CHAPTER X

Thermodynamic and Transport Properties of Some Monobasic Acetate Salts in Aqueous Binary Mixtures of Methanol at Different Temperatures*

10.1. *Introduction*

Studies on the thermodynamic transport properties and ultrasonic speeds of different electrolytes in different solvents are of great importance to obtain information on the behavior of ions in solutions. Among the various type of interactions occurring between solute molecules in solution, these solute- solute and solute- solvent interactions are of current interest in all branches of chemistry.[1-7] These interactions help in better understanding of the nature of solutes and solvents, i.e., whether the solute modifies or distorts the structure of the solvent. The inferences regarding these interactions are derived from density, viscosity and ultrasonic speed data measured experimentally. The literature is full of such data in pure solvents but investigations on mixed solvent systems are scanty. Partial molar volume, viscosity coefficients and adiabatic compressibilities reflects the cumulative effects[25,26] of solute-solvent and solute-solute interactions, it would be of interest to study these factors of acetate salts in binary aqueous mixtures of methanol. Such data are expected to highlight the role of acetate salts in influencing the partial molar volume, viscosity coefficients and adiabatic compressibilities in mixed solvent systems. These considerations prompted us to undertake the present study.

10.2. *Experimental Section*

10.2.1. *Materials*

Ammonium and sodium acetate (Riedel A.R.) were used as received. Lithium and potassium acetates were prepared and purified by the reported procedures.[8] The salts were dried and stored in vacuum desiccators.

Methanol (E. Merck, India, Uvasol grade 99.5% pure) was dried over 3 Å molecular sieves and distilled fractionally. The middle fraction was collected and

* *Published in Journal of Teaching and Research in Chemistry*

redistilled. The purified solvent had a density of 0.9799 g. cm^{-3} and a viscosity of 1.5809 m Pa. s at 298.15 K. These values agree well with the literature values.[27,24] The details have been reported earlier in chapter III.

10.2.2. *Apparatus and Procedure*

The densities (ρ) were measured with an Ostwald Sprengel type pycnometer having a bulb volume of 25 cm^3 and an internal diameter of the capillary of about 0.1 cm. The pycnometer was calibrated at (298, 308 and 318) K with doubly distilled water and benzene. An average of triplicate measurements was taken into account. The density values are reproducible to $\pm 3\times10^{-4}$ g. cm^{-3}. Details have been discussed earlier.[9]

The viscosities were measured by means of suspended level Ubbelohde type viscometer[00] at the derived temperature (accuracy ± 0.01K). The precision of the viscosity measurement was 0.05%. Details have been described earlier.[9]

Sound velocities were determined with an accuracy of 0.3% using a single crystal variable-path ultrasonic interferometer (Mittal Enterprises, New Delhi, India) working at 4 MHz, which was calibrated, with water, methanol and benzene at the required temperature.

The details of these experimental measurements have been included earlier in chapter III.

10.3. *Results and Discussion*

The apparent molar volumes V_ϕ were determined from the solution densities using the following equation,

$$V_\varphi = \frac{M}{\rho_0} - \frac{1000(\rho - \rho_0)}{c\rho_0} \qquad (1)$$

where M is the molar mass of the solute, c is the molarity of the solution and the other symbols have their usual significance.

The limiting apparent molar volumes V_ϕ^0 were calculated using the least-squares treatment of the plot of V_ϕ vs. $c^{\frac{1}{2}}$ using the Masson equation [10,11],

$$V_{\varphi} = V_{\varphi}^{0} + S_{v}^{*} c^{1/2} \quad (2)$$

where V_{ϕ}^{0} is the partial molar volume at infinite dilution and S_{v}^{*} the experimental slope. The variation of V_{ϕ} with temperature of the salts in the solvents follows the polynomial equation,

$$V_{\varphi}^{0} = a_0 + a_1 T + a_2 T^2 \quad (3)$$

Over the temperature range under the investigation. The apparent molar expansibilities are calculated from equation,

$$\varphi_{E}^{0} = \left(\frac{\delta V_{\varphi}^{0}}{\delta T}\right)_{p} \quad (4)$$

The sign of $\left(\frac{\delta V_{\varphi}^{0}}{\delta T}\right)_{p}$ was also determined to ascertain whether the chosen acetate salts are structure breaker or maker in methanol water mixtures.

The sign of $\left(\delta^2 V_{\phi}^{0} / \delta T^2\right)_{P}$ was also determined to ascertain whether the chosen acetate salts are structure breaker or maker in methanol water mixtures.

Here, the general thermodynamic expression,

$$\left(\delta c_P / \delta P\right) = \left(\delta^2 V_{\phi}^{0} / \delta T^2\right)_{P} \quad (5)$$

is used for this explanation.

The plots of V_{ϕ} against √c are all linear and the slopes and intercepts of these lines are taken as V_{ϕ}^{0} and S_{v}^{*} respectively and their values are recorded in table-(2).

The V_{ϕ}^{0} values are interpreted in terms of solute-solvent interactions (as ionic interactions vanish at infinite dilution).

Table-2 shows that the values of V_{ϕ}^{0} are positive and large and decreases with increase of temperature as well as with increase of mass% of methanol in the solvent mixture. This indicates the presence of strong solute-solvent interaction. These interactions are weakened with rise in temperature, suggesting more electrostrictive solvation at higher temperature. Similar results are reported for some 1:1 electrolytes in aqueous DMF.[18,19]

The values of experimental slope, (S_v^*) shown in Table-2 are negative for all investigated salts and increase with rise in temperature. This indicates the presence of weak solute-solute interactions and these interactions, however, increase with the increase of temperature which may be attributed to the solvation of solutes, *i.e.*, more and more solute is accommodated in the void space left in the packing of large associated solvent molecules with the increase of temperature.

The variation of V_ϕ^0 with temperature of the salts in the solvents follows according to equation (3) over the temperature range under the investigation. The coefficients (a_is) are presented in Table 3.

The limiting apparent molar expansibilities (ϕ_E^0) calculated from equation (4) are recorded in table-(4). The ϕ_E^0 values for lithium acetate and sodium acetate in methanol solutions increase with increase of temperature, whereas for ammonium acetate and potassium acetate the values decrease with increase of temperature. The increase in magnitude of ϕ_E^0 values with temperature may be ascribed to 'caging or packing effect'.[19] It also indicates that the behavior of these two salts in methanol are similar to that of some symmetrical Tetra alkyl ammonium salts.[12] On the other hand, the decrease in ϕ_E^0 values with increase of temperature, for ammonium acetate and potassium acetate indicates that they behave just like common salts, because in case of common salts, the molar expansibility decrease with increase of temperature.[12,15]

During the past few years it has been emphasized by some workers that S_v^* is not the sole criterion for determining the structure making / breaking nature of any electrolyte. Hepler[13] developed a technique of examining the sign of $\left(\delta^2 V_\phi^0 / \delta T^2\right)_P$ for various electrolytes in terms of long range structure making and structure breaking capacity of the electrolytes in methanol water mixtures. The structure making solutes should have positive value, whereas structure breaking ones have negative value $\left(\delta^2 V_\phi^0 / \delta T^2\right)_P$. These values of the selected acetates are recorded in table (4). It is seen from table (4) that, the $\left(\delta^2 V_\phi^0 / \delta T^2\right)_P$ values for lithium acetate and sodium

acetate are positive, indicating that they are structure makers in methanol water mixture whereas for ammonium acetate and potassium acetate the values are negative, indicating that they are structure breakers in this mixed solvent system.

The viscosity data of solutions for various electrolytes studied here have been analyzed using Jones-Dole equation.[16]

$$\left.\begin{aligned} \frac{\eta}{\eta_0} &= 1 + Ac^{1/2} + Bc \\ (\frac{\eta}{\eta_0} - 1)/c^{1/2} &= A + Bc^{1/2} \end{aligned}\right] \qquad (6)$$

$$\text{Where } \eta = (Kt - \frac{L}{t})\rho$$

where η and η_0 are the viscosities of solution and solvent mixture respectively. A and B are constants for the above equation, ρ is the density of the solution and K and L are constants for a particular viscometer. The values of A and B are estimated by least squares method.

The viscosity data for various solutions of electrolytes were analyzed according to Jones-Dole equation[16]. The values of A and B are recorded in Table (2).

Table (2) shows that the values of A are very small for all salts studied in methanol water mixtures at various temperatures thereby showing the presence of weak solute-solute interactions. In other words these results indicate that all the salts mix ideally with methanol + water mixtures and there is a perfect solvation of these molecules resulting in either the absence or weak solute-solute interactions.

Table (2) shows that two types of trends are observed in the change of B-coefficients with temperature. B values for lithium acetate and sodium acetate in methanol solutions decreases with increase of temperature, thereby showing that solute- solvent interactions are weakened with rise of temperature, whereas for ammonium and potassium acetate, value of B coefficient increases with the increase in temperature indicating improved solute-solvent interactions for the solutions with the increase in temperature which may be attributed to solvation of ions by the solvent system studied here.

It has been reported by a number of workers that dB/dT is a better criterion[10,20,21] for determining the structure making/braking capacity of any electrolyte rather than simply the B-coefficient values. It is evident from Table (2) that for lithium acetate and sodium acetate the B values decrease with increase of temperature (negative dB/dT) indicating that they are structure makers in methanol water mixture. On the other hand, for ammonium acetate and potassium acetate the B values increase with increase of temperature (positive dB/dT) indicating that they are structure breakers in methanol water mixture. These conclusions are in excellent agreement with that drawn from $\left(\delta^2 V_\phi^0/\delta T^2\right)_P$ values explained earlier.

Adiabatic compressibility coefficients β, were derived from the following relation

$$\beta = \frac{1}{u^2 \rho} \tag{7}$$

Where ρ is the density of solution and u is the ultrasonic speed in the solution.

The apparent molar adiabatic compressibilities (ϕ_K) of the solutions was calculated from the following equation

$$\phi_k = \beta \times \frac{M}{\rho_0} + \frac{1000(\beta\rho_0 - \beta_0\rho)}{m\rho\rho_0} \tag{8}$$

where, m is the molality of the solution, β_0 is the adiabatic compressibility of the solvent mixture and the other terms are described earlier.

The limiting apparent molar adiabatic compressibilities ϕ_K^0 and experimental slopes (S_K^*) were obtained[4,17] by extrapolating the plots of ϕ_K versus the square root of molar concentration ($\sqrt{m}$) of the electrolyte by the computerized least squares method using the following equation.

$$\varphi_K = \varphi_K^0 + S_K^* m^{1/2} \tag{9}$$

The values of ultrasonic speed (u), adiabatic compressibility (β), molality (m), limiting apparent molal adiabatic compressibility (ϕ_K^0), density (ρ), apparent molal adiabatic compressibility (ϕ_K) and experimental slope (S_K^*) are given in Table-5.

A perusal of Table-5 shows that the ϕ_K^0 values decrease whereas S_K^* value increase with the increase of mass % of Methanol in the mixtures at a particular temperature (298.15 K) for all the salts studied here. Since the values of ϕ_K^0 and S_K^* are measure of solute- solute and solute- solvent interactions respectively, the results are in good agreement with that drawn from the conclusion based on the values of V_ϕ^0 and S_v^* mentioned earlier. Negative values of ϕ_K^0 of the salts are interpreted in terms of the loss of compressibility of solvent-mixture due to the electrostrictive forces in the vicinity of the ions and hence the extent of compressibility electrostriction decreases with the increase of the amount of Methanol in the mixture for all the salts under investigation. Same results were observed for some electrolytes in aqueous ethanol, and in 2-Methoxyethanol[23] in case of the studies on sound velocities of some alkali metal halides in the THF + H_2O mixtures.[22]

9.4. *Conclusion:*

In the above chapter, inferences regarding solute- solute and solute- solvent interactions are derived from density, viscosity and ultrasonic speed data measurements. It is seen that, strong solute-solvent interaction are present here. These interactions are weakened with rise in temperature, suggesting more electrostrictive solvation at higher temperature. For lithium acetate and sodium acetate in methanol solutions 'caging or packing effect' seems to be present whereas, ammonium acetate and potassium acetate behaves just like common salts in methanol solutions. Lithium acetate and sodium acetate are structure makers in methanol water mixture whereas ammonium acetate and potassium acetate are structure breakers in this mixed solvent system. However, there is scope of improvement of the study by considering more parameters in details.

References

1. M.N. Roy, A Jha., *J. Chem. Eng. Data.* **2001**, *46*, 1247.
2. M.N Roy. and D.K. Hazra *N.B. Univ. Rev.* (Sci and technol), **1997**, *8*, 45.
3. G.G. Janz Non aqueous electrolytes hand book, Academic Press, New York, **1973**, Vol. 2.
4. M Iqbal. and R.E Verral., *Can. J. Chem.* **1989**, *76*, 727.
5. B Das. and D.K., Hazra *J. Chem. Eng. Data.* **1991**, 36, 405.
6. O Popovych. and R.P.T. Tomkins, 'Non-Aqueous Solution Chemistry', Wiley Interscience, New York. **1981**
7. M.N., Roy, A Jha and S Roy Chowdhury., *J. Indian Chem. Soc*, **2002**, *79*, 623.
8. P Franzosini. and F.W. Falgar *J. Chem. Thermodyn.* **1984**, *16*, 81.
9. P.S Nikam., A.B Sawant., J.S. Ather and R.S Khairmar. *J. Indian Chem. Soc.* **2000**, *77*, 197.
10. D.O. Mason, *Phil. Mag.* **1929**, *8*, 218.
11. D. Nandi , M.N Roy. and D.K. Hazra, *J. Indian Chem. Soc.* **1993**, *70*, 305.
12. F.J Millero. and H.W. Drost *J. Phys. Chem.* **1968**, 72, 1758.
13. D.S Hepler L.G. *Can. J. Chem.* **1969, 1968**, *47*, 4613.
14. Gill. and T.S. Cheema *Z. Phys. Chem.* (Neue Iolge), **1984**, *140*, 139.
15. B.N Prasad. and M.C.S Subba. *J. Indian Chem. Soc.* **2000**, *77*, 8.
16. G. Jones, and M. Dole, *J. Am. Chem. Soc.* **1929**, *51*, 2950.
17. S Bhowmik., A.K Das. and R.K Mohanty,. *Indian J. Chem. Sect.* **1985**, *24(A)*, 1018.
18. C Calvente., J.J Maestre., E. Yanes and Panedo Carcia. *J. Chem. Soc. Faraday Trans.* **1994**, *94*, 573.
19. F.J. Millero, 'In structure and transport processes in water and aqueous solutions', R.A. Horne, New York. **1972**
20. R Gopal. and M.A. Siddiqui, *J. Phys. Chem.* **1969**, *72*, 1814.
21. N Saha. and B Das. *J. Chem. Eng. Data.* **1997**, *42*, 277.
22. M.N Roy. and D.K Hazra. *N.B. Univ. Rev.* (Sci and technol), **1997**, *8*, 45.
23. B Das. and D.K Hazra *Bull. Chem. Soc. Jpn.* **1992**, *65*, 3740.
24. H.Doe., H. Ohe Matoba and A. Ichimura *Bull. Chem. Soc. Jpn.* **1990**, *63*, 2785.
25. E.J Kind. *J. Phys. Chem.* **1969**, *78*, 1221.
26. M.L., Parmar R.K. Awasthi and M.K Guleria. *J. Chem. Sci.* **2004**, *116*, 33.

Table 1

Concentration (c), Density (ρ), Viscosity (η), Apparent Molar Volume (V_ϕ) and $(\frac{\eta}{\eta_o}-1)/c^{1/2}$ of some acetate salts in various mass % of Methanol at different temperature

10% Methanol + H_2O mixture									
c / mol. dm^{-3}	$\rho \times 10^3$ / kg.m^{-3}	$\eta \times 10^3$ / Pa. s	$V_\phi \times 10^6$ / $m^3.mol^{-1}$	$(\frac{\eta}{\eta_o}-1)/c^{1/2}$	c / mol. dm^{-3}	$\rho \times 10^3$ / kg.m^{-3}	$\eta \times 10^3$ / Pa. s	$V_\phi \times 10^6$ / $m^3.mol^{-1}$	$(\frac{\eta}{\eta_o}-1)/c^{1/2}$
298.15K									
CH_3COONH_4					CH_3COONa				
0.0061	0.9799	1.1690	78.87	0.1208	0.0060	0.9799	1.1761	143.15	0.2001
0.0428	0.9800	1.1847	76.64	0.1112	0.0423	0.9799	1.2105	137.90	0.2203
0.0794	0.9801	1.1913	75.34	0.1017	0.0789	0.9803	1.2323	135.21	0.2280
0.1161	0.9803	1.1970	74.32	0.0985	0.1148	0.9806	1.2489	133.12	0.2311
0.1528	0.9805	1.2004	73.46	0.0935	0.1511	0.9801	1.2648	132.03	0.2372
0.1894	0.9808	1.2020	72.70	0.0872	0.1873	0.9815	1.2794	130.34	0.2424
CH_3COOLi					CH_3COOK				
0.0060	0.9799	1.1769	105.80	0.2101	0.0061	0.9799	1.1835	101.20	0.2611
0.0421	0.9801	1.2202	102.74	0.2615	0.0425	0.9800	1.2163	97.52	0.2020
0.0781	0.9802	1.2500	100.83	0.2840	0.0790	0.9803	1.2313	95.66	0.1723
0.1141	0.9805	1.2789	99.23	0.3086	0.1155	0.9806	1.2384	94.29	0.1432
0.1502	0.9808	1.3035	98.63	0.3240	0.1519	0.9809	1.2443	93.53	0.1201
0.1862	0.9812	1.3265	96.86	0.3371	0.1884	0.9817	1.2456	90.86	0.0960
308.15									

Contd.

		CH_3COONH_4					CH_3COONa		
0.0061	0.9742	0.9140	78.15	0.0756	0.0060	0.9772	0.9281	142.58	0.2770
0.0426	0.9743	0.9136	76.43	0.0801	0.0421	0.9773	0.9569	138.60	0.2587
0.0791	0.9745	0.9302	75.23	0.0844	0.0785	0.9775	0.9691	136.09	0.2377
0.1156	0.9747	0.9355	74.64	0.0872	0.1144	0.9778	0.9794	134.49	0.2301
0.1521	0.9750	0.9407	73.62	0.09061	0.1505	0.9781	0.9860	133.46	0.2195
0.1885	0.9524	0.9449	73.36	0.0923	0.1867	0.9785	0.9936	132.05	0.2163
		CH_3COOLi					CH_3COOK		
0.0060	0.9772	0.9253	104.93	0.2380	0.0061	0.9774	0.9188	140.70	0.1440
0.0419	0.9729	0.9588	103.18	0.2702	0.0423	0.9787	0.9395	137.29	0.1653
0.0778	0.9774	0.9827	101.61	0.2922	0.0785	0.9801	0.9535	135.73	0.1765
0.1137	0.9776	1.0042	101.03	0.3120	0.1147	0.9815	0.9656	133.62	0.1851
0.1495	0.9778	1.0232	100.82	0.3262	0.1512	0.9830	0.9771	133.52	0.1940
0.1854	0.9780	1.0412	98.58	0.3390	0.1875	0.9845	0.9862	130.95	0.1972
				318.15					
		CH_3COONH_4					CH_3COONa		
0.0061	0.9714	0.7406	76.69	0.0966	0.0060	0.9714	0.7559	140.70	0.3679
0.0425	0.9715	0.7510	75.63	0.1052	0.0419	0.9715	0.7833	137.29	0.3211
0.0788	0.9716	0.7580	75.20	0.1112	0.0781	0.9717	0.7985	135.73	0.2960
0.1152	0.9718	0.7640	74.89	0.1161	0.1139	0.9721	0.8040	133.62	0.2782
0.1495	0.9720	0.7689	74.65	0.1183	0.1497	0.9723	0.8094	133.52	0.2614
0.1878	0.9723	0.7733	74.42	0.1201	0.1858	0.9730	0.8136	130.95	0.2480

Contd.

CH_3COOLi					CH_3COOK				
0.0059	0.9714	0.7493	104.20	0.2524	0.0060	0.9715	0.7388	99.35	0.0666
0.0417	0.9715	0.7766	102.48	0.2771	0.0422	0.9724	0.7489	98.04	0.0921
0.0774	0.9717	0.7955	101.41	0.2960	0.0782	0.9733	0.7568	96.80	0.1059
0.1131	0.9719	0.8143	100.42	0.3207	0.1143	0.9742	0.7639	95.89	0.1160
0.1448	0.9722	0.8291	99.75	0.3316	0.1506	0.9752	0.7711	94.37	0.1265
0.1844	0.9725	0.8426	98.68	0.3407	0.1864	0.9782	0.7780	93.71	0.1353

20% Methanol + H_2O Mixture

298.15K

CH_3COONH_4					CH_3COONa				
0.0063	0.9644	1.4190	78.30	0.1696	0.0060	0.9652	1.4015	143.61	0.1288
0.0443	0.9645	1.4398	77.37	0.1345	0.0421	0.9653	1.4450	139.44	0.1562
0.0823	0.9647	1.4461	76.88	0.1144	0.0782	0.9655	1.4655	137.63	0.1669
0.1203	0.9648	1.4481	76.34	0.0988	0.1142	0.9658	1.4843	136.00	0.1779
0.1583	0.9650	1.4486	75.87	0.0871	0.1503	0.9663	1.5005	134.16	0.1850
0.1962	0.9653	1.4485	75.21	0.0780	0.1864	0.9668	1.5180	132.74	0.1951
CH_3COOLi					CH_3COOK				
0.0061	0.9653	1.4241	106.24	0.2201	0.0063	0.9652	1.4415	100.08	0.3710
0.0423	0.9653	1.4664	104.37	0.2324	0.0443	0.9653	1.4756	98.51	0.2561
0.0786	0.9654	1.4928	103.19	0.2362	0.0823	0.9655	1.4740	97.50	0.1842

Contd.

0.1149	0.9657	1.5145	102.09	0.2411	0.1203	0.9658	1.4613	96.53	0.1262
0.1511	0.9659	1.5335	101.56	0.2451	0.1583	0.9662	1.4464	95.57	0.0830
0.1874	0.9661	1.5504	101.05	0.2480	0.1962	0.9666	1.4287	94.60	0.0463
308.15K									
		CH_3COONH_4					CH_3COONa		
0.0063	0.9604	1.0664	78.28	0.1342	0.0060	0.96040	1.06816	143.08	0.1590
0.0441	0.9605	1.0816	78.07	0.1194	0.0419	0.96048	1.09117	139.63	0.1667
0.0819	0.9606	1.0887	77.94	0.1111	0.0778	0.96064	1.10567	137.77	0.1716
0.1196	0.9607	1.0935	77.81	0.1050	0.1137	0.96100	1.11752	136.18	0.1752
0.1574	0.9608	1.0968	77.69	0.0993	0.1495	0.96136	1.12788	135.01	0.1781
0.1953	0.9609	1.0992	77.59	0.0944	0.1853	0.96180	1.13713	133.81	0.1804
		CH_3COOLi					CH_3COOK		
0.00602	0.96041	1.07687	104.68	0.2648	0.0063	0.9604	1.0728	104.31	0.2101
0.04217	0.96051	1.09823	103.57	0.1986	0.0475	0.9605	1.0956	100.63	0.1761
0.07179	0.96062	1.02963	102.90	0.1691	0.0817	0.9607	1.1035	98.96	0.1609
0.09670	0.96078	1.10375	102.13	0.1482	0.1192	0.9610	1.1071	97.15	0.1424
0.15122	0.96111	1.09786	101.28	0.1041	0.1570	0.9614	1.1099	95.63	0.1309
0.18760	0.96142	1.09312	100.51	0.0833	0.1947	0.9619	1.1105	93.97	0.1211
318.15K									
		CH_3COONH_4					CH_3COONa		
0.0063	0.9543	0.8433	77.39	0.1160	0.0059	0.9543	0.8552	141.09	0.3036

Contd.

0.0438	0.9544	0.8577	77.43	0.1259	0.0416	0.9544	0.8754	139.90	0.2330
0.0814	0.9545	0.8668	77.44	0.1305	0.0773	0.9545	0.8809	138.98	0.1950
0.1189	0.9546	0.8748	77.45	0.1361	0.1128	0.9547	0.8805	138.56	0.1599
0.1565	0.9547	0.8816	77.46	0.1391	0.1486	0.9549	0.8808	137.85	0.1340
0.1942	0.9547	0.8877	77.46	0.1415	0.1858	0.9730	0.8136	130.95	0.2480
		CH_3COOLi					CH_3COOK		
0.0060	0.9543	0.8633	103.52	0.4281	0.0063	0.9543	0.8445	99.42	0.1335
0.0420	0.9544	0.8931	102.41	0.3363	0.0438	0.9543	0.8601	97.54	0.1398
0.0714	0.9545	0.9004	101.80	0.2901	0.0813	0.9546	0.8698	96.41	0.1435
0.0885	0.9544	0.9023	101.54	0.2680	0.1186	0.9549	0.8777	95.60	0.1462
0.1506	0.9547	0.9034	100.12	0.2092	0.1563	0.9552	0.8849	94.40	0.1490
0.1867	0.9548	0.9021	99.90	0.1841	0.1936	0.9556	0.8914	93.53	0.1515
					30% Methanol + H_2O Mixture				
					298.15K				
		CH_3COONH_4					CH_3COONa		
0.0062	0.9606	1.4208	78.32	0.1809	0.0060	0.9606	1.41131	143.60	0.0970
0.0436	0.9607	1.4417	77.83	0.1400	0.0423	0.9607	1.43791	139.44	0.1290
0.0810	0.9608	1.4482	77.50	0.1206	0.0786	0.9609	1.46028	137.63	0.1516
0.1184	0.9609	1.4518	77.27	0.1059	0.1148	0.9612	1.47956	136.00	0.1660
0.1158	0.9611	1.4516	76.99	0.0920	0.1511	0.9617	1.49930	134.16	0.1810
0.1931	0.9612	1.4475	76.79	0.0760	0.1874	0.9622	1.51751	132.74	0.1925

Contd.

		CH_3COOLi					CH_3COOK		
0.0061	0.9606	1.4294	104.09	0.2610	0.0061	0.9606	1.4517	99.80	0.4640
0.0429	0.9608	1.4543	102.30	0.2020	0.0429	0.9607	1.4922	97.91	0.3150
0.0796	0.9610	1.4687	101.05	0.1720	0.0798	0.9609	1.4945	96.70	0.2370
0.1164	0.9612	1.4691	100.86	0.1430	0.1166	0.9613	1.4825	95.47	0.1711
0.1531	0.9614	1.4665	100.17	0.1200	0.1534	0.9617	1.4666	94.71	0.1201
0.1898	0.9620	1.4593	99.32	0.0960	0.1902	0.9622	1.4412	93.14	0.0711
					308.15K				
		CH_3COONH_4					CH_3COONa		
0.0062	0.9542	1.1113	77.17	0.1511	0.0060	0.9542	1.1380	140.70	0.4650
0.0434	0.9543	1.1305	77.10	0.1413	0.0421	0.9543	1.1744	138.49	0.3381
0.0806	0.9544	1.1399	77.06	0.1336	0.0781	0.9546	1.1767	137.11	0.2562
0.1177	0.9546	1.1464	77.04	0.1280	0.1142	0.9549	1.1706	136.11	0.1951
0.1549	0.9547	1.5205	77.03	0.1245	0.1501	0.9552	1.1620	134.91	0.1501
0.1922	0.9549	1.5569	77.00	0.1194	0.1861	0.9558	1.4559	133.63	0.1001
		CH_3COOLi					CH_3COOK		
0.0061	0.9542	1.1306	103.77	0.3781	0.0061	0.9541	1.1947	98.01	0.2470
0.0427	0.9543	1.1602	102.45	0.2730	0.0428	0.9542	1.4227	96.67	0.1941
0.0794	0.9545	1.1632	101.60	0.2102	0.0794	0.9545	1.4648	95.86	0.1562
0.1161	0.9548	1.1580	100.73	0.1596	0.1146	0.9549	1.4691	96.35	0.1311
0.1530	0.9551	1.1519	100.57	0.1253	0.1525	0.9553	1.1441	94.43	0.1070

Contd.

0.1898	0.9556	1.1413	99.06	0.0902	0.1892	0.9560	1.1398	92.63	0.0872
318.15K									
		CH_3COONH_4					CH_3COONa		
0.0062	0.9503	0.8558	76.48	0.0717	0.0060	0.9503	0.8764	140.47	0.3851
0.0431	0.9504	0.8665	77.11	0.0871	0.0418	0.9504	0.9040	138.95	0.3041
0.0801	0.9505	0.8742	77.50	0.0962	0.0778	0.9506	0.9139	137.83	0.2653
0.1171	0.9506	0.8815	77.81	0.1043	0.1137	0.9509	0.9168	136.81	0.2290
0.1542	0.9507	0.8876	77.83	0.1092	0.1494	0.9512	0.9165	136.30	0.1991
0.1911	0.9508	0.8932	78.24	0.1131	0.1853	0.9513	0.9152	135.54	0.1753
		CH_3COOLi					CH_3COOK		
0.0061	0.9503	0.8881	104.02	0.4530	0.0061	0.9502	0.8637	99.15	0.1901
0.0424	0.9504	0.9077	103.88	0.3231	0.0425	0.9503	0.8809	98.09	0.1704
0.0790	0.9505	0.9097	103.82	0.2454	0.0789	0.9505	0.8890	97.69	0.1588
0.1155	0.9506	0.9069	103.77	0.1933	0.1152	0.9508	0.8950	97.89	0.1520
0.1522	0.9508	0.8979	103.70	0.1412	0.1516	0.9512	0.8992	96.92	0.1454
0.1907	0.9509	0.8904	103.66	0.1061	0.1881	0.9516	0.9017	96.51	0.1372

Table 2

Limiting apparent molar volume (V_ϕ^0), experimental slope (S_v^*), A and B parameters of viscosity for acetate salts in different mass % of Methanol at different temperatures

Mass % of CH_3OH	V_ϕ^0 at			S_v^* at			A at			B at		
	298.15K	308.15K	318.15K	298.15K	308.15K	318.15K	298.15K	308.15K	318.15K	298.15K	308.15K	318.15K
						CH_3COONa						
10	145.54	144.34	142.75	-35.66	-28.78	-26.03	0.1937	0.2918	0.3921	0.1138	-0.1807	-0.3380
20	144.05	143.62	142.06	-25.50	-21.78	-10.64	0.1261	0.1541	0.3461	0.1536	-0.0625	-0.5505
30	143.45	142.78	141.86	-22.96	-20.09	-14.14	0.0750	0.5460	0.4219	0.2711	-0.1028	-0.5934
						CH_3COOLi						
10	107.28	106.35	105.53	-23.61	-16.29	-15.31	0.1845	0.2133	0.2283	0.3596	0.2902	0.2624
20	106.53	105.81	104.50	-12.54	-11.74	-10.63	0.2137	0.3050	0.4728	0.0799	-0.5121	-0.6924
30	104.72	105.07	104.12	-12.50	-12.28	-1.01	0.2977	0.4369	0.5251	-0.4563	-0.8085	-0.9759
						CH_3COOK						
10	103.30	101.48	101.03	-17.20	-18.09	-16.30	0.3053	0.1331	0.0519	-0.2967	0.1529	0.1923
20	101.64	101.02	100.83	-14.92	-9.31	-16.04	0.4434	0.2303	0.1295	-0.9036	-0.2505	0.0494
30	100.67	99.414	99.668	-14.71	-13.02	-6.80	0.5524	0.2842	0.2009	-1.1116	-0.4527	-0.1456
						CH_3COONH_4						
10	80.22	79.23	78.35	-14.45	-13.82	-8.86	0.1289	0.0711	0.0916	-0.0925	0.0479	0.0683
20	79.07	78.06	77.39	-8.18	-1.86	0.19	0.1886	0.1426	0.1106	-0.2545	-0.1093	0.0715
30	78.68	77.21	76.15	-4.68	-0.46	4.59	0.2019	0.1587	0.0628	-0.2832	-0.0883	0.1178

Table 3

Values of various coefficients (a_0, a_1, a_2) of acetate salts in various mass % of water methanol mixtures

Mass % of CH_3OH	a_0/ $cm^3\ mol^{-1}$	a_1/ $cm^3\ mol^{-1}\ K^{-1}$	a_2/ $cm^3\ mol^{-1}\ K^{-1}$
		CH_3COONa	
10	480.47	-2.12	0.0034
20	791.35	-3.86	0.0057
30	458.06	-1.42	0.0013
		CH_3COOLi	
10	244.49	-0.83	0.0013
20	476.18	-2.38	0.0039
30	573.27	-3.50	0.0065
		CH_3COOK	
10	16.59	2.33	-0.0069
20	88.96	0.68	-0.0022
30	-218.51	3.32	-0.0076
		CH_3COONH_4	
10	59.20	0.23	-0.0006
20	-47.00	0.93	-0.0017
30	-65.83	1.10	-0.0021

Table 4

Limiting apparent molar compressibilities (ϕ_E^0) for acetate salts in various mass % of methanol at different temperature

Mass % of Methanol	ϕ_E^0 / cm^3 mol^{-1} K^{-1}			$\left(\delta\phi_E^0/\delta T\right)_P$
	298.15 K	308.15 K	318.15 K	
		CH_3COONa		
10	-0.1255	-0.0585	0.0085	Positive
20	-0.4856	-0.3735	-0.2605	Positive
30	-0.6825	-0.6575	-0.6325	Positive
		CH_3COOLi		
10	-0.0875	-0.0625	-0.0375	Positive
20	-0.0926	-0.0156	0.0615	Positive
30	0.3665	0.4965	0.6265	Positive
		CH_3COOK		
10	-1.7515	-1.8885	-2.0253	Negative
20	-0.5985	-0.6415	-0.6845	Negative
30	-1.1805	-1.3315	-1.4825	Negative
		CH_3COONH_4		
10	-0.0935	-0.1045	-0.1155	Negative
20	-0.0840	-0.1180	-0.1520	Negative
30	-0.1265	-0.1675	-0.2085	Negative

Table 6

Mass % THF, Molality (m), Density (ρ), Sound Velocity (u), Adiabatic Compressibility (β), Apparent Molal Adiabatic Compressibility (ϕ_K), Limiting Apparent Molal Adiabatic Compressibility (ϕ_K^0) and Experimental Slope (S_K^*) of some acetate salts in methanol water mixtures (10%, 20%, 30%) at 298.15 K

Mass % of Methanol	m / mol kg^{-1}	ρ / kg m^{-3}	u / m sec^{-1}	$\beta \times 10^{10}$/Pa^{-1}	$\phi_K \times 10^{10}$/m^{3}mol^{-1}Pa^{-1}	$\phi_K^0 \times 10^{10}$/ M^{3}mol^{-1}Pa^{-1}	$S_K^* \times 10^{10}$/ M^{3}mol$^{-3/2}$Pa^{-1}kg$^{1/2}$
				CH_3COONH_4			
10	0.0062	979.9	1465.23	4.7533	-33.379	-38.670	78.605
	0.0437	980.0	1500.36	4.5329	-9.660		
	0.0813	980.1	1547.72	4.2631	-8.443		
	0.1192	980.3	1647.72	3.9965	-7.940		
	0.1571	980.6	1715.00	3.8625	-6.854		
	0.1952	980.8	1748.27	3.7589	-5.010		
20	0.0066	964.4	1653.54	3.7923	-47.195	-55.103	117.50
	0.0460	964.5	1698.45	3.5941	-10.954		
	0.0857	964.5	1745.18	3.4037	-8.075		
	0.1254	964.8	1796.78	3.2104	-7.047		
	0.1655	965.0	1825.32	3.1102	-5.920		
	0.2057	965.3	1872.11	2.9558	-5.494		
30	0.0065	960.6	1695.00	3.6234	-96.108	-113.32	247.06
	0.0455	960.7	1732.15	3.4693	-58.400		
	0.0847	960.8	1758.36	3.3663	-40.001		
	0.1240	960.9	1789.92	3.2483	-25.202		
	0.1636	961.1	1821.02	3.1377	-11.503		
	0.2033	961.2	1867.36	2.9834	-6.121		
				CH_3COOK			
10	0.0062	979.9	1453.23	4.8321	-20.872	-24.399	44.699
	0.0435	980.0	1541.92	4.2917	-15.330		
	0.0801	980.3	1598.56	3.9920	-11.961		

Contd.

	0.1185	980.6	1629.16	3.8422	-9.265		
	0.1563	980.9	1637.14	3.0836	-7.182		
	0.1940	981.7	1636.49	3.8039	-5.714		
	0.0066	965.2	1619.35	3.9508	22.549		
	0.0460	965.3	1734.89	3.4418	14.400		
20	0.0855	965.5	1770.48	3.3041	9.264	-27.062	58.330
	0.1231	965.8	1801.66	3.1897	7.185		
	0.1650	966.2	1724.37	3.4808	3.510		
	0.2050	966.6	1672.79	3.6973	1.640		
30	0.0064	960.6	1605.78	4.0373	-27.501		
	0.0448	960.7	1759.84	3.3610	-18.890		
	0.0834	960.9	1829.67	3.1086	-13.610		
	0.1219	961.3	1843.05	3.0854	-9.412	-32.667	65.64
	0.1609	961.7	1781.83	3.2143	-6.201		
	0.1999	962.2	1736.83	3.4439	-3.700		
				CH_3COOLi			
	0.0061	979.9	1455.54	4.8168	-23.665		
	0.0430	980.0	1557.53	4.2062	-17.500		
10	0.0800	980.2	1627.16	3.8533	-13.731		
	0.1173	980.5	1630.54	3.8362	-9.414	-27.507	49.642
	0.1548	980.8	1648.45	3.7521	-7.607		
	0.1923	981.2	1671.72	3.6469	-6.614		
	0.0063	965.2	1641.36	3.8455	-41.001		
	0.0440	965.3	1890.99	2.8971	-27.900		
20	0.0819	965.4	2060.49	2.4397	-20.700		
	0.1013	965.7	2120.69	2.3027	-18.100	-52.751	115.67
	0.1592	965.9	2039.72	2.4880	-10.200		
	0.1981	966.1	1977.51	2.6470	-7.300		
	0.0064	960.6	1630.67	3.9149	-50.010		136.72
30	0.0448	960.7	1996.90	2.6104	37.201	-61.574	
	0.0836	960.9	2357.73	1.8720	29.103		
	0.1226	961.2	2668.21	1.4614	23.300		

Contd.

	0.1619	961.4	2770.96	1.3547	18.312		
	0.2013	962.0	2918.87	1.2201	15.400		
				CH_3COONa			
10	0.0062	979.9	1449.22	4.8590	-16.370	-20.21	38.896
	0.0433	980.0	1518.30	4.4265	-12.000		
	0.0810	980.3	1563.00	4.1757	-9.327		
	0.1184	980.6	1586.60	4.0512	-7.290		
	0.1563	980.9	1588.07	4.0425	-5.440		
	0.1945	981.5	1590.77	4.0262	-4.350		
20	0.0062	965.2	1614.56	3.9779	-19.700	-24.049	51.253
	0.0438	965.3	1720.34	3.5005	-13.600		
	0.0816	965.5	1785.67	3.2491	-10.300		
	0.1196	965.8	1808.63	3.1569	-7.690		
	0.1579	966.3	1814.23	3.1476	-5.780		
	0.1965	966.8	1831.61	3.0881	-4.880		
30	0.0063	960.6	1581.20	4.1638	-9.369	-32.161	70.184
	0.0442	960.7	1585.75	4.1395	-1.408		
	0.0824	960.9	1712.98	3.5467	-8.134		
	0.1208	961.2	1726.96	3.4058	-5.902		
	0.1595	961.7	1747.32	3.3249	-4.908		
	0.1984	962.2	1767.98		-4.289		