8. Solid State

Unit Cell	Corners	Body	Face	Total No. of atoms per unit cell
SCC	1/8×8=1	----	----	1
BCC	1/8×8=1	1	----	2
FCC/CCP	1/8×8=1	----	6×1/2=3	4
End Centred	1/8×8=1	----	2×1/2=1	2

Seven Primitive cells their Possible variations as centred unit cells			
Crystal system	**Possible variations**	**Axial distances or edge lengths**	**Axial angles**
Cubic	Primitive Body-centred	a=b=c	$\alpha=\beta=\gamma=90°$
Tetragonal	Primitive, Body-centred	a=b≠c	$\alpha=\beta=\gamma=90°$
Orthorhombic	Primitive, Body- centred, Face-centred, End-centred	a≠a≠c	$\alpha=\beta=\gamma=90°$
Rhombohedral or Trigonal	Primitive	a=b=c	$\alpha=\beta=\gamma\neq90°$
Hexagonal	Primitive	a=b≠c	$\alpha=\beta=90°$, $\gamma=120°$
Monoclinic	Primitive, End-centred	a≠b≠c	$\alpha=\gamma=90°$, $\beta\neq120°$
Triclinic	Primitive	a≠b≠c	$\alpha\neq\beta\neq\gamma\neq90°$

	S.C.	B.C.C.	F.C.C.	H.C.P.
No. of atom	**1**	**2**	**4**	**6**
P.E.	**52.4%**	**68%**	**74%**	**74%**
Void space	**47.6%**	**32%**	**26%**	**26%**
C.N.	**6**	**8**	**12**	**12**
No. of T.V.	**0**	**0**	**8**	**12**
No. of O.V.	**0**	**0**	**4**	**6**
Relationship between edge length and radius	$r=\frac{a}{2}$	$r=\frac{\sqrt{3}a}{4}$	$r=\frac{a}{2\sqrt{2}}$	$r=\frac{a}{2}$
Type of Packing	**AAA Type**		**ABCABC Type**	**ABAB AB type**

- $d = \frac{Z \times M}{N_A \times aq}$

  d = density z = number of atom in a unit cell.

  N_A = 6.022 × 10^{23}

Square Close Packing

- The spheres in the adjacent row lie just one over & show a horizontal & vertical alignment
- **Co-ordⁿ 4**
- Packing fraction = 78.5%

Hexagonal Close Packing

- The spheres in every second row are seated in the depression.
- **Co-ordn 6**
- Packing fraction = 90.75% (91%)

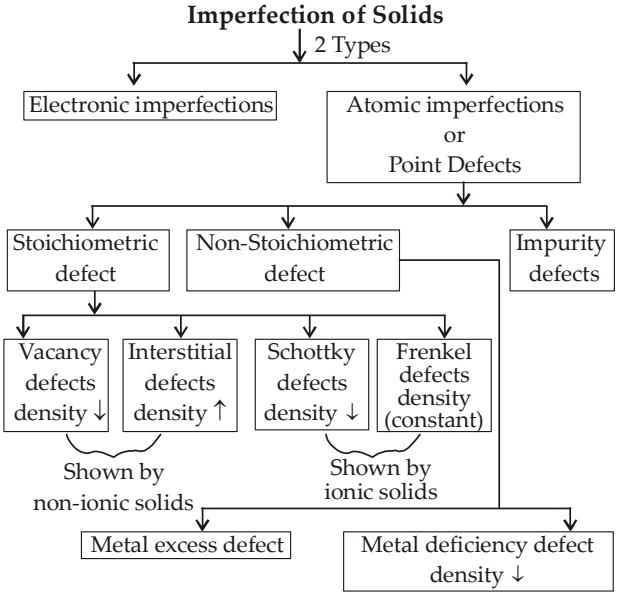
Tetrahedral Void

- **Co-ordⁿ = 4**
- **Radius Ratio=** $\frac{r_{void}}{r_{sphere}} = 0.225$
- **T.V's. Location at body diagonal**
- **Max No. of T.V. in one body diagonal = 2**
- **1st Nearest distn betn two T.V. = a/2**
- **2nd Nearest distn betn two T.V. =** $\frac{a}{\sqrt{2}}$
- **3nd Nearest distn betn two T.V. =** $\frac{\sqrt{3}a}{2}$
- **Distn betn Corner atom & T.V. =** $\frac{\sqrt{3}a}{4}$
- **Ratio betn T.V. & O.V. = 2 : 1**
- **Ratio betn T.V. & O.V. at 1 body digaonal=2:1**
- **Distance Between O.V. & T.V. =** $\frac{\sqrt{3}a}{4}$

Octahedral Void

- **Co-ordn = 6**
- **Radius Ratio=** $\frac{r_{void}}{r_{sphere}} = 0.414$
- **O.V's. Location at body center & as well as edge center**
- **Max No. of O.V. in one body diagonal = 1**
- **1st Nearest distn betn two O.V. =** $\frac{a}{\sqrt{2}}$
- **Distn betn edge center's O.V. & Body center's O.V. =** $\frac{a}{\sqrt{2}}$
- Diamond = $\frac{\pi\sqrt{3}}{6} = 0.34$

Defects in Crystal Structure :



➢ Radius ratio and co-ordination number (CN)

Limiting radius ratio	CN	Geometry
[0.155 – 0.225]	3	[Plane triangle]
[0.255 – 0.414]	4	[Tetrahedral]
[0.414 – 0.732]	6	[Octahedral]
[0.732 – 1]	8	[bcc]

➢ Relationship between radius of void (r) and the radius of the sphere (R): r (tetrahedral) **= 0.225 R; r (octahedral) = 0.414 R**

➢ Paramagnetic : Presence of unpaired electrons [attracted by magnetic field]

➢ **Ferromagnetic :**

Permanent magnetism [↑ ↑ ↑ ↑]

➢ **Antiferromagnetic :**

Net magnetic moment is zero [↑ ↓ ↑ ↓]