GLASSES: GENERAL INTRODUCTION

Contents

1.1 General Introduction
1.2 Review of Glass Research
1.3 Need of Investigation
1.4 Aim of Present Work
GLASSES: GENERAL INTRODUCTION

1.1 General Introduction:

Solids cover a very wide area of science. Solids can be classified according to variety of criteria, one being the description of solid as a crystalline or amorphous materials. The glass is one of the amorphous materials. It is most useful and common material in every day life. The glass is an amorphous, hard, brittle, transparent or translucent supercooled liquid of infinite viscosity. The glass can be obtained by fusing together appropriate amounts of chemicals. It does not have definite crystalline structure, formula and sharp melting point.

Upto the year 1954, the glasses were treated as insulators. Denton et al. have measured the resistivity of semiconducting glasses containing 90% V_2O_5 in the year 1954 since then, studies on electronic conduction in glasses increased rapidly as they found useful in many applications in industries and allied areas. Many research workers have studied glasses because of their wide range of applications, such as switching and memory devices, transducers, superior insulators and dielectrics etc. Thus the glass become an ordinary electronic material. Many kinds of components from switching and memory diodes to computer memory might be cheaply produced with glass.

The glasses are characterized by networking oxides (glass formers) which give rise to random linked tetrahedral arrangement broken at some places by the network modifier (glass modifier). The conventional technique of glass preparation involves melting of the thoroughly mixed ingredients and quenching.
of the homogeneous melt. The current interest in the field of glasses is to enhance the electrical conductivity for making them suitable for specific applications.

The ionic/electronic conductivity in the glasses was established a century ago. High ionic conductivity in the glasses was found in 1972 by Kulznetsov\textsuperscript{5}. There has been a revival of interest in this field over last two decades and as a result, by now, many glass system have been known which exhibits high ionic/electronic conductivity. The structure of the glass was proposed by Zanchariasen\textsuperscript{6}. Semiconducting glasses possess a structure that is disordered to some extent. Mott\textsuperscript{7} and Borland\textsuperscript{8} showed that in the completely disordered Kroning-Penny model, all the solutions of the wave equations are localised and no band formation occurs. A general conclusion had been that a disordered systems have short range order, similar conclusions were also arrived at empirically by Ioffe and Regel\textsuperscript{9}.

Studies on electronic conduction in glasses revealed several important features of the semiconducting glasses. Studies on semiconducting chalcogenide glasses based on As and Se have received attention because of their photoconducting and switching properties\textsuperscript{10,13}. The transition metal oxide glasses received a comparatively lesser attention. As long as 1880's it was shown that the conventional silicate based glasses are basically ionic conductors. The electricity being carried by the comparatively mobile alkali ions with some exceptions. Silicate and other oxide glasses can be regarded as solid electrolytes in which only the cations (usually alkali ions) are appreciably mobile.
Further a glass is defined as an inorganic product of fusion cooled to a rigid condition without crystallization\(^{14}\). Glasses differ from crystalline substances in many of their chemical and physical properties. Glasses do not possess a sharp melting point and in contrast to crystalline materials their structural lattice or network is non-periodic or irregular. By definition, metastable glass melts transforms to solid glasses at the glass transition temperature\(^{15}\) (Tg). The value of Tg depends on the chemical composition of the glass and upon the rate at which the metastable melt is cooled or quenched.

In glasses, the charge transfer mechanism is generally called 'hopping'. This hopping together with polarization induced by the charge is called a polaron, which is now thought to be the most likely conduction mechanism.

1.1.1 Applications and Utility of Glasses:

Transport properties of semiconducting glasses are very interesting and provide useful information about conduction mechanism. Now-a-days, glasses have a prominent role in the field of electronics and have wide applications in industry, space research and computer memories. Perovskite lead zirconate titanate, Pb\([Zr_{0.5}Ti_{1.5-\varepsilon}]\)O\(_3\) or PZT ceramics are well known materials which have very interesting ferroelectric properties for non-volatile memory applications\(^{16}\).

Amorphous solid is an ordinary electronic material. Many kinds of components from switching and memory diodes to computer memories, might be cheaply produced with glass if recent discoveries by glass scientists were exploited by electronic engineers. Glasses can now be made as semiconductors,
photoconductors, magnets, transducers, optical switches memory materials and superior insulators and dielectrics\(^{17}\).

The optical parameter like refractive index is an important parameter for the design of optical components such as prism, windows and optical fibres\(^{18}\).

Most useful applications of glasses are as follows:-

1] Batteries
2] Gas sensors
3] Smart windows
4] Glass ceramics
5] New magnetic materials
6] Optoelectronic switches and memories
7] Biomedical glasses
8] Elemental glass switches
9] Photoconducting glasses
10] Glass electrets in memories etc.

1.2 Review of Glass Research :

1.2.1 Review of XRD, FTIR and DSC Study :

\textit{X-ray Diffraction (X-RD)} :

X-RD technique is very much useful to check the amorphous nature of material.

Changwan \textit{et al.}\(^{19}\) have studied the relationship between the phase separation and crystal morphology in Li\(_2\)O-ZnO-Al\(_2\)O\(_3\)-SiO\(_2\) glass system.
The crystallization of Li$_2$O-CaO-SiO$_2$ glass system has been investigated using X-RD by Wang et al.$^{20}$ The major phase of tetragonal system was found.

X-ray diffraction and molecular dynamics simulations shows that the structure of vitreous B$_2$O$_3$ can be explained by a model of randomly connected BO$_3$ triangles.$^{21}$ X-ray diffraction studies indicate that for the slowly quenched glass the oxygen tend to be out of the plane of the adjacent BO$_3$ triangles. Sanad et al.$^{22}$ have investigated X-ray diffraction pattern of lithium borosilicate glasses containing transition metal oxides. They found that the silicon ions are coordinated to four oxygen in tetrahedral co-ordination and some borons change from triangular to tetrahedral positions.

X-ray diffraction study of crystalline products of some of the silicate systems containing fluoride has been done by Salama.$^{23}$ Phase formation and their transformation encountered during the crystallization are detected by means of X-ray diffraction and DTA techniques. The glass transition temperature (Tg) of lithium borosulphate glasses has been analysed on the basis of the fraction of four coordinated boron, which governs the glass structure.$^{24}$ An unconventional interpretation of the structure of chalcogenide glasses is proposed by theoretical approach.$^{25}$

The structure and physical properties of the lead-vanadate glasses prepared by the roller quenching technique have been studied by Mandel et al.$^{26}$ It has been shown by X-ray diffraction, scanning electron microscopy, density and oxygen molar volume measurement etc. that single phase homogeneous glasses with a random network structure can be obtained in this system.
Property-structure correlation of glasses in the system PbO-B<sub>2</sub>O<sub>3</sub>-MoO<sub>3</sub> was investigated by Gohar <i>et al</i><sup>27</sup>. High temperature X-RD, DTA, SEM and etching techniques shows that these glasses have a large tendency to phase separate and crystallise at low MoO<sub>3</sub> to give PbMoO<sub>4</sub>, as a result of the correlation between some physical properties such as density and molar volume, possible arrangements in the glasses network structure are suggested. The structure of rapidly quenched Li<sub>2</sub>O-SiO<sub>2</sub> glass system has been discussed on the basis of X-ray diffraction method by Umesaki <i>et al</i><sup>28</sup>.

The structure and ion transport properties of Na<sub>2</sub>O-Ga<sub>2</sub>O<sub>3</sub>-P<sub>2</sub>O<sub>5</sub> glasses were investigated by Berthel <i>et al</i><sup>29</sup> by vibrational (IR, Raman) and X-ray absorption spectroscopy. For the orthophosphate compositions, gallium is found in four-fold coordination whereas it is found in six-fold coordination in a metaphosphate glasses.

Soher <i>et al</i><sup>30</sup> have studies some properties of CaO-MgO-P<sub>2</sub>O<sub>5</sub> glasses. The properties of these glasses are compositionally dependent. The influence of MgO on some mechanical properties is evident and these reflect the possibility of structural changes in the glass system.

Glass formation and structural properties of the unconventional lead cuprate glasses of composition X-CuO-(100-X)PbO mol% are reported by Hazra <i>et al</i><sup>31</sup>. X-ray diffraction and microscopic studies shows that the glass formation occurs for X equals to 15-50 mol%. The compositional dependence of the density, molar volume and glass transition temperature suggests that all glass
compositions in this domain have the same topology and network connectivity. The glass structure is build up of PbO4 tetrahedral units glass forming regions. Addition of ZnO in Bi2O3-PbO-ZnF2 glass system significantly improves glass stability\cite{32} and transparent glass could be easily obtained from a 300 g batch. Glass transition and crystallization temperatures were found in the range 290-330°C and 340-370°C respectively.

Glass formation domains and structural properties of some binary transition metal ion glasses based on non-conventional network formers Bi2O3, CuO and PbO have been investigated by Ghosh\cite{33}. With the same network formers, the glass formation domains depend on the transition metal ions are reported.

The crystallization process of ternary system SiO2-CaO-MgO-Na2O is analysed using X-RD by Alizaden et al\cite{34}. The ability of Cr2O3 plus Fe2O3 as nucleating agents in inducing bulk nucleation via formation of spinel phase was proved.

Cervinka L et al\cite{35} have studied structure of Ag - tetraborate glasses AgIx (Ag2O-4B2O3) (1-x), x = 0 to 0.55 by x-ray diffraction method. The x-ray scattering diagram changes significantly when AgI is added to the tetraborate glass.

**Infrared Spectra (IR):**

In the literature different techniques such as X-RD, IR, SEM etc. are used to investigate microstructure. It is shown by Sanad et al\cite{32} that silicon
ions are coordinated to four oxygen in tetrahedral coordination and some boron changed from triangular to tetrahedral configuration.

Tawansi et al\textsuperscript{36} have been studied infrared spectra of lead borate glass. IR analysis indicated that both ionic and covalent bonding of lead ions is possible.

Khalifa et al\textsuperscript{40} have studied the infrared absorption spectra of some lead silicate glasses containing Na, K and Li with the glass composition of \(20\text{SiO}_2-(80-X)\text{PbO-X R}_2\text{O}\) where \(R\) is Na, K and Li. The values of \(X\) were 1 to 10.

Inelastic light scattering in strontium borate glasses was studied by Rahaman et al\textsuperscript{38}. Raman spectra of the glasses showed experimental evidence of glass network modifying nature of SrO in borate matrix. SrO causes a change of boron atom coordination number from 3 to 4 resulting in complex structural grouping comprising of \(\text{BO}_4\) and \(\text{BO}_3\) units.

Infrared spectroscopy and glass transition temperature measurement have been used to explore the structure\textsuperscript{39} and key physical properties of the low alkali phosphate glasses.

The structure by infrared spectroscopy of \(X\text{Na}_2\text{S}-(1-X)\text{B}_2\text{S}_3\) glasses in wide composition range is reported for the first time by Bloyer et al\textsuperscript{40}. Glass can be prepared in two composition regions (i) low alkali region and (ii) high alkali region. The structures of glasses in former region are dominated by the creation of tetrahedral boron units similar to those observed in the alkali borate glasses. The IR properties of the high-alkali glasses show a monotonic increase
in symmetry and simplicity, indicating an increase in structural simplicity as the orthothioborate composition is approached.

Infrared properties of barium borate glasses have been investigated by Kim et al\textsuperscript{41}. The Kramers Kroning analysis was used to obtain the complex dielectric function \( \varepsilon \) from the measured reflectivity.

Raman scattering study of alkali borate glasses has been carried out by Dwivedi et al\textsuperscript{42} to understand the role of the cation in determining the B-O network in glasses. Raman result shows that lighter cations favour a stronger B-O network in which three-dimensional BO\textsubscript{4} groups are attached to a large borate ring while the heavy cations are not easily inserted in the network interstices.

Dayanand et al\textsuperscript{43} have discussed the IR spectrum of a PbO based glass, containing a small amount of SiO\textsubscript{2}, formed by melt quenching, revealed an intense band at 844 cm\textsuperscript{-1} besides two other weak bands which have been attributed to the vibrational modes in the silicate group. The analysis indicates that the glass contains about 4 mole\% of SiO\textsubscript{2} in the form of silicate tetrahedra isolated and disconnected in the network. The results suggest that the PbO play the role of the glass former.

Infrared spectral investigation of some borate glasses in the frequency range 200-4000 cm\textsuperscript{-1} has been done by Yawale et al\textsuperscript{44}. The infrared (IR) spectra of Agl doped Ag\textsubscript{2}S-B\textsubscript{2}S\textsubscript{3} fast ion conducting thioborate glasses has been reported by Burns et al\textsuperscript{45}. The structure of the binary glasses changes with an increase in modifier content.
IR spectra and thin layer chromatograms of superionic conducting glasses in the system AgI-Ag₂O-P₂O₅ were studied by Minami et al. The glasses with mole ratio of Ag₂O/P₂O₅ = 3 or 2 consist of Ag⁺, I⁻ and PO₄³⁻ or P₂O₇⁴⁻ ions only. Partial covalancy between silver and oxygen ions is noted from the peaks of infrared absorption bands.

Boulos and Kreidl et al. have studied the structure and properties of silver borate glasses. They found that transparent glasses are formed in the system Ag₂O-B₂O₃ up to 35 mol% Ag₂O. Infrared absorption, thermal expansion and density data indicated an analogy to the Na₂O-B₂O₃ system.

Dwivedi et al. have done infrared investigation of binary silver borate glasses in the system xAg₂O-(1-x) B₂O₃ for various values of x (0<x<0.77). The IR spectra show clearly the disappearance of boroxol rings and the formation, in the first step, of tetraborate groups and later of diborate groups as the oxide content increases. For high Ag₂O content, borate groups with non-bridging oxygen atoms are formed.

Hudgens et al. studied mid IR and far IR of AgI doped silver borate glasses xAgI-(1-x) Ag₂O.2B₂O₃ where 0.2<x<0.6.

The mid IR spectra revealed that in those glasses prepared using AgNO₃ as a starting material for Ag₂O, the BO₄⁻/BO₃⁻ ratio is constant with increasing amounts of AgI as would be expected from the proposed behaviour of AgI in these glasses. The far IR analysis of the AgI doped silver diborate glasses suggest that there are three coordination environments for Ag⁺ ions.
**Differential Scanning Calorimetry (DSC):**

Kishore et al.\(^{50}\) have conducted DTA studies on sodium borate glasses containing iron with a view to see the variation of glass transition temperature \(T_g\) with network modifier concentration. They found that the ratio \(T_g/T_m = 2/3\) for all glasses which is characteristic of the organic glasses, where \(T_m\) is the melting temperature of the glass.

Soppe et al.\(^{21}\) have reported new insights into the structure of \(B_2O_3\) glass. The results of the structural investigations of various types of \(B_2O_3\) glass with different thermal histories are presented. The density and glass transition temperature \('T_g'\) depends on the cooling rate at which the glass is quenched.

Patnaik et al.\(^{51}\) have studied the glass transition temperature of AgI-Ag\(_2\)O-V\(_2\)O\(_5\) glass system. The results shows that glass transition temperature \((T_g)\) decreases with increasing AgI content, at a fixed \(V_2O_5\) (mol\%) and changes drastically with relative change in \(Ag_2O\) and \(V_2O_5\) (mol\%).

Effect of substitution of \(B_2O_3\) by \(P_2O_5\) on \(T_g\) and electrical properties of \(0.65[(1+X)Ag_2O-P_2O_5]0.35\) AgI glasses have been investigated by Constantini et al.\(^{52}\). The substitution of \(B_2O_3\) by \(P_2O_5\) has been found to be useful in making both \(T_g\) and conductivity to increase.

Coom et al.\(^{53}\) have studied the glass transition temperature of sodium lanthanum silicate glasses. It has been observed that, glass transformation temperature of these glasses increases when lanthanum oxide replaces either soda or silica.
The DTA at various heating rate (5, 10, 15°C/min) of strontium titanate borosilicate glass ceramic system has been recorded by Thakur et al. The results show that different heating rates influence the exothermic peaks drastically.

The activation energies of the glass transition and crystallization processes have been studied by Shaltaut from the shift of Tg and Tf in DSC curve with the heating rates using Kissinger's formula.

1.2.2 Physical Properties:

The physical and transport properties of semiconducting glasses are highly interesting because of usefulness regarding the structure and conduction mechanism. The physical and transport properties of Bi₂O₃-B₂O₃ glass system such as density, number of ions per unit volume, hoping distance and polaron radius are reported by Yawale et al. The physical property (density) is used to determine the probable structure of glass sample.

Khalifa et al. determined the density and molar volume of some sodium silicate, lead and lead silicate glasses. The density of the glasses increases while their molecular volume values decreases with the increase of soda in sodium silicate or with the increase of lead oxide in lead glasses.

El-Hazdi et al. have measured the density and molar volume of some lead borate glasses, shows that the value of density is increased while the value of the molar volume is decreased with the increase of the lead oxide content.
Glasses of the formula XPbCl₂ - (30 - X) PbO-4OB₂O₃-3OP₂O₅ were prepared and their physical properties studied by Bi-Damrawi et al. To enhance the conductivity of these glasses the mixed former effect and halide salt (PbCl₂) doping effect have been studied. The decrease in Tg and increase in both the thermal expansion coefficient and molar volume with increasing amount of PbCl₂ supports the idea of expansion of the glass network by chlorine ions. The electrical properties can be well described by the open network model.

Ghosh et al. have investigated the density and molar volume of non-conventional transition metal ion glasses and the results shows that the density increases with the increase of PbO content. They reported that the density of PbO-CuO glass is higher than that of the PbO - V₂O₅ glasses.

Blagojevic et al. has observed that substitution of Zn for PbO or SiO₂ in the PbO-B₂O₃-SiO₂ system strongly affects the density, thermal expansion and hydrolytic durability properties of all glasses.

Thermal and substituting effects of transition metal ions (Cr³⁺ or Mn⁴⁺) on physical properties of V₂O₅-P₂O₅ glass was studied by EL-Sharawy et al. The density and molar volume of the glasses were found to be changed with the composition and the heat treatment of the glasses.

1.2.3 Electrical Properties:

AC Conductivity

The ac electrical properties and infrared spectra of TeO₂-Fe₃O₅ glasses with various composition of PbO, B₂O₃, and SiO₂ were studied by
Samandoudy\textsuperscript{62}. The conduction mechanism is explained by them to be due to an electronic hopping process. The effects of composition and temperature on the dielectric constant and loss factor were also studied by them.

The ac conductivity of semiconducting oxides such as \( \text{Bi}_4\text{Sr}_3\text{Ca}_3\text{Cu}_y\text{O}_x \) (\( y = 0.5 \)) and \( \text{Bi}_4\text{Sr}_3\text{Ca}_3\text{zLi}_2\text{Cu}_4\text{O}_x \) (\( z = 0.1, 0.5 \) and 1) over wide temperature (77-450 K) and frequency (50-10\(^4\) Hz) range has been studied by Mollah et al\textsuperscript{63}. The universal power law behaviour (exponent \( s < 1 \) in \( \sigma(\omega) = \sigma + \omega^s \)) is found to be valid for most of these glasses. The correlated barrier hopping model based on the pair approximation is found to be more appropriate for explaining the frequency and temperature dependent ac-conductivity data.

The frequency and temperature dependent of real and imaginary parts of the ac conductivity of the tellurium cuprate glassy semiconductors in the frequency range 10\(^2\)-10\(^7\) Hz and in the temperature range 80-350 K is reported by Ghosh\textsuperscript{64}. Experimental data has been analysed with reference to various theoretical models based on quantum mechanical tunneling of electrons or polarons through the barrier separating localized states and on classical hopping of the same charge carriers over a similar barrier.

The results of measurements of ac-conductivity and dielectric modulus of the glassy [AgI - Ag\(_2\)O - XSeO\(_2\) - (1-X) V\(_2\)O\(_5\)] system over wide range of frequency and temperature are reported by Govindaraj et al\textsuperscript{65}. Kumar et al\textsuperscript{66} obtained the ac response from the measured real and imaginary parts of the impedance in the frequency range 5 Hz to 13 MHz of CuI-Agl-V\(_2\)O\(_5\) glasses.
Tsuchiya et al. have studied electrical conductivity and dielectric relaxation of Ag$_2$O-B$_2$O$_3$ glasses in the temperature range 20 to 120°C. In the silver containing glasses the values of $\varepsilon'$ and $\varepsilon''$ increases rapidly with increase of the amount of Ag$_2$O. The values of $\varepsilon'$ and $\varepsilon''$ were both larger in the silver containing glasses than in sodium containing glasses.

Mechanical and dielectric behaviour of some ionic glasses, in which the glassy matrix AgPO$_3$ was doped with various kinds of salt dopent, was studied by Curtroni et al. 68.

Electrical and magnetic properties of Lithium borosilicate glasses containing nickel and iron oxides have been discussed by El-Desoky et al. 69. It was found that when NiO content is changed from 2.5 to 10 mol%, the conductivity decreases due to the increase of the bridging oxygen ions.

A mixed alkali effect has been detected for the first time in the ac conductivity of LiF-KF-Al(PO$_3$)$_3$ glasses by Kulkarni et al. 70.

Venkateswar Rao et al. 71 have reported the electrical properties of LiF-PbO-B$_2$O$_3$ glass system. In this system, an attempt has been made to explain ac-conduction phenomenon on the basis of the quantum mechanical tunneling model / carrier barrier-hopping model.

The electrical relaxation in mixed alkali iron pyrophosphate glasses has been studied by Mogus et al. 72. The ac-conductivity as a function of the temperature is divided into two domains, one where the absolute magnitude of ac-conductivity is close to dc-conductivity and another where the absolute magnitude of ac conductivity is larger than dc.
The ionic conductivity of super ionic conducting glasses in the system AgI-Ag$_2$O-MoO$_3$ in the temperature range 250-300 K has been measured by Minami et al.$^{71}$ They found that the conductivity increases linearly with increasing AgI content. Such a composition dependence of conductivity is considered to be evidence that only a fraction of silver ion in glass contributes to the ionic conduction. The conductivities of bulk glasses slightly larger than those of pellets must be the evidence that the surface or boundary diffusion of mobile ions (Ag$^+$) is not dominant but that the bulk diffusion plays an important role in the super-ionic conducting glasses.

The role of PbO in lithium ion transport in Li$_2$O-PbO-B$_2$O$_3$ glasses was studied by Ganguli et al.$^{74}$ The presence of lead leads to a decrease in dc-conductivity, which is to be due to increase of partial charge on the oxygen atom and to the presence of the loan pair on the Pb atom, both of these factors impede Lithium ion motion.

Sekhon et al.$^{75}$ have studied, the partial replacement of silver iodide in ion conducting silver borate glass AgI-Ag$_2$O-B$_2$O$_3$ by sodium iodide and its effect on the properties of the glass system. Saito et al.$^{76}$ studied the ionic conductivities of rapidly quenched AgI-Ag$_2$O-B$_2$O$_3$ glasses containing large amount of AgI. Ionic conductivities of twin-roller rapidly quenched AgI-Ag$_2$O-B$_2$O$_3$ glasses (Ag$_2$O/B$_2$O$_3$=3) were measured in wide temperature range between 200 to 400 K. The activation energy of glass with 50 mol\% AgI was not changed in the whole temperature range.
Branda et al.$^{77}$ have studied the conduction activation energies of AgI doped glasses of the system Ag$_2$O-M$_2$O$_3$-P$_2$O$_5$ (M = Ga, B) are compared to those relative to the corresponding undoped glasses.

Agrawal et al.$^{78}$ have studied the (0.75 AgI : 0.25 AgCl) quenched system, a better choice as host compound in place of AgI to prepare Ag$^+$ ion conducting superionic glasses and composites.

Mochizuki et al.$^{79}$ have studied microstructure of binary silver borate glasses and electronic conductivity by polarization method. Electronic conductivity was found out to be two or three orders of magnitude smaller than the total electrical conductivity.

1.3 Need of Investigation

Most of the research workers have done work on semiconducting glasses. A review of the various compositions of different glasses investigated up to 1964 has been given by Mackenzie$^{80}$, while more recent information of the conduction process in glass is reported by Mott$^{81}$, Austin and Mott$^{82}$, and Owen$^{83}$. Recently it has been observed that the ceramics or high insulating oxide glasses which have the low conductivity becomes the super-conductors at low temperatures. The information regarding the super-conductive glasses has been reported by Chaudhary$^{84}$ in transition metal oxide glasses doped with Copper ions. In the advancement of technology, the amorphous materials play very important role. This is because of due to flexibility in composition, their structure and isotropic behaviour as regard to crystalline materials. The glassy alloys of
chalcogenides As-Ge-Te shows memory switching property\(^ {85-86} \) which is an important class of amorphous semiconductor.

The gas and humidity sensor is also a growing field today and most of the research workers are doing research on these lines. The solid state batteries in which ion conducting solid electrolytes plays important role.

Similarly the superconductivity is also a growing field today. The optical switches and optical devices are also fabricated with glassy materials because of their photoconductive property. As the field of amorphous materials is not new for research workers but still looking to their potential it is growing one and many investigations are remaining to carry out.

### 1.4 Aim of Present Work

In the present work, preparation of undoped silver borate glasses and AgI, AgBr doped silver borate glasses of different compositions and measurement of dc electrical conductivity (variation with temperature), ac- electrical conductivity (variation with temperature and frequency), dielectric constant and loss (variation with temperature, frequency), thermoelectric power of silver borate glasses are reported. Similarly, to understand the structure of the glasses X-RD, FTIR and DSC are incorporated. All these properties are studied with an aim to get some insight into the nature of glasses and to understand their general behaviour.
REFERENCES


2753-2759.

41. Kim Young, June Lee See Hyung, Non T W, Kim Junghwan, J Non-Cryst 
Solids 170(2) (1994) 190


309-315.

44. Yawale S S, Yawale S P and Adgaonkar C S, Ind J Engg Mater Soc 7 

45. Burns Andrew E, Royal Michael and Martin Steve W, J Non-Cryst Solids 

46. Minami Tsulomu, Tadashi Katsuda and Masami Tanaka, Phys Chem 
83(10) (1979) 1306-1309.


