

**STUDY OF THERMODYNAMIC AND TRANSPORT PROPERTIES OF
SOME WATER SOLUBLE VITAMINS IN BINARY AQUEOUS
MIXTURES OF UREA**

**REPORT OF DISSERTATION-II
MASTER OF SCIENCE M.Sc. (HONS)
IN CHEMISTRY**

**SUBMITTED BY
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**UNDER THE GUIDANCE
OF
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DECLARATION

I Sukhmeen kaur hereby affirm that the dissertation entitled “**Study of thermodynamics and transport properties of Nicotinic acid in binary aqueous mixture of Urea**” submitted in partial fulfillment of the requirement for the award of the degree of Masters Of Sciences and submitted to the Department Of Physical Sciences and Chemical Engineering(Chemistry)of Lovely Professional University is entirely an authentic record of my original work and all ideas and references have been duly acknowledged. It does not contain any work for the award of any other degree or diploma.

Date:

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ACKNOWLEDGEMENT

*I would like to express my deep and sincere gratitude to my supervisor **Dr. Ramesh Chand Thakur, Asstt. Professor, Department of Chemistry, Lovely Professional University**, whose help, stimulating suggestions, kindness, personal guidance and most of all, for his patience helped me in all the time of my research work and have provided a good basis for the present thesis. **It was a great pleasure for me to conduct this thesis under his supervision.** I believe that one of the main gain of this program was working with **Dr. Ramesh Chand Thakur**. . The legacy of scientific enquiry, hard work and value of temperance that inherited from my guide shall be a great wealth for me that I will cherish throughout my life. I consider myself privileged to have work under the supervision of best teachers in their respective field.*

*I also want to thanks my lab technician **Mr. Praveen,Mr. Varun,Mr. Manish and Mr. Manoj** and wish to extend my warmest thanks to all my friends for their great help in difficult times. Needless to say, that I am grateful to them.*

*I cannot end without thanking **my parents for their unflagging love and support** throughout my life; this dissertation is simply impossible without them. They teach me the good things that really matter in life.*

*Last but not least, I have no words to thanks **GOD** for his countless blessings.*

Sukhmeen Kaur

INTRODUCTION

During recent years Solution chemistry, has expanded in different directions. Recently emphasis has been given on the basis of use and importance of broad range of solvents as reaction media. The thermodynamics of ion-solvent interactions are of fundamental importance to an understanding of the rates and equilibria of reactions which are involving in electrolytes in the solutions. The study of thermodynamic and transport properties of the electrolytic solutions provides an opportunity for extending the range of properties from which the structure of electrolyte solution can be inferred.

If we look around we are surrounded by electrolytic and non-electrolytic solutions .These solutions plays a major role in environment and other systems. Properties of these solutions like mobility, reactivity, state and these further depend upon the certain various properties like thermodynamic and transport properties these solutions . Thermodynamic and transport properties are used to study the physical system and refer to the various qualities like pressure, heat and temperature which is affected from earth's atmosphere to the rates at which chemical reaction occur. These properties are used to define the current state of a substance. Thermodynamic properties are of two different types -intensive properties and extensive properties.

1. **Intensive properties:** An intensive property is any property which is basically depends on the chemical composition and structure of material and independent of amount of the material is present in system. Few examples of intensive properties are density, temperature, chemical potential, pressure, heat capacity and viscosity.

2. **Extensive properties:** An extensive property is a property of a system which depends on the amount of material and material size present in the system. Examples of extensive properties including: mass, volume, entropy and enthalpy.

Thermodynamic properties play an important role in the design and operation of chemical plants. The chemical industry requires precise thermodynamic data for different substances covering a wide range of temperature, pressure and composition. Most processes in the chemical industry demand for the data on vapour-liquid, liquid-liquid, solid-liquid equilibria, and transport properties.

Biomolecules: All living organisms are made up of different kind of biological molecules or biomolecules. A biomolecule is a molecule that is involved in the metabolic processes and maintenance of living organisms. Biomolecules are produced in the body by biological means and manage the growth of body. Different types of biomolecules like carbohydrates, vitamins, lipids, proteins (amino acids) and nucleic acids plays a major role in growth of human body.

Vitamins: Vitamins are organic compounds which are essential required in very little quantities to survive and play a very important role in our growth. We need to take vitamins from food because the human body either does not produce enough of vitamins or none at all. In biological system each living organism has different requirements for vitamin. For example, vitamin C (ascorbic acid) which is only necessary for humans but not for dogs, because dogs can synthesize enough of ascorbic acid for their own needs, while humans cannot synthesize .

Urea: There's a substance out there that is so versatile it can be used in everything from face creams to fertilizer to spandex to reducing emissions from diesel engines and it is even used by our own bodies to eliminate toxic materials like ammonia. In urea, there is a carbonyl group attached to two amide groups. Our bodies use urea to eliminate the products of proteins that have been broken down. When proteins breaks down in body, they are turned in to carbon dioxide, water, and ammonia. Ammonia is very toxic and would destroy your cells, so your body must convert it into something less harmful. Through the beauty of chemistry, your liver turns the ammonia into urea, which can then be safely transported to your kidneys and removed through the urine. Urea is manufactured by exposing ammonia and carbon dioxide to high temperatures and pressures. Urea is manufactured more than any other organic compound and its claim to fame is its use in fertilizers, with 90% of the urea produced going to fertilizers. Urea is relatively cheap, contains a lot of nitrogen, and is easy to transport, all of which make it a very popular nitrogeneous based fertilizer.

THERMODYNAMIC PROPERTIES

Partial Molar Volumes: The change in volumes of water upon the addition of one mole of electrolyte to the large reservoir of volume which is known as partial molar volume of the

electrolyte at the indicated concentration at constant temperature T, pressure P and no. of moles of other components n_1 . Mathematically partial volume V_2^0 it can be written as:

$$V_2^0 = \left(\frac{\partial V}{\partial n_2} \right)_{T, P, \dots}$$

The partial molar volume of an electrolyte V_2^0 can be determined from density measurements. The use of apparent molar volume v , is more convenient, particularly for binary solutions, which may be calculated with the help of following relation:

$$\phi_v = \frac{M}{\rho} - \frac{1000(\rho - \rho_0)}{c\rho_0}$$

where M is the molecular weight of an electrolyte, ρ is the density of electrolytic solution, ρ_0 is the density of water and m is the molal concentration of the electrolyte.

As per scale used by limiting Debye-Huckel, molarity is most commonly used to express the concentration dependence of ϕ_v . At infinite dilution, the partial molar volume and the apparent molar volume becomes equal ($\phi_v^0 = V_2^0$).

The apparent molar volumes ϕ_v^0 , varies with the square root of molar concentration by the linear equation termed as Masson equation's:

$$\phi_v = \phi_v^0 + S_v^* C^{1/2}$$

where ϕ_v^0 is the apparent molar volume at infinite dilution, and S_v^* the experimental slope which varies with electrolyte type and charge.

The ideal method is to make the measurements in very dilute solutions where the deviations from the limiting law are very small and hence ϕ_v and higher order terms of the Own-Brinkley equation do not have to be considered. Since the limiting law is not known above 700C, the Masson equation must be used at high temperature.

TRANSPORT PROPERTIES

Transport properties such as dielectric polarization relaxation, conductance, viscosity and self diffusion etc reflects the movement of solvent molecules in solutions. In general, the rates of movements of solvent molecules decrease if there is an increase in the structure due to increase rigidity and vice-versa.

The transport phenomenon arises because any system in non-equilibrium state will always try to approach equilibrium if the intensive state variables are constant at all times and have the same magnitude at all positions in a system. At equilibrium the gradients of the parameters are absent, spontaneous processes do not occur and there is no net exchange of matter between the system and its surrounding. If the system is in a state in which these conditions are not satisfied then the system is said to be in the non equilibrium state.

Suppose an equilibrium is disturbed to a non-equilibrium state by some external or internal disturbance, one of the state parameter becomes a function of position. When this disturbance is removed, an irreversible decay process occurs simultaneously and the system advances through a series of non equilibrium states until equilibrium is reached. This process is a transport process, because some quantity is transferred throughout the system as the system tries to make all parameters independent of position. Thus any process in which some physical quantity such as mass, energy, electrical charge etc. is transported from one region of a system to another is known as transport process. The amount of physical quantity transported per unit time is called flux and is proportional to the gradient of some other physical quantities like temperature, pressure, concentration and electrical potential. The agency causing the flux is known as force.

Many of the transport processes in biology and in non-living systems are similar since they obey all the laws of physics. Living systems are the open systems constantly exchanging matter and energy with environment. This exchange is not random, but a highly selective transport of substance and energy. In many biological systems of chemical reactions and flows, there is a resultant coupled flow of certain substances, even against a gradient such a transport flow of substance is called active transport. The viscosity of electrolytic or non-electrolytic solutions is interpreted using Jones-Dole equation.

$$\eta_{\text{rel}} = \eta/\eta_0 = 1 + AC^{1/2} + BC$$

Where η_{rel} is the relative viscosity of solution, A is a positive constant representing the inter-ionic forces where as B is an empirical constant representing the contributions of co-spheres of the ions and C is the molar concentration.

Structure breaking is more important in three dimensional solvents than in other classes of solvents. Since it is usually difficult to separate the ionic size effect from the structural effect of B-coefficient, the better criteria for solvent structural influence would be the temperature dependence of the B-coefficient i.e. dB/dT . According to these criteria, structure breaker solutes have positive values of dB/dT , whereas the structure makers have negative value of dB/dT .

REVIEW OF LITRATURE

The aqueous organic systems emphasize the significance of solvent-solvent interactions and also of co-ordinated ions interactions and solvent molecules in hydrogen bonding medium. Therefore ,the thermodynamic and transport properties of common electrolytic solutions have been reviewed with a special emphasis on binary aqueous-organic mixtures. It is well known that standard thermodynamic quantities of ionic and non-ionic solvents are intimately related with the solvent effect on the physical and chemical properties of the solutes.

As the review of literature is already discussed in pre dissertation report and it will be incorporated in the final report.

Amalendu Pal and Suresh Kumar¹, measured the viscosities and densities of l-glycine, l-alanine and l-valine at various temperatures 288.15, 298.15, 308.15 and 318.15 K in aqueous mixture of urea solutions. The viscosity data have been studied by using Jones–Dole equation whereas the density data have been evaluated by Masson's equation. The values of various parameters including apparent molar volume, limiting apparent molar volume and relative viscosity have been calculated from the density and viscosity data. Transfer volumes and the infinite dilution partial molar expansibilities which have been calculated from the temperature dependence of the limiting apparent molar volumes. The results were evaluated in the presence of interactions like ion–ion and ion–solvent interactions.

Nath Roy, Lovely Sarkar², studied the apparent molar volumes, ϕV , and viscosity B-coefficients, for nicotinic acid and benzoic acid in mixed solvents containing mass % 10, 20, 30 mass % of n-amyl alcohol or isoamyl alcohol in methanol and in pure methanol (MeOH) were determined at temperature 298.15 K as function of concentrations of nicotinic acid and benzoic acid. These results were, in conjunction with the determined results for the pure methanol, used to minimize the partial molar volumes of transfer, $\Delta \phi V$, and viscosity B-coefficients of transfer, ΔB , for nicotinic acid and benzoic acid from methanol to different mixed composition of methanol solvents. With increasing in mass % of n-amyl alcohol or isoamyl alcohol in methanol and an increase in the transfer properties of nicotinic acid and benzoic acid was observed and evaluated by the effect of structural changes.

Akhter and Huque³, measured viscosities and densities of NaCl and KCl aqueous solution in the presence of hydrazine at a wide range of temperatures (298.15, 303.15, 308.15, 313.15, 318.15K). Apparent specific volume of the solutions were calculated. The results we obtained were indicate that with various percentages of hydrazine, NaCl acts as structure maker. At low percentages of hydrazine KCl acts as structure breaker.

Parvinder Khanuja, V.R.Chourey and A.A.Ansari⁴, determined the structure making nature and solute-solvent interaction of Carbohydrate (glucose, fructose, sucrose, maltose) in aqueous solution using Jones-doles (A and B) coefficients and apparent molar volume which were determined from the data of viscosities and densities at a range of temperature (293.15, 303.15, and 313.15K). They proved that all these carbohydrates act as structure maker & their capacity lie in the order of Fructose < Glucose < Sucrose < Maltose.

OBJECTIVES OF THE STUDY

The behavior of electrolytes and non electrolytes depends on interactions as solute-solute and solute-solvent interactions in solution. The former interactions in general are stronger than the latter. In dilute electrolyte solution, ion-ion interaction is now well understood theoretically but the ion-solvent interaction (ion-solvation) is still a complex interactions. The survey of literature showed that although many studies on thermodynamic and transport properties (already

discussed in the literature) have been carried out both in single component and mixed solvent systems.

It has been realized that ion /solvent interactions play an important role in the solution chemistry .Most of these studies have been carried out in water (w) which is the structured solvent far excellence. If the nature of w can be modified by a co-solvent in such a way that the electrostatic effects , arising from dielectric constant , remain almost the same then the chemical effects of the co – solvent should also played an important role in influencing ion – ion interactions. Moreover, mixed binary aqueous solvent systems behave in unexpected systems. These observations have given a new impetus to the detailed study of structure of binary aqueous mixtures. The information drawn from the studies of thermodynamic and transport properties have been related to structural aspect of the solvent in terms of ion – solvent interactions and structure making/breaking capacity of various electrolytes.

Since the results in mixed aqueous systems highlighted the importance of solvent – solvent interactions and also of interactions between co-ordinate ions and solvent molecules in H-bonding medium. Therefore, the main objectives of the present study will be to investigate the thermodynamic property viz; partial molar volume and transport processes such as viscous flow nicotinic acid in binary aqueous mixtures of Urea. The main objectives of the present investigations are :

- To estimate the partial molar volumes of nicotinic acid in binary aqueous mixtures of urea at different temperatures.
- To find the limiting apparent molar volume ($\phi_v^0 = \bar{v}_2^0$) and experimental slope S_v^* from the plots of ϕ_v versus \sqrt{c} and infer the solute-solvent and solute-solute interactions.
- To verify the Jones-Dole equation some water soluble vitamins in binary aqueous mixtures of urea.
- To infer the ion-ion and ion-solvent interactions and the effect of nicotinic acid in binary aqueous mixtures of urea.
- To obtain the various transition state parameters.

The thermodynamic quantity such as partial molar volume has proved to be a very useful tool in illustrating the interactions occurring in aqueous and non-aqueous solutions. The partial molar

volume of a solute at infinite dilution, where solute/solute interactions vanish, is a appropriate to study the solute-solvent interactions. Recently many workers have interpreted the results of partial molar volumes of electrolytes and non-electrolytes in terms of ion/solvent and solute/solvent interactions. The structure making/breaking capacities of various solutes have also been reported from the studies on partial molar volumes.

In the present investigation information regarding solute/solvent and ion/solvent interactions shall be obtained from the measurements of partial molar volumes and viscosities of nicotinic acid in binary aqueous mixture of urea at different temperatures. These estimations are done through the measurements of densities and viscosities with the help of pycnometer and Ostwald viscometer respectively.

EXPERIMENTAL WORK DONE SO FAR

The thermodynamic quantity known as partial molar volume has proved to be a very useful tool in elucidating the interactions occurring in aqueous and non-aqueous solutions. The partial molar volume of a solute at infinite dilution, where solute-solute interactions vanish, is a appropriate to study the solute-solvent interactions. Recently many workers have interpreted the results of partial molar volumes of electrolytes and non-electrolytes in terms of ion-solvent and solute-solvent interactions. The structure making/breaking capacities of various solutes have also been reported from the studies on partial molar volumes.

In the present investigation information regarding solute-solvent/ion-solvent interactions are obtained from the measurements of partial molar volumes of nicotinic acid in binary aqueous mixture of urea at different temperatures. These estimations are done through the measurements of densities with the help of hydrostatic balance. The structure making/breaking capacities of various solutes are assessed by using Hepler's criteria⁷⁶.

For the sake of convenience of presentation the experimental part is described under the following sections:

- (a) Materials

- (b) Preparation of solutions
- (c) Apparatus
- (d) Experimental procedure
- (e) Sources of error

(a) MATERIALS

(i) Conductivity water : The water used for calibration of apparatus and for preparing various solutions was obtained by distilling the water twice over alkaline KMnO_4 and $\text{K}_2\text{Cr}_2\text{O}_7$ in glass apparatus using long fractionating column. The specific conductance of water was of the order of $10^{-6} \text{ Ohm}^{-1} \text{ cm}^{-1}$. The water was stored in glass bottles.

(ii) Reagents: The reagents nicotinic acid (M.W. 123.11, acetone and urea(M.W. 60.06).

(b) PREPARATION OF SOLUTION

The different compositions of Urea-water and solutions of the electrolytes were prepared by weight. The molality (m) of electrolyte solution was then converted into molarity (c) by using the following expression⁷⁷.

$$c = \frac{d \cdot M_2 \cdot \rho}{1000 \cdot M_1}$$

where d is the density of electrolyte solution, and M_2 is molecular weight of electrolyte.

(c) APPARATUS

Pycnometer, is a flask with a close-fitting ground glass stopper having a fine hole through it, so that a given volume can be accurately obtained. This is used to calculate density of a fluid to accurately, by reference to an appropriate working fluid such as water or mercury, using an analytical balance.

(d) EXPERIMENTAL PROCEDURE

Pycnometer is cleaned with water and then rinsed with a small amount of acetone . Measure the weight of the dry flask and stopper with the help of digital balance. To determine the exact volume of the pycnometer by filling it completely with water, inserting the stopper, and tapping the sides gently in order to ignore the air bubbles. Dry the sides of pycnometer by tissue paper and weigh the pycnometer with the help of analytical balance. Measure the temperature of the water also. Known density of water which is reported in literature is used to calculate the density of unknown solutions.

Density measurements:

The density of the pure solvents, aqueous solutions and mixed aqueous solutions are measured with the help of 30 ml single capillary pycnometer.



PYKNOMETER

EXPRIMENTAL DATA FOR DENSITY

Weight of empty pycnometer = 18.83gm

Weight of empty pycnometer + Water at different temperatures

Temperature	Weight of water(gm)
298.15	45.84
303.15	45.81

308.15	45.79
313.15	45.77

The following equation is used to calculate density:

$$\rho = \frac{W_3 - W_1}{W_2 - W_1} \rho_0$$

Where ρ is the density of the solution, W_1 is the weight of empty pycnometer, W_2 is the weight of empty pycnometer + water, W_3 is weight of empty pycnometer + solution and ρ_0 is the density of water at particular temperature. To obtain weight, pycnometer was filled up to fixed mark, then heated at particular temperature in water bath and measured the weight using electronic weighing balance.

CALIBRATION OF APPARATUS

PYCNOMETER: Calibration of pycnometer was done by calculating the density of pure ethanol which was found to be approximately 0.73366 gcm^{-3} which near to the literature value 0.78064 gcm^{-3} .

Determination of density of nicotinic acid in urea at different temperatures.

1. Nicotinic acid in 0.1m Urea

Temperature = 298.15 K

Density of water = $0.99704 \times 10^{-3} \text{ kg/m}^3$

Molal concentration (m)	Weight of sample (gm)	Density ($d \times 10^3 \text{ kg/m}^3$)
0.01	46.387	1.017239
0.03	46.397	1.017608
0.05	46.404	1.017866

0.07	46.408	1.018014
0.09	46.41	1.018088
0.1	46.412	1.018162

Temperature =303.15 K

Density of water= $0.99565 \times 10^{-3} \text{ kg/m}^3$

Molal concentration (m)	Weight of sample (gm)	Density ($d \times 10^3 \text{ kg/m}^3$)
0.01	46.228	1.011076
0.03	46.239	1.011481
0.05	46.247	1.011777
0.07	46.252	1.011961
0.09	46.257	1.012146
0.1	46.259	1.01222

Temperature =308.15 K

Density of water= $0.99403 \times 10^{-3} \text{ kg/m}^3$

Molal concentration (m)	Weight of sample (gm)	Density ($d \times 10^3 \text{ kg/m}^3$)
0.01	46.169	1.008008
0.03	46.182	1.008487
0.05	46.191	1.008819
0.07	46.197	1.00904
0.09	46.203	1.009262

0.1	46.206	1.009372
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Temperature = 313.15 K

Density of water = $0.99221 \times 10^{-3} \text{ kg/m}^3$

Molal concentration (m)	Weight of sample (gm)	Density ($d \times 10^3 \text{ kg/m}^3$)
0.01	46.064	1.003046
0.03	46.079	1.003599
0.05	46.086	1.003856
0.07	46.092	1.004077
0.09	46.099	1.004335
0.1	46.101	1.004409

2. Nicotinic acid in 0.2m Urea

Temperature = 303.15 K

Density of water = $0.99704 \times 10^{-3} \text{ kg/m}^3$

Molal concentration (m)	Weight of sample (gm)	Density ($d \times 10^3 \text{ kg/m}^3$)
0.01	46.358	1.015873
0.03	46.368	1.016242
0.05	46.374	1.016464
0.07	46.376	1.016537
0.09	46.38	1.016685
0.1	46.381	1.016722

2.Nicotinic acid in 0.3m Urea

Temperature = 303.15 K

Density of water = $0.99704 \times 10^{-3} \text{ kg/m}^3$

Molal concentration (m)	Weight of sample (gm)	Density ($d \times 10^3 \text{ kg/m}^3$)
0.01	46.588	1.024361
0.03	46.599	1.024767
0.05	46.606	1.025025
0.07	46.608	1.025099
0.09	46.609	1.025136
0.1	46.611	1.02521

VISCOSITY STUDIES DONE SO FAR

In this chapter uncoupled transport phenomenon viz., viscous flow of nicotinic acid in a binary aqueous solutions of Urea are described.

The viscosity of a liquid is a measure of its resistance to flow or its rate of strain. Since flow of a fluid takes place by displacement of equilibrium positions of molecules, the study of viscosity can therefore lead to the information about these displacements. It has been found by the no. of workers that the addition of an electrolyte or solute either breaks or makes the structure of a liquid.

The viscosity of electrolytic or non-electrolytic solutions is usually interpreted in terms of Jones-Dole equation.

$$\eta_{\text{rel}} = \eta/\eta_0 = 1 + AC^{1/2} + BC$$

Where η_{rel} is the relative viscosity of solution, A is a positive computable constant which represents the contribution of inter-ionic forces, B is an empirical constant which represents the contributions of co-spheres of the ions and C is called molar concentration.

In the region of dielectric saturation, even for ions that are structure-makers, the B-value of a particular ion may be seen as a result of positive and negative contribution.

Since it is usually difficult to separate the ionic size effect from the structural effect of B-coefficient, the better criteria for solvent structural influence would be the temperature dependence of the B-coefficient i.e. dB/dT . According to this criteria, structure breaker solutes have positive values of dB/dT , while the structure makers have negative value.

Recently lot of data on viscosity have been reported in water and some hydrogen bonded solvents and binary mixtures of aqueous-organic solvents for different types of solutes but data for nicotinic acid is extremely less and in particular no data have been noticed for some water soluble vitamins in binary aqueous mixture of urea. Therefore there is no reason for not trying a comparative study of nicotinic acid in binary aqueous mixture of urea.

MEASUREMENT OF VISCOSITY

Viscosity measurements are made with the help of suspended type viscometer. This has the time flow of at least 54.28 seconds for water at temperature 303.15K. Runs are repeated until three successive determinations are obtained within ± 0.1 second. The viscometer, shown in Fig.18 consists of a U-tube with two bulbs D and E, along with a side arm F. The left hand limb is essentially a pipette with two definite marks A and B above and below the bulb D and a capillary about 10" long. Some volume of solution is introduced into the bulb E. Keeping the side arm, 'F', closed, the solution is forced through capillary tube C until the meniscus stood above the mark A. On opening the side arm, F, while keeping the capillary limb closed, the solution below C will fall back and the column of the solution CA is held suspended. On opening the capillary limb the solution flows through the capillary and the time of flow of meniscus from

A to B is noted. The column of liquid CA is the same in each case, independent of the volume of the solution in the viscometer.

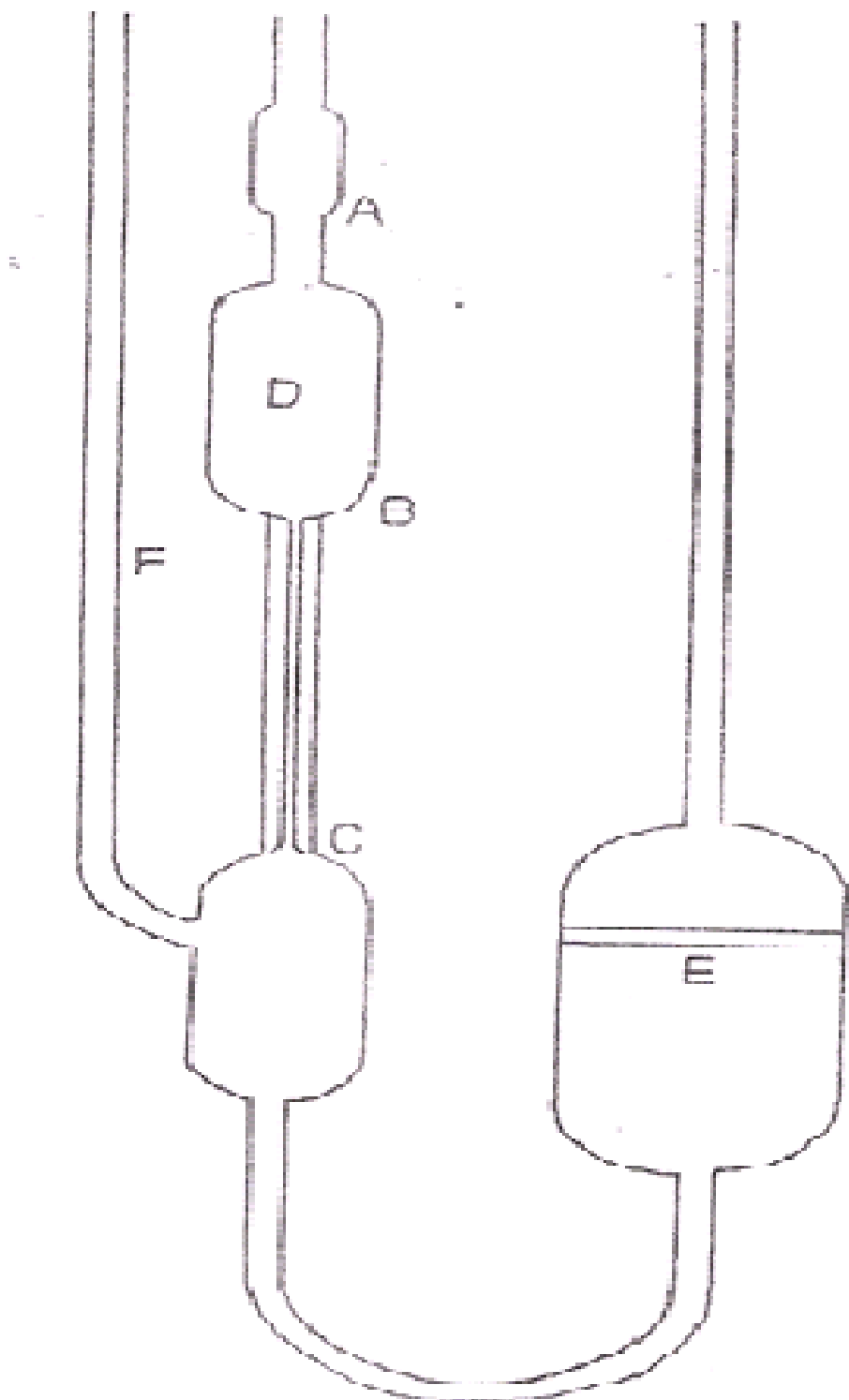


FIG. 18 VISCOMETER

CALIBRATION OF VISCOMETER:

Calibration of viscometer was done using the pure ethanol and the viscosity of pure ethanol was found to be approximately 0.6051cp which is equivalent to the original value 0.6056cp.

The viscometer was cleaned by filling it with chromic acid, followed by washing with water and finally with acetone. It was then dried by applying vacuum. Flow time for volume of solution through the capillary, between the marks A and B was measured with the help of a stop watch capable of recording time upto 0.1 second. Viscosities of solutions are determined at different temperatures in water thermostat controlled upto $\pm 0.01^{\circ}\text{C}$ by means of an electronic relay and contact thermometer. Time of flow (for solution in bulb) between marks A and B is determined by visual observation. The relative viscosities of various solutions are measured by using following equation:

$$\eta_r = \frac{\eta}{\eta_o} = \frac{d \cdot t}{d_o \cdot t_o} \quad (3.5)$$

where η and η_o are the viscosities of solution and solvent respectively, η_r is the relative viscosity, d and d_o are the densities of solution and solvent respectively, t and t_o are their respective flow times. Because all the flow times were greater than 100 seconds, kinetic energy correction is not necessary.

The calibration of the viscometer was done with the help of conductivity water used as a standard liquid.

EXPERIMENTAL DATA FOR VISCOSITY

Determination of viscosity of nicotinic acid in binary aqueous mixture of urea at different temperatures.

1. Nicotinic acid in 0.1m Urea

Temperature = 298.15 K

Molal concentration (m)	Time Flow of Sample (sec)
0.01	58.47
0.03	58.93
0.05	59.08
0.07	59.16
0.09	59.24
0.1	59.23

Temperature =303.15K

Molal concentration (m)	Time Flow of Sample (sec)
0.01	58.43
0.03	58.87
0.05	58.99
0.07	59.03
0.09	59.05
0.1	59.19

Temperature=308.15K

Molal concentration (m)	Time Flow of Sample (sec)
0.01	58.01
0.03	58.32
0.05	58.35
0.07	58.38
0.09	58.4
0.1	58.45

Temperature=313.15K

Molal concentration (m)	Time Flow of Sample (sec)
0.01	57.78
0.03	57.98
0.05	58.04
0.07	58.07
0.09	58.09
0.1	58.1

2.Nicotinic acid in 0.2m Urea

Temperature =303.15 K

Molal concentration (m)	Time Flow of Sample (sec)
0.01	55.36
0.03	55.77
0.05	55.97
0.07	56.08
0.09	56.13
0.1	56.16

3.Nicotinic acid in 0.3m Urea

Temperature =303.15 K

Molal concentration (m)	Time Flow of Sample (sec)
0.01	56.13
0.03	56.66
0.05	56.81
0.07	56.89
0.09	56.93
0.1	57.02

FUTUREPLAN FOR DISSERTATION-II

In dissertation-II we are going to study the pyridoxine hydrochloride and thiamine hydrochloride in aqueous mixtures of urea. Determine the densities and viscosities and analyze them with Masson's and Jones dole equation. The information drawn from the studies will be related to structural aspect of the solvent in terms of solute – solvent interactions and structure making/breaking capacity of various nicotinic acid and pyridoxine hydrochloride in binary aqueous mixtures of urea.

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