1. Solid States

Q. Distinguish between crystalline solids & Amorphous solids. [March 13, 14, 17, 19] [2 mks]

R. A. S. T. A. L

Crystalline solids	Amorphous solids
i) The constituent particles are arranged in a regular and periodic manner	i) The constituent particles are arranged randomly.
ii) They have sharp and characteristic melting point	ii) They do not have sharp melting point. They gradually soften over a range of temp.
iii) They are anisotropic, i.e., have different physical properties in different direction.	iii) They are isotropic, i.e., have same physical properties in all directions.
iv) They have long range order	iv) They have short range order.
e.g. Ice, NaCl, etc	e.g. Rubber, glass, plastic, etc.

Q. Define isomorphism. [July 23; sep 21]

=> when two or more crystals have similar chemical composition exist in the same crystalline form, this property is called isomorphism.

example. i) NaF and MgO ii) $NaNO_3$ and $CaCO_3$ are isomorphous pairs, and have the same atomic ratios, 1:1 and 1:1:3, respectively of the constituent atoms.

* Polymorphism.

- A single substance that exists in two or more forms.

For example : Calcite and aragonite are two forms of calcium carbonate ; α-quartz, β-quartz and cristobalite are three of the several forms of silica.

* Unit cell.

- The smallest repeating structural unit of a crystalline solid is called unit cell.

* Types of unit cell.

1.) simple unit cell
- located at corners.

$\frac{1}{8} \times 8 = \boxed{1}$

2.) Body centred unit cell
- one particle at the centre

$\frac{1}{8} \times 8 + 1 = \boxed{2}$

3.) Face-centred unit cell
- centre of each face

$\frac{1}{8} \times 8 + \frac{1}{2} \times 6 = \boxed{4}$

Lattice	Coordination no.	Packing efficiency
SC.	6	52.4%
bcc	8	68%.
fcc/hcp/ccp	12	74%.

Q. Derive the relationship between molar mass, density of the substance and unit cell edge length [march 24] [2 mks.]

⇒ Relationship between molar mass, density of the substance and unit cell edge length:

i.) Let the edge length of cubic unit cell is 'a' then the volume of unit cell is a^3.
Suppose that mass of one particle is 'm' and that there are 'n' particles per unit cell.

$\therefore$ mass of unit cell $= m \times n$ —— (i)

ii) The density of unit cell (ρ), which is same as the density of the substance is given by $\rho = \frac{\text{mass of unit cell}}{\text{volume of unit cell}}$

$= \frac{m \times n}{a^3}$ = density of substance —— (ii)

iii) molar mass (M) of the substance is given by
M = mass of one particle × no. of particles per mole.
$= m \times N_A$ ($\because N_A$ = avogadro no.)

Therefore,

$m = \frac{M}{N_A}$ —— (iii)

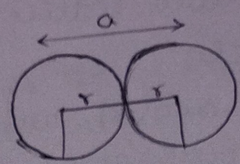
Combining equation (ii) and (iii)

$\rho = \frac{nM}{a^3 N_A}$ —— (iv)

Packing efficiency
52.4 %.

%.

Simple cubic lattice



1.) Radius of sphere

$a = 2r$

2.) volume of sphere

$= \frac{4}{3}\pi r^3$

3.) Total volume of sphere

$a^3 = (2r)^3$

$= 8r^3$

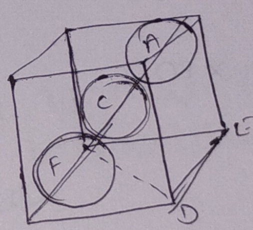
4.) Packing efficiency

$= \frac{\text{volume occupied by particle in unit cell}}{\text{total volume of unit cell}} \times 100$

$= \frac{\frac{4}{3}\pi r^3 \times 1}{8r^3} \times 100$

$= 52.36\%$

* Body-centred cubic lattice



1.) Radius of sphere

ΔFED

$b^2 = a^2 + a^2$

$b^2 = 2a^2$

ΔADF

$c^2 = b^2 + a^2$

$c^2 = 2a^2 + a^2$

$c^2 = 3a^2$

$(4r)^2 = 3a^2$

$4r = \sqrt{3} \cdot a$

$\boxed{\frac{4r}{\sqrt{3}} = a}$

2.) Volume of sphere

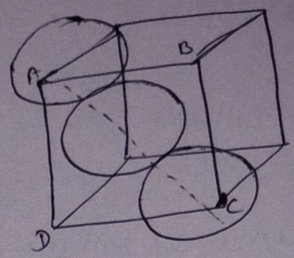
$= \frac{4}{3}\pi r^3$

3.) Packing efficiency

$= \frac{\frac{4}{3}\pi r^3 \times 2}{\left(\frac{4r}{\sqrt{3}}\right)^3} \times 100$

$= 68\%$

* Face - centred cubic lattice



• Radius of particle

The ΔABC is right angled with $\angle ABC = 90°$. Acc. to pythagoras theorem,

$AC^2 = AB^2 + BC^2 = a^2 + a^2 = 2a^2$

$$(4r)^2 = 2a^2$$

$$4r = \sqrt{2}a$$

$$\frac{4r}{\sqrt{2}} = a$$

$$\frac{2 \times 2 \times r}{\sqrt{2}} = a$$

$$\frac{\sqrt{2} \times \sqrt{2} \times 2 \cdot r}{\sqrt{2}} = a$$

$$\boxed{\sqrt{2} \cdot 2r = a}$$

• Packing efficiency :

$$= \frac{\frac{4}{3}\pi r^3 \times 4}{(\sqrt{2} \cdot 2r)^3} \times 100$$

$= 74\%$.

Q. Differentiate between Schottky and Frenkel defect.

Schottky defect	Frenkel defect
i.) It decreases the density of the crystal	It does not decrease the density of the crystals
ii.) occurs in compounds with high co-ordination number	It occurs in compounds with low coordination number
iii.) Occurs in which cations and anions are of similar size	occurs in which cations and anions differ in their size to a large
iv.) No change in the value of the dielectric constant.	The value of dielectric constant
Eg. NaCl, KCl, KBr, CsCl.	Eg. ZnS, AgCl, AgBr, AgI

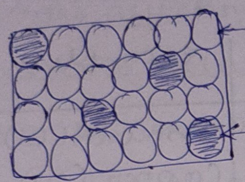
Impurity defect.

- It occurs when foreign atoms or ions are introduced into a material, disrupting its regular atomic structure.

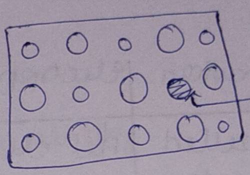
These defects can be of two types.

1.) Substitutional Defect : Foreign atoms replace the host atoms in the crystal lattice.

2.) Interstitial defect : Foreign atoms occupy spaces between the host atoms in the lattice.



◦ Brass.



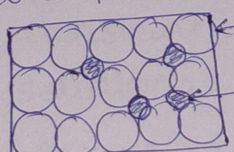
◦ vacancy through aliovalent ion.

Q. Explain impurity defect in stainless steel with diagram [march 15]

⇒ In interstitial impurity defect, the impurity atoms occupy interstitial spaces of lattice structure

eg. stainless steel.

In stainless steel, Fe atoms occupy normal lattice sites. The carbon atoms are present at interstitial spaces, as shown in fig.



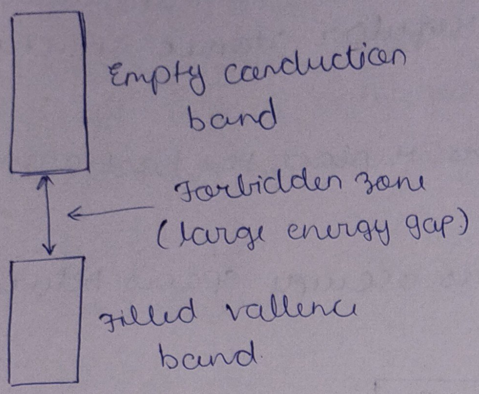
* electrical properties of solids.

i.) conductors : solids having electrical conductivities in the range 10^4 to 10^7 $ohm^{-1} m^{-1}$

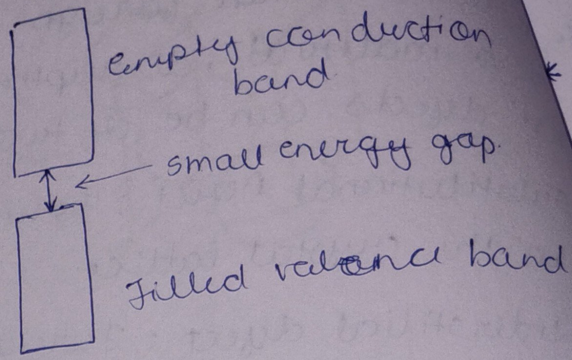
ii.) Insulators : solids having low electrical conductivities in the range 10^{-20} to 10^{-10} $ohm^{-1} m^{-1}$ are called insulators.

iii.) Semiconductors : solids having electrical conductivities in the range 10^{-6} to 10^4 $ohm^{-1} m^{-1}$.

* Insulators



* Semiconductors



* Type	Magnetic Behavior	Electron configuration	Examples.
Diamagnetic	Weakly repelled by a magnetic field.	All electrons are Paired	Bismuth (Bi), Copper (Cu), water
Paramagnetic	weakly attracted to a magnetic field	some unpaired electrons.	Aluminium (Al), Platinum (Pt)
Ferromagnetic	strongly attracted and can retain magnetization	many unpaired electrons, permanent magnetic moment	Iron (Fe), Nickel (Ni), cobalt (Co).