# Studies on Volumetric and Sound Velocity of Ciprofloxacin in Aqueous Solution of Glucose, Sodium Chloride & Potassium Chloride Salts at Different Temperatures

by

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A thesis submitted in partial fulfillment of the requirements for the degree of
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## Declaration

This is to certify that the thesis work entitled **"Studies on Volumetric and Sound Velocity of Ciprofloxacin in Aqueous Solution of Glucose, Sodium Chloride & Potassium Chloride Salts at Different Temperatures"** has been carried out by Masuda Khanam in the Department of Chemistry, Khulna University of Engineering & Technology, Khulna, Bangladesh. The above thesis work or any part of this work has not been submitted anywhere for the award of any degree or diploma.

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## Approval

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# ABSTRACT

In this study, volumetric and sound velocity method was applied to analyze the interaction of ciprofloxacin on the structure of glucose, NaCl and KCl. Densities and sound velocities of glucose, NaCl and KCl in water and in aqueous ciprofloxacin (0.03, 0.045 and 0.06) $mol.kg^{-1}$ solutions have been studied at 293.15 K to 318.15 K with an interval of 5 K temperature. The density values have been used to calculate apparent molar volume ($\varphi_v$), limiting apparent molar volume ($\varphi_v^0$), limiting apparent molar volume transfer ($\Delta_{tr}\varphi_v^0$), apparent molar expansibilities $(\delta\varphi_v^0/\delta T)_p$ and Hepler constant $(\delta^2\varphi_v^0/\delta T^2)_p$. The acoustic properties such as adiabatic compressibility ($\beta_s$), apparent molar adiabatic compressibility ($\varphi_k$), limiting apparent molar adiabatic compressibility ($\varphi_k^0$), apparent molar adiabatic compressibility of transfer ($\Delta_{tr}\varphi_k^0$), acoustic impedance (Z), relative association ($R_A$) and hydration number ($n_H$) have also been calculated by densities and sound velocities data.

The densities increase with the increase of concentration of glucose, NaCl and KCl. Densities of glucose, NaCl and KCl in aqueous ciprofloxacin solutions are higher than that of glucose, NaCl and KCl in aqueous solution. The increase of density with concentration of glucose, NaCl and KCl can be attributed to solute-solvent interaction. The limiting apparent molar volumes ($\varphi_v^0$) are positive at the studied temperatures for the all mixtures indicate the presence of solute-solvent interactions. The positive values of $S_v$ indicate strong solute-solute interaction and $\varphi_v^0$ values suggest the dominance of solute-solvent interaction.

The limiting apparent molar volume transfer ($\Delta_{tr}\varphi_v^0$) values have been found negative for NaCl and KCl in (0.03 and 0.045) and (0.03, 0.045 and 0.06) $mol.kg^{-1}$ aqueous ciprofloxacin solutions respectively, which suggest the existence of ion-hydrophobic and hydrophobic-hydrophobic group interaction. But $\Delta_{tr}\varphi_v^0$ values are positive for glucose and NaCl in (0.03, 0.045 and 0.06) and 0.06 $mol.kg^{-1}$ aqueous ciprofloxacin respectively, which suggest the existence of ion-hydrophilic and hydrophilic-hydrophilic interactions. The values of limiting apparent molar expansion ($E_\varphi^0$) are positive. The Hepler constant $(\delta^2\varphi_v^0/\delta T^2)_p$ values are small negative for all studied glucose, NaCl and KCl suggest the studied systems act as structure makers. The values of partial molar volumes ($\bar{V}_2$) increase with increasing concentration of glucose, NaCl and KCl for all studied systems.

The sound velocity increases with the increase of concentration of glucose, NaCl and KCl. Sound velocities of glucose, NaCl and KCl in aqueous ciprofloxacin solutions are higher than those of glucose, NaCl and KCl in aqueous solution. This indicate that the increase of compactness of the medium with the increase in glucose, NaCl and KCl and ciprofloxacin concentration.

The adiabatic compressibility ($\beta_s$) decreases with the increasing concentration of glucose, NaCl and KCl. This indicates that water molecules around the glucose, NaCl and KCl are less compressible than the water molecules in the bulk solution. The negative apparent molar adiabatic compressibility ($\varphi_k$) values indicate the greater loss of structural compressibility of water. The values of limiting apparent molar adiabatic compressibility ($\varphi_k^0$) are negative. The values of apparent molar adiabatic compressibility transfer ($\Delta_{tr}\varphi_k^0$) are mainly positive which suggest the existence of strong ion-solvent interaction. At lower concentration, negative values of $\Delta_{tr}\varphi_k^0$ indicate that increase in hydrophobic-hydrophobic group interactions. The small $S_k$ values also indicates the domination of solute-solvent interaction over solute-solute interaction.

The acoustic impedance, Z increases with the increase of concentration of glucose, NaCl and KCl. The relative association, $R_A$ decreases linearly with increasing the concentration of solute indicates the increase of solute-solvent interaction. The positive hydration number ($n_H$) values indicate an appreciable solvation of solutes.

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**Nomenclature**

| | |
|---|---|
| $\varphi_v$ | The apparent molar volume |
| $\rho_0$ | Density of solvent |
| $\rho$ | Density of solution |
| $u_0$ | Sound velocity of solvent |
| u | Sound velocity of solution |
| $\bar{V}_2$ | Partial molar volume |
| m | Molality |
| M | Molecular mass |
| $n_1$ | Number of moles of solvent |
| $n_2$ | Number of moles of solute |
| $n_H$ | Hydration number |
| $R_A$ | Relative association |
| Z | Acoustic impedance |
| $\beta_s$ | Adiabatic compressibility of solution |
| $\beta_{s,o}$ | Adiabatic compressibility of solvent |
| h | Plank's constant |
| N | Avogadro's number |
| R | Universal gas constant |
| A,B,C | Constants related with temperature effects |

# CHAPTER I

# Introduction

## 1.1 General

Densities and sound velocities are very important physicochemical properties of solution in chemical process. The densities and sound velocities properties of binary and ternary mixtures have been extensively used to understand the molecular interactions between the components of the mixture [1, 2]. Ultrasonic technique has been found to be more accurate and comprehensive in understanding solute-solvent interactions and understanding the role played by the biological molecules in living organism. The measurement of the macroscopic properties (densities, sound velocities, viscosities, surface tensions etc.) of the mixtures is of vital importance for accurate design of the equipment for various unit operations and unit processes [3]. Solid-liquid or liquid-liquid mixtures is of considerable importance in understanding the molecular interaction occurring among component molecules and finds their applications in several industrial and technological processes such as petrochemical, pharmaceutical and cosmetics etc. The interaction of important biomolecules such as glucose, NaCl and KCl with aqueous ciprofloxacin solutions and temperature dependence play an important role in the understanding of biomolecule action. It is also clear that if the solute and the solvent are interacting, as indeed they do, then the chemistry of the solute in a solvent must be different and the presence of a solvent can modify the properties of a solute. So the interactions of glucose, NaCl and KCl with their surrounding environment play an important role in their characteristic properties.

## 1.2 Properties of solute in solvent

In chemistry, a solution can be defined as a homogeneous mixture composed of two or more substances. In such a mixture, a solute is a substance dissolved in another substance, known as a solvent. The solution more or less takes on the characteristics of the solvent including its phase and the solvent is commonly the major fraction of the mixture. The concentration of a solute in a solution is a measure of how much of that solute is dissolved in the solvent, with regard to how much solvent is present.

The physicochemical properties involving solute-solvent interactions in mixed solvents have increased over the past decade in view of their greater complexity in comparison with pure solvents [4–6]. This puzzling behavior results from the combined effects of preferential solvation of the solute by one of the components in the mixture [7, 8] and of solvent–solvent interactions [9]. Preferential solvation occurs when the polar solute has in its microenvironment more of one solvent than the other, in comparison with the bulk composition. The understanding of these phenomena may help in the elucidation of kinetic, spectroscopic and thermodynamic events that occur in solution.

Theoretically, solute-solvent interactions that mean the properties of solutions can be calculated from the properties of the individual components. But, the liquid state creates inherent difficulties and the properties of solution cannot understand properly. The theoretical treatments, therefore, have to assume some model (e.g., lattice model, cell model etc.) for the structure of the components and their solution. Alternatively, it is considered convenient and useful to determine experimentally the values of certain macroscopic properties of solutions for proper understanding of the structure of the solution. Some of the usually experimentally determined macroscopic properties are: density, sound velocity, thermodynamic properties, surface tension, etc. which are readily measurable.

Physical properties like density, sound velocity, surface tension, conductivity, dielectric constant, refractive index etc. provide an indication about the molecular structure as well as the molecular interactions that occur when solute and solvent are mixed together. The density and sound velocity are two fundamental physicochemical properties of which are easy, simple, inexpensive and precise tools, by which one can get the valuable information about the

molecular interactions in solid and liquid mixture correlated with equilibrium and transport properties. From the above mentioned properties, quantitative conclusion can be drawn about the molecular interactions even in simple liquids or their mixtures. Our present investigation is based on the methods of physicochemical analysis, which is a useful tool in getting sound information about the structure of some aqueous ciprofloxacin with glucose, NaCl and KCl in studying the solute-solvent and solvent-solvent interactions in ternary systems.

### 1.3 Properties of glucose

Glucose is a simple sugar with the molecular formula $C_6H_{12}O_6$. The molar mass of glucose is 180.16 g/mol and density is 1.54 g/cm$^3$. It circulates in the blood of animals as blood sugar. It is made during photosynthesis from water and carbon dioxide, using energy from sunlight. It is the most important source of energy for cellular respiration. Glucose is stored as a polymer, in plants as starch and in animals as glycogen. Glucose can be obtained by hydrolysis of carbohydrates such as milk sugar (lactose), cane sugar (sucrose), maltose, cellulose, glycogen, etc. It is commonly commercially manufactured from cornstarch by hydrolysis via pressurized steaming at controlled $p^H$ in a jet followed by further enzymatic depolymerization [10].

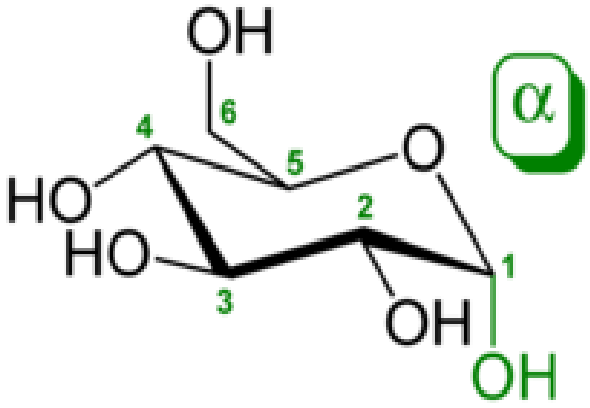



**Figure 1.1: Structure of glucose**

## 1.4 Properties of NaCl

The chemical formula of sodium chloride is NaCl. The molar mass of NaCl is 58.44 g/mol and density is 2.165 g/cm$^3$. Solid NaCl has a crystalline structure, in which each $Na^+$ ion is surrounded by six chloride ions ($Cl^-$) in an octahedral geometry. Sodium chloride is present in the sea and ocean waters, giving them their saltiness. About 1-5% of sea water is made of sodium chloride. It is also found as the mineral halite or rock salt.

Sodium chloride is best known as table salt and is used widely in the food industry for flavoring and preservation. Large quantities of sodium chloride are used in many industrial processes and it is a major source of sodium and chlorine compounds used as feed stocks for further chemical syntheses. A second major application of sodium chloride is de-icing of roadways in sub-freezing weather [11].

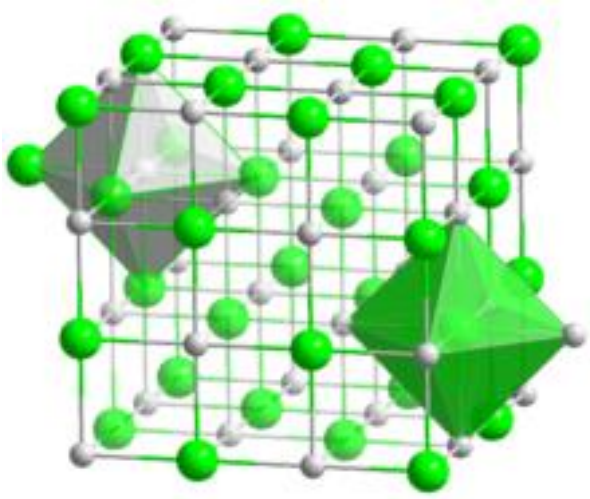


**Figure 1.2: Structure of Sodium chloride**

## 1.5 Properties of KCl

Potassium chloride (KCl) is a metal halide salt composed of potassium and chloride. The molar mass of NaCl is 74.5513 g/mol and density is 1.984 g/cm$^3$. It is odorless and has a white or colorless vitreous crystal appearance. The solid dissolves readily in water and its solutions have a salt-like taste. KCl is used as a fertilizer, in medicine, scientific applications, food processing, and used to cause cardiac arrest as the third drug in the "three drug cocktail" for executions by lethal injection. It occurs naturally as the mineral sylvite and in combination with sodium chloride as sylvinite [12].

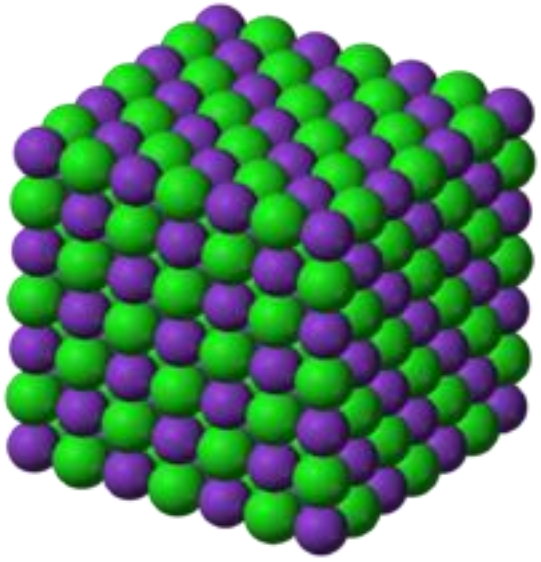


**Figure 1.2: Structure of Potassium Chloride**

## 1.6 Properties of ciprofloxacin

Ciprofloxacin is an antibiotic used to treat a number of bacterial infections [12]. Ciprofloxacin is 1-cyclopropyl-6-fluoro-1, 4-dihydro-4-oxo-7-(1-piperazinyl)-3-quinolinecarboxylic acid. Its empirical formula is $C_{17}H_{18}FN_3O_3$ and its molecular weight is 331.4 g/mol. It is a faintly yellowish to light yellow crystalline substance [13]. This includes bone and joint infections, intra-abdominal infections, certain type of infectious diarrhea, respiratory tract infections, skin infections, typhoid fever, and urinary tract infections, among others. For some infections it is used in addition to other antibiotics. It can be taken by mouth or used intravenously [14].

Ciprofloxacin is a broad-spectrum antibiotic of the fluoroquinolone class. It is active against both Gram-positive and Gram-negative bacteria. It functions by inhibiting DNA gyrase, and a type II topoisomerase, topoisomerase IV [15, 16], necessary to separate bacterial DNA, thereby inhibiting cell division. Ciprofloxacin is the most widely used of the second-generation quinolones [17, 18]. In 2010, over 20 million prescriptions were written, making it the 35th-most commonly prescribed generic drug and the 5th-most commonly prescribed antibacterial in the U.S [19].

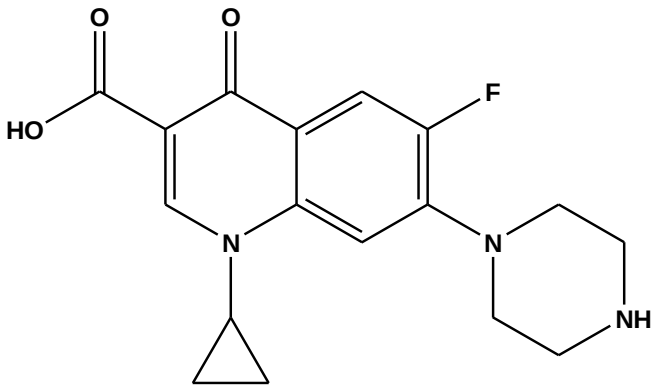



**Figure 1.4: Structure of ciprofloxacin**

## 1.7 Properties of water

Water has a very simple molecular structure. The nature of the molecular structure of water causes its molecules to have unique electrochemical properties. The hydrogen side of the water molecule has a slight positive charge. On the other side of the molecule a negative charge exists. This molecular polarity causes water to be a powerful solvent and is responsible for its strong surface tension.

When the water molecule makes a physical phase change its molecules arrange themselves in distinctly different patterns. The molecular arrangement taken by ice (the solid form of the water molecule) leads to an increase in volume and a decrease in density. Expansion of the water molecule at freezing allows ice to float on top of liquid water.

## 1.8 Structure of water

It has been recognized that water is an 'anomalous' liquid many of its properties is differ essentially from normal liquids of simple structures [20]. The deviations from regularity indicate some kind of association of water molecules. The notable unique physical properties exhibited by liquid water are [21] : i) negative volume of melting ii) density maximum in normal liquid range (at $4^0$ C) iii) isothermal compressibility minimum in the normal liquid range at ($46^0$ C) iv) numerous crystalline polymorphs v) high dielectric constant vi) abnormally high melting, boiling and critical temperatures for such a low molecular weight substance that is neither ionic nor metallic vii) increasing liquid fluidity with increasing pressure and viii) high mobility transport for $H^+$ and $OH^-$ ions pure water has a unique molecular structure. The O-H bond length is 0.096 nm and the H-O-H angle $104.5^0$. For a very long time the physical and the chemist have pondered over the possible structural arrangements that may be responsible for imparting very unusual properties to water. To understand the solute water interaction the most fundamental problem in solution chemistry the knowledge of water structure is a prerequisite. The physicochemical properties of aqueous solution in most of the cares are interpreted in terms of the structural change produced by solute molecules. It is

recognized that an understating of the structural changes in the solvent may be crucial to study of the role of water in biological systems.

Various structural models that have been developed to describe the properties of water may generally be grouped into two categories, namely the continuum model and the mixture models. The continuum models [22-23] treat liquid water as a uniform dielectric medium and when averaged over a large number of molecules the environment about a particular molecules is considered to be the same as about any other molecules that is the behavior of all the molecules is equivalent.

The mixture model theories [23-25] depict the water as being a mixture of short lived liquid clusters of varying extents consisting of highly hydrogen bonded molecules which are mixed with and which alternates role with non bonded monomers.

Among the mixture models, the flickering cluster of Frank and Wen [26], later developed by Nemethy and Scherage [27] is commonly adopted in solution chemistry. Properties of dilute aqueous solutions in terms of structural changes brought about by the solutes can be explained more satisfactorily using this model than any other model. According to this model the tetrahedral hydrogen bonded clusters, referred to as bulky water $(H_2O)_b$ , are in dynamic equilibrium with the monomers, referred to as dense water, $(H_2O)_d$ as represented by [28].

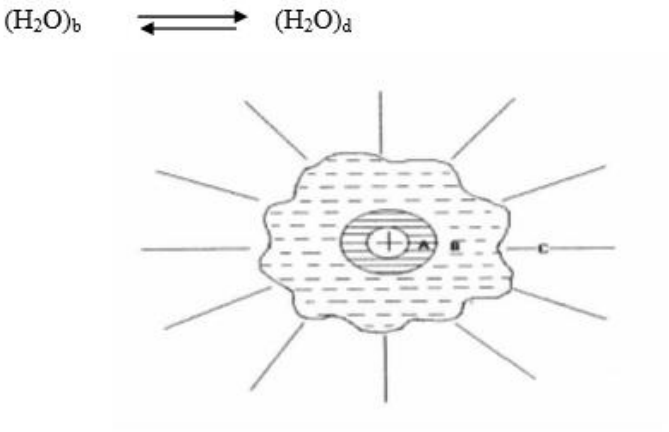



**Figure 1.5: Frank and Wen model for the structure modification produce by an ion**

The hydrogen bonding in the clusters is postulated [29] to be cooperative phenomenon. So that when one bond forms several others also come into existence. The properties of solution can be

accounted for in terms of solvent-solvent, solvent-solute and solute-solute interaction. In terms of thermodynamics, the concentration dependence of a given property extrapolated to the limit of infinite dilution provides a measure of solute-solvent interactions. Solute-water interaction or hydration phenomenon can be conveniently classified into three basic types:

i. Hydrophilic hydration
ii. Ionic hydration
iii. Hydrophobic hydration

The introduction of a solute into liquid water produces changes in the properties of the solvent which are analogous to these brought about by temperature or pressure. The solute that shifts the equilibrium to the left and increase the average half-life of the clusters is termed as structure maker whereas that which has an effect in the opposite direction is called 'Structure breaker'.

The experimental result on various macroscopic properties provides useful information for proper understanding of specific interactions between the components and the structure of the solution. The thermodynamic and transport properties are sensitive to the solute-solvent, solute-solute, and solvent-solvent interaction. In solution systems these three types of interaction are possible but solute-solute interaction are negligible at dilute solutions. The concentration dependencies of the thermodynamic properties are a measure of solute-solute interaction and in the limit of infinite dilutions these parameters serve as a measure of solute-solvent interactions. The solute induced changes in water structure also result in a change in solution viscosity.

## 1.9 Hydrophilic hydration

Solvation occurs as the consequences of solute-solvent interactions different from those between solvent molecules themselves. The solubilization of a solute molecule in water is characterized by changes in the water structure that depend on the nature of the solute.

Dissolution of any solute will disrupt the arrangement of water molecules in the liquid state and create a hydration shell around the solute molecule. If the solute is an ionic species, then this hydration shell is characterized to extend from an inner layer where water molecules near the charge species are strongly polarized and oriented by the electrostatic field, through an intermediate region where water molecules are significantly polarized but not strongly oriented, to an outer solvent region of bulk water where the water molecules are only slightly polarized by the electric field of the ion [30].

## 1.10 Hydrophobic hydration and hydrophobic interaction

The hydrophobic effect refers to the combined phenomena of low solubility and the entropy dominated character of the solvation energy of non-polar substances in aqueous media [31]. It is also reflected by anomalous behavior in other thermodynamic properties, such as the partial molar enthalpies, heat capacities and volumes of the non-polar solutes in water. This effect originated from a much stronger attractive interaction energy between the non-polar solutes merged in water than their vander waals interaction in free space [32]. The tendency of relativity non-polar molecules to "stick together" in aqueous solution is denoted as the hydrophobic interaction [33]. It results from hydrophobic hydration of a non-polar molecule. Because hydrophobic hydration plays an important role in facilitating amphiphiles to aggregates in the aqueous bulk phase and to absorb, excessively, at the aqueous solution/air interface, it has been an ongoing objective of chemists working in these areas to seek a clearer understanding of the molecular nature behind the subtle hydration phenomenon occurring between non-polar solutes and water. A brief but detailed account of the general aspects of hydrophobic hydration, which is essential to the rationalization of the results obtained in this work, is given at this point.

### 1.11 Glucose, NaCl and KCl-solvent systems

The study of volumetric and sound velocity of solution containing glucose, NaCl, KCl and drug (ciprofloxacin) are interesting. The experimental data on volumetric and ultrasonic properties provide valuable information for proper understanding the nature of interaction between the components of the solution. The correlation between solute-solvent interactions is complex. The environment of the solute affects the volumetric and sound velocity properties; it is of interesting to study the effect of the media changing from water-drug (ciprofloxacin) with glucose, NaCl and KCl on the thermodynamic properties. Research on density and optical properties of ciprofloxacin hydrochloride + aqueous-glucose mixtures at $30^{\circ}$ C has been reported [34]. Acoustic and volumetric properties of ciprofloxacin hydrochloride have been measured in dioxane-water mixture at 303.3 K previously [35].

### 1.12 The object of the present work

The developments in solution theory are still far from being adequate to account for the properties of the constituent molecules. Accordingly, it is the experimental data on various volumetric and ultrasonic properties, which provide useful information for proper understanding of specific interaction between the components and structure of the solution. The experimental approach of measurements of various macroscopic properties is also useful in providing guidance to theoretical approaches, since the experimentally determined values of solution properties may bring to light certain inadequacies in the proposed model on which theoretical treatments may be based. Volumetric and ultrasonic studies on ternary solutions have attracted a great deal of attention and experimental data on a good number of systems are available in a number of review articles [36, 37]. Since there has to be the same origin, namely, the characteristic intermolecular interactions, it is natural to seek functional relationships among the volumetric properties, ultrasonic properties and thermodynamic properties. However, such attempts have not met with much success.

Besides the theoretical importance, the knowledge of physicochemical properties of multicomponent mixtures is indispensable for many chemical process industries. For instance, in petroleum, petrochemical and related industries the above mentioned processes are commonly used to handle the mixture of hydrocarbons, alcohols, aldehydes, ketones etc. which exhibit ideal to non-ideal behavior. For accurate design of equipment required for these processes, it is necessary to have information regarding the interactions between the components. Similarly, knowledge of the sound velocity of liquids/mixtures is indispensable. Sound velocity and density data yield a lot of information on the nature of intermolecular interaction and mass transport.

The experimental data on volumetric and ultrasonic properties such as apparent molar volumes, partial molar volumes, apparent molar adiabatic compressibility and hydration number often provide valuable information for the understanding of the nature of homo and hetero-molecular interactions. The knowledge of the main factors involved in the solute-solvent and solvent-solvent interactions of liquid mixtures is fundamental for a better understanding of apparent molar volumes and ultrasonic properties.

The thermo-physical properties of liquid systems like density and sound velocity are strictly related to the molecular interactions taking place in the system [38]. The studies of glucose, NaCl and KCl express the interaction of dipolar ions with other functions and components in the biological system [39]. The interactions are of different types such as ionic or covalent, charge transfer, hydrogen bonding, ion-dipole and hydrophobic interactions. There are various papers appeared recently which use volumetric and ultrasonic method to access physiochemical parameters of biological molecule and interpreted the solute-solvent interactions [40-41]. Therefore we decided to study the density and sound velocities properties of glucose, NaCl and KCl in mixed solvent system.

In the present investigations, (i) densities, apparent molar volumes, partial molar volumes, apparent molar expansibilities (ii) sound velocities, apparent molar adiabatic compressibility, hydration number, acoustic impedance, relative association parameters of aqueous ciprofloxacin with glucose, NaCl and KCl at six different temperatures (293.15-318.15 K) have been determined. Research on density and sound velocity study of ciprofloxacin in aqueous glucose, NaCl and KCl solution has been reported by a researcher [42]. To the best of

our knowledge, no data on density, sound velocity, apparent molar volume, partial molar volume, adiabatic compression and isobaric expansion of ciprofloxacin in aqueous glucose, NaCl and KCl solutions at different temperatures under atmospheric pressure has previously been reported. With these points of view, we have undertaken this research and the measurement of density and sound velocity are thought to be powerful tools to investigate the intermolecular interactions of biological component glucose, NaCl and KCl with aqueous ciprofloxacin which are focused in this study. In order to understand the issue of solute-solvent interactions in aqueous solution of ciprofloxacin-glucose, NaCl and KCl systems a theoretical and experimental aspect of interactions in terms of apparent molar volume, partial molar volume, adiabatic compression and sound velocity properties analysis is necessary.

The specific aims of this study are-

i) to measure the density and sound velocity of ciprofloxacin in aqueous glucose, NaCl and KCl solution at different temperature,

ii) to understand the effect of ciprofloxacin on the structure of glucose, NaCl and KCl in solution,

iii) to predict about the structure making or breaking mechanism of ciprofloxacin in aqueous and aqueous glucose, NaCl and KCl systems,

iv) to examine the apparent molar volume, limiting apparent molar volume, apparent molar volume transfer, partial molar volume, apparent molar volume expansibilities, isentropic compression, acoustic impedance and relative association of the studied systems at different temperature,

v) to determine the hydration number of glucose, NaCl and KCl in binary and ternary systems.

# CHAPTER II

# Theoretical Background

## 2.1 Physical Properties and chemical constitutions

In interpreting the composition, the structure of molecules and the molecular interaction in the binary and ternary systems, it is inevitable to find out the size and the shape of the molecules and the geometry of the arrangement of their constituent atoms. For this purpose, the important parameters are bond lengths or interatomic distance and bond angles. The type of atomic and other motions as well as the distribution of electrons around the nuclei must also be ascertained; even for a diatomic molecule a theoretical approach for such information would be complicated. However the chemical analysis and molecular weight determination would reveal the composition of the molecules, and the study of its chemical properties would unable one to ascertain the group or sequence of atoms in a molecule. But this cannot help us to find out the structures of molecules, as bond length, bond angles, internal atomic and molecular motions, polarity etc. cannot be ascertained precisely.

For such information it is indispensable to study the typical physical properties, such as absorption or emission of radiations, refractivity, light scattering, electrical polarization, magnetic, susceptibility, optical rotations etc. The measurement of bulk properties like density, surface tension, viscosity etc. are also have gained increased importance during the recent years, because not only of their great usefulness in elucidating the composition and structure of molecules, but also the molecular interaction in binary and ternary systems.

The various physical properties based upon the measurement of density, viscosity, surface tension, refractive index, dielectric constant etc. have been found to fall into the following four categories [43].

i. Purely additive properties: An additive property is one, which for a given system is the sum of the corresponding properties of the constituents. The only strictly additive property is mass, for the mass of a molecule is exactly equal to the sum of the masses of its constituent atoms, and similarly the mass of a mixture is the sum of the separate masses of the constituent parts. There are other molecular properties like molar volume, radioactivity etc. are large additive in nature.

ii. Purely constitutive properties: The property, which depends entirely upon the arrangement of the atoms in the molecule and not on their number is said to be a purely constitutive property. For example, the optical activity is the property of the asymmetry of the molecule and occurs in all compounds having an overall asymmetry.

iii. Constitutive and additive properties: These are additive properties, but the additive character is modified by the way in which the atom or constituent parts of a system are linked together. Thus, atomic volume of oxygen in hydroxyl group ($OH^-$) is 7.8 while in kenotic group (=CO) it is 12.2. The parachor, molar refraction, molecular viscosity etc. are the other example of this type.

iv. Colligative properties: A colligative property is one which depends primarily on the number of molecules concerned and not on their nature and magnitude. These properties are chiefly encountered in the study of dilute solutions. Lowering of vapor pressure, elevation of boiling point, depression of freezing point and osmotic pressure of dilute solutions on the addition of non-volatile solute molecules are such properties.

## 2.2 Density

The density of a liquid may be defined as the mass per unit volume of the liquid unit of volume being the cubic centimeter ($cm^3$) or milliliter (mL). Since the milliliter is defined to be the volume occupied by one gram of water at temperature of maximum density (i.e., at $4^0$ C), the density of water at this temperature in $gmL^{-1}$ is unity and the density of water at any other temperature is expressed relative to that of water at $4^0$C and expressed by ($d^{10}_4$).

The relative density of a substance is the ratio of the weight of a given volume of the substance to the weight of an equal volume of water at the same temperature ($d^{10}_4$). The absolute density of a certain substance temperature $t^0$ C is equal to the relative density multiplied by the density of water at the temperature. The density of a liquid may be determined either by weighing a known volume of the liquid in a density bottle or picnometer or by buoyancy method based on "Archimedes principle".

In our present investigation, the densities of the pure components and the mixture were determined by weighing a definite volume of the respective liquid in a density bottle.

## 2.3 Density and temperature

An increase in temperature of a liquid slightly increases the volume of the liquid, thus decreasing its density to some extent. The temperature increase brings about an increase in molecular velocity. These energetic molecules then fly apart causing more holes in the bulk of the liquid. This causes the expansion of the liquid, thereby decreasing the number of molecules per unit volume and hence the density.

## 2.4 Molarity

Molarity (C), is defined as the number of moles of solute per liter of solution. If $n_2$ is number of moles of solute and V liters is the volume of the solution then,

$$Molarity(C) = \frac{Number\ of\ moles\ of\ solute}{Volume\ of\ solution}$$

Or, $C = \frac{n_2}{V}$……..…….….. (2.1)

For one mole of solute dissolved in one liter of solution, C=l i.e., molarity is one. Such a solution is called 1 molar. A solution containing two moles of solute in one liter is 2 molar and so on. As evident from expression (2.1), unit of molarity is $molL^{-1}$ [44].

## 2.5 Molar volume of mixtures

The volume in mL occupied by one gram of any substance is called its specific volume and the volume occupied by 1 mole is called the molar volume of the substance. Therefore, if ρ is the density and M is the molar mass, we have the molality (m) of a solution is defined as the number of moles of the solute per 1000 g of solvent [44]. Mathematically,

$$\text{Molality(m)} = \frac{\text{Number of moles of solute}}{\text{Weight of solvent in gram}} \times 1000$$

$$\text{Or, } m = \frac{\frac{a}{M_2} \times 1000}{\text{Volume of solvent in mL} \times \text{Density of solvent in g cm}^{-3}}$$

$$\text{Or, } m = \frac{\frac{a}{M_2} \times 1000}{V_1 \times \rho_0}$$

$$\text{Or, } m = \frac{a}{M_2} \times \frac{1000}{V_1 \times \rho_0} \quad \text{.....(2.2)}$$

Where,

a = Weight of solute in gram

$M_2$ = Molecular weight of solute in gram

$V_1$ = Volume of solvent in mL

$\rho_0$ = Density of solvent in g $cm^{-3}$

Specific volume, $(V) = \frac{1}{\rho} mLg^{-1}$……..…..(2.3)

And Molar volume, $(V_m) = \frac{M}{\rho} mLmol^{-1}$…….……....…….(2.4)

When two components are mixed together, there may be either a positive or a negative deviation in volume. The positive deviation in volume i.e., volume expansion has been explained by the breakdown of the mode of association through H-bonding of the associated liquids. The negative deviation in molar volume i.e. volume contraction has been thought of by many observers, as arising from the i) compound formation through association, ii) decrease in the intermolecular distance between the interacting molecules, iii) interstitial accommodation of smaller species in the structural network of the larger species and (iv) change in the bulk structure of either of the substance forming the mixture.

## 2.6 Apparent/ partial molar volume

The apparent molar volume of a solute in solution, generally denoted by is defined by $\varphi_v$ the relation [45]

$$\varphi_v = \frac{V - n\bar{V}_1^0}{n_2} \quad \text{……..(2.5)}$$

Where, V is the volume of solution containing $n_1$ moles of solvent and $n_2$ moles of solute and $\bar{V}_1^0$ is the molal volume of the pure solvent at specified temperature and pressure. For binary solution, the apparent molar volume ($\varphi_v$) of an electrolyte in an aqueous solution is given by [44],

$$\varphi_v = \frac{1}{n_2}\left[\frac{n_1M_1 + n_2M_2}{\rho} - n_1\bar{V}_1^0\right]$$

Where,

$V = \frac{n_1M_1 + n_2M_2}{\rho}$ and

$n_1$ and $n_2$ are the number of moles, $M_1$ and $M_2$ are molar masses of the solvent and solute respectively and ρ is the density of the solution. For molal concentration, $n_2$ = m, the molality and $n_1$ = 55.51, the number of moles of solvent in 1000 g of solvent (water), the equation for apparent molal volume takes the form [50, 51]

$$\varphi_v = \frac{1}{m}\left[\frac{1000 + mM_2}{\rho} - \frac{1000}{\rho_0}\right]$$

Or, $$\varphi_v = \left[\frac{M_2}{\rho} - \frac{1000(\rho - \rho_0)}{m\rho\rho_0}\right] \quad \text{.....(2.7)}$$

Or, $$\varphi_v = \frac{1}{\rho}\left[M_2 - \frac{1000}{m}\left(\frac{W - W_0}{W_0 - W_e}\right)\right] \quad \text{.....(2.8)}$$

where, $\rho_o$ and ρ are the densities of the solvent and solution and $W_e$, $W_0$ and W are the weight of empty bottle, weight of bottle with solvent and weight of bottle with solution respectively.

If the concentration is expressed in molarity (C), the equation 2.8 takes the form [50]:

$$\varphi_v = \left[\frac{M_2}{\rho_0} - \frac{1000(\rho - \rho_0)}{C\rho_0}\right] \quad \text{..... (2.9)}$$

Where, the relation, $$C = \frac{m.\varphi_v.1000}{1000 + \varphi_v.m.\rho_0} \quad \text{..... (2.10)}$$

is used for inter conversion of the concentration in the two scales [52].

The partial molal property of a solute is defined as the change in property when one mole of the solute is added to an infinite amount of solvent, at constant temperature and pressure, so that the concentration of the solution remains virtually unaltered. If Y represents partial molal property of a binary solution at constant temperature and pressure, Y will then be a function of two independent variables $n_1$ and $n_2$, which represent the number of moles of the two components present. The partial molar property of component one is then defined by the relation:

$$\overline{Y_1} = \left(\frac{\delta Y}{\delta n_1}\right)_{n_2,P,T} \quad \text{.....(2.11)}$$

Similarly for component 2

$$\overline{Y_2} = \left(\frac{\delta Y}{\delta n_2}\right)_{n_{12},P,T} \quad \text{.....(2.12)}$$

The partial molar property is designated by a bar above the letter representing the property and by a subscript, which indicates the components to which the value refers. The usefulness of the concept of partial molar property lies in the fact that it may be shown mathematically as,

$Y_{(n_1,n_2)} = n_1\overline{Y_1} + n_2\overline{Y_2}$ at constant T and P .....(2.13)

In respect of the volume of solution, equation 2.5 gives directly

$V = n_1\overline{V_1} + n_2\overline{V_2}$ at constant T and P .....(2.14)

The partial molar volumes of solute and solvent can be derived using the equation 2.5 as follows [49]

$$\overline{V_2} = \left(\frac{\delta V}{\delta n_2}\right)_{P,T,n_1} = \varphi_v + n_2\left(\frac{\delta \varphi_v}{\delta n_2}\right)_{P,T,n_1} = \varphi_v + m\left(\frac{\delta \varphi_v}{\delta m}\right)_{P,T,n_1} \quad \text{.....(2.15)}$$

and

$$\overline{V_1} = \frac{\left(V - n_2\overline{V_2}\right)}{n_1} = \frac{1}{n_1}\left[ n_1\overline{V_1^0} - n_2^2\left(\frac{\delta \varphi_v}{\delta n_2}\right) \right]_{P,T,n_1} = \overline{V_1^0} - \frac{m^2}{55.51}\left(\frac{\delta \varphi_v}{\delta m}\right)_{P,T,n_1} \quad \text{.....(2.16)}$$

For solutions of simple electrolytes, the apparent molar volumes ($\varphi_v$) vary linearly with $\sqrt{m}$, even up to moderate concentrations. This behavior is in agreement with the prediction of the Debye-Huckel theory of dilute solutions as [46]:

$$\frac{\delta \varphi_v}{\delta m} = \frac{\delta \varphi_v}{\delta \sqrt{m}} \cdot \frac{\delta \sqrt{m}}{\delta m} = \frac{1}{2\sqrt{m}} \cdot \frac{\delta \varphi_v}{\delta \sqrt{m}} \quad \text{.....(2.17)}$$

If $\varphi_v$ is available as a function of molal concentration, the partial molar volumes of solute and solvent can be obtained from equation 2.15 and 2.16 as:

$$\overline{V_2} = \varphi_v + \frac{\sqrt{m}}{2}\left(\frac{\delta\varphi_v}{\delta\sqrt{m}}\right) = \varphi^0{}_v + \frac{3\sqrt{m}}{2}\left(\frac{\delta\varphi_v}{\delta\sqrt{m}}\right) \quad \text{.....(2.18)}$$

and,

$$\overline{V_1} = \overline{V_1^0} - \frac{m}{55.51}\left(\frac{\sqrt{m}}{2}.\frac{\delta\varphi_v}{\delta\sqrt{m}}\right) = V_1^0 - \frac{M_1 m^{3/2}}{2000}\left(\frac{\delta\varphi_v}{\delta\sqrt{m}}\right) \quad \text{.....(2.19)}$$

Where, $\varphi^0{}_v$ is the apparent molal volumes at zero concentration. When molar concentration scale is used to express $\varphi_v$ as a function of concentration, then

$$\overline{V_2} = \varphi_v + \left[\frac{1000 - C\varphi_v}{2000 + C^{3/2}\left(\frac{\delta\varphi_v}{\delta\sqrt{C}}\right)}\right]\sqrt{C} \quad \text{.....(2.20)}$$

and,

$$\overline{V_1} = \frac{2000\overline{V_1}^0(18.016/\rho_0)}{2000 + C^{3/2}\left(\frac{\delta\varphi_v}{\delta\sqrt{C}}\right)} \quad \text{.....(2.21)}$$

From equation 2.18 and 2.20, it follows that at infinite dilution, (m or c → 0), the partial molar volume and the apparent molar volume are identical. To obtain reliable $\varphi_v$ values, it is necessary to measure the density ρ, with great precision because errors in ρ contribute, considerably to the uncertainties in $\varphi_v$.

The concentration dependence of the apparent molar volume of electrolytes has been described by the Masson equation [49], the Redlich-Mayer equation [51] and Owen Brinkley equation [50]. Masson [49] found that the apparent molar volume of the electrolytes vary with the square root of the molar concentration as,

$$\varphi_v = \varphi_v^0 + S_v\sqrt{c} \quad \text{(2.22)}$$

Where, $S_v$ is the experimental slope depending on the nature of the electrolyte.

Redlich and Rosenfeld predicated that a constant limiting slope $S_v$, should be obtained for a given electrolyte charge type if the Debye-Huckel limiting law is obeyed. By differentiating the Debye-Huckel limiting law for activity coefficients with respect to pressure, the theoretical limiting law slope $S_v$, could be calculated using the equation,

$$S_v = KW^{3/2} \quad \text{(2.23)}$$

Where, the terms K and W are given by

$$K = N^2 e^3 \left(\frac{8\pi}{100 D^3 RT}\right)^{1/2} \left\{\left(\frac{\delta \ln D}{\delta \rho}\right) - \left(\frac{\beta}{3}\right)\right\} \quad \text{(2.24)}$$

And $W = 0.5\sum \gamma_i Z_i^2$ (2.25)

Where, β is the compressibility of the solvent, $\gamma_i$ is the number of ions of the species i of valency $Z_i$ formed by one molecule of the electrolyte and the other symbols have their usual significance [51]. For dilute solutions the limiting law for the concentration dependence of the apparent molar volume of electrolytes is given by the equation,

$$\varphi_v = \varphi_v^0 + KW^{3/2}\sqrt{C} \quad \text{(2.26)}$$

And for not too low concentrations, the concentration dependence can be represented as,

$$\varphi_v = \varphi_v^0 + S_v\sqrt{C} + b_v C \quad \text{(2.27)}$$

Where, $S_v$, is the theoretical limiting law slope and $b_v$ an empirical constant for 1:1 electrolyte, the limiting law slope at 298.15 K is 1.868 $cm^3 mol^{-3/2}$. $L^{1/2}$.

## 2.7 Theory of ultrasonic velocity

Sound is propagated through a medium by longitudinal waves. A longitudinal wave is a type of periodic motion in which the displacement of the particles in the medium occurs in the same direction as the wave itself. A schematic diagram of a longitudinal sound wave is shown in Figure 2.1. For simplicity a one-dimensional wave is depicted, one can imagine that sound generated by an oscillating boundary at the left, is traveling to the right through a medium. The motion of the sound wave is a function of both time and space. The figure can be viewed as a density contour map of the medium. The darker areas have higher density; these are periodic compressions (C). The lighter areas have lower density; these are periodic expansions, or refractions (R). The density of the fluid ahead of the wave front is the undisturbed bulk density ( ρ), which is intermediate between the local densities of the medium C and R.

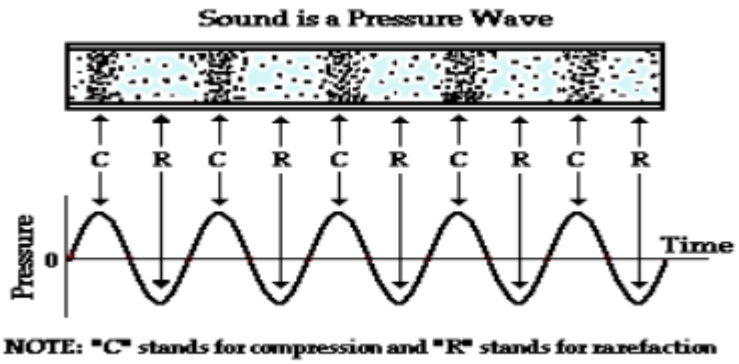



Figure 2.1: Schematic diagram of a longitudinal standing wave; C and R show positions of medium compressions and refractions (high and low densities) respectively.

When a layer of fluid medium is compressed or rarefied during the passage of a sound wave, the pressure in the layer changes from the equilibrium pressure. The amount of pressure changed is defined as the excess pressure or sound pressure or acoustic pressure. Considering the acoustic pressure an equation for sound wave [52] or sound velocity can be derived, which is expressed as,

$$u = \left(\frac{1}{\rho\beta}\right)^{1/2} \quad \text{(2.28)}$$

Where, ρ is the equilibrium density and β is the compressibility, which is the reciprocal of bulk modulus, k, of medium, given by

$$\beta = k^{-1} = -\frac{1}{v}\left(\frac{\partial v}{\partial P}\right) \quad \text{.....(2.29)}$$

Where, $\partial_V$ = volume changed during the passage of sound

$\partial$P = acoustic pressure

V = volume of medium at equilibrium

An important aspect of sound propagation as the fact that if the frequency of the sound being generated by high enough i.e., audio frequencies which are between $10^3$ and $10^4$ Hz.

(Oscillations per second), the compressions and refractions are established very rapidly as the sound way moves through the medium. This condition means that heat transport between the compressed and rarefied regions of the medium and the surroundings is slow relative to the creations of the compressions and refractions. Thus, on a local basis, the compressions and refractions are carried out adiabatically. At much lower sound frequencies, on the other hand, it is possible to imagine that heat transport between the medium and the surroundings is fast enough to allow the medium to be compressed and expanded isothermally (if the thermal mass of the surroundings is large enough). Accordingly, the compressibility β can be described under constant-temperature or constant-energy conditions, and one can thus distinguish between isothermal and adiabatic compressibility's of a substance, $\beta_T$, and $\beta_S$ respectively. Since audio frequencies are used in this experiment, we must use the adiabatic (or isentropic) , which can be explicitly written as,

$$\beta_s = -\frac{1}{v}\left(\frac{\partial v}{\partial P}\right)_s \quad \text{..... (2.30)}$$

Writing βs instead of β in equation (3.36) gives the Newton-La place equation of the form

$$u = \left(\frac{1}{\rho\beta_s}\right)^{1/2} \quad \text{..... (2.31)}$$

Various attempts [53-58] have been made to calculate theoretically ultrasonic sound velocity through binary mixtures.

## 2 .8 Adiabatic Compressibility

A more convenient path is to use the Newton-La Place equation to get the adiabatic Compressibility from speed of sound and density data. Rearranging equation (2.31) yields

$$\beta_s = \frac{1}{\rho u^2} \quad \text{..... (2.32)}$$

Differentiating equation (2.31) with respect to pressure, P at constant entropy and Combining the above equations with its yields the expression of apparent molar adiabatic compressibility $\varphi_{\beta,s}$

$$\varphi_{\beta,s} = \left(\frac{M\beta_s}{\rho}\right) - \left(\frac{\beta_{s,op} - \beta_s \rho_0}{m\rho\rho_0}\right) \quad \text{..... (2.33)}$$

Where, zero (0) in subscript and superscript refers to pure solvent (water) and symbols have their usual meaning.

## 2.9 Acoustic Impedance

Sound travels through materials under the influence of sound pressure. Because molecules or atoms of a solid are bound elastically to one another, the excess pressure results in a wave propagating through the solid. The acoustic impedance is important in i) the determination of acoustic transmission and reflection at the boundary of two materials having different acoustic impedance, ii) the design of ultrasonic transducers and iii) assessing absorption of sound in a medium. Mathematically, it is defined as,

$$Z = u\rho \quad \text{..... (2.34)}$$

Where, ρ and u are the densities and ultrasonic speeds of the mixture respectively.

## 2.10 Relative association

The relative association is defined as a measure of the extent of interaction between the component molecules in a real mixture relative to that in an ideal one

$$R_A = \left(\frac{\rho}{\rho_0}\right)\left(\frac{u_0}{u}\right) \quad \text{.....(2.35)}$$

Where $\rho$, $\rho_o$ and u, $u_o$ are the densities and ultrasonic speeds of the solution and solvent respectively.

## 2.11 Hydration number

Hydration number is the number of molecules of water with which an ion can combine in an aqueous solution of given concentration. Hydration number has been computed using the relation

$$n_H = \frac{n_1}{n_2}\left(1 - \frac{\beta_s}{\beta_{s,o}}\right) \quad \text{.....(2.36)}$$

Where, $n_H$ denotes the hydration number. $\beta_s$, $\beta_{s,o}$ are adiabatic compressibility's of solution and solvent respectively and $n_1$ and $n_2$ are number of moles of solvent and solute respectively.

# CHAPTER III

## Experimental

During the course of the present work constant efforts for attaining the ideal conditions for the experiments were always attempted. The glass pieces were thoroughly cleaned and dried in oven before used.

The following systems have been carried for the investigation of molecular interactions of glucose, NaCl and KCl with water and in aqueous solution of ciprofloxacin.

1. Water + glucose
2. Water + NaCl
3. Water + KCl
4. Water + glucose + 0.03 $mol.kg^{-1}$ciprofloxacin
5. Water + glucose + 0.045 $mol.kg^{-1}$ciprofloxacin
6. Water + glucose + 0.06 $mol.kg^{-1}$ciprofloxacin
7. Water + NaCl + 0.03 $mol.kg^{-1}$ciprofloxacin
8. Water + NaCl+ 0.045 $mol.kg^{-1}$ciprofloxacin
9. Water + NaCl+ 0.06 $mol.kg^{-1}$ciprofloxacin
10. Water + KCl + 0.03 $mol.kg^{-1}$ ciprofloxacin
11. Water + KCl + 0.045 $mol.kg^{-1}$ ciprofloxacin
12. Water + KCl + 0.06 $mol.kg^{-1}$ ciprofloxacin

All experiments have been carried out at six equidistant temperature viz. 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K over the aqueous 0.03, 0.045 and 0.06 $mol.kg^{-1}$ compositions, where m represents the molality of solution. The detail information have been described in the following sections.

## 3.1 Materials

The chemicals used for study were –glucose, NaCl and KCl and ciprofloxacin. All chemicals were of analytical reagent (A.R) grade. Specifications and structural formula for all of them are given below:

| **Chemicals** | **Molecular formula** | **Molar mass** | **Reported purity** | **Producer** |
|---|---|---|---|---|
| Ciprofloxacin | $C_{17}H_{18}FN_3O_3$ | 331.346 | 99.42% | SIGMA-ALDRICH, Germany |
| Glucose | $C_6H_{12}O_6$ | 180.16 | 99.5% | SIGMA-ALDRICH, Germany |
| Sodium Chloride | NaCl | 58.44 | 99.5% | SIGMA-ALDRICH, Germany |
| Potassium Chloride | KCl | 74.55 | 99.5% | SIGMA-ALDRICH, Germany |

## 3.2 Apparatus

A HR-200 electronic balance with an accuracy of ±0.0001g was used for the mass determination. Densities and speeds of sound was measured by an Anton Paar DSA 5000 model high precision vibrating tube digital density meter and speed of sound measuring device, with automatic velocity corrections.

### 3.3 Preparation of solution

The solutions were prepared immediately before the measurement. The binary solutions were prepared by mixing appropriate mass of the components. The amount of each component was later converted into the molality. The molalities of all samples are controlled to ±0.00005 $mol.kg^{-1}$. Precautions were taken to prevent the introduction of moisture into the experimental example. Each time, the solution was prepared immediately before the density measurement.

### 3.4 Density and sound velocity measurements

The density of liquid may be define as the mass per unit volume of the liquid, the unit of volume being the cubic centimeter ($cm^3$) or millimeter. Since the millimeter is defined to be the volume occupied by one gram of water at temperature in $gmL^{-1}$ is unity and the density of water at any other temperature is expressed relative to that of water at $4^0$ C. The absolute density of a certain substance at temperature $t^0$ C is equal to the relative density multiplied by the density of water at the temperature. Density and sound velocity of pure liquid and liquid-liquid mixtures was measured using high precession vibrating tube digital densitometer (Anton Paar, DSA -5000, Austria). The density and sound velocity values have been found with an error of ±0.000006 $gcm^{-3}$ and ±0.05 $ms^{-1}$ respectively. The method is based on the principle of time lapse measurement for certain member of oscillations of a vibrating U-shaped sample tube fill with the sample liquid. At constant temperature, the natural vibrational period of the U- tube is related to density of liquid filling the tube. In the latest version of Anton Paar digital density meter (DSA -5000), the natural vibration period is automatically converted into the density value and display directly on the LC display monitor of the decimeter. The DSA -5000 density measuring cell consists of a cell consists of a U-shaped oscillator glass cylinder. The temperature of the sample tube is controlled by two integrated in-built Pt 100 platinum thermometers to a level of highest accuracy and traceable to national standard. The temperature of the sample tube is controlled to ± 0.001 K. The design of the cell ensures identical volumes

to be used for the measurement on different samples. Using a polyethylene syringe the sample was continuously and slowly injected from the upper part of U tube until the excess fluid flowed out of the lower part. This ensured that the inner surface of the cell was completely wet and there are no micro bubbles inside the U-tube. The syringe was kept as such in plugged. After the measurement the sample was removed and air was passed, by built in pump, through the tube to remove excess liquid. The tube was then rinsed several times with the solution of higher concentration and finally the solution was injected for the measurement. Measuring the density of water supplied with the densitometer checked the working of the densitometer. All measurements were made starting from the lowest to the highest solute concentration.

### 3.5 Apparent/ Partial molar volume measurements

The apparent molar volumes of the solution for binary and ternary systems were determined from density measurement using the following equation [45, 46]:

$$\varphi_v = \frac{1}{\rho}\left\{M_2 - \frac{1000}{m}\left(\frac{\rho-\rho_0}{\rho_0}\right)\right\}$$

Or, $$\varphi_v = \frac{1000}{m\rho\rho_0}(\rho_0-\rho)+\frac{M_2}{\rho} \quad \text{.....(3.1)}$$

Where, ρ is the density of the experimental solution, $M_2$ and m are the molar mass and molality of the electrolyte respectively and $\rho_0$ is the density of the solvent. The molality 'm' of a solution was calculated from mole fraction of solute and solvent

$$m = \frac{X_2 \times 1000}{X_1 M_1}$$

Where, $M_1$ and $M_2$ = the molecular weight of solvent and solute

And also from molarity C,

$$m = \frac{1}{\left(\frac{\rho}{C} - \left(\frac{M_2}{1000}\right)\right)} \quad \text{.....(3.2)}$$

Where, C is the molarity, $M_2$ is the solute molecular weight and ρ is the density of the solution respectively.

The molarity 'C' of a solution was calculated from the following equation

$$C = \frac{1}{M_2} \times \frac{a}{\text{vol. of solution in liter}} \quad \text{.....(3.3)}$$

Where, a = weight of the solute (electrolyte) in gm, $M_2$ = solute molecular weight.

Molar volume of solvent (pure water) at experimental temperature was calculated using the following equation [45].

$$\overline{V}_1^0 = \frac{\text{Molecular masses of solvent}}{\text{Density of solvent (at expt. temp.)}} \quad \text{.....(3.4)}$$

The partial molar volumes of the solute and solvent can be obtained from density measurement using the following equation.

$$\overline{V}_2 = \varphi_v + \frac{\sqrt{m}}{2}\left(\frac{\delta\varphi_v}{\delta\sqrt{m}}\right) = \varphi^0{}_v + \frac{3\sqrt{m}}{2}\left(\frac{\delta\varphi_v}{\delta\sqrt{m}}\right) \quad \text{.....(3.5)}$$

Where, $\varphi^0{}_v$ = apparent molar volumes at zero concentration.

$$\text{and, } \overline{V}_1 = V_1^0 - \frac{M_1 m^{3/2}}{2000}\left(\frac{\delta\varphi_v}{\delta\sqrt{m}}\right) \quad \text{.....(3.6)}$$

The values of $\frac{\delta\varphi_v}{\delta\sqrt{m}}$ were obtained from the slope of the plot of $\varphi_v$ against $\sqrt{C}$ by the use of Masson (43) equation and the apparent molar volume of solutes at infinite dilution ($\varphi_v^0 \approx \bar{V}_2^0$) were determined from the intercept of the plot, at C equal to zero.

### 3.6 Limiting apparent molar volume of transfer

Limiting apparent molar volume of transfer can be obtained from using the following equation,

$\Delta \varphi_v^0 = \varphi_v^0$ (in aq. ciprofloxacin solution) - $\varphi_v^0$ (in water) ……. (3.7)

Where, $\varphi_v^0$ is limiting apparent molar volume.

### 3.7 Temperature dependent limiting apparent molar volume

At infinite dilution, the variation of limiting apparent molar volumes i.e. ($\Phi_v^0$) with the temperature can be expressed by the general polynomial equation as follows:

$\varphi_v^0 = A + B (T-Tm) + C (T-Tm)^2$ …….. (3.8)

Where, T is the temperature in Kelvin, $T_m$ is the average temperature A, B and C are the empirical constants.

The limiting apparent molar expansibilities are calculated as follows:

$E_\varphi^0 = B + 2C (T-T_m)$ ……. (3.9)

Hepler developed the general thermo-dynamic expression to determine the capacity of solute as a structure maker or structure breaker in mixed solvent system using general thermodynamic expression [59]:

$(\delta E^0\varphi/\delta T)_p = 2C$ ……..(3.10)

### 3.8 Adiabatic Compressibility measurements

The adiabatic compressibility, $\beta_s$ of the solution for binary and ternary systems were determined from density and sound velocity data using the following equation,

$$\beta_s = \frac{1}{\rho u^2} \quad \text{.....(3.11)}$$

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

### 3.9 Apparent molar Adiabatic Compressibility measurements

The apparent molar adiabatic compressibility, $\beta_s$ of the solution for binary and ternary systems were determined from density and sound velocity data using the following equation,

$$\varphi_{\beta,s} = \left(\frac{M\beta_s}{\rho}\right) - \left(\frac{\beta_{s,op} - \beta_s \rho_0}{m\rho\rho_0}\right) \quad \text{.....(3.12)}$$

Where, ρ and $\rho_o$ are the density of the experimental solution and solvent, m is the molarity of the solution and $\beta_s$ and $\beta_{s,o}$ are the adiabatic compressibility of the experimental solution and solvent.

### 3.10 Acoustic Impedance measurements

The acoustic impedance, Z is of the solution for binary and ternary systems were determined from density and sound velocity data using the following equation,

$$Z = u\rho \quad \text{..... (3.13)}$$

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

### 3.11 Relative association measurements

The relative associations, $R_A$ of the solution for binary and ternary systems were determined from density and sound velocity data using the following equation,

$$R_A = \left(\frac{\rho}{\rho_0}\right)\left(\frac{u_0}{u}\right) \quad \text{..... (3.14)}$$

Where, $\rho$,$\rho_o$ and u, $u_o$ are the densities and ultrasonic speeds of the experimental solution and solvent.

### 3.12 Hydration number

The hydration number, $n_H$ of the solution for binary and ternary systems were determined from density and sound velocity data using the following equation,

$$n_H = \frac{n_1}{n_2}\left(1 - \frac{\beta_s}{\beta_{s,o}}\right) \quad \text{.....(3.15)}$$

Where $n_H$ denotes the hydration number. $\beta_s$, $\beta_{s,o}$ are adiabatic compressibility of solution and solvent respectively and $n_1$ and $n_2$ are number of moles of solvent and solute respectively.

**CHAPTERE IV**

## Results and Discussion

Glucose, NaCl and KCl are very important for living organisms. Ciprofloxacin is a fluoroquinolone antibiotic that fights bacteria in the body. It is used to treat different types of bacterial infections. The interactions of glucose, NaCl and KCl with ciprofloxacin have been measured in terms of volumetric and sound velocity measurement. The experimental results and the properties derived from experimental data are presented in this chapter. The results have been discussed in the light of recent developments of the subject. The studied systems are:

a) Water + Glucose
b) Water + NaCl
c) Water + KCl
d) Water + Glucose + 0.03 $mol.kg^{-1}$ciprofloxacin
e) Water + Glucose + 0.045 $mol.kg^{-1}$ ciprofloxacin
f) Water + Glucose + 0.06 $mol.kg^{-1}$ ciprofloxacin
g) Water + NaCl + 0.03 $mol.kg^{-1}$ciprofloxacin
h) Water + NaCl + 0.045 $mol.kg^{-1}$ ciprofloxacin
i) Water + NaCl + 0.06 $mol.kg^{-1}$ciprofloxacin
j) Water + KCl + 0.03 $mol.kg^{-1}$ ciprofloxacin
k) Water + KCl + 0.045 $mol.kg^{-1}$ ciprofloxacin
l) Water + KCl + 0.06 $mol.kg^{-1}$ ciprofloxacin

The above mentioned systems have been studied precisely at six equidistant temperatures ranging from 293.15 K to 318.15 K at interval of 5 K by density and sound velocity methods. The volumetric properties such as apparent molar volume ($\phi_v$), partial molar

volume ($\bar{V}_2$), limiting apparent molar volume ($\phi_v^0$), limiting apparent molar volume transfer ($\Delta_{tr}\phi_v^0$), limiting apparent molar expansibilities ($E\phi^0 = \delta\phi_v^0/\delta T)_p$) and Hepler constant [$(\delta E\phi^0/\delta T)_p = (\delta^2\phi_v^0/\delta T^2)_p$] have been determined from density data. The ultrasonic properties like adiabatic compressibility ($\beta_s$), apparent molar adiabatic compressibility ($\phi_k$), limiting apparent molar adiabatic compressibility ($\phi_k^0$), experimental slope ($S_k$), apparent molar adiabatic compressibility of transfer ($\Delta_{tr}\phi_k^0$), acoustic impedance (Z), relative association ($R_A$) and hydration number ($n_H$) have been determined from sound velocity data. The obtained information of these systems have presented in various sections and discussed in the light of theories mentioned in the earlier chapter.

## 4.1 Volumetric Properties

The density vaules, ρ of glucose, NaCl and KCl in water systems have been determined at temperatures ranging from 293.15 K to 318.15 K with an interval of 5 K over the concentration range of 0.10 mol.kg$^{-1}$ to 0.50 mol.kg$^{-1}$. The densities of aqueous glucose, NaCl and KCl have been shown in Tables 4.1-4.3 and figures are graphically shown in 4.1-4.3 at different temperatures as a function of molality of aqueous glucose, NaCl and KCl. Figures 4.1-4.3 show that the densities of aqueous glucose, NaCl and KCl increase with the increase of glucose, NaCl and KCl concentration. These are due to the increase in number of particles in given region which leads to shrinkage in volume of solution [60, 61]. The densities of the aqueous glucose, NaCl and KCl decrease in the order of glucose > KCl > NaCl for the same molality of glucose, NaCl and KCl and at the same temperature, which supports that the density is higher for the higher molecular weight. The density values decrease with the increase of temperature in aqueous glucose, NaCl and KCl systems. Because the solution is heated, the thermal energy of molecules increases and as accordingly the intermolecular distance increases, which leads to the decrease of the density.

The densities, ρ of ternary systems such as glucose, NaCl and KCl in 0.03 mol.kg$^{-1}$, 0.045 mol.kg$^{-1}$ and 0.06 mol.kg$^{-1}$ aqueous ciprofloxacin solutions are listed in Tables 4.4-4.12

and figures are graphically shown in 4.4-4.12. The values of densities of glucose, NaCl and KCl in aqueous ciprofloxacin systems has been found to be in the increasing order as below,

Glucose, NaCl and KCl+ water + 0.06 mol.kg$^{-1}$ciprofloxacin > glucose, NaCl and KCl + water + 0.045 mol.kg$^{-1}$ciprofloxacin > glucose, NaCl and KCl + water + 0.03 mol.kg$^{-1}$ciprofloxacin

It is seen that the density increase with the increasing of ciprofloxacin concentration at a fixed glucose, NaCl and KCl concentration. The increase of density with concentration of ciprofloxacin can be attributed to solute-solvent interaction and weight of ciprofloxacin in solution. The densities of the glucose, NaCl and KCl solutions increase in the order of glucose > KCl > NaCl for the same molality of glucose, NaCl and KCl and ciprofloxacin at the same temperature. For ternary systems the densities also decrease with the increase of temperature. Because the solution is heated, the thermal energy of molecules increases and accordingly the intermolecular distance increases, which leads to the decrease of the density [62].

Densities of glucose, NaCl and KCl + ciprofloxacin + water are higher than that of glucose, NaCl and KCl + water systems. Increase in density with concentration is also due to the shrinkage in the volume which in turn is due to the presence of solute molecules. In other words, an increase in density may be interpreted to the structure making property of the solvent due to the added solute [60, 61].

The apparent molar volumes ($\varphi_v$) of glucose, NaCl and KCl in water are calculated from density data. The value of apparent molar volume of aqueous glucose, NaCl and KCl at different temperatures 293.15, 298.15, 303.15, 308.15, 313.15 and 318.15 K are given in Tables 4.13-4.15 and the variation of $\varphi_v$ with molality of glucose, NaCl and KCl are graphically represented in Figures 4.13-4.15. It appears from the figure that apparent molar volume is dependent upon the glucose, NaCl and KCl concentration as well as on the temperature. Plots of $\varphi_v$ vs. molality (m) of glucose, NaCl and KCl show linear relationship in water system. The values of apparent molar volume ($\varphi_v$) of aqueous glucose, NaCl and KCl are positive and linearly increase with the increase of concentration of glucose, NaCl and KCl. The positive values of $\varphi_v$ are indicating the domination of solute-solvent interactions in binary systems.

The values of apparent molar volume ($\varphi_v$) of aqueous glucose, NaCl and KCl solutions increase in the order of glucose > KCl > NaCl in all temperatures and concentrations, due to the increase in surface of solute to interact with solvent. The value of $\varphi_v$ increases with increase in temperature because of thermal agitation, which leads to the bond breaking.

The value of apparent molar volume of glucose, NaCl and KCl in aqueous ciprofloxacin solutions 0.03 $mol.kg^{-1}$, 0.045 $mol.kg^{-1}$ and 0.06 $mol.kg^{-1}$ at studied temperatures 293.15, 298.15, 303.15, 308.15, 313.15 and 318.15 K are given in Tables 4.16-4.24 and Figures 4.16-4.24 show the plots of apparent molar volume as a function of molality of glucose, NaCl and KCl at different temperatures. Plots of $\varphi_v$ vs. molality of glucose, NaCl and KCl show linear relationship in aqueous ciprofloxacin system. For glucose, NaCl and KCl in aqueous ciprofloxacin solutions systems, the values of apparent molar volume ($\varphi_v$) are also positive and linearly increase with the increase of concentration of glucose, NaCl and KCl. It has also been found that apparent molar volumes for glucose, NaCl and KCl increase with the increase of ciprofloxacin concentration. The positive values of $\varphi_v$ are indicative of greater solute-solvent interactions. At a fixed ciprofloxacin concentration and temperature, the increase of $\varphi_v$ with the concentration of added glucose, NaCl and KCl in the studied molality range may be due to the cluster formation or aggregation. Comparatively lower apparent molar volume, $\varphi_v$ of NaCl in aqueous ciprofloxacin solutions was found than those of aqueous glucose and KCl solution. This indicates that the NaCl is more compressed in aqueous ciprofloxacin solution than aqueous solution .Whereas higher apparent molar volume, $\varphi_v$ of glucose and KCl in aqueous ciprofloxacin solution than aqueous NaCl solution was found. This indicates that the glucose and KCl is less compressed in aqueous ciprofloxacin solution than aqueous solution.

The value of $\varphi_v$ increases with increase in temperature. This cause may be: (i) due to the increase in thermal energy at higher temperature, the relaxation to the bulk of the electrostricted water molecules from the interaction regions of ion-dipole or dipole-dipole interaction results in a positive volume change (ii) an increase in temperature renders the ion-ion interactions relatively stronger giving rise to positive volume change and (iii) the ciprofloxacin-ciprofloxacin or ciprofloxacin-water or water-water interactions decrease with the increase in temperature leading to a positive change in volume [49].

The limiting apparent molar volume ($\varphi_v^0$) which is also called the standard partial molar volume of aqueous glucose, NaCl and KCl at 293.15, 298.15, 303.15, 308.15, 313.15 and 318.15 K temperature are reported in Tables 4.25-4.27. The limiting apparent molar volumes ($\varphi_v^0$) of glucose, NaCl and KCl reflect the true volume of the solute. However, limiting apparent molar volumes at infinite dilution ($\varphi_v^0$) of the solute can provide further information regarding solute-solvent interactions. The apparent molar volumes ($\varphi_v$) were observed to correlate linearly with solution molality (m) at all experimental temperatures. Hence standard partial molar volumes ($\varphi_v^0$) were obtained from Masson equation [53]. Tables 4.25-4.27 show that values of limiting apparent molar volume ($\varphi_v^0$) are positive at each temperature. Furthermore, the values of $\varphi_v^0$ also increase with an increase in the molar mass and size of the glucose, NaCl and KCl, that is, higher values of $\varphi_v^0$ are obtained for glucose as compared to NaCl and KCl. The increase of $\varphi_v^0$ values with the increase in temperature for glucose, NaCl and KCl may be explained as release of some solvent molecules from the loose solvation layers of the solutes in solution [54].

The values of limiting apparent molar volume ($\varphi_v^0$) for glucose, NaCl and KCl in ternary (water + ciprofloxacin) solution at the studied temperatures are presented in Tables 4.28-4.36. These tables show that values of limiting apparent molar volume ($\varphi_v^0$) are positive and increase with an increase in the ciprofloxacin concentration. As per cosphere overlap model [63, 64], an overlap of hydration co-spheres of two ionic species causes an increase in volume, whereas overlap of hydrophobic-hydrophobic groups and ion-hydrophobic groups results in the volume decrease. In the present ternary systems the overlaps of cosphere of two ionic species take place. Furthermore, the values of $\varphi_v^0$ also increase with an increase in the molar mass and size of the glucose, NaCl and KCl, that is, higher values of $\varphi_v^0$ are obtained for glucose as compared to NaCl and KCl in aqueous ciprofloxacin solutions. The increase in $\varphi_v^0$ values with the increase in temperature for the studied systems may be explained as release of some solvent molecules from the loose solvation layers of the solutes in solution. This can also be explained by considering the size of primary and secondary solvation layers around zwitterions. At higher temperatures, the solvent from the secondary solvation layers of glucose, NaCl and KCl zwitterions is released into the bulk of the solvent, resulting into the expansion

of solution, as inferred from larger values of $\varphi_v^0$ at higher temperatures [39]. In simple terms, an increase in temperature reduces the electrostriction and hence $\varphi_v^0$ increases.

The values of experimental slope ($S_V$) for aqueous glucose, NaCl and KCl and glucose, NaCl and KCl in ternary (water + ciprofloxacin) solution at the experimental temperatures are reported in Tables 4.28-4.36. The values of experimental slope ($S_V$) are small positive for all the concentration of glucose, NaCl and KCl. Since there is no regular trend in the values of $S_V$, this clearly indicates that solute-solute interaction is also influenced by other factors. The positive values of $S_V$ indicate solute-solute interaction and $\varphi_v^0$suggest the dominance of solute-solvent interaction [66].

$S_V$ values are positive and decrease with an increase of temperature (with some exception) of glucose, NaCl and KCl in the aqueous and aqueous ciprofloxacin solution suggesting that less solute is accommodated in the void space left in the packing of the large associated solvent molecules. The results also indicate the presence of strong solute-solute interactions, and these interactions decrease with the increase in temperature. The values of Sv increase with the increase in composition of aqueous ciprofloxacin solution showing strong solute-solute interactions [67].

The values of limiting apparent molar volume transfer of glucose, NaCl and KCl from water to aqueous ciprofloxacin solutions at infinite dilution was calculated by using the equation,

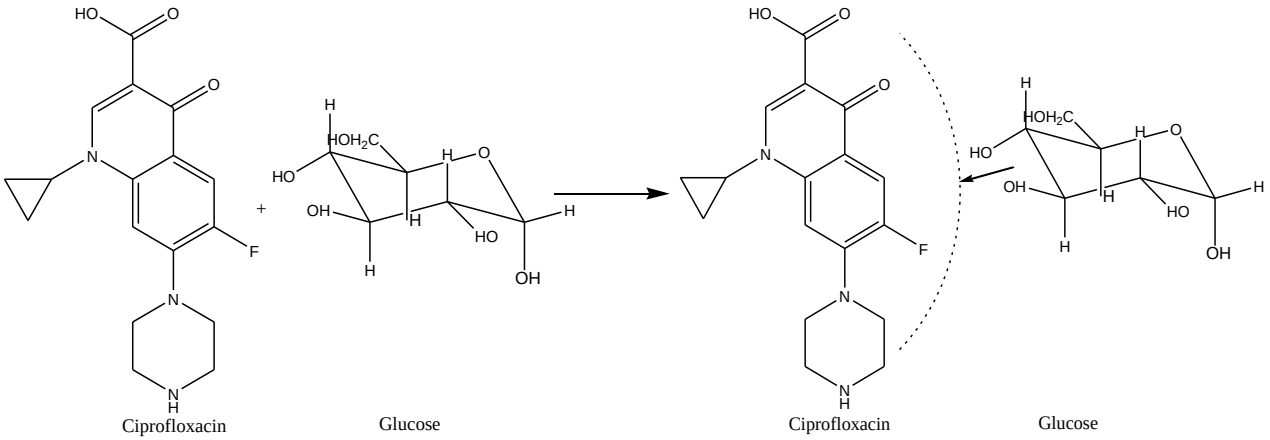
$\Delta_{tr}\varphi_v^0 = \varphi_v^0$ (in aq. ciprofloxacin) - $\varphi_v^0$ (in water).

The values of limiting apparent molar volume transfer ($\Delta_{tr}\varphi_v^0$) of glucose, NaCl and KCl in aqueous ciprofloxacin solutions have been reported in Tables 4.28-4.36. The $\Delta_{tr}\varphi_v^0$ values of glucose in aqueous ciprofloxacin solutions are positive and whereas $\Delta_{tr}\varphi_v^0$ values of NaCl in aqueous ciprofloxacin systems are both positive and negative. The $\Delta_{tr}\varphi_v^0$ values of KCl in aqueous ciprofloxacin solutions are negative. The observed positive values of $\Delta_{tr}\varphi_v^0$ suggest strong ion-ion interactions and hydrophilic-ionic interaction of glucose with ciprofloxacin. Since the structural moiety of glucose and NaCl and aqueous ciprofloxacin contain polar groups, so interactions between them promote the structure making ability of solute in the solvent. Hence, the mentioned positive values of transfer volume indicate structure promoter nature of the solute which is due to their solvophobic solvation as well as the structural

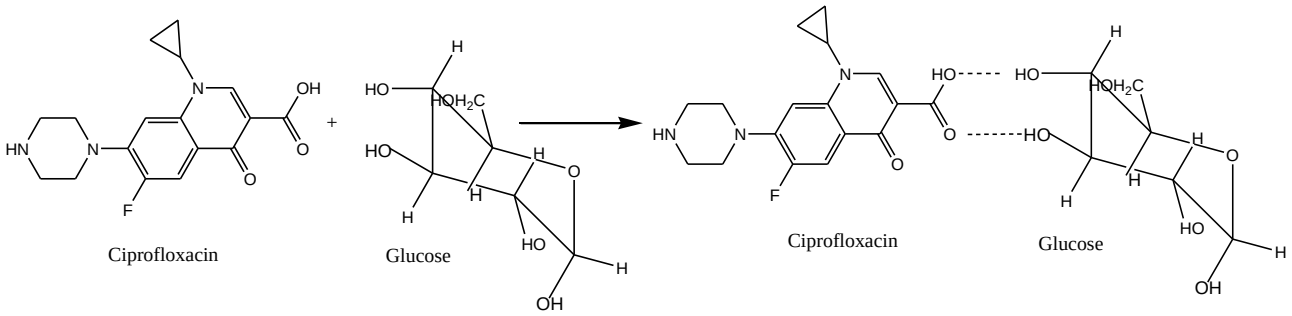
interaction according to co-sphere overlap model [64, 65]. And also then negative values of $\Delta_{tr}\varphi_v^0$ suggest strong ion-hydrophobic and hydrophobic-hydrophobic interactions of NaCl and KCl with ciprofloxacin. Depending upon the co-sphere overlap model regarding the values of $\Delta_{tr}\varphi_v^0$, there is negligible contribution from solute-solute interactions and hence they provide information regarding solute-solvent interactions. The various interactions that occur between glucose, NaCl and KCl and aqueous ciprofloxacin molecules can be categorized as: (i) ion-ion interactions (ii) hydrophilic-hydrophilic interactions (iii) ion-hydrophobic interactions (iv) hydrophobic-hydrophobic interactions. According to co-sphere overlap model, ion-hydrophobic interactions and hydrophobic-hydrophobic interactions contribute negatively whereas ion-hydrophilic and hydrophilic-hydrophilic interactions contribute positively to the $\Delta_{tr}\varphi_v^0$ values. Therefore, in case of (glucose + ciprofloxacin + water) and (NaCl + ciprofloxacin + water) hydrophilic-ionic and hydrophilic- hydrophilic interactions are dominating .Whereas ion-hydrophobic and hydrophobic-hydrophobic interactions are dominating for NaCl and KCl systems. Some possible interaction between solute-solvent are given bellow:

**For Glucose:**

1. Hydrophilic-ion interaction:

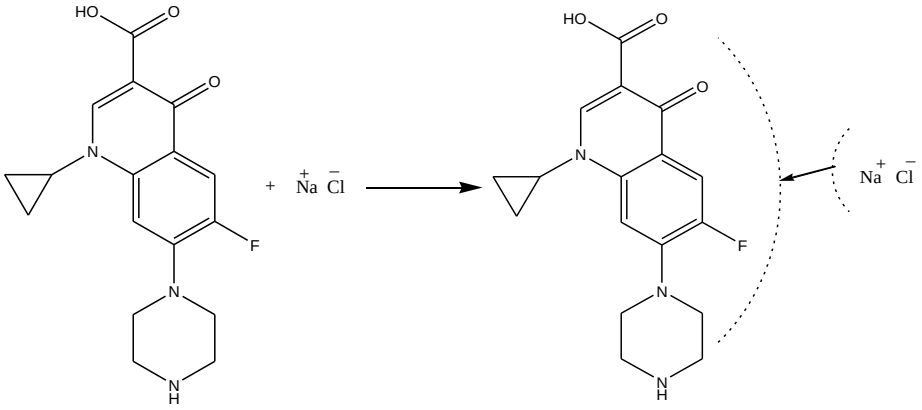


2. Hydrophilic-hydrophilic interaction:

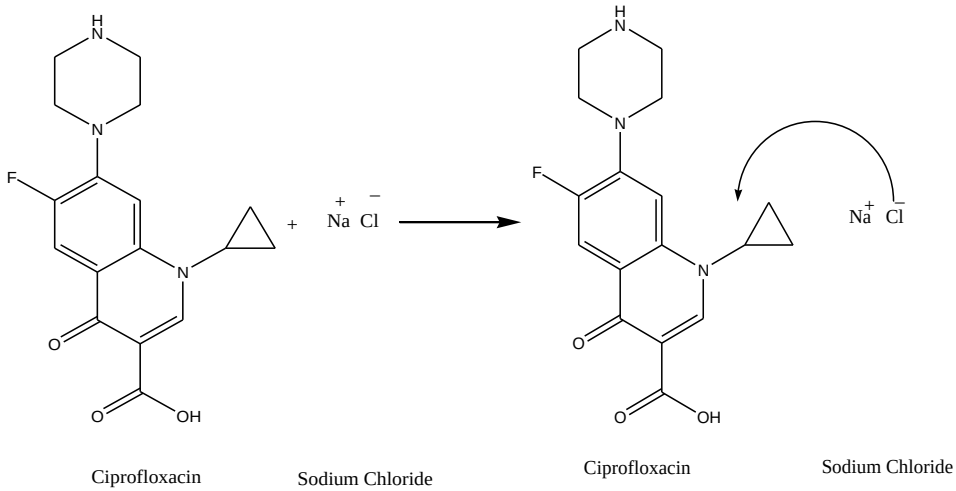



**For NaCl:**

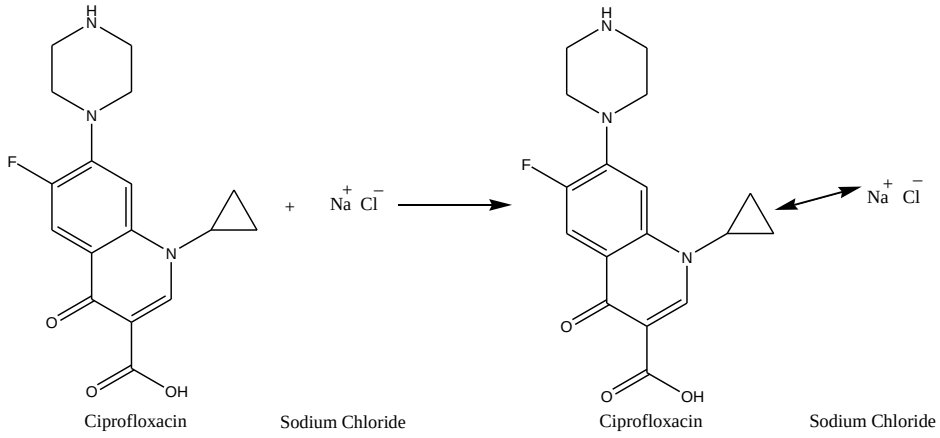
1. Hydrophilic-ion interaction




2. Hydrophobic-ion interaction:

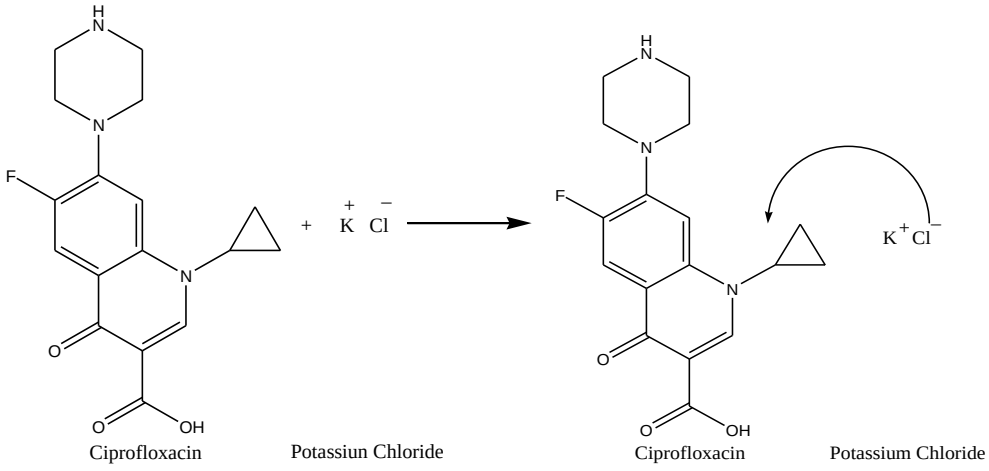


3. Hydrophobic-hydrophobic interaction:

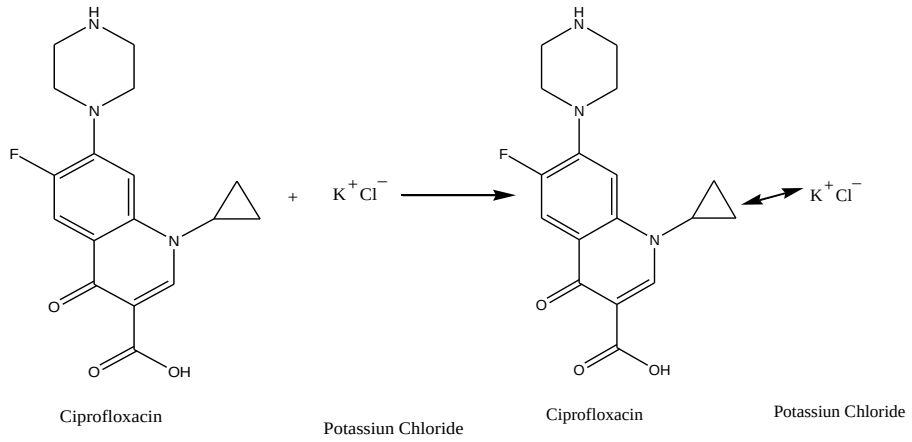



**For KCl:**

1. Hydrophobic – ion interaction:



2. Hydrophobic –hydrophobic interaction:




The values of limiting apparent molar volume expansibilities $E_\varphi^0$ and $(\delta E_\varphi^0/\delta T)_p$ of aqueous glucose, NaCl and KCl are reported in Tables 4.25-4.27. The $E_\varphi^0$ values are found to be positive at all temperatures and concentrations of glucose, NaCl and KCl. The positive values of $E_\varphi^0$ suggest that the presence of solute-solvent interactions in these systems, as already indicated by apparent molar volume data. The $E_\varphi^0$ values show an irregular trend with an increase of temperature. The sign of $(\delta E\varphi^0/\delta T)_p$ determines the tendency of a dissolved solute as a structure maker or structure breaker in a solvent which suggests that positive $(\delta E\varphi^0/\delta T)_p$ values are observed for solutes having structure making capacity. The small negative values of $(\delta E\varphi^0/\delta T)_p$ for studied systems may act as structure maker.

The values of Partial molar volume ($\bar{V}_2$) of aqueous glucose, NaCl and KCl and glucose, NaCl and KCl in ternary (water + ciprofloxacin) solutions are shown in Tables 4.37-4.48 and Figures 4.25-4.36 show the plots of partial molar volume as a function of concentration of aqueous glucose, NaCl and KCl and glucose, NaCl and KCl in aqueous solution of ciprofloxacin. The value of partial molar volume ($\bar{V}_2$) increases with the increase of concentration of glucose, NaCl and KCl. This suggests that solute-solvent interactions increase with the increase of concentration of glucose, NaCl and KCl.

## 4.2 Ultrasonic properties

The ultrasonic velocity is highly sensitive to molecular interactions and provides qualitative information about the physical nature and strength of molecular interaction in the liquid mixtures [66]. The ultrasonic velocity is a measure of arrangement, continuity, continuousness and availability of void space of the medium.

The sound velocities, u of aqueous glucose, NaCl and KCl and glucose, NaCl and KCl in ternary (water + ciprofloxacin) systems have been determined at temperatures ranging from 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K, and 318.15 K with an interval of 5 K over the concentration ranging from 0.10 $mol.kg^{-1}$ to 0.50 $mol.kg^{-1}$. The sound velocities of aqueous glucose, NaCl and KCl and glucose, NaCl and KCl in aqueous ciprofloxacin solution have been shown in Tables 4.49-4.60 at different temperatures. Figures 4.37-4.48 show the plots of sound velocities as a function of molality of aqueous glucose, NaCl and KCl and glucose, NaCl and KCl in aqueous ciprofloxacin solution. These figures show that the sound velocity increases with the increase of concentration of glucose, NaCl and KCl. This may be attributed to the increase of compactness of the medium with the increase in glucose, NaCl and KCl concentration [68]. The sound velocity of aqueous glucose and KCl is higher than aqueous NaCl. This is due to the molecular weight of glucose and KCl is higher than NaCl. The existence of molecular interactions between solute and solvent molecules is responsible for the observed increase in the sound velocity of these mixtures.

The compressibility is a very sensitive indicator of molecule interactions [69]. The structural change of molecules takes place due to existence of electrostatic field between interacting molecules. The change in adiabatic compressibility value in liquid and liquid mixtures may be ascribed to the strength of intermolecular attraction. The relative value change upon application of pressure is defined as adiabatic compressibility, which depends on intermolecular states. The liquids/solution having compact structure, rigid bonding and strong intermolecular interaction are less compressible. Evidently, hydrogen bonding, strong dipole-dipole interactions and geometrical fitting of one component into other structural network lead to decrease adiabatic compressibility.

The adiabatic compressibility ($\beta_s$) of aqueous glucose, NaCl and KCl has been shown in Tables 4.61-4.63 at different temperatures. Figures 4.49-4.51 show the plots of adiabatic compressibility as a function of molality of aqueous glucose, NaCl and KCl. From the figures it is apparent that the values of $\beta_s$ decrease with the increase of molar concentration of glucose, NaCl and KCl. The value of $\beta_s$ also decreases with the increases of temperature.

The decrease in the $\beta_s$ values with increasing concentration of glucose, NaCl and KCl indicates that the water molecules around the glucose, NaCl and KCl are less compressible than the water molecule in the bulk solution [70, 71]. The decrease in $\beta_s$ may be due to the introduction of glucose, NaCl and KCl molecule into water which reduces the void space in solution.

The values of adiabatic compressibility, $\beta_s$ of glucose, NaCl and KCl in ternary (water + ciprofloxacin) solution are shown in Tables 4.64-4.72 and Figures 4.52-4.60 show the plots of adiabatic compressibility as a function of molality of glucose, NaCl and KCl in aqueous solution of ciprofloxacin. From these figures it is apparent that the values of $\beta_s$ decrease with the increase of concentration of glucose, NaCl and KCl in ciprofloxacin solution which is similar with binary systems. The values of $\beta_s$ also decrease with the increase of temperature. The decrease in the $\beta_s$ values of glucose, NaCl and KCl in aqueous ciprofloxacin solutions by increasing concentration of glucose, NaCl and KCl indicates that the water molecules around glucose, NaCl and KCl are less compressible than the water molecule in the bulk solution [72, 73]. The decrease in $\beta_s$ may be due to the introduction of glucose, NaCl and KCl molecule into water and aqueous ciprofloxacin solutions which reduce the void space in solution.

The apparent molar adiabatic compressibility ($\varphi_k$) of aqueous glucose, NaCl and KCl are calculated from density and sound velocity data. The values of apparent molar adiabatic compressibility ($\varphi_k$) of aqueous glucose, NaCl and KCl at different temperatures 293.15, 298.15, 303.15, 308.15, 313.15 and 318.15 K are given in Tables 4.73-4.75 and the variation of $\varphi_k$ with molality of glucose, NaCl and KCl are graphically represented in Figures 4.61-4.63. From the data it is observed that values of $\varphi_k$ are negative at all temperatures and concentrations of glucose, NaCl and KCl. The values of $\varphi_k$ increase with an increase in the concentration of glucose, NaCl and KCl. The values of $\varphi_k$ also increase with the increase of temperature. The negative $\varphi_k$ values show that water molecules around ionic charged groups of glucose, NaCl and KCl are less compressible than water molecules in the bulk solution. This

indicates the ordering of water molecules around solute or the negative $\varphi_k$ values indicate greater loss of structural compressibility of water implying a greater ordering effect by the solute on the solvent [39].

The value of apparent molar adiabatic compressibility ($\varphi_k$) of glucose, NaCl and KCl in ternary (water + ciprofloxacin) solution at different temperatures 293.15 K to 318.15 K are given in Tables 4.76-4.84 and the variation of $\varphi_k$ with molality of glucose and NaCl are graphically represented in Figures 4.64-4.73. From the data it is observed that values of $\varphi_k$ are negative at all temperatures and concentrations of ciprofloxacin which is similar with binary systems. The values of $\varphi_k$ increase with an increase in the concentration of glucose, NaCl and KCl. The values of $\varphi_k$ also increase with the increase of temperature. The negative $\varphi_k$ values show that water molecules around ionic charged groups of glucose, NaCl and KCl are less compressible than water molecules in the bulk solution. This indicates the ordering of solvent molecules around solute [32].

The values of apparent molar adiabatic compressibility ($\varphi_k$) of glucose, NaCl and KCl+ ciprofloxacin + water are higher than the values of glucose, NaCl and KCl + water systems. This higher values of ternary systems than the binary systems show a greater ordering effect by the solute on the solvent.

The values of limiting apparent molar adiabatic compressibility ($\varphi_k^0$) and experimental slope ($S_k$) of aqueous glucose, NaCl and KCl and glucose, NaCl and KCl in ternary (water + ciprofloxacin) solution at different temperatures 293.15 K to 318.15 K are tabulated in Tables 4.85-4.96. The value of $S_k$ is the indicative of solute–solute interactions. As solute–solute interactions are negligible at infinite dilution due to small size of $S_k$ values, this indicates that solute–solvent interactions [74] are prevailing in the mixtures. The more negative values of $\varphi_k^0$ for glucose, NaCl and KCl at low temperature are attributed to the strong attractive interactions between glucose, NaCl and KCl and water [75]. With an increase in temperature, the $\varphi_k^0$ values become less negative, which means that electrostriction reduces and some water molecules are released to bulk. Furthermore, the attractive interactions between ciprofloxacin and water molecules induce the dehydration of glucose, NaCl and KCl and therefore at high ciprofloxacin concentrations the water molecules around the glucose, NaCl and KCl are more compressible than those at lower ciprofloxacin concentrations.

The values of apparent molar adiabatic compressibility of transfer ($\Delta_{tr}\varphi_k^0$) for molal concentrations of aqueous glucose, NaCl and KCl at different temperatures are reported in Tables 4.88-4.96. These values of apparent molar adiabatic compressibility of transfer ($\Delta_{tr}\varphi_k^0$) of glucose, NaCl and KCl are both positive and negative. Glucose in aqueous (0.03 and 0.06 mol.kg$^{-1}$) ciprofloxacin systems and NaCl in aqueous 0.06 mol.kg$^{-1}$ ciprofloxacin show the positive value. KCl in aqueous 0.06 mol.kg$^{-1}$ ciprofloxacin also shows positive value.

The positive values of $\Delta_{tr}\varphi_k^0$ indicate that the consequence of increase in the number of monomeric water molecules on breakdown of hydrogen bonding among the water molecules in overlapping of several hydration spheres such as zwitterionic group of glucose, NaCl and KCl and ciprofloxacin result the increase in the number of monomeric water molecules. The $\Delta_{tr}\varphi_k^0$ values of glucose, NaCl and KCl in aqueous ciprofloxacin solutions increase with increasing of ciprofloxacin concentration. Negative values of $\Delta_{tr}\varphi_k^0$ indicate that increase in hydrophilic-hydrophobic and hydrophobic-hydrophobic group interactions results in disruption of hydration sphere of charged centers of glucose, NaCl and KCl thereby reducing the positive contribution to $\Delta_{tr}\varphi_k^0$ [76]. The values of acoustic impedance, Z of aqueous glucose, NaCl and KCl have been shown in Tables 4.97-4.108 at different temperatures. Figures 4.74-4.85 show the plots of acoustic impedance as a function of molality of aqueous glucose and NaCl. It is evident from the Figures 4.74-4.85 that acoustic impedance increases with the increase in molality of glucose, NaCl and KCl. The increase in Z with the molality of glucose, NaCl and KCl indicates that as concentration increases the sound wave has to face resistance to flow. The positive acoustic impedance is, therefore, an evidential parameter for solute-solvent interaction [77]. The present data support that there exist a strong solute-solvent interaction in glucose, NaCl and KCl in aqueous ciprofloxacin solution. The values of acoustic impedance, Z of glucose, NaCl and KCl + ciprofloxacin + water are higher than the values of glucose, NaCl and KCl + water systems. These higher values of ternary systems than the binary systems show strong solute-solvent interaction in ternary systems than binary systems.

The values of relative association, $R_A$ of aqueous glucose, NaCl and KCl have been shown in Tables 4.109-4.120 at different temperatures. Figures 4.86-4.97 show the plots of relative association as a function of molality of aqueous glucose, NaCl and KCl. The relative association decrease with the increase of molality of glucose, NaCl and KCl. The linear

decrease in $R_A$ indicates that solute-solvent interaction is maxima at infinite dilution. As the concentration of amino acids increases, the deviation from ideality increases thereby solute-solvent interaction decreases. This may be due to the increase in solute-solute interaction [78]. The values of $R_A$ decrease with concentration but more decrease at higher temperature.

The hydration number ($n_H$) of glucose, NaCl and KCl in water are listed in Tables 4.121-4.123 and figures are graphically shown in 4.98-4.100. The hydration numbers decrease with the increase of concentration for aqueous glucose, NaCl and KCl. The hydration numbers also decrease with the increase of temperature. The hydration number of aqueous glucose and KCl are higher than the aqueous NaCl. The values of hydration number decreases as appreciable increases of solutes. This is an added support for the structure promoting nature of the glucose, NaCl and KCl as well as the presence of dipolar interaction between glucose, NaCl and KCl and water molecules. This also suggests that compressibility of the solution is less than that of the solvent. This may enhance the interaction between solute and solvent molecules [79]. From the tables it is observed that the values of hydration number decrease with the increase of concentration of glucose, NaCl and KCl.

The values of hydration number ($n_H$) of glucose, NaCl and KCl in 0.03, 0.045 and 0.06 $mol.kg^{-1}$ aqueous ciprofloxacin solutions at studied temperatures are reported in Tables 4.124-4.132. The variation of $n_H$ with molality is graphically shown in Figures 4.101-4.109. The hydration numbers decrease with the increase of concentration for glucose, NaCl and KCl in aqueous ciprofloxacin systems which is similar with binary systems. The hydration numbers decrease with the increase of temperature. The hydration number of glucose and NaCl in aqueous ciprofloxacin is more than KCl in aqueous ciprofloxacin.

The hydration number of glucose, NaCl and KCl at concentrated ciprofloxacin solution is lower than the dilute solutions. This is due to the decrease of water molecule around the glucose, NaCl and KCl at higher concentration. This also suggests that compressibility of the solution is less than that of the solvent. As a result glucose, NaCl and KCl will gain mobility and have more probability of contacting aqueous ciprofloxacin molecules. This may enhance the interaction between solute and solvent molecules [80].

Table 4.1: Density (ρ) of aqueous Glucose as a function of molality at different temperature

| Glucose + Water | | | | | | |
|---|---|---|---|---|---|---|
| | Density, ρ/kg.m$^{-3}$ | | | | | |
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 998.996 | 997.332 | 995.933 | 994.321 | 992.377 | 989.909 |
| 0.1 | 1005.793 | 1004.591 | 1003.137 | 1001.477 | 999.622 | 997.581 |
| 0.2 | 1012.284 | 1011.023 | 1009.535 | 1007.837 | 1005.948 | 1003.891 |
| 0.3 | 1018.242 | 1016.925 | 1015.383 | 1013.637 | 1011.705 | 1009.607 |
| 0.4 | 1025.09 | 1023.74 | 1022.168 | 1020.4 | 1018.451 | 1016.339 |
| 0.5 | 1030.972 | 1029.596 | 1028.004 | 1026.213 | 1024.248 | 1022.118 |

Table 4.2: Density (ρ) of aqueous NaCl as a function of molality at different temperature

| NaCl + Water | | | | | | |
|---|---|---|---|---|---|---|
| | Density, ρ/kg.m$^{-3}$ | | | | | |
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 998.996 | 997.332 | 995.933 | 994.321 | 992.377 | 989.909 |
| 0.1 | 1002.862 | 1001.42 | 999.983 | 998.333 | 996.489 | 993.896 |
| 0.2 | 1006.635 | 1005.383 | 1003.876 | 1001.984 | 1000.22 | 997.555 |
| 0.3 | 1010.537 | 1009.241 | 1007.691 | 1005.879 | 1003.81 | 1001.423 |
| 0.4 | 1014.74 | 1013.391 | 1011.817 | 1010.074 | 1008.081 | 1005.698 |
| 0.5 | 1019.114 | 1017.718 | 1016.12 | 1014.337 | 1012.377 | 1010.259 |

Table 4.3: Density (ρ) of aqueous KCl as a function of molality at different temperature

| KCl + Water | | | | | | |
|---|---|---|---|---|---|---|
| | Density, ρ/kg.m$^{-3}$ | | | | | |
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 998.996 | 997.332 | 995.933 | 994.321 | 992.377 | 989.509 |
| 0.1 | 1003.726 | 1001.932 | 1000.497 | 998.85 | 996.96 | 994.017 |
| 0.2 | 1007.957 | 1006.422 | 1004.954 | 1003.195 | 1001.081 | 998.442 |
| 0.3 | 1012.371 | 1011.041 | 1009.547 | 1007.817 | 1005.449 | 1002.199 |
| 0.4 | 1016.789 | 1015.475 | 1013.925 | 1011.921 | 1009.821 | 1006.917 |
| 0.5 | 1021.577 | 1019.807 | 1017.961 | 1015.672 | 1013.624 | 1010.958 |

Table 4.4: Density (ρ) of Glucose in aqueous solution of ciprofloxacin (0.03 $mol.kg^{-1}$) as a function of molality at different temperature

| 0.03 $mol.kg^{-1}$ Ciprofloxacin + Water + Glucose | | | | | | |
|---|---|---|---|---|---|---|
| Density, ρ/$kg.m^{-3}$ | | | | | | |
| m/$mol.kg^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 1001.891 | 1000.701 | 999.274 | 997.631 | 995.79 | 993.725 |
| 0.1 | 1008.359 | 1007.133 | 1005.665 | 1003.972 | 1002.095 | 1000.04 |
| 0.2 | 1014.762 | 1013.475 | 1011.958 | 1010.238 | 1008.336 | 1006.256 |
| 0.3 | 1021.267 | 1019.933 | 1018.377 | 1016.627 | 1014.691 | 1012.588 |
| 0.4 | 1027.415 | 1026.056 | 1024.475 | 1022.664 | 1020.68 | 1018.499 |
| 0.5 | 1033.313 | 1031.899 | 1030.272 | 1028.453 | 1026.466 | 1024.316 |

Table 4.5: Density (ρ) of Glucose in aqueous solution of ciprofloxacin (0.045 $mol.kg^{-1}$) as a function of molality at different temperature

| 0.045 $mol.kg^{-1}$Ciprofloxacin + Water + Glucose | | | | | | |
|---|---|---|---|---|---|---|
| Density, ρ/$kg.m^{-3}$ | | | | | | |
| m/$mol.kg^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 1003.639 | 1002.433 | 1000.991 | 999.388 | 997.479 | 995.447 |
| 0.1 | 1010.143 | 1008.887 | 1007.404 | 1005.711 | 1003.824 | 1001.761 |
| 0.2 | 1016.327 | 1015.029 | 1013.501 | 1011.78 | 1009.863 | 1007.775 |
| 0.3 | 1022.463 | 1021.133 | 1019.576 | 1017.79 | 1015.839 | 1013.72 |
| 0.4 | 1028.699 | 1027.311 | 1025.704 | 1023.908 | 1021.937 | 1019.799 |
| 0.5 | 1034.696 | 1033.271 | 1031.638 | 1029.818 | 1027.818 | 1025.659 |

Table 4.6: Density (ρ) of Glucose in aqueous solution of ciprofloxacin (0.06 $mol.kg^{-1}$) as a function of molality at different temperature

| 0.06 $mol.kg^{-1}$Ciprofloxacin + Water + Glucose | | | | | | |
|---|---|---|---|---|---|---|
| Density, ρ/$kg.m^{-3}$ | | | | | | |
| m/$mol.kg^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 1005.076 | 1003.855 | 1002.398 | 1000.733 | 998.87 | 996.823 |
| 0.1 | 1011.395 | 1010.127 | 1008.63 | 1006.926 | 1005.033 | 1002.961 |
| 0.2 | 1017.714 | 1016.401 | 1014.864 | 1013.123 | 1011.198 | 1009.101 |
| 0.3 | 1023.785 | 1022.43 | 1020.855 | 1019.079 | 1017.13 | 1015.01 |
| 0.4 | 1030.115 | 1028.713 | 1027.1 | 1025.292 | 1023.295 | 1021.108 |
| 0.5 | 1035.925 | 1034.484 | 1032.829 | 1030.985 | 1028.939 | 1026.716 |

Table 4.7: Density (ρ) of NaCl in aqueous solution of ciprofloxacin (0.03 $mol.kg^{-1}$) as a function of molality at different temperature

| 0.03 $mol.kg^{-1}$Ciprofloxacin + Water + NaCl | | | | | | |
|---|---|---|---|---|---|---|
| Density, $\rho/kg.m^{-3}$ | | | | | | |
| $m/mol.kg^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 1001.891 | 1000.701 | 999.274 | 997.631 | 995.79 | 993.725 |
| 0.1 | 1005.891 | 1004.701 | 1003.274 | 1001.631 | 999.79 | 997.725 |
| 0.2 | 1009.974 | 1008.687 | 1007.177 | 1005.467 | 1003.567 | 1001.495 |
| 0.3 | 1014.092 | 1012.759 | 1011.212 | 1009.47 | 1007.547 | 1005.453 |
| 0.4 | 1018.031 | 1016.654 | 1015.069 | 1013.297 | 1011.345 | 1009.231 |
| 0.5 | 1021.907 | 1020.492 | 1018.874 | 1017.072 | 1015.096 | 1012.943 |

Table 4.8: Density (ρ) of NaCl in aqueous solution of ciprofloxacin (0.045 $mol.kg^{-1}$) as a function of molality at different temperature

| 0.045 $mol.kg^{-1}$Ciprofloxacin + Water + NaCl | | | | | | |
|---|---|---|---|---|---|---|
| Density, $\rho/kg.m^{-3}$ | | | | | | |
| $m/mol.kg^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 1003.639 | 1002.433 | 1000.991 | 999.338 | 997.479 | 995.447 |
| 0.1 | 1007.664 | 1006.408 | 1004.925 | 1003.234 | 1001.35 | 999.287 |
| 0.2 | 1011.677 | 1010.381 | 1008.86 | 1007.139 | 1005.218 | 1003.134 |
| 0.3 | 1015.578 | 1014.228 | 1012.266 | 1010.912 | 1008.967 | 1006.863 |
| 0.4 | 1019.545 | 1018.154 | 1016.558 | 1014.769 | 1012.815 | 1010.689 |
| 0.5 | 1023.255 | 1021.82 | 1020.19 | 1018.373 | 1016.385 | 1014.236 |

Table 4.9: Density (ρ) of NaCl in aqueous solution of Ciprofloxacin (0.06 $mol.kg^{-1}$) as a function of molality at different temperature

| 0.06 $mol.kg^{-1}$Ciprofloxacin + Water + NaCl | | | | | | |
|---|---|---|---|---|---|---|
| Density, $\rho/kg.m^{-3}$ | | | | | | |
| $m/mol.kg^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 1005.076 | 1003.855 | 1002.398 | 1000.733 | 998.87 | 996.823 |
| 0.1 | 1009.012 | 1007.743 | 1006.25 | 1004.55 | 1002.658 | 1000.589 |
| 0.2 | 1012.983 | 1011.675 | 1010.143 | 1008.41 | 1006.48 | 1004.388 |
| 0.3 | 1016.931 | 1015.569 | 1013.998 | 1012.23 | 1010.286 | 1008.173 |
| 0.4 | 1020.796 | 1019.392 | 1017.788 | 1015.9 | 1014.022 | 1011.887 |
| 0.5 | 1024.625 | 1023.176 | 1021.534 | 1019.716 | 1017.731 | 1015.579 |

Table 4.10: Density (ρ) of KCl in aqueous solution of ciprofloxacin (0.03 $mol.kg^{-1}$) as a function of molality at different temperature

| 0.03 $mol.kg^{-1}$ Ciprofloxacin + Water + KCl | | | | | | |
|---|---|---|---|---|---|---|
| Density, ρ/$kg.m^{-3}$ | | | | | | |
| m/$mol.kg^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 1001.891 | 1000.701 | 999.274 | 997.631 | 995.79 | 993.725 |
| 0.1 | 1006.83 | 1005.6 | 1004.138 | 1002.453 | 1000.585 | 998.541 |
| 0.2 | 1010.962 | 1009.687 | 1008.195 | 1004.695 | 1004.603 | 1002.546 |
| 0.3 | 1015.562 | 1014.253 | 1012.726 | 1010.999 | 1009.092 | 1006.65 |
| 0.4 | 1020.024 | 1018.675 | 1017.115 | 1015.355 | 1013.437 | 1011.34 |
| 0.5 | 1024.205 | 1022.827 | 1021.229 | 1019.452 | 1017.498 | 1015.381 |

Table 4.11: Density (ρ) of KCl in aqueous solution of ciprofloxacin (0.045 $mol.kg^{-1}$) as a function of molality at different temperature

| 0.045 $mol.kg^{-1}$ Ciprofloxacin + Water + KCl | | | | | | |
|---|---|---|---|---|---|---|
| Density, ρ/$kg.m^{-3}$ | | | | | | |
| m/$mol.kg^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 1003.639 | 1002.433 | 1000.991 | 999.388 | 997.89 | 995.479 |
| 0.1 | 1008.188 | 1006.944 | 1005.467 | 1003.787 | 1001.915 | 999.661 |
| 0.2 | 1012.488 | 1011.2 | 1009.695 | 1007.987 | 1005.987 | 1004.02 |
| 0.3 | 1016.821 | 1015.502 | 1013.956 | 1012.22 | 1010.299 | 1008.207 |
| 0.4 | 1020.366 | 1020.008 | 1018.439 | 1016.68 | 1014.74 | 1012.634 |
| 0.5 | 1025.736 | 1024.34 | 1022.741 | 1020.961 | 1019.005 | 1016.884 |

Table 4.12: Density (ρ) of KCl in aqueous solution of ciprofloxacin (0.06 $mol.kg^{-1}$) as a function of molality at different temperature

| 0.06 $mol.kg^{-1}$ Ciprofloxacin + Water + KCl | | | | | | |
|---|---|---|---|---|---|---|
| Density, ρ/$kg.m^{-3}$ | | | | | | |
| m/$mol.kg^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 1005.076 | 1003.855 | 1002.398 | 1000.733 | 998.87 | 996.823 |
| 0.1 | 1009.273 | 1008.013 | 1006.528 | 1004.835 | 1002.946 | 1000.881 |
| 0.2 | 1013.919 | 1012.162 | 1011.631 | 1009.856 | 1007.886 | 1004.703 |
| 0.3 | 1018.268 | 1016.931 | 1015.381 | 1013.634 | 1011.705 | 1009.605 |
| 0.4 | 1022.648 | 1021.271 | 1019.699 | 1017.933 | 1015.984 | 1013.858 |
| 0.5 | 1027.065 | 1025.658 | 1024.055 | 1022.291 | 1020.36 | 1018.252 |

Table 4.13: Apparent molar volume ($\varphi_v$) of aqueous Glucose as a function of molality (m/mol.kg$^{-1}$) at different temperature

| Only Glucose + Water | | | | | | |
|---|---|---|---|---|---|---|
| $\varphi_v \times 10^6/m^3.mol^{-1}$ | | | | | | |
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.1 | 107.07 | 107.55 | 107.94 | 108.27 | 108.63 | 108.85 |
| 0.2 | 107.17 | 107.58 | 107.96 | 108.29 | 108.59 | 108.88 |
| 0.3 | 107.31 | 107.71 | 108.09 | 108.43 | 108.76 | 109.02 |
| 0.4 | 107.46 | 107.88 | 108.26 | 108.59 | 108.88 | 109.18 |
| 0.5 | 107.47 | 107.890 | 108.26 | 108.56 | 108.93 | 109.19 |

Table 4.14: Apparent molar volume ($\varphi_v$) of aqueous NaCl as a function of molality (m/mol.kg$^{-1}$) at different temperature

| Only NaCl +Water | | | | | | |
|---|---|---|---|---|---|---|
| $\varphi v \times 10^6/m^3.mol^{-1}$ | | | | | | |
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.1 | 18.21 | 18.56 | 18.95 | 19.29 | 19.64 | 19.85 |
| 0.2 | 18.18 | 18.58 | 18.97 | 19.30 | 19.60 | 19.88 |
| 0.3 | 18.32 | 18.71 | 19.09 | 19.44 | 19.78 | 20.05 |
| 0.4 | 18.46 | 18.85 | 19.27 | 19.60 | 19.90 | 20.14 |
| 0.5 | 18.47 | 18.90 | 19.29 | 19.70 | 19.95 | 20.20 |

Table 4.15: Apparent molar volume ($\varphi_v$) of aqueous KCl as a function of molality (m/mol.kg$^{-1}$) at different temperature

| Only KCl +Water | | | | | | |
|---|---|---|---|---|---|---|
| $\varphi_v \times 10^6/m^3.mol^{-1}$ | | | | | | |
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.1 | 27.03 | 27.53 | 28.03 | 28.55 | 29.05 | 29.60 |
| 0.2 | 27.13 | 27.59 | 28.15 | 28.67 | 29.16 | 29.71 |
| 0.3 | 27.28 | 27.72 | 28.26 | 28.76 | 29.28 | 29.84 |
| 0.4 | 27.43 | 27.87 | 28.36 | 28.92 | 29.38 | 29.96 |
| 0.5 | 27.50 | 27.99 | 28.47 | 29.09 | 29.57 | 30.02 |

Table 4.16: Apparent molar volume ($\varphi_v$) of Glucose in aqueous solution of ciprofloxacin (0.03 mol.kg$^{-1}$) as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.03 mol.kg$^{-1}$Ciprofloxacin + Water + Glucose | | | | | | |
|---|---|---|---|---|---|---|
| $\varphi_v \times 10^6/m^3.mol^{-1}$ | | | | | | |
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.1 | 114.27 | 114.67 | 115.05 | 115.46 | 115.72 | 115.98 |
| 0.2 | 114.35 | 114.81 | 115.17 | 115.52 | 115.78 | 116.08 |
| 0.3 | 114.47 | 114.88 | 115.28 | 115.62 | 115.91 | 116.15 |
| 0.4 | 114.49 | 114.94 | 115.30 | 115.66 | 115.99 | 116.31 |
| 0.5 | 114.69 | 115.13 | 115.52 | 115.82 | 116.10 | 116.43 |

Table 4.17: Apparent molar volume ($\varphi_v$) of Glucose in aqueous solution of ciprofloxacin (0.045 mol.kg$^{-1}$) as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.045 mol.kg$^{-1}$Ciprofloxacin + Water + Glucose | | | | | | |
|---|---|---|---|---|---|---|
| $\varphi_v \times 10^6/m^3.mol^{-1}$ | | | | | | |
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.1 | 115.27 | 115.67 | 116.07 | 116.48 | 116.72 | 116.98 |
| 0.2 | 115.35 | 115.80 | 116.19 | 116.55 | 116.78 | 117.11 |
| 0.3 | 115.49 | 115.86 | 116.36 | 116.62 | 116.91 | 117.18 |
| 0.4 | 115.58 | 115.92 | 116.44 | 116.73 | 116.99 | 117.33 |
| 0.5 | 115.66 | 116.14 | 116.54 | 116.82 | 117.10 | 117.44 |

Table 4.18: Apparent molar volume ($\varphi_v$) of Glucose in aqueous solution of ciprofloxacin (0.06 mol.kg$^{-1}$) as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.06 mol.kg$^{-1}$Ciprofloxacin + Water + Glucose | | | | | | |
|---|---|---|---|---|---|---|
| $\varphi_v \times 10^6/m^3.mol^{-1}$ | | | | | | |
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.1 | 114.42 | 114.84 | 115.17 | 115.46 | 115.75 | 116.03 |
| 0.2 | 114.52 | 114.96 | 115.27 | 115.53 | 115.85 | 116.13 |
| 0.3 | 114.66 | 115.01 | 115.40 | 115.71 | 115.96 | 116.18 |
| 0.4 | 114.75 | 115.16 | 115.47 | 115.77 | 116.03 | 116.31 |
| 0.5 | 114.89 | 115.31 | 115.64 | 115.92 | 116.15 | 116.41 |

Table 4.19: Apparent molar volume ($\varphi_v$) of NaCl in aqueous solution of ciprofloxacin (0.03 mol.kg$^{-1}$) as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.03 mol.kg$^{-1}$Ciprofloxacin + Water + NaCl | | | | | | |
|---|---|---|---|---|---|---|
| $\varphi_v \times 10^6/m^3.mol^{-1}$ | | | | | | |
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.1 | 17.27 | 17.66 | 18.04 | 18.46 | 18.71 | 19.00 |
| 0.2 | 17.35 | 17.81 | 18.17 | 18.51 | 18.78 | 19.07 |
| 0.3 | 17.46 | 17.89 | 18.27 | 18.61 | 18.89 | 19.18 |
| 0.4 | 17.50 | 17.92 | 18.29 | 18.63 | 18.99 | 19.17 |
| 0.5 | 17.70 | 18.12 | 18.50 | 18.83 | 19.11 | 19.42 |

Table 4.20: Apparent molar volume ($\varphi_v$) of NaCl in aqueous solution of ciprofloxacin (0.045 mol.kg$^{-1}$) as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.045 mol.kg$^{-1}$Ciprofloxacin + Water + NaCl | | | | | | |
|---|---|---|---|---|---|---|
| $\varphi_v \times 10^6/m^3.mol^{-1}$ | | | | | | |
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.1 | 17.29 | 17.65 | 18.06 | 18.48 | 18.73 | 19.01 |
| 0.2 | 17.37 | 17.83 | 18.19 | 18.50 | 18.80 | 19.09 |
| 0.3 | 17.45 | 17.85 | 18.25 | 18.63 | 18.88 | 19.21 |
| 0.4 | 17.51 | 17.92 | 18.31 | 18.66 | 18.99 | 19.25 |
| 0.5 | 17.66 | 18.06 | 18.51 | 18.86 | 19.12 | 19.41 |

Table 4.21: Apparent molar volume ($\varphi_v$) of NaCl in aqueous solution of ciprofloxacin (0.06 mol.kg$^{-1}$) as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.06 mol.kg$^{-1}$Ciprofloxacin + Water + NaCl | | | | | | |
|---|---|---|---|---|---|---|
| $\varphi_v \times 10^6/m^3.mol^{-1}$ | | | | | | |
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.1 | 18.54 | 18.95 | 19.39 | 19.71 | 20.03 | 20.36 |
| 0.2 | 18.65 | 19.06 | 19.47 | 19.79 | 20.13 | 20.44 |
| 0.3 | 18.77 | 19.13 | 19.53 | 19.86 | 20.20 | 20.51 |
| 0.4 | 18.91 | 19.33 | 19.71 | 19.97 | 20.28 | 20.63 |
| 0.5 | 19.03 | 19.46 | 19.79 | 20.07 | 20.38 | 20.72 |

Table 4.22: Apparent molar volume ($\varphi_v$) of KCl in aqueous solution of ciprofloxacin (0.03 mol.kg$^{-1}$) as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.03 mol.kg$^{-1}$Ciprofloxacin + Water + KCl | | | | | | |
|---|---|---|---|---|---|---|
| $\varphi_v \times 10^6/m^3.mol^{-1}$ | | | | | | |
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.1 | 26.13 | 26.50 | 26.98 | 27.35 | 27.75 | 28.04 |
| 0.2 | 26.26 | 26.62 | 27.12 | 27.46 | 27.88 | 28.19 |
| 0.3 | 26.40 | 26.74 | 27.25 | 27.58 | 27.93 | 28.31 |
| 0.4 | 26.52 | 26.86 | 27.38 | 27.73 | 28.09 | 28.42 |
| 0.5 | 26.65 | 26.92 | 27.40 | 27.87 | 28.21 | 28.55 |

Table 4.23: Apparent molar volume ($\varphi_v$) of KCl in aqueous solution of ciprofloxacin (0.045 mol.kg$^{-1}$) as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.045 mol.kg$^{-1}$Ciprofloxacin + Water + NaCl | | | | | | |
|---|---|---|---|---|---|---|
| $\varphi_v \times 10^6/m^3.mol^{-1}$ | | | | | | |
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.1 | 26.23 | 26.60 | 27.06 | 27.45 | 27.87 | 26.23 |
| 0.2 | 26.38 | 26.76 | 27.20 | 27.58 | 27.96 | 26.38 |
| 0.3 | 26.52 | 26.84 | 27.35 | 27.73 | 28.10 | 26.52 |
| 0.4 | 26.65 | 26.95 | 27.49 | 27.86 | 28.19 | 26.65 |
| 0.5 | 26.79 | 27.08 | 27.55 | 27.98 | 28.32 | 26.79 |

Table 4.24: Apparent molar volume ($\varphi_v$) of KCl in aqueous solution of ciprofloxacin (0.06 mol.kg$^{-1}$) as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.06 mol.kg$^{-1}$Ciprofloxacin + Water + NaCl | | | | | | |
|---|---|---|---|---|---|---|
| $\varphi_v \times 10^6/m^3.mol^{-1}$ | | | | | | |
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.1 | 27.01 | 27.40 | 27.88 | 28.27 | 28.65 | 28.95 |
| 0.2 | 27.15 | 27.52 | 28.02 | 28.34 | 28.70 | 29.09 |
| 0.3 | 27.28 | 27.61 | 28.16 | 28.46 | 28.83 | 29.21 |
| 0.4 | 27.42 | 27.75 | 28.24 | 28.61 | 29.00 | 29.32 |
| 0.5 | 27.54 | 27.86 | 28.30 | 28.79 | 29.11 | 29.45 |

Table 4.25: Limiting apparent molar volume ($\varphi_v^0$), experimental slope ($S_V$), limiting apparent molar volume expansibilities ($E\varphi^0$) and $(\delta E^0\varphi/\delta T)_p$ of Glucose+ water system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively

| Temp (K) | $\varphi_v^0\times10^6$ ($m^3.mol^{-1}$) | $S_V\times10^6$ ($m^3.mol^{-2}.kg$) | $E\varphi^0\times10^8$ ($m^3.mol^{-1}.K^{-1}$) | $(\delta E^0\varphi/\delta T)_p\times10^8$ ($m^3.mol^{-2}.K^{-2}$) |
|---|---|---|---|---|
| 293.15 K | 106.98 | 1.02 | 9.50 | |
| 298.15 K | 107.42 | 0.98 | 8.50 | |
| 303.15 K | 107.84 | 0.89 | 7.50 | -0.20 |
| 308.15 K | 108.17 | 0.89 | 6.50 | |
| 313.15 K | 108.49 | 0.92 | 5.50 | |
| 318.15 K | 108.76 | 0.89 | 4.50 | |

Table 4.26: Limiting apparent molar volume ($\varphi_v^0$), experimental slope ($S_V$), limiting apparent molar volume expansibilities ($E\varphi^0$) and $(\delta E^0\varphi/\delta T)_p$ of NaCl + water system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively

| Temp (K) | $\varphi_v^0\times10^6$ ($m^3.mol^{-1}$) | $S_V\times10^6$ ($m^3.mol^{-2}.kg$) | $E\varphi^0\times10^8$ ($m^3.mol^{-1}.K^{-1}$) | $(\delta E^0\varphi/\delta T)_p\times10^8$ ($m^3.mol^{-2}.K^{-2}$) |
|---|---|---|---|---|
| 293.15 K | 18.00 | 1.03 | 7.50 | |
| 298.15 K | 18.37 | 1.15 | 7.30 | |
| 303.15 K | 18.76 | 1.12 | 7.10 | -0.04 |
| 308.15 K | 18.98 | 1.55 | 6.90 | |
| 313.15 K | 19.40 | 1.15 | 6.70 | |
| 318.15 K | 19.70 | 1.08 | 6.50 | |

Table 4.27: Limiting apparent molar volume ($\varphi_v^0$), experimental slope ($S_V$), limiting apparent molar volume expansibilities ($E\varphi^0$) and $(\delta E^0\varphi/\delta T)_p$ of KCl + water system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively

| Temp (K) | $\varphi_v^0\times10^6$ ($m^3.mol^{-1}$) | $S_V\times10^6$ ($m^3.mol^{-2}.kg$) | $E\varphi^0\times10^8$ ($m^3.mol^{-1}.K^{-1}$) | $(\delta E^0\varphi/\delta T)_p\times10^8$ ($m^3.mol^{-2}.K^{-2}$) |
|---|---|---|---|---|
| 293.15 K | 26.91 | 1.24 | -10.75 | |
| 298.15 K | 27.38 | 1.21 | -10.45 | |
| 303.15 K | 27.93 | 1.09 | -10.15 | -0.06 |
| 308.15 K | 28.40 | 1.34 | -9.85 | |
| 313.15 K | 28.91 | 1.27 | -9.55 | |
| 318.15 K | 29.50 | 1.09 | -9.25 | |

Table 4.28: Limiting apparent molar volume ($\varphi_v^0$), experimental slope ($S_V$), limiting apparent molar volume transfer ($\Delta\varphi_v^0$), limiting apparent molar volume expansibilities ($E\varphi^0$) and $(\delta E^0\varphi/\delta T)_p$ of water + Glucose + 0.03 mol.kg$^{-1}$ciprofloxacin system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively

| Temp (K) | $\varphi_v^0\times10^6$ ($m^3.mol^{-1}$) | $S_V\times10^6$ ($m^3.mol^{-2}.kg$) | $\Delta_{tr}\varphi_v^0\times10^6$ ($m^3.mol^{-1}$) | $E\varphi^0\times10^8$ ($m^3.mol^{-1}.K^{-1}$) | $(\delta E^0\varphi/\delta T)_p\times10^8$ ($m^3.mol^{-2}.K^{-2}$) |
|---|---|---|---|---|---|
| 293.15 K | 114.16 | 0.97 | 7.18 | 9.00 | |
| 298.15 K | 114.58 | 1.04 | 7.16 | 8.20 | |
| 303.15 K | 114.94 | 1.07 | 7.11 | 7.40 | -0.16 |
| 308.15 K | 115.35 | 0.91 | 7.18 | 6.60 | |
| 313.15 K | 115.61 | 0.98 | 7.12 | 5.80 | |
| 318.15 K | 115.88 | 1.01 | 7.12 | 5.00 | |

Table 4.29: Limiting apparent molar volume ($\varphi_v^0$), experimental slope ($S_V$), limiting apparent molar volume transfer ($\Delta\varphi_v^0$), limiting apparent molar volume expansibilities ($E\varphi^0$) and $(\delta E^0\varphi/\delta T)_p$ of water + Glucose+ 0.045 mol.kg$^{-1}$ ciprofloxacin system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively

| Temp (K) | $\varphi_v^0\times10^6$ ($m^3.mol^{-1}$) | $S_V\times10^6$ ($m^3.mol^{-2}.kg$) | $\Delta_{tr}\varphi_v^0\times10^6$ ($m^3.mol^{-1}$) | $E\varphi^0\times10^8$ ($m^3.mol^{-1}.K^{-1}$) | $(\delta E^0\varphi/\delta T)_p\times10^8$ ($m^3.mol^{-2}.K^{-2}$) |
|---|---|---|---|---|---|
| 293.15 K | 115.17 | 1.00 | 8.09 | 9.50 | |
| 298.15 K | 115.56 | 1.05 | 8.12 | 8.50 | |
| 303.15 K | 115.97 | 1.18 | 8.17 | 7.50 | -0.20 |
| 308.15 K | 116.38 | 0.87 | 8.20 | 6.50 | |
| 313.15 K | 116.61 | 0.98 | 8.00 | 5.50 | |
| 318.15 K | 116.87 | 1.14 | 7.99 | 4.50 | |

Table 4.30: Limiting apparent molar volume ($\varphi_v^0$), experimental slope ($S_V$), limiting apparent molar volume transfer ($\Delta\varphi_v^0$), limiting apparent molar volume expansibilities ($E\varphi^0$) and $(\delta E^0\varphi/\delta T)$p of water + Glucose + 0.06 mol.kg$^{-1}$ciprofloxacin system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively

| Temp (K) | $\varphi_v^0\times10^6$ ($m^3.mol^{-1}$) | $S_V\times10^6$ ($m^3.mol^{-2}.kg$) | $\Delta_{tr}\varphi_v^0\times10^6$ ($m^3.mol^{-1}$) | $E\varphi^0\times10^8$ ($m^3.mol^{-1}.K^{-1}$) | $(\delta E^0\varphi/\delta T)_p\times10^8$ ($m^3.mol^{-2}.K^{-2}$) |
|---|---|---|---|---|---|
| 293.15 K | 114.30 | 1.16 | 7.33 | 8.20 | |
| 298.15 K | 114.72 | 1.13 | 7.28 | 7.25 | |
| 303.15 K | 115.05 | 1.14 | 7.22 | 6.20 | -0.18 |
| 308.15 K | 115.05 | 1.17 | 6.89 | 5.40 | |
| 313.15 K | 115.05 | 0.98 | 6.55 | 4.50 | |
| 318.15 K | 115.05 | 0.94 | 6.31 | 3.45 | |

Table 4.31: Limiting apparent molar volume ($\varphi_v^0$), experimental slope ($S_V$), limiting apparent molar volume transfer ($\Delta\varphi_v^0$), limiting apparent molar volume expansibilities ($E\varphi^0$) and $(\delta E^0\varphi/\delta T)_p$ of water + NaCl + 0.03 mol.kg$^{-1}$ ciprofloxacin system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively

| Temp (K) | $\varphi_v^0\times10^6$ ($m^3.mol^{-1}$) | $S_V\times10^6$ ($m^3.mol^{-2}.kg$) | $\Delta_{tr}\varphi_v^0\times10^6$ ($m^3.mol^{-1}$) | $E\varphi^0\times10^8$ ($m^3.mol^{-1}.K^{-1}$) | $(\delta E^0\varphi/\delta T)_p\times10^8$ ($m^3.mol^{-2}.K^{-2}$) |
|---|---|---|---|---|---|
| 293.15 K | 17.15 | 1.00 | -0.84 | 9.00 | |
| 298.15 K | 17.57 | 1.02 | -0.80 | 8.20 | |
| 303.15 K | 17.95 | 1.03 | -0.82 | 7.40 | -0.16 |
| 308.15 K | 18.35 | 0.87 | -0.63 | 6.60 | |
| 313.15 K | 18.60 | 1.01 | -0.81 | 5.80 | |
| 318.15 K | 18.88 | 0.95 | -0.82 | 5.00 | |

Table 4.32: Limiting apparent molar volume ($\varphi_v^0$), experimental slope ($S_V$), limiting apparent molar volume transfer ($\Delta\varphi_v^0$), limiting apparent molar volume expansibilities ($E\varphi^0$) and $(\delta E^0\varphi/\delta T)_p$ of water + NaCl + 0.045 mol.kg$^{-1}$ciprofloxacin system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively

| Temp (K) | $\varphi_v^0\times10^6$ ($m^3.mol^{-1}$) | $S_V\times10^6$ ($m^3.mol^{-2}.kg$) | $\Delta_{tr}\varphi_v^0\times10^6$ ($m^3.mol^{-1}$) | $E\varphi^0\times10^8$ ($m^3.mol^{-1}.K^{-1}$) | $(\delta E^0\varphi/\delta T)_p\times10^8$ ($m^3.mol^{-2}.K^{-2}$) |
|---|---|---|---|---|---|
| 293.15 K | 17.19 | 0.87 | -0.81 | 8.75 | |
| 298.15 K | 17.59 | 0.90 | -0.78 | 8.05 | -0.14 |
| 303.15 K | 17.96 | 1.01 | -0.80 | 7.35 | |
| 308.15 K | 18.35 | 0.93 | -0.68 | 6.65 | |
| 313.15 K | 18.62 | 0.97 | -0.79 | 5.95 | |
| 318.15 K | 18.90 | 0.97 | -0.80 | 5.25 | |

Table 4.33: Limiting apparent molar volume ($\varphi_v^0$), experimental slope ($S_V$), limiting apparent molar volume transfer ($\Delta\varphi_v^0$), limiting apparent molar volume expansibilities ($E\varphi^0$) and $(\delta E^0\varphi/\delta T)_p$ of Water + NaCl + 0.06 mol.kg$^{-1}$ciprofloxacin system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively

| Temp (K) | $\varphi_v^0\times10^6$ ($m^3.mol^{-1}$) | $S_V\times10^6$ ($m^3.mol^{-2}.kg$) | $\Delta_{tr}\varphi_v^0\times10^6$ ($m^3.mol^{-1}$) | $E\varphi^0\times10^8$ ($m^3.mol^{-1}.K^{-1}$) | $(\delta E^0\varphi/\delta T)_p\times10^8$ ($m^3.mol^{-2}.K^{-2}$) |
|---|---|---|---|---|---|
| 293.15 K | 18.40 | 1.24 | 0.41 | 8.70 | |
| 298.15 K | 18.80 | 1.29 | 0.43 | 8.01 | |
| 303.15 K | 19.26 | 1.05 | 0.50 | 7.32 | -0.14 |
| 308.15 K | 19.61 | 0.90 | 0.63 | 6.60 | |
| 313.15 K | 19.95 | 0.84 | 0.55 | 5.92 | |
| 318.15 K | 20.26 | 0.92 | 0.55 | 5.23 | |

Table 4.34: Limiting apparent molar volume ($\varphi_v^0$), experimental slope ($S_V$), limiting apparent molar volume transfer ($\Delta\varphi_v^0$), limiting apparent molar volume expansibilities ($E\varphi^0$) and $(\delta E^0\varphi/\delta T)_p$ of water + KCl + 0.03 mol.kg$^{-1}$ ciprofloxacin system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively

| Temp (K) | $\varphi_v^0\times10^6$ ($m^3.mol^{-1}$) | $S_V\times10^6$ ($m^3.mol^{-2}.kg$) | $\Delta_{tr}\varphi_v^0\times10^6$ ($m^3.mol^{-1}$) | $E\varphi^0\times10^8$ ($m^3.mol^{-1}.K^{-1}$) | $(\delta E^0\varphi/\delta T)_p\times10^8$ ($m^3.mol^{-2}.K^{-2}$) |
|---|---|---|---|---|---|
| 293.15 K | 26.00 | 1.30 | -0.91 | 9.50 | |
| 298.15 K | 26.40 | 1.08 | -0.98 | 8.90 | |
| 303.15 K | 26.89 | 1.11 | -1.04 | 8.30 | -0.12 |
| 308.15 K | 27.21 | 1.29 | -1.19 | 7.70 | |
| 313.15 K | 27.64 | 1.13 | -1.28 | 7.10 | |
| 318.15 K | 27.92 | 1.26 | -1.58 | 6.50 | |

Table 4.35: Limiting apparent molar volume ($\varphi_v^0$), experimental slope ($S_V$), limiting apparent molar volume transfer ($\Delta\varphi_v^0$), limiting apparent molar volume expansibilities ($E\varphi^0$) and $(\delta E^0\varphi/\delta T)_p$ of water + KCl + 0.045 mol.kg$^{-1}$ ciprofloxacin system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively

| Temp (K) | $\varphi_v^0\times10^6$ ($m^3.mol^{-1}$) | $S_V\times10^6$ ($m^3.mol^{-2}.kg$) | $\Delta_{tr}\varphi_v^0\times10^6$ ($m^3.mol^{-1}$) | $E\varphi^0\times10^8$ ($m^3.mol^{-1}.K^{-1}$) | $(\delta E^0\varphi/\delta T)_p\times10^8$ ($m^3.mol^{-2}.K^{-2}$) |
|---|---|---|---|---|---|
| 293.15 K | 26.88 | 1.24 | -0.81 | 8.50 | |
| 298.15 K | 27.28 | 1.21 | -0.88 | 8.30 | |
| 303.15 K | 27.8 | 1.09 | -0.98 | 8.10 | -0.04 |
| 308.15 K | 28.11 | 1.34 | -1.08 | 7.90 | |
| 313.15 K | 28.49 | 1.27 | -1.16 | 7.70 | |
| 318.15 K | 28.83 | 1.09 | -1.39 | 7.50 | |

Table 4.36: Limiting apparent molar volume ($\varphi_v^0$), experimental slope ($S_V$), limiting apparent molar volume transfer ($\Delta\varphi_v^0$), limiting apparent molar volume expansibilities ($E\varphi^0$) and $(\delta E^0\varphi/\delta T)_p$ of Water + KCl + 0.06 mol.kg$^{-1}$ ciprofloxacin system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively

| Temp (K) | $\varphi_v^0\times10^6$ ($m^3.mol^{-1}$) | $S_V\times10^6$ ($m^3.mol^{-2}.kg$) | $\Delta_{tr}\varphi_v^0\times10^6$ ($m^3.mol^{-1}$) | $E\varphi^0\times10^8$ ($m^3.mol^{-1}.K^{-1}$) | $(\delta E^0\varphi/\delta T)_p\times10^8$ ($m^3.mol^{-2}.K^{-2}$) |
|---|---|---|---|---|---|
| 293.15 K | 26.91 | 1.33 | -0.03 | 9.50 | |
| 298.15 K | 27.38 | 1.15 | -0.10 | 8.90 | |
| 303.15 K | 27.93 | 1.07 | -0.13 | 8.30 | -0.12 |
| 308.15 K | 28.4 | 1.29 | -0.30 | 7.70 | |
| 313.15 K | 28.91 | 1.22 | -0.42 | 7.10 | |
| 318.15 K | 29.5 | 1.24 | -0.67 | 6.50 | |

Table 4.37: Partial molar volume ($\bar{V}_2$) of aqueous Glucose as a function of molality ($m/mol.kg^{-1}$) at different temperature

| Glucose+ Water | | | | | | |
|---|---|---|---|---|---|---|
| $\bar{V}_2 \times 10^6/m^3.mol^{-1}$ | | | | | | |
| $m/mol.kg^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.1 | 108.45 | 108.89 | 109.45 | 109.96 | 110.51 | 111.05 |
| 0.2 | 109.11 | 109.75 | 110.26 | 110.77 | 111.33 | 111.87 |
| 0.3 | 110.22 | 110.69 | 111.26 | 111.57 | 112.12 | 112.64 |
| 0.4 | 110.98 | 111.59 | 112.03 | 112.49 | 113.03 | 113.58 |
| 0.5 | 111.86 | 112.44 | 112.83 | 113.26 | 113.81 | 114.36 |

Table 4.38: Partial molar volume ($\bar{V}_2$) of aqueous NaCl as a function of molality ($m/mol.kg^{-1}$) at different temperature

| NaCl+ Water | | | | | | |
|---|---|---|---|---|---|---|
| $\bar{V}_2 \times 10^6/m^3.mol^{-1}$ | | | | | | |
| $m/mol.kg^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.1 | 18.71 | 19.16 | 19.55 | 19.96 | 20.29 | 20.62 |
| 0.2 | 19.10 | 19.45 | 19.85 | 20.29 | 20.56 | 20.96 |
| 0.3 | 19.43 | 19.77 | 20.17 | 20.60 | 20.87 | 21.31 |
| 0.4 | 19.63 | 20.09 | 20.49 | 20.97 | 21.18 | 21.61 |
| 0.5 | 19.93 | 20.32 | 20.76 | 21.22 | 21.58 | 21.90 |

Table 4.39: Partial molar volume ($\bar{V}_2$) of aqueous KCl as a function of molality ($m/mol.kg^{-1}$) at different temperature

| KCl+ Water | | | | | | |
|---|---|---|---|---|---|---|
| $\bar{V}_2 \times 10^6/m^3.mol^{-1}$ | | | | | | |
| $m/mol.kg^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.1 | 28.45 | 28.79 | 29.19 | 29.48 | 29.82 | 30.05 |
| 0.2 | 28.75 | 29.03 | 29.43 | 29.70 | 30.03 | 30.29 |
| 0.3 | 28.98 | 29.29 | 29.71 | 29.96 | 30.32 | 30.59 |
| 0.4 | 29.24 | 29.54 | 29.96 | 30.21 | 30.58 | 30.80 |
| 0.5 | 29.50 | 29.75 | 30.20 | 30.45 | 30.83 | 31.06 |

Table 4.40: Partial molar volume ($\bar{V}_2$) of aqueous solution of ciprofloxacin (0.03 mol.kg$^{-1}$) with Glucose as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.03 mol.kg$^{-1}$ Ciprofloxacin + Water + Glucose | | | | | | |
|---|---|---|---|---|---|---|
| $\bar{V}_2\times10^6$/m$^3$.mol$^{-1}$ | | | | | | |
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.1 | 114.89 | 115.23 | 115.63 | 116.06 | 116.34 | 116.52 |
| 0.2 | 115.23 | 115.61 | 116.02 | 116.37 | 116.68 | 116.84 |
| 0.3 | 115.54 | 115.88 | 116.30 | 116.64 | 116.99 | 117.11 |
| 0.4 | 115.75 | 116.07 | 116.46 | 116.85 | 117.26 | 117.39 |
| 0.5 | 116.09 | 116.40 | 116.81 | 117.17 | 117.49 | 117.63 |

Table 4.41: Partial molar volume ($\bar{V}_2$) of aqueous solution of ciprofloxacin (0.045 mol.kg$^{-1}$) with Glucose as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.045 mol.kg$^{-1}$ Ciprofloxacin + Water + Glucose | | | | | | |
|---|---|---|---|---|---|---|
| $\bar{V}_2\times10^6$/m$^3$.mol$^{-1}$ | | | | | | |
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.1 | 108.66 | 109.09 | 109.52 | 110.02 | 110.61 | 111.14 |
| 0.2 | 109.37 | 109.85 | 110.35 | 110.87 | 111.46 | 111.95 |
| 0.3 | 110.42 | 110.76 | 111.36 | 111.66 | 112.23 | 112.74 |
| 0.4 | 111.09 | 111.70 | 112.14 | 112.57 | 113.13 | 113.68 |
| 0.5 | 111.86 | 112.53 | 112.93 | 113.35 | 113.92 | 114.50 |

Table 4.42: Partial molar volume ($\bar{V}_2$) of aqueous solution of ciprofloxacin (0.06 mol.kg$^{-1}$) with Glucose as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.06 mol.kg$^{-1}$ Ciprofloxacin + Water + Glucose | | | | | | |
|---|---|---|---|---|---|---|
| $\bar{V}_2\times10^6$/m$^3$.mol$^{-1}$ | | | | | | |
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.1 | 114.83 | 115.36 | 115.71 | 116.10 | 116.37 | 116.60 |
| 0.2 | 115.15 | 115.60 | 116.00 | 116.41 | 116.70 | 116.89 |
| 0.3 | 115.41 | 115.87 | 116.29 | 116.67 | 116.91 | 117.18 |
| 0.4 | 115.68 | 116.09 | 116.52 | 116.89 | 117.20 | 117.46 |
| 0.5 | 116.04 | 116.40 | 116.83 | 117.19 | 117.49 | 117.71 |

Table 4.43: Partial molar volume ($\bar{V}_2$) of aqueous solution of ciprofloxacin (0.03 mol.kg$^{-1}$) with NaCl as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.03 mol.kg$^{-1}$ Ciprofloxacin + Water + NaCl | | | | | | |
|---|---|---|---|---|---|---|
| $\bar{V}_2 \times 10^6/m^3.mol^{-1}$ | | | | | | |
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.1 | 17.89 | 18.23 | 18.63 | 19.03 | 19.35 | 19.53 |
| 0.2 | 18.22 | 18.55 | 19.00 | 19.38 | 19.66 | 19.81 |
| 0.3 | 18.52 | 18.81 | 19.28 | 19.65 | 19.95 | 20.11 |
| 0.4 | 18.74 | 19.06 | 19.56 | 19.84 | 20.16 | 20.38 |
| 0.5 | 19.07 | 19.38 | 19.80 | 20.18 | 20.44 | 20.64 |

Table 4.44: Partial molar volume ($\bar{V}_2$) of aqueous solution of ciprofloxacin (0.045 mol.kg$^{-1}$) with NaCl as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.045 mol.kg$^{-1}$ Ciprofloxacin + Water + NaCl | | | | | | |
|---|---|---|---|---|---|---|
| $\bar{V}_2 \times 10^6/m^3.mol^{-1}$ | | | | | | |
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.1 | 17.89 | 18.23 | 18.63 | 19.03 | 19.35 | 19.53 |
| 0.2 | 18.22 | 18.55 | 19.00 | 19.38 | 19.66 | 19.81 |
| 0.3 | 18.52 | 18.81 | 19.28 | 19.65 | 19.95 | 20.11 |
| 0.4 | 18.74 | 19.06 | 19.56 | 19.84 | 20.16 | 20.38 |
| 0.5 | 19.07 | 19.38 | 19.80 | 20.18 | 20.44 | 20.64 |

Table 4.45: Partial molar volume ($\bar{V}_2$) of aqueous solution of ciprofloxacin (0.06 mol.kg$^{-1}$) with NaCl as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.06 mol.kg$^{-1}$ Ciprofloxacin + Water + NaCl | | | | | | |
|---|---|---|---|---|---|---|
| $\bar{V}_2 \times 10^6/m^3.mol^{-1}$ | | | | | | |
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.1 | 18.76 | 19.01 | 19.27 | 19.46 | 19.72 | 19.97 |
| 0.2 | 18.85 | 19.11 | 19.37 | 19.58 | 19.82 | 20.08 |
| 0.3 | 18.93 | 19.18 | 19.47 | 19.68 | 19.94 | 20.19 |
| 0.4 | 19.01 | 19.25 | 19.57 | 19.78 | 20.05 | 20.30 |
| 0.5 | 19.10 | 19.33 | 19.62 | 19.89 | 20.14 | 20.38 |

Table 4.46: Partial molar volume ($\bar{V}_2$) of aqueous solution of ciprofloxacin (0.03 mol.kg$^{-1}$) with KCl as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.03 mol.kg$^{-1}$ Ciprofloxacin + Water + KCl | | | | | | |
|---|---|---|---|---|---|---|
| $\bar{V}_2\times10^6$/m$^3$.mol$^{-1}$ | | | | | | |
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.1 | 28.91 | 29.29 | 29.66 | 30.04 | 30.34 | 30.65 |
| 0.2 | 29.29 | 29.65 | 30.05 | 30.38 | 30.68 | 30.96 |
| 0.3 | 29.56 | 29.92 | 30.33 | 30.65 | 30.99 | 31.33 |
| 0.4 | 29.79 | 30.18 | 30.51 | 30.87 | 31.29 | 31.65 |
| 0.5 | 30.10 | 30.42 | 30.86 | 31.15 | 31.55 | 31.93 |

Table 4.47: Partial molar volume ($\bar{V}_2$) of aqueous solution of ciprofloxacin (0.045 mol.kg$^{-1}$) with KCl as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.045 mol.kg$^{-1}$ Ciprofloxacin + Water + KCl | | | | | | |
|---|---|---|---|---|---|---|
| $\bar{V}_2\times10^6$/m$^3$.mol$^{-1}$ | | | | | | |
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.1 | 29.03 | 29.39 | 29.79 | 30.17 | 30.44 | 30.76 |
| 0.2 | 29.41 | 29.74 | 30.17 | 30.48 | 30.78 | 31.06 |
| 0.3 | 29.68 | 30.03 | 30.46 | 30.76 | 31.10 | 31.43 |
| 0.4 | 29.92 | 30.28 | 30.65 | 31.05 | 31.41 | 31.75 |
| 0.5 | 30.19 | 30.54 | 30.96 | 31.31 | 31.67 | 32.05 |

Table 4.48: Partial molar volume ($\bar{V}_2$) of aqueous solution of ciprofloxacin (0.06 mol.kg$^{-1}$) with KCl as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.06 mol.kg$^{-1}$ Ciprofloxacin + Water + KCl | | | | | | |
|---|---|---|---|---|---|---|
| $\bar{V}_2\times10^6$/m$^3$.mol$^{-1}$ | | | | | | |
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.1 | 28.86 | 29.28 | 29.62 | 30.01 | 30.28 | 30.60 |
| 0.2 | 29.24 | 29.58 | 30.03 | 30.28 | 30.58 | 30.95 |
| 0.3 | 29.51 | 29.85 | 30.33 | 30.55 | 30.95 | 31.28 |
| 0.4 | 29.73 | 30.12 | 30.52 | 30.81 | 31.21 | 31.58 |
| 0.5 | 30.02 | 30.37 | 30.85 | 31.11 | 31.50 | 31.84 |

Table 4.49: Sound velocity (u) and of aqueous Glucose as a function of molality at different temperature

| Glucose+ Water | | | | | | |
|---|---|---|---|---|---|---|
| Sound velocity, u/m.s$^{-1}$ | | | | | | |
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 1482.27 | 1496.53 | 1508.81 | 1519.43 | 1528.5 | 1536.1 |
| 0.1 | 1489.17 | 1502.73 | 1515.06 | 1525.46 | 1534.29 | 1541.66 |
| 0.2 | 1495.55 | 1509.04 | 1520.83 | 1530.95 | 1539.54 | 1546.67 |
| 0.3 | 1503.83 | 1516.85 | 1528.16 | 1537.84 | 1546.03 | 1552.84 |
| 0.4 | 1508.37 | 1521.31 | 1532.55 | 1542.19 | 1550.36 | 1557.13 |
| 0.5 | 1514.56 | 1527.17 | 1538.13 | 1547.52 | 1555.46 | 1562.01 |

Table 4.50: Sound velocity (u) of aqueous NaCl as a function of molality at different temperature

| NaCl + Water | | | | | | |
|---|---|---|---|---|---|---|
| Sound velocity, u/m.s$^{-1}$ | | | | | | |
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 1482.27 | 1495.53 | 1508.81 | 1519.43 | 1528.5 | 1537.1 |
| 0.1 | 1489.14 | 1501.81 | 1514.9 | 1525.38 | 1534.29 | 1542.76 |
| 0.2 | 1496.48 | 1507.06 | 1520.85 | 1531.56 | 1540.27 | 1547.31 |
| 0.3 | 1502.33 | 1513.65 | 1526.79 | 1536.46 | 1545.54 | 1552.11 |
| 0.4 | 1508.08 | 1521.1 | 1532.54 | 1542.42 | 1550.82 | 1557.83 |
| 0.5 | 1514.56 | 1527.42 | 1538.67 | 1548.35 | 1556.57 | 1563.39 |

Table 4.51: Sound velocity (u) of aqueous KCl as a function of molality at different temperature

| KCl + Water | | | | | | |
|---|---|---|---|---|---|---|
| Sound velocity, u/m.s$^{-1}$ | | | | | | |
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 1482.27 | 1496.53 | 1508.81 | 1519.43 | 1528.5 | 1536.1 |
| 0.1 | 1488.2 | 1501.83 | 1513.94 | 1524.4 | 1533.33 | 1540.78 |
| 0.2 | 1493.66 | 1507.07 | 1518.97 | 1529.28 | 1538.05 | 1545.38 |
| 0.3 | 1499.15 | 1512.33 | 1524.02 | 1534.15 | 1542.99 | 1550.19 |
| 0.4 | 1504.38 | 1517.33 | 1528.83 | 1538.78 | 1547.48 | 1554.58 |
| 0.5 | 1509.24 | 1522.07 | 1533.44 | 1543.31 | 1551.74 | 1558.79 |

Table 4.52: Sound velocity (u) of Glucose in aqueous solution of ciprofloxacin (0.03 $mol.kg^{-1}$) as a function of molality at different temperature

| 0.03 $mol.kg^{-1}$ Ciprofloxacin + Water + Glucose | | | | | | |
|---|---|---|---|---|---|---|
| Sound velocity, $u/m.s^{-1}$ | | | | | | |
| $m/mol.kg^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 1486.33 | 1500.12 | 1512.33 | 1522.68 | 1531.54 | 1538.93 |
| 0.1 | 1492.59 | 1506.16 | 1518.08 | 1528.35 | 1537.05 | 1544.29 |
| 0.2 | 1498.71 | 1512.1 | 1523.86 | 1533.95 | 1542.5 | 1549.61 |
| 0.3 | 1505.24 | 1518.38 | 1529.89 | 1539.78 | 1548.15 | 1555.11 |
| 0.4 | 1511.42 | 1524.28 | 1535.58 | 1545.27 | 1553.49 | 1560.3 |
| 0.5 | 1517.41 | 1530.87 | 1540.93 | 1550.48 | 1558.58 | 1565.53 |

Table 4.53: Sound velocity (u) of Glucose in aqueous solution of ciprofloxacin (0.045 $mol.kg^{-1}$) as a function of molality at different temperature

| 0.045 $mol.kg^{-1}$ Ciprofloxacin + Water + Glucose | | | | | | |
|---|---|---|---|---|---|---|
| Sound velocity, $u/m.s^{-1}$ | | | | | | |
| $m/mol.kg^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 1484.75 | 1501.5 | 1513.54 | 1523.91 | 1532.691 | 1540 |
| 0.1 | 1496.16 | 1507.67 | 1519.46 | 1529.59 | 1538.15 | 1545.26 |
| 0.2 | 1500.31 | 1513.51 | 1525.04 | 1534.91 | 1543.27 | 1550.21 |
| 0.3 | 1506.36 | 1519.14 | 1530.4 | 1540.29 | 1548.45 | 1555.19 |
| 0.4 | 1512.74 | 1525.43 | 1535.58 | 1536.43 | 1545.84 | 1560.32 |
| 0.5 | 1518.91 | 1531.33 | 1542.1 | 1551.3 | 1559.05 | 1565.39 |

Table 4.54: Sound velocity (u) of Glucose in aqueous solution of ciprofloxacin (0.06 $mol.kg^{-1}$) as a function of molality at different temperature

| 0.06 $mol.kg^{-1}$ Ciprofloxacin + Water + Glucose | | | | | | |
|---|---|---|---|---|---|---|
| Sound velocity, $u/m.s^{-1}$ | | | | | | |
| $m/mol.kg^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 1489.19 | 1502.89 | 1514.86 | 1525.15 | 1533.86 | 1541.1 |
| 0.1 | 1495.57 | 1508.97 | 1520.68 | 1530.72 | 1539.22 | 1546.27 |
| 0.2 | 1501.79 | 1514.94 | 1526.39 | 1536.19 | 1544.47 | 1551.33 |
| 0.3 | 1507.84 | 1520.7 | 1531.89 | 1541.46 | 1549.55 | 1556.22 |
| 0.4 | 1514.27 | 1526.84 | 1537.75 | 1547.09 | 1554.96 | 1561.43 |
| 0.5 | 1520.29 | 1532.59 | 1543.24 | 1552.35 | 1560.01 | 1566.28 |

Table 4.55: Sound velocity (u) of NaCl in aqueous solution of ciprofloxacin (0.03 $mol.kg^{-1}$) as a function of molality at different temperature

| 0.03 $mol.kg^{-1}$ Ciprofloxacin + Water + NaCl | | | | | | |
|---|---|---|---|---|---|---|
| Sound velocity, $u/m.s^{-1}$ | | | | | | |
| $m/mol.kg^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 1486.33 | 1500.12 | 1512.33 | 1522.68 | 1531.54 | 1538.93 |
| 0.1 | 1492.59 | 1506.16 | 1518.08 | 1528.35 | 1537.05 | 1544.29 |
| 0.2 | 1498.71 | 1512.1 | 1523.86 | 1533.95 | 1542.5 | 1549.61 |
| 0.3 | 1505.24 | 1518.38 | 1529.89 | 1539.78 | 1548.15 | 1555.11 |
| 0.4 | 1511.42 | 1524.28 | 1535.58 | 1545.27 | 1553.49 | 1560.3 |
| 0.5 | 1517.41 | 1530.87 | 1540.93 | 1550.48 | 1558.58 | 1565.53 |

Table 4.56: Sound velocity (u) of NaCl in aqueous solution of ciprofloxacin (0.045 $mol.kg^{-1}$) as a function of molality at different temperature

| 0.045 $mol.kg^{-1}$ Ciprofloxacin + Water + NaCl | | | | | | |
|---|---|---|---|---|---|---|
| Sound velocity, $u/m.s^{-1}$ | | | | | | |
| $m/mol.kg^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 1484.75 | 1501.5 | 1513.54 | 1523.91 | 1532.69 | 1540 |
| 0.1 | 1493.91 | 1507.51 | 1519.39 | 1529.61 | 1538.24 | 1545.41 |
| 0.2 | 1500.07 | 1513.23 | 1524.87 | 1534.9 | 1543.65 | 1550.73 |
| 0.3 | 1506.45 | 1519.57 | 1531.02 | 1540.85 | 1549.19 | 1556.11 |
| 0.4 | 1512.61 | 1525.4 | 1536.61 | 1546.25 | 1554.41 | 1561.15 |
| 0.5 | 1518.68 | 1531.32 | 1542.32 | 1551.78 | 1559.75 | 1566.34 |

Table 4.57: Sound velocity (u) of NaCl in aqueous solution of ciprofloxacin (0.06 $mol.kg^{-1}$) as a function of molality at different temperature

| 0.06 $mol.kg^{-1}$ Ciprofloxacin + Water + NaCl | | | | | | |
|---|---|---|---|---|---|---|
| Sound velocity, $u/m.s^{-1}$ | | | | | | |
| $m/mol.kg^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 1489.19 | 1502.89 | 1514.86 | 1525.15 | 1533.86 | 1541.1 |
| 0.1 | 1495.4 | 1508.87 | 1520.66 | 1530.78 | 1530.78 | 1546.46 |
| 0.2 | 1501.6 | 1514.71 | 1526.29 | 1536.25 | 1544.93 | 1551.96 |
| 0.3 | 1507.79 | 1520.83 | 1532.2 | 1541.95 | 1550.21 | 1557.05 |
| 0.4 | 1513.89 | 1526.68 | 1537.83 | 1547.4 | 1555.49 | 1562.17 |
| 0.5 | 1519.99 | 1532.58 | 1543.49 | 1552.77 | 1560.52 | 1566.92 |

Table 4.58: Sound velocity (u) of KCl in aqueous solution of ciprofloxacin (0.03 $mol.kg^{-1}$) as a function of molality at different temperature

| 0.03 $mol.kg^{-1}$ Ciprofloxacin + Water + KCl | | | | | | |
|---|---|---|---|---|---|---|
| Sound velocity, $u/m.s^{-1}$ | | | | | | |
| $m/mol.kg^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 1486.33 | 1500.12 | 1512.33 | 1522.68 | 1531.54 | 1538.93 |
| 0.1 | 1491.82 | 1505.25 | 1517.16 | 1527.73 | 1536.49 | 1543.75 |
| 0.2 | 1496.91 | 1510.37 | 1522.14 | 1532.25 | 1540.83 | 1547.98 |
| 0.3 | 1502.37 | 1515.52 | 1527.08 | 1537.02 | 1545.45 | 1552.48 |
| 0.4 | 1507.49 | 1520.49 | 1531.84 | 1541.6 | 1549.9 | 1556.81 |
| 0.5 | 1512.31 | 1524.88 | 1536.34 | 1545.99 | 1554.17 | 1560.97 |

Table 4.59: Sound velocity (u) of KCl in aqueous solution of ciprofloxacin (0.045 $mol.kg^{-1}$) as a function of molality at different temperature

| 0.045 $mol.kg^{-1}$ Ciprofloxacin + Water + KCl | | | | | | |
|---|---|---|---|---|---|---|
| Sound velocity, $u/m.s^{-1}$ | | | | | | |
| $m/mol.kg^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 1487.75 | 1501.5 | 1513.54 | 1523.91 | 1532.69 | 1541 |
| 0.1 | 1493.4 | 1506.87 | 1518.73 | 1528.94 | 1537.58 | 1544.77 |
| 0.2 | 1498.37 | 1511.73 | 1523.41 | 1533.45 | 1541.96 | 1549.04 |
| 0.3 | 1503.43 | 1516.37 | 1528.13 | 1538.03 | 1546.42 | 1553.4 |
| 0.4 | 1508.78 | 1521.61 | 1532.9 | 1542.6 | 1550.82 | 1557.67 |
| 0.5 | 1513.78 | 1526.45 | 1537.48 | 1546.94 | 1554.95 | 1561.63 |

Table 4.60: Sound velocity (u) of KCl in aqueous solution of ciprofloxacin (0.06 $mol.kg^{-1}$) as a function of molality at different temperature

| 0.06 $mol.kg^{-1}$ Ciprofloxacin + Water + KCl | | | | | | |
|---|---|---|---|---|---|---|
| Sound velocity, $u/m.s^{-1}$ | | | | | | |
| $m/mol.kg^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 1489.19 | 1502.89 | 1514.86 | 1525.15 | 1533.86 | 1541.1 |
| 0.1 | 1494.48 | 1508 | 1519.81 | 1529.98 | 1538.59 | 1545.76 |
| 0.2 | 1499.9 | 1513.44 | 1524.12 | 1535.22 | 1543.97 | 1549.92 |
| 0.3 | 1505 | 1518 | 1529.43 | 1539.25 | 1547.57 | 1554.49 |
| 0.4 | 1509.88 | 1522.74 | 1533.97 | 1543.62 | 1551.81 | 1558.6 |
| 0.5 | 1515 | 1527.64 | 1538.59 | 1547.9 | 1555.76 | 1562.32 |

Table 4.61: Adiabatic compressibility ($\beta s \times 10^{10}/Pa^{-1}$) of aqueous Glucose as a function of molality ($m/mol.kg^{-1}$) at different temperature

| Water + Glucose | | | | | | |
|---|---|---|---|---|---|---|
| $m/mol.kg^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 4.60 | 4.52 | 4.45 | 4.40 | 4.37 | 4.35 |
| 0.1 | 4.56 | 4.48 | 4.41 | 4.36 | 4.31 | 4.28 |
| 0.2 | 4.48 | 4.41 | 4.34 | 4.29 | 4.25 | 4.22 |
| 0.3 | 4.42 | 4.34 | 4.28 | 4.23 | 4.19 | 4.16 |
| 0.4 | 4.34 | 4.27 | 4.22 | 4.17 | 4.14 | 4.11 |
| 0.5 | 4.29 | 4.22 | 4.17 | 4.12 | 4.09 | 4.06 |

Table 4.62: Adiabatic compressibility ($\beta s \times 10^{10}/Pa^{-1}$) of aqueous NaCl as a function of molality ($m/mol.kg^{-1}$) at different temperature

| Water + NaCl | | | | | | |
|---|---|---|---|---|---|---|
| $m/mol.kg^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 4.53 | 4.47 | 4.41 | 4.35 | 4.31 | 4.28 |
| 0.1 | 4.47 | 4.42 | 4.35 | 4.30 | 4.26 | 4.23 |
| 0.2 | 4.43 | 4.37 | 4.30 | 4.25 | 4.21 | 4.18 |
| 0.3 | 4.38 | 4.31 | 4.26 | 4.20 | 4.16 | 4.14 |
| 0.4 | 4.33 | 4.26 | 4.20 | 4.16 | 4.12 | 4.09 |
| 0.5 | 4.53 | 4.47 | 4.41 | 4.35 | 4.31 | 4.28 |

Table 4.63: Adiabatic compressibility ($\beta s \times 10^{10}/Pa^{-1}$) of aqueous KCl as a function of molality ($m/mol.kg^{-1}$) at different temperature

| Water + KCl | | | | | | |
|---|---|---|---|---|---|---|
| $m/mol.kg^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 4.56 | 4.48 | 4.41 | 4.36 | 4.31 | 4.28 |
| 0.1 | 4.56 | 4.48 | 4.41 | 4.36 | 4.31 | 4.28 |
| 0.2 | 4.50 | 4.43 | 4.36 | 4.31 | 4.27 | 4.24 |
| 0.3 | 4.45 | 4.37 | 4.31 | 4.26 | 4.22 | 4.19 |
| 0.4 | 4.40 | 4.32 | 4.26 | 4.22 | 4.18 | 4.15 |
| 0.5 | 4.35 | 4.28 | 4.22 | 4.17 | 4.14 | 4.11 |

Table 4.64: Adiabatic compressibility ($\beta s \times 10^{10}/Pa^{-1}$) of Glucose in aqueous solution of ciprofloxacin (0.03 $mol.kg^{-1}$) as a function of molality ($m/mol.kg^{-1}$) at different temperature

| 0.03 $mol.kg^{-1}$ Ciprofloxacin + Water + Glucose | | | | | | |
|---|---|---|---|---|---|---|
| $m/mol.kg^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 4.52 | 4.44 | 4.38 | 4.32 | 4.28 | 4.25 |
| 0.1 | 4.45 | 4.38 | 4.31 | 4.26 | 4.22 | 4.19 |
| 0.2 | 4.39 | 4.32 | 4.26 | 4.21 | 4.17 | 4.14 |
| 0.3 | 4.32 | 4.25 | 4.20 | 4.15 | 4.11 | 4.08 |
| 0.4 | 4.26 | 4.19 | 4.14 | 4.10 | 4.06 | 4.03 |
| 0.5 | 4.20 | 4.14 | 4.09 | 4.04 | 4.01 | 3.97 |

Table 4.65: Adiabatic compressibility ($\beta s \times 10^{10}/Pa^{-1}$) of Glucose in aqueous solution of ciprofloxacin (0.045 $mol.kg^{-1}$) as a function of molality ($m/mol.kg^{-1}$) at different temperature

| 0.045 $mol.kg^{-1}$ Ciprofloxacin + Water + Glucose | | | | | | |
|---|---|---|---|---|---|---|
| $m/mol.kg^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 4.50 | 4.42 | 4.36 | 4.31 | 4.27 | 4.24 |
| 0.1 | 4.42 | 4.36 | 4.30 | 4.25 | 4.21 | 4.18 |
| 0.2 | 4.37 | 4.30 | 4.24 | 4.20 | 4.16 | 4.13 |
| 0.3 | 4.31 | 4.24 | 4.19 | 4.14 | 4.11 | 4.08 |
| 0.4 | 4.25 | 4.18 | 4.13 | 4.14 | 4.09 | 4.03 |
| 0.5 | 4.19 | 4.13 | 4.08 | 4.04 | 4.00 | 3.98 |

Table 4.66: Adiabatic compressibility ($\beta s \times 10^{10}/Pa^{-1}$) of Glucose in aqueous solution of ciprofloxacin (0.06 $mol.kg^{-1}$) as a function of molality ($m/mol.kg^{-1}$) at different temperature

| 0.06 $mol.kg^{-1}$ Ciprofloxacin + Water + Glucose | | | | | | |
|---|---|---|---|---|---|---|
| $m/mol.kg^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 4.48 | 4.41 | 4.35 | 4.30 | 4.26 | 4.22 |
| 0.1 | 4.42 | 4.35 | 4.29 | 4.24 | 4.20 | 4.17 |
| 0.2 | 4.36 | 4.29 | 4.23 | 4.18 | 4.15 | 4.12 |
| 0.3 | 4.30 | 4.23 | 4.17 | 4.13 | 4.09 | 4.07 |
| 0.4 | 4.23 | 4.17 | 4.12 | 4.07 | 4.04 | 4.02 |
| 0.5 | 4.15 | 4.12 | 4.07 | 4.03 | 3.99 | 3.97 |

Table 4.67: Adiabatic compressibility ($\beta s \times 10^{10}/Pa^{-1}$) of NaCl in aqueous solution of ciprofloxacin (0.03 $mol.kg^{-1}$) as a function of molality ($m/mol.kg^{-1}$) at different temperature

| 0.03 $mol.kg^{-1}$ Ciprofloxacin + Water + NaCl | | | | | | |
|---|---|---|---|---|---|---|
| $m/mol.kg^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 4.52 | 4.44 | 4.38 | 4.32 | 4.28 | 4.25 |
| 0.1 | 4.46 | 4.39 | 4.33 | 4.27 | 4.23 | 4.20 |
| 0.2 | 4.41 | 4.34 | 4.28 | 4.23 | 4.19 | 4.16 |
| 0.3 | 4.35 | 4.28 | 4.23 | 4.18 | 4.14 | 4.11 |
| 0.4 | 4.30 | 4.23 | 4.18 | 4.13 | 4.10 | 4.07 |
| 0.5 | 4.25 | 4.18 | 4.13 | 4.09 | 4.06 | 4.03 |

Table 4.68: Adiabatic compressibility ($\beta s \times 10^{10}/Pa^{-1}$) of NaCl in aqueous solution of ciprofloxacin (0.045 $mol.kg^{-1}$) as a function of molality ($m/mol.kg^{-1}$) at different temperature

| 0.045 $mol.kg^{-1}$ Ciprofloxacin + Water + NaCl | | | | | | |
|---|---|---|---|---|---|---|
| $m/mol.kg^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 4.48 | 4.41 | 4.35 | 4.29 | 4.25 | 4.48 |
| 0.1 | 4.43 | 4.36 | 4.30 | 4.25 | 4.22 | 4.43 |
| 0.2 | 4.38 | 4.31 | 4.25 | 4.20 | 4.16 | 4.38 |
| 0.3 | 4.32 | 4.26 | 4.21 | 4.15 | 4.11 | 4.32 |
| 0.4 | 4.27 | 4.22 | 4.16 | 4.12 | 4.07 | 4.27 |
| 0.5 | 4.22 | 4.18 | 4.12 | 4.06 | 4.03 | 4.22 |

Table 4.69: Adiabatic compressibility ($\beta s \times 10^{10}/Pa^{-1}$) of NaCl in aqueous solution of ciprofloxacin (0.06 $mol.kg^{-1}$) as a function of molality ($m/mol.kg^{-1}$) at different temperature

| 0.06 $mol.kg^{-1}$ Ciprofloxacin + Water + NaCl | | | | | | |
|---|---|---|---|---|---|---|
| $m/mol.kg^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 4.48 | 4.41 | 4.34 | 4.29 | 4.25 | 4.22 |
| 0.1 | 4.43 | 4.35 | 4.29 | 4.24 | 4.20 | 4.17 |
| 0.2 | 4.37 | 4.30 | 4.24 | 4.20 | 4.16 | 4.13 |
| 0.3 | 4.32 | 4.25 | 4.20 | 4.15 | 4.11 | 4.09 |
| 0.4 | 4.27 | 4.20 | 4.15 | 4.11 | 4.07 | 4.04 |
| 0.5 | 4.22 | 4.16 | 4.10 | 4.06 | 4.03 | 4.01 |

Table 4.70: Adiabatic compressibility ($\beta s \times 10^{10}/Pa^{-1}$) of KCl in aqueous solution of ciprofloxacin (0.03 $mol.kg^{-1}$) as a function of molality ($m/mol.kg^{-1}$) at different temperature

| 0.03 $mol.kg^{-1}$ Ciprofloxacin + Water + KCl | | | | | | |
|---|---|---|---|---|---|---|
| $m/mol.kg^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 4.52 | 4.44 | 4.38 | 4.32 | 4.28 | 4.25 |
| 0.1 | 4.46 | 4.39 | 4.33 | 4.27 | 4.23 | 4.20 |
| 0.2 | 4.41 | 4.34 | 4.28 | 4.24 | 4.19 | 4.16 |
| 0.3 | 4.36 | 4.29 | 4.23 | 4.19 | 4.15 | 4.12 |
| 0.4 | 4.31 | 4.25 | 4.19 | 4.14 | 4.11 | 4.08 |
| 0.5 | 4.27 | 4.20 | 4.15 | 4.10 | 4.07 | 4.04 |

Table 4.71: Adiabatic compressibility ($\beta s \times 10^{10}/Pa^{-1}$) of KCl in aqueous solution of ciprofloxacin (0.045 $mol.kg^{-1}$) as a function of molality ($m/mol.kg^{-1}$) at different temperature

| 0.045 $mol.kg^{-1}$ Ciprofloxacin + Water + KCl | | | | | | |
|---|---|---|---|---|---|---|
| $m/mol.kg^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 4.50 | 4.42 | 4.36 | 4.31 | 4.27 | 4.23 |
| 0.1 | 4.45 | 4.37 | 4.31 | 4.26 | 4.22 | 4.19 |
| 0.2 | 4.40 | 4.33 | 4.27 | 4.22 | 4.18 | 4.15 |
| 0.3 | 4.35 | 4.28 | 4.22 | 4.18 | 4.14 | 4.11 |
| 0.4 | 4.31 | 4.23 | 4.18 | 4.13 | 4.10 | 4.07 |
| 0.5 | 4.25 | 4.19 | 4.14 | 4.09 | 4.06 | 4.03 |

Table 4.72: Adiabatic compressibility ($\beta s \times 10^{10}/Pa^{-1}$) of KCl in aqueous solution of ciprofloxacin (0.06 $mol.kg^{-1}$) as a function of molality ($m/mol.kg^{-1}$) at different temperature

| 0.06 $mol.kg^{-1}$ Ciprofloxacin + Water + KCl | | | | | | |
|---|---|---|---|---|---|---|
| $m/mol.kg^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 4.49 | 4.41 | 4.35 | 4.30 | 4.26 | 4.22 |
| 0.1 | 4.44 | 4.36 | 4.30 | 4.25 | 4.21 | 4.18 |
| 0.2 | 4.38 | 4.31 | 4.26 | 4.20 | 4.16 | 4.14 |
| 0.3 | 4.34 | 4.27 | 4.21 | 4.16 | 4.13 | 4.10 |
| 0.4 | 4.29 | 4.22 | 4.17 | 4.12 | 4.09 | 4.06 |
| 0.5 | 4.24 | 4.18 | 4.13 | 4.08 | 4.05 | 4.02 |

Table 4.73: Apparent molar adiabatic compressibility ($\varphi_k$) of aqueous Glucose as a function of molality (m/mol.kg$^{-1}$) at different temperature

| Only water + Glucose | | | | | | |
|---|---|---|---|---|---|---|
| $\varphi_k \times 10^{14}/m^3.mol^{-1}.Pa^{-1}$ | | | | | | |
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.1 | -2.4588 | -2.2019 | -1.9324 | -1.6969 | -1.4851 | -1.3551 |
| 0.2 | -2.3116 | -1.9941 | -1.8169 | -1.5653 | -1.3346 | -1.2046 |
| 0.3 | -2.1767 | -1.8588 | -1.6923 | -1.4428 | -1.2617 | -1.1417 |
| 0.4 | -2.0241 | -1.7291 | -1.4999 | -1.2989 | -1.1548 | -1.0248 |
| 0.5 | -1.8851 | -1.5980 | -1.3736 | -1.1772 | -1.03168 | -0.8968 |

Table 4.74: Apparent molar adiabatic compressibility ($\varphi_k$) of aqueous NaCl as a function of molality (m/mol.kg$^{-1}$) at different temperature

| Only water + NaCl | | | | | | |
|---|---|---|---|---|---|---|
| $\varphi_k \times 10^{14}/m^3.mol^{-1}.Pa^{-1}$ | | | | | | |
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.1 | -5.4136 | -5.0540 | -4.7299 | -4.4097 | -4.0283 | -3.7899 |
| 0.2 | -5.2150 | -4.9047 | -4.5715 | -4.1914 | -3.8909 | -3.6451 |
| 0.3 | -5.0192 | -4.7442 | -4.3847 | -4.0011 | -3.7344 | -3.4647 |
| 0.4 | -4.8509 | -4.5839 | -4.2016 | -3.8441 | -3.5586 | -3.3010 |
| 0.5 | -4.7529 | -4.4460 | -4.0557 | -3.7023 | -3.4041 | -3.1725 |

Table 4.75: Apparent molar adiabatic compressibility ($\varphi_k$) of aqueous KCl as a function of molality (m/mol.kg$^{-1}$) at different temperature

| Only water + KCl | | | | | | |
|---|---|---|---|---|---|---|
| $\varphi_k \times 10^{14}/m^3.mol^{-1}.Pa^{-1}$ | | | | | | |
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.1 | -4.2572 | -4.0473 | -3.8139 | -3.6511 | -3.4738 | -3.2954 |
| 0.2 | -4.0898 | -3.8720 | -3.6529 | -3.4687 | -3.3209 | -3.1071 |
| 0.3 | -3.9723 | -3.7205 | -3.5444 | -3.3676 | -3.1870 | -2.9961 |
| 0.4 | -3.8495 | -3.6200 | -3.4077 | -3.2559 | -3.0610 | -2.8990 |
| 0.5 | -3.7173 | -3.4679 | -3.2946 | -3.1513 | -2.9577 | -2.7861 |

Table 4.76: Apparent molar adiabatic compressibility ($\varphi_k$) of Glucose in aqueous solution of ciprofloxacin (0.03 mol.kg$^{-1}$) as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.03 mol.kg$^{-1}$ Ciprofloxacin + Water + Glucose | | | | | | |
|---|---|---|---|---|---|---|
| $\varphi_k \times 10^{14}$/m$^3$.mol$^{-1}$.Pa$^{-1}$ | | | | | | |
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.1 | -1.5997 | -1.3069 | -1.0145 | -0.7438 | -0.5176 | -0.3051 |
| 0.2 | -1.4403 | -1.1406 | -0.8560 | -0.6054 | -0.3876 | -0.1862 |
| 0.3 | -1.3779 | -1.0279 | -0.7498 | -0.5480 | -0.3244 | -0.1467 |
| 0.4 | -1.2003 | -0.9083 | -0.6294 | -0.3971 | -0.2631 | -0.0916 |
| 0.5 | -1.1714 | -0.8752 | -0.6019 | -0.3600 | -0.1673 | -0.0297 |

Table 4.77: Apparent molar adiabatic compressibility ($\varphi_k$) of Glucose in aqueous solution of ciprofloxacin (0.045 mol.kg$^{-1}$) as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.045 mol.kg$^{-1}$ Ciprofloxacin + Water + Glucose | | | | | | |
|---|---|---|---|---|---|---|
| $\varphi_k \times 10^{14}$/m$^3$.mol$^{-1}$.Pa$^{-1}$ | | | | | | |
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.1 | -1.5997 | -1.3069 | -1.0145 | -0.7438 | -0.5176 | -0.3051 |
| 0.2 | -1.4403 | -1.1406 | -0.8560 | -0.6054 | -0.3876 | -0.1862 |
| 0.3 | -1.3779 | -1.0279 | -0.7498 | -0.5480 | -0.3244 | -0.1467 |
| 0.4 | -1.2003 | -0.9083 | -0.6294 | -0.3971 | -0.2631 | -0.0916 |
| 0.5 | -1.1714 | -0.8752 | -0.6019 | -0.3600 | -0.1673 | -0.0297 |

Table 4.78: Apparent molar adiabatic compressibility ($\varphi_k$) of Glucose in aqueous solution of ciprofloxacin (0.06 mol.kg$^{-1}$) as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.06 mol.kg$^{-1}$ Ciprofloxacin + Water + Glucose | | | | | | |
|---|---|---|---|---|---|---|
| $\varphi_k \times 10^{14}$/m$^3$.mol$^{-1}$.Pa$^{-1}$ | | | | | | |
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.1 | -1.5997 | -1.3069 | -1.0145 | -0.7438 | -0.5176 | -0.3051 |
| 0.2 | -1.4403 | -1.1406 | -0.8560 | -0.6054 | -0.3876 | -0.1862 |
| 0.3 | -1.3779 | -1.0279 | -0.7498 | -0.5480 | -0.3244 | -0.1467 |
| 0.4 | -1.2003 | -0.9083 | -0.6294 | -0.3971 | -0.2631 | -0.0916 |
| 0.5 | -1.1714 | -0.8752 | -0.6019 | -0.3600 | -0.1673 | -0.0297 |

Table 4.79: Apparent molar adiabatic compressibility ($\varphi_k$) of NaCl in aqueous solution of ciprofloxacin (0.03 mol.kg$^{-1}$) as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.03 mol.kg$^{-1}$ Ciprofloxacin + Water + NaCl | | | | | | |
|---|---|---|---|---|---|---|
| $\varphi_k \times 10^{14}$/m$^3$.mol$^{-1}$.Pa$^{-1}$ | | | | | | |
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.1 | -4.6332 | -4.3897 | -4.1212 | -3.87560 | -3.5952 | -3.3710 |
| 0.2 | -4.5561 | -4.3155 | -4.0551 | -3.7920 | -3.5087 | -3.3012 |
| 0.3 | -4.4622 | -4.2541 | -3.9888 | -3.7073 | -3.4325 | -3.2289 |
| 0.4 | -4.4047 | -4.1826 | -3.9046 | -3.6300 | -3.3689 | -3.1338 |
| 0.5 | -4.3384 | -4.1013 | -3.8254 | -3.5767 | -3.3028 | -3.0750 |

Table 4.80: Apparent molar adiabatic compressibility ($\varphi_k$) of NaCl in aqueous solution of ciprofloxacin (0.045 mol.kg$^{-1}$) as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.045 mol.kg$^{-1}$ Ciprofloxacin + Water + NaCl | | | | | | |
|---|---|---|---|---|---|---|
| $\varphi_k \times 10^{14}$/m$^3$.mol$^{-1}$.Pa$^{-1}$ | | | | | | |
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.1 | -4.6232 | -4.3797 | -4.1212 | -3.8656 | -3.5952 | -3.3810 |
| 0.2 | -4.5661 | -4.3255 | -4.0551 | -3.7820 | -3.5187 | -3.3112 |
| 0.3 | -4.4722 | -4.2641 | -3.9988 | -3.7173 | -3.4525 | -3.2489 |
| 0.4 | -4.4147 | -4.1926 | -3.9246 | -3.6400 | -3.3689 | -3.1438 |
| 0.5 | -4.3384 | -4.1213 | -3.8454 | -3.5867 | -3.3228 | -3.0650 |

Table 4.81: Apparent molar adiabatic compressibility ($\varphi_k$) of NaCl in aqueous solution of ciprofloxacin (0.06 mol.kg$^{-1}$) as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.06 mol.kg$^{-1}$ Ciprofloxacin + Water + NaCl | | | | | | |
|---|---|---|---|---|---|---|
| $\varphi_k \times 10^{14}$/m$^3$.mol$^{-1}$.Pa$^{-1}$ | | | | | | |
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.1 | -4.6314 | -4.3664 | -4.1364 | -3.9643 | -3.8393 | -3.6549 |
| 0.2 | -4.5833 | -4.3183 | -4.0917 | -3.9158 | -3.7891 | -3.6165 |
| 0.3 | -4.5287 | -4.2666 | -4.0487 | -3.8658 | -3.7226 | -3.5670 |
| 0.4 | -4.4665 | -4.2050 | -3.9884 | -3.7906 | -3.6656 | -3.5179 |
| 0.5 | -4.4124 | -4.1575 | -3.9396 | -3.7529 | -3.5936 | -3.4638 |

Table 4.82: Apparent molar adiabatic compressibility ($\varphi_k$) of KCl in aqueous solution of ciprofloxacin (0.03 mol.kg$^{-1}$) as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.03 mol.kg$^{-1}$ Ciprofloxacin + Water + KCl | | | | | | |
|---|---|---|---|---|---|---|
| $\varphi_k \times 10^{14}$/m$^3$.mol$^{-1}$.Pa$^{-1}$ | | | | | | |
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.1 | -4.6447 | -4.4115 | -4.2286 | -4.0786 | -3.8931 | -3.7192 |
| 0.2 | -4.5267 | -4.3156 | -4.1056 | -3.9856 | -3.7994 | -3.5821 |
| 0.3 | -4.4188 | -4.2059 | -4.0265 | -3.8865 | -3.6913 | -3.5084 |
| 0.4 | -4.3225 | -4.1195 | -3.9191 | -3.7891 | -3.6048 | -3.4168 |
| 0.5 | -4.2203 | -4.0084 | -3.8218 | -3.6818 | -3.5175 | -3.3471 |

Table 4.83: Apparent molar adiabatic compressibility ($\varphi_k$) of KCl in aqueous solution of ciprofloxacin (0.045 mol.kg$^{-1}$) as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.045 mol.kg$^{-1}$ Ciprofloxacin + Water + KCl | | | | | | |
|---|---|---|---|---|---|---|
| $\varphi_k \times 10^{14}$/m$^3$.mol$^{-1}$.Pa$^{-1}$ | | | | | | |
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.1 | -4.7572 | -4.5473 | -4.3139 | -4.0511 | -3.8338 | -3.6054 |
| 0.2 | -4.5898 | -4.3772 | -4.1529 | -3.9687 | -3.7209 | -3.4571 |
| 0.3 | -4.4772 | -4.2405 | -4.0444 | -3.8476 | -3.5870 | -3.3061 |
| 0.4 | -4.3449 | -4.1220 | -3.9077 | -3.7159 | -3.4803 | -3.1990 |
| 0.5 | -4.2117 | -3.9967 | -3.7946 | -3.5913 | -3.3577 | -3.0461 |

Table 4.84: Apparent molar adiabatic compressibility ($\varphi_k$) of KCl in aqueous solution of ciprofloxacin (0.06 mol.kg$^{-1}$) as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.06 mol.kg$^{-1}$ Ciprofloxacin + Water + KCl | | | | | | |
|---|---|---|---|---|---|---|
| $\varphi_k \times 10^{14}$/m$^3$.mol$^{-1}$.Pa$^{-1}$ | | | | | | |
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.1 | -4.1572 | -3.9473 | -3.7439 | -3.5611 | -3.3738 | -3.1854 |
| 0.2 | -3.9998 | -3.7720 | -3.5829 | -3.3987 | -3.2609 | -3.0271 |
| 0.3 | -3.9023 | -3.6405 | -3.4844 | -3.2776 | -3.1270 | -2.9061 |
| 0.4 | -3.7495 | -3.5300 | -3.3277 | -3.1759 | -3.0010 | -2.8090 |
| 0.5 | -3.6573 | -3.4079 | -3.2146 | -3.0813 | -2.8977 | -2.7061 |

Table 4.85: Limiting apparent molar adiabatic compressibility ($\varphi_k^0$), experimental slope ($S_k$) of Glucose + water system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively

| Only water + Glucose | | |
|---|---|---|
| Temp (K) | $\varphi_k^0 \times 10^{14}$ ($m^3.mol^{-1}.Pa^{-1}$) | $S_k \times 10^{14}$ ($m^3.mol^{-1}.kg$) |
| 293.15 K | -2.8128 | 1.9049 |
| 298.15 K | -2.2952 | 1.3827 |
| 303.15 K | -2.1835 | 1.6947 |
| 308.15 K | -1.9620 | 1.6657 |
| 313.15 K | -1.8677 | 1.8068 |
| 318.15 K | -2.0918 | 2.4817 |

Table 4.86: Limiting apparent molar adiabatic compressibility ($\varphi_k^0$), experimental slope ($S_k$) of NaCl + water system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively

| Only water + NaCl | | |
|---|---|---|
| Temp (K) | $\varphi_k^0 \times 10^{14}$ ($m^3.mol^{-1}.Pa^{-1}$) | $S_k \times 10^{14}$ ($m^3.mol^{-1}.kg$) |
| 293.15 K | -4.7865 | 1.2481 |
| 298.15 K | -4.5712 | 1.1160 |
| 303.15 K | -4.3768 | 1.0637 |
| 308.15 K | -3.9874 | 0.5521 |
| 313.15 K | -4.0076 | 0.8009 |
| 318.15 K | -3.7754 | 0.3090 |

Table 4.87: Limiting apparent molar adiabatic compressibility ($\varphi_k^0$), experimental slope ($S_k$) of KCl + water system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively

| Only water + KCl | | |
|---|---|---|
| Temp (K) | $\varphi_k^0 \times 10^{14}$ ($m^3.mol^{-1}.Pa^{-1}$) | $S_k \times 10^{14}$ ($m^3.mol^{-1}.kg$) |
| 293.15 K | -4.1665 | 0.4129 |
| 298.15 K | -4.0193 | 0.6394 |
| 303.15 K | -3.8283 | 0.7199 |
| 308.15 K | -3.6705 | 0.8788 |
| 313.15 K | -3.5390 | 0.9057 |
| 318.15 K | -3.0436 | 0.1093 |

Table 4.88: Limiting apparent molar adiabatic compressibility ($\varphi_k^0$), experimental slope ($S_k$) and transfer compressibility ($\Delta_{tr}\varphi_k^0$) of water + Glucose+ 0.03 mol.kg$^{-1}$ciprofloxacin system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively

| 0.03 mol.kg$^{-1}$ Ciprofloxacin + Water + Glucose | | | |
|---|---|---|---|
| Temp (K) | $\varphi_k^0\times10^{14}$ ($m^3.mol^{-1}.Pa^{-1}$) | $S_k\times10^{14}$ ($m^3.mol^{-1}.kg$) | $\Delta K^0_{\varphi,s(Tr)}\times10^{14}$ |
| 293.15 K | -1.5509 | -0.0235 | 1.2619 |
| 298.15 K | -1.3045 | -0.1844 | 0.9907 |
| 303.15 K | -1.1135 | -0.0442 | 1.0699 |
| 308.15 K | -1.0017 | 0.0359 | 0.9603 |
| 313.15 K | -0.8646 | 0.0151 | 1.0031 |
| 318.15 K | -0.7724 | 0.0096 | 1.3194 |

Table 4.89: Limiting apparent molar adiabatic compressibility ($\varphi_k^0$), experimental slope ($S_k$) and transfer compressibility ($\Delta_{tr}\varphi_k^0$) of water + Glucose+ 0.045 mol.kg$^{-1}$ciprofloxacin system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively

| 0.045 mol.kg$^{-1}$ Ciprofloxacin + Water + Glucose | | | |
|---|---|---|---|
| Temp (K) | $\varphi_k^0\times10^{14}$ ($m^3.mol^{-1}.Pa^{-1}$) | $S_k\times10^{14}$ ($m^3.mol^{-1}.kg$) | $\Delta K^0_{\varphi,s(Tr)}\times10^{14}$ |
| 293.15 K | -1.3923 | 0.3513 | 0.8736 |
| 298.15 K | -1.3517 | 0.4013 | 0.9436 |
| 303.15 K | -1.1439 | 0.5027 | 1.0395 |
| 308.15 K | -1.0283 | 1.5808 | 0.9337 |
| 313.15 K | -0.8873 | 1.4131 | 0.9804 |
| 318.15 K | -0.6368 | 0.2980 | 1.4550 |

Table 4.90: Limiting apparent molar adiabatic compressibility ($\varphi_k^0$), experimental slope ($S_k$) and transfer compressibility ($\Delta_{tr}\varphi_k^0$) of water + Glucose+ 0.06 mol.kg$^{-1}$ciprofloxacin system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively

| 0.06 mol.kg$^{-1}$ Ciprofloxacin + Water + Glucose | | | |
|---|---|---|---|
| Temp (K) | $\varphi_k^0\times10^{14}$ ($m^3.mol^{-1}.Pa^{-1}$) | $S_k\times10^{14}$ ($m^3.mol^{-1}.kg$) | $\Delta K^0_{\varphi,s(Tr)}\times10^{14}$ |
| 293.15 K | -1.4435 | 0.1123 | 1.3693 |
| 298.15 K | -1.1804 | 0.0682 | 1.1148 |
| 303.15 K | -0.9630 | 0.0592 | 1.2204 |
| 308.15 K | -0.7640 | 0.0205 | 1.1980 |
| 313.15 K | -0.6094 | 0.0223 | 1.2583 |
| 318.15 K | -0.4826 | 0.0467 | 1.6092 |

Table 4.91: Limiting apparent molar adiabatic compressibility ($\varphi_k^0$), experimental slope ($S_k$) and transfer compressibility ($\Delta_{tr}\varphi_k^0$) of water + NaCl + 0.03 mol.kg$^{-1}$ ciprofloxacin system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively

| 0.03 mol.kg$^{-1}$ Ciprofloxacin + Water + NaCl | | | |
|---|---|---|---|
| Temp (K) | $\varphi_k^0 \times 10^{14}$ ($m^3.mol^{-1}.Pa^{-1}$) | $S_k \times 10^{14}$ ($m^3.mol^{-1}.kg$) | $\Delta K^0_{\varphi,s(Tr)} \times 10^{14}$ |
| 293.15 K | -4.7838 | 0.3187 | 1.0027 |
| 298.15 K | -4.5101 | 0.2121 | 0.0612 |
| 303.15 K | -4.3021 | 0.3989 | 0.0747 |
| 308.15 K | -4.1887 | 0.5406 | -0.2013 |
| 313.15 K | -4.0471 | 0.5597 | -0.0395 |
| 318.15 K | -3.9278 | 0.5194 | -0.1525 |

Table 4.92: Limiting apparent molar adiabatic compressibility ($\varphi_k^0$), experimental slope ($S_k$) and transfer compressibility ($\Delta_{tr}\varphi_k^0$) of water + NaCl + 0.045 mol.kg$^{-1}$ciprofloxacin system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively

| 0.045 mol.kg$^{-1}$ Ciprofloxacin + Water + NaCl | | | |
|---|---|---|---|
| Temp (K) | $\varphi_k^0 \times 10^{14}$ ($m^3.mol^{-1}.Pa^{-1}$) | $S_k \times 10^{14}$ ($m^3.mol^{-1}.kg$) | $\Delta K^0_{\varphi,s(Tr)} \times 10^{14}$ |
| 293.15 K | -4.5538 | 0.4092 | -0.5161 |
| 298.15 K | -4.4556 | 0.4650 | -0.4737 |
| 303.15 K | -4.2223 | 0.4888 | 0.3254 |
| 308.15 K | -4.0667 | 0.4992 | 0.2939 |
| 313.15 K | -3.9553 | 0.5651 | 0.3834 |
| 318.15 K | -3.7505 | 0.6106 | 0.7240 |

Table 4.93: Limiting apparent molar adiabatic compressibility ($\varphi_k^0$), experimental slope ($S_k$) and transfer compressibility ($\Delta_{tr}\varphi_k^0$) of water + NaCl + 0.06 mol.kg$^{-1}$ciprofloxacin system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively

| 0.06 mol.kg$^{-1}$ Ciprofloxacin + Water + NaCl | | | |
|---|---|---|---|
| Temp (K) | $\varphi_k^0 \times 10^{14}$ ($m^3.mol^{-1}.Pa^{-1}$) | $S_k \times 10^{14}$ ($m^3.mol^{-1}.kg$) | $\Delta K^0_{\varphi,s(Tr)} \times 10^{14}$ |
| 293.15 K | -3.7487 | 0.6702 | 0.1343 |
| 298.15 K | -3.5784 | 0.6815 | 0.137 |
| 303.15 K | -3.4486 | 0.7082 | 0.094 |
| 308.15 K | -3.2963 | 0.7049 | 0.1108 |
| 313.15 K | -3.2188 | 0.7831 | 0.0282 |
| 318.15 K | -3.0558 | 0.7026 | 0.0599 |

Table 4.94: Limiting apparent molar adiabatic compressibility ($\varphi_k^0$), experimental slope ($S_k$) and transfer compressibility ($\Delta_{tr}\varphi_k^0$) of water + KCl + 0.03 mol.kg$^{-1}$ ciprofloxacin system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively

| 0.03 mol.kg$^{-1}$ Ciprofloxacin + Water + KCl | | | |
|---|---|---|---|
| Temp (K) | $\varphi_k^0 \times 10^{14}$ ($m^3.mol^{-1}.Pa^{-1}$) | $S_k \times 10^{14}$ ($m^3.mol^{-1}.kg$) | $\Delta K^0_{\varphi,s(Tr)} \times 10^{14}$ |
| 293.15 K | -4.3673 | 1.3802 | -4.3673 |
| 298.15 K | -4.0609 | 1.2109 | -4.0609 |
| 303.15 K | -3.7799 | 1.0038 | -3.7799 |
| 308.15 K | -3.4006 | 0.6122 | -3.4006 |
| 313.15 K | -3.6588 | 1.3823 | -3.6588 |
| 318.15 K | -3.5618 | 1.4168 | -3.5618 |

Table 4.95: Limiting apparent molar adiabatic compressibility ($\varphi_k^0$), experimental slope ($S_k$) and transfer compressibility ($\Delta_{tr}\varphi_k^0$) of water + KCl + 0.045 mol.kg$^{-1}$ ciprofloxacin system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively

| 0.045 mol.kg$^{-1}$ Ciprofloxacin + Water + KCl | | | |
|---|---|---|---|
| Temp (K) | $\varphi_k^0 \times 10^{14}$ ($m^3.mol^{-1}.Pa^{-1}$) | $S_k \times 10^{14}$ ($m^3.mol^{-1}.kg$) | $\Delta K^0_{\varphi,s(Tr)} \times 10^{14}$ |
| 293.15 K | -4.0939 | 1.1668 | 0.9127 |
| 298.15 K | -3.7919 | 0.8570 | 0.2275 |
| 303.15 K | -3.6046 | 0.8487 | 0.2238 |
| 308.15 K | -3.3996 | 0.7659 | 0.2709 |
| 313.15 K | -3.7706 | 0.5002 | 0.2316 |
| 318.15 K | -3.3304 | 0.7019 | 0.7132 |

Table 4.96: Limiting apparent molar adiabatic compressibility ($\varphi_k^0$), experimental slope ($S_k$) and transfer compressibility ($\Delta_{tr}\varphi_k^0$) of water + KCl + 0.06 mol.kg$^{-1}$ ciprofloxacin system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively

| 0.06 mol.kg$^{-1}$ Ciprofloxacin + Water + KCl | | | |
|---|---|---|---|
| Temp (K) | $\varphi_k^0 \times 10^{14}$ ($m^3.mol^{-1}.Pa^{-1}$) | $S_k \times 10^{14}$ ($m^3.mol^{-1}.kg$) | $\Delta K^0_{\varphi,s(Tr)} \times 10^{14}$ |
| 293.15 K | -3.6694 | 0.0949 | 1.3371 |
| 298.15 K | -3.3809 | -0.0166 | 0.6384 |
| 303.15 K | -3.2830 | 0.1730 | 0.5453 |
| 308.15 K | -3.2906 | 0.5134 | 0.3800 |
| 313.15 K | -3.2093 | 0.6067 | 0.3297 |
| 318.15 K | -2.7600 | -0.0887 | 0.2836 |

Table 4.97: Acoustic impedance ($Z\times10^{-6}$/kg.m$^{-2}$.s$^{-1}$) of aqueous Glucose as a function of molality (m/mol.kg$^{-1}$) at different temperature

| Glucose + Water | | | | | | |
|---|---|---|---|---|---|---|
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 1.4800 | 1.4925 | 1.5027 | 1.5108 | 1.5168 | 1.5206 |
| 0.1 | 1.4978 | 1.5096 | 1.5198 | 1.5277 | 1.5337 | 1.5379 |
| 0.2 | 1.5139 | 1.5257 | 1.5353 | 1.5429 | 1.5487 | 1.5527 |
| 0.3 | 1.5313 | 1.5425 | 1.5517 | 1.5588 | 1.5641 | 1.5678 |
| 0.4 | 1.5462 | 1.5574 | 1.5665 | 1.5737 | 1.5790 | 1.5826 |
| 0.5 | 1.5615 | 1.5724 | 1.5812 | 1.5881 | 1.5932 | 1.5966 |

Table 4.98: Acoustic impedance ($Z\times10^{-6}$/kg.m$^{-2}$.s$^{-1}$) of aqueous NaCl as a function of molality (m/mol.kg$^{-1}$) at different temperature

| NaCl + Water | | | | | | |
|---|---|---|---|---|---|---|
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 1.4800 | 1.4925 | 1.5026 | 1.5128 | 1.5198 | 1.5265 |
| 0.1 | 1.4934 | 1.5039 | 1.5148 | 1.5228 | 1.5309 | 1.5393 |
| 0.2 | 1.5044 | 1.5161 | 1.5267 | 1.5345 | 1.5426 | 1.5505 |
| 0.3 | 1.5181 | 1.5285 | 1.5394 | 1.5484 | 1.5553 | 1.5634 |
| 0.4 | 1.5303 | 1.5414 | 1.5506 | 1.5589 | 1.5683 | 1.5757 |
| 0.5 | 1.5435 | 1.5544 | 1.5634 | 1.5725 | 1.5808 | 1.5883 |

Table 4.99: Acoustic impedance ($Z\times10^{-6}$/kg.m$^{-2}$.s$^{-1}$) of aqueous KCl as a function of molality (m/mol.kg$^{-1}$) at different temperature

| KCl +Water | | | | | | |
|---|---|---|---|---|---|---|
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 1.4800 | 1.4925 | 1.5027 | 1.5108 | 1.5168 | 1.5206 |
| 0.1 | 1.4937 | 1.5047 | 1.5147 | 1.5226 | 1.5287 | 1.5316 |
| 0.2 | 1.5055 | 1.5167 | 1.5265 | 1.5342 | 1.5397 | 1.5430 |
| 0.3 | 1.5177 | 1.5290 | 1.5386 | 1.5461 | 1.5514 | 1.5536 |
| 0.4 | 1.5296 | 1.5408 | 1.5501 | 1.5571 | 1.5627 | 1.5653 |
| 0.5 | 1.5418 | 1.5522 | 1.5610 | 1.5675 | 1.5729 | 1.5759 |

Table 4.100: Acoustic impedance ($Z\times10^{-6}$/kg.m$^{-2}$.s$^{-1}$) of Glucose in aqueous solution of ciprofloxacin (0.03 mol.kg$^{-1}$) as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.03 mol.kg$^{-1}$ Ciprofloxacin + Glucose + Water | | | | | | |
|---|---|---|---|---|---|---|
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 1.4891 | 1.5012 | 1.5112 | 1.5191 | 1.5251 | 1.5293 |
| 0.1 | 1.5051 | 1.5169 | 1.5267 | 1.5344 | 1.5403 | 1.5444 |
| 0.2 | 1.5208 | 1.5325 | 1.5421 | 1.5497 | 1.5554 | 1.5593 |
| 0.3 | 1.5373 | 1.5486 | 1.5580 | 1.5654 | 1.5709 | 1.5747 |
| 0.4 | 1.5529 | 1.5640 | 1.5732 | 1.5803 | 1.5856 | 1.5892 |
| 0.5 | 1.5680 | 1.5797 | 1.5876 | 1.5946 | 1.5998 | 1.6036 |

Table 4.101: Acoustic impedance ($Z\times10^{-6}$/kg.m$^{-2}$.s$^{-1}$) of Glucose in aqueous solution of ciprofloxacin (0.045 mol.kg$^{-1}$) as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.045 mol.kg$^{-1}$ Ciprofloxacin + Glucose + Water | | | | | | |
|---|---|---|---|---|---|---|
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 1.4901 | 1.5051 | 1.5150 | 1.5229 | 1.5288 | 1.5329 |
| 0.1 | 1.5099 | 1.5210 | 1.5307 | 1.5383 | 1.5440 | 1.5479 |
| 0.2 | 1.5248 | 1.5362 | 1.5456 | 1.5529 | 1.5584 | 1.5622 |
| 0.3 | 1.5401 | 1.5512 | 1.5603 | 1.5659 | 1.5729 | 1.5765 |
| 0.4 | 1.5561 | 1.5670 | 1.5750 | 1.5798 | 1.5867 | 1.5912 |
| 0.5 | 1.5716 | 1.5822 | 1.5908 | 1.5965 | 1.6024 | 1.6055 |

Table 4.102: Acoustic impedance ($Z\times10^{-6}$/kg.m$^{-2}$.s$^{-1}$) of Glucose in aqueous solution of ciprofloxacin (0.06 mol.kg$^{-1}$) as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.06 mol.kg$^{-1}$ Ciprofloxacin + Glucose + Water | | | | | | |
|---|---|---|---|---|---|---|
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 1.4967 | 1.5087 | 1.5185 | 1.5263 | 1.5321 | 1.5362 |
| 0.1 | 1.5126 | 1.5243 | 1.5338 | 1.5413 | 1.5470 | 1.5508 |
| 0.2 | 1.5284 | 1.5398 | 1.5491 | 1.5563 | 1.5618 | 1.5654 |
| 0.3 | 1.5437 | 1.5548 | 1.5638 | 1.5709 | 1.5761 | 1.5796 |
| 0.4 | 1.5599 | 1.5707 | 1.5794 | 1.5862 | 1.5912 | 1.5944 |
| 0.5 | 1.5749 | 1.5854 | 1.5939 | 1.6004 | 1.6052 | 1.6081 |

Table 4.103: Acoustic impedance ($Z\times10^{-6}$/kg.m$^{-2}$.s$^{-1}$) of NaCl in aqueous solution of ciprofloxacin (0.03 mol.kg$^{-1}$) as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.03 mol.kg$^{-1}$Ciprofloxacin + NaCl + Water | | | | | | |
|---|---|---|---|---|---|---|
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 1.4891 | 1.5012 | 1.5112 | 1.5191 | 1.5251 | 1.5293 |
| 0.1 | 1.5014 | 1.5132 | 1.5231 | 1.5308 | 1.5367 | 1.5408 |
| 0.2 | 1.5137 | 1.5252 | 1.5348 | 1.5423 | 1.5480 | 1.5519 |
| 0.3 | 1.5265 | 1.5378 | 1.5470 | 1.5544 | 1.5598 | 1.5636 |
| 0.4 | 1.5387 | 1.5497 | 1.5587 | 1.5658 | 1.5711 | 1.5747 |
| 0.5 | 1.5507 | 1.5622 | 1.5700 | 1.5769 | 1.5821 | 1.5858 |

Table 4.104: Acoustic impedance ($Z\times10^{-6}$/kg.m$^{-2}$.s$^{-1}$) of NaCl in aqueous solution of ciprofloxacin (0.045 mol.kg$^{-1}$) as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.045 mol.kg$^{-1}$Ciprofloxacin+NaCl+Water | | | | | | |
|---|---|---|---|---|---|---|
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 1.4902 | 1.5052 | 1.5150 | 1.5229 | 1.5288 | 1.5330 |
| 0.1 | 1.5054 | 1.5172 | 1.5269 | 1.5346 | 1.5403 | 1.5443 |
| 0.2 | 1.5176 | 1.5289 | 1.5384 | 1.5459 | 1.5517 | 1.5556 |
| 0.3 | 1.5299 | 1.5412 | 1.5498 | 1.5577 | 1.5631 | 1.5668 |
| 0.4 | 1.5422 | 1.5531 | 1.5621 | 1.5691 | 1.5743 | 1.5778 |
| 0.5 | 1.5540 | 1.5647 | 1.5735 | 1.5803 | 1.5853 | 1.5886 |

Table 4.105: Acoustic impedance ($Z\times10^{-6}$/kg.m$^{-2}$.s$^{-1}$) of NaCl in aqueous solution of ciprofloxacin (0.06 mol.kg$^{-1}$) as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.06 mol.kg$^{-1}$Ciprofloxacin+NaCl+Water | | | | | | |
|---|---|---|---|---|---|---|
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 1.4967 | 1.5086 | 1.5184 | 1.5262 | 1.5321 | 1.5377 |
| 0.1 | 1.5088 | 1.5205 | 1.5301 | 1.5377 | 1.5428 | 1.5473 |
| 0.2 | 1.5210 | 1.5323 | 1.5417 | 1.5491 | 1.5549 | 1.5587 |
| 0.3 | 1.5333 | 1.5445 | 1.5536 | 1.5608 | 1.5661 | 1.5697 |
| 0.4 | 1.5453 | 1.5562 | 1.5651 | 1.5720 | 1.5773 | 1.5807 |
| 0.5 | 1.5574 | 1.5680 | 1.5767 | 1.5833 | 1.5881 | 1.5923 |

Table 4.106: Acoustic impedance ($Z\times10^{-6}$/kg.m$^{-2}$.s$^{-1}$) of KCl in aqueous solution of ciprofloxacin (0.03 mol.kg$^{-1}$) as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.03 mol.kg$^{-1}$Ciprofloxacin+KCl+Water | | | | | | |
|---|---|---|---|---|---|---|
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 6.6858 | 6.4875 | 6.3048 | 6.2006 | 6.1082 | 5.9857 |
| 0.1 | 6.5134 | 6.3595 | 6.1485 | 6.0406 | 5.9401 | 5.8370 |
| 0.2 | 6.3750 | 6.1806 | 5.9945 | 5.8943 | 5.7877 | 5.6866 |
| 0.3 | 6.2552 | 6.0651 | 5.8930 | 5.7866 | 5.6956 | 5.5988 |
| 0.4 | 6.1255 | 5.9075 | 5.7627 | 5.6547 | 5.5464 | 5.4410 |
| 0.5 | 6.6858 | 6.4875 | 6.3048 | 6.2006 | 6.1082 | 5.9857 |

Table 4.107: Acoustic impedance ($Z\times10^{-6}$/kg.m$^{-2}$.s$^{-1}$) of KCl in aqueous solution of ciprofloxacin (0.045 mol.kg$^{-1}$) as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.045 mol.kg$^{-1}$Ciprofloxacin+KCl+Water | | | | | | |
|---|---|---|---|---|---|---|
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 1.4932 | 1.5052 | 1.5150 | 1.5230 | 1.5262 | 1.5361 |
| 0.1 | 1.5056 | 1.5173 | 1.5270 | 1.5347 | 1.5405 | 1.5442 |
| 0.2 | 1.5171 | 1.5287 | 1.5382 | 1.5457 | 1.5512 | 1.5553 |
| 0.3 | 1.5287 | 1.5399 | 1.5495 | 1.5568 | 1.5623 | 1.5661 |
| 0.4 | 1.5395 | 1.5521 | 1.5612 | 1.5683 | 1.5737 | 1.5773 |
| 0.5 | 1.5527 | 1.5636 | 1.5724 | 1.5794 | 1.5845 | 1.5880 |

Table 4.108: Acoustic impedance ($Z\times10^{-6}$/kg.m$^{-2}$.s$^{-1}$) of KCl in aqueous solution of ciprofloxacin (0.06 mol.kg$^{-1}$) as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.06 mol.kg$^{-1}$ Ciprofloxacin + KCl + Water | | | | | | |
|---|---|---|---|---|---|---|
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 1.4967 | 1.5087 | 1.5185 | 1.5263 | 1.5321 | 1.5362 |
| 0.1 | 1.5083 | 1.5201 | 1.5297 | 1.5374 | 1.5431 | 1.5471 |
| 0.2 | 1.5208 | 1.5318 | 1.5418 | 1.5504 | 1.5561 | 1.5572 |
| 0.3 | 1.5325 | 1.5437 | 1.5530 | 1.5602 | 1.5657 | 1.5694 |
| 0.4 | 1.5441 | 1.5551 | 1.5642 | 1.5713 | 1.5766 | 1.5802 |
| 0.5 | 1.5560 | 1.5668 | 1.5756 | 1.5824 | 1.5874 | 1.5908 |

Table 4.109: Relative association ($R_A$) of aqueous Glucose as a function of molality (m/mol.kg$^{-1}$) at different temperature

| Glucose + Water | | | | | | |
|---|---|---|---|---|---|---|
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| 0.1 | 0.9978 | 0.9980 | 0.9983 | 0.9985 | 0.9987 | 0.9989 |
| 0.2 | 0.9958 | 0.9963 | 0.9967 | 0.9972 | 0.9977 | 0.9981 |
| 0.3 | 0.9941 | 0.9948 | 0.9955 | 0.9960 | 0.9966 | 0.9972 |
| 0.4 | 0.9921 | 0.9930 | 0.9940 | 0.9948 | 0.9956 | 0.9964 |
| 0.5 | 0.9903 | 0.9914 | 0.9926 | 0.9936 | 0.9946 | 0.9955 |

Table 4.110: Relative association ($R_A$) of aqueous NaCl as a function of molality (m/mol.kg$^{-1}$) at different temperature

| NaCl + Water | | | | | | |
|---|---|---|---|---|---|---|
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| 0.1 | 0.9979 | 0.9980 | 0.9983 | 0.9985 | 0.9987 | 0.9989 |
| 0.2 | 0.9959 | 0.9963 | 0.9968 | 0.9972 | 0.9977 | 0.9981 |
| 0.3 | 0.9939 | 0.9947 | 0.9955 | 0.9960 | 0.9966 | 0.9972 |
| 0.4 | 0.9922 | 0.9930 | 0.9940 | 0.9948 | 0.9956 | 0.9964 |
| 0.5 | 0.9901 | 0.9913 | 0.9926 | 0.9935 | 0.9946 | 0.9955 |

Table 4.111: Relative association ($R_A$) of aqueous KCl as a function of molality (m/mol.kg$^{-1}$) at different temperature

| KCl +Water | | | | | | |
|---|---|---|---|---|---|---|
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| 0.1 | 0.9990 | 0.9989 | 0.9988 | 0.9987 | 0.9986 | 0.9985 |
| 0.2 | 0.9982 | 0.9980 | 0.9977 | 0.9973 | 0.9971 | 0.9970 |
| 0.3 | 0.9974 | 0.9970 | 0.9967 | 0.9963 | 0.9959 | 0.9955 |
| 0.4 | 0.9966 | 0.9960 | 0.9956 | 0.9951 | 0.9946 | 0.9941 |
| 0.5 | 0.9957 | 0.9951 | 0.9946 | 0.9938 | 0.9933 | 0.9928 |

Table 4.112: Relative association ($R_A$) of Glucose in aqueous solution of ciprofloxacin (0.03 mol.kg$^{-1}$) as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.03 mol.kg$^{-1}$ Ciprofloxacin+ Glucose +Water | | | | | | |
|---|---|---|---|---|---|---|
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| 0.1 | 0.9977 | 0.9976 | 0.9974 | 0.9973 | 0.9972 | 0.9971 |
| 0.2 | 0.9955 | 0.9952 | 0.9949 | 0.9948 | 0.9946 | 0.9944 |
| 0.3 | 0.9935 | 0.9930 | 0.9926 | 0.9923 | 0.9920 | 0.9916 |
| 0.4 | 0.9916 | 0.9909 | 0.9903 | 0.9899 | 0.9895 | 0.9892 |
| 0.5 | 0.9898 | 0.9891 | 0.9882 | 0.9877 | 0.9872 | 0.9864 |

Table 4.113: Relative association ($R_A$) of Glucose in aqueous solution of ciprofloxacin (0.045 mol.kg$^{-1}$) as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.045 mol.kg$^{-1}$ Ciprofloxacin + Glucose + Water | | | | | | |
|---|---|---|---|---|---|---|
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| 0.1 | 0.9977 | 0.9976 | 0.9974 | 0.9973 | 0.9972 | 0.9971 |
| 0.2 | 0.9955 | 0.9952 | 0.9949 | 0.9948 | 0.9946 | 0.9943 |
| 0.3 | 0.9935 | 0.9930 | 0.9926 | 0.9923 | 0.9920 | 0.9916 |
| 0.4 | 0.9916 | 0.9909 | 0.9903 | 0.9899 | 0.9895 | 0.9888 |
| 0.5 | 0.9898 | 0.9891 | 0.9882 | 0.9877 | 0.9872 | 0.9863 |

Table 4.114: Relative association ($R_A$) of Glucose in aqueous solution of ciprofloxacin (0.06 mol.kg$^{-1}$) as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.06 mol.kg$^{-1}$ Ciprofloxacin + Glucose + Water | | | | | | |
|---|---|---|---|---|---|---|
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| 0.1 | 0.9980 | 0.9978 | 0.9976 | 0.9975 | 0.9973 | 0.9972 |
| 0.2 | 0.9959 | 0.9956 | 0.9952 | 0.9949 | 0.9946 | 0.9944 |
| 0.3 | 0.9940 | 0.9935 | 0.9930 | 0.9925 | 0.9921 | 0.9917 |
| 0.4 | 0.9921 | 0.9914 | 0.9907 | 0.9901 | 0.9896 | 0.9891 |
| 0.5 | 0.9905 | 0.9896 | 0.9887 | 0.9880 | 0.9873 | 0.9867 |

Table 4.115: Relative association ($R_A$) of NaCl in aqueous solution of ciprofloxacin (0.03 mol.kg$^{-1}$) as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.03 mol.kg$^{-1}$ Ciprofloxacin + NaCl + Water | | | | | | |
|---|---|---|---|---|---|---|
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| 0.1 | 0.9983 | 0.9985 | 0.9986 | 0.9988 | 0.9988 | 0.9989 |
| 0.2 | 0.9965 | 0.9968 | 0.9972 | 0.9975 | 0.9976 | 0.9977 |
| 0.3 | 0.9949 | 0.9955 | 0.996 | 0.9963 | 0.9965 | 0.9967 |
| 0.4 | 0.9934 | 0.9941 | 0.9948 | 0.9952 | 0.9955 | 0.9958 |
| 0.5 | 0.9919 | 0.9928 | 0.9935 | 0.994 | 0.9945 | 0.9949 |

Table 4.116: Relative association ($R_A$) of NaCl in aqueous solution of ciprofloxacin (0.045 mol.kg$^{-1}$) as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.045 mol.kg$^{-1}$ Ciprofloxacin + NaCl + Water | | | | | | |
|---|---|---|---|---|---|---|
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| 0.1 | 0.9982 | 0.9985 | 0.9986 | 0.9988 | 0.9988 | 0.9989 |
| 0.2 | 0.9964 | 0.9968 | 0.9973 | 0.9975 | 0.9977 | 0.9979 |
| 0.3 | 0.9946 | 0.9953 | 0.9959 | 0.9964 | 0.9968 | 0.9971 |
| 0.4 | 0.993 | 0.994 | 0.9947 | 0.9952 | 0.9956 | 0.9961 |
| 0.5 | 0.9915 | 0.9925 | 0.9934 | 0.994 | 0.9946 | 0.9952 |

Table 4.117: Relative association ($R_A$) of NaCl in aqueous solution of ciprofloxacin (0.06 mol.kg$^{-1}$) as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.06 mol.kg$^{-1}$ Ciprofloxacin + NaCl + Water | | | | | | |
|---|---|---|---|---|---|---|
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| 0.1 | 0.9983 | 0.9985 | 0.9986 | 0.9988 | 0.9988 | 0.9989 |
| 0.2 | 0.9965 | 0.997 | 0.9972 | 0.9975 | 0.9977 | 0.998 |
| 0.3 | 0.9949 | 0.9955 | 0.996 | 0.9963 | 0.9967 | 0.997 |
| 0.4 | 0.9934 | 0.9941 | 0.9948 | 0.9952 | 0.9956 | 0.9961 |
| 0.5 | 0.9917 | 0.9926 | 0.9935 | 0.9941 | 0.9946 | 0.9952 |

Table 4.118: Relative association ($R_A$) of KCl in aqueous solution of ciprofloxacin (0.03 mol.kg$^{-1}$) as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.03 mol.kg$^{-1}$ Ciprofloxacin + KCl + Water | | | | | | |
|---|---|---|---|---|---|---|
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| 0.1 | 0.9990 | 0.9987 | 0.9985 | 0.9984 | 0.9983 | 0.9982 |
| 0.2 | 0.9980 | 0.9978 | 0.9975 | 0.9973 | 0.9970 | 0.9966 |
| 0.3 | 0.9971 | 0.9967 | 0.9963 | 0.9959 | 0.9954 | 0.9949 |
| 0.4 | 0.9962 | 0.9956 | 0.9950 | 0.9944 | 0.9938 | 0.9932 |
| 0.5 | 0.9953 | 0.9945 | 0.9937 | 0.9929 | 0.9921 | 0.9915 |

Table 4.119: Relative association ($R_A$) of KCl in aqueous solution of ciprofloxacin (0.045 mol.kg$^{-1}$) as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.045 mol.kg$^{-1}$ Ciprofloxacin + KCl + Water | | | | | | |
|---|---|---|---|---|---|---|
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| 0.1 | 0.9990 | 0.9987 | 0.9985 | 0.9984 | 0.9983 | 0.9982 |
| 0.2 | 0.9980 | 0.9978 | 0.9975 | 0.9973 | 0.9970 | 0.9966 |
| 0.3 | 0.9971 | 0.9967 | 0.9963 | 0.9958 | 0.9954 | 0.9949 |
| 0.4 | 0.9962 | 0.9956 | 0.9950 | 0.9944 | 0.9938 | 0.9932 |
| 0.5 | 0.9953 | 0.9945 | 0.9937 | 0.9931 | 0.9923 | 0.9915 |

Table 4.120: Relative association ($R_A$) of KCl in aqueous solution of ciprofloxacin (0.06 mol.kg$^{-1}$) as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.06 mol.kg$^{-1}$ Ciprofloxacin + KCl+ Water | | | | | | |
|---|---|---|---|---|---|---|
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| 0.1 | 0.9990 | 0.9988 | 0.9986 | 0.9984 | 0.9983 | 0.9982 |
| 0.2 | 0.9981 | 0.9979 | 0.9976 | 0.9974 | 0.9971 | 0.9966 |
| 0.3 | 0.9972 | 0.9967 | 0.9963 | 0.9958 | 0.9954 | 0.9949 |
| 0.4 | 0.9963 | 0.9956 | 0.9951 | 0.9944 | 0.9938 | 0.9932 |
| 0.5 | 0.9954 | 0.9947 | 0.9939 | 0.9929 | 0.9923 | 0.9915 |

Table 4.121: Hydration number ($n_H$) of aqueous Glucose as a function of molality (m/mol.kg$^{-1}$) at different temperature

| Only water + Glucose | | | | | | |
|---|---|---|---|---|---|---|
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.1 | 9.1276 | 8.7541 | 8.5291 | 8.3199 | 8.1794 | 7.9509 |
| 0.2 | 8.8683 | 8.4764 | 8.2576 | 8.0545 | 7.8638 | 7.7002 |
| 0.3 | 8.5504 | 8.1809 | 7.9777 | 7.7819 | 7.6335 | 7.4564 |
| 0.4 | 8.2449 | 7.9551 | 7.7251 | 7.5153 | 7.3456 | 7.2115 |
| 0.5 | 8.0396 | 7.7273 | 7.5311 | 7.3259 | 7.1568 | 7.0117 |

Table 4.122: Hydration number ($n_H$) of aqueous NaCl as a function of molality (m/mol.kg$^{-1}$) at different temperature

| Only water + NaCl | | | | | | |
|---|---|---|---|---|---|---|
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.1 | 4.6843 | 4.3833 | 4.0926 | 3.7849 | 3.5220 | 3.2561 |
| 0.2 | 4.4884 | 4.1576 | 3.8665 | 3.5719 | 3.3030 | 3.0588 |
| 0.3 | 4.2726 | 3.9876 | 3.7165 | 3.4119 | 3.1577 | 2.9053 |
| 0.4 | 4.1514 | 3.8376 | 3.6226 | 3.2751 | 3.0229 | 2.7865 |
| 0.5 | 4.0075 | 3.7201 | 3.4242 | 3.1727 | 2.9238 | 2.6353 |

Table 4.123: Hydration number ($n_H$) of aqueous KCl as a function of molality (m/mol.kg$^{-1}$) at different temperature

| Only water + KCl | | | | | | |
|---|---|---|---|---|---|---|
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.1 | 6.6977 | 6.4425 | 6.2715 | 6.1751 | 6.0682 | 5.9596 |
| 0.2 | 6.5872 | 6.3457 | 6.1637 | 6.0623 | 5.9740 | 5.8734 |
| 0.3 | 6.4869 | 6.2465 | 6.0642 | 5.9477 | 5.8356 | 5.7266 |
| 0.4 | 6.3883 | 6.1556 | 5.9641 | 5.8663 | 5.7525 | 5.6545 |
| 0.5 | 6.3152 | 6.0639 | 5.8562 | 5.7528 | 5.6541 | 5.5346 |

Table 4.124: Hydration number ($n_H$) of Glucose in aqueous solution of ciprofloxacin (0.03 mol.kg$^{-1}$) as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.03 mol.kg$^{-1}$ Ciprofloxacin + Water + Glucose | | | | | | |
|---|---|---|---|---|---|---|
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.1 | 8.1866 | 7.9889 | 7.8868 | 7.7797 | 7.6687 | 7.5360 |
| 0.2 | 8.1002 | 7.8846 | 7.7813 | 7.6886 | 7.5550 | 7.4317 |
| 0.3 | 8.0034 | 7.7896 | 7.6849 | 7.5878 | 7.4619 | 7.3453 |
| 0.4 | 7.9044 | 7.6966 | 7.5822 | 7.4865 | 7.3532 | 7.2590 |
| 0.5 | 7.8009 | 7.6086 | 7.4802 | 7.37415 | 7.2420 | 7.1439 |

Table 4.125: Hydration number ($n_H$) of Glucose in aqueous solution of ciprofloxacin (0.045 mol.kg$^{-1}$) as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.045 mol.kg$^{-1}$ Ciprofloxacin + Water + Glucose | | | | | | |
|---|---|---|---|---|---|---|
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.1 | 8.1430 | 7.8838 | 7.6568 | 7.4058 | 7.23504 | 7.0669 |
| 0.2 | 8.0141 | 7.7687 | 7.5463 | 7.3034 | 7.1319 | 6.9665 |
| 0.3 | 7.8951 | 7.6520 | 7.3944 | 7.1593 | 6.99785 | 6.8354 |
| 0.4 | 7.8001 | 7.5394 | 7.3523 | 7.1329 | 6.9494 | 6.7582 |
| 0.5 | 7.7076 | 7.4437 | 7.2210 | 6.9958 | 6.8236 | 6.6677 |

Table 4.126: Hydration number ($n_H$) of Glucose in aqueous solution of ciprofloxacin (0.06 mol.kg$^{-1}$) as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.06 mol.kg$^{-1}$ Ciprofloxacin + Water + Glucose | | | | | | |
|---|---|---|---|---|---|---|
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.1 | 8.1030 | 7.8238 | 7.5868 | 7.3658 | 7.1850 | 7.0269 |
| 0.2 | 7.9641 | 7.7087 | 7.4763 | 7.2634 | 7.0819 | 6.9265 |
| 0.3 | 7.7851 | 7.5320 | 7.3044 | 7.0993 | 6.9278 | 6.7754 |
| 0.4 | 7.7601 | 7.5094 | 7.2823 | 7.0829 | 6.9094 | 6.7524 |
| 0.5 | 7.6076 | 7.3637 | 7.1410 | 6.9458 | 6.7736 | 6.6177 |

Table 4.127: Hydration number ($n_H$) of NaCl in aqueous solution of ciprofloxacin (0.03 mol.kg$^{-1}$) as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.03 mol.kg$^{-1}$ Ciprofloxacin + Water + NaCl | | | | | | |
|---|---|---|---|---|---|---|
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.1 | 7.0193 | 6.8290 | 6.6066 | 6.4043 | 6.1903 | 6.0190 |
| 0.2 | 6.9249 | 6.7266 | 6.5421 | 6.3174 | 6.1029 | 5.9085 |
| 0.3 | 6.8105 | 6.6370 | 6.4671 | 6.2182 | 6.0111 | 5.8426 |
| 0.4 | 6.7077 | 6.5139 | 6.3718 | 6.1729 | 5.9481 | 5.7689 |
| 0.5 | 6.5966 | 6.4151 | 6.2983 | 6.1003 | 5.8756 | 5.6983 |

Table 4.128: Hydration number ($n_H$) of NaCl in aqueous solution of ciprofloxacin (0.045 mol.kg$^{-1}$) as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.045 mol.kg$^{-1}$ Ciprofloxacin + Water + NaCl | | | | | | |
|---|---|---|---|---|---|---|
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.1 | 6.8273 | 6.60752 | 6.4075 | 6.2853 | 6.0830 | 5.8517 |
| 0.2 | 6.7386 | 6.5207 | 6.3264 | 6.1835 | 6.0228 | 5.7948 |
| 0.3 | 6.6582 | 6.4467 | 6.2460 | 6.1289 | 5.9530 | 5.7254 |
| 0.4 | 6.6045 | 6.4028 | 6.1892 | 6.0421 | 5.8552 | 5.6626 |
| 0.5 | 6.5109 | 6.3172 | 6.1266 | 5.9630 | 5.8022 | 5.5952 |

Table 4.129: Hydration number ($n_H$) of NaCl in aqueous solution of ciprofloxacin (0.06 mol.kg$^{-1}$) as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.06 mol.kg$^{-1}$ Ciprofloxacin + Water + NaCl | | | | | | |
|---|---|---|---|---|---|---|
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.1 | 6.7656 | 6.5328 | 6.3515 | 6.1853 | 6.0156 | 5.8513 |
| 0.2 | 6.7168 | 6.4434 | 6.2538 | 6.0946 | 5.9607 | 5.8074 |
| 0.3 | 6.6545 | 6.4017 | 6.2060 | 6.0583 | 5.9114 | 5.7538 |
| 0.4 | 6.5735 | 6.3547 | 6.1641 | 5.9877 | 5.8416 | 5.6912 |
| 0.5 | 6.4992 | 6.2877 | 6.0952 | 5.9195 | 5.7596 | 5.6226 |

Table 4.130: Hydration number ($n_H$) of KCl in aqueous solution of ciprofloxacin (0.03 mol.kg$^{-1}$) as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.03 mol.kg$^{-1}$ Ciprofloxacin + Water + KCl | | | | | | |
|---|---|---|---|---|---|---|
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.1 | 6.6858 | 6.4875 | 6.3048 | 6.2006 | 6.1082 | 5.9857 |
| 0.2 | 6.5134 | 6.3595 | 6.1485 | 6.0406 | 5.9401 | 5.8370 |
| 0.3 | 6.3750 | 6.1806 | 5.9945 | 5.8943 | 5.7877 | 5.6866 |
| 0.4 | 6.2552 | 6.0651 | 5.8930 | 5.7866 | 5.6956 | 5.5988 |
| 0.5 | 6.1255 | 5.9075 | 5.7627 | 5.6547 | 5.5464 | 5.4410 |

Table 4.131: Hydration number ($n_H$) of KCl in aqueous solution of ciprofloxacin (0.045 mol.kg$^{-1}$) as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.045 mol.kg$^{-1}$ Ciprofloxacin + Water + KCl | | | | | | |
|---|---|---|---|---|---|---|
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.1 | 6.5458 | 6.3775 | 6.2448 | 6.1006 | 6.0082 | 5.8857 |
| 0.2 | 6.4034 | 6.2495 | 6.1085 | 5.9506 | 5.8401 | 5.7370 |
| 0.3 | 6.2750 | 6.0906 | 5.9845 | 5.8143 | 5.7077 | 5.5866 |
| 0.4 | 6.1552 | 5.9751 | 5.8530 | 5.7166 | 5.5956 | 5.4588 |
| 0.5 | 6.0255 | 5.8575 | 5.7127 | 5.5847 | 5.4764 | 5.3410 |

Table 4.132: Hydration number ($n_H$) of KCl in aqueous solution of ciprofloxacin (0.06 mol.kg$^{-1}$) as a function of molality (m/mol.kg$^{-1}$) at different temperature

| 0.06 mol.kg$^{-1}$ Ciprofloxacin + Water + KCl | | | | | | |
|---|---|---|---|---|---|---|
| m/mol.kg$^{-1}$ | 293.15 K | 298.15 K | 303.15 K | 308.15 K | 313.15 K | 318.15 K |
| 0.1 | 6.6380 | 6.4287 | 6.2848 | 6.1506 | 6.0382 | 5.9257 |
| 0.2 | 6.5034 | 6.3095 | 6.1385 | 6.0106 | 5.9001 | 5.7770 |
| 0.3 | 6.3550 | 6.1706 | 6.0145 | 5.8743 | 5.7577 | 5.6266 |
| 0.4 | 6.2252 | 6.0451 | 5.8930 | 5.7466 | 5.6556 | 5.5188 |
| 0.5 | 6.0855 | 5.9175 | 5.7727 | 5.6247 | 5.5064 | 5.3810 |

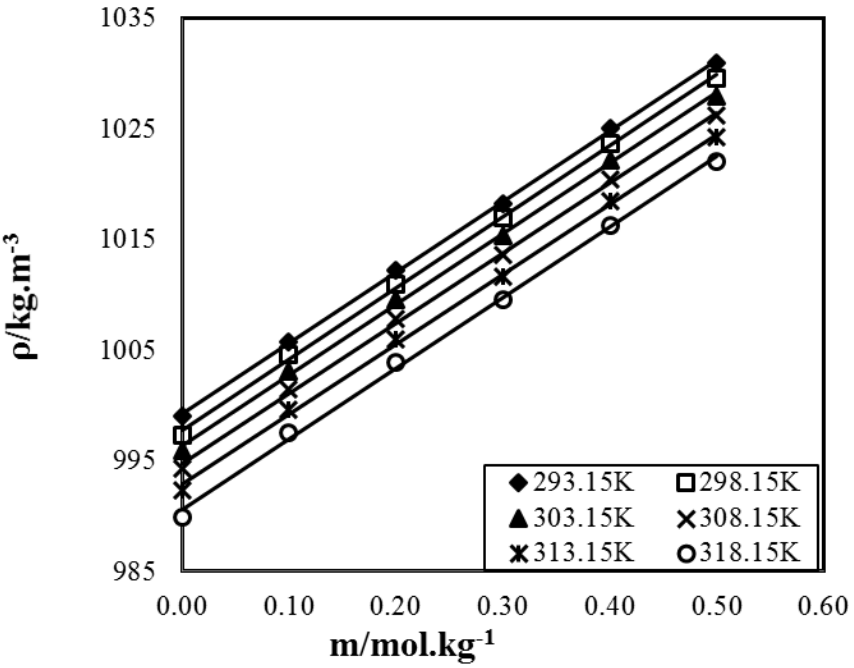



Figure 4.1: Plots of Density (ρ) vs. Molality (m) of Glucose + water system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

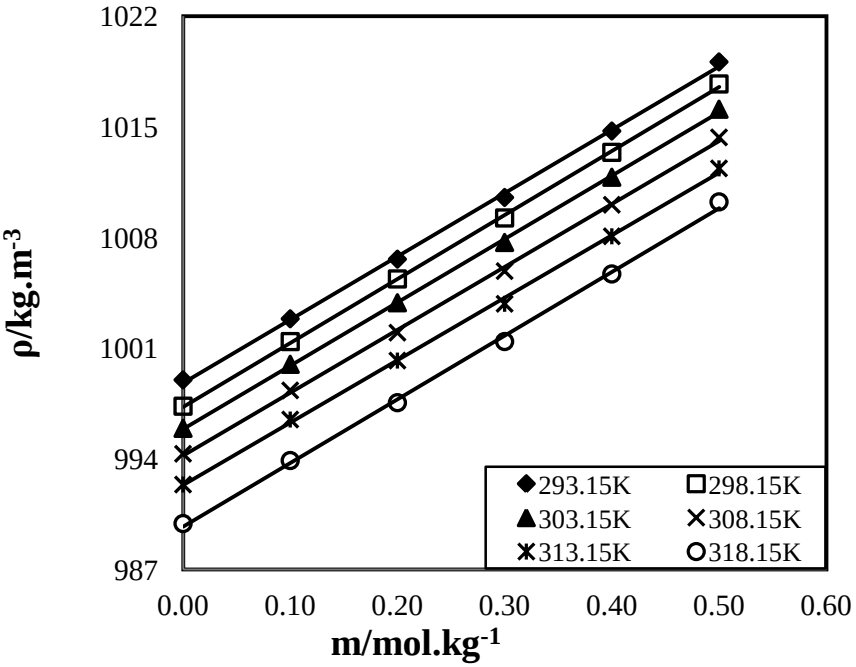



Figure 4.2: Plots of Density (ρ) vs. Molality (m) of NaCl + water system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

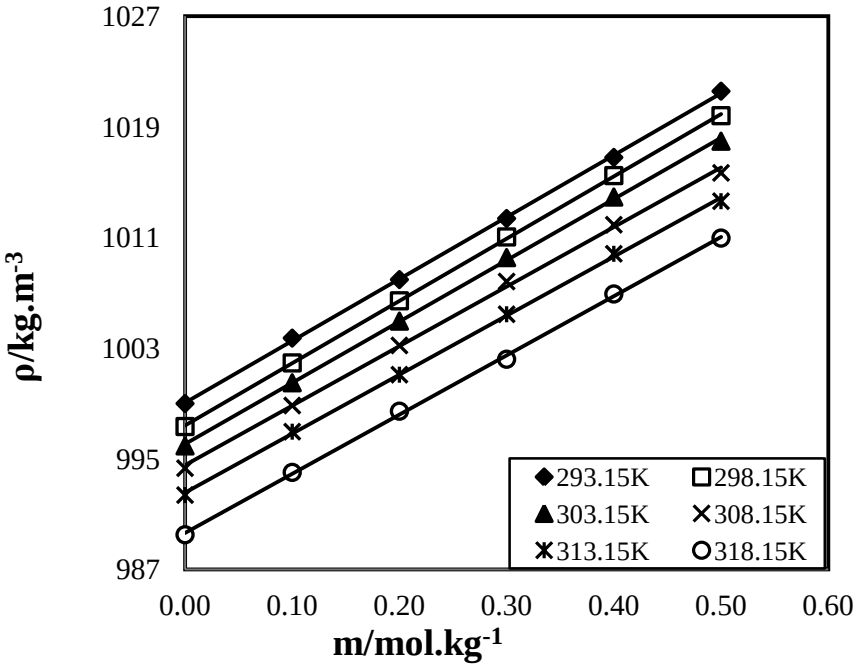



Figure 4.3: Plots of Density (ρ) vs. Molality (m) of KCl + water system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

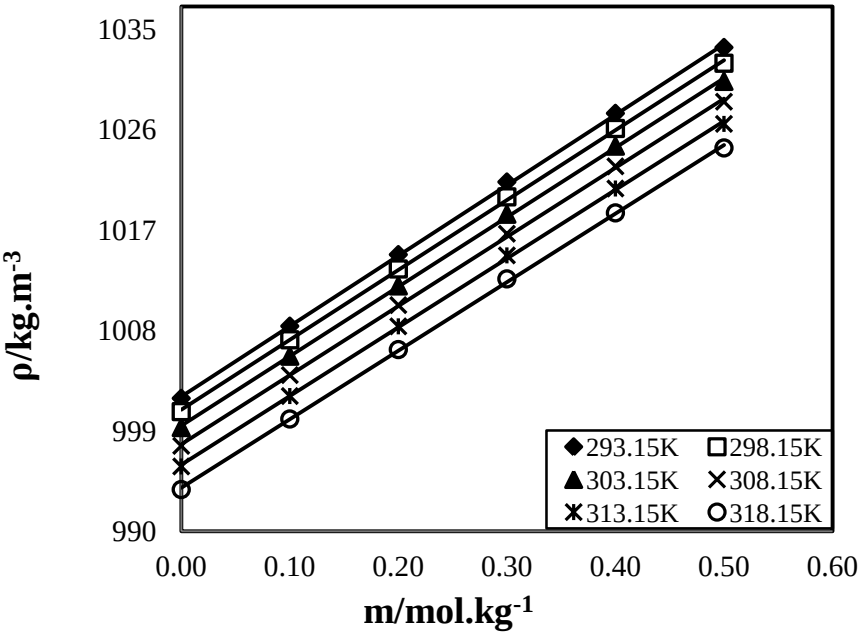



Figure 4.4: Plots of Density (ρ) vs. Molality (m) of water + Glucose + 0.03 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

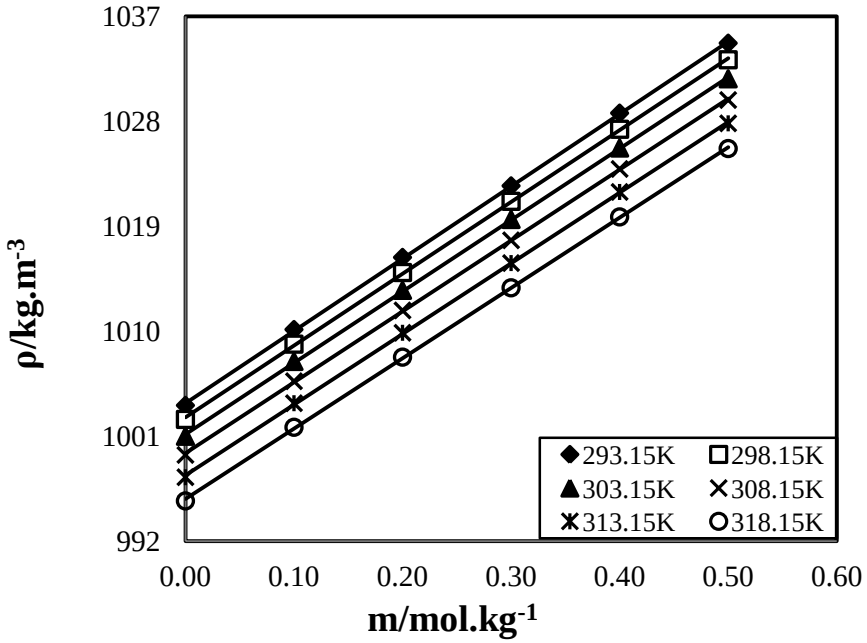



Figure 4.5: Plots of Density (ρ) vs. Molality (m) of water + Glucose + 0.045 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

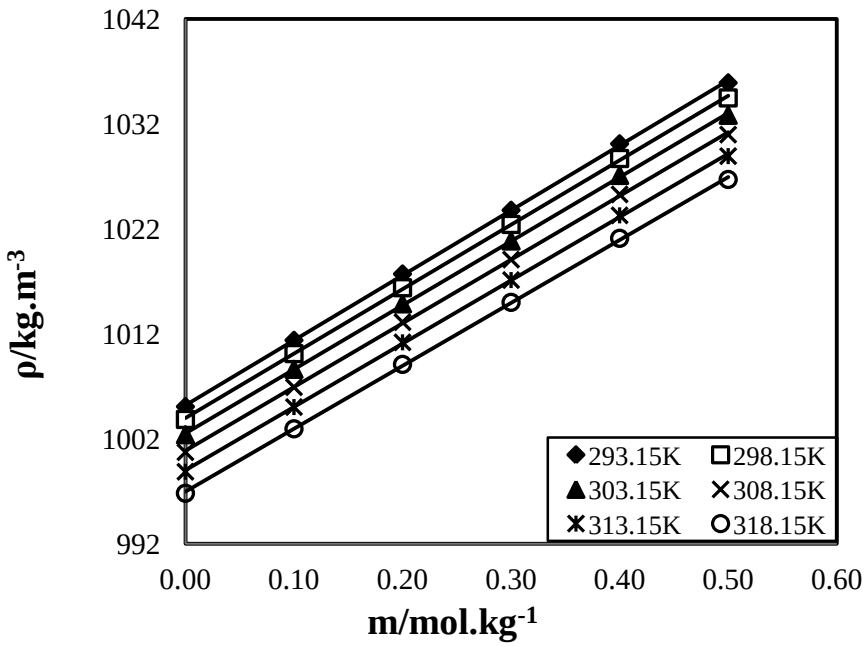



Figure 4.6: Plots of Density (ρ) vs. Molality (m) of water + Glucose + 0.06 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively

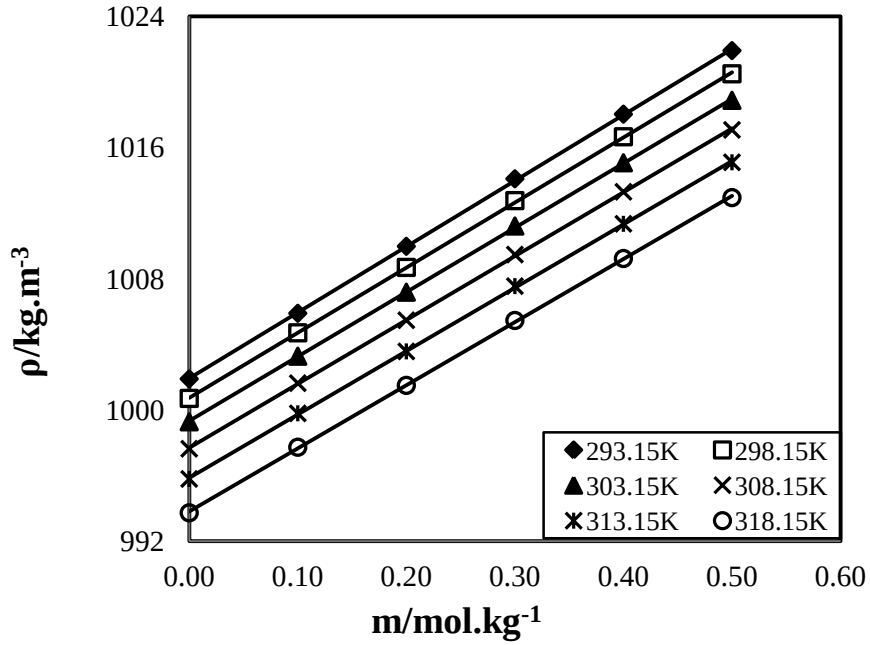



Figure 4.7: Plots of Density (ρ) vs. Molality (m) of water + NaCl + 0.03 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

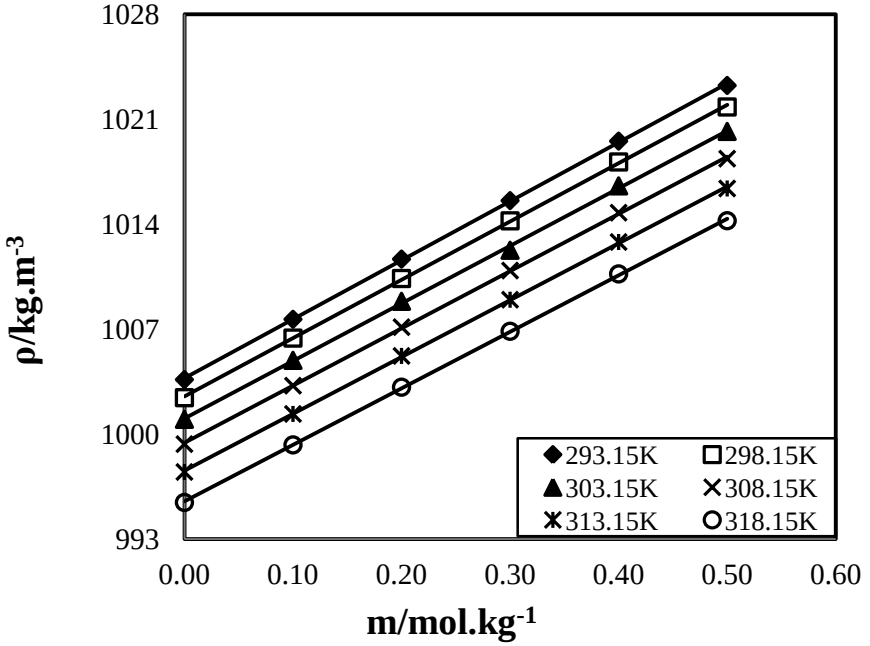



Figure 4.8: Plots of Density (ρ) vs. Molality (m) of water + NaCl + 0.045 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

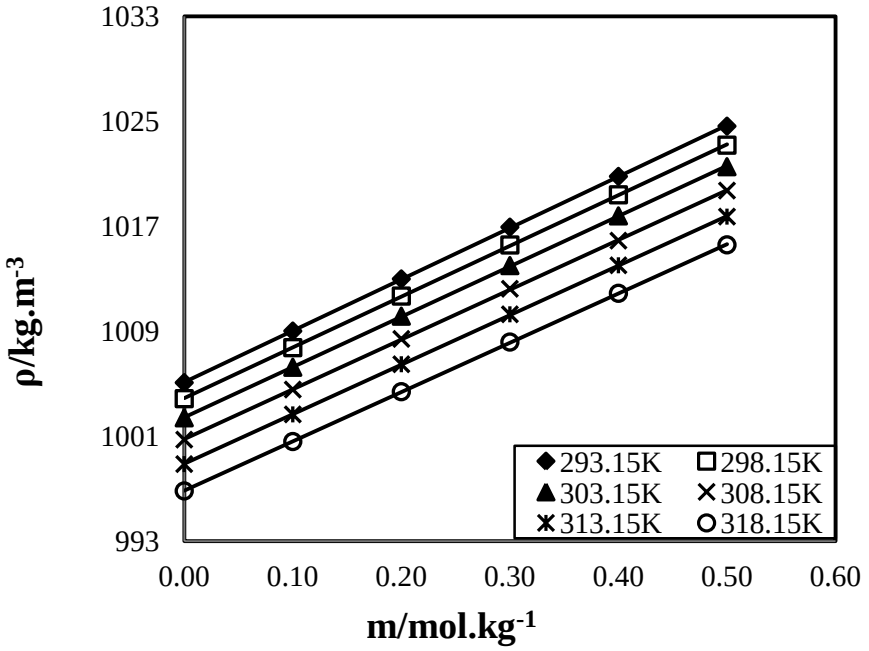



Figure 4.9: Plots of Density (ρ) vs. Molality (m) of water + NaCl + 0.06 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

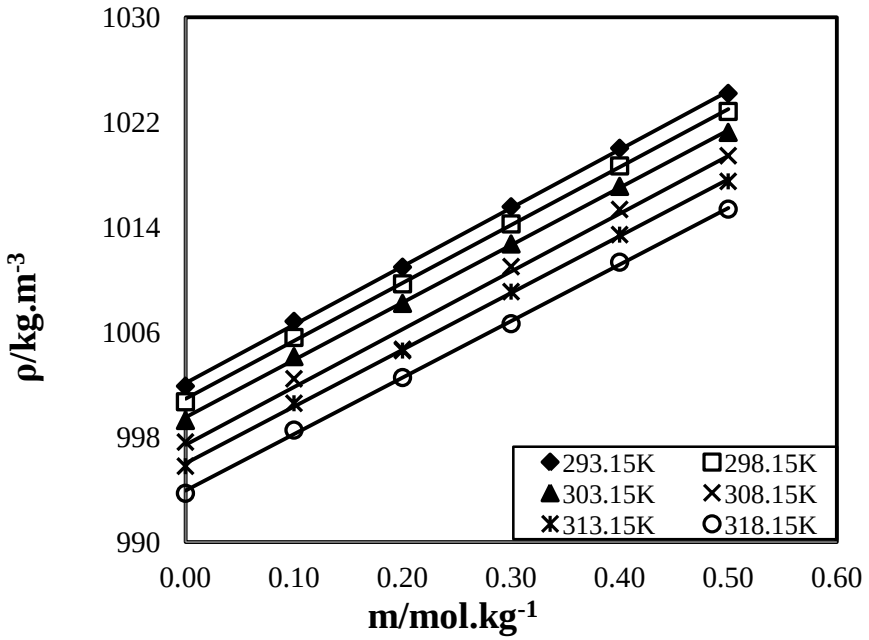



Figure 4.10: Plots of Density (ρ) vs. Molality (m) of water + KCl + 0.03 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

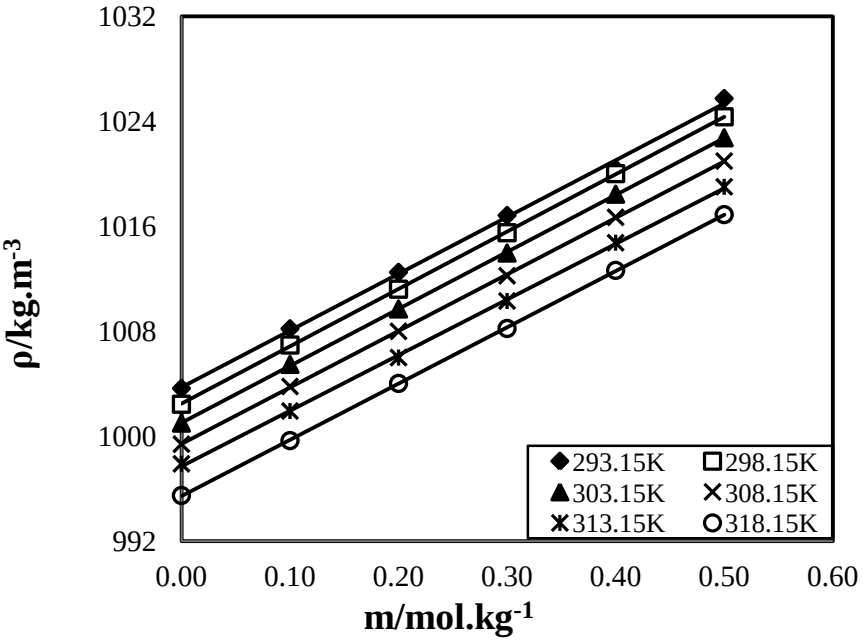



Figure 4.11: Plots of Density (ρ) vs. Molality (m) of water + KCl + 0.045 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

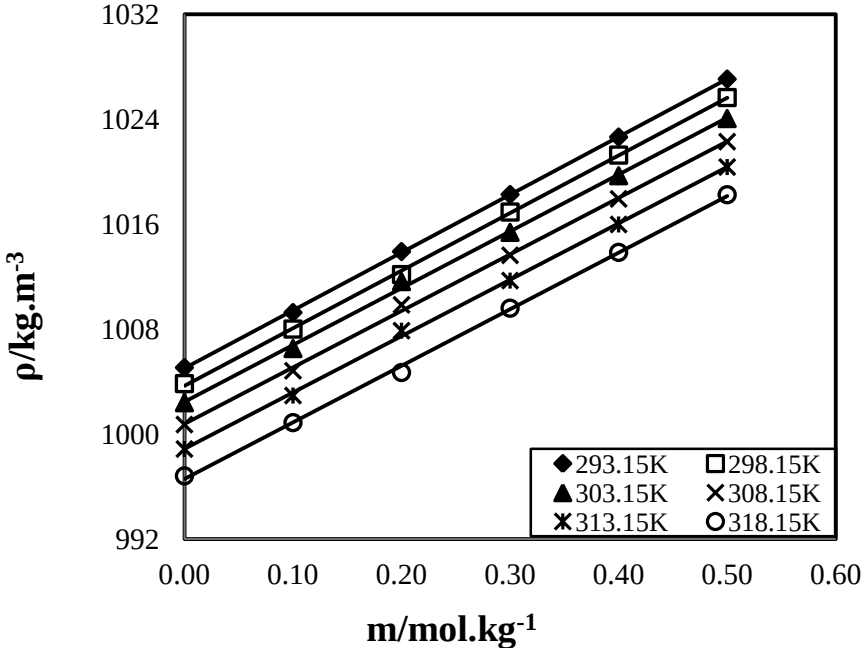



Figure 4.12: Plots of Density (ρ) vs. Molality (m) of water + KCl + 0.06 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

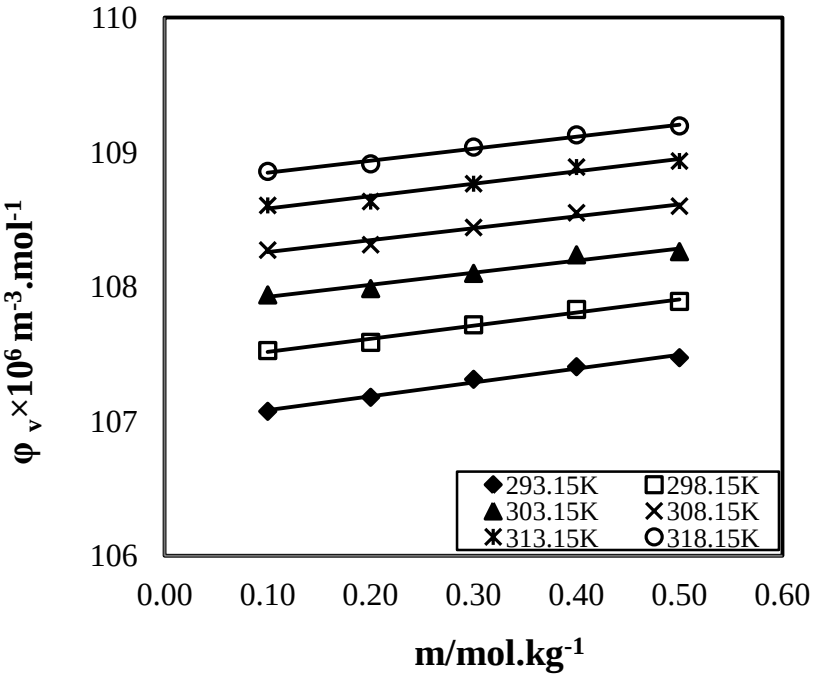



Figure 4.13: Plots of Apparent molar volume ($\phi_v$) vs. Molality of water + Glucose system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

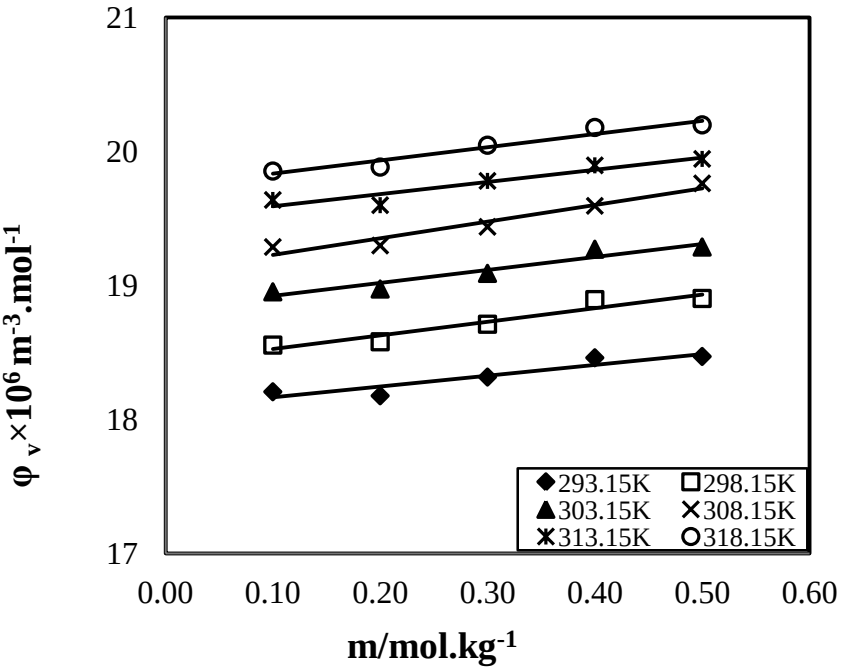



Figure 4.14: Plots of Apparent molar volume ($\phi_v$) vs. Molality of water + NaCl systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

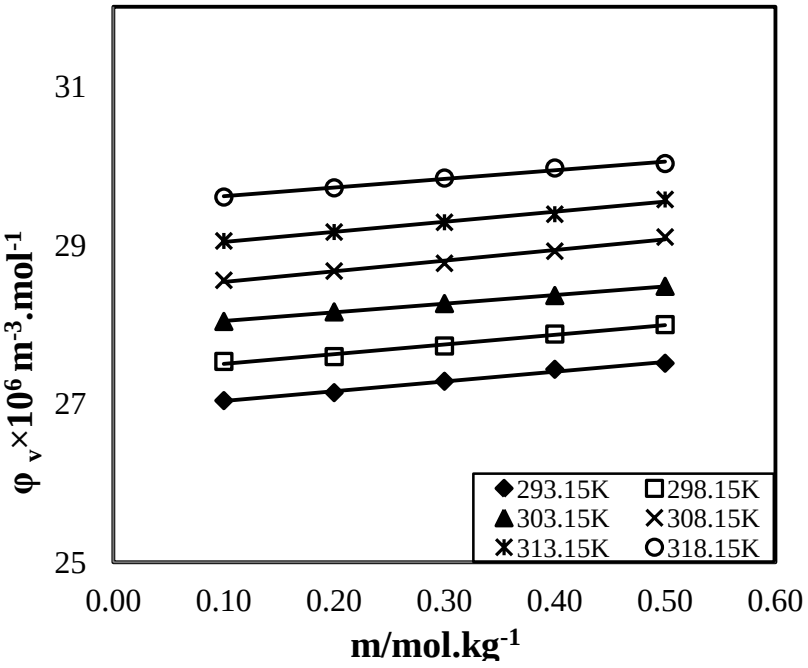



Figure 4.15: Plots of Apparent molar volume (ϕv) vs. Molality of water + KCl systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

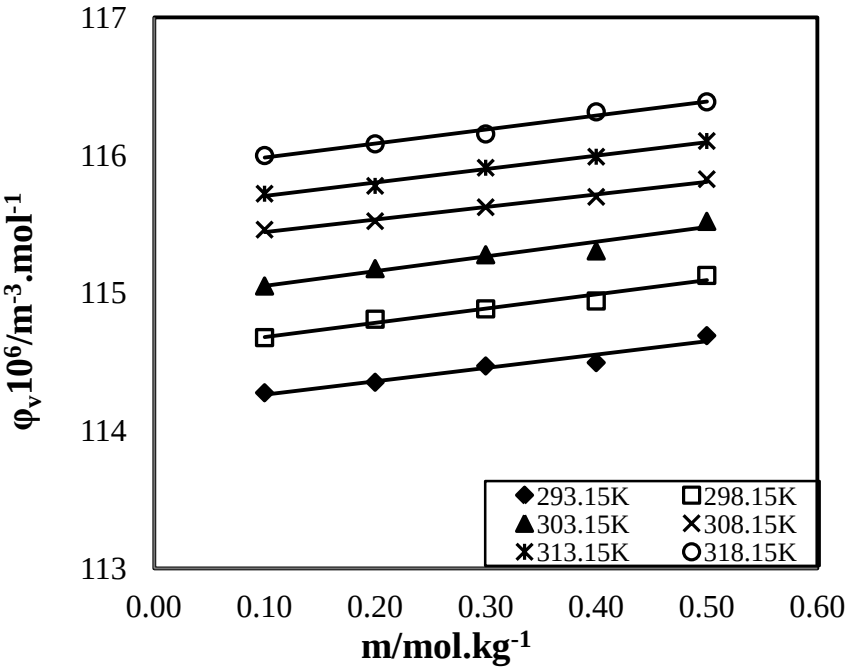



Figure 4.16: Plots of Apparent molar volume ($\phi_v$) vs. Molality of water+Glucose+0.03 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

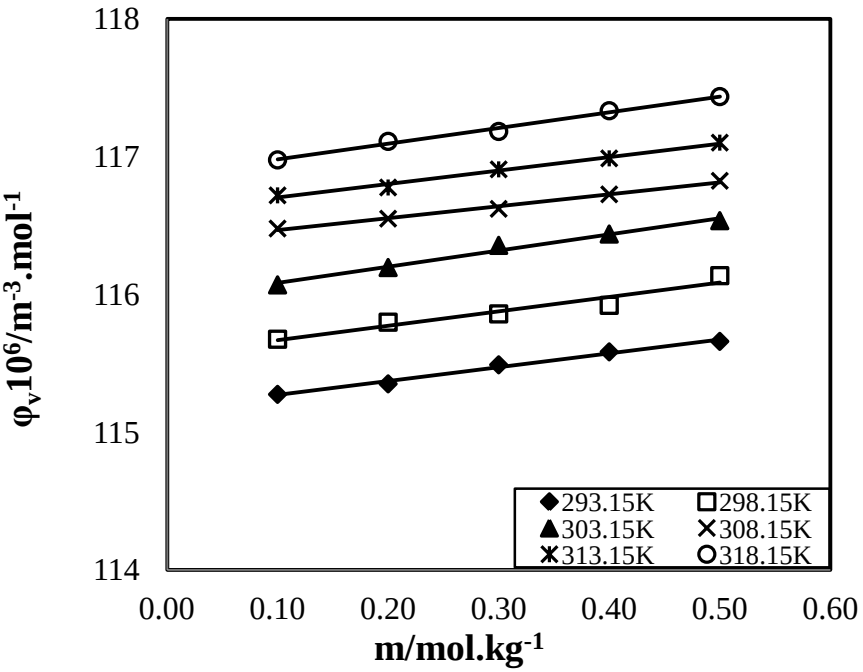



Figure 4.17:Plots of Apparent molar volume ($\phi_v$) vs. Molality of water +Glucose+ 0.045 mol.kg$^{-1}$ ciprofloxacin system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

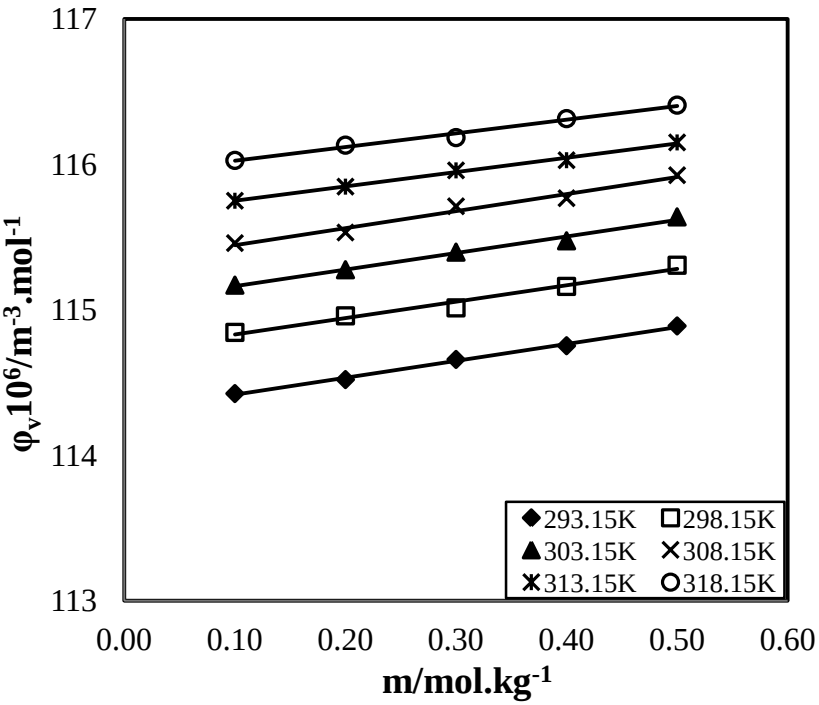



Figure 4.18:Plots of Apparent molar volume ($\phi_v$) vs. Molality of water + Glucose + 0.06 mol.kg$^{-1}$ ciprofloxacin system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

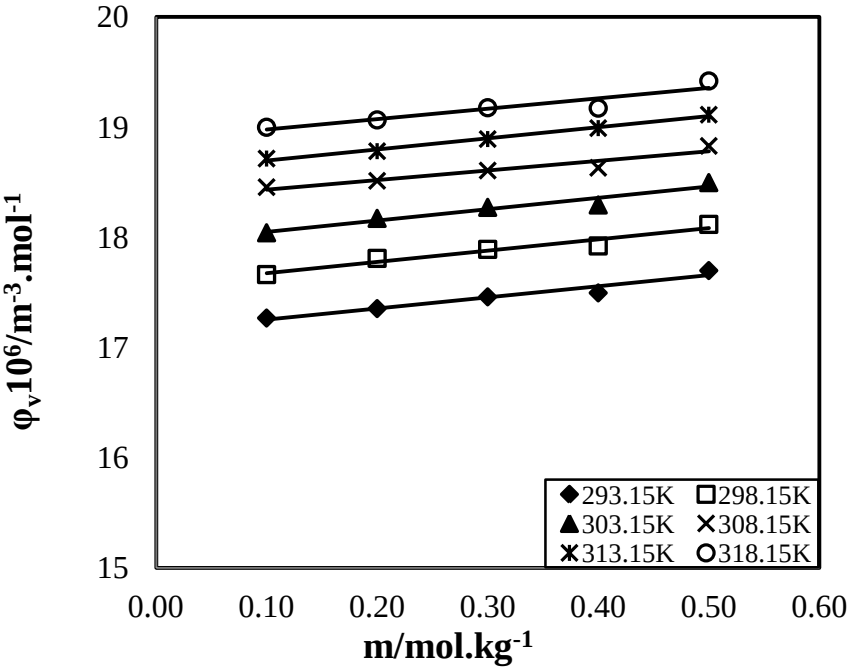



Figure 4.19: Plots of Apparent molar volume ($\phi_v$) vs. Molality of water + NaCl + 0.03 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

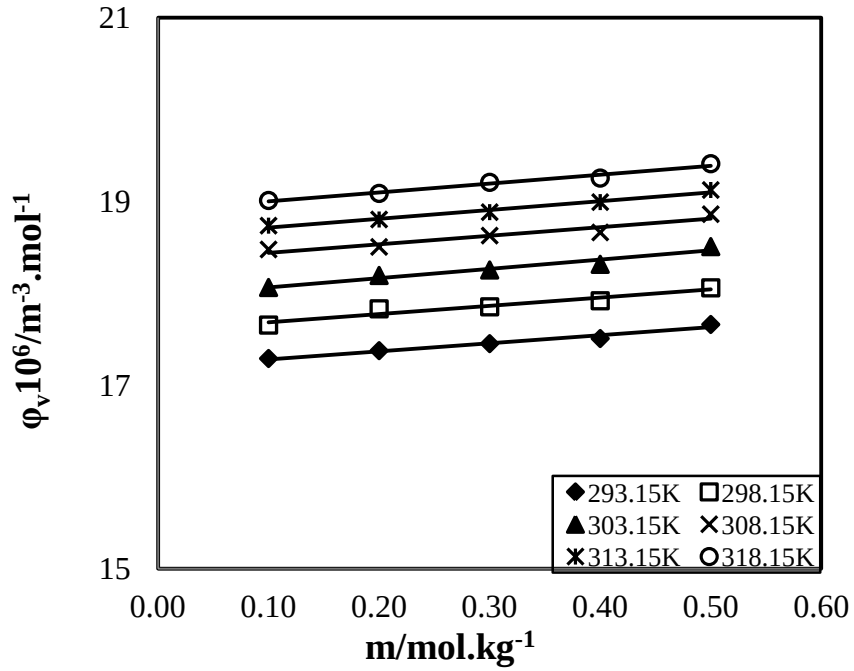



Figure 4.20: Plots of Apparent molar volume ($\phi_v$) vs. Molality of water + NaCl + 0.045 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

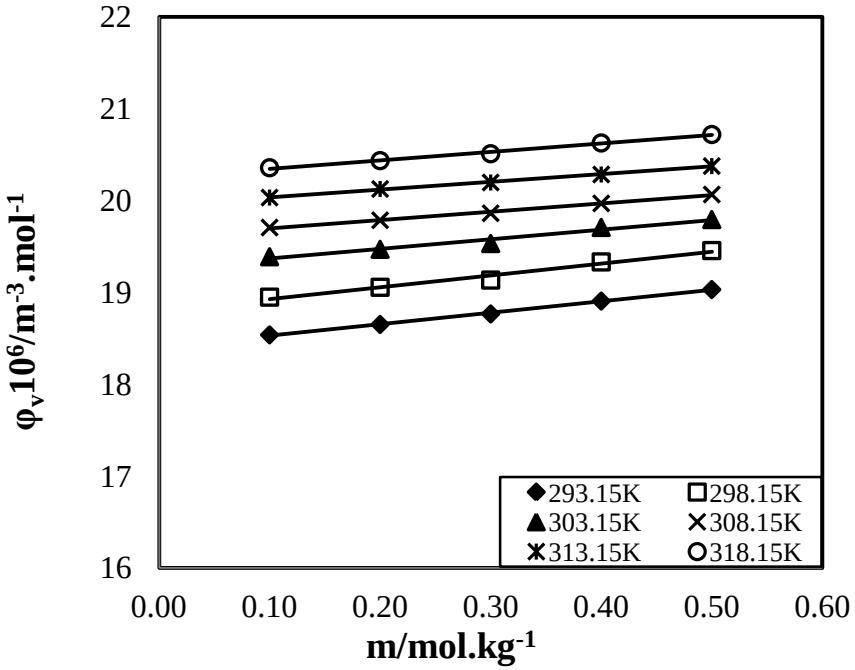



Figure 4.21: Plots of Apparent molar volume ($\phi_v$) vs. Molality of water + NaCl + 0.06 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

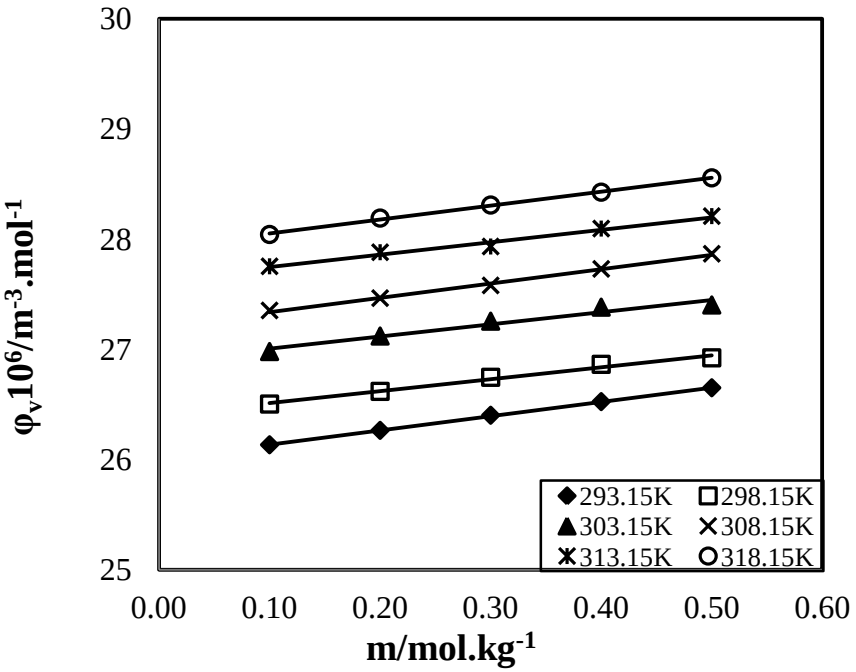



Figure 4.22: Plots of Apparent molar volume ($\phi$v) vs. Molality of water + KCl + 0.03 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

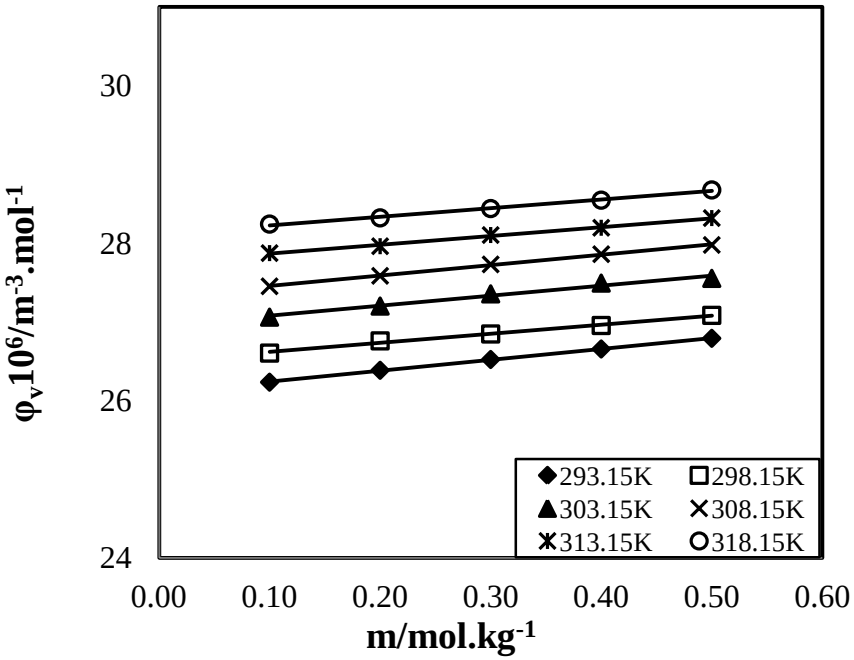



Figure 4.23: Plots of Apparent molar volume (ϕv) vs. Molality of water + KCl + 0.045 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

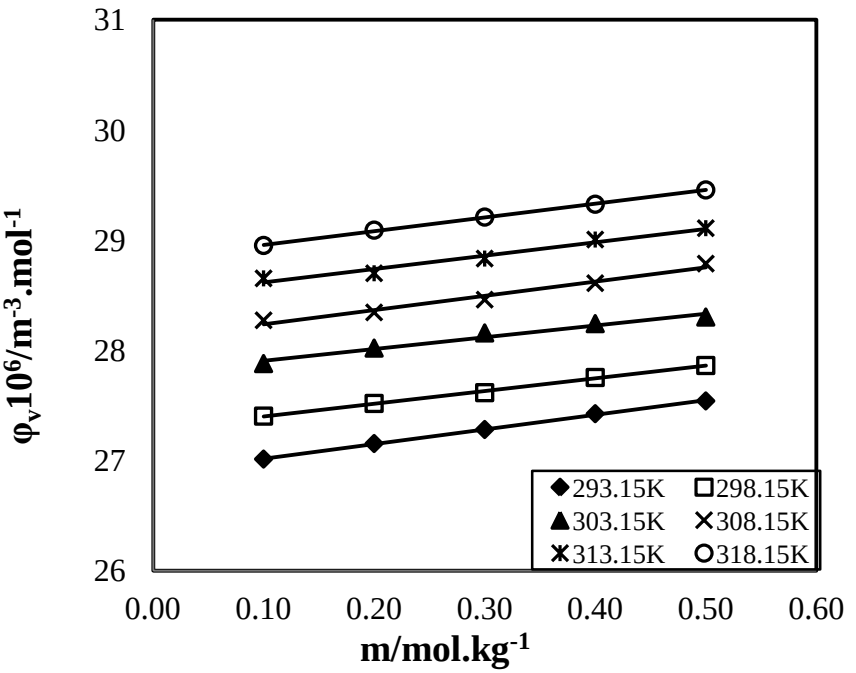



Figure 4.24: Plots of Apparent molar volume (ϕv) vs. Molality of water + KCl + 0.06 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

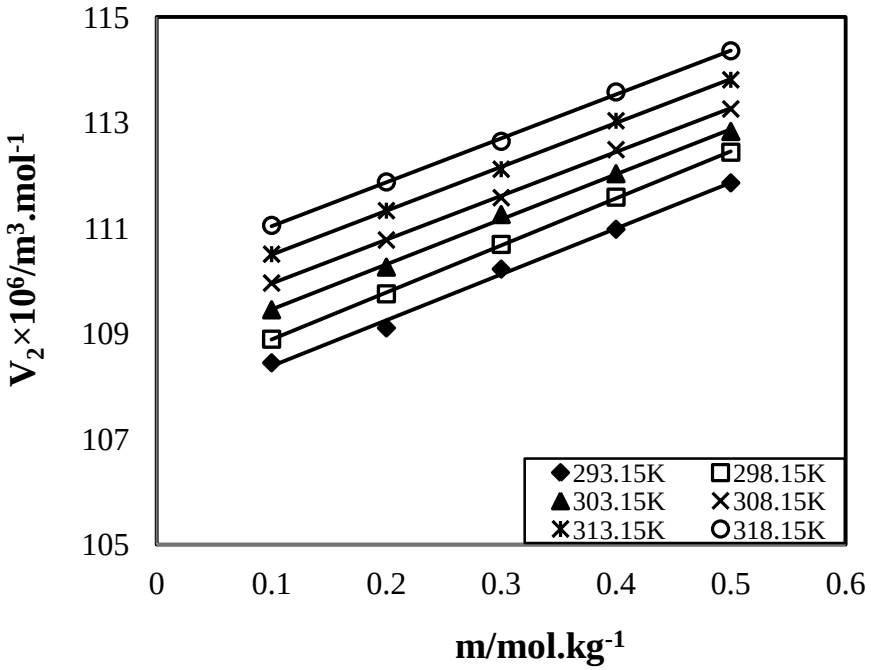



Figure 4.25: Plots of Partial molar volume ($\bar{V}_2$) vs. Molality of water + Glucose system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

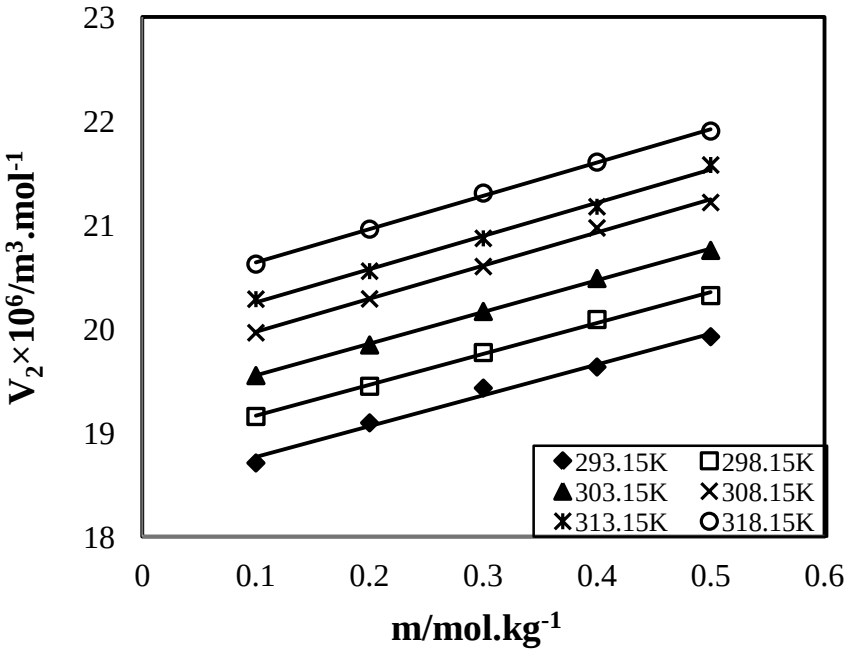



Figure 4.26: Plots of Partial molar volume ($\bar{V}_2$) vs. Molality of water + NaCl systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

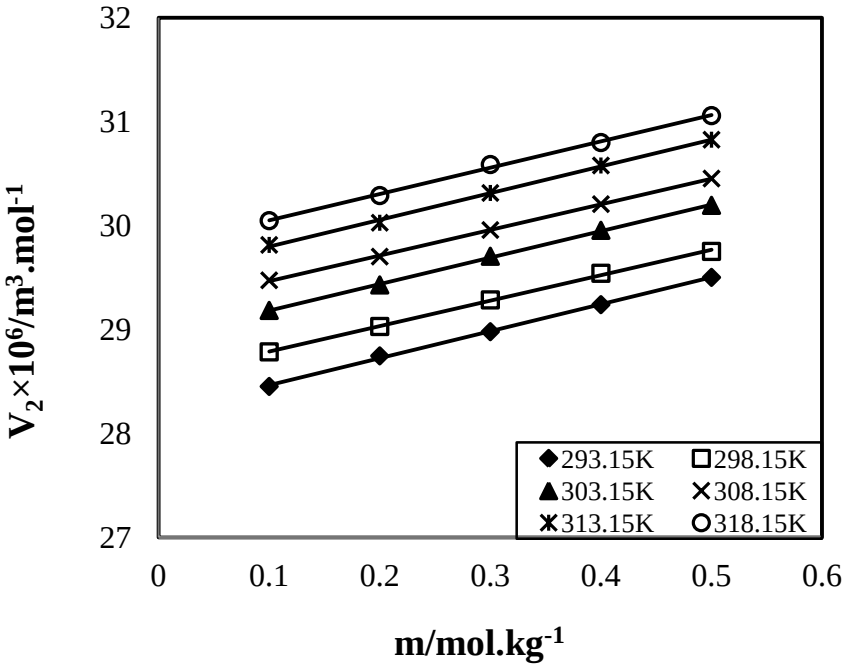



Figure 4.27: Plots of Partial molar volume ($\bar{V}2$) vs. Molality of water + KCl systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

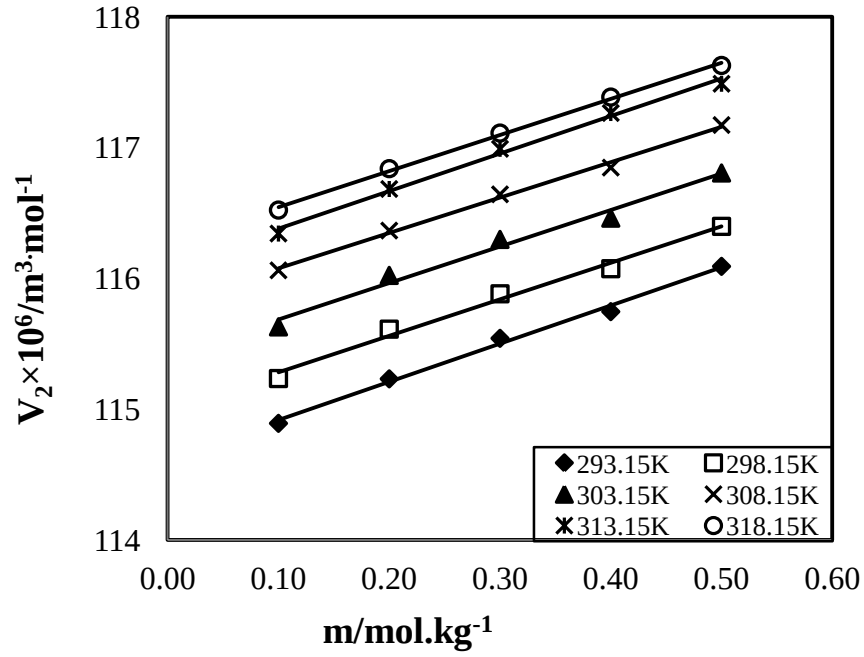



Figure 4.28: Plots of Partial molar volume ($\bar{V}_2$) vs. Molality of water + Glucose + 0.03 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

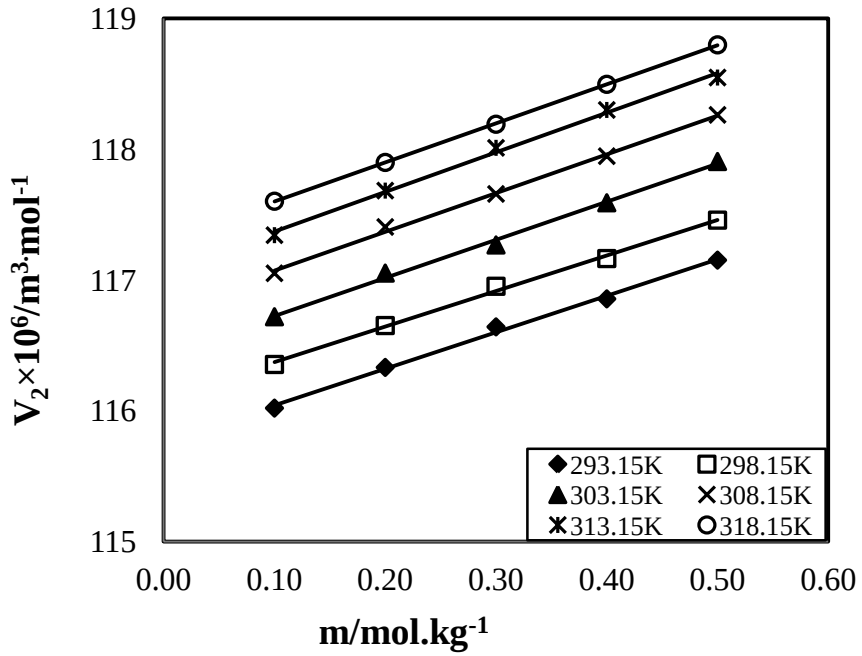



Figure 4.29: Plots of Partial molar volume ($\bar{V}_2$) vs. Molality of water + Glucose + 0.045 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

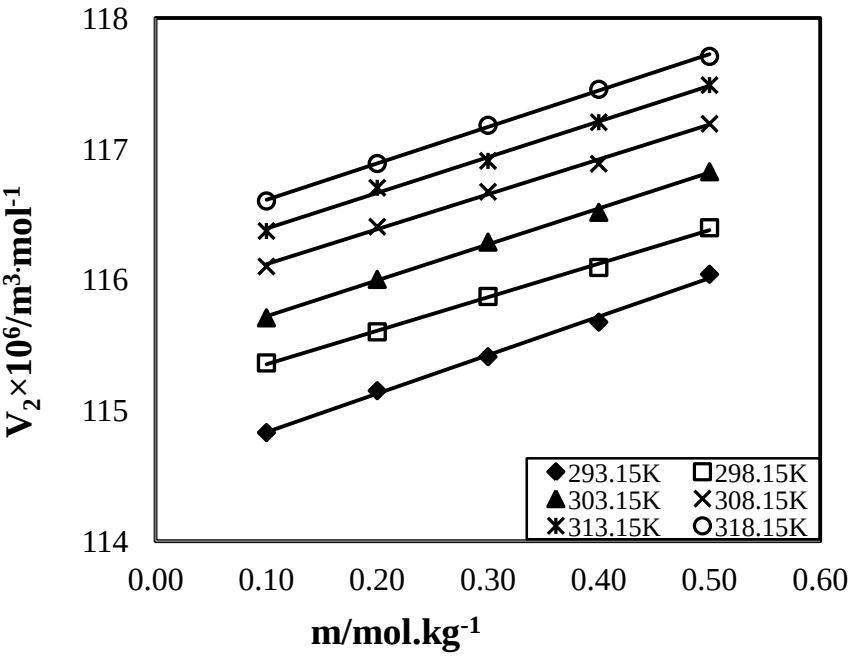



Figure 4.30: Plots of Partial molar volume ($\bar{V}_2$) vs. Molality of water + Glucose + 0.06 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

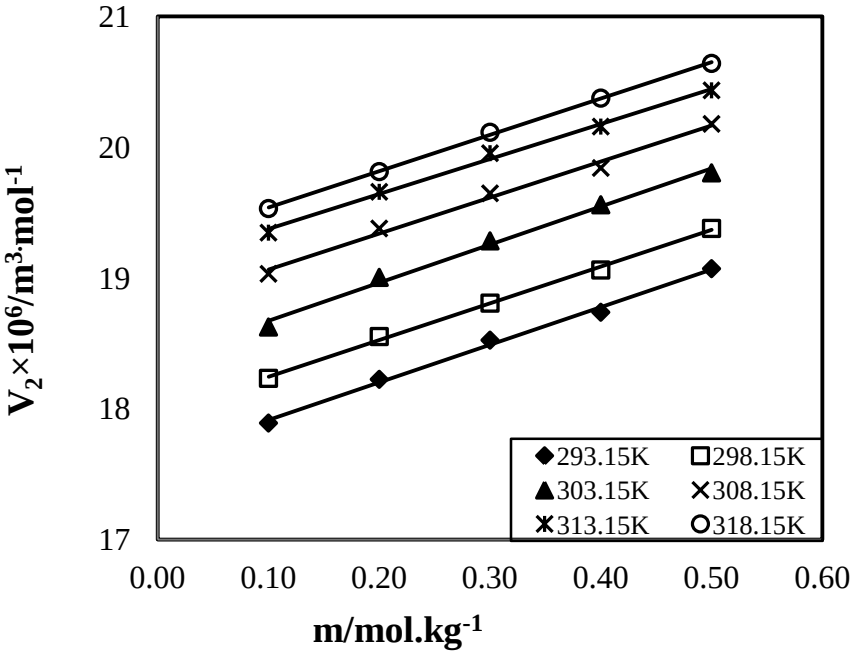



Figure 4.31: Plots of Partial molar volume ($\bar{V}_2$) vs. Molality of water + NaCl + 0.03 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

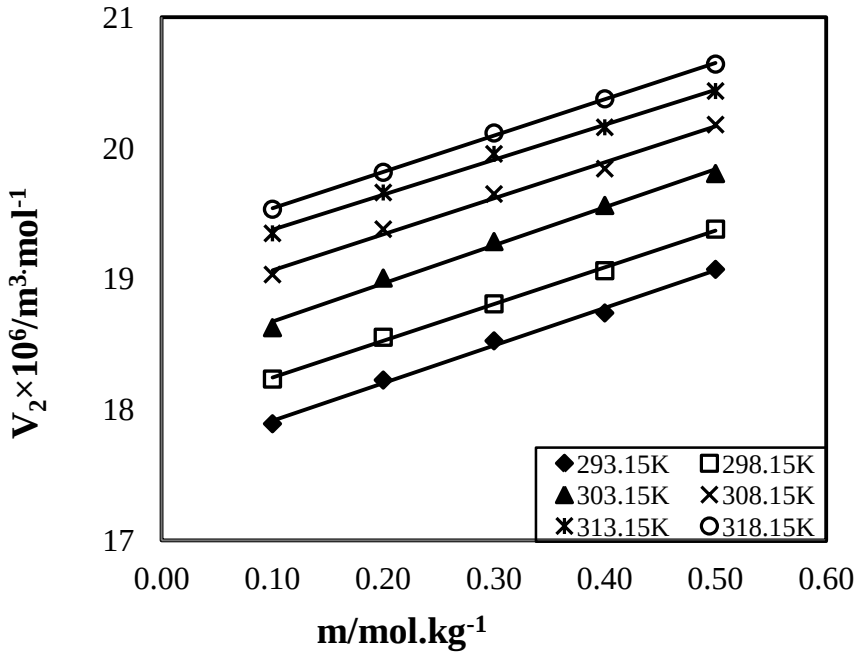



Figure 4.32: Plots of Partial molar volume ($\bar{V}_2$) vs. Molality of water + NaCl + 0.045 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

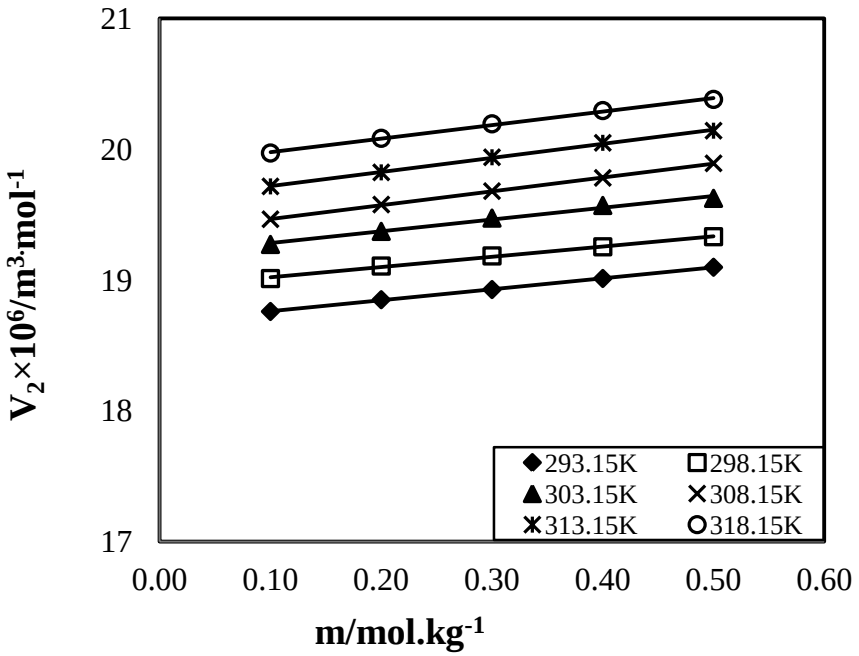



Figure 4.33: Plots of Partial molar volume ($\bar{V}_2$) vs. Molality of water + NaCl + 0.06 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

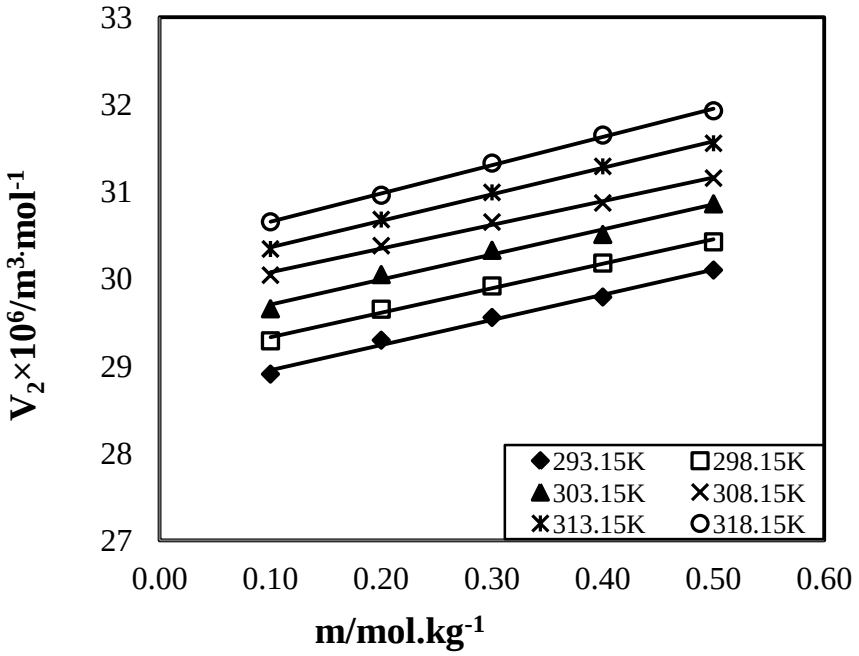



Figure 4.34: Plots of Partial molar volume ($\bar{V}2$) vs. Molality of water + KCl + 0.03 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

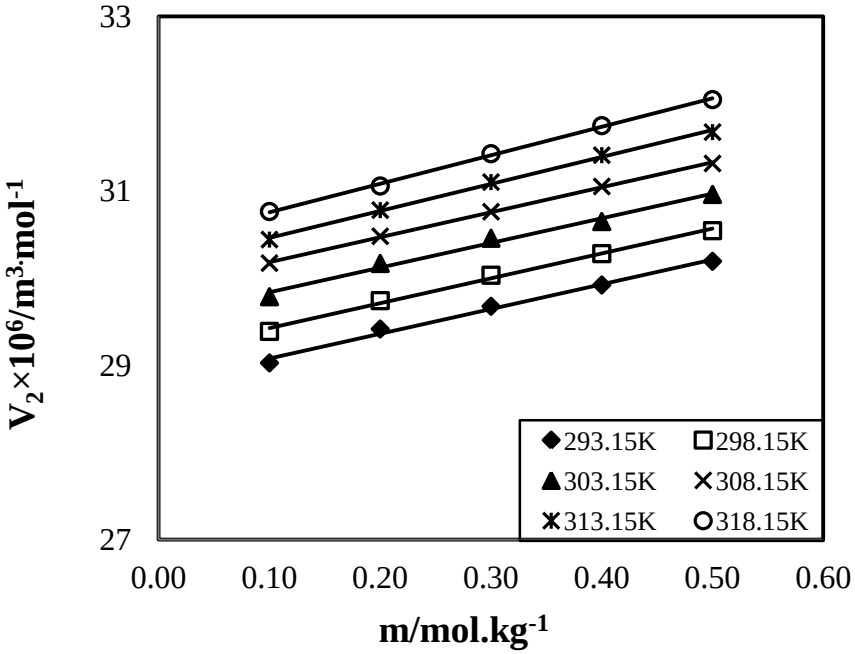



Figure 4.35: Plots of Partial molar volume ($\bar{V}2$) vs. Molality of water + KCl + 0.045 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

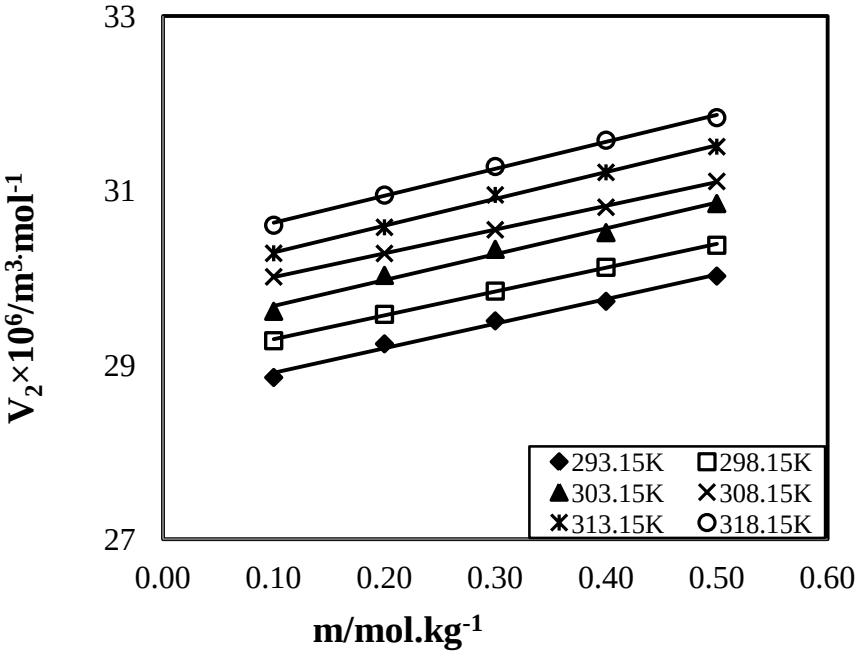



Figure 4.36: Plots of Partial molar volume ($\bar{V}2$) vs. Molality of water + KCl + 0.06 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

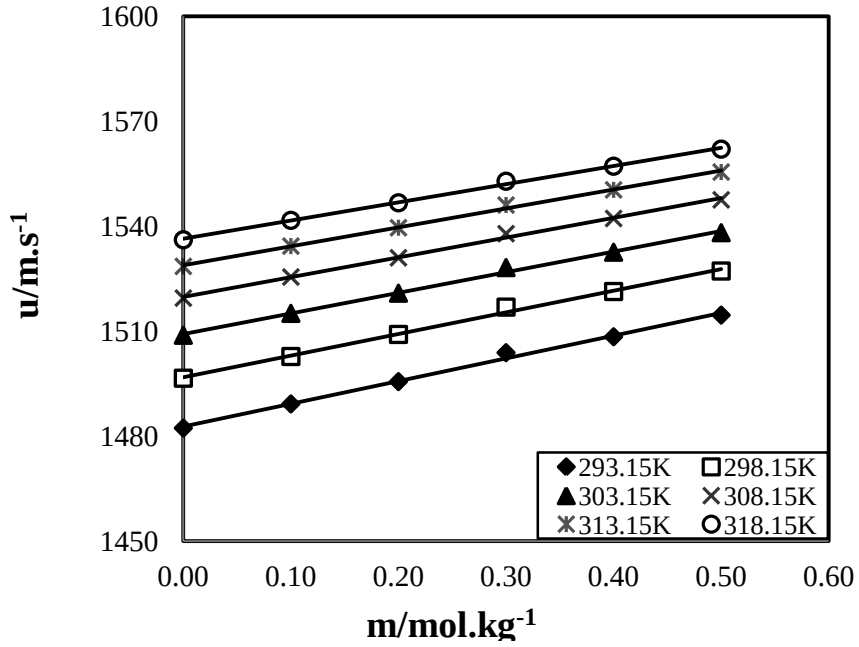



Figure 4.37: Plots of Sound velocity (u) vs. Molality (m) of Glucose + water system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

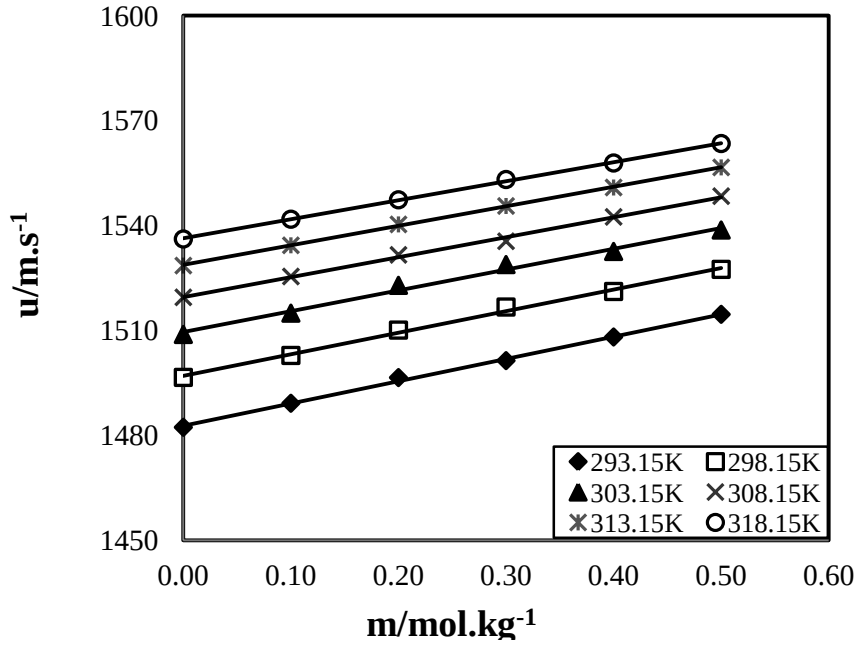



Figure 4.38: Plots of Sound velocity (u) vs. Molality (m) of NaCl + water system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

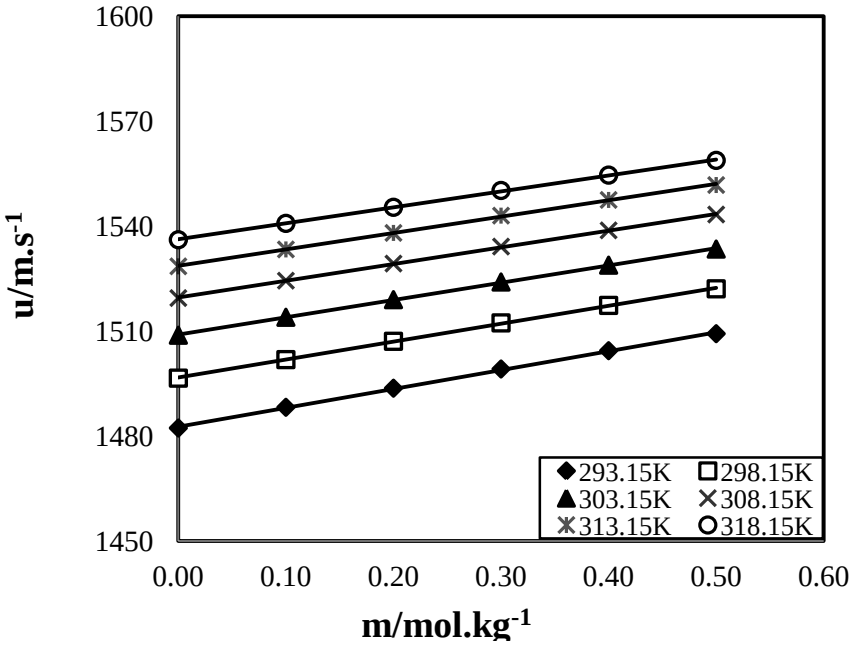



Figure 4.39: Plots of Sound velocity (u) vs. Molality (m) of KCl + water system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

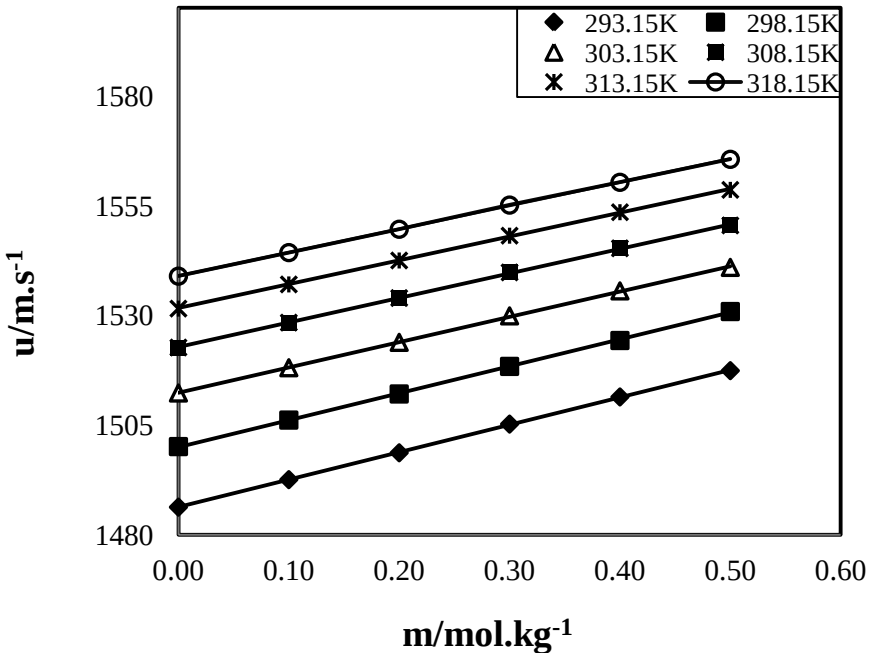



Figure 4.40: Plots of Sound velocity (u) vs. Molality (m) of water + Glucose + 0.03 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

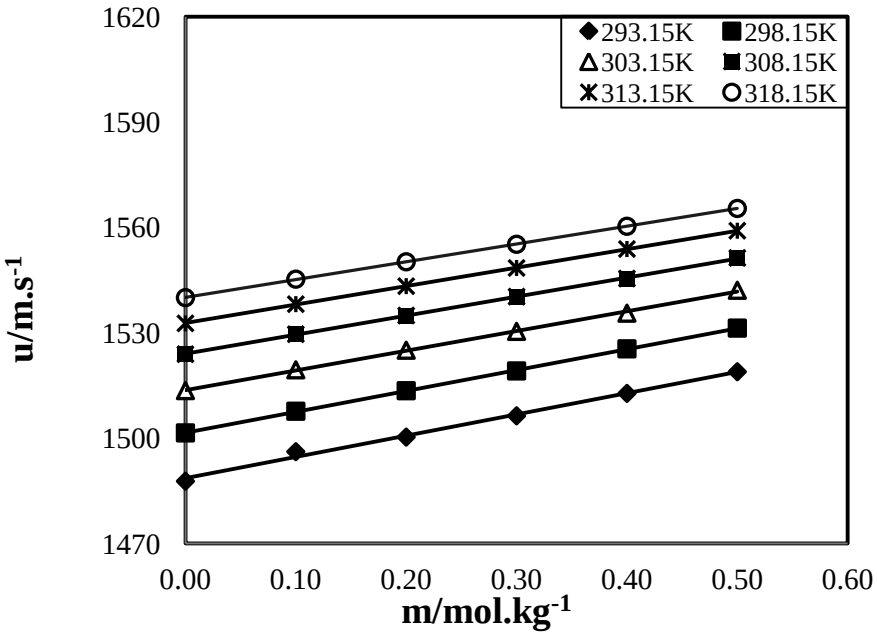



Figure 4.41: Plots of Sound velocity (u) vs. Molality (m) of water + Glucose + 0.045 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

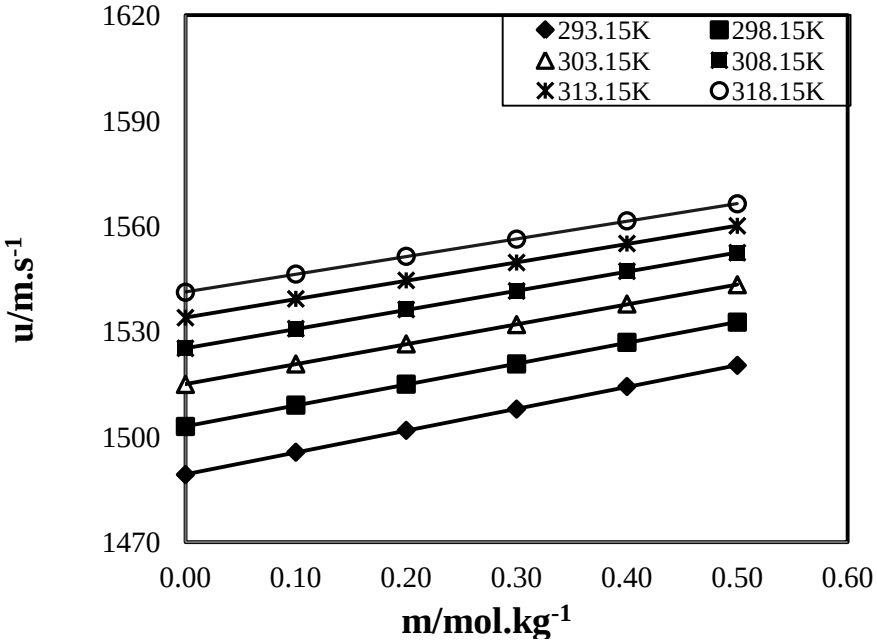



Figure 4.42: Plots of Sound velocity (u) vs. Molality (m) of water + Glucose + 0.06 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

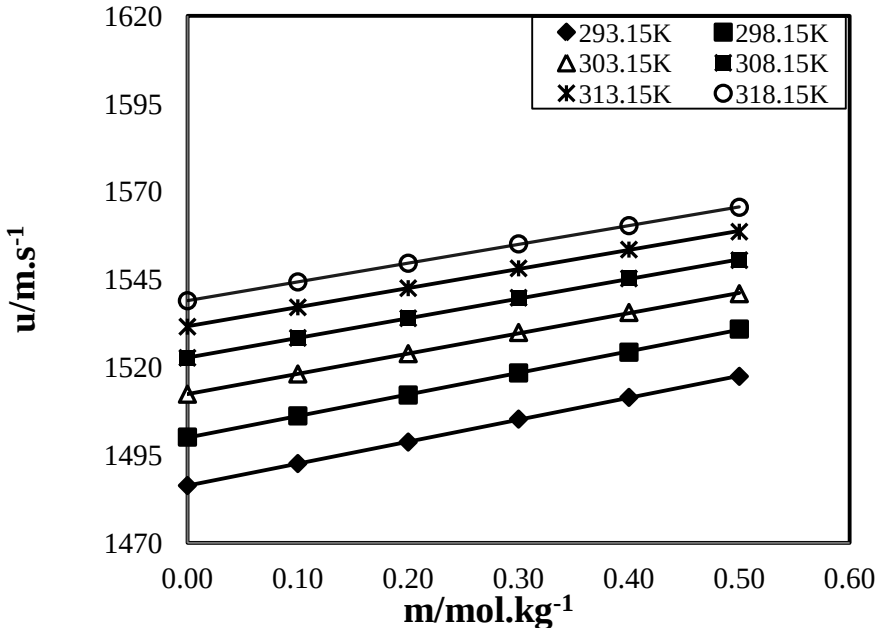



Figure 4.43: Plots of Sound velocity (u) vs. Molality (m) of water + NaCl + 0.03 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

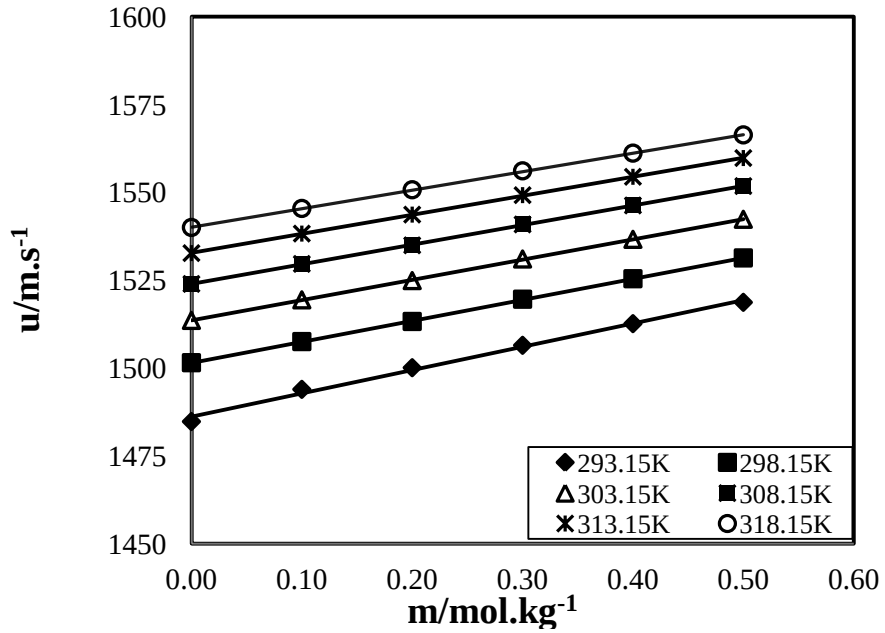



Figure 4.44: Plots of Sound velocity (u) vs. Molality (m) of water + NaCl + 0.045 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

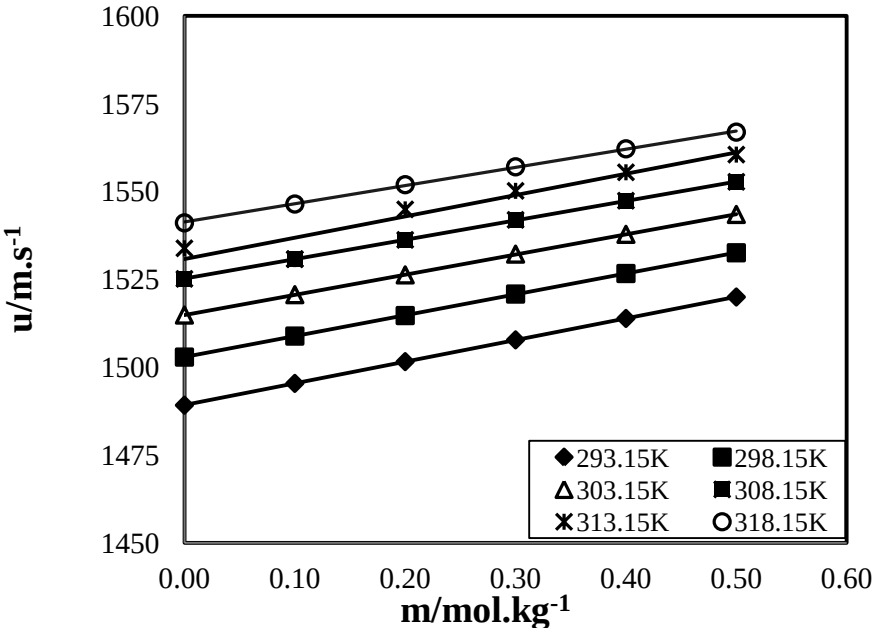



Figure 4.45: Plots of Sound velocity (u) vs. Molality (m) of water + NaCl + 0.06 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

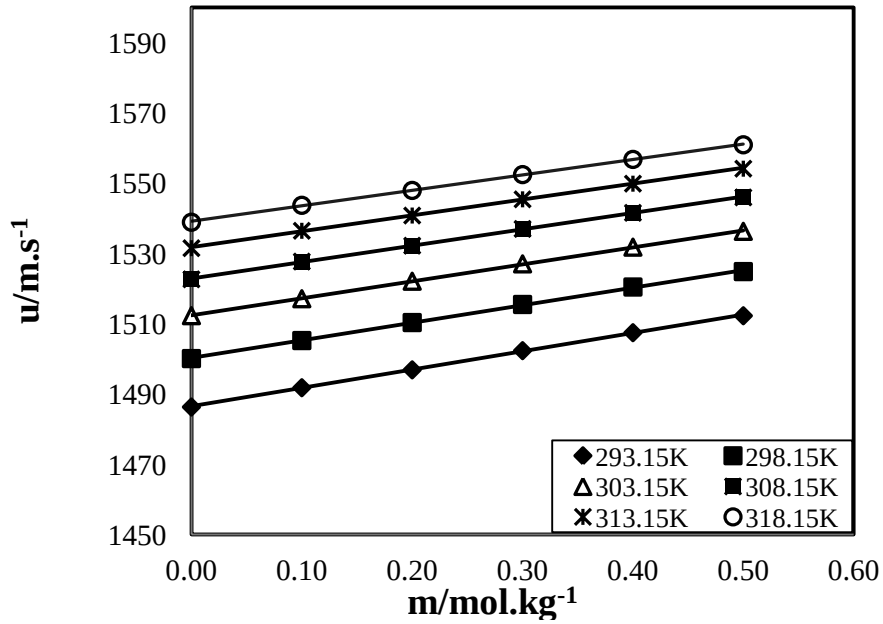



Figure 4.46: Plots of Sound velocity (u) vs. Molality (m) of water + KCl + 0.03 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

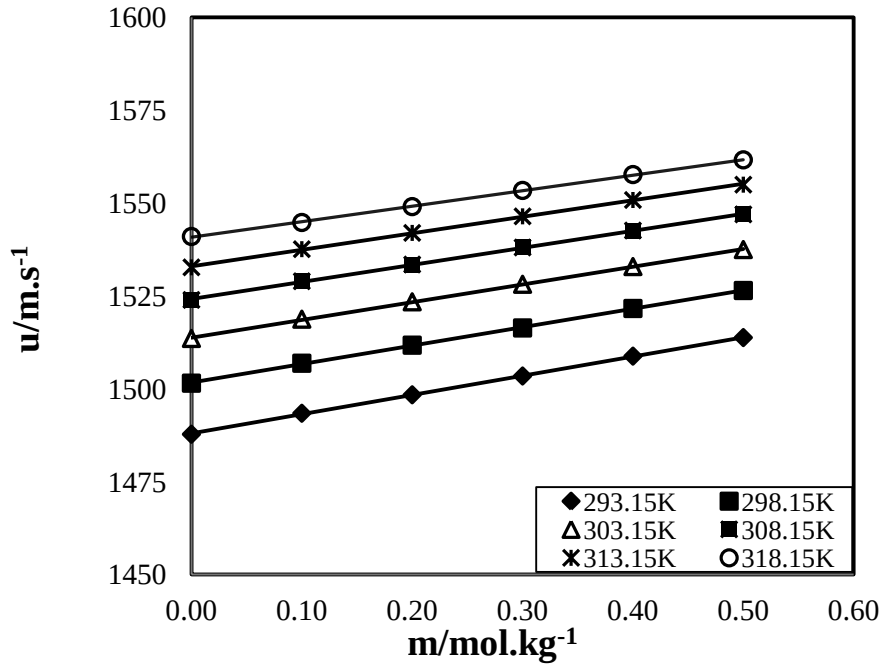



Figure 4.47: Plots of Sound velocity (u) vs. Molality (m) of water + KCl + 0.045 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

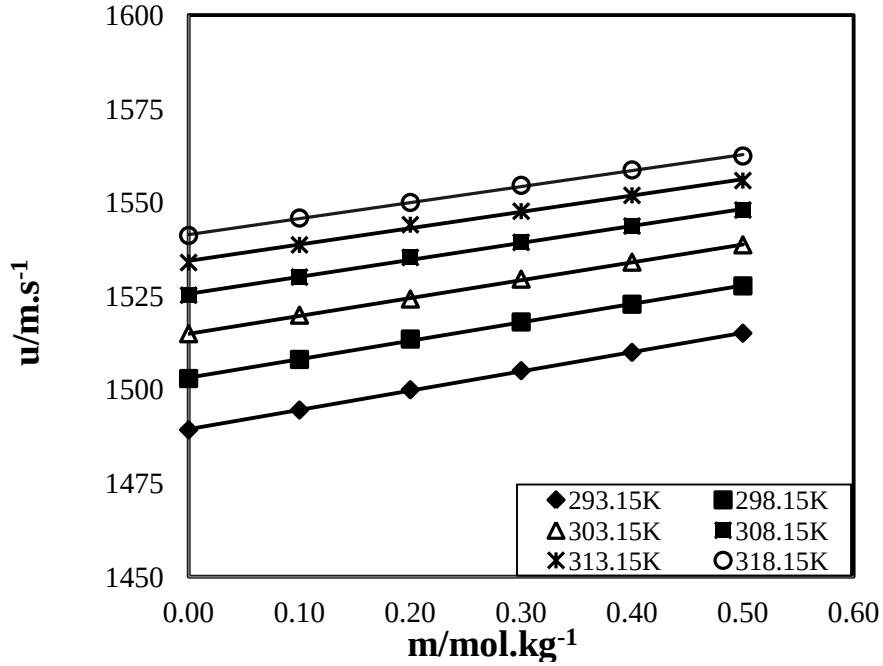



Figure 4.48: Plots of Sound velocity (u) vs. Molality (m) of water + KCl + 0.06 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

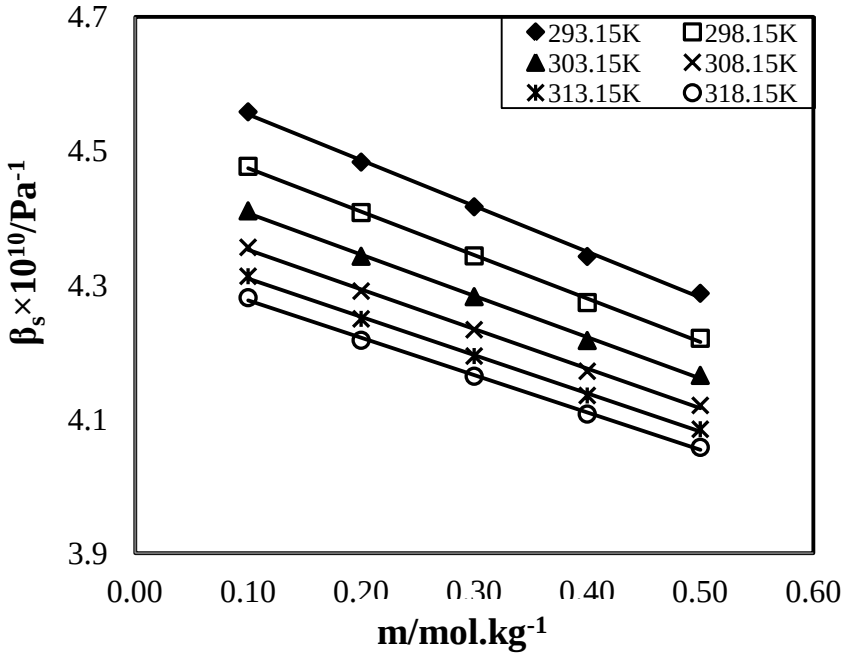



Figure 4.49: Plots of Adiabatic compressibility ($\beta_s$) vs. Molality (m) of Glucose + water system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

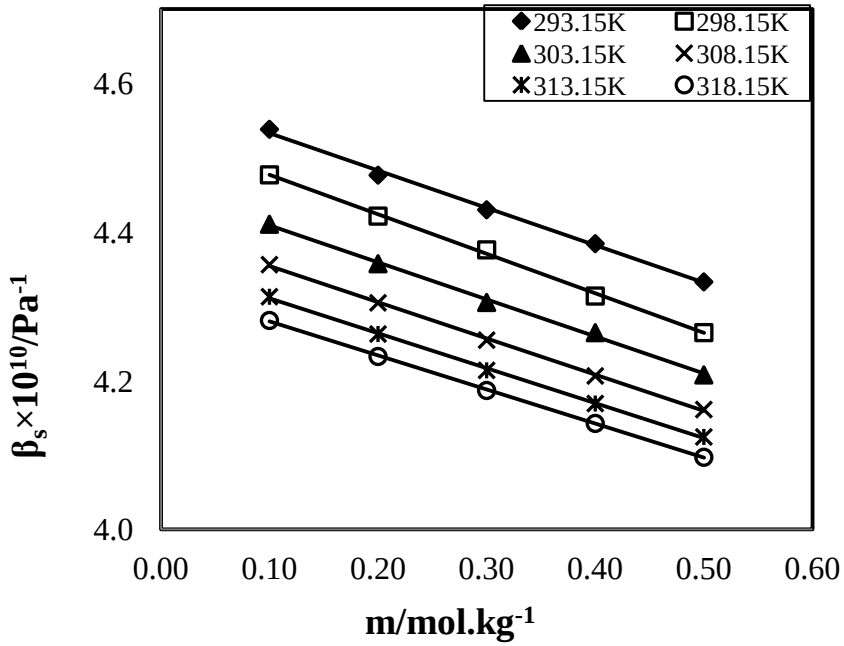



Figure 4.50: Plots of Adiabatic compressibility (βs) vs. Molality (m) of NaCl + water system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.1 5 K respectively

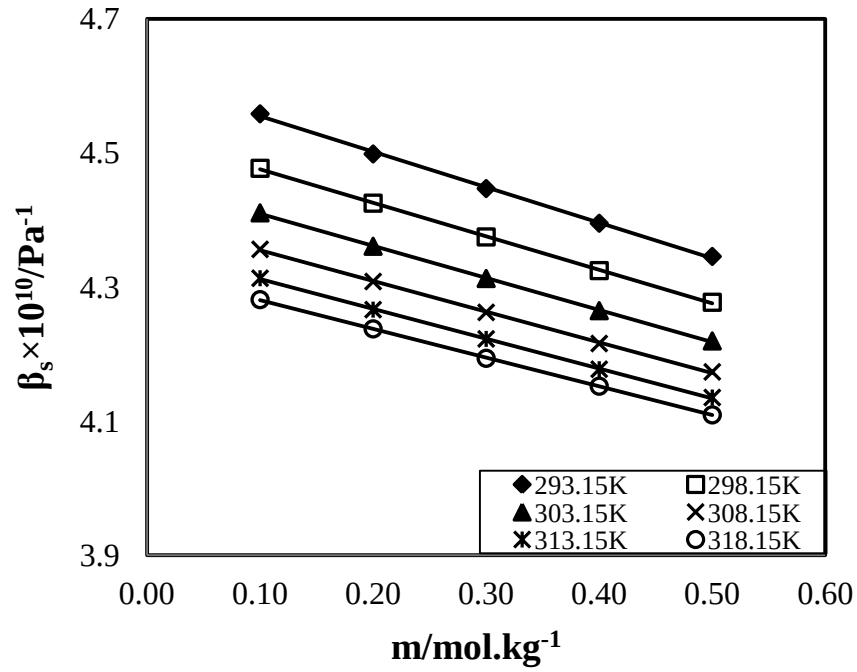



Figure 4.51: Plots of Adiabatic compressibility (βs) vs. Molality (m) of KCl + water system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

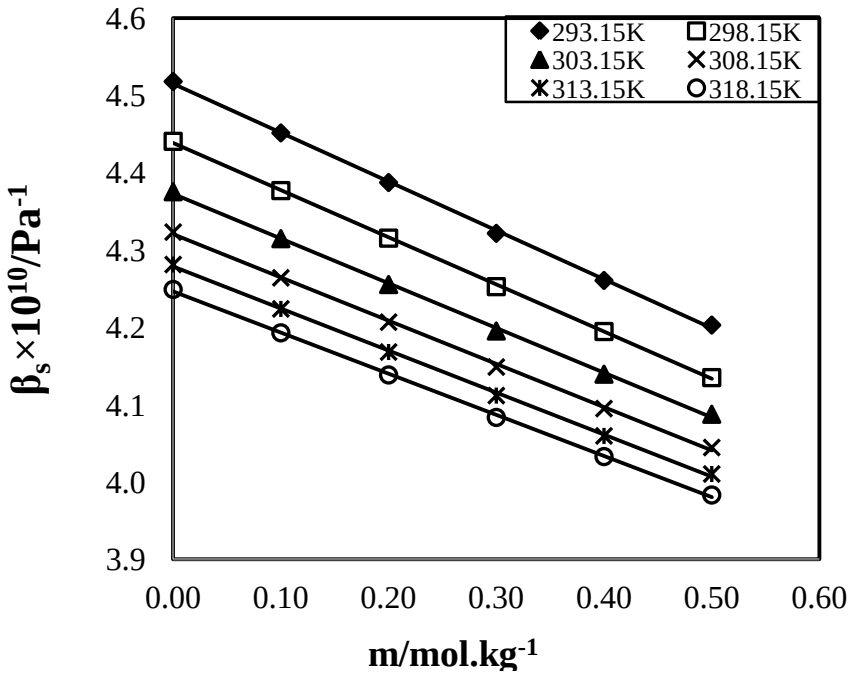



Figure 4.52: Plots of Adiabatic compressibility ($\beta_s$) vs. Molality (m) of water + Glucose + 0.03 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

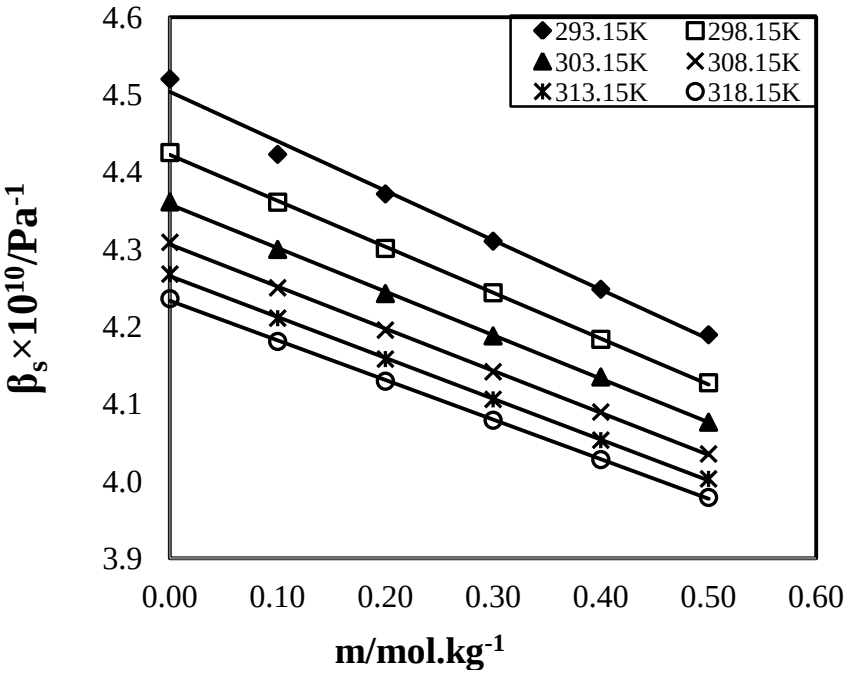



Figure 4.53: Plots of Adiabatic compressibility ($\beta_s$) vs. Molality (m) of water + Glucose + 0.045 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

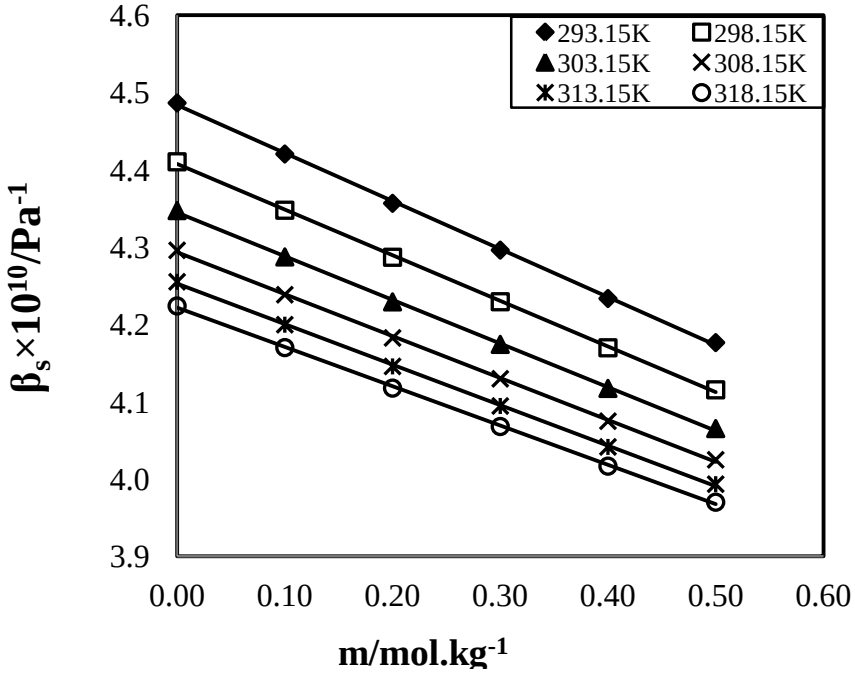



Figure 4.54: Plots of Adiabatic compressibility ($\beta_s$) vs. Molality (m) of water + Glucose + 0.06 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

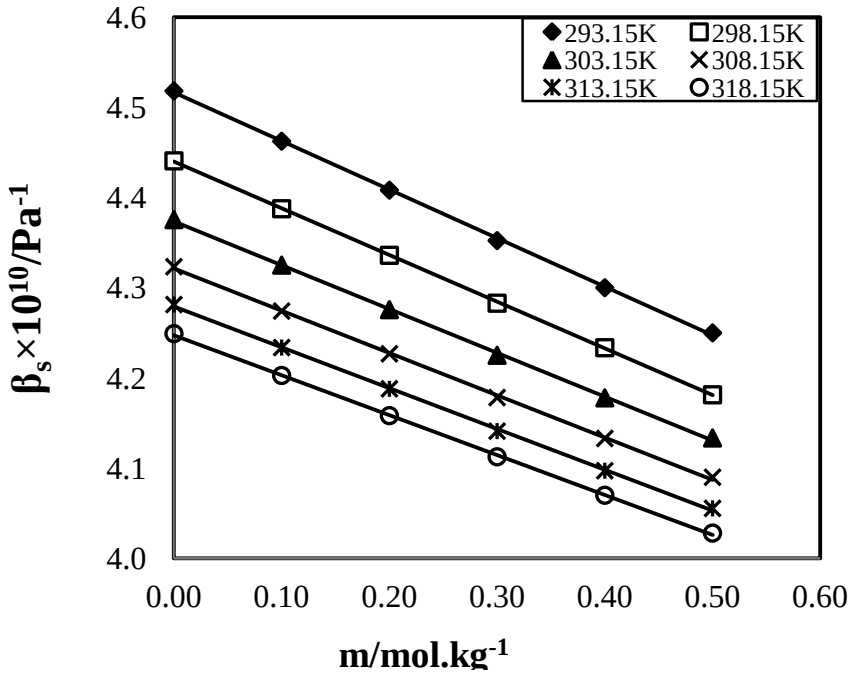



Figure 4.55: Plots of Adiabatic compressibility ($\beta_s$) vs. Molality (m) of water + NaCl + 0.03 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

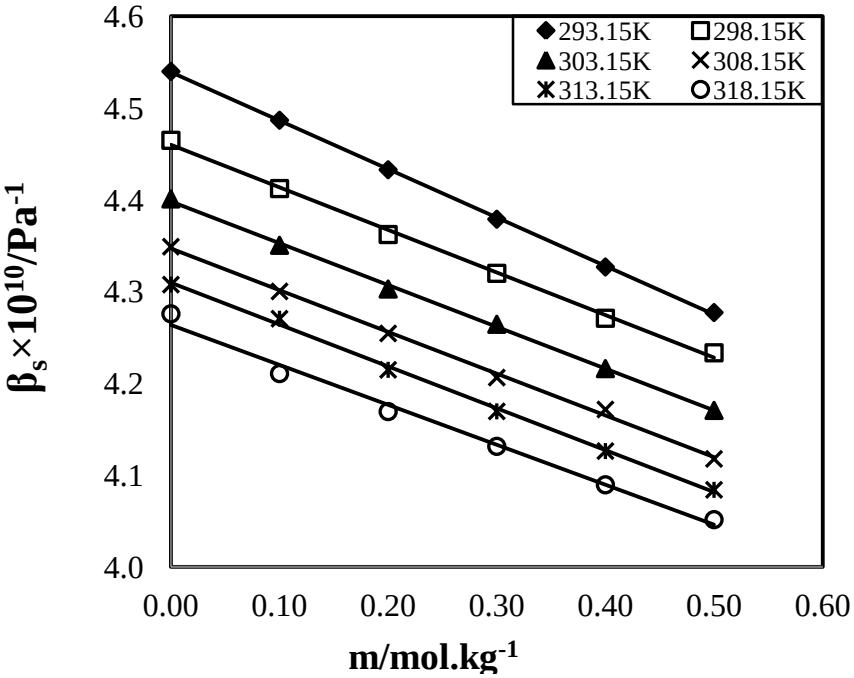



Figure 4.56: Plots of Adiabatic compressibility ($\beta_s$) vs. Molality (m) of water + NaCl + 0.045 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

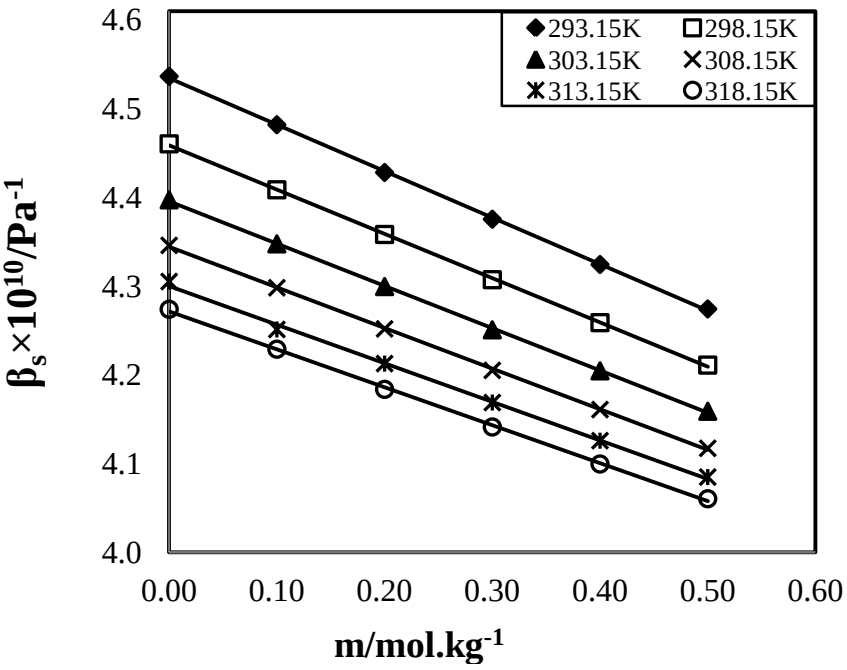



Figure 4.57: Plots of Adiabatic compressibility ($\beta_s$) vs. Molality (m) of water + NaCl + 0.06 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

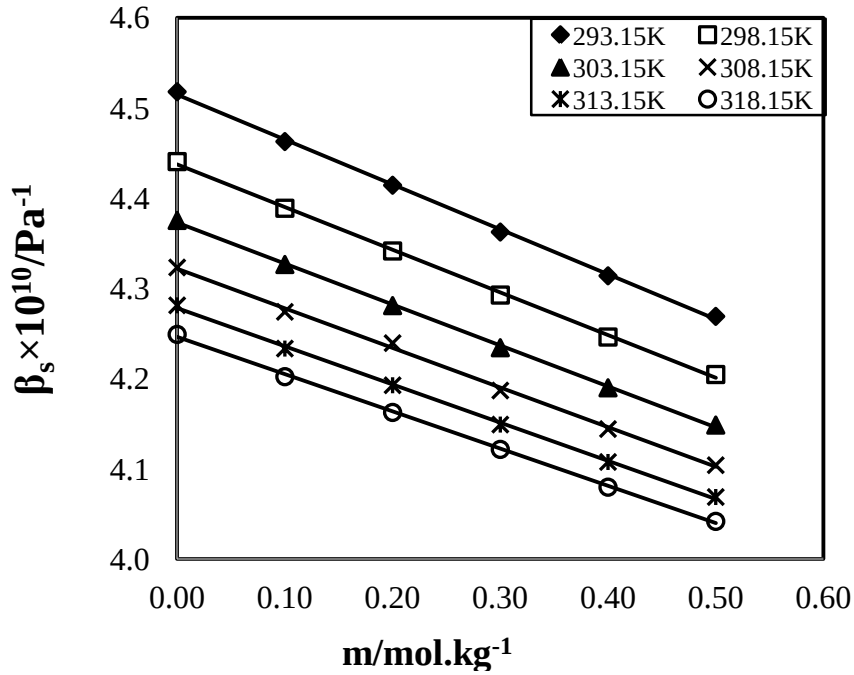



Figure4.58: Plots of Adiabatic compressibility (βs) vs. Molality (m) of water +KCl+0.03 mol.kg-1 ciprofloxacin system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

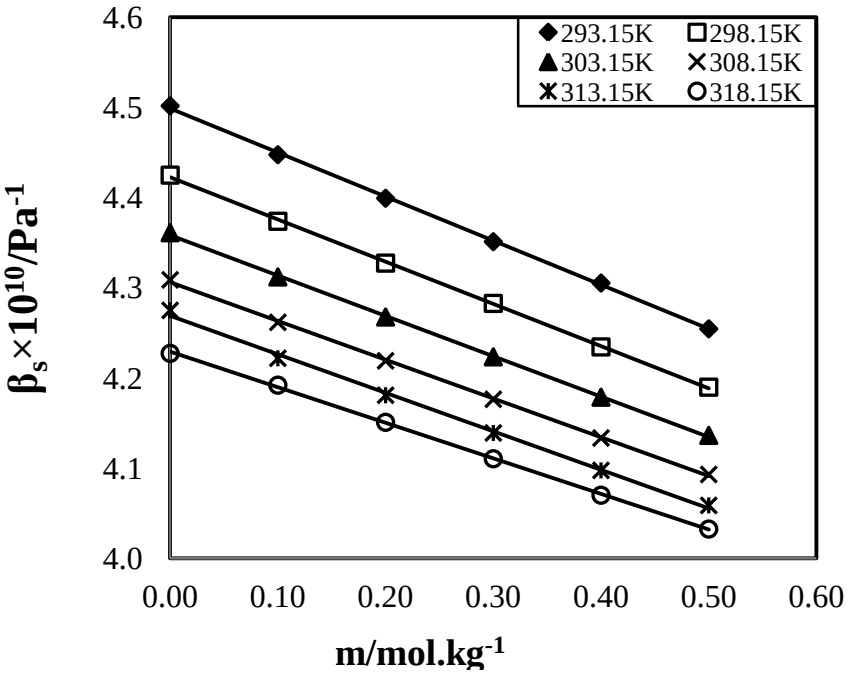



Figure 4.59: Plots of Adiabatic compressibility (βs) vs. Molality (m) of water + KCl + 0.045 mol.kg$^{-1}$ ciprofloxacin system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

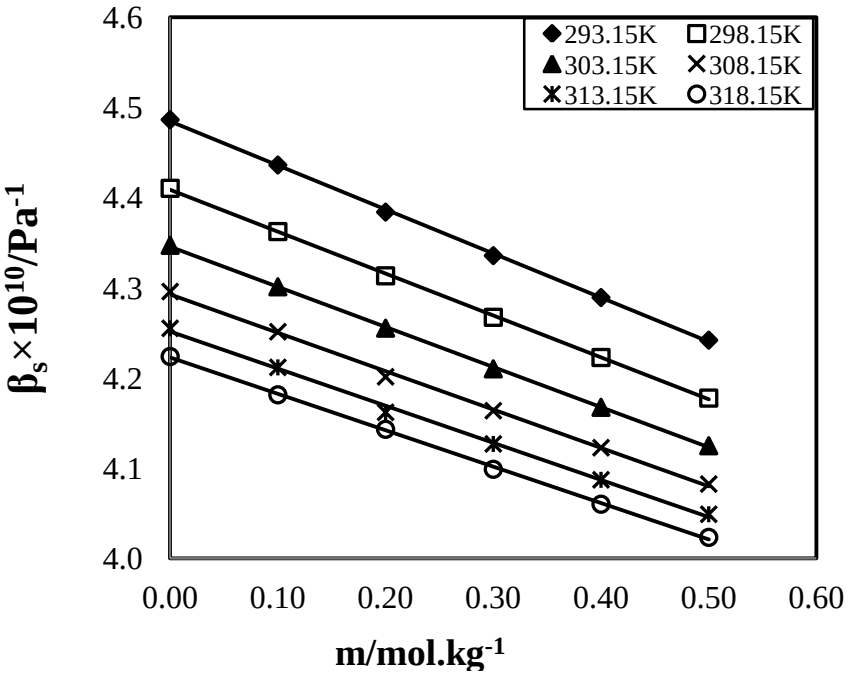



Figure 4.60: Plots of Adiabatic compressibility (βs) vs. Molality (m) of water + KCl + 0.06 mol.kg-$^{1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

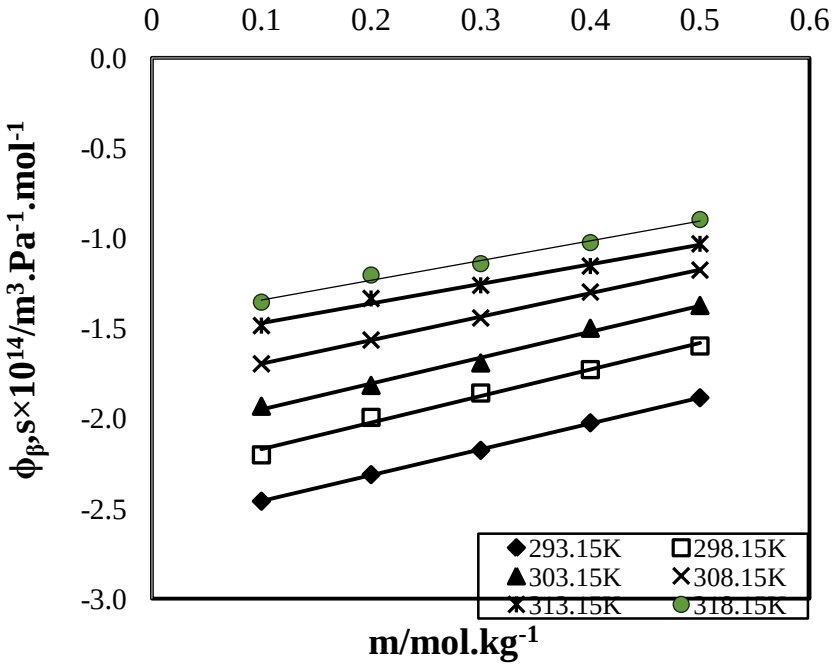



Figure 4.61: Plots of Apparent molar adiabatic compressibility ($\phi_k$) vs. Molality (m) of Glucose + water system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

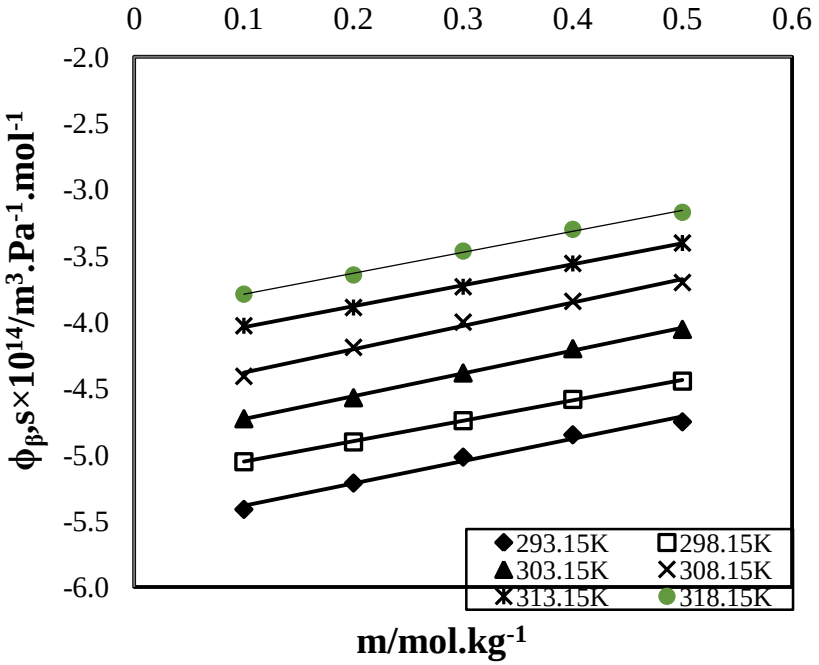



Figure 4.62: Plots of Apparent molar adiabatic compressibility ($\phi_k$) vs. Molality (m) of NaCl + water system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

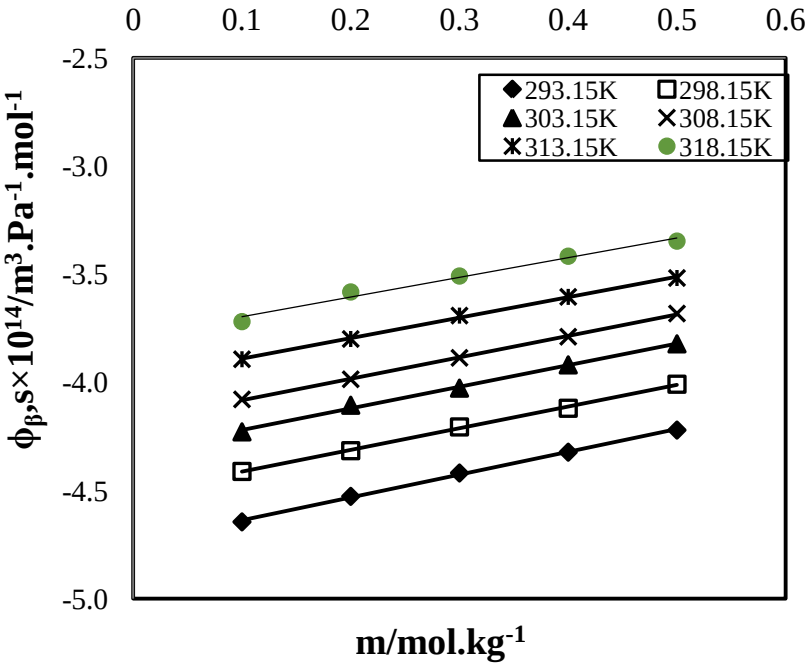



Figure 4.63: Plots of Apparent molar adiabatic compressibility (ϕk) vs. Molality (m) of KCl + water system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

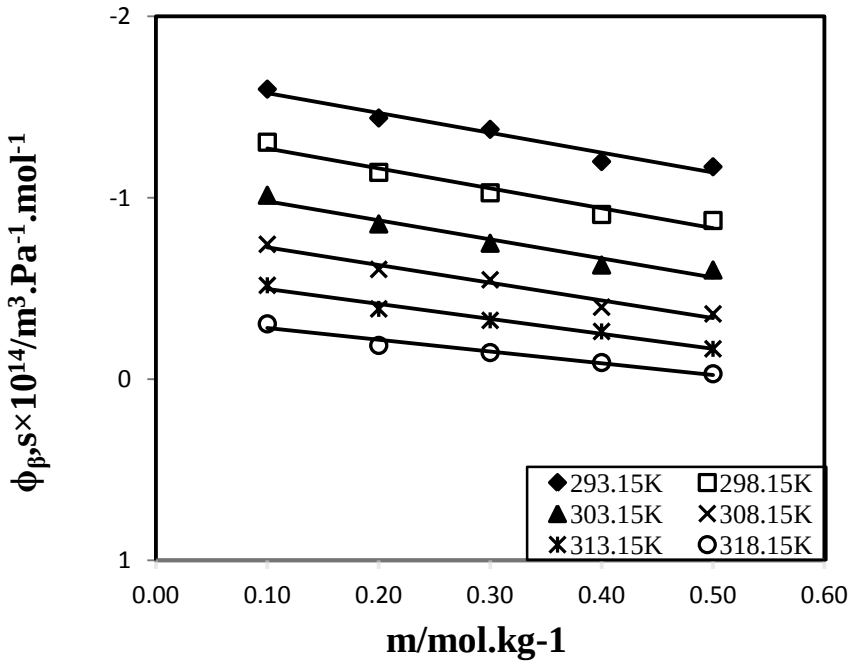



Figure 4.64: Plots of Apparent molar adiabatic compressibility ($\phi_k$) vs. Molality (m) of water + Glucose + 0.03 mol.kg$^{-1}$ ciprofloxacin system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

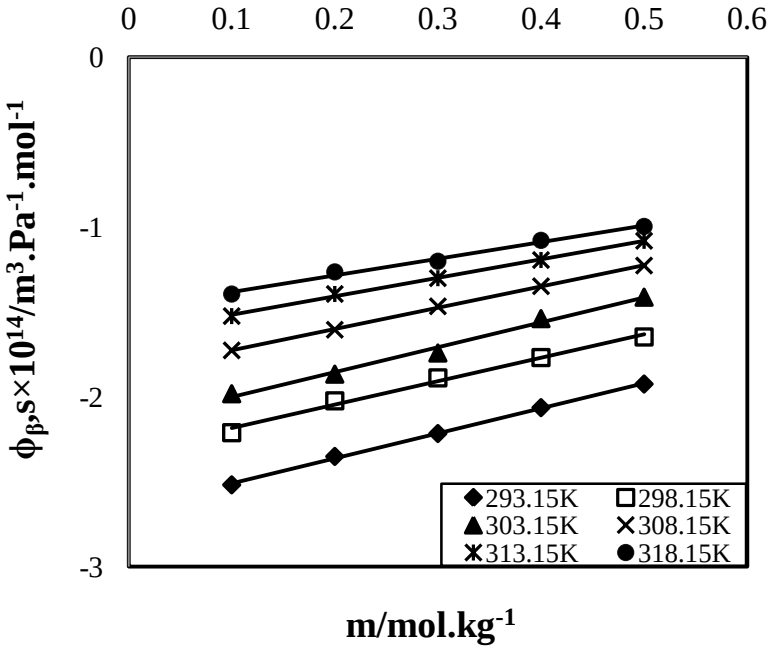



Figure 4.65: Plots of Apparent molar adiabatic compressibility ($\phi_k$) vs. Molality (m) of water + Glucose + 0.045 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

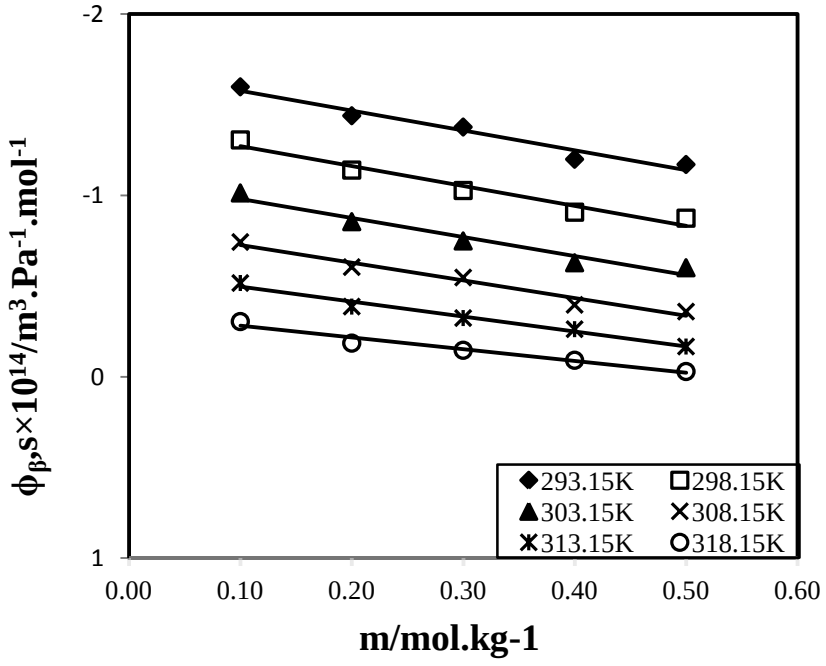



Figure 4.66: Plots of Apparent molar adiabatic compressibility ($\phi_k$) vs. Molality (m) of water + Glucose + 0.06 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

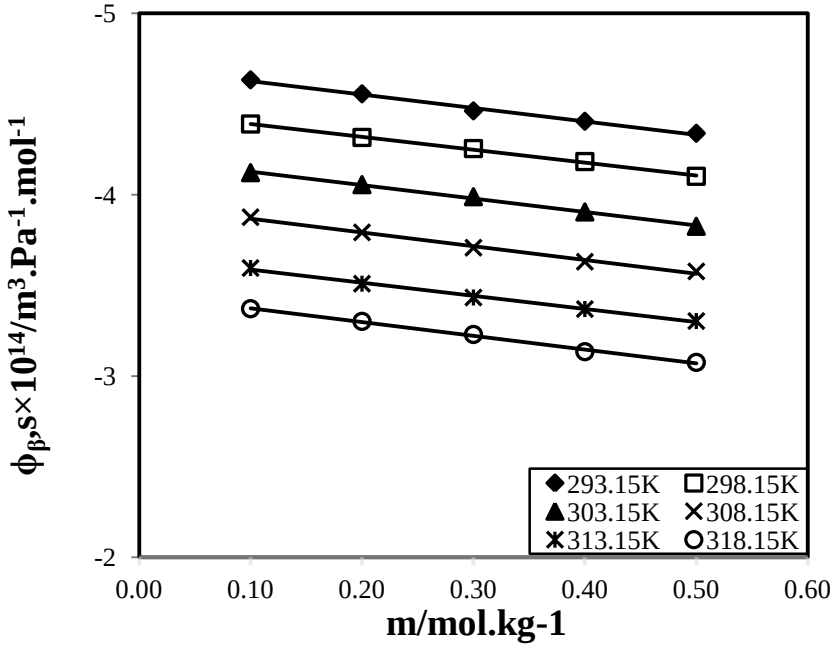



Figure 4.67: Plots of Apparent molar adiabatic compressibility ($\phi_k$) vs. Molality (m) of water + NaCl + 0.03 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

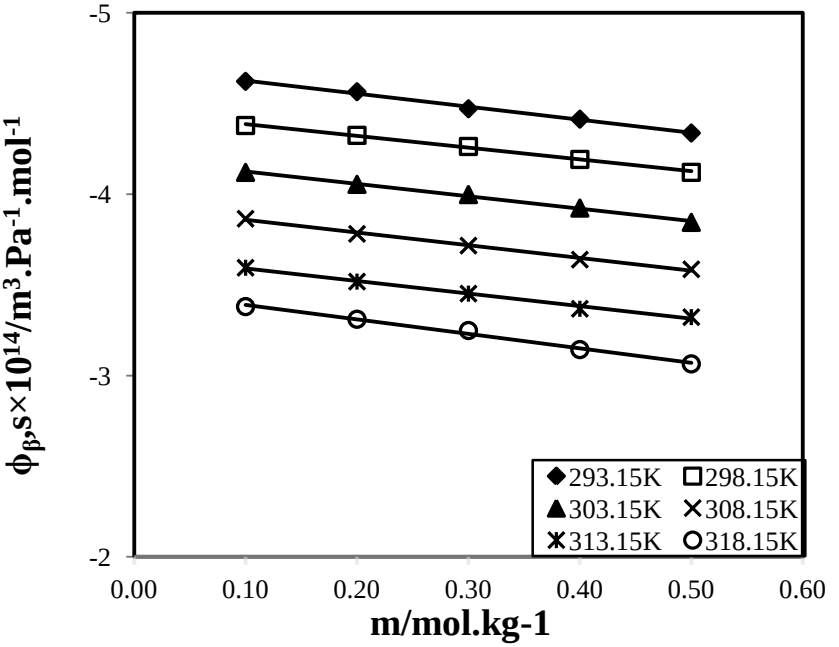



Figure 4.68: Plots of Apparent molar adiabatic compressibility ($\phi_k$) vs. Molality (m) of water + NaCl + 0.045 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

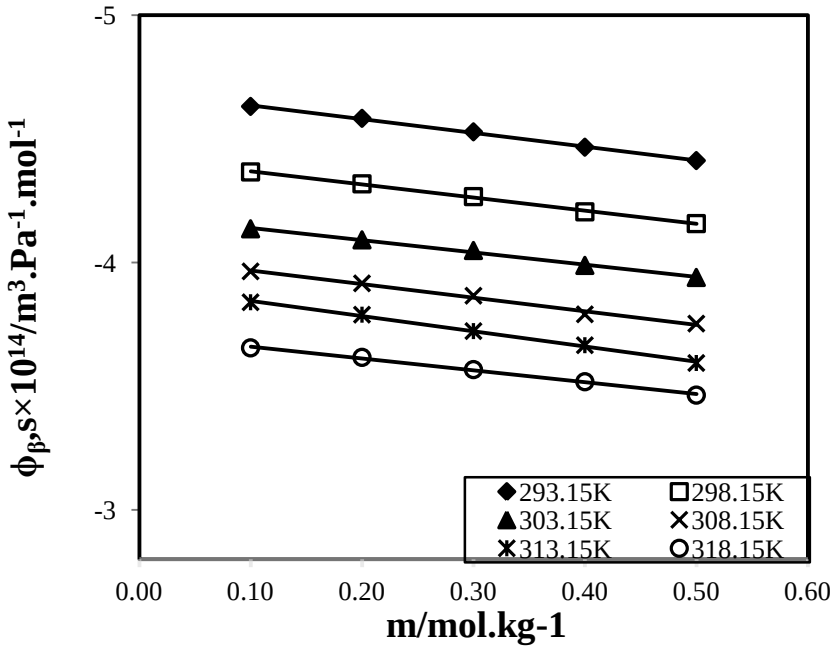



Figure 4.69: Plots of Apparent molar adiabatic compressibility ($\phi_k$) vs. Molality (m) of water + NaCl + 0.06 mol.kg$^{-1}$ ciprofloxacin system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

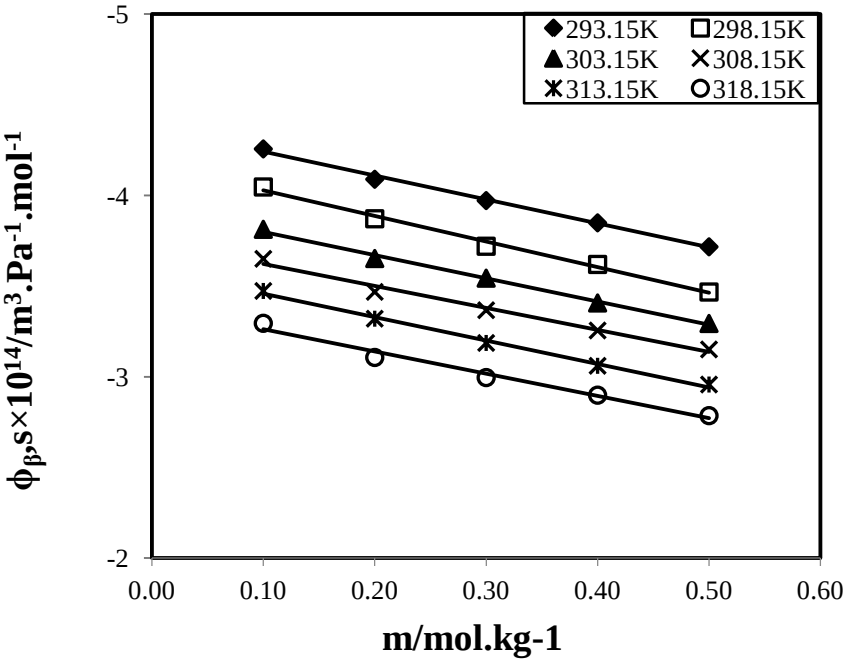



Figure 4.70: Plots of Apparent molar adiabatic compressibility (ϕk) vs. Molality (m) of water + KCl + 0.03 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

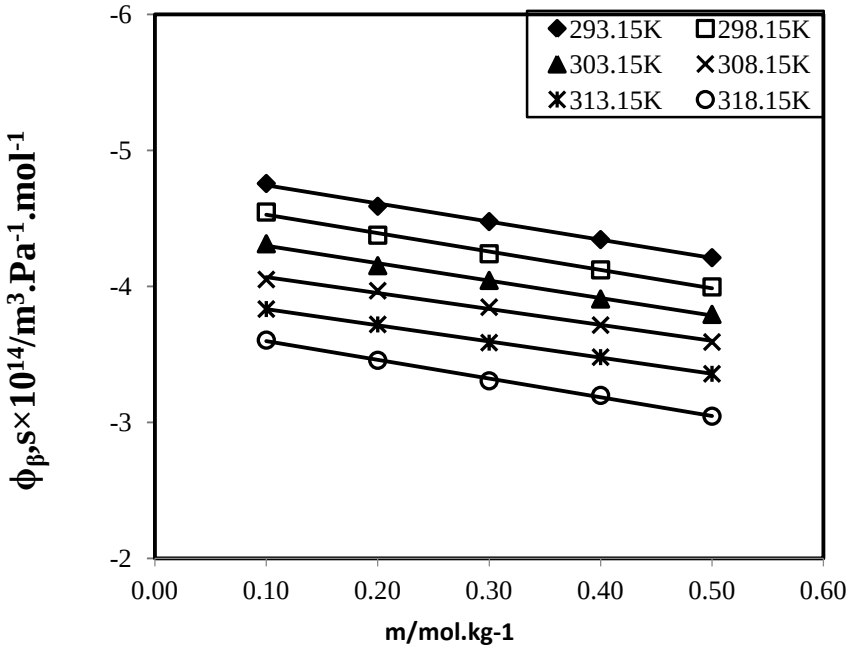



Figure 4.71: Plots of Apparent molar adiabatic compressibility (ϕk) vs. Molality (m) of water + KCl + 0.045 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

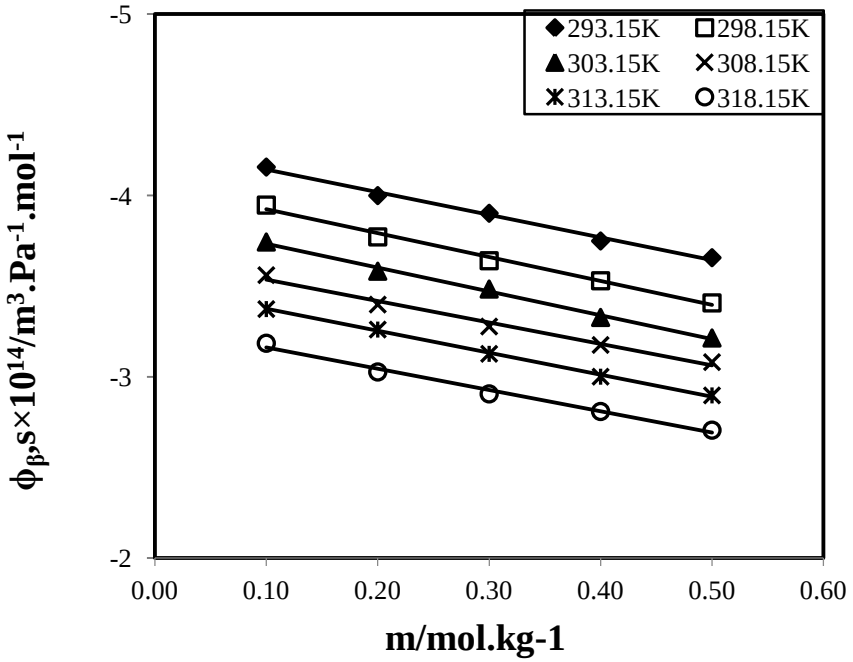



Figure 4.72: Plots of Apparent molar adiabatic compressibility (ϕk) vs. Molality (m) of water + KCl + 0.06 mol.kg-$^{1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

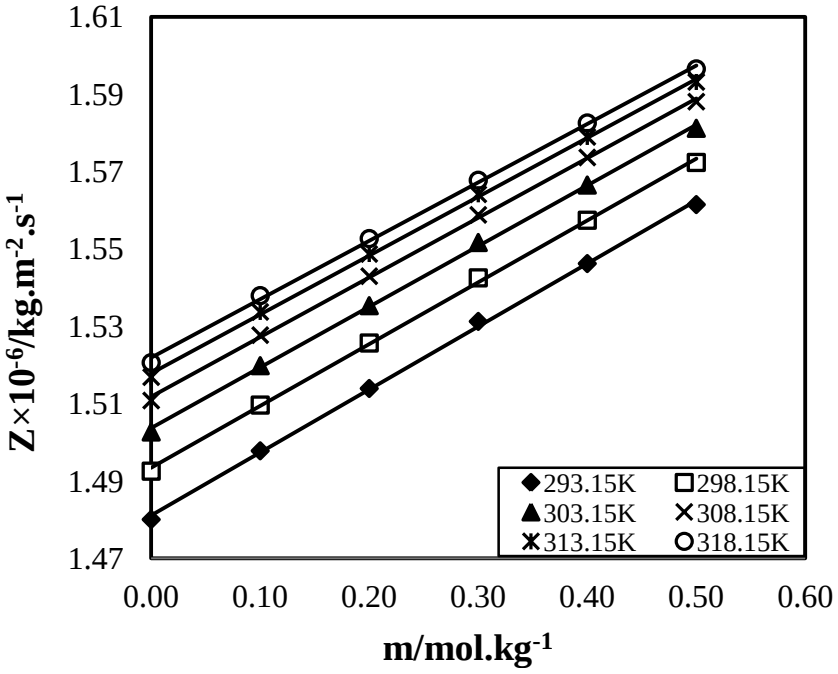



Figure 4.73: Plots of Acoustic impedance (Z) vs. Molality (m) of Glucose + water system at 293.15 K, 298.15 K, 303.15 K , 308.15K, 313.15 K and 318.15 K respectively.

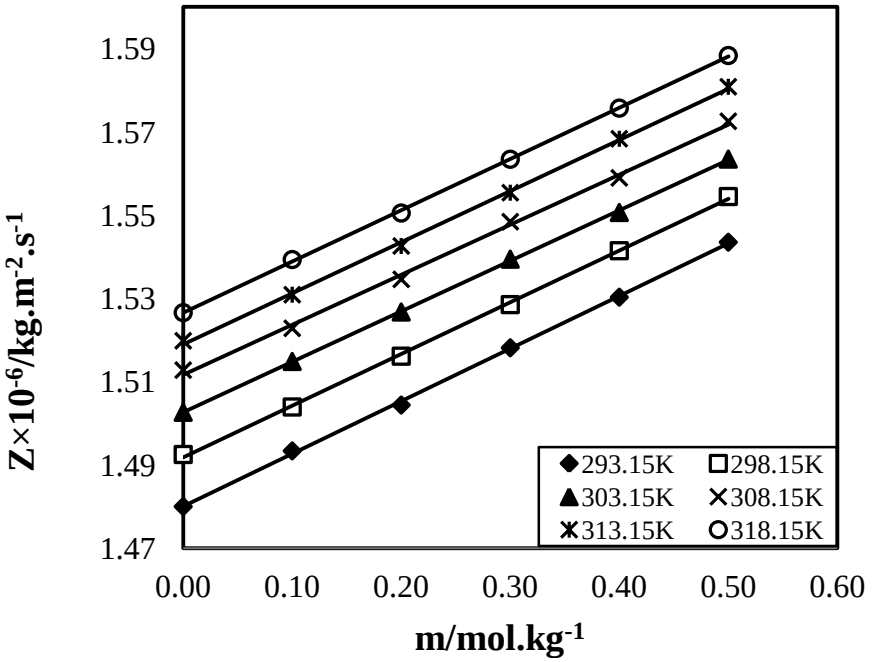



Figure 4.74: Plots of Acoustic impedance (Z) vs. Molality (m) of NaCl + water system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

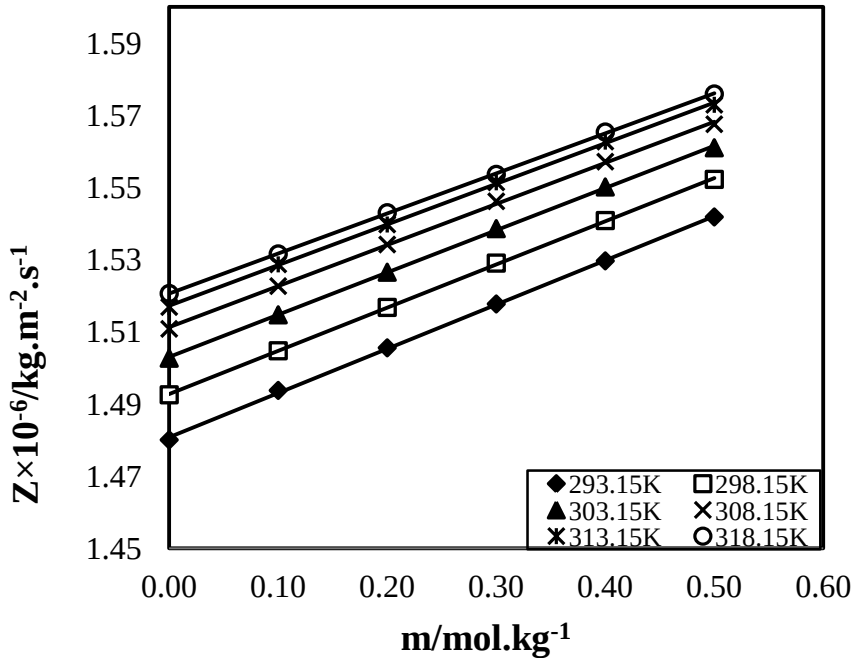



Figure 4.75: Plots of Acoustic impedance (Z) vs. Molality (m) of KCl + water system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

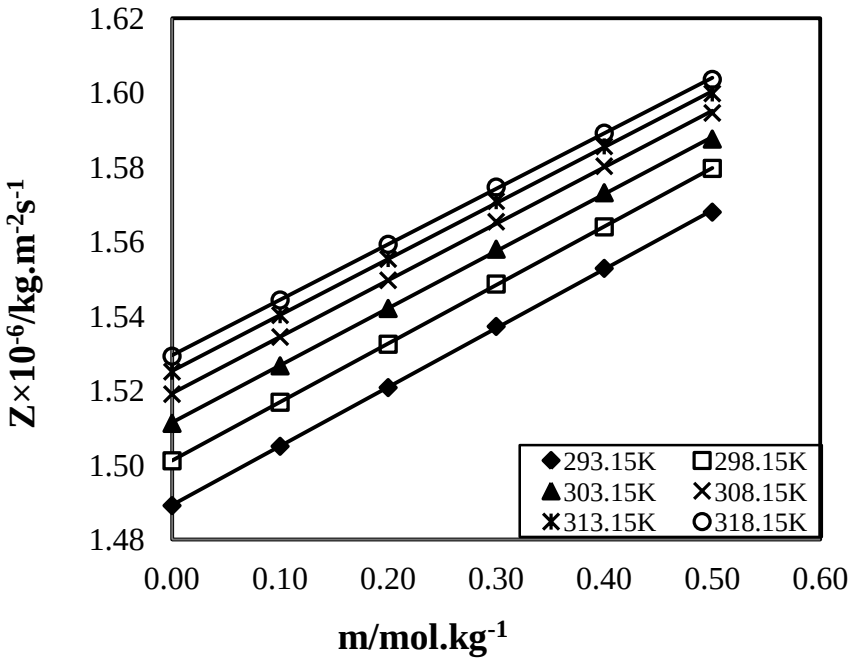



Figure 4.76: Plots of Acoustic impedance (Z) vs. Molality (m) of water + Glucose + 0.03 $mol.kg^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

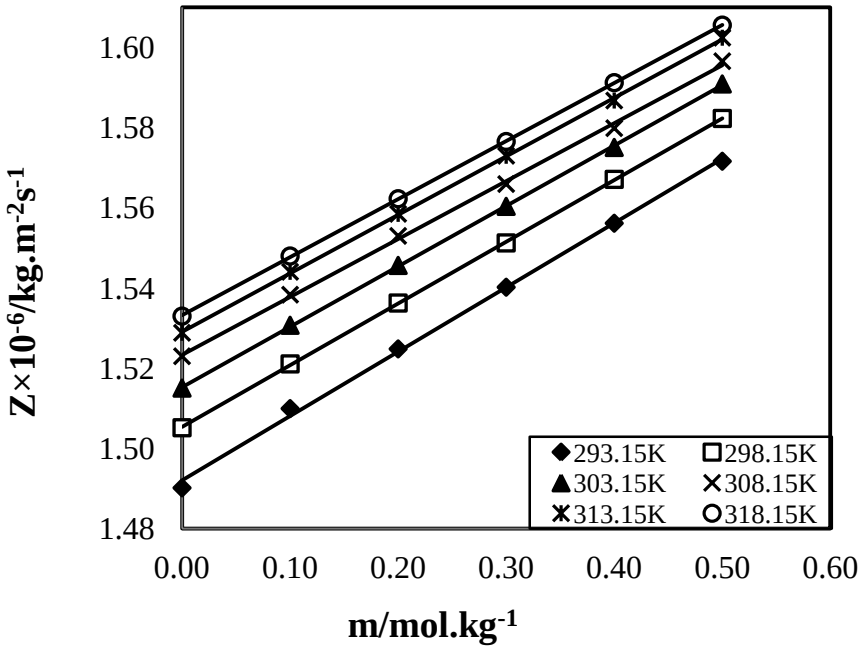



Figure 4.77: Plots of Acoustic impedance (Z) vs. Molality (m) of water + Glucose + 0.045 $mol.kg^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

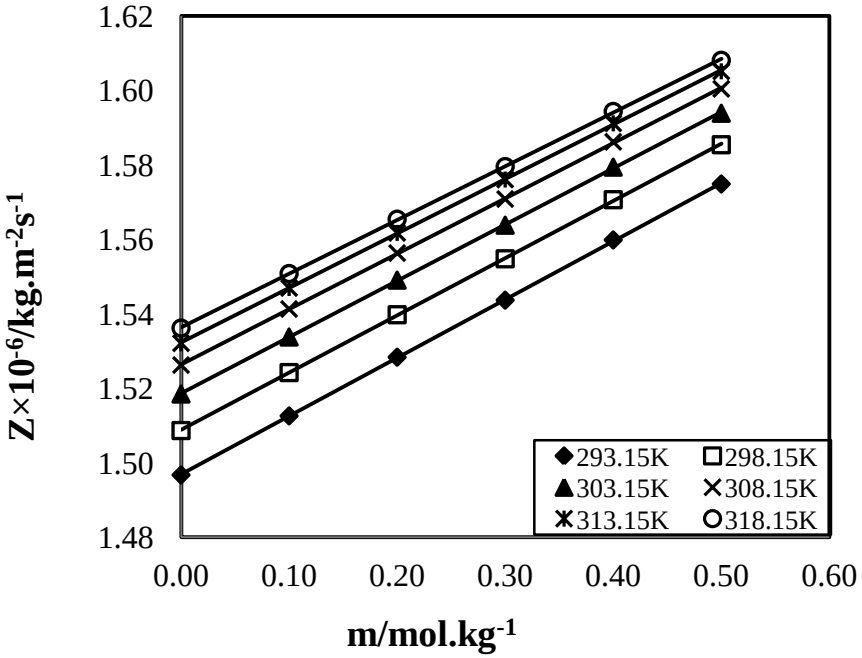



Figure 4.78: Plots of Acoustic impedance (Z) vs. Molality (m) of water + Glucose + 0.06 $mol.kg^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

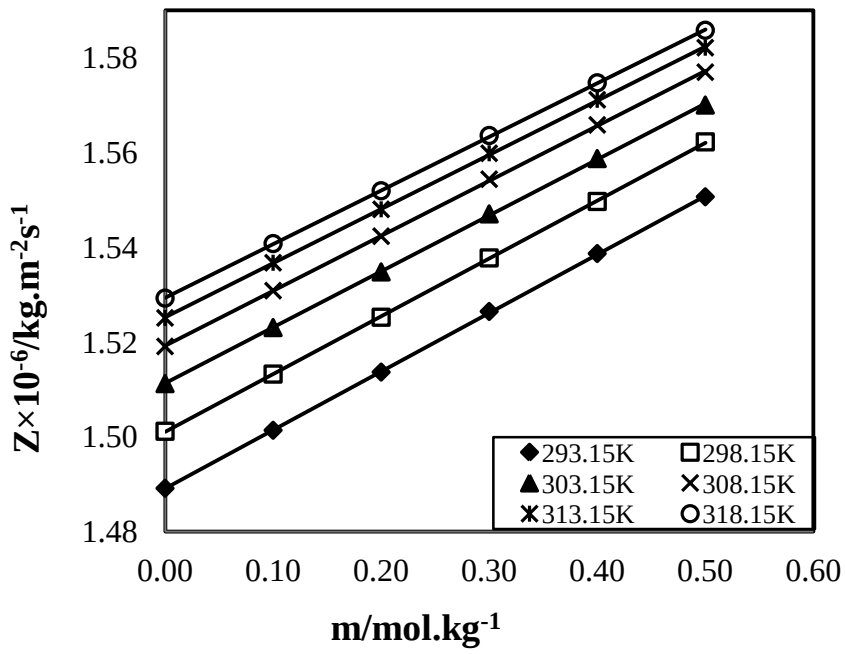



Figure 4.79: Plots of Acoustic impedance (Z) vs. Molality (m) of water + NaCl + 0.03 mol.kg$^{-1}$ ciprofloxacin system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

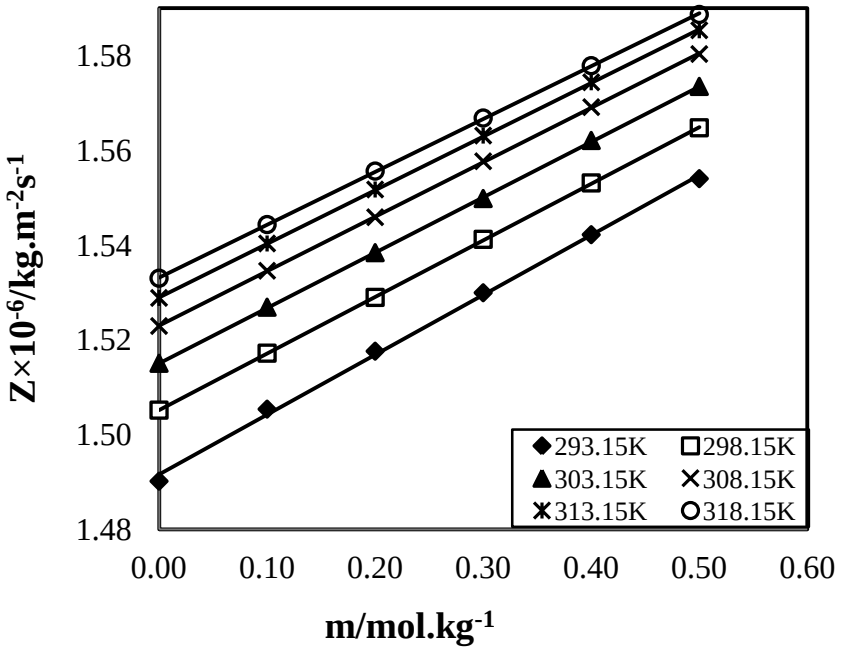



Figure 4.80: Plots of Acoustic impedance (Z) vs. Molality (m) of water + NaCl + 0.045 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

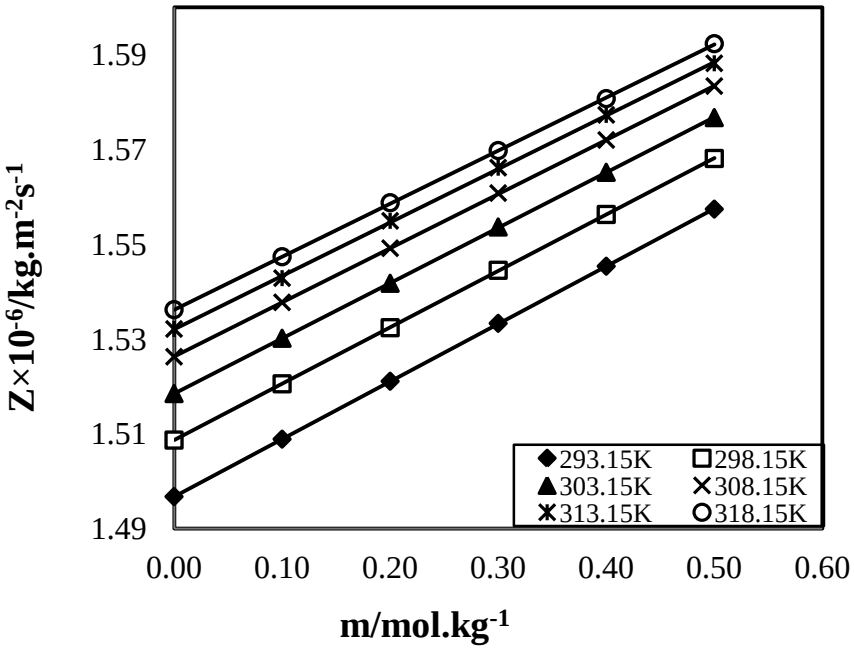



Figure 4.81: Plots of Acoustic impedance (Z) vs. Molality (m) of water + NaCl + 0.06 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

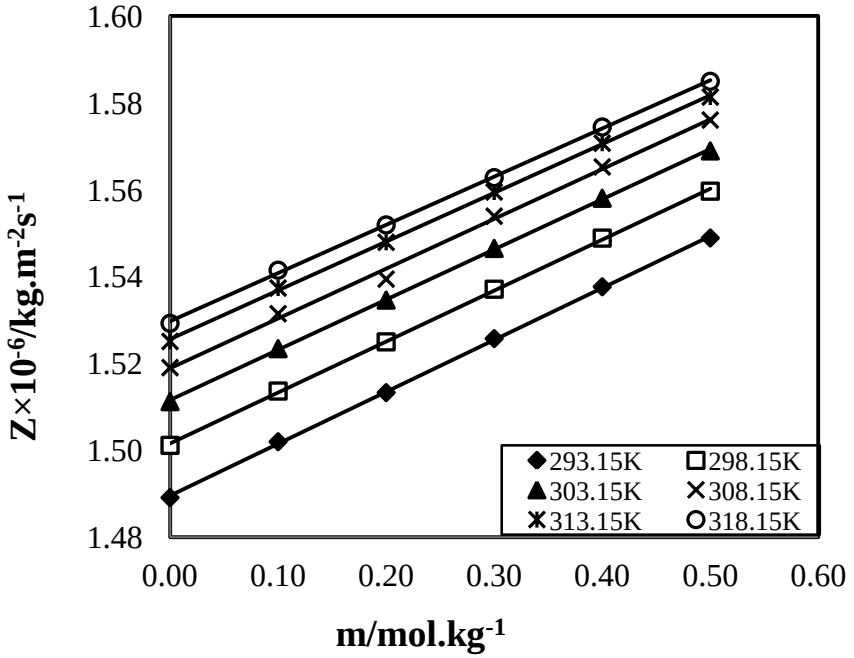



Figure 4.82: Plots of Acoustic impedance (Z) vs. Molality (m) of water + KCl + 0.03 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

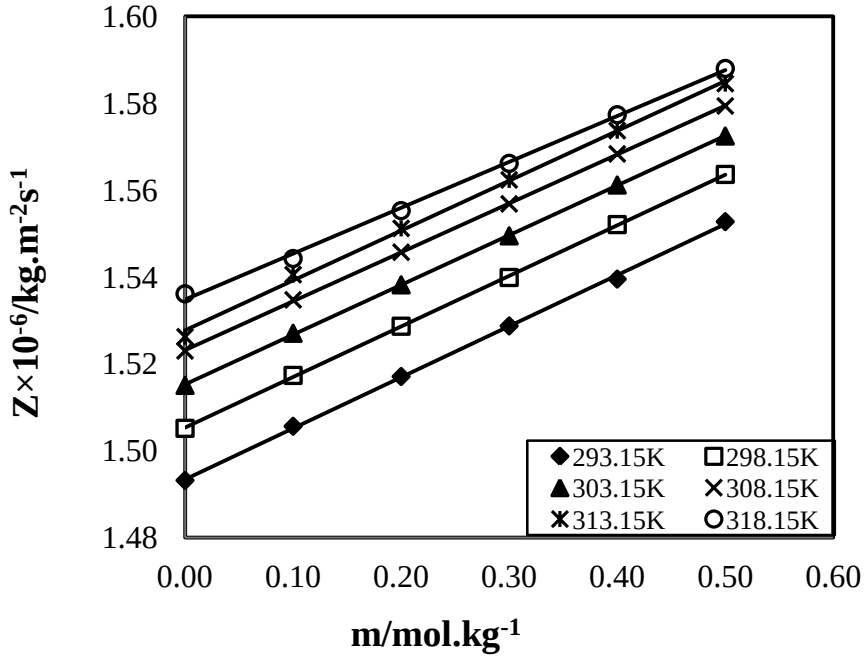



Figure 4.83: Plots of Acoustic impedance (Z) vs. Molality (m) of water + KCl + 0.045 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

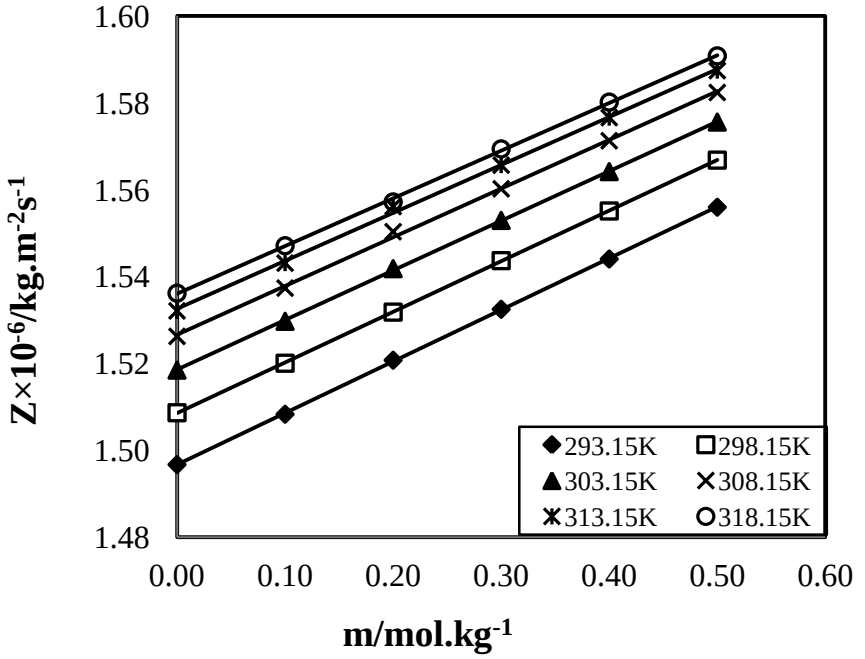



Figure 4.84: Plots of Acoustic impedance (Z) vs. Molality (m) of water + KCl + 0.06 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

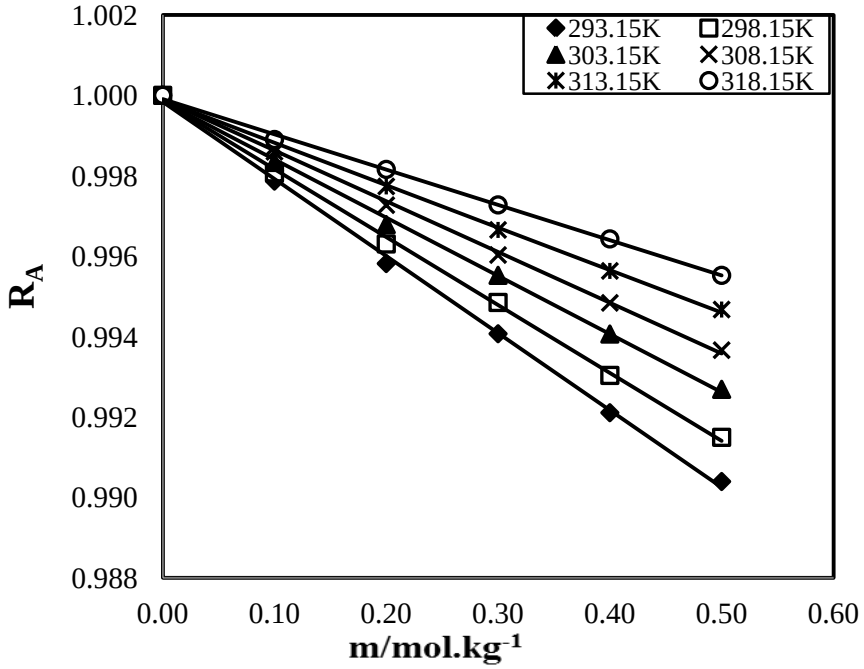



Figure 4.85: Plots of Relative association ($R_A$) vs. Molality (m) of Glucose + water system at 293.15 K, 298.15 K, 303.15K, 308.15 K, 313.15 K and 318.15 K respectively.

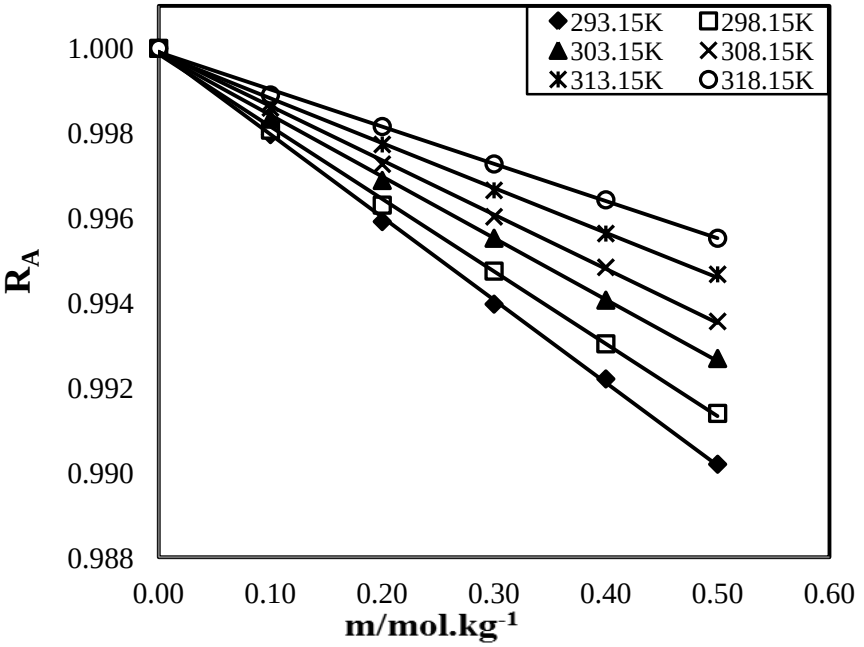



Figure 4.86: Plots of Relative association ($R_A$) vs. Molality (m) of NaCl + water system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

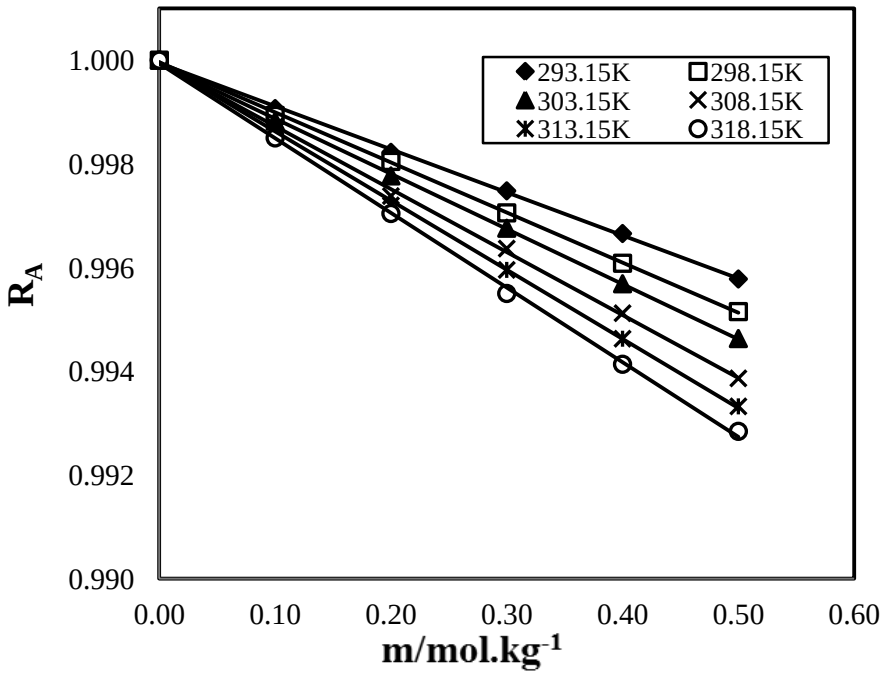



Figure 4.87: Plots of Relative association (RA) vs. Molality (m) of KCl + water system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

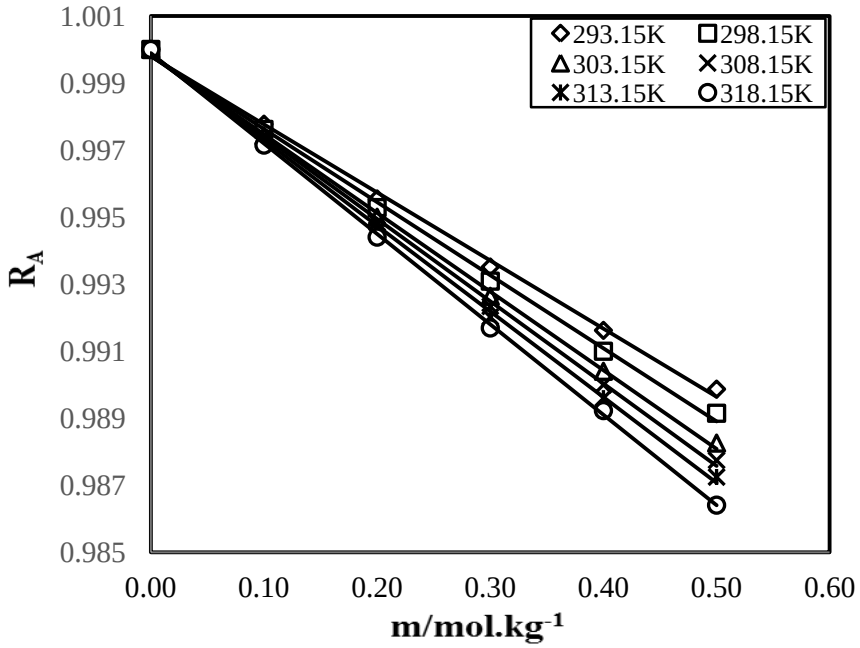



Figure 4.88: Plots of Relative association ($R_A$) vs. Molality (m) of water + Glucose + 0.03 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

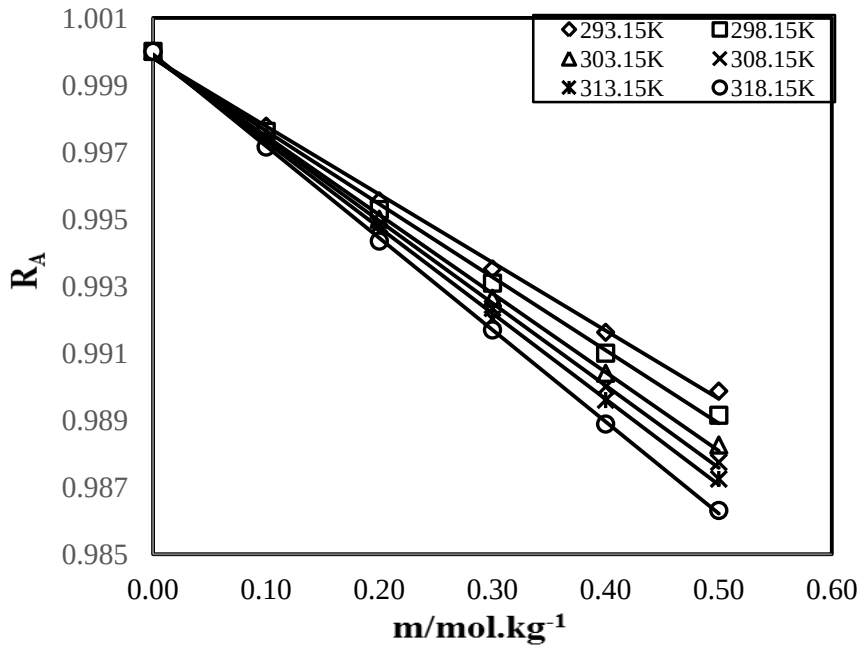



Figure 4.89: Plots of Relative association ($R_A$) vs. Molality (m) of water + Glucose + 0.045 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

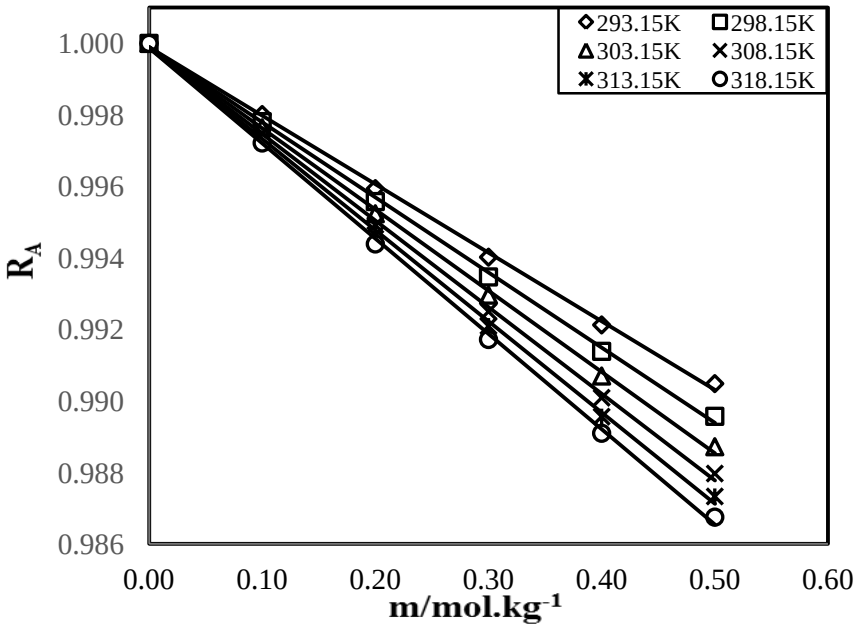



Figure 4.90: Plots of Relative association ($R_A$) vs. Molality (m) of water + Glucose + 0.06 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

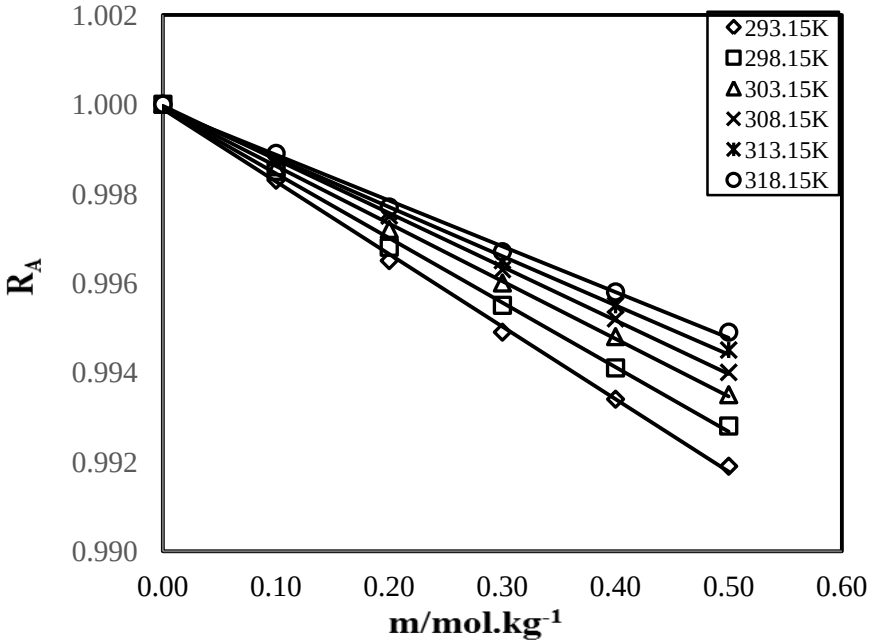



Figure 4.91: Plots of Relative association ($R_A$) vs. Molality (m) of water + NaCl + 0.03 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

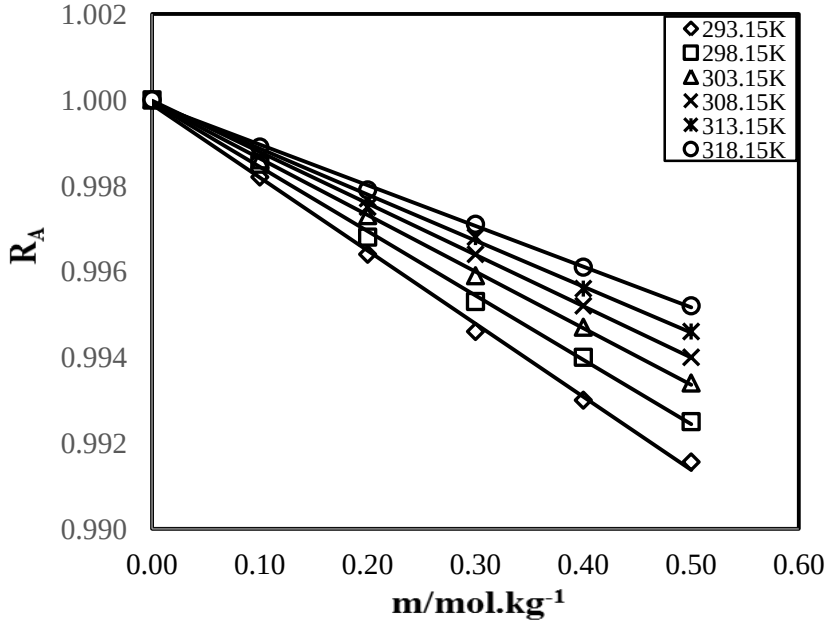



Figure 4.92: Plots of Relative association ($R_A$) vs. Molality (m) of water + NaCl + 0.045 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

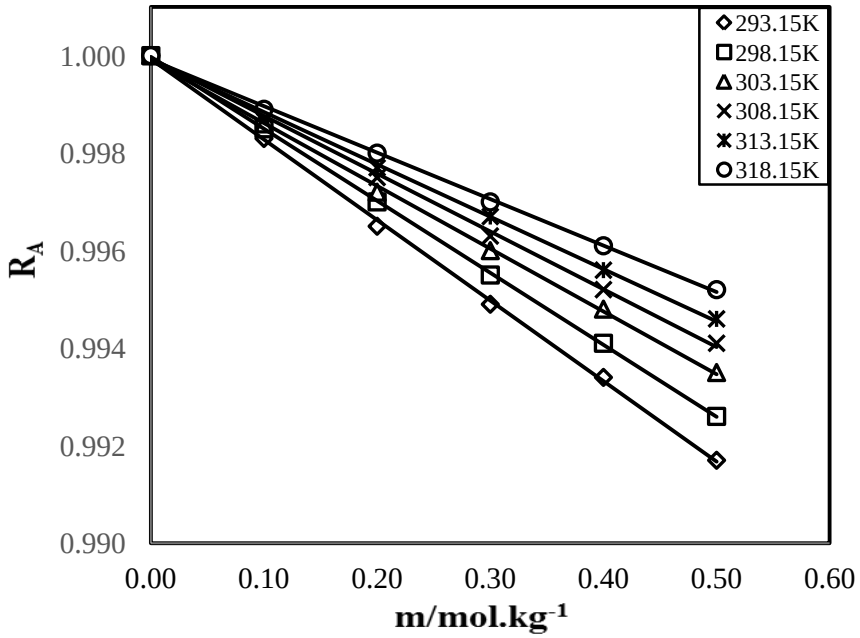



Figure 4.93: Plots of Relative association ($R_A$) vs. Molality (m) of water + NaCl + 0.06 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

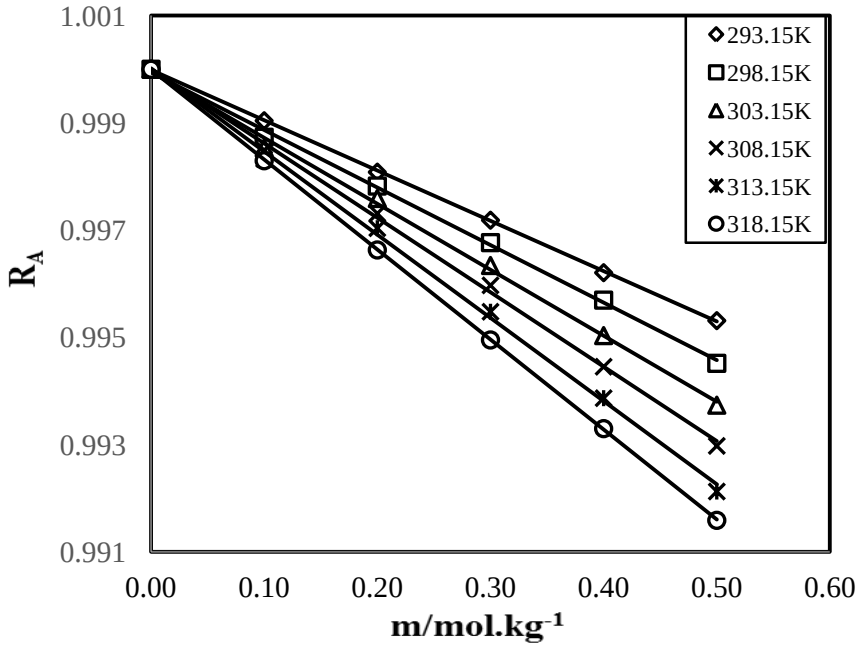



Figure 4.94: Plots of Relative association (RA) vs. Molality (m) of water + KCl + 0.03 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

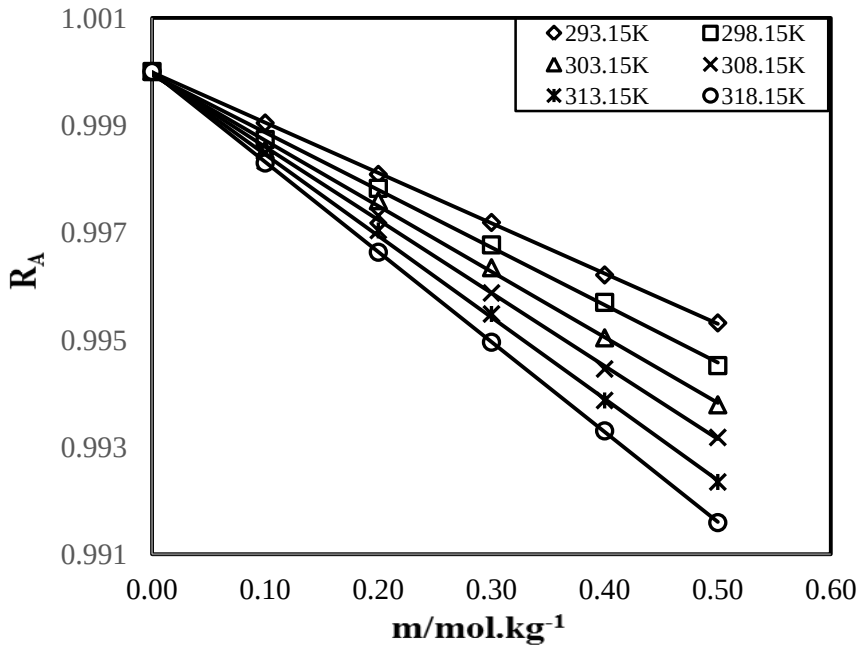



Figure 4.95: Plots of Relative association (RA) vs. Molality (m) of water + KCl + 0.045 mol.kg-1 ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

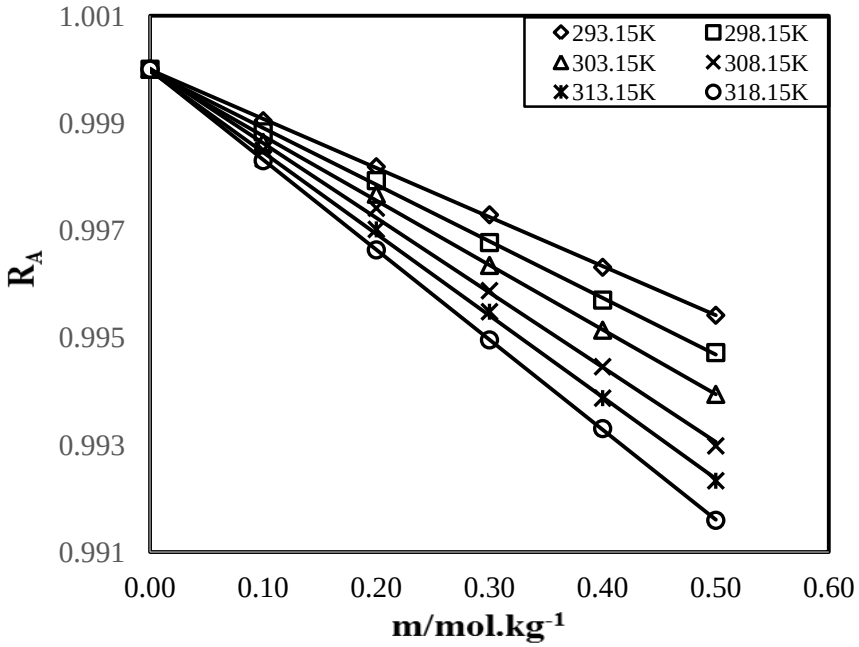



Figure 4.96: Plots of Relative association (RA) vs. Molality (m) of water + KCl + 0.06 mol.kg$^{-1}$ ciprofloxacin systems at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

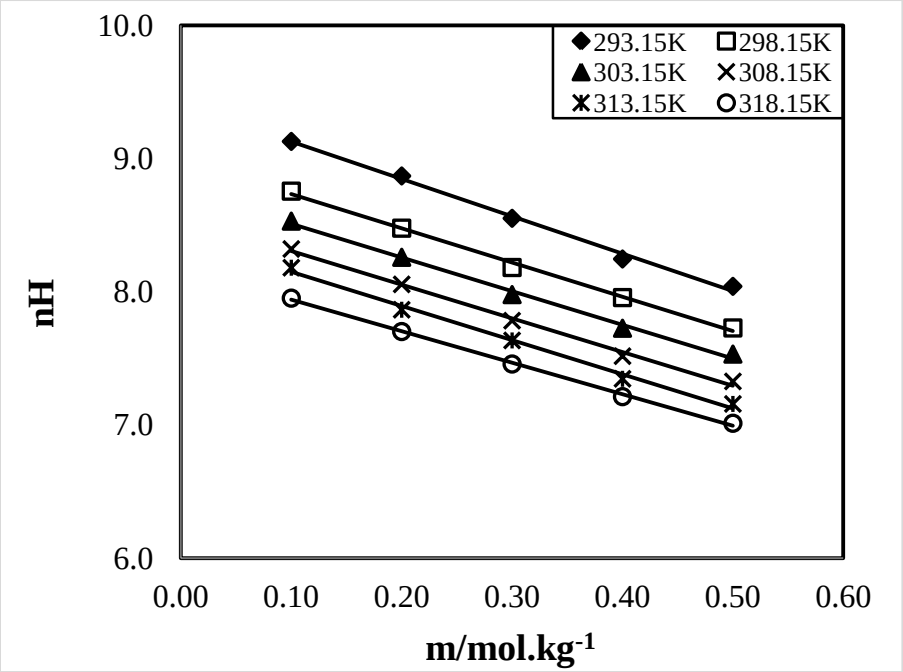



Figure 4.97: Plots of Hydration number ($n_H$) vs. Molality (m) of Glucose + water system at 293.15K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively

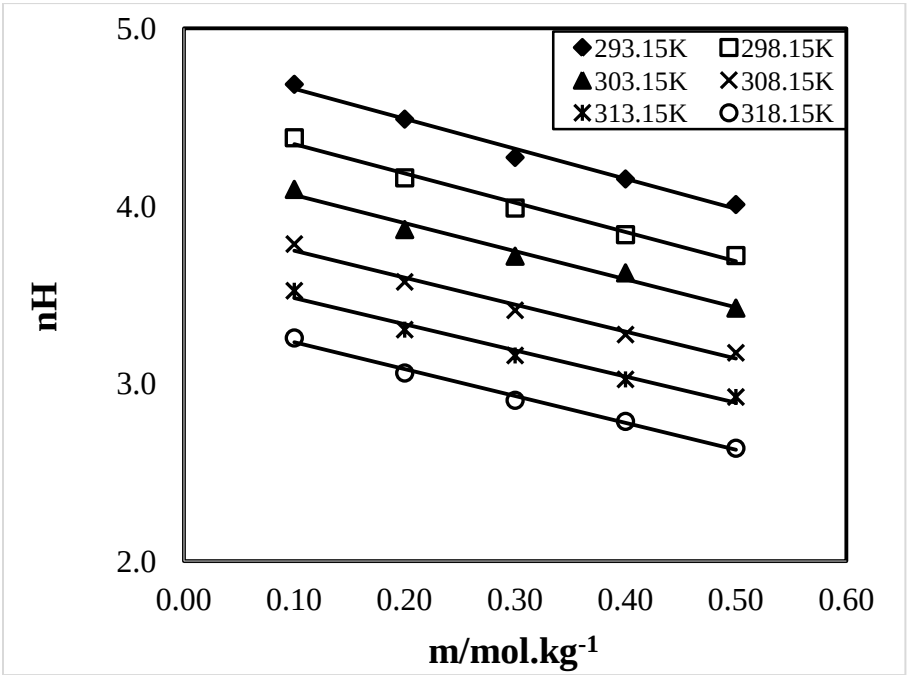



Figure 4.98: Plots of Hydration number ($n_H$) vs. Molality (m) of NaCl + water system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

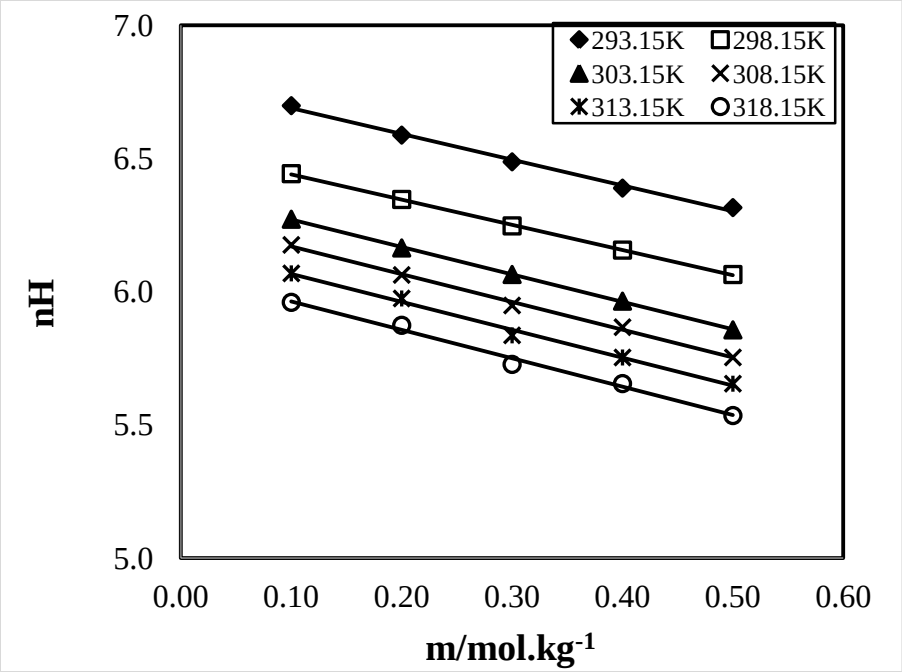



Figure 4.99: Plots of Hydration number (nH) vs. Molality (m) of KCl + water system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

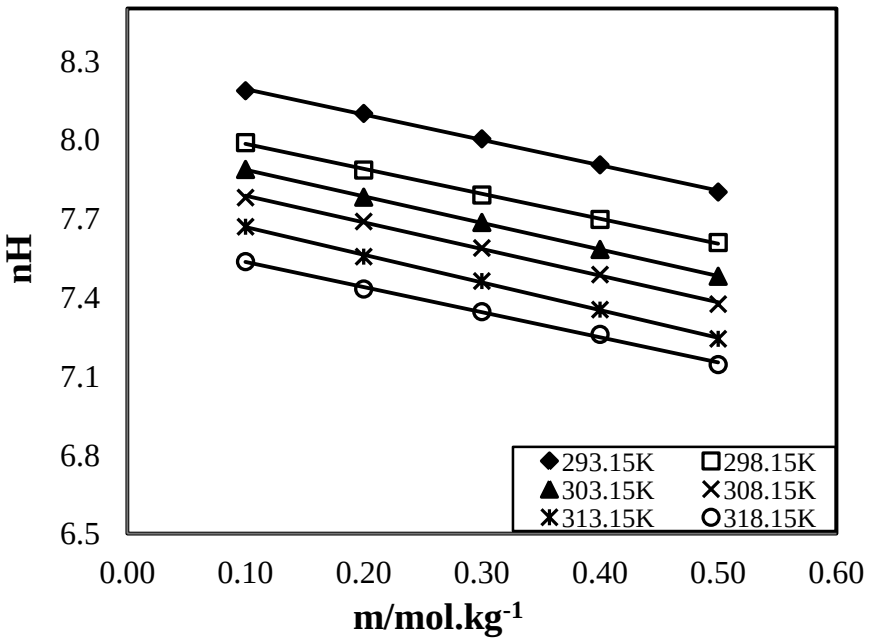



Figure 4.100: Plots of Hydration number ($n_H$) vs. Molality (m) of water + Glucose + 0.03 mol.kg$^{-1}$ ciprofloxacin system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

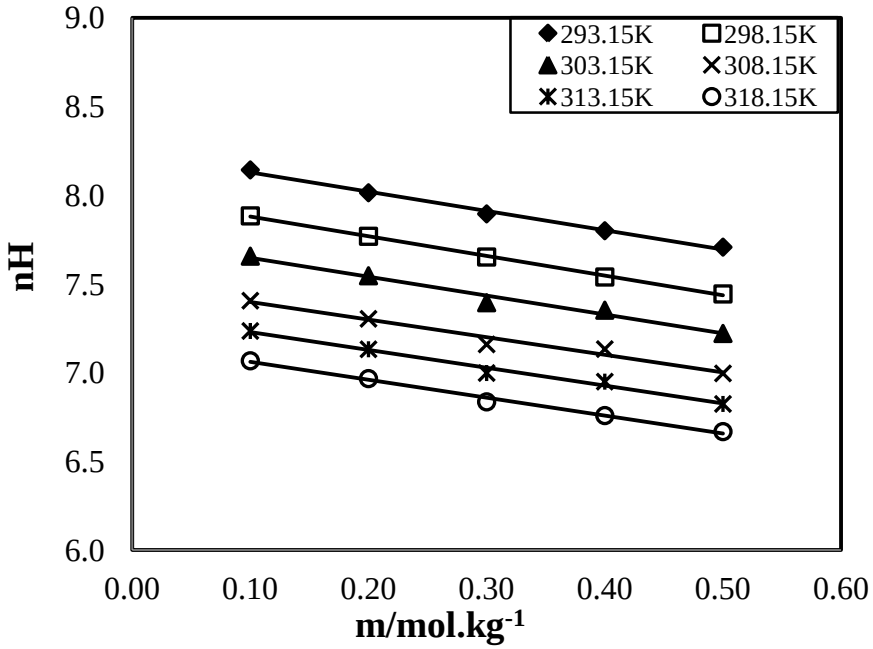



Figure 4.101: Plots of Hydration number (nH) vs. Molality (m) of water + Glucose + 0.045 $mol.kg^{-1}$ ciprofloxacin system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

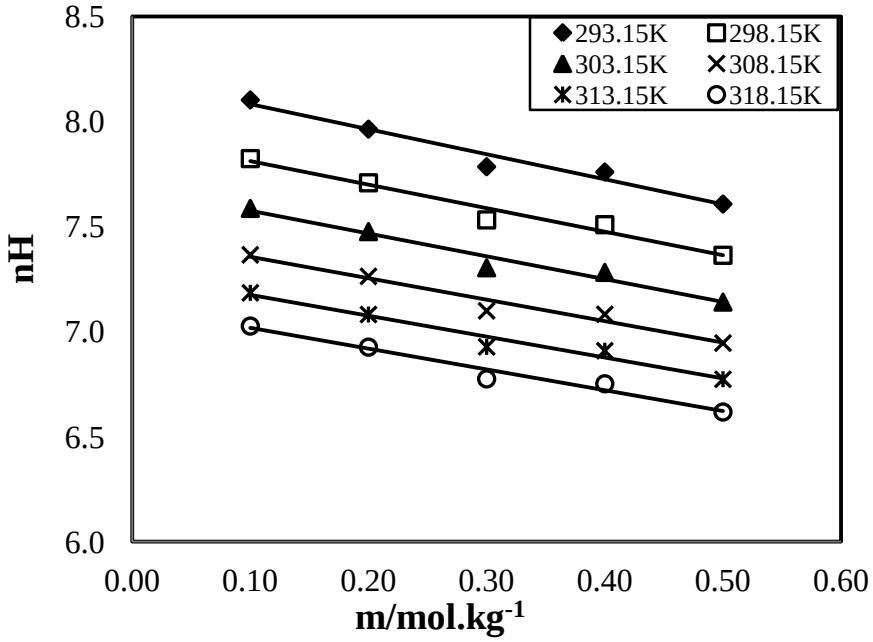



Figure 4.102: Plots of Hydration number ($n_H$) vs. Molality (m) of water + Glucose + 0.06 $mol.kg^{-1}$ ciprofloxacin system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

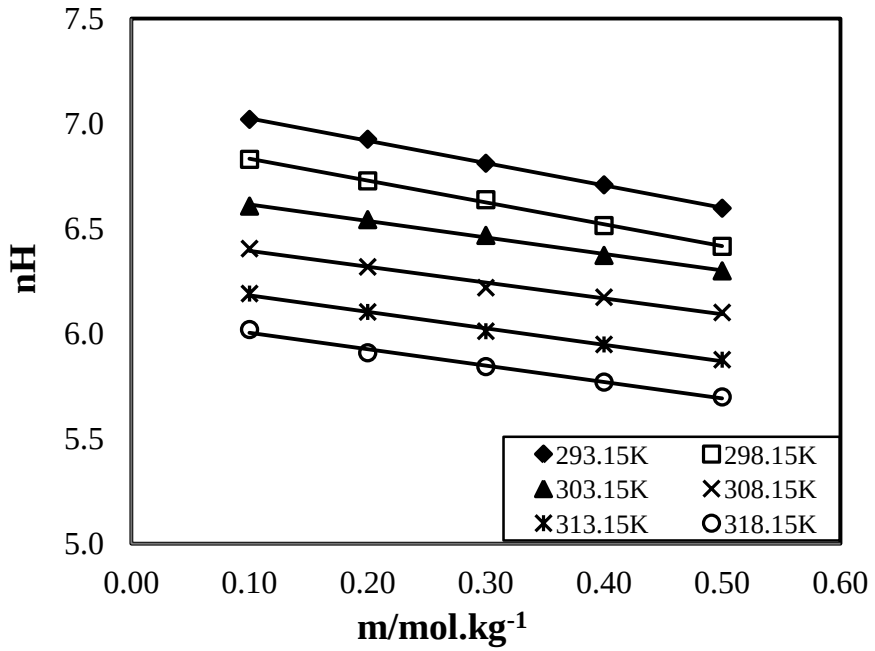



Figure 4.103: Plots of Hydration number ($n_H$) vs. Molality (m) of water + NaCl + 0.03 $mol.kg^{-1}$ ciprofloxacin system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

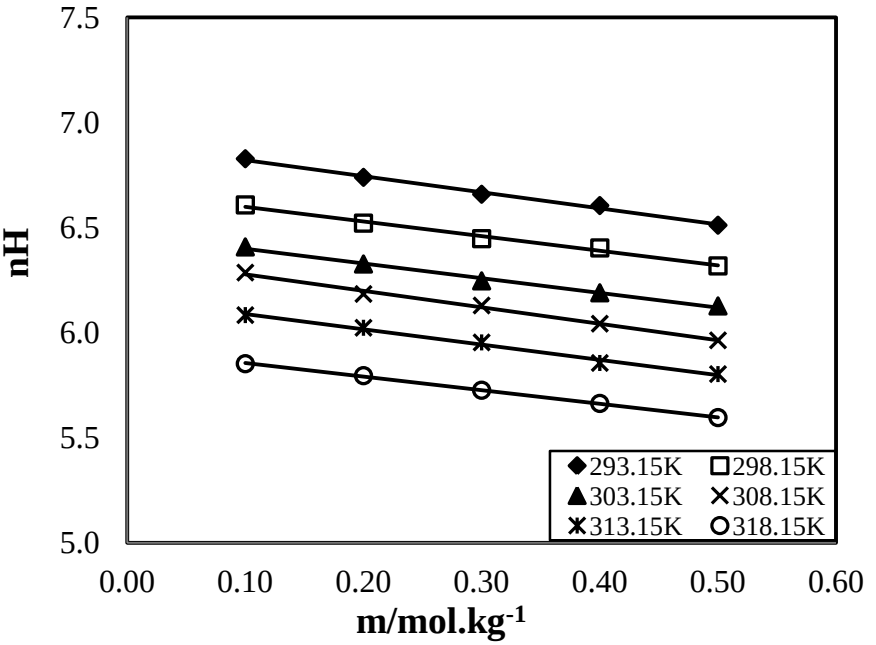



Figure 4.104: Plots of Hydration number ($n_H$) vs. Molality (m) of water + NaCl + 0.045 $mol.kg^{-1}$ ciprofloxacin system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

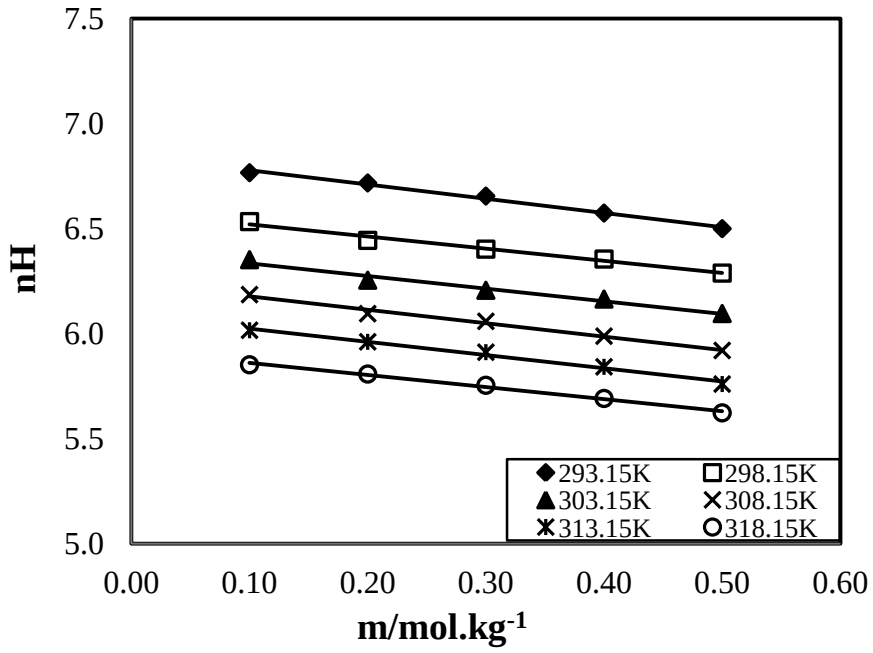



Figure 4.105: Plots of Hydration number ($n_H$) vs. Molality (m) of water + NaCl + 0.06 mol.kg$^{-1}$ ciprofloxacin system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

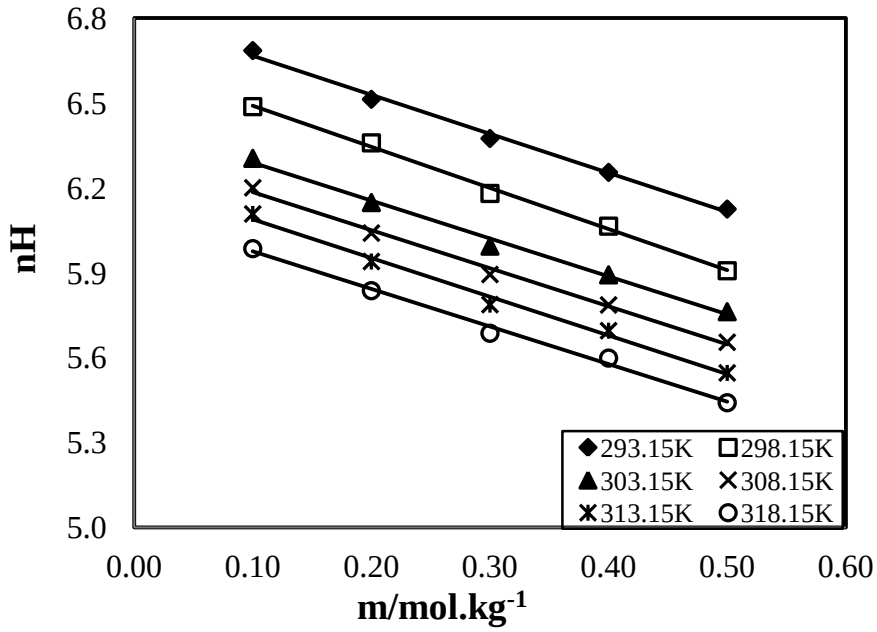



Figure 4.106: Plots of Hydration number (nH) vs. Molality (m) of water + KCl + 0.03 mol.kg$^{-1}$ ciprofloxacin system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

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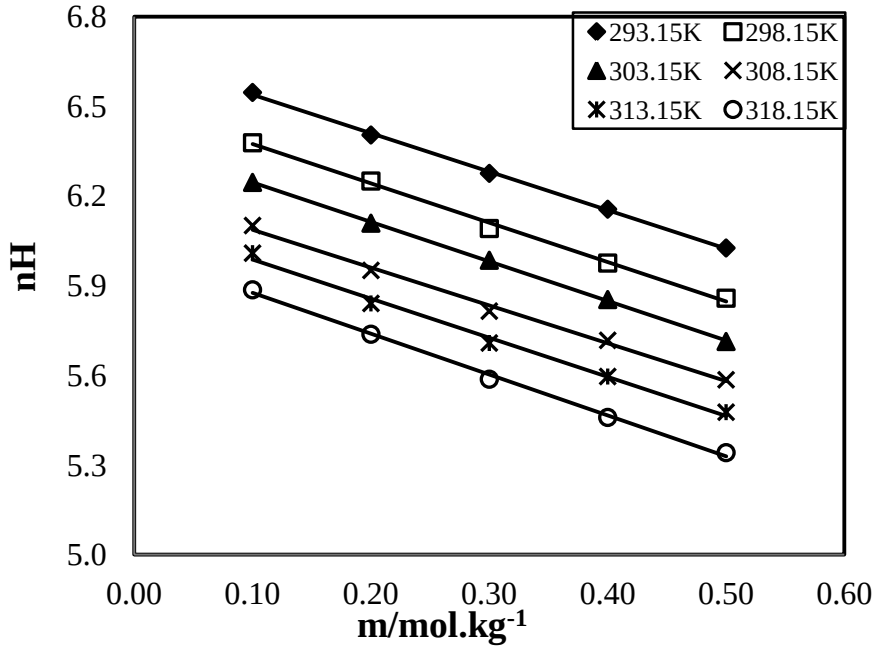


Figure 4.107: Plots of Hydration number (nH) vs. Molality (m) of water + KCl + 0.045 mol.kg$^{-1}$ ciprofloxacin system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

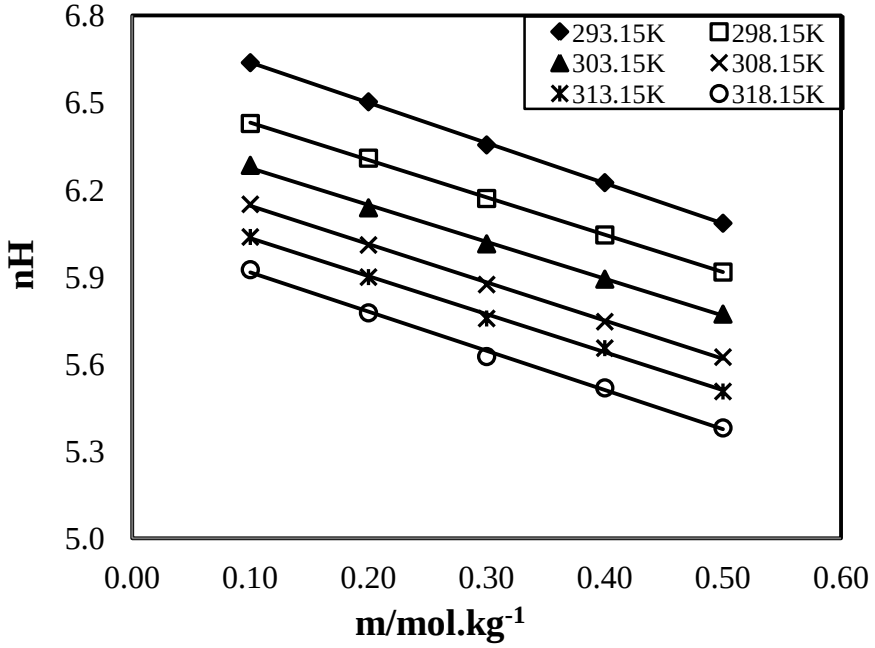


Figure 4.108: Plots of Hydration number (nH) vs. Molality (m) of water + KCl + 0.06 mol.kg$^{-1}$ ciprofloxacin system at 293.15 K, 298.15 K, 303.15 K, 308.15 K, 313.15 K and 318.15 K respectively.

# CHAPTER V

## Conclusion

Densities (ρ) and sound velocities (u) of glucose, NaCl and KCl in aqueous and in aqueous ciprofloxacin (0.03, 0.045 and 0.06) mol.kg$^{-1}$ solutions have been studied at 293.15 K to 318.15 K with an interval of 5 K temperature. The densities increase with the increasing concentration of glucose, NaCl and KCl and decrease with increasing temperature. The sound velocity values increase with increasing concentration of glucose, NaCl, KCl and ciprofloxacin.

Volumetric and acoustic properties such as apparent molar volume ($\varphi_v$), limiting apparent molar volume ($\varphi_v^0$), limiting apparent molar volume transfer ($\Delta_{tr}\varphi_v^0$), apparent molar expansibilities ($E_\varphi^0$) and Hepler constant $(\delta^2\varphi_v^0/\delta T^2)_p$, adiabatic compressibility ($\beta_s$), apparent molar adiabatic compressibility ($\varphi_k$), limiting apparent molar adiabatic compressibility ($\varphi_k^0$), apparent molar adiabatic compressibility of transfer ($\Delta_{tr}\varphi_k^0$), acoustic impedance (Z), relative association ($R_A$) and hydration number ($n_H$) have been calculated.

Apparent molar properties, limiting apparent molar properties and compressibility studies indicate the presence of strong solute-solvent interactions in the binary and ternary systems. The solute-solvent interactions increase in glucose, NaCl and KCl. The Hepler constant $(\delta^2\varphi_v^0/\delta T^2)_p$ shows the structure making property of glucose, NaCl and KCl in aqueous ciprofloxacin solution. From the above experimental results we can conclude:

- The mode of interaction of glucose, NaCl and KCl are different in all systems.
- Strong solute-solvent interactions are present in all systems.
- The compressibility of ternary solution is less than binary solution.

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