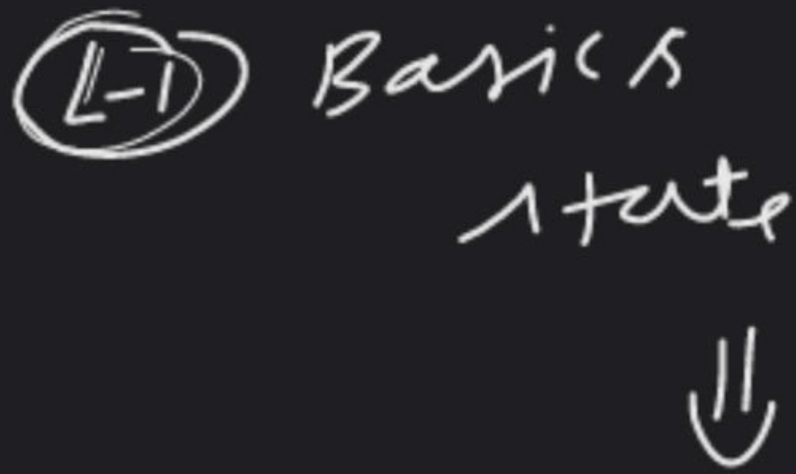
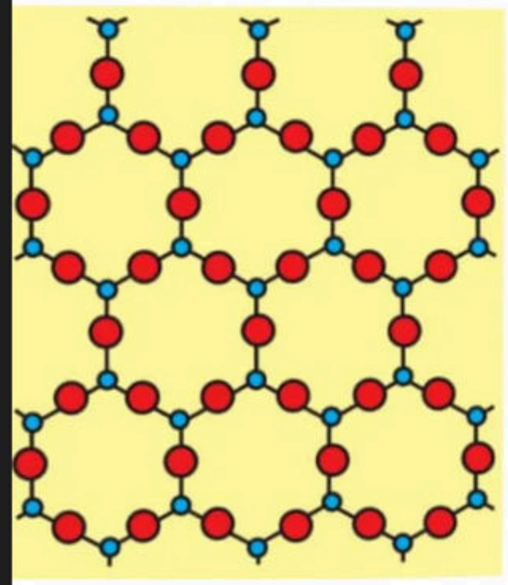
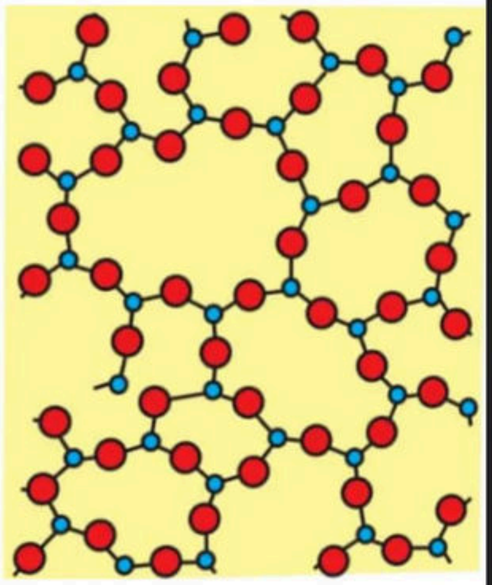


SOLID STATE L - 1

Special class

Harish Bhardwaj • Mar 8, 2021





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Amorphous substances show

(A) Short and long range order

(B) Short range order

(C) Long range order

(D) Have no sharp M.P.

(a) A and C are correct (b) B and C are correct

(c) C and D are correct (d) B and D are correct

The characteristic features of solids are [AMU 1994]

(a) Definite shape

(b) Definite size

(c) Definite shape and size

(d) Definite shape, size and rigidity

Which one of the following is a good conductor of electricity

[MP PMT 1994; AFMC 2002]

(a) Diamond (b) Graphite

(c) Silicon (d) Amorphous carbon

A crystalline solid [Kerala CET (Med.) 2003]

(a) Changes abruptly from solid to liquid when heated

(b) Has no definite melting point

(c) Undergoes deformation of its geometry easily

(d) Has an irregular 3-dimensional arrangements

(e) Softens slowly

Diamond is an example of

[MP PET/PMT 1998; CET Pune 1998]

(a) Solid with hydrogen bonding

(b) Electrovalent solid

(c) Covalent solid

(d) Glass

The solid $NaCl$ is a bad conductor of electricity since

[AIIMS 1980]

(a) In solid $NaCl$ there are no ions

(b) Solid $NaCl$ is covalent

(c) In solid $NaCl$ there is no velocity of ions

(d) In solid $NaCl$ there are no electrons

The existence of a substance in more than one solid modifications is known as **or** Any compound having more than two crystal structures is called

[MP PMT 1993; MP PET 1999]

(a) Polymorphism (b) Isomorphism

(c) Allotropy (d) Enantiomorphism

Which is not a property of solids [MP PET 1995]

(a) Solids are always crystalline in nature

(b) Solids have high density and low compressibility

(c) The diffusion of solids is very slow

(d) Solids have definite volume

Which solid will have the weakest intermolecular forces

(a) Ice (b) Phosphorus

(c) Naphthalene (d) Sodium fluoride

Dulong and Petit's law is valid only for [KCET 2004]

(a) Metals (b) Non-metals

(c) Gaseous elements (d) Solid elements

Which of the following is an example of metallic crystal solid

(a) C (b) Si

(c) W (d) $AgCl$

Under which category iodine crystals are placed among the following

(a) Ionic crystal (b) Metallic crystal

(c) Molecular crystal (d) Covalent crystal

Among solids the highest melting point is established by

[Kerala CET (Med.) 2002]

(a) Covalent solids (b) Ionic solids

To get a n- type semiconductor, the impurity to be added to silicon should have which of the following number of valence electrons [KCET (Engg.)

(a) 1 (b) 2

(c) 3 (d) 5

Which of the following is non-crystalline solid

(a) $CsCl$ (b) $NaCl$

(c) CaF_2 (d) Glass

The lustre of a metal is due to [AFMC 1998]

(a) Its high density (b) Its high polishing

(c) Its chemical inertness (d) Presence of free electrons

A crystalline solid have [DCE 2001]

(a) Long range order (b) Short range order

(c) Disordered arrangement (d) None of these

Crystalline solids are [Pb. PMT 1999]

(a) Glass (b) Rubber

(c) Plastic (d) Sugar

Davy and Faraday proved that [Kerala CET (Med.) 2002]

(a) Diamond is a form of carbon

(b) The bond lengths of carbon containing compounds are always equal

(c) The strength of graphite is minimum compared to platinum

(d) Graphite is very hard

Which one of the following metal oxides is antiferromagnetic in nature [MP PET 2002]

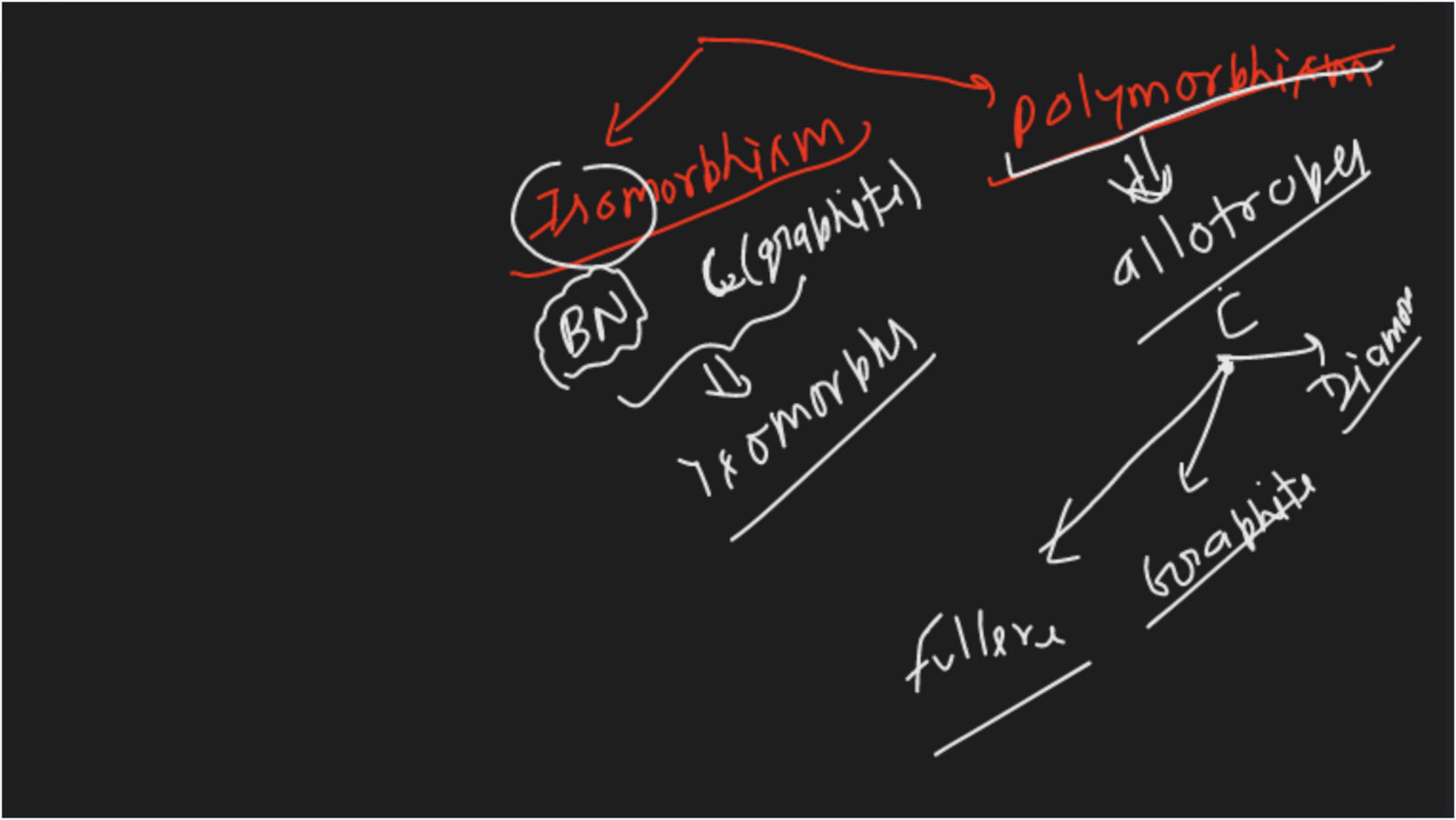
(a) MnO_2 (b) TiO_2

(c) VO_2 (d) CrO_2

In graphite, carbon atoms are joined together due to [AFMC 2002]

(a) Ionic bonding (b) Vander Waal's forces

(c) Metallic bonding (d) Covalent bonding


Isomorphism
polymorphism
BN
Graphite
Isomorphs
Allotropes
C
Diamor
Graphite
Fullere

Which of the following is not correct for ionic crystals

[Orissa JEE 2002]

(a) They possess high melting point and boiling point

(b) All are electrolyte

(c) Exhibit the property of isomorphism

(d) Exhibit directional properties of the bond

Which of the following is a molecular crystal

(a) SiC (b) $NaCl$

(c) Graphite (d) Ice

Quartz is a crystalline variety of [Pb. PMT 2000]

(a) Silica (b) Sodium silicate

(c) Silicon carbide (d) Silicon

Which type of solid crystals will conduct heat and electricity

[RPET 2000]

(a) Ionic (b) Covalent

(c) Metallic (d) Molecular

Which of the following is an example of covalent crystal solid

(a) Si (b) NaF

(c) Al (d) Ar

Which of the following is an example of ionic crystal solid

(a) Diamond (b) LiF

(c) Li (d) Silicon

Which one is an example of amorphous solid

(a) Glass (b) Salt

(c) Cesium chloride (d) Calcium fluoride

Which of the following statements about amorphous solids is incorrect [KCET 2004]

(a) They melt over a range of temperature

(b) They are anisotropic

(c) There is no orderly arrangement of particles

(d) They are rigid and incompressible

The ability of a given substance to assume two or more crystalline structure is called [DCE 2004]

(a) Amorphism (b) Isomorphism

(c) Polymorphism (d) Isomerism

Glass is

(a) Supercooled liquid (b) Crystalline solid

(c) Amorphous solid (d) Liquid crystal

Introduction

This chapter includes knowledge about

1. Most organised state of matter which includes study of various types of solids based upon arrangement of constituent particles in the bulk and different types of forces responsible to bind the particles together.
2. Arrangement of unit cells in lattice and packing of lattice points in different arrangements.
3. Calculation of density of unit cell and unit cell dimensions.
4. Calculation of packing efficiency of solids.
5. Types of voids, their locations and number of voids in different types of arrangements.
6. Imperfections or common defects in solid state.
7. Electrical and magnetic properties of solids.

GENERAL CHARACTERISTICS OF SOLID STATE

Solid state is characterised by its lowest compressibility and highest density as compared to liquid and gaseous state. Constituent particles are packed most closely. This state is distinguished from liquids and solids by their definite size, shape and volume. Solids have considerable mechanical strength, rigidity, very strong inter particle force of attraction and minimum distance among them. Due to the strong forces of attraction particles in solid state do not possess any translatory motion but can only have vibrational motion about their mean position. Solids have negligible fluidity as compared to liquids and gases. Diffusion of particles of solid state is negligible.

Classification of Solids

Solids are classified on the basis of two different parameters i.e.,

(i) Packing of constituent particles and

(ii) Forces of attraction among constituent particles.

Classification on the basis of packing of constituents in lattice

1. Crystalline Solids

(i) These are the solids in which the constituent particles (atoms, ions or molecules) are arranged in a regular, three dimensional orderly arrangement, which gets repeated throughout. Hence, these are also called as **long-range order solids.**

(ii) Crystalline solids have sharp melting point, it means they change abruptly into liquid state at a fixed temperature.

(iii) Their nature is **Anisotropic** it means a few of their physical properties such as mechanical strength, refractive index, electrical and thermal conductivity etc. have different values when measured from different directions, in same crystal.

(iv) On cutting with a knife they give sharp and smooth edges.

(v) They are considered as true solids with characteristic enthalpy of fusion.

Quartz, diamond, Boron Nitride (BN) etc. have covalently bonded particles. In NaCl, ZnS, CsCl etc particles are connected by electrostatic forces of attraction and in solid iodine and solid sulphur, particles have weak van der waals forces of attraction among them.

2. Amorphous Solids

(i) Constituent particles are randomly scattered with, no regular arrangement of particles. Therefore they do not have any definite shape or form.

(ii) If constituent particles are arranged in some orderly manner, then this arrangement does not continue for long distance, hence they are **short range order solids**.

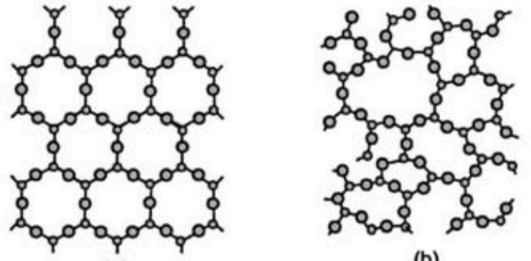
(iii) They have diffused melting points. It means they soften over a wide range of temperature instead of melting at a particular temperature only.

(iv) They are **isotropic** by nature. It means due to random arrangement of particles throughout the values of physical properties such as refractive index, electrical and thermal conductivity etc. will have same value in all directions.

(v) They form diffused and irregular edges, when cut with a sharp knife.

(vi) They are called **pseudo solids** or super cooled liquids, as they have a tendency to flow. They have no definite value of enthalpy of fusion.

Rubber, glass, plastic etc. are commonly known as amorphous solids.



(a) (b)

Representation of long-range order (Quartz)[a] and short-range order (Glass) [b]

Knowledge Cloud

Super Cooled Liquid : Like liquids amorphous solids have a tendency to flow, hence they are also called as pseudo solids or super cooled liquids. If we notice glass window **pane** of old buildings, we find them slightly thicker at the bottom than at the top. Hence, glass is also called as super cooled liquid. Super cooled liquids can flow slowly under their own weight and lose shape and can be easily distorted.

(a) **Diamond :** It has a three dimensional network of large number of sp^3 hybridised carbon atoms each bonded tetrahedrally to four more carbon atoms by single covalent bonds. It makes diamond extremely hard crystal with very high mp ≈ 3843 K. Diamond does not conduct electricity at all.

(b) **Graphite :** Each carbon atom is sp^2 hybridised and covalently bonded to three other carbon atoms of same layer by single bonds, forming a layer of hexagonal rings. At each carbon atom the fourth valence electron is available free, which moves among different layers and provides good electrical and thermal conducting nature to graphite. Different layers connect by van der Waals forces. As the forces are quite weak, the layers can slide over each other and make graphite a soft, lubricating solid.

4. **Molecular Solids :** Their molecules are held together by dispersion forces, London forces, dipole-dipole forces or hydrogen bonds. On the basis of type of interactive forces these solids are studied under the following sub-headings.

(a) **Non-Polar Molecular Solids :** Either atoms (e.g., He, Ne, Ar) or molecules (e.g., H_2, I_2 and Cl_2) are bonded together by weak dispersion forces or London forces. These are non-conductor soft solids with low m.p. and low enthalpies of vaporisation. They are volatile in nature hence, at room temperature and pressure they are available in liquid or gaseous state.

e.g. Iodine, Solid H_2 and CO_2 (dry ice). Naphthalene, Camphor etc.

(b) **Polar Molecular Solids :** Polar covalent molecules are held together by strong dipole-dipole forces. These are soft non-conducting solids with low Melting point and Boiling Points, which are still higher than non-polar molecular solids. They have high enthalpy of vaporisation.

Example : Solid HCl, NH_3 and SO_2 etc.

(c) **Hydrogen Bonded Molecular Solids :** Polar covalent molecules containing 'H' atom as positive pole and N,O or F atom as negative pole are held together by intermolecular H-bonding. Under room temperature and pressure conditions they are generally volatile liquids or soft solids and non-conductors of electricity.

Example : Ice

Try Yourself

1. Why are solids almost incompressible?
2. Classify the following solids into amorphous or crystalline solids.

   Bakelite, Platinum, Camphor, Oxalic acid, Melamine formaldehyde, Alum, Neoprene, Sugar, Solid CO_2, Polythene.
3. Thermal conductivity of a solid has different values along different directions. What kind of solid is this? Also comment on its melting point.
4. Classify following solids into four categories based on intermolecular forces of interaction.

   Caesium chloride. Solid carbon disulphide, Bronze, Neon, Boron nitride, Washing soda, Carborundum, Corrundum, Solid NH_3, Solid camphor, Silver, Silica.

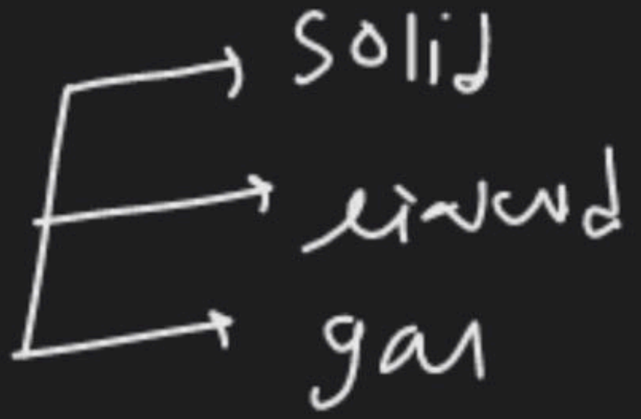
Knowledge Cloud

Isomorphous and Polymorphous Solids : Two or more solid substances existing in same crystalline form or structure are isomorphous to each other.

e.g., (i) $MgSO_4 \cdot 7H_2O$, $FeSO_4 \cdot 7H_2O$ and $ZnSO_4 \cdot 7H_2O$ are isomorphs.

(ii) Na_2S and Ag_2S also show isomorphism.

Solid state:



Water → ice → vapour

liquid — solid — gas

Classification on the basis of Nature of Intermolecular Forces

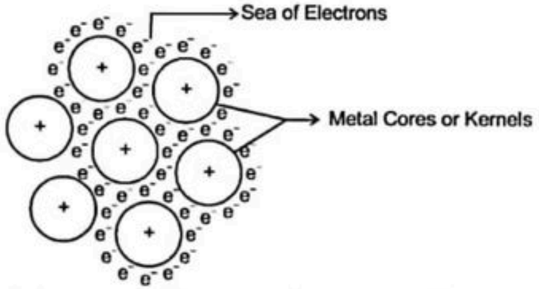
1. **Ionic Solids :** There is a regular arrangement of positively and negatively charged ions throughout the solid where ions are held together by strong coulombic or electrostatic forces. These solids are very hard and brittle and have very high melting points. In solid state, as ions are not free to move, hence they are insulators but in molten state or in aqueous state, it's ions become free to move and it becomes conductor. Ionic solids have high enthalpies of vaporisation. They are soluble in polar solvents like H_2O but insoluble in non-polar solvents such as C_6H_6, CS_2, CCl_4 etc.

   Examples : LiF, NaCl, KNO_3, Na_2SO_4 etc.

2. **Metallic Solids :** Metal cores (i.e. kernels) and a sea of mobile electrons are the constituents of metallic solids. Each metal atom contributes one or more electrons towards sea of electrons. These electrons are evenly spread out throughout the crystals and weak forces of attraction or metallic bond binds together kernels and sea of electrons.

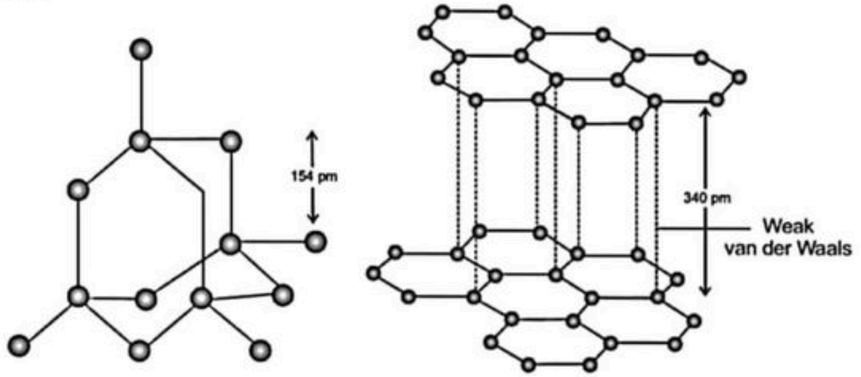
   Metallic crystals may be hard as well as soft having moderate enthalpies of fusion. Mobile sea of electrons is responsible for many properties of metals such as malleability (can be beaten into thin sheets), ductility (can be drawn into wires), metallic lustre, thermal conductivity and electrical conductivity etc.

   Example : Copper, Iron, Nickel, Metal alloys etc.



3. **Covalent Solids :** In these atoms are bonded together by covalent bond formation throughout the crystal. It means there is a continuous network of covalent bonds forming a giant three-dimensional structure or giant molecule. Covalent bonds are strong and directional in nature. These solids are very hard, brittle and very high melting. Due to absence of any free electrons or ions they are insulators. Their enthalpies of fusion are very high.

   Example : Diamond, Graphite, Boron Nitride (BN), Silicon Carbide (SiC) etc. are common examples of these solids.



(a) Diamond (b) Graphite

Structure of (a) diamond & (b) Graphite

Existence of a substance in two or more crystalline forms having similar chemical composition but different arrangement of constituent particles is polymorphism.

e.g., ZnS in the form of zinc blende and wurtzite.

In case of elements polymorphism is also called allotropy and all crystalline allotropes are polymorphs to each other.

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Assertion: The refractive index of Glass is same when ray of light is striked on Glass from different direction → isotropic

Reason: Glass is anisotropic in nature

a.

b.

c

d

Assertion: BN & Graphite are isomorphs

Reason: both BN & Graphite have same crystalline structure

(a) (b) (c) (d)

A: The bottom portion of glass of old window is thicker than the top portion

R: Glass is a super cooled liquid & hence has some property to flow

(a) (b) (c) (d)

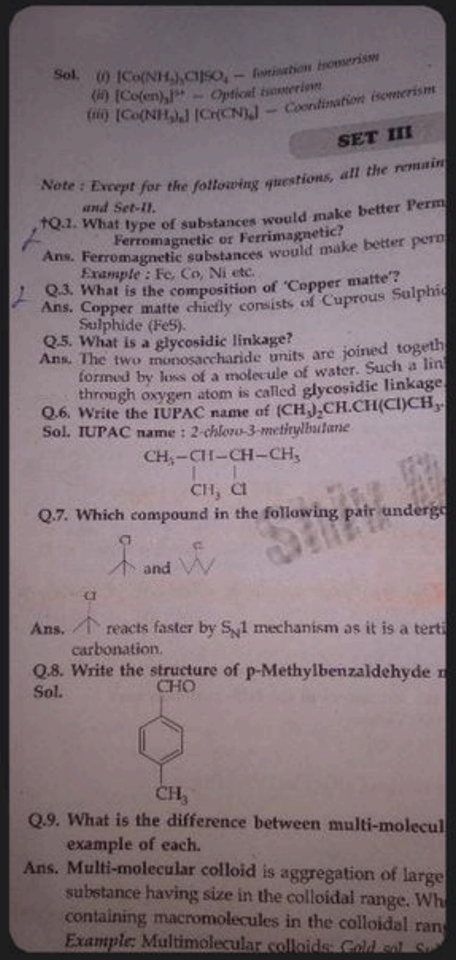
A: There is milky appearance in ancient Glasses

R: Some crystallization take place after a long interval of time in amorphous solids

(a) (b) (c) (d)

Cr

Question
from Harsh Tìwàrì



Sol. (i) $[Co(NH_3)_5Cl]SO_4$ – *Ionisation isomerism*
(ii) $[Co(en)_3]^{3+}$ – *Optical isomerism*
(iii) $[Co(NH_3)_6][Cr(CN)_6]$ – *Coordination isomerism*

SET III

***Note :** Except for the following questions, all the remain*
and Set-II.

†Q.1. What type of substances would make better Perm
Ferromagnetic or Ferrimagnetic?
Ans. Ferromagnetic substances would make better perm
Example : Fe, Co, Ni etc.

Q.3. What is the composition of 'Copper matte'?
Ans. Copper matte chiefly consists of Cuprous Sulphid
Sulphide (FeS).

Q.5. What is a glycosidic linkage?
Ans. The two monosaccharide units are joined togeth
formed by loss of a molecule of water. Such a lin
through oxygen atom is called **glycosidic linkage**.

Q.6. Write the IUPAC name of $(CH_3)_2CH.CH(Cl)CH_3$.
Sol. IUPAC name : *2-chloro-3-methylbutane*

$$CH_3-\underset{CH_3}{CH}-\underset{Cl}{CH}-CH_3$$

Q.7. Which compound in the following pair undergo

Ans. reacts faster by S_N1 mechanism as it is a terti
carbonation.

Q.8. Write the structure of p-Methylbenzaldehyde n
Sol.

Q.9. What is the difference between multi-molecul
example of each.
Ans. Multi-molecular colloid is aggregation of large
substance having size in the colloidal range. Wh
containing macromolecules in the colloidal ran
Example: Multimolecular colloids: *Gold sol.* S

two monosaccharide are linked together

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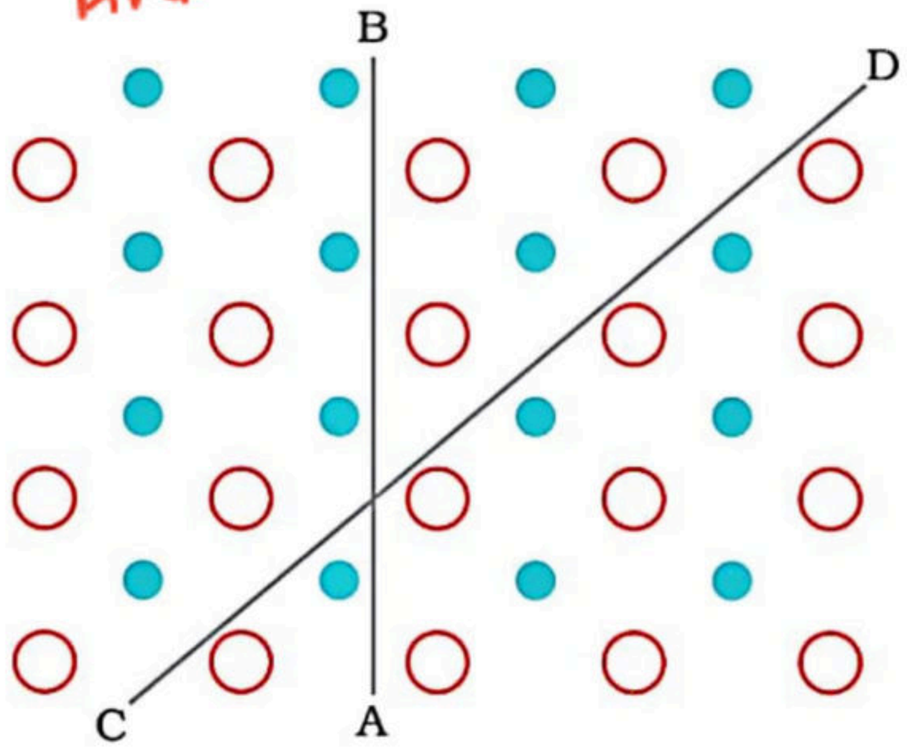
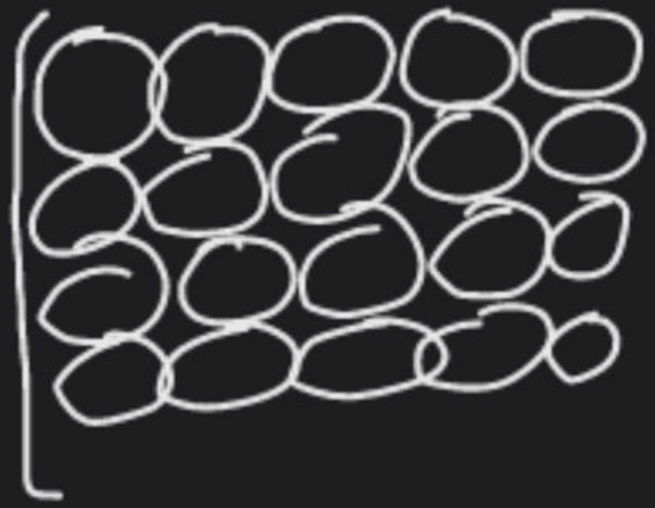


Fig. 1.2: *Anisotropy in crystals is due to different arrangement of particles along different directions.*



long range order

↓

crystalline solid

Salt

melt

Silica

Quartz

liquid

super cooled liquid

Glass

Amorphous

Crystalline

true solid

Iron, Gold, NaCl, ...

Amorphous?

pseudo solid

bottom portion is thicker

old Glass window

Glass