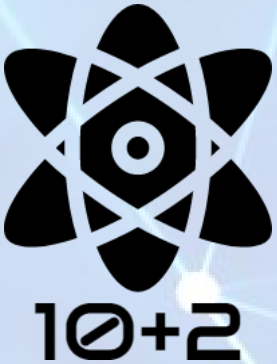
# 10+2 PCM NOTES

BY

## JOYOSHISH SAHA

(PDF version handwritten notes of Maths, Physics and Chemistry for 10+2 competitive exams like JEE Main, WBJEE, NEST, IISER Entrance Exam, CUCET, AIPMT, JIPMER, EAMCET etc.)





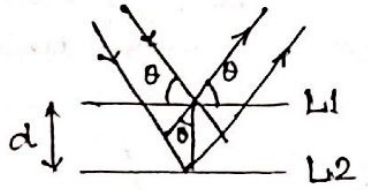

*With best wishes from* Joyoshish Saha

# Solid State.

* Solids have only vibrational motion as the constituents are in fixed positions.
* Two Types solids - a) Crystalline: constituents, arranged in a definite, orderly manner which repeats itself over long distances; have sharp melting points; anistropic - different properties in different directions; incompressible; clean cleavage.
b) Amorphous: constituents in a random manner; don't have sharp melting points; pseudo solids; isotropic; don't show clean cleavage.
* Crystal: Homogeneous part of solid substance made by regular pattern of structural units bonded by plane surface making definite angles with each other.
* Types of Crystalline solids:

| | Constituent | Force | M.P. (K) | B.E. (KJ/mole) | Conductivity | Ex. |
|---|---|---|---|---|---|---|
| Ionic | Cation/Anion | Electrostatic | >1300K | 400-4000 | Conductor | NaCl, KCl |
| Covalent/Network | Atoms | Covalent Bond | >3900K | 150-500 | Insulator | Sic, Diamond. |
| Molecular | Molecules | VanDer Waals | <293K | <40 | Insulator | Dryice, $I_2$ |
| Metallic. | Atoms | Metalic Bonds. | 800~1000 | 80~1000 | Conductor | All metals. |

* Bragg's Equ$^n$: $n\lambda = 2d\sin\theta$.
$n$ → order of reflection (generally 1)
$\lambda$ = wavelength of X-Rays
$d$ = distance between two layers of crystal
$\theta$ = angle of incidence.



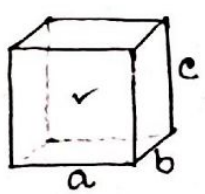

(beneficial for structure, dimension of ionic coystalline solid, explaining properties of X-Rays)

* Unit cell: Have properties of the crystal.
Charaterised by edge distances and angles.
Types: Simple, face-centered, body-centered, end-centered.

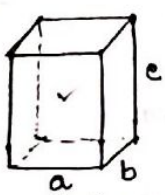
# Crystal system and Bravi's Lattices:

| Crystal System | Bravi's Lattice | Intercepts | Interfacial angle | Examples. |
|---|---|---|---|---|
| Cubic | Primitive, Face-cen, Body-cen (3) | $a=b=c$ | $\alpha=\beta=\gamma=\frac{\pi}{2}$ | Ag, Au, Diamond. |
| Ortho-Rombic | Primitive, Face, Body, End (4) | $a\neq b\neq c$ | $\alpha=\beta=\gamma=\frac{\pi}{2}$ | $K_2SO_4$, $KNO_2$ |
| Tetragonal | Prim, Body (2) | $a=b\neq c$ | $\alpha=\beta=\gamma=\frac{\pi}{2}$ | $TiO_2$, $SnO_2$. |
| Monoclinic | Prim, End (2) | $a\neq b\neq c$ | $\alpha=\beta=\frac{\pi}{2}$, $\gamma\neq\frac{\pi}{2}$ | $CaSO_4 \cdot 2H_2O$ |
| Triclinic | Prim (1) | $a\neq b\neq c$ | $\alpha\neq\beta\neq\gamma\neq\frac{\pi}{2}$ | $CuSO_4 \cdot 5H_2O$ |
| Hexagonal | Prim (1) | $a=b\neq c$ | $\alpha=\beta=\frac{\pi}{2}$, $\gamma=120^\circ$ | Zn, Mg |
| Rhombohedral | Prim (1) | $a=b=c$ | $\alpha=\beta=\gamma\neq 90^\circ$ | Bi, As, Sb. |

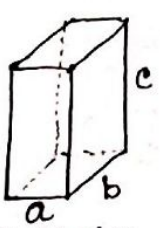
Tot → 14



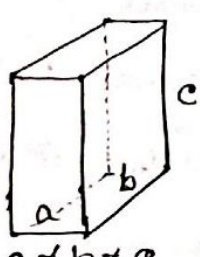

$a=b=c$
$\alpha=\beta=\gamma=\frac{\pi}{2}$
Cubic



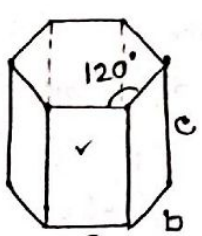

$a=b\neq c$
$\alpha=\beta=\gamma=\frac{\pi}{2}$
tetragonal



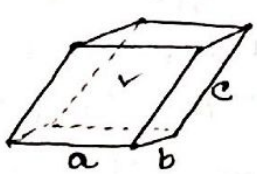

$a\neq b\neq c$
$\alpha=\beta=\gamma=\frac{\pi}{2}$
orthorhombic



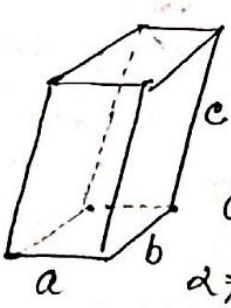

$a\neq b\neq c$
$\alpha=\beta=\frac{\pi}{2}$, $\gamma\neq\frac{\pi}{2}$
monoclinic.




$a=b\neq c$
$\alpha=\beta=\frac{\pi}{2}$, $\gamma=120^\circ$
Hexagonal




$a=b=c$
$\alpha\neq\beta\neq\gamma=\frac{\pi}{2}$.
Rhombohedral




$a\neq b\neq c$
$\alpha\neq\beta\neq\gamma=\frac{\pi}{2}$
Triclinic.

(CR) (HTe) (TOM).

* Cubic System: * for hexagonal primitive unit cell - height of unit cell (h) = $4r\sqrt{2/3}$ & packing fraction = **0.74**

| Property | Prim | FCC | BCC. |
|---|---|---|---|
| Diagonal | Facial $2\sqrt{2}r$ | facial $4r$ | Body diagonal $4r$ |
| Edge length | $a = 2r$ | $a = 2\sqrt{2}r$ | $a = \frac{4r}{\sqrt{3}}$ |
| Volume occupied by sphere | $\frac{4}{3}\pi r^3$ | $4 \times \frac{4}{3}\pi r^3$ | $2 \times \frac{4}{3}\pi r^3$. |
| Volume of unit cell | $8r^3$ | $(2\sqrt{2}r)^3$ | $\left(\frac{4r}{\sqrt{3}}\right)^3$. |
| Packing fraction | 0.524 | 0.74 | 0.68 |
| Percentage of free space. | 47.6 %. | 26%. | 32% |
| C.No. | 6 | 12 | 8 |

* $\rho = \frac{ZM}{N_A V}$ — Z → no. of atoms in unit cell; M → atomic weight; $N_A$, V → volume of cell

* Interstetial voids: $r^+_{oct} \geq 0.414r^-$ (CN-6), $r^+_{tetra} \geq 0.225r^-$ (CN-4), $r^+_{trian} \geq 0.155r^-$ (CN-3), $r^+_{cub} \geq 0.732\ r^-$ (CN-8)

* Close packing in 2D -

Square close packing - 52.4% space occupied by spheres.

Hexagonal close packing - 60.4% space occupied.

Packing in 3D - Hexagonal - 74% space occupied. CN(12).

Cubic close packing - CN(12). Body centered cubic - Body centered cubic - CN(8).

* Structure of some ionic compounds:

Rock salt (NaCl) Type: Close cubic packing, FCC, $Na^+$ in octahedral voids, CN-6 (LiX, NaX, KX, AgCl, AgBr, $NH_4Cl$). $r^+/r^- = 0.525$ (Theory - 0.414).

* **CsCl Type:** $CsX$, $TiCl$, $TiBr$, $NH_4Cl$, $NH_4Br$. | $Cl^-$ in corner of cube, $Cs^+$ in cubic void. CN - 8, $r^+/r^- = 0.93$ (Theory - 0.732).

* **ZnS Type:** ZnS, CuCl, CuBr, CuI, AgI, BeO. | CCP, $Zn^{2+}$ in alternate tetrahedral voids, CN - 4.

* **Fluorite structure ($CaF_2$ Type):** $CaF_2$, $BaCl_2$, $BaF_2$, $SrF_2$. $Ca^{2+} \rightarrow$ ccp, $F^- \rightarrow$ in tetrahedral void, CN ($Ca^{2+}$) - 8 | CN ($F^-$) - 4

* **Antifluorite structure ($Na_2O$ Type):** $Na_2O$, $Li_2O$. $O_2^- \rightarrow$ ccp, $Na^+ \rightarrow$ tetrahedral voids, CN ($Na^+$) - 4, CN ($O_2^-$) - 8

* **Normal Spinel structure ($AB_2O_4$):** A - Bivalent, B - Trivalent cation.

| $MgAl_2O_4$ | $Mg^+ \rightarrow$ 1/8th of tetrahedral voids<br>$O_2^- \rightarrow$ ccp<br>$Al^{3+} \rightarrow$ 1/2 of octahedral voids |
|---|---|

($ZnFe_2O_4$ may also have this structure).

These are used in telephones, memory loops of computers as magnetic materials.

* **Structure of $Fe_3O_4$ (Magnetite):** $Fe^{3+} : Fe^{2+} :: 2:1$. $O_2^- \rightarrow$ ccp, $Fe^{2+} \rightarrow$ octahedral voids, $Fe^{3+} \rightarrow$ oct, tet void. ($MgFe_2O_4$ may have this structure).

* **Electronic Imperfection:** Release of electron above 0K, (Si/Ge), free to move electron in crystal (intrinsic conduction).

* **Atomic Imperfection:** Stoichiometric Defects: a) Schottky Defect: Same number of positive and neg. ion missing (high CN, size of cation is equal). b) Interstetial defect - presence of ions in interstetial voids. c) Frenkel defect: Cation leaves its sight & moves to interstetial site.

# Solid State.

* Non Stoichiometric Defect:

a) metal excess (possessing defects): i) negative ion absent, leaving a hole (F-centres) (Schottky defects)
(excess of Na in NaCl → yellow crystal,
excess of K in KCl → violet,
excess of Li in LiCl → pink).

ii) extra cation (Frenkel defect) - ZnS yellow colour.

b) metal deficiency: i) cation vacancy, (Transition metal).

* $r_c + r_a = \frac{a}{2}$ (for fcc)

$r_c + r_a = \frac{\sqrt{3}}{2} a$ (for bcc)

| * limiting radius ratio | CN | shape |
|---|---|---|
| $x < 0.155$. | 2 | linear |
| $0.155 \leq x < 0.225$ | 3 | Planar triangle |
| $0.225 \leq x \leq 0.414$ | 4 | Tetrahedral |
| $0.414 \leq x < 0.732$ | 6 | Octahedral |
| $0.732 \leq x < 0.999$ | 8 | Body centered cubic. |

* Cubic crystal has 23 elements of symmetry.

Centre of symmetry = 1.

Plane of symmetry = 3 + 6 = 9.

Axes of symmetry = 3 + 4 + 6 = 13

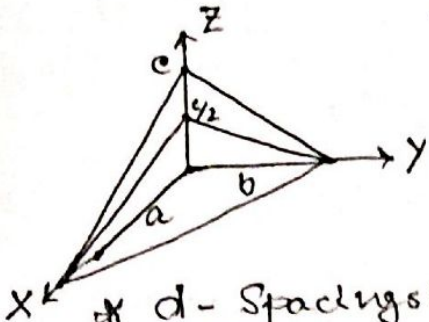
* Theoretical / calculated density of crystal $= \rho = \frac{ZM}{N_A V}$

[ Percentage occupancy = $\frac{\rho_{experimental}}{\rho_{theoretical}} \times 100\%$.

$V = abc\left(1 - \cos^2\alpha - \cos^2\beta - \cos^2\gamma + 2\cos\alpha\cos\beta\cos\gamma\right)^{1/2}$

* Miller indices (denoted as (h,k,l)).

To denote a plane in unit cell.




Procedure to obtain indices —
axis intercepts as a multiple of a/b/c → reciprocal → clearing fractions (RCMukherjee → 704)

* d-Spacings: Distance between two parallel planes in a cubic crystal.

$$d = \frac{a}{\sqrt{h^2+k^2+l^2}}$$ [a → length of side of cube].

* No. of Schottky defect formed per cc ($n_s$)

$$n_s = N e^{(-W_s/KT)}$$

N → lattice sites.
$W_s$ → work to form a schottky defect.
K → Boltzman constant ($R/N_A$)
T → abs. temperature

* No. of Frenkel defect formed per cc ($n_f$)

$$n_f = \sqrt{NN'}\, e^{(-W_f/KT)}$$

N → lattice sites
N' → no. of alternative interstitial space/cc

* Tetrahedral Voids = 2 × No. of particle
Octahedral Voids = No. of particles.

* In $CsI_3$ molecule, $Cs^+$ & $I_3^-$ ions are present.