5820	0.0004
78.44	4.6934	−1.4925	0.0003
85.24	4.9573	−1.7139	0.0012
100.00	5.2508	−1.9455	0.0006

These values are based on the work of Bogacz and Ziolek (Archimedean method) [179].

TABLE 519. Surface tension studies: $LiCl-UCl_4$

Investigations critically re-examined			
Ref.	UCl_4 Mol %	Temp. range (T)	Comments
179	0–100	883, 923	Cell material: quartz capillary tubes, melt in outer quartz tube; calibration: water, benzene, molten $NaNO_3$ and KNO_3

Deviations from previous NSRDS recommendations: [2, p. 55]			
Ref.	UCl_4 Mol %	Min. departure	Max. departure
179	0	11.8% (923 K)	

Comment: Bogacz and Ziolek [179] determined the surface tension of the molten salt mixtures by measuring the pressure difference required to release argon bubbles from two coaxial capillary tubes immersed in the melt at the same depth. The error in measurement was estimated to be between 3 and 5%.

TABLE 520. $LiCl-UCl_4$: Surface tension (dyn cm^{-1})

	Mol percent UCl_4															
T	100.00	92.80	74.36	61.25	59.38	53.39	47.32	44.16	33.89	32.50	27.38	17.90	13.76	8.47	4.30	0.00
883	40.0	40.5	43.5	45.5	47.0	48.0	54.0	57.0	64.5	61.5	66.0	68.5	72.4	77.0	94.5	147.9
923	35.5	36.5	40.5	42.0	43.5	45.0	52.5	56.5	63.0	60.0	64.0	63.0	65.5	71.0	86.0	141.5

These values are based on the work of Bogacz and Ziolek (maximum bubble pressure method) [179]. Due to limited data, the experimental results are given.

$LiCl-ZnCl_2$

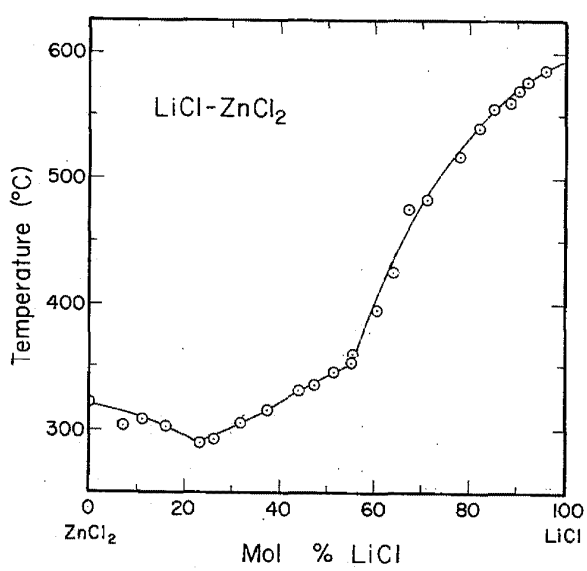

FIGURE 92. Temperature-composition phase diagram for $LiCl-ZnCl_2$.

N. N. Euseeva and A. G. Bergman, Z. Obshch. Khim., **21**, 1763 (1951).

Melt Preparation and Purification

Weeks [108] and Bloom and Weeks [199] used May and Baker LiCl, which was vacuum dried at 400 °C for one hour and then fused under dry argon. The salt was then purified by bubbling dry chlorine gas through the melt until it was clean. The preparation of $ZnCl_2$ is described under the system $CsCl-ZnCl_2$. Analysis for Zn^{2+} and Cl^- were performed using EDTA and silver nitrate (dichlorofluorescein indicator), respectively.

Markov and Bolkov [194] purified $ZnCl_2$ and LiCl in the manner described under the system $CsCl-ZnCl_2$.

TABLE 521. Density studies: $LiCl-ZnCl_2$

Investigations critically re-examined

Ref.	$ZnCl_2$ Mol %	Temp. range (T)	Comments
108	81.4–100	566–879	Cell material: silica pycnometer; calibration: water, 25 °C
194	0–100	695–924	Cell material: quartz sphere (containing tungsten for weight); calibration: water, 25 °C
199	81.4–100	566–879	Cell material: silica pycnometer; calibration: water, 25 °C

Comparisons with NSRDS recommendations: [1, pp. 4, 10 and this volume]

Ref.	$ZnCl_2$ Mol %	Min. departure	Max. departure
108	100	−0.08% (683 K)	0.40% (600 K)
194	100	−0.02% (733 K)	−0.16% (696 K)
199	100	−0.08% (683 K)	0.40% (600 K)
108	81.4	0.06% (759 K)	−0.71% (806 K)
194	0	−0.37% (924 K)	

Comment: Density measurements in reference [**108**, 199] were corrected for thermal expansion of the silica pycnometer and the total correction was 0.05–0.1%. The overall accuracy was reported to be between 0.05% and 0.1%. Experimental density values were reported in reference [**108**] while Bloom and Weeks [199] gave results in the form of linear temperature dependent equations with standard deviations in the range 0.92×10^{-3} g cm^{-3} (88.4 mol % $ZnCl_2$) to 1.13×10^{-3} g cm^{-3} (81.4 mol % $ZnCl_2$).

TABLE 522. $LiCl-ZnCl_2$: Density (g cm^{-3})

	Mol percent $ZnCl_2$													
T	100.0	94.8	90.1	81.4	79.6	76.2	69.95	59.8	49.8	39.9	29.4	19.6	9.02	0.0
700	2.472													
710	2.466													
720	2.461													
730	2.456													
740	2.451													
750								2.253						
760		2.416		2.350	2.379		2.304	2.246	2.182	2.120				
770		2.412		2.345	2.374		2.298	2.240	2.176	2.114				
780		2.407		2.340	2.369	2.309	2.293	2.234	2.171	2.108				
790		2.402		2.335	2.363	2.304	2.288	2.228	2.165	2.102				
800		2.397		2.329	2.358	2.298	2.282	2.222	2.159	2.096	1.994			
810		2.392	2.363	2.324	2.353	2.293	2.277	2.215	2.154	2.091	1.988			
820		2.387	2.358	2.319	2.348	2.288	2.271	2.209	2.148	2.085	1.983			
830		2.383	2.354	2.314	2.343	2.282	2.266	2.203	2.142	2.079	1.977			
840		2.378	2.350	2.309	2.337	2.277	2.260	2.197	2.137	2.073	1.972			
850		2.373	2.346	2.304	2.332	2.272	2.255	2.191	2.131	2.067	1.967	1.879		
860								2.184		2.061	1.961	1.871		
870								2.178		2.055		1.863		
880								2.172		2.049		1.855	1.687	
890													1.683	
900													1.680	1.488
910														1.484
920														1.480

TABLE 522. LiCl-$ZnCl_2$: Density (g cm^{-3})—Continued

Temperature-dependent equations $\rho = a + bT$			
Mol % $ZnCl_2$	a	$b \cdot 10^4$	Stand. error of est.
0.0	1.8514	−4.0345	0.01%
9.02	2.0210	−3.7939	0.04%
19.6	2.5643	−8.0647	0.28%
29.4	2.4288	−5.4389	0.02%
39.9	2.5682	−5.8972	0.44%
49.8	2.6138	−5.6810	0.06%
59.8	2.7188	−6.2145	0.06%
69.95	2.7168	−5.4332	0.31%
76.2	2.7263	−5.3488	0.07%
79.6	2.7748	−5.2072	0.01%
81.4	2.7361	−5.0830	0.28%
90.1	2.7038	−4.2109	0.03%
94.8	2.7824	−4.8163	0.09%
100.0	2.8369	−5.2167	0.00%

These values are based on the work of Markov and Bolkov (Archimedean method) [194].

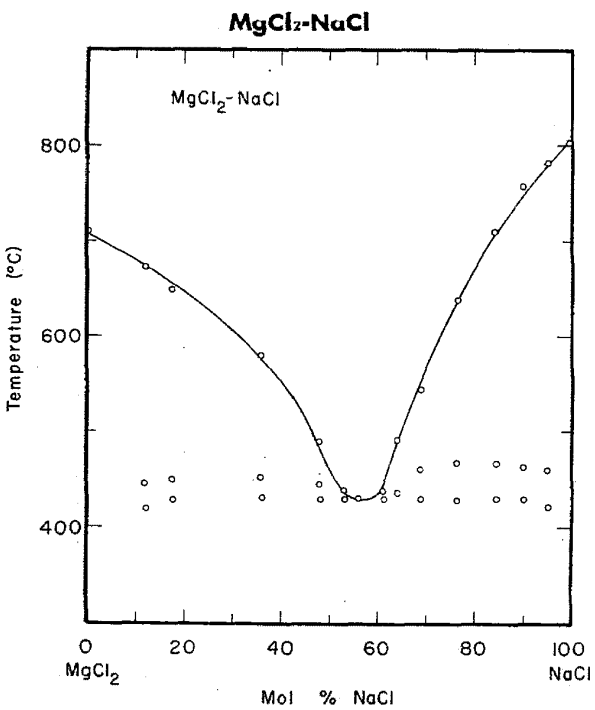

FIGURE 93. Temperature-composition phase diagram of $MgCl_2$-NaCl.

O. Menge, Z. Anorg. Chem., 72, 162 (1911).

Melt Preparation and Purification

Huber et al. [30] used c.p. analytical grade NaCl without further purification. The preparation of $MgCl_2$ is discussed under the system $BaCl_2$-$MgCl_2$.

Preparation of $MgCl_2$ in references [113, 114, 117] is discussed under the system KCl-$MgCl_2$. Markov and Shcrbakov [113] used "chemically pure" NaCl recrystallized twice and heated for two hours at 500 °C.

Lillebuen [130] and Grjotheim et al. [133] dehydrated NaCl (p.a., Baker) by heating at 500 °C under a vacuum of 0.1 to 0.01 mm. The preparation of pure $MgCl_2$ is described under the system $CaCl_2$-$MgCl_2$.

Desyatnikov [245] used chemically pure NaCl and $MgCl_2$; the MgO content in the anhydrous $MgCl_2$ was 0.2 to 0.4%. Dehydration of the $MgCl_2$ involved passing a stream of dry HCl gas through the melt for 6–8 hours, after which carbon dioxide was bubbled through for 20 to 30 minutes to displace the HCl.

Grjotheim et al. [109] dried "analytical grade" NaCl by heating at 300 °C and melting under vacuum. The salt was then slowly recrystallized and only clear crystals were used. The preparation of pure anhydrous $MgCl_2$ is described under the system $CaCl_2$-$MgCl_2$.

Mukaibo and Matsuno [246] used reagent grade $MgCl_2$ (Kauto Electrochem. Co.) without further purification. Sodium chloride was C.P. grade and was recrystallized.

TABLE 523. Electrical conductance studies: $MgCl_2$-NaCl

Investigations critically re-examined			
Ref.	NaCl Mol %	Temp. range (T)	Comments
30	54.87, 71.67 84.36, 100	906–1248	Cell material: silica cell; Pt electrodes; freq. range: 1000 Hz; calibration: saturated NaCl solution
109	0, 20, 40, 60 80, 100	956–1136	Cell material: Al_2O_3 tube in quartz tube container; Pt electrodes; freq. range: 2000–20,000 Hz; calibration: 1N KCl solution and saturated NaCl solution
113	42.12–100	953–1123	Cell material: quartz tube; Pt electrodes; calibration: sulfuric acid solutions
114	0–100	923–1123	Cell material: Pt cylinder, Pt disc electrodes; calibration: molten NaCl
117	0–100[a]	823–1023	Cell material: quartz vessel; Pt electrodes
151[b]	0–100 (g)	1073	
167	0–100[c]	1023–1173	

Comparisons with NSRDS recommendations: [1, pp. 4, 6 and this volume]

Ref.	NaCl Mol %	Min. departure	Max. departure
30	100	0.0% (1085 K)	−3.0% (1248 K)
109	100	0.29% (1126 K)	0.79% (1095 K)
113	100	1.9% (1123 K)	
114	100	−2.6% (1173 K)	−4.3% (1123 K)
167	100	−2.3% (1123 K)	−3.1% (1173 K)
113	100	1.6% (1123 K)	
114	100	−4.5% (1123 K)	
167	100	−2.9% (1123 K)	
114	80	−9.4% (1023 K)	
114	20	−7.6% (1023 K)	
109	0	0.36% (1038 K)	1.83% (1082 K)
114	0	−3.7% (1023 K)	−5.5% (1123 K)
117	0	0.65% (1023 K)	0.81% (973 K)
167	0	−0.25% (1073 K)	−5.4% (1173 K)
114	0	−3.7% (1023 K)	−6.6% (1023 K)
117	0	0.74% (1023 K)	
167	0	0.74% (1023 K)	−1.8% (1073 K)

[a]Graphical except for pure $MgCl_2$.
[b]Data (equivalent conductivities) from reference [167].
[c]Graphical except for pure salts.

Comment: A discussion of some experimental aspects in references [**109**] and [30] is given under the $CaCl_2$-KCl system.

TABLE 524. $MgCl_2$-NaCl: Specific conductance (ohm^{-1} cm^{-1})

Mol percent NaCl						
T	100	80	60	40	20	0
960				1.753		
970				1.784		
980				1.815	1.472	
990			2.136	1.845	1.496	

TABLE 524. $MgCl_2$-NaCl: Specific conductance (ohm^{-1} cm^{-1}) —Continued

Mol percent NaCl						
T	100	80	60	40	20	0
1000			2.156	1.876	1.520	
1010			2.177	1.907	1.544	
1020		2.877	2.197		1.567	1.073
1030		2.902	2.217		1.591	1.097
1040		2.926	2.238		1.615	1.121
1050		2.950	2.258		1.639	1.145
1060		2.974	2.278			1.169
1070			2.299			1.192
1080			2.319			1.216
1090			2.339			
1100	3.686					
1110	3.711					
1120	3.736					
1130	3.760					

Temperature-dependent equations
$\kappa = a + bT$

Mol % NaCl	a	$b \cdot 10^3$	Stand. error of est.
0	−1.3646	2.3899	0.01%
20	−0.8585	2.3784	0.30%
40	−1.1875	3.0634	0.31%
60	−0.1275	2.0290	0.25%
80	0.4203	2.4090	0.08%
100	0.9548	2.4828	0.02%

These values are based on the work of Grjotheim et al. (classical ac technique) [**109**].

TABLE 525. Density studies: $MgCl_2$-NaCl

Investigations critically re-examined			
Ref.	NaCl Mol %	Temp. range (T)	Comments
30	0–100	985–1241	Cell material: silica ball (hollow or solid), W suspension wire; calibration: water
130	0–100	1017–1172	Cell material: Pt–10%Rh sinker and Pt–10%Rh suspension wire; calibration: water
133[a]	0–100[b]	1073	Cell material and calibration: as for **130**
167	0–80 (g)	1023	
211, 267	0–100	800–1250	

Deviations from previous NSRDS recommendations: [1, pp. 4, 6]

Ref.	NaCl Mol %	Min. departure	Max. departure
30	100	~0% (1073 K)	−0.6% (1183 K)
130	100	0.39% (1088 K)	0.53% (1149 K)
30	0	0.49% (1140 K)	0.80% (1160 K)
130	0	0.30% (1017 K)	0.50% (1099 K)
133	0	0.50% (1073 K)	

[a]Data from reference [**130**].
[b]Graphical except for pure salts.

Comment: A brief disussion of the method of Lillebuen [**130**] and Grjotheim et al. [133] and the errors involved in their density measurements is to be found under the system LiCl-$MgCl_2$.

TABLE 526. $MgCl_2$-NaCl: Density (g cm^{-3})

	Mol percent NaCl											
T	100	90	80	70	60	50	40	30	20	10	0	60.1
1020											1.677	
1025											1.675	
1030										1.686	1.673	
1035										1.684	1.672	
1040									1.684	1.682	1.670	
1045								1.675	1.682	1.681	1.669	
1050							1.660	1.673	1.680	1.679	1.667	
1055						1.641	1.658	1.671	1.678	1.677	1.665	
1060				1.602	1.620	1.639	1.656	1.669	1.676	1.675	1.664	1.620
1065			1.584	1.599	1.618	1.636	1.653	1.667	1.674	1.673	1.662	1.617
1070		1.570	1.581	1.597	1.615	1.634	1.651	1.665	1.672	1.671	1.660	1.615
1075		1.568	1.579	1.594	1.613	1.631	1.649	1.662	1.670	1.670	1.659	1.612
1080		1.565	1.576	1.592	1.610	1.629	1.647	1.660	1.668	1.668	1.657	1.610
1085		1.562	1.573	1.589	1.607	1.627	1.644	1.658	1.666	1.666	1.655	1.607
1090	1.556	1.560	1.571	1.586	1.605	1.624	1.642	1.656	1.664	1.664	1.654	1.605
1095	1.553	1.557	1.568	1.584	1.602	1.622	1.639	1.654	1.662	1.662	1.652	1.602
1100	1.551	1.554	1.565			1.619	1.637	1.651	1.660			
1105	1.548	1.552	1.562			1.617	1.635	1.649	1.658			
1110	1.545	1.549	1.560			1.614	1.632	1.647	1.656			
1115	1.542	1.546					1.630	1.645	1.653			
1120	1.540	1.543					1.627	1.642				
1125	1.537						1.625	1.640				
1130	1.534											
1135	1.531											
1140	1.529											
1145	1.525											
1150	1.523											
1155	1.520											
1160	1.517											
1165	1.514											
1170	1.511											

Two-dimensional equation and statistical parameters

$$\rho = a + bC + cT^2 + dC^2 + eC^3 + fTC^2$$

a	$b \cdot 10^3$	$c \cdot 10^7$	$d \cdot 10^5$	$e \cdot 10^7$	$f \cdot 10^8$	Max. percent departure	Stand. error of est.
1.85184	−5.72548	−2.48988	2.44756	−3.61076	2.01655	−0.38% (1091.6 K, 23.6 mol % $MgCl_2$)	0.15%

These values are based on the work of Lillebuen (Archimedean method) **[130]**. C = mol % $MgCl_2$.

TABLE 527. $MgCl_2$-NaCl: Density (g cm^{-3})

	Mol percent NaCl											
T	100	95.0	89.0	76.4	71.1	66.3	58.2	48.5	37.7	25.6	17.7	0
1020											1.698	1.674
1030		1.588					1.637		1.674		1.693	1.671
1040		1.583			1.608		1.632	1.649	1.669		1.689	1.668
1050		1.578		1.598	1.603	1.612	1.627	1.644	1.664	1.679	1.684	1.666
1060		1.572		1.594	1.599	1.607	1.623	1.638	1.659	1.675	1.680	1.663
1070		1.567		1.590	1.595	1.602	1.618	1.633	1.653	1.670	1.675	1.660
1080		1.561	1.566	1.586	1.591	1.597	1.613	1.628	1.648	1.666	1.671	1.658
1090	1.554	1.556	1.561	1.581	1.587	1.593	1.608	1.623	1.643	1.662	1.667	1.655
1100	1.549	1.551	1.555		1.582	1.588	1.604	1.617	1.638	1.657	1.662	
1110	1.544	1.545	1.550			1.583		1.612	1.633	1.653	1.658	
1120	1.539	1.540	1.545					1.607	1.628	1.649		
1130	1.533											
1140	1.528											
1150	1.523											
1160	1.517											
1170	1.512											

TABLE 527. $MgCl_2$-NaCl: Density (g cm^{-3})—Continued

Temperature-dependent equations
$\rho = a + bT$

Mol % NaCl	a	$b \cdot 10^4$	Stand. error of est.
0	1.9483	−2.6917	0.03%
17.7	2.1501	−4.4361	0.01%
25.6	2.1348	−4.3414	0.01%
37.7	2.2029	−5.1352	0.07%
48.5	2.1967	−5.2669	0.04%
58.2	2.1253	−4.7419	0.02%
66.3	2.1182	−4.8222	0.03%
71.1	2.0431	−4.1877	0.03%
76.4	2.0488	−4.2896	0.02%
89.0	2.1392	−5.3070	0.01%
95.0	2.1429	−5.3845	0.02%
100	2.1321	−5.2995	0.04%

These values are based on the work of Lillebuen (Archimedean method) **[130]**.

TABLE 528. Viscosity studies: $MgCl_2$-NaCl

Investigations critically re-examined

Ref.	NaCl Mol %	Temp. range (T)
41	62.0	1061–1138
151	0–100[a]	973–1231
226	0–100	920–1250

Deviations from previous NSRDS recommendations: [1, p. 4]

Ref.	NaCl Mol %	Min. departure	Max. departure
151	100	−6.0% (1231 K)	−15.3% (1128 K)

[a]Graphical except for pure components.

Comment: The oscillation method used in reference **[151]** was checked by experimental measurements on water, nitrobenzene, aniline, molten sodium nitrate and potassium chloride. Agreement with literature values was satisfactory and the precision in viscosity measurements was reported to be ±5%.

TABLE 529. $MgCl_2$-NaCl: Viscosity (cp)

Mol % NaCl	973 K	1023 K	1073 K
0		2.05	1.80
10		1.87	1.66
20	1.99	1.69	1.52
30	1.80	1.53	1.40
40	1.60	1.38	1.24
50	1.40	1.22	1.08
60	1.22	1.06	0.95
70	1.38	1.24	1.08
80	1.45	1.34	1.16
90			1.19
100			1.20

These values have been interpolated to three significant figures from the graphical presentation of Bondarenko and Strelets (oscillating sphere method) **[151]**.

TABLE 530. Surface tension studies: $MgCl_2$-NaCl

Investigations critically re-examined

Ref.	NaCl Mol %	Temp. range (T)	Comments
245	0–100	973–1223	Cell material: Pt capillary and quartz beaker containing melt; calibration: water, alcohol
246	10–40, 100[a]	1013–1153	Cell material: Pt capillary tube; calibration: water and molten NaCl
253	0–100	1002–1169	Cell material: Density sinker and rod for surface tension measurements were made from Pt-10%Rh alloy; calibration: measurements on pure salts
258	0–100[b]	1073	Cell material and calibration: as for 253
226	0–100	870–1190	

Deviations from NSRDS recommendations:
[2, pp. 57, 59 and this volume]

Ref.	NaCl Mol %	Min. departure	Max. departure
245	100	0.18% (1123 K)	0.58% (1223 K)
246	100	−5.4% (1153 K)	−5.7% (1113 K)
253	100	1.7% (1169 K)	2.0% (1118 K)
253	70	−0.1% (1132 K)	1.7% (1031 K)
253	0	−5.9% (800 K)	−6.7% (729 K)

[a]Graphical except for pure NaCl.

[b]Graphical except for pure components.

Comment: Desyatnikov **[245]** reported that his surface tension measurements were reproducible to an accuracy of 0.8%. Results on the pure salts agreed with literature values obtained by other methods. Values for pure $MgCl_2$ were those recommended in NSRDS–NBS–28 [2].

Lillebuen [253] and Grjotheim et al. [258] reported a reproducibility for surface tension measurements of ±1%.

TABLE 531. $MgCl_2$-NaCl: Surface tension (dyn cm^{-1})

	Mol percent NaCl										
T	100	90	80	70	60	50	40	30	20	10	0
980			100.6	95.8	92.1	88.2	83.0	78.9	74.4	70.0	
990			100.1	95.5	91.7	88.0	82.7	78.7	74.2	69.9	
1000			99.7	95.1	91.4	87.7	82.5	78.5	74.1	69.8	66.7
1010			99.3	94.8	91.1	87.4	82.3	78.3	74.0	69.7	66.6
1020			98.8	94.4	90.7	87.2	82.0	78.1	73.8	69.6	66.5
1030		106.2	98.4	94.1	90.4	86.9	81.8	77.9	73.7	69.4	66.4
1040		105.7	98.0	93.7	90.1	86.6	81.6	77.7	73.5	69.3	66.3
1050		105.1	97.6	93.4	89.8	86.4	81.4	77.5	73.4	69.2	66.2
1060		104.5	97.1	93.0	89.4	86.1	81.1	77.3	73.3	69.1	66.1
1070		104.0	96.7	92.7	89.1	85.8	80.9	77.1	73.1	69.0	66.0
1080		103.4	96.3	92.3	88.8	85.5	80.7	76.9	73.0	68.8	65.9
1090	112.9	102.9	95.8	92.0	88.4	85.3	80.4	76.7	72.8	68.7	65.8
1100	112.2	102.3	95.4	91.6	88.1	85.0	80.2	76.5	72.7	68.6	65.7
1110	111.5	101.7	95.0	91.3	87.8	84.7	80.0	76.3	72.6	68.5	65.6
1120	110.8	101.2	94.5	90.9	87.4	84.5	79.7	76.1	72.4	68.4	65.5
1130	110.2	100.6	94.1	90.6	87.1	84.2	79.5	75.9	72.3	68.2	65.4
1140	109.5	100.1	93.7	90.2	86.8	83.9	79.3	75.7	72.1	68.1	65.3
1150	108.8	99.5	93.3	89.9	86.5	83.7	79.1	75.5	72.0	68.0	65.0
1160	108.1	98.9	92.8	89.5	86.1	83.4	78.8	75.3	71.9	67.9	65.1
1170	107.4	98.4	92.4	89.2	85.8	83.1	78.6	75.1	71.7	67.8	65.0
1180	106.8										64.9
1190	106.1										
1200	105.4										
1210	104.7										
1220	104.0										

Temperature-dependent equations

$$\gamma = a + bT$$

Mol % NaCl	a	$b \cdot 10^2$
0	76.7	−1.0
10	81.8	−1.2
20	88.1	−1.4
30	98.5	−2.0
40	105.5	−2.3
50	114.7	−2.7
60	124.4	−3.3
70	130.1	−3.5
80	142.7	−4.3
90	163.9	−5.6
100	187.0	−6.8

These values are based on the work of Desyatnikov (maximum bubble pressure method) [245].

$MgCl_2$-RbCl

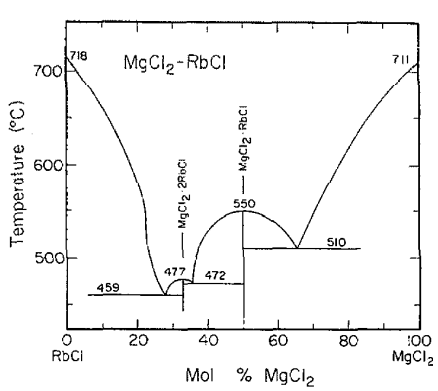

FIGURE 94. Temperature-composition phase diagram of $MgCl_2$-RbCl.

B. F. Markov and I. D. Panchenko. Zhur. Obschei Khim., **25**, 2039 (1955).

Melt Preparation and Purification

Grjotheim et al. [130,133] used Merck p.a. grade (min. 99.5% RbCl) RbCl, which was dehydrated by heating at 400 °C in an inert gas atmosphere. The preparation of pure $MgCl_2$ is described under the system $CaCl_2$-$MgCl_2$.

TABLE 532. Density studies: $MgCl_2$-RbCl

Investigations critically re-examined			
Ref.	RbCl Mol %	Temp. range (T)	Comments
130, 133[a]	0–100	959–1122	Cell material: Pt–10%Rh sinker and Pt–10%Rh suspension wire; calibration: water

Deviations from previous NSRDS recommendations: [1, p. 6]			
Ref.	RbCl Mol %	Min. departure	Max. departure
130	100	0.04% (1004 K)	0.14% (1112 K)
130	0	0.30% (1017 K)	0.50% (1099 K)

[a]Comments concerning references **[130]** and **[133]** are to be found under the system $CaCl_2$-KCl.

TABLE 533. $MgCl_2$-RbCl: Density (g cm^{-3})

	Mol percent RbCl												
T	100.0	94.4	84.9	75.5	68.8	66.7	63.0	51.6	31.9	20.0	14.3	7.7	0.0
960						1.976							
970						1.969							
980						1.962							
990						1.956							
1000						1.949		1.893					
1010	2.230		2.082			1.942		1.887	1.846				
1020	2.222		2.075	1.990		1.936		1.881	1.840			1.733	1.674
1030	2.213	2.159	2.067	1.983	1.944	1.929	1.912	1.875	1.833	1.813	1.782	1.729	1.671
1040	2.204	2.150	2.060	1.977	1.938	1.922	1.906	1.868	1.827	1.802	1.773	1.724	1.668
1050	2.196	2.142	2.053	1.970	1.932	1.916	1.899	1.862	1.821	1.792	1.764	1.720	1.666
1060	2.187	2.133	2.046	1.963	1.925	1.909	1.892	1.856	1.815	1.781	1.755	1.716	1.663
1070	2.178	2.125	2.039	1.957	1.919	1.902	1.886	1.850	1.808	1.771	1.746	1.712	1.660
1080	2.170	2.116	2.032	1.950	1.913		1.879	1.844		1.760	1.738	1.707	1.658
1090	2.161	2.108	2.025	1.943	1.906		1.873	1.838		1.750	1.729	1.703	1.655
1100	2.152	2.099		1.937	1.900		1.866	1.832		1.739	1.720	1.699	
1110	2.144	2.091		1.930	1.894		1.860			1.729	1.711	1.695	
1120				1.923						1.718			

Temperature-dependent equations

$$\rho = a + bT$$

Mol % RbCl	a	$b \cdot 10^3$	Stand. error of est.
0.0	1.9497	−0.2705	0.04%
7.7	2.1637	−0.4225	0.03%
14.3	2.6899	−0.8819	0.09%
20.0	2.8935	−1.0495	0.05%
31.9	2.4748	−0.6228	0.07%
51.6	2.5058	−0.6128	0.04%
63.0	2.5856	−0.6540	0.05%
66.7	2.6141	−0.6652	0.03%
68.8	2.5961	−0.6329	0.04%
75.5	2.6693	−0.6661	0.02%
84.9	2.7973	−0.7087	0.02%
94.4	3.0328	−0.8485	0.01%
100.0	3.1073	−0.8683	0.02%

These values are based on the work of Grjotheim et al. (Archimedean method) **[130, 133]**.

TABLE 534. Surface tension studies: $MgCl_2$-RbCl

Investigations critically re-examined			
Ref.	RbCl Mol %	Temp. range (T)	Comments
253, **258**[a]	0–100	967–1169	Cell material: density sinker and rod for surface tension measurements was made from Pt–10%Rh alloy; calibration: measurements on pure salts

Deviations from previous NSRDS recommendations [2, pp. 58, 59]			
Ref.	RbCl Mol %	Min. departure	Max. departure
253	100	−2.3% (1113 K)	−3.2% (1050 K)
253	0	−5.9% (800 K)	−6.7% (729 K)

[a]Lillebuen [**253**] reports a reproducibility for surface tension measurements of ±1%.

TABLE 535. $MgCl_2$-RbCl: Surface tension (dyn cm^{-1})

	Mol percent RbCl											
T	100.0	94.4	84.9	75.5	68.8	66.7	63.0	51.6	31.9	14.3	7.7	0.0
970						79.4						
980						78.9						
990						78.5						
1000						78.0						
1010	93.5		84.9			77.6		75.2	72.8			62.2
1020	92.8		84.3			77.1		74.7	72.4			62.2
1030	92.0		83.6	79.9	76.8	76.7	76.3	74.3	71.9	68.6	66.9	62.2
1040	91.3	87.2	82.9	79.4	76.4	76.3	75.8	73.8	71.5	68.3	66.7	62.2
1050	90.5	86.5	82.3	78.9	75.9	75.8	75.2	73.4	71.0	68.0	66.5	62.1
1060	89.8	85.9	81.6	78.4	75.5	75.4	74.7	72.9	70.6	67.8	66.3	62.1
1070	89.0	85.3	80.9	77.9	75.0	74.9	74.2	72.5	70.1	67.5	66.1	62.1
1080	88.3	84.6	80.3	77.5	74.6	74.5	73.7	72.0		67.2	65.9	62.0
1090	87.5	84.0	79.6	77.0	74.1		73.2	71.5		66.9	65.7	62.0
1100	86.8	83.4		76.5	73.7		72.6			66.7	65.5	62.0
1110	86.0	82.8		76.0	73.2		72.1			66.4		61.9
1120				75.6								61.9
1130												61.9
1140												61.8
1150												61.8
1160												61.8

Temperature-dependent equations

$$\gamma = a + bT$$

Mol % RbCl	a	$b \cdot 10^2$	Stand. error of est.
0.0	65.3426	−0.3073	0.09%
7.7	86.5949	−1.9163	0.10%
14.3	97.0127	−2.7599	0.05%
31.9	117.8016	−4.4561	0.60%
51.6	120.8727	−4.5257	0.03%
63.0	130.0286	−5.2186	0.00%
66.7	122.6536	−4.4621	0.28%
68.8	123.7692	−4.5565	0.20%
75.5	128.8105	−4.7538	0.02%
84.9	152.4109	−6.6810	0.11%
94.4	152.4464	−6.2780	0.03%
100.0	169.2893	−7.5036	0.23%

These values are based on the work of Grjotheim et al. (pin detachment method) [**253**, **258**].

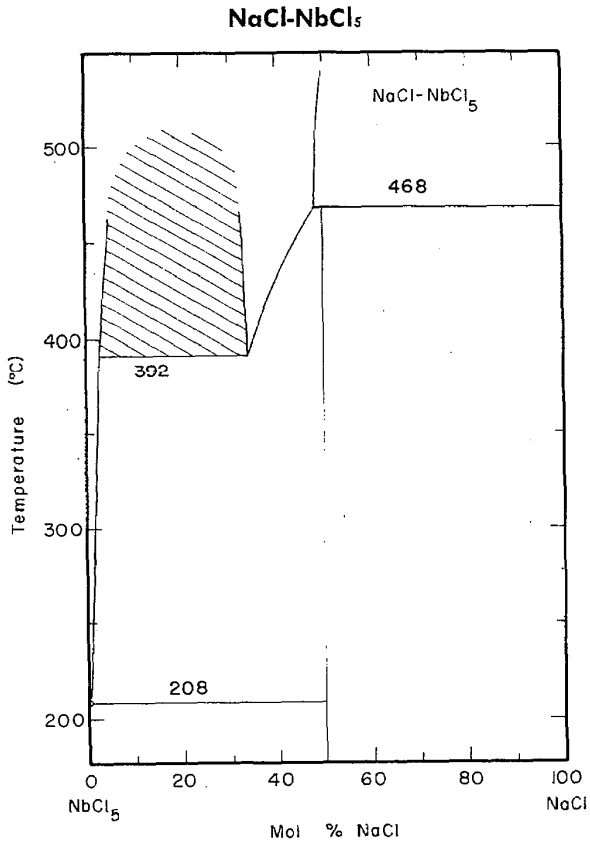

FIGURE 95. Temperature-composition phase diagram of $NaCl-NbCl_5$.

K. Huber, E. Jost, E. Neuenschu Ander, M. Studer, and B. Roth, Helv. Chim Acta, **XLI**, 2411 (1958).

TABLE 536. Electrical conductance studies: $NaCl-NbCl_5$

Investigations critically re-examined			
Ref.	$NbCl_5$ Mol %	Temp. range (T)	Comments
54	0–21.7	1073, 1123	Cell material: Pyrex and quartz vessels; Pt electrodes; freq. range: variable; calibration: 1N KCl solution

Deviations from previous NSRDS recommendations: [1, p. 4]			
Ref.	$NbCl_5$ Mol %	Min. departure	Max. departure
54	0	−3.5% (1123 K)	−3.9% (1073 K)

Comment: Belozerskii and Freidina [**54**] used Pyrex and quartz conductance vessels for systems rich and poor in the rare earth chloride respectively. Due to the volatility of the chloride and the strong tendency for $NbCl_5$ to dissociate the duration of experiments was minimized.

TABLE 537. $NaCl-NbCl_5$: Specific conductance (ohm^{-1} cm^{-1})

	Mol percent $NbCl_5$					
T	21.7	12.4	12.3	7.9	7.2	0
1073.2	1.32	2.20	2.19			3.34
1123.2	1.83	2.60	2.59	2.98	2.94	3.60

These values are based on the work of Belozerskii and Freidina (classical ac technique) [**54**]. Due to limited data, the experimental results are given.

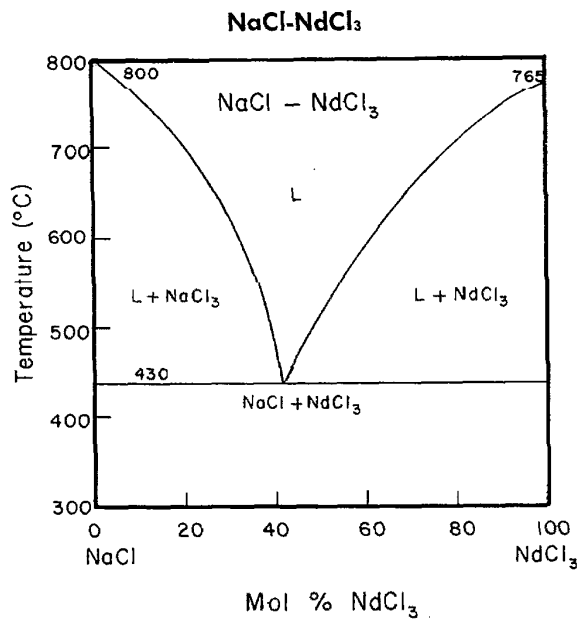

FIGURE 96. Temperature-composition phase diagram for $NaCl-NdCl_3$.

I. S. Morozov, Z. N. Sheutsova and L. V. Klyukina, Russ. J. Inorg. Chem., **7**, 1639 (1957).

Melt Preparation and Purification

Details are given under the system $KCl-NdCl_3$.

TABLE 538. Electrical conductance studies: $NaCl-NdCl_3$

Investigations critically re-examined			
Ref.	$NdCl_3$ Mol %	Temp. range (T)	Comments
186[a]	0–100 (g)	1073	Cell material and calibration: as for **190**
190[a]	0–100 (g)	1073, 1173	Cell material: quartz capillary cell; Pt electrodes; freq. range: 100,000–250,000 Hz; calibration: molten NaCl, KCl, CsCl

[a]Equivalent conductivities were reported.

Comment: Forthmann et al. [186, **190**] initially filled their quartz conductance cells with $NdCl_3$ under Ar flow; the pure $NdCl_3$ was melted and HCl gas was passed through the melt until the conductance was constant. Compositions were varied by adding the solid alkali chloride.

TABLE 539. $NaCl-NdCl_3$: Molar conductance (ohm^{-1} cm^2 mol^{-1})

Mol % NaCl	1073 K	Mol % NaCl	1073 K
0	74.3	60	94.0
10	76.2	70	98.4
20	78.9	80	105.
30	81.8	90	119.
40	86.1	100	135.
50	90.1		

These values have been interpolated to three significant figures from the graphical presentation of Forthmann and Schneider (classical ac technique) [190].

$NaCl-PbCl_2$

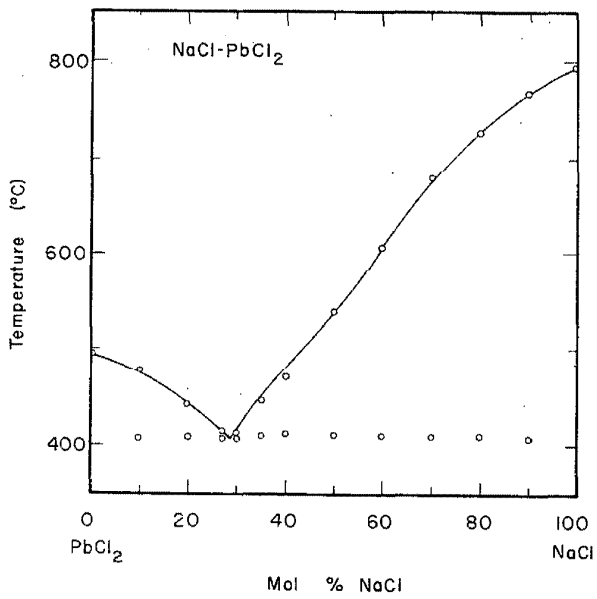

FIGURE 97. Temperature-composition phase diagram for $NaCl-PbCl_2$.

K. Treis Neues Jahrb. Mineral., Geol., Paläontol., Beil. Band, **37**, 766 (1914).

Melt Preparation and Purification

Bloom et al. [**103**] and Bloom and Macky [**49**] used analytical reagent grade sodium chloride. Their preparation of pure lead chloride is given under the system $CsCl-PbCl_2$. The solidified melts were analyzed by standard methods.

Bloom, Davis and James [**224**] used salts of analytical reagent purity which were dried before use. Mixtures were prepared by weighing the dried salts directly into silica tubes.

Dahl and Duke [238] used "Baker Analyzed" reagent grade sodium chloride. The preparation of dry $PbCl_2$ is described under the $CsCl-PbCl_2$ system.

Barzakovskii [63] used "chemically pure" salts which were purified by fusion in an atmosphere of dry HCl for a period of 2–3 hours.

TABLE 540. Electrical conductance studies: $NaCl-PbCl_2$

Investigations critically re-examined			
Ref.	$PbCl_2$ Mol %	Temp. range (T)	Comments
24	45.6, 68, 89, 100	773, 873	Cell material: quartz; Pt electrodes; freq. range: 20–20,000 Hz; calibration: KCl solutions
49	20–100	773–1083	Cell material: silica; Pt electrodes; freq. range: 1000 Hz; calibration: 1N KCl solutions
63	45.6, 68, 89, 100	678–1093	Cell material and calibration: as for 24
142[a]	20–100 (g)	993	Cell material and calibration: as for **49**

Deviations from previous NSRDS recommendations: [1, p. 13]			
Ref.	$PbCl_2$ Mol %	Min. departure	Max. departure
24	100	−0.93% (873 K)	
49	100	−0.41% (873 K)	−0.70% (923 K)
63	100	−0.19% (924 K)	−3.9% (841 K)

[a]Data from reference [**49**].

Comment: Bloom and Macky [**49**] estimated the accuracy of their conductance measurements on molten mixtures to be ±0.5%.

TABLE 541. NaCl-$PbCl_2$: Specific conductance (ohm^{-1} cm^{-1})

	Mol percent $PbCl_2$						
T	100.0	90.0	80.0	72.0	50.0	33.3	20.0
780			1.544	1.558			
790			1.587	1.607			
800			1.630	1.656			
810			1.672	1.704			
820			1.715	1.751			
830	1.737	1.755	1.758	1.797			
840	1.780	1.800	1.801	1.843			
850	1.823	1.845	1.844	1.887			
860	1.865	1.889	1.886	1.931			
870	1.908	1.932	1.929	1.974			
880	1.950	1.975	1.972	2.016	2.046		
890	1.991	2.016	2.015	2.058	2.084		
900	2.033	2.057	2.058	2.099	2.122		
910	2.074	2.098	2.101	2.139	2.160		
920	2.115	2.137	2.144	2.178	2.198		
930	2.156	2.178	2.187	2.216	2.236		
940	2.196	2.214	2.230	2.253	2.274		
950	2.236	2.251	2.273	2.290	2.312	2.447	
960	2.276	2.287	2.316	2.326	2.350	2.485	
970	2.315	2.323	2.359	2.361	2.388	2.523	
980	2.354	2.358	2.402	2.395	2.426	2.560	
990	2.393	2.392	2.445	2.429	2.464	2.598	
1000	2.432	2.425	2.488	2.462	2.502	2.635	
1010	2.470	2.458	2.532	2.493	2.540	2.672	
1020	2.508	2.490	2.575	2.524	2.578	2.708	
1030	2.546	2.521	2.618	2.555	2.616	2.745	
1040	2.583	2.551	2.661	2.584	2.654	2.781	
1050	2.621	2.581	2.704	2.613	2.692	2.817	
1060	2.658	2.610	2.748	2.641	2.730	2.853	3.115
1070	2.694	2.638	2.791	2.668	2.768	2.889	3.185
1080							3.255

Temperature-dependent equations

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

Mol % $PbCl_2$	a	$b \cdot 10^3$	$c \cdot 10^7$	Stand. error of est.
20.0	−4.2948	6.9903	0	0.02%
33.3	−2.1546	5.8766	−10.872	0.01%
50.0	−1.2982	3.8000	0	0.00%
72.0	−4.7648	11.224	−39.975	0.17%
80.0	−1.7172	4.0950	1.1064	0.08%
90.0	−4.6606	10.872	−37.860	0.22%
100.0	−2.8404	6.6977	−14.256	0.32%

These values are based on the work of Bloom and Macky (classical ac technique) [**49**].

TABLE 542. Density studies: NaCl-$PbCl_2$

Investigations critically re-examined				
Ref.	$PbCl_2$ Mol %	Temp. range (T)	Cell Material	Calibration
24	49.8–100	773, 873		
103	24.8–100	770–1075	Sinker of 10% Rh–Pt	Water
142	0–100 (g)	993		
165	50	673–973		
193	20–100	873, 973		

TABLE 542. Density studies: NaCl-$PbCl_2$

Deviations from previous NSRDS recommendations: [1, p. 13]			
Ref.	$PbCl_2$ Mol %	Min. departure	Max. departure
24	100	−0.41% (773 K)	−1.0% (873 K)
103	100	−0.04% (920 K)	−0.02% (960 K)
193	100	0.23% (873 K)	

Comment: Corrections were made by Bloom et al. [**103**] for melt condensation on the suspension wire, upthrust due to surface tension and the buoyancy of the sinker in air. Condensation was found to be a problem only for melts of pure $PbCl_2$. Total corrections amounted to 0.1 to 0.2%. Data was given in the form of linear temperature dependent equations with standard deviations in the range: 2.0×10^{-3} g cm^{-3} (100 mol % $PbCl_2$) to 3.0×10^{-3} g cm^{-3} (24.8, 50.0 and 75 mol % $PbCl_2$).

TABLE 543. $NaCl-PbCl_2$: Density (g cm^{-3})

	Mol percent $PbCl_2$			
T	100.0	75.0	50.0	24.8
770		4.394		
780		4.381		
790		4.367		
800		4.354		
810		4.340		
820		4.327		
830		4.313	3.635	
840		4.300	3.624	
850		4.286	3.613	
860		4.273	3.601	
870		4.259	3.590	
880		4.246	3.579	
890		4.232	3.568	
900		4.219	3.555	
910		4.205	3.545	
920	4.730	4.192	3.534	
930	4.715	4.178	3.523	
940	4.701	4.165	3.512	
950	4.686	4.151	3.500	
960	4.671	4.137	3.489	
970	4.656	4.124	3.478	
980	4.642		3.467	2.670
990	4.627		3.455	2.662
1000	4.612		3.444	2.653
1010	4.597		3.433	2.644
1020	4.582		3.422	2.636
1030	4.568		3.410	2.627
1040	4.553			2.618
1050	4.538			2.610
1060	4.523			2.601
1070				2.593

Temperature-dependent equations

$\rho = a + bT$

Mol % $PbCl_2$	a	$b \cdot 10^3$	Stand. deviation
24.8	3.517	−0.864	0.003
50.0	4.568	−1.124	0.003
75.0	5.435	−1.352	0.003
100.0	6.089	−1.477	0.002

These values are based on the work of Bloom et al. (Archimedean method) [**103**].

TABLE 544. Surface tension studies: $NaCl-PbCl_2$

Investigations critically re-examined

Ref.	$PbCl_2$ Mol %	Temp. range (T)	Comments
224	0, 25.0, 50.0, 75.2, 100	~723–1293	Cell material: capillary of Pt–10%Rh; calibration: microscope used to determine diameter of capillary, method checked using benzene
238	48.5, 54.1, 61.2, 80.4, 100	768–863	Cell material and calibration: as for **224**; melt contained in Pt crucible
250	0, 50, 75, 90, 100	773, 873, 1073, 1173, 1273	
254	0–100	768–1210	Cell material and calibration: as for 238

Deviations from previous NSRDS recommendations: [2, pp. 57, 61]

Ref.	$PbCl_2$ Mol %	Min. departure	Max. departure
224	100	−0.08% (813 K)	0.31% (853 K)
250	75	5.7% (773 K, 873 K)	
250	50	3.9% (773 K)	5.0% (873 K)
224	0	0.19% (1193 K)	1.8% (1093 K)
250	0	0.19% (1173 K)	
254	0	−1.9% (1126 K)	−3.0% (1099 K)

Comment: Bloom et al. [**224**] reported an accuracy in their method of ±0.25 dyn cm^{-1}. The temperature range studied was stated as 200 °C with an initial temperature of about 10 °C above the melting point. Remarks concerning reference [238] are given under the system $LiCl-PbCl_2$.

Values for pure $PbCl_2$, reported by Dahl and Duke [238, 254] were recommended in NSRDS–NBS–28 [2].

TABLE 545. NaCl-$PbCl_2$: Surface tension (dyn cm^{-1})

	Mol percent $PbCl_2$				
T	100.0	75.0	50.0	24.8	0.0
720		134.1			
740		132.0			
760		130.0			
780		127.9			
800	134.2	125.9			
820	132.0	123.9			
840	129.8	121.8	124.6		
860	127.6	119.8	122.5		
880	125.4	117.7	120.3		
900	123.2	115.7	118.2		
920	121.0	113.7	116.1		
940	118.8		113.9		
960	116.6		111.8		
980	114.4		109.6		
1000			107.5	112.6	
1020			105.4	110.6	
1040				108.6	
1060				106.6	
1080				104.6	
1100				102.6	113.9
1120				100.6	112.0
1140				98.6	110.2
1160				96.6	108.3
1180				94.6	106.5
1200					104.6
1220					102.7
1240					100.9
1260					90.0
1280					97.2

Temperature-dependent equations

$\gamma = a + bT$

Mol % $PbCl_2$	a	$b \cdot 10^2$
0.0	216.2	−9.3
24.8	212.6	−10.0
50.0	214.5	−10.7
75.0	207.5	−10.2
100.0	222.2	−11.0

These values are based on the work of Bloom et al. (maximum bubble pressure method) [**224**].

NaCl-$PrCl_3$

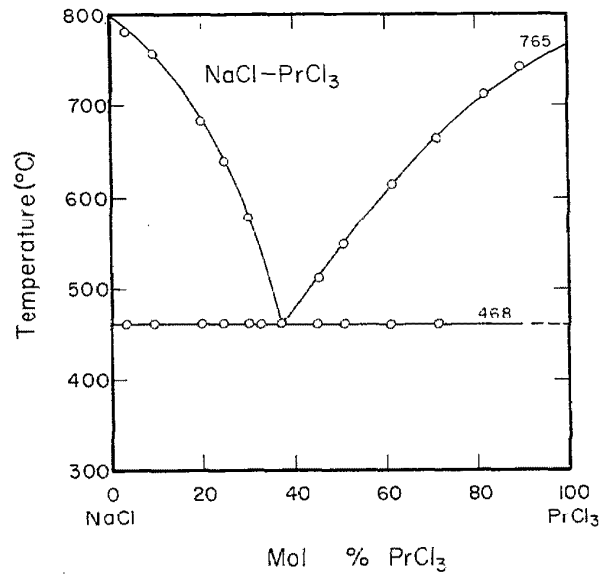

FIGURE 90. Temperature-composition phase diagram for NaCl-$PrCl_3$.

Z. N. Slestsona, E. N. Karzina and B. G. Karshunan, Russ. J. Inorg. Chem., 7, 1348 (1962).

Melt Preparation and Purification

Praseodymium trichloride was prepared and analyzed as described under the system KCl-$NdCl_3$.

TABLE 546. Electrical conductance studies: NaCl-$PrCl_3$

Investigations critically re-examined			
Ref.	$PrCl_3$ Mol %	Temp. range (T)	Comments
190[a]	0–100 (g)	1073	Cell material: quartz capillary cell; Pt electrodes; freq. range: 100,000–250,000 Hz; calibration: molten CsCl, KCl, NaCl

[a]Equivalent conductivities were reported.

Comment: Experimental details are briefly discussed under the system KCl-$NdCl_3$.

TABLE 547. NaCl-$PrCl_3$: Molar conductance (ohm^{-1} cm^2 mol^{-1})

Mol % NaCl	1073 K	Mol % NaCl	1073 K
0	76.4	60	92.9
10	78.7	70	96.3
20	80.9	80[a]	103.
30	83.4	90[a]	114.
40	86.5	100[a]	133.
50	89.5		

[a]Extrapolated values.

These values have been interpolated to three significant figures from the graphical presentation of Forthmann and Schneider (classical ac technique) [**190**].

NaCl-RbCl

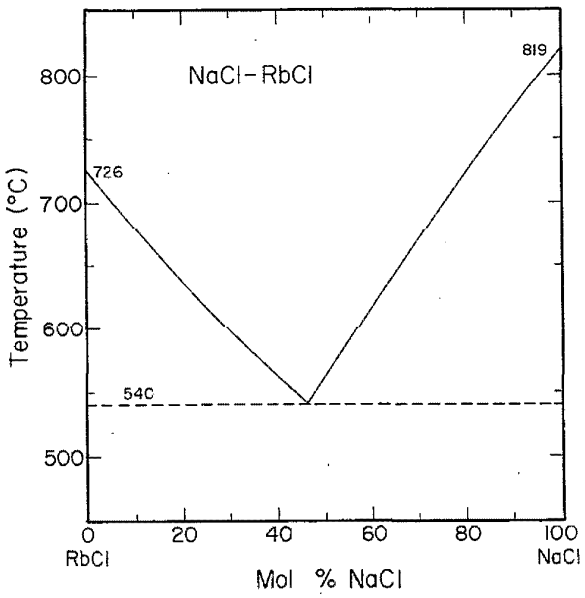

FIGURE 99. Temperature-composition phase diagram for NaCl-RbCl.

S. Zhenchuzhuni and F. Rambach, Z. Anorg. Chem., **65**, 415 (1910).

Melt Preparation and Purification

The preparation of pure sodium and rubidium chlorides by Zuca and Olteanu [**98**] is discussed under the CsCl-LiCl system. Dry argon was bubbled through the molten mixtures to eliminate small traces of HCl.

For viscosity measurements, Bertozzi [243] used carefully dried Merck and B. D. H. salts without further purification.

TABLE 549. NaCl-RbCl: Specific conductance (ohm^{-1} cm^{-1})

	Mol % RbCl				
T	100	75	50	25	0
1020	1.574				
1030	1.596				
1040	1.618				
1050	1.640	1.786		2.504	
1060	1.662	1.809	2.060	2.527	
1070	1.683	1.831	2.082	2.550	
1080	1.704	1.852	2.104	2.573	
1090	1.725	1.873	2.125	2.596	3.626
1100	1.745	1.894	2.147	2.619	3.652
1110	1.766	1.914	2.168	2.642	3.677
1120	1.785	1.934	2.190	2.665	3.702
1130	1.805	1.954	2.211	2.688	3.726
1140	1.824	1.973	2.233	2.711	3.749
1150	1.843	1.992	2.255	2.734	3.773
1160	1.862	2.010			3.795
1170	1.880				3.817
1180	1.889				
1190	1.916				

Temperature-dependent equations

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

Mol % RbCl	a	$b \cdot 10^3$	$c \cdot 10^6$	Stand. error of est.
0	−2.4204	8.4918	−2.7014	0.01%
25	0.0825	2.3058	0	0.19%
50	−0.2315	2.1618	0	0.17%
75	−2.7395	6.3710	−1.9625	0.10%
100	−2.3072	5.3381	−1.5035	0.02%

These values are based on the work of Zuca and Olteanu (classical ac technique) [**98**].

TABLE 548. Electrical conductance studies: NaCl-RbCl

Investigations critically re-examined			
Ref.	RbCl Mol %	Temp. range (T)	Comments
98	0, 25, 50, 75, 100	993–1233	Cell material: quartz or silica glass capillary cell; Pt electrodes; freq. range: 1000–7000 Hz; calibration: 0.1M and 1.0M KCl solutions
218	eutectic (g)	1106–1384	

Deviations from previous NSRDS recommendations: [1, pp. 4, 6]			
Ref.	RbCl Mol %	Min. departure	Max. departure
98	100	0.12% (1010 K)	−4.4% (1200 K)
98	0	−0.11% (1090 K)	−1.40% (1170 K)

Comment: Zuca and Olteanu [**98**] report, in addition to experimental specific conductivities, Arrhenius equations (equivalent conductances as a function of temperature) with standard deviations for E_λ, the activation energy, in the range: 1.3×10^{-2} Kcal mol^{-1} (75 mol % RbCl, $E_\lambda = 3.65$ Kcal mol^{-1}) to 2.8×10^{-2} Kcal mol^{-1} (100 mol % RbCl, $E_\lambda = 3.75$ Kcal mol^{-1}).

TABLE 550. Density studies: NaCl-RbCl

Investigations critically re-examined			
Ref.	RbCl Mol %	Temp. range (T)	Comments
98	0, 25, 50, 75, 100	1013–1223	Cell material: Pt ball; calibration: water
328	0–100 (g)	1073	

Deviations from previous NSRDS recommendations: [1, pp. 4, 6]			
Ref.	RbCl Mol %	Min. departure	Max. departure
98	100	−0.02% (1080 K)	0.15% (1200 K)
98	0	−0.06% (1090 K)	−0.13% (1170 K)

Comment: Density results in [**98**] were reported as linear temperature-dependent equations with standard deviations in the range: 2×10^{-4} g cm^{-3} (0 mol % RbCl) to 9×10^{-4} g cm^{-3} (100 mol % RbCl).

TABLE 551. NaCl-RbCl: Density (g cm^{-3})

	Mol percent RbCl											
T	100	90	80	70	60	50	40	30	20	10	0	55
1000			2.137	2.083								
1010		2.178	2.128	2.075	2.019	1.959	1.895	1.829	1.759			1.989
1020	2.217	2.170	2.120	2.067	2.010	1.951	1.887	1.821	1.751			1.981
1030	2.208	2.162	2.112	2.059	2.002	1.943	1.880	1.813	1.743			1.973
1040	2.200	2.154	2.104	2.051	1.994	1.935	1.872	1.805	1.736	1.663		1.965
1050	2.192	2.145	2.096	2.043	1.987	1.927	1.864	1.798	1.728	1.655		1.957
1060	2.183	2.137	2.088	2.035	1.979	1.919	1.856	1.790	1.721	1.648		1.949
1070	2.175	2.129	2.079	2.027	1.971	1.911	1.849	1.782	1.713	1.640		1.941
1080	2.166	2.121	2.071	2.019	1.963	1.903	1.841	1.775	1.706	1.633		1.933
1090	2.158	2.112	2.063	2.011	1.955	1.896	1.833	1.767	1.698	1.626	1.550	1.925
1100	2.150	2.104	2.055	2.003	1.947	1.888	1.826	1.760	1.691	1.619	1.543	1.918
1110	2.141	2.096	2.047	1.995	1.939	1.880	1.818	1.753	1.684	1.612	1.536	1.910
1120	2.133	2.087	2.039	1.987	1.931	1.873	1.811	1.745	1.677	1.605	1.529	1.902
1130	2.124	2.079	2.031	1.979	1.924	1.865	1.803	1.738	1.670	1.598	1.523	1.895
1140	2.116	2.071	2.022	1.971	1.916	1.858	1.796	1.731	1.663	1.591	1.516	1.887
1150	2.107	2.062	2.014			1.850	1.789	1.724	1.656	1.584	1.509	1.879
1160	2.099	2.054	2.006				1.781	1.717	1.649	1.578	1.503	
1170	2.090	2.046							1.642	1.571	1.497	
1180	2.082	2.037										
1190	2.073	2.029										
1200	2.064	2.021										
1210	2.056											
1220	2.047											
1230	2.039											

Two-dimensional equation and statistical parameters

$$\rho = a + bT^2 + cC^2 + dT^3 + eTC + fCT^2$$

a	$b \cdot 10^7$	$c \cdot 10^5$	$d \cdot 10^{10}$	$e \cdot 10^6$	$f \cdot 10^9$	Max. percent departure	Stand. error of est.
2.73858	−6.92120	−1.66805	1.86672	−9.50064	5.00290	0.47% (1173.2 K, 75 mol % NaCl)	0.12%

These values are based on the work of Zuca and Olteanu (Archimedean method) [98]. $C =$ mol % NaCl.

TABLE 552. NaCl-RbCl: Density (g cm^{-3})

	Mol % RbCl				
T	100	75	50	25	0
1000		2.108			
1010		2.100	1.958	1.797	
1020	2.218	2.092	1.950	1.789	
1030	2.209	2.084	1.943	1.781	
1040	2.201	2.076	1.936	1.773	
1050	2.192	2.068	1.928	1.765	
1060	2.184	2.060	1.921	1.757	
1070	2.175	2.052	1.914	1.749	
1080	2.167	2.044	1.906	1.741	
1090	2.158	2.036	1.899	1.733	1.546
1100	2.150	2.028	1.892	1.725	1.540
1110	2.141	2.020	1.885	1.717	1.535
1120	2.133	2.012	1.877	1.709	1.529
1130	2.124	2.004	1.870	1.701	1.524
1140	2.116	1.996	1.863	1.693	1.518
1150	2.107	1.988	1.855	1.685	1.513
1160	2.099			1.677	1.508
1170	2.090			1.669	1.502
1180	2.082				
1190	2.073				
1200	2.065				
1210	2.056				
1220	2.048				
1230	2.039				

TABLE 552. NaCl-RbCl: Density (g cm^{-3})—Continued

Temperature-dependent equations
$\rho = a + bT$

Mol % RbCl	a	$b \cdot 10^3$	Stand. dev.
0	2.1390	−0.5444	0.0002
25	2.6034	−0.7988	0.0005
50	2.6952	−0.7303	0.0007
75	2.9095	−0.8016	0.0007
100	3.0863	−0.8514	0.0009

These values are based on the work of Zuca and Olteanu (Archimedean method) [**98**].

TABLE 553. Surface tension studies: NaCl-RbCl

Investigations critically re-examined

Ref.	RbCl Mol %	Temp. range (T)
243	0, 25, 50, 75, 100	860–1160

Deviations from previous NSRDS recommendations: [2, pp. 57, 58]

Ref.	RbCl Mol %	Min. departure	Max. departure
243	100	0.2% (1120 K)	1.2% (1040 K)
243	0	3.2% (1140 K)	3.4% (1100 K)

Comment: Experimental aspects of this work [**243**] are discussed in NSRDS–NBS–28 [2].

TABLE 554. NaCl-RbCl: Surface tension (dyn cm^{-1})

	Mol % RbCl											
T	100	90	80	70	60	50	40	30	20	10	0	55
865					111.1	113.0						112.0
880				108.5	110.0	111.9	114.2					110.9
895				107.4	108.9	110.7	113.1					109.8
910				106.3	107.8	109.6	112.0					108.6
925			103.8	105.1	106.6	108.5	110.9					107.5
940			102.7	104.0	105.5	107.4	109.8	112.8				106.4
955			101.6	102.9	104.4	106.3	108.6	111.7				105.3
970			100.5	101.8	103.3	105.1	107.5	110.6				104.2
985		98.0	99.3	100.7	102.2	104.0	106.4	109.5				103.0
1000		96.9	98.2	99.5	101.0	102.9	105.3	108.3				101.9
1015	94.4	95.8	97.1	98.4	99.9	101.8	104.1	107.2	111.1			100.8
1030	93.3	94.7	96.0	97.3	98.8	100.6	103.0	106.1	110.0			99.7
1045	92.1	93.6	94.9	96.2	97.7	99.5	101.9	105.0	108.9			98.5
1060	91.0	92.4	93.7	95.0	96.5	98.4	100.8	103.8	107.8			97.4
1075	89.9	91.3	92.6	93.9	95.4	97.3	99.7	102.7	106.7	111.6		96.3
1090	88.8	90.2	91.5	92.8	94.3	96.2	98.5	101.6	105.5	110.5	116.6	95.2
1105	87.6	89.1	90.4	91.7	93.2	95.0	97.4	100.5	104.4	109.4	115.5	94.1
1120	86.5	88.0	89.2	90.6	92.1	93.9	96.3	99.4	103.3	108.2	114.4	92.9
1135		86.8	88.1	89.4	90.9	92.8	95.2	98.2	102.2	107.1	113.2	91.8
1150		85.7	87.0	88.3	89.8	91.7	94.1	97.1	101.0	106.0	112.1	90.7
1165			85.9	87.2	88.7	90.6	92.9	96.0	99.9	104.9	111.0	89.6

Two-dimensional equation and statistical parameters
$\gamma = a + bT + cC + dC^2 + eC^3$

a	$b \cdot 10^2$	$c \cdot 10^1$	$d \cdot 10^3$	$e \cdot 10^5$	Max. percent departure	Stand. error of est.
170.25851	−7.47624	1.55903	−1.54718	2.77189	0.30% (1163 K, 25 mol % NaCl)	0.13%

These values are based on the work of Bertozzi (Wilhelmy slide plate method) [**243**]. C = mol % NaCl.

TABLE 555. NaCl-RbCl: Surface tension (dyn cm^{-1})

	Mol % RbCl				
T	100	75	50	25	0
870			112.6		
880			111.9		
890			111.1		
900		106.4	110.4		
910		105.6	109.7		
920		104.9	108.9		
930		104.1	108.2		
940		103.4	107.4		
950		102.6	106.7		
960		101.8	106.0		
970		101.1	105.2		
980		100.3	104.5	111.5	
990		99.6	103.7	110.7	
1000		98.8	103.0	110.0	
1010	94.8	98.0	102.3	109.3	
1020	94.0	97.3	101.5	108.5	
1030	93.3	96.5	100.8	107.8	
1040	92.5	95.8	100.0	107.0	
1050	91.8	95.0	99.3	106.3	
1060	91.1	94.2	98.6	105.6	
1070	90.3	93.5	97.8	104.8	
1080	89.6	92.7	97.1	104.1	
1090	88.8	92.0	96.3	103.3	116.6
1100	88.1	91.2	95.6	102.6	115.9
1110	87.4	90.4	94.9	101.9	115.2
1120	86.6	89.7	94.1	101.1	114.4
1130	85.9	88.9	93.4	100.4	113.7
1140		88.2	92.6	99.6	112.9
1150		87.4	91.9	98.9	112.2
1160		86.6	91.2	98.2	111.5
1170		85.9	90.4	97.4	110.7

Temperature-dependent equations

$$\gamma = a + bT$$

Mol % RbCl	a	$b \cdot 10^2$
0	197.3	−7.4
25	184.0	−7.4
50	177.0	−7.4
75	174.8	−7.6
100	169.5	−7.4

These values are based on the work of Bertozzi (Wilhelmy slide plate method) [243].

NaCl-ScCl$_3$

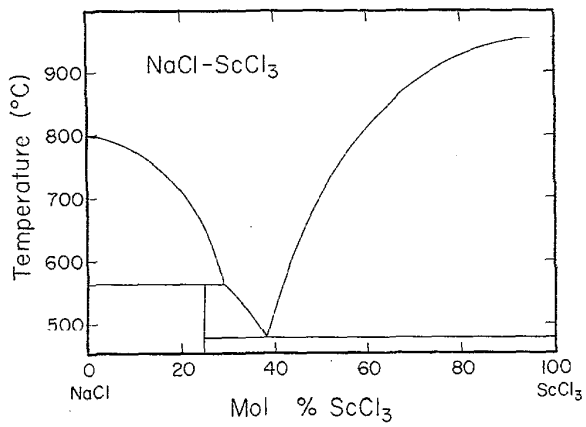

FIGURE 100. Temperature-composition phase diagram for NaCl-ScCl$_3$.

N. Ya. Fedorov and E. S. Petrov, Izv. Sib. Otd. Akad. Nauk. S.S.S.R. Ser Khim. Nauk., **1**, 48 (1967).

Melt Preparation and Purification

Chemically pure sodium chloride, recrystallized and fused, was used by Fedorov and Petrov [**73**]. The purification of ScCl$_3$ is given under the LiCl-ScCl$_3$ system.

TABLE 556. Electrical conductance studies: NaCl-ScCl$_3$

Investigations critically re-examined			
Ref.	ScCl$_3$ Mol %	Temp. range (T)	Comments
73	~0–85 (g)	833–1233	Cell material: quartz cell; Mo wire electrodes; calibration: 1N KCl solution

Comment: Refer to the system LiCl-ScCl$_3$ for remarks concerning the experimental method and accuracy of the study by Fedorov and Petrov [**73**].

TABLE 557. NaCl-ScCl$_3$: Specific conductance (ohm^{-1} cm^{-1})

Mol % ScCl$_3$	833 K	913 K	993 K	1073 K	1153 K	1233 K
0				3.55	3.74	3.89
10				2.92	3.11	3.27
20			2.05	2.27	2.44	2.63
30	1.16	1.42	1.64	1.82	2.00	2.16
40	0.89	1.11	1.31	1.52	1.68	1.80
50			1.05	1.22	1.36	1.46
60					1.15	1.24
70						1.14
80						1.02

These values have been interpolated to three significant figures from the graphical presentation of Fedorov and Petrov (classical ac technique) [**73**].

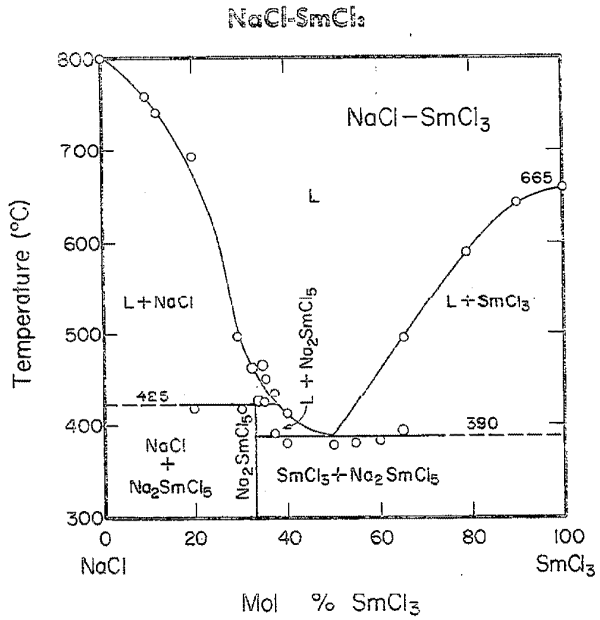

FIGURE 101. Temperature-composition phase diagram for NaCl-$SmCl_3$.

B. G. Korshunov, D. V. Drobot, V. V. Bukhtiyarov and S. N. Shevtsova, Russ. J. Inorg. Chem., 9, 773 (1964).

Melt Preparation and Purification

Samarium trichloride was prepared and analyzed as described under the system KCl-$NdCl_3$.

TABLE 558. Electrical conductance studies: NaCl-$SmCl_3$

Investigations critically re-examined			
Ref.	$SmCl_3$ Mol %	Temp. range (T)	Comments
190[a]	0–100 (g)	1073	Cell material: quartz capillary cell; Pt electrodes; freq. range: 100,000–250,000 Hz; calibration: molten CsCl, KCl, NaCl

Comment: Experimental details are briefly discussed under the system KCl-$NdCl_3$.

TABLE 559. NaCl-$SmCl_3$: Molar conductance (ohm^{-1} cm^2 mol^{-1})

Mol % NaCl	1073 K	Mol % NaCl	1073 K
0	66.3	60	91.2
10	71.0	70	94.0
20	74.0	80	102.
30	78.1	90	116.
40	83.3	100	137.
50	88.3		

These values have been interpolated to three significant figures from the graphical presentation of Forthmann and Schneider (classical ac technique) [190].

NaCl-$SrCl_2$

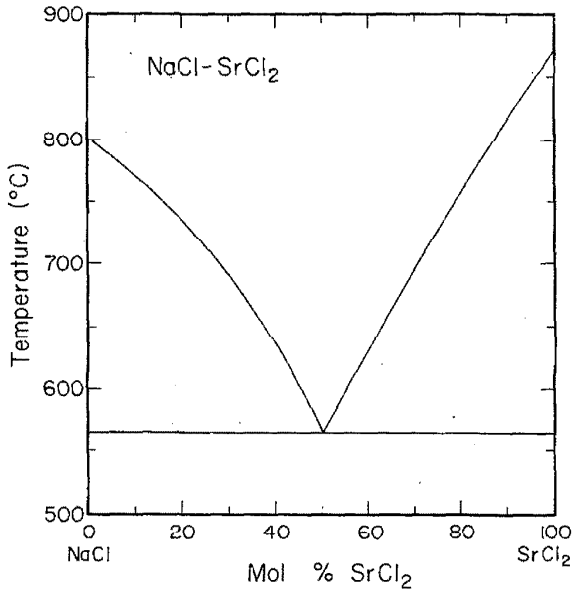

FIGURE 102. Temperature-composition phase diagram for NaCl-$SrCl_2$.

Erhard Vortisch, Neues Jahrb. Mineral., Geol., **38**, 202 (1914).

Melt Preparation and Purification

In their viscosity measurements, Bertozzi and Soldani [**244**] used carefully dried Merck and B. D. H. salts of analytical purity without further purification.

TABLE 560. Density studies: NaCl-$SrCl_2$

Density
A study of this system has been reported by Kuz'micheva and Zakhvalinskii [326]. No data are given. Isotherms were obtained at 10–20 molar percent steps in the temperature range of 923–1173 K. The densities were obtained using the hydrostatic method with a Pt ball.

TABLE 561. Surface tension studies: NaCl-$SrCl_2$

Investigations critically re-examined		
Ref.	$SrCl_2$ Mol %	Temp. range (T)
244	0–100 (g)	1123

Comment: The surface tension data reported in reference [**244**] were stated to be reproducible to within 0.5%.

TABLE 562. NaCl-$SrCl_2$: Surface tension (dyn cm^{-1})

Mol % $SrCl_2$	1073 K	Mol % $SrCl_2$	1073 K
0	114	60	142
10	118	70	148
20	122	80	155
30	126	90	162
40	132	100	171
50	136		

These values have been interpolated to three significant figures from the graphical presentation of Bertozzi and Soldani (Wilhelmy slide plate method) [**244**].

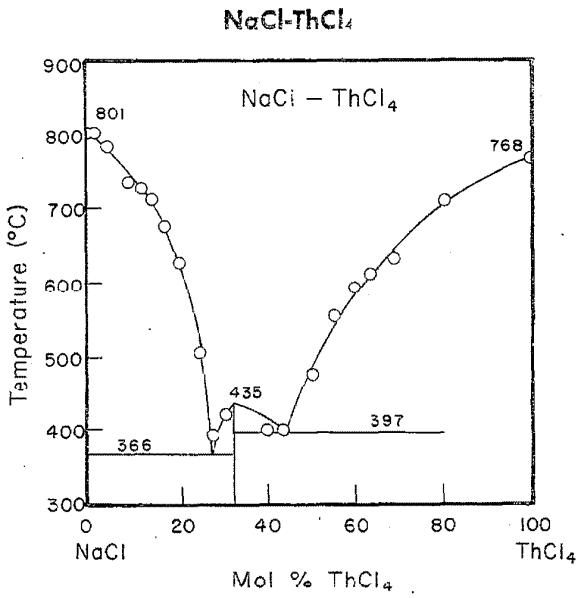

FIGURE 103. Temperature-composition phase diagram for NaCl-$ThCl_4$.

S. Yoshida, R. Oyamada, T. Kuroda, Denki. Kagaku, **36**, 297 (1968).

Melt Preparation and Purification

Reagent grade NaCl [**81**] was dried under vacuum at 180 °C for more than 24 hours, fused and cooled in an argon atmosphere and finally crushed into fine particles. Thorium tetrachloride was prepared by passing chlorine gas through a mixture of high purity ThO_2 and charcoal at 850 °C. The product was purified by vacuum distillation yielding large, colorless, transparent crystals which were stored in a glove box under dry argon.

Kuroda [**200**] recrystallized commercial (guaranteed reagent) NaCl which was then vacuum dried for two days at 120 °C. $ThCl_4$, prepared by chlorinating pure ThO_2, was vacuum distilled. Mixtures were prepared by stirring the fused melts in an argon atmosphere. Analysis for $ThCl_4$ consisted in EDTA titrations before and after experimental measurements.

TABLE 563. Electrical conductance studies: NaCl-$ThCl_4$

Investigations critically re-examined			
Ref.	$ThCl_4$ Mol %	Temp. range (T)	Comments
81	20–100[a]	823–1123	Cell material: quartz capillary cell; Pt electrodes; freq. range: 1000 Hz; calibration: 1N KCl solution

Deviations from previous NSRDS recommendations: [1, p. 9]			
Ref.	$ThCl_4$ Mol %	Min. departure	Max. departure
81	100	0.83% (1090 K)	−5.2% (1170 K)

[a]Mixtures reported graphically.

TABLE 564. NaCl-$ThCl_4$: Specific conductance (ohm^{-1} cm^{-1})

Mol % $ThCl_4$	823 K	873 K	923 K	973 K	1023 K	1073 K
0						3.61
10						2.46
20				1.50	1.62	1.80
30	0.88	1.00	1.12	1.22		
40	0.88	1.00	1.12	1.24		
50	0.70	0.85	0.92	1.02		
60		0.68	0.78	0.89		
70				0.58		

These values have been interpolated to three significant figures from the graphical presentation of Kuroda et al. (classical ac technique) [**81**].

TABLE 565. Density studies: NaCl-$ThCl_4$

Investigations critically re-examined			
Ref.	$ThCl_4$ Mol %	Temp. range (T)	Cell material
200	0–100	668–1173	Pt bob and suspension wire

Deviations from previous NSRDS recommendations: [1, pp. 4, 13]			
Ref.	$ThCl_4$ Mol %	Min. departure	Max. departure
200	100	2.2% (1120 K)	3.4% (1090 K)
200	0	2.7% (1080 K)	3.0% (1170 K)

TABLE 566. NaCl-$ThCl_4$: Density (g cm^{-3})

	Mol percent $ThCl_4$														
T	100	78	60	53	45	40	36	33	30	27	24	20	16	11	0
670										2.939					
680					3.218					2.929					
690					3.208	3.144				2.920					
700					3.198	3.134				2.910					
710					3.188	3.125	3.076	2.996		2.900					
720					3.178	3.115	3.066	2.986	2.945	2.891					
730					3.168	3.105	3.056	2.976	2.935	2.881					
740				3.276	3.157	3.095	3.046	2.966	2.925	2.871					
750				3.266	3.147	3.085	3.037	2.957	2.915	2.861					
760				3.256	3.137	3.075	3.027	2.947	2.906	2.852					
770				3.246	3.127	3.065	3.017	2.937	2.896	2.842					
780				3.236	3.117	3.055	3.007	2.927	2.886	2.832					
790				3.226	3.107	3.045	2.997	2.917	2.877	2.823	2.745				
800				3.216	3.097	3.035	2.988	2.908	2.867	2.813	2.736				
810				3.206	3.087	3.026	2.978	2.898	2.857	2.803	2.727				
820			3.276	3.196	3.077	3.016	2.968	2.888	2.848	2.794	2.718				
830			3.266	3.186	3.067	3.006	2.958	2.878	2.838	2.784	2.709				
840			3.255	3.175	3.056	2.996	2.948	2.868	2.828	2.774	2.699				
850			3.245	3.165	3.046	2.986	2.939	2.859	2.818	2.764	2.690				
860			3.235	3.155	3.036	2.976	2.929	2.849	2.809	2.755	2.681				
870			3.224	3.145	3.026	2.966	2.919	2.839	2.799	2.745	2.672				
880			3.214	3.135	3.016	2.956	2.909	2.829	2.789	2.735	2.663	2.471			
890			3.203	3.125	3.006	2.946	2.899	2.819	2.780	2.726	2.653	2.462			
900			3.193	3.115	2.996	2.936	2.890	2.810	2.770	2.716	2.644	2.454			
910			3.183	3.105	2.986	2.927	2.890	2.800	2.760	2.706	2.635	2.445			
920			3.172	3.095	2.976	2.917	2.870	2.790	2.751	2.697	2.626	2.437			
930			3.162	3.085	2.966	2.907	2.860	2.780	2.741	2.687	2.617	2.428			
940			3.151	3.074	2.955	2.897	2.851	2.771	2.731	2.677	2.607	2.419	2.365		
950			3.141	3.064	2.945	2.887	2.841	2.761	2.721	2.667	2.598	2.411	2.357		
960		3.261	3.131	3.054	2.935	2.877	2.831	2.751	2.712	2.658	2.589	2.402	2.348		
970		3.250	3.120	3.044	2.925	2.867	2.821	2.741	2.702	2.648	2.580	2.394	2.340		
980		3.240	3.110	3.034	2.915	2.857	2.811	2.731	2.692	2.638	2.571	2.385	2.331		
990		3.229	3.100	3.024	2.905	2.847	2.801	2.721	2.683	2.629	2.561	2.376	2.323		
1000		3.218	3.089	3.014	2.895	2.837	2.792	2.712	2.673	2.619	2.552	2.368	2.314		
1010		3.208	3.079	3.004	2.885	2.828	2.782	2.702	2.663	2.609	2.543	2.359	2.306	2.066	
1020		3.197	3.068	2.994	2.875	2.818	2.772	2.692	2.654	2.600	2.534	2.351	2.297	2.059	
1030		3.186	3.058	2.984	2.865	2.808	2.762	2.682	2.644	2.590	2.525	2.342	2.289	2.051	
1040		3.175	3.048	2.974	2.855	2.798	2.753	2.673	2.634	2.580	2.515	2.333	2.280	2.044	
1050	3.352	3.165	3.037	2.963	2.844	2.788	2.743	2.663	2.625	2.571	2.506	2.325	2.272	2.036	
1060	3.339	3.165	3.027	2.953	2.834	2.778	2.733	2.653	2.615	2.561	2.497	2.316	2.263	2.029	
1070	3.325	3.143	3.016	2.943	2.024	2.768	2.723	2.643	2.605	2.551	2.488	2.308	2.255	2.021	
1080	3.311	3.133										2.299	2.246	2.014	1.546
1090	3.297	3.122										2.290	2.238	2.006	1.541
1100	3.283	3.111										2.282	2.229	1.999	1.536
1110	3.268	3.101										2.273	2.221	1.991	1.531
1120	3.254	3.090										2.265	2.212	1.984	1.526
1130														1.976	1.521
1140														1.969	1.516
1150														1.961	1.511
1160														1.954	1.506
1170														1.946	1.501

TABLE 566. NaCl-$ThCl_4$: Density (g cm^{-3})—Continued

Temperature-dependent equations $\rho = a + bT$		
Mol % $ThCl_4$	a	$b \cdot 10^4$
0	2.086	−5.0
11	2.824	−7.5
16	3.164	−8.5
20	3.228	−8.6
24	3.472	−9.2
27	3.589	−9.7
30	3.643	−9.7
33	3.692	−9.8
36	3.772	−9.8
40	3.828	−9.9
45	3.905	−10.1
53	4.024	−10.1
60	4.129	−10.4
78	4.288	−10.7
100	4.823	−14.0

These values are based on the work of Kuroda et al. (Archimedean method) [**200**].

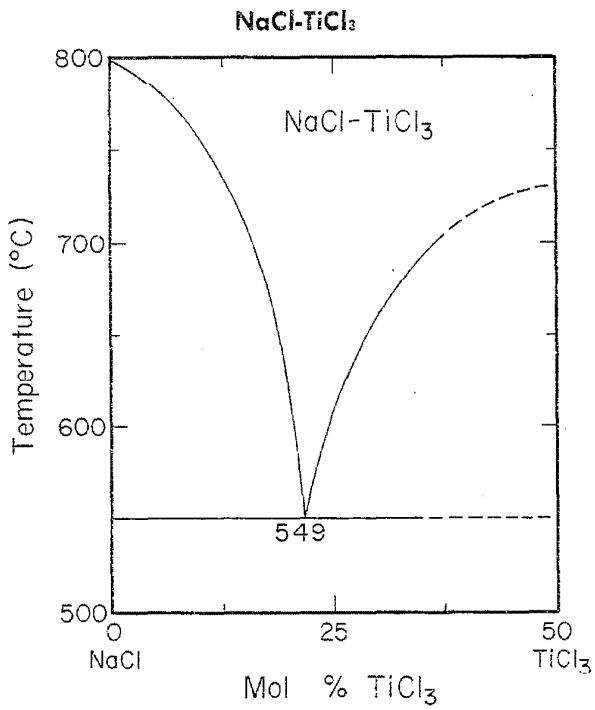

FIGURE 104. Temperature-composition phase diagram for NaCl-$TiCl_3$.

B. F. Markov and R. V. Chernov, Ukrain. Khim. Zhur., **25**, 280 (1959).

Melt Preparation and Purification

Refer to the system KCl-$TiCl_3$.

TABLE 567. Electrical conductance studies: NaCl-$TiCl_3$

Investigations critically re-examined			
Ref.	$TiCl_3$ Mol %	Temp. range (T)	Comments
55	≃0–50[a]	1073	Cell material: quartz; Pt electrodes; freq. range: 1400 Hz
59	≃0–50 (g)	1073	Cell material: quartz; Pt electrodes; freq. range: 1400 Hz
61	≃0–32[a]	1073–1223	Cell material: quartz; freq. range: 1150 Hz; calibration: 0.02N KCl solution

Deviations from previous NSRDS recommendations: [1, p. 5]			
Ref.	$TiCl_3$ Mol %	Min. departure	Max. departure
61	0	−4.7% (1223 K)	−5.1% (1123 K)
61	0	−6.0% (1073 K)	

[a]Graphical except for pure NaCl.

TABLE 568. NaCl-$TiCl_3$: Specific conductance (ohm^{-1} cm^{-1})

Mol % $TiCl_3$	1073 K
0	3.5
10	2.1
20	1.9
30	1.7
40	1.6

These values have been interpolated to two significant figures from the graphical presentation of Delimarskii and Chernov (classical ac technique) [**55**].

NaCl-UCl$_3$

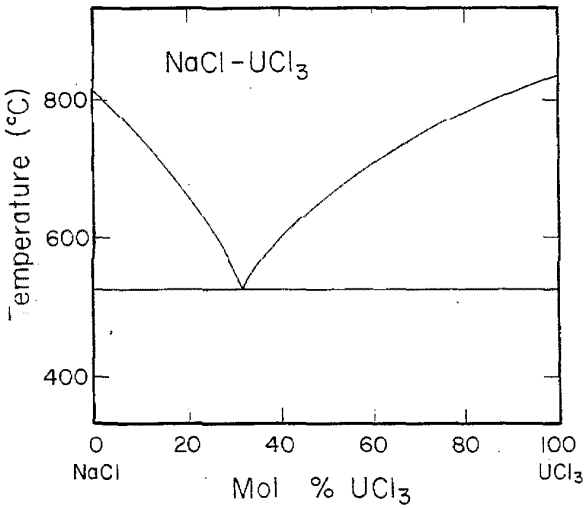

FIGURE 105. Temperature-composition phase diagram for NaCl-UCl$_3$.

C. A. Kraus, Report No. M-251, July 1, 1943. Confirmed at Oak Ridge National Laboratory, Oak Ridge, Tenn., by C. J. Barton, et al., Phase Diagrams of Nuclear Reactor Materials, R. F. Thoma, ed., ORNL-2548, p. 133 (1959).

Melt Preparation and Purification

Mochinga [**135**, 137] prepared UCl$_3$ using the method described under the system KCl-UCl$_3$.

TABLE 569. Electrical conductance studies: NaCl-UCl$_3$

Investigations critically re-examined		
Ref.	UCl$_3$ Mol %	Temp. range (T)
135	0–100 (g)	973–1123
137	5.0–84.9	872–1225
190	10–100 (g)	1123

TABLE 570. NaCl-UCl$_3$: Specific conductance (ohm^{-1} cm^{-1})

	Mol percent UCl$_3$							
T	84.9	75.1	54.9	45.0	31.7	25.7	20.0	5.0
880					1.09			
890					1.13			
900					1.16			
910					1.19			
920					1.22			
930					1.25			
940					1.28			
950				1.07	1.30	1.50		
960				1.10	1.33	1.53		
970				1.13	1.36	1.56	1.81	
980				1.16	1.38	1.59	1.83	
990				1.18	1.40	1.62	1.86	
1000				1.21	1.43	1.64	1.89	
1010				1.24	1.45	1.67	1.91	
1020			1.04	1.27	1.47	1.69	1.94	
1030			1.07	1.29	1.48	1.71	1.96	
1040			1.10	1.32	1.50	1.73	1.98	
1050			1.12	1.35	1.52	1.75	2.00	
1060			1.15	1.37	1.54	1.76	2.01	
1070		0.93	1.17	1.40	1.55	1.78	2.03	2.14
1080	1.02	0.96	1.20	1.42	1.56	1.79	2.05	2.15
1090	1.06	0.99	1.22	1.45	1.58	1.80	2.06	2.17
1100	1.08	1.03	1.25	1.47	1.59	1.81	2.07	2.18
1110	1.11	1.05	1.27	1.49		1.82	2.08	2.19
1120	1.14	1.08	1.29	1.52		1.82		2.20
1130	1.16	1.11	1.31	1.54				2.20
1140	1.18	1.13	1.33	1.56				2.21
1150	1.20	1.15	1.35	1.58				2.21
1160	1.22	1.18	1.37	1.60				2.20
1170	1.24	1.20	1.38	1.63				2.20
1180	1.26	1.22	1.40	1.65				
1190	1.27	1.23	1.42	1.67				
1200	1.28	1.25	1.43	1.68				
1210	1.29	1.26	1.45	1.70				
1220		1.28						

Temperature-dependent equations

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

Mol % UCl$_3$	a	$b \cdot 10^3$	$c \cdot 10^6$
5.0	−13.663	27.709	−12.096
20.0	−7.244	15.749	−6.617
25.7	−8.915	18.644	−8.087
31.7	−5.969	12.641	−5.247
45.0	−3.736	7.101	−2.153
54.9	−5.992	10.902	−3.930
75.1	−10.676	18.336	−6.999
84.9	−12.551	21.953	−8.688

These values are based on the work of Mochinaga et al. (classical ac technique) [**137**].

TABLE 571. Density studies: NaCl-UCl$_3$

Investigations critically re-examined			
Ref.	UCl$_3$ Mol %	Temp. range (T)	Comments
135	1.6, 8.7, 24.7, 53.8	973–1273	Cell material: quartz pycnometer; calibration: molten NaCl, KCl

TABLE 572. NaCl-UCl_3: Density (g cm^{-3})

	Mol percent UCl_3			
T	53.8	24.7	8.7	1.6
980	3.642	2.732	2.110	1.653
990	3.611	2.716	2.104	1.648
1000	3.581	2.700	2.097	1.642
1010	3.550	2.684	2.090	1.636
1020	3.520	2.668	2.083	1.631
1030	3.489	2.652	2.076	1.625
1040	3.458	2.636	2.069	1.619
1050	3.428	2.620	2.063	1.614
1060	3.397	2.604	2.056	1.608
1070	3.367	2.588	2.049	1.602
1080	3.336	2.572	2.042	1.597
1090	3.306	2.557	2.035	1.591
1100	3.275	2.541	2.029	1.585
1110	3.244	2.525	2.022	1.580
1120	3.214	2.509	2.015	1.574
1130	3.183	2.493	2.008	1.568
1140	3.153	2.477	2.001	1.563
1150	3.122	2.461	1.994	1.557
1160	3.091	2.445	1.988	1.552
1170	3.061	2.429	1.981	1.546
1180	3.030	2.413	1.974	1.540
1190	3.000	2.398	1.967	1.535
1200	2.969	2.382	1.960	1.529
1210	2.939	2.366	1.953	1.523
1220	2.908	2.350	1.947	1.518
1230	2.877	2.334	1.940	1.512
1240	2.847	2.318	1.933	1.506
1250	2.816	2.302	1.926	1.501
1260	2.786	2.286	1.919	1.495
1270	2.755	2.270	1.912	1.489

Temperature-dependent equations

$\rho = a + bT$

Mol % UCl_3	a	$b \cdot 10^3$
1.6	2.2075	−0.5655
8.7	2.7796	−0.6828
24.7	4.2900	−1.5903
53.8	6.6390	−3.0582

These values are based on the work of Mochinaga et al. (pycnometric method) [135].

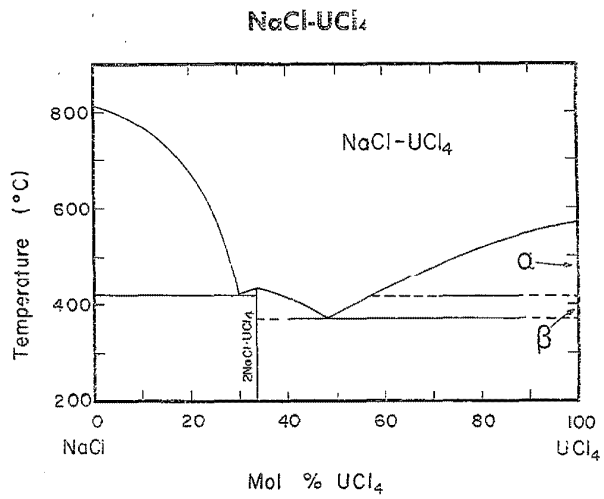

FIGURE 106. Temperature-composition phase diagram for NaCl-UCl_4.

C. J. Barton, R. J. Scheil, A. B. Wilkenson, and W. R. Grimes, Oak Ridge National Laboratory, Phase Diagrams of Nuclear Reactor Materials, R. F. Thoma, ed., ORNL-2584, p. 134 (1959).

Melt Preparation and Purification

The preparation of pure UCl_4 by Kuroda and Suzuki [52] is discussed under the KCl-UCl_4 system.

Bogacz and Ziolek [158] prepared and purified their salts using the procedure described under the system CsCl-UCl_4.

TABLE 573. Electrical conductance studies: NaCl-UCl_4

Investigations critically re-examined			
Ref.	UCl_4 Mol %	Temp. range (T)	Comments
52	32.9, 50.4, 100[a]	673–1023	Cell material: quartz U-tube; Pt electrodes; freq. range: 1000 Hz; calibration: 1N KCl solution
158	32.20–100	753–1001	Cell material: quartz U-tube; Pt electrodes; freq. range: 5000–10,000 Hz, measurements at 10,000 Hz; calibration: KCl solutions and fused KNO_3, $NaNO_3$ and KCl

Deviations from previous NSRDS recommendations: [1, p. 9]			
Ref.	UCl_4 Mol %	Min. departure	Max. departure
52	100	−2.1% (873 K)	−6.0% (883 K)
158	100	1.2% (870 K)	−4.4% (890 K)

Comment: Bogacz and Ziolek [158] report their conductance results in the form of equations of the type: $\kappa = a + bt + ct^2$ with standard deviations in the range 2.0×10^{-4} ohm^{-1} cm^{-1} (80.92, 92.69, and 100 mol % UCl_4) to 15.0×10^{-4} ohm^{-1} cm^{-1} (32.2 and 71.15 mol % UCl_4). The overall error in the conductivity measurements was reported to be less than 0.5%.

TABLE 574. NaCl-UCl_4: Specific conductance (ohm^{-1} cm^{-1})

	Mol percent UCl_4									
T	100.00	96.59	92.69	88.13	80.92	71.15	61.15	51.24	44.28	32.20
760										1.030
770										1.055
780										1.078
790							0.676			1.102
800							0.698	0.872		1.124
810							0.718	0.893		1.145
820							0.738	0.913		1.166
830					0.534	0.598	0.758	0.932	1.025	1.186
840					0.551	0.625	0.777	0.951	1.043	1.205
850				0.491	0.567	0.649	0.795	0.969	1.061	1.224
860			0.462	0.507	0.583	0.672	0.812	0.987	1.078	1.241
870		0.445	0.478	0.528	0.599	0.694	0.829	1.003	1.094	1.258
880	0.436	0.460	0.492	0.538	0.614	0.713	0.846	1.019	1.110	1.275
890	0.451	0.474	0.507	0.553	0.629	0.731	0.862	1.035	1.125	1.290
900	0.465	0.488	0.521	0.568	0.644	0.747	0.877	1.050		1.305
910	0.479	0.502	0.534	0.582	0.658	0.762	0.891	1.064		1.319
920	0.492	0.515	0.547		0.671		0.905	1.077		
930	0.505	0.527			0.685					
940	0.518									
950	0.530									
960	0.542									
970	0.554									
980	0.565									
990	0.576									
1000	0.587									

Temperature-dependent equations

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

Mol % UCl_4	a	$b \cdot 10^3$	$c \cdot 10^6$	Stand. dev.
32.20	−3.0620	8.2751	−3.8036	0.0015
44.28	−2.7660	7.2590	−3.2435	0.0006
51.24	−2.9084	7.3512	−3.2816	0.0003
61.15	−2.9391	6.9930	−3.0590	0.0012
71.15	−7.3136	16.3608	−8.2267	0.0015
80.92	−2.2063	4.9066	−1.9335	0.0002
88.13	−2.4598	5.2991	−2.1502	0.0003
92.69	−2.5711	5.5043	−2.2988	0.0002
96.59	−2.6969	5.7034	−2.4051	0.0003
100.00	−2.2782	4.6911	−1.8260	0.0002

These values are based on the work of Bogacz and Ziolek (classical ac technique) [**158**].

TABLE 575. Density studies: NaCl-UCl_4

Investigations critically re-examined			
Ref.	UCl_4 Mol %	Temp. range (T)	Comments
158	32.20–100	779–949	Cell material: Pt ball and suspension wire inside quartz tube

Comment: Density data in reference [**158**] were reported in the form of linear temperature dependent equations with standard deviations in the range: 2.0×10^{-4} g cm^{-3} (32.20 mol % UCl_4) to 6.0×10^{-4} g cm^{-3} (100 mol % UCl_4). The total error in density measurements was reported to be $\leq 0.2\%$.

TABLE 576. NaCl-UCl_4: Density (g cm^{-3})

	Mol percent UCl_4							
T	100	90	80	70	60	50	40	47
790					3.294			
800				3.403	3.283	3.138		
810				3.391	3.272	3.128		3.079
820				3.378	3.260	3.117		3.069
830			3.461	3.365	3.248	3.106		3.058
840			3.447	3.351	3.235	3.095	2.926	3.048
850		3.512	3.432	3.337	3.222	3.083	2.916	3.036
860		3.497	3.417	3.323	3.209	3.072	2.906	3.025
870	3.550	3.481	3.402	3.308	3.195	3.059	2.895	3.013
880	3.534	3.465	3.386	3.293	3.181	3.047	2.884	3.001
890	3.517	3.448	3.370	3.278	3.167	3.034	2.873	2.988
900	3.500	3.431	3.353	3.262	3.152	3.020	2.861	2.975
910	3.482	3.414	3.337	3.246	3.137	3.006	2.894	2.962
920	3.465		3.319	3.229	3.122			
930	3.446			3.212				
940	3.428							

Two-dimensional equation and statistical parameters

$$\rho = a + bC + cC^2 + dT^3 + eC^3 + fTC^2$$

a	$b \cdot 10^3$	$c \cdot 10^4$	$d \cdot 10^{10}$	$e \cdot 10^7$	$f \cdot 10^7$	Max. percent departure	Stand. error of est.
4.01834	−6.55152	−1.55434	−7.11184	−7.46456	1.46518	−0.40% (787.2 K, 38.85 mol % NaCl)	0.14%

These values are based on the work of Bogacz and Ziolek (Archimedean method) [158]. C = mol % NaCl.

TABLE 577. NaCl-UCl_4: Density (g cm^{-3})

	Mol percent UCl_4								
T	100.00	96.59	92.96	88.13	80.92	61.15	51.24	44.28	32.20
780							3.181		
790						3.322	3.169		
800						3.308	3.157		
810						3.293	3.144		
820						3.279	3.132		
830					3.465	3.265	3.120	3.012	
840					3.451	3.251	3.108	3.001	
850				3.493	3.436	3.236	3.096	2.991	
860			3.516	3.479	3.421	3.222	3.084	2.981	
870	3.558	3.527	3.500	3.465	3.406	3.208	3.071	2.971	
880	3.539	3.510	3.485	3.450	3.391	3.194	3.059	2.961	2.732
890	3.519	3.494	3.469	3.436	3.377	3.179	3.047	2.950	2.724
900	3.500	3.478	3.453	3.421	3.362	3.165	3.035	2.940	2.716
910	3.480	3.462	3.438	3.407	3.347	3.151	3.023	2.930	2.708
920	3.461	3.446	3.422		3.332	3.136	3.011		
930	3.441	3.430							
940	3.422								

Temperature-dependent equations

$$\rho = a + bT$$

Mol % UCl_4	a	$b \cdot 10^4$	Stand. dev.
32.20	3.4098	−7.707	0.0002
44.28	3.8614	−10.237	0.0003
51.24	4.1291	−12.157	0.0003
61.15	4.4491	−14.268	0.0004
80.92	4.6915	−14.773	0.0006
88.13	4.7175	−14.402	0.0006
92.96	4.8592	−15.620	0.0003
96.59	4.9313	−16.147	0.0004
100.00	5.2508	−19.455	0.0006

These values are based on the work of Bogacz and Ziolek (Archimedean method) [158].

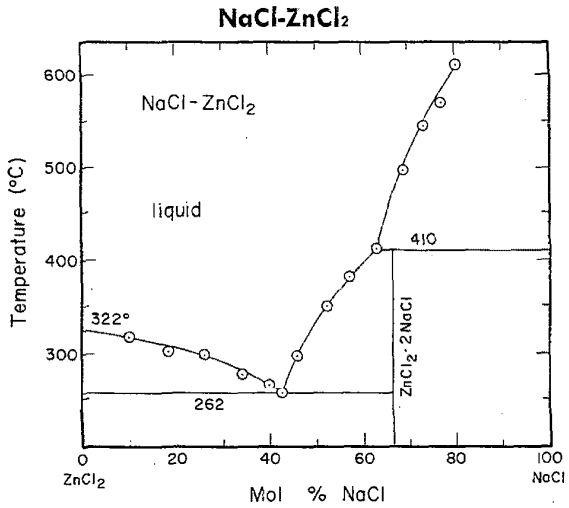

FIGURE 107. Temperature-composition phase diagram for NaCl-$ZnCl_2$.

N. N. Evseeva and A. G. Bergman, Izv. Sekt. Fiz.-Khim. Anal., Inst. Obshch. Neorg. Khim., Akad. Nauk S.S.S.R., **21**, 208 (1952).

Melt Preparation and Purification

Weeks [**108**] and Bloom and Weeks [**197,198,199**] used B.D.H. (AR) NaCl without further purification except for vacuum drying at 400 °C for three hours. Their purification of $ZnCl_2$ is described under the system CsCl-$ZnCl_2$. Following experimental measurements, the zinc chloride-alkali chloride mixtures were analyzed for Zn^{++} and Cl^- and the amount of alkali chloride was obtained by difference. Weight titrations were performed according to the method of Vogel (A.I. Vogel, "Quantitative Inorganic Analysis," 3rd Ed., Longmans, Green and Co., London, 1966).

Kochergin et al. [129] used "chemically pure" grade NaCl and $ZnCl_2$ which were recrystallized twice from water and heated at 500 °C. Zinc chloride was fused and dehydrated with HCl gas. Conductance and density measurements were also made on melts which were treated with metallic zinc.

TABLE 578. Electrical conductance studies: NaCl-$ZnCl_2$

Investigations critically re-examined			
Ref.	$ZnCl_2$ Mol %	Temp. range (T)	Comments
108, 197[a]	37.4–100	532–883	Cell material: silica glass; Pt electrodes; freq. range: 500–50,000 Hz; calibration: 0.1 and 1.0 demal KCl solutions (25 °C)
129[b]	72.9 (g)	533–873	Cell material: silica glass; Pt electrodes; freq. range: 1000–6000 Hz; calibration: fused KNO_3 and KCl

Deviations from previous NSRDS recommendations: [1, p. 10]			
Ref.	$ZnCl_2$ Mol %	Min. departure	Max. departure
108	100	−3.0% (830 K)	−53.0% (627 K)

[a]A brief discussion of the frequency dependence of conductance in references [**108, 197**] is to be found under the system KCl-$ZnCl_2$. Overall accuracy in the recommended values were reported to be 0.5% and 0.3% for pure zinc chloride and for mixtures respectively. Weeks [**108**] reported experimental specific conductivities and Bloom and Weeks [**197**] list results using Adam-Gibbs equations, $\Lambda = A \exp \cdot (-B/T \ln (T/T_c))$.

[b]Kochergin et al. [129] showed that differences of 15 to 20% were found in the experimental conductivity values depending upon whether the melts were previously treated with metallic zinc. Results suggested that hydrogen in the melt was removed by the zinc metal treatment resulting in a sharp decrease in electrical conductivity.

TABLE 579. NaCl-$ZnCl_2$: Specific conductance (ohm^{-1} cm^{-1})

	Mol percent $ZnCl_2$								
T	100.00	97.36	89.94	84.17	79.16	69.65	61.88	47.50	37.40
540							0.1897		
560						0.1687	0.2408		
580			0.02940	0.06393	0.09719	0.2176	0.2962		
600	0.001863	0.008684	0.04079	0.08659	0.1312	0.2692	0.3553		
620	0.003460	0.01286	0.05600	0.1131	0.1686	0.3231	0.4175	0.5551	
640	0.006394	0.01991	0.07490	0.1433	0.2091	0.3791	0.4821	0.6478	
660	0.01098	0.02991	0.09735	0.1769	0.2522	0.4369	0.5485	0.7374	
680	0.01753	0.04296	0.1232	0.2137	0.2979	0.4961	0.6161	0.8239	
700	0.02635	0.05912	0.1524	0.2535	0.3456	0.5567	0.6842	0.9073	0.9851
720	0.03776	0.07848	0.1848	0.2962	0.3953	0.6182	0.7523	0.9876	1.073
740	0.05208	0.1011	0.2202	0.3414	0.4465	0.6804	0.8196	1.065	1.158
760	0.06961	0.1271	0.2585	0.3889	0.4990	0.7431	0.8856	1.139	1.240
780	0.09067	0.1566	0.2996	0.4386		0.8059		1.210	1.318
800	0.1156	0.1896	0.3433	0.4902		0.8686		1.278	1.394
820	0.1446	0.2262	0.3896	0.5436		0.9309		1.343	1.466
840	0.1781	0.2664	0.4383	0.5984		0.9926		1.404	1.536
860		0.3105	0.4893	0.6545		1.053		1.463	1.602
880						1.113		1.519	

Temperature-dependent equations

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

Mol % $ZnCl_2$	a	$b \cdot 10^3$	$c \cdot 10^6$	$d \cdot 10^9$	Stand. error of est.
37.40	−4.0530	9.9178	−3.8864	0	0.33%
47.50	−3.8540	9.5115	−3.8709	0	0.61%
61.88	2.7513	−15.7520	27.4785	−13.1346	0.46%
69.65	0.9535	−6.9520	13.0714	−5.6426	0.23%
79.16	1.8818	−9.8304	15.1987	−6.1291	0.44%
84.17	2.0525	−9.3958	12.8840	−4.4754	0.41%
89.94	1.9342	−7.9397	9.5769	−2.6725	0.31%
97.36	0.81694	−2.22235	0.44201	1.69466	2.12%
100.00	−0.97574	5.55341	−10.95067	6.51758	1.30%

These values are based on the work of Bloom and Weeks (classical ac technique) [**108, 197**].

TABLE 580. Density studies: NaCl-$ZnCl_2$

Investigations critically re-examined

Ref.	$ZnCl_2$ Mol %	Temp. range (T)	Comments
108, 199[a]	35–100	557–880	Cell material: silica pycnometer; calibration: water
129	72.9 (g)	583–873	Cell material: Pt sphere and Pt suspension wire
165	50	673–873	
193	10–100	873, 973	
194	0–100 (g)	873	

Deviations from previous NSRDS recommendations: [1, p. 10]

Ref.	$ZnCl_2$ Mol %	Min. departure	Max. departure
108, 199	100	−0.08% (683 K)	0.40% (600 K)
193	100	−0.21% (873 K)	

Density measurements in references [**108, 199**] were corrected for thermal expansion of the silica glass and the total correction was 0.05–0.1%. The overall accuracy was reported to be between 0.05% and 0.1%. Weeks [**108**] reported experimental density values while Bloom and Weeks [**199**] gave results in the form of linear temperature dependent equations with standard deviations in the range: 0.30×10^{-3} g cm^{-3} (44.7 mol % $ZnCl_2$) to 1.75×10^{-3} g cm^{-3} (93.8 mol % $ZnCl_2$).

TABLE 581. $NaCl\text{-}ZnCl_2$: Density (g cm^{-3})

	Mol percent $ZnCl_2$													
T	100.00	97.39	95.40	93.79	90.30	87.50	80.80	75.60	70.20	60.40	59.30	53.40	44.70	35.00
560											2.378			
570									2.431	2.375	2.372	2.331		
580								2.440	2.425	2.368	2.365	2.325		
590	2.525	2.518	2.513	2.503	2.493			2.434	2.418	2.361	2.358	2.318		
600	2.520	2.512	2.507	2.498	2.487	2.474	2.451	2.428	2.412	2.355	2.352	2.311		
610	2.515	2.507	2.502	2.492	2.481	2.469	2.445	2.422	2.405	2.348	2.345	2.305		
620	2.509	2.501	2.496	2.486	2.476	2.463	2.439	2.416	2.398	2.341	2.338	2.298		
630	2.504	2.496	2.491	2.480	2.470	2.457	2.433	2.409	2.392	2.335	2.331	2.292		
640	2.499	2.490	2.485	2.475	2.465	2.452	2.427	2.403	2.385	2.328	2.325	2.285	2.216	
650	2.493	2.485	2.480	2.469	2.459	2.446	2.421	2.397	2.378	2.321	2.318	2.279	2.209	
660	2.488	2.479	2.474	2.463	2.454	2.440	2.415	2.391	2.372	2.314	2.311	2.272	2.203	
670	2.483	2.474	2.468	2.457	2.448	2.434	2.408	2.384	2.365	2.308	2.305	2.265	2.196	
680	2.478	2.468	2.463	2.452	2.443	2.429	2.402	2.378	2.359	2.301	2.298	2.259	2.190	
690	2.472	2.463	2.457	2.446	2.437	2.423	2.396	2.372	2.352	2.294	2.291	2.252	2.183	
700	2.467	2.458	2.452	2.440	2.431	2.417	2.390	2.366	2.345	2.288	2.285	2.246	2.177	
710	2.462	2.452	2.446	2.434	2.426	2.411	2.384	2.360	2.339	2.281	2.278	2.239	2.171	
720	2.456	2.447	2.441	2.429	2.420	2.406	2.378	2.353	2.332	2.274	2.271	2.232	2.164	
730	2.451	2.441	2.435	2.423	2.415	2.400	2.372	2.347	2.325	2.267	2.265	2.226	2.158	
740	2.446	2.436	2.430	2.417	2.409	2.394		2.341	2.319	2.261	2.258	2.219	2.151	2.084
750	2.441	2.430	2.424	2.411	2.404	2.389		2.325	2.312	2.254	2.251	2.213	2.145	2.078
760	2.435	2.425	2.419	2.406	2.398	2.383		2.328	2.306	2.247	2.244	2.206	2.138	2.071
770	2.430	2.419	2.413		2.393	2.377		2.322	2.299	2.240	2.238	2.199	2.132	2.065
780	2.425	2.414	2.408		2.387				2.292		2.231	2.193	2.126	2.058
790	2.419		2.402		2.381				2.286		2.224	2.186	2.119	2.052
800	2.414		2.397		2.376				2.279		2.218	2.180	2.113	2.045
810	2.409		2.391		2.370				2.272		2.211	2.173	2.106	2.039
820	2.403		2.386		2.365				2.266		2.204	2.167	2.100	2.032
830	2.398		2.380		2.359				2.259		2.198	2.160	2.093	2.026
840			2.374		2.354				2.253		2.191	2.153	2.087	2.019
850			2.369		2.348				2.246		2.184	2.147	2.081	
860			2.363		2.343				2.239		2.178	2.140	2.074	
870											2.171		2.068	
880											2.164			

Temperature-dependent equations

$$\rho = a + bT$$

Mol % $ZnCl_2$	a	$b \cdot 10^4$	Stand. error of est.
35.00	2.5626	−6.4660	0.05%
44.70	2.6269	−6.4288	0.02%
53.40	2.7068	−6.5899	0.08%
59.30	2.7530	−6.6697	0.09%
60.40	2.7582	−6.7248	0.08%
70.20	2.8091	−6.6262	0.10%
75.60	2.8011	−6.2198	0.05%
80.80	2.8189	−6.1266	0.03%
87.50	2.8179	−5.7254	0.04%
90.30	2.8202	−5.5558	0.28%
93.79	2.8427	−5.7501	0.08%
95.40	2.8391	−5.5320	0.11%
97.39	2.8425	−5.5535	0.07%
100.00	2.8375	−5.2926	0.09%

These values are based on the work of Bloom and Weeks (pycnometric method) [**108, 199**].

TABLE 582. Viscosity studies: $NaCl-ZnCl_2$

Investigations critically re-examined			
Ref.	$ZnCl_2$ Mol %	Temp. range (T)	Comments
108, 198[a]	44.3–88.3	533–772	Cell material: Pyrex glass viscometer with Pt wire electrodes; calibration: 30–65% sucrose solutions

[a]Viscometers used in references [**108, 198**] were recalibrated after each experiment with a reproducibility of 0.3%. The overall accuracy of the viscosity measurements was estimated to be 0.5%.

TABLE 583. $NaCl-ZnCl_2$: Viscosity[a] (cp)

Mol percent $ZnCl_2$									
88.3		79.3		69.6		61.9		44.3	
T	η	T	η	T	η	T	η	T	η
578.3	298.3	570.3	93.0	552.8	48.5	533.0	43.7	634.6	6.41
587.3	234.8	578.7	77.0	563.8	39.5	544.7	34.5	641.8	6.03
598.5	175.5	589.1	61.2	571.5	34.7	553.6	29.35	651.7	5.58
608.7	135.6	599.1	51.2	586.8	26.7	564.1	24.56	663.2	5.13
616.2	113.4	609.4	42.4	597.1	22.81	573.1	21.38	675.1	4.70
629.5	86.5	621.1	34.8	606.4	20.04	585.1	17.82	685.5	4.39
640.3	70.4	629.7	30.3	620.3	16.57	595.5	15.50	696.4	4.12
651.2	57.4	645.1	24.11	630.8	14.53	606.4	13.55	709.9	3.78
660.4	49.6	655.2	20.94	641.1	12.83	617.1	11.94	723.1	3.51
671.4	41.1	665.4	18.28	653.4	11.20	627.3	10.62	735.4	3.29
680.3	36.0	675.3	16.22	665.0	9.95	637.7	9.55	744.7	3.14
689.6	31.0	684.8	14.50	675.8	8.91	648.9	8.52	757.7	2.94
703.9	24.9	694.9	12.90	694.5	7.50	660.7	7.64	770.9	2.86
716.8	21.05	703.4	11.77	705.0	6.85	671.1	6.98		
729.7	18.12	714.7	10.49	715.0	6.32	682.1	6.35		
751.7	14.23	727.0	9.29	726.1	5.79	694.9	5.73		
769.4	12.04	736.3	8.48	737.6	5.35	704.4	5.31		
		745.7	7.80	747.6	5.03	718.2	4.80		
		755.3	7.17	756.9	4.71	731.9	4.39		
		768.4	6.46	769.2	4.36	745.0	4.02		
						756.8	3.75		
						772.3	3.44		

Temperature-dependent equations

$$\eta = A \exp [B/T \ln (T/T_0)]$$

Mol % $ZnCl_2$	$A \cdot 10^2$	$B \cdot 10^{-4}$	T_0	Standard deviation
44.3	0.5275	0.1336	273.0	2.14
61.9	0.4164	0.1822	255.5	6.57
69.6	0.2962	0.2519	226.1	7.16
79.3	0.3051	0.2544	261.2	2.09
88.3	0.3128	0.2776	287.3	8.29

[a]Since statistical analysis of the data to polynomial and exponential equations yielded poor fits, only the experimental values are reported. In addition, a fit of the data by the authors to the equation $\eta = A \exp (B/T \ln (T/T_0))$ is included.

These values are based on the work of Bloom and Weeks (capillary method) [**108, 198**].

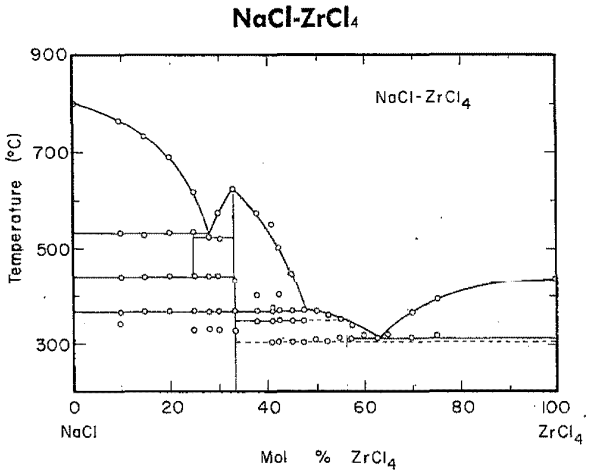

FIGURE 108. Temperature-composition phase diagram for NaCl-$ZrCl_4$.

R. E. Thoma, Oak Ridge National Laboratory, ORNL-2548, p. 129 (1959).

Melt Preparation and Purification

Howell and Kellogg [10] dehydrated reagent grade NaCl by evacuating the melt for two days at 400 °C and at a pressure of 0.2 microns. The $ZrCl_4$ was hafnium free material (U.S. Bureau of Mines, Albany, Oregon) and was purified by treatment with hydrogen gas at 200 °C (reduction of iron to nonvolatile ferrous form), followed by vacuum sublimation into glass ampoules which were then evacuated, sealed and stored. The purified $ZrCl_4$ was introduced into the "dipping electrode" conductivity cell, containing the NaCl melt, by heating the ampoule until thermal expansion ruptured the thin glass. Spectrographic analysis of the purified $ZrCl_4$ indicated the following impurities: 30 ppm Al, 2 ppm Bi, 10 ppm Cu, 15 ppm Fe, 5 ppm Mn, 5 ppm p, 10 ppm Pb, 20 ppm Sn, and < 1 ppm Mg.

TABLE 584. Electrical conductance studies: NaCl-$ZrCl_4$

Investigations critically re-examined			
Ref.	$ZrCl_4$ Mol %	Temp. range (T)	Comments
10	61.4, 65.0, 66.0	594–646	Cell material: Pyrex cell; W electrodes; freq. range: 4950–20,000 Hz; calibration: 0.1M KCl solution
54	0–31.9	723–1123	Cell material: Pyrex and quartz cells; Pt electrodes; variable freq. range; calibration: 1N KCl solution

Deviations from previous NSRDS recommendations: [1, p. 4]			
Ref.	$ZrCl_4$ Mol %	Min. departure	Max. departure
54	0	−3.5% (1123 K)	−3.9% (1073 K)

Comment: Howell and Kellogg [10] stated that the absolute accuracy of their conductivity values may be in error by as much as ±10% due to the frequency extrapolation used.

Due to the volatility and strong tendency for $ZrCl_4$ to dissociate, Belozerskii and Freidina [54] minimized the experimental time for their conductance measurements.

TABLE 585. NaCl-$ZrCl_4$: Specific conductance (ohm^{-1} cm^{-1})

	Mol percent $ZrCl_4$									
T	31.9	31.7	20.2	19.9	18.5	14.5	7.7	3.3	3.1	0
723.2		0.80	1.06	1.08						
823.2		0.95								
873.2		1.12								
923.2	1.08									
973.2	1.16									
1023.2					1.26					
1073.2	1.45				1.48	1.74	2.41	2.88	2.68	3.34
1098.2						1.83	2.83	3.08		3.42
1123.2						1.97	3.01	3.34	3.36	3.60

These values are based on the work of Belozerskii and Freidina (classical ac technique) [54]. Due to limited data, the experimental values are given.

$PbCl_2$-RbCl

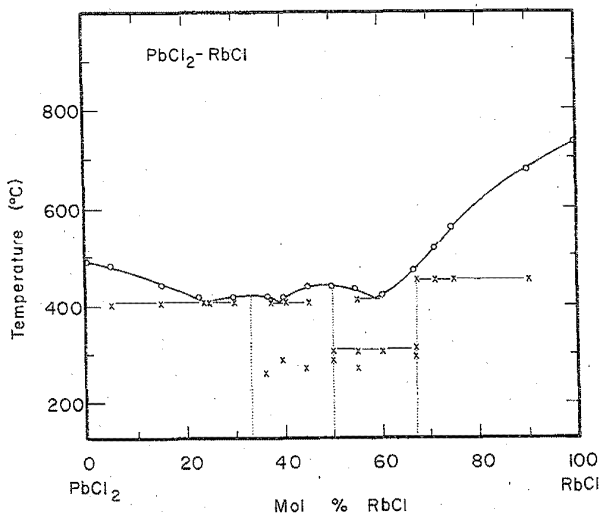

FIGURE 109. Temperature-composition phase diagram for $PbCl_2$-RbCl.

T. Liebisch and E. Korreng, Sitzb. Preuss. Akad. Wiss., 192–212 (1914).

Melt Preparation and Purification

Bloom et al. [103] and Bloom and Macky [49] used Koch-Light RbCl without further purification; the preparation of pure $PbCl_2$ is discussed under the CsCl-$PbCl_2$ system.

Dahl and Duke [238] used RbCl, obtained from A.D. MacKay Inc., without further purification except for drying. "Baker Analyzed" reagent $PbCl_2$ was fused at temperatures slightly above the melting point, crushed and stored in a drying oven at 110 °C.

TABLE 586. Electrical conductance studies: $PbCl_2$-RbCl

Investigations critically re-examined			
Ref.	RbCl Mol %	Temp. range (T)	Comments
49	0–90	723–1123	Calibration: silica cell; Pt electrodes; freq. range: 1000 Hz; calibration: 1M KCl solution at 25 °C

Deviations from previous NSRDS recommendations: [1, p. 13]			
Ref.	RbCl Mol %	Min. departure	Max. departure
49	0	−0.41% (873 K)	−0.70% (923 K)

Comment: Bloom and Macky [49] estimated the accuracy of their conductance measurements on molten mixtures to be ±0.5%.

TABLE 587. $PbCl_2$-RbCl: Specific conductance (ohm^{-1} cm^{-1})

	Mol percent RbCl						
T	90.0	75.0	66.7	50.0	33.3	15.0	0.0
740			0.603	0.745	0.925	1.135	
760			0.668	0.815	0.994	1.227	
780		0.808	0.732	0.883	1.062	1.316	
800		0.859	0.795	0.949	1.128	1.402	
820		0.909	0.857	1.014	1.193	1.486	
840		0.960	0.918	1.076	1.256	1.567	1.780
860		1.011	0.979	1.137	1.318	1.646	1.865
880		1.061	1.038	1.195	1.378	1.722	1.950
900		1.112	1.097	1.252	1.436	1.796	2.033
920		1.164	1.155	1.307	1.493	1.867	2.115
940	1.244	1.215	1.212	1.360	1.549	1.936	2.196
960	1.303	1.266	1.268	1.411	1.602	2.002	2.276
980	1.362	1.318	1.324	1.460	1.655	2.065	2.354
1000	1.421	1.370	1.378	1.507	1.705	2.126	2.432
1020	1.480	1.422	1.432	1.552	1.754	2.184	2.508
1040	1.540	1.474	1.484	1.596	1.802	2.240	2.583
1060	1.599	1.526	1.536	1.637	1.848	2.293	2.658
1080	1.658	1.578	1.588	1.677	1.892	2.344	
1100	1.717	1.631	1.638	1.714	1.935	2.392	
1120	1.776	1.683	1.687	1.750	1.976	2.437	

TABLE 587. $PbCl_2$-RbCl: Specific conductance (ohm^{-1} cm^{-1})—Continued

Temperature-dependent equations $\kappa = a + bT + cT^2$				
Mol % RbCl	a	$b \cdot 10^3$	$c \cdot 10^7$	Stand. error of est.
0.0	−2.8404	6.6977	−14.256	0.32%
15.0	−4.0501	9.3739	−31.981	0.29%
33.3	−2.7502	6.4194	−19.638	0.12%
50.0	−3.1886	7.0790	−23.834	0.29%
66.7	−2.3894	4.8322	−10.647	0.23%
75.0	−1.0421	2.2331	1.7878	0.11%
90.0	−1.5387	2.9600	0	0.64%

These values are based on the work of Bloom and Macky (classical ac technique) [**49**].

TABLE 588. Density studies: $PbCl_2$-RbCl

Investigations critically re-examined				
Ref.	RbCl Mol %	Temp. range (T)	Cell material	Calibration
103	0–100	873–1198	10% Rh-Pt sinker	Water
142[a]	0–100	873–1200		

Deviations from previous NSRDS recommendations: [1, pp. 6, 13]			
Ref.	RbCl Mol %	Min. departure	Max. departure
103	0	−0.04% (920 K)	−0.02% (960 K)
103	100	0.10% (1000 K)	0.41% (1200 K)

[a]Data from reference [**103**].

Comments: A brief discussion of the corrections applied by Bloom et al. [**103**] in their density measurements is given under the NaCl-$PbCl_2$ system. Data were given in the form of linear temperature dependent equations with standard deviations in the range of 0.7×10^{-3} g cm^{-3} (100 mol % RbCl) to 2.0×10^{-3} g cm^{-3} (0 mol % RbCl).

TABLE 589. $PbCl_2$-RbCl: Density (g cm^{-3})

	Mol percent RbCl						
T	100.0	85.2	69.7	61.4	41.4	21.6	0.0
880			3.094	3.264	3.725	4.227	
890			3.082	3.253	3.712	4.213	
900			3.071	3.241	3.700	4.199	
910			3.059	3.229	3.687	4.185	
920			3.048	3.218	3.674	4.171	4.730
930			3.036	3.206	3.661	4.157	4.715
940			3.025	3.195	3.649	4.143	4.701
950			3.013	3.183	3.636	4.130	4.686
960			3.002	3.172	3.623	4.116	4.671
970			2.990	3.160	3.611	4.102	4.656
980		2.622	2.979	3.149	3.598	4.088	4.642
990		2.613	2.967	3.137	3.585	4.074	4.627
1000	2.240	2.604	2.956	3.125	3.573	4.060	4.612
1010	2.231	2.595	2.944	3.114	3.560	4.046	4.597
1020	2.223	2.586	2.933	3.102	3.547	4.032	4.582

TABLE 589. $PbCl_2$-RbCl: Density (g cm^{-3})—Continued

	Mol percent RbCl						
T	100.0	85.2	69.7	61.4	41.4	21.6	0.0
1030	2.214	2.577	2.921	3.091	3.534	4.018	4.568
1040	2.206	2.568	2.910	3.079	3.522	4.004	4.553
1050	2.197	2.559	2.898	3.068	3.509	3.990	4.538
1060	2.189	2.550	2.887	3.056	3.496	3.977	4.523
1070	2.180	2.541	2.875	3.045	3.484	3.963	
1080	2.172	2.532					
1090	2.163	2.523					
1100	2.155	2.514					
1110	2.146	2.505					
1120	2.138						
1130	2.129						
1140	2.121						
1150	2.112						
1160	2.103						
1170	2.095						
1180	2.086						
1190	2.078						

Temperature-dependent equations

$$\rho = a + bT$$

Mol % RbCl	a	$b \cdot 10^3$	Stand. dev.
0.0	6.0890	−1.477	0.002
21.6	5.4510	−1.391	0.001
41.4	4.8425	−1.270	0.001
61.4	4.2805	−1.155	0.001
69.7	4.1049	−1.149	0.001
85.2	3.5064	−0.902	0.001
100.0	3.0918	−0.852	0.0007

These values are based on the work of Bloom et al. (Archimedean method) [**103**].

TABLE 590. Surface tension studies: $PbCl_2$-RbCl

Investigations critically re-examined			
Ref.	RbCl Mol %	Temp. range (T)	Comments
238	0–72.50	745–861	Cell material: Pt-10%Rh capillary, melt contained in Pt crucible; calibration: diameter of capillary was measured with microscope and checked with measurements on benzene as in **238**
254	0–72.5	745–861	Same as for **238**

Comment: Remarks concerning reference [**238**] are given under the system LiCl-$PbCl_2$. Surface tension data for pure $PbCl_2$ [**238**] are recommended in NSRDS–NBS–28 [2].

TABLE 591. $PbCl_2$-RbCl: Surface tension (dyn cm^{-1})

	Mol percent RbCl							
T	72.50	57.77	55.00	50.92	31.90	19.80	3.96	0.00
750		111.8	110.9	111.9	115.8	123.5		
755		111.2	110.6	111.4	115.3	123.0		
760		110.7	110.2	111.0	114.8	122.5		
765		110.2	109.8	110.5	114.3	121.9		
770		109.7	109.5	110.1	113.8	121.4		
775		109.2	109.1	109.6	113.4	120.9		
780		108.7	108.7	109.1	112.9	120.4		
785		108.2	108.4	108.7	112.4	119.9		
790		107.7	108.0	108.2	111.9	119.4	131.1	
795		107.1	107.6	107.8	111.4	118.8	130.5	134.9

TABLE 591. $PbCl_2$-RbCl: Surface tension (dyn cm^{-1})—Continued

	Mol percent RbCl							
T	72.50	57.77	55.00	50.92	31.90	19.80	3.96	0.00
800		106.6	107.3	107.3	110.9	118.3	129.9	134.3
805		106.1	106.9	106.9	110.4	117.8	129.3	133.6
810		105.6	106.5	106.4	109.9	117.3	128.7	133.0
815		105.1	106.2	105.9	109.4	116.8	128.1	132.4
820		104.6	105.8	105.5	108.9	116.3	127.6	131.8
825			105.4	105.0	108.4	115.8	127.0	131.1
830			105.1	104.6	107.9	115.2	126.4	130.5
835			104.7	104.1	107.4	114.7	125.8	129.9
840	104.5		104.3	103.7	106.9	114.2	125.2	129.3
845	104.1		104.0	103.2	106.4	113.7	124.6	128.7
850	103.7		103.6				124.0	
855	103.3							
860	102.9							

Temperature-dependent equations

$$\gamma = a + bT$$

Mol % RbCl	a	$b \cdot 10^2$	Stand. error of est.
0.00	233.6772	−12.4284	0.49%
3.96	224.1056	−11.7755	0.22%
19.80	200.7342	−10.3011	0.20%
31.90	189.8578	−9.8722	0.29%
50.92	180.3699	−9.1331	0.33%
55.00	166.1787	−7.3647	0.87%
57.77	188.6019	−10.2465	0.16%
72.50	174.1704	−8.2888	0.54%

These values are based on the work of Dahl and Duke (maximum bubble pressure method) [238].

$PbCl_2$-TlCl

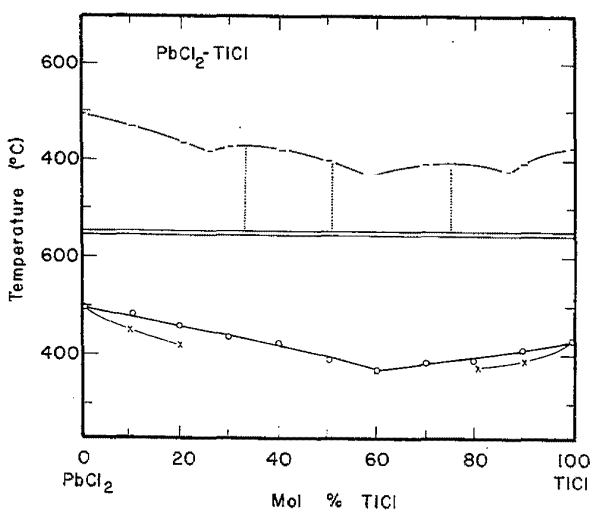

FIGURE 110. Temperature-composition phase diagram for $PbCl_2$-TlCl.

1) C. Sandonnini, Atti Accad Lincei., **22** II, 20 (1913).

2) L. I. Pavorskii, Ann secteur and phys. chem. Inst. chim. Gen. (U.S.S.R.), **13**, 281 (1940).

3) I. I. Il'yasov and A. G. Bergman, Zhur. Neorg. Khim., II [12], 2771 (1957).

Melt Preparation and Purification

Lantratov and Moiseeva [68] purified $PbCl_2$ and TlCl by heating the salts in a stream of dry HCl gas. The purified materials were kept in ground glass stoppered vessels and stored in a desiccator. Prior to experimental measurements the mixtures were subjected to a dry HCl gas stream for a period of ½ to 1 hour.

TABLE 592. Electrical conductance studies: $PbCl_2$-TlCl

Investigations critically re-examined			
Ref.	TlCl Mol %	Temp. range (T)	Comments
68	0–100	723–973	Cell material: quartz capillary cell; Pt electrodes; freq. range: 1000–3000 Hz; calibration: molten KCl, $PbCl_2$ and KNO_3

Deviations from previous NSRDS recommendations: [1, p. 131]			
Ref.	TlCl Mol %	Min. departure	Max. departure
68	100	−1.03% (723 K)	−3.31% (873 K)
68	0	−0.18% (823 K)	0.69% (773 K)

TABLE 593. $PbCl_2$-TlCl: Specific conductance (ohm^{-1} cm^{-1})

	Mol % TlCl										
T	100	90	86.5	75	59	50	33.3	26	15	10	0
730	1.182	1.063	1.026	0.973	1.001	1.041	1.105	1.070	1.116		
740	1.216	1.093	1.057	1.005	1.034	1.070	1.135	1.108	1.156		
750	1.250	1.123	1.089	1.038	1.066	1.099	1.165	1.147	1.195		
760	1.283	1.153	1.120	1.070	1.097	1.128	1.195	1.184	1.235		
770	1.317	1.183	1.151	1.102	1.129	1.157	1.226	1.222	1.273		
780	1.350	1.213	1.182	1.134	1.160	1.187	1.256	1.259	1.312	1.331	1.493
790	1.383	1.244	1.213	1.165	1.191	1.216	1.286	1.295	1.349	1.370	1.543
800	1.415	1.274	1.244	1.196	1.222	1.245	1.317	1.332	1.387	1.409	1.591
810	1.448	1.305	1.274	1.227	1.253	1.274	1.347	1.368	1.424	1.448	1.639
820	1.480	1.336	1.305	1.257	1.283	1.304	1.378	1.403	1.460	1.486	1.686
830	1.512	1.367	1.335	1.287	1.313	1.333	1.409	1.439	1.497	1.523	1.733
840	1.544	1.398	1.365	1.317	1.343	1.362	1.439	1.473	1.532	1.560	1.779
850	1.575	1.430	1.395	1.346	1.373	1.391	1.470	1.508	1.567	1.597	1.824
860	1.607	1.461	1.425	1.375	1.403	1.420	1.501	1.542	1.602	1.633	1.868
870	1.638	1.493	1.455	1.404	1.432	1.450	1.532	1.576	1.636	1.668	1.912
880	1.669	1.525	1.484	1.433	1.461	1.479	1.563	1.609	1.670	1.703	1.955
890	1.699	1.557	1.514	1.461	1.490	1.508	1.594	1.642	1.704	1.737	1.997
900	1.730	1.589	1.543	1.489	1.518	1.537	1.625	1.675	1.737	1.771	2.038
910	1.760	1.621	1.572	1.516	1.546	1.567	1.657	1.707	1.769	1.804	2.079
920	1.790	1.654	1.601	1.543	1.575	1.596	1.688	1.739	1.801	1.836	2.119
930	1.820	1.687	1.630	1.570	1.602	1.625	1.719	1.770	1.833	1.868	
940	1.849	1.719	1.658	1.597	1.630	1.654	1.751	1.801	1.864	1.900	
950	1.878	1.752	1.687	1.623	1.657	1.683	1.782	1.832	1.895	1.931	
960	1.908	1.786	1.715	1.649	1.685	1.713	1.814	1.863	1.925	1.961	
970	1.936	1.819	1.743	1.674	1.712	1.742	1.845	1.893	1.955	1.991	

Temperature-dependent equations

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

Mol % TlCl	a	$b \cdot 10^3$	$c \cdot 10^6$	Stand. error of est.
0	−4.5690	10.5707	−3.5880	0.32%
10	−3.4521	8.2686	−2.7397	0.13%
15	−3.0120	7.2773	−2.2233	0.26%
26	−2.7443	6.5768	−1.8521	0.53%
33.3	−0.9097	2.5147	0.3356	0.29%
50	−1.0927	2.9223	0	0.87%
59	−1.9746	4.9175	−1.1519	0.25%
75	−2.2859	5.6224	−1.5873	0.25%
86.5	−1.6734	4.2302	−0.7296	0.06%
90	−0.6681	1.7886	0.7994	0.50%
100	−1.9020	5.0391	−1.1154	0.55%

These values are based on the work of Lantratov and Moisceva (classical ac technique) [**68**].

TABLE 594. Density studies: $PbCl_2$-TlCl

Investigations critically re-examined			
Ref.	TlCl Mol %	Temp. range (T)	Comments
195	0–100	673–873	Cell material: quartz float (weighted with W), Pt suspension wire; calibration: water

Deviations from previous NSRDS recommendations: [1, pp. 12, 13]			
Ref.	TlCl Mol %	Min. departure	Max. departure
195	100	0.00% (780 K)	−0.12% (720 K)
195	0	0.05% (870 K)	0.10% (780 K)

TABLE 595. $PbCl_2$-TlCl: Density (g cm^{-3})

	Mol % $PbCl_2$											
T	100	90	80	70	60	50	40	30	20	10	0	57.1
690						5.223						5.264
700		5.514	5.420	5.337	5.266	5.207						5.248
710		5.498	5.404	5.321	5.250	5.191	5.143					5.232
720	5.587	5.482	5.388	5.305	5.234	5.175	5.127	5.090				5.216
730	5.571	5.466	5.372	5.289	5.218	5.159	5.110	5.074				5.200
740	5.555	5.450	5.356	5.273	5.202	5.143	5.094	5.058				5.184
750	5.539	5.434	5.340	5.257	5.186	5.126	5.078	5.042	5.016			5.168
760	5.523	5.418	5.324	5.241	5.170	5.110	5.062	5.026	5.000	4.986		5.152
770	5.507	5.402	5.308	5.225	5.154	5.094	5.046	5.009	4.984	4.970		
780	5.491							4.993	4.968	4.954		
790									4.952	4.938	4.936	
800									4.936	4.922	4.920	
810										4.906	4.904	
820										4.890	4.888	
830											4.872	
840											4.855	
850											4.839	
860											4.823	
870											4.807	

Two-dimensional equation and statistical parameters

$$\rho = a + bT + cC + dC^2$$

a	$b \cdot 10^3$	$c \cdot 10^2$	$d \cdot 10^5$	Max. percent departure	Stand. error of est.
6.74466	−1.60740	−1.11156	5.72606	0.16% (763.2 K, 30 mol % $PbCl_2$)	0.07%

These values are based on the work of Markov et al. (Archimedean method) **[195]**. C = mol % $PbCl_2$.

TABLE 596. $PbCl_2$-TlCl: Density (g cm^{-3})

	Mol % TlCl										
T	100	90	80	70	60	50	40	30	20	10	0
680						5.238					
690						5.222					
700		5.519	5.419	5.332	5.273	5.206					
710		5.503	5.402	5.315	5.257	5.190	5.142				
720		5.486	5.386	5.299	5.241	5.174	5.126	5.090			
730	5.574	5.469	5.369	5.282	5.224	5.158	5.110	5.075			
740	5.557	5.453	5.352	5.266	5.208	5.142	5.094	5.059			
750	5.540	5.436	5.336	5.249	5.192	5.126	5.078	5.043	5.018		
760	5.523	5.419	5.319	5.233	5.176	5.110	5.062	5.027	5.003	4.983	
770	5.506	5.402	5.302	5.216	5.159	5.094	5.046	5.012	4.987	4.967	
780	5.490							4.996	4.971	4.952	
790									4.956	4.937	4.932
800									4.940	4.921	4.917
810										4.906	4.902
820										4.891	4.886
830											4.871
840											4.856
850											4.840
860											4.825
870											4.810

Temperature-dependent equations

$\rho = a + bT$

Mol % TlCl	a	$b \cdot 10^3$
0	6.143	−1.532
10	6.153	−1.539
20	6.193	−1.566
30	6.226	−1.577
40	6.278	−1.600
50	6.333	−1.609
60	6.414	−1.630
70	6.487	−1.650
80	6.585	−1.666
90	6.691	−1.674
100	6.802	−1.682

These values are based on the work of Markov et al. (Archimedean method) [195].

$PbCl_2$-$ZnCl_2$

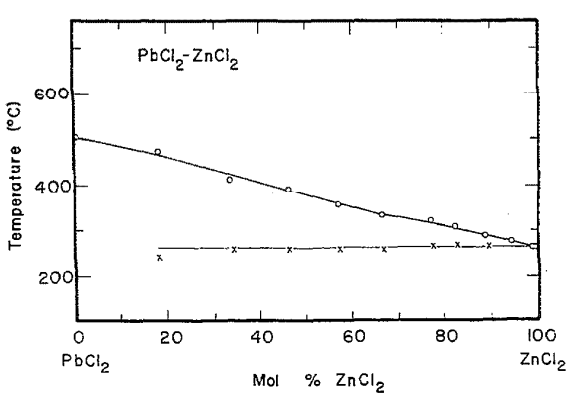

FIGURE 111. Temperature-composition phase diagram for $PbCl_2$-$ZnCl_2$.

G. Herrmann, Z. Anorg. Chem., **71**, 257, 302 (1911).

Melt Preparation and Purification

The chloride salts used in reference [19] were obtained from commercial sources of high purity and were dehydrated by melting in the presence of dry HCl gas.

After weighing and introducing the salts into the measuring cell, the molten mixture was treated with HCl gas for one hour.

TABLE 597. Density studies: $PbCl_2$-$ZnCl_2$

Investigations critically re-examined			
Ref.	$ZnCl_2$ Mol %	Temp. range (T)	Comments
19	0, 50.2, 100	759–825	Cell material: tungsten-weighted pyrex bulb; calibration: water

Deviations from previous NSRDS recommendations: [1, pp. 10, 13]			
Ref.	$ZnCl_2$ Mol %	Min. departure	Max. departure
19	100	−0.45% (770 K)	−0.53% (824 K)
19	0	−0.10% (809 K)	−0.24% (818 K)

Comment: Hildebrand and Wachter [**19**] measured densities by weighing a tungsten-weighted pyrex bulb in air, in water and in the fused salt, correcting for the expansion of the bulb.

TABLE 598. $PbCl_2$-$ZnCl_2$: Density (g cm^{-3})

	Mol % $ZnCl_2$		
T	100	50.2	0
760	2.430		
765	2.428		
770	2.426		
775	2.423		
780	2.421		4.936
785	2.419	3.732	4.928
790	2.416	3.729	4.919
795	2.414	3.725	4.911
800	2.412	3.722	4.902
805	2.409	3.718	4.894
810	2.407	3.715	4.886
815	2.405	3.711	4.877
820	2.402	3.708	
825		3.704	

Temperature-dependent equations
$\rho = a + bT$

Mol % $ZnCl_2$	a	$b \cdot 10^3$	Stand. error of est.
0	6.2490	−1.6832	0.22%
50.2	4.2829	−0.7014	0.22%
100	2.7813	−0.4619	0.15%

These values are based on the work of Hildebrand and Wachter (pycnometric method) [**19**].

RbCl-$ScCl_3$

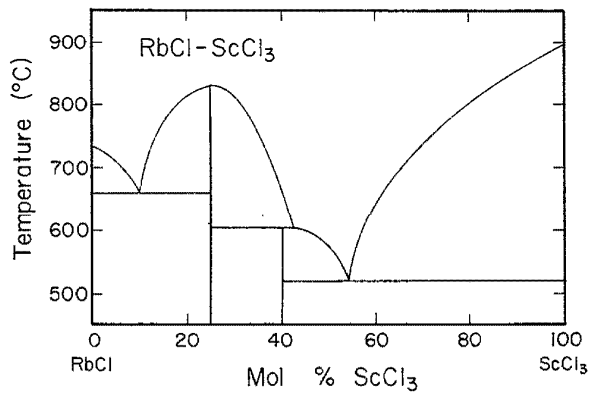

FIGURE 112. Temperature-composition phase diagram for RbCl-$ScCl_3$.

N. Ya. Fedorov, and E. S. Petrov, Izv. Sib. Otd. Akad. Nauk. S.S.S.R., Ser. Khim. Nauk., **1**, 57 (1967).

Melt Preparation and Purification

The preparation of pure $ScCl_3$ by Fedorov and Petrov [**71**] is discussed under the system LiCl-$ScCl_3$. No information was reported for the alkali metal chloride salts.

TABLE 599. Electrical conductivity studies: RbCl-$ScCl_3$

Investigations critically re-examined			
Ref.	$ScCl_3$ Mol %	Temp. range (T)	Comments
71	0–69.8 (g)	913–1233	Cell material: sealed quartz vessels; Mo wire electrodes; calibration: 1N KCl solution

Comment: Remarks concerning the experimental procedure of Fedorov and Petrov [**71**] are given under the LiCl-$ScCl_3$ system.

TABLE 600. RbCl-$ScCl_3$: Specific conductance (ohm^{-1} cm^{-1})

Mol % $ScCl_3$	913 K	933 K	953 K	973 K	993 K	1113 K	1133 K	1153 K
0					1.49	1.51	1.56	1.60
10				0.96	1.01	1.05	1.11	1.16
40		0.44	0.48	0.53	0.58	0.62	0.68	0.71
50	0.38	0.41	0.46	0.50	0.54	0.59	0.62	0.65
60					0.46	0.53	0.56	0.60

Mol % $ScCl_3$	1173 K	1193 K	1213 K	1233 K	1253 K	1273 K	1293 K	1313 K	1333 K
0	1.64	1.68	1.72	1.76	1.80	1.84	1.89	1.92	1.96
10	1.20	1.26	1.31	1.34	1.40	1.45	1.48	1.52	1.55
20		1.03	1.09	1.14	1.19	1.24	1.28	1.33	1.38
30		0.88	0.93	0.97	1.03	1.08	1.12	1.15	1.20
40	0.78	0.82	0.86	0.88	0.92	0.94	0.98	1.00	1.04
50	0.70	0.72	0.75	0.82	0.86	0.89	0.92	0.95	0.97
60	0.65	0.68	0.72	0.77	0.80	0.83	0.86	0.89	0.92
70		0.60	0.65	0.68	0.71	0.75	0.79	0.83	0.86

These values have been interpolated to a maximum of three significant figures from the graphical presentation of Fedorov and Petrov (classical ac technique) [**71**].

RbCl-$SrCl_2$

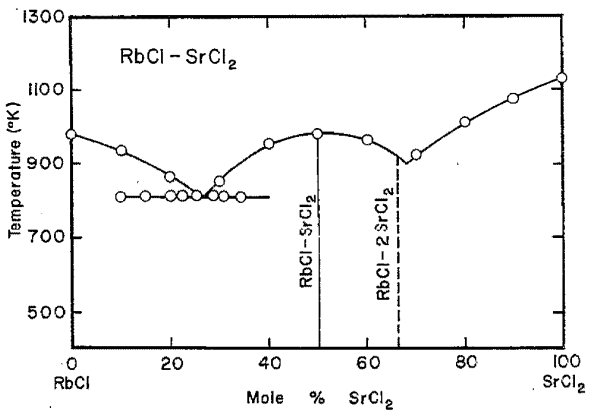

FIGURE 113. Temperature-composition phase diagram for RbCl-$SrCl_2$.

E. P. Dergurov and A. G. Bergman, Doklady Akad. Nauk. S.S.S.R., **75**, 815 (1950).

S. D. Gromakov, Zhur. Fiz. Khim., **24**, 641 (1950).

Melt Preparation and Purification

In their viscosity measurements, Bertozzi and Soldani [**244**] used carefully dried Merck and B. D. H. salts of analytical purity without further purification.

TABLE 601. Surface tension studies: RbCl $SrCl_2$

Investigations critically re-examined		
Ref.	$SrCl_2$ Mol %	Temp. range (T)
244[a]	0–100	1123

[a]The surface tension data reported in reference [**244**] was stated to be reproducible to within 0.5%.

TABLE 602. RbCl-$SrCl_2$: Surface tension (dyn cm^{-1})

Mol % $SrCl_2$	1123 K	Mol % $SrCl_2$	1123 K
0	86	60	116
10	90	70	123
20	94	80	131
30	99	90	146
40	104	100	172
50	109		

These values have been interpolated to three significant figures from the graphical presentation of Bertozzi and Soldani (Wilhelmy slide plate method) [**244**].

RbCl-$TiCl_3$

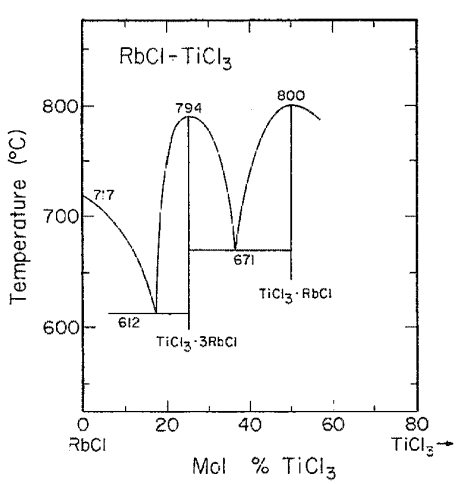

FIGURE 114. Temperature-composition phase diagram for RbCl-$TiCl_3$.

B. F. Markov and R. V. Chernov, Ukrain. Khim. Zhur., **25**, 282 (1959).

TABLE 603. Electrical conductance studies: RbCl-$TiCl_3$

Investigations critically re-examined			
Ref.	$TiCl_3$ Mol %	Temp. range (T)	Comments
59	~0–55 (g)	1073	Cell material: quartz vessel; Pt electrodes; freq. range: 1400 Hz

TABLE 604. RbCl-$TiCl_3$: Specific conductance (ohm^{-1} cm^{-1})

Mol % $TiCl_3$	1073 K	Mol % $TiCl_3$	1073 K
0	1.68	30	0.99
5	1.52	35	0.95
10	1.37	40	0.93
15	1.25	45	0.91
20	1.16	50	0.91
25	1.08		

These values have been interpolated to three significant figures from the graphical presentation of Chernov and Delimarskii (classical ac technique) [59].

RbCl-UCl_4

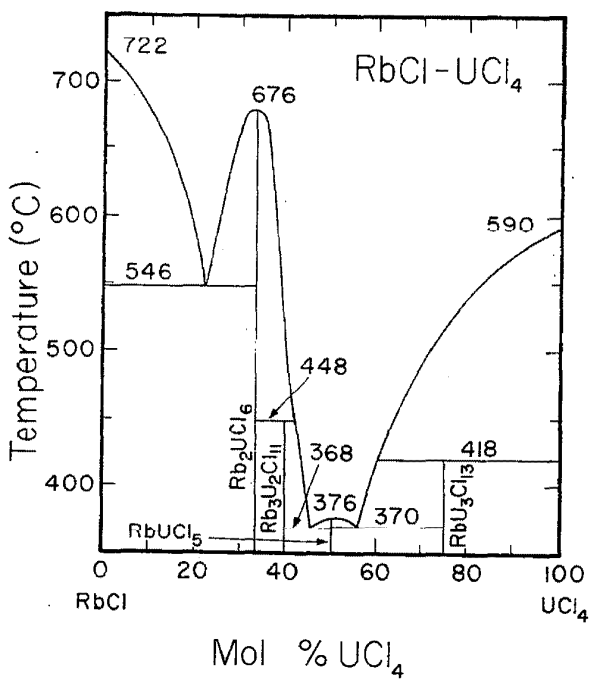

FIGURE 115. Temperature-composition phase diagram for RbCl-UCl_4.

A. Bogacz and B. Ziolek, Rocz. Chem., **44**, 664 (1970).

Melt Preparation and Purification

Bogacz and Ziolek [**158**] prepared and purified their salts using the procedure described under the system CsCl-UCl_4.

TABLE 605. Electrical conductance studies: RbCl-UCl_4

Investigations critically re-examined			
Ref.	UCl_4 Mol %	Temp. range (T)	Comments
158	0–100	690–1040	Cell material: quartz U-tube; Pt electrodes; freq. range: 5000–10,000 Hz; measurements at 10,000 Hz; calibration: KCl solutions and molten KNO_3, $NaNO_3$ and KCl

Deviations from previous NSRDS recommendations: [1, pp. 6, 9]			
Ref.	UCl_4 Mol %	Min. departure	Max. departure
158	100	1.2% (870 K)	−4.4% (890 K)
158	0	−0.90% (1010 K)	−1.9% (1040 K)

Comment: Bogacz and Ziolek [**158**] report their conductance results in the form of equations of the type $\kappa = a + bt + ct^2$ with standard deviations in the range 1.0×10^{-4} ohm^{-1} cm^{-1} (24.99, 28.81, and 56.54 mol % UCl_4) to 12.0×10^{-4} ohm^{-1} cm^{-1} (0.0 mol % UCl_4).

TABLE 606. RbCl-UCl_4: Specific conductance (ohm^{-1} cm^{-1})

	Mol percent UCl_4																				
T	100.0	95.17	92.31	88.29	82.74	71.24	64.82	59.68	56.54	50.83	42.25	39.50	34.00	28.81	24.99	20.24	16.54	12.35	9.12	1.62	0.00
700											0.247										
710											0.260										
720											0.273										
730											0.285										
740											0.298										
750											0.310										
760											0.323										
770											0.335										
780						0.306					0.347										
790						0.324					0.359										
800						0.342					0.372										
810				0.302		0.359			0.387		0.384										
820				0.324		0.375			0.399		0.396	0.419									
830				0.346	0.375	0.391	0.409		0.411		0.408	0.431									
840				0.367	0.390	0.406	0.422	0.419	0.422	0.410	0.419	0.444									
850				0.387	0.404	0.421	0.435	0.431	0.434	0.421	0.431	0.456									
860			0.404	0.406	0.417	0.435	0.447	0.443	0.445	0.433	0.443	0.468									
870			0.420	0.424	0.429	0.449	0.459	0.454	0.456	0.444	0.454	0.480									
880	0.436		0.437	0.442	0.441	0.461	0.470	0.465	0.467	0.455	0.466	0.491			0.574						
890	0.451	0.453	0.454	0.459	0.452	0.474	0.481	0.476	0.477	0.466	0.478	0.503			0.588						
900	0.465	0.471		0.475	0.463	0.486	0.492	0.486	0.487	0.477	0.489	0.515			0.603						
910	0.479	0.487		0.490	0.473		0.502	0.496	0.498	0.488	0.500	0.526			0.617						
920	0.492	0.502		0.504			0.511	0.506	0.507	0.498	0.512	0.537		0.601	0.632	0.697	0.762				
930	0.505	0.516		0.518			0.521	0.516	0.517	0.509	0.523	0.549		0.614	0.646	0.712	0.779				
940	0.518	0.528		0.531			0.529	0.525	0.526	0.519	0.534	0.560		0.626	0.660	0.727	0.797				
950	0.530	0.540		0.543			0.537	0.534	0.535	0.530	0.545	0.571	0.603	0.639	0.673	0.743	0.814	0.929			
960	0.542	0.550		0.554			0.545	0.543	0.544	0.540	0.556	0.581	0.619	0.651	0.687	0.758	0.830	0.948	1.043		
970	0.554	0.550		0.565			0.553	0.551	0.553	0.550	0.567	0.592	0.633	0.663	0.701	0.773	0.847	0.967	1.064		
980	0.565	0.558		0.574			0.560	0.559	0.562	0.560	0.578		0.645	0.675	0.714	0.788	0.863	0.986	1.084		
990	0.576	0.574		0.583			0.566		0.570				0.656	0.687	0.727	0.802	0.880	1.004	1.103	1.414	
1000	0.587			0.591			0.572						0.664	0.698	0.740	0.817	0.896	1.021	1.119	1.438	
1010							0.578								0.753	0.832	0.912	1.039	1.134		1.534
1020																0.846					1.562
1030																0.861					1.584
1040																					1.603

TABLE 606. RbCl-UCl_4: Specific conductance (ohm^{-1} cm^{-1})—Continued

Temperature-dependent equations $\kappa = a + bT + cT^2$				
Mol % UCl_4	a	$b \cdot 10^3$	$c \cdot 10^6$	Stand. dev.
0.00	−24.5084	48.6094	−22.5987	0.0012
1.62	−1.4295	3.3144	−0.4469	0.0002
9.12	−9.0148	18.6954	−8.5614	0.0005
12.35	−2.9862	6.2779	−2.2702	0.0002
16.54	−1.6281	3.4505	−0.9266	0.0002
20.24	−1.0915	2.3464	−0.4377	0.0003
24.99	−1.2782	2.7344	−0.7159	0.0001
28.81	−1.2183	2.6790	−0.7624	0.0001
34.00	−9.2818	19.1235	−9.1772	0.0003
39.50	−1.0149	2.2497	−0.6113	0.0002
42.25	−0.8108	1.7483	−0.3379	0.0002
50.83	−0.9408	2.0641	−0.5432	0.0002
56.54	−1.3525	3.0712	−1.1409	0.0001
59.68	−1.6334	3.6799	−1.4721	0.0002
64.82	−2.2234	5.0093	−2.2138	0.0004
71.24	−2.8423	6.2403	−2.8250	0.0009
82.74	−3.3464	7.4574	−3.5832	0.0004
88.29	−4.1325	8.6757	−3.9518	0.0004
92.31	0.7113	−2.2962	2.2551	0.0003
95.17	−5.7832	12.2168	−5.8535	0.0002
100.00	−2.2782	4.6911	−1.8260	0.0002

These values are based on the work of Bogacz and Ziolek (classical ac technique) **[158]**.

TABLE 607. Density studies: RbCl-UCl_4

Investigations critically re-examined			
Ref.	UCl_4 Mol %	Temp. range (T)	Comments
158	0–100	690–1032	Pt ball and suspension wire inside quartz tube

Deviations from previous NSRDS recommendations: [1, p. 6]			
Ref.	UCl_4 Mol %	Min. departure	Max. departure
158	0	−0.08% (1010 K)	−0.13% (1030 K)

Comment: Density data in reference [**158**] were reported in the form of linear temperature dependent equations with standard deviations in the range: 2.0×10^{-4} g cm^{-3} (95.17 mol % UCl_4) to 10.0×10^{-4} g cm^{-3} (28.81 mol % UCl_4). The total error in density measurements was reported to be $\leq 0.2\%$.

TABLE 608. RbCl-UCl_4: Density (g cm^{-3})

	Mol percent UCl_4															
T	100.00	95.17	64.82	59.68	56.54	50.83	45.25	39.50	34.00	28.81	24.99	20.24	12.35	9.12	1.62	0.00
700							3.229									
710							3.218									
720							3.207									
730							3.196									
740							3.185									
750							3.174									
760							3.164									
770							3.153									
780							3.142									
790							3.131									
800							3.120									
810							3.109									
820							3.098	3.013								
830			3.283				3.088	3.003								
840			3.270			3.148	3.077	2.994								
850			3.257		3.159	3.137	3.066	3.985								
860			3.244	3.183	3.147	3.126	3.055	2.975								
870	3.558		3.231	3.171	3.135	3.114	3.044	3.966								
880	3.539		3.218	3.158	3.123	3.103	3.033	2.956			2.749					
890	3.519		3.205	3.146	3.111	3.091	3.022	2.947			2.740					
900	3.500	3.472	3.193	3.134	30.99	3.080	3.011	2.938			2.732					
910	3.480	3.455	3.180	3.122	3.086	3.069	3.001	3.928			2.724					
920	3.461	3.438	3.167	3.110	3.074	3.057	2.990	2.919			2.715					
930	3.441	3.420	3.154	3.098	3.062	3.046	2.979	2.910		2.779	2.707	2.746				
940	3.422	3.403	3.141	3.085	3.050	3.034	2.968	2.900		2.766	2.699	2.736				
950			3.128	3.073	3.038	3.023		2.891	2.825	2.754	2.690	2.726				
960			3.115	3.061	3.026	3.012		2.882	2.817	2.741	2.682	2.716		2.495		
970			3.102	3.049	3.014	3.000		2.872	2.808	2.728	2.674	2.707		2.483		
980			3.089	3.037	3.002	2.989			2.799	2.716	2.666	2.697		2.471		
990			3.076		2.990				2.790	2.703	2.657	2.687	2.492	2.459	2.297	
1000			3.063		2.977				2.782	2.691	2.649	2.677	2.481		2.290	
1010					2.965							2.667	2.469			2.227
1020																2.218
1030																2.209

Temperature-dependent equations

$$\rho = a + bT$$

Mol % UCl_4	a	$b \cdot 10^4$	Stand. dev.
0.00	3.1751	−9.383	0.0004
1.62	2.9855	−6.957	0.0004
9.12	3.6704	−12.241	0.0004
12.35	3.6541	−11.736	0.0006
20.24	3.6618	−9.848	0.0007
24.99	3.4798	−8.309	0.0007
28.81	3.9520	−12.615	0.0010
34.00	3.6548	−8.732	0.0006
39.50	3.7796	−9.354	0.0005
45.25	3.9899	−10.872	0.0008
50.83	4.1070	−11.411	0.0004
56.64	4.1880	−12.105	0.0005
59.68	4.2313	−12.191	0.0005
64.82	4.3583	−12.953	0.0007
95.17	5.0411	17.430	0.0002
100.00	5.2508	−19.455	0.0006

These values are based on the work of Bogacz and Ziolek (Archimedean method) [158].

RbCl-$ZnCl_2$

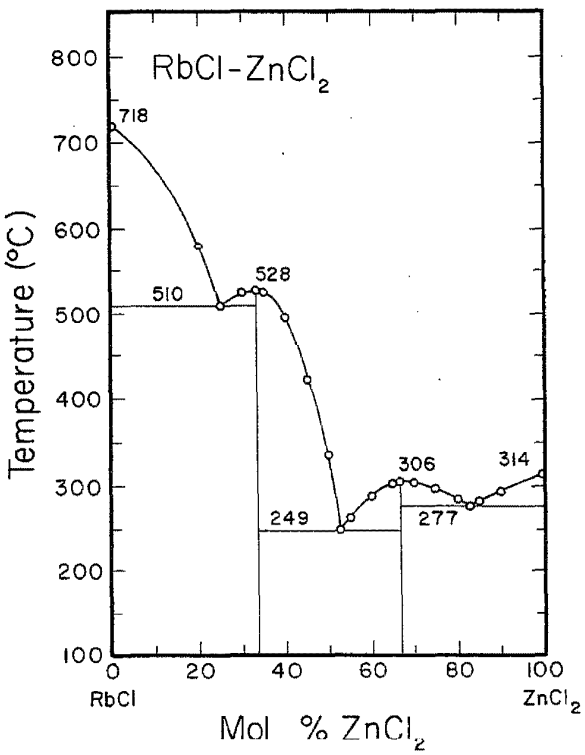

FIGURE 116. Temperature-composition phase diagram for RbCl-$ZnCl_2$.

F. B. Markov, I. D. Panchenko and T. S. Kostrenko, Ukr. Khim. Zh., **22**, 287 (1956)

Melt Preparation and Purification

Purification of $ZnCl_2$ [**194**] is discussed under the system CsCl-$ZnCl_2$. RbCl was recrystallized from water.

TABLE 609. Density studies: RbCl-$ZnCl_2$

Investigations critically re-examined			
Ref.	$ZnCl_2$ Mol %	Temp. range (T)	Comments
194	0–100	660–1058	Cell material: quartz float weighted with tungsten, Pt suspension wire; calibration: water

Deviations from previous NSRDS recommendations [1, pp. 6, 10]			
Ref.	$ZnCl_2$ Mol %	Min. departure	Max. departure
194	100	−0.02% (733 K)	−0.16% (696 K)
194	0	0.31% (1035 K)	0.50% (1059 K)

TABLE 610. RbCl-$ZnCl_2$: Density (g cm^{-3})

	Mol percent $ZnCl_2$									
T	100	90	79.8	69.8	59.7	50.18	40.11	29.86	20	0
660		2.536								
670		2.530								
680		2.523								
690		2.517								
700	2.473	2.510	2.509	2.506						
710	2.467	2.504	2.502	2.498						
720	2.462	2.497	2.495	2.490						
730	2.456	2.491	2.488	2.482						
740	2.451	2.484	2.481	2.474						
750		2.478	2.474	2.466	2.451					
760		2.471	2.467	2.458	2.443					
770		2.465	2.460	2.450	2.436					
780		2.458	2.453	2.442	2.428					
790		2.452	2.446	2.434	2.421					
800		2.445	2.439	2.425	2.413					
810						2.404				
820						2.395	2.397			
830						2.386	2.389			
840						2.377	2.382			
850						2.369	2.374			
860						2.360	2.366	2.376	2.377	
870						2.351	2.358	2.368	2.367	
880						2.342	2.350	2.360	2.357	
890							2.343	2.351	2.348	
900							2.335	2.343	2.339	
910							2.327	2.335	2.331	
920							2.319	2.327	2.324	
930								2.318	2.317	
940								2.310	2.310	
950								2.302	2.304	
960								2.294		
1040										[2.210]
1050										[2.203]

Temperature-dependent equations

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

Mol % $ZnCl_2$	a	$b \cdot 10^4$	$c \cdot 10^6$	Stand. error of est.
0	[2.9747]	[−7.3504]	0	0.00%
20	5.2367	−56.0638	2.6522	0.04%
29.86	3.0865	−8.2603	0	0.04%
40.11	3.0348	−7.7766	0	0.03%
50.18	3.1167	−8.8024	0	0.03%
59.7	3.0167	−7.5426	0	0.03%
69.8	3.0671	−8.0205	0	0.03%
79.8	2.9991	−7.0018	0	0.01%
90	2.9672	−6.5272	0	0.04%
100	2.8484	−5.3700	0	0.02%

These values are based on the work of Markov and Bolkov (Archimedean method) [194].

$SbCl_3$-$SbCl_5$

Melt Preparation and Purification

The antimony trichloride and pentachloride salts in reference [46] were prepared by passing dry chlorine gas through powdered antimony metal. Chlorine was removed from $SbCl_3$ by boiling the liquid over metallic Sb and by fractional distillation. $SbCl_5$ was vacuum distilled and sealed in ampoules. The boiling points of $SbCl_3$ and $SbCl_5$ were 216 °C and 65.6 °C, respectively.

TABLE 611. Electrical conductance studies: $SbCl_3$-$SbCl_5$

Investigations critically re-examined		
Ref.	$SbCl_5$ Mol %	Temp. range (T)
46	0–74.23	323–353

TABLE 612. $SbCl_3$-$SbCl_5$: Specific conductance (ohm^{-1} cm^{-1})

	Mol percent $SbCl_5$														
T	74.23	53.04	48.86	44.39	43.19	28.08	26.73	19.87	18.56	13.50	9.64	6.04	5.48	3.66	0.00
325	6.95	6.83	7.60	1.27	1.73	2.76	3.03	3.39	3.46	3.58	3.52	2.99	2.67	2.21	
330	7.03	6.92	8.19	1.28	1.73	2.80	3.05	3.45	3.51	3.64	3.57	2.98	2.74	2.21	
335	7.23	7.02	8.69	1.29	1.73	2.83	3.06	3.49	3.55	3.69	3.61	2.99	2.80	2.23	[1.51]
340	7.57	7.14	9.09	1.30	1.74	2.85	3.08	3.53	3.58	3.73	3.64	3.01	2.85	2.27	[1.63]
345	8.03	7.26	9.38	1.30	1.76	2.87	3.09	3.56	3.60	3.76	3.66	3.04	2.88	2.33	[1.81]
350	8.61	7.40	9.57	1.30	1.78	2.88	3.10	3.58	3.60	3.77	3.68	3.08	2.90	2.42	[2.07]

Temperature-dependent equations

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

Mol % $SbCl_5$	$a \cdot 10^3$	$b \cdot 10^5$	$c \cdot 10^8$	Stand. error of est.
0.00	[15.3256]	[−9.2196]	[14.0]	0.00%
3.66	4.8859	−2.8431	4.3318	1.32%
5.48	−3.2195	1.9824	−2.7992	0.39%
6.04	3.0784	−1.6831	2.5475	0.53%
9.67	−1.8848	1.2682	−1.7848	0.74%
13.50	−2.1969	1.4469	−2.0326	0.17%
18.56	−2.4419	1.6002	−2.2845	0.66%
19.87	−1.9386	1.2796	−1.7809	0.22%
26.73	−0.3649	0.3714	−0.5107	0.10%
28.08	−1.0385	0.7362	−1.0204	0.11%
43.19	1.5601	−0.8409	1.2742	0.64%
44.39	−0.4855	0.3538	−0.5082	0.01%
48.86	−2.5004	1.4556	−2.0396	1.39%
53.04	0.2843	0.1492	0.2546	0.22%
74.23	0.2748	−0.1651	0.2545	2.09%

These values are based on the work of Beketov et al. (classical ac technique) [**46**].

TABLE 613. Density studies: $SbCl_3$-$SbCl_5$

Investigations critically re-examined		
Ref.	$SbCl_5$ Mol %	Temp. range (T)
46	0–100	323–353

TABLE 614. $SbCl_3$-$SbCl_5$: Density (g cm^{-3})

	Mol percent $SbCl_5$																					
T	100.00	95.52	74.23	66.60	60.11	56.40	55.25	53.50	53.04	44.39	41.70	34.35	28.08	26.73	23.14	21.78	19.87	19.70	18.25	7.32	5.48	0.00
325	2.285	2.307	2.411	2.441	2.473	2.490	2.499	2.501	2.505	2.546	2.556	2.595	2.617	2.620	2.633	2.642	2.652	2.565	2.659	2.703	2.711	2.730
330	2.276	2.295	2.400	2.431	2.463	2.480	2.489	2.490	2.494	2.536	2.545	2.585	2.606	2.610	2.623	2.632	2.641	2.646	2.649	2.693	2.700	2.719
335	2.266	2.284	2.389	2.470	2.452	2.470	2.479	2.479	1.484	2.525	2.534	2.575	2.595	2.600	2.613	2.622	2.629	2.637	2.639	2.682	2.689	2.707
340	2.257	2.272	2.378	2.409	2.441	2.460	2.469	2.468	2.473	2.514	2.524	2.564	2.584	2.590	2.603	2.612	2.618	2.628	2.629	2.672	2.678	2.696
345	2.248	2.261	2.367	2.399	2.430	2.449	2.459	2.457	2.462	2.504	2.513	2.554	2.573	2.579	2.593		2.607	2.618	2.619	2.662	2.668	2.684
350	2.238	2.250	2.356	2.388	2.420	2.439	2.449	2.446	2.451	2.493	2.502	2.544	2.562	2.569	2.583		2.596	2.609	2.609	2.652	2.657	2.673

Temperature-dependent equations

$$\rho = a + bT$$

Mol % $SbCl_5$	a	$b \cdot 10^3$	Stand. error of est.
0.00	3.4755	−2.2931	0.03%
5.48	3.4081	−2.1460	0.004%
7.32	3.3675	−2.0451	0.04%
18.25	3.3111	−2.0061	0.10%
19.20	3.2607	−1.8621	0.08%
19.87	3.3765	−2.2301	0.03%
21.78	3.2753	−1.9501	0.07%
23.14	3.2903	−2.0081	0.06%
26.73	3.2780	−2.0251	0.09%
28.08	3.3220	−2.1701	0.06%
34.35	3.2664	−2.0651	0.08%
41.70	3.2537	−2.1471	0.03%
44.39	3.2368	−2.1251	0.07%
53.04	3.2039	−2.1500	0.08%
53.50	3.2232	−2.2211	0.03%
55.25	3.1550	−2.0171	0.02%
56.40	3.1620	−2.0671	0.10%
60.11	3.1742	−2.1561	0.03%
66.60	3.1368	−2.1401	0.07%
74.23	3.1255	−2.2000	0.11%
95.52	3.0459	−2.2751	0.16%
100.00	2.8924	−1.8691	0.09%

These values are based on the work of Beketov et al. (pycnometric method) [46].

TABLE 615. Viscosity studies: $SbCl_3$-$SbCl_5$

Investigations critically re-examined		
Ref.	$SbCl_5$ Mol %	Temp. range (T)
46	0–100	323–353

TABLE 616. $SbCl_3$-$SbCl_5$: Viscosity (cp)

	Mol percent $SbCl_5$											
T	100.00	95.52	74.23	66.60	60.11	56.40	55.25	53.50	53.04	44.39	41.70	
323.2	1.42	1.49	1.87	1.93		2.19	2.25	2.27	2.31	2.51	2.58	
333.2	1.29	1.31	1.59	1.67	1.78	1.84	1.88	1.90	1.93	2.10	2.09	
343.2	1.16	1.16	1.40	1.45	1.54	1.59	1.62	1.63	1.65	1.79	1.79	
353.2	1.03	1.04	1.26	1.30	1.34	1.39	1.43	1.42	1.44	1.51	1.54	
T	34.35	28.08	26.73	23.14	21.78	19.87	19.20	18.25	12.23	7.32	5.45	0.00
323.2	2.83	2.97	3.01	3.11	3.20	3.24	3.28	3.35	3.56		3.73	3.90
333.2	2.33	2.43	2.46	2.52	2.63	2.63	2.68	2.69	2.82	2.98	3.06	3.18
343.2	1.91	2.03	2.05	2.11	2.15	2.17	2.19	2.26	2.36	2.48	2.50	2.63
353.2	1.65	1.72	1.75	1.77		1.84	1.85	1.92	2.01	2.05	2.12	2.16

Due to limited data, the experimental values are given. These values are based on the work of Beketov (capillary method) [**46**].

$SnCl_4$-$TiCl_4$

Melt Preparation and Purification

Toropov [**48**] states that the usual methods were used to purify the substances in his study but gives no experimental details.

TABLE 617. Density studies: $SnCl_4$-$TiCl_4$

Investigations critically re-examined			
Ref.	$TiCl_4$ Mol %	Temp. range (T)	
48	0–100	293, 313, 333	
Comparisons with NSRDS recommendations: [1, p. 13]			
Ref.	$TiCl_4$ Mol %	Min. departure	Max. departure
48	0	−0.14% (333 K)	−0.49% (293 K)

TABLE 618. $SnCl_4$-$TiCl_4$: Density (g cm^{-3})

	Mol percent $TiCl_4$					
T	100	80	60	40	20	0
295	1.730	1.832	1.933	2.030	2.125	2.217
300	1.721	1.823	1.923	2.019	2.113	2.205
305	1.712	1.813	1.913	2.008	2.101	2.192
310	1.703	1.804	1.902	1.997	2.090	2.180
315	1.695	1.794	1.892	1.986	2.078	2.167
320	1.686	1.785	1.882	1.975	2.066	2.155
325	1.677	1.775	1.871	1.964	2.054	2.142
330	1.668	1.765	1.861	1.953	2.043	2.130

Temperature-dependent equations

$$\rho = a + bT$$

$TiCl_4$ Mol %	a	$b \cdot 10^3$	Stand. error of est.
0	2.9537	−2.4975	0.08%
20	2.8181	−2.3500	0.10%
40	2.6807	−2.2050	0.12%
60	2.5408	−2.0600	0.13%
80	2.3973	−1.9150	0.14%
100	2.2496	−1.7625	0.16%

These values are based on the work of Toropov (pycnometric method) [**48**].

TABLE 619. Viscosity studies: $SnCl_4$-$TiCl_4$

Investigations critically re-examined			
Ref.	$TiCl_4$ Mol %	Temp. range (T)	
48	0–100	293, 313, 333	
Comparison with previous NSRDS recommendations [1, p. 13]			
Ref.	$TiCl_4$ Mol %	Min. departure	Max. departure
48	0	1.3% (313 K)	9.1% (293 K)

TABLE 620. $SnCl_4$-$TiCl_4$: Viscosity (cp)

	Mol percent $TiCl_4$					
T	100	80	60	40	20	0
293.2	0.827	0.847	0.870	0.895	0.922	0.951
313.2	0.702	0.702	0.703	0.705	0.709	0.715
333.2	0.589	0.591	0.595	0.604	0.616	0.635

Due to limited data the experimental values are given. These values are based on the work of Toropov (capillary method) [48].

TABLE 621. Density studies: $SnCl_2$-$ZnCl_2$

Investigations critically re-examined		
Ref.	$ZnCl_2$ Mol %	Temp. range (*T*)
128	0–100	536–763

Comparisons with NSRDS recommendations: [1, p. 10]			
Ref.	$ZnCl_2$ Mol %	Min. departure	Max. departure
128	100	0.0% (680 K)	−0.24% (760 K)
128	0	0.86% (600 K)	0.91% (560 K)

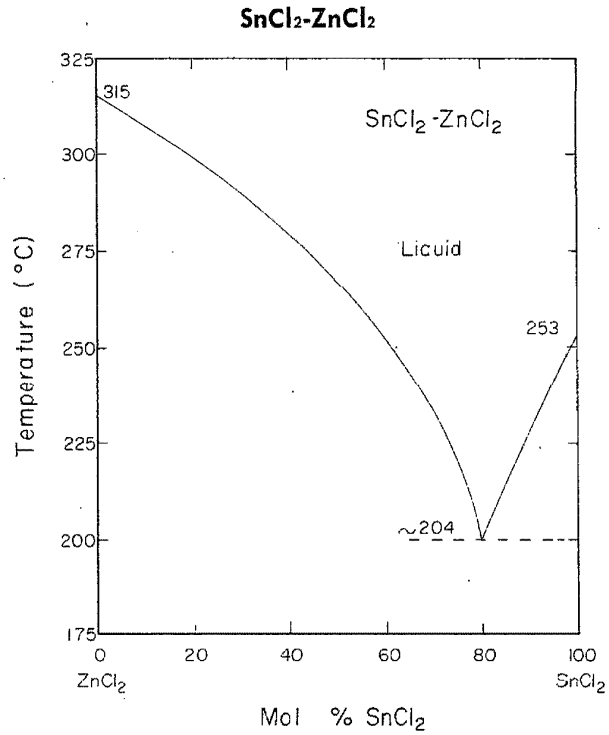

FIGURE 117. Temperature-composition phase diagram for $SnCl_2$-$ZnCl_2$.

L. A. Nisel'son, B. N. Ivanov-Emin, and L. E. Larionova, Zh. Neorgan. Khim., **6** [1], 186 (1961); Russ. J. Inorg. Chem. (English Transl.), 74 (1961).

TABLE 622. $SnCl_2$-$ZnCl_2$: Density (g cm^{-3})

	Mol percent $ZnCl_2$											
T	100	90	80	70	60	50	40	30	20	10	0	30
540							3.074	3.154	3.230			3.154
550						2.984	3.065	3.144	3.219	3.292	3.361	3.144
560			2.719	2.807	2.893	2.976	3.056	3.134	3.208	3.280	3.348	3.134
570		2.622	2.713	2.801	2.886	2.968	3.047	3.124	3.197	3.268	3.335	3.124
580		2.616	2.707	2.794	2.878	2.960	3.038	3.114	3.186	3.256	3.322	3.114
590		2.611	2.701	2.787	2.871	2.951	3.029	3.103	3.175	3.243	3.309	3.103
600		2.606	2.695	2.780	2.863	2.943	3.020	3.093	3.164	3.231	3.295	3.093
610		2.600	2.689	2.774	2.856	2.934	3.010	3.083	3.152	3.219		3.083
620		2.595	2.683	2.767	2.848	2.926	3.001	3.073				3.073
630	2.500											
640	2.495											
650	2.490											
660	2.486											
670	2.481											
680	2.476											
690	2.471											
700	2.467											
710	2.462											
720	2.457											
730	2.453											
740	2.448											
750	2.443											
760	2.438											

TABLE 622. $SnCl_2$-$ZnCl_2$: Density (g cm^{-3})—Continued

Two-dimensional equation and statistical parameters
$\rho = a + bT + cC + dTC^2 + eCT^2$

a	$b \cdot 10^4$	$c \cdot 10^2$	$d \cdot 10^8$	$e \cdot 10^9$	Max. percent departure	Stand. error of est.
2.79673	−4.71427	1.12048	−2.55020	−5.16503	0.22% (617.2 K, 40 mol % $SnCl_2$)	0.11%

These values are based on the work of Prikhod'ko (Archimedean method) [**128**]. $C =$ mol % $SnCl_2$.

TABLE 623. $SnCl_2$-$ZnCl_2$: Density (g cm^{-3})

	Mol percent $ZnCl_2$										
T	100	90	80	70	60	50	40	30	20	10	0
540							3.076		3.231		
550						2.985	3.067	3.147	3.220	3.293	3.357
560			2.720	2.808	2.889	2.977	3.058	3.137	3.210	3.280	3.344
570		2.625	2.713	2.800	2.881	2.968	3.049	3.127	3.199	3.268	3.331
580		2.619	2.706	2.793	2.873	2.960	3.040	3.117	3.188	3.255	3.318
590		2.612	2.699	2.785	2.865	2.951	3.031	3.107	3.178	3.243	3.305
600		2.606	2.692	2.778	2.857	2.943	3.021	3.097	3.167	3.230	3.292
610		2.599	2.685	2.770	2.849	2.934	3.012	3.087	3.157	3.217	
620		2.593	2.678	2.763	2.842	2.926	3.003	3.077	3.146		
630	2.503		2.671	2.755							
640	2.498										
650	2.493										
660	2.488										
670	2.483										
680	2.478										
690	2.473										
700	2.468										
710	2.463										
720	2.458										
730	2.453										
740	2.448										
750	2.442										
760	2.437										

Temperature-dependent equations
$\rho = a + bT$

Comp. (Mol % $ZnCl_2$)	a	$b \cdot 10^4$
0	4.072	−13.00
10	3.983	−12.55
20	3.802	−10.58
30	3.697	−10.00
40	3.571	−9.16
50	3.455	−8.54
60	3.332	−7.91
70	3.226	−7.47
80	3.114	−7.03
90	2.997	−6.52
100	2.822	−5.06

These values are based on the work of Prikhod'ko (Archimedean method) [**128**].

TlCl-$ZnCl_2$

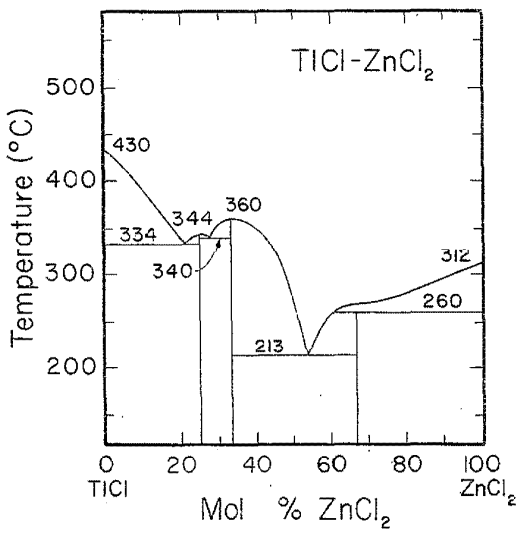

FIGURE 118. Temperature-composition phase diagram for TlCl-$ZnCl_2$.

I. P. Palyura and A. P. Palkin, Zh. Neorgan. Khim., 4 [12], 2717 (1957); Russ. J. Inorg. Chem. (English Transl.), 1258 (1959).

Melt Preparation and Purification

The purification method used by Markov et al. [195] for $ZnCl_2$ is discussed under the system CsCl-$ZnCl_2$.

TABLE 623. Density studies: TlCl-$ZnCl_2$

Investigations critically re-examined			
Ref.	$ZnCl_2$ Mol %	Temp. range (T)	Comments
195	0–100	623–784	Cell material: quartz float (weighted with W), Pt suspension wire; calibration: water

Comparisons with NSRDS recommendations: [1, pp. 10, 12]			
Ref.	$ZnCl_2$ Mol %	Min. departure	Max. departure
195	100	0.04% (660 K)	−0.14% (720 K)
195	0	0.00% (780 K)	−0.12% (720 K)

TABLE 624. TlCl-$ZnCl_2$: Density (g cm^{-3})

	Mol percent $ZnCl_2$										
T	100	90	80.6	72.2	60	50	40	30	20	10	0
630	2.503		3.059								
640	2.498		3.051		3.656						
650	2.493	2.776	3.043	3.286	3.645	3.946	4.198				
660	2.488	2.768	3.035	3.277	3.634	3.934	4.186	4.511	4.866		
670	2.483	2.760	3.027	3.268	3.623	3.922	4.174	4.497	4.852		
680	2.478	2.753	3.018	3.258	3.613	3.910	4.162	4.484	4.837	5.229	
690	2.473	2.745	3.010	3.249	3.602	3.898	4.150	4.470	4.822	5.213	
700	2.468	2.737	3.002	3.240	3.591	3.886	4.138	4.457	4.808	5.196	
710	2.463	2.730	2.994	3.231	3.580	3.874	4.126	4.443	4.793	5.180	
720	2.458	2.722	2.986	3.221	3.570	3.862	4.113	4.430	4.778	5.164	
730			2.978				4.101	4.416	4.764	5.148	5.574
740			2.970				4.089				5.557
750			2.962				4.077				5.540
760			2.954				4.065				5.523
770			2.946				4.053				5.508
780											5.490

Temperature-dependent equations

$$\rho = a + bT$$

Comp. (mol % $ZnCl_2$)	a	$b \cdot 10^4$
0	6.802	−16.82
10	6.334	−16.25
20	5.833	−14.65
30	5.405	−13.55
40	4.986	−12.12
50	4.732	−12.09
60	4.344	−10.75
72	3.890	−9.28
80	3.569	−8.10
90	3.272	−7.63
100	2.822	−5.06

These values are based on the work of Markov et al. (Archimedean method) [195].

6.2. General Summary Tables

TABLE 625. Total and recommended investigations

Specific conductance		
System	No. of invest.	Literature references
AgCl-KCl	1	**35**
AgCl-$PbCl_2$	3	**35**, 60, 131
AgCl-TlCl	2	**12**, 131
$AlCl_3$-KCl	6	27, **42**, 102, 112, 115, **175**
$AlCl_3$-LiCl	3	42, 102, **112**
$AlCl_3$-NaCl	6	16, **50**, 51, 112, 115, 164
$AlCl_3$-NH_4Cl	1	**42**
$AlCl_3$-RbCl	1	**112**
$BaCl_2$-$CaCl_2$	3	20, 74, **120**
$BaCl_2$-CsCl	2	**166**, 209
$BaCl_2$-$LaCl_3$	1	**172**
$BaCl_2$-LiCl	1	**155**
$BaCl_2$-$MgCl_2$	3	**30**, 151, 167
$BaCl_2$-NaCl	8	20, 24, 34, 44, **63**, 74, 151, 167
$BeCl_2$-NaCl	1	**69**
$BiCl_3$-$GaCl_3$	1	**64**
$CaCl_2$-KCl	6	12, 30, **109**, 94, 160, 171
$CaCl_2$-LiCl	1	**171**
$CaCl_2$-$MgCl_2$	2	**109**, 30
$CaCl_2$-NaCl	15	12, 20, 21, 24, 34, 44, 63, 74, 109, 129, 139, 144, **146**, 171, 192
$CaCl_2$-RbCl	1	**171**
$CaCl_2$-$SrCl_2$	1	**5**
$CdCl_2$-CsCl	1	**132**
$CdCl_2$-KCl	8	12, 13, 14, **25**, 116, 132, 147, 160
$CdCl_2$-LiCl	1	**31**
$CdCl_2$-NaCl	2	**25**, 132
$CdCl_2$-$PbCl_2$	4	**13**, 25, 94, 117
$CdCl_2$-TlCl	3	12, **14**, 70
CsCl-$GaCl_3$	1	**80**
CsCl-KCl	1	**98**
CsCl-$LaCl_3$	3	**154**, 186, 209
CsCl-LiCl	2	11, **104**
CsCl-NaCl	1	**98**
CsCl-$PbCl_2$	2	**49**, 142
CsCl-RbCl	1	**98**
CsCl-$ScCl_3$	1	**71**
CsCl-$TiCl_3$	1	**59**
CsCl-UCl_4	1	**158**
CsCl-$ZnCl_2$	2	**108**, 197
CuCl-KCl	1	**116**
$DyCl_3$-KCl	1	**190**
$DyCl_3$-NaCl	1	**190**
$ErCl_3$-KCl	1	**190**
$GaCl_3$-$HgCl_2$	1	**148**
$GaCl_3$-KCl	2	**80**, 148
$GaCl_3$-LiCl	1	**138**
$GaCl_3$-NaCl	2	**138**, 148
$GaCl_3$-RbCl	1	**80**
$GaCl_3$-$SbCl_3$	1	**148**
$GdCl_3$-KCl	1	**190**
$GdCl_3$-NaCl	1	**190**
$HgCl_2$-Hg_2Cl_2	1	**121**
$HgCl_2$-NH_4Cl	2	15, **123**
KCl-$LaCl_3$	2	**186**, 220
KCl-LiCl	13	23, **37**, 47, 60, 65, 84, 94, 102, 127, 159, 183, 192, 216
KCl-$MgCl_2$	12	30, 94, 96, 102, 109, 113, 114, **117**, 145, 153, 159, 216

TABLE 625. Total and recommended investigations—Continued

Specific conductance		
System	No. of invest.	Literature references
KCl-$MnCl_2$	1	**72**
KCl-NaCl	17	5, 12, 21, 24, **37**, 60, 65, 97, 102, 113, 114, 127, 160, 161, 192, 203, 208
KCl-$NdCl_3$	2	186, **190**
KCl-$PbCl_2$	7	13, 25, **43**, 116, 118, 142, 185
KCl-$PrCl_3$	1	**190**
KCl-RbCl	1	**98**
KCl-$ScCl_3$	1	**71**
KCl-$SnCl_2$	1	**119**
KCl-$TiCl_3$	3	**55**, 59, 61
KCl-UCl_3	2	**137**, 189
KCl-UCl_4	2	52, **158**
KCl-$ZnCl_2$	3	38, **108**, 197
$LaCl_3$-LiCl	1	**154**
$LaCl_3$-NaCl	2	**186**, 220
$LaCl_3$-RbCl	1	**186**
LiCl-$MgCl_2$	1	**77**
LiCl-NaCl	2	**11**, 127
LiCl-RbCl	1	**11**
LiCl-$ScCl_3$	1	**73**
LiCl-UCl_4	1	**179**
$MgCl_2$-NaCl	7	30, **109**, 113, 114, 117, 151, 167
NaCl-$NbCl_5$	1	**54**
NaCl-$NdCl_3$	2	186, **190**
NaCl-$PbCl_2$	4	24, **49**, 63, 142
NaCl-$PrCl_3$	1	**190**
NaCl-RbCl	1	**98**
NaCl-$ScCl_3$	1	**73**
NaCl-$SmCl_3$	1	**190**
NaCl-$TiCl_4$	1	**81**
NaCl-$TiCl_3$	3	**55**, 59, 61
NaCl-UCl_3	3	135, **137**, 190
NaCl-UCl_4	2	52, **158**
NaCl-$ZnCl_2$	3	**108**, 129, 197
NaCl-$ZrCl_4$	2	10, **54**
$PbCl_2$-RbCl	2	**49**, 142
$PbCl_2$-TlCl	1	**68**
RbCl-$ScCl_3$	1	**71**
RbCl-$TiCl_3$	1	**59**
RbCl-UCl_4	1	**158**
$SbCl_3$-$SbCl_5$	1	**46**

Density		
System	No. of invest.	Literature references
AgCl-KCl	1	**26**
AgCl-$PbCl_2$	1	**26**
$AlCl_3$-$BiCl_3$	1	**90**
$AlCl_3$-KCl	6	27, 42, **92**, 112, 134, 188
$AlCl_3$-LiCl	2	42, **112**
$AlCl_3$-NaCl	7	16, 42, **110**, 112, 157, 188, 317
$AlCl_3$-NH_4Cl	1	**42**
$AlCl_3$-RbCl	1	**112**
$BaCl_2$-$CdCl_2$	2	**26**, 165
$BaCl_2$-CsCl	2	**79**, 152
$BaCl_2$-$LaCl_3$	1	**172**
$BaCl_2$-KCl	4	**33**, 89, 150, 152
$BaCl_2$-$LaCl_3$	1	**168**
$BaCl_2$-LiCl	2	**126**, 152
$BaCl_2$-$MgCl_2$	3	30, **150**, 167
$BaCl_2$-NaCl	6	22, 24, **34**, 44, 89, 152

TABLE 625. Total and recommended investigations—Continued

Density		
System	No. of invest.	Literature references
$BaCl_2$-$PbCl_2$	3	9, **26**, 165
$BaCl_2$-$ZnCl_2$	1	**165**
$CaCl_2$-CsCl	1	**237**
$CaCl_2$-KCl	8	12, 28, 94, **130**, 133, 163, 171, 237
$CaCl_2$-LiCl	1	**171**
$CaCl_2$-$MgCl_2$	4	30, 95, **130**, 133
$CaCl_2$-$MnCl_2$	1	**202**
$CaCl_2$-NaCl	11	12, 17, 24, 34, 44, 129, **130**, 133, 144, 163, 171
$CaCl_2$-RbCl	1	**171**
$CaCl_2$-$SrCl_2$	1	**6**
$CdCl_2$-CsCl	1	**103**
$CdCl_2$-KCl	6	9, **26**, 122, 165, 193, 206
$CdCl_2$-LiCl	3	**31**, 165, 193
$CdCl_2$-NaCl	3	**26**, 165, 193
$CdCl_2$-$PbCl_2$	3	**26**, 94, 206
$CdCl_2$-RbCl	1	**103**
$CdCl_2$-TlCl	2	**195**, 204
$CdCl_2$-$ZnCl_2$	1	**93**
$CeCl_3$-KCl	1	**106**
CsCl-KCl	1	**98**
CsCl-$LaCl_3$	1	**177**
CsCl-LiCl	2	11, **75**
CsCl-$MgCl_2$	2	**130**, 133
CsCl-$MnCl_2$	1	**202**
CsCl-NaCl	1	**98**
CsCl-$PbCl_2$	2	103, **142**
CsCl-RbCl	1	**98**
CsCl-UCl_4	1	**158**
CsCl-$ZnCl_2$	4	91, **108**, 194, 199
CuCl-KCl	1	**18**
KCl-$LaCl_3$	2	**178**, 220
KCl-LiCl	5	23, **37**, 100, 149, 215
KCl-$MgCl_2$	12	30, 39, 62, 102, **130**, 133, 145, 150, 153, 207, 211, 267
KCl-$MnCl_2$	1	**72**
KCl-NaCl	11	12, 24, **37**, 78, 87, 89, 95, 143, 211, 215, 267
KCl-$PbCl_2$	6	9, **26**, 142, 165, 193, 206
KCl-RbCl	1	**98**
KCl-$SrCl_2$	1	**143**
KCl-UCl_3	1	**189**
KCl-UCl_4	1	**158**
KCl-$ZnCl_2$	9	28, 38, 78, **108**, 165, 187, 193, 194, 199
$LaCl_3$-$LaCl_3$	1	**111**
$LaCl_3$-LiCl	1	**176**
$LaCl_3$-NaCl	1	**220**
LiCl-$MgCl_2$	4	77, **130**, 133, 196
LiCl-$MnCl_2$	1	**202**
LiCl-NaCl	2	**11**, 196
LiCl-$PbCl_2$	2	165, **193**
LiCl-RbCl	1	**11**
LiCl-UCl_4	1	**179**
LiCl-$ZnCl_2$	3	108, **194**, 199
$MgCl_2$-NaCl	6	30, **130**, 133, 167, 211, 267
$MgCl_2$-RbCl	2	**130**, 133
NaCl-$PbCl_2$	5	24, **103**, 142, 165, 193
NaCl-RbCl	1	**98**
NaCl-$ThCl_4$	1	**200**
NaCl-UCl_3	1	**135**
NaCl-UCl_4	1	**158**
NaCl-$ZnCl_2$	6	**108**, 129, 165, 193, 194, 199

TABLE 625. Total and recommended investigations—Continued

Density		
System	No. of invest.	Literature references
$PbCl_2$-RbCl	2	**103**, 142
$PbCl_2$-TlCl	1	**195**
$PbCl_2$-$ZnCl_2$	1	**19**
RbCl-UCl_4	1	**158**
RbCl-$ZnCl_2$	1	**194**
$SbCl_3$-$SbCl_5$	1	**46**
$SnCl_4$-$TlCl_4$	1	**48**
$SnCl_2$-$ZnCl_2$	1	**128**
TlCl-$ZnCl_2$	1	**195**

Viscosity		
System	No. of invest.	Literature references
AgCl-KCl	2	**35**, 136
AgCl-$PbCl_2$	1	**35**
$AlCl_3$-NaCl	2	**32**, 45
$BaCl_2$-CsCl	1	**174**
$BaCl_2$-LiCl	1	**173**
$BaCl_2$-$MgCl_2$	1	**151**
$BaCl_2$-NaCl	3	24, 34, **151**
$CaCl_2$-NaCl	3	24, **34**, 144
$CdCl_2$-KCl	3	**36**, 180, 206
$CdCl_2$-NaCl	1	**36**
$CdCl_2$-$PbCl_2$	2	**36**, 206
CsCl-$LaCl_3$	2	**173**, 209
CsCl-LiCl	1	**82**
KCl-LiCl	8	23, 86, 88, 100, **149**, 187, 215, 216
KCl-$MgCl_2$	7	39, 41, 45, **66**, 207, 216, 226
KCl-NaCl	8	24, 29, **53**, 66, 86, 100, 215, 226
KCl-$PbCl_2$	2	**36**, 206
KCl-$SbCl_3$	1	**40**
$LaCl_3$-$LaCl_3$	1	**99**
$LaCl_3$-LiCl	1	**173**
LiCl-$MgCl_2$	1	**88**
$MgCl_2$-NaCl	3	41, **151**, 226
NaCl-$ZnCl_2$	2	108, **198**
$SbCl_3$-$SbCl_5$	1	**46**
$SnCl_4$-$TiCl_4$	1	**48**

Surface tension		
System	No. of invest.	Literature references
AgCl-KCl	1	**234**
AgCl-$PbCl_2$	1	**234**
$BaCl_2$-$CaCl_2$	1	**229**
$BaCl_2$-CsCl	2	**225**, 244
$BaCl_2$-KCl	3	**232**, 241, 244
$BaCl_2$-$LaCl_3$	1	**168**
$BaCl_2$-LiCl	1	**251**
$BaCl_2$-$MgCl_2$	2	**241**, 167
$BaCl_2$-NaCl	3	**233**, 244, 250
$BaCl_2$-RbCl	1	**244**
$CaCl_2$-CsCl	1	237
$CaCl_2$-KCl	4	237, **253**, 258, 223
$CaCl_2$-LiCl	1	**258**
$CaCl_2$-$MgCl_2$	3	**253**, 258, 223
$CaCl_2$-NaCl	4	**229**, 250, 253, 258
$CaCl_2$-RbCl	1	**258**

TABLE 625. Total and recommended investigations—Continued

Surface tension		
System	No. of invest.	Literature references
$CdCl_2$-KCl	2	**234**, 255
$CdCl_2$-NaCl	1	**234**
$CdCl_2$-$PbCl_2$	1	**234**
CsCl-$LaCl_3$	1	**177**
CsCl-LiCl	1	**252**
CsCl-$MgCl_2$	2	**253**, 258
CsCl-NaCl	1	**243**
CsCl-$PbCl_2$	2	**238**, 254
CsCl-$SrCl_2$	1	**244**
KCl-$LaCl_3$	1	**178**
KCl-LiCl	3	257, **231**, 230
KCl-$MgCl_2$	5	241, **245**, 246, 253, 226
KCl-NaCl	7	243, **245**, 250, 254, 257, 143, 226
KCl-$PbCl_2$	3	234, **238**, 254
KCl-$SrCl_2$	2	**143**, 244
KCl-UCl_4	1	**212**
KCl-$ZnCl_2$	2	**187**, 318
$LaCl_2$-$LaCl_3$	1	**248**
LiCl-$MgCl_2$	2	**253**, 258
LiCl-NaCl	1	**257**
LiCl-$PbCl_2$	2	**238**, 254
LiCl-RbCl	1	**256**
LiCl-UCl_4	1	**179**
$MgCl_2$-NaCl	3	**245**, 246, 253
$MgCl_2$-RbCl	2	**253**, 258
NaCl-$PbCl_2$	4	**224**, 238, 250, 254
NaCl-RbCl	1	**243**
NaCl-$SrCl_2$	1	**244**
$PbCl_2$-RbCl	2	**238**, 254

TABLE 626. Table of references. Total number of investigations, recommended and literature references for specific conductance, density, viscosity, and surface tension of molten chloride mixtures.

System	κ		ρ		η		γ	
	No. of Invest.	Rec. Ref.	No. of Invest.	Rec. Ref.	No. of Invest.	Rec. Ref.	No. of Invest.	Rec. Ref.
AgCl-KCl	1	35	1	26	2	35	1	234
AgCl-$PbCl_2$	3	35	1	26	1	35	1	234
AgCl-TlCl	2	12						
$AlCl_3$-$BiCl_3$			1	90				
$AlCl_3$-KCl	6	42						
		175						
$AlCl_3$-LiCl	3	112	2	112				
$AlCl_3$-NaCl	6	50	7	110	2	32		
$AlCl_3$-NH_4Cl	1	42	1	42				
$AlCl_3$-RbCl	1	112	1	112				
$BaCl_2$-$CaCl_2$	3	110					1	229
$BaCl_2$-$CdCl_2$			2	26				
$BaCl_2$-CsCl	2	166	2	79	1	174	2	225
$BaCl_2$-KCl			4	33			3	232
$BaCl_2$-$LaCl_3$	1	172	1	168			1	168
$BaCl_2$-LiCl	1	155	2	126	1	173	1	251
$BaCl_2$-$MgCl_2$	3	30	3	150	1	151	2	241
$BaCl_2$-NaCl	8	63	6	34	3	34	3	233
$BaCl_2$-$PbCl_2$			3	26				
$BaCl_2$-RbCl							1	244
$BaCl_2$-$ZnCl_2$			1	165				
$BeCl_2$-NaCl	1	69						
$BiCl_3$-$GaCl_3$	1	64						
$CaCl_2$-CsCl			1	237			1	237
$CaCl_2$-KCl	6	109	8	130			4	253
$CaCl_2$-LiCl	1	171	1	171			1	258
$CaCl_2$-$MgCl_2$	2	109	4	130			3	253
$CaCl_2$-$MnCl_2$			1	202				
$CaCl_2$-NaCl	18	146	11	130	3	34	4	229
$CaCl_2$-RbCl	1	171	1	171			1	258
$CaCl_2$-$SrCl_2$	1	5	1	6				
$CdCl_2$-CsCl	1	132	1	103				
$CdCl_2$-KCl	8	25	6	26	3	36	2	234
$CdCl_2$-LiCl	1	31	3	31				
$CdCl_2$-NaCl	2	25	3	26	1	36	1	234
$CdCl_2$-$PbCl_2$	4	13	3	26	2	36	1	234
$CdCl_2$-RbCl			1	103				
$CdCl_2$-TlCl	3	14	2	195				
$CdCl_2$-$ZnCl_2$			1	93				
$CeCl_3$-KCl			1	106				
CsCl-$GaCl_3$	1	80						
CsCl-KCl	1	98	1	98				
CsCl-$LaCl_3$	3	154	1	177	2	173	1	177
CsCl-LiCl	2	104	2	75	1	82	1	252
CsCl-$MgCl_2$			2	130			2	253
CsCl-$MnCl_2$			1	202				
CsCl-NaCl	1	98	1	98			1	243
CsCl-$PbCl_2$	2	49	2	103			2	238
CsCl-RbCl	1	98	1	98				
CsCl-$ScCl_3$	1	71						
CsCl-$SrCl_2$							1	244
CsCl-$TiCl_3$	1	59						
CsCl-UCl_4	1	158	1	158				
CsCl-$ZnCl_2$	2	108	4	108				
CuCl-KCl	1	116	1	18				
$DyCl_3$-KCl	1	190						
$DyCl_3$-NaCl	1	190						

TABLE 626. Table of references. Total number of investigations, recommended and literature references for specific conductance, density, viscosity, and surface tension of molten chloride mixtures.—Continued

System	κ		ρ		η		γ	
	No. of Invest.	Rec. Ref.	No. of Invest.	Rec. Ref.	No. of Invest.	Rec. Ref.	No. of Invest.	Rec. Ref.
$ErCl_3$-KCl	1	190						
$GaCl_3$-$HgCl_2$	1	148						
$GaCl_3$-KCl	2	80						
$GaCl_3$-LiCl	1	138						
$GaCl_3$-NaCl	2	138						
$GaCl_3$-RbCl	1	80						
$GaCl_3$-$SbCl_3$	1	148						
$GdCl_3$-KCl	1	190						
$GdCl_3$-NaCl	1	190						
Hg_2Cl_2-$HgCl_2$	1	121						
$HgCl_2$-NH_4Cl	2	123						
KCl-$LaCl_3$	2	186	2	178			1	178
KCl-LiCl	13	37	5	37	8	149	3	231, 230
KCl-$MgCl_2$	12	117	12	130	7	66	4	245
KCl-$MnCl_2$	1	72	1	72				
KCl-NaCl	17	37	11	37	8	53	7	245
KCl-$NdCl_3$	2	190						
KCl-$PbCl_2$	7	43	6	26	2	36	3	238
KCl-$PrCl_3$	1	190						
KCl-RbCl	1	98	1	98				
KCl-$SbCl_3$					1	40		
KCl-$ScCl_3$	1	71						
KCl-$SnCl_2$	1	119						
KCl-$SrCl_2$			1	143			2	143
KCl-$TlCl_3$	3	55						
KCl-UCl_3	2	137	1	189				
KCl-UCl_4	2	158	1	158			1	212
KCl-$ZnCl_2$	3	108	9	108			2	187
$LaCl_3$-$LaCl_3$			1	111	1	99	1	248
$LaCl_3$-LiCl	1	154	1	176	1	173		
$LaCl_3$-NaCl	2	186	1	220				
$LaCl_3$-RbCl	1	186						
LiCl-$MgCl_2$	1	77	4	130	1	88	2	253
LiCl-$MnCl_2$			1	202				
LiCl-NaCl	2	11	2	11			1	257
LiCl-$PbCl_2$			2	193			2	238
LiCl-RbCl	1	11	1	11			1	256
LiCl-$ScCl_3$	1	73						
LiCl-UCl_4	1	179	1	179			1	179
LiCl-$ZnCl_2$			3	194				
$MgCl_2$-NaCl	7	109	6	130	3	151	5	245
$MgCl_2$-RbCl			2	130			2	253
NaCl-$NbCl_5$	1	54						
NaCl-$NdCl_3$	2	190						
NaCl-$PbCl_2$	4	49	5	103			4	224
NaCl-$PrCl_3$	1	190						
NaCl-RbCl	1	98	1	98			1	243
NaCl-$ScCl_3$	1	73						
NaCl-$SmCl_3$	1	190						
NaCl-$SrCl_2$							1	244
NaCl-$ThCl_4$	1	81	1	200				
NaCl-$TiCl_3$	3	55						
NaCl-UCl_3	3	137	1	135				
NaCl-UCl_4	2	158	1	158				
NaCl-$ZnCl_2$	3	108	6	108	2	198		
NaCl-$ZrCl_4$	2	54						
$PbCl_2$-RbCl	2	49	2	103			2	238
$PbCl_2$-TlCl	1	68	1	195				
$PbCl_2$-$ZnCl_2$			1	19				

TABLE 626. Table of references. Total number of investigations, recommended and literature references for specific conductance, density, viscosity, and surface tension of molten chloride mixtures.—Continued

System	κ		ρ		η		γ	
	No. of Invest.	Rec. Ref.	No. of Invest.	Rec. Ref.	No. of Invest.	Rec. Ref.	No. of Invest.	Rec. Ref.
$RbCl-ScCl_3$	1	71						
$RbCl-TlCl_3$	1	59						
$RbCl-UCl_4$	1	158						
$RbCl-ZnCl_2$			1	194				
$SbCl_3-SbCl_5$	1	46	1	46	1	46		
$SnCl_4-TlCl_4$			1	48	1	48		
$SnCl_2-ZnCl_2$			1	195				
$ThCl_4-ZnCl_2$			1	195				

TABLE 627. Experimental techniques used and recommended references for specific conductance, density, viscosity, and surface tension of molten chloride mixtures

Specific conductance

A: Classical ac technique
B: Paper electrophoresis

System	Technique	Recommended reference
$AgCl-KCl$	A	**35** Harrap and Heymann
$AgCl-PbCl_2$	A	**35** Harrap and Heymann
$AgCl-TlCl$	A	**12** Sandonnini
$AlCl_3-KCl$	A	**42** Yamaguti and Sisido
		175 Boston et al.
$AlCl_3-LiCl$	A	**112** Moss
$AlCl_3-NaCl$	A	**50** Sisido and Yamaguti
$AlCl_3-NH_4Cl$	A	**42** Yamaguti and Sisido
$AlCl_3-RbCl$	A	**112** Moss
$BaCl_2-CaCl_2$	A	**120** Barzakovskii and Kochinashvili
$BaCl_2-CsCl$	A	**166** Smirnov and Khokhlov
$BaCl_2-LaCl_3$	A	**172** Smirnov and Khokhlov
$BaCl_2-LiCl$	A	**155** Khokhlov and Smirnov
$BaCl_2-MgCl_2$	A	**30** Huber, Potter and Clair
$BaCl_2-NaCl$	A	**63** Barzakovskii
$BeCl_2-NaCl$	A	**69** Delimarskii
$BiCl_3-GaCl_3$	A	**64** Couturier
$CaCl_2-KCl$	A	**109** Grjotheim et al.
$CaCl_2-LiCl$	A	**171** Emons et al.
$CaCl_2-MgCl_2$	A	**109** Grjotheim
$CaCl_2-NaCl$	A	**146** Story and Clarke
$CaCl_2-RbCl$	A	**171** Emons et al.
$CaCl_2-SrCl_2$	A	**5** Arndt and Gessler
$CdCl_2-CsCl$	B	**132** Kwak and Ketelaar
$CdCl_2-KCl$	A	**25** Bloom and Heymann
$CdCl_2-LiCl$	A	**31** Bloom et al.
$CdCl_2-NaCl$	A	**25** Bloom and Heymann
$CdCl_2-PbCl_2$	A	**13** Tarasova
$CdCl_2-TlCl$	A	**14** Protsenko and Popovskaya
$CdCl_2-GaCl_3$	A	**80** Arbekov and Petrov
$CsCl-KCl$	A	**98** Zuca and Olteanu
$CsCl-LaCl_3$	A	**154** Smirnov and Khokhlov
$CsCl-LiCl$	A	**104** Smirnov et al.
$CsCl-NaCl$	A	**98** Olteanu and Zuca
$CsCl-PbCl_2$	A	**49** Bloom and Macky
$CsCl-RbCl$	A	**98** Zuca and Olteanu
$CsCl-ScCl_3$	A	**71** Fedorov and Petrov
$CsCl-TiCl_3$	A	**59** Delimarskii and Chernov
$CsCl-UCl_4$	A	**158** Bogacz and Ziolek
$CsCl-ZnCl_2$	A	**108** Weeks
$CuCl-KCl$	A	**116** Kanazawa and Sakai

TABLE 627. Experimental techniques used and recommended references for specific conductance, density, viscosity, and surface tension of molten chloride mixtures—Continued

Specific conductance

System	Technique	Recommended reference
$DyCl_3-KCl$	A	**190** Forthmann and Schneider
$DyCl_3-NaCl$	A	**190** Forthmann and Schneider
$ErCl_3-KCl$	A	**190** Forthmann and Schneider
$GaCl_3-HgCl_2$	A	**148** Chretien and Couturier
$GaCl_3-KCl$	A	**80** Arbekov and Petrov
$GaCl_3-LiCl$	A	**138** Arbekov and Petrov
$GaCl_3-NaCl$	A	**138** Arbekov and Petrov
$GaCl_3-RbCl$	A	**80** Arbekov and Petrov
$GaCl_3-SbCl_3$	A	**148** Chretien and Couturier
$GdCl_3-KCl$	A	**190** Forthmann and Schneider
$GdCl_3-NaCl$	A	**190** Forthmann and Schneider
$HgCl_2-Hg_2Cl_2$	A	**121** Grantham
$HgCl_2-NH_4Cl$	A	**123** Belyaev and Mironov
$KCl-LaCl_3$	A	**186** Forthmann, Vogel and Schneider
$KCl-LiCl$	A	**37** Van Artsdalen and Yaffe
$KCl-MgCl_2$	A	**117** Sakai and Hayashi
$KCl-MnCl_2$	A	**72** Murgulescu and Zuca
$KCl-NaCl$	A	**37** Van Artsdalen and Yaffe
$KCl-NdCl_3$	A	**190** Forthmann and Schneider
$KCl-PbCl_2$	A	**43** Lantratov and Moiseeva
$KCl-PrCl_3$	A	**190** Forthmann and Schneider
$KCl-RbCl$	A	**98** Zuca and Olteanu
$KCl-ScCl_3$	A	**71** Fedorov and Petrov
$KCl-SnCl_2$	A	**119** Rafalskii
$KCl-TiCl_3$	A	**55** Delimarskii and Chernov
$KCl-UCl_3$	A	**137** Mochinaga et al.
$KCl-UCl_4$	A	**158** Bogacz and Ziolek
$KCl-ZnCl_2$	A	**108** Weeks
$LaCl_3-LiCl$	A	**154** Smirnov and Khokhlov
$LaCl_3-NaCl$	A	**186** Forthmann, Vogel and Schneider
$LaCl_3-RbCl$	A	**186** Forthmann, Vogel and Schneider
$LiCl-MgCl_2$	A	**77** Matsushima and Ito
$LiCl-NaCl$	A	**11** Zuca and Olteanu
$LiCl-RbCl$	A	**11** Zuca and Olteanu
$LiCl-ScCl_3$	A	**73** Fedorov and Petrov
$LiCl-UCl_3$	A	**179** Bogacz and Ziolek
$MgCl_2-NaCl$	A	**109** Grjotheim et al.
$NaCl-NbCl_5$	A	**54** Belozerskii and Freidlina
$NaCl-NdCl_3$	A	**190** Forthmann and Schneider
$NaCl-PbCl_2$	A	**49** Bloom and Macky

TABLE 627. Experimental techniques used and recommended references for specific conductance, density, viscosity, and surface tension of molten chloride mixtures—Continued

Specific conductance

System	Technique	Recommended reference	
$NaCl-PrCl_3$	A	**190**	Forthmann and Schneider
NaCl-RbCl	A	**98**	Zuca and Olteanu
$NaCl-ScCl_3$	A	**73**	Fedorov and Petrov
$NaCl-SmCl_3$	A	**190**	Forthmann and Schneider
$NaCl-ThCl_4$	A	**81**	Kuroda et al.
NaCl-TiCl	A	**55**	Delimarskii and Chernov
$NaCl-UCl_3$	A	**137**	Mochinaga et al.
$NaCl-UCl_4$	A	**158**	Bogacz and Ziolek
$NaCl-ZnCl_2$	A	**108**	Weeks
$NaCl-ZrCl_4$	A	**54**	Belozerskii and Freidlina
$PbCl_2-RbCl$	A	**49**	Bloom and Macky
$PbCl_2-TlCl$	A	**68**	Lantratov and Moiseeva
$RbCl-ScCl_3$	A	**71**	Fedorov and Petrov
$RbCl-TiCl_3$	A	**59**	Chernov and Delimarskii
$RbCl-UCl_4$	A	**158**	Bogacz and Ziolek
$SbCl_3-SbCl_5$	A	**46**	Beketov et al.

Density

A: Archimedean
B: Dilatometric
C: Flotation
D: Pycnometric
E: Bubble pressure

System	Technique	Recommended reference	
AgCl-KCl	B	**26**	Boardman et al.
$AgCl-PbCl_2$	B	**26**	Boardman et al.
$AlCl_3-BiCl_3$	C	**90**	Boston
$AlCl_3-KCl$	C	**92**	Carter and Morrey
$AlCl_3-LiCl$	B	**112**	Moss
$AlCl_3-NaCl$	C	**110**	Boston
$AlCl_3-NH_4Cl$	B	**42**	Yamaguti and Sisido
$AlCl_3-RbCl$	B	**112**	Moss
$BaCl_2-CdCl_2$	B	**26**	Boardman et al.
$BaCl_2-CsCl$	A	**79**	Smirnov et al.
$BaCl_2-KCl$	A	**33**	Peake and Bothwell
$BaCl_2-LaCl_3$	E	**168**	Smirnov and Stepanov
$BaCl_2-LiCl$	E	**126**	Smirnov et al.
$BaCl_2-MgCl_2$	A	**150**	Reding
$BaCl_2-NaCl$	A	**34**	Vereshchetina and Luzhnaya
$BaCl_2-PbCl_2$	B	**26**	Boardman et al.
$BaCl_2-ZnCl_2$	A	**165**	Alabyshev and Lantratov
$CaCl_2-CsCl$	E	**237**	Lehman
$CaCl_2-KCl$	A	**130**	Lillebuen
$CaCl_2-LiCl$	A	**171**	Emons et al.
$CaCl_2-MgCl_2$	A	**130**	Lillebuen
$CaCl_2-MnCl_2$	A	**202**	Markov et al.
$CaCl_2-NaCl$	A	**130**	Lillebuen
$CaCl_2-RbCl$	A	**171**	Emons et al.
$CaCl_2-SrCl_2$	A	**6**	Arndt and Gessler
$CdCl_2-CsCl$	A	**103**	Bloom et al.
$CdCl_2-KCl$	B	**26**	Boardman et al.
$CdCl_2-LiCl$	A	**31**	Bloom et al.
$CdCl_2-NaCl$	B	**26**	Boardman et al.
$CdCl_2-PbCl_2$	B	**26**	Boardman et al.
$CdCl_2-RbCl$	A	**103**	Bloom et al.
$CdCl_2-TlCl$	A	**195**	Markov et al.
$CdCl_2-ZnCl_2$	A	**93**	Markov et al.
$CeCl_3-KCl$	A	**106**	Smirnov and Lbov
CsCl-KCl	A	**98**	Zuca and Olteanu

TABLE 627. Experimental techniques used and recommended references for specific conductance, density, viscosity, and surface tension of molten chloride mixtures—Continued

Density

System	Technique	Recommended reference	
$CsCl-LaCl_3$	E	**177**	Smirnov and Stepanov
CsCl-LiCl	A	**75**	Smirnov et al.
$CsCl-MgCl_2$	A	**130**	Lillebuen
$CsCl-MnCl_2$	A	**202**	Markov
CsCl-NaCl	A	**98**	Olteanu and Zuca
$CsCl-PbCl_2$	A	**103**	Bloom et al.
CsCl-RbCl	A	**98**	Zuca and Olteanu
$CsCl-UCl_3$	A	**158**	Bogacz and Ziolek
$CsCl-ZnCl_2$	D	**108**	Weeks
CuCl-KCl	A	**18**	Sackur
$KCl-LaCl_3$	E	**178**	Smirnov and Stepanov
KCl-LiCl	A	**37**	Van Artsdalen and Yaffe
$KCl-MgCl_2$	A	**130**	Lillebuen
$KCl-MnCl_2$	A	**72**	Murgulescu and Zuca
KCl-NaCl	A	**37**	Van Artsdalen and Yaffe
$KCl-PbCl_2$	B	**26**	Boardman et al.
KCl-RbCl	A	**98**	Zuca and Olteanu
$KCl-SrCl_2$	A	**143**	Ellis and Smith
$KCl-UCl_3$	D	**189**	Mochinaga et al.
$KCl-UCl_4$	A	**158**	Bogacz and Ziolek
$KCl-ZnCl_2$	D	**108**	Weeks
$LaCl_3-LaCl_3$	A	**111**	Smirnov et al.
$LaCl_3-LiCl$	E	**176**	Smirnov and Stepanov
$LiCl-MgCl_2$	A	**130**	Lillebuen
$LiCl-MnCl_2$	A	**202**	Markov et al.
LiCl-NaCl	A	**11**	Zuca and Olteanu
$LiCl-PbCl_2$	A	**193**	Lantratov and Shevlyakova
$LiCl-UCl_4$	A	**179**	Bogacz and Ziolek
$LiCl-ZnCl_2$	A	**194**	Markov and Bolkov
$MgCl_2-NaCl$	A	**130**	Lillebuen
$MgCl_2-RbCl$	A	**130**	Lillebuen
$NaCl-PbCl_2$	A	**103**	Bloom et al.
NaCl-RbCl	A	**98**	Zuca and Olteanu
$NaCl-ThCl_4$	A	**200**	Kuroda et al.
$NaCl-UCl_4$	A	**158**	Bogacz and Ziolek
$NaCl-ZnCl_2$	D	**108**	Weeks
$PbCl_2-RbCl$	A	**103**	Bloom et al.
$PbCl_2-TlCl$	A	**195**	Markov et al.
$PbCl_2-ZnCl_2$	D	**19**	Hildebrand and Wachter
$RbCl-UCl_4$	A	**158**	Bogacz and Ziolek
$RbCl-ZnCl_2$	A	**194**	Markov and Bolkov
$SbCl_3-SbCl_5$	D	**46**	Beketov et al.
$SnCl_4-TiCl_4$	D	**48**	Toropov
$SnCl_2-ZnCl_2$	A	**128**	Prikhodko
$TlCl-ZnCl_2$	A	**195**	Markov et al.

Viscosity

A: Capillary
B: Oscillating sphere

System	Technique	Recommended reference	
AgCl-KCl	A	**35**	Harrap and Heymann
$AgCl-PbCl_2$	A	**35**	Harrap and Heymann
$AlCl_3-NaCl$	A	**32**	Kryagova
$BaCl_2-CsCl$	B	**174**	Smirnov and Khokhlov
$BaCl_2-LiCl$	B	**173**	Smirnov and Khokhlov
$BaCl_2-MgCl_2$	B	**151**	Bondarenko and Strelets
$BaCl_2-NaCl$	B	**34**	Vereshchetina and Luzhnaya

TABLE 627. Experimental techniques used and recommended references for specific conductance, density, viscosity, and surface tension of molten chloride mixtures—Continued

Viscosity

System	Technique	Recommended reference
$CaCl_2$-NaCl	B	**34** Vereshchetina and Luzhnaya
$CdCl_2$-KCl	A	**36** Harrap and Heymann
$CdCl_2$-NaCl	A	**36** Harrap and Heymann
$CdCl_2$-$PbCl_2$	A	**36** Harrap and Heymann
CsCl-$LaCl_3$	B	**173** Smirnov and Khokhlov
CsCl-LiCl	B	**82** Smirnov and Khokhlov
KCl-LiCl	B	**149** Zuca and Borcan
KCl-$MgCl_2$	B	**66** Bondarenko
KCl-NaCl	B	**53** Murgulescu and Zuca
KCl-$PbCl_2$	A	**36** Harrap and Heymann
KCl-$SbCl_3$	A	**40** Stromberg
$LaCl_3$-$LaCl_3$	B	**99** Smirnov et al.
$LaCl_3$-LiCl	B	**173** Smirnov and Khokhlov
LiCl-$MgCl_2$	B	**88** Bondarenko
$MgCl_2$-NaCl	B	**151** Bondarenko and Strelets
NaCl-$ZnCl_2$	A	**198** Bloom and Weeks
$SbCl_3$-$SbCl_5$	A	**46** Beketov
$SnCl_4$-$TiCl_4$	A	**48** Toropov

Surface tension

A: Maximum bubble pressure
B: Wilhelmy slide plate
C: Pin detachment

System	Technique	Recommended reference
AgCl-KCl	A	**234** Boardman, Palmer and Heymann
AgCl-$PbCl_2$	A	**234** Boardman, Palmer and Heymann
$BaCl_2$-$CaCl_2$	A	**229** Lantratov
$BaCl_2$-CsCl	A	**225** Smirnov and Stepanov
$BaCl_2$-KCl	A	**232** Bothwell and Peake
$BaCl_2$-$LaCl_3$	A	**168** Smirnov and Stepanov
$BaCl_2$-LiCl	A	**251** Smirnov et al.
$BaCl_2$-$MgCl_2$	A	**241** Reding
$BaCl_2$-NaCl	A	**233** Sokolova and Voskresenskaya
$BaCl_2$-RbCl	B	**244** Bertozzi and Soldani
$CaCl_2$-CsCl	A	**237** Lehman
$CaCl_2$-KCl	C	**253** Lillebuen
$CaCl_2$-LiCl	C	**258** Grjotheim et al.
$CaCl_2$-$MgCl_2$	C	**253** Lillebuen
$CaCl_2$-NaCl	A	**229** Lantratov
$CaCl_2$-RbCl	C	**258** Grjotheim et al.
$CdCl_2$-KCl	A	**234** Boardman et al.
$CdCl_2$-NaCl	A	**234** Boardman, Palmer and Heymann
$CdCl_2$-$PbCl_2$	A	**234** Boardman, Palmer and Heymann
CsCl-$LaCl_3$	A	**177** Smirnov and Stepanov
CsCl-LiCl	A	**252** Smirnov and Stepanov
CsCl-$MgCl_2$	C	**253** Lillebuen
CsCl-NaCl	B	**243** Bertozzi
CsCl-$PbCl_2$	A	**238** Dahl and Duke
CsCl-$SrCl_2$	B	**244** Bertozzi and Soldani
KCl-$LaCl_3$	A	**178** Smirnov and Stepanov
KCl-LiCl	A	**230, 231** Nissen and Carlsten
KCl-$MgCl_2$	A	**245** Desyatnikov
KCl-NaCl	A	**245** Desyatnikov
KCl-$PbCl_2$	A	**238** Dahl and Duke
KCl-$SrCl_2$	A	**143** Ellis
KCl-$ZnCl_2$	A	**187** Ellis

TABLE 627. Experimental techniques used and recommended references for specific conductance, density, viscosity, and surface tension of molten chloride mixtures—Continued

Surface tension

System	Technique	Recommended reference
$LaCl_3$-$LaCl_3$	A	**248** Smirnov et al.
LiCl-$MgCl_2$	C	**253** Lillebuen
LiCl-NaCl	A	**257** Mizuno et al.
LiCl-NaCl	A	**257** Mizuno et al.
LiCl-$PbCl_2$	A	**238** Dahl and Duke
LiCl-RbCl	A	**256** Semenchenko and Shikhobalova
LiCl-UCl_4	A	**179** Bogacz and Ziolek
$MgCl_2$-NaCl	A	**245** Desyatnikov
$MgCl_2$-RbCl	C	**253** Lillebuen
NaCl-$PbCl_2$	A	**224** Bloom et al.
NaCl-RbCl	B	**243** Bertozzi
NaCl-$SrCl_2$	B	**244** Bertozzi and Soldani
$PbCl_2$-RbCl	A	**238** Dahl and Duke

7. Unevaluated Systems

To make this manuscript more complete from the viewpoint of new systems that have been investigated, this section lists the publications that have been received too late for critical evaluation. These investigations are summarized in tables 628 and 629 for binary mixtures and single salts respectively, with an indication of the system, property, and investigator.

TABLE 628. Unevaluated binary systems

System	Property	Investigators	Ref.
$CaCl_2$-CsCl	κ	Emons, Brautigam, Vogt (1972)	331
	η	Ohta (1974)	332
$CaCl_2$-KCl	η	Dumas, Fjeld, Grjotheim, Øye (1973)	333
$CaCl_2$-LiCl	ρ	Brautigam, Emons (1972)	330
$CaCl_2$-$MgCl_2$	η	Dumas, Fjeld, Grjotheim, Øye (1973)	333
$CaCl_2$-NaCl	η	Dumas, Fjeld, Grjotheim, Øye (1973)	333
$CaCl_2$-RbCl	ρ	Brautigam, Emons (1972)	330
	η	Ohta (1974)	332
$CaCl_2$-UCl_3	ρ	Desyatnik, Katyshev, Melnikov, Raspopin (1973)	334
CsCl-KCl	ρ, η	Zuca, Borcan (1974)	352
CsCl-LiCl	ρ, η	Zuca, Borcan (1974)	352
CsCl-$MgCl_2$	η	Dumas, Fjeld, Grjotheim, Øye (1973)	333
CsCl-$MnCl_2$	κ	Kucharski, Flengas (1974)	335
CsCl-NaCl	η	Ohta (1974)	332
CsCl-RbCl	ρ, η	Zuca, Borcan (1974)	352
CsCl-$SrCl_2$	κ	Emons, Brautigam, Vogt (1973)	336
KCl-$LuCl_3$	γ	Kurmaev, Kuprianova, Maltsev, Krokhin (1974)	337
KCl-$MnCl_2$	κ	Kucharski, Flengas (1974)	335
KCl-$NdCl_3$	γ	Kurmaev, Kuprianova, Maltsev, Krokhin (1974)	337
KCl-RbCl	ρ, η	Zuca, Borcan (1974)	352

TABLE 628. Unevaluated binary systems[a]—Continued

System	Property	Investigators	Ref.
$KCl-SrCl_2$	κ	Yoshida, Oyamada (1973)	325,
		Emons, Brautigam, Vogt (1973)	336
KCl-TlCl	ρ	Buckle, Tsaoussoglou (1972)	219
$LiCl-MgCl_2$	η	Dumas, Fjeld, Grjotheim, Øye (1973)	333
$LiCl-MnCl_2$	κ	Kucharski, Flengas (1974)	335
LiCl-RbCl	ρ	Zuca, Borcan (1974)	352
	η	Dumas, Fjeld, Grjotheim, Øye (1973)	333
		Zuca, Borcan (1974)	352
$LiCl-SrCl_2$	κ	Emons, Brautigam, Vogt (1973)	336
$MgCl_2-RbCl$	η	Dumas, Fjeld, Grjotheim, Øye (1973)	333
$MgCl_2-UCl_3$	ρ	Desyatnikov, Katyshev, Melnikov, Raspopin (1973)	334
$MnCl_2-NaCl$	κ	Kucharski, Flengas (1974)	335
$MnCl_2-RbCl$	κ	Kucharski, Flengas (1974)	335
$NaCl-SrCl_2$	κ	Emons, Brautigam, Vogt (1973)	336
$NbCl_5-TaCl_5$	ρ	Niselson, Sokolova (1964)	217
$RbCl-SrCl_2$	ρ	Emons, Brautigam, Vogt (1973)	336
$RbCl-TiCl_4$	ρ	Buckle, Tsaoussoglu (1972)	219

[a]The following unevaluated systems were added at the galley proof stage: $BaCl_2$-LiCl (ρ) [366]; $BaCl_2$-NaCl (ρ) [366]; $BeCl_2$-KCl (ρ) [370]; $BeCl_2$-NaCl (ρ) [370]; $CaCl_2$-$DyCl_3$ (ρ) [367]; $CaCl_2$-$NdCl_3$ (ρ) [350]; $CaCl_2$-$PrCl_3$ (ρ) [350]; $CdCl_2$-$PbCl_2$ (κ) [363]; CsCl-LiCl (γ) [359]; CsCl-NaCl (γ) [359]; KCl-LiCl (γ) [359]; KCl-$MgCl_2$ (ρ) [368]; KCl-NaCl (γ) [359]; KCl-$NdCl_3$ (ρ) [350]; KCl-$PrCl_3$ (ρ) [350]; KCl-$SnCl_2$ (κ, γ) [364]; KCl-$ThCl_4$ (κ, ρ) [355]; KCl-UCl_3 (γ) [360]; KCl-UCl_4 (γ) [360]; KCl-YCl_3 (κ) [354]; ρ [356]; LiCl-NaCl (ρ) [366]; γ [359]; LiCl-$SrCl_2$ (ρ) [366]; $MnCl_2$-Bu_4NCl (κ) [365]; NaCl-$NdCl_3$ (ρ) [350]; NaCl-$PrCl_3$ (ρ) [350]; NaCl-$SrCl_2$ (ρ) [366]; NaCl-$ThCl_4$ (κ, ρ) [357]; NaCl-UCl_3 (γ) [360]; NaCl-YCl_3 (ρ) [356]; $PbCl_2$-$ZnCl_2$ (κ) [358], (κ, η) [369]; $SnCl_2$-$ZnCl_2$ (κ) [358], (κ, γ) [364].

TABLE 629. Unevaluated single salts[a]

System	Property	Investigators	Ref.
$BiCl_3$	κ	Treiber, Todheide (1973)	340
	ρ	Treiber, Todheide (1973)	341
$CaCl_2$	η	Ohta (1974)	332
$CaCl_2$	κ	Kucharski, Flengas (1974)	335
	ρ	Zuca, Borcan (1974)	352
	η	Ohta (1974)	332
		Zuca, Borcan (1974)	352
KCl	κ	Buckle, Tsaoussoglou (1972)	342
		Shabanov, Gadzhiev, Tagirov (1973)	343
		Kucharski, Flengas (1974)	335
	ρ	Zuca, Borcan (1974)	352
	η	Ohta (1974)	332
		Zuca, Borcan (1974)	352
$GaCl_3$	κ	Greenwood, Worrall (1957)	351
LiCl	κ	Kucharski, Flengas (1974)	335
		Shabanov, Gadzhiev, Tagirov (1973)	343
	ρ, η	Zuca, Borcan (1974)	352
$MnCl_2$	κ	Kucharski, Flengas (1974)	335
	ρ	Markov, Prisyazhnyii, Prikhod'ko (1970)	202
NaCl	κ	Kuvakin, Evstifeev, Ispolin, Talanova (1972)	339
		Shabanov, Gadzhiev, Tagirov (1973)	343
		Kucharski, Flengas (1974)	335
	η	Ohta (1974)	332
RbCl	κ	Kucharski, Flengas (1974)	335
		Shabanov, Gadzhiev, Tagirov (1973)	344
	ρ	Buckle, Tsaoussoglou (1972)	219
		Zuca, Borcan (1974)	352
	η	Ohta (1974)	332
		Schöneborn (1974)	345
		Zuca, Borcan (1974)	352
	γ	Grjotheim, Holm, Lillebuen, Øye (1972)	258
$ZnCl_2$	γ	Karamyshev, Vitkin, Ozhegov, Levenkov, Kipov (1973)	329

[a]The following unevaluated systems were added at the galley proof stage: $BaCl_2$ (ρ) [366]; $BeCl_2$ (κ) [362]; $DyCl_3$ (ρ) [367]; LiCl (ρ) [366]; NaCl (ρ) [366]; $SrCl_2$ (ρ) [366]; $ZnCl_2$ (η) [361].

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