Molten Salts: Volume 3 Nitrates, Nitrites, and Mixtures: Electrical Conductance, Density, Viscosity, and Surface Tension Data

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Molten Salts: Volume 3, Nitrates, Nitrites, 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 nitrate–nitrate, nitrite–nitrite, and nitrite–nitrate mixtures have been systematically collected and evaluated. Results are given for some 71 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: Data compilation; density; electrical conductance; molten salt mixtures; nitrates; nitrites; standard reference data; surface tension; viscosity.

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1. Introduction

Nitrates and nitrites have received wide attention in molten salt chemistry and technology, from a range of viewpoints, covering both practical and theoretical aspects. Mixtures of these salts have been especially popular, partially because the melting point ranges make possible studies at relatively low temperatures, and this minimizes problems of vaporization and corrosion. The four properties of the binary mixtures (nitrites–nitrites, nitrites–nitrates, and nitrates–nitrates) for which recommendations are advanced in the present volume are: specific electrical conductance, density, viscosity, and surface tension. These four properties were also re-examined for the single components of each binary system so as to up-date the recommendations for these salts as single-salt melts.

The work embraces the binary mixtures for which data were published up to December 31, 1970. Results are given for some 71 binary mixtures. In addition the examination of the data of the nitrates and nitrites in the light of new work led to revisions of the previously advanced recommendations [1][1] for some six nitrates as single-salt melts, and recommendations for three nitrites, not previously developed, are also reported.

The organization of the data for binary mixtures with temperature, composition, and the physical properties as variables, raised several problems since the interest was to develop a presentation that would enable facile property inter-comparisons without sacrifice of quality in the statistical methods of data re-analysis. For conductance and viscosity, the treatment was limited to comparisons at rounded temperatures, the recommendations being advanced at the same compositions as in the original experimental studies. For density and surface tension, it was possible in most cases to refine this treatment further, and the recommendations for these two properties are advanced at rounded values of temperature and composition. Two further points should be noted. The tables of numerical values follow immediately after the descriptive discussion of the data sources and the observations on merit, and secondly, a simple temperature-liquidus phase diagram has been included wherever possible, to delineate to the lower limits of the liquidus ranges for the binary mixtures. While the literature source for each diagram is given, it should be understood that phase diagrams in this work are not advanced as critically evaluated recommendations, but only to make this work more useful.

The general organization of the mixtures has been as follows: (*i*) nitrites–nitrites, (*ii*) nitrites–nitrates, and (*iii*) nitrates–nitrates. The arrangement within each of these classes is alphabetical, by cations according to the chemical symbols. A compound index is also given in the Contents.

The organization of the systems by quality of results, the methods of statistical analysis, and some observations on the experimental principles are described in the sections immediately preceding the discussions and numerical data sections.

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:

C = concentration (mol %)
T(K) Temperature in kelvin, defined on the thermodynamic scale by assigning 273.16 K to the triple point of water (freezing point, 273.15 K = 0 °C).

3. Theory and Practice

Several excellent surveys of the theory and practice of experimental measurements for molten salts have appeared in the past decade [6, 7, 8, 10, 11]. The remarks in this section will be limited to some observations concerning the methods of general utility for measure-

[1] Numbers in brackets refer to literature references in section 9.

[2] *For conversion to the SI system:*

1 ohm^{-1} cm^{-1} = 1 × 10^{2} Ω^{-1}m^{-1}
1 g cm^{-3} = 1 × 10^{3} K gm^{-3}
1 cp = 1 × 10^{-3} N s m^{-2}
1 dyn cm^{-1} = 1 × 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^{-2}; this is dimensionally identical to dyn cm^{-1}.

ments of electrical conductance, density, viscosity, and surface tension, particularly as applied to investigations of molten nitrates.

3.1. Electrical Conductance

Measurement of the electrical conductance of molten salt systems is of use in obtaining information on the conducting species, the degree of ionization, and the nature of the interactions in the system. The correlation of conductance with other transport properties, e.g., viscosity, is frequently a useful approach to certain structural aspects of ionic melts [8].

The specific conductance κ is related to the resistance of the salt by eq 1,

$$\kappa = \frac{C'}{R} \tag{1}$$

where C' is the cell constant, given by the ratio of the length to the cross-sectional area of the cell. The specific conductance is determined by the concentrations, charges, and electrical mobilities of the ionic species.

The equivalent conductance Λ is the property that is usually tabulated. For a fully dissociated binary electrolyte,

$$\Lambda = \frac{1000\kappa}{CZ} \tag{2}$$

where C is the concentration in moles per liter and Z is the ionic charge. For a pure fused salt, eq 2 becomes

$$\Lambda = \frac{\kappa M}{\rho} \tag{3}$$

where M is the equivalent weight of the salt and ρ is its density. The temperature dependence of conductance can frequently be expressed in the form of an exponential expression:

$$\Lambda - Ae^{E_\Lambda/RT} \tag{4}$$

where E_Λ is the "activation energy for conductance". This quantity has been used in constructing theories for the mechanism of conductance and for the structure of molten salts.[4]

For a molten binary mixture for which the two component compounds are both ionic compounds, the equivalent conductance (eq 3) may be expressed as [13]:

$$\Lambda = \frac{\kappa M_{\text{av.}}}{\rho_{\text{obs}}} \tag{5}$$

where $M_{\text{av.}}$, the equivalent weight of the mixture, is given by:

$$M_{\text{av.}} = X_1 M_1 + X_2 M_2 \tag{6}$$

the X_1 and X_2 being the equivalent fractions and M_1 and M_2, the respective equivalent weights for the two compounds and $\rho_{\text{obs.}}$ is the observed density of the molten mixture. If one of the two components is a molecular compound (e.g., $HgCl_2$), the expression for the equivalent conductance of the mixture reduces to:

$$\Lambda = \frac{\kappa M_{\text{av.}}}{\rho_{\text{obs}} X_2} \tag{7}$$

where the additional term, X_2, the equivalent fraction of the ionic compound appears, in the denominator.

Molten salts except covalent compounds like the mercuric halides, have high specific conductances. Thus, most molten nitrates in the region of their melting points have specific conductances falling in the range 0.5–2 $\text{ohm}^{-1}\ \text{cm}^{-1}$, which may be compared with $0.1N$ aqueous potassium chloride solution and 100 percent sulfuric acid, for which the specific conductances are about 0.01 $\text{ohm}^{-1}\ \text{cm}^{-1}$.

For measurements of resistance accurate to 0.5 percent or better, a good-quality conductance bridge, reading to $\pm 0.1\Omega$, is necessary, together with a cell with a cell constant of at least 200 cm^{-1} attained by capillary techniques. Descriptions of such cells with constants of 300–500 cm^{-1} are given in detail elsewhere [6, 7, 8, 10, 11]; in figure 1 are shown the designs for four typical molten salt conductance cells.

Direct current conductivity measurements with molten salts have been reported. The dc method is simpler in principle than the ac method. This type of measurement requires a steady current through the melt and through a standard resistance in series with it, together with a comparison of the potential developed between two fixed points in the solution with that across the standard resistance. Since potentiometric measurements can be made quite precisely ($\pm 0.001\%$), the method should be capable of an accuracy comparable to that of the best ac techniques. Strictly reversible electrodes for the potential measurements in the solution are required if the dc method is to be used, and this factor can be a major problem. This method was first used in aqueous electrolytes with high precision [17, 19, 20] and has been extended by Duke and King [21] and Grantham and Yosim [22] for studies of molten nitrates and metal-molten salt solutions, respectively. The method used by Brillant [24] in his conductance studies of molten nitrates, was adapted from the work of Bizouard [29] and combines the feature of the potentiometric measurement of electrolyte resistance with an ac current source (~ 1500 Hz). The potential probe electrodes, of platinum metal, were monitored with a high impedance voltmeter.

[4] For a discussion of measurements under high pressure-constant volume conditions, refer; A. F. M. Barton, B. Cleaver, and G. J. Hills, Trans. Faraday Soc. 64, 208 (1968).

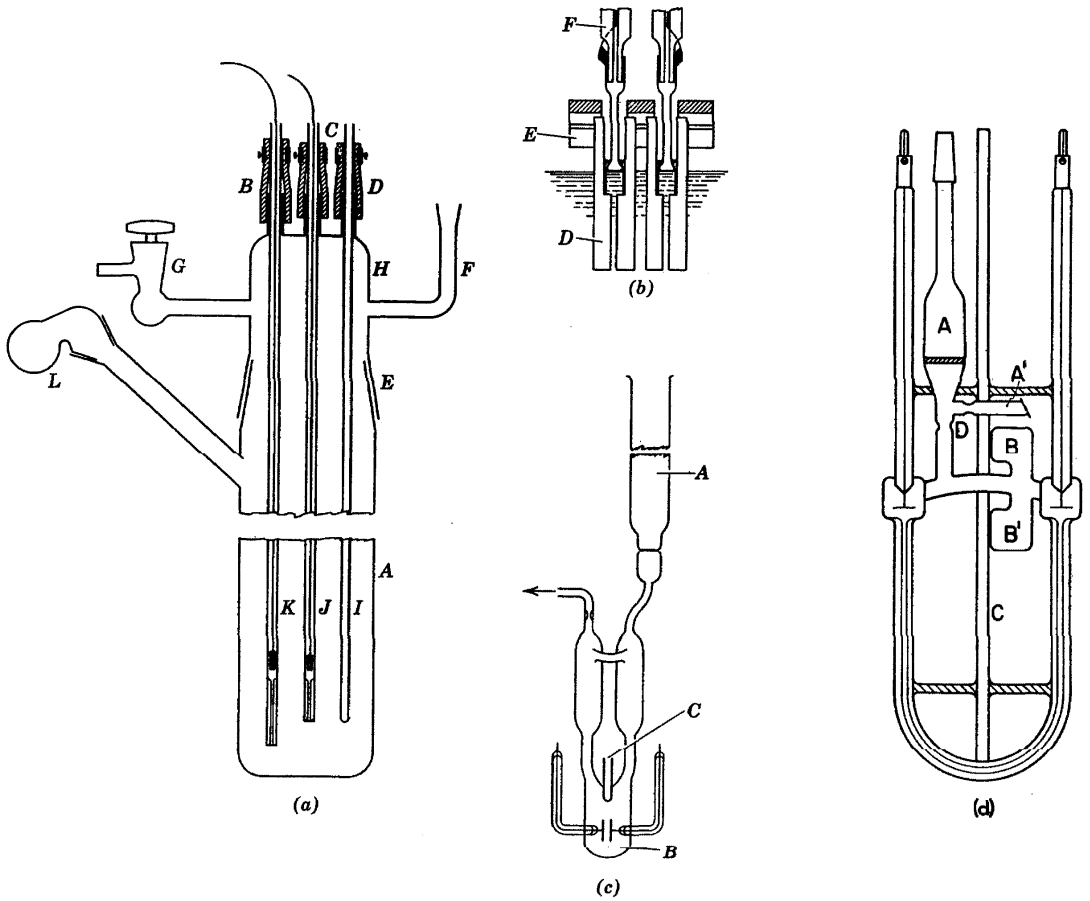

FIGURE 1.

(a) Molten-salt conductance cell assembly (Pyrex or silica): A, melt container; B, C, D, rubber sleeve slip joints; E, F, standard taper (interchangeable) joints; G, controlled atmosphere inlet; H, removable cell "head assembly"; I, thermocouple well; J, K, electrodes inside capillaries; L, flask for solute (solid) addition.

(b) MgO capillary assembly: D, single-crystal MgO capillaries suspended by a "tongue and groove" arrangement from a noble metal alloy (Au, 20% Pd) suspension block, E; electrical contact to the bridge circuit from the cylindrical electrodes within the capillary wells is via the alumina refractory insulated electrode leads, F.

(c) Cell design for volatile melts: A, loading tube showing fritted disc for final melt filtration; this is sealed off and removed once the sample is in the conductance cell, B. The chambers above the electrodes may be used for melt solidification by inversion of the cell after measurements. The thermocouple well, C, may be extended and used simultaneously for suspending the cell in the high-temperature thermostat.

(d) The bright Pt electrode discs (1.5 cm diam.) are spaced about 8 cm apart and connected by a capillary approximately 30 cm x 0.26 cm int. diam. The sample is introduced in the filtration chamber A, and the assembly is connected to a vacuum line (via A′) so that fusion, filtration, and the hermetic seal-off (D) can be accomplished in the conventional manner. The horizontal bridge connecting the electrode compartments facilitates the displacement of bubbles in the capillary arm; the chambers on this arm are for the collection of the sample (in B) after the measurement (by inversion of the assembly) and to ensure that there is no electrolyte bridge across this possible path (by sample over-flow, into B′). A thermocouple is placed in the well C.

It is of interest to note that the "electrodeless" technique for conductance measurements, based on an application of transformer bridge circuits [30], has been adapted for molten salt studies [31, 32].

Molten salts have conductances which depend strongly on temperature; the cell must therefore be held in a furnace possessing good characteristics of temperature control.

Another important matter is the material used for the construction of the cell. In many instances, Pyrex or Vycor glass or silica will prove satisfactory within the temperature ranges of their usability. Substances which attack silicates' can usually be handled in platinum. Yim and Feinleib [33] used cells fabricated from compressed boron nitride for measurements on molten alkali fluorides. Synthetic sapphire (single-crystal Al_2O_3) has been used for solutions of alkali metals in molten halides [34]; for measurements with carbonates, oxides, and fluorides single-crystal quality MgO for capillary construction [34] appears satisfactory.

The effect of conditioning the electrode surfaces with an electro-deposit of platinum black has been studied by various workers [35, 36, 37]. Variation of resistance with frequency is about 0.5 percent over a

range of 500–10,000 cps, the relationship being

$$R_{meas} = R_{inf} + (K/\omega^{1/2})$$

where R_{meas} and R_{inf} are the measured resistance at the frequency ω and the polarization-free resistance at infinite frequency, respectively, and K is a constant characteristic of the salt studied. This and related matters have been the subject of several recent publications concerned with precise and accurate conductance measurements [38–40].

3.2. Density

Two techniques of density measurement have been employed at high temperatures – the Archimedes method and the dilatometric method. The former uses the principle that the upthrust experienced by a body wholly or partially immersed in a fluid is equal to the weight of fluid displaced. In molten-salt studies, a plummet of platinum or gold-palladium alloy suspended from a balance pan by a fine platinum wire has frequently been used. A typical apparatus of this kind is shown, complete with furnace, in figure 2. The Archimedes method has the advantages of applicability to higher temperatures (in excess of 1000 °C) and to more corrosive melts. The adhesion of melt to, and condensation of vapor on, the suspending wire are possible difficulties which must be closely watched [37, 42–46].

Dilatometry in glass apparatus has been used below 550 °C (Pyrex) or 750 °C (silica); an apparatus of this type is shown in figure 2. A variation is the approach by Husband [47], and by Ubbelohde and coworkers [87, 49] who used the manometric technique in which one measures the pressure of an inert gas required to bring about a known difference in height between two columns of the liquid.

A difficulty encountered in dilatometry is the maintenance of constant temperature over a relatively great length of the furnace core. Both this problem and that of corrosion become more serious at higher temperatures.

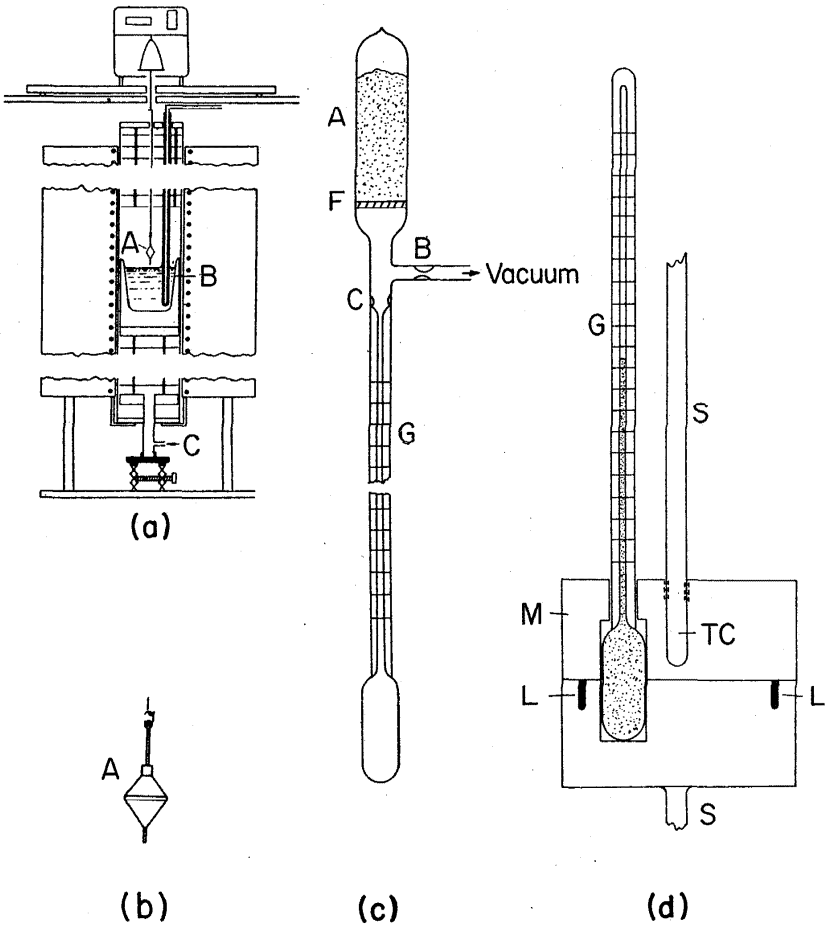

FIGURE 2. Density techniques

(a) Archimedes apparatus: A, density plummet, B, thermocouple; C, inlet for controlled atmospheres.

(b) Density plummet design: (The tip is designed to known dimensions for surface tension measurements using the detachment technique.

(c) Dilatometer and loading tube: A, loading tube filled with salt and sealed; B, C, constrictions for vacuum seals; F, fritted disk, G, graduated dilatometer stem.

(d) Dilatometer and support assembly: G, dilatometer stem; L, locking pins in aluminum block; M, aluminum block (two sections); S, support rods (hollow); TC, thermocouple well.

3.3. Viscosity

The methods which have been used for high-temperature viscosity measurements fall into the following four categories: capillary methods, falling body methods, rotational methods, and oscillational methods. Only the first and last of these have found wide application in measurements on simple molten salts since the falling body and rotational methods are better suited to determinations on liquids of relatively high viscosity such as glasses and some slags.

The capillary methods, based on the time of flow for a given volume of liquid through a precision capillary, are suited for melts of moderate viscosities (centipoise range) at moderately high temperatures. Both the Ostwald and Ubbelohde designs have been used with molten salts. The need for capillaries of precisely known dimensions that are inert to chemical attack severely limits this approach for the more "reactive" inorganic melts, especially in the higher temperature range. For nontransparent assemblies, electrical contacts or floats have been used to monitor the flow rates. A design of a silver metal viscometer with electrical contacts, due to Arndt and Ploetz [50] is shown in figure 3. Pressure is applied externally and the flow of the melt upward through the capillary is timed. Pyrex or quartz viscometers, as shown in figure 3, offer the advantage that ancillary apparatus (e.g. a purification system) may be incorporated in the initial design and, after filling the viscometer, it may be sealed off and removed. In the design shown in figure 3 [51], the cup below the capillary is filled with melt, the excess overflowing into the lower reservoir. The opposing hydrostatic head is thus maintained at a constant value, and the total volume of molten salt in the viscometer is therefore not critical. This apparatus was designed for visual observation, but is readily adapted for remote electrical observation.

The Ubbelohde design, shown in figure 3, was used by Bloom, Harrap, and Heyman [53]. In this style of viscometer, in contrast to the Ostwald type, a knowledge of the melt densities is not essential. The liquid levels are adjusted so that the hydrostatic head cancels in any one experiment; i.e., it is added to the driving pressure for the first half of the measurement, and opposes it during the second half. A design of an Ostwald capillary viscometer shown in figure 3, modified to attain a constant starting volume and suitable for accurate molten salt measurements, has recently been reported [54].

Viscometric techniques involving the timing of the free fall of a sphere through the melt are limited to liquids of viscosity greater than about 40 poise. However, liquids of lower viscosity, including molten salts, have been investigated in an apparatus in which a bob is suspended in the liquid from one arm of a balance. Partial counter-balancing of the bob allows its vertical motion to be studied [55–57].

Methods in which a cylinder is immersed in another cylinder containing the liquid, and one is rotated to produce a measurable torque, have been found suitable only for liquids of viscosity higher than that possessed by most simple molten electrolytes. In the more versatile instruments of this type (e.g., that of Bockris and Lowe [58]) the lowest viscosities for which this method has been applied are of the order of 5 cp.

Methods involving the observation of the damping of an oscillating plummet suspended in the melt have been developed by a number of workers [59, 60, 62, 63, 64] (spherical bobs), Lorenz and Höchberg (horizontal disc) [65], and Towers and Kay [66] (cylindrical bob). Those methods in which a container of liquid is itself caused to oscillate have also found wide application as they have the advantage that no object is suspended in the melt. A spherical container was used by Andrade et al. [67, 68] and by Janz and McIntyre [69], and a cylinder by Hopkins and Toye [70], Barfield and Kitchener [72], Yao [62], and Janz et al. [132, 133].

A disadvantage of oscillational methods is the complexity of the theory involved in relating the logarithmic decrement of the oscillations to the viscosity which often leads to somewhat lengthy calculations. However, this may be offset by several practical considerations. Only a relatively small zone of the furnace needs to be maintained at constant temperature and a wider choice of container materials is possible than is the case for the capillary methods.

3.4. Surface Tension

The principles and practice of the various techniques for molten salt surface tension measurements have been discussed in detail in the preceding volume of this series (see [2, p. 50–54]). In figure 4 are shown the designs which illustrate the basic principles involved in surface tension measurements.

3.5. Experimental Methods

In the course of this work, an assessment of the various techniques and the frequency of use was made. The results of this assessment are summarized in tabular format with the frequency of usage entered as "Percent Application." Further observations in each are given in Section 3.

Specific conductance

Percent application

Method	Nitrite–Nitrite	Nitrite–Nitrate	Nitrate–Nitrate
Classical ac technique...	100	100	79.2
Potentiometric:			
ac technique			16.7
dc technique			4.1

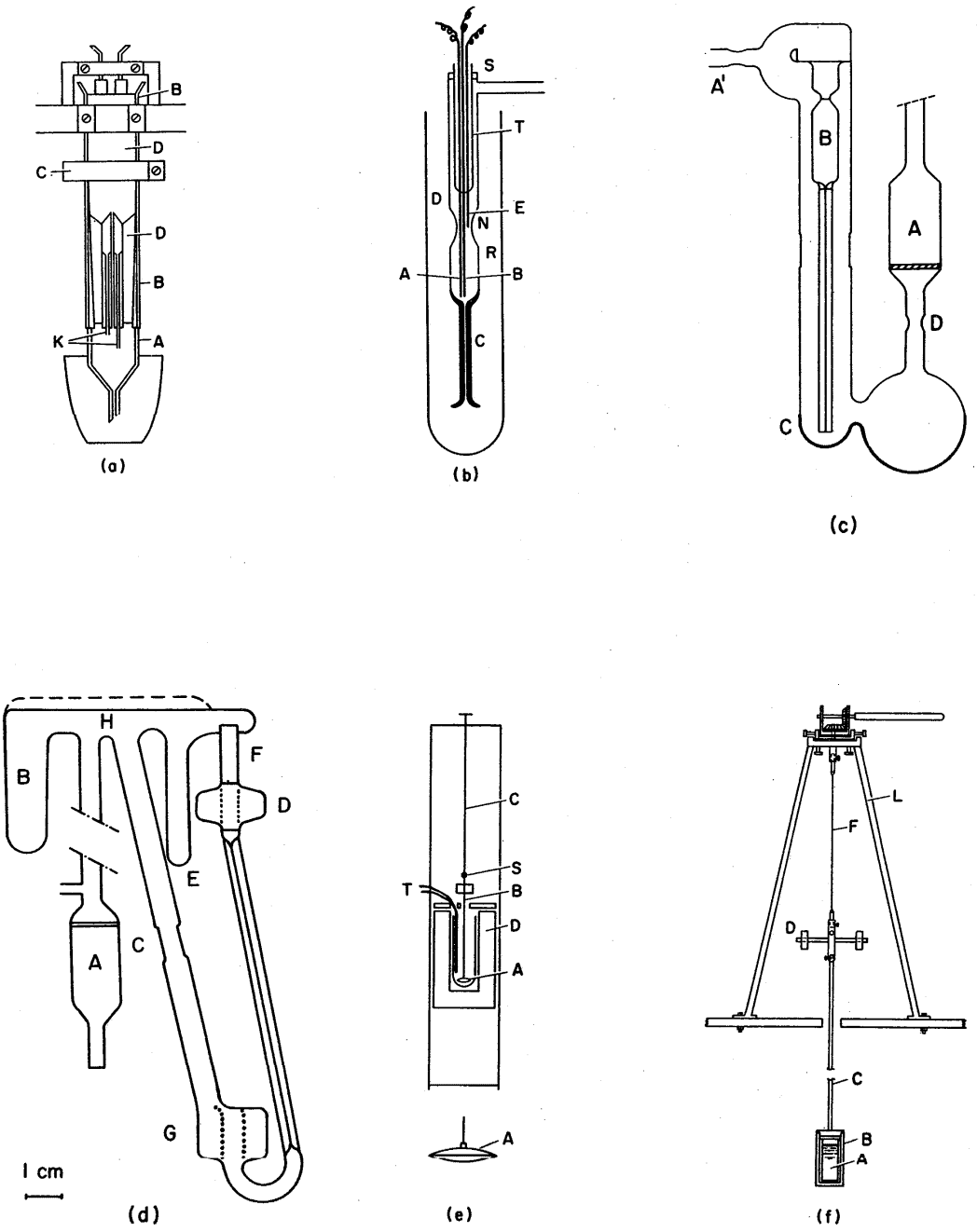

FIGURE 3.

(a) Silver Ostwald-type capillary viscometer with upward flow of melt: A, silver capillary; B, silver support wire; C, socket; D, porcelain tube; and K, silver electrode for timing the flow.

(b) Ubbelohde-type capillary viscometer: A, B, and E, electrodes for timing flow; C, capillary; D, glass tube; N, constriction; R, reservoir; S, side-arm connected to manometer; and T, glass tube with sealed-in platinum contacts.

(c) Capillary viscometer (modified design from that of Greenwood and Wade). The sample is introduced in the filling chamber A and the assembly is connected to a vacuum line (via A′) so that fusion, filtration, and the final hermetic seal-off (at D) can be made in the conventional manner. To minimize the building-up of a meniscus in the lower reservoir, C, the internal surface of this chamber is rough ground. The capillary is about 10 cm x 0.030 cm i.d., and the volume of the delivery chamber, B, about 2.5 ml.

(d) Sealed capillary viscometer suited for measurements with molten salts having appreciable vapor pressures and/or chemical reactivity to atmospheric moisture: A, medium porosity pyrex fritted filter disc; B, storage chamber; C, position for clamp to facilitate rotation; D, efflux tube; E, overflow side arm; F, raised lip reservoir tube; G, receiving bulb; H, horizontal manifold.

(e) Oscillating disc viscometer: A, platinum-iridium disc; B, platinum-iridium suspension wire; C, copper suspension wire; D, furnace; S, mirror; and T, thermocouple.

(f) Oscillating container viscometer: A, gold-palladium cylinder containing melt; B, stainless steel or Inconel container; C, stainless steel suspension rod; D, brass inertia bar with adjustable discs; F, tungsten suspension wire; and L, tripod.

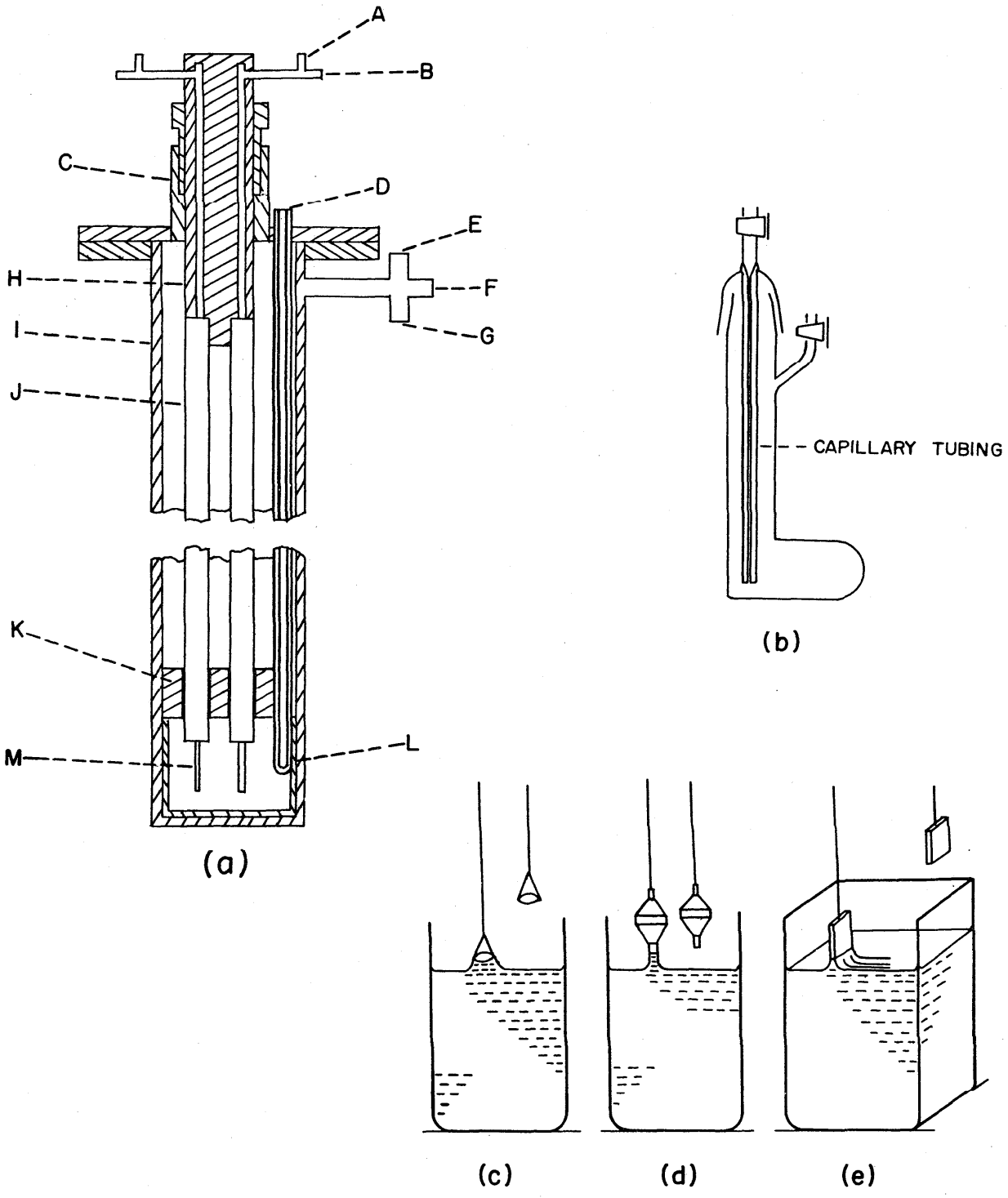

FIGURE 4.

(a) Maximum bubble pressure method using two tips of different diameters immersed in the melt. A, connections to manometer; B, argon inlet to bubble tips; C, packing gland; D. s–s. thermocouple well; E, argon inlet; F, vent; G, vacuum line; H, tube holder; I, s–s. shell; J, bubble tubes; K, crucible cover; M, graphite crucible; L, platinum bubble tips.

(b) Capillary rise method; The inner tube is a precision-bore capillary tube; an extension 5 cm wide at the foot of the outer tube makes possible a satisfactory reading of the level of the lower meniscus.

(c) Ring method.

(d) Pin method; a pin of precisely known diameter is fixed to the lower end of the density bob; the crucible containing the melt is raised and lowered to obtain the "make" and "break" weights.

(e) Wilhelmy Slide Plate method; the maximum pulling force is determined for the detachment of a thin platinum plate from the liquid surface.

For the total number of studies (i.e., 122) the "Percent application" of the classical ac, the potentiometric ac and dc techniques is as follows: 83.6 percent, 13.1 percent, and 3.3 percent respectively.

Density

Percent application

Method	Nitrite–Nitrite	Nitrite–Nitrate	Nitrate–Nitrate
Archimedean	100	100	83.6
Manometric			13.4
Densitometer Dilatometer			3.0

For the total number of studies (i.e., 77), the "Percent application" of the Archimedean, Manometric, and Dilatometric Densitometer techniques is 85.7 percent, 11.7 percent, and 2.6 percent respectively.

Viscosity

Percent application

Method	Nitrite–Nitrite	Nitrite–Nitrate	Nitrate–Nitrate
Capillary viscometer	100		20.7
Oscillating ball			62.5
Oscillating disc			4.2
Oscillating cylinder			4.2
Falling ball			4.2
Beam bending			4.2

For the total number of studies (i.e., 27), the "Percent application" of the Capillary viscometer, Oscillating ball, Oscillating disc, Oscillating cylinder, Falling ball, and Beam bending techniques is as follows: 29.6 percent, 55.6 percent, 3.7 percent, 3.7 percent, 3.7 percent, and 3.7 percent, respectively.

Surface tension

Percent application

Method	Nitrite–Nitrite	Nitrite–Nitrate	Nitrate–Nitrate
Maximum bubble pressure		100	55.6
Slide plate			44.4

For the total number of studies (i.e., 29), the "Percent application" of the Maximum bubble pressure and the Slide plate techniques is 58.6 percent and 41.4 percent respectively.

4. Treatment of Data

4.1. Statistical Analysis of Data

All calculations were made on the digital computer facilities at Rensselaer Polytechnic Institute. The specific conductance and viscosity 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 compositions. A similar treatment was used for the density and surface tension results, in cases where limited information was presented (less than five experimental compositions or temperatures). In all other cases values of density and surface tension were recalculated by a two-dimensional analysis, using a stepwise multiple regression routine. In this way a physical property-temperature-composition matrix was developed. For cases where a two-dimensional analysis yielded a poor statistical fit, values were recalculated using the one-dimensional approach at rounded temperatures and experimental compositions. The tabulated values and the corresponding temperature-dependent equations of investigations which reported only two (κ, ρ, η), three (κ) or four (η) data points at one composition are put in brackets due to the limited information.

(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[5] 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.

[5] System 360 Scientific Subroutine Package Programmers Manual; IBM H20–0205–3, 1969.

Statistical Procedures

The abbreviated Doolittle method[6] 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, D 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:

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

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.

The standard error of estimate is also expressed as a percentage. As a general guide about 68 percent of the results lie within the standard error of estimate, 95 percent within twice this value, and approximately 99 percent within three times the value.[7]

F Value for Analysis of Variance

This value is used to determine if a particular model is acceptable.[8] 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:

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

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

4.2. General Guidelines for Critical Assessments

For the purpose of this discussion it is convenient to separate the data types into several classes, as the criteria for selection vary with the nature and number of investigations. The following cases are considered:

a. More Than One Set of Experimental Data Available

The electrical conductance, density, viscosity, and surface tension data for each binary mixture were assessed using the following guidelines to select the most thorough study: experimental technique with emphasis on the preparation and purity of the salts; number of measurements; temperature range of the measurements, and chemical stability of the salts in this range. Where possible, the uncertainty and precision of related molten salt results from each center were also taken into consideration. In addition to the criteria outlined above, due cognizance was taken of the relevant statistical parameters discussed in section 4.1, and obtained from the one or two dimensional analysis of the experimental data. Results reported for the single components or computed statistically were compared with previous recommendations [1, 2] and the resulting percent departures were taken into account in making the final assessment of "best" values.

b. One Set of Experimental Data Reported

This group comprised single investigations made for a large number of compositions and temperatures, those with few data points and, in the extreme case,

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

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

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

measurements at the eutectic composition only. The standard errors of estimate were obtained by statistical analysis. The experimental uncertainties were estimated from a consideration of the values reported by the author together with a re-examination of the values, if given, in light of the experimental procedures of the investigations.

In table 1 the binary mixtures are listed together with the number of investigations reported for each of the four properties. Inspection shows that the numbers of binary mixtures for which more than one set of experimental results has been reported are as follows: conductance, 20; density, 16; viscosity, 3, and surface tension, 5. Table 1 is also informative from the viewpoint that it indicates areas where investigations are non existent.

TABLE 1. Conductance, density, viscosity and surface tension investigations for nitrite-nitrite, nitrite-nitrate, and nitrate-nitrate molten salt mixtures

System	Number of investigations			
Nitrite-Nitrite	κ	ρ	η	γ
$Ba(NO_2)_2$–$CsNO_2$	1	.....	.....	.....
–KNO_2	1	1	1	.....
–$NaNO_2$	1	.....	1	.....
$Ca(NO_2)_2$–$CsNO_2$	1	.....	.....	.....
–KNO_2	1	.....	.....	.....
–$NaNO_2$	1	.....	.....	.....
–$RbNO_2$	1	.....	.....	.....
$CsNO_2$ –$LiNO_2$	1	.....	.....	.....
KNO_2 –$NaNO_2$	1	1	1	.....
$LiNO_2$ –$NaNO_2$	1	.....	.....	.....
$NaNO_2$ –$TlNO_2$	1	.....	.....	.....
Nitrite-Nitrate				
$Ba(NO_2)_2$–$Ba(NO_3)_2$	1	1	.....	.....
–$CsNO_3$	1	.....	.....	.....
$Ba(NO_3)_2$–$CsNO_2$	1	.....	.....	.....
$Ba(NO_2)_2$–KNO_3	1	.....	.....	.....
$Ba(NO_3)_2$–KNO_2	1	.....	.....	.....
$CsNO_2$ –$CsNO_3$	1	.....	.....	.....
–$LiNO_3$	1	.....	.....	.....
$CsNO_3$ –$LiNO_2$	1	.....	.....	.....
KNO_2 –KNO_3	.....	2	.....	1
–$NaNO_3$	.....	1	.....	.....
KNO_3 –$NaNO_2$	1	1	.....	.....
$LiNO_2$ –$NaNO_3$	1	.....	.....	.....
$LiNO_3$ –$NaNO_2$	1	.....	.....	.....
$NaNO_2$ –$NaNO_3$	1	2	.....	1
–$TlNO_3$	1	.....	.....	.....
$NaNO_3$ –$TlNO_2$	1	.....	.....	.....
$TlNO_2$ –$TlNO_3$	1	1	.....	.....
Nitrate-Nitrate				
$AgNO_3$ –$Ba(NO_3)_2$	1	1	.....	.....
–$Ca(NO_3)_2$	1	1	.....	.....
–$Cd(NO_3)_2$	1	1	.....	.....
–$CsNO_3$	2	1	1	1
–KNO_3	7	4	2	3
–$LiNO_3$	4	3	1	1
–$Mg(NO_3)_2$	1	1	.....	.....
–$NaNO_3$	7	3	1	3
–$RbNO_3$	3	2	1	1
–$TlNO_3$	4	3	2	.....
$Ba(NO_3)_2$–$CsNO_3$	2	.....	.....	.....
–KNO_3	3	5	.....	.....
–$NaNO_3$	.....	1	.....	.....
–$RbNO_3$	.....	1	.....	.....
$Ca(NO_3)_2$–$CsNO_3$	.....	1	.....	1
–KNO_3	4	2	3	1
–$NaNO_3$	1	1	.....	1
$Cd(NO_3)_2$–$CsNO_3$	1	.....	.....	1
–KNO_3	1	1	.....	1
–$LiNO_3$	1	.....	.....	.....
–$NaNO_3$	1	.....	.....	1
–$RbNO_3$	1	.....	.....	1
–$TlNO_3$	1	.....	.....	.....
$CsNO_3$ –KNO_3	1	1	1	1
–$LiNO_3$	1	2	1	1
–$NaNO_3$	3	1	1	1
–$RbNO_3$	1	1	1	.....
–$Sr(NO_3)_2$	1	.....	.....	.....
–$TlNO_3$	1	.....	.....	.....
KNO_3 –$LiNO_3$	4	4	1	1
–$Mg(NO_3)_2$	.....	1	.....	.....
–$NaNO_3$	9	11	4	4
–$Pb(NO_3)_2$	.....	1	.....	.....
–$RbNO_3$	2	1	1	1
KNO_3 –$Sr(NO_3)_2$	1	2	.....	.....
–$TlNO_3$	3	2	.....	.....
$LiNO_3$ –$NaNO_3$	3	2	1	.....
–$RbNO_3$	2	1	1	1
–$TlNO_3$	3	2	.....	.....
$NaNO_3$ –$Pb(NO_3)_2$	.....	1	.....	.....
–$RbNO_3$	4	2	1	1
–$TlNO_3$	5	3	.....	.....
$RbNO_3$ –$TlNO_3$	5	2	.....	.....

c. No Experimental Data Points Reported

This class includes cases where results are reported in the form of temperature-dependent equations at experimental compositions. Such equations were used to generate values of the physical quantity at rounded temperatures within the experimental temperature range. Some investigators report results in graphical form only. While such practices make a critical assessment of the data impossible, the results have been included in order to make the overview of the data status in the present work as complete as possible.

4.3. Estimation of Uncertainty

The Estimates of Uncertainty are based on the precision of the experimental technique (when quoted) and on considerations of various experimental aspects, such as cell materials, temperature range, composition range, melt preparation, and purity of materials (see sec. 3, Theory and Practice, for further information). The limits of the values of the uncertainty estimates are, generally, ± 0.1 percent. For the cases where the in-

formation was minimal, the uncertainty estimates are more approximate.

The standard error of estimate should not be confused with the preceding uncertainty estimate. The standard error of estimate is the end result of a statistical analysis of the numerical data, and the statistical analysis depends on various factors, such as the number of data points, and the nature of the concentration dependence and the temperature dependence of the particular physical property.

It is possible to have a system with a small experimental uncertainty, and with a relatively large standard error of estimate.[9] On the other hand there are cases where the experimental uncertainty is large and due to a relatively small number of data points, the standard error of estimate is small.

The "Percent Departure" gives a comparison of the literature values with the values recommended in this work. The Percent Departure is defined as:

$$\text{Percent Departure} = \left[\frac{\text{"compared value"} - \text{"tabulated value"}}{\text{"tabulated value"}} \times 100\right].$$

Here "compared value" and "tabulated value" refer to the literature value and the value recommended in the present work. Both the "compared value" and the "tabulated value" were calculated from statistically derived equations since the results had to be interpolated to common temperatures and common compositions.

4.4. Preparation of the Tables

The electrical conductance and viscosity 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. The temperature-dependent equations, the standard errors of estimate and the literature sources are given in each table. The tables are reported immediately after the discussions.

For density and surface tension the results were either recalculated using a two-dimensional statistical analysis, or a one-dimensional analysis at the experimental compositions was undertaken in cases where insufficient data were given or where the two-dimensional analysis yielded unsatisfactory results.

The matrices produced by the two-dimensional analysis are reported in tabular form at rounded temperatures and compositions; in addition the two-dimensional equation, maximum percent departure, multiple correlation coefficient, standard error of estimate and literature reference are included in the table. Results generated by the one-dimensional analysis are presented as for electrical conductance and viscosity.

[9] See for example: $Cd(NO_3)_2$–$CsNO_3$, Electrical Conductance.

5. New Recommendations for Single-Salt Melts

Below is a summary of the compounds for which the "best values", have been updated in this volume; these values replace the recommendations advanced in NSRDS–NBS–15 (1968) [1]. The numerical values and temperature-dependent equations for the new recommendations are included in sections 5.1–5.8.

New Recommendations

Compound	NSRDS–NBS–15 (1968) [1] recommendations	Section containing up-dated recommendation (this work)
Specific conductance		
$AgNO_3$	p. 28	$AgNO_3$–$NaNO_3$
KNO_3	p. 26	KNO_3–$NaNO_3$, KNO_3–$RbNO_3$
$RbNO_3$	p. 27	KNO_3–$RbNO_3$
Density		
$AgNO_3$	p. 28	$AgNO_3$–$LiNO_3$
$NaNO_3$	p. 25	$NaNO_3$–$RbNO_3$
$RbNO_3$	p. 27	$NaNO_3$–$RbNO_3$
Viscosity		
$CsNO_3$	p. 25	$CsNO_3$–$LiNO_3$
KNO_3	p. 27	KNO_3–$NaNO_3$
Surface tension		

The single-salt recommendations advanced in NSRDS–NBS–28 (1969) [2] are up to date.

Compounds for which the NSRDS–NBS–15 (1968) [1] uncertainty estimate has been changed

For one compound, KNO_3, it was possible to refine the uncertainty estimate.

Property	Compound	NSRDS–NBS–15 (1968) [1] uncertainty estimate	Section containing up-dated uncertainty estimate (this work)
η	KNO_3	1.5%	KNO_3–$NaNO_3$

Single compounds not discussed in NSRDS–NBS–15 (1968) [1]

Compound	Property	Section containing up-dated recommendation (this work)
$Ba(NO_2)_2$	η	$Ba(NO_2)_2$–KNO_2
$Ca(NO_2)_2$	κ	$Ca(NO_2)_2$–$NaNO_2$
$TlNO_2$	ρ	$TlNO_2$–$TlNO_3$
$TlNO_2$	κ	$NaNO_2$–$TlNO_2$

5.1. $AgNO_3$

κ (ohm)$^{-1}$ cm^{-1})
$= -1.5943 + 4.634 \cdot 10^{-3}T$; (483.2 to 523.2 K)
$= -1.4588 + 4.395 \cdot 10^{-3}T$; (523.2 to 555.2 K)
$= -1.3088 + 4.105 \cdot 10^{-3}T$; (555.2 to 588.2 K)
$= -1.1754 + 3.878 \cdot 10^{-3}T$; (588.2 to 613.2 K)
$= -0.9897 + 3.575 \cdot 10^{-3}T$; (613.2 to 633.2 K)
$= 4.5386 - 1.170 \cdot 10^{-3}T$; (483.2 to 513.2 K)
$= 4.5035 - 1.100 \cdot 10^{-3}T$; (514.2 to 633.2 K)

T(K)	κ	ρ
490	0.676	3.965
500	0.723	3.954
510	0.769	3.942
520	0.815	3.932
530	0.860	3.921
540	0.904	3.910
550	0.947	3.899
560	0.990	3.888
570	1.031	3.877
580	1.072	3.866
590	1.113	3.855
600	1.151	3.844
610	1.190	3.833
620	1.227	3.822
630	1.263	3.811

Density: [1 (p. 28), 3, 4, 16, 24, 48, 52, 61, 101]
Conductance: [1 (p. 28), 4, 16, 24, 27, 52, 61, 73, 74, 75 78, 82, 100, 101, 111, 125]

5.2. $Ba(No_2)_2$

Viscosity values for $Ba(NO_2)_2$ are reported graphically [114] between 280 and 310 °C and are given in figures 47 and 49.

5.3. $Ca(NO_2)_2$

Conductance values for $Ca(NO_2)_2$ are reported graphically [102] between 390 and 420 °C and are given in figures 53 and 57.

5.4. $CsNO_3$

η(cp) $= 41.5319 - 6.9636 \cdot 10^{-2}T - 2.3480 \cdot 10^{-5}T^2 + 6.0738 \cdot 10^{-8}T^3$

T(K)	η
690	2.56
695	2.18
700	2.11
705	2.05
710	1.99
715	1.94
720	1.89
725	1.85
730	1.81

Viscosity: [1 (p. 28), 48, 118, 119]

5.5. KNO_3

κ(ohm^{-1} cm^{-1})$= -2.1230 + 5.7252 \cdot 10^{-3}T - 2.0221 \cdot 10^{-6}T^2$
η(cp)$= 19.16312 - 2.75146 \cdot 10^{-2}T - 1.512603 \cdot 10^{-5}T^2 + 2.721704 \cdot 10^{-8}T^3$

T(K)	κ	η
620	0.649	2.78
630	0.681	2.63
640	0.713	2.49
650	0.744	2.36
660	0.775	2.24
670	0.805	2.12
680	0.835	2.02
690	0.865	1.92
700	0.894	1.83
710	0.923	1.74
720	0.951	1.67
730	0.979	1.60
740	1.006	1.55
750	1.033	
760	1.060	
770	1.087	
780	1.112	
790	1.138	
800	1.163	
810	1.188	

Conductance: [1 (p. 26), 9, 23, 24, 29, 82, 89, 90, 94, 100, 107, 116, 117, 121, 122, 129]
Viscosity: [1 (p. 27), 48, 86, 107, 118, 119]

5.6. $NaNO_3$

ρ(g cm^{-3})$= 2.3339 - 7.665 \cdot 10^{-4}T$

T(K)	ρ
590	1.882
600	1.874
610	1.866
620	1.859
630	1.851
640	1.843
650	1.836
660	1.828
670	1.820
680	1.813
690	1.805

Density: [1 (p. 26), 9, 12, 25, 27, 71, 86, 95, 97, 115, 117, 118, 130]

5.7. $RbNO_3$

$\kappa(\text{ohm}^{-1}\,\text{cm}^{-1}) = -1.0021 + 2.390 \cdot 10^{-3}T$
$\rho(\text{g cm}^3) = 3.1366 - 1.0687 \cdot 10^{-3}T$

T(K)	κ	ρ
590	0.408	2.506
600	0.432	2.495
610	0.456	2.485
620	0.480	2.474
630	0.504	2.463
640	0.528	2.453
650	0.551	2.442
660	0.575	2.431
670	0.599	2.421
680	0.623	2.410
690	.....	2.399

Density: [1 (p. 27), 24, 25, 86, 109, 117, 118]

Conductance: [1 (p. 27), 24, 73, 88, 104, 121, 123, 125, 129, 135]

5.8. $TlNO_2$

$\kappa(\text{ohm}^{-1}\,\text{cm}^{-1}) = -0.8037 + 2.970 \cdot 10^{-3}T$
$\rho(\text{g cm}^{-3}) = 5.6166 - 1.570 \cdot 10^{-3}T$

T(K)	κ	ρ
470	0.59	.....
480	0.62	4.863
490	0.65	4.847
500	0.68	4.832
510	0.71	4.816
520	0.74	4.800
530	0.77	4.785
540	0.80	4.769
550	0.83	4.753
560	0.86	4.737
570	.....	4.722

Density: [103]

Conductance: [89, 103]

6. Phase Diagrams

Phase diagrams for each system, when available, are included in section 7. While the literature source for each diagram is given, 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.

7. Discussions, Numerical Values, and Statistically Generated Equations

This section comprises a discussion of significant features of each investigation, tables of values of physical properties at rounded or experimental compositions and temperatures, together with temperature or temperature composition-dependent equations. Liquidus-solidum diagrams are given as an aid to the user. Such details as experimental technique, number of data points, temperature range, estimates of uncertainty, and percent departure values are given where possible. Revised and new information relevant to single salt values are discussed to complement the earlier volumes in this series. For many investigations the preparation, purification and stability of the melts and other salient experimental features are discussed.

$AgNO_3$–$Ba(NO_3)_2$

Electrical Conductance

Twenty-three studies of the specific conductance of $AgNO_3$ [1 (p. 28), 4, 16, 24, 27, 52, 61, 73, 74, 75, 78, 82, 100, 101, 111, 125] have been reported. $Ba(NO_3)_2$ has not been investigated. Revised recommendations for $AgNO_3$ are based on the work of Brillant [24] and together with some experimental aspects are discussed in the section on $AgNO_3$–$NaNO_3$

Murphy and Wetmore [16] measured the specific conductance of molten $AgNO_3$–$Ba(NO_3)_2$ mixtures using the classical ac technique. Their results for pure $AgNO_3$ and mixtures containing 1.52 and 2.56 mole percent $Ba(NO_3)_2$, covering a temperature range from 490 to 600 K, were recalculated from the reported data of equivalent conductance and the equivalent volumes reported by the same authors. The values of specific conductance are given in table 2(a) for the experimental concentrations at rounded values of temperature. The corresponding temperature-dependent equations are given in table 2(b). The values for the mixture containing 2.56 mole percent $Ba(NO_3)_2$ are in brackets due to the limited number of data points. The experimental uncertainty of the results of Murphy and Wetmore is estimated to be about 0.5 percent. The results for $AgNO_3$ deviate from the newly recommended values [24] (0.34 to 0.70 percent) and from the recommendations [1] (−1.07 to −0.30 percent).

For melt preparation of Murphy and Wetmore see $AgNO_3$–$Ca(NO_3)_2$. The experimental technique used by these authors is discussed in the section on $AgNO_3$–$Mg(NO_3)_2$.

Density

Fourteen studies of the density of $AgNO_3$ [1 (p. 28), 3, 4, 16, 24, 48, 52, 61, 101, 142, 143] have been reported. $Ba(NO_3)_2$ has not been investigated. Revised recommendations for $AgNO_3$ are based on the work of Brillant [24] and together with some experimental aspects are discussed in the section on $AgNO_3$–$LiNO_3$.

Murphy and Wetmore [16] used the Archimedean method to measure the density of molten $AgNO_3$–$Ba(NO_3)_2$ mixtures, in the temperature range from 485 to 590 K for pure $AgNO_3$ and mixtures containing 1.52 and 2.56 mole percent $Ba(NO_3)_2$. The values are given in table 3(a) for the experimental concentrations at rounded values of temperature using one-dimensional statistical analysis of the density-data, recalculated from the reported molar volumes. The corresponding temperature-dependent equations are given in table 3(b). The experimental uncertainty of the results of Murphy and Wetmore is estimated to be about 0.3 percent. The results for $AgNO_3$ deviate from the newly recommended values [24] (− 0.22 to − 0.12 percent) and from the recommendations [1] (−0.16 to −0.05 percent).

For melt preparation and experimental technique of Murphy and Wetmore [16] see discussion in the section on $AgNO_3$–$Ca(NO_3)_2$.

TABLE 2(a). $AgNO_3$–$Ba(NO_3)_2$: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

Mole percent $Ba(NO_3)_2$

T(K)	2.56	1.52	0
490		0.648	0.681
500		0.694	0.728
510		0.740	0.774
520		0.785	0.820
530		0.829	0.865
540	(0.848)	0.873	0.909
550	(0.891)	0.915	0.952
560	(0.932)	0.957	0.994
570	(0.973)	0.998	1.036
580	(1.013)	1.038	1.076
590	(1.053)	1.077	1.116

TABLE 2(b). Temperature-dependent equations

$\kappa = a + bT + cT^2$ (ohm^{-1} cm^{-1})

Comp. (mol % $Ba(NO_3)_2$)	a	$b \cdot 10^2$	$c \cdot 10^5$	Stand. error of est. (percent)
0	−2.6126	0.86864	−0.40107	0.0001 = 0.01
1.52	−2.6214	0.86448	−0.40267	0.0000
2.56	(−2.6795)	(0.87644)	(−0.41333)	

Reference: [16]

TABLE 3(a). $AgNO_3$–$Ba(NO_3)_2$: Density

Numerical values (g cm^{-3})

Mole percent $Ba(NO_3)_2$

T(K)	2.56	1.52	0
490		3.940	3.960
500		3.928	3.948
510		3.917	3.937
520		3.905	3.925
530		3.894	3.914
540	3.869	3.882	3.903
550	3.857	3.871	3.891
560	3.846	3.860	3.880
570	3.835	3.849	3.868
580	3.823	3.837	3.857
590	3.812	3.826	3.846

TABLE 3(b). Temperature-dependent equations

$\rho = a + bT$ (g cm^{-3})

Comp. (mol % $Ba(NO_3)_2$)	a	$b \cdot 10^2$	Stand. error of est. (percent)
0	4.51914	−0.11415	0.0002 = 0.005
1.52	4.49724	−0.11378	0.0002 = 0.005
2.56	4.48596	−0.11427	0.0003 = 0.008

Reference: [16]

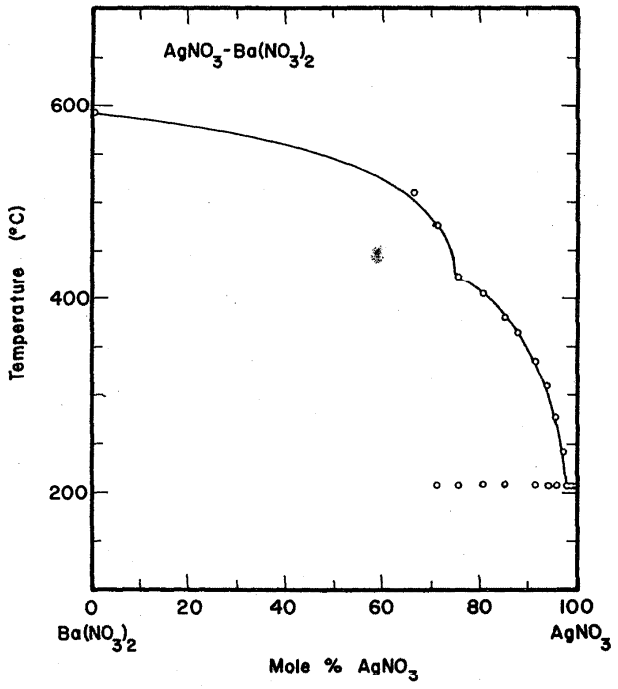

FIGURE 5. Temperature–composition phase diagram for $AgNO_3$–$Ba(NO_3)_2$.

A. P. Palkin, Byulleten' Sredneaziatskogo Gosudarstvennogo Universiteta, Issue 18, No. 10, 77 (1929).

$AgNO_3$–$Ca(NO_3)_2$

Electrical Conductance

Twenty-three studies of the specific conductance of $AgNO_3$ [1 (p. 28), 4, 16, 24, 27, 52, 61, 73, 74, 75, 78, 82, 100, 101, 111, 125] have been reported. $Ca(NO_3)_2$ has not been investigated. Revised recommendations for $AgNO_3$ are based on the work of Brillant [24] and together with some experimental aspects are discussed in the section on $AgNO_3$–$NaNO_3$.

Murphy and Wetmore [16] measured the specific conductance of molten $AgNO_3$–$Ca(NO_3)_2$ mixtures using the classical ac technique. Their results for pure $AgNO_3$ and mixtures containing 1.52, 2.56, 5.26, and 11.11 mole percent $Ca(NO_3)_2$, covering a temperature range from 490 to 600 K, were recalculated from the reported data of equivalent conductance and the equivalent volumes reported by the same authors. The values of specific conductance are given in table 4(a) for the experimental concentrations at rounded values of temperature. The corresponding temperature-dependent equations are given in table 4(b). The experimental uncertainty of the results of Murphy and Wetmore is estimated to be about 0.5 percent. The results for $AgNO_3$ deviate from the newly recommended values [24] (0.34 to 0.70 percent) and from the recommendations [1] (−1.07 to −0.27 percent).

For melt preparation of Murphy and Wetmore see $AgNO_3$–$Ca(NO_3)_2$. The experimental technique used by these authors is discussed in the section on $AgNO_3$–$Mg(NO_3)_2$.

Density

Fourteen studies of the density of $AgNO_3$ [1 (p. 28), 3, 4, 16, 24, 48, 52, 61, 101, 142, 143] have been reported. $Ca(NO_3)_2$ has not been investigated. Revised recommendations for $AgNO_3$ are based on the work of Brillant [24] and together with some experimental aspects are discussed in the section on $AgNO_3$–$LiNO_3$.

Murphy and Wetmore [16] used the Archimedean method to measure the density of molten $AgNO_3$–$Ca(NO_3)_2$ mixtures, in the temperature range from 485 to 590 K for pure $AgNO_3$ and mixtures containing 1.52, 2.56, 5.26, and 11.11 mole percent $Ca(NO_3)_2$. The results of a two-dimensional statistical analysis of these data are given in table 5(a) as a temperature-concentration-density matrix, for rounded concentrations and temperatures. The density data were recalculated from the reported molar volumes. The corresponding statistical parameters are given in table 5(b). The experimental uncertainty of the results of Murphy and Wetmore is estimated to be about 0.3 percent. The results for $AgNO_3$ deviate from the newly recommended values [24] (−0.22 to −0.12 percent) and from the recommendations [1] (−0.16 to −0.05 percent).

Murphy and Wetmore [16] used reagent grade silver nitrate, with a limit of 0.02 percent impurity, which was dried by oven-heating and finally by fusion. $Ba(NO_3)_2$ of reagent grade was dried in an oven whose temperature was raised slowly to a point just below fusion. $Ca(NO_3)_2$ was prepared from $Ca(NO_3)_2 \cdot 4H_2O$ by keeping it at 300 °C for more than 1 day and heating it to 450 °C for 1 hour before use. $Mg(NO_3)_2$ was prepared from reagent grade $Mg(NO_3)_2 \cdot 6H_2O$ by vacuum-exsiccation from 50° slowly up to 150°. All salts were stored under dry air. The measurements were carried out by the Archimedean method using a bob of silver encased in Pyrex. No surface tension correction is mentioned.

TABLE 4(a). $AgNO_3$–$Ca(NO_3)_2$: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

Mole percent $Ca(NO_3)_2$

T(K)	11.11	5.26	2.56	1.52	0
490	0.432	0.553	0.616	0.642	0.681
500	0.472	0.597	0.662	0.689	0.728
510	0.511	0.641	0.707	0.735	0.774
520	0.550	0.684	0.751	0.779	0.820
530	0.589	0.726	0.784	0.823	0.865
540	0.628	0.767	0.837	0.866	0.909
550	0.667	0.808	0.879	0.909	0.952
560	0.705	0.849	0.920	0.950	0.994
570	0.743	0.888	0.960	0.991	1.036
580	0.781	0.928	0.999	1.031	1.076
590	0.819	0.966	1.038	1.070	1.116

TABLE 4(b). Temperature-dependent equations

$\kappa = a + bT + cT^2$ (ohm^{-1} cm^{-1})

Comp. (mol % $Ca(NO_3)_2$)	a	$b \cdot 10^2$	$c \cdot 10^5$	Stand. error of est. (percent)
0	−2.6126	0.86864	−0.40107	0.0001=0.01
1.52	−2.6131	0.86129	−0.40176	0.0000
2.56	−2.5866	0.84542	−0.39158	0.0001=0.01
5.26	−2.3422	0.73873	−0.30165	0.0000
11.11	−1.7382	0.48971	−0.09539	0.0001=0.02

Reference: [16]

TABLE 5(a). $AgNO_3$–$Ca(NO_3)_2$: Density

Numerical values (g cm^{-3})

Mole percent $Ca(NO_3)_2$

T(K)	10	9	8	7	6	5	4	3	2	1	0	10.7
485	3.680	3.708	3.736	3.764	3.793	3.821	3.849	3.877	3.905	3.933	3.962	3.661
490	3.675	3.703	3.731	3.759	3.787	3.815	3.843	3.872	3.900	3.928	3.956	3.656
495	3.669	3.697	3.726	3.754	3.782	3.810	3.838	3.866	3.894	3.922	3.950	3.650
500	3.664	3.692	3.720	3.748	3.776	3,804	3.832	3.860	3.888	3.916	3.944	3.645
505	3.659	3.687	3.715	3.743	3.771	3.799	3,827	3.855	3.883	3.911	3.939	3.640
510	3.654	3.681	3.709	3.737	3.765	3.793	3.821	3.849	3.877	3.905	3.933	3.635
515	3.648	3.676	3.704	3.732	3.760	3.788	3.816	3.844	3.872	3.899	3.927	3.629
520	3.643	3.671	3.699	3.727	3.754	3.782	3.810	3.838	3.866	3.894	3.922	3.624
525	3.638	3.666	3.693	3.721	3.749	3.777	3.805	3.833	3.860	3.888	3.916	3.619
530	3.632	3.660	3.688	3.716	3.744	3.771	3.799	3.827	3.855	3.882	3.910	3.613
535	3.627	3.655	3.683	3.710	3.738	3.766	3.794	3.821	3.849	3.877	3.905	3.608
540	3.622	3.650	3.677	3.705	3.733	3.760	3.788	3.816	3.843	3.871	3.899	3.603
545	3.617	3.644	3.672	3.700	3.727	3.755	3.783	3.810	3.838	3.866	3.893	3.598
550	3.611	3.639	3.667	3.694	3.722	3.749	3.777	3.805	3.832	3.860	3.887	3.592
555	3.606	3.634	3.661	3.689	3.716	3.744	3.772	3.799	3.827	3.854	3.882	3.587
560	3.601	3.628	3.656	3.684	3.711	3.739	3.766	3.794	3.821	3.849	3.876	3.582
565	3.596	3.623	3.651	3.678	3.706	3.733	3.761	3.788	3.815	3.843	3.870	3.577
570	3.591	3.618	3.654	3.673	3.700	3.728	3.755	3.782	3.810	3.837	3.865	3.572
575	3.585	3.613	3.640	3.667	3.695	3.722	3.750	3.777	3.804	3.832	3.859	3.566
580	3.580	3.607	3.635	3.662	3.689	3.717	3.744	3.771	3.799	3.826	3.853	3.561
585	3.575	3.602	3.629	3.657	3.684	3.711	3.738	3.766	3.793	3.820	3.848	3.556
590	3.569	3.596	3.623	3.651	3.678	3.705	3.732	3.760	3.787	3.814	3.842	3.550

TABLE 5(b). Two-dimensional equation and statistical parameters

$\rho = a + bT + cC + dT^2 + eCT^2$ (g cm^{-3})

a	$b \cdot 10^3$	$c \cdot 10^2$	$d \cdot 10^7$	$e \cdot 10^9$	Max. percent departure	Stand. error of est.
1.50315	−1.14002	3.01134	8.29857	8.29857	−0.12 (593.2 K, 5.263 mol % $Ca(NO_3)_2$)	0.003 (0.08%)

Reference: [16]

C = mole percent $AgNO_3$

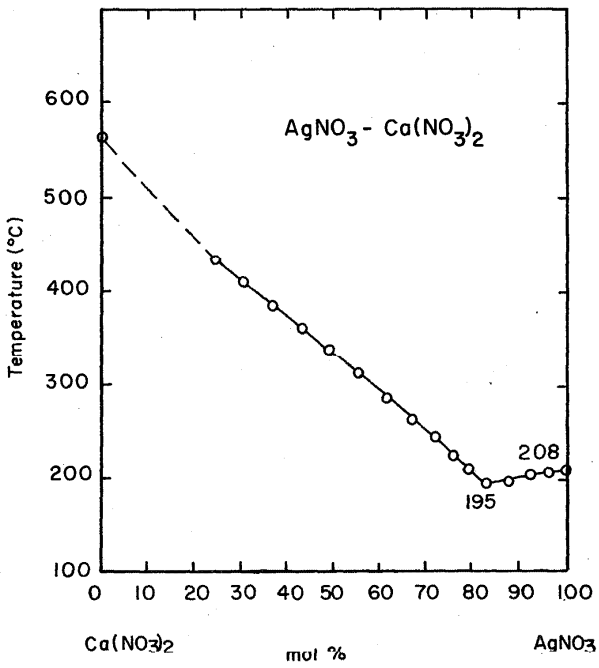

FIGURE 6. Temperature–composition phase diagram for $AgNO_3$–$Ca(NO_3)_2$.

P. I. Protsenko and Z. I. Belova, Zhur. Neorg. Khim., **2**, 2618 (1957).

$AgNO_3$–$Cd(NO_3)_2$

Electrical Conductance

Twenty-three studies of the specific conductance of $AgNO_3$ [1 (p. 28), 4, 16, 24, 27, 52, 61, 73, 74, 75, 78, 82, 100, 101, 111, 125] have been reported. $Cd(NO_3)_2$ has not been investigated. Revised recommendations for $AgNO_3$ are based on the work of Brillant [24] and together with some experimental aspects are discussed in the section on $AgNO_3$–$NaNO_3$.

Protsenko and Popovskaya [113] measured the specific conductance of molten $AgNO_3$–$Cd(NO_3)_2$ mixtures using the classical ac technique. The results for $AgNO_3$ alone and 16 different mixtures (8.2 to 53.9 mole percent $Cd(NO_3)_2$), covering a temperature range from 423.2 to 583.2 K, are given in table 6 for the compositions and temperatures reported by Protsenko and Popovskaya. A statistical analysis to produce values at rounded temperatures was unsatisfactory. The experimental uncertainty of the results of Protsenko and Popovskaya is estimated to be about 0.4 percent. The values for $AgNO_3$ alone deviate from the newly recommended values [24] (0.06 to 2.32 percent) and from the recommendations [1] (−0.78 to 0.70 percent).

For discussion of the experimental technique of Protsenko and Popovskaya see KNO_3–$RbNO_3$. However, no information is given by the authors about melt preparation.

Density

Fourteen studies of the density of $AgNO_3$ [1 (p. 28), 3, 4, 16, 24, 48, 52, 61, 101, 142, 143] have been reported. $Cd(NO_3)_2$ has not been investigated. Revised recommendations for $AgNO_3$ are based on the work of Brillant [24] and together with some experimental aspects are discussed in the section on $AgNO_3$–$LiNO_3$.

Popovskaya and Protsenko [142] used the Archimedean method to measure the density of molten $AgNO_3$–$Cd(NO_3)_2$ mixtures in the temperature range from 433 to 563 K for pure $AgNO_3$ and 14 mixture compositions. Their results were recalculated using a two-dimentional statistical analysis; the values in the form of a temperature-composition-density matrix are in table 6.1(a) at rounded compositions and temperatures.

The corresponding statistical parameters are given in table 6.1(b). Owing to the limited information an uncertainty estimate for the results of Popovskaya and Protsenko is not possible. The results for $AgNO_3$ deviate the newly recommended values [24] (−0.55 to −0.67 percent) and from the recommendations [1] (−0.32 to −0.56 percent).

Popovskaya and Protsenko [142] used for their measurements a glass ball filled with lead. The ball was calibrated in KNO_3, $NaNO_3$, and mixtures of the two. No information is given by the authors relative to melt preparation.

TABLE 6. $AgNO_3$–$Cd(NO_3)_2$: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

Mole percent $Cd(NO_3)_2$

$T(K)$	53.9	48.2	45.0	42.9	40.4	38.0	35.6	33.4	31.2	29.1	27.0	25.0	21.3	17.7	11.2	8.2	0
423.2						0.044	0.054	0.066	0.081	0.124	0.131	0.152	0.192				
443.2				0.056	0.063	0.076	0.089	0.106	0.124	0.170	0.180	0.200	0.242	0.290			
463.2			0.079	0.090	0.099	0.118	0.137	0.157	0.182	0.223	0.234	0.254	0.301	0.350	0.450		
483.2		0.096	0.119	0.135	0.146	0.171	0.192	0.218	0.245	0.280	0.292	0.311	0.363	0.416	0.510	0.570	
503.2		0.138	0.166	0.183	0.196	0.222	0.248	0.280	0.306	0.339	0.354	0.372	0.428	0.484	0.578	0.639	0.756
523.2	0.152	0.186	0.218	0.231	0.248	0.277	0.304	0.338	0.369	0.404	0.418	0.436	0.494	0.548	0.652	0.713	0.832
543.2	0.195	0.238	0.268	0.282	0.300	0.335	0.362	0.396	0.432	0.469	0.480	0.504	0.561	0.618	0.732	0.788	0.919
563.2	0.241	0.287	0.321	0.339	0.356	0.394	0.424	0.456	0.496	0.540	0.546	0.572	0.635	0.690	0.820	0.864	
583.2	0.300	0.346	0.386		0.436	0.458	0.485	0.528	0.573		0.616	0.648	0.705	0.766	0.890	0.946	

Reference: [113]

TABLE 6.1(a). $AgNO_3$–$Cd(NO_3)_2$: Density

Numerical values (g cm^{-3})

Mole percent $Cd(NO_3)_2$

T(K)	60	50	40	30	20	10	0	39
440		3.625						
445		3.620	3.691					
450		3.614	3.685					
455		3.609	3.680					3.687
460		3.603	3.674					3.682
465		3.598	3.669	3.741				3.676
470		3.592	3.663	3.736				3.671
475		3.587	3.658	3.730				3.665
480		3.581	3.652	3.725				3.659
485	3.506	3.576	3.647	3.719	3.793			3.654
490	3.501	3.570	3.641	3.714	3.788			3.648
495	3.495	3.565	3.636	3.708	3.782	3.858		3.643
500	3.490	3.559	3.630	3.703	3.777	3.853		3.637
505	3.484	3.554	3.625	3.697	3.771	3.847	3.924	3.632
510	3.478	3.548	3.619	3.692	3.766	3.841	3.919	3.626
515	3.473	3.542	3.613	3.686	3.760	3.836	3.913	3.621
520	3.467	3.537	3.608	3.681	3.755	3.830	3.908	3.615
525	3.462	3.531	3.602	3.675	3.749	3.825	3.902	3.610
530	3.456	3.526	3.597	3.669	3.744	3.819	3.897	3.604
535	3.451	3.520	3.591	3.664	3.738	3.814	3.891	3.599
540	3.445	3.515	3.586	3.658	3.733	3.808	3.885	3.593
545	3.440	3.509	3.580	3.653	3.727	3.803	3.880	3.587
550	3.434	3.504	3.575	3.647	3.721	3.797	3.874	3.582
555	3.429	3.498	3.569	3.642	3.716	3.792	3.869	3.576
560	3.423	3.493	3.564	3.636	3.710	3.786	3.863	3.571

TABLE 6.1(b). Two-dimensional equation and statistical parameters

$\rho = a + bT + cC + dC^2$ (g cm^{-3})

a	$b \cdot 10^3$	$c \cdot 10^3$	$d \cdot 10^6$	Max. percent departure	Stand. error of est.
3.78100	− 1.10794	6.25331	7.74124	0.22 (563.2K, 40 mol % $AgNO_3$)	0.002 (0.07%)

Reference: [142]

C = mole percent $AgNO_3$

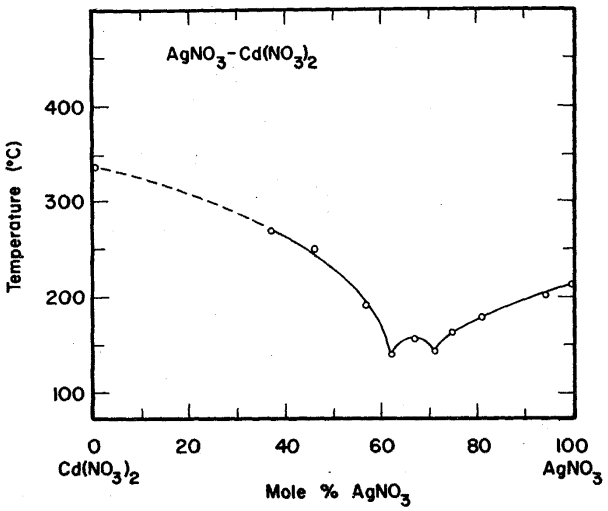

FIGURE 7. Temperature–composition phase diagram for $AgNO_3$–$Cd(NO_3)_2$.

P. I. Protsenko, Zh. Obshch. Khim. **23**, 1613 (1953).

$AgNO_3$–$CsNO_3$

Electrical Conductance

Twenty-three investigations of the specific conductance of $AgNO_3$ [1 (p. 28), 4, 16, 24, 27, 52, 61, 73, 74, 75, 78, 82, 100, 101, 111, 125] and seven investigations of $CsNO_3$ [1 (p. 28), 125, 126, 127, 129] have been reported. Revised recommendations for $AgNO_3$ are based on the work of Brillant [24] and together with some experimental aspects are discussed in the section on $AgNO_3$–$NaNO_3$. Some experimental aspects of the conductance measurements of $CsNO_3$ are discussed in the section on $CsNO_3$–KNO_3.

The specific conductance of molten $AgNO_3$–$CsNO_3$ mixtures has been measured by two groups [82, 123], both using the classical ac technique. The results of De Nooijer [1 (p. 28), 123] for the single components and mixtures containing 30, 50, and 75 mole percent $CsNO_3$, covering a temperature range from 495 to 740 K, are recommended as the "best" values and are given in table 7(a) for the experimental concentrations at rounded values of temperature. The corresponding temperature-dependent equations are given in table 7(b). The experimental uncertainty of the results of De Nooijer is estimated to be about 0.4 percent. The results for $AgNO_3$ deviate from the newly recommended values [24] (−1.23 to 0.34 percent) and from the recommended values [1] (−2.83 to −0.38 percent), whereas the results for $CsNO_3$ are in good agreement with the recommendations [1] (−0.53 to −0.17 percent). Protsenko and Popovskaya [82] measured the specific conductance of pure $AgNO_3$ and 14 different binary mixtures within the temperature range 453.2 to 573.2 K, but the results are reported graphically, and cannot be critically assessed.

For discussion of the melt preparation and experimental technique of De Nooijer see $CsNO_3$–KNO_3.

Density

Fourteen studies of the density of $AgNO_3$ [1 (p. 28), 3, 4, 16, 24, 48, 52, 61, 101, 142, 143] and seven investigations of $CsNO_3$ [1 (p. 28), 25, 48, 86, 109, 118] have been reported. Some experimental aspects of the density measurements of $CsNO_3$ are discussed in the section on $CsNO_3$–$NaNO_3$. Revised recommendations for $AgNO_3$ are based on the work of Brillant [24] and together with some experimental aspects are discussed in the section on $AgNO_3$–$LiNO_3$.

Zuca and Borcan [48] used the Archimedean method to measure the density of molten $AgNO_3$–$CsNO_3$ mixtures, in the temperature range from 450 to 797 K for the single components and mixtures containing 25, 50, and 75 mole percent $AgNO_3$. The results were recalculated using a two-dimensional statistical analysis, the values in the form of a temperature-composition-density matrix are given in table 7.1(a) at rounded compositions and temperatures. The corresponding statistical parameters are given in table 7.1(b). The experimental uncertainty of the results of Zuca and Borcan is estimated to be about 0.4 percent. The values for $AgNO_3$ agree with the newly recommended results [24] (−0.02 to 0.0 percent) and with the recommendations [1] (0.03 to 0.22 percent) whereas the results for $CsNO_3$ deviate from the recommendations [1] (−0.32 to −0.24 percent).

For melt preparation of Zuca and Borcan [48] see the the discussion of viscosity in the section on $AgNO_3$–KNO_3. The experimental method used by these authors is the same as reported in their earlier publication [118] and is discussed in the section on $NaNO_3$–$RbNO_3$.

Viscosity

Eleven studies of the viscosity of $AgNO_3$ [1 (p. 28), 3, 45, 48, 52, 78, 80, 101] and five investigations of $CsNO_3$ [1 (p. 28), 48, 118, 119] have been reported. Revised recommendations for $CsNO_3$ are based on the work of Timidei, Lederman and Janz [119] and together with some experimental aspects are discussed in the section on $CsNO_3$–$LiNO_3$. Some experimental aspects of the viscosity measurements of $AgNO_3$ are discussed in the section on $AgNO_3$–KNO_3. Zuca and Borcan [48] measured the viscosity of molten $AgNO_3$–$CsNO_3$ mixtures using the oscillating ball method. Their results for the single components and mixtures containing 25, 50, and 75 mole percent $CsNO_3$ covering a temperature range from 548 to 673 K are given in table 7.2(a) for the experimental compositions at rounded temperatures. The corresponding viscosity-temperature equations are in table 7.2(b). The experimental uncertainty of Zuca and Borcan is estimated to be about 1.5 percent. The results for $AgNO_3$ agree with the recommendation [1] (1.57 to 2.61 percent). Due to the different

temperature range a comparison of the values for $CsNO_3$ is not possible.

In the work of Zuca and Borcan [48] $CsNO_3$ (Merck p.a. reagent grade) was pre-dried for 24 h at 150 °C and melted under a dry nitrogen atmosphere. $AgNO_3$ has been discussed in the section on $AgNO_3$–KNO_3. The experimental procedure is discussed in the section on KNO_3–$NaNO_3$.

Surface Tension

Four investigations of the surface tension of $AgNO_3$ [2 (p. 68)] and four investigations of $CsNO_3$ [2 (p. 68), 41] have been reported.

Bertozzi and Sternheim [26] used the Wilhelmy slide plate method to measure the surface tension of molten $AgNO_3$–$CsNO_3$ mixtures, in the temperature range from the melting point up to 400 °C, for 25, 50, and 75 mole percent mixtures and for the single components. The results of a two-dimensional statistical analysis of these data are given in table 8(a) as a temperature-concentration-surface tension matrix, at rounded temperatures. The corresponding statistical parameters are given in table 8(b). The data of Bertozzi and Sternheim for the single components show percent departures from the recommendations [2] by −0.6 to 1.1 percent.

The experimental aspects of the investigations of Bertozzi and Sternheim [26] have been discussed previously [2 (p. 67)].

TABLE 7(a). $AgNO_3$–$CsNO_3$: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

	Mole percent $CsNO_3$			
T(K)	75	50	30	0
500				0.7193
510			0.4612	0.7668
520			0.4939	0.8134
530			0.5264	0.8592
540		0.4330	0.5587	0.9041
550	0.3908	0.4603	0.5908	0.9481
560	0.4082	0.4873	0.6226	0.9913
570	0.4255	0.5139	0.6543	1.0336
580	0.4429	0.5401	0.6857	1.0751
590	0.4602	0.5659	0.7170	1.1157
600	0.4776	0.5913	0.7480	
610	0.4950	0.6163	0.7788	
620	0.5123	0.6410	0.8094	
630	0.5297	0.6652		
640	0.5470	0.6891		
650	0.5644	0.7126		

TABLE 7(b). Temperature-dependent equations

$\kappa = a + bT + cT^2$ (ohm^{-1} cm^{-1})

(Mol % $CsNO_3$)	a	$b \cdot 10^3$	$c \cdot 10^6$	Stand. error of est. (percent)
0	−2.7472	9.0761	−4.2862	0.0038 = 0.41
30	−1.4846	4.3500	−1.0484	0.0019 = 0.30
50	−1.6209	4.8515	−1.9409	0.0013 = 0.22
75	−0.5638	1.7356	0	0.0046 = 0.95
100 [a]	−0.7663	1.8917	0	0.0008 = 0.14

Reference: [123]

[a] The temperature range for 100 mole percent $CsNO_3$ is 692.1 to 740.5 K.

TABLE 7.1(a). $AgNO_3$–$CsNO_3$: Density

Numerical values (g cm^{-3})

Mole percent $CsNO_3$

T(K)	100	90	80	70	60	50	40	30	20	10	0	32.5
460						3.436						
470						3.424	3.514					
480						3.412	3.502	3.603				
490						3.400	3.490	3.591	3.704			
500					3.307	3.388	3.478	3.579	3.692	3.818	3.961	3.553
510					3.295	3.376	3.466	3.567	3.680	3.806	3.949	3.541
520					3.283	3.364	3.454	3.555	3.668	3.794	3.937	3.529
530					3.271	3.352	3.442	3.543	3.656	3.782	3.925	3.517
540					3.259	3.340	3.430	3.531	3.644	3.770	3.913	3.505
550					3.247	3.329	3.418	3.519	3.632	3.758	3.901	3.493
560				3.161	3.235	3.317	3.407	3.507	3.620	3.746	3.889	3.481
570				3.149	3.223	3.305	3.395	3.495	3.608	3.734	3.877	3.469
580				3.137	3.211	3.293	3.383	3.483	3.596	3.722	3.865	3.457
590				3.125	3.200	3.281	3.371	3.471	3.584	3.710	3.853	3.445
600				3.113	3.188	3.269	3.359	3.459	3.572	3.698	3.841	3.433
610				3.102	3.176	3.257	3.347	3.447	3.560	3.686	3.829	3.421
620				3.090	3.164	3.245	3.335	3.435	3.548	3.674	3.817	3.409
630			3.009	3.078	3.152	3.233	3.323	3.423	3.536	3.662	3.805	3.397
640			2.997	3.066	3.140	3.221	3.311	3.411	3.524	3.650	3.793	3.385
650			2.985	3.054	3.178	3.209	3.299	3.399			3.781	3.373
660			2.973	3.042	3.116	3.197	3.287					
670			2.961	3.030	3.104	3.185						
680			2.949	3.018								
690		2.872	2.937	3.006								
700	2.796	2.860	2.925									
710	2.785	2.848	2.913									
720	2.773	2.836										
730	2.761	2.824										
740	2.749	2.812										
750	2.737	2.800										
760	2.725											
770	2.714											
780	2.702											
790	2.690											

TABLE 7.1(b). Two-dimensional equation and statistical parameters

$\rho = a + bT + cC + dC^3 + cTC$ (g cm^{-3})

a	$b \cdot 10^3$	$c \cdot 10^3$	$d \cdot 10^7$	$e \cdot 10^8$	Max. percent departure	Stand. error of est.
3.62941	−1.18994	6.39454	2.91637	−9.49658	0.27 (588.2 K, 25 mol % $AgNO_3$)	0.004 (0.12%)

Reference: [48]

C = mole percent $AgNO_3$

TABLE 7.2(a). $AgNO_3-CsNO_3$: Viscosity

Numerical values (cp)

Mole percent $CsNO_3$

T(K)	100	75	50	25	0
550	6.47	4.57	3.70	3.34	3.23
560	5.94	4.25	3.46	3.15	3.05
570	5.46	3.97	3.25	2.97	2.89
580	5.04	3.71	3.06	2.81	2.75
590	4.66	3.48	2.88	2.67	2.61
600	4.32	3.27	2.72	2.53	2.49
610	4.02	3.08	2.58	2.41	2.37
620	3.75	2.90	2.44	2.29	2.27
630	3.50	2.74	2.32	2.19	2.17
640	3.27	2.60	2.21	2.09	2.08
650	3.07	2.46	2.10	2.00	2.00
660	2.89	2.34	2.01	1.92	1.92
670	2.72	2.23	1.92	1.84	1.84

TABLE 7.2(b). Temperature-dependent equations

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

Comp. (mol % $CsNO_3$)	$A \cdot 10$	E (cal mol^{-1})	Stand. deviation [135]
0	1.4124	3418	0.035
25	1.1851	3648	0.028
50	0.9479	4002	0.015
75	0.8238	4386	0.047
100	0.5084	5294	0.039

Reference: [48]

TABLE 8(a). $AgNO_3$–$CsNO_3$: Surface tension

Numerical values: (dyn cm^{-1})

Mole percent $CsNO_3$

T(K)	100	90	80	70	60	50	40	30	20	10	0	32.5
445								124.7	129.2			123.9
460							120.6	123.5	128.1	135.5		122.7
475							119.4	122.3	127.0	134.6		121.5
490						116.0	118.2	121.1	125.9	133.6		120.2
505						114.8	116.9	119.9	124.8	132.7	144.7	119.0
520						113.6	115.7	118.7	123.7	131.8	144.0	117.8
535					110.2	112.4	114.5	117.5	122.6	130.9	143.3	116.6
550					109.1	111.2	113.3	116.3	121.5	129.9	142.6	115.4
565					108.0	110.0	112.0	115.2	120.5	129.0	141.9	114.2
580				104.1	107.0	108.8	110.8	114.0	119.4	128.1	141.2	113.0
595				103.2	105.9	107.7	109.6	112.8	118.3	127.2	140.5	111.8
610				102.2	104.8	106.5	108.4	111.6	117.2	126.2	139.9	110.6
625			97.1	101.3	103.7	105.3	107.2	110.4	116.1	125.3	139.2	109.4
640			96.4	100.4	102.6	104.1	105.9	109.2	115.0	124.4	138.5	108.2
655		89.1	95.7	99.5	101.5	102.9	104.7	108.0	113.9	123.5	137.8	107.0
670		88.7	95.0	98.6	100.4	101.7	103.5	106.8	112.8	122.5	137.1	105.8

TABLE 8(b). Two-dimensional equation and statistical parameters

$\gamma = a + bC^2 + cTC - dT^3 + eC^3 + fC + gTC^2$ (dyn cm^{-1})

a	$b \cdot 10^2$	$c \cdot 10^3$	$d \cdot 10^{11}$	$e \cdot 10^4$	f	$g \cdot 10^5$	Max percent departure	Standard error of est.
78.55812	−3.96979	−2.70346	−9.06653	1.80716	3.05694	2.24255	−2.28% (673 K, 90 mol % $CsNO_3$)	1.378 (0.12%)

Reference: [26]

C = mole percent $AgNO_3$

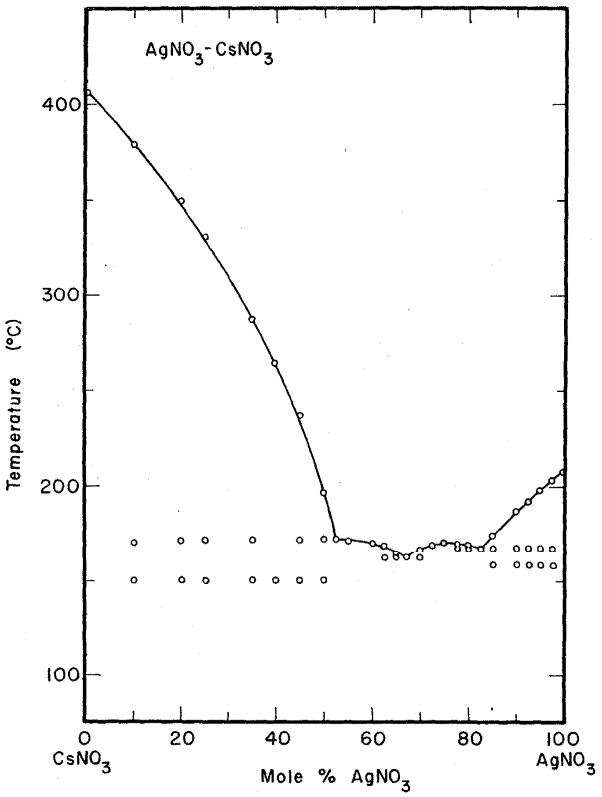

FIGURE 8. Temperature–composition phase diagram for $AgNO_3$–$CsNO_3$.

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$AgNO_3$–KNO_3

Electrical Conductance

Twenty-three investigations of the specific conductance of $AgNO_3$ [1 (p. 28), 4, 16, 24, 27, 52, 61, 73, 74, 75, 78, 82, 100, 101, 111, 125] and 27 investigations of KNO_3 [1 (p. 26), 9, 23, 24, 29, 82, 89, 90, 94, 100, 107, 116, 117, 121, 122, 129] have been reported. Revised recommendations for $AgNO_3$ and KNO_3 are based on the work of Brillant [24] and Robbins and Braunstein [122] respectively, and together with some experimental aspects are discussed in the sections on $AgNO_3$–$NaNO_3$, KNO_3–$RbNO_3$, and KNO_3–$NaNO_3$.

The specific conductance of molten $AgNO_3$–KNO_3 mixtures has been measured by seven groups, [4, 24, 29, 75, 82, 85, 98, 123] using the classical ac technique [4, 82, 98, 123], a modified potentiometric method [24, 29, 75], and a direct current technique [85]. The results of Brillant [24] for the single components and 10, 20, 30, 40, 50, 60, 70, 80, and 90 mole percent mixtures, covering a temperature range from 430 to 670 K, are recommended as the "best" values and are given in table 9(a) for the experimental concentrations at rounded temperatures. These were derived from the temperature-dependent equations reported by Brillant and listed in table 9(b).

The experimental uncertainty of the results of Brillant is estimated to be about 0.3 percent. The results for KNO_3 deviate from the newly recommended values [122] (0.16 to 0.48 percent) and from the recommendations [1] (−1.43 to −0.13 percent). Polyakov [4] reports data for the single components and 25 different mixture concentrations between 423.2 and 673.2 K. These data are generally higher than the other values and deviate from the results of Brillant [24] by up to 12.0 percent (50 mole percent KNO_3 433.2 K). The investigation by Duke and Fleming [85] for the single components and for five different mixture compositions covers a temperature range from 523.2 to 623.2 K. Their results for the single components and the mixture containing 30 mole percent KNO_3 agree with the recommended values [24] to within −3.35 to 1.32 percent. The values of De Nooijer [123] for the single components and mixtures containing 30, 50, and 75 mole percent KNO_3, covering a temperature range from 495 to 735 K, agree with the recommended values [24] to within −1.93 to 0.34 percent. The results of Bizouard [29, 75] (single components, 20, 40, 60, and 80 mole percent mixtures, 423.2 to 673.2 K) deviate from the recommended values [24] of Brillant (0.39 to 2.73 percent). The results by Protsenko and Popovskaya [82] and by Cowen and Axon [98] are reported graphically, and cannot be critically assessed.

The experimental technique used by Brillant [24] is discussed in the section on KNO_3–$RbNO_3$, whereas the melt preparation is described in the discussion of density in the section on $AgNO_3$–$LiNO_3$.

Density

Fourteen investigations of the density of $AgNO_3$ [1 (p. 28), 3, 4, 16, 24, 48, 52, 61, 101, 142, 143] and 19 investigations of KNO_3 [1 (p. 26), 4, 9, 12, 25, 27, 110, 115, 118, 130] have been reported. Revised recommendations for $AgNO_3$ are based on the work of Brillant [24] and together with some experimental aspects are discussed in the section on $AgNO_3$–$LiNO_3$. Some experimental aspects of the density measurements of KNO_3 are discussed in the section on KNO_3–$NaNO_3$.

The density of molten $AgNO_3$–KNO_3 mixtures has been measured by four groups [4, 24, 48, 105] using the Archimedean method. The results of Brillant [24] for the single compounds and 10, 20, 30, 40, 50, 60, 70, 80, and 90 mole percent mixtures cover a temperature range from 435 to 670 K and are recommended as the "best" values. The results were recalculated using a two-dimensional statistical analysis; the values in the form of a temperature-composition-density matrix are in table 10(a) for rounded concentrations and temperatures. The corresponding statistical parameters are given in table 10(b).

The experimental uncertainty of the results of Brillant is estimated to be about 0.2 percent. The results for KNO_3 deviate from the recommendations [1] (−0.08 to 0.13 percent). The results of Polyakov

[4] for the single components and 19 different mixture concentrations (95 to 5 mole percent in steps of 5 mole percent) deviate from the values of Brillant (−2.74 percent, 60 mole percent $AgNO_3$, 453.2 K to 1.83 percent, 100 mole percent $AgNO_3$, 623.2 K). Bloom [105] measured the densities of mixtures containing 30, 55, 58, and 70 mole percent $AgNO_3$ in the temperature range 425 K to 620 K. The values for the mixture containing 30 mole percent $AgNO_3$ agree with the results of Brillant to within −0.76 to −0.70 percent, the results for the mixture containing 70 mole percent $AgNO_3$ to within −0.03 to 0.14 percent. Zuca and Borcan [48] measured the densities of the single components and of mixtures containing 25, 50, and 75 mole percent $AgNO_3$ in the temperature range 499 to 756 K. The values for 0, 50, and 100 mole percent $AgNO_3$ agree with the results of Brillant to within (−0.03 to 0.12 percent), (−0.03 to 0.05 percent) and (−0.02 to 0.0 percent) respectively.

For melt preparation and experimental techniques of Brillant see the section on $AgNO_3$–$LiNO_3$.

Viscosity

Eleven studies of the viscosity of $AgNO_3$ [1 (p. 28), 3, 45, 48, 52, 78, 80, 101] and 13 investigations of KNO_3 [1 (p. 27), 48, 86, 107, 118, 119] have been reported. Some experimental aspects of the viscosity measurements of $AgNO_3$ are as follows: Zuca and Borcan [48] and Karpachev [131] used the oscillating ball method whereas all the other measurements were carried out with Ostwald viscometers. Pugsley and Wetmore [1] report the use of silica as a viscometer material, other investigators used platinum (Godwin and Maley [1]) or Pyrex (Davis, Rogers and Ubbelohde [1]). Revised recommendations for KNO_3 are based on the work of Timidei, Lederman and Janz [119] and together with some experimental aspects are discussed in the section on KNO_3–$NaNO_3$.

The viscosity of molten $AgNO_3$–KNO_3 mixtures has been measured by two groups [4, 48] using a capillary viscometer [4] and the oscillating ball technique [48]. The results of Zuca and Borcan [48] for the single components and mixtures containing 25, 50, and 75 mole percent KNO_3 covering a temperature range from 548 to 673 K are recommended as the "best" values and are given in table 11(a) for the experimental compositions at rounded temperatures. These were derived from the temperature-dependent equations reported by Zuca and Borcan and listed in table 11(b).

The experimental uncertainty of the results of Zuca and Borcan is estimated to be about 1.5 percent. The values for $AgNO_3$ and KNO_3 agree with the recommendations [1] (1.57 to 2.61 percent) and (−1.61 to −0.90 percent) respectively. The results of Polyakov [4] for 16 mixtures cover a temperature range from 413 to 573 K. They deviate from the values of Zuca and Borcan (55.6 to 57.9 percent, 25 mole percent KNO_3; 36.2 to 42.8 percent, 50 mole percent KNO_3; 69.9 to 73.0 percent, 75 mole percent KNO_3).

Zuca and Borcan used highly purified $AgNO_3$ obtained by adding to a saturated reagent silver nitrate solution concentrated nitric acid to effect crystallization of the salt. The nitric acid was completely eliminated by melting the crystals. KNO_3 (Merck p.a. grade) was predried for 24 h at 150 °C and melted in dried nitrogen gas. The experimental procedure is discussed in the section on KNO_3–$NaNO_3$.

Surface Tension

Four investigations of the surface tension of $AgNO_3$ [2 (p. 68)] and eight investigations of KNO_3 [2 (p. 67), 41, 84] have been reported.

Two different techniques have been used to measure the surface tension of molten $AgNO_3$–KNO_3 mixtures by three groups: the maximum bubble pressure method [5, 18], and the Wilhelmy slide plate method [26].

The data by Bloom, Davis and James [5] are recommended as the "best" values. The results were recalculated using a two-dimensional statistical analysis; the values in the form of a temperature-composition-surface tension matrix are in table 12(a), for rounded compositions and temperatures; the corresponding statistical parameters are given in table 12(b). The data of Bloom, Davis and James for the single components show percent departures from recommendations [2] by 6 to 0.05 percent.

The experimental aspects of the investigation of Bloom, Davis and James [5] have been discussed previously [2 (p. 64)]. The accuracy of the method, as assessed by the method of least squares, is ± 0.25 dyn cm^{-1}. The temperature range of the investigation was usually 200°, starting about 10° above the melting point. The upper temperature of investigation was limited so as to be below the decomposition temperature. The composition range employed was 30, 44, 58, and 70.1 mole percent $AgNO_3$.

A two-dimensional statistical analysis for the data of Dahl and Duke [18] and Bertozzi and Sternheim [26] yielded standard errors of estimate of 0.85 and 0.62 percent respectively. In addition the maximum percent departures were −1.96 and 1.24 percent respectively.

TABLE 9(a). $AgNO_3$–KNO_3: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

Mole percent KNO_3

T(K)	100	90	80	70	60	50	40	30	20	10	0
430						0.212	0.244	0.276			
440						0.248	0.280	0.315			
450						0.284	0.319	0.356	0.398		
460						0.320	0.357	0.398	0.441		
470						0.357	0.396	0.440	0.485	0.533	
480					0.354	0.395	0.436	0.482	0.529	0.578	0.630
490					0.391	0.432	0.476	0.524	0.572	0.623	0.676
500					0.428	0.471	0.516	0.566	0.615	0.668	0.723
510					0.464	0.509	0.556	0.607	0.658	0.713	0.769
520				0.457	0.500	0.547	0.595	0.658	0.700	0.756	0.815
530				0.492	0.537	0.585	0.634	0.698	0.742	0.799	0.860
540				0.527	0.573	0.622	0.673	0.737	0.783	0.843	0.904
550			0.515	0.562	0.609	0.659	0.711	0.777	0.824	0.884	0.947
560			0.549	0.597	0.645	0.696	0.749	0.817	0.865	0.925	0.990
570			0.582	0.631	0.681	0.733	0.786	0.845	0.903	0.966	1.031
580			0.616	0.666	0.716	0.769	0.823	0.883	0.942	1.006	1.072
590		0.602	0.649	0.699	0.751	0.805	0.860	0.919	0.980	1.045	1.113
600		0.634	0.682	0.733	0.785	0.839	0.895	0.955	1.017	1.083	1.151
610	0.620	0.667	0.715	0.767	0.819	0.873	0.931	0.991	1.053	1.120	1.190
620	0.651	0.699	0.748	0.800	0.852	0.907	0.965	1.025	1.090	1.156	1.227
630	0.683	0.731	0.780	0.832	0.884	0.940	0.998	1.059	1.124	1.193	1.263
640	0.714	0.763	0.812	0.864	0.917	0.972	1.031	1.093	1.159		
650	0.746	0.795	0.844								
660	0.777										
670	0.809										

TABLE 9(b). Temperature-dependent equations

$\kappa = a + bT$ (ohm^{-1} cm^{-1})

Comp. (mol % KNO_3)	a	$b \cdot 10^3$	Temp. range (K)
	−1.5943	4.634	483.2–523.2
	−1.4588	4.375	523.2–555.2
0	−1.3088	4.105	555.2–588.2
	−1.1754	3.878	588.2–613.2
	−0.9897	3.575	613.2–633.2
	−1.5942	4.525	473.2–506.2
	−1.4971	4.333	506.2–539.2
10	−1.3919	4.138	539.2–568.2
	−1.2993	3.975	568.2–587.2
	−1.1778	3.768	587.2–606.2
	−1.0899	3.623	606.2–633.2
	−1.5771	4.388	453.2–484.2
	−1.5224	4.275	484.2–519.2
20	−1.4357	4.108	519.2–561.2
	−1.2770	3.825	561.2–590.2
	−1.1885	3.675	590.2–618.2
	−1.0649	3.475	618.2–637.2
	−1.4138	3.930	433.2–444.2
	−1.5259	4.183	444.2–513.2
30	−1.4066	3.970	513.2–561.2
	−1.3212	3.800	561.2–579.2
	−1.2152	3.617	579.2–609.2
	−1.0829	3.400	609.2–639.2
	−1.3103	3.615	433.2–440.2
	−1.4138	3.850	440.2–471.2
40	−1.4907	4.013	471.2–515.2
	−1.4108	3.858	515.2–556.2
	−1.3201	3.695	556.2–588.2
	−1.2394	3.558	588.2–616.2
	−1.0806	3.300	616.2–643.2
	−1.3417	3.613	433.2–464.2
	−1.3959	3.730	464.2–485.2
50	−1.4420	3.825	485.2–523.2
	−1.3897	3.725	523.2–566.2
	−1-3047	3.575	566.2–591.2
	−1.2060	3.408	591.2–621.2
	−1.1046	3.245	621.2–643.2
	−1.4170	3.690	483.2–499.2
	−1.3826	3.621	499.2–565.2
60	−1.3357	3.538	565.2–580.2
	−1.2631	3.413	580.2–613.2
	−1.1631	3.250	613.2–643.2
	−1.3539	3.483	523.2–577.2
70	−1.2788	3.353	577.2–616.2
	−1.2049	3.233	616.2–643.2
	−1.3228	3.342	553.2–597.2
80	−1.2799	3.270	597.2–620.2
	−1.2414	3.208	620.2–653.2
90	−1.3232	3.263	593.2–619.2
	−1.2607	3.162	619.2–653.2
100	−1.3068	3.158	609.2–673.2

Reference: [24]

TABLE 10(a). $AgNO_3$–KNO_3: Density

Numerical values (g cm^{-3})

Mole percent KNO_3

T(K)	100	90	80	70	60	50	40	30	20	10	0	37
440						2.916	3.119	3.329				3.182
450						2.906	3.109	3.320				3.172
460						2.896	3.100	3.310	3.527			3.162
470						2.886	3.090	3.300	3.517			3.152
480						2.876	3.079	3.290	3.507	3.732		3.142
490					2.671	2.866	3.069	3.280	3.497	3.723	3.955	3.132
500					2.661	2.856	3.059	3.269	3.487	3.713	3.946	3.121
510					2.651	2.846	3.048	3.259	3.477	3.702	3.936	3.111
520					2.641	2.836	3.038	3.248	3.466	3.692	3.926	3.100
530				2.445	2.631	2.825	3.027	3.237	3.455	3.682	3.916	3.089
540				2.435	2.621	2.814	3.016	3.226	3.445	3.671	3.906	3.078
550				2.426	2.610	2.804	3.005	3.215	3.434	3.660	3.895	3.067
560			2.240	2.416	2.600	2.793	2.994	3.204	3.422	3.649	3.884	3.056
570			2.231	2.406	2.590	2.782	2.983	3.193	3.411	3.638	3.873	3.045
580			2.222	2.396	2.579	2.771	2.972	3.181	3.399	3.626	3.862	3.034
590			2.213	2.386	2.569	2.760	2.960	3.170	3.388	3.615	3.851	3.022
600		2.040	2.204	2.376	2.558	2.749	2.949	3.158	3.376	3.603	3.839	3.010
610	1.878	2.032	2.194	2.366	2.547	2.737	2.937	3.146	3.364	3.591	3.828	2.999
620	1.871	2.024	2.185	2.356	2.536	2.726	2.925	3.134	3.352	3.579	3.816	2.987
630	1.864	2.015	2.176	2.346	2.525	2.715	2.913	3.122	3.339	3.567	3.804	2.975
640	1.857	2.007	2.166	2.336	2.514	2.703	2.901	3.109				2.963
650	1.850	1.999	2.157									
660	1.843	1.990	2.148									
670	1.836	1.982	2.138									

TABLE 10(b). Two-dimensional equation and statistical parameters

$\rho = a + bT + cC + dTC^2 + eCT^2$ (g cm^{-3})

a	$b \cdot 10^4$	$c \cdot 10^2$	$d \cdot 10^8$	$e \cdot 10^8$	Max. percent departure	Stand. error of est.
2.31021	−7.07684	1.86284	7.58594	−1.01151	0.52% (675 K, 100 mol % KNO_3)	0.003 (0.10%)

Reference: [24].
C = mole percent $AgNO_3$.

TABLE 11(a). $AgNO_3$–KNO_3: Viscosity

Numerical values (cp)

Mole percent KNO_3

T(K)	100	75	50	25	0
550	4.34	3.66	3.32	3.27	3.23
560	4.04	3.44	3.13	3.08	3.05
570	3.76	3.23	2.95	2.91	2.89
580	3.52	3.04	2.79	2.75	2.75
590	3.30	2.87	2.65	2.60	2.61
600	3.10	2.71	2.51	2.47	2.49
610	2.91	2.57	2.39	2.35	2.37
620	2.75	2.44	2.27	2.24	2.27
630	2.59	2.32	2.17	2.13	2.17
640	2.45	2.21	2.07	2.04	2.08
650	2.33	2.11	1.98	1.95	2.00
660	2.21	2.01	1.90	1.86	1.92
670	2.10	1.92	1.82	1.79	1.84

TABLE 11(b). Temperature-dependent equations

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

Comp. (mol % KNO_3)	$A \cdot 10$	E (cal mol^{-1})	Stand. deviation [135]
0	1.4124	3418	0.035
25	1.1192	3687	0.028
50	1.1504	3674	0.032
75	1.0056	3927	0.029
100	0.7531	4428	0.005

Reference: [48]

TABLE 12(a). $AgNO_3$–KNO_3: Surface tension

Numerical values (dyn cm^{-1})

Mole percent KNO_3

T(K)	100	90	80	70	60	50	40	30	20	10	0	37.0
420				126.3	127.3							
440			124.0	125.0	126.0	127.3						
460		121.2	122.7	123.7	124.7	126.1						
480		119.9	121.4	122.5	123.5	124.8	126.8					
500		118.7	120.1	121.2	122.2	123.5	125.6					126.4
520	115.1	117.4	118.9	119.9	120.9	122.2	124.3	127.4				125.1
540	113.9	116.1	117.6	118.6	119.6	121.0	123.0	126.2				123.8
560	112.6	114.9	116.3	117.4	118.4	119.7	121.7	124.9	129.5			122.6
580	111.3	113.6	115.1	116.1	117.1	118.4	120.5	123.6	128.2			121.3
600	110.0	112.3	113.8	114.8	115.8	117.2	119.2	122.3	127.0	133.5		120.0
620	108.8	111.1	112.5	113.6	114.6	115.9	117.9	121.1	125.7	132.2		118.7
640	107.5	109.8	111.3	112.3	113.3	114.6	116.7	119.8	124.4	130.9	139.6	117.5
660	106.2	108.5	110.0	111.0	112.0	113.3	115.4	118.5	123.2	129.6	138.4	116.2
680	105.0	107.2	108.7	109.8	110.7	112.1	114.1	117.3	121.9	128.4	137.1	114.9
700	103.7	106.0	107.4	108.5	109.5	110.8	112.8	116.0	120.6	127.1	135.8	113.7
720	102.4	104.7	106.2	107.2	108.2	109.5	111.6	114.7	119.3	125.8	134.6	112.4
740	101.1	103.4	104.9	105.9	106.9	108.3	110.3	113.4	118.1	124.6	133.3	111.1
760	99.9	102.2	103.6	104.7	105.7	107.0	109.0	112.2	116.8	123.3	132.0	109.8
780	98.6	100.9	102.4	103.4	104.4	105.7	107.8	110.9	115.5	122.0	130.7	108.6
800	97.3	99.6	101.1	102.1	103.1	104.4	106.5	109.6	114.3	120.7	129.5	107.3
820	96.1	98.3	99.8	100.9	101.9	103.2	105.2	108.4	113.0	119.5	128.2	106.0

TABLE 12(b). Two-dimensional equation and statistical parameters

$\gamma = a + bT + cC + dC^2 + eC^3$ (dyn cm^{-1})

a	$b \cdot 10^2$	$c \cdot 10$	$d \cdot 10^3$	$e \cdot 10^5$	Max. percent departure	Standard error of est.
148.1642	−6.35443	2.81834	−5.97277	6.36863	−0.93% (493 K, 100 mol % $AgNO_3$)	0.443 (0.38%)

Reference: [5]

C = mol percent $AgNO_3$

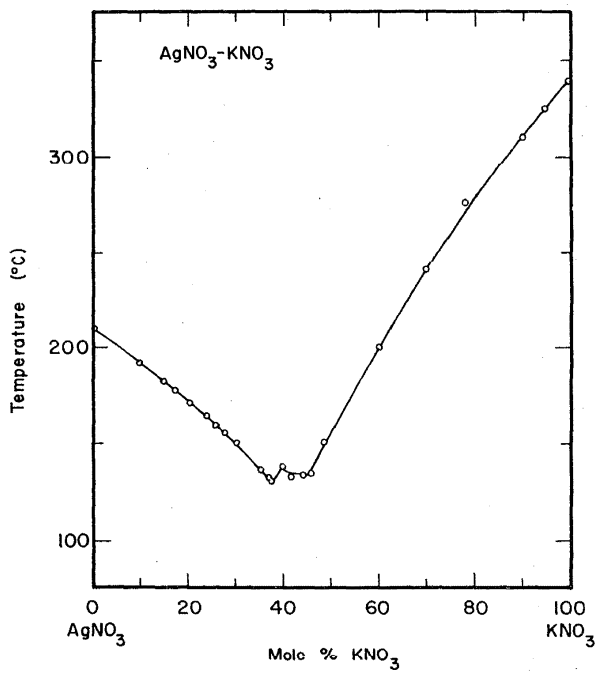

FIGURE 9. Temperature–composition phase diagram for $AgNO_3$–KNO_3.

A. Ussow, Z. Anorg. Chem. **38**, 419 (1904).

$AgNO_3$-$LiNO_3$

Electrical Conductance

Twenty-three studies of the specific conductance of $AgNO_3$ [1 (p. 28), 4, 16, 24, 27, 52, 61, 73, 74, 75, 78, 82, 100, 101, 111, 125] and 12 investigations of $LiNO_3$ [1 (p. 25), 24, 29, 73, 79, 117, 120, 129] have been reported. Revised recommendations for $AgNO_3$ are based on the work of Brillant [24] and together with some experimental aspects are discussed in the section on $AgNO_3$–$NaNO_3$. Some experimental aspects of the conductance measurements of $LiNO_3$ are discussed in the section on KNO_3–$LiNO_3$.

The specific conductance of molten $AgNO_3$–$LiNO_3$ mixtures has been measured by four groups [24, 29, 98, 123] using either the classical ac technique [98, 123] or a modified potentiometric ac technique [24, 29]. The results of Brillant [24] for the single components and 10, 20, 30, 40, 50, 60, 70, 80, and 90 mole percent mixtures covering a temperature range from 450 to 670 K, are recommended as the "best" values and are given in table 13(a) for the experimental compositions at rounded temperatures. These were derived from the temperature-dependent equations reported by Brillant and listed in table 13(b).

The experimental uncertainty of the results of Brillant is estimated to be about 0.3 percent. The values for $LiNO_3$ deviate from the recommendations [1] by −0.77 to 0.02 percent. The investigation by Bizouard [29] covering a temperature range from 475 to 675 K, includes the single components and 20, 40, 60, and 80 mole percent mixtures. These results agree with the values of Brillant to within −0.91 to 2.73 percent. Values for the single components and the equimolar mixture, covering a temperature range from 495 to 690 K, are reported by De Nooijer [123]. They deviate from the newly recommended results [24] (−1.23 to 0.34 percent). Additional results for the single components and six different mixture compositions are presented graphically by Cowen and Axon [98].

The experimental technique used by Brillant [24] is discussed in the section on KNO_3–$RbNO_3$, whereas the melt preparation is described in the discussion of density in the section on $AgNO_3$–$LiNO_3$.

Density

Fourteen investigations of the density of $AgNO_3$ [1 (p. 28), 3, 4, 16, 24, 48, 52, 61, 101, 142, 143] and seven investigations of $LiNO_3$ [1 (p. 25), 9, 24, 86, 117, 143] have been reported. The results for $AgNO_3$ reported by Brillant [24] (Archimedean method) are recommended as the "best" values, the experimental uncertainty being about 0.2 percent. The least squares equations

$$\rho(\text{g cm}^{-3}) = 4.5386 - 1.170 \cdot 10^{-3}T \text{ (483.2 to 513.2 K)}$$

$$\rho(\text{g cm}^{-3}) = 4.5035 - 1.100 \cdot 10^{-3}T \text{ (514.2 to 633.2 K)}$$

describe the temperature dependence of the density of $AgNO_3$ in two different temperature ranges. No standard error is reported by Brillant. The values of Brillant agree with the recommendations [1] to within 0.05 to 0.15 percent. Klemm and Boardman and coworkers [1] used the dilatometer method, whereas all other investigations of the density of $AgNO_3$ were carried out according to the Archimedean technique using either Pt-bobs (Jaeger [1], [3, 4, 52, 101]), quartz bobs with Pt-ballast [24] or pyrex bobs with silver ballast (Spooner and Wetmore [1, 16, 61]). Some experimental aspects of the density measurements of $LiNO_3$ are discussed in the section on KNO_3–$LiNO_3$.

The density of molten $AgNO_3$–$LiNO_3$ mixtures has been measured by three groups [24, 48, 143] using either the Archimedean [24, 28] or the dilatometric [143] method. The results of Brillant [24] for the single compounds and 10, 20, 30, 40, 50, 60, 70, 80, and 90 mole percent mixtures cover a temperature range from 455 to 670 K are recommended as the "best" values. The results are given in table 14(a) for the experimental compositions at rounded temperatures. These were derived from the temperature-dependent equations reported by Brillant and listed in table 14(b). The experimental uncertainty of the results of Brillant is estimated to be about 0.2 percent. The values for $LiNO_3$ deviate from the recommendations [1] (0.41 to 0.70 percent). Zuca and Borcan [48] measured the densities of the single components and of mixtures containing 25, 50, and 75 mole percent $AgNO_3$ in the temperature range

481 to 701 K. The values for 0, 50 and 100 mole percent $AgNO_3$ agree with the results of Brillant [24] to within (−0.42 to 0.12 percent), (0.17 to 0.12 percent) and (−0.02 to 0.0 percent) respectively.

Values for the single components and nine mixtures covering a temperature range from 498 to 648 K are reported by Kawamura [143]. The results for $AgNO_3$ and $LiNO_3$ agree with the newly recommended values [24] [−0.23 to 0.0 percent for $AgNO_3$] and with the recommendations [1] (−0.03 to 0.0 percent) and 0.74 to 1.11 percent) respectively.

Some experimental aspects of the density measurements of $AgNO_3$ are as follows:

All salts used by Brillant [24] were recrystallized ($RbNO_3$ and $TlNO_3$ twice) and dried for several days in vacuum. The salts were then premelted and further dehydrated on passing dry nitrogen through the melt at 20° above the melting point, then filtered, cooled and stored in vacuum prior to use. For silver nitrate all manipulations were done in the dark. The recrystallization of $LiNO_3$ turned out to be difficult, and in several cases dehydration was possible only in molten state which may have caused a slight decomposition. However, no significant effect on the results has been recognized in these cases.

Viscosity

Eleven studies of the viscosity of $AgNO_3$ [1 (p. 28), 3, 45, 48, 52, 78, 80, 101] and five investigations of $LiNO_3$ [1 (p. 25), 48] have been reported. Some experimental aspects of the viscosity measurements of $AgNO_3$ and $LiNO_3$ are discussed in the sections on $AgNO_3$–KNO_3 and $LiNO_3$–$NaNO_3$ respectively.

Zuca and Borcan [48] measured the viscosity of molten $AgNO_3$–$LiNO_3$ mixtures using the oscillating ball method. Their results for the single components and mixtures containing 25, 50, and 75 mole percent $LiNO_3$ covering a temperature range from 548 to 673 K are given in table 14.1(a) for the experimental compositions at rounded temperatures. The corresponding viscosity-temperature equations are in table 14.1(b). The experimental uncertainty of Zuca and Borcan is estimated to be about 1.5 percent. The results for $AgNO_3$ and $LiNO_3$ agree with the recommendations [1] (1.57 to 2.61 percent) and (−16.92 to −4.74 percent) respectively.

In the work of Zuca and Borcan [48] $LiNO_3$ (Merck p.a. reagent grade) was predried for 24 h at 150 °C and melted under a dry nitrogen atmosphere. $AgNO_3$ has been discussed in the section on $AgNO_3$–KNO_3. The experimental procedure is discussed in the section on KNO_3–$NaNO_3$.

Surface Tension

Four studies of the surface tension of $AgNO_3$ and three of $LiNO_3$ have been reported [2 (pp. 68 and 67 respectively)].

Bertozzi and Sternheim [26] used the Wilhelmy slide plate method to measure the surface tension of molten $AgNO_3$–$LiNO_3$ mixtures, in the temperature range from the melting point up to 400 °C, for 25, 50, and 75 mole percent mixtures and for the single components. The results of a two-dimensional statistical analysis of these data are given in table 15(a) as a temperature-composition-surface tension matrix, at rounded temperatures. The corresponding statistical parameters are given in table 15(b). The data of Bertozzi and Sternheim for the single components show percent departures from the recommendations [2] by −0.6 to 1.1 percent.

The experimental aspects of the investigation of Bertozzi and Sternheim [26] have been discussed previously [2 (p. 67)].

TABLE 13(a). $AgNO_3$–$LiNO_3$: Electrical Conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

Mole percent $LiNO_3$

T(K)	100	90	80	70	60	50	40	30	20	10	0
450								0.462	0.466		
460							0.497	0.510	0.514		
470						0.533	0.546	0.557	0.561	0.574	
480						0.583	0.595	0.606	0.609	0.620	0.630
490					0.625	0.634	0.645	0.656	0.657	0.667	0.676
500				0.669	0.677	0.684	0.694	0.705	0.705	0.714	0.723
510			0.714	0.721	0.729	0.735	0.743	0.753	0.752	0.761	0.769
520		0.760	0.767	0.774	0.781	0.785	0.792	0.800	0.800	0.807	0.815
530	0.807	0.815	0.821	0.827	0.831	0.834	0.840	0.847	0.845	0.852	0.860
540	0.864	0.870	0.874	0.880	0.882	0.883	0.887	0.894	0.891	0.896	0.904
550	0.921	0.925	0.928	0.931	0.932	0.931	0.934	0.941	0.936	0.941	0.947
560	0.978	0.970	0.981	0.983	0.982	0.980	0.981	0.986	0.982	0.985	0.990
570	1.034	1.035	1.033	1.034	1.032	1.028	1.028	1.029	1.026	1.028	1.031
580	1.091	1.090	1.085	1.084	1.081	1.077	1.073	1.073	1.069	1.069	1.072
590	1.148	1.143	1.137	1.134	1.131	1.128	1.118	1.117	1.112	1.110	1.113
600	1.205	1.196	1.189	1.184	1.178	1.172	1.162	1.160	1.155	1.150	1.151
610	1.262	1.249	1.239	1.234	1.225	1.217	1.207	1.201	1.194	1.190	1.190
620	1.318	1.303	1.288	1.283	1.271						1.227
630	1.372	1.356									1.263
640	1.426										
650	1.480										
660	1.532										
670	1.584										

TABLE 13(b). Temperature-dependent equations

$\kappa = a + bT$ (ohm^{-1} cm^{-1})

Comp. (mol % $LiNO_3$)	a	$b \cdot 10^3$	Temp. range (K)	Comp. (mol % $LiNO_3$)	a	$b \cdot 10^3$	Temp. range (K)
	−1.5943	4.634	483.2–523.2		−1.7647	4.917	463.2–523.2
	−1.4588	4.375	523.2–555.2	40	−1.6510	4.700	523.2–571.2
0	−1.3088	4.105	555.2–588.2		−1.5126	4.458	571.2–613.2
	−1.1754	3.878	588.2–613.2				
	−0.9897	3.575	613.2–633.2		−1.8407	5.050	473.2–520.2
				50	−1.7418	4.860	520.2–588.2
	−1.6237	4.675	473.2–520.2		−1.4977	4.450	588.2–615.2
	−1.5067	4.450	520.2–564.2				
10	−1.3235	4.125	564.2–593.2		−1.9355	5.225	493.2–517.2
	−1.2298	3.967	593.2–613.2		−1.8346	5.030	517.2–563.2
				60	−1.7839	4.940	563.2–593.2
	−1.6830	4.775	453.2–520.2		−1.6119	4.650	593.2–617.2
	−1.5661	4.550	520.2–565.2				
20	−1.4248	4.300	565.2–601.2		−1.9663	5.270	503.2–544.2
	−1.1312	3.812	601.2–613.2	70	−1.8863	5.123	544.2–575.2
					−1.8012	4.975	575.2–619.2
	−1.6870	4.775	453.2–475.2				
	−1.7822	4.975	475.2–496.2		−2.0190	5.358	513.2–554.2
	−1.6954	4.800	496.2–517.2	80	−1.9386	5.213	554.2–598.2
30	−1.6307	4.675	517.2–554.2		−1.8010	4.983	598.2–623.2
	−1.4599	4.367	554.2–600.2				
	−1.2996	4.100	600.2–613.2		−2.0935	5.488	523.2–581.2
				90	−1.9988	5.325	581.2–633.2
					−2.2089	5.690	525.2–617.2
				100	−2.0298	5.400	617.2–651.2
					−1.8670	5.150	651.2–673.2

Reference: [24]

TABLE 14(a). $AgNO_3$–$LiNO_3$: Density

Numerical values (g cm^{-3})

Mole percent $LiNO_3$

T(K)	100	90	80	70	60	50	40	30	20	10	0
460								3.403	3.605		
470							3.195	3.392	3.593		
480						2.961	3.184	3.380	3.582	3.787	
490						2.951	3.173	3.370	3.571	3.776	3.965
500					2.730	2.941	3.162	3.360	3.560	3.764	3.954
510				2.494	2.720	2.931	3.151	3.349	3.550	3.752	3.942
520			2.260	2.487	2.711	2.922	3.140	3.339	3.539	3.741	3.932
530	1.792	2.026	2.253	2.479	2.702	2.913	3.129	3.329	3.528	3.730	3.921
540	1.786	2.020	2.246	2.471	2.693	2.905	3.118	3.319	3.518	3.719	3.910
550	1.780	2.013	2.238	2.463	2.685	2.896	3.107	3.308	3.507	3.708	3.899
560	1.774	2.006	2.231	2.456	2.677	2.887	3.096	3.299	3.496	3.697	3.888
570	1.768	2.000	2.224	2.448	2.669	2.878	3.086	3.289	3.485	3.686	3.877
580	1.762	1.994	2.217	2.440	2.661	2.869	3.076	3.279	3.475	3.676	3.866
590	1.756	1.988	2.209	2.432	2.652	2.860	3.067	3.269	3.466	3.665	3.855
600	1.751	1.982	2.202	2.425	2.642	2.851	3.057	3.259	3.456	3.655	3.844
610	1.745	1.976	2.195	2.417	2.633	2.842	3.047	3.249	3.446	3.645	3.833
620	1.739	1.970	2.188	2.409							3.822
630	1.733	1.965									3.811
640	1.727										
650	1.721										
660	1.715										
670	1.709										

TABLE 14(b). Temperature-dependent equations

$\rho = a + bT$ (g cm^{-3})

Comp. (mol % $LiNO_3$)	a	$b \cdot 10^3$	Temp. range (K)
0	4.5386	−1.170	483.2–513.2
	4.5035	−1.100	514.2–633.2
10	4.3439	−1.160	473.2–523.2
	4.3125	−1.100	524.2–566.2
	4.2700	−1.025	567.2–613.2
20	4.1568	−1.200	453.2–473.2
	4.0953	−1.070	474.2–573.2
	4.0380	−0.970	574.2–613.2
30	3.9204	−1.125	453.2–483.2
	3.8720	−1.025	484.2–548.2
	3.8501	−0.985	549.2–613.2
40	3.7068	−1.090	463.2–564.2
	3.6447	−0.980	565.2–613.2
50	3.4412	−1.000	473.2–513.2
	3.3851	−0.890	514.2–615.2
60	3.1998	−0.940	493.2–537.2
	3.1246	−0.800	538.2–581.2
	3.1943	−0.920	582.2–617.2
70	2.8897	−0.775	503.2–619.2
80	2.6371	−0.725	513.2–598.2
	2.6131	−0.685	599.2–623.2
90	2.3868	−0.680	523.2–562.2
	2.3362	−0.590	563.2–633.2
100	2.1057	−0.592	525.2–673.2

Reference: [24]

TABLE 14.1(a). $AgNO_3$–$LiNO_3$: Viscosity

Numerical values (cp)

Mole percent $LiNO_3$

T(K)	100	75	50	25	0
550	4.98	4.16	3.48	3.42	3.23
560	4.63	3.90	3.27	3.23	3.05
570	4.32	3.66	3.08	3.05	2.89
580	4.04	3.45	2.91	2.89	2.75
590	3.78	3.25	2.75	2.75	2.61
600	3.55	3.08	2.60	2.62	2.49
610	3.34	2.91	2.47	2.49	2.37
620	3.15	2.77	2.35	2.38	2.27
630	2.97	2.63	2.23	2.27	2.17
640	2.81	2.50	2.13	2.18	2.08
650	2.67	2.39	2.03	2.09	2.00
660	2.53	2.28	1.94	2.00	1.92
670	2.41	2.18	1.86	1.92	1.84

TABLE 14.1(b). Temperature-dependent equations

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

Comp. (mol % $LiNO_3$)	$A \cdot 10$	E (cal mol^{-1})	Stand. deviation [135]
0	1.4124	3418	0.035
25	1.3815	3504	0.038
50	1.0481	3827	0.020
75	1.1289	3939	0.026
100	0.8556	4439	0.009

Reference: [48]

TABLE 15(a). $AgNO_3$–$LiNO_3$: Surface tension

Numerical values (dyn cm^{-1})

Mole percent $LiNO_3$

T(K)	100	90	80	70	60	50	40	30	20	10	0	25
460								139.1	142.8			140.9
475						131.6	134.7	138.1	141.8	145.8		139.9
490					127.7	130.6	133.7	137.1	140.8	144.8	149.1	139.0
505				124.2	126.8	129.6	132.8	136.2	139.9	143.8	148.1	138.0
520	117.1	118.9	120.9	123.2	125.8	128.7	131.8	135.2	138.9	142.9	147.1	137.0
535	116.1	117.9	119.9	122.2	124.8	127.7	130.8	134.2	137.9	141.9	146.2	136.1
550	115.2	116.9	119.0	121.3	123.9	126.7	129.9	133.3	137.0	140.9	145.2	135.1
565	114.2	116.0	118.0	120.3	122.9	125.7	128.9	132.3	136.0	140.0	144.2	134.1
580	113.2	115.0	117.0	119.3	121.9	124.8	127.9	131.3	135.0	139.0	143.3	133.1
595	112.3	114.0	116.1	118.4	120.9	123.8	126.9	130.4	134.1	138.0	142.3	132.2
610	111.3	113.1	115.1	117.4	120.0	122.8	126.0	129.4	133.1	137.1	141.3	131.2
625	110.3	112.1	114.1	116.4	119.0	121.9	125.0	128.4	132.1	136.1	140.3	130.2
640	109.4	111.1	113.1	115.5	118.0	120.9	124.0	127.5	131.2	135.1	139.4	129.3
655	108.4	110.2	112.2	114.5	117.1	119.9	123.1	126.5	130.2	134.2	138.4	128.3
670	107.4	109.2	111.2	113.5	116.1	119.0	122.1	125.5	129.2	133.2	137.4	127.3

TABLE 15(b). Two-dimensional equation and statistical parameters

$\gamma = a + bC + cT + dC^2$ (dyn cm^{-1})

a	$b \cdot 10$	$c \cdot 10^2$	$d \cdot 10^3$	Max. percent departure	Standard error of est.
150.68687	1.61345	−6.45621	1.38770	−0.65% (523 K, 0 mol % $LiNO_3$)	0.265 (0.2%)

Reference: [26]

C = mole percent $AgNO_3$

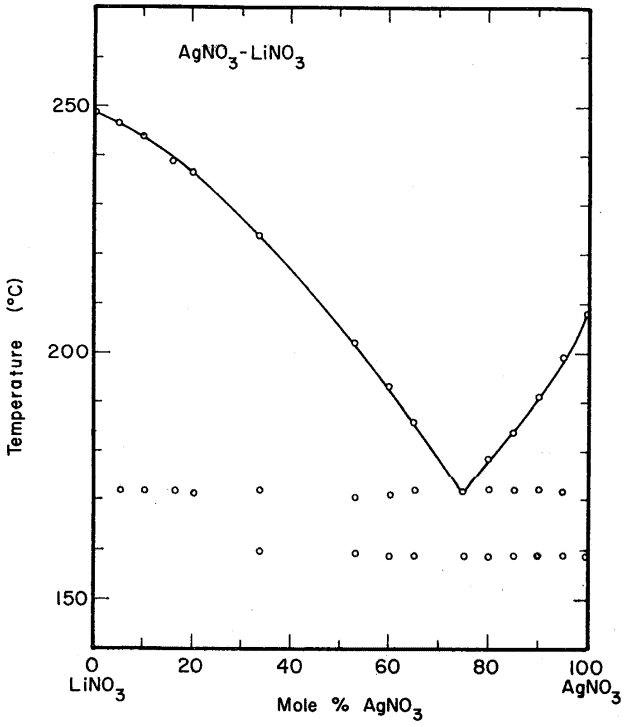

FIGURE 10. Temperature–composition phase diagram for $AgNO_3$–$LiNO_3$.

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$AgNO_3$–$Mg(NO_3)_2$

Electrical Conductance

Twenty-three studies of the specific conductance of $AgNO_3$ [1 (p. 28), 4, 16, 24, 27, 52, 61, 73, 74, 75, 78, 82, 100, 101, 111, 125] have been reported. $Mg(NO_3)_2$ has not been investigated. Revised recommendations for $AgNO_3$ are based on the work of Brillant [24] and together with some experimental aspects are discussed in the section on $AgNO_3$–$NaNO_3$.

Murphy and Wetmore [16] measured the specific conductance of molten $AgNO_3$–$Mg(NO_3)_2$ mixtures using the classical ac technique. Their results for pure $AgNO_3$ and mixtures containing 1.52, 2.56, 5.26, and 11.11 mole percent $Mg(NO_3)_2$, covering a temperature range from 490 to 600 K, were recalculated from the reported data of equivalent conductance and the equivalent volumes reported by the same authors. The values of specific conductance are given in table 16(a), for the experimental concentrations at rounded temperatures. The corresponding temperature-dependent equations are given in table 16(b). The experimental uncertainty of the results of Murphy and Wetmore is estimated to be about 0.5 percent. The results for $AgNO_3$ deviate from the newly recommended values [24] (0.34 to 0.70 percent) and from the recommendations [1] (−1.07 to −0.27 percent).

For melt preparation of Murphy and Wetmore [16] see the discussion of density in the section on $AgNO_3$–$Ca(NO_3)_2$. A silica conductivity cell and a bridge circuit similar to the Jones-bridge were used. The signal leaving the bridge could be sent through a wide-band filter (400 to 10000 Hz) or through one sharply peaked. Amplitude and phase angle of the signal were observed on a cathode ray tube. The small polarization was conveniently determined by measuring the conductance at two frequencies, 1000 and 4000 Hz. The cell was calibrated with KCl at 25 °C; appropriate correction was made for the thermal expansion of the silica.

Density

Fourteen investigations of the density of $AgNO_3$ [1 (p. 28), 3, 4, 16, 24, 48, 52, 61, 101, 142, 143] have been reported. $Mg(NO_3)_2$ has not been investigated. Revised recommendations for $AgNO_3$ are based on the work of Brillant [24] and together with some experimental aspects are discussed in the section on $AgNO_3$–$LiNO_3$.

Murphy and Wetmore [16] used the Archimedean method to measure the density of molten $AgNO_3$–$Mg(NO_3)_2$ mixtures, in the temperature range from 485 to 590 K for pure $AgNO_3$ and mixtures containing 1.52, 2.56, 5.26, and 11.11 mole percent $Mg(NO_3)_2$. The results were recalculated using a two-dimensional statistical analysis; the values in the form of a temperature-composition-density matrix are in table 17(a) at rounded compositions and temperatures. The density data were recalculated from the reported molar volumes. The corresponding statistical parameters are given in table 17(b). The experimental uncertainty of the results of Murphy and Wetmore is estimated to be about 0.3 percent. The results for $AgNO_3$ deviate from the newly recommended values [24] (−0.22 to −0.12 percent) and from the recommendations [1] (−0.16 to 0.05 percent).

For melt preparation and experimental technique of Murphy and Wetmore [16] see discussion in the section on $AgNO_3$–$Ca(NO_3)_2$.

TABLE 16(a). $AgNO_3$–$Mg(NO_3)_2$: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

Mole percent $Mg(NO_3)_2$

T(K)	11.11	5.26	2.56	1.52	0
490	0.419	0.543	0.614	0.636	0.681
500	0.456	0.585	0.658	0.682	0.728
510	0.493	0.627	0.701	0.727	0.774
520	0.530	0.669	0.743	0.772	0.820
530	0.567	0.709	0.785	0.815	0.865
540	0.603	0.750	0.827	0.858	0.909
550	0.639	0.780	0.868	0.900	0.952
560	0.675	0.829	0.909	0.941	0.994
570	0.710	0.868	0.949	0.982	1.036
580	0.745	0.906	0.989	1.021	1.076
590	0.780	0.944	1.028	1.060	1.116

TABLE 16(b). Temperature-dependent equations

$\kappa = a + bT + cT^2$ (ohm^{-1} cm^{-1})

Comp. (mol % $Mg(NO_3)_2$)	a	$b \cdot 10^2$	$c \cdot 10^5$	Stand. error of est. (percent)
0	−2.6126	0.86864	−0.40107	0.0001 = 0.01
1.52	−2.5948	0.85509	−0.39937	0.0001 = 0.01
2.56	−2.0871	0.66537	−0.23288	0.0016 = 0.20
5.26	−2.1297	0.66532	−0.24459	0.0001 = 0.01
11.11	−1.7753	0.51944	−0.14628	0.0000

Reference: [16]

TABLE 17(a). $AgNO_3$–$Mg(NO_3)_2$: Density

Numerical values (g cm^{-3})

Mole percent $Mg(NO_3)_2$

T(K)	10	9	8	7	6	5	4	3	2	1	0
485	3.666	3.696	3.726	3.756	3.786	3.815	3.845	3.875	3.905	3.935	3.964
490	3.661	3.691	3.720	3.750	3.780	3.810	3.840	3.869	3.898	3.929	3.959
495	3.655	3.685	3.715	3.745	3.774	3.804	3.834	3.864	3.894	3.923	3.953
500	3.650	3.680	3.709	3.739	3.769	3.799	3.828	3.858	3.888	3.918	3.947
505	3.644	3.674	3.704	3.734	3.763	3.793	3.823	3.853	3.882	3.912	3.942
510	3.639	3.669	3.698	3.728	3.758	3.788	3.817	3.847	3.877	3.906	3.936
515	3.634	3.663	3.693	3.723	3.752	3.782	3.812	3.841	3.871	3.901	3.930
520	3.628	3.658	3.687	3.717	3.747	3.776	3.806	3.836	3.865	3.895	3.925
525	3.623	3.652	3.682	3.712	3.741	3.771	3.800	3.830	3.860	3.889	3.919
530	3.617	3.647	3.677	3.706	3.736	3.765	3.795	3.824	3.854	3.884	3.913
535	3.612	3.641	3.671	3.701	3.730	3.760	3.789	3.819	3.848	3.878	3.908
540	3.607	3.636	3.666	3.695	3.725	3.754	3.784	3.813	3.843	3.872	3.902
545	3.601	3.631	3.660	3.690	3.719	3.749	3.778	3.808	3.837	3.867	3.896
550	3.596	3.625	3.655	3.684	3.714	3.743	3.773	3.802	3.832	3.861	3.890
555	3.590	3.620	3.649	3.679	3.708	3.738	3.767	3.796	3.826	3.855	3.885
560	3.585	3.614	3.644	3.673	3.703	3.732	3.761	3.791	3.820	3.850	3.879
565	3.579	3.609	3.638	3.668	3.697	3.726	3.756	3.785	3.815	3.844	3.873
570	3.574	3.603	3.633	3.662	3.692	3.721	3.750	3.780	3.809	3.838	3.868
575	3.569	3.598	3.627	3.657	3.686	3.715	3.745	3.774	3.803	3.833	3.862
580	3.563	3.593	3.622	3.651	3.680	3.710	3.739	3.768	3.798	3.827	3.856
585	3.558	3.587	3.616	3.646	3.675	3.704	3.734	3.763	3.792	3.821	3.851
590	3.553	3.581	3.611	3.640	3.670	3.699	3.729	3.758	3.787	3.816	3.846

TABLE 17(b). Two-dimensional equation and statistical parameters

$\rho = a + bT + cC + dT^2 + eCT^2$ (g cm^{-3})

a	$b \cdot 10^3$	$c \cdot 10^2$	$d \cdot 10^7$	$e \cdot 10^3$	Max. percent departure	Stand. error of est.
1.41453	−1.13809	3.10189	5.09641	−5.09641	−0.05 (593.2 K, 2.564 mol % $Mg(NO_3)_2$)	0.001 (0.03%)

Reference: [16]
C = mole percent $AgNO_3$

$AgNO_3-NaNO_3$

Electrical Conductance

Twenty-three studies of the specific conductance of $AgNO_3$ [1 (p. 28), 4, 16, 24, 27, 52, 61, 73, 74, 75, 78, 82, 100, 101, 111, 125] and 26 investigations of $NaNO_3$ [1 (p. 25), 9, 21, 24, 29, 75, 83, 89, 100, 104, 111, 112, 117, 120, 125, 128, 129] have been reported. The results of Brillant [24] for $AgNO_3$ (modified potentiometric ac technique) are recommended as the "best" values, the uncertainty estimate being about 0.3 percent. The temperature dependence of these values in the range from 483.2 to 633.2 K is given by the equations

$$\kappa = -1.5943 + 4.634 \cdot 10^{-3}T; \text{ (483.2 to 523.2 K)}$$
$$\kappa = -1.4588 + 4.375 \cdot 10^{-3}T; \text{ (523.2 to 555.2 K)}$$
$$\kappa = -1.3088 + 4.105 \cdot 10^{-3}T; \text{ (555.2 to 588.2 K)}$$
$$\kappa = -1.1754 + 3.878 \cdot 10^{-3}T; \text{ (588.2 to 613.2 K)}$$
$$\kappa = -0.9897 + 3.575 \cdot 10^{-3}T; \text{ (613.2 to 633.2 K)}$$

The recommendations [1] deviate from these values (0.62 to 2.14 percent). Brillant used a silica conductance cell whose constant was determined with saturated aqueous NaCl and aqueous KCl. $AgNO_3$ was recrystallized twice and dried for several days under vacuum. The salt was then premelted, treated with dry nitrogen, filtered, solidified and stored under vacuum. In other investigations of the conductance of $AgNO_3$ a potentiometric ac technique was also used by Bizouard [29], Doucet and Bizouard [75] and Bizouard, Cerisier and Barthélémy [111]. Duke and Fleming [1] report the use of a dc technique, whereas all other studies were carried out by means of the classical ac technique. The measurements were generally in pyrex or silica capillary cells except the investigation of Sundheim and Berlin [1] where cells with pyrex fritted discs were used.

Some experimental aspects of the conductance measurements of $NaNO_3$ are discussed in the section on KNO_3-NaNO_3.

The specific conductance of molten $AgNO_3-NaNO_3$ mixtures has been measured by seven groups [24, 29, 61, 111, 123, 125, 134] using either the classical ac technique [61, 123, 125, 134] or a modified potentiometric ac technique [24, 29, 111]. The results of Brillant [24] for the single components and 20, 40, 60, and 80 mole percent mixtures, covering a temperature range from 480 to 670 K, are recommended as the "best" values and are given in table 18(a) for the experimental compositions at rounded temperatures. These were derived from the temperature-dependent equations reported by Brillant and listed in table 18(b). The experimental uncertainty of the results of Brillant is estimated to be about 0.3 percent. The values for $NaNO_3$ agree with the recommendations [1] to within −0.39 to 0.39 percent. Byrne, Fleming and Wetmore [61] measured the specific conductance of $NaNO_3$ and six binary mixture compositions between 565 and 645 K (the values for $AgNO_3$ reported by these authors are the results of Spooner and Wetmore [1]. Their results for $NaNO_3$ agree with the values of Brillant to within −0.12 to 0.78 percent. Other values for the single components and 20, 40, 60, and 80 mole percent mixtures, between 475 to 675 K, are reported by Bizouard [29]. These results deviate from the values of Brillant [24] (−1.23 to 3.52 percent). The results of De Nooijer [123] for the single components and three different mixture concentrations cover a temperature range from 495 to 695 K. For $AgNO_3$ and $NaNO_3$ they show departures from the values of Brillant by −1.23 to 0.34 percent and −0.19 to 0.40 percent, respectively. Wagner, Berra, and Forcheri [134] reported data for $NaNO_3$ and 95 mole percent $NaNO_3$ between 585.2 and 673.2 K. Their results for $NaNO_3$ deviate from the values of Brillant within 0.47 to 1.83 percent. The results of two other groups (Bizouard, Cerisier and Barthélémy [111] and Popovskaya, Protsenko and Eliseeva [125]) are reported graphically and cannot be critically assessed.

For further details of the melt preparation of Brillant see the discussion of density in the section on $AgNO_3-LiNO_3$.

Density

Fourteen studies of the density of $AgNO_3$ [1 (p. 28), 3, 4, 16, 24, 48, 52, 61, 101, 142, 143] and 16 investigations of $NaNO_3$ [1 (p. 26), 9, 12, 25, 27, 71, 86, 95, 97, 115, 117, 118, 130] have been reported. Revised recommendations for $AgNO_3$ and $NaNO_3$ are based on the work of Brillant [24] and McAuley and Rhodes and Ubbelohde [25], respectively, and together with some experimental aspects are discussed in the sections on $AgNO_3-LiNO_3$ and $NaNO_3-RbNO_3$.

Three groups [61, 24, 48] used the Archimedean method to measure the density of molten $AgNO_3-NaNO_3$ mixtures. The results of Brillant [24] for the single components and 20, 40, 60, and 80 mole percent mixtures, covering a temperature range from 485 to 670 K, are recommended as the "best" values and are given in table 19(a) for the experimental compositions at rounded temperatures. These were derived from the temperature-dependent equations reported by Brillant and listed in table 19(b). The experimental uncertainty of the results of Brillant is estimated to be about 0.2 percent. The values for $NaNO_3$ deviate from the newly recommended results [25] (1.74 to 1.87 percent) and from the recommendations [1] (0.78 to 0.84 percent). Byrne, Fleming and Wetmore [61] measured densities for mixtures containing 5.2, 11.1, 17.7, 25.0, 42.9, and 66.7 mole percent $AgNO_3$ and the single components. Their results for $AgNO_3$ and $NaNO_3$ agree with the values of Brillant to within (−0.16 to −0.09 percent) and (−0.64 to −0.52 percent) respectively. Zuca and Borcan [48] measured the densities of the single components and of mixtures containing 25, 50, and 75 mole percent $AgNO_3$ in the temperature range 495 to 742 K. The values for $AgNO_3$ and $NaNO_3$ agree with the results of Brillant to within (−0.02 to 0.0 percent) and (−0.65 to −0.61 percent) respectively.

For melt preparation and experimental technique used by Brillant see the section on $AgNO_3$–$LiNO_3$.

Viscosity

Eleven studies of the viscosity of $AgNO_3$ [1 (p. 28), 3, 45, 48, 52, 78, 80, 101] and eleven investigations of $NaNO_3$ [1 (p. 26), 48, 56, 71, 86, 118] have been reported. Some experimental aspects of the viscosity measurements of $AgNO_3$ and $NaNO_3$ are discussed in the sections on $AgNO_3$–KNO_3 and KNO_3–$NaNO_3$, respectively.

Zuca and Borcan [48] measured the viscosity of molten $AgNO_3$–$NaNO_3$ mixtures using the oscillating ball method. Their results for the single components and mixtures containing 25, 50, and 75 mole percent $NaNO_3$ covering a temperature range from 548 to 673 K are given in table 19.1(a) for the experimental compositions at rounded temperatures. The corresponding viscosity-temperature equations are in table 19.1(b). The experimental uncertainty of Zuca and Borcan is estimated to be about 1.5 percent. The results for $AgNO_3$ and $NaNO_3$ agree with the recommendations [1] (1.57 to 2.61 percent) and (−0.52 to 0.0 percent) respectively.

In the work of Zuca and Borcan [48] $NaNO_3$ (Merck p.a. reagent grade) was predried for 24 h. at 150 °C and melted under a dry nitrogen atmosphere. $AgNO_3$ has been discussed in the section on $AgNO_3$–KNO_3. The experimental procedure is discussed in the section on KNO_3–$NaNO_3$.

Surface Tension

Four investigations of the surface tension of $AgNO_3$ [2 (p. 68)] and eight of $NaNO_3$ [2 (p. 67), 41, 92] have been reported.

Two different techniques have been used to measure the surface tension of molten $AgNO_3$–$NaNO_3$ mixtures by three groups; the maximum bubble pressure method [5, 18] and the Wilhelmy slide plate technique [26].

The data by Bertozzi and Sternheim [26] are recommended as the "best" values. The results were recalculated using a two-dimensional statistical analysis; the values in the form of a temperature-composition-surface tension matrix are in table 20(a) for rounded compositions and temperatures; the corresponding statistical parameters are given in table 20(b).

The experimental aspects of the investigation of Bertozzi and Sternheim [26] have been discussed previously [2 (p. 67)]. The determinations were performed in the temperature range from the melting point up to 400 °C, for 25, 50, 75, and 90 mole percent mixtures and for the single components.

The data of Bloom, Davis and James [5] and of Dahl and Duke [18] were subjected to a statistical analysis producing standard errors of estimate of 1.694 (2%) and 0.763 (1%) respectively, compared to 0.219 (0.2%) for the data of Bertozzi and Sternheim.

TABLE 18(a). $AgNO_3$–$NaNO_3$: Electrical conductance

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

Mole percent $NaNO_3$

T(K)	100	80	60	40	20	0
480						0.630
490					0.639	0.676
500					0.687	0.723
510					0.734	0.769
520				0.748	0.782	0.815
530				0.795	0.828	0.860
540				0.842	0.874	0.904
550			0.860	0.888	0.919	0.947
560			0.907	0.934	0.963	0.990
570		0.930	0.953	0.978	1.005	1.031
580	0.964	0.977	0.998	1.021	1.048	1.072
590	1.011	1.022	1.043	1.064	1.090	1.113
600	1.058	1.067	1.087	1.107	1.130	1.151
610	1.104	1.112	1.129	1.150	1.169	1.190
620	1.151	1.157	1.172	1.190		1.227
630	1.195	1.202				1.263
640	1.238					
650	1.282					
660	1.324					
670	1.367					

TABLE 18(b). Temperature-dependent equations

$\kappa = a + bT$ (ohm^{-1} cm^{-1})

Comp. (mol % $NaNO_3$)	a	$b \cdot 10^3$	Temp. range (K)
0	−1.5943	4.634	483.2–523.2
	−1.4588	4.375	523.2–555.2
	−1.3088	4.105	555.2–588.2
	−1.1754	3.878	588.2–613.2
	−0.9897	3.575	613.2–633.2
20	−1.7010	4.775	493.2–523.2
	−1.5818	4.547	523.2–556.2
	−1.3960	4.213	556.2–591.2
	−1.2333	3.938	591.2–615.2
40	−1.7011	4.710	523.2–540.2
	−1.6217	4.563	540.2–566.2
	−1.4728	4.300	566.2–608.2
	−1.3134	4.038	608.2–621.2
60	−1.7336	4.715	553.2–567.2
	−1.6163	4.508	567.2–595.2
	−1.4449	4.220	595.2–621.2
80	−1.7825	4.758	573.2–580.2
	−1.6258	4.488	580.2–633.2
100	−1.7424	4.667	583.2–618.2
	−1.5686	4.386	618.2–647.2
	−1.4806	4.250	647.2–673.2

Reference: [24]

TABLE 19(a). $AgNO_3$–$NaNO_3$: Density

Numerical values (g cm^{-3})

Mole percent $NaNO_3$

T(K)	100	80	60	40	20	0
490						3.965
500					3.555	3.954
510					3.544	3.942
520					3.533	3.932
530				3.125	3.522	3.921
540				3.115	3.511	3.910
550				3.104	3.500	3.899
560			2.700	3.093	3.489	3.888
570			2.690	3.082	3.478	3.877
580		2.301	2.681	3.072	3.467	3.866
590	1.914	2.293	2.671	3.061	3.456	3.855
600	1.907	2.284	2.661	3.050	3.445	3.844
610	1.899	2.275	2.652	3.040	3.434	3.833
620	1.892	2.267	2.642	3.029		3.822
630	1.884	2.258				
640	1.877					
650	1.869					
660	1.862					
670	1.854					

TABLE 19(b). Temperature-dependent equations

$\rho = a + bT$ (g cm^{-3})

Comp. (mol % $NaNO_3$)	a	$b \cdot 10^3$	Temp. range (K)
0	4.5386	−1.170	483.2–513.2
	4.5035	−1.100	514.2–633.2
20	4.1045	−1.100	493.2–615.2
40	3.6923	−1.070	523.2–621.2
60	3.2373	−0.960	553.2–623.2
80	2.8000	−0.860	573.2–633.2
100	2.3569	−0.750	583.2–673.2

Reference: [24]

TABLE 19.1(a). $AgNO_3$–$NaNO_3$: Viscosity

Numerical values (cp)

Mole percent $NaNO_3$

T(K)	100	75	50	25	0
550	3.62	3.37	3.51	3.31	3.23
560	3.40	3.18	3.31	3.12	3.05
570	3.20	3.00	3.12	2.95	2.89
580	3.02	2.83	2.95	2.80	2.75
590	2.85	2.68	2.80	2.65	2.61
600	2.70	2.54	2.65	2.52	2.49
610	2.56	2.42	2.52	2.40	2.37
620	2.43	2.30	2.40	2.29	2.27
630	2.31	2.19	2.29	2.19	2.17
640	2.20	2.09	2.19	2.10	2.08
650	2.10	2.00	2.10	2.01	2.00
660	2.01	1.92	2.01	1.93	1.92
670	1.92	1.84	1.93	1.85	1.84

TABLE 19.1(b). Temperature-dependent equations

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

Comp. (mol % $NaNO_3$)	$A \cdot 10$	E (cal mol^{-1})	Stand. deviation [135]
0	1.4124	3418	0.035
25	1.2903	3543	0.032
50	1.2345	3656	0.032
75	1.1369	3703	0.034
100	1.0392	3880	0.030

Reference: [48]

TABLE 20(a). $AgNO_3$–$NaNO_3$: Surface tension

Numerical values (dyn cm^{-1})

Mole percent $NaNO_3$

T(K)	100	90	80	70	60	50	40	30	20	10	0	80.5
490										144.9	149.1	
505									140.1	143.9	148.1	125.8
520							132.7	135.7	139.1	142.9	147.1	124.8
535						129.2	131.8	134.7	138.1	141.9	146.1	123.9
550					126.0	128.2	130.8	133.8	137.1	140.9	145.2	122.9
565				123.3	125.1	127.2	129.8	132.8	136.2	140.0	144.2	121.9
580		120.0	121.0	122.3	124.1	126.2	128.8	131.8	135.2	139.0	143.2	120.9
595	118.5	119.1	120.0	121.3	123.1	125.3	127.8	130.8	134.2	138.0	142.2	119.9
610	117.6	118.1	119.0	120.4	122.1	124.3	126.8	129.8	133.2	137.0	141.2	119.0
625	116.6	117.1	118.0	119.4	121.1	123.3	125.9	128.8	132.2	136.0	140.3	118.0
640	115.6	116.1	117.1	118.4	120.2	122.3	124.9	127.9	131.3	135.1	139.3	117.0
655	114.6	115.1	116.1	117.4	119.2	121.3	123.9	126.9	130.3	134.1	138.3	116.0
670	113.6	114.2	115.1	116.4	118.2	120.4	122.9	125.9	129.3	133.1	137.3	115.0

TABLE 20(b). Two-dimensional equation and statistical parameters

$\gamma = a + bC^2 + cT + dC$ (dyn cm^{-1})

a	$b \cdot 10^3$	$c \cdot 10^2$	$d \cdot 10^2$	Max. percent departure	Standard error of est.
157.44832	2.04990	−6.53910	3.18056	−0.31 % (573 K, 0 mol % $NaNO_3$)	0.219 (0.2 %)

Reference: [26]
C = mole percent $AgNO_3$

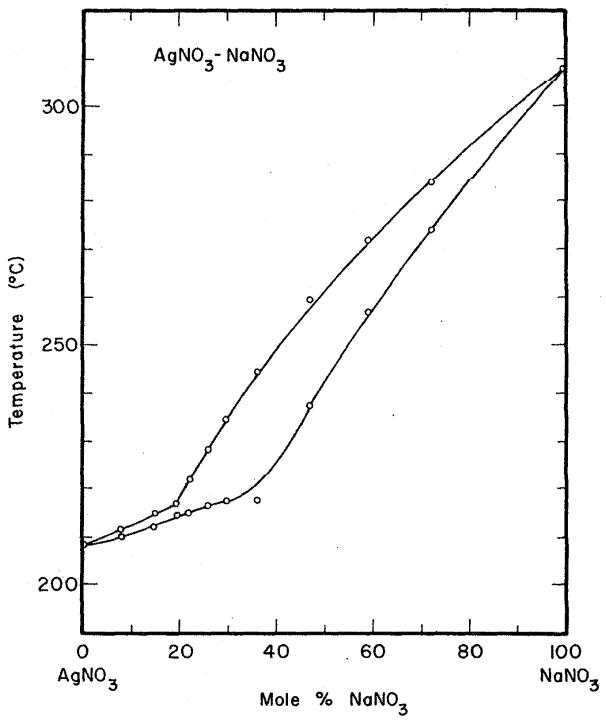

FIGURE 11. Temperature–composition phase diagram for $AgNO_3$–$NaNO_3$.

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$AgNO_3-RbNO_3$

Electrical Conductance

Twenty-three investigations of the specific conductance of $AgNO_3$ [1 (p. 28), 4, 16, 24, 27, 52, 61, 73, 74, 75, 78, 82, 100, 101, 111, 125] and 11 investigations of $RbNO_3$ [1 (p. 27), 24, 73, 88, 104, 121, 123, 125, 129, 135] have been reported. Revised recommendations for $AgNO_3$ and $RbNO_3$ are based on the work of Brillant [24] and together with some experimental aspects are discussed in the sections on $AgNO_3-NaNO_3$ and KNO_3-RbNO_3, respectively.

The specific conductance of molten $AgNO_3-RbNO_3$ mixtures has been measured by three groups [24, 73, 78, 123] using either the classical ac technique [73, 123] or a modified potentiometric ac technique [24]. The results of Brillant [24] for the single components and 10, 20, 30, 40, 50, 60, 70, 80, and 90 mole percent mixtures, covering a temperature range from 430 to 670 K, are recommended as the "best" values and are given in table 21(a) for the experimental concentrations at rounded temperatures. These were derived from the temperature-dependent equations reported by Brillant and listed in table 21(b). The experimental uncertainty of the results of Brillant is estimated to be about 0.3 percent. Protsenko [73] investigated the conductance of both single components and of the binary mixture at 28 different compositions between 433.2 and 593.2 K. His results deviate from the data by Brillant by up to 13.86 percent (30 mol percent $RbNO_3$, 433.2 K). The values reported by De Nooijer [123] include both single components and mixtures containing 30, 50, and 75 mole percent $RbNO_3$ and cover a temperature range from 490 to 725 K. The data for $AgNO_3$ and $RbNO_3$ agree with the results of Brillant to within −1.23 to 0.34 percent and −0.84 to 0.27 percent respectively.

The experimental technique used by Brillant [24] is discussed in the section on KNO_3-RbNO_3, whereas the melt preparation is described in the discussion of density in the section on $AgNO_3-LiNO_3$.

Density

Fourteen investigations of the density of $AgNO_3$ [1 (p. 28), 3, 4, 16, 24, 48, 52, 61, 101, 142, 143] and six investigations of $RbNO_3$ [1 (p. 27), 24, 25, 86, 109, 117, 118] have been reported. Revised recommendations for $AgNO_3$ and $RbNO_3$ are based on the work of Brillant [24] and McAuley, Rhodes and Ubbelohde [25] respectively, and together with some experimental aspects are discussed in the sections on $AgNO_3-LiNO_3$ and $NaNO_3-RbNO_3$.

The density of molten $AgNO_3-RbNO_3$ mixtures has been measured by two groups [24, 48] using the Archimedean method. The results of Brillant [24] for the single compounds and 10, 20, 30, 40, 50, 60, 70, 80, and 90 mole percent mixtures cover a temperature range from 435 to 670 K and are recommended as the "best" values. The results were recalculated using a two-dimensional statistical analysis; the values in the form of a temperature-composition-density matrix are presented in table 22(a) at rounded compositions and temperatures. The corresponding statistical parameters are given in table 22(b). The experimental uncertainty of the results of Brillant is estimated to be about 0.2 percent. The results for $RbNO_3$ deviate from the newly recommended values [25] (0.34 to 0.44 percent) and from the recommendations [1] (1.40 to 2.48 percent).

Zuca and Borcan [48] measured the densities of the single compounds and of mixtures containing 25, 50, and 75 mole percent $AgNO_3$ in the temperature range 463 to 733 K. The values for 0, 50 and 100 mole percent $AgNO_3$ agree with the results of Brillant [24] to within (−0.75 to −0.67 percent), (−0.25 to −0.16 percent) and (−0.02 to 0.0 percent) respectively.

For melt preparation of Brillant [24] and experimental aspects of this investigation see the section on $AgNO_3-LiNO_3$.

Viscosity

Eleven studies of the viscosity of $AgNO_3$ [1 (p. 28), 3, 45, 48, 52, 78, 80, 101] and four investigations of $RbNO_3$ [1 (p. 27), 48, 118] have been reported. Some experimental aspects of the viscosity measurements of $AgNO_3$ and $RbNO_3$ are discussed in the sections on $AgNO_3-KNO_3$ and $NaNO_3-RbNO_3$, respectively.

Zuca and Borcan [48] measured the viscosity of molten $AgNO_3-RbNO_3$ mixtures using the oscillating ball method. Their results for the single components and mixtures containing 25, 50, and 75 mole percent $RbNO_3$ covering a temperature range from 548 to 673 K are given in table 22.1(a) for the experimental compositions at rounded temperatures. The corresponding viscosity-temperature equations are in table 22.1(b). The experimental uncertainty of Zuca and Borcan is estimated to be about 1.5 percent. The results for $AgNO_3$ and $RbNO_3$ agree with the recommendation [1] (1.57 to 2.61 percent) and (−3.53 to 0.0 percent) respectively.

In the work of Zuca and Borcan [48] $RbNO_3$ (Merck p.a. reagent grade) was predried for 24 h at 150 °C and melted under a dry nitrogen atmosphere. $AgNO_3$ has been discussed in the section on $AgNO_3-KNO_3$. The experimental procedure is discussed in the section on KNO_3-NaNO_3.

Surface Tension

Four investigations of the surface tension of $AgNO_3$ and two investigations of $RbNO_3$ have been reported [2 (p. 68)].

Bertozzi and Sternheim [26] used the Wilhelmy slide plate method to measure the surface tension of molten $AgNO_3-RbNO_3$ mixtures, in the temperature range from the melting point up to 400 °C, for 10, 25, 50, and 75 mole percent $RbNO_3$ mixtures and for the single components. The data were subjected to a one-dimensional statistical analysis and values of surface tension

at the experimental concentrations at rounded temperatures are given in table 23(a). The surface tension-temperature equations are reported in table 23(b).

The experimental aspects of the investigations of Bertozzi and Sternheim [26] have been discussed previously [2 (p. 67)].

TABLE 21(a). $AgNO_3$–$RbNO_3$: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

Mole percent $RbNO_3$

T(K)	100	90	80	70	60	50	40	30	20	10	0
430					0.141	0.169	0.201	0.238			
440					0.167	0.198	0.233	0.274			
450				0.167	0.193	0.227	0.266	0.310			
460				0.192	0.221	0.258	0.300	0.347	0.403	0.463	
470				0.217	0.249	0.289	0.334	0.385	0.444	0.507	
480				0.244	0.278	0.321	0.369	0.422	0.484	0.551	0.630
490				0.271	0.308	0.353	0.403	0.459	0.525	0.595	0.676
500				0.298	0.338	0.385	0.438	0.496	0.566	0.639	0.723
510			0.288	0.326	0.368	0.416	0.472	0.534	0.606	0.682	0.769
520			0.314	0.354	0.398	0.448	0.507	0.571	0.645	0.726	0.815
530			0.340	0.382	0.428	0.480	0.540	0.607	0.683	0.766	0.860
540			0.367	0.410	0.458	0.512	0.574	0.643	0.721	0.807	0.904
550		0.350	0.393	0.437	0.487	0.544	0.607	0.679	0.759	0.847	0.947
560		0.376	0.419	0.465	0.517	0.576	0.641	0.715	0.796	0.888	0.990
570		0.401	0.445	0.493	0.546	0.607	0.673	0.749	0.833	0.927	1.031
580	0.384	0.427	0.471	0.521	0.576	0.637	0.706	0.783	0.870	0.966	1.072
590	0.408	0.452	0.497	0.549	0.604	0.668	0.738	0.817	0.906	1.003	1.113
600	0.432	0.477	0.523	0.576	0.633	0.698	0.769	0.850	0.941	1.040	1.151
610	0.456	0.501	0.549	0.603	0.661	0.726	0.800	0.883	0.974	1.076	1.190
620	0.480	0.526	0.575	0.630	0.689	0.755	0.830	0.915	1.007		1.227
630	0.504	0.551	0.601	0.657	0.717	0.783	0.860				1.263
640	0.528	0.576	0.626	0.683							
650	0.551	0.600									
660	0.575										
670	0.599										

TABLE 21(b). Temperature-dependent equations

$\kappa = a + bT$ (ohm^{-1} cm^{-1})

Comp. (mol % $RbNO_3$)	a	$b \cdot 10^3$	Temp. range (K)
	− 1.5943	4.634	483.2–523.2
	− 1.4588	4.375	523.2–555.2
0	− 1.3088	4.105	555.2–588.2
	− 1.1754	3.878	588.2–613.2
	− 0.9897	3.575	613.2–633.2
	− 1.5514	4.380	463.2–519.2
10	− 1.3776	4.045	519.2–560.2
	− 1.3103	3.925	560.2–583.2
	− 1.1502	3.650	583.2–613.2
	− 1.4694	4.070	463.2–514.2
	− 1.3219	3.783	514.2–556.2
20	− 1.2590	3.670	556.2–588.2
	− 1.1295	3.450	588.2–602.2
	− 1.0603	3.335	602.2–623.2
	− 1.3178	3.618	433.2–452.2
	− 1.3662	3.725	452.2–519.2
30	− 1.3065	3.610	519.2–558.2
	− 1.1876	3.397	558.2–596.2
	− 1.0999	3.250	596.2–623.2
	− 1.2077	3.275	433.2–453.2
	− 1.2843	3.444	453.2–522.2
	− 1.2367	3.353	522.2–559.2
40	− 1.1747	3.242	559.2–591.2
	− 1.0866	3.093	591.2–611.2
	− 1.0053	2.960	611.2–633.2
	− 1.0735	2.889	433.2–445.2
	− 1.1599	3.083	445.2–475.2
	− 1.2140	3.197	475.2–561.2
50	− 1.1235	3.036	561.2–596.2
	− 1.0322	2.883	596.2–621.2
	− 0.9651	2.775	621.2–633.2
	− 0.9660	2.575	433.2–448.2
	− 1.0624	2.790	448.2–476.2
	− 1.1706	3.017	476.2–522.2
60	− 1.1430	2.964	522.2–573.2
	− 1.0891	2.870	573.2–601.2
	1.0470	2.800	601.2–626.2
	− 0.9467	2.640	626.2–633.2
	− 0.9577	2.500	453.2–469.2
	− 1.0398	2.675	469.2–495.2
70	− 1.0933	2.783	495.2–597.2
	− 1.0318	2.680	597.2–643.2
	− 1.0552	2.633	513.2–567.2
80	− 1.0354	2.598	567.2–616.2
	− 0.9996	2.540	616.2–643.2
90	− 1.0522	2.550	553.2–582.2
	− 1.0085	2.475	582.2–653.2
100	− 1.0021	2.390	583.2–673.2

Reference: [24]

TABLE 22(a). $AgNO_3$–$RbNO_3$: Density

Numerical values (g cm^{-3})

Mole percent $RbNO_3$

T(K)	100	90	80	70	60	50	40	30	20	10	0	35
440						3.251	3.388	3.533				3.460
450					3.109	3.239	3.376	3.521				3.448
460					3.097	3.227	3.364	3.509				3.436
470				2.962	3.085	3.215	3.352	3.497	3.649	3.809		3.423
480				2.951	3.073	3.202	3.340	3.485	3.637	3.798		3.411
490				2.939	3.061	3.190	3.328	3.473	3.626	3.787	3.955	3.399
500			2.813	2.927	3.048	3.178	3.315	3.461	3.614	3.775	3.945	3.387
510			2.802	2.915	3.036	3.166	3.303	3.449	3.603	3.764	3.934	3.375
520			2.790	2.903	3.024	3.154	3.291	3.437	3.591	3.753	3.924	3.363
530			2.779	2.891	3.012	3.141	3.279	3.425	3.579	3.742	3.914	3.351
540		2.664	2.767	2.879	3.000	3.129	3.267	3.413	3.568	3.731	3.903	3.339
550		2.653	2.756	2.868	2.988	3.117	3.255	3.401	3.556	3.720	3.893	3.327
560		2.642	2.745	2.856	2.976	3.105	3.243	3.389	3.545	3.709	3.882	3.315
570		2.631	2.733	2.844	2.964	3.092	3.230	3.377	3.533	3.698	3.872	3.303
580		2.621	2.722	2.832	2.952	3.080	3.218	3.365	3.522	3.687	3.862	3.291
590		2.610	2.710	2.820	2.939	3.068	3.206	3.353	3.510	3.676	3.851	3.278
600	2.508	2.599	2.699	2.808	2.927	3.056	3.194	3.341	3.498	3.665	3.841	3.266
610	2.498	2.588	2.687	2.796	2.915	3.044	3.182	3.329	3.487	3.654	3.831	3.254
620	2.488	2.577	2.676	2.785	2.903	3.031	3.170	3.317	3.475		3.820	3.242
630	2.478	2.566	2.665	2.773	2.891	3.019					3.810	
640	2.468	2.556	2.653									

TABLE 22(b). Two-dimensional equation and statistical parameters

$\rho = a + bT + cC + dTC + eTC^2$ (g cm^{-3})

a	$b \cdot 10^3$	$c \cdot 10^2$	$d \cdot 10^6$	$e \cdot 10^8$	Max. percent departure	Stand. error of est.
3.11490	− 1.01077	1.34813	− 8.18504	7.92534	0.32% (515 K, 20 mol % $AgNO_3$)	0.003 (0.14%)

Reference: [24]

C = mole percent $AgNO_3$

TABLE 22.1(a). $AgNO_3$–$RbNO_3$: Viscosity

Numerical values (cp)

Mole percent $RbNO_3$

T(K)	100	75	50	25	0
550	4.74	3.92	3.48	3.23	3.23
560	4.45	3.70	3.28	3.05	3.05
570	4.19	3.49	3.11	2.89	2.89
580	3.96	3.31	2.94	2.75	2.75
590	3.74	3.14	2.80	2.61	2.61
600	3.55	2.98	2.66	2.49	2.49
610	3.37	2.84	2.54	2.37	2.37
620	3.20	2.70	2.42	2.27	2.27
630	3.05	2.58	2.31	2.17	2.17
640	2.91	2.47	2.21	2.08	2.08
650	2.78	2.36	2.12	2.00	2.00
660	2.66	2.27	2.04	1.92	1.92
670	2.54	2.18	1.96	1.84	1.84

TABLE 22.1(b). Temperature-dependent equations

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

Comp. (mol % $RbNO_3$)	$A \cdot 10$	E (cal mol^{-1})	Stand. deviation [135]
0	1.4124	3418	0.035
25	1.4207	3411	0.036
50	1.4094	3501	0.029
75	1.4693	3587	0.043
100	1.4711	3792	0.032

Reference: [48]

TABLE 23(a). $AgNO_3$–$RbNO_3$: Surface tension

Numerical values (dyn cm^{-1})

Mole percent $RbNO_3$

T(K)	100	75	50	25	10	0
420			126.2			
440			124.7	131.7		
460		119.6	123.3	130.3		
480		118.1	121.8	128.9	137.4	
500	115.5	116.5	120.3	127.5	136.0	
520	113.8	115.0	118.9	126.1	134.7	
540	112.2	113.5	117.4	124.7	133.3	
560	110.5	111.9	116.0	123.3	131.9	
580	108.8	110.4	114.5	121.9	130.5	
600	107.2	108.8	113.0	120.5	129.2	142.1
620	105.5	107.3	111.6	119.1	127.8	140.8
640	103.9	105.8			126.4	139.5
660	102.2				125.0	138.2
680	100.5					136.9
700						135.5
720						134.2
740						132.9
760						131.6
780						130.3
800						

TABLE 23(b). Temperature-dependent equations

$\gamma = a + bT$ (dyn cm^{-1})

Comp. (mol % $RbNO_3$)	$a \cdot 10^{-3}$	$b \cdot 10$	Stand. error of est. (percent)
0	0.181731	−0.659999	0.0000
10	0.170416	−0.687427	0.0080 = 0.006
25	0.162524	−0.699998	0.0000
50	0.156844	−0.730002	0.0000
75	0.155036	−0.769998	0.0000
100	0.156976	−0.830003	0.0000

Reference: [26]

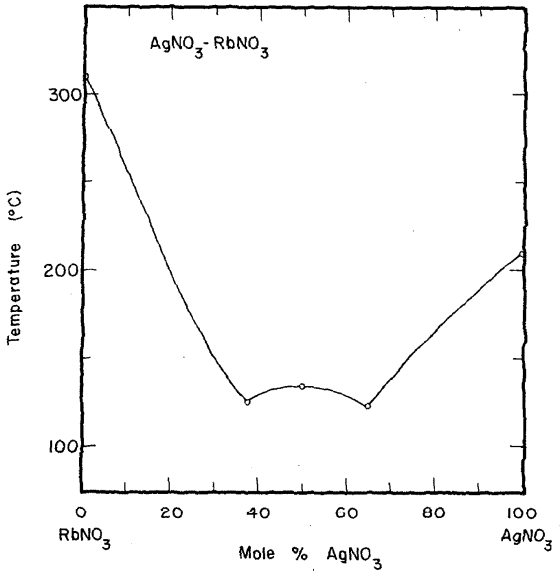

FIGURE 12. Temperature–composition phase diagram for $AgNO_3$–$RbNO_3$.

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$AgNO_3$–$TlNO_3$

Electrical Conductance

Twenty-three studies of the specific conductance of $AgNO_3$ [1 (p. 28), 4, 16, 24, 27, 52, 61, 73, 74, 75, 78, 82, 100, 101, 111, 125] and 17 investigations of $TlNO_3$ [1 (p. 28), 24, 27, 74, 89, 103, 104, 112, 117, 121] have been reported. Revised recommendations for $AgNO_3$ are based on the work of Brillant [24] and together with some experimental aspects are discussed in the section on $AgNO_3$–$NaNO_3$. Some experimental aspects of the conductance measurements of $TlNO_3$ are discussed in the section on $NaNO_3$–$TlNO_3$.

The specific conductance of molten $AgNO_3$–$TlNO_3$ mixtures has been measured by four groups [24, 27, 74, 81, 101] using either the classical ac technique [27, 81, 101] or a modified potentiometric ac technique [24, 74]. The results of Brillant [24, 74] for the single components and mixtures containing 21, 35, 50, 70, and 90 mole percent $TlNO_3$, covering a temperature range from 430 to 630 K, are recommended as the "best" values and are given in table 24(a), for the experimental compositions at rounded temperatures. These were derived from the temperature-dependent equations reported by Brillant and listed in table 24(b). The experimental uncertainty of the results of Brillant is estimated to be about 0.3 percent. The values for $TlNO_3$ deviate from the recommendations [1] (−0.78 to −0.60 percent). Sandonnini [27] reports results for the single components and four different mixture compositions at 523.2 K. His values for $AgNO_3$ and $TlNO_3$ deviate from the results of Brillant (−2.19 percent and −4.39 percent respectively). Rabinowitsch [81] reports one conductance value at 373.2 K, whereas data for both single components and 13 different mixture compositions covering a temperature range from 373.2 to 573.2 K, have been reported by Bokhovkin [101]. Due to the choice of different mixture compositions a direct comparison of the latter with the investigation of Brillant is not possible, except for the values for single $AgNO_3$ and $TlNO_3$ which deviate from the newly recommended data [24] (−4.90 to −3.27 percent) and (−4.27 to −3.15 percent) respectively.

The experimental technique used by Brillant [24] is discussed in the section on KNO_3–$RbNO_3$, whereas the melt preparation is described in the discussion of density in the section on $AgNO_3$–$LiNO_3$.

Density

Fourteen investigations of the density of $AgNO_3$ [1 (p. 28), 3, 4, 16, 24, 48, 52, 61, 101, 142, 143] and five investigations of $TlNO_3$ [1 (p. 28), 24, 103, 117] have been reported. Revised recommendations for $AgNO_3$ are based on the work of Brillant [24] and together with some experimental aspects are discussed in the section on $AgNO_3$–$LiNO_3$. Some experimental aspects of the density measurements of $TlNO_3$ are as follows: Jaeger [1], Brillant [24] and Popovskaya, Protsenko and Eliseeva [117] used the Archimedean method, whereas the investigation by Timidei and Janz [1] was carried out by means of a dilatometer. The sampling technique used by Timidei and Janz is as follows: The molten sample, after filtration into the dilatometer, was degassed by repeated cycles of solidification, evacuation and fusion. Reagent-grade $TlNO_3$ was recrystallized from aqueous solutions, dried at reduced pressure, first at 25 °C for 24 hours and finally at 110 °C for 12 hours, and stored in a desiccator over $MgClO_4$ prior to use.

The density of molten $AgNO_3$–$TlNO_3$ mixtures has been measured by three groups using the Archimedean method [24, 101] and the pycnometric method [81]. The results of Brillant [24] for 20, 40, 60, and 80 mole percent mixtures and the single components cover a temperature range from 435 to 635 K and are recommended as the "best" values. The results were recalculated using a two-dimensional statistical analysis; the values in the form of a temperature-composition-density matrix are given in table 25(a) for rounded compositions and temperatures. The corresponding statistical parameters are given in table 25(b). The experimental uncertainty of the results of Brillant is estimated to be about 0.2 percent. The values for $TlNO_3$ deviate from the recommendations [1] (0.18 to 0.22 percent). The results of Bokhovkin [101] for ten different mixture compositions and $AgNO_3$ cover a temperature range from 375 to 500 K. The value for $AgNO_3$ at 498.2 K deviates from the result by Brillant (−0.85 percent). Due to different compositions, no direct comparison of the mixture data is possible. Rabinowitsch [81] measured the density of an equimolar mixture at 373.2 K.

The melt preparation and experimental technique used by Brillant [24] are discussed in the section on $AgNO_3$–$LiNO_3$.

Viscosity

Eleven studies of the viscosity of $AgNO_3$ [1(p. 28), 3, 45, 48, 52, 78, 80, 101] and five investigations of $TlNO_3$ [1(p. 29), 101] have been reported. Some experimental aspects of the viscosity measurements of $AgNO_3$ are discussed in the section on $AgNO_3$–KNO_3. Some experimental aspects of the viscosity measurements of $TlNO_3$ are as follows: Frame, Rhodes and Ubbelohde [1] used an Ubbelohde viscometer, whereas all other measurements were carried out by means of Ostwald viscometers. In the work of Timidei and Janz [1] anhydrous $TlNO_3$ was filtered into the viscometer through a sintered glass disc. The viscometer was calibrated with n-hexane and water.

The viscosity of molten $AgNO_3$–$TlNO_3$ mixtures has been measured by two groups [81, 101] using an Ostwald capillary viscometer. The results of Bokhovkin [101] for the single components and 13 different mixtures (6.8 to 85.4 mole percent $TlNO_3$) are given in table 26 for the compositions and temperatures reported

by Bokhovkin. A statistical analysis to produce values at rounded temperatures was unsatisfactory. The experimental uncertainty of the results by Bokhovkin is estimated to be more than 5 percent. The single value reported for $TlNO_3$ deviates from the recommendations [1] (7.96 percent). Only one data point at 50 mole percent $TlNO_3$ and 373.1 K is reported by Rabinowitsch [81].

Bokhovkin [101] used α-naphthol to calibrate the viscometer. No information is available about melt purity and preparation.

TABLE 24(a). $AgNO_3$–$TlNO_3$: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

	Mole percent $TlNO_3$						
T(K)	100	90	70	50	35	21	0
430			0.259	0.289	0.316		
440			0.290	0.323	0.353		
450			0.320	0.357	0.390	0.428	
460		0.313	0.350	0.391	0.428	0.468	
470		0.339	0.380	0.425	0.465	0.509	
480	0.344	0.366	0.410	0.459	0.503	0.549	0.630
490	0.370	0.393	0.440	0.493	0.540	0.590	0.676
500	0.396	0.420	0.470	0.527	0.578	0.630	0.723
510	0.422	0.447	0.500	0.561	0.613	0.671	0.769
520	0.448	0.474	0.531	0.594	0.649	0.708	0.815
530	0.474	0.501	0.560	0.627	0.685	0.747	0.860
540	0.500	0.528	0.589	0.659	0.721	0.786	0.904
550	0.525	0.555	0.619	0.692	0.758	0.824	0.947
560	0.551	0.581	0.648	0.724	0.794	0.862	0.990
570	0.576						1.031
580	0.601						1.072
590	0.626						1.113
600	0.651						1.151
610	0.675						1.190
620	0.700						1.227
630							1.263

TABLE 24(b). Temperature-dependent equations

$\kappa = a + bT$ (ohm^{-1} cm^{-1})

Comp. (mol % $TlNO_3$)	a	$b \cdot 10^3$	Temp. range (K)
0	−1.5943	4.634	483.2–523.2
	−1.4588	4.375	523.2–555.2
	−1.3088	4.105	555.2–588.2
	−1.1754	3.878	588.2–613.2
	−0.9897	3.575	613.2–633.2
21	−1.3950	4.050	453.2–511.2
	−1.3048	3.871	511.2–545.2
	−1.2662	3.800	545.2–561.2
35	−1.2935	3.742	433.2–507.2
	−1.2230	3.600	507.2–543.2
	−1.2008	3.562	543.2–559.2
50	−1.1748	3.404	433.2–508.2
	−1.1193	3.294	508.2–543.2
	−1.0803	3.222	543.2–559.2
70	−1.0331	3.006	433.2–517.2
	−0.9945	2.933	517.2–559.2
90	−0.9244	2.689	463.2–559.2
100	−0.8980	2.588	483.2–558.2
	−0.8416	2.487	558.2–623.2

Reference: [24]

TABLE 25(a). $AgNO_3$–$TlNO_3$: Density

Numerical values (g cm^{-3})

Mole percent $TlNO_3$

T(K)	100	90	80	70	60	50	40	30	20	10	0	48
440				4.748	4.663	4.573	4.478	4.377				4.555
450			4.813	4.732	4.647	4.558	4.464	4.363	4.255			4.540
460			4.796	4.715	4.631	4.543	4.450	4.350	4.243			4.525
470		4.857	4.779	4.699	4.616	4.528	4.436	4.336	4.230	4.115		4.510
480		4.839	4.762	4.683	4.600	4.513	4.421	4.323	4.217	4.103		4.495
490	4.897	4.821	4.745	4.666	4.585	4.498	4.407	4.309	4.204	4.091	3.967	4.481
500	4.878	4.804	4.728	4.650	4.569	4.484	4.393	4.296	4.192	4.079	3.956	4.466
510	4.860	4.786	4.711	4.634	4.553	4.469	4.379	4.282	4.179	4.067	3.945	4.451
520	4.841	4.768	4.694	4.617	4.538	4.454	4.365	4.269	4.166	4.055	3.934	4.436
530	4.823	4.750	4.677	4.601	4.522	4.439	4.350	4.256	4.153	4.043	3.922	4.422
540	4.804	4.732	4.660	4.585	4.506	4.424	4.336	4.242	4.141	4.030	3.911	4.407
550	4.786	4.715	4.642	4.568	4.491	4.409	4.322	4.229	4.128	4.018	3.900	4.392
560	4.767	4.697	4.625	4.552	4.475	4.394	4.308	4.215	4.115	4.006	3.888	4.377
570	4.749	4.679	4.608	4.535	4.459	4.379	4.294	4.202	4.102	3.994	3.877	4.362
580	4.730	4.661	4.591	4.519	4.444	4.364	4.279	4.188	4.090	3.982	3.866	4.348
590	4.711	4.643	4.574	4.503	4.428	4.349	4.265	4.175	4.077	3.970	3.854	4.333
600	4.693	4.625								3.958	3.843	
610	4.674										3.832	
620	4.656										3.821	
630											3.809	

TABLE 25(b). Two-dimensional equation and statistical parameters

$\rho = a + bT + cC + dC^3 + eTC$ (g cm^{-3})

a	$b \cdot 10^3$	$c \cdot 10^2$	$d \cdot 10^7$	$e \cdot 10^6$	Max. percent departure	Stand. error of est.
5.80573	− 1.85467	− 1.10779	− 1.76833	7.24708	− 0.21 (485 K, 60 mol % $AgNO_3$)	0.003 (0.07%)

Reference: [24]
C = Mole percent $AgNO_3$

TABLE 26. $AgNO_3$–$TlNO_3$: Viscosity

Numerical values (cp)

Mole percent $TlNO_3$

T(K)	100	85.4	66.2	54.8	48.9	43.8	40.9	38.9	37.1	34.2	29.8	26.0	17.9	6.8	0
398.2					7.00	7.13	7.40	7.76	7.52	7.44	7.40				
423.2					5.36	5.60	5.80	6.08	5.86	5.72	5.68				
448.2			4.07	4.16	4.27	4.46	4.80	4.80	4.69	4.71	4.72	4.73	4.76		
473.2		3.83	3.88	3.92	4.00	4.08	4.30	4.33	4.30	4.30	4.32	4.34	4.46	4.61	
498.2	3.67	3.65	3.73	3.78	3.81	3.87	3.98	4.03	4.04	4.04	4.07	4.16	4.24	4.39	4.56

Reference: [101]

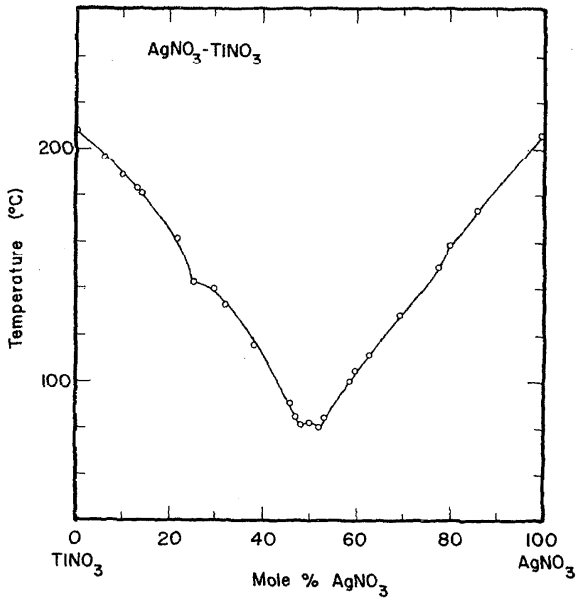

FIGURE 13. Temperature–composition phase diagram for $AgNO_3$–$TlNO_3$.

G. Van Eyk, Z. Phys. Chem. **51**, 721 (1905).

$Ba(NO_3)_2$–$CsNO_3$

Electrical Conductance

$Ba(NO_3)_2$ has not been investigated. Seven investigations of $CsNO_3$ [1 (p. 28), 125, 126, 127, 129] have been reported. Some experimental aspects of the conductance measurements of $CsNO_3$ are discussed in the section on $CsNO_3$–KNO_3.

The specific conductance of molten $Ba(NO_3)_2$–$CsNO_3$ mixtures has been measured by two groups [123, 126] both using the classical ac technique. The results of De Nooijer [123] for pure $CsNO_3$ and mixtures containing 10, 20, and 30 mole percent $Ba(NO_3)_2$, covering a temperature range from 615 to 740 K, are recommended as the "best" values and are given in table 27(a) for the experimental concentrations at rounded temperatures. The corresponding temperature-dependent equations are given in table 27(b). The experimental uncertainty of the results of De Nooijer is estimated to be about 0.4 percent. The results for $CsNO_3$ deviate from the recommendations [1] (−0.53 to −0.17 percent). Protsenko and Andreeva [126] measured the specific conductance of pure $CsNO_3$ and mixtures containing 5.3, 11.1, 17.6, 21.2, 25.0, 29.0, and 33.3 mole percent $Ba(NO_3)_2$ in the temperature range from 635 to 735 K. Their data for $CsNO_3$ deviate from the results of De Nooijer (−1.35 to −0.60 percent). Due to the larger deviation of the data for $CsNO_3$ from the recommended values [1], and considering the lack of sufficient information about the melt preparation the results of Protsenko and Andreeva could not be critically judged.

For discussion of the melt preparation and experimental technique of De Nooijer see the section on $CsNO_3$–KNO_3.

TABLE 27(a). $Ba(NO_3)_2$–$CsNO_3$: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

	Mole percent $CsNO_3$			
T(K)	100	90	80	70
620			0.2965	
630			0.3152	
640		0.3740	0.3339	
650		0.3959	0.3526	0.3506
660		0.4171	0.3713	0.3584
670		0.4378	0.3900	0.3684
680		0.4578	0.4087	0.3803
690		0.4772	0.4274	0.3944
700	0.5578	0.4960	0.4461	0.4105
710	0.5767	0.5141	0.4648	0.4287
720	0.5957	0.5317	0.4835	0.4489
730	0.6146			
740	0.6335			

TABLE 27(b). Temperature-dependent equations

$\kappa = a + bT + cT^2$ (ohm^{-1} cm^{-1})

Comp. (mol % $CsNO_3$)	a	$b \cdot 10^3$	$c \cdot 10^6$	Stand. error of est. (percent)
70	4.2610	−12.7158	10.3073	0.0173 = 4.43
80	−0.8630	1.8700	0	0.0007 = 0.18
90	−2.3246	6.2119	−3.1178	0.0009 = 0.20
100	−0.7663	1.8917	0	0.0008 = 0.14

Reference: [123]

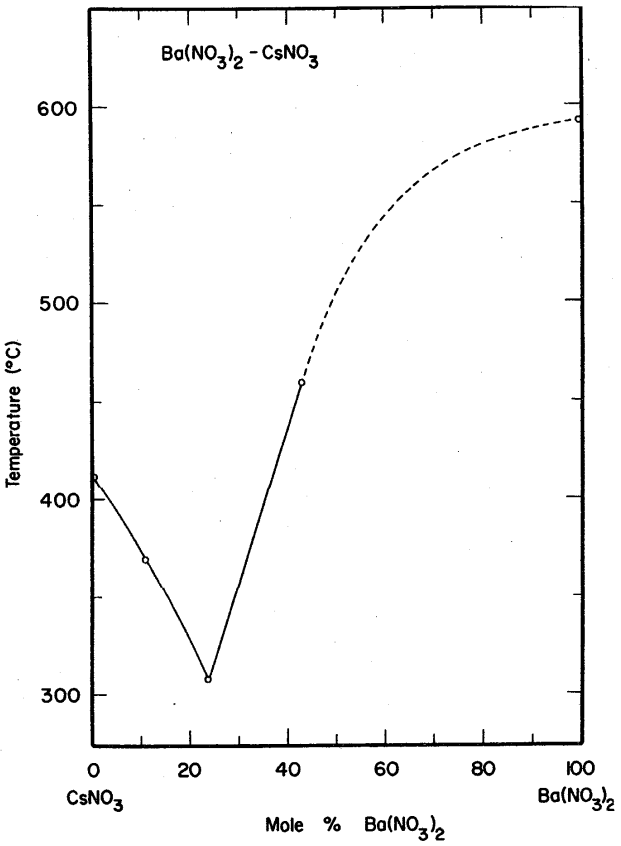

FIGURE 14. Temperature–composition phase diagram for $Ba(NO_3)_2$–$CsNO_3$.

P. I. Protsenko and T. A. Andreeva, Zh. Neorg. Khim. **6**, 1375 (1961).

$Ba(NO_3)_2$–KNO_3

Electrical Conductance

$Ba(NO_3)_2$ has not been investigated. Twenty-seven investigations of KNO_3 [1 (p. 26), 9, 23, 24, 29, 82, 89, 90, 94, 100, 107, 116, 117, 121, 122, 129] have been reported. Revised recommendations for KNO_3 are based on the work of Robbins and Braunstein [122] and together with some experimental aspects are discussed in the sections on KNO_3–$RbNO_3$ and KNO_3–$NaNO_3$.

The specific conductance of $Ba(NO_3)_2$–KNO_3 mixtures has been studied by three groups, each using the classical ac technique. The results of De Nooijer [123] for pure KNO_3 and mixtures containing, 10, 20, and 30 mole percent $Ba(NO_3)_2$, covering a temperature range from 610.8 to 738.9 K are recommended as the "best" values and are given in table 28(a) for the experimental compositions at rounded temperatures. The corresponding temperature-dependent equations are given in table 28(b). The experimental uncertainty of the results of Brillant is estimated to be about 0.4 percent. The values for KNO_3 deviate from the newly recommended values [122] (−0.65 to 0.41 percent) and from the recommendations [1] (−1.38 to −0.01 percent). Murgulescu and Zuca [97] measured the conductance of single KNO_3 and mixtures containing 10, 15, 20, 23, 25, 30, 40, and 50 mole percent $Ba(NO_3)_2$ in the temperature range from 623.2 to 773.2 K. Their results deviate from the values of De Nooijer (1.83 to 3.24 percent, pure KNO_3; 2.05 to 3.30 percent, 10 mole percent $Ba(NO_3)_2$; 1.70 to 1.92 percent, 20 mole percent $Ba(NO_3)_2$; −0.67 to −0.55 percent, 30 mole percent $Ba(NO_3)_2$). Another investigation is reported by Protsenko and Malakhova [23]. However, their results are presented graphically and cannot be critically assessed.

For discussion of the melt preparation and experimental technique of De Nooijer see the section on $CsNO_3$–KNO_3.

Density

$Ba(NO_3)_2$ has not been investigated. Nineteen investigations of KNO_3 [1 (p. 26), 4, 9, 12, 25, 27, 110, 115, 118, 130] have been reported. Some experimental aspects of the density measurements of KNO_3 are discussed in the section on KNO_3–$NaNO_3$.

The density of molten $Ba(NO_3)_2$–KNO_3 mixtures has been measured by five groups [25, 91, 93, 97, 130] using either the Archimedean method [91, 93, 97], a manometric densitometer [25] or a dilatometric method [130]. The results of Murgulescu and Zuca [97] for pure KNO_3 and mixtures containing 10, 15, 20, 23, 25, 30, 40, 50, and 60 mole percent $Ba(NO_3)_2$, covering a temperature range from 625 to 770 K, are recommended as the "best" values. The results were recalculated using a two-dimensional statistical analysis; the values in the form of a temperature-composition-density matrix are in table 29(a), for rounded compositions and temperatures. The corresponding statistical parameters are given in table 29(b).

The experimental uncertainty of the results of Murgulescu and Zuca is estimated to be about 0.5 percent. The values for KNO_3 deviate from the recommendations [1] (−0.36 to 0.07 percent). Cleaver, Rhodes and Ubbelohde measured molar volumes of pure KNO_3 and mixtures containing 2.5, 5.2, 8.1, 10.9, 14.1, 17.6, 21.2, 24.8, and 28.7 mole percent $Ba(NO_3)_2$. The results were presented in recalculated form by McAuley, Rhodes and Ubbelohde [25]. Due to different mixture compositions a direct comparison of these mixture values with the results of Murgulescu and Zuca is not possible. However, the values for KNO_3 agree with the results of Murgulescu and Zuca to within −0.05 to 0.03 percent. Protsenko and Malakhova [91] measured densities between 595 and 670 K for KNO_3 and mixtures containing 2.6, 5.3, 8.1, 11.1, 14.3, 17.7, 21.2, 25.0, and 29.0 mole percent $Ba(NO_3)_2$. These values agree with the results of Murgulescu and Zuca [97] to within −0.19 to 0.06 percent for pure KNO_3 and −0.02 to 0.12 percent for a mixture containing 25 mole percent $Ba(NO_3)_2$. The results of Petersen, Ewing and Smith [93] for KNO_3 and mixtures containing 90, 80, and 70 mole percent $Ba(NO_3)_2$ range between 600 and 795 K and deviate from the

values of Murgulescu and Zuca (−0.49 percent, 723.3 K, 100 mole percent KNO_3, to 0.13 percent, 773.2 K, 10 mole percent $Ba(NO_3)_2$). Laybourn and Madgin [130] measured pure KNO_3 and mixtures containing 60, 70, 80, and 90 mole percent KNO_3 between 587 and 744 K.

The melt preparation and experimental technique of Murgulescu and Zuca [97] are discussed in the section on KNO_3–$NaNO_3$.

TABLE 28(a). $Ba(NO_3)_2$–KNO_3: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

Mole percent KNO_3

T(K)	100	90	80	70
610			0.4796	
620	0.6413	0.5661	0.5058	
630	0.6748	0.5942	0.5320	
640	0.7077	0.6224	0.5502	
650	0.7402	0.6504	0.5845	
660	0.7722	0.6785	0.6108	
670	0.8037	0.7064	0.6372	
680	0.8347	0.7344	0.6635	0.6158
690	0.8652	0.7623	0.6899	0.6390
700	0.8953	0.7901	0.7163	0.6622
710	0.9248	0.8179	0.7428	0.6854
720	0.9539		0.7693	0.7086
730	0.9825			0.7318
740				0.7549

TABLE 28 (b). Temperature-dependent equations

$\kappa = a + bT + cT^2$ (ohm^{-1} cm^{-1})

Comp. (mol % KNO_3)	a	$b \cdot 10^3$	$c \cdot 10^6$	Stand. error of est. (percent)
70	−0.9608	2.3185	0	0.0032 = 0.47
80	−1.0594	2.4295	0.1533	0.0002 = 0.03
90	−1.2720	3.1100	−0.2346	0.0002 = 0.03
100	−2.3824	6.3849	−2.4322	0.0013 = 0.16

Reference: [123]

TABLE 29 (a). $Ba(NO_3)_2$–KNO_3: Density

Numerical values (g cm^{-3})

Mole percent KNO_3

T(K)	100	90	80	70	60	50	87.32
630	1.856	2.025	2.189	2.343			2.059
640	1.849	2.018	2.182	2.336			2.053
650	1.843	2.012	2.176	2.330			2.047
660	1.836	2.005	2.170	2.323			2.040
670	1.830	1.999	2.163	2.317			2.033
680	1.823	1.992	2.156	2.310	2.448		2.026
690	1.815	1.985	2.149	2.302	2.441		2.019
700	1.808	1.977	2.141	2.295	2.434		2.012
710	1.800	1.969	2.134	2.287	2.426		2.004
720	1.793	1.962	2.126	2.280	2.418		1.996
730	1.784	1.954	2.118	2.271	2.410	2.528	1.988
740	1.776	1.945	2.109	2.263	2.402	2.520	1.980
750	1.768	1.937	2.101	2.255	2.393	2.512	1.971
760	1.759	1.928	2.092	2.246	2.385	2.503	1.963
770	1.750	1.919	2.083	2.237	2.376	2.494	1.954

TABLE 29(b). Two-dimensional equation and statistical parameters

$\rho = a + bC + cT^3 + dC^3$ (g cm^{-3})

a	$b \cdot 10^2$	$c \cdot 10^{10}$	$d \cdot 10^7$	Max. percent departure	Mult. corr. coeff.	Standard error of est.
1.98333	1.69961	−5.11175	−8.46788	0.57% (773.2 K, 20 mol % $Ba(NO_3)_2$)	1.000	0.006 (0.28%)

Reference: [97]

C = mole percent $Ba(NO_3)_2$

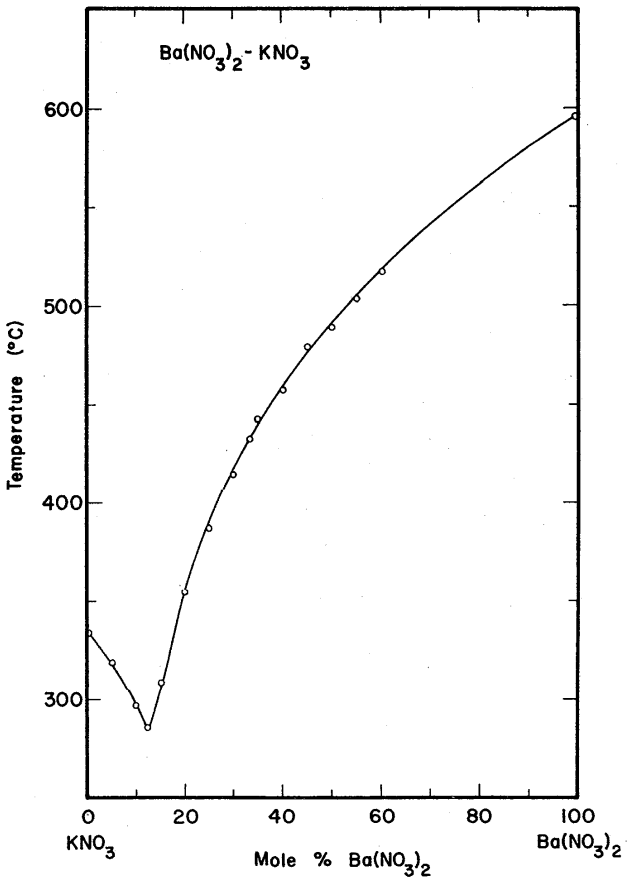

FIGURE 15. Temperature–composition phase diagram for $Ba(NO_3)_2$–KNO_3.

M. M. Markowitz, J. E. Ricci, and P. F. Winternitz, J. Am. Chem. Soc. **77**, 3482 (1955).

$Ba(NO_3)_2$–$NaNO_3$

Density

$Ba(NO_3)_2$ has not been investigated. Sixteen investigations of $NaNO_3$ [1 (p. 26), 9, 12, 25, 27, 71, 86, 95, 97, 115, 117, 118, 130] have been reported. Revised recommendations for $NaNO_3$ are based on the work of McAuley, Rhodes and Ubbelohde [25] and together with some experimental aspects are discussed in the section on $NaNO_3$–$RbNO_3$.

McAuley, Rhodes and Ubbelohde [25] used a manometric densitometer to measure equivalent volumes of molten $Ba(NO_3)_2$–$NaNO_3$ mixtures, in the temperature range from 575 to 730 K for pure $NaNO_3$ and mixtures containing 1.71, 2.59, 5.19, 7.83, 11.11, 14.06, 17.16, and 21.17 mole percent $Ba(NO_3)_2$. Using the molar volume equations reported by the authors, densities were recalculated for each experimental concentration at rounded temperatures. The results of a two-dimensional statistical analysis of these data are given in table 30(a) as a temperature-composition-density matrix at rounded compositions and temperatures; the corresponding statistical parameters are in table 30(b). The experimental uncertainty of the results of McAuley, Rhodes, and Ubbelohde is estimated to be about 0.3 percent.

McAuley, Rhodes and Ubbelohde [25] used the purest salts commercially available. Approximate required quantities of each salt were thoroughly dried by shock drying. $Ca(NO_3)_2$ was heated to 200 °C in an oven for at least 48 hours before use. $Mg(NO_3)_2 \cdot 6H_2O$ was heated very slowly under vacuum up to 85 °C for several days to constant weight. Before use, both $Ca(NO_3)_2$ and $Mg(NO_3)_2$ were pH tested for possible hydrolysis. The dried salts were weighed into a tared tube and melted together. The temperature was brought approximately to the melting point of the alkali nitrate whereupon the alkaline earth nitrate dissolved. The mixed melt was further dried by bubbling dry nitrogen through it for several hours then cooled and stored in a desiccator. The experimental technique is discussed in the section on $NaNO_3$–$RbNO_3$.

TABLE 30(a). $Ba(NO_3)_2$–$NaNO_3$: Density

Numerical values (g cm^{-3})

Mole percent $NaNO_3$

T(K)	100	95	90	85	80	93.3
580		2.025				
590		2.018				2.053
600	1.905	2.012				2.047
610	1.898	2.005				2.040
620	1.891	1.998	2.098			2.033
630	1.884	1.991	2.091			2.026
640	1.877	1.984	2.084			2.019
650	1.870	1.977	2.077			2.012
660	1.863	1.970	2.070			2.005
670	1.855	1.963	2.062	2.155		1.997
680	1.848	1.955	2.055	2.148		1.990
690	1.840	1.948	2.047	2.140		1.982
700	1.833	1.940	2.040	2.132	2.218	1.975
710	1.825	1.932	2.032	2.125	2.210	1.967
720	1.817		2.024	2.117	2.202	1.959
730					2.194	

TABLE 30(b). Two-dimensional equation and statistical parameters

$\rho = a + bC + cT^2 + dC^2$ (g cm^{-3})

a	$b \cdot 10^2$	$c \cdot 10^7$	$d \cdot 10^4$	Max. percent departure	Stand. error of est.
2.10377	2.21520	−5.53117	−1.45017	0.16% (580 K, 5.19 mol % $Ba(NO_3)_2$)	0.001 (0.05%)

Reference: [25]
C = mole percent $Ba(NO_3)_2$

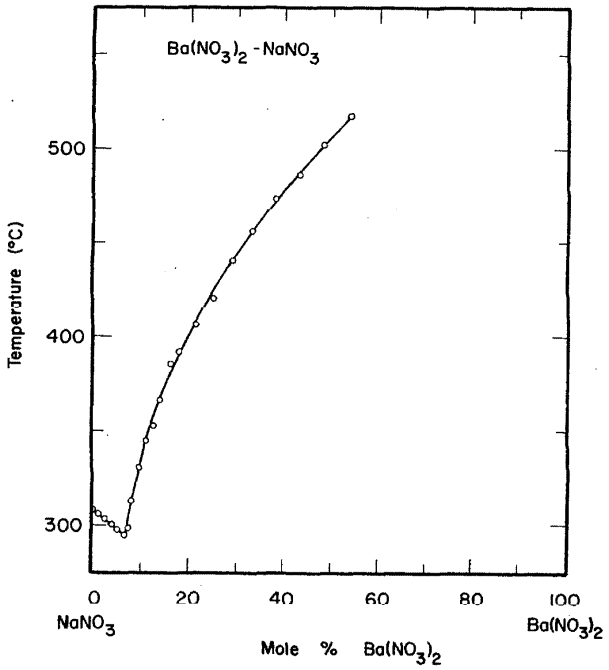

FIGURE 16. Temperature—composition phase diagram for $Ba(NO_3)_2$–$NaNO_3$.

P. I. Protsenko and A. G. Bergman, Zh. Obshch. Khim. **21**, 1580 (1951).

$Ba(NO_3)_2$–$RbNO_3$

Density

$Ba(NO_3)_2$ has not been investigated. Six studies of $RbNO_3$ [1 (p. 27), 24, 25, 86, 109, 117, 118] have been reported. Revised recommendations for $RbNO_3$ are based on the work of McAuley, Rhodes and Ubbelohde [25] and together with some experimental aspects are discussed in the section on $NaNO_3$–$RbNO_3$.

McAuley, Rhodes and Ubbelohde [25] used a manometric densitometer to measure the equivalent volumes of mixtures containing 3.89, 6.90, 8.65, 10.46, 12.87, and 13.52 mole percent $Ba(NO_3)_2$ in the temperature range: 535 K to 700 K. From the molar volume equations, densities were recalculated for each experimental concentration at rounded temperatures. The results of a two-dimensional statistical analysis of these data are given in table 31(a) as a temperature-composition-density matrix, for rounded compositions and temperatures; the corresponding statistical parameters are in table 31(b). The experimental uncertainty of the results of McAuley, Rhodes and Ubbelohde is estimated to be about 0.3 percent.

The melt preparation is discussed in the section on $Ba(NO_3)_2$–$NaNO_3$, and the experimental technique in the section on $NaNO_3$–$RbNO_3$.

TABLE 31(a). $Ba(NO_3)_2$–$RbNO_3$: Density

Numerical values (g cm^{-3})

Mole percent $RbNO_3$

T(K)	100	95	90	85
550			2.633	2.674
560			2.623	2.663
570		2.571	2.612	2.653
580		2.561	2.601	2.642
590		2.550	2.591	2.632
600	2.498	2.539	2.580	2.621
610	2.488	2.529	2.570	2.611
620	2.477	2.518	2.559	2.600
630	2.467	2.508	2.548	2.589
640	2.456	2.497	2.538	2.579
650	2.446	2.486	2.527	2.568
660	2.435	2.476	2.517	2.558
670	2.424	2.465	2.506	2.547
680	2.414	2.455	2.496	2.536
690	2.403	2.444	2.485	

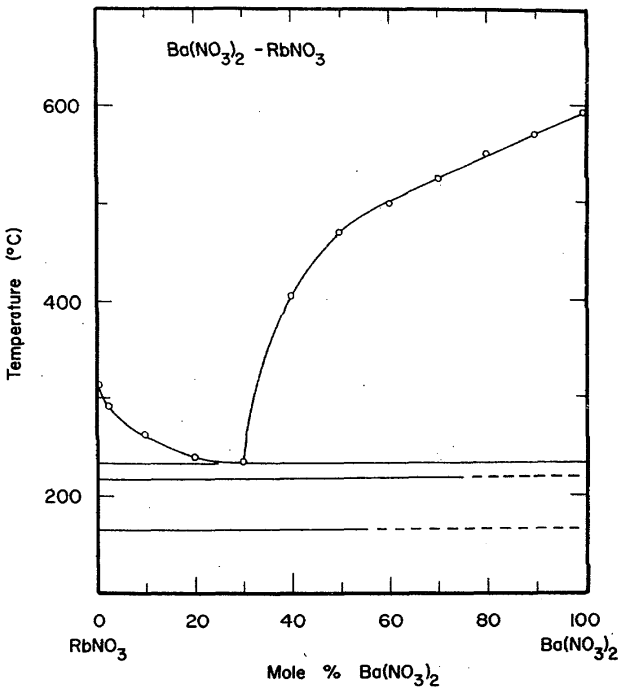

FIGURE 17. Temperature – composition phase diagram for $Ba(NO_3)_2$–$RbNO_3$.

V E. Plyushchev, I. B. Markina and L. P. Shklover, Doklady Akad. Nauk. S. S. S. R. **108** (4), 646 (1956).

TABLE 31(b). Two-dimensional equation and statistical parameters

$\rho = a + bT + cC$ (g cm^{-3})

a	$b \cdot 10^3$	$c \cdot 10^3$	Max. percent departure	Stand. error of est.
3.13387	−1.05898	8.17646	−0.29% (610 K, 13.52 mol % $Ba(NO_3)_2$)	0.003 (0.12%)

Reference: [25]

C = mole percent $Ba(NO_3)_2$

$Ca(NO_3)_2$–$CsNO_3$

Density

$Ca(NO_3)_2$ has not been investigated. Seven investigations of $CsNO_3$ [1 (p. 28), 25, 48, 86, 109, 118] have been reported. Some experimental aspects of the density measurements of $CsNO_3$ are discussed in the section on $CsNO_3$–$NaNO_3$.

McAuley, Rhodes and Ubbelohde [25] used a manometric densitometer to measure equivalent volumes of molten $Ca(NO_3)_2$–$CsNO_3$ mixtures, in the temperature range from 490 K to 725 K, for single $CsNO_3$ and mixtures containing 7.17, 14.74, 20.34, 28.13, 35.82, and 45.82 mole percent $Ca(NO_3)_2$. Using the molar volume equations reported by the authors, densities were recalculated for each experimental composition at rounded temperatures. The results of a two-dimensional statistical analysis of these data are given in table 32(a) as a temperature-composition-density matrix, for rounded compositions and temperatures; the corresponding statistical parameters are in table 32(b). The experimental uncertainty of the results of McAuley, Rhodes and Ubbelohde is estimated to be about 0.3 percent. The values for $CsNO_3$ deviate from the recommendations [1] (-0.92 to -0.87 percent).

The melt preparation of McAuley, Rhodes and Ubbelohde is discussed in the section on $Ba(NO_3)_2$–$NaNO_3$, and the experimental technique in the section on $NaNO_3$–$RbNO_3$.

Surface Tension

One investigation of the surface tension of $Ca(NO_3)_2$ [2 (p. 69)] and four investigations of $CsNO_3$ [2 (p. 68), 41] have been reported.

Eliseeva, Popovskaya and Protsenko [41] used the maximum bubble pressure method to measure the surface tension of molten $Ca(NO_3)_2$–$CsNO_3$ mixtures, in the temperature range from close to the melting point up to 510 °C for mixtures up to 60 mole percent $Ca(NO_3)_2$ and for pure $CsNO_3$. The results were recalculated using a two-dimensional statistical analysis; the values in the form of a temperature-composition-surface tension matrix are in table 32.1(a) for rounded compositions and temperatures; the corresponding statistical parameters are given in table 32.1(b).

The experimental aspects of the investigation of Eliseeva, Popovskaya and Protsenko [41] have been described previously.

The values for $CsNO_3$ agree with the recommendations [2] to within 0 to -0.33 percent.

TABLE 32(a). $Ca(NO_3)_2$–$CsNO_3$: Density

Numerical values (g cm^{-3})

Mole percent $CsNO_3$

T(K)	100	95	90	85	80	75	70	65	60	55	71.1
490											2.773
500							2.749				2.760
510							2.736				2.747
520							2.724				2.735
530							2.712	2.666			2.723
540						2.748	2.700	2.654			2.711
550						2.736	2.689	2.643	2.600		2.699
560						2.725	2.678	2.633	2.590	2.548	2.688
570						2.713	2.667	2.622	2.580	2.539	2.677
580					2.750	2.702	2.656	2.613	2.571	2.531	2.666
590					2.738	2.691	2.646	2.603	2.562	2.522	2.656
600					2.727	2.680	2.636	2.594	2.553	2.515	2.646
610					2.715	2.670	2.627	2.585	2.545	2.507	2.636
620				2.750	2.704	2.660	2.617		2.538	2.501	2.626
630				2.739	2.693	2.650	2.608		2.530	2.494	2.617
640				2.727	2.682	2.640	2.599			2.488	2.608
650			2.760	2.715	2.672	2.630	2.591			2.483	2.599
660			2.748	2.704	2.661	2.621					2.591
670		2.780	2.735	2.692	2.651	2.612					
680		2.766	2.723	2.681	2.641						
690	2.797	2.753	2.710		2.631						
700	2.782	2.739									
710	2.767										
720	2.751										

TABLE 32(b). Two-dimensional equation and statistical parameters

$\rho = a + bT + cC^2 + dT^3 + eTC + fCT^2$ (g cm^{-3})

a	$b \cdot 10^3$	$c \cdot 10^5$	$d \cdot 10^{10}$	$e \cdot 10^5$	$f \cdot 10^8$	Max. percent departure	Stand. error of est.
3.74426	−1.30839	3.74735	−1.35900	−5.21647	5.66289	−0.52% (650 K, 45.8 mol % $Ca(NO_3)_2$)	0.005 (0.19%)

Reference: [25]
C = mole percent $Ca(NO_3)_2$

TABLE 32.1(a). $Ca(NO_3)_2$–$CsNO_3$: Surface tension

Numerical values (dyn cm^{-1})

Mole percent $CsNO_3$

T(K)	100	95	90	85	80	75	70	65	60	55	50	45	40	71.1
600								95.5	96.0	96.6				
610							94.7	95.0	95.4	95.0	96.8	97.9		94.7
620						94.0	94.1	94.4	94.8	95.4	96.2	97.3		94.1
630					93.5	93.4	93.5	93.8	94.1	94.8	95.6	96.7		93.5
640				93.0	92.9	92.8	92.9	93.1	93.5	94.1	95.0	96.0		92.9
650				92.4	92.3	92.2	92.3	92.5	92.9	93.5	94.3	95.4	96.7	92.3
660			92.1	91.8	91.7	91.6	91.7	91.9	92.3	92.9	93.7	94.7	96.1	91.6
670			91.4	91.2	91.0	91.0	91.0	91.2	91.6	92.2	93.0	94.1	95.4	91.0
680		91.1	90.8	90.6	90.4	90.3	90.4	90.6	91.0	91.5	92.4	93.4	94.7	90.4
690		90.5	90.2	89.9	89.8	89.7	89.7	89.9	90.3	90.9	91.7	92.7	94.1	89.7
700	90.2	89.8	89.5	89.3	89.1	89.0	89.1	89.3	89.6	90.2	91.0	92.0	93.4	89.0
710	89.5	89.2	88.9	88.6	88.4	88.3		88.6	88.9	89.5	90.3	91.3		88.4
720	88.9	88.5	88.2	87.9						88.8	89.6	90.6		
730	88.2	87.9	87.5											
740	87.5	87.2												
750	86.9	86.5												
760	86.2													
770	85.5													
780	84.8													

TABLE 32.1(b). Two-dimensional equation and statistical parameters

$\gamma = a + bT^2 + cC^3 + dTC$ (dyn cm^{-1})

a	$b \cdot 10^5$	$c \cdot 10^5$	$d \cdot 10^5$	Max. percent departure	Stand. error of est.
112.61127	−4.57916	3.34892	−9.63813	0.43 (693.2 K, 0.0 mol % $Ca(NO_3)_2$)	0.140 (0.15%)

Reference: [41]
C = mole percent $Ca(NO_3)_2$

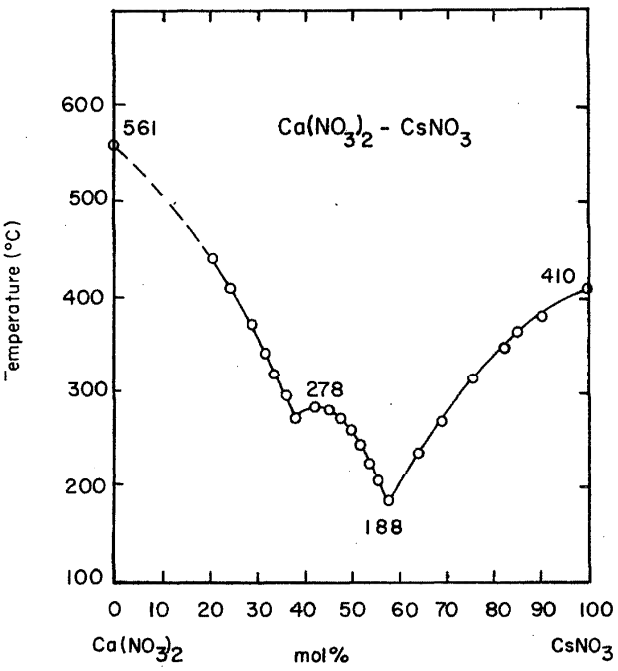

FIGURE 18. Temperature—composition phase diagram for $Ca(NO_3)_2$–$CsNO_3$.

P. I. Protsenko and Z. I. Belova, Zhur. Neorg. Khim., **2**, 2618 (1957).

$Ca(NO_3)_2$–KNO_3

Electrical Conductance

$Ca(NO_3)_2$ has not been investigated. Twenty-seven investigations of the specific conductance of KNO_3 [1 (p. 26), 9, 23, 24, 29, 82, 89, 90, 94, 100, 107, 116, 117, 121, 122, 129] have been reported. Revised recommendations for KNO_3 are based on the work of Robbins and Braunstein [122] and together with some experimental aspects are discussed in the sections on KNO_3–$RbNO_3$ and KNO_3–$NaNO_3$.

The specific conductance of molten $Ca(NO_3)_2$–KNO_3 mixtures has been studied by four groups [28, 107, 116, 123] using the classical ac technique. The results of De Nooijer [123] for pure KNO_3 and mixtures containing 10, 20, and 33.5 mole percent $Ca(NO_3)_2$, covering a temperature range from 520 to 730 K, are recommended as the "best" values and are given in table 33(a) for the experimental compositions at rounded temperatures. The corresponding temperature-dependent equations are given in table 33(b). The experimental uncertainty of the results of De Nooijer is estimated to be about 0.4 percent. The values for KNO_3 deviate from our newly recommended values [122] (−0.65 to 0.41 percent) and from the recommendations [1] (−1.38 to −0.01 percent). Rhodes, Smith and Ubbelohde [107] report values for pure KNO_3 and mixtures containing 20, 26, 33, 36, 40, and 45 mol percent $Ca(NO_3)_2$, covering a temperature range from 725 to 940 K. Their results for KNO_3 and the mixture containing 20 mole percent $Ca(NO_3)_2$ deviate from the values of De Nooijer (2.41 to 2.92 percent) and (−2.37 to 4.76 percent) respectively. Additional values for pure KNO_3 and 20 different mixture compositions, covering a temperature range from 425 to 700 K, are reported by Bergman and Natsvilishvili [28]. The pressure-dependence of the specific conductance of binary $Ca(NO_3)_2$–KNO_3 mixtures has been measured up to 3000 atm by Angell, Pollard and Strauss [116].

For melt preparation and experimental technique of De Nooijer see the section on $CsNO_3$–KNO_3.

Density

$Ca(NO_3)_2$ has not been investigated. Nineteen investigations of KNO_3 [1 (p. 26), 4, 9, 12, 25, 27, 110, 115, 118, 130] have been reported. Some experimental aspects of the density measurements of KNO_3 are discussed in the section on KNO_3–$NaNO_3$.

Two different methods were used to measure the density of molten $Ca(NO_3)_2$–KNO_3 mixtures: The Archimedean method by Petersen, Ewing and Smith [93] and a manometric densitometer method by McAuley, Rhodes and Ubbelohde [25] and Rhodes, Smith and Ubbelohde [107]. The results of McAuley, Rhodes, and Ubbelohde for KNO_3 and mixtures containing 14.57, 24.43, and 32.28 mol percent $Ca(NO_3)_2$, covering a temperature range from 465 to 690 K, are recommended as the "best" values. Using the molar volume equations reported by the authors, densities were recalculated and submitted to a one-dimensional statistical analysis. The values are given for the experimental compositions at rounded temperatures in table 34(a).

The corresponding temperature-dependent equations are given in table 34(b). The experimental uncertainty of the values of McAuley, Rhodes and Ubbelohde is estimated to be about 0.3 percent. The values of KNO_3 agree with the recommendations [1] to within −0.39 to −0.22 percent.

Rhodes, Smith and Ubbelohde [107] measured molar volumes of mixtures containing 20, 30, and 40 mol percent $Ca(NO_3)_2$ at three different temperatures (423.2, 523.2, 623.2 K). Due to the choice of different compositions no direct comparison of their values with the recommended results is possible. The results of Petersen, Ewing and Smith [93] for KNO_3 and mixtures containing 10, 20, and 30 mol percent $Ca(NO_3)_2$ cover a temperature range from 505 to 775 K. The values for KNO_3 deviate from the data of McAuley, Rhodes and Ubbelohde (−0.17 to −0.03 percent).

The melt preparation of McAuley, Rhodes and Ubbelohde is discussed in the section on $Ba(NO_3)_2$–$NaNO_3$, the experimental technique is in the section on $NaNO_3$–$RbNO_3$.

Viscosity

$Ca(NO_3)_2$ has not been investigated. Thirteen investigations of KNO_3 [1 (p. 27), 48, 86, 107, 118, 119] have

been reported. Revised recommendations for KNO_3 are based on the work of Timidei, Lederman and Janz [119] and together with some experimental aspects are discussed in the section on KNO_3–$NaNO_3$.

The viscosity of molten $Ca(NO_3)_2$–KNO_3 mixtures has been measured by two groups [107, 138, 139] using a capillary viscometer [107, 138], a rotating cylinder viscometer [138], and the beam bending method [139]. The results of Rhodes, Smith and Ubbelohde [107] for KNO_3 and mixtures containing 66.5, 80, and 90 mole percent KNO_3, covering a temperature range from 515 to 730 K, are given for the experimental compositions at rounded temperatures in table 35(a). These were derived from the temperature-dependent equations reported by Rhodes, Smith and Ubbelohde and listed in table 35(b). Two different types of equations were used for the temperature range above and below 525 K (dotted line in table 35(a)). The experimental uncertainty of the results of Rhodes, Smith and Ubbelohde is estimated to be about 1.5 percent. The values for KNO_3 deviate from the recommendations [1] and from the most recent results [119] (−0.98 to 0.38 percent) and (−1.15 to 1.19 percent) respectively. It should be noted that the thermal stability of the melts decreases with increasing composition of $Ca(NO_3)_2$. In a melt with 60 mol percent KNO_3 slight decomposition was reported above 650 K.

Weiler, Blaser, and Macedo [138] reported results for 60 mole percent KNO_3 between 352.5 and 473.4 K using the capillary method for viscosities up to about 750 P, the rotating cylinder viscometer for viscosities up to 7×10^4 P, and a modified rotating cylinder viscometer for viscosities up to 10^8 P. Tweer, Laberge, and Macedo [139] measured the viscosity of 60 mole percent KNO_3 between 330.2 and 346.3 K.

Rhodes, Smith and Ubbelohde [107] filtered the anhydrous melt into the viscometer through a sintered glass disc. The viscometer was calibrated with water at 25, 35, and 40 °C, and the calibration was checked with molten $NaNO_3$.

Surface Tension

One investigation of the surface tension of $Ca(NO_3)_2$ [2 (p. 69)] and eight investigations of KNO_3 [2 (p. 67), 41, 84] have been reported.

Eliseeva, Popovskaya and Protsenko [41] used the maximum bubble pressure method to measure the surface tension of molten $Ca(NO_3)_2$–KNO_3 mixtures, in the temperature range from close to the melting point to 500 °C for mixtures up to 60 mol percent $Ca(NO_3)_2$ and for pure KNO_3. The results for the experimental compositions at rounded temperatures are given in table 35.1(a). The corresponding temperature-dependent equations are given in table 35.1(b). The values for KNO_3 agree with the recommendations [2] to within −1.30 to −1.45 percent.

Eliseeva, Popovskaya and Protsenko [41] used "chemically pure" salts, which were recrystallized twice and carefully dried. $Ca(NO_3)_2$ was dehydrated under vacuum over an extended period, while the temperature was gradually raised to 180 °C. Mixtures containing $Ca(NO_3)_2$ were weighed in boxes in a dry air atmosphere. After measurement of the surface tension, a current of dry N_2 was passed through the melt to remove possible traces of moisture. Good agreement was observed for measurements during heating and cooling of the melt.

TABLE 33(a). $Ca(NO_3)_2$–KNO_3: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

	Mole percent KNO_3			
T(K)	100	90	80	66.5
520			0.2074	
530			0.2313	
540			0.2557	0.1805
550			0.2806	0.2043
560			0.3060	0.2281
570			0.3318	0.2520
580			0.3580	0.2758
590			0.3844	0.2996
600			0.4111	0.3235
610			0.4379	0.3473
620	0.6413	0.5576	0.4648	0.3711
630	0.6748	0.5856	0.4918	0.3950
640	0.7077	0.6136	0.5188	0.4188
650	0.7402	0.6416	0.5456	0.4426
660	0.7722	0.6696	0.5724	0.4665
670	0.8037	0.6976	0.5990	0.4903
680	0.8347	0.7256	0.6253	0.5141
690	0.8652	0.7537	0.6513	0.5380
700	0.8953	0.7817	0.6769	
710	0.9248	0.8097	0.7021	
720	0.9539	0.8377		
730	0.9825	0.8657		

TABLE 33(b). Temperature-dependent equations

$\kappa = a + bT + cT^2 + dT^3$ (ohm^{-1} cm^{-1})

Comp. (mol % KNO_3)	a	$b\cdot10^3$	$c\cdot10^6$	$d\cdot10^9$	Stand. error of est. (percent)
66.5	−1.1791	2.8011	0	0	0.0017=0.47
80	1.2331	−8.9669	18.582	−9.8673	0.0018=0.40
90	−1.1066	2.3834	0	0	0.0028=0.39
100	−2.3824	6.3849	−2.4322	0	0.0013=0.16

Reference: [123]

TABLE 34(a). $Ca(NO_3)_2$–KNO_3: Density

Numerical values (g cm^{-3})

Mole percent KNO_3

T(K)	100	85.43	75.57	67.72
470				2.065
480				2.058
490				2.051
500				2.043
510				2.036
520				2.029
530				2.021
540				2.014
550			1.988	2.007
560			1.980	2.000
570			1.973	1.992
580			1.966	1.985
590		1.929	1.958	1.978
600		1.922	1.951	1.970
610		1.915	1.944	1.963
620	1.863	1.907	1.937	1.956
630	1.856	1.900	1.930	1.949
640	1.848	1.892	1.922	1.941
650	1.841	1.885	1.915	1.934
660	1.833	1.877	1.908	1.927
670	1.826	1.870	1.900	
680	1.818			
690	1.811			
700	1.803			
710	1.796			

TABLE 34(b). Temperature-dependent equations

$\rho = a + bT$ (g cm^{-3})

Comp. (mol % KNO_3)	a	$b \cdot 10^4$	Stand. error of est. (percent)
67.72	2.4078	−7.2895	0.0009 = 0.05
75.57	2.3875	−7.2692	0.0004 = 0.02
85.43	2.3700	−7.4667	0.0004 = 0.02
100	2.3313	−7.5455	0.0004 = 0.02

Reference: [25]

TABLE 35(a). $Ca(NO_3)_2$–KNO_3: Viscosity

Numerical values (cp)

Mole percent KNO_3

T(K)	100	80	74	67	64	60	55
440				136.38			
450			54.08	92.66		163.66	
460			41.36	65.37	80.72	111.04	
470			32.35	47.71	58.52	78.18	
480			25.82	35.91	43.75	56.92	87.93
490			20.99	27.78	33.62	42.72	64.46
500		12.88	17.35	22.05	26.60	32.95	48.61
510		11.21	14.57	17.89	21.37	26.06	37.61
520		9.85	12.40	14.83	17.59	21.08	29.78
530	5.28	8.23	10.04	11.94	14.43	(18.30)	22.19
540	4.87	7.51	9.08	10.73	12.81	(16.12)	19.25
550	4.50	6.87	8.25	9.68	11.42	(14.26)	16.79
560	4.17	6.30	7.51	8.76	10.23	(12.67)	14.72
570	3.88	5.80	6.87	7.96	9.19	(11.30)	12.96
580	3.61	5.36	6.30	7.26	8.29	(10.12)	11.47
590	3.37	4.96	5.79	6.64	7.51	(9.10)	10.18
600	3.16	4.60	5.34	6.09	6.82	(8.21)	9.08
610	2.96	4.28	4.94	5.60	6.21	(7.44)	8.13
620	2.79	3.99	4.58	5.16	5.68	(6.75)	7.30
630	2.62	3.73	4.25	4.78	5.20	(6.15)	6.58
640	2.48	3.49	3.96	4.43	4.78	(5.62)	5.95
650	2.34	3.28	3.70	4.11	4.41	(5.15)	5.40
660	2.22	3.08	3.46	3.83	4.07	(4.73)	4.91
670	2.10	2.90	3.24	3.57	3.77	(4.36)	4.48

TABLE 35(b). Temperature-dependent equations

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

$\eta = A' \cdot \exp(E'/RT) \cdot \exp(B/RT^2)$ (cp)

Comp. (mol % KNO_3)	$A \cdot 10^2$	E (cal mol^{-1})	$A' \cdot 10^{-2}$	$E' \cdot 10^{-4}$ (cal mol^{-1})	$B \cdot 10^{-6}$ (cal · degree mol^{-1})	Temp. range (K)
55	1.047	8061	82.70	−2.3559	9.2291	480–525 526–667
60	1.903	7230	209.99	−2.5073	9.3306	450–525 526–667
64	2.337	6763	93.33	−2.2884	8.5303	460–525 526–667
67	3.711	6077	146.18	−2.3807	8.6776	440–525 526–667
74	4.475	5698	0.4329	−1.0868	4.9799	450–525 526–667
80	5.631	5247	0.02504	−0.3885	2.7556	550–525 526–667
100	6.464	4634				626–667

Reference: [107]

TABLE 35.1(a). $Ca(NO_3)_2$–KNO_3: Surface tension

Numerical values (dyn cm^{-1})

Mole percent KNO_3

T(K)	100	91.89	82.35	71.40	66.66	57.14	51.85	46.15	40.00
450				117.7					
460				117.1					
470				116.5					
480				115.8					
490				115.2	115.0				
500				114.6	114.4				
510				113.9	113.8				
520				113.3	113.2				
530			115.2	112.6	112.5	113.2			
540			114.6	112.0	111.9	112.6			
550			114.0	111.4	111.3	111.9			
560			113.4	110.7	110.7	111.3			
570			112.8	110.1	110.1	110.7			
580			112.2	109.5	109.4	110.1			
590		109.4	111.6	108.8	108.8	109.4			
600		108.8	111.0	108.2	108.2	108.8	109.3		
610		108.1	110.4	107.5	107.6	108.2	108.7		
620	108.9	107.4	109.8	106.9	107.0	107.6	108.0		
630	108.2	106.9	109.2	106.3	106.3	106.9	107.4		
640	107.5	106.2	108.6	105.6	105.7	106.3	106.7	107.4	
650	106.8	105.6	108.0	105.0	105.1	105.7	106.1	106.7	
660	106.0	105.0	107.4	104.4	104.5	105.1	105.4	106.0	
670	105.3	104.3	106.8	103.7	103.9	104.4	104.8	105.4	
680	104.6	103.7	106.2	103.1	103.2	103.8	104.1	104.7	
690	103.8	103.1	105.6	102.4	102.6	103.2		104.0	104.7
700	103.1	102.4		101.8				103.4	104.0
710	102.4	101.8		101.2				102.7	
720	101.6								
730	100.9								
740	100.2								
750	99.5								
760	98.7								
770	98.0								

TABLE 35.1(b). Temperature-dependent equations

$\gamma = a + bT$ (dyn cm^{-1})

Comp. (mol % KNO_3)	a	$b \cdot 10^2$
40.00	150.9	6.70
46.15	150.2	−6.69
51.85	148.3	−6.50
57.14	146.3	−6.25
66.66	145.4	−6.20
71.40	146.4	−6.37
82.35	147.0	−6.00
91.89	146.8	−6.34
100	154.2	−7.30

Reference: [41]

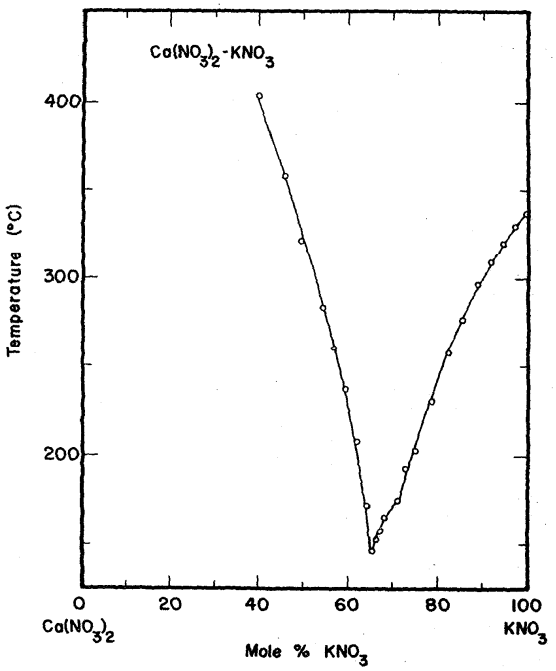

FIGURE 19. Temperature–composition phase diagram for $Ca(NO_3)_2$–KNO_3.

P. I. Protsenko and A. G. Bergman, Zh. Obshch. Khim. **20**, 1365 (1950).

$Ca(NO_3)_2$–$NaNO_3$

Electrical Conductance

$Ca(NO_3)_2$ has not been investigated. Twenty-six investigations of $NaNO_3$ [1 (p. 25), 9, 21, 24, 29, 75, 83, 89, 100, 104, 111, 112, 117, 120, 125, 128, 129] have been reported. Some experimental aspects of the conductance measurements are discussed in the section on KNO_3–$NaNO_3$.

De Nooijer [123], measured the specific conductance of molten $Ca(NO_3)_2$–$NaNO_3$ mixtures using the classical ac technique. His results for pure $NaNO_3$ and mixtures containing 10, 25, and 50 mole percent $Ca(NO_3)_2$, covering a temperature range from 550 to 695 K, are given in table 36(a) for the experimental compositions at rounded temperatures. The corresponding temperature-dependent equations are given in table 36(b). The experimental uncertainty of the results of De Nooijer is estimated to be about 0.4 percent. The values for $NaNO_3$ agree with the recommendations [1] to within 0.62 to 0.45 percent.

For discussion of the melt preparation and experimental technique of De Nooijer see the section on $CsNO_3$–KNO_3.

Density

$Ca(NO_3)_2$ has not been investigated. Sixteen investigations of $NaNO_3$ [1 (p. 26), 9, 12, 25, 27, 71, 86, 95, 97, 115, 117, 118, 130] have been reported. Revised recommendations for $NaNO_3$ are based on the work of McAuley, Rhodes and Ubbleohde [25] and together with some experimental aspects are discussed in the section $NaNO_3$–$RbNO_3$.

McAuley, Rhodes, and Ubbelohde [25] used a manometric densitometer to measure equivalent volumes of molten $Ca(NO_3)_2$–$NaNO_3$ mixtures, in the temperature range from 525 K to 690 K for pure $NaNO_3$ and mixtures containing 3.55, 7.98, 10.93, 16.18, 22.99, 27.23, 33.09, and 44.63 mole percent $Ca(NO_3)_2$. The values are given in table 37(a) for the experimental compositions at rounded temperatures using a one-dimensional statistical analysis of the density data, recalculated from the reported molar volume equations. The corresponding temperature-dependent equations are given in table 37(b). The experimental uncertainty of the results of McAuley, Rhodes and Ubbelohde is estimated to be about 0.3 percent.

The melt preparation of McAuley, Rhodes and Ubbelohde is discussed in the section on $Ba(NO_3)_2$–$NaNO_3$, the experimental technique is in the section on $NaNO_3$–$RbNO_3$.

Surface Tension

One investigation of the surface tension of $Ca(NO_3)_2$ [2 (p. 69)] and eight investigations of $NaNO_3$ [2 (p. 67), 41, 92] have been reported.

Eliseeva, Popovskaya and Protsenko [41] used the maximum bubble pressure method to measure the surface tension of molten $Ca(NO_3)_2$–$NaNO_3$ mixtures, in the temperature range from close to the melting point up to 450 °C for mixtures up to 46 mole percent $Ca(NO_3)_2$ and for pure $NaNO_3$. The results were recalculated using a two-dimensional statistical analysis; the values in the form of a temperature-composition-surface tension matrix are in table 37.1(a) for rounded compositions and temperatures; the corresponding statistical parameters are given in table 37.1(b).

The experimental aspects of the investigation of Eliseeva, Popovskaya and Protsenko [41] have been discussed previously.

The values for $NaNO_3$ agree with the recommendations [2] to within −3.24 to −3.94 percent.

TABLE 36(a). $Ca(NO_3)_2$–$NaNO_3$: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

Mole percent $NaNO_3$

T(K)	100	90	75	50
550			0.3155	
560			0.3487	
570			0.3820	0.2722
580		0.7314	0.4153	0.2951
590		0.7721	0.4488	0.3176
600		0.8126	0.4823	0.3396
610	1.1072	0.8528	0.5159	0.3612
620	1.1513	0.8929	0.5495	0.3824
630	1.1949	0.9327	0.5833	0.4031
640	1.2380	0.9723	0.6171	0.4234
650	1.2806	1.0117	0.6510	
660	1.3228	1.0509	0.6850	
670	1.3644	1.0899	0.7190	
680	1.4055	1.1286		
690	1.4461	1.1671		

TABLE 36(b). Temperature-dependent equations

$\kappa = a + bT + cT^2$ (ohm^{-1} cm^{-1})

Comp. (mol % $NaNO_3$)	a	$b \cdot 10^3$	$c \cdot 10^6$	Stand. error of est. (percent)
50	−1.7551	4.8003	−2.1816	0.0011 = 0.31
75	−1.3922	2.8933	0.3847	0.0001 − 0.02
90	−1.9995	5.3362	−1.0825	0.0027 = 0.28
100	−2.5247	7.4713	−2.4877	0.0011 = 0.09

Reference: [123]

TABLE 37(a). $Ca(NO_3)_2$–$NaNO_3$: Density

Numerical values (g cm^{-3})

Mole percent $NaNO_3$

T(K)	100	96.5	92.0	89.1	83.8	77.0	72.8	66.9	55.4
530						2.023	2.033	2.045	
540						2.016	2.026	2.038	
550					2.019	2.009	2.019	2.031	
560					2.012	2.002	2.012	2.024	
570				1.961	2.005	1.995	2.005	2.018	
580			1.941	1.954	1.997	1.988	1.998	2.011	
590		1.920	1.934	1.946	1.990	1.981	1.991	2.004	
600	1.905	1.913	1.927	1.939	1.983	1.974	1.985	1.997	
610	1.898	1.905	1.920	1.931	1.975	1.967	1.978	1.991	
620	1.891	1.898	1.913	1.924	1.968	1.960	1.971	1.984	
630	1.884	1.891	1.905	1.916	1.961	1.953	1.964	1.977	2.005
640	1.876	1.884	1.898	1.909	1.953	1.946	1.957	1.970	1.998
650	1.869	1.876	1.891	1.901	1.946	1.938			1.991
660	1.862	1.869	1.884	1.894	1.939	1.931			1.985
670	1.855	1.862	1.877	1.886	1.932				
680	1.847	1.855	1.870						
690	1.840								
700	1.833								
710	1.826								
720	1.819								

TABLE 37(b). Temperature-dependent equations

$\rho = a + bT$ (g cm^{-3})

Comp. (mol % $NaNO_3$)	a	$b \cdot 10^3$	Stand. error of est. (percent)
55.4	2.4269	−0.67000	0.0003 = 0.02
66.9	2.4017	−0.67378	0.0003 = 0.01
72.8	2.3956	−0.68497	0.0004 = 0.02
77.0	2.3980	−0.70703	0.0006 = 0.03
83.8	2.4226	−0.73297	0.0003 = 0.02
89.1	2.3920	−0.75530	0.0004 = 0.02
92.0	2.3573	−0.71727	0.0004 = 0.02
96.5	2.3475	−0.72485	0.0003 = 0.02
100	2.3384	−0.72198	0.0005 = 0.03

Reference: [25]

TABLE 37.1(a). $Ca(NO_3)_2$–$NaNO_3$: Surface tension

Numerical values (dyn cm^{-1})

	Mole percent $NaNO_3$										
T(K)	100	95	90	85	80	75	70	65	60	55	70.2
530							119.3				
540						118.3	118.8				118.7
550					117.4	117.8	118.2				118.2
560				116.6	116.9	117.2	117.6	118.1			117.6
570				116.1	116.3	116.6	117.0	117.5			117.0
580			115.4	115.5	115.8	116.1	116.4	116.9			116.4
590	114.7	114.7	114.8	115.0	115.2	115.5	115.9	116.3	116.8		115.9
600	114.2	114.2	114.3	114.5	114.7	115.0	115.3	115.7	116.2		115.3
610	113.6	113.7	113.8	113.9	114.1	114.4	114.7	115.1	115.5		114.7
620	113.1	113.1	113.2	113.4	113.6	113.8	114.1	114.5	114.9		114.1
630	112.6	112.6	112.7	112.8	113.0	113.3	113.6	113.9	114.3		113.6
640	112.0	112.1	112.2	112.3	112.5	112.7	113.0	113.3	113.7	114.2	113.0
650	111.5	111.5	111.6	111.7	111.9	112.1	112.4	112.7	113.1	113.5	112.4
660	111.0	111.0	111.1	111.2	111.4	111.6	111.8	112.1	112.5	112.9	111.8
670	110.4	110.5	110.5	110.6	110.8	111.0	111.3	111.5	111.9	112.3	111.2
680	109.9	109.9	110.0	110.1	110.3	110.4	110.7	111.0	111.3	111.6	110.7
690	109.4	109.4	109.5	109.6			110.1	110.4	110.7	111.0	110.1
700	108.8	108.9	108.9								
710	108.3										
720	107.8										

TABLE 37.1(b). Two-dimensional equation and statistical parameters

$\gamma = a + bT + cC^2 + dTC^2$ (dyn cm^{-1})

a	$b \cdot 10^2$	$c \cdot 10^3$	$d \cdot 10^6$	Max. percent departure	Stand. error of est.
146.19339	−5.33522	4.10095	−4.77749	0.51 (588.2 K, 0.0 mol % $Ca(NO_3)_2$)	0.183 (0.16%)

Reference: [41]

C = mole percent $Ca(NO_3)_2$

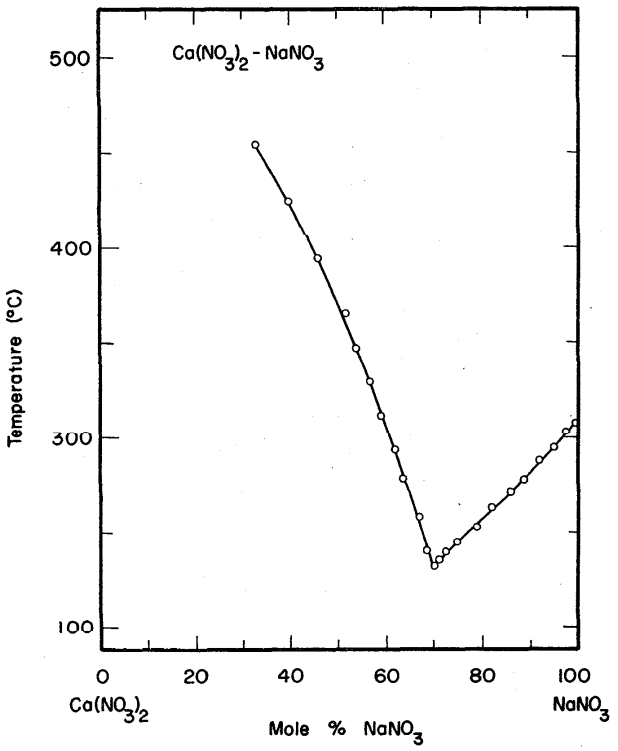

FIGURE 20. Temperature – composition phase diagram for $Ca(NO_3)_2$–$NaNO_3$.

P. I. Protsenko and A. G. Bergman, Zh. Obshch. Khim. **20**, 1365 (1950).

$Cd(NO_3)_2$–$CsNO_3$

Electrical Conductance

$Cd(NO_3)_2$ has not been investigated. Seven investigations of $CsNO_3$ [1 (p. 28), 125, 126, 127, 129] have been reported. Some experimental aspects of the conductance measurements of $CsNO_3$ are discussed in the section on $CsNO_3$–KNO_3.

Protsenko and Popovskaya [121] measured the specific conductance of molten $Cd(NO_3)_2$–$CsNO_3$ mixtures using the classical ac technique. Their results for fifteen different mixtures (33.3 to 78.8 mole percent $CsNO_3$), covering a temperature range from 430 to 590 K, are given in table 38(a) for the experimental compositions at rounded temperatures. The corresponding temperature-dependent equations are given in table 38(b). The values in brackets, for the mixtures containing 33.3, 40, and 78.8 mole percent $CsNO_3$, indicate that these are based on rather limited data. The large standard errors are mainly attributed to the large temperature range involved and to the fact that the values reported by the authors are already recalculated data. The experimental uncertainty of the results of Protsenko and Popovskaya is estimated to be about 0.4 percent.

For discussion of the experimental technique of Protsenko and Popovskaya see the section on KNO_3–$RbNO_3$. No information is given by the authors relative to melt preparation.

Surface Tension

$Cd(NO_3)_2$ has not been investigated. Four investigations of $CsNO_3$ have been reported [2 (p. 68), 41].

Popovskaya and Eliseeva [84] used the maximum bubble pressure method to measure the surface tension of molten $Cd(NO_3)_2$–$CsNO_3$ mixtures in the temperature range from the melting point up to 620 K, for 26.08, 33.33, 37.39, 46.15, 51.85, 60.13, 61.84, 66.66, 75.0, 85.7, 88.7, and 100 mole percent $CsNO_3$. The results of a two-dimensional statistical analysis of these data are given in table 39(a) as a temperature-composition-surface tension matrix. at rounded temperatures. The corresponding statistical parameters are given in table 39(b).

Some of the experimental aspects of the investigation of Popovskaya and Eliseeva [84] are as follows: Reagent grade $Cd(NO_3)_2$ and $RbNO_3$ were recrystallized twice. The cadmium nitrate was vacuum dried at 5 mm Hg at 380–430 K. Before measurements of surface tension were commenced a rapid current of dry N_2 was passed through the melt for 1 hour. A Pt/Ir capillary with diam. ~ 0.6 mm was used and the depth of immersion was about 0.2 mm. At least two series of measurements were taken for each melt. The upper temperature was determined by the thermal stability of the cadmium nitrate. The experimental uncertainty is estimated to be ± 0.7 percent.

TABLE 38(a). $Cd(NO_3)_2$–$CsNO_3$: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

Mole percent $CsNO_3$

T(K)	78.8	76.9	75	73	71	68.9	66.7	64.4	62.1	59.6	57.1	51.9	46.2	40	33.3
430										0.031	0.026				
440										0.042	0.037				
450					0.061	0.060	0.059	0.057	0.054	0.053	0.049				
460					0.074	0.073	0.072	0.070	0.067	0.065	0.061				
470				0.086	0.087	0.086	0.085	0.084	0.080	0.078	0.074	0.059			
480				0.101	0.100	0.100	0.099	0.097	0.094	0.090	0.087	0.073			
490			0.117	0.115	0.114	0.114	0.113	0.111	0.108	0.104	0.100	0.087			
500			0.133	0.130	0.128	0.129	0.127	0.126	0.122	0.118	0.114	0.102			
510		0.150	0.149	0.146	0.143	0.143	0.142	0.140	0.137	0.132	0.129	0.117	0.098		
520		0.167	0.165	0.161	0.159	0.159	0.157	0.155	0.152	0.147	0.143	0.132	0.114		
530		0.183	0.181	0.177	0.175	0.174	0.172	0.171	0.167	0.162	0.159	0.148	0.131		
540		0.200	0.198	0.193	0.191	0.190	0.188	0.187	0.183	0.178	0.174	0.165	0.147		
550	(0.220)	0.217	0.214	0.210	0.208	0.207	0.205	0.203	0.199	0.194	0.190	0.181	0.164	(0.143)	
560	(0.238)	0.234	0.231	0.226	0.225	0.223	0.221	0.219	0.215	0.211	0.207	0.199	0.181	(0.160)	
570	(0.256)	0.251	0.248	0.243	0.243	0.241	0.238	0.236	0.232	0.228	0.224	0.216	0.199	(0.178)	(0.147)
580	(0.275)	0.268	0.266	0.261	0.262	0.258	0.256	0.253	0.249	0.246	0.241	0.234	0.216	(0.196)	(0.166)
590	(0.294)	0.285	0.283	0.278		0.276	0.274	0.270	0.267	0.264	0.259	0.253	0.234	(0.215)	(0.184)

TABLE 38(b). Temperature-dependent equations

$\kappa = a + bT + cT^2$ (ohm^{-1} cm^{-1})

Comp. (mol % $CsNO_3$)	a	$b \cdot 10^3$	$c \cdot 10^6$	Stand. error of est. (percent)
33.3	(−0.9074)	(1.8500)	(0)	(0.0000)
40	(0.0204)	(−1.2562)	(2.6877)	(0.0000)
46.2	−0.4221	0.4268	1.1620	0.0001 = 0.06
51.9	−0.0882	−0.7207	2.2013	0.0009 = 0.61
57.1	−0.0501	−0.7547	2.1666	0.0021 = 1.84
59.6	−0.0009	−0.9351	2.3449	0.0014 = 1.06
62.1	−0.1433	−0.3878	1.8363	0.0018 = 1.18
64.4	−0.1762	−0.2476	1.7028	0.0013 = 0.84
66.7	−0.1013	−0.5395	1.9923	0.0007 = 0.44
68.9	−0.1245	−0.4528	1.9180	0.0008 = 0.50
71	0.0206	−1.0332	2.4976	0.0008 = 0.53
73	−0.2780	0.1172	1.3988	0.0007 = 0.40
75	−0.3986	0.5507	1.0250	0.0010 = 0.50
76.9	−0.6045	1.2999	0.3526	0.0005 = 0.23
78.8	(0.0882)	(−1.2436)	(2.6985)	(0.0000)

Reference: [121]

TABLE 39(a). $Cd(NO_3)_2$–$CsNO_3$: Surface tension

Numerical values (dyn cm^{-1})

Mole percent $CsNO_3$

T(K)	80	70	60	50	40	30	60.6
450							99.2
460		99.7	98.4				98.4
470		99.0	97.6				97.7
480		98.2	96.8				96.9
490		97.5	95.0				96.1
500		96.7	95.2				95.3
510	98.0	96.0	94.5				94.5
520	97.3	95.2	93.7	92.9			93.8
530	96.6	94.5	92.9	92.1			93.0
540	95.9	93.7	92.1	91.3	91.4		92.2
550	95.1	93.0	91.4	90.5	90.6	91.7	91.5
560	94.4	92.3	90.6	89.7	89.8	90.9	90.7
570	93.7	91.5	89.9	89.0	89.0	90.1	90.0
580	93.0	90.8	89.1	88.2	88.2	89.3	89.2
590	92.3	90.1	88.4	87.4	87.4	88.5	88.5
600	91.6	89.3	87.6	86.7	86.6	87.7	87.7
610	90.9	88.6	86.9	85.9	85.8	86.9	87.0
620	90.2	87.9	86.2	85.2	85.1	86.1	86.2
630	89.5	87.2	85.4	84.4	84.3	85.3	85.5

TABLE 39(b). Two-dimensional equation and statistical parameters

$\gamma = a + bT + cC^3 + dCT + eCT^2$ (dyn cm^{-1})

a	$b \cdot 10^2$	$c \cdot 10^5$	$d \cdot 10^4$	$e \cdot 10^7$	Max. percent departure	Stand. error of est.
137.32062	−6.71623	3.06490	−7.76669	5.05566	−0.47% (580 K; 73.92 mol % $Cd(NO_3)_2$)	0.232 (0.25%)

Reference: [84]

C = mole percent $Cd(NO_3)_2$

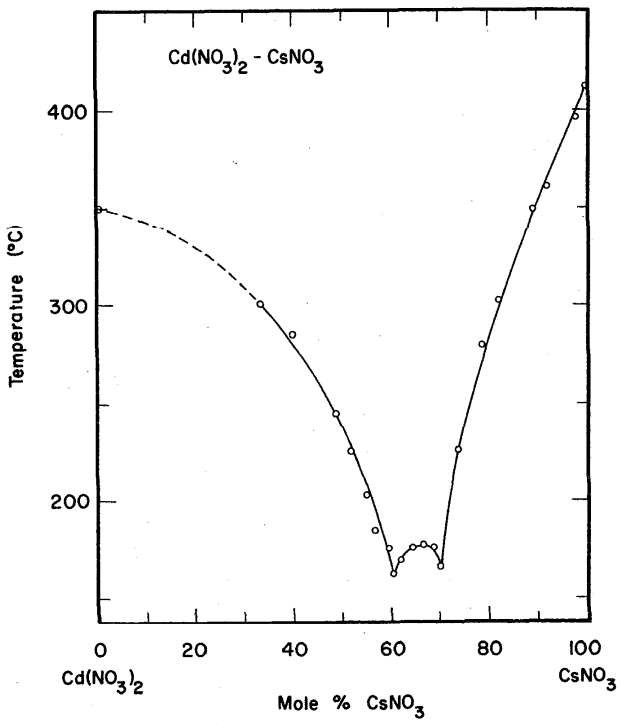

FIGURE 21. Temperature – composition phase diagram for $Cd(NO_3)_2$–$CsNO_3$.

P. I. Protsenko and V. V. Rubleva, Zh. Obshch. Khim. **25**, 238 (1955).

$Cd(NO_3)_2$–KNO_3

Electrical Conductance

$Cd(NO_3)_2$ has not been investigated. Twenty-seven investigations of KNO_3 [1 (p. 26), 9, 23, 24, 29, 82, 89, 90, 94, 100, 107, 116, 117, 121, 122, 129] have been reported. Revised recommendations for KNO_3 are based on the work of Robbins and Braunstein [122] and together with some experimental aspects are discussed in the section on KNO_3–$RbNO_3$.

Protsenko and Popovskaya [113] measured the specific conductance of molten $Cd(NO_3)_2$–KNO_3 mixtures using the classical ac technique. The results for 19 different mixtures (40 to 94.7 mole percent KNO_3), covering a temperature range from 453.2 to 593 K, are given in table 40 for the compositions and temperatures reported by Protsenko and Popovskaya. A statistical analysis to produce values at rounded temperatures was unsatisfactory. The experimental uncertainty of the results of Protsenko and Popovskaya is estimated to be about 0.4 percent.

For discussion of the experimental technique of Protsenko and Popovskaya see the section on KNO_3–$RbNO_3$. No information is given by the authors relative to melt preparation.

Density

Nineteen investigations of the density of KNO_3 [1 (p. 26), 4, 9, 12, 25, 27, 110, 115, 118, 130] have been reported. $Cd(NO_3)_2$ has not been investigated. Some experimental aspects of the density measurements of KNO_3 are discussed in the section on KNO_3–$NaNO_3$.

Popovskaya and Protsenko [142] used the Archimedean method to measure the density of molten $Cd(NO_3)_2$–KNO_3 mixtures in the temperature range from 453 to 573 K for sixteen mixture compositions. The results were recalculated using a two-dimensional statistical analysis; the values in the form of a temperature-composition-density matrix are in table 40.1(a) at rounded compositions and temperatures. The corresponding statistical parameters are given in table 40.1(b). Owing to the limited information an uncertainty estimate for the results of Popovskaya and Protsenko is not possible. The results for $AgNO_3$ deviate from the newly recommended values [24] (−0.55 to −0.67 percent) and from the recommendations [1] (−0.32 to −0.56 percent).

Popovskaya and Protsenko [142] used for their measurements a steel ball-bearing calibrated in KNO_3, $NaNO_3$, and mixtures of the two. The steel ball-bearing was heated in KNO_3 at 400 to 425 °C until its volume reached a stable value. During this procedure its surface was oxidized, the resulting oxide film proved to be stable under the experimental conditions. No information is given by the authors relative to melt preparation.

Surface Tension

$Cd(NO_3)_2$ has not been investigated. Eight investigations of KNO_3 have been reported [2 (p. 67), 41, 84].

Popovskaya and Eliseeva [84] used the maximum bubble pressure method to measure the surface tension of molten $Cd(NO_3)_2$–KNO_3 mixtures for 26.08, 33.33, 46.15, 54.54, 66.66, 70.04, 75.0, 85.7, and 100 mole percent KNO_3. Values of surface tension at experimental compositions and rounded temperatures are given in table 41(a). The surface tension-temperature equations are reported in table 41(b). The values for KNO_3 deviate from the recommendations [2] (1.1–1.8 percent).

The experimental aspects of the work of Popovskaya and Eliseeva [84] are discussed in the section on $Cd(NO_3)_2$–$CsNO_3$.

TABLE 40. $Cd(NO_3)_2$–KNO_3: Electrical conductance
Specific conductance: Numerical values (ohm^{-1} cm^{-1})
Mol percent KNO_3

T(K)	94.7	88.8	85.7	82.3	78.7	75.0	73.0	70.9	68.8	66.6	64.8	62.0	59.6	57.1	55.0	51.8	49.0	46.1	40.0
453.2						0.099		0.089				0.070		0.047	0.040	0.034	0.030	0.022	0.010
473.2						0.140	0.133	0.128		0.116	0.110	0.102	0.088	0.079	0.071	0.062	0.053	0.044	0.023
493.2					0.206	0.188	0.183	0.177	0.165	0.161	0.151	0.142	0.130	0.117	0.109	0.098	0.083	0.074	0.050
513.2					0.253	0.235	0.230	0.224	0.212	0.206	0.196	0.183	0.168	0.159	0.149	0.136	0.116	0.103	0.072
533.2				0.331	0.303	0.290	0.285	0.271	0.265	0.251	0.240	0.237	0.220	0.203	0.191	0.177	0.155	0.139	0.104
553.2			0.390	0.380	0.350	0.340	0.330	0.318	0.311	0.297	0.289	0.274	0.265	0.253	0.238	0.222	0.199	0.182	0.142
573.2		0.460	0.450	0.438	0.410	0.393	0.390	0.370	0.360	0.347	0.341	0.326	0.312	0.306	0.292	0.271	0.245	0.229	0.184
593.2	0.560	0.530	0.509	0.490	0.480	0.452	0.443	0.428	0.420	0.406	0.391	0.384	0.370	0.353	0.340	0.330	0.302	0.280	0.230

Reference: [113]

TABLE 40.1(a) $Cd(NO_3)_2$–KNO_3: Density
Numerical values (g cm^{-3})
Mole percent KNO_3

T (K)	75	70	65	60	55	50	45	40	35	30	54.5
465								2.573			
470								2.569			
475					2.394	2.447	2.504	2.564			2.400
480				2.340	2.390	2.443	2.499	2.559	2.624		2.395
485				2.335	2.385	2.438	2.494	2.555	2.619		2.390
490				2.331	2.380	2.433	2.490	2.550	2.614		2.385
495			2.279	2.326	2.376	2.429	2.485	2.545	2.610		2.381
500			2.274	2.321	2.371	2.424	2.480	2.541	2.605		2.376
505			2.269	2.316	2.366	2.419	2.476	2.536	2.600		2.371
510			2.265	2.312	2.362	2.414	2.471	2.531	2.596		2.367
515			2.260	2.307	2.357	2.410	2.466	2.526	2.591		2.362
520			2.255	2.302	2.352	2.405	2.461	2.522	2.586		2.357
525			2.251	2.298	2.347	2.400	2.457	2.517	2.581		2.353
530			2.246	2.293	2.343	2.396	2.452	2.512	2.577		2.348
535		2.197	2.241	2.288	2.338	2.391	2.447	2.508	2.572	2.641	2.343
540		2.192	2.237	2.284	2.333	2.386	2.443	2.503	2.567	2.636	2.339
545		2.187	2.232	2.279	2.329	2.382	2.438	2.498	2.563	2.632	2.334
550		2.183	2.227	2.274	2.324	2.377	2.433	2.494	2.558	2.627	2.329
555		2.178	2.223	2.269	2.319	2.372	2.429	2.489	2.553	2.622	2.324
560	2.131	2.173	2.218	2.265	2.315	2.367	2.424	2.484	2.549	2.618	2.320
565	2.126	2.169	2.213	2.260	2.310	2.363	2.419	2.479	2.544	2.613	2.315
570	2.121	2.164	2.208	2.255	2.305	2.358	2.414	2.475	2.539	2.608	2.310

TABLE 40.1(b). Two-dimensional equation and statistical parameters
$\rho = a + bT + cC + dC^3$ (g cm^{-3})

a	$b \cdot 10^4$	$c \cdot 10^3$	$d \cdot 10^7$	Max. percent departure	Stand. error of est
2.46393	−9.39473	7.42961	4.65431	0.18 (573.2K, 42 mol % Cd $(NO_3)_2$)	0.002 (0.08%)

Reference: [142]
C = mole percent Cd $(NO_3)_2$

TABLE 41(a). $Cd(NO_3)_2$–KNO_3: Surface tension

Numerical values (dyn cm^{-1})

	Mole percent KNO_3								
T(K)	100	85.7	75.0	70.04	66.66	54.54	46.15	33.33	26.08
460			112.8			108.3			
480			111.2	109.1	108.1	106.7	105.1		
500			109.6	107.5	106.7	105.1	103.5		
520			108.0	106.0	105.2	103.5	101.9		
540		109.3	106.4	104.5	103.7	101.9	100.2		
560		107.8	104.7	103.0	102.3	100.2	98.6	97.3	
580		106.3	103.1	101.5	100.8	98.6	96.9	95.6	
600		104.7	101.5	100.0	99.3	97.0	95.3	94.0	93.4
620	108.9	103.2	99.9	98.4	97.9	95.4	93.6	92.4	91.8
640	107.5								
660	106.0								
680	104.6								
700	103.1								
720	101.6								
740	100.2								
760	98.7								
780	97.3								

TABLE 41(b). Temperature-dependent equations

$\gamma = a + bT$ (dyn cm^{-1})

Comp. (mol % KNO_3)	a	b
26.08	142.3	− 0.0815
33.33	142.8	−0.0813
46.15	144.6	− 0.0822
54.54	145.6	− 0.0810
66.66	143.2	− 0.0731
70.04	145.5	− 0.0759
75.0	150.1	− 0.0810
85.7	150.1	− 0.0756
100.0	154.2	− 0.0730

Reference: [84]

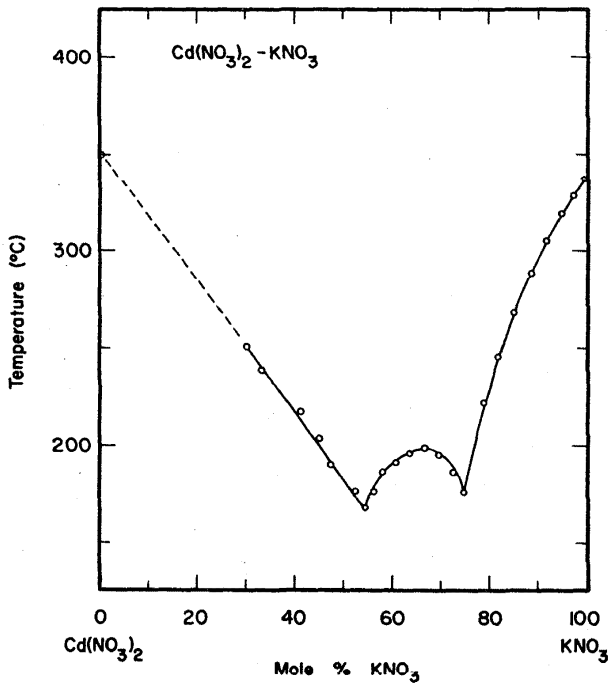

FIGURE 22. Temperature – composition phase diagram for $Cd(NO_3)_2$–KNO_3.

P. I. Protsenko, Zh. Obshch. Khim. **22**, 1313 (1952).

TABLE 42(a). $Cd(NO_3)_2$–$LiNO_3$: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

Mole percent $LiNO_3$

T(K)	100	94.7	88.9	85.7	82.4	78.8	75.0	73.0	71.0	68.9	66.7	64.9	63.5	62.1	59.6	57.1	54.5	51.9	46.2
480										0.118	0.098	0.085	0.079						
490										0.143	0.122	0.107	0.101						
500							0.221	0.205	0.182	0.170	0.148	0.132	0.125	0.107					
510							0.255	0.237	0.212	0.198	0.174	0.158	0.150	0.130					
520				0.398	0.343	0.311	0.289	0.270	0.244	0.227	0.203	0.185	0.177	0.155	0.146				
530				0.439	0.382	0.349	0.324	0.304	0.277	0.258	0.232	0.214	0.205	0.182	0.172				
540	0.841	0.609	0.507	0.480	0.422	0.387	0.360	0.339	0.311	0.290	0.263	0.244	0.235	0.211	0.200	0.182	0.167		
550	0.909	0.671	0.561	0.522	0.463	0.426	0.398	0.376	0.346	0.323	0.294	0.276	0.266	0.241	0.230	0.210	0.192		
560	0.978	0.731	0.613	0.564	0.505	0.466	0.436	0.413	0.383	0.358	0.328	0.309	0.299	0.273	0.262	0.241	0.220		
570	1.047	0.791	0.662	0.606	0.547	0.506	0.475	0.452	0.420	0.394	0.362	0.344	0.333	0.307	0.296	0.274	0.251		
580	1.117	0.849	0.708	0.649	0.591	0.546	0.515	0.492	0.459	0.431	0.398	0.381	0.369	0.343	0.332	0.310	0.285	(0.266)	(0.231)
590	1.188	0.907	0.752	0.692	0.636	0.586	0.557	0.533	0.499	0.470	0.435	0.419	0.407	0.380	0.369	0.348	0.322	(0.311)	(0.267)

TABLE 42(b). Temperature-dependent equations

$\kappa = a + bT + cT^2$ (ohm^{-1} cm^{-1})

Comp. (mol % $LiNO_3$)	a	$b \cdot 10^3$	$c \cdot 10^6$	Stand. error of est. (percent)
46.2	(−1.8575)	(3.6000)	(0)	
51.9	(−1.7355)	(3.4500)	(0)	
54.5	3.2859	−13.8937	15.0335	0.0006=0.27
57.1	2.1796	−10.1227	11.8942	0.0008=0.33
59.6	1.3621	−7.2162	9.3783	0.0007=0.30
62.1	1.1644	−6.4831	8.7355	0.0008=0.38
63.5	0.8319	−5.2650	7.7018	0.0012=0.58
64.9	0.7654	−5.0441	7.5533	0.0013=0.61
66.7	0.4038	−3.6496	6.2741	0.0010=0.43
68.9	0.4501	−3.8617	6.6019	0.0006=0.23
71.0	0.1222	−2.7661	5.7704	0.0010=0.32
73.0	0.0712	−2.5957	5.7266	0.0016=0.47
75.0	−0.1769	−1.6869	4.9663	0.0015=0.42
78.8	−1.0802	1.5620	2.1403	0.0011=0.26
82.4	−0.2863	−1.4040	5.0289	0.0007=0.15
85.7	−1.2414	2.2231	1.7868	0.0001=0.02
88.9	−6.1381	19.0800	−12.5444	0.0032=0.52
94.7	−4.2078	11.6375	−5.0315	0.0003=0.04
100	−1.9082	3.4014	3.1282	0.0008=0.08

Reference: [120]

$Cd(NO_3)_2$–$LiNO_3$

Electrical Conductance

$Cd(NO_3)_2$ has not been investigated. Twelve studies of $LiNO_3$ [1 (p. 25), 24, 29, 73, 79, 117, 120, 129] have been reported. Some experimental aspects of the conductance measurements of $LiNO_3$ are discussed in the section on KNO_3–$LiNO_3$.

Popovskaya and Protsenko [120] measured the specific conductance of molten $Cd(NO_3)_2$–$LiNO_3$ mixtures using the classical ac technique. Their results for pure $LiNO_3$ and fourteen of the 18 different mixture compositions (containing 46.2 to 94.7 mole percent $LiNO_3$), covering a temperature range from 470 to 590°, are given in table 42(a) at rounded temperatures and experimental concentrations. The corresponding temperature-dependent equations for pure $LiNO_3$ and all 18 mixtures are given in table 42(b). The values in brackets, for the mixtures containing 46.2 and 51.9 mole percent $LiNO_3$, indicate that these are based on rather limited data. The experimental uncertainty of the results of Protsenko and Popovskaya is estimated to be about 0.4 percent. The values for $LiNO_3$ deviate from the recommendations [1] (−1.65 to 3.68 percent).

For discussion of the experimental technique of Popovskaya and Protsenko see the section on KNO_3–$RbNO_3$. No information on melt preparation is given by the latter investigators.

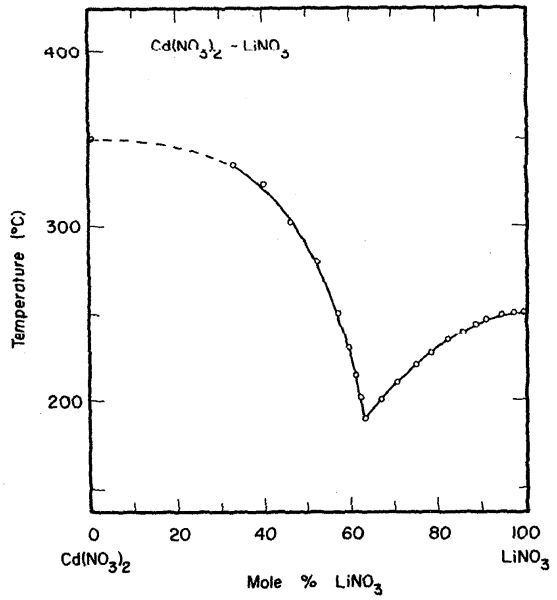

FIGURE 23. Temperature–composition phase diagram for $Cd(NO_3)_2$–$LiNO_3$.

P. I. Protsenko, Zh. Obshch. Khim. 22, 1313 (1952).

$Cd(NO_3)_2$–$NaNO_3$

Electrical Conductance

$Cd(NO_3)_2$ has not been investigated. Twenty-six investigations of $NaNO_3$ [1 (p. 25), 9, 21, 24, 29, 75, 83, 89, 100, 104, 111, 112, 117, 120, 125, 128, 129] have been reported. Some experimental aspects of the conductance measurements of $NaNO_3$ are discussed in the section on KNO_3–$NaNO_3$.

Popovskaya and Protsenko [120] measured the specific conductance of molten $Cd(NO_3)_2$–$NaNO_3$ mixtures using the classical ac technique. The results for 18 different mixture compositions (40 mole percent $NaNO_3$ to 88.9 mole percent $NaNO_3$), covering a temperature range from 453.2 to 593.2 K, are given in table 43 for the compositions and temperatures reported by Popovskaya and Protsenko. A statistical analysis to produce values at rounded temperatures was unsatisfactory. The experimental uncertainty of the results of Popovskaya and Protsenko is estimated to be about 0.4 percent.

For discussion of the experimental technique of Popovskaya and Protsenko see the section on KNO_3–$RbNO_3$. No information is given by the authors relative to melt preparation.

Surface Tension

$Cd(NO_3)_2$ has not been investigated. Eight investigations of $NaNO_3$ have been reported [2 (p. 67), 41, 92].

Eliseeva, Popovskaya and Protsenko [92] used the maximum bubble pressure method to measure the surface tension of molten $Cd(NO_3)_2$–$NaNO_3$ mixtures in the temperature range from the melting point up to 350 °C, the thermal stability point of $Cd(NO_3)_2$, for 30.51, 40.0, 52.94, 60.13, 66.66, 75.00, 77.3, 84.45, 85.70, 91.89 mole percent $NaNO_3$ and for pure $NaNO_3$. Values of surface tension at experimental compositions and rounded temperatures are given in table 44(a). The surface tension-temperature equations are reported in table 44(b). The values for $NaNO_3$ deviate from the recommendations [2] (10 percent). The experimental uncertainty of the results of Eliseeva, Popovskaya and Protsenko is estimated to be about 0.7 percent.

The experimental aspects of the work of Eliseeva, Popovskaya and Protsenko [92] are discussed in the section on $Cd(NO_3)_2$–$CsNO_3$.

TABLE 43. $Cd(NO_3)_2$–$NaNO_3$: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

Mole percent $NaNO_3$

T(K)	88.9	82.4	78.8	75.0	73.0	71.0	68.9	66.7	64.4	62.1	59.6	57.1	54.5	52.9	50.7	49.1	46.2	40.0
453.2									0.061	0.055	0.045	0.043	0.031	0.028	0.025	0.021		
473.2								0.111	0.096	0.090	0.080	0.073	0.058	0.055	0.047	0.042	0.032	
493.2							0.180	0.160	0.148	0.136	0.125	0.115	0.097	0.093	0.083	0.073	0.056	
513.2				0.306	0.284	0.266	0.243	0.219	0.203	0.190	0.176	0.158	0.141	0.132	0.120	0.125	0.088	
533.2		0.458	0.408	0.378	0.354	0.324	0.307	0.278	0.259	0.243	0.227	0.208	0.187	0.180	0.167	0.154	0.132	0.105
553.2	0.634	0.537	0.488	0.449	0.424	0.389	0.374	0.343	0.320	0.302	0.283	0.263	0.240	0.230	0.218	0.205	0.180	0.150
573.2	0.735	0.614	0.568	0.521	0.485	0.460	0.442	0.406	0.382	0.360	0.336	0.315	0.292	0.284	0.269	0.257	0.230	0.195
593.2	0.792	0.692	0.646	0.592	0.564		0.510	0.470	0.446	0.416	0.390	0.369	0.346	0.335	0.319	0.307	0.279	0.245

Reference: [120]

TABLE 44(a). $Cd(NO_3)_2$–$NaNO_3$: Surface tension

Numerical values (dyn cm^{-1})

Mole percent $NaNO_3$

T(K)	100	91.89	85.8	84.45	77.3	75.0	66.66	60.13	52.94	40.0	30.51
420									134.0		
460								133.8	132.6		
480							133.4	132.3	131.2		
500							132.0	130.9	129.8		
520					132.8	132.4	130.5	129.5	128.4		
540				132.7	131.5	131.0	129.1	128.1	127.0	125.2	
560			130.5	131.4	130.1	129.6	127.7	126.6	125.6	123.7	
580		130.9	129.2	130.0	128.7	128.2	126.3	125.2	124.2	122.2	120.2
600	131.2	129.7	127.9	128.6	127.3	126.8	124.9	123.8	125.6	120.6	118.7
620	130.0	128.4	126.6	127.2	125.9	125.4	123.5	122.3	124.2	119.1	117.1
640	128.9								122.8		
660	127.7								121.5		
680	126.5								120.1		
700	125.3										
720	124.1										
740	123.0										
760	121.8										

TABLE 44(b). Temperature-dependent equations

$\gamma = a + bT$ (dyn cm^{-1})

Comp. (mol % $NaNO_3$)	a	b
30.51	143.7	− 0.0766
40.0	145.5	− 0.0761
52.94	144.2	− 0.0696
60.13	147.1	− 0.0714
66.66	147.9	− 0.0703
75.0	149.7	− 0.0701
77.3	150.1	− 0.0699
84.45	151.0	− 0.0685
85.8	149.0	− 0.0646
91.89	150.5	− 0.0638
100.0	150.5	− 0.0590

Reference: [92]

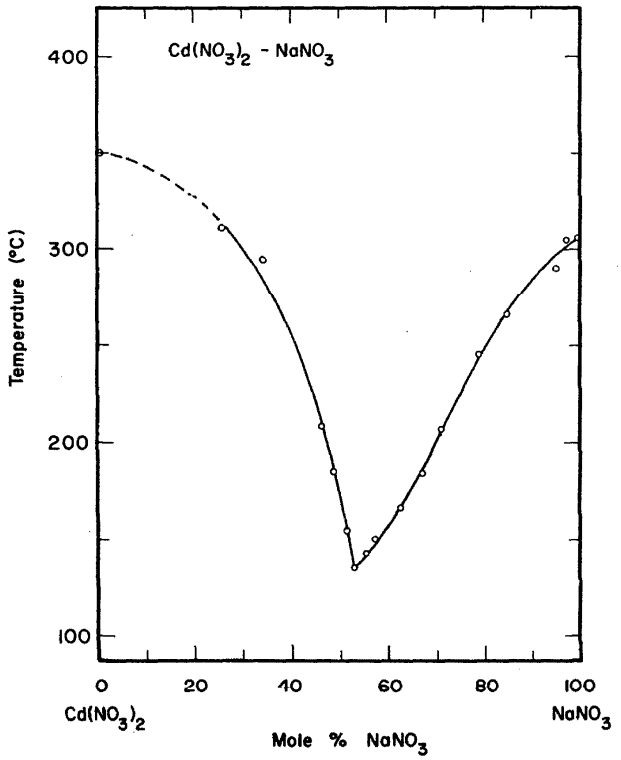

FIGURE 24. Temperature – composition phase diagram for $Cd(NO_3)_2$–$NaNO_3$.

P. I. Protsenko, Zh. Obshch. Khim. **22**, 1307 (1952).

$Cd(NO_3)_2$–$RbNO_3$

Electrical Conductance

$Cd(NO_3)_2$ has not been investigated. Eleven investigations of $RbNO_3$ [1 (p. 27), 24, 73, 88, 104, 121, 123, 125, 129, 135] have been reported. Revised recommendations for $RbNO_3$ are based on the work of Brillant [24] and together with some experimental aspects are discussed in the section on KNO_3–$RbNO_3$.

Protsenko and Popovskaya [113] measured the specific conductance of molten $Cd(NO_3)_2$–$RbNO_3$ mixtures using the classical ac technique. The results for pure KNO_3 and 20 different mixtures (33.3 to 94.7 mole percent $RbNO_3$), covering a temperature range from 453.2 to 593 K, are given in table 45 for the compositions and temperatures reported by Protsenko and Popovskaya. A statistical analysis to produce values at rounded temperatures was unsatisfactory. The experimental uncertainty of the results of Protsenko and Popovskaya is estimated to be about 0.4 percent. The value for $RbNO_3$ at 593 K deviates from our newly recommended value [24] (5.38 percent) and from the recommendation [1] (−0.70 percent).

For discussion of the experimental technique of Protsenko and Popovskaya see the section on KNO_3–$RbNO_3$. No information is given by the authors relative to melt preparation.

Surface Tension

$Cd(NO_3)_2$ has not been investigated. Three investigations of $Rb(NO_3)_2$ have been reported [2 (p. 68), 84].

Popovskaya and Eliseeva [84] used the maximum bubble pressure method to measure the surface tension of molten $Cd(NO_3)_2$–$RbNO_3$ mixtures from temperatures close to the melting point up to 630 K. Values of surface tension at the experimental compositions and rounded temperatures are given in table 46(a). The surface tension-temperature equations at the experimental compositions are given in table 46(b).

Values for pure $RbNO_3$ deviate from the recommendations [2] (0.6–0.8 percent).

The experimental aspects of the investigations of Popovskaya and Eliseeva [84] are discussed in the section on $Cd(NO_3)_2$–$CsNO_3$.

TABLE 45. $Cd(NO_3)_2$–$RbNO_3$: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

	Mole percent $RbNO_3$																							
T(K)	100	94.7	88.8	82.3	78.7	76.9	75.0	73.0	70.9	68.8	66.6	64.4	62.0	59.6	57.1	54.5	51.8	49.0	46.1	40.0	33.3
453.2				0.085	0.080	0.079	0.076	0.072	0.065	0.062	0.061	0.059	0.060	0.054	0.048						
473.2				0.115	0.110	0.106	0.102	0.100	0.100	0.099	0.099	0.088	0.089	0.079	0.075						
493.2				0.154	0.145	0.142	0.139	0.139	0.129	0.129	0.125	0.124	0.121	0.112	0.106	0.102					
513.2			0.204	0.196	0.186	0.184	0.181	0.175	0.178	0.170	0.167	0.162	0.160	0.149	0.142	0.136	0.126				
533.2			0.246	0.235	0.226	0.222	0.221	0.222	0.217	0.210	0.206	0.202	0.200	0.186	0.180	0.165	0.162	0.142			
553.2		0.310	0.297	0.285	0.275	0.268	0.265	0.264	0.262	0.255	0.242	0.245	0.241	0.228	0.220	0.216	0.202	0.182	0.177		
573.2		0.410	0.340	0.325	0.320	0.310	0.310	0.308	0.307	0.295	0.287	0.285	0.282	0.268	0.257	0.250	0.240	0.224	0.200	0.184	
593.2	0.438	0.520	0.400	0.385	0.368	0.362	0.352	0.352	0.350	0.343	0.338	0.325	0.320	0.312	0.300	0.290	0.284	0.265	0.260	0.226	0.199

Reference: [113]

TABLE 46(a). $Cd(NO_3)_2$–$RbNO_3$: Surface tension

Numerical values (dyn cm^{-1})

Mole percent $RbNO_3$

T(K)	100	91.89	84.39	77.30	69.28	66.66	58.65	49.62	33.33	26.08
410							108.4			
430				110.8			106.9			
450				109.3			105.4			
470				107.8		106.5	103.8			
490				106.3	102.0	105.0	102.3	101.0		
510			105.9	104.7	100.5	103.6	100.8	99.5		
530			104.4	103.2	99.0	102.1	99.3	98.0		
550		105.0	103.0	101.7	97.5	100.6	97.7	96.5		
570		103.6	101.6	100.2	96.0	99.2	96.2	95.0	94.5	
590		102.1	100.1	98.7	94.5	97.7	94.7	93.5	93.0	92.8
610	105.4	100.7	98.7	97.2	93.0	96.3	93.2	92.0	91.6	91.4
630	104.0		97.2	95.6	91.5	94.8	91.6	90.5	90.1	89.9
650	102.6									
670	101.2									
690	99.8									
710	98.4									
730	97.0									

TABLE 46(b). Temperature-dependent equations

$\gamma = a + bT$ (dyn cm^{-1})

Comp. (mol % $RbNO_3$)	a	b
26.08	135.9	− 0.0730
33.33	136.7	− 0.0740
49.62	137.7	− 0.0750
58.65	139.7	− 0.0763
66.66	140.8	− 0.0730
69.28	138.8	− 0.0750
77.30	143.4	− 0.0758
84.39	142.6	− 0.0720
91.89	145.2	− 0.0730
100.0	148.1	− 0.0700

Reference: [84]

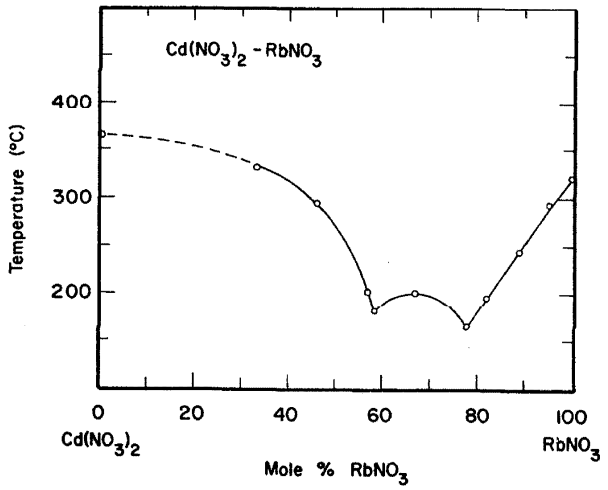

FIGURE 25. Temperature – composition phase diagram for $Cd(NO_3)_2$–$RbNO_3$.

P. I. Protsenko and N. P. Popovskaya, Zh. Obshch. Khim. **23**, 1246 (1953).

TABLE 47(a). $Cd(NO_3)_2$–$TlNO_3$: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

Mole percent $TlNO_3$

T(K)	100	94.7	91.9	88.9	85.7	82.4	78.8	76.9	75	73	71	68.9	66.7	64.4	62.1	59.6	57.1	51.9	46.2
370									0.021	0.018	0.015								
380									0.038	0.034	0.030								
390									0.055	0.050	0.046	0.034	0.026						
400									0.073	0.067	0.062	0.050	0.041						
410						0.112	0.096	0.093	0.092	0.085	0.079	0.066	0.057						
420						0.134	0.118	0.112	0.111	0.103	0.097	0.084	0.073						
430					0.164	0.156	0.139	0.131	0.130	0.122	0.115	0.102	0.090	0.075					
440					0.188	0.179	0.161	0.152	0.150	0.142	0.134	0.120	0.108	0.093					
450			0.242	0.231	0.212	0.202	0.183	0.173	0.170	0.162	0.153	0.139	0.126	0.112					
460			0.268	0.256	0.237	0.224	0.206	0.195	0.191	0.182	0.173	0.158	0.145	0.132					
470		0.309	0.293	0.281	0.261	0.248	0.229	0.217	0.213	0.203	0.194	0.179	0.164	0.152	0.142	0.129			
480		0.334	0.318	0.331	0.286	0.271	0.252	0.240	0.235	0.225	0.215	0.199	0.184	0.172	0.163	0.150			
490	0.388	0.359	0.344	0.306	0.310	0.294	0.275	0.264	0.257	0.247	0.237	0.220	0.205	0.193	0.184	0.171	0.157		
500	0.413	0.384	0.369	0.356	0.335	0.318	0.298	0.289	0.280	0.270	0.259	0.242	0.226	0.214	0.205	0.192	0.178		
510	0.438	0.409	0.394	0.381	0.359	0.342	0.322	0.314	0.304	0.293	0.282	0.265	0.248	0.235	0.227	0.213	0.199	0.164	
520	0.464	0.434	0.419	0.406	0.384	0.366	0.346	0.339	0.328	0.317	0.305	0.288	0.270	0.257	0.249	0.235	0.220	0.186	
530	0.489	0.459	0.444	0.431	0.409	0.390	0.370	0.366	0.352	0.341	0.329	0.311	0.293	0.280	0.271	0.257	0.242	0.208	
540	0.515	0.483	0.469	0.455	0.434	0.415	0.394		0.377	0.366	0.354	0.335	0.317	0.303	0.293	0.279	0.264	0.230	
550	0.540	0.508	0.493	0.480	0.459	0.439	0.418		0.402	0.392	0.379	0.360	0.341	0.326	0.316	0.301	0.287	0.252	(0.213)
560	0.565	0.533	0.518	0.505	0.484	0.464	0.443		0.428	0.418	0.404	0.385	0.365	0.349	0.339	0.324	0.310	0.275	(0.234)
570	0.591	0.558	0.543	0.529	0.509	0.489	0.468		0.455	0.445	0.431	0.411	0.391	0.374	0.362	0.347	0.333	0.297	(0.254)

$Cd(NO_3)_2$–$TlNO_3$

Electrical Conductance

$Cd(NO_3)_2$ has not been investigated. Seventeen investigations of $TlNO_3$ [1 (p. 25), 24, 27, 74, 89, 103, 104, 112, 117, 121] have been reported. Some experimental aspects of the conductance measurements of $TlNO_3$ are discussed in the section on $NaNO_3$–$TlNO_3$.

Protsenko and Popovskaya [121] measured the specific conductance of molten $Cd(NO_3)_2$–$TlNO_3$ mixtures using the classical ac technique. Their results for pure $TlNO_3$ and 18 different mixture concentrations up to mixtures containing 53.8 mole percent $Cd(NO_3)_2$, covering a temperature range from 370 to 570 K, are given in table 47(a) for the experimental concentrations at rounded temperatures. The corresponding temperature-dependent equations are given in table 47(b). The values in brackets, for the mixture containing 53.8 mole percent $TlNO_3$, indicate that these are based on rather limited data. The larger standard errors are mainly attributed to the large temperature range involved and to the fact that the values reported by the authors are already recalculated data. The experimental uncertainty of the results of Protsenko and Popovskaya is estimated to be about 0.4 percent. The values for pure $TlNO_3$ deviate from the recommendations [1] (1.96 to 3.96 percent).

For a discussion of the experimental technique of Protsenko and Popovskaya see the section on KNO_3–$RbNO_3$. No information on melt preparation is given by the latter investigators.

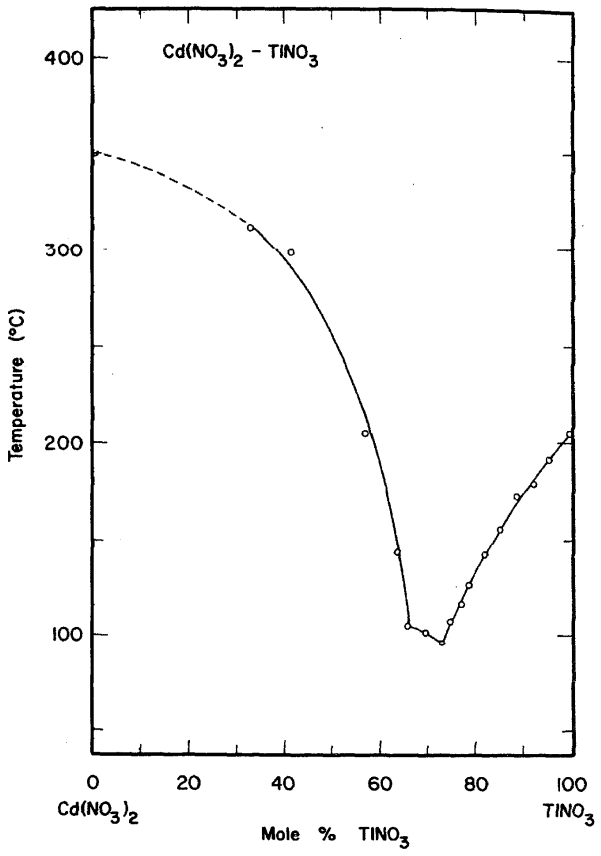

FIGURE 26. Temperature – composition phase diagram for $Cd(NO_3)_2$–$TlNO_3$.

P. I. Protsenko and V. V. Rubleva, Zh. Obshch. Khim. **25**, 238 (1955).

TABLE 47(b). Temperature-dependent equations

$\kappa = a + bT + cT^2$ (ohm^{-1} cm^{-1})

Comp. (mol % $TlNO_3$)	a	$b \cdot 10^3$	$c \cdot 10^6$	Stand. error of est. (percent)
46.2	(−0.9141)	(2.0501)	(0)	(0.0000)
51.9	−0.8668	1.8474	0.3407	0.0001 = 0.04
57.1	−0.4217	0.3064	1.7851	0.0007 = 0.29
59.6	−0.5587	0.8747	1.2529	0.0004 = 0.17
62.1	−0.5746	0.9662	1.1866	0.0003 = 0.12
64.4	−0.3298	0.0383	2.0977	0.0017 = 0.79
66.7	−0.1065	−0.8171	2.9638	0.0028 = 1.52
68.9	−0.1562	−0.6139	2.8216	0.0030 = 1.51
71	−0.1448	−0.6393	2.8931	0.0044 = 2.27
73	−0.1786	−0.5112	2.8159	0.0046 = 2.27
75	−0.2491	−0.2047	2.5261	0.0051 = 2.39
76.9	−0.1134	−0.8715	3.3507	0.0031 = 1.43
78.8	−0.5869	1.1908	1.1583	0.0023 = 0.84
82.4	−0.6366	1.4411	0.9367	0.0023 = 0.78
85.7	−0.8050	2.0927	0.3733	0.0005 = 0.15
88.9	−0.9518	2.7402	−0.2488	0.0001 = 0.03
91.9	−0.9741	2.8624	−0.3530	0.0006 = 0.15
94.7	−0.8820	2.5706	−0.0777	0.0003 = 0.07
100	−0.8572	2.5412	−0.0011	0.0005 = 0.10

Reference: [121]

$CsNO_3$–KNO_3

Electrical Conductance

Seven investigations of the specific conductance of $CsNO_3$ [1 (p. 28), 125, 126, 127, 129] and 27 investigations of KNO_3 [1 (p. 26), 9, 23, 24, 29, 82, 89, 90, 94, 100, 107, 116, 117, 121, 122, 129] have been reported. Some experimental aspects of the conductance measurements of $CsNO_3$ are as follows: The classical ac technique was used by most investigators [1, 125, 126], whereas a modified potentiometric ac technique was used by Bizouard, Cerisier and Pantaloni [127]. The use of capillary cells is reported by De Nooijer [123], Protsenko and coworkers [125, 126] and Smith and Artsdalen [1], whereas Jaeger and Kapma [1] carried out their investigations with a Pt-crucible cell. In the work of Smith and Artsdalen [1] a Jones bridge was used. $CsNO_3$ was prepared by adding an excess of $AgNO_3$ to an aqueous solution of CsCl and filtering from the precipitated AgCl. The excess $AgNO_3$ was removed with H_2S and the $CsNO_3$ purified by recrystallization. After preliminary drying, it was dehydrated under high vacuum for 18 h at 330 °C. Revised

recommendations for KNO_3 are based on the work of Robbins and Braunstein [122] and together with some experimental aspects are discussed in the sections on KNO_3–$RbNO_3$ and KNO_3–$NaNO_3$.

De Nooijer [123] measured the specific conductance of molten $CsNO_3$–KNO_3 mixtures using the classical ac technique. His results for the single components and 25, 50 and 75 mole percent mixtures, covering a temperature range from 575 to 740 K, are given in table 48(a) for the experimental concentrations at rounded temperatures. The corresponding temperature-dependent equations are given in table 48(b). The experimental uncertainty of the results of De Nooijer is estimated to be about 0.4 percent. The results for KNO_3 deviate from our newly recommended values [316] (−0.65 to 0.41 percent) and from the recommendations [1] (−1.38 to −0.01 percent), whereas the results for $CsNO_3$ agree with the recommendations [1] to within −0.53 to −0.17 percent.

De Nooijer [123] used a Jones bridge and a capillary dip cell made from pyrex (for systems containing $LiNO_3$) or Jena-glass (for all other systems). A notable corrosion of pyrex by melts containing $LiNO_3$ was observed. However, this did not affect the experimental results. All substances being either reagent grade ($LiNO_3$, $NaNO_3$, KNO_3, $AgNO_3$) or chemically pure ($RbNO_3$, $CsNO_3$, $TlNO_3$, $Ca(NO_3)_2$, $Sr(NO_3)_2$, $Ba(NO_3)_2$ were submitted (except $LiNO_3$) to drying at 110 °C. $LiNO_3$, only available as $LiNO_3 \cdot 3H_2O$, was first submitted to drying in a vacuum-desiccator at 120 °C and then transferred to a dry box for storage. Mixtures were premelted and stored in a vacuum desiccator.

Density

Seven investigations of the density of $CsNO_3$ [1 (p. 28), 25, 48, 86, 109, 118] and 19 investigations of KNO_3 [1 (p. 26), 4, 9, 12, 25, 27, 110, 115, 118, 130] have been reported. Some experimental aspects of the density measurements are discussed in the sections on $CsNO_3$–$NaNO_3$ and KNO_3–$NaNO_3$.

Murgulescu and Zuca [118] used the Archimedean method to measure the density of molten $CsNO_3$–KNO_3 mixtures, in the temperature range 565 to 795 K for 75, 50 and 25 mole percent mixtures and for the single components. The results were recalculated using a two-dimensional statistical analysis; the values in the form of a temperature-composition-density matrix are in table 49(a) at rounded compositions and temperatures. The corresponding statistical parameters are given in table 49(b). The experimental uncertainty of the results of Murgulescu and Zuca is estimated to be about 0.4 percent. The results for $CsNO_3$ and KNO_3 deviate from the recommendations [1] (−0.32 to −0.24 percent) and (0.08 to −0.13 percent) respectively.

For melt preparation of Murgulescu and Zuca see the discussion of viscosity in the section on $CsNO_3$–KNO_3. The experimental procedure is discussed in the section on $NaNO_3$–$RbNO_3$.

TABLE 48(a). $CsNO_3$–KNO_3: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

T(K)	Mole percent KNO_3 100	75	50	25	0
580			0.3861		
590		0.4645	0.4117		
600		0.4926	0.4371		
610		0.5206	0.4623		
620	0.6413	0.5486	0.4873		
630	0.6748	0.5764	0.5122		
640	0.7077	0.6041	0.5369	0.4792	
650	0.7402	0.6318	0.5615	0.4992	
660	0.7722	0.6593	0.5858	0.5199	
670	0.8037	0.6868	0.6100	0.5413	
680	0.8347		0.6340	0.5633	
690	0.8652				
700	0.8953				0.5578
710	0.9248				0.5767
720	0.9539				0.5957
730	0.9825				0.6146
740					0.6335

TABLE 48(b). Temperature-dependent equations

$\kappa = a + bT + cT^2$ (ohm^{-1} cm^{-1})

Comp. (mol % KNO_3)	a	$b \cdot 10^3$	$c \cdot 10^6$	Stand. error of est. (percent)
0	−0.7663	1.8917	0	0.0008 = 0.14
25	0.6470	−2.4900	3.4808	0.0008 = 0.15
50	−1.3892	3.5572	−0.8556	0.0015 = 0.29
75	−1.3689	3.3968	−0.4905	0.0010 = 0.18
100	−2.3824	6.3849	−2.4322	0.0013 = 0.16

Reference: [123]

Viscosity

Five investigations of the viscosity of $CsNO_3$ [1 (p. 28), 48, 118, 119] and 13 investigations of KNO_3 [1 (p. 27), 48, 86, 107, 118, 119] have been reported. Revised recommendations for $CsNO_3$ and KNO_3 are based on the work of Timidei, Lederman and Janz [119] and together with some experimental aspects are discussed in the sections on $CsNO_3$–$LiNO_3$ and KNO_3–$NaNO_3$.

Murgulescu and Zuca [118] used the oscillating ball technique to measure the viscosity of molten $CsNO_3$–KNO_3 mixtures (25, 50, and 75 mol percent KNO_3 for a temperature range from 570–770 K). The data are given at rounded temperatures and experimental concentrations in table 50(a). The corresponding temperature-dependent equations are in table 50(b). The experimental uncertainty of the results of Murgulescu and Zuca is estimated to be larger than 2.5 percent. The results for $CsNO_3$ deviate from our newly recommended values [119] (8.4 to 9.4 percent) and from the recommendations [1] (1.5 to 8.2 percent), whereas the values for KNO_3 agree with the recommended values [1] to within −1.2 to −0.4 percent.

TABLE 49(a). $CsNO_3$–KNO_3: Density

Numerical values (g cm^{-3})

Mole percent KNO_3

T(K)	100	90	80	70	60	50	40	30	20	10	0	60
575				2.26	2.37	2.47						2.37
590			2.14	2.25	2.36	2.46	2.56					2.36
605		2.01	2.13	2.24	2.34	2.44	2.54	2.64				2.34
620		2.00	2.11	2.22	2.33	2.43	2.53	2.62				2.33
635	1.87	1.98	2.10	2.21	2.32	2.42	2.52	2.61	2.70			2.32
650	1.85	1.97	2.08	2.20	2.30	2.40	2.50	2.60	2.69			2.30
665	1.84	1.96	2.07	2.18	2.29	2.39	2.49	2.58	2.67	2.76		2.29
680	1.82	1.94	2.06	2.17	2.27	2.38	2.48	2.57	2.66	2.74		2.27
695	1.81	1.93	2.04	2.15	2.26	2.36	2.46	2.55	2.64	2.73	2.81	2.26
710	1.80	1.92	2.03	2.14	2.25	2.35	2.45	2.54	2.63	2.71	2.79	2.25
725	1.78	1.90	2.02	2.13	2.23	2.33	2.43	2.52	2.61	2.69	2.77	2.23
740	1.77	1.89	2.01	2.11	2.22	2.32	2.42	2.51	2.59	2.68	2.75	2.22
755	1.76	1.88	1.99	2.10	2.21	2.31	2.40	2.49	2.58	2.66	2.73	2.21
770			1.98	2.09	2.19	2.29	2.38	2.47	2.56	2.64	2.71	2.19
785										2.62	2.69	

TABLE 49(b). Two-dimensional equation and statistical parameters

$\rho = a + bT + cC + dTC^2$ (g cm^{-3})

a	$b \cdot 10^4$	$c \cdot 10^2$	$d \cdot 10^8$	Max. percent departure	Stand. error of est.
2.41752	−8.72597	1.20939	−3.13370	0.60% (626.2 K, 100 mol % KNO_3)	0.005 (0.22%)

Reference: [118]
C = mole percent $CsNO_3$

In the work of Murgulescu and Zuca [118] $CsNO_3$ and KNO_3 (Merck reagent grade) were predried for 24 h at 150 °C and melted in dried nitrogen gas. The experimental procedure is discussed in the section on KNO_3–$NaNO_3$.

Surface Tension

Three investigations of the surface tension of $CsNO_3$ [2 (p. 68)] and eight investigations of KNO_3 [2 (p. 67), 41, 84] have been reported.

Bertozzi and Sternheim [26] used the Wilhelmy slide plate method to measure the surface tension of molten $CsNO_3$–KNO_3 mixtures, in the temperature range from the melting point up to 400 °C, for 25, 50, and 75 mole percent mixtures and for the single components. Surface tension-temperature equations are reported in table 51 for the experimental compositions.

The experimental aspects of the investigations of Bertozzi and Sternheim [26] have been discussed previously [2 (p. 67)].

TABLE 50(a). $CsNO_3$–KNO_3: Viscosity

Numerical values (cp)

Mole percent KNO_3

T(K)	100	75	50	25	0
580			3.794		
590			3.553		
600		3.177	3.334		
610		2.982	3.135		
620		2.802	2.954		
630	2.606	2.639	2.789	2.881	
640	2.460	2.492	2.637	2.752	
650	2.336	2.356	2.499	2.628	
660	2.217	2.232	2.371	2.509	
670	2.107	2.116	2.254	2.395	
680	2.005	2.012	2.145	2.285	
690	1.912	1.914	2.045	2.180	
700	1.825	1.824	1.952	2.080	2.307
710	1.744	1.741	1.865	1.985	2.187
720	1.700	1.663	1.785	1.895	2.076
730	1.600	1.592	1.710	1.810	1.974
740	1.534	1.524	1.641	1.730	1.879
750	1.473	1.462	1.576	1.656	1.793
760	1.416	1.403	1.515	1.586	1.711
770	1.363	1.349	1.457	1.522	1.635

TABLE 50(b). Temperature-dependent equations

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

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

Comp. (mol % KNO_3)	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. (percent)
0					5.236	5263	0.0177 = 0.92
25	18.0970	−3.1817	6.7689	8.5664			0.0239 = 1.15
50					7.851	4467	0.0329 = 1.50
75					6.704	4625	0.0137 = 0.68
100					7.375	4461	0.0101 = 0.55

Reference: [118]

TABLE 51. $CsNO_3$–KNO_3: Surface tension

Temperature-dependent equations

$\gamma = a - bT$ (dyn cm^{-1})

Mol % $CsNO_3$	a	$b \cdot 10^2$
0	161.9	8.1
25	155.3	7.9
50	150.4	7.7
75	145.3	7.4
100	142.3	7.4

Reference: [26]

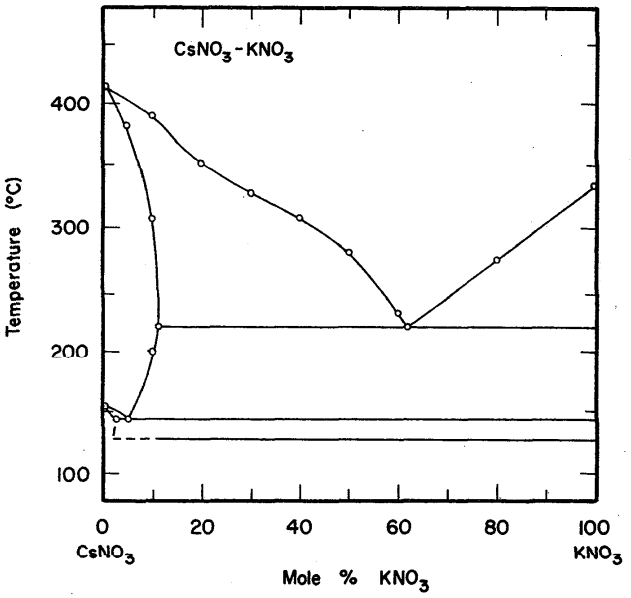

FIGURE 27. Temperature – composition phase diagram for $CsNO_3$–KNO_3.

K. A. Bol'shakov, B. I. Pokrovskii, and V. E. Plyushchev, Zh. Neorg. Khim. 6 (9), 2120 (1961).

$CsNO_3$–$LiNO_3$

Electrical Conductance

Seven studies of the specific conductance of $CsNO_3$ [1 (p. 28), 125, 126, 127, 129] and 12 investigations of $LiNO_3$ [1 (p. 25), 24, 29, 73, 79, 117, 120, 129] have been reported. Some experimental aspects of the conductance measurements of $CsNO_3$ and $LiNO_3$ are discussed in the sections on $CsNO_3$–KNO_3 and KNO_3–$LiNO_3$, respectively.

De Nooijer [123] measured the specific conductance of molten $CsNO_3$–$LiNO_3$ mixtures using the classical ac technique. His results for the single components and 25, 50, and 75 mole percent mixtures, covering a temperature range from 525 to 740 K, are given in table 52(a) for the experimental compositions at

TABLE 52(a). $CsNO_3$–$LiNO_3$: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

	Mole percent $LiNO_3$				
T(K)	100	75	50	25	0
530			0.3207		
540			0.3483		
550			0.3758		
560			0.4031		
570		0.6373	0.4303	0.3487	
580	1.0895	0.6717	0.4572	0.3690	
590	1.1477	0.7062	0.4840	0.3894	
600	1.2049	0.7406	0.5107	0.4098	
610	1.2613	0.7750	0.5371	0.4302	
620	1.3166	0.8095	0.5634	0.4505	
630	1.3711	0.8439	0.5895	0.4709	
640	1.4246	0.8783	0.6155	0.4913	
650	1.4771	0.9128		0.5117	
660	1.5288			0.5320	
670	1.5795				
680	1.6292				
690	1.6781				
700					0.5578
710					0.5767
720					0.5957
730					0.6146
740					0.6335

rounded temperatures. The corresponding temperature-dependent equations are given in table 52(b). The experimental uncertainty of the results of De Nooijer is estimated to be about 0.4 percent. The values for $CsNO_3$ and $LiNO_3$ agree with the recommendations [1] to within −0.53 to −0.17 percent and −0.44 to −0.24

For discussion of the melt preparation and experimental technique of De Nooijer see the section on $CsNO_3$–KNO_3.

TABLE 52(b). Temperature-dependent equations

$\kappa = a + bT + cT^2$ (ohm^{-1} cm^{-1})

Comp. (mol % $LiNO_3$)	a	$b \cdot 10^3$	$c \cdot 10^6$	Stand. error of est. (percent)
0	−0.7663	1.8917	0	0.0008 = 0.14
25	−0.8126	2.0373	0	0.0019 = 0.44
50	−1.3866	3.6696	−0.8460	0.0030 = 0.64
75	−1.3253	3.4432	0	0.0010 = 0.13
100	−3.8855	11.2903	−4.6769	0.0014 = 0.36

Reference: [123]

Density

Seven studies of the density of $CsNO_3$ [1 (p. 28), 25, 48, 86, 109, 118] and seven investigations of $LiNO_3$ [1 (p. 25), 9, 24, 86, 117, 143] have been reported. Some experimental aspects of the density measurements of $CsNO_3$ and $LiNO_3$ are discussed in the sections on $CsNO_3$–$NaNO_3$ and KNO_3–$LiNO_3$, respectively.

The density of binary $CsNO_3$–$LiNO_3$ mixtures has been measured by two groups [86, 109] using the Archimedean method. The results of Murgulescu and Zuca [86] for 20, 40, 60, and 80 mole percent mixtures and the single components, covering the temperature range 510–795 K, are recommended as the "best" values. The results of a two-dimensional statistical analysis of these data are given in table 53(a) as a temperature-composition-density matrix, at rounded compositions and temperatures. The corresponding statistical parameters are given in table 53(b). The experimental uncertainty of the results of Murgulescu and Zuca is estimated to be about 0.4 percent. The values for $CsNO_3$ and $LiNO_3$ agree with the recommendations [1] to within −0.32 to −0.24 percent and 0.29 to 0.30 percent, respectively. Other results for three different mixtures and pure $CsNO_3$ over a temperature range from 550 to 825 K, are reported by James and Liu [109]. The values for $CsNO_3$ alone and a mixture containing 80 mole percent $LiNO_3$ agree with the corresponding results of Murgulescu and Zuca to within −0.07 to −0.04 percent and 0.08 to 0.11 percent respectively.

The experimental method used by Murgulescu and Zuca [86] is the same as reported in their later publication [118] and is discussed in the section on $NaNO_3$–$RbNO_3$. For melt preparation see the following discussion of viscosity in this section.

Viscosity

Five studies of the viscosity of $CsNO_3$ [1 (p. 28), 48, 118, 119] and five investigations of $LiNO_3$ [1 (p. 25), 48] have been reported. Most recently the viscosity of $CsNO_3$ has been studied by Timidei, Lederman and

TABLE 53 (a). $CsNO_3$ – $LiNO_3$: Density

Numerical values (g cm^{-3})

Mole percent $LiNO_3$

T(K)	100	90	80	70	60	50	40	30	20	10	0	57
515					2.41							2.45
530			2.11	2.26	2.40	2.52	2.65					2.44
545		1.95	2.10	2.25	2.38	2.51	2.63					2.42
560	1.78	1.94	2.09	2.24	2.37	2.50	2.62	2.73				2.41
575	1.77	1.93	2.08	2.22	2.36	2.48	2.60	2.71	2.81			2.40
590	1.76	1.92	2.07	2.21	2.35	2.47	2.59	2.69	2.79			2.38
605	1.75	1.91	2.06	2.20	2.33	2.46	2.57	2.68	2.77			2.37
620	1.74	1.80	2.05	2.19	2.32	2.44	2.56	2.66	2.76			2.36
635	1.73	1.89	2.04	2.18	2.31	2.43	2.54	2.65	2.74	2.82		2.35
650	1.72	1.88	2.03	2.17	2.30	2.42	2.53	2.63	2.72	2.80		2.33
665	1.71	1.87	2.02	2.16	2.28	2.40	2.51	2.61	2.70	2.78		2.32
680	1.70	1.85	2.00	2.14	2.27	2.39	2.50	2.60	2.69	2.76		2.31
695	1.68	1.84	1.99	2.13	2.26	2.38	2.49	2.58	2.67	2.74	2.81	2.30
710						2.36	2.47	2.57	2.65	2.72	2.79	
725							2.46			2.70	2.77	
740										2.68	2.74	
755											2.72	
770											2.70	
785											2.68	

TABLE 53(b). Two-dimensional equation and Statistical parameters

$\rho = a + bT + cC + dTC^2$ (g cm^{-3})

a	$b \cdot 10^4$	$c \cdot 10^2$	$d \cdot 10^8$	Max. percent departure	Stand. error of est.
2.17212	− 7.02122	1.64810	− 7.52613	1.26% (525.2 K, 40 mol % $CsNO_3$	0.014 (0.61 %)

Reference: [86]
C = mole percent $CsNO_3$

Janz [119] using a capillary viscometer-assembly. The results obtained in this investigation show deviations from the recommendations [1] ranging from −5.3 to 1.9 percent, the percent departure increasing with increasing temperatures. The results of this investigation are recommended as "best" values, the uncertainty being about 1.8 percent. The equation $\eta(\text{cp}) = 41.5319 - 6.96361 \cdot 10^{-2}T - 2.34803 \cdot 10^{5}T^2 + 6.0738 \cdot 10^{-8}T^3$ describes the temperature-dependence of the viscosity in the range from 684 to 739 K with a standard error of 0.0344 = 1.75 percent.

Some additional experimental aspects of the viscosity measurements of $CsNO_3$ are as follows:

Protsenko and Razumovskaya [1] used a pyrex capillary viscometer. In the investigation by Timidei, Lederman and Janz [119] $CsNO_3$ and KNO_3 (Fisher certified reagent grade) were recrystallized from conductance water, vacuum oven dried at 110 °C and stored over P_2O_5 in a vacuum desiccator. The viscometer was calibrated with *n*-hexane and *n*-decane at 25 °C, and the effect of thermal expansion on the viscosity-measurement was evaluated using both the coefficients of linear and cubic expansion of pyrex and assuming proportionality between viscosity and the fourth power of the capillary diameter. A surface tension effect of about 0.47 percent in the change from the calibrating liquids to molten salts was considered. Some experimental aspects of the viscosity measurements of $LiNO_3$ are discussed in the section on $LiNO_3$–$NaNO_3$.

Murgulescu and Zuca [86] used the oscillating ball technique to measure the viscosity of molten $CsNO_3$–$LiNO_3$ mixtures. The results for the single components and 20, 40, 60, and 80 mole percent mixtures, covering a temperature range from 530 to 770 K, are given in table 54(a) for the experimental compositions at rounded temperatures, the corresponding least squares equations are given in table 54(b). For $CsNO_3$ the values reported by the same authors in another publication [118] have been selected. They deviate from our newly recommended values [119] (8.4 to 9.4 percent) and from the recommendations [1] (1.5 to 8.2 percent). The results for $LiNO_3$ show deviations from the recommendations [1] ranging from −16.7 to 4.5 percent. Considering these deviations and the minimum information about the preparation of both $LiNO_3$ and $CsNO_3$ used for the binary mixtures, an uncertainty estimate is not possible.

Only limited information concerning the melt preparation of Murgulescu and Zuca is available. For the viscosity measurements of $CsNO_3$ reported by the same authors [118] the salt (Merck p.a. reagent grade) was predried for 24 h at 150 °C and melted in dried nitrogen gas. The experimental procedure is discussed in the section on KNO_3–$NaNO_3$.

TABLE 54 (a). $CsNO_3 - LiNO_3$: Viscosity

Numerical values (cp)

	Mole percent $LiNO_3$					
T(K)	100	80	60	40	20	0
530		4.837	4.240			
540		4.504	3.982			
550	4.946	4.194	3.737	3.985		
560	4.637	3.907	3.508	3.711		
570	4.344	3.641	3.293	3.459		
580	4.068	3.397	3.094	3.230	3.748	
590	3.809	3.175	2.909	3.021	3.500	
600	3.567	2.973	2.740	2.833	3.273	
610	3.342	2.791	2.587	2.666	3.065	
620	3.135	2.629	2.449	2.518	2.877	
630	2.947	2.487	2.325	2.390	2.709	
640	2.776	2.364	2.223	2.281	2.563	
650	2.624	2.258	2.134	2.190	2.437	
660	2.490	2.171	2.063	2.118	2.333	
670	2.376	2.100	2.008	2.063	2.252	
680	2.281	2.048	1.970	2.026	2.192	
690	2.205	2.012	1.950	2.005	2.155	
700						2.307
710						2.187
720						2.076
730						1.974
740						1.879
750						1.793
760						1.711
770						1.635

TABLE 54(b). Temperature-dependent equations

$$\eta = a + bT + cT^2 + dT^3 \text{ (cp)}$$

$$\eta = A \cdot \exp(E/RT) \text{ (cp)}$$

Comp. (mol % $LiNO_3$)	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. (percent)
0					5.236	5263	0.0177 = 0.92
20	38.5403	−7.3499	−1.2566	6.1831			0.0248 = 0.94
40	65.3870	−21.629	22.2930	−7.0961			0.0621 = 2.47
60	33.1341	−7.2774	1.6158	3.4508			0.0790 = 3.06
80	67.8034	−22.507	24.129	−7.8146			0.0395 = 1.42
100	39.8180	−8.2245	1.0941	4.2394			0.0209 = 0.67

Reference: [86] for binary mixtures and 100 mole percent $LiNO_3$
[118] for 100 mole percent $CsNO_3$

Surface Tension

Three investigations of the surface tension of $CsNO_3$ and three investigations of $LiNO_3$ have been reported [2 (pp. 68 and 67), respectively].

Bertozzi and Sternheim [26] used the Wilhelmy slide plate method to measure the surface tension of molten $CsNO_3$–$LiNO_3$ mixtures, in the temperature range from the melting point up to 400 °C, for 25, 50, and 75 mole percent mixtures and for the single components. The results of a two-dimensional statistical analysis of these data are given in table 55(a) as a temperature-composition-surface tension matrix, at rounded temperatures. The corresponding statistical parameters are given in table 55(b). The data of Bertozzi and Sternheim for the single components show percent departures from the recommendations [2] by −0.6 to 1.1 percent.

The experimental aspects of the investigations of Bertozzi and Sternheim [26] have been discussed previously [2 (p. 67)].

TABLE 55(a). $CsNO_3$–$LiNO_3$: Surface tension

Numerical values (dyn cm^{-1})

Mole percent $LiNO_3$

T(K)	100	90	80	70	60	50	40	30	20	10	0	57.0
460					109.9							109.7
475				110.0	108.7	108.2						108.5
490				109.0	107.6	107.0	107.1					107.3
505			110.1	107.9	106.4	105.7	105.8					106.2
520			109.1	106.8	105.3	104.5	104.5					105.0
535	115.1	111.2	108.1	105.8	104.2	103.3	103.3					103.8
550	114.3	110.3	107.2	104.7	103.1	102.2	102.0	102.6				102.7
565	113.4	109.4	106.2	103.7	102.0	101.0	100.8	101.3				101.6
580	112.6	108.5	105.2	102.7	100.9	99.8	99.6	100.0				100.5
595	111.8	107.6	104.3	101.6	99.8	98.7	98.3	98.8	99.9			99.4
610	110.9	106.7	103.3	100.6	98.7	97.6	97.2	97.5	98.6			98.3
625	110.1	105.8	102.3	99.6	97.7	96.4	96.0	96.3	97.4			97.2
640	109.2	104.9	101.4	98.6	96.6	95.3	94.8	95.1	96.1			96.1
655	108.4	104.1	100.5	97.6	95.6	94.3	93.7	93.9	94.9			95.1
670	107.6	103.2	99.5	96.7	94.5	93.2	92.6	92.7	93.7			94.1

TABLE 55(b). Two-dimensional equation and statistical parameters

$$\gamma = a + bC^2 + CT + dTC + eCT^2 \text{ (dyn cm}^{-1}\text{)}$$

a	$b \cdot 10^3$	$c \cdot 10^2$	$d \cdot 10^3$	$e \cdot 10^7$	Max. percent departure	Standard error of est.
145.04079	3.78881	−5.59470	−1.11977	6.08869	−1.56% (673 K; 50 mol % $CsNO_3$)	0.930 (0.9%)

Reference: [26]
C = mol percent $CsNO_3$

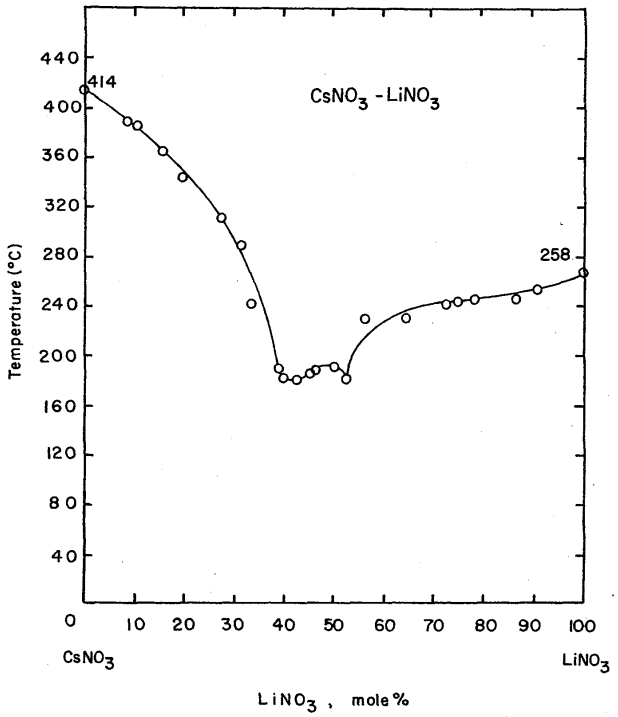

FIGURE 28. Temperature – composition phase diagram for $CsNO_3$–$LiNO_3$.

K. A. Bol'shakov, B. I. Pokrovskii, and V. E. Plyushchev, Russ. J. Inorg. Chem. 1084 (1961).

$CsNO_3$–$NaNO_3$

Electrical Conductance

Seven investigations of the specific conductance of $CsNO_3$ [1 (p. 28), 125, 126, 127, 129] and 26 investigations of $NaNO_3$ [1 (p. 25), 9, 21, 24, 29, 75, 83, 89, 100, 104, 111, 112, 117, 120, 125, 128, 129] have been reported. Some experimental aspects of the conductance measurements of $CsNO_3$ and $NaNO_3$ are discussed in the sections on $CsNO_3$–KNO_3 and KNO_3–$NaNO_3$, respectively.

The specific conductance of molten $CsNO_3$–$NaNO_3$ mixtures has been measured by three groups [123, 125, 134], using the classical ac technique. The results of De Nooijer [123] for the single components and 25, 50, and 75 mole percent mixtures, covering a temperature range from 565 to 740 K, are recommended as the "best" values and are given in table 56(a) for the experimental concentrations at rounded temperatures. The corresponding temperature-dependent equations are given in table 56(b). The experimental uncertainty of the results of DeNooijer is estimated to be about 0.4 percent. The results for $CsNO_3$ and $NaNO_3$ deviate from the recommendations [1] (−0.53 to −0.17 percent) and (−0.62 to 0.45 percent), respectively.

Wagner, Berra, and Forcheri [134] reported data for 3.1, 3.4, and 100 mole percent $NaNO_3$ between 585.2 and 673.2 K. Their results for $NaNO_3$ deviate from the values of De Nooijer within 0.28 to 2.02 percent.

TABLE 56(a). $CsNO_3$–$NaNO_3$: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

Mole percent $NaNO_3$

T(K)	100	75	50	25	0
570			0.4375		
580			0.4662		
590			0.4944		
600		0.6976	0.5223		
610	1.1072	0.7320	0.5499	0.4482	
620	1.1513	0.7660	0.5771	0.4710	
630	1.1949	0.7996	0.6040	0.4936	
640	1.2380	0.8328	0.6305	0.5161	
650	1.2806	0.8656	0.6567	0.5384	
660	1.3228	0.8981	0.6825	0.5605	
670	1.3644	0.9301	0.7079	0.5825	
680	1.4055	0.9618		0.6043	
690	1.4461				
700					0.5578
710					0.5767
720					0.5957
730					0.6146
740					0.6335

TABLE 56(b). Temperature-dependent equations

$\kappa = a + bT + cT^2$ (ohm^{-1} cm^{-1})

Comp. (mol % $NaNO_3$)	a	$b \cdot 10^3$	$c \cdot 10^6$	Stand. error of est. (percent)
0	−0.7663	1.8917	0	0.0008 = 0.14
25	−1.2608	3.3143	−0.8404	0.0003 = 0.06
50	−1.7716	4.8724	−1.7487	0.0002 = 0.04
75	−2.0770	5.7915	−1.9452	0.0007 = 0.08
100	−2.5247	7.4713	−2.4877	0.0011 = 0.09

Reference: [123]

Popovskaya, Protsenko, and Eliseeva [125] measured the conductance of 10, 20, 30, 40, 50, 60, 70, 80, and 90 mole percent mixtures as well as the single components for 593.2 K, 653.2 K, and 693.2 K, but the results are reported graphically, and cannot be critically assessed.

For discussion of the melt preparation and experimental technique of De Nooijer see the section on $CsNO_3$–KNO_3.

Density

Seven investigations of the density of $CsNO_3$ [1 (p. 28), 25, 48, 86, 109, 118] and 16 investigations of $NaNO_3$ [1 (p. 26), 9, 12, 25, 27, 71, 86, 95, 97, 115, 117, 118, 130] have been reported.

Most of the $CsNO_3$ density investigations [1, 86, 109, 118] are based on the Archimedean method using Pt-bobs, but no study reports a correction of the density data due to the surface tension effects on the suspension wire. A manometric densitometer was used by Mc-

Auley, Rhodes, and Ubbelohde [25]. For further details see the section on $NaNO_3$–$RbNO_3$.

Murgulescu and Zuca [118] used the Archimedean method to measure the density of molten $CsNO_3$–$NaNO_3$ mixtures, in the temperature range from 520 to 795 K for 25, 50, and 75 mole percent mixtures and for the single components. The results were recalculated using a two-dimensional statistical analysis; the values in the form of a temperature-composition-density matrix are in table 57(a) at rounded compositions and temperatures. The corresponding statistical parameters are given in table 57(b). The experimental uncertainty of the results of Murgulescu and Zuca is estimated to be about 0.4 percent. The results for $NaNO_3$ deviate from our newly recommended values [25] (1.10 to 1.31 percent) and from the recommendations [1] (0.15 to 0.19 percent). Powers, Katz and Kleppa [124] measured the excess volumes in binary $CsNO_3$–$NaNO_3$ mixtures at 425° C. The excess volumes can also be calculated from the above results of Murgulescu and Zuca, and the molar volume data for $NaNO_3$ [25] and $CsNO_3$ [1]. Comparison shows that the results of Powers, Katz and Kleppa deviate by as much as 200 percent from the values thus gained.

For melt preparation of Murgulescu and Zuca [118] see the section on $CsNO_3$–$LiNO_3$. The experimental procedure is discussed in the section on $NaNO_3$–$RbNO_3$.

Viscosity

Five investigations of the viscosity of $CsNO_3$ [1 (p. 28), 48, 118, 119] and 11 investigations of $NaNO_3$ [1 (p. 26), 48, 56, 71, 86, 118] have been reported. Revised recommendations for $CsNO_3$ are based on the work of Timidei, Lederman and Janz [119] and together with some experimental aspects are discussed in the section on $CsNO_3$–$LiNO_3$. Some experimental aspects of the viscosity measurements of $NaNO_3$ are discussed in the section on KNO_3–$NaNO_3$.

Murgulescu and Zuca [118] used the oscillating ball technique to measure the viscosity of molten $CsNO_3$–$NaNO_3$ mixtures (25, 50, and 75 mole percent $NaNO_3$

TABLE 57(a). $CsNO_3$–$NaNO_3$: Density

Numerical values (g cm^{-3})

Mole percent $NaNO_3$

T(K)	100	90	80	70	60	50	40	30	20	10	0	55
545			2.21	2.33	2.44							
560			2.20	2.32	2.43	2.53						2.48
575		2.05	2.18	2.31	2.42	2.52	2.61					2.47
590		2.04	2.17	2.30	2.41	2.51	2.60					2.45
605	1.90	2.03	2.16	2.28	2.39	2.50	2.59	2.67				2.44
620	1.89	2.02	2.15	2.27	2.38	2.48	2.57	2.66				2.43
635	1.88	2.01	2.14	2.26	2.37	2.47	2.56	2.64	2.72			2.41
650	1.87	2.00	2.13	2.24	2.35	2.45	2.55	2.63	2.71			2.40
665	1.86	1.99	2.11	2.23	2.34	2.44	2.53	2.62	2.69	2.76		2.39
680	1.84	1.97	2.10	2.21	2.32	2.42	2.51	2.60	2.68	2.75		2.37
695	1.83	1.96	2.08	2.20	2.31	2.41	2.50	2.58	2.66	2.73	2.79	2.36
710	1.82	1.95	2.07	2.18	2.29	2.39	2.48	2.57	2.64	2.72	2.78	2.34
725	1.81	1.93	2.05	2.16	2.27	2.37	2.46	2.55	2.63	2.70	2.77	2.33
740	1.79			2.15	2.25	2.35	2.44	2.53	2.61	2.68	2.75	2.31
755								2.51	2.59	2.67	2.73	
770									2.57	2.65	2.72	
785											2.70	

TABLE 57(b). Two-dimensional equation and statistical parameters

$$\rho = a + bT + cC + dC^2 + eT^3 + fCT + gC^2T \text{ (g cm}^{-3}\text{)}$$

a	$b \cdot 10^4$	$c \cdot 10^2$	$d \cdot 10^4$	$e \cdot 10^{10}$	$f \cdot 10^5$	$g \cdot 10^8$	Max. percent departure	Standard error of est.
1.96887	1.13681	2.08394	−1.04197	−6.44721	−1.08458	0.70898	0.91% (732.2 K, 75 mol % $NaNO_3$)	0.008 (0.35%)

Reference: [118]

C = mole percent $CsNO_3$

for a temperature range 570–750 K). The values are given for rounded temperatures and experimental compositions in table 58(a) the corresponding viscosity-temperature equations are in table 58(b). The experimental uncertainty of the results of Murgulescu and Zuca is estimated to be about (2.5 percent). The results for $CsNO_3$ deviate from our newly recommended values [119] (8.4 to 9.4 percent) and from the recommendations [1] (1.5 to 8.2 percent). The values for $NaNO_3$ agree with the recommendations [1] to within −0.4 to 0.3 percent.

In the work of Murgulescu and Zuca [118] $CsNO_3$ and $NaNO_3$ (Merck p.a. reagent grade) were predried for 24 h at 150 °C and melted under a dry nitrogen atmosphere. The experimental procedure is discussed in the section on KNO_3–$NaNO_3$.

Surface Tension

Three investigations of the surface tension of $CsNO_3$ [2 (p. 68)] and eight investigations of $NaNO_3$ [2 (p. 67), 41, 92] have been reported.

Bertozzi and Sternheim [26] used the Wilhelmy slide plate method to measure the surface tension of molten $CsNO_3$–$NaNO_3$ mixtures in the temperature range from the melting point up to 400 °C for 25, 50, and 75 mole percent mixtures and for the single components. Surface tension-temperature equations are reported in table 59 for the experimental compositions.

The experimental aspects of the investigations of Bertozzi and Sternheim [26] have been discussed previously [2 (p. 67)].

TABLE 58(a). $CsNO_3$–$NaNO_3$: Viscosity

Numerical values (cp)

	Mole percent $NaNO_3$				
T(K)	100	75	50	25	0
580		3.267	3.383		
590		3.080	3.177		
600	2.708	2.903	2.992	3.209	
610	2.573	2.735	2.820	3.033	
620	2.445	2.578	2.666	2.873	
630	2.323	2.429	2.523	2.725	
640	2.209	2.291	2.393	2.589	
650	2.101	2.163	2.273	2.463	
660	2.000	2.044	2.162	2.347	
670	1.907	1.935	2.060	2.241	
680	1.821	1.836	1.965	2.141	
690	1.744	1.746	1.878	2.049	
700	1.675	1.666	1.797	1.963	2.307
710	1.613	1.596	1.721	1.884	2.187
720	1.560	1.536	1.650	1.809	2.076
730	1.517	1.485	1.584	1.740	1.974
740	1.482	1.445	1.523	1.674	1.879
750					1.793
760					1.711
770					1.635

TABLE 58(b). Temperature-dependent equations

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

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

Comp. (mol % $NaNO_3$)	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. (percent)
0					5.236	5263	0.0177 = 0.92
25					10.300	4098	0.0155 = 0.69
50					8.442	4251	0.0247 = 1.14
75	30.9164	−7.6278	4.9557	−0.04035			0.0202 = 0.39
100	14.4048	−1.2376	−3.3248	3.5640			0.0055 = 0.29

Reference: [118]

TABLE 59. $CsNO_3$–$NaNO_3$: Surface tension

Temperature-dependent equations

$\gamma = a - bT$ (dyn cm^{-1})

Mol % $CsNO_3$	a	$b \cdot 10^2$
0	154.0	6.0
25	149.1	6.8
50	147.5	7.4
75	143.1	7.2
100	142.3	7.4

Reference: [26]

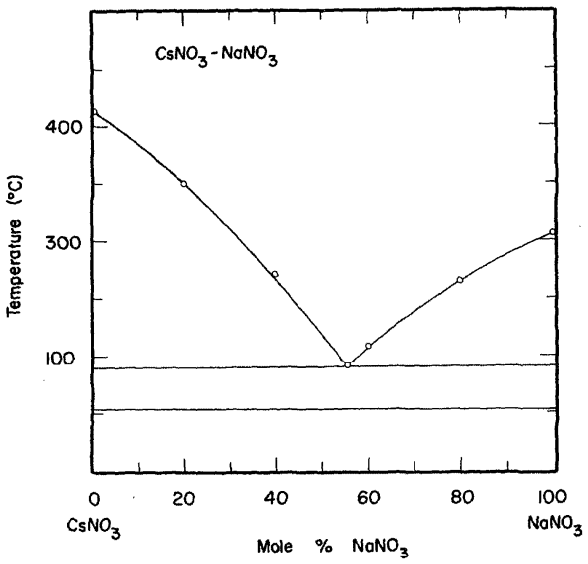

FIGURE 29. Temperature – composition phase diagram for $CsNO_3$–$NaNO_3$.

K. A. Bol'shakov, B. I. Pokrovskii, and V. E. Plyushchev, Zh. Neorg. Khim. **6** (9), 2120 (1961).

$CsNO_3$–$RbNO_3$

Electrical Conductance

Seven investigations of the specific conductance of $CsNO_3$ [1 (p. 28), 125, 126, 127, 129] and 11 investigations of $RbNO_3$ [1 (p. 27), 24, 73, 88, 104, 121, 123, 125, 129, 135] have been reported. Some experimental aspects of the conductance measurements of $CsNO_3$ are discussed in the section on $CsNO_3$–KNO_3. Revised recommendations for $RbNO_3$ are based on the work of Brillant [24] and together with some experimental aspects are discussed in the section on KNO_3–$RbNO_3$.

De Nooijer [123] measured the specific conductance of molten $CsNO_3$–$RbNO_3$ mixtures using the classical ac technique. His results for the single components and the equimolar mixture, covering a temperature range from 590 to 740 K, are given in table 60(a), for the experimental concentrations at rounded temperatures. The corresponding temperature-dependent equations are given in table 60(b). The experimental uncertainty of the results of De Nooijer is estimated to be about 0.4 percent. The results for $RbNO_3$ deviate from our newly recommended values [24] (−0.84 to 0.27 percent) and from the recommendations [1] (−6.49 to −0.26 percent), whereas the results for $CsNO_3$ agree with the recommendations [1] to within −0.53 to −0.17 percent. For discussion of the melt preparation and experimental technique of De Nooijer see the section of $CsNo_3$–KNO_3.

TABLE 60(a). $CsNO_3$–$RbNO_3$: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

	Mole percent $RbNO_3$		
T(K)	100	50	0
590	0.4069		
600	0.4303		
610	0.4537		
620	0.4771		
630	0.5006	0.4623	
640	0.5240	0.4828	
650	0.5474	0.5033	
660	0.5708	0.5238	
670	0.5942	0.5443	
680	0.6177	0.5649	
690	0.6411	0.5854	
700	0.6645	0.6059	0.5578
710	0.6879	0.6264	0.5767
720	0.7113		0.5957
730			0.6146
740			0.6335

TABLE 60(b). Temperature-dependent equations

$\kappa = a + bT$ (ohm^{-1} cm^{-1})

Comp. (mol % $RbNO_3$)	a	$b \cdot 10^3$	Stand. error of est. (percent)
0	−0.7663	1.8917	0.0008 = 0.14
50	−0.8294	2.0503	0.0041 = 0.75
100	−0.9749	2.3421	0.0012 = 0.21

Reference: [123]

Density

Seven investigations of the density of $CsNO_3$ [1)p. 28), 25, 48, 86, 109, 118] and six investigations of $RbNO_3$ [1 (p. 27), 24, 25, 86, 109, 117, 118] have been reported. Some experimental aspects of the density measurements of $CsNO_3$ are discussed in the section on $CsNO_3$–$NaNO_3$. Revised recommendations for $RbNO_3$ are based on the work of McAuley, Rhodes and Ubbelohde [25] and together with some experimental aspects are discussed in the section on $NaNO_3$–$RbNO_3$.

Murgulescu and Zuca [118] used the Archimedean method to measure the density of molten $CsNO_3$–$RbNO_3$ mixtures, in the temperature range from 575 to 795 K for 25, 50, and 75 mole percent mixtures and for the single components. The results were recalculated using a two-dimensional statistical analysis; the values in the form of a temperature-composition-density matrix are in table 61(a) at rounded compositions and temperatures. The corresponding statistical parameters are given in table 61(b). The experimental uncertainty of the results of Murgulescu and Zuca is estimated to be about 0.4 percent. The results for $RbNO_3$ deviate from our newly recommended data [25] (1.10 to 1.31 percent)

TABLE 61(a). $CsNO_3$–$RbNO_3$: Density

Numerical values (g cm^{-3})

Mole percent $RbNO_3$

T(K)	100	90	80	70	60	50	40	30	20	10	0	82.7
575			2.60									2.59
590		2.54	2.58	2.62	2.67							2.57
605	2.48	2.53	2.57	2.61	2.65	2.69						2.56
620	2.47	2.51	2.56	2.60	2.64	2.68	2.72					2.54
635	2.45	2.50	2.54	2.58	2.63	2.67	2.71	2.75				2.53
650	2.44	2.48	2.53	2.57	2.61	2.65	2.69	2.73				2.51
665	2.42	2.47	2.51	2.55	2.60	2.64	2.68	2.72	2.76			2.50
680	2.41	2.45	2.50	2.54	2.58	2.62	2.66	2.70	2.74	2.78		2.48
695	2.39	2.44	2.48	2.52	2.57	2.61	2.65	2.69	2.73	2.77	2.80	2.47
710	2.37	2.42	2.46	2.51	2.55	2.59	2.63	2.67	2.71	2.75	2.79	2.45
725	2.36	2.40	2.45	2.49	2.53	2.58	2.62	2.66	2.70	2.73	2.77	2.43
740		2.39	2.43	2.47	2.52	2.56	2.60	2.64	2.68	2.72	2.75	2.42
755		2.37	2.41	2.46	2.50	2.54	2.58	2.62	2.66	2.70	2.74	2.40
770			2.40	2.44	2.48	2.52	2.56	2.60	2.64	2.68	2.72	2.39
785										2.66	2.70	

TABLE 61(b). Two-dimensional equation and statistical parameters

$\rho = a + bT + cC + dTC^2$ (g cm^{-3})

a	$b \cdot 10^3$	$c \cdot 10^3$	$d \cdot 10^9$	Max. percent departure	Stand. error of est. (percent)
3.11226	−1.04227	4.53289	−5.87492	0.26 (641.2 K, 75 mol % $CsNO_3$)	0.003 (0.12)

Reference: [118]
C = mole percent $CsNO_3$

and from the recommendations [1] (0.15 to 0.19 percent), whereas the results for $CsNO_3$ agree with the recommendations [1] to within −0.32 to −0.24 percent.

For melt preparation of Murgulescu and Zuca [118] see the section on $CsNO_3$–$LiNO_3$. The experimental procedure is discussed in the section on $NaNO_3$–$RbNO_3$.

Viscosity

Five investigations of the viscosity of $CsNO_3$ [1 (p. 28), 48, 118, 119] and four investigations of $RbNO_3$ [1 (p. 27), 48, 118] have been reported. Revised recommendations for $CsNO_3$ are based on the work of Timidei, Lederman and Janz [119] and together with some experimental aspects are discussed in the section on $CsNO_3$–$LiNO_3$. Some experimental aspects of the viscosity measurements of $RbNO_3$ are discussed in the section $NaNO_3$–$RbNO_3$.

Murgulescu and Zuca [118] used the oscillating ball technique to measure the viscosity of molten $CsNO_3$–$RbNO_3$ mixtures, (25, 50, and 75 mole percent over a temperature range of 600–770 K). The results are given for rounded temperatures and experimental compositions in table 62(a). The corresponding viscosity-temperature equations are in table 62(b). The experimental uncertainty of the results of Murgulescu and Zuca is estimated to be larger than 2.5 percent. The values for $CsNO_3$ deviate from our newly recommended values [119] (8.4 to 9.4 percent) and from the recommendations [1] (1.5 to 8.2 percent).

In the work of Murgulescu and Zuca [118] $CsNO_3$ and $RbNO_3$ (Merck p.a. reagent grade) were predried for 24 h at 150 °C and melted under a dry nitrogen atmosphere. The experimental procedure is discussed in the section on KNO_2–$NaNO_3$.

TABLE 62(a). $CsNO_3$–$RbNO_3$: Viscosity

Numerical values (cp)

Mole percent $RbNO_3$

T(K)	100	75	50	25	0
600	3.645	3.404			
610	3.451	3.267			
620	3.273	3.133			
630	3.111	3.005	2.978		
640	2.960	2.880	2.856		
650	2.821	2.760	2.738	2.827	
660	2.694	2.645	2.624	2.701	
670	2.574	2.533	2.513	2.579	
680	2.463	2.427	2.406	2.461	
690	2.361	2.325	2.304	2.348	
700	2.266	2.228	2.205	2.239	2.307
710	2.176	2.135	2.111	2.135	2.187
720	2.093	2.047	2.022	2.035	2.076
730	2.015	1.963	1.937	1.941	1.974
740	1.942	1.885	1.858	1.852	1.879
750		1.811	1.783	1.769	1.793
760		1.742	1.713	1.691	1.711
770		1.677	1.649	1.618	1.635

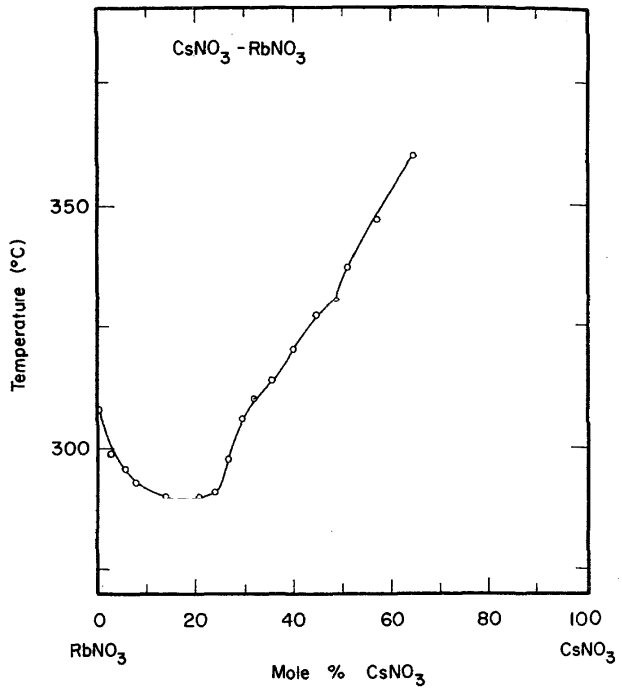

FIGURE 30. Temperature – composition phase diagram for $CsNO_3$–$RbNO_3$.

V. P. Blidin, Izv. Sekt. Fiz. Khim. Ann. **23**, 233 (1953).

TABLE 62(b). Temperature-dependent equations

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

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

Comp. (mol % $RbNO_3$)	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. (percent)
0					5.236	5236	0.0177 = 0.92
25	12.8396	−0.74787	−2.8324	2.4819			0.0193 = 0.90
50	11.2167	−0.39026	−3.0284	2.4955			0.0069 = 0.31
75	18.4604	−3.4366	1.7383	0.5119			0.0166 = 0.70
100					13.076	3966	0.0310 = 1.07

Reference: [118]

$CsNO_3$–$Sr(NO_3)_2$

Electrical Conductance

Seven investigations of the specific conductance of $CsNO_3$ [1 (p. 28), 125, 126, 127, 129] have been reported. $Sr(NO_3)_2$ has not been investigated. Some experimental aspects of the conductance measurements of $CsNO_3$ are discussed in the section on $CsNO_3$–KNO_3.

De Nooijer [123] measured the specific conductance of molten $CsNO_3$–$Sr(NO_3)_2$ mixtures using the classical ac technique. His results for pure $CsNO_3$ and mixtures containing 10, 20, and 34.5 mole percent $Sr(NO_3)_2$, covering a temperature range from 575 to 740 K, are given in table 63(a) for the experimental concentrations and rounded temperatures. The corresponding temperature-dependent equations are given in table 63(b). The experimental uncertainty of the results of De Nooijer is estimated to be about 0.4 percent. The results for $CsNO_3$ deviate from the recommendations [1] (−0.53 to −0.17 percent).

For discussion of the melt preparation and experimental technique of De Nooijer see the section on $CsNO_3$–KNO_3.

TABLE 63(a). $CsNO_3$–$Sr(NO_3)_2$: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

Mole percent $Sr(NO_3)_2$

T(K)	34.5	20	10	0
580		0.2111		
590		0.2280		
600		0.2452		
610	0.2235	0.2627		
620	0.2406	0.2804		
630	0.2578	0.2983		
640	0.2749	0.3165		
650	0.2921	0.3349		
660	0.3092	0.3536	0.4145	
670	0.3264	0.3725	0.4323	
680	0.3436	0.3917	0.4503	
690	0.3607	0.4111	0.4686	
700	0.3779		0.4871	0.5578
710	0.3950		0.5059	0.5767
720	0.4122		0.5248	0.5957
730				0.6146
740				0.6335

TABLE 63(b). Temperature-dependent equations

$\kappa = a + bT + cT^2$ (ohm^{-1} cm^{-1})

Comp. (mol % $Sr(NO_3)_2$)	a	$b \cdot 10^3$	$c \cdot 10^6$	Stand. error of est. (percent)
0	−0.7663	1.8917	0	0.0008=0.14
10	−0.2353	0.2016	1.1863	0.0008=0.17
20	−0.3520	0.2580	1.2289	0.0006=0.20
34.5	−0.8232	1.7159	0	0.0004=0.12

Reference: [123]

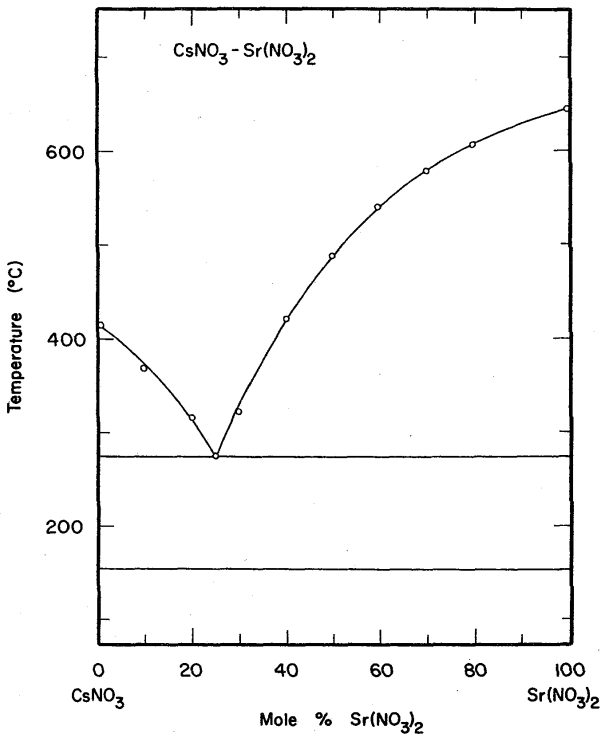

FIGURE 31. Temperature – composition phase diagram for $CsNO_3$–$Sr(NO_3)_2$.

V. E. Plyushchev, I. B. Markina, and L. P. Shklover, Zhur. Neorg. Khim. 1 (7), 1614 (1956).

$CsNO_3$–$TlNO_3$

Electrical Conductance

Seven investigations of the specific conductance of $CsNO_3$ [1 (p. 28), 125, 126, 127, 129] and seventeen investigations of $TlNO_3$ [1 (p. 28), 24, 27, 74, 89, 103, 104, 112, 117, 121] have been reported. Some experimental aspects of the conductance measurements of $CsNO_3$ and $TlNO_3$ are discussed in the sections on $CsNO_3$–KNO_3 and $NaNO_3$–$TlNO_3$, respectively.

De Nooijer [123] measured the specific conductance of molten $CsNO_3$–$TlNO_3$ mixtures using the classical ac technique. The results for $TlNO_3$ and the equimolar mixture, covering a temperature range from 495 to 740 K, are given in table 64(a) for the experimental compositions at rounded temperatures. The temperature-dependent equations for the mixture and both single components are given in table 64(b). The experimental uncertainty of the results of De Nooijer is estimated to be about 0.4 percent. The values for $CsNO_3$ and $TlNO_3$ agree with the recommendations [1] to within −0.53 to −0.17 percent and −0.30 to 0.95 percent, respectively.

For discussion of the melt preparation and experimental technique of De Nooijer see the section on $CsNO_3$–KNO_3.

TABLE 64(a). $CsNO_3$–$TlNO_3$: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

Mole percent $TlNO_3$

T(K)	100	50
500	0.4011	
510	0.4268	
520	0.4524	
530	0.4780	
540	0.5036	
550	0.5292	
560	0.5549	
570	0.5805	0.4256
580	0.6061	0.4482
590	0.6317	0.4707
600	0.6574	0.4930
610		0.5152
620		0.5372

TABLE 64(b). Temperature-dependent equations

$\kappa = a + bT + cT^2$ (ohm^{-1} cm^{-1})

Comp. (mol % $TlNO_3$)	a	$b \cdot 10^3$	$c \cdot 10^7$	Stand. error of est. (percent)
0	−0.7663	1.8917	0	0.0008 = 0.14
50	−1.1231	3.1626	−7.8190	0.0004 = 0.08
[a] 100	−0.8800	2.5623	0	0.0021 = 0.40

Reference: [123]

[a] The temperature range for 100 mole percent $CsNO_3$ is 692.1 to 740.5 K.

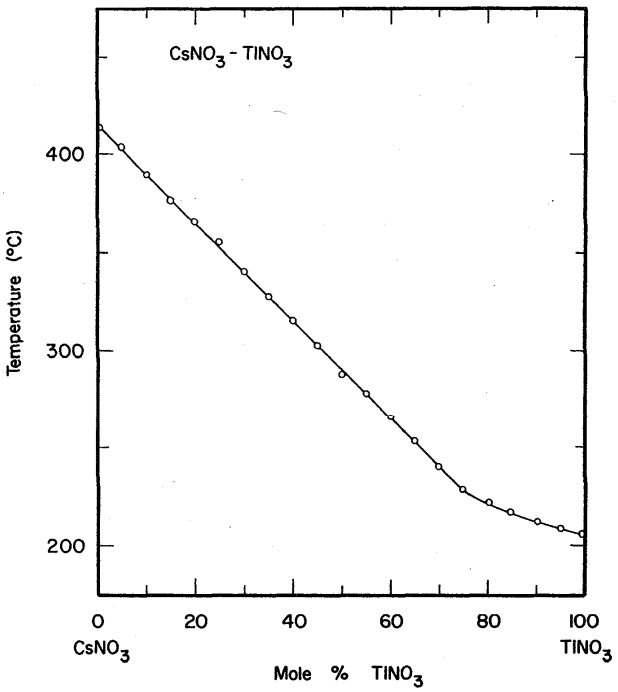

FIGURE 32. Temperature – composition phase diagram for $CsNO_3$–$TlNO_3$.

P. I. Protsenko and U. V. Rubleva, Zh. Obshch. Khim. **25**, 238 (1955).

KNO_3–$LiNO_3$

Electrical Conductance

Twenty-seven studies of the specific conductance of KNO_3 [1 (p. 26), 9, 23, 24, 29, 82, 89, 90, 94, 100, 107, 116, 117, 121, 122, 129] and 12 investigations of $LiNO_3$ [1 (p. 25), 24, 29, 73, 79, 117, 120, 129] have been reported. Revised recommendations for KNO_3 are based on the work of Robbins and Braunstein [122] and together with some experimental aspects are discussed in the sections on KNO_3–$RbNO_3$ and KNO_3–$NaNO_3$. Three different methods were used to measure the specific conductance of $LiNO_3$: A dc technique [1 (p. 25), 21], a modified potentiometric ac technique [24, 29], and in all other studies, the classical ac technique. The measurements were carried out in quartz capillary cells (Goodwin and Mailey [79] and Brillant [24]), in a cell consisting of a platinum crucible and movable electrodes (Jaeger and Kapma [1]) or (in all other investigations) in pyrex capillary cells. The pressure dependence of the specific conductance of $LiNO_3$ was studied by Barton, Cleaver and Hills [129].

The specific conductance of molten KNO_3–$LiNO_3$ mixtures has been studied by four groups [21, 29, 90, 123] using the classical ac technique [90, 123], a modified potientometric ac technique [29], and a dc technique [21]. The results of King and Duke [21] for the single components and mixtures containing 23.31, 50.12, and 74.8 mole percent $LiNO_3$, covering a temperature range from 550 to 700 K, are recommended as the "best" values and are given in table 65 (a) for the experimental compositions at rounded temperatures. The corresponding temperature-dependent equations are given in table 65(b). The experimental uncertainty of the results of King and Duke is estimated to be about 0.5 percent. The values for KNO_3 deviate from our

TABLE 65(a). KNO_3–$LiNO_3$: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

Mole percent $LiNO_3$

T(K)	100	74.80	50.12	23.31	0
550				0.506	
560	0.983	0.787	0.649	0.542	
570	1.038	0.834	0.687	0.577	
580	1.093	0.880	0.725	0.612	
590	1.149	0.926	0.763	0.647	
600	1.205	0.970	0.800	0.682	
610	1.262	1.014	0.838	0.716	
620	1.319	1.057	0.875	0.750	
630	1.376	1.099	0.913	0.784	0.688
640		1.141	0.950	0.817	0.720
650			0.987	0.851	0.752
660			1.025	0.884	0.783
670			1.062	0.917	0.814
680			1.099	0.949	0.844
690			1.136	0.982	0.873
700			1.173		

TABLE 65(b). Temperature-dependent equations

$\kappa = a + bT + cT^2$ (ohm^{-1} cm^{-1})

Comp. (mol % $LiNO_3$)	a	$b \cdot 10^3$	$c \cdot 10^6$	Stand. error of est. (percent)
0	−2.4566	6.7289	−2.7583	0.0008 = 0.10
23.31	−1.8330	4.9378	−1.2446	0 0020 = 0.27
50.12	−1.5558	4.0963	−0.2828	0.0010 = 0.11
74.80	−3.0806	9.0763	−3.8750	0.0020 = 0.21
100.0	−1.5242	3.4674	−1.8027	0.0010 = 0.08

Reference: [21]

newly recommended values [122] (0.93 to 1.13 percent) and from the recommendations [1] (−0.51 to 0.53 percent). The results of Bizouard [29] for the single components and 20, 40, 60, and 80 mole percent mixtures cover a temperature range from 473.2 to 723.2 K. The values for KNO_3 and $LiNO_3$ deviate from the results of King and Duke (up to 0.09 percent) and (−1.19 to 0.58 percent) respectively. De Nooijer [123] reports data for the single components and the equimolar mixture between 520 and 735 K. The results for KNO_3 and $LiNO_3$ agree with the values of King and Duke to within −1.67 to −1.15 percent and −1.12 to −0.54 percent, respectively. Other values for KNO_3 and the the eutectic KNO_3–$LiNO_3$ mixture (containing 43 mole percent $LiNO_3$) are reported by Papaioannou and Harrington [90] over a temperature range from 435 to 725 K. The results for KNO_3 deviate from the values of King and Duke (−1.93 to −0.32 percent).

For melt preparation and experimental technique of King and Duke see the section on KNO_3–$NaNO_3$.

Density

Nineteen investigations of the density of KNO_3 [1 (p. 26), 4, 9, 12, 25, 27, 110, 115, 118, 130] and seven investigations of $LiNO_3$ [1 (p. 25), 9, 24, 86, 117, 143] have been reported. Some experimental aspects of the density measurements of $LiNO_3$ are as follows: all investigations were carried out according to the Archimedean method, using either platinum bobs [1, 9, 139, 309] or a silica bob with a platinum ballast [180]. A surface tension correction of the density data is reported by Brillant [24] only. Some experimental aspects of the density measurements of KNO_3 are discussed in the section on KNO_3–$NaNO_3$.

The density of binary KNO_3–$LiNO_3$ mixtures has been measured by four groups [86, 90, 110, 136] using the Archimedean method. The data of Murgulescu and Zuca [86] for 20, 40, 60, and 80 mole percent mixtures and pure $LiNO_3$, covering a temperature range from 520 to 720 K, were combined with the values for KNO_3 reported by the same authors in another publication [118] and are recommended as the "best" values. The results of a two-dimensional statistical analysis of these data are given in table 66(a) as a temperature-composition-density matrix, at rounded compositions and temperatures. The corresponding statistical parameters are given in table 66(b).

The experimental uncertainty of the values of Murgulescu and Zuca is estimated to be about 0.4 percent. The values for KNO_3 and $LiNO_3$ agree with the recommendations [1] to within −0.08 to 0.13 percent and 0.29 to 0.30 percent, respectively. Papaioannou and Harrington [90] report results for the eutectic composition which have been discussed by Bredig [106]. An investigation by Smith and Petersen [110] covers a temperature range from 495 to 775 K reporting results for eight different compositions and the single components. The results of Smith and Petersen for KNO_3

TABLE 66(a). KNO_3–$LiNO_3$: Density

Numerical values (g cm^{-3})

Mole percent $LiNO_3$

T(K)	100	90	80	70	60	50	40	30	20	10	0	42
525							1.85					
540						1.86	1.84	1.82	1.82			
555	1.77	1.84	1.88	1.89	1.87	1.85	1.83	1.81	1.81			1.83
570	1.77	1.83	1.87	1.88	1.86	1.84	1.82	1.80	1.80			1.82
585	1.76	1.83	1.86	1.87	1.85	1.83	1.81	1.79	1.79	1.82		1.81
600	1.75	1.82	1.85	1.86	1.84	1.82	1.80	1.78	1.78	1.81		1.80
615	1.74	1.81	1.84	1.85	1.83	1.81	1.79	1.77	1.77	1.80		1.79
630	1.73	1.80	1.83	1.83	1.82	1.80	1.78	1.76	1.76	1.79	1.85	1.78
645	1.72	1.79	1.82	1.82	1.81	1.79	1.77	1.75	1.75	1.78	1.84	1.77
660	1.71	1.78	1.81	1.81	1.80	1.78	1.76	1.74	1.74	1.77	1.83	1.76
675	1.70	1.77	1.80	1.80	1.79	1.77	1.75	1.73	1.73	1.76	1.82	1.75
690	1.69	1.76	1.79	1.79	1.78	1.76	1.74	1.72	1.72	1.75	1.81	1.74
705			1.78	1.78	1.77	1.75	1.72	1.71	1.71	1.74	1.80	1.73
720					1.76					1.73	1.79	

TABLE 66(b). Two-dimensional equation and statistical parameters

$$\rho = a + bT + cC + dC^2 + eC^3 + fTC^2 + gCT^2 \text{ (g cm}^{-3}\text{)}$$

a	$b \cdot 10^4$	$c \cdot 10^2$	$d \cdot 10^4$	$e \cdot 10^6$	$f \cdot 10^8$	$g \cdot 10^3$	Max. percent departure	Stand. error of est.
2.09901	−5.86663	1.02857	−2.49431	1.40515	5.31099	−3.97169	0.91% (732.2 K 60 mol % KNO_3)	0.009 (0.49%)

References: [86] for binary mixtures and 100 mole percent $LiNO_3$.
[118] for 100 mole percent KNO_3.
C = mole percent KNO_3.

and $LiNO_3$ agree with the data of Murgulescu and Zuca within −0.51 and −0.36 percent, respectively. However, for the mixture containing 80 mole percent $LiNO_3$ the two investigations deviate by up to 4.9 percent, the results of Smith and Petersen being consistently lower. Boxall and Johnson [136] report values for 41 and 59 mole percent $LiNO_3$ between 432.0 and 691.2 K.

The experimental method used by Murgulescu and Zuca [86] is the same as reported in the later publication [118] and is discussed in the section on $NaNO_3$–$RbNO_3$. For melt preparation see the discussion of viscosity in the section on KNO_3–$LiNO_3$.

Viscosity

Thirteen investigations of the viscosity of KNO_3 [1 (p. 27), 48, 86, 107, 118, 119] and five investigations of the viscosity of $LiNO_3$ [1 (p. 25), 48] have been reported. Revised recommendations for KNO_3 are based on the work of Timidei, Lederman and Janz [119] and together with some experimental aspects are discussed in the section on KNO_3–$NaNO_3$. Some experimental aspects of the viscosity measurements of $LiNO_3$ are discussed in the section on $LiNO_3$–$NaNO_3$.

Murgulescu and Zuca [86] used the oscillating ball technique to measure the viscosity of molten KNO_3–$LiNO_3$ mixtures. Their results for the single components and 20, 40, 60, and 80 mole percent mixtures, covering a temperature range from 530 to 690 K, are given for the experimental compositions at rounded temperatures in table 67(a). The corresponding temperature-dependent equations are given in table 67(b). For KNO_3 the values reported by the same authors in another publication [118] were selected. The results of

TABLE 67(a). KNO_3–$LiNO_3$: Viscosity

Numerical values (cp)

Mole percent $LiNO_3$

T (K)	100	80	60	40	20	0
530			4.889	4.324		
540			4.514	4.026		
550	4.946	4.324	4.169	3.750	3.842	
560	4.637	4.030	3.853	3.497	3.584	
570	4.344	3.757	3.565	3.265	3.361	
580	4.068	3.505	3.304	3.054	3.159	
590	3.809	3.274	3.069	2.862	2.975	
600	3.567	3.062	2.858	2.688	2.806	
610	3.342	2.871	2.670	2.532	2.654	
620	3.135	2.698	2.504	2.392	2.513	
630	2.947	2.545	2.360	2.269	2.384	2.606
640	2.776	2.410	2.235	2.160	2.266	2.460
650	2.624	2.294	2.129	2.065	2.157	2.336
660	2.490	2.195	2.040	1.984	2.056	2.217
670	2.376	2.113	1.967	1.915	1.963	2.107
680	2.281	2.049	1.910	1.856	1.876	2.005
690	2.205	2.002	1.866	1.809	1.796	1.912

TABLE 67(b). Temperature-dependent equations

$$\eta = a + bT + cT^2 + dT^3 \text{ (cp)}$$

$$\eta = A \cdot \exp(E/RT) \text{ (cp)}$$

Comp. (mol % $LiNO_3$)	a	$b \cdot 10^2$	$c \cdot 10^5$	$d \cdot 10^8$	$A \cdot 10^2$	E (cal mol)	Stand. error of est. (percent)
0					7.375	4461	0.0101 = 0.46
20					9.139	4081	0.0383 = 1.51
40	76.5978	−28.379	35.751	−14.972			0.0550 = 2.18
60	99.3868	−37.296	47.197	−19.751			0.0658 = 2.47
80	64.1768	−20.614	21.143	−6.2709			0.0620 = 2.30
100	39.8180	−8.2245	1.0941	4.2394			0.0209 = 0.67

Reference: [86] for binary mixtures and 100 mole percent $LiNO_3$.
[118] for 100 mole percent KNO_3.

Murgulescu and Zuca for KNO_3 agree with the recommendations [1] to within −1.2 to −0.4 percent. However, for $LiNO_3$ the deviations from the recommendations [1] range from −16.7 to 4.5 percent. Considering these deviations and the minimum information about melt preparation, an uncertainty estimate is not possible.

Only limited information concerning the melt preparation of Murgulescu and Zuca is available. The experimental procedure is discussed in the section on KNO_3–$NaNO_3$.

Surface Tension

Eight investigations of the surface tension of KNO_3 [2 (p. 67), 41, 84] and three of $LiNO_3$ [2 (p. 67)] have been reported.

Bertozzi and Sternheim [26] used the Wilhelmy slide plate method to measure the surface tension of molten KNO_3–$LiNO_3$ mixtures, in the temperature range from the melting point up to 400 °C, for 25, 50, and 75 mole percent mixtures and for the single components. The results of a two-dimensional statistical analysis of these data are given in table 68(a) as a temperature-composition-surface tension matrix at rounded temperatures. The corresponding statistical parameters are given in table 68(b). The data of Bertozzi and Sternheim for the single components show percent departures from the recommendations [2] by −0.06 to 1.1 percent.

The experimental aspects of the investigation of Bertozzi and Sternheim [26] have been discussed previously [2 (p. 67)].

TABLE 68(a). KNO_3–$LiNO_3$: Surface tension

Numerical values (dyn cm^{-1})

	Mole percent $LiNO_3$											
T(K)	100	90	80	70	60	50	40	30	20	10	0	42
445						119.1	119.9	120.9				119.7
460						118.2	118.9	119.9				118.8
475					116.8	117.2	117.9	118.9	120.0			117.8
490				115.8	115.9	116.3	117.0	117.8	118.9			116.8
505				114.9	115.0	115.3	116.0	116.8	117.8			115.8
520			114.3	114.0	114.1	114.4	115.0	115.8	116.8			114.8
535	115.3	114.2	113.5	113.1	113.1	113.4	114.0	114.8	115.7	116.8		113.9
550	114.5	113.4	112.6	112.3	112.2	112.5	113.0	113.7	114.7	115.7		112.9
565	113.7	112.6	111.8	111.4	111.3	111.5	112.0	112.7	113.6	114.6		111.9
580	113.0	111.8	110.9	110.5	110.4	110.6	111.0	111.7	112.5	113.5		110.9
595	112.2	110.9	110.1	109.6	109.5	109.6	110.1	110.7	111.5	112.4		110.0
610	111.4	110.1	109.3	108.8	108.6	108.7	109.1	109.7	110.4	111.4		109.0
625	110.7	109.3	108.4	107.9	107.7	107.7	108.1	108.6	109.4	110.3	111.2	108.0
640	109.9	108.5	107.6	107.0	106.8	106.8	107.1	107.6	108.3	109.2	110.1	107.0
655	109.1	107.7	106.7	106.1	105.8	105.9	106.1	106.6	107.3	108.1	109.0	106.0
670	108.4	106.9	105.9	105.3	104.9	104.9	105.1	105.6	106.2	107.0	107.9	105.1

TABLE 68(b). Two-dimensional equation and statistical parameters

$\gamma = a + bT + cC^3 + dCT^2 + eC^2 + fTC$ (dyn cm^{-1})

a	$b \cdot 10^2$	$c \cdot 10^6$	$d \cdot 10^8$	$e \cdot 10^3$	$f \cdot 10^4$	Max percent departure	Standard error of est.
142.69394	−5.12562	−6.25975	1.12949	2.22139	−2.52894	−0.27 (673 K, 0 mol % $LiNO_3$)	0.115 (0.1%)

Reference: [26]
C = mol percent KNO_3

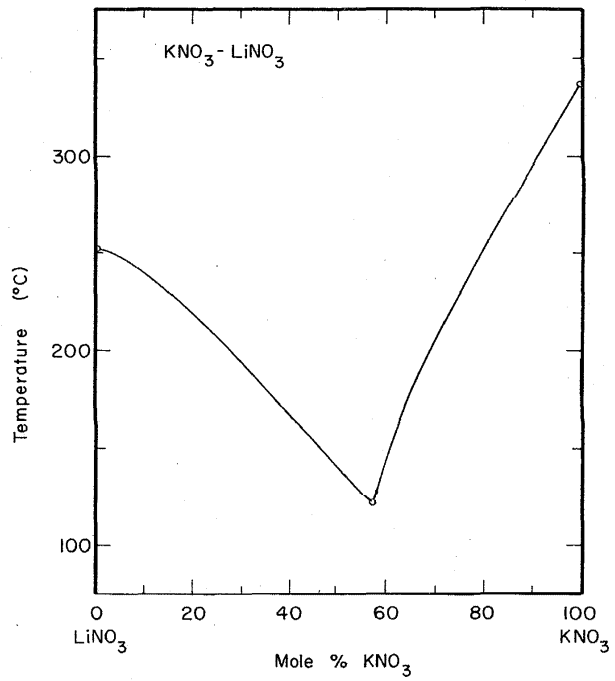

FIGURE 33. Temperature – composition phase diagram for KNO_3–$LiNO_3$.

P. I. Protsenko, Zh. Obshch. Khim. **22**, 1313 (1952).

KNO_3–$Mg(NO_3)_2$

Density

Nineteen investigations of the density of KNO_3 [1 (p. 26), 4, 9, 12, 25, 27, 110, 115, 118, 130] have been reported. $Mg(NO_3)_2$ has not been investigated. Some experimental aspects of the density measurements of KNO_3 are discussed in the section on KNO_3–$NaNO_3$.

McAuley, Rhodes and Ubbelohde [25] used a manometric densitometer to measure equivalent volumes of molten KNO_3–$Mg(NO_3)_2$ mixtures, in the temperature range from 475 K to 690 K, for single KNO_3 and mixtures containing 5.3, 11.0, 17.0, 24.4, and 33.4 mole percent $Mg(NO_3)_2$. The values are given in table 69(a) for the experimental compositions at rounded temperatures using one-dimensional statistical analysis of the density-data, recalculated from the reported molar volume equations. The corresponding temperature-dependent equations are given in table 69(b). The experimental uncertainty of the results of McAuley, Rhodes and Ubbelohde is estimated to be about 0.3 percent. The values for KNO_3 deviate from the recommendations [1] (−0.39 to −0.22 percent).

The melt preparation of McAuley, Rhodes and Ubbelohde is discussed in the section on $Ba(NO_3)_2$–$NaNO_3$, the experimental technique in the section on $NaNO_3$–$RbNO_3$.

TABLE 69(a). KNO_3–$Mg(NO_3)_2$: Density

Numerical values (g cm^{-3})

Mole percent $Mg(NO_3)_2$

T(K)	33.4	24.4	17.0	11.0	5.3	0
480		2.460				
490		2.449				
500	2.626	2.439				
510	2.615	2.429				
520	2.605	2.419	2.275			
530		2.409	2.266			
540		2.399	2.257			
550		2.390	2.248			
560		2.380	2.239	2.123		
570		2.370	2.230	2.114		
580			2.221	2.105		
590			2.212	2.096	2.028	
600			2.203	2.088	2.019	
610			2.194	2.079	2.010	
620				2.070	2.001	1.859
630					1.993	1.851
640					1.984	1.843
650					1.976	1.835
660					1.967	1.828
670						1.820
680						1.813
690						1.805

TABLE 69(b). Temperature-dependent equations

$\rho = a + bT$ (g cm^{-3})

Comp. (mol % $Mg(NO_3)_2$)	a	$b \cdot 10^4$	Stand. error of est. (percent)
0	2.3339	−0.76667	0.0003 = 0.02
5.3	2.5389	−0.86667	0.0003 = 0.02
11.0	2.6148	−0.87857	0.0002 = 0.01
17.0	2.7417	−0.89818	0.0005 = 0.02
24.4	2.9356	−0.99273	0.0004 = 0.02
33.4	3.1403	−1.05000	0.0002 = 0.01

Reference: [25]

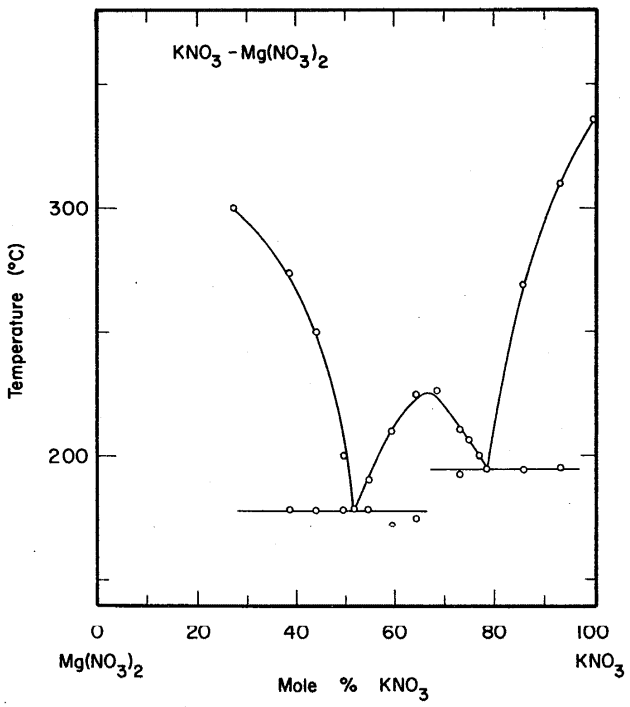

FIGURE 34. Temperature – composition phase diagram for KNO_3–$Mg(NO_3)_2$.

E. Jänecke, Z. Elektrochem. **48**, 453 (1932).

KNO_3–$NaNO_3$

Electrical Conductance

Twenty-seven investigations of the specific conductance of KNO_3 [1 (p. 26), 9, 23, 24, 29, 82, 89, 90, 94, 100, 107, 116, 117, 121, 122, 129] and 26 investigations of $NaNO_3$ [1 (p. 25), 9, 21, 24, 29, 75, 83, 89, 100, 104, 111, 112, 117, 120, 125, 128, 129] have been reported. Revised recommendations for KNO_3 are based on the work of Robbins and Braunstein [122] and are discussed in the section on KNO_3–$RbNO_3$.

Some additional experimental aspects of the conductance measurements of KNO_3 and of $NaNO_3$ are as follows: The conductance measurements were carried out using three different methods: A dc technique by King and Duke [21] and Duke and Fleming [85], a modified potentiometric ac technique by Doucet and Bizouard [75, 76], Bizouard, Cerisier and Barthelemy [111], and Brillant [24, 74] and (in all other investigations) the classical ac method. The main cell materials used were quartz (Byrne, Fleming and Wetmore [1], Goodwin and Mailey [9], Bloom, Knaggs, Molloy and Welch [1], Murgulescu and Zuca [97], Aten [1] and Brillant [24, 74]) and (in most other investigations) pyrex. An alumina conductance cell was used by Kroger and Weisberger [1]. The influence of elevated pressure on the conductance of KNO_3 and $NaNO_3$ was studied by Copeland and Zybko [128] and Barton, Cleaver and Hills [129].

The specific conductance of KNO_3–$NaNO_3$ mixtures has been studied by nine groups [9, 21, 27, 29 75, 90, 97, 100, 123, 134] using three different techniques: The classical ac technique [9, 27, 90, 97, 100 123, 134], a dc technique [21], and a modified potentiometric ac technique [29, 75]. The results of King and Duke [21] for the single components and 24.85, 50.31 and 75.09 mole percent mixtures, covering a temperature range from 560 to 720 K, are recommended as the "best" values and are given in table 70(a) for the experimental compositions at rounded temperatures. The corresponding temperature-dependent equations are given in table 70(b). The experimental uncertainty of the results of King and Duke is estimated to be about 0.5 percent. The values for KNO_3 deviate from our newly recommended values [316] (0.93 to 1.13 percent) and from the recommendations [1] (−0.51 to 0.53 percent), whereas the data for $NaNO_3$ agree with the recommendations [1] to within 0.65 to 1.35 percent.

Other investigations are reported by Goodwin and Mailey [9] (single components and 20, 50, 80 mole

TABLE 70(a). KNO_3–$NaNO_3$: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

Mole percent $NaNO_3$

T(K)	100	75.09	50.31	24.85	0
560			0.620	0.537	
570			0.660	0.573	
580		0.816	0.699	0.608	
590		0.860	0.738	0.643	
600		0.903	0.776	0.677	
610	1.118	0.945	0.813	0.711	
620	1.163	0.986	0.851	0.745	
630	1.207	1.027	0.887	0.778	0.688
640	1.250	1.066	0.924	0.811	0.720
650	1.292	1.105	0.959	0.844	0.752
660	1.334	1.143	0.994	0.876	0.783
670	1.375	1.181	1.029	0.908	0.814
680	1.415		1.063	0.940	0.844
690	1.454		1.097	0.971	0.873
700	1.493				
710	1.531				
720	1.569				

TABLE 70(b). Temperature-dependent equations

$\kappa = a + bT + cT^2$ (ohm^{-1} cm^{-1})

Comp. (mol % $NaNO_3$)	a	$b \cdot 10^2$	$c \cdot 10^5$	Stand. error of est. (percent)
0	−2.4566	0.67289	−0.27583	0.0008=0.1
24.85	−2.0386	0.56214	−0.18254	0.0006=0.08
50.31	−2.4156	0.68424	−0.25391	0.0020=0.23
75.09	−3.0522	0.89412	−0.39159	0.0020=0.20
100	−2.9565	0.88732	−0.35949	0.0020=0.15

Reference: [21]

percent mixtures, between 590 and 780 K), Sandonnini [27] (single components and 20, 50, 80 mole percent mixtures, at 623.2 and 673.2 K), Doucet and Bizouard [29, 75] (single components and 20, 40, 60, 80 mole percent mixtures between 523.2 and 723.2 K), Papaioannou and Harrington [90] pure (KNO_3 and eutectic mixture containing 47 mole percent $NaNO_3$ between 543.2 and 673.2 K). Murgulescu and Zuca [97] (single components and 10, 20, 30, 40, 50, 60, 70, 80, 90 mole percent mixtures between 623.2 and 723.2 K), Bergman and Chagin [100] (single components and nine different mixtures between 523.2 and 773.2 K), De Nooijer [123] (single components and 10, 30, 50, 70, 90 mole percent mixtures between 535 and 735 K) and Wagner, Berra, and Forcheri [134] (pure $NaNO_3$ and 90.9, 95.1 mole percent $NaNO_3$ between 585.2 and 673.2 K). The deviations of the results of these investigations from the values of King and Duke [21] are as follows:

—Sandonnini [27]: −0.64 percent (KNO_3), −0.96 to 1.11 percent (equimolar mixture), 1.21 to −0.60 percent ($NaNO_3$).
—Goodwin and Mailey [9]: −0.52 to 3.18 percent (KNO_3), −0.29 to 1.32 percent (equimolar mixture), −0.95 to 0.89 percent ($NaNO_3$).
—Doucet and Bizouard [29]: −0.09 percent (KNO_3), 0.84 to 4.09 percent ($NaNO_3$).
—Papaioannou and Harrington [90]: −1.93 to −0.32 percent (KNO_3).
—Murgulescu and Zuca [97]: 1.19 to 2.04 percent (KNO_3), 0.06 to 0.87 percent (equimolar mixture), −0.85 to 0.42 percent ($NaNO_3$).
—Bergman and Chagin [100]: −0.64 to −0.55 percent (KNO_3), −1.71 to −1.45 percent ($NaNO_3$).
—De Nooijer [123]: −1.67 to −1.15 percent (KNO_3), −1.19 to −0.17 percent (equimolar mixture), −1.12 to −0.54 percent ($NaNO_3$).
—Wagner, Berra, and Forcheri [134]: −0.72 to 1.24 percent ($NaNO_3$).

King and Duke used "Baker analyzed" chemicals. KNO_3, $LiNO_3$ and $NaNO_3$ were dried, mixed, premelted and allowed to stand in the molten state for 12 to 24 h. Each mixture was filtered, cooled and stored in a desiccator over $Mg(ClO_4)_2$. The mixture composition was determined by direct weight analysis. The electrodes were Pt-wire-helices for the direct current supply and reversible $Ag-AgNO_3$-electrodes for the determination of the potential drop. The cells were calibrated with demal aqueous KCl solution at 25 °C (using calomel electrodes instead of the reversible $Ag-AgNO_3$-electrodes), and the temperature dependence of the cell constant was taken into account.

Density

Nineteen investigations of the density of KNO_3 [1 (p. 26), 4, 9, 12, 25, 27, 110, 115, 118, 130] and 16 investigations of $NaNO_3$ [1 (p. 26), 9, 12, 25, 27, 71, 86, 95, 97, 115, 117, 118, 130] have been reported. Two different methods were used to measure the density of KNO_3: a manometric densitometer technique (McAuley, Rhodes and Ubbelohde [25]) and, in all other studies, the Archimedean method. Three different materials were used for the Archimedean bobs: Pt-10 percent Rh (Bloom, Knaggs, Molloy and Welch [1]), Au–Pd (Bockris, Calandra and Solomons [115]) and (in all other investigations) Pt. Revised recommendations for $NaNO_3$ are based on the work of McAuley, Rhodes and Ubbelohde [25] and together with some experimental aspects are discussed in the section on $NaNO_3$–$RbNO_3$.

The density of KNO_3–$NaNO_3$ mixtures has been studied by 12 groups [9, 12, 27, 90, 95, 97, 109, 118, 124, 130, 136] using either the Archimedean method [9, 12, 27, 90, 95, 97, 109, 118, 136], the dilatometric method [130], or measuring the volume change on mixing [124]. The results of Murgulescu and Zuca [97] for the single components and 10, 20, 30, 40, 50, 60, 70, 80, and 90 mole percent mixtures, covering a temperature range from 625 to 775 K, are recommended as the "best" values. The results were recalculated using a two-dimensional statistical analysis; the values in the form of a temperature-composition-density matrix are given in table 71(a) for rounded compositions and temperatures. The corresponding statistical parameters are given in table 71(b). The experimental uncertainty of the results of Murgulescu and Zuca is estimated to be about 0.5 percent. The values for KNO_3 agree with the recommendations [1] to within −0.08 to 0.07 percent, whereas the values for $NaNO_3$ deviate from our newly recommended values [25] (1.50 to 1.71 percent) and from the recommendations [1] (0.40 to 0.51 percent).

Other investigations are reported by Goodwin and Mailey [9] (single components and 20, 50, and 80 mole percent mixtures, 580–780 K), Fawsitt [12] (single components and mixtures containing 17.4, 35.9, 50.2, 61.0 and 72.7 mole percent KNO_3, 502–680 K), Sandonnini [27] (single components and 20, 50 and 80 mole percent mixtures, at 623.2 and 673 K), Papaioannou and Harrington [90] pure (KNO_3 and the eutectic mixture containing 53 mole percent KNO_3, 540–720 K), Polyakov and Beruli [95] (single components and mixtures containing 25, 35, 45, 50, 60, 75, and 85 mole percent KNO_3, 530–770 K), James and Liu [109] (equimolar mixture, 510–650 K), Murgulescu and Zuca [118] (single components and 25, 50, and 75 mole percent mixtures, 560–750 K), Laybourn and Madgin [130] (single components and 9 mixtures, 515–735 K), and Boxall and Johnson [136] (55 mole percent KNO_3; 525.4–774.9 K). The deviations of the results of these investigators from the values of Murgulescu and Zuca [97] are as follows:

—Goodwin and Mailey [9]: −0.10 to 0.14 percent (KNO_3), −0.07 to 0.16 percent (80 mole percent

TABLE 71(a). KNO_3–$NaNO_3$: Density

Numerical values (g cm^{-3})

Mole percent $NaNO_3$

T(K)	100	90	80	70	60	50	40	30	20	10	0	46
625	1.878	1.876	1.874	1.872	1.870	1.867	1.865	1.863	1.861	1.859	1.856	1.866
630	1.875	1.873	1.871	1.869	1.866	1.864	1.862	1.860	1.857	1.855	1.853	1.863
635	1.872	1.870	1.868	1.865	1.863	1.861	1.859	1.856	1.854	1.852	1.850	1.860
640	1.869	1.867	1.865	1.862	1.860	1.858	1.855	1.853	1.851	1.849	1.846	1.857
645	1.866	1.864	1.862	1.859	1.857	1.855	1.852	1.850	1.848	1.845	1.843	1.854
650	1.863	1.861	1.858	1.856	1.854	1.851	1.849	1.847	1.844	1.842	1.839	1.850
655	1.860	1.858	1.855	1.853	1.850	1.848	1.846	1.843	1.841	1.838	1.836	1.847
660	1.857	1.854	1.852	1.850	1.847	1.845	1.842	1.840	1.837	1.835	1.832	1.844
665	1.854	1.851	1.849	1.846	1.844	1.841	1.839	1.836	1.834	1.831	1.829	1.840
670	1.851	1.848	1.845	1.843	1.840	1.838	1.835	1.833	1.830	1.828	1.825	1.837
675	1.847	1.845	1.842	1.840	1.837	1.835	1.832	1.829	1.827	1.824	1.822	1.834
680	1.844	1.842	1.839	1.836	1.834	1.831	1.829	1.826	1.823	1.821	1.818	1.830
685	1.841	1.838	1.836	1.833	1.830	1.828	1.825	1.822	1.820	1.817	1.815	1.827
690	1.838	1.835	1.832	1.830	1.827	1.824	1.822	1.819	1.816	1.814	1.811	1.823
695	1.834	1.832	1.829	1.826	1.823	1.821	1.818	1.815	1.813	1.810	1.807	1.820
700	1.831	1.828	1.825	1.823	1.820	1.817	1.814	1.812	1.809	1.806	1.803	1.816
705	1.828	1.825	1.822	1.819	1.816	1.814	1.811	1.808	1.805	1.803	1.800	1.813
710	1.824	1.821	1.819	1.816	1.813	1.810	1.807	1.804	1.802	1.799	1.796	1.809
715	1.821	1.818	1.815	1.812	1.809	1.807	1.804	1.801	1.798	1.795	1.792	1.805
720	1.817	1.815	1.812	1.809	1.806	1.803	1.800	1.797	1.794	1.791	1.788	1.802

TABLE 71(b). Two-dimensional equation and statistical parameters

$\rho = a + bT^2 + cCT^2$ (g cm^{-3})

a	$b \cdot 10^7$	$c \cdot 10^{10}$	Max percent departure	Stand. error of est.
2.06431	−4.76248	−5.60825	+0.20% (630 K, 100 mol % KNO_3)	0.002 (0.1%)

Reference: [97]

C = mole percent KNO_3

KNO_3), −0.46 to 0.21 percent (equimolar mixture), 0 to 0.27 percent (20 mole percent KNO_3), 0.09 to 0.16 percent ($NaNO_3$).

- Fawsitt [12]: −0.23 to 0.16 percent (KNO_3), up to 0.29 percent (equimolar mixture), 0.32 to 0.37 percent ($NaNO_3$).
- Sandonnini [27]: 0 to 0.25 percent (KNO_3), −0.05 to 0.11 percent (80 mole percent KNO_3), 0.02 to 0.27 percent (equimolar mixture), −0.11 to −0.05 percent (20 mole percent KNO_3), 0.04 to 0.05 percent ($NaNO_3$).
- Papaioannou and Harrington [90]: −0.15 to 0.08 percent (KNO_3), −2.90 to −1.05 percent (equimolar mixture).
- Polyakov and Beruli [95]: −0.22 to −0.07 percent (KNO_3) 0.29 to 1.07 percent (60 mole percent KNO_3), −0.14 to 0.75 percent (equimolar mixture), −0.37 to 0 percent ($NaNO_3$).
- James and Liu [109]: −0.28 to −0.05 percent (equimolar mixture).
- *Murgulescu and Zuca [118]: −0.05 to 0.18 percent* (KNO_3), −0.34 to 0.37 percent (equimolar mixture), −0.48 to −0.28 percent ($NaNO_3$).

The more recently reported results of Murgulescu and Zuca [118] can also be recommended, and their uncertainty is estimated to be about 0.5 percent. Due to the smaller number of mixture compositions the rounded values in table 71(a) are not based on this investigation. Powers, Katz and Kleppa [124] measured the excess volumes in binary KNO_3–$NaNO_3$ mixtures at 623.2 and 698.2 K.

Murgulescu and Zuca premelted the single salts and stored the samples in a desiccator over conc. H_2SO_4 before use. The mixtures were made up by direct weight analysis. Possible errors due to surface tension effects or condensation of salt on the suspension wire are not discussed in this study.

Viscosity

Thirteen investigations of the viscosity of KNO_3 [1 (p. 27), 48, 86, 107, 118, 119] and 11 investigations of $NaNO_3$ [1 (p. 26), 48, 56, 71, 86, 118] have been reported. The results of Timidei, Lederman and Janz for KNO_3 (capillary viscometer-assembly) agree with the recommendations [1] to within 0.5 percent, and the uncertainty estimate of the recommended values [1] can be revised from 1.5 to 1.0 percent. Within this limit molten KNO_3 may be used as a high temperature viscometer calibration standard. For melt preparation and experimental technique of Timidei, Lederman and Janz see the section on $CsNO_3$–$LiNO_3$. Other studies of the viscosity of KNO_3 and $NaNO_3$ were carried out with pyrex capillary viscometers (Protsenko and Razumovskaya [1]), a platinum capillary viscometer (Goodwin and Mailey [1, 79]), a dropping ball method using a nickel ball (Ogawa [56]) or (in all other studies) with damped oscillation methods using platinum bobs.

The viscosity of molten KNO_3–$NaNO_3$ mixtures has been measured by four groups [12, 56, 79, 118] using a capillary viscometer [79], the oscillating disc technique [12], the oscillating ball method [118] and the dropping ball method [56]. The results of Murgulescu and Zuca [118] for the single components and 25, 50, and 75 mole percent mixtures, covering a temperature range from 525 to 725 K, are recommended as the "best" values and are given in table 72(a), for the experimental compositions at rounded temperatures. The corresponding temperature-dependent equations are given in table 72(b). The experimental uncertainty of the results of Murgulescu and Zuca is estimated to be about 1.5 percent. The values for KNO_3 and $NaNO_3$ agree with the recommendations [1] to within -1.2 to -0.4 percent and -0.4 to 0.3 percent, respectively. The results of Fawsitt [12] for the single components and mixtures containing 17.4, 35.9, 50.2, 61.0, and 72.7 mole percent KNO_3 cover a temperature range from 500 to 680 K. They deviate from the values of Murgulescu and Zuca (5.36 to 1.71 percent, KNO_3; -16.46 to 0.89 percent, 50 mole percent KNO_3; -2.44 to 3.04 percent, $NaNO_3$). Goodwin and Mailey [79] reported values for the single components and mixtures containing 50 and 80 mole percent KNO_3 in the temperature range from 600 to 780 K. These results deviate from the values of Murgulescu and Zuca (-2.45 to 1.23 percent, KNO_3; -1.40 to 1.16 percent, 50 mole percent KNO_3; -3.17 to -1.28 percent, $NaNO_3$). The results of Ogawa [56] are reported graphically and cannot be critically assessed.

Murgulescu and Zuca dried the single components (Merck p.a. grade) for 24 hours at 150 °C and melted them in a dry nitrogen atmosphere. The apparatus was calibrated with water, benzene and aniline, and the temperature dependence of the volume of the platinum bob was taken into account. The oscillations were automatically recorded by means of a PHD photodyne.

TABLE 72(a). KNO_3–$NaNO_3$: Viscosity

Numerical values (cp)

	Mole percent $NaNO_3$				
T(K)	100	75	50	25	0
520			4.725		
530			4.381		
540			4.064		
550			3.772		
560			3.506		
570		3.038	3.262	3.372	
580		2.879	3.040	3.165	
590		2.728	2.839	2.978	
600	2.708	2.585	2.657	2.808	
610	2.574	2.450	2.494	2.653	
620	2.445	2.323	2.348	2.511	2.763
630	2.323	2.205	2.217	2.380	2.608
640	2.208	2.094	2.100	2.260	2.465
650	2.101	1.992	1.997	2.150	2.334
660	2.000	1.899	1.906	2.048	2.214
670	1.907	1.812	1.826	1.954	2.102
680	1.822	1.735	1.755	1.867	2.001
690	1.744	1.665	1.692	1.786	1.906
700	1.675	1.604	1.636	1.710	1.819
710	1.614	1.551	1.585	1.640	1.738
720	1.562	1.506	1.540	1.574	1.662

TABLE 72(b). Temperature dependent equations

$$\eta = a + bT + cT^2 + dT^3 \text{ (cp)}$$

$$\eta = A \cdot \exp\,(E/RT) \text{ (cp)}$$

Comp. (mol % $NaNO_3$)	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. (percent)
0					7.127	4506	0.0073 = 0.35
25					8.710	4141	0.0115 = 0.51
50	90.8112	−35.1716	46.64877	−20.8610			0.0523 = 2.2
75	25.6156	−6.2877	4.08206	0			0.0098 = 0.47
100	14.2464	−1.1549	−3.46657	3.6440			0.0066 = 0.33

Reference: [118]

Surface Tension

Eight investigations of the surface tension of KNO_3 [2 (p. 67), 41, 84] and eight investigations of $NaNO_3$ [2 (p. 67), 41, 84] have been reported.

Two different techniques have been used to measure the surface tension of molten KNO_3–$NaNO_3$ mixtures by four groups: the maximum bubble pressure method [14, 18, 140], and the Wilhelmy slide plate method [26].

The data by Bertozzi and Sternheim [26] are recommended as the "best" values. The results were recalculated using a two-dimensional statistical analysis; the values in the form of a temperature-composition-surface tension matrix are in table 73(a) for rounded compositions and temperatures; the corresponding statistical parameters are given in table 73(b). The data of Bertozzi and Sternheim for the single components show percent departures from recommendations [2] by −0.6 to 1.1 percent.

The experimental aspects of the investigation of Bertozzi and Sternheim [26] have been discussed previously [2 (p. 67)]. The determinations were performed in the temperature range from the melting point up to 400 °C, for 25, 50, and 75 mole percent mixtures and for the single components.

The departure of the values of Dahl and Duke [18] for two compositions only, range between 0.8 and 3.8 percent. Due to insufficient data the investigations of Boardman, Palmer and Heymann [14] could not be critically assessed. Krivovyazov, Sokolova and Voskresenskaya [140] report a surface tension-temperature equation for an equimolar mixture of KNO_3 and $NaNO_3$.

TABLE 73(a). KNO_3–$NaNO_3$: Surface tension

Numerical values (dyn cm^{-1})

Mole percent $NaNO_3$

T(K)	100	90	80	70	60	50	40	30	20	10	0	46
500						122.2						122.1
510					121.8	121.4	121.2					121.3
520					121.0	120.7	120.4					120.6
530					120.3	120.0	119.7	119.4				119.8
540				120.1	119.6	119.2	118.9	118.7				119.1
550				119.4	118.9	118.5	118.2	117.9	117.7			118.4
560			119.2	118.7	118.2	117.8	117.4	117.1	116.9			117.6
570			118.5	118.0	117.5	117.0	116.6	116.3	116.1	115.9		116.9
580			117.9	117.3	116.7	116.3	115.9	115.5	115.3	115.1		116.1
590		117.9	117.2	116.6	116.0	115.5	115.1	114.8	114.5	114.3	114.1	115.3
600		117.2	116.5	115.9	115.3	114.8	114.3	114.0	113.7	113.4	113.3	114.6
610		116.6	115.8	115.2	114.5	114.0	113.6	113.2	112.9	112.6	112.4	113.8
620	116.8	115.9	115.1	114.4	113.8	113.3	112.8	112.4	112.0	111.8	111.6	113.1
630	116.2	115.3	114.5	113.7	113.1	112.5	112.0	111.6	111.2	110.9	110.7	112.3
640	115.5	114.6	113.8	113.0	112.3	111.7	111.2	110.8	110.4	110.1	109.9	111.5
650	114.9	114.0	113.1	112.3	111.6	111.0	110.4	110.0	109.6	109.2	109.0	110.8
660	114.3	113.3	112.4	111.6	110.9	110.2	109.6	109.1	108.7	108.4	108.1	110.0
670	113.6	112.6	111.7	110.9	110.1	109.5	108.9	108.3	107.9	107.5	107.3	109.2

TABLE 73(b). Two-dimensional equation and statistical parameters

$\gamma = a + bT + cCT^2 + dTC^2$ (dyn cm^{-1})

a	$b \cdot 10^2$	$c \cdot 10^7$	$d \cdot 10^7$	Max percent departure	Stand. error of est.
155.67822	−6.27403	−2.31449	5.98777	−0.35% (540 K, 75 mol % $NaNO_3$)	0.143 (0.1%)

Reference: [26]

C = mole percent KNO_3

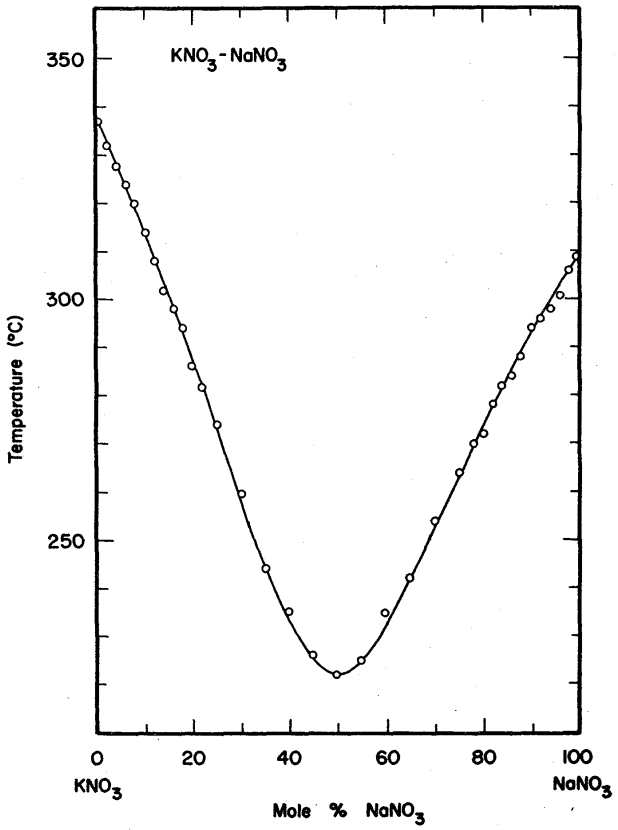

FIGURE 35. Temperature–composition phase diagram for KNO_3–$NaNO_3$.

A. G. Bergman and S. I. Beruli, Izv. Sekt. Fiz. Khim. Ann. **21**, 178 (1952).

KNO_3–$Pb(NO_3)_2$

Density

Nineteen investigations of the density of KNO_3 [1 (p. 26), 4, 9, 12, 25, 27, 110, 115, 118, 130] have been reported. $Pb(NO_3)_2$ has not been investigated. Some experimental aspects of the density measurements of KNO_3 are discussed in the section on KNO_3–$NaNO_3$.

Laybourn and Madgin [130] used a dilatometric method to measure the density of molten KNO_3–$Pb(NO_3)_2$ mixtures in the temperature range from 503 K to 735 K for pure KNO_3 and mixtures containing 31.4, 23.4, 16.9, 11.6, 7.1, and 3.3 mole percent $Pb(NO_3)_2$. The results were recalculated using a two-dimensional statistical analysis; the values in the form of a temperature-composition-density matrix are in table 74(a) for rounded compositions and temperatures. The corresponding statistical parameters are given in table 74(b). The experimental uncertainty of the results of Laybourn and Madgin is estimated to be about 0.3 percent. The values for KNO_3 deviate from the recommendations [1] to within −0.17 to −0.11 percent.

The salts used by Laybourn and Madgin [130] were recrystallized three times from water. KNO_3 was fused after the first recrystallization and any scum formed was removed. $Pb(NO_3)_2$ was purified by adding concentrated nitric acid to a saturated solution, which caused the $Pb(NO_3)_2$ to precipitate. The crystals were dissolved in water and the above cycle of operations was repeated six times. $Pb(NO_3)_2$ was dried in an air-bath at 100 °C, pulverized and heated for 24 hours at about 120 °C and finally dried at 160 °C for 1 hour. It was stored in a sulphuric acid desiccator.

Laybourn and Madgin used the dilatometric method for their measurements. The pyrex bulb was calibrated with different amounts of mercury for a series of temperatures up to 300 °C. The density of mercury at 0 °C was used to calculate the volumes corresponding to the various heights. Corrections were applied for the shape of the meniscus, and expansion of the pyrex. In order to discover if the molten nitrates had any effect on the glass, the bulbs were filled with various mixtures and kept at 350–450 °C for 6 days. In most cases no loss in weight could be detected. The temperature range was restricted by the decomposition of $Pb(NO_3)_2$.

TABLE 74(a). KNO_3–$Pb(NO_3)_2$: Density

Numerical values (g cm^{-3})

	Mole percent $Pb(NO_3)_2$							
T(K)	30	25	20	15	10	5	0	23
510		2.684						
520		2.675						2.623
530		2.665	2.534					2.614
540	2.777	2.655	2.525					2.604
550	2.767	2.646	2.516					2.595
560	2.757	2.636	2.507	2.369				2.585
570	2.747	2.627	2.498	2.360				2.576
580	2.738	2.617	2.488	2.351				2.567
590	2.728	2.608	2.479	2.343	2.198			2.557
600	2.718	2.598	2.470	2.334	2.190			2.548
610	2.708	2.588	2.461	2.325	2.182	2.030		2.538
620	2.698	1.579	2.452	2.317	2.173	2.022	1.862	2.529
630		2.569	2.443	2.308	2.165	2.014	1.855	2.520
640			2.434	2.299	2.157	2.007	1.848	2.510
650				2.291	2.149	1.999	1.841	
660					2.141	1.991	1.834	
670						1.984	1.827	
680						1.976	1.820	
690							1.813	
700							1.806	
710							1.799	
720							1.792	
730							1.785	

TABLE 74(b). Two-dimensional equation and statistical parameters

$\rho = a + bT + cC^2 + dTC^2$ (g cm^{-3})

a	$b \cdot 10^3$	$c \cdot 10^4$	$d \cdot 10^8$	Max. percent departure	Standard error of est.
4.29304	−1.27892	−1.99301	5.72872	0.35% (691.6 K, 96.7 mol % KNO_3)	0.004 (0.17%)

Reference: [130]
C = mole percent KNO_3

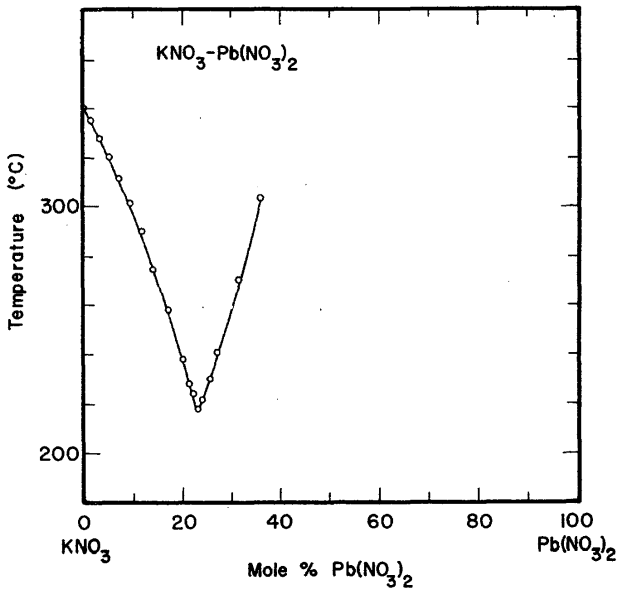

FIGURE 36. Temperature – composition phase diagram for KNO_3–$Pb(NO_3)_2$.

H. M. Glass, K. Laybourn, and W. M. Madgin, J. Chem. Soc. (Lond.) 874 (1932).

KNO_3–$RbNO_3$

Electrical Conductance

Twenty-seven investigations of the specific conductance of KNO_3 [1 (p. 26), 9, 23, 24, 29, 82, 89, 90, 94, 100, 107, 116, 117, 121, 122, 129] and 11 investigations of $RbNO_3$ [1 (p. 27), 24, 73, 88, 104, 121, 123, 125, 129, 135] have been reported.

The results for KNO_3 by Robbins and Braunstein [122] classical ac technique are recommended as the "best" values, the uncertainty estimate being about 0.3 percent. The least squares equation κ (ohm^{-1} cm^{-1}) $= -2.1230 + 5.7252 \cdot 10^{-3}T - 2.0221 \cdot 10^{-6}T^2$ describes the temperature dependence in the range from 620 to 815 K with a standard error of 0.0008 = 0.08 percent. The recommended values [1] deviate from these values (0.5 to 2.2 percent). The results of Brillant [24] for $RbNO_3$ (modified potentiometric ac technique) are recommended as "best" values to replace the recommendation [1]. The temperature dependence of these data in the range from 585 to 685 K is given by κ (ohm^{-1} cm^{-1}) $= -1.0021 + 2.390 \cdot 10^{-3}T$. The uncertainty is estimated to be about 0.3 percent. The recommended values [1] deviate from the values of Brillant (1.9 to 6.3 percent).

Some experimental aspects of these two studies: A modified conductance-bridge (1 to 50 KHz) with series components in the balancing arm and a silica conductance cell was used by Robbins and Braunstein. The cell constant was calibrated with 0.1 demal aqueous KCl. "Baker analyzed" reagent grade KNO_3 was dried at 100 °C for several days. Possible errors due to nitrite formation were checked. However, up to 541 °C no indication of any nitrite formation was observed. Brillant used a modified potentiometric ac technique (1500–2000 Hz) with a silica conductance cell. The cell constant was determined with saturated aqueous NaCl and aqueous KCl. $RbNO_3$ was recrystallized twice and dried for several days in vacuum. The salt was premelted and treated in molten state with dry nitrogen, then filtered, solidified and stored in vacuum.

The specific conductance of molten KNO_3–$RbNO_3$ mixtures has been measured by two groups [121, 123] both using the classical ac technique. The results by Protsenko and Popovskaya [121] for 18 different compositions and for the single components, covering a temperature range from 570 to 670 K, are recommended as the "best" values. The results are given for rounded temperatures and experimental concentrations in table 75(a). The corresponding least squares equations are in table 75(b). The uncertainty of the results of Protsenko and Popovskaya is estimated to be about 0.4 percent. The results for KNO_3 and $RbNO_3$ deviate from our newly recommended data [24, 122] (0.7 to 1.2 percent) and (0.2 to 1.5 percent) respectively and from the recommendations [1] (−0.4 to 0.2 percent) and (−4.3 to −1.6 percent) respectively. De Nooijer [123] reports data for the equimolar mixture and the single components as well. The values for the 50 mole percent mixture, however, deviate from the results of Protsenko and Popovskaya (−2.4 to −0.2 percent).

Protsenko and Popovskaya used an ac technique (1200–2400 Hz), with a pyrex conductance cell. The cell

TABLE 75(a). KNO_3–$RbNO_3$: Electrical conductance

Specific conductance: Numerical values ($ohm^{-1}\ cm^{-1}$)

Mole percent $RbNO_3$

T(K)	100	90	85	80	75	70	67.5	65.0	62.5	60	55	50	45	40	35	30	20	15	10	0
570				0.389	0.392	0.394	0.397	0.400	0.404	0.408	0.414		0.429	0.435						
580				0.414	0.417	0.420	0.424	0.426	0.430	0.435	0.441		0.456	0.463						
590	0.414	0.427	0.430	0.438	0.442	0.445	0.451	0.452	0.456	0.462	0.468	0.479	0.484	0.491	0.500	0.510	0.533			
600	0.438	0.452	0.454	0.462	0.467	0.471	0.477	0.478	0.483	0.488	0.494	0.506	0.512	0.519	0.528	0.538	0.561			
610	0.462	0.477	0.478	0.487	0.492	0.496	0.503	0.503	0.509	0.514	0.521	0.533	0.539	0.546	0.556	0.566	0.590	0.594	0.600	0.625
620	0.486	0.502	0.502	0.511	0.517	0.522	0.529	0.529	0.535	0.541	0.547	0.560	0.566	0.574	0.584	0.594	0.618	0.624	0.631	0.656
630	0.509	0.526	0.526	0.536	0.542	0.547	0.555	0.555	0.561	0.567	0.574	0.587	0.593	0.601	0.612	0.623	0.646	0.654	0.660	0.688
640	0.532	0.551	0.550	0.560	0.567	0.572	0.581	0.581	0.587	0.593	0.600	0.613	0.620	0.629	0.640	0.651	0.675	0.684	0.690	0.719
650	0.555	0.574	0.574	0.585	0.592	0.598	0.607	0.607	0.613	0.619	0.626	0.639	0.647	0.656	0.668	0.678	0.703	0.713	0.720	0.750
660	0.578	0.598	0.598	0.610	0.617	0.623	0.632	0.632	0.640	0.645	0.652	0.665	0.674	0.683	0.695	0.706	0.732	0.742	0.749	0.781
670	0.601	0.621	0.622	0.634	0.642	0.648	0.658	0.658	0.666	0.671	0.678	0.691	0.700	0.709	0.723	0.734	0.760	0.771	0.778	0.811

TABLE 75(b). Temperature-dependent equations

$\kappa = a + bT + cT^2$ (ohm^{-1} cm^{-1})

Comp. (mol % $RbNO_3$)	a	$b \cdot 10^3$	$c \cdot 10^6$	Stand. error of est. (percent)
0	−1.6105	4.1723	−0.8324	0.0001 = 0.01
10	−1.7103	4.5434	−1.2387	0.0000
15	−1.7094	4.5404	−1.2519	0.0003 = 0.04
20	−1.1401	2.8312	0.0070	0.0005 = 0.08
30	−1.2872	3.2602	−0.3634	0.0004 = 0.06
35	−1.2781	3.2187	−0.3464	0.0005 = 0.08
40	−1.4315	3.7229	−0.7874	0.0006 = 0.10
45	−1.4336	3.7373	−0.8253	0.0006 = 0.11
50	−1.5051	3.9935	−1.0688	0.0008 = 0.14
55	−1.2696	3.2223	−0.4706	0.0004 = 0.07
60	−1.2719	3.2188	−0.4758	0.0006 = 0.11
62.5	−1.0770	2.5829	0.0275	0.0006 = 0.11
65	−1.1665	2.8861	−0.2433	0.0005 = 0.09
67.5	−1.3849	3.5745	−0.7853	0.0006 = 0.11
70	−1.1628	2.8935	−0.2848	0.0004 = 0.08
75	−1.0458	2.5327	−0.0193	0.0006 = 0.12
80	−0.9448	2.2466	0.1643	0.0004 = 0.08
85	−0.9847	2.3968	0.0025	0.0000
90	−1.5671	4.2170	−1.4190	0.0008 = 0.15
100	−1.3081	3.4380	−0.8789	0.0004 = 0.08

Reference: [121]

was calibrated with molten KNO_3, using the values of Jaeger [1].

Density

Nineteen investigations of the density of KNO_3 [1 (p. 26), 4, 9, 12, 25, 27, 110, 115, 118, 130] and six investigations of $RbNO_3$ [1 (p. 27), 24, 25, 86, 109, 117, 118] have been reported. Some experimental aspects of the density measurements of KNO_3 are discussed in the section on KNO_3–$NaNO_3$. Revised recommendations for $RbNO_3$ are based on the work of McAuley, Rhodes and Ubbelohde [25] and together with some experimental aspects are discussed in the section on $NaNO_3$–$RbNO_3$.

Murgulescu and Zuca [118] used the Archimedean method to measure the density of molten KNO_3–$RbNO_3$ mixtures, in the temperature range from 570 to 785 K for 25, 50, and 75 mole percent mixtures and for the single components. The results of a two-dimensional statistical analysis of these data are given in table 76(a) as a temperature-composition-density matrix, at rounded compositions and temperatures. The corresponding statistical parameters are given in table 76(b). The experimental uncertainty of the results of Murgulescu and Zuca is estimated to be about 0.4 percent. The results for $RbNO_3$ deviate from our newly recommended

TABLE 76(a). KNO_3–$RbNO_3$: Density

Numerical values (g cm^{-3})

Mole percent $RbNO_3$

T(K)	100	90	80	70	60	50	40	30	20	10	0	30.0
575			2.39	2.33	2.27	2.21						
590		2.43	2.37	2.31	2.25	2.19	2.13	2.07				2.07
605	2.48	2.42	2.36	2.30	2.24	2.18	2.12	2.06	2.00			2.06
620	2.47	2.41	2.35	2.29	2.23	2.17	2.11	2.05	1.99	1.93		2.05
635	2.45	2.39	2.33	2.27	2.21	2.15	2.10	2.04	1.98	1.92	1.86	2.04
650	2.44	2.38	2.32	2.26	2.20	2.14	2.08	2.02	1.97	1.91	1.85	2.02
665	2.42	2.36	2.30	2.25	2.19	2.13	2.07	2.01	1.95	1.89	1.84	2.01
680	2.41	2.35	2.29	2.23	2.17	2.12	2.06	2.00	1.94	1.88	1.82	2.00
695	2.39	2.33	2.28	2.22	2.16	2.10	2.04	1.99	1.93	1.87	1.81	1.99
710	2.38	2.32	2.26	2.20	2.15	2.09	2.03	1.97	1.92	1.86	1.80	1.97
725	2.36	2.31	2.25	2.19	2.13	2.08	2.02	1.96	1.90	1.85	1.79	1.96
740		2.29	2.23	2.18	2.12	2.06	2.01	1.95	1.89	1.83	1.78	1.95
755		2.28	2.22	2.16	2.11	2.05	1.99				1.77	
770			2.21	2.15	2.09							

TABLE 76(b). Two-dimensional equation and statistical parameters

$\rho = a + bT + cC + dCT^2$ (g cm^{-3})

a	$b \cdot 10^4$	$c \cdot 10^3$	$d \cdot 10^9$	Max. percent departure	Standard error of est.
3.06983	−9.76043	−6.49560	1.44281	−0.46% (572.2 K, 50 mol % KNO_3)	0.005 (0.2%)

Reference: [118]

C = mole percent KNO_3

values [25] (−0.47 to −0.20 percent) and from the recommendations [1] (0.77 to 0.64 percent). For KNO_3 the deviations from the recommended values [1] range between −0.08 and 0.13 percent.

For melt preparation of Murgulescu and Zuca see the section on KNO_3–$NaNO_3$. The experimental procedure is discussed in the section on $NaNO_3$–$RbNO_3$.

Viscosity

Thirteen investigations of the viscosity of KNO_3 [1 (p. 27), 48, 86, 107, 118, 119] and four investigations of $RbNO_3$ [1 (p. 27), 48, 118] have been reported. Revised recommendations for KNO_3 are based on the work of Timidei, Lederman and Janz [119] and together with some experimental aspects are discussed in the section on KNO_3–$NaNO_3$. Some experimental aspects of the viscosity measurements of $RbNO_3$ are discussed in the section on $NaNO_3$–$RbNO_3$.

Murgulescu and Zuca [118] used the oscillating ball technique to measure the viscosity of molten KNO_3–$RbNO_3$ mixtures (25, 50, and 75 mole percent for the temperature range, 570–700 K). The values are given for rounded temperatures and experimental concentrations in table 77(a). The corresponding least squares equations are in table 77(b). The experimental uncertainty of the results of Murgulescu and Zuca is estimated to be about (1.5 percent). The values for KNO_3 agree with the recommendations [1] to within −1.2 to −0.4 percent.

In the work of Murgulescu and Zuca [118] both KNO_3 and $RbNO_3$ were Merck p.a. reagents, predried for 24 h at 150 °C and melted under a dry nitrogen atmosphere. The experimental procedure is discussed in the section on KNO_3–$NaNO_3$.

Surface Tension

Eight investigations of the surface tension of KNO_3 [2 (p. 67), 41, 84] and two of $RbNO_3$ [2 (p. 68)] have been reported.

Bertozzi and Sternheim [26] used the Wilhelmy slide plate method to measure the surface tension of molten KNO_3–$RbNO_3$ mixtures, in the temperature range from the melting point up to 400 °C, for 25, 50, and 75 mole percent mixtures and for the single components. The results of a two-dimensional statistical analysis of these data are given in table 78(a) as a temperature-composition-surface tension matrix, at rounded values of composition and temperature. The corresponding statistical parameters are given in table 78(b). The data of Bertozzi and Sternheim for the single components show percent departures from the recommendations [2] by −0.6 to 1.1 percent.

The experimental aspects of the investigation of Bertozzi and Sternheim [26] have been discussed previously [2 (p. 67)].

TABLE 77(a). KNO_3–$RbNO_3$: Viscosity

Numerical values (cp)

Mole percent $RbNO_3$

T(K)	100	75	50	25	0
580			3.749		
590			3.523		
600	3.645	3.387	3.316	3.232	
610	3.451	3.226	3.129	3.042	
620	3.273	3.072	2.957	2.867	
630	3.111	2.925	2.800	2.708	2.606
640	2.960	2.786	2.656	2.563	2.460
650	2.821	2.654	2.523	2.429	2.336
660	2.694	2.530	2.401	2.305	2.217
670	2.574	2.413	2.288	2.192	2.107
680	2.463	2.303	2.183	2.086	2.005
690	2.361	2.201	2.085	1.992	1.912
700	2.266	2.107	1.995	1.899	1.825
710	2.176	2.020	1.912	1.817	1.744
720	2.093	1.940	1.833	1.739	1.700
730	2.015	1.868	1.761	1.666	1.600
740	1.942	1.803	1.692	1.599	1.534

TABLE 77(b). Temperature-dependent equations

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

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

Comp. (mol % $RbNO_3$)	a	$b \cdot 10^2$	$c \cdot 10^5$	$d \cdot 10^3$	A	E (cal mol^{-1})	Stand. error of est (percent)
0					7.375	4461	0.0101 = 0.52
25					7.819	4435	0.0083 = 0.38
50					9.477	4237	0.0144 = 0.60
75	26.3313	−5.961	3.4992	1.0399			0.0224 = 0.93
100					13.076	3966	0.0310 = 1.20

Reference: [118]

TABLE 78(a). KNO_3–$RbNO_3$: Surface tension

Numerical values (dyn cm^{-1})

	Mole percent $RbNO_3$											
T(K)	100	90	80	70	60	50	40	30	20	10	0	30.0
565				111.3	111.6							
570			111.3	111.0	111.2	111.9						113.6
575		112.1	110.9	110.6	110.9	111.5	112.4					113.3
580		111.8	110.6	110.2	110.5	111.1	112.0	112.9				112.9
585	113.7	111.4	110.2	109.8	110.1	110.7	111.6	112.5				112.5
590	113.4	111.1	109.8	109.4	109.7	110.3	111.2	112.2	112.9			112.2
595	113.1	110.8	109.5	109.0	109.3	109.9	110.8	111.8	112.6			111.8
600	112.8	110.4	109.1	108.6	108.8	109.5	110.4	111.4	112.2	112.7		111.4
605	112.5	110.0	108.7	108.2	108.4	109.1	110.0	111.0	111.8	112.3		111.0
610	112.2	109.7	108.3	107.8	108.0	108.6	109.6	110.6	111.5	112.0	112.0	110.6
615	111.8	109.3	107.9	107.4	107.5	108.2	109.1	110.2	111.1	111.7	111.7	110.2
620	111.5	109.0	107.5	107.0	107.1	107.8	108.7	109.7	110.7	111.3	111.4	109.7
625	111.2	108.6	107.1	106.5	106.7	107.3	108.2	109.3	110.3	110.9	111.1	109.3
630	110.8	108.2	106.7	106.1	106.2	106.8	107.8	108.9	109.9	110.6	110.8	108.9
635	110.5	107.8	106.3	105.6	105.7	106.4	107.3	108.4	109.4	110.2	110.4	108.4
640	110.2	107.4	105.8	105.2	105.3	105.9	106.9	108.0	109.0	109.8	110.1	108.0
645	109.8	107.0	105.4	104.7	104.8	105.4	106.4	107.5	108.6	109.4	109.7	107.5
650	109.4	106.6	104.9	104.2	104.3	104.9	105.9	107.0	108.1	109.0	109.4	107.0
655	109.1	106.2	104.5	103.8	103.8	104.4	105.4	106.5	107.7	108.5	109.0	106.5
660	108.7	105.8	104.0	103.3	103.3	103.9	104.9	106.1	107.2	108.1	108.6	106.1

TABLE 78 (b). Two-dimensional equation and statistical parameters

$\gamma = a + bT^3 + cC^3 + dCT^2 + eTC^2$ (dyn cm^{-1})

a	$b \cdot 10^8$	$c \cdot 10^5$	$d \cdot 10^7$	$e \cdot 10^5$	Max percent departure	Standard error of est.
125.03339	−5.67508	−3.35262	−8.24878	1.05084	1.14% (673 K, 50 mol % $RbNO_3$)	0.495 (0.5%)

Reference: [26]
C = mole percent KNO_3

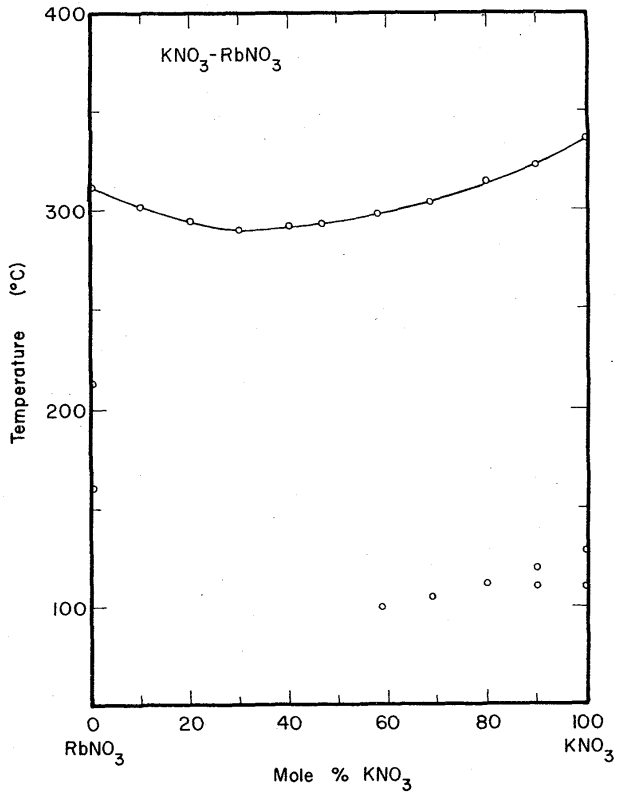

FIGURE 37. Temperature–composition phase diagram for KNO_3–$RbNO_3$.

N. A. Pushin and M. Radonchie, Glasnik Hemiskog Drustva Kraljevine Jugoslovije **6–8**, 25 (1937).

TABLE 79(a). KNO_3–$Sr(NO_3)_2$: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

	Mole percent $Sr(NO_3)_2$			
T(K)	30	21.5	10	0
590			0.4722	
600			0.5018	
610			0.5312	
620			0.5605	0.6413
630			0.5895	0.6748
640			0.6184	0.7077
650			0.6470	0.7402
660	0.5100	0.5719	0.6755	0.7722
670	0.5361	0.5988	0.7038	0.8037
680	0.5621	0.6258	0.7320	0.8347
690	0.5882	0.6528	0.7599	0.8652
700	0.6143	0.6797	0.7877	0.8953
710	0.6403	0.7067	0.8152	0.9248
720	0.6664	0.7336	0.8426	0.9539
730				0.9825

TABLE 79(b). Temperature-dependent equations

$\kappa = a + bT + cT^2$ (ohm^{-1} cm^{-1})

Comp. (mol % $Sr(NO_3)_2$)	a	$b \cdot 10^3$	$c \cdot 10^6$	Stand. error of est. (percent)
0	−2.3824	6.3849	−2.4322	0.0013 = 0.16
10	−1.5993	4.0533	−0.9192	0.0013 = 0.20
21.5	−1.2076	2.6962	0	0.0032 = 0.49
30	−1.2102	2.6064	0	0.0030 = 0.51

Reference: [123]

KNO_3–$Sr(NO_3)_2$

Electrical Conductance

Twenty-seven investigations of the specific conductance of KNO_3 [1 (p. 26), 9, 23, 24, 29, 82, 89, 90, 94, 100, 107, 116, 117, 121, 122, 129] have been reported. $Sr(NO_3)_2$ has not been investigated. Revised recommendations for KNO_3 are based on the sork of Robbins and Braunstein [122] and together with some experimental aspects are discussed in the sections on KNO_3–$RbNO_3$ and KNO_3–$NaNO_3$.

De Nooijer [123] measured the specific conductance of molten KNO_3–$Sr(NO_3)_2$ mixtures using the classical ac technique. His results for pure KNO_3 and mixtures containing 10, 21.5, and 30 mole percent $Sr(NO_3)_2$, covering a temperature range from 530 to 735 K, are given in table 79(a) for the experimental compositions at rounded temperatures. The corresponding temperature-dependent equations are given in table 79(b). The experimental uncertainty of the results of De Nooijer is estimated to be about 0.4 percent. The values for KNO_3 deviate from our newly recommended values [122] (−0.65 to 0.41 percent) and from the recommendations [1] (−1.38 to −0.01 percent).

For discussion of the melt preparation and experimental technique of De Nooijer see the section on $CsNO_3$–KNO_3.

Density

Nineteen investigations of the density of KNO_3 [1 (p. 26), 4, 9, 12, 25, 27, 110, 115, 118, 130] have been reported. $Sr(NO_3)_2$ has not been investigated. Some experimental aspects of the density measurements of KNO_3 are discussed in the section on KNO_3–$NaNO_3$.

Three different methods were used to measure the density of molten KNO_3–$Sr(NO_3)_2$ mixtures: the Archimedean method by Petersen, Ewing and Smith [93], a manometric densitometer by McAuley, Rhodes and Ubbelohde [25] and a dilatometric method by K. Laybourn and W. M. Madgin [130]. The results of McAuley, Rhodes and Ubbelohde for KNO_3 and mixtures containing 3.56, 8.83, 10.0, 13.52, 17.08, and 20.55 mole percent $Sr(NO_3)_2$, covering a temperature range from 570 to 695 K, are recommended as the "best" values. Using the molar volume equations reported by the authors, densities were recalculated. The results of a two-dimensional statistical analysis of these data are given in table 80(a) as a temperature-composition-density matrix, for rounded compositions and temperatures; the corresponding statistical parameters are given in table 80(b). The experimental uncertainty of the results of

McAuley, Rhodes and Ubbelohde is estimated to be about 0.3 percent. The values for KNO_3 deviate from the recommendations [1] (−0.39 to −0.22 percent). Petersen, Ewing and Smith used the Archimedean method to measure densities in the temperature range from 620 to 775 K for KNO_3 alone and mixtures containing 10, 20, and 30 mole percent $Sr(NO_3)_2$. Their values deviate from the results of McAuley, Rhodes and Ubbelohde (−0.17 to −0.03 percent for KNO_3 alone and −0.48 to −0.42 percent for a mixture containing 10 mole percent $Sr(NO_3)_2$).

The melt preparation of McAuley, Rhodes and Ubbelohde is discussed in the section on $Ba(NO_3)_2$–$NaNO_3$; the experimental technique in the section on $NaNO_3$–$RbNO_3$.

TABLE 80(a). KNO_3–$Sr(NO_3)_2$: Density

Numerical values (g cm^{-3})

Mole percent $Sr(NO_3)_2$

T(K)	20	15	10	5	0	14.3
580			2.001			
590		2.041	1.993			2.034
600		2.034	1.986			2.027
610		2.027	1.978	1.926		2.021
620		2.021	1.971	1.918	1.862	2.014
630	2.062	2.014	1.963	1.909	1.853	2.007
640	2.056	2.007	1.956	1.901	1.844	2.000
650	2.050	2.001	1.948	1.893	1.834	1.994
660	2.044	1.994	1.941	1.884	1.825	1.987
670	2.038	1.987	1.933	1.876	1.816	1.980
680	2.032	1.981	1.926	1.868	1.807	1.973
690				1.859	1.797	

TABLE 80(b). Two-dimensional equation and statistical parameters

$\rho = a + bTC^2$ (g cm^{-3})

a	$b \cdot 10^8$	Max. percent departure	Stand. error of est.
2.43399	−9.22581	0.74% (670 K, 82.9 mol % KNO_3)	0.004 (0.21%)

Reference: [25]

C = mole percent KNO_3

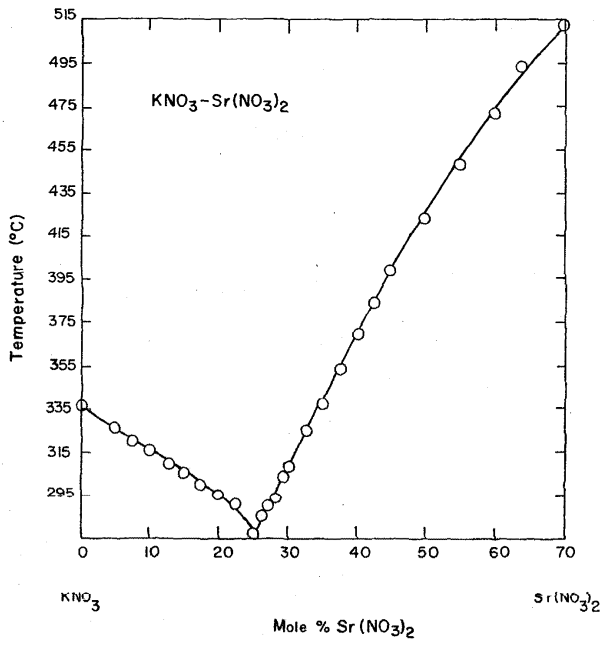

FIGURE 38. Temperature – composition phase diagram for KNO_3–$Sr(NO_3)_2$.

P. I. Protsenko and A. G. Bergman, Zh. Obshch. Khim. **21**, 1380 (1951).

KNO_3–$TlNO_3$

Electrical Conductance

Twenty-seven investigations of the specific conductance of KNO_3 [1 (p. 26), 9, 23, 24, 29, 82, 89, 90, 94, 100, 107, 116, 117, 121, 122, 129] and 17 investigations of $TlNO_3$ [1 (p. 28), 24, 27, 74, 89, 103, 104, 112, 117, 121] have been reported. Revised recommendations for KNO_3 are based on the work of Robbins and Braunstein [122] and together with some experimental aspects are discussed in the sections on KNO_3–$RbNO_3$ and KNO_3–$NaNO_3$. Some experimental aspects of the conductance measurements of $TlNO_3$ are discussed in the section on $NaNO_3$–$TlNO_3$.

The specific conductance of molten KNO_3–$TlNO_3$ mixtures has been measured by three groups [24, 117, 123] using either the classical ac technique [123, 117] or a modified potentiometric ac technique [24]. The results of Brillant [24] for the single components and mixtures containing 20, 30, 40, 60, and 80 mole percent $TlNO_3$, covering a temperature range from 470 to 670 K, are recommended as the "best" values and are given in table 81(a) for the experimental concentrations at rounded temperatures. These were derived from the temperature-dependent equations reported by the author and listed in table 81(b). The experimental uncertainty of the results of Brillant is estimated to be about 0.3 percent. The results for KNO_3 deviate from our newly recommended values [122] (0.16 to 0.48 percent) and from the recommendations [1] (−1.43 to −0.13 percent), whereas the data for $TlNO_3$ agree with the recommendations [1] to within −0.78 to −0.60 percent. Popovskaya, Protsenko and Eliseeva [117] measured the specific conductance of the binary mixture at nine different concentrations as well as pure $TlNO_3$ for two temperatures (513.2 K, 593.2 K). Their results deviate from the values of Brillant (−0.66 to 3.22 percent, pure $TlNO_3$; up to 1.56 percent, 20 mole percent $TlNO_3$; up to 0.59 percent, 40 mole percent $TlNO_3$; 0.31 to 5.39 percent, 60 mole percent $TlNO_3$; and −0.27 to 5.52 percent, 80 mole percent $TlNO_3$). The results of De Nooijer [123] for the single components and the equimolar mixture deviate from our newly recommended values [180] (−0.89 to −1.74 percent, pure KNO_3; and 0.40 to 1.64 percent, pure $TlNO_3$).

The experimental technique used by Brillant [24] is discussed in the section on KNO_3–$RbNO_3$, whereas the melt preparation is described in the section on $AgNO_3$–$LiNO_3$.

TABLE 81(a). KNO_3–$TlNO_3$: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

Mole percent $TlNO_3$

T(K)	100	80	60	40	30	20	0
470		0.290					
480	0.344	0.317					
490	0.370	0.344					
500	0.396	0.370	0.347				
510	0.422	0.397	0.375				
520	0.448	0.424	0.402				
530	0.474	0.450	0.430				
540	0.500	0.477	0.457				
550	0.525	0.504	0.485	0.466			
560	0.551	0.530	0.513	0.495			
570	0.576	0.557	0.540	0.523	0.514		
580	0.601	0.583	0.568	0.551	0.543		
590	0.626	0.609	0.595	0.580	0.572	0.566	
600	0.651	0.635	0.622	0.608	0.601	0.596	
610	0.675	0.661	0.649	0.636	0.630	0.626	0.620
620	0.700	0.687	0.676	0.665	0.660	0.656	0.651
630					0.689	0.686	0.683
640							0.714
650							0.746
660							0.777
670							0.809

TABLE 81(b). Temperature-dependent equations

$\kappa = a + bT$ (ohm^{-1} cm^{-1})

Comp. (mol % $TlNO_3$)	a	$b \cdot 10^3$	Temp. range (K)
0	−1.3068	3.158	609.2–673.2
20	−1.2036	3.000	593.2–633.2
30	−1.1490	2.917	573.2–631.2
40	−1.0919	2.833	553.2–623.2
60	−1.0331	2.760	503.2–596.2
	−0.9872	2.683	596.2–619.2
80	−0.9621	2.665	473.2–577.2
	−0.9199	2.592	577.2–617.2
100	−0.8980	2.588	483.2–558.2
	−0.8416	2.487	558.2–623.2

Reference: [24]

Density

Nineteen investigations of the density of KNO_3 [1 (p. 26), 4, 9, 12, 25, 27, 110, 115, 118, 130] and five investigations of $TlNO_3$ [1 (p. 28), 24, 103, 117] have been reported. Some experimental aspects of the density measurements of KNO_3 and $TlNO_3$ are discussed in the sections on KNO_3–$NaNO_3$ and $AgNO_3$–$TlNO_3$, respectively.

The density of molten KNO_3–$TlNO_3$ mixtures has been measured by two groups [24, 117] using the Archimedean method. The results of Brillant [24] for the single components and mixtures containing 20, 30, 40, 60, and 80 mole percent $TlNO_3$ cover a temperature range from 475 to 675 K are recommended as the "best" values. The results of a two-dimensional statistical analy-

sis of these data are given in table 82(a) as a temperature-concentration-density matrix, at rounded compositions and temperatures. The corresponding statistical parameters are given in table 82(b). The experimental uncertainty of the results of Brillant is estimated to be about 0.2 percent. The results for KNO_3 and $TlNO_3$ deviate from the recommendations [1] (−0.08 to 0.13 percent) and (0.18 to 0.22 percent), respectively. The data by Popovskaya, Protsenko and Eliseeva [117] for mixtures containing 10, 20, 28, 40, 50, 60, 70, 80, and 90 mole percent KNO_3 and $TlNO_3$ alone are for one temperature only (593.2 K) and deviate from the values of Brillant (0.07 percent, 70 mole percent KNO_3 to 0.48 percent, 40 mole percent KNO_3).

For melt preparation and experimental techniques of Brillant see the section on $AgNO_3$–$LiNO_3$.

TABLE 82(a). KNO_3–$TlNO_3$: Density

Numerical values (g cm^{-3})

	Mole percent $TlNO_3$											
T(K)	100	90	80	70	60	50	40	30	20	10	0	72
480		4.617	4.338									
490	4.880	4.601	4.322	4.043								4.099
500	4.865	4.585	4.306	4.027								4.083
510	4.849	4.570	4.290	4.011	3.732							4.067
520	4.833	4.554	4.275	3.995	3.716							4.051
530	4.817	4.538	4.259	3.980	3.700	3.421						4.035
540	4.801	4.522	4.243	3.964	3.685	3.405						4.020
550	4.786	4.506	4.227	3.948	3.669	3.390						4.004
560	4.770	4.491	4.211	3.932	3.653	3.374	3.095					3.988
570	4.754	4.475	4.196	3.916	3.637	3.358	3.079					3.972
580	4.738	4.459	4.180	3.901	3.621	3.342	3.063	2.784				3.956
590	4.722	4.443	4.164	3.885	3.606	3.326	3.047	2.768				3.941
600	4.707	4.427	4.148	3.869	3.590	3.311	3.031	2.752	2.473			3.925
610	4.691	4.412	4.132	3.853	3.574	3.295	3.016	2.736	2.457	2.178	1.899	3.909
620	4.675	4.396			3.558	3.279	3.000	2.721	2.441	2.162	1.883	
630								2.705	2.426	2.146	1.867	
640										2.131	1.851	
650										2.115	1.836	
660											1.820	
670											1.804	

TABLE 82(b). Two-dimensional equation and statistical parameters

$\rho = a + bT + cC$ (g cm^{-3})

a	$b \cdot 10^2$	$c \cdot 10^3$	Max. percent departure	Stand. error of est.
5.6539	−1.57877	−2.79209	1.47% (675 K, 100 mol % KNO_3)	0.010 (0.30%)

Reference: [24]

C = mole percent KNO_3

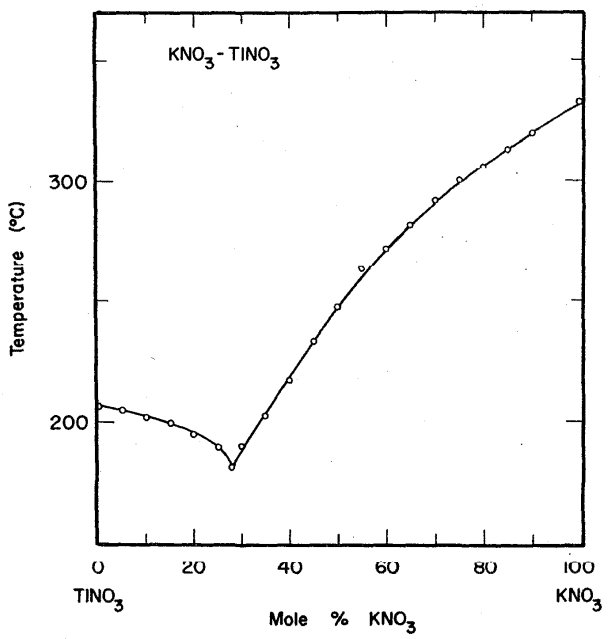

FIGURE 39. Temperature–composition phase diagram for KNO_3–$TlNO_3$.

P. I. Protsenko and I. K. Shelomov, Zh. Obshch. Khim. **23**, 1433 (1953).

$LiNO_3$–$NaNO_3$

Electrical Conductance

Twelve studies of the specific conductance of $LiNO_3$ [1 (p. 25), 24, 29, 73, 79, 117, 120, 129] and 26 investigations of $NaNO_3$ [1 (p. 25), 9, 21, 24, 29, 75, 83, 89, 100, 104, 111, 112, 117, 120, 125, 128, 129] have been reported. Some experimental aspects of the conductance measurements of $LiNO_3$ and $NaNO_3$ are discussed in the sections on KNO_3–$LiNO_3$ and KNO_3–$NaNO_3$, respectively.

The specific conductance of molten $LiNO_3$–$NaNO_3$ mixtures has been measured by three groups [76, 21, 29, 123] using the classical ac technique [123], a modified potentiometric ac technique [76, 29], or a dc technique [21]. The results of King and Duke [21] for the single components and 25.30, 49.96, and 74.95 mole percent mixtures, covering a temperature range from 550 to 720 K, are recommended as the "best" values and are given in table 83(a) for the experimental compositions at rounded temperatures. The corresponding temperature-dependent equations are given in table 83(b). The experimental uncertainty of the results of King and Duke is estimated to be about 0.5 percent. The values for $NaNO_3$ deviate from the recommendations [1] (0.65 to 1.35 percent). The results reported by Bizouard [29] and Doucet and Bizouard [76] for the single components and 20, 40, 60, and 80 mole percent mixtures cover a temperature range from 525.8 to 773.2 K. Their values for $LiNO_3$ and $NaNO_3$ deviate from the results of King and Duke (−1.19 to −0.58 percent) and (0.84 to 4.09 percent), respectively. De Nooijer [123] reports values for the single components and the equimolar mixture, between 555 and 695 K. His results compare with the recommended values as follows: $LiNO_3$, −0.44 to −0.24 percent; $NaNO_3$, −1.12 to −0.54 percent; equimolar mixtures, −0.66 to 0.03 percent.

For melt preparation and experimental technique of King and Duke [21] see the section on KNO_3–$NaNO_3$.

TABLE 83(a). $LiNO_3$–$NaNO_3$: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

	Mole percent $NaNO_3$				
T(K)	100	74.95	49.96	25.30	0
500		0.857			
560		0.907	0.935	0.961	0.983
570		0.956	0.985	1.014	1.038
580		1.005	1.033	1.066	1.093
590		1.052	1.082	1.118	1.149
600		1.100	1.130	1.170	1.205
610	1.118	1.146	1.178	1.221	1.262
620	1.163	1.192	1.225	1.271	1.319
630	1.207	1.237	1.272	1.321	1.376
640	1.250	1.282	1.319	1.371	
650	1.292	1.326	1.366	1.421	
660	1.334	1.369	1.412	1.469	
670	1.375	1.412	1.457	1.518	
680	1.415	1.454			
690	1.454	1.496			
700	1.493				
710	1.531				
720	1.569				

TABLE 83(b). Temperature-dependent equations

$\kappa = a + bT + cT^2$ (ohm^{-1} cm^{-1})

Comp. (mol % $NaNO_3$)	a	$b \cdot 10^2$	$c \cdot 10^5$	Stand. error of est. (percent)
0	−1.5242	0.34674	−0.18027	0.0010 = 0.09
25.30	−2.7074	0.77919	−0.22173	0.0010 = 0.08
49.96	−2.3808	0.69058	−0.17573	0.0040 = 0.35
74.95	−2.8718	0.85492	−0.32169	0.0010 = 0.08
100	−2.9565	0.88732	−0.35949	0.0020 = 0.15

Reference: [21]

Density

Seven studies of the density of $LiNO_3$ [1 (p. 25), 9, 24, 86, 117, 143] and 16 investigations of $NaNO_3$ [1 (p. 26), 9, 12, 25, 27, 71, 86, 95, 97, 115, 117, 118, 130] have been reported. Revised recommendations for $NaNO_3$ are based on the work of McAuley, Rhodes and Ubbelohde [25] and together with some experimental aspects are discussed in the section $NaNO_3$–$RbNO_3$, some experi-

mental aspects of the density measurements of $LiNO_3$ are discussed in the section on KNO_3–$LiNO_3$.

The density of molten $LiNO_3$–$NaNO_3$ mixtures has been measured by two groups [86, 136] using the Archimedean method. The results of Murgulescu and Zuca, [86] for 20, 40, 60, and 80 mole percent mixtures, covering a temperature range from 505 to 740 K, are recommended as the "best" values. These values were combined with the values for pure $NaNO_3$ reported by the same authors in a later publication [118]. The results were recalculated using a two-dimensional statistical analysis. The values in the form of a temperature-composition-density matrix are given in table 84(a) at rounded compositions and temperatures, the corresponding statistical parameters are given in table 84(b). The experimental uncertainty of the results of Murgulescu and Zuca is estimated to be about 0.4 percent. The results for $NaNO_3$ deviate from our newly recommended values [25] (1.10 to 1.31 percent) and from the recommendations [1] (0.15 to 0.19 percent). For $LiNO_3$ the deviations from the recommendations [1] range between 0.29 to 0.30 percent. Boxall and Johnson [136] reported values for 46 mole percent $NaNO_3$ between 480.8 and 664.2 K.

Powers, Katz and Kleppa [124] measured the excess volumes in binary $LiNO_3$–$NaNO_3$ mixtures at 340 °C. For a mixture containing 80 mole percent $NaNO_3$ these results are much lower than the excess volumes recalculated from the results of Murgulescu and Zuca (using the molar volume data of McAuley, Rhodes and Ubbelohde [25] for $NaNO_3$ and the recommendations [1] for $LiNO_3$).

The experimental method used by Murgulescu and Zuca [86] is the same as reported in their later publication [118] and is discussed in the section on $NaNO_3$–$RbNO_3$. For melt preparation see the following discussion of viscosity-values.

TABLE 84(a). $LiNO_3$–$NaNO_3$: Density

Numerical values (g cm^{-3})

	Mole percent $NaNO_3$											
T(K)	100	90	80	70	60	50	40	30	20	10	0	49.6
515					1.88	1.87	1.85					1.87
530					1.87	1.86	1.85					1.86
545				1.88	1.87	1.85	1.84	1.82				1.85
560			1.89	1.87	1.86	1.84	1.83	1.81	1.80	1.78	1.77	1.84
575			1.88	1.86	1.85	1.83	1.82	1.80	1.79	1.78	1.76	1.83
590		1.88	1.87	1.85	1.84	1.82	1.81	1.80	1.78	1.77	1.75	1.82
605	1.89	1.87	1.86	1.84	1.83	1.82	1.80	1.79	1.77	1.76	1.74	1.81
620	1.88	1.86	1.85	1.83	1.82	1.81	1.79	1.78	1.76	1.75	1.74	1.81
635	1.87	1.85	1.84	1.82	1.81	1.80	1.78	1.77	1.75	1.74	1.73	1.80
650	1.86	1.84	1.83	1.81	1.80	1.79	1.77	1.76	1.75	1.73	1.72	1.79
665	1.85	1.83	1.82	1.81	1.79	1.78	1.76	1.75	1.74	1.72	1.71	1.78
680	1.84	1.82	1.81	1.80	1.78	1.77	1.76	1.74	1.73	1.71	1.70	1.77
695	1.83	1.81	1.80	1.79	1.77	1.76	1.75	1.73	1.72	1.71	1.69	1.76
710	1.82	1.80	1.79	1.78	1.76	1.75			1.71			1.75
725	1.80	1.79	1.78	1.77	1.75							
740	1.79											

TABLE 84(b). Two-dimensional equation and statistical parameters

$\rho = a + bT + cT^3 + dTC + eT^2C$ (g cm^{-3})

a	$b \cdot 10^4$	$c \cdot 10^{10}$	$d \cdot 10^6$	$e \cdot 10^9$	Max. percent departure	Standard error of est.
2.1797	−4.07663	−2.10510	−5.38677	4.99430	+0.52% (599.2 K, 100 mol % $NaNO_3$)	0.004 (0.2%)

Reference: [86]

C = mole percent $LiNO_3$

Viscosity

Five studies of the viscosity of $LiNO_3$ [1 (p. 25), 48] and 11 investigations of $NaNO_3$ [1 (p. 26), 48, 56, 71, 86, 118] have been reported. Some experimental aspects of the viscosity measurements of $LiNO_3$ are as follows; Protsenko and Razumovskaya [1] and Goodwin and Mailey [1] used pyrex and platinum capillary viscometers, respectively. The results of Dantuma [1] were carried out by means of the oscillating ball technique using a platinum and photographic registration of the damped oscillations. Some experimental aspects of the viscosity measurements of $NaNO_3$ are discussed in the section KNO_3–$NaNO_3$.

Murgulescu and Zuca [86] used the oscillating ball technique to measure the viscosity of molten $LiNO_3$–$NaNO_3$ mixtures. Their values for the single components and 20, 40, 60, and 80 mole percent mixtures, covering a temperature range from 530 to 700 K, are given in table 85(a) for the experimental compositions at rounded temperatures. The corresponding temperature-dependent equations are given in table 85(b). For $NaNO_3$ the results reported by the same authors in another publication were selected. The results of Murgulescu and Zuca for $NaNO_3$ agree with the recommendations [1] to within −0.4 to 0.3 percent. However, for $LiNO_3$ the deviations from the recommendations [1] range from −16.7 to 4.5 percent. Considering these deviations and the minimum information about melt preparation an uncertainty estimate is not possible.

Only limited information concerning the melt preparation of Murgulescu and Zuca is available. The experimental procedure is discussed in the section on KNO_3–$NaNO_3$.

TABLE 85(a). $LiNO_3$–$NaNO_3$: Viscosity

Numerical values (cp)

	Mole percent $NaNO_3$					
T(K)	100	80	60	40	20	0
530			4.136	4.584	5.125	
540			3.927	4.318	4.763	
550			3.726	4.066	4.438	4.946
560			3.529	3.829	4.147	4.637
570			3.345	3.606	3.882	4.344
580		3.065	3.167	3.397	3.644	4.068
590		2.908	2.996	3.202	3.428	3.809
600	2.708	2.758	2.834	3.019	3.230	3.567
610	2.573	2.615	2.682	2.849	3.051	3.342
620	2.445	2.480	2.538	2.693	2.886	3.135
630	2.323	2.353	2.404	2.548	2.735	2.947
640	2.209	2.234	2.280	2.415	2.596	2.776
650	2.101	2.123	2.165	2.294	2.469	2.624
660	2.000	2.020	2.062	2.184	2.352	2.490
670	1.907	1.926	1.969	2.085	2.243	2.376
680	1.821	1.841	1.887	1.996	2.141	2.281
690	1.744	1.765	1.816	1.918	2.047	2.205
700	1.675					

TABLE 85(b). Temperature-dependent equations

$$\eta = a + bT + cT^2 + dT^3 \text{ (cp)}$$

$$\eta = A \cdot \exp\,(E/RT) \text{ (cp)}$$

Comp. (mol % $NaNO_3$)	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. (percent)
0	39.8180	−8.2245	1.0941	4.2394			0.0209 = 0.66
20					9.815	4164	0.0229 = 0.75
40	48.2920	−15.255	16.055	−5.3434			0.0389 = 1.36
60	17.2248	−1.3799	−4.7702	5.1212			0.0133 = 0.50
80	18.1724	−2.5460	−1.9191	3.1344			0.0156 = 0.68
100	14.4048	−1.2376	−3.3248	3.5640			0.0055 = 0.26

Reference: [86] for binary mixtures and 100 mole percent $LiNO_3$.
[118] for 100 mole percent $NaNO_3$.

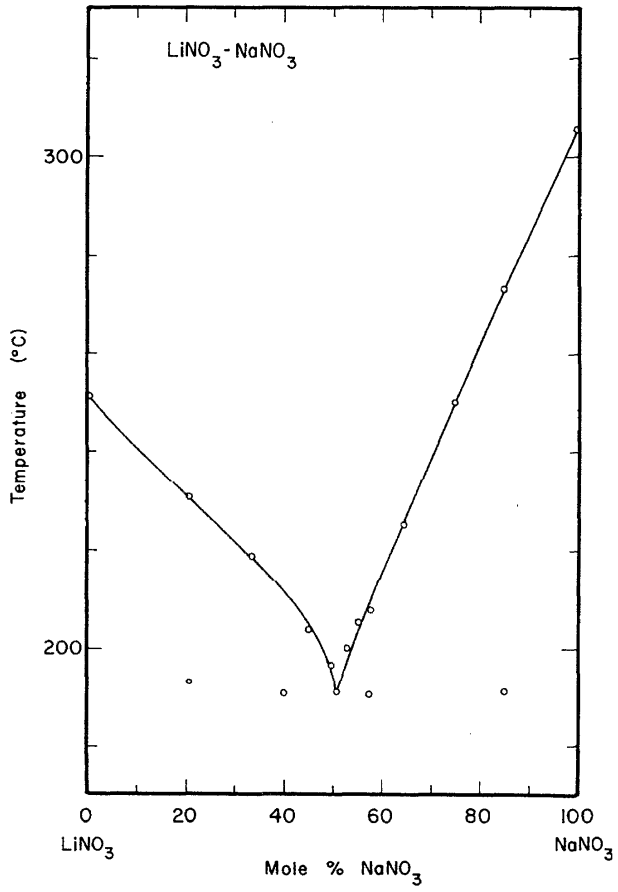

FIGURE 40. Temperature – composition phase diagram for $LiNO_3$–$NaNO_3$.

A. Lehrman and D. Breslow, J. Am. Chem. Soc. **60**, 873 (1938).

TABLE 86(a). $LiNO_3$–$RbNO_3$: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

	Mole percent $RbNO_3$		
T(K)	100	50	0
560		0.5067	
570		0.5389	
580		0.5709	1.0895
590	0.4069	0.6026	1.1477
600	0.4303	0.6342	1.2049
610	0.4537	0.6655	1.2613
620	0.4771	0.6966	1.3166
630	0.5006	0.7275	1.3711
640	0.5240	0.7581	1.4246
650	0.5474	0.7886	1.4771
660	0.5708	0.8188	1.5288
670	0.5942	0.8489	1.5795
680	0.6177		1.6292
690	0.6411		1.6781
700	0.6645		
710	0.6879		
720	0.7113		

TABLE 86(b). Temperature-dependent equations

$\kappa = a + bT + cT^2$ (ohm^{-1} cm^{-1})

Comp. (mol % $RbNO_3$)	a	$b \cdot 10^3$	$c \cdot 10^6$	Stand. error of est. (percent)
0	−3.8855	11.2903	−4.6769	0.0014=0.36
50	−1.6415	4.4428	−1.0833	0.0007=0.09
100	−0.9749	2.3421	0	0.0012=0.21

Reference: [123]

$LiNO_3$–$RbNO_3$

Electrical Conductance

Twelve studies of the specific conductance of $LiNO_3$ [1 (p. 25), 24, 29, 73, 79, 117, 120, 129] and 11 investigations of $RbNO_3$ [1 (p. 27), 24, 73, 88, 104, 121, 123, 125, 129, 135] have been reported. Some experimental aspects of the conductance measurements of $LiNO_3$ are discussed in the section KNO_3–$LiNO_3$. Revised recommendations for $RbNO_3$ are based on the work of Brillant [24] and together with some experimental aspects are discussed in the section on KNO_3–$RbNO_3$.

The specific conductance of molten $LiNO_3$–$RbNO_3$ mixtures has been measured by two groups [73, 123] both using the classical ac technique. The results of De Nooijer [123] for the single components and the equimolar mixture, covering a temperature range from 560 to 725 K, are recommended as the "best" values and are given in table 86(a) for the experimental compositions at rounded temperatures. The corresponding temperature-dependent equations are given in table 86(b). The experimental uncertainty of the results of De Nooijer is estimated to be about 0.4 percent. The results for $LiNO_3$ agree with the recommendations [1] to within −0.44 to −0.24 percent, whereas the results for $RbNO_3$ deviate from the newly recommended values [24] (−0.84 to 0.27 percent) and from the recommendations [1] (−6.49 to −0.26 percent). The results of Protsenko [73] for the single components and 26 binary mixtures cover a temperature range from 450 to 595 K. These values deviate from the results of De Nooijer [123] (up to 1.91 percent, $LiNO_3$; up to 2.79 percent, $RbNO_3$; 2.24 to 2.61 percent, equimolar mixture) and the evaluations were not extended.

For melt preparation and experimental technique of De Nooijer see the section on $CsNO_3$–KNO_3.

Density

Seven studies of the density of $LiNO_3$ [1 (p. 25), 9, 24, 86, 117, 143] and six investigations of $RbNO_3$ [1 (p. 27), 24, 25, 86, 109, 117, 118] have been reported. Some experimental aspects of the density measurements of $LiNO_3$ are discussed in the section on KNO_3–$LiNO_3$. Revised recommendations for $RbNO_3$ are based

on the work of McAuley, Rhodes and Ubbelohde [25] and together with some experimental aspects are discussed in the section $NaNO_3$–$RbNO_3$.

Murgulescu and Zuca [86] used the Archimedean method to measure the density of molten $LiNO_3$–$RbNO_3$ mixtures, in the temperature range from 475 to 730 K for the single components and mixtures containing 80, 65, 55, 50, 45, 35, 25, 20, and 10 mole percent $LiNO_3$. The results were recalculated using a two-dimensional statistical analysis; the values in the form of a temperature-composition-density matrix are given in table 87(a) at rounded compositions and temperatures. The corresponding statistical parameters are given in table 87(b). The experimental uncertainty of the results of Murgulescu and Zuca is estimated to be about 0.4 percent. The values for $RbNO_3$ deviate from the newly recommended results [25] (1.10 to 1.31 percent) and form the recommendations [1] (0.15 to 0.19 percent), whereas the results for $LiNO_3$ agree with the recommendations [1] to within 0.29 to 0.30 percent.

For melt preparation of Murgulescu and Zuca [86] see the discussion of viscosity in the section on $LiNO_3$–$RbNO_3$. The experimental method used by these authors is the same as reported in their later publication [118] and is discussed in the section on $NaNO_3$–$RbNO_3$.

TABLE 87(a). $LiNO_3$–$RbNO_3$: Density

Numerical values (g cm^{-3})

Mole percent $RbNO_3$

T(K)	100	90	80	70	60	50	40	30	20	10	0	68
500					2.35	2.28	2.20					
515			2.46	2.40	2.34	2.27	2.19	2.10				2.39
530			2.44	2.39	2.32	2.25	2.17	2.09				2.37
545		2.48	2.43	2.37	2.31	2.24	2.16	2.07	1.98			2.36
560		2.46	2.41	2.36	2.29	2.22	2.15	2.06	1.97		1.77	2.35
575		2.45	2.40	2.34	2.28	2.21	2.13	2.05	1.96	1.86	1.76	2.33
590		2.44	2.39	2.33	2.27	2.20	2.12	2.04	1.95	1.85	1.75	2.32
605	2.47	2.42	2.37	2.32	2.25	2.18	2.11	2.03	1.94	1.85	1.75	2.30
620	2.45	2.41	2.36	2.30	2.24	2.17	2.10	2.02	1.93	1.84	1.74	2.29
635	2.44	2.40	2.34	2.29	2.22	2.16	2.08	2.00	1.92	1.83	1.73	2.28
650	2.43	2.38	2.33	2.27	2.21	2.14	2.07	1.99	1.91	1.82	1.73	2.26
665	2.42	2.37	2.32	2.26	2.20	2.13	2.06	1.98	1.90	1.81	1.72	2.25
680	2.41	2.36	2.30	2.25	2.18	2.12	2.04	1.97	1.89	1.80	1.71	2.23
695	2.39	2.34	2.29	2.23	2.17	2.10	2.03	1.96	1.88	1.79	1.70	2.22
710	2.38		2.28	2.22	2.16	2.09						
725	2.37											

TABLE 87(b). Two-dimensional equation and statistical parameters

$\rho = a + bT + cC^2 + dTC + eTC^2$ (g cm^{-3})

a	$b \cdot 10^4$	$c \cdot 10^5$	$d \cdot 10^6$	$e \cdot 10^7$	Max. percent departure	Stand. error of est.
2.96600	−8.25211	−9.45050	−6.82045	1.05220	−0.65% (703.2 K, 100 mol % $LiNO_3$)	0.006 (0.29%)

Reference: [86]

C = mole percent $LiNO_3$

Viscosity

Five studies of the viscosity of $LiNO_3$ [1 (p. 25), 48] and four investigations of $RbNO_3$ [1 (p. 27), 48, 118] have been reported. Some experimental aspects of the viscosity measurements of $LiNO_3$ and $RbNO_3$ are discussed in the sections on $LiNO_3$–$NaNO_3$ and $NaNO_3$–$RbNO_3$, respectively.

Murgulescu and Zuca [86] used the oscillating ball technique to measure the viscosity of molten $LiNO_3$–$RbNO_3$ mixtures. The values for the single components and mixtures containing 20, 35, 45, 50, 55, 65, 75, 80, and 90 mole percent $RbNO_3$, covering a temperature range from 500 to 690 K, are given in table 88(a) for the experimental compositions at rounded temperatures. The corresponding temperature-dependent equations are given in table 88(b). For $LiNO_3$ the deviations of the results of Murgluescu and Zuca from the recommendations [1] range from −16.7 to 4.5 percent. Considering these devi-

ations and the minimum information about the preparation of $LiNO_3$ an uncertainty estimate is not possible.

Murgulescu and Zuca, according to a later publication [118], predried analytical grade $RbNO_3$ for 24 h at 150 °C and melted it in dried nitrogen gas. However, no information about melt preparation of $LiNO_3$ is available. The experimental procedure is discussed in the section on KNO_3–$NaNO_3$.

Surface Tension

Three investigations of the surface tension of $LiNO_3$ and two studies of $RbNO_3$ have been reported. [2 (pp. 67 and 68, respectively)].

Bertozzi and Sternheim [26] used the Wilhelmy slide plate method to measure the surface tension of molten $LiNO_3$–$RbNO_3$ mixtures, in the temperature range from the melting point up to 400 °C, for 25, 50, and 75 mole percent mixtures and for the single components. The results of a two-dimensional statistical analysis of these data are given in table 89(a) as a temperature-composition-surface tension matrix, at rounded temperatures and compositions. The corresponding statistical parameters are given in table 89(b). The data of Bertozzi and Sternheim for the single components show percent departures from the recommendations [2] by −0.6 to 1.1 percent.

The experimental aspects of the investigations of Bertozzi and Sternheim [26] have been discussed previously [2 (p. 67)].

TABLE 88(a). $LiNO_3$–$RbNO_3$: Viscosity

Numerical values (cp)

	Mole percent $RbNO_3$										
T(K)	100	90	80	75	65	55	50	45	35	20	0
500				6.726	6.259	5.933	6.050	6.402			
510				6.174	5.778	5.493	5.591	5.872			
520				5.668	5.335	5.083	5.167	5.388			
530			5.360	5.207	4.926	4.706	4.777	4.947	5.031		
540			4.967	4.792	4.554	4.361	4.420	4.547	4.658		
550		4.791	4.603	4.415	4.216	4.044	4.091	4.184	4.316	4.345	4.946
560		4.440	4.270	4.075	3.910	3.754	3.795	3.860	4.000	4.079	4.637
570		4.157	3.965	3.771	3.630	3.491	3.527	3.571	3.712	3.828	4.344
580		3.893	3.687	3.501	3.382	3.258	3.285	3.314	3.447	3.590	4.068
590		3.647	3.436	3.262	3.161	3.045	3.070	3.084	3.211	3.369	3.809
600	3.645	3.421	3.211	3.052	2.964	2.855	2.874	2.886	2.995	3.163	3.567
610	3.451	3.214	3.009	2.869	2.787	2.691	2.705	2.713	2.811	2.973	3.342
620	3.273	3.025	2.831	2.714	2.636	2.543	2.556	2.563	2.635	2.799	3.135
630	3.111	2.856	2.675	2.577	2.505	2.415	2.428	2.432	2.486	2.641	2.947
640	2.960	2.705	2.540	2.460	2.392	2.305	2.317	2.323	2.362	2.495	2.776
650	2.821	2.573	2.425	2.361	2.295	2.216	2.219	2.231	2.254	2.370	2.624
660	2.694	2.460	2.329	2.227	2.209	2.137	2.141	2.154	2.168	2.262	2.490
670	2.574	2.366	2.251	2.206	2.142	2.073	2.076	2.085	2.096	2.171	2.376
680	2.463	2.291	2.190	2.146	2.085	2.027	2.025	2.030	2.046	2.097	2.281
690	2.361	2.234	2.144	2.095	2.039	1.988	1.984	1.984	2.008	2.042	2.205

TABLE 88(b). Temperature dependent equations

$$\eta = a + bT + cT^2 + dT^3 \text{ (cp)}$$

$$\eta = A \cdot \exp(E/RT) \text{ (cp)}$$

Comp. (mol % $RbNO_3$)	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. (percent)
0	39.8180	−8.2245	1.0941	4.2394			0.0209=0.67
20	33.4838	−6.5069	−0.2762	4.4953			0.0210=0.75
35	88.1923	−31.578	37.636	−14.454			0.0665=2.37
45	139.9243	−57.074	79.151	−36.824			0.0784=2.53
50	105.9024	−41.142	54.303	−23.920			0.0464=1.57
55	98.5059	−37.729	49.015	−21.172			0.0406=1.38
65	115.9214	−45.780	61.556	−27.723			0.0563=1.84
75	144.7337	−58.908	81.556	−37.887			0.0851=2.70
80	97.9978	−35.838	44.028	−17.713			0.0615=1.99
90	50.4372	13.506	9.4540	0.0067			0.0342=1.13
100					13.076	3966	0.0310=1.07

Reference: [86] for binary mixtures and 100 mole percent $LiNO_3$.
[118] for 100 mole percent $RbNO_3$.

TABLE 89(a). $LiNO_3$–$RbNO_3$: Surface tension

Numerical values (dyn cm^{-1})

Mole percent $RbNO_3$

T(K)	100	90	80	70	60	50	40	30	20	10	0	68.0
445				117.3								117.1
460				116.2	115.4	114.8	114.4					116.0
475				115.1	114.3	113.7	113.4	113.5				114.9
490			114.7	114.0	113.3	112.7	112.4	112.6				113.8
505			113.6	112.9	112.2	111.7	111.4	111.7				112.7
520			112.4	111.8	111.1	110.6	110.4	110.7	111.6			111.6
535			111.3	110.7	110.0	109.6	109.4	109.8	110.7		115.1	110.5
550		110.6	110.2	109.5	108.9	108.5	108.4	108.8	109.8		114.4	109.4
565		109.5	109.0	108.4	107.8	107.4	107.4	107.8	108.9		113.6	108.3
580		108.3	107.8	107.3	106.7	106.4	106.4	106.9	108.0	109.9	112.9	107.2
595	107.3	107.1	106.7	106.1	105.6	105.3	105.3	105.9	107.1	109.1	112.1	106.0
610	106.1	106.0	105.5	105.0	104.5	104.2	104.3	104.9	106.2	108.2	111.3	104.9
625	104.9	104.8	104.3	103.8	103.4	103.1	103.3	103.9	105.2	107.4	110.5	103.7
640	103.7	103.6	103.2	102.7	102.2	102.0	102.2	102.9	104.3	106.5	109.7	102.6
655	102.5	102.4	102.0	101.5	101.1	100.9	101.2	101.9	103.4	105.7	109.0	101.4
670	101.3	101.2	100.8	100.3	100.0	99.8	100.1	100.9	102.4	104.8	108.2	100.2

TABLE 89(b). Two-dimensional equation and statistical parameters

$$\gamma = a + bT^2 + cC^3 + dC^2 + eTC^2 + fT^3 \text{ (dyn cm}^{-1}\text{)}$$

a	$b \cdot 10^5$	$c \cdot 10^5$	$d \cdot 10^3$	$e \cdot 10^6$	$f \cdot 10^2$	Max percent departure	Standard error of est.
149.40079	−1.35130	2.56607	−3.71980	2.74096	−6.26922	0.91% (453 K, 50 mole % $RbNO_3$)	0.525 (0.5%)

Reference: [26]
C = mole percent $LiNO_3$

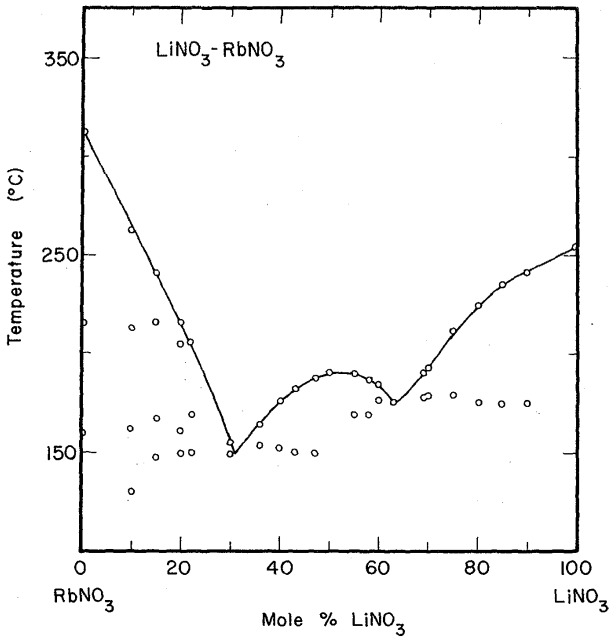

FIGURE 41. Temperature — composition phase diagram for $LiNO_3$–$RbNO_3$.

N. A. Pushin and M. Radonchie, Glasnik Hemiskog Drustra Kraljevine Jugoslovije **6-8**, 28 (1937).

$LiNO_3$–$TlNO_3$

Electrical Conductance

Twelve studies of the specific conductance of $LiNO_3$ [1 (p. 25), 24, 29, 73, 79, 117, 120, 129] and 17 investigations of $TlNO_3$ [1 (p. 28), 24, 27, 74, 89, 103, 104, 112, 117, 121] have been reported. Some experimental aspects of the conductance measurements of $LiNO_3$ and $TlNO_3$ are discussed in the sections on KNO_3–$LiNO_3$ and $NaNO_3$–$TlNO_3$, respectively.

The specific conductance of molten $LiNO_3$–$TlNO_3$ mixtures has been measured by three groups [24, 117, 123] using either the classical ac technique [117, 123] or a modified potentiometric ac technique [24]. The results of Brillant [24] for the single components and 20, 40, 60, and 80 mole percent mixtures, covering a temperature range from 430 to 670 K are recommended as the "best" values and are given in table 90(a) for the experimental compositions at rounded temperatures. These were derived from the temperature-dependent equations reported by Brillant and listed in table 90(b). The experimental uncertainty of the results of Brillant is estimated to be about 0.3 percent. The values for $LiNO_3$ and $TlNO_3$ agree with the recommendations [1] to within −0.77 to 0.02 percent and −0.78 to −0.60 percent, respectively. Popovskaya, Protsenko and Eliseeva [117] measured the specific conductance of the single components and of the binary mixture at 11 different compositions and at three temperatures (453.2 K, 513.2 K, 593.2 K). Their results deviate from the values of Brillant (up to 0.31 percent, pure $LiNO_3$; up to 4.40 percent, 20 mole percent $TlNO_3$; 4.85 to 6.33 percent, 40 mole percent $TlNO_3$; 6.12 to 9.59 percent, 60 mole percent $TlNO_3$;

TABLE 90(a). $LiNO_3$–$TlNO_3$: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

	Mole percent $TlNO_3$					
T(K)	100	80	60	40	20	0
430			0.214			
440		0.239	0.244			
450		0.267	0.275			
460		0.295	0.305			
470		0.323	0.336			
480	0.344	0.352	0.367	0.398		
490	0.370	0.380	0.399	0.435		
500	0.396	0.408	0.431	0.472		
510	0.422	0.436	0.463	0.509	0.584	
520	0.448	0.464	0.495	0.546	0.629	
530	0.474	0.492	0.526	0.583	0.674	0.807
540	0.500	0.520	0.558	0.620	0.718	0.864
550	0.525	0.549	0.590	0.657	0.763	0.921
560	0.551	0.577	0.621	0.694	0.808	0.978
570	0.576	0.605	0.652	0.731	0.853	1.034
580	0.601	0.633	0.683	0.768	0.897	1.091
590	0.626	0.931	0.715	0.804	0.940	1.148
600	0.651	0.660	0.746	0.840	0.984	1.205
610	0.675	0.687	0.777	0.875	1.027	1.262
620	0.700	0.714		0.911	1.071	1.318
630						1.372
640						1.426
650						1.480
660						1.532
670						1.584

TABLE 90(b). Temperature-dependent equations

$\kappa = a + bT$ (ohm^{-1} cm^{-1})

Comp. (mol % $TlNO_3$)	a	$b \cdot 10^3$	Temp. range (K)
0	−2.2089	5.690	525.2–617.2
	−2.0298	5.400	617.2–651.2
	−1.8670	5.150	651.2–673.2
20	−1.6954	4.470	513.2–574.2
	−1.6282	4.353	574.2–623.2
40	−1.3778	3.700	483.2–581.2
	−1.3023	3.570	581.2–621.2
60	−1.1012	3.058	433.2–474.2
	−1.1605	3.183	474.2–546.2
	−1.1267	3.121	546.2–615.2
80	−0.9991	2.814	443.2–576.2
	−0.9380	2.708	576.2–613.2
100	−0.8980	2.588	483.2–558.2
	−0.8416	2.487	558.2–623.2

Reference: [24]

5.63 to 8.62 percent, 80 mole percent $TlNO_3$; and 0.63 to 3.22 percent, pure $TlNO_3$). The results of De Nooijer for the single components and the equimolar mixture deviate from the recommended values [24] (−0.24 to −0.01 percent, pure $LiNO_3$; and 0.40 to 1.64 percent, pure $TlNO_3$).

The experimental technique used by Brillant [24] is discussed in the section on KNO_3–$RbNO_3$, whereas the melt preparation is described in the discussion of density in the section on $AgNO_3$–$LiNO_3$.

Density

Seven studies of the density of $LiNO_3$ [1 (p. 25), 9, 24, 86, 117, 143] and five investigations of $TlNO_3$ [1 (p. 28), 24, 103, 117] have been reported. Some experimental aspects of the density measurements of $LiNO_3$ and $TlNO_3$ are discussed in the sections on KNO_3–$LiNO_3$ and $AgNO_3$–$TlNO_3$, respectively.

The density of molten $LiNO_3$–$TlNO_3$ mixtures has been measured by two groups [24, 117] using the Archimedean method. The results of Brillant [24] for 20, 40, 60, and 80 mole percent mixtures and the single components, are recommended as the "best" values and are given for the experimental compositions at rounded temperatures in table 91(a). These were derived from the one-dimensional statistical equations reported by Brillant and listed in table 91(b). The experimental uncertainty of the results of Brillant is estimated to be about 0.2 percent. The results for $LiNO_3$ and $TlNO_3$ agree with the recommendations [1] to within 0.41 to 0.70 percent and 0.18 to 0.22 percent, respectively. The values of Popovskaya, Protsenko and Eliseeva [117] for the single components and mixtures containing 10, 20, 25, 30, 35, 40, 50, 60, 70, 80, and 90 mole percent $LiNO_3$ cover three different temperatures (453.2, 513.2, 593.2 K) and deviate from the values of Brillant (−1.84 percent, 20 mole percent $LiNO_3$, 513.2 K to 1.33 percent, 60 mole percent $LiNO_3$, 593.2 K).

For melt preparation and experimental techniques of Brillant see the section on $AgNO_3$–$LiNO_3$.

TABLE 91(a). $LiNO_3$–$TlNO_3$: Density

Numerical values (g cm^{-3})

T(K)	Mole percent $TlNO_3$ 100	80	60	40	20	0
440			3.980			
450		4.495	3.965			
460		4.478	3.950			
470		4.461	3.935			
480		4.444	3.920			
490	4.895	4.427	3.905	3.308		
500	4.876	4.410	3.890	3.297		
510	4.858	4.393	3.875	3.285		
520	4.839	4.376	3.860	3.273	2.596	
530	4.821	4.359	3.845	3.262	2.587	1.792
540	4.802	4.342	3.830	3.250	2.578	1.786
550	4.784	4.326	3.815	3.238	2.569	1.780
560	4.765	4.310	3.802	3.226	2.560	1.774
570	4.748	4.294	3.789	3.215	2.551	1.768
580	4.730	4.278	3.776	3.203	2.542	1.762
590	4.713	4.262	3.763	3.191	2.533	1.756
600	4.695	4.246	3.750	3.180	2.524	1.751
610	4.677	4.230	3.737	3.168	2.515	1.745
620	4.659				2.506	1.739
630						1.733
640						1.727
650						1.721
660						1.715
670						1.709

TABLE 91(b). Temperature-dependent equations

$\rho = a + bT$ (g cm^{-3})

Comp. (mol % $TlNO_3$)	a	$b \cdot 10^3$	Temp. range (K)
0	2.1057	−0.592	525.2–673.2
20	3.0639	−0.900	513.2–623.2
40	3.8816	−1.170	483.2–617.2
60	4.6398	−1.500	433.2–547.2
	4.5359	−1.310	548.2–615.2
80	5.2604	−1.700	443.2–543.2
	5.2061	−1.600	544.2–613.2
100	5.8014	−1.850	483.2–560.2
	5.7599	−1.775	561.2–623.2

Reference: [24]

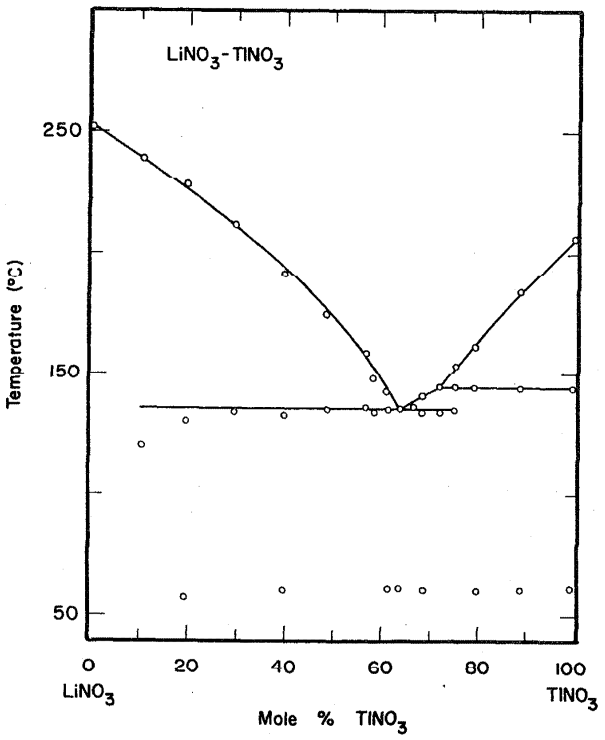

FIGURE 42. Temperature–composition phase diagram for $LiNO_3$–$TlNO_3$.

H. V. A. Briscoe, C. Evans, and P. L. Robinson, J. Chem. Soc. 1100 (1932).

$NaNO_3$–$Pb(NO_3)_2$

Density

Sixteen investigations of the density of $NaNO_3$ [1 (p. 26), 9, 12, 25, 27, 71, 86, 95, 97, 115, 117, 118, 130] have been reported. $Pb(NO_3)_2$ has not been investigated. Revised recommendations for $NaNO_3$ are based on the work of McAuley, Rhodes and Ubbelohde [25] and together with some experimental aspects are discussed in the section on $NaNO_3$–$RbNO_3$.

Laybourn and Madgin [130] used a dilatometric method to measure the density of molten $NaNO_3$–$Pb(NO_3)_2$ mixtures in the temperature range from 591 K to 731 K for pure $NaNO_3$ and mixtures containing 27.8, 20.4, 14.6, 9.9, 6.0, and 2.8 mole percent $Pb(NO_3)_2$. The results were recalculated using a two-dimensional statistical analysis; the values in the form of a temperature-composition-density matrix are given in table 92(a) for rounded compositions and temperatures. The corresponding statistical parameters are given in table 92(b). The experimental uncertainty of the results of Laybourn and Madgin is estimated to be about 0.3 percent. The values for $NaNO_3$ deviate from the newly recommended data [25] (1.28 to 1.83 percent) and from the recommendations [1] (0.37 to 0.60 percent).

The $NaNO_3$ was recrystallized three times from water. For melt preparation and experimental technique of Laybourn and Madgin see the section on KNO_3–$Pb(NO_3)_2$.

TABLE 92(a). $NaNO_3$–$Pb(NO_3)_2$: Density

Numerical values (g cm^{-3})

Mole percent $Pb(NO_3)_2$

T(K)	25	20	15	10	5	0	15.8
560			2.468				
570			2.459	2.293			2.485
580		2.604	2.451	2.285	2.106		2.476
590		2.595	2.442	2.277	2.098		2.468
600	2.727	2.586	2.434	2.269	2.091	1.898	2.459
610	2.718	2.577	2.425	2.261	2.084	1.892	2.450
620	2.708	2.568	2.417	2.253	2.076	1.885	2.442
630	2.699	2.559	2.408	2.245	2.069	1.879	2.433
640	2.690	2.550	2.400	2.237	2.062	1.872	2.425
650		2.541	2.391	2.229	2.054	1.866	2.416
660			2.383	2.221	2.047	1.859	
670				2.213	2.040	1.853	
680					2.033	1.846	
690					2.025	1.840	
700						1.833	
710						1.827	
720						1.820	
730						1.814	

TABLE 92(b). Two-dimensional equation and statistical parameters

$$\rho = a + bC^2 + cC^3 + dTC + eTC^2 \text{ (g cm}^{-3}\text{)}$$

a	$b \cdot 10^5$	$c \cdot 10^6$	$d \cdot 10^5$	$e \cdot 10^7$	Max. percent departure	Standard error of est.
4.13640	− 5.28184	− 1.31952	− 2.98702	2.33641	− 0.34% (581.1 K, 90.1 mol % $NaNO_3$)	0.003 (0.13%)

Reference: [130]

C = mol percent $NaNO_3$

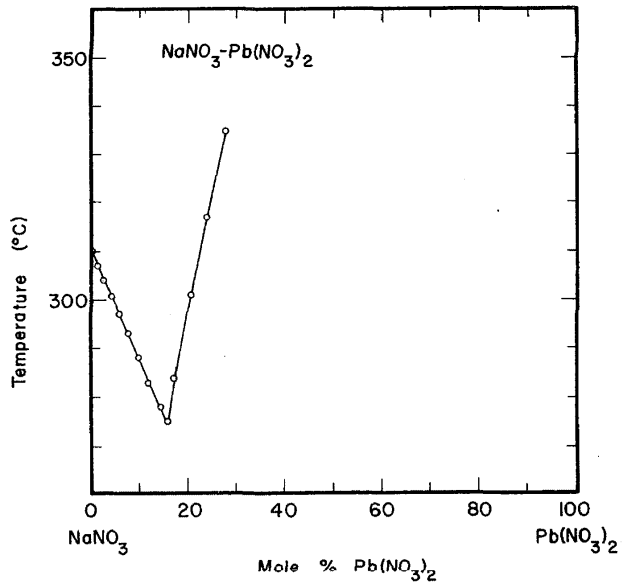

FIGURE 43. Temperature – composition phase diagram for $NaNO_3$–$Pb(NO_3)_2$.

H. M. Glass, K. Laybourn, and W. M. Madgin, J. Chem. Soc. (Lond.), 874 (1932).

$NaNO_3$–$RbNO_3$

Electrical Conductance

Twenty-six studies of the specific conductance of $NaNO_3$ [1 (p. 25), 9, 21, 24, 29, 75, 83, 89, 100, 104, 111, 112, 117, 120, 125, 128, 129] and 11 investigations of $RbNO_3$ [1 (p. 27) 24, 73, 88, 104, 121, 123, 125, 129, 135] have been reported. Some experimental aspects of the conductance measurements of $NaNO_3$ are discussed in the section on KNO_3–$NaNO_3$. Revised recommendations for $RbNO_3$ are based on the work of Brillant [24] and together with some experimental aspects are discussed in the section on KNO_3–$RbNO_3$.

The specific conductance of molten $NaNO_3$–$RbNO_3$ mixtures has been measured by three groups [123, 104, 125, 134, 135] all using the classical ac technique. The results of De Nooijer [123] for the single components and 25, 50, and 75 mole percent mixtures, covering a temperature range from 495 to 725 K, are recommended as the "best" values and are given in table 93(a) for the experimental compositions at rounded temperatures. The corresponding temperature-dependent equations are given in table 93(b). The experimental uncertainty of the results of De Nooijer is estimated to be about 0.4 percent. The values for $RbNO_3$ deviate from the newly recommended data [24] (−0.84 to 0.27 percent) and from the recommendations [1] (−6.49 to −0.26 percent), whereas the results for $NaNO_3$ agree with the recommendations [1] to within −0.62 to 0.45 percent. The results of Forcheri, Wagner and Berra [104, 134, 135] reported graphically in [104] cover both single components and seven different mixture compositions between 470.6 and 684.9 K. Their results for $NaNO_3$ and $RbNO_3$ deviate from the values of De Nooijer [123] within 0.25 to 2.02 percent and 0.43 to 1.66 percent, respectively. The investigation by Popovskaya, Protsenko and Eliseeva [125] for the single components and 10, 20, 30, 40, 50, 60, 70, 80, and 90 mole percent mixtures at 513.2, 553.2 and 593.2 K is represented graphically.

For discussion of the melt preparation and experimental technique of De Nooijer see the section on $CsNO_3$–KNO_3.

Density

Sixteen studies of the density of $NaNO_3$ [1 (p. 26), 9, 12, 25, 27, 71, 86, 95, 115, 117, 118, 130] and six

TABLE 93(a). $NaNO_3$–$RbNO_3$: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

	Mole percent $RbNO_3$				
T(K)	100	75	50	25	0
500			0.2903		
510			0.3229		
520			0.3555		
530			0.3881		
540			0.4207		
550			0.4533		
560			0.4859		
570		0.4265	0.5185		
580		0.4541	0.5511	0.7070	
590	0.4069	0.4817	0.5837	0.7440	
600	0.4303	0.5091	0.6163	0.8181	
610	0.4537	0.5363	0.6489	0.8181	1.1072
620	0.4771	0.5635	0.6815	0.8551	1.1513
630	0.5006	0.5905	0.7141	0.8921	1.1949
640	0.5240	0.6174	0.7467	0.9291	1.2380
650	0.5474	0.6442	0.7794	0.9662	1.2806
660	0.5708	0.6708		1.0032	1.3228
670	0.5942	0.6974		1.0402	1.3644
680	0.6177	0.7238		1.0773	1.4055
690	0.6441				1.4461
700	0.6645				
710	0.6879				
720	0.7113				

TABLE 93(b). Temperature-dependent equations

$\kappa = a + bT + cT^2$ (ohm^{-1} cm^{-1})

Comp. (mol % $RbNO_3$)	a	$b \cdot 10^3$	$c \cdot 10^6$	Stand. error of est. (percent)
0	−2.5247	7.4713	−2.4877	0.0011 = 0.09
25	−1.4407	3.7028	0	0.0041 = 0.46
50	−1.3400	3.2606	0	0.0031 = 0.59
75	−1.3522	3.4709	−0.6148	0.0004 = 0.07
100	−0.9749	2.3421	0	0.0012 = 0.21

Reference: [123]

investigations of $RbNO_3$ [1 (p. 27), 24, 25, 86, 109, 117, 118] have been reported. For both $RbNO_3$ and $NaNO_3$ the values reported by McAuley, Rhodes, and Ubbelohde [25] using a manometric densitometer are recommended as the "best" values, the uncertainty being about 0.3 percent. The least squares equation:

$$\rho\ (\mathrm{gcm^{-3}}) = 3.1366 - 1.0687 \cdot 10^{-3}\ T$$

describes the temperature dependence of the density of $RbNO_3$ betweeb 590 and 690 K with a standard error of $0.0004 = 0.02$ percent, whereas the temperature-dependence of the density of $NaNO_3$ between 590 and 690 K is given by the equation:

$$\rho\ (\mathrm{gcm^{-3}}) = 2.3339 - 0.7665 \cdot 10^{-3}\ T,$$

the standard error of estimate being $0.0003 = 0.02$ percent. The values of McAuley, Rhodes and Ubbelohde deviate from the recommendations [1], (-0.52 to -0.57 percent for $NaNO_3$ and 0.92 to 1.24 percent for $RbNO_3$). Some experimental aspects of the density measurements of $RbNO_3$ and $NaNO_3$ are as follows: McAuley, Rhodes and Ubbelohde [25] report the use of a pyrex manometric densitometer, made of two ideal capillaries with a 2 mm precision bore. The diameter of these capillaries was checked by means of the Hg thread method, and the densitometer volume calibrated with distilled water at 25 °C. Thermal expansion of the pyrex was taken into account. All other investigations are based on the Archimedean method, using either platinum [1, 86, 109, 117, 118] or silica [24] bobs.

The density of molten $NaNO_3$–$RbNO_3$ mixtures has been measured by two groups using the Archimedean method [86, 109]. The results of Murgulescu and Zuca [86] for 20, 40, 60, and 80 mole percent mixtures and the single compounds cover a temperature range from 430 to 755 K and are recommended as the "best" values. The results were recalculated using a two-dimensional statistical analysis; the values in the form of a temperature-composition-density matrix are given in table 94(a) for rounded compositions and temperatures. The corresponding statistical parameters are given in table 94(b).

The experimental uncertainty of the results of Murgulescu and Zuca is estimated to be about 0.4 percent. The values for $NaNO_3$ and $RbNO_3$ deviate from the newly recommended values [25] (1.10 to 1.31 percent and -0.47 to -0.20 percent respectively) and from the recommendations [1] (0.15 to 0.19 percent and 0.77 to 0.64 percent, respectively). James and Liu [109] report results for mixtures containing 80.0, 59.9, 39.9 and 20.6 mole percent $NaNO_3$ and pure $RbNO_3$, which agree with the recommended values to within 0.17 to 0.54 percent, 0.34 to 0.44 percent, 0.11 to 0.29 percent, -0.32 to -0.03 percent and 0.01 to 0.05 percent, respectively.

Powers, Katz and Kleppa [124] measured the excess volumes in binary $NaNO_3$–$RbNO_3$ mixtures at 340 °C. The excess volumes can also be calculated from the above results of Murgulescu and Zuca, and the molar volume data for $NaNO_3$ and $RbNO_3$ [25]. Comparison shows that the results of Powers, Katz and Kleppa agree with the values of Murgulescu and Zuca to within 0.1 percent.

The measurements of Murgulescu and Zuca were carried out according to the Archimedian method in a nitrogen atmosphere. However, no surface tension effect was taken into account. For melt preparation

TABLE 94(a). $NaNO_3$–$RbNO_3$: Density

Numerical values (g cm^{-3})

Mole percent $RbNO_3$

T(K)	100	90	80	70	60	50	40	30	20	10	0	59
490			2.50									
505			2.49	2.43	2.38	2.32	2.26					2.37
520			2.47	2.42	2.36	2.31	2.25					2.36
535		2.50	2.45	2.40	2.35	2.29	2.23					2.34
550		2.49	2.44	2.39	2.33	2.27	2.21	2.15				2.33
565		2.47	2.42	2.37	2.32	2.26	2.20	2.14				2.31
580		2.46	2.41	2.36	2.30	2.24	2.18	2.12	2.05			2.30
595	2.49	2.44	2.39	2.34	2.29	2.23	2.17	2.11	2.04	1.97		2.28
610	2.48	2.43	2.38	2.33	2.27	2.21	2.15	2.09	2.03	1.96	1.89	2.27
625	2.46	2.41	2.36	2.31	2.26	2.20	2.14	2.08	2.01	1.95	1.88	2.25
640	2.45	2.40	2.35	2.30	2.24	2.19	2.13	2.07	2.00	1.93	1.86	2.24
655	2.43	2.38	2.34	2.28	2.23	2.17	2.11	2.05	1.99	1.92	1.85	2.22
670	2.41	2.37	2.32	2.27	2.22	2.16	2.10	2.04	1.98	1.91	1.84	2.21
685	2.40	2.35	2.31	2.26	2.20	2.15	2.09	2.03	1.97	1.90	1.83	2.20
700	2.38	2.34	2.29	2.24	2.19	2.14	2.08	2.02	1.96	1.89	1.82	2.19
715	2.37	2.33	2.28	2.23	2.18	2.12	2.07	2.01	1.94	1.88	1.81	2.17
730	2.35	2.31	2.27	2.22	2.17	2.11	2.06	2.00	1.93	1.87	1.80	2.16
745					2.15	2.10	2.05	1.99	1.93	1.86	1.80	2.15

TABLE 94(b). Two-dimensional equation and statistical parameters

$\rho = a + bT + cC^2 + dTC + eT^2C$ (g cm^{-3})

a	$b \cdot 10^3$	$c \cdot 10^5$	$d \cdot 10^5$	$e \cdot 10^8$	Max. percent departure	Standard error of est.
3.08881	− 1.00648	− 1.31604	− 1.62650	+ 1.44222	−0.53% (504.2 K, 60 mol % $NaNO_3$)	0.004 (0.2%)

Reference: [86]
C = mole percent $NaNO_3$

see the discussion of the viscosity in the section on $NaNO_3$–$RbNO_3$.

Viscosity

Eleven studies of the viscosity of $NaNO_3$ [1 (p. 26), 48, 56, 71, 86, 118] and four investigations of $RbNO_3$ [1 (p. 27), 48, 118] have been reported. Some experimental aspects of the viscosity measurements of $NaNO_3$ and $RbNO_3$ are as follows: Protsenko and Razumovskaya [1] used pyrex capillary viscometers, whereas the results reported by Ogawa [56] were obtained by means of the dropping ball technique using a nickel ball. All other investigations, based on damped oscillation methods, were carried out with Pt-bobs.

Murgulescu and Zuca [86] used the oscillating ball technique to measure the viscosity of molten $NaNO_3$–$RbNO_3$ mixtures. The results for the single components and 20, 40, 60, and 80 mole percent mixtures, covering a temperature range from 520 to 750 K, are given in table 95. Zuca is estimated to be about 1.5 percent. The values for $NaNO_3$ agree with the recommendations [1] to within −0.4 to 0.3 percent.

TABLE 95. $NaNO_3$–$RbNO_3$: Viscosity

Numerical values (cp)

Mole percent $RbNO_3$

T(K)	100	80	60	40	20	0
523.2			5.16	6.44	7.32	
548.2			4.27	4.67	5.56	
573.2		4.22	3.82	3.49	3.18	
598.2	3.720	3.29	3.05	2.95	2.86	2.730
623.2	3.195	2.86	2.56	2.40	2.37	2.410
648.2	2.800	2.41	2.21	2.12	1.99	2.120
673.2	2.535	2.26	2.07	1.94	1.87	1.880
698.2	2.300	2.07	1.90	1.78	1.71	1.680
723.2	2.080					1.550
748.2	1.875					

References: [86] for binary mixture.
[118] for 100 mole percent $NaNO_3$. and 100 mole percent $RbNO_3$.

Only limited information concerning the melt preparation of Murgulescu and Zuca is available. According to a later publication [118] both $RbNO_3$ and $NaNO_3$ were Merck p.a. reagents, predried for 24 h at 150 °C and melted in dried nitrogen gas. The experimental procedure is discussed in the section on KNO_3–$NaNO_3$.
95 for the compositions and temperatures reported by Murgulescu and Zuca. For $NaNO_3$ and $RbNO_3$ the values reported by the same authors in another paper [118] were selected. A statistical analysis to produce values at rounded temperatures was unsatisfactory. The experimental uncertainty of the results of Murgulescu and

Surface Tension

Six investigations of the surface tension of $NaNO_3$ and two investigations of $RbNO_3$ have been reported [2 (pp. 67 and 68, respectively)].

Bertozzi and Sternheim [26] used the Wilhelmy slide plate method to measure the surface tension of molten $NaNO_3$–$RbNO_3$ mixtures, in the temperature range from the melting point up to 400 °C, for 25, 50, and 75 mole percent mixtures and for the single components. The results of a two-dimensional statistical analysis of these data are given in table 96(a) as a temperature-composition-surface tension matrix, at rounded temperatures. The corresponding statistical parameters are given in table 96(b). The data of Bertozzi and Sternheim for the single components show percent departures from the recommendations [1] by −0.6 to 1.1 percent.

The experimental aspects of the investigation of Bertozzi and Sternheim [26] have been discussed previously [2 (p. 67)].

TABLE 96(a). $NaNO_3$–$RbNO_3$: Surface tension

Numerical values (dyn cm^{-1})

Mole percent $RbNO_3$

T(K)	100	90	80	70	60	50	40	30	20	10	0	60.0
460				118.6	119.2							119.2
475				117.5	118.1	118.9						118.1
490			116.0	116.4	117.0	117.8	118.8					117.0
505			114.8	115.3	115.9	116.8	117.8					115.9
520			113.7	114.2	114.8	115.7	116.7	117.9				114.8
535		112.3	112.5	113.0	113.7	114.6	115.7	116.9				113.7
550		111.1	111.4	111.9	112.6	113.5	114.6	115.9	117.4			112.6
565		109.9	110.2	110.8	111.5	112.4	113.5	114.9	116.4	118.2		111.5
580		108.8	109.1	109.6	110.4	111.3	112.5	113.8	115.4	117.2		110.4
595		107.6	107.9	108.5	109.2	110.2	111.4	112.8	114.4	116.3	118.3	109.2
610	106.3	106.4	106.8	107.3	108.1	109.1	110.3	111.7	113.4	115.3	117.4	108.1
625	105.1	105.2	105.6	106.1	106.9	108.0	109.2	110.7	112.4	114.3	116.5	106.9
640	103.9	104.1	104.4	105.0	105.8	106.8	108.1	109.6	111.4	113.4	115.6	105.8
655	102.7	102.9	103.2	103.8	104.6	105.7	107.0	108.6	110.4	112.4	114.6	104.6
670	101.5	101.7	102.0	102.6	103.5	104.6	105.9	107.5	109.3	111.4	113.7	103.5

TABLE 96(b). Two-dimensional equation statistical parameters

$\gamma = a + bT_2 + cTC^2 + dT$ (dyn cm^{-1})

a	$b \cdot 10^5$	$c \cdot 10^6$	$d \cdot 10^2$	Max. percent departure	Standard error of est.
150.01096	− 1.17980	1.81784	− 6.44422	0.19% (573 K, 0 mol % $RbNO_3$)	0.127 (0.1%)

Reference: [26]

C = mole percent $NaNO_3$

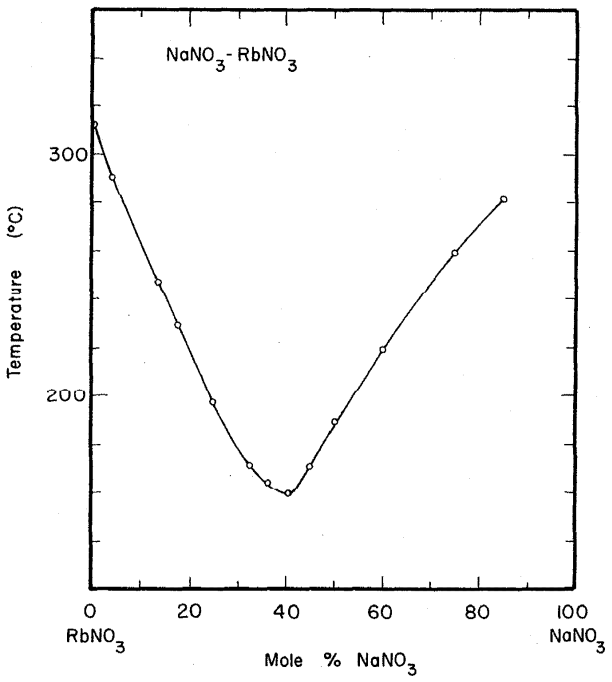

FIGURE 44. Temperature – composition phase diagram for $NaNO_3$–$RbNO_3$.

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$NaNO_3$–$TlNO_3$

Electrical Conductance

Twenty-six investigations of the specific conductance of $NaNO_3$ [1 (p. 25), 9, 21, 24, 29, 75, 83, 89, 100, 104, 111, 112, 117, 120, 125, 128, 129] and 17 investigations of $TlNO_3$ [1 (p. 28), 24, 27, 74, 89, 103, 104, 112, 117, 121] have been reported. Some experimental aspects of the conductance measurements of $NaNO_3$ are discussed in the section on KNO_3–$NaNO_3$. All conductance measurements of $TlNO_3$ have been carried out by means of the classical ac technique except the investigation by Brillant [24]. It should be noted that $TlNO_3$ is thermally stable only up to 538 K [2 (p. 69)], above which the anhydrous salt begins to lose oxides of nitrogen. In the work of Brillant [24] no significant influence of the elevated temperatures (up to 620 K) on the results is reported.

The specific conductance of molten $NaNO_3$–$TlNO_3$ mixtures has been measured by four groups [24, 104, 112, 117, 123, 134] using either the classical ac technique [104, 112, 117, 123, 134] or a modified potentiometric ac technique [24]. The results of Brillant [24] for the single components and mixtures containing 10, 20, 30, 40, 50, 60, 68, 76.4, 80, and 90 mole percent $TlNO_3$, covering a tempera-

ture range from 440 to 630 K, are recommended as the "best" values and are given in table 97(a) for the experimental concentrations at rounded temperatures. These were derived from the temperature-dependent equations reported by the authors and listed in table 97(b). The experimental uncertainty of the results of Brillant is estimated to be about 0.3 percent. The results for $NaNO_3$ and $TlNO_3$ deviate from the recommendations [1] (−0.39 to 0.39 percent) and (−0.78 to −0.60 percent), respectively. Popovskaya, Protsenko and Eliseeva [117] measured the specific conductance of the binary mixture at ten different concentrations as well as the single components at three different temperatures (473.2, 513.2, 593.2 K). Their results deviate from the data of Brillant (up to −0.01 percent, pure $NaNO_3$; up to 1.11 percent, 20 mole percent $TlNO_3$; up to 0.76 percent, 40 mole percent $TlNO_3$; 1.23 to 2.59 percent, 60 mole percent $TlNO_3$; 0.86 to 2.96 percent, 80 mole percent $TlNO_3$; and 0.63 to 1.82 percent, pure $TlNO_3$). The results of Wagner, Berra and Forcheri [104, 112, 134], reported graphically in [104], cover both single components and five different mixture concentrations in a temperature range from 465 to 673.2 K. Their results for pure $NaNO_3$ and $TlNO_3$ agree with the values of Brillant [24] to within 0.31 to 1.20 percent and −0.01 to 0.83 percent, respectively. Another set of data, covering the single components and the equimolar mixture, is reported by De Nooijer [123]. The values for $NaNO_3$ and $TlNO_3$ deviate from the data of Brillant (−0.19 to 0.40 percent) and (0.40 to 1.64 percent) respectively.

The experimental technique used by Brillant [24] is discussed in the section on KNO_3–$RbNO_3$, whereas the melt preparation is described in the section on $AgNO_3$–$LiNO_3$.

Density

Sixteen investigations of the density of $NaNO_3$ [1 (p. 26), 9, 12, 25, 27, 71, 86, 95, 97, 115, 117, 118, 130] and five investigations of $TlNO_3$ [1 (p. 28), 24, 103, 117] have been reported. Revised recommendations for $NaNO_3$ are based on the work of McAuley, Rhodes and Ubbelohde [25] and together with some experimental aspects are discussed in the section on $NaNO_3$–$RbNO_3$. Some experimental aspects of the density measurements of $TlNO_3$ are discussed in the section on $AgNO_3$–$TlNO_3$.

The density of molten $NaNO_3$–$TlNO_3$ mixtures has been measured by three groups [24, 112, 117] using the Archimedean method. The results of Brillant [24] for the single components and 20, 40, 60, and 80 mole percent mixtures cover a temperature range from 445 to 670 K and are recommended as the "best" values. The results of a two-dimensional statistical analysis of these data are given in table 98(a) as a temperature-composition-density matrix, at rounded compositions and temperatures. The corresponding statistical parameters are given in table 98(b). The experimental uncertainty of the results of Brillant is estimated to be about 0.2 percent. The results for $NaNO_3$ deviate from the newly recommended data [25] (1.74 to 1.87 percent) and from the recommenda-

TABLE 97(a). $NaNO_3$–$TlNO_3$: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

Mole percent $TlNO_3$

T(K)	100	90	80	76.4	68	60	50	40	30	20	10	0
440			0.232									
450			0.261									
460			0.289									
470		0.317	0.318	0.316								
480	0.344	0.345	0.347	0.345	0.349							
490	0.370	0.372	0.376	0.375	0.380							
500	0.396	0.399	0.404	0.405	0.411	0.415						
510	0.422	0.427	0.433	0.434	0.442	0.448	0.459					
520	0.448	0.454	0.462	0.464	0.472	0.480	0.494					
530	0.474	0.481	0.491	0.493	0.503	0.513	0.528	0.548				
540	0.500	0.509	0.519	0.523	0.534	0.545	0.563	0.585	0.616			
550	0.525	0.536	0.548	0.553	0.564	0.578	0.597	0.622	0.667	0.695		
560	0.551	0.563	0.576	0.582	0.595	0.610	0.632	0.659	0.697	0.738		
570	0.576	0.590	0.604	0.610	0.626	0.641	0.665	0.694	0.736	0.781	0.837	
580	0.601	0.616	0.632	0.639	0.655	0.672	0.699	0.730	0.775	0.822	0.881	0.964
590	0.626	0.642	0.660	0.668	0.685	0.704	0.732	0.765	0.814	0.863	0.926	1.011
600	0.651	0.668	0.687	0.695	0.714	0.734	0.765	0.800	0.850	0.903	0.969	1.058
610	0.675	0.694	0.713	0.721	0.742	0.764	0.797	0.834	0.887	0.943	1.012	1.104
620	0.700				0.771	0.794	0.829	0.868	0.924	0.983	1.054	1.151
630							0.860	0.901		1.021	1.093	1.195
640												1.238
650												1.282
660												1.367

TABLE 97(b). Temperature-dependent equations

$\kappa = a + bT$ (ohm^{-1} cm^{-1})

Comp. (mol % $TlNO_3$)	a	$b \cdot 10^3$	Temp. range (K)
0	−1.7424	4.667	583.2–618.2
	−1.5686	4.386	618.2–647.2
	−1.4806	4.250	647.2–673.2
10	−1.6962	4.444	573.2–595.2
	−1.5806	4.250	595.2–620.2
	−1.3448	3.870	620.2–631.2
20	−1.6884	4.333	553.2–571.2
	−1.5457	4.083	571.2–591.2
	−1.4764	3.966	591.2–623.2
	−1.3293	3.730	623.2–631.2
30	−1.5889	4.083	543.2–555.2
	−1.4890	3.903	555.2–589.2
	−1.3499	3.667	589.2–623.2
40	−1.4109	3.696	533.2–559.2
	−1.3252	3.543	559.2–590.2
	−1.2669	3.444	590.2–615.2
	−1.1830	3.308	615.2–627.2
50	−1.3046	3.458	513.2–561.2
	−1.2345	3.333	561.2–599.2
	−1.1470	3.187	599.2–623.2
	−1.0803	3.080	623.2–633.2
60	−1.2144	3.259	503.2–553.2
	−1.1447	3.133	553.2–587.2
	−1.0830	3.028	587.2–623.2
68	−1.1246	3.071	483.2–566.2
	−1.0617	2.960	566.2–593.2
	−1.0046	2.864	593.2–619.2
76.4	−1.0759	2.961	473.2–553.2
	−1.0285	2.875	553.2–588.2
	−0.9177	2.687	588.2–613.2
80	−1.0341	2.877	443.2–554.2
	−0.9809	2.781	554.2–586.2
	−0.9257	2.687	586.2–609.2
90	−0.9673	2.733	473.2–563.2
	−0.8923	2.600	563.2–613.2
100	−0.8980	2.588	483.2–558.2
	−0.8416	2.487	558.2–623.2

Reference: [24]

tions [1] (0.78 to 0.84 percent). For $TlNO_3$ the results of Brillant agree with the recommendations [1] to within 0.18 to 0.22 percent. The results of Popovskaya, Protsenko and Eliseeva [117] for pure $TlNO_3$ and mixtures containing 15, 20, 25, 30, 40, 50, 60, and 70 mole percent $NaNO_3$ cover two temperatures only (513.2, 593.2 K) and deviate from the values of Brillant (−3.18 percent, 20 mole percent $NaNO_3$, 513.2 K to 1.38 percent, 60 mole percent $NaNO_3$, 593.2 K). Wagner and Forcheri measured the density of molten $NaNO_3$–$TlNO_3$ for mixtures containing 20.1, 33.4, 52.9, 66.8 and 79.0 mole percent $TlNO_3$ in a temperature range from 450 K to 670 K. The results for the mixture containing 20.1 mole percent $TlNO_3$ deviate from the corresponding data of Brillant (−0.33 to −0.24 percent).

For melt preparation and experimental techniques of Brillant see discussion in the section on $AgNO_3$–$LiNO_3$.

TABLE 98(a). $NaNO_3$–$TlNO_3$: Density

Numerical values (g cm^{-3})

Mole percent $TlNO_3$

T(K)	100	90	80	70	60	50	40	30	20	10	0	77
450			4.483									
460			4.465									4.393
470		4.685	4.447									4.374
480		4.667	4.428	4.180								4.355
490	4.880	4.650	4.410	4.161								4.337
500	4.864	4.633	4.393	4.412	3.882							4.319
510	4.847	4.616	4.376	4.125	3.863							4.301
520	4.830	4.600	4.359	4.107	3.845	3.573						4.284
530	4.814	4.583	4.342	4.090	3.828	3.555	3.271					4.268
540	4.797	4.567	4.326	4.074	3.811	3.538	3.254					4.251
550	4.780	4.551	4.310	4.058	3.795	3.521	3.237	2.941				4.235
560	4.764	4.535	4.294	4.043	3.780	3.506	3.221	2.925	2.616			4.220
570	4.747	4.519	4.279	4.028	3.765	3.491	3.206	2.909	2.601			4.205
580	4.730	4.503	4.264	4.014	3.751	3.478	3.192	2.895	2.587	2.267		4.190
590	4.714	4.488	4.250	4.000	3.738	3.465	3.180	2.883	2.574	2.253	1.921	4.176
600	4.697	4.472	4.235	3.987	3.726	3.453	3.168	2.871	2.562	2.241	1.908	4.162
610	4.680	4.457	4.222	3.974	3.714	3.442	3.157	2.861	2.552	2.231	1.898	4.148
620	4.664	4.442			3.703	3.431	3.148	2.852	2.543	2.222	1.889	
630									2.536	2.215	1.882	
640										2.209	1.876	
650										2.205	1.872	

TABLE 98(b). Two-dimensional equation and statistical parameters

$$\rho = a + bT + cTC + dTC^2 + eCT^2 \text{ (g cm}^{-3}\text{)}$$

a	$b \cdot 10^3$	$c \cdot 10^5$	$d \cdot 10^7$	$e \cdot 10^8$	Max. percent departure	Stand. error of est.
5.69625	− 1.66527	− 8.80895	− 1.00022	8.60250	− 0.51% (585 K, 100 mol % $NaNO_3$)	0.008 (0.24%)

Reference: [24]

C = mole percent $NaNO_3$

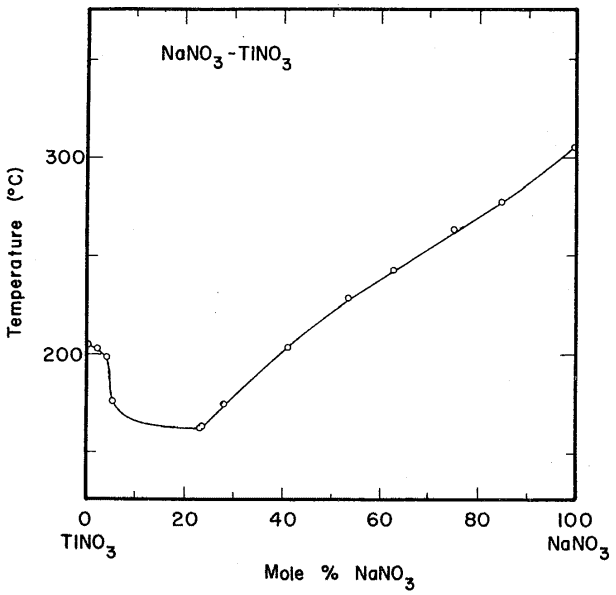

FIGURE 45. Temperature – composition phase diagram for $NaNO_3$–$TlNO_3$.

C. Van Eyk, Z. Anorg, Chem. **51**, 721 (1905).

$RbNO_3$–$TlNO_3$

Electrical Conductance

Eleven investigations of the specific conductance of $RbNO_3$ [1 (p. 27), 24, 73, 88, 104, 121, 123, 125, 129, 135] and 17 investigations of $TlNO_3$ [1 (p. 28), 24, 27, 74, 89, 103, 104, 112, 117, 121] have been reported. Revised recommendations for $RbNO_3$ are based on the work of Brillant [24] and together with some experimental aspects are discussed in the section on KNO_3–$RbNO_3$. Some experimental aspects of the conductance measurements of $TlNO_3$ are discussed in the section on $NaNO_3$–$TlNO_3$.

The specific conductance of molten $RbNO_3$–$TlNO_3$ mixtures has been measured by four groups [24, 104, 117, 123, 135] using either the classical ac technique [104, 117, 123, 135] or a modified potentiometric ac technique [24]. The results of Brillant [24] for the single components and mixtures containing 20, 40, 60, and 80 mole percent $TlNO_3$, covering a temperature range from 480 to 670 K, are recommended as "best" values and are given in table 99(a) for the experimental concentrations and rounded temperatures. These were derived from the temperature-dependent equations reported by the author and listed in table 99(b). The experimental uncertainty of the results of Brillant is estimated to be about 0.3 percent. The results for $TlNO_3$ deviate from the recommendations [1] (−0.78 to −0.60 percent). Popovskaya, Protsenko, and Eliseeva [117] measured the specific conductance of the binary mixture at eight different concentrations as well as the single components for two temperatures (533.2 K, 593.2 K). Their results deviate from the values of Brillant [24] (up to 5.86 percent, $RbNO_3$ alone; −0.12 to 1.70 percent, 80 mole percent $TlNO_3$; and 0.68 to 2.30 percent, $TlNO_3$ alone). The results of De Nooijer [123] for the single components and the equimolar mixture deviate from the recommended values [24] (−0.84 to 0.27 percent $RbNO_3$ alone; and 0.40 to 1.64 percent, $TlNO_3$ alone). The data by Forcheri, Wagner and Berra [104, 135] reported graphically in [104] for the single components and six different mixture compositions between 494.2 and 676.2 K deviate for $RbNO_3$ from the values of Brillant [24] within 2.26 and 2.68 percent.

TABLE 99(a). $RbNO_3$–$TlNO_3$: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

	Mole percent $TlNO_3$					
T(K)	100	80	60	40	20	0
480	0.344					
490	0.370	0.327				
500	0.396	0.352	0.311			
510	0.422	0.378	0.336			
520	0.448	0.404	0.361	0.319		
530	0.474	0.429	0.386	0.344		
540	0.500	0.455	0.411	0.369	0.328	
550	0.525	0.481	0.436	0.393	0.352	
560	0.551	0.506	0.462	0.418	0.376	
570	0.576	0.532	0.487	0.443	0.400	
580	0.601	0.557	0.512	0.467	0.424	0.384
590	0.626	0.581	0.536	0.492	0.448	0.408
600	0.651	0.605	0.561	0.516	0.472	0.432
610	0.675	0.629	0.585	0.540	0.496	0.456
620	0.700			0.565	0.521	0.480
630						0.504
640						0.528
650						0.551
660						0.575
670						0.599

TABLE 99(b). Temperature-dependent equations

$\kappa = a + bT$ (ohm^{-1} cm^{-1})

Comp. (mol % $TlNO_3$)	a	$b \cdot 10^3$	Temp. range (K)
0	−1.0021	2.390	583.2–673.2
20	−0.9749	2.412	543.2–623.2
40	−0.9634	2.467	523.2–573.2
	−0.9462	2.437	573.2–617.2
60	−0.9457	2.513	503.2–576.2
	−0.9093	2.450	576.2–615.2
80	−0.9301	2.565	493.2–572.2
	−0.8516	2.428	572.2–613.2
100	−0.8980	2.588	483.2–558.2
	−0.8416	2.487	558.2–623.2

Reference: [24]

The experimental technique used by Brillant [24] is discussed in the section on KNO_3–$RbNO_3$, whereas the melt preparation is described in the section on $AgNO_3$–$LiNO_3$.

Density

Six investigations of the density of $RbNO_3$ [1 (p. 27), 24, 25, 86, 109, 117, 118] and five investigations of $TlNO_3$ [1 (p. 28), 24, 103, 117] have been reported. Revised recommendations for $RbNO_3$ are based on the work of McAuley, Rhodes and Ubbelohde [25] and together with some experimental aspects are discussed in the section on $NaNO_3$–$RbNO_3$. Some experimental aspects of the density measurements of $TlNO_3$ are discussed in the section on $AgNO_3$–$TlNO_3$.

The density of molten $RbNO_3$–$TlNO_3$ mixtures has been measured by two groups [24, 117] using the Archimedean method. The results of Brillant [24] for 20, 40, 60, and 80 mole percent mixtures as well as the single components cover a temperature range from 485 to 670 K, are recommended as the "best" values, and are given for the experimental concentrations and rounded temperatures in table 100(a) using one-dimensional statistical analysis. The corresponding temperature-dependent equations are given in table 100(b). The experimental uncertainty of the results of Brillant is estimated to be about 0.2 percent. The results for $RbNO_3$ deviate from the newly recommended values [25] (−0.47 to −0.20 percent) and from the recommendations [1] (0.77 to 0.64 percent), whereas the values for $TlNO_3$ agree with the recommendations [1] to within 0.18 to 0.22 percent. The results of Popovskaya, Protsenko and Eliseeva [117] for the single components and mixtures containing 20, 30, 44.7, 50, 58.3, 68.5, 83.8, and 92.8 mole percent $RbNO_3$ are given for one temperature only (593.2 K) and deviate from the values of Brillant by −7.49 percent (100 mole percent $RbNO_3$) to 0.06 percent (100 mole percent $TlNO_3$).

For melt preparation and experimental technique of Brillant see the section on $AgNO_3$–$LiNO_3$.

TABLE 100(a). $RbNO_3$–$TlNO_3$: Density

Numerical values (g cm^{-3})

	Mole percent $TlNO_3$					
T(K)	100	80	60	40	20	0
490	4.895					
500	4.876	4.408				
510	4.858	4.391	3.931			
520	4.839	4.374	3.915			
530	4.821	4.356	3.899	3.453		
540	4.802	4.339	3.883	3.439		
550	4.784	4.322	3.867	3.424	3.096	
560	4.765	4.306	3.851	3.410	3.085	
570	4.748	4.290	3.836	3.396	3.075	
580	4.730	4.273	3.821	3.381	3.065	
590	4.713	4.257	3.806	3.367	3.054	2.515
600	4.695	4.241	3.790	3.352	3.044	2.504
610	4.677	4.225	3.775	3.338	3.034	2.494
620	4.659				3.023	2.483
630						2.473
640						2.463
650						2.452
660						2.442
670						2.431

TABLE 100(b). Temperature-dependent equations

$\rho = a + bT$ (g cm^{-3})

Comp. (mol % $TlNO_3$)	a	$b \cdot 10^3$	Temp. range (K)
0	3.1281	− 1.040	583.2–673.2
20	3.6620	− 1.230	543.2–613.2
40	4.2164	− 1.440	523.2–617.2
60	4.7414	− 1.590	503.2–558.2
	4.7023	− 1.520	559.2–615.2
80	5.2679	− 1.720	493.2–547.2
	5.2159	− 1.625	548.2–613.2
100	5.8014	− 1.850	483.2–560.2
	5.7599	− 1.775	561.2–623.2

Reference: [24]

$Ba(NO_2)_2$–$CsNO_2$

Electrical Conductance

Three studies of the specific conductance of $Ba(NO_2)_2$ [1 (p. 25), 23, 126] and three investigations of $CsNO_2$ [1 (p. 25), 102, 126] have been reported. All measurements of the specific conductance of $Ba(NO_2)_2$ are based on the classical ac technique using capillary-type cells. Some experimental aspects of the conductance measurements of $CsNO_2$ are discussed in the section on $CsNO_2$–$LiNO_2$.

Protsenko and Andreeva [126] measured the specific conductance of molten $Ba(NO_2)_2$–$CsNO_2$ mixtures using the classical ac technique. Their results for the single components and thirteen different mixtures (18.2 to 94.7 mole percent $CsNO_2$), covering a temperature range from 550 to 735 K, are given in table 101 for the experimental compositions and temperatures. A statistical analysis to produce values at rounded temperatures was unsatisfactory. The experimental uncertainty of the results of Protsenko and Andreeva is estimated to be more than 3 percent. The results for $Ba(NO_2)_2$ and $CsNO_2$ deviate from the recommendations [1] (−6.0 to −4.25 percent) and (−0.75 to −0.42 percent), respectively.

Protsenko and Andreeva used a capillary-type cell. $CsNO_2$ was prepared from $Ba(NO_2)_2$ and Cs_2SO_4 and had a purity of 99.34 percent. Twice recrystallized "chemically pure" grade $Ba(NO_3)_2$, $Ba(NO_2)_2$ and $CsNO_3$ were used.

TABLE 101. $Ba(NO_2)_2$–$CsNO_2$: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

Mole percent $CsNO_2$

T(K)	100	94.7	88.9	82.4	75.0	71.0	66.7	62.1	57.1	46.2	40.0	33.3	26.1	18.2	0
553.2															0.171
573.2															0.225
593.2										0.232	0.241		0.253	0.268	0.279
613.2				0.390	0.341				0.289	0.284	0.293	0.293	0.305	0.322	0.331
633.2				0.432	0.381	0.360	0.335	0.324	0.330	0.336	0.344	0.344			
653.2		0.577	0.496	0.475	0.421	0.400	0.376	0.365	0.370						
673.2	0.686	0.622	0.548	0.517	0.463	0.442	0.416	0.405	0.411						
693.2	0.735	0.666	0.600	0.560											
713.2	0.784														
733.2	0.833														

Reference: [126]

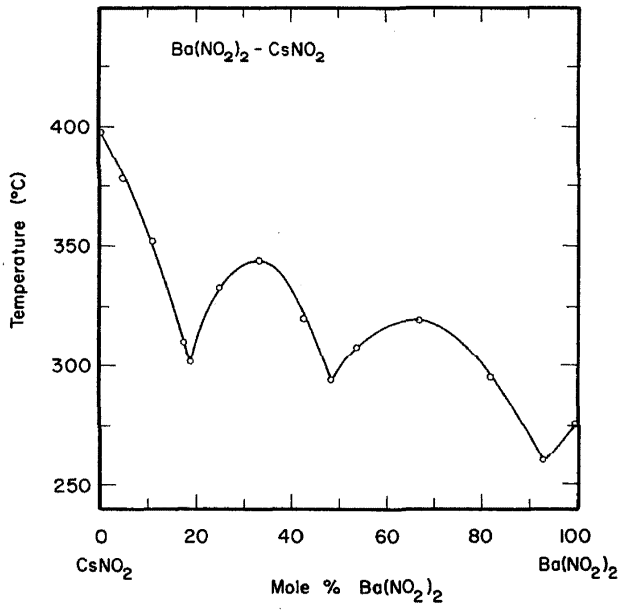

FIGURE 46. Temperature–composition phase diagram for $Ba(NO_2)_2$–$CsNO_2$.

P. I. Protsenko, and T. A. Andreeva, Zh. Neorg. Khim. **6**, 1375 (1961).

$Ba(NO_2)_2$–KNO_2

Electrical Conductance

Three studies of the specific conductance of $Ba(NO_2)_2$ [1 (p. 25), 23, 126] and three investigations of KNO_2 [1 (p. 24), 87, 96] have been reported. Some experimental aspects of the conductance measurements of $Ba(NO_2)_2$ and KNO_2 are discussed in the sections on $Ba(NO_2)_2$–$CsNO_2$ and KNO_2–$NaNO_2$.

Protsenko and Shokina [96] measured the specific conductance of molten $Ba(NO_2)_2$–KNO_2 mixtures using the classical ac technique. Their results for $Ba(NO_2)_2$ above and fifteen of the 21 mixtures (containing 4.9 to 82.4 mole percent KNO_2), covering a temperature range from 575 to 625 K, are given in table 102(a) for the experimental concentrations at rounded temperatures. The temperature-dependent equations for $Ba(NO_2)_2$ and KNO_2 and all 21 mixtures are given in table 102(b). The values in brackets for pure $Ba(NO_2)_2$, pure KNO_2 and the mixture containing 82.4 mole percent KNO_2, indicate that these are based on rather limited data. The experimental uncertainty of the results of Protsenko and Shokina is estimated to be more than 3 percent. The

TABLE 102(a). $Ba(NO_2)_2$–KNO_2: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

Mole percent KNO_2

T(K)	82.4	75.0	66.7	62.1	57.1	51.9	46.2	40.0	33.3	29.8	26.1	18.2	14.0	9.5	4.9	0
575		0.500	0.444	0.416	0.400	0.379							0.278	0.268	0.260	(0.240)
580		0.517	0.461	0.433	0.416	0.396							0.294	0.283	0.275	(0.252)
585		0.533	0.478	0.451	0.433	0.414	0.387					0.317	0.310	0.299	0.291	
590		0.550	0.495	0.469	0.450	0.431	0.404					0.334	0.327	0.315	0.306	
595		0.567	0.512	0.486	0.468	0.448	0.422	0.406	0.392	0.382	0.372	0.350	0.343	0.331	0.321	
600		0.583	0.529	0.504	0.485	0.465	0.439	0.423	0.408	0.398	0.388	0.367	0.360	0.346	0.336	
605		0.600	0.546	0.521	0.503	0.483	0.457	0.440	0.425	0.414	0.404	0.384	0.376	0.362	0.351	
610		0.617	0.564	0.539	0.521	0.500	0.474	0.456	0.441	0.431	0.421	0.401	0.393	0.378	0.366	
615	(0.676)	0.633	0.581	0.557	0.539	0.517	0.492	0.473	0.457	0.448	0.438	0.417	0.410	0.394	0.381	
620	(0.692)	0.650	0.598	0.574	0.558	0.534	0.509	0.490	0.474	0.465	0.455	0.434	0.427	0.410	0.396	
625	(0.708)	0.666	0.615	0.592	0.577	0.551	0.527	0.506	0.490	0.483	0.473	0.451	0.444	0.425	0.412	

TABLE 102(b). Temperature-dependent equations

$\kappa = a + bT + cT^2$ (ohm^{-1} cm^{-1})

Comp. (mol % KNO_2)	a	$b \cdot 10^2$	$c \cdot 10^6$	Stand. error of est. (percent)
0	(−1.1980)	(2.5000)	(0)	
4.9	−1.4795	3.0258	0	0.0003=0.09
9.5	−1.4099	2.7014	0.3762	0.0004=0.12
14.0	−1.0269	1.2963	1.6915	0.0005=0.14
18.2	−1.6369	3.3401	0	0.0005=0.13
22.2	−1.5793	3.2601	0	0.0005=0.13
26.1	0.5862	−3.9037	5.9550	0.0003=0.07
29.8	0.5731	−3.8277	5.8924	0.0003=0.07
33.3	−1.5600	3.2802	0	0.0005=0.11
36.7	−1.5953	3.3502	0	0.0007=0.16
40.0	−1.5752	3.3302	0	0.0003=0.07
43.1	2.4097	−9.7864	10.8155	0.0005=0.11
46.2	−1.6548	3.4901	0	0.0005=0.11
49.1	−1.0050	1.4968	1.5430	0.0006=0.13
51.9	−1.6004	3.4479	0	0.0006=0.13
57.1	0.0939	−2.2327	4.8083	0.0024=0.49
62.1	−1.6065	3.5172	0	0.0005=0.10
66.7	−1.5227	3.4201	0	0.0016=0.30
71.0	−1.4835	3.4029	0	0.0004=0.07
75.0	−1.4122	3.3258	0	0.0006=0.10
78.0	−1.3737	3.2972	0	0.0004=0.07
82.4	(−1.2922)	(3.2000)	(0)	
100	(−0.9896)	(3.1500)	(0)	

Reference; [96]

values for KNO_2 deviate from the recommendations [1] (−0.15 to 0.56 percent).

The experimental technique used by Protsenko and Shokina is discussed in the section on KNO_2–$NaNO_2$.

Density

One investigation of the density of $Ba(NO_2)_2$ [1 (p. 25) 91] and two studies of KNO_2 [1 (p. 24), 91] have been reported. The study of Protsenko and Malakhova [1 (p. 25), 91] for $Ba(NO_2)_2$ is based on the Archimedean method. Some experimental aspects of the density measurements of KNO_2 are discussed in the section on KNO_2–$NaNO_2$.

Protsenko and Malakhova [91] used the Archimedean method to measure the density of molten $Ba(NO_2)_2$–KNO_2 mixtures, in the temperature range from 555 to 735 K for the single components and fifteen different mixtures (9.5 to 85.7 mole percent KNO_2). The results for $Ba(NO_2)_2$ and the 15 mixtures are given in table 103 for the experimental compositions and temperatures. Due to the limited number of data points at several compositions the values are not reported at rounded temperatures. Owing to the limited information an uncertainty estimate for the results of Protsenko and Malakhova is not possible.

No information is given by Protsenko and Malakhova about salt purity or melt preparation.

Viscosity

One study of the viscosity of $Ba(NO_2)_2$ [114] and three investigations of KNO_2 [1 (p. 24), 114] have been reported. The results of Shokina and Protsenko [114] for $Ba(NO_2)_2$ (capillary viscometer) are presented graphically and are given in figures 47 ($Ba(NO_2)_2$–KNO_2) and 48 ($Ba(NO_2)_2$–$NaNO_2$). Some experimental aspects of the viscosity measurements of KNO_2 are discussed in the section on KNO_2–$NaNO_2$.

Shokina and Protsenko [114] measured the viscosity of molten $Ba(NO_2)_2$–KNO_2 mixtures using a capillary viscometer. Isotherms of viscosity against molar composition at five different temperatures between 310 and 350° C are given in figure 47. Due to the graphical presentation of the results a critical assessment is not possible.

The experimental technique used by Shokina and Protsenko is discussed in the section on KNO_2–$NaNO_2$.

TABLE 103. $Ba(NO_2)_2$–KNO_2: Density

Numerical values (g cm^{-3})

Mole percent KNO_2

T(K)	85.7	82.3	78.8	75.0	71.0	66.7	62.1	57.1	51.8	46.2	40.0	33.3	26.1	18.2	9.5	0
553.2				2.274	2.352	2.421	2.492	2.562							3.154	3.252
573.2				2.260	2.334	2.405	2.475	2.553	2.631						3.140	3.028
593.2			2.175	2.245	2.316	2.384	2.458	2.543	2.615	2.695	2.780	2.870	2.950	3.035	3.126	3.224
613.2		2.095	2.160	2.231	2.300	2.370	2.440	2.522	2.596	2.683	2.765	2.853	2.924	3.022	3.113	3.210
633.2	2.022	2.080	2.144	2.218	2.282	2.355	2.422	2.500	2.577	2.670	2.750	2.836	2.921	3.009	3.099	

Reference: [91]

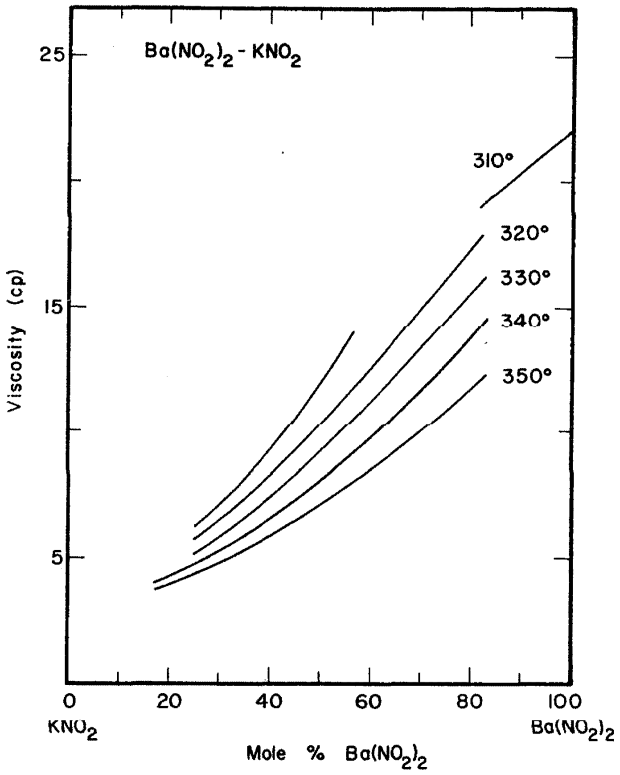

FIGURE 47. Isotherms [105] (°C) of viscosity against molar composition for the system $Ba(NO_2)_2$–KNO_2.

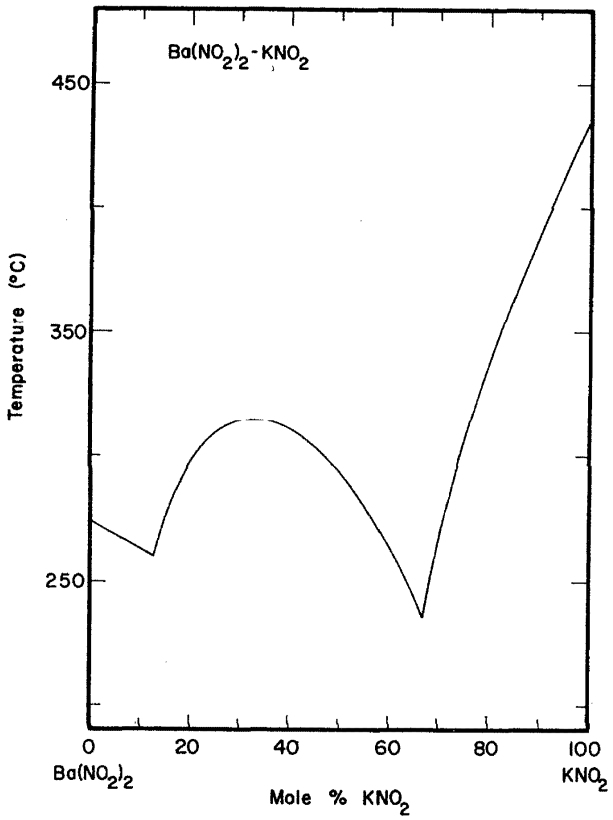

FIGURE 48. Temperature–composition phase diagram for $Ba(NO_2)_2$–KNO_2.

P. I. Protsenko and O. N. Shokina, Zh. Neorg. Khim, **5**, 437 (1960).

TABLE 104(a). $Ba(NO_2)_2$–$NaNO_2$: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

	Mole percent $NaNO_2$																					
T(K)	100	98.0	95.7	92.8	89.2	84.7	82.0	78.6	75.0	70.2	65.3	58.1	49.4	43.8	38.1	30.5	20.6	0				
520						0.679	0.632	0.571	0.522	0.460	0.403	0.342	0.284	0.255	0.226							
530						0.734	0.684	0.623	0.572	0.507	0.449	0.384	0.322	0.291	0.259							
540					0.888	0.788	0.735	0.674	0.622	0.555	0.494	0.426	0.360	0.326	0.292	0.252	0.220					
550					0.941	0.841	0.787	0.726	0.672	0.602	0.540	0.468	0.398	0.362	0.325	0.281	0.250					
560				1.084	0.994	0.895	0.840	0.777	0.722	0.650	0.586	0.510	0.436	0.397	0.359	0.311	0.280	(0.200)				
570			1.158	1.138	1.047	0.949	0.892	0.829	0.772	0.698	0.631	0.552	0.474	0.433	0.392	0.342	0.310	(0.227)				
580	(1.402)	(1.333)	1.214	1.191	1.100	1.002	0.945	0.880	0.822	0.746	0.677	0.594	0.513	0.468	0.425	0.375	0.340					
590	(1.463)	(1.393)	1.270	1.243	1.153	1.055	0.997	0.931	0.871	0.794	0.723	0.636	0.551	0.504	0.459	0.409	0.370					
600	(1.523)	(1.452)	1.325	1.296	1.206	1.108	1.051	0.983	0.921	0.842	0.768											
610	(1.581)	(1.511)	1.381	1.348	1.258	1.161	1.104	1.034	0.970	0.890	0.814											
			1.436																			

$Ba(NO_2)_2$–$NaNO_2$

Electrical Conductance

Three studies of the specific conductance of $Ba(NO_2)_2$ [1 (p. 25), 23, 126] and seven investigations of $NaNO_2$ [1 (p. 24), 89, 94, 96, 102] have been reported. Some experimental aspects of the conductance measurements of $Ba(NO_2)_2$ and $NaNO_2$ are discussed in the sections on $Ba(NO_2)_2$–$CsNO_2$ and KNO_2–$NaNO_2$, respectively.

Protsenko and Shokina [96] measured the specific conductance of molten $Ba(NO_2)_2$–$NaNO_2$ mixtures using the classical ac technique. Their results for the single components and 13 of the 16 different mixtures (containing 20.6 to 98.0 mole percent $NaNO_2$), covering a temperature range from 515 to 615 K, are given in table 104(a) for the experimental concentrations at rounded temperatures. The temperature-dependent equations for the single components and all sixteen mixtures are given in table 104(b). The values in brackets, for the single components and the mixture containing 98 mole percent $NaNO_2$, indicate that these are based on rather limited data. The experimental uncertainty of the results of Protsenko and Shokina is estimated to be more than 3 percent. The results for $NaNO_2$ deviate from the recommendations [1] (−2.44 to −1.11 percent).

The experimental technique used by Protsenko and Shokina is discussed in the section on KNO_2–$NaNO_2$.

Viscosity

One study of the viscosity of $Ba(NO_2)_2$ [114] and three investigations of $NaNO_2$ [1 (p. 24), 99, 114] have been reported. Some experimental aspects of the viscosity

TABLE 104(b). Temperature-dependent equations

$\kappa = a + bT + cT^2$ (ohm^{-1} cm^{-1})

Comp. (mol % $NaNO_2$)	a	$b \cdot 10^3$	$c \cdot 10^6$	Stand. error of est. (percent)
0	(−1.2040)	(2.6500)	(0)	
20.6	−1.3996	3.0000	0	0.0000
30.5	0.5475	−3.9246	6.2541	0.0028 = 0.87
38.1	−1.5060	3.3300	0	0.0005 = 0.15
43.8	−1.5936	3.5550	0	0.0030 = 0.81
49.4	−1.4919	3.0056	0.6909	0.0004 = 0.10
58.1	−1.8476	4.2100	0	0.0008 = 0.17
65.3	−1.9695	4.5629	0	0.0006 = 0.10
70.2	−1.8036	3.9908	0.6969	0.0006 = 0.09
75.0	−2.2850	5.7575	−0.6915	0.0006 = 0.08
78.6	−2.1935	5.4698	−0.2941	0.0004 = 0.05
82.0	−1.7296	3.9457	1.1466	0.0016 = 0.19
84.7	−2.3543	6.2429	−0.7864	0.0009 = 0.10
89.2	−1.9715	5.2950	0	0.0005 = 0.05
92.8	−2.5445	7.5926	−1.9870	0.0008 = 0.07
95.7	−2.2013	6.3995	−0.7155	0.0002 = 0.02
98.0	(−2.9972)	(8.9160)	(−2.5000)	
100	(−3.8366)	(11.9320)	(−5.0000)	

Reference: [96]

measurements of $Ba(NO_2)_2$ and $NaNO_2$ are discussed in the sections on $Ba(NO_2)_2$–KNO_2 and KNO_2–$NaNO_2$, respectively.

Shokina and Protsenko [114] measured the viscosity of molten $Ba(NO_2)_2$–$NaNO_2$ mixtures using a capillary viscometer. Isotherms of viscosity against molar composition at six different temperatures between 240 and 340 °C are given in figure 49. Due to the graphical presentation of the results a critical assessment is not possible.

The experimental technique used by Shokina and Protsenko is discussed in the section on KNO_2–$NaNO_2$.

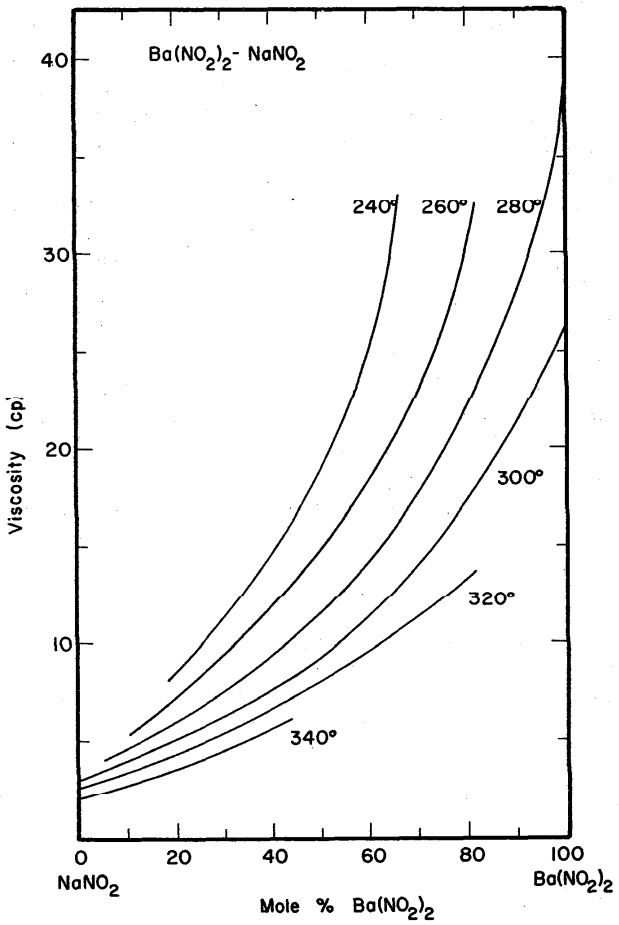

FIGURE 49. Isotherms [114] (°C) of viscosity against molar composition for the system $Ba(NO_2)_2$–$NaNO_2$.

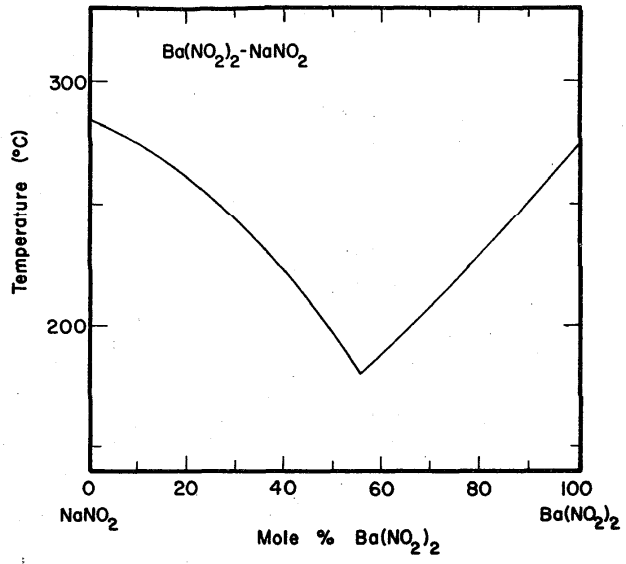

FIGURE 50. Temperature–composition phase diagram for $Ba(NO_2)_2$–$NaNO_2$.

P. I. Protsenko and O. N. Shokina, Zh. Neorg. Khim, **5**, 437 (1960).

$Ca(NO_2)_2$–$CsNO_2$

Electrical Conductance

One study of the specific conductance of $Ca(NO_2)_2$ [102] and two investigations of $CsNO_2$ [1 (p. 25), 102, 126] have been reported. Some experimental aspects of the conductance measurements of $Ca(NO_2)_2$ and $CsNO_2$ are discussed in the sections on $Ca(NO_2)_2$–$NaNO_2$ and $CsNO_2$–$LiNO_2$, respectively.

Protsenko, Shatskaya and Venerovskaya [102] measured the specific conductance of molten $Ca(NO_2)_2$–$CsNO_2$ mixtures using the classical ac technique. Isotherms of specific conductance against molar composition at nine different temperatures between 260 and 420 °C are given in figure 51. Additional results at 420 and 440 °C (dotted lines in fig. 51) were extrapolated by Protsenko, Shatskaya and Venerovskaya beyond the experimental temperature range. Due to the graphical presentation of the results a critical assessment is not possible.

The melt preparation used by Protsenko, Shatskaya and Venerovskaya is discussed in the section on $Ca(NO_2)_2$–$NaNO_2$.

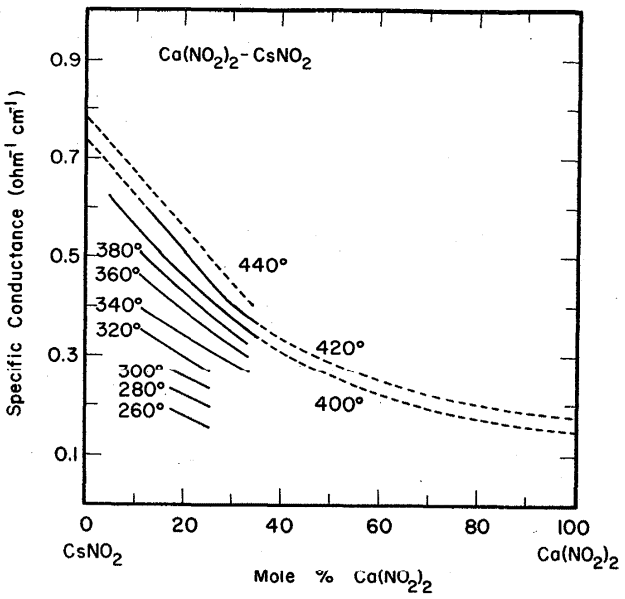

FIGURE 51. Isotherms [102] (°C) of specific conductance against molar composition for the system $Ca(NO_2)_2$–$CsNO_2$.

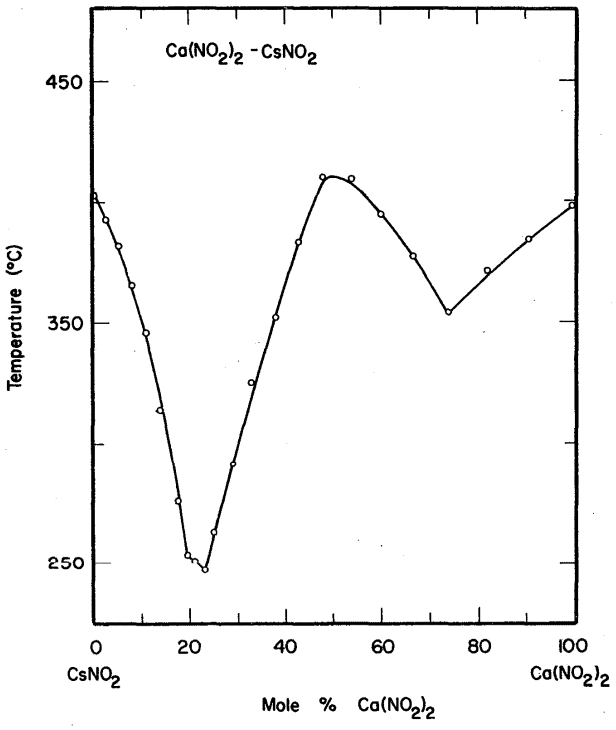

FIGURE 52. Temperature–composition phase diagram for $Ca(NO_2)_2$–$CsNO_2$.

P. I. Protsenko and B. S. Medvedev, Zh. Neorg. Khim, **10**, 1906 (1965).

$Ca(NO_2)_2$–KNO_2

Electrical Conductance

One study of the specific conductance of $Ca(NO_2)_2$ and three investigations of KNO_2 [1 (p. 24), 87, 96] have been reported. Some experimental aspects of the conductance measurements of $Ca(NO_2)_2$ and KNO_2 are discussed in the sections $Ca(NO_2)_2$–$NaNO_2$ and KNO_2–$NaNO_2$, respectively.

Protsenko, Shatskaya and Venerovskaya [102] measured the specific conductance of molten $Ca(NO_2)_2$–KNO_2 mixtures using the classical ac technique. Isotherms of specific conductance against molar composition at seven different temperatures between 210 and 330 °C are given in figure 53. Additional isotherms at 350, 370, 390, and 410 °C (dotted lines in fig. 53) were extrapolated by Protsenko, Shatskaya and Venerovskaya beyond the experimental temperature range. Due to the graphical presentation of the results a critical assessment is not possible.

The melt preparation used by Protsenko, Shatskaya and Venerovskaya is discussed in the section on $Ca(NO_2)_2$–$NaNO_2$.

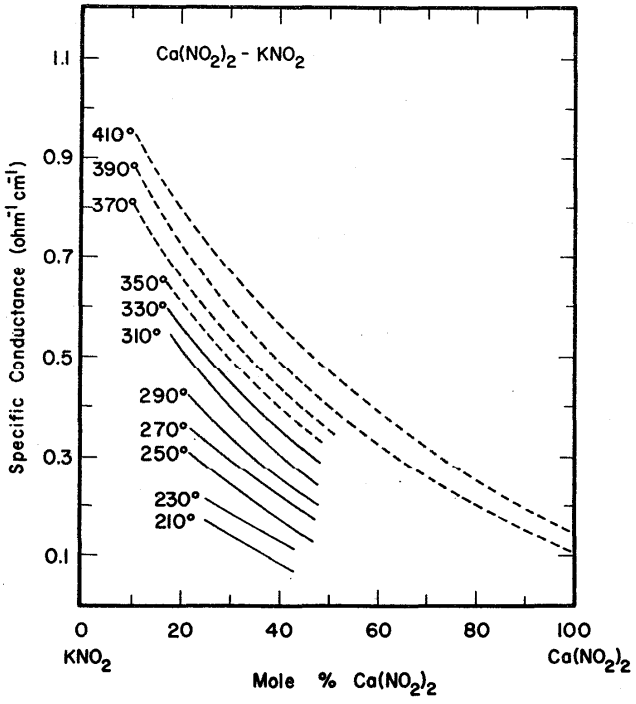

FIGURE 53. Isotherms [102] (°C) of specific conductance against molar composition for the system $Ca(NO_2)_2$–KNO_2.

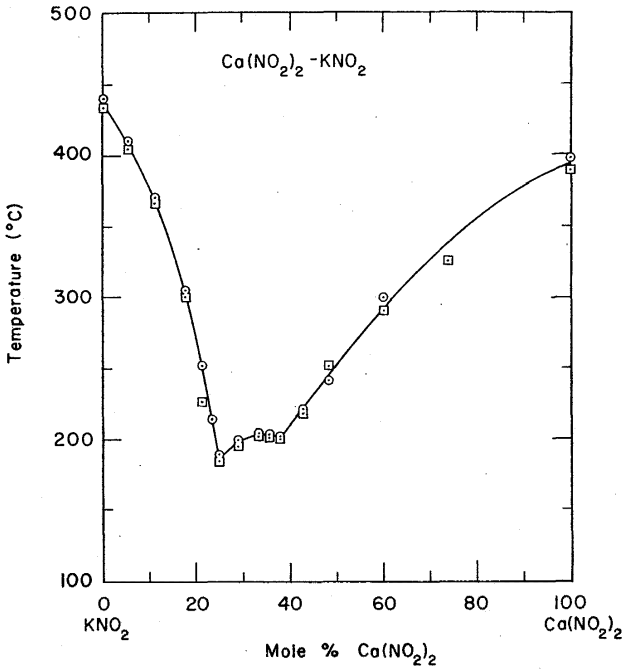

FIGURE 54. Temperature–composition phase diagram for $Ca(NO_2)_2$–KNO_2.

P. I. Protsenko and B. S. Medvedev, Ukr. Khim. Zh., **32**, No. 7, 690 (1966).

$Ca(NO_2)_2$–$NaNO_2$

Electrical Conductance

One study of the specific conductance of $Ca(NO_2)_2$ [102] and seven investigations of $NaNO_2$ [1 (p. 24), 89, 94, 96, 102] have been reported. The results of Protsenko, Shatskaya and Venerovskaya [102] for $Ca(NO_2)_2$ are presented graphically and are given in figures 54 ($Ca(NO_2)_2$–KNO_2), 57 ($Ca(NO_2)_2$–$RbNO_2$) and 51 ($Ca(NO_2)_2$–$CsNO_2$). Some experimental aspects of the conductance measurements of $NaNO_2$ are discussed in the section on KNO_2–$NaNO_2$.

Protsenko, Shatskaya and Venerovskaya [102] used the classical ac technique to measure the specific conductance of molten $Ca(NO_2)_2$–$NaNO_2$ mixtures. Isotherms of specific conductance against molar composition at seven different temperatures between 240 and 360 °C are given in figure 55. Due to the graphical presentation of the results a critical assessment is not possible.

Protsenko, Shatskaya and Venerovskaya recrystallized $NaNO_2$ and $Ca(NO_2)_2$ twice from water. KNO_2, $RbNO_2$ and $CsNO_2$ were prepared from the corresponding sulphates and $Ba(NO_2)_2$, recrystallized and premelted at 180 °C under reduced pressure (5 mm).

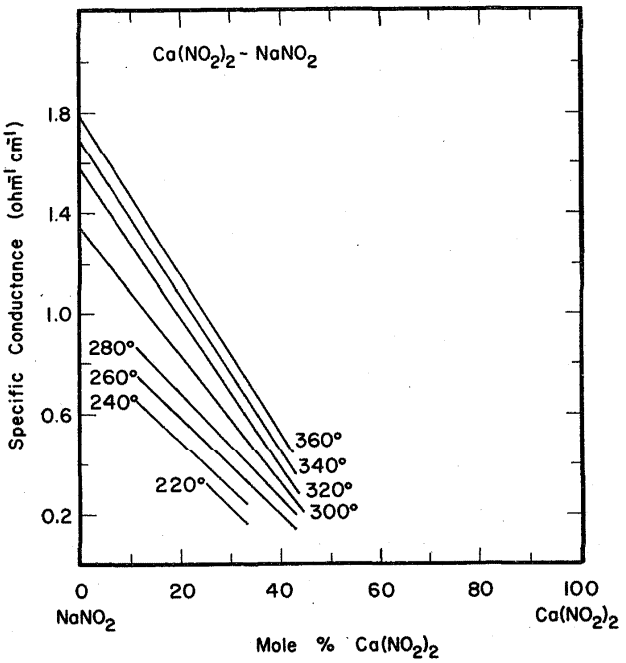

FIGURE 55. Isotherms [102] (°C) of specific conductance against molar composition for the system $Ca(NO_2)_2$–$NaNO_2$.

$Ca(NO_2)_2$–$RbNO_2$

Electrical Conductance

One study of the specific conductance of $Ca(NO_2)_2$ [102] and two investigations of $RbNO_2$ [1 (p. 25), 102] have been reported. Some experimental aspects of the conductance measurements of $Ca(NO_2)_2$ are discussed in the section on $Ca(NO_2)_2$–$NaNO_2$. The results of Protsenko, Shatskaya and Venerovskaya [102] for $Ca(NO_2)_2$ are based on the classical ac technique. No experimental aspects are given for the recommendation for $RbNO_2$.

Protsenko, Shatskaya and Venerovskaya [102] measured the specific conductance of molten $Ca(NO_2)_2$–$RbNO_2$ mixtures using the classical ac technique. Isotherms of specific conductance against molar composition at eight different temperatures between 240 and 380 °C are given in figure 57. Additional isotherms at 400 and 420 °C (dotted lines in fig. 57) were extrapolated by Protsenko, Shatskaya, and Venerovskaya beyond the experimental temperature range. Due to the graphical presentation of the results a critical assessment is not possible.

The melt preparation used by Protsenko, Shatskaya and Venerovskaya is discussed in the section on $Ca(NO_2)_2$–$NaNO_2$.

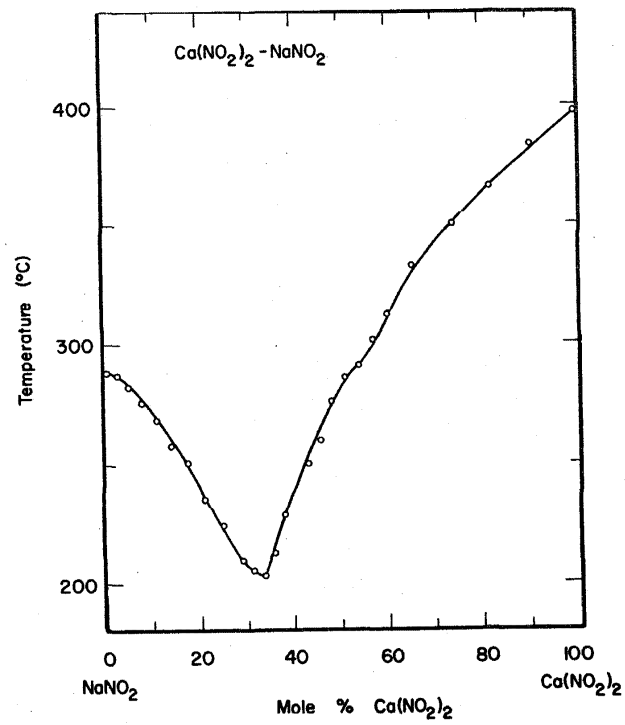

FIGURE 56. Temperature–composition phase diagram for $Ca(NO_2)_2$–$NaNO_2$.

P. I. Protsenko, and B. S. Medvedev, Zh. Neorg. Khim. **8**, 2737 (1963).

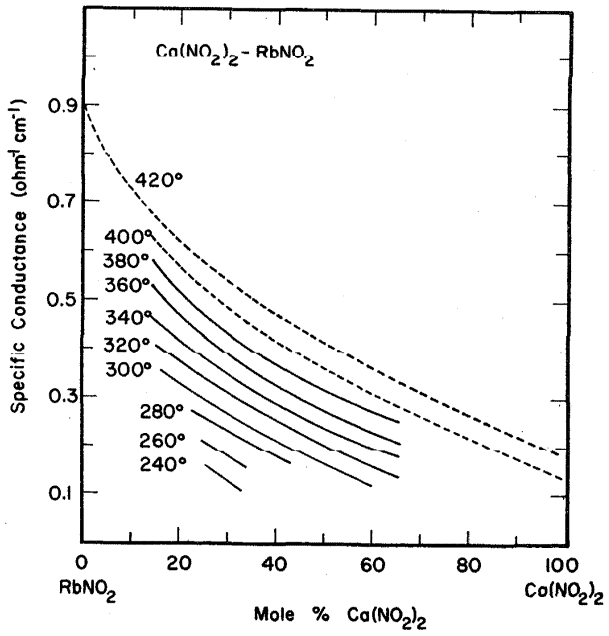

FIGURE 57. Isotherms [102] (°C) of specific conductance against molar composition for the system $Ca(NO_2)_2$–$RbNO_2$.

FIGURE 58. Temperature–composition data for $Ca(NO_2)_2$–$RbNO_2$.

P. I. Protsenko, and B. S. Medvedev, Zh. Neorg. Khim. **9**, 2438 (1964).

Comp. of mixture	M.P. (°C)
88.9 mol % $RbNO_2$ + 11.1 mol % $Ca(NO_2)_2$	345
73.0 mol % $RbNO_2$ + 27.0 mol % $Ca(NO_2)_2$	246
62.1 mol % $RbNO_2$ + 37.9 mol % $Ca(NO_2)_2$	272

$CsNO_2$–$LiNO_2$

Electrical Conductance

Three studies of the specific conductance of $CsNO_2$ [1 (p. 25), 102, 126] and two investigations of $LiNO_2$ [1 (p. 24)] have been reported. No experimental aspects are given for the recommendations for $CsNO_2$ and $LiNO_2$ referred to by Protsenko, Protsenko and Razumovskaya [1].

Protsenko and Shisholina [108] measured the specific conductance of molten $CsNO_2$–$LiNO_2$ mixtures using the classical ac technique. Their results for 10, 20, 30, 40, 45, 50, 55, 60, 70, 80, and 90 mole percent mixtures, covering a temperature range from 395 to 715 K, are given in table 105, for the experimental compositions and temperatures. A statistical analysis to produce values at rounded temperatures was unsatisfactory. Due to limited data for the single components, a critical assessment of these values is not possible.

Protsenko and Shisholina used a capillary-type cell made from heat-resistant glass. The cell constant was determined periodically with molten KNO_3 (twice recrystallized). No information is given about melt preparation.

TABLE 105. $CsNO_2$–$LiNO_2$: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

Mole percent $LiNO_2$

T(K)	90	80	70	60	55	50	45	40	30	20	10
393.2				0.070	0.065	0.050	0.040	0.030			
433.2			0.164	0.153	0.140	0.137	0.134	0.120			
473.2	0.421	0.331	0.274	0.251	0.247	0.235	0.207	0.205			
513.2	0.563	0.451	0.384	0.392	0.327	0.320	0.301	0.290	0.273		
553.2	0.744	0.605	0.521	0.463	0.441	0.435	0.421	0.410	0.394		
593.2		0.753	0.650	0.575	0.562	0.531	0.518	0.507	0.495	0.490	
633.2				0.741	0.700	0.674	0.650	0.638	0.607	0.602	
673.2						0.791	0.779	0.754	0.735	0.714	0.705
713.2									0.877	0.830	0.809

Reference: [108]

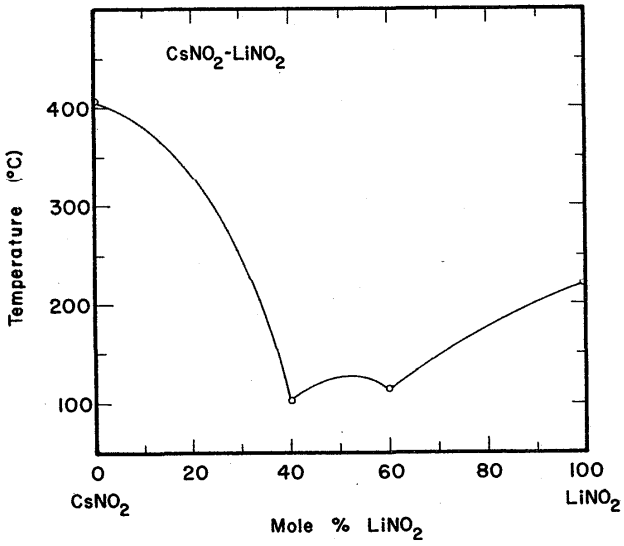

FIGURE 59. Temperature–composition phase diagram for $CsNO_2$–$LiNO_2$.

P. I. Protsenko and R. P. Shisholina, Ukr. Khim Zh. **30**, 912 (1964).

KNO_2–$NaNO_2$

Electrical Conductance

Three studies of the specific conductance of KNO_2 [1 (p. 24), 87, 96] and seven investigations of $NaNO_2$ [1 (p. 24), 89, 94, 96, 102] have been reported. All measurements of the specific conductance of KNO_2 and $NaNO_2$ are based on the classical ac technique and were carried out by means of capillary-type cells. Frame, Rhodes and Ubbelohde [1 (p. 24), 87] recrystallized $NaNO_2$ twice from aqueous solution and KNO_2 from the melt. Both salts were then air-dried at 180 °C for 48 hours and finally shock-dried. The cell was calibrated with 0.1m KCl. The conductance cells used by Bloom, Knaggs, Molloy and Welch [1 (p. 24)] for measurements with $NaNO_2$ were made either from silica or from B.T.H. glass, and the salts used had a purity of not less than 99.8 percent.

Protsenko and Shokina [96] measured the specific conductance of molten KNO_2–$NaNO_2$ mixtures using

TABLE 106(a). KNO_2–$NaNO_2$: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

T(K)	Mole percent $NaNO_2$																					
	100	95	90	85	80	75	70	65	60	55	50	45	40	35	30	25	20	10	0
580	(1.402)	1.348	1.299	1.252	1.211	1.181	1.142	1.106	1.085	1.058	1.030	0.999	0.970						
590	(1.463)	1.404	1.351	1.304	1.262	1.231	1.192	1.155	1.104	1.077	1.012	1.042							
600	(1.523)	1.460	1.404	1.356	1.313	1.282	1.242	1.205	1.181	1.151	1.123	1.086	1.054	1.026					
610	(1.581)	1.515	1.457	1.409	1.364	1.332	1.293	1.254	1.229	1.197	1.169	1.130	1.096	1.067					
620		1.569	1.510	1.461	1.416	1.382	1.343	1.303	1.276	1.244	1.215	1.174	1.138	1.107	1.068				
630		1.623	1.553	1.513	1.467	1.432	1.393	1.353	1.324	1.290	1.261	1.218	1.180	1.148	1.109				
640				1.565	1.518	1.482	1.443	1.402	1.372	1.337	1.307	1.262	1.222	1.189	1.150	1.112			
650				1.618	1.569	1.532	1.494	1.451	1.420	1.383	1.352	1.306	1.265	1.230	1.190	1.152			
660						1.581	1.544	1.500	1.467	1.430	1.398	1.350	1.307	1.270	1.231	1.192	1.159		
670						1.630	1.594	1.549	1.515	1.476	1.443	1.395	1.349	1.311	1.271	1.232	1.196		
680								1.598	1.562	1.523	1.489	1.439	1.392	1.352	1.312	1.272	1.235		
690								1.646	1.610	1.569	1.534	1.484	1.434	1.393	1.352	1.312	1.274		
700										1.616	1.579	1.529	1.476	1.433	1.392	1.351	1.313	(1.267)	
710										1.662	1.625	1.573	1.519	1.474	1.432	1.391	1.352	(1.303)	
720												1.618	1.551	1.515	1.472	1.430	1.391	(1.338)	(1.278)
730												1.663	1.604	1.556	1.512	1.469	1.430	(1.373)	(1.310)

the classical ac technique. Their results for the single components and 12 of the 17 different mixtures (containing 10 to 95 percent $NaNO_2$), covering a temperature range from 575 to 735 K, are given in table 106(a) for the experimental compositions at rounded temperatures. The temperature-dependent equations for the single components and all 17 mixtures are given in table 106(b). The values in brackets, for the single components and the mixture containing 10 mole percent $NaNO_2$, indicate that these are based on rather limited data.

The experimental uncertainty of the results of Protsenko and Shokina is estimated to be more than 3 percent. The results for KNO_2 and $NaNO_2$ deviate from the recommendations [1] (−0.15 to 0.56 percent) and (−2.44 to −1.11 percent), respectively.

Protsenko and Shokina used a capillary-type cell. No information is given about melt preparation.

Density

Two studies of the density of KNO_2 [1 (p. 24), 95] and three investigations of $NaNO_2$ [1 (p. 24), 95] have been reported. Two different methods were used to measure the density of KNO_2 and $NaNO_2$: The study of Frame, Rhodes, and Ubbelohde [1 (p. 24)] is based on a manometric densitometer technique, whereas the other investigations are based on the Archimedean method. Polyakov and Beruli [95] used a platinum bob, whereas Bloom, Knaggs, Molloy, and Welch [1 (p. 24)] used a bob made from platinum-10 percent rhodium.

Polyakov and Beruli [95] used the Archimedean method to measure the density of molten KNO_2–$NaNO_2$ mixtures, in the temperature range from 515 to 775 K

TABLE 106(b). Temperature-dependent equations

$\kappa = a + bT + cT^2$ (ohm^{-1} cm^{-1})

Comp. (mol % $NaNO_2$)	a	$b \cdot 10^3$	$c \cdot 10^6$	Stand error of est. (percent)
0	(−0.9896)	(3.1500)	(0)	
10	(−1.8358)	(5.3080)	(−1.2500)	
20	−1.5901	4.3995	−0.3603	0.0004 = 0.03
25	−1.6783	4.6992	−0.5305	0.0006 = 0.05
30	−1.6797	4.7701	−0.5454	0.0006 = 0.05
35	−1.4183	4.0738	0	0.0008 = 0.06
40	−1.4137	4.0152	0.1619	0.0007 = 0.06
45	−1.3695	3.8072	0.4755	0.0009 = 0.07
50	−1.8106	5.1669	−0.4629	0.0010 = 0.08
55	−1.6384	4.6488	0	0.0007 = 0.05
60	−1.7987	5.1389	−0.2888	0.0004 = 0.03
65	−1.8752	5.3307	−0.3288	0.0005 = 0.04
70	−1.7730	5.0257	0	0.0005 = 0.04
75	−2.0842	6.1767	−0.9441	0.0004 = 0.03
80	−1.7527	5.1100	0	0.0010 = 0.07
85	−1.7818	5.2300	0	0.0005 = 0.04
90	−1.7639	5.2801	0	0.0015 = 0.11
95	−2.9256	9.0988	−2.9830	0.0003 = 0.02
100	(−3.8366)	(11.9320)	(−5.0000)	

Reference: [96]

for the single components and mixtures containing 15, 25, 40, 45, 50, 60, 70, and 75 mole percent KNO_2. The results were recalculated using a two-dimensional statistical analysis; the values in the form of a temperature-composition-density matrix are in table 107(a) at rounded compositions and temperatures. The corresponding statistical parameters are given in table 107(b). Due to the limited information an uncertainty estimate of the results of Polyakov and Beruli is not possible. The results for KNO_2 and $NaNO_2$ deviate from the recommendations [1] (−0.02 to 0.05 percent) and (−1.02 to 0.30 percent) respectively.

No information is given by Polyakov and Beruli about salt purity and melt preparation.

Viscosity

Three studies of the viscosity of KNO_2 [1 (p. 24), 114] and three investigations of $NaNO_2$ [1 (p. 24), 99, 114] have been reported. Frame, Rhodes and Ubbelohde [1 (p. 24)] used a modified Ubbelohde viscometer to measure the viscosity of KNO_2 and $NaNO_2$. The viscometer was calibrated with water at 20, 30, and 40 °C, and the calibration was checked with molten $NaNO_3$. The melt was filtered into the viscometer through a sintered glass disc, and the flow time was determined under a steady pressure of nitrogen. The measurements of Protsenko and Razumovskaya [1 (p. 24)], Protsenko and Shokina [1 (p. 24), 99] and Shokina and Protsenko [114] for KNO_2 and $NaNO_2$ were carried out by means of a capillary viscometer.

Protsenko and Shokina [99] measured the viscosity of molten KNO_2–$NaNO_2$ mixtures using a capillary viscometer. Their results for the single components and 10, 20, 30, 40, 50, 60, 70, 80, and 90 mole percent mixtures, covering a temperature range from 565 to 745 K, are given in table 108(a) for the experimental compositions at rounded temperatures. The corresponding temperature-dependent equations are given in table 108(b). The values in brackets, for KNO_2 and the mixtures containing 10, 20, and 90 mole percent $NaNO_2$, indicate that these are based on rather limited data. The experimental uncertainty of the values of Prot-

TABLE 107(a). KNO_2–$NaNO_2$: Density

Numerical values (g cm^{-3})

Mole percent $NaNO_2$

T(K)	100	90	80	70	60	50	40	30	20	10	0	65
515				1.815	1.815							1.815
530			1.806	1.806	1.806							1.806
545		1.798	1.797	1.797	1.797							1.797
560		1.789	1.788	1.788	1.788	1.787						1.788
575	1.780	1.780	1.780	1.779	1.779	1.778	1.778					1.779
590	1.771	1.771	1.771	1.770	1.770	1.769	1.769					1.770
605	1.763	1.762	1.762	1.761	1.761	1.760	1.760	1.760				1.761
620	1.754	1.753	1.753	1.752	1.752	1.752	1.751	1.751				1.752
635	1.745	1.744	1.744	1.743	1.743	1.743	1.742	1.742	1.741			1.743
650	1.736	1.736	1.735	1.735	1.734	1.734	1.733	1.733	1.732			1.734
665	1.727	1.727	1.726	1.726	1.725	1.725	1.724	1.724	1.723			1.725
680	1.718	1.718	1.717	1.717	1.716	1.716	1.715	1.715	1.714	1.714		1.716
695	1.709	1.709	1.708	1.708	1.707	1.707	1.706	1.706	1.705	1.705		1.708
710	1.701	1.700	1.699	1.699	1.698	1.698	1.697	1.697	1.696	1.695		1.699
725	1.692	1.691	1.791	1.690	1.689	1.689	1.688	1.688	1.687	1.686	1.686	1.690
740	1.683	1.682	1.682	1.681	1.680	1.680	1.679	1.679	1.678	1.677	1.677	1.681
755	1.674	1.673	1.673	1.672	1.671	1.671	1.670	1.670	1.669	1.668	1.668	1.612
770	1.665	1.665	1.664	1.663	1.662	1.662	1.661	1.660	1.660	1.659	1.658	1.663

TABLE 107(b). Two-dimensional equation and statistical parameters

$\rho = a + bT + cCT^2$ (g cm^{-3})

a	$b \cdot 10^4$	$c \cdot 10^{10}$	Max percent departure	Stand. error of est.
2.11964	−5.90215	−1.12835	−0.56% (773.2 K, 60 mol % KNO_2)	0.002 (0.12%)

Reference: [95]

C = mole percent KNO_2

TABLE 108(a). KNO_2–$NaNO_2$: Viscosity

Numerical values (cp)

Mole percent $NaNO_2$

T(K)	100	90	80	70	60	50	40	30	20	10	0
570	3.04										
580	2.84	(2.86)	2.89	2.92	2.95	2.98	2.99				
590	2.65	(2.68)	2.71	2.74	2.76	2.80	2.82				
600	2.47	(2.50)	2.54	2.57	2.60	2.63	2.66				
610	2.31	(2.35)	2.39	2.42	2.45	2.48	2.51				
620		(2.20)	2.25	2.28	2.31	2.34	2.38	2.41			
630		(2.08)	2.12	2.15	2.18	2.21	2.26	2.30			
640			2.02	2.03	2.07	2.10	2.14	2.19			
650			1.93	1.93	1.96	1.99	2.04	2.08	(2.10)		
660				1.83	1.86	1.89	1.94	1.99	(2.03)		
670				1.74	1.77	1.80	1.86	1.90	(1.95)		
680					1.69	1.72	1.77	1.82	(1.87)		
690					1.61	1.64	1.70	1.75	(1.79)		
700						1.57	1.63	1.67	(1.71)	(1.78)	
710						1.50	1.56	1.61	(1.64)	(1.72)	
720										(1.66)	(1.70)
730										(1.60)	(1.64)
740											(1.58)

TABLE 108(b). Temperature-dependent equations

$$\eta = a + bT + cT^2 + dT^3 \text{ (cp)}$$

$$\eta = A \cdot \exp(E/RT) \text{ (cp)}$$

Comp. (mol % $NaNO_2$)	a	$b \cdot 10$	$c \cdot 10^3$	$d \cdot 10^4$	$A \cdot 10^2$	E (cal mol^{-1})	Stand. error of est. (percent)
0	(636.3094)	(−26.2092)	(3.6160)	(−16.6667)			
10	(5.9792)	(−0.0600)	(0)	(0)			
20	(−119.7038)	(5.5833)	(−0.8415)	(4.1667)			
30					9.819	3945	0.0177=0.89
40					8.506	4104	0.0115=0.54
50					7.052	4315	0.0155=0.74
60					6.768	4348	0.0189=0.88
70					6.095	4460	0.0164=0.72
80	1.3444	0.7897	−0.2264	1.6356			0.0036=0.15
90	(39.3925)	(−1.0648)	(0.0750)	(0)			
100	18.3524	−0.0822	−0.0765	0.7688			0.0079=0.29

Reference: [99]

senko and Shokina is estimated to be about 1.5 percent. The results for KNO_2 deviate from the recommendations [1] (4.43 to 6.02 percent).

The viscometers used by Protsenko and Shokina [1 (p. 24), 99], Protsenko and Razumovskaya [1 (p. 24)] and Shokina and Protsenko [114] were made from molybdenum glass and were calibrated with molten "chemically pure" grade KNO_3. The flow time was recorded automatically by means of an electric clock and a resistance bridge. "Chemically pure" grade $NaNO_2$ was recrystallized from aqueous solution, whereas KNO_2 was prepared from K_2SO_4 and $Ba(NO_2)_2$. The salts were dehydrated in vacuum at 160 °C.

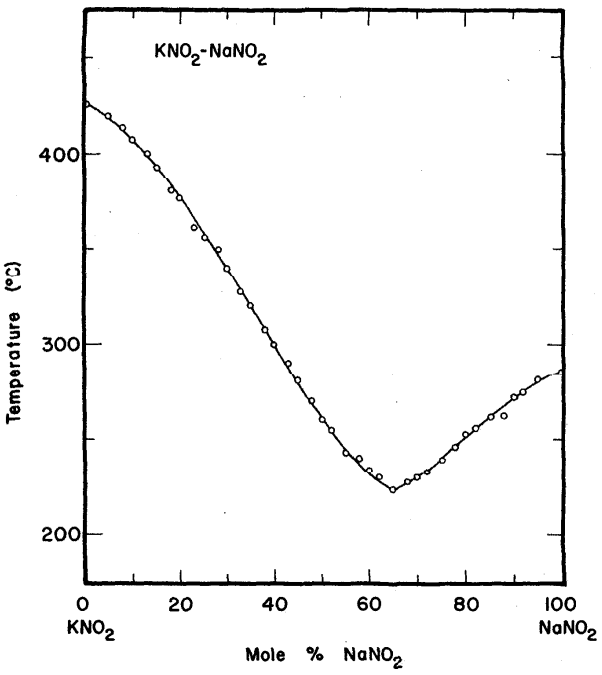

FIGURE 60. Temperature–composition phase diagram for KNO_2–$NaNO_2$.

A. G. Bergman and S. I. Beruli, Izv. Sekt. Fiz. Khim. A. **21**, 172 (1952).

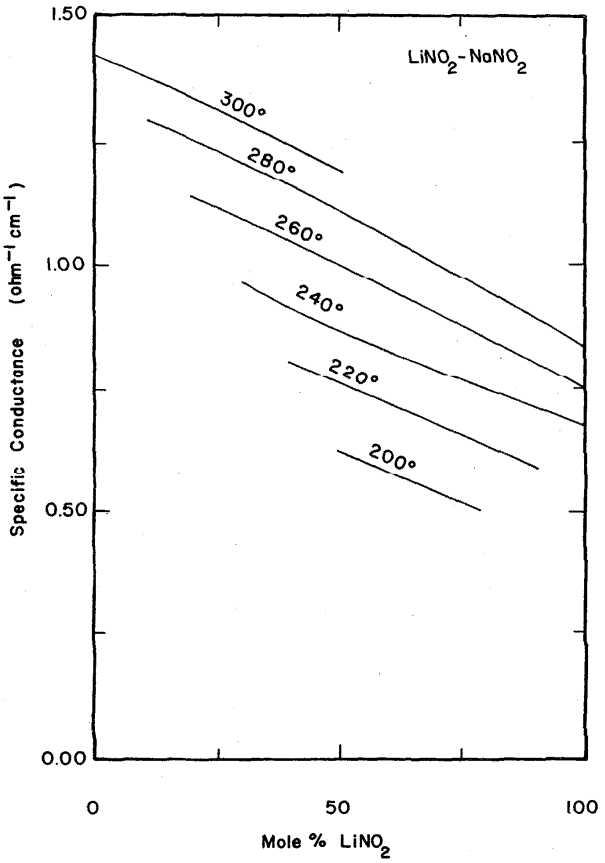

FIGURE 61. Isotherms [94] (°C) of specific conductance against molar composition for the system $LiNO_2$–$NaNO_2$.

$LiNO_2$–$NaNO_2$

Electrical Conductance

Two studies of the specific conductance of $LiNO_2$ [1 (p. 24)] and seven investigations of $NaNO_2$ [1 (p. 24), 89, 94, 96, 102] have been reported. Some experimental aspects of the conductance measurements of $LiNO_2$ and $NaNO_2$ are discussed in the sections on $CsNO_2$–$LiNO_2$ and KNO_2–$NaNO_2$, respectively.

Protsenko and Shisholina [94] measured the specific conductance of molten $LiNO_2$–$NaNO_2$ mixtures using the classical ac technique. Isotherms of specific conductance against molar composition at six different temperatures between 200 and 300 °C are given in figure 61. Due to the graphical presentation of the results a critical assessment is not possible.

Protsenko and Shisholina used a pyrex conductance cell calibrated with KNO_3. No information is given relative to melt preparation.

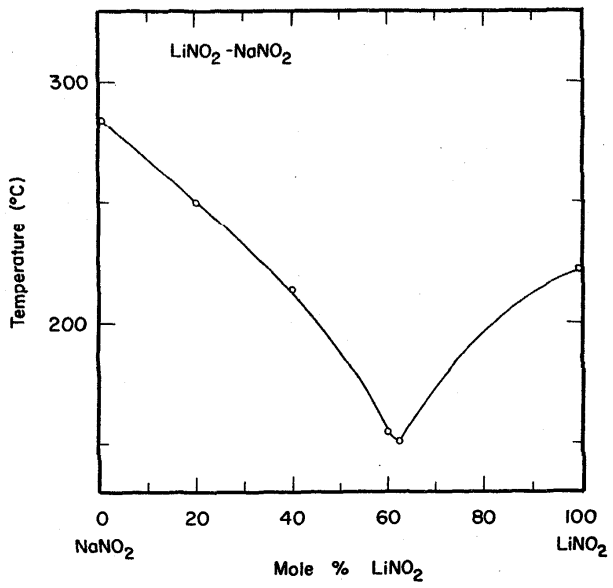

FIGURE 62. Temperature–composition phase diagram for $LiNO_2$–$NaNO_2$.

R. P. Shisholina and P. I. Protsenko, Zh. Neorg. Khim. **8**, 2741 (1963).

$NaNO_2$–$TlNO_2$

Electrical Conductance

Seven studies of the specific conductance of $NaNO_2$ [1 (p. 24), 89, 94, 96, 102] and two investigations of $TlNO_2$ [89, 103] have been reported. Some experimental aspects of the conductance measurements of $NaNO_2$ are discussed in the section on KNO_2–$NaNO_2$. The results of Protsenko, Protsenko, Gabitova, and Shatskaya [103] for $TlNO_2$ based on the classical ac technique, are recommended as the "best" values. The temperature dependence of the conductance values in the range from 465 to 565 K is given by the equation

$$\kappa\ (\text{ohm}^{-1}\ \text{cm}^{-1}) = -0.8037 + 2.970 \cdot 10^{-3}\ T$$

reported by Protsenko, Protsenko, Gabitova, and Shatskaya. No standard error is given. The experimental uncertainty is estimated to be about 2 percent. $TlNO_2$ was prepared from Tl_2SO_4 and $Ba(NO_2)_2$. The salt was dehydrated and vacuum dried for 5 min at 160 °C. The melting point was 190 °C (463.2 K). A capillary-type cell was used for the conductance measurements.

Protsenko and Gabitova [89] used the classical ac technique to measure the specific conductance of molten $NaNO_2$–$TlNO_2$ mixtures. Isotherms of specific conductance against molar composition at five different temperatures between 200 and 280 °C are given in figure 63. It should be noted that the scale of the ordinate in figure 63, as reported by Protsenko and Gabitova, is inconsistent. Due to the graphical presentation of the results a critical assessment is not possible.

Protsenko and Gabitova recrystallized $NaNO_2$ and $NaNO_3$ twice from water. $TlNO_2$ was prepared from Tl_2SO_4 and $Ba(NO_2)_2$.

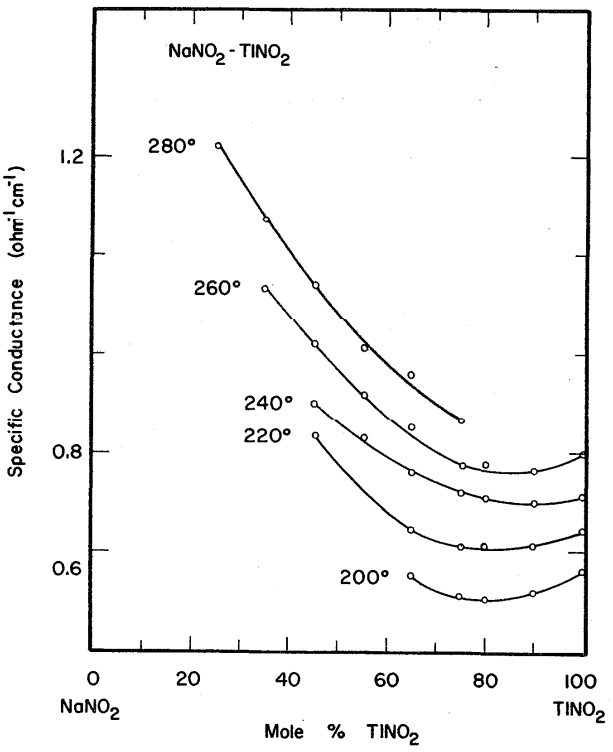

FIGURE 63. Isotherms [89] (°C) of specific conductance against molar composition for the system $NaNO_2$–$TlNO_2$.

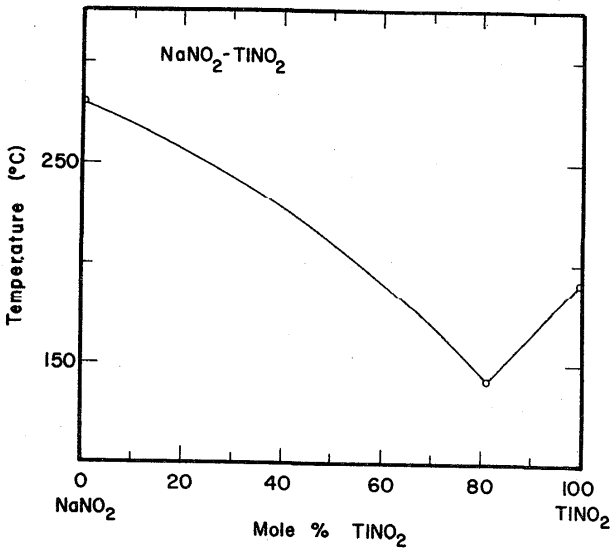

FIGURE 64. Temperature – composition phase diagram for $NaNO_2$–$TlNO_2$.

P. I. Protsenko and L. L. Gabitova, Ukr. Khim. Zh. **33**, 777 (1962).

$Ba(NO_2)_2$–$Ba(NO_3)_2$

Electrical Conductance

Three studies of the specific conductance of $Ba(NO_2)_2$ [1 (p. 25), 23, 126] have been reported. $Ba(NO_3)_2$ has not been investigated. Some experimental aspects of the conductance measurements of $Ba(NO_2)_2$ are discussed in the section on $Ba(NO_2)_2$ $CsNO_2$.

Protsenko and Andreeva [126] measured the specific conductance of molten $Ba(NO_2)_2$–$Ba(NO_3)_2$ mixtures using the classical ac technique. Their results for $Ba(NO_2)_2$ and mixtures containing 5, 10, and 15 mole percent $Ba(NO_3)_2$, covering a temperature range from 555 to 615 K, are given in table 109, for the experimental compositions and temperatures. Due to the limited number of data points the values are not presented at rounded temperatures. The experimental uncertainty of the values of Protsenko and Andreeva is estimated to be more than 3 percent. The results for $Ba(NO_2)_2$ deviate from the recommendations [1] (−6.03 to −4.25 percent).

The melt preparation and experimental technique used by Protsenko and Andreeva is discussed in the section on $Ba(NO_2)_2$–$CsNO_2$.

TABLE 109. $Ba(NO_2)_2$–$Ba(NO_3)_2$: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

	Mole percent $Ba(NO_3)_2$			
T(K)	15	10	5	0
553.2			0.165	0.171
573.2		0.215	0.220	0.225
593.2		0.270	0.273	0.279
613.2	0.320	0.323	0.325	0.331

Reference: [126]

Density

One study of the density of $Ba(NO_2)_2$ [1 (p. 25), 91] has been reported. $Ba(NO_3)_2$ has not been investigated. Some experimental aspects of the density measurements of $Ba(NO_2)_2$ are discussed in the section on $Ba(NO_2)_2$–KNO_2.

Protsenko and Malakhova [91] used the Archimedean method to measure the density of molten $Ba(NO_2)_2$–$Ba(NO_3)_2$ mixtures. Their results for $Ba(NO_2)_2$ and mixtures containing 5 and 10.9 mole percent $Ba(NO_3)_2$, covering a temperature range from 575 to 610 K, are given in table 110(a) for the experimental compositions at rounded temperatures. The corresponding temperature-dependent equations are given in table 110(b). Due to the limited data the results are not presented in a temperature-composition density matrix. Considering the lack of experimental information an uncertainty estimate of the results of Protsenko and Malakhova is not possible.

No information is given by Protsenko and Malakhova relative to salt purity and melt preparation.

TABLE 110(a). $Ba(NO_2)$–$Ba(NO_3)_2$: Density

Numerical values (g cm^{-3})

	Mole percent $Ba(NO_3)_2$		
T(K)	10.9	5.0	0
575	3.242	3.239	3.237
580	3.238	3.235	3.233
585	3.235	3.232	3.230
590	3.231	3.228	3.226
595	3.228	3.225	3.223
600	3.225	3.221	3.219
605	3.221	3.218	3.216
610	3.218	3.214	3.212

TABLE 110(b). Temperature-dependent equations

$\rho = a + bT$ (g cm^{-3})

Comp. (mol % $Ba(NO_3)_2$)	a	$b \cdot 10^3$	Stand. error of est. (percent)
0	3.6392	−0.7000	0.0000
5.0	3.6412	−0.7000	0.0000
10.9	3.6297	−0.6750	0.0002=0.01

Reference: [91]

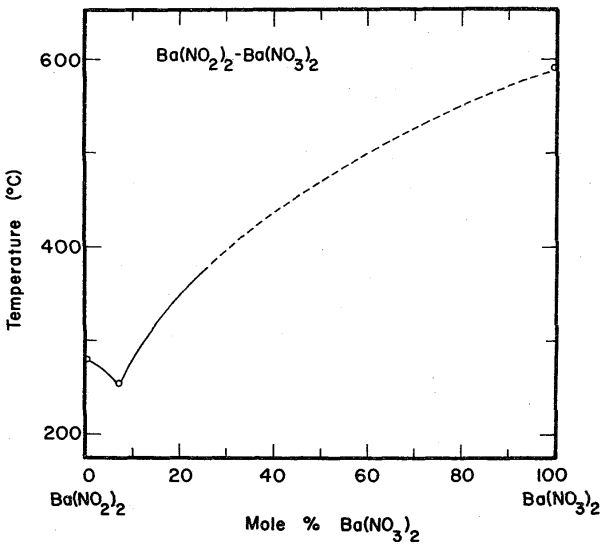

FIGURE 65. Temperature – composition phase diagram for $Ba(NO_2)_2$–$Ba(NO_3)_2$.

P. I. Protsenko and A. Ya. Malakhova, Zh. Neorg. Khim. 6, 1662 (1961).

$Ba(NO_2)_2$–$CsNO_3$

Electrical Conductance

Three studies of the specific conductance of $Ba(NO_2)_2$ [1 (p. 25), 23, 126] and seven investigations of $CsNO_3$ [1 (p. 28), 125, 126, 127, 129] have been reported. Some experimental aspects of the conductance measurements of $Ba(NO_2)_2$ and $CsNO_3$ are discussed in the sections on $Ba(NO_2)_2$–$CsNO_2$ and $CsNO_3$–KNO_3, respectively.

Protsenko and Andreeva [126] used the classical ac technique to measure the specific conductance of molten $Ba(NO_2)_2$–$CsNO_3$ mixtures. Their results for the single components and sixteen different mixtures (9.5 to 94.7 mole percent $CsNO_3$), covering a temperature range from 555 to 735 K, are given in table 111(a) for the experimental compositions at rounded temperatures. The corresponding temperature-dependent equations are given in table 111(b). The values in brackets, for $CsNO_3$ and the mixture containing 9.5 mole percent $CsNO_3$, indicate that these are based on rather limited data. The experimental uncertainty of the results of Protsenko and Andreeva is estimated to be more than 3 percent. The values for $Ba(NO_2)_2$ and $CsNO_3$ deviate from the recommendations [1] (−6.03 to −4.25 percent) and (−2.57 to −0.89 percent) respectively.

The melt preparation and experimental technique used by Protsenko and Andreeva is discussed in the section on $Ba(NO_2)_2$–$CsNO_2$.

TABLE 111(a). $Ba(NO_2)_2$–$CsNO_3$: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

Mole percent $CsNO_3$

T(K)	100	94.7	88.9	82.4	78.8	75.0	71.0	66.7	62.1	57.1	51.9	46.2	40.0	33.3	26.1	18.2	9.5	0
560																		0.190
570																		0.217
580					0.218	0.206	0.197	0.190	0.182	0.176	0.175	0.173	0.176	0.177	0.198	0.201	(0.220)	0.244
590					0.237	0.225	0.216	0.207	0.201	0.193	0.193	0.190	0.193	0.194	0.219	0.221	(0.238)	0.270
600					0.255	0.243	0.234	0.225	0.219	0.211	0.210	0.206	0.210	0.211	0.237	0.240		0.297
610					0.274	0.261	0.252	0.242	0.237	0.228	0.228	0.222	0.227	0.228	0.252	0.258		0.323
620				0.310	0.292	0.279	0.269	0.259	0.255	0.246	0.246	0.238	0.244	0.245	0.264	0.274		
630				0.329	0.311	0.297	0.285	0.277	0.273	0.263	0.263	0.255	0.261	0.263	0.273	0.288		
640				0.347	0.329	0.316	0.301	0.294	0.291									
650				0.366	0.347	0.334	0.316	0.311	0.309									
660			0.416	0.384	0.366	0.352												
670			0.435	0.403	0.384	0.370												
680		0.475	0.453	0.421	0.403													
690		0.494	0.472	0.440	0.421													
700	(0.547)	0.513	0.491	0.459														
710	(0.568)	0.532	0.509	0.477														
720	(0.589)	0.551	0.528															
730	(0.610)	0.570	0.547															

TABLE 111(b). Temperature-dependent equations

$\kappa = a + bT + cT^2$ (ohm^{-1} cm^{-1})

Comp. (mol % $CsNO_3$)	a	$b \cdot 10^3$	$c \cdot 10^6$	Stand. error of est. (percent)
0	−1.7535	4.2081	−1.3186	0.0003 = 0.12
9.5	(−0.8238)	(1.8000)	(0)	
18.2	−3.5397	10.7868	−7.4781	0.0015 = 0.63
26.1	−6.3383	20.2542	−15.4914	0.0007 = 0.30
33.3	−0.8210	1.7200	0	0.0003 = 0.14
40.0	−0.8105	1.7000	0	0.0000
46.2	−0.7722	1.6300	0	0.0003 − 0.15
51.9	−0.8517	1.7700	0	0.0003 = 0.14
57.1	−0.8391	1.7500	0	0.0000
62.1	−0.8704	1.8150	0	0.0003 = 0.12
66.7	−0.8165	1.7350	0	0.0003 = 0.12
71.0	−1.8208	5.0617	−2.7289	0.0021 = 0.82
75.0	−0.8510	1.8229	0	0.0003 = 0.11
78.8	−0.8505	1.8429	0	0.0004 = 0.13
82.4	−0.7452	1.5675	0.2173	0.0004 = 0.10
88.9	−0.8183	1.8700	0	0.0003 = 0.06
94.7	−0.8171	1.9000	0	0.0000
100	(−0.9227)	(2.1000)	(0)	

Reference: [126]

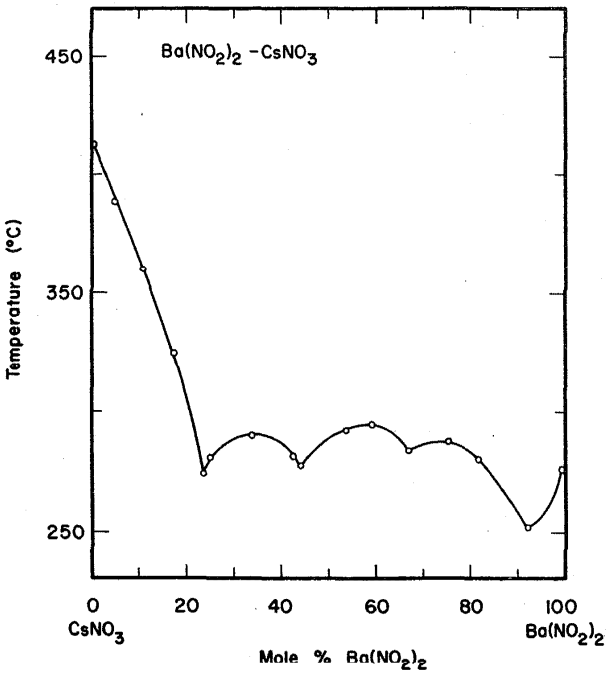

FIGURE 66. Temperature – composition phase diagram for $Ba(NO_2)_2$–$CsNO_3$.

P. I. Protsenko and T. A. Andreeva, Zh. Neorg. Khim. **6**, 1375 (1961).

$Ba(NO_3)_2$–$CsNO_2$

Electrical Conductance

$Ba(NO_3)_2$ has not been investigated. Three investigations of the specific conductance of $CsNO_2$ [1 (p. 25), 102, 126] have been reported. Some experimental aspects of the conductance measurements of $CsNO_2$ are discussed in the section on $CsNO_2$–$LiNO_2$.

Protsenko and Andreeva [126] measured the specific conductance of molten $Ba(NO_3)_2$–$CsNO_2$ mixtures using the classical ac technique. Their results for $CsNO_2$ and nine different mixtures (57.1 to 94.7 mole percent $CsNO_2$), covering a temperature range from 575 to 735 K, are given in table 112(a) for the experimental compositions at rounded temperatures. The corresponding temperature-dependent equations are given in table 112(b). The values in brackets, for the mixture containing 94.7 mole percent $CsNO_2$, indicate that these are based on rather limited data. The experimental uncertainty of the results of Protsenko and Andreeva is estimated to be more than 3 percent. The values for $CsNO_2$ deviate from the recommendations [1] (−0.75 to −0.42 percent).

The melt preparation and experimental technique used by Protsenko and Andreeva is discussed in the section on $Ba(NO_2)_2$–$CsNO_2$.

TABLE 112(a). $Ba(NO_3)_2$–$CsNO_2$: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

Mole percent $CsNO_2$

T(K)	100	94.7	88.9	82.4	78.8	75.0	71.0	66.7	62.1	57.1
580					0.242	0.220	0.208	0.194		
590					0.261	0.237	0.226	0.212		
600				0.311	0.280	0.255	0.245	0.230	0.223	
610				0.330	0.299	0.273	0.263	0.248	0.241	
620				0.350	0.319	0.292	0.283	0.267	0.260	
630				0.369	0.339	0.312	0.302	0.286	0.278	
640			0.449	0.389	0.359	0.332	0.322	0.305	0.297	0.286
650			0.470	0.408	0.378	0.353	0.342	0.325	0.316	0.305
660		(0.565)	0.492	0.428	0.399	0.375	0.363	0.345	0.335	0.324
670		(0.587)	0.513	0.448	0.419	0.397	0.384	0.365	0.354	0.343
680	0.703	(0.609)	0.535	0.468	0.439	0.420	0.405	0.385	0.373	0.362
690	0.727	(0.630)	0.556	0.488	0.460	0.443	0.427	0.406	0.393	0.382
700	0.752									
710	0.776									
720	0.801									
730	0.825									

TABLE 112(b). Temperature-dependent equations

$\kappa = a + bT + cT^2$ (ohm^{-1} cm^{-1})

Comp. (mol % $CsNO_2$)	a	$b \cdot 10^3$	$c \cdot 10^6$	Stand. error of est. (percent)
57.1	−0.6761	1.1188	0.6003	0.0002 = 0.06
62.1	−0.5564	0.7903	0.8482	0.0002 = 0.07
66.7	−0.3033	−0.0412	1.5498	0.0003 = 0.10
71.0	−0.2396	−0.2497	1.7609	0.0005 = 0.16
75.0	0.3469	−2.1108	3.2616	0.0040 = 1.29
78.8	−0.6129	1.0451	0.7385	0.0005 = 0.14
82.4	−0.7009	1.4493	0.3959	0.0004 = 0.10
88.9	−0.9274	2.1500	0	0.0000
94.7	(−1.4367)	(3.8580)	(−1.2500)	
100	−0.9633	2.4500	0	0.0000

Reference: [126]

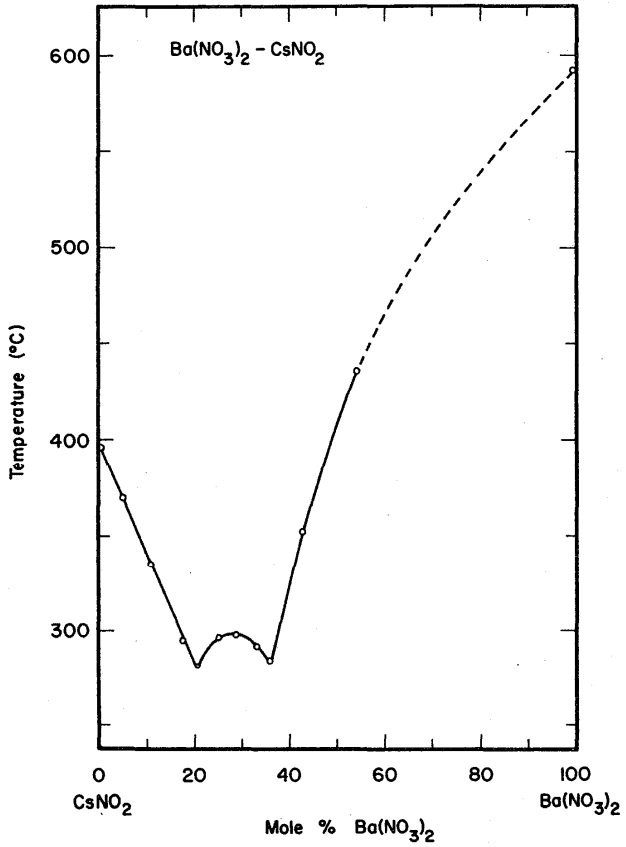

FIGURE 67. Temperature – composition phase diagram for $Ba(NO_3)_2$–$CsNO_2$.

P. I. Protsenko and T. A. Andreeva, Zh. Neorg. Khim. **6**, 1375 (1961).

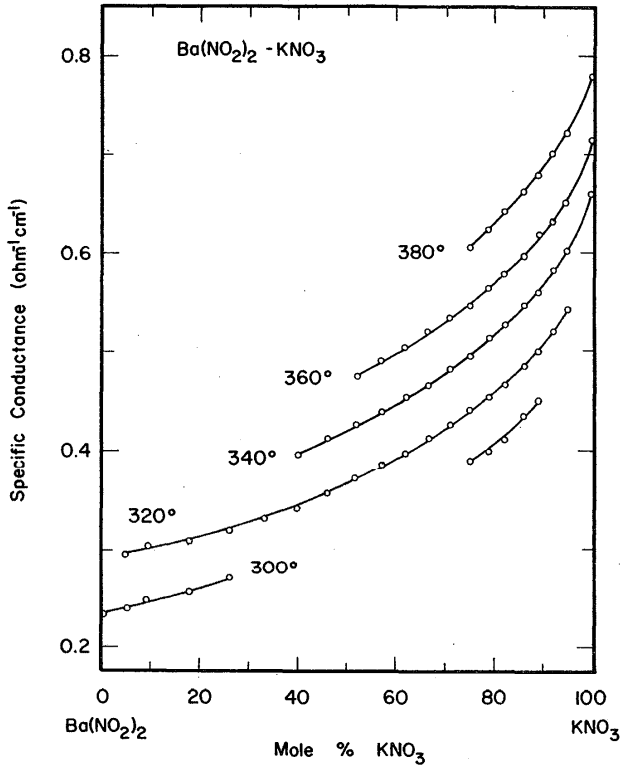

FIGURE 68. Isotherms [23] (°C) of specific conductance against molar composition for the system $Ba(NO_2)_2$–KNO_3.

$Ba(NO_2)_2$–KNO_3

Electrical Conductance

Three studies of the specific conductance of $Ba(NO_2)_2$ and 27 investigations of KNO_3 [1 (p. 26), 9, 23, 24, 29, 82, 89, 90, 94, 100, 107, 116, 117, 121, 122, 129] have been reported. Some experimental aspects of the conductance measurements of $Ba(NO_2)_2$ are discussed in the section on $Ba(NO_2)_2$–$CsNO_2$. Revised recommendations for KNO_3 are based on the work of Robbins and Braunstein [122] and together with some experimental aspects are discussed in the sections on KNO_3–$RbNO_3$ and KNO_3–$NaNO_3$.

Protsenko and Malakhova [23] measured the specific conductance of molten $Ba(NO_2)_2$–KNO_3 mixtures using the classical ac technique. Isotherms of specific conductance against molar composition at five different temperatures between 300 and 380 °C are given in figure 68. Due to the graphical presentation of the results a critical assessment is not possible.

No information is given by Protsenko and Malakhova relative to salt purity and melt preparation.

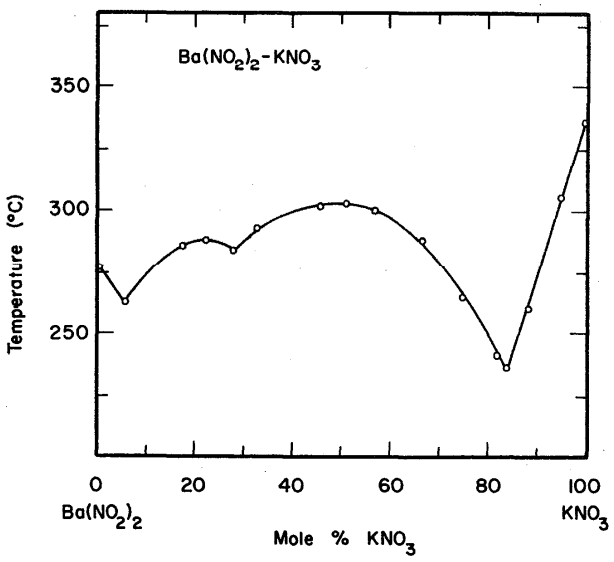

FIGURE 69. Temperature – composition phase diagram for $Ba(NO_2)_2$–KNO_3.

P. I. Protsenko and A. Ya. Malakhova, Zh. Neorg. Khim. **2**, 2145 (1957).

$Ba(NO_3)_2$–KNO_2

Electrical Conductance

$Ba(NO_3)_2$ has not been investigated. Three investigations of the specific conductance of KNO_2 [1 (p. 24), 87, 96] have been reported. Some experimental aspects of the conductance measurements of KNO_2 are discussed in the section on KNO_2–$NaNO_2$.

Protsenko and Malakhova [23] measured the specific conductance of molten $Ba(NO_3)_2$–KNO_2 mixtures using the classical ac technique. Isotherms of specific conductance against molar composition at four different temperatures between 260 and 320 °C are given in figure 70. Due to the graphical presentation of the results a critical assessment is not possible.

No information is given by Protsenko and Malakhova relative to salt purity and melt preparation.

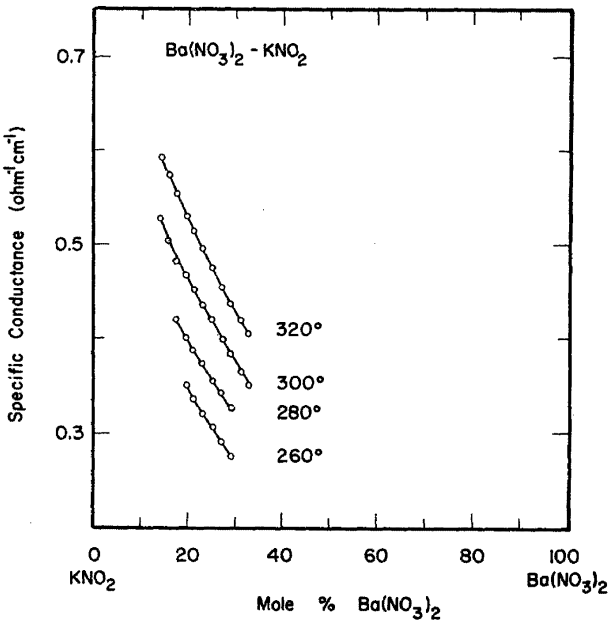

FIGURE 70. Isotherm [23] (°C) of specific conductance against molar composition for the system $Ba(NO_3)_2$–KNO_2.

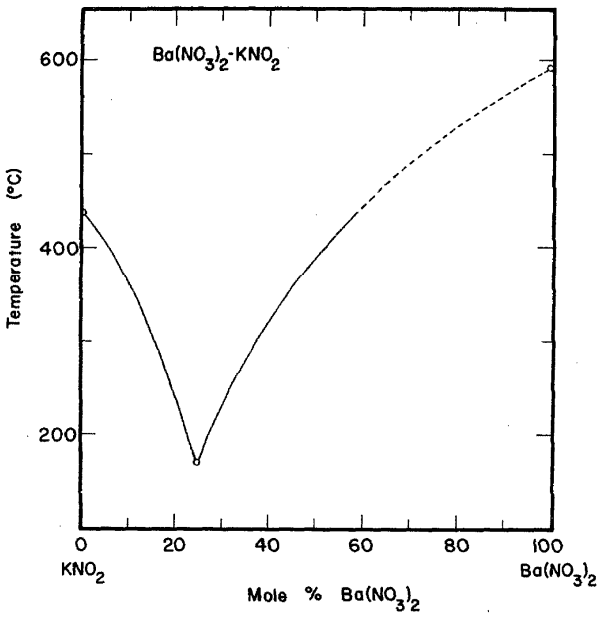

FIGURE 71. Temperature – composition phase diagram for $Ba(NO_3)_2$–KNO_2.

P. I. Protsenko and A. Ya. Malakhova, Zh. Neorg. Khim. **2**, 214 (1957).

$CsNO_2$–$CsNO_3$

Electrical Conductance

Three studies of the specific conductance of $CsNO_2$ [1 (p. 25), 102, 126] and seven investigations of $CsNO_3$ [1 (p. 28), 125, 126, 127, 129] have been reported. Some experimental aspects of the conductance measurements of $CsNO_2$ and $CsNO_3$ are discussed in the sections on $CsNO_2$–$LiNO_2$ and $CsNO_3$–KNO_3, respectively.

Protsenko and Andreeva [126] used the classical ac technique to measure the specific conductance of molten $CsNO_2$–$CsNO_3$ mixtures. Their results for the single components and 10, 20, 30, 40, 50, 60, 70, 80, and 90 mole percent mixtures, covering a temperature range from 675 to 735 K, are given in table 113(a) for the experimental compositions at rounded temperatures. The corresponding temperature-dependent equations are given in table 113(b). The values in brackets for $CsNO_3$ and the mixture containing 90 mole percent $CsNO_3$, indicate that these are based on rather limited data. The experimental uncertainty of the results of Protsenko and Andreeva is estimated to be more than 3 percent. The results for $CsNO_2$ and $CsNO_3$ deviate from the recommendations [1] (−0.75 to −0.42 percent) and (−2.57 to −0.89 percent) respectively.

The melt preparation and experimental technique used by Protsenko and Andreeva is discussed in the section on $Ba(NO_2)_2$–$CsNO_2$.

TABLE 113(a). $CsNO_2$–$CsNO_3$: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

	Mole percent $CsNO_3$										
T(K)	100	90	80	70	60	50	40	30	20	10	0
675			0.563	0.577	0.593	0.609	0.625	0.644	0.656	0.678	0.690
680			0.573	0.588	0.605	0.621	0.637	0.655	0.668	0.690	0.703
685			0.584	0.599	0.617	0.632	0.648	0.667	0.680	0.703	0.715
690			0.595	0.610	0.629	0.644	0.660	0.678	0.692	0.715	0.727
695	(0.537)	(0.583)	0.606	0.621	0.641	0.655	0.672	0.690	0.704	0.727	0.739
700	(0.547)	(0.593)	0.616	0.632	0.652	0.667	0.683	0.701	0.716	0.739	0.752
705	(0.558)	(0.603)	0.627	0.643	0.664	0.678	0.695	0.713	0.728	0.751	0.764
710	(0.568)	(0.614)	0.638	0.654	0.675	0.690	0.706	0.724	0.740	0.763	0.776
715	(0.579)	(0.625)	0.648	0.665	0.687	0.701	0.718	0.736	0.752	0.775	0.788
720	(0.589)	(0.636)	0.659	0.676	0.698	0.713	0.730	0.747	0.764	0.787	0.801
725	(0.600)	(0.647)	0.670	0.687	0.710	0.724	0.741	0.758	0.776	0.799	0.813
730	(0.610)	(0.658)	0.680	0.698	0.721	0.736	0.753	0.770	0.788	0.811	0.825

TABLE 113(b). Temperature-dependent equations

$\kappa = a + bT + cT^2$ (ohm^{-1} cm^{-1})

Comp. (mol % $CsNO_3$)	a	$b \cdot 10^3$	$c \cdot 10^6$	Stand. error of est. (percent)
0	−0.9633	2.4500	0	0.0000
10	−0.9553	2.4200	0	0.0003 = 0.04
20	−0.9637	2.4000	0	0.0000
30	−0.9018	2.2900	0	0.0005 = 0.07
40	−0.9409	2.3200	0	0.0003 = 0.04
50	−0.9434	2.3000	0	0.0000
60	−1.6469	4.2401	−1.3653	0.0003 = 0.05
70	−0.9080	2.2000	0	0.0000
80	−0.8819	2.1400	0	0.0005 = 0.08
90	(0.3592)	(−1.4160)	(2.5000)	
100	(−0.9227)	(2.100)	(0)	

Reference: [126]

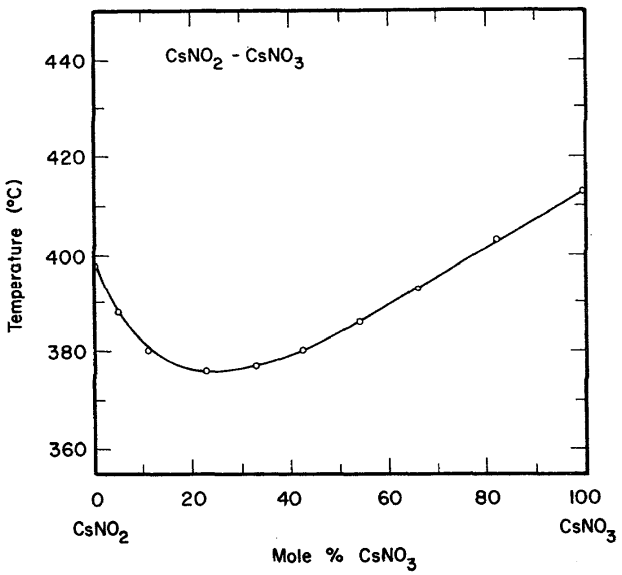

FIGURE 72. Temperature – composition phase diagram for $CsNO_2$–$CsNO_3$.

P. I. Protsenko and T. A. Andreeva, Zh. Neorg. Khim. **6**, 1375 (1961).

$CsNO_2$–$LiNO_3$

Electrical Conductance

Three studies of the specific conductance of $CsNO_2$ [1 (p. 25), 102, 126] and 12 investigations of $LiNO_3$ [1 (p. 25), 24, 29, 73, 79, 117, 120, 129] have been reported. Some experimental aspects of the conductance measurements of $CsNO_2$ and $LiNO_3$ are discussed in the sections on $CsNO_2$–$LiNO_2$ and KNO_3–$LiNO_3$.

Protsenko and Shisholina [108] measured the specific conductance of molten $CsNO_2$–$LiNO_3$ mixtures using the classical ac technique. Their results for 10, 20, 30, 40, 50, 60, 70, 80, and 90 mole percent mixtures, covering a temperature range from 435 to 715 K, are given in table 114, for the experimental compositions and temperatures. A statistical analysis to produce values at rounded temperatures was unsatisfactory.

The experimental technique used by Protsenko and Shisholina is discussed in the section on $CsNO_2$–$LiNO_2$.

TABLE 114. $CsNO_2$–$LiNO_3$: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

Mole percent $LiNO_3$

T(K)	90	80	70	60	50	40	30	20	10
433.2		0.153	0.140	0.125	0.112				
473.2		0.301	0.265	0.251	0.233	0.215			
513.2		0.400	0.369	0.347	0.318	0.298			
553.2	0.708	0.583	0.474	0.435	0.399	0.374	0.361		
593.2	0.875	0.734	0.602	0.525	0.488	0.467	0.455	0.451	
633.2	0.998	0.861	0.750	0.663	0.601	0.574	0.550	0.544	
673.2		0.898	0.824	0.749	0.698	0.668	0.650	0.645	0.663
713.2					0.996	0.831	0.797	0.765	0.763

Reference: [108]

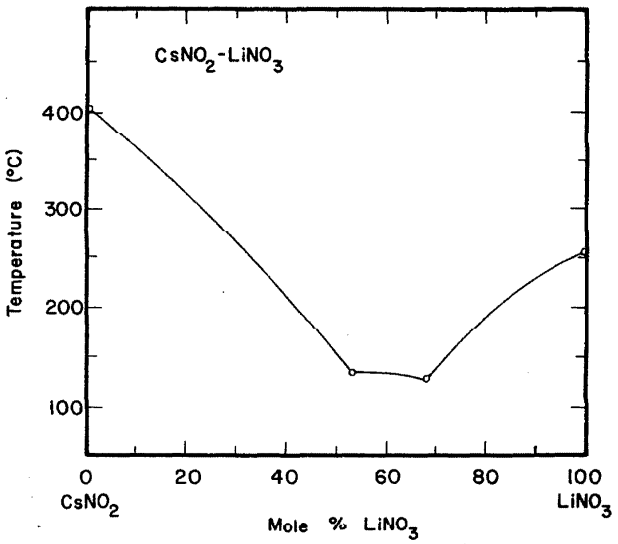

FIGURE 73. Temperature – composition phase diagram for $CsNO_2$–$LiNO_3$.

P. I. Protsenko and R. P. Shisholina, Ukr. Khim. Zh. **30**, 912 (1964).

$CsNO_3$–$LiNO_2$

Electrical Conductance

Seven studies of the specific conductance of $CsNO_3$ [1 (p. 28), 125, 126, 127, 129] and two investigations of $LiNO_2$ [1 (p. 24)] have been reported. Some experimental aspects of the conductance measurements of $CsNO_3$ and $LiNO_2$ are discussed in the sections on $CsNO_3$–KNO_3 and $CsNO_2$–$LiNO_2$.

Protsenko and Shisholina [108] measured the specific conductance of molten $CsNO_3$–$LiNO_2$ mixtures using the classical ac technique. Their results for 10, 20, 30, 40, 50, 60, 70, 80, and 90 mole percent mixtures, covering a temperature range from 415 to 735 K, are given in table 115(a) for the experimental concentrations at rounded temperatures. The corresponding statistical parameters are given in table 115(b). The values in brackets, for the mixtures containing 90 and 10 mole percent $LiNO_2$, indicate that these are based on rather limited data.

The experimental technique used by Protsenko and Shisholina is discussed in the section on $CsNO_2$–$LiNO_2$.

TABLE 115(a). $CsNO_3$–$LiNO_2$: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

Mole percent $LiNO_2$

T(K)	90	80	70	60	50	40	30	20	10
415			0.084	0.084	0.085				
430			0.126	0.119	0.113				
445			0.168	0.153	0.142				
460		0.267	0.210	0.188	0.172				
475		0.326	0.252	0.222	0.202				
490		0.382	0.294	0.257	0.234				
505	(0.588)	0.435	0.336	0.291	0.267	0.265			
520	(0.637)	0.485	0.378	0.326	0.300	0.293			
535		0.531	0.420	0.360	0.335	0.323			
550		0.575	0.462	0.395	0.371	0.354			
565		0.616	0.504	0.429	0.407	0.386			
580				0.464	0.445	0.420	0.410		
595				0.499	0.483	0.456	0.439		
610				0.533	0.523	0.493	0.471		
625					0.563	0.532	0.505	0.485	
640					0.604	0.572	0.542	0.508	
655						0.614	0.581	0.536	
670						0.657	0.622	0.571	
685						0.702	0.665	0.611	
700								0.657	(0.581)
715								0.709	(0.621)
730								0.766	(0.661)

TABLE 115(b). Temperature-dependent equations

$\kappa = a + bT + cT^2$ (ohm^{-1} cm^{-1})

Comp. (mol % $LiNO_2$)	a	$b \cdot 10^3$	$c \cdot 10^6$	Stand. error of est. (percent)
10	(−1.2913)	(2.6750)	(0)	
20	4.6417	−14.6400	12.7822	0.0120 = 2.10
30	1.0490	−4.0929	5.1567	0.0008 = 0.15
40	0.2206	−1.6364	3.4149	**0.0038 = 0.83**
50	−2.9932	0.0313	2.1576	0.0111 = 3.35
60	−0.8713	2.3021	0	0.0050 = 1.61
70	−1.0790	2.8025	0	0.0081 = 2.75
80	−3.0119	10.2214	−6.7264	0.0128 = 2.77
90	(−1.0876)	(3.3000)	(0)	

Reference: [108]

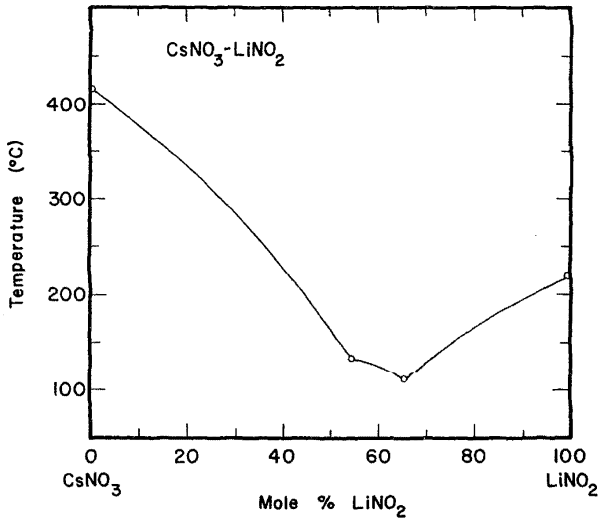

FIGURE 74. Temperature – composition phase diagram for $CsNO_3$–$LiNO_2$.

P. I. Protsenko and R. P. Shisholina, Ukr. Khim. Zh. **30**, 912 (1964).

KNO_2–KNO_3

Density

Two studies of the density of KNO_2 [1 (p. 24), 95] and 19 investigations of KNO_3 [1 (p. 26), 4, 9, 12, 25, 27, 110, 115, 118, 130] have been reported. Some experimental aspects of the density measurements of KNO_2 and KNO_3 are discussed in the sections on KNO_2–$NaNO_2$ and KNO_3–$NaNO_3$, respectively.

The density of molten KNO_2–KNO_3 mixtures has been measured by two groups [91, 95] using the Archimedean method. The results of Polyakov and Beruli [95] for the single components and mixtures containing 30, 35, 40, 45, 50, and 55 mole percent KNO_2, covering a temperature range from 615 to 775 K, are recommended as the "best" values. The results of a two-dimensional statistical analysis of these data are given in table 116(a) as a temperature-composition-density matrix, at rounded compositions and temperatures. The corresponding statistical parameters are given in table 116(b). Due to limited information an uncertainty estimate of the results of Polyakov and Beruli is not possible. The values for

TABLE 116(a). KNO_2–KNO_3: Density

Numerical values (g cm^{-3})

Mole percent KNO_3

T (K)	100	90	80	70	60	50	40	30	20	10	0	77.5
620	1.858	1.849	1.839	1.830	1.821	1.812						1.837
630	1.851	1.841	1.832	1.823	1.814	1.805						1.830
640	1.843	1.834	1.825	1.816	1.807	1.798	1.789					1.823
650	1.836	1.827	1.818	1.809	1.800	1.791	1.782					1.816
660	1.829	1.820	1.811	1.802	1.793	1.784	1.775	1.766				1.809
670	1.822	1.813	1.804	1.795	1.786	1.777	1.768	1.758				1.802
680	1.815	1.806	1.797	1.788	1.779	1.770	1.761	1.751	1.742			1.795
690	1.808	1.799	1.790	1.781	1.772	1.763	1.753	1.744	1.735			1.788
700	1.801	1.792	1.783	1.774	1.765	1.755	1.746	1.737	1.728	1.719		1.781
710	1.794	1.785	1.776	1.767	1.758	1.748	1.739	1.730	1.721	1.712		1.773
720	1.787	1.778	1.769	1.760	1.750	1.741	1.732	1.723	1.714	1.705	1.696	1.766
730	1.780	1.771	1.762	1.752	1.743	1.734	1.725	1.716	1.707	1.698	1.689	1.759
740	1.773	1.764	1.755	1.745	1.736	1.727	1.718	1.709	1.700	1.691	1.682	1.752
750	1.766	1.757	1.747	1.738	1.729	1.720	1.711	1.702	1.693	1.684	1.675	1.745
760	1.759	1.749	1.740	1.731	1.722	1.713	1.704	1.695	1.686	1.677	1.667	1.738
770	1.752	1.742	1.733	1.724	1.715	1.706	1.697	1.688	1.679	1.669	1.660	1.731

TABLE 116(b). Two-dimensional equation and statistical parameters

$\rho = a + bT + cC$ (g cm^{-3})

a	$b \cdot 10^4$	$c \cdot 10^4$	Max. percent departure	Stand. error of est.
2.29629	−7.07498	−9.11455	−0.27% (713.2 K, 100 mol % KNO_2)	0.002 (0.11%)

Reference: [95]

C = mole percent KNO_2

KNO_2 and KNO_3 agree with the recommendations [1] to within −0.02 to 0.05 percent and −0.36 to −0.13 percent respectively. Protsenko and Malakhova [91] measured the density of the single components and 18 different mixtures (5 to 90 mole percent KNO_2) in the temperature range from 615 to 735 K. Their results deviate from the values of Polyakov and Beruli (−0.05 to 0.06 percent, KNO_3; 0.14 to 0.22 percent, 30 mole percent KNO_2; 0.18 to 0.29 percent, 35 mole percent KNO_2; 0.14 to 0.19 percent, 40 mole percent KNO_2; 0.06 to 0.11 percent, 45 mole percent KNO_2; −0.05 to 0.04 percent, 50 mole percent KNO_2; −0.21 to 0 percent, 55 mole percent KNO_2; −0.03 to 0.05 percent, KNO_2).

No information is given by Polyakov and Beruli relative to salt purity and melt preparation.

Surface Tension

One investigation of the surface tension of KNO_2 [2 (p. 70)] and eight investigations of the surface tension of KNO_3 [2 (p. 67), 41, 84] have been reported.

Bloom, Davies and James [5] used the maximum bubble pressure technique to measure the surface tension of molten KNO_2–KNO_3 mixtures, in the temperature range (605–860 K), for 20, 40, 60, and 80 mole percent KNO_2, and for pure KNO_3. The results of a two-dimensional statistical analysis of these data are given in table 117(a) as a temperature-composition-surface tension matrix, at rounded temperatures. The corresponding statistical parameters are given in table 117(b).

The experimental aspects of the investigation of Bloom, Davies and James [5] have been discussed previously [2 (p. 63)].

Data by Protsenko and Gurvich [141] for 10, 20, 30, 40, 50, 60, 70, 80, 90, and 100 mole percent KNO_2 using the maximum bubble pressure method have recently been reported.

TABLE 117(a). KNO_2–KNO_3: Surface tension

Numerical values (dyn cm^{-1})

	Mole percent KNO_3									
T(K)	100	90	80	70	60	50	40	30	20	77.5
605							112.5	113.4	114.4	
620						111.1	111.8	112.6	113.6	
635					109.7	110.3	111.0	111.8	112.9	
650					108.9	109.5	110.2	111.0	112.1	
665				107.6	108.1	108.7	109.4	110.3	111.3	
680			106.1	106.7	107.3	107.9	108.6	109.5	110.5	106.3
695	103.8	104.6	105.3	105.9	106.5	107.1	107.8	108.7	109.7	105.4
710	102.9	103.7	104.4	105.1	105.7	106.3	107.1	107.9	109.0	104.6
725	101.9	102.8	103.6	104.2	104.9	105.5	106.3	107.1	108.2	103.7
740	101.0	101.9	102.7	103.4	104.1	104.8	105.5	106.4	107.4	102.9
755	100.1	101.0	101.8	102.6	103.3	104.0	104.7	105.6	106.6	102.0
770	99.1	100.1	101.0	101.7	102.5	103.2	103.9	104.8	105.8	101.2
785	98.2	99.2	100.1	100.9	101.6	102.4	103.2	104.0	105.0	100.3
800	97.3	98.3	99.3	100.1	100.8	101.6	102.4	103.2	104.3	99.5
815	96.3	97.4	98.4	99.2	100.0	100.8	101.6	102.5	103.5	98.6
830	95.4	96.5	97.5	98.4	99.2	100.0	100.8	101.7	102.7	97.8
845	94.4	95.6	96.7	97.6	98.4	99.2	100.0	100.9	101.9	96.9
860	93.5	94.8	95.8	96.7	97.6	98.4	99.2	100.1	101.1	96.1

TABLE 117(b). Two-dimensional equation and statistical parameters

$\gamma = a + bT + cC + dC^2 + eC^3 + fTC + gTC^2$ (dyn cm^{-1})

a	$b \cdot 10^2$	$c \cdot 10$	$d \cdot 10^4$	$e \cdot 10^6$	$f \cdot 10^4$	$g \cdot 10^6$	Max. percent departure	Stand. error of est.
147.27202	−6.25138	−1.23422	6.98025	8.06743	3.00452	−2.13986	0.87% (638 K; 40 mol % KNO_2)	0.579 (0.56%)

Reference: [1]

C = mole percent KNO_2

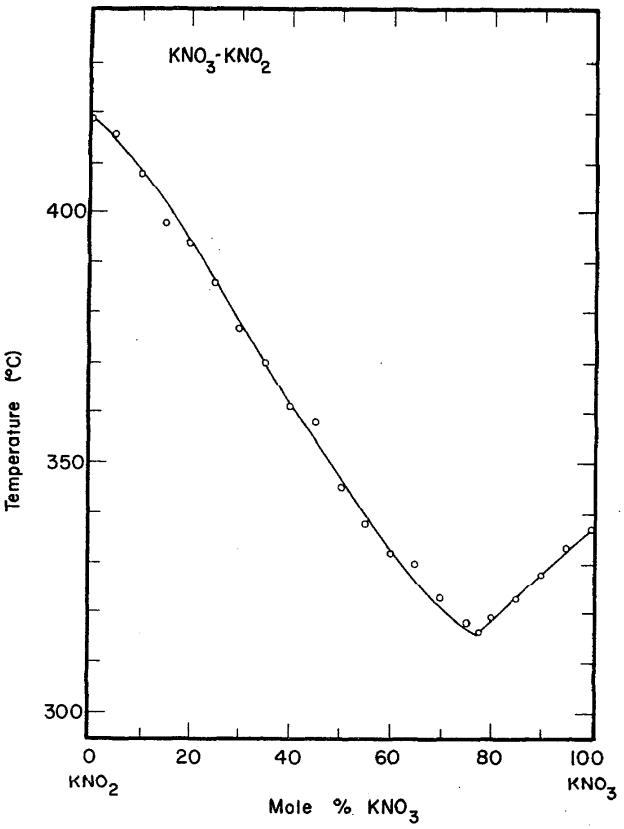

FIGURE 75. Temperature – composition phase diagram for KNO_2–KNO_3.

S. I. Beruli and A. G. Bergman, Izv. Sekt. Fiz. Khim. A. **21**, 172 (1952).

KNO_2–$NaNO_3$

Density

Two studies of the density of KNO_2 [1 (p. 24), 95] and 16 investigations of $NaNO_3$ [1 (p. 26), 9, 12, 25, 27, 71, 86, 95, 97, 115, 117, 118, 130] have been reported. Some experimental aspects of the density measurements of KNO_2 are discussed in the section on KNO_2–$NaNO_2$. Revised recommendations for $NaNO_3$ are based on the work of McAuley, Rhodes and Ubbelohde [25] and together with some experimental aspects are discussed in the section on $NaNO_3$–$RbNO_3$.

Polyakov and Beruli [95] used the Archimedean method to measure the density of molten KNO_2–$NaNO_3$ mixtures, in the temperature range from 475 to 775 K for 15, 25, 35, 45, 50, 55, 65, 75, and 85 mole percent mixtures and the single components. The results were recalculated using a two-dimensional statistical analysis; the values in the form of a temperature-composition-density matrix are in table 118(a) at rounded compositions and temperatures. The corresponding statistical parameters are given in table 118(b). Due to the limited information an uncertainty estimate of the results of Polyakov and Beruli is not possible. The values for KNO_2 agree with the recommendations [1] to within −0.02 to 0.05 percent, whereas the results for $NaNO_3$ deviate from the newly recommended values [25] (0.79 to 1.44 percent) and from the recommendations [1] (−0.10 to 0.55 percent).

No information is given by Polyakov and Beruli relative to salt purity and melt preparation.

TABLE 110(a). KNO_2 $NaNO_3$: Density

Numerical values (g cm^{-3})

Mole percent $NaNO_3$

T(K)	100	90	80	70	60	50	40	30	20	10	0	52
475					1.933	1.920						1.923
490					1.923	1.910	1.897					1.913
505				1.927	1.913	1.900	1.887					1.903
520				1.917	1.903	1.890	1.877					1.893
535			1.920	1.907	1.893	1.880	1.866	1.853				1.883
550			1.910	1.897	1.883	1.870	1.856	1.843				1.873
565		1.914	1.900	1.887	1.873	1.860	1.846	1.833				1.862
580		1.903	1.890	1.877	1.863	1.850	1.836	1.823	1.809			1.852
595	1.907	1.893	1.880	1.867	1.853	1.840	1.826	1.813	1.799			1.842
610	1.897	1.883	1.870	1.857	1.843	1.830	1.816	1.803	1.789			1.832
625	1.887	1.873	1.860	1.846	1.833	1.820	1.806	1.793	1.779			1.822
640	1.877	1.863	1.850	1.836	1.823	1.810	1.796	1.783	1.769	1.756		1.812
655	1.867	1.853	1.840	1.826	1.813	1.800	1.786	1.773	1.759	1.746		1.802
670	1.857	1.843	1.830	1.816	1.803	1.789	1.776	1.763	1.749	1.736		1.792
685	1.847	1.833	1.820	1.806	1.793	1.779	1.766	1.753	1.739	1.726		1.782
700	1.837	1.823	1.810	1.796	1.783	1.769	1.756	1.742	1.729	1.716		1.772
715	1.826	1.813	1.800	1.786	1.773	1.759	1.746	1.732	1.719	1.706	1.692	1.762
730	1.816	1.803	1.790	1.776	1.763	1.749	1.736	1.722	1.709	1.696	1.682	1.752
745	1.806	1.793	1.779	1.766	1.753	1.739	1.726	1.712	1.699	1.685	1.672	1.742
760	1.796	1.783	1.769	1.756	1.743	1.729	1.716	1.702	1.689	1.675	1.662	1.732

TABLE 118(b). Two-dimensional equation and statistical parameters

$\rho = a + bT + cC$ (g cm^{-3})

a	$b \cdot 10^4$	$c \cdot 10^3$	Max. percent departure	Stand. error of est.
2.30556	− 6.70079	− 1.34308	−0.74% (593.2 K, 100 mol % $NaNO_3$)	0.004 (0.22%)

Reference: [95]
C = mole percent KNO_2

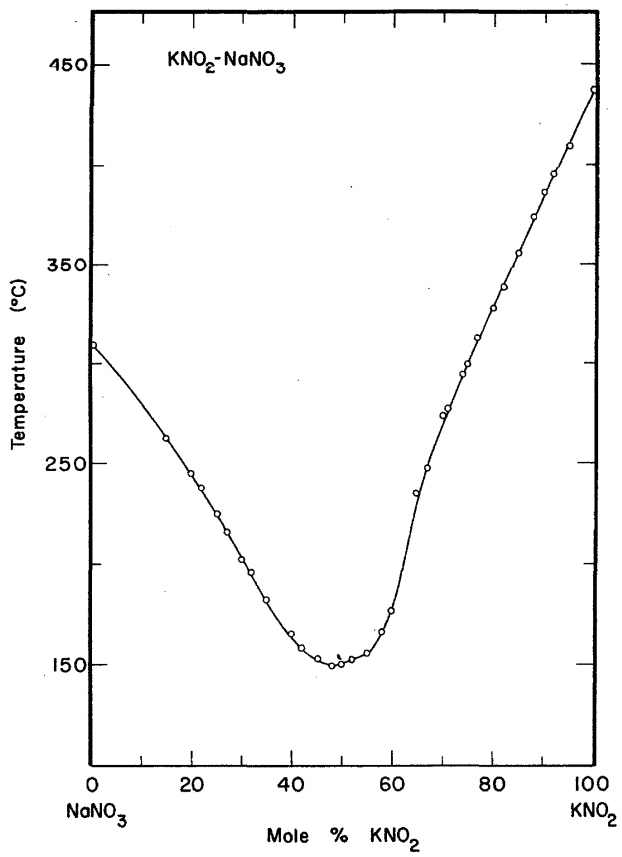

FIGURE 76. Temperature – composition phase diagram for KNO_2–$NaNO_3$.

S. I. Beruli and A. G. Bergman, Izv. Sekt. Fiz. Khim. A. 25, 218 (1954).

KNO_3–$NaNO_2$

Electrical Conductance

Twenty-seven studies of the specific conductance of KNO_3 [1 (p. 26), 9, 23, 24, 29, 82, 89, 90, 94, 100, 107, 116, 117, 121, 122, 129] and seven investigations of $NaNO_2$ [1 (p. 24), 89, 94, 96, 102] have been reported. Revised recommendations for KNO_3 are based on the work of Robbins and Braunstein [122] and together with some experimental aspects are discussed in the sections on KNO_3–$RbNO_3$ and KNO_3–$NaNO_3$. Some experimental aspects of the conductance measurements of $NaNO_2$ are discussed in the section on KNO_2–$NaNO_2$.

Sakai and Hayaski [137] used a quartz capillary conductance cell to measure the specific conductance of molten KNO_3–$NaNO_2$ mixtures. Isotherms of specific conductance against molar composition at four different temperatures are given in figure 77. Due to the graphical presentation of the results a critical assessment is not possible.

Density

Nineteen studies of the density of KNO_3 [1 (p. 26), 4, 9, 12, 25, 27, 110, 115, 118, 130] and three investigations of $NaNO_2$ [1 (p. 24), 184] have been reported. Some experimental aspects of the density measurements of KNO_3 and $NaNO_2$ are discussed in the sections on KNO_3–$NaNO_3$ and KNO_2–$NaNO_2$, respectively.

Polyakov and Beruli [95] used the Archimedean method to measure the density of molten KNO_3–$NaNO_2$ mixtures, in the temperature range from 355 to 775 K for the single components and mixtures containing 15, 25, 35, 50, 55, 65, 75, and 85 mole percent KNO_3. The results were recalculated using two-dimensional statistical analysis; the values in the form of a temperature-composition-density matrix are in table 119(a) at rounded compositions and temperatures. The corresponding statistical parameters are given in table 119 (b). Due to the limited information an uncertainty estimate of the results of Polyakov and Beruli is not possible. The values for KNO_3 and $NaNO_2$ deviate from the recommendations [1] (−0.36 to −0.13 percent) and (−1.02 to 0.30 percent) respectively.

No information is given by Polyakov and Beruli relative to salt purity and melt preparation.

TABLE 119(a). KNO_3–$NaNO_2$: Density

Numerical values (g cm^{-3})

	Mole percent $NaNO_2$											
T (K)	100	90	80	70	60	50	40	30	20	10	0	52.5
460					1.911	1.922	1.933					1.919
475				1.890	1.901	1.912	1.923	1.932				1.910
490				1.880	1.892	1.902	1.913	1.922				1.900
505			1.859	1.871	1.882	1.892	1.903	1.912				1.890
520			1.849	1.861	1.872	1.882	1.893	1.902	1.911			1.880
535		1.828	1.839	1.851	1.862	1.873	1.883	1.892	1.901			1.870
550		1.818	1.829	1.841	1.852	1.863	1.872	1.882	1.891			1.860
565		1.808	1.820	1.831	1.842	1.853	1.862	1.872	1.880			1.850
580	1.786	1.798	1.810	1.821	1.832	1.843	1.852	1.862	1.870	1.878		1.840
595	1.776	1.788	1.800	1.812	1.823	1.833	1.842	1.851	1.860	1.868		1.830
610	1.766	1.778	1.790	1.802	1.813	1.823	1.832	1.841	1.850	1.857		1.820
625	1.756	1.769	1.781	1.792	1 803	1.813	1.822	1.831	1.839	1.847	1.854	1.810
640	1.746	1.759	1.771	1.782	1.793	1.803	1.812	1.821	1.829	1.837	1.843	1.801
655	1.736	1.749	1.761	1.772	1.783	1.793	1.802	1.811	1.819	1.826	1.833	1.791
670	1.727	1.739	1.751	1.763	1.773	1.783	1.792	1.801	1.809	1.816	1.822	1.781
685	1.717	1.730	1.742	1.753	1.763	1.773	1.782	1.791	1.798	1.805	1.812	1.771
700	1.707	1.720	1.732	1.743	1.753	1.763	1.772	1.781	1.788	1.795	1.801	1.761
715	1.697	1.710	1.722	1.733	1.744	1.753	1.762	1.770	1.778	1.785	1.791	1.751
730	1.688	1.700	1.712	1.723	1.734	1.743	1.752	1.760	1.768	1.774	1.780	1.741
745	1.678	1.691	1.702	1.713	1.724	1.733	1.742	1.750	1.757	1.764	1.770	1.731
760	1.668	1.681	1.693	1.704	1.714	1.723	1.732	1.740	1.747	1.754	1.759	1.721

TABLE 119(b). Two-dimensional equation and statistical parameters

$\rho = a + bT + cC + dTC^2$ (g cm^{-3})

a	$b \cdot 10^4$	$c \cdot 10^3$	$d \cdot 10^9$	Max. percent departure	Stand. error of est.
2.16190	−6.49654	1.30161	−5.15053	0.34% (553.2 K, 85 mol % KNO_3)	0.002 (0.11%)

Reference: [95]

C = mole percent KNO_3

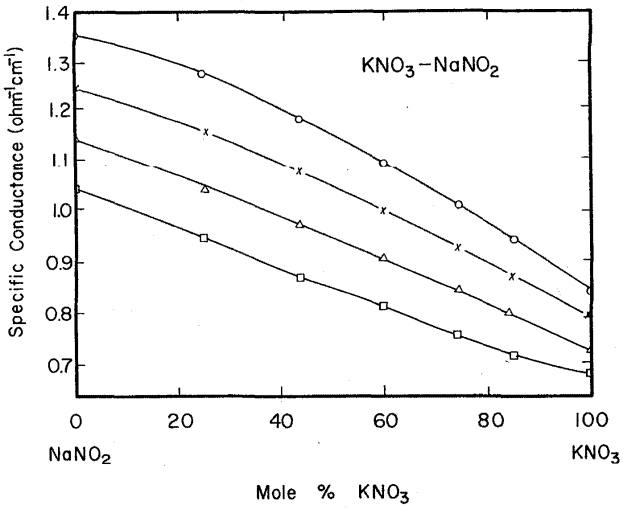

FIGURE 77. Isotherms [137] (°C) of specific conductance against molar composition for the system KNO_3–$NaNO_2$.

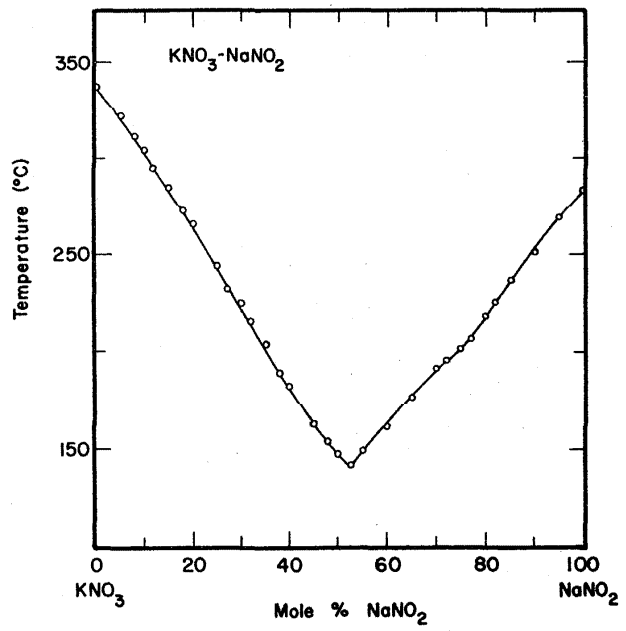

FIGURE 77a. Temperature–composition phase diagram for KNO_3–$NaNO_2$.

A. I. Beruli and A. G. Bergman, Izv. Sekt. Fiz. Khim. A. **25**, 218 (1954).

$LiNO_2$–$NaNO_3$

Electrical Conductance

Two studies of the specific conductance of $LiNO_2$ [1 (p. 24)] and 26 investigations of $NaNO_3$ [1 (p. 25), 9, 21, 24, 29, 75, 83, 89, 100, 104, 111, 112, 117, 120, 125, 128, 129] have been reported. Some experimental aspects of the conductance measurements of $LiNO_2$ and $NaNO_3$ are discussed in the sections on $CsNO_2$–$LiNO_2$ and KNO_3–$NaNO_3$, respectively.

Protsenko and Shisholina [94] measured the specific conductance of molten $LiNO_2$–$NaNO_3$ mixtures using the classical ac technique. Isotherms of specific conductance against molar composition at 11 different temperatures between 160 and 360°C are given in figure 78. Due to the graphical presentation of the results a critical assessment is not possible.

The experimental technique used by Protsenko and Shisholina is discussed in the section on $LiNO_2$–$NaNO_2$. No information is given relative to melt preparation.

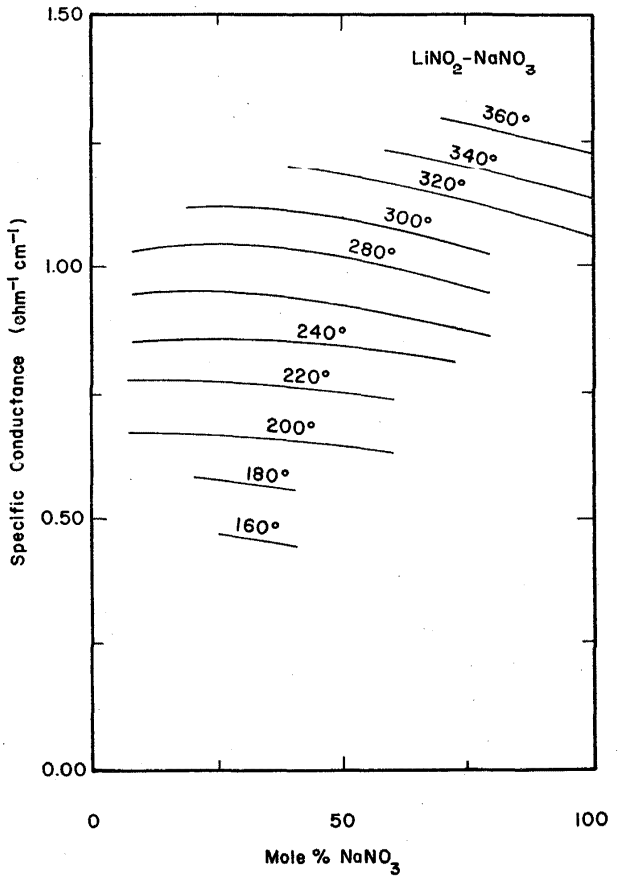

FIGURE 78. Isotherms [94] (°C) of specific conductance against molar composition for the system $LiNO_3$–$NaNO_3$.

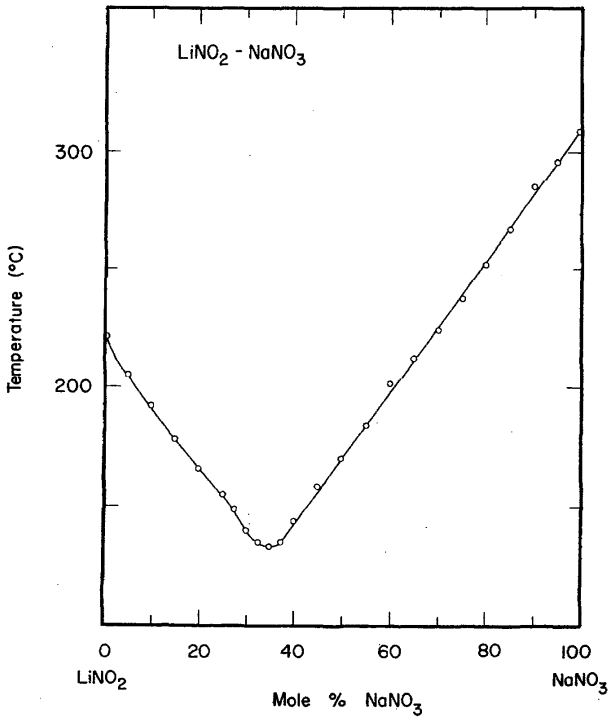

FIGURE 79. Temperature—composition phase diagram for $LiNO_2$–$NaNO_3$.

R. P. Shisholina and P. I. Protsenko, Zh. Neorg. Khim. **8**, 2741 (1963).

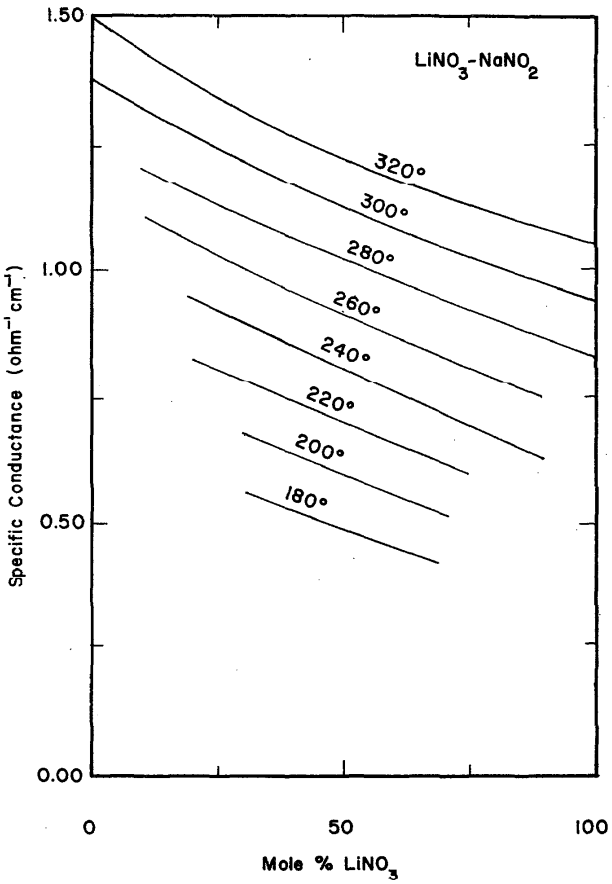

FIGURE 80. Isotherms [94] (°C) of specific conductance against molar composition for the system $LiNO_3$–$NaNO_2$.

$LiNO_3$–$NaNO_2$

Electrical Conductance

Twelve studies of the specific conductance of $LiNO_3$ [1 (p. 25), 24, 29, 73, 79, 117, 120, 129] and seven investigations of $NaNO_2$ [1 (p. 24), 89, 94, 96, 102] have been reported. Some experimental aspects of the conductance measurements of $LiNO_3$ and $NaNO_2$ are discussed in the sections on KNO_3–$LiNO_3$ and KNO_2–$NaNO_2$, respectively.

Protsenko and Shisholina [94] measured the specific conductance of molten $LiNO_3$–$NaNO_2$ mixtures using the classical ac technique. Isotherms of specific conductance against molar composition at eight different temperatures between 180 and 320 °C are given in figure 80. Due to the graphical presentation of the results a critical assessment is not possible.

The experimental technique used by Protsenko and Shisholina is discussed in the section on $LiNO_2$–$NaNO_2$. No information is given relative to melt preparation.

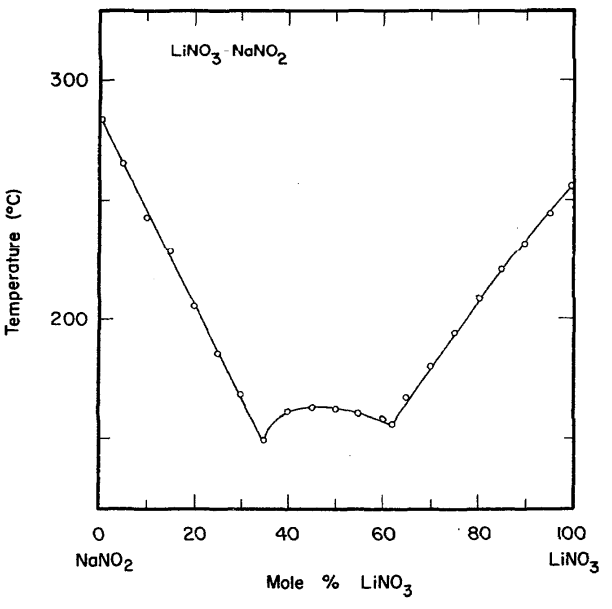

FIGURE 81. Temperature—composition phase diagram for $LiNO_3$–$NaNO_2$.

R. P. Shisholina and P. I. Protsenko, Zh. Neorg. Khim. **8**, 2741 (1963).

$NaNO_2$–$NaNO_3$

Electrical Conductance

Seven studies of the specific conductance of $NaNO_2$ [1 (p. 24), 89, 94, 96, 102] and 26 investigations of $NaNO_3$ [1 (p. 25), 9, 21, 24, 29, 75, 83, 89, 100, 104, 111, 112, 117, 120, 125, 128, 129] have been reported. Some experimental aspects of the conductance measurements of $NaNO_2$ and $NaNO_3$ are discussed in the sections on KNO_2–$NaNO_2$ and KNO_3–$NaNO_3$.

Bloom, Knaggs, Molloy and Welch [36] measured the specific conductance of molten $NaNO_2$–$NaNO_3$ mixtures using the classical ac technique. Their results for the single components and mixtures containing 7.5, 15, 30, 50, 75, and 80 mole percent $NaNO_3$, covering a temperature range from the melting point of the mixtures up to 725 K, are given in table 120(a) for the experimental compositions at rounded temperatures. These were derived from the temperature-dependent equations reported by Bloom, Knaggs, Molloy and Welch and listed in table 120(b). The experimental uncertainty of the results of Bloom, Knaggs, Molloy and Welch is estimated to be more than 3 percent. The results for $NaNO_3$ deviate from the recommendations [1] (−7.6 to −5.3 percent).

Bloom, Knaggs, Molloy and Welch used either silica or B.T.H. glass as cell material, and the salts used had a purity of not less than 99.8 percent.

TABLE 120(a). $NaNO_2$–$NaNO_3$: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

Mole percent $NaNO_3$.

T(K)	100	80.0	75.0	50.0	30.0	15.0	7.5	0
520				0.887	0.950			
530				0.931	0.997			
540				0.974	1.044			
550				1.019	1.091	1.136		
560			0.988	1.063	1.139	1.185	1.242	
570		0.993	1.032	1.108	1.187	1.236	1.294	1.329
580		1.037	1.076	1.153	1.236	1.286	1.347	1.383
590		1.081	1.121	1.198	1.284	1.337	1.400	1.437
600	0.978	1.126	1.165	1.244	1.333	1.388	1.454	1.491
610	1.021	1.171	1.210	1.290	1.382	1.439	1.507	1.545
620	1.065	1.217	1.255	1.335	1.431	1.490	1.561	1.600
630	1.108	1.262	1.301	1.381	1.480	1.541	1.615	1.654
640	1.152	1.308	1.346	1.427	1.529	1.593	1.669	1.709
650	1.197	1.354	1.391	1.473	1.578	1.644	1.723	1.763
660	1.241	1.401	1.437	1.519	1.628	1.696	1.777	1.818
670	1.286	1.447	1.483	1.565	1.677	1.747	1.831	1.872
680	1.331	1.493	1.529	1.611	1.726	1.799	1.885	1.927
690	1.377	1.540	1.574	1.657	1.775	1.850	1.939	1.981
700	1.422	1.586	1.620	1.703	1.824	1.902	1.992	2.036
710	1.468	1.633	1.666	1.749	1.873	1.953	2.046	2.090
720	1.513	1.680	1.712	1.794	1.922	2.004	2.100	2.144

TABLE 120(b). Temperature-dependent equations

$\kappa = A \cdot \exp(-E/RT)$ (ohm^{-1} cm^{-1})

Comp. (mol % $NaNO_3$)	A	E (cal mol^{-1})
0	13.2	2600
7.5	13.2	2640
15.0	12.6	2630
30.0	12.0	2620
50.0	11.2	2620
75.0	11.7	2750
80.0	12.4	2860
100	13.4	3120

Reference: [36]

Density

Three studies of the density of $NaNO_2$ [1 (p. 24), 95] and 16 investigations of $NaNO_3$ [1 (p. 26), 9, 12, 25, 27, 71, 86, 95, 97, 115, 117, 118, 130] have been reported. Some experimental aspects of the density measurements of $NaNO_2$ are discussed in the section on KNO_2–$NaNO_2$. Revised recommendations for $NaNO_3$ are based on the work of McAuley, Rhodes and Ubbelohde [25] and together with some experimental aspects are discussed in the section on $NaNO_3$–$RbNO_3$.

The density of molten $NaNO_2$–$NaNO_3$ mixtures has been measured by two groups [36, 95] using the Archimedean method. The results of Polyakov and Beruli [95] for the single components and mixtures containing 25, 35, 40, 50, 55, 60, 65, 75 mole percent $NaNO_2$, covering a temperature range from 495 to 775 K, are recommended as the "best" values. The results of a two-dimensional statistical analysis of these data are given in table 121(a) as a temperature-composition-density matrix, at rounded compositions and temperatures. The corresponding statistical parameters are given in table 121(b). Due to the limited information an uncertainty estimate of the results of Polyakov and Beruli is not possible. The values for $NaNO_3$ deviate from the newly recommended results [25] (0.79 to 1.44 percent) and from the recommendations [1] (−0.10 to 0.55 percent), whereas the results for $NaNO_2$ agree with the recommendations [1] to within −1.02 to 0.30 percent. Bloom, Knaggs, Molloy and Welch [36] measured the density of the single components and mixtures containing 20, 25, 50, 70, 85, and 92.5 mole percent $NaNO_2$ in the temperature range from the melting point to 725 K. Their results deviate from the values of Polyakov and Beruli (−0.45 to 0.64 percent, $NaNO_2$; 1.35 to 2.30 percent, 50 mole percent $NaNO_2$; −0.38 to 0.38 percent, 25 mole percent $NaNO_2$; 0.21 to 0.76 percent, $NaNO_3$).

No information is given by Polyakov and Beruli relative to salt purity and melt preparation.

Surface Tension

Three investigations of the surface tension of $NaNO_2$ [2 (p. 70)] and eight investigations of $NaNO_3$ [2 (p. 67), 41, 92] have been reported.

Bloom, Davies and James [5] used the maximum bubble pressure technique to measure the surface tension of molten $NaNO_2$–$NaNO_3$ mixtures, in the

temperature range (515–770 K), for 20, 40, 60, and 80 mole percent $NaNO_2$ and for the single components. The results of a two-dimensional statistical analysis of these data are given in table 122(a) as a temperature-composition-surface tension matrix at rounded temperatures. The corresponding statistical parameters are given in table 122(b).

The experimental aspects of the investigation of Bloom, Davies and James [5] have been discussed previously [2 (p. 63)]. Data by Protsenko and Gurvich [141] for 10, 20, 30, 40, 50, 60, 70, 80, 90, and 100 mole percent $NaNO_2$ using the maximum bubble pressure method have recently been reported.

TABLE 121(a). $NaNO_2$–$NaNO_3$: Density

Numerical values (g cm^{-3})

Mole percent $NaNO_3$

T(K)	100	90	80	70	60	50	40	30	20	10	0	32.5
505					1.901	1.889						
520					1.892	1.880	1.868					
535				1.894	1.882	1.870	1.859					
550				1.885	1.873	1.861	1.849					
565			1.888	1.876	1.864	1.852	1.840	1.828				1.831
580		1.890	1.878	1.866	1.854	1.842	1.830	1.818	1.806	1.794	1.783	1.821
595	1.893	1.881	1.869	1.857	1.845	1.833	1.821	1.809	1.797	1.785	1.773	1.812
610	1.883	1.871	1.859	1.847	1.835	1.824	1.812	1.800	1.788	1.776	1.764	1.803
625	1.874	1.862	1.850	1.838	1.826	1.814	1.802	1.790	1.778	1.766	1.754	1.793
640	1.864	1.853	1.841	1.829	1.817	1.805	1.793	1.781	1.769	1.757	1.745	1.784
655	1.855	1.843	1.831	1.819	1.807	1.795	1.783	1.771	1.760	1.748	1.736	1.774
670	1.846	1.834	1.822	1.810	1.798	1.786	1.774	1.762	1.750	1.738	1.725	1.765
685	1.836	1.824	1.812	1.801	1.789	1.777	1.765	1.653	1.741	1.729	1.717	1.756
700	1.827	1.815	1.803	1.791	1.779	1.767	1.755	1.743	1.731	1.719	1.708	1.746
715	1.818	1.806	1.794	1.782	1.770	1.758	1.746	1.734	1.722	1.710	1.698	1.737
730	1.808	1.796	1.784	1.772	1.760	1.748	1.737	1.725	1.713	1.701	1.689	1.728
745	1.799	1.787	1.775	1.763	1.751	1.739	1.727	1.715	1.703	1.691	1.679	1.718
760	1.789	1.777	1.766	1.754	1.742	1.730	1.718	1.706	1.694	1.682	1.670	1.709

TABLE 121(b). Two-dimensional equation and statistical parameters

$\rho = a + bT + cC$ (g cm^{-3})

a	$b \cdot 10^4$	$c \cdot 10^3$	Max. percent departure	Stand. error of est.
2.26498	−6.25760	−1.19446	0.58% (553.2 K, 25 mol % $NaNO_2$)	0.004 (0.22%)

Reference: [95]

C = mole percent $NaNO_2$

TABLE 122(a). $NaNO_2$–$NaNO_3$: Surface tension

Numerical values (dyn cm^{-1})

Mole percent $NaNO_3$

T (K)	100	90	80	70	60	50	40	30	20	10	0	32.5
515				119.8	119.4	119.1						
530			119.7	119.2	118.8	118.5	118.3					
545		119.6	119.1	118.7	118.3	117.9	117.7	117.5				117.6
560		119.1	118.6	118.1	117.7	117.4	117.1	116.9	116.9			117.0
575	119.1	118.6	118.1	117.6	117.2	116.8	116.5	116.3	116.3	116.3		116.4
590	118.6	118.1	117.6	117.1	116.6	116.2	116.0	115.8	115.7	115.7	115.9	115.8
605	118.1	117.6	117.1	116.5	116.1	115.7	115.4	115.2	115.1	115.1	115.3	115.2
620	117.7	117.1	116.5	116.0	115.6	115.2	114.8	114.6	114.5	114.5	114.7	114.7
635	117.2	116.6	116.1	115.5	115.0	114.6	114.3	114.0	113.9	113.9	114.1	114.1
650	116.7	116.1	115.6	115.0	114.5	114.1	113.7	113.5	113.3	113.3	113.5	113.5
665	116.3	115.7	115.1	114.5	114.0	113.6	113.2	112.9	112.8	112.8	112.9	113.0
680	115.8	115.2	114.6	114.0	113.5	113.0	112.7	112.4	112.2	112.2	112.3	112.4
695	115.4	114.7	114.1	113.5	113.0	112.5	112.1	111.8	111.7	111.6	111.7	111.9
710	114.9	114.3	113.7			112.0	111.6	111.3	111.1	111.1	111.1	111.4
725	114.5	113.8						110.8	110.6	110.5	110.6	
740	114.1								110.0	109.9	110.0	
755	113.7									109.4	109.4	
770											108.9	

TABLE 122(b). Two-dimensional equation and statistical parameters

$\gamma = a + bT + cT^2 + dC^3 + eTC$ (dyn cm^{-1})

a	$b \cdot 10^2$	$c \cdot 10^5$	$d \cdot 10^6$	$e \cdot 10^5$	Max. percent departure	Stand. error of est.
142.36398	−4.81341	1.34004	2.76423	−9.24499	−0.41% (543 K; 20 mol % $NaNO_2$	0.192 (0.17%)

Reference: [5]

C = mole percent $NaNO_2$

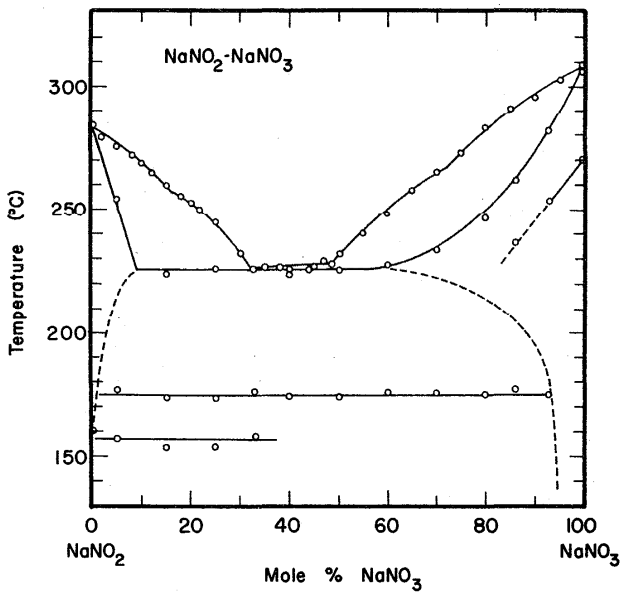

FIGURE 82. Temperature–composition phase diagram for $NaNO_2$–$NaNO_3$.

A. G. Bergman, S. I. Beruli, and I. N. Nikonova, Izv. Sekt. Fiz. Khim. A. **23**, 183 (1953).

$NaNO_2$–$TlNO_3$

Electrical Conductance

Seven studies of the specific conductance of $NaNO_2$ [1 (p. 24), 89, 94, 96, 102] and 17 investigations of $TlNO_3$ [1 (p. 28), 24, 27, 74, 89, 103, 104, 112, 117, 121] have been reported. Some experimental aspects of the conductance measurements of $NaNO_2$ and $TlNO_3$ are discussed in the sections on KNO_2–$NaNO_2$ and $NaNO_3$–$TlNO_3$, respectively.

Protsenko and Gabitova [89] used the classical ac technique to measure the specific conductance of molten $NaNO_2$–$TlNO_3$ mixtures. Isotherms of specific conductance against molar composition at seven different temperatures between 180 and 300 °C are given in figure 83. It should be noted that the scale of the ordinate in figure 84 as reported by Protsenko and Gabitova, is inconsistent. Due to the graphical presentation of the results a critical assessment is not possible.

The melt preparation used by Protsenko and Gabitova is discussed in the section on $NaNO_2$–$TlNO_2$.

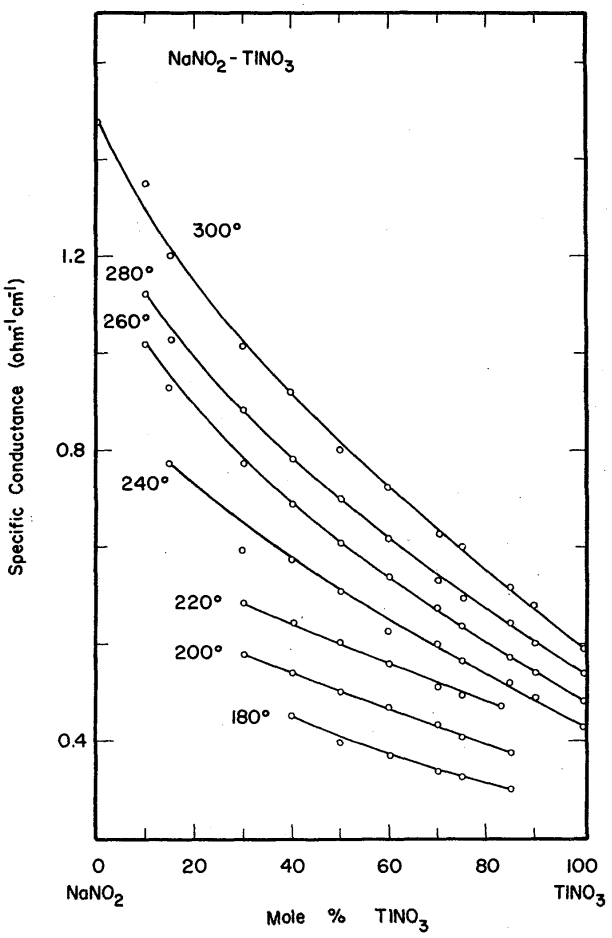

FIGURE 83. Isotherms [89] (°C) of specific conductance against molar composition for the system $NaNO_2$–$TlNO_3$.

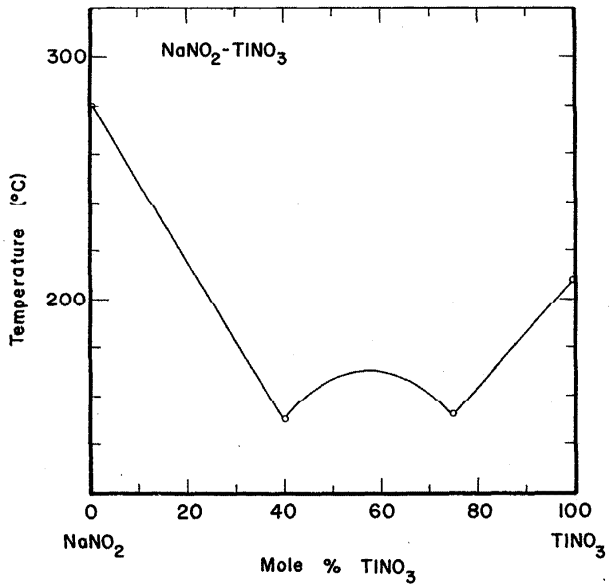

FIGURE 84. Temperature–composition phase diagram for $NaNO_2$–$TlNO_3$.

P. I. Protsenko and L. L. Gabitova, Ukr. Khim. Zh. **33**, 777 (1962).

$NaNO_3$–$TlNO_2$

Electrical Conductance

Twenty-six studies of the specific conductance of $NaNO_3$ [1 (p. 25), 9, 21, 24, 29, 75, 83, 89, 100, 104, 111, 112, 117, 120, 125, 128, 129] and two investigations of $TlNO_2$ [89, 103] have been reported. Some experimental aspects of the conductance measurements of $NaNO_3$ and $TlNO_2$ are discussed in the sections on KNO_3–$NaNO_3$ and $NaNO_2$–$TlNO_2$.

Protsenko and Gabitova [89] used the classical ac technique to measure the specific conductance of molten $NaNO_3$–$TlNO_2$ mixtures. Isotherms of specific conductance against molar composition at six different temperatures between 180 and 280 °C are given in figure 85. It should be noted that the scale of the ordinate in figure 86, as reported by Protsenko and Gabitova, is inconsistent. Due to the graphical presentation of the results a critical assessment is not possible.

The melt preparation used by Protsenko and Gabitova is discussed in the section on $NaNO_2$–$TlNO_2$.

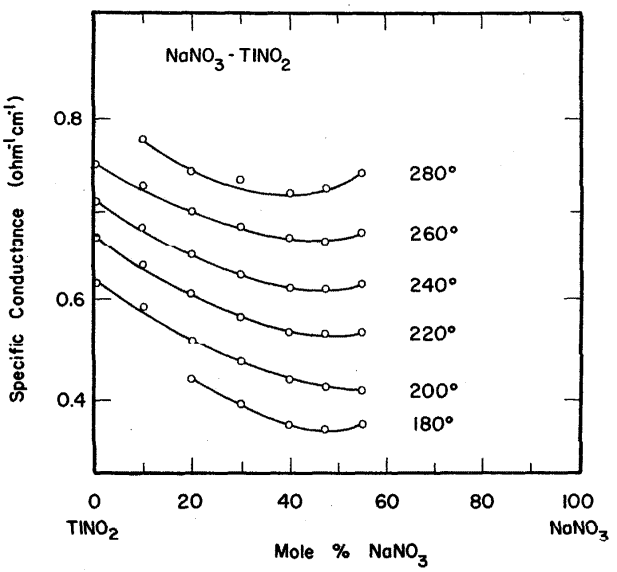

FIGURE 85. Isotherms [89] (°C) of specific conductance against molar composition for the system $NaNO_3$–$TlNO_2$.

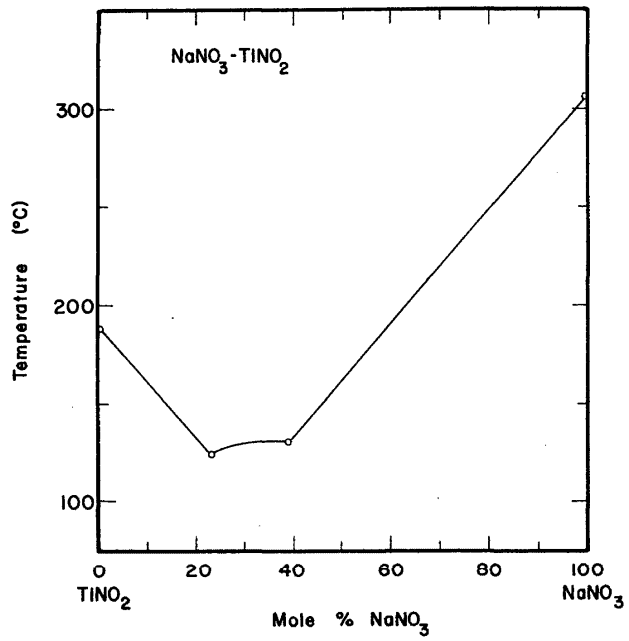

FIGURE 86. Temperature—composition phase diagram for $NaNO_3$–$TlNO_2$.

P. I. Protsenko and L. L. Gabitova, Ukr. Khim. Zh. **33**, 777 (1962).

$TlNO_2$–$TlNO_3$

Electrical Conductance

Two studies of the specific conductance of $TlNO_2$ [89, 103] and 17 investigations of $TlNO_3$ [1 (p. 28), 24, 27, 74, 89, 103, 104, 112, 117, 121] have been reported. Some experimental aspects of the conductance measurements of $TlNO_2$ and $TlNO_3$ are discussed in the sections on $NaNO_2$–$TlNO_2$ and $NaNO_3$–$TlNO_3$, respectively.

Protsenko, Protsenko, Gabitova and Shatskaya [103] measured the specific conductance of molten $TlNO_2$–$TlNO_3$ mixtures using the classical ac technique. Isotherms of specific conductance against molar composition at 200, 240, and 280 °C are given in figure 87. The results for the single components are reported in form of temperature-dependent equations (see the section on $NaNO_2$–$TlNO_2$ for $TlNO_2$). The experimental uncertainty of the results of Protsenko, Protsenko, Gabitova and Shatskaya is estimated to be about 2 percent. The recalculated values for $TlNO_3$ deviate from the recommendations [1] (1.03 to 1.45 percent).

Recrystallized $TlNO_3$ (analytical grade) was used by Protsenko, Protsenko, Gabitova and Shatskaya. $TlNO_2$ was prepared from Tl_2SO_4 and $Ba(NO_2)_2$. The salts were dehydrated and finally vacuum dried for 5 min at 160 °C. The conductance measurements were carried out by means of a capillary-type cell.

Density

One study of the density of $TlNO_2$ [103] and five investigations of $TlNO_3$ [1 (p. 28), 24, 103, 117] have been reported. The results of Protsenko, Protsenko, Gabitova and Shatskaya [103] for $TlNO_2$ are based on the Archimedean method. The temperature dependence of the density values in the range from 475 to 575 K is given by the equation

$$\rho\ (\mathrm{g\ cm^{-3}}) = 5.6166 - 0.1570 \cdot 10^{-2} T$$

reported by Protsenko, Protsenko, Gabitova and Shatskaya. No standard error is reported. Some experimental aspects of the density measurements of $TlNO_3$ are discussed in the section on $AgNO_3$–$TlNO_3$.

Protsenko, Protsenko, Gabitova and Shatskaya [103] measured the density of molten $TlNO_2$–$TlNO_3$ mixtures using the Archimedean method. The results for the single components are reported in the form of temperature-dependent equations, whereas the values for the mixtures are presented graphically. Isotherms of density versus molar composition at 200, 240, and 280 °C are given in figure 88. The experimental uncertainty of the results of Protsenko, Protsenko, Gabitova and Shatskaya is estimated to be about 0.4 percent. The recalculated values for $TlNO_3$ deviate from the recommendations [1] (−0.61 to −0.43 percent).

The melt preparation used by Protsenko, Protsenko, Gabitova and Shatskaya is discussed in the section on $TlNO_2$–$TlNO_3$.

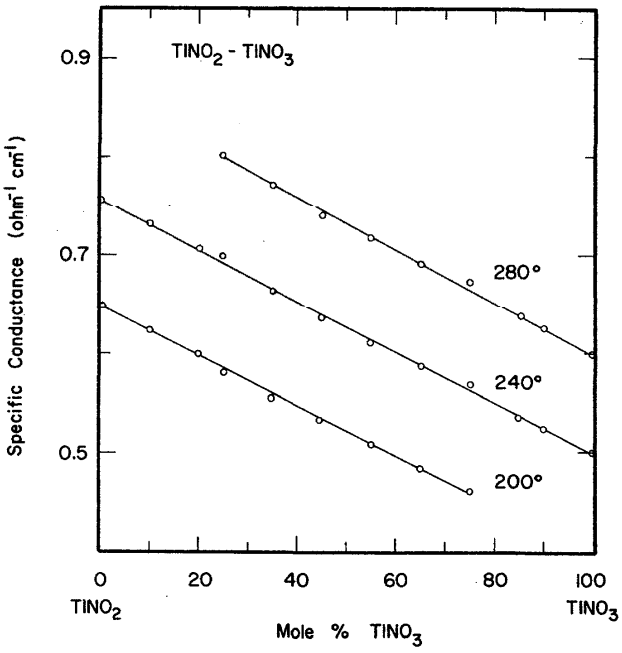

FIGURE 87. Isotherms [103] (°C) of specific conductance against molar composition for the system $TlNO_2$–$TlNO_3$.

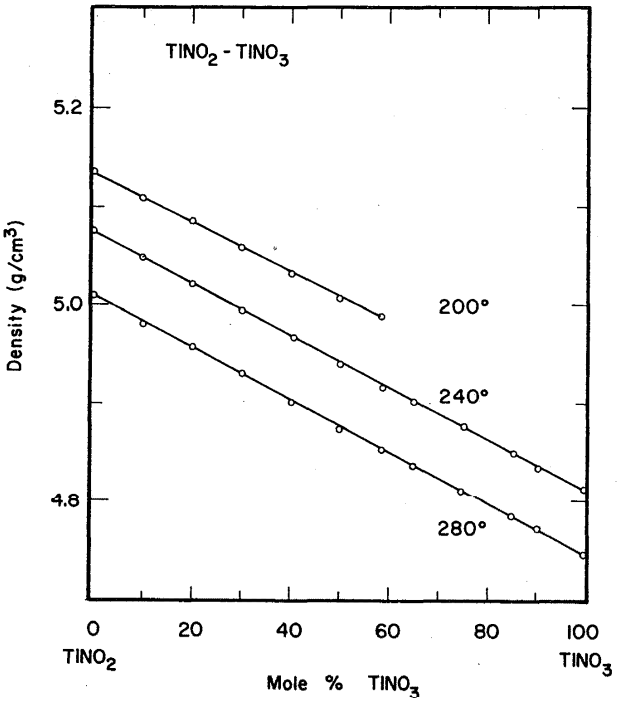

FIGURE 88. Isotherms [103] (°C) of density against molar composition for the system $TlNO_2$–$TlNO_3$.

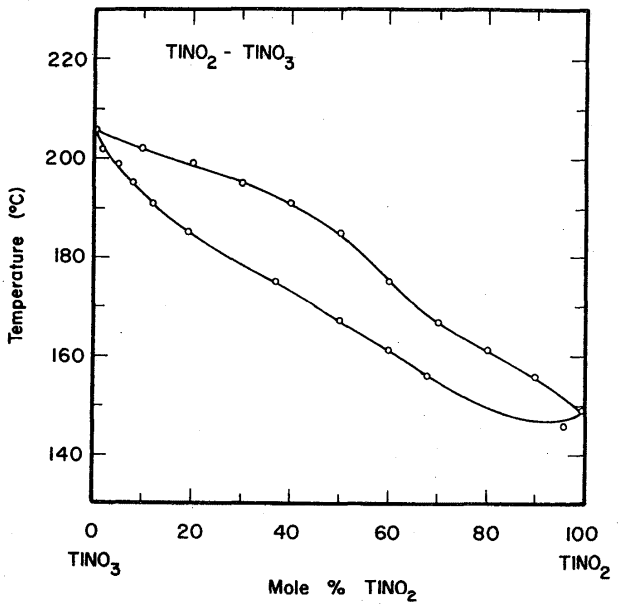

FIGURE 89. Temperature – composition phase diagram for $TlNO_2$–$TlNO_3$.

V. Cuttica, Atti della Reale Accad. dei Lincei, (6), **29**, 289 (1920).

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