Ultrasonic and Thermodynamic Investigations of Concentrated Aqueous Solutions of RbCl and CsCl

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Abstract- **This study presents a comprehensive analysis of concentrated aqueous solutions of Rubidium Chloride (RbCl) and Cesium Chloride (CsCl) using ultrasonic and thermodynamic techniques. The behavior of these solutions under varying concentrations and temperatures provides valuable insights into their structural and thermodynamic properties. Ion-solvent interactions of electrolyte play very significant role in understanding the nature, physicochemical behaviour and forces operating between the component molecules in the solutions. In the present study most widely investigated thermodynamic properties of electrolyte solutions include the density $\rho(T,c)$, the expansion coefficient $\alpha(T,c)$, the apparent molar volumes $V_\phi(T,c)$ and limiting apparent molar volume V_ϕ^o, constant S_v, adiabatic compressibility K_s, hydration number n_H, apparent molar compressibility ϕ_K, limiting apparent molar compressibility ϕ_K^o, and constant S_K. These properties provide better insight into the ionic interactions in solution of electrolytes. The findings of this research contribute to the fundamental understanding of the properties of concentrated aqueous solutions of RbCl and CsCl, which have implications in various fields including chemical engineering, pharmaceuticals, and environmental science. Additionally, the data obtained can serve as a reference for further theoretical modeling and experimental studies in similar systems.**

Key words: Apparent molar volume, adiabatic compressibility, hydration number, ion-solvent interaction.

I. INTRODUCTION

It is well known that the rubidium, cesium and their salts are rare all over the world. They cannot form any minerals of their own because of the extreme reactivity. The market for them is very small, the price is very high. There are less thermodynamic property data for the two metals and their salts than other alkali metals and the related compounds. Actually, some studies on rubidium[1] and cesium[2] show that both metals and their salts have many uses, such as specialty glasses used in fiber optic telecommunication systems, night-vision equipment and ingredient of metal-ion catalysts and so on. Thermodynamic properties of aqueous electrolyte solutions were studied theoretically and experimentally, and still are widely investigated considering their importance in natural and industrial processes. These properties are most commonly determined as a function of concentration and temperature.[3-22] The most widely investigated thermodynamic properties of electrolyte solutions include the density $\rho(T,c)$, the expansion coefficient $\alpha(T,c)$, the apparent molar volumes $V_\phi(T,c)$ and limiting apparent molar volume V_ϕ^o, constant S_v, adiabatic compressibility K_s, hydration number n_H, apparent molar compressibility ϕ_K, limiting apparent molar compressibility ϕ_K^o, and constant S_K. These properties provide better insight into the ionic interactions in solution of electrolytes. These properties are important when molecular interactions in fluids are correlated and related to change in water structure (e.g hydrogen bonding, and hydration of ions in water). A considerable number of compressibility studies on aqueous electrolytic solutions have been reported[23-28] by a few workers in acetonitrile[29], in methanol and ethanol.[30-33] Apparent molar compressibility of aqueous solutions of chloride, sulphate and nitrate have been reported[34].

There has been a lot of active interest in the study of intermolecular/interionic interactions[23-28], such as solute-solute, solute-solvent, ion-ion, ion-solvent, and solvent-solvent interactions. Several studies[35-38] on the

experimental measurements of ultrasound velocity and density of aqueous electrolyte solutions as function of concentration and temperature have been reported. In the present chapter, an attempt has been made to measure ultrasound velocity and density of aqueous solutions of alkali metal chlorides (RbCl and CsCl) at five different temperatures (298.15K, 303.15K, 308.15K, 313.15K & 318.15K) and concentration upto 0.1M. A number of useful and important properties (isentropic compressibility, apparent and partial molar compressibility, apparent and partial molar volume, acoustic impedance and hydration number) of these two solutions have been obtained from velocity and density data. The results are discussed in the light of various type of interactions (ion-solvent, ion-ion etc) occurring in aqueous solutions of RbCl and CsCl. For RbCl and CsCl, it's reasonable to expect hydration numbers to be relatively high since both rubidium (Rb) and cesium (Cs) ions are relatively large and have low charge densities, which can lead to significant hydration. However, the exact hydration numbers would depend on factors such as concentration, temperature, and specific experimental conditions. Experimentally determining these hydration numbers would require conducting specific studies using techniques mentioned earlier.

Theoretical

Apparent molar volume:
The apparent molar volume (ϕ_v) of the aqueous solution of salt is calculated using the relation

$$\phi_v = \frac{1000(\rho_o - \rho)}{c\rho_o} + \frac{M_2}{\rho_o} \qquad ---- (1)$$

where M_2 is the molar mass of the salt, c is the molar concentration of the solution, and ρ and ρ_o are the densities of the solution and solvent respectively. The limiting values of apparent molar volume were calculated by the method of least squares solving the equation. $\phi_v = \phi_v^o + S_v \sqrt{c}$ ---- (2)
where ϕ_v^o is the apparent molar volume or partial molar volume at infinite dilution, and S_v is the experimental slopes. ϕ_v^o and S_v of Eq (2) have been evaluated by the least square method.
Apparent molar compressibility

The apparent molar compressibility ϕ_K of the electrolyte solutions is obtained from ultrasonic velocity and density data at different temperature (298.15 to 318.15) K. The structural properties of the solutions, say the coefficient of a adiabatic compressibility K_S, and the apparent molar compressibility ϕ_K have been calculated by means of the following relation:

$$K_s = \left(u^2 \rho\right)^{-1} \qquad ---- (3)$$

$$\phi_K = \frac{1000\left(K_s \rho_o + K_s^o \rho\right)}{c\rho\rho_o} + \frac{MK_s^o}{\rho_o} \quad ---- (4)$$

where K_s, ρ and K_s^o, ρ_o are the adiabatic compressibility and density of solution and solvent respectively, m is the molar concentration of the solute and M the molar mass. The limiting values of apparent molar adiabatic compressibilities were calculated by a linear extrapolation using the least square fit. According to the Masson equation[39] ϕ_K is a linear function of $\sqrt{c}$ and given by $\phi_K = \phi_K^o + S_K \sqrt{c}$ (5)
where ϕ_K^o is the apparent molar compressibility at infinite dilution and S_K is experimental slope of the Masson equation.

The ideal adiabatic compressibility of the aqueous solution of RbCl and CsCl was calculated by the expression

$$K_{id} = \frac{\rho_w n_1 M_1 K_1 + \rho_1 n_w M_w K_w}{\rho_w n_1 M_1 + \rho_1 n_w M_w} \qquad ---- (6)$$

where ρ_1, n_1, M_1, K_1, ρ_w, n_w, M_w and K_w are the density, number of mole, molecular mass and adiabatic compressibility of solution and solvent respectively.

$$\Delta K_s = K_s^o - K_s \qquad ---- (7)$$

$$\frac{\Delta K_s}{K_s^o} = \frac{K_s^o - K_s}{K_s^o} \qquad ---- (8)$$

where ΔK_s is the change in adiabatic compressibility.

Acoustic impedance (Z)

The specific acoustic impedance, Z, is another acoustical parameter related to the ultrasonic velocity. The specific acoustic impedance is a ratio of acoustic pressure in a medium to specific flow or flow velocity. Acoustic impedance of a sound medium on a given surface lying in a wave front is given as the complex quotient of sound pressure on that surface derived by the flux to the surface. The application of acoustic impedance in the study of molecular association has been recently discussed by Glinski.[40] It is defined as

$$Z_o = u_o \rho_o \qquad \text{- - - - (9)}$$

$$Z = u \rho \qquad \text{- - - - (10)}$$

where Z, ρ, u and Z_o, ρ_o, u_o are the specific acoustic impedance, density, ultrasonic velocity of solution and solvent respectively.

Relative association (R_A)

The relative association, R_A has been determined using the following relation[41,42]:

$$R_A = \left(\frac{\rho}{\rho_o} \right) \left(\frac{u_o}{u} \right)^{1/3} \qquad \text{- - - - (11)}$$

where all the symbols have their usual notations.

Hydration number (n_H)

Hydration number has been computed, using the relation[41-43]:

$$n_H = \left(\frac{n_1}{n_w} \right) \left(1 - \frac{K_s}{K_s^o} \right) \qquad \text{- - - - (12)}$$

where n_1 and n_w are number of moles of solute and solvent, respectively.

The experimental values of density of these systems have been fitted by least squares to two- as well as three parameters equations, $\rho = \rho_o + \rho_1 c$ and $\rho = \rho_o + \rho_1 c + \rho_2 c^2$ in which ρ is the density, c is the molrity while ρ_o, ρ_1 and ρ_2 the constants for obtaining the densities at the desired concentration. Similarly, the ultrasonic velocities were fitted by the method of least square by relevant equation. The uncertainties in the measurement of density and ultrasonic velocity were ± 0.2 kgm^{-3} and ± 0.2 ms^{-1} respectively.

RESULTS AND DISCUSSION

Experimental values of density and ultrasonic velocity of RbCl and CsCl solutions in water at 298.15K, 303.15K, 308.15K, 313.15K & 318.15K are recorded in Tables 1-2. The experimental values of density and ultrasonic velocity have been used to calculate a number of thermodynamic parameters such as adiabatic compressibility, relative association, specific acoustic impedance as a function of electrolyte concentration and temperature. The temperature dependence of ultrasonic velocities in aqueous solutions of RbCl and CsCl is given in Table-2. Ultrasonic velocity in aqueous CsCl solution is lower than that in water over all the range of temperature and concentration. The difference of the sound velocities in the salt solutions and water increases with increasing concentration. In addition, the temperature of maximum ultrasonic velocity in water is changed by the presence of ions.[44-47] Thus, from the effect of ions on the velocity and compressibility of water it is possible to obtain some information about the ion-water interactions. These results are discussed on the basis of the dynamic structure of water around the cation. The ultrasonic velocity in the solutions of alkali metal chlorides has been found to decrease in the order;

RbCl > CsCl
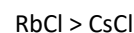
Also, the values of compressibility for the salt solutions are found to be lower than that of the water, and the order of magnitude differs in different concentrations. From the results it seems difficult to connect directly the ultrasonic velocity and compressibility with the structure of the solutions.[48,49] However the values of the compressibility of aqueous electrolytic solutions are found to be smaller than that of the pure water. This is ascribed to two effects:[48] (1) the decrease of compressibility caused by the introduction of incompressible ions, and (2) the change of water structure around the ion.

The apparent molar volume, ϕ_v, is calculated from the density data by using Eq (1). ϕ_v values of RbCl and CsCl in aqueous solutions at different temperatures and concentrations (0.01 to 0.1M) are recorded in Table-3. Apparent molar volume has been used to investigate the structural interaction in solution. The concentration dependence of apparent molar volume and partial molar volume has been used to study the

solute-solute interaction[43]. The apparent molar volume in Table-3, decreases with increase in concentration and increase of temperature. The apparent molar volume has been found to be linear with the square root of the concentration of the electrolytes and is represented by Masson's equation.[39] ϕ_v^o values are obtained from the linear plots of ϕ_v vs $\sqrt{c}$. These values are negative with rising temperature. S_V parameters are negative and increase with temperature.

The partial molar volume at infinite dilution, ϕ_v^o, and the slopes, S_V, for such systems in concentrated aqueous solutions at different temperatures (298.15, 303.15, 308.15, 313.15 and 318.15)K are reported in Table-7. The negative slopes in case of RbCl and CsCl are due to structure breaker at different temperatures which indicates weak solute-solute or ion-ion interaction. S_V values are positive and large which indicates that ion-ion interactions are quite strong. The limiting apparent molar volume, ϕ_v^o, is a measure of solute-solvent interaction. It is clear from the results of Table-7, that ϕ_v^o values are positive for RbCl and CsCl indicating thereby the presence of solute-solvent interactions.

The apparent molar compressibilities, ϕ_K, of the electrolyte solutions have been determined from ultrasound velocity and density values at different temperatures (298.15, 303.15, 308.15, 313.15 and 318.15)K. The temperature dependence of compressibilities is given in Table-4. It is found that, adiabatic compressibility decreases with increase concentration of solute as well as with temperature. The values of apparent molar compressibility, ϕ_K, decrease with increase in concentration and increase of temperature. ϕ_K^o values are obtained from the linear plot of ϕ_K vs $\sqrt{c}$. According to Masson's theory, the concentration dependence of this parameter has been expressed in terms of Eq (5). S_K is the experimental slope which is also used to investigate the solute-solvent interaction. Kaulgud and Rao[50] have reported that limiting apparent molar compressibility, ϕ_K^o, is an important parameter for investigating and understanding such interactions. The positive values

of ϕ_K^o indicate the presence of strong interaction and the negative values of S_K indicate the presence of weak interactions (Table-7). The ideal value of adiabatic compressibility of the aqueous solution of alkali metal salts decrease with increase in the concentration of salt as well as temperature. The relative change in adiabatic compressibility, ΔK_{rel}, follows the same pattern as exhibited by the change in adiabatic compressibility (ΔK_s), the tendency of the system exhibiting an almost ideal behaviour is somewhat improved.[24]

The behaviour of acoustic impedance can be explained on the basis of lyophobic interaction between solute and solvent molecules which increase the intermolecular distance, and becomes responsible for the propagation of ultrasound waves. The values of acoustic impedance, Z, indicate an increase with increase in temperature and concentration. A linear increase of acoustic impedance with electrolyte concentration has also been reported for aqueous solutions of lithium salts in ethanol, acetone and methyl ethyl ketone.[41] This parameter may also be discussed in terms of structure making properties of ions in the similar way as explained in the case of ultrasonic velocity. The variation of acoustic impedance of aqueous solutions of RbCl and CsCl at 298.15K is shown in Figure-1. This indicates that Z is also a linear function of concentration.

The variation of relative association with concentration has been examined after consideration of the error limits involved in the measurements of density and ultrasonic velocity. In Table-5, the relative association is found to increase with the concentration and temperature of the aqueous solutions of alkali metal salts. The increase in R_A with electrolyte concentration indicates the ion-solvent interaction. Similar behaviour of R_A has also been reported by Nikam and Hiray[51] for binary solvent mixture containing electrolyte.

A perusal of Table-7 shows that the positive values of molar hydration number indicate an appreciable solution of solutes.[41,42] This is an added support for the structure promoting nature of solute as well as the presence of dipole-dipole interaction between solute and water molecules. Hydration number increases non-linearly with solute concentration which further confirms the molecular interaction between solute and

solvent molecules. The hydration number of an electrolyte should be independent of concentration in dilute solutions for which there are many water molecules present for each ion.

CONCLUSION

Ultrasonic method is a powerful probe for characterizing the physico-chemical properties and existence of molecular interaction. In addition, the density and the derived acoustical and thermodynamic parameters provide evidence of confirmation. A number of useful and important thermodynamic and structural parameters are deduced from the temperature and concentration dependence of experimental density and ultrasonic velocity of aqueous RbCl and CsCl solutions. The measurements were made at five different temperatures (298.15K, 303.15K, 308.15K, 313.15K & 318.15K) and concentration from 0.01M to 0.1M solution. The results were used to test the applicability of simple equations for the density and ultrasonic velocity of electrolytic solutions. The results show that equations can yield good prediction for the density and ultrasonic velocity of electrolyte solutions. The hydration numbers for these alkali metal chlorides tend to be quite high due to the strong interaction between the ions and water molecules. At last, it can be concluded that solute-solute interactions are dominating over the solute-solvent interactions.

Table 1-Density (ρ , $\times$ 10^{-3}kgm^{-3}) of aqueous solution of RbCl and CsCl as a function of concentration and temperatures.

c (mol lit^{-1})		RbCl T (K)			
	298.15	303.15	308.15	313.15	318.15
0.00	4.480	4.421	4.374	4.328	4.295
0.01	4.473	4.413	4.366	4.316	4.279
0.02	4.469	4.411	4.363	4.313	4.272
0.03	4.460	4.404	4.354	4.307	4.265
0.04	4.452	4.396	4.343	4.297	4.252
0.05	4.449	4.392	4.340	4.296	4.251
0.06	4.445	4.388	4.337	4.291	4.248
0.07	4.436	4.380	4.331	4.283	4.244
0.08	4.425	4.369	4.321	4.277	4.236
0.09	4.421	4.361	4.317	4.273	4.232
0.10	4.417	4.357	4.313	4.264	4.219

c (mol lit^{-1})		RbCl T (K)			
	298.15	303.15	308.15	313.15	318.15
0.00	0.99680	0.99549	0.99403	0.99212	0.98798
0.01	0.99701	0.99583	0.99426	0.99268	0.99045
0.02	0.99760	0.99602	0.99445	0.99287	0.99129
0.03	0.99925	0.99749	0.99573	0.99397	0.99221
0.04	1.00042	0.99894	0.99747	0.99600	0.99453
0.05	1.00061	0.99913	0.99765	0.99616	0.99468
0.06	1.00125	0.99966	0.99807	0.99648	0.99488
0.07	1.00304	1.00109	0.99913	0.99798	0.99522
0.08	1.00517	1.00309	1.00100	0.99891	0.99681
0.09	1.00560	1.00353	1.00145	0.99938	0.99730
0.10	1.00598	1.00396	1.00203	1.00098	0.99987

c (mol lit^{-1})		CsCl T (K)			
	298.15	303.15	308.15	313.15	318.15
0.00	0.99680	0.99549	0.99403	0.99212	0.98798
0.01	0.99742	0.99617	0.99492	0.99367	0.98992
0.02	0.99877	0.99734	0.99590	0.99446	0.99303
0.03	1.00086	0.99933	0.99780	0.99628	0.99475
0.04	1.00270	1.00119	0.99953	0.99809	0.99658
0.05	1.00410	1.00258	1.00105	0.99953	0.99800
0.06	1.00545	1.00401	1.00256	1.00112	0.99967
0.07	1.00755	1.00603	1.00452	1.00300	1.00149
0.08	1.01378	1.01238	1.01098	1.00958	1.00819
0.09	1.01810	1.01669	1.01527	1.01386	1.01245
0.10	1.02251	1.02033	1.01875	1.01711	1.01578

Table 2-Ultrasonic velocity (u,ms^{-1}) of aqueous solution of RbCl and CsCl solution as a function of concentration and temperatures.

c (mol lit^{-1})		RbCl T (K)			
	298.15	303.15	308.15	313.15	318.15
0.00	1496.5	1507.3	1516.5	1526.1	1535.2
0.01	1497.4	1508.4	1517.7	1527.8	1536.0
0.02	1497.6	1508.6	1518.1	1528.1	1536.6
0.03	1498.0	1508.7	1518.8	1528.3	1537.2
0.04	1498.4	1509.1	1519.4	1528.6	1537.7
0.05	1498.8	1509.5	1519.7	1528.7	1537.9
0.06	1499.0	1509.8	1519.9	1529.3	1538.2
0.07	1499.2	1510.1	1520.2	1529.5	1538.7
0.08	1499.5	1510.6	1520.6	1530.0	1538.9
0.09	1499.8	1511.6	1520.8	1530.2	1539.2
0.10	1500.1	1512.0	1521.2	1530.6	1539.7

		CsCl			
c		T (K)			
(mol lit⁻¹)	298.15	303.15	308.15	313.15	318.15
0.00	1496.5	1507.3	1516.5	1526.1	1535.2
0.01	1496.4	1507.1	1516	1525.8	1535.1
0.02	1496.1	1506.8	1515.7	1525.6	1534.9
0.03	1496	1506.7	1515.3	1525.3	1534.7
0.04	1495.7	1506.5	1515	1525.1	1534.6
0.05	1495.5	1506.2	1514.6	1525	1534.3
0.06	1495.2	1506	1514.2	1524.8	1534.1
0.07	1494.9	1505.7	1514	1524.5	1534
0.08	1494.6	1505.3	1513.8	1524.1	1533.8
0.09	1494.2	1505	1513.4	1523.9	1533.7
0.10	1493.8	1504.9	1513.1	1523.6	1533.5

(mol lit⁻¹)	298.15	303.15	308.15	313.15	318.15
0.00	1.00000	1.00000	1.00000	1.00000	1.00000
0.01	1.00001	1.00010	0.99997	1.00019	1.00233
0.02	1.00056	1.00025	1.00007	1.00032	1.00305
0.03	1.00212	1.00170	1.00120	1.00138	1.00385
0.04	1.00321	1.00307	1.00282	1.00336	1.00608
0.05	1.00331	1.00317	1.00294	1.00350	1.00619
0.06	1.00390	1.00364	1.00331	1.00369	1.00633
0.07	1.00565	1.00501	1.00431	1.00516	1.00656
0.08	1.00772	1.00690	1.00610	1.00599	1.00813
0.09	1.00809	1.00712	1.00651	1.00642	1.00856
0.10	1.00840	1.00747	1.00701	1.00794	1.01105

Table-3 Apparent molar volume ($\phi_v \times 10^6, m^3 \bullet mol^{-1}$) as a function of concentration of aqueous RbCl and CsCl at different temperatures.

		RbCl			
c		T (K)			
(mol lit⁻¹)	298.15	303.15	308.15	313.15	318.15
0.01	100.44	86.91	98.61	65.44	-127.61
0.02	81.28	94.65	100.57	84.08	-45.12
0.03	39.45	54.37	64.67	59.72	-20.32
0.04	30.57	34.73	35.15	24.11	-43.35
0.05	44.90	48.26	48.83	40.44	-13.24
0.06	46.94	51.59	53.93	48.64	5.99
0.07	31.91	41.05	48.37	37.50	17.70
0.08	16.37	25.99	34.01	36.33	10.67
0.09	23.24	31.69	38.72	40.57	17.58
0.10	29.23	36.34	41.18	32.58	2.04

		CsCl			
c		T (K)			
(mol lit⁻¹)	298.15	303.15	308.15	313.15	318.15
0.00	1.00000	1.00000	1.00000	1.00000	1.00000
0.01	1.0005	1.0007	1.0008	1.0010	1.0016
0.02	1.0021	1.0021	1.0020	1.0020	1.0024
0.03	1.0033	1.0042	1.0041	1.0040	1.0043
0.04	1.0054	1.0061	1.0061	1.0058	1.0061
0.05	1.0077	1.0076	1.0075	1.0073	1.0077
0.06	1.0090	1.0090	1.0091	1.0089	1.0093
0.07	1.0113	1.0111	1.0111	1.0109	1.0112
0.08	1.0175	1.0175	1.0176	1.0175	1.0179
0.09	1.0219	1.0219	1.0220	1.0219	1.0222
0.10	1.0261	1.0263	1.0257	1.0254	1.0256

Table 4-Adiabatic compressibility ($\beta_s \times 10^{10}, m^2 \bullet N^{-1}$) as a function of concentration of aqueous RbCl and CsCl at different temperatures.

		CsCl			
c		T (K)			
(mol lit⁻¹)	298.15	303.15	308.15	313.15	318.15
0.00	4.480	4.421	4.374	4.328	4.295
0.01	4.477	4.420	4.373	4.323	4.287
0.02	4.473	4.416	4.371	4.320	4.274
0.03	4.464	4.408	4.365	4.314	4.268
0.04	4.458	4.401	4.359	4.308	4.261
0.05	4.453	4.397	4.355	4.302	4.256
0.06	4.449	4.391	4.350	4.296	4.250
0.07	4.441	4.384	4.343	4.290	4.243
0.08	4.416	4.359	4.316	4.264	4.216
0.09	4.399	4.342	4.300	4.247	4.199
0.10	4.383	4.328	4.287	4.235	4.186

		CsCl			
c		T (K)			
(mol lit⁻¹)	298.15	303.15	308.15	313.15	318.15
0.01	106.90	100.41	79.94	13.47	-25.95
0.02	70.18	76.00	75.36	51.77	-85.16
0.03	33.20	40.41	42.98	29.93	-58.00
0.04	20.98	25.88	31.07	19.26	-47.21
0.05	22.47	26.60	28.15	20.32	-32.43
0.06	24.30	26.41	26.37	18.51	-26.80
0.07	14.86	17.81	18.63	13.03	-24.94
0.08	-44.01	-43.01	-43.76	-50.29	-85.29
0.09	-68.50	-67.54	-68.03	-73.78	-104.79
0.10	-89.00	-80.44	-79.30	-82.19	-110.97

Table 6 Hydration Number (n_H) as a function of concentration of aqueous CsCl at different temperatures,(298.15 - 318.15)K.

		CsCl			
c		T (K)			
(mol lit⁻¹)	298.15	303.15	308.15	313.15	318.15
0.01	1.3	1.2	0.6	3.2	5.1
0.02	2.0	1.7	1.1	2.3	6.5

Table 5Relative association (RA) as a function of concentration of aqueous RbCl and CsCl at different temperatures,(298.15 - 318.15)K.

		RbCl			
c		T (K)			

0.03	3.1	2.8	2.0	2.9	5.6
0.04	3.3	3.2	2.4	3.2	5.4
0.05	3.2	3.1	2.5	3.3	4.8
0.06	3.1	3.1	2.5	3.3	4.7
0.07	3.3	3.2	2.8	3.4	4.6
0.08	4.8	4.8	4.5	5.0	6.2
0.09	5.4	5.3	5.1	5.6	6.7
0.10	5.8	5.7	5.3	5.7	6.8

Table 7 Experimental values of ϕ_v^o, $\phi_{K_s}^o$, S_v and S_{K_s} of aqueous solution of RbCl and CsCl at different temperatures.

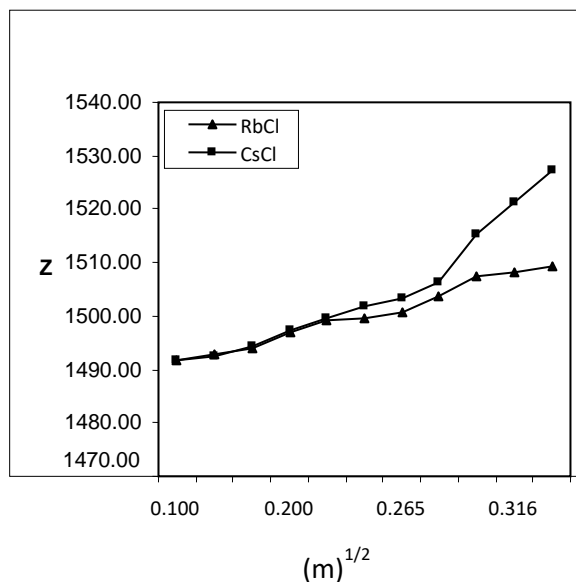|		298.15	303.15	308.15	313.15	318.15
	Φ_{ks}^o	9.60E-06	9.49E-06	9.40E-06	9.31E-06	9.27E-06
RbCl	S_k	-3.10E-05	-3.07E-05	-3.04E-05	-3.01E-05	-3.00E-05
	Φ_v^o	116.60	112.79	122.20	87.95	-142.58
	S_v	-321.16	-276.98	-292.82	-182.49	547.45
	Φ_{ks}^o	9.62E-06	9.50E-06	9.42E-06	9.33E-06	9.28E-06
CsCl	S_k	-3.11E-05	-3.07E-05	-3.04E-05	-3.02E-05	-3.00E-05
	Φ_v^o	213.77	212.10	196.11	131.76	8.64
	S_v	-871.87	-850.88	-788.92	-570.43	-274.44

Fig.1 Dependence of Acoustic Impedance on the Square Root of Molar Concentration in Water Solution

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