LAKSHYA BATCH

JEE

Solid State -L-03

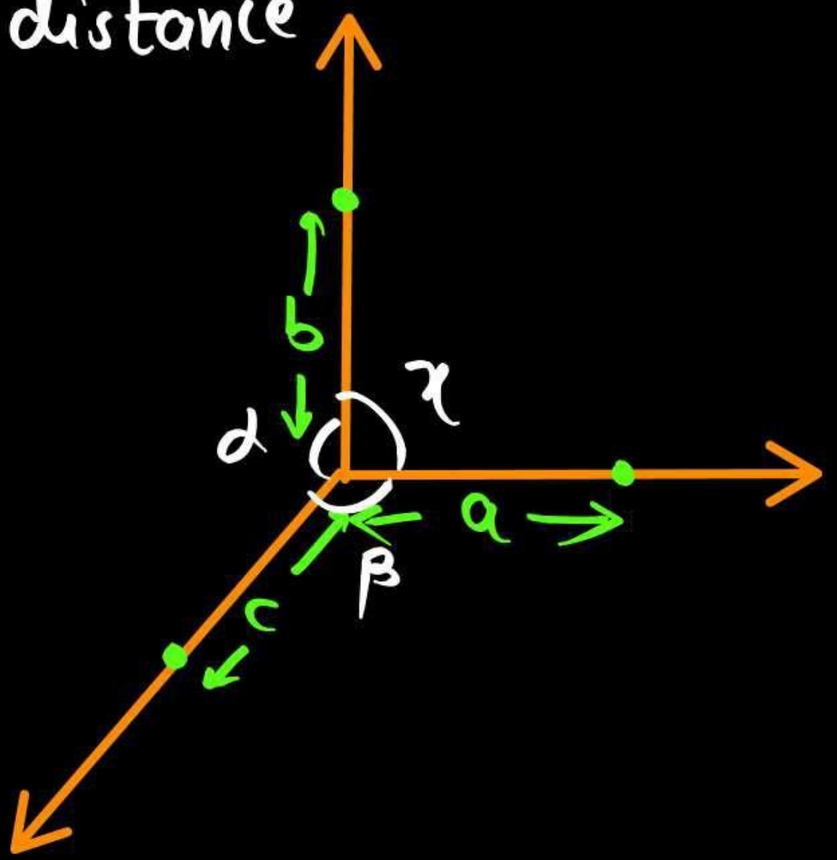
Today's GOAL

Crystal System ,
Packing Fraction
and

Empirical formula determination

Crystal System

Parameters ① Inter axial distance
(a, b, c)
② Interaxial
angles
(α, β, γ)

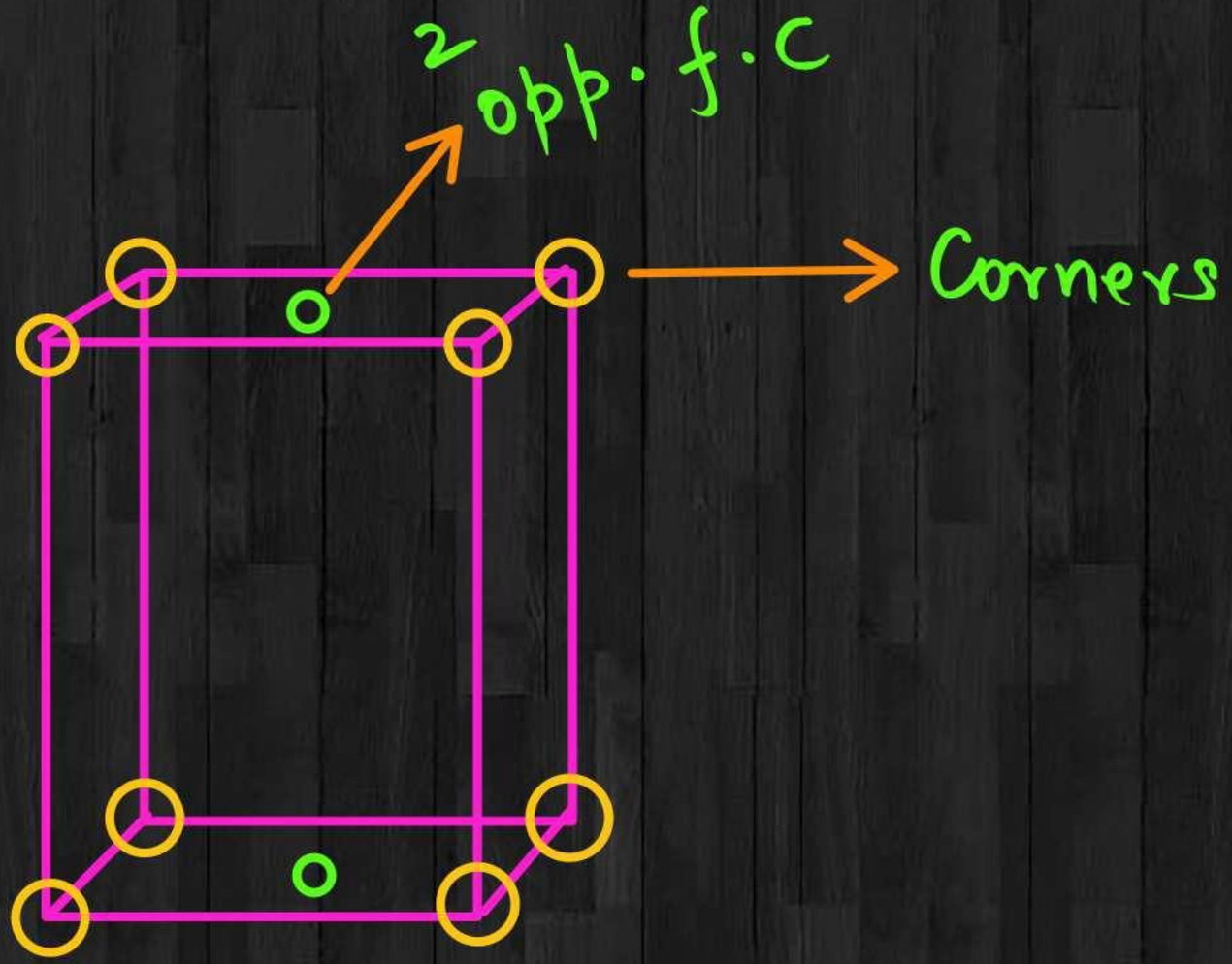


Super Trick

Crystal System	Axial Distance	Axial angle	Unit Cell
Cubic (Cu)	$a=b=c$	$\alpha=\beta=\gamma=90$	3 (SC, BCC, FCC)
Rhombotedral (Rh) (or Trigonal)	$a=b=c$	$\alpha=\beta=\gamma\neq90$	1 (SC)
Tetragonal (Te)	$a=b\neq c$	$\alpha=\beta=\gamma=90$	2 (SC, BCC)
Hexagonal (He)	$a=b\neq c$	$\alpha=\beta=90, \gamma=120$	1 (SC)
Orthorhombic (Or)	$a\neq b\neq c$	$\alpha=\beta=\gamma=90$	4 (SC, BCC, FCC)
Monoclinic (Mo)	$a\neq b\neq c$	$\alpha=\gamma=90, \beta\neq90$	2 (SC, EC*) (SC, EC*)
Triclinic (Tri)	$a\neq b\neq c$	$\alpha\neq\beta\neq\gamma\neq90$	1 (SC)

End centered
(E.C)

orthorhombic
or
monoclinic



Q and A of crystal system

1. Total crystal system (7)
2. Total Bravais lattice (14)
3. Most sym crystal — cubic
4. Most Unsymm Crystal — Triclinic
5. Crystal sys having max no of Braivais lattice — orthorhombic
6. Geometry of match box — orthorhombic

Packing Fraction or Efficiency

The space occupied by atoms in an unit cell is called P.F or P.E.

$$\%\cdot P\cdot F = \frac{Z \times V_{atom}}{V_{unit\ cell}} \times 100$$

$$\%\cdot P\cdot F = \frac{Z \times \frac{4}{3}\pi r^3}{a^3} \times 100$$

Case① In S.C

$2r = a$

$$\%.PF = \frac{2 \times \frac{4}{3}\pi r^3}{a^3} \times 100$$

$$= \frac{1 \times \frac{4}{3}\pi r^3}{(2r)^3} \times 100$$

$$= \frac{\pi}{6} \times 100$$

$$= 52.4\%$$

Case ② In B.C.C

$$\%PF = \frac{2 \times \frac{4}{3}\pi r^3}{a^3} \times 100$$

$$= \frac{2 \times \frac{4}{3}\pi r^3}{\left(\frac{4r}{\sqrt{3}}\right)^3} \times 100$$

$$= \frac{\sqrt{3}\pi}{8} \times 100$$

$$= 68\%$$

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

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

Case ③ In F.C.C

$$\%PF = \frac{2 \times \frac{4}{3}\pi r^3}{a^3} \times 100$$

$$= \frac{4 \times \frac{4}{3}\pi r^3}{\left(\frac{4r}{\sqrt{2}}\right)^3} \times 100$$

$$= \frac{\pi}{3\sqrt{2}} \times 100$$

$$= 74\%$$

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

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

Formulae

Unit cells	S.C	B.C.C	F.C.C
Zeff	1	2	4
Relation b/w a and r	a = 2r	$a = \frac{4r}{\sqrt{3}}$	$a = \frac{4r}{\sqrt{2}}$
C.N	6	8	12
%P.F	52.4%	68%	74%
%voids = 100 − % PF	47.6%	32%	26%

How to find Empirical formula of a compounds.

Q/ A ⟶ Corners $8 \times \frac{1}{8} = 1$ find Empirical formula

B ⟶ Body center of Comp.

1

Contribution

Corners	$\frac{1}{8}$
F . C	$\frac{1}{2}$
B . C	1
E . C	$\frac{1}{4}$

Q

A ⟶ Corners $8 \times \frac{1}{8} = 1$

B ⟶ B.C $1 = 1$

C ⟶ F.C $6 \times \frac{1}{2} = 3$

ABC_3

Q

A ⟶ Corners $8 \times \frac{1}{8} = 1$

B ⟶ B.C $1 = 1$

C ⟶ F.C $6 \times \frac{1}{2} = 3$

D ⟶ E.C $12 \times \frac{1}{4} = 3$

ABC_3D_3

Q A ⟶ Corners $8 \times \frac{1}{8} = 1$

B ⟶ F.C $6 \times \frac{1}{2} = 3$

AB_3

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

Q A ⟶ Corners if one of the F.C atom is removed then new E.F will be ÷

B ⟶ F.C $5 \times \frac{1}{2} = \frac{5}{2}$

$AB_{\frac{5}{2}}$

A_2B_5

Q A ⟶ Corners $8 \times \frac{1}{8} = 1$

B ⟶ E.C $12 \times \frac{1}{4} = 3$

AB_3

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

Q A ⟶ Corners

B ⟶ E.C $11 \times \frac{1}{4} = \frac{11}{4}$

if one of the E.C atom is removed then new empirical formula will be -

$AB_{\frac{11}{4}}$

A_4B_{11}

Q. The correct order of the packing efficiency in different types of unit cells is____.

a. $fcc < bcc <$ simple cubic

b. $fcc > bcc >$ simple cubic

c. $fcc < bcc >$ simple cubic

d. $bcc < fcc >$ simple cubic

Q. The edge lengths of the unit cells in terms of the radius of spheres constituting *fcc*, *bcc* and simple cubic unit cell are respectively_____.

a. $2\sqrt{2}r, \frac{4r}{\sqrt{3}}, 2r$

b. $\frac{4r}{\sqrt{3}}, 2\sqrt{2}r, 2r$

c. $2r, 2\sqrt{2}r, \frac{4r}{\sqrt{3}}$

d. $2r, \frac{4r}{\sqrt{3}}, 2\sqrt{2}r$

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

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

comprehension

Packing fraction of a unit cell is defined as the fraction of the total volume of the unit cell occupied by the atom(s).

$$\text{P.F.} = \frac{\text{Volume of the atom(s) present in a unit cell}}{\text{Volume of unit cell}} = \frac{Z \times \frac{4}{3}\pi r^3}{a^3}$$

Void

and % of empty space = $100 - \text{P.F.} \times 100$ = 100 − P.F

where Z = effective number of atoms in a cube

r = radius of an atom

a = edge length of the cube

Q. % of empty space in simple cubic unit cell is nearly:

a. 52.4

b. 47.6

c. 32

d. 26

Q. Pacl<ing fraction in face centered cubic unit cell is:

a. 0.7406

b. 0.6802

c. 0.5236

d. None of these

Q. Column-I and Column-II contains four entries each. Entries of Column-I are to be matched with some entries of Column-II. One or more than one entries of Column-I may have the matching with the same entries of Column-II.

Column-I		Column-II	
(A)	Tetragonal and Hexagonal	(P)	are two crystal systems
(B)	Cubic and Rhombohedral	(Q)	have cell parameters $a = b = c$ and $\alpha = \beta = 90° \neq \gamma$ are different
(C)	Monoclinic and Triclinic	(R)	$a \neq b \neq c$
(D)	Cubic and Hexagonal	(S)	$a = b = c$

(P, S)

(P, R)

P

Q.

Column-I [Bravais Lattice(s)]	Column-II (Crystal System)
(A) Primitive, face centered, body centered, end centered	(P) Cubic
(B) Primitive, face centered, body centered	(Q) Orthorhombic
(C) Primitive, body centered	(R) Hexagonal
(D) Primitive only	(S) Tetragonal

Thank you!!