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Effect of Dilution on the Thermodynamic Parameters of some Transition Metal Salt by Viscosity Method

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ABSTARCT
The physical properties such as density, specific viscosity of $MnCl_2$, $CaCl_2$ and $NiCl_2$ at different concentration in the range ($1X10^{-2}$ M to $6X10^{-4}$ M) in aqueous medium at temperature 299K, 305K and 311K were reported. The experimental data shows, the effect of concentration of solute on viscosity in aqueous medium revels the idea about the different types of molecular interactions present in different solutions. Desired molecular interactions have been observed between the salts of chloride such as Ca2+ Mn^{2+} & Ni^{2+} and water.
The thermodynamic parameters such as ΔH, ΔG & ΔS for the dissolution of $MnCl_2$, $CaCl_2$ and $NiCl_2$ were calculated from values of viscosity and densities at different temperatures such as 299K, 305K and 311K in aqueous medium. The experimental data gives the idea about effect of temperature on the molecular interaction and structural changes in solute.
Keywords: *Viscosity, Density, Thermodynamic Parameters, Thermodynamic Parameters ΔH, ΔG and ΔS, Chloride Salt of* Ca^{2+}, Mn^{2+} & Ni^{2+}.

I. INTRODUCTION

The physicochemical and thermodynamic investigations playan important role in understanding the nature and the extent of the patterns of molecular aggregation that exist in liquid mixtures and their sensitivities to variations in composition and the molecular structure of the pure components[1]. Since most of the biochemical processes occur in aqueous media, the studies on the thermodynamic and transport properties of drugs in the aqueous phase provide useful information in pharmaceutical and medicinal chemistry[2].
Understanding the nature of the solute depends heavily on the molecular interactions between the solute and the solvent and how these change with temperature. Viscometric characteristics give important hints about how solute-solvent interactions behave in the solution phase. These findings can aid in the prediction of metal salt absorption and metal transport across biological membranes.

Therefore, it could be interesting to look into how various transition metal salts, such $CaCl_2$, $MnCl_2$, and $NiCl_2$, change with temperature in order to understand how they work. A thorough review of the literature reveals a paucity of studies on the thermodynamic and transport characteristics of the metal chloride salt indicated above in aqueous media. As a result, we looked into the transport and thermodynamic characteristics of three important metal salts in aqueous solutions at various temperatures.

The salts of Ca^{2+}, Mn^{2+} & Ni^{2+} has a variety of biological roles in enzymology, cell membrane/wall structure, muscle cell physiology, and nucleic acid structure. Ca^{2+}, Mn^{2+} &Ni^{2+} are an essential co-factor in many enzymes, including DNAse, some restriction enzymes, and Ribonuclease-H. $CaCl_2$, $MnCl_2$ and $NiCl_2$ are widely used to supply the Ca^{2+}, Mn^{2+} & Ni^{2+} ion in various molecular biology applications, including PCR reactions[3,4].

The ongoing work into the viscometric characteristics of some transition metal chlorides in aqueous media at various temperatures is represented by the current work. One of the crucial physical characteristics that the liquid possesses is its viscosity. The viscous aspect of the liquid, which is nothing more than the flow of liquid layers over one another, is caused by the shearing effect in the liquid.

II. MATERIAL AND METHOD

All systems in this work have β-coefficient values that are negative at all temperatures. Table 4 clearly shows that the β-coefficient, which measures the actual thermodynamic volume of the solute and takes into consideration the interaction between the solute and the solvent, is shown to be negative for all systems. It is referred to as a measurement of disorder brought about by a solute in the solvent. Table 4's findings lead to the conclusion that Ni2+>Ca2+> Mn2+ are in the order of the Falkenhagen coefficient.

III. RESULTS AND DISCUSSION

Currently being studied is the connection between the concentration of $CaCl_2$, $MnCl_2$, and $NiCl_2$ solutions and their respective relative viscosity, which shows a decrease when concentration also decreases. The rise in thickness as the concentration increases can be attributed to the escalation in the connections between the solute and the solvent. At any temperature examined, the order in which the solutions of $CaCl_2$, $MnCl_2$, and $NiCl_2$ display greater relative viscosity is: $Ni^{2+} > Ca^{2+} > Mn^{2+}$

Table (4) contains thermodynamic parameters that demonstrate how the metal ion changes in the presence of water. In all cases, the possibility of interaction is shown by a free energy change (ΔG) that is negative. The change in enthalpy (ΔH) indicates that the combination of metal ion and water solvent is both spontaneous and gives off heat, while a positive value for entropy change (ΔS) suggests that the solute molecules become more disordered within the solvent. In water, solute molecules separate or break down

Table 1. Densities (d) gm/cc and relative viscosities (η_r) of Chloride salt of Ca^{2+}, Mn^{2+} & Ni^{2+} at different concentration in aqueous solvent at 299K.

Conc. mole/lit	$CaCl_2$		$MnCl_2$		$NiCl_2$	
	ensity(d) (Kgm^{-3})	Rel. Viscosityη_r	ensity(d) (Kgm^{-3})	Rel. Viscosityη_r	ensity(d) (Kgm^{-3})	Rel. Viscosityη_r
0.01	0.9984	2.5232	0.9999	1.7551	1.0052	2.6785
0.005	0.9927	2.1986	0.9962	1.6137	0.9989	2.4232
0.0025	0.9876	1.9074	0.9923	1.4725	0.9968	2.1346
0.00125	0.9848	1.6778	0.9901	1.3553	0.9987	1.8574
0.000625	0.9856	1.4904	0.9802	1.2601	0.9909	1.6357

Table 2. Densities (d) gm/cc and relative viscosities (η_r) of Chloride salt of Ca^{2+}, Mn^{2+} & Ni^{2+} at different Concentration in aqueous solvent at 306K.

Conc. mole/lit	$CaCl_2$		$MnCl_2$		$NiCl_2$	
	ensity(d) (Kgm^{-3})	Rel. Viscosityη_r	ensity(d) (Kgm^{-3})	Rel. Viscosityη_r	ensity(d) (Kgm^{-3})	Rel. Viscosityη_r
0.01	0.9933	2.3835	0.9937	1.5245	1.0001	2.4962
0.005	0.9852	2.1402	0.9902	1.4013	0.9983	2.3303
0.0025	0.9813	1.9405	0.9886	1.3030	0.9961	2.1420
0.00125	0.9793	1.7462	0.9856	1.2245	0.9923	1.9195
0.000625	0.9769	1.5621	0.9815	1.1663	0.9884	1.7091

Table 3. Densities (d) gm/cc and relative viscosities (η_r) of Chloride salt of Ca^{2+}, Mn^{2+} & Ni^{2+} at different concentration in aqueous solvent at 311K.

Conc. mole/lit	$CaCl_2$		$MnCl_2$		$NiCl_2$	
	ensity(d) (Kgm^{-3})	Rel. Viscosityη_r	ensity(d) (Kgm^{-3})	Rel. Viscosityη_r	ensity(d) (Kgm^{-3})	Rel. Viscosityη_r
0.01	0.9896	2.2704	0.9903	1.3411	0.9986	2.3461
0.005	0.9835	2.0355	0.9881	1.2938	0.9953	2.1717
0.0025	0.9811	1.8125	0.9859	1.2355	0.9922	1.9651
0.00125	0.9795	1.6221	0.9833	1.1774	0.9910	1.7520
0.000625	0.9764	1.4644	0.9809	1.1306	0.9895	1.5721

Table 4. Values of Thermodynamic Parameters for temperature difference **299K – 306K**

System	□G ($J\ mol^{-1}\ K^{-1}$)	□H ($J\ mol^{-1}\ K^{-1}$)	□S ($J\ mol^{-1}\ K^{-1}$)
$CaCl_2$	-6676473	-6774.60	2156.73
$MnCl_2$	-5397364	-17333.30	17294.72
$NiCl_2$	-2657385	-8523.87	8515.04

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