Asian Journal of Chemistry Vol. 3, No. 4 (1991), 373–378

Partial Molar Volumes of KX-glucose Solutions

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The mean apparent molar volumes of Glucose-KX (X = Cl, Br, I) solutions have been calculated by density measurements. The modified Young's Rule for non-electrolyte-electrolyte system has been verified. Young's Rule has been found to hold good for these solutions.

INTRODUCTION

Partial molar volume, one of the important thermodynamic properties, has always been utilised for elucidating ion-ion. solute-solvent and solvent-solvent interactions occurring in solutions. Since multicomponent solutions are widely found in sea water, industries and biofluids, the study of their properties is a matter of interest both for practical and theoretical purposes. With this view the present work has been carried out on a multicomponent system. KX-Glucose (X = Cl, Br, I) to investigate the dependence of partial molar volume of one electrolyte on the concentration of other constituents. Attempt has also been made to examine the applicability of Young's Rule to these solutions.

EXPERIMENTAL

The compounds KCl, KBr, KI and glucose used were of AnalaR grade. Water used for the preparation of solutions was obtained by distillating the distilled water over potassium permanganate and sodium hydroxide in an all glass apparatus till the water had a specific conductance of the order of 10^{-6} ohm^{-1} $cm.^{-1}$ The densities required for the estimation of partial molar volumes were determined with the help of a double capillary pyknometer.

RESULTS AND DISCUSSION

The mean apparent molar volume ϕ_v of glucose-KX (X = Cl, Br, I) solutions have been estimated by measuring their densities. For a ternary system ϕ_v has been given by the equation:

$$\phi_v = \sum_{i=1}^{2} Y_i \phi_v(i) + \frac{\Delta V}{m_T} \quad (1)$$

Here $\phi_v(i)$ represents the apparent molar volume for the electrolyte

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component i in water at the same ionic strength as the total mixture. Y_i is a molar weighing factor given by $Yi = \frac{m_i}{m_T}$ where m_i is the molality of component i and $m_T = \Sigma m_i$ is the total molality. Further ΔV is the increase in volume on mixing and is called the excess apparent molar volume of mixing. The densities have been measured for glucose-KX solutions at 35°C for various molarities of glucose in 0.1, 0.125 and 0.25 M KX solutions. The mean apparent molar volume of the solution is calculated by the relation:

$$\phi_v = \frac{1000\,(d^\circ - d)}{d^\circ \cdot d \cdot m_T} + \frac{M_T}{d} \tag{2}$$

where d is the density of the solution, d° is the density of the conductivity water used and m_T is the total molality ($m_T = \Sigma m_i$). M_T, the mean molecular weight is given by:

$$M_T = \Sigma Y_i M_i \tag{3}$$

where M_i is the molecular weight of component i and Y_i is the molar weighing factor as described before. The ϕ_v of glucose-KX calculated from equation (2) are given as a function of glucose concentration Tables 1–3.

TABLE 1

DATA OF GLUCOSE-KCl SOLUTION AT 35°C

M_{KCl}	$M_{glucose}$	d(c.g.s. unit)	ϕ_v(Obs)	ϕ_v(Cal)	$\Delta\phi_v$ (excess)
0.1	0.3333	1.0201	95.536	92.858	+ 2.678
	0.2222	1.0150	83.612	84.416	− 0.804
	0.1777	1.0134	75.012	76.382	− 1.370
0.125	0.2222	1.0158	80.5463	82.426	− 1.879
	0.1776	1.0131	75.3570	76.642	− 1.285
	0.1111	1.0102	58.8408	59.637	− 0.796
	0.0888	1.0091	51.5679	52.793	− 1.225
0.25	0.2222	1.0226	63.500	64.605	− 1.105
	0.1777	1.0200	58.312	56.416	+ 1.896
	0.1333	1.0164	55.014	56.812	− 1.798
	0.8888	1.0131	47.718	44.384	+ 3.334

The ϕ_v of glucose-KX solutions are plotted versus m_T. In Fig. 1 the plots for glucose-KCl are given. The three curves represent various concentrations of glucose in the three solutions of 0.1, 0.125

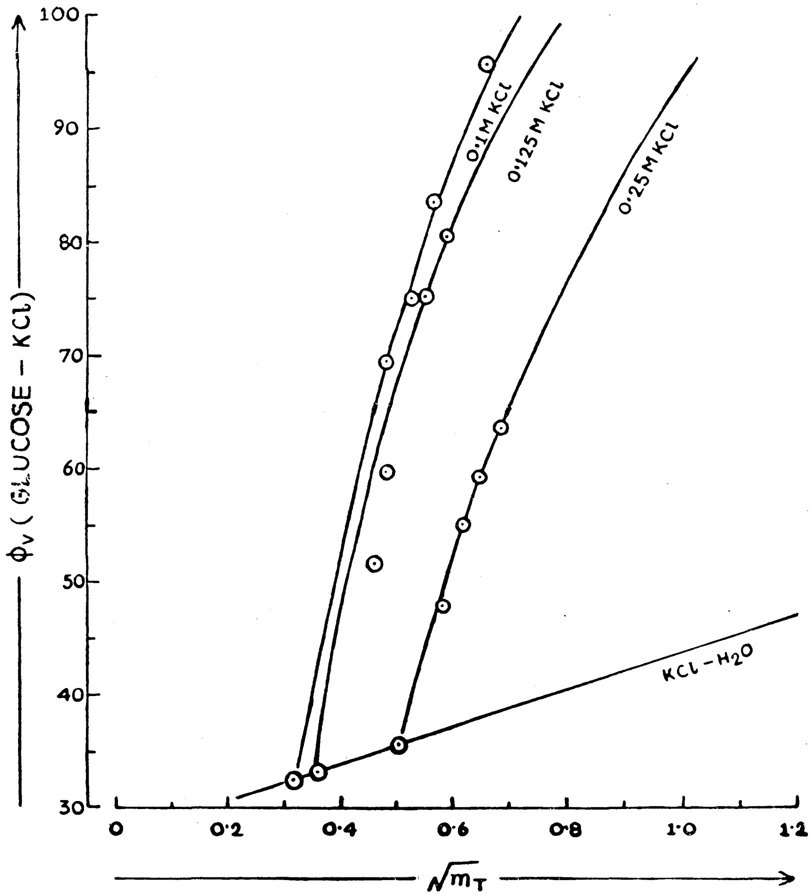

Fig. 1 The mean apparent molal volume of glucose-KCl solutions versus $\sqrt{m_T}$ at 35°C

TABLE 2

DATA GLUCOSE-KBr SOLUTION AT 35°C

M_{KBr}	$M_{glucose}$	d(c.g.s.unit)	ϕ_v(Obs)	ϕ_v(Cal)	$\Delta\phi_v$ (excess)
0.1	0.1851	1.0160	81.4827	80.364	+ 1.118
	0.14808	1.0123	80.2166	80.468	– 0.2514
	0.11106	1.0105	76.0100	74.186	+ 1.824
	0.07404	1.0078	67.5770	67.682	– 0.105
0.125	0.1851	1.0177	80.2120	80.984	– 0.772
	0.14808	1.0149	75.3511	73.764	+ 1.587
	0.11106	1.0121	73.9010	75.126	– 1.225
	0.07404	1.0087	68.2065	70.134	– 1.927
0.25	0.5555	1.0560	78.9527	79.646	– 0.6933
	0.4444	1.0472	77.0111	79.989	– 2.978
	0.3333	1.0398	71.6286	71.846	– 0.2174
	0.2222	1.0323	66.5720	69.128	– 2.566

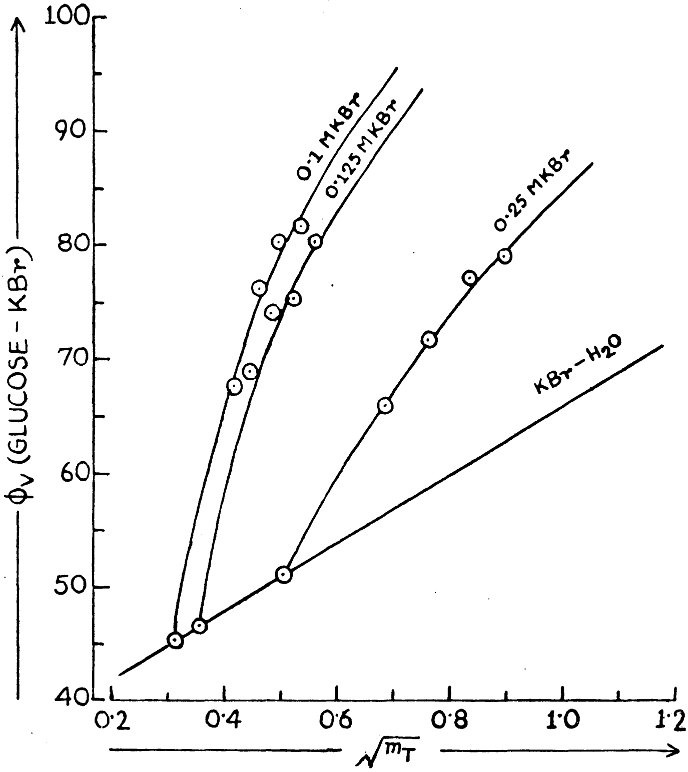

Fig. 2 The mean apparent molal volume of glucose-KBr solutions versus $\sqrt{m_T}$ at 35°C

TABLE 3

DATA OF GLUCOSE-KI SOLUTION AT 35°C

M_{KI}	$M_{glucose}$	d(c.g.s. unit)	ϕ_v(Obs)	ϕ_v(Cal)	$\Delta\phi_v$(excess)
0.10	0.1852	1.0196	87.3680	87.4000	– 0.032
	0.14818	0.0167	85.0180	85.7120	– 0.694
	0.11106	0.0144	79.8315	79.9542	– 0.1227
	0.07404	1.0102	82.8031	82.9031	– 0.0998
0.125	0.1851	1.0212	87.3868	87.886	– 0.5
	0.14808	1.0197	83.6589	83.742	– 0.0831
	0.09259	1.0156	75.7211	76.843	– 1.1218
	0.07404	1.0148	74.2229	74.543	– 0.3201
0.25	0.1851	1.0360	73.7880	74.125	– 0.337
	0.14808	1.0340	70.3456	71.452	– 1.106
	0.11106	1.0312	67.5090	68.982	– 1.473
	0.07404	1.0285	63.4868	63.954	– 0.4672

and 0.25 M KCl. The bottom points of each curve represent the glucose-KCl solution extrapolated to $m_{glucose} = 0$ and were determined from the densities of the solutions before the addition of glucose. Hence the line drawn through the bottom point of each curve represents the concentration dependence of the ϕ_v of KCl in water. The plots of other systems are shown in Fig. 2 & 3.

ϕ_v can also be calculated from the modified Young's Rule for non-

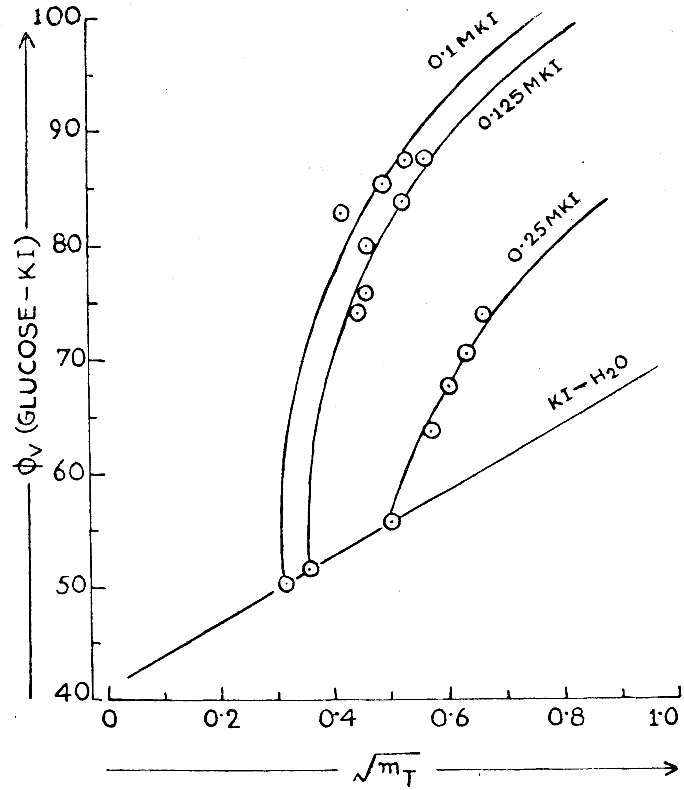

Fig. 3 The mean apparent molal volume of glucose-KI solutions versus $\sqrt{m_T}$ at 35°C

electrolyte-electrolyte system. The modified Young's Rule for the systems reported here can be stated as

$$\phi_v(\text{Cal}) = Y_{KX} \cdot \phi_v(\text{KX}) \times Y_{(\text{glucose})}\, \phi_{v(\text{glucose})} \tag{4}$$

where ϕ_v(Cal) is the mean apparent molar volume calculated from pure water molar volume data, $Y_{KX} = m_{KX}/m_T$, $Y_{\text{glucose}} = \frac{m_{\text{glucose}}}{m_T}$, is the apparent molar volume of KX in pure water at ionic strength of the solution ($I_m = m_{KX}$) and $\phi_{v(\text{glucose})}$ is the apparent molar volume of glucose in the conductivity water at m_T. The ϕ_v(Cal) of glucose-KX solution determined from equation (4) is contained in Table 1–3. These values were compared to the density measured ϕ_v(Obs) calculated from equation (2) and the difference between the ϕ_v(Obs) and ϕ_v(Cal) are related as under:

$$\phi_v(\text{Obs}) - \phi_v(\text{Cal}) = \Delta\phi_v(\text{excess}) \quad (5)$$

where

$$\Delta\phi_v(\text{excess}) = \frac{\Delta v_m}{m_T} \quad (2)$$

ϕ_v(excess) is the deviation from the Young's rule approximation.

Observation of Table 1–3 clearly indicates that Young's rule hold good for these solutions.

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[*Received*: 18 November 1989; *Accepted*: 5 July 1990] AJC–201