1. Solid State

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01. Solid State

Synoptic Notes

1. ***Solid : A solid is defined as that form of matter which have rigidity and due to which possess a definite shape and definite volume.***

2. **Types and Classification of solids:-**

   Solids can be broadly classified into following two types,

   (i) Crystalline solids/True solids, (ii) Amorphous solids/Pseudo solids

Crystalline solids	Amorphous solids
1. They have **longrange order.**	They have **short range order.**
2. They have **definite melting point**	Not have **definite melting point**
3. They have a **definite heat of fusion**	Not have **definite heat of fusion**
4. They are **rigid and incompressible**	**Not be compressed to any appreciable extent**
5. They have **regular cleavage** i.e. they break intotwopieces with plane surfaces	They are given irregular cleavage i.e. they break into two pieces with irregular surface
6. They are usuallyanisotropic because of thesesubstances show different property indifferentdirection Ionic crystals : Anisotropic Metallic crystals : Isotropic	They are **isotropic** because of these substances show same property in all directions
7. There is a **sudden change in volume** whenit melts.	There is **no sudden change in volume on melting.**
8. These possess **symmetry**	**Do Not** possess any **symmetry.**
9. These possess **interfacialangles.**	**Do Not** possess any**interfacial angles.**
10. They have **sharp edges.**	They do **not** have **sharp edges**.

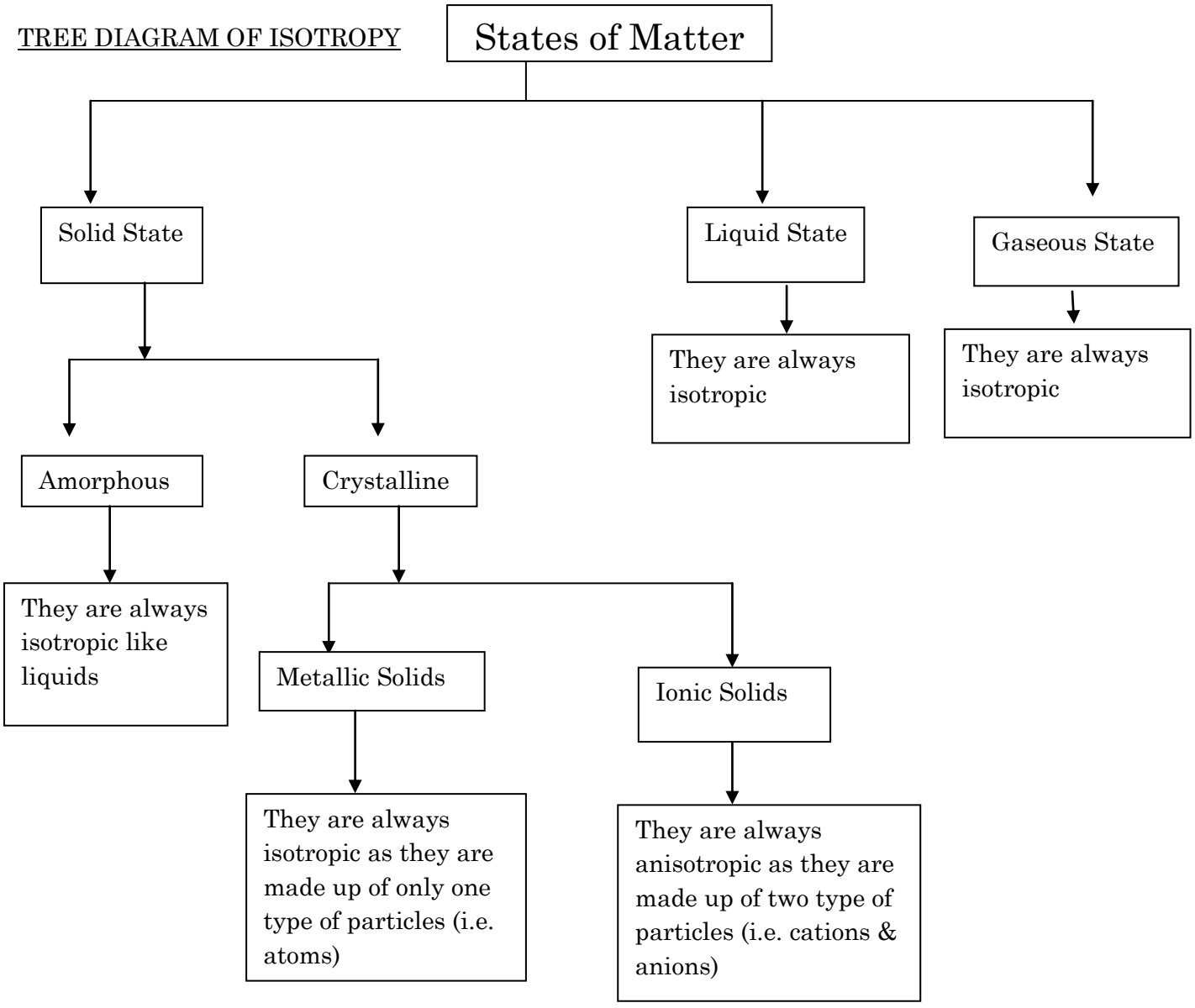
Note: Crystalline substance with only one kind of particles like pure metals (Cu) are isotropic While with two more kind of particles (NaCl, Na^+& Cl^- are separately present) are anisotropic.

Silica has two different forms:

Quartz	Amorphous silica
It is **crystalline** in nature	It is **light (fluffy) white powder**
All four corners of SiO_4^{4-} tetrahedron are shared by others to give a network solid	The SiO_4^{4-} tetrahedral are randomly joined, giving rise to polymeric chains, sheets or three-dimensional units
It has **high and sharp melting point** (1710°C)	It does **not** have **sharp melting point**

- ❖ Glass is a highly viscous substance.
- ❖ Isomorphous substance have same crystal lattice same ratio of different atoms of different elements. e.g. : K_2SO_4 & K_2SeO_4 (2:1:4) and $NaNO_3$ & $CaCO_3$ (1:1:3)
  Vice versa statement is **NOT** true, i.e. if atomic ratio is same, it does mean that they are isomorphous.
  e.g. NaC*l*, KC*l* have same atomic ratio of 1:1, but have different crystal structure.
- ❖ Polymorphous : Two or more crystalline forms.
- ❖ Polymorphy is used for only crystalline forms while allotropy is used for both amorphous and crystalline forms.
- ❖ Gases, Liquids, amorphous solids, crystalline metallic solids do not possess anisotropy as they are considered to have same composition throughout.
- ❖ Only crystalline ionic solids show anisotropy

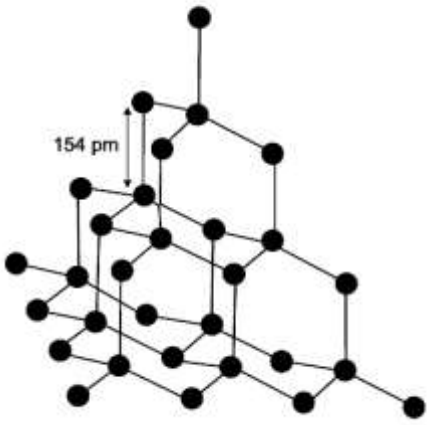
TREE DIAGRAM OF ISOTROPY



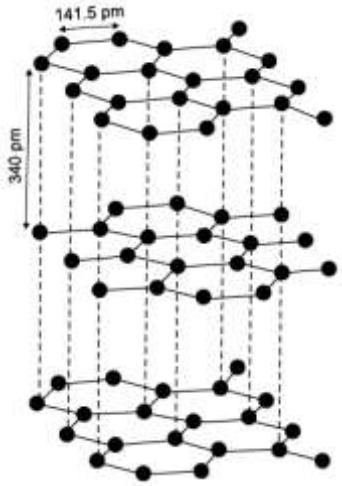
3. Diamond and graphite

Diamond and graphite are two allotropes of carbon. Diamond and graphite both are covalent crystals. But, they differ considerably in their properties.

Diamond	Graphite
It occurs naturally in free state	It occurs naturally, as well as manufactured artificially
It is the hardest natural substance known.	It is soft and greasy to touch
It has high relative density (about 3.5)	Its relative density is 2.3
It is transparent and has high refractive index (2.45)	It has black in colour and opaque
It is non-conductor of heat and electricity.	Graphite is a good conductor of heat and electricity
It burns in air at 900°C to give CO_2	It burns in air at 700°C to give CO_2
It occurs as octahedral crystals	It occurs as hexagonal crystals



Structure of diamond



Structure of Graphite

4. Classification of Crystalline solids:

	Types of solid	Constituent Particle	Bonding /attractive forces	Examples	Physical nature	Electrical Conductivity	Melting point
1)	**Molecular solids**						
	(i) Non polar	Molecules	Dispersion or London forces	Ar, CCl_4, H_2, I_2, CO_2,	Soft	Insulator	Very low
	(ii) Polar		Dipole-dipole interactions	HCl, SO_2	Soft	Insulator	Low
	(iii) Hydrogen bonded		Hydrogen Bonding	H_2O (ice)	Hard	Insulator	Low
2)	**Ionic solids**	Ions	Coulombic or electrostatic	NaCl, MgO, ZnS, CaF_2, KCl, $BaSO_4$, K_2SO_4, CaO,LiF	Hard but brittle	Insulator in solid state but conductors in molten state and in aqueous solutions	High
3)	**Metallic solids**	Positive ions in a sea of delocalised electrons	Metallic Bonding	Fe, Cu, Ag, Mg, Na, Au and alloys	Hard but malleable and ductile	Conductors in solid state as well as in molten state	Fairly high
4)	**Covalent or network solids**	Atoms	Covalent Bonding	SiO_2 (quartz), SiC, C (diamond), AIN $C_{(graphite)}$	Hard Soft	Insulators Conductor (exception)	Very high

- Atomic Solids (noble gases) are molecular solids with atomicity of 1.
- Ionic bonds, metallic bonds are non-directional.
- Covalent bonds involving only overlapping of s-orbitals. (H_2) molecule is non-directional.

5. Space lattice, Lattice points, Unit cell

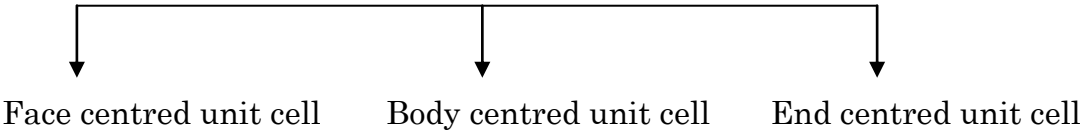
- **Space lattice** : The collection of all the points in crystal having similar environment is called space lattice.
- **Lattice point** : The positions occupied by constituent particles so as to form a crystal lattice are known as lattice points

  → Each point in a space lattice represents an atom ion or molecule
  → Each point in a space lattice has identical surrounding throughout
- **Unit cell** : A unit cell is the smallest repeating structure unit of a crystalline solid. When unit cells of the same crystalline substance are repeated in space in all directions a crystalline solid is formed.

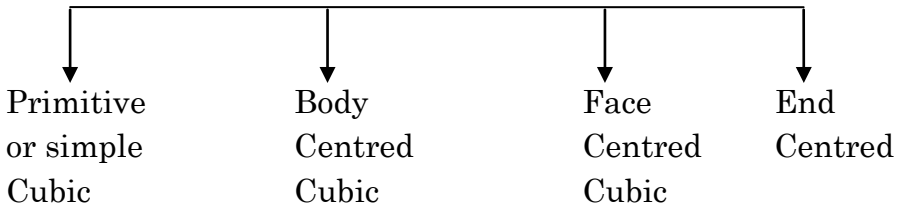
6. Types of crystal system / classification unit cells

1) **Primitive / simple unit cell** : Unit cells which have lattice points (constituents) only at corners.
2) **Centred unit cells**: Unit cells which have lattice points (constituents) at corners as well as at some other positions.

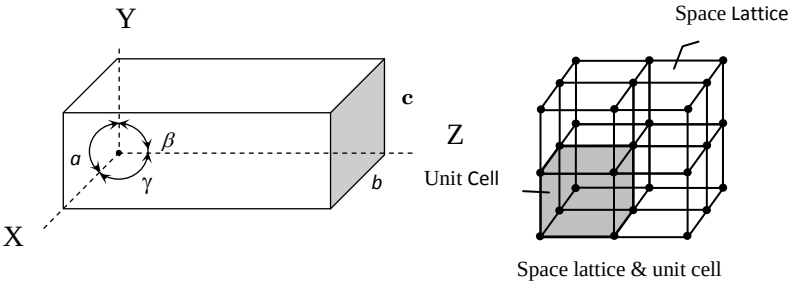
*** Centred unit cell are of three types:-**



Types of unit cell:-



Space lattice and Unit cell



7. Distinguish between Hexagonal unit cell and Monoclinic unit cell

Hexagonal Unit Cell	Monoclinic Unit Cell
1. Hexagonal unit cell has two edges of equal length ($a = b \neq c$)	*Monoclinic unit cell has all three edges of unequal lengths ($a \neq b \neq c$)*
2. In hexagonal unit cell two angles are 90° and one angle of 120° ($\propto=\beta= 90°, \gamma = 120°$)	In monoclinic unit cell two angles are 90° but one angle is not 90° ($\propto=\gamma= 90°, \beta\neq 90°$)

8. Distinguish between Face centred unit cell and End centred unit cell

Face Centred Unit Cell	End Centred Unit Cell
1. It has points at the corners as well as the centre of each face	It has points at all the corners and at the centre of any two opposite faces
2. It has four atoms per unit cell	It has two atoms per unit cell

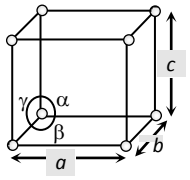
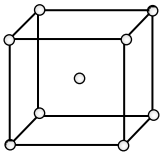
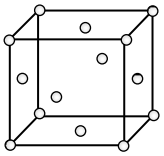
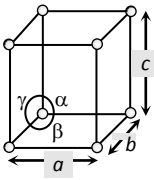
9. Distinguish between Crystal lattice and Unit cell:

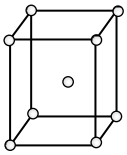
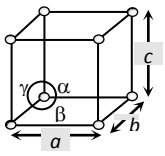
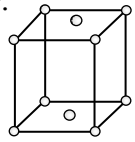
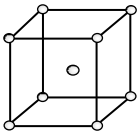
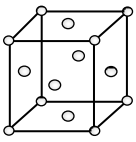
Crystal lattice	Unit Cell
1. It is regular arrangement of constituent particles of crystalline solids in three dimensional space	It is the smallest repeating structure unit which when repeated in space in all dimension generates a crystal lattice
2. It is made up of a large number of unit cells	It is one fundamental unit of crystal lattice which possess all the properties of the crystal
3. It is macroscopic system	It is microscopic system
4. Crystal lattice on further splitting may form numerous unit cell	Unit cell cannot be further subdivided without changing crystalline properties
5. Crystal lattice is defined in terms of properties of unit cell	Unit cell describe the fundamental properties of crystal lattice

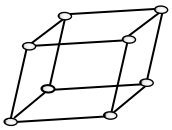
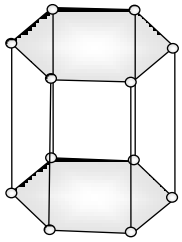
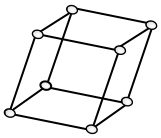
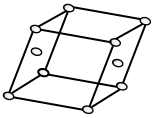
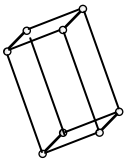
10. Distinguish between Hexagonal close packing and Cubic close packing:

Hexagonal Close Packing	Cubic Close Packing
1. In this type spheres of third layer lie directly above spheres of first layer	In this the spheres of third layer do not lie above the spheres of first layer
2. In this first and third layer are identical	In this first and third layers are different
3. The arrangement of packing is ABAB type	The arrangement of packing is ABCABC type
4. In this three dimensional building of unitcell, sphere of third layer are placed on triangular shaped tetrahedral voids of the second layer	In this three dimensional building of unit cell, the crests of spheres of third layer are placed in the positions of tetrahedral voids having apices upward

11. Bravais lattices corresponding to different crystal system:

<table>
<tr><td>Crystal system</td><td colspan="4">Space lattice</td></tr>
<tr><td>Cubic
$a = b = c$
$\alpha = \beta = \gamma = 90^o$
Base = square
Side = square</td><td>Simple : Lattice points at the eight corners of the unit cells.
 
</td><td>Body centered :
Points at the eight corners and at the body centred.
  </td><td colspan="2">Face centered :
Points at the eight corners and at the six face centres.
dense)
  </td></tr>
<tr><td></td><td>e.g. Polonium
(metallic solid)</td><td>e.g. Fe, Rb, Na,Ti,W,U, Zr
(metallic solid)</td><td colspan="2">e.g. Cu, Al, Ni, Au, Ag ,Pt, NaCl, KCl,diamond
(metallic solid)</td></tr>
<tr><td>Tetragonal
$a = b \neq c$,
$\alpha = \beta = \gamma = 90^o$
Note:
Base = Square
Side = Rectangle</td><td colspan="2">Simple : Points at the eight corners of the unit cell.
 

Also called as Premitive)</td><td colspan="2">Body centered : Points at the eight corners and at the body centre.
  </td></tr>
<tr><td></td><td colspan="2">e.g. SnO_2</td><td colspan="2">e.g. TiO_2, $CaSO_4$</td></tr>
<tr><td>Orthorhombic
(Rhombic)
$a \neq b \neq c$,
$\alpha = \beta = \gamma = 90^o$
Note:
Base = Rectangle
Side = Rectangle</td><td>Simple:
Points at the eight corners of the unit cell.
 
</td><td>End centered :
Also called side centered or base centered. Points at the eight corners and at two face centres opposite to each other.
  </td><td>Body centered :
Points at the eight corners and at the body centre
  </td><td>Face centered:
Points at the eight corners and at the six face centres.
  </td></tr>
</table>

<table>
<tr><td></td><td>Rhombic sulphur</td><td>$MgSO_4.7H_2O$</td><td>KNO_3</td><td>$BaSO_4$</td></tr>
<tr><td>Rhombohedral
$a = b = c$,
$\alpha = \beta = \gamma \neq 90°$</td><td colspan="4">Simple : Points at the eight corners of the unit cell
  </td></tr>
<tr><td>Base = Rhombus
Side =Rhombus</td><td colspan="4">e.g. $NaNO_3$, $CaSO_4$, $FeCO_3$, Calcite, quartz, HgS, As, Sb, Bi etc.</td></tr>
<tr><td>Hexagonal
$a = b \neq c$,
$\alpha = \beta = 90^o$,
$\gamma = 120^o$</td><td colspan="4">Simple: Points at the twelve corners of the unit cell out lined by thick line.
  </td></tr>
<tr><td></td><td colspan="4">e.g. ZnO, BeO, CoS, SnS, Mg, CdS</td></tr>
<tr><td>Monoclinic
$a \neq b \neq c$
$\alpha = \gamma = 90^o, \beta \neq 90^o$
Note:
Base = Right angled trapezium
Right angled Trapezium</td><td colspan="2">Simple: Points at the eight corners of the unit cell
  </td><td colspan="2">End centered: Point at the eight corners and at two face centres opposite to the each other.
  </td></tr>
<tr><td></td><td colspan="2">e.g. Monoclinic sulphur</td><td colspan="2">$Na_2SO_4.10H_2O$</td></tr>
<tr><td>Triclinic
$a \neq b \neq c$,
$\alpha \neq \beta \neq \gamma \neq 90^o$
Note:
Base = Trapezium
Side = Trapezium</td><td colspan="4">Simple: Points at the eight corners of the unit cell.
  </td></tr>
<tr><td></td><td colspan="4">e.g. $K_2Cr_2O_7$, H_3BO_3, $CuSO_4.5H_2O$</td></tr>
</table>

** All examples which are made bold, has to be byhearted.*

12. Analysis of cubic system

(1)Number of atoms in per unit cell

The simplest relation can determine for it is, $\frac{n_c}{8}+\frac{n_f}{2}+\frac{n_i}{1}$

Where n_c = Number of atoms at the corners of the cube=8

n_f = Number of atoms at six faces of the cube = 6

n_i = Number of atoms inside the cube = 1

(1)

Cubic unit cell	n_c	***Contribution***	n_f	***Contribution***	n_i	***Contribution***	**Total atom/s in per unit cell**
Simple cubic cell (*scc*)	8	⅛	0	½	0	1	1
body centered cubic (*bcc*)	8	⅛	0	½	1	1	2
Face centered cubic (*fcc*)	8	⅛	6	½	0	1	4
Hexagonal close packed (*hcp*)	12	⅙	2	½	3	1	6

(2) Co-ordination number : (C.N.)

	Cubic unit cell	Co-ordination number
1.	For simple cubic system (sc)	6
2.	For body centred cubic system (bcc)	8
3.	For face centred cubic system (fcc) or ccp or hcp	12
4.	For hexagonal close packed (*hcp*)	12

(3) Density of the unit cell (ρ): It is defined as the ratio of mass per unit cell to the total volume of unit cell.

$$\rho = \frac{Z \times M}{a^3 \times N_0}$$

Where Z = Number of particles per unit cell (***Rank***)

M = Atomic mass or molecular mass

N_0 = Avogadro number $(6.022 \times 10^{23} mol^{-1})$

a = Edge length of the unit cell= a pm = a × 10^{-10} cm

a^3 = volume of the unit cell

i.e. $\rho = \dfrac{Z \times M}{a^3 \times N_0 \times 10^{-30}}\ g/cm^3$

Simplification – 1

If a = 400pm = 4×10^{-8} cm ($y \times 10^{-8}$ cm)

Then $\rho = \dfrac{Z \times M \times 10}{y^3 \times 6}\ g/cm^3$

Simplification – 2

If a = 400 pm, M = 100 g.mol^{-1}, then density (ρ) = $2.6 \times Z$

(4) Packing fraction (P.F.):

Let radius of the atom in the packing = *r*

Edge length of the cube = *a*

Volume of the cube *V* = a^3

Volume of the atom (spherical) $v = \dfrac{4}{3}\pi r^3$

Packing density $= \dfrac{vZ}{V} = \dfrac{\frac{4}{3}\pi r^3 Z}{a^3}$

Structure	**Co-ordination Number**	**'*r*' related to '*a*'**	**Volume of the atom (*v*)**	**Packing density**	**% of void**	**Volume of cubic unit cell** a^3	**Nearest neighbour**
Simple cubic	6	$r = \frac{a}{2}$	$\frac{4}{3}\pi\left(\frac{a}{2}\right)^3$	$\frac{\pi}{6} = 0.52$	100–52 = 48%	$8r^3$	a
Face-centred cubic	12	$r = \frac{a}{2\sqrt{2}}$	$\frac{4}{3}\pi\left(\frac{a}{2\sqrt{2}}\right)^3$	$\frac{\sqrt{2}\pi}{6} = 0.74$	100 – 74 = 26%	$8\sqrt{8}r^3$	$\frac{\sqrt{a}}{2}$
Body-centred cubic	8	$r = \frac{\sqrt{3}a}{4}$	$\frac{4}{3}\pi\left(\frac{\sqrt{3}a}{4}\right)^3$	$\frac{\sqrt{3}\pi}{8} = 0.68$	100 – 68 = 32%	$\frac{64r^3}{3\sqrt{3}}$	$\frac{\sqrt{3}a}{2}$
Hexagonal Close Packing	12	$r = \frac{a}{2}$	$6 \times \frac{\sqrt{3}}{4}(2r)^2 \times 4r\sqrt{\frac{3}{2}}$	$\frac{6 \times \frac{4}{3}\pi r^3}{6 \times \frac{\sqrt{3}}{4}(2r)^2 \times 4r\sqrt{\frac{2}{3}}} \approx \mathbf{0.74}$	100 – 74 = 26%	$8r^3$	

* Packing fraction of diamond = $\dfrac{\pi\sqrt{3}}{6} = 0.34$

* Length of Body diagonal = $\sqrt{3} \times a$

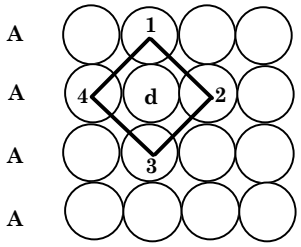
* Length of Face diagonal = $\sqrt{2} \times a$

***** For FCC lattice of an ionic crystal of NaC*l* (Rock salt) type, edge length a = $2(r_+ + r_-)$

Order of packing ccp (fcc) = hcp > bcc > scc

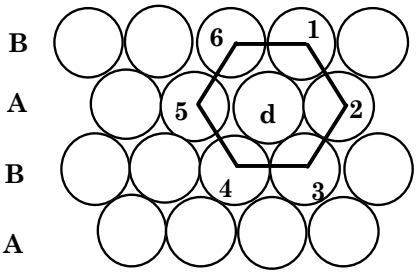
13. Close packing in two dimensional

Square close packing



Co-ordination No: 4

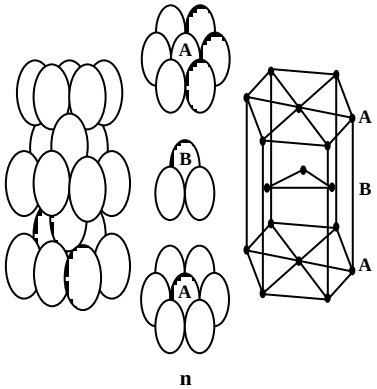
Hexagonal close packing



Co-ordination No: 6

14. Close packing in three dimensional

Hexagonal close packing

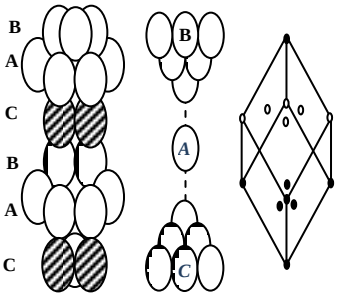


(hcp)

ABAB (3d) close packing

C. N. = 12

cubic close packing

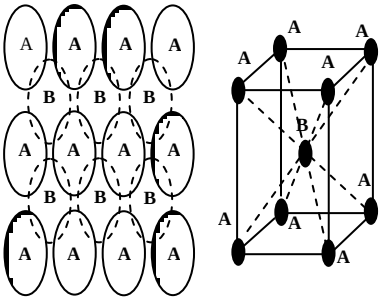


(ccp)

ABCABC (3d) close packing

C. N. = 12

Body centred cubic



(bcc)

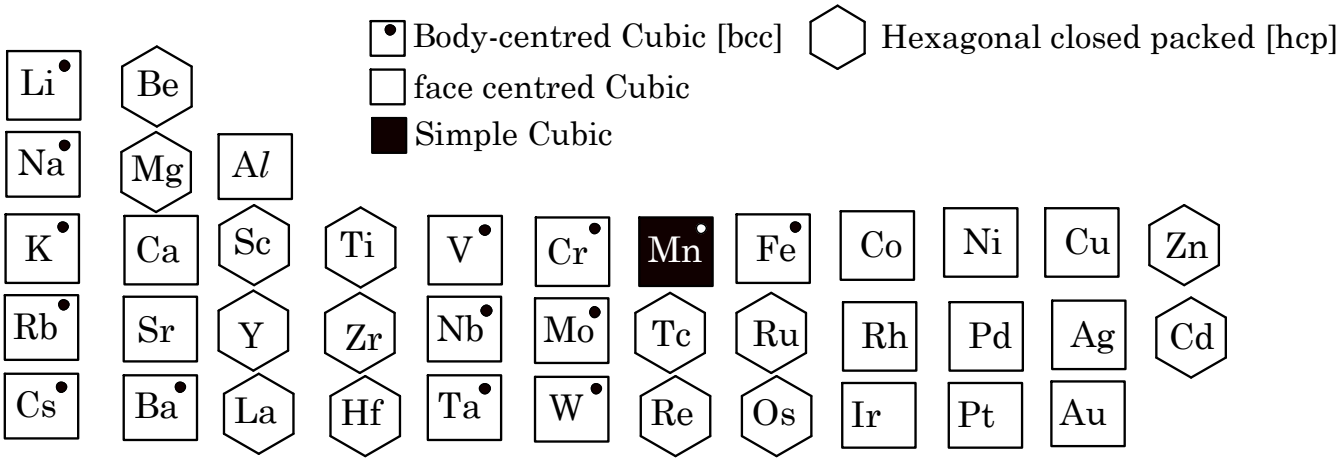
ABAB (3d)loose packing

C. N. = 8

15. Comparison of hcp , ccp and bcc

Property	*hcp*	*ccp*	*bcc*
Arrangement of packing	Close packed	Close packed	Not close packed i.eLoose Packed
Type of packing	ABABA...	ABCABCA...	AB AB A...
Available space occupied	74%	74%	68%
Coordination number	12	12	8
Malleability, ductility, other Physical Parameters	Malleable and ductile, Hard, high density	Malleable and ductile, Hard, high density	Malleable and ductile
Examples	Be, Mg, Ca, Cr, Mo, Zn	Cu, Ag, Au, Pt, A*l*, Ni	Alkali metals, Fe

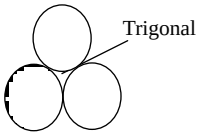
❖ <u>All noble gases have ccp structure except 'He' which has hcp structure in solid state.</u>



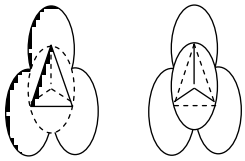
16. Interstitial sites in close packing

In *ccp (fcc), hcp*

Trigonal void

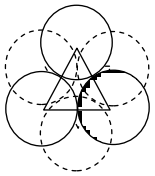


Tetrahedral void

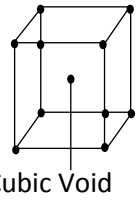


In *scc*

Octahedral void



Cubic Void

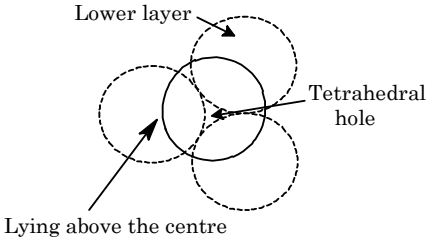


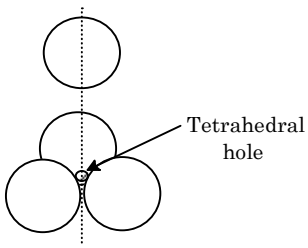
The size of void increases with the increase in coordination number of voids.

The increasing order of the size of the various voids is,

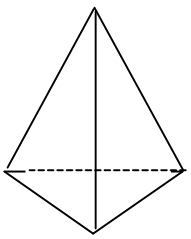
Trigonal<Tetrahedral <Octahedral < Cubic

For close packing of 'N' spheres, there are '2N' Tetrahedral and 'N' Octahedral void

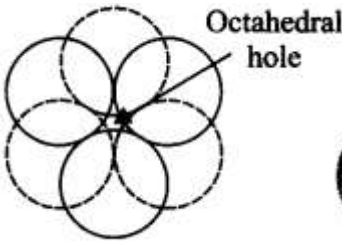


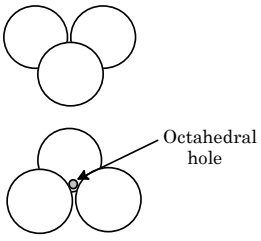


A tetrahedral interstices



Tetrahedron geometry





A octahedral interstices

i) Triangular : All anions touches each other and co-ordination number is 3

$$\text{Cos}\,\theta = \frac{r_-}{r_- + r_+}$$

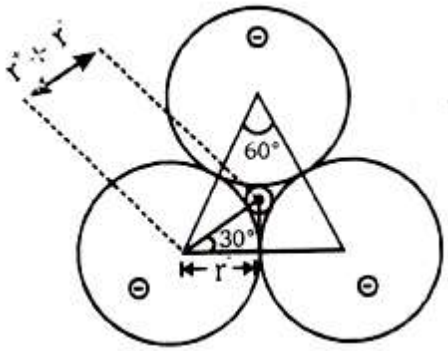
$$\text{Cos}\,30^\circ = \frac{\sqrt{3}}{2} = \frac{r_-}{r_- + r_+}$$

$$\sqrt{3}r_- + \sqrt{3}r_+ = 2r_-$$

$$\sqrt{3}r_+ = \left(2 - \sqrt{3}\right)r_-$$

$$\frac{r_+}{r_-} = \frac{2-\sqrt{3}}{\sqrt{3}} = \frac{2-1.73}{1.73} = \frac{0.27}{1.73} = 0.155$$

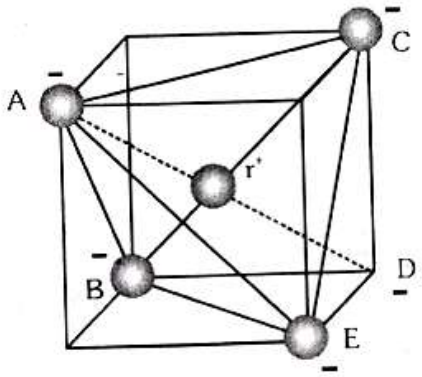
$$\text{L.R.R.} = 0.155 = \frac{r_+}{r_-} < 1$$



ii) **Tetrahedral void** : All anions touches each other and co ordination number of cation is 4.

Face diagonal AC = $\sqrt{2}a = 2r$

$$r_- = \frac{a}{\sqrt{2}} \text{ or } a = \sqrt{2}r$$



Triangle ACD –

$AD^2 = AC^2 + CD^2$

$$AD^2 = \left(\sqrt{2}a\right)^2 + (a)^2 = 2a^2 + a^2 = 3a^2$$

$AD = \sqrt{3}\,a$

According to cube diagonal AD

$$\because \frac{\sqrt{3}a}{2} = r_+ + r_-$$

$$\therefore \sqrt{3}a = 2r_+ + 2r_- = AD$$

Put the value of a = $\sqrt{3} \times \sqrt{2}r_- = 2r_+ + 2r_-$

$$\frac{\sqrt{3} \times \sqrt{2}r_-}{2r} = \frac{2r_+ + 2r_-}{2r_-}$$

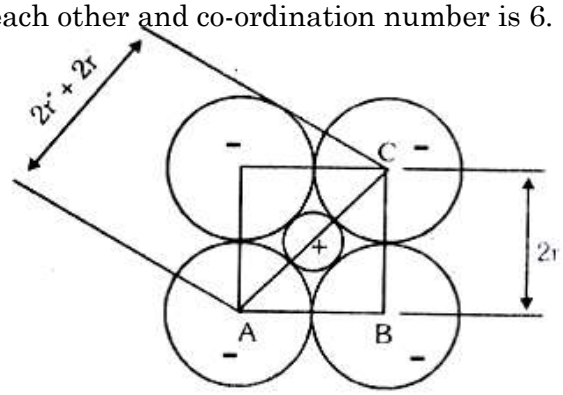
$$\frac{\sqrt{3}}{\sqrt{2}} = \frac{r_+}{r_-} + 1$$

$$\frac{r_+}{r_-} = \frac{\sqrt{3}}{\sqrt{2}} - 1$$

$$\frac{r_+}{r_-} = \frac{\sqrt{3}-\sqrt{2}}{\sqrt{2}} = \frac{1.73-1.414}{1.414} = 0.225$$

iii) **Octahedral void**: All the anions are touch each other and co-ordination number is 6.

In ΔABC $AC^2 = AB^2 + BC^2$



$= a^2 + a^2$

$AC = \sqrt{2}\,a$

$2r_+ + 2r_- = AC = \sqrt{2}\,a$

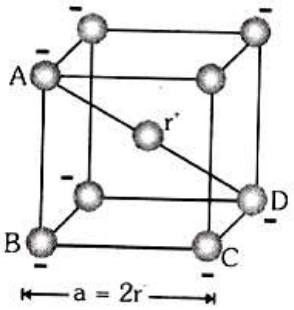
$BC = a = 2r^-$

$$\frac{2r_+ + 2r_-}{2r} = \frac{\sqrt{2} \times 2r_-}{2r}$$

$$\frac{r_+}{r_-} + 1 = \sqrt{2} \quad \Rightarrow \quad \frac{r^+}{r^-} = \sqrt{2} - 1 = 1.414 - 1 = 0.414$$

iv) **Cubic void**: All the anions are touch each other and co-ordination number is8.

According to cube diagonal



$AD = \sqrt{3}a = 2r_+ + 2r_-$

$(a = 2r_- = BC)$

$\sqrt{3} \times 2r_- = 2r_+ + 2r_-$

Dividing by $2r^-$ on both sides

$$\sqrt{3} = \frac{r_+}{r_-} + 1 \Rightarrow \frac{r_+}{r_-} = \sqrt{3} - 1 = 1.732 - 1 = 0.732$$

The preferred direction of the structure with increase in the radius ratio is as follows:

Plane triangular $\xrightarrow{0.225}$ Tetrahedral $\xrightarrow{0.414}$ Octahedral $\xrightarrow{0.732}$ cubic

17. Limiting radius ratios and structure

Limiting radius ratio $(r_+) / (r_-)$	C.N.	Shapes	Examples
< 0.155	2	Linear	----------
0.155 – 0.225	3	Planar triangular	B_2O_3
0.225 – 0.414	4	Tetrahedral	ZnS
0.414 – 0.732	6	Octahedral	NaCl
0.732 – 0.999 or 1.000	8	Body-centred cubic	CsCl

Note :

Universal Logic: 1 atom/molecule ⇒ N_A atoms/molecules ⇒ 1 mol⇒'M' g ⇒ 1 g ⇒ W g

Number of unit cell : 'Z' particles = 1 unit cell

'N' particles = ? unit cell

Number of unit cell in 'N' Particles = N/Z

Number of unit cells in 1 g of substance

Number of unit cells containing 'N_A'atoms =N_A/Z

1 mol of substance = 'M' g of substance = N_A/Z (Where M = molar mass)

$$1 \text{ g of substance} = \frac{N_A}{(M \times Z)} \text{ unit cells}$$

No. of unit cells in Wg of substance

$$1 \text{ g of substance} = \frac{N_A}{(M \times Z)} \text{ unit cells}$$

$$\text{'W' g of substance} = \frac{(N_A \times W)}{(M \times Z)} \text{ unit cells}$$

Closest Approach = distance between two nearest particles [Neighbour distance] (d)
(In scc, along edge length; In fcc, along face diagonal; In bcc, along body diagonal)
Closest Approach in Metallic Solids = 2r⇒ scc, d =a,

$$\text{bcc, } d = \frac{a\sqrt{3}}{2},$$

$$\text{fcc, } d = \frac{a\sqrt{2}}{2}$$

Closest Approach in ionic solids = $r_+ + r_-$

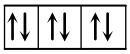
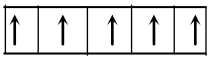
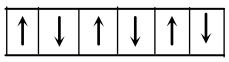
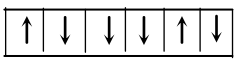
18. Distinguish between Tetrahedral voids and Octahedral voids

Tetrahedral voids	Octahedral voids
1. As r = 0.225 R, tetrahedral void is much smaller than the size of the spheres in the packing.	As r = 0.414 R, the size of the octahedral void is smaller than that of the spheres in the packing but larger than the tetrahedral voids.
2. Each tetrahedral void is surrounded by 4 spheres. Hence, its coordination number is 4.	Each octahedral void is surrounded by 6 spheres. Hence, its coordination number is 6
3. In the hcp or ccp packing, each spheres is in contact with three spheres in the layer above it and three spheres in the layer below it, thus forming one tetrahedral void above and one tetrahedral void below. Hence, there are two tetrahedral voids per spheres, i.e., number of tetrahedral void is double the number of spheres in the packing. .	As octahedral void is a combination of two void of the two layers, number of octahedral void is equal to half the number of tetrahedral voids and hence equal to the number of spheres in the packing

19.Structure of ionic crystal:

Crystal structure type	Brief description	Examples	Co-ordination number	Number of formula units per unit cell
Type AB Rock salt (NaCl) type	It has *fcc* arrangement in which Cl^- ions occupy the corners and face centres of a cube while Na^+ ions are present at the body and edge of centres.	Halides of *Li*, *Na*, *K*, *Rb*, *AgF*, *AgBr*, NH_4Cl, NH_4Br, NH_4I etc. (except Co)	$Na^+ = 6$ $Cl^- = 6$	4
Zinc blende (ZnS) type	It has *ccp* arrangement in which S^{2-} ions form *fcc* and each Zn^{2+} ion is surrounded tetrahedrally by four S^{2-} ions and vice versa.	CuCl, CuBr, CuI, AgI, BeS	$Zn^{2+} = 4$ $S^{2-} = 4$	4
Caesium Chloride (CsCl) type	It has the *bcc* arrangement with Cs^+ at the body centre and Cl^- ions at the corners of a cube or vice versa.	*CsCl, CsBr, CsI, CsCN, TlBr* and *TlCN*	$Cs^+ = 8$ $Cl^- = 8$	1
Additional Information				
Type AB_2 Fluorite (CaF_2) type	It has arrangement in which Ca^{2+} ionsform fcc with eachCa^{2+}ions surrounded by $8F^-$ ions and each F^- ions by $4Ca^{2+}$ions.	BaF_2, $BaCl_2$, SrF_2 $SrCl_2$, CdF_2, PbF_2	$Ca^{2+} = 8$ $F^- = 4$	4
Antifluorite type	Here negative ions form the ccp arrangement so that each positive ion is surrounded by 4 negative ions and each negative ion by 8 positive ions.	Na_2O	$Na^+ = 4$ $O^{2-} = 8$	4

20. Magnetic properties of solids

Properties	Description	Alignment of Magnetic Dipoles	Examples	Applications
Diamagnetic	Feebly repelled by the magnetic fields.Non-metallicelements (excepts O_2, S) inert gases and species with paired electrons are diamagnetic	All paired electrons 	TiO_2, V_2O_5, $NaCl$, C_6H_6 (benzene)	Insulator
Paramagnetic	Attracted by the magnetic field due to the presence of permanent magnetic dipoles (unpaired electrons). In magnetic field, these tend to orient themselves parallel to the direction of the field and thus, produce magnetism in the substances.	At least one unpaired electron	O_2, Cu^{2+}, Fe^{3+}, TiO, Ti_2O_3, VO, VO_2, CuO	Electronic appliances
Ferromagnetic	Permanent magnetism even in the absence of magnetic field, Above a temperature called**Curie** temperature, there isno ferromagnetism.	Dipoles are aligned in the same direction 	*Fe, Ni, Co,* CrO_2, Gd	CrO_2 is used in audio and video tapes
Additional Information				
Antiferromagnetic	*This arises when the dipole alignment is zero due to equal and opposite alignment.*		***MnO***, MnO_2, Mn_2O, *FeO*, Fe_2O_3; *NiO*, Cr_2O_3, *CoO*, Co_3O_4,	–
Ferrimagnetic	*This arises when there is net dipole moment.*		Fe_3O_4, *ferrites like* $MgFe_2O_4$ *and* $ZnFe_2O_4$	–

 # Shortcut for Identifying Magnetic Nature of Substances (with reference to 10+2 syllabus)

Step 1:Byheart

Ferromagnetic substances (**Fe, Co, Ni, Gd, CrO_2**)

Antiferromagnetic substances (*MnO, MnO_2, Mn_2O, FeO, Fe_2O_3; NiO, Cr_2O_3, CoO, Co_3O_4,*)

Ferrimagnetic Substances (Fe_3O_4, ferrites)

Step 2: Other than Ferromagnetic substance:

Use following method

 # Molecular Species (or Polyatomic ionic species): (Made up of two moreatoms of same or different elements)

For e.g: H_2^-, N_2^+

First Count total electrons

Case 1: Odd electrons ⇒ Paramagnetic

Case 2: Even electrons ⇒ Diamagnetic except C_2, B_2, O_2, S_2 (explained by MOT)

 # Monoatomic Species

For e.g: C*l*, Cr^{3+}, C*l*$^-$

First Write electronic configuration

If one or more unpaired electrons present ⇒ Paramagnetic

If no unpaired electrons are present ⇒ Diamagnetic

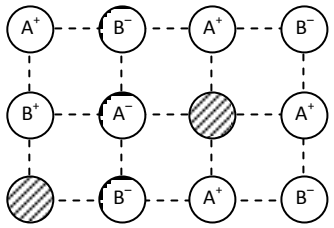
For e.g:

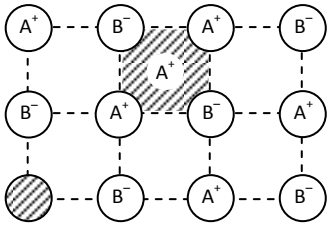
1) Water (H_2O):	2(1) + 8	= 10 e^{-s}	⇒ Diamagnetic
2) NH_4^+:	7 + 4(1) – 1 (e^- lost)	= 10 e^{-s}	⇒ Diamagnetic
3) SO_4^{2-}:	16 + 4(8) + 2 (e^- gained)	= even	⇒ Diamagnetic

	INFORMATION	**Eg.**
Schottky defect:	Missing of ions from lattice points, density is decreased.	NaC*l*, CsC*l*
Frenkel defect:	Ions are displaced to interstitial sites creating hole (no change in density)	AgC*l*, $ZnCl_2$

21. Distinguish between Schottky defect and Frenkel defect

Schottky defect	Frenkel defect
1. It is produced because of missing atoms or ions from their normal crystal sites.	1. It is produced when some atoms or ions are displaced from their normal sites and occupy interstitial sites.
2. The presence of Schottky defect lower the density of the crystal.	2. It does not affect the density of the crystal.
3. It is generally shown by ionic solids having high co-ordination number.	3. It is generally exhibited by ionic solids having low co-ordination number.
4. It is shown by ionic solids in which cations andanions are nearly of same size. i.e. radius ratio isalmost 1	4. It is shown by ionic solids in which anions are larger than the size of cations. i.e. radius ratio isvery small
5. e.g. NaC*l*, CsC*l*.	5. e.g. AgC*l*, ZnCl_2.

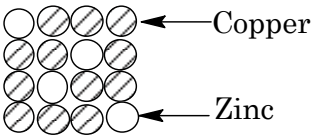




❖ **AgBr has both Schottky and Frenkel defects.**

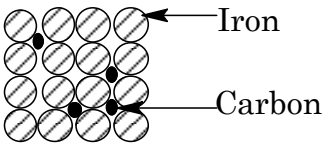
21. Impurity Defect

a) Substitution impurity defect



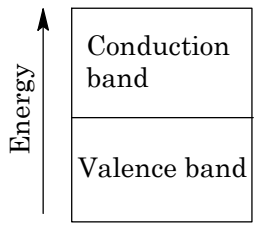
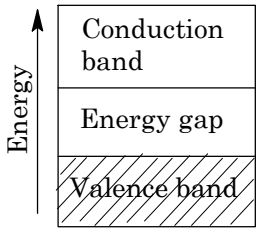
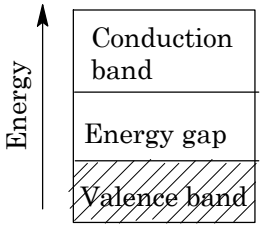
Brass

b) Interstitial impurity defect



Steel

22. Distinguish between conductor, insulator and semiconductor:

Conductor	Insulator	Semiconductor
1. A substance which conducts heat and electricity to a greater extent is called conductor.	A substance which cannot conduct heat and electricity under any conditions is called insulator.	A substance which has poor electrical conductance at low temperature but higher conductance at higher temperature is called semiconductor.
2. In this, conduction bands and valence bands overlap or are very closely spaced.	In this, conduction bands and valence bands are far apart.	In this, conduction bands and valence bonds are spaced closely.
3. There is no energy difference or very less energy difference between valence bands and conduction bands.	The energy difference between conduction bands and valence bands is very large.	The energy difference between conduction bands and valence bands is small.
4. There are free electrons in the conduction bands.	There are no free electrons in the conduction bands and electrons can't be excited from valence bands to conduction bands due to large energy difference.	The electrons can be easily excited from valence bands to conduction bands by heating.
5. The conductance decreases with the increase in temperature.	No effect of temperature on conducting properties.	Conductance increases with the increase in temperature.
6. e.g. Metals, alloys.	Wood, rubber, plastics.	Si, Ge.
7. The conducting properties can't be improved by adding third substance.	No effect of addition of any substance.	By doping, conducting properties improve. e.g., *n*-type, *p*-type semiconductors.
8. 		

24. ADDITIONAL INFORMATION

X-ray study of crystal structure

Bragg's equation.

When a beam of monochromatic X-ray strikes two planes of atoms in a crystal at certain angle θ*, it is reflected. Intensity of reflection will be maximum if*

$$n\lambda = 2d\sin\theta.$$

Where, $n \rightarrow$ *order of reflection.*

$\lambda \rightarrow$ *Wavelength of X-ray.*

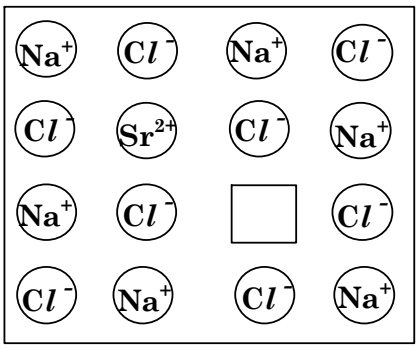
$d \rightarrow$ *distance between two planes.*

Impurity defects

i) *If molten NaCl containing a little amount of* $SrCl_2$ *is crystallised, some of the sites of* Na^+ *ions are occupied by* Sr^{2+}.

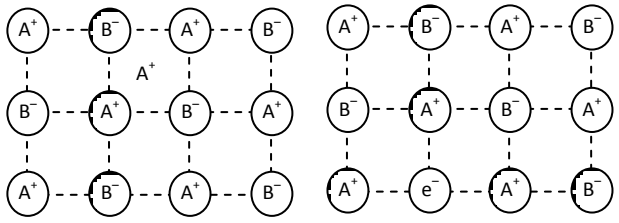
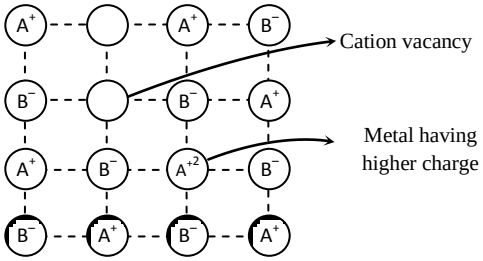
ii) *Each* Sr^{2+} *replaces two* Na^+ *ions. It occupies the site of one ion and the other site remains vacant.*

iii) *The cationic vacancies thus produced are equal in number to that of* Sr^{2+} *ions. Another similar example is the solid solution of* $CdCl_2$ *and AgCl.*



Non stoichiometric defects

These defects are of two types:

Metal excess defectdue to anionic or cationic vacancies: (An F – center in a crystal)	***Metal deficiency defect.***
 ***Metal excess defect due to extra cation*** ***Metal excess defect due to anion vacancy*** *e.g. ZnO* *e.g. NaCl,KCl* *(The anionic sites occupied by unpaired electrons are called F – centre)*	❖ *A typical example of this type is FeO which is mostly found with a composition of $Fe_{0.95}O$.* ❖ *It may actually range from $Fe_{0.93}O$ to $Fe_{0.96}O$.* ❖ *In crystals of FeO some Fe^{2+} cations are missing and the loss of positive charge is made up by the presence of required number of Fe^{3+} ions.*  ***Metal deficiency defect due to cation vacancy*** *e.g. NiO, FeO, Fes,TiO*

Structure of Diamond

Lattice Points:	Carbon Atoms make up cubic close packed (ccp or fcc) structure.
Voids:	50% of Tetrahedral voids are occupied by carbon atoms as each carbon is tetrahedrally bonded to other carbon atoms.
Unit Cell:	Number of carbon atoms in unit cell = 8 (4 atoms as lattice points of ccp, 4 atoms as50% tetrahedral voids)
Rank:	8 (total carbon atoms = 8)

Co-ordination Number of carbon in diamond = 4

Structures of IONIC SOLIDS

	NaCl (Rock Salt Structure)	CsCl	ZnS (Zinc Blende)
Anions	*ccp or fcc* (Cl^- will be present at eight corners & six face centres)	Simple Cubic cell (*scc*) i.e Cl^- ions are present at eight corners	*ccp or fcc* (S^{2-} will be present at eight corners & six face centres)
Cations	Octahedral voids (edge centre & body centre)	Cubic Void	Tetrahedral Voids
Actual number	Cl^- ions = 4 Na^+ ions = 4	Cl^- ions = 1 Cs^+ ions = 1	S^{-2} ions = 4 Zn^{2+} ions = 4
Rank of ionic solid	Z = 4 (4 NaCl formula units) where M = 23 + 35.5 = 58.5	Z = 1 (one CsCl formula unit) Where, M = 133 + 35.5 = 168.5	Z = 4 (four ZnS formula units) Where M = 65 + 32 = 97
Co-ordination Number	C.N of Na^+ = 6 C.N of Cl^- = 6	C.N of Cs^+ = 8 C.N of Cl^- = 8	C.N of Zn^{2+} (TV) = 4 C.N of S^{2-} = 4
Formulae	1) $2(r_+ + r_-) = a$ 2) $4r_-$ = face diagonal = $a\sqrt{2}$ …. . (if anions touch each other) 3) $0.414 \le r_+/r_- \le 0.732$ 4) If cation exactly fits into octahedral void, $r_+/r_- = 0.414$ For NaCl, $r_+/r_- = 0.52$	1) $2(r_+ + r_-)$ = body diagonal = $a\sqrt{3}$ 2) $0.732 \le r_+/r_- \le 1$ 3) If cation exactly fits into cubic void, $r_+/r_- = 0.732$ For CsCl, $r_+/r_- = 0.93$ (Note: for bcc ionic solid, z = 1 & for bcc metallic solid, z = 2)	1) $0.225 \le r_+/r_- \le 0.414$ 2) $4r_-$ = face diagonal = $a\sqrt{2}$. (if anion touch each other) 3) If cation exactly fits into tetrahedral void, $r_+/r_- = 0.225$ For ZnS, $r_+/r_- = 0.4$

Note: In *ccp*, Actual Number of spheres = 4 (Rank)
Octahedral voids are always at edge centre & body centres

	Position	Numbers	Contribution	Actual Contribution	Total OV
Octahedral voids	Edge Centre	12	¼	3	4
	Body Centre	1	1	1	
		13 O.Vs			

In *ccp*, tetrahedral voids are first & last point of tetra-section of body diagonal.
In a cube, four body diagonals, hence eight tetrahedral voids.
As tetrahedral voids are NOT shared, they contribution is 100% i.e any *ccp* has eight tetrahedral voids.
Every Sphere is surrounded by six octahedral voids (e.g: Cl^- sphere is surrounded by six Na^+ present in their corresponding octahedral voids.)
Every sphere is surrounded by eight tetrahedral voids (Through every corner, there are eight body diagonal, each body diagonal is having two tetrahedral voids of which one each tetrahedral void is closer to the corner)

Table 2. Characteristic features of structures of Simple Ionic Compounds

S.No.	Type	Radius Ratio r_+/r_-	Coordination No. of		Lattice structure and ions making it	Position of the other ion	Examples
			Cation	Anion			
I.	**AB Type**						
1.	Zinc blende (ZnS)	0.4	4	4	FCC of S^{2-}	Zn^{2+} in alternate tetrahedral voids	ZnS, CuBr, CuI, AgI, ZnO, BaS, CdS, HgS
2.	Wurtzite ZnS (another structure)	0.4	4	4	HCP of S^{2-}	Zn^{2+} in alternate tetrahedral voids	ZnS(Wurtzite), BaS
3.	Sodium chloride NaCl	0.52	6	6	FCC of Cl^- (expanded due to large size Na^+)	Na^+ in all octahedral voids (Na^+ at each edge centre and body centre)	Halides of Li^+, Na^+, K^+, Rb^+, MgO, CaO, CaS, MnO (*Changes to CsCl structure on applying high pressure*)
4.	Caesium Chloride CsCl	0.93	8	8	Simple cubic lattice of Cl^- (expanded)	Cs^+ at the body centre of cube	CsCl, CsBr, CsI , NH_4Cl, TlCl, TlBr TlI(*changes to NaCl structure on heating*)
II.	**AB_2 Type**						
1.	Fluorite CaF_2	0.73	8	4	FCC of Ca^{2+} ions	F^- in all tetrahedral voids	CaF_2, HgF_2, CdF_2, SrF_2, BaF_2, ZrO_2, PrO_2, ThO_2 UO_2
2.	Anti fluorite (Structure of A_2B type, e.g., Na_2O)	0.73	4	8	FCC of O^{2-} ions	Na^+ in all tetrahedral voids	Na_2O, Li_2O, K_2O, Na_2S
3.	Rutile TiO_2	0.68	6	3	HCP of O^{2-} ions	Ti^{4+} in all octahedral voids	TiO_2, MgF_2, NiF_2, FeF_2, MnO_2, PbO_2

01. SOLID STATE

Atomic masses: Use atomic Masses given on Cover page

LEVEL - I

CLASSIFICATION OF SOLIDS

1] Ionic solids are characterised by
1) Good conductivity in solid state
2) High vapour pressure
3) Low melting point
4) Solubility in polar solvents

2] Which of the following is NOT a crystalline solid?
1) KC*l* 2) CsC*l*
3) Glass 4) Rhombic sulphur

3] Which of the following is an example of molecular solid ?
1) ZnS 2) MgO
3) Ice 4) Diamond

4] Which of the following is NOT an example of molecular crystal?
1) Hydrogen
2) Iodine
3) Ice
4) Sodium chloride

5] Which one has highest melting point?
1) Ionic crystal
2) Molecular crystal
3) Covalent crystal
4) Metallic crystal

6] ZnS is
1) Ionic crystal
2) Covalent crystal
3) Metallic crystal
4) van der Waal's crystal

7] Fullerene reacts with Potassium to from
1) $K_{39}C_{57}$
2) $K_{37}C_{63}$
3) $K_{40}C_{62}$
4) $K_{35}C_{60}$

8] CO_2 belongs to
1) covalent crystal
2) molecular crystal
3) ionic crystal
4) metallic crystal

9] Amorphous solids
1) possess sharp melting points
2) undergo clean cleavage when cut with knife
3) do not undergo clean cleavage when cut with knife
4) possess orderly arrangement over long distances.

UNIT CELLS, SEVEN CRYSTAL SYSTEMS, BRAVAIS LATTICE

10] In a tetragonal crystal.
1) $\alpha = \beta = 90^0 \neq \gamma$ and $a = b = c$
2) $\alpha = \beta = \gamma = 90^0$ and $a \neq b \neq c$
3) $\alpha = \beta = \gamma = 90^0$ and $a = b \neq c$
4) $\alpha = \beta = 90^0$ and $\gamma = 120^0$ and $a = b \neq c$

11] A single substance that exists in two or more forms is called
1) polymorphous 2) amorphous
3) isomorphous 4) mono-morphous

12] The number of Basic crystal systems is
1) 7 2) 8
3) 6 4) 4

13] How many kinds of space lattices are possible in a crystal?
1) 23 2) 9
3) 30 **4) 14**

14] NaC*l* crystal belongs to the crystal system
1) hexagonal
2) cubic
3) tetragonal
4) orthorhombic.

15] Which of the following does NOT represent a type of crystal system ?
1) Triclinic 2) Monoclinic
3) Rhombohedral **4) Isotropical**

16] In a face centred cubic lattice the no.of nearest cube neighbours for a given, cube is
1) 6 2) 4
3) 8 4) 12

17] How many unit cells are present in a cube-shaped ideal crystal of NaC*l* of mass 1.00 g?
1) 2.57×10^{21} unit cells
2) 5.14×10^{21} unit cells
3) 1.28×10^{21} unit cells
4) 1.71×10^{21} unit cells

18] In a face centred cubic cell, an atom at the face centre is shared by
1) 4 unit cells **2) 2 unit cells**
3) 1 unit cell 4) 6 unit cells

19] An element having bcc structure has 12.08×10^{23} unit cells. The number of atoms in these cells is
1) 12.08×10^{23}
2) 24.16×10^{23}
3) 48.38×10^{23}
4) 12.08×10^{22}

20] The number of unit cells in 58.5 g of NaC*l* is
1) 6×10^{20} 2) 3×10^{22}
3) 1.5×10^{23} 4) 0.5×10^{24}

PACKING OF SOLIDS, VOIDS, PACKING EFFICIENCY AND DENSITY OF UNIT CELL

21] In which of the following arrangements, a metal could have least density
1) BCC 2) CCP
3) HCP **4) Simple cubic**

22] The number of atoms in a unit cell of a cubic crystal system is 2, the arrangment of atoms is
1) body centred cubic
2) face centred cubic
3) end centred cubic
4) simple cubic

23] 8 : 8 type of packing is present in
1) NaC*l* **2) CsC*l***
3) KC*l* 4) MgO

24] The co-ordination number of a body-centred atom in a body centred cubic structure is

1) 4 2) 6

3) 8 4) 12

25] For an ionic crystal or general formula AX and co-ordination number 6, the value of radius ratio will be

1) Greater than 0.73

2) In between 0.732 and 0.414

3) In between 0.41 and 0.22

4) Less than 0.22

26] Which of the following describes hexagonal closed packed arrangement of spheres?

1) ABC ABA..... 2) ABC ABC .....

3) ABA B ..... 4) ABA ABB .....

27] The greater the value of r_+/r_-

1) The lower will be the C.N.

2) The higher the value of C.N.

3) The higher will be the number of cations

4) The lower will be the number of anions

28] Potassium crystallizes with a

1) Face-centred cubic lattice

2) Body-centred cubic lattice

3) Simple cubic lattice

4) Orthorhombic lattice

29] The space occupied by bcc arrangement is approximately

1) 50% **2) 68%**

3) 74% 4) 56%

30] The maximum percentage of available volume that can be filled in a face centred cubic system by an atom is

1) 74% 2) 68%

3) 34% 4) 26%

31] The closest-packing sequence ABAB ..... represents

1) Primitive cubic packing

2) Body-centred cubic packing

3) Face-centred cubic packing

4) Hexagonal packing

32] Which has minimum percent volume occupied by the spheres?

1) Simple cubic

2) Body-centred cubic

3) Hexagonal closest packed

4) Cubic closest packed

33] When molten Zn is cooled to solid state, it assumes hcp structure. Then the number of nearest neighbours of Zn atoms will be

1) 4 2) 6

3) 8 **4) 12**

34] The ratio of close packed atoms to tetrahedral holes in cubic close packing is

1) 1 : 1 **2) 1 : 2**

3) 1 : 3 4) 2 : 1

35] The number of octahedral sites per sphere in *f*cc structure is

1) 1 2) 2

3) 4 4) 8

36] Close packing is maximum in the crystal lattice of:

1) Face-centred cubic

2) Body-centred cubic

3) Simple-centred cubic

4) Both 1) and 2)

37] The more efficient mode of packing for identical atoms is

1) Square close packing pattern

2) Hexagonal close packing pattern

3) Both (1) and (2)

4) simple cubic

38] In a closed packed array of N spheres, the number of octahedral holes are

1) N/2 **2) N**

3) 4N 4) 2N

39] For tetrahedral co-ordination the radius ratio (r^+/r^-) should be

1) 0.414 – 0.732 2) > 0.732

3) 0.156 – 0.225 **4) 0.225 – 0.414**

40] In the unit cell of NaC*l* lattice there are

1) $3Na^+$ ions 2) $6Na^+$ ions

3) $6Cl^-$ ions **4) 4 NaC*l* units**

41] What is the simplest formula of a solid whose cubic unit of cell has the atom A at each corner the atom B at each face centre and C atom at the body centre

1) AB_2C 2) A_2BC

3) AB_3C 4) ABC_3

42] A solid has a structure in which 'W' atoms are located at the corners of a cubic lattice 'O' atoms at the center of edge and 'Na' atoms at the centre of the cube.The formulafor the compound is

1) $NaWO_2$ **2) $NaWO_3$**

3) Na_2WO_3 4) $NaWO_4$

43] The units cell presents in ABCABC…. Closest packing of atoms is

1) body centered cube

2) hexagonal

3) face centred cube

4) tetragonal

44] The packing efficiency for a body centred cubic structure is

1) 0.42 2) 0.53

3) 0.68 4) 0.82

45] Which of the following expressions is CORRECT in case of a sodium chloride unit cell (edge length, a)?

1) $r_c + r_a = 0$ **2)** $r_c + r_a = \frac{a}{2}$

3) $r_c + r_a = 2a$ 4) $r_c + r_a = \sqrt{2}a$

46] Which of the following expressions is correct in case of a s CsC*l* unit cell (edge length, a)

1) $r_c + r_a = a$ 2) $r_c + r_a = \frac{a}{\sqrt{2}}$

3) $r_c + r_a = \frac{\sqrt{3}a}{2}$ 4) $r_c + r_a = \frac{a}{2}$

47] The ratio of close packed atoms to Octahedral holes in cubic packing is

1) 1 : 1 2) 1 : 2

3) 2 : 1 4) 1 : 3

48] Total volume of atoms present in a face-centerd cubic unit cell of a metal is (r is atomic radius)

1) $\frac{12}{3}\pi r^3$ **2)** $\frac{16}{3}\pi r^3$

3) $\frac{20}{3}\pi r^3$ 4) $\frac{24}{3}\pi r^3$

49] 1 g of magnesium contains approximately _____ valence shells

1) 3 . . . . ^{3}

3) 10^{30} **4) 10^{22}**

50] Copper crystallizers in a face-centred cubic lattice with a unit cell length of 361 pm. What is the radius of copper atom in pm?

1) 157 2) 181

3) 108 **4) 128**

51] The formula for determination of density of unit cell is

1) $\frac{a^3 \times N_0}{z \times M} gcm^{-3}$

2) $\frac{z \times M}{a^3 \times N_0} g\ cm^{-3}$

3) $\frac{a^3 \times M}{z \times N_0} g\ cm^{-3}$

4) $\frac{M \times N_0}{a^3 \times z} g\ cm^{-3}$

52] A solid has a b.c.c. structure. If the distance of closest approach between the two atoms is 1.73 angstrom. The edge length of the cell is

1) 200 pm

2) $\frac{\sqrt{3}}{\sqrt{2}}$ pm

3) 142.2 pm

4) $\sqrt{2}$ pm

53] The total number of atoms required to from a unit cell of bcc lattice will be

1) 6 2) 8

3) 9 4) 12

54] CCP tallies with

1) bcc

2) fcc

3) hcp

4) either 2) or 3)

55] A double triangular void surrounded by three spheres above the three spheres below is called

1) triangular void

2) tetrahedral void

3) octahedral void

4) trigonal bipyramidal void

56] The size of an octahedral void from in a closest packed lattice as compared to tetrahedral void is

1) equal

2) smaller

3) larger

4) not definite

57] If a is the edge length of unit cell of sodium chloride, the distance between two nearest Na^+ ions is

1) a
2) $\sqrt{2}a$
3) $\sqrt{3}a$
4) $\frac{a}{\sqrt{2}}$

58] A fcc element (Atomic mass = 60) has a cell edge of 400 pm. What is its density?

1) 6.2 g cm^{-3}
2) 24.8 g cm^{-3}
3) 12.4 g cm^{-3}
4) 3.1 g cm^{-3}.

59] The radius of Na^+ 95 pm and that of Cl^- ions is 181 pm. Hence the co-ordination number of Na^+ will be

1) 4
2) 6
3) 8
4) Unpredicatable

60] In sodium chloride crystal the number of nearest neighbor of each Na^+ ion is

1) 8 Cl^- ions
2) 8 Na^+ ions
3) 6 Cl^- ions
4) 12 Cl^- ions

DEFECTS IN SOLIDS

61] In a solid lattice, the cation has left a lattice site and is located at interstitial position, the lattice defect is

1) intrinsic defect
2) Vacancy defect
3) Frenkel defect
4) Schottky defect

62] Schottky defect is found in

1) NaCl
2) $BaSO_4$
3) $MgCl_2$
4) $CaCl_2$

63] Which defect causes decrease in the density of crystal?

1) Frenkel
2) Schottky
3) Interstitial
4) Intrinsic

64] An example of Frenkel defect is

1) NaBr
2) TlBr
3) AgBr
4) CuBr

65] Which one of the following is CORRECT?

1) Schottky defect lowers the density
2) Frenkel defect increases the dielectric constant of the crystals
3) Stoichiometric defects make the crystals good electrical conductors
4) All of these

66] Frenkel defect generally appears in

1) AgBr
2) ZnS
3) AgI
4) All of these

67] Ionic solids with Schottky defects contain in their structure

1) Equal number of cation and anion vacancies.
2) Anion vacancies and interstitital anions
3) Cation vacancies
4) Cation vacancies and interstitial cations

68] Schottky defect in crystals is observed when
1) An ion leaves its normal site and occupies an interstitial site
2) Equal number of cations and anions are missing from the lattice
3) Unequal number of cations and anions are missing from the lattice
4) Density of the crystal is increased

69] Which of the following crystals does NOT exhibit Frenkel defect?
1) AgBr 2) AgCl
3) KBr 4) ZnS

70] Due to Frenkel defect the density of ionic solids
1) Decreases 2) Increases
3) Does not change 4) Changes

71] Schottky defects are present in
1) Ionic solids 2) Molecular solids
3) Amorphous solids 4) Liquids

72] Schottky defect is found in
1) . . . ***l***
2) . . . . $_2$
3) MgCl_2
4) can exhibit in all

73] Missing of one cation and one anion from crystal lattice is called
1) Ionic defect
2) Crystal defect
3) Schottky defect
4) Frenkel defect.

74] Frenkel defect is found in crystals in which the radius ratio is
1) low
2) 1.3
3) 1.5
4) slightly less than unity

ELECTRICAL AND MAGNETIC PROPERTIES

75] Which of the following is a ferromagnetic compound.
1) Fe_2O_3
2) Fe_3O_4
3) Cr_2O_3
4) CrO_2

76] Germanium is an example of
1) An intrinsic semiconductor
2) An n-type semiconductor
3) A p-type semiconductor
4) Insulator

77] If Indium is added in small quantity of Ge metal, we get
1) An n-type semiconductor
2) A p-type semiconductor
3) Rectifier
4) Insulator

78] The electrical conductivity of semiconductors
1) Increases with temperature
2) Decreases with temperature
3) Remains constants on heating
4) All the above

79] Silicon is a
1) Conductor
2) Semiconductor
3) Non conductor
4) Metal complex

80] Which substance will conduct the current in the solid state?
1) Diamond
2) Graphite
3) Iodine
4) Sodium chloride

81] Which of the following is an insulator?
1) Graphite 2) Silicon
3) Diamond 4) Aluminium

82] A solid with high electrical and thermal conductivity from the following is
1) Si **2) Li**
3) . . . *l* 4) Ice

83] On adding a little phosphorus to silicon, we get a/an
1) n-Type semiconductor
2) p-Type semiconductor
3) Metallic conductor
4) Insulator

84] Semiconductors are derived from compounds of
1) *p*-block elements
2) Lanthanides
3) Actinides
4) Transition elements

85] To get n-type doped semiconductor, impurity to be added to silicon should have the following number of valence electrons
1) 1 2) 2
3) 3 **4) 5**

86] The property of ability to conduct electricity of metals non- metals and semiconductor are explined by
1) Energy gain enthaplys
2) band theory
3) bond theory
4) hydride gap.

87] Which of the following is paramagnetic substance?
1) Oxygen 2) Water
3) Cobalt 4) Nickel

88] The unbalance spin of electron exhibit
1) magnetism 2) spectra
3) visible colours 4) allotropy

89] Silicon doped with arsenic is
1) p-type semiconductor
2) n-type semiconductor
3) like metallic conductor
4) a insulator

90] The substance which possesses zero resistance at zero K is called
1) conductor **2) superconductor**
3) insulator 4) semiconductor

91] Germanium or silicon becomes better conductor due to
1) vacancy defect 2) Chemical impurity
3) Frenkel defect **4) Both 1) and 2)**

MISCELLANEOUS

1] A pseudo solids is
1) glass
2) pitch (tar)
3) KC*l*
4) glass and pitch both

2] Which of the following will have lowest heat of fusion?
1) Covalent solid 2) An ionic solid
3) Metallic solid **4) Molecular solid**

3] The edge atom of a cube provides how many atoms to the unit cell?
1) $\frac{1}{2}$ **2)** $\frac{1}{4}$
3) $\frac{1}{8}$ 4) 1

4] The most unsymmetrical crystal structure is
1) cubic 2) hexagonal
3) triclinic 4) orthorhombic

5] Co-ordination number for Cu is
1) 1 2) 6
3) 8 **4) 12**

6] A matchbox exhibits
1) cubic geometry
2) monoclinic geometry
3) tetragonal geometry
4) orthorhombic geometry

7] In CCP arrangement pattern of successive layers will be designed as
1) AB,AB,AB , …. etc
2) AB ,ABC, AB …. etc
3) ABC, ABC,ABC, ….. etc
4) BBABC

8] In Bragg's equation for diffraction of X-rays 'n' represents
1) The number of mole
2) Quantum number
3) The order of reflection
4) Avogadro's number

9] In the X-ray diffraction of a set of crystal planes having d equal to 0.18 nm a first order reflection is found at an angle of 22^0. The wavelength of X-rays is (Given sin 22^0 = 0.208)
1) 0.0749 nm 2) 0.0374 nm
3) 0.749 nm 4) 0. 374 nm

10] A metallic element crystallises into a lattice containing a sequence of layers ABABAB… Any close packing of spheres leaves out voids iv the lattice Percentage of empty space by volume is
1) 52 % **2) 26 %**
3) 50 % 4) 74 %

11] The arrangement of the first two layers in hcp and ccp arrangement is
1) Exactly same in both cases.
2) Partly same and partly different
3) Different from each other
4) Nothing definite

12] The crystal system of compound with unit cell dimensions a = 0.387, b = 0.387 and c= 0.504 nm and $\alpha = \beta = 90^0$ and $\gamma = 120^0$ is

1) Cubic **2) Hexagonal**
3) Orthorhombic 4) Rhombohedral

13] A cubic crystal possesses in all _____ elements of symmetry.

1) 9 2) 13
3) 1 **4) 23**

14] Value of heat of fusion of NaC*l* is

1) Very low **2) Very high**
3) Moderate 4) Zero

15] The elements of symmetry in a crystal are

1) Plane of symmetry
2) Axis of symmetry
3) Centre of symmetry
4) All

LEVEL - II

1] A solid melts slightly above 273 K and is a poor conductor of heat and electricity. To which of the following categories does it belong ?

1) ionic solid 2) covalent solid
3) metallic **4) molecular**

2] At very low temperature, oxygen O_2, freezes and forms a crystalline solid. Which term best describes the solid?

1) Covalent network
2) Molecular crystals
3) Metalic
4) Ionic

3] In a face centered cubic arrangement of A and B atoms if A atoms are at the corners of the unit cell and B atoms at the face centers. One of the atom A atom is missing from one corner in unit cell. Then the simplest formula of compound is

1) A_7B_7 2) AB_3
3) A_7B_{24} 4) $A_{7/8}B_{24}$

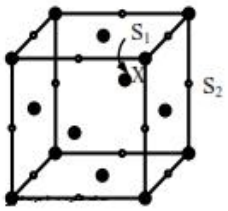
4] A salt AB crystallises in the CsC*l* structure. The anions at the corners and the cation in the centre. hence, radius ratio r_+ / r_-

1) 0.225 2) 0.441
3) 0.625 **4) 0.732**

5] For an octahedral arrangement the lowest radius ratio limit is

1) 0.155 2) 0.732
3) 0.414 4) 0.225

6] In the structure given below the sites S_1 and S_2 represent



1) both octahedral voids
2) both tetrahedral voids
3) S_1 - octahedral voids, S_2 - tetrahedral void
4) S_1 - tetrahedral voids, S_2 - octahedral voids

7] In a hexagonal close packed (hcp) structure of spheres, the fraction of the volume occupied by the spheres is A. In a cubic close packed structure, the fraction is B. The relation for A and B is

1) A = B
2) A > B
3) A < B
4) either a or b

8] The unit cell with crystallographic dimensions $a = b \neq c; \sim = \quad = ¥ = 90^0$ is

1) cubic
2) tetragonal
3) monoclinic
4) hexagonal

9] Each unit cell of NaC*l* consists of 14 chloride ions and _____.

1) 13 Na^+ ions 2) 14 Na^+ ions
3) 6 Na^+ ions 4) 8 Na^+ ions

10] An element crystalizes in a structure having F.C.C. unit cell of an edge 200 pm. Calculate the density if 200 g of it contains 24×10^{23} aroms

1) 41.6 g/cm³ 2) 42.6 g/cm³

3) 43.6 g/cm³ 4) 44.6 g/cm³

11] Sodium atom crystallises in body centred cubic lattice with cell edge a = 4.29A⁰. The radius of sodium atom is

1) $18.6\,\text{Å}$ **2)** $1.86\,\text{Å}$

3) 186 nm 4) 1860 pm

12] The crystalline sodium has body centred cubic unit cell with $a = 0.424\,nm$ at 298K density of sodium metal is

1) $1.002\times10^{3}\,kgm^{-3}$ 2) $1.002\times10^{-3}\,kgm^{-3}$

3) $2\times10^{3}\,kgm^{-3}$ 4) $2\times10^{-3}\,kgm^{-3}$

13] If 'a' is edge length of a face centred cubic unit cell, then the distance of closest approach of two particles is.

1) 0.866 a

2) 1.732 a

3) 0.707 a

4) 1.414 a

14] An element (at. mass=100) having bcc structure has unit cell edge 400 pm. The density of the element is

1) 10.376 g/cm³

2) 5.188 g/cm³

3) 7.289 g/cm³

4) 2.144 g/cm³

15] The no.of atoms in 100 g of fcc crystal with . . . . ⁻³ and edge length of 200 pm is

1) 1×10^{25} **2) 5 ò 10^{24}**

3) 5×10^{26} 4) 5×10^{20}

16] The intermetallic compound LiAg crystallizes in a cubic lattice in which lithium and silver atoms have co-ordination number of 8. To what crystal class does the unit cell belong?

1) Simple cubic

2) Face centred cubic

3) Body-centred cubic

4) end centred cubic

17] In hcp structure, the packing fraction is

1) 0.68 **2) 0.74**

3) 0.50 4) 0.54

18] In orthorhombic, the value of a, b and c are respectively 4.2 Å, 8.6 Å and 8.3 Å. Given the molecular mass of the solute is 155 g.mol^{-1} and that of density is 3.3 g/cc, the number of formula units per unit cell is

1) 2 2) 3

3) 4 4) 6

19] Ferrimagnetism is in

1) ↑↑↑↑↑

2) ↑↓↑↓

3) ↑↑↑↓↓

4) ↑↑↓↓↑↑↑↓↓↓

20] Which set of characteristics of ZnS crystal is CORRECT?

1) Coordination number (4 : 4); ccp ; Zn^{2+} ions in the alternate tetrahedral voids

2) Coordination number (6 : 6); hcp ; Zn^{2+} ions all tetrahedral voids

3) Coordination number (6 : 4); hcp ; Zn^{2+} ions all octahedral voids

4) Coordination number (4 : 4); hcp ; Zn^{2+} ions all tetrahedral voids

21] A semiconductor of Ge can be made p-type by adding

1) trivalent impurity

2) tetravalent

3) pentavalent impurity

4) hexavalent impurity

22] Assertion (A): Electrical conductivity of semiconductors increases with increasing temperature

Reason (R): With increase in temperature, large number of electrons from the valence band can jump to the conduction band.

1) Both (1) and (R) are true and (R) is the correct explanation of (A)

2) Both (A) and (R) are true but (R) is not the correct explanation of (A)

3) (A) is true but (R) is false.

4) (A) is false but (R) is true

23] **Assertion (A):** Group-15 doped crystals of silicon are called a n-type semiconductor.

Reason (R): Neutrons, are responsible for the semiconducting properties.

1) Both (A) and (R) are true and (R) is the correct explanation of (A)

2) Both (A) and (R) are true but (R) is not the correct explanation of (A)

3) (A) is true but (R) is false.

4) (A) is false but (R) is true

24] Magnetic property of VO_2 is

1) dia magnetic

2) paramagnetic

3) Ferromagnetic

4) Anti ferromagnetic

Assertion (A): Group-13 doped crystals of silicon are called a p-type semiconductors.

Reason (R): Holes (positive in charge) appear to be responsible for the semiconducting properties.

1) Both (A) and (R) are true and (R) is the correct explanation of (A)

2) Both (A) and (R) are true but (R) is not the correct explanation of (A)

3) (A) is true but (R) is false.

4) (A) is false but (R) is true

26] If density of NaC*l* = 2.165 g cm^{-3} and the distance between Na^+ and Cl^- = 281 pm, Avogadro's number is equal to

1) $7\times10^{23}\ mol^{-1}$

2) $8\times10^{23}\ mol^{-1}$

3) $6\times10^{23}\ mol^{-1}$

4) $4\times10^{23}\ mol^{-1}$

27] A solids X^+Y^- has BCC structure. If the distance of closed approach between the two ions is 173 pm the edge length of the cell is

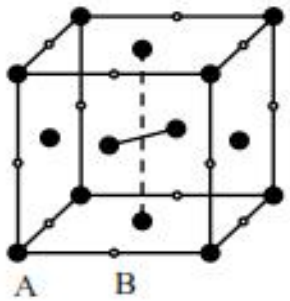
1) 200 pm

2) $\frac{\sqrt{3}}{\sqrt{2}}$ pm

3)142.2 pm

4) $\sqrt{2}$ pm

28] For a solid with the following structure, the co-ordination number of the points A and B respectively are



1) 6,8

2) 8,8

3) 6,6

4) 4,6

29] The number of atoms in 240 g of fcc crystal with density = 10g/cc and cell edge equal to 200 pm is equal to

1) 6×10^{24}

2) 4.8×10^{25}

3) 1.2×10^{25}

4) 1.2×10^{24}

30] If 'a' stands for the edge length of the cubic system; simple cubic body centred cubic and face centred cubic, then the ratio of the radii of the spheres in these system will be respectively.

1) $\frac{1}{2}a$; $\frac{\sqrt{3}}{4}a$: $\frac{1}{2\sqrt{2}}a$

2) $\frac{1}{2}a$: $\sqrt{3}a$: $\frac{1}{\sqrt{2}}a$

3) $\frac{1}{2}a$: $\frac{\sqrt{3}}{2}a$: $\frac{\sqrt{2}}{2}a$

4) $1a$: $\sqrt{3}a$: $\sqrt{2}a$

31] Lithium metal crystallizes in a body centerd cubic crystal. If the length of the side of the unit cell of lithium is 351 pm, the atomic radius of the lithium will be _____ pm.

1) 151.8

2) 75.5

3) 300.5

4) 240.8

32] Conductors have conductivity of the order of (ohm^{-1} m^{-1})

1) 10^2 - 10^4 **2) 10^4 - 10^7**

3) 10^7 - 10^8 4) >10^8

33] . . . . . l is doped with 10^{-4} mol % of $SrCl_2$, the concentration of cation vacancies will be

1) $6.02\times10^{14}\,mol^{-1}$ **2)** $6.02\times10^{15}\,mol^{-1}$

3) $6.02\times10^{16}\,mol^{-1}$ 4) $6.02\times10^{17}\,mol^{-1}$

34] _____ is antiferromagnetic in nature.

1) VO_2 2) CrO_2

3) TiO_2 **4) MnO**

35] The flame colours of metals ions are due to

1) Frenkel defect.

2) Schottky defect.

3) Metal deficiency defect

4) Metal excess defect.

36] Which of the following metal oxides is ferrimagnetic in nature?

1) V_2O_3 2) Ni

3) Fe_3O_4 **4)** $Mg(Fe_2O_4)$

37] The maximum proportion of available volume that can be filled by hard spheres in diamond is:

1) 0.52

2) 0.34

3) 0.42

4) 0.68

38] F-centres in an ionic crystal are

1) lattice sites containing electrons

2) interstitial sites containing electrons

3) lattice sites that are vacant

4) interstitial sites containing cations.

39] ZnO is white when cold and yellow when heated it is due to development of

1) Frenkal defect

2) Schottky defect

3) metal excess defect

4) either 1) or 2)

40] Ferromagnetism is in

1) ↑↑↑↑↑ 2) ↑↓↑↓

3) ↑↑↑↓↓ 4) ↑↑↓↓↑↑↑↓↓↓

41] A diode used as a rectifier is

1) n-type semiconductor

2) p-type semiconductor

3) a combination of the above two types

4) either (1) or (2)

42] Bragg' law is given by the equation

1) $n\lambda = 2\theta \sin\theta$

2) $n\lambda = 2d \sin\theta$

3) $2n\lambda = d \sin\theta$

4) $n\frac{\theta}{2} = \frac{d}{2} \sin\theta$

LEVEL - III

AMU

1] An ionic compound *XY* has a structure of ZnS type. If the radius of X^+ is 22.5 pm. The ideal radius of Y^- will be **[1999]**

1)100 pm 2) 50 pm
3) 20 pm 4) 30 pm

2] A solid is formed from atoms A and B and crystallizes into a face centred cubic lattice with A at the face centred position and B at the corners of the cube, Its molecular formula is reppresented by **[2000]**

1) A_3B
2) A_2B
3) AB_2
4) AB_3

3] Some of the polar crystal when heated produce electric current. This phenomena is termed as **[2001]**

1) ferroelectric effect
2) pyroelectric effect
3) antiferroelectric effect
4) piezoelectric effect

4] In ionic crystal an increase in temperature **[2002]**

1) increases the coordination number
2) lowers coordination number
3) causes no change in the structure
4) causes no change in the coordination number

5] The coordination number of an atom in the simple cubic unit cell in a crystal lattice is **[2002]**

1) 3
2) 2
3) 4
4) 6

6] The number of atoms per unit fcc cell in a crystal lattice is **[2003]**

1) 1
2) 2
3) 3
4) 4

7] Number of chloride ions around a single sodium ion in NaCl crystal is **[2004]**

1) 3
2) 4
3) 6
4) 8

8] The limiting radius ratio for tetrahedral shape is **[2005]**

1) 0 to 0.153
2) 0.225 to 0.414
3) 0.155 to 0.225
4) 0.414 to 0.732

AIIMS

1] An example of a body cube is **[1996]**

1) Sodium (bcc)

2) Magnesium (hcp)

3) Zinc(hcp)

4) Copper (fcc)

2] Body centered cubic lattice has a coordination number of **[1996]**

1) 4 **2) 8**

3) 12 4) 6

3] Sodium metal crystallizes as a body centred cubic lattice with the cell edge 4.29 Å. What is the radius of sodium atom **[1999]**

1) 1.857×10^{-8} cm

2) . . . . . $^{-8}$ cm

3) 3.817×10^{-8} cm

4) 9.312×10^{-8} cm

4] In a cubic structure of compound which is made from *X* and *Y*, where *X* atoms are at the corners of the cube and *Y* at the face centres of the cube. The molecular formula of the compound is **[2000]**

1) X_2Y 2) X_3Y

3) XY_2 **4) XY_3**

5] The edge length of face centred cubic unit cell is 508 pm. If the radius of the cation is 110 pm, the radius of the anion is **[2000]**

1) 288 pm 2) 398 pm

3) 144 pm 4) 618 pm

6] A solid AB has NaCl type structure. The radius of A^+ is 100 pm. What is the radius of B^-? **[2001]**

1) 190.47 2) 540.13

3) 525 4) 78.12

7] Crystalline solids have **[2001]**

1) short range order

2) long range order

3) anisotropic distribution

4) both (2) and (3)

8] Schottky defect defines imperfection in the lattice structure of a **[2002]**

1) Solid 2) Liquid

3) Gas 4) Plasma

9] An AB_2 type structure is found in **[2002]**

1) NaCl **2) CaF_2**

3) Al_2O_3 4) N_2O

10] What is the coordination number of sodium in Na_2O? **[2003]**

1) 6 **2) 4**

3) 8 4) 2

11] The crystal system of a compound with unit cell dimensions a = 0.387, b = 0.387 and c = 0.504 nm and $\alpha = \beta = 90^o$ and $\gamma = 120^o$ is **[2004]**

1) Cubic **2) Hexagonal**

3) Orthorhombic 4) Rhombohedral

12] If '*Z*' is the number of atoms in the unit cell that represents the closest packing sequence $---ABCABC---$, the number of tetrahedral voids in the unit cell is equal to **[2005]**

1) Z **2) 2 Z**
3) Z/2 4) Z/4

13] Ca^{2+} and F^- are located in CaF_2 crystal. respectively at face centred cubic lattice points and in **[2006, 2015]**

1) tetrahedral voids
2) half of tetrahedral voids
3) octahedral voids
4) half of octahedral voids

14] The energy gaps (E_g) between valence band and conduclion band for diamond, silicon and germanium are in the order **[2006]**

1) E_g(diamond) > E_g(silicon) > E_g(germanium)
2) E_g(diamond) < E_g(silicon) < E_g(germanium)
3) E_g(diamond) = E_g(silicon) = E_g(germanium)
4) E_g(diamond) > E_g(germanium) > E_g(silicon)

15] The coordination number in hcp is **[2007]**

1) 6
2) 12
3) 18
4) 24

16] The flame colours of metal ions are due to **[2008]**

1) Frenkel defect
2) Schottky defect
3) metal deficiency defect
4) metal excess defect

17] A unit cell of sodium chloride has four formula units. The edge length of the unit cell is 0.564 nm. What is the density of sodium chloride? **[2008]**

1) 1.2 g/cm^3 **2) 2.165 g/cm^3**
3) 3.64 g/cm^3 4) 4.56 g/cm^3

18] In tetragonal crystal system, which of the following is NOT true? **[2010]**

1) All axial lengths and all axial angles are equal.
2) All three axial lengths are equal
3) All three axial angles are equal
4) Two axial angles are equal but the third is different

19] In bcc structure contribution of corner and central atom is **[2012]**

1) $\frac{1}{8}, 1$ 2) $\frac{1}{4}, \frac{1}{8}$
3) $\frac{1}{8}, \frac{1}{2}$ 4) $1, \frac{1}{2}$

20] CsCl has bcc arrangement. Its unit cell edge length is 400 pm. Its inter-ionic distance is **[2012]**

1) 400 pm
2) 800 pm
3) $\sqrt{3} \times 100\,\text{pm}$
4) $\frac{\sqrt{3}}{2} \times 400\,\text{pm}$

21] A forms hcp lattice and B are occupying 1/3rd of tetrahedral voids, then the formula of compound is **[2014, 2018]**

1) AB
2) A_3B_2
3) A_2B_3
4) AB_4

22] Which of the following is an amorphous solid? **[2015]**

1) Iron
2) Graphite
3) Diamond
4) Glass

23] The yellow colour in NaCl crystals is due to **[2015]**

1) excitation of electrons in F-centres
2) reflection of light from Cl^- ions on the surface
3) refraction of light from Na^+ ions
4) all of the above

24] Addition of group-13 elements to intrinsic semiconductors results in **[2015]**

1) creation of conduction band slightly above the valence band
2) creation of conduction band slightly below the valence band
3) creation of valence band slightly above the conduction band
4) overlapping of valence band and conduction band.

25] If an atom crystallises in bcc lattice with r = 4 A° then the edge length will be **[2016]**

1) 2 Å
2) 8 Å
3) 2.39 Å
4) 9.23 Å

26] ZnO is white when cold and yellow when heated. It is due to the development of **[2017]**

1) Frenkel defect
2) metal excess defect
3) Schottky defect
4) metal deficiency defect

27] What colour is observed when ZnO is heated? **[2018]**

1) Yellow
2) Violet
3) Green
4) Blue

NEET

1] The intermetallic compound LiAg crystallizes in a cubic lattice in which both lithium and silver atoms have coordination number of eight. To what crystal class does the unit cell belong? **[1997]**

1) Simple cubic
2) Face-centred cubic
3) Body-centred cubic
4) None

2] The second order Bragg diffraction of X-rays with λ = 1.00 Å from a set of parallel planes in a metal occurs at an angle 60°. The distance between the scattering planes in the crystal is **[1998]**

1) 0.575 Å
2) 1.00 Å
3) 2.00 Å
4) 1.15 Å

3] In the solid state, MgO has the same structure as that of sodium chloride. The number of oxygens surrounding each magnesium in MgO is **[1999]**

1) 6
2) 1
3) 2
4) 4

4] A compound is formed by elements A and B. The crystalline cubic structure has the A atoms at the corners of the cube and B atoms at the body centre. The simplest formula of the compound is **[2000]**

1) AB
2) A_6B
3) AB_6
4) A_8B_4

5] When molten zinc is converted into solid state it acquires hcp structure. The number of nearest neighbours will be **[2001]**

a) 6
b) 12
c) 8
d) 4

6] A compound formed by elements and crystallises in a cubic structure in which the atoms of X are at the corners of a cube and the atoms of Y are at the face centres. The formula of the compound is **[2004]**

1) XY_3
2) X_3Y
3) XY
4) XY_2

7] In a face-centered cubic lattice, a unit cell is shared equally by how many unit cells? **[2005]**

1) 2
2) 4
3) 6
4) 8

8] CsBr crystallises in a body centred cubic lattice. The unit cell length is 436.6 pm. Given that the atomic mass of Cs = 133 and that of Br = 80 amu and Avogadro number being 6.022×10^{23} mol^{-1}, the density of CsBr is **[2006]**

1) 4.25 g/cm³
2) 42.5 g/cm³
3) 0.425 g/cm³
4) 8.25 g/cm³

9] The appearance of colour in solid alkali metal halides is generally due to **[2006]**

1) interstitial positions
2) F– centres
3) Schottky defect
4) Frenkel defect

10] Percentage of free space in a body centred cubic unit cell is **[2008]**

1) 34% 2) 28%

3) 30% **4) 32%**

11] Which of the following statement is NOT CORRECT? **[2008]**

1) The number of carbon atoms in a unit cell of diamond is 8.
2) The number of Bravais lattices in which a crystal can be categorized is 14.
3) **The fraction of the total volume occupied by the atoms in a primitive** cell is 0.48
4) Molecular solids are generally volatile.

12] With which one of the following elements silicon should be doped so as to give p-type of semiconductor? **[2008]**

1) Selenium
2) **Boron**
3) Germanium
4) Arsenic

13] Lithium metal crystallizes in a body- centred cubic crystal. If the length of the side of the unit cell of lithium is 351 pm, the atomic radius of lithium will be **[2009]**

1) 151.8 pm
2) 75.5 pm
3) 300.5 pm
4) 240.8 pm

14] Copper crystallizes in a face-centred cubic lattice with a unit cell length of 361 pm. What **[2009]**

1) 157
2) 181
3) 108
4) 128

15] AB crystallizes in a body centred cubic lattice with edge length 'a' equal to 387 pm. The distance between two oppositely charged ions in the lattice is **[2010]**

1) 335 pm
2) 250 pm
3) 200 pm
4) 300 pm

16] A metal crystallizes with a face-centred cubic lattice. The edge of the unit cell is 408 pm. The diameter of the metal atom is **[2012]**

1) 288 pm
2) 408 pm
3) 144 pm
4) 204 pm

17] A solid compound XY has NaC*l* structure. If the radius of the cations is 100 pm, the max. radius of the anion (Y^-) will be **[2011]**

1) 275.1 pm
2) 322.5 pm
3) 241.5 pm
4) 165.7 pm

18] Structure of a mixed oxide is cubic close packed (ccp). The cubic unit cell of a mixed oxide is composed of oxide ions. One fourth of the tetrahedral voids are occupies by a monovalent metal B. The formula of the oxide is: (Consider 'A' cation is trivalent) **[2012]**

1) ABO_2
2) A_2BO_2
3) $A_2B_3O_4$
4) AB_2O_2

19] A metal has a fcc lattice. The edge length of the unit cell is 404 pm. The density of the metal is 2.72 g cm^{-3}. The molar mass of the metal is:
(NA Avogadro's constant = 6.02×10^{23} mol^{-1}) **[2013]**

1) 30 g mol^{-1}
2) 27 g mol^{-1}
3) 20 g mol^{-1}
4) 40 g mol^{-1}

20] Which of the following statement about the interstitial compounds INCORRECT. **[2013]**

1) They are chemically reactive.
2) They are much harder than the pure metal.
3) They have lower melting points than the pure metal
4) They retain metallic conductivity.

21] The number of carbon atoms per unit cell of diamond unit cell is: **[2013]**

1) 8 2) 6
3) 1 4) 4

22] If a is the length of the side of a cube, the distance between the body centered and corner atom in the cube will be: **[2014]**

1) $\frac{2}{\sqrt{3}}a$ 2) $\frac{4}{\sqrt{3}}a$
3) $\frac{\sqrt{3}}{4}a$ **4)** $\frac{\sqrt{3}}{2}a$

23] A given metal crystallizes out with a cubic structure Having edge length of 361 pm. If there are four metal atoms in one unit cell, what is the radius of one atom? **[2015]**

1) 127 pm 2) 80 pm
3) 108 pm 4) 40 pm

24] Lithium has a bcc structure. Its density is 530 kg m^{-3} and its atomic mass is 6.94 g mol^{-1}. Calculate the edge length of a unit cell of Lithium metal.
($N_A = 6.02 \times 10^{23}$ mol^{-1}) **[2016]**

1) 352 pm 2) 527 pm
3) 264 pm 4) 154 pm

25] The ionic radii of A' and B ions are 0.98×10^{-10} in and 1.81×10^{-10} m. The coordination number of each ion in AB is: **[2016]**

1) 4 2) 8
3) 2 **4) 6**

26] Which is the INCORRECT statement? **[2017]**

1) NaCl(s) is insulator, silicon is semiconductor silver is conductor, quartz electric crystal.
2) **Frenkel defect is favoured in those ionic compounds in which sizes of cation and anions are almost equal.**
3) $FeO_{0.98}$ has non stoichiometric metal deficiency defect.
4) Density decreases in case of crystals with Shottky's defect.

27] Iron exhibits bcc structure at room temperature. Above 900°C, it transforms to fcc structure. The ratio of density of iron at room temperature to that at 900°C, (assuming molar mass and atomic radii of iron remains constant with temperature) is **[2018]**

1) $\frac{3\sqrt{3}}{4\sqrt{2}}$ 2) $\frac{\sqrt{3}}{\sqrt{2}}$

3) $\frac{1}{2}$ 4) $\frac{4\sqrt{3}}{3\sqrt{2}}$

01. SOLID STATE

Answer Key

1. 4	2. 3	3.3	4.4	5.3
6. 1	7. 4	8. 2	9. 3	10. 3
11. 1	12. 1	13. 4	14. 2	15. 4
16. 1	17. 1	18. 2	19. 2	20. 3
21. 4	22. 1	23. 2	24. 3	25. 2
26. 3	27. 2	28. 2	29. 2	30. 1
31. 4	32. 1	33. 4	34. 2	35. 1
36. 1	37. 2	38. 2	39. 4	40. 4
41. 3	42. 2	43. 3	44. 3	45. 2
46. 3	47. 1	48. 2	49. 4	50. 4
51. 2	52. 1	53. 3	54. 2	55. 3
56. 3	57. 4	58.1	59. 2	60. 3
61. 3	62. 1	63. 2	64. 3	65. 4
66. 4	67. 1	68. 2	69. 3	70. 3
71. 1	72. 1	73. 3	74. 1	75. 4
76. 1	77. 2	78. 1	79. 2	80. 2
81. 3	82. 2	83. 1	84. 1	85. 4
86. 2	87. 1	88. 1	89. 2	90. 2
91. 4				

MISCELLANEOUS

1. 4	2. 4	3. 2	4. 3	5. 4
6. 4	7. 3	8. 3	9. 1	10. 2
11. 1	12. 2	13. 4	14. 2	15.4

LEVEL - II

1. 4	2. 2	3. 3	4. 4	5. 3
6. 4	7. 1	8. 2	9. 1	10. 1
11. 2	12. 1	13. 3	14. 2	15. 2
16. 3	17. 2	18. 3	19. 3	20. 1
21. 1	22. 1	23. 3	24. 2	25. 1
26. 3	27. 1	28. 3	29. 3	30. 1
31. 1	32. 2			
33. 2	34. 4	35. 4	36. 3,4	37. 2
38. 1	39. 3	40. 1	41. 3	42. 2

LEVEL - III

AMU

1.1	2. 1	3. 2	4. 2	5. 4
6. 4	7. 3	8. 2		

AIIMS

1.1	2. 2	3. 1	4. 4	5. 3
6. 1	7. 4	8.1	9.2	10.2
11.2	12.2	13.1	14. 1	15.2
16. 2	17.2	18. 3	19. 1	20.3
21. 2	22. 4	23.1	24. 1	25. 4
26.2	27.1			

NEET

1.3	2. 4	3.1	4. 1	5. 2
6. 1	7. 3	8.1	9. 2	10. 4
11. 3	12. 2	13. 1	14.4	15.1
16.1	17.3	18.1	19.2	20.3
21.1	22. 4	23. 1	24. 1	25.4
26. 2	27.1			

01.Solid State

Hints & Solution of Selected MCQ's

Level – I

1] Ionic Solids are soluble due to polarity

2] Glass is amorphous solid

3] In Ice the Lattice points are H_2O therefore Ice is Molecular solid

4] In NaC*l* the lattice points are ions thus it is Ionic solid

5] Covalent crystal. High melting Point

6] In ZnS the lattice points are ions therefore it is Ionic solid

7] Factual

8] CO_2 is example of non-polar molecular solid

9] Since the particles don't repeat itself for a long range also they have random arrangements of molecules thus when cut through knife produces rough edges

13] Basic type : 7
Total : 14

14] NaC*l* = FCC/CCP structure

16] In face centred cubic lattice the no. of nearest cube neighbours for given cube is 6

17] Mole concept:
1 mol = $N_A \equiv$ 'M' g of (spheres)

For 1 g, $\frac{N_A}{Z} \times \frac{1}{M}$

$= \frac{1}{4} \times \frac{6.022 \times 10^{23}}{58.5}$

$= 2.57 \times 10^{21}$ unit cells.

$\therefore$ CORRECT value $> 2.5 \times 10^{21}$

18] corner : 8
Edge : 4
Body centre : 1
Face centre : 2 unit cell

19] A bcc cell contains 2 atom

$\therefore$ No. of atom $= 2 \times 12.08 \times 10^{23}$

$= 24.16 \times 10^{23}$

Also, In bcc, Z = 2.

1 unit cell $\equiv$ 2 atoms.

12.08×10^{23} Unit cells $\equiv$? atoms

$= Z \times$ No. of unit cells

$= 24.16 \times 10^{23}$

20]
1 mol NaC*l* = 58.5g NaC*l* = 6.022×10^{23} NaC*l*
Each unit cell of NaC*l*, contains 4 Unit cell.

$\therefore$ No. of unit cell $= \frac{6.023 \times 10^{23}}{4}$

$= 1.505 \times 10^{23}$

OR,

20] Number of particle in 58.5 $\equiv N_A$ particles

No. of unit cell= $\frac{N}{Z}$

$= \frac{6 \times 10^{23}}{4} = 1.5 \times 10^{23}$

21] Density α Packing efficiency.
Simple cubic arrangement have least packing efficiency (52.4%)
hence, have lowest density .

22] A bcc cell contains 2 atom

24] In bcc, each atom is surrounded by 8 atom.
$\therefore$ Co – ordination no. = 8

25] C.N = 6 thus it is octahedral void
$\therefore$ radius ratio = 0.414-0.732

26] ABAB 3D close packing results in HCP

28] K is bcc (factual)

29] BCC Packing efficiency = 68%

30] For FCC P.E. = 74%

32] For SCC P.E = 52.4% which is least compare to other packing

33] For hcp nearest neighbours
= co-ordination no. = 12

34] Octahedral Void = N
Tetrahedral Void = 2N
For FCC/CCP rank = Z= 4
therefore T.V = 8
hence ratio is 1 : 2

35] Octahedral Void = N
Tetrahedral Void = 2N
For FCC rank = Z= 4
therefore O.V = 4
thus 1 O.V per Sphere

36] FCC/CCP has the highest packing efficiency

37]Hexagonal close packing pattern

38] Total O.V. = N

40] 1unit cell =4 Na+ & 4 Cl^- = 4Na + Cl^- ion pair (Formula Unit)
Z = 4 (No of Formula Units /Units cell)

41] No. of 'A' atom $= \frac{1}{8} \times 8 = 1$

No. of 'B' atom $= \frac{1}{2} \times 6 = 3$

No. of 'C' atom = 1

$\therefore$ Formula = AB_3C

Also,

	Position	No.	contribution	Actual contribution
A	corner	8	$\frac{1}{8}$	1
B	bcc	b	$\frac{1}{2}$	3
C	fcc	1	1	1

$= AB_3C$

42] No. of 'W' atom $= \frac{1}{8} \times 8 = 1$

$\therefore$ No. of 'B' atom $= \frac{1}{4} \times 12 = 3$

No. of 'Na' atom = 1

$\therefore$ Formula = $NaWO_3$.

Also,

	position	No.	Cont.	Act.cont
W	corner	8	$\frac{1}{8}$	1
O	Edge centre	12	$\frac{1}{4}$	3
Na	bcc	1	1	1

$\Rightarrow NaWO_3$

43] ABCABC gives FCC/CCP structure

44] P.E of BCC = 68%

45] Closest approach

Metallic solid ionic solid

$\therefore$ for cation and anion.

$2(r_+ + r_-) = a$

$(r_+ + r_-) = \frac{a}{2}$

46] CsC*l* $\equiv$ bcc

Body diagonal= $2(r_+ + r_-) = a\sqrt{3}$

$r_c + r_a = \frac{a\sqrt{3}}{2}$

47] If No. of atom = N
Then, No. of octahedral void = N
$\therefore$ Ratio = 1:1

48] Volume of 1atom $= \frac{4}{3}\pi r^3$

Volume of all atoms of fcc =
Volume of 4 atoms

$= 4 \cdot \frac{4}{3}\pi r^3 = \frac{16}{3}\pi r^3$

49] 1 mol Mg $\equiv$ 24g Mg $\equiv 6.022 \times 10^{23}$ Mg atom

$\therefore$ 1g Mg = $= \frac{6.023 \times 10^{23}}{24}$

$= 2.50 \times 10^{22}$ Mg atom

Each atom have only one valence shell

$\therefore$ No. of Valence shell = $2.5 \times 10^{22} \approx 10^{22}$

OR,

49] Every atom = 1 valence shell.
1 Mg atom = 1 valence shell
N_A Mg atom = N_A valence shell
1 mole = 24 g = N_A valence shell.

$$\therefore 1g = \frac{N_A}{24} \Rightarrow \frac{6\times10^{23}}{24}$$
$$\Rightarrow 2.5 \times 10^{22}$$

50] For fcc Ca : a = 361 pm

$2\sqrt{2}r = a$

$$\therefore r = \frac{a}{2\sqrt{2}} = \frac{361}{2\sqrt{2}} \cong \frac{360}{2\times1.5} = \frac{360}{3} = 120$$

Real answer . more than 120 pm = 128 pm

OR

50] For fcc :

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

a = 361

$2\sqrt{2}r = 361$

$$r = \frac{361}{2\sqrt{2}} \quad \therefore r = \frac{180}{1.414} \simeq \frac{200}{1.5} = \frac{400}{3} \equiv 133.33$$

OR

$$r = \frac{180}{1.414} \simeq \frac{185}{3/2}$$

$$\simeq \frac{370}{3} \simeq 123.33 \qquad \therefore \text{answer = (D)}$$

52] 2r….. metallic solid.
$2(r_+ + r_-)$ ….. Ionic solid
2r = 1.73 A

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

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

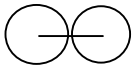
$$\therefore \text{Distance} = 2r = 2\left(\frac{a\sqrt{3}}{4}\right) = \frac{\sqrt{3}a}{2} = 1.73\ A^o$$

$$\therefore a = 2A^o = 2 \times 10^{-10}\ m$$
$$= 2 \times 10^2 \times 10^{-12} = 200\ pm$$

OR

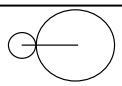
52] 200 pm GENERAL CONCEPT

$2r$



$\therefore$ Closest approach for metallic solid = 2r

For IONIC SOLID:-



$r_+ + r_-$

$\therefore$ Closest approach for ionic solid = $r_+ + r_-$

Answer:- closest approach = 1.73 Å

$\therefore 2r = 1.73$ Å

B.C.C:- $a = \frac{4}{\sqrt{3}}r$

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

$$\therefore a = (2r)\frac{2}{\sqrt{3}}$$

$$= 1.73\ Å \times \frac{2}{1.73}$$

$$\Rightarrow 173\ pm \times \frac{2}{173pm} \Rightarrow 200\ pm$$

53] For BCC lattice point = 9

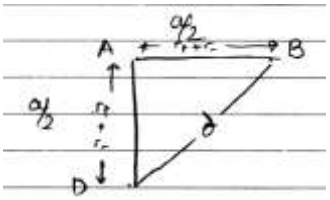
55] Octahedral void

56] Radius ratio of tetrahedral void
= 0.225-0.414
Radius ratio of octahedral voids =0.414-0.732
Therefore O.V are larger than T.V.

57] For NaCl , $2(r_+ + r_-) = a$

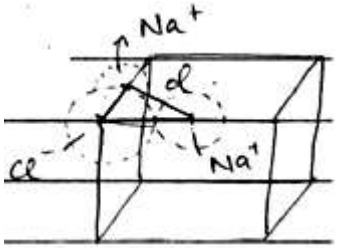
$$r_+ + r_- = \frac{a}{2}$$

$$\therefore d^2 = 2\left(\frac{a}{2}\right)^2, \quad d = \frac{a}{\sqrt{2}}$$



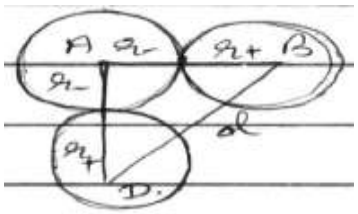
OR

57]



$2(r_+ + r_-) = a$

$\therefore r_+ + r_- = \frac{a}{2}$



Distance between two nearest Na^+ atoms
= length BD = d.
For right angled Δ ABD,
$AB^2 + AD^2 = BD^2$

$$\left(\frac{a}{2}\right)^2 + \left(\frac{a}{2}\right)^2 = d^2$$

$$d^2 = 2\left(\frac{a}{2}\right)^2$$

$$d = \sqrt{2}\frac{a}{2} = \frac{a}{\sqrt{2}}$$

58] a = 400 pm = 4×10^{-8} cm , Z = 4
M = 60

$$d = \frac{Z \times M \times 10}{y^3 \times 6} = \frac{4 \times 60 \times 10}{4^3 \times 6} = \frac{100}{16} = 6.28 \text{ g cm}^{-3}$$

59] $\frac{r_+}{r_-}$ for NaCl = 0.52

$$0.414 \leq \frac{r_+}{r_-} \leq 0.732$$

Na^+ occupies octahedral void.
Co-ordination number = 6

60] In NaCl, Na^+ ions belongs to octahedral void, hence surrounded by 6 Cl^- ion.

63] In Schottky density of metals increases.

65] Schottky defect – vacancies are created
Frankel – polarization happens.
Due to defects mobility increases
$\therefore$ conductivity increases

74] The cation slips so its size should be very small as compared to anion.

76] Group -14 semiconductors are called as intrinsic semiconductors

77] Doping with group 13 results in p-type

78] As temperature bonds break result in more free electrons

80] Graphite conduct electricity due to presence of free electrons.

82] Si – network should – no free e^-
(semi conductor)
Li – metallic solid – sea of e^-
(good conductor)
NaCl – ionic solid – no. mobile e^-
(nonconductor in solid state)
Ice – molecular solid – no free e^-
(insulator)

OR

82]

Si	Network solid	Semi conductor
Li	Metallic solid	Good conductor
NaCl	Ionic solid	Non-conductor in solid state
Ice	Molecular solid	Does NOT conduct electricity

83] Doping with Group-15 results in n-type.

89] Doping with Group - 15 results in n-type

91] Schottky defect – (vacancy defect)
Some e^- will not be bonded and are available for conduction

OR

91] Intrinsic: pure semiconductor .
Extrinsic: impure, problematic
↓ ↓
Chemical Addition Schottky

MISCELLANEOUS

1] Glass and pitch both pitch – tar.

4] Triclinic is most unsymmetrical

5] Cu – F.C.C crystal structure.
$\therefore$ C.N = 12.

8] $2d \sin\theta = n\lambda$ .....Brags equation
n= order of reflection

9] from Bragg's equation

$n\lambda = 2d \sin\theta$

$1 \times \lambda = 2 \times 0.18 \times 10^{-9} \times \sin 22$

$\therefore \lambda = 0.36 \times 0.208$ nm

$\therefore \lambda = 0.0749$ nm

10] 26%

ABAB – closed packing – HCP.

$\therefore$ packing efficiency = 74%

$\therefore$ void = 26%

14]

NaCl is ionic solid $\Rightarrow$ heat of fusion of ionic solids are very high

15] In crystal there are 3 type of element of symmetry

i] Centre of symmetry $\rightarrow$ 1

ii] Plane of symmetry $\rightarrow$9

iii] Axis of symmetry $\rightarrow$ 13

Total $\rightarrow$ 23

Level- II

1] Molecular solid have low melting point and are poor conductor of heat and electricity.

2] Held by van der Waal's force and very low temperature of freeze.

3]

	position	no	cont	Total
A	corners	8-1= 7	1/8	7/8
B	Face ----	6	1/2	3

A B

7 24

$\therefore A_7 B_{24}$

4] Radius ratio for Cubic void = 0.732

6] S_1 – tetrahedral voids;

S_2 – octahedral voids.

7] hcp and ccp (fcc) have same packing efficiency i.e. 74%

9] In NaC*l* their are 14 Cl^- and 13 Na+ ions

10] a = 200 pm = 200 x 10^{-10} cm , M = 200 g

Particles = 24 x 10^{23}

24 x 10^{23} particle $\equiv$ 200 g

$\therefore$ 4 particle = $\left(\frac{200\times 4}{24\times 10^{23}}\right)$ = 41.66 g cm^{-3}

11] For bcc

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

$\therefore 4.29 = \frac{4r}{\sqrt{3}}$

$r = \frac{4.29\times 1.73}{4}$ = 1.8 Å

12] Na (bcc)

a = 0.424 nm = 4.24 × 10^{-1} nm

= 4.24 × 10^{-1} × 10^{-7} cm = 4.24 × 10^{-8} cm

$= \frac{17}{4} \times 10^{-8}$ cm

$d = \frac{z\times M\times 10}{a^3\times 6} = \frac{2\times 23\times 10^5}{4^3\times 6} \simeq \frac{5}{4}$

= 1.25 g/cm^{-3}= 1.25 × 10^3 kg m^{-3}

Real answer = less than 1.25.

$\therefore$ option (A)

OR

12] a) For B.C.C (Na)

a = 0.424 nm = 4.24 × 10^{-8} cm $\approx$ 4 × 10^{-8} cm

M = 23g mol^{-1}

$d = \frac{Z\times M}{a^3\times N_A}\times 10$

$\Rightarrow \frac{2\times 23\times 10}{4\times 4\times 4\times 6}$

$\rightarrow \frac{5}{4} \Rightarrow 1.25$ g cm^{-3}

$\approx 1.25 \frac{10^{-3}\text{ kg}}{10^{-6}\text{ m}^{-3}}$

$\therefore \approx 1.25 \times 10^3$ kg m^{-3}

$\therefore$ Real answer < 1.25 × 10^3 kg m^{-3}

13] Distance of closest approach

= 2r (metallic solid) = $r_+ + r_-$ (ionic solid)

For fcc:

$a = 2\sqrt{2r}$

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

$r = \frac{a\sqrt{2}}{2} = a\left[\frac{1.414}{2}\right] = 0.707\ a$

= distance of closest approach .

14] a = 400pm = 400×10^{-8} cm

M = 100g, Z = 2

$\therefore$ density = $\frac{Z \times M \times 10}{a^3 \times 6}$

$= \frac{2 \times 100 \times 10}{4^3 \times 6}$

$\therefore d = \frac{2 \times 10^3}{64 \times 6}$

$= \frac{1000}{64 \times 3} \approx 5.2$ g/cm^3

15] a = 2×10^{-8} cm , d = 10 g cm^{-3}

fcc Z = 4

$d = \frac{ZM}{N_A \times a^3}$

No. of atoms = $\frac{ZM}{d \times a^3} = \frac{4 \times 100}{10 \times (2 \times 10^{-8})^3}$

No. of atom = $\frac{100 \times 4 \times 10^{24}}{10 \times 8} = 5 \times 10^{24}$

16] Li $\rightarrow$ Corner

Ag $\rightarrow$ Body

$\therefore$ Co – ordination no is 8

$\therefore$ Body centre cubic

17] For HCP P.E= 74%

18] Orthorhombic lattice

$d = \frac{z}{xyz} \times \frac{M}{N_A}$

$Z = \frac{d \times x \times y \times z \times N_A}{M}$

$= \frac{3.3 \times 4.2 \times 8.6 \times 8.3 \times 10^{-24} \times 6 \times 10^{23}}{155}$

$z = \frac{4 \times 4 \times 9 \times 8 \times 6 \times 10^{-1}}{10}$

$= 9 \times 8 \times 6 \times 10^{-2}$

$= 3.2 \approx 4$ g cm

= fcc (z = 4)

19] Has net dipole moment not uniformly aligned.

20] 1unit cell = 4 Zn^{+2} & 4 S^{-2}

=4 ZnS Ion Pair (Formula Unit)

Z=4 (No of Formula Units/Unit Cell)

Zn occupy alternate tetrahedral void

S occupy CCP/FCC

21] Trivalent impurity has $3e^-$

$\therefore$ generates hole

22] With rise in temperature more bond breaks which results in increase of free electrons thus increase in conductivity

23] e^- are responsible for conducting properties.

24] Paramagnetic VO_2

Total electrons = 13 + 2(8) = odd

$\therefore$ Paramagnetic

25] Trivalent impurity has $3e^-$

$\therefore$ generates hole

27] For bcc, $d = \frac{\sqrt{3}}{2}a$

$173 = \frac{1.73}{2}a$

a = 200pm

OR

27] For CsC*l* like crystal .

$2(r_+ + r_-) = \sqrt{3}a$

$\therefore r_+ + r_- = \frac{\sqrt{3}}{2}a$

173 pm = $\frac{\sqrt{3}}{2}a$

a = 200 pm

28] The structure is similar to NaC*l*

OR

28] NaC*l* solid

6 : 6 solid $\therefore$ C.N $\Rightarrow$ 6

29] $d = \frac{mass \times Z}{no.atom \times a^3}$

$10 = \frac{240 \times 4}{no.of\ atoms \times (2 \times 10^{-8})^3}$

No. of atom = 1.2×10^{25}

OR,

29] $d = \frac{ZM}{N_A a^3}$

$20 = \frac{4 \times M}{6 \times 10^{23} \times (2)^3 \times 10^{-24}}$

$\therefore M = \frac{220 \times 6 \times 8}{4 \times 10}$

= 12 g mol^{-1}

No. of atoms = $\frac{W}{M} \times N_A$

$= \frac{240}{12} \times 6 \times 10^{23} = 20 \times 6 \times 10^{23}$

$= 1.2 \times 10^{25}$ atoms.

30] scc, r = $\frac{1}{2}a$ bcc, r = $\frac{\sqrt{3}a}{4}$

fcc, r = $\frac{1}{2\sqrt{2}}a$

31] In case of body centred cubic (bcc) crystal,

Hence, atomic radius of lithium, r = $\frac{a\sqrt{3}}{4}$

$= (351 \times 1.732)/4$

$= 151.98$ pm

32] 10^4 to $10^6 \Omega^{-1}$ cm^{-1}

$\therefore 10^2$ to 10^4 $\Omega^{-1}m^{-1}$

33] If NaCl is doped with 10^{-4} mol% of $SrCl_2$,

2 Na^+ ions doped by Sr^{2+} $N_A = 6.02 \times 10^{23}$

The concentration of cation vacancies =

$6.02 \times 10^{23} \times 10^{-8} = 6.02 \times 10^{15}$ mol^{-1}

37] The proportion of space occupied in diamond = 0.68

$\therefore$ Vacant space = 0.32 (nearest ans)

38] Anion from lattice point is lost and is trapped by e-

39] Metal excess defect due to interstitial cation.

42] $n\lambda = 2d \sin\theta$

Level – III

AIIMS

2] In bcc, co-ordination no = 8

3] For bcc

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

$\therefore 4.29 = \frac{4r}{\sqrt{3}}$

$r = \frac{4.29 \times 1.73}{4} = 1.8$ Å

4] $X \rightarrow$ Corner $\rightarrow 1$

$Y \rightarrow$ face centre $\rightarrow 3$

$\therefore$ formula - XY_3

10] Na^+ is surrounded by 4 O^{2-} ions

Na^+ occupy tetrahedral voids

NEET

10] For BCC

P.E = 68%

Thus void = 32%

12] Group 13 element result in p-type

13] In case of body centred cubic (bcc) crystal,

$a\sqrt{3}=4r$

Hence, atomic radius of lithium, $r = a\sqrt{3}/4$

$= (351 \times 1.732)/4$

15] $d = \sqrt{3} \times 387/2 = 335$

16] For FCC $r = a/2\sqrt{2}$

Hence Diameter = $a/\sqrt{2}$

$= 408/1.414 = 288.5$pm

19] density = $\frac{Z \times M}{a^3 \times N_A}$

For an fcc , Z = 4 , d = 2.72 g cm^{-3}

a = 404 pm = 404×10^{-10} cm

$M = \frac{d \times a^3 \times N_A}{Z}$

$= \frac{2.72 \times (404 \times 10^{-10})^3 \times 6.022 \times 10^{23}}{4}$

= 27 g mol^{-1}

23] $r = \frac{\sqrt{2}a}{4} = \frac{\sqrt{2} \times 316}{4} = 127$pm

24] density = $\frac{Z \times M}{a^3 \times N_A}$

25] Radius ratio = 0.98/1.81 = 0.54

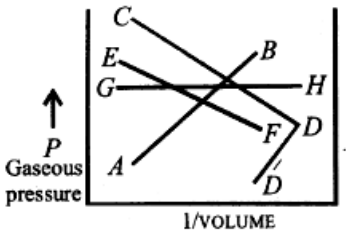
$\therefore$ octahedral void

C.N of Octahedral void = 6

02. States of Matter
(Level III)

AMU

1] Which one of the following pressure versus volume plots represents Boyle's Law? (see the accompanied diagram).



[1995]

1) line GH 2) line COD
3) line EF 4) line GH

2] Which of the following statement INCORRECT in respect of ideal gaseous behaviour?

[1995]

1) All the molecules are identical and have intermolecular force of attraction
2) The gaseous molecules exchange energies during molecular collisions
3) The collisions are inelastic
4) All the above.

3] Which is NOT true is case of an ideal gas? **[1996]**

1) It cannot be converted into a liquid
2) There is no interaction between the molecules
3) All molecules of the gas move with same speed
4) At a given temperature, *PV* is proportional to the amount of the gas

4] A gas is enclosed in a room. The temperature, pressure, density and number of moles of the gas respectively are t°C, p atm, g cm^{-3} and n. If the room is partitioned into four equal compartments which of these quantities will be different in the small compartments? **[1996]**

1) Temperature 2) Pressure
3) Density **4) Number of moles.**

5] A gas has a volume of 15 mL at 300 K and 740 mm of Hg. Find the temperature if volume becomes 10 mL at 760 mm pressure of Hg. **[1997]**

1) 205K 2) 209K
3) 275K 4) 200K

6] One mole of ideal gas is filled in 2 litre flask at 0°C, the pressure of the gas will be **[1998]**

1) 1 atm **2) 11.2 atm**
3) 22.4 atm 4) 44.8 atm

7] Translational kinetic energy for 2 mol of gas at 27°C is **[1998]**

1) 7.48×10^3 J 2) 6.48×10^3 J
3) 5.48×10^3 J 4) 4.48×10^3 J

8] The molecular mass of an unknown gas that diffuses twice as fast as oxygen is **[1998]**

1) 0.032 kg mol^{-1} 2) 0.016 kg mol^{-1}
3) 0.004 kg mol^{-1} **4) 0.008 kg mol^{-1}**

9] At high temperature and low pressure, the compressibility factor (Z) of a van der Waal's gas is given by **[2000]**

1) $Z \to 0$ **2) $Z \to 1$**
3) $Z < 1$ 4) $Z > 1$

10] Which of the following is true for the value of gas constant R? **[2000]**

1) 0.0821 L.atm.K^{-1} mol^{-1}
2) 8.31 JK^{-1} mol^{-1}
3) 1.987cal $K^{-1}mol^{-1}$
4) All the above

11] 16 mL of hydrogen was found to diffuse in 60 seconds. What volume of sulphur dioxide would diffuse in the same time under the same conditions? **[2001]**

1) 2 mL **2)** $4/\sqrt{2}$ mL
3) $4\sqrt{2\text{mL}}$ 4) 60 mL

12] Equal masses of CH_4 and O_2 are mixed in an empty container at 25°C. the fraction of the total pressure exerted by CH_4 is

1) 2/3 2) 1/2S
3) 1/3 4) 1/6

13] Kinetic energy of one mole of an ideal gas at 300 K is **[2005]**

1) 3.48 kJ **2) 3.74 kJ**
3) 37.4 kJ 4) 34.8 kJ.

14] A gas has a vapour density 11.2. The volume occupied by 1 g of gas at NTP is **[2005]**

1) 1 litre 2) 11.2 litre
3) 22.4 litre 4) unpredictable

15] A gas can only be liquefied only **[2006]**

1) When the temperature of the gas is greater than the critical temperature
2) When the pressure of the gas is less than the critical pressure
3) When the temperature is less than the critical temperature and the pressure greater than the critical pressure
4) When the temperature is less than the critical temperature and the pressure is less than that of the critical pressure

16] Equal masses of methane and oxygen are mixed in an empty container at 25°C. The fraction of the total pressure exerted by oxygen is **[2007]**

1) $\frac{1}{2}$ **2)** $\frac{1}{3}$
3) $\frac{2}{3}$ 4) $\frac{1}{2}\times\frac{298}{273}$

17] At 27°C average kinetic energy of one mole of helium gas can be given **[2008]**

1) 3741.30 J mol^{-1} 2) 374.13 J mol^{-1}
3) 1662.8 J mol^{-1} 4) 166.28 J mol^{-1}

18] The units of constants a in van der Waals equation is **[2009]**

1) dm^6 atm mol^{-2} 2) dm^3 atm mol^{-1}
3) dm atm mol^{-1} 4) atm mol^{-1}

19] Critical temperature of H_2O, NH_3, CO_2 and O_2 are 647 K, 405.6 K, 304.10 K and 154.2 K respectively. If the cooling starts from 500 K to their critical temperature, the gas that liquefies first is **[2009]**

1) H_2O **2) NH_3**
3) CO_2 4) O_2

AIIMS

1] If the density ration of O_2 and H_2 is 16: 1, then ratio of their V_{rms} will be **[1994, 1999]**

1) 1: 1 **2) 1: 4**
3) 16: 1 4) 1: 16

2] Which of the following gases will have the highest rate of diffusion? **[1994]**

1) CO_2 2) N_2
3) NH_3 4) O_2

3] A mixture of 40 g of oxygen and 40 g of helium has a total pressure of 0.9 atm. The partial pressure of oxygen is **[1994]**

1) 0.5 atm **2) 0.1 atm**
3) 0.9 atm 4) 0.2 atm

4] Two different gases enclosed in different flasks *A* and *B* at same temperature and pressure were found to contain same number of molecules. The ratio of volumes of the flasks *A* and *B* must be **[1995]**

1) 1: 3 **2) 1: 1**
3) 1: 4 4) 1: 2

5] The temperature, at which the density of O_2 at 1 atm, is the same as that of CH_4 at STP, is **[1995]**

1) 273°C 2) 100°C
3) 546°C 4) 150°C

6] A certain gas diffuses four times as quickly as oxygen. The molecular mass of the gas is **[1995]**

1) 2 2) 1
3) 16 4) 1.5

7] Which of the following gas molecules have equal total kinetic energy and translational kinetic energy? **[1996]**

1) O_2 **2) He**
3) CH_4 4) N_2

8] If a gas occupies a volume of 300 cc at 27°C and 620 mm pressure, then the volume of the gas at 47°C and 640 mm pressure, is **[1997]**

1) 310 cc 2) 410 cc
3) 500 cc 4) 600 cc

9] The compressibility factor of an ideal gas is **[1997]**

1) 1 2) 2
3) 4 4) 6

10] In the gas equation, $PV = nRT$ **[1998]**

1) V is the volume of one mole of the gas
2) n no. of moles of the gas have volume V
3) n is the number of molecules of the gas
4) P is the pressure of one mole of the gas

11] At what pressure will a quantity of gas, this occupies 100 mL at a pressure of 720 mm, occupy a volume of 84 mL **[1998]**

1) 820.20 mm 2) 784.15 mm
3) 736.18 mm **4) 857.14 mm**

12] If 300 mL of a gas at 27°C is cooled to 7°C at constant pressure, its final volume will be **[1999]**

1) 350 mL 2) 540 mL
3) 135 mL **4) 280 mL**

13] Pressure in a mixture of 4 g of O_2 and 2 g of H_2 confined in a bulb of 1 litre at 0°C is **[1999]**

1) 45.215 atm 2) 31.205 atm
3) 25.215 atm 4) 15.210 atm

14] Helium atom is two times heavier than a hydrogen molecule. At 298 K, the average kinetic energy of the helium atom is **[2000]**

1) two times that of a hydrogen molecule
2) same as that of a hydrogen molecule
3) four times that of a hydrogen molecule
4) half that of a hydrogen molecule.

15] If the r.m.s speed of a gas molecule at 27°C is $100\sqrt{2}$ ms^{-1} the r.m.s speed at 327°C would be **[2000]**

1) 100 ms^{-1} **2) 200 ms^{-1}**
3) 300 ms^{-1} 4) 400 ms^{-1}

16] If P is pressure and ρ is density a gas, then P and ρ are related as **[2002]**

1) $P \propto \rho$ 2) $P \propto [1/\rho)$
3) $P \propto \rho^2$ 4) $P \propto [1/\rho^2)$

17] Dominance of strong repulsive force among the molecules of the gas [Z = compressibility factor] **[2006]**

1) Depends on and indicated by Z = 1
2) Depends on Z and indicated by Z > 1
3) Depends on Z and indicated by Z < 1
4) is independent of Z.

18] In P versus V graph, the horizontal line is found in which _____exists **[2006]**

1) Gas
2) Liquid
3) Equilibrium between gas and liquid
4) super critical temperature.

19] Critical temperatures for A, B, C and D gases are 25°C, 10°C - 80°C and 15°C respectively. Which gas will be liquefied more easily? **[2006]**

1) A 2) B
3) C 4) D

20] The root mean square speed of the molecules of diatomic gas is u. When the temperature is doubled, the molecules dissociate in two atoms. The new rms speed of the atom is **[2008]**

1) $\sqrt{2u}$ 2) u
3) 2u **4) 4u**

21] Two flasks X and Y have capacity 1L and 2L respectively and each of them contains 1 mole of a gas. The temperatures of the flasks are so adjusted that average speed of molecules in X is twice as those in Y. The pressure in flask X would be **[2010]**

1) same as that in Y
2) half of that in Y
3) twice of that in Y
4) 8 times of that in Y

22] In the van der Waals equation, 'a' signifies **[2011]**

1) Intermolecular attraction
2) Intramolecular attraction
3) attraction between molecules and wall of container
4) volume of molecules

23] If pressure becomes double at the same absolute temperature on 2*L* CO_2, then the volume of CO_2 becomes [**1992]**

1) 2 L
2) 4 L
3) 25 L
4) 1 L

24] Which of the following exhibits the weakest intermolecular forces **[2000]**

1) NH_3
2) HC*l*
3) He
4) H_2O

25] Pressure of a mixture of 4 g of O_2 and 2 g of H_2 confined in a bulb of 1 litre at O°C is **[2000]**

1) 25.215 atm
2) 31.205 atm
3) 45.215 atm
4) 15.210 atm

NEET

1] 50 mL of hydrogen diffuses out through a small hole of a vessel, in 20 minutes. The time taken by 40 mL of oxygen to diffuse out is **[1994]**

1) 32 minutes **2) 64 minutes**
3) 8 minutes 4) 12 minutes

2] The temperature of a gas is raised from 27°C to 927°C. The root mean square speed of the gas **[1999]**

1) remains same 2) gets $\sqrt{\frac{927}{27}}$ times
3) gets halved **4) gets doubled**

3] An ideal gas, obeying kinetic theory of gases CAN NOT be liquefied because **[1995]**

1) it solidifies before becoming a liquid
2) forces acting between its molecules are negligible
3) its critical temperature is above 0°C
4) its molecules are relatively small in size.

4] The average kinetic energy of an ideal gas, per molecule in S.I. units, at 25°C will be **[1996]**

1) 6.17×10^{-20} J 2) 7.16×10^{-20} J
3) 61.7×10^{-21} J **4) 6.17×10^{-21} J**

5] At what temperature, the rate of effusion of N_2 would be 1.625 times than the rate of SO_2 at 500°C? **[1996]**

1) 373°C **2) 620°C**
3) 110°C 4) 173°C

6] At 25°C and 730 mm pressure, 380 mL of dry oxygen was collected. If the temperature is constant, what volume will the oxygen occupy at 760 mm pressure? **[1999]**

1) 569 mL **2) 365 mL**
3) 265 mL 4) 621 mL

7] Which of the following statements is WRONG for gases? **[1999]**

1) Confined gas exerts uniform pressure on the walls of its container in all directions
2) Volume of the gas is equal to volume of container confining the gas
3) Gases do not have a definite shape and volume
4) **Mass of a gas CANNOT be determined by weighing a container in which it is enclosed.**

8] Which of the following does NOT show electrical conduction? **[1999]**

1) Diamond 2) Graphite
3) Potassium 4) Sodium

9] Average molar kinetic energy of CO and N_2 at same temperature is **[1999]**

1) $KE_1 = KE_2$
2) $KE_1 > KE_2$
3) $KE_1 < KE_2$
4) Can't say anything. Both volumes are not given.

10] van der Waal's real gas, act as an ideal gas, at **[1999]**

1) high temperature, low pressure
2) low temperature, high pressure
3) high temperature, high pressure
4) Low temperature, low pressure

11] The surface tension of which of the following liquid is maximum? **[2005]**

1) C_2H_5OH 2) CH_3OH
3) H_2O 4) C_6H_6

12] If a gas expands at constant temperature, it indicates that **[2008]**

1) kinetic energy of molecules remains the same
2) number of the molecules of gas increases
3) kinetic energy of molecules decreases
4) pressure of the gas increases.

13] The energy absorbed by each molecule $[A_2]$ of a substance is 4.4×10^{-19} J and bond energy per molecule is 4.0×10^{-19} J. The kinetic energy of the molecule per atom will be **[2009]**

1) 2.2×10^{-19} J 2) 2.0×10^{-19} J
3) 4.0×10^{-20} J **4) 2.0×10^{-20} J**

14] The pressure exerted by 6.0 g of methane gas in a 0.03 m^3 vessel at 129°C is [Atomic masses: C = 12.01, H = 1.01 and R = 8.314 J K^{-1} mol^{-1}] **[2010]**

1) 215216 Pa 2) 13409 Pa
3) 41648 Pa 4) 31684 Pa

15] By what factor does the average velocity of a gaseous molecule increase when the temperature (in K) is doubled? **[2011]**

1) 2.0 2) 2.8
3) 4.0 **4) 1.4**

16] A gaseous mixture was prepared by taking equal mole of CO and N_2. If the total pressure of the mixture was found 1 atmosphere, the partial pressure of the nitrogen (N_2) in the mixture is **[2011]**

1) 0.5 atm 2) 0.8 atm
3) 0.9 atm 4) 1 atm

17] A bubble of air is underwater at temperature 15°C and the pressure 1.5 bar. If the bubble rises to the surface where the temperature is 25°C and the pressure is 1.0 bar, what will happen to the volume of the bubble? **[2011]**

1) Volume will become grater by a factor of 1.6
2) Volume will become greater by a factor of 1.1.
3) Volume will become smaller by a factor of 0.70
4) Volume will become greater by a factor of 2.5.

18] 50 mL of each gas *A* and of gas *B* takes 150 and 200 seconds respectively for effusing through a pin hole under the similar conditions. If molecular mass of gas *B* is 36, the molecular mass of gas *A* will be **[2012]**

1) 96 2) 128
3) 32 **4) none of the above**

19] For real gases van der Waals equation is

Written as $\left(p+\frac{an^2}{V^2}\right)(V-nb)=nRT$

Where, a and b are van der Waals constants. Two sets of gases are
(I) O_2, CO_2, H_2 and (II) CH_4, O_2 and H_2
The gases given in set-I in increasing order of b and gases given in set-II in decreasing order of a, are arranged below. Select the CORRECT order from the following **[2012]**

1) (I) $He < H_2 < CO_2 < O_2$ (II) $CH_4 > H_2 > O_2$
2) (I) $O_2 < He < H_2 < CO_2$ (II) $H_2 > O_2 > CH_4$
3) (I) $H_2 < He < O_2 < CO_2$ (II) $CH_4 > O_2 > H_2$
4) (I) $H_2 < O_2 < He < CO_2$ (II) $O_2 > CH_4 > H_2$

20] Maximum deviation from ideal gas is expected from : **[2013]**

1) $NH_{3(g)}$
2) $H_{2(g)}$
3) $N_{2(g)}$
4) $CH_{4(g)}$

21] Dipole induced dipole interactions are present in which of the following pairs :- **[2013]**

1) SiF_4 and He atoms
2) H_2O and alcohol
3) CI_2 and CCI_4
4) HC*l* and He atoms

22] Equal moles of hydrogen and oxygen gases are placed in a container with a pin-hole through which both can escape. What fraction of the oxygen escapes in the time required for one-half of the hydrogen to escape ? **[2016]**

1) 1/4 2) 3/8
3) 1/2 **4) 1/8**

23] A 20 litre container at 400 K contains $CO_{2(g)}$ at pressure 0.4 atm and an excess of SrO (neglect the volume of solid SrO). The volume of the container is now decreased by moving the movable piston fitted in the container. The maximum volume of the container, when pressure of CO_2 attains its maximum value, will be: (Given that : $SrCO_{3(s)}$, K_p = 1.6 atm) **[2017]**

1) 2 litre
2) 5 litre
3) 10 litre
4) 4 litre

24] The correction factor 'a' to the ideal gas equation corresponds to – **[2018]**

1) density of the gas molecules
2) volume of the gas molecules
3) electric field present between the gas molecules
4) forces of attraction between the gas molecules

25] Given van der Waals constant for NH_3, H_2, O_2 and CO_2 are respectively 4.17, 0.244, 1.36 and 3.59, which one of the following gases is most easily liquefied? **[2018]**

1) NH_3
2) H_2
3) O_2
4) CO_2

CBSE PMT

1] Internal energy and pressure of a gas per unit volume are related as **[1993]**
[Here, E = total kinetic energy)

1) $P = \frac{2}{3}E$ 2) $P = \frac{3}{2}E$

3) $P = \frac{1}{2}E$ 4) $P = 2E$

2] At STP, 0.50 *mol* H_2 gas and 1.0 *mol* He gas **[1993, 2000]**

1) Have equal average kinetic energies
2) Have equal molecular speeds
3) Occupy equal volumes
4) Have equal effusion rates

3] Which of the following expressions correctly represents the relationship between the average molar kinetic energy, K.E, of *CO* and N_2 molecules at the same temperature **[2000]**

1) $\overline{KE}_{CO} = \overline{KE}_{N_2}$

2) $\overline{KE}_{CO} > \overline{KE}_{N_2}$

3) $\overline{KE}_{CO} < \overline{KE}_{N_2}$

4) Cannot be predicted unless the volumes of the gases are given

4] If *P*, *V*, *M*, *T* and *R* are pressure, volume, molar mass, temperature and gas constant respectively, then for an ideal gas, the density is given by **[1989, 91]**

1) $\frac{RT}{PM}$ 2) $\frac{P}{RT}$

3) $\frac{M}{V}$ **4)** $\frac{PM}{RT}$

5] Ratio of C_p and C_v of a gas '*X*' is 1.4. The number of atoms of the gas '*X*' present in 11.2 litres of it at N.T.P. is **[1989]**

1) 6.02×10^{23} 2) 1.2×10^{24}

3) 3.01×10^{23} 4) 2.01×10^{23}

6] The density of neon will be highest at **[1990]**

1) S.T.P. **2) 0°C, 2 atm**

3) 273°C, 1 atm 4) 273°C, 2 atm

7] Absolute zero is defined as the temperature **[1990]**

1) At which all molecular motion ceases
2) At which liquid helium boils
3) At which ether boils
4) All of the above

8] Which one of the following statements is wrong for Gases **[1999]**

1) Gases do not have a definite shape and volume
2) Volume of the gas is equal to the volume of the container confining the gas
3) Confined gas exerts uniform pressure on the walls of its container in all directions
4) Mass of the gas cannot be determined by weighing a container in which it is enclosed

9] At constant temperature, in a given mass of an ideal gas **[1991]**

1) The ratio of pressure and volume always remains constant
2) Volume always remains constant
3) Pressure always remains constant
4) The product of pressure and volume always remains constant

10] Pressure remaining the same, the volume of a given Mass of an ideal gas increases for every degree centigrade rise in temperature by definite fraction of its volume at **[1989]**

1) 0°C
2) Its critical temperature
3) Absolute zero
4) Its Boyle temperature

11] In a closed flask of 5 *litres*, 1.0 *g* of H_2 is heated from 300 to 600 *K*. which statement is NOT CORRECT **[1991]**

1) Pressure of the gas increases
2) The rate of collision increases
3) The number of moles of gas increases
4) The energy of gaseous molecules increases

12] Select one CORRECT statement. In the gas equation, PV = nRT **[1992]**

1) *n* is the number of molecules of a gas
2) *V* denotes volume of one mole of the gas
3) *n* moles of the gas have a volume *V*
4) *P* is the pressure of the gas when only one mole of gas is present

13] The CORRECT value of the gas constant *R* is close to **[1992]**

1) 0.082 litre- atmosphere K
2) 0.082 litre- atmosphere K^{-1} mol^{-1}
3) 0.082 litre- $atmosphere^{-1}$ K mol^{-1}
4) 0.082 $litre^{-1}$ $atmopshere^{-1}$ K mol

14] CORRECT gas equation is **[1989,1991]**

1) $\frac{V_1T_2}{P_1} = \frac{V_2T_1}{P_2}$ **2)** $\frac{P_1V_1}{P_2V_2} = \frac{T_1}{T_2}$

3) $\frac{P_1T_2}{V_1} = \frac{P_2V_2}{T_2}$ 4) $\frac{V_1V_2}{T_1T_2} = P_1P_2$

15] One litre of a gas weighs 2 g at 300 K and 1 atm pressure. If the pressure is made 0.75 atm, at which of the following temperatures will one litre of the same gas mass 1 g **[1992]**

1) 450 K 2) 600 K
3) 800 K 4) 900 K

16] A whether balloon filled with hydrogen at 1 atm and 27°C has volume equal to 12000 litres. On ascending it reaches a place where the temperature is –23°C and pressure is 0.5 atm. The volume of the balloon is **[1991]**

1) 24000 litres **2) 20000 litres**
3) 10000 litres 4) 12000 litres

17] The density of a gas at 27°C and 1 atm is d. Pressure remaining constant at which of the following temperatures will its density become 0.75 d **[1992]**

1) 20°C 2) 30°C
3) 400 *K* 4) 300 *K*

18] Which of the following mixtures of gases does NOT obey Dalton's law of partial pressure **[1996]**

1) $O_2$and CO_2 2) N_2 and O_2
3) Cl_2 and O_2 **4) NH_3 and HC*l***

19] Equal amounts of two gases of molecular mass 4 and 40 are mixed. The pressure of the mixture is 1.1 atm. The partial pressure of the light gas in this mixture is **[1991]**

1) 0.55 atm
2) 0.11 atm
3) 1 atm
4) 0.12 atm

20] At what temperature, the rate of effusion of N_2 would be 1.625 times that of SO_2 at 50°C **[1996]**

1) 110 K
2) 173 K
3) 373 K
4) 273 K

21] A bottle of cold drink contains 200 mL liquid in which CO_2 is 0.1 molar. Suppose CO_2 behaves like an ideal gas, the volume of the dissolved CO_2 at STP is **[1991]**

1) 0.224 litre **2) 0.448 litre**
3) 22.4 litre 4) 2.24 litre

22] The vapour density of a gas is 11.2. The volume occupied by 11.2 *g* of this gas at S.T.P. is **[1982, 1991]**

1) 1 L **2) 11.2 L**
3) 22.4 L 4) 20 L

23] The maximum number of molecules is present in **[2004]**

1) 0.5 g of H_2 gas
2) 10 g of O_2 gas
3) 15 L of H_2 gas at STP
4) 5 L of N_2 gas at STP

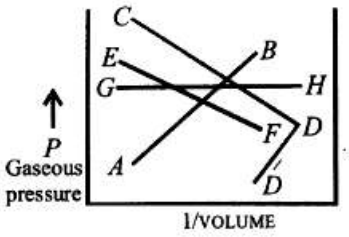
States Of Matters - Level III
Answer Key

AMU									
1	2	3	4	5	6	7	8	9	10
1	**1,3**	**3**	**4**	**1**	**2**	**1**	**4**	**2**	**4**
11	12	13	14	15	16	17	18	19	
2	**1**	**2**	**1**	**3**	2	1	1	2	
AIIMS									
1	2	3	4	5	6	7	8	9	10
2	**3**	**2**	**2**	**1**	**1**	**2**	**1**	**1**	**2**
11	12	13	14	15	16	17	18	19	20
4	**4**	**3**	**2**	**2**	**1**	**2**	**3**	**1**	**3,4**
21	22	23	24	25					
4	**1**	**4**	**3**	**1**					
NEET									
1	2	3	4	5	6	7	8	9	10
2	**4**	**2**	**4**	**2**	**2**	**4**	**1**	**1**	**1**
11	12	13	14	15	16	17	18	19	20
3	**1**	**4**	**3**	**4**	**1**	**1**	**4**	**3**	**1**
21	22	23	24	25					
4	**4**	**2**	**4**	**1**					
CBSE PMT									
1	2	3	4	5	6	7	8	9	10
1	**1**	**1**	**4**	**1**	**2**	**1**	**4**	**4**	**1**
11	12	13	14	15	16	17	18	19	20
3	**3**	**2**	**2**	**1**	**2**	**3**	**4**	**3**	**3**
21	22	23							
2	**2**	**3**							

02. States of Matter
[Level III)

AMU

1] Which one of the following pressure versus volume plots represents Boyle's Law? [see the accompanied diagram).



[1995]

1) line GH 2) line COD
3) line EF 4) line GH

2] Which of the following statement INCORRECT in respect of ideal gaseous behaviour?

[1995]

1) All the molecules are identical and have intermolecular force of attraction
2) The gaseous molecules exchange energies during molecular collisions
3) The collisions are inelastic
4) All the above.

3] Which is NOT true is case of an ideal gas?

[1996]

1) It cannot be converted into a liquid
2) There is no interaction between the molecules
3) All molecules of the gas move with same speed
4) At a given temperature, *PV* is proportional to the amount of the gas

4] A gas is enclosed in a room. The temperature, pressure, density and number of moles of the gas respectively are t°C, p atm, g cm^{-3} and n. If the room is partitioned into four equal compartments which of these quantities will be different in the small compartments? **[1996]**

1) Temperature 2) Pressure
3) Density 4) Number of moles.

5] A gas has a volume of 15 mL at 300 K and 740 mm of Hg. Find the temperature if volume becomes 10 mL at 760 mm pressure of Hg. **[1997]**

1) 205K 2) 209K
3) 275K 4) 200K

6] One mole of ideal gas is filled in 2 litre flask at 0°C, the pressure of the gas will be **[1998]**

1) 1 atm 2) 11.2 atm
3) 22.4 atm 4) 44.8 atm

7] Translational kinetic energy for 2 mol of gas at 27°C is **[1998]**

1) 7.48×10^3 J 2) 6.48×10^3 J
3) 5.48×10^3 J 4) 4.48×10^3 J

8] The molecular mass of an unknown gas that diffuses twice as fast as oxygen is **[1998]**

1) 0.032 kg mol^{-1} 2) 0.016 kg mol^{-1}
3) 0.004 kg mol^{-1} 4) 0.008 kg mol^{-1}

9] At high temperature and low pressure, the compressibility factor (Z) of a van der Waal's gas is given by **[2000]**

1) $Z \to 0$ 2) $Z \to 1$
3) $Z < 1$ 4) $Z > 1$

10] Which of the following is true for the value of gas constant R? **[2000]**

1) 0.0821 L.atm.K^{-1} mol^{-1}
2) 8.31 JK^{-1} mol^{-1}
3) 1.987cal $K^{-1}mol^{-1}$
4) All the above

11] 16 mL of hydrogen was found to diffuse in 60 seconds. What volume of sulphur dioxide would diffuse in the same time under the same conditions? **[2001]**

1) 2 mL 2) $4/\sqrt{2}$ mL
3) $4\sqrt{2\text{mL}}$ 4) 60 mL

12] Equal masses of CH_4 and O_2 are mixed in an empty container at 25°C. the fraction of the total pressure exerted by CH_4 is

1) 2/3 2) 1/2S
3) 1/3 4) 1/6

13] Kinetic energy of one mole of an ideal gas at 300 K is **[2005]**

1) 3.48 kJ 2) 3.74 kJ
3) 37.4 kJ 4) 34.8 kJ.

14] A gas has a vapour density 11.2. The volume occupied by 1 g of gas at NTP is **[2005]**

1) 1 litre 2) 11.2 litre
3) 22.4 litre 4) unpredictable

15] A gas can only be liquefied only **[2006]**

1) When the temperature of the gas is greater than the critical temperature
2) When the pressure of the gas is less than the critical pressure
3) When the temperature is less than the critical temperature and the pressure greater than the critical pressure
4) When the temperature is less than the critical temperature and the pressure is less than that of the critical pressure

16] Equal masses of methane and oxygen are mixed in an empty container at 25°C. The fraction of the total pressure exerted by oxygen is **[2007]**

1) $\frac{1}{2}$ 2) $\frac{1}{3}$
3) $\frac{2}{3}$ 4) $\frac{1}{2}\times\frac{298}{273}$

17] At 27°C average kinetic energy of one mole of helium gas can be given **[2008]**

1) 3741.30 J mol^{-1} 2) 374.13 J mol^{-1}
3) 1662.8 J mol^{-1} 4) 166.28 J mol^{-1}

18] The units of constants a in van der Waals equation is **[2009]**

1) dm^6 atm mol^{-2} 2) dm^3 atm mol^{-1}
3) dm atm mol^{-1} 4) atm mol^{-1}

19] Critical temperature of H_2O, NH_3, CO_2 and O_2 are 647 K, 405.6 K, 304.10 K and 154.2 K respectively. If the cooling starts from 500 K to their critical temperature, the gas that liquefies first is **[2009]**

1) H_2O 2) NH_3
3) CO_2 4) O_2

AIIMS

1] If the density ration of O_2 and H_2 is 16: 1, then ratio of their V_{rms} will be **[1994, 1999]**

1) 1: 1 2) 1: 4
3) 16: 1 4) 1: 16

2] Which of the following gases will have the highest rate of diffusion? **[1994]**

1) CO_2 2) N_2
3) NH_3 4) O_2

3] A mixture of 40 g of oxygen and 40 g of helium has a total pressure of 0.9 atm. The partial pressure of oxygen is **[1994]**

1) 0.5 atm 2) 0.1 atm
3) 0.9 atm 4) 0.2 atm

4] Two different gases enclosed in different flasks *A* and *B* at same temperature and pressure were found to contain same number of molecules. The ratio of volumes of the flasks *A* and *B* must be **[1995]**

1) 1: 3 2) 1: 1
3) 1: 4 4) 1: 2

5] The temperature, at which the density of O_2 at 1 atm, is the same as that of CH_4 at STP, is **[1995]**

1) 273°C 2) 100°C
3) 546°C 4) 150°C

6] A certain gas diffuses four times as quickly as oxygen. The molecular mass of the gas is **[1995]**

1) 2 2) 1
3) 16 4) 1.5

7] Which of the following gas molecules have equal total kinetic energy and translational kinetic energy? **[1996]**

1) O_2 2) He
3) CH_4 4) N_2

8] If a gas occupies a volume of 300 cc at 27°C and 620 mm pressure, then the volume of the gas at 47°C and 640 mm pressure, is **[1997]**

1) 310 cc 2) 410 cc
3) 500 cc 4) 600 cc

9] The compressibility factor of an ideal gas is **[1997]**

1) 1 2) 2
3) 4 4) 6

10] In the gas equation, $PV = nRT$ **[1998]**

1) V is the volume of one mole of the gas
2) n no. of moles of the gas have volume V
3) n is the number of molecules of the gas
4) P is the pressure of one mole of the gas

11] At what pressure will a quantity of gas, this occupies 100 mL at a pressure of 720 mm, occupy a volume of 84 mL **[1998]**

1) 820.20 mm 2) 784.15 mm
3) 736.18 mm 4) 857.14 mm

12] If 300 mL of a gas at 27°C is cooled to 7°C at constant pressure, its final volume will be **[1999]**

1) 350 mL 2) 540 mL
3) 135 mL 4) 280 mL

13] Pressure in a mixture of 4 g of O_2 and 2 g of H_2 confined in a bulb of 1 litre at 0°C is **[1999]**

1) 45.215 atm 2) 31.205 atm
3) 25.215 atm 4) 15.210 atm

14] Helium atom is two times heavier than a hydrogen molecule. At 298 K, the average kinetic energy of the helium atom is **[2000]**

1) two times that of a hydrogen molecule
2) same as that of a hydrogen molecule
3) four times that of a hydrogen molecule
4) half that of a hydrogen molecule.

15] If the r.m.s speed of a gas molecule at 27°C is $100\sqrt{2}$ ms^{-1} the r.m.s speed at 327°C would be **[2000]**

1) 100 ms^{-1} 2) 200 ms^{-1}
3) 300 ms^{-1} 4) 400 ms^{-1}

16] If P is pressure and ρ is density a gas, then P and ρ are related as **[2002]**

1) $P \propto \rho$ 2) $P \propto [1/\rho)$
3) $P \propto \rho^2$ 4) $P \propto [1/\rho^2)$

17] Dominance of strong repulsive force among the molecules of the gas [Z = compressibility factor] **[2006]**

1) Depends on and indicated by Z = 1
2) Depends on Z and indicated by $Z > 1$
3) Depends on Z and indicated by $Z < 1$
4) is independent of Z.

18] In P versus V graph, the horizontal line is found in which _____exists **[2006]**

1) Gas
2) Liquid
3) Equilibrium between gas and liquid
4) super critical temperature.

19] Critical temperatures for A, B, C and D gases are 25°C, 10°C - 80°C and 15°C respectively. Which gas will be liquefied more easily? **[2006]**

1) A 2) B
3) C 4) D

20] The root mean square speed of the molecules of diatomic gas is u. When the temperature is doubled, the molecules dissociate in two atoms. The new rms speed of the atom is **[2008]**

1) $\sqrt{2u}$ 2) u
3) 2u 4) 4u

21] Two flasks X and Y have capacity 1L and 2L respectively and each of them contains 1 mole of a gas. The temperatures of the flasks are so adjusted that average speed of molecules in X is twice as those in Y. The pressure in flask X would be **[2010]**

1) same as that in Y
2) half of that in Y
3) twice of that in Y
4) 8 times of that in Y

22] In the van der Waals equation, 'a' signifies **[2011]**

1) Intermolecular attraction
2) Intramolecular attraction
3) attraction between molecules and wall of container
4) volume of molecules

23] If pressure becomes double at the same absolute temperature on 2*L* CO_2, then the volume of CO_2 becomes [**1992]**

1) 2 L
2) 4 L
3) 25 L
4) 1 L

24] Which of the following exhibits the weakest intermolecular forces **[2000]**

1) NH_3
2) HC*l*
3) He
4) H_2O

25] Pressure of a mixture of 4 g of O_2 and 2 g of H_2 confined in a bulb of 1 litre at O°C is **[2000]**

1) 25.215 atm
2) 31.205 atm
3) 45.215 atm
4) 15.210 atm

NEET

1] 50 mL of hydrogen diffuses out through a small hole of a vessel, in 20 minutes. The time taken by 40 mL of oxygen to diffuse out is **[1994]**

1) 32 minutes
2) 64 minutes
3) 8 minutes
4) 12 minutes

2] The temperature of a gas is raised from 27°C to 927°C. The root mean square speed of the gas **[1999]**

1) remains same
2) gets $\sqrt{\frac{927}{27}}$ times
3) gets halved
4) gets doubled

3] An ideal gas, obeying kinetic theory of gases CAN NOT be liquefied because **[1995]**

1) it solidifies before becoming a liquid
2) forces acting between its molecules are negligible
3) its critical temperature is above 0°C
4) its molecules are relatively small in size.

4] The average kinetic energy of an ideal gas, per molecule in S.I. units, at 25°C will be **[1996]**

1) 6.17×10^{-20} J
2) 7.16×10^{-20} J
3) 61.7×10^{-21} J
4) 6.17×10^{-21} J

5] At what temperature, the rate of effusion of N_2 would be 1.625 times than the rate of SO_2 at 500°C? **[1996]**

1) 373°C
2) 620°C
3) 110°C
4) 173°C

6] At 25°C and 730 mm pressure, 380 mL of dry oxygen was collected. If the temperature is constant, what volume will the oxygen occupy at 760 mm pressure? **[1999]**

1) 569 mL
2) 365 mL
3) 265 mL
4) 621 mL

7] Which of the following statements is WRONG for gases? **[1999]**

1) Confined gas exerts uniform pressure on the walls of its container in all directions
2) Volume of the gas is equal to volume of container confining the gas
3) Gases do not have a definite shape and volume
4) Mass of a gas CANNOT be determined by weighing a container in which it is enclosed.

8] Which of the following does NOT show electrical conduction? **[1999]**

1) Diamond 2) Graphite
3) Potassium 4) Sodium

9] Average molar kinetic energy of CO and N_2 at same temperature is **[1999]**

1) $KE_1 = KE_2$
2) $KE_1 > KE_2$
3) $KE_1 < KE_2$
4) Can't say anything. Both volumes are not given.

10] van der Waal's real gas, act as an ideal gas, at **[1999]**

1) high temperature, low pressure
2) low temperature, high pressure
3) high temperature, high pressure
4) Low temperature, low pressure

11] The surface tension of which of the following liquid is maximum? **[2005]**

1) C_2H_5OH 2) CH_3OH
3) H_2O 4) C_6H_6

12] If a gas expands at constant temperature, it indicates that **[2008]**

1) kinetic energy of molecules remains the same
2) number of the molecules of gas increases
3) kinetic energy of molecules decreases
4) pressure of the gas increases.

13] The energy absorbed by each molecule $[A_2]$ of a substance is 4.4×10^{-19} J and bond energy per molecule is 4.0×10^{-19} J. The kinetic energy of the molecule per atom will be **[2009]**

1) 2.2×10^{-19} J 2) 2.0×10^{-19} J
3) 4.0×10^{-20} J 4) 2.0×10^{-20} J

14] The pressure exerted by 6.0 g of methane gas in a 0.03 m^3 vessel at 129°C is [Atomic masses: C = 12.01, H = 1.01 and R = 8.314 J K^{-1} mol^{-1}] **[2010]**

1) 215216 Pa 2) 13409 Pa
3) 41648 Pa 4) 31684 Pa

15] By what factor does the average velocity of a gaseous molecule increase when the temperature (in K) is doubled? **[2011]**

1) 2.0 2) 2.8
3) 4.0 4) 1.4

16] A gaseous mixture was prepared by taking equal mole of CO and N_2. If the total pressure of the mixture was found 1 atmosphere, the partial pressure of the nitrogen (N_2) in the mixture is **[2011]**

1) 0.5 atm 2) 0.8 atm
3) 0.9 atm 4) 1 atm

17] A bubble of air is underwater at temperature 15°C and the pressure 1.5 bar. If the bubble rises to the surface where the temperature is 25°C and the pressure is 1.0 bar, what will happen to the volume of the bubble? **[2011]**

1) Volume will become grater by a factor of 1.6
2) Volume will become greater by a factor of 1.1.
3) Volume will become smaller by a factor of 0.70
4) Volume will become greater by a factor of 2.5.

18] 50 mL of each gas *A* and of gas *B* takes 150 and 200 seconds respectively for effusing through a pin hole under the similar conditions. If molecular mass of gas *B* is 36, the molecular mass of gas *A* will be **[2012]**

1) 96 2) 128
3) 32 4) none of the above

19] For real gases van der Waals equation is

Written as $\left(p+\frac{an^2}{V^2}\right)(V-nb)=nRT$

Where, a and b are van der Waals constants. Two sets of gases are
(I) O_2, CO_2, H_2 and (II) CH_4, O_2 and H_2
The gases given in set-I in increasing order of b and gases given in set-II in decreasing order of a, are arranged below. Select the CORRECT order from the following **[2012]**

1) (I) $He < H_2 < CO_2 < O_2$ (II) $CH_4 > H_2 > O_2$
2) (I) $O_2 < He < H_2 < CO_2$ (II) $H_2 > O_2 > CH_4$
3) (I) $H_2 < He < O_2 < CO_2$ (II) $CH_4 > O_2 > H_2$
4) (I) $H_2 < O_2 < He < CO_2$ (II) $O_2 > CH_4 > H_2$

20] Maximum deviation from ideal gas is expected from : **[2013]**

1) $NH_{3(g)}$ 2) $H_{2(g)}$
3) $N_{2(g)}$ 4) $CH_{4(g)}$

21] Dipole induced dipole interactions are present in which of the following pairs :- **[2013]**

1) SiF_4 and He atoms
2) H_2O and alcohol
3) CI_2 and CCI_4
4) HCI and He atoms

22] Equal moles of hydrogen and oxygen gases are placed in a container with a pin-hole through which both can escape. What fraction of the oxygen escapes in the time required for one-half of the hydrogen to escape ? **[2016]**

1) 1/4
2) 3/8
3) 1/2
4) 1/8

23] A 20 litre container at 400 K contains $CO_{2(g)}$ at pressure 0.4 atm and an excess of SrO (neglect the volume of solid SrO). The volume of the container is now decreased by moving the movable piston fitted in the container. The maximum volume of the container, when pressure of CO_2 attains its maximum value, will be: (Given that : $SrCO_{3(s)}$, K_p = 1.6 atm) **[2017]**

1) 2 litre
2) 5 litre
3) 10 litre
4) 4 litre

24] The correction factor 'a' to the ideal gas equation corresponds to – **[2018]**

1) density of the gas molecules
2) volume of the gas molecules
3) electric field present between the gas molecules
4) forces of attraction between the gas molecules

25] Given van der Waals constant for NH_3, H_2, O_2 and CO_2 are respectively 4.17, 0.244, 1.36 and 3.59, which one of the following gases is most easily liquefied? **[2018]**

1) NH_3
2) H_2
3) O_2
4) CO_2

CBSE PMT

1] Internal energy and pressure of a gas per unit volume are related as **[1993]**
[Here, E = total kinetic energy)

1) $P = \frac{2}{3}E$ 2) $P = \frac{3}{2}E$

3) $P = \frac{1}{2}E$ 4) $P = 2E$

2] At STP, 0.50 *mol* H_2 gas and 1.0 *mol* He gas **[1993, 2000]**

1) Have equal average kinetic energies
2) Have equal molecular speeds
3) Occupy equal volumes
4) Have equal effusion rates

3] Which of the following expressions correctly represents the relationship between the average molar kinetic energy, K.E, of *CO* and N_2 molecules at the same temperature **[2000]**

1) $\overline{KE}_{CO} = \overline{KE}_{N_2}$
2) $\overline{KE}_{CO} > \overline{KE}_{N_2}$
3) $\overline{KE}_{CO} < \overline{KE}_{N_2}$
4) Cannot be predicted unless the volumes of the gases are given

4] If *P*, *V*, *M*, *T* and *R* are pressure, volume, molar mass, temperature and gas constant respectively, then for an ideal gas, the density is given by **[1989, 91]**

1) $\frac{RT}{PM}$ 2) $\frac{P}{RT}$

3) $\frac{M}{V}$ 4) $\frac{PM}{RT}$

5] Ratio of C_p and C_v of a gas '*X*' is 1.4. The number of atoms of the gas '*X*' present in 11.2 litres of it at N.T.P. is **[1989]**

1) 6.02×10^{23} 2) 1.2×10^{24}
3) 3.01×10^{23} 4) 2.01×10^{23}

6] The density of neon will be highest at **[1990]**

1) S.T.P. 2) 0^oC, 2 atm
3) 273^oC, 1 atm 4) 273^oC, 2 atm

7] Absolute zero is defined as the temperature **[1990]**

1) At which all molecular motion ceases
2) At which liquid helium boils
3) At which ether boils
4) All of the above

8] Which one of the following statements is wrong for Gases **[1999]**

1) Gases do not have a definite shape and volume
2) Volume of the gas is equal to the volume of the container confining the gas
3) Confined gas exerts uniform pressure on the walls of its container in all directions
4) Mass of the gas cannot be determined by weighing a container in which it is enclosed

9] At constant temperature, in a given mass of an ideal gas **[1991]**

1) The ratio of pressure and volume always remains constant
2) Volume always remains constant
3) Pressure always remains constant
4) The product of pressure and volume always remains constant

10] Pressure remaining the same, the volume of a given Mass of an ideal gas increases for every degree centigrade rise in temperature by definite fraction of its volume at **[1989]**

1) 0^oC
2) Its critical temperature
3) Absolute zero
4) Its Boyle temperature

11] In a closed flask of 5 *litres*, 1.0 *g* of H_2 is heated from 300 to 600 *K*. which statement is NOT CORRECT **[1991]**

1) Pressure of the gas increases
2) The rate of collision increases
3) The number of moles of gas increases
4) The energy of gaseous molecules increases

12] Select one CORRECT statement. In the gas equation, PV = nRT **[1992]**

1) *n* is the number of molecules of a gas
2) *V* denotes volume of one mole of the gas
3) *n* moles of the gas have a volume *V*
4) *P* is the pressure of the gas when only one mole of gas is present

13] The CORRECT value of the gas constant *R* is close to **[1992]**

1) 0.082 litre- atmosphere K
2) 0.082 litre- atmosphere K^{-1} mol^{-1}
3) 0.082 litre- $atmosphere^{-1}$ K mol^{-1}
4) 0.082 $litre^{-1}$ $atmopshere^{-1}$ K mol

14] CORRECT gas equation is **[1989,1991]**

1) $\frac{V_1T_2}{P_1} = \frac{V_2T_1}{P_2}$
2) $\frac{P_1V_1}{P_2V_2} = \frac{T_1}{T_2}$
3) $\frac{P_1T_2}{V_1} = \frac{P_2V_2}{T_2}$
4) $\frac{V_1V_2}{T_1T_2} = P_1P_2$

15] One litre of a gas weighs 2 g at 300 K and 1 atm pressure. If the pressure is made 0.75 atm, at which of the following temperatures will one litre of the same gas mass 1 g **[1992]**

1) 450 K
2) 600 K
3) 800 K
4) 900 K

16] A whether balloon filled with hydrogen at 1 atm and 27°C has volume equal to 12000 litres. On ascending it reaches a place where the temperature is –23°C and pressure is 0.5 atm. The volume of the balloon is **[1991]**

1) 24000 litres
2) 20000 litres
3) 10000 litres
4) 12000 litres

17] The density of a gas at 27°C and 1 atm is d. Pressure remaining constant at which of the following temperatures will its density become 0.75 d **[1992]**

1) 20°C
2) 30°C
3) 400 *K*
4) 300 *K*

18] Which of the following mixtures of gases does NOT obey Dalton's law of partial pressure **[1996]**

1) $O_2$and CO_2
2) N_2 and O_2
3) Cl_2 and O_2
4) NH_3 and HC*l*

19] Equal amounts of two gases of molecular mass 4 and 40 are mixed. The pressure of the mixture is 1.1 atm. The partial pressure of the light gas in this mixture is **[1991]**

1) 0.55 atm
2) 0.11 atm
3) 1 atm
4) 0.12 atm

20] At what temperature, the rate of effusion of N_2 would be 1.625 times that of SO_2 at 50°C **[1996]**

1) 110 K
2) 173 K
3) 373 K
4) 273 K

21] A bottle of cold drink contains 200 mL liquid in which CO_2 is 0.1 molar. Suppose CO_2 behaves like an ideal gas, the volume of the dissolved CO_2 at STP is **[1991]**

1) 0.224 litre
2) 0.448 litre
3) 22.4 litre
4) 2.24 litre

22] The vapour density of a gas is 11.2. The volume occupied by 11.2 *g* of this gas at S.T.P. is **[1982, 1991]**

1) 1 L
2) 11.2 L
3) 22.4 L
4) 20 L

23] The maximum number of molecules is present in **[2004]**

1) 0.5 g of H_2 gas
2) 10 g of O_2 gas
3) 15 L of H_2 gas at STP
4) 5 L of N_2 gas at STP

States Of Matters - Level III
Answer Key

AMU									
1	2	3	4	5	6	7	8	9	10
1	**1,3**	**3**	**4**	**1**	**2**	**1**	**4**	**2**	**4**
11	12	13	14	15	16	17	18	19	
2	**1**	**2**	**1**	**3**	2	1	1	2	
AIIMS									
1	2	3	4	5	6	7	8	9	10
2	**3**	**2**	**2**	**1**	**1**	**2**	**1**	**1**	**2**
11	12	13	14	15	16	17	18	19	20
4	**4**	**3**	**2**	**2**	**1**	**2**	**3**	**1**	**3,4**
21	22	23	24	25					
4	**1**	**4**	**3**	**1**					
NEET									
1	2	3	4	5	6	7	8	9	10
2	**4**	**2**	**4**	**2**	**2**	**4**	**1**	**1**	**1**
11	12	13	14	15	16	17	18	19	20
3	**1**	**4**	**3**	**4**	**1**	**1**	**4**	**3**	**1**
21	22	23	24	25					
4	**4**	**2**	**4**	**1**					
CBSE PMT									
1	2	3	4	5	6	7	8	9	10
1	**1**	**1**	**4**	**1**	**2**	**1**	**4**	**4**	**1**
11	12	13	14	15	16	17	18	19	20
3	**3**	**2**	**2**	**1**	**2**	**3**	**4**	**3**	**3**
21	22	23							
2	**2**	**3**							

States of Matter
Level - III (Hints & Solution)

AMU

1] According to Boyle's law, at constant temperature, $P \propto \frac{1}{V}$

3] Molecules of a gas move with different speeds.

5] According to gas equation.

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$\frac{740 \times 15}{300} = \frac{760 \times 10}{T_2}$$

$\therefore T_2 = 205$ K

6] According to ideal gas equation, PV = nRT

R = 0.0821 L. atm K^{-1} mol^{-1}

$P \times 2 = 1 \times 0.0821 \times 273$

P = 11.2 atm.

7] Translational kinetic energy = $\frac{3nRT}{2}$

n = no of moles

R = gas contact

T = temperature

$$K.E = \frac{3 \times 2 \times 8.314 \times 300}{2} = 7.48 \times 10^3 \text{ J}$$

8] Acc. To Graham's law of diffusion.

$$\frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}}$$

$$\frac{r_1}{2r_1} = \sqrt{\frac{M_2}{32}}$$

$$\frac{1}{4} = \frac{M_2}{32}; \qquad M_2 = 8 \text{ g or } 0.008 \text{ kg mol}^{-1}$$

9] All gases tend to behave ideally at low pressure and high temperature and value of Z approaches to 1.

11] According to Graham's law of diffusion

$$\frac{(Rate)_1}{(Rate)_2} = \frac{V_1 / t_1}{V_2 / t_2} = \sqrt{\frac{M_2}{M_1}}$$

$$\therefore \frac{V_{H_2} \cdot t_{SO_2}}{t_{H_2} \cdot V_{SO_2}} = \sqrt{\frac{M_{SO_2}}{M_{H_2}}} \Rightarrow \frac{16 \times 60}{60 \times V_{SO_2}} = \sqrt{\frac{64}{2}}$$

$$\Rightarrow \frac{16}{V_{SO_2}} = \sqrt{32} \Rightarrow V_{SO_2} = \frac{16}{\sqrt{32}}$$

Or, $V_{SO_2} = \frac{16}{4\sqrt{2}} = \frac{4}{\sqrt{2}}$ mL

12] $p_{total} = p_{O_2} + p_{CH_4}$

$$p_{total} = \frac{n_{O_2} \cdot R \cdot T}{V} + \frac{n_{CH_4} \cdot R \cdot T}{V}$$

$$p_{total} = \left(\frac{w}{32} + \frac{w}{16}\right)\frac{RT}{V} = \frac{3w}{32} \times \frac{RT}{V}$$

$$\frac{p_{CH_4}}{p_{total}} = \frac{w}{16} \times \frac{32}{3w} \times \frac{2}{3}$$

13] Kinetic energy $= \frac{3}{2}nRT = \frac{3}{2} \times 1 \times 8.31 \times 300$

= 3739.5 Joule = 3.74 kJ

14] Given vapour density = 11.2

$\therefore$ Molecular mass = $2 \times 11.2 = 22.4$

Now, $\because$ at NTP 22.4 g of gas occupies = 22.4 L

$\therefore$ At NTP 1 g gas occupies is = $\frac{22.4}{22.4} = 1$ L

16] Let the mass of each gas = m

Number of molecules of O_2 (n_o) = $\frac{m}{32} \times 6.023 \times 10^{23}$

Number of molecules of CH_4(n_m)= $\frac{m}{16} \times 6.023 \times 10^{23}$

Partial pressure of O_2, $P_O = \frac{n_o \times RT}{V}$ ……(i)

Total pressure of two gas, $P = \frac{nRT}{V}$ ……(ii)

Where $n = n_o + n_m$

Dividing (i) from (ii) $\frac{P_o}{P} = \frac{n_o RT}{V} \times \frac{V}{nRT}$

$$= \frac{n_o}{n} = \frac{\frac{m}{32}}{\frac{m}{32} + \frac{m}{16}} = \frac{m}{32} \times \frac{32}{3m} = \frac{1}{3}$$

17] The average kinetic energy per mole does not depend on the nature of the gas but depends only on temperature.

Average kinetic energy per mole = $\frac{3}{2}RT$

Given:

$T = 27^oC = 273 + 27 = 300\ K$

$R = 8.314\ JK^{-1}\ mol^{-1}$

$\Rightarrow$ K.E. = $3/2 \times 8.314 \times 300 = 3741.3\ J\ mol^{-1}$.

18] $P = \frac{n^2a}{V^2}$

$a = \frac{PV^2}{n^2}$ = atm dm^6 mol^{-2}

19] Since the cooling start from 500 K, so water is not under consideration. As it is much easier to achieve 500K from 405.6 K so, NH_3 will get liquefied first.

AIIMS

1] $\frac{p_{O_2}}{p_{H_2}} = \frac{16}{1} \Rightarrow \frac{m_{O_2}}{m_{H_2}} = \frac{16}{1}$

$V_{rms} \propto \left(\frac{1}{m}\right)^{1/2} \Rightarrow \frac{V_{rms}(O_2)}{V_{rms}(H_2)} = \left(\frac{m_{H_2}}{m_{O_2}}\right)^{1/2} = \left(\frac{1}{16}\right)^{1/2} = \frac{1}{4}$

2] Rate of diffusion $\propto (1/M)$

M = molecular mass

$M(CO_2) = 44$ $M(N_2) = 28$

$M(NH_3) = 17$ $M(O_2) = 32$

Therefore, rate of diffusion of NH_3 is greater than others.

3] No. of mol of O_2 = $\frac{\text{Mass}}{\text{Mol.mass}} = \frac{40}{32} = 1.25\,\text{mol}$

No. of mol of He = $\frac{40}{4} = 10\,\text{mol}$

Mole fraction of O_2 = $\frac{1.25}{1.25+10} = \frac{1.25}{11.25} = \frac{1}{9}$

Partial Pressure of Oxygen = $\frac{1}{9} \times 0.9\,\text{atm}$

= 0.1 atm

4] The Avogadro's law states that same volume of all gases at the same temperature and pressure, contain equal number of molecules. Hence ratio of volumes must be 1 : 1.

5] The density of O_2 at STP. (d_1) = $\frac{32}{22.4}$ g / L and

that of CH_4 at STP (d_2) = $\frac{16}{22.4}$ g/L.

We know that $d_1T_1 = d_2T_2$ or $T_2 = \frac{d_1T_1}{d_2}$

$= \frac{32}{22.4} \times \frac{273}{1} \times \frac{22.4}{16} = 546\,K = 273\ ^oC$

(where T_1 at STP is 273 K.)

6] Rate of diffusion $\propto \frac{1}{\sqrt{M}}$

M = Molecular mass

$\Rightarrow \frac{r_x}{r_{O_2}} = 4 = \sqrt{\frac{M_{O_2}}{M_x}}$

$\Rightarrow 16 = \frac{32}{M_x} \Rightarrow M_x = 2$

r_x = rate of diffusion of x (gas)

M_x = molecular mass of x

7] The total kinetic energy of a molecule is the sum of its translational, vibrational and rotational kinetic energies. The monoatomic moleucles do not possess vibrational and rotational kinetic energies. Hence noble gases (like He, Ar etc) fulfill the criteria.

8] According to Charles' and Boyle's law,

$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

$\Rightarrow \frac{620 \times 300}{300} = \frac{640 \times V_2}{320}$

$\Rightarrow$ V_2 = 310 cc

9] Compressibility factor is defined as:

$Z = \frac{PV}{(PV)\text{ideal}} = \frac{PV}{nRT}$

for non-ideal gases, $Z \neq 1$

for ideal gases, $Z = 1$

11] According to Boyle's law,

$P_1V_1 = P_2V_2$

Putting values here, we get;

$100 \times 720 = P_2 \times 84$

$\Rightarrow P_2 = 857.14$ mm

12] According to Charles' law,

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

$\Rightarrow$ putting the given values:

$$\frac{300\text{mL}}{300\text{K}} = \frac{V_2}{280} \Rightarrow V_2 = 280\text{mL}$$

13] Moles of oxygen, $n_{O_2} = \frac{4}{32} = 0.125\,\text{mol}$

Moles of Hydrogen, $n_{H_2} = \frac{2}{2} = 1\,\text{mol}$

Temperature = 273 K, volume = 1 L

$$\Rightarrow \text{Total pressure} = \frac{(n_{O_2} + n_{H_2}) \times RT}{V}$$

$$= \frac{1.125 \times 0.0821 \times 273}{1}$$

= 25.215 atm.

14] Average kinetic energy per mole does not depend on the nature of the gas. it depends only on temperature.

Average kinetic energy per molecule = $\frac{3}{2}kT$

k = Boltzman constant, T = temperature.

15] Root mean square velocity is given by:

$$V_{rms} = \sqrt{\frac{3kT}{m}} \Rightarrow V_{rms} \propto \sqrt{T}$$

$$\Rightarrow \frac{V_{rms}(\text{at } 27^\circ\text{C})}{V_{rms}(\text{at } 327^\circ\text{C})} = \sqrt{\frac{(27+273)\text{K}}{(327+273)\text{K}}}$$

$$= \sqrt{\frac{300}{600}} = \frac{1}{\sqrt{2}}$$

$\therefore V_{rms}$ (at 327°C) = $100\sqrt{2} \times \sqrt{2} = 200$ ms^{-1}

16] Ideal gas equation is given as:

PV = nRT

P = Pressure of gas, V = volume of gas

n = moles of gas, R = gas constant

T = temperature

$\Rightarrow PV = \frac{w}{M}RT$ w = mass of gas

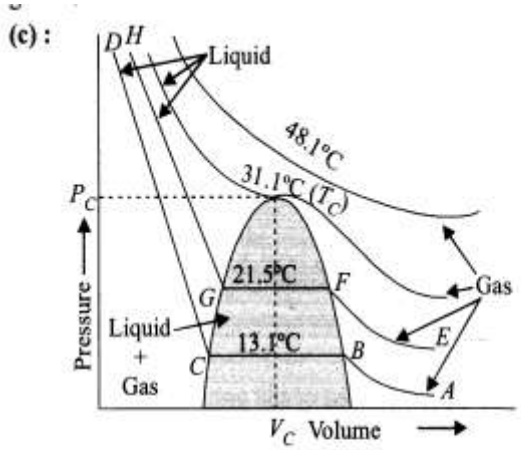
M = molecular mass of gas

$$P = \left(\frac{w}{V}\right)\frac{RT}{M} \Rightarrow P = \rho\frac{RT}{M}$$

$$\left(\text{As}\,\rho = \frac{w}{V}\right) \qquad \Rightarrow P \propto \rho$$

17] When the value of Z < 1, it is due to attractive forces between molecules. At high pressure, when Z > 1, it is due to repulsive forces between electron clouds of the molecules of gases.

18]



From the graph, at point *A*, CO_2 exists as a gas,
As pressure is increased, the volume of the gas decreases along the curve *AB*. At *B* liquefaction of the gas starts. Hence, volume decreases rapidly along *BC* because liquid has much less volume than the gas. At point *C*, liquefaction is complete. Amount of gas decreased = Amount of liquid formed or increased.
Because along horizontal line, gas converts into liquid.

19] Critical temperature of gas may be defined as that temperature above which it cannot be liquefied. How so ever high pressure may be applied on the gas

As we know, $T_C = \frac{8a}{27Rb}$

Where a = van der Waal's constant which is a measure of intermolecular forces of attraction.

Greater the value of 'a' more easily the gas can be liquefied and hence larger T_C mean larger the value of a.

20] $u = \sqrt{\frac{3RT}{M}}$

If T = 2T and M = M/2, then $u_1 = \sqrt{\frac{3R \times 2T}{M/2}}$

$\therefore \frac{u_1}{u} = \sqrt{4} = 2$

21] $P = \frac{1}{3}\frac{mnu^2}{V}$

$$\frac{P_X}{P_Y} = \frac{n_X u_X V_Y}{n_Y u_Y V_x} = \frac{(N_0/1000)}{(N_0/2000)} \times 2 \times \frac{2}{1} = 8$$

22] In van der Waal's equation, a signifies the intermolecular force of attraction.

NEET

1] Volume of hydrogen = 50 mL; Time for diffusion (t) = 20 min and volume of oxygen = 40 mL.
Rate of diffusion of hydrogen (r_1)

$= \frac{50}{20} = 2.5$ mL/min

And rate of diffusion of oxygen (r_2)

$= \frac{40}{t}$ mL / min

Since the molecular mass of hydrogen (M_1) = 2 and that of oxygen (M_2) = 32, therefore,

$$\frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}} \Rightarrow \frac{2.5}{40/t} = \sqrt{\frac{32}{2}} \Rightarrow \frac{t}{16} = 4 \Rightarrow t = 64 \text{ min}$$

2] $T_1 = 27^oC = 300K$ and
$T_2 = 927^oC = 1200K$
We know that root mean square speed (v) $\propto \sqrt{T}$. Therefore root mean square speed of the gas, when its temperature is raised

$= \sqrt{\frac{T_2}{T_1}} = \sqrt{\frac{1200}{300}} = 2$

3] A gas can only be liquefied, if some forces of attraction are acting in its molecules. Since an ideal gas is devoid of force of attraction in its molecules, therefore it cannot be liquefied.

4] Avg. K.E per molecule

$= \frac{3}{2}K_B.T$

$= \frac{3}{2} \times 1.38 \times 10^{-23} \times 298$

$= 617 \times 10^{-23}$

$= 6.17 \times 10^{-21}$ J

5] $R_1 = 1.625\ R_2$ and $T_2 = 500^oC = 773$ K.

We know that $\frac{R_1}{R_2} = \sqrt{\frac{M_2}{M_1} \times \frac{T_1}{T_2}}$

Or $1.2625 = \sqrt{\frac{64}{28} \times \frac{T_1}{773}}$

or $T_1 = \frac{(1.625)^2 \times 28 \times 773}{64} = 893K = 620^oC$

6] $V_1 = 380mL$, $P_1 = 730$ mm, $V_2 = ?$, $P_2 = 760$ mm.
From Boyle's law, $P_1V_1 = P_2V_2$

$\Rightarrow V_2 = \frac{380 \times 730}{760} = 365mL$

8] Except diamond other three conduct electricity. Potassium and sodium are metallic conductors, while graphite is a non-metallic conductor.

9] KE = $\frac{3}{2}$RT(for one mole of a gas)

As temperatures are same and KE is independent of molecular mass, so $KE_1 = KE_2$.

10] As low pressure and high temperature van der Waal's real gas act as ideal gas and observed to obey PV = nRT relation.

11] Hydrogen bonding in $H_2O > C_2H_5OH > CH_3OH$
Hence H_2O has maximum surface tension.

12] The average translational K.E. of one molecule of an ideal gas will be given by

$E_t = \frac{KE}{N_A} = \frac{3/2RT}{N_A} = \frac{3}{2}KT$

When R/N_A = Boltzmann constant i.e. $E_t \propto T$
So, at constant temperature KE of molecules remains same.

13] Energy absorbed by each molecule = 4.4×10^{-19} J
Energy required to break the bond = 4.0×10^{-19} J
Remaining energy to get converted to kinetic energy
= $(4.4 \times 10^{-19} - 4.0 \times 10^{-19})$J
= 0.4×10^{-19} J per molecule

$\therefore$ Kinetic energy per atom = 0.2×10^{-19} J
or 2×10^{-20} J

14] Given, mass of CH_4 w = 6g
Volume of CH_4, V = 0.03 m^3
T = 129°C = 129 + 273 = 402 K
R = 8.314 J K^{-1} mol^{-1}
Molecular mass of CH_4, M = 12.01 + 4 ×1.01
= 16.05

$$PV = nRT = \frac{w}{M}RT$$

$$\therefore P = \frac{w}{M}\frac{RT}{V} = \frac{6}{16.05} \times \frac{8.314 \times 402}{0.03}$$

= 41647.7Pa ≈ 41648 Pa

15]$V_{avg} = \sqrt{\frac{8RT}{\pi M}}$

$\therefore V \propto \sqrt{T}$

$\therefore \frac{V_2}{V_1} = \sqrt{\frac{2}{1}}$ $\quad \therefore V_2 = 1.41\ V$

16] $P_{CO} + P_{N_2} = 1$ atm

$2P_{N_2} = 1$ $\quad [\because n_{CO} = n_{N_2}]$

$P_{N_2} = \frac{1}{2} = 0.5$ atm

17] We know that from Ideal gas equation

$$V \propto \frac{T}{P}$$

Given: $T_1 = 15 + 273 = 288$, $P_1 = 1.5$ bar
$T_2 = 25 + 273 = 298$, $P_2 = 1$ bar

$$V_1 \propto \frac{288}{1.5}$$

i.e. $V_1 \propto 192$

$$V_2 \propto \frac{298}{1}$$

$$\frac{V_2}{V_1} = \frac{288}{192} = 1.55 \approx 1.6$$

18] None is correct
According to Graham's law of diffusion,

$$\frac{r_1}{r_2} = \sqrt{\frac{d_2}{d_1}} = \sqrt{\frac{M_2}{M_1}}$$

$$r_A = \frac{V_A}{T_A},\ r_B = \frac{V_B}{T_B}$$

$$\frac{V_A / T_A}{T_A / T_B} = \sqrt{\frac{M_B}{M_A}}$$

$V_A = V_B$, T_A = 150sec, T_B = 200 sec

$$\frac{T_B}{T_A} = \sqrt{\frac{M_B}{M_A}} \Rightarrow \frac{200}{150} = \sqrt{\frac{36}{M_A}}$$

$$\frac{4}{3} = \sqrt{\frac{36}{M_A}} \quad \text{or} \quad \frac{4 \times 4}{3 \times 3} = \frac{36}{M_A}$$

$$M_A = \frac{36}{4 \times 4} \times 3 \times 3 = 20.25$$

19] van der Waal's gas constants
'a' = intermolecular force of attraction of gaseous molecules
'b' = effective size of molecules resp.
Therefore order should be
(I) $H_2 < He < O_2 < CO_2$ (II) $CH_4 > O_2 > H_2$

20] NH_3 will show maximum deviation from ideal gas due to dipole-dipole attraction.

21] Dipole – induced dipole occurs between polar & Non –polar molecule

HC*l*	He
Polar	Non-polar
$\mu \neq 0$	$\mu = 0$

22] $\frac{r_{O_2}}{r_{H_2}} = \sqrt{\frac{M_{H_2}}{M_{O_2}}}$

$$\frac{\frac{n_{O_2}}{t}}{\frac{n_{H_2}}{t}} = \sqrt{\frac{2}{32}} = \sqrt{\frac{1}{16}} = \frac{1}{4}$$

$\therefore \frac{n_{O_2}}{n_{H_2}} = \frac{1}{4}$

As $\frac{1}{2}$ moles of H_2 are diffused, moles of O_2 diffused in same time.

$$\frac{n_{O_2}}{1/2} = \frac{1}{4} \Rightarrow n_{O_2} = \frac{1}{8}$$

23] $\underset{(s)}{SrCO_3} \rightleftharpoons \underset{(s)}{SrO} + \underset{(g)}{CO_2}$

At maximum pressure of CO_2

$K_P = P_{CO_2} = 1.6$ atm

Temperature is constant

$\therefore P_1V_1 = P_2V_2$

$0.4 \times 20 = 1.6 \times V_2$

$V_2 = 5$ L

25] NH_3 because its van der waal's gas constant is high so it will easily liquefied. Because more force of attraction.

CBSE PMT

1] $K.E = \frac{3}{2}RT = \frac{3}{2}PV$

$\therefore P = \frac{2}{3}\frac{E}{V}$ for unit volume (V = 1) $\Rightarrow P = \frac{2}{3}E$

2] For same temperature kinetic energies of H_2 & He molecules will be same because kinetic energy depends only on temperature.

3] For same temp. kinetic energies would be equal for all molecules, whatever their molecular mass will be, it doesn't matter.

4] $PV = nRT = \frac{m}{M}RT$

$\therefore \frac{m}{V} = \frac{PM}{RT} = \text{density}$

5] Since $\frac{C_p}{C_v} = 1.4$, the gas should be diatomic

If volume is 11.2 L then, no. of moles = $\frac{1}{2}$

$\therefore$ no. of molecules = $\frac{1}{2} \times$ Avogadro's No.

No. of atoms = 2 × no. molecules

$= 2 \times \frac{1}{2} \times$ Avogadro's No

$= 6.023 \times 10^{23}$

6] The density of neon will be highest at 0^oC, 2 atm according to $d \propto \frac{P}{T}$

8] The mass of gas can be determined by weighing the container, filled with gas and again weighing this container after removing the gas. The difference between the two weights gives the mass of the gas.

9] According to Boyle's law $V \propto \frac{1}{P}$

$V = \frac{\text{Constant}}{P}$; VP = Constant

10] $V_t = V_o(1 + \alpha_v t)$

$\therefore (V_2 - V_1) = \Delta V = V_o \alpha (t_2 - t_1)$

If $t_2 - t_1 = 1^o$ then $\Delta V = \alpha V_o$

For every 1^oC increase in temperature, the volume of a given mass of an ideal gas increase by a definite fraction $\frac{1}{273.15}$ of V_o.

Here V_o is volume at 0^oC temperature.

11] At constant V of a definite mass

$\frac{P_1}{T_1} = \frac{P_2}{T_2}$ $\quad \therefore \frac{P_1}{P_2} = \frac{300}{600} = \frac{1}{2}$

i.e. pressure ↑ and temperature ↑

energy of molecules ↑ so the rate of collisions ↑ and number of moles remains constant

because there is neither addition nor removal of gas in the occurring.

14] $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T}$ $\quad \therefore \frac{P_1V_1}{P_2V_2} = \frac{T_1}{T_2}$

15] $\frac{P_1V_1}{n_1T_1} = \frac{P_2V_2}{n_2T_2}$ $\quad \therefore T_2 = \frac{P_2}{P_1}\frac{V_1}{V_2}T_1\frac{m_1}{m_2}$

$= \frac{0.75}{1} \times \frac{1}{1} \times \frac{2}{1} \times 300K = 450K$

16] $V_2 = \frac{P_1}{P_2}\frac{T_2}{T_1}$

$\therefore V_1 = \frac{1}{0.5} \times \frac{250}{300} \times 12000\,L = 20000\ L$

17] At constant pressure

$V \propto nT \propto \frac{m}{M}T$

$\frac{V_1}{V_2} = \frac{m_1 T_1}{m_2 T_2} \quad \therefore \frac{T_1}{T_2} = \frac{V_1}{m_1} \times \frac{d_2}{d_1}$

$\Rightarrow \frac{300K}{T_2} = \frac{0.75d}{d}$

$T_2 = \frac{300}{0.75} = 400K$

18] Because HC*l* & NH_3 gases may react to produce NH_4C*l* gas. Dalton's Law is applicable for non reacting gas mixtures.

19] No. of moles of lighter gas = $\frac{m}{4}$

No. of moles of heavier gas = $\frac{m}{40}$

Total no. of moles = $\frac{m}{4} + \frac{m}{40} = \frac{11m}{40}$

Mole fraction of lighter gas = $\frac{\frac{m}{4}}{\frac{11m}{40}} = \frac{10}{11}$

Partial pressure due to lighter gas = $P_o \times \frac{10}{11}$

$= 1.1 \times \frac{10}{11} = 1atm$

20] $\frac{r_{N_2}}{r_{SO_2}} = \frac{V_{rms}(N_2)}{V_{rms}(SO_2)} = \sqrt{\frac{T_{N_2}}{T_{SO_2}} \cdot \frac{M_{SO_2}}{M_{N_2}}} = \sqrt{\frac{T_{N_2}}{323} \times \frac{64}{28}}$

$1.625 = \sqrt{\frac{T_{N_2}}{323} \cdot \frac{16}{7}}$

$T_{N_2} = \frac{(1.625)^2 \times 323 \times 7}{16} = 373K$

21] No. of moles of CO_2 present in 200 mL (0.2L) solution

= molarity × Volume (in L)

$= 0.1 \times \frac{200}{1000} = 0.2$

Volume of 0.02 mol of CO_2 = 22.4 × 0.2 L

= 0.448 L

22] Molecular mass = V.D. × 2 = 11.2 × 2 = 22.4 L

Volume of 22.4 g Substance of NTP = 22.4 L

1 g substance at NTP = $\frac{22.4}{22.4}$ L

11.2 g substance of NTP = 11.2 L

23] In 22.4 L of H_2 maximum number of molecules

$= 6.023 \times 10^{23}$

ln 1L H_2 maximum number of molecules

$= \frac{6.023 \times 10^{23}}{22.4}$

ln 15L of H_2 maximum number of molecules

$= \frac{6.023 \times 10^{23}}{22.4} \times 15 = 4.03 \times 10^{23}$ molecules.

MILLER INDICES (SOLID STATE)

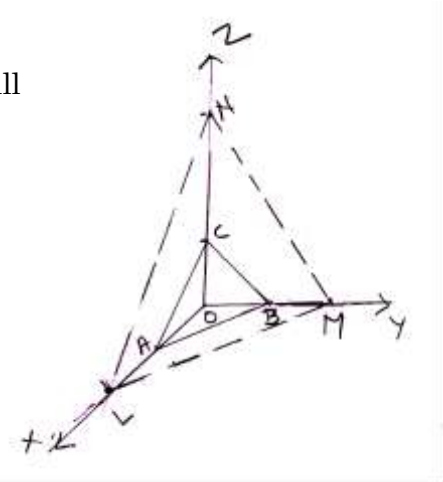
Introduction:

- M.I. Play important role in Material science, physics, chemistry and electronics.
- M.I. are used to specify directions and planes in lattices or crystals.
- In one dimension, there will be one index, in two dimension , there will be two indices and so on.
- Notation: (h k l) ; no comma is used between h k and l .
- Negative numbers / directions are denoted with a bar on the top of the number.
  (h K *l*) → plane; [h k, *l*] → directions
  < h k *l* > or { h k *l* } → a family of directions.

Law of Rational indices (Hauy's)

It states that the intercepts made by any face of a crystal on suitable crystallographic axes are equal to or same simple whole number multiples of the intercepts made by the unit plane.
Let ox, oy and oz represent the three crystallographic axes and let ABC be a unit plane.

The unit intercepts will then be a, b and c (See Figure)



According to the above low the intercept of any faces such as LMN on the same three axes will be simple whole number multiples of a, b and c respectively
In figure above the simple multiples are 2, 2 and 3
i.e., OL = 2 OA = 2a
OM = 2OB = 2b and
OK = 3OC = 3c
Here 2,2, 3 are called Weiss indices If a face does not cut an axis at all its intercept is ∞
Hence, instead of Weiss indices it is more common to use miller indices which are obtained as follows.
Reciprocals of the Weiss indices are taken and then multiplied by the LCM of denominators to express them as integers.
For example, if the intercepts made by a face are ∞, 2b, 3c
Reciprocal of Weiss indices are:

$$\frac{1}{\infty},\frac{1}{2},\frac{1}{3} \quad \text{or} \quad 0,\frac{1}{2},\frac{1}{3}$$

Multiplying with LCM is 6, we get 0, 3, 2.
Hence the miller indices of the face will be 032

The face is represented as (032)

In general we represent a face by (hk*l*) here h = 0. k = 3, *l* =2

The negative intercepts are represented by putting a bar over the value.

Example:-

If the intercepts made by a face are **(2a, –3b, –3c)**

Reciprocal of Weiss

Indices are $\frac{1}{2}, -\frac{1}{3}, -\frac{1}{3}$

LCM of 2, 3, 3 = 6

Multiplying with 6, we get 3, –2, –2

Hence h = 3, k = –2, *l* = –2

Is miller indices will be $\left(3,\ \bar{2},\ \bar{2}\right)$

Negative intercept of the plane on an axis means the it cuts the axis when extended in a direction opposite to that shown in Figure above.

The perpendicular distance of the face (hkl) from the origin is represented by $^{d}_{hkl}$

If the axes chosen are orthogonal and it $\alpha = \beta = r = 90°$

(i.e. cubic, tetragonal and orthorhombic)

Then mathematically it can be shown that

$$\frac{1}{^{d}hkl} = \sqrt{\frac{h^2}{a^2} + \frac{k^2}{b^2} + \frac{l^2}{c^2}}$$

For cubic system, a = b = c,

Hence $^{d}hkl = \frac{a}{\sqrt{h^2 + k^2 + l^2}}$

Properties of M.I.

M.I. of equally spaced parallel planes are same.

M.I. indices of a plane passing through the origin is shown by M.I. in a plane parallel to it.

Note:

Parallel planes having low index number are widely separated to each other, then those having high index numbers.

All members of family or directions are not necessarily parallel to each other.

Importance of M.I. :

It is important to have notation system for atomic planes since these planes influence:

a. Optical properties
b. Reactivity
c. Surface tension
d. Dislocations

M.I. describes the arrangement of atoms within a unit cell. Knowing the unit cell distance, distances can be calculated between the atoms and hence the forces holding the atoms in the lattice can also be determined. The forces holding the lattice determines, which electrons can participate in the conduction process and also the electrical and optical properties. This is very useful in working with semiconductor devices.

Numericals:-

1. Calculate the miller indices of crystal planes which cut through the crystal axes at
   (i) (2a, 3b, c) (ii) (2a, –3b, –3c) (iii) (6a, 3b, 3c)

(i) (2a, 3b, c)

Weiss indices are	2	3	1
Reciprocal of Weiss indices	$\frac{1}{2}$	$\frac{1}{3}$	$\frac{1}{1}$

L,C,M = 6 , multiplying with 6, we get 3, 2, 6
Hence miller indices are (3 2 6)

(ii) (2a, –3b, –3c)

	A	**b**	**c**
Weiss indices	2	–3	–3
Reciprocals	$\frac{1}{2}$	$-\frac{1}{3}$	$-\frac{1}{3}$

L C M = 6, Multiplying with 6 we get(3, 2,–2)

Hence miller indices are $\left(3,\ 2,\ \bar{2}\right)$

(iii) (6a, 3b, 3c)

	A	**b**	**c**
Weiss indices	6	3	3
Reciprocals	$\frac{1}{6}$	$\frac{1}{3}$	$\frac{1}{3}$

LCM of 6,3,3 is 6
Multiplying with 6 we get 1, 2, 2.

Hence miller indices are (1, 2, 2)

2. Calculate the distance between parallel planes in a cubic unit all
(i) d_{100} (ii) d_{110} (iii) d_{111}
Solution:-

$$d_{hkl} = \frac{a}{\sqrt{h^2+k^2+l^2}}$$

(i) $d_{100} = \frac{a}{\sqrt{1^2+0^2+0^2}} = a$

(ii) $d_{110} = \frac{a}{\sqrt{1^2+1^2+0^2}} = \frac{a}{\sqrt{2}}$

(iii) $d_{111} = \frac{a}{\sqrt{1^2+1^2+1^2}} = \frac{a}{\sqrt{3}}$

3) KC*l* crystallises in a bcc lattice
Calculate the distance between the 200, 100 and 222 planes. Assume the length of side of the unite cell to be 5A°.
Solution:-

$$d_{hkl} = \frac{a}{\sqrt{h^2+k^2+l^2}}$$

For 200 plane

$$d_{200} = \frac{5}{\sqrt{2^2+o^2+c^2}} = \frac{5}{2} = 2.5A^\circ$$

Similary $d_{100} = \frac{5}{\sqrt{1^2+0^2+0^2}} = 5 = \frac{5}{2} = 2.5A^\circ$

$$d_{225} = \frac{5}{\sqrt{2^2+2^2+2^2}} = \frac{5}{2\times\sqrt{3}} = 1.44\ A^\circ$$

4) Diamond has FCC lattice. They are atoms at 2 atoms at (0, 0, 0) and $\left(\frac{a}{4},\frac{a}{4},\frac{a}{4}\right)$ co-ordinates, the ratio of the C–C bond distance to the edge of the unit (a) cell is :-

a) $\sqrt{3/6}$ **b)** $\sqrt{1/4}$ **c)** $\frac{1}{4}$ **d)** $\frac{1}{\sqrt{2}}$

Solution:-

Distance between (0, 0, 0) and $\left(\frac{a}{4},\frac{a}{4},\frac{a}{4}\right)$ = 2r

Also $2r = \frac{\sqrt{3}}{4}a$

$\therefore \frac{2r}{a} = \frac{\sqrt{3}}{4} = \sqrt{3/16}$

Assignments:-

1. The lattice constant for a unit cell of Al is $4.03A^0$. Calculate the interplanar spacing in(211) plane.

   (Ans: 1.645A°)

2. Find the distance between the two parallel planes indicated by the miller indices (121) and (212) in a unit cell of a cubic lattice with a lattice constant parameter "a".

   (Ans:0.0749a)

3. A certain crystal has lattice parameter of 4.24, 10 and 3.66 A^0 on X, Y and Z axes respectively. Determine the M.I. of a plane of intercept 2.12, 10 and $1.82A^0$ on X.,Y and Z axes.

   Ans: (212) or (424)

4. What is the distance between the adjacent Miller planes , if the first order reflection from x-rays of wavelength $2.29A^0$ occurs at 27.8^0

   (Ans: 2.51 A^0)

5. The edge length of the Ag FCC structure is 408.6 pm. An X-ray beam produces first order reflection from the 111plane at $2\theta = 38.2^0$. What is the x-ray wavelength?
   ($\sin 19.1° = 0.3272$) **(Ans: 154.38 pm)**