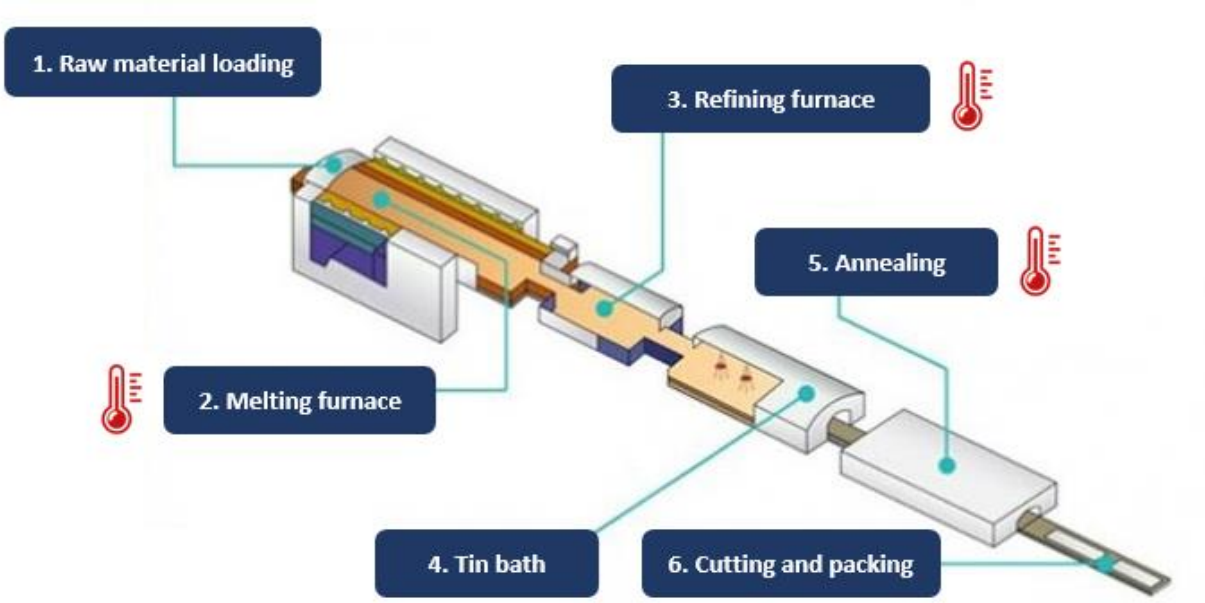
Glass manufacturing process



The manufacturing of glass involves several chemical processes. Here is a brief overview of the chemistry involved:

1. **Raw materials**: Glass is primarily made from silica, which is obtained from sand. Other materials such as soda ash, limestone, and feldspar may also be added to the mix to modify the properties of the glass.

2. **Melting**: The raw materials are heated in a furnace at high temperatures (typically around 1500°C) until they melt and form a viscous liquid. This process is known as melting.

3. **Refining**: Once the raw materials have melted, they undergo refining to remove any impurities. This process involves adding chemicals such as sulfur dioxide or chlorine to the molten glass, which react with the impurities to form gases that can be removed.

4. **Forming**: Once the glass has been refined, it can be formed into the desired shape. This can be done through a variety of methods such as blowing, pressing, or casting.

5. **Annealing**: Finally, the glass is cooled slowly in a process called annealing. This helps to relieve any internal stresses in the glass and make it stronger and more resistant to breakage.

Overall, the chemistry involved in glass manufacturing is quite complex and requires careful control of temperature, pressure, and chemical composition to ensure that the final product meets the desired specifications.

The chemistry of glass

Thousands of different chemical compositions can be made into glass. Different formulas affect the mechanical, electrical, chemical, optical, and thermal properties of the glasses that are produced. There is no single chemical composition that characterizes all glass.

Typical glass contains *formers*, *fluxes*, and *stabilizers*

- **Formers** make up the largest percentage of the mixture to be melted. In typical soda-lime-silica glass the *former* is silica (Silicon dioxide) in the form of sand.

- **Fluxes** lower the temperature at which the formers will melt. Soda (Sodium carbonate) and Potash (Potassium carbonate), both alkalis, are common fluxes. Potash glass is slightly denser than soda glass.
- **Stabilizers** make the glass strong and water resistant. Calcium carbonate, often called calcined limestone, is a stabilizer. Without a stabilizer, water and humidity attack and dissolve glass.

Glasses begin as mixtures of **oxides**. Their compositions can be represented by listing the weight percentages of their components. Compare the percentages for **1**, a typical, modern soda-lime-silica glass (used to make bottles and windows); **2**, laboratory and some baking ware; **3**, optical, high lead crystal; **4**, 96% silica glass (can withstand very high temperatures); **5**, a typical, ancient Roman soda-lime-silica glass.

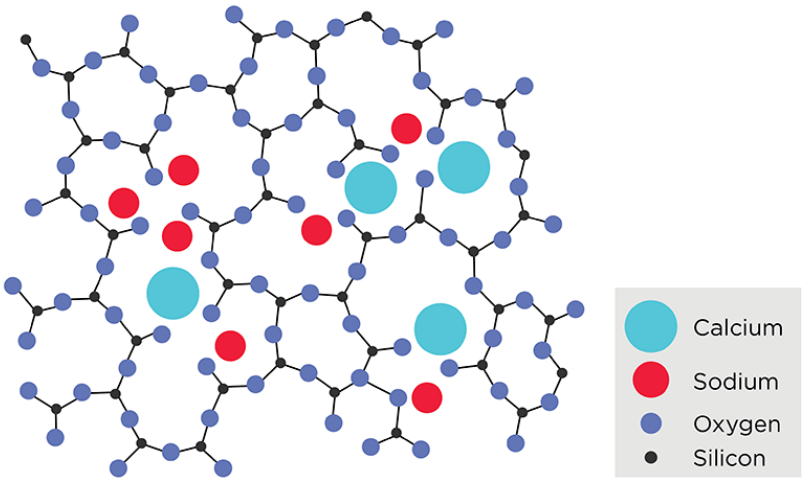
		1	2	3	4	5
Silica	SiO_2	73.6%	80.0%	35.0%	96.5%	67.0%
Soda	Na_2O	16.0	4.	--	--	18.0
Lime	CaO	5.2	--	--	--	8.0
Potash	K_2O	0.6	0.4	7.2	--	1.0
Magnesia	MgO	3.6	--	--	--	1.0
Alumina	Al_2O_3	1.0	2.0	--	0.5	2.5
Iron Oxide	Fe_2O_3	--	--	--	--	0.5
Boric Oxide	B_2O_3	--	13.0	--	3.0	--
Lead Oxide	PbO	--	--	58.0	--	0.01

The main constituent of Flat Glass is SiO2 (silica sand). This has a high melting temperature in the region of 1700 degrees C and its state at this temperature is like syrup on a very cold day. The basic building block of silica has a tetrahedral pyramid shape with silicon at its centre linked symmetrically to four oxygen atoms at its corners: it has the chemical formula SiO4 and is negatively charged.

$$Na_2CO_3 + SiO_2 \xrightarrow{1{,}500^\circ C} Na_2SiO_3 + CO_2 \uparrow$$

$$Na_2SiO_3 + x\,SiO_2 \xrightarrow[\text{Digestion}]{Na_2SO_4} (Na_20)(SiO_2)_{(x+1)}$$

On cooling molten silica quickly, a random organised network of these tetrahedra are formed, linked at their corners, to give an amorphous material known as vitreous silica.



For practical and economic reasons, the high melting point and viscosity of silica is reduced by adding sodium oxide (a flux) in the form of a carbonate and the sodium-oxygen atoms enter the silicon-oxygen network, in accordance with their valency states. These atoms are known as Network Formers. Other major constituents of Flat Glass: Calcium and Magnesium enter the network structure as Network Modifiers and the action of these modifiers is to make the structures more complex so that when the components are melted together, in the cooling process, it is more difficult for the atoms to arrange themselves in suitable configurations for crystallization to occur. In the glass making process, the cooling rate is arranged such that viscosity increases and the mobility of the atoms is hindered thus preventing arrangements and crystallization from occurring.

Thus glass is often referred to as a super cooled liquid in that it has no crystallization or melting point and does not exhibit the phenomenon of the latent heat of crystallization or fusion.