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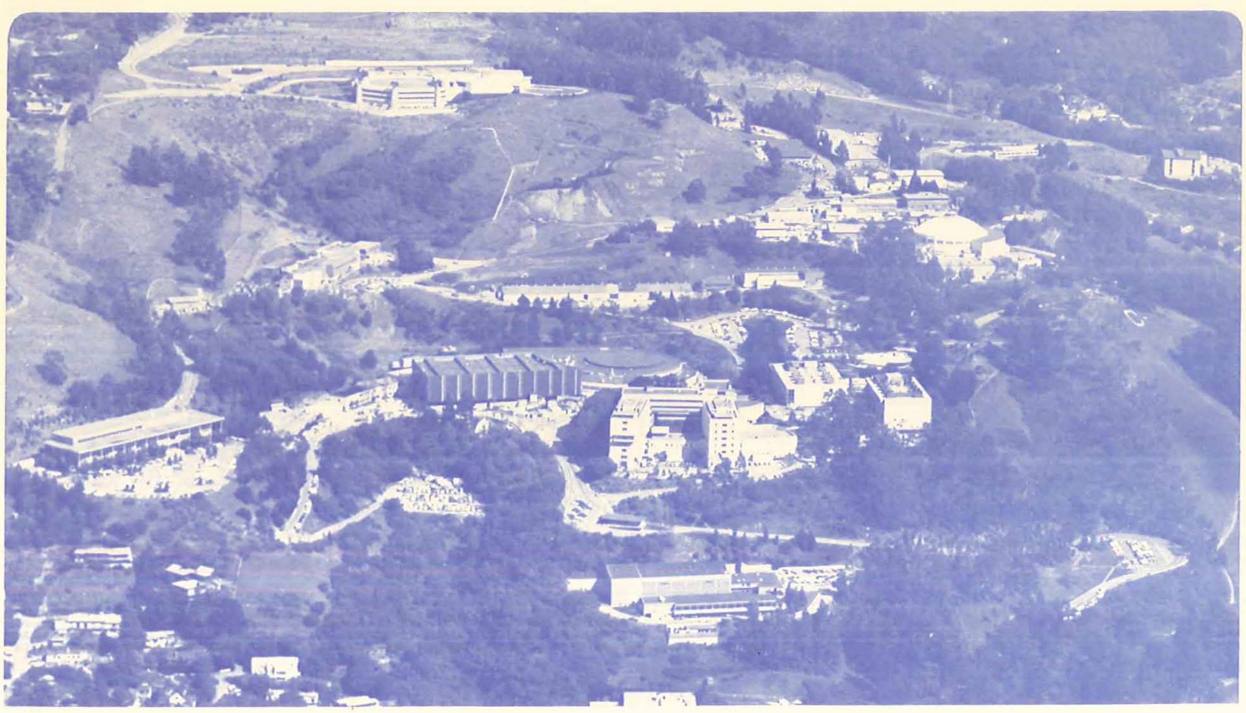
A TECHNICAL DATABOOK FOR GEOTHERMAL ENERGY UTILIZATION

S.L. Phillips, A. Igbene, J.A. Fair, H. Ozbek,
and M. Tavana

June 1981



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A Technical Databook for Geothermal Energy Utilization*

S. L. Phillips, A. Igbene, J. A. Fair,
H. Ozbek and M. Tavana

Lawrence Berkeley Laboratory
University of California
Berkeley, CA 94720

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List of Tables and Figures	iii
Acknowledgment	vi
Objective and Scope of Technical Databook	vii
Prologue	viii
Recommendations	ix
Contents	Page
Abstract	1
Introduction	2
Transport Properties of Aqueous Solutions	5
Viscosity	5
Thermal Conductivity	7
Electrical Resistivity	9
Thermodynamic Properties of Aqueous Solutions	10
Enthalpy	10
Heat Capacity	11
Physical Properties of Aqueous Solutions	12
Solubility	12
Density	14
Vapor Pressure	16
Summary and Conclusions	17
References	18
Units Conversion	19
Appendix I. Properties of sodium chloride solutions.	28
*Appendix II. Properties of potassium chloride solutions.	64
*Appendix III. Properties of calcium chloride solutions.	75
*Appendix IV. Properties of mixtures of sodium, potassium and calcium chloride solutions.	78

*In preparation.

Tables of Recommended or Best Values

Table		Page
1.	Viscosity of NaCl solutions, saturated vapor pressure (svp); 25 - 350 °C; 0 - 4 molal.	20
2.	Thermal conductivity of NaCl solutions, svp; 20 - 330 °C; 0 - 4 molal.	20
3.	Resistivity of NaCl solutions, 30 MPa; 25 - 350 °C; 0 - 4 molal.	20
4.	Enthalpy of NaCl solutions, svp; 25 - 300 °C; 0 - 4.2777 molal	21
5.	Heat capacity of NaCl solutions, svp; 25 - 300 °C; 0.4708 - 4.2777 molal.	21
6.	Solubility of NaCl, KCl, $CaCl_2$, SiO_2, svp; 25 - 350 °C.	21
7.	Skeleton table, density of NaCl solutions; 0.1 - 50 MPa; 0 - 4 molal; 25 - 350 °C.	22
8.	Density of NaCl solutions; 2 MPa; 25 - 200 °C; 0 - 0.5 molal.	23
9.	Vapor pressure of NaCl solutions; 25 - 325 °C; 0 - 4 molal.	23
Appendix I.	Density of NaCl solutions at 5 °C intervals; svp; 5 - 350 °C; 1 - 5 molal.	29
	Density of NaCl solutions at 5 °C intervals; 100 - 1000 bars (0.1 - 100 MPa); 5 -350 °C; 0.25 - 5 molal	31
	Enthalpy of NaCl solutions; svp; 0 - 300 °C; 0.25 - 25.00 percent by weight.	43
	Heat capacity of NaCl solutions; svp; 0 - 300 °C; 0.25 - 25.00 percent by weight.	45
	*Viscosity of NaCl solutions at 5 °C intervals; 0.1 - 50 MPa; 0 - 350 °C; 0 - 4 molal.	47
	*Thermal conductivity of NaCl solutions; svp; 0 - 5 molal.	60
	*Solubility of NaCl in steam; 350 - 450 °C; 10 - 25.9MPa	61
	*Heat of solution at infinite dilution; svp; 0 - 300 °C.	62
	*Standard state heat capacity of NaCl solutions; svp; 0 - 300 °C.	63
Appendix II.	*Viscosity of KCl solutions; 0.1 - 35 MPa; 25 - 150 °C; 0 - 5 molal.	65

*In preparation.

Tables of Recommended or Best Values

Table		Page
*Appendix II.	Density of KCl solutions; svp; 20 - 150 °C; 0.1 - 3.5 molal.	73
	Vapor pressure of KCl solutions; 20 - 150 °C; 0.1 - 3.5 molal.	74
*Appendix III.	Viscosity of $CaCl_2$ solutions; svp; 10 - 100 °C; 0.1 - 3 molal.	76
	Density of $CaCl_2$ solutions; 20 bars; 25 - 250 °C; 0. 05 - 1 molal.	77
*Appendix IV.	Viscosity of NaCl - KCl, and NaCl- $CaCl_2$ solutions; svp; 25 - 150 °C; 0.4807 - 3.0221 molal.	79

*In preparation.

List of Figures

Figure		Page
1.	Comparative viscosities of water and 1 m concentrations of NaCl, KCl and $CaCl_2$ solutions.	24
2.	Solubility of $CaCO_3$ in water and 0.2 m NaCl, 0.5 m NaCl, 1.0 m NaCl at CO_2 pressures of 1 - 62 bars; 100 - 350 °C.	25
3.	Solubility of CO_2 in 0 - 2 m NaCl solutions, given as Ostwald coefficient; 100 - 350 °C.	26
4.	Density of NaCl solutions at 500 bars; 25 - 350 °C; 1 - 5 molal.	27

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Objective and Scope of Work

The objective of this project is to provide comprehensive and in-depth data for geothermal energy power production and direct use. Worldwide published experimental and calculated data are collected, organized and critically evaluated. Interpolating equations are developed to reproduce the data over stated ranges of temperatures and pressures, with the least error. Theoretically based equations are used to calculate values in temperature regions where data do not currently exist, to cover the ranges expected for power production and direct use. Reports are written which identify those areas where data are needed, and to recommend research that will provide the required data.

Prologue

How happy is the man who finds wisdom,
The man who gains understanding!
...
She is more precious than corals,
and none of your heart's desires can compare with her.
...
Her ways are ways of pleasantness
And all her paths are peace.
She is a tree of life to those who grasp her,
And happy is every one who holds her fast.

Proverbs

Rigidity threatens all realization: what lives and glows today may be crusted over tomorrow and, becoming all-powerful, suppress the strivings of the day after.

Martin Buber

Recommendations

An ideal data bank for geothermal energy utilization would permit accurate calculations of the quantity of steam available to economically produce electricity, and of hot water for heating or manufacturing purposes. A reliable data system would include the following information:

1. Measurements at high temperatures and pressures of the properties of geothermal brines (e.g.,Baca,Salton Sea) to include density, solubility, enthalpy, viscosity and ionic strength. There is currently very little available data, and this is both widely scattered in the published literature, and largely unevaluated.

2. Laboratory instrumentation for measuring brine properties at high temperatures and pressures. These instruments would be corrosion resistant, have self-cleaning features to remove precipitated salts, and be computer-automated to facilitate obtaining reproducible results.

3. Theoretically-based equations for use in calculating brine properties at temperatures, pressures and concentrations where experimental values are not available. Of special value is the calculation of properties of mixtures such as the viscosity of NaCl and $CaCl_2$ solutions, the solubility of silica in NaCl solutions, and the distribution of carbon dioxide between the liquid and gas phases.

4. Data on multigas equilibria at high temperatures and pressures, e.g., carbon dioxide-ammonia-hydrogen sulfide and methane in water and salt solutions. These equilibrium constants are needed to characterize a hot brine reservoir, and to predict the likely changes such as precipitation taking place when a one phase hot brine flashes to a gas and liquid phase under reduced pressures, with a change in liquid pH.

5. Experimentally obtained data on the solubility of rocks and minerals to compare with those values calculated in the widely used publication by Helgeson [28].

6. Experimental data on the principal dissolved species in a geothermal brine to include the formation constants for each metal-ligand ratio to high temperatures and pressures, to compare with those values calculated by the widely used WATEQ computer program [29].

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ABSTRACT

A critical survey is made of selected basic data on those aqueous solutions needed to model geothermal energy utilization. The data are useful in the design and construction of power plants and for direct use. The result of the survey is given as a current status of data. More emphasis is placed on the viscosity, thermal conductivity and density of sodium chloride solutions up to 350^{o} C and 50 MPa. An ideal data book for geothermal energy is described.

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Introduction

It is central to the utilization of our geothermal energy resources that reliable data on hot aqueous solutions be readily available. Up to now, the need has been to calculate and model the flow of heat as transported by a hot brine or by steam. These data are used to predict scale formation in heat exchangers, corrosion in pipelines, solids precipitation in wells and the expected lifetime of a power plant. Future needs include data on geopressured and magma systems, and hot dry rock.

The past ten years has seen a substantial growth in the quantity of thermodynamic and transport data available to geothermal scientists and engineers. Most of the experimental results and calculated values have been published in the United Stated by the National Laboratories, the U. S. Geological Survey and by universities. Important research outside the United States is published by laboratories in New Zealand, Iceland, Scotland, the USSR and West Germany. However, these data are widely scattered and largely unevaluated. This data book provides selected evaluated data which is available from one source.

Early calculations for modeling geothermal energy systems were based on the enthalpy and heat capacity of pure water and steam; steam tables were extensively used. Beginning about fifteen years ago, research results were published by Ellis[1] on the density of sodium chloride and other solutions to more closely approximate a geothermal hot brine. Calculations were generally made at saturated vapor pressures. Extensive use was made of existing tabulations used by the petroleum industry for viscosity, and in water desalination technology for thermal conductivity, viscosity and density. For example, data on the viscosity of NaCl solutions up to 150^{o} C were available in the report by Korosi and Fabuss[2] published in 1968, and the series of curves in the publication Pressure Buildup in Wells[3]. Density data for NaCl solutions to 300^{o} C were obtained from the correlation developed by Haas, which was published in 1970[4].

The reliability of experimental measurements used to develop the various correlations for the geothermal properties of aqueous solutions is variable. This is especially true of measurements at high temperatures and pressures. This is partly due to the corrosiveness of NaCl solutions at high temperatures toward materials used in laboratory instruments; gold-lined bomb calorimeters and other resistant materials are required. Other uncertainties include purity of solutions, calibration with known standards, pressure corrections, and changes in solution concentrations due to the change from the O^{16} to the C^{12} standard. An additional uncertainty relates to data published as values relative to that of water: references may not be given to which values for water were used in calculating the relative values. There are so few experimental data at high temperatures and pressures that one set of values are selected on the premise that data with a large uncertainty are often better than no data at all. Thermal conductivity is an example of this last case.

A geothermal brine is an aqueous solution with a large number of dissolved solids and gases. The concentrations of these dissolved substances varies from μg/L levels for heavy metals to over 30,000 g/L for NaCl. However, the properties discussed here are governed mainly by the major dissolved substances: NaCl, KCl and $CaCl_2$. The range of conditions for geothermal hot brines are 20^o - 350^o C, 1 to 500 bar (.1 - 50 MPa) and 0 - 5 m concentrations.

Additional information on basic data for geothermal energy calculations is found in a number of publications including the following: International Critical Tables[5]; Physical Properties of the Coexisting Phase and Thermochemical Properties of the H_2O Component in Boiling NaCl Solutions[6]; Properties of Sea Water and Solutions Containing Sodium Chloride, Potassium Chloride, Sodium Sulfate and Magnesium Sulfate[2]; Thermodynamics of High Temperatures Brines[7]; Viscosity of $CaCl_2$, KCl and NaCl Solutions[8,9]. The results of recent research are published, for example, in the Journal of Chemical and Engineering Data, and the Journal of Solution Chemistry. Of special note is the recent book Thermodynamics of Aqueous Systems with Industrial Applications, which contains an excellent summary of basic data up to about the year 1979[10].

TRANSPORT PROPERTIES

Transport properties for geothermal solutions are used to calculate the ease with which a hot brine will flow or can be pumped, and to predict how well the liquid conducts heat and electricity. The properties covered here are viscosity, thermal conductivity and electrical resistivity.

Viscosity

Viscosity represents one property of geothermal fluids where very good experimental data are available up to 150^{o} C. Most of the recent research in the United States has been published by Kestin for NaCl, KCl and $CaCl_2$ for temperatures and pressures up to 150^{o} C and 35 MPa[8]. Elsewhere, important publications are those by Pepinov, Yusufova and Lobkova for NaCl solutions up to 350^{o} C; and by Semenyuk, Zarembo and Fedorov covering temperatures to 356^{o} C and pressures up to 150 MPa for both NaCl and KCl[11].

We developed a theoretically based correlation for NaCl solutions using over 1,500 selected experimental values[9]. The model used was derived by Vand in 1948 for colloidal suspensions and solutions of non-electrolytes; however, the equation has been used extensively for electrolytes such as NaCl after suitable modification:[27]

$$\frac{\eta}{\eta_w} = 1 + am + bm^2 + cm^3 + dT(1 - e^{km}) \qquad (1)$$

where a = 0.0816

b = 0.0122

c = 0.000128

d = 0.000629

k = -0.7

T = temperature, ^{o}C

$\dot{m}$ = molal concentration, g-moles NaCl/kg H_2O

η = viscosity of NaCl solutions, cp

η_w = viscosity of water, cp

Equation (1) reproduces data to an average of better than $\pm$ 2%, over the ranges 10 - 350 C, 0.1 - 50 MPa and 0 - 5 m. Table 1 consists of viscosity values for NaCl solutions calculated from Eq. (1) at saturated vapor pressures; water viscosity values are taken from the recent correlation by Watson, Basu and Sengers[12]. As shown in Table 1, the viscosity decreases with increasing temperature, and increases with increased salt concentration. See Fig. 1.

The variation in relative viscosity at saturated vapor pressures and temperatures between 150 - 350^{o} C was calculated recently by Lindsay using the Othmer rule[13]. Lindsay's work predicts a dip in the relative viscosity at these temperatures, followed by an increase at 350^{o} C, and agrees well with experimental data published by Semenyuk, Zarembo and Fedorov[11]. However, a linear increase is predicted by Eq. (1), and by the data of Pepinov, Yusufova and Lobkova[11]. Additional experimental data over this temperature range are needed to clarify this point.

Besides NaCl, the viscosity of both KCl and $CaCl_2$ solutions and their mixtures is important. The viscosity of KCl solutions is lower than those of NaCl solutions at equivalent concentrations; however, $CaCl_2$ solutions have a higher viscosity. The change in viscosity of 1 m solutions of NaCl, KCl and $CaCl_2$ with temperature is shown in Fig. 1. More information on the viscosity of geothermal solutions is contained in references 8, 9, 11, 12, 13.

Thermal Conductivity

The current published literature on the thermal conductivity of sodium chloride solutions to high temperatures and pressures is not extensive; this is especially true for data at temperatures above 80^o C and pressures exceeding saturated vapor values[14]. Only one series of experimental measurements is available to 150^o C; by far the most extensive data are contained in graphical form in the paper by Yusufova, Pepinov, Nikolaev and Guseinov. However, while the latter publication consists of over 50 data points between 100^o C and 330^o C, accurate values cannot be read from the graphs[15].

Yusufova et al. measured the thermal conductivity of aqueous NaCl solutions from 20^o - 330^o C, and 5 - 25% weight. The data were correlated with the following equation for over 50 data points with a reported deviation of 2%.

$$\lambda/\lambda_w = 1.0 - (2.3434 \times 10^{-3} - (7.924 \times 10^{-6})T + (3.924 \times 10^{-8})T^2)S + (1.06 \times 10^{-5} - (2 \times 10^{-8})T - (1.2 \times 10^{-10})T^2)S^2 \qquad (2)$$

where

$$S = \frac{5844.3m}{1000 + 58.443m}$$

$$\lambda_w = -0.92247 + 2.8395\left(\frac{T + 273.15}{273.15}\right) - 1.8007\left(\frac{T + 273.15}{273.15}\right)^2 + 0.52577\left(\frac{T + 273.15}{273.15}\right)^3 - 0.07344\left(\frac{T + 273.15}{273.15}\right)^4 \qquad (3)$$

We found Eq. (2) and Eq. (3) generally reproduce other experimental data to better than $\pm$ 2% between 20° - 80° C; an exception is the data of Korosi and Fabuss where the deviation ranges between +5.3% to +13.8%. Over the range 100° - 150° C, the deviation between the calculated values and the data of Korosi and Fabuss increases up to +31.6% at 150° C. However, we assumed their values to be incorrect partly because they are consistently higher than the other experimental values at temperatures below 80° C, and partly because Korosi and Fabuss felt their measurements should be considered tentative. In addition, their data for sea water up to 150° C are consistently lower than those of Jamieson and Tudhope[16].

The thermal conductivity increases with increasing temperatures up to a broad maximum near 140^{o} C, then decreases with concentration, by a maximum of 7% for 5m NaCl as compared with pure water. Table 2 consists of smoothed values for the thermal conductivity of aqueous NaCl solutions from 20^{o} C to 330^{o} C over the concentration range 0 to 4 molal, at saturated vapor pressures. Additional information is obtained from the recent review by Jamieson[17].

Electrical Resistivity

Physical measurements using instrumental methods are preferred for locating potential geothermal reservoirs. Electrical resistivity is widely used as one of the main instrumental methods for indicating a subsurface hot brine.

Electrical resistivity data were recently published for geothermal energy applications by Ucok, Olhoeft and Ershaghi. Measurements were made on NaCl, KCl and $CaCl_2$ solutions at a frequency of 1 KH_z and 30 MPa for temperatures between 22^{o} - 375^{o} C. The resistivity decreases with increasing temperature and salt concentration for concentrations of 3 - 20 %w NaCl solutions; there is a broad minimum between about 250^{o} C and 325^{o} C. At temperatures exceeding 325^{o} C, the resistivity increases. The correlation reproduces their experimental data to an accuracy of $\pm$ 2%; calculations of resistivity values for any selected temperature and concentration can be done using the BASIC program listed in the publication [18]. See Table 3.

In summary, the electrical resistivity of NaCl, KCl and $CaCl_2$ solutions has been correlated for geothermal applications. Data for fundamental use such as ion-pair formation are obtained in the publications by both Franck and Marshall. See the literature cited in reference 18.

THERMODYNAMIC PROPERTIES

The thermodynamic properties covered here are enthalpy and heat capacity. Despite the need of experimental measurements to 350^{o} C and 50 MPa, the majority of data are still below 100^{o} C, and at saturated vapor pressures. The lack of data at higher temperatures and pressures is so acute that only three or four newly published values are sufficient cause for recalculating correlation equtions to improve the accuracy of a fit. The most widely used thermodynamic data are those published by Pitzer.

Enthalpy

Pitzer, Bradley, Rogers and Peiper fit selected experimental data to a 30 parameter theoretically based equation[7]. Values of the total relative molal enthalpy at saturated vapor pressures agree with those of Ensor and Anderson, and Messikomer and Wood to within $\pm$ 60 J/mole up to 75^{o} C, and 250 J/mole at 100^{o} C for 5 molal concentration. The large value at 100^{o} C is attributed to incompatibility between the various types of data. The low molality heat of solution data published by Cobble were fit within the stated experimental error. See Table 4, and Appendix I.

The effect of added NaCl is to lower the enthalpy of pure water over the temperature range 0^{o} to 300^{o} C. Maximally at 300^{o} C, a 5 m NaCl solution has a difference in enthalpy of about 500 KJ/kg as compared with pure water at the same temperature. The effect of pressure up to 100 MPa is given as pressure correction terms with an uncertainty of 10 - 20% in the recent publication by Rogers[19].

In summary, experimental data such as heat of solution and heat of dilution needed to calculate the enthalpy of NaCl solutions at high temperatures is limited. The most extensive tabulated values are calculated. Recent calculations by Rogers extended the pressure range to include pressures exceeding vapor saturated values.

Heat Capacity

Experimental data on heat capacity are available to 350^{o} and 0.001-6 molal; however, only one set of data is available at pressures different from vapor saturation. The experimental data were fit by Pitzer et al.[7]. The data below 100^{o} C were fit to better than 0.004 J/gm-^{o}C, but the error was as large as 0.01 J/gm-^{o}C at high molalities at temperatures of 45^{o} C and 65^{o} C. Also the error in the fit to experimental data increased with increasing temperature and was $\pm$ 0.03 J/mole-^{o}C at 250^{o} C for concentrations below 5 molal; 0.05 J/mole-^{o}C at 275^{o} C; 0.17 J/mole-^{o}C at 300^{o}C; and the error had an average value of 0.56 J/mole-^{o}C at 325^{o} C and 16 J/mole-^{o}C at 350^{o} C.

Table 5 shows the decrease in heat capacity of NaCl solutions for NaCl concentrations between .4-4molal. At each concentration, the heat capacity increases with temperature; the magnitude of the increase is less as the concentration increases. Appendix I contains more data.

In summary, equations are available for providing tables of smooth values for heat capacity to 350^{o} C and 6 molal. However, data are needed at temperatures above 275^{o} C, especially from 300^{o} - 350^{o} C, and at pressures up to 50 MPa. The recent publication by Rogers contains tables of pressure-correction terms calculated for the heat capacity of NaCl solutions up to 100 MPa[19].

PHYSICAL PROPERTIES

Solubility

Solubility information is needed to predict scale formation in pipes, flash tanks and turbines traceable to silica and calcite deposition. The solubility of NaCl, KCl and $CaCl_2$ provides a means for calculating salt deposition onto heat exchangers and turbines, and to establish an upper limit for the concentration of these salts at high temperatures.

The U. S. Geological Survey has been very active in publishing research results at high temperatures. Potter, Babcock and Brown published data on the solubility of NaCl and KCl at high temperatures[20];

Potter and Clynne published similar correlations up to 100^{o} C for NaCl, KCl and $CaCl_2$ solutions[21].

We have correlated both Potter and Clynne's data and the solubility data for $CaCl_2$ solutions in the International Critical Tables to better than $\pm$ 1% with the following empirical equations:

$$\%w \; CaCl_2 = 34.81 + 0.4136 \; T, \quad 10 < T < 30^{o} \; C$$
$$= 35.13 + 0.4495 \; T, \quad 30 < T < 40^{o} \; C$$
$$= 52.17 + 0.07643 \; T, \quad 40 < T < 100^{o} \; C$$
$$= 52.805 + 0.06820 \; T - 1.666 \times 10^{-4} \; T^2 + 1.984 \times 10^{-6} \; T^3$$

for $50 < T < 160°$ C (see Reference 21)

Table 6 consists of smoothed values for the solubilities of NaCl, KCl, $CaCl_2$ and silica from 25^{o} - 350^{o} C, and at saturated vapor pressures. The solubility of $CaCO_3$ depends on the pressure of CO_2 gas; see Fig. 2. As shown, the solubility increases with CO_2 pressure, and decreases with increasing temperature. Fig. 3 depicts the solubility of CO_2 in water given as the Ostwald coefficient.

$$\text{Ostwald Coefficient} = \frac{g \; CO_2/cm^3 \text{ (liquid phase)}}{g \; CO_2/cm^3 \text{ (vapor phase)}}$$

Information and tabulated values on the solubility of the following substances at high temperatures are obtained from the references indicated: NaCl in steam[22], SiO_2 in water[23], $CaCO_3$[24], and CO_2[25].

Density

The variation in density of NaCl solution as a function of temperature is useful in calculating pumping requirements for hot brines. For example, a decrease in density may be reflected by a need for increased pump requirements because the volume of hot brine will be increased. Density values are also needed to calculate the pressure dependence of enthalpy, heat capacity and activity coefficients at high temperatures, and to calculate molal volumes. In the latter case, density data of the highest possible accuracy are desired, e.g., < 10 parts per million.

The published data on density of aqueous NaCl solutions is extensive; we used over 1,300 selected experimental values for temperatures up to 770^{o} C and pressures to 270MPa in developing the following correlation:

$$d = A + Bx + Cx^2 + Dx^3 \quad (4)$$

$$x = c_1 e^{a_1 m} + c_2 e^{a_2 T} + c_3 e^{a_3 P} \quad (5)$$

d = density, g/cm^3; T = ^{o}C; P = bar

$10<T<350^{o}C$

$0.25<m<5$ molal

vs<P<50 megapascal (500 bar)

where

c_1 = -9.9595 c_2 = 7.0845 c_3 = 3.9093

a_1 = -0.004539 a_2 = -0.0001638 a_3 = 0.00002551

(a_1 = -0.00500 for vapor saturated values)

A = -3.033405

B = 10.128163

C = -8.750567

D = 2.663107

The experimental data are reproduced to a maximum deviation of $\pm$ 2% over the entire range of concentration, 0^o C to 350^o C, and pressures up to 50 MPa. Values calculated from Eq. (4) and Eq. (5) are given in Tables 7 and 8. Rogers, Bradley and Pitzer recently published very accurate data for .05 - 4.4 m NaCl solutions from 75^o - 200^o C at a constant pressure of 20.27 bar[26]. The estimated uncertainty of their measurements was $\pm$ 2 x 10^{-4} g/cm^3 at 100^o C, increased to $\pm$ 5 x 10^{-4} g/cm^3 at 200^o C. The data extended the highly accurate results published earlier by Ellis[1] for lower concentrations. Our density data in Table 8 calculated with Eq. (4) reproduce the data of Ellis[1] and Rogers, Bradley and Pitzer[26] to an average % difference of better than $\pm$ 1%. For m = 0, the density of water to 200^o C is reproduced to $\pm$ 1% by Eq. (4) and Eq. (5). Fig. 4 shows the variation in density according to these equations at 500 bars (50 MPa), for 25 - 350^o C and 1 - 5 m NaCl solutions. Appendix I gives density values at 5°C intervals for pressures up to 1000 bars.

Vapor Pressure

Vapor pressure data for NaCl solutions cover the temperature range 25^{o} - 700^{o} C and concentrations from 0 to saturation. The experimental results published by Liu and Lindsay for 75^{o} - 300^{o} C have been widely used[7].

Correlation equations which reproduce vapor pressure data were developed by Haas[6]. Haas gives a table of data covering the temperature range 80^{o} - 325^{o} C and concentrations from 0 to saturation; the standard error is 0.32% of the observed pressure (Table 9). The vapor pressure decreases with increasing NaCl concentration, and increases markedly at any particular concentration as the temperature increases.

The vapor pressure of NaCl solutions from 80^{o} - 325^{o} C may be calculated using the following correlation[6]:

$$\ln p = e_0 + \frac{e_1}{z} + \frac{e_2 w}{z} \left[10^{(e_3 w^2)} - 1.0\right] + e_4 10^{(e_5 y^{1.25})} \qquad \text{(bars)} \qquad (6)$$

where

$w = z^2 - e_6$
$y = 647.27 - T_0$
$z = T_0 + 0.01$
$e_0 = 12.50849$
$e_1 = -4.616913 \times 10^3$
$e_2 = 3.193455 \times 10^{-4}$
$e_3 = 1.1965 \times 10^{-11}$
$e_4 = -1.013137 \times 10^{-2}$
$e_5 = -5.7148 \times 10^{-3}$
$e_6 = 2.9370 \times 10^5$

$$\ln T_o = (a + bT_x)^{-1} \ln T_x$$

$a = 1.0 + a_1 x + a_2 x^2 + a_3 x^3$

$b = 0.0 + b_1 x + b_2 x^2 + b_3 x^3 + b_4 x^4 + b_5 x^5$

$a_1 = 5.93582 \times 10^{-6}$
$a_2 = -5.19386 \times 10^{-5}$
$a_3 = 1.23156 \times 10^{-5}$

$b_1 = 1.15420 \times 10^{-6}$
$b_2 = 1.41254 \times 10^{-7}$
$b_3 = -1.92476 \times 10^{-8}$
$b_4 = -1.70717 \times 10^{-9}$
$b_5 = 1.05390 \times 10^{-10}$

Tabulated values for the vapor pressure of 0.1 - 3.5m KCl solutions from 20 - 150^{o} C are given by Fabuss and Korosi[2]; a correlation equation for calculating the vapor pressure of $CaCl_2$ solutions is also given in the paper by Fabuss and Korosi on page 6-15[2].

SUMMARY AND CONCLUSIONS

In summary, the contents of a databook mainly for industrial use and engineering applications has been described. While the current data are satisfactory in many respects, an ideal databook requires extensive experimental data at high temperatures and pressures. These data would be correlated by theoretical equations, rather than empirically based interpolating equations. These measurements and theory would be combined so that the properties of mixtures of solids and gases in water could be calculated for any temperature. In this way, the geothermal properties of a hot brine are more closely approximated, thereby lending greater credibility to predictions of some of the factors important to the lifetime of a power plant such as maintenance of steam pressure, tendency toward scaling, pumping requirements, brine treatment methodology and brine injection.

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UNITS CONVERSION

Percent weight =(100)(m)(M)/(1000+(m)(M))

Molality =(1000)(Percent weight)/(M)(100-Percent weight)

where:

m = molality
M = molecular weight:
$CaCl_2$ = 110.99
KCl = 74.56
NaCl = 58.44

ft x 3.048 E-01 = m
ft-lbf x 1.355 818 E+00 = Joule
degree F(F°-32)/1.8 = °C
in x 2.54 E+00 = cm
psi x 6.894 757 E-03 = MPa
1 bar = 0.1MPa = 0.986 923 atm = 750.062 mm Hg = 14.5083 lb/in^2
1 mm Hg = 1.333 22 E-03 bar
1 g/cm^3 = 1 kg/m^3 E-03 = 62.427 961 lb/ft^3

Tables 1 - 6 refer to sodium chloride aqueous solutions.

Table 1. Viscosity, cp, at molal concentration shown

DegC	0	.5	1	2	3	4
25	0.8904	0.9336	0.9810	1.0907	1.2215	1.3753
50	0.5471	0.5762	0.6072	0.6766	0.7581	0.8531
75	0.3778	0.3996	0.4223	0.4717	0.5287	0.5947
100	0.2818	0.2994	0.3172	0.3552	0.3983	0.4477
150	0.1824	0.1957	0.2085	0.2347	0.2633	0.2957
200	0.1346	0.1455	0.1558	0.1760	0.1977	0.2218
250	0.1065	0.1161	0.1249	0.1418	0.1593	0.1787
300	0.08648	0.0951	0.1028	0.1172	0.1318	0.1476
350	0.06697	0.0743	0.0807	0.0923	0.1039	0.1163

Table 2. Thermal conductivity, W/(m-C), at molal concentration shown

DegC	0	1	2	3	4
20	0.603	0.596	0.590	0.585	0.580
50	.643	.636	.630	.625	.621
70	.662	.655	.649	.644	.640
100	.681	.674	.668	.662	.658
150	.687	.679	.673	.667	.663
200	.665	.656	.649	.643	.638
250	.616	.607	.599	.592	.586
300	.541	.531	.522	.515	.508
330	.482	.472	.463	.455	.449

Table 3. Resistivity, ohm-meter, at molal concentration shown

DegC	.5292	1.9012	4.2777
25	0.1980	0.0710	0.0396
50	0.1280	0.0568	0.0250
75	0.0894	0.0409	0.0188
100	0.0688	0.0313	0.0150
150	0.0485	0.0215	0.0106
200	0.0394	0.0170	0.0084
250	0.0352	0.0148	0.0073
300	0.0344	0.0140	0.0069
350	0.0368	0.0145	0.0072

Table 4. Enthalpy, J/g, at molal concentration shown

DegC	0	.4708	.9006	1.9012	3.0197	4.2777
25	104.89	100.74	97.12	88.29	78.59	68.39
50	209.33	201.84	195.72	181.88	167.80	153.81
75	313.93	303.16	294.55	275.65	257.07	239.11
100	419.04	404.88	393.71	369.55	346.28	324.17
150	632.20	610.7	594.0	558.6	525.3	494.4
200	852.45	822.2	799.2	751.3	707.3	667.0
250	1085.4	1043.2	1012.2	949.1	892.2	840.9
300	1344.0	1279.4	1234.5	1146.9	1070.8	1003.6

Table 5. Heat capacity, J/g-C, at molal concentration shown

DegC	0	.4708	.9006	1.9012	3.0197	4.2777
25		4.0382	3.9348	3.7322	3.5617	3.4188
50		4.0464	3.9469	3.7484	3.5766	3.4291
75		4.0564	3.9550	3.7515	3.5738	3.4197
100		4.0733	3.9676	3.7560	3.5718	3.4121
150		4.150	4.032	3.802	3.606	3.439
200		4.292	4.155	3.895	3.681	3.503
250		4.553	4.363	4.026	3.763	3.550
300		5.075	4.699	4.131	3.792	3.608

Table 6. Solubility, % weight, at temperature shown

DegC	NaCl	KCl	CaCl2	SiO2(1)
25	26.464	26.09	45.15	117.4
50	26.843	29.44	55.99	181.9
75	27.354	32.77	57.80	263.0
100	27.998	36.11	59.94	363.1
150	29.683	40.36	65.98	616.6
200	31.898	44.79		93.31
250	34.643	49.38		1349
300	37.918	54.09		2570(2)
350	41.723	58.94		3311(2)

(1) mg/kg
(2) P=1034 bars

Table 7. Density of NaCl solutions, g/cm^3

T,C	P/MPA	Molal Concentration of NaCl: *0	.5	1	2	3	4
25	.1-1	0.9968		1.0420	1.0692	1.0966	1.1261
	10	1.0013	1.0323	1.0450	1.0697	1.0946	1.1210
	20	1.0056	1.0380	1.0506	1.0752	1.1003	1.1274
	30	1.0098	1.0437	1.0561	1.0807	1.1062	1.1339
	50	1.0179	1.0548	1.0671	1.0920	1.1183	1.1476
50	.1-1	0.9879		1.0255	1.0534	1.0804	1.1083
	10	0.9921	1.0154	1.0287	1.0539	1.0784	1.1036
	20	0.9963	1.0214	1.0345	1.0594	1.0839	1.1095
	30	1.0003	1.0273	1.0401	1.0649	1.0896	1.1156
	50	1.0079	1.0388	1.0513	1.0759	1.1011	1.1282
75	.1-1	0.9747		1.0082	1.0375	1.0646	1.0917
	10	0.9790	0.9973	1.0116	1.0379	1.0627	1.0872
	20	0.9833	1.0038	1.0177	1.0436	1.0681	1.0928
	30	0.9873	1.0101	1.0237	1.0491	1.0736	1.0986
	50	0.9948	1.0223	1.0353	1.0602	1.0848	1.1104
100	.1-1	0.9583		0.9897	1.0209	1.0489	1.0758
	10	0.9628	0.9779	0.9933	1.0214	1.0469	1.0714
	20	0.9672	0.9849	0.9999	1.0273	1.0525	1.0769
	30	0.9714	0.9917	1.0063	1.0331	1.0580	1.0824
	50	0.9792	1.0048	1.0186	1.0445	1.0690	1.0937
150	.1-1	0.9166		0.9476	0.9847	1.0163	1.0446
	10	0.9220	0.9332	0.9519	0.9853	1.0141	1.0401
	20	0.9272	0.9417	0.9598	0.9920	1.0202	1.0457
	30	0.9322	0.9499	0.9675	0.9987	1.0261	1.0512
	50	0.9415	0.9657	0.9820	1.0114	1.0375	1.0623
200							
	10	0.8708	0.8787	0.9019	0.9426	0.9771	1.0068
	20	0.8774	0.8892	0.9116	0.9508	0.9841	1.0129
	30	0.8839	0.8994	0.9209	0.9587	0.9909	1.0191
	50	0.8961	0.9187	0.9387	0.9738	1.0041	1.0309
250							
	10	0.8105	0.8117	0.8404	0.8908	0.9330	0.9687
	20	0.8192	0.8247	0.8524	0.9009	0.9416	0.9761
	30	0.8277	0.8374	0.8639	0.9106	0.9498	0.9831
	50	0.8443	0.8613	0.8859	0.9291	0.9655	0.9967
300							
	10	0.7441	0.7299	0.7652	0.8273	0.8795	0.9233
	20	0.7551	0.7459	0.7799	0.8397	0.8900	0.9322
	30	0.7660	0.7614	0.7942	0.8518	0.9001	0.9408
	50	0.7880	0.7909	0.8213	0.8746	0.9194	0.9571
350							
	20	0.6880	0.6503	0.6917	0.7650	0.8269	0.8789
	30	0.7015	0.6692	0.7091	0.7798	0.8394	0.8895
	50	0.7292	0.7051	0.7423	0.8079	0.8631	0.9095

*Calculated from specific volume data in reference 12.

Table 8. Density of NaCl solutions, g/cm^3, at molal concentrations shown
A1=-.005299,P= 2MPa

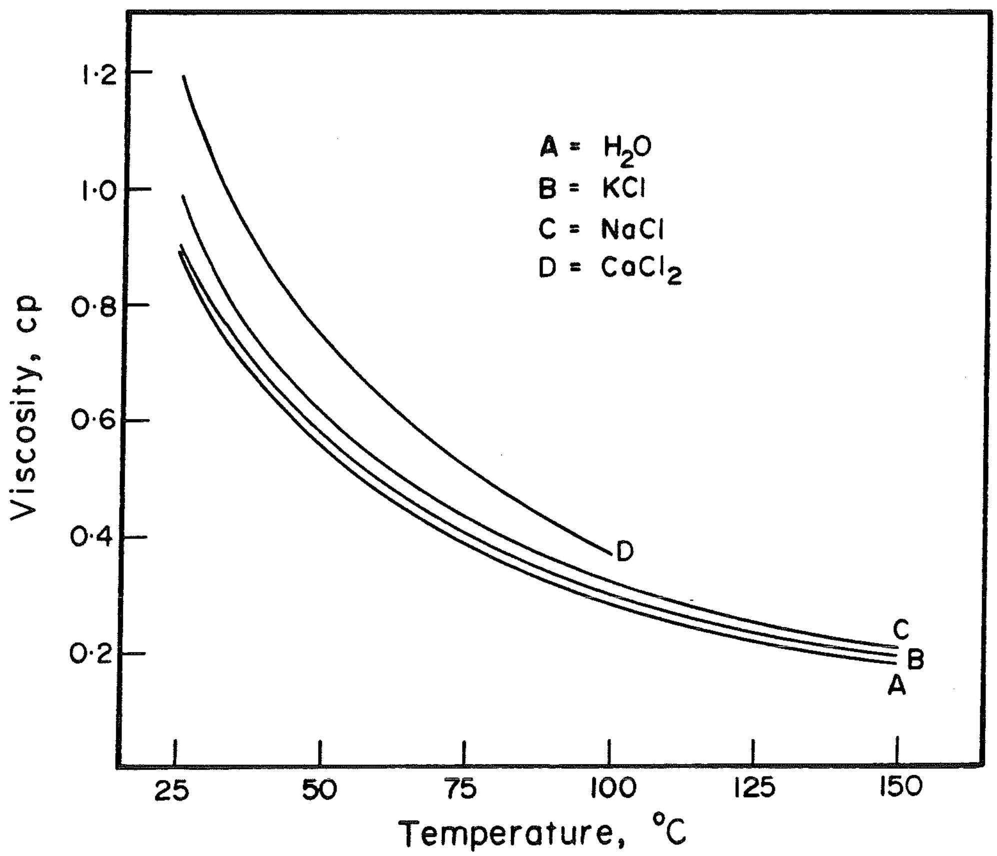
TEMP DEG C	P/MP	MOLAL CONCENTRATION 0	.1	.2	.3	.4	.5
25	2.0	1.01178	1.01496	1.01810	1.02120	1.02427	1.02730
50	2.0	.99367	.99709	1.00046	1.00378	1.00705	1.01028
75	2.0	.97410	.97783	.98149	.98510	.98864	.99213
100	2.0	.95270	.95681	.96084	.96479	.96868	.97249
125	2.0	.92912	.93368	.93814	.94252	.94681	.95102
150	2.0	.90304	.90810	.91306	.91793	.92269	.92736
175	2.0	.87410	.87975	.88528	.89069	.89599	.90119
200	2.0	.84201	.84829	.85445	.86048	.86639	.87217

Table 9.

Vapor pressure, bar, at molal concentration shown *

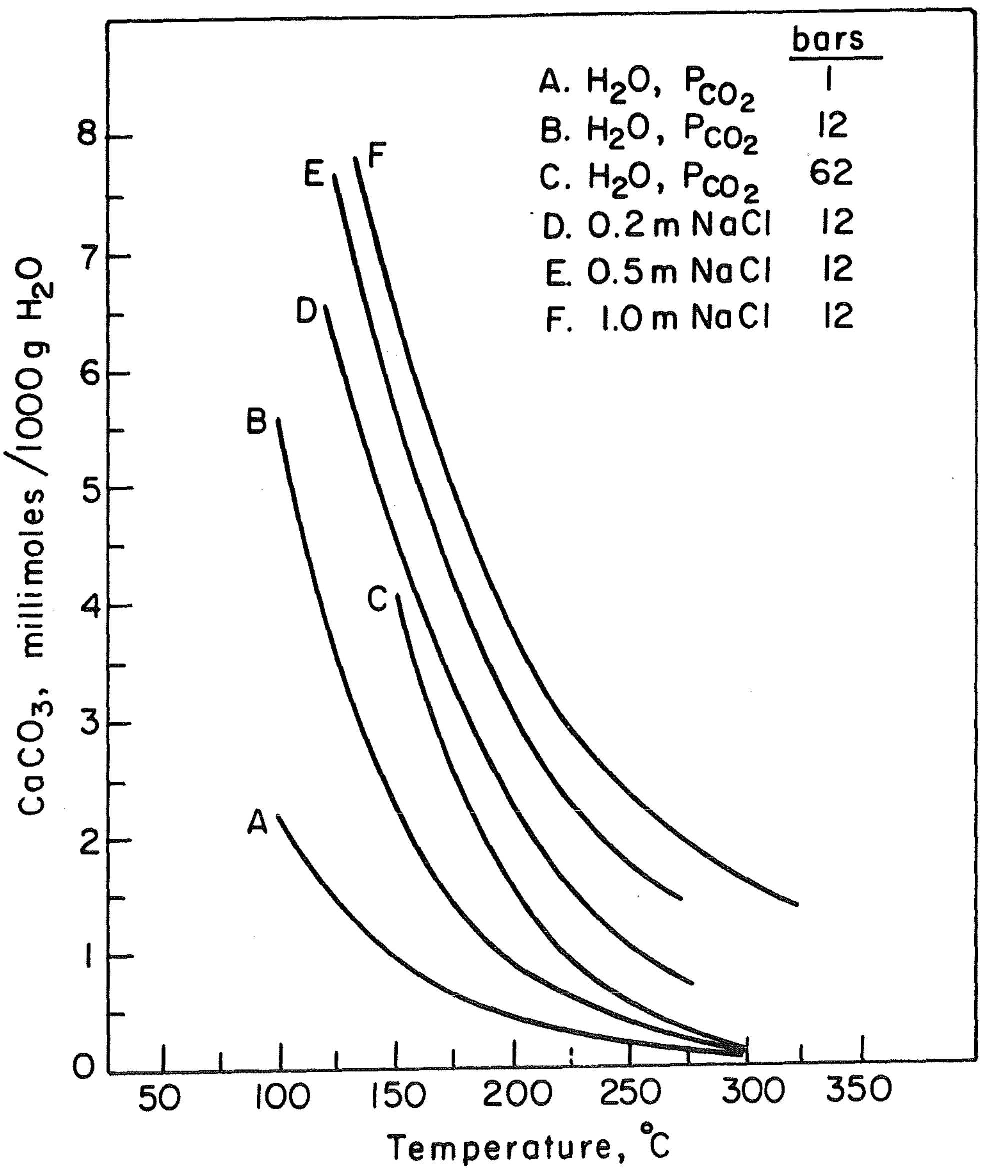
DegC	0	.5	1	2	3	4
25						
50						
75						
100	1.013	0.996	0.979	0.943	0.906	0.867
150	4.760	4.679	4.597	4.430	4.257	4.080
200	15.551	15.287	15.019	14.469	13.907	13.341
250	39.776	39.098	38.405	36.982	35.535	34.107
300	85.917	84.426	82.896	79.753	76.581	73.495
325	120.571	118.444	116.259	111.771	107.258	102.901

*Sodium chloride solutions.



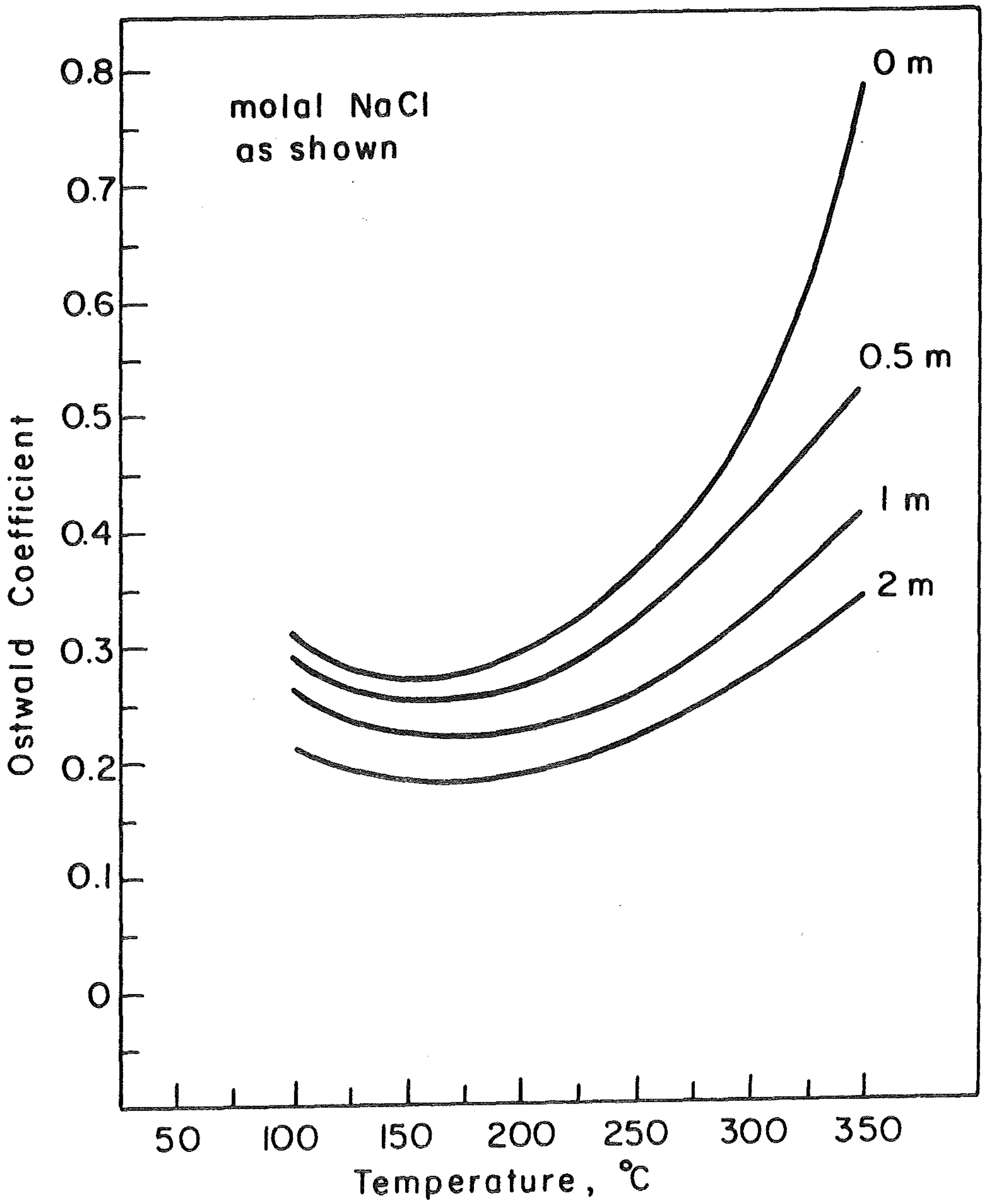
XBL 816-10036

Fig. 1. Comparative viscosities of water and 1 m concentrations of NaCl, KCl and $CaCl_2$ solutions.



XBL 816-10037

Fig. 2. Solubility of $CaCO_3$ in water and in NaCl solutions at indicated pressures.



XBL 816-10035

Fig. 3. Solubility of CO_2 in NaCl solutions, given as Ostwald coefficient:

$$g/cm^3\ CO_2(liq.)/g/cm^3\ CO_2\ (vapor)$$

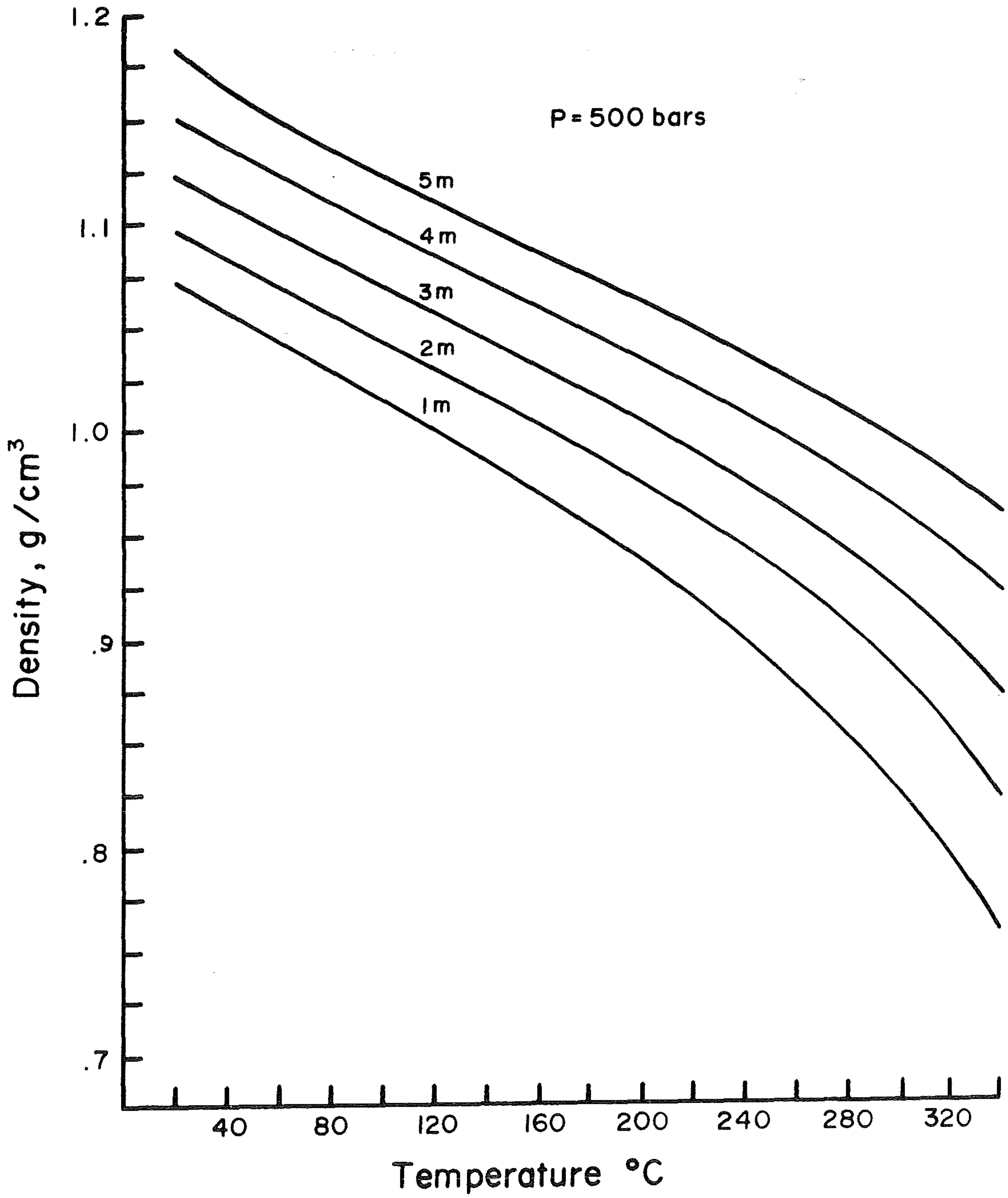


Fig. 4. Density of NaCl solutions calculated from Eq(4) and Eq(5).

Appendix I. Density,Enthalpy and Heat Capacity of NaCl solutions

CONCENTRATION, m NACL

TEMP. DEG.C	1	2	3	4	5
5	1.054845	1.081957	1.110171	1.141357	1.177325
10	1.051659	1.078751	1.106720	1.137440	1.172725
15	1.048463	1.075561	1.103313	1.133593	1.168221
20	1.045255	1.072385	1.099945	1.129813	1.163811
25	1.042030	1.069219	1.096614	1.126096	1.159491
30	1.038786	1.066061	1.093317	1.122440	1.155257
35	1.035521	1.062907	1.090051	1.118840	1.151106
40	1.032230	1.059754	1.086811	1.115293	1.147036
45	1.028911	1.056599	1.083597	1.111798	1.143042
50	1.025562	1.053440	1.080403	1.108349	1.139121
55	1.022178	1.050272	1.077227	1.104945	1.135271
60	1.018758	1.047093	1.074067	1.101582	1.131489
65	1.015298	1.043901	1.070918	1.098257	1.127770
70	1.011795	1.040691	1.067778	1.094966	1.124111
75	1.008246	1.037462	1.064644	1.091707	1.120511
80	1.004649	1.034209	1.061513	1.088477	1.116964
85	1.001000	1.030931	1.058382	1.085273	1.113469
90	.997297	1.027624	1.055247	1.082090	1.110022
95	.993537	1.024286	1.052107	1.078928	1.106621
100	.989717	1.020913	1.048957	1.075782	1.103261
105	.985834	1.017502	1.045795	1.072649	1.099940
110	.981886	1.014051	1.042619	1.069526	1.096655
115	.977869	1.010557	1.039424	1.066411	1.093403
120	.973781	1.007017	1.036209	1.063301	1.090181
125	.969620	1.003429	1.032970	1.060192	1.086986
130	.965381	.999788	1.029704	1.057082	1.083814
135	.961063	.996093	1.026410	1.053967	1.080663
140	.956663	.992341	1.023083	1.050845	1.077530
145	.952179	.988529	1.019720	1.047713	1.074412
150	.947606	.984654	1.016320	1.044568	1.071306
155	.942944	.980714	1.012880	1.041408	1.068209
160	.938188	.976706	1.009395	1.038228	1.065118
165	.933338	.972627	1.005865	1.035027	1.062030
170	.928389	.968474	1.002286	1.031802	1.058943
175	.923339	.964245	.998654	1.028549	1.055853
180	.918186	.959936	.994969	1.025267	1.052758
185	.912927	.955547	.991226	1.021952	1.049655
190	.907559	.951073	.987423	1.018601	1.046540
195	.902080	.946512	.983558	1.015212	1.043412
200	.896488	.941862	.979627	1.011782	1.040267

TEMP. DEG.C	CONCENTRATION, m NACL 1	2	3	4	5
205	.890779	.937119	.975629	1.008309	1.037103
210	.884952	.932282	.971560	1.004789	1.033916
215	.879003	.927348	.967417	1.001220	1.030705
220	.872931	.922313	.963199	.997599	1.027466
225	.866732	.917177	.958903	.993924	1.024196
230	.860405	.911935	.954525	.990191	1.020894
235	.853947	.906586	.950064	.986399	1.017555
240	.847354	.901127	.945516	.982545	1.014178
245	.840626	.895556	.940880	.978625	1.010760
250	.833760	.889870	.936153	.974638	1.007298
255	.826752	.884066	.931331	.970581	1.003789
260	.819601	.878143	.926414	.966450	1.000232
265	.812304	.872097	.921397	.962245	.996622
270	.804860	.865926	.916279	.957962	.992958
275	.797265	.859629	.911058	.953598	.989238
280	.789517	.853202	.905730	.949151	.985457
285	.781614	.846642	.900293	.944619	.981615
290	.773553	.839949	.894746	.939999	.977708
295	.765333	.833119	.889084	.935289	.973734
300	.756951	.826150	.883307	.930486	.969690
305	.748405	.819039	.877411	.925587	.965573
310	.739691	.811785	.871395	.920591	.961382
315	.730810	.804384	.865255	.915494	.957114
320	.721757	.796836	.858990	.910294	.952766
325	.712530	.789137	.852597	.904990	.948336
330	.703128	.781284	.846074	.899578	.943821
335	.693549	.773277	.839418	.894057	.939219
340	.683789	.765112	.832627	.888423	.934528
345	.673848	.756788	.825699	.882674	.929745
350	.663722	.748301	.818632	.876809	.924867

Note: alpha one is set equal to -0.00500 for this table.

Reference: Ozbek,H., Phillips,S.L.,Fair,J.A., 1978. To be published.

P=100 bar

CONCENTRATION, m NACL

TEMP. DEG.C	.25	.5	1	2	3	4	5
5	1.039087	1.045399	1.057814	1.082451	1.108027	1.135945	1.167571
10	1.035811	1.042167	1.054637	1.079242	1.104601	1.132120	1.163167
15	1.032509	1.038917	1.051453	1.076050	1.101217	1.128361	1.158852
20	1.029180	1.035644	1.048259	1.072873	1.097871	1.124664	1.154623
25	1.025819	1.032347	1.045051	1.069706	1.094560	1.121025	1.150478
30	1.022424	1.029021	1.041828	1.066547	1.091280	1.117443	1.146412
35	1.018993	1.025664	1.038586	1.063393	1.088030	1.113913	1.142423
40	1.015521	1.022273	1.035321	1.060241	1.084804	1.110432	1.138507
45	1.012007	1.018846	1.032032	1.057087	1.081601	1.106998	1.134661
50	1.008447	1.015378	1.028714	1.053929	1.078418	1.103606	1.130882
55	1.004837	1.011867	1.025365	1.050763	1.075250	1.100255	1.127166
60	1.001177	1.008311	1.021982	1.047586	1.072096	1.096940	1.123511
65	.997461	1.004706	1.018562	1.044397	1.068951	1.093659	1.119914
70	.993688	1.001049	1.015102	1.041190	1.065814	1.090408	1.116370
75	.989855	.997338	1.011599	1.037965	1.062680	1.087185	1.112877
80	.985959	.993569	1.008051	1.034716	1.059548	1.083986	1.109432
85	.981996	.989740	1.004453	1.031443	1.056413	1.080808	1.106032
90	.977965	.985848	1.000805	1.028141	1.053274	1.077649	1.102673
95	.973862	.981890	.997102	1.024808	1.050126	1.074505	1.099353
100	.969684	.977863	.993342	1.021441	1.046968	1.071373	1.096068
105	.965430	.973765	.989521	1.018037	1.043795	1.068250	1.092816
110	.961095	.969593	.985638	1.014593	1.040606	1.065134	1.089593
115	.956677	.965343	.981690	1.011106	1.037397	1.062021	1.086397
120	.952174	.961014	.977673	1.007574	1.034166	1.058908	1.083223
125	.947583	.956602	.973585	1.003993	1.030909	1.055793	1.080071
130	.942901	.952105	.969423	1.000362	1.027623	1.052672	1.076935
135	.938125	.947520	.965184	.996676	1.024306	1.049543	1.073814
140	.933252	.942844	.960866	.992934	1.020956	1.046402	1.070704
145	.928281	.938075	.956465	.989132	1.017568	1.043247	1.067603
150	.923208	.933209	.951980	.985268	1.014141	1.040075	1.064507
155	.918031	.928245	.947408	.981338	1.010671	1.036883	1.061414
160	.912747	.923180	.942745	.977341	1.007156	1.033669	1.058321
165	.907353	.918011	.937989	.973274	1.003593	1.030429	1.055225
170	.901847	.912735	.933138	.969133	.999979	1.027160	1.052123
175	.896226	.907350	.928189	.964917	.996311	1.023860	1.049012
180	.890488	.901853	.923140	.960622	.992588	1.020526	1.045889
185	.884630	.896242	.917987	.956246	.988805	1.017156	1.042752
190	.878650	.890514	.912728	.951786	.984960	1.013746	1.039597
195	.872545	.884666	.907360	.947240	.981052	1.010293	1.036423
200	.866312	.878696	.901882	.942604	.977076	1.006796	1.033226

P=100 bars

Molal NaCl

	.25	.5	1	2	3	4	5
205	.859950	.872602	.896290	.937877	.973030	1.003251	1.030002
210	.853454	.866381	.890581	.933056	.968912	.999656	1.026751
215	.846824	.860030	.884755	.928138	.964720	.996007	1.023468
220	.840057	.853548	.878807	.923120	.960449	.992303	1.020152
225	.833149	.846931	.872735	.918001	.956098	.988540	1.016799
230	.826100	.840177	.866537	.912777	.951665	.984717	1.013407
235	.818905	.833283	.860211	.907446	.947146	.980829	1.009973
240	.811563	.826248	.853754	.902005	.942540	.976876	1.006494
245	.804072	.819068	.847163	.896453	.937842	.972853	1.002968
250	.796429	.811742	.840436	.890786	.933052	.968759	.999392
255	.788631	.804267	.833571	.885002	.928166	.964591	.995763
260	.780677	.796641	.826565	.879099	.923182	.960346	.992079
265	.772564	.788861	.819416	.873073	.918098	.956022	.988338
270	.764289	.780924	.812122	.866924	.912911	.951616	.984536
275	.755851	.772830	.804679	.860647	.907618	.947126	.980671
280	.747246	.764574	.797087	.854242	.902217	.942550	.976740
285	.738474	.756155	.789341	.847705	.896705	.937884	.972742
290	.729530	.747572	.781441	.841034	.891081	.933126	.968673
295	.720414	.738820	.773384	.834227	.885342	.928274	.964530
300	.711123	.729898	.765167	.827281	.879485	.923325	.960312
305	.701654	.720805	.756789	.820195	.873507	.918277	.956016
310	.692006	.711536	.748246	.812965	.867408	.913128	.951639
315	.682175	.702091	.739537	.805589	.861183	.907874	.947180
320	.672161	.692468	.730659	.798066	.854831	.902515	.942634
325	.661960	.682663	.721611	.790392	.848350	.897046	.938001
330	.651571	.672674	.712389	.782566	.841737	.891466	.933277
335	.640991	.662500	.702992	.774585	.834989	.885773	.928460
340	.630219	.652139	.693418	.766446	.828106	.879963	.923547
345	.619251	.641587	.683664	.758149	.821083	.874036	.918538
350	.608087	.630844	.673728	.749690	.813919	.867987	.913427

P=200 bars

CONCENTRATION, m NACL

TEMP. DEG.C	.25	.5	1	2	3	4	5
5	1.044692	1.050940	1.063289	1.088037	1.114044	1.142709	1.175392
10	1.041455	1.047738	1.060121	1.084796	1.110544	1.138769	1.170832
15	1.038200	1.044523	1.056952	1.081577	1.107092	1.134900	1.166366
20	1.034921	1.041291	1.053777	1.078378	1.103683	1.131098	1.161992
25	1.031617	1.038039	1.050595	1.075195	1.100314	1.127361	1.157707
30	1.028284	1.034765	1.047403	1.072025	1.096982	1.123685	1.153507
35	1.024920	1.031465	1.044196	1.068865	1.093685	1.120067	1.149389
40	1.021520	1.028136	1.040972	1.065713	1.090418	1.116504	1.145349
45	1.018083	1.024775	1.037729	1.062564	1.087179	1.112992	1.141386
50	1.014606	1.021380	1.034463	1.059416	1.083964	1.109529	1.137494
55	1.011085	1.017947	1.031171	1.056265	1.080771	1.106111	1.133671
60	1.007517	1.014473	1.027850	1.053110	1.077596	1.102735	1.129914
65	1.003900	1.010956	1.024497	1.049946	1.074437	1.099398	1.126220
70	1.000231	1.007393	1.021110	1.046771	1.071290	1.096097	1.122585
75	.996506	1.003780	1.017685	1.043582	1.068152	1.092828	1.119006
80	.992724	1.000115	1.014219	1.040376	1.065020	1.089590	1.115481
85	.988880	.996394	1.010710	1.037149	1.061892	1.086377	1.112005
90	.984973	.992616	1.007155	1.033899	1.058764	1.083189	1.108577
95	.981000	.988777	1.003550	1.030624	1.055633	1.080020	1.105192
100	.976957	.984875	.999894	1.027319	1.052496	1.076870	1.101848
105	.972841	.980906	.996182	1.023983	1.049350	1.073733	1.098542
110	.968651	.976868	.992413	1.020612	1.046193	1.070609	1.095270
115	.964383	.972758	.988583	1.017203	1.043022	1.067492	1.092030
120	.960035	.968573	.984690	1.013754	1.039833	1.064381	1.088818
125	.955603	.964311	.980731	1.010262	1.036623	1.061273	1.085632
130	.951086	.959968	.976703	1.006723	1.033390	1.058165	1.082469
135	.946480	.955543	.972604	1.003136	1.030131	1.055053	1.079325
140	.941782	.951031	.968430	.999497	1.026844	1.051935	1.076198
145	.936991	.946432	.964179	.995804	1.023524	1.048807	1.073084
150	.932103	.941741	.959848	.992053	1.020170	1.045668	1.069981
155	.927115	.936957	.955434	.988243	1.016778	1.042514	1.066886
160	.922026	.932076	.950936	.984369	1.013346	1.039343	1.063796
165	.916832	.927096	.946349	.980430	1.009871	1.036150	1.060707
170	.911531	.922015	.941673	.976423	1.006351	1.032935	1.057618
175	.906120	.916829	.936903	.972346	1.002781	1.029693	1.054525
180	.900596	.911537	.932037	.968194	.999161	1.026423	1.051426
185	.894958	.906135	.927073	.963967	.995486	1.023120	1.048317
190	.889202	.900620	.922008	.959660	.991755	1.019783	1.045196
195	.883326	.894992	.916839	.955272	.987965	1.016409	1.042060
200	.877327	.889246	.911564	.950800	.984112	1.012995	1.038906

P=200 bars

	Molal NaCl						
	.25	.5	1	2	3	4	5
205	.871203	.883381	.906181	.946241	.980195	1.009538	1.035731
210	.864952	.877393	.900686	.941593	.976210	1.006036	1.032533
215	.858570	.871281	.895077	.936853	.972155	1.002485	1.029309
220	.852056	.865041	.889352	.932018	.968027	.998884	1.026056
225	.845407	.858672	.883509	.927087	.963824	.995230	1.022771
230	.838620	.852171	.877544	.922055	.959543	.991519	1.019452
235	.831693	.845535	.871455	.916922	.955182	.987749	1.016096
240	.824624	.838762	.865240	.911683	.950738	.983918	1.012700
245	.817410	.831850	.858896	.906338	.946208	.980023	1.009262
250	.810048	.824796	.852421	.900883	.941589	.976061	1.005779
255	.802538	.817598	.845812	.895315	.936880	.972030	1.002248
260	.794875	.810252	.839068	.889633	.932078	.967928	.998667
265	.787058	.802758	.832185	.883834	.927180	.963750	.995033
270	.779084	.795113	.825161	.877915	.922184	.959496	.991343
275	.770951	.787314	.817994	.871875	.917087	.955163	.987595
280	.762657	.779358	.810682	.865710	.911887	.950747	.983787
285	.754199	.771244	.803221	.859418	.906581	.946248	.979915
290	.745575	.762970	.795611	.852997	.901167	.941661	.975978
295	.736783	.754532	.787848	.846444	.895642	.936984	.971972
300	.727820	.745930	.779930	.839758	.890005	.932216	.967895
305	.718684	.737159	.771855	.832935	.884252	.927353	.963745
310	.709374	.728219	.763620	.825973	.878381	.922393	.959519
315	.699886	.719106	.755224	.818871	.872390	.917334	.955214
320	.690219	.709820	.746663	.811625	.866277	.912174	.950829
325	.680370	.700356	.737937	.804233	.860039	.906909	.946360
330	.670337	.690714	.729041	.796694	.853673	.901537	.941806
335	.660118	.680891	.719976	.789005	.847178	.896057	.937163
340	.649710	.670885	.710737	.781163	.840551	.890465	.932430
345	.639113	.660693	.701323	.773166	.833790	.884760	.927604
350	.628322	.650314	.691731	.765012	.826892	.878939	.922682

P=300 bars

CONCENTRATION, m NACL

TEMP. DEG.C	.25	.5	1	2	3	4	5
5	1.050253	1.056456	1.068775	1.093707	1.120217	1.149702	1.183517
10	1.047048	1.053275	1.065607	1.090423	1.116635	1.145637	1.178790
15	1.043829	1.050086	1.062443	1.087168	1.113104	1.141649	1.174164
20	1.040592	1.046885	1.059279	1.083938	1.109622	1.137734	1.169635
25	1.037335	1.043670	1.056113	1.080729	1.106186	1.133888	1.165201
30	1.034055	1.040438	1.052941	1.077539	1.102793	1.130109	1.160857
35	1.030748	1.037185	1.049761	1.074365	1.099439	1.126394	1.156600
40	1.027412	1.033909	1.046570	1.071202	1.096121	1.122739	1.152428
45	1.024044	1.030607	1.043364	1.068049	1.092837	1.119140	1.148336
50	1.020640	1.027275	1.040140	1.064902	1.089582	1.115596	1.144323
55	1.017198	1.023910	1.036896	1.061758	1.086354	1.112102	1.140383
60	1.013714	1.020510	1.033628	1.058615	1.083150	1.108655	1.136515
65	1.010187	1.017072	1.030334	1.055468	1.079966	1.105253	1.132715
70	1.006612	1.013593	1.027010	1.052315	1.076800	1.101892	1.128979
75	1.002987	1.010069	1.023653	1.049153	1.073649	1.098569	1.125305
80	.999310	1.006499	1.020262	1.045980	1.070509	1.095281	1.121690
85	.995577	1.002879	1.016832	1.042791	1.067377	1.092025	1.118130
90	.991785	.999205	1.013361	1.039584	1.064251	1.088798	1.114622
95	.987932	.995477	1.009846	1.036357	1.061127	1.085596	1.111163
100	.984014	.991689	1.006284	1.033106	1.058003	1.082417	1.107751
105	.980030	.987841	1.002672	1.029829	1.054876	1.079258	1.104381
110	.975975	.983928	.999008	1.026521	1.051742	1.076116	1.101051
115	.971848	.979949	.995288	1.023182	1.048598	1.072987	1.097758
120	.967646	.975900	.991510	1.019807	1.045442	1.069869	1.094499
125	.963366	.971778	.987671	1.016394	1.042272	1.066759	1.091270
130	.959004	.967581	.983769	1.012940	1.039082	1.063653	1.088070
135	.954559	.963307	.979799	1.009442	1.035872	1.060550	1.084894
140	.950028	.958951	.975761	1.005898	1.032639	1.057445	1.081740
145	.945408	.954513	.971650	1.002304	1.029378	1.054336	1.078604
150	.940696	.949988	.967465	.998658	1.026088	1.051221	1.075485
155	.935890	.945375	.963202	.994957	1.022766	1.048096	1.072378
160	.930986	.940670	.958859	.991199	1.019408	1.044958	1.069282
165	.925984	.935871	.954433	.987380	1.016012	1.041805	1.066193
170	.920878	.930976	.949922	.983498	1.012576	1.038634	1.063108
175	.915668	.925981	.945323	.979550	1.009096	1.035441	1.060024
180	.910351	.920884	.940632	.975533	1.005570	1.032225	1.056939
185	.904923	.915683	.935849	.971446	1.001995	1.028982	1.053849
190	.899383	.910374	.930969	.967284	.998369	1.025709	1.050753
195	.893728	.904956	.925990	.963046	.994688	1.022404	1.047646
200	.887955	.899426	.920911	.958728	.990949	1.019065	1.044526

P=300 bars

	Molal NaCl						
	.25	.5	1	2	3	4	5
205	.882061	.893781	.915727	.954329	.987151	1.015687	1.041391
210	.876045	.888018	.910437	.949845	.983291	1.012269	1.038238
215	.869904	.882136	.905038	.945275	.979365	1.008808	1.035063
220	.863635	.876132	.899528	.940614	.975372	1.005301	1.031864
225	.857235	.870002	.893904	.935862	.971308	1.001746	1.028639
230	.850703	.863745	.888163	.931014	.967171	.998139	1.025384
235	.844035	.857359	.882303	.926070	.962959	.994478	1.022098
240	.837230	.850840	.876322	.921025	.958668	.990761	1.018776
245	.830285	.844187	.870217	.915878	.954297	.986985	1.015417
250	.823198	.837396	.863986	.910627	.949842	.983147	1.012018
255	.815965	.830466	.857626	.905268	.945301	.979245	1.008577
260	.808586	.823394	.851134	.899799	.940672	.975275	1.005090
265	.801057	.816178	.844509	.894217	.935952	.971237	1.001554
270	.793375	.808815	.837748	.888521	.931139	.967126	.997968
275	.785540	.801303	.830848	.882708	.926229	.962940	.994329
280	.777547	.793640	.823808	.876775	.921221	.958678	.990634
285	.769396	.785823	.816624	.870720	.916112	.954335	.986881
290	.761084	.777849	.809295	.864540	.910900	.949911	.983066
295	.752608	.769718	.801818	.858234	.905582	.945401	.979188
300	.743965	.761426	.794190	.851798	.900156	.940805	.975244
305	.735155	.752971	.786411	.845231	.894619	.936118	.971231
310	.726175	.744350	.778476	.838529	.888969	.931340	.967147
315	.717021	.735562	.770384	.831692	.883204	.926467	.962990
320	.707693	.726605	.762133	.824716	.877321	.921497	.958756
325	.698188	.717475	.753720	.817598	.871317	.916428	.954444
330	.688503	.708171	.745143	.810338	.865191	.911257	.950051
335	.678637	.698691	.736401	.802932	.858940	.905982	.945574
340	.668587	.689032	.727489	.795378	.852562	.900600	.941011
345	.658351	.679193	.718408	.787674	.846054	.895109	.936360
350	.647927	.669170	.709153	.779818	.839414	.889506	.931618

P=500 bars

TEMP. DEG.C	CONCENTRATION, m NACL .25	.5	1	2	3	4	5
5	1.061309	1.067475	1.079845	1.105363	1.133103	1.164449	1.200750
10	1.058139	1.064308	1.076648	1.101968	1.129324	1.160106	1.195662
15	1.054965	1.061143	1.073466	1.098611	1.125609	1.155850	1.190686
20	1.051784	1.057978	1.070296	1.095291	1.121954	1.151678	1.185818
25	1.048594	1.054809	1.067134	1.092002	1.118355	1.147587	1.181056
30	1.045392	1.051633	1.063977	1.088743	1.114810	1.143573	1.176395
35	1.042173	1.048448	1.060822	1.085511	1.111315	1.139634	1.171832
40	1.038936	1.045249	1.057667	1.082301	1.107867	1.135766	1.167365
45	1.035677	1.042035	1.054507	1.079111	1.104462	1.131966	1.162989
50	1.032393	1.038802	1.051341	1.075939	1.101099	1.128230	1.158702
55	1.029081	1.035548	1.048165	1.072780	1.097773	1.124556	1.154500
60	1.025739	1.032268	1.044975	1.069631	1.094482	1.120940	1.150381
65	1.022363	1.028961	1.041770	1.066491	1.091222	1.117379	1.146340
70	1.018950	1.025623	1.038546	1.063355	1.087990	1.113870	1.142374
75	1.015498	1.022251	1.035300	1.060220	1.084783	1.110409	1.138481
80	1.012004	1.018843	1.032029	1.057084	1.081599	1.106995	1.134658
85	1.008464	1.015395	1.028730	1.053944	1.078433	1.103623	1.130900
90	1.004876	1.011905	1.025400	1.050796	1.075283	1.100290	1.127205
95	1.001237	1.008369	1.022037	1.047638	1.072147	1.096994	1.123571
100	.997544	1.004786	1.018638	1.044467	1.069020	1.093731	1.119992
105	.993794	1.001151	1.015199	1.041280	1.065901	1.090498	1.116468
110	.989985	.997463	1.011717	1.038073	1.062785	1.087292	1.112993
115	.986113	.993718	1.008191	1.034844	1.059671	1.084111	1.109566
120	.982176	.989914	1.004616	1.031591	1.056555	1.080951	1.106184
125	.978171	.986047	1.000991	1.028309	1.053433	1.077809	1.102843
130	.974096	.982116	.997313	1.024997	1.050304	1.074682	1.099540
135	.969947	.978116	.993578	1.021652	1.047165	1.071568	1.096272
140	.965722	.974047	.989783	1.018270	1.044012	1.068463	1.093037
145	.961418	.969904	.985927	1.014849	1.040842	1.065364	1.089830
150	.957032	.965685	.982007	1.011385	1.037653	1.062269	1.086650
155	.952562	.961387	.978019	1.007878	1.034443	1.059174	1.083494
160	.948005	.957008	.973960	1.004322	1.031207	1.056077	1.080357
165	.943359	.952545	.969830	1.000716	1.027943	1.052975	1.077238
170	.938620	.947995	.965623	.997058	1.024649	1.049865	1.074134
175	.933786	.943356	.961338	.993343	1.021321	1.046744	1.071041
180	.928855	.938625	.956973	.989570	1.017958	1.043609	1.067957
185	.923823	.933799	.952524	.985735	1.014555	1.040458	1.064879
190	.918689	.928877	.947989	.981837	1.011111	1.037287	1.061804
195	.913450	.923854	.943365	.977872	1.007622	1.034094	1.058729
200	.908102	.918729	.938650	.973838	1.004086	1.030876	1.055652

P=500 bars

Molal NaCl

	.25	.5	1	2	3	4	5
205	.902644	.913499	.933841	.969732	1.000501	1.027631	1.052568
210	.897073	.908161	.928935	.965552	.996863	1.024355	1.049477
215	.891387	.902713	.923930	.961294	.993169	1.021046	1.046375
220	.885582	.897153	.918823	.956956	.989418	1.017701	1.043258
225	.879657	.891478	.913613	.952536	.985606	1.014318	1.040125
230	.873609	.885685	.908295	.948031	.981732	1.010893	1.036973
235	.867435	.879772	.902868	.943439	.977791	1.007424	1.033798
240	.861133	.873736	.897330	.938756	.973782	1.003909	1.030599
245	.854701	.867575	.891677	.933981	.969702	1.000344	1.027372
250	.848136	.861287	.885907	.929111	.965548	.996727	1.024115
255	.841436	.854868	.880018	.924142	.961318	.993056	1.020825
260	.834597	.848318	.874008	.919074	.957010	.989328	1.017499
265	.827619	.841632	.867873	.913903	.952620	.985540	1.014136
270	.820499	.834810	.861612	.908627	.948147	.981689	1.010731
275	.813233	.827848	.855222	.903243	.943587	.977774	1.007283
280	.805820	.820744	.848701	.897749	.938938	.973791	1.003788
285	.798258	.813495	.842046	.892142	.934198	.969738	1.000245
290	.790543	.806100	.835254	.886420	.929364	.965612	.996651
295	.782675	.798556	.828325	.880581	.924434	.961412	.993003
300	.774650	.790861	.821254	.874623	.919405	.957133	.989298
305	.766466	.783012	.814041	.868542	.914275	.952775	.985534
310	.758121	.775007	.806681	.862336	.909042	.948334	.981709
315	.749612	.766844	.799174	.856004	.903702	.943808	.977820
320	.740938	.758520	.791517	.849542	.898254	.939194	.973864
325	.732096	.750034	.783708	.842948	.892695	.934491	.969839
330	.723083	.741383	.775744	.836221	.887023	.929695	.965743
335	.713899	.732564	.767623	.829357	.881235	.924804	.961572
340	.704540	.723576	.759342	.822355	.875330	.919816	.957325
345	.695004	.714416	.750901	.815212	.869304	.914729	.952999
350	.685289	.705083	.742296	.807926	.863155	.909539	.948592

P=700 bars

CONCENTRATION, m NACL

TEMP. DEG.C	.25	.5	1	2	3	4	5
5	1.072385	1.078589	1.091156	1.117557	1.146824	1.180333	1.219422
10	1.069212	1.075397	1.087893	1.114011	1.142811	1.175671	1.213933
15	1.066046	1.072219	1.084655	1.110515	1.138872	1.171109	1.208568
20	1.062884	1.069051	1.081440	1.107066	1.135005	1.166641	1.203321
25	1.059723	1.065891	1.078244	1.103660	1.131205	1.162265	1.198191
30	1.056561	1.062734	1.075064	1.100294	1.127469	1.157978	1.193174
35	1.053393	1.059578	1.071897	1.096965	1.123794	1.153777	1.188266
40	1.050218	1.056421	1.068741	1.093670	1.120178	1.149657	1.183464
45	1.047031	1.053258	1.065590	1.090406	1.116616	1.145616	1.178765
50	1.043830	1.050087	1.062444	1.087170	1.113106	1.141651	1.174166
55	1.040612	1.046905	1.059299	1.083958	1.109644	1.137757	1.169663
60	1.037374	1.043709	1.056151	1.080768	1.106227	1.133933	1.165253
65	1.034113	1.040495	1.052997	1.077595	1.102853	1.130175	1.160933
70	1.030826	1.037262	1.049836	1.074439	1.099517	1.126480	1.156699
75	1.027510	1.034005	1.046663	1.071294	1.096217	1.122844	1.152548
80	1.024162	1.030722	1.043476	1.068159	1.092950	1.119265	1.148478
85	1.020779	1.027410	1.040271	1.065030	1.089713	1.115739	1.144484
90	1.017358	1.024067	1.037047	1.061904	1.086503	1.112263	1.140564
95	1.013897	1.020688	1.033799	1.058778	1.083316	1.108834	1.136715
100	1.010392	1.017272	1.030525	1.055650	1.080150	1.105449	1.132933
105	1.006841	1.013815	1.027222	1.052516	1.077001	1.102105	1.129215
110	1.003241	1.010315	1.023887	1.049373	1.073867	1.098798	1.125558
115	.999588	1.006769	1.020518	1.046219	1.070744	1.095527	1.121960
120	.995881	1.003174	1.017111	1.043050	1.067630	1.092287	1.118416
125	.992116	.999526	1.013664	1.039863	1.064522	1.089076	1.114924
130	.988291	.995824	1.010173	1.036657	1.061416	1.085891	1.111481
135	.984402	.992064	1.006636	1.033427	1.058311	1.082729	1.108084
140	.980448	.988245	1.003051	1.030171	1.055202	1.079586	1.104730
145	.976424	.984362	.999413	1.026886	1.052087	1.076460	1.101415
150	.972330	.980413	.995722	1.023570	1.048963	1.073348	1.098137
155	.968161	.976396	.991973	1.020219	1.045827	1.070247	1.094893
160	.963915	.972307	.988164	1.016831	1.042676	1.067154	1.091680
165	.959590	.968145	.984292	1.013402	1.039508	1.064067	1.088495
170	.955182	.963906	.980355	1.009931	1.036320	1.060981	1.085334
175	.950690	.959587	.976350	1.006414	1.033109	1.057895	1.082195
180	.946110	.955187	.972274	1.002849	1.029871	1.054805	1.079076
185	.941440	.950702	.968125	.999232	1.026605	1.051709	1.075972
190	.936677	.946130	.963900	.995562	1.023307	1.048604	1.072882
195	.931818	.941468	.959596	.991835	1.019975	1.045487	1.069802
200	.926862	.936713	.955210	.988049	1.016606	1.042355	1.066730

P=700 bars

	Molal NaCl						
	.25	.5	1	2	3	4	5
205	.921805	.931864	.950740	.984201	1.013198	1.039206	1.063663
210	.916645	.926916	.946184	.980289	1.009746	1.036036	1.060597
215	.911379	.921869	.941538	.976309	1.006250	1.032843	1.057530
220	.906004	.916719	.936801	.972259	1.002706	1.029625	1.054460
225	.900520	.911463	.931969	.968137	.999111	1.026377	1.051383
230	.894921	.906100	.927041	.963939	.995463	1.023099	1.048297
235	.889207	.900626	.922012	.959664	.991759	1.019786	1.045199
240	.883375	.895039	.916882	.955309	.987996	1.016437	1.042086
245	.877422	.889337	.911647	.950871	.984173	1.013049	1.038955
250	.871345	.883517	.906306	.946347	.980285	1.009618	1.035804
255	.865143	.877577	.900854	.941736	.976332	1.006143	1.032630
260	.858813	.871514	.895291	.937034	.972309	1.002620	1.029431
265	.852353	.865326	.889613	.932238	.968215	.999048	1.026203
270	.845759	.859010	.883818	.927348	.964047	.995423	1.022944
275	.839030	.852564	.877904	.922359	.959802	.991743	1.019652
280	.832163	.845986	.871868	.917270	.955478	.988005	1.016323
285	.825157	.839273	.865708	.912078	.951073	.984206	1.012955
290	.818007	.832423	.859422	.906781	.946583	.980345	1.009546
295	.810713	.825433	.853006	.901375	.942006	.976419	1.006093
300	.803272	.818302	.846459	.895860	.937341	.972424	1.002592
305	.795682	.811026	.839778	.890232	.932584	.968359	.999043
310	.787939	.803604	.832961	.884488	.927733	.964221	.995442
315	.780043	.796032	.826006	.878627	.922785	.960008	.991786
320	.771990	.788310	.818910	.872647	.917738	.955716	.988073
325	.763778	.780434	.811671	.866544	.912590	.951345	.984301
330	.755406	.772403	.804287	.860316	.907339	.946890	.980467
335	.746871	.764213	.796755	.853962	.901981	.942350	.976569
340	.738170	.755864	.789073	.847478	.896514	.937722	.972603
345	.729301	.747352	.781239	.840863	.890937	.933004	.968568
350	.720263	.738675	.773250	.834114	.885247	.928193	.964462

P=1000 bars

CONCENTRATION, m NACL

TEMP. DEG.C	.25	.5	1	2	3	4	5
5	1.089331	1.095731	1.108876	1.137168	1.169294	1.206619	1.250468
10	1.086081	1.092431	1.105440	1.133322	1.164856	1.201406	1.244302
15	1.082855	1.089161	1.102047	1.129544	1.160508	1.196308	1.238276
20	1.079649	1.085917	1.098692	1.125828	1.156248	1.191323	1.232386
25	1.076461	1.082697	1.095374	1.122172	1.152072	1.186446	1.226630
30	1.073288	1.079498	1.092087	1.118573	1.147977	1.181674	1.221003
35	1.070125	1.076316	1.088830	1.115028	1.143960	1.177004	1.215502
40	1.066971	1.073148	1.085600	1.111533	1.140017	1.172433	1.210124
45	1.063822	1.069991	1.082392	1.108085	1.136145	1.167957	1.204866
50	1.060675	1.066842	1.079205	1.104681	1.132342	1.163574	1.199724
55	1.057527	1.063698	1.076034	1.101318	1.128603	1.159279	1.194695
60	1.054375	1.060556	1.072877	1.097993	1.124926	1.155069	1.189775
65	1.051216	1.057413	1.069731	1.094702	1.121308	1.150942	1.184961
70	1.048047	1.054266	1.066593	1.091443	1.117744	1.146895	1.180251
75	1.044865	1.051112	1.063460	1.088212	1.114233	1.142923	1.175640
80	1.041667	1.047947	1.060328	1.085006	1.110771	1.139023	1.171126
85	1.038450	1.044770	1.057195	1.081823	1.107355	1.135194	1.166705
90	1.035211	1.041577	1.054057	1.078659	1.103981	1.131430	1.162374
95	1.031947	1.038364	1.050913	1.075511	1.100648	1.127730	1.158130
100	1.028656	1.035130	1.047758	1.072377	1.097351	1.124091	1.153969
105	1.025334	1.031871	1.044590	1.069252	1.094087	1.120508	1.149889
110	1.021978	1.028584	1.041406	1.066135	1.090854	1.116979	1.145887
115	1.018586	1.025267	1.038203	1.063022	1.087649	1.113501	1.141958
120	1.015155	1.021916	1.034978	1.059910	1.084468	1.110070	1.138101
125	1.011682	1.018529	1.031728	1.056797	1.081308	1.106684	1.134311
130	1.008164	1.015102	1.028451	1.053679	1.078167	1.103340	1.130586
135	1.004598	1.011634	1.025143	1.050554	1.075042	1.100035	1.126924
140	1.000981	1.008121	1.021802	1.047418	1.071929	1.096765	1.123319
145	.997311	1.004560	1.018424	1.044269	1.068826	1.093528	1.119771
150	.993586	1.000949	1.015008	1.041103	1.065729	1.090321	1.116275
155	.989801	.997285	1.011550	1.037919	1.062636	1.087140	1.112828
160	.985955	.993565	1.008047	1.034713	1.059545	1.083983	1.109429
165	.982044	.989786	1.004497	1.031482	1.056451	1.080846	1.106072
170	.978067	.985946	1.000897	1.028224	1.053353	1.077728	1.102757
175	.974020	.982042	.997244	1.024935	1.050246	1.074624	1.099479
180	.969900	.978071	.993535	1.021614	1.047130	1.071533	1.096236
185	.965705	.974031	.989769	1.018256	1.044000	1.068451	1.093024
190	.961433	.969918	.985941	1.014860	1.040853	1.065375	1.089841
195	.957080	.965731	.982049	1.011423	1.037688	1.062302	1.086685
200	.952644	.961466	.978092	1.007942	1.034501	1.059230	1.083551

P=1000 bars

Molal NaCl

	.25	.5	1	2	3	4	5
205	.948123	.957121	.974065	1.004413	1.031290	1.056156	1.080437
210	.943513	.952693	.969967	1.000836	1.028051	1.053077	1.077341
215	.938813	.948180	.965794	.997206	1.024782	1.049990	1.074259
220	.934019	.943579	.961544	.993521	1.021481	1.046893	1.071189
225	.929129	.938888	.957215	.989779	1.018144	1.043782	1.068127
230	.924140	.934104	.952804	.985977	1.014769	1.040655	1.065071
235	.919051	.929224	.948308	.982112	1.011353	1.037509	1.062019
240	.913858	.924245	.943725	.978181	1.007893	1.034342	1.058967
245	.908559	.919167	.939052	.974182	1.004387	1.031150	1.055912
250	.903151	.913985	.934287	.970113	1.000833	1.027931	1.052853
255	.897632	.908697	.929427	.965971	.997227	1.024682	1.049785
260	.892000	.903301	.924470	.961753	.993567	1.021401	1.046707
265	.886252	.897795	.919412	.957456	.989850	1.018085	1.043615
270	.880385	.892175	.914253	.953079	.986074	1.014732	1.040508
275	.874397	.886440	.908988	.948618	.982236	1.011338	1.037381
280	.868286	.880587	.903617	.944072	.978333	1.007901	1.034234
285	.862049	.874613	.898135	.939437	.974364	1.004418	1.031062
290	.855685	.868517	.892541	.934711	.970325	1.000888	1.027863
295	.849189	.862296	.886833	.929892	.966214	.997306	1.024635
300	.842561	.855947	.881008	.924977	.962028	.993671	1.021375
305	.835797	.849467	.875063	.919963	.957766	.989981	1.018081
310	.828896	.842856	.868996	.914849	.953423	.986232	1.014749
315	.821855	.836110	.862806	.909632	.948999	.982422	1.011378
320	.814672	.829227	.856488	.904309	.944490	.978548	1.007964
325	.807345	.822205	.850042	.898879	.939894	.974609	1.004505
330	.799870	.815041	.843465	.893337	.935208	.970601	1.000999
335	.792246	.807733	.836754	.887684	.930431	.966522	.997443
340	.784471	.800279	.829907	.881915	.925560	.962370	.993834
345	.776543	.792676	.822922	.876029	.920592	.958142	.990171
350	.768458	.784923	.815797	.870022	.915524	.953836	.986449

Total enthalpy of sodium chloride solutions, Joules/g, referenced to the triple point of water.

	T(C)						
WT. PERCENT	0.00	25.00	50.00	75.00	100.00	125.00	150.00
.25	-.02	104.52	208.63	312.91	417.69	523.3	630.1
.50	-.02	104.15	207.94	311.91	416.37	521.6	628.1
.75	-.03	103.78	207.26	310.92	415.07	520.0	626.1
1.00	-.04	103.40	206.58	309.94	413.77	518.4	624.1
1.25	-.06	103.03	205.90	308.96	412.49	516.8	622.2
1.50	-.09	102.65	205.23	307.99	411.21	515.2	620.2
1.75	-.13	102.28	204.55	307.02	409.93	513.6	618.3
2.00	-.17	101.90	203.87	306.05	408.66	512.0	616.4
2.25	-.22	101.51	203.20	305.09	407.40	510.4	614.5
2.50	-.28	101.13	202.52	304.12	406.14	508.8	612.6
2.75	-.34	100.74	201.84	303.16	404.88	507.3	610.7
3.00	-.41	100.35	201.17	302.20	403.63	505.7	608.8
3.25	-.48	99.95	200.49	301.24	402.38	504.2	606.9
3.50	-.56	99.56	199.81	300.28	401.13	502.6	605.0
3.75	-.65	99.16	199.13	299.32	399.89	501.1	603.2
4.00	-.75	98.75	198.45	298.37	398.65	499.5	601.3
4.25	-.85	98.35	197.77	297.41	397.41	498.0	599.5
4.50	-.95	97.94	197.09	296.46	396.18	496.5	597.6
4.75	-1.07	97.53	196.41	295.51	394.94	494.9	595.8
5.00	-1.19	97.12	195.72	294.55	393.71	493.4	594.0
6.00	-1.72	95.43	192.98	290.75	388.81	487.4	586.7
7.00	-2.34	93.71	190.23	286.96	383.95	481.4	579.5
8.00	-3.05	91.94	187.46	283.18	379.11	475.4	572.5
9.00	-3.85	90.14	184.67	279.41	374.32	469.6	565.5
10.00	-4.72	88.29	181.88	275.65	369.55	463.8	558.6
11.00	-5.67	86.41	179.07	271.90	364.82	458.0	551.7
12.00	-6.70	84.50	176.26	268.16	360.13	452.3	545.0
13.00	-7.79	82.56	173.44	264.45	355.47	446.7	538.4
14.00	-8.94	80.59	170.62	260.75	350.85	441.1	531.8
15.00	-10.15	78.59	167.80	257.07	346.28	435.6	525.3
16.00	-11.41	76.58	164.98	253.41	341.75	430.2	519.0
17.00	-12.72	74.54	162.17	249.79	337.27	424.8	512.7
18.00	-14.06	72.50	159.36	246.19	332.85	419.5	506.5
19.00	-15.44	70.44	156.58	242.63	328.48	414.3	500.4
20.00	-16.83	68.39	153.81	239.11	324.17	409.2	494.4
21.00	-18.24	66.33	151.06	235.64	319.92	404.1	488.6
22.00	-19.65	64.29	148.35	232.21	315.74	399.2	482.8
23.00	-21.05	62.26	145.67	228.84	311.64	394.3	477.2
24.00	-22.43	60.26	143.04	225.54	307.62	389.5	471.7
25.00	-23.78	58.29	140.46	222.31	303.69	384.9	466.3

Molality = (1000)(Wt.Percent)/(58.44)(100- Wt.Percent)

Total enthalpy of sodium chloride solutions, Joules/g, referenced to the triple point of water.

	T(C)					
WT. PERCENT	175.00	200.00	225.00	250.00	275.00	300.00
.25	738.7	849.5	963.2	1081.1	1204.8	1337.1
.50	736.3	846.6	959.8	1077.0	1199.8	1330.7
.75	733.9	843.8	956.5	1073.0	1194.9	1324.5
1.00	731.5	841.0	953.2	1069.1	1190.2	1318.4
1.25	729.2	838.2	950.0	1065.3	1185.6	1312.5
1.50	726.9	835.5	946.8	1061.5	1181.0	1306.8
1.75	724.6	832.8	943.6	1057.8	1176.5	1301.1
2.00	722.3	830.1	940.4	1054.1	1172.1	1295.6
2.25	720.0	827.4	937.3	1050.4	1167.7	1290.1
2.50	717.7	824.8	934.2	1046.8	1163.4	1284.7
2.75	715.5	822.2	931.2	1043.2	1159.1	1279.4
3.00	713.3	819.6	928.1	1039.6	1154.9	1274.2
3.25	711.0	817.0	925.1	1036.1	1150.7	1269.0
3.50	708.8	814.4	922.1	1032.6	1146.5	1263.9
3.75	706.6	811.8	919.1	1029.2	1142.4	1258.9
4.00	704.4	809.3	916.2	1025.7	1138.4	1253.9
4.25	702.3	806.7	913.2	1022.3	1134.3	1249.0
4.50	700.1	804.2	910.3	1018.9	1130.3	1244.1
4.75	697.9	801.7	907.4	1015.5	1126.4	1239.3
5.00	695.8	799.2	904.5	1012.2	1122.4	1234.5
6.00	687.2	789.2	893.1	999.0	1107.0	1215.8
7.00	678.8	779.5	881.9	986.1	1092.0	1197.8
8.00	670.5	769.9	870.9	973.5	1077.3	1180.3
9.00	662.4	760.5	860.1	961.2	1063.1	1163.3
10.00	654.3	751.3	849.6	949.1	1049.1	1146.9
11.00	646.4	742.2	839.2	937.2	1035.5	1130.9
12.00	638.6	733.2	829.0	925.7	1022.2	1115.3
13.00	630.9	724.4	819.0	914.3	1009.2	1100.1
14.00	623.3	715.8	809.2	903.2	996.5	1085.2
15.00	615.8	707.3	799.5	892.2	984.0	1070.8
16.00	608.5	698.9	790.1	881.5	971.8	1056.7
17.00	601.3	690.7	780.8	871.1	959.9	1042.9
18.00	594.2	682.6	771.7	860.8	948.2	1029.5
19.00	587.2	674.7	762.8	850.7	936.8	1016.4
20.00	580.4	667.0	754.1	840.9	925.6	1003.6
21.00	573.6	659.4	745.5	831.3	914.7	991.1
22.00	567.1	652.0	737.2	821.8	904.0	978.9
23.00	560.6	644.7	729.0	812.6	893.6	967.0
24.00	554.3	637.6	721.0	803.6	883.4	955.4
25.00	548.2	630.6	713.2	794.9	873.4	944.1

Reference: Pitzer,K.S.,Bradley,D.J.,Rogers,P.S.Z.,Peiper,J.C., "Thermodynamics of High Temperature Brines", LBL-8973, Lawrence Berkeley Laboratory, University of California, Berkeley, CA 94720 (April 1979).

Total specific heat capacity of sodium chloride solutions, Joules/g-K

	T(C)						
WT. PERCENT	0.00	25.00	50.00	75.00	100.00	125.00	150.00
.25	4.1991	4.1654	4.1672	4.1791	4.2015	4.240	4.296
.50	4.1813	4.1519	4.1544	4.1661	4.1879	4.225	4.281
.75	4.1638	4.1386	4.1418	4.1533	4.1745	4.211	4.265
1.00	4.1468	4.1255	4.1294	4.1407	4.1614	4.197	4.250
1.25	4.1300	4.1126	4.1172	4.1283	4.1484	4.183	4.235
1.50	4.1136	4.0998	4.1051	4.1160	4.1356	4.169	4.220
1.75	4.0975	4.0872	4.0931	4.1039	4.1229	4.156	4.206
2.00	4.0817	4.0748	4.0813	4.0918	4.1103	4.143	4.192
2.25	4.0661	4.0625	4.0695	4.0799	4.0978	4.129	4.178
2.50	4.0509	4.0503	4.0579	4.0681	4.0855	4.116	4.164
2.75	4.0359	4.0382	4.0464	4.0564	4.0733	4.104	4.150
3.00	4.0211	4.0263	4.0350	4.0447	4.0612	4.091	4.137
3.25	4.0066	4.0145	4.0237	4.0332	4.0492	4.078	4.123
3.50	3.9924	4.0028	4.0124	4.0218	4.0372	4.066	4.110
3.75	3.9784	3.9912	4.0013	4.0104	4.0254	4.053	4.097
4.00	3.9647	3.9797	3.9903	3.9992	4.0137	4.041	4.084
4.25	3.9511	3.9683	3.9793	3.9880	4.0020	4.029	4.071
4.50	3.9379	3.9570	3.9684	3.9769	3.9905	4.016	4.058
4.75	3.9248	3.9458	3.9577	3.9659	3.9790	4.004	4.045
5.00	3.9120	3.9348	3.9469	3.9550	3.9676	3.992	4.032
6.00	3.8629	3.8914	3.9049	3.9120	3.9229	3.946	3.983
7.00	3.8172	3.8496	3.8641	3.8702	3.8795	3.900	3.936
8.00	3.7747	3.8091	3.8244	3.8296	3.8372	3.856	3.890
9.00	3.7352	3.7700	3.7859	3.7900	3.7961	3.813	3.845
10.00	3.6987	3.7322	3.7484	3.7515	3.7560	3.772	3.802
11.00	3.6648	3.6957	3.7120	3.7140	3.7171	3.731	3.760
12.00	3.6335	3.6604	3.6767	3.6775	3.6793	3.692	3.720
13.00	3.6045	3.6264	3.6423	3.6420	3.6424	3.654	3.680
14.00	3.5775	3.5935	3.6090	3.6074	3.6066	3.617	3.642
15.00	3.5525	3.5617	3.5766	3.5738	3.5718	3.581	3.606
16.00	3.5291	3.5310	3.5452	3.5412	3.5380	3.547	3.570
17.00	3.5070	3.5015	3.5148	3.5095	3.5051	3.513	3.536
18.00	3.4860	3.4729	3.4853	3.4787	3.4732	3.480	3.502
19.00	3.4657	3.4454	3.4567	3.4488	3.4422	3.448	3.470
20.00	3.4457	3.4188	3.4291	3.4197	3.4121	3.418	3.439
21.00	3.4257	3.3932	3.4023	3.3916	3.3828	3.388	3.409
22.00	3.4051	3.3684	3.3764	3.3642	3.3545	3.359	3.380
23.00	3.3836	3.3444	3.3514	3.3377	3.3269	3.331	3.351
24.00	3.3606	3.3211	3.3272	3.3120	3.3002	3.304	3.324
25.00	3.3354	3.2985	3.3038	3.2871	3.2742	3.277	3.298

Molality = (1000)(Wt.Percent)/(58.44)(100 -Wt.Percent)

Total specific heat capacity of sodium chloride solutions, Joules/g-K

	T(C)					
WT. PERCENT	175.00	200.00	225.00	250.00	275.00	300.00
.25	4.371	4.472	4.614	4.819	5.138	5.672
.50	4.353	4.452	4.590	4.788	5.093	5.597
.75	4.336	4.432	4.566	4.758	5.051	5.526
1.00	4.319	4.414	4.544	4.729	5.010	5.460
1.25	4.303	4.395	4.522	4.702	4.972	5.398
1.50	4.287	4.377	4.501	4.675	4.935	5.338
1.75	4.271	4.360	4.480	4.649	4.899	5.281
2.00	4.256	4.342	4.460	4.624	4.865	5.227
2.25	4.240	4.325	4.440	4.600	4.831	5.174
2.50	4.225	4.309	4.421	4.576	4.799	5.124
2.75	4.211	4.292	4.402	4.553	4.768	5.075
3.00	4.196	4.276	4.384	4.530	4.737	5.028
3.25	4.181	4.260	4.365	4.507	4.707	4.982
3.50	4.167	4.244	4.347	4.486	4.678	4.938
3.75	4.153	4.229	4.330	4.464	4.650	4.895
4.00	4.139	4.214	4.312	4.443	4.622	4.853
4.25	4.125	4.199	4.295	4.423	4.595	4.813
4.50	4.112	4.184	4.278	4.402	4.568	4.774
4.75	4.098	4.169	4.262	4.382	4.542	4.736
5.00	4.085	4.155	4.245	4.363	4.517	4.699
6.00	4.032	4.098	4.182	4.288	4.420	4.560
7.00	3.982	4.044	4.122	4.217	4.331	4.436
8.00	3.934	3.992	4.065	4.150	4.247	4.324
9.00	3.887	3.943	4.010	4.087	4.169	4.222
10.00	3.842	3.895	3.957	4.026	4.096	4.131
11.00	3.799	3.849	3.907	3.969	4.028	4.048
12.00	3.757	3.804	3.859	3.914	3.963	3.973
13.00	3.716	3.762	3.812	3.862	3.902	3.906
14.00	3.677	3.721	3.768	3.811	3.845	3.846
15.00	3.639	3.681	3.725	3.763	3.790	3.792
16.00	3.603	3.643	3.684	3.717	3.739	3.745
17.00	3.567	3.606	3.644	3.673	3.690	3.703
18.00	3.533	3.571	3.606	3.630	3.644	3.666
19.00	3.500	3.536	3.569	3.589	3.600	3.635
20.00	3.469	3.503	3.533	3.550	3.559	3.608
21.00	3.438	3.472	3.499	3.512	3.520	3.586
22.00	3.409	3.441	3.466	3.475	3.482	3.569
23.00	3.380	3.411	3.433	3.440	3.447	3.555
24.00	3.353	3.383	3.402	3.406	3.413	3.546
25.00	3.326	3.355	3.372	3.373	3.381	3.540

Reference: Pitzer,K.S.,Bradley,D.J.,Rogers,P.S.Z.,Peiper,J.C.,"Thermodynamics of High Temperature Brines", LBL-8973, Lawrence Berkeley Laboratory, University of California, Berkeley, CA 94720 (April 1979).