VOLUMETRIC AND SOUND VELOCITY STUDIES OF L-SERINE, L-ASPARAGINE AND L-GLUTAMINE IN AQUEOUS VITAMIN B6 SOLUTION AT DIFFERENT TEMPERATURES

by

Musharat Islam

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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Declaration

This is to certify that the thesis work entitled " Volumetric and Sound Velocity Studies of L-Serine, L-Asparagine and L-Glutamine in Aqueous Vitamin B6 Solution at Different Temperatures " has been carried out by Musharat Islam in the Department of Chemistry, Khulna University of Engineering & Technology, Khulna, Bangladesh. The above thesis work or any part of this work has not been submitted anywhere for the award of any degree or diploma.

Signature of Supervisor Signature of Candidate

Approval

This is to certify that the thesis work submitted by MUSHARAT ISLAM entitled "Volumetric and Sound Velocity Studies of L-Serine, L-Asparagine and L-Glutamine in Aqueous Vitamin B6 Solution at Different Temperatures" has been approved by the board of examiners for the partial fulfillment of the requirements for the degree of Master of science in the Department of Chemistry, Khulna University of Engineering & Technology, Khulna, Bangladesh in March, 2018.

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ABSTRACT

In this study, a simple volumetric and sound velocity method was used for the analysis of effect of vitamin B6 (pyridoxine) on the structure of amino acids (L-serine, L-asparagine and L-glutamine). Densities and sound velocities of L-serine, L-asparagine and L-glutamine in aqueous and in aqueous 0.05 mol.kg^{-1}, 0.20 mol.kg^{-1}, 0.35 mol.kg^{-1} and 0.50 mol.kg^{-1} vitamin B6 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 (E_φ^0) and Helper's constant $(\delta E_\varphi^0/\delta T)_p$. The ultrasonic 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) 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. Densities of amino acids in aqueous vitamin B6 solutions are higher than that of amino acids in aqueous solution. The limiting apparent molar volumes (φ_v^0) are positive at the studied temperatures for the binary and ternary mixtures indicate the presence of solute-solvent interactions. The smaller values of experimental slope (S_v) as compared to φ_v^0 values suggest the dominance of solute-solvent interaction over the solute-solute interaction.

The limiting apparent molar volume transfer ($\Delta_{tr}\varphi_v^0$) values of L-glutamine and L-asparagine in aqueous 0.2 mol.kg^{-1}, 0.35 mol.kg^{-1} and 0.5 mol.kg^{-1} vitamin B6 solution are negative which suggest the dominance of ion-hydrophobic and hydrophobic-hydrophobic interactions. But $\Delta_{tr}\varphi_v^0$ values of L-serine in aqueous 0.05 mol.kg^{-1}, 0.20 mol.kg^{-1}, 0.35 mol.kg^{-1} and 0.50 mol.kg^{-1} vitamin B6 solutions positive which suggest the dominance of ion-hydrophilic and hydrophilic-hydrophilic interactions. The values of limiting apparent molar expansion ($E\varphi^0$) are positive. The Hepler's constant $(\delta E_\varphi^0/\delta T)_p$ values of binary system are small negative for all studied amino acids. In ternary systems,

the Hepler's constant values are mainly positive. This suggest that amino acids in ternary solution are more structural than binary solution. The values of partial molar volumes (V_2) increase with increasing of concentration of L-serine, L-asparagine and L-glutamine for the studied systems.

The sound velocity increases with the increase of concentration of amino acids (L-serine, L-asparagine and L-glutamine). Sound velocities of amino acids in aqueous vitamin B6 solutions are higher than that of amino acids in aqueous solution. This indicate that the increase of compactness of the medium with the increase in amino acids and vitamin B6 concentration.

The adiabatic compressibility (β_s) decreases with the increase of concentration of amino acids. 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 mainly negative. Negative values of $\Delta_{tr}\varphi_k^0$ indicate that increase in hydrophobic-hydrophobic and hydrophilic-hydrophobic group interactions. The small S_k values also indicates the dominating of solute-solvent interaction over solute-solute interaction.

The increase of acoustic impedance, Z with the increase of concentration of amino acids indicates the presence of effective solute-solvent interactions. The positive hydration number (n_H) indicate the appreciable solvation of solutes.

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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
h	Plank's constant
N	Avogadro's number
R	Universal gas constant
A,B,C	Constants related with temperature effects

CHAPTER I

Introduction

1.1 General

Densities and sound velocities are two very important physicochemical properties of solution in chemical process design. Meanwhile, the derivative thermodynamics and transport properties of solution from its densities and sound velocities are usually used for describing the intermolecular interactions to understand their real behavior [1]. Ultrasonic technique has been found to be more accurate and comprehensive in understanding solute-solvent interactions and understanding the role played by the biological molecules in living organism [2, 3]. The measurement of density, surface tension, viscosity, sound velocity etc. are have gained increased importance during the recent years for it's great usefulness in elucidating the composition and structure of molecules and also the molecular interaction. The volumetric properties of amino acids in aqueous and non-aqueous solvent are played an important role for understanding their behavior like as biological fluids containing different ionic species. Also, it can provide useful information regarding conformational stability and interaction in the ternary system. The solute-solvent interactions that mean the properties of solutions can be calculated from the properties of the individual components. 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. Amino acids have zwitter-ion and are the constituents of the most important class of biopolymers, i.e. Proteins. Solid-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. [4]. The vitamin B complexes as essential micronutrients play a vital role in the metabolism of human and animals. Usually, they are water-soluble and are based mainly on the pyridine ring as their molecular structures [5]. Vitamin B complexes because of its wide functions in various systems of the body (immune system, nervous system, lipid metabolism, gluconeogenesis,

hormone modulation, niacin formation, gene expression). It participates in more than 100 enzymatic reactions in which the most striking function lies in its service as a cofactor for enzymes during the biosynthesis process of amino acid [6].

1.2 Properties of solute in solvent

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

The physicochemical properties involving solute–solvent interactions in mixed solvents have increased over the past decade in view of their greater complexity in comparison with pure solvents [7-10]. This puzzling behavior results from the combined effects of preferential solvation of the solute by one of the components in the mixture [11, 12] and of solvent-solvent interactions [13]. Preferential solvation occurs when the polar solute has in its microenvironment more of one solvent than the other, in comparison with the bulk composition. The understanding of these phenomena may help in the elucidation of kinetic, spectroscopic and thermodynamic events that occur in solution.

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

1.3 Physical and chemical properties of chemical constituents

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 in ternary systems.

The chemical analysis and molecular weight determination would reveal the composition of the molecules, and the study of its chemical properties would unable one to ascertain the group or sequence of atoms in a molecule. But this cannot help us to find out the structures of molecules, as bond length, bond angles, internal atomic and molecular motions, polarity etc. cannot be ascertained precisely.

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

The various physical properties based upon the measurement of density, viscosity, surface tension, refractive index, dielectric constant etc., have been found to fall into the following four categories [7].

(i) **Purely additive properties**: An additive property is one, which for a given system is the sum of the corresponding properties of the constituents. The only strictly additive property is mass, for the mass of a molecule is exactly equal to the sum of the masses of its constituent atoms and similarly the mass of a mixture is the sum of

the separate masses of the constituent parts. There are other molecular properties like molar volume, radioactivity etc. are large additive in nature.

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

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

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

1.4 Amino Acids

Amino acids are defined as organic substances containing both amino and acid groups. Among more than 300 amino acids in nature, 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 [14].

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. The α-carbon atom (usually) has hydrogen and a side chain at the last two sites.

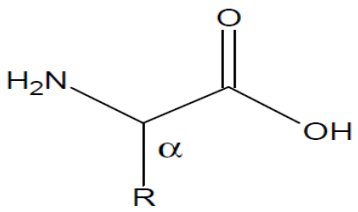


Figure 1.1: Basic structure of α-amino acids.

When two amino acids are linked together by a peptide bond is called a dipeptide. Continuing this process will eventually lead to the formation of protein [15]. 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 [16].

The physicochemical properties of amino acids in aqueous solutions provide valuable information on solute–solute and solute–solvent interactions that are important in understanding the stability of proteins, and are implicated in several biochemical and physiological processes in a living cell.

1.5 Properties of serine

Serine is an α-amino acid that is used in the biosynthesis of proteins. It contains an α-amino group (which is in the protonated $-NH_3^+$ form under biological conditions), a carboxyl group (which is in the deprotonated $-COO^-$ form in physiological conditions) and a side chain consisting of a hydroxymethyl group (hydroxyl), classifying it as a polar amino acid. The molecular weight of serine is 105.09 $g.mol^{-1}$ and density is 1.6 $g.cm^{-3}$. It can be synthesized in the human body under normal physiological circumstances, making

it a nonessential amino acid. This compound is one of the naturally occurring proteinogenic amino acids. Only the L-stereoisomer appears naturally in proteins. It is not essential to the human diet, since it is synthesized in the body from other metabolites, including glycine. Serine was first obtained from silk protein, a particularly rich source in 1865. Its name is derived from the Latin for silk, sericum [17].

In order for serine to be manufactured in the body sufficient amounts of vitamin B3, vitamin B6 and folic acid must be present. Serine is especially important to proper functioning of the brain and central nervous system. Serine helps form the phospholipids needed to make every cell in your body. It also involved in the function of RNA and DNA, fat and fatty acid metabolism, muscle formation and the maintenance of healthy immune system. Without serine, the myelin sheaths could fray and become less efficient at delivering messages between the brain and nerve endings in the body, essentially short circuiting mental function [18].

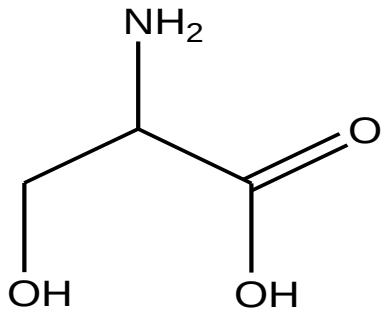


Figure 1.2: Structure of Serine

1.6 Properties of asparagine

Asparagine is an α-amino acid that is used in the biosynthesis of proteins. 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 carboxamide, classifying it as a polar (at physiological pH), aliphatic amino acid. The molecular weight of asparagine is 132.12 $g.mol^{-1}$ and density is 1.54 $g.cm^{-3}$. It is non-essential in humans, meaning the body can synthesize it. A reaction between asparagine and reducing sugars or other source of carbonyls produces acrylamide in food when heated to sufficient temperature. These products occur in baked goods such as French fries, potato chips, and toasted bread [19, 20].

Asparagine is amino acids that the body can manufacture in liver. Only the L form of amino acids is constituents of protein. It prevents human from being either overly nervous or overly calm. It releases energy that brain and nervous system cells use for metabolism. Overall this amino acid is needed to maintain balance in the central nervous system [21].

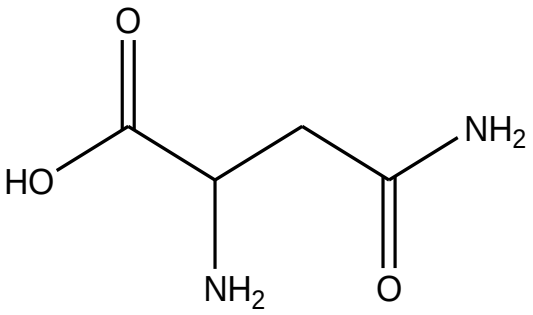


Figure 1.2: Structure of Asparagine

1.7 Properties of glutamine

Glutamine is an α-amino acid that is used in the biosynthesis of proteins. 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 amide which replaces the side chain hydroxyl of glutamic acid with an amine functional group, classifying it as a charge neutral, polar (at physiological pH) amino acid. The molecular weight of glutamine is 146.15 $g.mol^{-1}$ and density is 1.36 $g.cm^{-3}$. It is nonessential and conditionally essential in humans, meaning the body can usually synthesize sufficient amounts of it, but in some instances of stress, the body's demand for glutamine increases and glutamine must be obtained from the diet [22, 23]. In human blood, glutamine is the most abundant free amino acid. In states where tissue is being built or repaired, like growth of infants, or healing from traumatic wounds or severe illness, glutamine becomes conditionally essential [24].

Glutamine plays a role in a variety of biochemical functions: Protein synthesis, as any other of the 20proteinogenic amino acids Lipid synthesis, especially by cancer cells [25, 26]. Regulation of acid-base balance in the kidney by producing ammonium [27]. Cellular energy, as a source, next to glucose [28]. Nitrogen donation for many anabolic processes, including the synthesis of purines [24]. Carbon donation as a source, refilling the citric acid

cycle [29]. Nontoxic transporter of ammonia in the blood circulation Precursor to the neurotransmitter glutamate on the level of tissue, glutamine plays a role in maintaining the normal integrity of the intestinal mucosa [30].

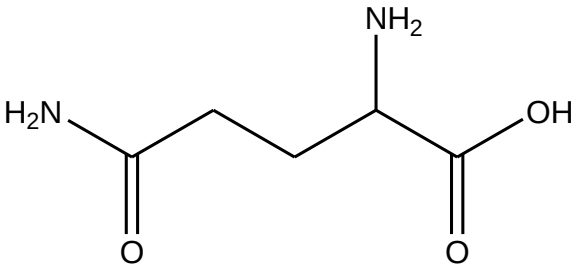


Figure 1.3: Structure of Glutamine

1.8 Properties of vitamin B6

Pyridoxine, also known as vitamin B6 and pyridoxol, is a form of vitamin B6 found commonly in food and used as dietary supplement [31]. The molecular weight of vitamin B6 is 205.64 $g.mol^{-1}$. As a supplement it is used to treat and prevent pyridoxine deficiency, sideroblastic anaemia, pyridoxine-dependent epilepsy, certain metabolic disorders, problems from isoniazid, and certain types of mushroom poisoning. It is used by mouth or by injection [32].

It is usually well tolerated. Occasionally side effects include headache, numbness, and sleepiness. Normal doses are safe during pregnancy and breast feeding. Pyridoxine is in the vitamin B family of vitamins. It is required by the body to make amino acids, carbohydrates and lipids [32]. Sources in the diet include fruit, vegetables and grain [33].

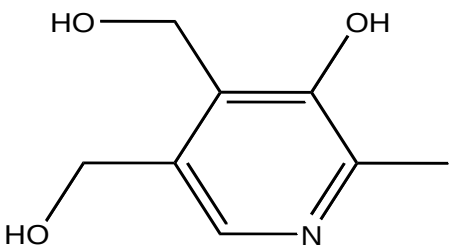


Figure 1.4: Structure of vitamin B6

1.9 Properties of water

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

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

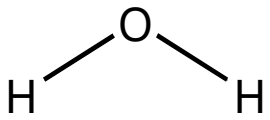


Figure 1.5: Structure of water

Water is a tiny bent molecule with the molecular formula H_2O, consisting of two light hydrogen atoms attached to each 16-fold heavier oxygen atom. Each molecule is electrically neutral but polar, with the center of positive and negative charges located in different places. It has been recognized that water is an 'anomalous' liquid many of its properties is differ essentially from normal liquids of simple structures [34]. The deviations from regularity indicate some kind of association of water molecules. The notable unique physical properties exhibited by liquid water are [35] : i) negative volume of melting ii) density maximum in normal liquid range (at 4^0C) iii) isothermal compressibility minimum in the normal liquid range at (46^0C) iv) numerous crystalline polymorphs v) high dielectric constant vi) abnormally high melting, boiling and critical temperatures for such a low molecular weight substance that is neither ionic nor metallic vii) increasing liquid fluidity

with increasing pressure and viii) high mobility transport for H^+ and OH^- ions pure water has a unique molecular structure. The O-H bond length is 0.096 nm and the H-O-H angle 104.5^0. For a very long time the physical and the chemist have pondered over the possible structural arrangements that may be responsible for imparting very unusual properties to water. To understand the solute water interaction the most fundamental problem in solution chemistry the knowledge of water structure is a prerequisite. The physico-chemical properties of aqueous solution in most of the cares are interpreted in terms of the structural change produced by solute molecules. It is recognized that an understating of the structural changes in the solvent may be crucial to study of the role of water in biological systems.

Various structural models that have been developed to describe the properties of water may generally be grouped into two categories, namely the continumm model and the mixture models. The continumm models [36, 37] 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 [38-40] 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, later developed by Nemethy and Scherage, is commonly adopted in solution chemistry [35, 41]. 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.

$$(H_2O)_b \rightleftharpoons (H_2O)_d$$

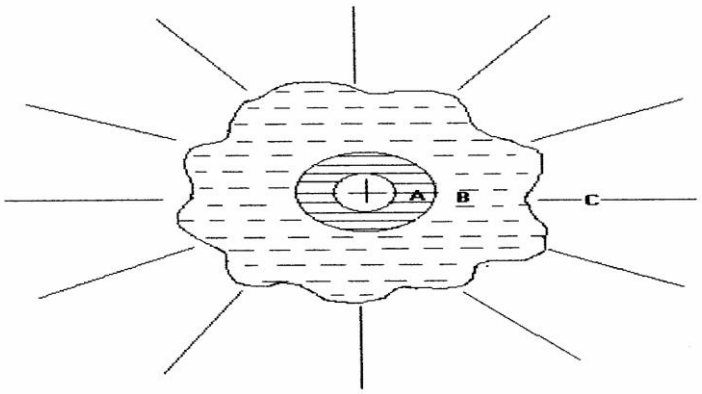


Fig 1.6: Frank and Wen model for the structure modification produce by an ion

The hydrogen bonding in the clusters is postulated [42] to be cooperative phenomenon. So that when one bond forms several others also come into existence. The properties of solution can be accounted for in terms of solvent-solvent, solvent-solute and solute-solute interaction. In terms of thermodynamics, the concentration dependence of a given property extrapolated to the limit of infinite dilution provides a measure of solute-solvent interactions. Solute-water interaction or hydration phenomenon can be conveniently classified into three basic types:

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

The introduction of a solute into liquid water produces changes in the properties of the solvent which are analogous to these brought about by temperature or pressure. The solute that shifts the equilibrium to the left and increase the average half-life of the clusters is termed as structure maker whereas that which has an effect in the opposite direction is called 'Structure breaker' [43].

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 [44]. 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 [45, 46].

1.10 Amino acids-solvent systems

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 study of volumetric and sound velocity of solution containing amino acids and vitamin (pyridoxine) are interacting. The correlation between solute-solvent interactions is complex. The environment of the solute affects the volumetric and sound velocity properties; it is of interesting to study the effect of the media changing from water-vitamin (pyridoxine, nicotinic acid, thiamine, nicotinamide etc.) with amino acids on the thermodynamic properties. Research on density and sound velocity study of L-serine and L-threonine in aqueous nicotinamide solution has been reported [47]. Volumetric and viscometric studies of amino acids in vitamin B6 aqueous solutions at various temperatures have been measured [6]. Volumetric and ultrasonic investigation of molecular interactions of l-serine and l-threonine in aqueous nicotinamide solutions at T= (288.15–318.15) K have been reported [48]. Explorations of diverse interactions of some vitamins in aqueous mixtures of cysteine have been reported [49]. Thermodynamics of solute-solute and solute-solvent interactions of homologous series of amino acids with thiamine hydrochloride in aqueous medium at 305.15 K, 310.15 K, and 315.15 K. A volumetric and acoustic approach also have been investigated [50]. Studies on volumetric and sound velocity of L-proline and L-lysine in aqueous nicotinamide solution at different temperatures have been measured [51]. The structure making and structure breaking properties of amino acids in aqueous glucose solution at different temperatures have been reported [52]. Volumetric and viscometric studies of some amino acids in aqueous solutions of cadmium chloride at t = (288.15 to 318.15) k and at atmospheric pressure have been reported [53]. 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 have been reported [54].

1.11 The object of the present work

The developments in solution theory are still far from being adequate to account for the properties of the constituent molecules. Accordingly, it is the experimental data on various volumetric and ultrasonic properties, which provide useful information for proper understanding of specific interaction between the components and structure of the solution. The experimental approach of measurements of various macroscopic properties is also useful in providing guidance to theoretical approaches, since the experimentally determined values of solution properties may bring to light certain inadequacies in the proposed model on which theoretical treatments may be based. Volumetric and ultrasonic studies on ternary solutions have attracted a great deal of attention and experimental data on a good number of systems are available in a number of review articles [55-56]. Since there has to be the same origin, namely, the characteristic intermolecular interactions, it is natural to seek functional relationships among the volumetric properties, ultrasonic properties and thermodynamic properties. However, such attempts have not met with much success.

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

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

The thermo-physical properties of liquid systems like density and sound velocity are strictly related to the molecular interactions taking place in the system [6]. The studies of amino acids express the interaction of dipolar ions with other functions and components in the biological system [57]. 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 [45]. Therefore we decided to study the density and sound velocities properties of amino acids in mixed solvent system.

In the present investigations, (i) densities, apparent molar volumes, partial molar volumes, apparent molar expansibilities (ii) sound velocities, Apparent molar adiabatic compressibility, hydration number, Acoustic impedance, Relative association parameters of aqueous vitamin B6 with amino acids at six different temperatures (293.15-318.15K) have been determined. To the best of our knowledge, no data on density, sound velocity, apparent molar volume, partial molar volume, adiabatic compression and isobaric expansion of L-serine, L-asparagine and L-glutamine in aqueous vitamin B6 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 L-serine, L-asparagine and L-glutamine with aqueous vitamin B6 which are focused in this study. In order to understand the issue of solute-solvent interactions in aqueous solution of vitamin B6-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-

i. to measure the density and sound velocity of L-serine, L-asparagine and L-glutamine in aqueous vitamin B6 solution at different temperature,
ii. to understand the effect of vitamin B6 on the structure of L-serine, L-asparagine and L-glutamine in solution,
iii. to predict about the structure making or breaking mechanism of L-serine, L-asparagine and L-glutamine in aqueous and aqueous vitamin B6 systems,

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

v. to determine the hydration number of L-serine, L-asparagine and L-glutamine in binary and ternary systems,

vi. to enrich the available data on physico-chemical properties of the system.

CHAPTER II

Literature review

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. Pyridoxine is in the vitamin B family of vitamins. It is required by the body to make amino acids, carbohydrates, and lipids. Sources in the diet include fruit, vegetables, and grain. Currently, volumetric and sound velocity 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. In this chapter various fields where the solute-solvent interactions find applications and several aspects explored by the researchers has been reviewed in detail.

Xiaohui X. et al, measued the densities and viscosities of ternary solutions (erythritol/xylitol/sorbitol/maltitol + vitamin B6 + water) at 293.15 K, 303.15 K, 313.15 K, 323.15 K and atmospheric pressure. The experimental densities were correlated in terms of the Guimara esequation and the apparent molar volumes (V_φ). The limiting partial molar volumes (V_φ^0) and the limiting partial molar volumes of transfer ($\Delta_{tr}V_\varphi^0$) were calculated through the densities. The experimental viscosities were correlated according to the extended Jones-Dole equation to obtain the viscosity B coefficients, and the free energies ofactivation per mole of solute and per mole of solvent were calculated [1].

Daofan Ma. et al, measured the densities and viscosities of glycine, L-alanine, L-valine, L-threonine and L-arginine in (0.1 to 0.4) $mol.kg^{-1}$ vitamin B6 aqueous solutions and studied over the entire molality range at (293.15, 303.15, 313.15, and 323.15) K and atmospheric pressure. They used the density data for calculating 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 (E_φ) and Helper's constant $(\delta E_\varphi/\delta T)_p$ [6].

Kumar, H. and Behal studied on volumetric and ultrasonic investigation of molecular interactions of L-serine and L-threonine in aqueous nicotinamide solution at different temperature. He reported on density by calculated the apparent molar volumes (V_φ). The limiting partial molar volumes (V_φ^0) and the limiting partial molar volumes of transfer ($\Delta_{tr}V_\varphi^0$). And also on the structure-making and breaking behavior of L-serine and L-threonine in aqueous nicotinamide solution at different temperature [47].

Paula C. et al, on density and sound velocity study of L-serine and L-threonine in aqueous ammonium sulfate solution [53].

Ashwani et al, 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. 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 [58].

Mirikar et al, studied adiabatic compressibility (βs), 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 [59].

Elena et al, 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 [60].

Hildebrand J. H., performed the volumetric and viscometric studies of amino acids in vitamin B6 aqueous solutions at various temperatures [61].

Khanuja et al, studied partial molar volume, the transfer partial molar volume, partial molar volume expansibility and viscosity B-coefficient with temperature dB/dT 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 [62].

Palani et al, reported on ultrasonic studies of amino acids in aqueous sucrose solution at different temperatures by calculating adiabatic compressibility, hydration number, apparent molal compressibility, apparent molal volume, apparent molal compressibility and limiting apparent molal volume. These parameters were used to study the ion-solvent interaction present in each solution [63].

Zhuo et al, 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 [64].

Chunmei W. et al, performed on the mixing enthalpies of N,N′-hexamethylenebisacetamide (HMBA) with glycine, L-alanine and L-serine in D-mannitol solutions with different molar fractions have been determined by means of mixing-flow isothermal microcalorimetry at 298.15 K. The heterotacticenthalpic interaction coefficients in the molar fraction (x) range of D-mannitol, have been calculated in terms of McMillan−Mayer theory [65].

Palani et al, performed volumetric studies of glutamine, arginine and 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 [66].

Balakrishnan S. et al, performed volumetric studies of three amino acids viz., asparagine, histidine and lysine in aqueous K_2SO_4 solution (0.5m) 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 [67].

Palani et al, 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 [68].

Palani R. and Geetha A. reported about acoustical and thermodynamical studies of l-serine, l-glutamine and l-asparagine in aqueous d-glucose solutions at 293.15 K. In this report they discuss about partial molar volume, apparent molar volume, partial molar compressibility, transfer volume, limiting apparent molar compressibility etc [69].

From the literature review, it is seen that densities and speeds of sound of L-serine, L-asparagine and L-glutamine in aqueous vitamin B6 solution at different temperatures were not reported previously. In this work, solute-solvent interaction 0f amino acids (L-serine, L-asparagine and L-glutamine) with vitamin B6 (Pyridoxine) have been carried out by using Anton Paar DSA 5000M vibrating tube density and sound velocity.

CHAPTER III

Experimental

This chapter deals with the experimental methods for the investigation of molecular interactions of L-serine, L-asparagine and L-glutamine with water and in aqueous solution of vitamin B6. The studied systems are

1. L-serine + water
2. L-asparagine + water
3. L-glutamine + water
4. L- serine + water + 0.05 mol.kg^{-1} pyridoxine
5. L- serine + water + 0.20 mol.kg^{-1} pyridoxine
6. L- serine + water + 0.35 mol.kg^{-1} pyridoxine
7. L- serine + water + 0.50 mol.kg^{-1} pyridoxine
8. L- asparagine + water + 0.05 mol.kg^{-1} pyridoxine
9. L- asparagine + water + 0.20 mol.kg^{-1} pyridoxine
10. L- asparagine + water + 0.35 mol.kg^{-1} pyridoxine
11. L- asparagine + water + 0.50 mol.kg^{-1} pyridoxine
12. L-glutamine + water + 0.05 mol.kg^{-1} pyridoxine
13. L-glutamine + water + 0.20 mol.kg^{-1} pyridoxine
14. L-glutamine + water + 0.35 mol.kg^{-1} pyridoxine
15. L-glutamine + water + 0.50 mol.kg^{-1} pyridoxine

Experimental have been carried out at six equidistant temperatures as 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K over the aqueous 0.05, 0.20, 0.35 and 0.50 mol.kg^{-1} aqueous vitamin B6 solution. The details of various information have been described in the following sections.

3.1 Materials

The chemicals used for study were L-serine, L-asparagine, L-glutamine and vitamin B6. All chemicals were of analytical reagent (A.R) grade. Specifications and structural formula for all of them are given below:

Chemicals	Molecular formula	Molar mass	Reported purity	Producer
Vitamin B6	$C_8H_{12}ClNO_3$	205.64	99.5%	LOBA Chemical, India
L-serine	$C_3H_7NO_3$	105.09	99.0%	WAKOPURE Chemical, Japan.
L-asparagine	$C_4H_8N_2O_3.H_2O$	150.13	99.0%	LOBA Chemical, India
L-glutamine	$C_5H_{10}N_2O_3$	146.15	99.0%	SIGMA Chemical, USA.

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 molality 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^0C 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 density meter (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 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 liter of solution. If n_2 is number of moles of solute and V (liters) is the volume of the solution then,

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

$$\text{or, } C = \frac{n_2}{V} \quad \text{.....(3.1)}$$

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 (2.1), unit of molarity is $molL^{-1}$ [70].

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, if ρ 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 [70]. Mathematically,

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

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

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

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

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 [70, 76]:

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

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

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,

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

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:

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

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 [70].

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

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

$$\overline{V}_2 = \varphi_v + \frac{\sqrt{m}}{2}\left(\frac{\delta\varphi_v}{\delta\sqrt{m}}\right) = \varphi^0{}_v + \frac{3\sqrt{m}}{2}\left(\frac{\delta\varphi_v}{\delta\sqrt{m}}\right) \text{……..(3.9)}$$

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

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

……..(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 ternary system) - φ_v^0 (in binary system) ....……..…….…….(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:

$E_\varphi^0 = B + 2C(T-T_m)$ ……..……(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 [71]:

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

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

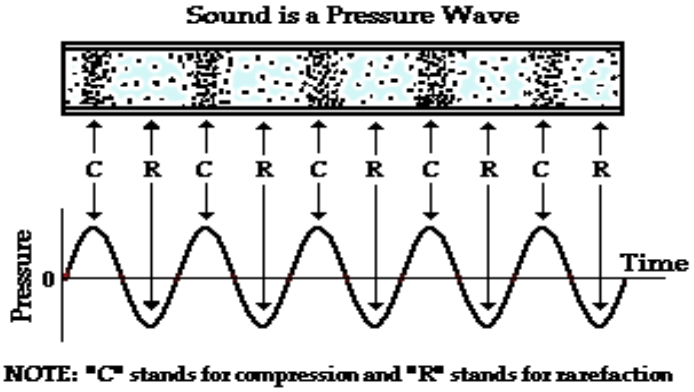


Figure 2.1: Schematic diagram of a longitudinal standing wave; C and R show positions of medium compressions and refractions (high and low densities) respectively.

When a layer of fluid medium is compressed or rarefied during the passage of a sound wave, the pressure in the layer changes from the equilibrium pressure. The amount of pressure changed is defined as the excess pressure or sound pressure or acoustic pressure.

Considering the acoustic pressure an equation for sound wave [72] 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 compressibilities of a substance, β_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,

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

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

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

Various attempts [73-78] 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,

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

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 $\beta_{s,\rho}$ 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,

$$Z = u\rho \quad \text{(3.21)}$$

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

3.16 Hydration number

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

$$n_H = \frac{n_1}{n_2}\left(1 - \frac{\beta_s}{\beta_{s,o}}\right) \quad \text{(3.22)}$$

Where n_H denotes the hydration number. β_s, φ_k 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

The interaction of amino acids (L-serine, L-asparagine and L-glutamine) with vitamin B6 have been measured in terms of volumetric and sound velocity measurement. The experimental results and the properties derived from experimental data are presented in this chapter. The results have been discussed in the light of recent developments of the subject. The studied systems are:

1. L-serine + water
2. L-asparagine + water
3. L-glutamine + water
4. L- serine + water + 0.05 mol.kg^{-1} pyridoxine
5. L- serine + water + 0.20 mol.kg^{-1} pyridoxine
6. L- serine + water + 0.35 mol.kg^{-1} pyridoxine
7. L- serine + water + 0.50 mol.kg^{-1} pyridoxine
8. L- asparagine + water + 0.05 mol.kg^{-1} pyridoxine
9. L- asparagine + water + 0.20 mol.kg^{-1} pyridoxine
10. L- asparagine + water + 0.35 mol.kg^{-1} pyridoxine
11. L- asparagine + water + 0.50 mol.kg^{-1} pyridoxine
12. L-glutamine + water + 0.05 mol.kg^{-1} pyridoxine
13. L-glutamine + water + 0.20 mol.kg^{-1} pyridoxine
14. L-glutamine + water + 0.35 mol.kg^{-1} pyridoxine
15. L-glutamine + water + 0.50 mol.kg^{-1} pyridoxine

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 (V_2), limiting apparent molar volume (φ_v^0), limiting apparent molar volume transfer ($\Delta_{tr}\varphi_v^0$), limiting apparent molar expansibilities ($E\varphi^0 = \delta\varphi_v^0/\delta T)_p$) and Hepler's constant [$(\delta E\varphi^0/\delta T)_p = (\delta^2\varphi_v^0/\delta T^2)_p$] have been determined from density data. The ultrasonic properties like adiabatic compressibility (βs), 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) 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 of amino acids in water systems have been determined at temperatures ranging (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 densities of aqueous L-serine, L-asparagine and L-glutamine have been shown in tables 4.1-4.3 and figures are graphically shown in 4.1 at different temperatures as a function of molality of aqueous amino acids. Figures 4.1 show that the densities of aqueous L-serine, L-asparagine and L-glutamine increase with the increase of L-serine, L-asparagine and L-glutamine concentration. These are due to the increase in number of particles in given region which leads to shrinkage in volume of solution [79, 80]. The densities of the aqueous L-serine, L-asparagine and L-glutamine decrease in the order of L-serine < L-asparagine < L-glutamine for the same molality of amino acids and at the same temperature, which provides that the density is higher for the higher molecular weight. The densities decrease with the increase of temperature in aqueous L-serine, L-asparagine and L-glutamine 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 of ternary systems such as L-serine, L-asparagine and L-glutamine in 0.05 mol.kg^{-1}, 0.20 mol.kg^{-1}, 0.35 mol.kg^{-1} and 0.50 mol.kg^{-1} aqueous vitamin B6 solutions are listed in tables 4.4-4.15. Figures are graphically shown in fig. 4.2-4.4. The values of densities of amino acids (L-serine, L-asparagine and L-glutamine) in aqueous vitamin B6 systems has been found to be in the order of,

> Amino acids + water + 0.50 mol.kg^{-1} vitamin B6 > Amino acids + water + 0.35 mol.kg^{-1} vitamin B6 > Amino acids + water + 0.20 mol.kg^{-1} vitamin B6 > Amino acids + water + 0.05 mol.kg^{-1} vitamin B6

It is seen that the density increase with the increasing of vitamin B6 concentration at a fixed amino acid concentration. The increase of density with concentration of vitamin B6 can be attributed to solute-solvent interaction and weight of vitamin B6 in solution. The densities of the L-serine, L-asparagine and L-glutamine solutions increase in the order of L-serine < L-asparagine < L-glutamine for the same molality of amino acids and vitamin B6 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 [81]. Densities of ternary system (amino acids + vitamin B6 + water) are higher than that of binary system (amino acids + water). 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.

The apparent molar volumes (φ_v) of L-serine, L-asparagine and L-glutamine in water are calculated from density data. The value of apparent molar volume of aqueous L-serine, L-asparagine and L-glutamine 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 L-serine, L-asparagine and L-glutamine are graphically represented in figures 4.5. 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 values of apparent molar volume (φ_v) of aqueous L-serine, L-asparagine and L-glutamine solutions increase in the order of: L-asparagine > L-glutamine > L-serine. It may be due to the number of carbon present in alkyl group in amino acids and the structural orientation of amino acids. 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 L-serine, L-asparagine and L-glutamine in aqueous vitamin B6 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. Figures 4.6-4.8 show the plots of apparent molar volume as a function of

molality of L-serine, L-asparagine and L-glutamine at different temperatures. Plots of φ_v vs. molality of amino acids show linear relationship in aqueous vitamin B6 system. For L-serine, L-asparagine and L-glutamine in aqueous vitamin B6 solutions systems, the values of apparent molar volume (φ_v) are also positive and linearly increase with the increase of concentration of L-serine, L-asparagine and L-glutamine. It has been also found that apparent molar volumes for L-serine increase with the increase of vitamin B6 concentration (0.05 $mol.kg^{-1}$, 0.20 $mol.kg^{-1}$, 0.35 $mol.kg^{-1}$ and 0.50 $mol.kg^{-1}$) whereas also apparent molar volumes for L-asparagine and L-glutamine decrease with the increase of vitamin B6 concentration (0.05 $mol.kg^{-1}$, 0.20 $mol.kg^{-1}$, 0.35 $mol.kg^{-1}$ and 0.50 $mol.kg^{-1}$). At a fixed vitamin B6 concentration and temperature, the increase of φ_v with the concentration of 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 present in alkyl group in amino acids that may be due to the increase in surface of solute to interact with solvent which is also depend on structure [82]. Comparatively lower apparent molar volume, φ_v of L-serine in aqueous vitamin B6 solutions was found than those of aqueous L-glutamine and L-asparagine solution. This indicates that the L-serine is more compressed in aqueous vitamin B6 solution than aqueous solution. Whereas higher apparent molar volume, φ_v of L-glutamine and L-asparagine in aqueous vitamin B6 solution than aqueous L-serine solution was found. This indicates that the L-glutamine and L-asparagine is less compressed in aqueous vitamin B6 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 vitamin B6–vitamin B6 or vitamin B6-water or water–water interactions decrease with the increase in temperature leading to a positive change in volume [83].

The limiting apparent molar volume (φ_v^0) which is also called the standard partial molar volume of aqueous L-serine, L-asparagine and L-glutamine 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 [84]. 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 L-serine, L-glutamine and L-asparagine. Furthermore, the values of φ_v^0 also depends on the molar mass, size and structure of the amino acid, that is, higher values of φ_v^0 are obtained for L-asparagine as compared to L-serine and L-glutamine. The increase of 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 L-serine, L-asparagine and L-glutamine in ternary (water + vitamin B6) solution at the studied temperatures are presented in tables 4.34-4.45. As per co-sphere overlap model [85-86], 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 and hydrophobic-hydrophobic interaction takes place. Furthermore, the values of φ_v^0 also increase with an increase in the molar mass, size and structure of the amino acid that is higher values of φ_v^0 are obtained for L-glutamine and L-asparagine as compared to L-serine in aqueous vitamin B6 solutions. The increase in φ_v^0values 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^0at higher temperatures [82]. 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 (water + vitamin B6) solution are reported in tables 4.31-4.45. The values of experimental

slope (S_V) are small positive for all the concentration 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 [87]. S_V values are positive and decrease with an increase of temperature (with some exception) in amino acids in the aqueous solution but increase in aqueous vitamin B6 solution suggesting that less solute is accommodated in the void space left in the packing of the large associated solvent molecules. The values of limiting apparent molar volume transfer of amino acids from water to aqueous vitamin B6 solutions at infinite dilution was calculated by using the equation,

$$\Delta_{tr}\varphi_v^0 = \varphi_v^0 \text{ (in aq. vitamin B6)} - \varphi_v^0 \text{ (in water)}.$$

The values of limiting apparent molar volume transfer ($\Delta_{tr}\varphi_v^0$) of L-serine, L-asparagine and L-glutamine in aqueous vitamin B6 solutions have been reported in tables 4.34-4.45. The $\Delta_{tr}\varphi_v^0$ values of L-serine in aqueous vitamin B6 solutions are both negative and positive and whereas $\Delta_{tr}\varphi_v^0$ the values of L-asparagine and L-glutamine in aqueous vitamin B6 solutions are negatives. The observed positive values of $\Delta_{tr}\varphi_v^0$ suggest strong ion-ion interactions and hydrophilic–ionic interaction of L-serine with vitamin B6. Since the structural moiety of amino acids and aqueous vitamin B6 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 [85-86]. And also the negative values of $\Delta_{tr}\varphi_v^0$ suggest strong ion-hydrophobic and hydrophobic-hydrophobic interactions of amino acids with vitamin B6. 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 vitamin B6 molecules can be categorized as: (i) Hydrophilic–ionic interaction between −OH groups of vitamin B6 and zwitterions of L-serine. (ii) Hydrophilic–hydrophilic interaction the −OH groups of vitamin B6 and −OH groups or −NH groups in the side chain of amino acid L-serine mediated through hydrogen bonding. (iii) Hydrophilic-hydrophobic interaction between the −OH groups of vitamin B6 molecule and non-polar ($-CH_2$) in the side chain of L-asparagine and L-glutamine

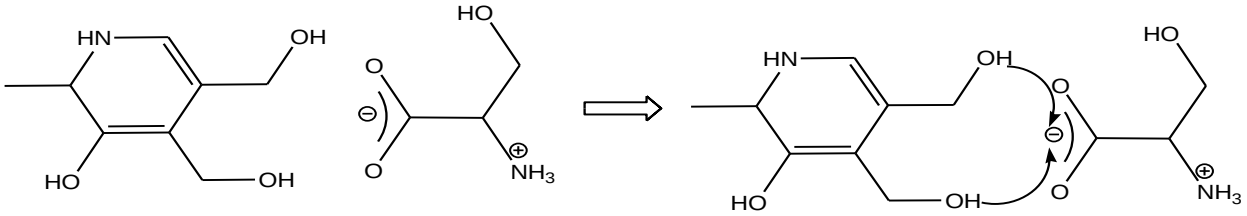
molecule and (iv) Hydrophobic–hydrophobic group interactions between the non-polar groups of vitamin B6 and non-polar (CH_2) in the side chain of L-asparagine and L-glutamine molecule. According to co-sphere overlap model, ion-hydrophobic interactions and hydrophobic-hydrophobic interactions contribute negatively whereas hydrophilic–ionic and hydrophilic-hydrophilic interactions contribute positively to the $\Delta_{tr}\varphi_v^0$ values. Therefore, in case of L-serine + vitamin B6 + water hydrophilic-ionic and hydrophilic-hydrophilic interactions are dominating. Whereas ion-hydrophobic and hydrophobic-hydrophobic interactions are dominating for L-asparagine and L-glutamine systems.

From the structural view point of L-serine, L-asparagine and L-glutamine, it is seen that the structure of L-serine, L-asparagine and L-glutamine is open chain. In addition to that L-asparagine and L-glutamine contains two amino groups whereas L-serine contains one amino group. And also the carbon numbers of L-serine, L-asparagine and L-glutamine are 3, 4 and 5 respectively. Therefore the hydrophobic-hydrophobic interactions of L-asparagine and L-glutamine is higher than L-serine. The values of limiting apparent molar volume expansibilities E_φ^0 and $(\delta E_\varphi^0/\delta T)_p$ of aqueous L-serine, L-asparagine and L-glutamine 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. The small negative or positive values of $(\delta E_\varphi^0/\delta T)_p$ for all the studied systems may act as the structure making solute.

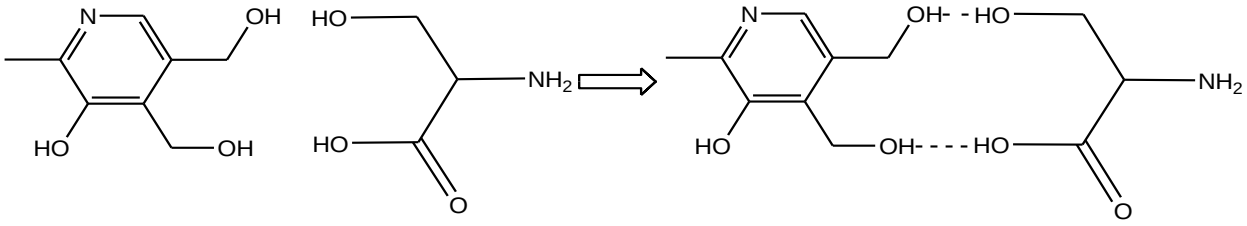
The values of limiting apparent molar volume expansibilities E_φ^0 and $(\delta E_\varphi^0/\delta T)_p$ of L-serine, L-asparagine and L-glutamine in ternary (water + vitamin B6) solutions are reported in tables 4.34-4.45. The E_φ^0 values are found to be positive at all temperatures and concentrations of amino acids in vitamin B6 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 vitamin B6 molecules. The small negative or positive values of $(\delta E_\varphi^0/\delta T)_p$ for studied systems show the structure making ability of amino acids in all aqueous vitamin B6 solutions [77, 88-92]. Some possible interaction between solute-solvent are given bellow.

For serine

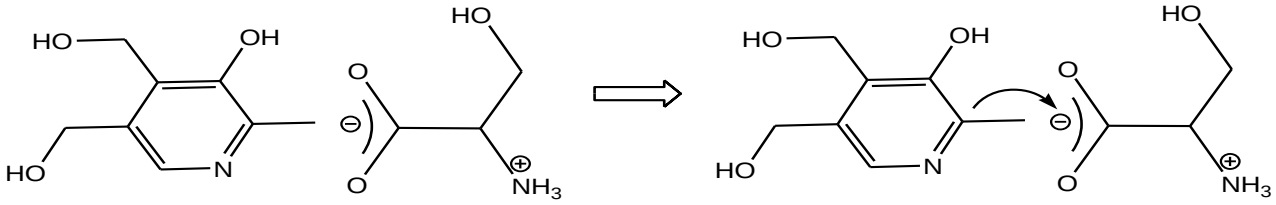
1. Hydrophilic-ion interaction



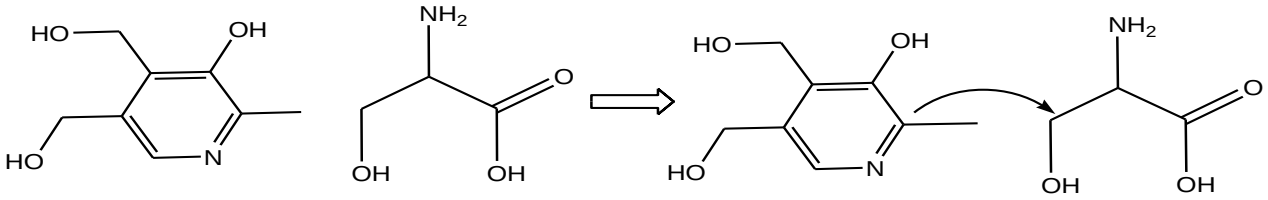
2. Hydrophilic-hydrophilic interaction



3. Hydrophobic-ion interaction

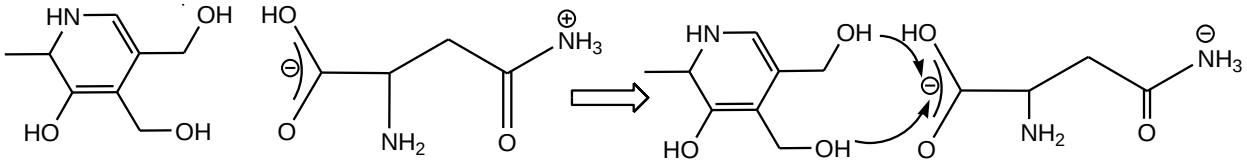


4. Hydrophobic-hydrophobic interaction

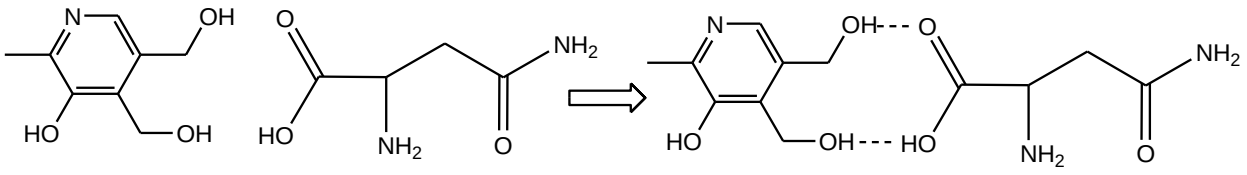


For asparagine

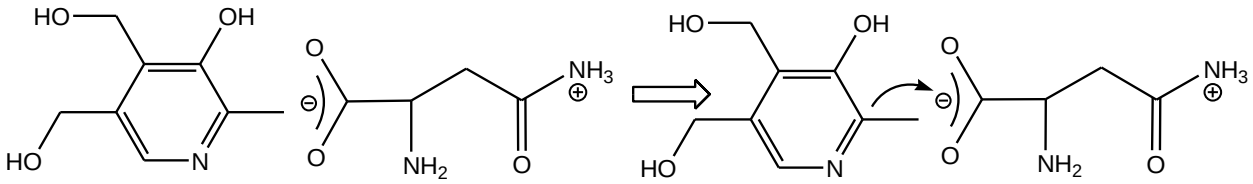
1. Hydrophilic-ion interaction



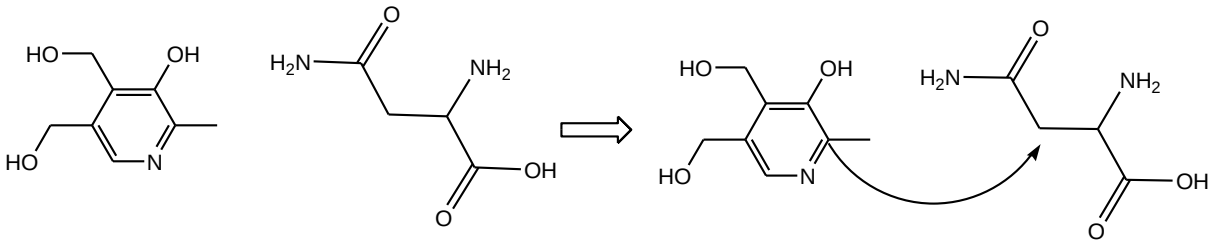
2. Hydrophilic-hydrophilic interaction



3. Hydrophobic-ion interaction

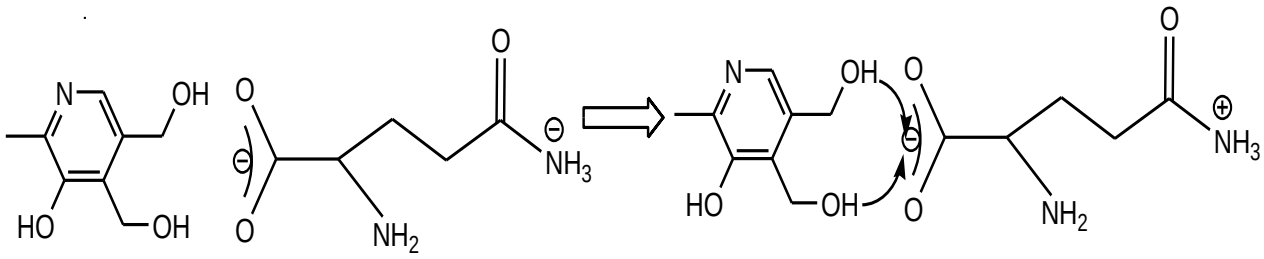


4. Hydrophobic-hydrophobic interaction

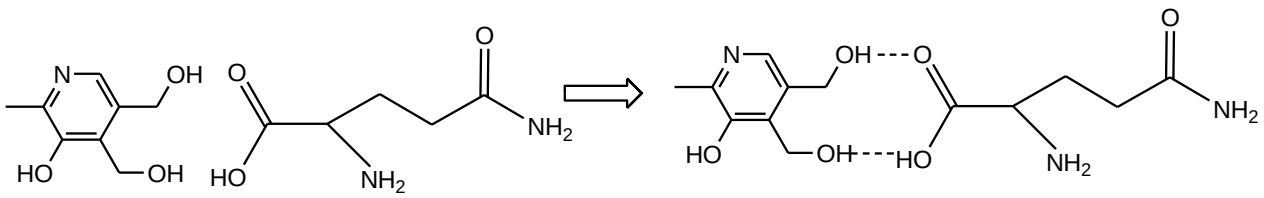


For glutamine

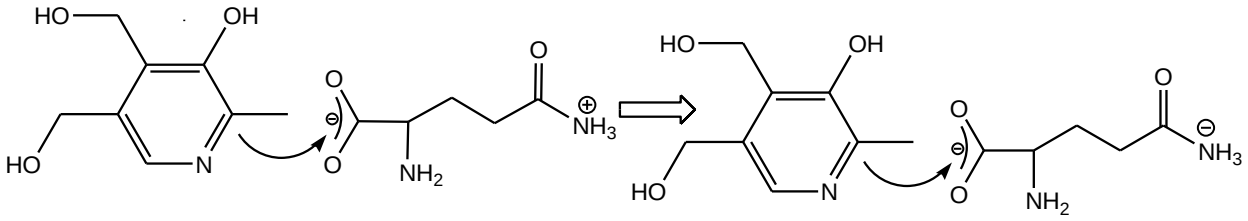
1. Hydrophilic-ion interaction



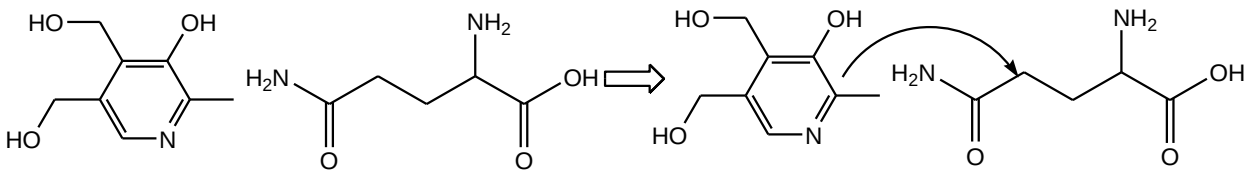
2. Hydrophilic-hydrophilic interaction



3. Hydrophobic-ion interaction



3. Hydrophobic-hydrophobic interaction



The values of Partial molar volume (V_2) of aqueous amino acids and amino acids in binary and ternary (water + vitamin B6) solutions are shown in tables 4.46-4.60. Figures 4.9-4.12 show the plots of partial molar volume as a function of concentration of aqueous amino acids and amino acids in aqueous solution of vitamin B6. The value of partial molar volume (V_2) increases with the increase of concentration of amino acid.

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

The sound velocities, u of aqueous amino acids and amino acids in ternary (water + vitamin B6) systems have been determined at temperatures ranging (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 sound velocities of aqueous amino acids and amino acids in aqueous vitamin B6 solution have been shown in tables 4.61-4.75 at different temperatures. Figures 4.13-4.16 show the plots of sound velocities as a function of molality of aqueous amino acids and amino acids in aqueous vitamin B6 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 [94]. The sound velocity of aqueous L-glutamine and L-asparagine is higher than aqueous L-serine. This is due to the molecular weight of L-glutamine and L-asparagine is higher than L-serine. 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 for molecular interactions [95]. 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 L-serine, L-asparagine and L-glutamine has been shown in tables 4.76-4.78 at different temperatures. Figures 4.17 show the plots of adiabatic compressibility as a function of molality of aqueous L-serine, L-asparagine and L-glutamine. From the figures it is apparent that the values of β_s decrease with the increase of molar concentration of L-serine, L-asparagine and L-glutamine. The value of β_s also decreases with the increases of temperature. The decrease in the β_s values with increasing concentration of L-serine, L-asparagine and L-glutamine indicates that the water molecules around the amino acids are less compressible than the water molecule in the bulk solution [96-97]. The decrease in adiabatic compressibility (β_s) 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 L-serine, L-asparagine and L-glutamine in ternary (water + vitamin B6) solution are shown in tables 4.79-4.90 and figures 4.18-4.20 show the plots of adiabatic compressibility as a function of molality of L-serine, L-asparagine and L-glutamine in aqueous solution of vitamin B6. From these figures it is apparent that the values of β_s decrease with the increase of concentration of L-serine, L-asparagine and L-glutamine in vitamin B6 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 L-serine, L-asparagine and L-glutamine in aqueous vitamin B6 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 [96-97]. The decrease in βs may be due to the introduction of amino acids molecule into water and aqueous vitamin B6 solutions which reduce the void space in solution.

The apparent molar adiabatic compressibility (φ_k) of aqueous L-serine, L-asparagine and L-glutamine are calculated from density and sound velocity data. The values of apparent molar adiabatic compressibility (φ_k) of aqueous L-serine, L-asparagine and L-glutamine at different temperatures (293.15, 298.15, 303.15, 308.15, 313.15, 318.15) K are given in tables 4.91-4.93 and the variation of φ_k with molality of L-serine, L-asparagine and L-glutamine are graphically represented in figures 4.21. From the data it is observed that values of φ_k are negative at all temperatures and concentrations of L-serine, L-asparagine and L-glutamine. The values of φ_k decrease with an increase in the concentration of amino acids. 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 [97].

The value of apparent molar adiabatic compressibility (φ_k) of L-serine, L-asparagine and L-glutamine in ternary (water + vitamin B6) solution at different temperatures (293.15, 298.15, 303.15, 308.15, 313.15, 318.15) K are given in tables 4.94-4.105 and the variation of φ_k with molality of L-serine, L-asparagine and L-glutamine are graphically represented in figures 4.22-4.24. From the data it is observed that values of φ_k are negative at all temperatures and concentrations of vitamin B6 which is similar with binary systems. 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 solvent molecules around solute [97].

The values of apparent molar adiabatic compressibility (φ_k) of amino acids + vitamin B6 + water are lower than the values of amino acids + water systems. This lower 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 (water + vitamin B6)

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 [97]. 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. 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 vitamin B6 and water molecules induce the dehydration of amino acids and therefore at high vitamin B6 concentrations the water molecules around the amino acids are more compressible than those at lower vitamin B6 concentrations.

The values of apparent molar adiabatic compressibility of transfer ($\Delta_{tr}\varphi_k^0$) for molal concentrations of aqueous L-serine, L-asparagine and L-glutamine in vitamin B6 at different temperatures are reported in tables 4.109-4.120. Apparent molar adiabatic compressibility of transfer ($\Delta_{tr}\varphi_k^0$) of amino acids are both positive and negative. L-asparagine in aqueous 0.05, 0.20, 0.35 and 0.50 $mol.kg^{-1}$ vitamin B6 systems and L-glutamine in aqueous 0.20, 0.35, 0.50 $mol.kg^{-1}$ vitamin B6 systems show the negative value, whereas L-serine in higher concentration show positive 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 zwitter ionic group of amino acids and alkyl chains of both amino acids and vitamin B6 result the increase in the number of monomeric water molecules. The $\Delta_{tr}\varphi_k^0$ values of amino acids in aqueous vitamin B6 solutions increase with increasing of vitamin B6 concentration. Negative values of $\Delta_{tr}\varphi_k^0$ indicate that increase in hydrophilic-hydrophobic and hydrophobic-hydrophobic group interactions results in disruption of hydration sphere of charged centers of amino acid thereby reducing the positive contribution to $\Delta_{tr}\varphi_k^0$ [97].

The values of acoustic impedance, Z of aqueous L-serine, L-asparagine, L-glutamine and L-serine, L-asparagine, L-glutamine in aqueous vitamin B6 solution have been shown in tables 4.121-4.135 at different temperatures. Figures 4.25-4.28 show the plots of acoustic impedance as a function of molality of aqueous L-serine, L-asparagine, L-glutamine and

L-serine, L-asparagine, L-glutamine in aqueous vitamin B6 solution. 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 [94]. The values of acoustic impedance, Z of amino acids + vitamin B6 + water are higher than the values of amino acids + water systems.

The hydration number (n_H) of L-serine, L-asparagine and L-glutamine in water are listed in tables 4.136-4.138 and figures are graphically shown in 4.29. The hydration numbers decrease with the increase of concentration for aqueous L-serine, L-asparagine and L-glutamine system. The hydration numbers also decrease with the increase of temperature. The hydration number of aqueous L-glutamine and L-asparagine are higher than the aqueous L-serine. 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 [97].

The hydration number (n_H) of L-serine, L-asparagine and L-glutamine in 0.05, 0.20, 0.35 and 0.50 $mol.kg^{-1}$ aqueous vitamin B6 solutions at different temperatures are reported in tables 4.139-4.150. The variation of hydration number (n_H) with molality is graphically shown in figures 4.30-4.32. The hydration numbers decrease with the increase of concentration for L-serine, L-asparagine and L-glutamine in aqueous vitamin B6 systems which is similar with binary systems. The hydration numbers decrease with the increase of temperature. The hydration number of L-serine and L-asparagine in aqueous vitamin B6 is higher than L-glutamine in aqueous vitamin B6 solution. The hydration number of amino acids at concentrated vitamin B6 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 in less than that of the solvent. As a result amino acids will gain mobility and have more probability of contacting aqueous vitamin B6 molecules. This may enhance the interaction between solute and solvent molecules [68].

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

L-serine + water						
m/mol.kg^{-1}	Density, ρ/kg.m^{-3}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	998.423	997.274	995.876	994.248	992.425	990.424
0.04912	1000.605	999.431	998.017	996.378	994.548	992.535
0.09988	1002.841	1001.644	1000.211	998.564	996.723	994.699
0.14903	1004.989	1003.774	1002.324	1000.664	998.815	996.778
0.19989	1007.200	1005.965	1004.499	1002.823	1000.959	998.918
0.24978	1009.350	1008.090	1006.607	1004.920	1003.043	1000.995
0.29934	1011.469	1010.192	1008.692	1006.990	1005.105	1003.046
0.35056	1013.642	1012.353	1010.840	1009.127	1007.222	1005.152
0.40053	1015.748	1014.434	1012.904	1011.170	1009.275	1007.197
0.44999	1017.814	1016.483	1014.940	1013.202	1011.279	1009.203
0.50195	1019.976	1018.626	1017.068	1015.318	1013.379	1011.296

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

L-asparagine +water						
m/mol.kg^{-1}	Density, ρ/kg.m^{-3}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	998.423	997.274	995.876	994.248	992.425	990.424
0.02005	999.624	998.465	997.055	995.417	993.585	991.577
0.03901	1000.741	999.569	998.147	996.499	994.660	992.648
0.05919	1001.911	1000.727	999.292	997.637	995.788	993.769
0.07921	1003.047	1001.849	1000.411	998.738	996.879	994.859
0.09899	1004.155	1002.945	1001.493	999.811	997.949	995.919
0.11901	1005.255	1004.031	1002.572	1000.875	999.004	996.971
0.14079	1006.435	1005.195	1003.734	1002.013	1000.145	998.105
0.16089	1007.505	1006.253	1004.771	1003.039	1001.162	999.116
0.18099	1008.549	1007.277	1005.783	1004.056	1002.171	1000.119
0.19901	1009.435	1008.161	1006.657	1004.946	1003.048	1000.993

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

L-glutamine + water						
m/mol.kg^{-1}	Density, ρ/kg.m^{-3}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	998.423	997.274	995.876	994.248	992.425	990.424
0.05029	1001.309	1000.132	998.704	997.059	995.225	993.208
0.10095	1004.154	1002.950	1001.509	999.837	997.981	995.945
0.14978	1006.830	1005.591	1004.112	1002.431	1000.562	998.514
0.20098	1009.545	1008.308	1006.811	1005.110	1003.223	1001.160
0.24947	1012.050	1010.767	1009.249	1007.532	1005.619	1003.545
0.29955	1014.587	1013.296	1011.749	1010.007	1008.076	1005.986
0.34958	1017.118	1015.777	1014.216	1012.464	1010.512	1008.414
0.39908	1019.528	1018.150	1016.555	1014.785	1012.839	1010.720
0.45099	1022.000	1020.589	1019.000	1017.205	1015.243	1013.122
0.50099	1024.392	1022.978	1021.344	1019.540	1017.564	1015.425

Table 4.4: Density (ρ) of L-serine in aqueous solution of 0.05 mol.kg^{-1} vitamin B6 as a function of molality at different temperature

L-serine + aqueous solution of 0.05 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	Density, ρ/kg.m^{-3}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1001.444	1000.262	998.838	997.198	995.358	993.338
0.04988	1003.641	1002.441	1000.994	999.340	997.491	995.459
0.10034	1005.844	1004.621	1003.155	1001.488	999.628	997.587
0.14900	1007.946	1006.702	1005.221	1003.541	1001.670	999.618
0.20007	1010.124	1008.865	1007.365	1005.669	1003.788	1001.728
0.24927	1012.205	1010.925	1009.408	1007.702	1005.812	1003.744
0.30069	1014.359	1013.053	1011.529	1009.807	1007.903	1005.825
0.35067	1016.429	1015.105	1013.568	1011.835	1009.919	1007.829
0.39888	1018.416	1017.073	1015.523	1013.774	1011.850	1009.756
0.45005	1020.502	1019.141	1017.576	1015.819	1013.887	1011.785
0.49988	1022.502	1021.132	1019.547	1017.778	1015.836	1013.730

Table 4.5: Density (ρ) of L-serine in aqueous solution of 0.20 mol.kg^{-1} vitamin B6 as a function of molality at different temperature

L-serine + aqueous solution of 0.20 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	Density, ρ/kg.m^{-3}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1010.185	1008.915	1007.412	1005.713	1003.823	1001.762
0.04921	1012.265	1010.974	1009.455	1007.746	1005.844	1003.769
0.09932	1014.364	1013.050	1011.516	1009.795	1007.882	1005.792
0.15099	1016.507	1015.171	1013.625	1011.890	1009.964	1007.856
0.19986	1018.512	1017.161	1015.599	1013.850	1011.913	1009.794
0.25009	1020.558	1019.191	1017.612	1015.851	1013.901	1011.762
0.30000	1022.568	1021.182	1019.599	1017.815	1015.856	1013.699
0.34982	1024.556	1023.157	1021.556	1019.763	1017.788	1015.609
0.39888	1026.499	1025.089	1023.469	1021.657	1019.674	1017.476
0.45099	1028.554	1027.121	1025.490	1023.658	1021.646	1019.431
0.50009	1030.459	1029.012	1027.370	1025.525	1023.494	1021.264

Table 4.6: Density (ρ) of L-serine in aqueous solution of 0.35 mol.kg^{-1} vitamin B6 as a function of molality at different temperature

L-serine + aqueous solution of 0.35 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	Density, ρ/kg.m^{-3}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1018.524	1017.14	1015.603	1013.843	1011.886	1009.792
0.05004	1020.582	1019.184	1017.631	1015.861	1013.895	1011.791
0.09999	1022.611	1021.193	1019.625	1017.849	1015.871	1013.752
0.14911	1024.575	1023.144	1021.562	1019.773	1017.785	1015.655
0.20056	1026.606	1025.159	1023.565	1021.762	1019.759	1017.619
0.25005	1028.538	1027.076	1025.469	1023.644	1021.636	1019.479
0.30029	1030.468	1029.000	1027.369	1025.534	1023.509	1021.329
0.34998	1032.342	1030.869	1029.215	1027.374	1025.329	1023.133
0.39998	1034.218	1032.741	1031.069	1029.211	1027.141	1024.931
0.45012	1036.058	1034.568	1032.888	1031.009	1028.922	1026.691
0.50005	1037.889	1036.372	1034.670	1032.783	1030.655	1028.411

Table 4.7: Density (ρ) of L-serine in aqueous solution of 0.50 mol.kg^{-1} vitamin B6 as a function of molality at different temperature

L-serine + aqueous solution of 0.50 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	Density, ρ/kg.m^{-3}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1001.444	1000.262	998.838	997.198	995.358	993.338
0.05039	1028.491	1027.052	1025.409	1023.576	1021.581	1019.400
0.10005	1030.417	1028.975	1027.325	1025.482	1023.467	1021.272
0.15003	1032.338	1030.888	1029.233	1027.377	1025.348	1023.137
0.19996	1034.241	1032.789	1031.119	1029.253	1027.197	1024.971
0.24999	1036.128	1034.669	1032.983	1031.099	1029.039	1026.789
0.30016	1038.002	1036.522	1034.823	1032.933	1030.879	1028.596
0.35003	1039.846	1038.369	1036.658	1034.751	1032.665	1030.392
0.40014	1041.673	1040.199	1038.481	1036.566	1034.463	1032.183
0.45021	1043.479	1041.999	1040.279	1038.358	1036.259	1033.939
0.50019	1045.273	1043.790	1042.051	1040.114	1037.996	1035.657

Table 4.8: Density (ρ) of L-asparagine in aqueous solution of 0.05 mol.kg^{-1} vitamin B6 as a function of molality at different temperature

L-asparagine + aqueous solution of 0.05 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	Density, ρ/kg.m^{-3}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1001.444	1000.262	998.838	997.198	995.358	993.338
0.01968	1002.540	1001.298	999.824	998.138	996.268	994.219
0.04075	1003.680	1002.378	1000.842	999.117	997.217	995.136
0.06088	1004.750	1003.385	1001.819	1000.046	998.090	995.998
0.08072	1005.742	1004.312	1002.740	1000.939	998.931	996.819
0.10069	1006.730	1005.258	1003.641	1001.800	999.776	997.608
0.12038	1007.690	1006.140	1004.460	1002.620	1000.584	998.426
0.14027	1008.627	1007.082	1005.334	1003.482	1001.354	999.181
0.16091	1009.591	1008.015	1006.210	1004.291	1002.154	999.925
0.18079	1010.562	1008.880	1007.055	1005.040	1002.939	1000.667
0.20041	1011.441	1009.728	1007.790	1005.772	1003.662	1001.278

Table 4.9: Density (ρ) of L-asparagine in aqueous solution of 0.20 $mol.kg^{-1}$ vitamin B6 as a function of molality at different temperature

L-asparagine + aqueous solution of 0.20 $mol.kg^{-1}$ vitamin B6						
$m/mol.kg^{-1}$	Density, $\rho/kg.m^{-3}$					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1010.185	1008.915	1007.412	1005.713	1003.823	1001.762
0.01968	1011.483	1010.200	1008.685	1006.968	1005.059	1002.979
0.04085	1012.828	1011.529	1009.999	1008.265	1006.338	1004.238
0.06038	1014.020	1012.705	1011.167	1009.414	1007.468	1005.355
0.07912	1015.118	1013.799	1012.235	1010.475	1008.518	1006.390
0.10019	1016.300	1014.965	1013.398	1011.616	1009.643	1007.499
0.12038	1017.396	1016.036	1014.469	1012.668	1010.685	1008.523
0.13927	1018.355	1016.997	1015.404	1013.592	1011.604	1009.431
0.16091	1019.413	1018.028	1016.435	1014.625	1012.616	1010.413
0.18079	1020.322	1018.939	1017.327	1015.495	1013.493	1011.295
0.20041	1021.204	1019.817	1018.208	1016.369	1014.336	1012.093

Table 4.10: Density (ρ) of L-asparagine in aqueous solution of 0.35 $mol.kg^{-1}$ vitamin B6 as a function of molality at different temperature

L-asparagine + aqueous solution of 0.35 $mol.kg^{-1}$ vitamin B6						
$m/mol.kg^{-1}$	Density, $\rho/kg.m^{-3}$					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1018.524	1017.140	1015.603	1013.843	1011.886	1009.792
0.02003	1020.582	1019.184	1017.631	1015.861	1013.895	1011.791
0.04004	1022.611	1021.193	1019.625	1017.849	1015.871	1013.752
0.05971	1024.575	1023.144	1021.562	1019.773	1017.785	1015.655
0.08027	1026.606	1025.159	1023.565	1021.762	1019.759	1017.619
0.10011	1028.538	1027.076	1025.469	1023.644	1021.636	1019.479
0.12028	1030.468	1029.000	1027.369	1025.534	1023.509	1021.329
0.14004	1032.342	1030.869	1029.215	1027.374	1025.329	1023.133
0.16011	1034.218	1032.741	1031.069	1029.211	1027.141	1024.931
0.18019	1036.058	1034.568	1032.888	1031.009	1028.922	1026.691
0.20041	1037.889	1036.372	1034.670	1032.783	1030.655	1028.411

Table 4.11: Density (ρ) of L-asparagine in aqueous solution of 0.50 mol.kg^{-1} vitamin B6 as a function of molality at different temperature

L-asparagine + aqueous solution of 0.50 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	Density, ρ/kg.m^{-3}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1026.514	1025.084	1023.451	1021.630	1019.648	1017.480
0.02055	1028.492	1027.009	1025.338	1023.471	1021.447	1019.254
0.04099	1030.422	1028.882	1027.169	1025.267	1023.202	1020.987
0.05992	1032.173	1030.572	1028.831	1026.891	1024.794	1022.559
0.07902	1033.903	1032.221	1030.446	1028.478	1026.339	1024.088
0.09915	1035.685	1033.973	1032.146	1030.111	1027.982	1025.695
0.11908	1037.416	1035.643	1033.793	1031.702	1029.547	1027.238
0.13888	1039.127	1037.299	1035.414	1033.240	1031.067	1028.739
0.16025	1040.928	1039.099	1037.155	1034.940	1032.721	1030.369
0.18065	1042.608	1040.717	1038.782	1036.557	1034.218	1031.881
0.20010	1044.199	1042.316	1040.299	1037.995	1035.645	1033.258

Table 4.12: Density (ρ) of L-glutamine in aqueous solution of 0.05 mol.kg^{-1} vitamin B6 as a function of molality at different temperature

L-glutamine + aqueous solution of 0.05 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	Density, ρ/kg.m^{-3}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1001.444	1000.262	998.838	997.198	995.358	993.338
0.04966	1004.183	1002.964	1001.514	999.855	998.000	995.962
0.09911	1006.867	1005.619	1004.148	1002.472	1000.598	998.530
0.15069	1009.629	1008.352	1006.857	1005.156	1003.268	1001.171
0.20069	1012.256	1010.961	1009.446	1007.726	1005.813	1003.699
0.25012	1014.797	1013.478	1011.935	1010.196	1008.275	1006.152
0.30039	1017.359	1016.023	1014.455	1012.706	1010.768	1008.629
0.35022	1019.852	1018.477	1016.905	1015.123	1013.173	1011.058
0.40119	1022.393	1021.027	1019.412	1017.588	1015.633	1013.504
0.45085	1024.821	1023.378	1021.730	1019.953	1017.986	1015.813
0.50155	1027.276	1025.802	1024.143	1022.313	1020.314	1018.151

Table 4.13: Density (ρ) of L-glutamine in aqueous solution of 0.20 mol.kg^{-1} vitamin B6 as a function of molality at different temperature

L-glutamine + aqueous solution of 0.20 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	Density, ρ/kg.m^{-3}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1010.185	1008.915	1007.412	1005.713	1003.823	1001.762
0.05055	1013.352	1012.035	1010.492	1008.749	1006.801	1004.699
0.09988	1016.381	1015.011	1013.427	1011.636	1009.639	1007.479
0.14939	1019.357	1017.926	1016.288	1014.460	1012.416	1010.219
0.19925	1022.294	1020.789	1019.118	1017.239	1015.131	1012.897
0.24918	1025.167	1023.608	1021.895	1019.946	1017.785	1015.542
0.29948	1027.999	1026.353	1024.595	1022.656	1020.399	1018.099
0.34957	1030.721	1029.057	1027.226	1025.239	1022.989	1020.599
0.40095	1033.491	1031.743	1029.898	1027.795	1025.489	1023.126
0.44866	1035.994	1034.211	1032.316	1030.207	1027.851	1025.449
0.50099	1038.658	1036.812	1034.859	1032.664	1030.331	1027.879

Table 4.14: Density (ρ) of L-glutamine in aqueous solution of 0.35 mol.kg^{-1} vitamin B6 as a function of molality at different temperature

L-glutamine + aqueous solution of 0.35 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	Density, ρ/kg.m^{-3}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1018.524	1017.140	1015.603	1013.843	1011.886	1009.792
0.04999	1022.299	1020.799	1019.117	1017.219	1015.132	1012.924
0.10077	1025.910	1024.289	1022.440	1020.427	1018.241	1015.894
0.15076	1029.254	1027.450	1025.564	1023.434	1021.124	1018.662
0.20075	1032.389	1030.407	1028.432	1026.279	1023.858	1021.280
0.25034	1035.331	1033.305	1031.190	1028.841	1026.414	1023.641
0.30088	1037.962	1035.913	1033.759	1031.378	1028.912	1025.998
0.34925	1040.449	1038.401	1036.199	1033.864	1031.112	1027.999
0.39956	1042.930	1040.796	1038.686	1036.059	1033.192	1030.041
0.44946	1045.395	1043.080	1040.994	1038.246	1035.135	1032.196
0.50085	1047.911	1045.553	1043.521	1040.475	1037.373	1034.122

Table 4.15: Density (ρ) of L-glutamine in aqueous solution of 0.5 mol.kg^{-1} vitamin B6 as a function of molality at different temperature

L-glutamine + aqueous solution of 0.50 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	Density, ρ/kg.m^{-3}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1001.444	1000.262	998.838	997.198	995.358	993.338
0.04966	1004.183	1002.964	1001.514	999.855	998.000	995.962
0.09911	1006.867	1005.619	1004.148	1002.472	1000.598	998.530
0.15069	1009.629	1008.352	1006.857	1005.156	1003.268	1001.171
0.20069	1012.256	1010.961	1009.446	1007.726	1005.813	1003.699
0.25012	1014.797	1013.478	1011.935	1010.196	1008.275	1006.152
0.30039	1017.359	1016.023	1014.455	1012.706	1010.768	1008.629
0.35022	1019.852	1018.477	1016.905	1015.123	1013.173	1011.058
0.40119	1022.393	1021.027	1019.412	1017.588	1015.633	1013.504
0.45085	1024.821	1023.378	1021.730	1019.953	1017.986	1015.813
0.50155	1027.276	1025.802	1024.143	1022.313	1020.314	1018.151

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

L-serine + water						
m/mol.kg^{-1}	$\varphi_v \times 10^6$/m^3·mol^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.04912	60.56	61.09	61.44	61.70	61.88	62.16
0.09988	60.61	61.12	61.50	61.72	61.93	62.20
0.14903	60.66	61.12	61.50	61.75	61.96	62.24
0.19989	60.67	61.13	61.50	61.77	62.01	62.25
0.24978	60.71	61.17	61.54	61.81	62.07	62.30
0.29934	60.74	61.19	61.56	61.84	62.09	62.33
0.35056	60.78	61.20	61.56	61.84	62.11	62.35
0.40053	60.81	61.25	61.61	61.91	62.12	62.36
0.44999	60.85	61.28	61.63	61.91	62.17	62.38
0.50195	60.87	61.29	61.64	61.92	62.19	62.40

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

L-asparagine + water						
m/mol.kg^{-1}	$\varphi_v \times 10^6$/m^3.mol^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.02005	90.17	90.71	91.35	91.91	92.43	92.85
0.03901	90.55	91.18	91.84	92.42	92.90	93.25
0.05919	90.93	91.57	92.24	92.76	93.27	93.65
0.07921	91.38	92.04	92.60	93.23	93.76	94.08
0.09899	91.75	92.41	93.01	93.62	94.09	94.47
0.11901	92.15	92.82	93.39	94.04	94.52	94.87
0.14079	92.54	93.23	93.74	94.47	94.86	95.23
0.16089	92.90	93.58	94.17	94.89	95.30	95.67
0.18099	93.30	94.03	94.62	95.24	95.66	96.03
0.19901	93.82	94.50	95.10	95.59	96.05	96.41

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

L-glutamine + water						
m/mol.kg^{-1}	$\varphi_v \times 10^6$/m^3.mol^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.05029	88.56	89.15	89.80	90.20	90.48	90.87
0.10095	88.92	89.51	89.98	90.48	90.88	91.30
0.14978	89.32	89.97	90.56	90.98	91.36	91.75
0.20098	89.87	90.35	90.90	91.33	91.72	92.11
0.24947	90.35	90.94	91.48	91.90	92.34	92.72
0.29955	90.78	91.30	91.86	92.31	92.75	93.14
0.34958	91.03	91.63	92.16	92.59	93.04	93.40
0.39908	91.40	92.03	92.59	93.02	93.41	93.80
0.45099	91.77	92.41	92.90	93.35	93.74	94.10
0.50099	91.99	92.58	93.12	93.55	93.94	94.31

Table 4.19: Apparent molar volume (φ_v) of L-serine in aqueous solution of 0.05 mol.kg^{-1} vitamin B6 as a function of molality (m/mol.kg^{-1}) at different temperature

L-serine + aqueous solution of 0.05 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	$\varphi_v \times 10^6/m^3.mol^{-1}$					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.04988	60.89	61.27	61.75	62.07	62.28	62.57
0.10034	60.95	61.38	61.82	62.12	62.36	62.61
0.14900	61.03	61.47	61.88	62.18	62.43	62.68
0.20007	61.15	61.56	61.96	62.28	62.52	62.76
0.24927	61.23	61.65	62.05	62.35	62.59	62.83
0.30069	61.32	61.76	62.12	62.43	62.68	62.92
0.35067	61.41	61.84	62.19	62.49	62.75	63.00
0.39888	61.47	61.90	62.25	62.56	62.81	63.04
0.45005	61.54	61.97	62.31	62.61	62.85	63.08
0.49988	61.64	62.04	62.39	62.69	62.94	63.16

Table 4.20: Apparent molar volume (φ_v) of L-serine in aqueous solution of 0.2 mol.kg^{-1} vitamin B6 as a function of molality (m/mol.kg^{-1}) at different temperature

L-serine + aqueous solution of 0.20 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	$\varphi_v \times 10^6/m^3.mol^{-1}$					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.04921	62.48	62.93	63.28	63.52	63.80	64.14
0.09932	62.54	63.00	63.34	63.60	63.87	64.21
0.15099	62.61	63.07	63.38	63.66	63.94	64.30
0.19986	62.69	63.11	63.44	63.73	64.00	64.34
0.25009	62.74	63.15	63.49	63.77	64.06	64.42
0.30000	62.81	63.22	63.52	63.84	64.12	64.49
0.34982	62.88	63.27	63.58	63.89	64.18	64.57
0.39988	63.03	63.41	63.74	64.06	64.34	64.73
0.45099	62.97	63.36	63.68	64.01	64.33	64.72
0.50009	63.04	63.42	63.73	64.06	64.39	64.78

Table 4.21: Apparent molar volume (φ_v) of L-serine in aqueous solution of 0.35 mol.kg^{-1} vitamin B6 as a function of molality (m/mol.kg^{-1}) at different temperature

L-serine + aqueous solution of 0.35 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	$\varphi_v \times 10^6/m^3.mol^{-1}$					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.05004	63.41	63.71	64.06	64.29	64.52	64.77
0.09999	63.52	63.89	64.22	64.42	64.68	64.98
0.14911	63.68	64.02	64.35	64.59	64.84	65.13
0.20056	63.83	64.17	64.48	64.74	65.01	65.29
0.25005	63.95	64.28	64.59	64.89	65.15	65.45
0.30029	64.09	64.39	64.74	65.03	65.30	65.64
0.34998	64.25	64.53	64.90	65.17	65.47	65.82
0.39998	64.36	64.63	65.00	65.29	65.62	65.96
0.45012	64.52	64.78	65.14	65.44	65.78	66.15
0.50005	64.62	64.92	65.28	65.58	65.97	66.33

Table 4.22: Apparent molar volume (φ_v) of L-serine in aqueous solution of 0.5 mol.kg^{-1} vitamin B6 as a function of molality (m/mol.kg^{-1}) at different temperature

L-serine + aqueous solution of 0.50 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	$\varphi_v \times 10^6/m^3.mol^{-1}$					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.05039	65.02	65.23	65.46	65.74	66.04	66.35
0.10005	65.11	65.26	65.47	65.73	66.10	66.43
0.15003	65.17	65.33	65.52	65.79	66.15	66.49
0.19996	65.21	65.36	65.58	65.85	66.26	66.61
0.24999	65.27	65.42	65.67	65.96	66.32	66.71
0.30016	65.32	65.52	65.78	66.06	66.35	66.78
0.35003	65.38	65.55	65.81	66.10	66.45	66.81
0.40014	65.46	65.60	65.85	66.14	66.49	66.83
0.45021	65.53	65.68	65.91	66.18	66.49	66.89
0.50019	65.59	65.73	65.98	66.26	66.58	66.99

Table 4.23: Apparent molar volume (φ_v) of L-asparagine in aqueous solution of 0.05 mol.kg^{-1} vitamin B6 as a function of molality (m/mol.kg^{-1}) at different temperature

L-asparagine + aqueous solution of 0.05 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	$\varphi_v \times 10^6/m^3.mol^{-1}$					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.01968	94.28	97.38	99.99	102.42	104.06	105.67
0.04075	94.99	97.98	100.81	103.00	104.59	106.23
0.06088	95.45	98.51	100.92	103.21	105.25	106.57
0.08072	96.41	99.54	101.46	103.56	105.77	107.06
0.10069	97.05	100.00	102.00	104.11	106.07	107.70
0.12038	97.57	100.70	102.91	104.69	106.45	107.75
0.14027	98.15	100.81	103.21	104.84	107.04	108.28
0.16091	98.63	101.15	103.62	105.47	107.47	108.93
0.18079	98.73	101.57	103.89	106.10	107.69	109.25
0.20041	99.18	101.92	104.59	106.61	108.11	110.10

Table 4.24: Apparent molar volume (φ_v) of L-asparagine in aqueous solution of 0.20 mol.kg^{-1} vitamin B6 as a function of molality (m/mol.kg^{-1}) at different temperature

L-asparagine + aqueous solution of 0.20 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	$\varphi_v \times 10^6/m^3.mol^{-1}$					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.01968	83.88	84.55	85.18	86.12	87.12	88.14
0.04085	84.99	85.72	86.40	87.29	88.24	89.25
0.06038	86.05	86.81	87.42	88.35	89.33	90.24
0.07912	87.09	87.74	88.54	89.35	90.25	91.16
0.10019	88.27	88.95	89.62	90.50	91.38	92.28
0.12038	89.28	90.05	90.63	91.52	92.36	93.27
0.13927	90.40	91.06	91.75	92.62	93.39	94.27
0.16091	91.58	92.33	92.94	93.69	94.50	95.47
0.18079	92.74	93.41	94.06	94.86	95.56	96.40
0.20041	93.71	94.34	94.93	95.69	96.49	97.49

Table 4.25: Apparent molar volume (φ_v) of L-asparagine in aqueous solution of 0.35 mol.kg^{-1} vitamin B6 as a function of molality (m/mol.kg^{-1}) at different temperature

L-asparagine + aqueous solution of 0.35 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	$\varphi_v \times 10^6/m^3.mol^{-1}$					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.02003	48.26	48.87	49.56	49.96	50.31	50.70
0.04004	48.81	49.56	50.24	50.54	50.96	51.48
0.05971	49.42	50.11	50.77	51.16	51.58	52.08
0.08027	49.95	50.64	51.26	51.70	52.17	52.64
0.10011	50.48	51.17	51.77	52.33	52.74	53.27
0.12028	51.08	51.69	52.38	52.91	53.38	53.99
0.14004	51.58	52.14	52.88	53.37	53.90	54.53
0.16011	52.11	52.61	53.36	53.88	54.49	55.12
0.18019	52.69	53.20	53.90	54.48	55.10	55.77
0.20041	53.24	53.83	54.56	55.11	55.86	56.52

Table 4.26: Apparent molar volume (φ_v) of L-asparagine in aqueous solution of 0.50 mol.kg^{-1} vitamin B6 as a function of molality (m/mol.kg^{-1}) at different temperature

L-asparagine + aqueous solution of 0.50 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	$\varphi_v \times 10^6/m^3.mol^{-1}$					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.02055	54.80	57.20	58.92	61.01	62.92	64.05
0.04099	55.56	58.06	59.88	61.72	63.62	64.68
0.05992	56.31	58.98	60.65	62.51	64.31	65.35
0.07902	57.10	60.09	61.76	63.50	65.37	66.34
0.09915	57.95	60.61	62.44	64.46	65.85	66.98
0.11908	58.74	61.44	63.14	65.27	66.63	67.75
0.13888	59.33	62.01	63.71	66.11	67.40	68.48
0.16025	60.05	62.37	64.19	66.51	67.90	68.99
0.18065	60.75	63.14	64.70	66.81	68.68	69.56
0.20010	61.32	63.44	65.23	67.51	69.26	70.30

Table 4.27: Apparent molar volume (φ_v) of L-glutamine in aqueous solution of 0.05 mol.kg^{-1} vitamin B6 as a function of molality (m/mol.kg^{-1}) at different temperature

L-glutamine + aqueous solution of 0.05 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	$\varphi_v \times 10^6/m^3 \cdot mol^{-1}$					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.04966	90.70	91.48	92.06	92.51	92.89	93.33
0.09911	90.89	91.60	92.13	92.56	92.98	93.55
0.15069	91.03	91.71	92.24	92.71	93.11	93.71
0.20069	91.24	91.85	92.36	92.83	93.27	93.83
0.25012	91.49	92.08	92.62	93.09	93.49	94.00
0.30039	91.65	92.22	92.76	93.19	93.60	94.09
0.35022	91.84	92.45	92.93	93.41	93.81	94.17
0.40119	91.95	92.46	93.00	93.54	93.91	94.27
0.45085	92.09	92.72	93.29	93.67	94.03	94.47
0.50155	92.20	92.85	93.38	93.84	94.25	94.63

Table 4.28: Apparent molar volume (φ_v) of L-glutamine in aqueous solution of 0.20 mol.kg^{-1} vitamin B6 as a function of molality (m/mol.kg^{-1}) at different temperature

L-glutamine + aqueous solution of 0.20 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	$\varphi_v \times 10^6/m^3 \cdot mol^{-1}$					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.05055	83.02	83.96	84.78	85.68	86.87	87.74
0.09988	83.38	84.39	85.23	86.18	87.30	88.35
0.14939	83.75	84.84	85.78	86.68	87.76	88.73
0.19925	84.11	85.31	86.18	87.13	88.28	89.21
0.24918	84.50	85.68	86.56	87.61	88.75	89.55
0.29948	84.89	86.17	87.05	87.91	89.19	90.06
0.34957	85.37	86.53	87.50	88.38	89.47	90.49
0.40095	85.74	86.96	87.85	88.92	90.02	90.86
0.44866	86.11	87.28	88.20	89.17	90.28	91.13
0.50099	86.54	87.73	88.68	89.73	90.69	91.56

Table 4.29: Apparent molar volume (φ_v) of L-glutamine in aqueous solution of 0.35 mol.kg^{-1} vitamin B6 as a function of molality (m/mol.kg^{-1}) at different temperature

L-glutamine + aqueous solution of 0.35 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	$\varphi_v \times 10^6/m^3.mol^{-1}$					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.04999	70.44	72.68	75.49	78.19	80.76	83.03
0.10077	72.31	74.59	77.60	80.07	82.32	84.84
0.15076	74.10	76.81	79.07	81.49	83.82	86.28
0.20075	75.88	78.78	80.93	82.87	85.18	87.62
0.25034	77.50	80.00	82.28	84.62	86.51	89.26
0.30088	79.70	81.87	83.90	85.97	87.69	90.46
0.34925	81.23	83.11	85.01	86.67	88.98	91.95
0.39956	82.63	84.50	85.94	88.13	90.45	93.16
0.44946	83.65	85.72	86.96	89.19	91.81	93.77
0.50085	84.49	86.44	87.46	90.06	92.41	94.81

Table 4.30: Apparent molar volume (φ_v) of L-glutamine in aqueous solution of 0.50 mol.kg^{-1} vitamin B6 as a function of molality (m/mol.kg^{-1}) at different temperature

L-glutamine + aqueous solution of 0.50 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	$\varphi_v \times 10^6/m^3.mol^{-1}$					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.04998	80.58	81.73	83.01	84.70	85.29	86.67
0.10045	82.16	83.00	84.18	85.65	86.87	87.92
0.14957	83.36	84.30	85.58	86.99	88.28	89.72
0.20000	84.53	85.31	86.67	88.10	89.17	90.45
0.25000	85.62	86.68	87.92	89.27	90.43	91.58
0.29887	86.68	87.73	88.85	90.19	91.21	92.08
0.34948	88.10	88.98	89.89	91.10	91.84	92.75
0.39978	89.02	89.96	90.94	92.00	92.79	93.58
0.44888	89.71	90.55	91.86	92.88	93.45	94.17
0.50097	90.61	91.52	92.78	93.80	94.62	95.56

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 Aqueous L-serine system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively

Temp (K)	$\varphi_v^0\times10^6$ ($m^3.mol^{-1}$)	$S_V\times10^6$ ($m^3.mol^{-2}.kg$)	$E_\varphi^0\times10^8$ ($m^3.mol^{-1}.K^{-1}$)	$(\delta E^0\varphi/\delta T)_p\times10^8$ ($m^3.mol^{-1}.K^{-2}$)
293.15K	60.54	0.66	9.42	-0.26
298.15K	61.06	0.46	8.10	
303.15K	61.43	0.63	6.78	
308.15K	61.67	0.53	5.46	
313.15K	61.87	0.68	4.14	
318.15K	62.16	0.52	2.82	

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 Aqueous L-asparagine system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively

Temp (K)	$\varphi_v^0\times10^6$ ($m^3.mol^{-1}$)	$S_V\times10^6$ ($m^3.mol^{-2}.kg$)	$E_\varphi^0\times10^8$ ($m^3.mol^{-1}.K^{-1}$)	$(\delta E^0\varphi/\delta T)_p\times10^8$ ($m^3.mol^{-1}.K^{-2}$)
293.15K	89.77	19.82	13.77	-0.21
298.15K	90.35	20.54	12.70	
303.15K	91.01	20.04	11.63	
308.15K	91.58	20.38	10.56	
313.15K	92.11	19.85	9.49	
318.15K	92.49	19.72	8.42	

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 Aqueous L-glutamine system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively

Temp (K)	$\varphi_v^0\times10^6$ ($m^3.mol^{-1}$)	$S_V\times10^6$ ($m^3.mol^{-2}.kg$)	$E_\varphi^0\times10^8$ ($m^3.mol^{-1}.K^{-1}$)	$(\delta E^0\varphi/\delta T)_p\times10^8$ ($m^3.mol^{-1}.K^{-2}$)
293.15K	88.23	7.89	12.41	-0.25
298.15K	88.80	7.95	11.18	
303.15K	89.38	7.50	9.95	
308.15K	89.82	7.83	8.72	
313.15K	90.17	7.97	7.49	
318.15K	90.58	7.88	6.26	

Table 4.34: 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-serine in aqueous solution of 0.05 mol.kg^{-1} vitamin B6 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	60.80	1.70	0.25	9.75	-0.24
298.15K	61.21	1.72	0.15	8.55	
303.15K	61.68	1.43	0.25	7.36	
308.15K	61.99	1.41	0.32	6.16	
313.15K	62.22	1.46	0.36	4.97	
318.15K	62.49	1.35	0.34	3.77	

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 L-serine in aqueous solution of 0.20 mol.kg^{-1} vitamin B6 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	62.42	1.31	1.87	8.11	-0.15
298.15K	62.89	1.11	1.83	7.38	
303.15K	63.23	1.04	1.80	6.64	
308.15K	63.47	1.25	1.80	5.90	
313.15K	63.73	1.34	1.87	5.17	
318.15K	64.06	1.49	1.90	4.43	

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 L-serine in aqueous solution of 0.35 mol.kg^{-1} vitamin B6 system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectivel

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	63.27	2.75	2.72	6.98	-0.14
298.15K	63.62	2.59	2.56	6.28	
303.15K	63.94	2.67	2.51	5.59	
308.15K	64.16	2.87	2.48	4.89	
313.15K	64.36	3.18	2.49	4.19	
318.15K	64.61	3.42	2.46	3.49	

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 L-serine in aqueous solution of 0.50 mol.kg^{-1} vitamin B6 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	64.97	1.22	4.42	3.16	.18
298.15K	65.15	1.15	4.09	4.07	
303.15K	65.36	1.25	3.93	4.99	
308.15K	65.63	1.26	3.96	5.90	
313.15K	66.00	1.20	4.13	6.82	
318.15K	66.31	1.36	4.16	7.73	

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-asparagine in aqueous solution of 0.05 mol.kg^{-1} vitamin B6 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	93.97	27.81	4.19	64.40	-1.57
298.15K	97.16	25.32	6.80	56.55	
303.15K	99.58	25.02	8.57	48.70	
308.15K	101.89	22.73	10.31	40.85	
313.15K	103.80	22.20	11.69	33.00	
318.15K	105.19	23.15	12.71	25.15	

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-asparagine in aqueous solution of 0.20 mol.kg^{-1} vitamin B6 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	64.40	64.40	-7.01	22.18	-0.37
298.15K	56.55	56.55	-6.87	20.32	
303.15K	48.70	48.70	-6.84	18.46	
308.15K	40.85	40.85	-6.46	16.60	
313.15K	33.00	33.00	-5.97	14.74	
318.15K	25.15	25.15	-5.38	12.88	

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-asparagine in aqueous solution of 0.35 mol.kg^{-1} vitamin B6 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	47.73	27.52	-42.04	14.66	-0.43
298.15K	48.46	26.51	-41.89	12.51	
303.15K	49.10	26.94	-41.91	10.36	
308.15K	49.45	28.13	-42.14	8.21	
313.15K	49.74	30.05	-42.37	6.06	
318.15K	50.14	31.46	-42.34	3.91	

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-asparagine in aqueous solution of 0.50 mol.kg^{-1} vitamin B6 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	54.16	36.76	-35.62	50.60	-1.11
298.15K	56.90	34.91	-33.45	45.03	
303.15K	58.64	34.80	-32.37	39.46	
308.15K	60.45	37.20	-31.13	33.88	
313.15K	62.29	35.56	-29.82	28.31	
318.15K	63.39	35.09	-29.09	22.74	

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-glutamine in aqueous solution of 0.05 mol.kg^{-1} vitamin B6 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	90.56	3.45	2.33	12.62	-0.18
298.15K	91.28	3.12	2.49	11.74	
303.15K	91.82	3.10	2.44	10.86	
308.15K	92.28	3.11	2.46	9.99	
313.15K	92.69	3.06	2.52	9.11	
318.15K	93.27	2.66	2.69	8.24	

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-glutamine in aqueous solution of 0.20 mol.kg^{-1} vitamin B6 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	82.58	7.86	-5.68	17.36	0.17
298.15K	83.59	8.34	-5.23	18.22	
303.15K	84.43	8.57	-4.99	19.08	
308.15K	85.32	8.79	-4.52	19.94	
313.15K	86.51	8.55	-3.69	20.80	
318.15K	87.48	8.33	-3.13	21.66	

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-glutamine in aqueous solution of 0.35 mol.kg^{-1} vitamin B6 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	69.28	32.38	-18.94	59.35	-0.60
298.15K	71.93	30.95	-16.87	56.36	
303.15K	75.07	26.87	-14.32	53.37	
308.15K	77.49	26.29	-12.33	50.38	
313.15K	79.75	26.33	-10.42	47.39	
318.15K	82.26	26.36	-8.32	44.39	

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-glutamine in aqueous solution of 0.50 mol.kg^{-1} vitamin B6 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	79.93	22.21	-8.29	23.81	0.22
298.15K	80.93	21.99	-7.86	24.89	
303.15K	82.20	21.71	-7.18	25.98	
308.15K	83.89	20.31	-5.93	27.06	
313.15K	85.02	19.57	-5.16	28.15	
318.15K	86.43	18.26	-4.15	29.23	

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

L-serine + water						
m/mol.kg^{-1}	$\bar{V}_2\times10^6$/m^3.mol^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.049	60.63	61.14	61.49	61.75	61.95	62.22
0.0998	60.71	61.18	61.56	61.80	62.04	62.28
0.1488	60.78	61.21	61.58	61.84	62.09	62.34
0.1999	60.82	61.22	61.58	61.88	62.16	62.36
0.2496	60.86	61.28	61.64	61.94	62.23	62.42
0.2992	60.91	61.31	61.67	61.98	62.27	62.46
0.3499	60.96	61.33	61.68	61.98	62.30	62.50
0.4005	61.01	61.38	61.73	62.06	62.33	62.52
0.4505	61.06	61.42	61.76	62.08	62.39	62.55
0.5025	61.09	61.44	61.78	62.10	62.43	62.58

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

L-asparagine + water						
m/mol.kg^{-1}	$\bar{V}_2\times10^6$/m^3.mol^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.02005	91.01	91.58	92.20	92.78	93.27	93.69
0.03901	91.72	92.39	93.03	93.62	94.07	94.42
0.05919	92.37	93.06	93.70	94.25	94.72	95.09
0.07921	93.05	93.78	94.29	94.96	95.44	95.74
0.09899	93.62	94.35	94.90	95.55	95.97	96.33
0.11901	94.19	94.95	95.46	96.15	96.58	96.91
0.14079	94.76	95.54	95.98	96.76	97.10	97.44
0.16089	95.27	96.05	96.57	97.34	97.69	98.04
0.18099	95.81	96.64	97.17	97.84	98.20	98.55
0.19901	96.46	97.25	97.77	98.32	98.71	99.05

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

L-glutamine + water						
m/mol.kg^{-1}	$\bar{V}_2\times10^6$/m^3·mol^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.05029	89.40	90.00	90.64	91.03	91.34	91.72
0.10095	90.12	90.71	91.17	91.67	92.09	92.50
0.14978	90.78	91.44	92.00	92.42	92.83	93.21
0.20098	91.56	92.05	92.57	93.00	93.43	93.80
0.24947	92.24	92.83	93.34	93.76	94.25	94.60
0.29955	92.85	93.38	93.90	94.35	94.84	95.20
0.34958	93.26	93.87	94.36	94.79	95.29	95.64
0.39908	93.78	94.42	94.94	95.37	95.82	96.18
0.45099	94.30	94.96	95.40	95.85	96.30	96.63
0.50099	94.66	95.26	95.75	96.19	96.64	96.98

Table 4.49: Partial molar volume ($\bar{V}_2$) of aqueous solution of 0.05 mol.kg^{-1} vitamin B6 with L-serine as a function of molality (m/mol.kg^{-1}) at different temperature

L-serine + aqueous solution of 0.05 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	$\bar{V}_2\times10^6$/m^3·mol^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.04988	61.07	61.45	61.91	62.22	62.44	62.71
0.10034	61.20	61.64	62.04	62.33	62.58	62.81
0.14900	61.34	61.78	62.14	62.44	62.69	62.93
0.20007	61.51	61.92	62.27	62.58	62.83	63.05
0.24927	61.64	62.06	62.39	62.68	62.94	63.15
0.30069	61.76	62.21	62.49	62.79	63.06	63.27
0.35067	61.89	62.33	62.59	62.89	63.16	63.38
0.39888	61.98	62.42	62.67	62.98	63.24	63.44
0.45005	62.08	62.52	62.76	63.05	63.32	63.51
0.49988	62.21	62.62	62.87	63.16	63.43	63.61

Table 4.50: Partial molar volume ($\bar{V}_2$) of aqueous solution of 0.20 mol.kg^{-1} vitamin B6 with L-serine as a function of molality (m/mol.kg^{-1}) at different temperature

L-serine + aqueous solution of 0.20 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	$\bar{V}_2\times10^6$/m^3.mol^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.04921	62.62	63.05	63.39	63.65	63.94	64.29
0.09932	62.73	63.16	63.49	63.78	64.06	64.43
0.15099	62.84	63.26	63.56	63.88	64.17	64.56
0.19986	62.95	63.34	63.65	63.98	64.27	64.64
0.25009	63.04	63.40	63.72	64.05	64.36	64.75
0.30000	63.14	63.50	63.78	64.15	64.45	64.86
0.34982	63.23	63.57	63.86	64.23	64.54	64.97
0.39988	63.41	63.73	64.03	64.41	64.72	65.16
0.45099	63.37	63.70	63.99	64.39	64.73	65.18
0.50009	63.46	63.77	64.06	64.46	64.82	65.26

Table 4.51: Partial molar volume ($\bar{V}_2$) of aqueous solution of 0.35 mol.kg^{-1} vitamin B6 with L-serine as a function of molality (m/mol.kg^{-1}) at different temperature

L-serine + aqueous solution of 0.35 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	$\bar{V}_2\times10^6$/m^3.mol^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.05004	63.70	63.98	64.34	64.60	64.85	65.13
0.09999	63.93	64.27	64.62	64.85	65.15	65.49
0.14911	64.18	64.50	64.84	65.11	65.42	65.76
0.20056	64.41	64.72	65.05	65.34	65.68	66.02
0.25005	64.60	64.90	65.23	65.57	65.90	66.26
0.30029	64.80	65.07	65.43	65.77	66.13	66.53
0.34998	65.02	65.26	65.65	65.98	66.36	66.77
0.39998	65.19	65.41	65.80	66.15	66.57	66.98
0.45012	65.39	65.61	65.99	66.36	66.79	67.23
0.50005	65.54	65.79	66.18	66.54	67.04	67.47

Table 4.52: Partial molar volume ($\bar{V}_2$) of aqueous solution of 0.50 mol.kg^{-1} vitamin B6 with L-serine as a function of molality (m/mol.kg^{-1}) at different temperature

L-serine + aqueous solution of 0.50 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	$\bar{V}_2\times10^6$/m^3·mol^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.05039	65.15	65.35	65.59	65.87	66.17	66.50
0.10005	65.29	65.43	65.65	65.92	66.28	66.63
0.15003	65.39	65.54	65.75	66.02	66.37	66.75
0.19996	65.47	65.60	65.84	66.11	66.52	66.90
0.24999	65.56	65.69	65.96	66.26	66.61	67.03
0.30016	65.64	65.82	66.10	66.38	66.66	67.14
0.35003	65.72	65.87	66.16	66.45	66.79	67.19
0.40014	65.82	65.95	66.23	66.51	66.85	67.24
0.45021	65.92	66.04	66.31	66.58	66.88	67.33
0.50019	66.00	66.11	66.40	66.68	66.99	67.45

Table 4.53: Partial molar volume ($\bar{V}_2$) of aqueous solution of 0.05 mol.kg^{-1} vitamin B6 with L-asparagine as a function of molality (m/mol.kg^{-1}) at different temperature

L-asparagine + aqueous solution of 0.05 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	$\bar{V}_2\times10^6$/m^3·mol^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.01968	95.47	98.46	101.04	103.37	105.00	106.64
0.04075	96.70	99.55	102.32	104.36	105.94	107.62
0.06088	97.54	100.42	102.77	104.87	106.90	108.27
0.08072	98.81	101.74	103.59	105.47	107.68	109.01
0.10069	99.74	102.45	104.38	106.25	108.20	109.88
0.12038	100.50	103.38	105.52	107.02	108.78	110.14
0.14027	101.32	103.71	106.02	107.36	109.55	110.86
0.16091	102.02	104.25	106.63	108.17	110.16	111.69
0.18079	102.32	104.86	107.08	108.96	110.54	112.17
0.20041	102.97	105.38	107.95	109.63	111.11	113.19

Table 4.54: Partial molar volume ($\bar{V}_2$) of aqueous solution of 0.20 mol.kg^{-1} vitamin B6 with L-asparagine as a function of molality (m/mol.kg^{-1}) at different temperature

L-asparagine + aqueous solution of 0.20 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	$\bar{V}_2\times10^6$/m^3.mol^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.01968	86.17	86.84	87.46	88.37	89.30	90.30
0.04085	88.30	89.02	89.69	90.52	91.38	92.36
0.06038	90.08	90.83	91.42	92.28	93.14	94.04
0.07912	91.70	92.33	93.11	93.85	94.62	95.50
0.10019	93.46	94.12	94.77	95.56	96.30	97.16
0.12038	94.96	95.72	96.27	97.07	97.75	98.62
0.13927	96.51	97.16	97.82	98.59	99.19	100.03
0.16091	98.15	98.88	99.46	100.10	100.74	101.66
0.18079	99.71	100.35	100.97	101.66	102.17	102.96
0.20041	101.05	101.65	102.20	102.85	103.45	104.40

Table 4.55: Partial molar volume ($\bar{V}_2$) of aqueous solution of 0.35 mol.kg^{-1} vitamin B6 with L-asparagine as a function of molality (m/mol.kg^{-1}) at different temperature

L-asparagine + aqueous solution of 0.35 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	$\bar{V}_2\times10^6$/m^3.mol^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.02003	49.43	49.99	50.71	51.16	51.58	52.03
0.04004	50.46	51.15	51.85	52.23	52.76	53.36
0.05971	51.43	52.06	52.74	53.22	53.78	54.38
0.08027	52.28	52.89	53.54	54.09	54.72	55.31
0.10011	53.09	53.68	54.33	55.00	55.58	56.25
0.12028	53.94	54.45	55.18	55.83	56.49	57.26
0.14004	54.67	55.11	55.90	56.52	57.26	58.05
0.16011	55.41	55.79	56.59	57.26	58.09	58.89
0.18019	56.19	56.58	57.33	58.05	58.92	59.76
0.20041	56.93	57.39	58.17	58.88	59.89	60.74

Table 4.56: Partial molar volume ($\bar{V}_2$) of aqueous solution of 0.50 mol.kg^{-1} vitamin B6 with L-asparagine as a function of molality (m/mol.kg^{-1}) at different temperature

L-asparagine + aqueous solution of 0.50 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	$\bar{V}_2\times10^6$/m^3.mol^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.02055	56.39	58.74	60.44	62.63	64.47	65.57
0.04099	57.81	60.23	62.03	64.02	65.80	66.83
0.05992	59.03	61.60	63.26	65.28	66.94	67.95
0.07902	60.22	63.09	64.75	66.69	68.39	69.33
0.09915	61.45	63.98	65.79	68.03	69.24	70.32
0.11908	62.58	65.13	66.82	69.18	70.34	71.41
0.13888	63.48	66.00	67.68	70.33	71.40	72.44
0.16025	64.50	66.65	68.46	71.05	72.20	73.23
0.18065	65.48	67.68	69.23	71.63	73.25	74.07
0.20010	66.29	68.22	70.00	72.58	74.06	75.04

Table 4.57: Partial molar volume ($\bar{V}_2$) of aqueous solution of 0.05 mol.kg^{-1} vitamin B6 with L-glutamine as a function of molality (m/mol.kg^{-1}) at different temperature

L-glutamine + aqueous solution of 0.05 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	$\bar{V}_2\times10^6$/m^3.mol^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.04966	91.06	91.81	92.38	92.83	93.21	93.62
0.09911	91.41	92.06	92.59	93.02	93.43	93.95
0.15069	91.67	92.28	92.80	93.28	93.67	94.20
0.20069	91.97	92.50	93.01	93.48	93.92	94.40
0.25012	92.31	92.82	93.35	93.82	94.21	94.63
0.30039	92.56	93.02	93.55	93.99	94.39	94.79
0.35022	92.81	93.31	93.79	94.27	94.66	94.92
0.40119	92.99	93.39	93.92	94.46	94.82	95.08
0.45085	93.19	93.71	94.26	94.65	95.00	95.32
0.50155	93.37	93.88	94.41	94.87	95.27	95.53

Table 4.58: Partial molar volume ($\bar{V}_2$) of aqueous solution of 0.20 mol.kg^{-1} vitamin B6 with L-glutamine as a function of molality (m/mol.kg^{-1}) at different temperature

L-glutamine + aqueous solution of 0.20 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	$\bar{V}_2\times10^6$/m^3·mol^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.05055	83.86	84.85	85.70	86.62	87.79	88.63
0.09988	86.73	87.71	88.50	89.24	90.27	91.13
0.14939	87.85	88.90	89.78	90.42	91.40	92.13
0.19925	88.85	89.99	90.80	91.45	92.48	93.14
0.24918	89.80	90.92	91.73	92.44	93.45	93.94
0.29948	90.70	91.91	92.72	93.20	94.34	94.87
0.34957	91.65	92.73	93.62	94.10	95.04	95.69
0.40095	92.46	93.60	94.41	95.05	95.98	96.42
0.44866	93.21	94.31	95.13	95.66	96.59	97.02
0.50099	94.05	95.16	96.00	96.58	97.35	97.78

Table 4.59: Partial molar volume ($\bar{V}_2$) of aqueous solution of 0.35 mol.kg^{-1} vitamin B6 with L-glutamine as a function of molality (m/mol.kg^{-1}) at different temperature

L-glutamine + aqueous solution of 0.35 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	$\bar{V}_2\times10^6$/m^3·mol^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.04999	73.90	76.00	78.39	81.01	83.56	85.85
0.10077	75.68	79.31	81.72	84.07	86.30	88.84
0.15076	78.22	82.58	84.11	86.38	88.69	91.17
0.20075	80.64	85.45	86.74	88.51	90.79	93.27
0.25034	82.81	87.45	88.76	90.92	92.78	95.57
0.30088	85.52	90.03	91.01	92.88	94.56	97.38
0.34925	87.50	91.90	92.67	94.11	96.38	99.41
0.39956	89.34	93.90	94.14	96.09	98.37	101.14
0.44946	90.77	95.69	95.65	97.63	100.20	102.23
0.50085	92.00	96.97	96.64	98.97	101.27	103.74

Table 4.60: Partial molar volume ($\bar{V}_2$) of aqueous solution of 0.50mol.kg^{-1} vitamin B6 with L-glutamine as a function of molality (m/mol.kg^{-1}) at different temperature

L-glutamine + aqueous solution of 0.50 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	$\bar{V}_2\times10^6$/m^3.mol^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.04998	82.95	84.08	85.32	86.87	87.40	88.63
0.10045	85.52	86.33	87.46	88.72	89.85	90.70
0.14957	87.47	88.36	89.59	90.73	91.92	93.12
0.20000	89.27	90.01	91.30	92.43	93.38	94.39
0.25000	90.92	91.93	93.09	94.11	95.13	95.97
0.29887	92.48	93.46	94.50	95.48	96.35	96.88
0.34948	94.38	95.19	96.01	96.83	97.40	97.94
0.39978	95.73	96.60	97.48	98.12	98.74	99.14
0.44888	96.82	97.59	98.79	99.36	99.76	100.06
0.50097	98.12	98.95	100.11	100.65	101.28	101.79

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

L-serine + water						
m/mol.kg^{-1}	Sound velocity, u/m.s^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1483.61	1497.40	1509.61	1520.32	1529.40	1536.98
0.04912	1485.87	1499.63	1511.82	1522.37	1531.59	1539.10
0.09988	1489.44	1503.19	1515.29	1525.77	1534.66	1542.09
0.14903	1492.32	1506.05	1518.09	1528.48	1537.28	1544.63
0.19989	1495.39	1508.99	1520.97	1531.27	1540.01	1547.29
0.24978	1498.46	1512.02	1523.89	1534.11	1542.77	1549.99
0.29934	1501.49	1514.95	1526.74	1536.88	1545.48	1552.64
0.35056	1504.48	1517.88	1529.59	1539.72	1548.25	1555.37
0.40053	1507.55	1520.89	1532.52	1542.55	1550.95	1557.98
0.44999	1510.67	1523.86	1535.39	1545.36	1553.70	1560.66
0.50195	1513.88	1526.96	1538.39	1548.22	1556.55	1563.40

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

L-asparagine + water						
m/mol.kg^{-1}	Sound velocity, u/m.s^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1483.61	1497.40	1509.61	1520.32	1529.40	1536.98
0.02005	1484.74	1498.42	1510.53	1521.10	1530.09	1537.60
0.03901	1485.90	1499.50	1511.49	1522.00	1530.91	1538.34
0.05919	1487.21	1500.73	1512.68	1523.05	1531.88	1539.22
0.0791	1488.62	1501.95	1513.81	1524.14	1532.92	1540.12
0.0978	1490.05	1503.42	1515.16	1525.35	1534.00	1541.10
0.1158	1491.65	1504.89	1516.57	1526.69	1535.15	1542.09
0.14079	1493.45	1506.58	1518.11	1527.98	1536.61	1543.47
0.16089	1495.23	1508.28	1519.76	1529.60	1537.89	1544.89
0.18099	1497.13	1509.94	1521.47	1531.14	1539.18	1546.05
0.1989	1498.99	1511.59	1522.95	1532.72	1540.75	1547.62

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

L-glutamine + water						
m/mol.kg^{-1}	Sound velocity, u/m.s^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1483.61	1497.40	1509.61	1520.32	1529.40	1536.98
0.05029	1487.68	1501.37	1513.50	1524.14	1533.11	1540.59
0.10095	1491.86	1505.46	1517.46	1528.02	1536.88	1544.28
0.14978	1495.59	1509.08	1521.00	1531.44	1540.19	1547.51
0.20098	1500.12	1513.47	1525.22	1535.52	1544.13	1551.34
0.24947	1504.11	1517.33	1528.91	1539.13	1547.66	1554.75
0.29955	1508.32	1521.35	1532.85	1542.87	1551.26	1558.19
0.34958	1512.59	1525.63	1536.86	1546.75	1554.99	1561.77
0.39908	1516.91	1529.67	1540.91	1550.56	1558.65	1565.19
0.45099	1521.36	1534.00	1544.99	1554.58	1562.47	1568.80
0.50099	1526.04	1538.45	1549.33	1558.60	1566.40	1572.51

Table 4.64: Sound velocity (u) of L-serine in aqueous solution of 0.05 mol.kg^{-1} vitamin B6 as a function of molality at different temperature

L-serine + aqueous solution of 0.05 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	Sound velocity, u/m.s^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1487.48	1500.97	1513.2	1523.71	1532.53	1539.89
0.04988	1490.72	1504.11	1516.27	1526.69	1535.40	1542.63
0.10034	1493.91	1507.23	1519.32	1529.61	1538.18	1545.35
0.14900	1496.97	1510.25	1522.16	1532.33	1540.85	1548.00
0.20007	1499.99	1513.20	1525.09	1535.18	1543.56	1550.66
0.24927	1503.04	1516.22	1527.89	1537.97	1546.33	1553.34
0.30069	1505.99	1519.04	1530.68	1540.59	1548.89	1555.86
0.35067	1509.15	1522.03	1533.47	1543.31	1551.64	1558.55
0.39888	1511.68	1524.52	1535.88	1545.71	1553.81	1560.70
0.45005	1514.63	1527.36	1538.87	1548.58	1556.78	1563.47
0.49988	1517.49	1530.40	1541.52	1551.26	1559.40	1565.83

Table 4.65: Sound velocity (u) of L-serine in aqueous solution of 0.20 mol.kg^{-1} vitamin B6 as a function of molality at different temperature

L-serine + aqueous solution of 0.20 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	Sound velocity, u/m.s^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1500.61	1513.38	1524.95	1534.67	1542.88	1549.68
0.04921	1503.55	1516.26	1527.72	1537.37	1545.52	1552.25
0.09932	1506.52	1519.19	1530.51	1540.07	1548.14	1554.82
0.15099	1509.57	1522.21	1533.39	1542.86	1550.90	1557.50
0.19986	1512.50	1525.02	1536.09	1545.52	1553.45	1560.00
0.25009	1515.40	1527.90	1538.79	1548.12	1555.99	1562.46
0.30000	1518.28	1530.68	1541.48	1550.75	1558.55	1564.98
0.34982	1521.16	1533.39	1544.09	1553.38	1561.09	1567.43
0.39888	1523.89	1536.09	1546.81	1555.97	1563.66	1569.97
0.45099	1526.94	1539.09	1549.69	1558.69	1566.37	1572.63
0.50009	1529.67	1541.72	1552.23	1561.21	1568.73	1574.96

Table 4.66: Sound velocity (u) of L-serine in aqueous solution of 0.35 mol.kg^{-1} vitamin B6 as a function of molality at different temperature

L-serine + aqueous solution of 0.35 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	Sound velocity, u/m.s^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1513.5	1525.72	1536.34	1545.42	1553.06	1559.32
0.05004	1515.91	1528.06	1538.61	1547.62	1555.18	1561.38
0.09999	1518.45	1530.52	1540.99	1549.94	1557.46	1563.59
0.14911	1521.08	1533.09	1543.47	1552.35	1559.87	1565.86
0.20056	1523.85	1535.85	1546.16	1555.03	1562.43	1568.34
0.25005	1526.65	1538.54	1548.78	1557.65	1564.99	1570.85
0.30029	1529.55	1541.48	1551.74	1560.45	1567.65	1573.39
0.34998	1532.61	1544.38	1554.66	1563.09	1570.26	1575.99
0.39998	1535.74	1547.45	1557.52	1565.99	1573.04	1578.75
0.45012	1538.99	1550.59	1560.63	1568.99	1575.97	1581.80
0.50005	1542.46	1554.02	1563.97	1572.42	1579.29	1584.85

Table 4.67: Sound velocity (u) of L-serine in aqueous solution of 0.50 mol.kg^{-1} vitamin B6 as a function of molality at different temperature

L-serine + aqueous solution of 0.50 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	Sound velocity, u/m.s^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.0000	1524.79	1536.31	1546.29	1554.80	1561.89	1567.41
0.05039	1527.61	1539.07	1548.99	1557.45	1564.45	1569.89
0.10005	1530.36	1541.72	1551.59	1559.99	1566.91	1572.28
0.15003	1533.12	1544.40	1554.12	1562.44	1569.35	1574.69
0.19996	1535.78	1546.99	1556.65	1564.86	1571.71	1577.00
0.24999	1538.47	1549.55	1559.15	1567.30	1574.14	1579.32
0.30016	1541.18	1552.18	1561.76	1569.81	1576.51	1581.61
0.35003	1543.82	1554.77	1564.23	1572.22	1578.85	1584.00
0.40014	1546.65	1557.58	1567.00	1574.79	1581.34	1586.33
0.45021	1549.16	1559.94	1569.23	1577.09	1583.62	1588.61
0.50019	1552.01	1562.53	1571.95	1579.74	1586.15	1591.10

Table 4.68: Sound velocity (u) of L-asparagine in aqueous solution of 0.05 $mol.kg^{-1}$ vitamin B6 as a function of molality at different temperature

L-asparagine + aqueous solution of 0.05 $mol.kg^{-1}$ vitamin B6						
$m/mol.kg^{-1}$	Sound velocity, $u/m.s^{-1}$					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1487.48	1500.97	1513.20	1523.71	1532.53	1539.89
0.01968	1488.91	1502.41	1514.66	1525.20	1534.04	1541.42
0.04075	1490.48	1503.98	1516.27	1526.83	1535.69	1543.09
0.06088	1491.99	1505.50	1517.81	1528.40	1537.30	1544.70
0.08072	1493.54	1507.06	1519.37	1529.97	1538.91	1546.32
0.10069	1495.11	1508.62	1520.96	1531.59	1540.54	1547.99
0.12038	1496.67	1510.20	1522.59	1533.21	1542.16	1549.60
0.14027	1498.28	1511.77	1524.21	1534.84	1543.86	1551.31
0.16091	1499.96	1513.45	1525.92	1536.59	1545.62	1553.11
0.18079	1501.55	1515.09	1527.57	1538.31	1547.31	1554.82
0.20041	1503.19	1516.73	1529.29	1540.03	1549.04	1556.63

Table 4.69: Sound velocity (u) of L-asparagine in aqueous solution of 0.20 $mol.kg^{-1}$ vitamin B6 as a function of molality at different temperature

L-asparagine + aqueous solution of 0.20 $mol.kg^{-1}$ vitamin B6						
$m/mol.kg^{-1}$	Sound velocity, $u/m.s^{-1}$					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1500.61	1513.38	1524.95	1534.67	1542.88	1549.68
0.01968	1502.27	1514.90	1526.28	1535.82	1543.87	1550.55
0.04085	1503.99	1516.43	1527.67	1537.02	1544.89	1551.46
0.06038	1505.52	1517.83	1528.94	1538.14	1545.85	1552.26
0.07912	1506.97	1519.15	1530.09	1539.11	1546.71	1553.04
0.10019	1508.58	1520.65	1531.40	1540.26	1547.63	1553.81
0.12038	1510.05	1522.00	1532.50	1541.33	1548.49	1554.57
0.13927	1511.53	1523.24	1533.61	1542.24	1549.36	1555.31
0.16091	1512.87	1524.38	1534.59	1543.18	1550.21	1556.00
0.18079	1514.21	1525.69	1535.75	1544.29	1551.07	1556.72
0.20041	1515.59	1526.97	1536.89	1545.22	1551.77	1557.38

Table 4.70: Sound velocity (u) of L-asparagine in aqueous solution of 0.35 mol.kg^{-1} vitamin B6 as a function of molality at different temperature

L-asparagine + aqueous solution of 0.35 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	Sound velocity, u/m.s^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1513.50	1525.72	1536.34	1545.42	1553.06	1559.32
0.02003	1515.91	1528.06	1538.61	1547.62	1555.18	1561.38
0.04004	1518.45	1530.52	1540.99	1549.94	1557.46	1563.59
0.05971	1521.08	1533.09	1543.47	1552.35	1559.87	1565.86
0.08027	1523.85	1535.85	1546.16	1555.03	1562.43	1568.34
0.10011	1526.65	1538.54	1548.78	1557.65	1564.99	1570.85
0.12028	1529.55	1541.48	1551.74	1560.45	1567.65	1573.39
0.14004	1532.61	1544.38	1554.66	1563.09	1570.26	1575.99
0.16011	1535.74	1547.45	1557.52	1565.99	1573.04	1578.75
0.18019	1538.99	1550.59	1560.63	1568.99	1575.97	1581.80
0.20041	1542.46	1554.02	1563.97	1572.42	1579.29	1584.85

Table 4.71: Sound velocity (u) of L-asparagine in aqueous solution of 0.50 mol.kg^{-1} vitamin B6 as a function of molality at different temperature

L-asparagine + aqueous solution of 0.50 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	Sound velocity, u/m.s^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1524.79	1536.31	1546.29	1554.80	1561.89	1567.41
0.02089	1526.99	1538.45	1548.38	1556.88	1563.97	1569.49
0.04159	1529.15	1540.56	1550.44	1558.92	1566.01	1571.52
0.06075	1531.14	1542.49	1552.36	1560.79	1567.88	1573.39
0.07962	1533.15	1544.46	1554.29	1562.69	1569.79	1575.29
0.09995	1535.25	1546.47	1556.29	1564.71	1571.78	1577.28
0.11968	1537.31	1548.48	1558.24	1566.65	1573.69	1579.19
0.13908	1539.40	1550.54	1560.13	1568.57	1575.62	1581.09
0.16065	1541.52	1552.61	1562.14	1570.58	1577.58	1583.07
0.18075	1543.55	1554.53	1564.02	1572.46	1579.55	1584.99
0.20010	1545.62	1556.22	1565.83	1574.33	1581.43	1586.86

Table 4.72: Sound velocity (u) of L-glutamine in aqueous solution of 0.05 mol.kg^{-1} vitamin B6 as a function of molality at different temperature

L-glutamine + aqueous solution of 0.05 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	Sound velocity, u/m.s^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1487.48	1500.97	1513.20	1523.71	1532.53	1539.89
0.04966	1491.66	1505.07	1517.17	1527.41	1536.09	1543.31
0.09911	1495.76	1508.99	1520.93	1530.99	1539.56	1546.68
0.15069	1500.02	1513.20	1524.92	1534.88	1543.32	1550.34
0.20069	1504.08	1517.13	1528.67	1538.52	1546.80	1553.73
0.25012	1508.38	1521.38	1532.76	1542.41	1550.63	1557.44
0.30039	1512.96	1525.70	1536.84	1546.42	1554.49	1561.16
0.35022	1516.86	1529.57	1540.63	1550.12	1558.12	1564.74
0.40119	1521.55	1533.92	1544.81	1554.18	1562.00	1568.44
0.45085	1525.33	1537.86	1548.26	1557.37	1564.97	1571.46
0.50155	1530.63	1542.58	1552.94	1561.79	1569.27	1575.41

Table 4.73: Sound velocity (u) of L-glutamine in aqueous solution of 0.20 mol.kg^{-1} vitamin B6 as a function of molality at different temperature

L-glutamine + aqueous solution of 0.20 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	Sound velocity, u/m.s^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1500.61	1513.38	1524.95	1534.67	1542.88	1549.68
0.05055	1505.20	1517.79	1529.24	1538.88	1546.99	1553.68
0.09988	1509.55	1522.01	1533.36	1542.99	1550.96	1557.48
0.14939	1514.00	1526.31	1537.54	1547.03	1554.95	1561.39
0.19925	1518.20	1530.45	1541.62	1551.19	1559.04	1565.03
0.24818	1522.65	1534.55	1545.55	1555.00	1562.65	1568.94
0.29948	1526.99	1538.67	1549.58	1559.00	1566.53	1572.39
0.34957	1530.85	1542.84	1553.69	1563.00	1570.38	1576.20
0.40095	1535.62	1546.91	1557.68	1567.13	1574.07	1579.79
0.44866	1539.75	1551.09	1561.53	1570.82	1577.72	1583.68
0.50099	1544.19	1555.53	1566.12	1575.34	1582.19	1587.73

Table 4.74: Sound velocity (u) of L-glutamine in aqueous solution of 0.35 mol.kg^{-1} vitamin B6 as a function of molality at different temperature

L-glutamine + aqueous solution of 0.35 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	Sound velocity, u/m.s^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1513.50	1525.72	1536.34	1545.42	1553.06	1559.32
0.04999	1518.18	1530.17	1540.65	1549.47	1556.95	1562.99
0.10077	1522.86	1534.64	1545.01	1553.69	1560.94	1566.84
0.15076	1527.53	1539.16	1549.09	1557.67	1564.84	1570.47
0.20075	1532.19	1543.77	1553.25	1561.63	1568.61	1574.16
0.25034	1536.62	1548.15	1556.99	1565.56	1572.14	1577.39
0.30088	1541.41	1552.56	1561.06	1569.46	1576.07	1581.39
0.34925	1545.63	1556.97	1564.99	1572.88	1579.16	1584.54
0.39956	1550.37	1561.14	1569.18	1577.14	1584.11	1589.00
0.44946	1555.00	1565.77	1573.79	1581.62	1588.24	1593.14
0.50085	1558.87	1569.42	1577.52	1585.19	1592.54	1597.13

Table 4.75: Sound velocity (u) and relative sound velocity (u-u$_0$) of L-glutamine in aqueous solution of 0.50 mol.kg^{-1} vitamin B6 as a function of molality at different temperature

L-glutamine + aqueous solution of 0.50 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	Sound velocity, u/m.s^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1524.79	1536.31	1546.29	1554.80	1561.89	1567.41
0.04998	1530.80	1541.83	1551.49	1559.59	1566.24	1571.46
0.10045	1535.97	1546.85	1556.29	1563.95	1570.13	1574.91
0.14957	1540.80	1551.13	1560.42	1567.69	1573.61	1578.06
0.20000	1545.19	1555.27	1563.78	1570.85	1576.88	1581.16
0.25000	1549.15	1558.80	1567.12	1574.04	1579.14	1583.35
0.29887	1553.15	1562.30	1570.12	1576.14	1581.14	1585.00
0.34948	1556.81	1565.10	1572.93	1578.85	1583.66	1587.32
0.39978	1558.81	1567.31	1574.96	1580.46	1585.46	1588.88
0.44888	1561.59	1569.30	1576.41	1582.32	1586.93	1590.11
0.50097	1563.96	1572.39	1578.45	1583.96	1588.17	1591.16

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

L-serine + serine						
$m/mol.kg^{-1}$	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	4.55	4.47	4.41	4.35	4.31	4.27
0.04912	4.53	4.45	4.38	4.33	4.29	4.25
0.09988	4.49	4.42	4.35	4.30	4.26	4.23
0.14903	4.47	4.39	4.33	4.28	4.24	4.20
0.19989	4.44	4.37	4.30	4.25	4.21	4.18
0.24978	4.41	4.34	4.28	4.23	4.19	4.16
0.29934	4.39	4.31	4.25	4.20	4.17	4.14
0.35056	4.36	4.29	4.23	4.18	4.14	4.11
0.40053	4.33	4.26	4.20	4.16	4.12	4.09
0.44999	4.31	4.24	4.18	4.13	4.10	4.07
0.50195	4.28	4.21	4.15	4.11	4.07	4.05

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

L-asparagine + water						
$m/mol.kg^{-1}$	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	4.55	4.47	4.41	4.35	4.31	4.27
0.02005	4.54	4.46	4.40	4.34	4.30	4.27
0.03901	4.53	4.45	4.39	4.33	4.29	4.26
0.05919	4.51	4.44	4.37	4.32	4.28	4.25
0.07921	4.50	4.42	4.36	4.31	4.27	4.24
0.09899	4.49	4.41	4.35	4.30	4.26	4.23
0.11901	4.47	4.40	4.34	4.29	4.25	4.22
0.14079	4.45	4.38	4.32	4.27	4.23	4.21
0.16089	4.44	4.37	4.31	4.26	4.22	4.19
0.18099	4.42	4.35	4.30	4.25	4.21	4.18
0.19901	4.41	4.34	4.28	4.24	4.20	4.17

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

L-glutamine + water						
$m/mol.kg^{-1}$	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	4.55	4.47	4.41	4.35	4.31	4.27
0.05029	4.51	4.44	4.37	4.32	4.27	4.24
0.10095	4.47	4.40	4.34	4.28	4.24	4.21
0.14978	4.44	4.37	4.30	4.25	4.21	4.18
0.20098	4.40	4.33	4.27	4.22	4.18	4.15
0.24947	4.37	4.30	4.24	4.19	4.15	4.12
0.29955	4.33	4.26	4.21	4.16	4.12	4.09
0.34958	4.30	4.23	4.17	4.13	4.09	4.07
0.39908	4.26	4.20	4.14	4.10	4.06	4.04
0.45099	4.23	4.16	4.11	4.07	4.03	4.01
0.50099	4.19	4.13	4.08	4.04	4.01	3.98

Table 4.79: Adiabatic compressibility ($\beta_s \times 10^{10}/Pa^{-1}$) of L-serine in aqueous solution of 0.05 $mol.kg^{-1}$ vitamin B6 as a function of molality ($m/mol.kg^{-1}$) at different temperature

L-serine + aqueous solution of 0.05 $mol.kg^{-1}$ vitamin B6						
$m/mol.kg^{-1}$	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	4.5	4.44	4.34	4.32	4.27	4.24
0.04988	4.48	4.41	4.35	4.29	4.25	4.22
0.10034	4.45	4.38	4.32	4.27	4.23	4.20
0.14900	4.43	4.36	4.29	4.24	4.20	4.17
0.20007	4.40	4.33	4.27	4.22	4.18	4.15
0.24927	4.37	4.30	4.24	4.20	4.16	4.13
0.30069	4.35	4.28	4.22	4.17	4.14	4.11
0.35067	4.32	4.25	4.20	4.15	4.11	4.08
0.39888	4.30	4.23	4.17	4.13	4.09	4.07
0.45005	4.27	4.21	4.15	4.11	4.07	4.04
0.49988	4.25	4.18	4.13	4.08	4.05	4.02

Table 4.80: Adiabatic compressibility ($\beta_s \times 10^{10}/Pa^{-1}$) of L-serine in aqueous solution of 0.20 $mol.kg^{-1}$ vitamin B6 as a function of molality ($m/mol.kg^{-1}$) at different temperature

L-serine + aqueous solution of 0.20 $mol.kg^{-1}$ vitamin B6						
$m/mol.kg^{-1}$	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	4.39	4.32	4.26	4.22	4.18	4.15
0.04921	4.37	4.30	4.24	4.20	4.16	4.13
0.09932	4.34	4.28	4.22	4.18	4.14	4.11
0.15099	4.32	4.25	4.20	4.15	4.12	4.09
0.19986	4.29	4.23	4.17	4.13	4.10	4.07
0.25009	4.27	4.20	4.15	4.11	4.07	4.05
0.30000	4.24	4.18	4.13	4.09	4.05	4.03
0.34982	4.22	4.16	4.11	4.06	4.03	4.01
0.39988	4.20	4.13	4.08	4.04	4.01	3.99
0.45099	4.17	4.11	4.06	4.02	3.99	3.97
0.50009	4.15	4.09	4.04	4.00	3.97	3.95

Table 4.81: Adiabatic compressibility ($\beta_s \times 10^{10}/Pa^{-1}$) of L-serine in aqueous solution of 0.35 $mol.kg^{-1}$ vitamin B6 as a function of molality ($m/mol.kg^{-1}$) at different temperature

L-serine + aqueous solution of 0.35 $mol.kg^{-1}$ vitamin B6						
$m/mol.kg^{-1}$	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	4.29	4.22	4.17	4.13	4.10	4.07
0.05004	4.26	4.20	4.15	4.11	4.08	4.05
0.09999	4.24	4.18	4.13	4.09	4.06	4.03
0.14911	4.22	4.16	4.11	4.07	4.04	4.02
0.20056	4.19	4.14	4.09	4.05	4.02	4.00
0.25005	4.17	4.11	4.07	4.03	4.00	3.98
0.30029	4.15	4.09	4.04	4.00	3.98	3.96
0.34998	4.12	4.07	4.02	3.98	3.96	3.94
0.39998	4.10	4.04	4.00	3.96	3.93	3.91
0.45012	4.08	4.02	3.98	3.94	3.91	3.89
0.50005	4.05	4.00	3.95	3.92	3.89	3.87

Table 4.82: Adiabatic compressibility ($\beta_s \times 10^{10}/Pa^{-1}$) of L-serine in aqueous solution of 0.50 $mol.kg^{-1}$ vitamin B6 as a function of molality ($m/mol.kg^{-1}$) at different temperature

L-serine + aqueous solution of 0.50 $mol.kg^{-1}$ vitamin B6						
$m/mol.kg^{-1}$	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	4.19	4.13	4.09	4.05	4.02	4.00
0.05039	4.17	4.11	4.06	4.03	4.00	3.98
0.10005	4.14	4.09	4.04	4.01	3.98	3.96
0.15003	4.12	4.07	4.02	3.99	3.96	3.94
0.19996	4.10	4.05	4.00	3.97	3.94	3.92
0.24999	4.08	4.03	3.98	3.95	3.92	3.90
0.30016	4.06	4.00	3.96	3.93	3.90	3.89
0.35003	4.03	3.98	3.94	3.91	3.88	3.87
0.40014	4.01	3.96	3.92	3.89	3.87	3.85
0.45021	3.99	3.94	3.90	3.87	3.85	3.83
0.50019	3.97	3.92	3.88	3.85	3.83	3.81

Table 4.83: Adiabatic compressibility ($\beta_s \times 10^{10}/Pa^{-1}$) of L-asparagine in aqueous solution of 0.05 $mol.kg^{-1}$ vitamin B6 as a function of molality ($m/mol.kg^{-1}$) at different temperature

L-asparagine + aqueous solution of 0.05 $mol.kg^{-1}$ vitamin B6						
$m/mol.kg^{-1}$	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	4.51	4.44	4.37	4.32	4.28	4.25
0.01968	4.50	4.42	4.36	4.31	4.27	4.23
0.04075	4.48	4.41	4.35	4.29	4.25	4.22
0.06088	4.47	4.40	4.33	4.28	4.24	4.21
0.08072	4.46	4.38	4.32	4.27	4.23	4.20
0.10069	4.44	4.37	4.31	4.26	4.21	4.18
0.12038	4.43	4.36	4.29	4.24	4.20	4.17
0.14027	4.42	4.34	4.28	4.23	4.19	4.16
0.16091	4.40	4.33	4.27	4.22	4.18	4.15
0.18079	4.39	4.32	4.26	4.20	4.16	4.13
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-asparagine in aqueous solution of 0.20 mol.kg^{-1} vitamin B6 as a function of molality (m/mol.kg^{-1}) at different temperature

L-asparagine + aqueous solution of 0.20 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	4.40	4.33	4.27	4.22	4.18	4.16
0.01968	4.38	4.31	4.26	4.21	4.17	4.15
0.04075	4.36	4.30	4.24	4.20	4.16	4.14
0.06088	4.35	4.29	4.23	4.19	4.15	4.13
0.08072	4.34	4.27	4.22	4.18	4.14	4.12
0.10069	4.32	4.26	4.21	4.17	4.14	4.11
0.12038	4.31	4.25	4.20	4.16	4.13	4.10
0.14027	4.30	4.24	4.19	4.15	4.12	4.10
0.16091	4.29	4.23	4.18	4.14	4.11	4.09
0.18079	4.27	4.22	4.17	4.13	4.10	4.08
0.20041	4.26	4.21	4.16	4.12	4.09	4.07

Table 4.85: Adiabatic compressibility ($\beta_s \times 10^{10}/Pa^{-1}$) of L-asparagine in aqueous solution of 0.35 mol.kg^{-1} vitamin B6 as a function of molality (m/mol.kg^{-1}) at different temperature

L-asparagine + aqueous solution of 0.35 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	4.29	4.22	4.17	4.13	4.10	4.07
0.02003	4.26	4.20	4.15	4.11	4.08	4.05
0.04004	4.24	4.18	4.13	4.09	4.06	4.03
0.05971	4.22	4.16	4.11	4.07	4.04	4.02
0.08027	4.19	4.14	4.09	4.05	4.02	4.00
0.10011	4.17	4.11	4.07	4.03	4.00	3.98
0.12028	4.15	4.09	4.04	4.00	3.98	3.96
0.14004	4.12	4.07	4.02	3.98	3.96	3.94
0.16011	4.10	4.04	4.00	3.96	3.93	3.91
0.18019	4.08	4.02	3.98	3.94	3.91	3.89
0.20041	4.05	4.00	3.95	3.92	3.89	3.87

Table 4.86: Adiabatic compressibility ($\beta_s \times 10^{10}/Pa^{-1}$) of L-asparagine in aqueous solution of 0.5 $mol.kg^{-1}$ vitamin B6 as a function of molality ($m/mol.kg^{-1}$) at different temperature

L-asparagine + aqueous solution of 0.50 $mol.kg^{-1}$ vitamin B6						
$m/mol.kg^{-1}$	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	4.19	4.13	4.09	4.05	4.02	4.00
0.02055	4.17	4.11	4.07	4.03	4.00	3.98
0.04099	4.15	4.10	4.05	4.01	3.99	3.97
0.05992	4.13	4.08	4.03	4.00	3.97	3.95
0.07902	4.11	4.06	4.02	3.98	3.95	3.93
0.09915	4.10	4.04	4.00	3.97	3.94	3.92
0.11908	4.08	4.03	3.98	3.95	3.92	3.90
0.13888	4.06	4.01	3.97	3.93	3.91	3.89
0.16025	4.04	3.99	3.95	3.92	3.89	3.87
0.18065	4.03	3.98	3.94	3.90	3.88	3.86
0.20010	4.01	3.96	3.92	3.89	3.86	3.84

Table 4.87: Adiabatic compressibility ($\beta_s \times 10^{10}/Pa^{-1}$) of L-glutamine in aqueous solution of 0.05 $mol.kg^{-1}$ vitamin B6 as a function of molality ($m/mol.kg^{-1}$) at different temperature

L-glutamine + aqueous solution of 0.05 $mol.kg^{-1}$ vitamin B6						
$m/mol.kg^{-1}$	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	4.51	4.44	4.37	4.32	4.28	4.25
0.04966	4.48	4.40	4.34	4.29	4.25	4.22
0.09911	4.44	4.37	4.31	4.26	4.22	4.19
0.15069	4.40	4.33	4.27	4.22	4.18	4.16
0.20069	4.37	4.30	4.24	4.19	4.16	4.13
0.25012	4.33	4.26	4.21	4.16	4.12	4.10
0.30039	4.29	4.23	4.17	4.13	4.09	4.07
0.35022	4.26	4.20	4.14	4.10	4.07	4.04
0.40119	4.22	4.16	4.11	4.07	4.04	4.01
0.45085	4.19	4.13	4.08	4.04	4.01	3.99
0.50155	4.16	4.10	4.05	4.01	3.98	3.96

Table 4.88: Adiabatic compressibility ($\beta_s \times 10^{10}/Pa^{-1}$) of L-glutamine in aqueous solution of 0.20 $mol.kg^{-1}$ vitamin B6 as a function of molality ($m/mol.kg^{-1}$) at different temperature

L-glutamine + aqueous solution of 0.20 $mol.kg^{-1}$ vitamin B6						
$m/mol.kg^{-1}$	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	4.40	4.33	4.27	4.22	4.18	4.16
0.05055	4.36	4.29	4.23	4.19	4.15	4.12
0.09988	4.32	4.25	4.20	4.15	4.12	4.09
0.14939	4.28	4.22	4.16	4.12	4.09	4.06
0.19925	4.24	4.18	4.13	4.09	4.05	4.03
0.24918	4.21	4.15	4.10	4.05	4.02	4.00
0.29948	4.17	4.12	4.06	4.02	3.99	3.97
0.34957	4.14	4.08	4.03	3.99	3.96	3.94
0.40095	4.10	4.05	4.00	3.96	3.94	3.92
0.44866	4.07	4.02	3.97	3.93	3.91	3.89
0.50099	4.04	3.99	3.94	3.90	3.88	3.86

Table 4.89: Adiabatic compressibility ($\beta_s \times 10^{10}/Pa^{-1}$) of L-glutamine in aqueous solution of 0.35 $mol.kg^{-1}$ vitamin B6 as a function of molality ($m/mol.kg^{-1}$) at different temperature

L-glutamine + aqueous solution of 0.35 $mol.kg^{-1}$ vitamin B6						
$m/mol.kg^{-1}$	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	4.29	4.22	4.17	4.13	4.10	4.07
0.04998	4.24	4.18	4.13	4.09	4.06	4.04
0.10045	4.20	4.15	4.10	4.06	4.03	4.01
0.14957	4.16	4.11	4.06	4.03	4.00	3.98
0.20000	4.13	4.07	4.03	4.00	3.97	3.95
0.25000	4.09	4.04	4.00	3.97	3.94	3.93
0.29887	4.05	4.00	3.97	3.94	3.91	3.90
0.34948	4.02	3.97	3.94	3.91	3.89	3.87
0.39978	3.99	3.94	3.91	3.88	3.86	3.85
0.44888	3.96	3.91	3.88	3.85	3.83	3.82
0.50097	3.93	3.88	3.85	3.82	3.80	3.79

Table 4.90: Adiabatic compressibility ($\beta_s \times 10^{10}/Pa^{-1}$) of L-glutamine in aqueous solution of 0.50 $mol.kg^{-1}$ vitamin B6 as a function of molality ($m/mol.kg^{-1}$) at different temperature

L-glutamine + aqueous solution of 0.50 $mol.kg^{-1}$ vitamin B6						
$m/mol.kg^{-1}$	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	4.19	4.13	4.09	4.05	4.02	4.00
0.04998	4.14	4.09	4.05	4.01	3.99	3.97
0.10045	4.10	4.05	4.01	3.98	3.96	3.94
0.14957	4.07	4.02	3.98	3.95	3.93	3.91
0.20000	4.03	3.99	3.95	3.92	3.90	3.89
0.25000	4.00	3.96	3.92	3.90	3.88	3.87
0.29887	3.97	3.93	3.90	3.88	3.86	3.85
0.34948	3.94	3.91	3.88	3.86	3.84	3.83
0.39978	3.93	3.89	3.86	3.84	3.83	3.82
0.44888	3.90	3.87	3.85	3.83	3.81	3.80
0.50097	3.88	3.85	3.83	3.81	3.80	3.79

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

L-serine + water						
$m/mol.kg^{-1}$	$\varphi_k \times 10^{14}/m^3.mol^{-1}.Pa^{-1}$					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.04912	-2.0961	-1.9595	-1.8645	-1.6258	-1.7541	-1.6381
0.09988	-2.8351	-2.6954	-2.5426	-2.3503	-2.1969	-2.0735
0.14903	-2.8239	-2.6879	-2.5336	-2.3489	-2.1978	-2.0715
0.19989	-2.8398	-2.6728	-2.5195	-2.3389	-2.1957	-2.0757
0.24978	-2.8563	-2.6898	-2.5245	-2.3498	-2.2071	-2.0917
0.29934	-2.8581	-2.6829	-2.5159	-2.3441	-2.2070	-2.0936
0.35056	-2.8310	-2.6589	-2.4926	-2.3362	-2.1993	-2.0910
0.40053	-2.8308	-2.6574	-2.4903	-2.3302	-2.1913	-2.0804
0.44999	-2.8374	-2.6531	-2.4837	-2.3288	-2.1897	-2.0811
0.50195	-2.8335	-2.6455	-2.4748	-2.3147	-2.1836	-2.0716

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

L-asparagine + water						
m/mol.kg^{-1}	$\varphi_k \times 10^{14}$/m^3.mol^{-1}.Pa^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.02005	-2.0937	-1.6620	-1.2779	-0.8084	-0.5041	-0.2754
0.03901	-2.1980	-1.7926	-1.3662	-1.0006	-0.7044	-0.4594
0.05919	-2.2873	-1.8983	-1.5418	-1.1429	-0.8498	-0.5896
0.07921	-2.3897	-1.9218	-1.5740	-1.2192	-0.9484	-0.6511
0.09899	-2.4612	-2.0850	-1.7114	-1.3302	-1.0318	-0.7264
0.11901	-2.5720	-2.1698	-1.8146	-1.4459	-1.0964	-0.7629
0.14079	-2.6724	-2.2629	-1.8900	-1.4558	-1.2270	-0.9064
0.16089	-2.7756	-2.3697	-2.0054	-1.6028	-1.2744	-1.0373
0.18099	-2.8832	-2.4238	-2.1029	-1.6884	-1.3117	-1.0564
0.19901	-2.9861	-2.4960	-2.1441	-1.7984	-1.4440	-1.2082

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

L-glutamine + water						
m/mol.kg^{-1}	$\varphi_k \times 10^{14}$/m^3.mol^{-1}.Pa^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.05029	-3.5536	-3.2895	-3.0698	-2.9041	-2.7211	0.05029
0.10095	-3.5489	-3.2932	-3.0607	-2.8817	-2.6907	0.10095
0.14978	-3.3892	-3.1260	-2.8958	-2.7091	-2.5212	0.14978
0.20098	-3.4519	-3.1913	-2.9445	-2.7433	-2.5471	0.20098
0.24947	-3.3931	-3.1203	-2.8630	-2.6684	-2.4774	0.24947
0.29955	-3.3565	-3.0763	-2.8281	-2.6137	-2.4185	0.29955
0.34958	-3.3414	-3.0786	-2.8095	-2.5959	-2.3955	0.34958
0.39908	-3.3244	-3.0359	-2.7870	-2.5572	-2.3586	0.39908
0.45099	-3.2903	-3.0048	-2.7479	-2.5278	-2.3217	0.45099
0.50099	-3.3121	-3.0200	-2.7628	-2.5235	-2.3229	0.50099

Table 4.94: Apparent molar adiabatic compressibility (φ_k) of L-serine in aqueous solution of 0.05 mol.kg^{-1} vitamin B6 as a function of molality (m/mol.kg^{-1}) at different temperature

L-serine + aqueous solution of 0.05 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	$\varphi_k \times 10^{14}$/m^3.mol^{-1}.Pa^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.04988	-3.1623	-2.9333	-2.7493	-2.5760	-2.4048	-2.2191
0.10034	-3.0907	-2.8783	-2.7001	-2.5074	-2.3201	-2.1778
0.14900	-3.0470	-2.8522	-2.6353	-2.4394	-2.2794	-2.1640
0.20007	-2.9544	-2.7656	-2.5769	-2.3918	-2.2230	-2.1157
0.24927	-2.9284	-2.7490	-2.5309	-2.3693	-2.2210	-2.1090
0.30069	-2.8577	-2.6662	-2.4699	-2.2942	-2.1527	-2.0474
0.35067	-2.8520	-2.6461	-2.4354	-2.2661	-2.1431	-2.0384
0.39888	-2.7701	-2.5730	-2.3690	-2.2118	-2.0682	-1.9713
0.45005	-2.7325	-2.5341	-2.3639	-2.2045	-2.0850	-1.9719
0.49988	-2.6967	-2.5312	-2.3266	-2.1812	-2.0633	-1.9317

Table 4.95: Apparent molar adiabatic compressibility (φ_k) of L-serine in aqueous solution of 0.20 mol.kg^{-1} vitamin B6 as a function of molality (m/mol.kg^{-1}) at different temperature

L-serine + aqueous solution of 0.20 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	$\varphi_k \times 10^{14}$/m^3.mol^{-1}.Pa^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.04921	-2.5346	-2.3692	-2.1699	-2.0416	-1.9324	-1.8184
0.09932	-2.5054	-2.3517	-2.1390	-1.9998	-1.8822	-1.7797
0.15099	-2.4797	-2.3356	-2.1226	-1.9802	-1.8778	-1.7679
0.19986	-2.4718	-2.3092	-2.1010	-1.9694	-1.8530	-1.7492
0.25009	-2.4371	-2.2867	-2.0670	-1.9307	-1.8168	-1.7083
0.30000	-2.4080	-2.2502	-2.0432	-1.9080	-1.7951	-1.6909
0.34982	-2.3842	-2.2118	-2.0093	-1.8905	-1.7738	-1.6643
0.39888	-2.3491	-2.1856	-2.0023	-1.8735	-1.7646	-1.6596
0.45099	-2.3375	-2.1769	-1.9941	-1.8546	-1.7500	-1.6471
0.50009	-2.3081	-2.1456	-1.9660	-1.8337	-1.7180	-1.6189

Table 4.96: Apparent molar adiabatic compressibility (φ_k) of L-serine in aqueous solution of 0.35 mol.kg^{-1} vitamin B6 as a function of molality (m/mol.kg^{-1}) at different temperature

L-serine + aqueous solution of 0.35 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	$\varphi_k \times 10^{14}$/m^3.mol^{-1}.Pa^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.05004	-1.6587	-1.5215	-1.3923	-1.2828	-1.1726	-1.0881
0.09999	-1.7164	-1.5679	-1.4336	-1.3320	-1.2397	-1.1456
0.14911	-1.7695	-1.6271	-1.4869	-1.3799	-1.3078	-1.1878
0.20056	-1.7925	-1.6668	-1.5309	-1.4372	-1.3428	-1.2271
0.25005	-1.8296	-1.6916	-1.5573	-1.4706	-1.3778	-1.2677
0.30029	-1.8577	-1.7407	-1.6202	-1.5132	-1.4048	-1.2854
0.34998	-1.8998	-1.7673	-1.6567	-1.5188	-1.4148	-1.3062
0.39998	-1.9370	-1.8063	-1.6741	-1.5523	-1.4391	-1.3377
0.45012	-1.9723	-1.8355	-1.7091	-1.5819	-1.4686	-1.3872
0.50005	-2.0252	-1.8884	-1.7579	-1.6484	-1.5270	-1.4234

Table 4.97: Apparent molar adiabatic compressibility (φ_k) of L-serine in aqueous solution of 0.5 mol.kg^{-1} vitamin B6 as a function of molality (m/mol.kg^{-1}) at different temperature

L-serine + aqueous solution of 0.50 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	$\varphi_k \times 10^{14}$/m^3.mol^{-1}.Pa^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.05039	-1.8303	-1.7139	-1.6071	-1.5168	-1.3929	-1.2871
0.10005	-1.8006	-1.6683	-1.5694	-1.4758	-1.3514	-1.2496
0.15003	-1.7810	-1.6484	-1.5194	-1.4172	-1.3199	-1.2322
0.19996	-1.7411	-1.6139	-1.4896	-1.3768	-1.2759	-1.1907
0.24999	-1.7176	-1.5799	-1.4585	-1.3473	-1.2611	-1.1630
0.30016	-1.7007	-1.5612	-1.4491	-1.3354	-1.2401	-1.1363
0.35003	-1.6775	-1.5466	-1.4271	-1.3151	-1.2152	-1.1348
0.40014	-1.6791	-1.5582	-1.4439	-1.3172	-1.2154	-1.1236
0.45021	-1.6412	-1.5126	-1.3940	-1.2867	-1.1938	-1.1052
0.50019	-1.6461	-1.5000	-1.4011	-1.2935	-1.1941	-1.1072

Table 4.98: Apparent molar adiabatic compressibility (φ_k) of L-asparagine in aqueous solution of 0.05 mol.kg^{-1} vitamin B6 as a function of molality (m/mol.kg^{-1}) at different temperature

L-asparagine + aqueous solution of 0.05 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	$\varphi_k \times 10^{14}$/m^3.mol^{-1}.Pa^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.01968	-2.6530	-2.3331	-2.1250	-1.9557	-1.8490	-1.7506
0.04075	-2.6411	-2.3208	-2.1066	-1.9508	-1.8464	-1.7496
0.06088	-2.6266	-2.3014	-2.1147	-1.9553	-1.8322	-1.7442
0.08072	-2.5906	-2.2675	-2.1057	-1.9514	-1.8228	-1.7363
0.10069	-2.5698	-2.2538	-2.0908	-1.9407	-1.8229	-1.7232
0.12038	-2.5528	-2.2296	-2.0620	-1.9251	-1.8126	-1.7278
0.14027	-2.5353	-2.2359	-2.0604	-1.9330	-1.8033	-1.7219
0.16091	-2.5216	-2.2331	-2.0539	-1.9152	-1.7965	-1.7064
0.18079	-2.5237	-2.2239	-2.0515	-1.8993	-1.7976	-1.7006
0.20041	-2.5121	-2.2211	-2.0338	-1.8907	-1.7944	-1.6789

Table 4.99: Apparent molar adiabatic compressibility (φ_k) of L-asparagine in aqueous solution of 0.20 mol.kg^{-1} vitamin B6 as a function of molality (m/mol.kg^{-1}) at different temperature

L-asparagine + aqueous solution of 0.20 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	$\varphi_k \times 10^{14}$/m^3.mol^{-1}.Pa^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.01968	-4.0411	-3.4915	-2.8380	-2.2217	-1.6863	-1.2658
0.04085	-3.8404	-3.2372	-2.6721	-2.0683	-1.5239	-1.1295
0.06038	-3.6575	-3.0815	-2.5518	-1.9713	-1.4286	-1.0050
0.07912	-3.5051	-2.9525	-2.3905	-1.8099	-1.3065	-0.9127
0.10019	-3.3467	-2.8216	-2.2610	-1.6921	-1.1554	-0.7509
0.12038	-3.1876	-2.6676	-2.0802	-1.5770	-1.0280	-0.6346
0.13927	-3.0839	-2.5312	-1.9519	-1.4300	-0.9361	-0.5395
0.16091	-2.8490	-2.2822	-1.7235	-1.2581	-0.7894	-0.3780
0.18079	-2.6889	-2.1716	-1.6167	-1.1757	-0.6867	-0.2815
0.20048	-2.5730	-2.0727	-1.5323	-1.0733	-0.5576	-0.1633

Table 4.100: Apparent molar adiabatic compressibility (φ_k) of L-asparagine in aqueous solution of 0.35 mol.kg^{-1} vitamin B6 as a function of molality (m/mol.kg^{-1}) at different temperature

L-asparagine + aqueous solution of 0.35 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	$\varphi_k \times 10^{14}$/m^3.mol^{-1}.Pa^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.02003	-8.8402	-8.4357	-8.0638	-7.7527	-7.4507	-7.2224
0.04004	-8.9440	-8.5128	-8.1290	-7.8387	-7.5822	-7.3306
0.05971	-9.0428	-8.6278	-8.2304	-7.9273	-7.7216	-7.4064
0.08027	-9.0734	-8.7004	-8.3147	-8.0452	-7.7844	-7.4805
0.10011	-9.1270	-8.7249	-8.3442	-8.0926	-7.8367	-7.5475
0.12028	-9.1558	-8.8069	-8.4610	-8.1606	-7.8670	-7.5556
0.14004	-9.2422	-8.8554	-8.5346	-8.1582	-7.8759	-7.5915
0.16011	-9.2946	-8.9135	-8.5406	-8.2048	-7.9007	-7.6347
0.18019	-9.3474	-8.9524	-8.5948	-8.2464	-7.9429	-7.7265
0.20041	-9.4266	-9.0330	-8.6665	-8.3628	-8.0405	-7.7708

Table 4.101: Apparent molar adiabatic compressibility (φ_k) of L-asparagine in aqueous solution of 0.50 mol.kg^{-1} vitamin B6 as a function of molality (m/mol.kg^{-1}) at different temperature

L-asparagine + aqueous solution of 0.50 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	$\varphi_k \times 10^{14}$/m^3.mol^{-1}.Pa^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.02055	-7.2431	-6.7688	-6.4112	-6.1506	-5.9515	-5.8377
0.04099	-7.1196	-6.6531	-6.2898	-6.0388	-5.8426	-5.7228
0.05992	-7.0152	-6.5305	-6.2121	-5.9313	-5.7443	-5.6312
0.07902	-6.9198	-6.4215	-6.1023	-5.8295	-5.6451	-5.5333
0.09915	-6.8124	-6.3249	-6.0101	-5.7409	-5.5789	-5.4589
0.11908	-6.7082	-6.2254	-5.9111	-5.6391	-5.4693	-5.3528
0.13888	-6.6428	-6.1741	-5.8135	-5.5388	-5.3827	-5.2598
0.16025	-6.5221	-6.0879	-5.7202	-5.4569	-5.2807	-5.1672
0.18065	-6.4168	-5.9653	-5.6251	-5.3825	-5.1977	-5.0882
0.20010	-6.3652	-5.8565	-5.5431	-5.3053	-5.1340	-5.0127

Table 4.102: Apparent molar adiabatic compressibility (φ_k) of L-glutamine in aqueous solution of 0.05 mol.kg^{-1} vitamin B6 as a function of molality (m/mol.kg^{-1}) at different temperature

L-glutamine + aqueous solution of 0.05 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	$\varphi_k \times 10^{14}$/m^3.mol^{-1}.Pa^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.04966	-3.4811	-3.2275	-2.9566	-2.5614	-2.3425	-2.1331
0.09911	-3.4075	-3.1044	-2.8238	-2.4847	-2.2807	-2.0842
0.15069	-3.3561	-3.0915	-2.7866	-2.4959	-2.2947	-2.1055
0.20069	-3.2910	-3.0269	-2.7230	-2.4552	-2.2421	-2.0640
0.25012	-3.3016	-3.0529	-2.7500	-2.4748	-2.2815	-2.1053
0.30039	-3.3434	-3.0671	-2.7521	-2.4996	-2.3013	-2.1215
0.35022	-3.2560	-2.9947	-2.7032	-2.4589	-2.2712	-2.1126
0.40119	-3.2892	-3.0043	-2.7096	-2.4657	-2.2727	-2.1050
0.45085	-3.2054	-2.9504	-2.6165	-2.3733	-2.1711	-2.0186
0.50155	-3.2974	-2.9890	-2.6764	-2.4162	-2.2132	-2.0387

Table 4.103: Apparent molar adiabatic compressibility (φ_k) of L-glutamine in aqueous solution of 0.20 mol.kg^{-1} vitamin B6 as a function of molality (m/mol.kg^{-1}) at different temperature

L-glutamine + aqueous solution of 0.20 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	$\varphi_k \times 10^{14}$/m^3.mol^{-1}.Pa^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.05055	-4.3003	-3.9232	-3.6493	-3.4364	-3.1973	-2.9907
0.09988	-4.1702	-3.8173	-3.5543	-3.3762	-3.1224	-2.8694
0.14939	-4.1203	-3.7652	-3.4925	-3.2863	-3.0624	-2.8382
0.19925	-3.9893	-3.6560	-3.4059	-3.2404	-3.0199	-2.7138
0.24918	-3.9428	-3.5653	-3.3028	-3.1137	-2.8728	-2.6853
0.29948	-3.8676	-3.4776	-3.2214	-3.0546	-2.8031	-2.5549
0.34957	-3.7185	-3.4198	-3.1663	-2.9900	-2.7504	-2.5095
0.40095	-3.7117	-3.3308	-3.0900	-2.9268	-2.6472	-2.4284
0.44866	-3.6578	-3.3104	-3.0417	-2.8722	-2.6070	-2.4308
0.50099	-3.5880	-3.2607	-3.0213	-2.8446	-2.6033	-2.3935

Table 4.104: Apparent molar adiabatic compressibility (φ_k) of L-glutamine in aqueous solution of 0.35 mol.kg^{-1} vitamin B6 as a function of molality (m/mol.kg^{-1}) at different temperature

L-glutamine + aqueous solution of 0.35 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	$\varphi_k \times 10^{14}$/m^3.mol^{-1}.Pa^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.04999	-5.2819	-4.7435	-4.2873	-3.7427	-3.3377	-2.9121
0.10077	-5.0479	-4.5268	-4.0774	-3.6218	-3.2110	-2.8123
0.15076	-4.8751	-4.3492	-3.8564	-3.4438	-3.0695	-2.6480
0.20075	-4.6989	-4.2017	-3.6663	-3.2876	-2.9099	-2.5258
0.25034	-4.4976	-4.0613	-3.4468	-3.1154	-2.7261	-2.2959
0.30088	-4.3127	-3.8669	-3.2811	-2.9636	-2.6321	-2.2487
0.34925	-4.1240	-3.7607	-3.1700	-2.8288	-2.4312	-2.0653
0.39956	-4.0023	-3.5872	-3.0875	-2.7389	-2.4537	-2.0646
0.44946	-3.9012	-3.4952	-3.0491	-2.7011	-2.3656	-2.0563
0.50085	-3.7226	-3.3254	-2.9389	-2.5639	-2.3354	-1.9796

Table 4.105: Apparent molar adiabatic compressibility (φ_k) of L-glutamine in aqueous solution of 0.50 mol.kg^{-1} vitamin B6 as a function of molality (m/mol.kg^{-1}) at different temperature

L-glutamine + aqueous solution of 0.50 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	$\varphi_k \times 10^{14}$/m^3.mol^{-1}.Pa^{-1}					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.04998	-5.6110	-4.9011	-4.3964	-3.7964	-3.2796	-2.8613
0.10045	-4.9725	-4.4818	-4.0467	-3.4596	-2.8866	-2.4309
0.14957	-4.6210	-4.0507	-3.6548	-3.0895	-2.5784	-2.1063
0.20000	-4.2374	-3.7277	-3.1952	-2.6903	-2.3268	-1.9171
0.25000	-3.8904	-3.3529	-2.8738	-2.4220	-1.9241	-1.5755
0.29887	-3.6543	-3.1019	-2.6079	-2.0638	-1.6284	-1.2883
0.34948	-3.3549	-2.7572	-2.3392	-1.8553	-1.4679	-1.1377
0.39978	-2.9340	-2.4243	-2.0231	-1.5490	-1.2238	-0.9078
0.44888	-2.7072	-2.1641	-1.7139	-1.3330	-1.0117	-0.7047
0.50097	-2.4323	-2.0050	-1.4908	-1.1030	-0.7542	-0.4392

Table 4.106: Limiting apparent molar adiabatic compressibility (φ_k^0), experimental slope (S_k) of Aqueous L-serine 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	-2.5432	-0.8038
298.15K	-2.4120	-0.6849
303.15K	-2.2858	-0.5759
308.15K	-2.0696	-0.7168
313.15K	-2.0264	-0.4576
318.15K	-1.9026	-0.4881

Table 4.107: Limiting apparent molar adiabatic compressibility (φ_k^0), experimental slope (S_k) of Aqueous L-asparagine 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	-1.9954	-4.8904
298.15K	-1.5993	-4.6383
303.15K	-1.2030	-4.9200
308.15K	-0.7928	-5.0722
313.15K	-0.5194	-4.7372
318.15K	-0.2513	-4.7031

Table 4.108: Limiting apparent molar adiabatic compressibility (φ_k^0), experimental slope (S_k) of Aqueous L-glutamine 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	-3.5519	0.5660
298.15K	-3.2994	0.6389
303.15K	-3.0747	0.7188
308.15K	-2.9110	0.8670
313.15K	-2.7272	0.9075
318.15K	-2.5867	1.0182

Table 4.109: Limiting apparent molar adiabatic compressibility (φ_k^0), experimental slope (S_k) and transfer compressibility ($\Delta_{tr}\varphi_k^0$) of L-serine in aqueous solution of vitamin B6 0.05 mol.kg^{-1} vitamin B6 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	-3.1911	1.0255	-0.6479
298.15K	-2.9750	0.9534	-0.5630
303.15K	-2.7814	0.9664	-0.4955
308.15K	-2.5862	0.8804	-0.5165
313.15K	-2.3987	0.7372	-0.3723
318.15K	-2.2507	0.6406	-0.3481

Table 4.110: Limiting apparent molar adiabatic compressibility (φ_k^0), experimental slope (S_k) and transfer compressibility ($\Delta_{tr}\varphi_k^0$) of L-serine in aqueous solution of 0.20 mol.kg^{-1} vitamin B6 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	-2.5600	0.5034	-0.0168
298.15K	-2.4058	0.5222	0.0062
303.15K	-2.1862	0.4539	0.0996
308.15K	-2.0508	0.4457	0.0189
313.15K	-1.9389	0.4455	0.0876
318.15K	-1.8281	0.4282	0.0745

Table 4.111: Limiting apparent molar adiabatic compressibility (φ_k^0), experimental slope (S_k) and transfer compressibility ($\Delta_{tr}\varphi_k^0$) of L-serine in aqueous solution of 0.35 mol.kg^{-1} vitamin B6 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	-1.6367	-0.7605	0.9064
298.15K	-1.4973	-0.7781	0.9147
303.15K	-1.3622	-0.7990	0.9237
308.15K	-1.2655	-0.7498	0.8041
313.15K	-1.1799	-0.6895	0.8465
318.15K	-1.0752	-0.6923	0.8274

Table 4.112: Limiting apparent molar adiabatic compressibility (φ_k^0), experimental slope (S_k) and transfer compressibility ($\Delta_{tr}\varphi_k^0$) of L-serine in aqueous solution of 0.50 mol.kg^{-1} vitamin B6 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	-1.8379	0.4230	0.7052
298.15K	-1.7132	0.4469	0.6987
303.15K	-1.5978	0.4430	0.6880
308.15K	-1.5026	0.4885	0.5671
313.15K	-1.3866	0.4385	0.6398
318.15K	-1.2852	0.4081	0.6174

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-asparagine in aqueous solution of 0.05 mol.kg^{-1} vitamin B6 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	-2.6662	0.8461	-0.6708
298.15K	-2.3338	0.6494	-0.7345
303.15K	-2.1365	0.5067	-0.9334
308.15K	-1.9724	0.3682	-1.1797
313.15K	-1.8539	0.3270	-1.3345
318.15K	-1.7646	0.3676	-1.5133

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-asparagine in aqueous solution of 0.20 mol.kg^{-1} vitamin B6 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	-1.9954	-4.8904	-2.172
298.15K	-1.5993	-4.6383	-1.985
303.15K	-1.2030	-4.9200	-1.783
308.15K	-0.7928	-5.0722	-1.547
313.15K	-0.5194	-4.7372	-1.271
318.15K	-0.2513	-4.7031	-1.128

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-asparagine in aqueous solution of 0.35 mol.kg^{-1} vitamin B6 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	-8.8198	-2.9928	-6.785
298.15K	-8.4089	-3.1544	-6.772
303.15K	-8.0212	-3.3310	-6.783
308.15K	-7.7411	-3.0678	-6.914
313.15K	-7.4994	-2.7325	-6.9477
318.15K	-7.2206	-2.7797	-6.9393

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-asparagine in aqueous solution of 0.50 mol.kg^{-1} vitamin B6 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	-5.3219	-5.3219	-5.3219
298.15K	-5.2373	-5.2373	-5.2373
303.15K	-5.2905	-5.2905	-5.2905
308.15K	-5.4266	-5.4266	-5.4266
313.15K	-5.5061	-5.5061	-5.5061
318.15K	-5.6589	-5.6589	-5.6589

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-glutamine in aqueous solution of 0.05 mol.kg^{-1} vitamin B6 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	-3.4382	0.4186	0.1137
298.15K	-3.1754	0.4520	0.1240
303.15K	-2.8966	0.5332	0.1780
308.15K	-2.5418	0.2658	0.3692
313.15K	-2.3315	0.2337	0.3957
318.15K	-2.1271	0.1389	0.4596

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-glutamine in aqueous solution of 0.20 $mol.kg^{-1}$ 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	-4.3369	1.5657	-0.7850
298.15K	-3.9680	1.5115	-0.6686
303.15K	-3.6956	1.4596	-0.6210
308.15K	-3.4956	1.3883	-0.5846
313.15K	-3.2649	1.4425	-0.5378
318.15K	-3.0155	1.3611	-0.4288

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-glutamine in aqueous solution of 0.35 $mol.kg^{-1}$ vitamin B6 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	-5.3931	3.4391	-1.8412
298.15K	-4.8375	3.0726	-1.5381
303.15K	-4.3158	3.0141	-1.2411
308.15K	-3.8394	2.6832	-0.9283
313.15K	-3.4001	2.3719	-0.6729
318.15K	-2.9631	2.1878	-0.3764

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-glutamine in aqueous solution of 0.50 $mol.kg^{-1}$ vitamin B6 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	-5.7003	6.7643	-2.1484
298.15K	-5.0819	6.4964	-1.7825
303.15K	-4.6158	6.4835	-1.5411
308.15K	-3.9918	6.0248	-1.0808
313.15K	-3.4240	5.5164	-0.6969
318.15K	-2.9529	5.1530	-0.3662

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

L-serine + water						
m/mol.kg^{-1}	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1.4813	1.4933	1.5034	1.5116	1.5178	1.5223
0.04912	1.4868	1.4988	1.5088	1.5169	1.5232	1.5276
0.09988	1.4937	1.5057	1.5156	1.5236	1.5296	1.5339
0.14903	1.4998	1.5117	1.5216	1.5295	1.5355	1.5397
0.19989	1.5062	1.5180	1.5278	1.5356	1.5415	1.5456
0.24978	1.5125	1.5243	1.5340	1.5417	1.5475	1.5515
0.29934	1.5187	1.5304	1.5400	1.5476	1.5534	1.5574
0.35056	1.5250	1.5366	1.5462	1.5538	1.5594	1.5634
0.40053	1.5313	1.5428	1.5523	1.5598	1.5653	1.5692
0.44999	1.5376	1.5490	1.5583	1.5658	1.5712	1.5750
0.50195	1.5441	1.5554	1.5646	1.5719	1.5774	1.5811

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

L-asparagine + water						
m/mol.kg^{-1}	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1.4813	1.4933	1.5034	1.5116	1.5178	1.5223
0.02005	1.4842	1.4961	1.5061	1.5141	1.5203	1.5246
0.03901	1.4870	1.4989	1.5087	1.5167	1.5227	1.5270
0.05919	1.4901	1.5018	1.5116	1.5195	1.5254	1.5296
0.07921	1.4932	1.5047	1.5144	1.5222	1.5281	1.5322
0.09899	1.4962	1.5078	1.5174	1.5251	1.5309	1.5348
0.11901	1.4995	1.5110	1.5205	1.5280	1.5336	1.5374
0.14079	1.5031	1.5144	1.5238	1.5311	1.5368	1.5405
0.16089	1.5065	1.5177	1.5270	1.5342	1.5397	1.5435
0.18099	1.5099	1.5209	1.5303	1.5374	1.5425	1.5462
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-glutamine as a function of molality (m/mol.kg^{-1}) at different temperature

L-glutamine + water						
m/mol.kg^{-1}	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1.4813	1.4933	1.5034	1.5116	1.5178	1.5223
0.05029	1.4896	1.5016	1.5115	1.5197	1.5258	1.5301
0.10095	1.4981	1.5099	1.5197	1.5278	1.5338	1.5380
0.14978	1.5058	1.5175	1.5273	1.5352	1.5411	1.5452
0.20098	1.5144	1.5260	1.5356	1.5434	1.5491	1.5531
0.24947	1.5222	1.5337	1.5431	1.5507	1.5564	1.5603
0.29955	1.5303	1.5416	1.5509	1.5583	1.5638	1.5675
0.34958	1.5385	1.5497	1.5587	1.5660	1.5713	1.5749
0.39908	1.5465	1.5574	1.5664	1.5735	1.5787	1.5820
0.45099	1.5548	1.5656	1.5743	1.5813	1.5863	1.5894
0.50099	1.5633	1.5738	1.5824	1.5891	1.5939	1.5968

Table 4.124: Acoustic impedance ($Z\times10^{-6}$/kg.m^{-2}.s^{-1}) of L-serine in aqueous solution of 0.05 mol.kg^{-1} vitamin B6 as a function of molality (m/mol.kg^{-1}) at different temperature

L-serine + aqueous solution of 0.05 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.0000	1.4896	1.5014	1.5114	1.5194	1.5254	1.5296
0.04988	1.4961	1.5078	1.5178	1.5257	1.5315	1.5356
0.10034	1.5026	1.5142	1.5241	1.5319	1.5376	1.5416
0.14900	1.5089	1.5204	1.5301	1.5378	1.5434	1.5474
0.20007	1.5152	1.5266	1.5363	1.5439	1.5494	1.5533
0.24927	1.5214	1.5328	1.5423	1.5498	1.5553	1.5592
0.30069	1.5276	1.5389	1.5483	1.5557	1.5611	1.5649
0.35067	1.5339	1.5450	1.5543	1.5616	1.5670	1.5708
0.39888	1.5395	1.5505	1.5597	1.5670	1.5722	1.5759
0.45005	1.5457	1.5566	1.5659	1.5731	1.5784	1.5819
0.49988	1.5516	1.5627	1.5717	1.5788	1.5841	1.5873

Table 4.125: Acoustic impedance ($Z\times10^{-6}$/kg.m^{-2}.s^{-1}) of L-serine in aqueous solution of 0.20 mol.kg^{-1} vitamin B6 as a function of molality (m/mol.kg^{-1}) at different temperature

L-serine + aqueous solution of 0.20 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1.5159	1.5269	1.5363	1.5434	1.5488	1.5524
0.04921	1.5220	1.5329	1.5422	1.5493	1.5546	1.5581
0.09932	1.5282	1.5390	1.5481	1.5552	1.5603	1.5638
0.15099	1.5345	1.5453	1.5543	1.5612	1.5664	1.5697
0.19986	1.5405	1.5512	1.5601	1.5669	1.5720	1.5753
0.25009	1.5466	1.5572	1.5659	1.5727	1.5776	1.5808
0.30000	1.5525	1.5631	1.5717	1.5784	1.5833	1.5864
0.34982	1.5585	1.5689	1.5774	1.5841	1.5889	1.5919
0.39988	1.5643	1.5746	1.5831	1.5897	1.5944	1.5974
0.45099	1.5705	1.5808	1.5892	1.5956	1.6003	1.6032
0.50009	1.5763	1.5864	1.5947	1.6011	1.6056	1.6084

Table 4.126: Acoustic impedance ($Z\times10^{-6}$/kg.m^{-2}.s^{-1}) of L-serine in aqueous solution of 0.35 mol.kg^{-1} vitamin B6 as a function of molality (m/mol.kg^{-1}) at different temperature

L-serine + aqueous solution of 0.35 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.0000	1.5415	1.5519	1.5603	1.5668	1.5715	1.5746
0.05004	1.5471	1.5574	1.5657	1.5722	1.5768	1.5798
0.09999	1.5528	1.5630	1.5712	1.5776	1.5822	1.5851
0.14911	1.5585	1.5686	1.5768	1.5830	1.5876	1.5904
0.20056	1.5644	1.5745	1.5826	1.5889	1.5933	1.5960
0.25005	1.5702	1.5802	1.5882	1.5945	1.5989	1.6014
0.30029	1.5762	1.5862	1.5942	1.6003	1.6045	1.6069
0.34998	1.5822	1.5921	1.6001	1.6059	1.6100	1.6124
0.39998	1.5883	1.5981	1.6059	1.6117	1.6157	1.6181
0.45012	1.5945	1.6042	1.6120	1.6176	1.6216	1.6240
0.50005	1.6009	1.6105	1.6182	1.6240	1.6277	1.6299

Table 4.127: Acoustic impedance ($Z\times10^{-6}$/kg.m^{-2}.s^{-1}) of L-serine in aqueous solution of 0.50 mol.kg^{-1} vitamin B6 as a function of molality (m/mol.kg^{-1}) at different temperature

L-serine + aqueous solution of 0.50 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.0000	1.5652	1.5748	1.5826	1.5884	1.5926	1.5948
0.05039	1.5711	1.5807	1.5883	1.5942	1.5982	1.6003
0.10005	1.5769	1.5864	1.5940	1.5997	1.6037	1.6057
0.15003	1.5827	1.5921	1.5996	1.6052	1.6091	1.6111
0.19996	1.5884	1.5977	1.6051	1.6106	1.6145	1.6164
0.24999	1.5941	1.6033	1.6106	1.6160	1.6199	1.6216
0.30016	1.5997	1.6089	1.6161	1.6215	1.6252	1.6268
0.35003	1.6053	1.6144	1.6216	1.6269	1.6304	1.6321
0.40014	1.6111	1.6202	1.6273	1.6324	1.6358	1.6374
0.45021	1.6165	1.6255	1.6324	1.6376	1.6410	1.6425
0.50019	1.6223	1.6310	1.6381	1.6431	1.6464	1.6478

Table 4.128: Acoustic impedance ($Z\times10^{-6}$/kg.m^{-2}.s^{-1}) of L-asparagine in aqueous solution of 0.05 mol.kg^{-1} vitamin B6 as a function of molality (m/mol.kg^{-1}) at different temperature

L-asparagine + aqueous solution of 0.05 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1.4896	1.5014	1.5114	1.5194	1.5254	1.5296
0.04988	1.4927	1.5044	1.5144	1.5224	1.5283	1.5325
0.10034	1.4960	1.5076	1.5175	1.5255	1.5314	1.5356
0.14900	1.4991	1.5106	1.5206	1.5285	1.5344	1.5385
0.20007	1.5021	1.5136	1.5235	1.5314	1.5373	1.5414
0.24927	1.5052	1.5166	1.5265	1.5343	1.5402	1.5443
0.30069	1.5082	1.5195	1.5294	1.5372	1.5431	1.5472
0.35067	1.5112	1.5225	1.5323	1.5402	1.5460	1.5500
0.39888	1.5143	1.5256	1.5354	1.5432	1.5489	1.5530
0.45005	1.5174	1.5285	1.5383	1.5461	1.5519	1.5559
0.49988	1.5204	1.5315	1.5412	1.5489	1.5547	1.5586

Table 4.129: Acoustic impedance ($Z\times10^{-6}$/kg.m^{-2}.s^{-1}) of L-asparagine in aqueous solution of 0.20 mol.kg^{-1} vitamin B6 as a function of molality (m/mol.kg^{-1}) at different temperature

L-asparagine + aqueous solution of 0.20 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1.5159	1.5269	1.5363	1.5434	1.5488	1.5524
0.01968	1.5195	1.5304	1.5395	1.5465	1.5517	1.5552
0.04085	1.5233	1.5339	1.5429	1.5497	1.5547	1.5580
0.06038	1.5266	1.5371	1.5460	1.5526	1.5574	1.5606
0.07912	1.5298	1.5401	1.5488	1.5552	1.5599	1.5630
0.10019	1.5332	1.5434	1.5519	1.5582	1.5626	1.5655
0.12038	1.5363	1.5464	1.5547	1.5609	1.5650	1.5678
0.13927	1.5393	1.5491	1.5572	1.5632	1.5673	1.5700
0.16091	1.5422	1.5519	1.5598	1.5657	1.5698	1.5722
0.18079	1.5450	1.5546	1.5624	1.5682	1.5720	1.5743
0.20041	1.5477	1.5572	1.5649	1.5705	1.5740	1.5762

Table 4.130: Acoustic impedance ($Z\times10^{-6}$/kg.m^{-2}.s^{-1}) of L-asparagine in aqueous solution of 0.35 mol.kg^{-1} vitamin B6 as a function of molality (m/mol.kg^{-1}) at different temperature

L-asparagine + aqueous solution of 0.35 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1.5415	1.5519	1.5603	1.5668	1.5715	1.5746
0.02003	1.5471	1.5574	1.5657	1.5722	1.5768	1.5798
0.04004	1.5528	1.5630	1.5712	1.5776	1.5822	1.5851
0.05971	1.5585	1.5686	1.5768	1.5830	1.5876	1.5904
0.08027	1.5644	1.5745	1.5826	1.5889	1.5933	1.5960
0.10011	1.5702	1.5802	1.5882	1.5945	1.5989	1.6014
0.12028	1.5762	1.5862	1.5942	1.6003	1.6045	1.6069
0.14004	1.5822	1.5921	1.6001	1.6059	1.6100	1.6124
0.16011	1.5883	1.5981	1.6059	1.6117	1.6157	1.6181
0.18019	1.5945	1.6042	1.6120	1.6176	1.6216	1.6240
0.20041	1.6009	1.6105	1.6182	1.6240	1.6277	1.6299

Table 4.131: Acoustic impedance ($Z\times10^{-6}$/kg.m^{-2}.s^{-1}) of L-asparagine in aqueous solution of 0.50 mol.kg^{-1} vitamin B6 as a function of molality (m/mol.kg^{-1}) at different temperature

L-asparagine + aqueous solution of 0.50 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1.5652	1.5748	1.5826	1.5884	1.5926	1.5948
0.02055	1.5705	1.5800	1.5876	1.5934	1.5975	1.5997
0.04099	1.5757	1.5851	1.5926	1.5983	1.6023	1.6045
0.05992	1.5804	1.5896	1.5971	1.6028	1.6068	1.6089
0.07902	1.5851	1.5942	1.6016	1.6072	1.6111	1.6132
0.09915	1.5900	1.5990	1.6063	1.6118	1.6158	1.6178
0.11908	1.5948	1.6037	1.6109	1.6163	1.6202	1.6222
0.13888	1.5996	1.6084	1.6154	1.6207	1.6246	1.6265
0.16025	1.6046	1.6133	1.6202	1.6255	1.6292	1.6311
0.18065	1.6093	1.6178	1.6247	1.6299	1.6336	1.6355
0.20010	1.6139	1.6221	1.6289	1.6341	1.6378	1.6396

Table 4.132: Acoustic impedance ($Z\times10^{-6}$/kg.m^{-2}.s^{-1}) of L-glutamine in aqueous solution of 0.05 mol.kg^{-1} vitamin B6 as a function of molality (m/mol.kg^{-1}) at different temperature

L-glutamine + aqueous solution of 0.05 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1.4896	1.5014	1.5114	1.5194	1.5254	1.5296
0.04966	1.4979	1.5095	1.5195	1.5272	1.5330	1.5371
0.09911	1.5060	1.5175	1.5272	1.5348	1.5405	1.5444
0.15069	1.5145	1.5258	1.5354	1.5428	1.5484	1.5522
0.20069	1.5225	1.5338	1.5431	1.5504	1.5558	1.5595
0.25012	1.5307	1.5419	1.5511	1.5581	1.5635	1.5670
0.30039	1.5392	1.5501	1.5591	1.5661	1.5712	1.5746
0.35022	1.5470	1.5578	1.5667	1.5736	1.5786	1.5820
0.40119	1.5556	1.5662	1.5748	1.5815	1.5864	1.5896
0.45085	1.5632	1.5738	1.5819	1.5884	1.5931	1.5963
0.50155	1.5724	1.5824	1.5904	1.5966	1.6011	1.6040

Table 4.133: Acoustic impedance ($Z\times10^{-6}$/kg.m^{-2}.s^{-1}) of L-glutamine in aqueous solution of 0.20 mol.kg^{-1} vitamin B6 as a function of molality (m/mol.kg^{-1}) at different temperature

L-glutamine + aqueous solution of 0.20 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1.5159	1.5269	1.5363	1.5434	1.5488	1.5524
0.05055	1.5253	1.5361	1.5453	1.5523	1.5575	1.5610
0.09988	1.5343	1.5449	1.5539	1.5609	1.5659	1.5691
0.14939	1.5433	1.5537	1.5626	1.5694	1.5743	1.5773
0.19925	1.5520	1.5623	1.5711	1.5779	1.5826	1.5852
0.24918	1.5610	1.5708	1.5794	1.5860	1.5904	1.5933
0.29948	1.5697	1.5792	1.5877	1.5943	1.5985	1.6008
0.34957	1.5779	1.5877	1.5960	1.6024	1.6065	1.6087
0.40095	1.5870	1.5960	1.6043	1.6107	1.6142	1.6163
0.44866	1.5952	1.6042	1.6120	1.6183	1.6217	1.6240
0.50099	1.6039	1.6128	1.6207	1.6268	1.6302	1.6320

Table 4.134: Acoustic impedance ($Z\times10^{-6}$/kg.m^{-2}.s^{-1}) of L-glutamine in aqueous solution of 0.35 mol.kg^{-1} vitamin B6 as a function of molality (m/mol.kg^{-1}) at different temperature

L-glutamine + aqueous solution of 0.35 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1.5415	1.5519	1.5603	1.5668	1.5715	1.5746
0.04999	1.5520	1.5620	1.5701	1.5762	1.5805	1.5832
0.10077	1.5623	1.5719	1.5797	1.5854	1.5894	1.5917
0.15076	1.5722	1.5814	1.5887	1.5942	1.5979	1.5998
0.20075	1.5818	1.5907	1.5974	1.6027	1.6060	1.6077
0.25034	1.5909	1.5997	1.6056	1.6107	1.6137	1.6147
0.30088	1.5999	1.6083	1.6138	1.6187	1.6216	1.6225
0.34925	1.6081	1.6168	1.6216	1.6261	1.6283	1.6289
0.39956	1.6169	1.6248	1.6299	1.6340	1.6367	1.6367
0.44946	1.6256	1.6332	1.6383	1.6421	1.6440	1.6444
0.50085	1.6336	1.6409	1.6462	1.6494	1.6521	1.6516

Table 4.135: Acoustic impedance ($Z\times10^{-6}$/kg.m^{-2}.s^{-1}) of L-glutamine in aqueous solution of 0.50 mol.kg^{-1} vitamin B6 as a function of molality (m/mol.kg^{-1}) at different temperature

L-glutamine + aqueous solution of 0.50 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.00000	1.5652	1.5748	1.5826	1.5884	1.5926	1.5948
0.04998	1.5763	1.5854	1.5927	1.5981	1.6017	1.6035
0.10045	1.5864	1.5953	1.6023	1.6071	1.6102	1.6115
0.14957	1.5958	1.6041	1.6108	1.6151	1.6178	1.6186
0.20000	1.6047	1.6127	1.6185	1.6225	1.6253	1.6259
0.25000	1.6129	1.6203	1.6259	1.6297	1.6314	1.6319
0.29887	1.6209	1.6277	1.6328	1.6355	1.6371	1.6373
0.34948	1.6282	1.6342	1.6393	1.6420	1.6435	1.6434
0.39978	1.6339	1.6400	1.6449	1.6471	1.6487	1.6484
0.44888	1.6403	1.6456	1.6496	1.6522	1.6535	1.6530
0.50097	1.6463	1.6522	1.6550	1.6571	1.6578	1.6568

Table 4.136: Hydration number (n_H) of aqueous L-serine as a function of molality (m/mol.kg^{-1}) at different temperature

L-serine + water						
m/mol.kg^{-1}	n_H					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.04912	6.82	6.72	6.62	6.41	6.24	6.11
0.09988	6.78	6.69	6.56	6.36	6.19	6.06
0.14903	6.75	6.66	6.53	6.34	6.17	6.04
0.19989	6.74	6.62	6.49	6.30	6.15	6.02
0.24978	6.75	6.62	6.48	6.30	6.15	6.03
0.29934	6.73	6.59	6.45	6.28	6.13	6.01
0.35056	6.68	6.54	6.40	6.25	6.11	5.99
0.40053	6.66	6.53	6.38	6.22	6.08	5.96
0.44999	6.65	6.50	6.35	6.21	6.06	5.95
0.50195	6.63	6.47	6.32	6.17	6.04	5.92

Table 4.137: Hydration number (n_H) of aqueous L-asparagine as a function of molality (m/mol.kg^{-1}) at different temperature

L-asparagine + water						
m/mol.kg^{-1}	n_H					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.02005	8.64	8.14	7.77	7.39	6.98	6.7
0.03901	8.54	8.08	7.74	7.28	6.84	6.53
0.05919	8.41	8	7.61	7.17	6.71	6.5
0.07921	8.28	7.86	7.46	6.97	6.71	6.32
0.09899	8.15	7.74	7.36	6.95	6.54	6.13
0.11901	8.02	7.63	7.23	6.8	6.45	6.08
0.14079	7.93	7.43	7.05	6.65	6.34	5.97
0.16089	7.79	7.38	7	6.54	6.19	5.88
0.18099	7.66	7.23	6.76	6.34	5.99	5.69
0.19901	7.54	7.07	6.65	6.09	5.73	5.45

Table 4.138: Hydration number (n_H) of aqueous L-glutamine as a function of molality (m/mol.kg^{-1}) at different temperature

L-glutamine + water						
m/mol.kg^{-1}	n_H					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.05029	9.20	8.97	8.78	8.63	8.43	8.25
0.10095	9.12	8.91	8.69	8.53	8.33	8.16
0.14978	9.15	8.92	8.71	8.52	8.32	8.16
0.20098	9.03	8.80	8.57	8.38	8.17	8.01
0.24947	8.98	8.74	8.50	8.31	8.11	7.94
0.29955	8.92	8.66	8.43	8.22	8.02	7.83
0.34958	8.84	8.62	8.36	8.15	7.94	7.75
0.39908	8.80	8.55	8.32	8.08	7.88	7.67
0.45099	8.74	8.49	8.24	8.03	7.81	7.59
0.50099	8.70	8.44	8.21	7.97	7.76	7.53

Table 4.139: Hydration number (n_H) of L-serine in aqueous solution of 0.05 mol.kg^{-1} vitamin B6 as a function of molality (m/mol.kg^{-1}) at different temperature

L-serine + aqueous solution of 0.05 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	n_H					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.04988	7.21	7.00	6.85	6.53	6.47	6.32
0.10034	7.17	6.98	6.82	6.63	6.42	6.26
0.14900	7.09	6.93	6.72	6.52	6.34	6.22
0.20007	6.96	6.80	6.63	6.44	6.26	6.14
0.24927	6.92	6.77	6.56	6.40	6.24	6.12
0.30069	6.82	6.66	6.47	6.29	6.14	6.03
0.35067	6.79	6.61	6.40	6.23	6.11	5.99
0.39888	6.68	6.51	6.31	6.15	6.00	5.90
0.45005	6.61	6.44	6.29	6.13	6.01	5.88
0.49988	6.56	6.42	6.23	6.09	5.97	5.82

Table 4.140: Hydration number (n_H) of L-serine in aqueous solution of 0.20 mol.kg^{-1} vitamin B6 as a function of molality (m/mol.kg^{-1}) at different temperature

L-serine + aqueous solution of 0.20 mol.kg^{-1} vitamin B6						
m/mol.kg^{-1}	n_H					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.04921	6.73	6.58	6.37	6.24	6.12	5.99
0.09932	6.67	6.54	6.31	6.17	6.04	5.92
0.15099	6.62	6.50	6.27	6.12	6.01	5.89
0.19986	6.59	6.45	6.23	6.09	5.97	5.85
0.25009	6.54	6.41	6.17	6.03	5.90	5.78
0.30000	6.48	6.34	6.12	5.98	5.86	5.75
0.34982	6.44	6.28	6.06	5.94	5.82	5.70
0.39988	6.38	6.23	6.04	5.91	5.79	5.68
0.45099	6.34	6.20	6.01	5.87	5.76	5.65
0.50009	6.29	6.14	5.96	5.82	5.70	5.60

Table 4.141: Hydration number (n_H) of L-serine in aqueous solution of 0.35 $mol.kg^{-1}$ vitamin B6 as a function of molality ($m/mol.kg^{-1}$) at different temperature

L-serine + aqueous solution of 0.35 $mol.kg^{-1}$ vitamin B6						
$m/mol.kg^{-1}$	n_H					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.05039	6.19	6.07	5.95	5.85	5.70	5.56
0.10005	6.13	5.98	5.87	5.77	5.62	5.49
0.15003	6.08	5.94	5.79	5.67	5.55	5.45
0.19996	6.01	5.87	5.73	5.60	5.48	5.38
0.24999	5.97	5.81	5.67	5.54	5.45	5.33
0.30016	5.93	5.77	5.65	5.51	5.40	5.28
0.35003	5.88	5.74	5.60	5.47	5.35	5.26
0.40014	5.87	5.73	5.61	5.46	5.34	5.23
0.45021	5.80	5.66	5.52	5.40	5.29	5.19
0.50019	5.79	5.63	5.52	5.40	5.28	5.18

Table 4.142: Hydration number (n_H) of L-serine in aqueous solution of 0.5 $mol.kg^{-1}$ vitamin B6 as a function of molality ($m/mol.kg^{-1}$) at different temperature

L-serine + aqueous solution of 0.50 $mol.kg^{-1}$ vitamin B6						
$m/mol.kg^{-1}$	n_H					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.05004	6.13	6.00	5.87	5.76	5.62	5.50
0.09999	6.08	5.95	5.82	5.68	5.55	5.46
0.14911	6.05	5.92	5.78	5.65	5.52	5.40
0.20056	6.01	5.88	5.77	5.62	5.50	5.37
0.25005	5.97	5.86	5.74	5.62	5.49	5.35
0.30029	5.94	5.81	5.66	5.57	5.47	5.33
0.34998	5.91	5.78	5.64	5.54	5.43	5.29
0.39998	5.89	5.74	5.59	5.47	5.39	5.24
0.45012	5.83	5.68	5.54	5.42	5.31	5.20
0.50005	5.76	5.62	5.48	5.36	5.22	5.12

Table 4.143: Hydration number (n_H) of L-asparagine in aqueous solution of 0.05 $mol.kg^{-1}$ vitamin B6 as a function of molality ($m/mol.kg^{-1}$) at different temperature

L-asparagine + aqueous solution of 0.05 $mol.kg^{-1}$ vitamin B6						
$m/mol.kg^{-1}$	n_H					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.01968	8.52	8.34	8.25	8.19	8.15	8.11
0.04075	8.51	8.32	8.24	8.18	8.14	8.11
0.06088	8.51	8.31	8.24	8.18	8.14	8.10
0.08072	8.50	8.31	8.24	8.18	8.14	8.10
0.10069	8.49	8.30	8.23	8.18	8.14	8.10
0.12038	8.48	8.30	8.23	8.17	8.13	8.10
0.14027	8.48	8.29	8.23	8.17	8.14	8.10
0.16091	8.47	8.29	8.23	8.17	8.13	8.09
0.18079	8.46	8.29	8.22	8.17	8.13	8.09
0.20041	8.45	8.28	8.22	8.16	8.13	8.09

Table 4.144: Hydration number (n_H) of L-asparagine in aqueous solution of 0.20 $mol.kg^{-1}$ vitamin B6 as a function of molality ($m/mol.kg^{-1}$) at different temperature

L-asparagine + aqueous solution of 0.20 $mol.kg^{-1}$ vitamin B6						
$m/mol.kg^{-1}$	n_H					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.01968	9.90	9.29	8.52	7.78	7.13	6.62
0.04085	9.68	9.00	8.34	7.62	6.95	6.48
0.06038	9.49	8.85	8.23	7.54	6.88	6.36
0.07912	9.33	8.71	8.06	7.36	6.75	6.27
0.10019	9.18	8.59	7.94	7.26	6.60	6.11
0.12038	9.02	8.44	7.74	7.15	6.47	6.00
0.13927	8.86	8.25	7.57	6.95	6.35	5.87
0.16091	8.68	8.04	7.38	6.82	6.25	5.75
0.18079	8.52	7.94	7.29	6.76	6.16	5.66
0.20041	8.41	7.85	7.21	6.66	6.03	5.56

Table 4.145: Hydration number (n_H) of L-asparagine in aqueous solution of 0.35 $mol.kg^{-1}$ vitamin B6 as a function of molality ($m/mol.kg^{-1}$) at different temperature

L-asparagine + aqueous solution of 0.35 $mol.kg^{-1}$ vitamin B6						
$m/mol.kg^{-1}$	n_H					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.02003	12.98	12.58	12.27	12.08	11.95	11.87
0.04004	12.84	12.46	12.14	11.95	11.82	11.72
0.05971	12.73	12.33	12.06	11.83	11.70	11.62
0.08027	12.63	12.22	11.95	11.73	11.61	11.52
0.10011	12.52	12.10	11.85	11.64	11.53	11.43
0.12028	12.40	12.00	11.74	11.53	11.40	11.31
0.14004	12.33	11.95	11.62	11.42	11.31	11.21
0.16011	12.19	11.83	11.50	11.31	11.18	11.09
0.18019	12.08	11.69	11.38	11.21	11.09	10.99
0.20041	12.02	11.54	11.28	11.13	11.01	10.91

Table 4.146: Hydration number (n_H) of L-asparagine in aqueous solution of 0.50 $mol.kg^{-1}$ vitamin B6 as a function of molality ($m/mol.kg^{-1}$) at different temperature

L-asparagine + aqueous solution of 0.50 $mol.kg^{-1}$ vitamin B6						
$m/mol.kg^{-1}$	n_H					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.02055	15.35	15.02	14.69	14.40	14.06	13.77
0.04099	15.23	14.89	14.58	14.23	13.91	13.68
0.05992	15.15	14.83	14.49	14.16	13.84	13.54
0.07902	15.07	14.74	14.47	14.08	13.78	13.46
0.09915	14.94	14.66	14.36	14.07	13.75	13.39
0.11908	14.88	14.54	14.18	13.96	13.69	13.36
0.13888	14.80	14.50	14.13	13.88	13.61	13.25
0.16025	14.75	14.39	14.01	13.71	13.51	13.14
0.18065	14.60	14.22	13.85	13.56	13.29	13.01
0.20010	14.43	14.07	13.73	13.41	13.07	12.81

Table 4.147: Hydration number (n_H) of L-glutamine in aqueous solution of 0.05 $mol.kg^{-1}$ vitamin B6 as a function of molality ($m/mol.kg^{-1}$) at different temperature

L-glutamine + aqueous solution of 0.05 $mol.kg^{-1}$ vitamin B6						
$m/mol.kg^{-1}$	n_H					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.04966	9.30	9.09	8.83	8.38	8.13	7.89
0.09911	9.19	8.91	8.63	8.25	8.03	7.81
0.15069	9.09	8.86	8.55	8.23	8.01	7.81
0.20069	8.98	8.74	8.43	8.15	7.92	7.72
0.25012	8.96	8.75	8.44	8.15	7.94	7.75
0.30039	8.98	8.73	8.41	8.15	7.94	7.74
0.35022	8.85	8.62	8.33	8.07	7.87	7.70
0.40119	8.85	8.59	8.30	8.05	7.85	7.66
0.45085	8.72	8.50	8.16	7.91	7.69	7.53
0.50155	8.80	8.51	8.20	7.93	7.72	7.53

Table 4.148: Hydration number (n_H) of L-glutamine in aqueous solution of 0.20 $mol.kg^{-1}$ vitamin B6 as a function of molality ($m/mol.kg^{-1}$) at different temperature

L-glutamine + aqueous solution of 0.20 $mol.kg^{-1}$ vitamin B6						
$m/mol.kg^{-1}$	n_H					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.05055	10.14	9.78	9.52	9.33	9.10	8.88
0.09988	9.96	9.63	9.39	9.24	8.99	8.72
0.14939	9.87	9.55	9.30	9.11	8.89	8.66
0.19925	9.68	9.39	9.16	9.03	8.82	8.48
0.24918	9.65	9.29	9.05	8.89	8.65	8.46
0.29948	9.49	9.13	8.89	8.75	8.51	8.24
0.34957	9.29	9.04	8.81	8.66	8.42	8.17
0.40095	9.26	8.91	8.69	8.57	8.28	8.05
0.44866	9.18	8.86	8.61	8.47	8.21	8.03
0.50099	9.08	8.79	8.58	8.43	8.19	7.97

Table 4.149: Hydration number (n_H) of L-glutamine in aqueous solution of 0.35 $mol.kg^{-1}$ vitamin B6 as a function of molality ($m/mol.kg^{-1}$) at different temperature

L-glutamine + aqueous solution of 0.35 $mol.kg^{-1}$ vitamin B6						
$m/mol.kg^{-1}$	n_H					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.04999	10.98	10.47	10.08	9.53	9.13	8.68
0.10077	10.74	10.26	9.88	9.43	9.01	8.61
0.15076	10.58	10.11	9.62	9.23	8.87	8.43
0.20075	10.38	9.96	9.41	9.04	8.67	8.29
0.25034	10.19	9.82	9.17	8.88	8.47	8.04
0.30088	10.02	9.62	9.00	8.71	8.37	8.00
0.34925	9.82	9.51	8.87	8.53	8.13	7.80
0.39956	9.70	9.32	8.78	8.45	8.21	7.83
0.44946	9.58	9.22	8.74	8.42	8.12	7.81
0.50085	9.35	9.00	8.59	8.25	8.07	7.73

Table 4.150: Hydration number (n_H) of L-glutamine in aqueous solution of 0.50 $mol.kg^{-1}$ vitamin B6 as a function of molality ($m/mol.kg^{-1}$) at different temperature

L-glutamine + aqueous solution of 0.50 $mol.kg^{-1}$ vitamin B6						
$m/mol.kg^{-1}$	n_H					
	293.15K	298.15K	303.15K	308.15K	313.15K	318.15K
0.04998	10.85	10.55	10.35	9.96	9.70	9.29
0.10045	10.65	10.47	10.21	9.84	9.60	9.29
0.14957	10.55	10.37	10.14	9.79	9.42	9.15
0.20000	10.50	10.28	10.04	9.75	9.31	9.03
0.25000	10.42	10.16	9.92	9.67	9.13	8.95
0.29887	10.23	10.04	9.87	9.57	9.04	8.85
0.34948	10.19	9.98	9.75	9.52	8.96	8.70
0.39978	10.14	9.86	9.69	9.39	8.90	8.68
0.44888	10.02	9.72	9.61	9.34	8.91	8.68
0.50097	9.96	9.61	9.42	9.14	8.76	8.54

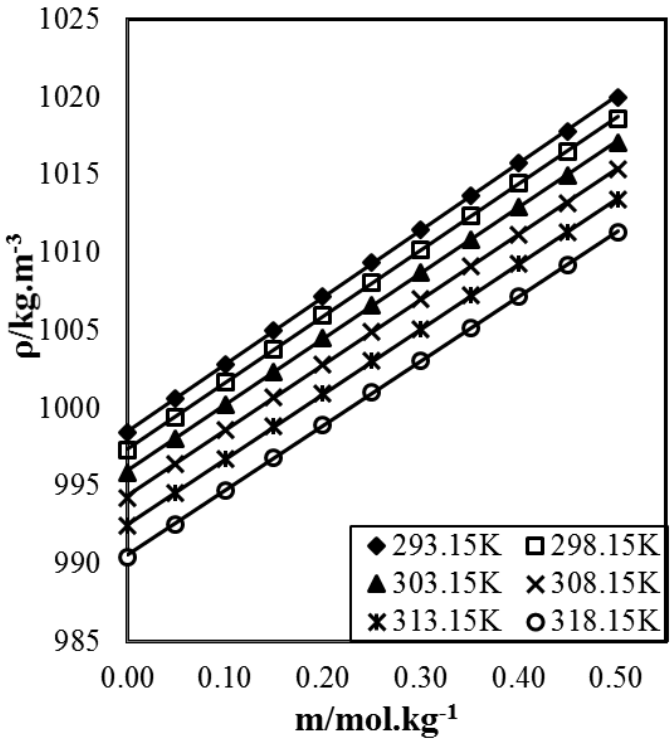


Figure 4.1**:** Plots of Density (ρ) vs. Molality (m) of L-serine in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

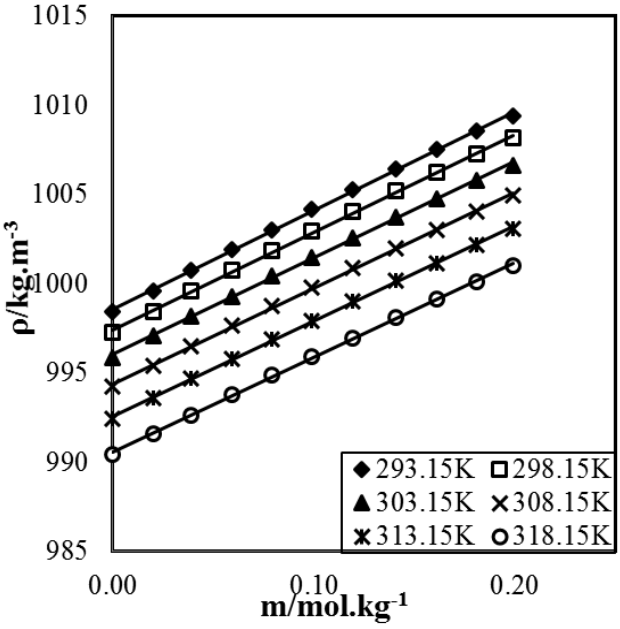


Figure 4.2**:** Plots of Density (ρ) vs. Molality (m) of L-asparagine in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

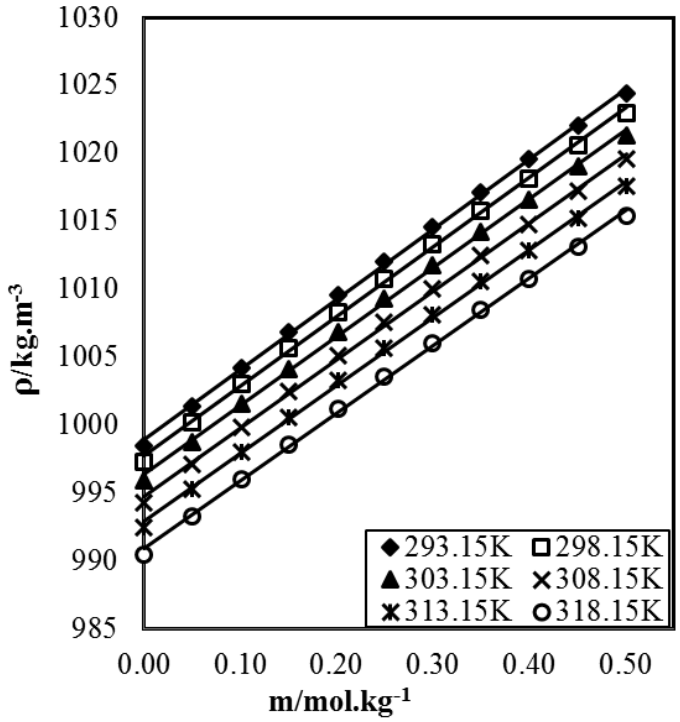


Figure 4.3: Plots of Density (ρ) vs. Molality (m) of L-glutamine in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

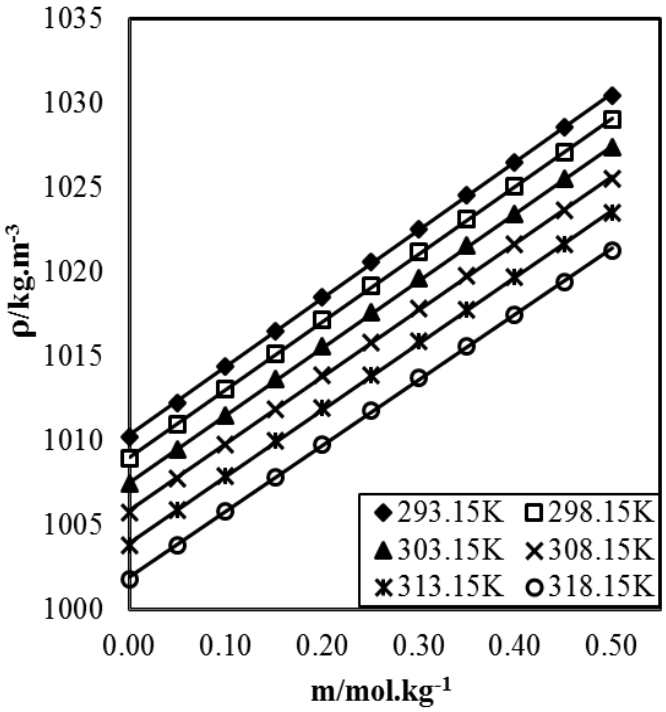


Figure 4.4: Plots of Density (ρ) vs. Molality (m) of L-serine + 0.05 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

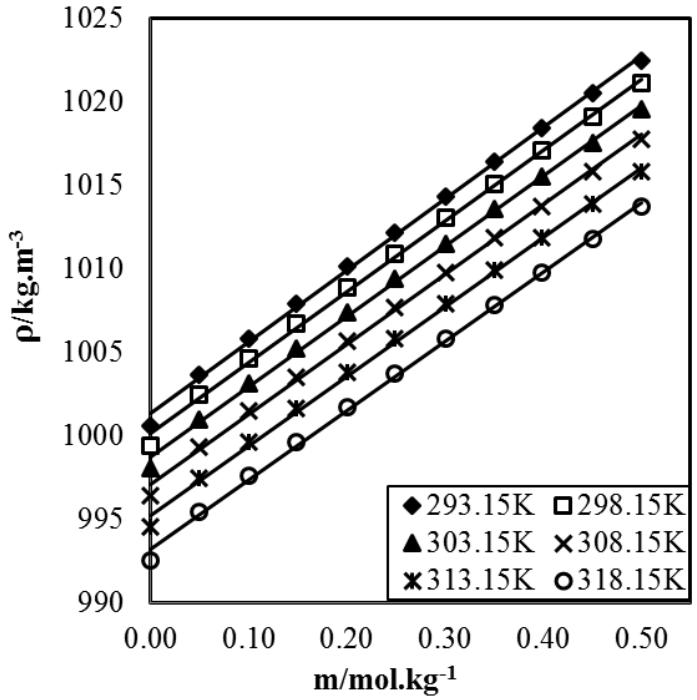


Figure 4.5: Plots of Density (ρ) vs. Molality (m) of L-serine + 0.20 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

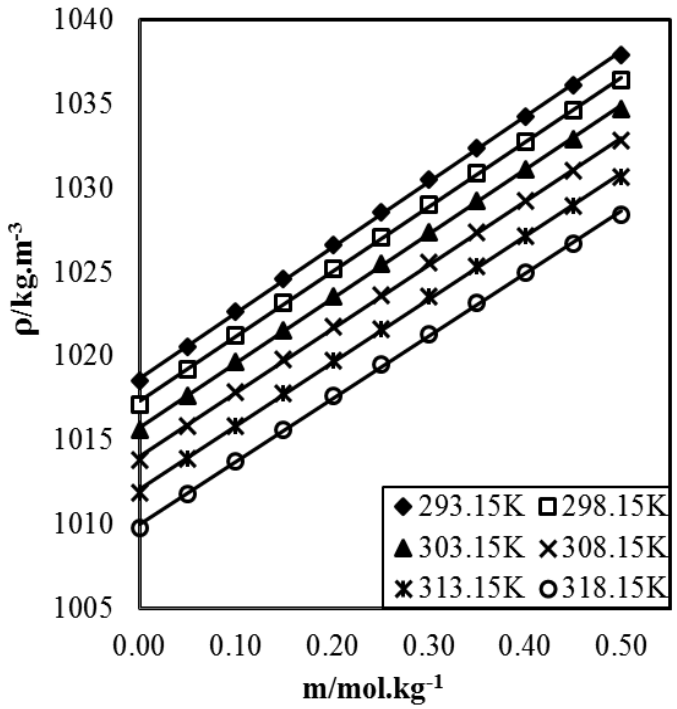


Figure 4.6: Plots of Density (ρ) vs. Molality (m) of L-serine + 0.35 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

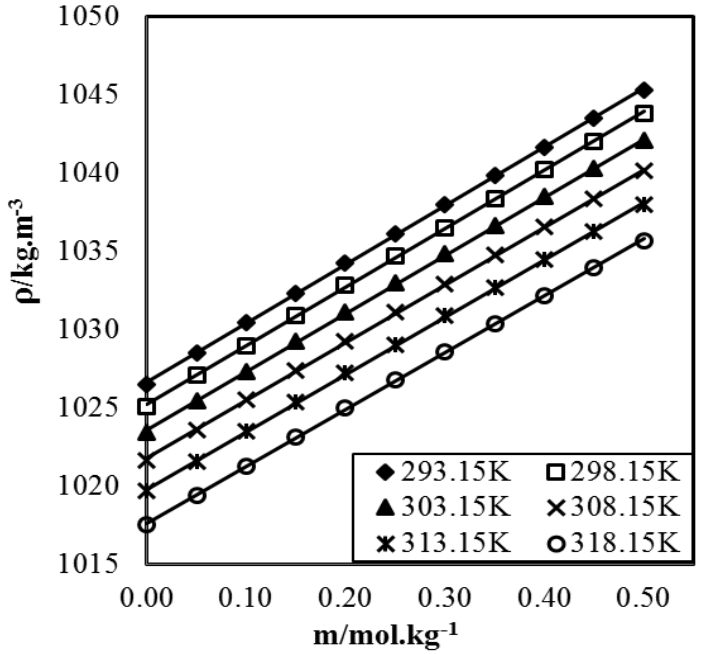


Figure 4.7: Plots of Density (ρ) vs. Molality (m) of L-serine + 0.50 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

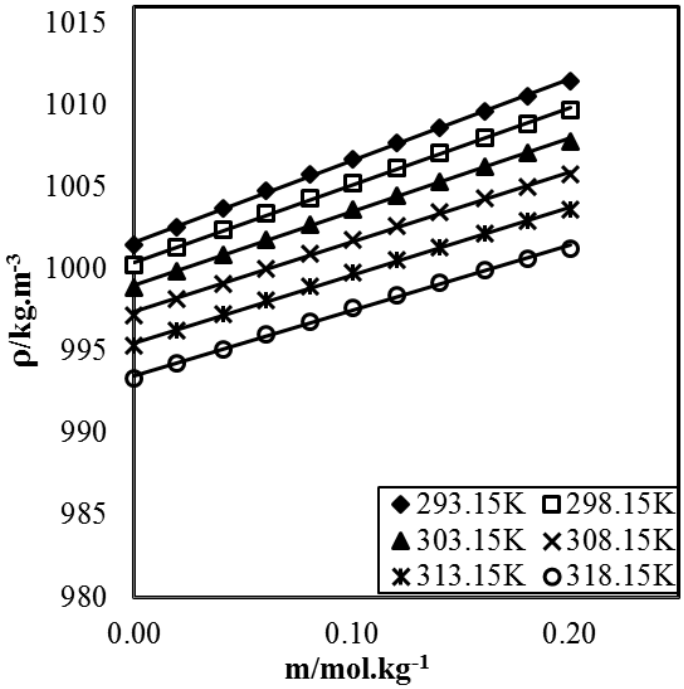


Figure 4.8: Plots of Density (ρ) vs. Molality (m) of L-asparagine + 0.05 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

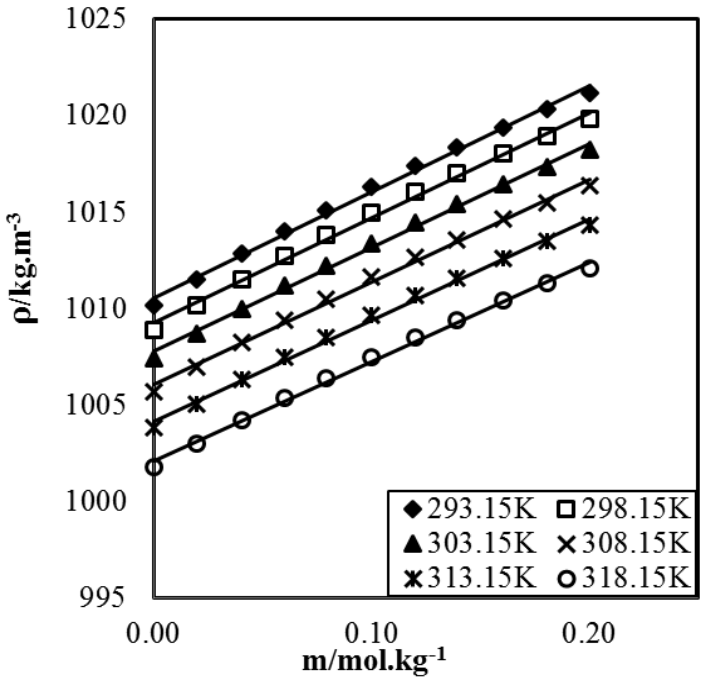


Figure 4.9: Plots of Density (ρ) vs. Molality (m) of L-asparagine + 0.20 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

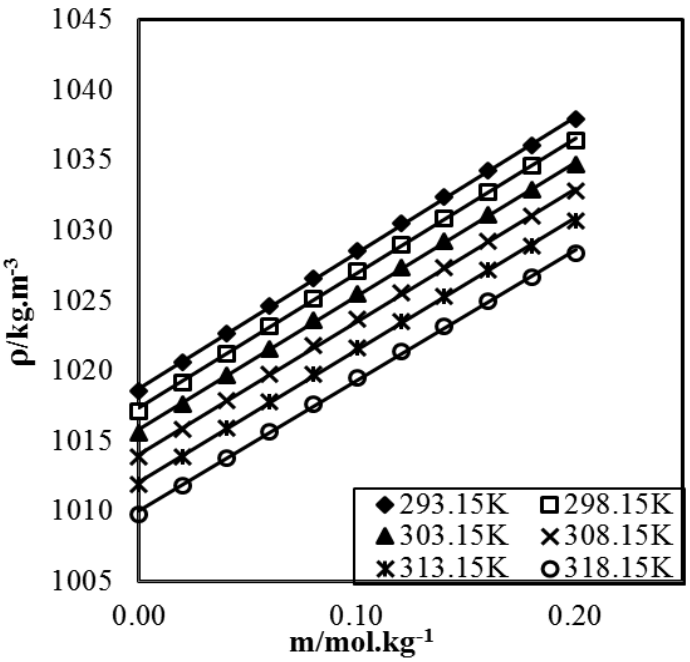


Figure 4.10: Plots of Density (ρ) vs. Molality (m) of L-asparagine + 0.35 mol.kg-^{1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

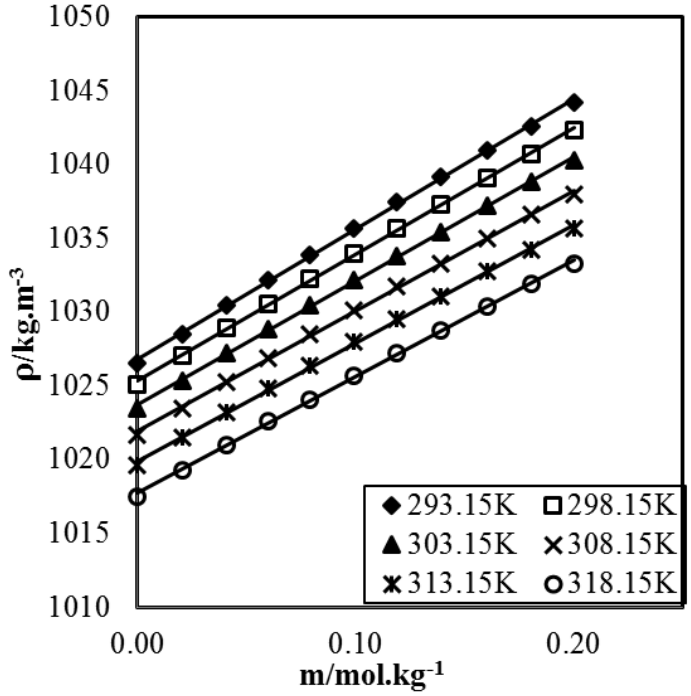


Figure 4.11: Plots of Density (ρ) vs. Molality (m) of L-asparagine + 0.50 mol.kg-^{1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

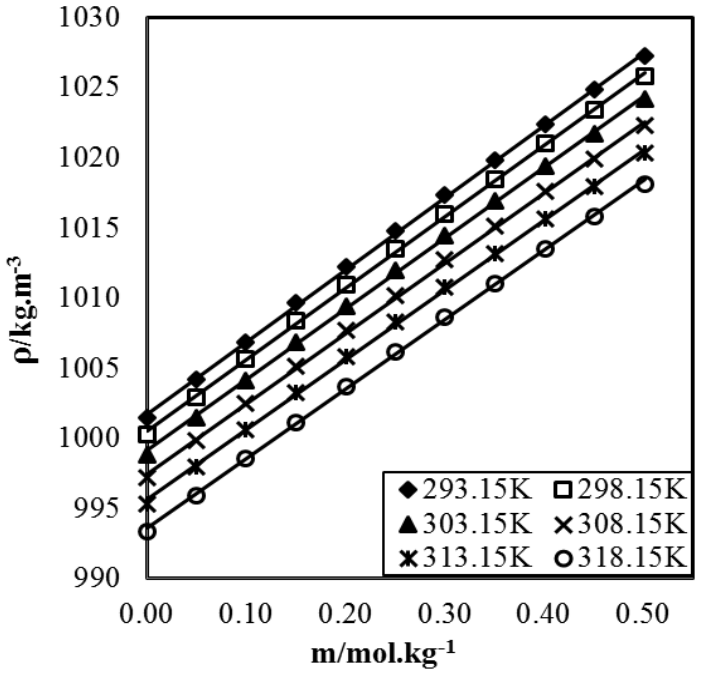


Figure 4.12: Plots of Density (ρ) vs. Molality (m) of L-glutamine + 0.05 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

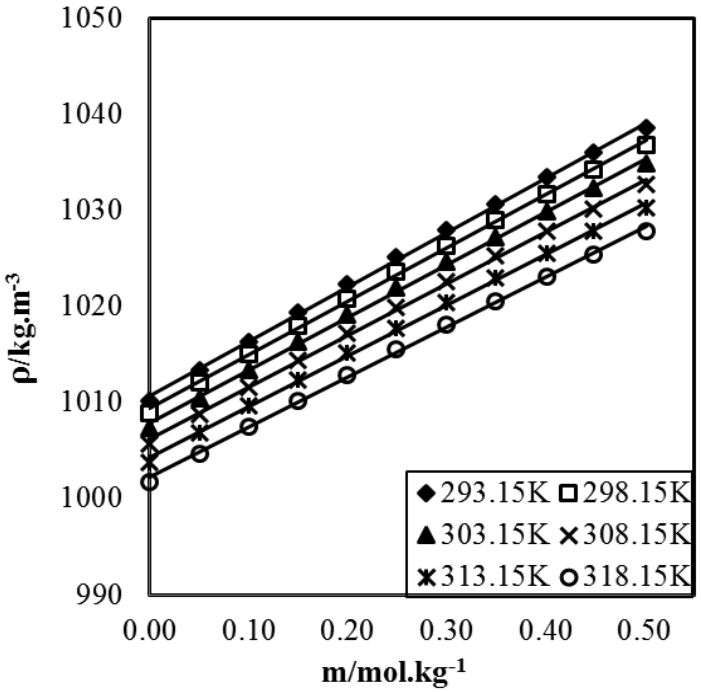


Figure 4.13: Plots of Density (ρ) vs. Molality (m) of L-glutamine + 0.20 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

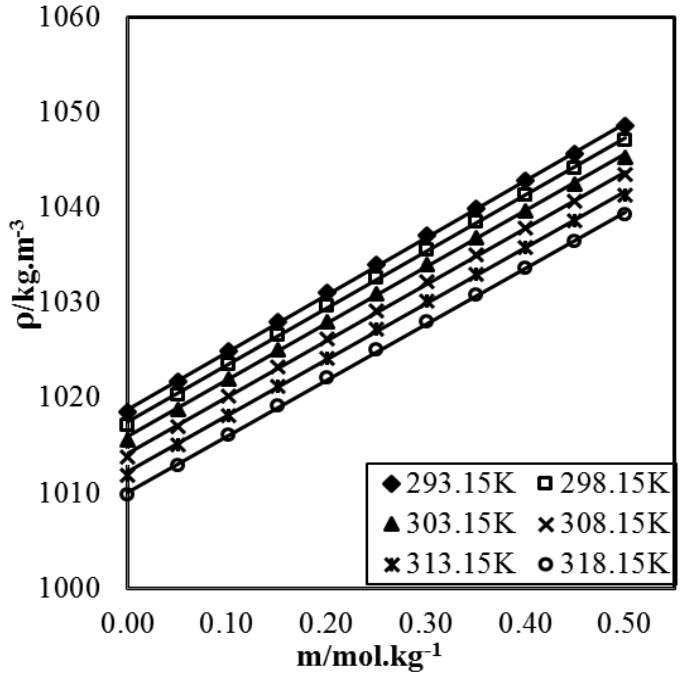


Figure 4.14: Plots of Density (ρ) vs. Molality (m) of L-glutamine + 0.35 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

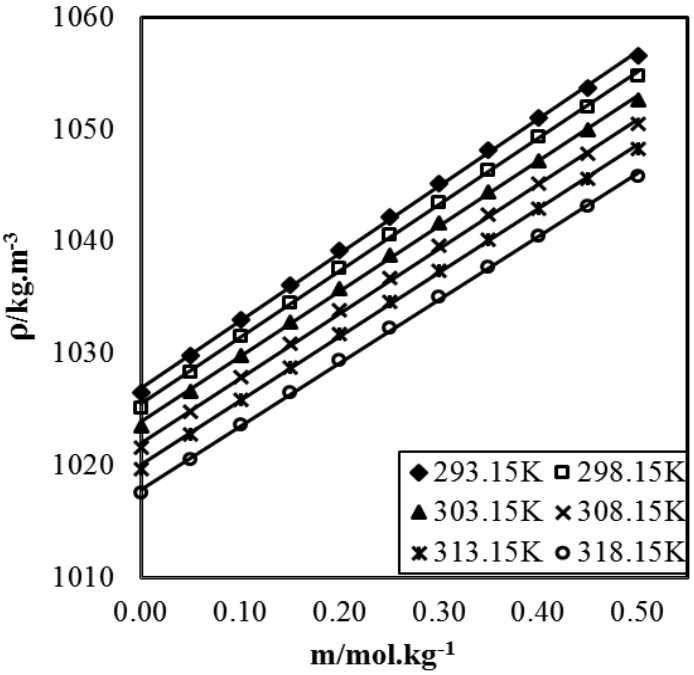


Figure 4.15: Plots of Density (ρ) vs. Molality (m) of L-glutamine + 0.50 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

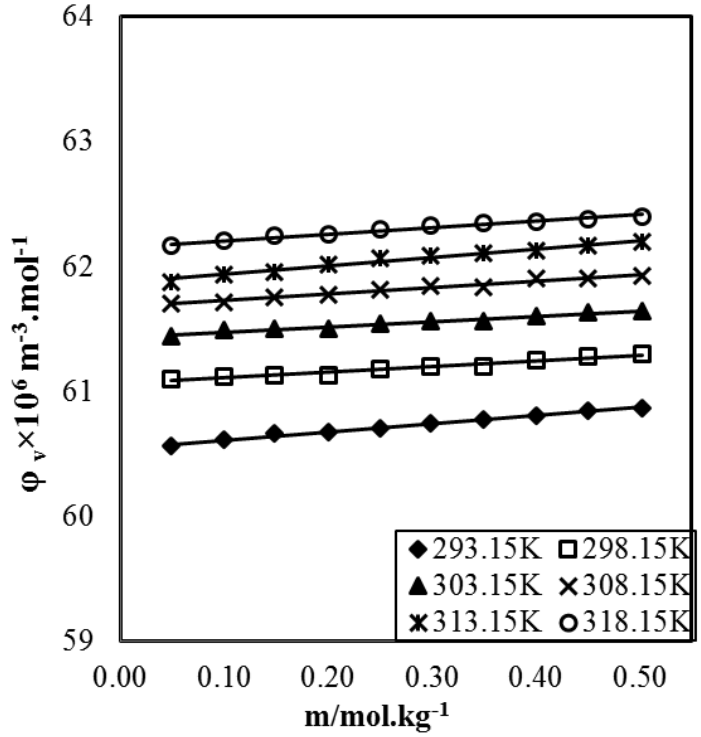


Figure 4.16:Plots of Apparent molar volume (φ_v) vs. Molality of L-serine system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

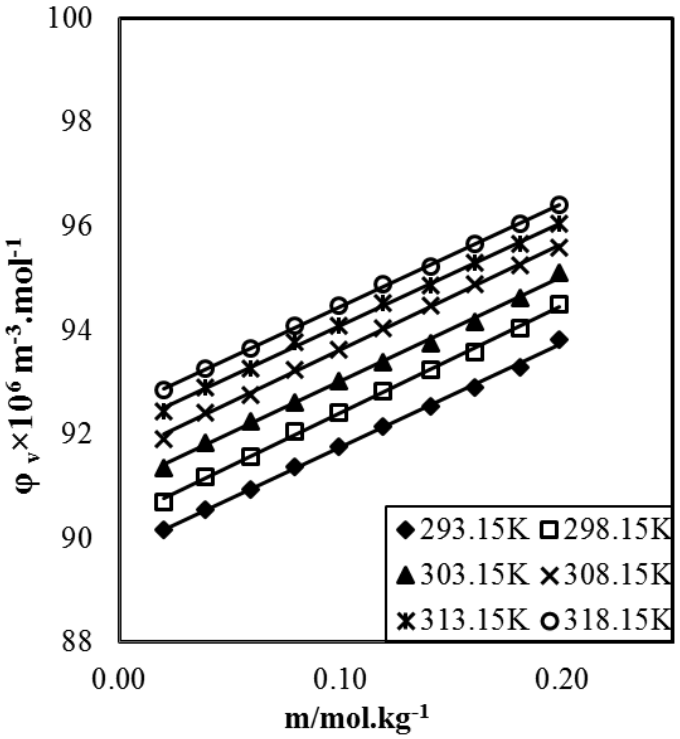


Figure 4.17: Plots of Apparent molar volume (φ_v) vs. Molality of L-asparagine systems at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

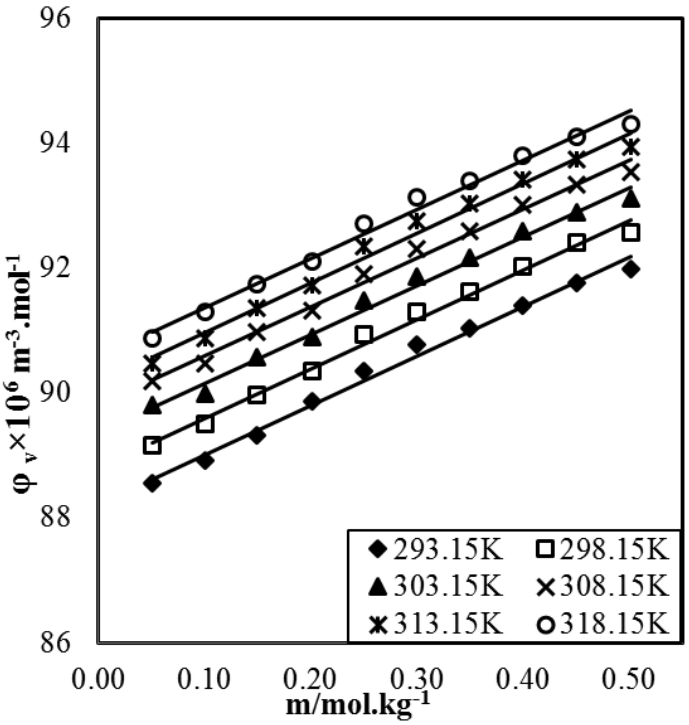


Figure 4.18: Plots of Apparent molar volume (φ_v) vs. Molality of L-Glutamine systems at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

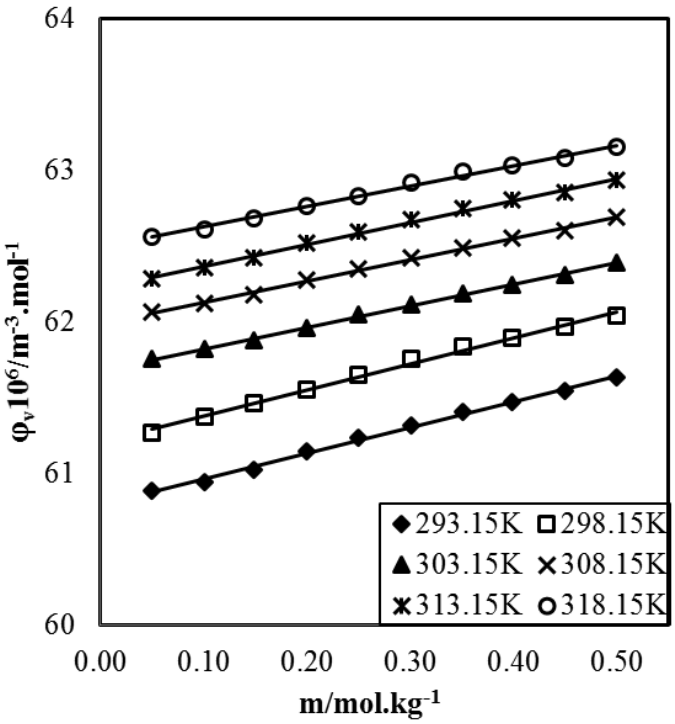


Figure 4.19: Plots of Apparent molar volume (φ_v) vs. Molality of L-serine + 0.05 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

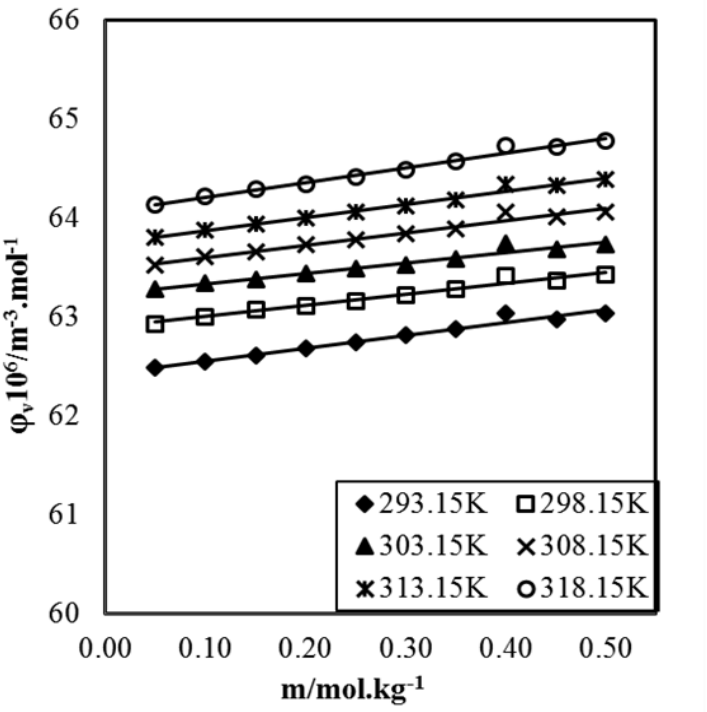


Figure 4.20: Plots of Apparent molar volume (φ_v) vs. Molality of L-serine + 0.20 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

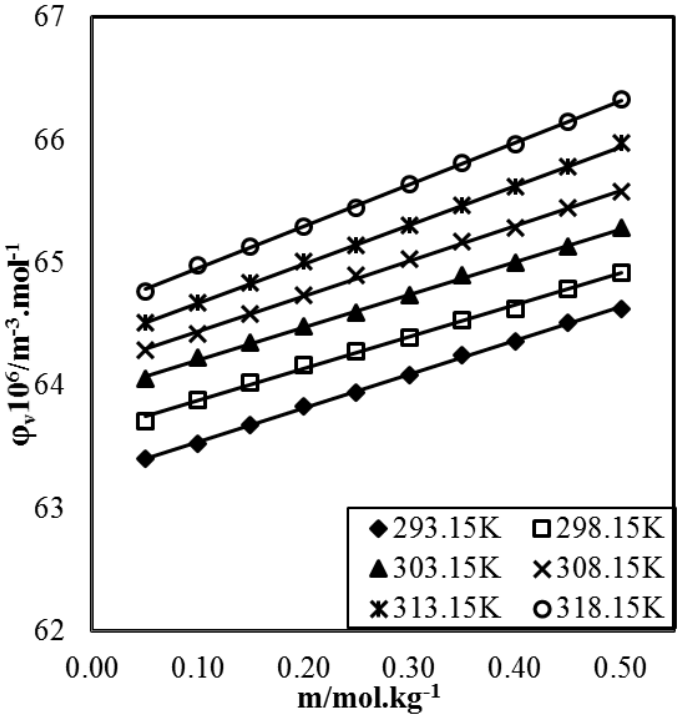


Figure 4.21: Plots of Apparent molar volume (φ_v) vs. Molality of L-serine + 0.35 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

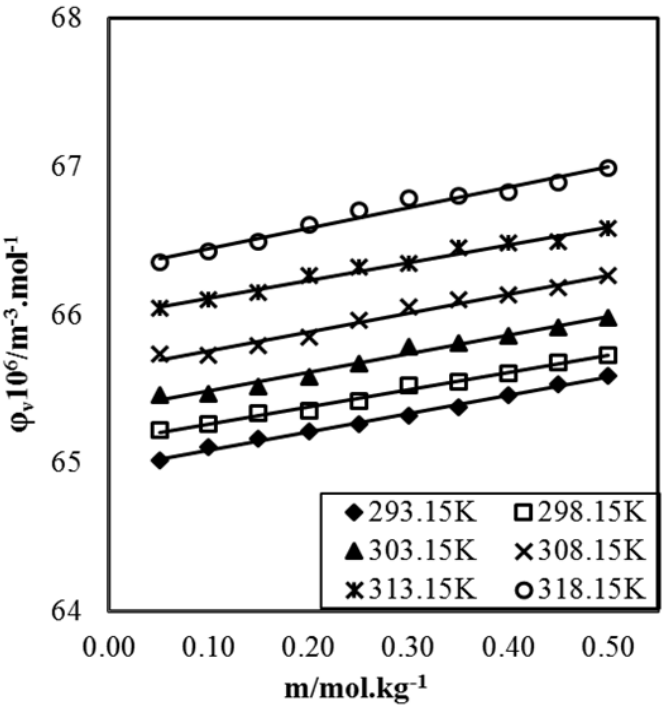


Figure 4.22: Plots of Apparent molar volume (φ_v) vs. Molality of L-serine + 0.50 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

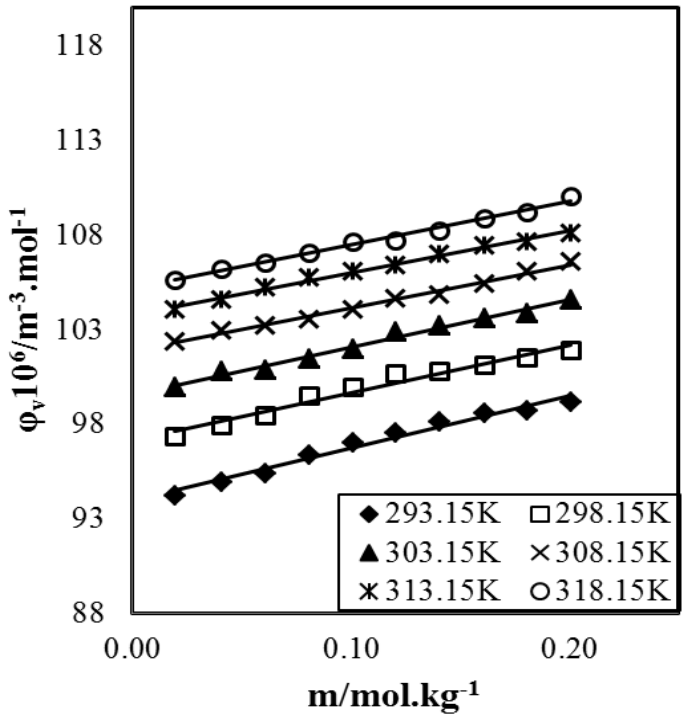


Figure 4.23: Plots of Apparent molar volume (φ_v) vs. Molality of L-asparagine + 0.05 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

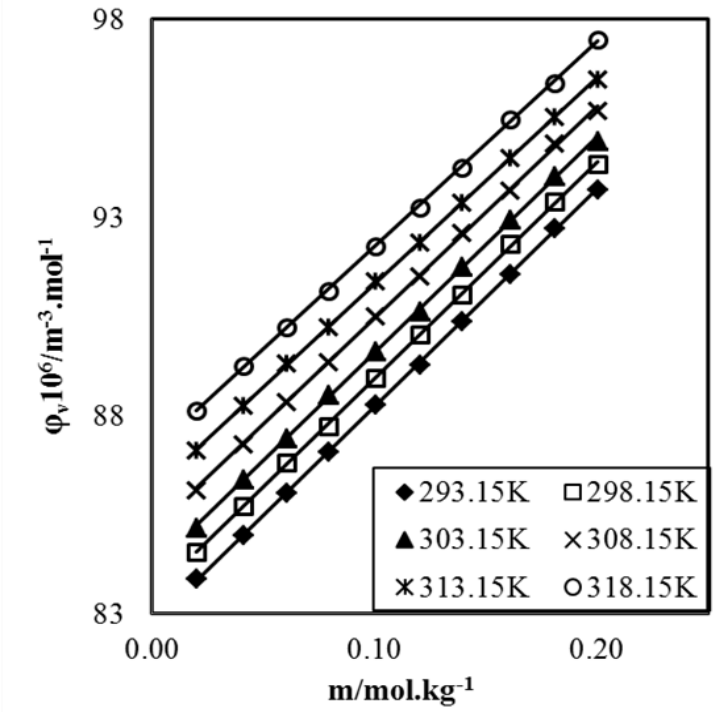


Figure 4.24: Plots of Apparent molar volume (φ_v) vs. Molality of L-asparagine + 0.20 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

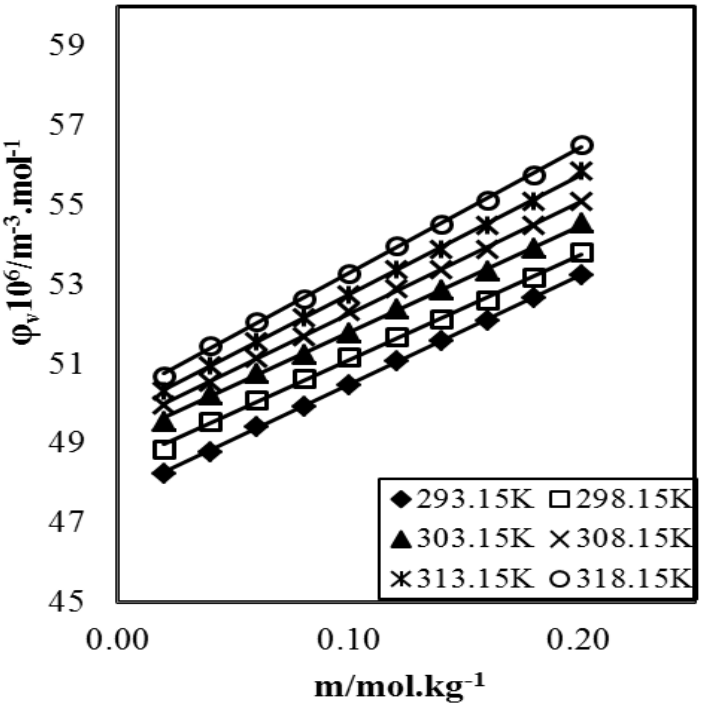


Figure 4.25: Plots of Apparent molar volume (φ_v) vs. Molality of L-asparagine + 0.35 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

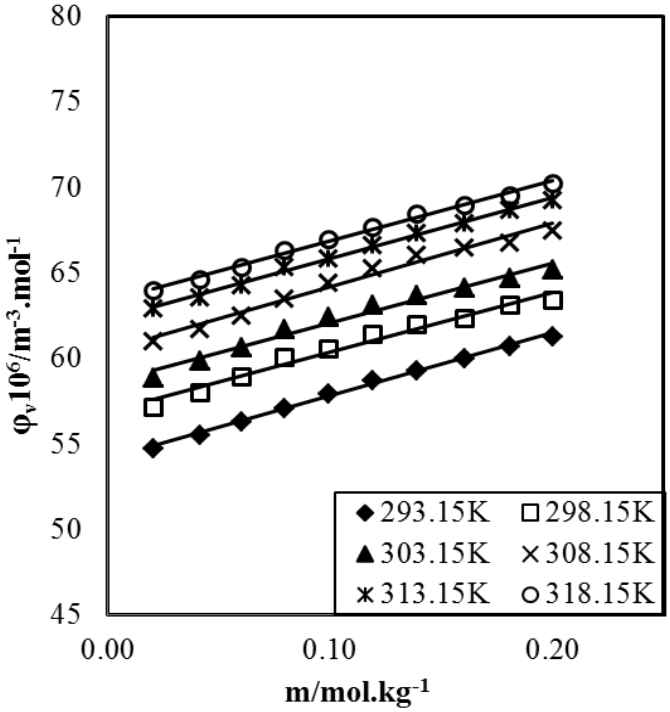


Figure 4.26: Plots of Apparent molar volume (φ_v) vs. Molality of L-asparagine + 0.50 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

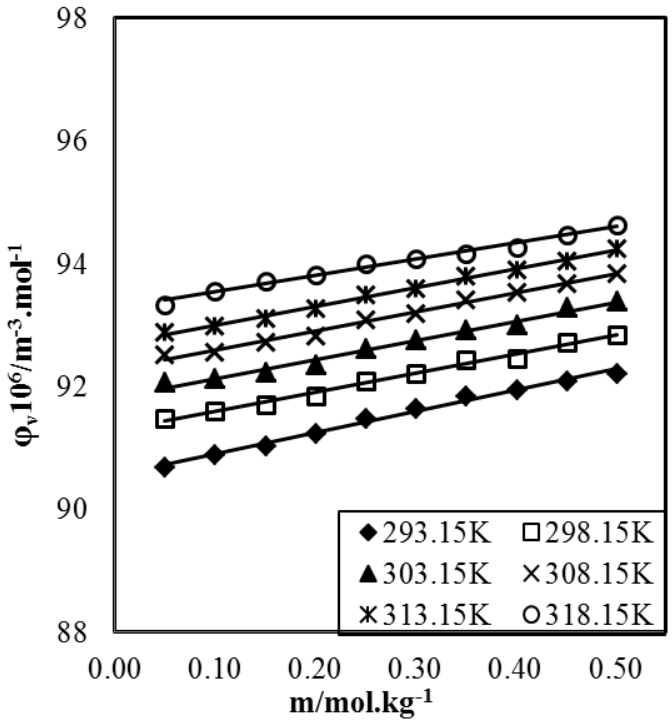


Figure 4.27: Plots of Apparent molar volume (φ_v) vs. Molality of L-glutamine + 0.05 mol.kg^{-1}vitamin B6 in water systems at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

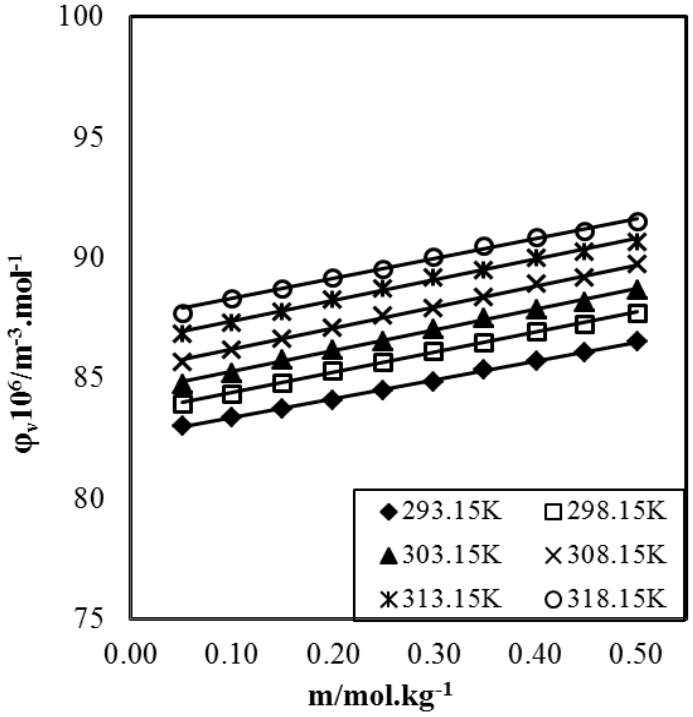


Figure 4.28: Plots of Apparent molar volume (φ_v) vs. Molality of L-glutamine + 0.20 mol.kg^{-1} vitamin B6 in water systems at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

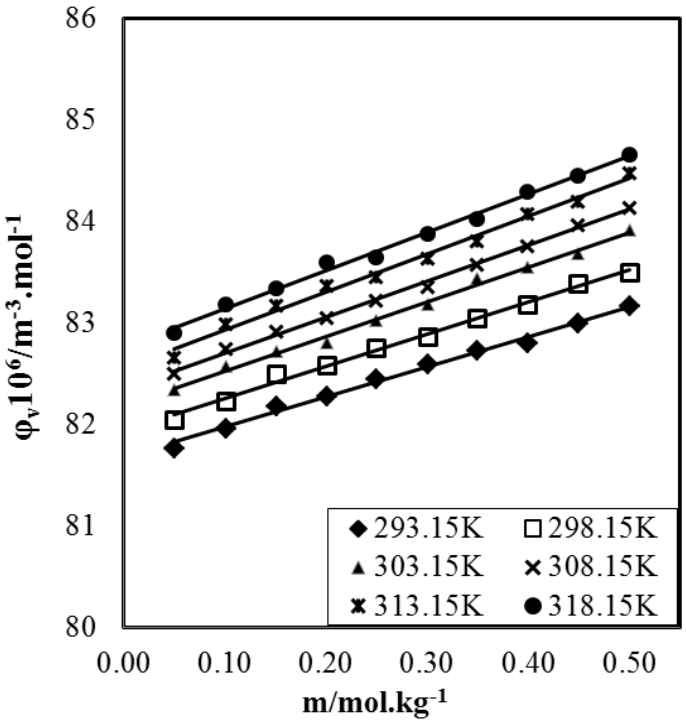


Figure 4.29: Plots of Apparent molar volume (φ_v) vs. Molality of L-glutamine + 0.35 mol.kg^{-1} vitamin B6 in water systems at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

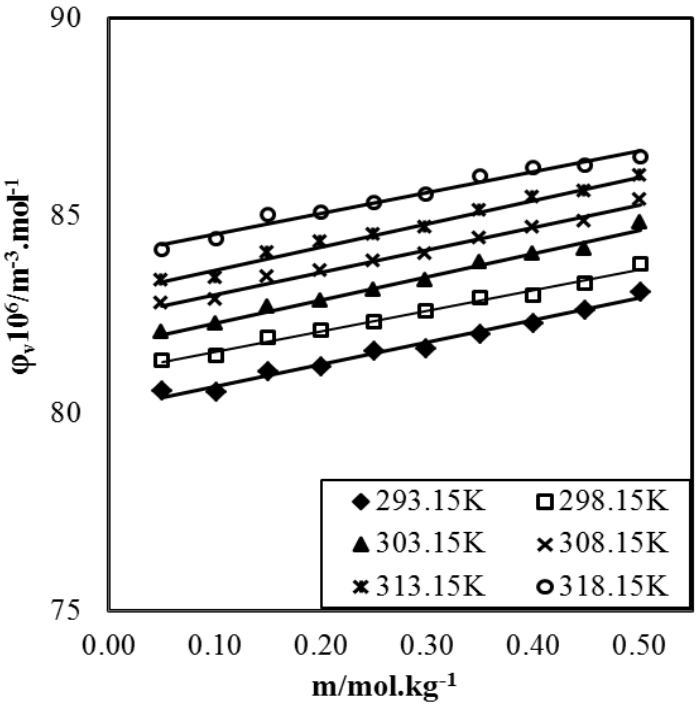


Figure 4.30: Plots of Apparent molar volume (φ_v) vs. Molality of L-glutamine + 0.50 mol.kg^{-1} vitamin B6 in water systems at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

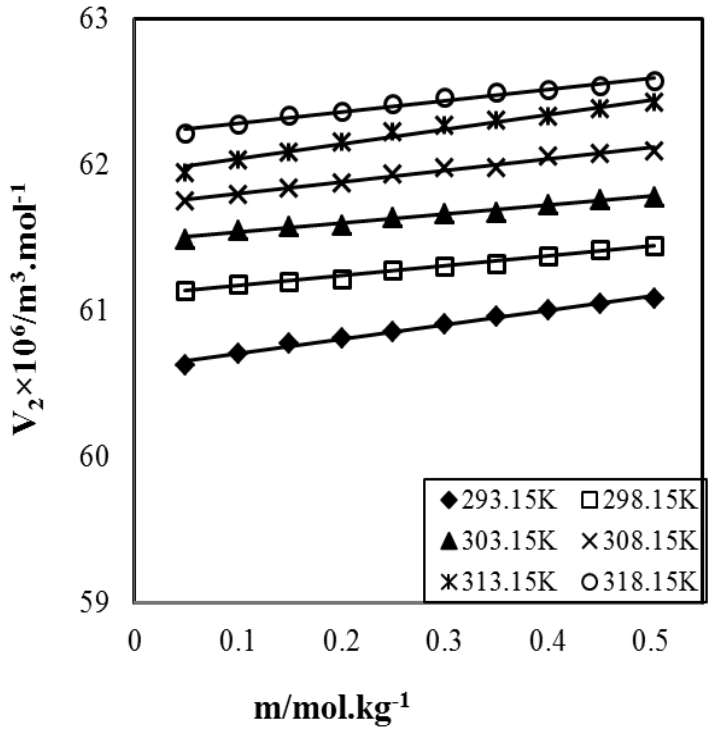


Figure 4.31: Plots of Partial molar volume (V_2) vs. Molality of L-serine in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

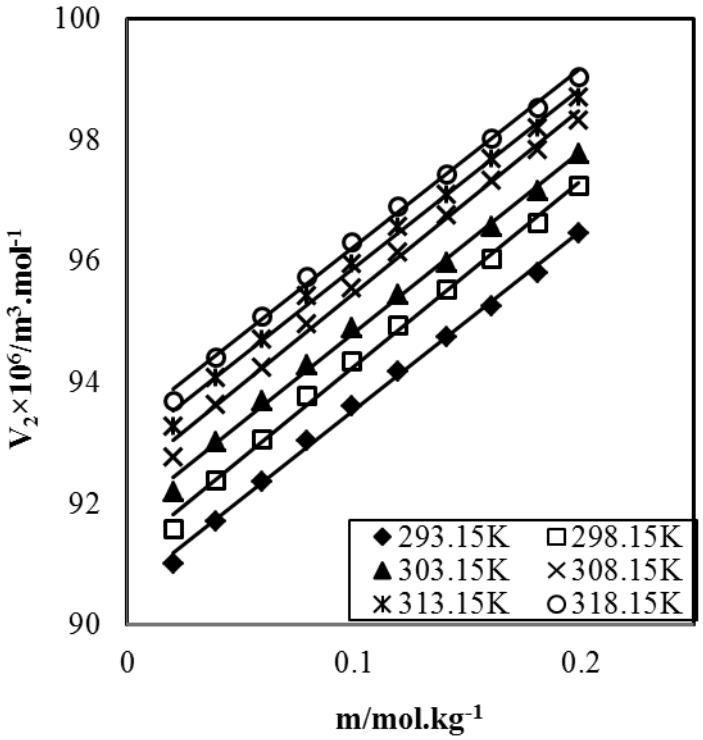


Figure 4.32: Plots of Partial molar volume (V_2) vs. Molality of L-asparagine system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

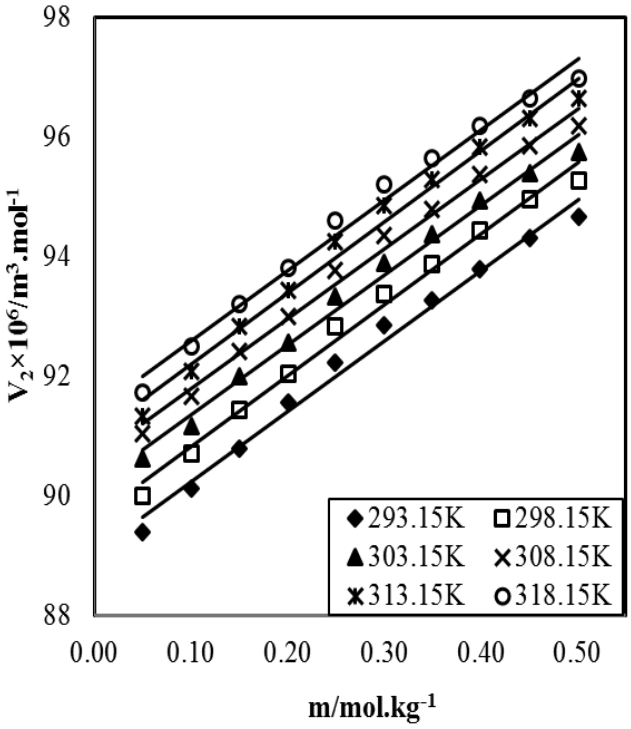


Figure 4.33: Plots of Partial molar volume (V_2) vs. Molality of L-glutamine systems at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

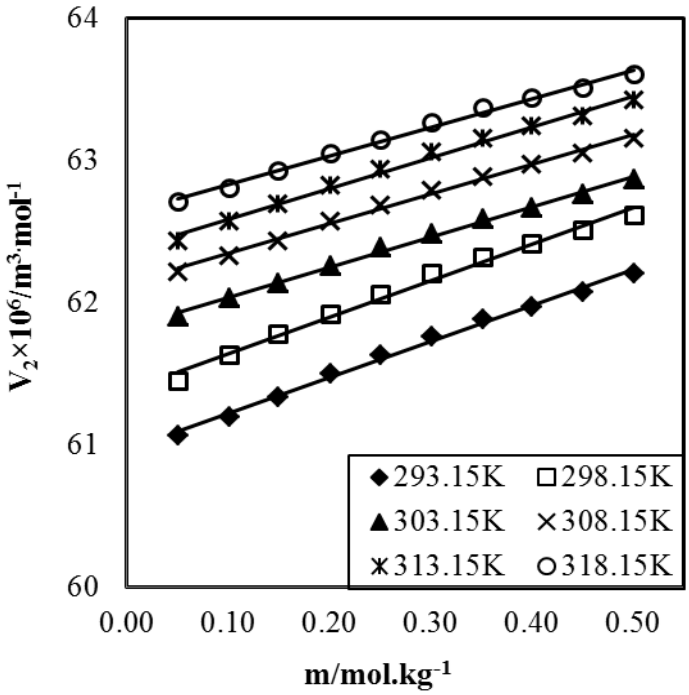


Figure 4.34: Plots of Partial molar volume (V_2) vs. Molality of L-serine + 0.05 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respective

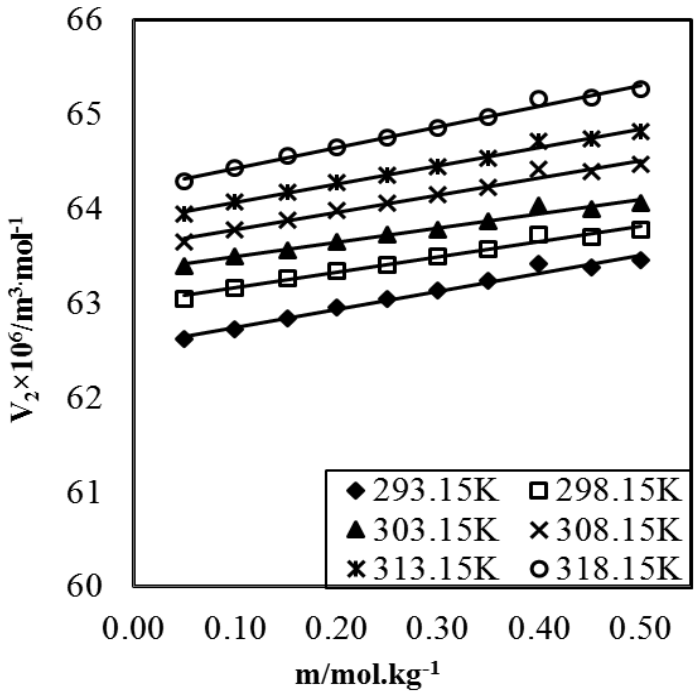


Figure 4.35: Plots of Partial molar volume (V_2) vs. Molality of L-serine + 0.20 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

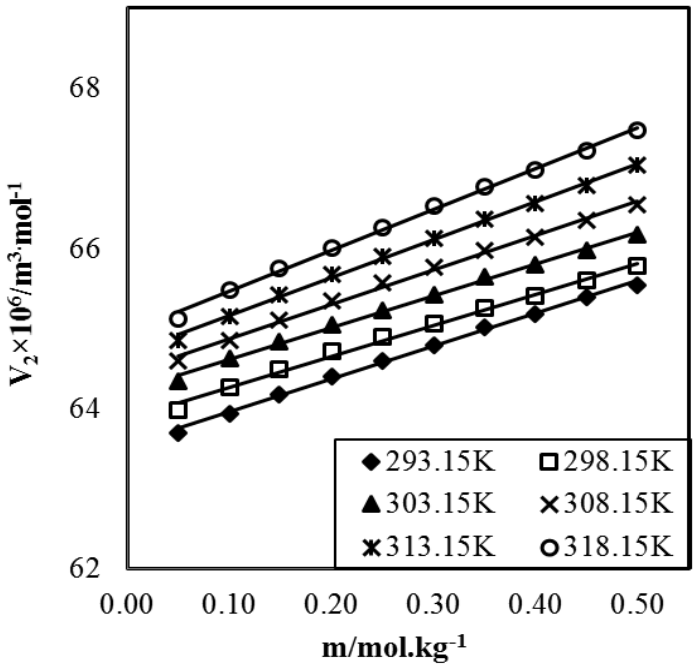


Figure 4.36: Plots of Partial molar volume (V_2) vs. Molality of L-serine + 0.35 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

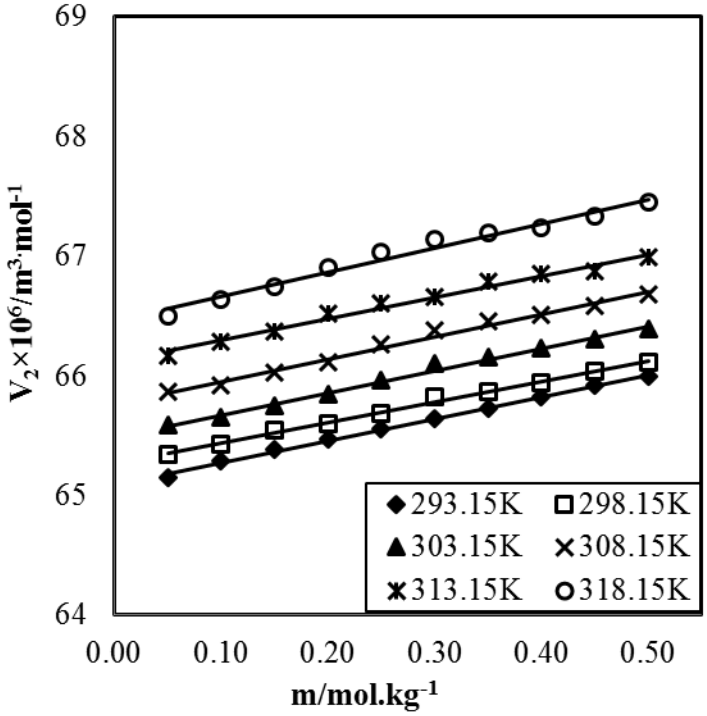


Figure 4.37: Plots of Partial molar volume (V_2) vs. Molality of L-serine + 0.50 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

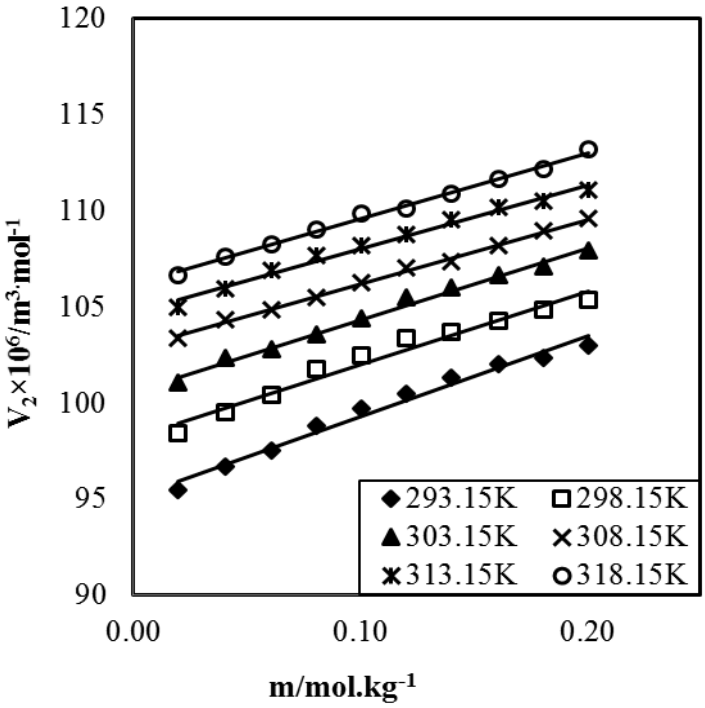


Figure 4.38: Plots of Partial molar volume (V_2) vs. Molality of L-asparagine + 0.05 mol.kg-^{1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respective.

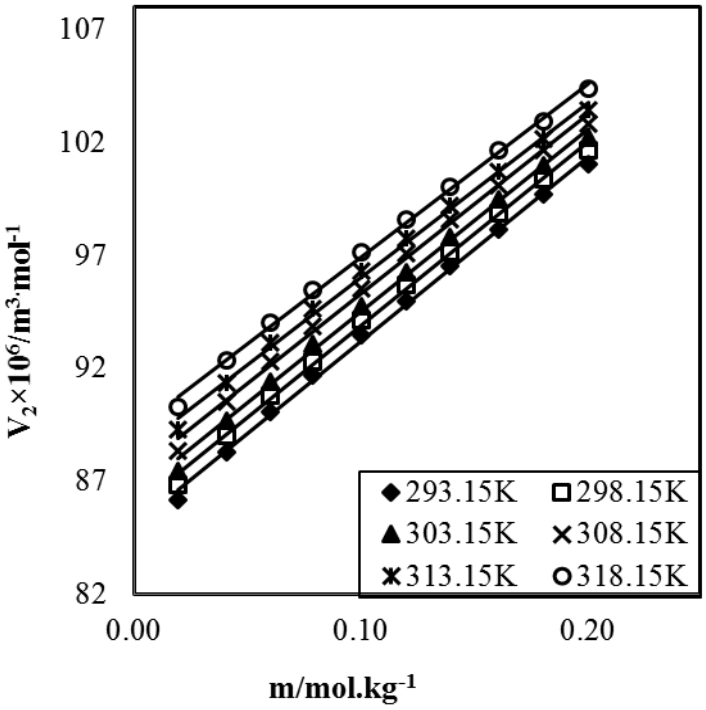


Figure 4.39: Plots of Partial molar volume (V_2) vs. Molality of L-asparagine + 0.20 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respective.

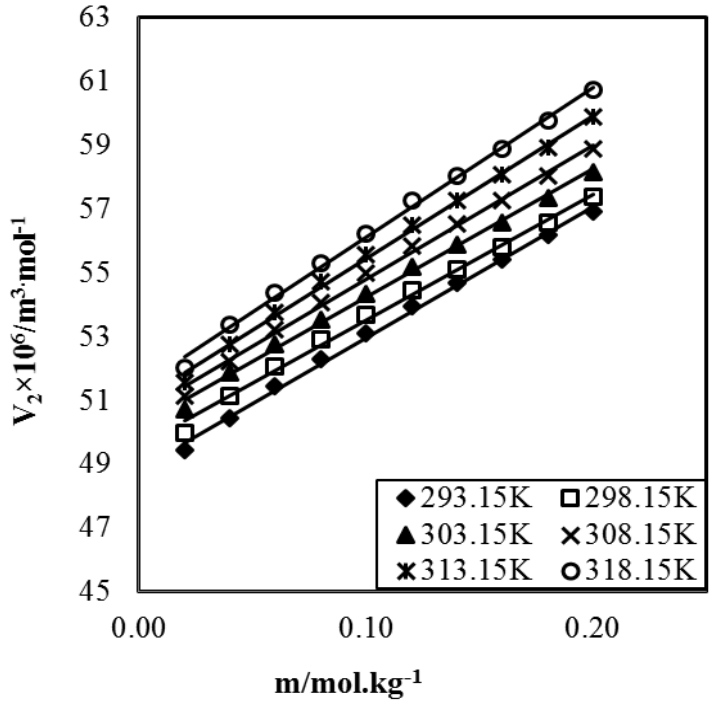


Figure 4.40: Plots of Partial molar volume (V_2) vs. Molality of L-asparagine + 0.35 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respective.

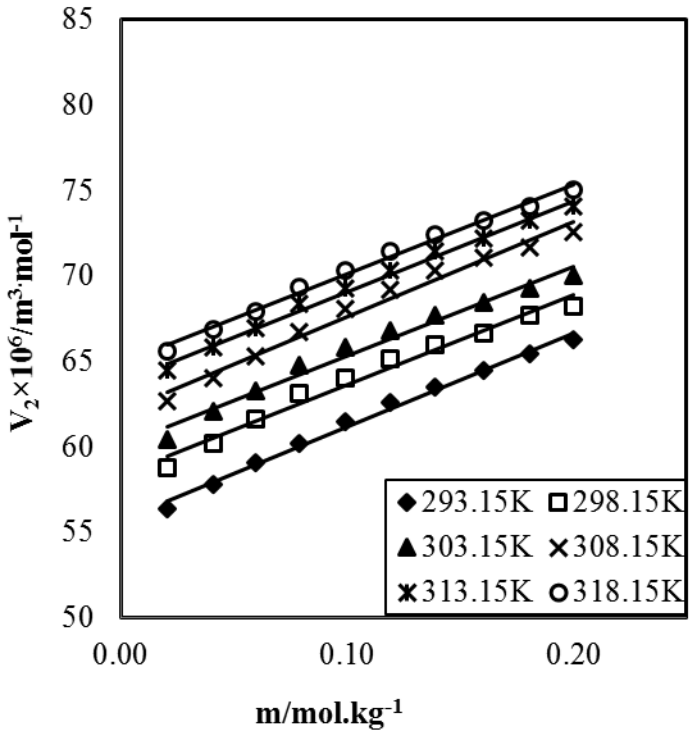


Figure 4.41: Plots of Partial molar volume (V_2) vs. Molality of L-asparagine + 0.5 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respective

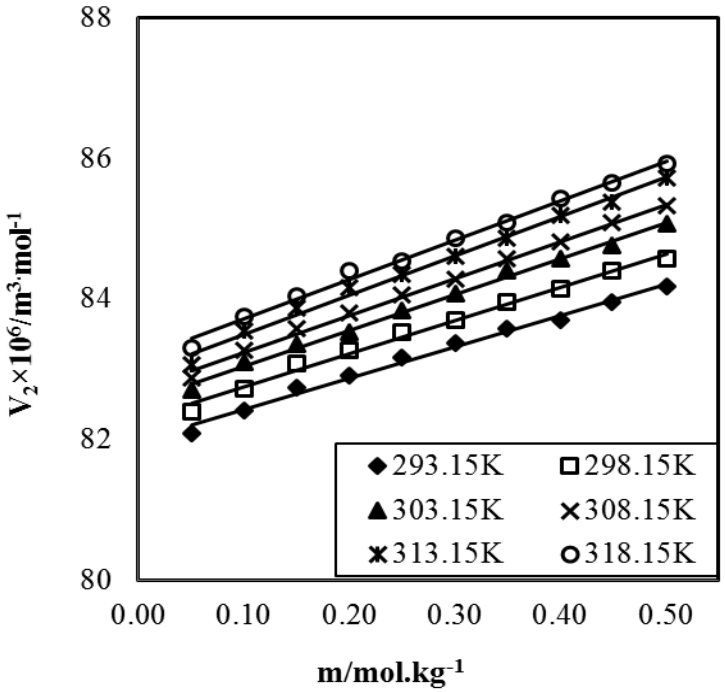


Figure 4.42: Plots of Partial molar volume (V_2) vs. Molality of L-glutamine + 0.05 mol.kg^{-1} vitamin B6 in water systems at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

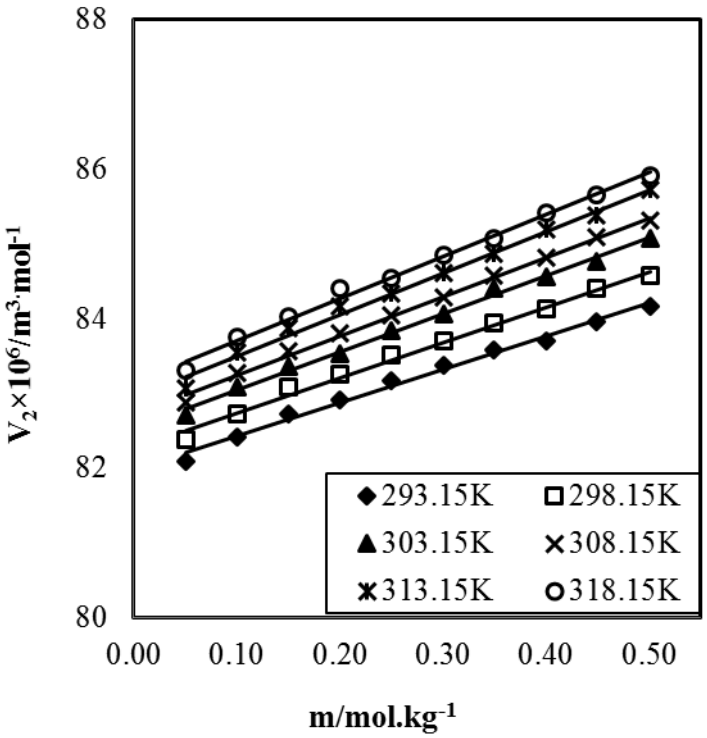


Figure 4.43: Plots of Partial molar volume (V_2) vs. Molality of L-glutamine + 0.2 mol.kg^{-1} vitamin B6 in water systems at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

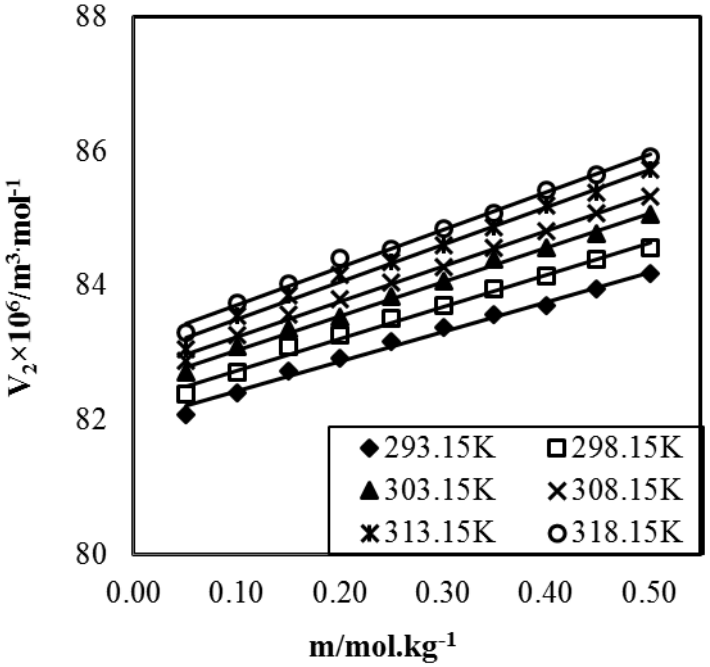


Figure 4.44: Plots of Partial molar volume (V_2) vs. Molality of L-glutamine + 0.35 mol.kg^{-1} vitamin B6 in water systems at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

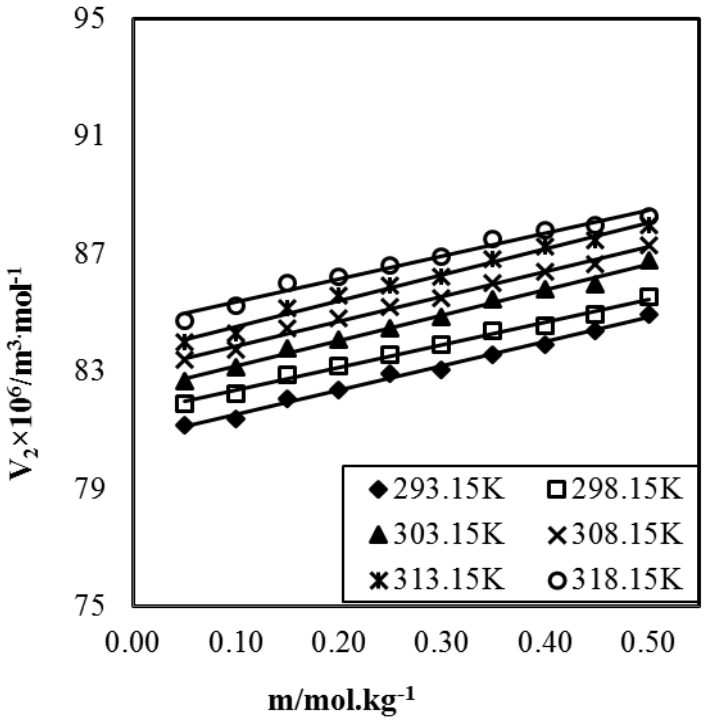


Figure 4.45: Plots of Partial molar volume (V_2) vs. Molality of L-glutamine + 0.5 mol.kg^{-1} vitamin B6 in water systems at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

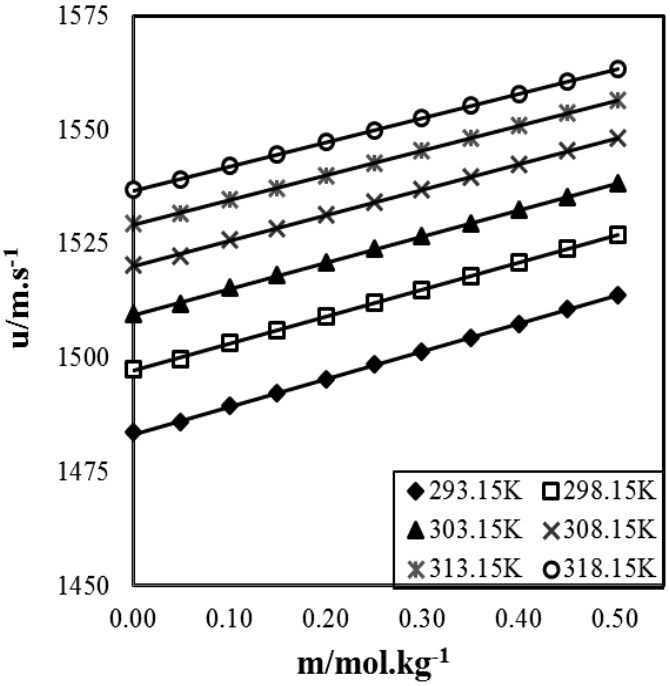


Figure 4.46**:** Plots of Sound velocity (u) vs. Molality (m) of L-serine in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

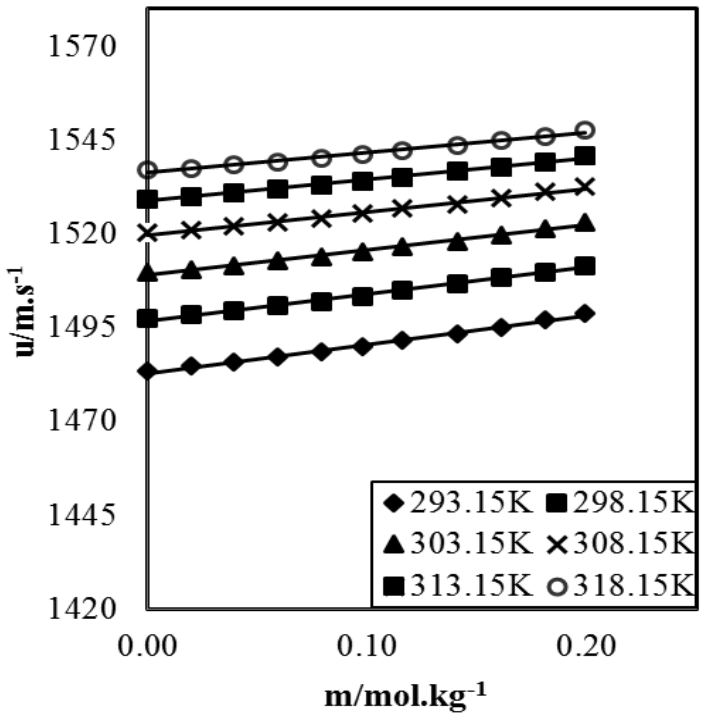


Figure 4.47: Plots of Sound velocity (u) vs. Molality (m) of L-asparagine in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

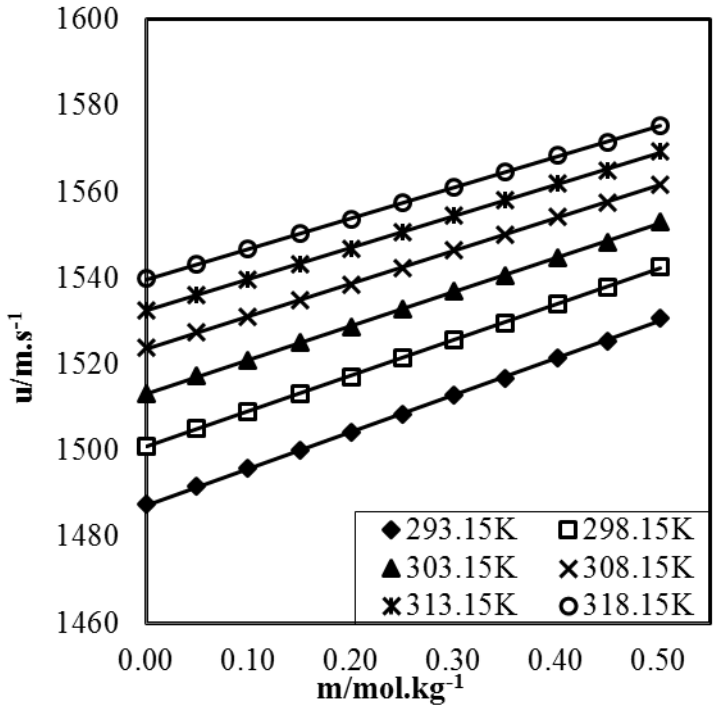


Figure 4.48**:** Plots of Sound velocity (u) vs. Molality (m) of L-glutamine in watersystem at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

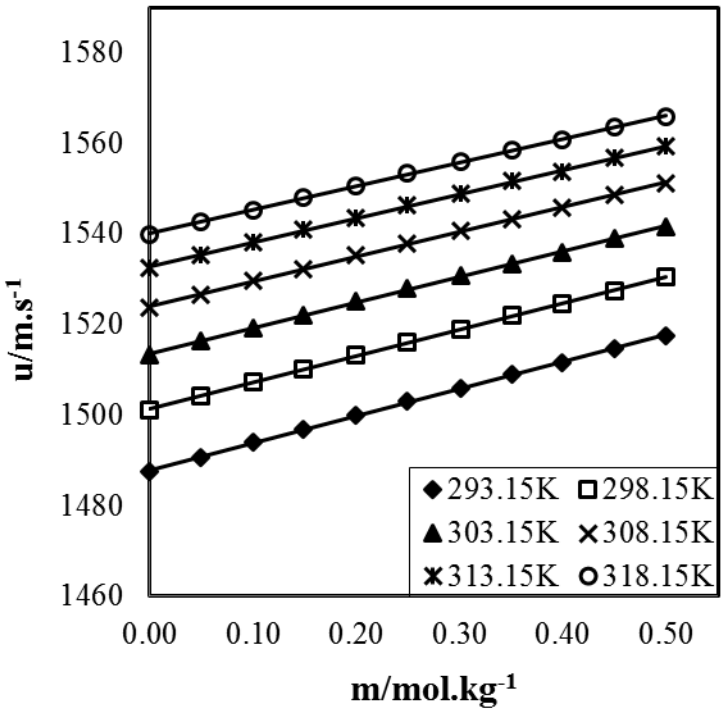


Figure 4.49: Plots of Sound velocity (u) vs. Molality (m) of L-serine + 0.05 $mol.kg^{-1}$ vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

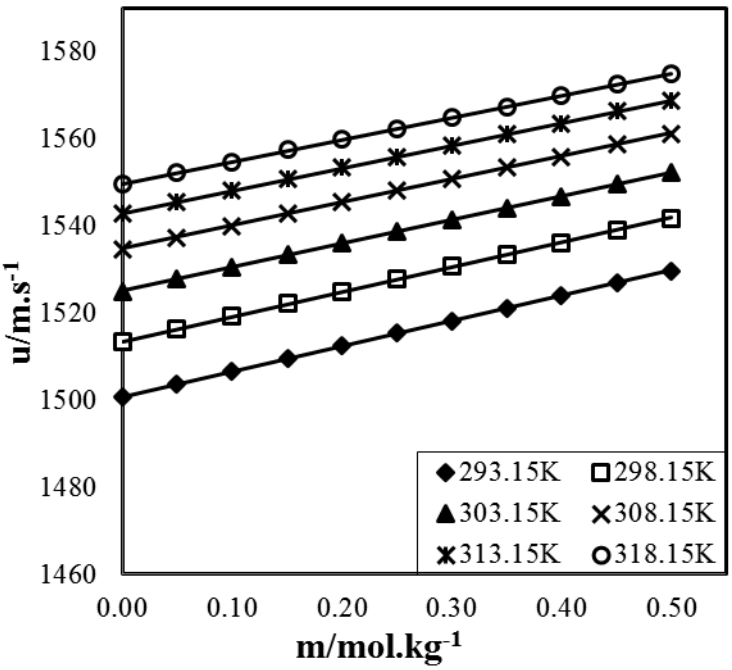


Figure 4.50: Plots of Sound velocity (u) vs. Molality (m) of L-serine + 0.20 $mol.kg^{-1}$ vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively

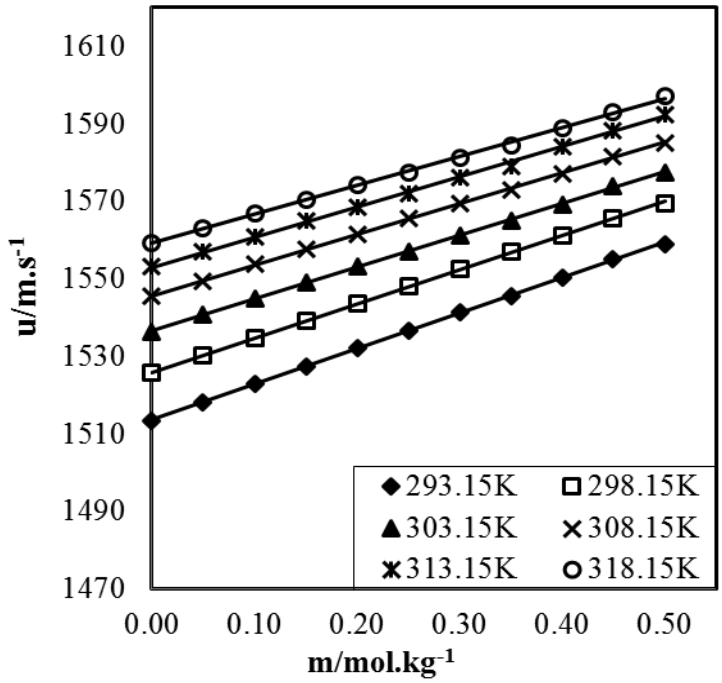


Figure 4.51: Plots of Sound velocity (u) vs. Molality (m) of L-serine + 0.35 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

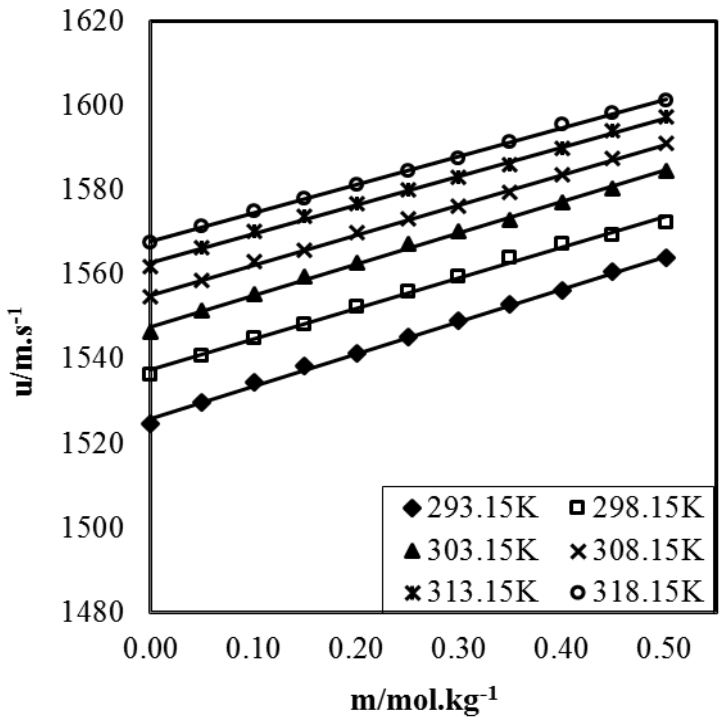


Figure 4.52: Plots of Sound velocity (u) vs. Molality (m) of L-serine + 0.50 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

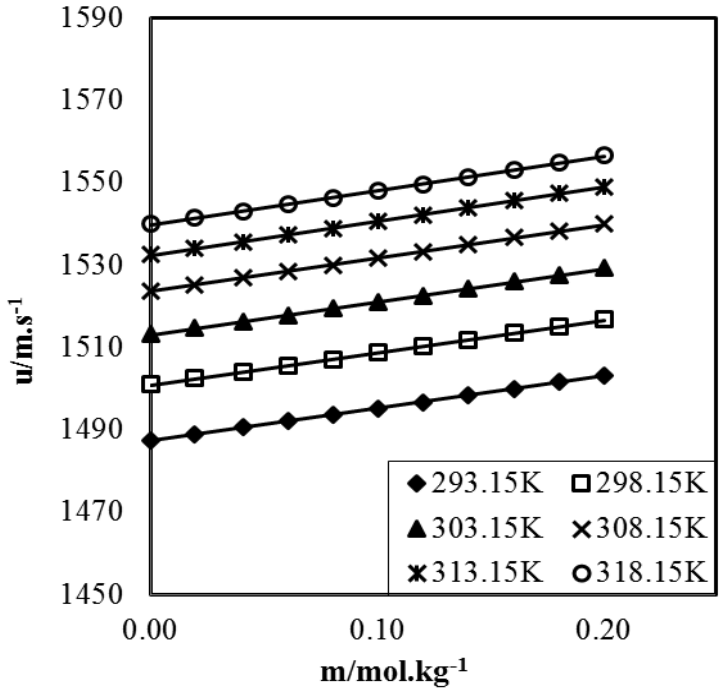


Figure 4.53: Plots of Sound velocity (u) vs. Molality (m) of L-asparagine + 0.05 mol.kg-^{1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

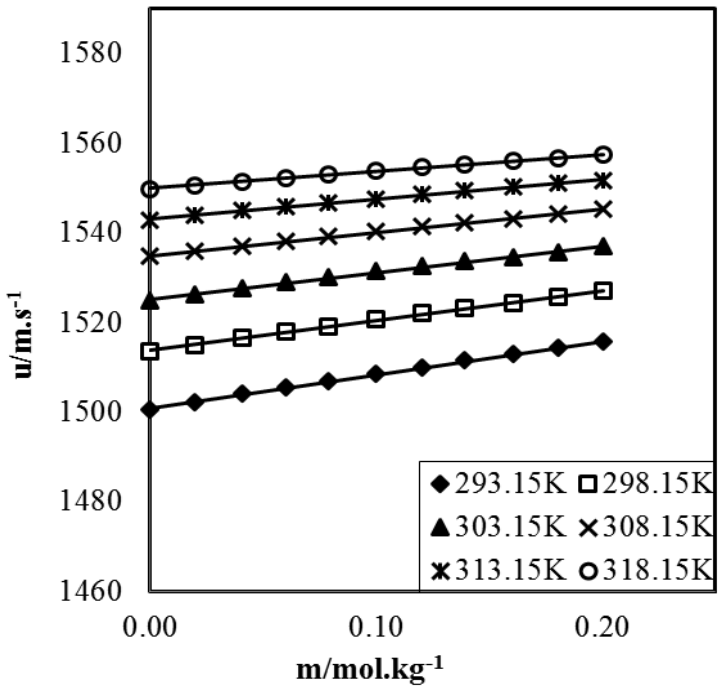


Figure 4.54: Plots of Sound velocity (u) vs. Molality (m) of L-asparagine + 0.20 mol.kg^{1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

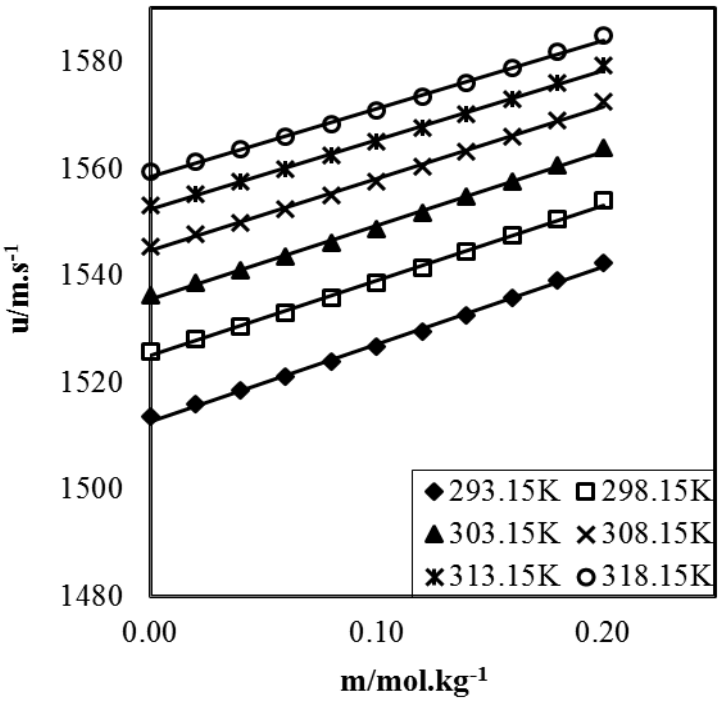


Figure 4.55: Plots of Sound velocity (u) vs. Molality (m) of L-asparagine + 0.35 mol.kg-^{1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

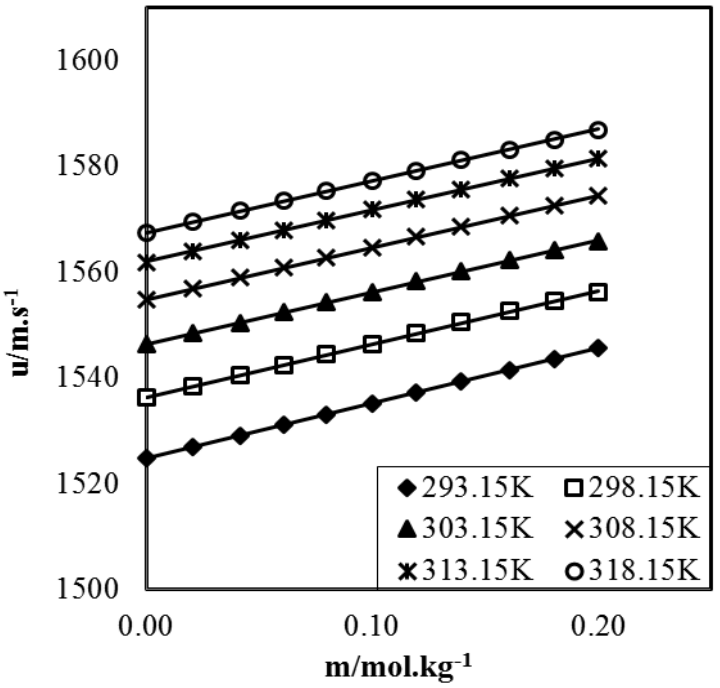


Figure 4.56: Plots of Sound velocity (u) vs. Molality (m) of L-asparagine + 0.50 mol.kg-^{1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

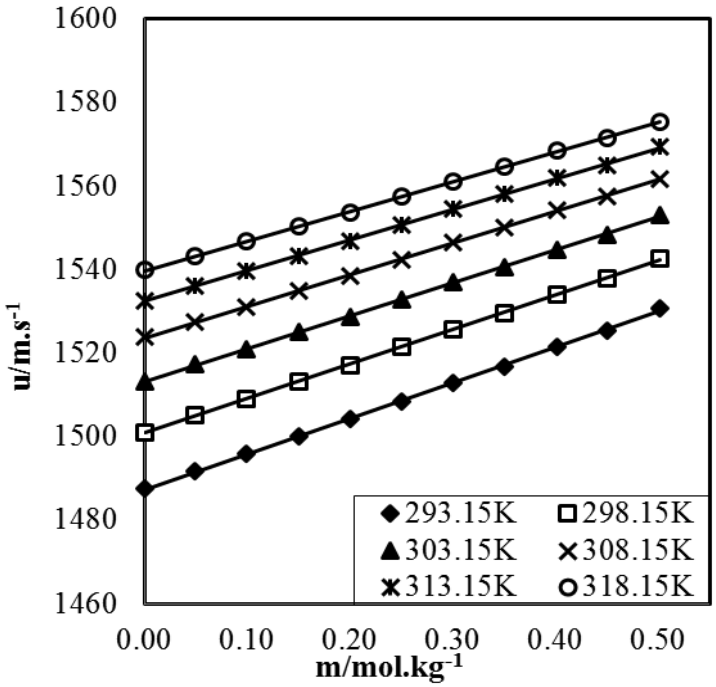


Figure 4.57: Plots of Sound velocity (u) vs. Molality (m) of L-glutamine + 0.05 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

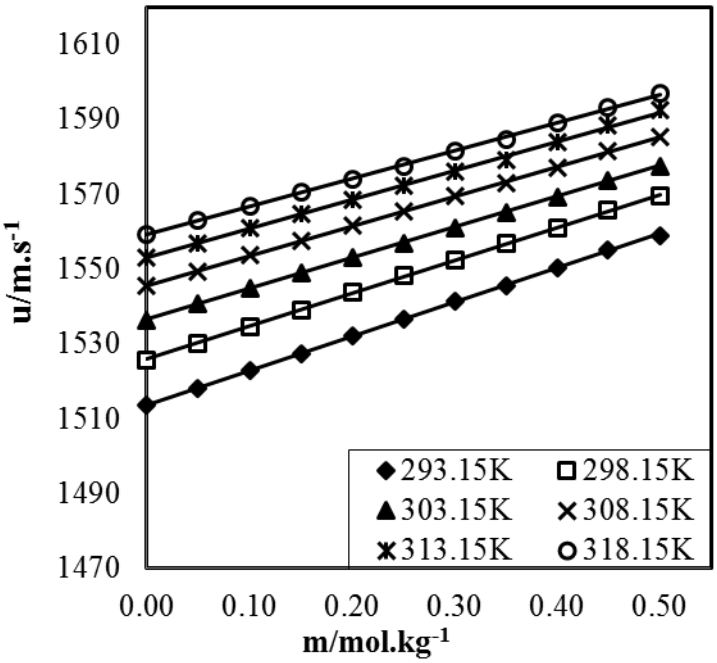


Figure 4.58: Plots of Sound velocity (u) vs. Molality (m) of L-glutamine + 0.20 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

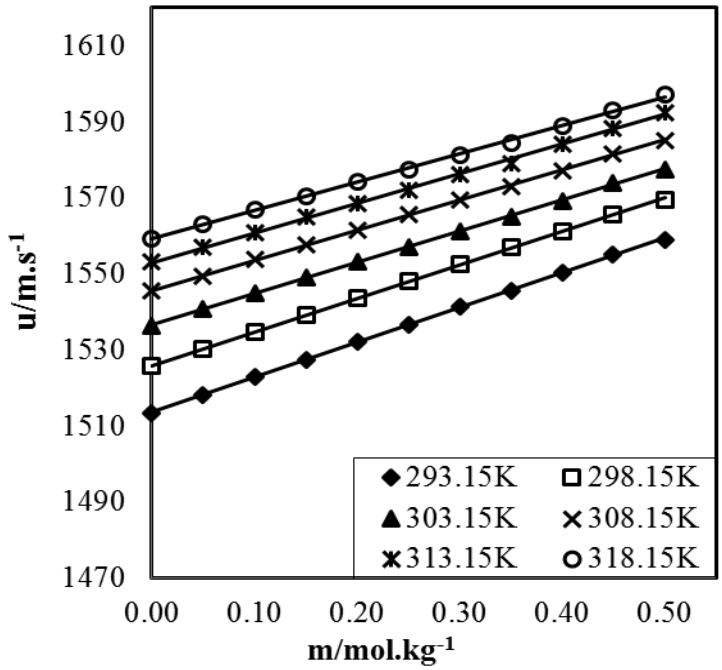


Figure 4.59: Plots of Sound velocity (u) vs. Molality (m) of L-glutamine + 0.35 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

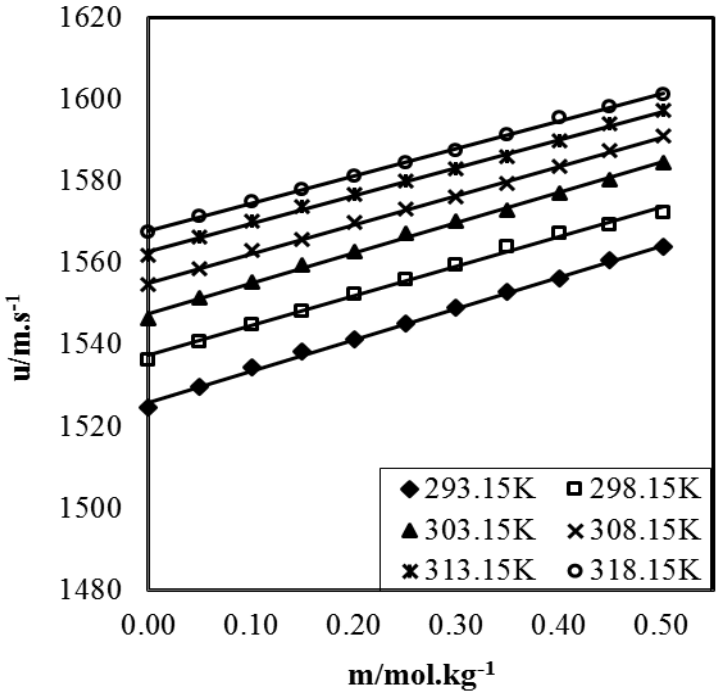


Figure 4.60: Plots of Sound velocity (u) vs. Molality (m) of L-glutamine + 0.50 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

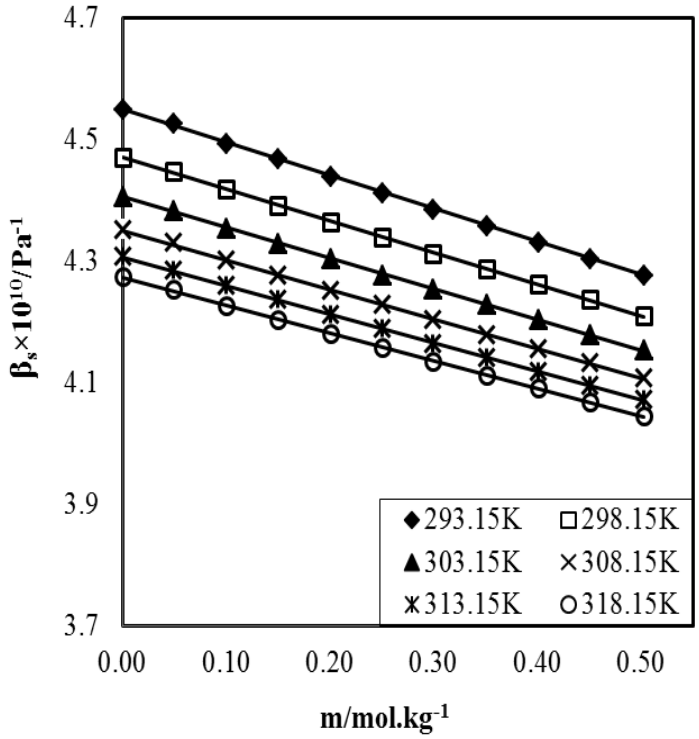


Figure 4.61**:** Plots of Adiabatic compressibility (β_s) vs. Molality (m) of L-serine in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

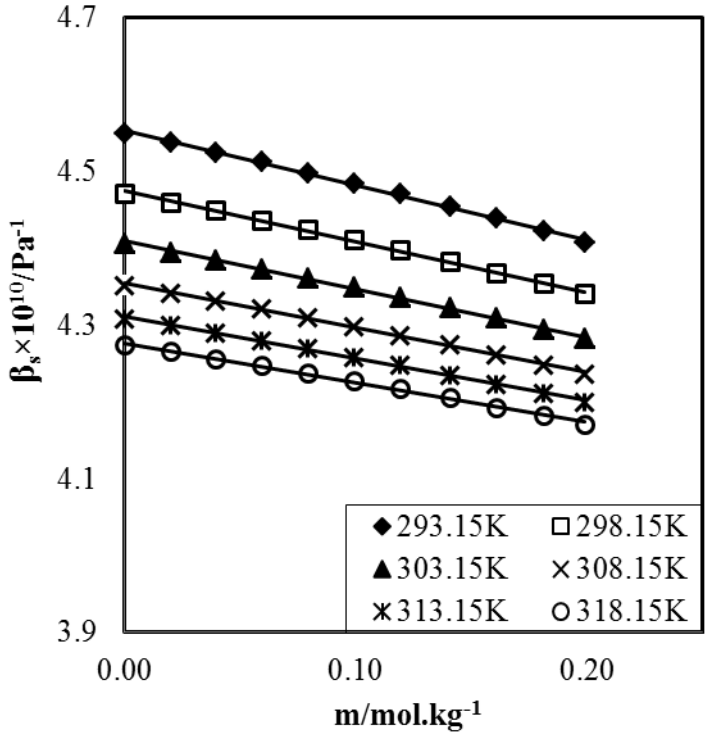


Figure 4.62: Plots of Adiabatic compressibility (β_s) vs. Molality (m) of L-asparagine in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

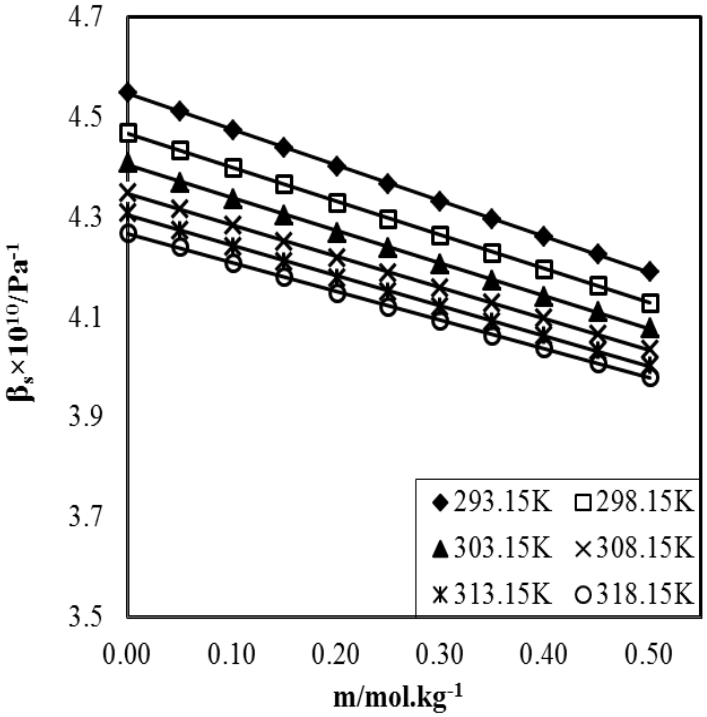


Figure 4.63**:** Plots of Adiabatic compressibility (β_s) vs. Molality (m) of L-glutamine in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

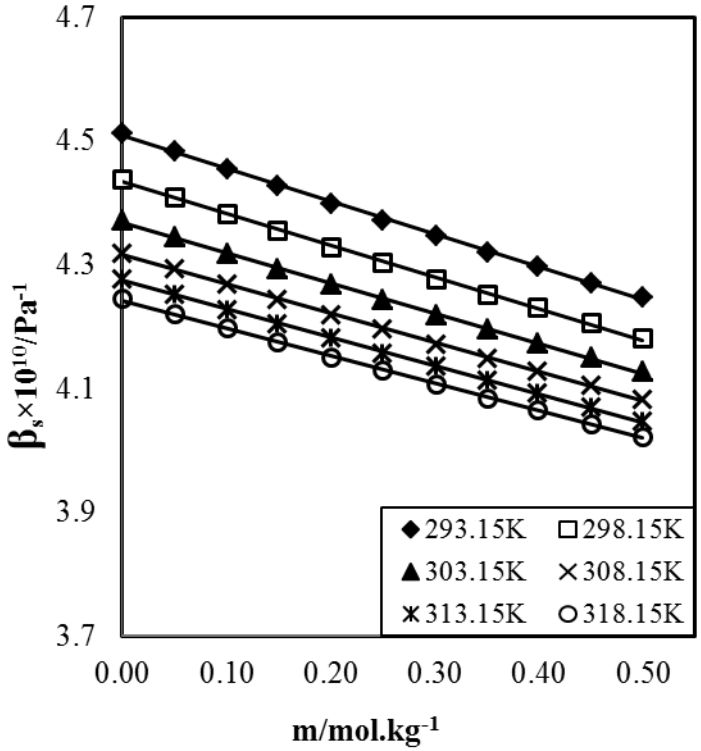


Figure 4.64: Plots of Adiabatic compressibility (β_s) vs. Molality (m) of L-serine + 0.05 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

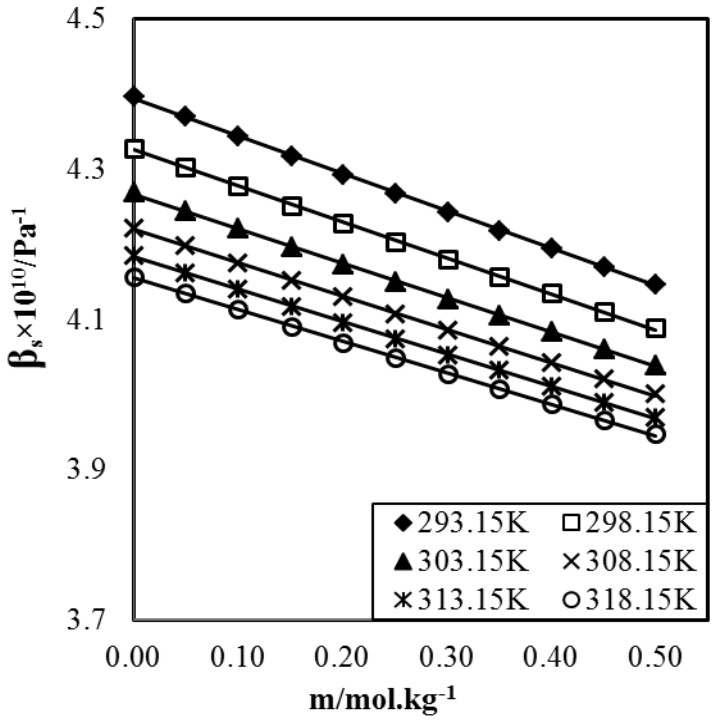


Figure 4.65: Plots of Adiabatic compressibility (β_s) vs. Molality (m) of L-serine + 0.20 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

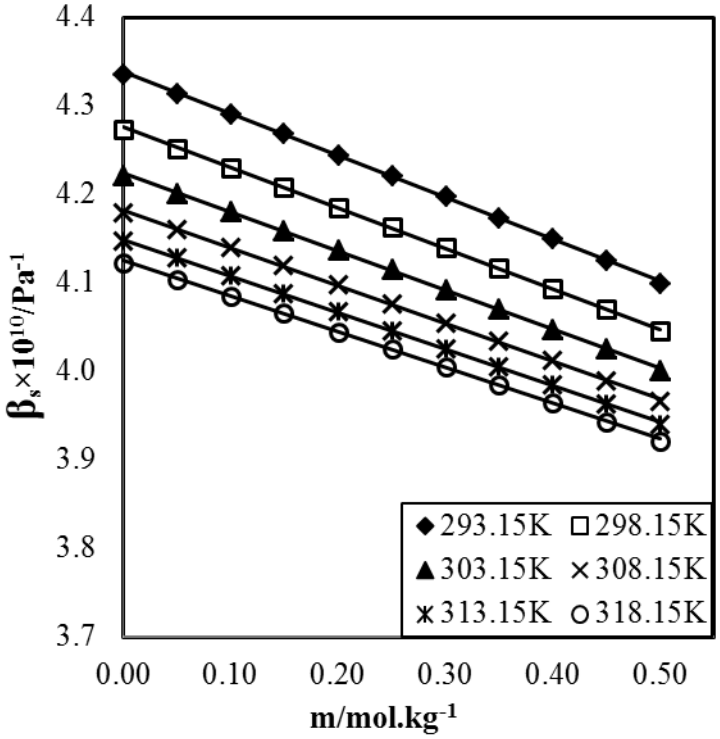


Figure 4.66: Plots of Adiabatic compressibility (β_s) vs. Molality (m) of L-serine + 0.35 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

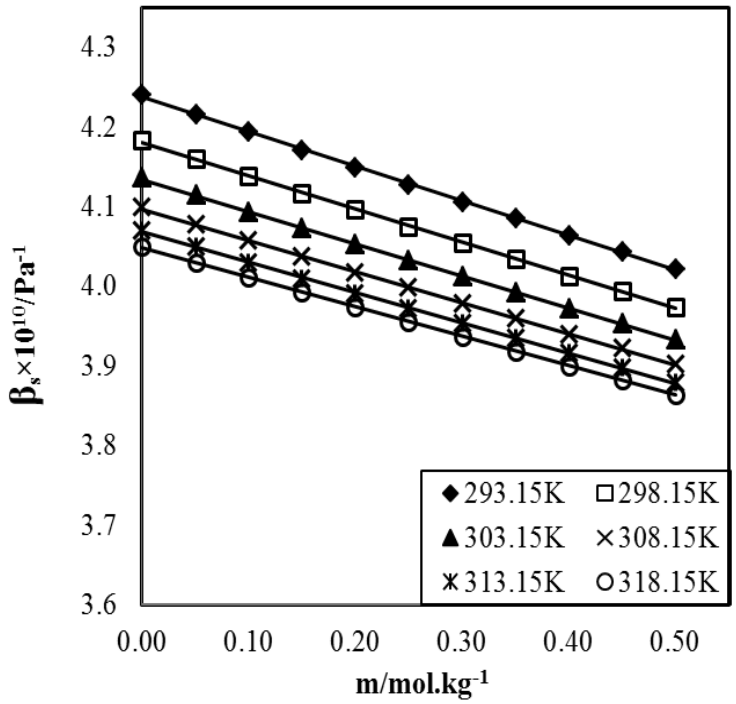


Figure 4.67: Plots of Adiabatic compressibility (β_s) vs. Molality (m) of L-serine + 0.50 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

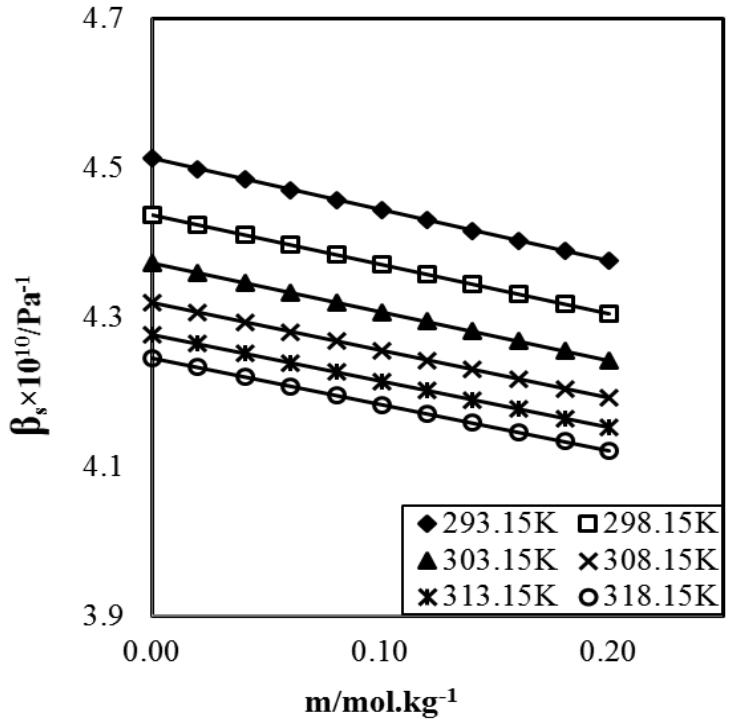


Figure 4.68: Plots of Adiabatic compressibility (β_s) vs. Molality (m) of L-asparagine+ 0.05 mol.kg-^{1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

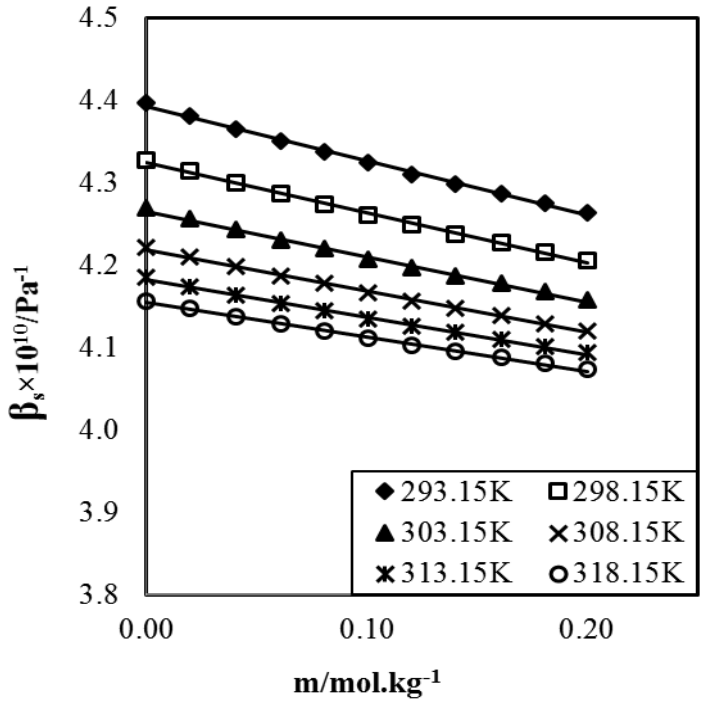


Figure 4.69: Plots of Adiabatic compressibility (β_s) vs. Molality (m) of L-asparagine + 0.20 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively

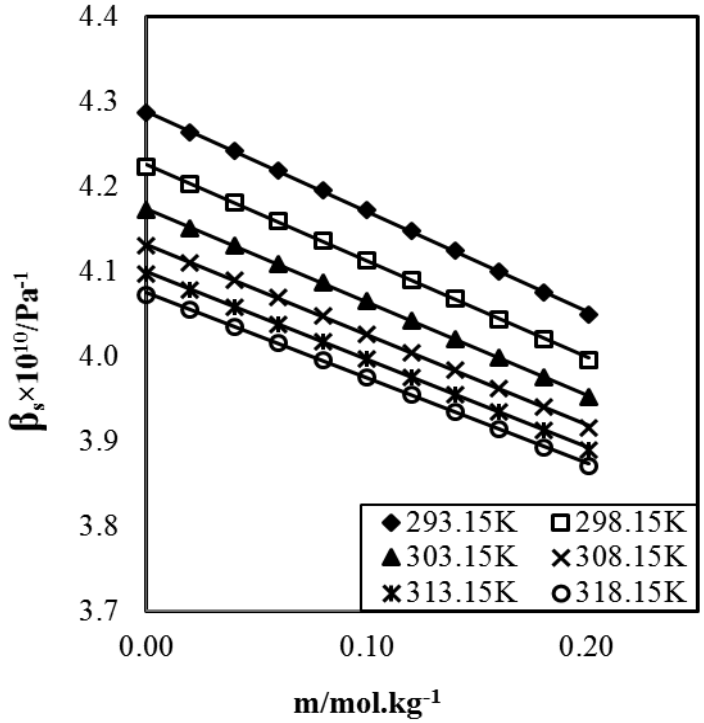


Figure 4.70: Plots of Adiabatic compressibility (β_s) vs. Molality (m) of L-asparagine + 0.35 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively

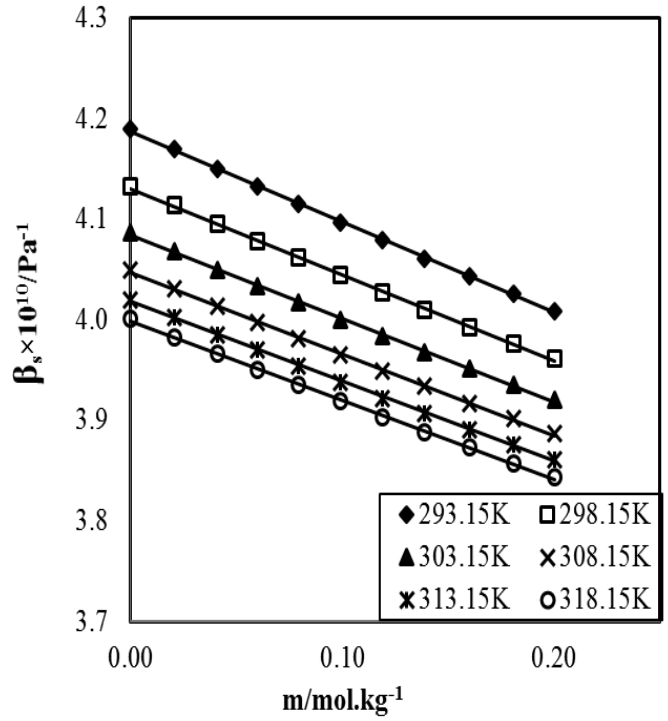


Figure 4.71: Plots of Adiabatic compressibility (β_s) vs. Molality (m) of L-asparagine + 0.50 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively

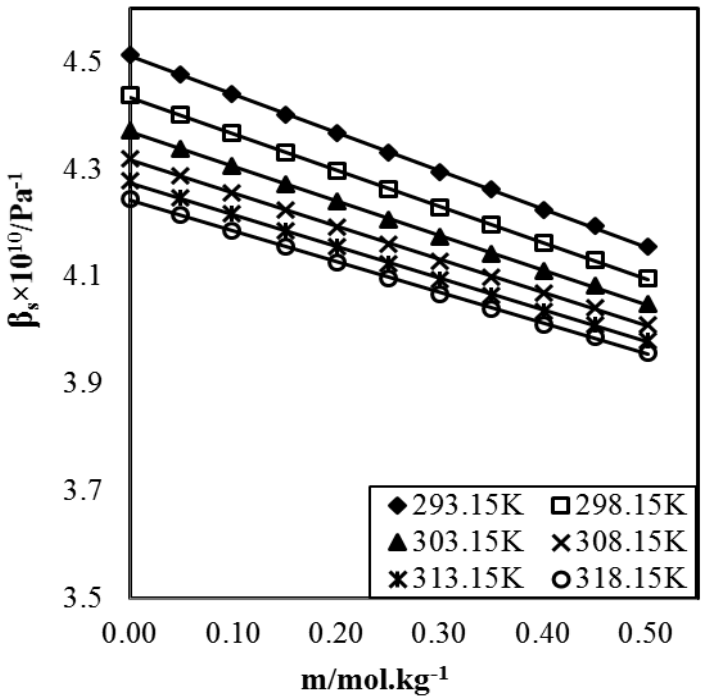


Figure 4.72: Plots of Adiabatic compressibility (β_s) vs. Molality (m) of L-Glutamine + 0.05 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

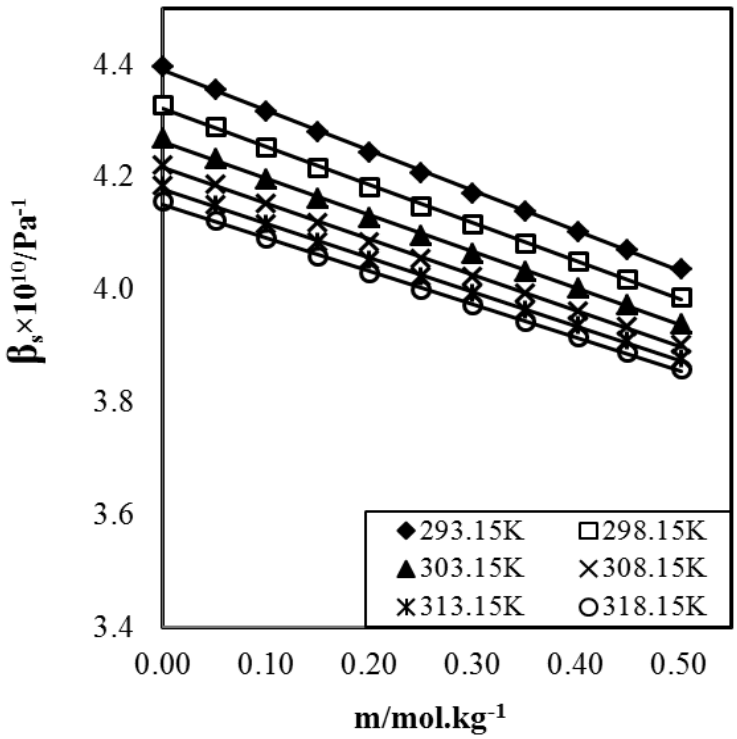


Figure 4.73: Plots of Adiabatic compressibility (β_s) vs. Molality (m) of L-glutamine + 0.35 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

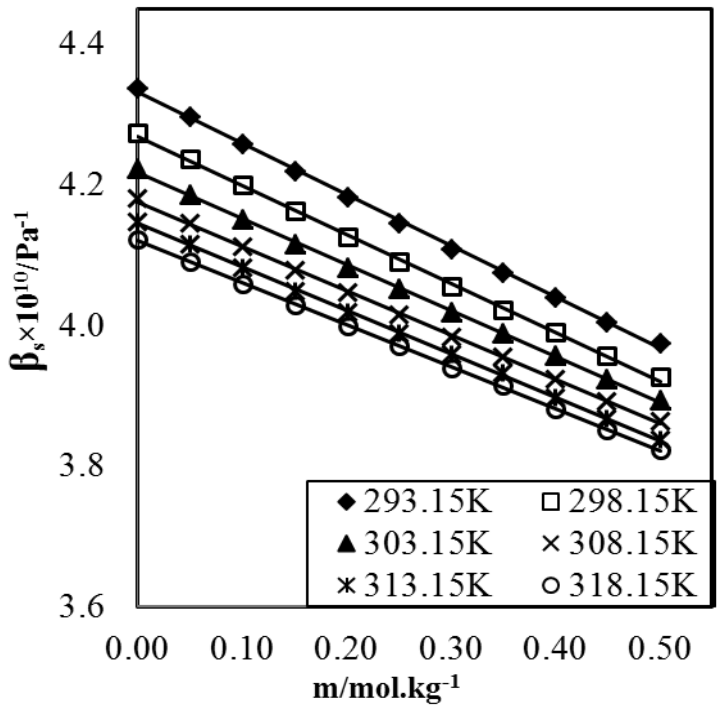


Figure 4.74: Plots of Adiabatic compressibility (β_s) vs. Molality (m) of L-glutamine + 0.35 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

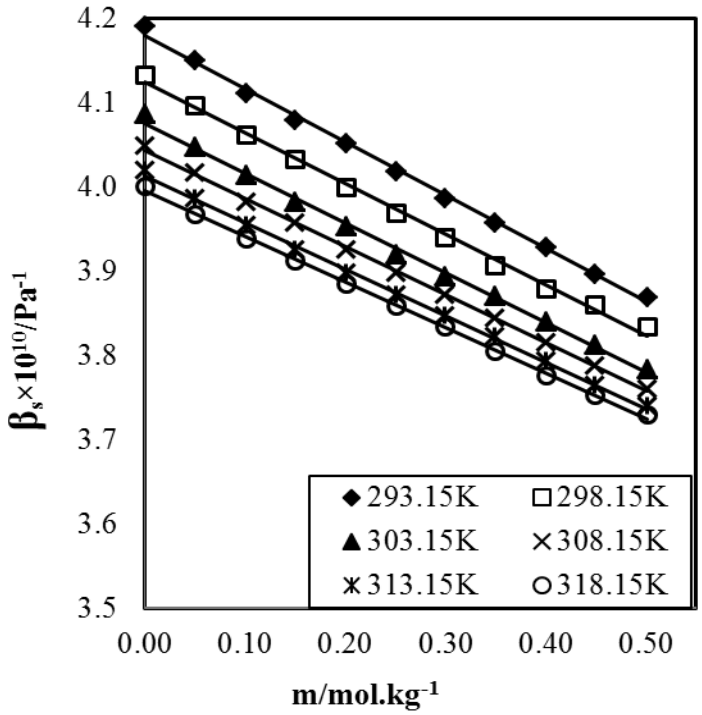


Figure 4.75: Plots of Adiabatic compressibility (β_s) vs. Molality (m) of L-Glutamine + 0.50 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

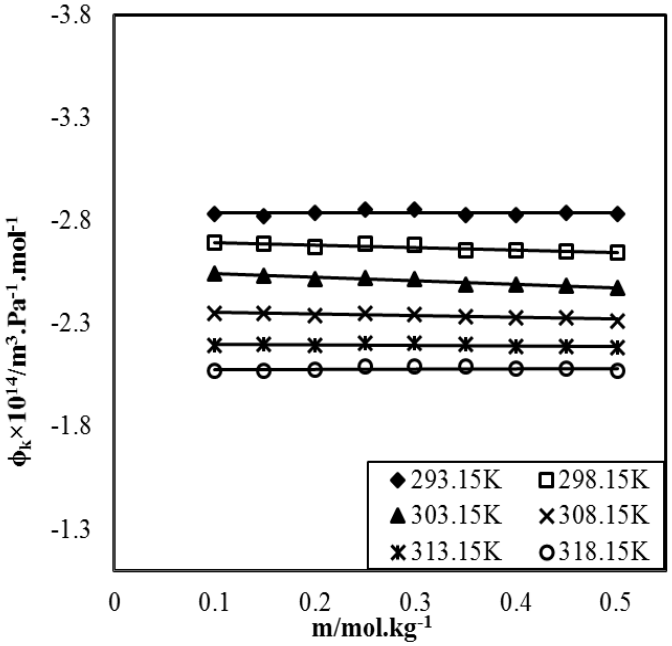


Figure 4.76**:** Plots of Apparent molar adiabatic compressibility (φ_k) vs. Molality (m) of L-serine in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

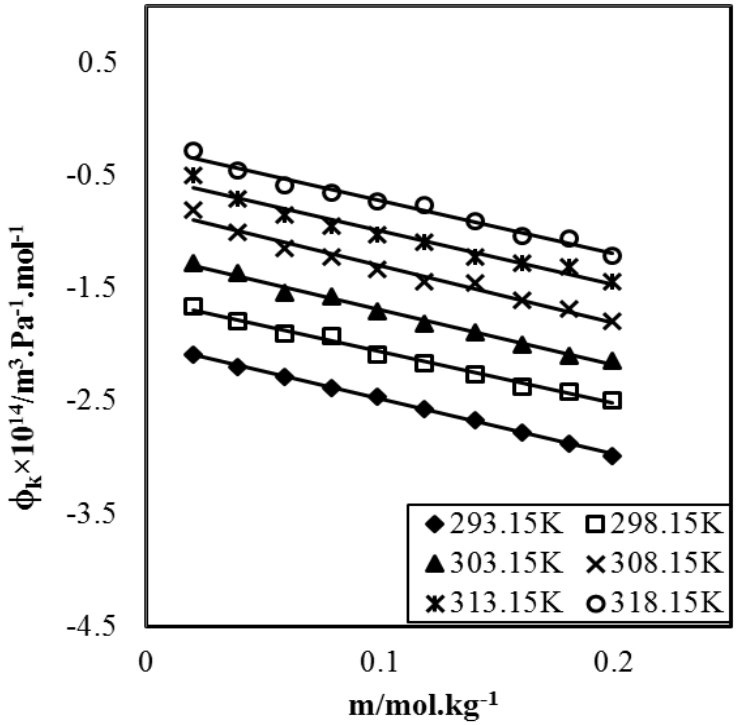


Figure 4.77: Plots of Apparent molar adiabatic compressibility φ_k) vs. Molality (m) of L-asparagine in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

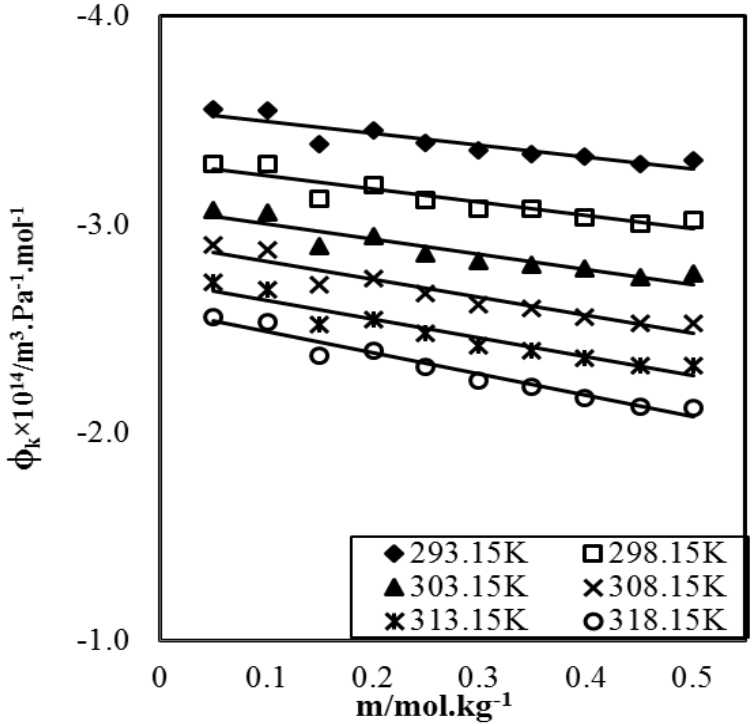


Figure 4.78**:** Plots of Apparent molar adiabatic compressibility (φ_k) vs. Molality (m) of L-glutamine + water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

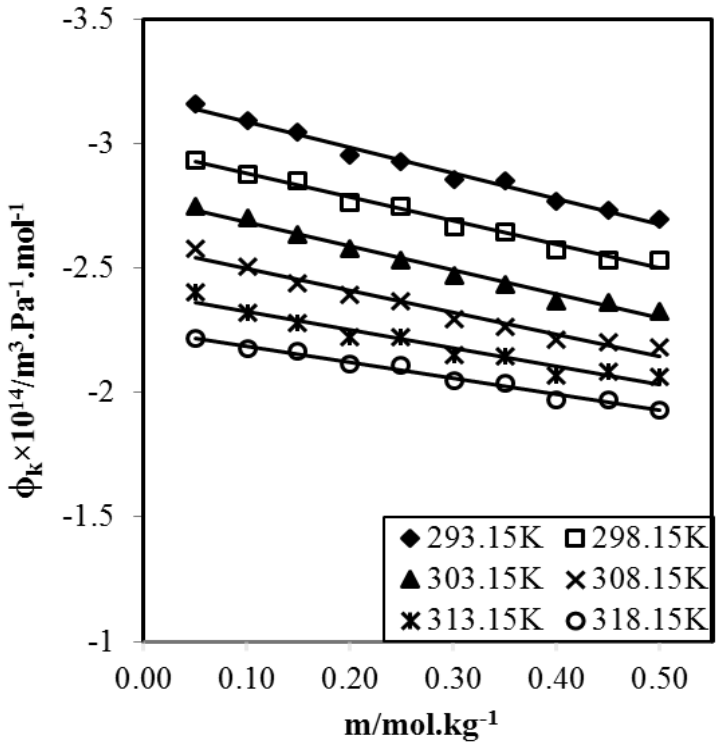


Figure 4.79: Plots of Apparent molar adiabatic compressibility (φ_k) vs. Molality (m) of L-serine + 0.05 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

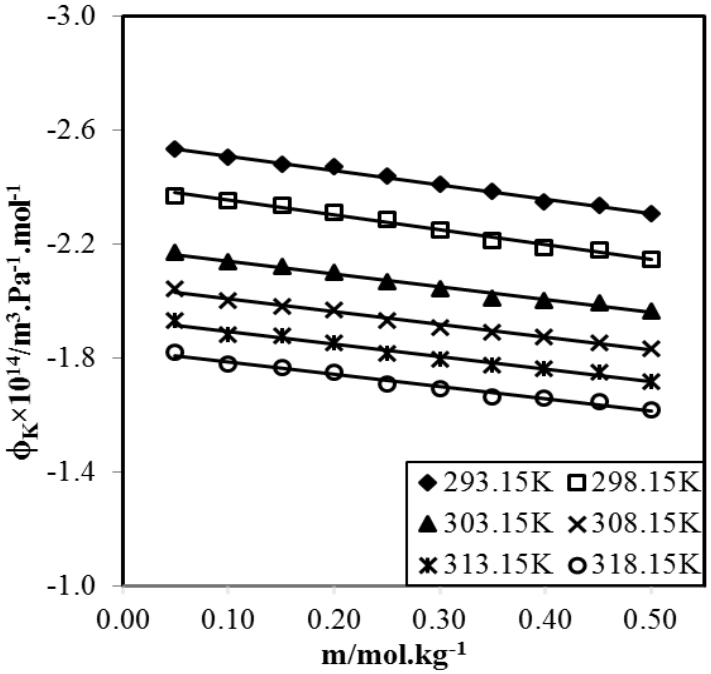


Figure 4.80: Plots of Apparent molar adiabatic compressibility (φ_k) vs. Molality (m) of L-serine + 0.20 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

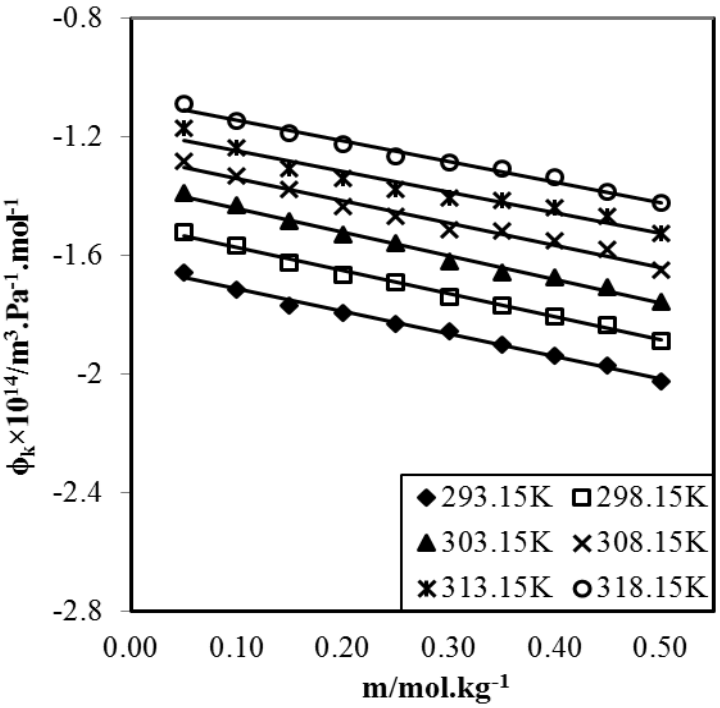


Figure 4.81: Plots of Apparent molar adiabatic compressibility (φ_k) vs. Molality (m) of L-serine + 0.35 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

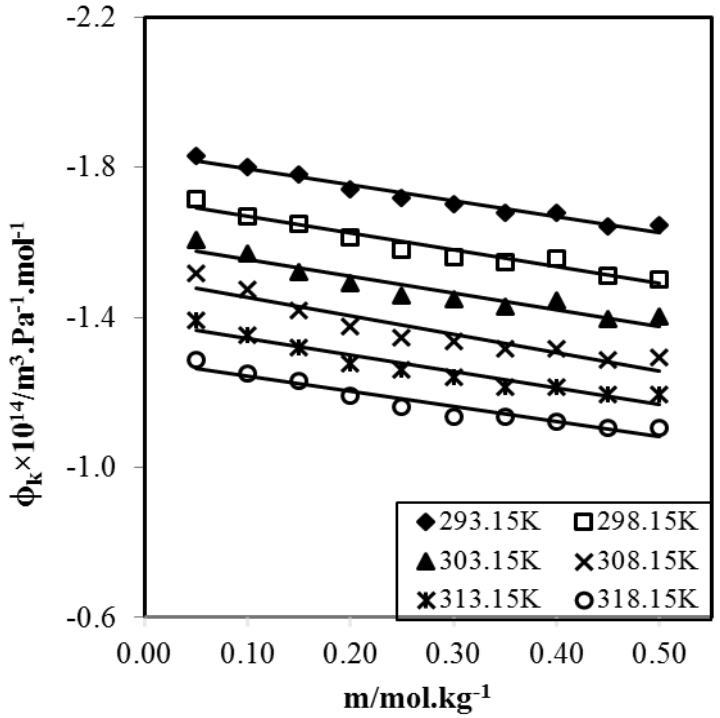


Figure 4.82: Plots of Apparent molar adiabatic compressibility (φ_k) vs. Molality (m) of L-serine + 0.50 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

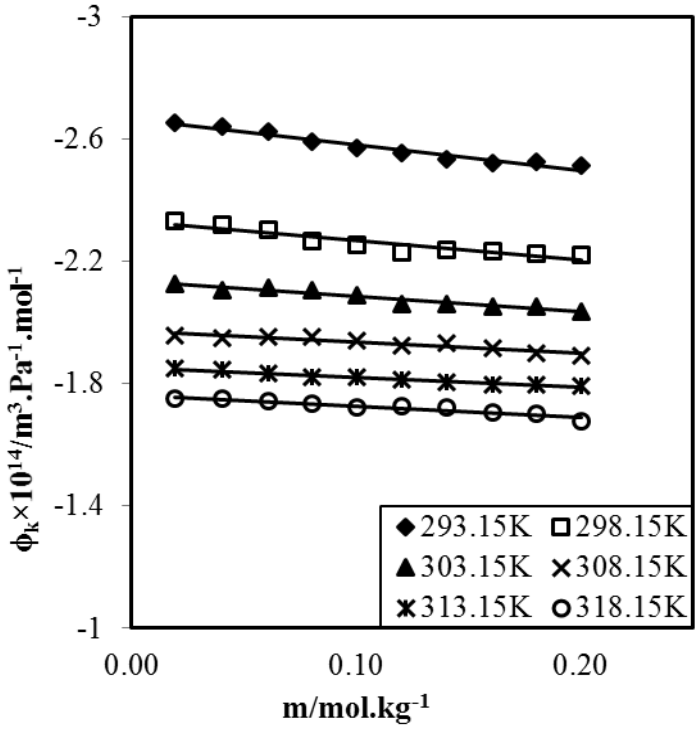


Figure 4.83: Plots of Apparent molar adiabatic compressibility (φ_k) vs. Molality (m) of L-asparagine + 0.05 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

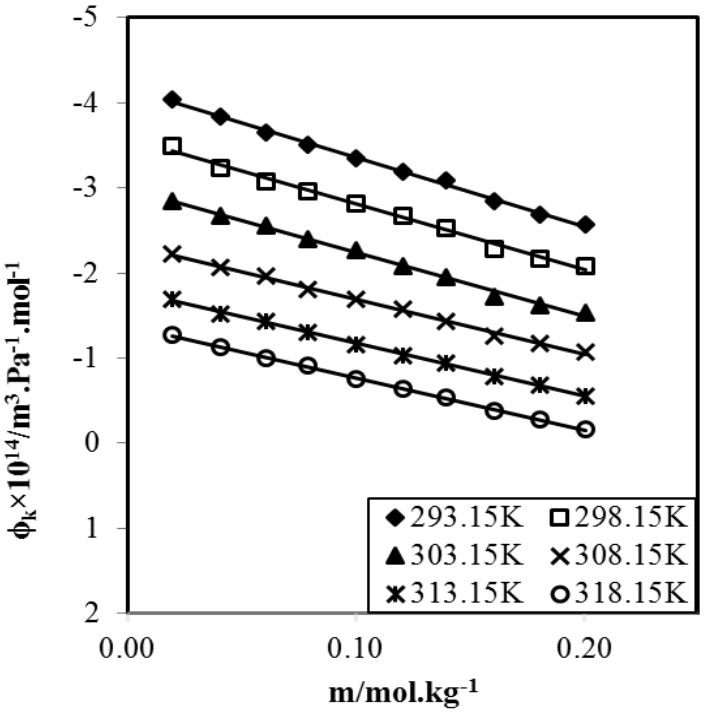


Figure 4.84: Plots of Apparent molar adiabatic compressibility (φ_k) vs. Molality (m) of L-asparagine + 0.20 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

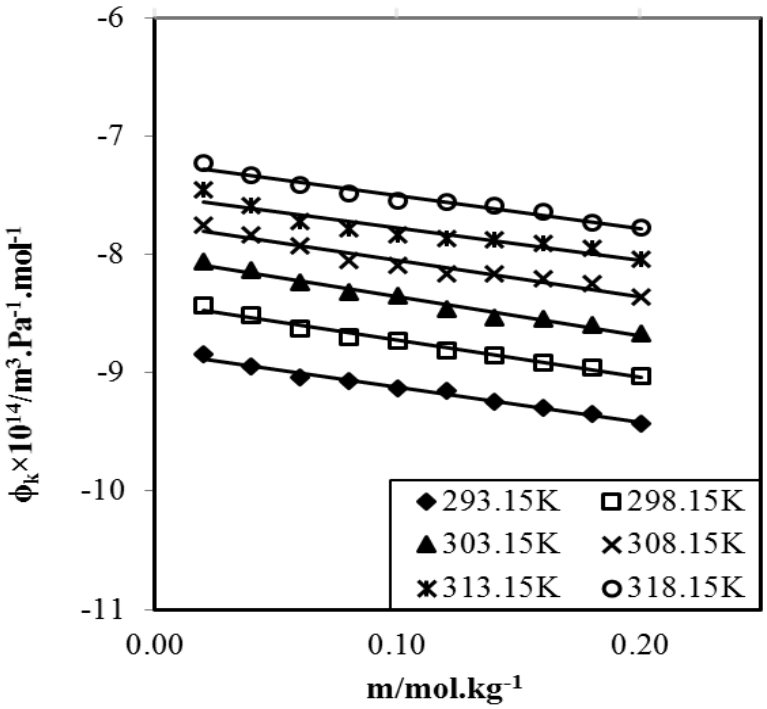


Figure 4.85: Plots of Apparent molar adiabatic compressibility (φ_k) vs. Molality (m) of L-asparagine + 0.35 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

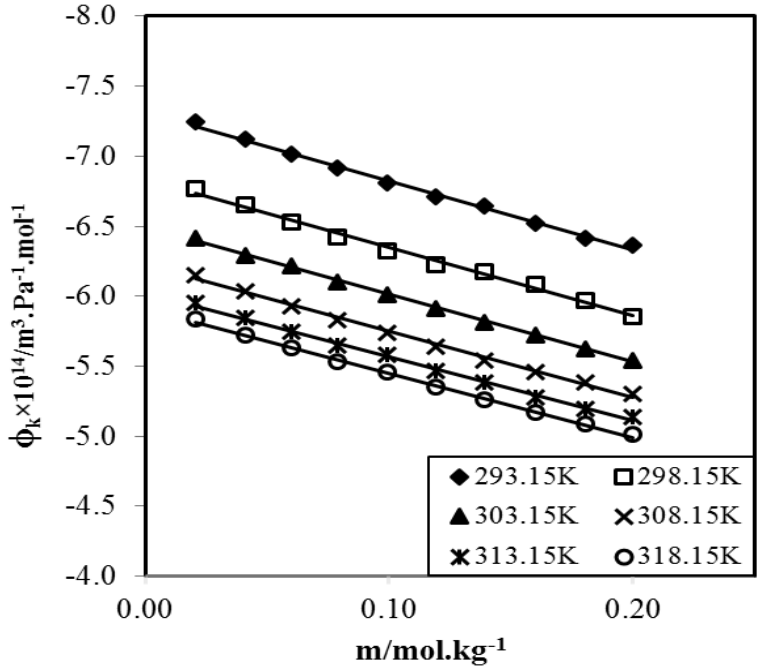


Figure 4.86: Plots of Apparent molar adiabatic compressibility (φ_k) vs. Molality (m) of L-asparagine + 0.50 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

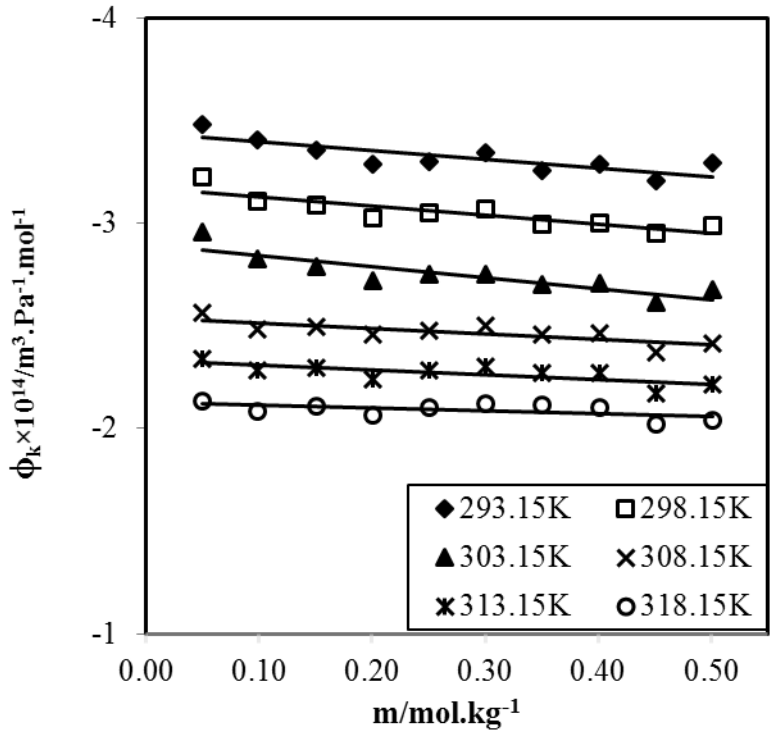


Figure 4.87: Plots of Apparent molar adiabatic compressibility (φ_k) vs. Molality (m) of L-glutamine + 0.05 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

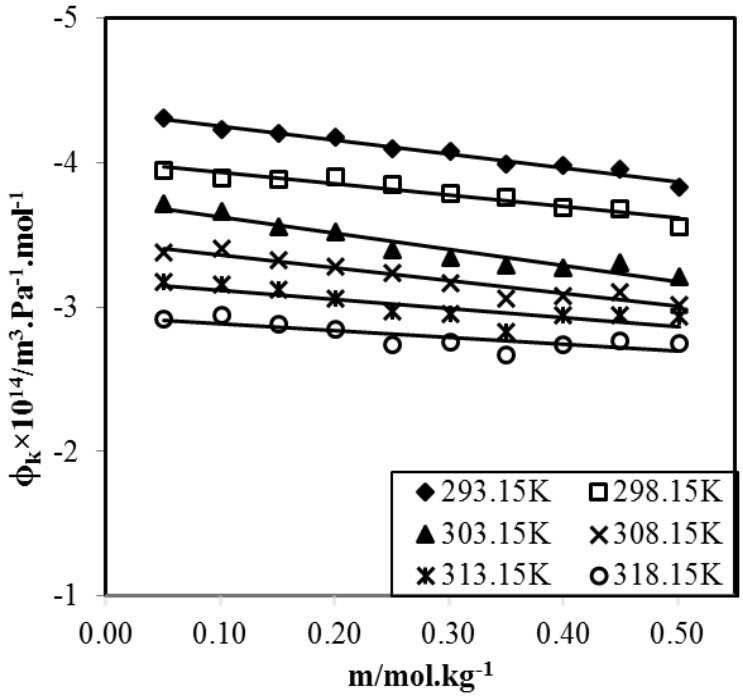


Figure 4.88: Plots of Apparent molar adiabatic compressibility (φ_k) vs. Molality (m) of L-glutamine + 0.20 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

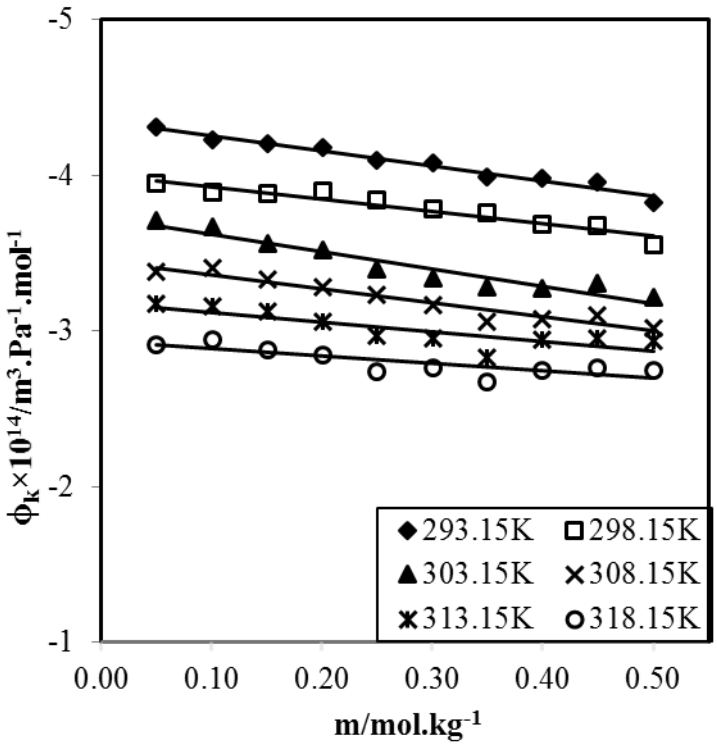


Figure 4.89: Plots of Apparent molar adiabatic compressibility (φ_k) vs. Molality (m) of L-glutamine + 0.35 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

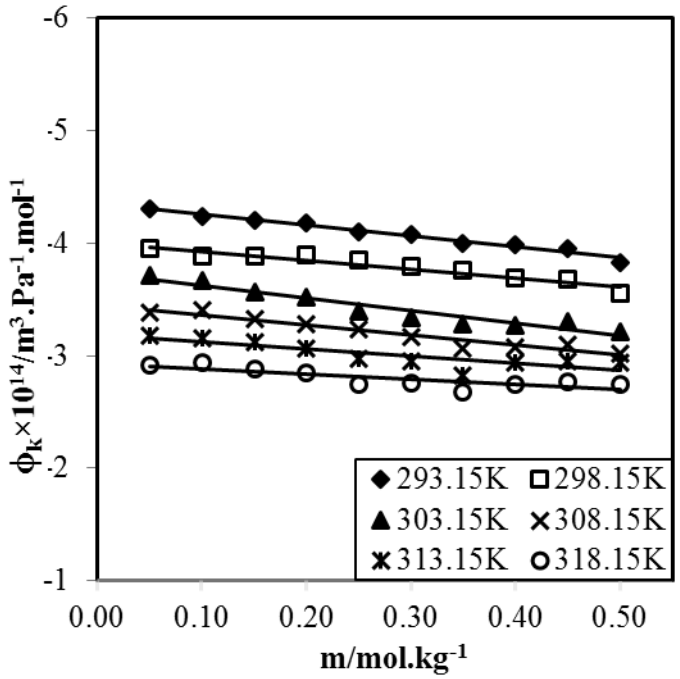


Figure 4.90: Plots of Apparent molar adiabatic compressibility (φ_k) vs. Molality (m) of L-glutamine + 0.50 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

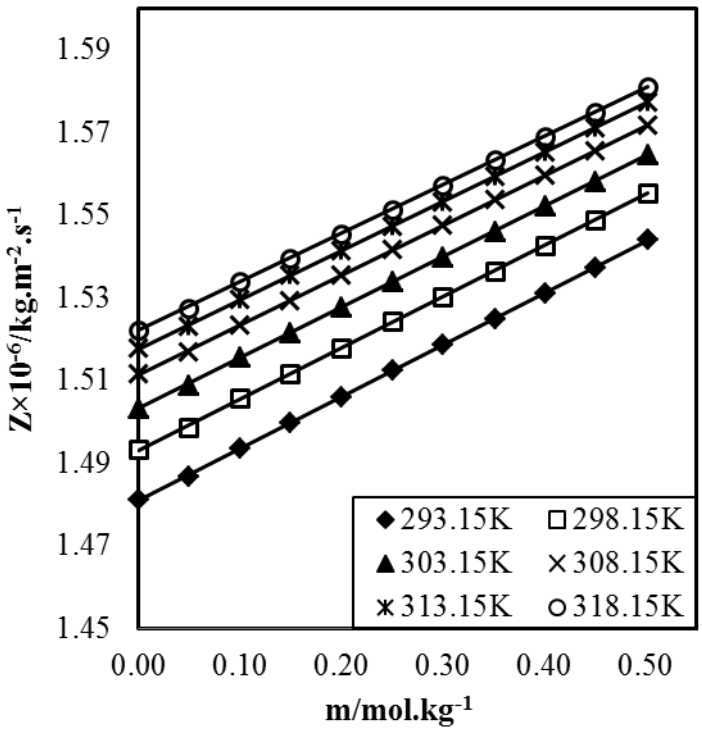


Figure 4.91**:** Plots of Acoustic impedance (Z) vs. Molality (m) of L-serine in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

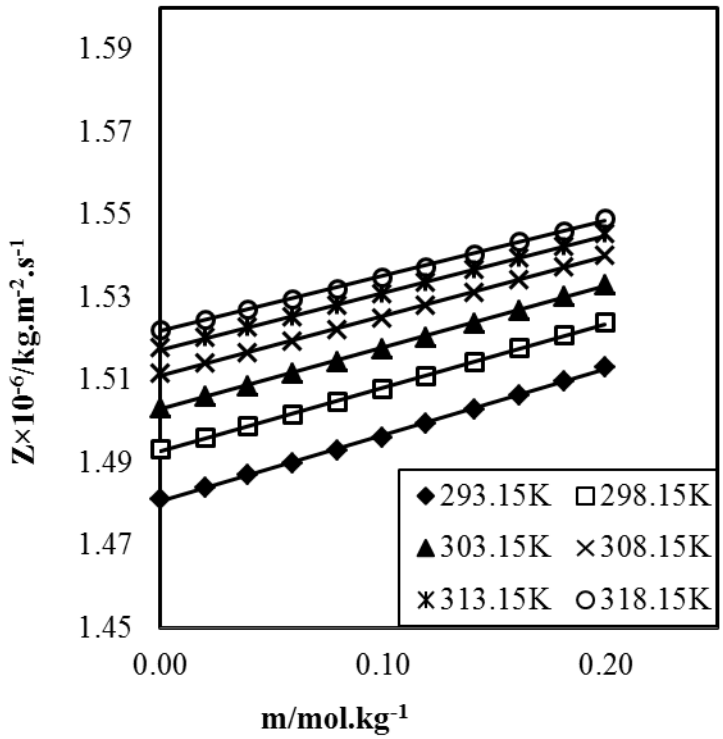


Figure 4.92: Plots of Acoustic impedance (Z) vs. Molality (m) of L-asparagine in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

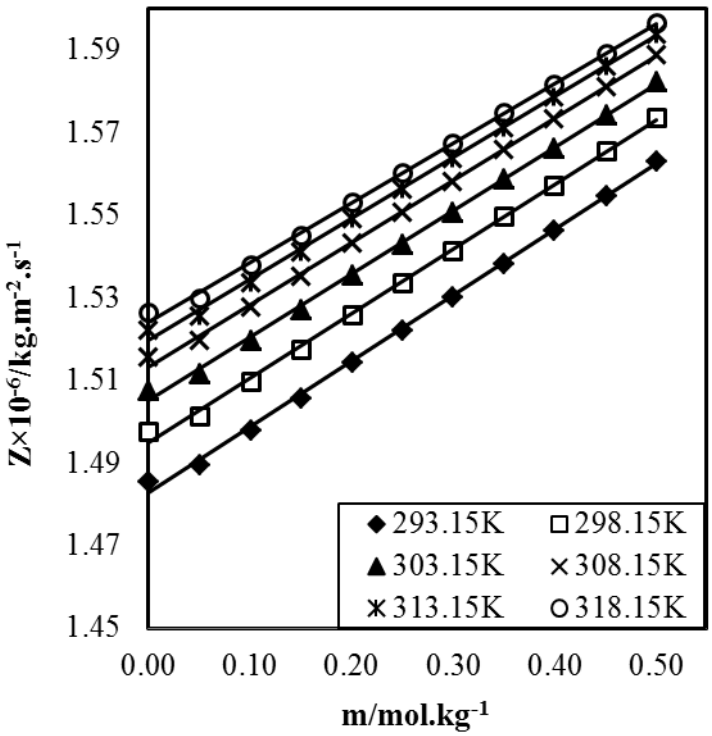


Figure 4.93**:** Plots of Acoustic impedance (Z) vs. Molality (m) of L-glutamine in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

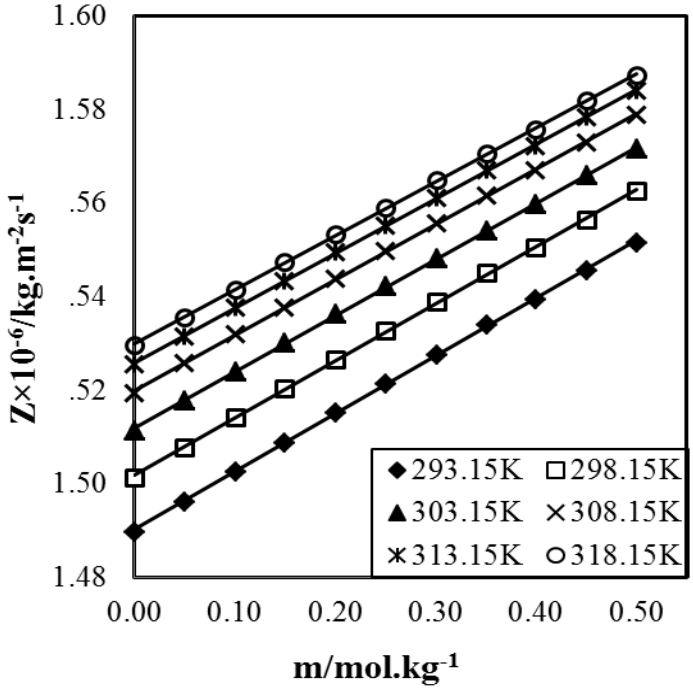


Figure 4.94: Plots of Acoustic impedance (Z) vs. Molality (m) of L-serine + 0.05 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

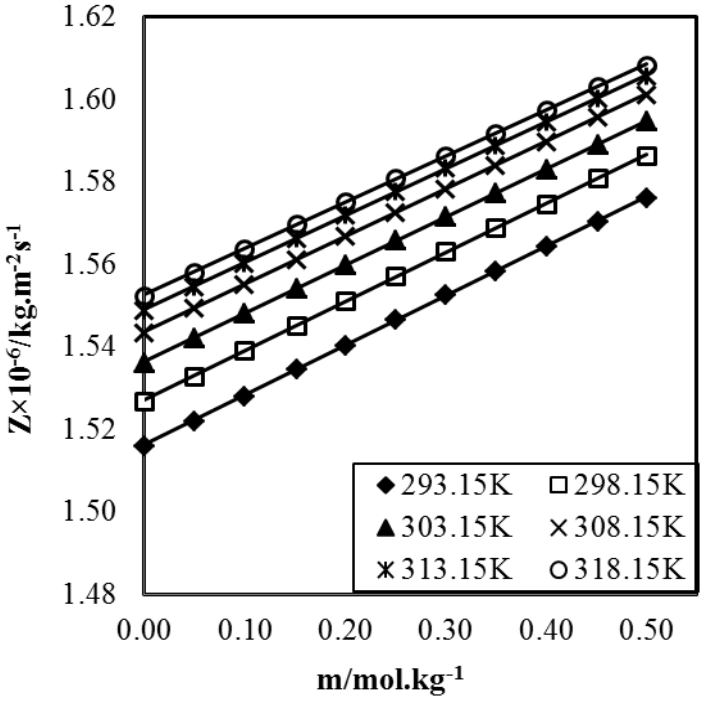


Figure 4.95: Plots of Acoustic impedance (Z) vs. Molality (m) of L-serine + 0.20 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

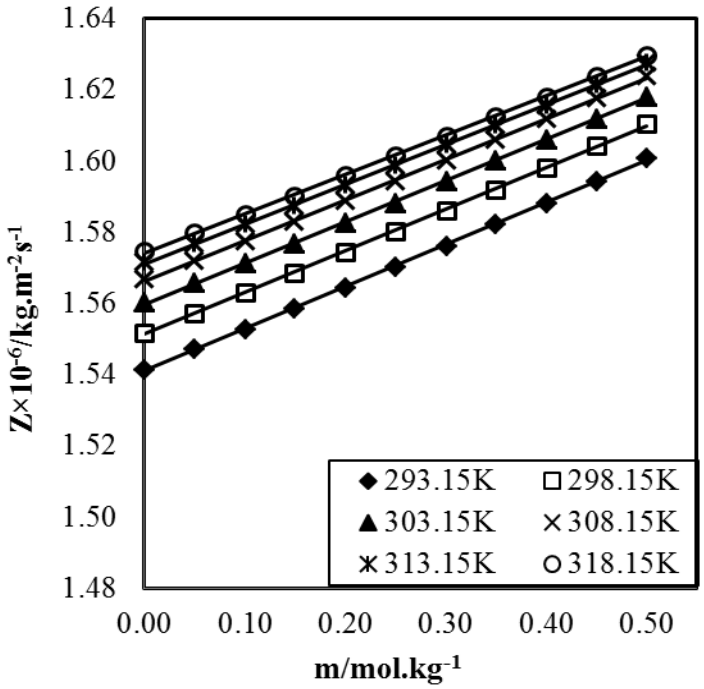


Figure 4.96: Plots of Acoustic impedance (Z) vs. Molality (m) of L-serine + 0.35 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

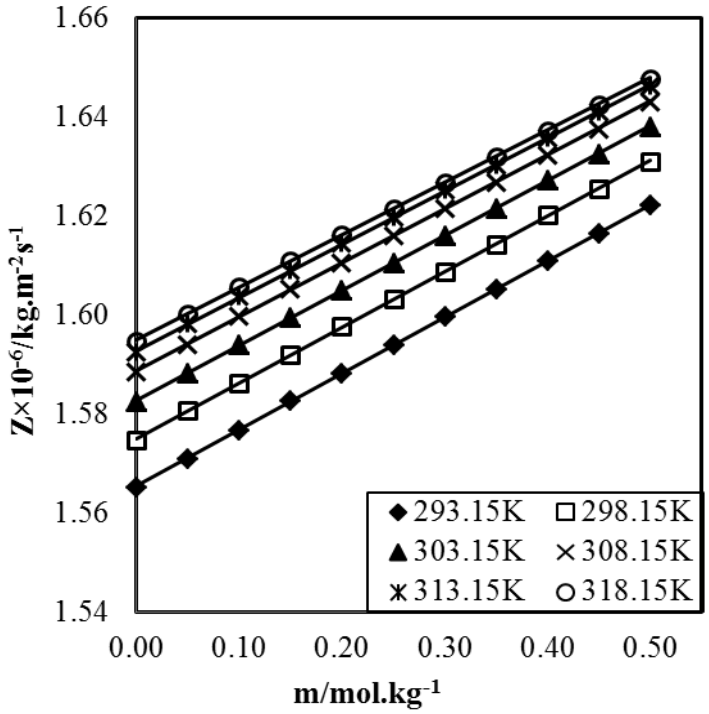


Figure 4.97: Plots of Acoustic impedance (Z) vs. Molality (m) of L-serine + 0.50 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

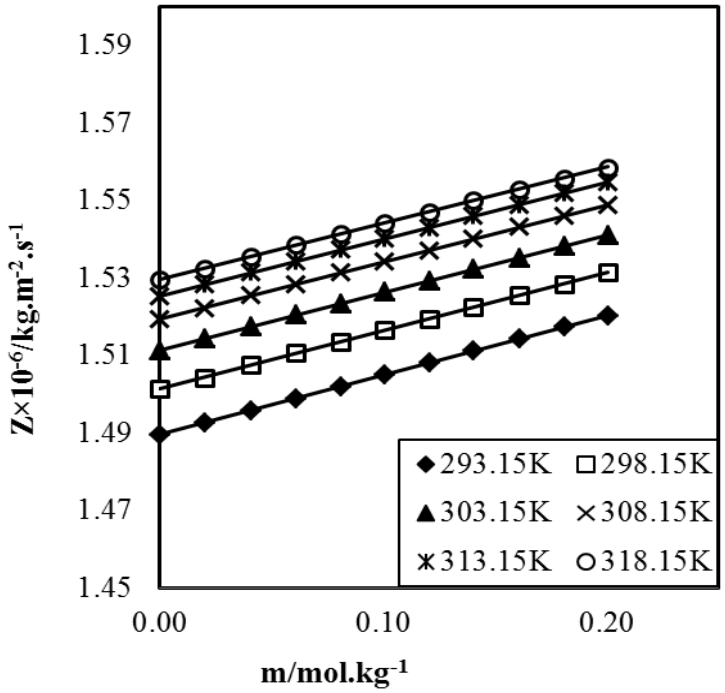


Figure 4.98: Plots of Acoustic impedance (Z) vs. Molality (m) of L-asparagine + 0.05 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

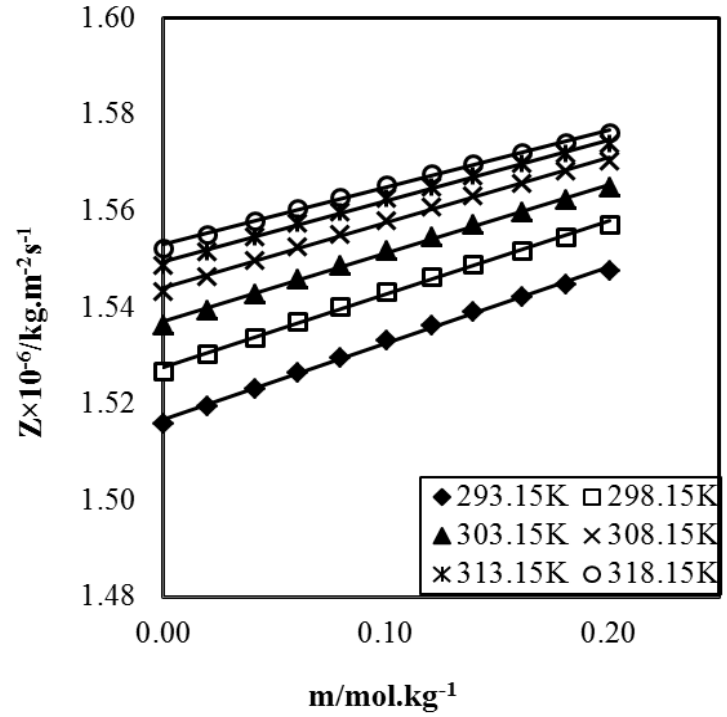


Figure 4.99: Plots of Acoustic impedance (Z) vs. Molality (m) of L-asparagine + 0.20 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

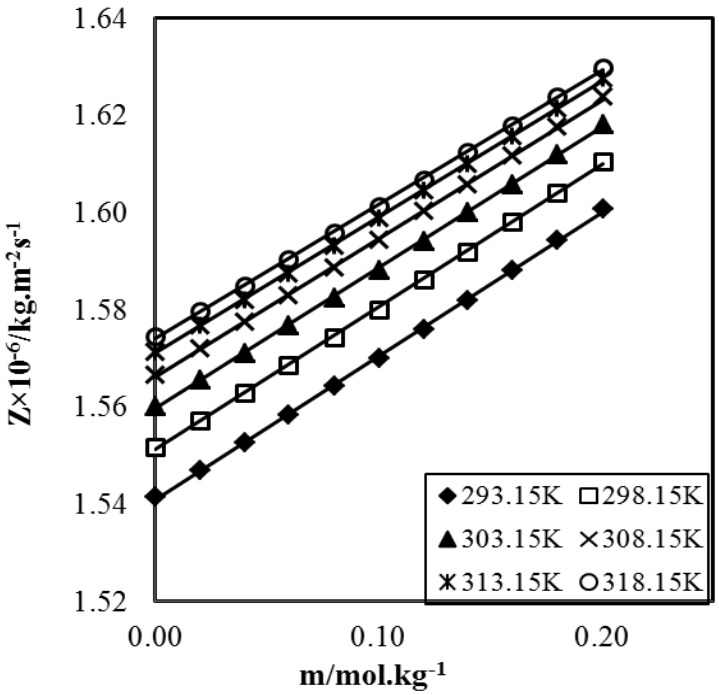


Figure 4.100: Plots of Acoustic impedance (Z) vs. Molality (m) of L-asparagine + 0.35 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

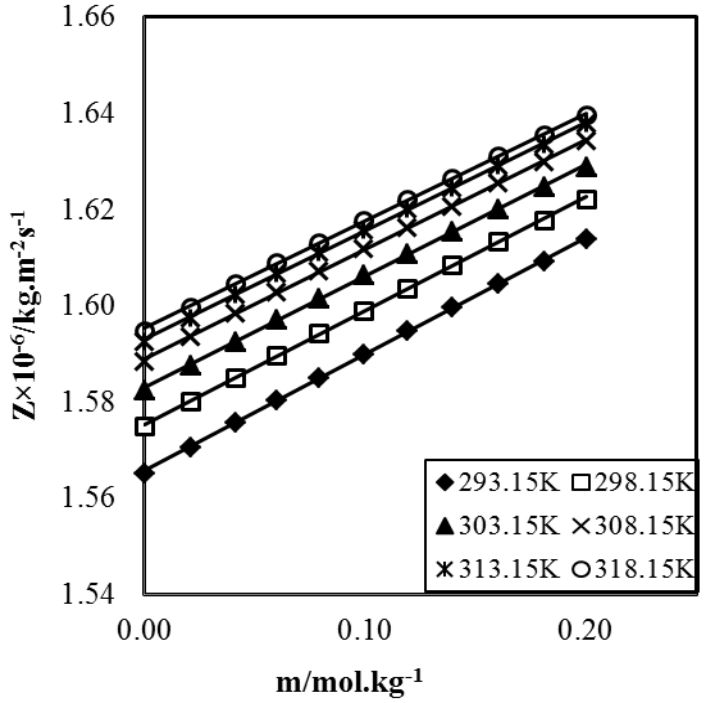


Figure 4.101: Plots of Acoustic impedance (Z) vs. Molality (m) of L-asparagine + 0.35 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

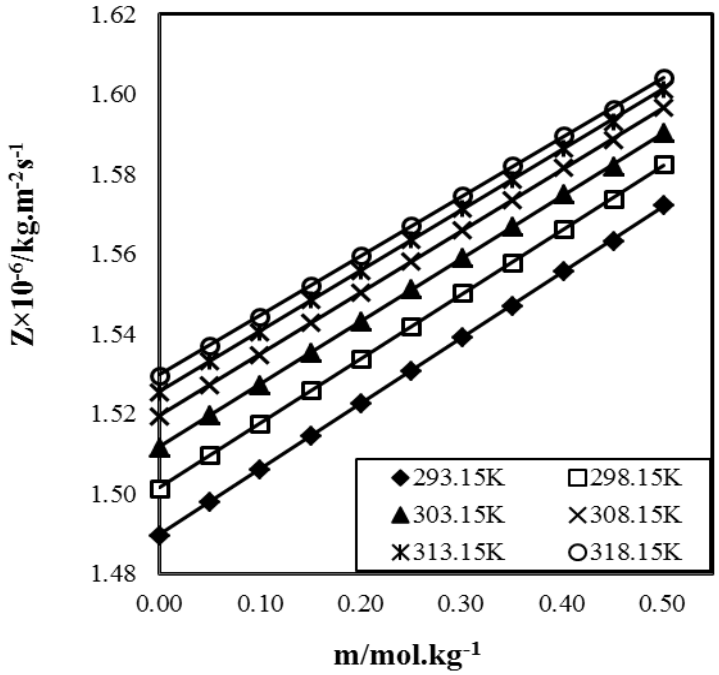


Figure 102: Plots of Acoustic impedance (Z) vs. Molality (m) of L-glutamine + 0.05 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

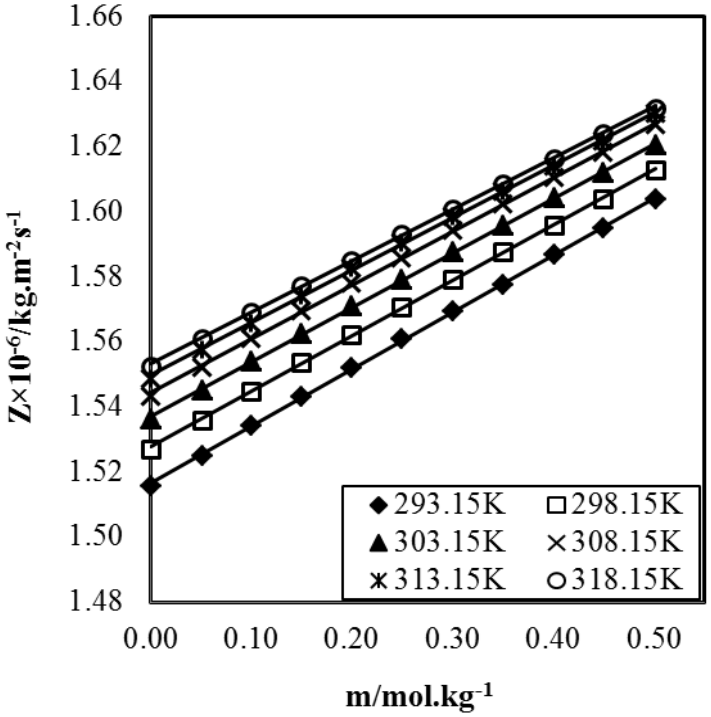


Figure 4.103: Plots of Acoustic impedance (Z) vs. Molality (m) of L-glutamine + 0.20 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

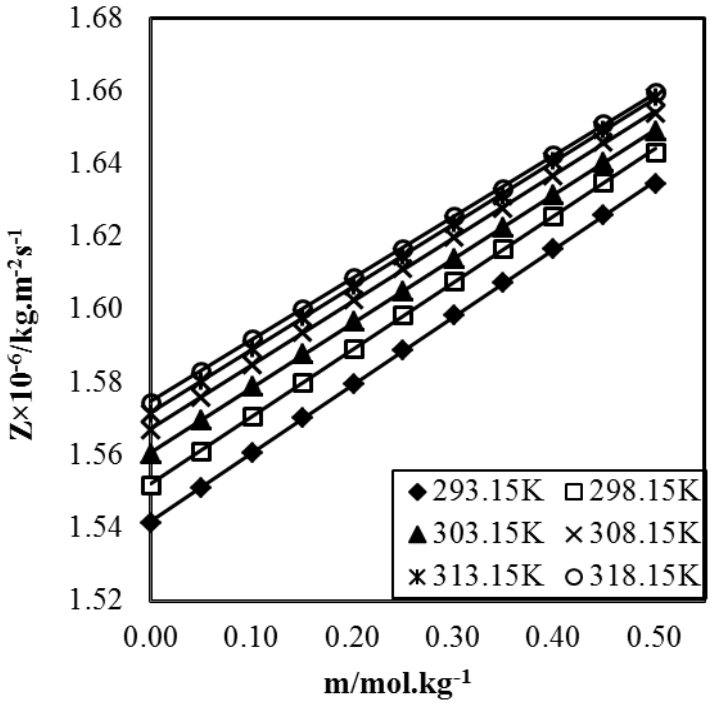


Figure 4.104: Plots of Acoustic impedance (Z) vs. Molality (m) of L-glutamine + 0.35 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

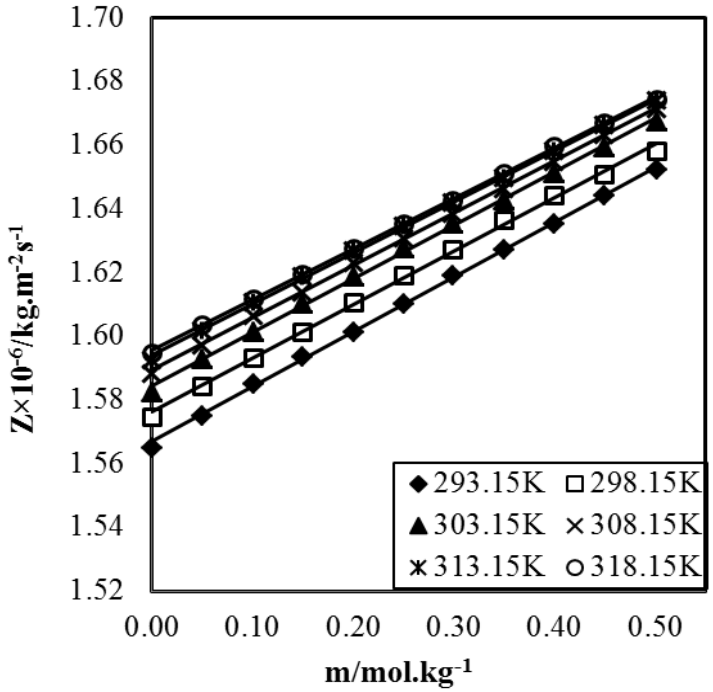


Figure 4.105: Plots of Acoustic impedance (Z) vs. Molality (m) of L-glutamine + 0.50 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

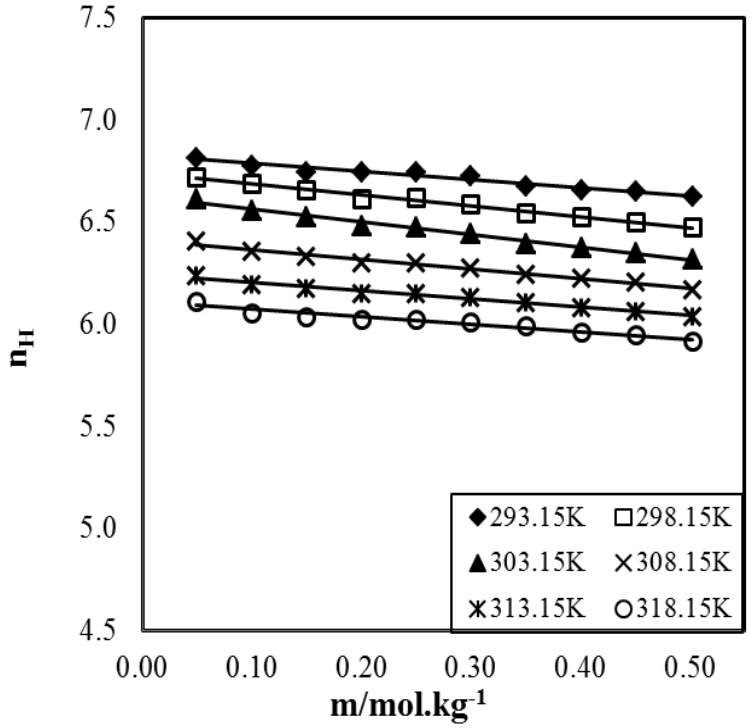


Figure 4.106**:** Plots of Hydration number (n_H) vs. Molality (m) of L-serine in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

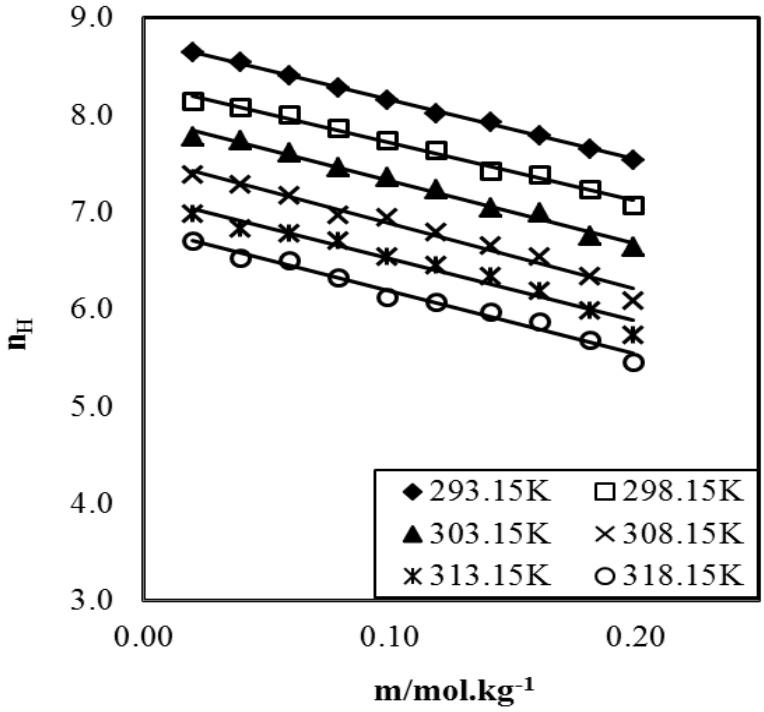


Figure 4.107**:** Plots of Hydration number (n_H) vs. Molality (m) of L-asparagine+ water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

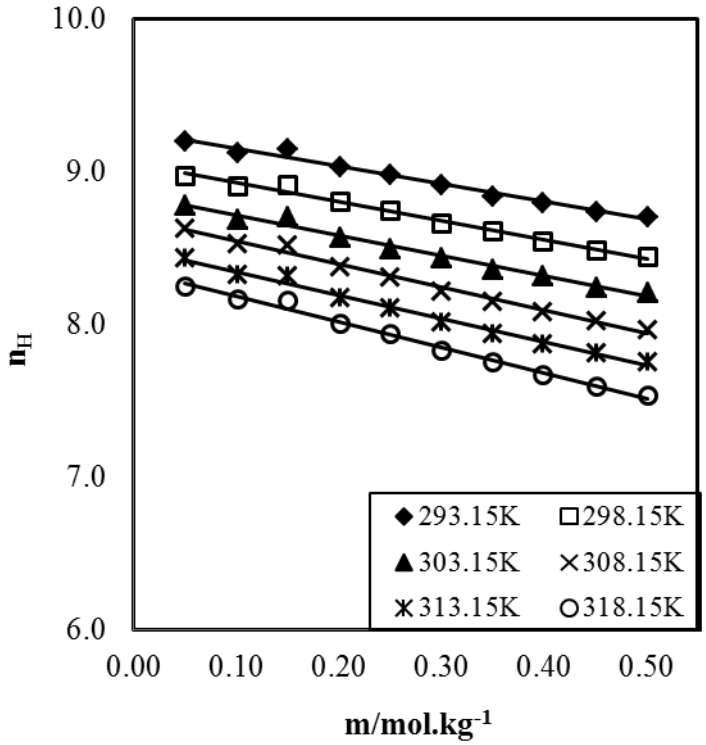


Figure 4.108**:** Plots of Hydration number (n_H) vs. Molality (m) of L-glutamine in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

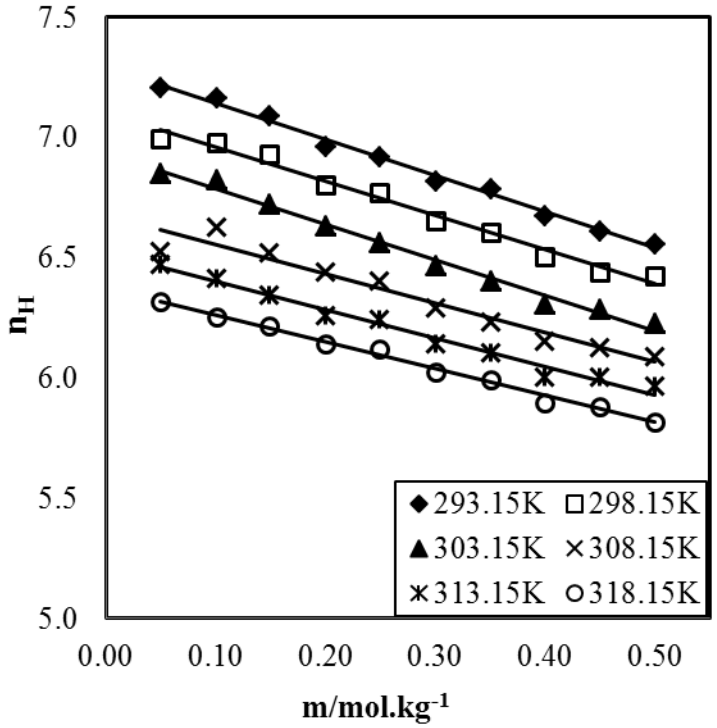


Figure 4.109: Plots of Hydration number (n_H) vs. Molality (m) of L-serine + 0.05 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

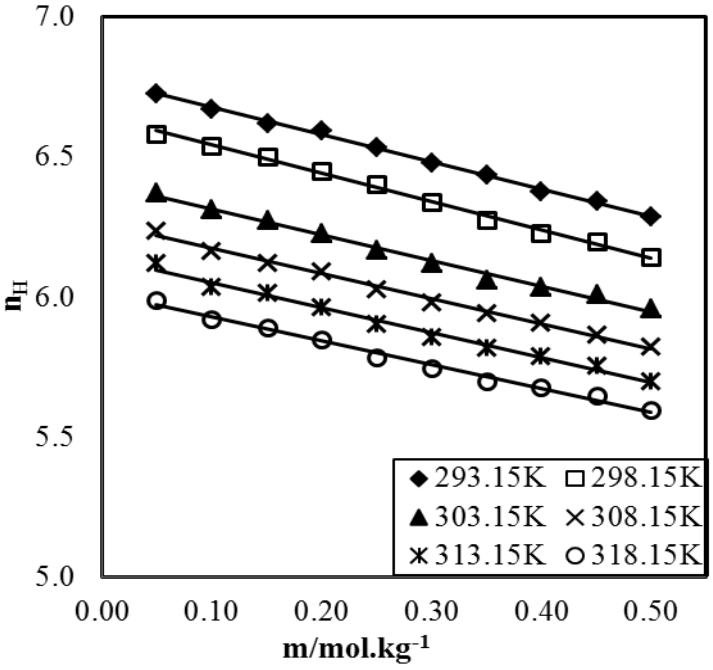


Figure 4.110: Plots of Hydration number (n_H) vs. Molality (m) of L-serine+ 0.20 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

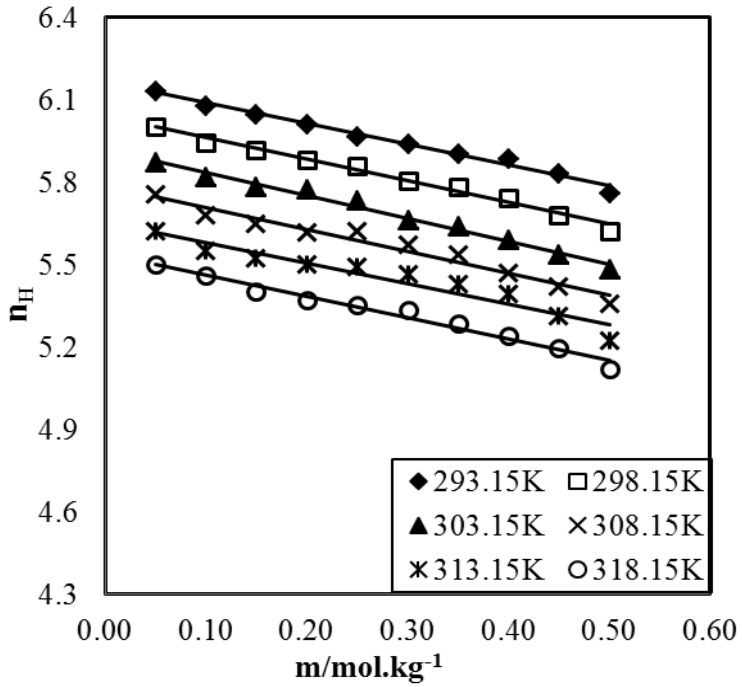


Figure 4.111: Plots of Hydration number (n_H) vs. Molality (m) of L-serine + 0.35 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

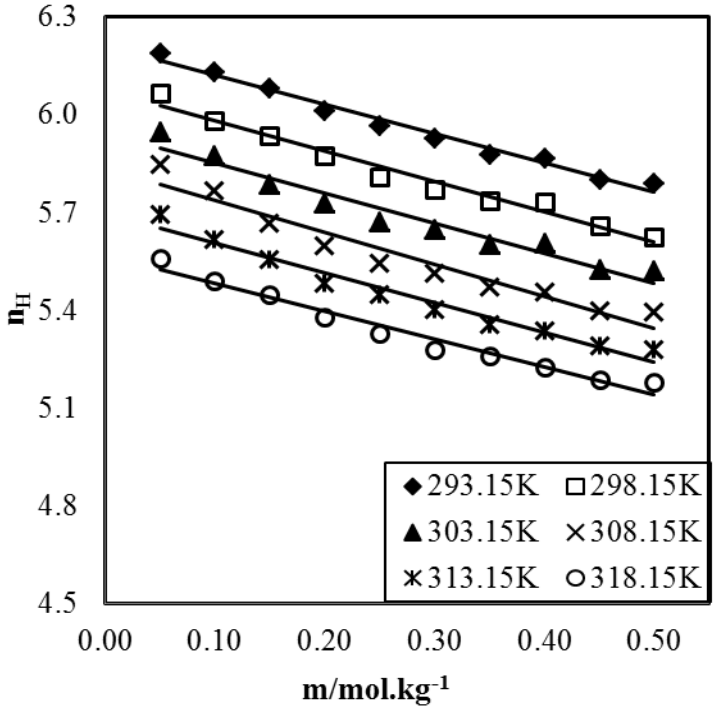


Figure 4.112: Plots of Hydration number (n_H) vs. Molality (m) of L-serine + 0.50 mol.kg^{1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively

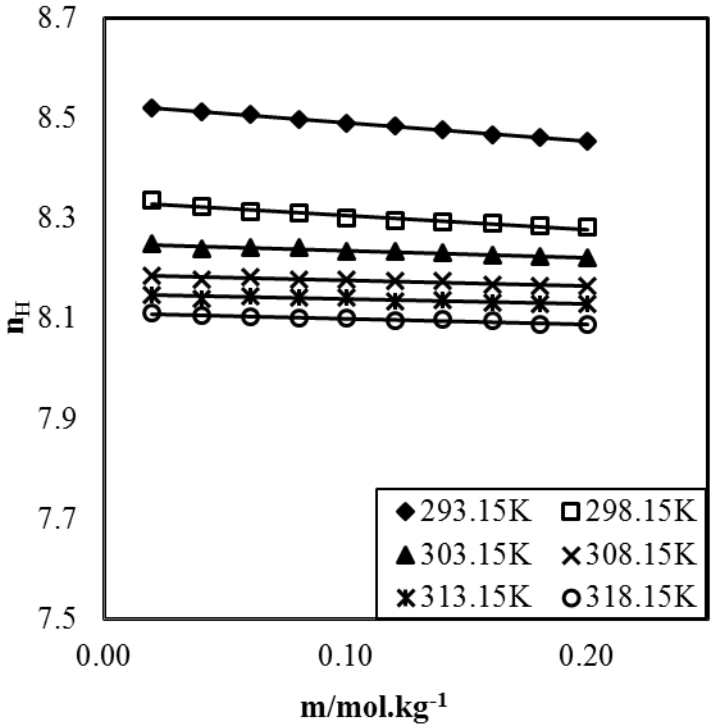


Figure 4.113: Plots of Hydration number (n_H) vs. Molality (m) of L-asparagine + 0.05 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

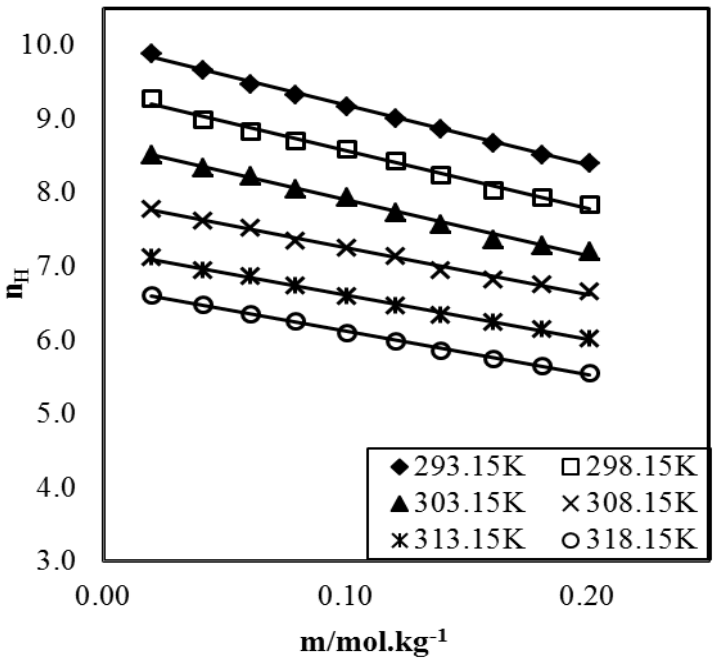


Figure 4.114: Plots of Hydration number (n_H) vs. Molality (m) of L-asparagine + 0.20 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

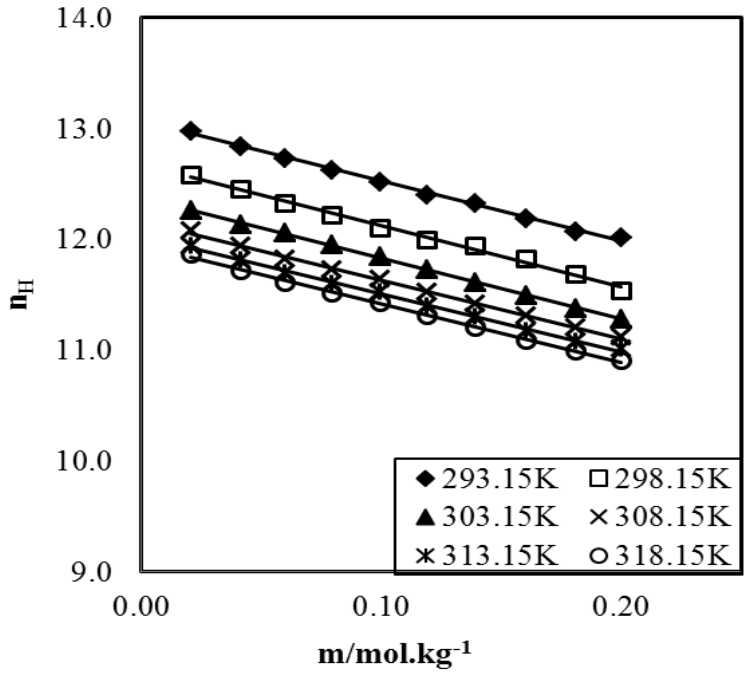


Figure 4.115: Plots of Hydration number (n_H) vs. Molality (m) of L-asparagine + 0.35 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

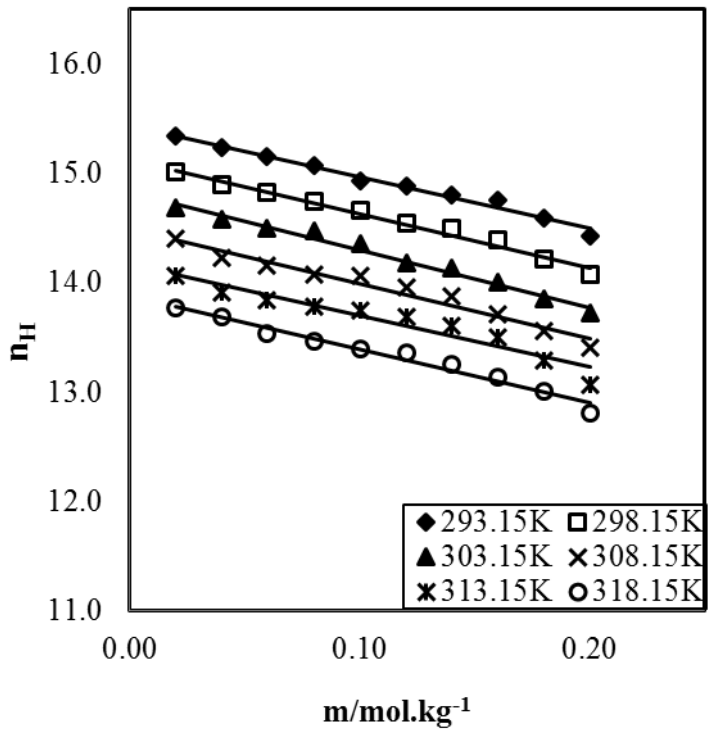


Figure 4.116: Plots of Hydration number (n_H) vs. Molality (m) of L-asparagine + 0.50 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

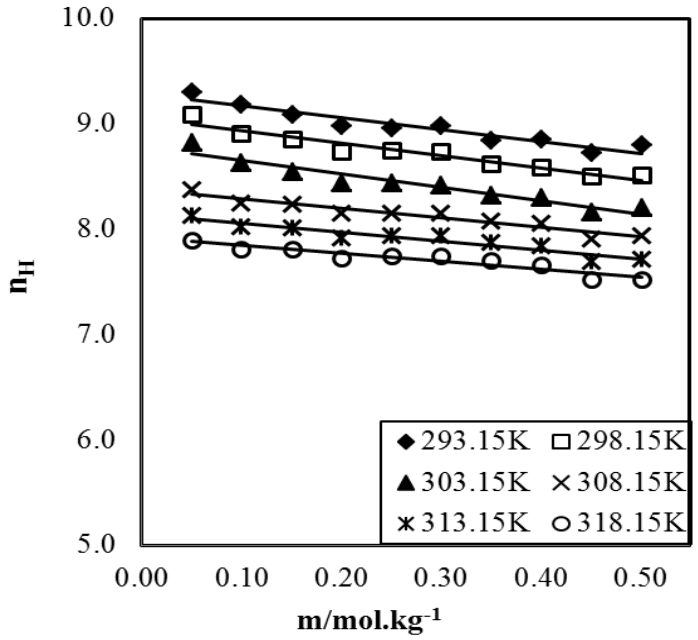


Figure 4.117: Plots of Hydration number (n_H) vs. Molality (m) of L-glutamine + 0.05 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

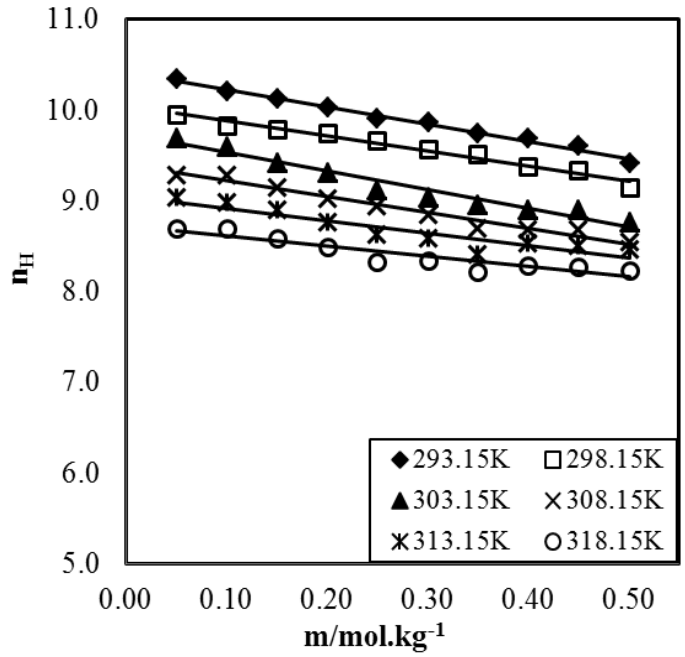


Figure 4.118: Plots of Hydration number (n_H) vs. Molality (m) of L-glutamine + 0.20 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

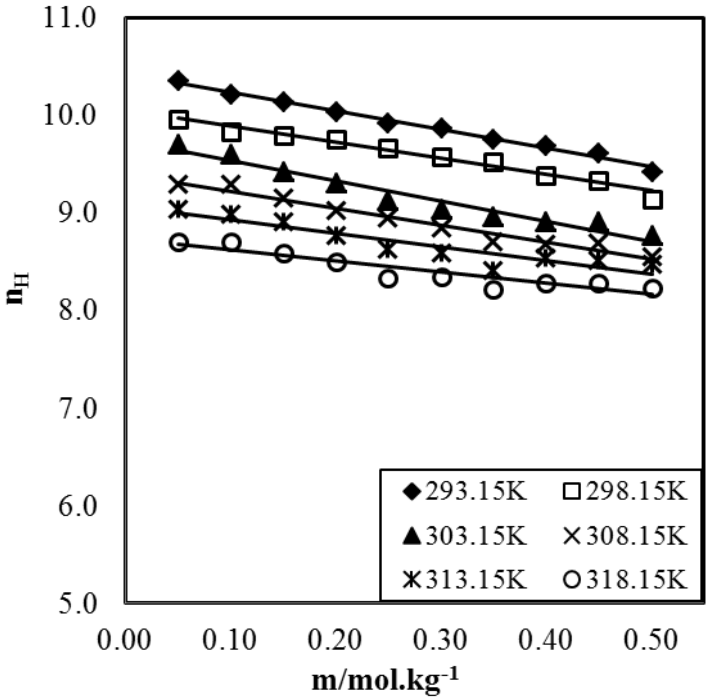


Figure 4.119: Plots of Hydration number (n_H) vs. Molality (m) of L-glutamine + 0.35 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively.

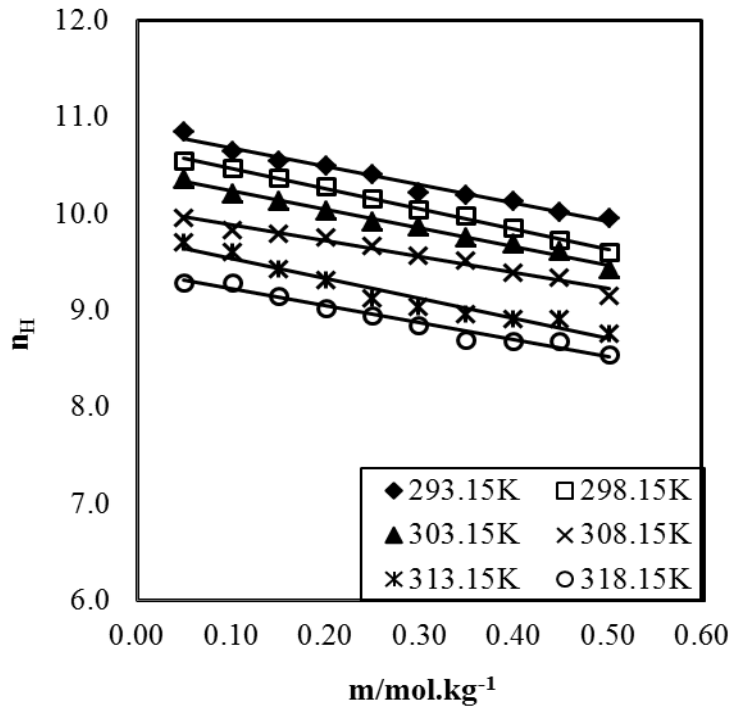


Figure 4.120: Plots of Hydration number (n_H) vs. Molality (m) of L-glutamine + 0.50 mol.kg^{-1} vitamin B6 in water system at 293.15K, 298.15K, 303.15K, 308.15K, 313.15K and 318.15K respectively

CHAPTER V

Conclusion

Densities of L-serine, L-asparagine and L-glutamine in aqueous and aqueous 0.05, 0.20, 0.35 and 0.50 mol.kg^{-1} vitamin B6 solutions have been studied at 293.15K to 318.15K with an interval of 5K. The densities increase with increasing of concentration of L-serine, L-asparagine and L-glutamine and decrease with increasing of temperature.

The apparent molar volumes (φ_v) of L-serine, L-asparagine and L-glutamine in aqueous and aqueous vitamin B6 solution are found to be positive and increase with increasing of concentration of L-serine, L-asparagine and L-glutamine. The values of transfer apparent molar volume ($\Delta_{tr}\varphi_v^0$) are found to be positive for L-serine systems whereas negative for L-asparagine and L-glutamine systems. The values of limiting apparent molar volume expansibilities (E_φ^0) are positive. The Hepler's constant $(\delta E^0\varphi/\delta T)_p$ values are negative in binary solution but positive in ternary solution. The values of partial molar volumes ($\bar{V}_2$) increase with increasing of concentration of L-serine, L-asparagine and L-glutamine for these systems.

The sound velocities (u) increase with increasing of concentration of amino acids and vitamin B6. The values of apparent molar adiabatic compressibility (φ_k) are found to be negative and φ_k values increase with increasing of concentration of L-serine, L-asparagine and L-glutamine and also increase with increasing of temperature. The values of limiting apparent molar adiabatic compressibility (φ_k^0) are found to be mainly negative. The values of apparent molar adiabatic compressibility transfer ($\Delta_{tr}\varphi_k^0$) are found to be negative. The values of acoustic impedance (Z) increase with increasing of concentration of amino acids. The hydration number (n_H) decrease with the increase of concentration of amino acids and vitamin B6.

In case of L-serine, ion–hydrophilic and hydrophilic–hydrophilic interactions are dominating whereas hydrophobic–hydrophobic and ion–hydrophobic interactions are dominating for L-asparagine and L-glutamine systems.

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