Correlations

A Model for Calculating the Heat Capacity of Aqueous Solutions, with Updated Density and Viscosity Data

Marc Laliberté*

Golder Associates, 9200 boul. de l'Acadie, Montreal (Quebec), Canada H4N 2T2

A model for calculating the heat capacity of complex aqueous solutions with an arbitrary number of solutes and at an arbitrary temperature was developed. Parameters for 79 solutes were established based on a critical review of the literature for solutions of one solute in water, with about 6600 points included. The average difference between the calculated and experimental heat capacity is -0.0003 kJ·kg^{-1}·K^{-1} with a standard deviation of 0.010 kJ·kg^{-1}·K^{-1}. The model was validated by comparing published and calculated heat capacities for 13 systems of more than one solute in water, with a total of 485 data points. The average difference between experimental and calculated values is -0.003 kJ·kg^{-1}·K^{-1} with a standard deviation of 0.029 kJ·kg^{-1}·K^{-1}. Data are presented on the following 109 solutes, including data on density (16 300 points) and viscosity (10 700 points): $(NH_4)_2SO_4$, $Al_2(SO_4)_3$, $AlCl_3$, $Ba(NO_3)_2$, $BaCl_2$, $Ca(CH_3CO_2)_2$, $Ca(NO_3)_2$, $CaCl_2$, $CaSO_4$, $Cd(NO_3)_2$, $CdCl_2$, $CdSO_4$, CH_3CH_2OH, CO_2, $CoCl_2$, $CoSO_4$, $Cr_2(SO_4)_3$, $CrCl_3$, $Cu(NO_3)_2$, $CuCl_2$, $CuSO_4$, $Fe_2(SO_4)_3$, $FeCl_2$, $FeCl_3$, $FeSO_4$, H_2O_2, H_2SO_4, H_3AsO_3, H_3AsO_4, H_3PO_4, HBr, HCH_3CO_2, $HCHO_2$, HCl, HCN, HNO_3, K_2CO_3, $K_2Cr_2O_7$, K_2HPO_4, K_2SO_4, K_3PO_4, KBr, KCH_3CO_2, $KCHO_2$, KCl, KF, KH_2PO_4, $KHCO_3$, $KHSO_3$, KI, KNO_2, KNO_3, KOH, Li_2SO_4, $LiCH_3CO_2$, LiCl, $LiNO_3$, LiOH, $Mg(CH_3CO_2)_2$, $Mg(NO_3)_2$, $MgCl_2$, $MgSO_4$, $Mn(NO_3)_2$, $MnCl_2$, $MnSO_4$, $Na_2C_2O_4$, Na_2CO_3, Na_2CrO_4, Na_2HPO_4, Na_2MoO_4, Na_2S, $Na_2S_2O_3$, Na_2SO_3, Na_2SO_4, Na_2WO_4, Na_3PO_4, $NaAl(OH)_4$, NaBr, $NaCH_3CO_2$, $NaCHO_2$, NaCl, $NaClO_3$, NaF, NaH_2PO_4, $NaHCO_3$, NaHS, $NaHSO_3$, $NaHSO_4$, NaI, $NaMnO_4$, $NaNO_2$, $NaNO_3$, NaOH, NH_3, NH_4Cl, NH_4HCO_3, NH_4NO_3, $Ni(NO_3)_2$, $NiCl_2$, $NiSO_4$, $Pb(NO_3)_2$, SO_2, $Sr(NO_3)_2$, $SrCl_2$, Sucrose, $TiOSO_4$, $Zn(NO_3)_2$, $ZnCl_2$, $ZnSO_4$.

Introduction

The heat capacity of aqueous solutions is difficult to estimate based on available published models. While a number of models have been published over the years, the Pitzer equations[1] are the best-known and most precise thermodynamically consistent correlative equations for excess thermodynamic quantities of aqueous electrolytes, including heat capacity. Pitzer equations are computationally complex, and their capability to predict heat capacities outside the parametrization space is rather poor, especially when considering that they contain no explicit temperature or pressure dependence.[2] Many modifications have been proposed to enable the use of Pitzer equations at arbitrary temperatures, but none have found general acceptance.

We have found that there is a need for a simpler empirical model that would allow for the prediction of solution heat capacities of solutions containing an arbitrary number of solutes (ionic or not) and at arbitrary temperatures. The model should use mass-based units, should be robust, and should be easily programmable in common tools available to chemists and engineers. The fitting of the model parameters for new solutes should be easy and should require a minimum of experimental data, ideally no more than heat capacity data for solutions of this new solute in water at three or four concentrations and two or three temperatures. Finally, this model should extrapolate well.

* Corresponding author. Fax: +1-514-383-5332. E-mail: marc_laliberte@golder.com.

Pitzer equations unfortunately fail all these requirements and will be discussed no further. We will instead present a new empirical model that we believe meets these requirements. Before we do so, however, we will present a short review of our previous work.

Previous Work

We have recently presented empirical models for estimating the density[3] and viscosity[4] of aqueous solutions. A summary of these papers is presented below. Since then, readers have come back with information that was overlooked, pointed out errors and inconsistencies, or have requested that additional solutes be fitted. While it is impossible to incorporate all the published data for all solutes in a single database, we have tried to be as accommodating as possible. We originally published density data on 59 solutes (10 700 data points): we now present data on 109 solutes (16 300 data points). In our viscosity paper, we published data on 74 solutes (9000 data points): we now present data on 95 solutes (10 700 data points). To keep all this information available in one convenient location, we are including in this paper all information on solutions of one solute in water we have currently fitted. Information on the density or viscosity of solutions of more than one solute is however not repeated, and the interestesd readers are referred to our original publications.[3,4]

We have decided to include in this paper (not in the Supporting Information, as the Supporting Information is not crawled by search engines) the formula, name, and CAS number

10.1021/je8008123 CCC: $40.75 © 2009 American Chemical Society
Published on Web 04/06/2009

of all solutes. We also included herein the notes attached to many of the Excel files in the Supporting Information. In many cases, the notes help to understand some limitations of the data, will refer to data that were not included, or will explain some changes we have made to the data. This has made this paper longer, but we hope that it will be more useful.

Density. In a previous paper[3] we presented a model for estimating the density of aqueous solutions. The following equation allows the calculation of the solution density from the solvent density and the solutes apparent density

$$\rho_m/\mathrm{kg{\cdot}m^{-3}} = \frac{1}{\dfrac{w_w}{\rho_w/\mathrm{kg{\cdot}m^{-3}}} + \displaystyle\sum_i \dfrac{w_i}{\rho_{app,i}/\mathrm{kg{\cdot}m^{-3}}}} \quad (1)$$

where w_w is the mass fraction of water; w_i is the mass fraction of solute i (it being understood that for a system with n solutes, $w_w + \sum_{i=1}^{n} w_i = 1$); ρ_w is the density of water; $\rho_{app,i}$ is the solute apparent density; and ρ_m is the solution density (all densities expressed in $\mathrm{kg{\cdot}m^{-3}}$). In this paper the, subscript "i" designates a solute; the subscript "m" stands for "mixture" or solution; while the subscript "w" stands for "water".

The density of water can be calculated using the following equation

$$\begin{aligned}\rho_w/\mathrm{kg{\cdot}m^{-3}} = {} & (((((-2.8054253{\cdot}10^{-10}{\cdot}t/^{\circ}\mathrm{C} + 1.0556302{\cdot}10^{-7}){\cdot} \\ & t/^{\circ}\mathrm{C} - 4.6170461{\cdot}10^{-5}){\cdot}t/^{\circ}\mathrm{C} - 0.0079870401){\cdot} \\ & t/^{\circ}\mathrm{C} + 16.945176){\cdot}t/^{\circ}\mathrm{C} + 999.83952) \\ & 1 + 0.01687985{\cdot}t/^{\circ}\mathrm{C}\end{aligned} \quad (2)$$

where t is the temperature. The apparent density of the solutes is calculated using

$$\rho_{app,i}/\mathrm{kg{\cdot}m^{-3}} = \frac{(c_0(1 - w_w) + c_1){\cdot}e^{(0.000001(t/^{\circ}\mathrm{C} + c_4)^2)}}{(1 - w_w) + c_2 + c_3 t/^{\circ}\mathrm{C}} \quad (3)$$

where c_0 to c_4 are dimensionless empirical constants.

For the purpose of fitting coefficients c_0 to c_4, the apparent solute density is calculated from the density data for solution of one solute in water by using

$$\rho_{app,i} = \frac{\rho_m w_i}{1 - \dfrac{\rho_m w_w}{\rho_w}} \quad (4)$$

Viscosity. In another paper,[4] we proposed the following equation to estimate the viscosity of aqueous solutions

$$\eta_m = \eta_w^{w_w} \prod \eta_i^{w_i} \quad (5)$$

where η_m is the solution viscosity; η_w is the viscosity of water; and η_i is the viscosity of the component i, expressed in mPa·s.

The viscosity of water can be evaluated using

$$(\eta_w/\mathrm{mPa{\cdot}s}) = \frac{t/^{\circ}\mathrm{C} + 246}{(0.05594t/^{\circ}\mathrm{C} + 5.2842)t/^{\circ}\mathrm{C} + 137.37} \quad (6)$$

The component i viscosity is calculated using

$$(\eta_i/\mathrm{mPa{\cdot}s}) = \frac{e^{\left(\frac{v_1(1 - w_w)^{v_2} + v_3}{v_4(t/^{\circ}\mathrm{C}) + 1}\right)}}{v_5(1 - w_w)^{v_6} + 1} \quad (7)$$

where v_1 to v_6 are dimensionless empirical constants.

For a solution of one solute in water, the solute viscosity η_i is simply calculated by

$$\eta_i = \left(\frac{\eta_m}{\eta_w^{w_w}}\right)^{1/w_i} \quad (8)$$

Note that eq 7 was incorrect in our original publication and that a correction to that effect was subsequently published. Equation 8 also contains a correction to the original (η_w should be used in the denominator instead of η_m).

Heat Capacity of Aqueous Solutions

Heat Capacity of Liquid Water. To calculate solute heat capacity from solution heat capacity, and vice-versa, the heat capacity of water must be known. The International Association for the Properties of Water and Steam has published equations to this effect.[5] We have used the Russian national committee to IAPWS' MathCAD implementation of the IAPWS 1997 formulation available at http://twt.mpei.ac.ru/ochkov/WSPHB/Engindex.html to compute the values found in Table 1. The IAPWS equations are not suited for temperatures below the freezing point, so we have used the data for subcooled water from Archer[6] between (−15 and 0) °C in Table 1. The data in Table 1 are at a pressure of 0.1 MPa up to 95 °C and then at saturation pressure.

We have been unable to find a simple equation that would fit the data in Table 1. We have instead used a quadratic interpolation of this data, using the following equation from Bevington.[7]

Given Cp_1, Cp_2, and Cp_3, the heat capacity of water at three different temperatures t_1, t_2, and t_3, these three temperatures being uniformly spaced and in increasing order, we can estimates Cp_w at an arbitrary temperature t

$$\begin{aligned}Cp_w = {} & Cp_1 + (Cp_2 - Cp_1)\left(\frac{t - t_1}{t_2 - t_1}\right) + \\ & \frac{(Cp_3 - 2Cp_2 + Cp_1)}{2}\left(\frac{t - t_1}{t_2 - t_1}\right)\left(\frac{t - t_1}{t_2 - t_1} - 1\right)\end{aligned} \quad (9)$$

t does not have to be included in the range t_1 to t_3, but the accuracy of the interpolation is obviously increased if it is. We present in Table 2 a comparison of interpolated and of IAPWS heat capacities at random temperatures ($t_1 \le t \le t_3$). The maximum difference of 0.0001 $\mathrm{kJ{\cdot}kg^{-1}{\cdot}K^{-1}}$ is found close to the freezing point. The difference is on average 0.00002 (std dev = 0.00004) $\mathrm{kJ{\cdot}kg^{-1}{\cdot}K^{-1}}$. This precision is sufficient for our purpose.

Heat Capacities of Solutions. We have used the following equations to calculate the heat capacity of solutions

Table 1. Heat Capacity of Pure Liquid Water

t/°C	Cp/kJ·kg^{-1}·K^{-1}	ref
−15	4.29403	Interpolated from Archer[6]
−10	4.25688	Interpolated from Archer[6]
−5	4.23358	Interpolated from Archer[6]
0	4.21944	From IAPWS[5] at P/MPa = 0.1
5	4.20495	From IAPWS[5] at P/MPa = 0.1
10	4.19545	From IAPWS[5] at P/MPa = 0.1
15	4.18910	From IAPWS[5] at P/MPa = 0.1
20	4.18480	From IAPWS[5] at P/MPa = 0.1
25	4.18190	From IAPWS[5] at P/MPa = 0.1
30	4.18002	From IAPWS[5] at P/MPa = 0.1
35	4.17895	From IAPWS[5] at P/MPa = 0.1
40	4.17886	From IAPWS[5] at P/MPa = 0.1
45	4.17877	From IAPWS[5] at P/MPa = 0.1
50	4.17956	From IAPWS[5] at P/MPa = 0.1
55	4.18089	From IAPWS[5] at P/MPa = 0.1
60	4.18277	From IAPWS[5] at P/MPa = 0.1
65	4.18517	From IAPWS[5] at P/MPa = 0.1
70	4.18810	From IAPWS[5] at P/MPa = 0.1
75	4.19155	From IAPWS[5] at P/MPa = 0.1
80	4.19552	From IAPWS[5] at P/MPa = 0.1
85	4.20001	From IAPWS[5] at P/MPa = 0.1
90	4.20502	From IAPWS[5] at P/MPa = 0.1
95	4.21057	From IAPWS[5] at P/MPa = 0.1
100	4.21664	From IAPWS[5] at saturation pressure
105	4.22323	From IAPWS[5] at saturation pressure
110	4.23036	From IAPWS[5] at saturation pressure
115	4.23807	From IAPWS[5] at saturation pressure
120	4.24637	From IAPWS[5] at saturation pressure
125	4.25528	From IAPWS[5] at saturation pressure
130	4.26484	From IAPWS[5] at saturation pressure
135	4.27508	From IAPWS[5] at saturation pressure
140	4.28604	From IAPWS[5] at saturation pressure

Table 2. Comparison between Quadratic Interpolation of Data from Table 1 and IAPWS Data at Random Temperatures

	interpolated Cp	IAPWS Cp	$(Cp_{(\text{Interpolated})} - Cp_{(\text{IAPWS})})$
t/°C	kJ·kg^{-1}·K^{-1}	kJ·kg^{-1}·K^{-1}	kJ·kg^{-1}·K^{-1}
3.56	4.20861	4.20851	–0.00010
11.33	4.19356	4.19351	–0.00005
27.47	4.18087	4.18086	–0.00001
33.38	4.17919	4.17922	0.00003
43.02	4.17870	4.17862	–0.00008
53.91	4.18055	4.18056	0.00001
65.03	4.18519	4.18519	0.00000
70.77	4.18860	4.18860	0.00000
80.95	4.19633	4.19633	0.00000
97.92	4.21405	4.21405	0.00000
108.82	4.22863	4.22863	0.00000
112.71	4.23447	4.23447	0.00000
		average residual	–0.00002
		std dev of residual	0.00004

$$Cp_m = w_w Cp_w + \sum w_i Cp_i \qquad (10)$$

where Cp_m is the solution's heat capacity; Cp_w is the heat capacity of water; and Cp_i is the heat capacity of the solute. Estimating Cp_i is more complex. The following equation has been found to fit the data accurately

$$Cp_i/\text{kJ·kg}^{-1}\text{·K}^{-1} = a_1 e^{\alpha} + a_5(1 - w_w)^{a_6} \qquad (11)$$

where

$$\alpha = a_2 t/°\text{C} + a_3 e^{0.01t/°\text{C}} + a_4(1 - w_w) \qquad (12)$$

and a_1 to a_6 are dimensionless empirical coefficients.

When estimating a solute heat capacity for a solution of one solute in water, the following form of eq 10 is used

$$Cp_i = \frac{Cp_m - w_w Cp_w}{w_i} \qquad (13)$$

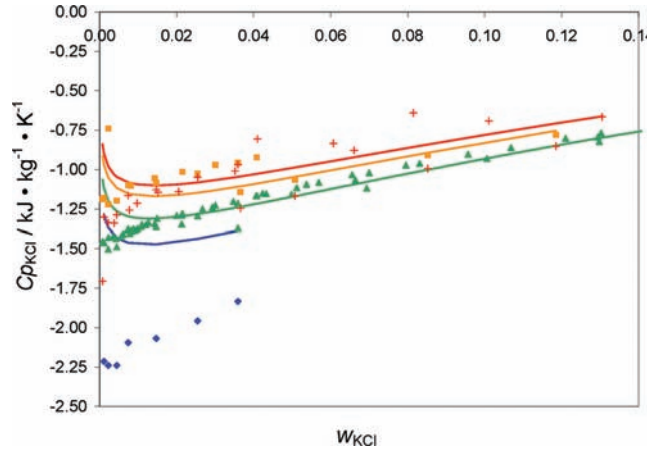

Figure 1. Heat capacity of potassium chloride in aqueous solutions at various temperatures, as calculated using eq 10 (blue ◊, experimental at 5 °C; blue line, calculated at 5 °C; green Δ, experimental at 25 °C; green line, calculated at 25 °C; orange ■, experimental at 50 °C; orange line, calculated at 50 °C; red +, experimental at 100 °C; red line, calculated at 100 °C). Notice the scatter at higher temperature and the model inaccuracy at 0 °C.

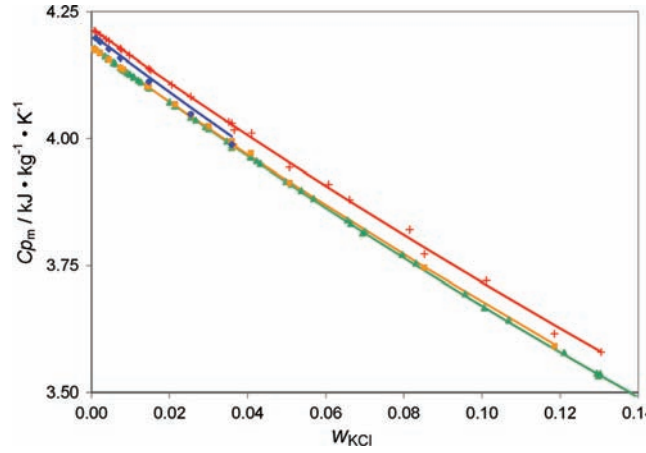

Figure 2. Heat capacity of solutions of potassium chloride at various temperatures (blue ◊, experimental at 5 °C; blue line, calculated at 5 °C; green Δ, experimental at 25 °C; green line, calculated at 25 °C; orange ■, experimental at 50 °C; orange line, calculated at 50 °C; red +, experimental at 100 °C; red line, calculated at 100 °C). Notice that the scatter has mostly disappeared, except at 100 °C.

Equations 10 to 12 give good results for solutions of one solute in water. Figure 1 shows the values for the heat capacity of aqueous potassium chloride Cp_{KCl} at different temperatures and concentrations, as calculated using eq 13. There is clearly a problem at 5 °C, but then there are only seven data points at that temperature and they all come from the same reference. At higher temperature, the fit is good, even if some significant data scatter is obvious at temperatures of 50 °C and above. Figure 2 shows the solution heat capacity for the same system. At low mass fraction ($w < 0.03$), the difference between the experimental and calculated heat capacities of KCl is not significant for most purposes. Scatter is also less obvious but still apparent at 100 °C. Figure 3 is a comparison between experimental and calculated values of the heat capacity for the same system. The problem at 5 °C is still obvious. At higher temperature, the model limitation becomes data scatter: the model is precise, but the data are inaccurate. To fit a better model better data would be required. Another way to look at the problem would be to say that the model is accurate enough considering the data accuracy.

To establish the accuracy of eqs 10 to 12 in multisolute systems, we have found data for the following 13 systems:

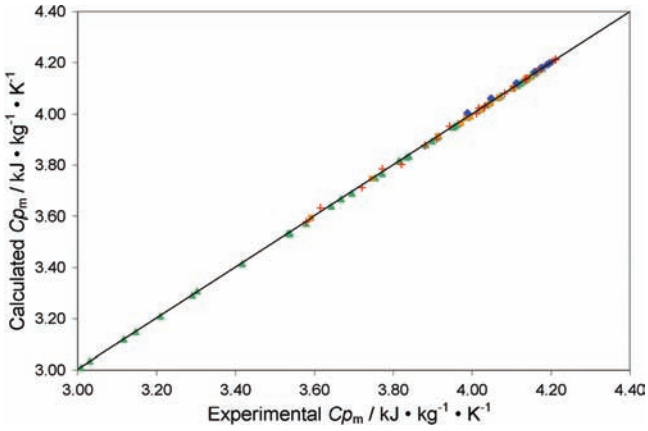

Figure 3. Comparison of experimental and calculated heat capacity of solutions of potassium chloride at various temperatures (blue ◊, at 5 °C; green Δ, at 25 °C; orange ■, at 50 °C; red +, at 100 °C). The model is inaccurate at 5 °C, but overall there is generally a very good correlation between experimental and calculated values.

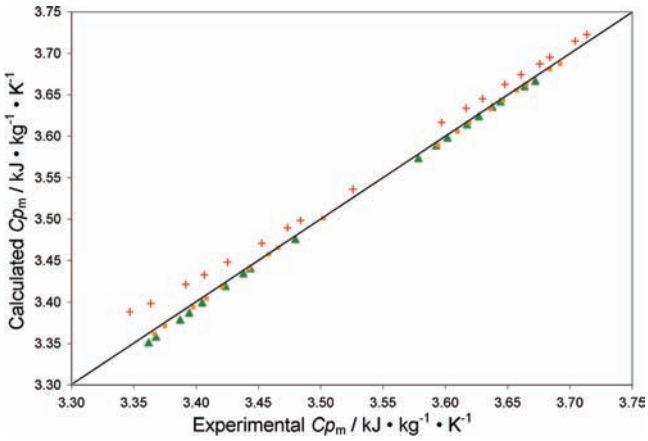

Figure 4. Comparison of experimental and calculated heat capacity of solutions of magnesium chloride and sodium chloride at various temperatures (green Δ, at 25 °C; orange ■, at 50 °C; red +, at 100 °C). The model is inaccurate at 100 °C, but overall there is a good correlation between experimental and calculated values (overall $R^2 = 0.992$).

$BaCl_2-MgCl_2$, $CaCl_2-KCl-MgCl_2-NaCl$, $CaCl_2-MgCl_2$, $CaCl_2-NaCl$,HCl$-SO_2$,KOH$-NH_3$,$MgCl_2-NaCl$,$MgCl_2-SrCl_2$, $Na_2CO_3-NaHCO_3$, Na_2CO_3-NaOH, $Na_2HPO_4-NaH_2PO_4$, Na_3PO_4-NaOH, and $NaOH-NH_3$. Figure 4 shows a comparison between experimental and calculated values of the solution heat capacity of the system $MgCl_2-NaCl$ at various temperatures, while Figure 5 shows a similar comparison for the system $CaCl_2-KCl-MgCl_2-NaCl$.

Table 3 presents a summary of the quality of the fit for all the systems named above. The detailed calculations are included in the Supporting Information. 485 data points were found. The average residual (experimental − calculated heat capacity) is −0.003 kJ•kg^{-1}•K^{-1} (0.10 % of the heat capacity), with a standard deviation of 0.029 kJ•kg^{-1}•K^{-1} (0.82 % of the heat capacity). The first percentile value for the residuals is −0.110 kJ•kg^{-1}•K^{-1} (3.0 % of the heat capacity); the median is 0.001 kJ•kg^{-1}•K^{-1} (0.04 % of the heat capacity); and the 99th percentile is 0.093 kJ•kg^{-1}•K^{-1} (2.5 % of the heat capacity). Most of the error is in the $KOH-NH_3$ and $NaOH-NH_3$ systems, as demonstrated by their much higher standard deviation. This might be because the fit for the heat capacity of NH_3 is of lower quality than for most other solutes. Interestingly, for the systems $CaCl_2-KCl-MgCl_2-NaCl$ and $CaCl_2-MgCl_2$, the model slightly underestimates the heat capacity, while it overestimates it for

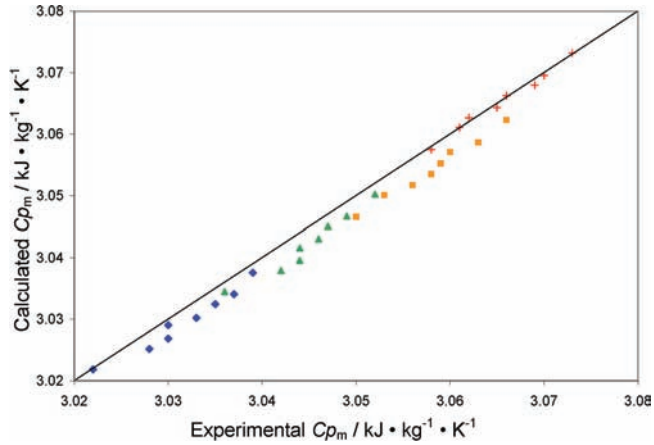

Figure 5. Comparison of experimental and calculated heat capacity of solutions of calcium chloride, potassium chloride, magnesium chloride, and sodium chloride at various temperatures (blue ◊, at 15 °C; green Δ, at 25 °C; orange ■, at 35 °C; red +, at 45 °C). The calculated solution heat capacity is on average 0.004 kJ•kg^{-1}•K^{-1} lower than the experimental value (overall $R^2 = 0.997$).

the $CaCl_2-NaCl$ and $MgCl_2-NaCl$ systems, which are subsets of the $CaCl_2-KCl-MgCl_2-NaCl$ system.

The fit between the experimental and the calculated heat capacity for solutions of many solutes is therefore excellent and is sufficient for most engineering purposes.

Effect of Pressure. Not much has been published regarding the effect of pressure on the heat capacity of solutions. For pure water, the effect is small. At 50 °C and 0.1 MPa, it is 4.1796 kJ•kg^{-1}•K^{-1}, while at 30 MPa it is 4.1162 kJ•kg^{-1}•K^{-1}, a decrease of 1.5 % (data from IAPWS[5]).

When known, the pressure at which the solution heat capacity was measured is shown in the Supporting Information. When both the mass and the apparent molar heat capacities were measured at high pressure, we used the apparent molar heat capacity. Because the water heat capacity from Table 1 is then used to calculate the solution heat capacity, this significantly reduces the error due to pressure.

Pabalan[248] reported on the heat capacity of KCl solutions at high pressure and temperature. At 139.8 °C, 20 MPa, and $m =$ 3, he reports that the solution heat capacity is 3.370 kJ•kg^{-1}•K^{-1}, while the apparent molar heat capacity of KCl is −36.67 J•mol^{-1}•K^{-1}. Using the apparent molar heat capacity and the water heat capacity interpolated from data in Table 1 (4.286 kJ•kg^{-1}•K^{-1}), we calculated an equivalent experimental solution heat capacity of 3.412 kJ•kg^{-1}•K^{-1} at saturation pressure. If we had used the IAPWS water heat capacity at 139.8 °C and 20 MPa (4.232 kJ•kg^{-1}•K^{-1}), we would have calculated an equivalent experimental solution heat capacity of 3.368 kJ•kg^{-1}•K^{-1}.

The difference between Pabalan data at 20 MPa and the calculated data at saturation pressure is therefore about 1 %. This is probably acceptable for most purposes. If a more accurate fit was required, the easiest way to do that would be to use in eq 10 the water heat capacity at the required pressure.

Fitting Data

We will now describe how the fit to the various empirical coefficients was made using the available information. The focus of this paper is on heat capacities, but much of what follows can equally apply to density and viscosity. What follows is significantly modified and expanded from what was published previously.

Table 3. Main Results for Systems of More than One Solute

system	average heat capacity qaresidual / kJ·kg^{-1}·K^{-1}	standard deviation of heat capacity residual / kJ·kg^{-1}·K^{-1}	number of points used in the correlation	t_{min} / °C	t_{max} / °C	w_{max} solute 1	w_{max} solute 2	w_{max} solute 3	w_{max} solute 4
$BaCl_2 + MgCl_2$	–0.0026	0.0064	7	25	25	0.133	0.061	-	-
$CaCl_2 + KCl + MgCl_2 + NaCl$	0.0036	0.0024	73	15	45	0.040	0.012	0.141	0.081
$CaCl_2 + MgCl_2$	0.0024	0.0046	79	25	100	0.195	0.168	-	-
$CaCl_2 + NaCl$	–0.0015	0.0106	72	25	100	0.136	0.203	-	-
$HCl + SO_2$	–0.0004	0.0009	4	30	103	0.002	0.012	-	-
$KOH + NH_3$	0.0064	0.0462	54	30	79	0.168	0.361	-	-
$MgCl_2 + NaCl$	–0.0047	0.0106	72	25	100	0.107	0.203	-	-
$MgCl_2 + SrCl_2$	–0.0007	0.0102	3	25	25	0.170	0.102	-	-
$Na_2CO_3 + NaHCO_3$	–0.0027	0.0015	34	25	25	0.038	0.059	-	-
$Na2CO_3 + NaOH$	–0.0022	0.0016	5	25	25	0.021	0.002	-	-
$Na_2HPO_4 + NaH_2PO_4$	0.0015	0.0073	33	25	25	0.043	0.081	-	-
$Na_3PO_4 + NaOH$	0.0017	0.0013	7	25	25	0.027	0.001	-	-
$NaOH + NH_3$	–0.0397	0.0652	47	30	79	0.170	0.367	-	-

Solutions of One Solute. The best source of data for estimating the empirical coefficients a_1 to a_6 is heat capacity data for solutions of one solute in water. Ideally, we should have at least 18 data points (using the rule of thumb of three data points per coefficient to be fitted) at different concentrations and temperatures. Data at very low concentration are less useful: when w_i becomes less than about 0.003 the solution heat capacity becomes too close to the heat capacity of water to be effective in predicting the best values of the coefficients.

The procedure is as follows:

1. Initial values are entered for a_1 to a_6. We have found that much better results are obtained if these initial guesses come from actual fits instead of arbitrary numbers. We recommend using coefficients from solutes that have already been fitted and where the data are of good quality. Three to five different guesses should be made using fits where the temperature coefficient (a_2 for heat capacity) is different. For the purpose of our work, we have used the coefficients for KCl, $MgSO_4$, $NaCH_3CO_2$, NH_3, and NaOH.

2. A solution heat capacity is calculated for all data points using the initial values from the first step.

3. A residual δ_η is calculated by subtracting the experimental solution heat capacity from its calculated value ($\delta_\eta = Cp_m - Cp_{calc}$).

4. The sum of the square of the residuals δ_η is calculated, and this value is minimized by varying a_1 to a_6 using a nonlinear optimization program.

5. The solution heat capacity is calculated at $w_i = 0.1$ and t/°C = 25 and at $w_i = 0.2$ and t/°C = 100 using the optimized coefficients. These heat capacities are compared to the calculated values for other solutes at the same temperature and composition. If the calculated values are outside of the interval defined by the average plus or minus two times the standard deviation, especially if the concentration or the temperature ranges are very narrow, the guess may be discarded. Judgement must be used here to avoid rejecting valid guesses, but this additional step was added to avoid the problem of fitted coefficients that are optimal within the data space but give aberrant results when extrapolated outside the data space: for example, using the parameters for $Cr_2(SO_4)_3$ published previously,[3,4] the density of a solution at $w_{Cr_2(SO4)_3} = 0.2$ and t/°C = 100 is 194 kg·m^{-3}! The present coefficients predict that the density would be 1204 kg·m^{-3}, which may or may not be right but at least is reasonable.

6. Steps 1 to 5 are repeated using different initial guesses, and the values of a_1 to a_6 that give the lowest sum of square of residuals are kept, provided the constraint in step 5 is met.

7. The data are checked for consistency (see below). If inconsistent data are found, they are removed and steps 1 to 6 are repeated. This is repeated until there are no more inconsistent data.

In some cases there are very little data available, for some systems as little as three data points. In this case, the procedure above was varied as follow. Steps 1 to 4 were performed for each initial guess, but without trying to minimize the sum of the squares of the residuals. Using the guess that gave the lowest sum of square only, this guess was optimized by using the conjugate search method and specifying only 10 to 20 iterations. While this was not sufficient to truly minimize the sum of the square, it did allow the error to become reasonable, while making sure that the solution heat capacities calculated in step 5 did not become abherant.

As in our previous work, experimental data points with significant error were removed from the calculation of the constants. Significant error here is defined as a point where the residual is greater than the average residual plus or minus 4 times the standard deviation of the residuals, but provided that points at similar concentration and temperature do not show a similarly high residual.

A data point which shows a very high residual compared to other points at similar compositions or temperatures is usually a sign of a measurement or a transcription error. A group of points at similar concentration and temperature that show high residual usually would indicate a model error. While the former were removed from the set of data used to optimize coefficients a_1 to a_6, the latter have been kept. All points where the residual is more than 4 standard deviation away from the average are clearly identified in the Supporting Information.

Solutions of Many Solutes. In recent papers, Reynolds and Carter considered the use of our density model in multicomponent systems.[8,9] Most of what they discussed can also be applied with minimum changes to viscosity and heat capacity.

In a first paper,[8] they established that it is possible to derive coefficients for solutes that cannot exist in solution with water alone, such as $NaAl(OH)_4$ using data from multicomponent solutions. In a detailed review for that particular solute, they developed

> a model of the densities of multi-component aqueous electrolyte solutions containing NaOH and $NaAl(OH)_4$. Coefficients for the Laliberte−Cooper model of multi-component electrolyte solutions were developed from published density data for the NaOH−$NaAl(OH)_4$−H_2O system. The density data were split into two groups, data for parameterization and data for validation. The model was able to predict the validation data well, with an R^2 greater than 0.99 for five of seven datasets and greater than 0.95 for all datasets. The model was shown to extrapolate to temperature and composition ranges outside those used for model parameterization. Similarly, using

Table 4. $(NH_4)_2SO_4$ - Ammonium Sulfate - 7783-20-2

	Density	Viscosity	Heat capacity
t_{min}/°C	15.0 °C	15.0 °C	-
t_{max}/°C	55.0 °C	60.0 °C	-
w_{max}	0.429	0.463	-
Average residual	0.06 kg·m^{-3}	0.0008 mPa·s	-
Standard deviation of residual	0.46 kg·m^{-3}	0.0128 mPa·s	-
Number of points in the correlation	142	148	-
Number of inconsistent points	10	1	-
References	24, 68, 121, 159	63, 68, 121, 159, 239	

Table 5. $Al_2(SO_4)_3$ - Aluminum Sulfate - 10043-01-3

	Density	Viscosity	Heat Capacity
t_{min}/°C	15.0 °C	25.0 °C	-
t_{max}/°C	95.0 °C	35.0 °C	-
w_{max}	0.398	0.033	-
Average residual	0.06 kg·m^{-3}	−0.0002 mPa·s	-
Standard deviation of residual	0.69 kg·m^{-3}	0.0006 mPa·s	-
Number of points in the correlation	55	14	-
Number of inconsistent points	4	0	-
References	77, 320	239	

Table 6. $AlCl_3$ - Aluminum Chloride - 7784-13-6

	Density	Viscosity	Heat Capacity
t_{min}/°C	18.0 °C	25.0 °C	-
t_{max}/°C	25.0 °C	25.0 °C	-
w_{max}	0.194	0.036	-
Average residual	0.08 kg·m^{-3}	0.0004 mPa·s	-
Standard deviation of residual	0.30 kg·m^{-3}	0.0022 mPa·s	-
Number of points in the correlation	26	5	-
Number of inconsistent points	2	0	-
References	87, 223, 387	87	

Table 7. $Ba(NO_3)_2$ - Barium Nitrate - 10022-31-8

	Density	Viscosity	Heat Capacity
t_{min}/°C	5.0 °C	25.0 °C	5.0 °C
t_{max}/°C	95.0 °C	60.0 °C	120.0 °C
w_{max}	0.084	0.172	0.047
Average residual	0.00 kg·m^{-3}	0.0000 mPa·s	0.0000 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.09 kg·m^{-3}	0.0009 mPa·s	0.0006 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	50	15	96
Number of inconsistent points	1	0	0
References	86, 237	63, 86	
Comments	Data available at lower concentration in Niederhauser[237]		

Table 8. $BaCl_2$ - Barium Chloride - 10361-37-2

	Density	Viscosity	Heat Capacity
t_{min}/°C	15.0 °C	10.0 °C	25.0 °C
t_{max}/°C	140.0 °C	70.0 °C	25.0 °C
w_{max}	0.253	0.331	0.248
Average residual	0.11 kg·m^{-3}	0.0000 mPa·s	−0.0004 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.46 kg·m^{-3}	0.0088 mPa·s	0.0035 kJ·kg^{-1}·K^{-1}
Number of points in the> correlation	207	172	16
Number of inconsistent points	1	5	0
References	160, 220, 264, 285, 357	18, 63, 160, 168, 347	108, 264

Table 9. $Ca(CH_3CO2)2$ - Calcium Acetate - 62-54-4

	Density	Viscosity	Heat Capacity
t_{min}/°C	15.0 °C	15.0 °C	20.0 °C
t_{max}/°C	45.0 °C	45.0 °C	52.0 °C
w_{max}	0.088	0.040	0.150
Average residual	0.00 kg·m^{-3}	0.0001 mPa·s	−0.0000 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.08 kg·m^{-3}	0.0011 mPa·s	0.0003 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	33	22	3
Number of inconsistent points	0	0	0
References	385	385	235

Table 10. $Ca(NO_3)_2$ - Calcium Nitrate - 10124-37-5

	Density	Viscosity	Heat Capacity
t_{min}/°C	25.0 °C	−10.0 °C	-
t_{max}/°C	60.0 °C	100.0 °C	-
w_{max}	0.768	0.677	-
Average residual	−0.07 kg·m^{-3}	−0.0459 mPa·s	-
Standard deviation of residual	0.83 kg·m^{-3}	0.5035 mPa·s	-
Number of points in the correlation	130	167	-
Number ofinconsistent points	39	5	-
References	105, 298, 302, 363	12, 27, 216, 302	
Comments	Data from Rodnyanski[298] and Roy[302] inconsistent and excluded		

Table 11. $CaCl_2$ - Calcium Chloride - 10043-52-4

	Density	Viscosity	Heat Capacity
t_{min}/°C	15.0 °C	0.0 °C	25.0 °C
t_{max}/°C	126.7 °C	100.0 °C	100.0 °C
w_{max}	0.513	0.513	0.418
Average residual	0.20 kg·m^{-3}	0.0086 mPa·s	−0.0004 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	1.08 kg·m^{-3}	0.1658 mPa·s	0.0066 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	369	532	91
Number of inconsistent points	231	17	0
References	113, 114, 160, 200, 242, 264, 267, 299, 307, 331, 328, 366, 374, 380	18, 44, 159, 366, 374, 380	108, 264, 267, 306, 307, 328
Comments	Romankiw[299] clearly overevaluates densities when compared to other authors. Wahab[366] shows unacceptable scatter. Both have been tagged as "Inconsistent" even if not all data points are inconsistent.		

Table 12. $CaSO_4$ - Calcium Sulfate - 7778-18-9

	Density	Viscosity	Heat Capacity
t_{min}/°C	25.0 °C	-	25.0 °C
t_{max}/°C	25.0 °C	-	25.0 °C
w_{max}	0.001	-	0.001
Average residual	0.00 kg·m^{-3}	-	0.0000 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.00 kg·m^{-3}	-	0.0000 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	9	-	6
Number of inconsistent points	6	-	0
References	139, 227		227
Comments			Millero[227] values are estimated, not experimental. However, because there is no other data and because of the importance of $CaSO_4$ in natural waters, these are given here as is.

Table 13. $Cd(NO_3)_2$ - Cadmium Nitrate - 10325-94-7

	Density	Viscosity	Heat Capacity
t_{min}/°C	15.0 °C	15.0 °C	-
t_{max}/°C	85.0 °C	55.0 °C	-
w_{max}	0.700	0.542	-
Average residual	0.01 kg·m^{-3}	0.0002 mPa·s	-
Standard deviation of residual	1.13 kg·m^{-3}	0.0034 mPa·s	-
Number of points in the correlation	143	84	-
Number of inconsistent points	12	7	-
References	86, 104, 160, 325, 328	86, 160	

Table 14. $CdCl_2$ - Cadmium Chloride - 10108-64-2

	Density	Viscosity	Heat Capacity
t_{min}/°C	25.0 °C	25.0 °C	5.0 °C
t_{max}/°C	75.0 °C	25.0 °C	120.0 °C
w_{max}	0.538	0.159	0.155
Average residual	0.11 kg·m^{-3}	0.0023 mPa·s	−0.0006 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.41 kg·m^{-3}	0.0057 mPa·s	0.0026 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	88	16	216
Number of inconsistent points	90	0	0
References	49, 87, 143, 290, 293	87, 293	49
Comments	Data from Call[49] were marked as inconsistent as they show scatter in the apparent densities and they are inconsistent with data from Herrington,[143] Rard,[290] and Reilly.[293] However, data on $MgCl_2$ in the same paper are consistent.		Data from Call[49] are used, but the same data for density were judged inconsistent. Use with caution.

coefficients derived here for $NaAl(OH)_4$ and published coefficients for NaOH and $NaNO_2$, the model was shown to accurately predict the density of solutions that contain $NaNO_2$ in addition to NaOH−$NaAl(OH)_4$ ($R^2 = 0.993$). This indicates that the model coefficients developed here can be incorporated into models of diverse multicomponent electrolyte solutions.

Their approach was used to develop coefficients for the density and viscosity of $NaAl(OH)_4$ and for the density of

Table 15. $CdSO_4$ - Cadmium Sulfate - 10124-36-4

	Density	Viscosity	Heat Capacity
t_{min}/°C	25.0 °C	18.0 °C	-
t_{max}/°C	75.0 °C	75.0 °C	-
w_{max}	0.297	0.357	-
Average residual	0.09 kg·m^{-3}	−0.0084 mPa·s	-
Standard deviation of residual	0.55 kg·m^{-3}	0.0643 mPa·s	-
Number of points in the correlation	44	59	-
Number of inconsistent points	25	1	-
References	33, 34, 313	34, 276	

Table 16. CH_3CH_2OH - Ethanol - 64-17-5

	Density	Viscosity	Heat Capacity
t_{min}/°C	−5.0 °C	−5.0 °C	3.0 °C
t_{max}/°C	50.0 °C	50.0 °C	41.0 °C
w_{max}	1.000	1.000	1.000
Average residual	−0.28 kg·m^{-3}	−0.0017 mPa·s	−0.0037 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	2.05 kg·m^{-3}	0.0806 mPa·s	0.0460 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	200	120	39
Number of inconsistent points	0	0	0
References	235, 292	292	235
Comments	These data are presented as a "proof of concept" that the density model works with nonionic organic solutes. It should not be considered a definite review of this particular system. The data from ICT[235] and Rehman[292] are generally in good agreement except at $w = 0.2212$ ($x = 0.1$). Rehman data on LiCl are generally consistent, and there is no deviation at low temperature. The data are kept, but the fit should be used with caution.	Same general comment.	Same general comment.

Table 17. CO_2 - Carbon Dioxide - 124-38-9

	Density	Viscosity	Heat Capacity
t_{min}/°C	4.9 °C	-	25.0 °C
t_{max}/°C	150.0 °C	-	100.4 °C
w_{max}	0.072	-	0.009
Average residual	0.02 kg·m^{-3}	-	0.0000 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.20 kg·m^{-3}	-	0.0003 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	28	-	12
Number of inconsistent points	0	-	0
References	37, 96, 151, 349		37, 150
Comments	Data available at higher pressure (and thus higher CO_2 concentration) in Teng[349] and at higher temperature in Hnedkovsky.[151] Molarity for Ellis[96] interpreted to have been measured at 25 °C. Densities for Ellis measured at 20 atm, so the delta density was used instead to better represent values at atmospheric pressure.		Data available at higher temperaturein Hnedkovsky.[150]

Table 18. $CoCl_2$ - Cobalt(II) Chloride - 7646-79-9

	Density	Viscosity	Heat Capacity
t_{min}/°C	15.0 °C	20.0 °C	25.0 °C
t_{max}/°C	75.0 °C	50.0 °C	25.0 °C
w_{max}	0.303	0.345	0.030
Average residual	0.09 kg·m^{-3}	0.0000 mPa·s	0.0000 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.63 kg·m^{-3}	0.0086 mPa·s	0.0001 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	214	61	8
Number of inconsistent points	21	0	0
References	103, 143, 262, 268, 280, 328	18, 268	328
Comments	The data from Pena[262] and Phang[268] are inconsistent and have been excluded.		

Table 19. $CoSO_4$ - Cobalt(II) Sulfate - 10124-43-3

	Density	Viscosity	Heat Capacity
t_{min}/°C	25.0 °C	25.0 °C	-
t_{max}/°C	75.0 °C	75.0 °C	-
w_{max}	0.331	0.331	-
Average residual	0.12 kg·m^{-3}	0.0070 mPa·s	-
Standard deviation of residual	1.76 kg·m^{-3}	0.0506 mPa·s	-
Number of points in the correlation	37	29	-
Number of inconsistent points	4	1	-
References	34, 313	34	

NH_4HCO_3 (for some reason, the only density data found for that solute are for solutions of more than one solute).

The procedure is simple. Apparent densities, viscosities, or heat capacities are calculated for solutes where coefficients are known. Initial guesses are then made for the unknown coefficients, and a residual is calculated. The sum of the square of these residuals is then minimized using a nonlinear optimization program. Different guesses are tried, and the optimized coefficients giving the lowest sum of square are kept. Readers who are interested are referred to the files for $NaAl(OH)_4$ and NH_4HCO_3 in the Supporting Information for examples of the calculations.

This is the best way to generate coefficients for solutes that are not stable in solution with pure water such as salts of metals that hydrolyze easily in water such as $Al_2(SO_4)_3$ or $CrCl_3$. The method is unfortunately less accurate than the usual method; however, it is better to have inaccurate data than no data at all, and the use of this method is encouraged.

Estimating Properties for Solutes Where No Experimental Data Are Available. In a second paper,[9] Reynolds and Carter demonstrated that the properties for components where no experimental data are available could be estimated if data are available for other components with the same anions and cations. An individual electrolyte is a cation and anion pair, and our model

Table 20. $Cr_2(SO_4)_3$ - Chromium(III) Sulfate - 10101-53-8

	Density	Viscosity	Heat Capacity
t_{min}/°C	25.0 °C	25.0 °C	-
t_{max}/°C	25.0 °C	25.0 °C	-
w_{max}	0.001	0.001	-
Average residual	0.00 kg·m^{-3}	0.0001 mPa·s	-
Standard deviation of residual	0.01 kg·m^{-3}	0.0001 mPa·s	-
Number of points in the correlation	16	16	-
Number of inconsistent points	0	0	-
References	32	32	

Table 21. $CrCl_3$ - Chromium(III) Chloride - 10025-73-7

	Density	Viscosity	Heat Capacity
t_{min}/°C	18.0 °C	20.0 °C	-
t_{max}/°C	18.0 °C	50.0 °C	-
w_{max}	0.120	0.253	-
Average residual	0.00 kg·m^{-3}	−0.0014 mPa·s	-
Standard deviation of residual	0.02 kg·m^{-3}	0.0232 mPa·s	-
Number of points in the correlation	5	62	-
Number of inconsistent points	0	1	-
References	269	18	
Comments		Afzal[18] does not specify at which temperature he measured his molarities. We have assumed 20 °C. Furthermore, there are no density data for $w > 0.12$, so conversions of molarities to mass fraction above this concentration are suspect.	

Table 22. $Cu(NO_3)_2$ - Copper(II) Nitrate - 3251-23-8

	Density	Viscosity	Heat Capacity
t_{min}/°C	5.0 °C	25.0 °C	5.0 °C
t_{max}/°C	95.0 °C	25.0 °C	120.0 °C
w_{max}	0.350	0.458	0.085
Average residual	0.04 kg·m^{-3}	0.0006 mPa·s	−0.0003 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.24 kg·m^{-3}	0.0089 mPa·s	0.0010 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	110	10	144
Number of inconsistent points	10	0	0
References	46, 86, 101, 135	86	46
Comments	Data from Doan[86] are inconsistent and excluded. Data available from Brown[46] at lower concentration.	Only data from Doan[86] are available. Since Doan data are inconsistent for densities, his viscosities are suspect. Doan did not test for purity of his chemicals, so it is possible that his chemicals were impure. However, for some other solutes such as $Cd(NO_3)_2$, Doan density data are inconsistent but his viscosities are consistent. Use this data with caution.	

Table 23. $CuCl_2$ - Copper(II) Chloride - 7447-39-4

	Density	Viscosity	Heat Capacity
t_{min}/°C	15.0 °C	20.0 °C	19.0 °C
t_{max}/°C	55.0 °C	50.0 °C	51.0 °C
w_{max}	0.445	0.375	0.425
Average residual	0.02 kg·m^{-3}	0.0000 mPa·s	−0.0024 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.49 kg·m^{-3}	0.0142 mPa·s	0.0106 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	149	73	10
Number of inconsistent points	16	0	0
References	87, 97, 101, 221, 231, 279	18, 87, 147	235
Comments	Data from Motin[231] inconsistent and excluded		The ICT data[235] are the average *Cp* between (19 and 51) °C.

Table 24. $CuSO_4$ - Copper(II) Sulfate - 7758-98-7

	Density	Viscosity	Heat Capacity
t_{min}/°C	10.0 °C	15.0 °C	18.0 °C
t_{max}/°C	60.0 °C	60.0 °C	18.0 °C
w_{max}	0.284	0.413	0.150
Average residual	0.04 kg·m^{-3}	−0.0042 mPa·s	−0.0008 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.86 kg·m^{-3}	0.0494 mPa·s	0.0041 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	304	180	4
Number of inconsistent points	1	5	0
References	84, 101, 146, 259, 286, 335, 382	22, 33, 63, 84, 377	235
Comments	Data from Demichowicz-Pigoniowa[84] generally inconsistent and excluded		

depends on the user's arbitrary choice of how the cations and anions are paired together in multi-ion mixtures. Reynold and Cooper demonstrated the self-consistency of our model when cations and anions are paired in different ways. The authors showed for example that the model coefficients for $KAl(OH)_4$ could be calculated solely from the coefficients for $NaAl(OH)_4$, NaOH, and KOH without directly fitting the model to experimental data. The results were confirmed by comparing the calculated densities to published experimental data. The model was able to accurately predict experimentally determined densities ($R^2 > 0.99$) using model coefficients derived without using any experimental data from solutions containing $KAl(OH)_4$.

Review of Density, Viscosity, and Heat Capacity Data for 105 Solutes

The data for density, viscosity, and heat capacity for the solutes listed in the Abstract are found in Tables 4 to 112

Table 25. $Fe_2(SO_4)_3$ - Iron(III) Sulfate - 10028-22-5

	Density	Viscosity	Heat Capacity
t_{min}/°C	15.0 °C	20.0 °C	-
t_{max}/°C	25.0 °C	50.0 °C	-
w_{max}	0.301	0.301	-
Average residual	-0.06 kg·m^{-3}	-0.0017 mPa·s	-
Standard deviation of residual	1.72 kg·m^{-3}	0.0111 mPa·s	-
Number of points in the correlation	31	35	-
Number of inconsistent points	18	0	-
References	65, 235, 386	65	
Comments	The data is generally old and inconsistent. The fit was limited to $w \leq 0.3$, the data is too poor above that limit.		

Table 26. $FeCl_2$ - Iron(II) Chloride - 7758-94-3

	Density	Viscosity	Heat Capacity
t_{min}/°C	15.0 °C	18.0 °C	16.2 °C
t_{max}/°C	45.0 °C	40.0 °C	35.7 °C
w_{max}	0.210	0.037	0.359
Average residual	0.01 kg·m^{-3}	0.0002 mPa·s	0.0000 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.14 kg·m^{-3}	0.0003 mPa·s	0.0000 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	93	43	3
Number of inconsistent points	7	2	0
References	176, 280, 387	176	42
Comments			The data are very limited and should be used with caution. The solution in Bernarducci[32] contained 0.1 m of HCl, the effect of which is neglected in his calculations.

Table 27. $FeCl_3$ - Iron(III) Chloride - 7705-08-0

	Density	Viscosity	Heat Capacity
t_{min}/°C	0.0 °C	0.0 °C	-
t_{max}/°C	35.0 °C	35.0 °C	-
w_{max}	0.500	0.432	-
Average residual	0.17 kg·m^{-3}	0.0026 mPa·s	-
Standard deviation of residual	1.13 kg·m^{-3}	0.0299 mPa·s	-
Number of points in the correlation	111	38	-
Number of inconsistent points	16	2	-
References	235, 386, 387	235	
Comments	The data from the International Critical Tables[235] are calculated from many sources from the late XIX and early XX centuries. Two of those sources (Franz[386] and Heidweiller[387]) have been consulted, and it so appears that they are both mutually inconsistent and seem to have little relation with the data published in the ICT. Heyweiller is supposed to have been given a greater weight in the ICT tables, which is strange given the difference between his data and the ICT data. Use with caution.		

Table 28. $FeSO_4$ - Iron(II) Sulfate - 7720-78-7

	Density	Viscosity	Heat Capacity
t_{min}/°C	15.0 °C	25.0 °C	25.0 °C
t_{max}/°C	25.0 °C	75.0 °C	45.0 °C
w_{max}	0.233	0.211	0.350
Average residual	0.11 kg·m^{-3}	0.0009 mPa·s	0.0004 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	1.27 kg·m^{-3}	0.0114 mPa·s	0.0045 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	66	30	9
Number of inconsistent points	38	0	0
References	34, 83, 235, 388	34	235
Comments	Good data for this solute are difficult to find. We have used Konisberger[388] data and based on his findings have removed Bakeev[34] from the fit. The most concentrated data from Degremont[83] were found to be of poorer quality and were also excluded. The data at 25 °C are probably good, but extrapolations at very different temperatures are of unknown quality. Use with caution.	Bakeev[34] data are inconsistent for density. Use with caution.	The ICT[235] reports that the data represent the average *Cp* between (25 and 45) °C

Table 29. H_2O_2 - Hydrogen Peroxide - 7722-84-1

	Density	Viscosity	Heat Capacity
t_{min}/°C	0.0 °C	0.0 °C	25.0 °C
t_{max}/°C	96.0 °C	20.0 °C	25.0 °C
w_{max}	0.996	1.000	0.715
Average residual	−0.13 kg·m^{-3}	−0.0014 mPa·s	0.0015 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	1.41 kg·m^{-3}	0.0094 mPa·s	0.1116 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	122	46	4
Number of inconsistent points	1	0	6
References	92, 117, 156, 212	212, 272	235

Table 30. H_2SO_4 - Sulfuric Acid - 7664-93-9

	Density	Viscosity	Heat Capacity
t_{min}/°C	−11.2 °C	−10.0 °C	−20.0 °C
t_{max}/°C	75.0 °C	75.0 °C	55.0 °C
w_{max}	0.782	0.782	0.939
Average residual	0.05 kg·m^{-3}	−0.0139 mPa·s	−0.0021 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	1.59 kg·m^{-3}	0.1133 mPa·s	0.0410 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	232	141	187
Number of inconsistent points	18	17	6
References	55, 138, 154, 204, 234, 284, 294	55, 118, 294, 312, 364	116, 154, 202, 204
Comments	The quality of the fit decreases significantly if the concentration range is extended to $w = 1$. Data at higher concentration are however available in the Supporting Information.	The "molality" in Gillespie[118] has been interpreted to be based on sulfuric acid as the solvent. The quality of the fit decreases significantly if the concentration range is extended to $w = 1$. Data at higher concentration are however available in the Supporting Information.	Additional data at higher concentration (eg oleum) in Giauque.[116] The model can fit data to $w = 1$ but at the cost of a decrease in the accuracy at lower concentration. The parameters given above are chosen to best fit the range $0 < w < 0.94$. Data at higher concentration are however available in the Supporting Information.

Table 31. H_3AsO_3 - Arsenious Acid - 13464-58-9

	Density	Viscosity	Heat Capacity
t_{min}/°C	25.1 °C	-	55.7 °C
t_{max}/°C	100.1 °C	-	76.0 °C
w_{max}	0.036	-	0.037
Average residual	0.01 kg·m^{-3}	-	−0.0001 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.12 kg·m^{-3}	-	0.0006 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	15	-	16
Number of inconsistent points	0	-	0
References	263		263
Comments	Data available in Perfetti[263] at higher pressure (to 30 MPa) and temperature (to 350 °C).		Data available in Perfetti[116] at higher pressure (to 30 MPa) and temperature (to 350 °C). The ratio Cp_{H3AsO3}/Cp_{H2O} is used instead of the apparent molal heat capacity to reduce the effect of the higher pressure

Table 32. H_3AsO_4 - Arsenic Acid - 7778-39-4

	Density	Viscosity	Heat Capacity
t_{min}/°C	15.0 °C	25.0 °C	50.7 °C
t_{max}/°C	50.0 °C	25.0 °C	74.9 °C
w_{max}	0.700	0.124	0.069
Average residual	0.21 kg·m^{-3}	−0.0004 mPa·s	−0.0001 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.56 kg·m^{-3}	0.0014 mPa·s	0.0023 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	42	4	7
Number of inconsistent points	0	0	0
References	235, 263	235	263
Comments	Data at higher pressure and temperature available in Perfetti.[269] Delta densities for Perfetti averaged when more than 1 data point available.		Data at higher pressure and temperature available in Perfetti.[269]

Table 33. H_3PO_4 - Phosphoric Acid - 7664-38-2

	Density	Viscosity	Heat Capacity
t_{min}/°C	15.9 °C	20.0 °C	24.7 °C
t_{max}/°C	81.4 °C	25.0 °C	101.1 °C
w_{max}	0.850	0.800	0.986
Average residual	0.10 kg·m^{-3}	−0.0223 mPa·s	−0.0018 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.40 kg·m^{-3}	0.0518 mPa·s	0.0202 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	215	25	134
Number of inconsistent points	0	12	24
References	72, 94, 204, 317, 334	89, 93, 321	95, 204, 317, 370
Comments		Data from Simon[321] inconsistent and excluded. All data sets are however old.	The data from Wakefield[370] are not so much inconsistent as simply at too high a concentration to truly be considered representative of the *Cp* of H_3PO_4 solutions.

Table 34. HBr - Hydrobromic Acid - 10035-10-6

	Density	Viscosity	Heat Capacity
t_{min}/°C	−10.0 °C	0.0 °C	24.9 °C
t_{max}/°C	75.0 °C	25.0 °C	24.9 °C
w_{max}	0.407	0.195	0.028
Average residual	0.00 kg·m^{-3}	−0.0001 mPa·s	0.0000 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.85 kg·m^{-3}	0.0018 mPa·s	0.0001 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	211	11	21
Number of inconsistent points	16	0	0
References	137, 142, 322	235	322
Comments	The data from Haase[137] are not very accurate.		

Table 35. HCH_3CO_2 - Acetic Acid - 64-19-7

	Density	Viscosity	Heat Capacity
t_{min}/°C	5.0 °C	15.0 °C	0.0 °C
t_{max}/°C	85.0 °C	55.0 °C	120.0 °C
w_{max}	1.000	1.000	0.153
Average residual	0.13 kg·m^{-3}	−0.0032 mPa·s	0.0000 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.75 kg·m^{-3}	0.0185 mPa·s	0.0024 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	328	238	214
Number of inconsistent points	7	0	0
References	25, 35, 53, 89, 126, 127, 159, 187, 203, 375	53, 80, 89, 126, 159, 205	15, 25, 35
Comments	Data at lower concentration available in Ballerat-Busserolles.[35] In the same paper, when two apparent molar volumes are given at the same concentration and temperature, the average is used.		Data at lower concentration available in Ballerat-Busserolles.[35] The heat capacity in Ballerat-Busserolles is a bit higher than in Allred.[25]

Table 36. $HCHO_2$ - Formic Acid - 64-18-6

	Density	Viscosity	Heat Capacity
t_{min}/°C	15.0 °C	15.0 °C	0.0 °C
t_{max}/°C	55.0 °C	55.0 °C	120.0 °C
w_{max}	1.000	1.000	0.116
Average residual	0.00 kg·m^{-3}	0.0003 mPa·s	−0.0001 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.98 kg·m^{-3}	0.0137 mPa·s	0.0032 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	182	153	52
Number of inconsistent points	0	0	0
References	127, 159, 187	159	15
Comments			Ackermann[15] data point at $m = 0.982$ and $t = 0$ is shown as 0.997 cal/g/C. This is probably a typo and we have used 0.979 cal/g/C instead.

Table 37. HCl - Hydrochloric Acid - 7647-01-0

	Density	Viscosity	Heat Capacity
t_{min}/°C	5.0 °C	10.0 °C	5.0 °C
t_{max}/°C	98.8 °C	42.5 °C	130.0 °C
w_{max}	0.376	0.360	0.065
Average residual	0.06 kg·m^{-3}	0.0013 mPa·s	0.0000 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.21 kg·m^{-3}	0.0134 mPa·s	0.0028 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	287	163	348
Number of inconsistent points	168	0	0
References	21, 26, 110, 121, 142, 145, 282, 297, 308, 322, 352	57, 121, 157, 240	26, 35, 131, 255, 282, 308, 322, 353, 373
Comments	Data available at lower concentration in Allred.[26] Akerlof[21] seems to systematically underestimate the density when compared to more recent data. It has been excluded from the fit even if not all residuals are greater than ± 4 std dev.		Tremaine[353] has additional data at 139.46 °C and 0.5 MPa. Data available at lower concentration in Allred[26] and in Ballerat-Busserolles.[35] The data are scattered, and the fit is not very good. Consider for example the variation in apparent heat capacity at 100 °C.

Table 38. HCN - Hydrogen Cyanide - 74-90-8

	Density	Viscosity	Heat Capacity
t_{min}/°C	0.0 °C	0.0 °C	-
t_{max}/°C	20.0 °C	0.0 °C	-
w_{max}	1.000	1.000	-
Average residual	0.06 kg·m^{-3}	0.0203 mPa·s	-
Standard deviation of residual	2.34 kg·m^{-3}	0.0731 mPa·s	-
Number of points in the correlation	56	12	-
Number of inconsistent points	0	0	-
References	192, 235	192	

Table 39. HNO_3 - Nitric Acid - 7697-37-2

	Density	Viscosity	Heat Capacity
t_{min}/°C	−10.0 °C	4.0 °C	5.0 °C
t_{max}/°C	95.0 °C	25.0 °C	120.0 °C
w_{max}	0.701	0.309	0.065
Average residual	−0.12 kg·m^{-3}	0.0000 mPa·s	−0.0002 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	1.02 kg·m^{-3}	0.0027 mPa·s	0.0011 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	295	16	159
Number of inconsistent points	17	0	0
References	136, 155, 153, 256	45, 351	98, 155, 153, 256
Comments	Data from Haase[136] at higher concentration (w > 0.75) excluded because the model cannot fit it very well.		

Table 40. K_2CO_3 - Potassium Carbonate - 584-08-7

	Density	Viscosity	Heat Capacity
t_{min}/°C	5.0 °C	19.0 °C	5.0 °C
t_{max}/°C	95.0 °C	89.0 °C	120.0 °C
w_{max}	0.361	0.518	0.065
Average residual	0.09 kg·m^{-3}	0.0032 mPa·s	0.0002 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.79 kg·m^{-3}	0.0820 mPa·s	0.0010 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	75	61	96
Number of inconsistent points	42	0	0
References	119, 149, 229, 326	76, 149, 252	326
Comments	Data at lower concentration available from Sorenson.[326] Data from Ginsburg[119] excluded because inconsistent and scattered.		Data at lower concentration available from Sorenson.[326]

Table 41. $K_2Cr_2O_7$ - Potassium Dichromate - 7778-50-9

	Density	Viscosity	Heat Capacity
t_{min}/°C	0.0 °C	0.2 °C	-
t_{max}/°C	90.0 °C	89.3 °C	-
w_{max}	0.400	0.400	-
Average residual	0.06 kg·m^{-3}	−0.0012 mPa·s	-
Standard deviation of residual	2.24 kg·m^{-3}	0.0229 mPa·s	-
Number of points in the correlation	38	43	-
Number of inconsistent points	4	0	-
References	140, 181, 189, 190, 288	63, 140, 181	

Table 42. K_2HPO_4 - Dipotassium Hydrogen Phosphate - 7758-11-4

	Density	Viscosity	Heat Capacity
t_{min}/°C	25.0 °C	21.0 °C	-
t_{max}/°C	25.0 °C	50.0 °C	-
w_{max}	0.181	0.181	-
Average residual	0.14 kg·m^{-3}	0.0002 mPa·s	-
Standard deviation of residual	1.39 kg·m^{-3}	0.0050 mPa·s	-
Number of points in the correlation	12	42	-
Number of inconsistent points	0	0	-
References	67, 334	67	
Comments	The data from Chenlo[67] are inconsistent with the data from Surdo.[334] The quality of the fit is therefore poor, and the coefficients should be used with caution.	Note that density data are available only at 25 °C, and therefore conversions of kinematic to dynamic viscosities at other temperatures are subject to systematic errors.	

Table 43. K_2SO_4 - Potassium Sulfate - 7778-80-5

	Density	Viscosity	Heat Capacity
t_{min}/°C	0.0 °C	0.0 °C	25.0 °C
t_{max}/°C	98.7 °C	89.5 °C	100.0 °C
w_{max}	0.152	0.155	0.080
Average residual	0.05 kg·m^{-3}	0.0012 mPa·s	−0.0001 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.18 kg·m^{-3}	0.0078 mPa·s	0.0013 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	239	214	43
Number of inconsistent points	6	0	0
References	82, 155, 158, 177, 228, 245, 265, 309	63, 75, 106, 158, 167, 177, 239, 333, 346	155, 245, 309

Table 44. K_3PO_4 - Potassium Phosphate - 7778-53-2

	Density	Viscosity	Heat Capacity
t_{min}/°C	24.9 °C	20.0 °C	-
t_{max}/°C	25.0 °C	50.0 °C	-
w_{max}	0.209	0.209	-
Average residual	0.16 kg·m^{-3}	0.0000 mPa·s	-
Standard deviation of residual	3.89 kg·m^{-3}	0.0030 mPa·s	-
Number of points in the correlation	14	42	-
Number of inconsistent points	9	9	-
References	67, 89, 334	67, 89	
Comments	The data from Drucker[89] are clearly inconsistent with the data from Chenlo[67] or Surdo.[334] On the other hand, the agreement between Chenlo and Surdo is not that good either (see K_2HPO_4). Use with caution.	Density data are available only at 25 °C, and therefore conversions of kinematic to dynamic viscosities at other temperatures are subject to systematic errors.	

Table 45. KBr - Potassium Bromide - 7758-02-3

	Density	Viscosity	Heat Capacity
t_{min}/°C	0.0 °C	0.0 °C	25.0 °C
t_{max}/°C	95.0 °C	95.0 °C	25.0 °C
w_{max}	0.504	0.462	0.105
Average residual	0.06 kg·m^{-3}	0.0000 mPa·s	0.0000 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.36 kg·m^{-3}	0.0089 mPa·s	0.0010 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	266	347	20
Number of inconsistent points	23	6	0
References	38, 110, 152, 160, 170, 172, 208, 229, 232, 247, 288, 314, 322, 331, 332	63, 123, 122, 160, 170, 172, 208, 232, 247, 311, 345	110, 322

Table 46. KCH_3CO_2 - Potassium Acetate - 127-08-2

	Density	Viscosity	Heat Capacity
t_{min}/°C	15.0 °C	15.0 °C	20.0 °C
t_{max}/°C	55.0 °C	55.0 °C	51.0 °C
w_{max}	0.595	0.595	0.500
Average residual	−0.05 kg·m^{-3}	−0.0030 mPa·s	−0.0007 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.21 kg·m^{-3}	0.0138 mPa·s	0.0063 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	147	148	10
Number of inconsistent points	0	0	0
References	89, 159, 385	89, 159, 205, 385	235
Comments			The ICT[235] reports that the data represent the average *Cp* between (20 and 51) °C. The data were modeled at 35.5 °C.

Table 47. $KCHO_2$ - Potassium Formate - 590-29-4

	Density	Viscosity	Heat Capacity
t_{min}/°C	15.0 °C	15.0 °C	-
t_{max}/°C	55.0 °C	55.0 °C	-
w_{max}	0.678	0.813	-
Average residual	0.02 kg·m^{-3}	−0.0094 mPa·s	-
Standard deviation of residual	0.30 kg·m^{-3}	0.0602 mPa·s	-
Number of points in the correlation	122	140	-
Number of inconsistent points	0	0	-
References	69, 159	69, 159, 295	

Table 48. KCl - Potassium Chloride - 7447-40-7

	Density	Viscosity	Heat Capacity
t_{min}/°C	5.0 °C	5.0 °C	5.0 °C
t_{max}/°C	125.0 °C	150.0 °C	140.0 °C
w_{max}	0.264	0.306	0.258
Average residual	0.06 kg·m^{-3}	−0.0001 mPa·s	−0.0001 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.22 kg·m^{-3}	0.0030 mPa·s	0.0061 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	655	647	315
Number of inconsistent points	45	7	0
References	39, 82, 89, 110, 113, 125, 133, 161, 177, 191, 198, 208, 213, 229, 236, 244, 247, 255, 299, 309, 322, 381	18, 57, 63, 89, 125, 129, 161, 162, 177, 191, 208, 232, 236, 246, 247, 331, 337, 345, 381	210, 244, 248, 255, 303, 309, 322, 329, 348
Comments	To keep the data set size reasonnable, data points where $w < 0.003$ are excluded. The data from Bell[39] are generally scattered and have been excluded.		Data at higher temperature available in Likke[210] and Pabalan.[248]

Table 49. KF - Potassium Fluoride - 7789-23-3

	Density	Viscosity	Heat Capacity
t_{min}/°C	0.0 °C	5.0 °C	25.0 °C
t_{max}/°C	50.0 °C	55.0 °C	130.0 °C
w_{max}	0.424	0.424	0.084
Average residual	0.05 kg·m^{-3}	0.0025 mPa·s	0.0000 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.58 kg·m^{-3}	0.0255 mPa·s	0.0021 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	158	98	57
Number of inconsistent points	0	0	0
References	110, 208, 229, 260, 344	123, 122, 208	110, 303
Comments	Perdersen[260] has detailed data available for 25 °C, with more than 150 densities at different concentrations. Only some of the data are used here. Tamas[344] and Lengyel[208] report values that are suspiciously close (concentrations, when reported in the same units, are identical to 5 significant figures). The two data sets are however not inconsistent with the other data and do not cover quite the same temperature range, so both sets have been kept.		

Table 50. KH_2PO_4 - Potassium Dihydrogen Phosphate - 7778-77-0

	Density	Viscosity	Heat Capacity
t_{min}/°C	20.0 °C	20.0 °C	-
t_{max}/°C	40.0 °C	50.0 °C	-
w_{max}	0.232	0.232	-
Average residual	0.04 kg·m^{-3}	0.0004 mPa·s	-
Standard deviation of residual	0.53 kg·m^{-3}	0.0591 mPa·s	-
Number of points in the correlation	41	60	-
Number of inconsistent points	8	0	-
References	67, 70, 225, 233, 334	67, 233	
Comments	Data from Mullin[233] at $m = 2.2209$ and $t = 30$ °C were changed from (1713 to 1173) kg·m^{-3}. Chenlo[67] clearly overestimates the density, and his data are excluded (see also K_2HPO_4 and K_3PO_4).	The data published for this solute in our previous publication on viscosity were incorrect at $t = (44.95$ and $49.95)$ °C for Chenlo.[67] There might be a local minimum in the apparent viscosity near $w = 0.1$, which would not be modeled correctly. The data are however a bit scattered and difficult to interpret.	

Table 51. $KHCO_3$ - Potassium Bicarbonate - 298-14-6

	Density	Viscosity	Heat Capacity
t_{min}/°C	5.0 °C	25.0 °C	5.0 °C
t_{max}/°C	95.0 °C	25.0 °C	120.0 °C
w_{max}	0.344	0.247	0.095
Average residual	0.03 kg·m^{-3}	0.0000 mPa·s	0.0000 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.15 kg·m^{-3}	0.0044 mPa·s	0.0035 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	66	12	106
Number of inconsistent points	0	0	0
References	37, 229, 326, 356	252	37, 326
Comments	Data at lower concentration available in Sorenson.[326]		Data at lower concentration available in Sorenson.[326]

Table 52. $KHSO_3$ - Potassium Bisulfite - 298-14-6

	Density	Viscosity	Heat Capacity
t_{min}/°C	25.0 °C	-	25.0 °C
t_{max}/°C	25.0 °C	-	25.0 °C
w_{max}	0.106	-	0.106
Average residual	0.01 kg·m^{-3}	-	0.0000 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.16 kg·m^{-3}	-	0.0007 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	8	-	8
Number of inconsistent points	0	-	0
References	37		37

Table 53. KI - Potassium Iodide - 7681-11-0

	Density	Viscosity	Heat Capacity
t_{min}/°C	0.0 °C	5.0 °C	5.0 °C
t_{max}/°C	100.0 °C	95.0 °C	120.0 °C
w_{max}	0.667	0.627	0.476
Average residual	0.02 kg·m^{-3}	−0.0001 mPa·s	0.0002 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.47 kg·m^{-3}	0.0099 mPa·s	0.0115 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	297	245	180
Number of inconsistent points	32	0	1
References	110, 178, 208, 229, 232, 247, 283, 288, 309, 314, 315, 341	63, 85, 122, 178, 208, 232, 247, 311	110, 309, 341
Comments	Data from Prokash[283] assumed constant concentration and molarity measured at 25 °C. The data are inconsistent with the other data sets and have been excluded. Data from Swenson[341] available at lower concentration. The Lengyel[208] and the Swenson[341] data are not in good agreement at higher concentration, but there is not enough information to select one or the other.		Data from Swenson[341] available at lower concentration. There is an unexplained inversion of Solute exp heat capacity in Swenson data at high temperature between $m = 4.0008$ and $m = 5.4786$ There is no mention of this in the original paper. The inversion is the cause of the relatively high standard deviation. There are not enough data from other references at high concentration to be able to check whether this is an error or not. The data were kept but are suspect.

Table 54. KNO_2 - Potassium Nitrite - 7758-09-0

	Density	Viscosity	Heat Capacity
t_{min}/°C	20.0 °C	25.0 °C	-
t_{max}/°C	80.0 °C	25.0 °C	-
w_{max}	0.750	0.623	-
Average residual	−0.04 kg·m^{-3}	0.0011 mPa·s	-
Standard deviation of residual	1.06 kg·m^{-3}	0.0043 mPa·s	-
Number of points in the correlation	55	15	-
Number of inconsistent points	1	0	-
References	78, 325	78	
Comments	Data from Daniel[78] at $M = 0.6005$ are shown as 1029.6. However, the calculated data are 1026.9, and we have corrected it assuming this is a typo.		

Table 55. KNO_3 - Potassium Nitrate - 7757-79-1

	Density	Viscosity	Heat Capacity
t_{min}/°C	5.0 °C	15.0 °C	5.0 °C
t_{max}/°C	95.0 °C	60.0 °C	120.0 °C
w_{max}	0.284	0.495	0.200
Average residual	0.05 kg·m^{-3}	0.0001 mPa·s	0.0000 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.20 kg·m^{-3}	0.0071 mPa·s	0.0010 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	179	146	147
Number of inconsistent points	32	3	0
References	40, 86, 98, 160, 189, 229, 244, 256, 261, 302	63, 86, 160, 171, 304, 331, 339	99, 244, 256
Comments	Korin[189] has only 4 data points at much higher concentration than the balance of the data. His data seem inconsistent and have been excluded. Roy[302] data are generally inconsistent and are excluded.		

Table 56. KOH - Potassium Hydroxide - 1310-58-3

	Density	Viscosity	Heat Capacity
t_{min}/°C	4.0 °C	−14.1 °C	4.0 °C
t_{max}/°C	95.0 °C	40.0 °C	120.0 °C
w_{max}	0.519	0.519	0.465
Average residual	0.06 kg·m^{-3}	0.0282 mPa·s	−0.0004 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.64 kg·m^{-3}	0.1097 mPa·s	0.0018 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	237	50	285
Number of inconsistent points	305	0	2
References	19, 141, 149, 222, 255, 300, 305, 322, 323, 350	149, 182, 323	131, 255, 300, 322
Comments	Data from Akerlof,[19] Hitchcock,[149] Salavera,[305] and Tham[350] generally inconsistent		

Table 57. Li_2SO_4 - Lithium Sulfate - 10377-48-7

	Density	Viscosity	Heat Capacity
t_{min}/°C	0.0 °C	5.0 °C	25.0 °C
t_{max}/°C	65.0 °C	128.6 °C	25.0 °C
w_{max}	0.260	0.260	0.094
Average residual	0.04 kg·m^{-3}	0.0004 mPa·s	0.0000 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.39 kg·m^{-3}	0.0138 mPa·s	0.0092 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	192	179	11
Number of inconsistent points	1	0	0
References	59–61, 146, 176, 258, 376	14, 59, 176	28

Table 58. $LiCH_3CO_2$ - Lithium Acetate - 546-89-4

	Density	Viscosity	Heat Capacity
t_{min}/°C	15.0 °C	15.0 °C	-
t_{max}/°C	45.0 °C	45.0 °C	-
w_{max}	0.047	0.039	-
Average residual	0.01 kg·m^{-3}	0.0002 mPa·s	-
Standard deviation of residual	0.05 kg·m^{-3}	0.0011 mPa·s	-
Number of points in the correlation	35	22	-
Number of inconsistent points	0	0	-
References	385	385	
Comments		There is an unexplained inversion in the (mass frac vs concentration) slope at 25 °C.	

Table 59. LiCl - Lithium Chloride - 7447-41-8

	Density	Viscosity	Heat Capacity
t_{min}/°C	−5.0 °C	−5.0 °C	5.0 °C
t_{max}/°C	127.1 °C	100.0 °C	130.0 °C
w_{max}	0.454	0.460	0.160
Average residual	0.00 kg·m^{-3}	0.0141 mPa·s	0.0000 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	1.13 kg·m^{-3}	0.2060 mPa·s	0.0025 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	592	651	166
Number of inconsistent points	4	12	0
References	47, 113, 128, 160, 166, 208, 218, 229, 247, 246, 292, 331, 332, 359, 374	44, 85, 128, 160, 208, 246, 247, 292, 311, 331, 367, 374	47, 110, 131, 303, 329
Comments	The data are scattered, especially at higher temperature. Data from Brown[47] available at lower concentration. Data available at higher temperature and pressure in Majer.[218] Majer has a lot of duplicate and triplicate data. His average Delta density is reported here.	The viscosity of LiCl solutions at high concentration is very high, and the data are somewhat scattered. The data from Lengyel[208] and Rehman[292] seem inconsistent, but both data sets have been kept in the fit, except for Rehman at $m = 17.8$.	Data from Brown[47] available at lower concentration.

Table 60. $LiNO_3$ - Lithium Nitrate - 7790-69-4

	Density	Viscosity	Heat Capacity
t_{min}/°C	0.0 °C	0.0 °C	20.0 °C
t_{max}/°C	110.0 °C	110.0 °C	20.0 °C
w_{max}	0.624	0.671	0.130
Average residual	0.01 kg·m^{-3}	−0.0005 mPa·s	−0.0006 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.85 kg·m^{-3}	0.0394 mPa·s	0.0046 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	128	104	4
Number of inconsistent points	10	25	0
References	29, 50, 51, 302, 374, 384	29, 50, 51, 302, 374	
Comments	More data are available from Appleby[29] at (18 and 25) °C, but data are not very good.	Data from Roy[302] seem offset by about 0.05 mPa·s. His viscosity also increases much too rapidly with concentration. These data were therefore excluded.	

Table 61. LiOH - Lithium Hydroxide - 1310-65-2

	Density	Viscosity	Heat Capacity
t_{min}/°C	20.0 °C	20.0 °C	25.0 °C
t_{max}/°C	75.0 °C	40.0 °C	25.0 °C
w_{max}	0.113	0.113	0.052
Average residual	0.00 kg·m^{-3}	0.0061 mPa·s	0.0000 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.35 kg·m^{-3}	0.1227 mPa·s	0.0006 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	119	29	15
Number of inconsistent points	5	0	0
References	141, 148, 300, 323, 342	148, 323, 342	132
Comments	Hitchcock[148] used constant molarity concentrations at different temperatures. We assumed that he measured the concentrations at 20 °C and then reused the same solutions at different temperatures.	The data are very scattered.	

Table 62. $Mg(CH_3CO_2)_2$ - Magnesium Acetate - 142-72-3

	Density	Viscosity	Heat Capacity
t_{min}/°C	15.0 °C	15.0 °C	21.0 °C
t_{max}/°C	45.0 °C	45.0 °C	52.0 °C
w_{max}	0.122	0.042	0.140
Average residual	0.01 kg·m^{-3}	0.0005 mPa·s	0.0000 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.04 kg·m^{-3}	0.0018 mPa·s	0.0006 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	33	22	3
Number of inconsistent points	0	0	0
References	385	385	235
Comments			The ICT[235] reports that the data represent the average *Cp* between (21 and 52) °C. The data were modeled at 36.5 °C.

Table 63. $Mg(NO_3)_2$ - Magnesium Nitrate - 10377-60-3

	Density	Viscosity	Heat Capacity
t_{min}/°C	5.0 °C	0.0 °C	5.0 °C
t_{max}/°C	95.0 °C	120.0 °C	120.0 °C
w_{max}	0.439	0.720	0.131
Average residual	-0.07 kg·m^{-3}	0.0290 mPa·s	-0.0003 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.77 kg·m^{-3}	0.2089 mPa·s	0.0017 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	385	235	216
Number of inconsistent points	94	0	0
References	86, 147, 173, 174, 302, 319, 331, 369	86, 147, 302, 319, 369	173
Comments	The data from Wahab[369] at $m = 3.17$ are off by about 5 kg·m^{-3}. Data from Sheerson[319] available at higher temperature. His data are however inconsistent and excluded. Jubin[171] seems to underestimate the density. His densities were measured by volume and are not as accurate as other measurements. Excluded.		

Table 64. $MgCl_2$ - Magnesium Chloride - 7786-30-3

	Density	Viscosity	Heat Capacity
t_{min}/°C	0.0 °C	15.0 °C	5.0 °C
t_{max}/°C	98.7 °C	70.0 °C	120.0 °C
w_{max}	0.324	0.386	0.345
Average residual	0.24 kg·m^{-3}	0.0047 mPa·s	-0.0004 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.76 kg·m^{-3}	0.0850 mPa·s	0.0040 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	386	332	315
Number of inconsistent points	119	85	1
References	41, 49, 64, 73, 113, 160, 177, 228, 264, 267, 299, 307, 332, 357	18, 41, 106, 160, 177, 216, 271, 346	49, 108, 210, 264, 267, 306, 307
Comments	To keep the data set size reasonnable, data points where $w < 0.003$ are excluded. The densities from Bereck[41] are systematically higher than the densities from the other references. This data set has therefore been excluded. The densities from Isono[160] at 3 and 4 molal seem systematically lower than the densities from the other references. This part of Isono's data has therefore been excluded.	Data from Berek[41] at 5.501 m are inconsistent. Data from Afzal[18] at 0.5 M and 30 °C assumed to be 0.96 mPa·s, not 1.96. Data from Afzal excluded because many points are inconsistent.	

Table 65. $MgSO_4$ - Magnesium Sulfate - 7487-88-9

	Density	Viscosity	Heat Capacity
t_{min}/°C	0.0 °C	15.0 °C	25.0 °C
t_{max}/°C	125.0 °C	150.0 °C	130.0 °C
w_{max}	0.268	0.301	0.276
Average residual	0.06 kg·m^{-3}	0.0001 mPa·s	0.0005 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.86 kg·m^{-3}	0.0117 mPa·s	0.0056 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	420	182	68
Number of inconsistent points	22	11	0
References	32, 31, 64, 73, 90, 107, 146, 147, 159, 169, 177, 191, 228, 229, 231, 265, 274, 275, 288, 310, 331, 382	32, 31, 63, 106, 147, 159, 177, 191	210, 265, 275, 278
Comments	To keep the data set size reasonnable, data points where $w < 0.003$ are excluded. Data available at higher temperature in Phutala.[274,275] Motin[231] and Rakshit[288] excluded because inconsistent.	Data available at higher concentration in Chatterji[63] ($w = 0.6$ and 0.7). Including these data in the overall data set however increases the standard deviation significantly. These data are therefore excluded.	Data at higher temperature available in Likke[210] and Phutela.[275]

Table 66. $Mn(NO_3)_2$ - Manganese(II) Nitrate - 10377-66-9

	Density	Viscosity	Heat Capacity
t_{min}/°C	5.0 °C	25.0 °C	5.0 °C
t_{max}/°C	95.0 °C	25.0 °C	120.0 °C
w_{max}	0.084	0.349	0.084
Average residual	0.00 kg·m^{-3}	−0.0005 mPa·s	−0.0002 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.05 kg·m^{-3}	0.0012 mPa·s	0.0009 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	54	6	192
Number of inconsistent points	1	0	0
References	173	235	173

Table 67. $MnCl_2$ - Manganese(II) Chloride - 7773-01-5

	Density	Viscosity	Heat Capacity
t_{min}/°C	15.0 °C	25.0 °C	25.0 °C
t_{max}/°C	75.0 °C	25.0 °C	25.0 °C
w_{max}	0.435	0.420	0.019
Average residual	0.09 kg·m^{-3}	−0.0011 mPa·s	0.0000 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.61 kg·m^{-3}	0.0075 mPa·s	0.0000 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	195	14	9
Number of inconsistent points	0	0	0
References	143, 147, 269, 280, 290, 327, 352	269	327

Table 68. $MnSO_4$ - Manganese(II) Sulfate - 10034-96-5

	Density	Viscosity	Heat Capacity
t_{min}/°C	20.0 °C	20.0 °C	20.0 °C
t_{max}/°C	25.0 °C	80.0 °C	50.0 °C
w_{max}	0.364	0.364	0.150
Average residual	−0.19 kg·m^{-3}	0.0010 mPa·s	0.0007 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	2.11 kg·m^{-3}	0.0438 mPa·s	0.0061 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	33	93	4
Number of inconsistent points	31	15	0
References	33, 34, 81, 147, 284, 313	33, 34, 81, 147	235
Comments	Deckwer[81] generally underestimates the density, while Schmelzer[313] generally overestimates it. However, there is no sufficient evidence to decide between the two data sets. Bakeev[34] generally overestimates the density and has been excluded.	Deckwer[81] concentration data are probably in error, as he is using constant molarity concentrations at different temperatures. We assumed that he measured the concentrations at 20 °C and then reused the same solutions at different temperatures. Therefore, we calculated the mass fraction at 20 °C.	The ICT[235] reports that the data represent the average *Cp* between (20 and 50) °C. The data were modeled at 35 °C.

Table 69. $Na_2C_2O_4$ - Sodium Oxalate - 62-76-0

	Density	Viscosity	Heat Capacity
t_{min}/°C	0.0 °C	0.0 °C	25.0 °C
t_{max}/°C	50.0 °C	50.0 °C	25.0 °C
w_{max}	0.032	0.032	0.032
Average residual	0.02 kg·m^{-3}	0.0003 mPa·s	0.0000 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.18 kg·m^{-3}	0.0026 mPa·s	0.0000 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	18	13	6
Number of inconsistent points	1	0	0
References	343, 354	343	354
Comments	Data available in Taft[343] and Tromans[354] at lower concentration.		

Table 70. Na_2CO_3 - Sodium Carbonate - 497-19-8

	Density	Viscosity	Heat Capacity
t_{min}/°C	0.0 °C	20.0 °C	25.0 °C
t_{max}/°C	100.1 °C	90.0 °C	25.0 °C
w_{max}	0.209	0.309	0.209
Average residual	0.02 kg·m^{-3}	0.0035 mPa·s	0.0001 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.73 kg·m^{-3}	0.0540 mPa·s	0.0005 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	167	63	23
Number of inconsistent points	23	0	0
References	144, 149, 214, 229, 250, 251, 265, 318	76, 149, 251	214, 265
Comments	Molarities for Palaty[251] interpreted as being measured at 25 °C. Palaty[250] obviously uses the same experimental data but at 20 °C. There is no information allowing us to determine at which temperature the molarities were actually determined. The data from Hershey[144] show scatter, especially at higher temperature. The data from Hitchcock[149] are excluded because he significantly underestimates the density compared to other data sets. Data at higher pressure and temperature available from Sharygin.[318]	Molarities for Palaty[251] interpreted as being measured at 25 °C.	

Table 71. Na_2CrO_4 - Sodium Chromate - 7775-11-3

	Density	Viscosity	Heat Capacity
t_{min}/°C	0.0 °C	0.2 °C	-
t_{max}/°C	90.0 °C	89.3 °C	-
w_{max}	0.500	0.500	-
Average residual	0.16 kg·m^{-3}	0.0075 mPa·s	-
Standard deviation of residual	2.82 kg·m^{-3}	0.0479 mPa·s	-
Number of points in the correlation	47	48	-
Number of inconsistent points	0	0	-
References	140, 181, 183	140, 181	

Table 72. Na_2HPO_4 - Disodium Hydrogen Phosphate - 7782-85-6

	Density	Viscosity	Heat Capacity
t_{min}/°C	25.0 °C	20.0 °C	24.0 °C
t_{max}/°C	45.0 °C	50.0 °C	55.0 °C
w_{max}	0.077	0.099	0.073
Average residual	−0.01 kg·m^{-3}	0.0002 mPa·s	−0.0001 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.62 kg·m^{-3}	0.0162 mPa·s	0.0003 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	35	41	2
Number of inconsistent points	12	0	0
References	67, 325, 334, 379	67, 124	235
Comments	Data from Sohnel[325] inconsistent with the other data sets and excluded.		The ICT[235] reports that the data represent the average *Cp* between (24 and 55) °C. The data were modeled at 39.5 °C.

Table 73. Na_2MoO_4 - Sodium Molybdate - 7631-95-0

	Density	Viscosity	Heat Capacity
t_{min}/°C	25.0 °C	-	25.0 °C
t_{max}/°C	80.0 °C	-	25.0 °C
w_{max}	0.350	-	0.032
Average residual	0.09 kg·m^{-3}	-	0.0000 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.29 kg·m^{-3}	-	0.0001 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	30	-	10
Number of inconsistent points	0	-	0
References	245, 325		245

Table 74. Na_2S - Sodium Sulfide - 1313-82-2

	Density	Viscosity	Heat Capacity
t_{min}/°C	25.0 °C	-	25.0 °C
t_{max}/°C	25.0 °C	-	25.0 °C
w_{max}	0.084	-	0.084
Average residual	−0.01 kg·m^{-3}	-	0.0000 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.38 kg·m^{-3}	-	0.0016 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	8	-	8
Number of inconsistent points	0	-	0
References	37		37

Table 75. $Na_2S_2O_3$ - Sodium Thiosulfate - 7772-98-7

	Density	Viscosity	Heat Capacity
t_{min}/°C	25.0 °C	11.9 °C	25.0 °C
t_{max}/°C	80.0 °C	50.0 °C	25.0 °C
w_{max}	0.600	0.494	0.037
Average residual	0.16 kg·m^{-3}	−0.0012 mPa·s	0.0000 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.51 kg·m^{-3}	0.1119 mPa·s	0.0001 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	38	85	17
Number of inconsistent points	0	13	0
References	245, 325	175, 217	245
Comments		The data from Kalita[175] at higher concentration do not seem to be very accurate. The experimental apparent density at $x = 0.18$ is lower than at $x = 0.14$, while if the trend was maintained it should have been lower. In no other solute can a "s" curve like this be seen. There is a high apparent density value at $w = 0$, a low around $w = 0.1$, another high around $w = 0.6$, followed by another low around $w = 0.65$. The model can fit all the data, but at the cost of a significant decrease in accuracy at lower concentration. The fit has therefore been limited to $w < 0.5$.	

Table 76. Na_2SO_3 - Sodium Sulfite - 7757-83-7

	Density	Viscosity	Heat Capacity
t_{min}/°C	25.0 °C	25.0 °C	-
t_{max}/°C	80.0 °C	40.0 °C	-
w_{max}	0.200	0.060	-
Average residual	−0.54 kg·m^{-3}	0.0000 mPa·s	-
Standard deviation of residual	2.82 kg·m^{-3}	0.0029 mPa·s	-
Number of points in the correlation	36	20	-
Number of inconsistent points	0	0	-
References	325, 360	363	

Table 77. Na_2SO_4 - Sodium Sulfate - 7757-82-6

	Density	Viscosity	Heat Capacity
t_{min}/°C	0.0 °C	15.0 °C	25.0 °C
t_{max}/°C	125.0 °C	150.0 °C	140.4 °C
w_{max}	0.325	0.331	0.211
Average residual	0.14 kg·m^{-3}	0.0010 mPa·s	−0.0002 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.47 kg·m^{-3}	0.0064 mPa·s	0.0040 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	402	222	106
Number of inconsistent points	16	3	0
References	64, 73, 82, 107, 109, 120, 160, 178, 191, 214, 228, 249, 265, 274, 309, 310, 376	75, 106, 109, 120, 160, 178, 191, 346	74, 210, 214, 245, 249, 265, 309
Comments	To keep the size of the data set reasonable, data where $w < 0.003$ are excluded. The data from Pabalan[249] were excluded. The data are probably good, but the pressure correction at 20 MPa becomes significant. Data at higher temp are available from the same reference. Data available in Phutela[274] at higher pressure and temperature.		Data at higher temperature available from Likke[210] and Pabalan.[249]

Table 78. Na_2WO_4 - Sodium Tungstate - 13472-45-2

	Density	Viscosity	Heat Capacity
t_{min}/°C	20.0 °C	-	25.0 °C
t_{max}/°C	80.0 °C	-	25.0 °C
w_{max}	0.400	-	0.045
Average residual	0.00 kg·m^{-3}	-	0.0000 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.20 kg·m^{-3}	-	0.0001 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	27	-	11
Number of inconsistent points	0	-	0
References	245, 325		245

Table 79. Na_3PO_4 - Sodium Phosphate - 7601-54-9

	Density	Viscosity	Heat Capacity
t_{min}/°C	25.0 °C	20.0 °C	25.0 °C
t_{max}/°C	80.0 °C	50.0 °C	25.0 °C
w_{max}	0.300	0.076	0.028
Average residual	0.00 kg·m^{-3}	0.0000 mPa·s	0.0002 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.62 kg·m^{-3}	0.0026 mPa·s	0.0007 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	29	35	7
Number of inconsistent points	5	0	0
References	67, 204, 325, 334	67	204
Comments	Chemlo[67] systematically overestimates density and is excluded.	Only Chemlo[67] data available. Use with caution.	

Table 80. $NaAl(OH)_4$ - Sodium Aluminate - 11138-49-1

	Density	Viscosity	Heat Capacity
t_{min}/°C	22.0 °C	22.0 °C	-
t_{max}/°C	90.0 °C	75.0 °C	-
w_{max}	0.380	0.995	-
Average residual	−0.15 kg·m^{-3}	−0.0028 mPa·s	-
Standard deviation of residual	2.02 kg·m^{-3}	0.1297 mPa·s	-
Number of points in the correlation	219	113	-
Number of inconsistent points	84	0	-
References	188, 209, 324	209, 324	
Comments	The CAS number is for $NaAlO_2$. The form in solution is however $NaAl(OH)_4$. See detailed notes on the methodology used for this solute in the Supporting Information.	See detailed notes on the methodology used for this solute in the Supporting Information.	

Table 81. NaBr - Sodium Bromide - 7647-15-6

	Density	Viscosity	Heat Capacity
t_{min}/°C	0.0 °C	5.0 °C	5.0 °C
t_{max}/°C	95.0 °C	60.0 °C	120.0 °C
w_{max}	0.548	0.540	0.439
Average residual	0.14 kg·m^{-3}	−0.0018 mPa·s	0.0000 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.71 kg·m^{-3}	0.0147 mPa·s	0.0046 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	291	217	262
Number of inconsistent points	20	22	0
References	38, 88, 110, 113, 130, 133, 160, 179, 229, 314, 315, 322, 331, 359, 383	88, 122, 123, 159, 311, 347	110, 179, 322, 348, 383
Comments	Baxter[38] and Doménech[88] data generally not accurate and excluded	Goldsack[122] data at $m = 6$ and 7 mol·kg^{-1} inconsistent and excluded.	

Table 82. $NaCH_3CO_2$ - Sodium Acetate - 127-09-3

	Density	Viscosity	Heat Capacity
t_{min}/°C	5.0 °C	25.0 °C	5.0 °C
t_{max}/°C	95.0 °C	55.0 °C	120.0 °C
w_{max}	0.082	0.456	0.038
Average residual	0.01 kg·m^{-3}	0.0061 mPa·s	0.0000 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.14 kg·m^{-3}	0.0509 mPa·s	0.0010 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	93	25	133
Number of inconsistent points	7	0	0
References	25, 35, 36, 69, 89, 186, 187, 288, 296, 385	63, 69, 89, 296, 385	15, 25, 35
Comments	Data from Rakshit[288] and from Banipal[36] are inconsistent and have been excluded. Data available at lower concentration from Ballerat-Brusserolles.[15]		Data available at lower concentration from Ballerat-Brusserolles.[15] The data from Ackermann[35] are old and are offset by about (0.01 to 0.02) kJ·kg^{-1}·K^{-1} compared to more recent data. It also goes to much higher concentration, but because of the "offset" it must be excluded.

Table 83. $NaCHO_2$ - Sodium Formate - 141-53-7

	Density	Viscosity	Heat Capacity
t_{min}/°C	25.0 °C	25.0 °C	0.0 °C
t_{max}/°C	45.0 °C	25.0 °C	120.0 °C
w_{max}	0.406	0.008	0.162
Average residual	0.01 kg·m^{-3}	0.0000 mPa·s	−0.0001 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.15 kg·m^{-3}	0.0002 mPa·s	0.0033 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	99	5	51
Number of inconsistent points	4	0	1
References	69, 211, 187, 378	69	15
Comments		This fit is really more an indication than anything else as the maximum available concentration is too low to be meaningful.	

Table 84. NaCl - Sodium Chloride - 7647-14-5

	Density	Viscosity	Heat Capacity
t_{min}/°C	0.0 °C	5.0 °C	1.5 °C
t_{max}/°C	140.0 °C	154.0 °C	120.0 °C
w_{max}	0.266	0.264	0.261
Average residual	0.07 kg·m^{-3}	0.0006 mPa·s	0.0000 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.32 kg·m^{-3}	0.0045 mPa·s	0.0049 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	869	552	356
Number of inconsistent points	13	17	0
References	26, 64, 73, 82, 107, 110, 113, 125, 133, 161, 176, 191, 198, 208, 220, 226, 229, 231, 244, 247, 266, 267, 299, 322, 358, 381	57, 106, 161, 125, 165, 176, 184, 185, 191, 201, 208, 230, 232, 247, 311, 340, 347, 381	26, 30, 100, 110, 210, 266, 267, 306, 322, 329, 348
Comments	To limit the data set size, only data where $w \geq 0.003$ are reported.		Data at higher temperature available in Likke.[210] Data available at lower concentration in Allred,[26] Fortier.[110]

Table 85. $NaClO_3$ - Sodium Chlorate - 7775-09-9

	Density	Viscosity	Heat Capacity
t_{min}/°C	25.0 °C	25.0 °C	25.0 °C
t_{max}/°C	35.0 °C	65.0 °C	25.0 °C
w_{max}	0.501	0.583	0.272
Average residual	0.01 kg·m^{-3}	−0.0003 mPa·s	0.0000 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.39 kg·m^{-3}	0.0181 mPa·s	0.0004 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	48	46	13
Number of inconsistent points	3	0	0
References	56, 301	56, 63, 164	301

Table 86. NaF - Sodium Fluoride - 7681-49-4

	Density	Viscosity	Heat Capacity
t_{min}/°C	0.0 °C	5.0 °C	5.0 °C
t_{max}/°C	98.7 °C	55.0 °C	120.0 °C
w_{max}	0.037	0.039	0.029
Average residual	0.02 kg·m^{-3}	0.0003 mPa·s	0.0000 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.24 kg·m^{-3}	0.0051 mPa·s	0.0014 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	226	67	176
Number of inconsistent points	6	3	0
References	110, 195, 228, 229, 260, 309, 383	85, 122, 195, 238	110, 309, 383
Comments	The data from Krishnamurty[195] are inconsistent and have been excluded.	Data available at lower concentration in Nightingale.[238] In his paper Nightingale refers to concentrations as molar, but in Table 2 they are labeled as mol/1000 g. We have assumed the text is correct.	Data at lower concentration available from Ziemer.[383]

Table 87. NaH_2PO_4 - Sodium Dihydrogen Phosphate - 7758-80-7

	Density	Viscosity	Heat Capacity
t_{min}/°C	25.0 °C	20.0 °C	24.0 °C
t_{max}/°C	45.0 °C	50.0 °C	55.0 °C
w_{max}	0.357	0.300	0.200
Average residual	0.04 kg·m^{-3}	0.0016 mPa·s	−0.0003 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.38 kg·m^{-3}	0.0070 mPa·s	0.0025 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	88	53	5
Number of inconsistent points	16	3	0
References	67, 224, 325, 334, 379	48, 67, 124	235
Comments			The ICT[235] reports that the data represent the average *Cp* between (24 and 55) °C. The data were modeled at 39.5 °C.

Table 88. $NaHCO_3$ - Sodium Bicarbonate - 144-55-8

	Density	Viscosity	Heat Capacity
t_{min}/°C	0.0 °C	20.0 °C	25.0 °C
t_{max}/°C	125.0 °C	30.0 °C	25.0 °C
w_{max}	0.126	0.084	0.083
Average residual	0.03 kg·m^{-3}	0.0001 mPa·s	0.0000 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.85 kg·m^{-3}	0.0020 mPa·s	0.0002 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	145	12	20
Number of inconsistent points	181	0	0
References	37, 96, 144, 229, 250, 251, 265, 291, 318, 355	251	37, 265
Comments	Data from Rashkovskaya[291] inconsistent and excluded. Data available at higher temperature in Ellis.[96] Data available at higher temperature and pressure in Sharygin.[318] Molarities from Palaty[251] interpreted as being measured at 25 °C. Palaty[250] in his 1994 paper obviously use the same experimental data but reports values at 20 °C. There is no indication allowing us to determine at which temperature the molarities were determined. The data from Trypuc[355] are not very accurate but have been kept as they are the highest concentration available.	Molarities from Palaty[251] interpreted as being measured at 25 °C.	

Table 89. NaHS - Sodium Hydrogen Sulfide - 16721-80-5

	Density	Viscosity	Heat Capacity
t_{min}/°C	10.0 °C	-	10.0 °C
t_{max}/°C	125.0 °C	-	40.0 °C
w_{max}	0.053	-	0.052
Average residual	0.05 kg·m^{-3}	-	0.0000 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.35 kg·m^{-3}	-	0.0020 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	49	-	29
Number of inconsistent points	0	-	0
References	37, 96		37
Comments	Data at higher temperature available in Ellis.[96]		

Table 90. $NaHSO_3$ - Sodium Hydrogen Sulfite - 7631-90-5

	Density	Viscosity	Heat Capacity
t_{min}/°C	10.0 °C	-	25.0 °C
t_{max}/°C	40.0 °C	-	25.0 °C
w_{max}	0.243	-	0.093
Average residual	−0.07 kg·m^{-3}	-	0.0000 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	1.85 kg·m^{-3}	-	0.0009 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	103	-	16
Number of inconsistent points	5	-	0
References	37, 71		37
Comments	The data sets from Barbero[37] and Choudary[71] seem inconsistent, but it is not possible to evaluate which set best fit the solution density. There seems to be a lot of variability in Choudary's data. It is however the only data set at temperatures different than 25 °C.		

Table 91. $NaHSO_4$ - Sodium Hydrogen Sulfate - 7681-38-1

	Density	Viscosity	Heat Capacity
t_{min}/°C	25.0 °C	18.0 °C	21.0 °C
t_{max}/°C	45.0 °C	18.0 °C	21.0 °C
w_{max}	0.298	0.375	0.200
Average residual	0.03 kg·m^{-3}	0.0004 mPa·s	0.0002 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.17 kg·m^{-3}	0.0048 mPa·s	0.0044 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	45	5	5
Number of inconsistent points	0	0	0
References	379	235	235

Table 92. NaI - Sodium Iodide - 7681-82-5

	Density	Viscosity	Heat Capacity
t_{min}/°C	10.0 °C	5.0 °C	25.0 °C
t_{max}/°C	100.0 °C	97.8 °C	100.0 °C
w_{max}	0.629	0.629	0.232
Average residual	0.07 kg·m^{-3}	0.0005 mPa·s	0.0000 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.49 kg·m^{-3}	0.0221 mPa·s	0.0005 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	99	166	22
Number of inconsistent points	10	0	0
References	110, 208, 213, 229, 232, 308, 314, 315, 359	13, 85, 91, 122, 208, 232, 304, 311	110, 308
Comments	Data from Scott[314] (1930) are at high concentration and seem to underestimate the density. The data from the same author 1934 paper seem bang on. Data at lower concentration available in Fortier.[110]	Note that data from Satoh[311] are inconsistent if using *absolute* viscosity but are consistent if interpreted as *relative* viscosity. Data at higher pressure available in Abdulagatov.[13]	Data at lower concentration available in Fortier.[110]

Table 93. $NaMnO_4$ - Sodium Permanganate - 10101-50-5

	Density	Viscosity	Heat Capacity
t_{min}/°C	1.4 °C	-	-
t_{max}/°C	37.5 °C	-	-
w_{max}	0.256	-	-
Average residual	−0.04 kg·m^{-3}	-	-
Standard deviation of residual	0.25 kg·m^{-3}	-	-
Number of points in the correlation	20	-	-
Number of inconsistent points	0	-	-
References	372		

Table 94. $NaNO_2$ - Sodium Nitrite - 7632-00-0

	Density	Viscosity	Heat Capacity
t_{min}/°C	15.0 °C	-	-
t_{max}/°C	20.0 °C	-	-
w_{max}	0.200	-	-
Average residual	0.01 kg·m^{-3}	-	-
Standard deviation of residual	0.16 kg·m^{-3}	-	-
Number of points in the correlation	15	-	-
Number of inconsistent points	0	-	-
References	134, 235		
Comments	The data are very fragmentary. Use with caution.		

Table 95. $NaNO_3$ - Sodium Nitrate - 7631-99-4

	Density	Viscosity	Heat Capacity
t_{min}/°C	0.0 °C	10.0 °C	2.0 °C
t_{max}/°C	100.0 °C	60.0 °C	120.0 °C
w_{max}	0.489	0.552	0.460
Average residual	0.02 kg·m^{-3}	0.0001 mPa·s	0.0001 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.81 kg·m^{-3}	0.0300 mPa·s	0.0027 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	259	338	206
Number of inconsistent points	7	2	0
References	10, 40, 86, 160, 180, 229, 256, 261, 287, 302	63, 86, 160, 165, 180, 217, 304, 338, 347	58, 99, 100, 256, 301
Comments	Data from Isono[160] at $m = 8$ molal are systematically off by about 5 kg·m^{-3} and have been excluded.		

Table 96. NaOH - Sodium Hydroxide - 1310-73-2

	Density	Viscosity	Heat Capacity
t_{min}/°C	4.0 °C	12.5 °C	4.0 °C
t_{max}/°C	120.0 °C	70.0 °C	120.0 °C
w_{max}	0.503	0.560	0.303
Average residual	0.07 kg·m^{-3}	0.0164 mPa·s	−0.0008 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	1.50 kg·m^{-3}	0.1152 mPa·s	0.0060 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	517	180	322
Number of inconsistent points	292	0	0
References	20, 26, 141, 145, 149, 157, 188, 193, 214, 219, 229, 255, 265, 300, 305, 322–324, 362	149, 157, 194, 323, 324, 362	26, 35, 74, 132, 214, 255, 300, 322
Comments	Molarity from Vazquez[362] interpreted to have been measured at 25 °C. Data available at lower concentration in Allred.[26] Data from Arkelof,[20] Krey,[193] and Maksimova[219] excluded because of scatter even if not all points have a high residual: their observed densities are significantly lower than the densities from the other data sets.	Molarities from Vazquez[362] interpreted to have been measured at 25 °C.	Data available at lower concentration in Ballerat-Busserolles.[35]

Table 97. NH_3 - Ammonia - 7664-41-7

	Density	Viscosity	Heat Capacity
t_{min}/°C	20.0 °C	19.9 °C	−13.2 °C
t_{max}/°C	140.7 °C	39.9 °C	100.4 °C
w_{max}	0.522	0.340	0.321
Average residual	−0.11 kg·m^{-3}	−0.0007 mPa·s	−0.0002 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	2.26 kg·m^{-3}	0.0127 mPa·s	0.0054 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	205	25	51
Number of inconsistent points	128	0	13
References	151, 215, 243, 291, 305	43, 111, 206	25, 62, 112, 150
Comments	The H_2O-NH_3 is highly ideal and not well described by our model. To keep the error reasonable we have decided to limit the fit above to the range $0 \le w_{NH3} < 0.53$. The available data at higher concentration are presented in the Supporting Information.		Data at higher pressure available in Fujita[112] and Hnedkovsky.[150] The fit covers the entire range $0 \le w_{NH3} \le 1$. A better fit could be obtained if the concentration range was more limited.

Table 98. NH_4Cl - Ammonium Chloride - 12125-02-9

	Density	Viscosity	Heat Capacity
t_{min}/°C	12.5 °C	10.0 °C	10.0 °C
t_{max}/°C	100.0 °C	73.5 °C	40.0 °C
w_{max}	0.400	0.324	0.141
Average residual	0.10 kg·m^{-3}	0.0005 mPa·s	0.0000 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.52 kg·m^{-3}	0.0024 mPa·s	0.0003 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	364	265	58
Number of inconsistent points	2	9	0
References	24, 147, 160, 178, 229, 231, 259, 291	63, 79, 115, 122, 147, 159, 171, 178, 230, 254, 304	25, 207, 301

Table 99. NH_4HCO_3 - Ammonium Hydrogen Carbonate - 1066-33-7

	Density	Viscosity	Heat Capacity
t_{min}/°C	19.9 °C	-	-
t_{max}/°C	49.9 °C	-	-
w_{max}	0.367	-	-
Average residual	−1.61 kg·m^{-3}	-	-
Standard deviation of residual	8.25 kg·m^{-3}	-	-
Number of points in the correlation	96	-	-
Number of inconsistent points	0	-	-
References	355, 356		
Comments	Data available only at high concentration. Use with caution at low concentration.		

Table 100. NH_4NO_3 - Ammonium Nitrate - 6484-52-2

	Density	Viscosity	Heat Capacity
t_{min}/°C	25.0 °C	15.0 °C	25.0 °C
t_{max}/°C	95.0 °C	60.0 °C	25.0 °C
w_{max}	0.787	0.785	0.642
Average residual	−0.02 kg·m^{-3}	0.0013 mPa·s	0.0002 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	1.19 kg·m^{-3}	0.0110 mPa·s	0.0021 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	152	277	17
Number of inconsistent points	46	24	0
References	16, 51, 52, 54, 115, 301, 302, 316	51, 52, 54, 53, 63, 115, 230, 365	301
Comments	Data from Getman[115] and Roy inconsistent and excluded.		

Table 101. $Ni(NO_3)_2$ - Nickel(II) Nitrate - 13138-45-9

	Density	Viscosity	Heat Capacity
t_{min}/°C	5.0 °C	24.7 °C	5.0 °C
t_{max}/°C	95.0 °C	102.7 °C	120.0 °C
w_{max}	0.422	0.422	0.086
Average residual	0.03 kg·m^{-3}	0.0005 mPa·s	0.0000 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.19 kg·m^{-3}	0.0041 mPa·s	0.0010 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	72	48	144
Number of inconsistent points	6	0	0
References	46, 86	11, 86	46
Comments	The data from Doan[86] are not consistent at low concentration. It might also be inconsistent at high concentration, but there is nothing to compare it against. Use with caution for $w_{Ni(NO3)2} > 0.1$. Data available at lower concentration from Brown.[46]	Data at higher pressure and temperature available in Abdulagatov.[11]	

Table 102. $NiCl_2$ - Nickel(II) Chloride - 7718-54-9

	Density	Viscosity	Heat Capacity
t_{min}/°C	15.0 °C	14.9 °C	25.0 °C
t_{max}/°C	75.0 °C	50.0 °C	25.0 °C
w_{max}	0.411	0.424	0.411
Average residual	−0.01 kg·m^{-3}	0.0047 mPa·s	−0.0002 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.59 kg·m^{-3}	0.1037 mPa·s	0.0011 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	253	160	30
Number of inconsistent points	12	0	0
References	87, 102, 143, 257, 267, 270, 279, 289, 313, 328, 330	18, 87, 216, 270	267, 328
Comments		Molarity from Afzal[18] was interpreted to have been measured at 25 °C.	

Table 103. $NiSO_4$ - Nickel(II) Sulfate - 7786-81-4

	Density	Viscosity	Heat Capacity
t_{min}/°C	15.0 °C	15.0 °C	41.0 °C
t_{max}/°C	60.0 °C	60.0 °C	41.0 °C
w_{max}	0.353	0.353	0.150
Average residual	0.05 kg·m^{-3}	−0.0009 mPa·s	−0.0006 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.36 kg·m^{-3}	0.0230 mPa·s	0.0045 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	105	99	3
Number of inconsistent points	3	0	0
References	161, 273, 313	161, 273	235

Table 104. $Pb(NO_3)_2$ - Lead(II) Nitrate - 10099-74-8

	Density	Viscosity	Heat Capacity
t_{min}/°C	18.0 °C	25.0 °C	-
t_{max}/°C	25.0 °C	50.0 °C	-
w_{max}	0.332	0.375	-
Average residual	−0.08 kg·m^{-3}	0.0002 mPa·s	-
Standard deviation of residual	1.48 kg·m^{-3}	0.0598 mPa·s	-
Number of points in the correlation	13	14	-
Number of inconsistent points	5	0	-
References	86, 147, 288, 387	63, 86, 147	
Comments	Doan,[86] Heyweiller,[387] and Herz[147] are consistent with each other, while Rakshit[288] is not. Rakshit has therefore been excluded, but additional data would be welcome.		

Table 105. SO_2 - Sulfur Dioxide - 7446-09-5

	Density	Viscosity	Heat Capacity
t_{min}/°C	25.0 °C	-	25.0 °C
t_{max}/°C	25.0 °C	-	103.1 °C
w_{max}	0.133	-	0.053
Average residual	0.10 kg·m^{-3}	-	−0.0001 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.29 kg·m^{-3}	-	0.0011 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	22	-	22
Number of inconsistent points	0	-	0
References	37, 317		37, 317
Comments			Data at higher temperature (up to 350 °C) available in Sharygin.[317]

Table 106. $Sr(NO_3)_2$ - Strontium Nitrate - 10042-76-9

	Density	Viscosity	Heat Capacity
t_{min}/°C	5.0 °C	25.0 °C	5.0 °C
t_{max}/°C	95.0 °C	25.0 °C	120.0 °C
w_{max}	0.438	0.388	0.388
Average residual	0.04 kg·m^{-3}	0.0001 mPa·s	−0.0001 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.50 kg·m^{-3}	0.0010 mPa·s	0.0032 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	125	7	216
Number of inconsistent points	5	0	0
References	86, 173, 221, 331	86	173
Comments	Data from Sugden[331] inconsistent and excluded.		

Table 107. $SrCl_2$ - Strontium Chloride - 10476-85-4

	Density	Viscosity	Heat Capacity
t_{min}/°C	15.0 °C	10.0 °C	25.0 °C
t_{max}/°C	98.8 °C	91.3 °C	100.0 °C
w_{max}	0.284	0.454	0.142
Average residual	−0.01 kg·m^{-3}	−0.0014 mPa·s	−0.0001 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	1.25 kg·m^{-3}	0.0393 mPa·s	0.0007 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	98	195	28
Number of inconsistent points	21	2	14
References	147, 160, 229, 264, 254, 277, 307	17, 18, 147, 160, 254, 347	108, 264, 307
Comments	Data from Paranjpe[254] inconsistent and excluded.		Data from Fedyainov[108] inconsistent and excluded.

Table 108. Sucrose - 57-50-1

	Density	Viscosity	Heat Capacity
t_{min}/°C	15.0 °C	15.0 °C	-
t_{max}/°C	55.0 °C	55.0 °C	-
w_{max}	0.507	0.507	-
Average residual	−0.02 kg·m^{-3}	−0.0069 mPa·s	-
Standard deviation of residual	0.07 kg·m^{-3}	0.0245 mPa·s	-
Number of points in the correlation	82	81	-
Number of inconsistent points	0	0	-
References	159, 222	159	
Comments	As for ethanol, these data are presented as a "proof of concept" that the density model works with nonionic organic solutes. It should not be considered a definite review of this particular system.	These data are presented as a "proof of concept" that the viscosity model works with nonionic organic solutes. It should not be considered a definite review of this particular system.	

Table 109. $TiOSO_4$ - Titanyl Sulfate - 13825-74-6

	Density	Viscosity	Heat Capacity
t_{min}/°C	25.0 °C	-	-
t_{max}/°C	50.0 °C	-	-
w_{max}	0.486	-	-
Average residual	−0.05 kg·m^{-3}	-	-
Standard deviation of residual	1.79 kg·m^{-3}	-	-
Number of points in the correlation	76	-	-
Number of inconsistent points	0	-	-
References	391		

Table 110. $Zn(NO_3)_2$ - Zinc Nitrate - 7779-88-6

	Density	Viscosity	Heat Capacity
t_{min}/°C	5.0 °C	0.0 °C	5.0 °C
t_{max}/°C	95.0 °C	50.0 °C	120.0 °C
w_{max}	0.595	0.582	0.077
Average residual	0.04 kg·m^{-3}	−0.0004 mPa·s	−0.0002 kJ·kg^{-1}·K^{-1}
Standard deviation of residual	0.37 kg·m^{-3}	0.0381 mPa·s	0.0007 kJ·kg^{-1}·K^{-1}
Number of points in the correlation	283	222	144
Number of inconsistent points	106	0	0
References	46, 86, 163, 368	86, 368	46
Comments	Data available at lower concentration in Brown,[46] Jain,[163] and Wahab.[368] Data from Jain inconsistent and excluded.		Data available at lower concentration in Brown.[46]

Table 111. $ZnCl_2$ - Zinc Chloride - 7646-85-7

	Density	Viscosity	Heat Capacity
t_{min}/°C	15.0 °C	25.0 °C	-
t_{max}/°C	75.0 °C	25.0 °C	-
w_{max}	0.520	0.520	-
Average residual	−0.01 kg·m^{-3}	0.0050 mPa·s	-
Standard deviation of residual	0.65 kg·m^{-3}	0.0114 mPa·s	-
Number of points in the correlation	191	13	-
Number of inconsistent points	0	0	-
References	143, 281, 290, 371	371	

Table 112. $ZnSO_4$ - Zinc Sulfate - 7733-02-0

	Density	Viscosity	Heat Capacity
t_{min}/°C	15.0 °C	15.0 °C	-
t_{max}/°C	60.0 °C	55.0 °C	-
w_{max}	0.368	0.318	-
Average residual	0.04 kg·m^{-3}	−0.0001 mPa·s	-
Standard deviation of residual	1.01 kg·m^{-3}	0.0311 mPa·s	-
Number of points in the correlation	221	46	-
Number of inconsistent points	35	138	-
References	23, 34, 147, 161, 286, 336	34, 147, 161, 336	
Comments	Data from Bakkev[34] inconsistent and excluded.	The data from Bakeev[34] and Suryanarayana[336] are not consistent with the data from Isono[147] and Herz.[161] The latter look more self-consistent and are generally more reliable than the former, but this is not based on any statistical analysis . Therefore, the results should be used with caution.	

and in the Supporting Information.The solutes are listed in alphabetical order of their formula, and their common name and CAS number are included. These tables present basic statistical data (average residual, standard deviation of the residuals, number of data points used and not used in the calculation of the coefficients), maximum mass fraction, minimum and maximum temperature of the data used in the calculation of the coefficients, references, and comments. To save space, the actual coefficients and the predicted value at $w = 0.1$ and $t = 25$ °C and $w = 0.2$ and $t = 100$ °C are not listed but are found in the file _PropertyAqueousSolutions.xls in the Supporting Information.

Acknowledgment

Edward Cooper contributed to the initial data gathering while working on our density paper. He also came upon equations 10 and 11 and demonstrated that they were promising equations to use in order to fit the solute heat capacity.

Supporting Information Available:

Calculation spreadsheets for all the data presented in this paper are available, each solute or system having its own Excel spreadsheet. The Excel file "_PropertiesAqueousSolution.xls" contains a summary of all the data and a Visual Basic program that allows Excel to calculate the density, viscosity, or heat capacity of

a solution. The references are listed in the file ReferenceMaster.xls. Finally, a file named _Read_Me_First.doc is included and should be referred to for more details, especially regarding security and the execution of macros. This material is available free of charge via the Internet at http://pubs.acs.org.

Literature Cited

(1) Pitzer K. S. (ed.) *Activity Coefficients in Electrolyte Solutions*, 2nd ed.; CRC Press: Boca Raton, FL, 1991.

(2) Könisberger, E. Solubility equilibria. From data optimization to process simulation. *Pure Appl. Chem.* **2002**, *74*, 1831–1841.

(3) Laliberté, M.; Cooper, W. E. Model for Calculating the Density of Aqueous Electrolyte Solutions. *J. Chem. Eng. Data* **2004**, *49*, 1141–1151.

(4) Laliberté, M. Model for Calculating the Viscosity of Aqueous Solutions. *J. Chem. Eng. Data* **2007**, *52*, 321–335 (with corrections in **2007**, *52*, 1507−1508).

(5) International Association for the Properties of Water and Steam, Revised Release on the IAPWS Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam, Lucerne, Switzerland, 2007 (http://www.iapws.org/relguide/IF97-Rev.pdf).

(6) Archer, D. G.; Carter, R. W. Thermodynamic Properties of the NaCl + H_2O System. 4. Heat Capacities of H_2O and NaCl(aq) in Cold-Stable and Supercooled States. *J. Phys. Chem. B* **2000**, *112*, 8563–8584.

(7) Bevington, P. R. *Data Reduction and Error Analysis for the Physical Sciences*; McGraw-Hill: New York, 1969.

(8) Reynolds, J. G.; Carter, R. Density model for sodium hydroxide-sodium aluminate solutions. *Hydrometallurgy* **2007**, *89*, 233–241.

(9) Reynolds, J. G.; Carter, R. The Laliberté-Cooper density model: Self-consistency and a new method of parameterization. *Fluid Phase Equilib.* **2008**, *266*, 14–20.

(10) Abdulagatov, I. M.; Azizov, N. D. Densities and Apparent Molar Volumes of Aqueous $NaNO_3$ Solutions at Temperatures from 292 to 573 K and at Pressures Up to 30 MPa. *J. Solution Chem.* **2003**, *32*, 573–599.

(11) Abdulagatov, I. M.; Zeinalova, A. B.; Azizov, N. D. Viscosity of aqueous $Ni(NO_3)_2$ solutions at temperatures from (297 to 475) K and at pressures up to 30 MPa and concentration between (0.050 and 2.246) mol · kg^{-1}. *J. Chem. Thermodyn.* **2006**, *38*, 179–189.

(12) Abdulagatov, I. M.; Zeinalova, A. A.; Azizov, N. D. Viscosity of the Aqueous $Ca(NO_3)_2$ Solutions at Temperatures from 298 to 573 K and at Pressure up to 40 MPa. *J. Chem. Eng. Data* **2004**, *49*, 1444–1450.

(13) Abdulagatov, I. M.; Zeinalova, A. B.; Azizov, N. D. Viscosity of Aqueous Electrolyte Solutions at High Temperatures and High Pressures. Viscosity B-coefficient. Sodium Iodide. *J. Chem. Eng. Data* **2006**, *51*, 1645–1659.

(14) Abdulagatov, I. M.; Azizov, N. D. Viscosity for Aqueous Li_2SO_4 Solutions at Temperatures from 298 to 575 K and at Pressure up to 30 MPa. *J. Chem. Eng. Data* **2003**, *48*, 1549–1556.

(15) Ackermann, T.; Schreiner, F. Molwärmen und Entropien einiger Fettsäuren und ihrer Anionen in wäβriger Lösung (Molar heat and entropies of some fatty acids and their anions in aqueous solution). *Z. Elektrochem.* **1958**, *62*, 1143–1151.

(16) Adams, L. H. Equilibrium in Binary Systems Under Pressure. III. The Influence of Pressure on the Solubility of Ammonium Nitrate in Water at 25°C. *J. Am. Chem. Soc.* **1932**, *54*, 4520–4537.

(17) Abdulagatov, I. M.; Aziov, N. D. Experimental Study on the Effect of Temperature, Pressure, and Concentration on the Viscosity of Aqueous $SrCl_2$ Solutions in the Range of (293 to 473) K and (0.1 to 20) MPa. *J. Chem. Eng. Data* **2007**, *52*, 841–850.

(18) Afzal, M.; Saleem, M.; Mahmood, M. T. Temperature and Concentration Dependence of Viscosity of Aqueous Electrolytes from 20 to 50 °C. Chlorides of Na^+, K^+, Mg^{2+}, Ca^{2+}, Ba^{2+}, Sr^{2+}, Co^{2+}, Ni^{2+}, Cu^{2+}, and Cr^{3+}. *J. Chem. Eng. Data* **1989**, *34*, 339–346.

(19) Akerlof, G.; Bender, P. The Density of Aqueous Solutions of Potassium Hydroxide. *J. Am. Chem. Soc.* **1941**, *63*, 1085–1088.

(20) Akerlof, G.; Kegeles, G. The density of aqueous solutions of sodium hydroxide. *J. Am. Chem. Soc.* **1939**, *61*, 1027–1032.

(21) Akerlof, G; Teare, J. A. Note on the Density of Aqueous Solutions of Hydrochloric Acid. *J. Am. Chem. Soc.* **1938**, *60*, 1226–1228.

(22) Alamelu, S.; Suryanarayanara, C. V. A study of viscosity of aqueous solutions of copper sulphate and zinc sulphate. *Acta Chim. Acad. Hung.* **1959**, *21*, 333.

(23) Albright, J. G.; Miller, D. G. Mutual Diffusion Coefficient of $ZnSO_4$ at 25°C. *J. Solution Chem.* **1975**, *4*, 809–816.

(24) Albright, J. G.; Mitchell, J. P.; Miller, D. G. Interdiffusion coefficients, densities, and refractive indices of ammonium chloride + water and ammonium sulfate + water at 25°C. *J. Chem. Eng. Data* **1994**, *39*, 195–200.

(25) Allred, G. C.; Woolley, E. A. Heat Capacities of aqueous acetic acid, sodium acetate, ammonia, and ammonium chloride at 238.15, 298.15 and 313.15 K: dCp0 for ionization of acetic acid and for dissociation of ammonium ion. *J. Chem. Thermodyn.* **1981**, *13*, 155–164.

(26) Allred, G. C.; Woolley, E. M. Heat capacities of aqueous HCl, NaOH and NaCl at 283.15, 298.15 and 313.15 K: dCp for ionization of water. *J. Chem. Thermodyn.* **1981**, *13*, 147–154.

(27) Ambrus, J. H.; Moynihan, C. T.; Macedo, P. B. The temperature dependence of viscosity and conductivity of concentrated aqueous calcium nitrate solutions. *J. Electrochem. Soc.* **1972**, *119*, 192–198.

(28) Apelblat, A. Enthalpy of solution of lithium sulfate and lithium sulfate monohydrate in water at 298.15 K. *J. Chem. Thermodyn.* **1985**, *17*, 769–773.

(29) Appleby, M. P. The viscosity of salt solutions. *J. Chem. Soc. (Trans.)* **1910**, 2000–2025.

(30) Archer, D. G.; Carter, R. W. Thermodynamic properties of the NaCl + H_2O system. 4. Heat capacities of H_2O and NaCl(aq) in cold-stable and supercooled states. *J. Phys. Chem. B* **2000**, *104*, 8563–8584.

(31) Asmus, A. Experiments on Falkenhagen's theory of the viscosity of dilute aqueous solutions of strong electrolyte. *Z. Physik* **1938**, *108*, 491.

(32) Asmus, A. The viscosities of aqueous solutions of strong electrolytes of high valence type. *Ann. Phys., Ser. 5* **1939**, *35*, 1–22.

(33) Asmus, E. The viscosities of aqueous solutions of strong electrolytes of high valence types. *Ann Phys.* **1939**, *35*, 1–22.

(34) Bakeev, M. I.; Zharmenov, A. A.; Andamasov, R. S.; Baikenova, N. A.; Abdygalimova, S. Sh. Electrical Conductivity and Viscosity of the Binary Systems $MeSO_4$-H_2O (Me=Mn^{2+}, Fe^{2+}, Co^{2+}, Zn^{2+}, Cd^{2+}) at 25−75 Degree and the Structure of Electrolyte Solutions. *Izv. Nats. Akad. Nauk Resp. Kaz., Ser. Khim.* **1994**, *6*, 25–30.

(35) Ballerat-Busserolles, K.; Ford, T. D.; Call, T. G.; Woolley, E. M. Apparent molar volumes and heat capacities of aqueous acetic acid and sodium acetate at temperatures from $T = 278.15$ K to $T = 393.15$ K at the pressure 0.35 MPa. *J. Chem. Thermodyn.* **1999**, *31*, 741–762.

(36) Banipal, T. S.; Kaur, D.; Banipal, P. K. Apparent Molar Volumes and Viscosities of Some Amino Acids in Aqueous Sodium Acetate Solutions at 298.15 K. *J. Chem. Eng. Data* **2004**, *49*, 1236–1246.

(37) Barbero, J. A.; Hepler, L. G.; McCurdy, K. G.; Tremaine, P. R. Thermodynamics of aqueous carbon dioxide and sulfur dioxide: heat capacities, volumes, and the temperature dependence of ionization. *Can. J. Chem.* **1983**, *61*, 2509–2519.

(38) Baxter, G. P.; Wallace, C. C. Changes in volume upon solution in water of the halogen salts of the alkali metals. II. *J. Am. Chem. Soc.* **1916**, *38*, 70–105.

(39) Bell, J. T.; Helton, D. M.; Rogers, T. G. Densities of aqueous potassium chloride and uranyl sulfate from 25° to 374°. *J. Chem. Eng. Data* **1970**, *15*, 44–46.

(40) Berchiesi, M. A.; Berchiesi, G.; Lobbia, G. G. Apparent Molal Volumes of Alkali Metal Nitrates at 30°C. *J. Chem. Eng. Data* **1974**, *19*, 326–328.

(41) Berecz, E.; Bader, I. Physicochemical study of ternary aqueous electrolyte solutions. VII. *Acta. Chim. Acad. Sci. Hung.* **1973**, *77*, 285.

(42) Bernarducci, E. E.; Morss, L. R.; Miksztal, A. R. Partial Molal Heat Capacity of Aqueous Ferrous Chloride from Measurements of Integral Heat of Dilution. *J. Solution Chem.* **1979**, *8*, 717–727.

(43) Blanchard, A. A.; Pushee, H. B. Viscosity of solutions of the metal ammonia salts. *J. Am. Chem. Soc.* **1912**, *34*, 28–32.

(44) Bogatykh, S. A.; Evnovitch, I. D. The viscosity of aqueous solutions of LiCl, LiBr, and $CaCl_2$ applicable to the conditions of drying of gases. *Zh. Prikl. Khim.* **1963**, *36*, 1867.

(45) Bousfield, W. R. The study of the density and viscosity of aqueous solutions, with special reference to nitric acid, Part II. Viscosities. *J. Chem. Soc. (Trans.)* **1915**, *107*, 1781–1797.

(46) Brown, B. R.; Merkley, E. D.; McRae, B. R.; Origlia-Luster, M. L.; Woolley, E. M. Apparent molar volumes and apparent molar heat capacities of aqueous nickel(II) nitrate, copper(II) nitrate, and zinc(II) nitrate at temperatures from (278.15 to 393.15) K at the pressure 0.35 MPa. *J. Chem. Thermodyn.* **2004**, *36*, 437–446.

(47) Brown, B. R.; Origlia-Luster, M. L.; Niederhauser, T. L.; Woolley, E. M. Apparent molar volumes and apparent molar heat capacities of aqueous lithium chloride, rubidium chloride, and cesium chloride at temperatures from 278.15 to 393.15 K at the pressure 0.35 MPa. *J. Chem. Thermodyn.* **2004**, *36*, 331–339 (corrections in **2004**, *36*, 1025).

(48) Burkell, J. E.; Spinks, J. W. T. Measurements of self-diffusion in aqueous solutions of sodium dihydrogen phosphate. *Can. J. Chem.* **1952**, *30*, 311–319.

(49) Call, T. G.; Ballerat-Busserolles, K.; Origlia, M. L.; Ford, T. D.; Woolley, E. M. Apparent Molar Volumes and Heat Capacities of Aqueous Magnesium Chloride and Cadmium Chloride at Temper-

atures from 278.15 to 393.15 K at the Pressure 0.35 MPa: a Comparison of Ion-Ion Interactions. *J. Chem. Thermodyn.* **2000**, *32*, 1525–1538.
(50) Campbell, A. N.; Debus, G. H.; Kartzmark, E. M. Conductances of aqueous lithium nitrate solutions at 25 and 110 °C. *Can. J. Chem.* **1955**, *33*, 1508–1514.
(51) Campbell, A. N.; Friesen, R. J. Conductance in the range of medium concentration. *Can. J. Chem.* **1959**, *37*, 1288–1293.
(52) Campbell, A. N.; Gray, A. P.; Kartzmark, E. M. Conductances, densities, and fluidities of solutions of silver nitrate and of ammonium nitrate at 35°. *Can. J. Res.* **1953**, *31*, 617–630.
(53) Campbell, A. N.; Kartzmark, E. M. Conductances of strong solutions of strong electrolytes. *Can. J. Res.* **1950**, *28B*, 43.
(54) Campbell, A. N.; Kartzmark, E. M. The Conductances of Strong Solutions of Strong Electrolytes at 95°C. *Can. J. Chem.* **1952**, *30*, 128–134.
(55) Campbell, A. N.; Kartzmark, E. M.; Bisset, D.; Bednas, M. E. The conductances of aqueous solutions of sulphuric acid at 50° and 75°. *Can. J. Chem.* **1953**, *31*, 303–305.
(56) Campbell, A. N.; Kartzmark, E. M.; Oliver, B. G. The electrolytic conductances of sodium chlorate and of lithium chlorate in water and in water-dioxane. *Can. J. Chem.* **1966**, *44*, 925–934.
(57) Carman, P. C. Transport in concentrated solutions of 1:1 electrolytes. *J. Phys. Chem.* **1969**, *73*, 1095–1105.
(58) Carter, R. W.; Archer, D. G. Heat Capacity of $NaNO_3$(aq) in Stable and Supercooled States. Ion Association in the Supercooled Solution. *Phys. Chem. Chem. Phys.* **2000**, *2*, 5138–5145.
(59) Cartón, A.; Sobrón, F.; Bolado, S.; Gerbolés, J. I. Density, Viscosity, and Electrical Conductivity of Aqueous Solutions of Lithium Sulfate. *J. Chem. Eng. Data* **1995**, *40*, 987–991.
(60) Carton, A.; Sobron, F.; Bolado, S.; Tabares, J. Composition and density of saturated solutions of lithium sulfate + water + ethanol. *J. Chem. Eng. Data* **1994**, *39*, 61–62.
(61) Carton, A.; Sobron, F.; Bolado, S.; Tabares, J. Composition and density of saturated solutions of lithium sulfate + water + methanol. *J. Chem. Eng. Data* **1994**, *39*, 733–734.
(62) Chan, J. P.; Giauque, W. F. The Entropy of $NH_3 \cdot 2H_2O$. Heat Capacity from 15 to 300K. *J. Phys. Chem.* **1964**, *68*, 3053–3057.
(63) Chatterji, A. C.; Gopal, R. The variation of relative viscosity with temperature. *J. Indian Soc.* **1947**, *24*, 455.
(64) Chen, C.-T. A.; Chen, J. H.; Millero, F. J. Densities of NaCl, $MgCl_2$, Na_2SO_4, and $MgSO_4$ Aqueous Solutions at 1 atm. from 0 to 50°C and from 0.001 to 1.5 m. *J. Chem. Eng. Data* **1980**, *25*, 307–310.
(65) Chenlo, F.; Moreira, R.; Pereira, G.; Vázquez, M. J. Viscosidad de disoluciones acusas de $Fe_2(SO_4)_3$, $Fe_2(SO_4)_3$ - Na_2SO_4 y $Fe_2(SO_4)_3$ - NaCl a diferentes concentrationes y temperaturas (Viscosity of aqueous solutions of $Fe_2(SO_4)_3$, $Fe_2(SO_4)_3$ - Na_2SO_4 and $Fe_2(SO_4)_3$ - NaCl at different concentrations and temperatures). *Afinidad* **1997**, *54*, 126–128.
(66) Chenlo, F.; Moreira, R.; Pereira, G.; Vazquez, M. J. Viscosities of Solutions of K2SO4, Na_2SO_4, KCl, NaCl, KNO_3, and $NaNO_3$ in (K_2CO_3 + $KHCO_3$) and (Na_2CO_3 + $NaHCO_3$) Buffers. *J. Chem. Eng. Data* **1997**, *42*, 93–97.
(67) Chenlo, F.; Moreira, R.; Pereira, G.; Vázquez, M. J. Viscosity of Binary and Ternary Aqueous Systems of NaH_2PO_4, Na_2HPO_4, KH_2PO_4, K_2HPO_4, and K_3PO_4. *J. Chem. Eng. Data* **1996**, *41*, 906–909.
(68) Chertkov, B. A.; Pekareva, T. I. Density and viscosity of aqueous $(NH_4)_2SO_3$, NH_4HSO_3, and $(NH_4)_2SO_4$ solutions. *J. Appl. Chem. USSR* **1961**, *34*, 135.
(69) Chmielewska, A.; Wypych-Stasiewicz, A.; Bald, A. Viscosimetric studies of aqueous solutions of salts of carboxylic acids. *J. Mol. Liq.* **2005**, *122*, 110–115.
(70) Chomjakow, S.; Jaworowskaja, S.; Schirokich, P. Heats of solution and dilution of potassium and ammonium phosphate. *Z. Phys. Chem.* **1933**, *A167*, 35.
(71) Choudary, N. V.; Jasra, R. V. Densities of Aqueous Solutions of Sodium Bisulfite and Sodium 2-Methalallyl Sulfate. *J. Chem. Eng. Data* **1994**, *39*, 181–183.
(72) Christensen, J. H.; Reed, R. B. Density of Aqueous Solutions of Phosphoric Acid. Measurements at 25°C. *Ind. Eng. Chem.* **1955**, *47*, 1277–1279.
(73) Connaughton, L. M.; Hershey, J. P.; Millero, F. J. PVT properties of concentrated aqueous electrolytes: V. Densities and apparent molal volumes of the four major sea salts from dilute solution to saturation and from 0 to 100°C. *J. Solution Chem.* **1986**, *15*, 989–1002.
(74) Conti, G.; Gianni, P.; Papini, A.; Matteoli, E. Apparent molar heat capacity and relative enthalpy of aqueous NaOH between 323 and 523K. *J. Solution Chem.* **1988**, *17*, 481–497.
(75) Correla, R. J.; Kestin, J. Viscosity and density of aqueous sodium sulfate and potassium sulfate solutions in the temperature range 20−90 °C and the pressure range 0−30 Mpa. *J. Chem. Eng. Data* **1981**, *26*, 43–47.
(76) Correla, R. J.; Kestin, J. Viscosity and Density of Aqueous Na_2CO_3 and K_2CO_3 Solutions in the temperature Range 20−90 °C and the Pressure Range 0−30 MPa. *J. Chem. Eng. Data* **1980**, *25*, 201–206.
(77) Cupples, H. L. Surface Tension of Aluminium Sulfate Solutions. *J. Phys. Chem.* **1946**, *50*, 256–260.
(78) Daniel, V.; Albright, J. G. Interdiffusion Coefficients, Densities, and Viscosities of KNO_2 + H_2O and $KClO_3$ + H_2O at 25 °C. *J. Chem. Eng. Data* **1995**, *40*, 519–522.
(79) Das, P. K. Viscosity and apparent molal volume of aqueous solutions of ammonium chloride and ammonium bromide at 35 °. *J. Indian Chem. Soc.* **1954**, *31*, 170.
(80) Davies, C. W. The conductivity of electrolytes. III. The correlation of strong and weak electrolytes. *J. Phys. Chem.* **1925**, *29*, 977–986.
(81) Deckwer, W. D. Density, viscosity, vapor pressure, and hydrogen solubility of aqueous MnSO4 solutions. *J. Chem. Eng. Data* **1980**, *25*, 75–76.
(82) Dedick, E. A.; Hershey, J. P.; Sotolongo, S.; Stade, D. J.; Millero, F. J. The PVT Properties of Concentrated Aqueous Electrolytes IX. The Volume Properties of KCl and K_2SO_4 and their Mixtures with NaCl and Na_2SO_4 as a Function of Temperature. *J. Solution Chem.* **1990**, *19*, 353–374.
(83) Degremont, Memento Technique de l'eau, Paris, 1989.
(84) Demichowicz-Pigoniowa, J. Dependence of Density, Viscosity and Electric Conductivity of Aqueous $CuSO_4$ Solutions on Temperature and Concentration. *Ann. Soc. Chim. Polonorum* **1973**, *47*, 2183–2190.
(85) Desnoyers, J. E.; Perron, G. The viscosity of aqueous solutions of alkali and tetraalkylammonium halides at 25 °C. *J. Solution Chem.* **1972**, *1*, 199–212.
(86) Doan, T. H.; Sangster, J. Viscosities of concentrated aqueous solutions of some 1:1, 2:1, and 3:1 nitrates at 25 °C. *J. Chem. Eng. Data* **1981**, *26*, 141–144.
(87) Dolian, F. E. The Viscosities of Solutions of Chlorides in Certain Solvents. *J. Phys. Chem.* **1937**, *41*, 1129–1138.
(88) Doménech, J.; Rivera, S. Viscosity B-Coefficient for Sodium Bromide in Formamide-Water Mixtures. *Z. Phys. Chem. N. F.* **1983**, *136*, 153–161.
(89) Drucker, C. Viscometric studies of chemical equilibria. *Ark. Kemi Min. Geol. 22A* **1946**, *21*, 1.
(90) Ducker, K.-H. Partial molar volumes of magnesium sulphate in aqueous solutions at 25°. *Ber. Bunsenges. Phys. Chem.* **1970**, *74*, 416.
(91) Dunlop, P. J.; Stokes, R. H. The diffusion coefficients of sodium and potassium iodides in aqueous solutions at 25°. *J. Am. Chem. Soc.* **1951**, *73*, 5456–5457.
(92) Easton, M. F.; Mitchell, A. G.; Wynne-Jones, W. F. K. The Behaviour of Mixtures of Hydrogen Peroxide and Water. *Trans. Faraday Soc.* **1952**, *48*, 796–801.
(93) Edwards, O. W.; Huffman, E. O. Viscosity of aqueous solutions of phosphoric acid at 25°C. *J. Chem. Eng. Data* **1958**, *3*, 145.
(94) Egan, E. P.; Luff, B. B. Density of Aqueous Solutions of Phosphoric Acid. Measurements at 15° to 80°C. *Ind. Eng. Chem.* **1955**, *47*, 1280–1280.
(95) Egan, E. P.; Luff, B. B.; Wakefield, Z. T. Heat Capacity of Phosphoric Acid Solutions, 15 to 80. *J. Phys. Chem.* **1958**, *62*, 1091–1095.
(96) Ellis, A.; McFadden, I. Partial molal volumes of ions in hydrothermal solutions. *Geochim. Cosmochim. Acta* **1972**, *36*, 413–426.
(97) Ellis, R. N.; Stokes, R. H.; Wright, A. C.; Spiro, M. Transference Numbers and Conductance in Concentrated Copper (II) Chloride Solutions at 25°C. *Aust. J. Chem.* **1983**, *36*, 1913–1921.
(98) Enea, O.; Singh, P. P.; Woolley, E. M.; McCurdy, K. G.; Hepler, L. G. Heat Capacities of Aqueous Nitric Acid, Sodium Nitrate, and Potassium Nitrate at 298.15 K: $\Delta C°p$ of Ionization of Water. *J. Chem. Thermodyn.* **1977**, *9*, 731–734.
(99) Enea, O.; Singh, P. P.; Woolley, E. M.; McCurdy, K. G.; Hepler, L. G. Heat capacities of aqueous nitric acid, sodium nitrate, and potassium nitrate at 298.15 K: $\Delta Cp°$ of ionization of water. *J. Chem. Thermodyn.* **1977**, *9*, 731–734.
(100) Epikhin, Y. A.; Stakhanova, M. S. Volume and heat capacity changes in aqueous salt solutions. V. The sodium chloride-sodium nitrate-water and sodium chloride-sodium perchlorate-water systems. *Russ. J. Phys. Chem.* **1967**, *41*, 2148.
(101) Ernst, S.; Gepert, M.; Manikowski, R. Apparent Molar Compressibilities of Aqueous Solutions of $Cu(NO_3)_2$, $CuSO_4$, and $CuCl_2$ from 288.15 to 313.15 K. *J. Chem. Eng. Data* **1999**, *44*, 1199–1203.
(102) Ernst, S.; Manikowski, R. Measurements of the Speed of Sound and Density of Aqueous Solutions of the First-Row Transition Metal Halides. 1. Apparent and Molar Compressibilities and Volumes of Aqueous NiCl2 and NiBr2 within the Temperature Range 291.15 to 297.15 K. *J. Chem. Eng. Data* **1997**, *42*, 647–650.
(103) Ernst, S.; Manikowski, R.; Bebek, M. Measurements of the Speed of Sound and Density of Aqueous Solutions of the First-Row Transition Metal Halides. 1. Apparent and Molar Compressibilities

and Volumes of Aqueous $CoCl_2$ and $CoBr_2$ within the Temperature Range 291.15 to 297.15 K. *J. Chem. Eng. Data* **1996**, *41*, 397–401.
(104) Ewing, W. W.; Herty, C. H. III Partial molal volumes of cadmium nitrate and water in concentrated aqueous solutions. *J. Phys. Chem.* **1953**, *57*, 245–246.
(105) Ewing, W. W.; Mikovsky, R. J. Calcium nitrate. V. Partial molal volumes of water and calcium nitrate in concentrated solutions. *J. Am. Chem. Soc.* **1950**, *72*, 1390–1393.
(106) Ezrokhi, L. L. Viscosity of aqueous solutions of the individual salts of sea water systems. *J. Appl. Chem. USSR* **1952**, *25*, 917.
(107) Fabuss, B. M.; Korosi, A.; Huq, A. K. M. S. Densities of Binary and Ternary Aqueous Solutions of NaCl, Na2SO4, and MgSO4, of Sea Waters, and Sea Water Concentrates. *J. Chem. Eng. Data* **1966**, *3*, 325–331.
(108) Fedyainov, N. V. Specific heat of two- and three-component aqueous solutions of beryllium subgroup metal chlorides at 25°C. *Russ. J. Phys. Chem.* **1970**, *44*, 1817.
(109) Fleischmann, W.; Mersmann, A. Solubility, density and viscosity for sodium sulfate-methanol-water systems. *J. Chem. Eng. Data* **1984**, *29*, 452–456.
(110) Fortier, J.-L.; Leduc, P.-A.; Desnoyers, J. E. Thermodynamic Properties of Alkali Halides. II. Enthalpies of Dilution and Heat Capacities in Water at 25 °C. *J. Solution Chem.* **1974**, *3*, 323–349.
(111) Frank, M. J. W.; Kuipers, J. A. M.; van Swaaij, W. P. M. Diffusion Coefficients and Viscosities of $CO_2 + H_2O$, $CO_2 + CH_3OH$, $NH_3 + H_2O$, and $NH_3 + CH_3OH$ Liquid Mixtures. *J. Chem. Eng. Data* **1996**, *41*, 297–302.
(112) Fujitaa, I.; Suzukia, T.; Uematsu, M. Isobaric specific heat capacity of $\{xH_2O + (1-x)NH_3\}$ with $x = (0.0000, 0.1566, 0.1597, 0.3030, 0.3048, 0.4956, 0.7061,$ and $0.8489)$ at $T = (280, 300, 320,$ and $360)$ K over the pressure range from (0.1 to 15) MPa. *J. Chem. Thermodyn.* **2008**, *40*, 260–264.
(113) Gates, J. A.; Wood, R. H. Densities of Aqueous Solutions of NaCl, $MgCl_2$, KCl, NaBr, LiCl, and $CaCl_2$ from 0.05 to 5.0 mol kg-1 and 0.1013 to 40 MPa at 298.15K. *J. Chem. Eng. Data* **1985**, *30*, 44–49.
(114) Gates, J. A.; Wood, R. H. Density and apparent molar volume of aqueous calcium chloride at 323−600 K. *J. Chem. Eng. Data* **1989**, *34*, 53–56.
(115) Getman, F. H. A study of the solutions of some salts exhibiting negative viscosity. *J. Am. Chem. Soc.* **1908**, *30*, 721–737.
(116) Giauque, W. F.; Hornung, E. W.; Kunzler, J. E.; Rubin, T. R. The Thermodynamic Properties of Aqueous Sulfuric Acid Solutions and Hydrates from 15 to 300° K. *J. Am. Chem. Soc.* **1960**, *82*, 62–70.
(117) Giguère, P. A.; Geoffrion, P. Changes of Density of Hydrogen Peroxide Solutions on Cooling and Freezing. *Can. J. Res.* **1950**, *28B*, 599–607.
(118) Gillespie, R. J.; Wasif, S. Solutions in sulphuric acid. Part XI. The densities and viscosities of some sulfuric acid solutions. *J. Chem. Soc.* **1953**, *21*, 5–221.
(119) Ginzburg, D. M.; Pikulina, N. S.; Litvin, V. P. Density of Potassium Carbonate Solutions. *J. Appl. Chem. USSR* **1964**, *37*, 2353–2357.
(120) Glass, H. M.; Madgin, W. M. Viscosities of aqueous solutions of electrolytes. Part I. Sodium sulphate solutions over the temperature range 25 - 40 °C. *J. Chem. Soc.* **1934**, *112*, 4–1128.
(121) Goldsack, D. E.; Franchetto, A. A. The Viscosity of Concentrated Electrolyte Solutions. III. A Mixture Law. *Electrochim. Acta* **1977**, *22*, 1287–1294.
(122) Goldsack, D. E.; Franchetto, R. C. The Viscosity of Concentrated Electrolyte Solutions. II. Temperature Dependence. *Can. J. Chem.* **1978**, *56*, 1442–1450.
(123) Goldsack, D. E.; Franchetto, R. The Viscosity of Concentrated Electrolyte Solutions. I. Concentration Dependence at Fixed Temperature. *Can. J. Chem.* **1977**, *55*, 1062–1072.
(124) Gonçalves, C. B.; Trevisan, N., Jr.; Meirelles, A. J. A Kinematic Viscosity of Systems Containing Polyethylene Glycol + Salt + Water at 298.2 K. *J. Chem. Eng. Data* **2004**, *49*, 177–181.
(125) Gonçalves, F.; Kestin, J. The Viscosity of NaCl and KCl solutions in the range 25−50 °C. *Ber. Bunsenges. Phys. Chem.* **1977**, *81*, 1156–1161.
(126) González, B.; Domínguez, A.; Tojo, J. Dynamic Viscosities, Densities, and Speed of Sound and Derived Properties of the Binary Systems Acetic Acid with Water, Methanol, Ethanol, Ethyl Acetate and Methyl Acetate at $T = (293.15, 298.15,$ and $303.15)$ K at Atmospheric Pressure. *J. Chem. Eng. Data* **2004**, *49*, 1590–1596.
(127) Granados, K.; Gracia-Fadrique, J.; Amigo, A.; Bravo, R. Refractive Index, Surface Tension, and Density of Aqueous Mixtures of Carboxylic Acids at 298.15 K. *J. Chem. Eng. Data* **2006**, *135*, 6–1360.
(128) Green, W. H. Studies in the viscosity and the conductivity of some aqueous solutions. Part I. Solutions of sucrose, hydrogen chloride and lithium chloride. *J. Chem. Soc. (Trans.)* **1908**, *93*, 2023–2048.
(129) Grimes, C. E.; Kestin, J.; Khalifa, H. E. Viscosity of aqueous potassium chloride solutions in the temperature range 25−150 °C and the pressure range 0−30 MPa. *J. Chem. Eng. Data* **1979**, *24*, 121–126.
(130) Grzybkowski, W.; Atkinson, G. Thermodynamics of concentrated electrolyte mixtures. Part 8. Apparent molal volumes, adiabatic compressibilities, and hydration numbers of aqueous zinc bromide, calcium bromide, and sodium bromide at 25.degree.C. *J. Chem. Eng. Data* **1986**, *31*, 309–312.
(131) Gucker, F. T.; Schminke, K. H. A study of the heat capacity and related thermodynamic properties of aqueous solutions of lithium chloride, hydrochloric acid and potassium hydroxide at 25°. *J. Am. Chem. Soc.* **1932**, *54*, 1358–1373.
(132) Gucker, F. T.; Schminke, K. H. The heat capacity and related thermodynamic properties of aqueous solutions. II. Lithium and Sodium Hydroxides at 25°. *J. Am. Chem. Soc.* **1933**, *55*, 1013–1019.
(133) Gucker, F. T.; Stubley, D.; Hill, D. J. The Isentropic Compressibilities of Aqueous Solutions of Some Alkali Halides at 298.15K. *J. Chem. Thermodyn.* **1975**, *7*, 865–869.
(134) Gunther, P.; Perschke, W. Comparison of some physical constants of thyocyanate, azide and nitrite solutions. *J. Chem. Soc.* **1930**, 100–104.
(135) Haase, R.; Lehnert, G.; Jansen, H.-J. Transport numbers at high electrolyte concentrations. II. Measurements. *Z. Phys. Chem. N. F.* **1964**, *42*, 32.
(136) Haase, R.; Saurmann, P.-F.; Dücker, K.-H. Conductivities of Concentrated Electrolyte Solutions. II. Nitric Acid. *Z. Phys. Chem. N. F.* **1965**, *46*, 129–139.
(137) Haase, R.; Saurmann, P.-F.; Dücker, K.-H. Conductivities of Concentrated Electrolyte Solutions. IV. Hydrochloric acids. *Z. Phys. Chem. N. F.* **1965**, *47*, 224.
(138) Haase, R.; Saurmann, P.-F.; Dücker, K.-H. Conductivity of Concentrated Electrolyte Solutions. V. Sulfuric Acid. *Z. Phys. Chem. N. F.* **1966**, *48*, 206–212.
(139) Harkins, W. D.; Paine, H. M. Intermediate and complex ions, V. The solubility product and activity of the ions in bi-valent salts. *J. Am. Chem. Soc.* **1919**, *41*, 1155–1168.
(140) Hartford, W. H. Properties of technically important hexavalent chromium compounds. *Ind. Eng. Chem.* **1949**, *41*, 1993–1997.
(141) Herrington, T. M.; Pethybridge, A. D.; Roffey, M. G. Densities of aqueous lithium, sodium and potassium hydroxides from 25 to 75 °C at 1 atm. *J. Chem. Eng. Data* **1986**, *31*, 31–34.
(142) Herrington, T. M.; Pethybridge, A. D.; Roffey, M. G. Densities of hydrochloric, hydrobromic, hydriodic, and perchloric acids from 25 to 75 °C at 1 atm. *J. Chem. Eng. Data* **1985**, *30*, 264–267.
(143) Herrington, T. M.; Roffey, M. G.; Smith, D. P. Densities of Aqueous Electrolytes $MnCl_2$, $CoCl_2$, $NiCl_2$, $ZnCl_2$ and $CdCl_2$ from 25 to 72°C at 1 atm. *J. Chem. Eng. Data* **1986**, *31*, 221–225.
(144) Hershey, J. P.; Sotolongo, S.; Millero, F. J. Densities and Compressibilities of Aqueous Sodium Carbonate and Bicarbonate from 0 to 45°C. *J. Solution Chem.* **1983**, *12*, 233–254.
(145) Hershey, J. P.; Sotolongo, S.; Millero, F. J. Densities and Compressiblities of Aqueous HCl and NaOH from 0 to 45°C. The Effect of Pressure on the Ionization of Water. *J. Solution Chem.* **1984**, *13*, 825–848.
(146) Hervello, M. F.; Sanchez, A. Densities of (Lithium, Magnesium, or Copper(II)) Sulfates in Ethanol-Water Solutions. *J. Chem. Eng. Data* **2007**, *52*, 906–909.
(147) Herz, W. Internal Friction of Salt Solutions. *Z. Anorg. Chemie* **1914**, *89*, 393–396.
(148) Hitchcock, L. B. Mechanism of gas-liquid reaction. Batch absorption of carbon dioxide by stirred alkaline solutions. *Ind. Eng. Chem.* **1937**, *29*, 302–308.
(149) Hitchcock, L. B.; McIlhenny, J. S. Viscosity and Density of Pure Alkaline Solutions and their Mixtures. *Ind. Eng. Chem.* **1935**, *27*, 461–466.
(150) Hnedkovský, L.; Wood, R. H. Apparent molar heat capacities of aqueous solutions of CH_4, CO_2, H_2S and NH_3 at temperatures from 304 to 704 K and pressures to 28 MPa. *J. Chem. Thermodyn.* **1997**, *29*, 731–737.
(151) Hnedkovský, L.; Wood, R. H.; Majer, V. Volumes of aqueous solutions of CH_4, CO_2, H_2S and NH_3 at temperatures from 298.15 to 705 K and pressures to 35 MPa. *J. Chem. Thermodyn.* **1996**, *28*, 125–142.
(152) Holemann, P.; Kohner, H. The dependence of equivalent refraction of strong electrolytes in solution upon temperature. *Z. Phys. Chem. B* **1931**, *13*, 338.
(153) Hovey, J. K.; Hepler, L. G. Apparent and partial molar heat capacities and volumes of aqueous $HClO_4$ and HNO_3 from 10 to 55 °C. *Can. J. Chem.* **1989**, *67*, 1489–1495.
(154) Hovey, J. K.; Hepler, L. G. Thermodynamics of sulphuric acid: apparent and partial molar heat capacities and volumes of aqueous

HSO_4^- from 10−55 °C and calculation of the second dissociation constant to 350 °C. *J. Chem. Soc., Faraday Trans.* **1990**, *86*, 2831–2839.
(155) Hovey, J. K.; Hepler, L. G.; Tremaine, P. R. Apparent molar heat capacities and volumes of aqueous $HClO_4$, HNO_3, $(CH_3)_4NOH$ and K_2SO_4 at 298.15 K. *Thermochim. Acta* **1988**, *126*, 245–253.
(156) Huckaba, C. E.; Keyes, F. G. The Density of Aqueous Hydrogen Peroxide Solutions. *J. Am. Chem. Soc.* **1948**, *70*, 2578–2581.
(157) Huckel, E.; Schaaf, H. Concentration and temperature dependence of the viscosity of aqueous solutions of strong electrolytes. IV. HCl, NaOH, $N(CH_3)_4I$, and $N(C_2H_5)_4I$ solutions. *Z. Phys. Chem. N. F.* **1959**, *21*, 326.
(158) Ishii, T.; Fujita, S. Properties of potassium sulfate aqueous solution and crystals. *J. Chem. Eng. Data* **1978**, *23*, 19–23.
(159) Isono, T. Densities, Viscosities, and Electrolytic Conductivities of Concentrated Aqueous Electrolyte Solutions of 31 Solutes in the Temperature Range 15−55°C and Empirical Equations for the Relative Viscosity. *Rikagaku Kenkyusho Hokoku* **1985**, *61*, 53–79.
(160) Isono, T. Densities, Viscosities, and Electrolytic Conductivity of Concentrated Aqueous Electrolyte Solutions at Several Temperatures. Alkaline-Earth Chlorides, $LaCl_3$, Na_2SO_4, $NaNO_3$, NaBr, KNO_3, KBr, and $Cd(NO_3)_2$. *J. Chem. Eng. Data* **1984**, *29*, 45–52.
(161) Isono, T. Measurements of Density, Viscosity, and Electrolytic Conductivity of Concentrated Aqueous Electrolyte Solutions. *Rikagaku Kenkyusho Hokoku* **1980**, *56*, 103–114.
(162) Jacopetti, M. M. Conductimetric behavior of potassium chloride solutions. *Gazz. Chim. Ital.* **1940**, *70*, 95.
(163) Jain, S. K.; Jain, A. K.; Gupta, A. K.; Singh, V. V. Densities and Refractive Indices of Aqueous Zinc Nitrate Solutions. *J. Chem. Eng. Data* **1985**, *30*, 301–304.
(164) Janssen, L. J. J. Physical properties of aqueous solutions containing $NaClO_3$ and/or $NaClO_4$. *J. Appl. Electrochem.* **1995**, *25*, 291–293.
(165) Janz, G. J.; Oliver, B. G.; Lakshiminarayanan, G. R.; Mayer, G. E. Electrical conductance, diffusion, viscosity, and density of sodium nitrate, sodium perchlorate, and sodium thiocyanate in concentrated aqueous solutions. *J. Phys. Chem.* **1970**, *74*, 1285–1289.
(166) Jones, G.; Bradshaw, B. C. The transference number of lithium chloride as a function of the concentration. *J. Am. Chem. Soc.* **1932**, *54*, 138–150.
(167) Jones, G.; Colvin, J. H. The viscosity of solutions of electrolytes as a function of their concentration. VIISilver nitrate, potassium sulfate and potassium chromate. *J. Am. Chem. Soc.* **1940**, *62*, 338–340.
(168) Jones, G.; Dole, M. The viscosity of aqueous solutions of strong electrolytes with special reference to barium chloride. *J. Am. Chem. Soc.* **1929**, *51*, 2950–2664.
(169) Jones, G.; Ray, W. A. The surface tension of solutions of electrolytes as a function of the concentration. IV. Magnesium sulfate. *J. Am. Chem. Soc.* **1942**, *64*, 2744–2745.
(170) Jones, G.; Stauffer, R. E. The viscosity of solutions of electrolytes as a function of the concentration. VI. Potassium bromide and lanthanum chloride. *J. Am. Chem. Soc.* **1940**, *62*, 335–337.
(171) Jones, G.; Talley, S. K. The viscosity of aqueous solutions as a function of the concentration. *J. Am. Chem. Soc.* **1933**, *55*, 624–642.
(172) Jones, G.; Talley, S. K. The viscosity of solutions of electrolytes as a function of the concentration. II. Potassium bromide and potassium chloride. *J. Am. Chem. Soc.* **1933**, *55*, 4124–4125.
(173) Jones, J. S.; Ziemer, S. P.; Brown, B. R.; Woolley, E. M. Apparent molar volumes and apparent molar heat capacities of aqueous magnesium nitrate, strontium nitrate, and manganese nitrate at temperatures from 278.15 to 393.15 K and at the pressure 0.35 MPa. *J. Chem. Thermodyn.* **2007**, *39*, 550–560.
(174) Jubin, R. T.; Marleyu, J. L.; Counce, R. M. Density study of magnesium nitrate-water-nitric acid solutions at different temperatures. *J. Chem. Eng. Data* **1986**, *31*, 86–88.
(175) Kalita, G.; Dass, N. N.; Mahiuddin, S. Mixed anion effect in sodium thiocyanate + sodium thiosulfate + water systems. *Can. J. Chem.* **1998**, *76*, 1836–1843.
(176) Kaminsky, M. Concentration and Temperature Dependence of the Viscosity of Aqueous Solutions of Strong Electrolytes. II. NaCl, Li_2SO_4, $FeCl_2$, and $CeCl_3$ Solutions. *Z. Phys. Chem. N. F* **1956**, *8*, 173–191.
(177) Kaminsky, M. Concentration and Temperature Dependence of the Viscosity of Aqueous Solutions of Strong Electrolytes. III. KCl, K_2SO_4, $MgCl_2$, $BeSO_4$, and $MgSO_4$ Solutions. *Z. Phys. Chem. N. F.* **1957**, *12*, 206–231.
(178) Kaminsky, M. Experimental Investigations of the Concentration and Temperature Dependence of the Viscosity of Aqueous Solutions of Strong Electrolytes. I. Potassium Iodide, Ammonium Chloride, and Sodium Sulphate Solutions. *Z. Phys. Chem. N. F.* **1955**, *5*, 154–191.
(179) Karapet'yants, M. Kh.; Vasilev, V. A.; Mikkhailin, B. V.; Strakhov, V. N. Specific heat and density of aqueous sodium and rubidium bromide solutions at 25°C. *Russ. J. Phys. Chem.* **1979**, *53*, 111–112.
(180) Kartzmark, E. M. Conductances, Densities, and Viscosities of Solutions of Sodium Nitrate in Water and in Dioxane-Water at 25°C. *Can. J. Chem.* **1972**, *50*, 2845–2850.
(181) Kearley, R. A. Some physical properties of sodium chromate, sodium dichromate, and potassium dichromate, and their aqueous solutions. *J. Chem. Eng. Data* **1964**, *9*, 548–551.
(182) Kelly, W. R.; Borza, P. F.; Harriger, R. D. Densities and viscosities of potassium hydroxide solutions at low temperature. *J. Chem. Eng. Data* **1965**, *10*, 233–234.
(183) Kelly, W. R.; Morgan, T. R. Specific conductances of aqueous sodium chromate. *J. Chem. Eng. Data* **1965**, *10*, 290–291.
(184) Kestin, J.; Khalifa, H. E.; Abe, Y.; Grimes, C. E.; Sookiazian, H.; Wakeham, W. A. Effect of pressure on the viscosity of aqueous sodium chloride solutions in the temperature range 20−150 °C. *J. Chem. Eng. Data* **1978**, *23*, 328–336.
(185) Kestin, J.; Khalifa, H. E.; Ro, S.-T.; Wakeham, W. A. Preliminary data on the pressure effect on the viscosity of sodium chloride-water solutions in the range 10−40 °C. *J. Chem. Eng. Data* **1977**, *22*, 207–214.
(186) Kharat, S. J. Density, viscosity and ultrasonic velocity studies of aqueous solutions of sodium acetate at different temperatures. *J. Mol. Liq.* **2008**, *140*, 10–14.
(187) King, E. J. Volume changes for ionization of formic, acetic, and butyric acids and the glycinium ion in aqueous solution at 25 °C. *J. Phys. Chem.* **1969**, *73*, 1220–1232.
(188) Königsberger, E.; Bevis, S.; Hefter, G.; May, P. M. Comprehensive Model of Synthetic Bayer Liquors. Part 2. Densities of Alkaline Aluminate Solutions to 90 °C. *J. Chem. Eng. Data* **2005**, *50*, 1270–1276.
(189) Korin, E.; Soifer, L. Phase Diagram for the System $K_2Cr_2O_7 + KNO_3 + H_2O$ in the Temperature Range 10 C to 40 °C. *J. Chem. Eng. Data* **1997**, *42*, 508–510.
(190) Korin, E.; Soifer, L. Solubility of Potassium Dichromate in Dilute Aqueous Methanol and 2-Propanol Solutions in the Temperature Range 283 to 303 K. *J. Chem. Eng. Data* **1998**, *43*, 823–825.
(191) Korosi, A.; Fabuss, B. M. Viscosities of Binary Aqueous Solutions of NaCl, KCl, Na_2SO_4, and $MgSO_4$ at Concentrations and Temperatures of Interest in Desalination Processes. *J. Chem. Eng. Data* **1968**, *13*, 548–552.
(192) Kortüm, G.; Reber, H. Density, viscosity, and dielectric constant of pure hydrocyanic acid and of hydrocyanic acid - water mixtures at 0°. *Z. Elektrochem.* **1961**, *65*, 809.
(193) Krey, J. Vapour Pressure and Density of the System Water-Sodium Hydroxide. *Z. Phys. Chem. N. F.* **1972**, *81*, 252–273.
(194) Krings, W. The viscosity and density of sodium hydroxide solutions to high concentrations and at high temperatures. *Z. Anorg. Chem.* **1948**, *255*, 294.
(195) Krishnamurty, B. Ultrasonic Studies in Electrolytes: Part I - Alkali Halides. *Ind. Res. (India)* **1950**, *9B*, 215–219.
(196) Krumgalz, B. S.; Malester, I. A.; Ostrich, I. J.; Millera, F. J. Heat Capacities of Concentrated Multicomponent Aqueous Electrolyte Solutions at Various Temperatures. *J. Solution Chem.* **1992**, *21*, 635–649.
(197) Krumgalz, B. S.; Millero, F. J. Physico-Chemical Study of Dead Sea Waters II. Density Measurements and Equation of State of Dead Sea Waters at 1 atm. *Marine Chem.* **1982**, *11*, 477–492.
(198) Kumar, A. Mixture densities of aqueous potassium chloride with sodium chloride up to ionic strength 4.5 mol kg-1 and at 298.15 K. *J. Chem. Eng. Data* **1988**, *33*, 198–199.
(199) Kumar, A.; Atkinson, G. Thermodynamics of Concentrated Electrolyte Mixtures. 3. Apparent Molal Volume, Compressibilities, and Expansibilities of NaCl-$CaCl_2$ Mixtures from 5 to 35 °C. *J. Phys. Chem.* **1983**, *87*, 5504–5507.
(200) Kumar, A.; Atkinson, G.; Howell, R. D. Thermodynamics of Concentrated Electrolyte Mixtures. II. Densities and Compressibilities of Aqueous NaCl-$CaCl_2$ at 25°C. *J. Solution Chem.* **1982**, *11*, 857–870.
(201) Kume, T.; Tanaka, M. Concentrated solutions of electrolytes: viscosity. *Nippon Kagasu Zasshi* **1960**, *81*, 534.
(202) Kunzler, J. E.; Giauque, W. F. Aqueous Sulfuric Acid. Heat Capacity. Partial Specific Heat Content of Water at 25 and−20. *J. Am. Chem. Soc.* **1952**, *74*, 3472–3476.
(203) Lanman, E. H.; Mair, B. J. The compressibility of aqueous solutions. *J. Am. Chem. Soc.* **1934**, *56*, 390–393.
(204) Larson, J. W.; Zeeb, K. G.; Hepler, L. G. Heat capacities and volumes of dissociation of phosphoric acid (1st, 2nd, and 3rd), bicarbonate ion and bisulfate ion in aqueous solution. *Can. J. Chem.* **1982**, *60*, 2141–2150.
(205) Laurence, V. D.; Wolfenden, J. H. The viscosity of solutions of strong electrolytes. *J. Chem. Soc.* **1934**, 1144–1147.
(206) Leaist, D. G. Proton-coupled transport of ammonia in aqueous hydrochloric acid. *Aust. J. Chem.* **1985**, *38*, 249–260.

(207) Leduc, P.-A.; Desnoyers, J. E. Apparent molal heat capacities and volumes of tetrabutylammonium carboxylates and related solutes in water at 25 °C. *Can. J. Chem.* **1973**, *51*, 2993–2998.

(208) Lengyel, S.; Tamás, J; Giber, J.; Holderith, J. Study of Viscosity of Aqueous Alkali Halide Solutions. *Acta Chim. Acad. Sci. Hung.* **1964**, *40*, 125–143.

(209) Li, J.; Prestidge, C. A.; Addai-Mensah, J. Viscosity, Density, and Refractive Index of Aqueous Sodium and Potassium Aluminate Solutions. *J. Chem. Eng. Data* **2000**, *45*, 665–671.

(210) Likke, S.; Bromley, L. A. Heat Capacities of Aqueous NaCl, KCl, $MgCl_2$, $MgSO_4$, and Na_2SO_4 Solutions Between 80° and 200°C. *J. Chem. Eng. Data* **1973**, *18*, 189–195.

(211) Luhdemann, R. The dependence on concentration of the equivalent refraction of a few salts and acids in aqueous solutions. *Z. Phys. Chem. Abt.* **1935**, *B29*, 133.

(212) Maass, O.; Hatcher, W. H. The properties of pure hydrogen peroxide. *J. Am. Chem. Soc.* **1920**, *42*, 2548–2569.

(213) MacInnes, D. A.; Dayhoff, M. O. The Partial Molal Volumes of Potassium Chloride, Potassium and Sodium Iodides and Iodine in Aqueous Solution at 25°C. *J. Am. Chem. Soc.* **1952**, *74*, 1017–1020.

(214) Magalhães, M. C. F.; Königsberger, E.; May, P. M.; Hefter, G. Heat Capacities of Concentrated Aqueous Solutions of Sodium Sulfate, Sodium Carbonate, and Sodium Hydroxide at 25 °C. *J. Chem. Eng. Data* **2002**, *47*, 590–598.

(215) Magee, J. E.; Kagawa, N. Specific Heat Capacity at Constant Volume for $\{xNH_3 + (1 - x)H_2O\}$ at Temperatures from 300 to 520 K and Pressures to 20 Mpa. *J. Chem. Eng. Data* **1998**, *43*, 1082–1090.

(216) Mahiuddin, S.; Ismail, K. Concentration Dependence of the Viscosity of Aqueous Electrolytes. A Probe into Higher Concentration. *J. Phys. Chem.* **1983**, *87*, 5241–5244.

(217) Mahiuddin, S.; Ismail, K. Temperature and concentration dependence of the viscosity of aqueous sodium nitrate and sodium thiosulphate electrolytic systems. *Fluid Phase Equilib.* **1996**, *123*, 231–243.

(218) Majer, V.; Inglese, A.; Wood, R. H. Volumetric properties of LiCl(aq) from 0,05 to 3,0 mol·kg-1, 322 to 550 K, and 0,8 to 32,6 Mpa. *J. Chem. Thermodyn.* **1989**, *21*, 321–329.

(219) Maksimova, I. N.; Yushkevich, V. F. Electrical Conductivity of Sodium Hydroxide Solutions at High Temperatures. *Z. Fiz. Khim.* **1963**, *37*, 903–907.

(220) Manohar, S.; Puchalska, D.; Atkinson, G. Pressure-Volume-Temperature Properties of Aqueous Mixed Electrolyte Solutions: NaCl + $BaCl_2$ from 25 C to 140 °C. *J. Chem. Eng. Data* **1994**, *39*, 150–154.

(221) Martinez-Andreu, A.; Vercher, E.; Pena, M. P. Apparent Molar Volumes of Strontium Nitrate and Copper(II) Chloride in Ethanol + Water at 298.15 K. *J. Chem. Eng. Data* **1999**, *44*, 86–92.

(222) Mashovets, V. P.; Dibrov, I. A.; Krumgal'z, B. S.; Mateeva, R. P. Density of Aqueous KOH Solutions at High Temperatures over a Wide Range of Concentrations. *J. Appl. Chem. USSR* **1965**, *38*, 2344–2347.

(223) Mason, C. M. The activity and osmotic coefficient of trivalent metal chlorides in aqueous solution from vapor pressure measurements at 25°C. *J. Am. Chem. Soc.* **1938**, *60*, 1638–1647.

(224) Mason, C. M.; Culvern, J. B. Electrical conductivity of orthophosphoric acid and of sodium and potassium dihydrogen phosphates at 25 °C. *J. Am. Chem. Soc.* **1949**, *71*, 2387–2393.

(225) Mason, C. M.; Culvern, J. B. Electrical conductivity of orthophosphoric acid and of sodium and potassium phosphates at 25 °C. *J. Am. Chem. Soc.* **1949**, *71*, 2387–2393.

(226) Millero, F. J. The apparent and partial volume of aqueous sodium chloride solutions at various termperature. *J. Phys. Chem.* **1970**, *74*, 356–362.

(227) Millero, F. J.; Gombar, F.; Oster, J. The partial molal volume and compressibility change for the formation of the calcium sulfate ion pair at 25°C. *J. Solution Chem.* **1977**, *6*, 269–280.

(228) Millero, F. J.; Knox, J. H. Apparent Molal Volumes of Aqueous NaF, Na_2SO_4, KCl, K_2SO_4, $MgCl_2$, and $MgSO_4$ Solutions at 0° and 50°C. *J. Chem. Eng. Data* **1973**, *18*, 407–411.

(229) Millero, F. J.; Ward, G. K.; Chetirkin, P. V. Relative Sound Velocities of Sea Salts at 25°C. *J. Acoust. Soc. Am.* **1977**, *61*, 1492–1498.

(230) Monica, D. M.; Ceglie, A.; Agostiano, A. A conductivity equation for concentrated aqueous solutions. *Electrochim. Acta* **1984**, *29*, 933–937.

(231) Motin, M. A. Temperature and Concentration Dependence of Apparent Molar Volumes and Viscosities of NaCl, NH_4Cl, $CuCl_2$, and $MgSO_4$ in Pure Water and Water + Urea Mixtures. *J. Chem. Eng. Data* **2004**, *49*, 94–98.

(232) Mulcahy, D. E.; Steel, B. J. Relative viscosity and density data for some alkali halides in aqueous 20 % sucrose solution at 25 °C. *J. Chem. Eng. Data* **1985**, *30*, 191–194.

(233) Mullin, J. W.; Amatavivadhana, A. Growth kinetics of ammonium - and potassium - dihydrogen phosphate crystals. *J. Appl. Chem.* **1967**, *17*, 151.

(234) Myhre, C. E. L.; Nielsen, C. J.; Saastad, O. W. Density and Surface Tension of Aqueous H2SO4 at Low Temperature. *J. Chem. Eng. Data* **1998**, *43*, 617–622.

(235) National Research Council, *International Critical Tables of Physical and Numerical Data, Physics, Chemistry, and Technology*; McGraw-Hill: New York, 1928.

(236) Nickels, L.; Allmand, A. J. The electrical conductivities and viscosities at 25 °C of solutions of potassium, sodium, and lithium chlorides, in water and in one-tenth molar hydrochloric acid. *J. Phys. Chem.* **1937**, *41*, 861–872.

(237) Niederhauser, T. L.; Woolley, E. M. Apparent molar volumes and apparent molar heat capacities of aqueous barium nitrate at temperatures from (278.15 to 393.15) K and at the pressure 0.35 MPa. *J. Chem. Thermodyn.* **2004**, *36*, 325–330.

(238) Nightingale, E. R., Jr.; Benck, R. F. Viscosity of Aqueous Sodium Fluoride and Sodium Periodate Solutions. Ionic Energies and Entropies of Activation for Viscous Flow. *J. Phys. Chem.* **1959**, *63*, 1777–1781.

(239) Nikam, P. S.; Aher, J. S.; Kharat, S. J. Viscosities of Ammonium Sulfate, Potassium Sulfate, and Aluminum Sulfate in Water and Water + N,N-Dimethylformamide Mixtures at Different Temperatures. *J. Chem. Eng. Data* **2008**, *50*, 2469–2472.

(240) Nishikata, E.; Ishii, T.; Ohta, T. Viscosities of aqueous hydrochloric acid solutions, and densities and viscosities of aqueous hydroiodic acid solutions. *J. Chem. Eng. Data* **1981**, *26*, 254–256.

(241) Nowlan, M.-F.; Doan, T. H.; Sangster, J. Prediction of the Viscosity of Mixed Electrolyte Solutions from Single-Salt Data. *Can. J. Chem. Eng.* **1980**, *58*, 637–642.

(242) Oakes, C. S.; Simonson, J. M.; Bodnar, R. J. The system NaCI-$CaCI_2$-H_2O. 2. Densities for Ionic Strengths of 0.1−19.2 mol.kg-1 at 298.15 and 308.15 K and at 0.1 Mpa. *J. Chem. Eng. Data* **1990**, *35*, 304–309.

(243) Oguchi, K.; Ibusuki, Y. The pVTx Properties of Aqueous Solutions of Ammonia in the Range of Around 50 mol% of Ammonia. *14th International Conference on the Properties of Water and Steam in Kyoto*, 2002; pp 103−106.

(244) Olofsson, I. V. Apparent molar heat capacities and volumes of aqueous NaCl, KCl, and KNO3 at 298.15 K. Comparison of Picker flow calorimeter with other calorimeters. *J. Chem. Thermodyn.* **1979**, *11*, 1005–1014.

(245) Olofsson, I. V.; Spitzer, J. J.; Hepler, L. G. Apparent molar heat capacities and volumes of aqueous electrolytes at 25 °C: Na_2SO_4, K_2SO_4, $Na_2S_2O_3$, $Na_2S_2O_8$, $K_2S_2O_8$, K_2CrO_4, Na_2MoO_4, and Na_2WO_4. *Can. J. Chem.* **1978**, *56*, 1871–1873.

(246) Ostroff, A. G.; Snowden, B. S, Jr; Woessner, D. E. Viscosities of protonated and deuterated water solutions of alkali metal chlorides. *J. Phys. Chem.* **1969**, *73*, 2784–2785.

(247) Out, D. J. P.; Los, J. M. Viscosity of Aqueous Solutions of Univalent Electrolytes from 5 to 95°C. *J. Solution Chem.* **1980**, *9*, 19–35.

(248) Pabalan, R. T.; Pitzer, K. S. Apparent molar heat capacity and other thermodynamic properties of aqueous potassium chloride solutions to high temperatures and pressures. *J. Chem. Eng. Data* **1988**, *33*, 354–362.

(249) Pabalan, R. T.; Pitzer, K. S. Heat capacity and other thermodynamic properties of Na_2SO_4 (aq) in hydrothermal solutions and the solubilities of sodium sulfate minerals in the system Na-Cl-SO_4-OH-H_2O to 300 °C. *Geochim. Cosmochim. Acta* **1988**, *52*, 2393–2404.

(250) Palatý, Z. Density of Aqueous Solutions of Na_2CO_3 - $NaHCO_3$. *Collect. Czech. Chem. Commun.* **1994**, *59*, 1571–1583.

(251) Palatý, Z. Viscosity and density of aqueous solutions of Na_2CO_3/$NaHCO_3$. *Chem. Biochem. Eng. Q.* **1991**, *5*, 145–150.

(252) Palatý, Z. Viscosity of Diluted Aqueous K_2CO_3/$KHCO_3$ Solutions. *Chem. Biochem. Eng. Q.* **1993**, *7*, 155–159.

(253) Palaty, Z. Viscosity of diluted aqueous NaOH/Na_2CO_3 solutions. *Chem. Eng. Sci.* **1989**, *44*, 1585–1589.

(254) Paranjpe, G. R.; Rajderkar, E. B. The temperature-variation of the viscosities of aqueous solutions of strong electrolytes. *J. Univ. Bombay* **1935**, *3*, 21.

(255) Patterson, B. A.; Call, T. G.; Jardine, J. J.; Origlia-Luster, M. L.; Woolley, E. M. Thermodynamics for Ionization of Water at Temperatures from 278.15 to 393.15 K and at the Pressure 0.35 MPa: Apparent Molar Volumes of Aqueous KCl, KOH, and NaOH and Apparent Molar Heat Capacities of Aqueous HCl, KCl, KOH, and NaOH. *J. Chem. Thermodyn.* **2001**, *33*, 1237–1262.

(256) Patterson, B. A.; Woolley, E. M. Thermodynamics for Ionization of Water at Temperatures from 278.15 to 393.15 K and at the Pressure 0.35 MPa: Apparent Molar Volumes and Apparent Molar Heat Capacities of Aqueous Solutions of Potassium and Sodium Nitrates and Nitric Acid. *J. Chem. Thermodyn.* **2002**, *34*, 535–556.

(257) Pearce, J. N.; Eckstrom, H. C. The Vapor Pressure and some Thermodynamic Properties of Aqueous Solutions of Nickel Chloride at 25°C. *J. Phys. Chem.* **1937**, *41*, 563–565.

(258) Pearce, J. N.; Eckstrom, H. C. Vapor Pressures and Partial Molal Volumes of Aqueous Solutions of the Alkali Sulfates at 25°C. *J. Am. Chem. Soc.* **1937**, *59*, 2689–2691.

(259) Pearce, J. N.; Pumplin, G. G. The Apparent and Partial Molal Volume of Ammonium Chloride and of Cupric Sulfate in Aqueous Solutions at 25°C. *J. Am. Chem. Soc.* **1937**, *59*, 1221–1222.

(260) Pedersen, T. G.; Dethlefsen, C.; Hvidt, A. Volumetric Properties of Aqueous Solutions of Alkali Halides. *Carlsberg Res. Commun.* **1984**, *49*, 445–455.

(261) Pena, M. P.; Vercher, E.; Martinez-Andreu, A. Apparent Molar Volumes of Potassium Nitrate and Sodium Nitrate in Ethanol + Water at 298.15 K. *J. Chem. Eng. Data* **1998**, *43*, 626–631.

(262) Pena, M. P.; Vercher, E.; Martinez-Andreu, A. Partial Molar Volumes of Cobalt(II) Chloride in Ethanol + Water at 298.15 K. *J. Chem. Eng. Data* **1996**, *41*, 752–754.

(263) Perfetti, E.; Pokrovski, G. L.; Ballerat-Busserolles, K.; Majer, V.; Gibert, F. Densities and heat capacities of aqueous arsenious and arsenic acid solutions to 350 °C and 300 bar, and revised thermodynamic properties of $As(OH)_{3(aq)}$, $AsO(OH)_{3(aq)}$ and iron sulfarsenide minerals. *Geochim. Cosmochim. Acta* **2008**, *72*, 713–731.

(264) Perron, G.; Desnoyers, J. E. Apparent Molal Volumes and Heat Capacities of Alkaline Earth Chlorides in Water at 25°C. *Can. J. Chem.* **1974**, *52*, 3738–3741.

(265) Perron, G.; Desnoyers, J. E.; Millero, F. J. Apparent molal volumes and heat capacities of some sulfates and carbonates in water at 25 °C. *Can. J. Chem.* **1975**, *53*, 1134–1138.

(266) Perron, G.; Fortier, J-. L.; Desnoyers, J. E. Apparent Molar Heat Capacities and Volumes of Aqueous NaCl from 0.01 to 3 mol kg-1 in the Temperature Range 274.65 to 318.15 K. *J. Chem. Thermodyn.* **1975**, *7*, 1177–1184.

(267) Perron, G.; Roux, A.; Desnoyers, J. E. Heat capacities and volumes of NaCl, $MgCl_2$, $CaCl_2$, and $NiCl_2$ up to 6 molal in water. *Can. J. Chem.* **1981**, *59*, 3049–3054.

(268) Phang, S. The density, Viscosity and Transference Number of Aqueous Cobalt Chloride at 298.15 K. *Aust. J. Chem.* **1980**, *33*, 641–645.

(269) Phang, S. The Density, Viscosity, and Transference Number of Aqueous Manganese Chloride at 298.15 K. *Aust. J. Chem.* **1980**, *33*, 413–417.

(270) Phang, S. Viscosity and Transference Number Measurements of Concentrated Nickel Chloride Solutions at 298.15K. *Aust. J. Chem.* **1979**, *32*, 1149–1153.

(271) Phang, S.; Stokes, R. H. Density, viscosity, conductance, and transference number of concentrated aqueous magnesium chloride at 25 °C. *J. Solution Chem.* **1980**, *9*, 497–505.

(272) Phibbs, M. K.; Giguère, P. A. Hydrogen peroxide and its analogues. I. Density, refractive index, viscosity, and surface tension of deuterium peroxide - deuterium oxide solutions. *Can. J. Chem.* **1951**, *29*, 173–181.

(273) Phillips, V. R. Specific Gravity, Viscosity, and Solubility for Aqueous Nickel Sulfate Solutions. *J. Chem. Eng. Data* **1972**, *17*, 357–360.

(274) Phutela, R. C.; Pitzer, K. S. Densities and apparent molar volumes of aqueous magnesium sulfate and sodium sulfate to 473 K and 100 bar. *J. Chem. Eng. Data* **1986**, *31*, 320–327.

(275) Phutela, R. C.; Pitzer, K. S. Heat capacity and other thermodynamic properties of aqueous magnesium sulfate to 473 K. *J. Phys. Chem.* **1986**, *90*, 895–901.

(276) Pigoniowa, J. D. Temperature dependence of viscosity of aqueous solutions of cadmium sulphate. *Ann. Soc. Chim. Polonorum* **1962**, *36*, 1677.

(277) Pilar Peña, M.; Vercher, E.; Martínez-Andreu, A. Apparent Molar Volumes of Strontium Chloride in Ethanol + Water at 298.15 K. *J. Chem. Eng. Data* **1997**, *42*, 187–189.

(278) Poczopko, S.; Orzesko, W. Calorimetric Investigations of $MgSO_4$-$CO(NH_2)_2$-H_2O System at 25 °C. *Roczniki Chemii* **1972**, *46*, 259–268.

(279) Pogue, R. F.; Atkinson, G. Solution Thermodynamics of First-Row Transition Elements. 1. Apparent Molal Volumes of Aqueous $NiCl_2$, $Ni(ClO_4)_2$, $CuCl_2$, and $Cu(ClO_4)_2$, from 15 to 55°C. *J. Chem. Eng. Data* **1988**, *33*, 370–376.

(280) Pogue, R. F.; Atkinson, G. Solution Thermodynamics of First-Row Transition Elements. 2. Apparent Molal Volumes of Aqueous $MnCl_2$, $Mn(ClO_4)_2$, $CoCl_2$, $Co(ClO_4)_2$, $FeCl_2$, and $Fe(ClO_4)_2$, from 15 to 55°C. *J. Chem. Eng. Data* **1989**, *34*, 227–232.

(281) Pogue, R. F.; Atkinson, G. Solution Thermodynamics of First-Row Transition Elements. 3. Apparent Molal Volumes of Aqueous $ZnCl_2$ and $Zn(ClO_4)_2$ from 15 to 55°C and an Examination of Solute-Solute and Solute-Solvent Interactions. *J. Solution Chem.* **1989**, *18*, 249–264.

(282) Pogue, R.; Atkinson, G. Apparent Molal Volumes and Heat Capacities of Aqueous HCl and $HClO_4$ at 15−55 °C. *J. Chem. Eng. Data* **1988**, *33*, 495–499.

(283) Prokash, S.; Shivapuri, T. N.; Ichhaporia, F. M. Temperature effect on the molecular solution volumes of urea, potassium iodide, potassium chloride, and potassium chromate. *J. Indian Chem. Soc.* **1963**, *40*, 700.

(284) Przepiera, A.; Zielenkiewicz, A. Apparent Molar Volumes of Aqueous Solution in the $MnSO_4$ + H_2SO4 System. *Bull. Pol. Acad. Sci. Chem.* **2000**, *48*, 267–272.

(285) Puchalska, D.; Atkinson, G. Densities and apparent molal volumes of aqueous $BaCl_2$ solutions from 15 to 140 °C and from 1 to 200 bar. *J. Chem. Eng. Data* **1991**, *36*, 449–452.

(286) Puchalska, D.; Atkinson, G.; Routh, S. Solution Thermodynamics of First-Row Transition Elements. 4. Apparent Molal Volumes of Aqueous $ZnSO_4$ and $CuSO_4$ Solutions from 15 to 55°C. *J. Solution Chem.* **1993**, *22*, 625–639.

(287) Puchkov, L. V.; Matashkin, V. G. Densities of $LiNO_3$-H_2O and $NaNO_3$-H_2O Solutions at Temperatures in the Range 25−300°C. *J. Appl. Chem. USSR* **1970**, *43*, 1848–1851.

(288) Rakshit, J. N. Contraction of solution of various substances in water and ethyl alcohol. *Z. Electrochem. Angew. Phys. Chem.* **1925**, *31*, 97.

(289) Rard, J. A. Densities and Apparent Molal Volumes of Aqueous Nickel Chloride at 25 °C. *J. Chem. Eng. Data* **1986**, *31*, 183–185.

(290) Rard, J. A.; Miller, D. G. Densities and Apparent Molal Volumes of Aqueous Manganese, Cadmium, and Zinc Chlorides at 25 °C. *J. Chem. Eng. Data* **1984**, *29*, 151–156.

(291) Rashkovskaya, E. A.; Chernen'kaya, E. I. Densities of Solutions of NH_4HCO_3, $NaHCO_3$, NH_4Cl and Ammonia in the 20−100° Range. *J. Appl. Chem. USSR* **1967**, *40*, 301–308.

(292) Rehman, H.-ur-; Ansari, M. S. Density, Viscosity, and Electrical Conductivity Measurements on the Ternary System H_2O + C_2H_5OH + LiCl over the Entire Ranges of Solvent Composition and LiCl Solubility from (−5 to +50) °C. *J. Chem. Eng. Data* **2008**, *53*, 2072–2088.

(293) Reilly, P. J.; Stokes, R. H. The Diffusion Coefficients of Cadmium Chloride and Cadmium Perchlorate in Water at 25 °C. *Aust. J. Chem.* **1971**, *24*, 1361–1367.

(294) Rhodes, F. H.; Barbour, C. B. The viscosity of mixtures of sulfuric acid and water. *Ind. Eng. Chem.* **1923**, *15*, 850–852.

(295) Rice, M. J., Jr.; Kraus, C. A. Conductance and viscosity of concentrated aqueous sal solutions at 50.5 °C. *Proc. Natl. Acad. Sci.* **1953**, *39*, 802.

(296) Rivett, A. C. D. The contribution of magnesium acetate solutions. *J. Chem. Soc.* **1926**, 1063–1069.

(297) Rizzo, P.; Albraight, J. G.; Miller, D. G. Measurements of Interdiffusion Coefficients and Densities for the System HCl + H2O at 25 °C. *J. Chem. Eng. Data* **1997**, *42*, 623–630.

(298) Rodnyanskii, I. M.; Korobkov, V. I.; Galinker, I. S. Specific volumes of aqueous electrolyte solutions at high temperatures. *Russ. J. Phys. Chem.* **1962**, *36*, 1192.

(299) Romankiw, L. A.; I-Ming, C. Densities of aqueous sodium chloride, potassium chloride, magnesium chloride, and calcium chloride binary solutions in the concentration range 0.5−6.1 m at 25, 30, 35, 40, and 45 °C. *J. Chem. Eng. Data* **1983**, *28*, 300–305.

(300) Roux, A. H.; Perron, G.; Desnoyers, J. E. Capacités calorifiques, volumes, expansibilités et compressibilités des solutions aqueuses concentrées de LiOH, NaOH et KOH. *Can. J. Chem.* **1984**, *62*, 878–885.

(301) Roux, A.; Musbally, G. M.; Perron, G.; Singh, P. P.; Woolley, E. M.; Hepler, L. G. Apparent Molal Heat Capacities and Volumes of Aqueous Electrolytes at 25°C: $NaClO_3$, $NaClO_4$, $NaNO_3$, $NaBrO_3$, $NaIO_3$, $KClO_3$, $KBrO_3$, KIO_3, NH_4NO_3, NH_4Cl, and NH_4ClO_4. *Can. J. Chem.* **1978**, *56*, 24–28.

(302) Roy, M. N.; Jha, A.; Choudhury, A. Densities, Viscosities and Adiabatic Compressibilities of Some Mineral Salts in Water at Different Temperatures. *J. Chem. Eng. Data* **2004**, *49*, 291–296.

(303) Rüterjans, H.; Schreiner, F.; Sage, U. Ackermann, Th. Apparent Molal Heat Capacities of Aqueous Solutions of Alkali Halides and Alkylammonium Salts. *J. Phys. Chem.* **1969**, *73*, 986–994.

(304) Sahu, B.; Behera, B. Viscosity of concentrated aqueous solutions of 1:1 electrolytes. *Indian J. Chem.* **1980**, *19A*, 1153.

(305) Salavera, D.; Libotean, S.; Patil, K. R.; Esteve, X.; Coronas, A. Densities and Heat Capacities of the Ammonia + Water + NaOH and Ammonia + Water + KOH Solutions. *J. Chem. Eng. Data* **2006**, *51*, 1020–1025.

(306) Saluja, P. P. S.; Jobe, D. J.; LeBlanc, J. C.; Lemire, R. J. Apparent Molar Heat Capacities and Volumes of Mixed Electrolytes: [NaCl(aq) + $CaCl_2$(aq)], [NaCl(aq) + $MgCl_2$(aq)], and [$CaCl_2$(aq) + $MgCl_2$(aq)]. *J. Chem. Eng. Data* **1995**, *40*, 398–406.

(307) Saluja, P. P. S.; LeBlanc, J. C. Apparent Molar Heat Capacities and Volumes of Aqueous Solutions of $MgCl_2$, $CaCl_2$, and $SrCl_2$ at Elevated Temperatures. *J. Chem. Eng. Data* **1987**, *32*, 72–76.

(308) Saluja, P. P. S.; LeBlanc, J. C.; Hume, H. B. Apparent molar heat capacities and volumes of aqueous solutions of several 1:1 electrolytes at elevated temperatures. *Can. J. Chem.* **1986**, *64*, 926–931.
(309) Saluja, P. P. S.; Lemire, R. J.; LeBlanc, J. C. High-Temperature Thermodynamics of Aqueous Alkali-Metal Salts. *J. Chem. Thermodyn.* **1992**, *24*, 181–203.
(310) Sanchez, M. M.; Dominguez, B.; Raposo, R. R.; Vivo, A. Densities and Molar Volumes of Na_2SO_4 and $MgSO_4$ in Ethanol + Water Mixtures at 15, 25, and 35 °C. *J. Chem. Eng. Data* **1994**, *39*, 453–456.
(311) Satoh, T.; Kayashi, K. The viscosity of concentrated aqueous solutions of strong electrolytes. *Bull. Chem. Soc. Jpn.* **1961**, *34*, 1260.
(312) Savino, M. R.; Vitagliano, V. Diffusion and viscosity in aqueous solutions of H_2SO_4 at 25°. *Consiglio Nazionale delle Ricerche, Ser. II, Rendiconti. Sez. A* **1962**, *2*, 341.
(313) Schmelzer, N.; Einfeldt, J. Density Measurements in Some Aqueous and Non-Aqueous Electrolyte Solutions at 25°C. *Wiss. Z. Uni. Rostock* **1989**, *38*, 81–82.
(314) Scott, A. F.; Durham, E. J. Studies in the solubilities of the soluble electrolytes. *J. Phys. Chem.* **1930**, *34*, 1424–1438.
(315) Scott, A. F.; Obenhaus, V. M.; Wilson, R. W. The Compressibility Coefficients of Solutions of Eight Alkali Halides. *J. Phys. Chem.* **1934**, *38*, 931–940.
(316) Sharma, R. C.; Gaur, H. C. Densities and Molar Volumes of the Ammonium Nitrate-Water System. *J. Chem. Eng. Data* **1977**, *22*, 41–44.
(317) Sharygin, A. V.; Inglese, A.; Sedlbauer, J.; Wood, R. H. Apparent molar heat capacities of aqueous solutions of phosphoric acid and sulfur dioxide from 303 to 623 K and a pressure of 28 MPa. *J. Solution Chem.* **1997**, *26*, 183–197.
(318) Sharygin, A. V.; Wood, R. H. Volumes and heat capacities of aqueous solutions of sodium carbonate and sodium bicarbonate from the temperatures 298.15 to 623 K and pressures to 28 MPa. *J. Chem. Thermodyn.* **1998**, *30*, 1555–1570.
(319) Sheerson, A. L.; Filipova, Z. M.; Miniovich, M. A. Density and viscosity of concentrated magnesium nitrate solutions in the range 100−150 °C. *J. Appl. Chem. USSR* **1965**, *38*, 2063.
(320) Silva, J. W.; Chenevey, J. E. Specific Gravity of Aluminum Sulfate Solutions. *Ind. Eng. Chem.* **1945**, *37*, 1016–1018.
(321) Simon, A.; Weist, M. Acidium salts. Raman-spectroscopic and viscometric investigations of the structures of anhydrous nitric, phosphoric, and perchloric acids as well as phosphoric acid perchlorate. *Z. Anorg. Chem.* **1952**, *268*, 301.
(322) Singh, P. P.; Woolley, E. M.; McCurdy, K. G.; Hepler, L. G. Heat capacities of aqueous electrolytes: eight 1:1 electrolytes and $\Delta Cp0$ for ionization of water at 298 K. *Can. J. Chem.* **1976**, *54*, 3315–3318.
(323) Sipos, P. M.; Hefter, G.; May, P. M. Viscosities and Densities of Highly Concentrated Aqueous MOH Solutions (M+ = Na+, K+, Li+, Cs+, $(CH3)_4N$+) at 25.0 °C. *J. Chem. Eng. Data* **2000**, *45*, 613–617.
(324) Sipos, P.; Stanley, A.; Bevis, S.; Hefter, G.; May, P. M. Viscosities and Densities of Concentrated Aqueous NaOH/$NaAl(OH)_4$ Mixtures at 25 °C. *J. Chem. Eng. Data* **2001**, *46*, 657–661.
(325) Sohnel, P.; Novotny, P; Solc, Z. Densities of aqueous solutions of 18 inorganic substances. *J. Chem. Eng. Data* **1984**, *29*, 379–382.
(326) Sorenson, E. C.; Woolley, E. M. Thermodynamics of proton dissociation from aqueous bicarbonate: apparent molar volumes and apparent molar heat capacities of potassium carbonate and potassium bicarbonate at T=(278.15 to 393.15) K and at the pressure 0.35 MPa. *J. Chem. Thermodyn.* **2004**, *36*, 289–298.
(327) Spitzer, J. J.; Olofsson, I. V.; Singh, P. P.; Hepler, L. G. Apparent molar heat capacities and volumes of aqueous electrolytes at 25°C: $NaIO_3$, $KMnO_4$, and $MnCl_2$. *Thermochim. Acta* **1979**, *28*, 155–160.
(328) Spitzer, J. J.; Singh, P. P.; McCurdy, K. G.; Hepler, L. G. Apparent Molar Heat Capacities and Volumes of Aqueous Electrolytes: $CaCl_2$, $Cd(NO_3)_2$, $CoCl_2$, $Cu(ClO_4)_2$, $Mg(ClO_4)_2$, and $NiCl_2$. *J. Solution Chem.* **1978**, *7*, 81–86.
(329) Stakhanova, M. S. A comparative study of the specific heats and densities of aqueous electrolyte solutions. *Russ. J. Phys. Chem.* **1964**, *38*, 1306.
(330) Stokes, R. H.; Phang, S.; Mills, R. Density, Conductance, Transference Numbers, and Diffusion Measurements in Concentrated Solutions of Nickel Chloride. *J. Solution Chem.* **1979**, *8*, 489–500.
(331) Sugden, J. N. The hydratation of strong electrolytes, the viscosity of their aqueous solutions, and the dilution law. *J. Chem. Soc.* **1926**, 174–196.
(332) Suhrmann, R.; Wiedersich, I. The effect of foreign ions on the conductivity of hydrogen ions in aqueous solutions. *Z. Annorg. Allg. Chem.* **1953**, *272*, 167.
(333) Sulston, W. J. The temperature variation of the viscosity of aqueous solutions of strong electrolytes. *Proc. Phys. Soc. (London)* **1935**, *47*, 657.
(334) Surdo, A. L.; Bernstrom, K.; Jonsson, C. A.; Millero, F. J. Molal volume and adiabatic compressibility of aqueous phosphate solutions at 25 °C. *J. Phys. Chem.* **1979**, *83*, 1255–1262.
(335) Suryanarayana, C. V.; Alamelu, S. Electrical Conductance of Concentrated Aqueous Solutions of Copper Sulfate. *Bull. Chem. Soc. Jpn.* **1959**, *32*, 333–339.
(336) Suryanarayana, C. V.; Alamelu, S. Electrical Conductance of Concentrated Aqueous Solutions of Zinc Sulphate. *Acta Chim. Hung.* **1959**, *20*, 91–102.
(337) Suryanarayana, C. V.; Venkatesan, V. K. A new viscosity relationship in a wide concentration range of aqueous solutions of potassium chloride. *Bull. Chem. Soc. Jpn.* **1958**, *31*, 442.
(338) Suryanarayana, C. V.; Venkatesan, V. K. A new viscosity relationship in highly concentrated aqueous solutions of silver nitrate and sodium nitrate. *Acta Chim. Acad. Sci. Hung.* **1958**, *16*, 149.
(339) Suryanarayana, C. V.; Venkatesan, V. K. Electrical conductance of concentrated solutions of strong electrolytes. *Acta Chim. Acad. Sci. Hung.* **1958**, *17*, 327.
(340) Suryanarayana, C. V.; Venkatesan, V. K. The viscosity of concentrated aqueous solutions of sodium chloride. *Trans. Faraday Soc.* **1958**, *54*, 1709.
(341) Swenson, D. M.; Woolley, E. M. Apparent molar volumes and apparent molar heat capacities of aqueous KI, HIO_3, $NaIO_3$, and KIO_3 at temperatures from 278.15 to 393.15 K and at the pressure 0.35 MPa. *J. Chem. Thermodyn.* **2008**, *40*, 54–66.
(342) Taboada, M. E.; Véliz, D. M.; Galleguillos, H. R.; Graber, T. A. Solubility, Density, Viscosity, Electrical Conductivity, and Refractive Index of Saturated Solutions of Lithium Hydroxide in Water + Ethanol. *J. Chem. Eng. Data* **2005**, *50*, 187–190.
(343) Taft, R.; Welch, F. H. Physical Properties of Aqueous Solutions of Sodium Oxalate, Sodium Malonate, and Sodium Succinate, I. *Tr. Kansas Acad. Sci.* **1951**, *54*, 233–246.
(344) Tamas, J. Density of some aqueous electrolyte solutions. *Acta Chim. Acad. Sci. Hung.* **1964**, *40*, 117.
(345) Tanaka, M. Concentrated solutions of electrolytes. Viscosities. II. *Nippon Kagaku Zasshi* **1961**, *82*, 147.
(346) Tanaka, M. Viscosites of concentrated aqueous solutions of sodium sulfate, potassium sulfate, magnesium chloride, strontium chloride, and barium chloride. *Nippon Kagaku Zasshi* **1962**, *83*, 645.
(347) Tanaka, M. Viscosities of concentrated aqueous solutions of sodium chloride, sodium bromide and sodium nitrate. *Nippon Kagaku Zasshi* **1962**, *I*, 639.
(348) Tanner, J. E.; Lamb, F. W. Specific heats of aqueous solutions of NaCl, NaBr, and KCl: comparisons with related thermal properties. *J. Solution Chem.* **1978**, *7*, 303–316.
(349) Teng, H.; Yamasaki, A.; Chum, M.-K.; Lee, H. Solubility of liquid CO_2 in water at temperatures from 278 to 293 K and pressures from 6.44 to 29.49 MPa and densities of the corresponding aqueous solutions. *J. Chem. Thermodyn.* **1997**, *29*, 1301–1310.
(350) Tham, M. K.; Gubbins, K. E.; Walker Jr., R. D. Densities of Potassium Hydroxide Solutions. *J. Chem. Eng. Data* **1967**, *12*, 525–526.
(351) Tollert, H. Viscosity of aqueous solutions of the cerium earth nitrates in the determination of their basicity. *Z. Phys. Chem. A* **1939**, *184*, 165.
(352) Torók, T. I.; Berecz, E. Volumetric Properties and Electrolytic Conductances of Aqueous Ternary Mixtures of Hydrogen Chloride and some Transition Metal Chlorides at 25 °C. *J. Solution Chem.* **1989**, *18*, 1117–1131.
(353) Tremaine, P. R.; Sway, K.; Barbero, J. A. The apparent molar heat capacity of aqueous hydrochloric acid from 10 to 140 °C. *J. Solution Chem.* **1986**, *15*, 1–22.
(354) Tromans, A.; Königsberger, E.; May, P. M.; Hefter, G. Heat Capacities and Volumes of Aqueous Dicarboxylate Salt Solutions of Relevance to the Bayer Process. *J. Chem. Eng. Data* **2005**, *50*, 2019–2025.
(355) Trypuc, M.; Kielkowska, U. Solubility in the NH_4HCO_3 + $NaHCO_3$ + H2O System. *J. Chem. Eng. Data* **1998**, *43*, 201–204.
(356) Trypuc, M.; Kielkowska, U.; Stefanowicz, D. Solubility Investigations in the $KHCO_3$ + NH_4HCO_3 + H_2O System. *J. Chem. Eng. Data* **2001**, *46*, 800–804.
(357) Vasilev, Y. A.; Fedyainov, N. V.; Kurenkov, V. V. Specific Heats and Specific Volumes of Isopiestic Aqueous Solutions of Beryllium-Subgroup Metal Chlorides. *Russ. J. Phys. Chem.* **1973**, *47*, 2799–2803.
(358) Vaslow, F. The apparent molal volumes of the alkali metal chlorides in aqueous solutions and evidence for salt-induced structure transitions. *J. Phys. Chem.* **1966**, *70*, 2286–2294.
(359) Vaslow, F. The Apparent Molal Volumes of the Lithium and Sodium Halides. Critical Type Transitions in Aqueous Solution. *J. Phys. Chem.* **1969**, *73*, 3745–3750.
(360) Vázquez, G.; Alvarez, E.; Cancela, A.; Navaza, J. M. Density, Viscosity, and Surface Tension of Aqueous Solutions of Sodium

Sulfite and Sodium Sulfite + Sucrose from 25 to 40 °C. *J. Chem. Eng. Data* **1995**, *40*, 1101–1105.
(361) Vazquez, G.; Alvarez, E.; Navaza, J. M. Density, Viscosity, and Surface Tension of Sodium Carbonate + Sodium Bicarbonate Buffer Solutions in the Presence of Glycerine, Glucose, and Sucrose from 25 to 40 °C. *J. Chem. Eng. Data* **1998**, *43*, 128–132.
(362) Vazquez, G.; Alvarez, E.; Varela, R.; Cancela, A.; Navaza, J. M. Density and Viscosity of Aqueous Solutions of Sodium Dithionite, Sodium Hydroxide, Sodium Dithionite + Sucrose, and Sodium Dithionite + Sodium Hydroxide + Sucrose from 25 C to 40 °C. *J. Chem. Eng. Data* **1996**, *41*, 244–248.
(363) Vercher, E.; Rojo, F. J.; Martinez-Andreu, A. Apparent Molar Volumes of Calcium Nitrate in 1-Propanol + Water at 298.15 K. *J. Chem. Eng. Data* **1999**, *44*, 1212–1215.
(364) Vinal, G. W.; Craig, D. N. The viscosity of sulphuric-acid solutions used for battery electrolytes. *J. Research Natl. Bur. Stand.* **1933**, *10*, 781.
(365) Wahab, A.; Mahiuddin, S. Electrical conductivity, speeds of sound, and viscosity of aqueous ammonium nitrate solutions. *Can. J. Chem.* **2001**, *79*, 1207–1212.
(366) Wahab, A.; Mahiuddin, S. Isentropic Compressibility and Viscosity of Aqueous and Methanolic Calcium Chloride Solutions. *J. Chem. Eng. Data* **2001**, *46*, 1457–1463.
(367) Wahab, A.; Mahiuddin, S. Isentropic Compressibility and Viscosity of Aqueous and Methanolic Lithium Chloride Solutions. *Can. J. Chem.* **2002**, *80*, 175–182.
(368) Wahab, A.; Mahiuddin, S. Isentropic Compressibility, Electrical Conductivity, Shear Relaxation Time, Surface Tension, and Raman Spectra of Aqueous Zinc Nitrate Solutions. *J. Chem. Eng. Data* **2004**, *49*, 126–132.
(369) Wahab, A.; Mahiuddin, S.; Hefter, G.; Kunz, W. Densities, Ultrasonic Velocities, Viscosities, and Electrical Conductivities of Aqueous Solutions of $Mg(OAc)_2$ and $Mg(NO_3)_2$. *J. Chem. Eng. Data* **2006**, *51*, 1609–1616.
(370) Wakefield, Z. T.; Luff, B. B.; Reed, R. B. Heat capacity and enthalpy of phosphoric acid. *J. Chem. Eng. Data* **1972**, *17*, 420–423.
(371) Weingärtner, H.; Müller, K. J.; Hertz, H. G.; Edge, A. V. J.; Mills, R. Unusual Behavior of Transport Coefficients in Aqueous Solutions of Zinc Chloride. *J. Phys. Chem.* **1984**, *88*, 2173–2178.
(372) White, J. C.; Miller, R. R. Densities and Freezing Points of Sodium Permanganate Solutions. *J. Am. Chem. Soc.* **1953**, *75*, 3282–3283.
(373) Wicke, E.; Eigen, M.; Ackermann, Th. Über den Zustand des Protons (Hydroniumions) in wäβriger Lösung (On the condition of the proton in aqueous solution). *Z. Phys. Chem.* **1954**, *1*, 340–364.
(374) Wimby, J. M.; Berntsson, T. S. Viscosity and Density of Aqueous Solutions of LiBr, LiCl, ZnBr2, CaCl2, and LiNO3. 1. Single Salt Solutions. *J. Chem. Eng. Data* **1994**, *39*, 68–72.
(375) Wirth, H. E. The Partial Molal Volume of Acetic Acid in Sodium Acetate and in Sodium Chloride Solutions. *J. Am. Chem. Soc.* **1948**, *70*, 462–465.
(376) Wirth, H. E.; Lo Surdo, A. Temperature Dependence of Volume Changes on Mixing Electrolyte Solutions. *J. Chem. Eng. Data* **1968**, *13*, 226–231.
(377) Woolf, L. A.; Hoveling, A. W. Mutual diffusion coefficients of aqueous copper (II) sulfate solutions at 25 °C. *J. Phys. Chem.* **1970**, *74*, 2406–2408.
(378) Zafarani-Moattar, M. T.; Hamzehzadeh, Sh. Measurement and Correlation of Densities, Ultrasonic Velocities, and Compressibilities for Binary Aqueous Poly(ethylene glycol), Disodium Succinate, or Sodium Formate and Ternary Aqueous Poly(ethylene glycol) Systems Containing Disodium Succinate or Sodium Formate at $T =$ (298.15, 308.15, and 318.15. *J. Chem. Eng. Data* **2005**, *50*, 603–607.
(379) Zafarani-Moattar, M. T.; Mehrdad, A. Measurement and Correlation of Density for PEG + H2O + NaHSO4, NaH2PO4, and Na2HPO4 at Three Temperatures. *J. Chem. Eng. Data* **2000**, *45*, 386–390.
(380) Zhang, H.-L.; Chen, G.-H.; Han, S.-J. Viscosity and Density of H_2O+NaCl+$CaCl_2$ and H_2O+KCl+$CaCl_2$ at 298.15K. *J. Chem. Eng. Data* **1997**, *42*, 526–530.
(381) Zhang, H.-L.; Han, S-J. Viscosity and Density of Water + Sodium Chloride + Potassium Chloride Solutions at 298.15 K. *J. Chem. Eng. Data* **1996**, *41*, 516–520.
(382) Zhuo, K.; Chen, Y.; Wang, W.; Wang, J. Volumetric and Viscosity Properties of $MgSO_4$/$CuSO_4$ in Sucrose + Water Solutions at 298.15 K. *J. Chem. Eng. Data* **2008**, *50*, 2022–2028.
(383) Ziemer, S. P.; Niederhauser, T. L.; Sargent, J. D.; Woolley, E. M. Apparent molar volumes and apparent molar heat capacities of aqueous sodium bromide and sodium fluoride at temperatures from (278.15 to 393.15) K and at the pressure 0.35 MPa. *J. Chem. Thermodyn.* **2004**, *36*, 147–154.
(384) Zodejs, Z.; Sacchetto, G. A. Theory of volumetric behaviour of hydrous melts. The systems $LiNO_3$ - H_2O and NH_4NO_3 - H_2O. *J. Chem. Soc., Faraday Trans. I* **1982**, *78*, 3529–3535.
(385) Banipal, T. S.; Singh, K.; Banipal, P. K.; Sood, A. K.; Singh, P.; Singh, G.; Patyar, P. Volumetric and Viscometric Studies of Some Metal Acetates in Aqueous Solutions at $T =$ (288.15 to 318.15) K. *J. Chem. Eng. Data* **2008**, *53*, 2758–2765.
(386) Franz, B. Die specifischen Gewichte einiger wässrigen Lösungen (Of the specific weight of some aqueous solutions). *Praktische Chem.* **1872**, *5*, 274–308.
(387) Heydweiller, A. Elektrische Leitfähigkeit und Dichte wäβriger Elektrolytlösungen (Electrical conductivity and density of aqueous electrolytic solutions). *Z. Anorg. Allg. Chem.* **1921**, *116* (1), 42–44.
(388) Königsberger, E.; Königsberger, L.-C.; Szilágyi, I.; May, P. M. Measurement and Prediction of Physicochemical Properties of Liquors Relevant to the Sulfate Process for Titania Production. 1. Densities in the $TiOSO_4 + FeSO_4 + H_2SO_4 + H_2O$ System. *J. Chem. Eng. Data* **2009**, *54*, 520–525.

Received for review October 31, 2008. Accepted February 18, 2009.

JE8008123