STUDIES ON VOLUMETRIC AND ULTRASONIC PROPERTIES OF L-LYSINE, L-ORNITHINE AND GLYCINE IN AQUEOUS FRUCTOSE SOLUTION AT DIFFERENT TEMPERATURES

by

Md. Tariquzzaman

A thesis submitted in partial fulfillment of the requirements for the degree of
Master of Science (M.Sc) in Chemistry

Khulna University of Engineering & Technology
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ABSTRACT

In this study, the interaction of amino acids (glycine, L-ornithine and L-lysine) in water and aqueous fructose solution has been determined by using volumetric and sound velocity method. Interactions of glycine, L-ornithine and L-lysine in aqueous fructose solution play an important role to understand biochemical process in living cells. Densities and sound velocities of glycine, L-ornithine and L-lysine in water and in aqueous 0.05 mol.kg^{-1}, 0.20 mol.kg^{-1}, 0.35 mol.kg^{-1} and 0.50 mol.kg^{-1} fructose solutions have been studied at 293.15K to 318.15K with an interval of 5K. The density data have been used to calculate apparent molar volume (φ_v), limiting apparent molar volume (φ_v^0), limiting apparent molar volume transfer ($\Delta_{tr}\varphi_v^0$), apparent molar expansibilities $(\delta\varphi_v^0/\delta T)_p$ and Hepler's constant $(\delta^2\varphi_v^0/\delta T^2)_p$. The acoustic properties such as adiabatic compressibility (β_s), apparent molar adiabatic compressibility (φ_k), limiting apparent molar adiabatic compressibility (φ_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 by densities and sound velocities data.

The densities increase with the increase of concentration of amino acids (glycine, L-ornithine and L-lysine). Densities of glycine, L-ornithine and L-lysine in aqueous fructose solutions are higher than that of glycine, L-ornithine and L-lysine in aqueous solution. The smaller values of experimental slope (S_v) as compared to limiting apparent molar volume (φ_v^0) values suggest the dominance of solute-solvent interaction over the solute-solute interaction. The true volume (φ_v^0) of amino acids are found to be order of L-lysine > L-ornithine > glycine.

The limiting apparent molar volume transfer ($\Delta_{tr}\varphi_v^0$) values of glycine, L-ornithine and L-lysine are positive which suggest the dominance of ion-hydrophilic and hydrophilic-hydrophilic interactions over the hydrophobic-hydrophobic and ion-hydrophobic interaction. The values of limiting apparent molar expansion $(\delta\varphi_v^0/\delta T)_p$ are positive. Hepler's constant $(\delta^2\varphi_v^0/\delta T^2)_p$ values are small negative for all studied amino acids in binary and ternary system suggest the studied systems act as structure maker. The values of partial molar volumes ($\bar{V}_2$) increase with increasing of concentration of glycine,

L-ornithine and L-lysine for the studied systems. This trend of $\bar{V}_2$ indicates solute-solvent interactions increase with increasing concentration of amino acids.

The sound velocity increases with the increase of concentration of L-lysine, L-ornithine and glycine. This may be attributed to the increase of compactness of the medium with the increase in amino acids concentration. Sound velocities of L-lysine, L-ornithine and glycine in aqueous fructose solutions are higher than that of L-lysine, L-ornithine and glycine in aqueous solution. The adiabatic compressibility (β_s) decreases with the increase of concentration of L-lysine, L-ornithine and glycine. This indicates the water molecules around the amino acids are less compressible than the water molecules in the bulk solution. The negative apparent molar adiabatic compressibility (φ_k) values indicate the greater loss of structural compressibility of water. The values of limiting apparent molar adiabatic compressibility (φ_k^0) are negative. The values of apparent molar adiabatic compressibility transfer ($\Delta_{tr}\varphi_k^0$) are positive which suggest the existence of strong solute-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 dominating of solute-solvent interactions over solute-solute interaction. The acoustic impedance, Z increases with the increase of concentration of amino acids. The relative association, R_A decreases linearly with increasing the concentration of solute. The positive hydration number (n_H) values indicate an appreciable solvation of solutes.

Therefore, the water molecules around amino acids are less compressible than water molecules in the bulk solution. The compressibility of ternary solution is lower than binary solution. This result suggests that the proteins or peptides generated from the studied amino acids will be denatured in ternary fructose solution.

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Nomenclature

φ_v	The apparent molar volume
ρ_0	Density of solvent
ρ	Density of solution
u_0	Sound velocity of solvent
u	Sound velocity of solution
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
β_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

The study of volumetric properties of electrolytes and non-electrolytes solution in aqueous medium provide information about solute-solvent and solute-solute interactions that help us to understand several biochemical processes and biological fluids containing different ionic species. Also, it can provide useful information regarding conformational stability and interaction in the ternary system [1]. Ultrasonic investigation in aqueous solutions of electrolytes and non-electrolytes provides useful information in understanding the degree and nature of interaction because intra molecular and intermolecular association related to structural changes affects the ultrasonic velocity [2]. Recently, there has been a growing interest in the measurement of the physico-chemical properties like density and ultrasonic velocity that provide insight into the molecular interactions taking place in studied systems. 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. [3]. The solute-solvent interactions have large effects on the structure and the properties of biologically important compounds like proteins, carbohydrates etc. Carbohydrates are very important for some physiological process. They are not only basic material but also plays significant role in the configuration of biological molecules. There has been number of physicochemical studies of amino acids in aqueous carbohydrates solutions [4-6]. Amino acids have zwitter-ion and are the constituents of the most important class of biopolymers, i.e. proteins. The studies on carbohydrate-protein interactions are very important for the field of immunology, biosynthesis, pharmacology, and medicine [7]. The interaction of important biomolecules such as amino acids with aqueous fructose solutions plays an important role in the understanding of biomolecule action. Such studies can provide better and valuable information towards understanding the behavior of these biomolecules in aqueous media. In this study systems, we made an attempt to interpret the interactions (ion-ion, solute-solvent, and solute-solute), the effect of fructose on these interactions and investigate the structure-making/breaking properties of the amino acids [8].

1.2 Properties of solutions

A solution is a homogeneous type of mixture of two or more substances. A solution has two parts: a solute and a solvent. The solute is the substance that dissolves and the solvent is the majority of the solution. The mixing process of a solution happens at a scale where the effects of chemical polarity are involved, resulting in interactions that are specific to solvation. The solution assumes the phase of the solvent when the solvent is the larger fraction of the mixture, as is commonly the case. The concentration of a solute in a solution is the mass of that solute expressed as a percentage of the mass of the whole solution.

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 [10]. 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. The physical 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 [11]. This puzzling behavior results from the combined effects of preferential solvation of the solute by one of the components in the mixture and of solvent-solvent interactions. Preferential solvation occurs when the polar solute has in its microenvironment more of one solvent than the other, in comparison with the bulk composition [12].

The physical properties of compounds such as melting point and boiling point change when other compounds are added. Together they are called colligative properties. There are several ways to quantify the amount of one compound dissolved in the other compounds collectively called concentration. Examples include molarity, volume fraction, and mole fraction. 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 physico-chemical 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 physico-chemical analysis, which is a useful tool in getting sound information about the structure of some aqueous fructose with amino acids in studying the solute-solvent and solvent-solvent interactions.

1.3 Physical and chemical properties of constituents in solution

Any physical or chemical property depends on the constitution or structure of the molecules. The typical physical properties of solution are absorption or emission of radiations, refractivity, light scattering, electrical polarization, magnetic susceptibility, optical rotations etc. In illustrating 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.

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 [9].

(i) **Purely additive properties**: When a property of substance is equal to the sum of corresponding properties of the constituent atoms it is called an additive property. Molecular mass of a compound is given by the sum of the atomic masses of the constituent atoms. An additive property is one, which for a given system is the sum of the corresponding properties of the constituents. There are other molecular properties like molar volume, radioactivity etc. are large additive in nature.

(ii) **Purely constitutive properties**: Any physical or chemical property that depends on the constitution or structure of the molecule. 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. Surface tension and viscosity and optical activity are examples of constitutive property

(iii) **Constitutive and additive properties**: An additive property which also depends on the intermolecular structure is called additive and constitutive property. 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 and atomic volume are the example of constitutive and additive properties.

(iv) **Colligative properties**: Colligative properties of solutions are properties that depend upon the concentration of solute molecules or ions, but not upon the identity of the solute. Colligative properties include vapor pressure lowering, boiling point elevation, freezing point depression, and osmotic pressure.

1.4 Amino acids

Amino acids are organic compounds containing amine (-NH_2) and carboxyl (-COOH) functional groups, along with a side chain (R group) specific to each amino acid. About 500 naturally occurring amino acids, only 20 of them (α-amino acid) serve as building blocks of protein, of which 19 are α-amino acids and one is a cyclic α-amino acid (proline). Contrary to plants and some microorganisms, animals and humans are only capable of synthesizing 10 of the 20 naturally occurring amino acids. The rest must be included in the diet; these amino acids are classified as essential. Because of variations in their side chains, amino acids have remarkably different biochemical properties and functions [13]. From a chemical viewpoint an amino acid is a base as well as an acid, i.e. it consists both of an amino group and a carboxylic group. The amino acid is therefore an ampholyte since it can react both as a base and as an acid. The most common amino acids are the α-amino acids which are amino acids where the amino group is located at the α-carbon atom of the carboxylic group as shown in Figure 1.1.

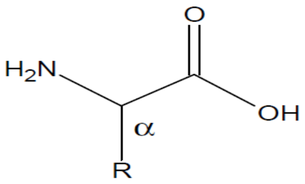


Figure 1.1. Basic structure of α-amino acids.

In the structure shown, R represents a side chain specific to each amino acid. The carbon atom next to the carboxyl group (which is therefore numbered 2 in the carbon chain starting from that functional group) is called the α-carbon. Amino acids containing an amino group bonded directly to the alpha carbon are referred to as alpha amino acids.

Amino acids are the structural units (monomers) that make up proteins. They join together to form short polymer chains called peptides or longer chains called either polypeptides or proteins. These polymers are linear and branched, with each amino acid within the chain attached to two neighboring amino acids. The process of making proteins encoded by DNA/RNA genetic material is called translation and involves the step-by-step addition of amino acids to a growing protein chain by a ribozyme that is called a ribosome [14].

Amino acids have a higher solubility in polar solvents (e.g. water, ammonia) than in less polar solvents (e.g. ethanol, methanol, and acetone). They are crystalline solids with relatively high melting points. In aqueous solutions, the amino acids are generally stable, at physiological pH, and they exist as neutral dipolar ions, i.e., due to physiological conditions, the two terminals of amino acids are both charged; positive charge (amino group) and negative charge (carboxyl group) therefore the molecules have the properties of zwitterion [15]. The 20 amino acids encoded directly by the genetic code can be divided into several groups based on their properties. Important factors are charge, hydrophobicity or hydrophobicity, size, and functional groups. These properties are important for protein structure and protein-protein interactions. The water-soluble proteins tend to have their hydrophobic residues buried in the middle of the protein, whereas hydrophilic side chains are exposed to the aqueous solvent.

1.5 Properties of glycine

Glycine is a non-essential amino acid having no functional group in side chain whose isoelectric point is 6.0. Glycine is the smallest of the 20 amino acids commonly found in proteins. The chemical formula of glycine is NH_2-CH_2-COOH. The molecular weight of glycine is 75.07 g.mol^{-1}and density is 1.607 g.cm^{-3}. Glycine is colorless, sweet-tasting crystalline solid. It is unique among the proteinogenic amino acids in that it is achiral. It can fit into hydrophilic or hydrophobic environments since it exists as zwitterion at natural pH, due to its minimal side chain of only one hydrogen atom. The principal function of glycine is as a precursor to proteins also a building block to numerous natural products. It acts as inhibitory neurotransmitter in the central nervous system and as a biosynthetic intermediate [16]. Glycine is not essential to the human diet, as it is biosynthesized in the body from the amino acid serine, which is in turn derived from 3-phosphoglycerate, but the metabolic capacity for glycine biosynthesis does not satisfy the need for collagen synthesis [17].

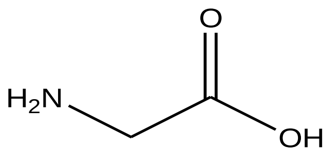


Figure 1.4: Structure of glycine

1.6 Properties of ornithine

Ornithine is a non proteinogenic amino acid that plays a role in the urea cycle. The molecular weight of ornithine is 132.16 g.mol^{-1}and density is 1.2±0.1 g.cm^{-3}. Ornithine is abnormally accumulated in the body in ornithine transcarbamylase deficiency. L-Ornithine is one of the products of the action of the enzyme arginase on L arginine, creating urea.

Therefore, ornithine is a central part of the urea cycle, which allows for the disposal of excess nitrogen. Ornithine is recycled and, in a manner, is a catalyst. First, ammonia is converted into carbonyl phosphate ($H_2NC(O)OPO_{2-3}$). Ornithine is converted into a urea derivative at the δ (terminal) nitrogen by carbamoyl phosphate syntheses. Nitrogen is added from aspartate; producing the denitrogenated fumarate and the resulting arginine (a guanidinium compound) is hydrolyzed back to ornithine producing urea. The nitrogen of urea comes from the ammonia and aspartate, and the nitrogen in ornithine remains intact [18].

Ornithine is not an amino acid coded for by DNA, that is, not protein genic. However, in mammalian non-hepatic tissues, the main use of the urea cycle is in arginine biosynthesis, so, as an intermediate in metabolic processes, ornithine is quite important [19]. L-Ornithine supplementation attenuated fatigue in subjects in a placebo-controlled study using a cycle ergometer. The results suggested that L-ornithine has an antifatigue effect in increasing the efficiency of energy consumption and promoting the excretion of ammonia [20]. L-Ornithine L-aspartate (LOLA), a stable salt of ornithine and aspartic acid, has been used in the treatment of cirrhosis.

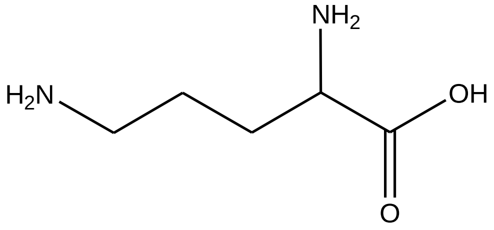


Figure 1.4: Structure of ornithine

1.7 Properties of lysine

Lysine is an α-amino acid that is used in the biosynthesis of proteins. The molecular weight of lysine is 146.19 $g.mol^{-1}$and density is 1.1±0.1 $g.cm^{-3}$. It contains an α-amino group (which is in the protonated $-NH_3^+$ form under biological conditions), an α-carboxylic acid group (which is in the deprotonated $-COO^-$ form under biological conditions) and a side chain $(CH_2)_4NH_2$ classifying it as a charged (at physiological pH) aliphatic amino acid. It is essential in humans, meaning the body cannot synthesize it and thus it must be obtained from the diet. The amino group often participates in hydrogen bonding and as a general base in catalysis. The α-amino group ($-NH_3^+$) is attached to the fifth carbon from the α-carbon, which is attached to the carboxyl group. The side chain of lysine has three methylene groups, so that even though the terminal amino group will be charged under physiological conditions, the side chain does have significant hydrophobic character. Lysine is often found buried with only the amino group exposed to solvent [21]. It is the building blocks of protein. Lysine is important for proper growth, and it plays an essential role in the production of carnitine, a nutrient responsible for converting fatty acids into energy and helping lower cholesterol. Lysine appears to help the body absorb calcium and it plays an important role in the formation of collagen, a substance important for bones and connective tissues including skin, tendons, and cartilage [22].

Deficiency of Lysine may lead to anemia, blood shoot eyes, enzyme problems, hair loss, inability to concentrate, irritability, lack of energy, poor appetite, reproductive problems, retarded growth and weight loss. Lysine has been studied for the prevention and treatment of herpes infections and cold sores. It also increases the intestinal absorption of calcium and eliminates its excretion by the kidney suggesting that it might be helpful in osteoporosis. Lysine has been investigated for its effects on increasing muscle mass, lowering glucose and improving anxiety. Case reports suggest lysine may ameliorate angina. Lysine acetylsalicylate has been used to treat pain and to detoxify the body after heroin use. Lysine clonixinate has been used to treat migraine headaches and other painful conditions [23].

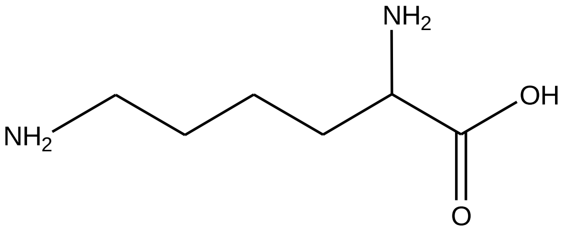


Figure 1.3: Structure of Lysine

1.8 Properties of fructose

Fructose, or fruit sugar, is a simple ketonic monosaccharide found in many plants, where it is often bonded to glucose to form the disaccharide sucrose. The molecular weight of fructose is 180.16 g.mol^{-1}and density is 1.69 g.cm^{3}. Fructose is a 6-carbon polyhydroxyketone [24]. This form is formally called D-fructopyranose. D-fructose is a ketohexose commonly called as fruit sugar, much sweeter than sucrose and more reactive than glucose. Human seminal fluid is rich in fructose and sperms utilize fructose for energy [25]. Pure dry fructose is a very sweet, white, odorless and crystalline solid and is the most water-soluble of all the sugars [26].

Fructose has higher solubility than other sugars as well as other sugar alcohols. Fructose is, therefore, difficult to crystallize from an aqueous solution. Fructose is used commercially in foods and beverages, besides its low cost are its high relative sweetness. It is the sweetest of all naturally occurring carbohydrates. In general, fructose is regarded as being 1.73 times as sweet as sucrose. Fructose is an excellent humectant and retains moisture for a long period of time even at low relative humidity (RH). Therefore, fructose can contribute a more palatable texture, and longer shelf life to the food products in which it is used [27].

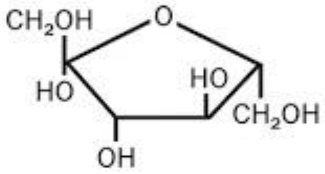


Figure 1.4: Structure of fructose

1.9 Properties of water

Water (H_2O) is a polar inorganic compound that is at room temperature a tasteless and odorless liquid, which is nearly colorless apart from a hint of blue. It is by far the most studied chemical compound and is described as the "universal solvent" for its ability to dissolve many substances. 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.

1.10 Structure of water

An important feature of water is its polar nature. The structure has a bent molecular geometry for the two hydrogens from the oxygen vertex. The oxygen atom also has two lone pairs of electrons. One effect usually ascribed to the lone pairs is that the H–O–H gas phase bend angle is 104.48°, which is smaller than the typical tetrahedral angle of 109.47°. The lone pairs are closer to the oxygen atom than the electrons sigma bonded to the hydrogens, so they require more space. The increased repulsion of the lone pairs forces the O–H bonds closer to each other. It has been recognized that water is an 'anomalous' liquid many of its properties is differ essentially from normal liquids of simple structures. The deviations from regularity indicate some kind of association of water molecules. The notable unique physical properties exhibited by liquid water are [28] : 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 [34]. Various structural models that have been developed to describe the properties of water may generally be grouped into two categories, namely the continumm model and the mixture models. The continumm models [29, 30] 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 [31] 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 [32], later developed by Nemethy and Scherage [29] are 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 tetrahedraly 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.

$$(H_2O)_b \rightleftarrows (H_2O)_d$$

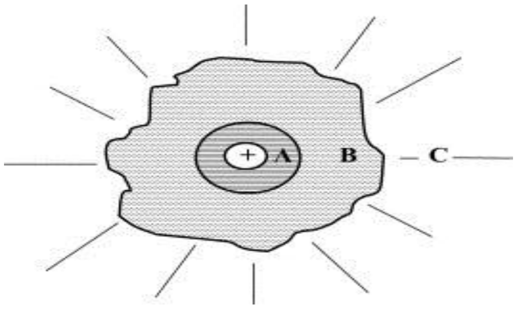


Fig 1.5: Frank and Wen model for the structure modification produce by an ion

A simple model for the structure modifications produced by a small ion: (A) region of immobilization of water molecules (B) region of structure breaking. The hydrogen bonding in the clusters is postulated [33] 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:

1. Hydrophilic Hydration
2. Ionic hydration
3. 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.

1.11 Hydrophilic hydration

Hydrophobic hydration is accompanied by a negative enthalpy change, due in part to the multiple van der Waals interactions between water and the hydrophobic material, a negative entropy change due to the increased order in the surrounding water and positive heat capacity change (CP) due to the negative enthalpy change. The solubilization of a solute molecule in water is characterized by changes in the water structure that depend on the nature of the solute. Solvation occurs as the consequences of solute-solvent interactions different from those between solvent molecules themselves. 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 [34].

1.12 Hydrophobic hydration and hydrophobic interaction

Hydrophobic hydration is the hydration of hydrophobic molecules and surfaces. 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 [35]. It is also reflected by anomalous behavior in other thermodynamic properties, such as the partial molar enthalpies, heat capacities and volumes of the nonpolar solutes in water.

This effect originated from much stronger attractive interaction energy between the nonpolar solutes merged in water than their Vander Waals interaction in free space [36]. The tendency of relativity nonpolar molecules to “stick together” in aqueous solution is denoted as the hydrophobic interaction [37]. It results from hydrophobic hydration of a nonpolar 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 nonpolar solutes and water.

1.13 Amino acids-solvent systems

The study of volumetric and ultrasonic velocity of solution containing amino acids and carbohydrate (fructose) are interesting. The correlation between solute-solvent interactions is complex. 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 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-carbohydrate (fructose, maltose, glucose, sucrose etc.) with amino acids on the thermodynamic properties. Thermodynamic interactions of L-histidine in aqueous fructose solutions have been reported [38]. Densities, speeds of sound and viscosities of L-alanine in aqueous fructose, maltose and lactose solutions at different temperatures have been measured [39]. Studies on volumetric, ultrasonic and viscometric behavior of L-histidine in aqueous glucose solutions, L-histidine in aqueous sucrose solutions and has reported volumetric and viscometric properties of arginine in aqueous-carbohydrate solutions have been measured [40-42]. Thermodynamics of solute-solute and solute-solvent interactions of homologous series of glycine, L-alanine, L-valine and L-leucine with thiamine hydrochloride in aqueous medium have been investigated [43]. Studies on volumetric and sound velocity of L-proline and L-lysine in aqueous nicotinamide solution at different temperatures have been measured [44]. The structure making and structure breaking properties of amino acids (L-asparagine, L-glutamine, L-serine and L-threonine) in aqueous glucose solution at different temperatures have been reported [45]. Volumetric and viscometric studies of glycine, dl-α-alanine, dl-α-amino-*n*-butyric acid, L-valine, and L-leucine in aqueous solutions of cadmium chloride at T = (288.15 to 318.15) K and at atmospheric pressure have been reported [46]. Partial molar volumes of L-serine and L-threonine in aqueous ammonium sulfate solutions at (278.15, 288.15, 298.15 and 308.15) K also have been reported [47]. From the above literature review, it is seen that volumetric and ultrasonic properties of glycine, L-ornithine and L-lysine in aqueous fructose solution at different temperatures were not reported previously. The literature survey suggests that volumetric and ultrasonic properties of systems consist of biologically important compounds remain a fruitful field of investigation. Literature survey also clearly shows the importance of the effects of added electrolytes to the molecular interactions thereby changing the volumetric and ultrasonic properties.

1.14 The object of the present work

The solution theory has been developed still far from being adequate to account for the properties of the constituent molecules. The experimental data on various volumetric and ultrasonic properties 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 [48]. 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.

The physicochemical properties of multicomponent mixtures are 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 [49]. The studies of amino acids express the interaction of dipolar ions with other functions and components in the biological system [50]. 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 [51, 52]. Therefore we decided to study the density and sound velocities properties of amino acids in mixed solvent system.

In the present researches, (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 fructose with amino acids at six different temperatures (293.15-318.15K) have been determined. Research on density and sound velocity study of L-histidine in aqueous fructose solution has been reported by a researcher [38]. To the best of our knowledge, no data on density, sound velocity, apparent molar volume, partial molar volume, adiabatic compression and isobaric expansion of glycine, L-ornithine and L-lysine in aqueous fructose 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 glycine, L-ornithine and L-lysine with aqueous fructose which is focused in this study. In order to understand the issue of solute-solvent interactions in aqueous solution of fructose-amino acids 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-

- to measure the density and sound velocity of glycine, L-ornithine and L-lysine in aqueous fructose solution at different temperature,
- 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, relative association and hydration number of the studied systems at different temperature,
- to predict about the structure making or breaking mechanism of glycine, L-ornithine and L-lysine in aqueous and aqueous fructose systems,
- to understand the effect of fructose on the structure of glycine, L-ornithine and L-lysine in solution,
- to improve the available data on physico-chemical properties of the system.

CHAPTER II

Literature review

A literature review discusses published information in a particular subject area within a period of time. The reports help to keep the professionals to update with what is current in the field. The depth and breadth of the literature review emphasizes the credibility of the writers in their fields. Literature reviews also provide a solid background for a research paper's investigation

Nowadays, volumetric and ultrasonic properties of systems consist of biologically important compounds in aqueous medium provides information about solute-solvent and solute-solute interactions that help us to understand several biochemical processes such as hydration, denaturation, aggregation, etc. It has been found out that solute-solvent solutions have large effects on the structure and the properties of biologically important compounds like proteins, carbohydrates, etc. In this chapter various fields where the solute-solvent interactions find applications and several aspects explored by the researchers has been reviewed in detail.

Rajagopal *et al.,* 2015, studied apparent molal volume, partial apparent molal volume, Hepler's constant, apparent molalcompressibiliity, partial apparent molal compressibility, transfer volume, transfer compressibility, Jones–Dole coefficient, B, Jones–Dole coefficient transfer of L-histidine in aqueous fructose solutions at different temperatures and reported positive transfer of volume from water to 0.02 M, 0.4M, 0.06M, 0.08M and 0.10 M aqueous fructose solutions [38].

Parvinder *et al.,* 2014 studied structure making and structure breaking capacity of amino acids in aqueous glucose solution is obtained from the sign of dB/dT values and the partial molar volume expansibility has been determined. The results found that amino acids shows structure making ability in aqueous glucose solution [53].

Ashwani *et al.,* 2016 reported apparent molar volume, limiting apparent molar volume, transfer volume, as well as apparent molar compressibility, limiting apparent molar compressibility, transfer compressibility, pair and triple interaction coefficients, partial molar expansibilities of L-arginine (0.025–0.2 mol kg−1) in aqueous + D-maltose (0–6 mass% of maltose in water) were obtained at different temperatures. The results have been discussed in terms of solute–solute and solute–solvent interactions in these systems. Solute-solvent (hydrophilic-ionic group and hydrophilic-hydrophilic group) interactions were found to be dominating over solute-solute (hydrophobic-hydrophilic group) interactions in the solution, which increases with increase in maltose concentration [54].

Mirikar *et al*., 2015 studied adiabatic compressibility (βa), acoustic impedance (z) and relative association (RA). The variations of these parameters with composition of mixture indicate the nature and extent of interaction between unlike molecules & suggest that the interactions occurring between amino acid and water molecules [55].

Elena *et al.,* 2004 performed the apparent molal volumes, hydration of D-maltose and sucrose with some amino acids (glycine, DL-alanine, DL-leucine, and L-serine). These results are interpreted in terms of the influence of the nature of the solutes, their specific conformations, and hydration, on the ability of the disaccharides to form associated complexes with the amino acids [56].

Khanuja *et al.,* 2013 studied partial molar volume, the transfer partial molar volume, partial molar volume expansibility, viscosity *B*-coefficient, variation of *B* with temperature d*B*/d*T* of amino acids in 0.05-0.25 M aqueous sucrose at 293.15, 303.15 and 313.15 K. The results were interpreted in terms of solute-solute and solute-solvent interactions and structure making/breaking ability of solutes in aqueous sucrose solution [57].

Palani *et al.,* 2011 reportedadiabatic compressibility, hydration number, apparent molal compressibility, apparent molal volume,apparent molal compressibility, limiting apparent molal volume were calculated. These parameters were used to study the ion-solvent interaction present in each solution [58].

Zhuo *et al.,* 2006 studied apparent molar volumes and transfer volumes of monosaccharides in Aqueous Amino Acid Solutions at 298.15K and reported that values of transfer volumes are positive and increase with increasing amino acid contents. Volumetric parameters indicating the interactions of saccharides with amino acids in water have been obtained from the transfer volumes of the saccharides. The interactions between saccharides and amino acids are discussed in terms of the structural interaction model and the stereo structure of monosaccharide molecules [59].

Banipal *et al.,* 2010 studied the effect of sodium acetate on the volumetric behavior of some mono-, di- and trisaccharides in aqueous solutions over temperature range (288.15 to 318.15 K) and reported positive transfer volumes for most of the saccharides, whose magnitude increases with the concentration of sodium acetate as well as temperature and negative values were observed for L(-) – sorbose, D(-) – fructose and D(+) – xylose at lower concentrations of co-solute. The negative magnitude of transfer volume values decrease with rise of temperature from 288.15 to 318.15 K. Parameters calculated have been utilized to understand various mixing effects in aqueous solutions due to the interactions between saccharide and sodium acetate [60].

Zhao *et al.,* 2005 reported partial molar volumes and viscosity B-coefficients of arginine in aqueous glucose, sucrose and L-ascorbic acid solutions at 298.15 K. Partial molar volumes of transfer and viscosity B-coefficients of arginine increase with increasing the mass concentration of sugar or L-ascorbic acid, and the hydration number of arginine decreases owing to the interaction of sugar or L-ascorbic acid and the zwitterionic groups [61].

Pal *et al.,* 2005 performed volumetric studies of glycine in binary aqueous solutions of sucrose at different temperatures and the results have been discussed in terms of solute-solute, solute-solvent interactions and the structural changes of the solutes in solutions [62].

Palani *et al.,* 2010 performed volumetric studies of glutamine, arginine, lysine in aqueous DMSO solutions at 303.15K. Using the 42 experimental values, the adiabatic compressibility and hydration number, apparent molar compressibility apparent molar volume, limiting apparent molar compressibility, limiting apparent molar volume and their constants and transfer volume were calculated. The experimental results have been discussed in terms of ion-solvent and solute-co-solute interactions on the basis of co-sphere over lap model [63].

Palani *et al.,* 2010 performed volumetric studies of three amino acids viz., asparagine, histidine and lysine in aqueous K_2 SO_4 solution (0.5 m) at 303.15K. Using the experimental values, the adiabatic compressibility, hydration number, apparent molar compressibility, apparent molar volume, limiting apparent molar compressibility, limiting apparent molar volume and their constants transfer volumes were calculated. The results of the parameters have been discussed in terms of ion-ion and ion-solvent interactions [64].

Rajagopal *et al.,* 2010 studied volumetric studies of glycine, DL-α-alanine DL-α-valine, and DL-α-leucine in 0.05, 0.10, 0.15 and 0.20 mol. L-1 aqueous metformin hydrochloride at 308.15, 313.15 and 318.15K. The measured values were used to estimate some important parameters, such as partial molal volume standard partial molal volume, transfer volume, hydration number, the second derivative of infinite dilution of partial molal volume with respect to temperature These parameters are interpreted in terms of solute-solute and solute-solvent interactions and structure making / breaking ability of solutes in the given solution [65].

Ali *et al.,* 2010 reported the apparent molar volumes for glycine, L-alanine, phenylalanine, and glycylglycine in 0.10 m aqueous D-galactose solutions have been determined from density measurements at (298.15, 303.15, 308.15, and 313.15)K. The data were utilized to estimate the partial molar volume at infinite dilution, and experimental slope. The transfer volume, and hydration number, (n_H) were also evaluated. The results were discussed in terms of hydrophilic-ionic, hydrophilic-hydrophobic, and hydrophobic-hydrophobic interactions, and structure-making/-breaking ability of the solute in aqueous D-galactose solutions [66].

Thirumaran *et al.,* 2010 reported the ultrasonic velocity (u) and density (ρ) of four amino acids namely L-alanine, L-leucine, L-valine and L-proline in aqueous sodium acetate solution as a function of composition at 303, 308 and 313 K. experimental data have been used to estimate the adiabatic compressibility, change in adiabatic compressibility, relative change in adiabatic compressibility, apparent molal compressibility, apparent molal volume, limiting apparent molal compressibility and limiting apparent molal volume. The results are discussed in terms of structure-making or structure-breaking effects of amino acids in the mixture [67].

Roy *et al.,* 2010 studied the apparent molar volumes, and apparent isentropic compressibilities of glycine, L-alanine, L-valine and L-leucine in 0.05, 0.10, 0.15 mol kg-1 catechol solutions have been determined at 298.15 K by measuring the densities and ultrasonic speed of the above solutions respectively. The standard partial molar volumes, standard volumes of transfer, standard partial isentropic compressibilities, transfer compressibilities, hydration number, of the amino acids have been calculated for investigating the various interactions in the ternary solutions. The linear correlation of partial molar volume with increasing number of carbon atoms in the alkyl chain 46 have been used to explain the contribution of charged end group (NH_3^+, COO-) and the $-CH_2$ group to the standard partial molar volume. The results have been interpreted in the light of solute-solvent interactions in the mixed ternary solutions [68].

Thirumaran *et al.,* 2010 reported the ultrasonic velocity (u) and density (ρ) of three amino acids namely L-arginine, L-lysine and L-histidine in aqueous sodium butyrate solution as a function of composition at 303, 308 and 313 K. Using these experimental values, the acoustical parameters such as adiabatic compressibility, apparent molal compressibility, apparent molal volume, limiting apparent molal compressibility, limiting apparent molal volume were calculated for all the systems. The results are interpreted in the light of structure-making or structure-breaking effects of these amino acids in the mixture [69].

Palani *et al.,* 2010 reported density (ρ), and ultrasonic velocity (u) for L-glutamine, L asparagine and L-lysine in water and aqueous glycerin (0, 0.5 and 1 mol dm-3) at 303.15K. These measurements have been performed to evaluate some important parameters viz. adiabatic compressibility, molar hydration number, apparent molar compressibility, apparent molar volume, limiting apparent molar compressibility, limiting apparent molar volume and their constants (SK, SV), and transfer volumes. The results have been discussed in terms of solute-co-solute and ion-solvent interaction [70].

From the above literature review, it is seen that volumetric and ultrasonic properties of glycine, L-ornithine and L-lysine in aqueous fructose solution at different temperatures were not reported previously. The literature survey suggests that volumetric and ultrasonic properties of systems consist of biologically important compounds remain a fruitful field of investigation. Literature survey also clearly shows the importance of the effects of added electrolytes to the molecular interactions thereby changing the volumetric and ultrasonic properties. In this context, the objective of the present set of studies was framed to investigate in detail, the volumetric and ultrasonic properties of biologically important compounds such as carbohydrates and amino acids.

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 glycine, L-ornithine and L-lysine with water and in aqueous solution of fructose.

1. glycine + water
2. L-ornithine + water
3. L-lysine + water
4. glycine + water + 0.05 mol.kg^{-1} fructose
5. glycine + water + 0.20 mol.kg^{-1} fructose
6. glycine + water + 0.35 mol.kg^{-1} fructose
7. glycine + water + 0.50 mol.kg^{-1} fructose
8. L-ornithine + water + 0.05 mol.kg^{-1} fructose
9. L-ornithine + water + 0.20 mol.kg^{-1} fructose
10. L-ornithine + water + 0.35 mol.kg^{-1} fructose
11. L-ornithine + water + 0.50 mol.kg^{-1} fructose
12. L-lysine + water + 0.05 mol.kg^{-1} fructose
13. L-lysine + water + 0.20 mol.kg^{-1} fructose
14. L-lysine + water + 0.35 mol.kg^{-1} fructose
15. L-lysine + water + 0.50 mol.kg^{-1} fructose

All experiments have been carried out at six equidistant temperature viz. 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K over the aqueous 0.05, 0.20, 0.35 and 0.0.50 mol.kg^{-1} composition, where m represents the molality of solution. The details information has been described in the following sections.

3.1 Materials

The chemicals used for study were glycine, L-ornithine, L-lysine and fructose. 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 (g.mol^{-1})	Reported purity	Producer
Fructose	$C_6H_{12}O_6$	180.16	Extra Pure	LOBA Chemical, India
Glycine	NH_2CH_2COOH	75.07	99.5%	LOBA Chemical, India
L-ornithine	$C_5H_{12}N_2O_2$	132.16	99.0%	Riedel-de Haen Hanover, Germany
L-lysine	$C_6H_{14}N_2O_2$	146.19	98.5-100%	LOBA Chemical, India

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 5000M model high precision vibrating tube digital density meter and speed of sound measuring device, with automatic viscosity 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 the 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 g mL^{-1} is unity and the density of water at any other temperature is expressed relative to that of water at 4^0c. 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 5000M, Austria). The density and sound velocity values have been found with an error of ±0.000006 g cm^{-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 5000M), the natural vibration period is automatically converted into the density value and display directly on the LC display monitor of the decimeter. The DSA 5000M 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 ± 0.001K. 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 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 4^0C), 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 4^0C 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^0C 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.

3.6 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.

3.7 Molarity

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

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

Or, $C = \frac{n_2}{V}$ ……………………………………………………………..…….(3.1)

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 (3.1), unit of molarity is $molL^{-1}$ [71].

3.8 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, ifρ is the density and M be 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 [71]. Mathematically,

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

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

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

$$\text{or, } \mathrm{m} = \frac{\mathrm{a}}{\mathrm{M_2}} \times \frac{1000}{\mathrm{V_1} \times \rho_0} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3.2)$$

Where, a = Weight of solute in gram

M_2 = Molecular weight of solute in gram

V_1 = Volume of solvent in mL

ρ_0 = Density of solvent in g cm^{-3}

Specific volume, (V) = $\frac{1}{\rho} mLg^{-1}$ ……………………………………………………(3.3)

And Molar volume, (V_m) = $\frac{M}{\rho} mLmol^{-1}$ ………………………………………………(3.4)

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.

3.9 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 [71, 72]:

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

or, $\varphi_v = \frac{1}{m\rho\rho_0}(\rho_0 - \rho) + \frac{M_2}{\rho}$ ……………………………………….………………(3.5)

Where, ρ is the density of the experimental solution, M_2 and m are the molar mass and molality of the electrolyte respectively and ρ_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,

$$m = \frac{1}{\left(\frac{\rho}{C} - \left(\frac{M_2}{1000}\right)\right)} \qquad \text{………………………….……………………………….. (3.6)}$$

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:

$$C = \frac{1}{M_2} \times \frac{a}{\text{vol. of solution in liter}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.7)$$

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 [72].

$$\overline{V}_1^0 = \frac{\text{Molecular masses of solvent}}{\text{Density of solvent (at expt. temp.)}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.8)$$

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

$$\overline{V_2} = \varphi_v + \frac{\sqrt{m}}{2}\left(\frac{\delta\varphi_V}{\delta\sqrt{m}}\right) = \varphi^0{}_v + \frac{3\sqrt{m}}{2}\left(\frac{\delta\varphi_V}{\delta\sqrt{m}}\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.9)$$

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

and $$\overline{V_1} = V_1^0 - \frac{M_1 m^{3/2}}{2000}\left(\frac{\delta\varphi_v}{\delta\sqrt{m}}\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.10)$$

The values of $\frac{\delta\varphi_v}{\delta\sqrt{m}}$ were obtained from the slope of the plot of φ_v against $\sqrt{C}$ by the use of Masson (50) equation and the apparent molar volume of solutes at infinite dilution ($\varphi_v^0 \approx \overline{V}_2{}^0$) were determined from the intercept of the plot, at C equal to zero.

3.10 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. fructose solution) - φ_v^0 (in water) ……..……………………………(3.11)

Where, φ_v^0 is limiting apparent molar volume.

3.11 Temperature dependent limiting apparent molar volume

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

$\varphi_v^0 = A + B (T-T_m) + C (T-T_m)^2$ …………………………………………..(3.12)

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:

$E_\varphi^0 = (\delta\varphi_v^0/\delta T)_p = B + 2C (T-T_m)$ ……………………………………………… (3.13)

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 [73]:

$(\delta E^0\varphi/\delta T)_p = (\delta^2\varphi_v^0/\delta T^2)_p = 2C$ ……..…………………………………………..(3.14)

Where $(\delta^2\varphi_v^0/\delta T^2)_p$ is Hepler's constant.

3.12 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 3.1. 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.

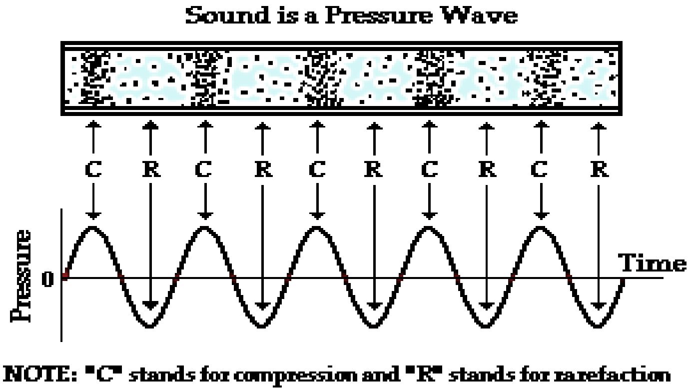


Figure 3.1: Schematic diagram of a longitudinal standing wave C and R show positions of medium compressions and refractions (high and low densities) respectively.

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 [74] or sound velocity can be derived, which is expressed as,

$$u = \left(\frac{1}{\rho\beta}\right)^{½} \quad \text{…………………………………………..….................. (3.15)}$$

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

$$\beta = k^{-1} = -\frac{1}{V}\left(\frac{\partial V}{\partial P}\right) \quad \text{…………………………………………………………...... (3.16)}$$

Where, ∂V = volume changed during the passage of sound

∂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 β_S respectively. Since audio frequencies are used in this experiment, we must use the adiabatic (or isentropic), which can be explicitly written as,

$$\beta_s = -\frac{1}{V}\left(\frac{\partial V}{\partial P}\right)_s \text{...} (3.17)$$

Writing β_s instead of β in equation (3.16) gives the Newton-La place equation of the form

$$u = \left(\frac{1}{\rho\beta_S}\right)^{½} \text{...} (3.18)$$

Various attempts [75-80] have been made to calculate theoretically ultrasonic sound velocity through binary mixtures.

3.13 Adiabatic Compressibility measurements

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

$$\beta_s = \frac{1}{\rho u^2} \quad \text{..} (3.19)$$

Where, ρ is the density of the experimental solution and u is the adiabatic compressibility of the solution.

3.14 Apparent molar Adiabatic Compressibility measurements

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

$$\varphi_K = \frac{M\beta_s}{\rho} + \left(\frac{\beta_{s,o}\rho - \beta_s\rho}{m\rho\rho_o}\right) \qquad (3.20)$$

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

3.15 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,

$$Z = u\rho \qquad (3.21)$$

Where, ρ is the density of the experimental solution and u is the adiabatic compressibility of the solution.

3.16 Relative association measurements

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

$$R_A = \left(\frac{\rho}{\rho_0}\right)\left(\frac{u}{u_0}\right) \qquad (3.22)$$

Where, ρ, ρ_o, u and u_o are the densities and ultrasonic speeds of the experimental solution and solvent.

3.17 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,

$$n_H = \frac{n_1}{n_2}\left(1 - \frac{\beta_s}{\beta_{s,o}}\right) \qquad (3.23)$$

Where n_H denotes the hydration number. β_s, $\beta_{s,o}$ are adiabatic compressibilities 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

Amino acids are the chemical units or "building blocks" of the body that make up proteins and proteins play an important role in the biological processes of nearly all living organisms. Fructose or fruit sugar is a simple ketonic monosaccharide found in many plants, where it is often bonded to glucose to form the disaccharide sucrose. It is one of the three dietary mono saccharides, along with fructose and galactose that are absorbed directly into the bloodstream during digestion [24]. Our studies included the interaction of amino acids (glycine, L-ornithine and L-lysine) with fructose 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:

1. glycine + water
2. L-ornithine + water
3. L-lysine + water
4. glycine + water + 0.05 mol.kg^{-1} fructose
5. glycine + water + 0.20 mol.kg^{-1} fructose
6. glycine + water + 0.35 mol.kg^{-1} fructose
7. glycine + water + 0.50 mol.kg^{-1} fructose
8. L-ornithine + water + 0.05 mol.kg^{-1} fructose
9. L-ornithine + water + 0.20 mol.kg^{-1} fructose
10. L-ornithine + water + 0.35 mol.kg^{-1} fructose
11. L-ornithine + water + 0.50 mol.kg^{-1} fructose
12. L-lysine + water + 0.05 mol.kg^{-1} fructose
13. L-lysine + water + 0.20 mol.kg^{-1} fructose
14. L-lysine + water + 0.35 mol.kg^{-1} fructose
15. L-lysine + water + 0.50 mol.kg^{-1} fructose

The above-mentioned systems have been studied precisely at six equidistant temperatures ranging from 293.15K to 318.15K at interval of 5K by density and sound velocity methods. The volumetric properties such as apparent molar volume (φ_v), partial molar volume ($\bar{V}_2$), limiting apparent molar volume (φ_v^0), limiting apparent molar volume transfer ($\Delta_{tr}\varphi_v^0$), limiting apparent molar expansibilities ($(\delta\varphi_v^0/\delta T)_p$) and Hepler's constant $(\delta^2\varphi_v^0/\delta T^2)_p$] have been determined from density data. The ultrasonic properties like adiabatic compressibility (β_s), apparent molar adiabatic compressibility (φ_k), limiting apparent molar adiabatic compressibility (φ_k^0), experimental slope (S_k), 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 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 densities, ρ and the relative densities, (ρ-ρ_0) of amino acids in water systems have been determined at temperatures ranging from (293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K) with an interval of 5K over the concentration ranging from 0.05 mol.kg^{-1} to 0.50 mol.kg^{-1}. The densities of aqueous glycine, L-ornithine and L-lysine 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 amino acids. Figures 4.1-4.3 show that the densities of aqueous glycine, L-ornithine and L-lysine increase with the increase of glycine, L-ornithine and L-lysine concentration. These are due to the increase in number of particles in given region which leads to shrinkage in volume of solution [92-93]. The densities of the aqueous glycine, L-ornithine and L-lysine decrease in the order of L-ornithine > L-lysine > glycine for the same molality of amino acids and at the same temperature. The densities decrease with the increase of temperature in aqueous glycine, L-ornithine and L-lysine systems. 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.

The densities, ρ and the relative densities, (ρ-ρ_0) of ternary systems such as glycine, L-ornithine and L-lysine in 0.05 mol.kg^{-1}, 0.20 mol.kg^{-1}, 0.35 mol.kg^{-1} and 0.50 mol.kg^{-1} aqueous fructose solutions are listed in tables 4.4-4.15 and figures are graphically shown in 4.4-4.15. The values of densities of amino acids (glycine, L-ornithine and L-lysine) in aqueous fructose systems has been found to be in the order of,

> Amino acids in aqueous 0.50 mol.kg^{-1} fructose > Amino acids in aqueous 0.35 mol.kg^{-1} fructose > Amino acids in aqueous 0.20 mol.kg^{-1} fructose > Amino acids in aqueous 0.05 mol.kg^{-1} fructose

It is seen that the density increase with the increasing of fructose concentration at a fixed amino acid concentration. The increase of density with concentration of fructose can be attributed to solute-solvent interaction and weight of fructose in solution. The densities of the glycine, L-ornithine and L-lysine solutions increase in the order of L-ornithine > L-lysine > glycine for the same molality of amino acids and fructose 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 [83].

Densities of amino acids in aqueous fructose system are higher than that of amino acids in 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-maker of the solvent due to the added solute [81, 82].

The apparent molar volumes (φ_v) of glycine, L-ornithine and L-lysine in water are calculated from density data. The value of apparent molar volume of aqueous glycine, L-ornithine and L-lysine at different temperatures (293.15, 298.15, 303.15, 308.15, 313.15, 318.15) K are given in tables 4.16-4.18 and the variation of φ_v with molality of glycine, L-ornithine and L-lysine are graphically represented in figures 4.16-4.18. It appears from the figure that apparent molar volume is dependent upon the amino acids concentration as well as on the temperature. Plots of φ_v vs. molality (m) of amino acids show linear relationship in water system. The values of apparent molar volume (φ_v) of aqueous amino acids are positive and linearly increase with the increase of concentration of amino acids.

The positive values of φ_v are indicative of greater solute-solvent interactions [38]. The values of apparent molar volume (φ_v) of aqueous glycine, L-ornithine and L-lysine solutions increase in the order of L-lysine > L-ornithine > glycine which due to the increasing of number of carbon in alkyl group present in amino acids i.e. from glycine, L-ornithine and L-lysine at all temperatures and concentrations, due to the increase in surface of solute to interact with solvent. The value of φ_v increases with increase in temperature because of thermal agitation, which leads to the bond breaking.

The value of apparent molar volume of glycine, L-ornithine and L-lysine in aqueous fructose solutions (0.05 $mol.kg^{-1}$, 0.20 $mol.kg^{-1}$, 0.35 $mol.kg^{-1}$ and 0.50 $mol.kg^{-1}$) at different temperatures (293.15, 298.15, 303.15, 308.15, 313.15, 318.15) K are given in tables 4.19-4.30 and figures 4.19-4.30 show the plots of apparent molar volume as a function of molality of glycine, L-ornithine and L-lysine at different temperatures. Plots of φ_v vs. molality of amino acids show linear relationship in aqueous fructose system. For glycine, L-ornithine and L-lysine in aqueous fructose solutions systems, the values of apparent molar volume (φ_v) are also positive and linearly increase with the increase of concentration of glycine, L-ornithine and L-lysine. It has been also found that apparent molar volumes for glycine, L-ornithine and L-lysine increase with the increase of fructose concentration (0.05 $mol.kg^{-1}$, 0.20 $mol.kg^{-1}$, 0.35 $mol.kg^{-1}$ and 0.50 $mol.kg^{-1}$). The positive values of φ_v are indicative of greater solute-solvent interactions. At a fixed fructose concentration and temperature, the increase of φ_v with the concentration of added amino acids in the studied molality range may be due to the cluster formation or aggregation. Also, the apparent molar volumes increase with an increase in the number of carbon in alkyl group present in amino acids i.e. from glycine, L-ornithine and L-lysine at all temperatures and concentrations of fructose, due to the increase in surface of solute to interact with solvent [38].

Comparatively lower apparent molar volume, φ_v of glycine in aqueous fructose solutions than aqueous L-lysine and L-ornithine was found. This indicates that the glycine in aqueous fructose solution is more compressed than L-lysine and L-ornithine in aqueous fructose solution. The apparent molar volume, φ_v of glycine, L-ornithine and L-lysine in aqueous fructose solution is higher than aqueous glycine, L-ornithine and L-lysine solution. This indicates that the glycine, L-ornithine and L-lysine is less compressed in aqueous fructose solution than aqueous solution.

The value of φ_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) that an increase in temperature renders the ion-ion interactions relatively stronger giving rise to positive volume change and (iii) the fructose-fructose or fructose-water or water-water interactions decrease with the increase in temperature leading to a positive change in volume [84].

The limiting apparent molar volume (φ_v^0) which is also called the standard partial molar volume of aqueous glycine, L-ornithine and L-lysine at 293.15, 298.15, 303.15, 308.15, 313.15 and 318.15K are reported in tables 4.31-4.33. The limiting apparent molar volumes (φ_v^0) of amino acids reflect the true volume of the solute. However, limiting apparent molar volumes at infinite dilution (φ_v^0) of the solute can provide further information regarding solute-solvent interactions. The apparent molar volumes (φ_v) were observed to correlate linearly with solution molality (m) at all experimental temperatures, hence standard partial molar volumes (φ_v^0) were obtained from Masson equation [85]. Tables 4.31-4.33 show that values of limiting apparent molar volume (φ_v^0) are positive. At each temperature, the φ_v^0 values increase with size of carbon chain i.e. increase in the number of carbon of alkyl part from glycine, L-ornithine and L-lysine. Furthermore, the values of φ_v^0 also increase with an increase in the molar mass and size of the amino acid, that is, higher values of φ_v^0 are obtained for L-lysine as compared to L-ornithine and glycine. These trends in limiting apparent molar volumes (φ_v^0) indicate the presence of strong solute-solvent interactions. The increase in φ_v^0 values with the increase in temperature for all amino acids may be explained as release of some solvent molecules from the loose solvation layers of the solutes in solution.

The values of limiting apparent molar volume (φ_v^0) for glycine, L-ornithine and L-lysine in ternary solution at the studied temperatures are presented in tables 4.34-4.45. These tables show that values of limiting apparent molar volume (φ_v^0) are positive and increase with an increase in the fructose concentration. Further, at each temperature, the φ_v^0 values increase with the size of carbon chain i.e. increase in chain length of alkyl part from glycine to L-lysine and ornithine. As per co-sphere overlap model [86, 87] 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 overlap of co-sphere of two ionic species takes place. Furthermore, the values of φ_v^0 also increase with an increase in the molar mass and size of the amino acid, that is, higher values of φ_v^0 are obtained for L-lysine and L-ornithine as compared to glycine in aqueous fructose solutions. The increase in φ_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 amino acid zwitterions is released into the bulk of the solvent, resulting into the expansion of solution, as inferred from larger values of φ_v^0 at higher temperatures [38]. In simple terms, an increase in temperature reduces the electrostriction and hence φ_v^0 increases.

The values of experimental slope (S_V) for aqueous amino acids and amino acids in ternary solution at the experimental temperatures are reported in tables 4.31-4.45. The values of experimental slope (S_V) are positive for all the concentration of amino acids. The non-zero values of S_V indicate the presence of solute-solute interactions in solutions of amino acids. 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 smaller values of S_V as compared to φ_v^0 suggest the dominance of solute-solvent interaction over the solute-solute interaction [88].

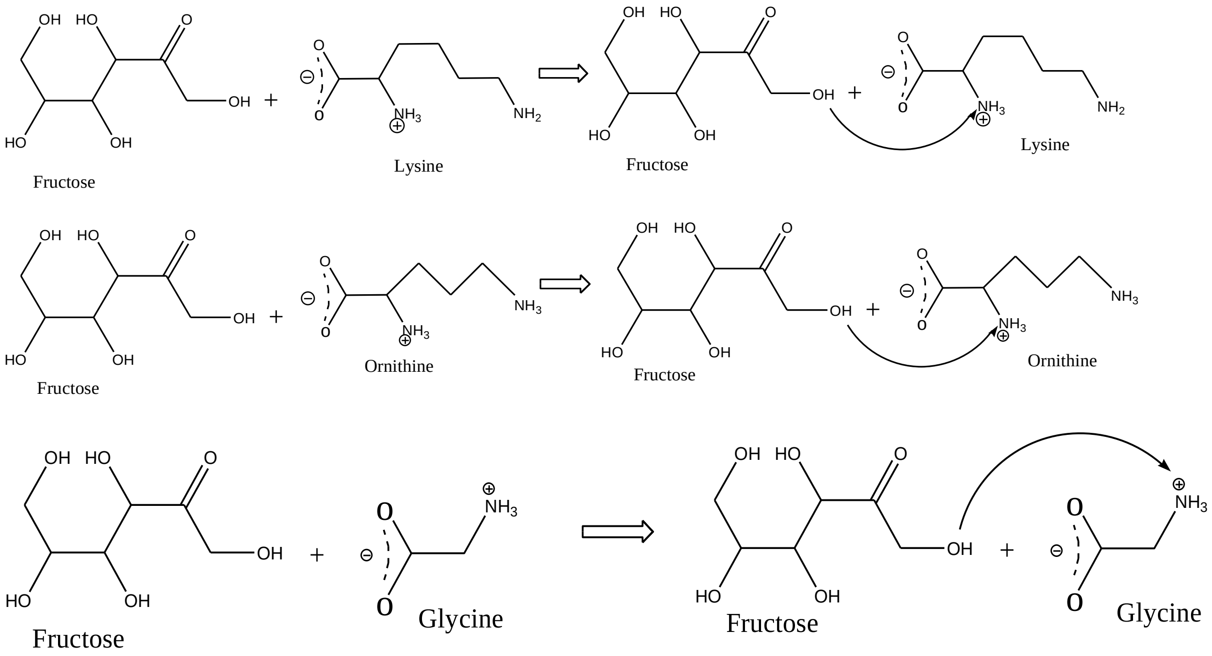
S_V values are positive and decrease with an increase of temperature in amino acids in the aqueous solution (with some exception) but increase in aqueous fructose solution suggesting that less solute is accommodated in the void space left in the packing of the large associated solvent molecules. The results also indicate the presence of strong solute-solute interactions, and these interactions decrease with the increase in temperature. The values of S_v increase with the increase in composition of aqueous fructose solution showing strong solute-solute interactions.

The values of limiting apparent molar volume transfer of amino acids from water to aqueous fructose solutions at infinite dilution was calculated by using the equation,

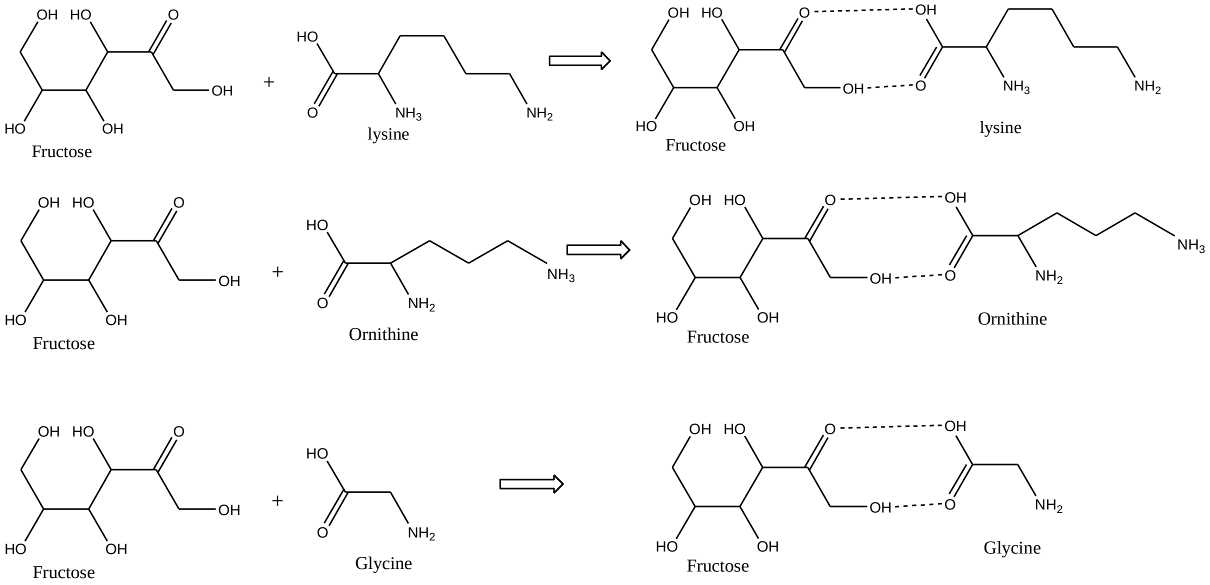
$\Delta_{tr}\varphi_v^0 = \varphi_v^0$ (in aq. fructose) - φ_v^0 (in water).

The values of limiting apparent molar volume transfer ($\Delta_{tr}\varphi_v^0$) of glycine, L-ornithine and L-lysine in aqueous fructose solutions have been reported in tables 4.34-4.45. The $\Delta_{tr}\varphi_v^0$ values of glycine, L-ornithine and L-lysine in aqueous fructose solutions are positive. The observed positive values of $\Delta_{tr}\varphi_v^0$ suggest strong ion-ion interactions of amino acids with fructose. Since the structural moiety of amino acids and aqueous fructose contain polar groups, so interactions between them promote the structure maker 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 [86, 87]. 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 amino acids and aqueous fructose molecules can be categorized as: (i) Hydrophilic-ionic interaction between OH groups of fructose and zwitterions of glycine, L-ornithine and L-lysine. (ii) Hydrophilic-hydrophilic interaction the OH groups of fructose and NH groups in the side chain of acid glycine, L-ornithine and L-lysine mediated through hydrogen bonding. (iii) Hydrophilic-hydrophobic interaction between the OH groups of fructose molecule and non-polar ($-CH_2$) in the side chain of glycine, L-ornithine and L-lysine molecule and (iv) Hydrophobic-hydrophobic group interactions between the non-polar groups of fructose and non-polar ($-CH_2$) in the side chain of glycine, L-ornithine and L-lysine molecule. According to co-sphere overlap model, ion-hydrophobic interactions and hydrophobic-hydrophobic interactions contribute negatively whereas hydrophilic-ionic and hydrophilic-hydrophilic interactions contribute positively to the $\Delta_{tr}\varphi_v^0$ values. Therefore, in our study of amino acid (glycine, L-ornithine and L-lysine) in aqueous fructose shows that hydrophilic-ionic and hydrophilic-hydrophilic interaction are dominating (scheme 1&2).

From the structural view point of glycine, L-ornithine and L-lysine, it is seen that the structure of glycine, L-ornithine and L-lysine is open chain. In addition to that L-lysine and L-ornithine contains two amino groups and glycine contains one amino group. Therefore, in glycine, L-ornithine and L-lysine hydrophilic-hydrophilic or ion-hydrophilic interactions are dominating.



Scheme 1: Hydrophilic-ionic interaction



Scheme 2: Hydrophilic-hydrophilic interaction

The values of limiting apparent molar volume expansibilities E_φ^0 and $(\delta E_\varphi^0/\delta T)_p$ of aqueous glycine, L-ornithine and L-lysine are reported in tables 4.31-4.34. The E_φ^0 values are found to be positive at all temperatures and concentrations of amino acids. The positive values of E_φ^0 suggest that the presence of solute-solvent interactions in these systems, as already indicated by apparent molar volume data. 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 small negative $(\delta E_\varphi^0/\delta T)_p$ 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 the structure making ability.

The values of limiting apparent molar volume expansibilities E_φ^0 and $(\delta E_\varphi^0/\delta T)_p$ of glycine, L-ornithine and L-lysine in ternary (aqueous fructose) solutions are reported in tables 4.34-4.45. The E_φ^0 values are found to be positive at all temperatures and concentrations of amino acids in fructose solution which is similar with the binary systems. The positive values of E_φ^0 suggest that the presence of solute-solvent interactions in these systems. The positive values of E_φ^0 may occur due to phenomenon of packing effect or caging which further suggests interaction between amino acids and aqueous fructose molecules. The small negative values of $(\delta E_\varphi^0/\delta T)_p$ for studied systems show the structure making ability of amino acids in all aqueous fructose solutions [73,89-93].

The values of Partial molar volume $(\bar{V}_2)$ of aqueous amino acids and amino acids in ternary (aqueous fructose) solutions are shown in tables 4.46-4.60. Figures 4.31-4.45 show the plots of partial molar volume as a function of concentration of aqueous amino acids and amino acids in aqueous solution of fructose. The value of partial molar volume $(\bar{V}_2)$ increases with the increase of concentration of amino acid. This suggests that solute-solvent interactions increase with the increase of concentration of amino acids.

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 [94]. The ultrasonic velocity is a measure of arrangement, continuity, continuousness and availability of void space of the medium.

The sound velocities, u and the relative sound velocities, (u-u_0) of aqueous amino acids and amino acids in ternary (aqueous fructose) systems have been determined at temperatures ranging from (293.15K to 318.15K) with an interval of 5K over the concentration ranging from 0.05 mol.kg^{-1} to 0.50 mol.kg^{-1}. The sound velocities of aqueous amino acids and amino acids in aqueous fructose solution have been shown in tables 4.61-4.75 at different temperatures. Figures 4.46-4.60 show the plots of sound velocities as a function of molality of aqueous amino acids and amino acids in aqueous fructose solution. These figures show that the sound velocity increases with the increase of concentration of amino acids. This may be attributed to the increase of compactness of the medium with the increase in amino acids concentration [95]. The sound velocity of aqueous L-lysine and L-ornithine is higher than aqueous glycine. This is due to the molecular weight of L-lysine and L-ornithine is higher than glycine. 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 [96]. 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 (β_s) of aqueous glycine, L-ornithine and L-lysine has been shown in tables 4.76-4.78 at different temperatures. Figures 4.61-4.63 show the plots of adiabatic compressibility as a function of molality of aqueous glycine, L-ornithine and L-lysine. From the figures it is apparent that the values of β_s decrease with the increase of molar concentration of glycine, L-ornithine and L-lysine. The value of β_s also decreases with the increases of temperature. The decrease in the β_s values with increasing concentration of glycine, L-ornithine and L-lysine indicates that the water molecules around the amino acids are less compressible than the water molecule in the bulk solution [97, 98]. The decrease in βs may be due to the introduction of amino acids molecule into water which reduces the void space in solution.

The values of adiabatic compressibility, β_s of glycine, L-ornithine and L-lysine in ternary (aqueous fructose) solution are shown in tables 4.79-4.90 and figures 4.64-4.75 show the plots of adiabatic compressibility as a function of molality of glycine, L-ornithine and L-lysine in aqueous solution of fructose. From these figures it is apparent that the values of β_s decrease with the increase of concentration of glycine, L-ornithine and L-lysine in fructose solution which is similar with binary systems. The values of β_s also decrease with the increase of temperature. The decrease in the β_s values of glycine, L-ornithine and L-lysine in aqueous fructose solutions by increasing concentration of amino acids indicates that the water molecules around the amino acids are less compressible than the water molecule in the bulk solution [97, 98]. The decrease in βs may be due to the introduction of amino acids molecule into water and aqueous fructose solutions which reduce the void space in solution.

The apparent molar adiabatic compressibility (φ_k) of aqueous glycine, L-ornithine and L-lysine are calculated from density and sound velocity data. The values of apparent molar adiabatic compressibility (φ_k) of aqueous glycine, L-ornithine and L-lysine at different temperatures (293.15, 298.15, 303.15, 308.15, 313.15, 318.15) K are given in tables 4.91-4.105 and the variation of φ_k with molality of glycine, L-ornithine and L-lysine are graphically represented in figures 4.76-4.90. From the data it is observed that values of φ_k are negative at all temperatures and concentrations of glycine, L-ornithine and L-lysine. The values of φ_k increase with an increase in the concentration of amino acids. The values of φ_k also increase with the increase of temperature. The negative φ_k values show that water molecules around ionic charged groups of amino acids are less compressible than water molecules in the bulk solution. This indicates the ordering of water molecules around solute or the negative φ_k values indicate greater loss of structural compressibility of water implying a greater ordering effect by the solute on the solvent [38].

The values of apparent molar adiabatic compressibility (φ_k) of amino acids in aqueous fructose are higher than the values of amino acids in aqueous 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 (φ_k^0) and experimental slope (S_k) of aqueous amino acids and amino acids in ternary (aqueous fructose) solution at different temperatures (293.15, 298.15, 303.15, 308.15, 313.15, 318.15) K are tabulated in tables 4.106-4.120. 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 are prevailing in the mixtures [99].

The more negative values of φ_k^0 for amino acids at low temperature are attributed to the strong attractive interactions between amino acids and water [100]. With an increase in temperature, the φ_k^0 values become less negative, which means that electrostriction reduces and some water molecules are released to bulk. Furthermore, the attractive interactions between fructose and water molecules induce the dehydration of amino acids and therefore at high fructose concentrations the water molecules around the amino acids are more compressible than those at lower fructose concentrations.

The values of apparent molar adiabatic compressibility of transfer ($\Delta_{tr}\varphi_k^0$) for molal concentrations of aqueous glycine, L-ornithine and L-lysine in fructose at different temperatures are reported in tables 4.109-4.120. These values of apparent molar adiabatic compressibility of transfer ($\Delta_{tr}\varphi_k^0$) of amino acids are positive but L-lysine in aqueous 0.05 mol.kg^{-1} fructose systems show the negative value.

The positive values of $\Delta_{tr}\varphi_k^0$ indicated 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 amino acids and alkyl chains of both amino acids and fructose result the increase in the number of monomeric water molecules. The $\Delta_{tr}\varphi_k^0$ values of amino acids in aqueous fructose solutions increase with increasing the mass of chain is due to the strengthening the hydrophobic-hydrophobic interaction and rapid increase from L-lysine and L-ornithine is on account of lacking the alkyl group of glycine [101]. 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 amino acid thereby reducing the positive contribution to $\Delta_{tr}\varphi_k^0$ [38].

The values of acoustic impedance, Z of aqueous glycine, L-ornithine and L-lysine and aqueous glycine, L-ornithine and L-lysine in fructose have been shown in tables 4.121-4.135 at different temperatures. Figures 4.91-4.105 show the plots of acoustic impedance as a function of molality of aqueous glycine, L-ornithine and L-lysine and aqueous glycine, L-ornithine and L-lysine in fructose. It is evident from the figures 4.91-4.105 that acoustic impedance increases with the increase in molality of amino acids. The increase in Z with the molality of amino acids 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 [95].

The values of acoustic impedance, Z of amino acids in aqueous fructose are higher than the values of amino acids in aqueous 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 glycine, L-ornithine and L-lysine and aqueous glycine, L-ornithine and L-lysine in fructose have been shown in tables 4.136-4.150 at different temperatures. Figures 4.106-4.120 show the plots of relative association as a function of molality of aqueous glycine, L-ornithine and L-lysine. The relative association decrease with the increase of molality of glycine, L-ornithine and L-lysine. 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 decreasing the solute-solvent interaction. This may be due to the increase in solute-solute interaction [95]. The values of R_A decrease with concentration but more decrease at higher temperature.

The hydration number (n_H) of glycine, L-ornithine and L-lysine in water are listed in tables 4.151-4.153 and figures are graphically shown in 4.121-4.123. The hydration numbers decrease with the increase of concentration for aqueous glycine, L-ornithine and L-lysine system. The hydration numbers also decrease with the increase of temperature. The hydration number of aqueous L-lysine and L-ornithine is higher than the aqueous glycine.

The values of hydration number decreases as appreciable increases of solutes. This is an added support for the structure promoting nature of the amino acids as well as the presence of dipolar interaction between amino acids 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 [100].

The hydration number (n_H) of glycine, L-ornithine and L-lysine in aqueous fructose (0.05, 0.20, 0.35 and 0.50) mol.kg^{-1} solutions at different temperatures are reported in tables 4.154-4.165. The variation of n_H with molality is graphically shown in figures 4.124-4.135. The hydration numbers decrease with the increase of concentration for glycine, L-ornithine and L-lysine in aqueous fructose systems which is similar with binary systems. The hydration numbers decrease with the increase of temperature.

The hydration number of L-lysine and L-ornithine in aqueous fructose is higher than glycine in aqueous fructose solution. The hydration number of amino acid at concentrate fructose solution is lower than the dilute solutions. This is due to the decrease of water molecule around the amino acid at higher concentration. This also suggests that compressibility of the solution is less than that of the solvent. As a result amino acids will gain mobility and have more probability of contacting aqueous fructose molecules. This may enhance the interaction between solute and solvent molecules [102].

The values of hydration number (n_H) of amino acids in aqueous fructose are lower than the values of amino acids in aqueous systems. The lower values of hydration number in ternary system compared to binary system suggest strong amino acids-fructose interaction in ternary system than binary system.

CHAPTER V

Conclusion

Volumetric and ultrasonic studies of glycine, L-ornithine and L-lysine in water and in aqueous fructose 0.05, 0.20, 0.35 and 0.50 ($mol.kg^{-1}$) solutions have been carried out in the temperature range 293.15K to 318.15K with an interval of 5K. The densities increase with the increasing of concentration of amino acids and decrease with increasing of temperature. Sound velocity also increases with increasing of concentration of amino acids and temperature.

Apparent molar properties, limiting apparent molar properties and compressibility studies indicate the presence of strong solute-solvent interaction in the binary and ternary systems. The extent of interactions increases with increase in the molar mass of amino acids and increase in the concentration of fructose solution. The Hepler's constant ($\delta^2\varphi_v^0/\delta T^2$) values suggest the structure making property of amino acids in water and fructose solution. Hydrophilic-hydrophilic or hydrophilic-ionic interactions are dominating for L-lysine, L-ornithine and glycine in binary and ternary systems. The decrease of hydration number at higher concentrations of amino acids suggests that the strength of interaction gets weakened between the solute and water molecules. It also suggests that compressibility of the solution is less than that of pure solvent. From the above experimental results we can conclude:

- The densities and sound velocities of ternary solution are higher than binary solution.
- Strong interactions are happened in glycine, L-lysine and L-ornithine with aqueous fructose solution.
- Hydrophilic-hydrophilic and ion-hydrophilic interaction are dominating over hydrophobic-hydrophobic interaction.
- The water molecules around amino acids are less compressible than water molecules in the bulk solution.
- The true volume (φ_v^0) of amino acids in water and aqueous fructose solution are found to be order of L-lysine > L-ornithine > glycine.
- Positive values of hydration number indicate an appreciable solvation of solute.

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

m/mol.kg^{-1}	Glycine + water					
	Density, ρ/kg.m^{-3}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	998.377	997.225	995.825	994.207	992.386	990.379
0.05016	999.992	998.821	997.405	995.777	993.949	991.935
0.10001	1001.586	1000.396	998.965	997.327	995.492	993.469
0.15002	1003.171	1001.962	1000.519	998.865	997.024	994.995
0.19991	1004.741	1003.512	1002.056	1000.389	998.538	996.507
0.24989	1006.299	1005.051	1003.585	1001.91	1000.048	998.008
0.30042	1007.86	1006.598	1005.116	1003.429	1001.558	999.514
0.34988	1009.376	1008.099	1006.604	1004.909	1003.03	1000.976
0.40091	1010.931	1009.638	1008.129	1006.425	1004.538	1002.479
0.45087	1012.441	1011.145	1009.624	1007.905	1006.009	1003.934
0.50109	1013.952	1012.638	1011.102	1009.379	1007.476	1005.381

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

m/mol.kg^{-1}	L-ornithine + water					
	Density, ρ/kg.m^{-3}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	998.377	997.225	995.825	994.207	992.386	990.379
0.05001	1001.421	1000.243	998.821	997.193	995.359	993.337
0.09920	1004.405	1003.194	1001.756	1000.115	998.271	996.235
0.14991	1007.339	1006.101	1004.644	1002.985	1001.127	999.087
0.19949	1010.194	1008.935	1007.458	1005.783	1003.917	1001.861
0.24988	1013.041	1011.759	1010.266	1008.578	1006.691	1004.63
0.30001	1015.817	1014.513	1013.001	1011.301	1009.409	1007.336
0.35001	1018.545	1017.22	1015.694	1013.981	1012.077	1009.987
0.39909	1021.167	1019.828	1018.286	1016.56	1014.636	1012.533
0.45018	1023.847	1022.488	1020.931	1019.184	1017.263	1015.159
0.50099	1026.475	1025.096	1023.524	1021.767	1019.836	1017.714

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

$m/mol.kg^{-1}$	L-lysine + water					
	Density, $\rho/kg.m^{-3}$					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	998.377	997.225	995.825	994.207	992.386	990.379
0.04998	1001.255	1000.073	998.654	997.024	995.191	993.179
0.09980	1004.077	1002.867	1001.428	999.788	997.944	995.925
0.14991	1006.837	1005.603	1004.145	1002.496	1000.639	998.618
0.20011	1009.562	1008.305	1006.829	1005.158	1003.299	1001.265
0.24991	1012.207	1010.926	1009.433	1007.747	1005.879	1003.848
0.30003	1014.817	1013.514	1012.005	1010.304	1008.434	1006.397
0.35005	1017.378	1016.055	1014.529	1012.815	1010.935	1008.892
0.40002	1019.878	1018.542	1016.999	1015.279	1013.386	1011.336
0.45024	1022.355	1020.998	1019.441	1017.708	1015.8	1013.745
0.50099	1026.475	1025.096	1023.524	1021.767	1019.836	1017.714

Table 4.4: Density (ρ) of glycine in aqueous solution of fructose (0.05 $mol.kg^{-1}$) as a function of molality at different temperature

$m/mol.kg^{-1}$	Glycine + water + 0.05 $mol.kg^{-1}$ fructose					
	Density, $\rho/kg.m^{-3}$					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1001.896	1000.705	999.276	997.631	995.786	993.758
0.05033	1003.495	1002.291	1000.849	999.191	997.34	995.304
0.10013	1005.064	1003.844	1002.389	1000.721	998.861	996.819
0.15034	1006.633	1005.395	1003.926	1002.249	1000.378	998.331
0.20018	1008.178	1006.920	1005.437	1003.750	1001.869	999.816
0.25021	1009.713	1008.436	1006.945	1005.242	1003.354	1001.294
0.29952	1011.211	1009.919	1008.411	1006.700	1004.807	1002.741
0.35013	1012.734	1011.433	1009.911	1008.191	1006.287	1004.217
0.40012	1014.227	1012.917	1011.383	1009.655	1007.731	1005.654
0.45044	1015.721	1014.392	1012.846	1011.106	1009.189	1007.101
0.50061	1017.197	1015.852	1014.296	1012.548	1010.622	1008.523

Table 4.5: Density (ρ) of glycine in aqueous solution of fructose (0.20 $mol.kg^{-1}$) as a function of molality at different temperature

$m/mol.kg^{-1}$	Glycine + water + 0.20 $mol.kg^{-1}$ fructose					
	Density, $\rho/kg.m^{-3}$					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.0000	1012.124	1010.83	1009.318	1007.599	1005.682	1003.599
0.04987	1013.633	1012.328	1010.804	1009.076	1007.151	1005.061
0.09987	1015.137	1013.821	1012.283	1010.545	1008.613	1006.516
0.14963	1016.624	1015.295	1013.745	1011.996	1010.058	1007.955
0.19952	1018.108	1016.767	1015.205	1013.442	1011.501	1009.390
0.24961	1019.586	1018.232	1016.659	1014.886	1012.937	1010.819
0.29987	1021.062	1019.696	1018.110	1016.330	1014.369	1012.247
0.34989	1022.521	1021.141	1019.543	1017.753	1015.790	1013.660
0.40085	1024.003	1022.613	1021.001	1019.198	1017.226	1015.089
0.45097	1025.448	1024.045	1022.421	1020.608	1018.628	1016.485
0.50163	1026.901	1025.491	1023.854	1022.031	1020.041	1017.892

Table 4.6: Density (ρ) of glycine in aqueous solution of fructose (0.35 $mol.kg^{-1}$) as a function of molality at different temperature

$m/mol.kg^{-1}$	Glycine + water + 0.35 $mol.kg^{-1}$ fructose					
	Density, $\rho/kg.m^{-3}$					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1021.966	1020.602	1019.001	1017.217	1015.236	1013.082
0.05008	1023.421	1022.044	1020.434	1018.64	1016.652	1014.494
0.09978	1024.856	1023.467	1021.848	1020.043	1018.048	1015.886
0.15056	1026.315	1024.913	1023.285	1021.467	1019.465	1017.301
0.19968	1027.719	1026.301	1024.665	1022.836	1020.829	1018.660
0.24991	1029.147	1027.712	1026.068	1024.229	1022.216	1020.040
0.29961	1030.554	1029.103	1027.448	1025.598	1023.578	1021.397
0.35035	1031.981	1030.515	1028.848	1026.989	1024.961	1022.775
0.40009	1033.371	1031.893	1030.215	1028.348	1026.315	1024.121
0.45051	1034.765	1033.282	1031.591	1029.712	1027.676	1025.476
0.49919	1036.112	1034.614	1032.912	1031.031	1028.982	1026.782

Table 4.7: Density (ρ) of glycine in aqueous solution of fructose (0.50 mol.kg^{-1}) as a function of molality at different temperature

m/mol.kg^{-1}	Glycine + water + 0.50 mol.kg^{-1} fructose					
	Density, ρ/kg.m^{-3}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1031.489	1030.024	1028.355	1026.494	1024.443	1022.241
0.04938	1032.895	1031.421	1029.74	1027.873	1025.818	1023.608
0.09971	1034.315	1032.832	1031.140	1029.265	1027.205	1024.988
0.14938	1035.705	1034.213	1032.512	1030.628	1028.565	1026.339
0.19971	1037.102	1035.602	1033.891	1031.995	1029.929	1027.696
0.24949	1038.474	1036.967	1035.246	1033.338	1031.264	1029.031
0.29971	1039.848	1038.332	1036.598	1034.683	1032.599	1030.361
0.35085	1041.241	1039.714	1037.968	1036.045	1033.952	1031.707
0.39934	1042.542	1041.001	1039.251	1037.323	1035.229	1032.978
0.45091	1043.923	1042.368	1040.607	1038.670	1036.567	1034.315
0.49899	1045.19	1043.62	1041.850	1039.907	1037.802	1035.545

Table 4.8: Density (ρ) of L-ornithine in aqueous solution of fructose (0.05 mol.kg^{-1}) as a function of molality at different temperature

m/mol.kg^{-1}	L-ornithine + water + 0.05 mol.kg^{-1} fructose					
	Density, ρ/kg.m^{-3}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1001.896	1000.705	999.276	997.631	995.786	993.758
0.04981	1004.871	1003.655	1002.207	1000.551	998.697	996.665
0.09979	1007.806	1006.567	1005.101	1003.429	1001.566	999.531
0.15022	1010.715	1009.451	1007.967	1006.283	1004.411	1002.369
0.20001	1013.536	1012.249	1010.748	1009.051	1007.171	1005.124
0.25012	1016.324	1015.015	1013.496	1011.786	1009.899	1007.845
0.30021	1019.065	1017.733	1016.197	1014.474	1012.575	1010.514
0.34993	1021.733	1020.387	1018.838	1017.103	1015.189	1013.122
0.39991	1024.379	1023.007	1021.441	1019.694	1017.777	1015.707
0.45005	1026.990	1025.598	1024.017	1022.260	1020.340	1018.254
0.50086	1029.595	1028.184	1026.587	1024.818	1022.888	1020.781

Table 4.9: Density (ρ) of L-ornithine in aqueous solution of fructose (0.20 mol.kg^{-1}) as a function of molality at different temperature

m/mol.kg^{-1}	L-ornithine + water + 0.20 mol.kg^{-1} fructose					
	Density, ρ/kg.m^{-3}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1012.124	1010.83	1009.318	1007.599	1005.682	1003.599
0.04964	1014.952	1013.644	1012.115	1010.386	1008.461	1006.373
0.09971	1017.759	1016.435	1014.888	1013.148	1011.215	1009.121
0.14981	1020.525	1019.182	1017.621	1015.865	1013.929	1011.826
0.20032	1023.269	1021.910	1020.333	1018.565	1016.619	1014.514
0.24975	1025.921	1024.531	1022.938	1021.161	1019.211	1017.097
0.29982	1028.557	1027.147	1025.539	1023.751	1021.779	1019.667
0.34990	1031.153	1029.721	1028.101	1026.295	1024.318	1022.199
0.39986	1033.694	1032.245	1030.610	1028.800	1026.825	1024.703
0.44934	1036.170	1034.705	1033.053	1031.233	1029.253	1027.128
0.49978	1038.652	1037.17	1035.505	1033.675	1031.687	1029.558

Table 4.10: Density (ρ) of L-ornithine in aqueous solution of fructose (0.35 mol.kg^{-1}) as a function of molality at different temperature

m/mol.kg^{-1}	L-ornithine + water + 0.35 mol.kg^{-1} fructose					
	Density, ρ/kg.m^{-3}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1021.966	1020.602	1019.001	1017.217	1015.236	1013.082
0.05009	1024.72	1023.337	1021.724	1019.929	1017.941	1015.784
0.10014	1027.426	1026.022	1024.399	1022.589	1020.597	1018.437
0.14975	1030.065	1028.640	1027.003	1025.180	1023.180	1021.020
0.19915	1032.651	1031.201	1029.548	1027.714	1025.710	1023.545
0.24995	1035.256	1033.787	1032.122	1030.276	1028.262	1026.098
0.29971	1037.769	1036.282	1034.603	1032.750	1030.728	1028.559
0.35036	1040.286	1038.780	1037.079	1035.212	1033.188	1031.022
0.39941	1042.676	1041.155	1039.451	1037.578	1035.543	1033.368
0.45002	1045.102	1043.563	1041.846	1039.964	1037.926	1035.747
0.49991	1047.452	1045.897	1044.170	1042.281	1040.230	1038.056

Table 4.11: Density (ρ) of L-ornithine in aqueous solution of fructose (0.50 mol.kg^{-1}) as a function of molality at different temperature

m/mol.kg^{-1}	L-ornithine + water + 0.50 mol.kg^{-1} fructose					
	Density, ρ/kg.m^{-3}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1031.489	1030.024	1028.355	1026.494	1024.443	1022.241
0.05071	1034.169	1032.689	1031.003	1029.133	1027.076	1024.869
0.09939	1036.699	1035.203	1033.502	1031.624	1029.560	1027.349
0.14922	1039.242	1037.732	1036.013	1034.125	1032.062	1029.846
0.20031	1041.804	1040.276	1038.543	1036.648	1034.581	1032.361
0.24982	1044.235	1042.693	1040.958	1039.049	1036.979	1034.759
0.29939	1046.631	1045.070	1043.321	1041.406	1039.334	1037.108
0.34861	1048.972	1047.392	1045.635	1043.709	1041.623	1039.399
0.40063	1051.393	1049.799	1048.030	1046.098	1044.011	1041.786
0.45021	1053.664	1052.057	1050.278	1048.337	1046.246	1044.018
0.49932	1055.87	1054.248	1052.459	1050.511	1048.411	1046.180

Table 4.12: Density (ρ) of L-lysine in aqueous solution of fructose (0.05 mol.kg^{-1}) as a function of molality at different temperature

m/mol.kg^{-1}	L-lysine + water + 0.05 mol.kg^{-1} fructose					
	Density, ρ/kg.m^{-3}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1001.912	1000.728	999.298	997.654	995.814	993.788
0.05018	1004.741	1003.526	1002.075	1000.419	998.567	996.534
0.10019	1007.516	1006.275	1004.810	1003.142	1001.279	999.243
0.15011	1010.229	1008.965	1007.480	1005.796	1003.926	1001.886
0.19944	1012.850	1011.565	1010.063	1008.365	1006.487	1004.444
0.24971	1015.467	1014.158	1012.641	1010.932	1009.040	1006.986
0.30027	1018.048	1016.716	1015.183	1013.461	1011.558	1009.504
0.34982	1020.519	1019.175	1017.627	1015.894	1013.984	1011.913
0.40051	1023.000	1021.630	1020.066	1018.319	1016.408	1014.341
0.45029	1025.394	1024.005	1022.423	1020.662	1018.751	1016.680
0.50099	1027.803	1026.401	1024.807	1023.021	1021.102	1019.021

Table 4.13: Density (ρ) of L-lysine in aqueous solution of fructose (0.20 mol.kg^{-1}) as a function of molality at different temperature

m/mol.kg^{-1}	L-lysine + water + 0.20 mol.kg^{-1} fructose					
	Density, ρ/kg.m^{-3}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1012.075	1010.795	1009.284	1007.561	1005.653	1003.565
0.04948	1014.779	1013.472	1011.941	1010.211	1008.287	1006.197
0.09950	1017.415	1016.092	1014.544	1012.804	1010.874	1008.777
0.14951	1020.002	1018.658	1017.097	1015.341	1013.407	1011.304
0.19982	1022.561	1021.194	1019.616	1017.848	1015.909	1013.799
0.25015	1025.075	1023.685	1022.088	1020.311	1018.363	1016.255
0.29969	1027.505	1026.092	1024.486	1022.697	1020.738	1018.624
0.35020	1029.935	1028.508	1026.886	1025.087	1023.123	1021.004
0.39985	1032.279	1030.835	1029.199	1027.387	1025.420	1023.297
0.45008	1034.605	1033.151	1031.512	1029.692	1027.717	1025.591
0.50041	1036.889	1035.428	1033.776	1031.946	1029.953	1027.831

Table 4.14: Density (ρ) of L-lysine in aqueous solution of fructose (0.35 mol.kg^{-1}) as a function of molality at different temperature

m/mol.kg^{-1}	L-lysine + water + 0.35 mol.kg^{-1} fructose					
	Density, ρ/kg.m^{-3}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1021.966	1020.602	1019.001	1017.217	1015.236	1013.082
0.04989	1024.501	1023.12	1021.506	1019.708	1017.723	1015.567
0.09969	1026.994	1025.595	1023.968	1022.157	1020.167	1018.008
0.14941	1029.447	1028.029	1026.387	1024.563	1022.569	1020.408
0.19930	1031.872	1030.435	1028.779	1026.946	1024.941	1022.781
0.24962	1034.283	1032.831	1031.163	1029.315	1027.302	1025.138
0.29973	1036.648	1035.176	1033.493	1031.634	1029.615	1027.446
0.34995	1038.984	1037.488	1035.794	1033.923	1031.892	1029.726
0.40024	1041.289	1039.771	1038.066	1036.185	1034.147	1031.979
0.45046	1043.556	1042.019	1040.303	1038.411	1036.361	1034.191
0.49971	1045.741	1044.19	1042.460	1040.562	1038.499	1036.335

Table 4.15: Density (ρ) of L-lysine in aqueous solution of fructose (0.50 mol.kg^{-1}) as a function of molality at different temperature

m/mol.kg^{-1}	L-lysine + water + 0.50 mol.kg^{-1} fructose					
	Density, ρ/kg.m^{-3}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1031.601	1030.154	1028.434	1026.583	1024.557	1022.348
0.05063	1033.951	1032.475	1030.795	1028.924	1026.871	1024.665
0.10041	1036.331	1034.844	1033.151	1031.271	1029.214	1027.004
0.15001	1038.663	1037.163	1035.456	1033.567	1031.508	1029.294
0.20015	1040.982	1039.465	1037.745	1035.849	1033.784	1031.568
0.24963	1043.237	1041.702	1039.971	1038.064	1035.989	1033.773
0.30105	1045.537	1043.984	1042.240	1040.322	1038.240	1036.029
0.35055	1047.717	1046.148	1044.389	1042.466	1040.376	1038.160
0.40086	1049.899	1048.311	1046.543	1044.609	1042.521	1040.298
0.44971	1051.981	1050.379	1048.600	1046.659	1044.560	1042.337
0.49992	1054.088	1052.471	1050.681	1048.732	1046.638	1044.403

Table 4.16: Apparent molar volume (φ_v) of aqueous glycine as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	Glycine + water					
	$\varphi_v \times 10^6/m^3 \cdot mol^{-1}$					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.05016	42.74	43.21	43.55	43.77	43.94	44.10
0.10001	42.80	43.26	43.59	43.81	43.97	44.14
0.15002	42.89	43.32	43.63	43.89	44.05	44.22
0.19991	42.98	43.38	43.68	43.95	44.12	44.27
0.24989	43.05	43.45	43.73	43.98	44.17	44.33
0.30042	43.11	43.50	43.79	44.04	44.24	44.39
0.34988	43.18	43.55	43.84	44.09	44.28	44.44
0.40091	43.23	43.60	43.89	44.13	44.33	44.49
0.45087	43.29	43.62	43.91	44.16	44.36	44.54
0.50109	43.33	43.67	43.97	44.20	44.39	44.60

Table 4.17: Apparent molar volume (φ_v) of aqueous L-ornithine as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-ornithine + water					
	φ_v ×10^6/m$^3\cdot$mol^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.05001	107.50	108.08	108.59	108.87	109.22	109.63
0.09992	107.72	108.37	108.82	109.14	109.46	109.86
0.14991	107.95	108.58	109.04	109.40	109.74	110.07
0.19949	108.18	108.78	109.25	109.62	109.94	110.30
0.24988	108.43	109.01	109.46	109.83	110.20	110.52
0.30001	108.68	109.25	109.70	110.07	110.40	110.74
0.35001	108.89	109.45	109.89	110.25	110.59	110.95
0.39909	109.11	109.65	110.09	110.45	110.82	111.18
0.45018	109.34	109.88	110.31	110.69	111.02	111.35
0.50099	109.54	110.07	110.50	110.87	111.20	111.55

Table 4.18: Apparent molar volume (φ_v) of aqueous L-lysine as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-lysine + water					
	φ_v ×10^6/m$^3\cdot$mol^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.04998	124.82	125.50	125.98	126.34	126.71	126.95
0.09998	125.04	125.70	126.19	126.53	126.89	127.16
0.14991	125.27	125.90	126.39	126.72	127.09	127.33
0.20011	125.47	126.08	126.57	126.95	127.28	127.56
0.24991	125.69	126.29	126.77	127.17	127.49	127.74
0.30003	125.90	126.50	126.97	127.37	127.67	127.93
0.35005	126.09	126.67	127.15	127.55	127.86	128.11
0.40002	126.30	126.86	127.33	127.71	128.04	128.30
0.45024	126.48	127.03	127.50	127.88	128.22	128.48
0.50004	126.68	127.25	127.72	128.10	128.42	128.68

Table 4.19: Apparent molar volume (φ_v) of glycine in aqueous solution of fructose (0.05 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	Glycine + water + 0.05 mol.kg^{-1} fructose					
	φ_v ×10^6/m^3·mol^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.05018	43.21	43.48	43.76	44.04	44.18	44.31
0.10019	43.27	43.58	43.85	44.11	44.28	44.40
0.15011	43.33	43.66	43.95	44.18	44.38	44.51
0.19944	43.39	43.74	44.03	44.26	44.47	44.61
0.24971	43.47	43.82	44.09	44.35	44.55	44.70
0.30027	43.54	43.89	44.18	44.42	44.61	44.77
0.34982	43.62	43.95	44.24	44.47	44.67	44.82
0.40051	43.69	44.00	44.29	44.52	44.74	44.90
0.45029	43.75	44.07	44.35	44.59	44.78	44.94
0.50099	43.81	44.13	44.41	44.64	44.83	44.99

Table 4.20: Apparent molar volume (φ_v) of glycine in aqueous solution of fructose (0.20 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	Glycine + water + 0.20 mol.kg^{-1} fructose					
	φ_v ×10^6/m^3·mol^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.04998	44.63	44.87	45.13	45.33	45.52	45.69
0.10009	44.65	44.89	45.17	45.38	45.56	45.73
0.14988	44.66	44.91	45.18	45.41	45.58	45.75
0.19979	44.67	44.92	45.19	45.43	45.58	45.76
0.24981	44.68	44.94	45.20	45.44	45.60	45.78
0.30001	44.69	44.95	45.22	45.45	45.62	45.79
0.34999	44.71	44.97	45.24	45.47	45.63	45.80
0.40085	44.72	44.97	45.24	45.48	45.65	45.82
0.45067	44.72	44.98	45.25	45.48	45.66	45.82
0.50098	44.72	44.97	45.24	45.48	45.66	45.82

Table 4.21: Apparent molar volume (φ_v) of glycine in aqueous solution of fructose (0.35 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	Glycine + water + 0.35 mol.kg^{-1} fructose					
	$\varphi_v \times 10^6$/m^3·mol^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.05008	45.57	45.85	46.05	46.27	46.45	46.56
0.09978	45.60	45.86	46.06	46.30	46.47	46.59
0.15056	45.61	45.87	46.07	46.33	46.50	46.60
0.19968	45.61	45.90	46.10	46.35	46.51	46.63
0.24991	45.62	45.92	46.12	46.36	46.53	46.65
0.29961	45.63	45.93	46.14	46.38	46.55	46.68
0.35035	45.64	45.94	46.16	46.40	46.57	46.70
0.40009	45.65	45.95	46.17	46.40	46.57	46.71
0.45051	45.68	45.96	46.19	46.42	46.58	46.72
0.49919	45.69	45.98	46.20	46.42	46.60	46.73

Table 4.22: Apparent molar volume (φ_v) of glycine in aqueous solution of fructose (0.50 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	Glycine + water + 0.50 mol.kg^{-1} fructose					
	$\varphi_v \times 10^6$/m^3·mol^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.04938	45.95	46.15	46.42	46.57	46.68	46.88
0.09971	46.01	46.21	46.46	46.63	46.76	46.95
0.14938	46.06	46.26	46.50	46.68	46.80	47.00
0.19971	46.11	46.31	46.54	46.74	46.85	47.05
0.24949	46.15	46.34	46.57	46.79	46.92	47.08
0.29971	46.19	46.38	46.62	46.83	46.97	47.14
0.35085	46.22	46.41	46.65	46.86	47.02	47.18
0.39934	46.27	46.48	46.70	46.90	47.05	47.21
0.45091	46.30	46.52	46.75	46.95	47.10	47.25
0.49899	46.36	46.59	46.81	47.01	47.15	47.31

Table 4.23: Apparent molar volume (φ_v) of L-ornithine in aqueous solution of fructose (0.05 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-ornithine + water + 0.05 mol.kg^{-1} fructose					
	φ_v ×10^6/m^3·mol^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.04981	108.48	109.04	109.49	109.80	110.07	110.26
0.09979	108.66	109.20	109.65	110.00	110.28	110.46
0.15022	108.86	109.41	109.85	110.20	110.47	110.68
0.20001	109.06	109.60	110.04	110.39	110.66	110.87
0.25012	109.26	109.80	110.24	110.59	110.86	111.07
0.30021	109.45	109.99	110.43	110.78	111.06	111.29
0.34993	109.66	110.17	110.59	110.94	111.25	111.47
0.39991	109.83	110.35	110.78	111.13	111.42	111.64
0.45005	110.00	110.52	110.94	111.29	111.56	111.81
0.50086	110.16	110.68	111.10	111.44	111.72	112.00

Table 4.24: Apparent molar volume (φ_v) of L-ornithine in aqueous solution of fructose (0.20 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-ornithine + water + 0.20 mol.kg^{-1} fructose					
	φ_v ×10^6/m^3·mol^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.04964	110.68	111.02	111.44	111.74	112.01	112.22
0.09971	110.82	111.18	111.61	111.92	112.18	112.41
0.14981	110.94	111.33	111.74	112.08	112.32	112.57
0.20032	111.07	111.46	111.87	112.21	112.46	112.69
0.24975	111.16	111.61	112.02	112.35	112.59	112.84
0.29982	111.29	111.75	112.15	112.48	112.78	113.00
0.34990	111.42	111.88	112.28	112.63	112.91	113.14
0.39986	111.56	112.03	112.42	112.75	113.01	113.23
0.44934	111.71	112.16	112.57	112.89	113.15	113.37
0.49978	111.85	112.31	112.71	113.03	113.29	113.51

Table 4.25: Apparent molar volume (φ_v) of L-ornithine in aqueous solution of fructose (0.35 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-ornithine + water + 0.35 mol.kg^{-1} fructose					
	φ_v ×10^6/m^3·mol^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.05009	112.05	112.50	112.82	113.14	113.39	113.58
0.10014	112.19	112.66	112.96	113.32	113.55	113.74
0.14975	112.32	112.80	113.13	113.49	113.73	113.90
0.19915	112.45	112.95	113.30	113.65	113.89	114.07
0.24995	112.62	113.11	113.46	113.81	114.06	114.24
0.29971	112.77	113.25	113.60	113.94	114.20	114.38
0.35036	112.91	113.39	113.77	114.11	114.36	114.52
0.39941	113.06	113.53	113.88	114.21	114.47	114.66
0.45002	113.21	113.68	114.03	114.36	114.61	114.80
0.49991	113.36	113.82	114.17	114.49	114.76	114.93

Table 4.26: Apparent molar volume (φ_v) of L-ornithine in aqueous solution of fructose (0.50 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-ornithine + water + 0.50 mol.kg^{-1} fructose					
	φ_v ×10^6/m^3·mol^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.05071	113.51	113.88	114.30	114.58	114.83	115.06
0.09939	113.63	114.02	114.43	114.71	114.97	115.19
0.14922	113.78	114.16	114.59	114.88	115.09	115.32
0.20031	113.93	114.33	114.74	115.02	115.23	115.46
0.24982	114.11	114.50	114.86	115.16	115.37	115.58
0.29939	114.26	114.66	115.03	115.32	115.52	115.75
0.34861	114.40	114.81	115.16	115.47	115.70	115.91
0.40063	114.57	114.97	115.32	115.62	115.84	116.05
0.45021	114.71	115.11	115.46	115.76	115.98	116.19
0.49932	114.86	115.27	115.61	115.91	116.14	116.35

Table 4.27: Apparent molar volume (φ_v) of L-lysine in aqueous solution of fructose (0.05 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-lysine + water + 0.05 mol.kg^{-1} fructose					
	φ_v ×10^6/m^3·mol^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.05018	125.47	126.03	126.57	126.90	127.18	127.42
0.10019	125.72	126.30	126.77	127.11	127.43	127.66
0.15011	125.95	126.53	127.01	127.39	127.69	127.92
0.19944	126.21	126.77	127.24	127.63	127.94	128.16
0.24971	126.45	127.02	127.48	127.86	128.19	128.45
0.30027	126.67	127.24	127.70	128.08	128.42	128.66
0.34982	126.91	127.44	127.90	128.28	128.61	128.89
0.40051	127.13	127.68	128.13	128.52	128.83	129.08
0.45029	127.33	127.87	128.33	128.72	129.01	129.27
0.50099	127.49	128.02	128.47	128.88	129.18	129.44

Table 4.28: Apparent molar volume (φ_v) of L-lysine in aqueous solution of fructose (0.20 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-lysine + water + 0.20 mol.kg^{-1} fructose					
	φ_v ×10^6/m^3·mol^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.04948	127.75	128.10	128.59	128.94	129.23	129.53
0.09950	127.88	128.27	128.74	129.08	129.36	129.66
0.14951	128.03	128.46	128.90	129.27	129.54	129.83
0.19982	128.15	128.61	129.06	129.44	129.69	129.99
0.25015	128.28	128.76	129.22	129.58	129.86	130.12
0.29969	128.41	128.91	129.34	129.71	130.00	130.27
0.35020	128.55	129.03	129.47	129.83	130.12	130.39
0.39985	128.69	129.17	129.60	129.98	130.25	130.52
0.45008	128.84	129.30	129.71	130.07	130.36	130.62
0.50041	128.99	129.44	129.84	130.20	130.51	130.76

Table 4.29: Apparent molar volume (φ_v) of L-lysine in aqueous solution of fructose (0.35 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-lysine + water + 0.35 mol.kg^{-1} fructose					
	φ_v ×10^6/m^3·mol^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.04989	129.75	130.19	130.57	130.98	131.22	131.44
0.09969	129.79	130.24	130.62	131.03	131.28	131.51
0.14941	129.83	130.29	130.69	131.10	131.34	131.57
0.19930	129.87	130.34	130.74	131.13	131.41	131.61
0.24962	129.91	130.37	130.76	131.16	131.45	131.67
0.29973	129.96	130.42	130.82	131.21	131.50	131.73
0.34995	130.00	130.48	130.87	131.27	131.57	131.79
0.40024	130.04	130.53	130.92	131.31	131.62	131.83
0.45046	130.09	130.58	130.96	131.35	131.67	131.88
0.49971	130.14	130.63	131.02	131.39	131.72	131.92

Table 4.30: Apparent molar volume (φ_v) of L-lysine in aqueous solution of fructose (0.50 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-lysine + water + 0.50 mol.kg^{-1} fructose					
	φ_v ×10^6/m^3·mol^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.05063	131.06	131.38	131.73	132.07	132.28	132.55
0.10041	131.14	131.47	131.83	132.17	132.40	132.66
0.15001	131.21	131.56	131.94	132.28	132.50	132.77
0.20015	131.29	131.66	132.04	132.37	132.61	132.87
0.24963	131.35	131.74	132.12	132.46	132.72	132.97
0.30105	131.43	131.83	132.22	132.56	132.83	133.05
0.35055	131.50	131.91	132.30	132.63	132.92	133.15
0.40086	131.56	131.98	132.37	132.71	132.97	133.22
0.44971	131.63	132.05	132.44	132.77	133.06	133.29
0.49992	131.70	132.12	132.51	132.84	133.10	133.36

Table 4.31: Limiting apparent molar volume (φ_v^0), experimental slope (S_V), limiting apparent molar volume expansibilities (E_φ^0) and $(\delta E^0\varphi/\delta T)_p$ of glycine in aqueous system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively

Temp (K)	$\varphi_v^0 \times 10^6$ ($m^3.mol^{-1}$)	$S_V \times 10^6$ ($m^3.mol^{-2}.kg$)	$E_\varphi^0 \times 10^8$ ($m^3.mol^{-1}.K^{-1}$)	$(\delta E^0\varphi/\delta T)_p \times 10^8$ ($m^3.mol^{-1}.K^{-2}$)
293.15K	42.75	1.18	9.26	-0.32
298.15K	43.17	1.05	7.66	
303.15K	43.49	0.96	6.06	
308.15K	43.74	0.97	4.46	
313.15K	43.89	1.05	2.86	
318.15K	44.06	1.09	1.26	

Table 4.32: Limiting apparent molar volume (φ_v^0), experimental slope (S_V), limiting apparent molar volume expansibilities (E_φ^0) and $(\delta E^0\varphi/\delta T)_p$ of L-ornithine in aqueous system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively

Temp (K)	$\varphi_v^0 \times 10^6$ ($m^3.mol^{-1}$)	$S_V \times 10^6$ ($m^3.mol^{-2}.kg$)	$E_\varphi^0 \times 10^8$ ($m^3.mol^{-1}.K^{-1}$)	$(\delta E^0\varphi/\delta T)_p \times 10^8$ ($m^3.mol^{-1}.K^{-2}$)
293.15K	107.27	4.59	11.56	-0.26
298.15K	107.91	4.36	10.26	
303.15K	108.40	4.24	8.96	
308.15K	108.71	4.40	7.66	
313.15K	109.05	4.39	6.36	
318.15K	109.43	4.30	5.06	

Table 4.33: Limiting apparent molar volume (φ_v^0), experimental slope (S_V), limiting apparent molar volume expansibilities (E_φ^0) and $(\delta E^0\varphi/\delta T)_p$ of L-lysine in aqueous system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively

Temp (K)	$\varphi_v^0 \times 10^6$ ($m^3.mol^{-1}$)	$S_V \times 10^6$ ($m^3.mol^{-2}.kg$)	$E_\varphi^0 \times 10^8$ ($m^3.mol^{-1}.K^{-1}$)	$(\delta E^0\varphi/\delta T)_p \times 10^8$ ($m^3.mol^{-1}.K^{-2}$)
293.15K	124.63	4.14	13.36	-0.40
298.15K	125.32	3.86	11.36	
303.15K	125.81	3.80	9.36	
308.15K	126.15	3.92	7.36	
313.15K	126.52	3.80	5.36	
318.15K	126.77	3.81	3.36	

Table 4.35: Limiting apparent molar volume (φ_v^0), experimental slope (S_V), limiting apparent molar volume transfer ($\Delta\varphi_v^0$), limiting apparent molar volume expansibilities (E_φ^0) and $(\delta E^0\varphi/\delta T)_p$ of glycine in aqueous 0.05 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively

Temp (K)	$\varphi_v^0\times10^6$ ($m^3.mol^{-1}$)	$S_V\times10^6$ ($m^3.mol^{-2}.kg$)	$\Delta_{tr}\varphi_v^0\times10^6$ ($m^3.mol^{-1}$)	$E_\varphi^0\times10^8$ ($m^3.mol^{-1}.K^{-1}$)	$(\delta E^0\varphi/\delta T)_p\times10^8$ ($m^3.mol^{-1}.K^{-2}$)
293.15K	43.13	1.37	0.38	7.14	-0.20
298.15K	43.44	1.42	0.27	6.14	
303.15K	43.72	1.42	0.23	5.14	
308.15K	43.98	1.36	0.25	4.14	
313.15K	44.15	1.43	0.26	3.14	
318.15K	44.32	1.42	0.27	2.14	

Table 4.35: Limiting apparent molar volume (φ_v^0), experimental slope (S_V), limiting apparent molar volume transfer ($\Delta\varphi_v^0$), limiting apparent molar volume expansibilities (E_φ^0) and $(\delta E^0\varphi/\delta T)_p$ of glycine in aqueous 0.20 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively

Temp (K)	$\varphi_v^0\times10^6$ ($m^3.mol^{-1}$)	$S_V\times10^6$ ($m^3.mol^{-2}.kg$)	$\Delta_{tr}\varphi_v^0\times10^6$ ($m^3.mol^{-1}$)	$E_\varphi^0\times10^8$ ($m^3.mol^{-1}.K^{-1}$)	$(\delta E^0\varphi/\delta T)_p\times10^8$ ($m^3.mol^{-1}.K^{-2}$)
293.15K	44.55	0.43	1.85	5.56	-0.10
298.15K	44.79	0.47	1.62	5.06	
303.15K	45.05	0.47	1.56	4.56	
308.15K	45.27	0.52	1.54	4.06	
313.15K	45.45	0.51	1.55	3.56	
318.15K	45.62	0.50	1.57	3.06	

Table 4.36: Limiting apparent molar volume (φ_v^0), experimental slope (S_V), limiting apparent molar volume transfer ($\Delta\varphi_v^0$), limiting apparent molar volume expansibilities (E_φ^0) and $(\delta E^0\varphi/\delta T)_p$ of glycine in aqueous 0.35 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K 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	$E_\varphi^0\times10^8$ ($m^3.mol^{-1}.K^{-1}$)	$(\delta E^0\varphi/\delta T)_p\times10^8$ ($m^3.mol^{-1}.K^{-2}$)
293.15K	45.56	0.24	2.87	5.50	-0.12
298.15K	45.84	0.29	2.67	4.90	
303.15K	46.03	0.29	2.53	4.30	
308.15K	46.27	0.34	2.54	3.70	
313.15K	46.44	0.32	2.55	3.10	
318.15K	46.55	0.38	2.50	2.50	

Table 4.37: Limiting apparent molar volume (φ_v^0), experimental slope (S_V), limiting apparent molar volume transfer ($\Delta\varphi_v^0$), limiting apparent molar volume expansibilities (E_φ^0) and ($\delta E^0\varphi/\delta T)_p$ of glycine in aqueous 0.50 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively

Temp (K)	$\varphi_v^0\times10^6$ ($m^3.mol^{-1}$)	$S_V\times10^6$ ($m^3.mol^{-2}.kg$)	$\Delta_{tr}\varphi_v^0\times10^6$ ($m^3.mol^{-1}$)	$E_\varphi^0\times10^8$ ($m^3.mol^{-1}.K^{-1}$)	$(\delta E^0\varphi/\delta T)_p\times10^8$ ($m^3.mol^{-1}.K^{-2}$)
293.15K	45.93	0.85	3.24	4.40	-0.06
298.15K	46.12	0.91	2.95	4.10	
303.15K	46.37	0.91	2.87	3.80	
308.15K	46.54	0.93	2.80	3.50	
313.15K	46.65	1.02	2.76	3.20	
318.15K	46.85	0.91	2.81	2.90	

Table 4.38: Limiting apparent molar volume (φ_v^0), experimental slope (S_V), limiting apparent molar volume transfer ($\Delta\varphi_v^0$), limiting apparent molar volume expansibilities (E_φ^0) and ($\delta E^0\varphi/\delta T)_p$ of L-ornithine in aqueous 0.05 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively

Temp (K)	$\varphi_v^0\times10^6$ ($m^3.mol^{-1}$)	$S_V\times10^6$ ($m^3.mol^{-2}.kg$)	$\Delta_{tr}\varphi_v^0\times10^6$ ($m^3.mol^{-1}$)	$E_\varphi^0\times10^8$ ($m^3.mol^{-1}.K^{-1}$)	$(\delta E^0\varphi/\delta T)_p\times10^8$ ($m^3.mol^{-1}.K^{-2}$)
293.15K	108.30	3.80	1.03	11.89	-0.38
298.15K	108.86	3.70	0.94	9.99	
303.15K	109.31	3.70	0.91	8.09	
308.15K	109.65	3.67	0.94	6.19	
313.15K	109.92	3.69	0.87	4.29	
318.15K	110.09	3.87	0.66	2.39	

Table 4.39: Limiting apparent molar volume (φ_v^0), experimental slope (S_V), limiting apparent molar volume transfer ($\Delta\varphi_v^0$), limiting apparent molar volume expansibilities (E_φ^0) and ($\delta E^0\varphi/\delta T)_p$ of L-ornithine in aqueous 0.20 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively

Temp (K)	$\varphi_v^0\times10^6$ ($m^3.mol^{-1}$)	$S_V\times10^6$ ($m^3.mol^{-2}.kg$)	$\Delta_{tr}\varphi_v^0\times10^6$ ($m^3.mol^{-1}$)	$E_\varphi^0\times10^8$ ($m^3.mol^{-1}.K^{-1}$)	$(\delta E^0\varphi/\delta T)_p\times10^8$ ($m^3.mol^{-1}.K^{-2}$)
293.15K	110.54	2.56	3.27	8.66	-0.18
298.15K	110.90	2.82	2.98	7.76	
303.15K	111.32	2.82	2.92	6.86	
308.15K	111.63	2.82	2.93	5.96	
313.15K	111.89	2.83	2.84	5.06	
318.15K	112.13	2.80	2.70	4.16	

Table 4.40: Limiting apparent molar volume (φ_v^0), experimental slope (S_V), limiting apparent molar volume transfer ($\Delta\varphi_v^0$), limiting apparent molar volume expansibilities (E_φ^0) and $(\delta E^0\varphi/\delta T)_p$ of L-ornithine in aqueous 0.35 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K 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^{-1}.K^{-2})
293.15K	111.89	2.92	4.62	9.47	-0.26
298.15K	112.36	2.93	4.45	8.17	
303.15K	112.68	2.93	4.28	6.87	
308.15K	113.04	2.97	4.33	5.57	
313.15K	113.27	3.02	4.22	4.27	
318.15K	113.45	3.02	4.02	2.97	

Table 4.41: Limiting apparent molar volume (φ_v^0), experimental slope (S_V), limiting apparent molar volume transfer ($\Delta\varphi_v^0$), limiting apparent molar volume expansibilities (E_φ^0) and $(\delta E^0\varphi/\delta T)_p$ of L-ornithine in aqueous 0.50 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K 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^{-1}.K^{-2})
293.15K	113.33	3.06	6.06	9.01	-0.22
298.15K	113.71	3.14	5.80	7.91	
303.15K	114.14	3.14	5.75	6.81	
308.15K	114.43	2.97	5.72	5.71	
313.15K	114.66	2.94	5.61	4.61	
318.15K	114.90	2.87	5.47	3.51	

Table 4.42: Limiting apparent molar volume (φ_v^0), experimental slope (S_V), limiting apparent molar volume transfer ($\Delta\varphi_v^0$), limiting apparent molar volume expansibilities (E_φ^0) and $(\delta E^0\varphi/\delta T)_p$ of L-lysine in aqueous 0.05 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K 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^{-1}.K^{-2})
293.15K	125.28	4.57	0.64	12.03	-0.35
298.15K	125.86	4.46	0.54	10.28	
303.15K	126.36	4.46	0.55	8.52	
308.15K	126.71	4.46	0.56	6.77	
313.15K	127.01	4.48	0.49	5.01	
318.15K	127.24	4.56	0.47	3.26	

Table 4.43: Limiting apparent molar volume (φ_v^0), experimental slope (S_V), limiting apparent molar volume transfer ($\Delta\varphi_v^0$), limiting apparent molar volume expansibilities (E_φ^0) and $(\delta E^0\varphi/\delta T)_p$ of L-lysine in aqueous 0.20 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively

Temp (K)	$\varphi_v^0\times10^6$ ($m^3.mol^{-1}$)	$S_V\times10^6$ ($m^3.mol^{-2}.kg$)	$\Delta_{tr}\varphi_v^0\times10^6$ ($m^3.mol^{-1}$)	$E_\varphi^0\times10^8$ ($m^3.mol^{-1}.K^{-1}$)	$(\delta E^0\varphi/\delta T)_p\times10^8$ ($m^3.mol^{-1}.K^{-2}$)
293.15K	127.61	2.73	2.97	9.38	-0.18
298.15K	128.00	2.93	2.68	8.48	
303.15K	128.49	2.93	2.67	7.58	
308.15K	128.84	2.80	2.69	6.68	
313.15K	129.11	2.85	2.59	5.78	
318.15K	129.42	2.73	2.64	4.88	

Table 4.44: Limiting apparent molar volume (φ_v^0), experimental slope (S_V), limiting apparent molar volume transfer ($\Delta\varphi_v^0$), limiting apparent molar volume expansibilities (E_φ^0) and $(\delta E^0\varphi/\delta T)_p$ of L-lysine in aqueous 0.35 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively

Temp (K)	$\varphi_v^0\times10^6$ ($m^3.mol^{-1}$)	$S_V\times10^6$ ($m^3.mol^{-2}.kg$)	$\Delta_{tr}\varphi_v^0\times10^6$ ($m^3.mol^{-1}$)	$E_\varphi^0\times10^8$ ($m^3.mol^{-1}.K^{-1}$)	$(\delta E^0\varphi/\delta T)_p\times10^8$ ($m^3.mol^{-1}.K^{-2}$)
293.15K	129.71	0.85	5.07	9.84	-0.24
298.15K	130.14	0.96	4.82	8.64	
303.15K	130.53	0.96	4.72	7.44	
308.15K	130.94	0.90	4.79	6.24	
313.15K	131.17	1.11	4.65	5.04	
318.15K	131.40	1.08	4.62	3.84	

Table 4.45: Limiting apparent molar volume (φ_v^0), experimental slope (S_V), limiting apparent molar volume transfer ($\Delta\varphi_v^0$), limiting apparent molar volume expansibilities (E_φ^0) and $(\delta E^0\varphi/\delta T)_p$ of L-lysine in aqueous 0.50 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively

Temp (K)	$\varphi_v^0\times10^6$ ($m^3.mol^{-1}$)	$S_V\times10^6$ ($m^3.mol^{-2}.kg$)	$\Delta_{tr}\varphi_v^0\times10^6$ ($m^3.mol^{-1}$)	$E_\varphi^0\times10^8$ ($m^3.mol^{-1}.K^{-1}$)	$(\delta E^0\varphi/\delta T)_p\times10^8$ ($m^3.mol^{-1}.K^{-2}$)
293.15K	130.99	1.42	6.36	7.54	-0.12
298.15K	131.31	1.67	5.99	6.94	
303.15K	131.67	1.67	5.86	6.34	
308.15K	132.01	1.72	5.86	5.74	
313.15K	132.23	1.86	5.71	5.14	
318.15K	132.49	1.81	5.72	4.54	

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

m/mol.kg^{-1}	Glycine + water					
	$\bar{V}_2 \times 10^6$/m^{3}·mol^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.05016	43.20	43.64	43.99	44.27	44.40	44.65
0.10001	43.45	43.86	44.20	44.51	44.62	44.92
0.15002	43.68	44.06	44.38	44.74	44.85	45.17
0.19991	43.89	44.23	44.55	44.93	45.05	45.37
0.24989	44.07	44.40	44.71	45.08	45.20	45.56
0.30042	44.23	44.54	44.86	45.25	45.37	45.73
0.34988	44.39	44.68	45.00	45.39	45.50	45.89
0.40091	44.53	44.81	45.13	45.53	45.63	46.04
0.45087	44.66	44.91	45.23	45.64	45.74	46.18
0.50109	44.78	45.03	45.35	45.76	45.85	46.34

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

m/mol.kg^{-1}	L-ornithine + water					
	$\bar{V}_2 \times 10^6$/m^{3}·mol^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.05001	107.96	108.51	109.03	109.36	109.68	110.18
0.09992	108.37	108.97	109.44	109.83	110.11	110.63
0.14991	108.74	109.32	109.79	110.25	110.54	111.02
0.19949	109.10	109.64	110.12	110.60	110.86	111.39
0.24988	109.45	109.97	110.44	110.93	111.23	111.75
0.30001	109.79	110.30	110.77	111.27	111.53	112.08
0.35001	110.09	110.58	111.05	111.56	111.81	112.40
0.39909	110.40	110.86	111.32	111.85	112.12	112.72
0.45018	110.71	111.16	111.62	112.17	112.40	113.00
0.50099	110.99	111.42	111.88	112.44	112.66	113.29

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

m/mol.kg^{-1}	L-lysine + water					
	$\bar{V}_2 \times 10^6$/m^3·mol^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.04998	125.27	125.93	126.42	126.83	127.17	127.50
0.09998	125.68	126.31	126.81	127.23	127.54	127.93
0.14991	126.06	126.64	127.15	127.57	127.89	128.28
0.20011	126.38	126.93	127.44	127.94	128.20	128.66
0.24991	126.71	127.25	127.75	128.27	128.52	128.96
0.30003	127.02	127.54	128.04	128.58	128.80	129.27
0.35005	127.30	127.80	128.30	128.85	129.07	129.56
0.40002	127.59	128.07	128.57	129.11	129.34	129.85
0.45024	127.85	128.32	128.81	129.36	129.60	130.13
0.50004	128.13	128.60	129.10	129.66	129.87	130.41

Table 4.49: Partial molar volume ($\bar{V}_2$) of aqueous solution of fructose (0.05 mol.kg^{-1}) with glycine as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	Glycine + water + 0.05 mol.kg^{-1} fructose					
	$\bar{V}_2 \times 10^6$/m^3·mol^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.05033	43.65	43.89	44.18	44.47	44.63	44.75
0.10013	43.90	44.15	44.44	44.71	44.92	44.99
0.15034	44.10	44.36	44.67	44.92	45.16	45.20
0.20018	44.28	44.55	44.87	45.12	45.37	45.40
0.25021	44.45	44.73	45.03	45.30	45.55	45.57
0.29952	44.62	44.88	45.20	45.47	45.71	45.71
0.35013	44.79	45.02	45.34	45.60	45.86	45.84
0.40012	44.94	45.15	45.47	45.73	46.01	45.99
0.45044	45.07	45.29	45.61	45.87	46.13	46.10
0.50061	45.21	45.42	45.73	45.99	46.25	46.23

Table 4.50: Partial molar volume ($\bar{V}_2$) of aqueous solution of fructose (0.20 mol.kg^{-1}) with glycine as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	Glycine + water + 0.20 mol.kg^{-1} fructose					
	$\bar{V}_2$×10^6/m^3·mol^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.04987	45.01	45.21	45.48	45.69	45.90	46.01
0.09987	45.21	45.39	45.69	45.92	46.13	46.21
0.14963	45.38	45.56	45.86	46.10	46.31	46.37
0.19952	45.51	45.69	45.98	46.25	46.44	46.49
0.24961	45.65	45.82	46.11	46.38	46.58	46.61
0.29987	45.76	45.93	46.23	46.48	46.71	46.72
0.34989	45.87	46.04	46.34	46.59	46.81	46.81
0.40085	45.97	46.12	46.43	46.69	46.92	46.91
0.45097	46.07	46.21	46.52	46.79	47.02	47.00
0.50163	46.16	46.29	46.60	46.87	47.11	47.08

Table 4.51: Partial molar volume ($\bar{V}_2$) of aqueous solution of fructose (0.35 mol.kg^{-1}) with glycine as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	Glycine + water + 0.35 mol.kg^{-1} fructose					
	$\bar{V}_2$×10^6/m^3·mol^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.05008	46.02	46.25	46.47	46.70	46.90	46.95
0.09978	46.22	46.43	46.65	46.90	47.11	47.13
0.15056	46.37	46.57	46.80	47.07	47.28	47.27
0.19968	46.50	46.71	46.93	47.20	47.41	47.40
0.24991	46.61	46.83	47.05	47.32	47.53	47.51
0.29961	46.71	46.92	47.16	47.43	47.65	47.62
0.35035	46.81	47.02	47.26	47.53	47.76	47.72
0.40009	46.90	47.10	47.35	47.61	47.84	47.80
0.45051	47.01	47.18	47.44	47.71	47.93	47.88
0.49919	47.09	47.26	47.52	47.78	48.02	47.95

Table 4.52: Partial molar volume ($\bar{V}_2$) of aqueous solution of fructose (0.50mol.kg^{-1}) with glycine as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	Glycine + water + 0.50 mol.kg^{-1} fructose					
	$\bar{V}_2$×10^6/m^3·mol^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.04938	46.39	46.56	46.83	46.99	47.13	47.26
0.09971	46.64	46.78	47.05	47.24	47.39	47.49
0.14938	46.83	46.96	47.22	47.42	47.57	47.66
0.19971	46.99	47.11	47.37	47.59	47.75	47.82
0.24949	47.14	47.24	47.50	47.74	47.92	47.94
0.29971	47.27	47.37	47.64	47.87	48.07	48.08
0.35085	47.39	47.49	47.76	47.99	48.21	48.20
0.39934	47.52	47.62	47.88	48.11	48.32	48.30
0.45091	47.63	47.74	48.00	48.23	48.45	48.41
0.49899	47.75	47.86	48.13	48.36	48.57	48.52

Table 4.53: Partial molar volume ($\bar{V}_2$) of aqueous solution of fructose (0.05 mol.kg^{-1}) with L-ornithine as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-ornithine + water + 0.05 mol.kg^{-1} fructose					
	$\bar{V}_2$×10^6/m^3·mol^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.04981	108.92	109.44	109.91	110.22	110.52	110.64
0.09979	109.28	109.77	110.24	110.61	110.92	111.00
0.15022	109.62	110.11	110.57	110.94	111.25	111.34
0.20001	109.94	110.41	110.87	111.24	111.56	111.64
0.25012	110.25	110.70	111.17	111.55	111.86	111.94
0.30021	110.53	110.98	111.45	111.83	112.16	112.23
0.34993	110.83	111.24	111.70	112.08	112.44	112.49
0.39991	111.08	111.50	111.96	112.34	112.69	112.73
0.45005	111.32	111.73	112.19	112.57	112.91	112.96
0.50086	111.56	111.96	112.42	112.80	113.14	113.22

Table 4.54: Partial molar volume ($\bar{V}_2$) of aqueous solution of fructose (0.20 mol.kg^{-1}) with L-ornithine as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-ornithine + water + 0.20 mol.kg^{-1} fructose					
	$\bar{V}_2$×10^6/m^3·mol^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.04964	111.12	111.43	111.86	112.16	112.45	112.61
0.09971	111.44	111.75	112.20	112.52	112.82	112.96
0.14981	111.70	112.03	112.46	112.82	113.09	113.24
0.20032	111.95	112.27	112.70	113.06	113.36	113.46
0.24975	112.15	112.52	112.95	113.31	113.60	113.70
0.29982	112.37	112.74	113.18	113.53	113.88	113.94
0.34990	112.59	112.95	113.38	113.76	114.10	114.16
0.39986	112.81	113.17	113.60	113.96	114.28	114.32
0.44934	113.03	113.38	113.82	114.17	114.50	114.52
0.49978	113.25	113.59	114.03	114.38	114.71	114.73

Table 4.55: Partial molar volume ($\bar{V}_2$) of aqueous solution of fructose (0.35 mol.kg^{-1}) with L-ornithine as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-ornithine + water + 0.35 mol.kg^{-1} fructose					
	$\bar{V}_2$×10^6/m^3·mol^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.05009	112.49	112.90	113.24	113.57	113.84	113.97
0.10014	112.82	113.23	113.56	113.93	114.19	114.28
0.14975	113.09	113.50	113.85	114.23	114.51	114.57
0.19915	113.33	113.76	114.13	114.51	114.78	114.84
0.24995	113.61	114.02	114.39	114.77	115.07	115.10
0.29971	113.85	114.24	114.63	114.99	115.30	115.32
0.35036	114.08	114.46	114.87	115.24	115.54	115.54
0.39941	114.31	114.67	115.06	115.42	115.74	115.75
0.45002	114.53	114.89	115.28	115.64	115.96	115.96
0.49991	114.75	115.10	115.49	115.84	116.18	116.15

Table 4.56: Partial molar volume ($\bar{V}_2$) of aqueous solution of fructose (0.50 mol.kg^{-1}) with L-ornithine as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-ornithine + water + 0.50 mol.kg^{-1} fructose					
	$\bar{V}_2 \times 10^6/\text{m}^3 \cdot \text{mol}^{-1}$					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.05071	113.95	114.28	114.72	115.01	115.28	115.45
0.09939	114.25	114.59	115.02	115.31	115.60	115.74
0.14922	114.55	114.86	115.31	115.62	115.87	115.99
0.20031	114.82	115.14	115.57	115.88	116.13	116.23
0.24982	115.10	115.40	115.79	116.12	116.37	116.45
0.29939	115.34	115.65	116.05	116.37	116.62	116.69
0.34861	115.57	115.88	116.27	116.59	116.88	116.92
0.40063	115.82	116.12	116.51	116.83	117.12	117.14
0.45021	116.04	116.33	116.72	117.04	117.33	117.34
0.49932	116.26	116.55	116.93	117.26	117.56	117.56

Table 4.57: Partial molar volume ($\bar{V}_2$) of aqueous solution of fructose (0.05 mol.kg^{-1}) with L-lysine as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-lysine + water + 0.05 mol.kg^{-1} fructose					
	$\bar{V}_2 \times 10^6/\text{m}^3 \cdot \text{mol}^{-1}$					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.05018	125.91	126.43	126.99	127.33	127.63	127.81
0.10019	126.34	126.88	127.36	127.72	128.07	128.20
0.15011	126.72	127.23	127.73	128.13	128.47	128.59
0.19944	127.09	127.58	128.08	128.49	128.83	128.93
0.24971	127.44	127.92	128.41	128.82	129.19	129.31
0.30027	127.76	128.23	128.72	129.13	129.52	129.60
0.34982	128.08	128.52	129.00	129.41	129.80	129.91
0.40051	128.38	128.83	129.31	129.73	130.10	130.17
0.45029	128.66	129.09	129.58	130.00	130.36	130.42
0.50099	128.89	129.30	129.79	130.24	130.60	130.66

Table 4.58: Partial molar volume ($\bar{V}_2$) of aqueous solution of fructose (0.20 mol.kg^{-1}) with L-lysine as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-lysine + water + 0.20 mol.kg^{-1} fructose					
	$\bar{V}_2$×10^{6}/m^{3}·mol^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.04948	128.19	128.50	129.01	129.37	129.68	129.91
0.09950	128.51	128.84	129.33	129.68	129.99	130.20
0.14951	128.79	129.16	129.62	130.01	130.31	130.50
0.19982	129.04	129.42	129.89	130.29	130.59	130.76
0.25015	129.27	129.67	130.15	130.54	130.86	130.98
0.29969	129.49	129.90	130.36	130.75	131.10	131.21
0.35020	129.72	130.10	130.57	130.96	131.31	131.41
0.39985	129.94	130.32	130.78	131.18	131.52	131.61
0.45008	130.17	130.52	130.96	131.35	131.70	131.78
0.50041	130.39	130.72	131.16	131.56	131.93	131.98

Table 4.59: Partial molar volume ($\bar{V}_2$) of aqueous solution of fructose (0.35 mol.kg^{-1}) with L-lysine as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-lysine + water + 0.35 mol.kg^{-1} fructose					
	$\bar{V}_2$×10^{6}/m^{3}·mol^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.04989	130.19	130.59	130.99	131.41	131.67	131.82
0.09969	130.42	130.81	131.21	131.64	131.92	132.05
0.14941	130.60	130.99	131.41	131.83	132.12	132.23
0.19930	130.76	131.15	131.57	131.98	132.30	132.38
0.24962	130.90	131.27	131.69	132.11	132.45	132.53
0.29973	131.04	131.41	131.84	132.26	132.60	132.67
0.34995	131.17	131.55	131.98	132.40	132.76	132.80
0.40024	131.29	131.68	132.10	132.52	132.89	132.92
0.45046	131.41	131.79	132.22	132.63	133.02	133.04
0.49971	131.54	131.91	132.34	132.75	133.14	133.14

Table 4.60: Partial molar volume ($\bar{V}_2$) of aqueous solution of fructose (0.50mol.kg^{-1}) with L-lysine as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-lysine + water + 0.50 mol.kg^{-1} fructose					
	$\bar{V}_2$×10^6/m^3·mol^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.05063	131.50	131.79	132.15	132.50	132.74	132.93
0.10041	131.76	132.04	132.42	132.78	133.04	133.21
0.15001	131.98	132.26	132.66	133.02	133.28	133.43
0.20015	132.17	132.47	132.88	133.23	133.51	133.64
0.24963	132.33	132.64	133.05	133.41	133.73	133.83
0.30105	132.51	132.83	133.24	133.61	133.94	134.00
0.35055	132.67	132.98	133.41	133.76	134.11	134.17
0.40086	132.81	133.13	133.55	133.92	134.25	134.31
0.44971	132.96	133.27	133.69	134.05	134.40	134.45
0.49992	133.10	133.41	133.83	134.19	134.52	134.58

Table 4.61: Sound velocity (u) of aqueous glycine as a function of molality at different temperature

m/mol.kg^{-1}	Glycine + water					
	Sound velocity, u/m.s^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1482.68	1496.51	1508.77	1519.4	1528.46	1536.24
0.05016	1485.48	1499.21	1511.49	1522.05	1531.03	1538.71
0.10001	1488.23	1501.91	1514.07	1524.56	1533.48	1541.13
0.15002	1490.99	1504.61	1516.71	1527.11	1535.95	1543.52
0.19991	1493.6	1507.22	1519.25	1529.58	1538.38	1545.88
0.24989	1496.22	1509.78	1521.78	1532.02	1540.76	1548.21
0.30042	1498.82	1512.35	1524.24	1534.46	1543.15	1550.56
0.34988	1501.39	1514.86	1526.67	1536.83	1545.46	1552.85
0.40091	1504.09	1517.43	1529.18	1539.3	1547.89	1555.21
0.45087	1506.72	1519.99	1531.65	1541.73	1550.26	1557.51
0.50109	1509.29	1522.57	1534.18	1544.17	1552.68	1559.84

Table 4.62: Sound velocity (u) of aqueous L-ornithine as a function of molality at different temperature

$m/mol.kg^{-1}$	L-ornithine + water					
	Sound velocity, $u/m.s^{-1}$					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1482.68	1496.51	1508.77	1519.4	1528.46	1536.24
0.05001	1489.15	1502.9	1515.004	1525.52	1534.48	1542.14
0.09992	1495.39	1509.08	1521.12	1531.5	1540.32	1547.77
0.14991	1501.5	1515.12	1527.02	1537.27	1545.99	1553.27
0.19949	1507.53	1520.94	1532.7	1542.82	1551.42	1558.6
0.24988	1513.71	1527.01	1538.58	1548.61	1556.91	1563.99
0.30001	1519.42	1532.52	1543.99	1553.88	1562.28	1569.26
0.35001	1525.19	1538.14	1549.48	1559.25	1567.53	1574.41
0.39909	1530.76	1543.43	1554.63	1564.31	1572.51	1579.33
0.45018	1536.64	1549.11	1559.96	1569.82	1578.01	1584.71
0.50099	1542.74	1554.91	1565.66	1575.38	1583.49	1590.11

Table 4.63: Sound velocity (u) of aqueous L-lysine as a function of molality at different temperature

$m/mol.kg^{-1}$	L-lysine + water					
	Sound velocity, $u/m.s^{-1}$					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1482.68	1496.51	1508.77	1519.4	1528.46	1536.24
0.04998	1489.73	1503.46	1515.52	1526.01	1534.91	1542.41
0.09998	1496.59	1510.21	1522.16	1532.45	1541.22	1548.51
0.14991	1503.33	1516.77	1528.54	1538.68	1547.29	1554.46
0.20011	1510.01	1523.25	1534.84	1544.82	1553.3	1560.34
0.24991	1516.63	1529.61	1541.11	1550.91	1559.22	1566.14
0.30003	1523.04	1535.87	1547.11	1556.8	1565.01	1571.8
0.35005	1529.35	1541.98	1553.06	1562.58	1570.62	1577.27
0.40002	1535.56	1547.89	1558.81	1568.18	1576.12	1582.8
0.45024	1541.91	1554.01	1564.84	1573.84	1581.81	1588.14
0.50004	1547.8	1559.89	1570.45	1579.51	1587.16	1593.47

Table 4.64: Sound velocity (u) of glycine in aqueous solution of fructose (0.05 mol.kg^{-1}) as a function of molality at different temperature

m/mol.kg^{-1}	Glycine + water + 0.05 mol.kg^{-1} fructose					
	Sound velocity, u/m.s^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1486.07	1499.7	1511.84	1522.33	1531.25	1538.7
0.05033	1488.85	1502.48	1514.56	1524.98	1533.82	1541.22
0.10013	1491.59	1505.23	1517.24	1527.57	1536.36	1543.67
0.15034	1494.29	1507.89	1519.82	1530.09	1538.82	1546.08
0.20018	1496.89	1510.43	1522.29	1532.49	1541.17	1548.34
0.25021	1499.49	1512.95	1524.81	1534.91	1543.52	1550.66
0.29952	1502.00	1515.45	1527.19	1537.28	1545.83	1552.96
0.35013	1504.65	1518.01	1529.72	1539.72	1548.22	1555.30
0.40012	1507.19	1520.48	1532.09	1541.99	1550.51	1557.53
0.45044	1509.85	1522.95	1534.46	1544.36	1552.76	1559.74
0.50061	1512.42	1525.44	1536.85	1546.7	1555.04	1561.98

Table 4.65: Sound velocity (u) of glycine in aqueous solution of fructose (0.20 mol.kg^{-1}) as a function of molality at different temperature

m/mol.kg^{-1}	Glycine + water + 0.20 mol.kg^{-1} fructose					
	Sound velocity, u/m.s^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1496.34	1509.67	1521.36	1531.38	1539.83	1546.86
0.04987	1499.08	1512.31	1523.92	1533.87	1542.28	1549.31
0.09987	1501.74	1514.88	1526.42	1536.33	1544.71	1551.61
0.14963	1504.30	1517.39	1528.84	1538.65	1546.96	1553.88
0.19952	1506.90	1519.90	1531.28	1541.05	1549.31	1556.14
0.24961	1509.54	1522.42	1533.73	1543.44	1551.64	1558.42
0.29987	1512.04	1524.91	1536.16	1545.81	1553.96	1560.69
0.34989	1514.64	1527.41	1538.58	1548.16	1556.25	1562.94
0.40085	1517.15	1529.85	1540.94	1550.53	1558.54	1565.21
0.45097	1519.63	1532.29	1543.35	1552.83	1560.81	1567.41
0.50163	1522.26	1534.79	1545.77	1555.19	1563.12	1569.65

Table 4.66: Sound velocity (u) of glycine in aqueous solution of fructose (0.35 $mol.kg^{-1}$) as a function of molality at different temperature

$m/mol.kg^{-1}$	Glycine + water + 0.35 $mol.kg^{-1}$ fructose					
	Sound velocity, $u/m.s^{-1}$					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1506.29	1519.21	1530.4	1539.97	1548.02	1554.65
0.05008	1509.01	1521.8	1532.93	1542.42	1550.42	1557.01
0.09978	1511.64	1524.31	1535.36	1544.79	1552.74	1559.29
0.15056	1514.27	1526.84	1537.82	1547.21	1555.11	1561.60
0.19968	1516.77	1529.28	1540.20	1549.55	1557.39	1563.83
0.24991	1519.35	1531.73	1542.59	1551.86	1559.66	1566.03
0.29961	1521.90	1534.13	1544.95	1554.12	1561.88	1568.23
0.35035	1524.37	1536.63	1547.36	1556.54	1564.23	1570.53
0.40009	1526.89	1539.07	1549.74	1558.84	1566.48	1572.73
0.45051	1529.28	1541.42	1552.02	1561.07	1568.65	1574.86
0.49919	1531.61	1543.75	1554.31	1563.31	1570.83	1577

Table 4.67: Sound velocity (u) of glycine in aqueous solution of fructose (0.50 $mol.kg^{-1}$) as a function of molality at different temperature

$m/mol.kg^{-1}$	Glycine + water + 0.50 $mol.kg^{-1}$ fructose					
	Sound velocity, $u/m.s^{-1}$					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1516.37	1528.73	1539.44	1548.58	1556.22	1562.46
0.04938	1518.91	1531.24	1541.88	1550.96	1558.55	1564.74
0.09971	1521.48	1533.72	1544.30	1553.32	1560.85	1567.00
0.14938	1524.03	1536.14	1546.68	1555.64	1563.13	1569.23
0.19971	1526.59	1538.61	1549.09	1557.98	1565.39	1571.45
0.24949	1529.08	1541.04	1551.44	1560.29	1567.67	1573.68
0.29971	1531.62	1543.40	1553.74	1562.55	1569.88	1575.85
0.35085	1534.09	1545.82	1556.09	1564.82	1572.12	1578.07
0.39934	1536.44	1548.15	1558.38	1567.05	1574.28	1580.22
0.45091	1538.90	1550.58	1560.72	1569.33	1576.51	1582.44
0.49899	1541.28	1552.9	1562.98	1571.54	1578.69	1584.48

Table 4.68: Sound velocity (u) of L-ornithine in aqueous solution of fructose (0.05 mol.kg^{-1}) as a function of molality at different temperature

m/mol.kg^{-1}	L-ornithine + water + 0.05 mol.kg^{-1} fructose					
	Sound velocity, u/m.s^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1486.07	1499.7	1511.84	1522.33	1531.25	1538.7
0.04981	1492.39	1506.02	1518.01	1528.42	1537.25	1544.58
0.09979	1498.65	1512.26	1524.07	1534.38	1543.05	1550.24
0.15022	1504.89	1518.31	1530.04	1540.13	1548.69	1555.83
0.20001	1510.88	1524.12	1535.70	1545.68	1554.14	1561.18
0.25012	1516.79	1529.88	1541.33	1551.20	1559.57	1566.51
0.30021	1522.59	1535.58	1546.91	1556.67	1564.93	1571.77
0.34993	1528.16	1540.98	1552.19	1561.65	1570.04	1576.82
0.39991	1534.00	1546.66	1557.74	1567.24	1575.27	1581.93
0.45005	1539.66	1552.18	1563.09	1572.46	1580.38	1586.95
0.50086	1545.27	1557.63	1568.41	1577.67	1585.5	1591.99

Table 4.69: Sound velocity (u) of L-ornithine in aqueous solution of fructose (0.20 mol.kg^{-1}) as a function of molality at different temperature

m/mol.kg^{-1}	L-ornithine + water + 0.20 mol.kg^{-1} fructose					
	Sound velocity, u/m.s^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1496.34	1509.67	1521.36	1531.38	1539.83	1546.86
0.04964	1502.65	1515.9	1527.42	1537.31	1545.67	1552.6
0.09971	1508.75	1521.81	1533.21	1542.99	1551.25	1558.08
0.14981	1514.76	1527.74	1538.97	1548.65	1556.74	1563.52
0.20032	1520.77	1533.52	1544.64	1554.20	1562.25	1568.89
0.24975	1526.40	1538.99	1549.99	1559.43	1567.39	1573.95
0.29982	1532.17	1544.62	1555.50	1564.81	1572.65	1579.13
0.34990	1537.74	1549.84	1560.55	1569.97	1577.72	1584.12
0.39986	1543.41	1555.61	1566.21	1575.29	1582.94	1589.24
0.44934	1549.14	1561.15	1571.55	1580.46	1587.81	1594.09
0.49978	1554.48	1566.37	1576.71	1585.56	1592.99	1599.09

Table 4.70: Sound velocity (u) of L-ornithine in aqueous solution of fructose (0.35 mol.kg^{-1}) as a function of molality at different temperature

m/mol.kg^{-1}	L-ornithine + water + 0.35 mol.kg^{-1} fructose					
	Sound velocity, u/m.s^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1506.29	1519.21	1530.4	1539.97	1548.02	1554.65
0.05009	1512.57	1525.29	1536.35	1545.81	1553.76	1560.29
0.10014	1518.63	1531.18	1542.09	1551.44	1559.29	1565.74
0.14975	1524.49	1536.90	1547.71	1556.94	1564.70	1571.05
0.19915	1530.32	1542.69	1553.26	1562.37	1570.01	1576.28
0.24995	1536.37	1548.52	1559.07	1568.05	1575.60	1581.78
0.29971	1542.02	1554.05	1564.37	1573.24	1580.81	1586.83
0.35036	1547.55	1559.43	1569.57	1578.44	1585.84	1591.80
0.39941	1552.77	1564.46	1574.62	1583.28	1590.54	1596.47
0.45002	1558.24	1569.76	1579.80	1588.35	1595.52	1601.36
0.49991	1563.75	1575.16	1585.07	1593.5	1600.54	1606.26

Table 4.71: Sound velocity (u) of L-ornithine in aqueous solution of fructose (0.50 mol.kg^{-1}) as a function of molality at different temperature

m/mol.kg^{-1}	L-ornithine + water + 0.50 mol.kg^{-1} fructose					
	Sound velocity, u/m.s^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1516.37	1528.73	1539.44	1548.58	1556.22	1562.46
0.05071	1522.56	1534.74	1545.3	1554.33	1561.88	1568.03
0.09939	1528.39	1540.40	1550.86	1559.76	1567.20	1573.29
0.14922	1534.22	1546.14	1556.43	1565.30	1572.64	1578.62
0.20031	1540.05	1551.85	1562.06	1570.71	1578.03	1583.81
0.24982	1545.52	1557.20	1567.29	1575.85	1583.00	1588.81
0.29939	1551.04	1562.56	1572.52	1580.98	1588.05	1593.78
0.34861	1556.52	1567.79	1577.62	1585.96	1592.92	1598.57
0.40063	1562.03	1573.26	1582.99	1591.24	1598.10	1603.66
0.45021	1567.31	1578.42	1588.02	1596.17	1602.94	1608.42
0.49932	1572.62	1583.57	1593.04	1601.07	1607.75	1613.14

Table 4.72: Sound velocity (u) of L-lysine in aqueous solution of fructose (0.05 mol.kg^{-1}) as a function of molality at different temperature

m/mol.kg^{-1}	L-lysine + water + 0.05 mol.kg^{-1} fructose					
	Sound velocity, u/m.s^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1486.89	1500.74	1512.89	1523.39	1532.28	1539.69
0.05018	1493.28	1506.85	1518.83	1529.14	1537.88	1545.17
0.10019	1500.25	1513.72	1525.52	1535.66	1544.26	1551.43
0.15011	1506.92	1520.31	1531.98	1541.89	1550.36	1557.38
0.19944	1513.44	1526.54	1537.97	1547.82	1556.17	1563.08
0.24971	1519.86	1532.75	1544.02	1553.73	1561.94	1568.62
0.30027	1526.13	1538.81	1549.90	1559.44	1567.49	1574.14
0.34982	1532.24	1544.52	1555.43	1564.83	1572.78	1579.57
0.40051	1538.53	1550.85	1561.61	1570.84	1578.63	1585.05
0.45029	1544.59	1556.71	1567.27	1576.34	1583.99	1590.30
0.50099	1550.84	1562.8	1573.18	1582.09	1589.61	1595.81

Table 4.73: Sound velocity (u) of L-lysine in aqueous solution of fructose (0.20 mol.kg^{-1}) as a function of molality at different temperature

m/mol.kg^{-1}	L-lysine + water + 0.20 mol.kg^{-1} fructose					
	Sound velocity, u/m.s^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1496.37	1509.71	1521.38	1531.39	1539.84	1546.86
0.04948	1503.12	1516.28	1527.76	1537.65	1546	1552.88
0.09950	1509.79	1522.78	1534.08	1543.82	1552.05	1558.81
0.14951	1516.37	1529.15	1540.30	1549.88	1557.95	1564.61
0.19982	1522.91	1535.49	1546.46	1555.88	1563.80	1570.32
0.25015	1529.23	1541.67	1552.52	1561.78	1569.58	1575.98
0.29969	1535.59	1547.81	1558.46	1567.55	1575.18	1581.45
0.35020	1542.08	1554.11	1564.58	1573.44	1581.06	1587.13
0.39985	1548.58	1560.38	1570.59	1579.31	1586.71	1592.71
0.45008	1554.91	1566.61	1576.57	1585.06	1592.54	1598.37
0.50041	1561.07	1572.52	1582.5	1591.03	1598.15	1603.77

Table 4.74: Sound velocity (u) of L-lysine in aqueous solution of fructose (0.35 mol.kg^{-1}) as a function of molality at different temperature

m/mol.kg^{-1}	L-lysine + water + 0.35 mol.kg^{-1} fructose					
	Sound velocity, u/m.s^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1506.29	1519.21	1530.4	1539.97	1548.02	1554.65
0.04989	1513.05	1525.79	1536.81	1546.22	1554.14	1560.64
0.09969	1519.63	1532.11	1542.96	1552.25	1560.02	1566.44
0.14941	1526.05	1538.33	1549.01	1558.14	1565.80	1572.07
0.19930	1532.37	1544.47	1555.01	1564.01	1571.54	1577.69
0.24962	1538.56	1550.52	1560.90	1569.76	1577.15	1583.19
0.29973	1544.75	1556.55	1566.62	1575.32	1582.62	1588.59
0.34995	1550.95	1562.54	1572.52	1581.11	1588.29	1594.11
0.40024	1557.15	1568.51	1578.38	1586.78	1593.80	1599.48
0.45046	1563.20	1574.38	1584.10	1592.38	1599.25	1604.82
0.49971	1569.01	1580.02	1589.59	1597.71	1604.45	1609.9

Table 4.75: Sound velocity (u) of L-lysine in aqueous solution of fructose (0.50 mol.kg^{-1}) as a function of molality at different temperature

m/mol.kg^{-1}	L-lysine + water + 0.50 mol.kg^{-1} fructose					
	Sound velocity, u/m.s^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1516.51	1528.86	1539.55	1548.68	1556.32	1562.55
0.05063	1522.94	1535.11	1545.66	1554.66	1562.17	1568.25
0.10041	1529.23	1541.22	1551.62	1560.46	1567.84	1573.83
0.15001	1535.46	1547.28	1557.53	1566.23	1573.48	1579.38
0.20015	1541.79	1553.38	1563.41	1571.99	1579.19	1584.90
0.24963	1548.02	1559.39	1569.27	1577.75	1584.85	1590.41
0.30105	1554.24	1565.50	1575.24	1583.51	1590.40	1595.95
0.35055	1560.12	1571.20	1580.79	1588.94	1595.71	1601.16
0.40086	1566.16	1577.05	1586.46	1594.45	1601.08	1606.41
0.44971	1571.85	1582.60	1591.87	1599.72	1606.21	1611.43
0.49992	1577.69	1588.25	1597.37	1605.08	1611.46	1616.58

Table 4.76: Adiabatic compressibility ($\beta_s \times 10^{10}/Pa^{-1}$) of aqueous glycine as a function of molality ($m/mol.kg^{-1}$) at different temperature

$m/mol.kg^{-1}$	Glycine + water					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	4.56	4.48	4.41	4.36	4.31	4.28
0.05016	4.53	4.45	4.39	4.33	4.29	4.26
0.10001	4.51	4.43	4.37	4.31	4.27	4.24
0.15002	4.48	4.41	4.34	4.29	4.25	4.22
0.19991	4.46	4.39	4.32	4.27	4.23	4.20
0.24989	4.44	4.37	4.30	4.25	4.21	4.18
0.30042	4.42	4.34	4.28	4.23	4.19	4.16
0.34988	4.40	4.32	4.26	4.21	4.17	4.14
0.40091	4.37	4.30	4.24	4.19	4.15	4.12
0.45087	4.35	4.28	4.22	4.17	4.14	4.11
0.50109	4.33	4.26	4.20	4.15	4.12	4.09

Table 4.77: Adiabatic compressibility ($\beta_s \times 10^{10}/Pa^{-1}$) of aqueous L-ornithine as a function of molality ($m/mol.kg^{-1}$) at different temperature

$m/mol.kg^{-1}$	L-ornithine + water					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	4.56	4.48	4.41	4.36	4.31	4.28
0.05001	4.50	4.43	4.36	4.31	4.27	4.23
0.09992	4.45	4.38	4.31	4.26	4.22	4.19
0.14991	4.40	4.33	4.27	4.22	4.18	4.15
0.19949	4.36	4.28	4.23	4.18	4.14	4.11
0.24988	4.31	4.24	4.18	4.13	4.10	4.07
0.30001	4.26	4.20	4.14	4.10	4.06	4.03
0.35001	4.22	4.16	4.10	4.06	4.02	3.99
0.39909	4.18	4.12	4.06	4.02	3.99	3.96
0.45018	4.14	4.08	4.03	3.98	3.95	3.92
0.50099	4.09	4.03	3.99	3.94	3.91	3.89

Table 4.78: Adiabatic compressibility ($\beta_s \times 10^{10}$/Pa^{-1}) of aqueous L-lysine as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-lysine + water					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	4.56	4.48	4.41	4.36	4.31	4.28
0.04998	4.50	4.42	4.36	4.31	4.27	4.23
0.09998	4.45	4.37	4.31	4.26	4.22	4.19
0.14991	4.39	4.32	4.26	4.21	4.17	4.14
0.20011	4.34	4.27	4.22	4.17	4.13	4.10
0.24991	4.30	4.23	4.17	4.13	4.09	4.06
0.30003	4.25	4.18	4.13	4.08	4.05	4.02
0.35005	4.20	4.14	4.09	4.04	4.01	3.98
0.40002	4.16	4.10	4.05	4.01	3.97	3.95
0.45024	4.11	4.06	4.01	3.97	3.93	3.91
0.50004	4.07	4.02	3.97	3.93	3.90	3.88

Table 4.79: Adiabatic compressibility ($\beta_s \times 10^{10}$/Pa^{-1}) of glycine in aqueous solution of fructose (0.05 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	Glycine + water + 0.05 mol.kg^{-1} fructose					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	4.52	4.44	4.38	4.33	4.28	4.25
0.05033	4.50	4.42	4.36	4.30	4.26	4.23
0.10013	4.47	4.40	4.33	4.28	4.24	4.21
0.15034	4.45	4.37	4.31	4.26	4.22	4.19
0.20018	4.43	4.35	4.29	4.24	4.20	4.17
0.25021	4.40	4.33	4.27	4.22	4.18	4.15
0.29952	4.38	4.31	4.25	4.20	4.16	4.14
0.35013	4.36	4.29	4.23	4.18	4.15	4.12
0.40012	4.34	4.27	4.21	4.17	4.13	4.10
0.45044	4.32	4.25	4.19	4.15	4.11	4.08
0.50061	4.30	4.23	4.17	4.13	4.09	4.06

Table 4.80: Adiabatic compressibility ($\beta_s \times 10^{10}/Pa^{-1}$) of glycine in aqueous solution of fructose (0.20mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	Glycine + water + 0.20 mol.kg^{-1} fructose					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	4.41	4.34	4.28	4.23	4.19	4.16
0.04987	4.39	4.32	4.26	4.21	4.17	4.15
0.09987	4.37	4.30	4.24	4.19	4.16	4.13
0.14963	4.35	4.28	4.22	4.17	4.14	4.11
0.19952	4.33	4.26	4.20	4.15	4.12	4.09
0.24961	4.30	4.24	4.18	4.14	4.10	4.07
0.29987	4.28	4.22	4.16	4.12	4.08	4.06
0.34989	4.26	4.20	4.14	4.10	4.06	4.04
0.40085	4.24	4.18	4.12	4.08	4.05	4.02
0.45097	4.22	4.16	4.11	4.06	4.03	4.00
0.50163	4.20	4.14	4.09	4.05	4.01	3.99

Table 4.81: Adiabatic compressibility ($\beta_s \times 10^{10}/Pa^{-1}$) of glycine in aqueous solution of fructose (0.35 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	Glycine + water + 0.35 mol.kg^{-1} fructose					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	4.31	4.25	4.19	4.15	4.11	4.08
0.05008	4.29	4.22	4.17	4.13	4.09	4.07
0.09978	4.27	4.21	4.15	4.11	4.07	4.05
0.15056	4.25	4.19	4.13	4.09	4.06	4.03
0.19968	4.23	4.17	4.11	4.07	4.04	4.01
0.24991	4.21	4.15	4.10	4.05	4.02	4.00
0.29961	4.19	4.13	4.08	4.04	4.00	3.98
0.35035	4.17	4.11	4.06	4.02	3.99	3.96
0.40009	4.15	4.09	4.04	4.00	3.97	3.95
0.45051	4.13	4.07	4.02	3.99	3.95	3.93
0.49919	4.11	4.06	4.01	3.97	3.94	3.92

Table 4.82: Adiabatic compressibility ($\beta_s \times 10^{10}/Pa^{-1}$) of glycine in aqueous solution of fructose (0.50 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	Glycine + water + 0.50 mol.kg^{-1} fructose					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	4.22	4.15	4.10	4.06	4.03	4.01
0.04938	4.20	4.14	4.08	4.04	4.01	3.99
0.09971	4.18	4.12	4.07	4.03	4.00	3.97
0.14938	4.16	4.10	4.05	4.01	3.98	3.96
0.19971	4.14	4.08	4.03	3.99	3.96	3.94
0.24949	4.12	4.06	4.01	3.98	3.95	3.92
0.29971	4.10	4.04	4.00	3.96	3.93	3.91
0.35085	4.08	4.03	3.98	3.94	3.91	3.89
0.39934	4.06	4.01	3.96	3.93	3.90	3.88
0.45091	4.04	3.99	3.95	3.91	3.88	3.86
0.49899	4.03	3.97	3.93	3.89	3.87	3.85

Table 4.83: Adiabatic compressibility ($\beta_s \times 10^{10}/Pa^{-1}$) of L-ornithine in aqueous solution of fructose (0.05 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-ornithine + water + 0.05 mol.kg^{-1} fructose					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	4.52	4.44	4.38	4.33	4.28	4.25
0.04981	4.47	4.39	4.33	4.28	4.24	4.21
0.09979	4.42	4.34	4.28	4.23	4.19	4.16
0.15022	4.37	4.30	4.24	4.19	4.15	4.12
0.20001	4.32	4.25	4.20	4.15	4.11	4.08
0.25012	4.28	4.21	4.15	4.11	4.07	4.04
0.30021	4.23	4.17	4.11	4.07	4.03	4.01
0.34993	4.19	4.13	4.07	4.03	4.00	3.97
0.39991	4.15	4.09	4.03	3.99	3.96	3.93
0.45005	4.11	4.05	4.00	3.96	3.92	3.90
0.50086	4.07	4.01	3.96	3.92	3.89	3.87

Table 4.84: Adiabatic compressibility ($\beta_s \times 10^{10}$/Pa^{-1}) of L-ornithine in aqueous solution of fructose (0.20mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-ornithine + water + 0.20 mol.kg^{-1} fructose					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	4.41	4.34	4.28	4.23	4.19	4.16
0.04964	4.36	4.29	4.23	4.19	4.15	4.12
0.09971	4.32	4.25	4.19	4.15	4.11	4.08
0.14981	4.27	4.20	4.15	4.10	4.07	4.04
0.20032	4.23	4.16	4.11	4.06	4.03	4.00
0.24975	4.18	4.12	4.07	4.03	3.99	3.97
0.29982	4.14	4.08	4.03	3.99	3.96	3.93
0.34990	4.10	4.04	3.99	3.95	3.92	3.90
0.39986	4.06	4.00	3.96	3.92	3.89	3.86
0.44934	4.02	3.97	3.92	3.88	3.85	3.83
0.49978	3.98	3.93	3.88	3.85	3.82	3.80

Table 4.85: Adiabatic compressibility ($\beta_s \times 10^{10}$/Pa^{-1}) of L-ornithine in aqueous solution of fructose (0.35 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-ornithine + water + 0.35 mol.kg^{-1} fructose					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	4.31	4.25	4.19	4.15	4.11	4.08
0.05009	4.27	4.20	4.15	4.10	4.07	4.04
0.10014	4.22	4.16	4.10	4.06	4.03	4.01
0.14975	4.18	4.12	4.06	4.02	3.99	3.97
0.19915	4.14	4.07	4.03	3.99	3.96	3.93
0.24995	4.09	4.03	3.99	3.95	3.92	3.90
0.29971	4.05	4.00	3.95	3.91	3.88	3.86
0.35036	4.01	3.96	3.91	3.88	3.85	3.83
0.39941	3.98	3.92	3.88	3.84	3.82	3.80
0.45002	3.94	3.89	3.85	3.81	3.78	3.77
0.49991	3.90	3.85	3.81	3.78	3.75	3.73

Table 4.86: Adiabatic compressibility ($\beta_s \times 10^{10}/Pa^{-1}$) of L-ornithine in aqueous solution of fructose (0.50 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-ornithine + water + 0.50 mol.kg^{-1} fructose					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	4.52	4.44	4.38	4.33	4.29	4.26
0.05031	4.46	4.39	4.33	4.28	4.24	4.21
0.10052	4.41	4.34	4.28	4.23	4.19	4.17
0.14902	4.36	4.29	4.24	4.19	4.15	4.13
0.19934	4.31	4.25	4.19	4.15	4.11	4.08
0.24911	4.27	4.20	4.15	4.11	4.07	4.05
0.29904	4.22	4.16	4.11	4.06	4.03	4.01
0.34936	4.17	4.11	4.06	4.02	3.99	3.97
0.4012	4.13	4.07	4.02	3.98	3.95	3.93
0.44891	4.09	4.03	3.99	3.95	3.92	3.90
0.50085	4.05	3.99	3.95	3.91	3.88	3.86

Table 4.87: Adiabatic compressibility ($\beta_s \times 10^{10}/Pa^{-1}$) of L-lysine in aqueous solution of fructose (0.05 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-lysine + water + 0.05 mol.kg^{-1} fructose					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	4.51	4.44	4.37	4.32	4.28	4.24
0.05018	4.46	4.39	4.33	4.27	4.23	4.20
0.10019	4.41	4.34	4.28	4.23	4.19	4.16
0.15011	4.36	4.29	4.23	4.18	4.14	4.12
0.19944	4.31	4.24	4.19	4.14	4.10	4.07
0.24971	4.26	4.20	4.14	4.10	4.06	4.04
0.30027	4.22	4.15	4.10	4.06	4.02	4.00
0.34982	4.17	4.11	4.06	4.02	3.99	3.96
0.40051	4.13	4.07	4.02	3.98	3.95	3.92
0.45029	4.09	4.03	3.98	3.94	3.91	3.89
0.50099	4.05	3.99	3.94	3.91	3.88	3.85

Table 4.88: Adiabatic compressibility ($\beta_s \times 10^{10}/Pa^{-1}$) of L-lysine in aqueous solution of fructose (0.20mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-lysine + water + 0.20 mol.kg^{-1} fructose					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	4.41	4.34	4.28	4.23	4.19	4.16
0.04948	4.36	4.29	4.23	4.19	4.15	4.12
0.09950	4.31	4.24	4.19	4.14	4.11	4.08
0.14951	4.26	4.20	4.14	4.10	4.07	4.04
0.19982	4.22	4.15	4.10	4.06	4.03	4.00
0.25015	4.17	4.11	4.06	4.02	3.99	3.96
0.29969	4.13	4.07	4.02	3.98	3.95	3.93
0.35020	4.08	4.03	3.98	3.94	3.91	3.89
0.39985	4.04	3.98	3.94	3.90	3.87	3.85
0.45008	4.00	3.94	3.90	3.87	3.84	3.82
0.50041	3.96	3.91	3.86	3.83	3.80	3.78

Table 4.89: Adiabatic compressibility ($\beta_s \times 10^{10}/Pa^{-1}$) of L-lysine in aqueous solution of fructose (0.35 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-lysine + water + 0.35 mol.kg^{-1} fructose					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	4.53	4.45	4.39	4.34	4.30	4.26
0.05082	4.50	4.42	4.36	4.31	4.27	4.24
0.50856	4.47	4.40	4.34	4.29	4.25	4.22
0.15012	4.44	4.37	4.31	4.26	4.22	4.19
0.20142	4.41	4.34	4.28	4.23	4.20	4.17
0.24991	4.38	4.31	4.26	4.21	4.18	4.15
0.29843	4.36	4.29	4.23	4.19	4.16	4.13
0.34905	4.33	4.27	4.21	4.17	4.13	4.11
0.40005	4.30	4.24	4.19	4.14	4.11	4.09
0.45081	4.28	4.21	4.16	4.12	4.09	4.06
0.50144	4.25	4.19	4.14	4.10	4.07	4.05

Table 4.90: Adiabatic compressibility ($\beta_s \times 10^{10}/Pa^{-1}$) of L-lysine in aqueous solution of fructose (0.50 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-lysine + water + 0.50 mol.kg^{-1} fructose					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	4.22	4.15	4.10	4.06	4.03	4.01
0.05063	4.17	4.11	4.06	4.02	3.99	3.97
0.10041	4.13	4.07	4.02	3.98	3.95	3.93
0.15001	4.08	4.03	3.98	3.94	3.92	3.89
0.20015	4.04	3.99	3.94	3.91	3.88	3.86
0.24963	4.00	3.95	3.90	3.87	3.84	3.82
0.30105	3.96	3.91	3.87	3.83	3.81	3.79
0.35055	3.92	3.87	3.83	3.80	3.77	3.76
0.40086	3.88	3.84	3.80	3.77	3.74	3.73
0.44971	3.85	3.80	3.76	3.73	3.71	3.69
0.49992	3.81	3.77	3.73	3.70	3.68	3.66

Table 4.91: Apparent molar adiabatic compressibility (φ_k) of aqueous glycine as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	Glycine + water					
	$\varphi_k \times 10^{14}/m^3.mol^{-1}.Pa^{-1}$					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.05016	-2.9499	-2.7216	-2.6583	-2.5148	-2.3789	-2.2315
0.10001	-2.9161	-2.7186	-2.5748	-2.4328	-2.3094	-2.2002
0.15002	-2.8943	-2.7038	-2.5589	-2.4065	-2.2807	-2.1677
0.19991	-2.8333	-2.6649	-2.5170	-2.3672	-2.2500	-2.1399
0.24989	-2.7915	-2.6229	-2.4839	-2.3332	-2.2168	-2.1107
0.30042	-2.7486	-2.5879	-2.4382	-2.2996	-2.1865	-2.0867
0.34988	-2.7191	-2.5586	-2.4070	-2.2712	-2.1590	-2.0652
0.40091	-2.7010	-2.5305	-2.3807	-2.2502	-2.1418	-2.0470
0.45087	-2.6824	-2.5145	-2.3624	-2.2347	-2.1265	-2.0288
0.50109	-2.6571	-2.4983	-2.3485	-2.2195	-2.1162	-2.0135

Table 4.92: Apparent molar adiabatic compressibility (φ_k) of aqueous L-ornithine as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-ornithine + water					
	φ_k ×10^{14}/m^3.mol^{-1}.Pa^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.05001	-5.8215	-5.5208	-5.1733	-4.9284	-4.7212	-4.5091
0.09992	-5.6298	-5.3408	-5.0572	-4.8005	-4.5763	-4.3179
0.14991	-5.4714	-5.1892	-4.8988	-4.6407	-4.4259	-4.1749
0.19949	-5.3561	-5.0406	-4.7485	-4.4920	-4.2801	-4.0478
0.24988	-5.2763	-4.9648	-4.6627	-4.4182	-4.1651	-3.9490
0.30001	-5.1204	-4.7976	-4.5075	-4.2638	-4.0619	-3.8549
0.35001	-5.0113	-4.6892	-4.4042	-4.1641	-3.9630	-3.7618
0.39909	-4.9049	-4.5672	-4.2849	-4.0521	-3.8556	-3.6649
0.45018	-4.8197	-4.4802	-4.1757	-3.9804	-3.8005	-3.6138
0.50099	-4.7739	-4.4218	-4.1270	-3.9285	-3.7522	-3.5702

Table 4.93: Apparent molar adiabatic compressibility (φ_k) of aqueous L-lysine as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-lysine + water					
	φ_k ×10^{14}/m^3.mol^{-1}.Pa^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.04998	-5.6046	-5.2697	-4.8737	-4.5941	-4.3198	-3.9457
0.09998	-5.4291	-5.0964	-4.7577	-4.4496	-4.1968	-3.8638
0.14991	-5.2889	-4.9352	-4.5926	-4.2979	-4.0421	-3.7609
0.20011	-5.1663	-4.7995	-4.4580	-4.1635	-3.9210	-3.6596
0.24991	-5.0705	-4.6830	-4.3638	-4.0680	-3.8227	-3.5810
0.30003	-4.9417	-4.5646	-4.2304	-3.9484	-3.7173	-3.4853
0.35005	-4.8252	-4.4489	-4.1209	-3.8404	-3.6071	-3.3811
0.40002	-4.7126	-4.3255	-4.0031	-3.7288	-3.5033	-3.3045
0.45024	-4.6323	-4.2446	-3.9358	-3.6388	-3.4347	-3.2129
0.50004	-4.5132	-4.1498	-3.8323	-3.5641	-3.3428	-3.1381

Table 4.94: Apparent molar adiabatic compressibility (φ_k) of glycine in aqueous solution of fructose (0.05 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	Glycine + water + 0.05 mol.kg^{-1} fructose					
	φ_k ×10^{14}/m^3.mol^{-1}.Pa^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.05033	-2.8244	-2.7306	-2.5814	-2.4363	-2.3055	-2.2156
0.10013	-2.8028	-2.7126	-2.5580	-2.4045	-2.2881	-2.1779
0.15034	-2.7607	-2.6522	-2.4931	-2.3501	-2.2347	-2.1339
0.20018	-2.7091	-2.5856	-2.4278	-2.2874	-2.1761	-2.0688
0.25021	-2.6690	-2.5326	-2.3941	-2.2467	-2.1346	-2.0366
0.29952	-2.6272	-2.4972	-2.3461	-2.2132	-2.1031	-2.0149
0.35013	-2.6048	-2.4678	-2.3236	-2.1884	-2.0802	-1.9937
0.40012	-2.5739	-2.4348	-2.2865	-2.1487	-2.0498	-1.9626
0.45044	-2.5609	-2.4031	-2.2520	-2.1239	-2.0202	-1.9343
0.50061	-2.5383	-2.3790	-2.2259	-2.1007	-1.9971	-1.9122

Table 4.95: Apparent molar adiabatic compressibility (φ_k) of glycine in aqueous solution of fructose (0.20mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	Glycine + water + 0.20 mol.kg^{-1} fructose					
	φ_k ×10^{14}/m^3.mol^{-1}.Pa^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.04987	-2.5332	-2.3384	-2.1813	-2.0543	-1.9728	-1.9445
0.09987	-2.4727	-2.2858	-2.1342	-2.0239	-1.9493	-1.8520
0.14963	-2.4123	-2.2429	-2.0875	-1.9610	-1.8756	-1.8098
0.19952	-2.3879	-2.2166	-2.0652	-1.9459	-1.8616	-1.7815
0.24961	-2.3752	-2.1961	-2.0477	-1.9300	-1.8428	-1.7631
0.29987	-2.3361	-2.1733	-2.0286	-1.9129	-1.8248	-1.7463
0.34989	-2.3237	-2.1575	-2.0125	-1.8962	-1.8082	-1.7312
0.40085	-2.2934	-2.1305	-1.9856	-1.8793	-1.7877	-1.7149
0.45097	-2.2693	-2.1118	-1.9732	-1.8608	-1.7723	-1.6971
0.50163	-2.2621	-2.1001	-1.9610	-1.8493	-1.7610	-1.6840

Table 4.96: Apparent molar adiabatic compressibility (φ_k) of glycine in aqueous solution of fructose (0.35 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	Glycine + water + 0.35 mol.kg^{-1} fructose					
	φ_k ×10^{14}/m^3.mol^{-1}.Pa^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.05008	-2.2731	-2.0557	-1.9368	-1.8067	-1.7229	-1.6621
0.09978	-2.2256	-2.0156	-1.8868	-1.7671	-1.6837	-1.6232
0.15056	-2.1837	-1.9849	-1.8576	-1.7484	-1.6658	-1.6000
0.19968	-2.1479	-1.9637	-1.8396	-1.7359	-1.6515	-1.5842
0.24991	-2.1281	-1.9381	-1.8167	-1.7089	-1.6278	-1.5554
0.29961	-2.1128	-1.9155	-1.7987	-1.6844	-1.6053	-1.5385
0.35035	-2.0784	-1.9048	-1.7838	-1.6820	-1.5997	-1.5326
0.40009	-2.0648	-1.8943	-1.7741	-1.6700	-1.5886	-1.5207
0.45051	-2.0315	-1.8701	-1.7496	-1.6469	-1.5656	-1.4988
0.49919	-2.0084	-1.8564	-1.7387	-1.6384	-1.5554	-1.4901

Table 4.97: Apparent molar adiabatic compressibility (φ_k) of glycine in aqueous solution of fructose (0.50 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	Glycine + water + 0.50 mol.kg^{-1} fructose					
	φ_k ×10^{14}/m^3.mol^{-1}.Pa^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.04938	-1.9607	-1.8696	-1.7428	-1.6463	-1.5718	-1.4981
0.09971	-1.9398	-1.8182	-1.6994	-1.6029	-1.5237	-1.4569
0.14938	-1.9316	-1.7859	-1.6778	-1.5806	-1.5076	-1.4386
0.19971	-1.9164	-1.7703	-1.6623	-1.5617	-1.4820	-1.4155
0.24949	-1.8953	-1.7557	-1.6437	-1.5471	-1.4719	-1.4070
0.29971	-1.8834	-1.7272	-1.6157	-1.5233	-1.4476	-1.3843
0.35085	-1.8559	-1.7074	-1.5953	-1.5003	-1.4275	-1.3680
0.39934	-1.8337	-1.6935	-1.5858	-1.4914	-1.4169	-1.3612
0.45091	-1.8103	-1.6764	-1.5660	-1.4721	-1.3977	-1.3463
0.49899	-1.7988	-1.6659	-1.5561	-1.4635	-1.3917	-1.3301

Table 4.98: Apparent molar adiabatic compressibility (φ_k) of L-ornithine in aqueous solution of fructose (0.05 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-ornithine + water + 0.05 mol.kg^{-1} fructose					
	φ_k ×10^{14}/m^3.mol^{-1}.Pa^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.04981	-5.4659	-5.2737	-4.9466	-4.7450	-4.5607	-4.3734
0.09979	-5.3635	-5.1645	-4.8258	-4.6120	-4.3919	-4.1975
0.15022	-5.2633	-4.9980	-4.6978	-4.4405	-4.2299	-4.0658
0.20001	-5.1386	-4.8465	-4.5476	-4.3004	-4.0985	-3.9371
0.25012	-5.0164	-4.7176	-4.4252	-4.1852	-3.9919	-3.8322
0.30021	-4.9005	-4.6076	-4.3226	-4.0881	-3.8960	-3.7380
0.34993	-4.7746	-4.4781	-4.2004	-3.9418	-3.7874	-3.6372
0.39991	-4.7061	-4.4058	-4.1314	-3.9004	-3.7112	-3.5598
0.45005	-4.6195	-4.3210	-4.0456	-3.8169	-3.6309	-3.4801
0.50086	-4.5289	-4.2307	-3.9596	-3.7353	-3.5533	-3.4036

Table 4.99: Apparent molar adiabatic compressibility (φ_k) of L-ornithine in aqueous solution of fructose (0.20mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-ornithine + water + 0.20 mol.kg^{-1} fructose					
	φ_k ×10^{14}/m^3.mol^{-1}.Pa^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.04964	-4.9581	-4.7112	-4.3887	-4.1514	-3.9844	-3.8302
0.09971	-4.7616	-4.4577	-4.1696	-3.9478	-3.7794	-3.6275
0.14981	-4.6351	-4.3542	-4.0629	-3.8484	-3.6585	-3.5244
0.20032	-4.5382	-4.2306	-3.9557	-3.7428	-3.5750	-3.4298
0.24975	-4.4138	-4.1020	-3.8355	-3.6251	-3.4624	-3.3211
0.29982	-4.3285	-4.0217	-3.7616	-3.5512	-3.3823	-3.2470
0.34990	-4.2268	-3.8922	-3.6316	-3.4566	-3.2923	-3.1597
0.39986	-4.1570	-3.8629	-3.6083	-3.4033	-3.2425	-3.1101
0.44934	-4.1099	-3.8131	-3.5528	-3.3438	-3.1621	-3.0391
0.49978	-4.0113	-3.7214	-3.4733	-3.2732	-3.1136	-2.9821

Table 4.100: Apparent molar adiabatic compressibility (φ_k) of L-ornithine in aqueous solution of fructose (0.35 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-ornithine + water + 0.35 mol.kg^{-1} fructose					
	$\varphi_k \times 10^{14}$/m^3.mol^{-1}.Pa^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.05009	-4.4472	-4.0838	-3.8388	-3.6404	-3.4788	-3.3402
0.10014	-4.2891	-3.9459	-3.6957	-3.4972	-3.3404	-3.2139
0.14975	-4.1595	-3.8360	-3.6011	-3.4012	-3.2480	-3.1207
0.19915	-4.0769	-3.7892	-3.5247	-3.3257	-3.1687	-3.0446
0.24995	-4.0209	-3.7201	-3.4873	-3.2875	-3.1334	-3.0118
0.29971	-3.9255	-3.6349	-3.3869	-3.1921	-3.0594	-2.9265
0.35036	-3.8147	-3.5284	-3.2768	-3.1009	-2.9582	-2.8340
0.39941	-3.7083	-3.4208	-3.1955	-3.0086	-2.8606	-2.7441
0.45002	-3.6270	-3.3414	-3.1197	-2.9357	-2.7908	-2.6750
0.49991	-3.5698	-3.2920	-3.0724	-2.8897	-2.7418	-2.6248

Table 4.101: Apparent molar adiabatic compressibility (φ_k) of L-ornithine in aqueous solution of fructose (0.50 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-ornithine + water + 0.50 mol.kg^{-1} fructose					
	$\varphi_k \times 10^{14}$/m^3.mol^{-1}.Pa^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.05071	-3.8782	-3.5717	-3.3196	-3.1412	-3.0047	-2.8839
0.09939	-3.7856	-3.4830	-3.2573	-3.0689	-2.9210	-2.8152
0.14922	-3.6818	-3.4133	-3.1739	-3.0170	-2.8743	-2.7576
0.20031	-3.5748	-3.3168	-3.0975	-2.9116	-2.7910	-2.6487
0.24982	-3.4615	-3.2113	-2.9996	-2.8205	-2.6838	-2.5722
0.29939	-3.3854	-3.1327	-2.9220	-2.7480	-2.6159	-2.5055
0.34861	-3.3243	-3.0573	-2.8489	-2.6751	-2.5397	-2.4321
0.40063	-3.2318	-2.9839	-2.7817	-2.6137	-2.4805	-2.3740
0.45021	-3.1624	-2.9196	-2.7188	-2.5534	-2.4221	-2.3168
0.49932	-3.1101	-2.8672	-2.6675	-2.5026	-2.3721	-2.2669

Table 4.102: Apparent molar adiabatic compressibility (φ_k) of L-lysine in aqueous solution of fructose (0.05 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-lysine + water + 0.05 mol.kg^{-1} fructose					
	$\varphi_k \times 10^{14}$/m^3.mol^{-1}.Pa^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.05018	-5.5810	-5.3097	-4.9596	-4.6398	-4.3560	-4.1216
0.10019	-5.3914	-5.1009	-4.7525	-4.4428	-4.1817	-3.9738
0.15011	-5.1786	-4.8958	-4.5673	-4.2395	-3.9946	-3.7860
0.19944	-5.0253	-4.6885	-4.3427	-4.0561	-3.8226	-3.6258
0.24971	-4.8607	-4.5122	-4.1774	-3.9005	-3.6693	-3.4525
0.30027	-4.7012	-4.3474	-4.0175	-3.7426	-3.5112	-3.3208
0.34982	-4.5708	-4.1860	-3.8606	-3.5926	-3.3715	-3.2213
0.40051	-4.4677	-4.1191	-3.8009	-3.5334	-3.3134	-3.1308
0.45029	-4.3674	-4.0191	-3.7009	-3.4357	-3.2196	-3.0409
0.50099	-4.2906	-3.9486	-3.6341	-3.3695	-3.1566	-2.9805

Table 4.103: Apparent molar adiabatic compressibility (φ_k) of L-lysine in aqueous solution of fructose (0.20mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-lysine + water + 0.20 mol.kg^{-1} fructose					
	$\varphi_k \times 10^{14}$/m^3.mol^{-1}.Pa^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.04948	-4.6438	-4.2951	-3.9251	-3.6869	-3.5110	-3.2993
0.09950	-4.4963	-4.1518	-3.8066	-3.5626	-3.3799	-3.1876
0.14951	-4.3873	-4.0295	-3.7082	-3.4573	-3.2607	-3.0837
0.19982	-4.2933	-3.9331	-3.6159	-3.3648	-3.1650	-2.9856
0.25015	-4.1735	-3.8273	-3.5263	-3.2772	-3.0811	-2.9080
0.29969	-4.1098	-3.7582	-3.4563	-3.2061	-3.0035	-2.8308
0.35020	-4.0543	-3.7069	-3.4070	-3.1485	-2.9670	-2.7851
0.39985	-4.0215	-3.6712	-3.3627	-3.1091	-2.9166	-2.7447
0.45008	-3.9587	-3.6242	-3.3131	-3.0547	-2.8875	-2.7126
0.50018	-3.8875	-3.5509	-3.2649	-3.0303	-2.8370	-2.6571

Table 4.104: Apparent molar adiabatic compressibility (φ_k) of L-lysine in aqueous solution of fructose (0.35 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-lysine + water + 0.35 mol.kg^{-1} fructose					
	$\varphi_k \times 10^{14}$/m^3.mol^{-1}.Pa^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.04989	-4.0835	-3.7441	-3.4534	-3.1967	-3.0080	-2.8391
0.09969	-3.9628	-3.5841	-3.2978	-3.0665	-2.8692	-2.7271
0.14941	-3.8512	-3.4835	-3.1995	-2.9642	-2.7795	-2.6239
0.19930	-3.7500	-3.3954	-3.1225	-2.8957	-2.7103	-2.5574
0.24962	-3.6407	-3.3057	-3.0375	-2.8131	-2.6273	-2.4773
0.29973	-3.5659	-3.2396	-2.9484	-2.7240	-2.5473	-2.4060
0.34995	-3.5063	-3.1785	-2.9048	-2.6876	-2.5118	-2.3671
0.40024	-3.4555	-3.1251	-2.8624	-2.6412	-2.4625	-2.3161
0.45046	-3.3953	-3.0699	-2.8117	-2.5955	-2.4151	-2.2707
0.49971	-3.3309	-3.0114	-2.7563	-2.5410	-2.3611	-2.2186

Table 4.105: Apparent molar adiabatic compressibility (φ_k) of L-lysine in aqueous solution of fructose (0.50 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-lysine + water + 0.50 mol.kg^{-1} fructose					
	$\varphi_k \times 10^{14}$/m^3.mol^{-1}.Pa^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.05063	-3.3914	-3.0831	-2.8315	-2.6226	-2.4530	-2.2648
0.10041	-3.2771	-2.9763	-2.7301	-2.5131	-2.3429	-2.1896
0.15001	-3.2106	-2.9162	-2.6723	-2.4602	-2.2913	-2.1502
0.20015	-3.1746	-2.8680	-2.6094	-2.4069	-2.2580	-2.0999
0.24963	-3.1426	-2.8308	-2.5784	-2.3842	-2.2361	-2.0763
0.30105	-3.0688	-2.7751	-2.5300	-2.3250	-2.1617	-2.0261
0.35055	-2.9978	-2.7069	-2.4650	-2.2660	-2.1038	-1.9703
0.40086	-2.9478	-2.6580	-2.4165	-2.2165	-2.0552	-1.9210
0.44971	-2.8864	-2.6036	-2.3664	-2.1683	-2.0054	-1.8726
0.49992	-2.8320	-2.5508	-2.3168	-2.1209	-1.9624	-1.8303

Table 4.106: Limiting apparent molar adiabatic compressibility (φ_k^0), experimental slope (S_k) of glycine in aqueous system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively

Temp (K)	$\varphi_k^0 \times 10^{14}$ ($m^3.mol^{-1}.Pa^{-1}$)	$S_k \times 10^{14}$ ($m^3.mol^{-1}.kg$)
293.15K	-2.9765	0.6798
298.15K	-2.7673	0.5634
303.15K	-2.6574	0.6700
308.15K	-2.5043	0.6223
313.15K	-2.3711	0.5613
318.15K	-2.2427	0.4852

Table 4.107: Limiting apparent molar adiabatic compressibility (φ_k^0), experimental slope (S_k) of L-ornithine in aqueous system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively

Temp (K)	$\varphi_k^0 \times 10^{14}$ ($m^3.mol^{-1}.Pa^{-1}$)	$S_k \times 10^{14}$ ($m^3.mol^{-1}.kg$)
293.15K	-5.8550	2.3149
298.15K	-5.5751	2.4510
303.15K	-5.2646	2.4025
308.15K	-4.9933	2.2784
313.15K	-4.7612	2.1859
318.15K	-4.5083	2.0434

Table 4.108: Limiting apparent molar adiabatic compressibility (φ_k^0), experimental slope (S_k) of L-lysine in aqueous system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively

Temp (K)	$\varphi_k^0 \times 10^{14}$ ($m^3.mol^{-1}.Pa^{-1}$)	$S_k \times 10^{14}$ ($m^3.mol^{-1}.kg$)
293.15K	-5.6661	2.3548
298.15K	-5.3269	2.4548
303.15K	-4.9573	2.3287
308.15K	-4.6585	2.2877
313.15K	-4.3862	2.1651
318.15K	-4.0344	1.8222

Table 4.109: Limiting apparent molar adiabatic compressibility (φ_k^0), experimental slope (S_k) and transfer compressibility ($\Delta_{tr}\varphi_k^0$) of glycine in aqueous 0.05 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively

Temp (K)	$\varphi_k^0 \times 10^{14}$ ($m^3.mol^{-1}.Pa^{-1}$)	$S_k \times 10^{14}$ ($m^3.mol^{-1}.kg$)	$\Delta_{tr}\varphi_k^0 \times 10^{14}$ ($m^3.mol^{-1}.Pa^{-1}$)
293.15K	-2.8523	0.6731	0.1241
298.15K	-2.7665	0.8246	0.0008
303.15K	-2.6134	0.8160	0.0440
308.15K	-2.4608	0.7661	0.0435
313.15K	-2.3355	0.7142	0.0356
318.15K	-2.2297	0.6711	0.0130

Table 4.110: Limiting apparent molar adiabatic compressibility (φ_k^0), experimental slope (S_k) and transfer compressibility ($\Delta_{tr}\varphi_k^0$) of glycine in aqueous 0.20 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively

Temp (K)	$\varphi_k^0 \times 10^{14}$ ($m^3.mol^{-1}.Pa^{-1}$)	$S_k \times 10^{14}$ ($m^3.mol^{-1}.kg$)	$\Delta_{tr}\varphi_k^0 \times 10^{14}$ ($m^3.mol^{-1}.Pa^{-1}$)
293.15K	-2.5224	0.5661	0.4596
298.15K	-2.3323	0.4978	0.4350
303.15K	-2.1738	0.4583	0.4837
308.15K	-2.0496	0.4298	0.4546
313.15K	-1.9706	0.4542	0.4005
318.15K	-1.9076	0.4913	0.3357

Table 4.111: Limiting apparent molar adiabatic compressibility (φ_k^0), experimental slope (S_k) and transfer compressibility ($\Delta_{tr}\varphi_k^0$) of glycine in aqueous 0.35 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively

Temp (K)	$\varphi_k^0 \times 10^{14}$ ($m^3.mol^{-1}.Pa^{-1}$)	$S_k \times 10^{14}$ ($m^3.mol^{-1}.kg$)	$\Delta_{tr}\varphi_k^0 \times 10^{14}$ ($m^3.mol^{-1}.Pa^{-1}$)
293.15K	-2.2774	0.5528	0.7045
298.15K	-2.0555	0.4202	0.7118
303.15K	-1.9298	0.4057	0.7276
308.15K	-1.8067	0.3559	0.6976
313.15K	-1.7233	0.3514	0.6478
318.15K	-1.6602	0.3622	0.5831

Table 4.112: Limiting apparent molar adiabatic compressibility (φ_k^0), experimental slope (S_k) and transfer compressibility ($\Delta_{tr}\varphi_k^0$) of glycine in aqueous 0.50 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively

Temp (K)	$\varphi_k^0\times10^{14}$ ($m^3.mol^{-1}.Pa^{-1}$)	$S_k\times10^{14}$ ($m^3.mol^{-1}.kg$)	$\Delta_{tr}\varphi_k^0\times10^{14}$ ($m^3.mol^{-1}.Pa^{-1}$)
293.15K	-1.9839	0.3689	0.9980
298.15K	-1.8637	0.4247	0.9036
303.15K	-1.7444	0.4002	0.9130
308.15K	-1.6459	0.3894	0.8584
313.15K	-1.5685	0.3808	0.8026
318.15K	-1.4951	0.3438	0.7482

Table 4.113: Limiting apparent molar adiabatic compressibility (φ_k^0), experimental slope (S_k) and transfer compressibility ($\Delta_{tr}\varphi_k^0$) of L-ornithine in aqueous 0.05 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively

Temp (K)	$\varphi_k^0\times10^{14}$ ($m^3.mol^{-1}.Pa^{-1}$)	$S_k\times10^{14}$ ($m^3.mol^{-1}.kg$)	$\Delta_{tr}\varphi_k^0\times10^{14}$ ($m^3.mol^{-1}.Pa^{-1}$)
293.15K	-5.5650	2.1350	0.2899
298.15K	-5.3527	2.3569	0.2224
303.15K	-5.0204	2.2180	0.2441
308.15K	-4.7936	2.2429	0.1998
313.15K	-4.5852	2.1811	0.1760
318.15K	-4.3978	2.0912	0.1105

Table 4.114: Limiting apparent molar adiabatic compressibility (φ_k^0), experimental slope (S_k) and transfer compressibility ($\Delta_{tr}\varphi_k^0$) of L-ornithine in aqueous 0.20 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively

Temp (K)	$\varphi_k^0\times10^{14}$ ($m^3.mol^{-1}.Pa^{-1}$)	$S_k\times10^{14}$ ($m^3.mol^{-1}.kg$)	$\Delta_{tr}\varphi_k^0\times10^{14}$ ($m^3.mol^{-1}.Pa^{-1}$)
293.15K	-4.9636	1.9999	0.8914
298.15K	-4.6822	2.0581	0.8929
303.15K	-4.3730	1.9252	0.8915
308.15K	-4.1439	1.8541	0.8494
313.15K	-3.9706	1.8391	0.7906
318.15K	-3.8172	1.7834	0.6911

Table 4.115: Limiting apparent molar adiabatic compressibility (φ_k^0), experimental slope (S_k) and transfer compressibility ($\Delta_{tr}\varphi_k^0$) of L-ornithine in aqueous 0.35 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively

Temp (K)	$\varphi_k^0 \times 10^{14}$ ($m^3.mol^{-1}.Pa^{-1}$)	$S_k \times 10^{14}$ ($m^3.mol^{-1}.kg$)	$\Delta_{tr}\varphi_k^0 \times 10^{14}$ ($m^3.mol^{-1}.Pa^{-1}$)
293.15K	-4.4859	1.8993	1.3691
298.15K	-4.1357	1.7336	1.4394
303.15K	-3.8797	1.6730	1.3849
308.15K	-3.6750	1.6266	1.3184
313.15K	-3.5152	1.5906	1.2460
318.15K	-3.3803	1.5528	1.1279

Table 4.116: Limiting apparent molar adiabatic compressibility (φ_k^0), experimental slope (S_k) and transfer compressibility ($\Delta_{tr}\varphi_k^0$) of L-ornithine in aqueous 0.50 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively

Temp (K)	$\varphi_k^0 \times 10^{14}$ ($m^3.mol^{-1}.Pa^{-1}$)	$S_k \times 10^{14}$ ($m^3.mol^{-1}.kg$)	$\Delta_{tr}\varphi_k^0 \times 10^{14}$ ($m^3.mol^{-1}.Pa^{-1}$)
293.15K	-3.9379	1.7407	1.9171
298.15K	-3.6385	1.6117	1.9366
303.15K	-3.3926	1.5067	1.8719
308.15K	-3.2103	1.4742	1.7831
313.15K	-3.0696	1.4525	1.6916
318.15K	-2.9464	1.4163	1.5618

Table 4.117: Limiting apparent molar adiabatic compressibility (φ_k^0), experimental slope (S_k) and transfer compressibility ($\Delta_{tr}\varphi_k^0$) of L-lysine in aqueous 0.05 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively

Temp (K)	$\varphi_k^0 \times 10^{14}$ ($m^3.mol^{-1}.Pa^{-1}$)	$S_k \times 10^{14}$ ($m^3.mol^{-1}.kg$)	$\Delta_{tr}\varphi_k^0 \times 10^{14}$ ($m^3.mol^{-1}.Pa^{-1}$)
293.15K	-5.6379	2.8872	0.0282
298.15K	-5.3576	3.0708	-0.0308
303.15K	-5.0046	2.9921	-0.0473
308.15K	-4.6797	2.8509	-0.0212
313.15K	-4.4070	2.7161	-0.0208
318.15K	-4.1786	2.5922	-0.1442

Table 4.118: Limiting apparent molar adiabatic compressibility (φ_k^0), experimental slope (S_k) and transfer compressibility ($\Delta_{tr}\varphi_k^0$) of L-lysine in aqueous 0.20 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively

Temp (K)	$\varphi_k^0\times10^{14}$ (m^3.mol^{-1}.Pa^{-1})	$S_k\times10^{14}$ (m^3.mol^{-1}.kg)	$\Delta_{tr}\varphi_k^0\times10^{14}$ (m^3.mol^{-1}.Pa^{-1})
293.15K	-4.6411	1.5953	1.0250
298.15K	-4.2850	1.5650	1.0419
303.15K	-3.9318	1.4305	1.0255
308.15K	-3.6865	1.4434	0.9721
313.15K	-3.4970	1.4410	0.8892
318.15K	-3.3013	1.3893	0.7332

Table 4.119: Limiting apparent molar adiabatic compressibility (φ_k^0), experimental slope (S_k) and transfer compressibility ($\Delta_{tr}\varphi_k^0$) of L-lysine in aqueous 0.35 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively

Temp (K)	$\varphi_k^0\times10^{14}$ (m^3.mol^{-1}.Pa^{-1})	$S_k\times10^{14}$ (m^3.mol^{-1}.kg)	$\Delta_{tr}\varphi_k^0\times10^{14}$ (m^3.mol^{-1}.Pa^{-1})
293.15K	-4.1043	1.6380	1.5618
298.15K	-3.7363	1.5375	1.5906
303.15K	-3.4420	1.4651	1.5152
308.15K	-3.1960	1.3953	1.4626
313.15K	-3.0038	1.3631	1.3825
318.15K	-2.8449	1.3268	1.1895

Table 4.120: Limiting apparent molar adiabatic compressibility (φ_k^0), experimental slope (S_k) and transfer compressibility ($\Delta_{tr}\varphi_k^0$) of L-lysine in aqueous 0.50 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively

Temp (K)	$\varphi_k^0\times10^{14}$ (m^3.mol^{-1}.Pa^{-1})	$S_k\times10^{14}$ (m^3.mol^{-1}.kg)	$\Delta_{tr}\varphi_k^0\times10^{14}$ (m^3.mol^{-1}.Pa^{-1})
293.15K	-3.4163	1.1748	2.2498
298.15K	-3.1050	1.1191	2.2219
303.15K	-2.8501	1.0840	2.1072
308.15K	-2.6364	1.0465	2.0221
313.15K	-2.4706	1.0303	1.9156
318.15K	-2.2977	0.9356	1.7368

Table 4.121: Acoustic impedance ($Z\times10^{-6}$/kg.m^{-2}.s^{-1}) of aqueous glycine as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	Glycine + water					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1.4803	1.4924	1.5025	1.5106	1.5168	1.5215
0.05016	1.4855	1.4974	1.5076	1.5156	1.5218	1.5263
0.10001	1.4906	1.5025	1.5125	1.5205	1.5266	1.5311
0.15002	1.4957	1.5076	1.5175	1.5254	1.5314	1.5358
0.19991	1.5007	1.5125	1.5224	1.5302	1.5361	1.5405
0.24989	1.5056	1.5174	1.5272	1.5349	1.5408	1.5451
0.30042	1.5106	1.5223	1.5320	1.5397	1.5456	1.5498
0.34988	1.5155	1.5271	1.5368	1.5444	1.5501	1.5544
0.40091	1.5205	1.5321	1.5416	1.5492	1.5549	1.5591
0.45087	1.5255	1.5369	1.5464	1.5539	1.5596	1.5636
0.50109	1.5303	1.5418	1.5512	1.5587	1.5643	1.5682

Table 4.122: Acoustic impedance ($Z\times10^{-6}$/kg.m^{-2}.s^{-1}) of aqueous L-ornithine as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-ornithine + water					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1.4803	1.4924	1.5025	1.5106	1.5168	1.5215
0.05001	1.4913	1.5033	1.5132	1.5212	1.5274	1.5319
0.09992	1.5020	1.5139	1.5238	1.5317	1.5377	1.5419
0.14991	1.5125	1.5244	1.5341	1.5419	1.5477	1.5519
0.19949	1.5229	1.5345	1.5441	1.5517	1.5575	1.5615
0.24988	1.5335	1.5450	1.5544	1.5619	1.5673	1.5712
0.30001	1.5435	1.5548	1.5641	1.5714	1.5770	1.5808
0.35001	1.5535	1.5646	1.5738	1.5810	1.5865	1.5901
0.39909	1.5632	1.5740	1.5831	1.5902	1.5955	1.5991
0.45018	1.5733	1.5839	1.5926	1.5999	1.6053	1.6087
0.50099	1.5836	1.5939	1.6025	1.6097	1.6149	1.6183

Table 4.123: Acoustic impedance ($Z\times10^{-6}$/kg.m^{-2}.s^{-1}) of aqueous L-lysine as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-lysine + water					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1.4803	1.4924	1.5025	1.5106	1.5168	1.5215
0.04998	1.4916	1.5036	1.5135	1.5215	1.5275	1.5319
0.09998	1.5027	1.5145	1.5243	1.5321	1.5381	1.5422
0.14991	1.5136	1.5253	1.5349	1.5425	1.5483	1.5523
0.20011	1.5244	1.5359	1.5453	1.5528	1.5584	1.5623
0.24991	1.5351	1.5463	1.5556	1.5629	1.5684	1.5722
0.30003	1.5456	1.5566	1.5657	1.5728	1.5782	1.5819
0.35005	1.5559	1.5667	1.5756	1.5826	1.5878	1.5913
0.40002	1.5661	1.5766	1.5853	1.5921	1.5972	1.6007
0.45024	1.5764	1.5866	1.5953	1.6017	1.6068	1.6100
0.50004	1.5861	1.5963	1.6047	1.6112	1.6160	1.6191

Table 4.124: Acoustic impedance ($Z\times10^{-6}$/kg.m^{-2}.s^{-1}) of glycine in aqueous solution of fructose (0.05 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	Glycine + water + 0.05 mol.kg^{-1} fructose					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1.4889	1.5008	1.5107	1.5187	1.5248	1.5291
0.05033	1.4941	1.5059	1.5158	1.5237	1.5297	1.5340
0.10013	1.4991	1.5110	1.5209	1.5287	1.5346	1.5388
0.15034	1.5042	1.5160	1.5258	1.5335	1.5394	1.5435
0.20018	1.5091	1.5209	1.5306	1.5382	1.5441	1.5481
0.25021	1.5141	1.5257	1.5354	1.5430	1.5487	1.5527
0.29952	1.5188	1.5305	1.5400	1.5476	1.5533	1.5572
0.35013	1.5238	1.5354	1.5449	1.5523	1.5580	1.5619
0.40012	1.5286	1.5401	1.5495	1.5569	1.5625	1.5663
0.45044	1.5336	1.5449	1.5542	1.5615	1.5670	1.5708
0.50061	1.5384	1.5496	1.5588	1.5661	1.5716	1.5753

Table 4.125: Acoustic impedance ($Z\times10^{-6}$/kg.m^{-2}.s^{-1}) of glycine in aqueous solution of fructose (0.20mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	Glycine + water + 0.20 mol.kg^{-1} fructose					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1.5145	1.5260	1.5355	1.5430	1.5486	1.5524
0.04987	1.5195	1.5310	1.5404	1.5478	1.5533	1.5572
0.09987	1.5245	1.5358	1.5452	1.5525	1.5580	1.5617
0.14963	1.5293	1.5406	1.5499	1.5571	1.5625	1.5662
0.19952	1.5342	1.5454	1.5546	1.5618	1.5671	1.5708
0.24961	1.5391	1.5502	1.5593	1.5664	1.5717	1.5753
0.29987	1.5439	1.5549	1.5640	1.5711	1.5763	1.5798
0.34989	1.5488	1.5597	1.5686	1.5756	1.5808	1.5843
0.40085	1.5536	1.5644	1.5733	1.5803	1.5854	1.5888
0.45097	1.5583	1.5691	1.5780	1.5848	1.5899	1.5932
0.50163	1.5632	1.5739	1.5826	1.5895	1.5944	1.5977

Table 4.126: Acoustic impedance ($Z\times10^{-6}$/kg.m^{-2}.s^{-1}) of glycine in aqueous solution of fructose (0.35 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	Glycine + water + 0.35 mol.kg^{-1} fructose					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1.5394	1.5505	1.5595	1.5665	1.5716	1.5750
0.05008	1.5444	1.5553	1.5643	1.5712	1.5762	1.5796
0.09978	1.5492	1.5601	1.5689	1.5758	1.5808	1.5841
0.15056	1.5541	1.5649	1.5736	1.5804	1.5854	1.5886
0.19968	1.5588	1.5695	1.5782	1.5849	1.5898	1.5930
0.24991	1.5636	1.5742	1.5828	1.5895	1.5943	1.5974
0.29961	1.5684	1.5788	1.5874	1.5939	1.5987	1.6018
0.35035	1.5731	1.5835	1.5920	1.5985	1.6033	1.6063
0.40009	1.5778	1.5882	1.5966	1.6030	1.6077	1.6107
0.45051	1.5824	1.5927	1.6010	1.6075	1.6121	1.6150
0.49919	1.5869	1.5972	1.6055	1.6118	1.6164	1.6192

Table 4.127: Acoustic impedance ($Z\times10^{-6}$/kg.m^{-2}.s^{-1}) of glycine in aqueous solution of fructose (0.50 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	Glycine + water + 0.50 mol.kg^{-1} fructose					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1.5641	1.5746	1.5831	1.5896	1.5943	1.5972
0.04938	1.5689	1.5794	1.5877	1.5942	1.5988	1.6017
0.09971	1.5737	1.5841	1.5924	1.5988	1.6033	1.6062
0.14938	1.5784	1.5887	1.5970	1.6033	1.6078	1.6106
0.19971	1.5832	1.5934	1.6016	1.6078	1.6122	1.6150
0.24949	1.5879	1.5980	1.6061	1.6123	1.6167	1.6194
0.29971	1.5927	1.6026	1.6106	1.6167	1.6211	1.6237
0.35085	1.5974	1.6072	1.6152	1.6212	1.6255	1.6281
0.39934	1.6018	1.6116	1.6195	1.6255	1.6297	1.6323
0.45091	1.6065	1.6163	1.6241	1.6300	1.6342	1.6367
0.49899	1.6109	1.6206	1.6284	1.6343	1.6384	1.6408

Table 4.128: Acoustic impedance ($Z\times10^{-6}$/kg.m^{-2}.s^{-1}) of L-ornithine in aqueous solution of fructose (0.05 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-ornithine + water + 0.05 mol.kg^{-1} fructose					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1.4889	1.5008	1.5107	1.5187	1.5248	1.5291
0.04981	1.4997	1.5115	1.5214	1.5293	1.5352	1.5394
0.09979	1.5103	1.5222	1.5318	1.5396	1.5455	1.5495
0.15022	1.5210	1.5327	1.5422	1.5498	1.5555	1.5595
0.20001	1.5313	1.5428	1.5522	1.5597	1.5653	1.5692
0.25012	1.5416	1.5529	1.5621	1.5695	1.5750	1.5788
0.30021	1.5516	1.5628	1.5720	1.5792	1.5846	1.5883
0.34993	1.5614	1.5724	1.5814	1.5884	1.5939	1.5975
0.39991	1.5714	1.5822	1.5911	1.5981	1.6033	1.6068
0.45005	1.5812	1.5919	1.6006	1.6075	1.6125	1.6159
0.50086	1.5910	1.6015	1.6101	1.6168	1.6218	1.6251

Table 4.129: Acoustic impedance ($Z\times10^{-6}$/kg.m^{-2}.s^{-1}) of L-ornithine in aqueous solution of fructose (0.20mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-ornithine + water + 0.20 mol.kg^{-1} fructose					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1.5145	1.5260	1.5355	1.5430	1.5486	1.5524
0.04964	1.5251	1.5366	1.5459	1.5533	1.5587	1.5625
0.09971	1.5355	1.5468	1.5560	1.5633	1.5686	1.5723
0.14981	1.5459	1.5570	1.5661	1.5732	1.5784	1.5820
0.20032	1.5562	1.5671	1.5760	1.5831	1.5882	1.5917
0.24975	1.5660	1.5767	1.5855	1.5924	1.5975	1.6009
0.29982	1.5759	1.5866	1.5952	1.6020	1.6069	1.6102
0.34990	1.5856	1.5959	1.6044	1.6113	1.6161	1.6193
0.39986	1.5954	1.6058	1.6142	1.6207	1.6254	1.6285
0.44934	1.6052	1.6153	1.6235	1.6298	1.6343	1.6373
0.49978	1.6146	1.6246	1.6327	1.6390	1.6435	1.6464

Table 4.130: Acoustic impedance ($Z\times10^{-6}$/kg.m^{-2}.s^{-1}) of L-ornithine in aqueous solution of fructose (0.35 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-ornithine + water + 0.35 mol.kg^{-1} fructose					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1.4856	1.4838	1.4954	1.5048	1.5123	1.5179
0.04993	1.4968	1.5085	1.5181	1.5258	1.5315	1.5355
0.50992	1.5077	1.5192	1.5286	1.5361	1.5417	1.5456
0.14996	1.5188	1.5302	1.5395	1.5468	1.5522	1.5560
0.20027	1.5289	1.5399	1.5490	1.5562	1.5615	1.5654
0.25021	1.5397	1.5507	1.5596	1.5666	1.5718	1.5753
0.29997	1.5499	1.5604	1.5692	1.5761	1.5814	1.5848
0.34925	1.5602	1.5707	1.5793	1.5860	1.5909	1.5942
0.39814	1.5698	1.5803	1.5887	1.5952	1.6000	1.6031
0.44998	1.5806	1.5906	1.5988	1.6051	1.6099	1.6130
0.50008	1.5911	1.6011	1.6092	1.6155	1.6201	1.6231

Table 4.131: Acoustic impedance ($Z \times 10^{-6}$/kg.m^{-2}.s^{-1}) of L-ornithine in aqueous solution of fructose (0.50 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-ornithine + water + 0.50 mol.kg^{-1} fructose					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1.5641	1.5746	1.5831	1.5896	1.5943	1.5972
0.05071	1.5746	1.5849	1.5932	1.5996	1.6042	1.6070
0.09939	1.5845	1.5946	1.6028	1.6091	1.6135	1.6163
0.14922	1.5944	1.6045	1.6125	1.6187	1.6231	1.6257
0.20031	1.6044	1.6144	1.6223	1.6283	1.6326	1.6351
0.24982	1.6139	1.6237	1.6315	1.6374	1.6415	1.6440
0.29939	1.6234	1.6330	1.6406	1.6464	1.6505	1.6529
0.34861	1.6327	1.6421	1.6496	1.6553	1.6592	1.6616
0.40063	1.6423	1.6516	1.6590	1.6646	1.6684	1.6707
0.45021	1.6514	1.6606	1.6679	1.6733	1.6771	1.6792
0.49932	1.6605	1.6695	1.6766	1.6819	1.6856	1.6876

Table 4.132: Acoustic impedance ($Z \times 10^{-6}$/kg.m^{-2}.s^{-1}) of L-lysine in aqueous solution of fructose (0.05 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-lysine + water + 0.05 mol.kg^{-1} fructose					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1.4897	1.5018	1.5118	1.5198	1.5259	1.5301
0.05018	1.5004	1.5122	1.5220	1.5298	1.5357	1.5398
0.10019	1.5115	1.5232	1.5329	1.5405	1.5462	1.5503
0.15011	1.5223	1.5339	1.5434	1.5508	1.5564	1.5603
0.19944	1.5329	1.5442	1.5534	1.5608	1.5663	1.5700
0.24971	1.5434	1.5545	1.5635	1.5707	1.5761	1.5796
0.30027	1.5537	1.5645	1.5734	1.5804	1.5856	1.5891
0.34982	1.5637	1.5741	1.5828	1.5897	1.5948	1.5984
0.40051	1.5739	1.5844	1.5929	1.5996	1.6045	1.6078
0.45029	1.5838	1.5941	1.6024	1.6089	1.6137	1.6168
0.50099	1.5940	1.6041	1.6122	1.6185	1.6232	1.6262

Table 4.133: Acoustic impedance ($Z\times10^{-6}$/kg.m^{-2}.s^{-1}) of L-lysine in aqueous solution of fructose (0.20mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-lysine + water + 0.20 mol.kg^{-1} fructose					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1.5144	1.5260	1.5355	1.5430	1.5485	1.5524
0.04948	1.5253	1.5367	1.5460	1.5534	1.5588	1.5625
0.09950	1.5361	1.5473	1.5564	1.5636	1.5689	1.5725
0.14951	1.5467	1.5577	1.5666	1.5737	1.5788	1.5823
0.19982	1.5573	1.5680	1.5768	1.5836	1.5887	1.5920
0.25015	1.5676	1.5782	1.5868	1.5935	1.5984	1.6016
0.29969	1.5778	1.5882	1.5966	1.6031	1.6078	1.6109
0.35020	1.5882	1.5984	1.6066	1.6129	1.6176	1.6205
0.39985	1.5986	1.6085	1.6164	1.6226	1.6270	1.6298
0.45008	1.6087	1.6185	1.6263	1.6321	1.6367	1.6393
0.50041	1.6187	1.6282	1.6360	1.6419	1.6460	1.6484

Table 4.134: Acoustic impedance ($Z\times10^{-6}$/kg.m^{-2}.s^{-1}) of L-lysine in aqueous solution of fructose (0.35 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-lysine + water + 0.35 mol.kg^{-1} fructose					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1.5394	1.5505	1.5595	1.5665	1.5716	1.5750
0.04989	1.5501	1.5611	1.5699	1.5767	1.5817	1.5849
0.09969	1.5607	1.5713	1.5799	1.5866	1.5915	1.5946
0.14941	1.5710	1.5814	1.5899	1.5964	1.6011	1.6042
0.19930	1.5812	1.5915	1.5998	1.6062	1.6107	1.6136
0.24962	1.5913	1.6014	1.6095	1.6158	1.6202	1.6230
0.29973	1.6014	1.6113	1.6191	1.6252	1.6295	1.6322
0.34995	1.6114	1.6211	1.6288	1.6347	1.6389	1.6415
0.40024	1.6214	1.6309	1.6385	1.6442	1.6482	1.6506
0.45046	1.6313	1.6405	1.6479	1.6535	1.6574	1.6597
0.49971	1.6408	1.6498	1.6571	1.6625	1.6662	1.6684

Table 4.135: Acoustic impedance ($Z\times10^{-6}$/kg.m^{-2}.s^{-1}) of L-lysine in aqueous solution of fructose (0.50 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-lysine + water + 0.50 mol.kg^{-1} fructose					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1.5644	1.5750	1.5833	1.5898	1.5945	1.5975
0.05063	1.5746	1.5850	1.5933	1.5996	1.6041	1.6069
0.10041	1.5848	1.5949	1.6031	1.6093	1.6136	1.6163
0.15001	1.5948	1.6048	1.6128	1.6188	1.6231	1.6256
0.20015	1.6050	1.6147	1.6224	1.6283	1.6325	1.6349
0.24963	1.6150	1.6244	1.6320	1.6378	1.6419	1.6441
0.30105	1.6250	1.6344	1.6418	1.6474	1.6512	1.6535
0.35055	1.6346	1.6437	1.6510	1.6564	1.6601	1.6623
0.40086	1.6443	1.6532	1.6603	1.6656	1.6692	1.6711
0.44971	1.6536	1.6623	1.6692	1.6744	1.6778	1.6797
0.49992	1.6630	1.6716	1.6783	1.6833	1.6866	1.6884

Table 4.136: Relative association (R_A) of aqueous glycine as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	Glycine + water					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
0.05016	0.9997	0.9998	0.9998	0.9998	0.9999	1.0000
0.10001	0.9995	0.9996	0.9996	0.9997	0.9998	0.9999
0.15002	0.9992	0.9993	0.9995	0.9996	0.9998	0.9999
0.19991	0.9990	0.9992	0.9993	0.9995	0.9997	0.9999
0.24989	0.9988	0.9990	0.9992	0.9994	0.9997	0.9999
0.30042	0.9986	0.9988	0.9991	0.9994	0.9996	0.9999
0.34988	0.9984	0.9987	0.9990	0.9993	0.9996	0.9999
0.40091	0.9982	0.9985	0.9988	0.9992	0.9995	0.9999
0.45087	0.9979	0.9983	0.9987	0.9991	0.9995	0.9998
0.50109	0.9977	0.9981	0.9985	0.9990	0.9994	0.9998

Table 4.137: Relative association (R_A) of aqueous L-ornithine as a function of molality ($m/mol.kg^{-1}$) at different temperature

$m/mol.kg^{-1}$	L-ornithine + water					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
0.05001	0.9987	0.9988	0.9989	0.9990	0.9991	0.9991
0.09992	0.9975	0.9976	0.9978	0.9980	0.9982	0.9984
0.14991	0.9963	0.9965	0.9968	0.9971	0.9974	0.9977
0.19949	0.9952	0.9955	0.9959	0.9963	0.9966	0.9971
0.24988	0.9939	0.9943	0.9948	0.9953	0.9959	0.9964
0.30001	0.9929	0.9934	0.9940	0.9946	0.9951	0.9957
0.35001	0.9918	0.9924	0.9932	0.9938	0.9944	0.9951
0.39909	0.9907	0.9916	0.9924	0.9931	0.9938	0.9945
0.45018	0.9895	0.9905	0.9916	0.9922	0.9929	0.9937
0.50099	0.9881	0.9893	0.9905	0.9912	0.9919	0.9928

Table 4.138: Relative association (R_A) of aqueous L-lysine as a function of molality ($m/mol.kg^{-1}$) at different temperature

$m/mol.kg^{-1}$	L-lysine + water					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
0.04998	0.9981	0.9982	0.9984	0.9985	0.9986	0.9988
0.09998	0.9964	0.9965	0.9968	0.9970	0.9973	0.9976
0.14991	0.9946	0.9949	0.9953	0.9957	0.9960	0.9965
0.20011	0.9929	0.9934	0.9939	0.9944	0.9948	0.9954
0.24991	0.9912	0.9918	0.9924	0.9930	0.9936	0.9942
0.30003	0.9895	0.9903	0.9911	0.9918	0.9924	0.9932
0.35005	0.9879	0.9888	0.9897	0.9906	0.9913	0.9922
0.40002	0.9864	0.9875	0.9885	0.9894	0.9903	0.9911
0.45024	0.9847	0.9860	0.9870	0.9882	0.9891	0.9901
0.50004	0.9832	0.9845	0.9858	0.9869	0.9880	0.9891

Table 4.139: Relative association (R_A) of glycine in aqueous solution of fructose (0.05 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	Glycine + water + 0.05 mol.kg^{-1} fructose					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
0.05033	0.9997	0.9997	0.9998	0.9998	0.9999	0.9999
0.10013	0.9994	0.9995	0.9995	0.9997	0.9998	0.9999
0.15034	0.9992	0.9992	0.9994	0.9995	0.9997	0.9998
0.20018	0.9990	0.9991	0.9993	0.9995	0.9996	0.9998
0.25021	0.9988	0.9989	0.9991	0.9994	0.9996	0.9998
0.29952	0.9986	0.9987	0.9990	0.9993	0.9995	0.9998
0.35013	0.9983	0.9985	0.9988	0.9992	0.9995	0.9997
0.40012	0.9981	0.9984	0.9987	0.9991	0.9994	0.9997
0.45044	0.9978	0.9982	0.9986	0.9990	0.9994	0.9998
0.50061	0.9976	0.9980	0.9985	0.9990	0.9994	0.9997

Table 4.140: Relative association (R_A) of glycine in aqueous solution of fructose (0.20mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	Glycine + water + 0.20 mol.kg^{-1} fructose					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
0.04987	0.9997	0.9997	0.9998	0.9998	0.9999	0.9999
0.09987	0.9994	0.9995	0.9996	0.9997	0.9997	0.9998
0.14963	0.9991	0.9993	0.9995	0.9996	0.9997	0.9998
0.19952	0.9989	0.9991	0.9993	0.9995	0.9996	0.9998
0.24961	0.9986	0.9989	0.9991	0.9994	0.9995	0.9997
0.29987	0.9984	0.9987	0.9990	0.9992	0.9995	0.9997
0.34989	0.9981	0.9985	0.9988	0.9991	0.9994	0.9996
0.40085	0.9979	0.9983	0.9987	0.9990	0.9993	0.9996
0.45097	0.9976	0.9981	0.9985	0.9989	0.9993	0.9996
0.50163	0.9973	0.9979	0.9984	0.9988	0.9992	0.9995

Table 4.141: Relative association (R_A) of glycine in aqueous solution of fructose (0.35 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	Glycine + water + 0.35 mol.kg^{-1} fructose					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
0.05008	0.9996	0.9997	0.9998	0.9998	0.9998	0.9999
0.09978	0.9993	0.9995	0.9996	0.9996	0.9997	0.9998
0.15056	0.9990	0.9992	0.9994	0.9995	0.9996	0.9997
0.19968	0.9987	0.9990	0.9992	0.9993	0.9995	0.9996
0.24991	0.9984	0.9987	0.9990	0.9992	0.9994	0.9996
0.29961	0.9981	0.9985	0.9988	0.9991	0.9993	0.9995
0.35035	0.9978	0.9983	0.9986	0.9989	0.9991	0.9994
0.40009	0.9975	0.9980	0.9984	0.9987	0.9990	0.9993
0.45051	0.9973	0.9978	0.9983	0.9986	0.9989	0.9992
0.49919	0.9971	0.9976	0.9981	0.9984	0.9988	0.9992

Table 4.142: Relative association (R_A) of glycine in aqueous solution of fructose (0.50 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	Glycine + water + 0.50 mol.kg^{-1} fructose					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
0.04938	0.9997	0.9997	0.9998	0.9998	0.9998	0.9999
0.09971	0.9994	0.9995	0.9996	0.9996	0.9997	0.9998
0.14938	0.9990	0.9992	0.9993	0.9995	0.9996	0.9997
0.19971	0.9987	0.9990	0.9991	0.9993	0.9995	0.9996
0.24949	0.9984	0.9987	0.9989	0.9991	0.9993	0.9995
0.29971	0.9981	0.9985	0.9987	0.9990	0.9992	0.9994
0.35085	0.9978	0.9982	0.9985	0.9988	0.9991	0.9993
0.39934	0.9975	0.9980	0.9983	0.9986	0.9989	0.9991
0.45091	0.9972	0.9977	0.9981	0.9985	0.9988	0.9990
0.49899	0.9969	0.9974	0.9979	0.9983	0.9986	0.9989

Table 4.143: Relative association (R_A) of L-ornithine in aqueous solution of fructose (0.05 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-ornithine + water + 0.05 mol.kg^{-1} fructose					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
0.04981	0.9987	0.9987	0.9989	0.9989	0.9990	0.9991
0.09979	0.9975	0.9975	0.9978	0.9979	0.9981	0.9983
0.15022	0.9962	0.9964	0.9967	0.9970	0.9973	0.9976
0.20001	0.9950	0.9953	0.9958	0.9962	0.9965	0.9969
0.25012	0.9939	0.9943	0.9948	0.9953	0.9958	0.9962
0.30021	0.9927	0.9933	0.9939	0.9945	0.9950	0.9955
0.34993	0.9917	0.9924	0.9931	0.9938	0.9943	0.9948
0.39991	0.9905	0.9912	0.9921	0.9928	0.9935	0.9942
0.45005	0.9894	0.9902	0.9912	0.9920	0.9928	0.9935
0.50086	0.9883	0.9892	0.9903	0.9912	0.9921	0.9928

Table 4.144: Relative association (R_A) of L-ornithine in aqueous solution of fructose (0.20mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-ornithine + water + 0.20 mol.kg^{-1} fructose					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
0.04964	0.9986	0.9987	0.9988	0.9989	0.9990	0.9991
0.09971	0.9973	0.9975	0.9977	0.9979	0.9981	0.9983
0.14981	0.9960	0.9963	0.9967	0.9970	0.9972	0.9975
0.20032	0.9948	0.9952	0.9957	0.9960	0.9964	0.9967
0.24975	0.9937	0.9942	0.9948	0.9952	0.9956	0.9960
0.29982	0.9925	0.9932	0.9938	0.9943	0.9948	0.9952
0.34990	0.9914	0.9923	0.9930	0.9935	0.9941	0.9946
0.39986	0.9902	0.9910	0.9919	0.9926	0.9932	0.9938
0.44934	0.9889	0.9899	0.9908	0.9917	0.9925	0.9931
0.49978	0.9878	0.9889	0.9899	0.9908	0.9916	0.9924

Table 4.145: Relative association (R_A) of L-ornithine in aqueous solution of fructose (0.35mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-ornithine + water + 0.35 mol.kg^{-1} fructose					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
0.05009	0.9985	0.9987	0.9988	0.9989	0.9990	0.9990
0.10014	0.9972	0.9975	0.9977	0.9978	0.9980	0.9982
0.14975	0.9959	0.9963	0.9966	0.9968	0.9971	0.9973
0.19915	0.9946	0.9950	0.9955	0.9958	0.9962	0.9965
0.24995	0.9932	0.9937	0.9943	0.9947	0.9951	0.9955
0.29971	0.9919	0.9926	0.9933	0.9938	0.9942	0.9947
0.35036	0.9908	0.9916	0.9923	0.9929	0.9934	0.9940
0.39941	0.9897	0.9906	0.9914	0.9921	0.9927	0.9933
0.45002	0.9885	0.9896	0.9904	0.9912	0.9919	0.9926
0.49991	0.9873	0.9884	0.9894	0.9902	0.9910	0.9917

Table 4.146: Relative association (R_A) of L-ornithine in aqueous solution of fructose (0.50mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-ornithine + water + 0.50 mol.kg^{-1} fructose					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
0.05071	0.9985	0.9987	0.9988	0.9989	0.9989	0.9990
0.09939	0.9971	0.9974	0.9976	0.9978	0.9980	0.9981
0.14922	0.9958	0.9961	0.9964	0.9967	0.9969	0.9971
0.20031	0.9945	0.9949	0.9953	0.9957	0.9959	0.9963
0.24982	0.9933	0.9938	0.9943	0.9947	0.9951	0.9955
0.29939	0.9920	0.9926	0.9932	0.9937	0.9942	0.9946
0.34861	0.9907	0.9915	0.9922	0.9928	0.9933	0.9938
0.40063	0.9895	0.9904	0.9911	0.9918	0.9924	0.9929
0.45021	0.9883	0.9892	0.9901	0.9908	0.9915	0.9921
0.49932	0.9870	0.9881	0.9890	0.9898	0.9906	0.9913

Table 4.147: Relative association (R_A) of L-lysine in aqueous solution of fructose (0.05 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-lysine + water + 0.05 mol.kg^{-1} fructose					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
0.05018	0.9980	0.9981	0.9982	0.9983	0.9985	0.9986
0.10019	0.9961	0.9963	0.9965	0.9968	0.9970	0.9973
0.15011	0.9944	0.9946	0.9950	0.9954	0.9957	0.9961
0.19944	0.9927	0.9931	0.9936	0.9941	0.9946	0.9950
0.24971	0.9910	0.9916	0.9923	0.9929	0.9934	0.9940
0.30027	0.9894	0.9902	0.9910	0.9917	0.9924	0.9930
0.34982	0.9879	0.9889	0.9898	0.9906	0.9914	0.9919
0.40051	0.9862	0.9872	0.9883	0.9892	0.9901	0.9909
0.45029	0.9847	0.9858	0.9870	0.9880	0.9890	0.9899
0.50099	0.9830	0.9843	0.9856	0.9867	0.9878	0.9887

Table 4.148: Relative association (R_A) of L-lysine in aqueous solution of fructose (0.20mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-lysine + water + 0.20 mol.kg^{-1} fructose					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
0.04948	0.9981	0.9982	0.9984	0.9985	0.9986	0.9987
0.09950	0.9963	0.9966	0.9968	0.9971	0.9972	0.9975
0.14951	0.9945	0.9949	0.9953	0.9957	0.9960	0.9962
0.19982	0.9927	0.9933	0.9938	0.9943	0.9947	0.9951
0.25015	0.9910	0.9917	0.9923	0.9929	0.9934	0.9939
0.29969	0.9892	0.9901	0.9909	0.9916	0.9922	0.9928
0.35020	0.9874	0.9884	0.9893	0.9902	0.9908	0.9915
0.39985	0.9855	0.9866	0.9877	0.9887	0.9895	0.9903
0.45008	0.9837	0.9849	0.9862	0.9873	0.9881	0.9890
0.50041	0.9820	0.9834	0.9847	0.9858	0.9868	0.9878

Table 4.149: Relative association (R_A) of L-lysine in aqueous solution of fructose (0.35 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-lysine + water + 0.35 mol.kg^{-1} fructose					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
0.04989	0.9980	0.9981	0.9983	0.9984	0.9985	0.9986
0.09969	0.9961	0.9964	0.9967	0.9969	0.9971	0.9973
0.14941	0.9943	0.9948	0.9951	0.9955	0.9958	0.9961
0.19930	0.9925	0.9931	0.9936	0.9940	0.9945	0.9948
0.24962	0.9908	0.9915	0.9922	0.9927	0.9932	0.9937
0.29973	0.9891	0.9899	0.9908	0.9914	0.9920	0.9925
0.34995	0.9874	0.9884	0.9893	0.9900	0.9906	0.9913
0.40024	0.9856	0.9868	0.9877	0.9886	0.9894	0.9901
0.45046	0.9840	0.9852	0.9863	0.9872	0.9881	0.9889
0.49971	0.9824	0.9837	0.9849	0.9860	0.9869	0.9878

Table 4.50: Relative association (R_A) of L-lysine in aqueous solution of fructose (0.50 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-lysine + water + 0.50 mol.kg^{-1} fructose					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
0.05063	0.9981	0.9982	0.9983	0.9984	0.9986	0.9987
0.10041	0.9962	0.9965	0.9968	0.9970	0.9972	0.9974
0.15001	0.9944	0.9949	0.9952	0.9955	0.9959	0.9961
0.20015	0.9926	0.9932	0.9937	0.9941	0.9944	0.9948
0.24963	0.9907	0.9915	0.9921	0.9926	0.9930	0.9935
0.30105	0.9889	0.9897	0.9905	0.9911	0.9917	0.9922
0.35055	0.9872	0.9882	0.9890	0.9898	0.9904	0.9910
0.40086	0.9855	0.9866	0.9875	0.9884	0.9891	0.9898
0.44971	0.9839	0.9851	0.9861	0.9870	0.9879	0.9887
0.49992	0.9822	0.9835	0.9847	0.9857	0.9866	0.9875

Table 4.151: Hydration number (n_H) of aqueous glycine as a function of molality ($m/mol.kg^{-1}$) at different temperature

$m/mol.kg^{-1}$	Glycine + water					
	n_H					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.05016	5.95	5.75	5.73	5.59	5.45	5.29
0.10001	5.90	5.74	5.62	5.48	5.35	5.24
0.15002	5.87	5.71	5.59	5.44	5.31	5.19
0.19991	5.78	5.65	5.53	5.38	5.26	5.14
0.24989	5.72	5.59	5.47	5.33	5.21	5.10
0.30042	5.66	5.54	5.41	5.28	5.17	5.06
0.34988	5.62	5.50	5.36	5.23	5.12	5.02
0.40091	5.59	5.45	5.32	5.20	5.09	4.99
0.45087	5.56	5.42	5.29	5.17	5.06	4.96
0.50109	5.52	5.39	5.26	5.14	5.04	4.93

Table 4.152: Hydration number (n_H) of aqueous L-ornithine as a function of molality ($m/mol.kg^{-1}$) at different temperature

$m/mol.kg^{-1}$	L-ornithine + water					
	n_H					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.05001	12.98	12.75	12.43	12.20	11.99	11.77
0.09992	12.69	12.48	12.23	11.98	11.76	11.47
0.14991	12.45	12.24	11.98	11.73	11.52	11.24
0.19949	12.26	12.00	11.74	11.50	11.29	11.03
0.24988	12.11	11.86	11.59	11.36	11.10	10.86
0.30001	11.87	11.61	11.35	11.12	10.92	10.70
0.35001	11.69	11.43	11.18	10.95	10.75	10.54
0.39909	11.52	11.24	10.98	10.77	10.57	10.37
0.45018	11.37	11.08	10.81	10.63	10.46	10.26
0.50099	11.27	10.97	10.70	10.52	10.35	10.17

Table 4.153: Hydration number (n_H) of aqueous L-lysine as a function of molality ($m/mol.kg^{-1}$) at different temperature

$m/mol.kg^{-1}$	L-lysine + water					
	n_H					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.04998	13.66	13.39	13.00	12.72	12.43	11.98
0.09998	13.38	13.11	12.79	12.47	12.21	11.82
0.14991	13.14	12.84	12.52	12.22	11.95	11.62
0.20011	12.92	12.61	12.28	11.99	11.73	11.44
0.24991	12.74	12.40	12.10	11.81	11.55	11.28
0.30003	12.53	12.19	11.88	11.60	11.36	11.10
0.35005	12.32	11.99	11.68	11.41	11.16	10.91
0.40002	12.13	11.78	11.48	11.21	10.98	10.76
0.45024	11.97	11.63	11.34	11.04	10.84	10.59
0.50004	11.78	11.46	11.16	10.90	10.67	10.45

Table 4.154: Hydration number (n_H) of glycine in aqueous solution of fructose (0.05 $mol.kg^{-1}$) as a function of molality ($m/mol.kg^{-1}$) at different temperature

$m/mol.kg^{-1}$	Glycine + water + 0.05 $mol.kg^{-1}$ fructose					
	n_H					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.05033	5.88	5.83	5.70	5.56	5.42	5.33
0.10013	5.85	5.80	5.67	5.51	5.39	5.27
0.15034	5.79	5.72	5.58	5.44	5.32	5.21
0.20018	5.71	5.63	5.49	5.35	5.24	5.12
0.25021	5.66	5.56	5.44	5.29	5.18	5.07
0.29952	5.60	5.50	5.37	5.24	5.13	5.03
0.35013	5.56	5.46	5.33	5.20	5.09	5.00
0.40012	5.52	5.41	5.28	5.14	5.04	4.95
0.45044	5.49	5.36	5.22	5.10	5.00	4.91
0.50061	5.46	5.32	5.18	5.06	4.96	4.87

Table 4.155: Hydration number (n_H) of glycine in aqueous solution of fructose (0.20 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	Glycine + water + 0.20 mol.kg^{-1} fructose					
	n_H					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.04987	5.77	5.58	5.42	5.28	5.20	5.18
0.09987	5.68	5.50	5.35	5.24	5.16	5.05
0.14963	5.59	5.43	5.27	5.14	5.05	4.98
0.19952	5.55	5.39	5.23	5.11	5.02	4.93
0.24961	5.52	5.35	5.20	5.08	4.99	4.90
0.29987	5.46	5.31	5.17	5.05	4.95	4.87
0.34989	5.44	5.28	5.14	5.02	4.92	4.84
0.40085	5.39	5.23	5.09	4.98	4.88	4.80
0.45097	5.34	5.20	5.06	4.95	4.86	4.77
0.50163	5.32	5.17	5.04	4.92	4.83	4.74

Table 4.156: Hydration number (n_H) of glycine in aqueous solution of fructose (0.35 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	Glycine + water + 0.35 mol.kg^{-1} fructose					
	n_H					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.05008	5.65	5.41	5.29	5.14	5.05	4.97
0.09978	5.58	5.35	5.21	5.08	4.98	4.91
0.15056	5.51	5.29	5.16	5.04	4.95	4.87
0.19968	5.45	5.25	5.12	5.01	4.92	4.83
0.24991	5.41	5.21	5.08	4.97	4.87	4.78
0.29961	5.38	5.17	5.05	4.92	4.83	4.75
0.35035	5.32	5.14	5.02	4.91	4.81	4.73
0.40009	5.29	5.12	4.99	4.88	4.79	4.71
0.45051	5.24	5.07	4.95	4.84	4.75	4.67
0.49919	5.20	5.05	4.92	4.82	4.72	4.64

Table 4.157: Hydration number (n_H) of glycine in aqueous solution of fructose (0.50 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	Glycine + water + 0.50 mol.kg^{-1} fructose					
	n_H					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.04938	5.40	5.32	5.18	5.06	4.97	4.88
0.09971	5.36	5.24	5.10	4.99	4.89	4.81
0.14938	5.34	5.18	5.06	4.95	4.86	4.78
0.19971	5.31	5.15	5.03	4.92	4.82	4.73
0.24949	5.27	5.12	5.00	4.89	4.79	4.71
0.29971	5.24	5.07	4.95	4.84	4.75	4.67
0.35085	5.20	5.03	4.91	4.80	4.71	4.64
0.39934	5.16	5.00	4.89	4.78	4.69	4.62
0.45091	5.11	4.97	4.85	4.74	4.65	4.59
0.49899	5.09	4.95	4.83	4.72	4.64	4.56

Table 4.158: Hydration number (n_H) of L-ornithine in aqueous solution of fructose (0.05 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-ornithine + water + 0.05 mol.kg^{-1} fructose					
	n_H					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.04981	12.71	12.60	12.30	12.11	11.93	11.72
0.09979	12.53	12.41	12.09	11.89	11.66	11.44
0.15022	12.35	12.15	11.87	11.62	11.40	11.22
0.20001	12.15	11.91	11.63	11.39	11.18	11.00
0.25012	11.94	11.70	11.43	11.19	11.00	10.82
0.30021	11.75	11.51	11.25	11.02	10.83	10.66
0.34993	11.54	11.29	11.04	10.78	10.64	10.47
0.39991	11.42	11.17	10.92	10.69	10.50	10.34
0.45005	11.26	11.01	10.76	10.54	10.35	10.19
0.50086	11.11	10.86	10.61	10.39	10.21	10.05

Table 4.159: Hydration number (n_H) of L-ornithine in aqueous solution of fructose (0.20 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-ornithine + water + 0.20 mol.kg^{-1} fructose					
	n_H					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.04964	12.52	12.31	11.98	11.73	11.55	11.37
0.09971	12.21	11.92	11.63	11.40	11.22	11.04
0.14981	11.99	11.73	11.44	11.22	11.01	10.85
0.20032	11.81	11.52	11.24	11.03	10.84	10.68
0.24975	11.59	11.30	11.04	10.82	10.64	10.48
0.29982	11.43	11.15	10.89	10.67	10.49	10.34
0.34990	11.25	10.93	10.67	10.50	10.33	10.18
0.39986	11.11	10.84	10.59	10.38	10.21	10.06
0.44934	11.00	10.73	10.47	10.26	10.06	9.92
0.49978	10.83	10.56	10.32	10.12	9.95	9.80

Table 4.160: Hydration number (n_H) of L-ornithine in aqueous solution of fructose (0.35 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-ornithine + water + 0.35 mol.kg^{-1} fructose					
	n_H					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.05009	12.23	11.84	11.58	11.37	11.18	11.01
0.10014	11.96	11.60	11.33	11.12	10.94	10.78
0.14975	11.73	11.40	11.15	10.94	10.76	10.60
0.19915	11.57	11.28	11.00	10.78	10.60	10.45
0.24995	11.44	11.14	10.90	10.68	10.50	10.35
0.29971	11.26	10.97	10.71	10.50	10.35	10.19
0.35036	7.34	7.15	6.97	6.85	6.74	6.64
0.39941	10.88	10.59	10.36	10.16	9.99	9.85
0.45002	10.72	10.44	10.21	10.01	9.85	9.71
0.49991	10.60	10.32	10.10	9.90	9.74	9.60

Table 4.161: Hydration number (n_H) of L-ornithine in aqueous solution of fructose (0.50 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-ornithine + water + 0.50 mol.kg^{-1} fructose					
	n_H					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.05071	11.82	11.48	11.19	10.98	10.82	10.66
0.09939	11.63	11.30	11.05	10.83	10.65	10.51
0.14922	11.44	11.15	10.88	10.70	10.53	10.38
0.20031	11.23	10.96	10.72	10.50	10.36	10.17
0.24982	11.03	10.76	10.53	10.32	10.16	10.01
0.29939	10.87	10.61	10.37	10.17	10.01	9.87
0.34861	10.74	10.45	10.23	10.03	9.86	9.72
0.40063	10.56	10.30	10.08	9.89	9.73	9.59
0.45021	10.42	10.17	9.95	9.76	9.60	9.47
0.49932	10.30	10.05	9.83	9.65	9.49	9.36

Table 4.162: Hydration number (n_H) of L-lysine in aqueous solution of fructose (0.05 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-lysine + water + 0.05 mol.kg^{-1} fructose					
	n_H					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.05018	13.78	13.58	13.24	12.91	12.59	12.32
0.10019	13.48	13.25	12.91	12.59	12.31	12.07
0.15011	13.15	12.93	12.61	12.27	12.01	11.77
0.19944	12.90	12.61	12.27	11.98	11.73	11.50
0.24971	12.64	12.33	12.00	11.72	11.48	11.23
0.30027	12.38	12.06	11.74	11.47	11.22	11.00
0.34982	12.16	11.81	11.49	11.22	10.99	10.83
0.40051	11.98	11.67	11.36	11.09	10.86	10.66
0.45029	11.80	11.49	11.18	10.92	10.69	10.49
0.50099	11.65	11.34	11.04	10.78	10.55	10.36

Table 4.163: Hydration number (n_H)of L-lysine in aqueous solution of fructose (0.20 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-lysine + water + 0.20 mol.kg^{-1} fructose					
	n_H					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.04948	13.06	12.71	12.32	12.06	11.86	11.61
0.09950	12.80	12.46	12.09	11.83	11.62	11.39
0.14951	12.59	12.23	11.90	11.63	11.40	11.19
0.19982	12.40	12.04	11.71	11.44	11.21	11.00
0.25015	12.18	11.84	11.53	11.26	11.04	10.84
0.29969	12.03	11.69	11.38	11.11	10.88	10.67
0.35020	11.90	11.56	11.25	10.97	10.77	10.55
0.39985	11.79	11.45	11.13	10.86	10.65	10.44
0.45008	11.65	11.33	11.01	10.73	10.55	10.34
0.50041	11.50	11.17	10.88	10.64	10.43	10.22

Table 4.164: Hydration number (n_H) of L-lysine in aqueous solution of fructose (0.35 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-lysine + water + 0.35 mol.kg^{-1} fructose					
	n_H					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.04989	12.74	12.38	12.05	11.76	11.53	11.31
0.09969	12.50	12.09	11.77	11.51	11.27	11.09
0.14941	12.28	11.88	11.57	11.30	11.07	10.87
0.19930	12.07	11.69	11.39	11.13	10.91	10.72
0.24962	11.85	11.50	11.21	10.95	10.73	10.54
0.29973	11.68	11.34	11.02	10.77	10.56	10.38
0.34995	11.54	11.20	10.90	10.65	10.45	10.27
0.40024	11.40	11.06	10.77	10.53	10.32	10.14
0.45046	11.26	10.92	10.64	10.40	10.19	10.02
0.49971	11.11	10.78	10.51	10.27	10.06	9.89

Table 4.165: Hydration number (n_H) of L-lysine in aqueous solution of fructose (0.50 mol.kg^{-1}) as a function of molality (m/mol.kg^{-1}) at different temperature

m/mol.kg^{-1}	L-lysine + water + 0.50 mol.kg^{-1} fructose					
	n_H					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.05063	12.15	11.79	11.49	11.24	11.02	10.76
0.10041	11.92	11.57	11.28	11.02	10.79	10.59
0.15001	11.75	11.42	11.13	10.87	10.66	10.47
0.20015	11.63	11.28	10.98	10.73	10.55	10.34
0.24963	11.52	11.16	10.87	10.64	10.45	10.24
0.30105	11.34	11.02	10.74	10.49	10.29	10.11
0.35055	11.18	10.86	10.58	10.35	10.15	9.97
0.40086	11.05	10.73	10.45	10.22	10.02	9.84
0.44971	10.90	10.60	10.33	10.09	9.89	9.72
0.49992	10.69	10.39	10.12	9.89	9.70	9.53

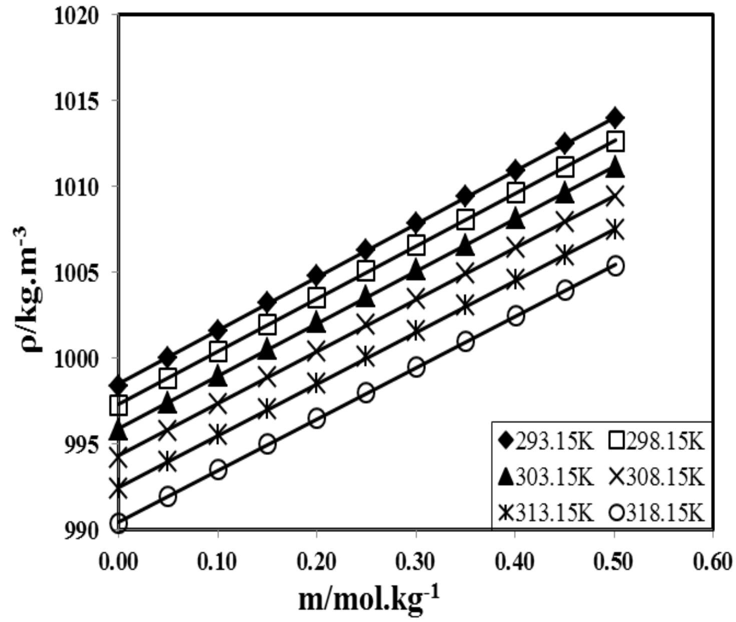


Figure 4.1**:** Plots of Density (ρ) vs. Molality (m) of glycine in aqueous system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

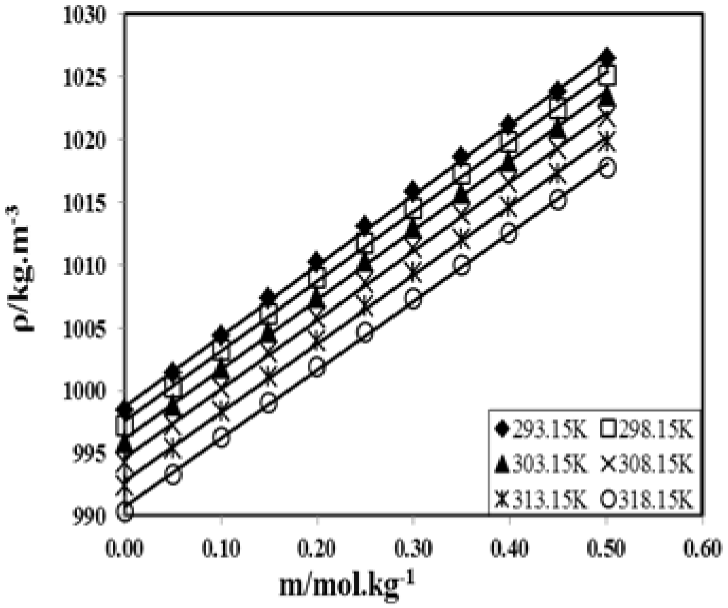


Figure 4.2**:** Plots of Density (ρ) vs. Molality (m) of L-ornithine in aqueous system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

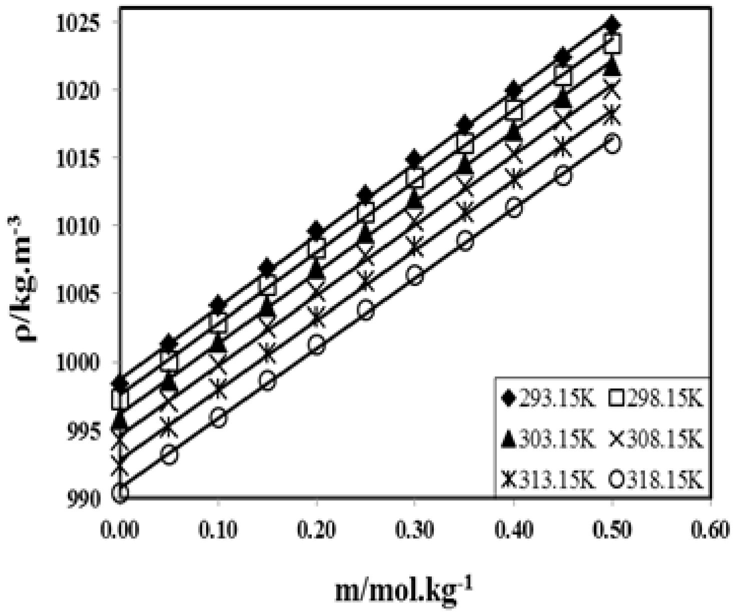


Figure 4.3**:** Plots of Density (ρ) vs. Molality (m) of L-lysine in aqueous system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

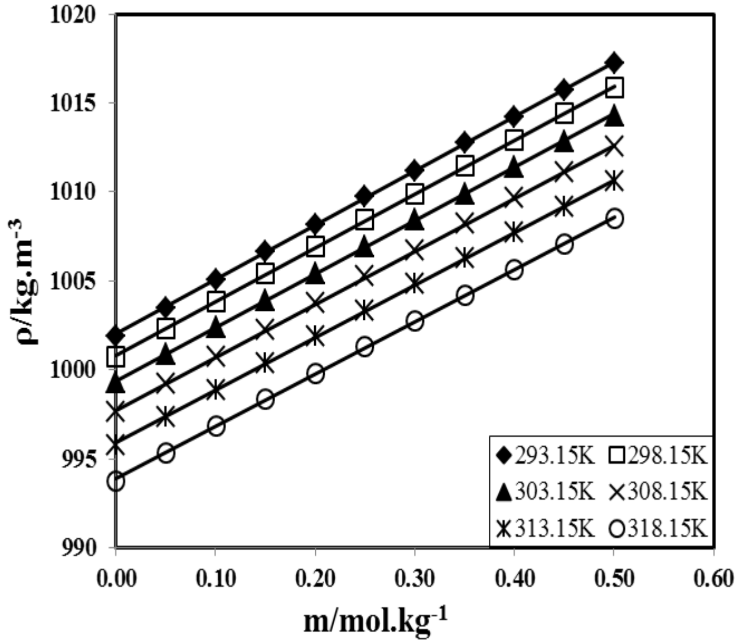


Figure 4.4: Plots of Density (ρ) vs. Molality (m) of glycine in aqueous 0.05 mol.kg^{-1} fructose systems at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively

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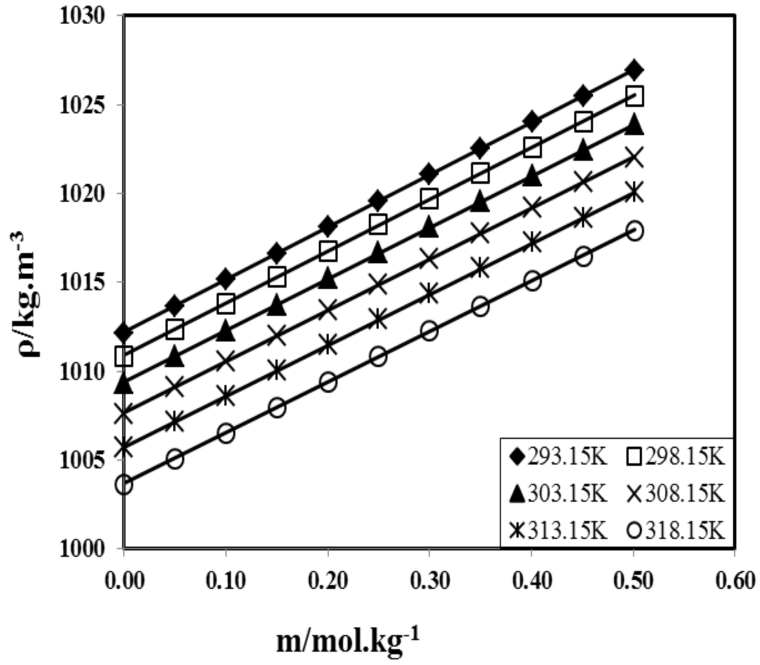

Figure 4.5: Plots of Density (ρ) vs. Molality (m) of glycine in aqueous 0.20 mol.kg^{-1} fructose systems at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

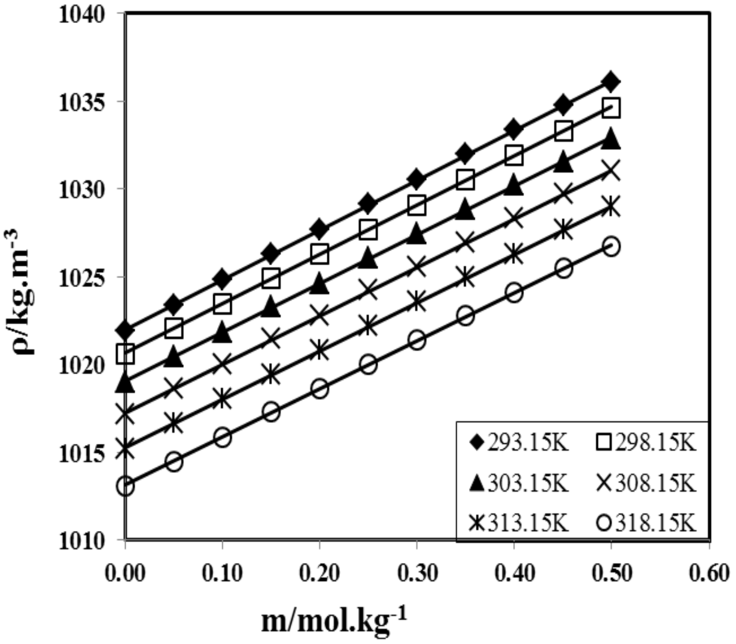

Figure 4.6: Plots of Density (ρ) vs. Molality (m) of glycine in aqueous 0.35 mol.kg^{-1} fructose systems at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

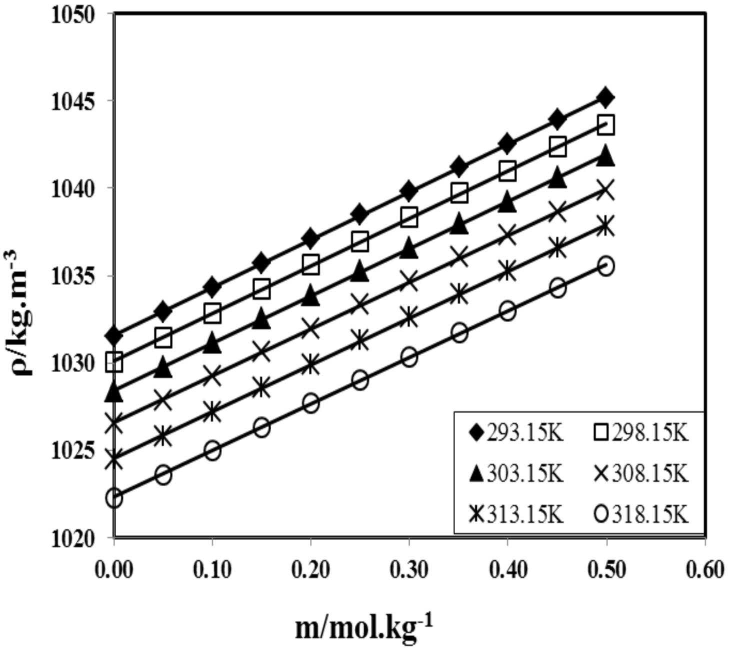

Figure 4.7: Plots of Density (ρ) vs. Molality (m) of glycine in aqueous 0.50 mol.kg^{-1} fructose systems at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

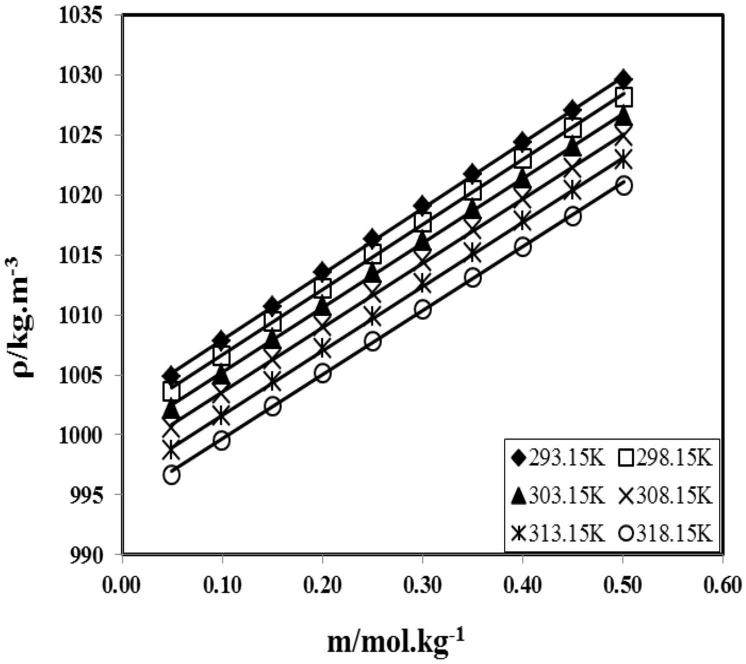

Figure 4.8: Plots of Density (ρ) vs. Molality (m) of L-ornithine in aqueous 0.05 mol.kg^{-1} fructose systems at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

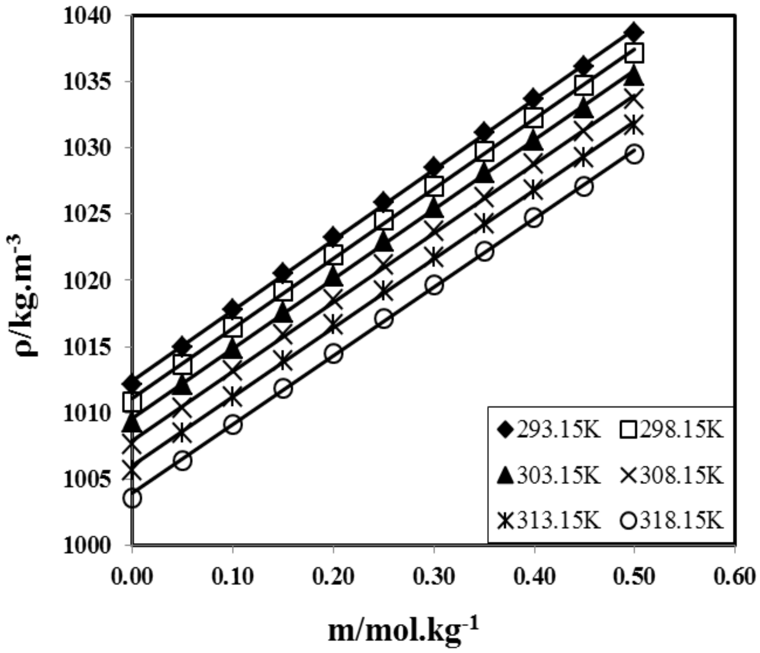

Figure 4.9: Plots of Density (ρ) vs. Molality (m) of L-ornithine in aqueous 0.20 mol.kg^{-1} fructose systems at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

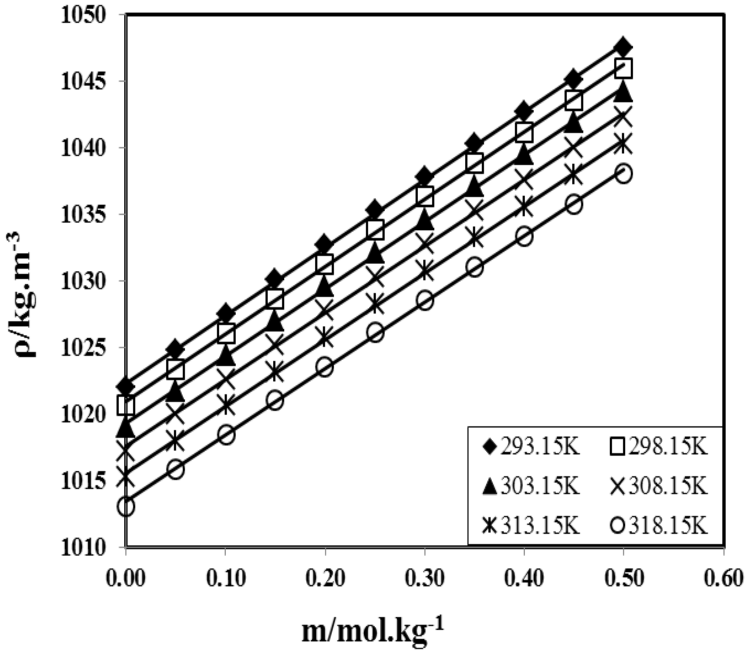

Figure 4.10: Plots of Density (ρ) vs. Molality (m) of L-ornithine in aqueous 0.35 mol.kg^{-1} fructose systems at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

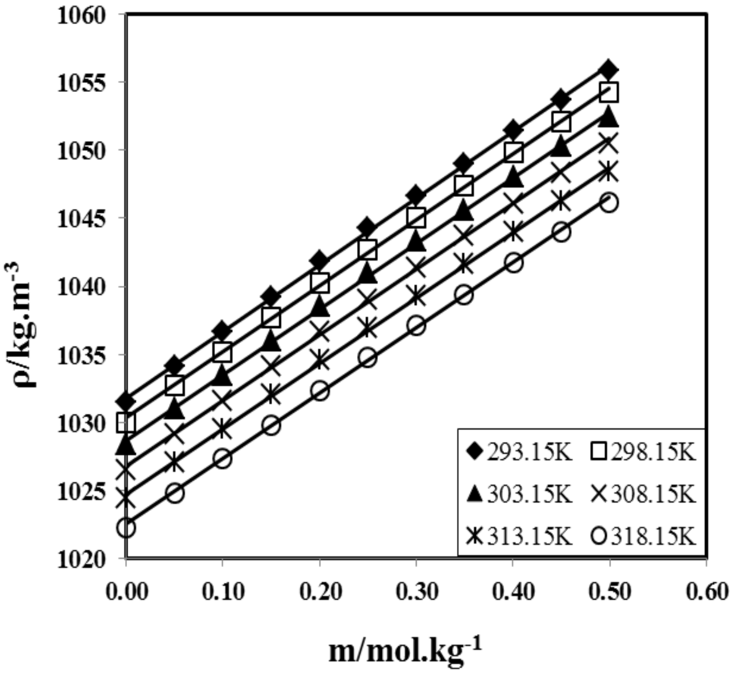

Figure 4.11: Plots of Density (ρ) vs. Molality (m) of L-ornithine in aqueous 0.50 mol.kg^{-1} fructose systems at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

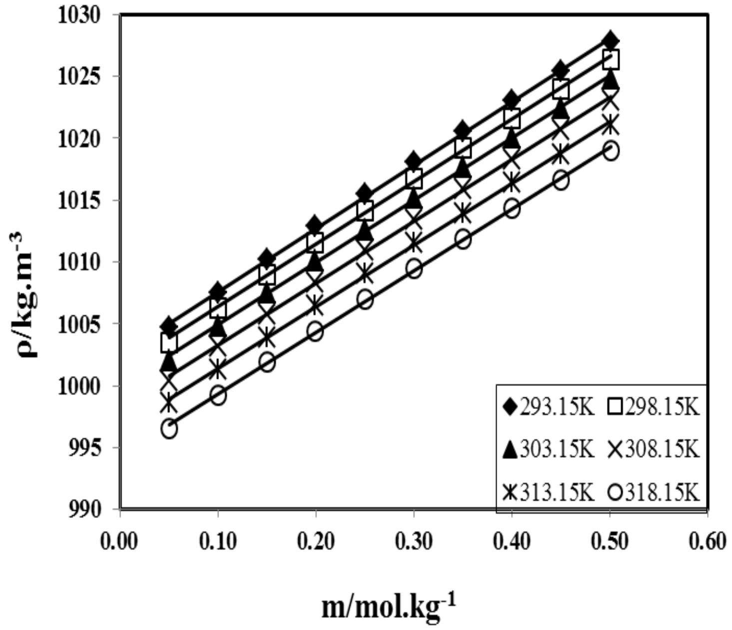

Figure 4.12: Plots of Density (ρ) vs. Molality (m) of L-lysine in aqueous 0.05 mol.kg^{-1} fructose systems at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

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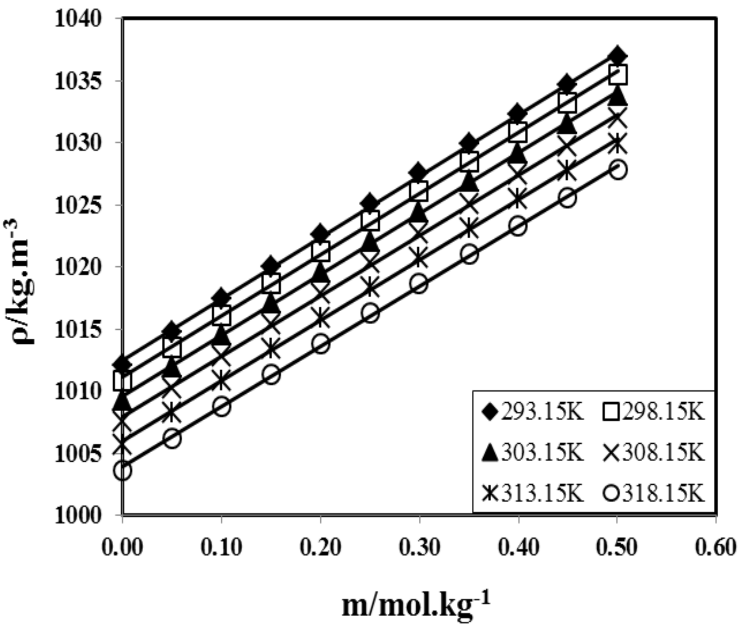

Figure 4.13: Plots of Density (ρ) vs. Molality (m) of L-lysine in aqueous 0.20 mol.kg^{-1} fructose systems at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

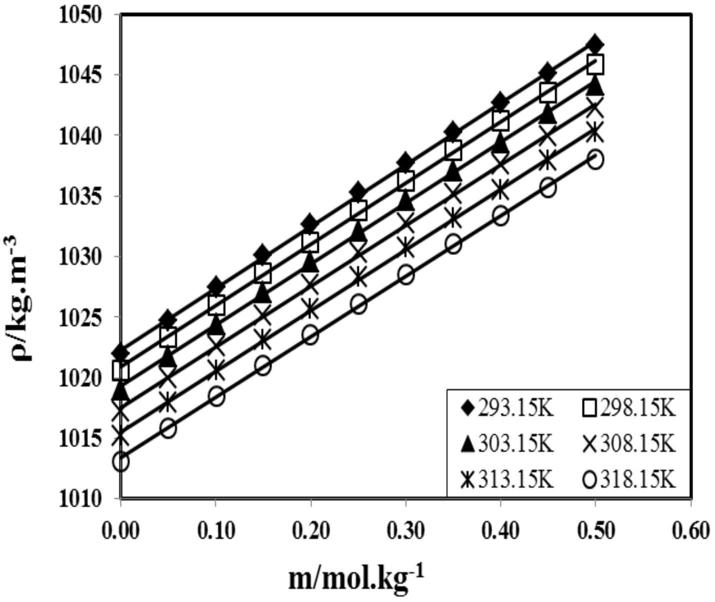

Figure 4.14: Plots of Density (ρ) vs. Molality (m) of L-lysine in aqueous 0.35 mol.kg^{-1} fructose systems at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

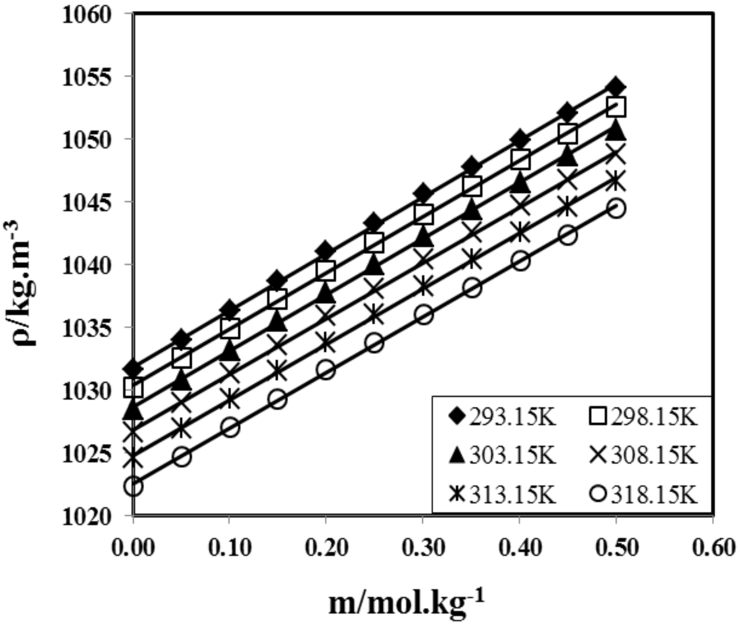

Figure 4.15: Plots of Density (ρ) vs. Molality (m) of L-lysine in aqueous 0.50 mol.kg^{-1} fructose systems at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

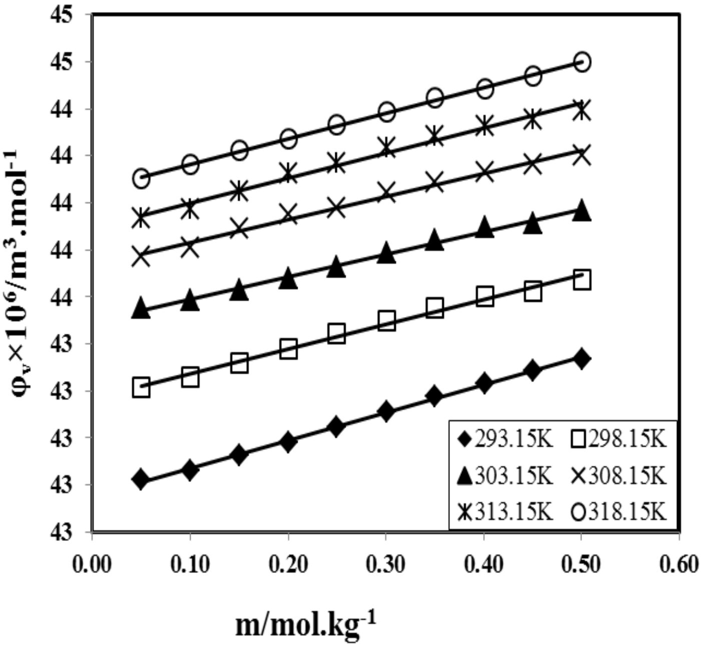

Figure 4.16: Plots of Apparent molar volume (φ$_v$) vs. Molality of glycine in aqueous system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

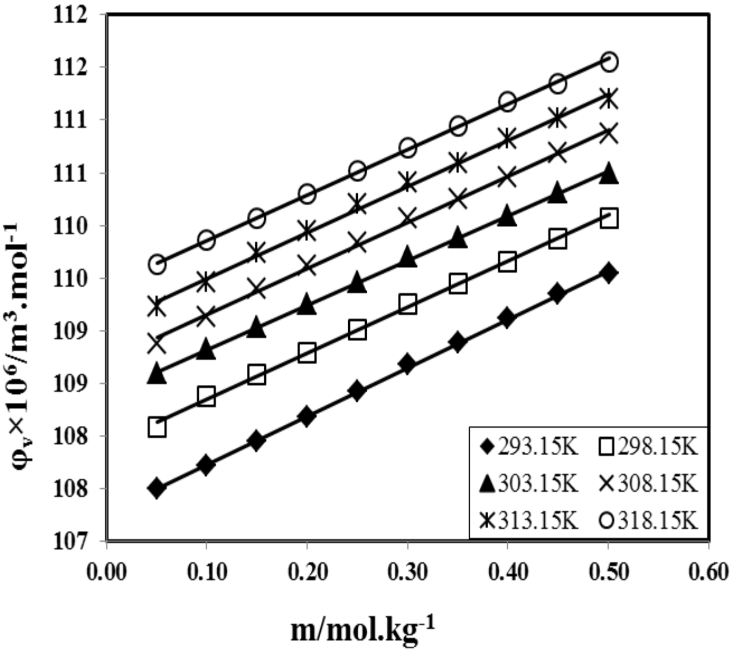

Figure 4.17: Plots of Apparent molar volume (φ_v) vs. Molality of L-ornithine in aqueous systems at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

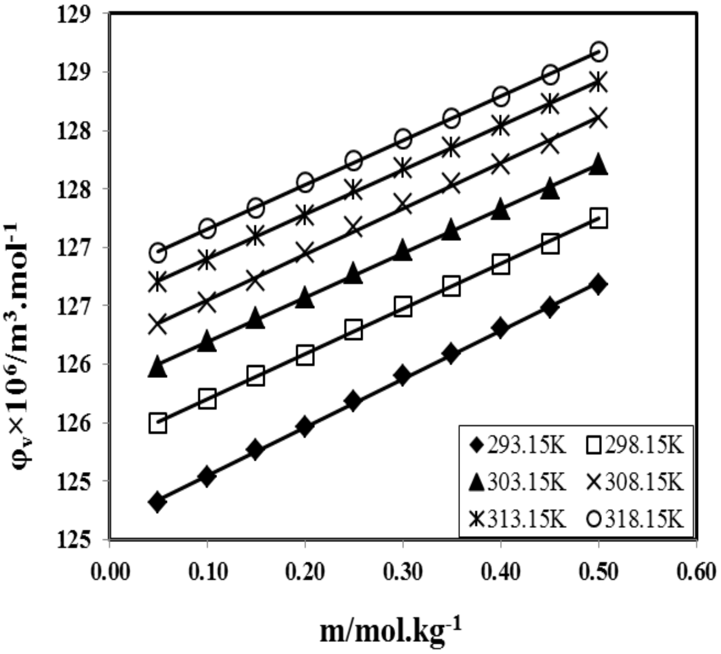

Figure 4.18: Plots of Apparent molar volume (φ_v) vs. Molality of L-lysine in aqueous system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

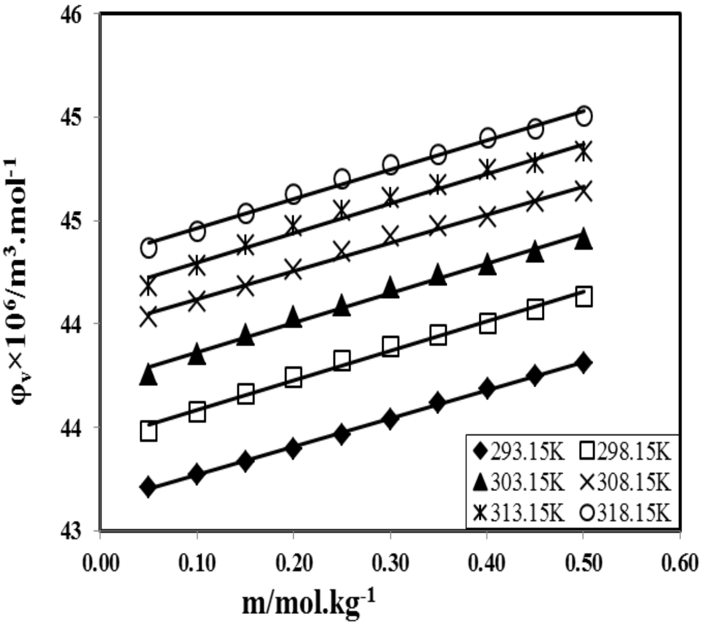

Figure 4.19: Plots of Figure 4.18: Apparent molar volume (φ_v) vs. Molality of glycine in aqueous 0.05 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

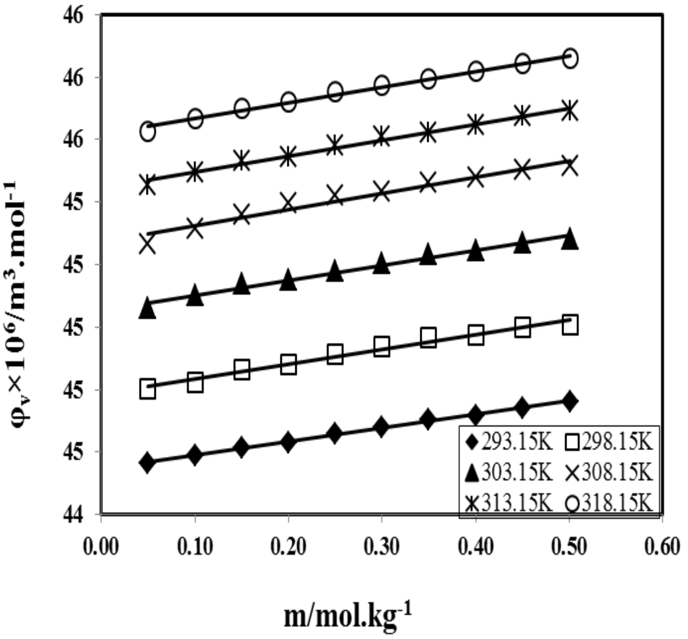

Figure 4.20: Plots of Apparent molar volume (φ_v) vs. Molality of glycine in aqueous 0.20 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

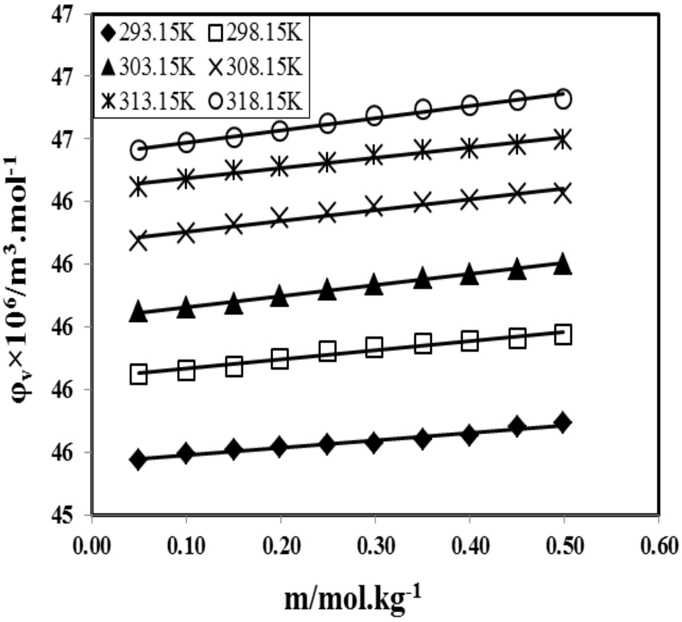

Figure 4.21: Plots of Apparent molar volume (φ_v) vs. Molality of glycine in aqueous 0.35 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

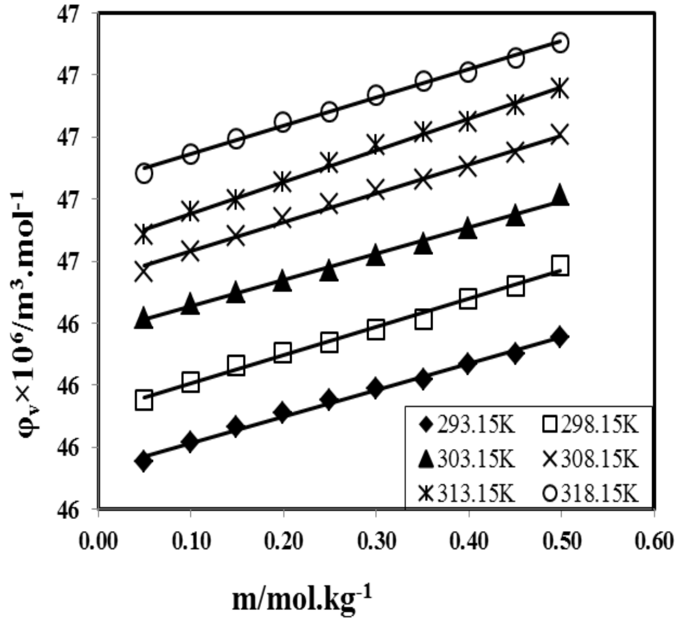

Figure 4.22: Plots of Apparent molar volume (φ_v) vs. Molality of glycine in aqueous 0.50 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

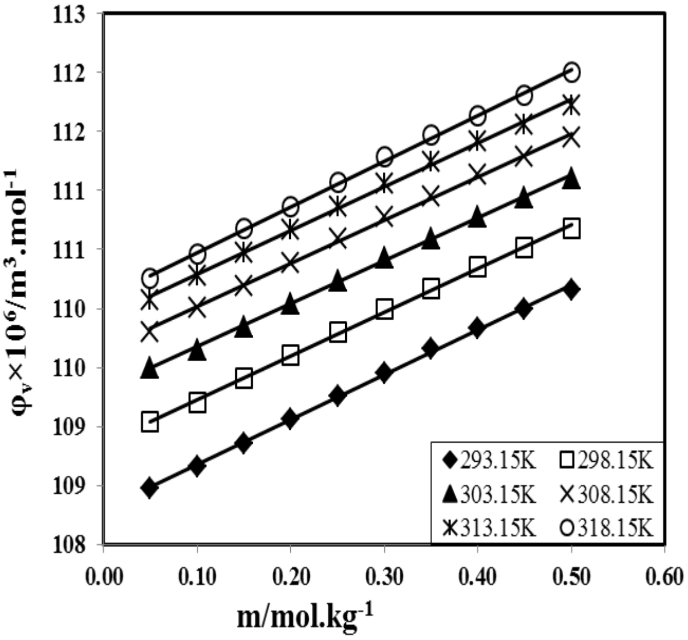

Figure 4.23: Plots of Apparent molar volume (φ_v) vs. Molality of L-ornithine in aqueous 0.05 mol.kg^{-1} fructose systems at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

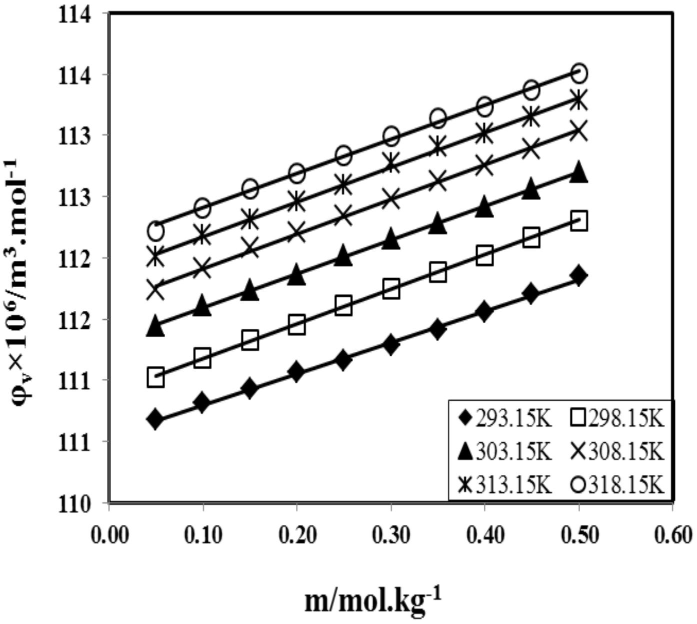

Figure 4.24: Plots of Apparent molar volume (φ_v) vs. Molality of L-ornithine in aqueous 0.20 mol.kg^{-1} fructose systems at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

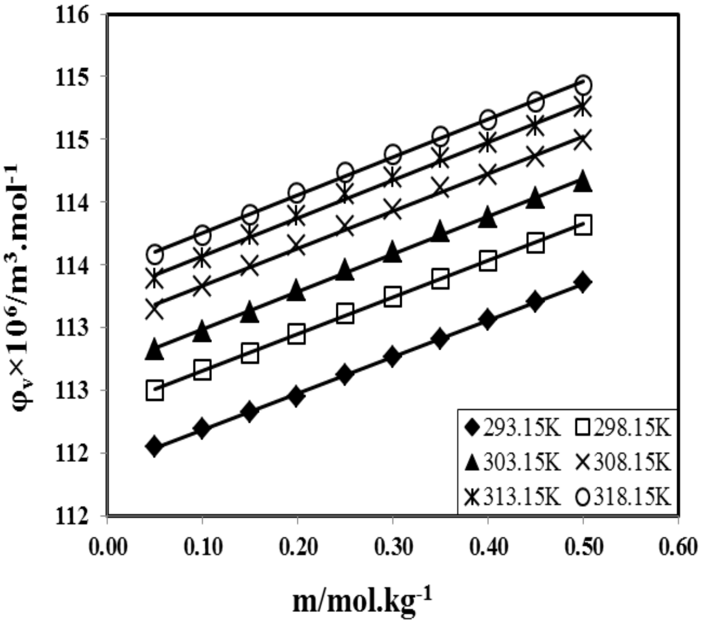

Figure 4.25: Plots of Apparent molar volume (φ_v) vs. Molality of L-ornithine in aqueous 0.35 mol.kg^{-1} fructose systems at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

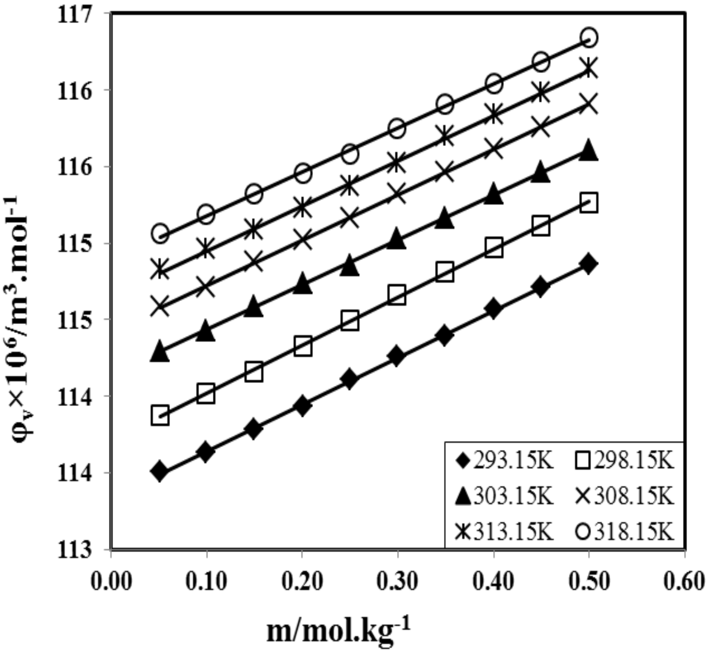

Figure 4.26: Plots of Apparent molar volume (φ_v) vs. Molality of L-ornithine in aqueous 0.50 mol.kg^{-1} fructose systems at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

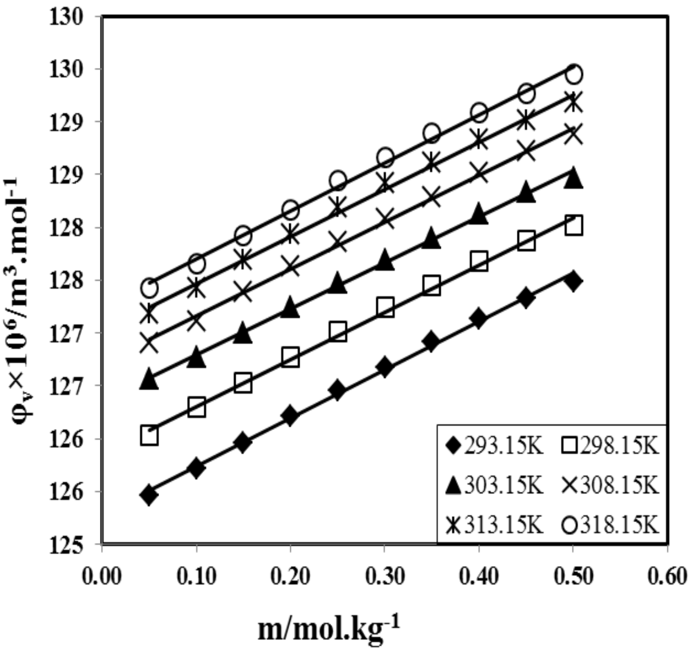

Figure 4.27: Plots of Apparent molar volume (φ_v) vs. Molality of L-lysine in aqueous 0.05 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

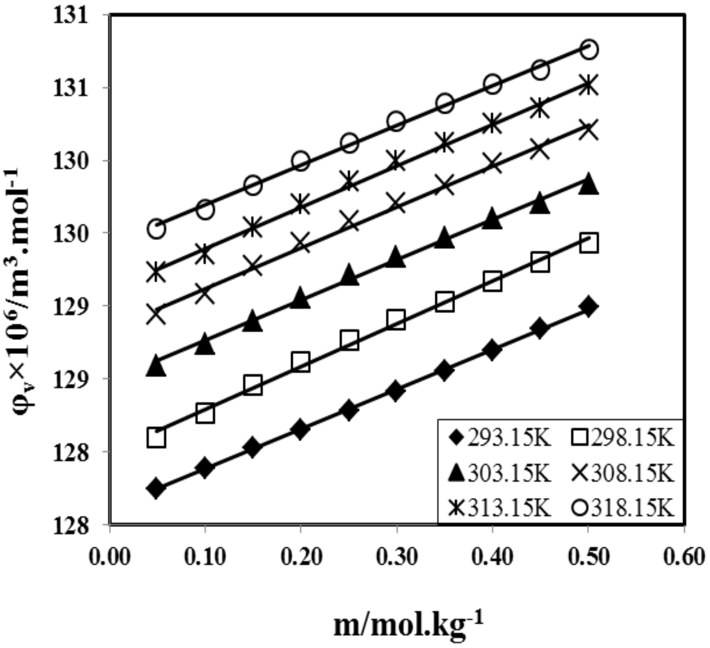

Figure 4.28: Plots of Apparent molar volume (φ_v) vs. Molality of L-lysine in aqueous 0.20 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

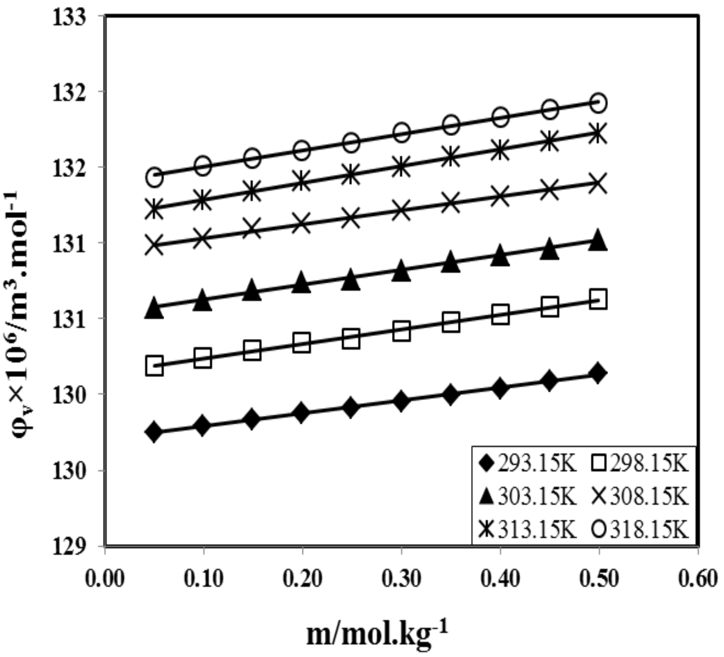

Figure 4.29: Plots of Apparent molar volume (φ_v) vs. Molality of L-lysine in aqueous 0.35 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

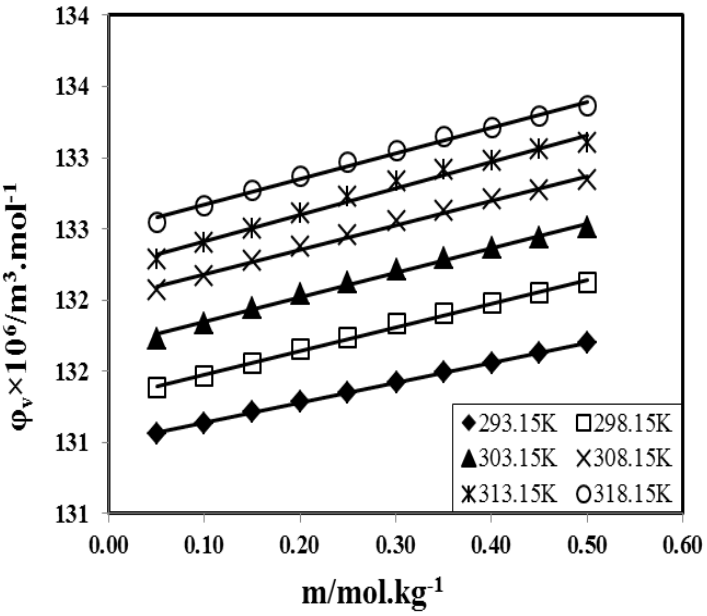

Figure 4.30: Plots of Apparent molar volume (φ_v) vs. Molality of L-lysine in aqueous 0.50 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

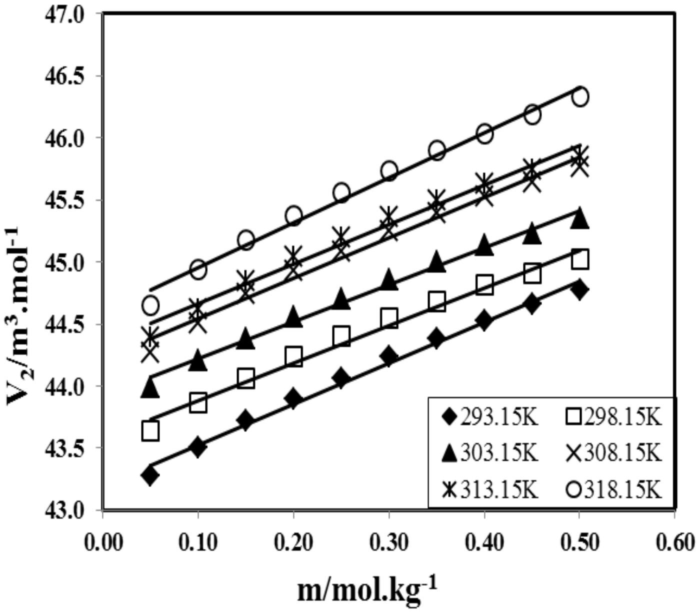

Figure 4.31: Plots of Partial molar volume (V_2) vs. Molality of glycine in aqueous system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

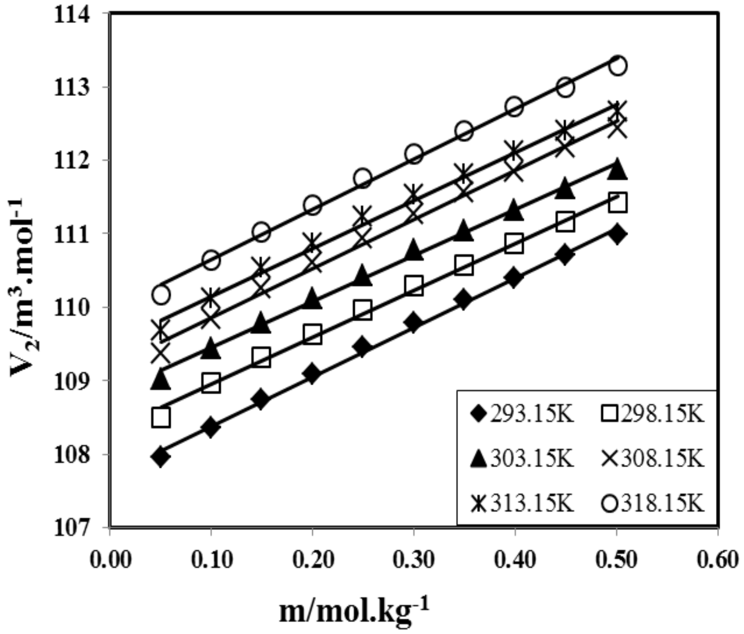

Figure 4.32: Plots of Partial molar volume (V_2) vs. Molality of L-ornithine in aqueous systems at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

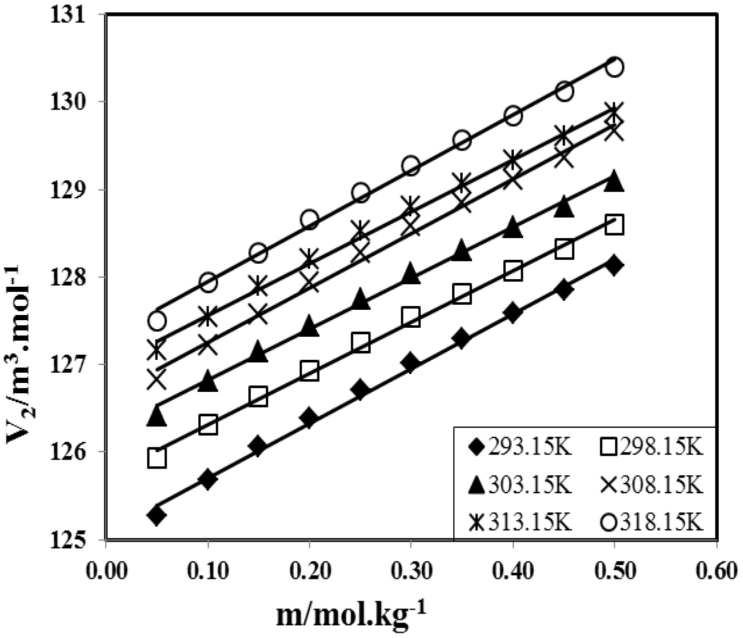

Figure 4.33: Plots of Partial molar volume (V_2) vs. Molality of L-lysine in aqueous system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

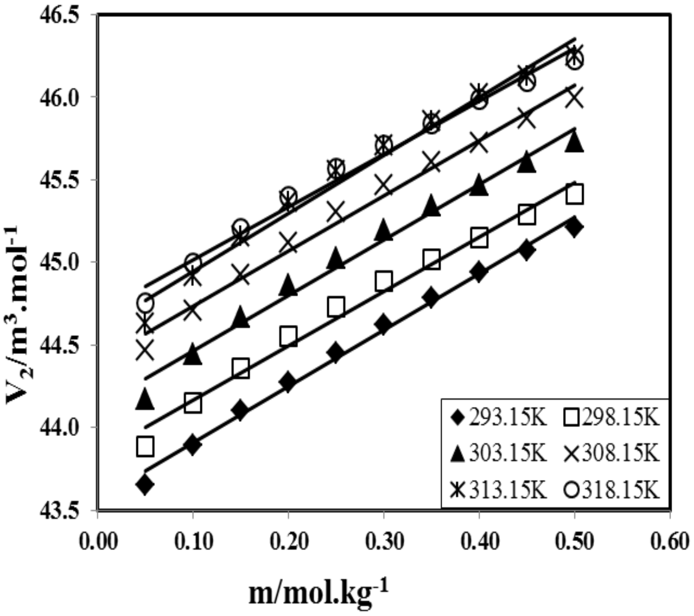

Figure 4.34: Plots of Partial molar volume (V_2) vs. Molality of glycine in aqueous 0.05 $mol.kg^{-1}$ fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

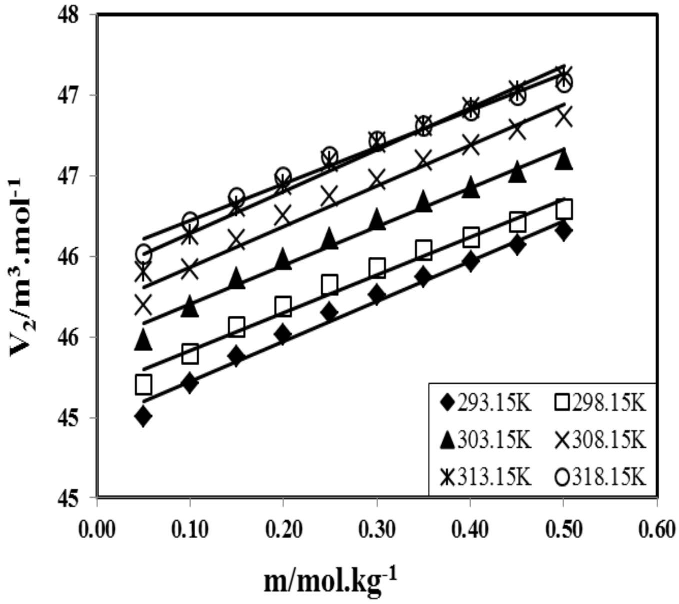

Figure 4.35: Plots of Partial molar volume (V_2) vs. Molality of glycine in aqueous 0.20 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

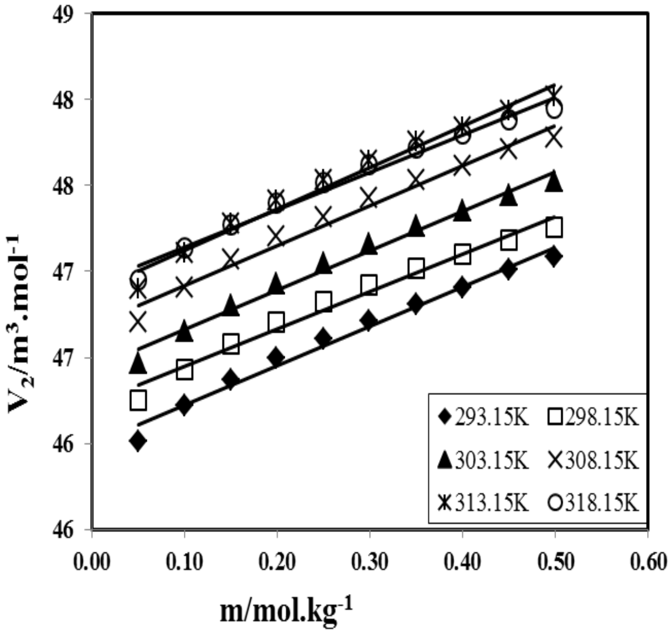

Figure 4.36: Plots of Partial molar volume (V_2) vs. Molality of glycine in aqueous 0.35 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

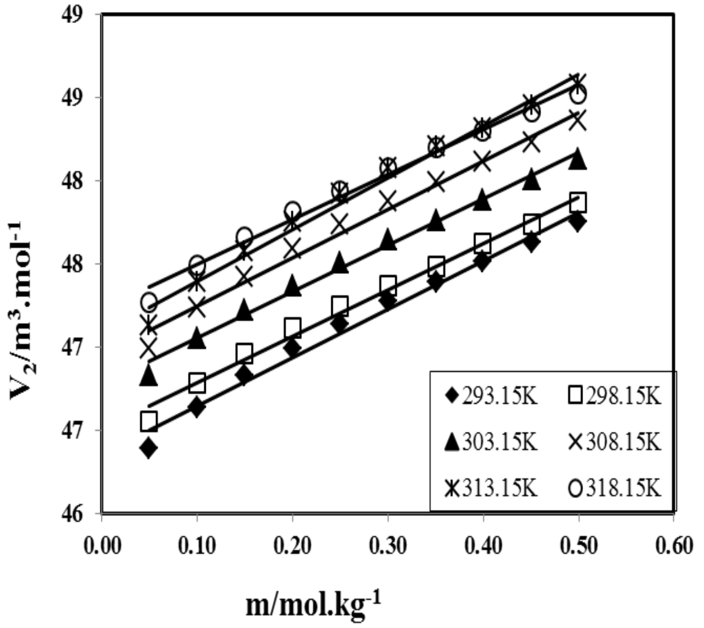

Figure 4.37: Plots of Partial molar volume (V_2) vs. Molality of glycine in aqueous 0.50 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

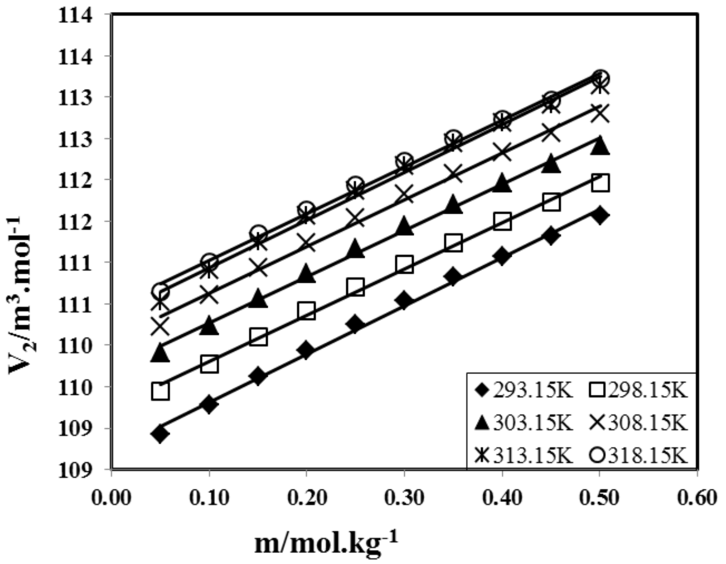

Figure 4.38: Plots of Partial molar volume (V_2) vs. Molality of L-ornithine in aqueous 0.05 mol.kg^{-1} fructose systems at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

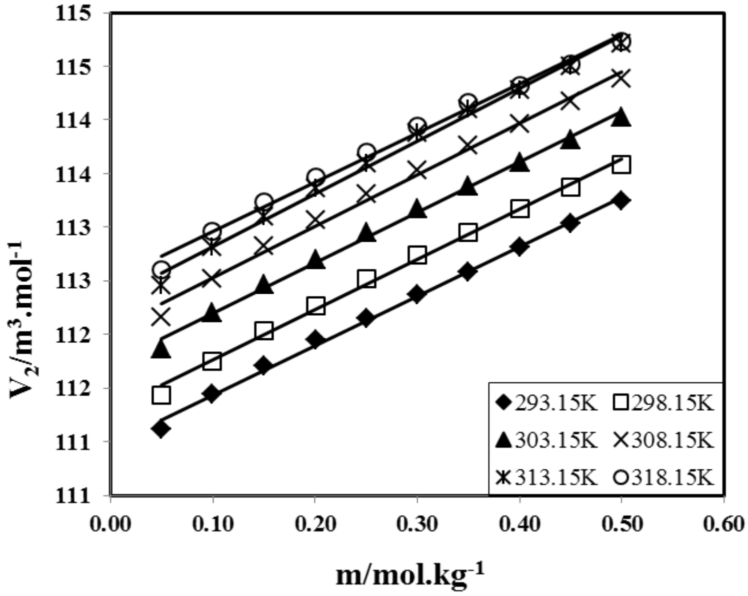

Figure 4.39: Plots of Partial molar volume (V_2) vs. Molality of L-ornithine in aqueous 0.20 mol.kg^{-1} fructose systems at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

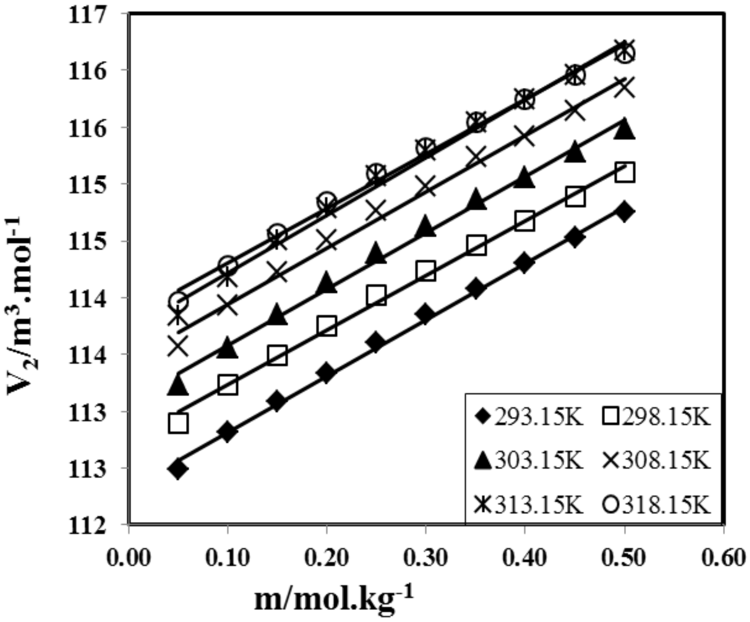

Figure 4.40: Plots of Partial molar volume (V_2) vs. Molality of L-ornithine in aqueous 0.35 mol.kg^{-1} fructose systems at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

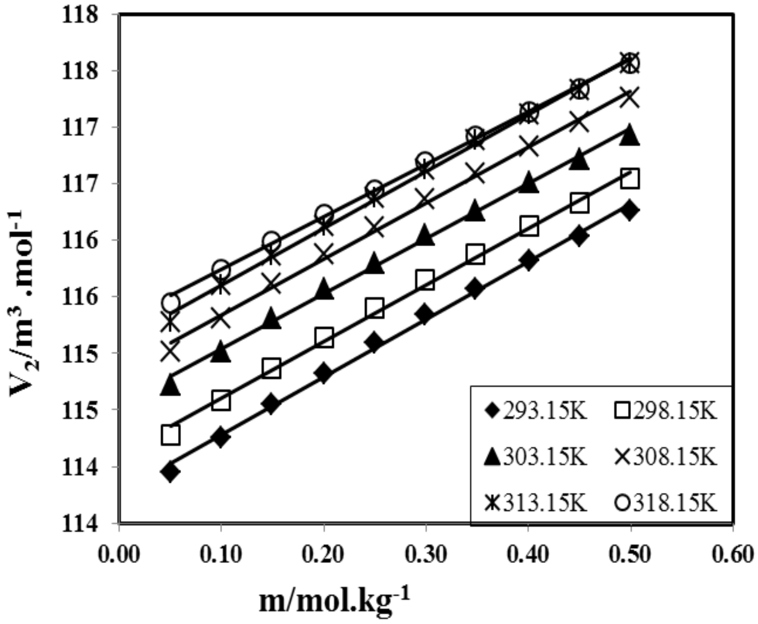

Figure 4.41: Plots of Partial molar volume (V_2) vs. Molality of L-ornithine in aqueous 0.50 mol.kg^{-1} fructose systems at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

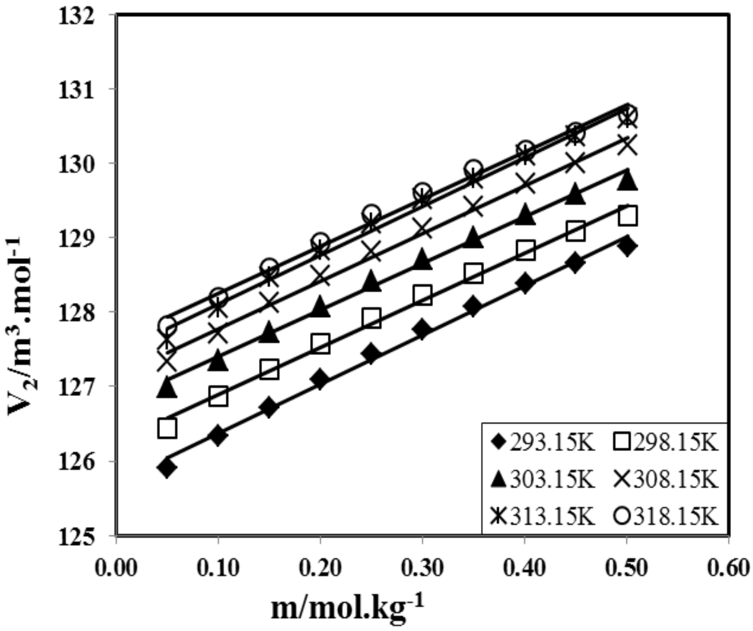

Figure 4.42: Plots of Partial molar volume (V_2) vs. Molality of L-lysine in aqueous 0.05 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respective

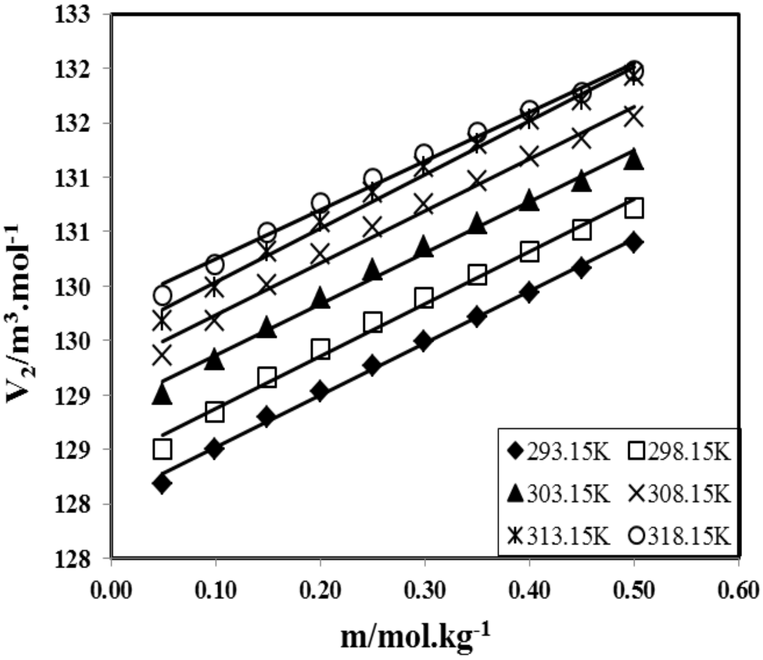

Figure 4.43: Plots of Partial molar volume (V_2) vs. Molality of L-lysine in aqueous 0.20 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

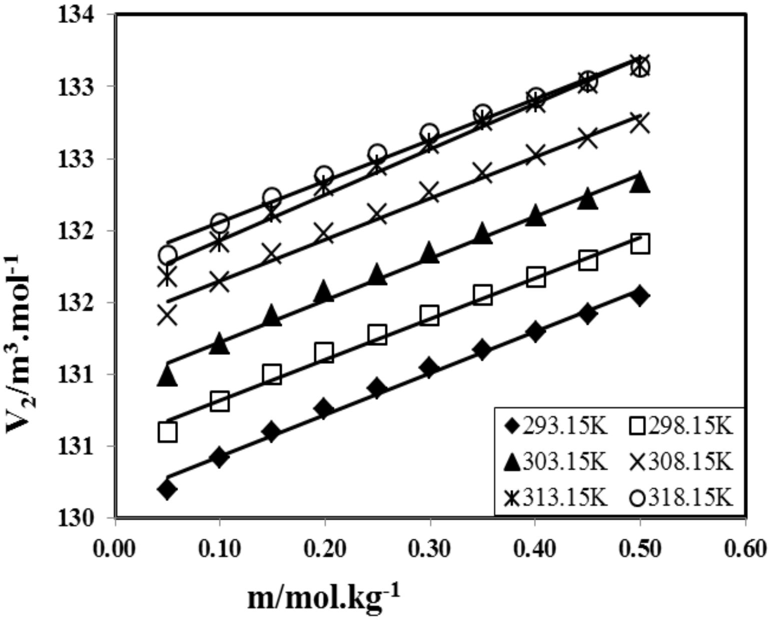

Figure 4.44: Plots of Partial molar volume (V_2) vs. Molality of L-lysine in aqueous 0.35 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

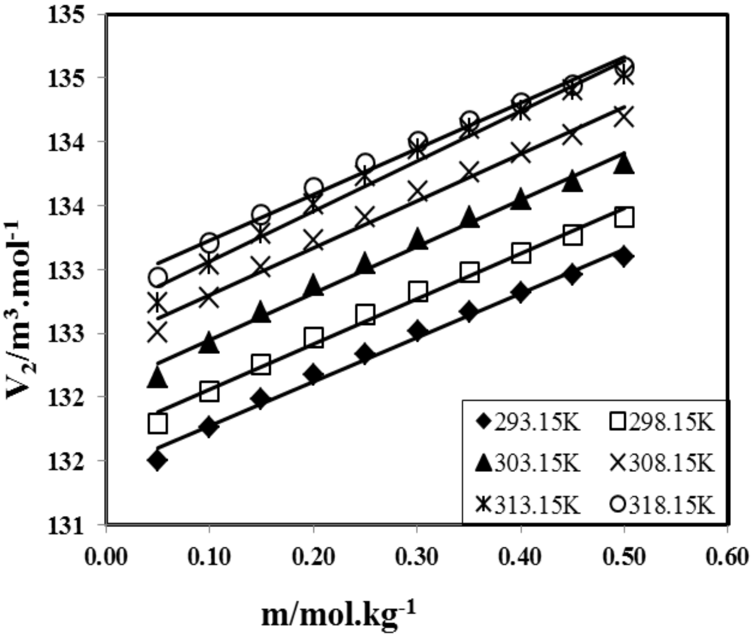

Figure 4.45: Plots of Partial molar volume (V_2) vs. Molality of L-lysine in aqueous 0.50 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

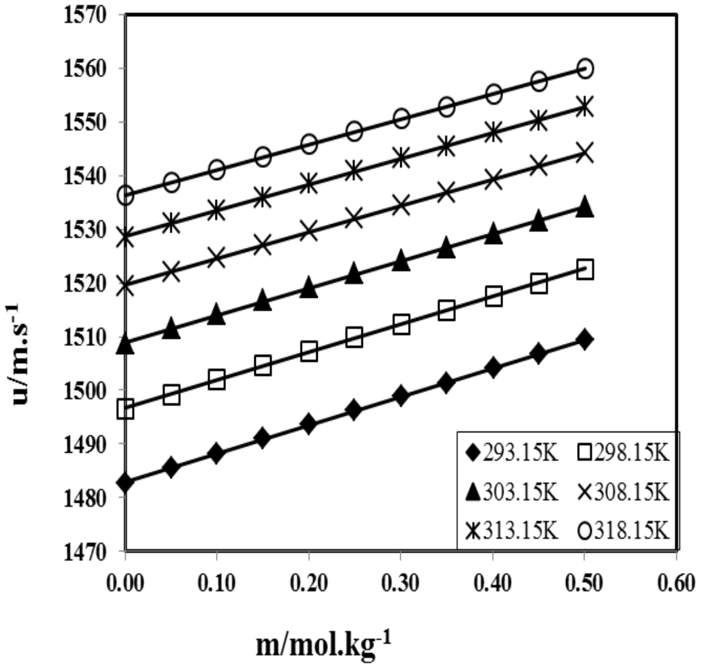

Figure 4.46**:** Plots of Sound velocity (u) vs. Molality (m) of glycine in aqueous system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

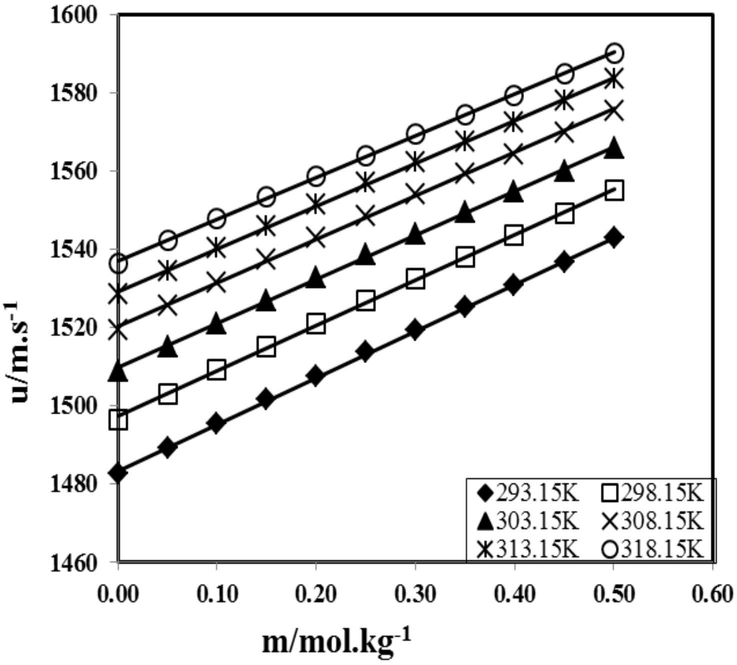

Figure 4.47**:** Plots of Sound velocity (u) vs. Molality (m) of L-ornithine in aqueous system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

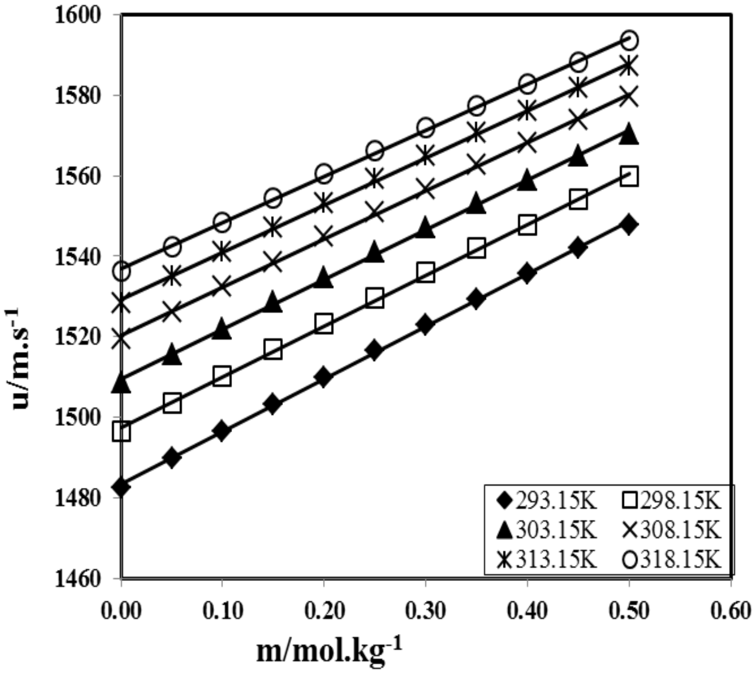

Figure 4.48**:** Plots of Sound velocity (u) vs. Molality (m) of L-lysine in aqueous system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

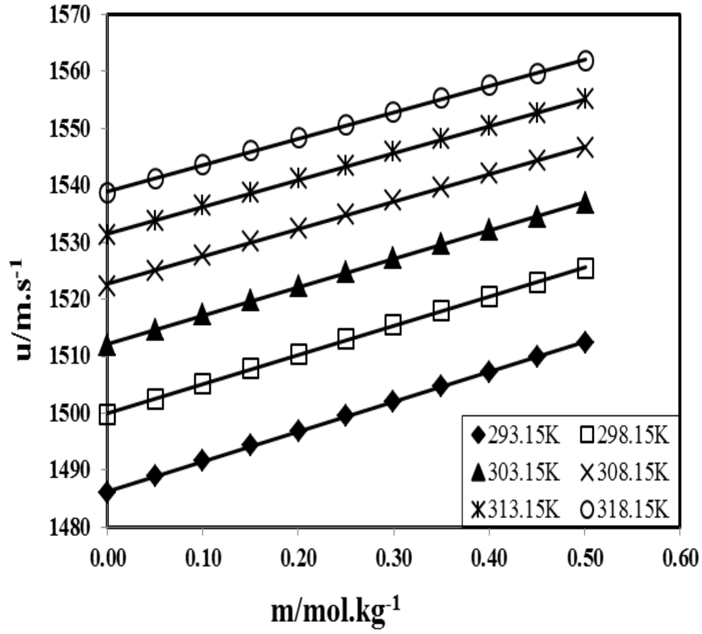

Figure 4.49: Plots of Sound velocity (u) vs. Molality (m) of glycine in aqueous 0.05 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

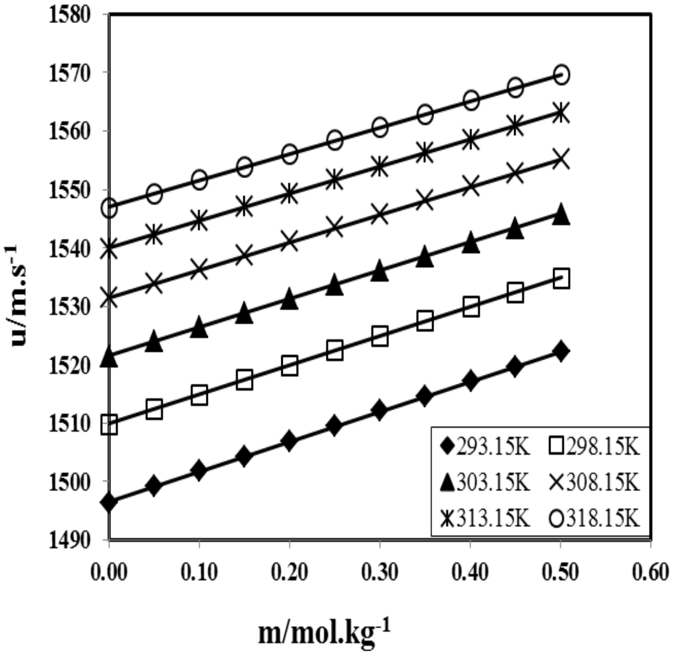

Figure 4.50: Plots of Sound velocity (u) vs. Molality (m) of glycine in aqueous 0.20 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

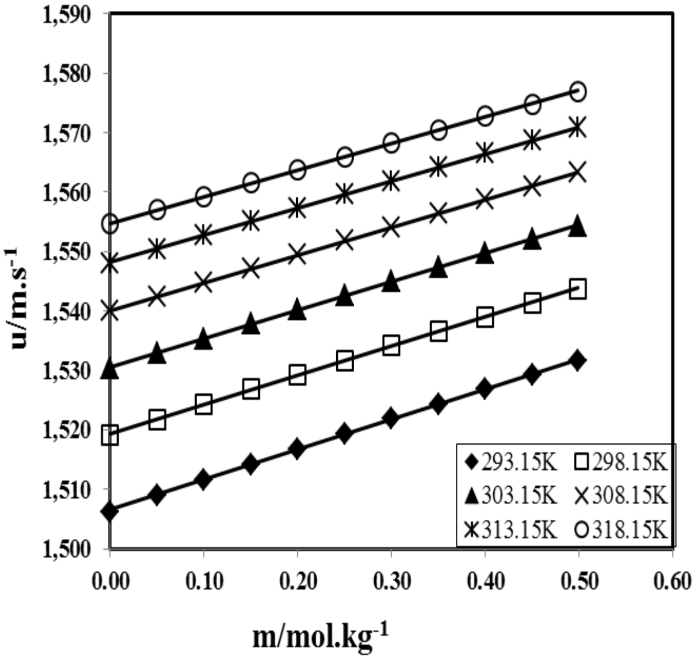

Figure 4.51: Plots of Sound velocity (u) vs. Molality (m) of glycine in aqueous 0.35 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

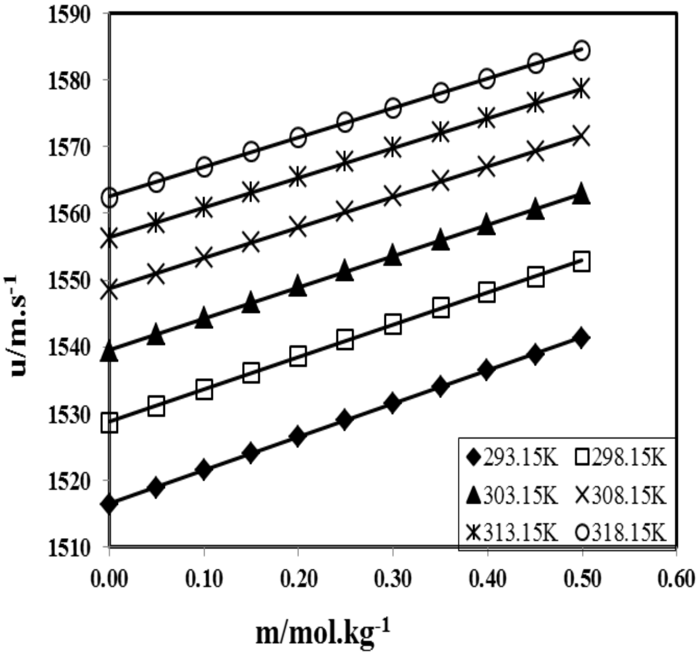

Figure 4.52: Plots of Sound velocity (u) vs. Molality (m) of glycine in aqueous 0.50 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

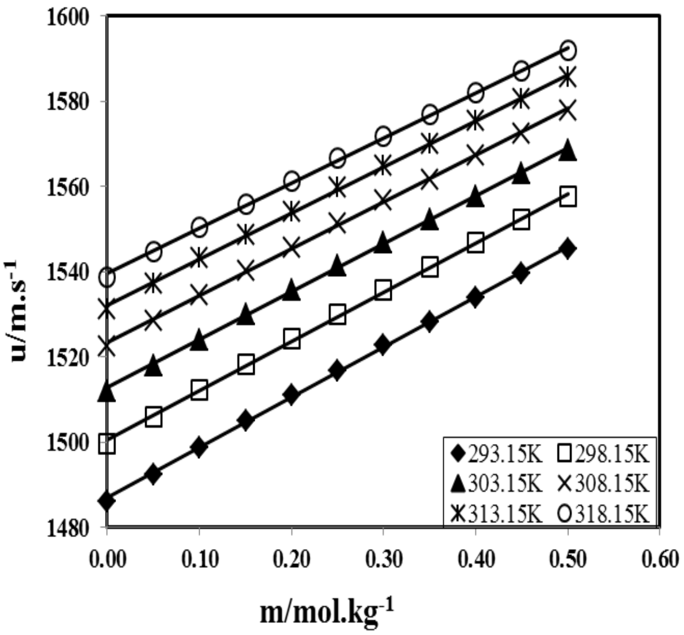

Figure 4.53: Plots of Sound velocity (u) vs. Molality (m) of L-ornithine in aqueous 0.05 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

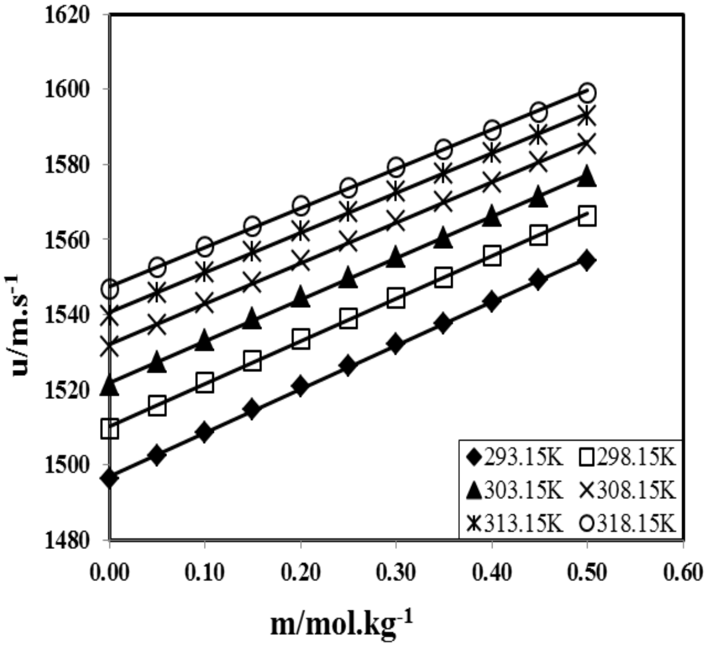

Figure 4.54: Plots of Sound velocity (u) vs. Molality (m) of L-ornithine in aqueous 0.20 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

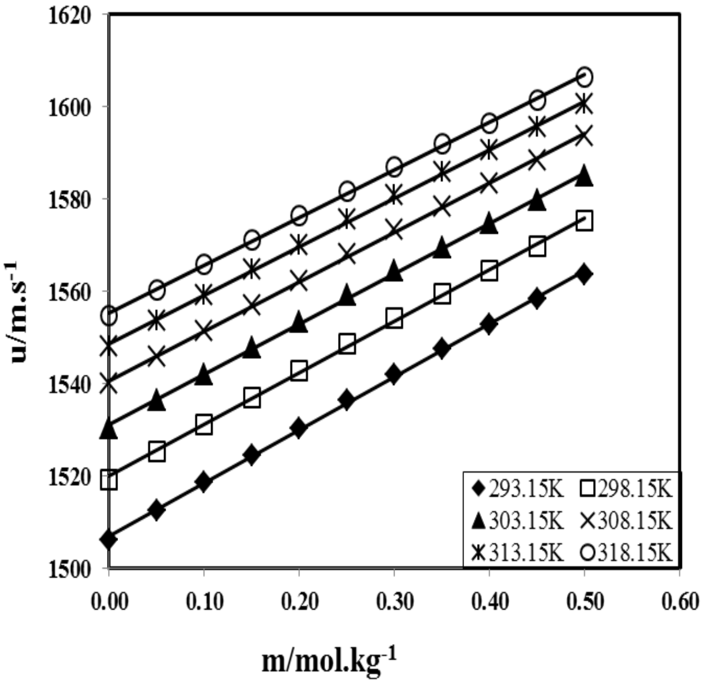

Figure 4.55: Plots of Sound velocity (u) vs. Molality (m) of L-ornithine in aqueous 0.35 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

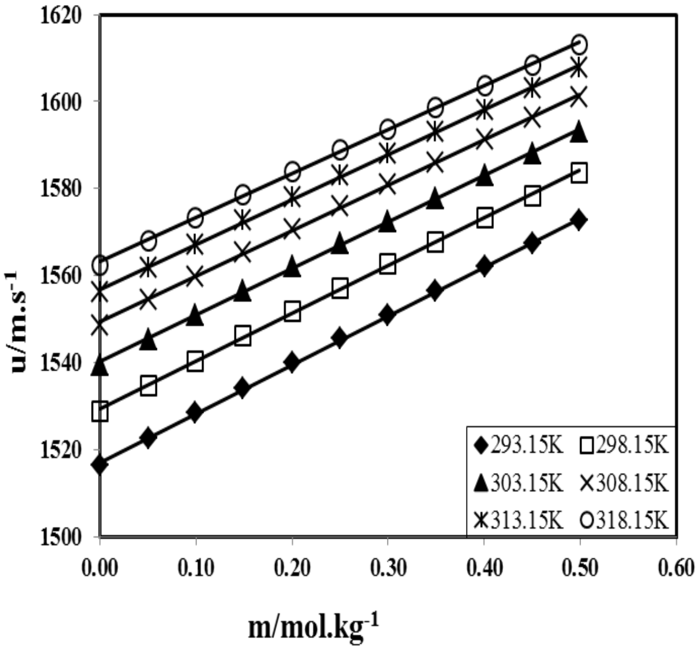

Figure 4.56: Plots of Sound velocity (u) vs. Molality (m) of L-ornithine in aqueous 0.50 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

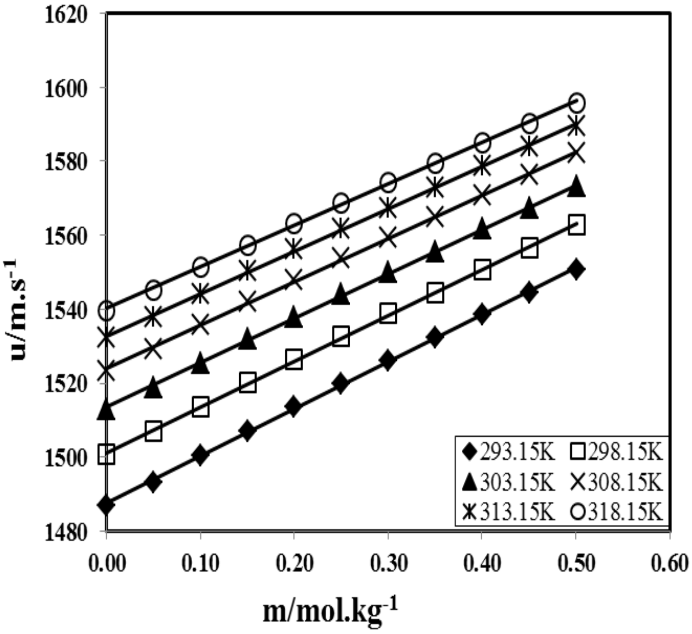

Figure 4.57: Plots of Sound velocity (u) vs. Molality (m) of L-lysine in aqueous 0.05 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

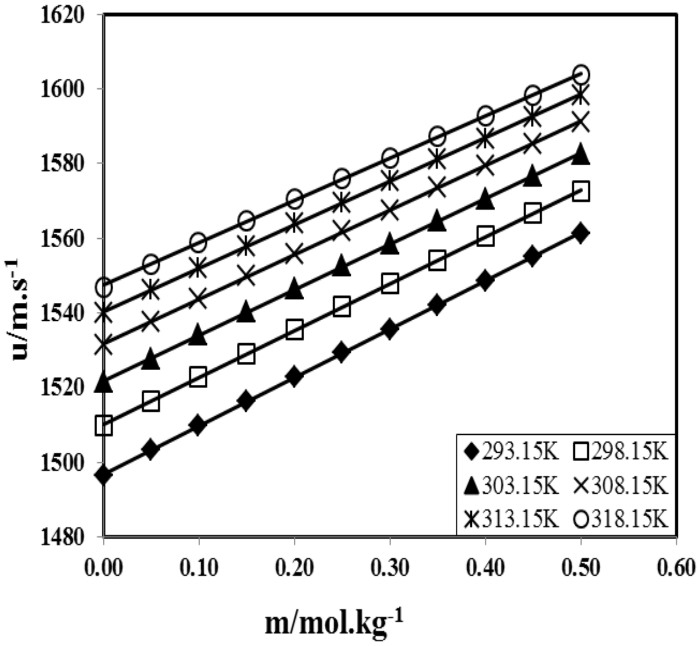

Figure 4.58: Plots of Sound velocity (u) vs. Molality (m) of L-lysine in aqueous 0.20 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively

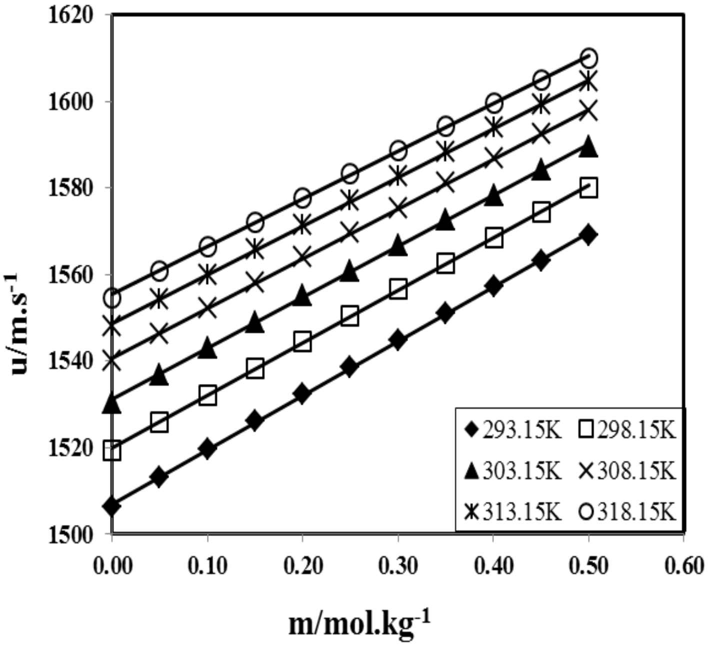

Figure 4.59: Plots of Sound velocity (u) vs. Molality (m) of L-lysine in aqueous 0.35 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

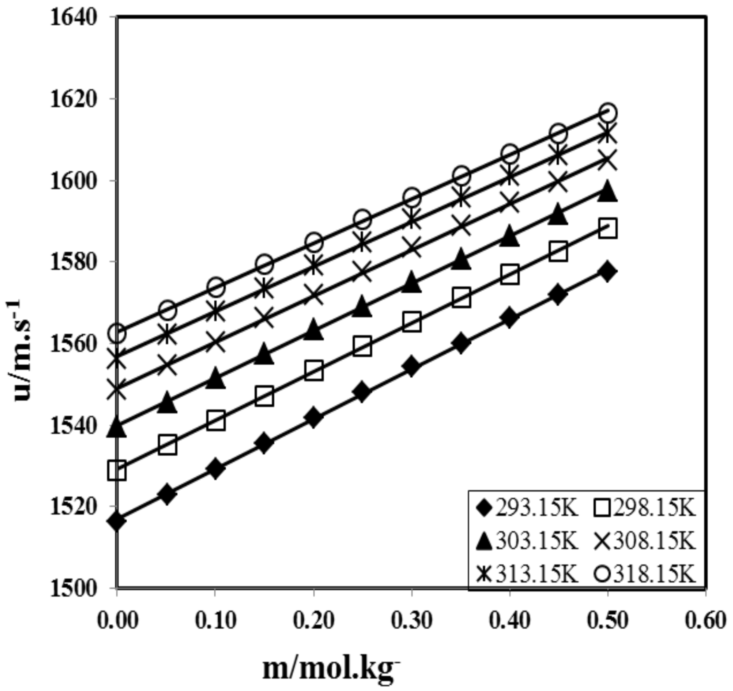

Figure 4.60: Plots of Sound velocity (u) vs. Molality (m) of L-lysine in aqueous 0.50 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

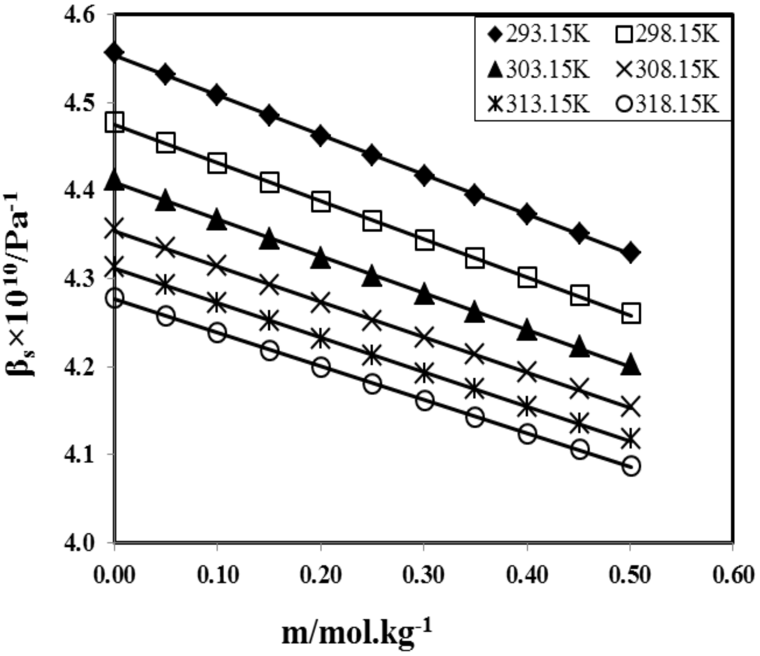

Figure 4.61**:** Plots of Adiabatic compressibility (β_s) vs. Molality (m) of glycine in aqueous system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively

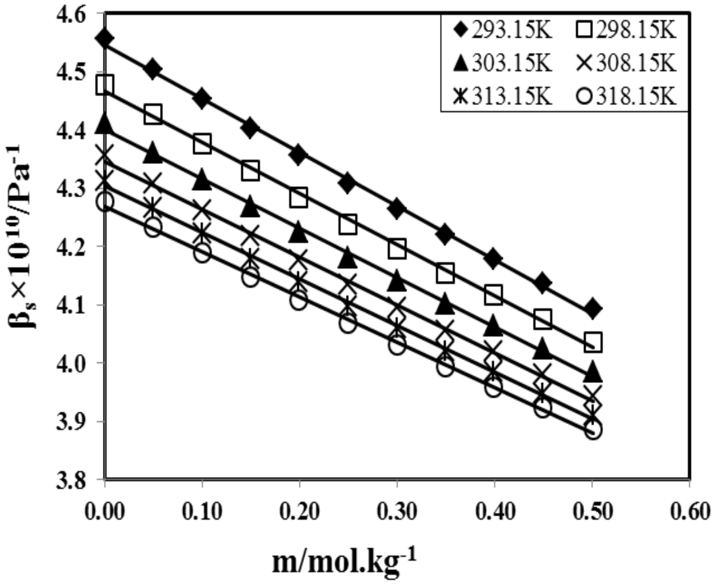

Figure 4.62**:** Plots of Adiabatic compressibility (β_s) vs. Molality (m) of L-ornithine in aqueous system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

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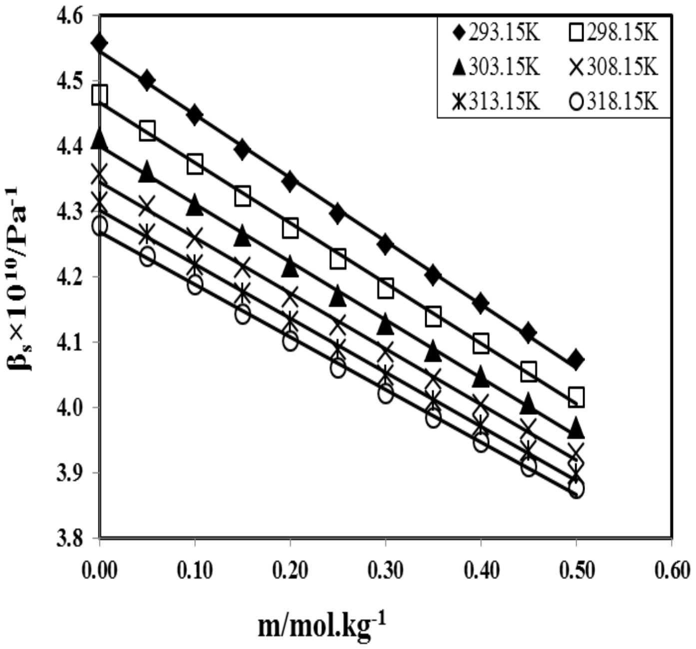

Figure 4.63**:** Plots of Adiabatic compressibility (β_s) vs. Molality (m) of L-lysine in aqueous system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

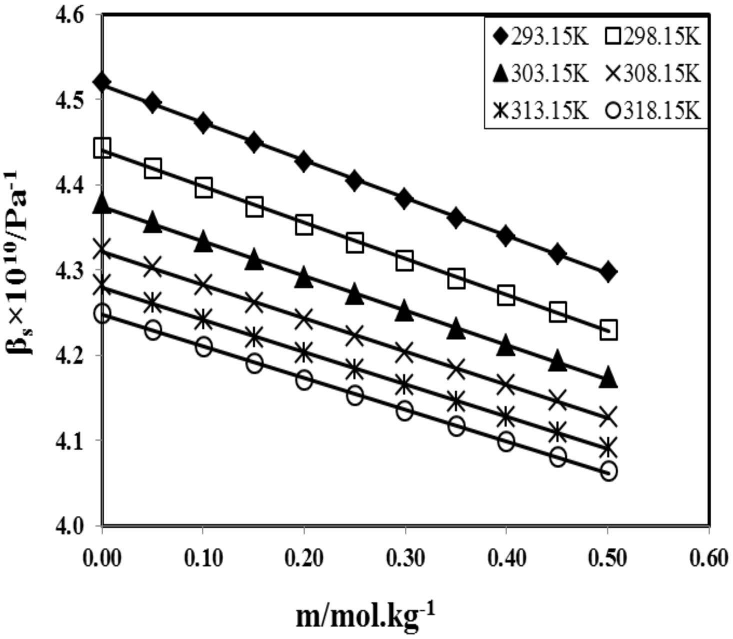

Figure 4.64: Plots of Adiabatic compressibility (β_s) vs. Molality (m) of glycine in aqueous 0.05 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

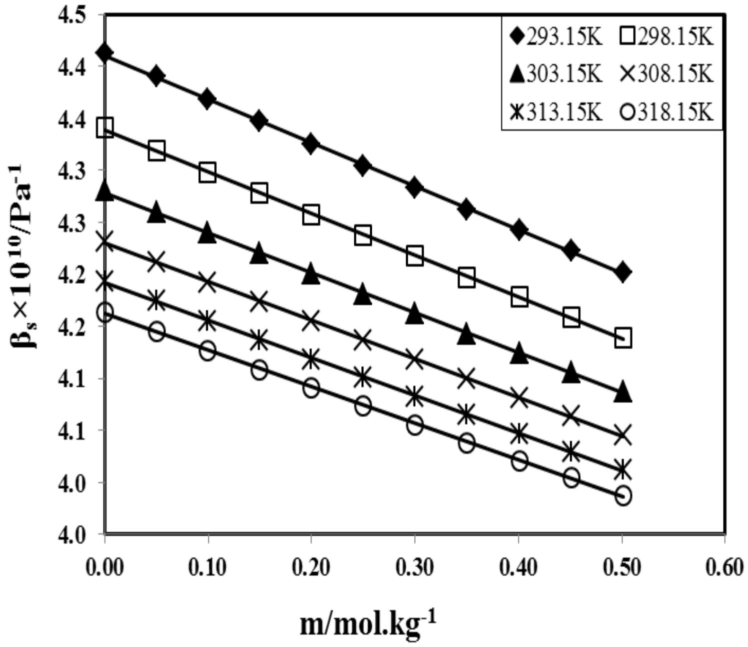

Figure 4.65: Plots of Adiabatic compressibility (β_S) vs. Molality (m) of glycine in aqueous 0.20 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

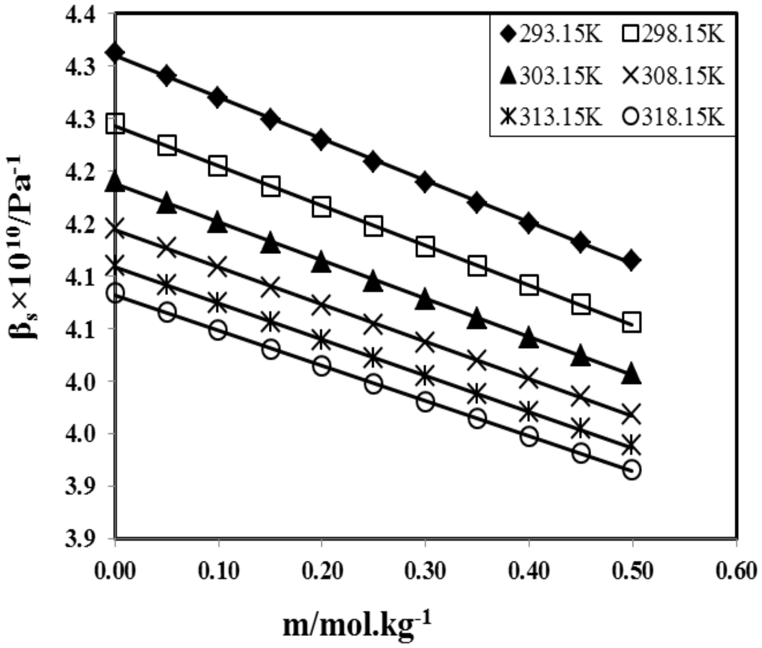

Figure 4.66: Plots of Adiabatic compressibility (β_S) vs. Molality (m) of glycine in aqueous 0.35 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

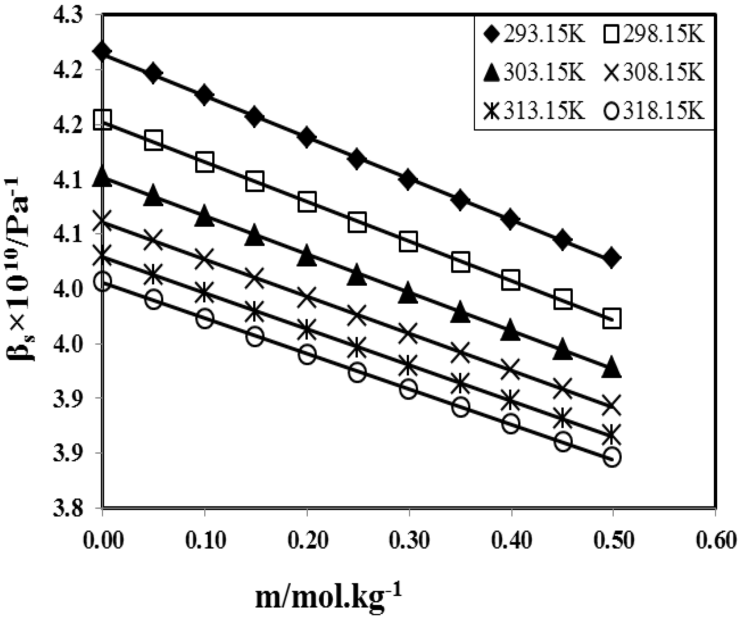

Figure 4.67: Plots of Adiabatic compressibility (β_s) vs. Molality (m) of glycine in aqueous 0.50 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

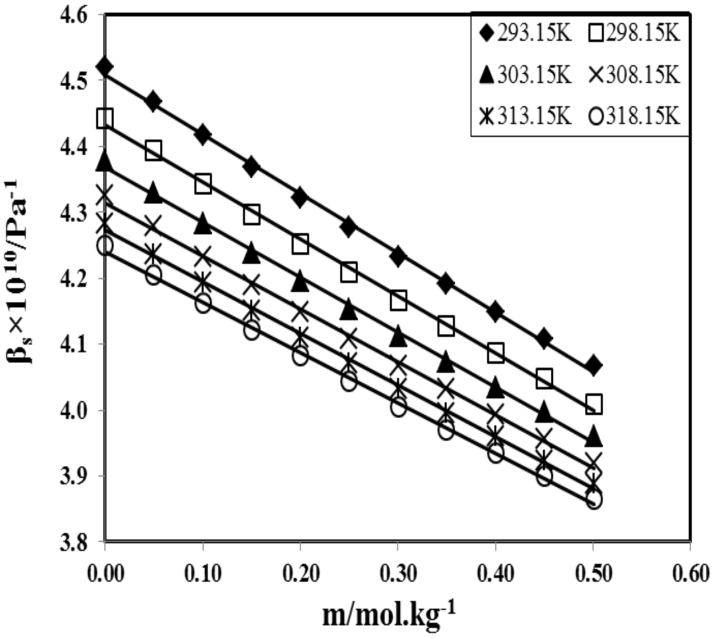

Figure 4.68: Plots of Adiabatic compressibility (β_s) vs. Molality (m) of L-ornithine in aqueous 0.05 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

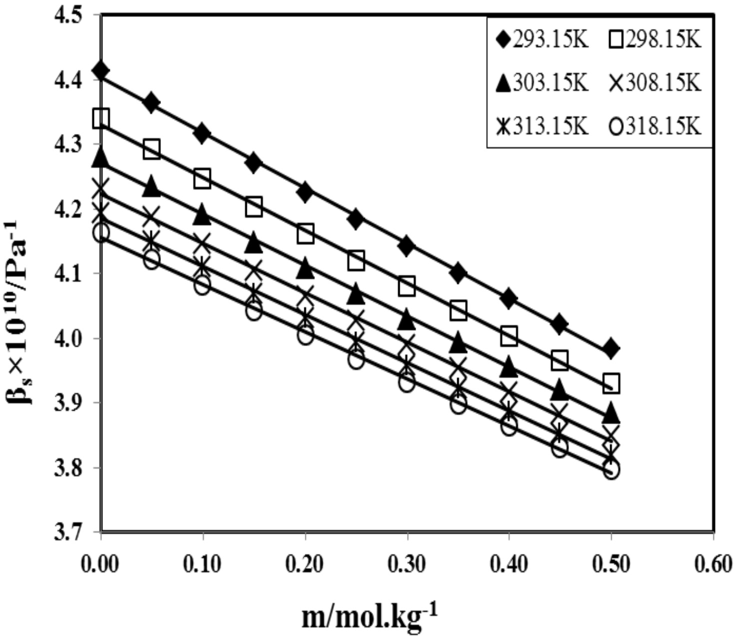

Figure 4.69: Plots of Adiabatic compressibility (β_s) vs. Molality (m) of L-ornithine in aqueous 0.20 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

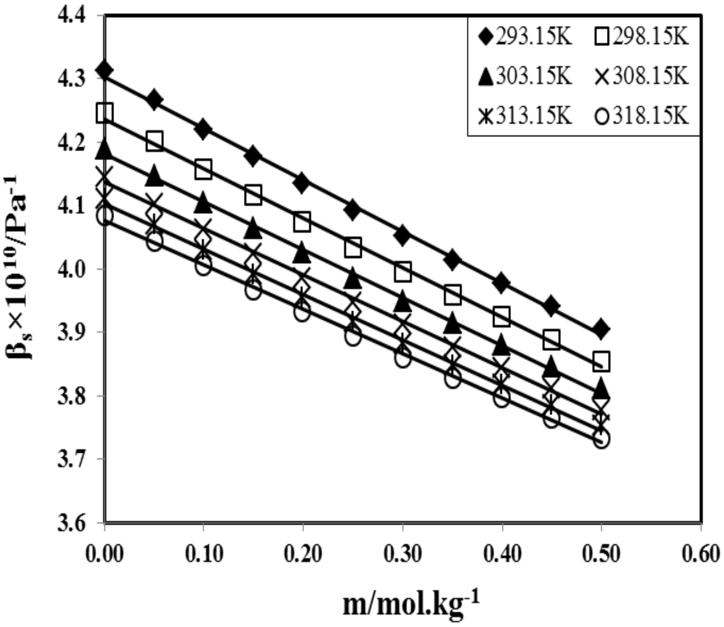

Figure 4.70: Plots of Adiabatic compressibility (β_s) vs. Molality (m) of L-ornithine in aqueous 0.35 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

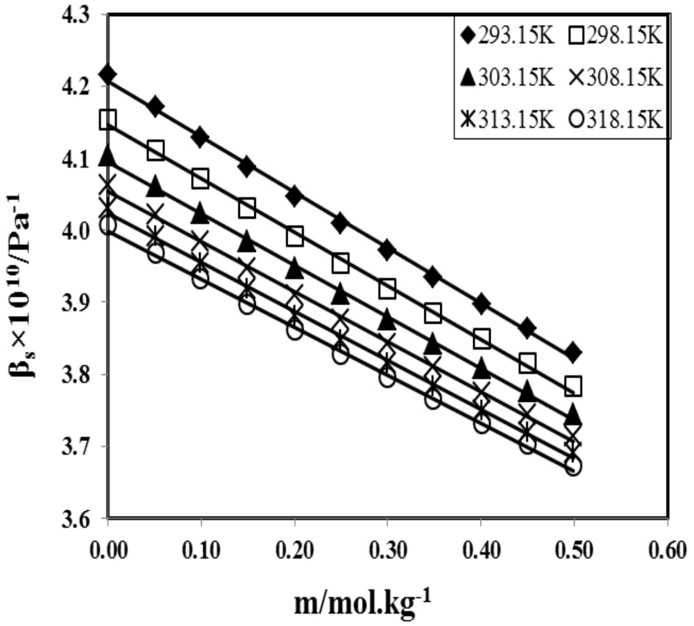

Figure 4.71: Plots of Adiabatic compressibility (β_s) vs. Molality (m) of L-ornithine in aqueous 0.50 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

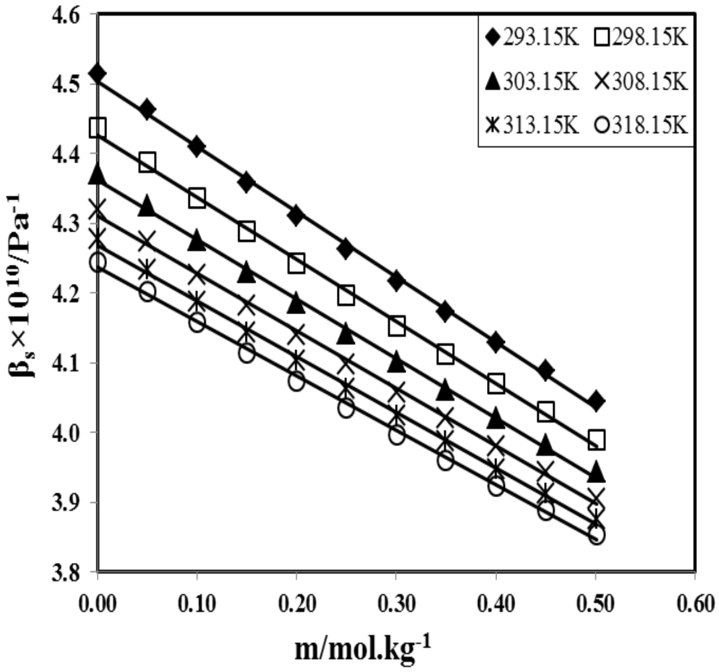

Figure 4.72: Plots of Adiabatic compressibility (β_s) vs. Molality (m) of L-lysine in aqueous 0.05 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

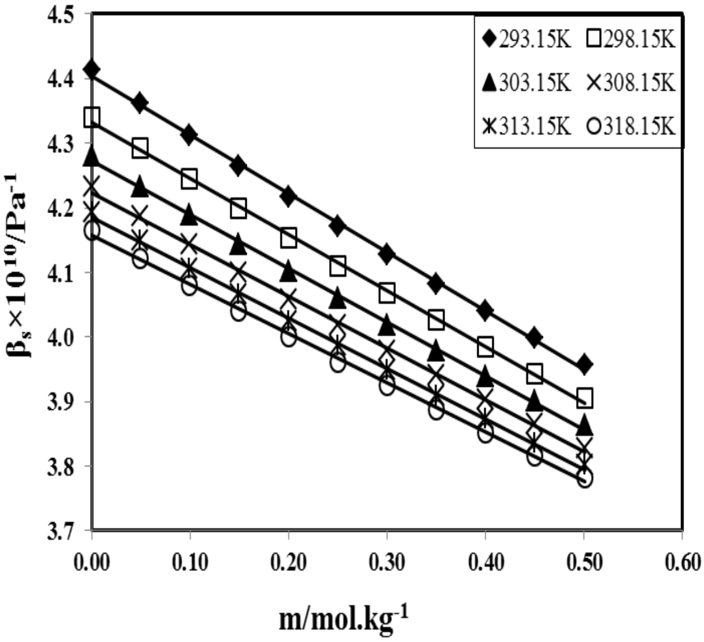

Figure 4.73: Plots of Adiabatic compressibility (β_s) vs. Molality (m) of L-lysine in aqueous 0.20 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

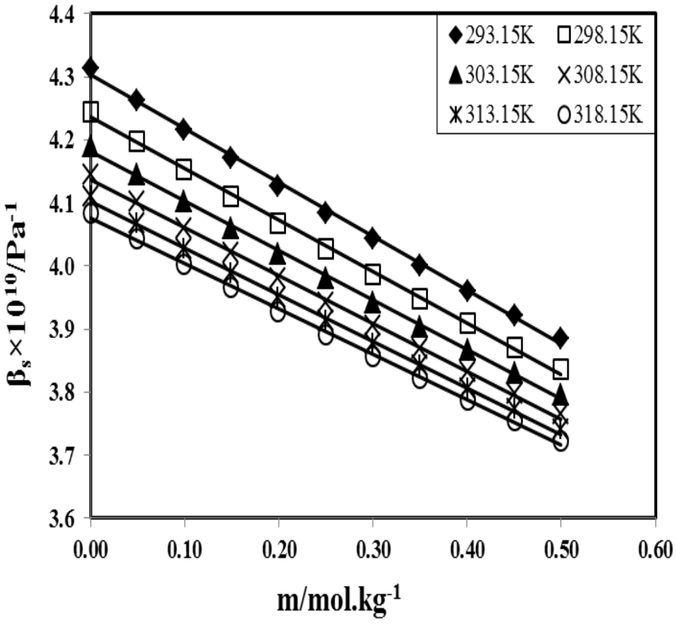

Figure 4.74: Plots of Adiabatic compressibility (β_s) vs. Molality (m) of L-lysine in aqueous 0.35 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

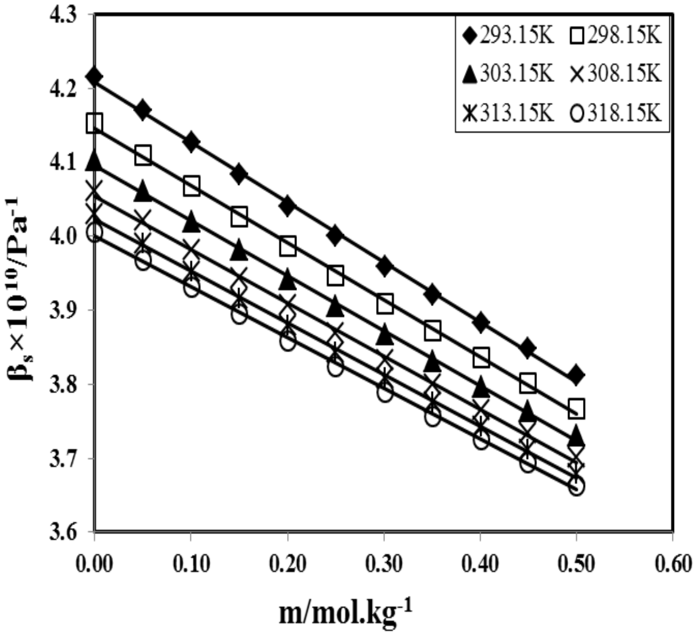

Figure 4.75: Plots of Adiabatic compressibility (β_s) vs. Molality (m) of L-lysine in aqueous 0.50 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

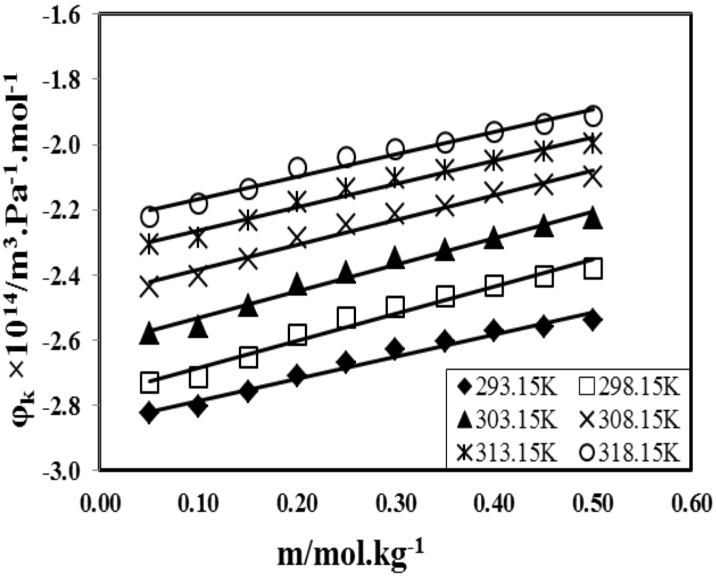

Figure 4.76**:** Plots of Apparent molar adiabatic compressibility (φ_k) vs. Molality (m) of glycine in aqueous system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

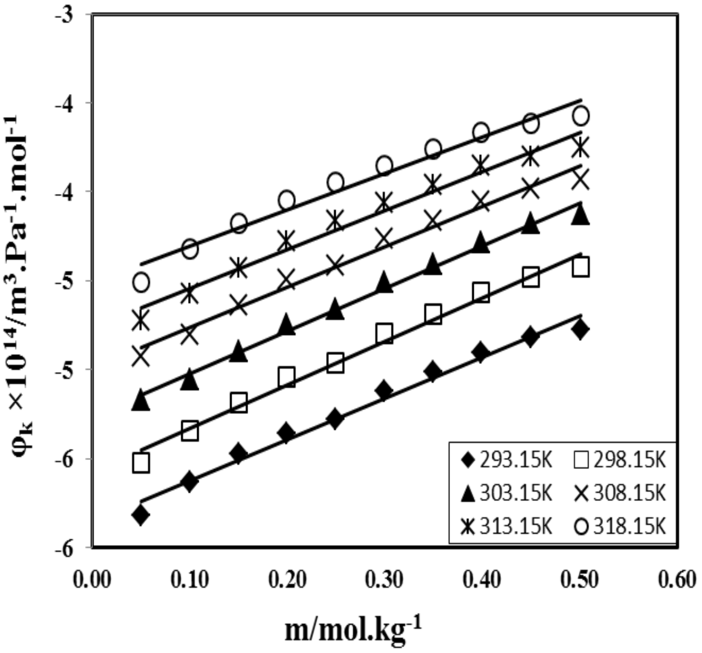

Figure 4.77**:** Plots of Apparent molar adiabatic compressibility (φ_k) vs. Molality (m) of L-ornithine in aqueous system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

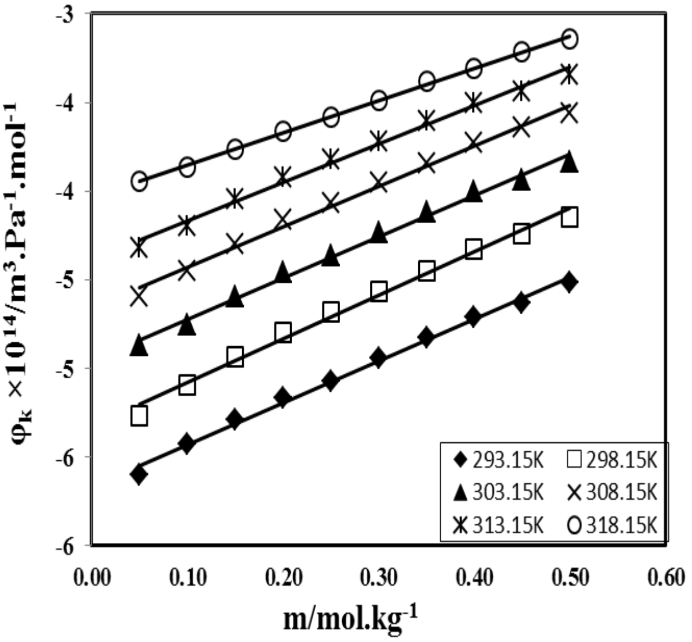

Figure 4.78**:** Plots of Apparent molar adiabatic compressibility (φ_k) vs. Molality (m) of L-lysine in aqueous system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

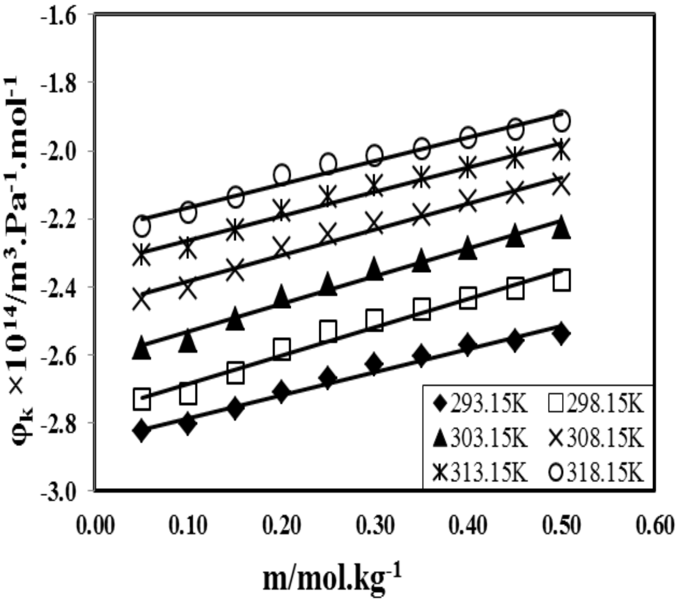

Figure 4.79: Plots of Apparent molar adiabatic compressibility (φ_k) vs. Molality (m) of glycine in aqueous 0.05 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

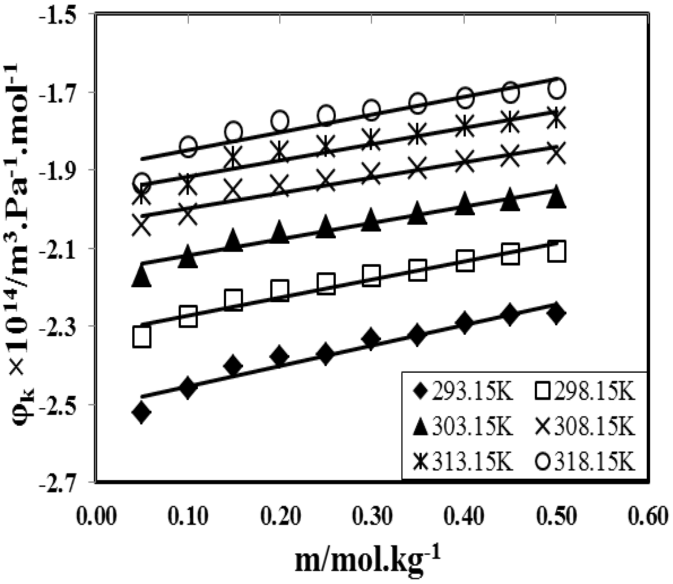

Figure 4.80: Plots of Apparent molar adiabatic compressibility (φ_k) vs. Molality (m) of glycine in aqueous 0.20 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

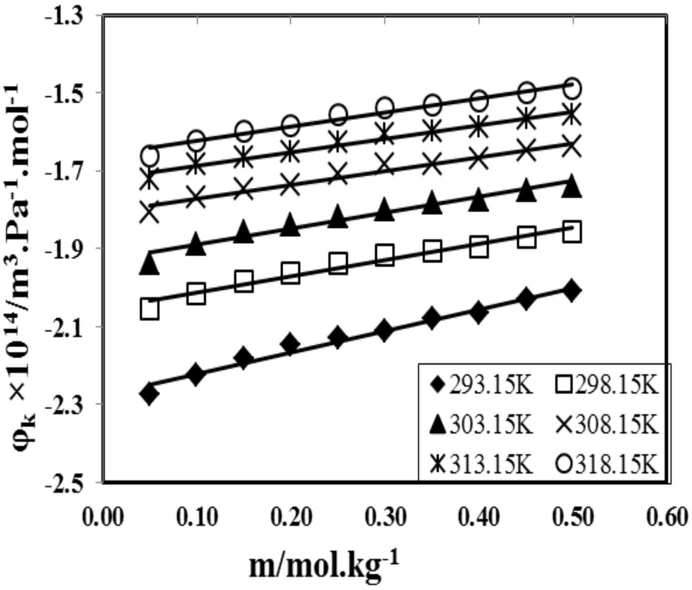

Figure 4.81: Plots of Apparent molar adiabatic compressibility (φ_k) vs. Molality (m) of glycine in aqueous 0.35 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

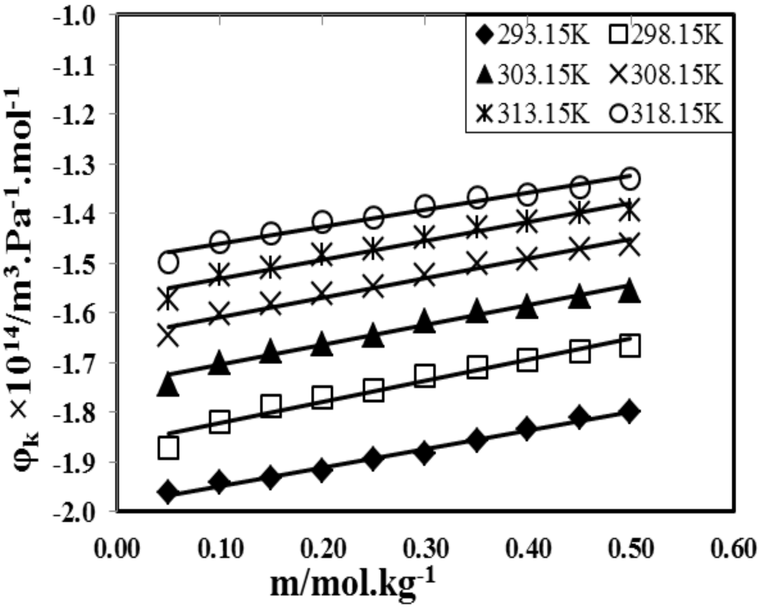

Figure 4.82: Plots of Apparent molar adiabatic compressibility (φ_k) vs. Molality (m) of glycine in aqueous 0.50 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

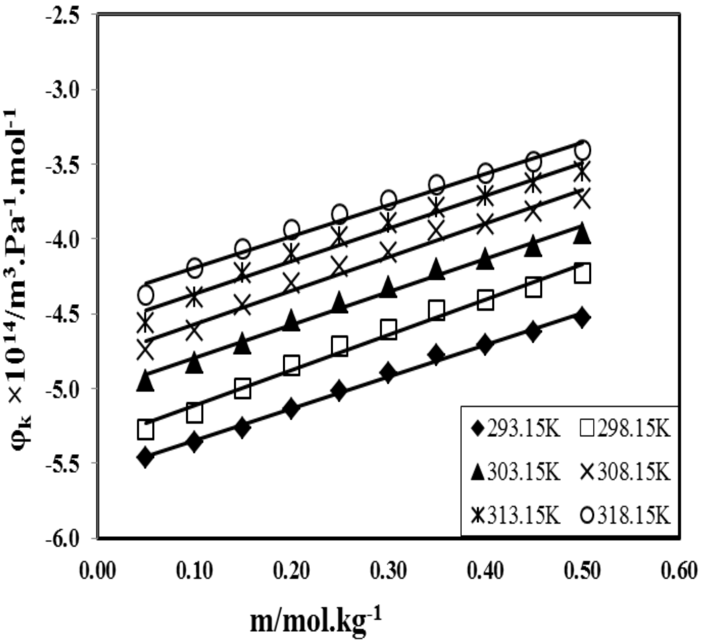

Figure 4.83: Plots of Apparent molar adiabatic compressibility (φ_k) vs. Molality (m) of L-ornithine in aqueous 0.05 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

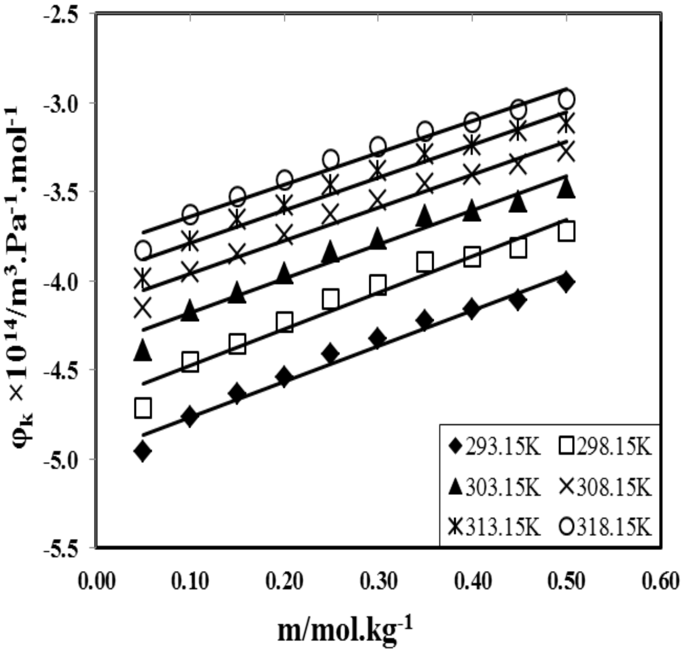

Figure 4.84: Plots of Apparent molar adiabatic compressibility (φ_k) vs. Molality (m) of L-ornithine in aqueous 0.20 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

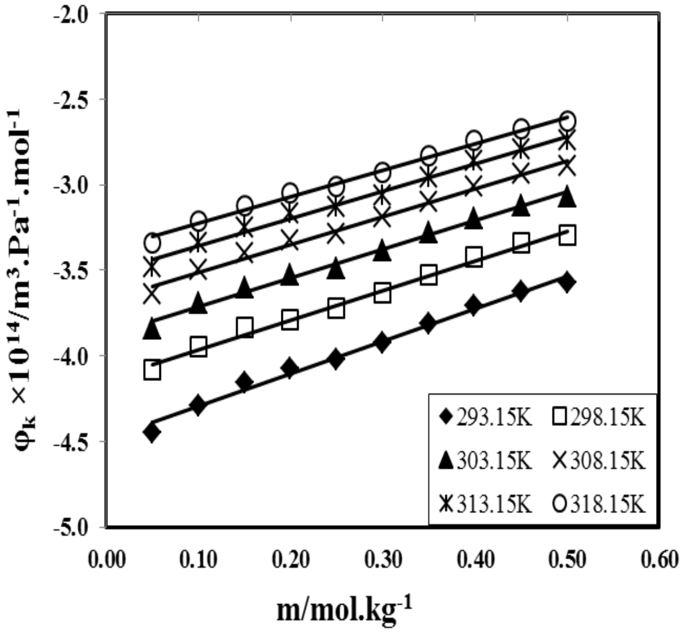

Figure 4.85: Plots of Apparent molar adiabatic compressibility (φ_k) vs. Molality (m) of L-ornithine in aqueous 0.35 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

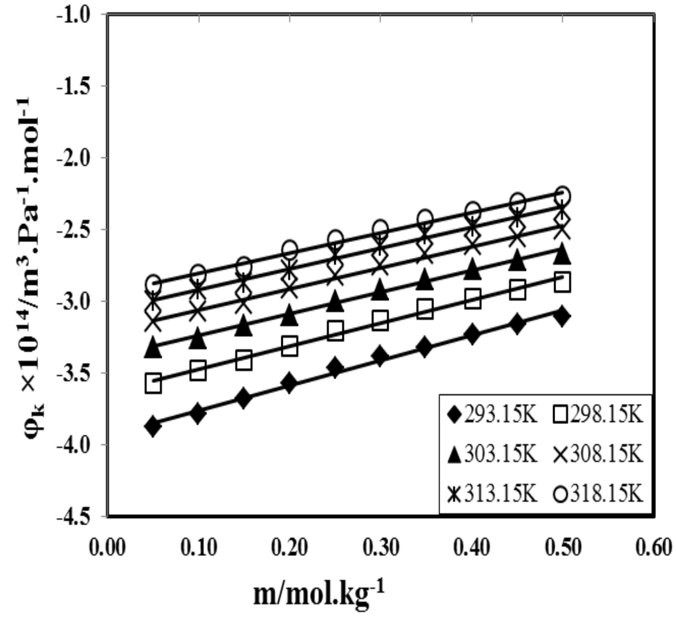

Figure 4.86: Plots of Apparent molar adiabatic compressibility (φ_k) vs. Molality (m) of L-ornithine in aqueous 0.50 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

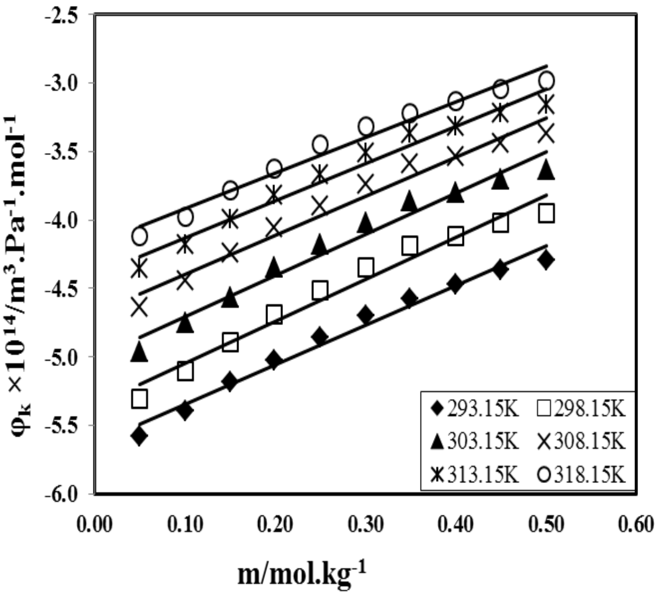

Figure 4.87: Plots of Apparent molar adiabatic compressibility (φ_k) vs. Molality (m) of L-lysine in aqueous 0.05 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

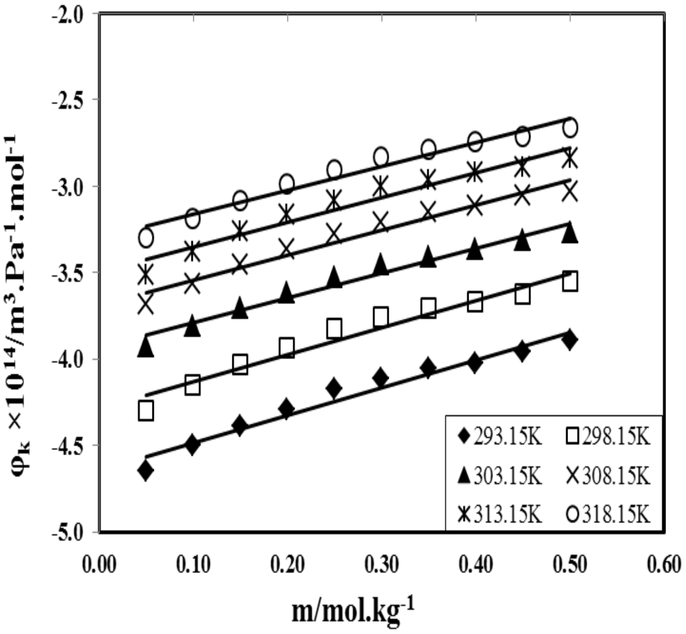

Figure 4.88: Plots of Apparent molar adiabatic compressibility (φ_k) vs. Molality (m) of L-lysine in aqueous 0.20 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

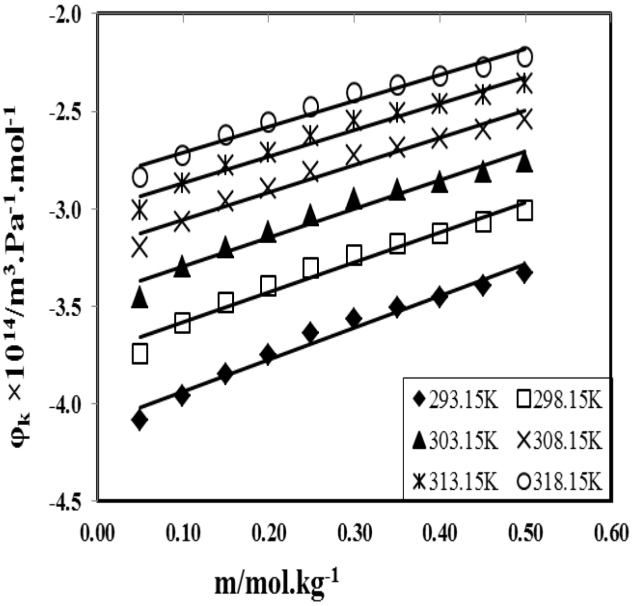

Figure 4.89: Plots of Apparent molar adiabatic compressibility (φ_k) vs. Molality (m) of L-lysine in aqueous 0.35 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

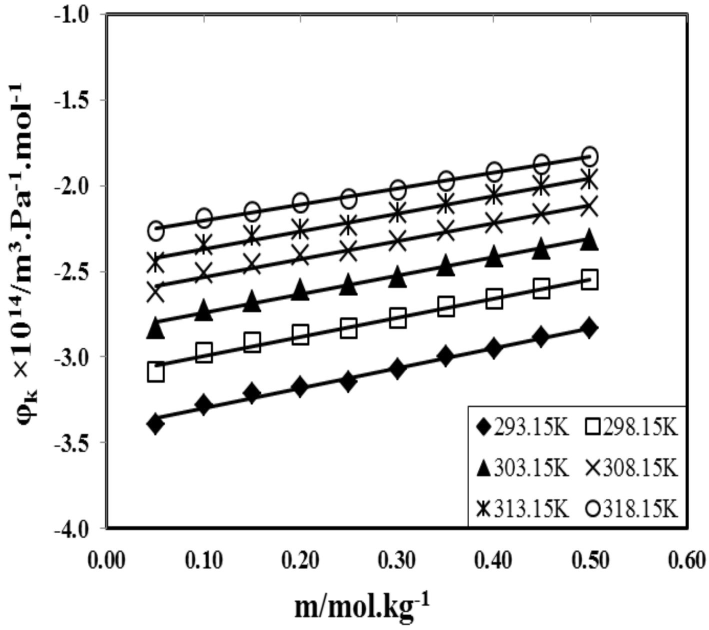

Figure 4.90: Plots of Apparent molar adiabatic compressibility (φ_k) vs. Molality (m) of L-lysine in aqueous 0.50 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

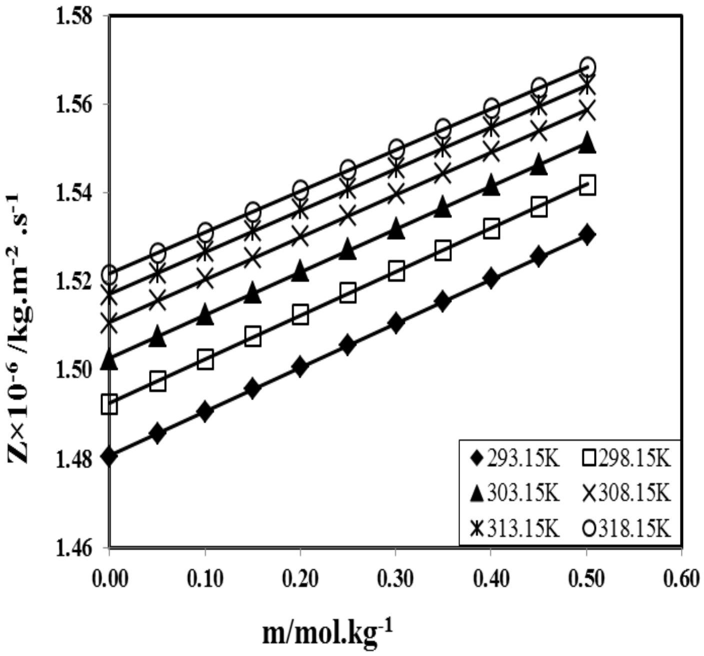

Figure 4.91**:** Plots of Acoustic impedance (Z) vs. Molality (m) of glycine in aqueous system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

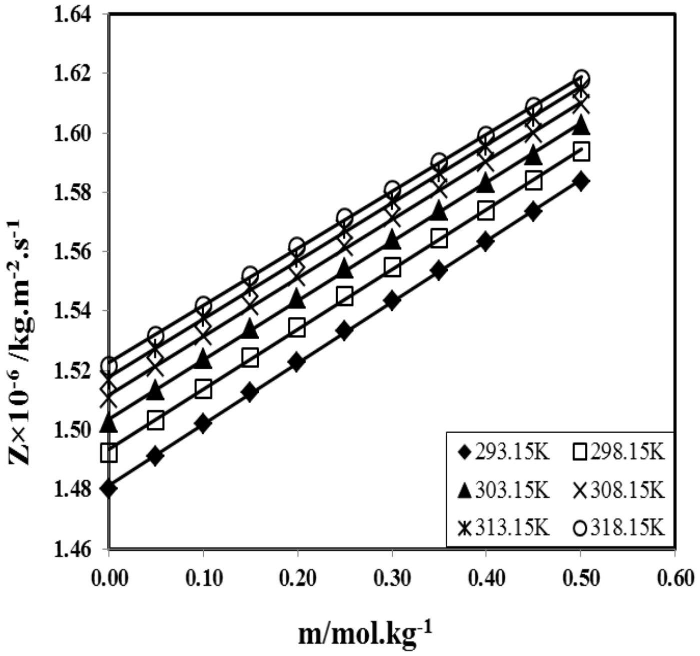

Figure 4.92**:** Plots of Acoustic impedance (Z) vs. Molality (m) of L-ornithine in aqueous system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

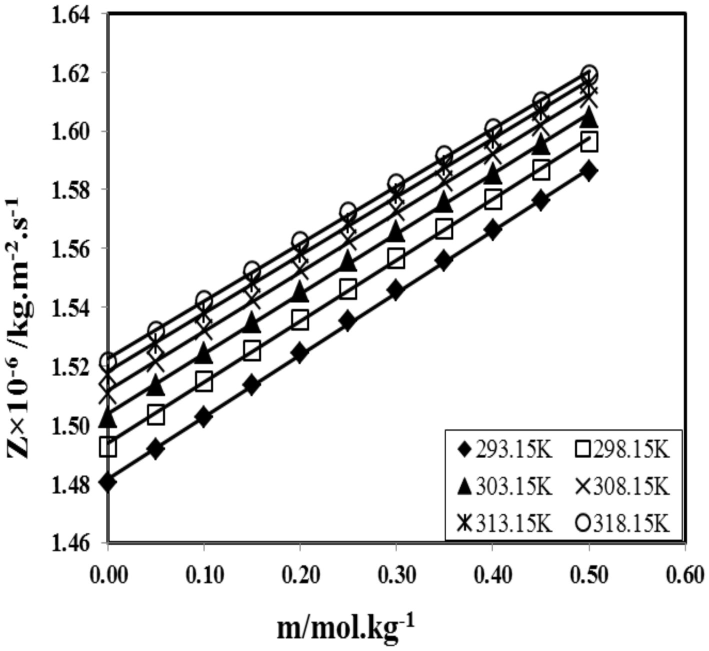

Figure 4.93**:** Plots of Acoustic impedance (Z) vs. Molality (m) of L-lysine in aqueous system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

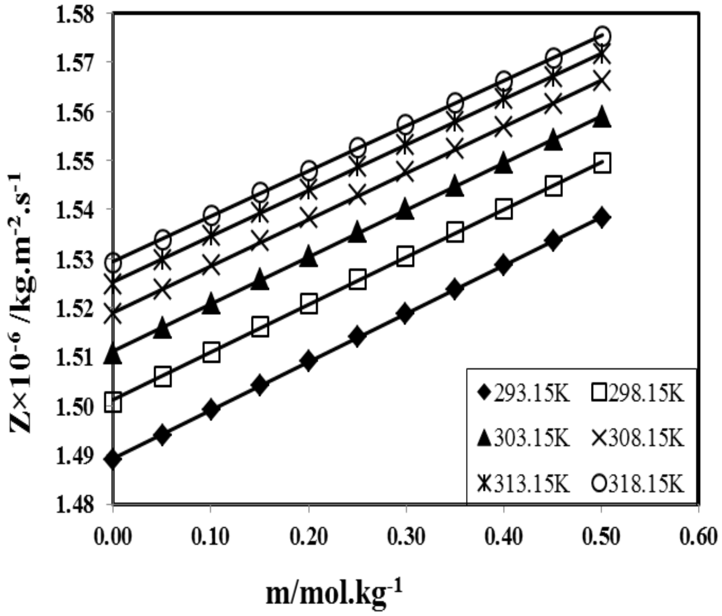

Figure 4.94: Plots of Acoustic impedance (Z) vs. Molality (m) of glycine in aqueous 0.05 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

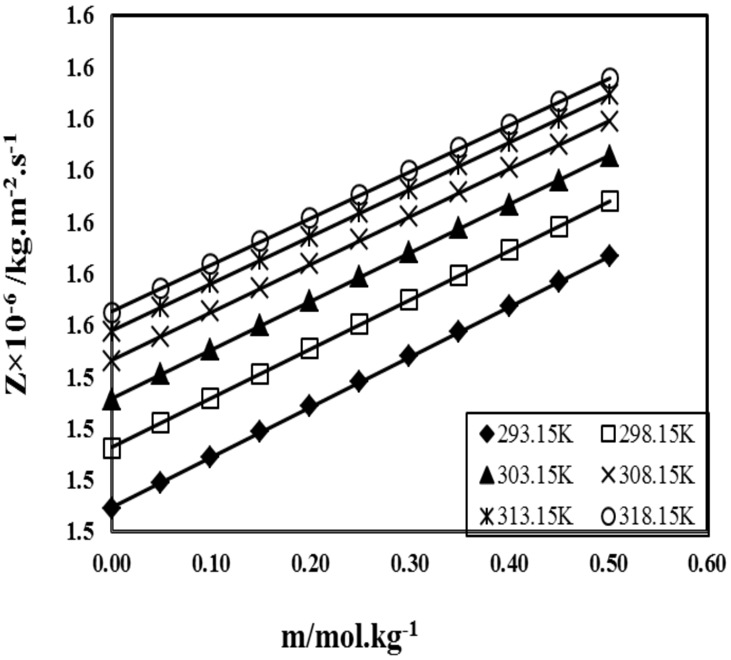

Figure 4.95: Plots of Acoustic impedance (Z) vs. Molality (m) of glycine in aqueous 0.20 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

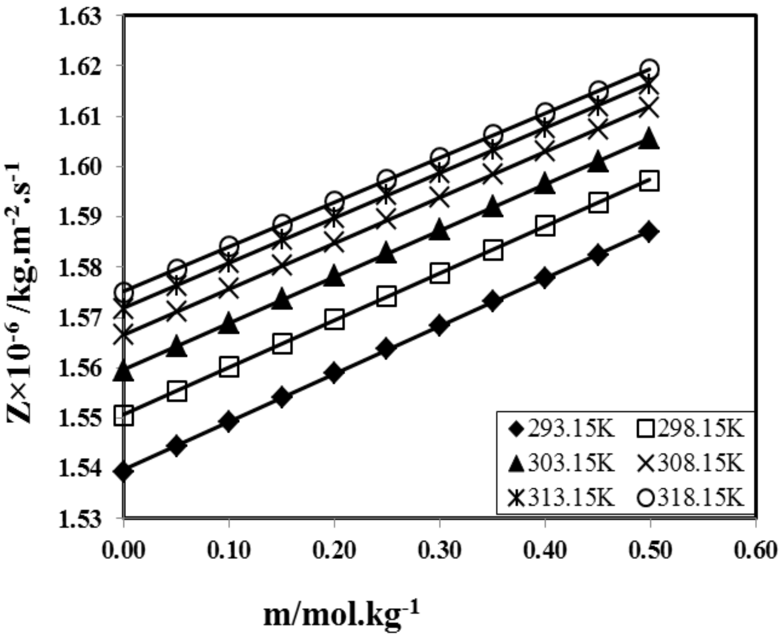

Figure 4.96: Plots of Acoustic impedance (Z) vs. Molality (m) of glycine in aqueous 0.35 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

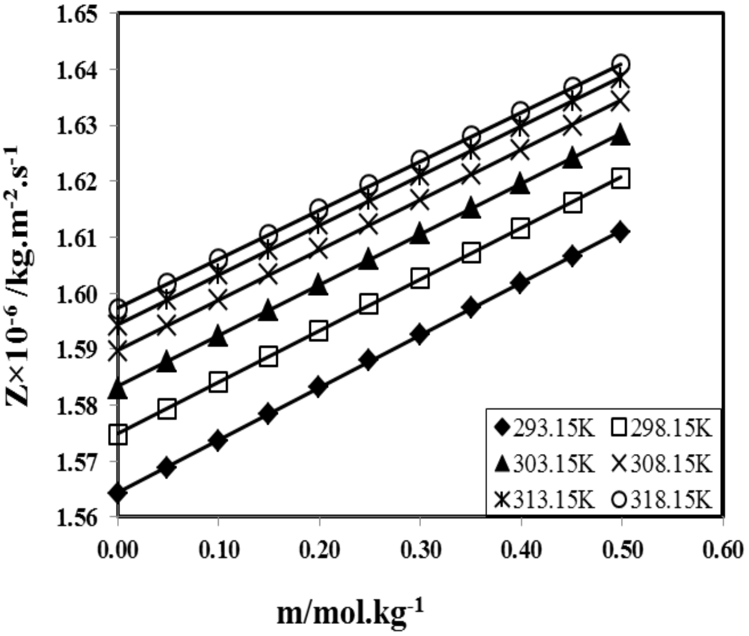

Figure 4.97: Plots of Acoustic impedance (Z) vs. Molality (m) of glycine in aqueous 0.50 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

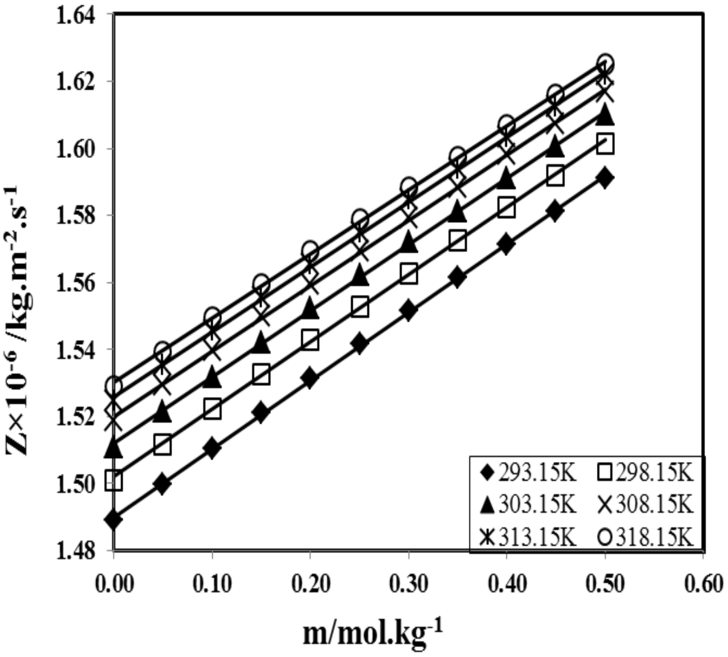

Figure 4.98: Plots of Acoustic impedance (Z) vs. Molality (m) of L-ornithine in aqueous 0.05 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

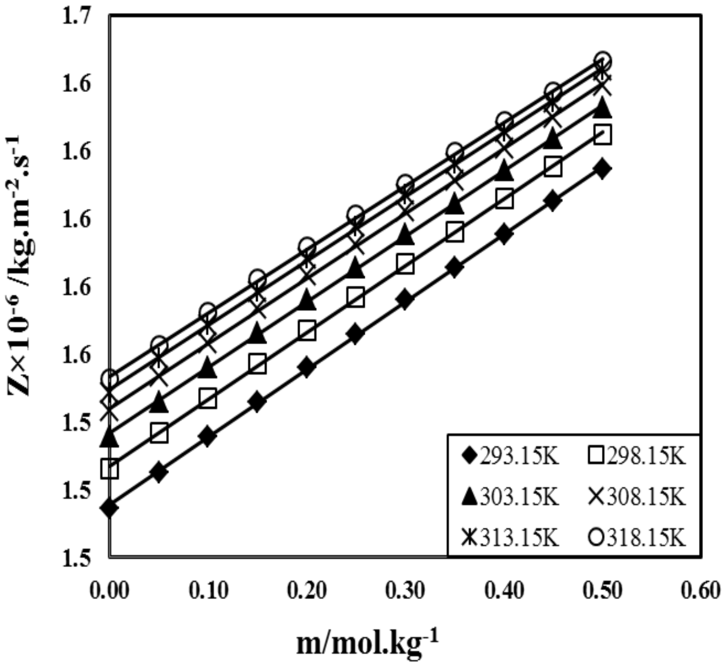

Figure 4.99: Plots of Acoustic impedance (Z) vs. Molality (m) of L-ornithine in aqueous 0.20 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

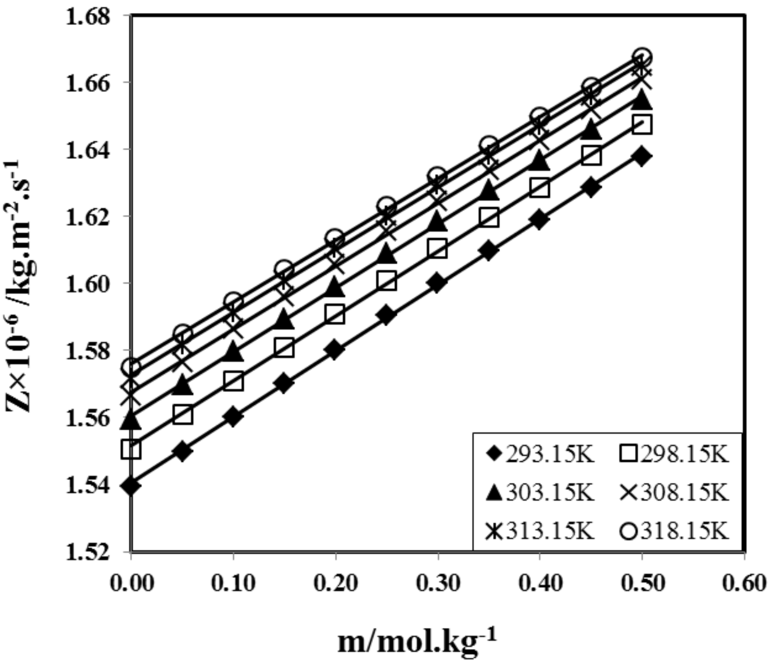

Figure 4.100: Plots of Acoustic impedance (Z) vs. Molality (m) of L-ornithine in aqueous 0.35 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

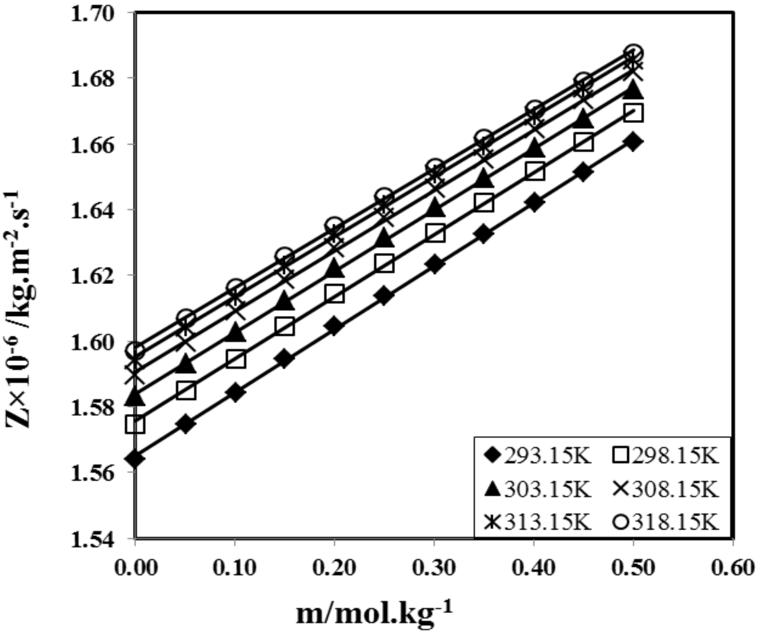

Figure 4.101: Plots of Acoustic impedance (Z) vs. Molality (m) of L-ornithine in aqueous 0.50 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

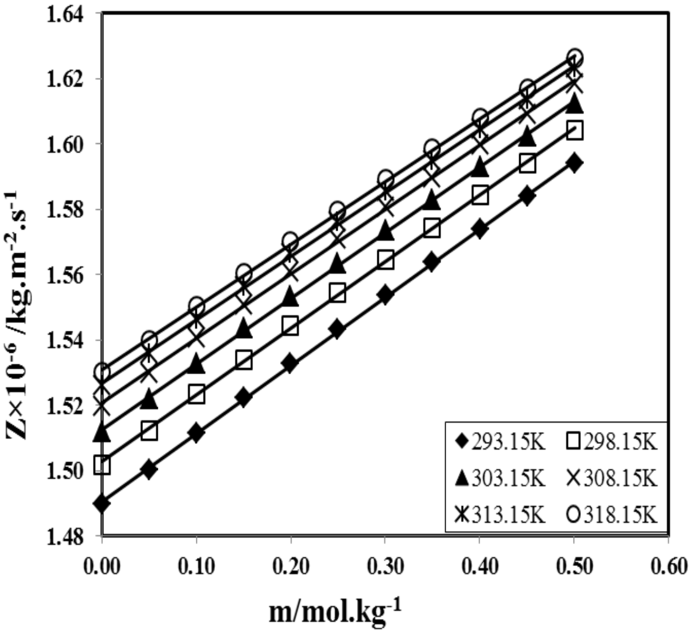

Figure 4.102: Plots of Acoustic impedance (Z) vs. Molality (m) of L-lysine in aqueous 0.05 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

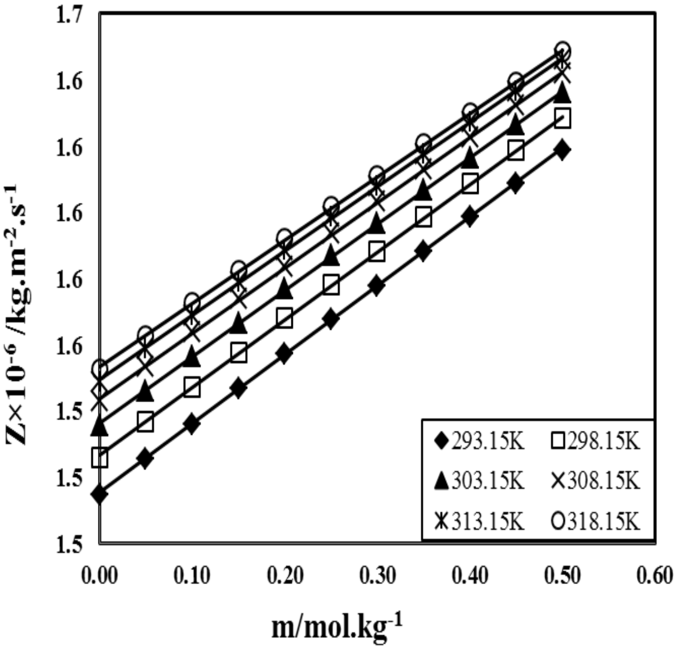

Figure 4.103: Plots of Acoustic impedance (Z) vs. Molality (m) of L-lysine in aqueous 0.20 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

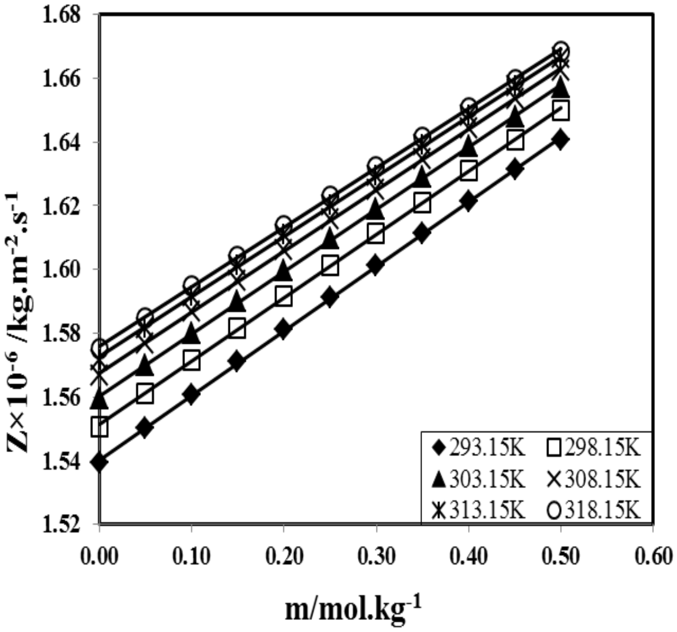

Figure 4.104: Plots of Acoustic impedance (Z) vs. Molality (m) of L-lysine in aqueous 0.35 mol.kg^{-1} fructose systems at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

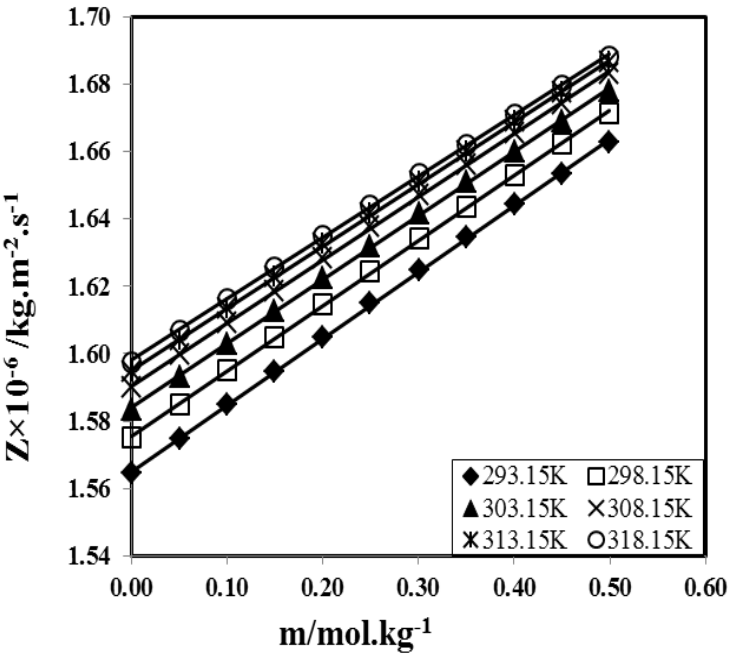

Figure 4.105: Plots of Acoustic impedance (Z) vs. Molality (m) of L-lysine in aqueous 0.50 $mol.kg^{-1}$ fructose systems at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

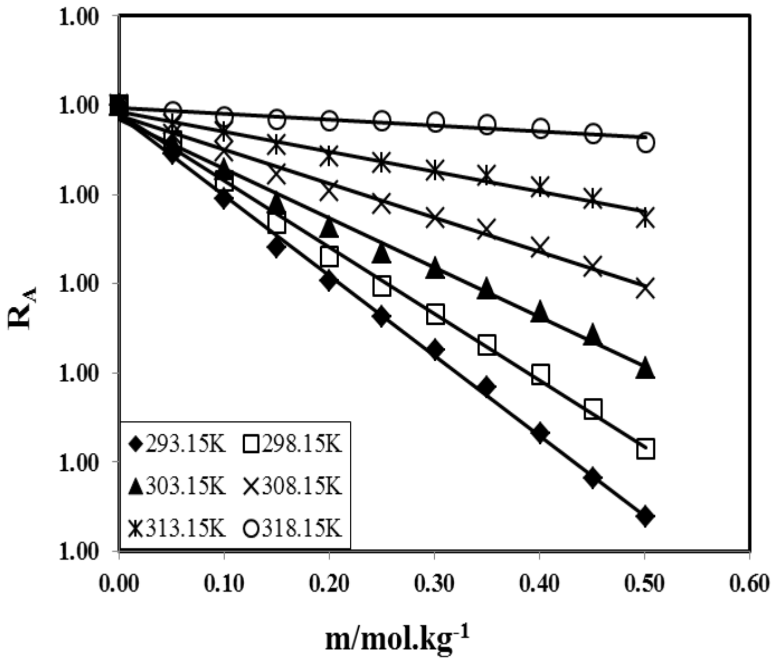

Figure 4.106**:** Plots of Relative association (R_A) vs. Molality (m) of glycine in aqueous system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

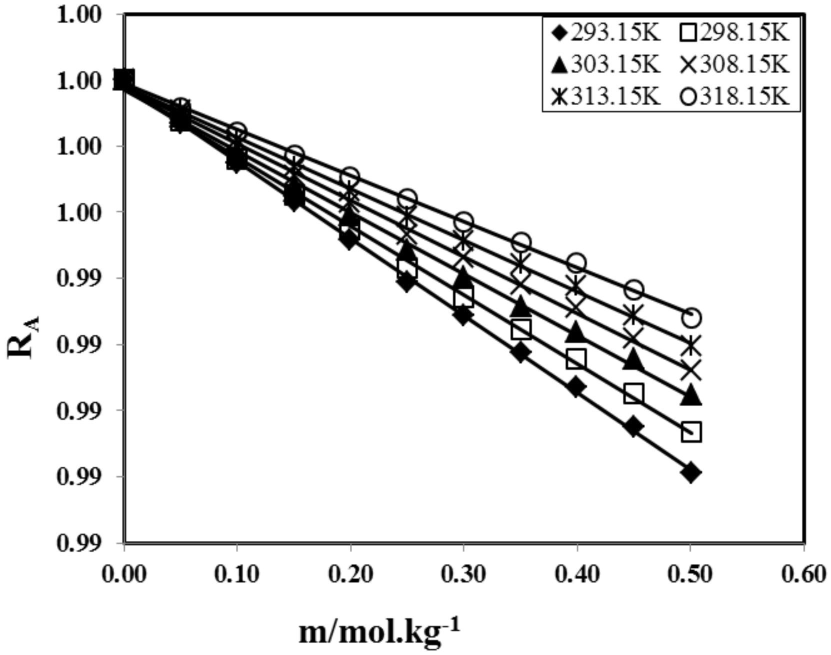

Figure 4.107**:** Plots of Relative association (R_A) vs. Molality (m) of L-ornithine in aqueous system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

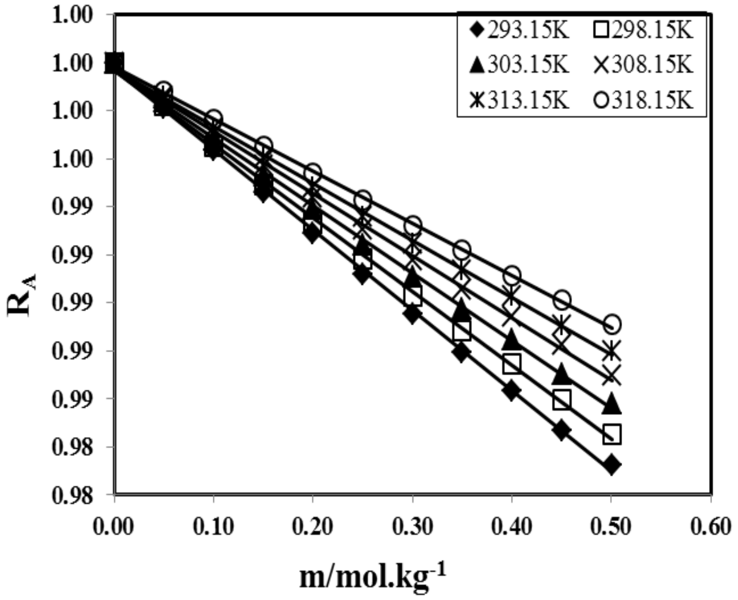

Figure 4.108**:** Plots of Relative association (R_A) vs. Molality (m) of L-lysine in aqueous system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

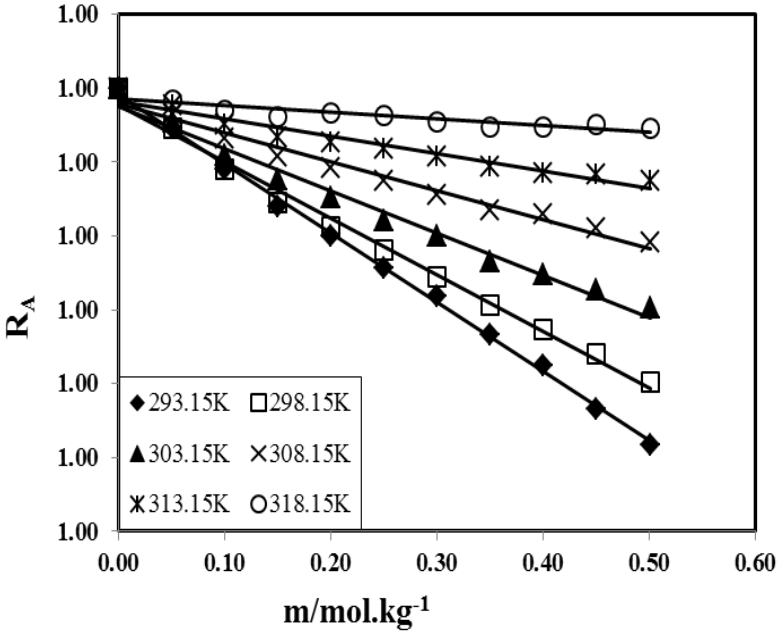

Figure 4.109: Plots of Relative association (R_A) vs. Molality (m) of glycine in aqueous 0.05 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

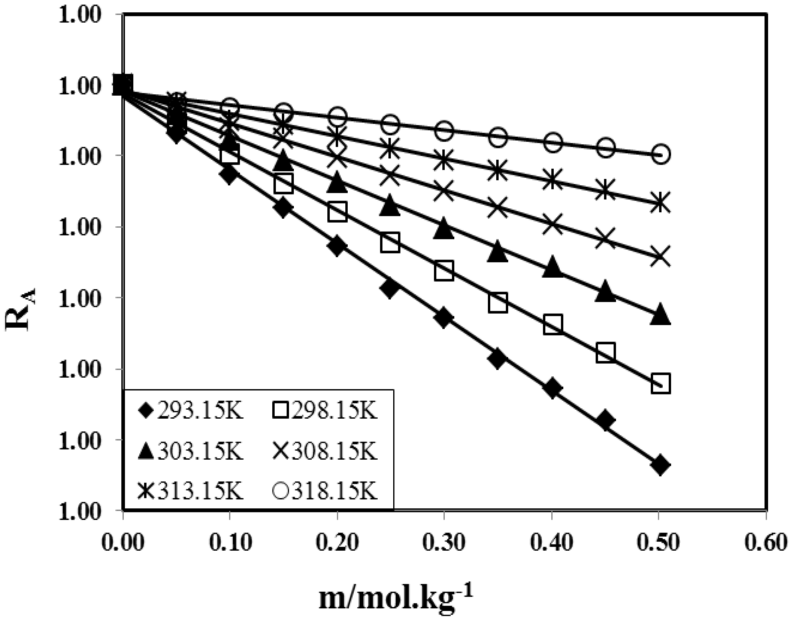

Figure 4.110: Plots of Relative association (R_A) vs. Molality (m) of glycine in aqueous 0.20 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

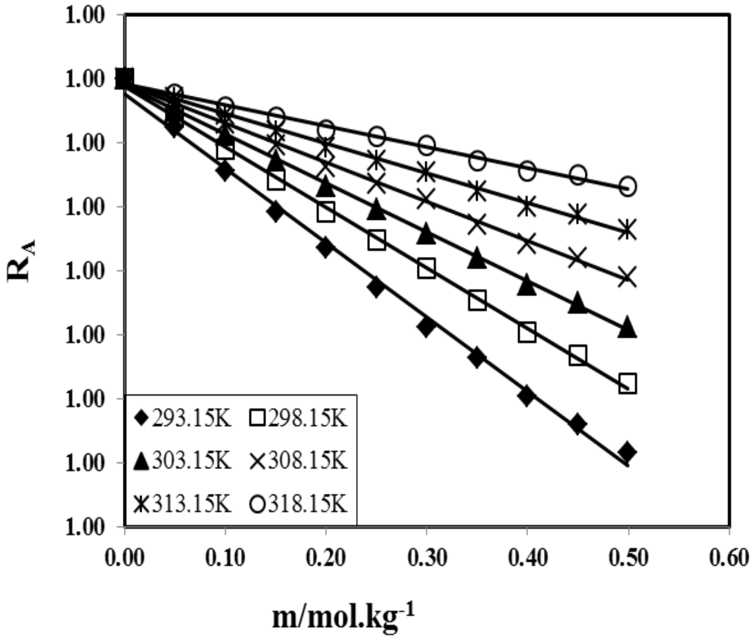

Figure 4.111: Plots of Relative association (R_A) vs. Molality (m) of glycine in aqueous 0.35 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

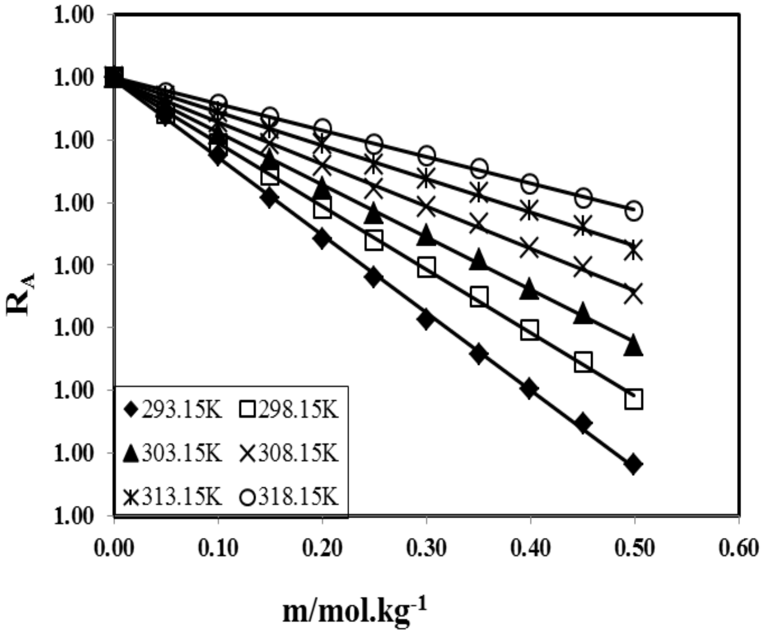

Figure 4.112: Plots of Relative association (R_A) vs. Molality (m) of glycine in aqueous 0.50 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

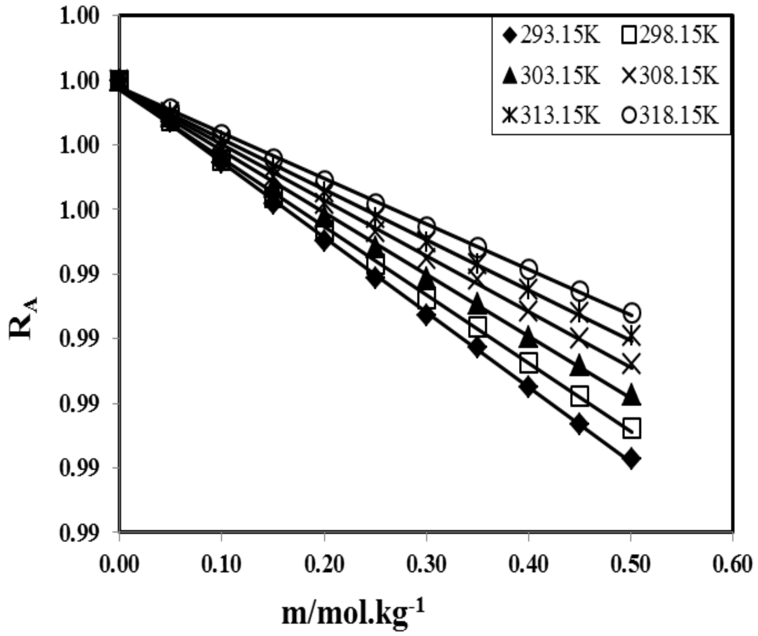

Figure 4.113: Plots of Relative association (R_A) vs. Molality (m) of L-ornithine in aqueous 0.05 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

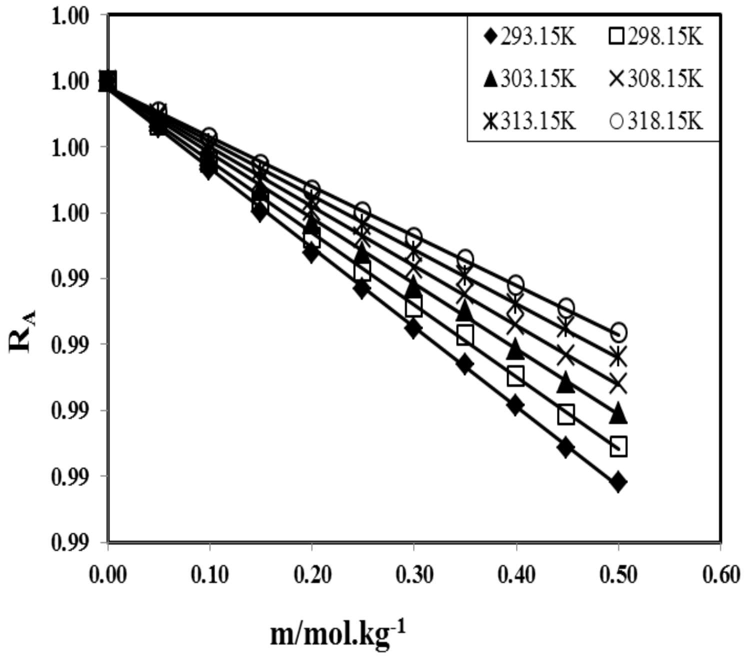

Figure 4.114: Plots of Relative association (R_A) vs. Molality (m) of L-ornithine in aqueous 0.20 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

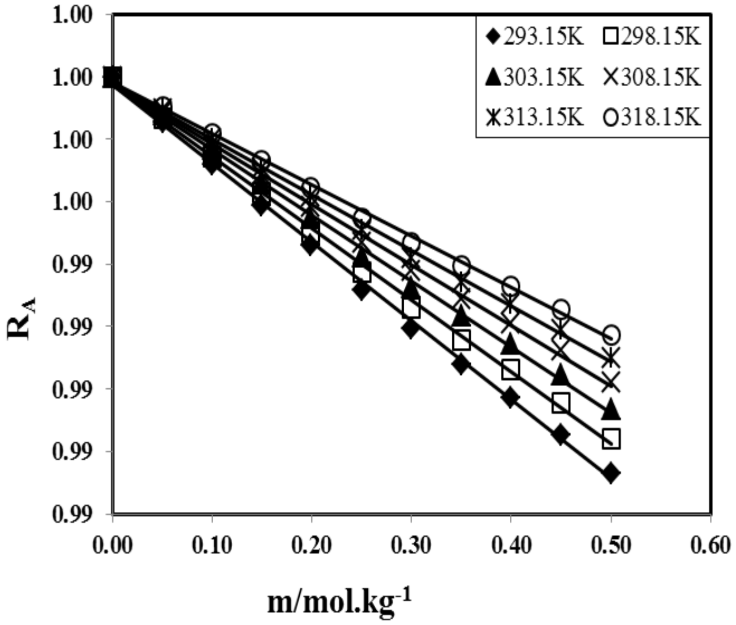

Figure 4.115: Plots of Relative association (R_A) vs. Molality (m) of L-ornithine in aqueous 0.35 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

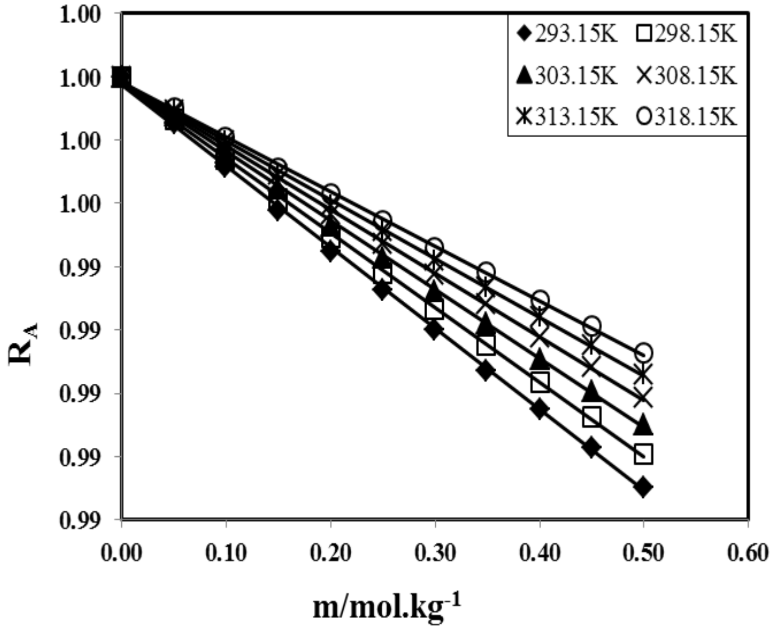

Figure 4.116: Plots of Relative association (R_A) vs. Molality (m) of L-ornithine in aqueous 0.50 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

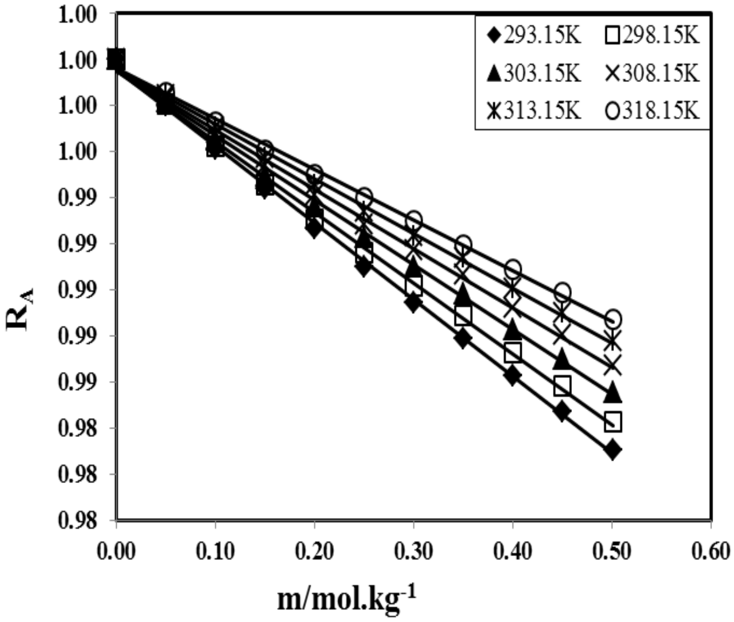

Figure 4.117: Plots of Relative association (R_A) vs. Molality (m) of L-lysine in aqueous 0.05 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

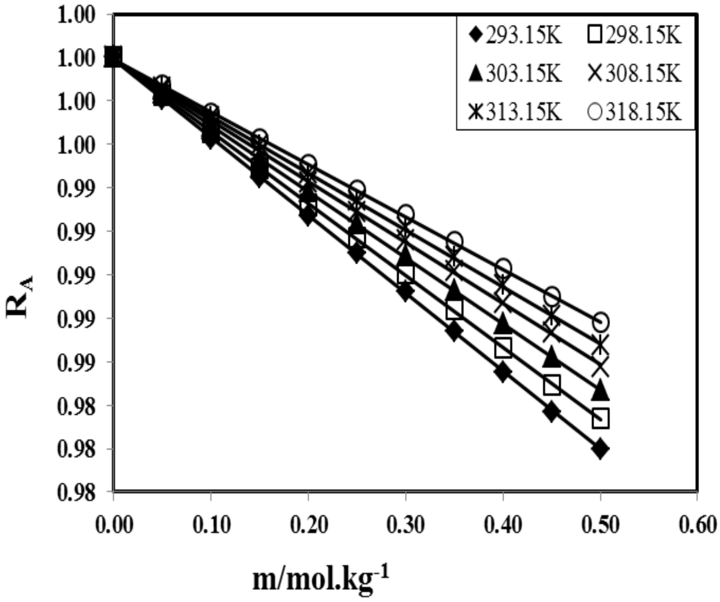

Figure 4.118: Plots of Relative association (R_A) vs. Molality (m) of L-lysine in aqueous 0.20 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

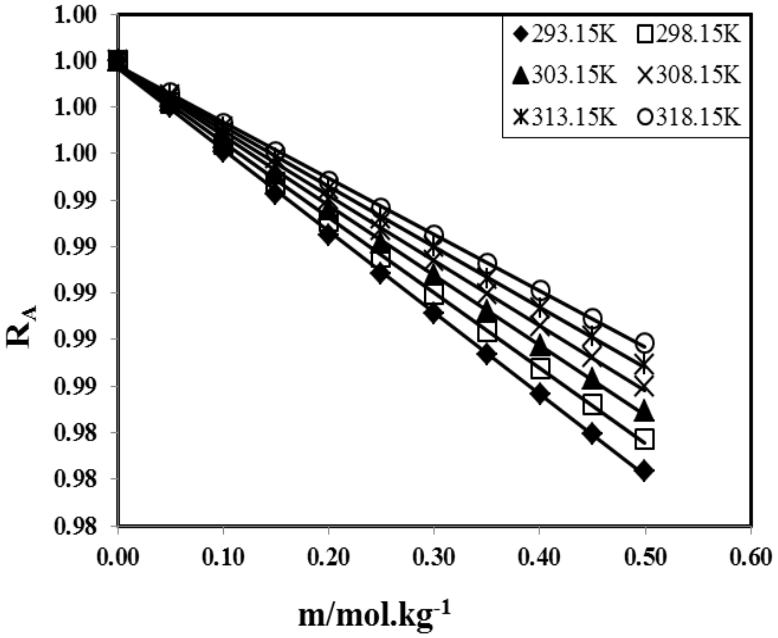

Figure 4.119: Plots of Relative association (R_A) vs. Molality (m) of L-lysine in aqueous 0.35 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

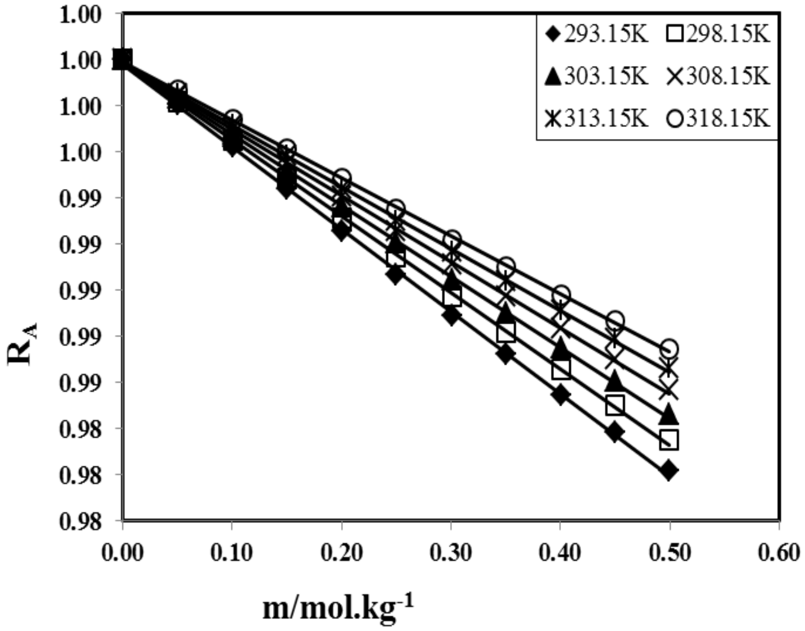

Figure 4.120: Plots of Relative association (R_A) vs. Molality (m) of L-lysine in aqueous 0.50 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

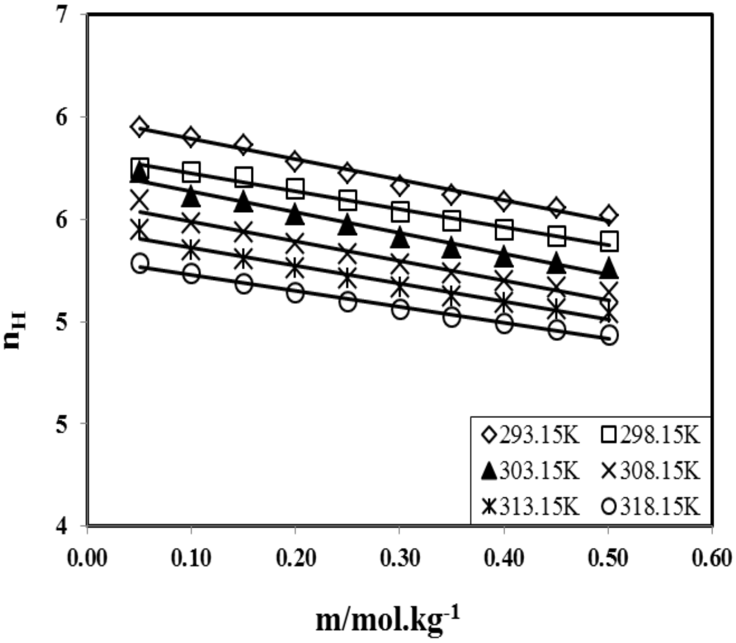

Figure 4.121**:** Plots of Hydration number (n_H) vs. Molality (m) of glycine in aqueous system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

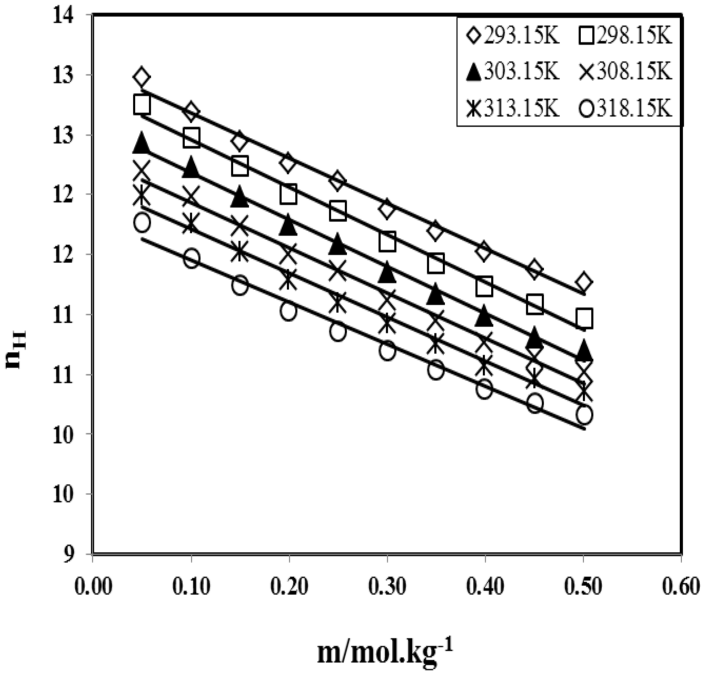

Figure 4.122**:** Plots of Hydration number (n_H) vs. Molality (m) of L-ornithine in aqueous system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

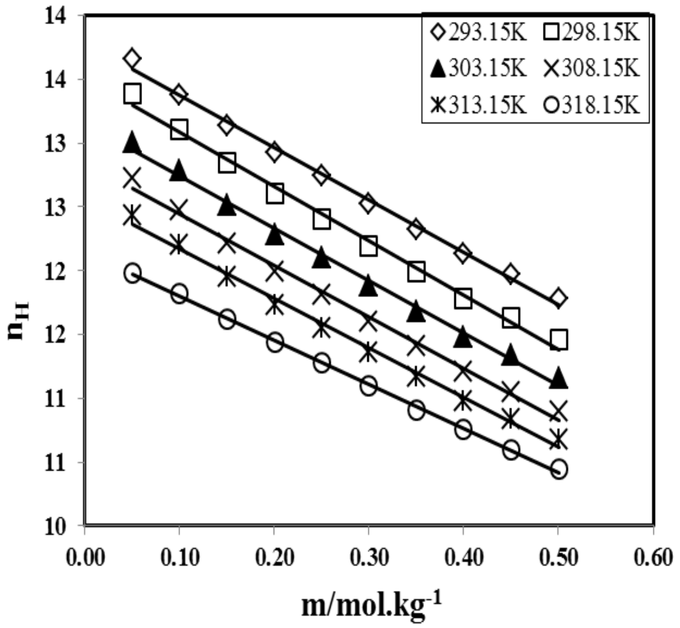

Figure 4.123**:** Plots of Hydration number (n_H) vs. Molality (m) of L-lysine in aqueous system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

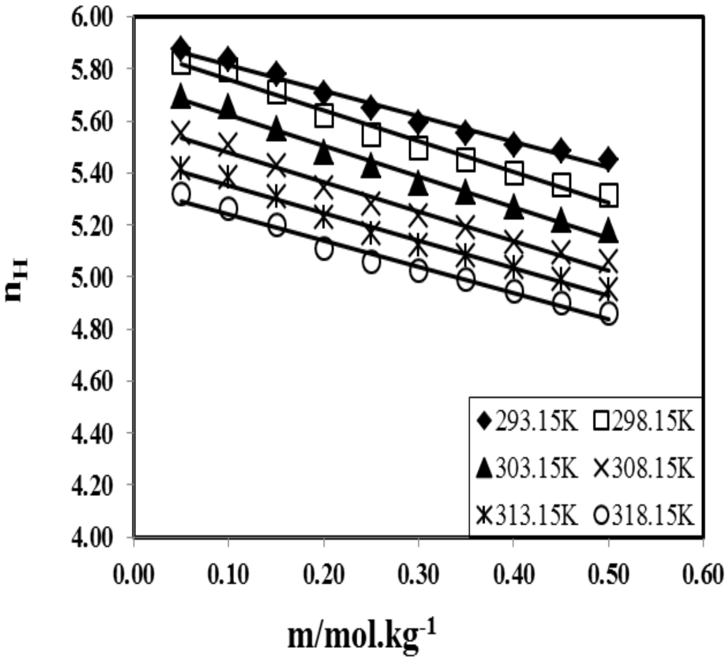

Figure 4.124: Plots of Hydration number (n_H) vs. Molality (m) of glycine in aqueous 0.05 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

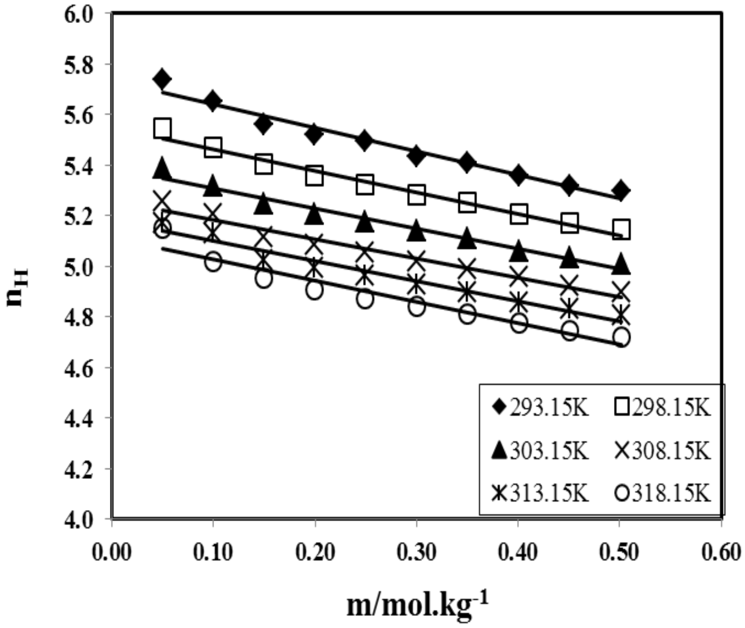

Figure 4.125: Plots of Hydration number (n_H) vs. Molality (m) of glycine in aqueous 0.20 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

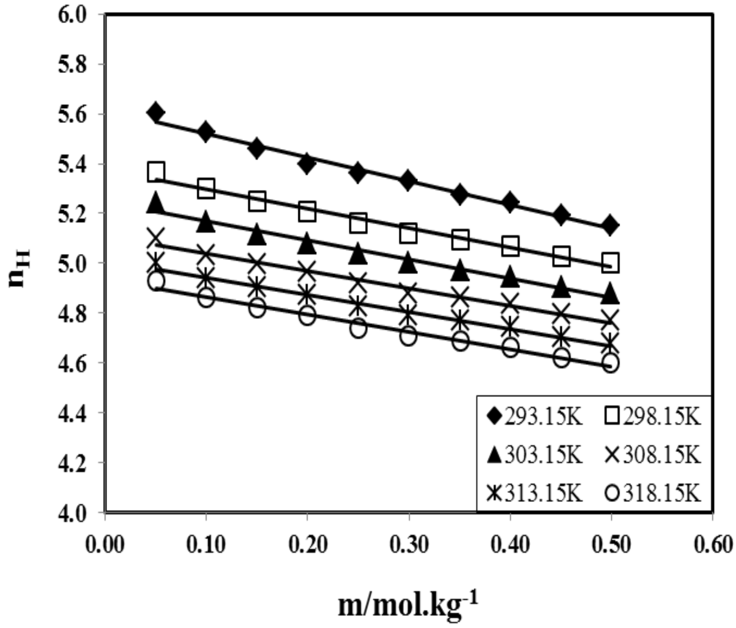

Figure 4.126: Plots of Hydration number (n_H) vs. Molality (m) of glycine in aqueous 0.35 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

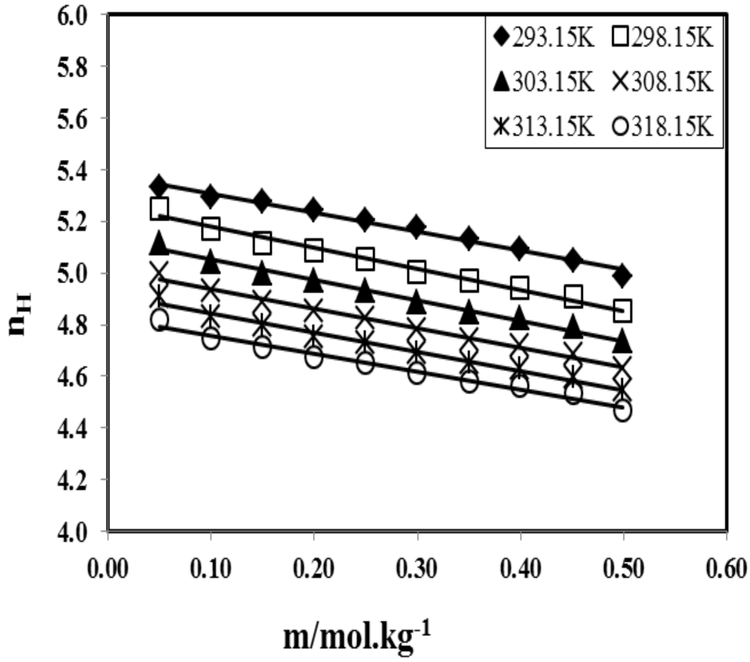

Figure 4.127: Plots of Hydration number (n_H) vs. Molality (m) of glycine in aqueous 0.50 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

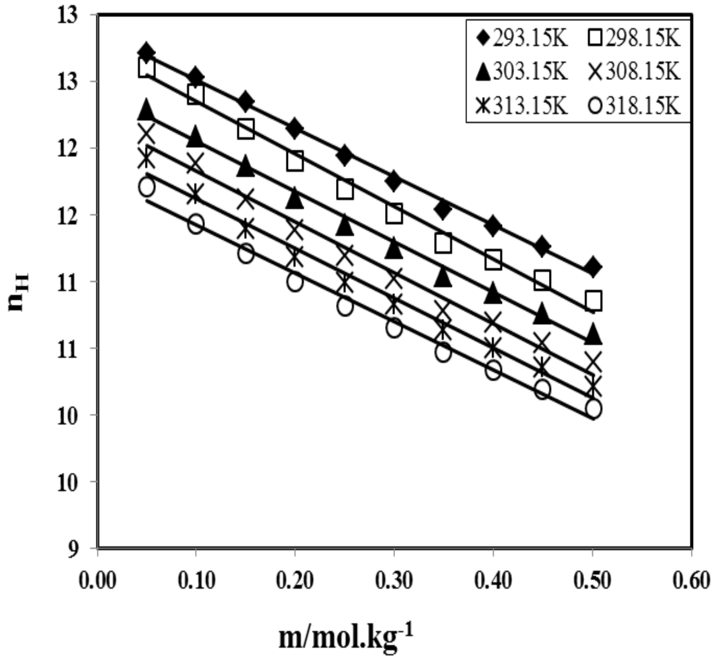

Figure 4.128: Plots of Hydration number (n_H) vs. Molality (m) of L-ornithine in aqueous 0.05 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

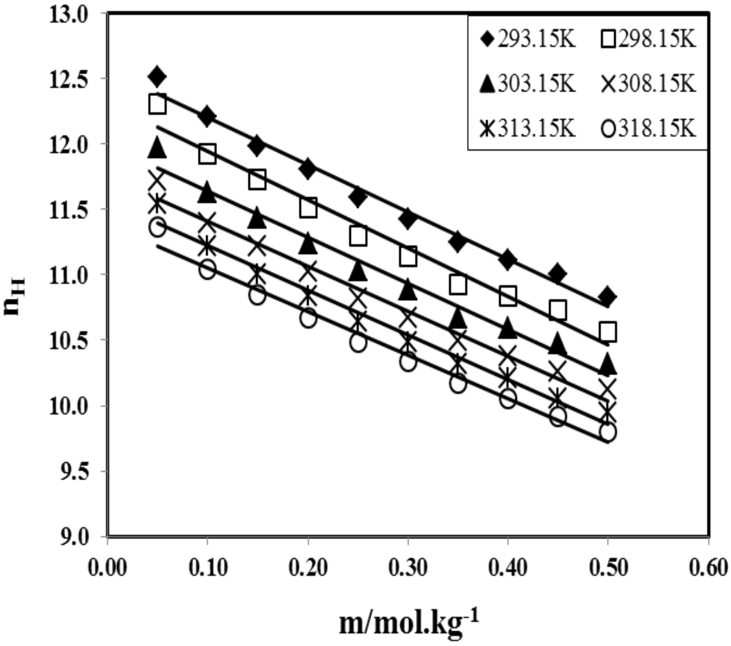

Figure 4.129: Plots of Hydration number (n_H) vs. Molality (m) of L-ornithine in aqueous 0.20 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

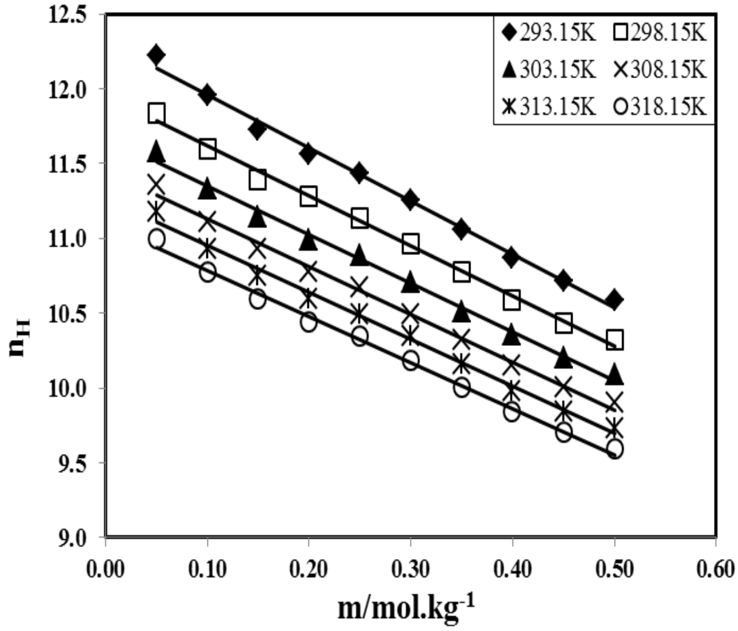

Figure 4.130: Plots of Hydration number (n_H) vs. Molality (m) of L-ornithine in aqueous 0.35 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

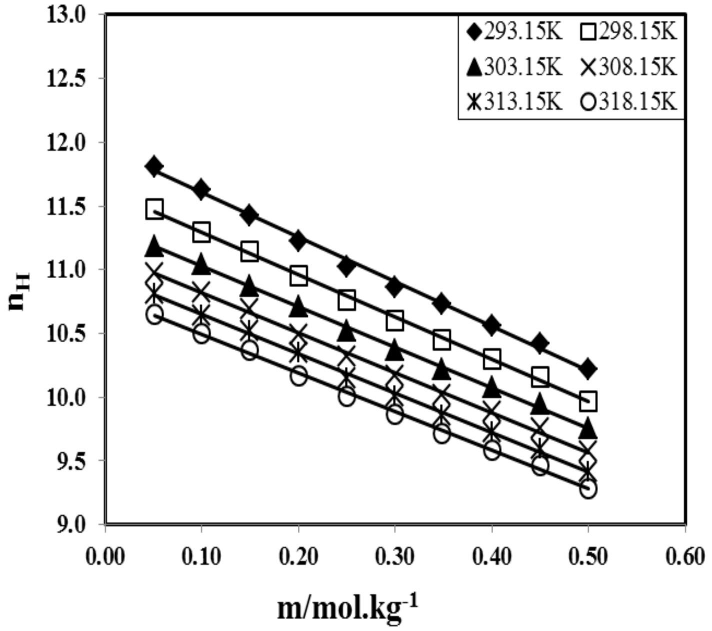

Figure 4.131: Plots of Hydration number (n_H) vs. Molality (m) of L-ornithine in aqueous 0.50 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

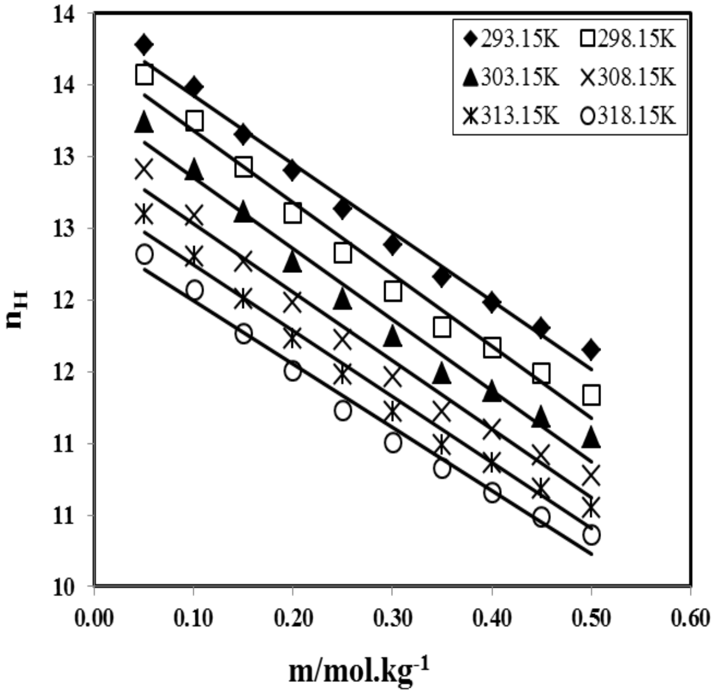

Figure 4.132: Plots of Hydration number (n_H) vs. Molality (m) of L-lysine in aqueous 0.05 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

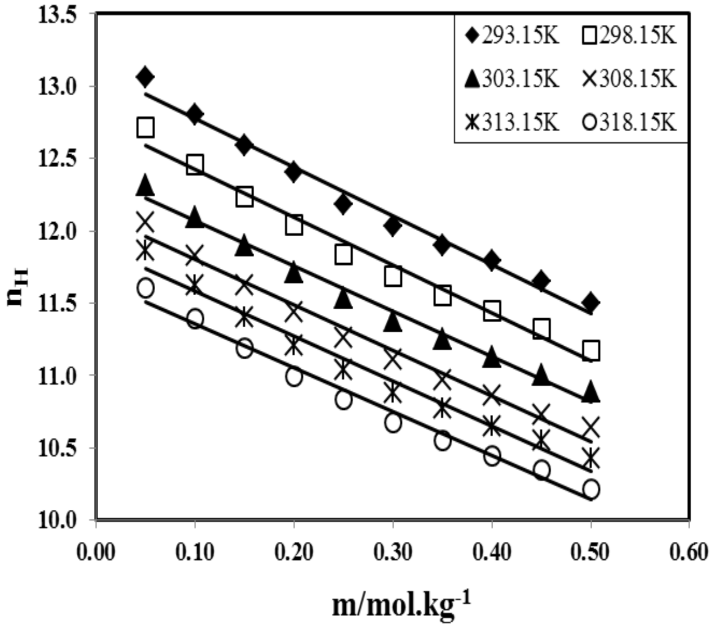

Figure 4.133: Plots of Hydration number (n_H) vs. Molality (m) of L-lysine in aqueous 0.20 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

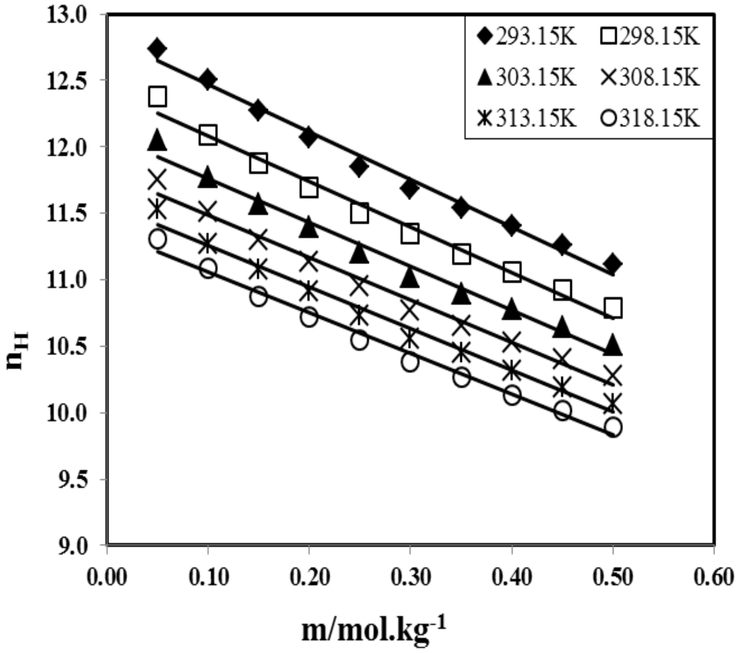

Figure 4.134: Plots of Hydration number (n_H) vs. Molality (m) of L-lysine in aqueous 0.35 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

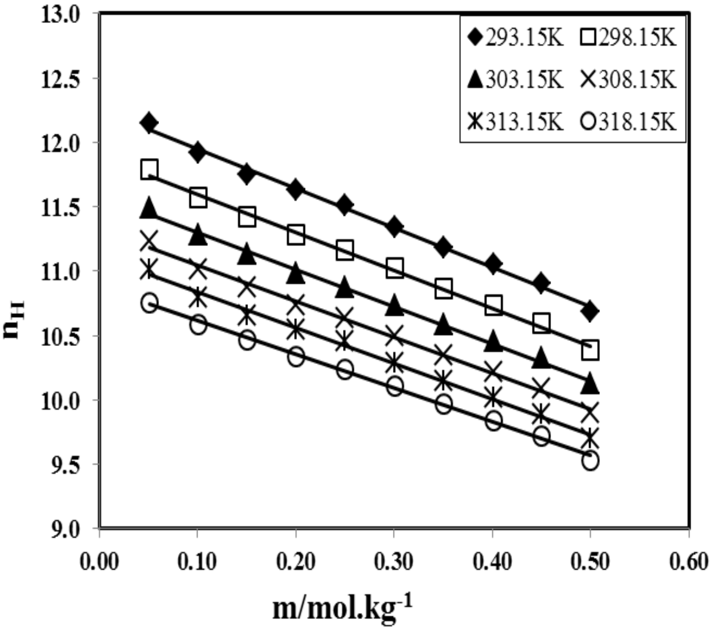

Figure 4.135: Plots of Hydration number (n_H) vs. Molality (m) of L-lysine in aqueous 0.50 mol.kg^{-1} fructose system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

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