Glass is one of the oldest synthetic materials used by man and knowledge of glass has been acquired over many centuries. Scientific study of glasses began with Faraday and others at the beginning of the nineteenth century and today it is still a rapidly developing subject, both in the development of new glassy materials with special properties and in the application of new scientific methods to improve our understanding of the structure and properties of glasses. The ever increasing interest on glasses is motivated by their widespread practical applications and by the fact that they exhibit a number of physical properties, which suggest specific structural singularities that differentiate the glassy state of matter from the crystalline as well as the ordinary amorphous state. So far, however, a unified theory of glassy state has failed to emerge, and so the specifics of the structure of glasses continue to be less than fully understood.

Glasses have some unique properties which are not found in other engineering materials. The combination of hardness and transparency at room temperature along with sufficient strength and excellent corrosion resistance.
make glasses indispensible for many practical applications. Glassy materials are generally good electrical insulators and glassy metals are more resistant to chemical attack than polycrystalline metals. In recent years the growth of the new field of solid state ionics has caused renewed interest in the properties of glassy ionic conductors. Glassy materials have acknowledged advantages like physical isotropy, the absence of grain boundaries, continuously variable composition and good workability over their crystalline counterparts.

Due to potential practical applications in various engineering and technological fields, the study of the properties of glasses is of great significance. Recent years have seen notable achievements in the development of new glass systems with interesting properties. Continued effort for the development of new glassy materials and study of their properties is highly relevant in view of the role these materials are expected to play in technological fields.

CaO-B₂O₃-Al₂O₃ glass system usually known as cabal glass system has exceptionally high resistance. Sir Herbert Jackson at the British Scientific Instruments Research Association was the person who first prepared this glass and coined the name 'cabal' glass. The
The electrical properties of this system of glass was first studied by Owen. Owen reported that it has a very high resistance and it acts almost as an insulator. The present work deals with the study of the effect of addition of an alkali oxide like Na$_2$O or a transition metal oxide like Fe$_2$O$_3$ on the physical properties of cabal glasses. Cabal glasses containing different mole percentages (mol%) of Na$_2$O or Fe$_2$O$_3$ were prepared and their d.c. conductivity, a.c. conductivity and dielectric constant were studied in detail. The vibrational properties of these glasses were studied using laser Raman spectroscopy. The elastic properties of the glass samples were investigated using ultrasonic techniques.

The thesis entitled, "Study of Physical Properties of Certain Borate Glasses" is a detailed account of the investigations carried out on the preparation, d.c. conductivity, a.c. conductivity and dielectric constant, vibrational properties using laser Raman spectroscopy and elastic properties of cabal glasses containing Na$_2$O or Fe$_2$O$_3$.

The thesis is divided into six chapters. Chapter 1 provides a general introduction to amorphous materials (especially glasses) and their importance in various fields. A brief report on the various techniques of
preparation, different types of glasses, structure of glasses and thermodynamic behaviour of glasses are also included.

Chapter 2 gives a brief account of the various instruments used for the preparation of glass systems and their characterization. For the preparation of glasses an horizontal muffle furnace and quenching system were used. The d.c. conductivity was studied using a conductivity cell and a programmable Keithley electrometer. a.c. conductivity and dielectric constant measurements were made with the help of a Hewlett-Packard impedance analyser (4192A LF). The structure of the glass system was investigated using laser Raman spectrometer. An ultrasonic pulse-echo overlap system was used to investigate the ultrasonic velocity and elastic constants of the glass system.

Part I of Chapter 3 gives a brief review of the earlier studies on d.c. electrical conductivity in alkali and transition metal oxide containing oxide glass systems. The preparation and d.c conductivity studies of Na$_2$O-CaO-B$_2$O$_3$-Al$_2$O$_3$ and Fe$_2$O$_3$-CaO-B$_2$O$_3$-Al$_2$O$_3$ glass systems investigated in the present work are described in Part II and Part III respectively. The popular technique of splat-quenching was used for the preparation of the glass
systems and amorphous nature of the glass samples was confirmed with X-ray diffraction patterns. The effects of Na⁺, Ca²⁺ and Al³⁺ ions on conductivity were systematically investigated by preparing three series of glass samples containing varying concentrations of Na₂O, CaO or Al₂O₃. Conductivity measurements were carried out over a temperature range from 300 to 525 K. It was observed that by the addition of the alkali oxide (Na₂O) the insulator-like cabal glass system can be made conducting to a reasonable extent. The author has also made an attempt to make the glass system electronic conducting by the addition of a transition metal oxide Fe₂O₃. To make the study a systematic one, the effects of Fe₂O₃, CaO and Al₂O₃ in this glass system were studied by preparing three series of glass samples containing varying concentrations of Fe₂O₃, CaO or Al₂O₃. It was observed that the d.c. conductivity of this glass system vary with temperature and with the concentration of the constituents. The experimental results are discussed on the basis of ionic and polaronic conducting models. It is concluded that the insulator type cabal glass system can be made conducting to a reasonable extent by the incorporation of Na₂O or Fe₂O₃ to the glass system.

A brief review of the recent studies on dielectric constant and a.c. conductivity measurements in oxide
glasses is given in Part I of the Chapter 4. Part II and Part III respectively deal with the measurement of real part of dielectric constant ($\varepsilon'$) and a.c. conductivity ($\sigma_{ac}$) of Na$_2$O-CaO-B$_2$O$_3$-Al$_2$O$_3$ and Fe$_2$O$_3$-CaO-B$_2$O$_3$-Al$_2$O$_3$ glass systems. The measurements were carried out with the help of Hewlett-Packard impedance analyzer (4192A LF) having a frequency range from 5Hz to 13MHz. Variation of $\varepsilon'$ and $\sigma_{ac}$ with frequency and temperature has been studied for glasses containing different mol% of the constituents. It is observed that the values of $\varepsilon'$ and $\sigma_{ac}$ depend on the temperature, frequency of the applied field and the concentration of the constituents. The experimental results are discussed on the basis of the existing theories.

A brief review of laser Raman studies on borate glasses is given in the beginning of Chapter 5. Chapter 5 describes the laser Raman studies of vibrational properties of the glass systems Na$_2$O-CaO-B$_2$O$_3$-Al$_2$O$_3$ and Fe$_2$O$_3$-CaO-B$_2$O$_3$-Al$_2$O$_3$. Since the glass system lacks long-range periodicity the laser Raman spectra of glasses are important for getting an insight into the structure of glasses. The peaks in the spectra are discussed in the light of reported spectra of other borate glasses. The effects of variation of composition of the glasses on the vibrational frequencies are studied.
Chapter 6 provides an account of the ultrasonic investigations carried out on the glass systems \( \text{Na}_2\text{O}-\text{CaO-}\text{B}_2\text{O}_3-\text{Al}_2\text{O}_3 \) and \( \text{Fe}_2\text{O}_3-\text{CaO-}\text{B}_2\text{O}_3-\text{Al}_2\text{O}_3 \). A brief introduction to elastic properties of solids and a short review of recent ultrasonic studies on oxide glasses are given in the beginning of Chapter 6. In this chapter, the author presents the experimental results and discussions of ultrasonic velocity and elastic constant measurements as a function of composition of the \( \text{Na}_2\text{O}-\text{CaO-}\text{B}_2\text{O}_3-\text{Al}_2\text{O}_3 \) and \( \text{Fe}_2\text{O}_3-\text{CaO-}\text{B}_2\text{O}_3-\text{Al}_2\text{O}_3 \) glass systems.

Parts of the research work presented in this thesis are published/communicated for publication or presented/accepted for publication in National/International Journals or Seminars.

1. Influence of \( \text{Na}_2\text{O} \) on the d.c electrical conductivity (materials and applications) of cabal glasses, Solid State Ionics\(^a\), 499 (1992).

2. Dielectric constant and a.c conductivity of \( \text{B}_2\text{O}_3-\text{Al}_2\text{O}_3-\text{Na}_2\text{O-}\text{CaO} \) glass system, J. Mat. Sci. Lett. (communicated).

3. Dielectric properties of cabal glasses containing \( \text{Fe}_2\text{O}_3 \), Solid State Physics Symposium, BARC, Bombay, (December 1993)(accepted for publication in the proceedings).
4. d.c electrical conductivity of B$_2$O$_3$-ZnO-CaO glass system, Proceedings of the Third Kerala Science Congress, Kozhikode, 296 (Feb. 1991).

5. d.c conductivity of cabal glass system containing Fe$_2$O$_3$, XXV$^{\text{th}}$ National Seminar on Crystallography-Abstracts, Madras University, Madras (Dec. 1993).


7. Laser Raman study of CaO-B$_2$O$_3$-Al$_2$O$_3$-Na$_2$O and CaO-B$_2$O$_3$-Al$_2$O$_3$-Fe$_2$O$_3$ glass systems (communicated).

8. Ultrasonic velocity and elastic constants measurements of CaO-B$_2$O$_3$-Al$_2$O$_3$-Fe$_2$O$_3$ glass systems (communicated).

9. d.c conductivity measurements in Fe$_2$O$_3$ containing cabal glasses (communicated).

10. Effect of Na$^+$, Ca$^{2+}$ and Al$^{3+}$ ions in the d.c conductivity of CaO-B$_2$O$_3$-Al$_2$O$_3$-Na$_2$O and CaO-B$_2$O$_3$-Al$_2$O$_3$-Fe$_2$O$_3$ glasses (communicated).