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A CORRELATION OF AVAILABLE LITHIUM CHLORIDE AND HYDROCHLORIC ACID ACTIVITY COEFFICIENT DATA

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CHEMICAL TECHNOLOGY DIVISION

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ABSTRACT

Density data at 25°C for HCl solutions with concentrations up to 13.1 M and for LiCl solutions with concentrations up to 12.0 M have been fitted to a second-degree polynomial as a function of both molality and molarity. From the equations obtained, available literature values of molality and activity coefficients on the molal scale ($\gamma_{\pm}$) were converted to molarity and activity coefficients on the molar scale ($\gamma_{\pm}$). The latter (up to 11.9 M for HCl and up to 14.0 M for LiCl) were fitted to an extended Debye-Hückel expression. Appropriate tables and graphs of the various values were prepared. The activities of HCl and LiCl were noted to be very similar (HCl was slightly higher) over the concentration range up to 11.9 M.

INTRODUCTION

A large amount of information relative to the density and mean ionic activity coefficients of HCl and LiCl solutions is available;¹⁻³ however, for many purposes, it is poorly organized and arranged. A major inadequacy is the lack of equations that will allow accurate interpolation of values between the experimental points. In connection with some recent work on solvent extraction equilibria in HCl-LiCl mixtures, the author required a method by which activity coefficients of HCl and LiCl could be calculated over a very wide concentration range, as well as a means for estimating the activity of HCl in concentrated LiCl solutions. To fulfill these needs, the data contained herein were collected and fitted to suitable equations. This report does not represent an attempt to prepare an exhaustive or critical compilation; it simply presents results obtained by using the most readily available, and what are generally considered to be the most reliable, data. The compiled data, the fitted equations, and the

pertinent plots are presented here in the belief that the information in this form will be more widely useful than as arranged in the original references.

CALCULATIONS

Data relative to the density, D , of HCl ¹ and of LiCl ² were given in the sources used as weight percent, WPCT, of the salt. Molality, m , and molarity, M , were calculated as follows:

$$m = \frac{1000 (\text{WPCT})}{\text{FW} (100 - \text{WPCT})},$$

$$M = \frac{10 (D)(\text{WPCT})}{\text{FW}},$$

where FW is the formula weight of the compound.

Density values were fitted to a second-degree polynomial as a function of molality and molarity for both HCl and LiCl solutions. The resulting equations are presented below.

Density of HCl solutions up to 18.3 m as a function of molality:

$$D = 0.99840 + 0.016197 m - 0.002977 m^2$$

Standard error of fit, 8.15×10^{-4}

Density of HCl solutions up to 13.1 M as a function of molarity:

$$D = 0.99716 + 0.017490 M - 0.001733 M^2$$

Standard error of fit, 4.84×10^{-4}

Density of LiCl solutions up to 19.3 m as a function of molality:

$$D = 1.00012 + 0.020947 m - 0.003145 m^2$$

Standard error of fit, 1.68×10^{-3}

Density of LiCl solutions up to 13.7 M as a function of molarity:

$$D = 0.99871 + 0.022255 M - 0.0007647 M^2$$

Standard deviation of fit, 8.58×10^{-4}

Hydrochloric acid density values are shown in Table 1 and Fig. 1(a) and (b). Lithium chloride density values are shown in Table 2 and Fig. 2(a) and (b).

Table 1. HCl Density Data

PERCENT ANHYDROUS HCl	MOLALITY	MOLALITY	DENSITY (LITERATURE)	DENSITY CALC. FROM FIT TO MOLALITY	DENSITY CALC. FROM FIT TO MOLALITY
0.0	0.0	0.0	9.97044000D-01	9.98403734D-01	9.97156403D-01
1.00000000D 00	2.77043677D-01	2.74821787D-01	1.00200000D 00	1.00286815D 00	1.00194993D 00
2.00000000D 00	5.59741307D-01	5.52331451D-01	1.00690000D 00	1.00737658D 00	1.00676378D 00
3.00000000D 00	8.48267754D-01	8.32528994D-01	1.01180000D 00	1.01192890D 00	1.01159718D 00
4.00000000D 00	1.14280517D 00	1.11541441D 00	1.01670000D 00	1.01652495D 00	1.01644936D 00
6.00000000D 00	1.75068026D 00	1.68908432D 00	1.02640000D 00	1.02584711D 00	1.02620405D 00
8.00000000D 00	2.38498470D 00	2.27317662D 00	1.03600000D 00	1.03534005D 00	1.03601881D 00
1.00000000D 01	3.04748045D 00	2.86807527D 00	1.04570000D 00	1.04499916D 00	1.04589353D 00
1.20000000D 01	3.74008964D 00	3.47427399D 00	1.05560000D 00	1.05481795D 00	1.05582987D 00
1.40000000D 01	4.46491322D 00	4.09171791D 00	1.06560000D 00	1.06478760D 00	1.06581954D 00
1.60000000D 01	5.22425220D 00	4.72013276D 00	1.07560000D 00	1.07489652D 00	1.07585106D 00
1.80000000D 01	6.02063211D 00	5.35951854D 00	1.08560000D 00	1.08512977D 00	1.08591727D 00
2.00000000D 01	6.85683101D 00	6.01042379D 00	1.09570000D 00	1.09546832D 00	1.09601933D 00
2.20000000D 01	7.73591191D 00	6.67301308D 00	1.10590000D 00	1.10588820D 00	1.10615193D 00
2.40000000D 01	8.66126022D 00	7.34745098D 00	1.11620000D 00	1.11635948D 00	1.11630950D 00
2.60000000D 01	9.63662736D 00	8.03247583D 00	1.12640000D 00	1.12684492D 00	1.12646517D 00
2.80000000D 01	1.06661816D 01	8.72792305D 00	1.13650000D 00	1.13729844D 00	1.13660902D 00
2.80000000D 01	1.06661816D 01	8.73560271D 00	1.13750000D 00	1.13729844D 00	1.13672010D 00
3.00000000D 01	1.17545674D 01	9.43362810D 00	1.14650000D 00	1.14766314D 00	1.14673117D 00
3.00000000D 01	1.17545674D 01	9.44267912D 00	1.14760000D 00	1.14766314D 00	1.14685987D 00
3.20000000D 01	1.29069760D 01	1.01599585D 01	1.15760000D 00	1.15786886D 00	1.15696895D 00
3.40000000D 01	1.41292275D 01	1.08882088D 01	1.16760000D 00	1.16782914D 00	1.16705027D 00
3.60000000D 01	1.54278698D 01	1.16254553D 01	1.17740000D 00	1.17743745D 00	1.17706893D 00
3.80000000D 01	1.68102954D 01	1.23526085D 01	1.18520000D 00	1.18656238D 00	1.18676593D 00
4.00000000D 01	1.82848827D 01	1.31332998D 01	1.19710000D 00	1.19504158D 00	1.19697295D 00

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Fig. 1(a). HCl Density vs Molality.

Fig. 1(b). HCl Density vs Molarity.

Table 2. LiCl Density Data

PERCENT	MOLALITY	MOLARITY	DENSITY (LITERATURE)	DENSITY CALC. FROM FIT TO MOLALITY	DENSITY CALC. FROM FIT TO MOLARITY
0.0	0.C	0.0	9.97100000D-01	1.00011675D 00	9.98712611D-01
1.00000000D 00	2.38231405D-01	2.36537770D-01	1.00292000D 00	1.00508911D 00	1.00397239D 00
2.00000000D 00	4.81324675D-01	4.75801955D-01	1.00870000D 00	1.01012615D 00	1.00928408D 00
4.00000000D 00	9.82704544E-01	9.62443535D-01	1.02019000D 00	1.02039766D 00	1.02006058D 00
6.00000000D 00	1.50541973D 00	1.45982568D 00	1.03161000D 00	1.03093791D 00	1.03103749D 00
8.00000000D 00	2.05086166D 00	1.96798142D 00	1.04303000D 00	1.04175319D 00	1.04221309D 00
1.00000000D 01	2.62054545E 00	2.48700507D 00	1.05449000D 00	1.05284936D 00	1.05358694D 00
1.20000000D 01	3.21612396E 00	3.01703317D 00	1.06602000D 00	1.06423164D 00	1.06515953D 00
1.40000000D 01	3.83940380E 00	3.55827881D 00	1.07765000D 00	1.07590441D 00	1.07693248D 00
1.60000000D 01	4.49236363D 00	4.11098172D 00	1.08941000D 00	1.08787094D 00	1.08890852D 00
1.80000000D 01	5.17717516E 00	4.67541577D 00	1.10132000D 00	1.10013308D 00	1.10109053D 00
2.00000000D 01	5.89622726D 00	5.25198189D 00	1.11342000D 00	1.11269087D 00	1.11348408D 00
2.20000000D 01	6.65215384D 00	5.84110461D 00	1.12574000D 00	1.12554198D 00	1.12609503D 00
2.40000000D 01	7.44786602D 00	6.44326508D 00	1.13831000D 00	1.13863118D 00	1.13893021D 00
2.60000000D 01	8.23658967D 00	7.05893970D 00	1.15115000D 00	1.15209947D 00	1.15199610D 00
2.80000000D 01	9.17190908D 00	7.68864262D 00	1.16428000D 00	1.16578320D 00	1.16529974D 00
3.00000000D 01	1.01078182D 01	8.33285497D 00	1.17771000D 00	1.17971279D 00	1.17884716D 00
3.50000000D 01	1.26995664D 01	1.00108269D 01	1.21274000D 00	1.21541166D 00	1.21383598D 00
4.00000000D 01	1.57232727D 01	1.17926432D 01	1.25002000D 00	1.25172032D 00	1.25051874D 00
4.50000000D 01	1.92967138D 01	1.36889171D 01	1.28980000D 00	1.28721634D 00	1.28902450D 00
a {	6.22584658E-01	6.13900000D-01	1.01208000D 00	1.01303607D 00	1.01234589D 00
	9.57450238E-01	9.38500000D-01	1.02000000D 00	1.01988407D 00	1.01953120D 00
	3.50820954D 00	3.27300000D 00	1.07173000D 00	1.06973221D 00	1.07073274D 00
	6.34883728D 00	5.61400000D 00	1.12229000D 00	1.12042863D 00	1.12123984D 00
	1.06383916D 01	8.69800000D 00	1.18640000D 00	1.18736487D 00	1.18649777D 00
	1.61328359D 01	1.20400000D 01	1.25680000D 00	1.25619613D 00	1.25557276D 00

(a) FOR THESE DATA THE VALUE GIVEN IN THE LITERATURE WAS MOLARITY

Fig. 2(a). LiCl Density vs Molality.

Fig. 2(b). LiCl Density vs Molarity.

Activity coefficient data obtained from the literature were given in terms of $\gamma_{\pm}$ and molality.³ Molality was converted to molarity using

$$M = \frac{1000 D (m)}{1000 + FW (m)} .$$

The molal-scale activity coefficient, $\gamma_{\pm}$, was converted to the molar-scale coefficient, $y_{\pm}$, using the relationship

$$y_{\pm} = \frac{m \cdot \gamma_{\pm} \cdot D_{H_2O} (25^{\circ}C)}{M} .$$

The molar activity coefficient, $y_{\pm}$, was fitted to the molarity using the equation

$$-\log y_{\pm} = \frac{0.509 \sqrt{M}}{1 + B_1 \sqrt{M}} + B_2 M + B_3 M^2 + B_4 M^3 .$$

In the computer fitting, the model actually used was:

$$X = \frac{0.509 \sqrt{M}}{1 + B_1 \sqrt{M}} + B_2 C + B_3 C^2 + B_4 C^3 ,$$

where X had been precalculated as

$$X = -0.4342944819 \log_e y_{\pm} ;$$

thus, from the fitted value X,

$$y_{\pm} = e^{(X/-0.4342944819)} .$$

The equations obtained were:

A. For HCl solutions

$$-\log y_{\pm} = \frac{0.509 \sqrt{M}}{1 + 1.53225570 \sqrt{M}} - 0.10811097 M - 0.01097202 M^2 + 0.0004895 M^3 .$$

The standard error of the fit was 1.88×10^{-3} . The maximum deviation of a calculated (fitted) value of $y_{\pm}$ from a literature value of $y_{\pm}$ was 1.5% at 3.69 M. The various calculated values are shown in Table 3.

B. For LiCl solutions

$$-\log y_{\pm} = \frac{0.509 \sqrt{M}}{1 + 1.6 \sqrt{M}} - 0.069130896 M - 0.01723299 M^2 + 0.0007758 M^3 .$$

Table 3. HCl Activity Coefficient Data

MOLALITY	MOLALITY	$\gamma_{\pm}$ HCl	$\gamma_{\pm}$ HCl CALC. FROM FITTED EQUATION	DIFFERENCE	PERCENT DIFFERENCE	CALCULATED ACTIVITY
1.000000000-04	1.000114560-04	9.86063229D-C1	9.88547053D-01	-2.48382382D-03	-2.51892957D-01	9.88660296D-05
2.000000000-04	2.00022482D-04	9.81180378D-01	9.83955740D-01	-2.77536256D-03	-2.82859566D-01	1.96813269D-04
5.000000000-04	5.00052988D-04	9.72214245D-C1	9.75059559D-01	-2.88531374D-03	-2.96777562D-01	4.87601448D-04
1.000000000-03	1.00009525D-03	9.62653960D-01	9.65506741D-01	-2.85278178D-03	-2.96345505D-01	9.65558708D-04
2.000000000-03	2.00014761D-03	9.49215503D-01	9.52603513D-01	-3.38801012D-03	-3.56927390D-01	1.90534764D-03
5.000000000-03	5.00004737D-03	9.25746552D-01	9.29110418D-01	-3.36386588D-03	-3.63367908D-01	4.64559611D-03
1.000000000-02	9.99902279D-03	9.02213547D-01	9.05621854D-01	-3.40830690D-03	-3.77771639D-01	9.05533350D-03
2.000000000-02	1.99937595D-02	8.73184447D-01	8.77021670D-01	-3.83722292D-03	-4.39451588D-01	1.75349604D-02
5.000000000-02	4.99522891D-02	8.28736105D-01	8.33079760D-01	-4.34365478D-03	-5.24130028D-01	4.16142410D-02
1.000000000-01	9.97977819D-02	7.95654774D-01	7.99002140D-01	-3.34736608D-03	-4.20705838D-01	7.97386413D-02
1.000000000-01	9.97977819D-02	7.95255148D-01	7.99002140D-01	-3.74699178D-03	-4.71168504D-01	7.97386413D-02
2.000000000-01	1.99170136D-01	7.67618704D-01	7.71004896D-01	-3.38619205D-03	-4.41129435D-01	1.53561150D-01
2.000000000-01	1.99170136D-01	7.67919064D-01	7.71004896D-01	-3.08583257D-03	-4.01843465D-01	1.53561150D-01
3.000000000-01	2.98120542D-01	7.58517243D-C1	7.61855845D-01	-3.33860252D-03	-4.40148534D-01	2.27124878D-01
4.000000000-01	3.96652421D-01	7.59121242D-C1	7.61096856D-01	-1.97561446D-03	-2.60250188D-01	3.01890910D-01
5.000000000-01	4.94769135D-01	7.62842641D-C1	7.65250350D-01	-2.40770902D-03	-3.15623288D-01	3.78622254D-01
5.000000000-01	4.94769135D-01	7.62741882D-01	7.65250350D-01	-2.50846753D-03	-3.28875021D-01	3.78622254D-01
6.000000000-01	5.92473995D-01	7.70408038D-01	7.72741742D-01	-2.33370439D-03	-3.02917970D-01	4.57829387D-01
7.000000000-01	6.89770254D-01	7.81133365D-01	7.82735040D-01	-1.60167480D-03	-2.05044986D-01	5.39907348D-01
8.000000000-01	7.86661113D-01	7.93922988D-01	7.94740521D-01	-8.17532941D-04	-1.02973834D-01	6.25191462D-01
9.000000000-01	8.83149720D-01	8.07773521D-C1	8.08452816D-01	-6.79295417D-04	-8.40947864D-02	7.13984878D-01
1.000000000 00	9.79239172D-01	8.23709460D-01	8.23673388D-01	3.60725273D-05	4.37927801D-03	8.06573246D-01
1.000000000 00	9.79239172D-01	8.23709460D-01	8.23673388D-01	3.60725273D-05	4.37927801D-03	8.06573246D-01
1.200000000 00	1.17023275D 00	8.58820879D-C1	8.58152759D-01	6.68119855D-04	7.77950178D-02	1.00423846D 00
1.400000000 00	1.35966564D 00	8.99320160D-01	8.97562079D-01	1.75808111D-03	1.95490014D-01	1.22038432D 00
1.500000000 00	1.45380405D 00	9.21944192D-C1	9.19026904D-01	2.91728784D-03	3.16427812D-01	1.33608504D 00
1.600000000 00	1.54756088D 00	9.44239195D-01	9.41645972D-01	2.59322359D-03	2.74636301D-01	1.45725447D 00
1.800000000 00	1.73394077D 00	9.93627926D-C1	9.90343892D-01	3.28403396D-03	3.30509427D-01	1.71719766D 00
2.000000000 00	1.91882694D 00	1.04857540D 00	1.04371396D 00	4.86143593D-03	4.63622925D-01	2.00270647D 00
2.000000000 00	1.91882694D 00	1.04857540D 00	1.04371396D 00	4.86143593D-03	4.63622925D-01	2.00270647D 00
2.500000000 00	2.37464315D 00	1.20398030D 00	1.19862127D 00	5.35902826D-03	4.45109298D-01	2.84629780D 00
3.000000000 00	2.82156279D 00	1.39508843D 00	1.38726083D 00	7.82759547D-03	5.61082390D-01	3.91424353D 00
3.000000000 00	2.82156279D 00	1.37176628D 00	1.38726083D 00	-1.54945515D-02	-1.12953290D 00	3.91424353D 00
3.000000000 00	2.82156279D 00	1.39508843D 00	1.38726083D 00	7.82759547D-03	5.61082390D-01	3.91424353D 00
3.500000000 00	3.25987304D 00	1.62500028D 00	1.61463293D 00	1.03673503D-02	6.37990681D-01	5.26349835D 00
4.000000000 00	3.68984031D 00	1.90446341D 00	1.88693102D 00	1.75323910D-02	9.20594792D-01	6.96247416D 00
4.000000000 00	3.68984031D 00	1.87311867D C0	1.88693102D 00	-1.38123530D-02	-7.37398717D-01	6.96247416D 00
4.000000000 00	3.68984031D 00	1.86555270D 00	1.88693102D 00	-2.13783257D-02	-1.14595132D 00	6.96247416D 00
4.500000000 00	4.11171201D 00	2.22604686D 00	2.21147997D 00	1.45668903D-02	6.54383812D-01	9.09296876D 00
5.000000000 00	4.52571826D 00	2.59080137D C0	2.59674915D 00	-5.94778255D-03	-2.29573082D-01	1.17521550D 01
5.000000000 00	4.52571826D 00	2.62164424D C0	2.59674915D 00	2.48950909D-02	9.49598366D-01	1.17521550D 01
5.500000000 00	4.93207333D 00	3.07983353D 00	3.05239281D 00	2.74407291D-02	8.90980919D-01	1.50546252D 01
6.000000000 00	5.33097705D 00	3.59655563D 00	3.58929180D 00	7.26382162D-03	2.01966058D-01	1.91344322D 01
6.000000000 00	5.33097705D 00	3.61338818D C0	3.58929180D 00	2.40963753D-02	6.66863732D-01	1.91344322D 01
7.000000000 00	6.10716431D 00	4.98835087D C0	4.95667683D 00	3.16740390D-02	6.34960127D-01	3.02712399D 01
8.000000000 00	6.85563171D 00	6.87264306D 00	6.81109806D 00	6.15449983D-02	8.95506979D-01	4.66943799D 01
9.000000000 00	7.57756502D 00	9.38009337D C0	9.28363182D 00	9.64615452D-02	1.02836445D 00	7.03473238D 01
1.000000000 01	8.27400879D 00	1.26407785D 01	1.25204594D 01	1.20319018D-01	9.51832344D-01	1.03594392D 02
1.100000000 01	8.94588681D 00	1.67836744D 01	1.66759573D 01	1.07717048D-01	6.41796582D-01	1.49181227D 02
1.200000000 01	9.59401901D 00	2.19611125D C1	2.19024760D 01	5.86365742D-02	2.67001838D-01	2.10132771D 02
1.300000000 01	1.02191357D 01	2.82591231D 01	2.83371921D 01	-7.80689317D-02	-2.76260984D-01	2.89581612D 02
1.400000000 01	1.08218895D 01	3.58191379D 01	3.60870399D 01	-2.67901946D-01	-7.47929631D-01	3.90529959D 02
1.500000000 01	1.14028654D 01	4.47770098D C1	4.52133009D 01	-4.36291121D-01	-9.74364129D-01	5.15561185D 02
1.600000000 01	1.19625892D 01	5.53156285D C1	5.57178497D 01	-4.02221239D-01	-7.27138513D-01	6.66529748D 02

The standard error of the fit was 5.05×10^{-3} . The maximum deviation of a calculated (fitted) value of $y_{\pm}$ from a literature value of $y_{\pm}$ was 3.2% at 5.33 M. Calculated values are tabulated in Table 4. Both HCl and LiCl activity coefficients are shown in Fig. 3(a)-(c).

In fitting the LiCl data, the first parameter was fixed at 1.6. If the fitting procedure was allowed to adjust this parameter, a slightly improved overall fit was obtained as the result of a better fit in the range $M = 3$ to 10; however, the fit at low concentrations, up to 0.2 M, was much poorer. The fit with the first parameter fixed was chosen as the most useful for the majority of purposes. The equation derived by allowing all parameters to be fitted was as follows:

$$-y_{\pm} = \frac{0.509 \sqrt{M}}{1 + 1.773 \sqrt{M}} - 0.058842 M - 0.018644 M^2 + 0.000834 M^3.$$

The interpretative program ϕ RDEAL⁴ was used with FORTRAN subroutines to make the necessary calculations and to do the fitting.

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 - (b) H. S. Harned and B. B. Owen, The Physical Chemistry of Electrolytic Solutions, 3d ed., p. 751, Reinhold, New York, 1958. [Taken from Gösta Åkerlöf, J. W. Teare, and Harlow Turck, J. Am. Chem. Soc. 59, 1916 (1937) and smoothed by H. S. Harned and B. B. Owen]

Table 4. LiCl Activity Coefficient Data

MOLALITY	MOLALITY	$\gamma_{\pm}$ LiCl	$\gamma_{\pm}$ LiCl CALC. FROM FITTED EQUATION	DIFFERENCE	PERCENT DIFFERENCE	CALCULATED ACTIVITY
1.000000000-06	1.000116680-06	9.957313340-01	9.988306320-01	-3.099297820-03	-3.112584400-01	9.989471740-07
5.000000000-06	5.000582960-06	9.943357210-01	9.973926850-01	-3.056964850-03	-3.074379000-01	4.987544870-06
1.000000000-05	1.000116490-05	9.932392070-01	9.963205830-01	-3.081376670-03	-3.102351020-01	9.964366400-06
5.000000000-05	5.000578140-05	9.887538790-01	9.918462250-01	-3.092345050-03	-3.127517490-01	4.959804550-05
1.000000000-04	1.000114560-04	9.854650710-01	9.885457850-01	-3.080713400-03	-3.126151790-01	9.886590280-05
5.000000000-04	5.000529880-04	9.720148580-01	9.750919260-01	-3.077068170-03	-3.165659600-01	4.875976310-04
1.000000000-03	1.000095250-03	9.624545700-01	9.654897070-01	-3.035137000-03	-3.153537940-01	9.655816720-04
5.000000000-03	5.000047370-03	9.259459550-01	9.289927650-01	-3.046805400-03	-3.290478640-01	4.645007830-03
1.000000000-02	9.999022790-03	9.022135470-01	9.053478840-01	-3.134337820-03	-3.474053160-01	9.052594130-03
2.000000000-02	1.999375950-02	8.733340500-01	8.763863480-01	-3.052297430-03	-3.494994190-01	1.752225790-02
3.000000000-02	2.998421380-02	8.541783410-01	8.571790570-01	-3.000715390-03	-3.512984630-01	2.570184610-02
4.000000000-02	3.997038910-02	8.398236340-01	8.427350970-01	-2.911463330-03	-3.466755650-01	3.368444980-02
5.000000000-02	4.995228910-02	8.283369670-01	8.311895890-01	-2.852682700-03	-3.443867680-01	4.151982270-02
6.000000000-02	5.992991720-02	8.189513850-01	8.216158460-01	-2.664461500-03	-3.253503870-01	4.923936970-02
7.000000000-02	6.990327700-02	8.109196040-01	8.134792600-01	-2.559656080-03	-3.156485630-01	5.686486610-02
8.000000000-02	7.987237210-02	8.040826540-01	8.064404620-01	-2.357807650-03	-2.932295130-01	6.441231260-02
9.000000000-02	8.983720580-02	7.980817190-01	8.002698440-01	-2.188125310-03	-2.741730900-01	7.189400670-02
1.000000000-01	9.979778190-02	7.927574870-01	7.948041360-01	-2.046648290-03	-2.581682700-01	7.931968980-02
1.000000000-01	9.979778190-02	7.892607620-01	7.948041360-01	-5.543373190-03	-7.023500290-01	7.931968980-02
1.100000000-01	1.097541040-01	7.881004020-01	7.899229980-01	-1.822596390-03	-2.312644920-01	8.669729070-02
1.200000000-01	1.197061750-01	7.839109940-01	7.855346480-01	-1.623653650-03	-2.071221950-01	9.403334780-02
1.300000000-01	1.296539990-01	7.801395800-01	7.815679020-01	-1.428322180-03	-1.830854650-01	1.013334040-01
1.400000000-01	1.395975750-01	7.785362860-01	7.779659370-01	5.703495180-04	7.325920800-02	1.086021610-01
1.500000000-01	1.495369190-01	7.736617870-01	7.746831430-01	-1.021356700-03	-1.320159160-01	1.158437300-01
1.600000000-01	1.594720220-01	7.708758360-01	7.716817890-01	-8.059530110-04	-1.045503010-01	1.230616550-01
1.700000000-01	1.694026920-01	7.683387470-01	7.689308560-01	-5.921091490-04	-7.706355450-02	1.302551110-01
1.800000000-01	1.793295320-01	7.660206550-01	7.664040540-01	-3.833980980-04	-5.005062140-02	1.374388800-01
1.900000000-01	1.892519460-01	7.639116930-01	7.640791340-01	-1.674411290-04	-2.191891170-02	1.446034630-01
2.000000000-01	1.991701360-01	7.579070810-01	7.619371070-01	-4.030025750-03	-5.317308480-01	1.517551170-01
2.100000000-01	2.090841080-01	7.602315660-01	7.599614760-01	2.700895010-04	3.552726740-02	1.588958670-01
2.200000000-01	2.189938630-01	7.586305840-01	7.581382120-01	4.923714480-04	6.490266260-02	1.660276160-01
2.400000000-01	2.388007400-01	7.558371500-01	7.548999550-01	9.371956520-04	1.239943880-01	1.802706680-01
2.600000000-01	2.585907930-01	7.535221780-01	7.521397040-01	1.382473740-03	1.834682220-01	1.944964030-01
2.800000000-01	2.783640520-01	7.516261060-01	7.497920930-01	1.834013090-03	2.440060400-01	2.087151650-01
3.000000000-01	2.981205420-01	7.464772870-01	7.478047440-01	-1.327457560-03	-1.778295980-01	2.229359560-01
3.200000000-01	3.178602920-01	7.488719920-01	7.461352280-01	2.736763190-03	3.654514020-01	2.371667610-01
3.400000000-01	3.375833270-01	7.479144190-01	7.447484530-01	3.165965310-03	4.233058260-01	2.514146610-01
3.600000000-01	3.572896760-01	7.472269340-01	7.436152220-01	3.611711350-03	4.833486570-01	2.656860420-01
3.800000000-01	3.769793650-01	7.467596310-01	7.427109110-01	4.048719760-03	5.421717510-01	2.799866870-01
4.000000000-01	3.966524210-01	7.440393630-01	7.420145850-01	2.024778270-03	2.721332200-01	2.943218810-01
4.200000000-01	4.163088700-01	7.444263430-01	7.415082970-01	4.918046120-03	6.588789590-01	3.086964810-01
4.400000000-01	4.359487400-01	7.465206180-01	7.411764740-01	5.344144010-03	7.158735980-01	3.231149500-01
4.600000000-01	4.555720560-01	7.467757110-01	7.410059290-01	5.769781380-03	7.726257420-01	3.375815930-01
4.800000000-01	4.751788460-01	7.471716830-01	7.409848000-01	6.186882500-03	8.280402810-01	3.521003620-01
5.000000000-01	4.947691350-01	7.446053510-01	7.411028550-01	3.502496440-03	4.703829270-01	3.666748190-01
5.200000000-01	5.143429510-01	7.483668200-01	7.413509790-01	7.015841040-03	9.374869190-01	3.813086500-01
5.400000000-01	5.339003190-01	7.461461570-01	7.417212360-01	7.424921790-03	9.911179170-01	3.960052640-01
5.600000000-01	5.534412650-01	7.500367890-01	7.422061770-01	7.830612170-03	1.044030410 00	4.107675250-01
5.800000000-01	5.729658150-01	7.510186700-01	7.427996280-01	8.219041840-03	1.094385820 00	4.255987940-01
6.000000000-01	5.924739950-01	7.502138560-01	7.434957550-01	6.718101310-03	8.954914990-01	4.405019000-01
6.200000000-01	6.119658320-01	7.532869430-01	7.442894700-01	8.997472050-03	1.194428250 00	4.554797250-01
6.400000000-01	6.314413510-01	7.545634840-01	7.451761160-01	9.387367140-03	1.244079180 00	4.705350130-01
6.600000000-01	6.606240880-01	7.566161880-01	7.466710290-01	9.945159180-03	1.314425910 00	4.932688680-01
7.000000000-01	6.897702540-01	7.568494260-01	7.483528290-01	8.496597550-03	1.122627200 00	5.161915210-01
7.200000000-01	7.091807570-01	7.604260840-01	7.495724290-01	1.085365480-02	1.427312270 00	5.315823430-01

Table 4 (continued)

MOLALITY	MOLALITY	$y_{\pm}$ LiCl	$y_{\pm}$ LiCl CALC. FROM FITTED EQUATION	DIFFERENCE	PERCENT DIFFERENCE	CALCULATED ACTIVITY
7.500000000-01	7.382661610-01	7.629295810-01	7.515423070-01	1.138727390-02	1.492572080 00	5.548382540-01
8.000000000-01	7.866611130-01	7.655323830-01	7.551786000-01	1.035378220-02	1.352494350 00	5.940696380-01
9.000000000-01	8.831497200-01	7.762754340-01	7.636610120-01	1.261442190-02	1.624993060 00	6.744270090-01
1.000000000 00	9.792391720-01	7.880730800-01	7.735949710-01	1.447810920-02	1.837153120 00	7.575344990-01
1.200000000 00	1.170232750 00	8.138350230-01	7.973045190-01	1.653050420-02	2.031186140 00	9.330318600-01
1.400000000 00	1.359665640 00	8.449092370-01	8.256395990-01	1.929663780-02	2.280675480 00	1.122593790 00
1.600000000 00	1.547560880 00	8.792969800-01	8.582967230-01	2.100025680-02	2.388300800 00	1.328266430 00
1.800000000 00	1.733540770 00	9.160007440-01	8.951700450-01	2.083069930-02	2.274091960 00	1.552171840 00
2.000000000 00	1.918826940 00	9.571238280-01	9.362743570-01	2.084947080-02	2.178346230 00	1.796548460 00
2.500000000 00	2.374643150 00	1.076969300 00	1.058325160 00	1.864413950-02	1.731167220 00	2.513144600 00
3.000000000 00	2.821562790 00	1.225472810 00	1.210513770 00	1.495903780-02	1.220674800 00	3.415540610 00
3.500000000 00	3.259873040 00	1.385211040 00	1.397313580 00	-1.210254460-02	-8.736968060-01	4.555064890 00
4.000000000 00	3.689840310 00	1.602905360 00	1.624450660 00	-2.154529890-02	-1.344140430 00	5.993963530 00
4.500000000 00	4.111712010 00	1.865951040 00	1.898842620 00	-3.289157690-02	-1.762724530 00	7.807494020 00
5.000000000 00	4.525718260 00	2.179930230 00	2.228615890 00	-4.868565190-02	-2.233358260 00	1.008608760 01
5.500000000 00	4.932073330 00	2.579499570 00	2.623146640 00	-4.364707660-02	-1.692075360 00	1.293755160 01
6.000000000 00	5.330977050 00	2.996194550 00	3.093097840 00	-9.690329360-02	-3.234212330 00	1.648923360 01
6.500000000 00	5.722615930 00	3.544683020 00	3.650437000 00	-1.057539800-01	-2.983453800 00	2.089004890 01
7.000000000 00	6.107164310 00	4.216956410 00	4.308417950 00	-9.146154240-02	-2.168899410 00	2.631221630 01
7.500000000 00	6.484785310 00	4.958478410 00	5.081518490 00	-1.230400860-01	-2.481408120 00	3.295255650 01
8.000000000 00	6.855631710 00	5.875545530 00	5.985320130 00	-1.097746030-01	-1.868330400 00	4.103315050 01
8.500000000 00	7.219846790 00	6.972550990 00	7.036321510 00	-6.377051460-02	-9.145937360-01	5.080116330 01
9.000000000 00	7.577565020 00	8.218387570 00	8.251676280 00	-3.328870730-02	-4.050515620-01	6.252761350 01
9.500000000 00	7.928912740 00	9.652407260 00	9.648854670 00	3.552589640-03	3.680521910-02	7.650492680 01
1.000000000 01	8.274008790 00	1.127909310 01	1.124522220 01	3.387083200-02	3.002974780-01	9.304306780 01
1.050000000 01	8.612965020 01	1.316374260 01	1.305754220 01	1.062004200-01	8.067646360-01	1.124641540 02
1.100000000 01	8.945886810 01	1.527571820 01	1.510140680 01	1.743114200-01	1.141101300 00	1.350954760 02
1.150000000 01	9.272873540 01	1.762027480 01	1.739062130 01	2.296535030-01	1.303348020 00	1.612610320 02
1.200000000 01	9.594019010 00	2.024013950 01	1.993653820 01	3.036013250-01	1.459996210 00	1.912715260 02
1.250000000 01	9.909411820 00	2.307876230 01	2.274739600 01	3.313663170-01	1.435806270 00	2.254133150 02
1.300000000 01	1.021513570 01	2.612827360 01	2.582765790 01	3.006157800-01	1.150538240 00	2.639363410 02
1.350000000 01	1.052326990 01	2.954672480 01	2.917741180 01	3.693129670-01	1.249928610 00	3.070417810 02
1.400000000 01	1.082188950 01	3.327813320 01	3.279184640 01	4.862867520-01	1.461280140 00	3.548697390 02
1.450000000 01	1.111506560 01	3.719943270 01	3.666083460 01	5.385980860-01	1.447866400 00	4.074875800 02
1.500000000 01	1.140286540 01	4.131446420 01	4.076866720 01	5.457969520-01	1.321079590 00	4.648796250 02
1.550000000 01	1.168535310 01	4.545488930 01	4.509394930 01	4.009399590-01	8.812857120-01	5.269387180 02
1.600000000 01	1.196258920 01	5.000810190 01	4.960967010 01	3.984317750-01	7.967344490-01	5.934601050 02
1.650000000 01	1.223463160 01	5.418915830 01	5.428349760 01	-9.433929960-02	-1.740925720-01	6.641385930 02
1.700000000 01	1.250153500 01	5.857113480 01	5.907821370 01	-5.070788650-01	-8.657487460-01	7.385683540 02
1.750000000 01	1.276335160 01	6.329486530 01	6.395240310 01	-6.575178770-01	-1.038816760 00	8.162470060 02
1.800000000 01	1.302013110 01	6.795452430 01	6.886122570 01	-9.067013930-01	-1.334276710 00	8.965821880 02
1.850000000 01	1.327192090 01	7.282551130 01	7.375739310 01	-9.318817700-01	-1.279608960 00	9.789022830 02
1.900000000 01	1.351676590 01	7.791223370 01	7.859222410 01	-6.799904200-01	-8.727646320-01	1.062469880 03
1.950000000 01	1.376070920 01	8.293659580 01	8.331673510 01	-3.801393280-01	-4.583493260-01	1.146497360 03
2.000000000 01	1.399779180 01	8.789616750 01	8.788280090 01	1.336656420-02	1.520722070-02	1.230165150 03

Fig. 3(a). LiCl and HCl Activity Coefficient Data (Full Concentration Range).

Fig. 3(b). LiCl and HCl Activity Coefficient Data (0.0 to 0.5 M).

Fig. 3(c). LiCl and HCl Activity Coefficient Data (0.5 to 8.0 M).

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