Date: 02/08/2024

Unit Test no - I

Chapter : Crystal Structure

Marks : 25

Time : 01:00 to 02:00 pm

Sr. No	Name of Student	Sign.	Marks
1	Sakshi Raju Biranje.	S.R.Biranje	21
2	Surekha Tanaji Desai.	Sdesai	23
3.	Sahil Chetan Patnekar	Sahil	21
4.	Atharv Hariprasad Kognolikar		23
5.	Ritesh shekhar sawlekar		22
6.	Riya D. Patil	R Patil	24

Atharv N. Kognolikar

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Suppliment No. : 01	Subject : Physics
Roll No. : -	Test / Tutorial No. : -
Class : Bsc-TY	Div. : A

Q.1

1) a) 60°

2) a) One

3) c) Seven groups

4) c) (ii), (iii), (iv)

5) a) 0.74

Q.2

1) Lattice is imagenary atoms formed different shapes in space. Basic is the molecules we put on lattice. Then the ~~when~~ Crystal structure are formed in space.

The Bravis Lattice in 3-D are classified into seven groups i.e.

1) Cubic
2) Tetragonal
3) Orthorhombic
4) Monoclinic
5) Triclinic

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6) Hexagonal

7) Trigonal

1) Cubic :-

In cubic structure,

i) The sides are equal to each other

i.e. ~~A = B = C~~ $a = b = c$

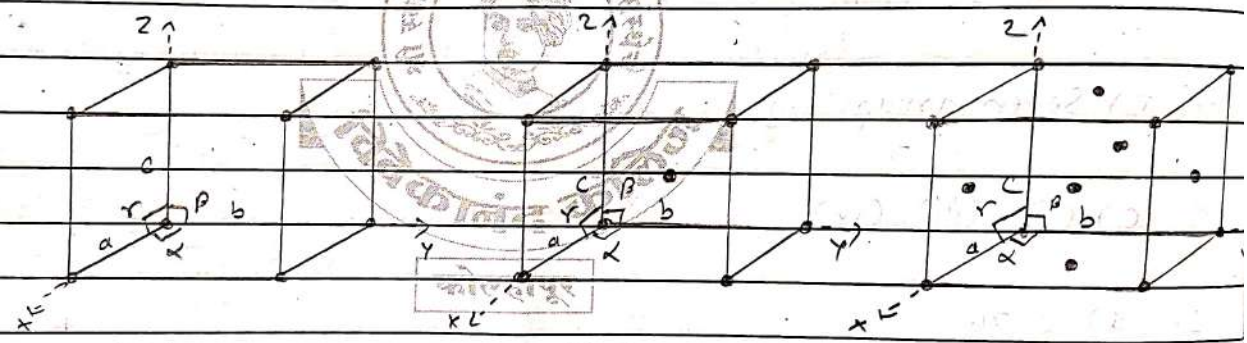
ii) The angles are equal to 90°.

i.e. $\alpha = \beta = \gamma = 90°$

iii) There are three types i.e.,

(P) Primitive, Body centered (I), Face centered (F)

The fig. are given below,



2) Tetragonal :-

In tetragonal structure,

i) The sides are given as,

i.e. $a = b \neq c$

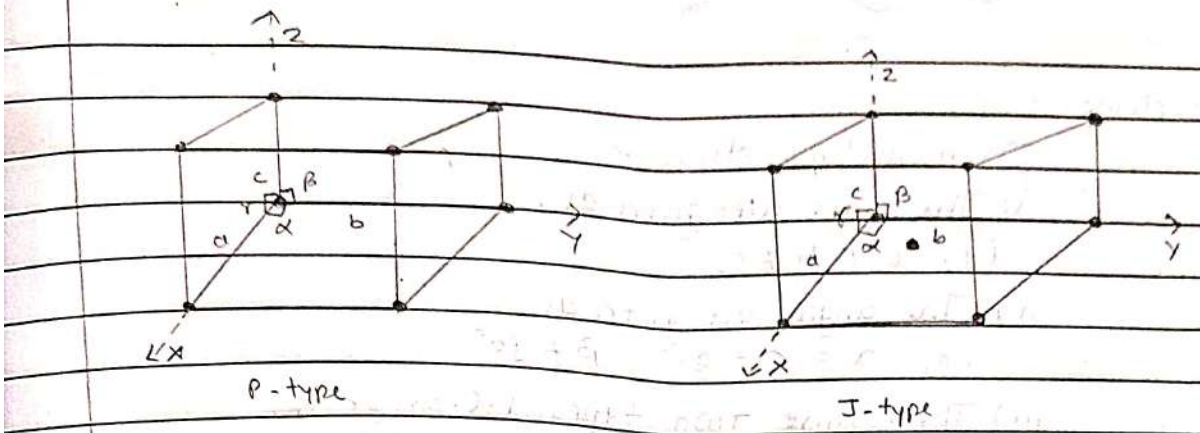
ii) The angles are given as,

i.e. $\alpha = \beta = \gamma = 90°$

iii) There are ~~by~~ two types i.e.

Primitive and Body centered.

The fig. are given below,



P - type

I - type

3) Orthorhombic :-

In orthorhombic structure,

i) The sides are given as,

i.e. $a \neq b \neq c$

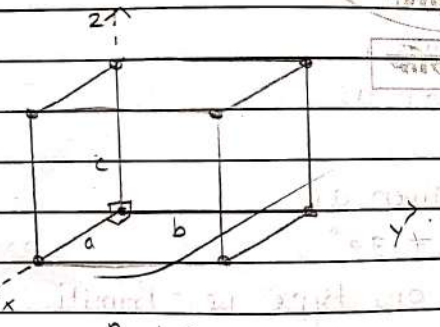
ii) The angles are given as,

i.e. $\alpha = \beta = \gamma = 90°$

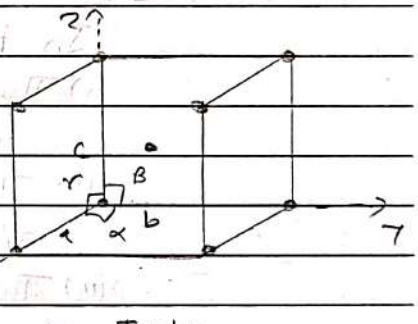
iii) There are four types i.e.

Primitive (P), Face centered (F), Body centered (I) and Base centered (C)

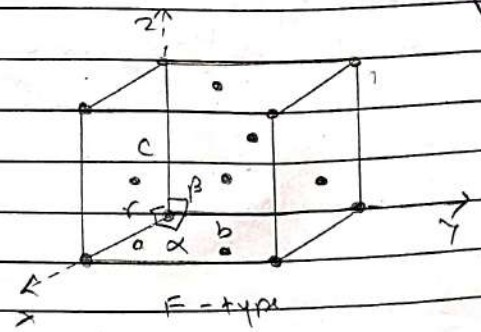
The fig. are given below,



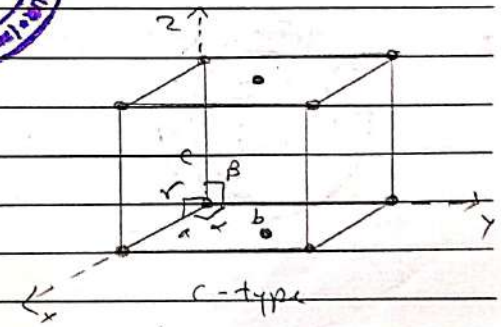
P - type



I - type



F - type



C - type

4) Monoclinic :-

In monoclinic structure,

i) The sides are given as,
i.e. $a \neq b \neq c$

ii) The angles are given as,
i.e. $\alpha = \gamma = 90°$, $\beta \neq 90°$

iii) They have two types i.e.
Primitive (P), Base centered (C)

The fig. are given below,

5) Triclinic :-

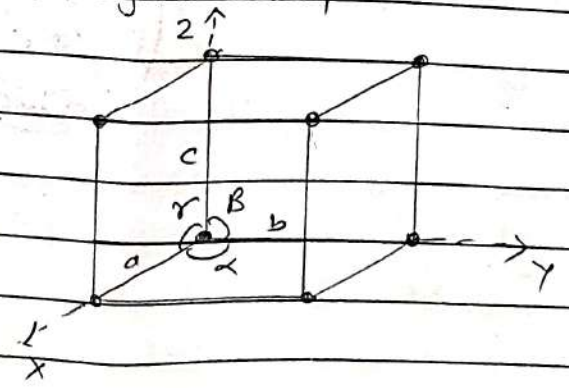
In triclinic structure,

i) The sides are given as,
i.e. $a \neq b \neq c$

ii) The angles are given as,
i.e. $\alpha = \beta = \gamma \neq 90°$

iii) They have only one type i.e. Primitive (P).

The fig. is given below,



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Test / Tutorial No. : -
Div. : A

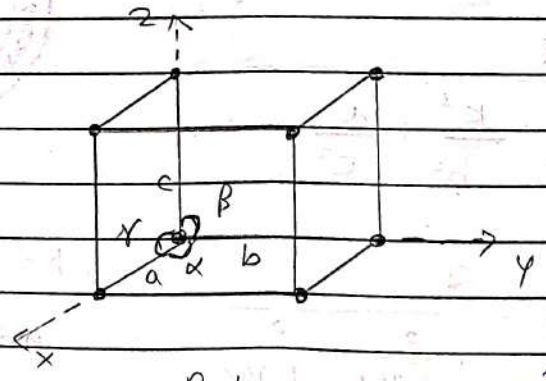
6) Hexagonal :-

In Hexagonal structure,

i) The sides are given as,
i.e. $a = b \neq c$

ii) The angles are given as,
i.e. $\alpha = \beta = 90°$, $\gamma = 120°$

iii) It has only one type i.e. primitive (P).
The fig. is given below.



P-type

7) Trigonal :-

In trigonal ✱ structure,

i) The sides are given as,

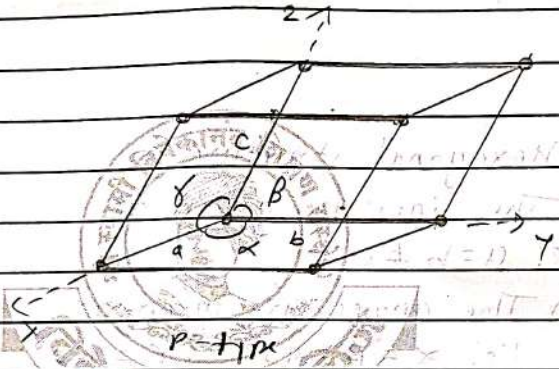
i.e. $a = b = c$

ii) The angles are given as,

i.e. $\alpha = \beta = \gamma \neq 90°$

iii) They have only one type that is Primitive (P).

The fig. is given below.



Q.3

3) $\gamma = 1.746$

b) $d^2 = \dfrac{1}{\sqrt{\dfrac{h^2}{a^2} + \dfrac{k^2}{b^2} + \dfrac{l^2}{c^2}}}$

i) $d^2 = \dfrac{1}{\sqrt{\dfrac{4}{1.746} + \dfrac{0}{1.746} + \dfrac{0}{1.746}}}$

$h = 2, \; k = 0, \; l = 0$

$a = 1.746$

$\therefore d = 0.660$

(ii) $h = 2, \quad k = 2, \quad k = 2$

$$d = \frac{1}{\sqrt{\frac{h^2}{a^2} + \frac{k^2}{b^2} + \frac{l^2}{c^2}}}$$

$$= \frac{1}{\sqrt{12}}$$

$$\sqrt{3.746}$$

$$\therefore d = 0.381$$

Ritesh shekhar sawtekar.

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Q.1)

1) a) 60° ✓

2) a) one ✓

3) c) seven groups

4) c) (PP). (P.PP). & (PP).

Q2)

1) space lattice

all the atoms of imaginary in sp is imagined lattice points is called a space lattice.

Q3) short ans (any two) [10]

2) Amorphus :

- This is type of solid crystal structure
- In this solid the atoms or molecule are arranged random order
- i.e Their are irregular arranged of atoms or molecules in such a solids.

e.g. glass, plastic.

crystalline solid :

- all atoms or molecules are arranged in regular or periodically manner, i.e these solids have ordered structure
- In crystalline solid most of the solid are crystalline structure.
- crystalline solid have two types

1) single crystalline solid.
2) poly-crystalline solid.

1) single crystalline solid :

- In this solid identical atoms are arranged periodically or regularly

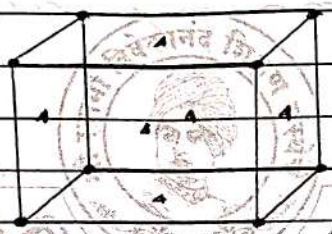
eg. diamond.

2) poly-crystalline solid :

- different atoms are arranged regularly and periodically with different orientation
- most of the metal exhibit poly-crystalline structure.

Q.3)

1) FCC



The cubic cell for fcc structure contain 8 corners atoms share among 8 cell & at 6 face centre atom each atom share between two cell hence. Total no. of atom per unit cell is

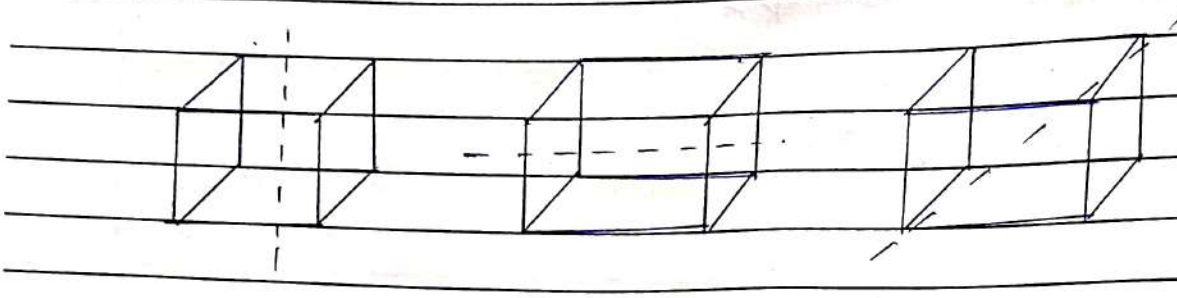
$\frac{1}{8} \times 8 + \frac{1}{2} \times 6 = 1 + 3 = 4$

∴ This cubic cell is non-primitive.

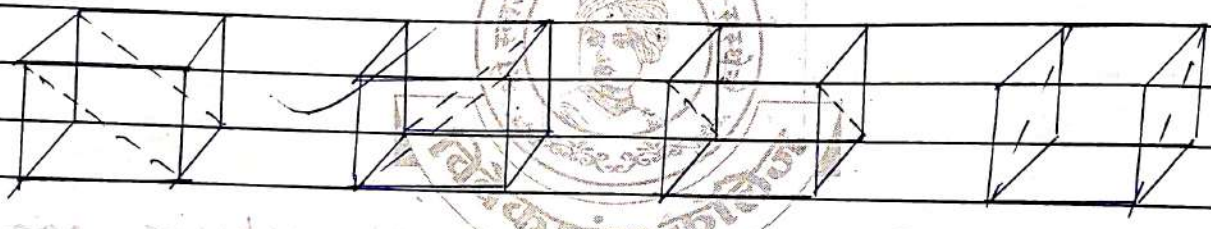
Q2)

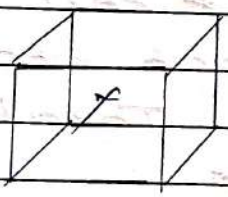
a) Symmetry element in cube.

plane symmetry cube.



Rotating symmetry cube





Sakshi Raju Bixagye.

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21/25

Q 1

1) a) 60°

2) → a) one.

3) → 3) Seven group

4) → c) ii) iii) iv)

5) → a) 0.74

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Space lattice

Array of atoms are homogenously, repetatly arra in space called space lattice.
The copy of atoms are repeated and ea ment atoms has same symmetry. moti atoms are arrange in ~~sqa~~ space ~~a~~ If If the aranged in two Dimensional called diamentiandl space lattice similarly for 3

Bravois lattice

i) There are 14 Bravois lattice a 5 among the in 2 Diamentional and remaining in 3 Dimen

ii) There are many type of lattice present in universe but lattices rotate in $\frac{2\pi}{n}$ where $n = 1, 2, 3, 4$ 6 are mirrors ~~ref~~ patterns are specral type lattices are called Bravois lattices

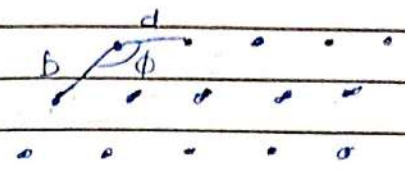
iii) Bravois lattice invested by scientist Bravois.

Bravois lattices in 2 Dimensions.

a) Oblique lattice.

vectors a and b are not same angle betn them is not equal to 90°

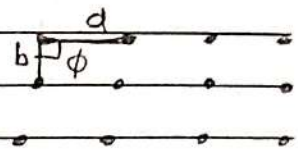
$|\bar{a}| \neq |\bar{b}| \quad \phi \neq 90°$



It has parallelogram structure

b) square lattice

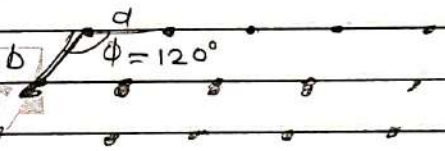
a vectors a and b are same and angle betⁿ them is 90°



$|\bar{a}| = |\bar{b}| \quad \phi = 90°$

If struxe is like square

c) Hexagonal lattice



$\bar{a} \neq \bar{b} \quad \phi = 120°$

d) lattice Rectangular body lattice.

If vectors a and b.

then $\bar{a} = iax + jdy$

$\bar{b} = ibx + jby$

If crystal is rotate and give mirror image then $\bar{a}'$ and $\bar{b}'$ ~~con~~ vector can be write as

$\bar{a}' = i\bar{a}x - jay$

$\bar{b}' = ibx - jby$

and

If

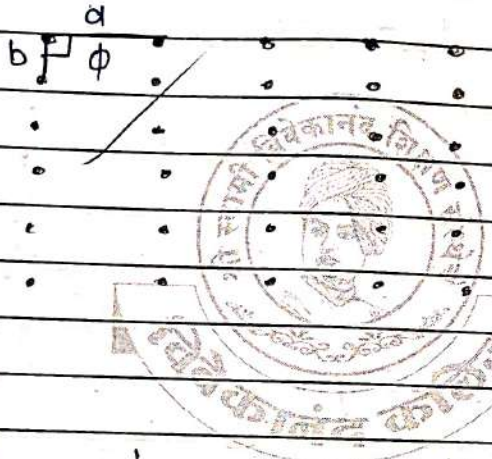
$\bar{a} = ia_x$ and $\bar{b} = ib_y$

then

$\bar{a} = \bar{a}'$ and $\bar{b}' = \bar{b}$

The structure is like rectangular.

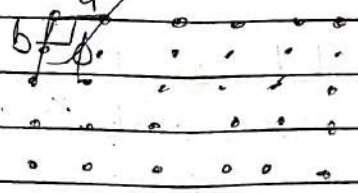
$a \neq b \quad \phi = 90°$



centred rectangular lattice

It has also rectangular structure

$a \neq b \quad \phi = 90°$



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Q3

i)

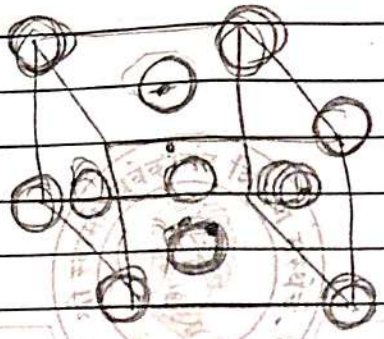
amporphous structure	crystalline structure
unRegular arrangment of crystal	regular arrangment of crystal of atom
low melting point	sharp melting point
They are less harder than crystalline structure	They are harder one
ex quardz	ex Diamond.

Q 3

b) Packing fraction of fcc crystal.

Packing fraction is also called. Packing den

fa Packing fraction = $\frac{\text{no. of atoms involve in lattice}}{\text{amount of constribution of atoms.}}$



constribution of

Numbe of atoms Present in fcc.

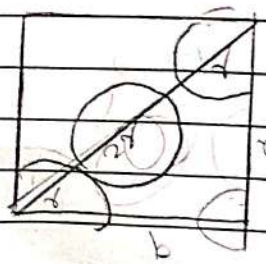
cornern atoms $\times \frac{1}{8}$ + atoms an surface.

part $\times \frac{1}{2}$ + centre atoms one.

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

$= 1 + 3 + 1$

$= 5$ atoms



$c^2 =$

$(3r)^2 = a^2 + a^2$

$9r^2 = 2a^2$

$3r = 2a$

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

area of atoms in lattice $= \frac{4}{3}\pi r^2$

$= \frac{4}{3} \times 3.14 \times \frac{3}{2}a^2$

$= \frac{1.7}{16} \times 3.14\ a^2$

The packing fraction of fcc structure is 0.74.

The Packing fraction of fcc is same as hcc. (hexagonal closed cubic)

Sahil Chetan Patnekar.

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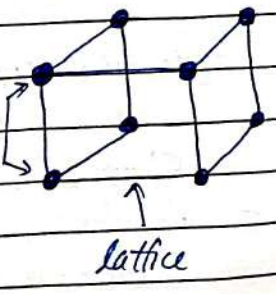
Q1.

1. d) 30°
2. a) One
3. c) Seven groups
4. c) (ii), (iii) and (iv)
5. a) > 0.74

Q2.

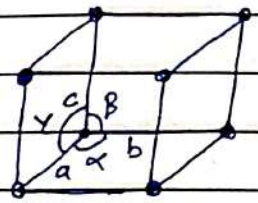
1. (i) In solid crystal structure, atoms are arranged in a definite / fixed patterns, periodic repeatition.
(ii) A ~~lattice~~ space lattice is a combination of lattice + bases.
(iii) At bases, atoms are located and they are attatched to ~~nebi~~ neibghaving atom by an imaginary line called lattice.



(iv) This is called a lattice. When a lattice is arranged in space, it is called as space lattice.
(v) Bravais lattices are the lattice which have same or identical atoms throughout the crystal structure.
(vi) There are 14 types of Bravais lattice in 3-D.
(vii) But these are catogorised in (7) seven groups.
(viii) They are as follows,

① ② ⑦
CUTE OUR MOTHER
② ④ ⑥ ⑤

① Cubic Bravais Lattice:
- This lattice has all sides equal. i.e $a = b = c$.
- All the angles are also equal i.e $\alpha = \beta = \gamma = 90°$
- This group has 3 lattice, namely SC, FCC & BCC.

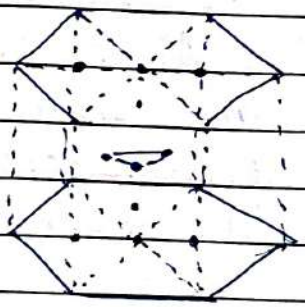


② Tetragonal Bravais Lattice:
- This lattice has two sides equal.
$a = b \neq c$
- also $\alpha = \beta = \gamma = 90°$

③ Orthorhombic Bravais Lattice:

In this we have, $a \neq b \neq c$
$\alpha = \beta \neq \gamma = 90°$.

④ Hexagonal Bravais Lattice:



Sides: $a = b \neq c$
Angles: $\alpha = \beta$, $\gamma = 120°$
Volume: $a^2 c \sin 120$

⑥ Monoclinic Bravais Lattice:

Side: $a \neq b \neq c$

Angle: $\alpha = \gamma$, $\beta \neq 90^\circ$

⑦ Triclinic Bravais Lattice:

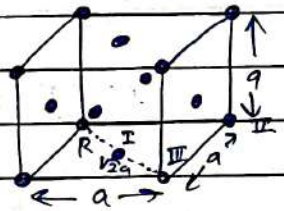
side: $a = b \neq c$

Angle: $\alpha \neq \beta \neq \gamma$

This is the most distorted structure in 3-D Bravais Lattices.

Q3.

1. Atomic Packing fraction = $\frac{\text{Neff} \times \text{Vol. of largest atom}}{\text{Vol. of unit cell.}}$



First we will calculate Neff i.e effective no. of atoms,

R = reference atom.

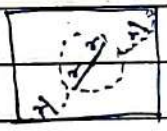
$\therefore \text{Neff} = \frac{1}{8} \times 8 + \frac{1}{2} \times 6 = 1 + 3 = 4$

Now radius of largest atom =

I, II & III are positions of atoms from 'R' i.e reference point.

Now, I is located nearst to reference atom.

$\therefore r = \frac{a}{\sqrt{2}}$ .... (by using pythagoras theorem)



$4r = a^2 + a^2$

$4r = \sqrt{2}a$

$2r = a\sqrt{2}$

$r = a \quad r =$

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

$\frac{\sqrt{2}a}{\sqrt{2} \times 2 \times \sqrt{2}} \quad \frac{4}{\sqrt{2}}$

Volume of Unit cell = a^3

Now. $A.P.F = \frac{\text{Neff} \times \text{Vol. of largest atom}}{\text{Vol. of unit cell.}}$

we get

$$A.P.F = \frac{4 \times \frac{4}{3}\left(\frac{a}{\sqrt{2}}\right)^3}{a^3}$$

$$= 4 \times \frac{4}{3} \times \frac{a^3}{2\sqrt{2}}$$

$$= \frac{16}{3 \times 2\sqrt{2}}$$

$$= \frac{8}{3\sqrt{2}}$$

$A.P.F. = 0.74 \approx 74\%$ space is filled

26% space is empty.

2. Amphormus ~~Crystal~~ Structure	Crystalline Structure
① This structure is made from more than one atom.	① This ~~is~~ structure is only made by identical atoms.
② They may have mixed shape, colour & structure according to constituent atoms.	② They have definite shape, structure, colour.
③ They are brittle, i.e they ~~get~~ broke drown by small forces.	③ They ~~but~~ are harder to break.

।। ज्ञान, विज्ञान आणि सुसंस्कार यांसाठी शिक्षण प्रसार ।।

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Desai sureka Tanaji

Suppliment No. : topic → crystal structure

Roll No. :

Class : BSC. TY

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Q.1 MCQ

23/25

① 60°

② one

③ 7

④ (ii), (iii), (iv)

⑤ 0.74

Q.2 Space lattice.

① There are 7 type crystal structure.

① triclinic / Asymetric crystal

② monoclinic ~~structure~~ crystal

③ orthorombic crystal

④ trigonal crystal

⑤ cubic crystal

⑥ tetragonal crystal.

⑦ Hexagonal crystal.

In space lattice the atom placed on the

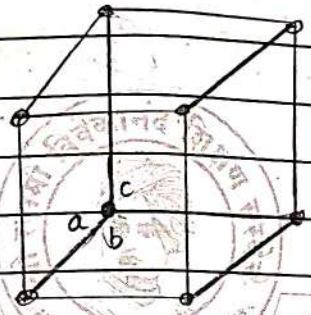
3.2

Space lattice.

① triclinic / Asymetric symmtry

- In these type general type of space lattice another 3 crystalographic are equal, $a \neq b \neq c$ not angles are equal.
- The unit cell of these type contain atom at corner and this are Primitive or P type crystal.

e.g $K_2Cr_2O_3$ - Potassiume dicarbonate.



② Monoclinic symmtry.

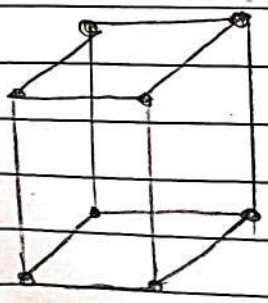
In these type the crystal two type of unit cell.

① Primitive ② Base centered.

both unit cell crystal axis are unequal and one axis are ⊥ (Perpendicular) to two other axis. $\alpha = \beta$, $\gamma \neq 9$

e.g Borax.

①



* Primitive

* Base centered.

③ orthorhombic ~~syn~~ symmetry.

In these type the crystal four type of unit cell.

① Primitive

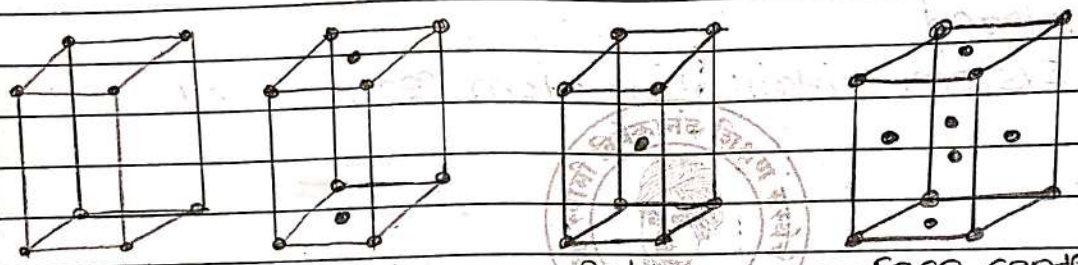
② Base centered

③ Body centered

④ Face centered.

In these type crystal axis are unequal and this axis are ⊥ to each other.

$a \neq b \neq c$ $\quad \alpha = \beta = \gamma = 90^\circ$

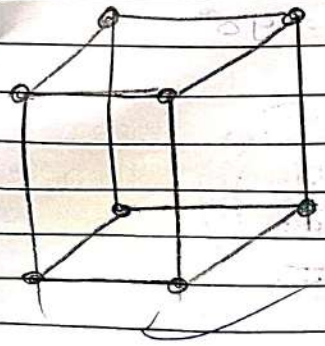


* Primitive * Base centered Body centered Face centered

④ Trigonal / Rhombohedral symmetry.

- In these type this are Primitive.
- 3 crystal axis are equal to each other and ~~eth~~ angle are ~~equal~~ equal to each other ~~bet~~ but not equal to 90°

~~at~~ $a = b = c$ $\quad \alpha = \beta = \gamma \neq 90^\circ$



⑤ cubic.

- In these type the crystal axis are equal and these axis are ⊥ to each other
- unit cell are 3 type

① Primitive.

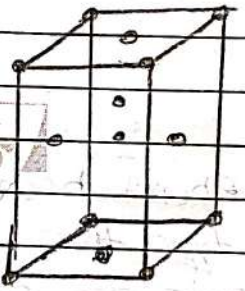
In this system the unit cell contain the type 1atom or lattice Point per unit cell.

② Body Centered.

In this system contain two atom or lattice Point Per unit cell.

③ Face centered.

In this system contain Four atom Per unit cell



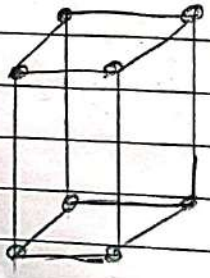
⑥ Tetragonal.

This are Primitive.

They are ⊥ to each other and two lateral axis are equal.

$a = b \neq c$, $\alpha = \beta = \gamma = 90°$

e.g. Iodium.



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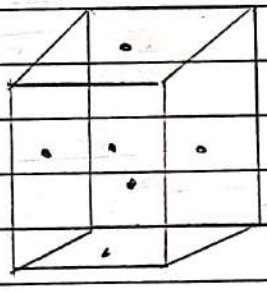
⑦ Hexagonal
In this system they are not crystal axis are not equal to each other and also angle.

3
2.① * Packing Fraction of Face centered cubic.



In this FCC crystal.
the 8 corner atom Placed on 6 Face centered.
The co-ordination no. of FCC crystal is 12
inter planner distance = a.
Now,
The 8 corner atom are Placed each 8 corner
So its share the unit cell $\frac{1}{8}$.
and Face centered are 6. so each face centered
share the $\frac{1}{2}$

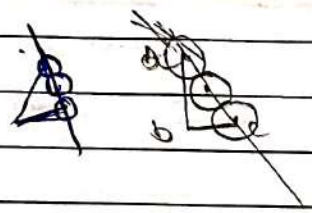
$\frac{1}{8} \times 8 + \frac{1}{2} \times 6 = 1 + 3 = 4$

Volume of atom Per unit cell.

$$\frac{4}{3}\pi r^3 \times 4$$

$$= \frac{16}{3}\pi r^3 \quad - (1)$$

Consider the diagonal Part.



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

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

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

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

Volume of atom Per unit cell

$$\frac{16}{3}\pi r^3$$

$$= \frac{16}{3}\pi \left[\frac{a\sqrt{2}}{4}\right]^3$$

$$= \frac{16}{3}\pi \left[\frac{a^3 2\sqrt{2}}{6a}\right]$$

$$= \frac{\pi\sqrt{2}\,a^3}{6} \quad - (2)$$

Now,

Volume of atom = Volume of cube

$= a^3$

Now eqn (2) become

$$\frac{\pi\sqrt{2}\,a^3}{6} \times \frac{1}{a^3}$$

$$= \frac{\pi\sqrt{2}}{6}$$

$= 0.74$

The Packing fraction of Fcc is 0.74
e.g Mg.

2

Crystaline structure	Amorphous solid.
① The Crystaline structure is regular and Periodically.	① The Amorphous solid. Crystal are irregular

3

③ ZnO is simple cubic structure.
In cubic structure $a = b = c$.

$$d = \left[\frac{h^2}{a^2} + \frac{k^2}{b^2} + \frac{l^2}{c^2}\right]^{1/2}$$

$$= \frac{1}{\left[\frac{h^2}{a^2} + \frac{k^2}{a^2} + \frac{l^2}{c^2}\right]^{1/2}}$$

$$d = \frac{a}{[h^2 + k^2 + l^2]^{1/2}}$$

$$d = \frac{1.746}{[2^2 + 0^2 + 0^2]}$$

$$= \frac{1.746}{4}$$

$$= \frac{1.746}{2}$$

$$= 0.873 \times 10^{-10}\ m$$