

Glass

❖ what is Glass ?



❑ *Definition of Glass:*

- Glass is an amorphous or non-crystalline solid formed by rapid cooling of a liquid to prevent crystallization.
- It is usually an inorganic material composed primarily of silica (SiO_2) combined with other oxides.

❑ *Key Characteristics:*

- Random atomic structure (unlike crystalline solids).
- High viscosity at room temperature ($\approx 10^{18}$ Pa·s).
- Maintains transparency, hardness, and chemical durability.
- Glass can be made from sand, soda, lime, and heat, and its properties are tailored by adding different oxides (modifiers and intermediates).

❖ Brief history of glass: past and present of glass

In the 3,500 years since glass was first discovered it has been used to create incredibly stunning and highly practical objects and now forms an essential part of our everyday lives.



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❖ Brief history of glass: past and present of glass



~3000 B.C.



~1500 B.C.

❖ Ancient Era

- ❑ ~3000 B.C.: First glass appeared as glaze on ceramic vessels.
- ❑ ~1500 B.C.: First glass vessels in Egypt & Mesopotamia.

❖ Early Revival

- ❑ 700 B.C.: Glass revived in Mesopotamia.
- ❑ 500 B.C.: Glass revived in Egypt.
- ❑ Major glassmaking centers: Egypt, Syria, Eastern Mediterranean.



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Millefiori Roman cup



The Lycurgus Cup.

❖ Roman Era

- ❑ Glass industry spread throughout the Roman Empire.
- ❑ **First Golden Age of Glass:** First four centuries of Christian Era.

❖ Middle Ages

- ❑ Glassmaking revived in Murano (Venice).
- ❑ Developed **soda-lime glass (crystal)** → Second Golden Age.

❖ Introduction to America

- ❑ 1608: First glass plant in Jamestown (failed).
- ❑ 1739: First successful US glass plant in New Jersey.

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One of the earliest Egyptian glass vessels about 1425 B.C, height 8.7 cm., British museum, Uk



Lotus Bud Beaker, Roman, Eastern Mediterranean, 1st century C.E., mold-blown glass, 8-3/8 inches (The J. Paul Getty Museum, 2003.320)



Mosque lamp ,mamluk period ,V&A Museum

❖ Industrial Developments

- ❑ 1820: Bakewell Co. introduced mechanical pressing of hot glass.
- ❑ Post-1890: Rapid glass industry growth.

❖ Modern Era

- ❑ 1950s: Float glass process invented by Pilkington (90% of flat glass still made this way).
- ❑ 1970s: Optical fibers for communication; glass for nuclear waste storage.

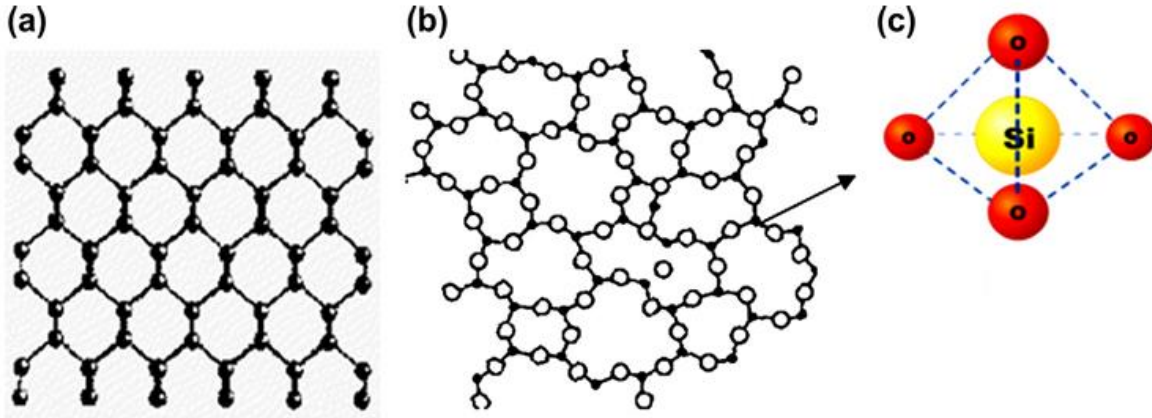
❖ Recent Innovations

Development of specialty glasses:

- ❑ Transparent glass-ceramics (cookware)
- ❑ Chalcogenide glass (infrared applications)
- ❑ Smart glasses: Photochromic, electrochromic.
- ❑ Present: Glass essential in energy, electronics, medical, and construction sectors.

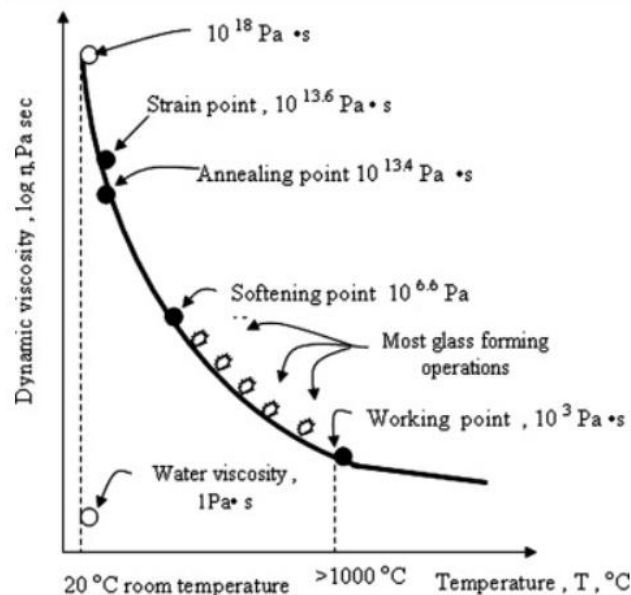
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❖ Brief about the physics of glass: how it is made



Crystalline structures (a) amorphous randomized structures (b) and the molecular structure of silica-based glass (c).

Dynamic viscosity of glass vs heating temperature.



❖ Structure of Glass

- ❑ Glass is an amorphous solid (non-crystalline structure).
- ❑ Formed by rapid cooling of a liquid → prevents crystallization.
- ❑ Structure: Random network of SiO_2 tetrahedra and modifiers.

❖ Glass Formation

- ❑ Glass is a supercooled liquid that becomes rigid without crystallizing.
- ❑ High cooling rate → atoms cannot arrange into an ordered lattice.

❑ Oxides in Glass Formation: Four types of oxides used

Glass formers: SiO_2 , B_2O_3 (form the network).

Conditional formers: GeO_2 , P_2O_5 (need conditions).

Intermediates: Al_2O_3 , TiO_2 (cannot form glass alone but mix with formers).

Modifiers: Na_2O , K_2O , CaO (modify properties, lower melting point).

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❖ Brief about the physics of glass: how it is made

☐ Types of oxides used in glass fabrication.

No.	Oxide type	Characteristics	Examples
1	Main glass former oxides	Suitable structures and low crystallization rates Form glass under slow cooling rates	SiO ₂ B ₂ O ₃ GeO ₂ P ₂ O ₅
2	Conditional glass formers oxides	Form glass under certain conditions	Al ₂ O ₃ ; Bi ₂ O ₃ WO ₃ ; MoO ₃
3	Intermediate oxides	Cannot form glass themselves but form glass in mixture with former oxides	TiO ₂ ; ZnO; PbO; Zr ₂ O ₃
4	Network modifier oxides	Cannot form glass themselves nether in mixture with former oxides They can modify the properties of glass by affecting Si–O bonds	MgO CaO Na ₂ O K ₂ O

☐ The Standard points of glass.

No.	Standard point name	Viscosity (Pas)	Temperature descriptions
1	Working point	10 ³	At this temperature, the viscosity is sufficiently low for glass forming. Casting processes are possibly below 10Pas viscosity
2	Softening point	10 ^{6.6}	At this temperature, the viscosity is sufficiently low for glass to slump under own weight. Near below this temperature glass is stiff, but a little effort is necessary for yield and flow
3	Glass transition temperature	10 ¹²	Range of temperatures at which glass transitions from super cooled liquid in a solid state
4	Annealing point	10 ^{13.4}	Internal stresses are relieved in minutes
5	Strain point	10 ^{13.6}	Internal stresses are relieved in hours

1 Pas (SI)=0.1 P (P – poise, physics system of units).

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❖ Basic technology for glass fabrication

