Introduction:-

The ancient Egyptians possibly knew Glass making 6000 years ago \cite{1}. The temple of Belus was constructed with bricks colored with glass enamel in Egypt about 2000 years ago. After words, Alexandria became the centre of glass industry & the knowledge of glass manufacture passed from the East to Greece and Europe. In the first century B.C. Romans established a few glass factories in their country. England, France and Germany started glass making in 15th and 16th century. The first scientific glass was prepared in 1854 by Germans in Jena\cite{1}.

The ancient Hindus knew technique of glass making before the Christian Era. The glass bangles found during the excavation of Harappa in Punjab indicate that these belong to the period 3000 B.C. In recent times, glass industry has made tremendous progress all over the world. Modern India is proud of making glass industry successful & profitable.

Humans have been producing glasses by melting of raw materials for thousands of years. Egyptian glasses date from at least 7000 B.C. How did the first production of artificial glasses occur? One scenario suggests that the combination of sea salt (NaC1) and perhaps bones (CaO) Present in the embers of a fire built on the sands (SiO,) at the edge of a saltwater sea (the Mediterranean?), sufficiently reduced the melting point of the sand to a temperature where crude, low quality glass could form. At some later time, some other nomad found these lumps of glass in the sand and recognized their unusual nature. Eventually, some genius of ancient times realized that the glass found in the remains of such fires might be produced deliberately, and discovered the combination of materials which lead to the formation of the first commercial Glasses.\cite{2}

The first crude man-made glasses were used to produce beads, or to shape into tools requiring sharp edges. Eventually, methods for production of controlled shapes were developed. Bottles were produced by winding glass ribbons around a mold of compacted sand. After cooling the glass, the sand was scraped from inside the bottle, leaving a hollow container with rough, translucent walls and usually lopsided shape. Eventually, the concept of molding and pressing jars and bottles replaced the earlier methods and the quality of the glassware improved. It began to be possible to produce glasses which were reasonably transparent, although usually still filled with bubbles and other flaws.\cite{2}.
Silica based glasses are used in day to day life and for other special allocations. The manufacturing technology of these silica based glasses for various applications is well established. These glasses are also used in high technology areas like optoelectronics, space, automobiles. The melting of a silica based glasses requires very high temperature Viz 1400-1600°C and the glasses are quite stable and can be tailored for any thermal shock. The main drawback of these glasses is in high melting temperatures creating the difficulties for fabrication. Lot of wastage occurs during the fabrication of any good glass sheet or blank. Lead oxide has been used in glasses to reduce the glass melting temperature but it has limited application and it is environmentally hazardous. Therefore it is necessary to search low melting glasses for various applications. The glass is an inorganic material & analogous to a liquid with very high viscosity, the material is rigid and often glass is referred to as super cooled liquid. In principle, almost any subspace, for that matter can be converted from liquid state into a glass provided the cooling rate is far enough to prevent crystallization.\(^3\)

Glass manufacture probably persisted in many places through the dark ages. Neri has published a book “L’ArteVeteriaria”, which is a treasure house of glass history.\(^4\) He has described the use of lead oxide and borax, which did not become common glass constituents until later, and of arsenic oxide as fining agent. This great work by Neri was the beginning of the scientific approach in glass technology. From this period onwards, the development of glass was rapid. Factories multi in Europe, and glass became more and more a part of every man’s life.\(^2\) A real advance was made in this period in the selection and purification of raw materials.

Types of Glasses:-

Depending on the network former used, glasses can be classified as silicate, borosilicate, alumino silicate, borate, phosphate glasses, chalcogenide glasses etc. and depending on its end used as optical glasses, sealing glasses, special application glasses etc.

Large varieties of glass are obtained by varying the composition of the batch. Based on the composition the different types of glasses have been discussed as follows.

1] Soda lime Glass: (Soda glass or Normal Glass or Soft Glass):-
This glass is used in making glass tubes, bottle glass, glass bricks, plate glass, ordinary chemical apparatus like test tubes, beakers, tubing, glass bends, window glass, jars, electric lamps, eye lenses etc.

2] Borosilicate Glasses:-

The glass is used in the manufacture of kitchenware, glass pipelines in factories, high tension insulators; it is mainly used as heat resistant ware like oven ware and laboratory glass ware.

3] Alumina silicate glasses:-

Alumina silicate glasses are used commercially because they are chemically stable and withstand at high temperatures. Thus applications include combustion tubes, gauge glasses for high-pressure steam boilers and in halogen-tungsten lamps capable of operating at temperature as high as 750°C.

4] Lead Glasses:-

Any glass containing at least 24% PbO can be described as Lead Crystal Glass. This is mainly a mixture of potassium and lead silicates. Its rough composition is $\text{K}_2\text{O}$, PbO, $6\text{SiO}_2$. Lead glasses are easily melted and have a long working range and a high refractive index, which makes them useful for lead crystal, optical glass and handmade art ware.

5] Borate Glasses:-

Although borate glasses are a little commercial importance because they are water soluble, $\text{B}_2\text{O}_3$ is an important constituent of borosilicate glasses such as Pyrex.

6] Phosphate Glasses:-

Glasses having $\text{P}_2\text{O}_5$ as one of the major component are called ‘phosphate glasses’, phosphorous penta oxide is used as a glass former. They melt at relatively lower temperature also have got very high thermal expansion coefficient.

7] Germanate glasses:-

Pure Germanium dioxide acts as a glass former if readily forms glass. The germanium glass structure is quite similar to that of silica. Germanate glasses have lower melting points, higher refractive indices and greater densities than the corresponding silicates.
8] Aluminate Glasses:-

Although pure Al\(_2\)O\(_3\) does not form a glass, it assists the glass formation. Binary and ternary aluminate glasses namely Cao-Al\(_2\)O\(_3\) and CaO-MgO-Al\(_2\)O\(_3\) were prepared by Shepherd et al \([18]\) and the glass formation tendency of these compositions has been thoroughly studied by these authors.

9] Tellurite Glasses:-

Tellurite glasses were first prepared and studied by Starwort in 1952 \([19]\). The important properties of these glasses are refractive index up to 2.3 and high thermal expansion coefficient ~25.0\(\times\)10\(^{-6}\) \(^{\circ}\)C, TeO\(_2\) based glasses have also been used in preparation of transparent glass ceramics.

10] Vanadate Glasses:-

Pure V\(_2\)O\(_3\) melts at around 660\(^{\circ}\)C and forms glass only when it is cooled rapidly. Glass formation between V\(_2\)O\(_3\) and a number of oxides like P\(_2\)O\(_5\), TeO\(_2\), B\(_2\)O\(_3\), GeO\(_2\), BaO, ZnO, CdO, MgO etc. has been investigated by various authors \([20-22]\) and the regions of glass formation and the quenching rate required for the glass formation have been reported.

11] Chalcogenide glasses:-

Glasses formed by compounds containing elements of Group V-VI of the periodic table Viz S, As, Sb, Se, Te are known as chalcogenide glasses.

**Phosphate glasses:-**

Phosphate glasses have a relatively poor chemical durability, which often limits their usefulness in various applications.\([25]\)

Chemical durability of phosphate glasses can be improved by the addition of various oxides such as Bi\(_2\)O\(_3\), Al\(_2\)O\(_3\), and Fe\(_2\)O\(_3\) etc.\([26]\)

Phosphate glasses have considerable potential applications in optical data transmission, solid state batteries, sensing & laser technologies.\([27]\)
Phosphate glasses have wide technological interest due to their unique physical properties such as low glass transition temperature (T_g), lower melting temperature, high thermal expansion coefficient, high ionic conductivity, & bio compatibility.\cite{28}

Phosphate glasses have several advantages like high thermal expansion coefficient, high thermal conductivity, low melting and softening temperature and high ultraviolet transmission over conventional silicate and borate glasses for hosting lasing ions\cite{29} In view of these characteristics phosphate and fluorophosphates glasses doped with different rare earth ions like Nd3þ, Ho3 þ, etc. have been widely used in laser technology\cite{30} These glasses are also found to be highly suitable for high energy and high peak power laser applications used in fused energy research\cite{31} However, the poor chemical durability, high hygroscopic and volatile nature of phosphate glasses restricted them from replacing the conventional glasses by and large in technological applications.

There has been an enormous amount of research on improving the physical properties and the chemical durability of phosphate glasses by introducing a number of glass formers and modifiers such as Al2O3, MoO3, TeO2, Ta2O5, Bi2O3, As2O3, etc. into P2O5 glass network \cite{13} Among different phosphate glass systems the alkali free phosphate glasses are observed to be relatively moisture resistant and possess low rate of crystallization \cite{32}.

Tungsten ions are well known due to their unusual influence on the optical and electro chemical properties of the glasses for the simple reason that the oxides of tungsten participate in the glass network with different structural units like WO4(Td) and WO6(Oh) of W6þ ions and W3þO3(Oh) ofW5þ ions \cite{33} Quite recently, we have reported the influence of WO3 on the structure of P2O5 glasses by studying various physical properties; these studies have showed that there is a considerable improvement in chemical durability, electrical insulating strength and infrared transmission of these glasses.\cite{34} The addition of alkali ions to the phosphate network depolymerizes the phosphate network and decreases the connectivity. Aluminium can be incorporated into phosphate structure as a network former as AlO4 units thus contributing the P=O bonds into bridging oxygen’s. The local charge balance is maintained by the alkali ions. Hence, it is expected that adding alumina to sodium phosphate glasses would increase the strength of the glass. A similar increase was observed in Na2O-SiO2 glasses with the addition of Al2O3.\cite{36}