Solid State

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- IMF —— Vanderwaal's attraction Forces

① London Forces or Dispersion Forces $\propto$ surface area $\propto \frac{1}{r^6}$

② Dipole - Dipole $\propto \frac{1}{r^3}$ (stationary) $\propto \frac{1}{r^6}$ (Rotating)

③ Dipole - Induced Dipole $\propto \frac{1}{r^6}$

④ H-Bonding —— D-D —— N, O, F } H

- K.E $\propto$ T.E

T.E $\propto$ T

① IM - very strong, T.E - low } solid state

② IMF - very weak, T.E - very high } Gaseous state

③ IMF, T.E } liquid state

-	Crystalline solids	Amorphous solids
①	Systematic geometric pattern	Random arrangement
②	Long Range order	Short Range Order
③	Smooth surface	Rough surface
④	Sharp M.P	No sharp M.P
⑤	Definite Heat of Fusion	No definite Heat of Fusio
⑥	Symmetry elements	No symmetry
⑦	Anisotropic Nature	Isotropic nature.

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	Molecular Solids	C·P	attraction Forces	Examples	physical nature	Electrical conduct	M·P
①	Non polar		London	H_2 Cl_2 Ar CO_2	Soft	Insulators	
②	Polar	Molecules	D-D	HCl, HBr, SO_2	soft		Very
③	H-bonded		H-Bonding	H_2O	Hard		low
④	Ionic Solids	Ions	Ionic Bond	NaCl, CsCl KCl, MgO, ZnS	Hard Brittle	Insulators Solid state Conductors in molten/aq soln	High
⑤	Metallic Solids	Metal ions in the sea of $e^{\ominus}$s (Kernels)	Metallic bonding	Cu, Ag, Au Pt; Na, K etc.	Hard Malleable Ductile	Conductors	Fairly High
⑥	Covalent Solids	Atoms	Covalent Bond sp^2 Td	SiC, AlN, SiO_2 — C (diamond) C (Graphite) — Soft — conductor sp^2 linear	Hard	Insulators	Very High

- Amorphous silicon — Used as photovoltaic material
  - converts light ⟶ Electrical energy

- Poly crystalline solids ⟶ overall amorphous - isotropic
  single crystalline - anisotropic

- Crystal lattice: 3D arrangement of C·P
  - lattice points / lattice sites
- Unit cell : smallest part of crystal by which we can explain all the properties of crystal is called Unit cell.

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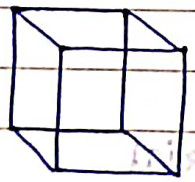
- Based on Dimension (Interfacial angles and edge lengths) are of unit cell are classified into 7 types → crystal systems

①	Cubic	$a=b=c$	$\alpha=\beta=\lambda=90°$	S FC BC
②	tetragonal	$a=b\neq c$	$\alpha=\beta=\gamma=90°$	S BC
③	Orthorhombic	$a\neq b\neq c$	$\alpha=\beta=\gamma=90°$	S FC BC EC
④	Monoclinic	$a\neq b\neq c$	$\alpha=\lambda=90°$ $\beta\neq90°$	S EC
⑤	Triclinic	$a\neq b\neq c$	$\alpha\neq\beta\neq\gamma\neq90°$	S
⑥	Hexagonal	$a=b\neq c$	$\alpha=\beta=90°$ $\gamma=120°$	S
⑦	Rhombohedral	$a=b=c$	$\alpha=\beta=\gamma\neq90°$	S

- Unit Cell → Simple / Primitive — CP are present only corners
  - Centred → Face centred — corners + Face centers
    - → Body centered — Corners + Body centre
    - → Edge centred — Corners + alternate Face centres (any two opp. Faces)



8 - corners (8C)
12 - edges (4C) $a=b=c=a$
6 - Faces (2C) $\alpha=\beta=\gamma=90°$

		location	Zeff	Rel	C.N	P.F	V.F
①	simple Cubic	Corners	$8\times\frac{1}{8}=1$	$a=2r$	6	52% / 0.52	48% / 0.48
②	Face centred (FCC/CCP)	Corners + Face Centres	$8\times1/8+6\times1/2=4$	$a=2\sqrt{2}r$	12	74% / 0.74	26% / 0.26
③	Body Centred (BCC)	Corners + Body Centres	$8\times1/8+1=2$	$a=\frac{4r}{\sqrt{3}}$	8	68% / 0.68	32% / 0.32

classmate

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- Density: $d = \frac{zeff \times M}{a^3 \times N_A}$ M - Molar mass, N_A - Avagadro number
- Close packing in crystals:

① 1D — C.NO - 2 Linear

② 2D — ① Square closepacking C.NO - 4 AAA

② Hexagonal closepacking (HCP) C.NO - 6 ABAB

③ 3D

From HCP in 2D

— ① HCP → ABABAB TV — CN - 4 OC — CN - 6

② FCC/CCP — ABCABC Cubic close packaging arrangement

- In HCP unit cell
  - zeff = 6
  - PF = 74%
  - VF = 26%
  - C.N = 12
  - each Body Diagonal has 2 TV = $\sqrt{3}\,a$
- No. of Voids in a unit cell
  - O.V = zeff
  - TV = 2 × zeff
  - Total voids = 3 × zeff
  - ① In FCC: T.V = 8, O.V = 4, Total = 12
  - ② In HCP: T.V = 12, O.V = 6, Total = 18
  - 1 at Body centre (6 Face centres) + 3 at edge centre (2 centre + 4 Face centres)
- Ionic crystals:
  - C.P = Ions
  - C.N of C^+ = no. of anions surrounding
  - C.N of A^- = no. of cations surrounding

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① If the charges of C^+ and A^- are same then C.No are also same.

② Higher the charge higher will be C.No.

③ The Ratio of C.No always equal to the inverse ratio of their numbers

- $\frac{r^+}{r^-}$ values → Radius Ratio (w.r.t C^+)

	C.N	Geometry
< 0.155	2	linear
0.155 - 0.225	3	TGP
0.225 - 0.414	4	Tetrahedral
0.414 - 0.732	6	Octahedral
0.732 - 0.999	8	BCC

① Rock salt (NaCl)

$Cl^{\ominus}$ = FCC = 4

$Na^{\oplus}$ = all OVS = 4

each unit cell has 4 NaCl formula units

C.NO $Na^+ = 6$

C.NO $Cl^- = 6$

$r^+ + r^- = \frac{a}{2}$

② zinc Blende (ZnS)

S^{2-} = FCC = 4

Zn^{2+} = alternate TVS = 4

each unit cell has 4 ZnS Units

C.No $Zn^{2+} = 4$

C.No $S^{-2} = 4$

$r^+ + r^- = \frac{\sqrt{3}\,a}{4}$

③ CsCl

Cl^- = Simple cube = 1

Cs^+ = at Body centre = 1 (cubic void)

each unit cell has 1 CsCl Formula units.

C.N of $Cs^+ = 8$

C.N of $Cl^- = 8$

$r^+ + r^- = \frac{\sqrt{3}\,a}{2}$

④ Fluorite (CaF_2)

Ca^{+2} = FCC = 4

F^- = all TVS = 8

each unit cell has 4 CaF_2 Formula units

C.N of $Ca^{2+} = 8$

C.N of $F^- = 4$

$r^+ + r^- = \frac{\sqrt{3}\,a}{4}$

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⑤ Anti Fluorite (Na_2O)

O_2^- = FCC = 4

Na^+ = all TVS = 8

each unit cell has 4 Na_2O molecules

C·No of Na^+ = 4

C·No of O_2^{-2} = 8

$r^+ + r^- = \frac{\sqrt{3}\,a}{4}$

- Imperfections / defects in solids:
  Deviation From Ideal arrangement.

Defects

Point Defects — Line Defects

- Point Defects
  - ① Stiochiometric — Formula does not change.
  - ② Impurity — Si → P: n-type; Al: p-type
  - ③ Non-stiochemetric — Formula will change

Defects

- Vacancy defect — Density decreases.
  Interstitial defect — Density increases.

- Ionic solids (stiochiometric defects)

Schottky	Frenkel
- same no. of C^+ and A^- are missing.	- Generally C^+ missing its position and occupies same interstitial void
- Maintain electrical neutrality	- Maintain electrical neutrality
- density decreases	- No change in density
- Ionic crystals having High C·N.	- Ionic crystals having low CN.
- In which C^+ and A^- having almost same size.	- C^+ is much smaller than A^-
- Vacancy defect.	- Interstitial defect.

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- Impurity defects :

$NaCl \xrightarrow{SrCl_2} 2Na^+$

electrical neutrality should be maintained

each Sr^{2+} ion make 1 cation vacancy on doping NaCl

P-type — Si $\xrightarrow{Al}$

n-type — Si $\xrightarrow{P}$

- Non stiochiometric defects : —— ① Vacancy
  - Anion
  - extra metal ion
  - ② Metal deficiency
    - Schottky defect
    - Frenkel defect

FeO : Fe^{+2} Fe^{+3}

$Fe_{0.94}O$

$Ni_{0.96}O$

NaCl - Yellow

KCl - Lilac

F-centre

ZnO - Yellow white

Metal excess

- Magnetic properties :

① Paramagnetic :- Weakly attracted in magnetic field unpaired $e^{\ominus}$ are present.

② Diamagnetic :- Weakly repelled in magnetic field due to absence of unpaired $e^{\ominus}$s.

③ Ferro-magnetic - Fe, Co, Ni, Gd and CrO_2 ⇑⇑⇑⇑

④ Anti-Ferromagnetic - MnO ⇑⇓⇑⇓⇑

- unpaired $e^{\ominus}$ present But diamagnetic

⑤ Ferri-magnetic - Fe_3O_4 ⇑⇑⇑⇑⇓

$MgFe_2O_4$

$ZnFe_2O_4$