PHYSICAL CHEMISTRY CRASH COURSE

SOLID STATE
IN 1 SHOT

Full Chapter REVISION

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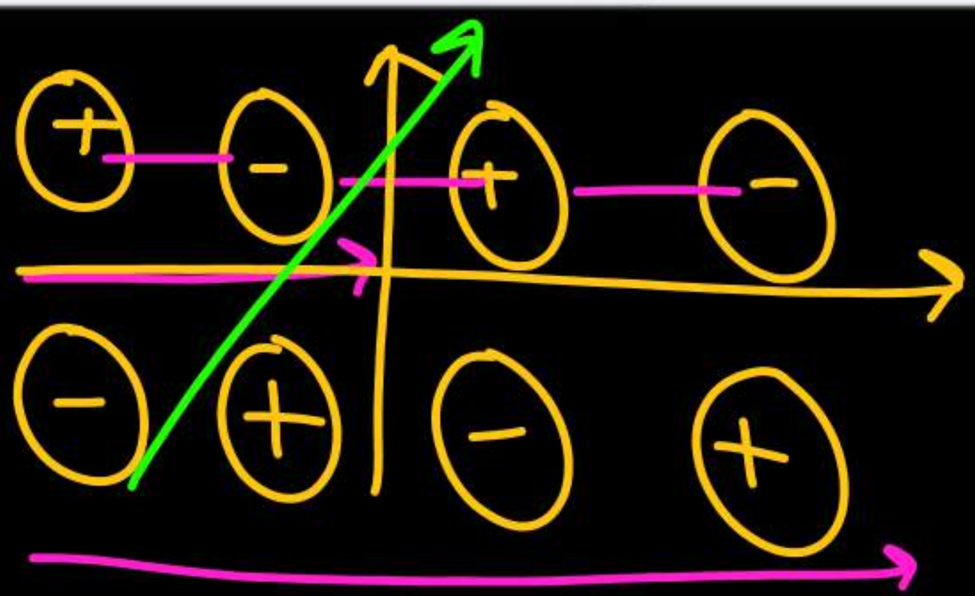
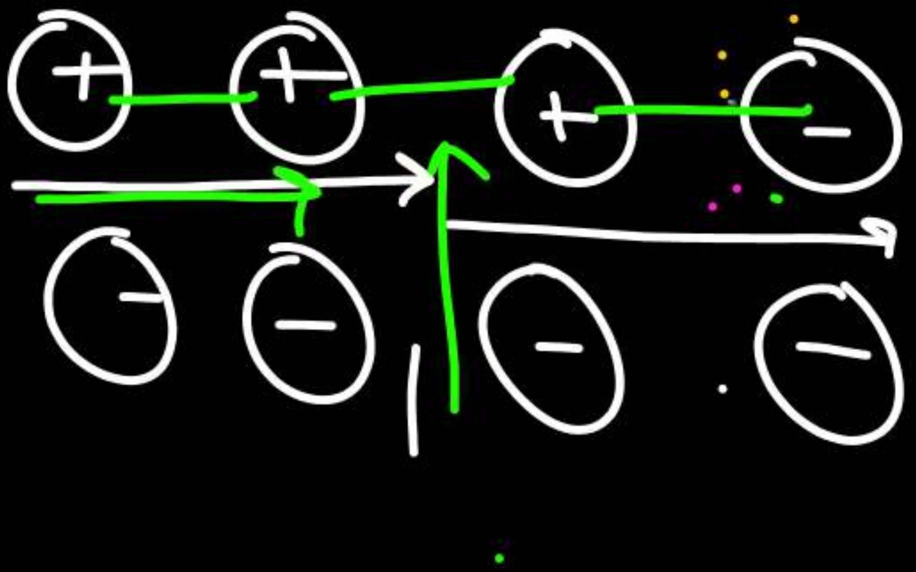
Types of Solid

Crystalline	Amorphous
➢ True Solid ➢ Regular Arrangement ➢ Follows short as well as long order ➢ Sharp melting point ➢ Definite Geometry	➢ Pseudo solids (super cooled liquids) ➢ Irregular arrangement ➢ Follows short range order ➢ Diffused melting points ➢ Indefinite Geometry
Anisotropic in nature (Have different physics properties like thermal conductance, thermal expansion are different direction)	Isotropic in nature (Have same directional properties. Example:- Glass, Rubber, Polymer





Solid

- Amorphous
- Crystalline
  - Ionic
  - Covalent
  - Molecular
  - Metallic

Unit cell

Types of Crystalline Solid

(Network)

Ionic	Covalent	Metallic	Molecular
➢ Constituent particles are ions ➢ Strong electrostatics force of attraction between oppositely charged ions termed as ionic bond ➢ Insulated at room temperature but conductor in molten state ➢ Ex. NaCl, $CaCO_3$	➢ Constituent particle are atoms ➢ Bond formed by Sharing electrons ➢ These are insulator in molten and solid state ➢ $\boxed{\text{Except graphite}}$ it is bad conductor due to presence of free electron ➢ Ex. Diamond, AlN, SIC, BN	➢ Constituent particle are $\boxed{\text{kernels}}$ and mobile electrons ➢ Attraction between positive charge kernel is metallic bond ➢ Metals are always good conductor at room temperature ➢ Ex. All metals are solid except Mercury	➢ Constituent particle are molecules ➢ Dipole-Dipole ➢ Hydrogen bonded solids

Note:- Crystalline solids are also called true solid but Ice is not a true solid although its crystalline reason volume of true solid increases on melting that is of ice decreases

Q1. Which is Crystalline Hydrogen bonded solid?

(A) H_2O (B) NH_3 (C) Ice (D) CH_4

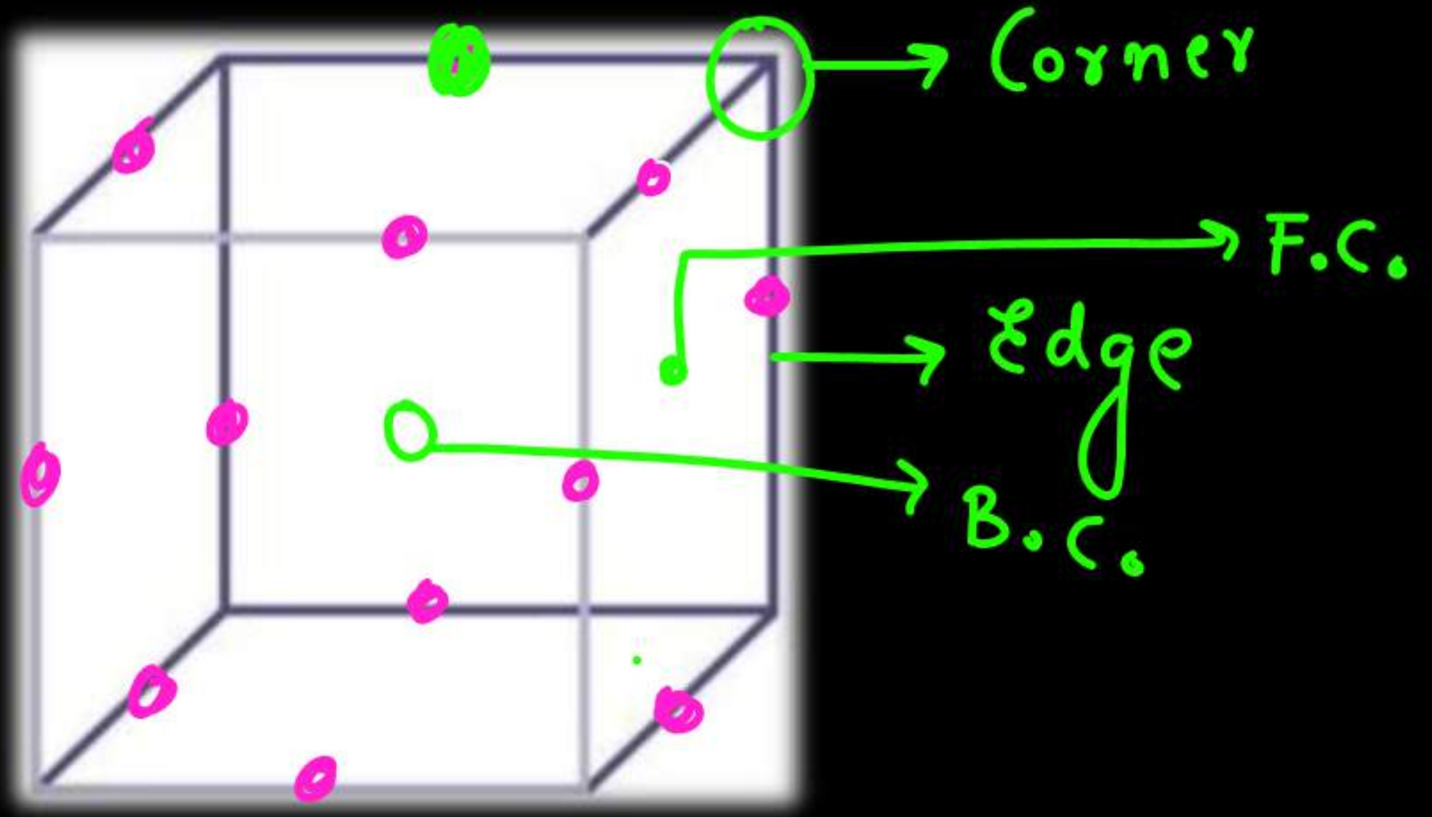
Q2. Which is Hydrogen bonded ?

(A) H_2O (B) NH_3 (C) HF (D) All

Q3. Which is true solid?

(A) Glass (B) Ice (C) Copper (D) Both A and C

Any Cube Contains



→ 8 Corners

→ 6 Faces

→ 12 Edges

→ 1 B.C.

→ 12 Face diagonals

→ 4 Body diagonals

Contribution of Single Property in a Unit Cell

① Corners → $8 \times \frac{1}{8} \Rightarrow 1$

② Face centre → $6 \times \frac{1}{2}$

③ Edge Centre → $12 \times \frac{1}{4}$

④ 1 B.C. → 1×1

⑤ face diagonal → $12 \times \frac{1}{2}$

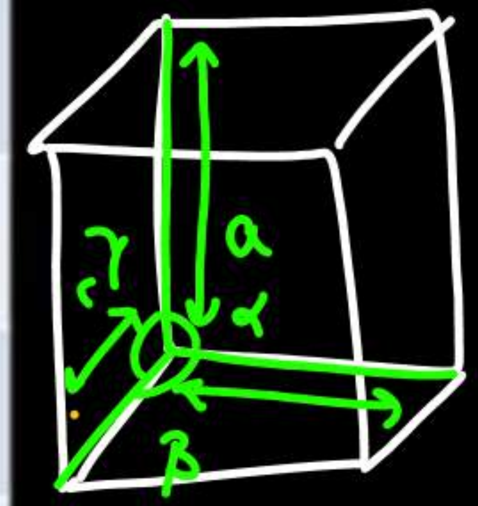
⑥ body diagonal → 1×1

Types of Crystal System

S. No	Crystal System	Edge length	Interfacial Angle	Type of Unit Cell
1.	Cubic	a = b = c	$\alpha = \beta = \gamma = 90°$	3 P, BCC, FCC
2.	Tetragonal	$a = b \neq c$	$\alpha = \beta = \gamma = 90°$	2 P, BCC
3.	Orthorhombic	$a \neq b \neq c$	$\alpha = \beta = \gamma = 90°$	4 P, BCC, FCC, ECC
4.	Rhombohedral	a = b = c	$\boxed{\alpha = \beta = \gamma} \neq 90°$	1 P
5.	Hexagonal	$a = b \neq c$	$\alpha = \beta = 90°, \gamma = 120°$	1 P
6.	Monoclinic	$a \neq b \neq c$	$\alpha = \gamma = 90°, \beta \neq 90°$	2 P, ECC
7.	Triclinic	$a \neq b \neq c$	$\alpha \neq \beta \neq \gamma \neq 90°$	1 P

क C
खु T
र O.
R
है H
मा M
ला T

FCC
BCC
P → Primitive



→ most asymmetric

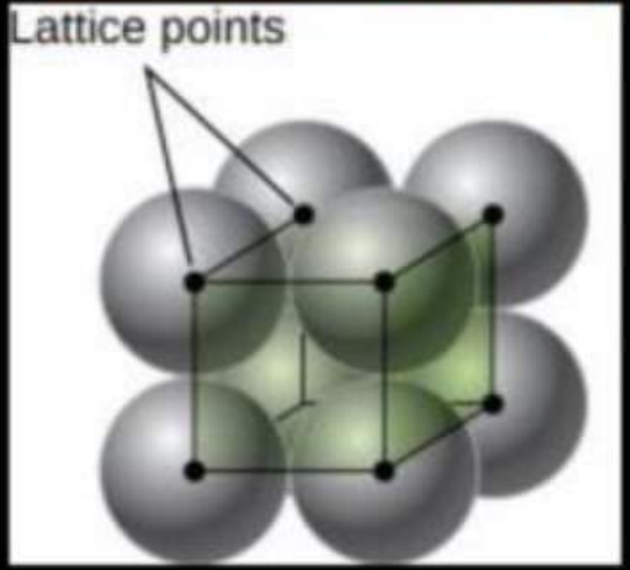
Types of Unit Cell

(Z = No. of atoms in a Unit cell)

Primitive

$Z = 1$

Simple Cubic

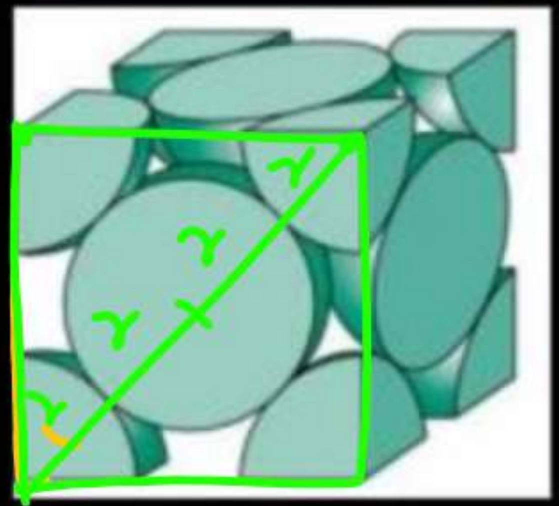


$Z = 8 \times \frac{1}{8} = 1$

Non-Primitive

FCC

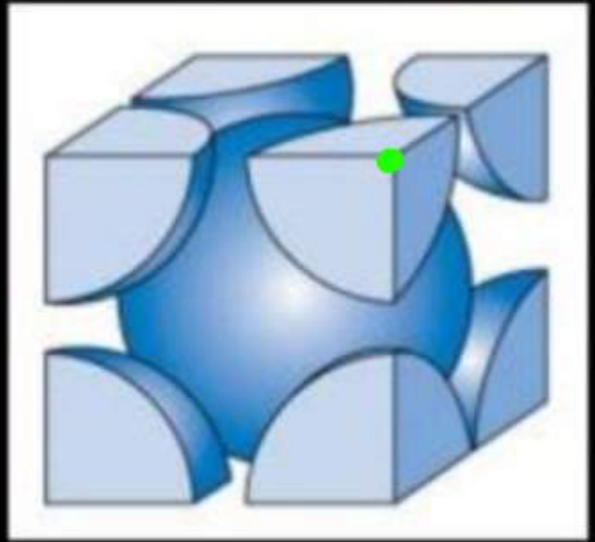
$Z = 4$



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

BCC

$Z = 2$

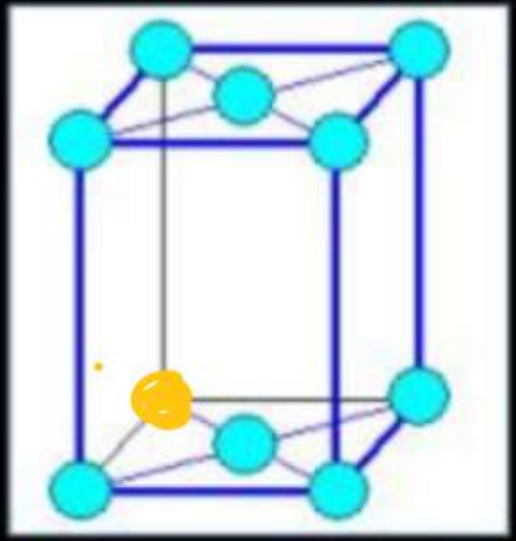


$Z = 8 \times \frac{1}{8} + 1 \times 1 = Z = 2$

ECC

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

$Z = 2$



Calculation of number of atoms in a Unit Cell

- **Simple Cubic**: Z = 1
- **FCC**: Z = 4
- **BCC**: Z = 2
- **ECC**: Z = 2

Q1. Calculate the total number of atoms per unit cell if particle are present at each corner, at the centre of each face and also at the centre of each Edge.

Corners + face centre + Edge centre

$\Rightarrow 8 \times \frac{1}{8} + 6 \times \frac{1}{2} + 12 \times \frac{1}{4}$

$\Rightarrow 1 + 3 + 3 \Rightarrow 7$ atoms / Unit cell

Q2. Calculate the total number of atoms per unit cell if lattice point lies of each corner and there are two lattice point at each body diagonal?

$$\Rightarrow 8 \times \frac{1}{8} + 4 \times 2$$

$$\Rightarrow 1 + 8 \Rightarrow 9$$ atoms / Unit cell

Q3. **Find out the stoichiometry if A lies at each corner, B lies at centre of each face and O lies at the centre of each edge.**

A	B	O
corners	Face centre	Edge centre
$8 \times \frac{1}{8}$	$6 \times \frac{1}{2}$	$12 \times \frac{1}{4}$
1	3	3

AB_3O_3

Q4. Unit cell is made of A and B where A lies at each corner and B lies at body centre. Find out the formula of resulting unit cell if one of A is replaced by C.

A	B	C
Corners	B.C.	
$7 \times \frac{1}{8}$	1	$1 \times \frac{1}{8}$

$$\begin{array}{ccc} A & B & C \\ \frac{7}{8} & 1 & \frac{1}{8} \end{array} \times 8$$

$A_7B_8C_1$

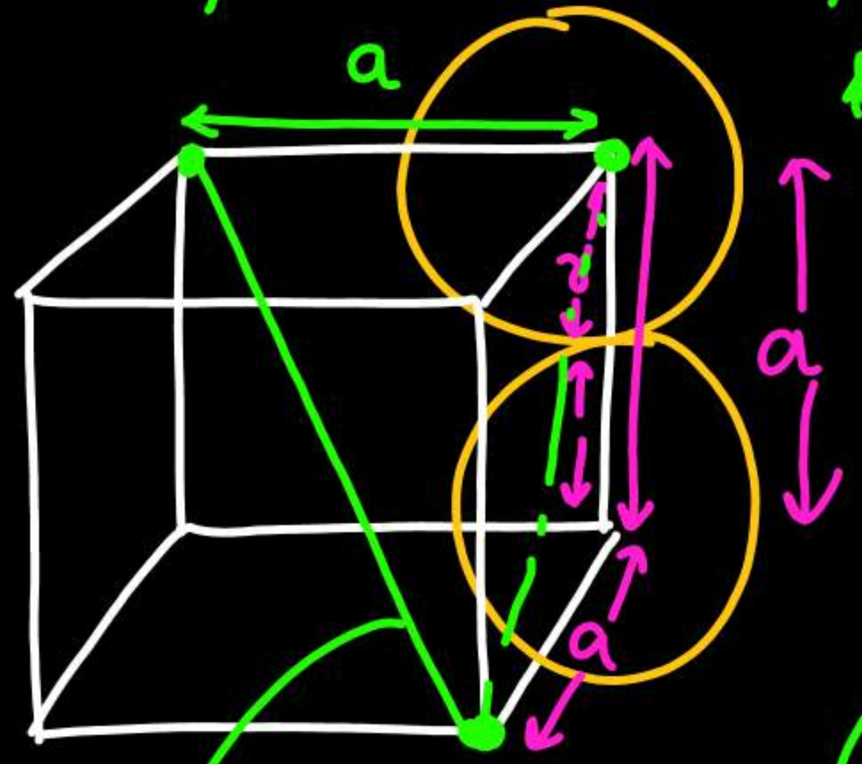
Relation Between a, r & d

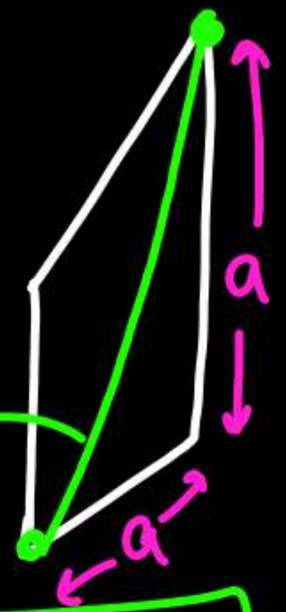
a → Edge length

r → radius

① Simple Cubic Unit cell

$\boxed{a = 2r}$





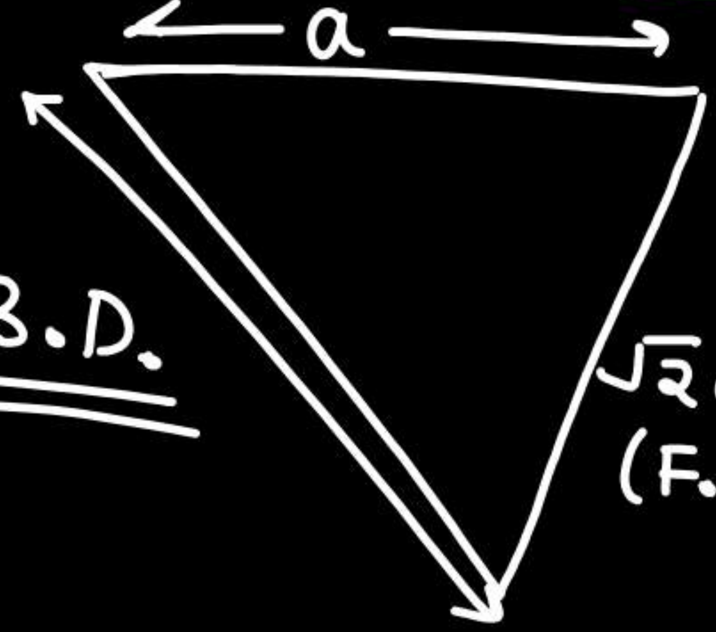
Body diagonal

Face diagonal $= \sqrt{2}a$

$= \sqrt{a^2 + a^2}$

$= \sqrt{2a^2} \Rightarrow \sqrt{2}a$

$\Rightarrow$



$\sqrt{3}a$

↑

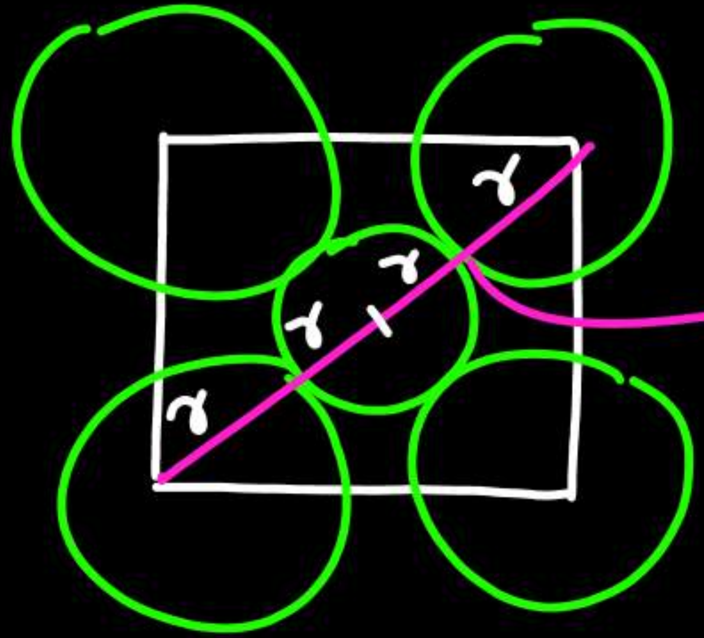
Body diagonal

$= \sqrt{2a^2 + a^2}$

$\Rightarrow \sqrt{3a^2}$

$\Rightarrow \sqrt{3}a$

(2) FCC $Z = 4$



Face diagonal

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

(3) BCC $Z = 2$

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

$z=4$

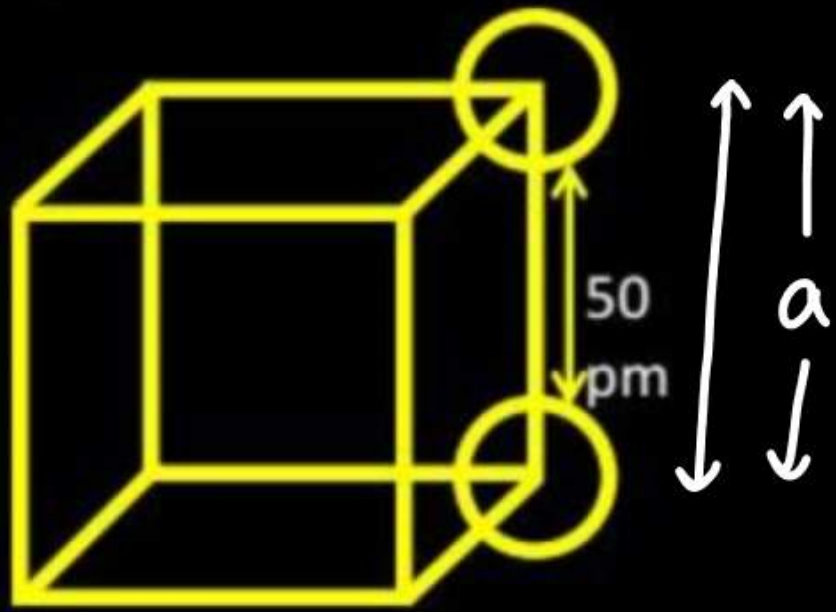
$\sqrt{2}a = 4r$

$a = ?$

$\sqrt{2}a$

$\sqrt{3}a$

Q1. Given FCC unit cell. Calculate edge length, face diagonal and body diagonal.



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

$\Rightarrow a = 2r + 50$ — (1)

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

$2r = \frac{a}{\sqrt{2}}$ — (2)

From (1) & (2)

$\Rightarrow a = \frac{a}{\sqrt{2}} + 50$

$\Rightarrow a - \frac{a}{\sqrt{2}} = 50$

$\Rightarrow a\left(1 - \frac{1}{\sqrt{2}}\right) = 50$

$a\left(1 - \frac{1}{1.414}\right) = 50$

$a\left(\frac{1.414 - 1}{1.414}\right) = 50$

$a = \frac{50 \times 1.414}{0.414}$

$\boxed{a = 170.7\ pm}$

$\Rightarrow$ Face diagonal $\Rightarrow \sqrt{2}\,a$

$= 1.414 \times 170.7$

$=$ ______

$\Rightarrow$ Body diagonal $= \sqrt{3}\,a$

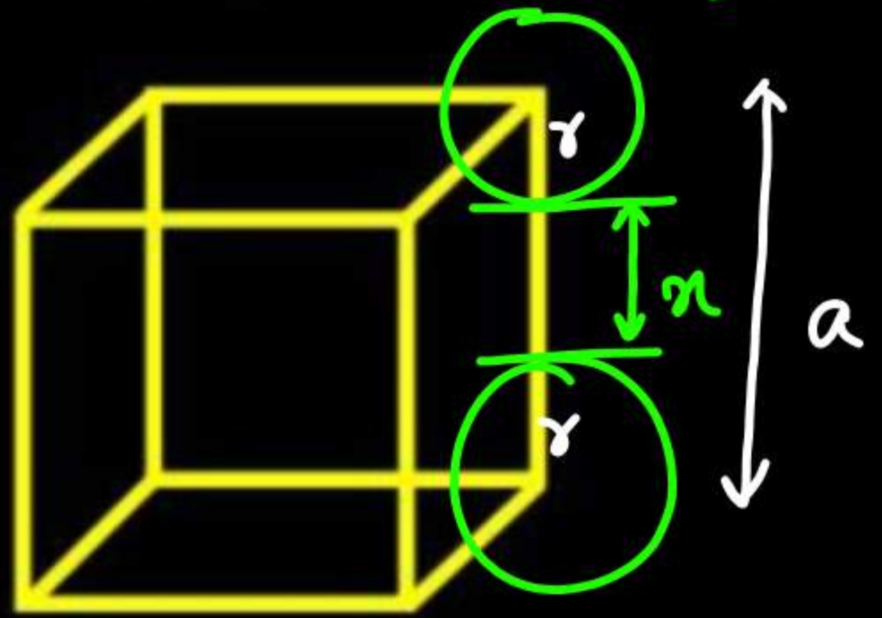
$\Rightarrow 1.732 \times 170.7$

$\Rightarrow$ ______ //

Q2. Calculate the percent of vacant space along the edge in BCC unit cell.

$z = 2$

$\sqrt{3}a = 4r$



$a = 2r + x$ — (2)

from (1) & (2)

$a = \frac{\sqrt{3}a}{2} + x$

$x = a - \frac{\sqrt{3}a}{2}$

$x = a\left[1 - \frac{\sqrt{3}a}{2}\right]$

$x = a\left[\frac{2 - 1.732}{2}\right]$

$x = a\left[\frac{0.268}{2}\right]$

$\frac{\sqrt{3}a}{2} = 2r$ — (1)

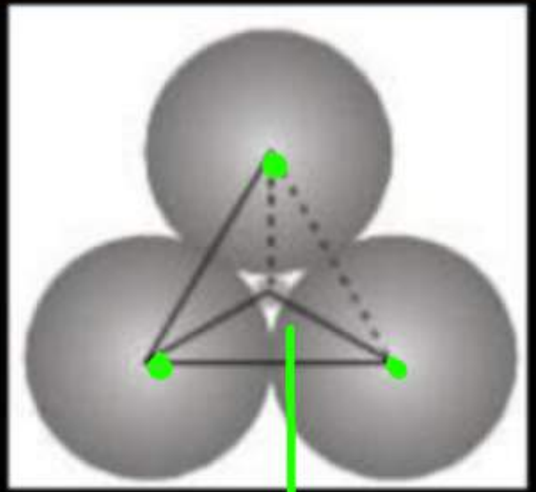
$x = 0.134\,a$

% vacant space $\Rightarrow \frac{0.134\cancel{a}}{\cancel{a}} \times 100$

$\Rightarrow 13.4\%$

Types of Void

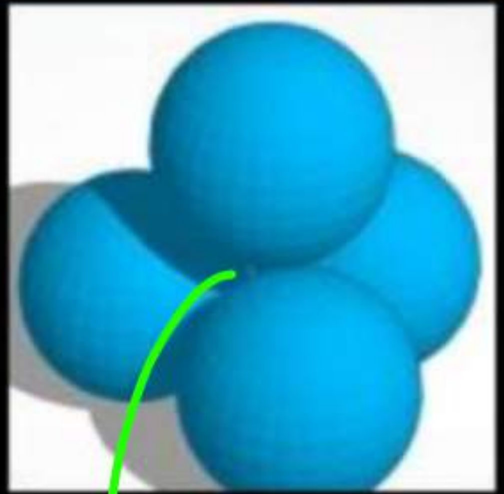
Triagonal



Triagonal void

C.No → 3

Tetrahedral

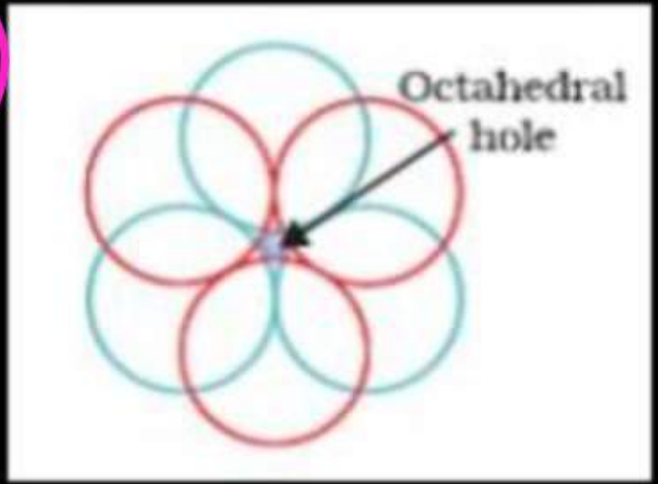


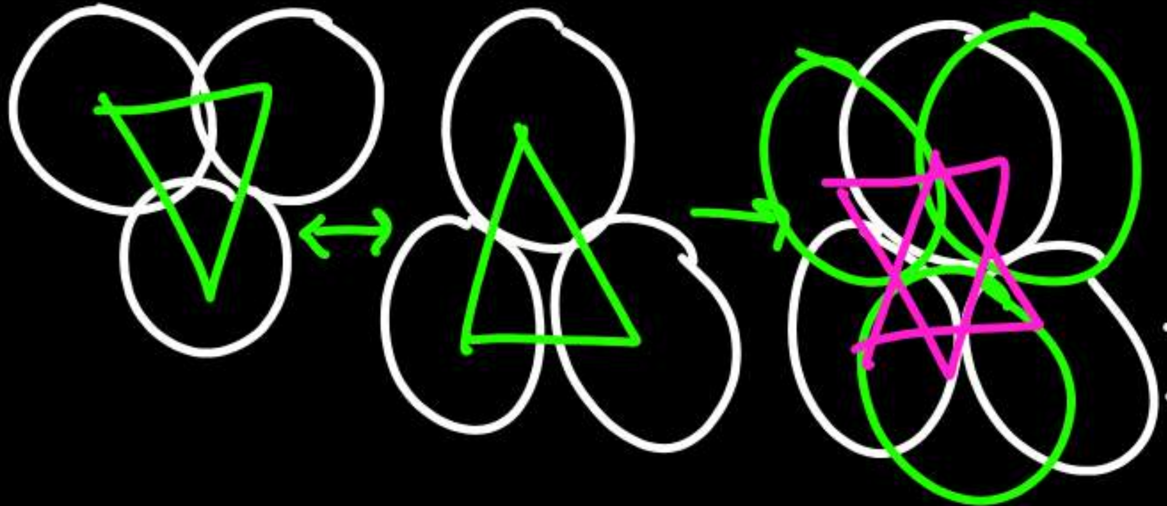
Td void

C.No → 4

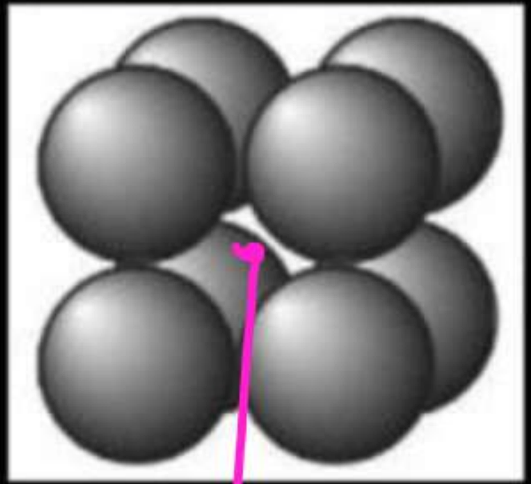
Octahedral

C.No → 6





Cubic



Cubic Void

C.No. → 8

Packing efficiency

↳ % of space occupied.

$\boxed{\text{2-D}}$ (By Area)

$$\Rightarrow \boxed{P.E = \frac{Z \times \pi r^2}{l_1 \times l_2} \times 100}$$

$\boxed{\text{3-D}}$ (By Volume)

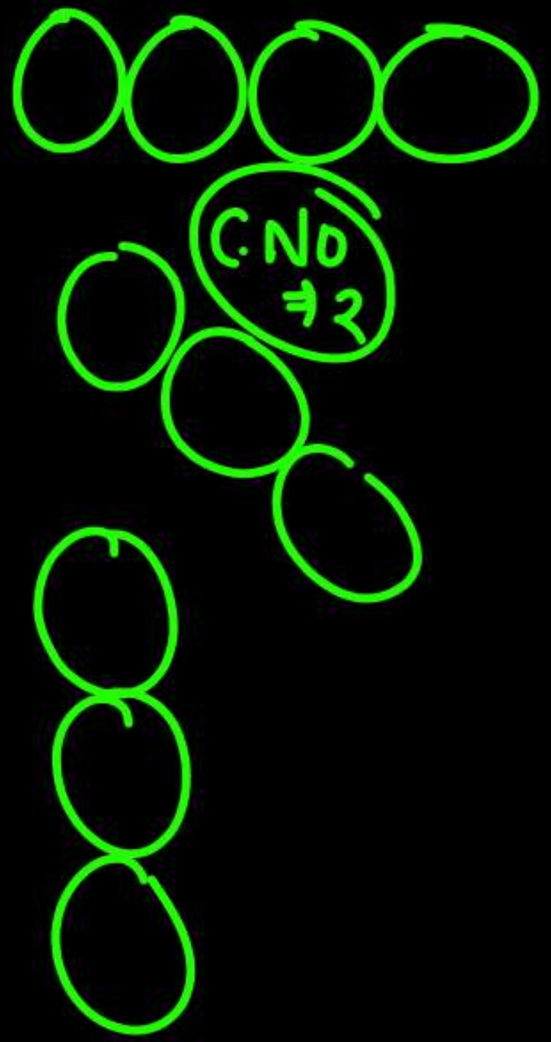
$$\boxed{P.E = \frac{Z \times \frac{4}{3}\pi r^3}{a^3}}$$

Close Packing in Solids

1 Dimensional

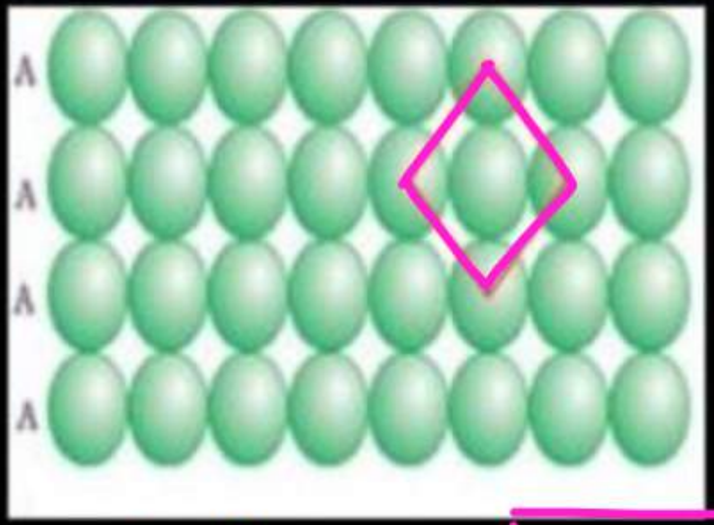
2 Dimensional

3 Dimensional



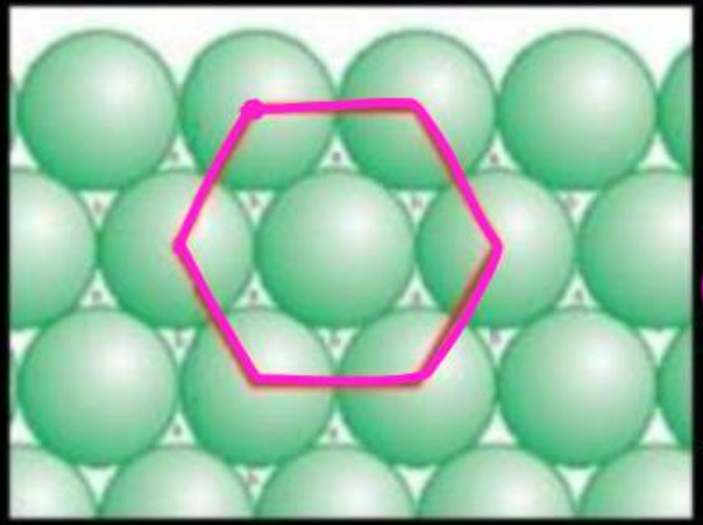
C.NO = 2

Square close Packing



C.NO = 4 $\boxed{P.E. = 78.4\%}$

Hexagonal close Packing



C.NO = 6

P.E = 90.4 %

3 Dimensional

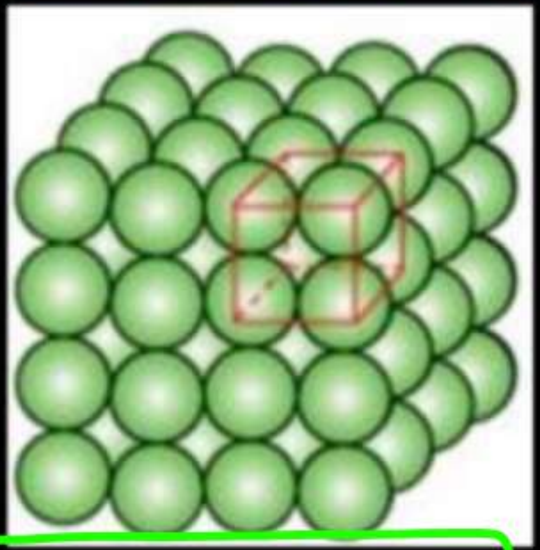
Square close Packing

$a = 2r$

$Z = 1$

Simple Cubic

AAA..... type



$\boxed{P.E = 52.4\%}$

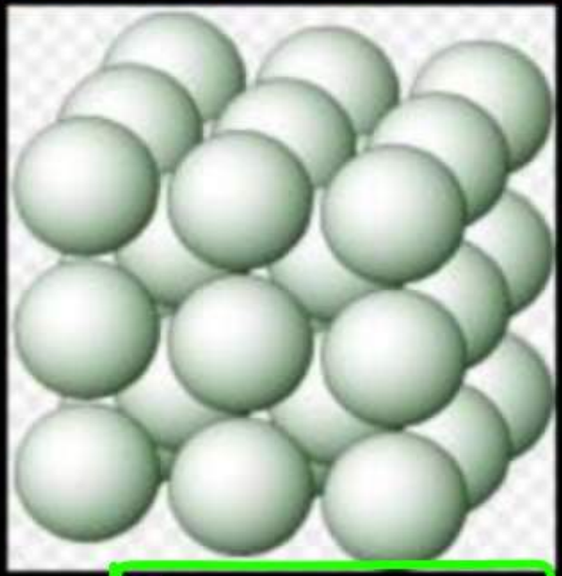
$\boxed{C.No = 6}$

$Z = 2$

$\sqrt{3}a = 4r$

$\boxed{BCC}$

ABAB.... type



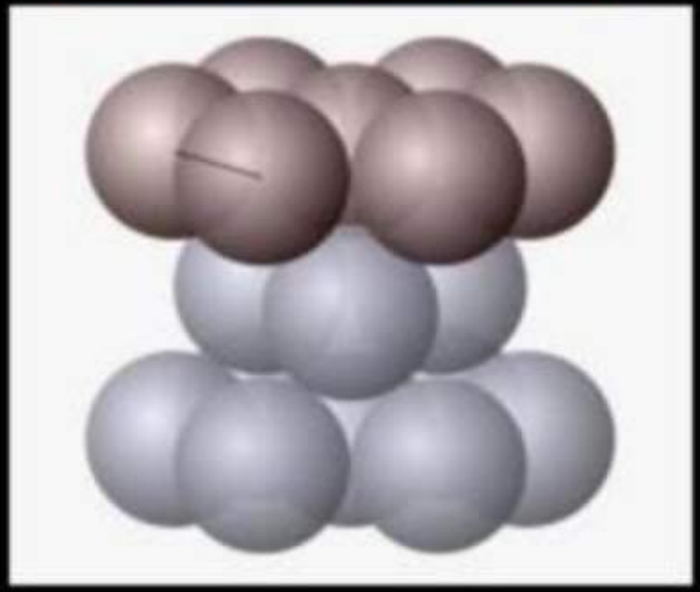
$\boxed{P.E = 68\%}$

C.No. = 8

Hexagonal close Packing

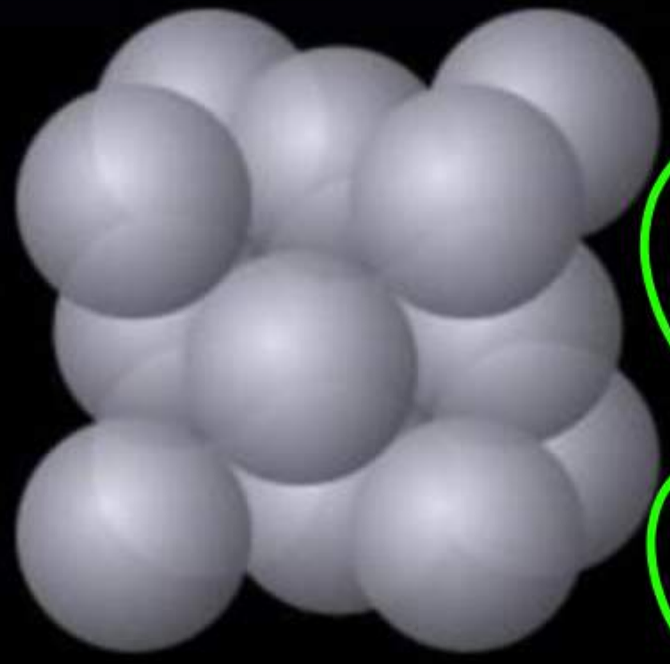
(HCP-3D)

ABAB.... type



(FCC or CCP)

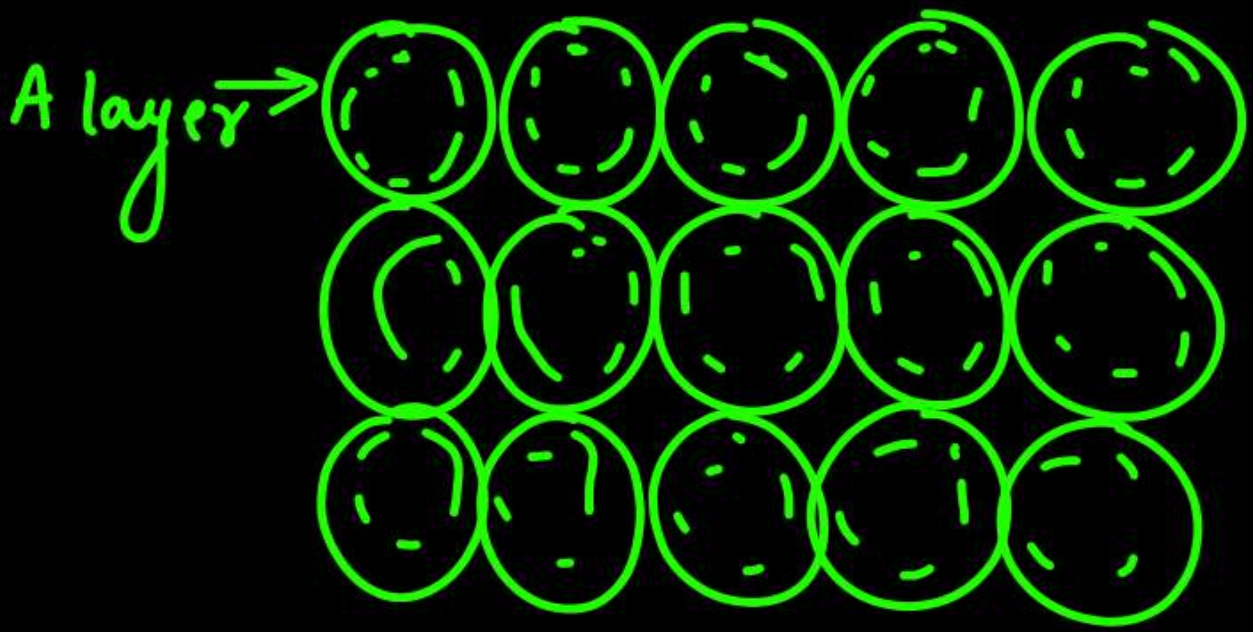
ABCABC.... type

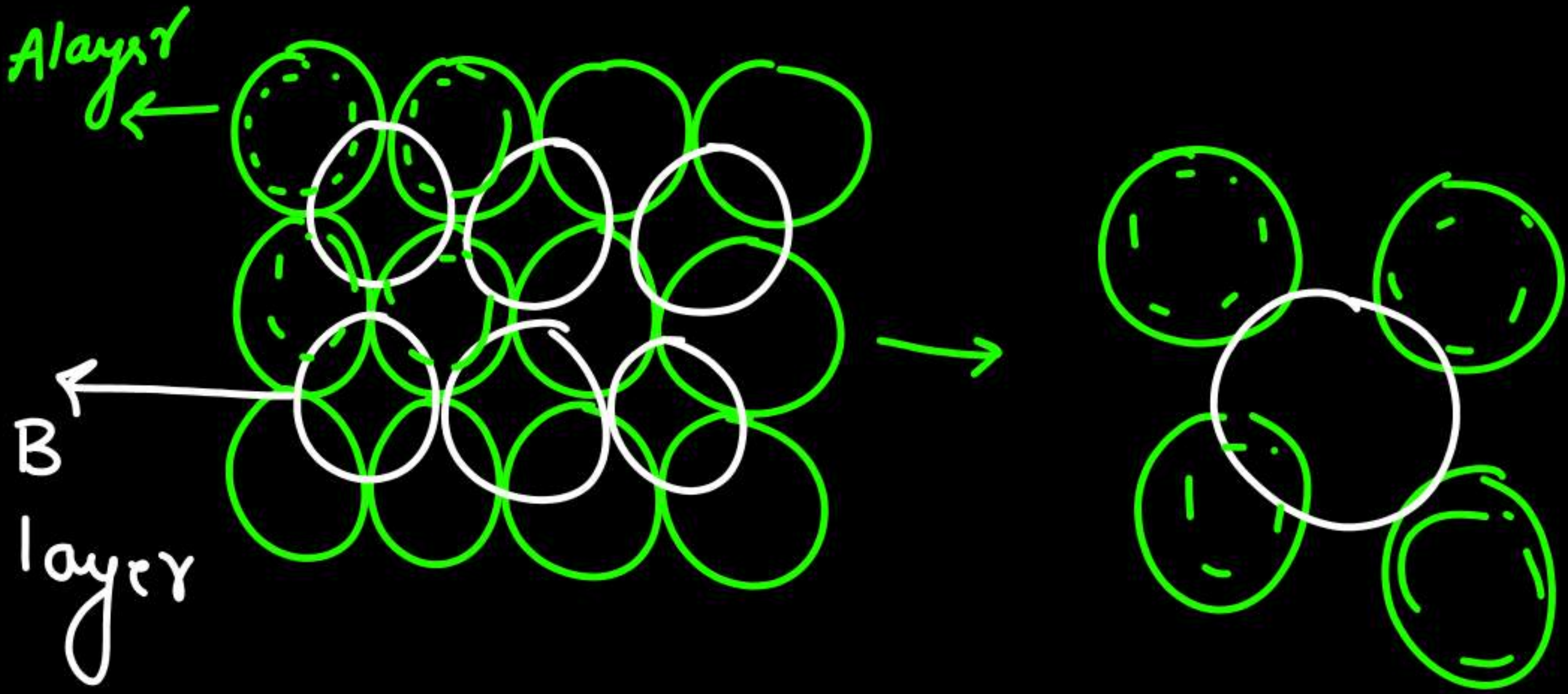


P.E = 74%

CNo = 12

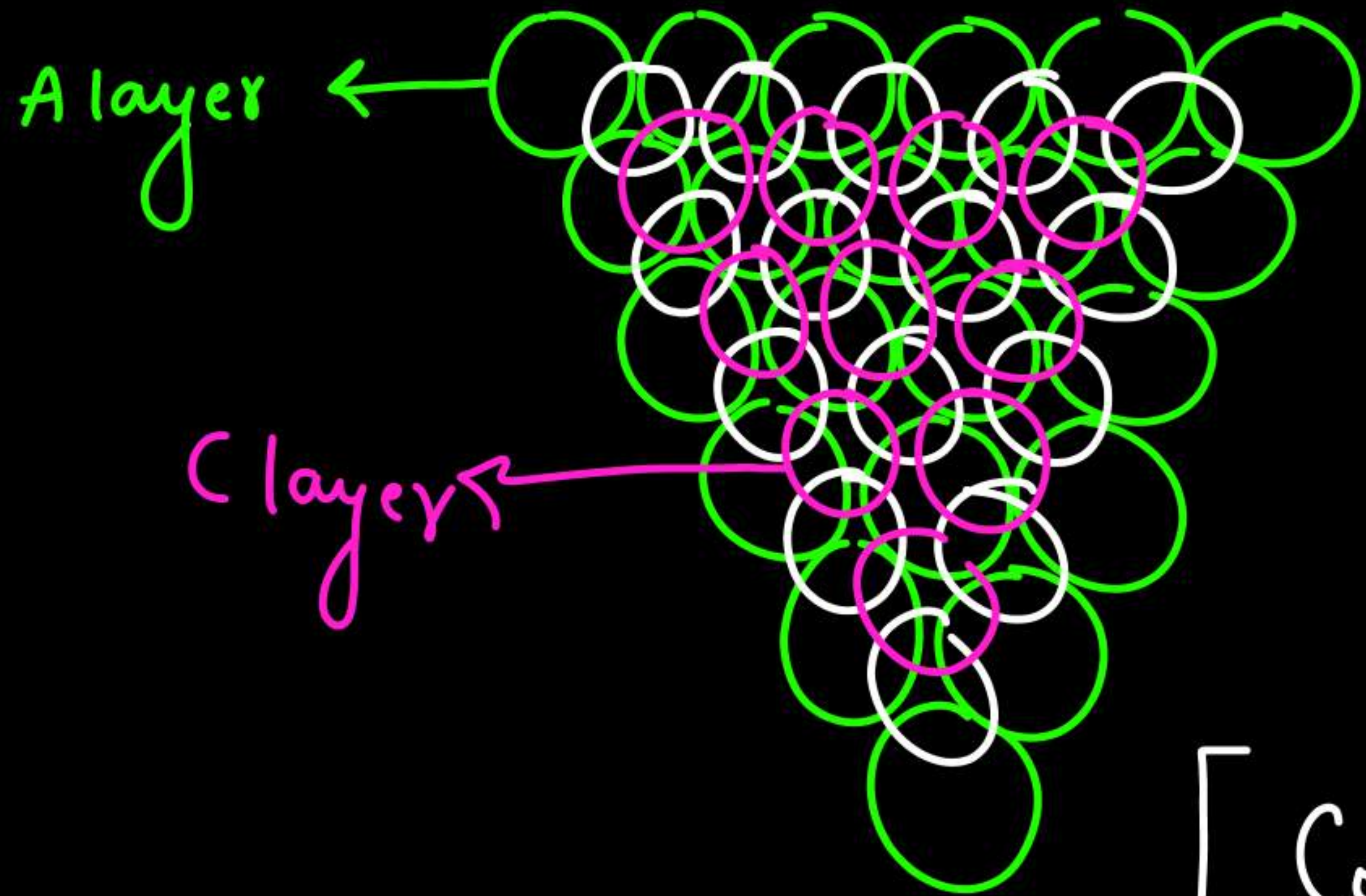
AAA (Square close)





HCP

(FCC)



→ if third layer is put on Td void then its is ABAB type close packing (HCP-3D)

→ if third layer is put on Oh void then it is ABCABC type close packing (FCC) or CCP

[Co.No ⇒ 12
P.E ⇒ 74%]

Q1. Percent of space occupied in FCC unit cell when half of the atoms are removed from faces?

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

$$P.E. = \frac{z \times \frac{4}{3}\pi r^3}{a^3} \Rightarrow \frac{\frac{5}{2} \times \frac{4}{3}\pi r^3}{\left(\frac{4r}{\sqrt{2}}\right)^3} \times 100 \Rightarrow$$

$$z = 8 \times \frac{1}{8} + 3 \times \frac{1}{2}$$

$$\Rightarrow 1 + \frac{3}{2} \Rightarrow \frac{5}{2}$$

Q2. Percent of void in BCC unit cell when half of the atoms are removed?

$$\text{\% of void} \Rightarrow 100 - \frac{\text{\% of space occupied}}{2} (\text{P.E.})$$

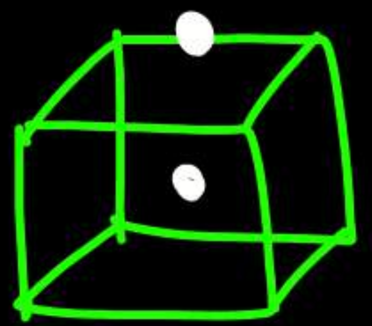
$$\Rightarrow 100 - \frac{68}{2} \Rightarrow 100 - 34 \Rightarrow 66\%$$

Location of Voids

- **Cubic void:-** Lies at centre of cube in simple cubic close packing.

C.No $\Rightarrow$ 8

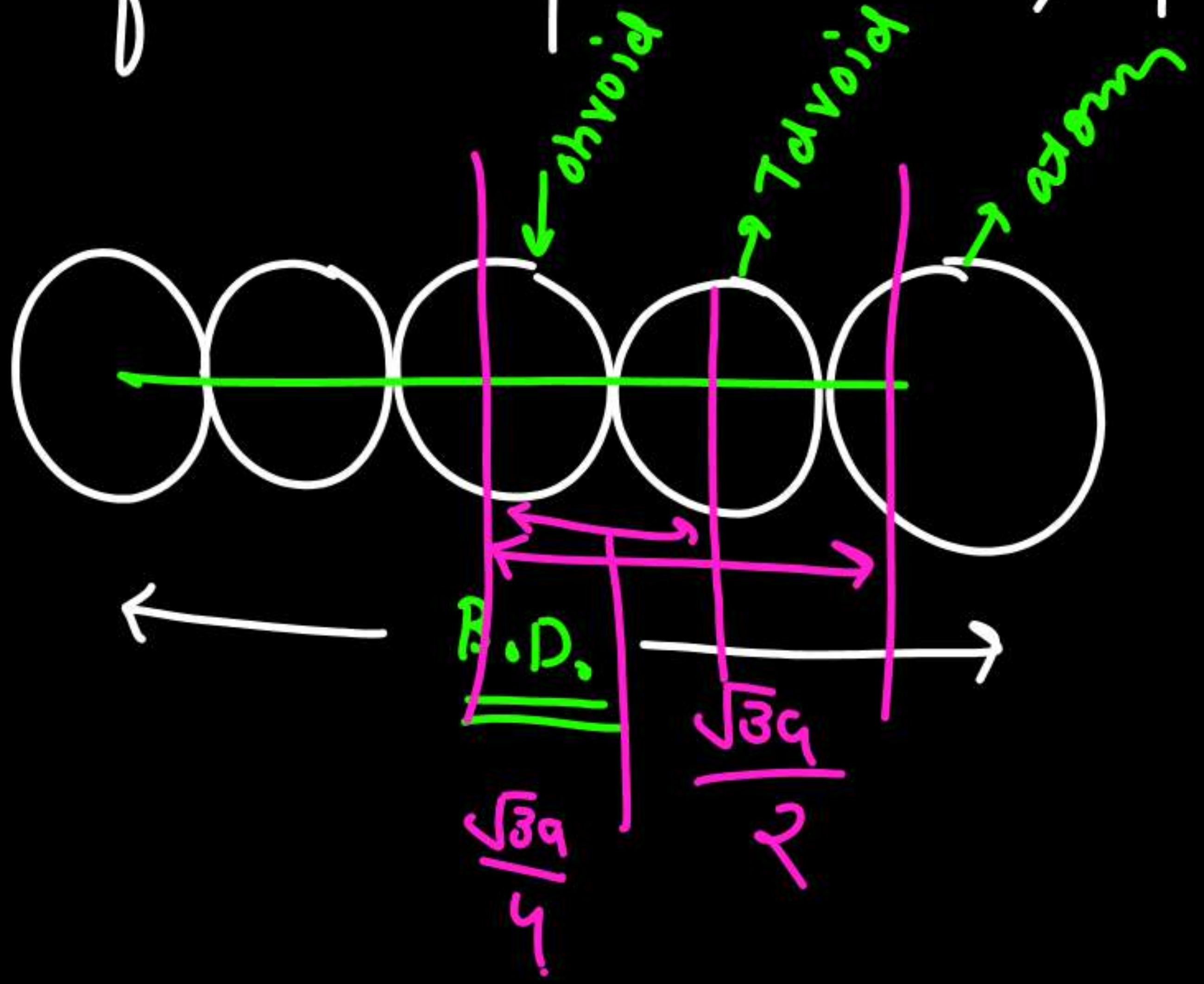
- **Octahedral void:-** Lies at centre of each edge as well as at the centre of cube in FCC or CCP type unit cell



No. of oh void / unit cell $\Rightarrow 12 \times \frac{1}{4} + 1 \Rightarrow$ 4 oh voids / unit cell

- **Tetrahedral void**:- Lies at body diagonal. Two tetrahedral voids lies at each body diagonal in FCC or CCP type close packing..

No. of Td void per unit cell ⇒ 4 × 2 ⇒ 8 Td voids / unit cell



Some Key Points

- The coordination number of void and the coordination number of the atom present in that void would be the same:

- $\boxed{\text{In FCC or CCP type unit cell:-}}$

1. Total number of atoms per unit cell →N ~~4~~ 4 1
2. Total number of octahedral void per unit cell →N ~~4~~ 1
3. Total number of tetrahedral void per unit cell →2N 8 2

Note:- Same as for HCP 3D.

Questions Based Voids

Q1. In a solid oxide ions are arranged in ccp manner, cation A occupy $\frac{1}{6}$ part of tetrahedral void and cation B occupy $\frac{1}{3}$ part of octahedral void. Find our the formula

$1\ \overset{-2}{O}$ / Unit cell

2 Td void   1 Oh void

$A \rightarrow 2 \times \frac{1}{6}$

$B \rightarrow \frac{1}{3} \times 1$

$$\begin{array}{ccc} A & B & O \end{array}$$
$$\left(\begin{array}{ccc} \frac{1}{3} & \frac{1}{3} & 1 \end{array}\right) \times 3$$

ABO_3

Q2. In a crystalline solid anions B are arranged in CCP lattice and cation A occupy 50% of octahedral void and 50% of tetrahedral void. Find the formula.

1 B^- ion / unit cell

1 Oh void

2 Td void

$$A \rightarrow \frac{\cancel{50}}{\cancel{100}_{2}} \times 2 + \frac{50}{100} \times 1$$

$$\Rightarrow 1 + \frac{1}{2} \Rightarrow \frac{3}{2}$$

$$\begin{array}{cc} A & B \end{array}$$

$$\left(\frac{3}{2} \quad 1 \right) \times 2 \rightarrow A_3B_2$$

Q3. Iron oxide crystallize in HCP manner, oxide ions form skeleton and two out of every three octahedral voids are occupied by iron. Then find out the formula.

1 O^{-2} ion / Unit cell

Oh void → 1

Td void → 2

$Fe \rightarrow \frac{2}{3} \times 1$

Fe	O
$\frac{2}{3}$	1

$\left(\frac{2}{3} \quad 1\right) \times 3$

Fe_2O_3

Td void → $\underline{\text{oh void}}$

$\underline{\text{ccp lattice}}$

Q4. $\boxed{MgAl_2O_4}$

What percent of octahedral void occupied?

What percent of tetrahedral void occupied?

What percent of total void occupied?

$4O^{-2}$/unit cell

4 oh void

8 Td void

% oh void $= \frac{2}{4} \times 100$

$\Rightarrow 50\%$

$\Rightarrow \frac{1}{8} \times 100$

$\Rightarrow 12.5\%$

% Total void

$\Rightarrow \frac{3}{12} \times 100$

$\Rightarrow 25\%$

AB_2O_4

A^{+2}

$2B^{+3}$

Radius Ratio

void

Ratio of radius of cation to the radius of anion

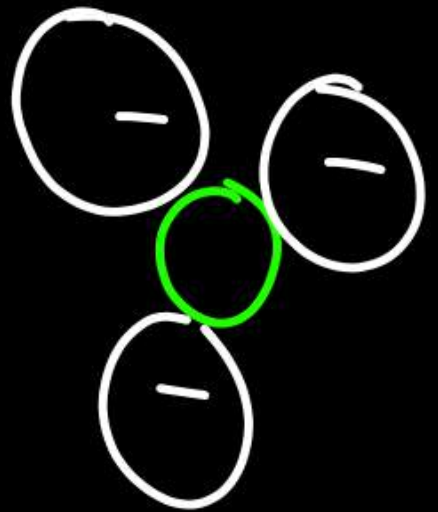
Structure

$\frac{r_+}{r_-} \rightarrow$ R.R.

ideal Dist.

Radius Ratio X (Min) ⟶ Y (Max)	Type of void	Coordination Number	Example
0.155 – 0.225	Trigonal	3	B_2O_3
0.225 – 0.414	Tetrahedral	4	ZnS, Na_2O
0.414 – 0.732	Octahedral	6	NaCl
0.732 – 1.00	Cubic	8	CsCl

ideal



Distorted :

Some Key Points

- Each atom is surround by 8 cubic void in simple cubic.
- Each atom is surrounded by 6 octahedral void in FCC or CCP type close packing.
- Each atom is surrounded by 8 tetrahedral voids in FCC/CCP type close packing.

Based on Radius Ratio

Q1. A solid having formula AB, cation A occupy octahedral void, if anion B has radius of 241.5 pm, then what should be the minimum radius of cation.

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

$$r_- = 241.5\ pm$$

$$\frac{r_+}{r_-} = 0.414$$

$$\Rightarrow r_+ = 0.414 \times 241.5\ pm$$

$$\Rightarrow \underline{99.98\ pm.}$$

Q2. Predict the coordination number of M and Y in MY if ionic radius of M^+ and Y^- are 97pm and 251 pm respectively.

$r_+ = 97\,pm$

$r_- = 251\,pm.$

$\rightarrow \frac{r_+}{r_-} = \frac{97}{251} \rightarrow 0.38$

$M^+ \rightarrow$ Td void $\rightarrow$ Co No $\rightarrow$ 4

$Y \rightarrow$ Co No $\rightarrow$ 8

Structure of Some Ionic Solid

NaCl:

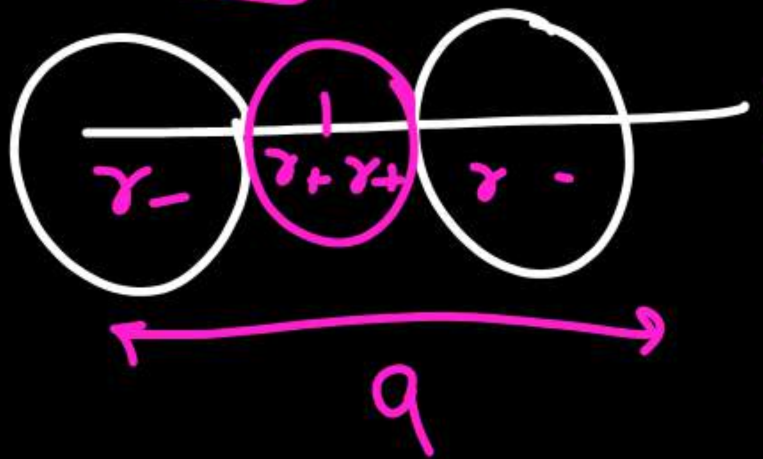
NaCl

Na^+ → oh void → 4 Na^+ / Unit cell

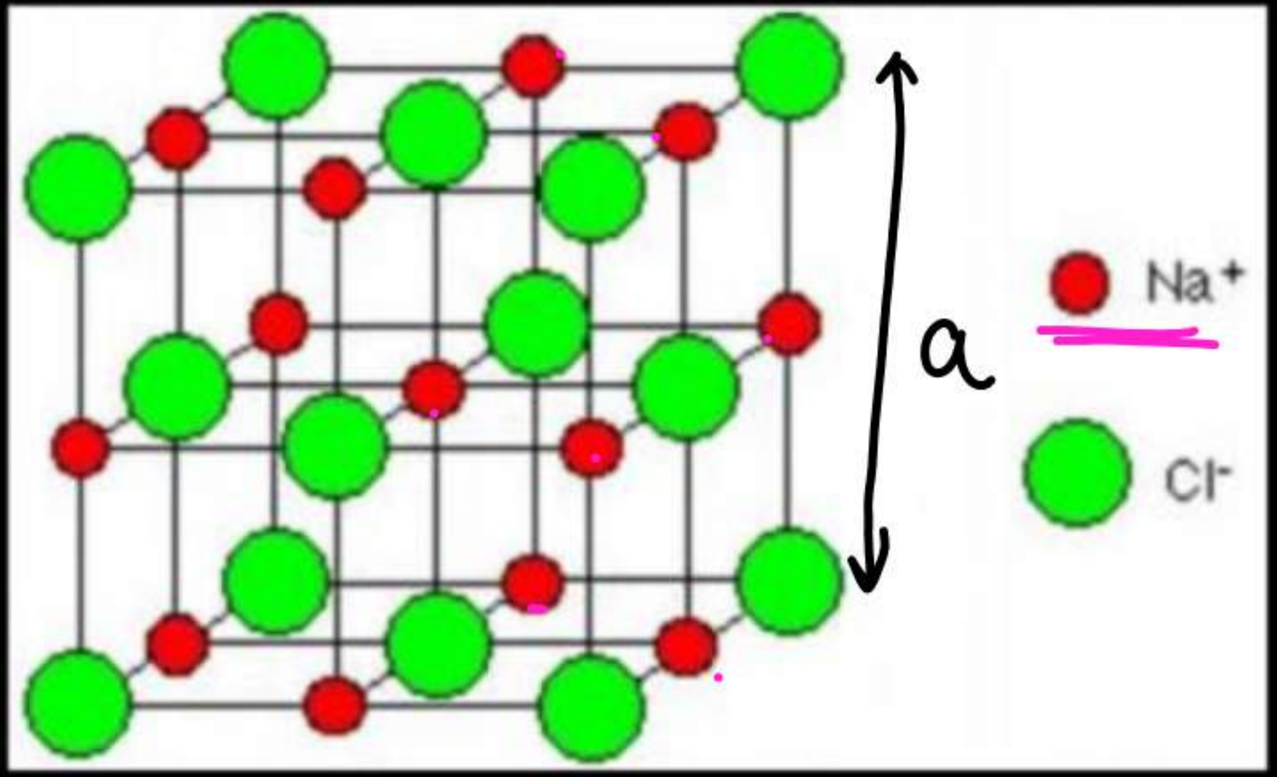
$\boxed{Z=4}$

Cl^- → FCC lattice ⇒ 4 atoms / Unit cell

$\boxed{\text{Co No} \rightarrow 6}$ $\boxed{\text{Co No} \rightarrow 6}$



$a = 2r_+ + 2r_-$



1 Cl^- / Unit cell → 1 oh void, 2 Td void

% oh void = $\frac{1}{1} \times 100$ ⇒ 100%

ZnS (Zinc Blende):

$1\,S^{-2}$/Unit cell

1 oh void

2 Td void

$\%Td = \frac{1}{2} \times 100 = 50\%$

Zn^{+2}

Td void

$\rightarrow 4\,Zn^{+2}$/Unit cell

$\boxed{C.No \rightarrow 4}$

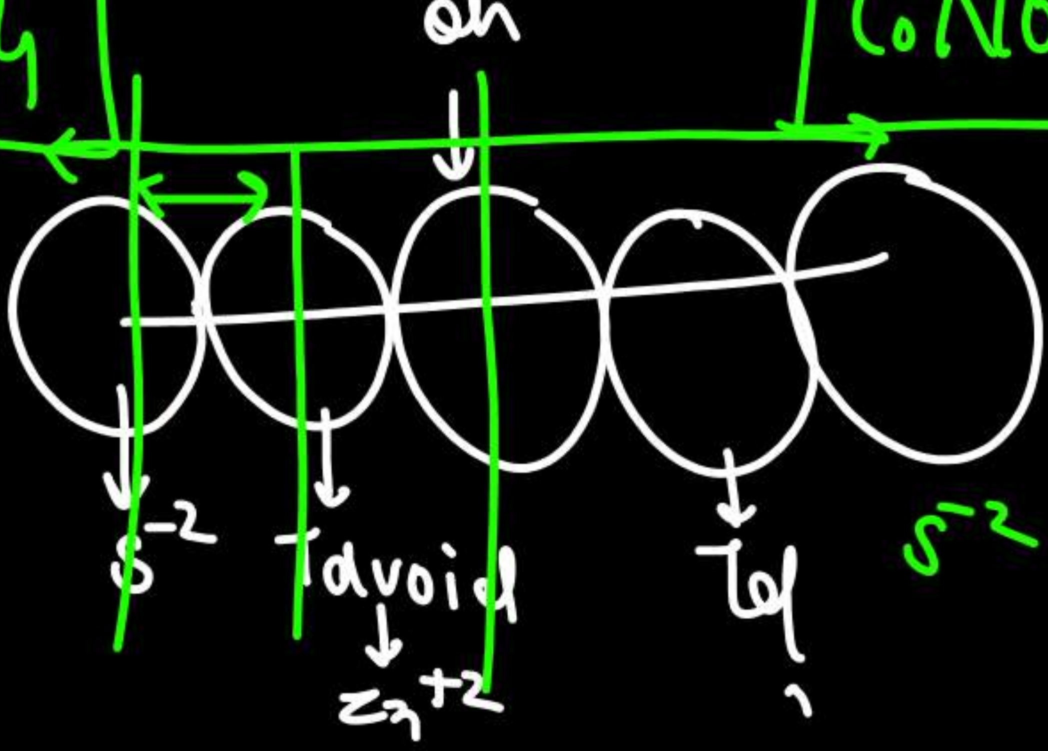
$Z = 4$

S^{-2}

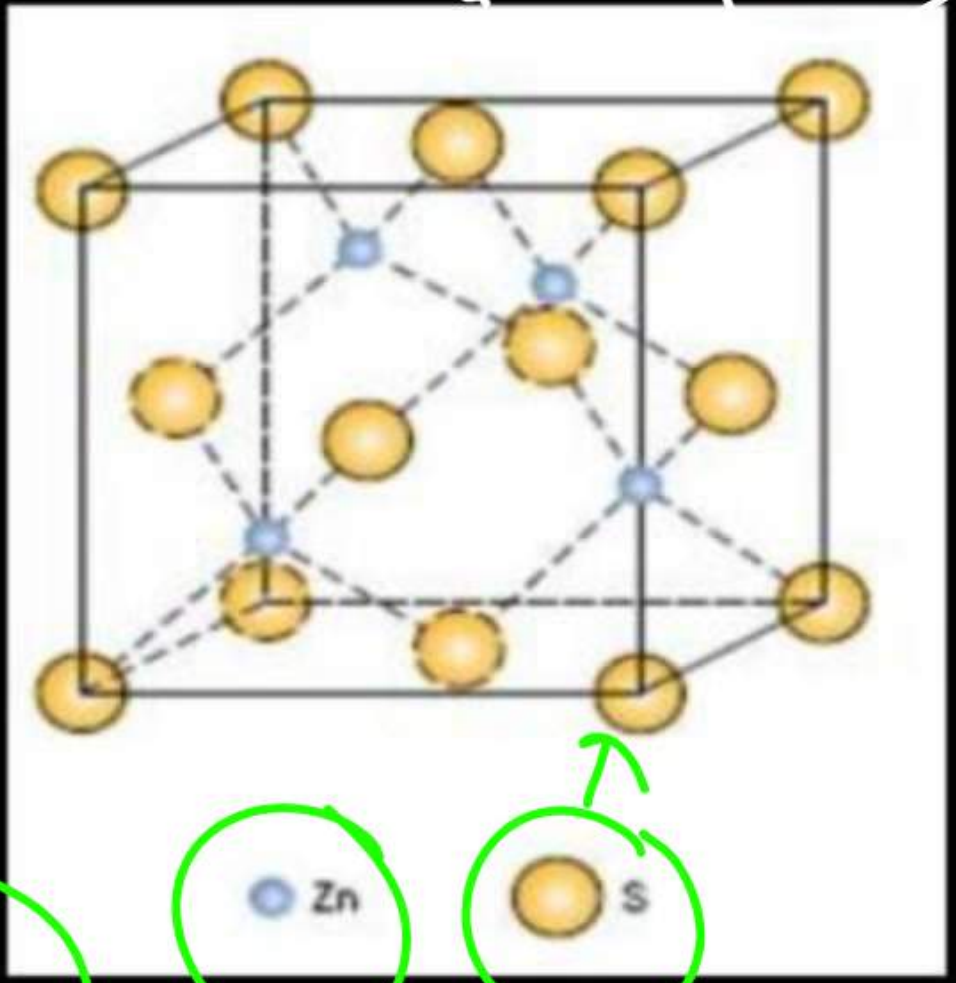
FCC lattice

$\rightarrow 4\,S^{-2}$/Unit cell

$\boxed{C.No \rightarrow 4}$



$$\frac{\sqrt{3}a}{4} = r_+ + r_-$$



Na_2O (Antiflourite Strucute):

$1\ O^{-2}$/unit cell

2 Td void — 1 oh void

$\frac{2}{2} \times 100 \Rightarrow 100\%$

Na^+

Td void

$\Rightarrow 8\ Na^+$ ion/Unit cell

$Z = 4$

O^{-2}

FCC lattice

$\Rightarrow 4\ O^{-2}$ ion/Unit cell

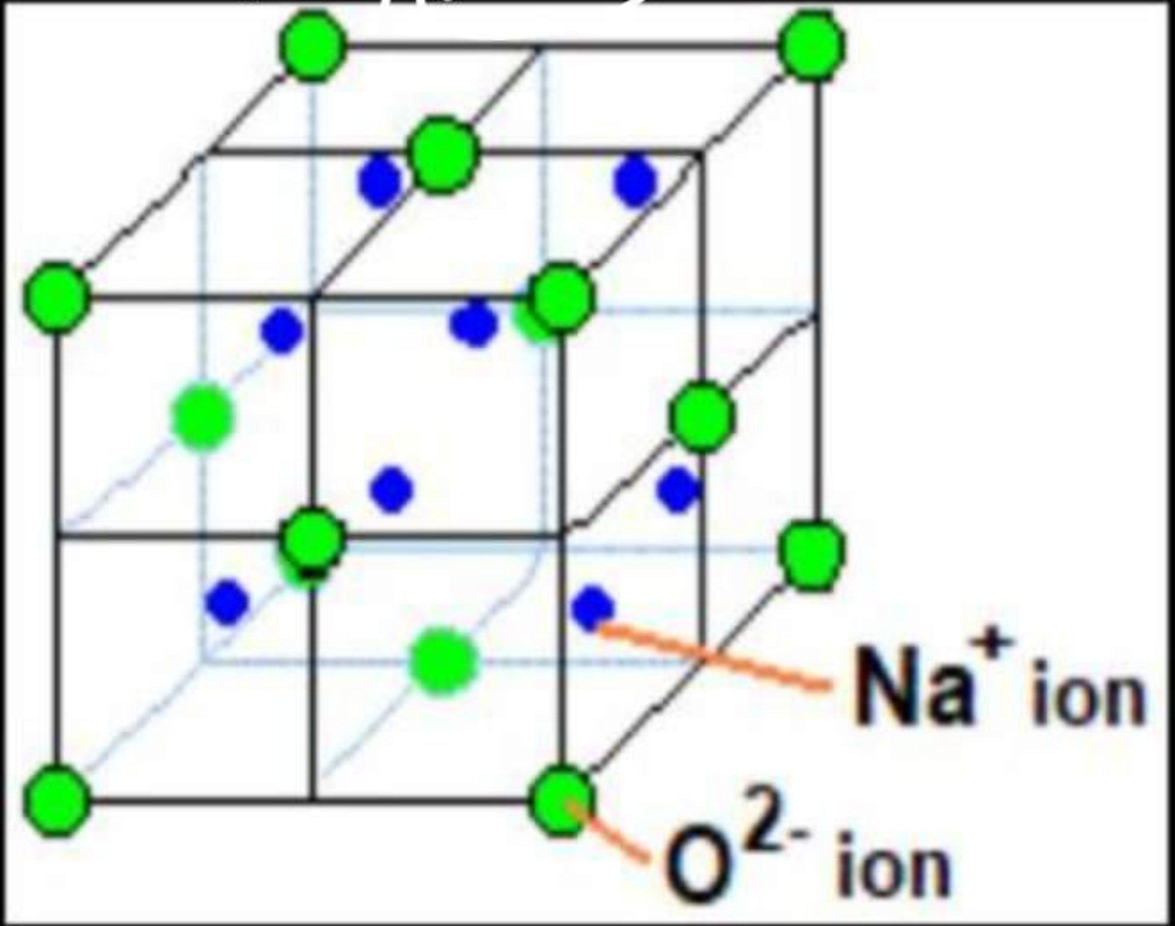
$\Rightarrow 8 \rightarrow$ C.No.

$2Na^+ \rightarrow 1O^{-2}$

$8Na^+ \rightarrow 4O^{-2}$

4

$$\frac{\sqrt{3}a}{4} = r_+ + r_-$$



CaF_2 (Fluorite Structure):

F^-

Td void

$\Rightarrow 8F^-$/Unit cel

C.No $\Rightarrow$ 4

Z = 4

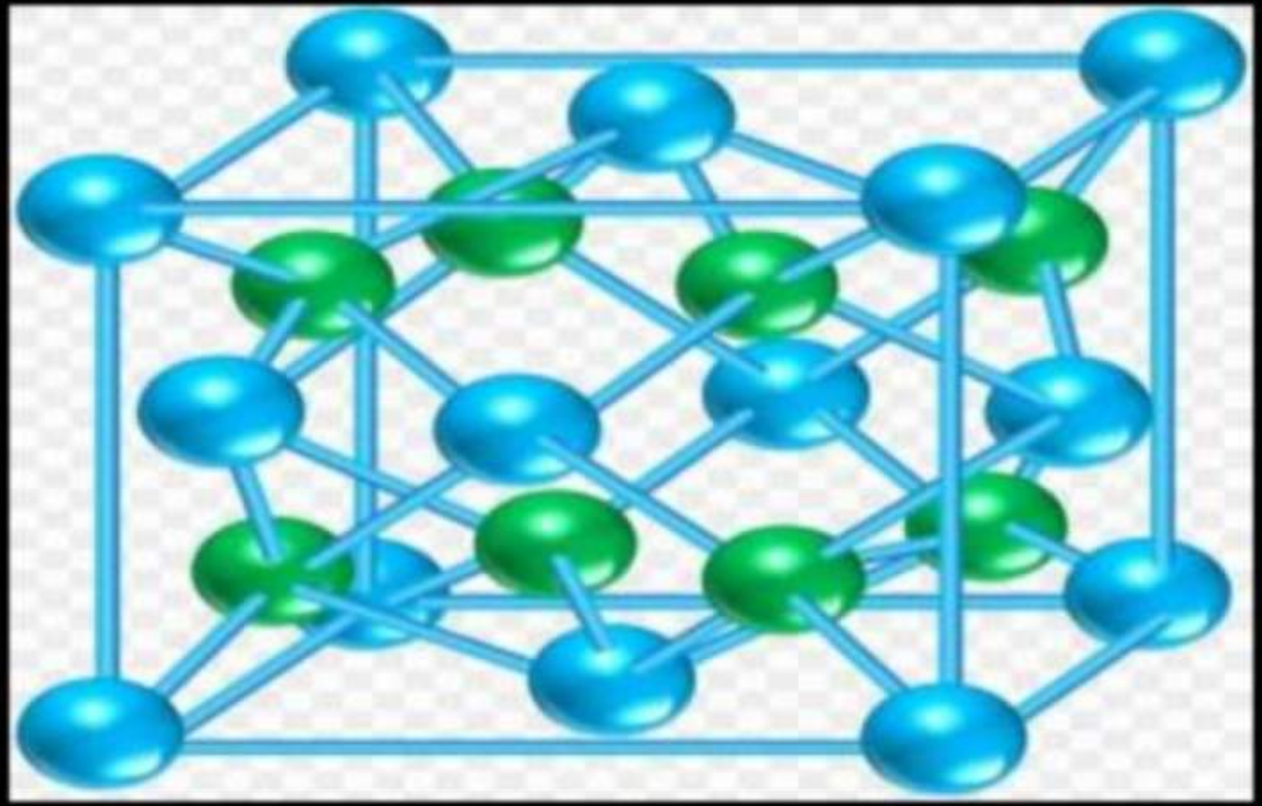
Ca^{+2}

FCC lattice

4 Ca^{+2} ion/Unit

8

$$\frac{\sqrt{3}a}{4} = r_+ + r_-$$



CsCl:

Cs^+

Cubic void

1 Cs^+ / Unit cell

C.No = 8

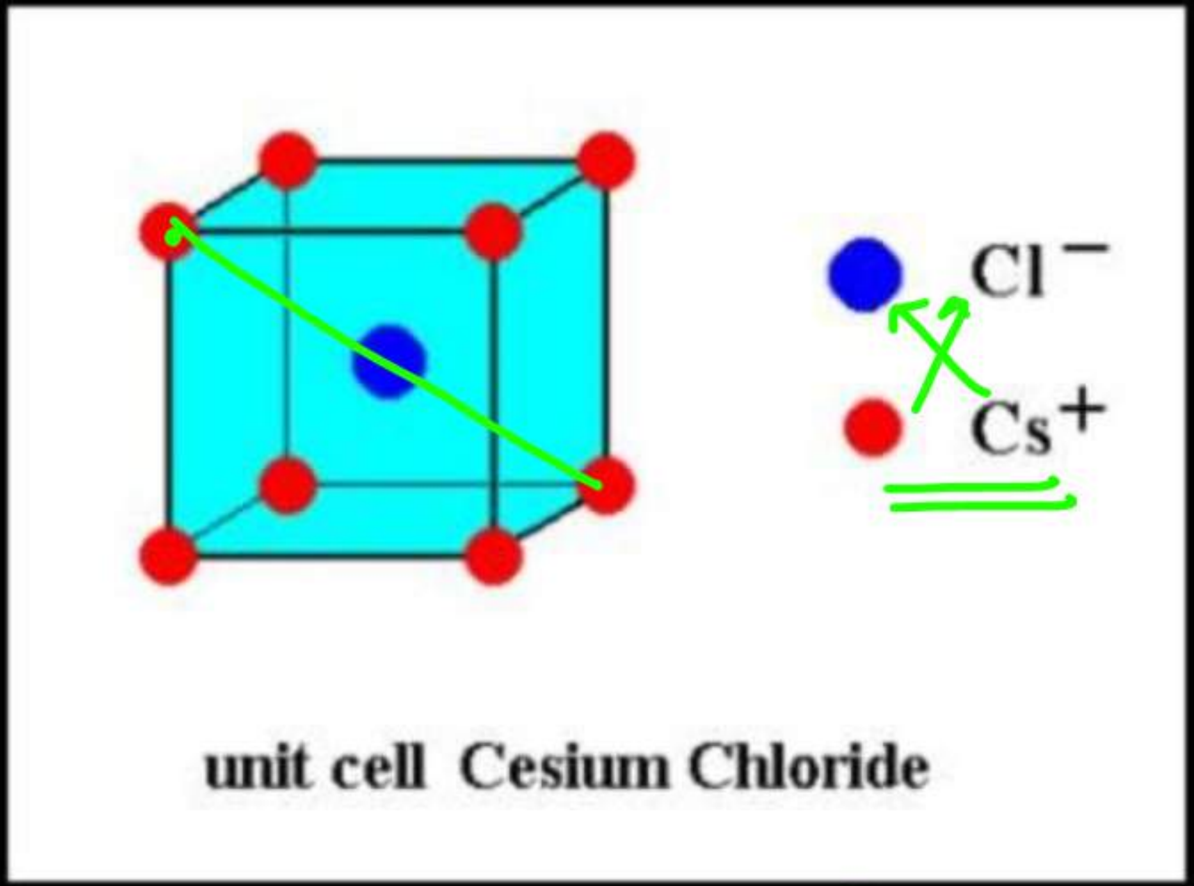
$Z = 1$

Cl^-

Simple cubic

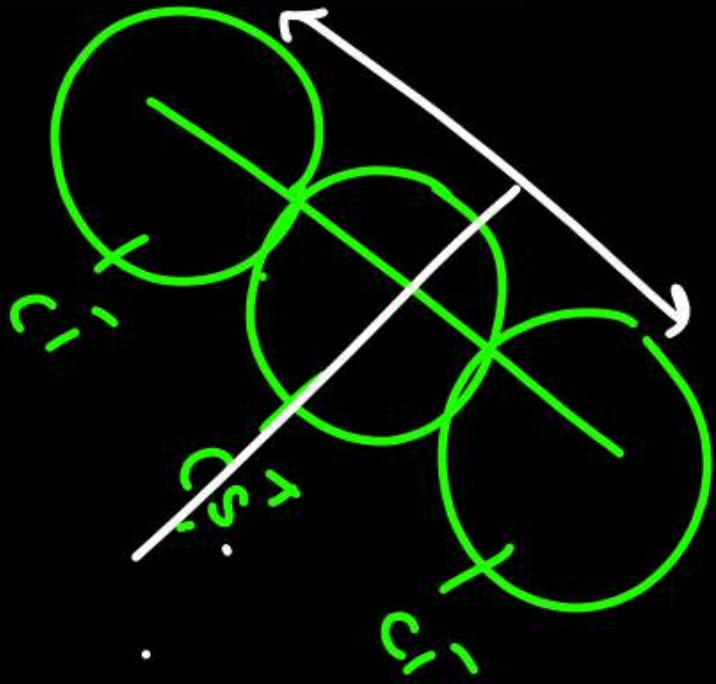
1 Cl^- / unit cell

C.No = 8



unit cell Cesium Chloride

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



Diamond:

$C \rightarrow$ Td void

$\boxed{Z=8}$

C

FCC lattice

% Td void occupied $= 50\%$

4 C atoms / Unit cell

4 C atoms / Unit cell

$\rightarrow$ C.No $\rightarrow$ 4

C.No $\rightarrow$ 4

$\frac{\sqrt{3}a}{4} = 2r$

$\sqrt{3}a = 8r$

$$P.E. \Rightarrow \frac{Z \times \frac{4}{3}\pi r^3}{a^3}$$

$$\Rightarrow \frac{8 \times \frac{4}{3}\pi r^3}{\left(\frac{8r}{\sqrt{3}}\right)^3} \times 100$$

$$\boxed{P.E = 34\%}$$

Conclusion

Imp

Type of ionic solid	Z	Coordination number ratio	Relation between a and r
NaCl	4	6 : 6	$a = 2r^+ + 2r^-$
ZnS	4	4 : 4	$\frac{\sqrt{3}a}{4} = r^+ + r^-$
Na_2O (Antifluorite Structure)	4	4 : 8	$\frac{\sqrt{3}a}{4} = r^+ + r^-$
CaF_2 (fluorite structure)	4	4 : 8	$\frac{\sqrt{3}a}{4} = r^+ + r^-$
CsCl	1	4 : 8	$\sqrt{3}a = 2(r^+ + r^-)$
Diamond	8	4 : 4	$\sqrt{3}a = 8r$

Density of Unit Cell

$d = \frac{w}{V}$

$d \rightarrow$ density

$n = \frac{w}{mm} = \frac{N_0}{N_A}$

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

$Z \rightarrow$ No. of atoms / Unit cell

$N_A \rightarrow 6.022 \times 10^{23}$

$$\boxed{d = \frac{Z \times w}{N_0 \times a^3}}$$

$a \rightarrow$ edge length

$w \rightarrow$ given mass

$N_0 \rightarrow$ No. of atoms.

Q1. The density of KBr is 2.75 g/cm^3. the edge length of unit cell 654 pm. Predict the type of unit cell a cubic lattice to which unit cell of KBr belongs?

$d = 2.75\ g/cm^3$

$a = 654\ pm$

$Z = ?$

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

$$2.75 = \frac{Z \times 119}{6.02 \times 10^{23} \times (654)^3 \times 10^{-30}}$$

$Z = 3.8 \approx 4 \rightarrow$ FCC Unit cell

Q2. An element occurs in BCC structure with edge length 288 pm. Calculate density of 200 g of this element contains 24×10^{23} atoms.

$Z = 2$

$a = 288\ pm$

$d = ?$

$w = 200\ g$

$N_0 = 24 \times 10^{23}$

$$d = \frac{Z \times w}{N_0 \times a^3}$$

$$d = \frac{2 \times 200}{24 \times 10^{23} \times (288)^3 \times 10^{-30}} \Rightarrow 6.97\ g/cm^3$$

Q3. The edge length of the metal having molar mass 75 is 5A°. Which crystallize in cubic lattice. If density is 2 g/cm^3. then find out the radius of metal atoms.

$MM = 75$

$a = 5 A^\circ$

$d = 2 g/cm^3$

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

$$2 = \frac{Z \times 75}{6.02 \times 10^{23} \times 5 \times 10^{-24}}$$

$Z = 2$

BCC

$\sqrt{3} a = 4r$

$$\frac{1.732 \times 5}{4} = r$$

$\boxed{2.16 A^\circ = r}$

Q4. AB crystallize in rock salt type structure with A : B is 1 : 1. The shortest distance between A and B is $y^{1/3}$ nm. The formula mass of AB is 6.023 y g. Here y is constant, then find out the density of the unit cell in kg/m^3?

NaCl

$Z = 4$

$a = 2r_+ + 2r_-$

6:6

$a = 2y^{1/3}$ nm

$M = 6.023y$

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

$d = \frac{\cancel{4} \times \cancel{6.023}y}{\cancel{6.023} \times 10^{23} \times (2y^{1/\cancel{3}})^{\cancel{3}} \times 10^{-21}}$

$8 \quad 2$

$\Rightarrow \frac{1}{2 \times 100}$ g/cm^3

$\Rightarrow \frac{1 \times 10^{\cancel{6}}}{2\cancel{00} \times 1\cancel{000}} 10$ kg/m^3 = 5 kg/m^3

1 m = 100 cm

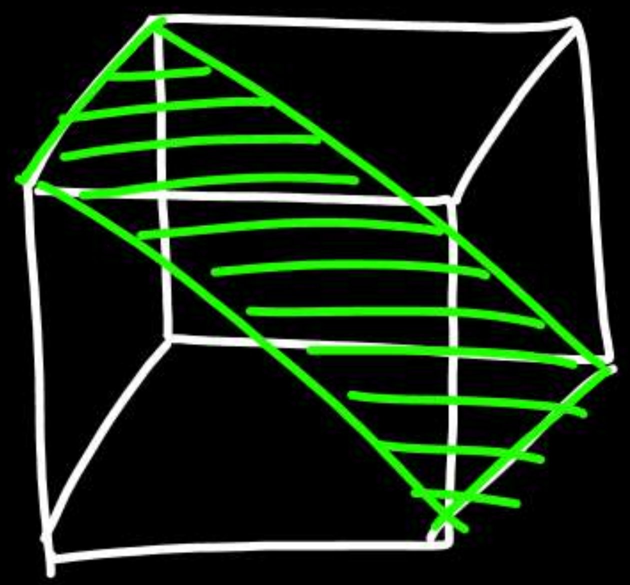
Elements of Symmetry (23)

$C_n = \frac{360^\circ}{n}$

- 13 Axis of Symmetry

  $C_2 = \frac{360^\circ}{2} = 180^\circ$

  - $6C_2$ — passing through oppossite edge via B.C.
  - $4C_3$ — passing through corner to corner via B.C.
  - $3C_4$ — passing through face to face via B.C.
- 9 plane of Symmetry
  - 6 Diagonal plane — Edge to edge via B.C.
  - 3-Rectangular plane — face to face vial B.C.
- 1 Centre of Symmetry



4 corner ⟶

2 F.C ⟶

2 E.C ⟶

1 B.C ⟶

Q. Find out the formula of a Crystal whose A atoms are present at Corners, B atoms at F.C. and C at B.C. & D at Edge Centre. but all the Atoms along one Diagonal plane are removed.

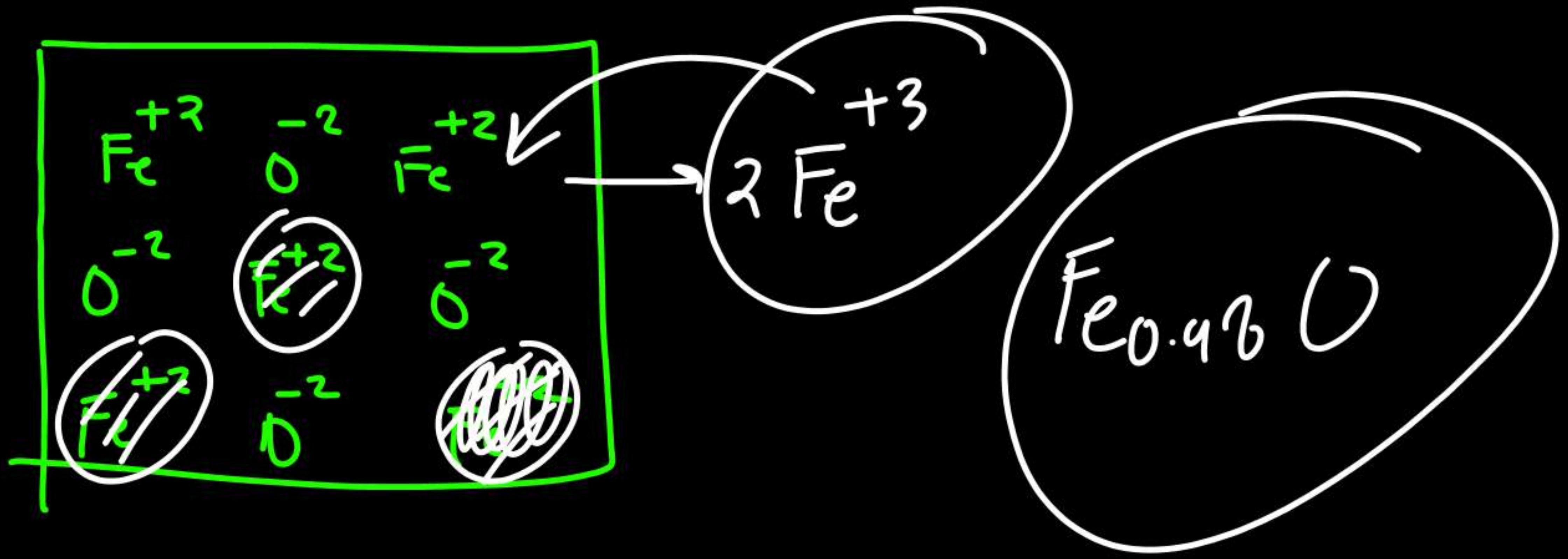
A	B	C	D
Corners	F.C.	B.C.	E.C.
$4 \times \frac{1}{8}$	$4 \times \frac{1}{2}$	0	$10 \times \frac{1}{4}$

A	B	D
$\frac{1}{2}$	2	$\frac{5}{2}$

$$\boxed{AB_4D_5}$$

DEFFECTS

- **POINT DEFFECT**
  → Lattice Point is missing
  - **Stoichiometric**
    - **Schottky**
      Eg:- NaCl, KCl, CsCl
      CsBr etc
      AgBr
    - **FRENKEL**
      Eg:- ZnS, AgCl,
      AgBr, AgI
  - **Non-Stoichiometric**
    - **METAL EXCESS DEFFECT**
      Eg:- KCl crystal appears violet
      + LiCl turns pink
    - **METAL DEFFICIENCY DEFFECT**
  - **Impurity Deffect**
- **LINE DEFFECT**
  → Complete Lattice point line missing



Fe+2 O-2 Fe+2
O-2 Fe+2 O-2
Fe+2 O-2
2Fe+3
Fe0.93 O

Schottky Defect

→ Equal no. of Cations & Anions are missing from their normal position

→ Radius of cation & Anion are nearly same.

→ Electrical Neutrality maintained

→ After defect → density (↓)

→ Entropy (↑), Crystal becomes Unstable.

Frenkel Defect

→ Generally Cations (Smaller ions) are missing from their normal site to some interstitial site.

→ Size are not equal

→ C.No. (↓)

→ After Defects → density remains same.

Stability (↓), Entropy (↑), Conductance (↑)

PROPERTIES OF SOLID

Electrical PROPERTIES

CONDUCTORS → C.B. / V.B.

$\Rightarrow 10^{4} - 10^{7}\ \Omega^{-1} m^{-1}$

INSULATORS → C.B. — very large Energy gap — V.B.

$\Rightarrow 10^{-20} - 10^{-10}\ \Omega^{-1} m^{-1}$

SEMICONDUCTORS → C.B. — small energy gap — V.B.

$\Rightarrow 10^{-6} - 10^{4}\ \Omega^{-1} m^{-1}$

e^- rich Impurities

Elements of gp-14 doped with elements of gp-15 → n-type Semicond.

e^- deficient Impurities

elements of gp-14 doped with elements of gp-13

p-type semicond.

Magnetic PROPERTIES

1. Diamagnetic Eg:- NaCl, C_6H_6, H_2O
2. Paramagnetic → Cu^{+2}, Fe^{+3}, O_2, CuO, TiO, VO_2 etc
3. Ferromagnetic, Fe, Co, Ni
4. Antiferromagnetic Eg - MnO
5. Ferrimagnetic → Fe_3O_4, $MgFe_2O_4$, $ZnFe_2O_4$

→ **Piezoelectric Crystals** → These crystals are non-polar and non-conducting in nature. but once mechanically stress is applied they become good Conductor due to Polarization of Crystals. Eg:- $BaTiO_3$, $PbTiO_3$, $PbZrO_3$, Grammo phones

→ **Pyroelectric Crystals** → Heat is applied to the N.P. Crystals they become polarise. Eg:- Crystals of Tartaric acid.

⇒ **Ferro Electricity** :- Some pyroelectric Crystals are become permanently Polarise

Eg:- $BaTiO_3$

Coordination No. of Different type of Close Packing

	I (C.No.)	II (C.No.)	III (C.No.)
Simple Cubic	a (6)	$\sqrt{2}a$ (12)	$\sqrt{3}a$ (8)
BCC	$\sqrt{3}a/2$ (8)	a (6)	$\sqrt{2}a$ (12)
FCC	$\sqrt{2}a/2$ (12)	a (6)	$\sqrt{3}a/4$ (24)

Q5. Which type of 'defect' has the presence of cations in the interstitial sites? [Mains-2018]

(A) Metal deficiency defect

(B) Schottky defect

(C) Vacancy defect

(D) Frenkel defect

Q8. CsCl crystallises in body cnetred cubic lattice. If 'a' is its edge length then which of the following expressions is correct? [Mains-2014]

(A) $r_{Cs^+} + r_{Cl^-} = \frac{\sqrt{3}}{2}a$

(B) $r_{Cs^+} + r_{Cl^-} = \sqrt{3}a$

(C) $r_{Cs^+} + r_{Cl^-} = 3a$

(D) $r_{Cs^+} + r_{Cl^-} = \frac{3a}{2}$

Q9. Experiment it was found that a metal oxide has formula $M_{0.98}O$. Metal M, is present as M^{2+} and M^{3+} in its oxide. Fraction of the metal which exists as M^{3+} would be: [Mains-2013]

(A) 4.08%
(B) 6.05%
(C) 5.08%
(D) 7.01%

$M_{0.98}O$

$M^{+2} \rightarrow 98-x$

$M^{+3} \rightarrow x$

$\Rightarrow 2(98-x) + 3(x) = 200$

$\Rightarrow 196 - 2x + 3x = 200$

$M^{+3} \longrightarrow x = 4$ $\quad M^{+2} \rightarrow 94$

$\% M^{+3} \rightarrow \frac{4}{98} \times 100$

$\Rightarrow 4.08$ ✓

Q10. Lithium forms body cubic structure. The length of the side of its unit cell is 351 pm. Atomic radius of the lithium will be: [Mains-2012]

(A) 75 pm
(B) 300 pm
(C) 240 pm
(D) 152 pm

BCC

$Z = 2$

$\sqrt{3}a = 4r$

$a = 351$ pm

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

$\Rightarrow \frac{1.732 \times 351}{4} \Rightarrow 152$ pm

Q11. Copper crystallises in fcc lattice with a unit cell edge of 361 pm. The radius of copper atom is [Mains-2011]

(A) 157 pm (B) 181 pm

(C) 108 pm (D) 128 pm

FCC

Z = 4

$a = 361 \text{ pm}$

$\sqrt{2}a = 4r$

$\sqrt{2}a = 4r$

$r = \frac{1.414 \times 361}{4}$

$\Rightarrow \underline{128 \text{ pm}}$

Q12. The edge length of a face centred cubic cell of an ionic substance is 508 pm. If the radius of the cation is 110 pm, the radius of the anion is

[Mains-2010]

(A) 288 pm

(B) 398 pm

(C) 618 pm

(D) 144 pm

$a = 508\ pm$

$r_+ = 110\ pm$

$r_- = ?$

$a = 2r_+ + 2r_-$

$508 = 2(110) + 2r_-$

$\frac{508 - 220}{2} = r_-$

$r_- = 144\ pm$

Q13. Percentage of free space in cubic packed structure and in body centred packed structure are respectively. [Mains-2010]

(A) 30% and 26%

(B) 26% and 32%

(C) 32% and 48%

(D) 48% and 26%

CCP BCC

P.E → 74% 68%

Vacant space → 26% 32%

Q15. In a compound atoms of element Y from ccp lattice and those of element X occupy 2/3rd of tetrahedral voids. The formula of the compound will be [Mains-2008]

(A) X_4Y_3 (B) X_2Y_3

(C) X_2Y (D) X_3Y_4

1 Y^- ions / unit cell

2 Td void   1 Oh void

$X \rightarrow \frac{2}{3} \times 2$

$$\begin{array}{cc} X & Y \\ \frac{4}{3} & 1 \end{array} \times 3$$

X_4Y_3

Q17. An ionic compound has a unit cell consisting of A ions at the corners of a cube and B ions on the centre of the faces cube. The empirical formula for this compound would be [Mains-2005]

(A) AB
(B) A_2B
(C) AB_3
(D) A_3B

A	B
Corner	Face centre
$8 \times \frac{1}{8}$	$6 \times \frac{1}{2}$
1	3

AB_3

Q19. Glass is a

(A) super-cooled liquid

(B) Gel

(C) Polymeric mixture

(D) Micro-crystalline solid

Thank You बच्चों 😊