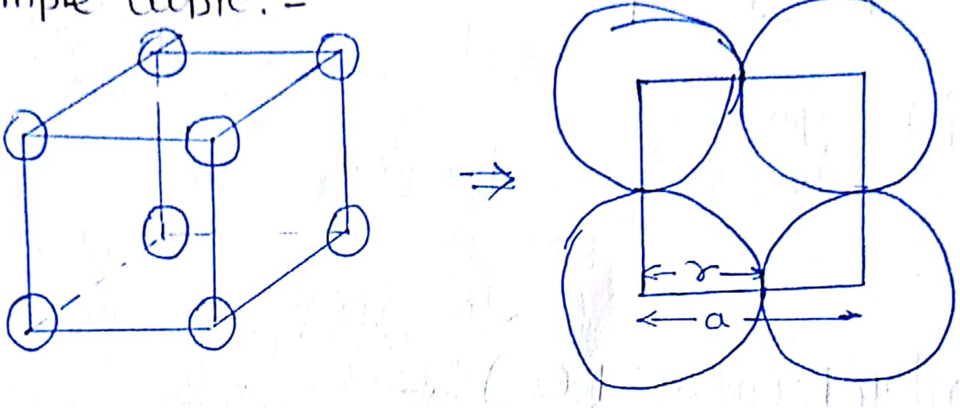
* Crystallography :-

Cubic:-

① simple Cubic:-



$$a = 2r$$

no. of atom/cell $= \frac{1}{8} \times 8 = 1$

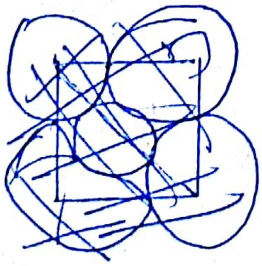
Atomic packing Factor (APF) $= \dfrac{n \times \frac{4}{3}\pi r^3}{a^3}$

$$APF = \frac{\frac{4}{3}\pi r^3}{8r^3} = \frac{\pi}{6}$$

$$\boxed{APF = 0.52}$$

Coordination no. → No. of nearest atoms Here $\boxed{C.N. = 6}$

② BCC



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

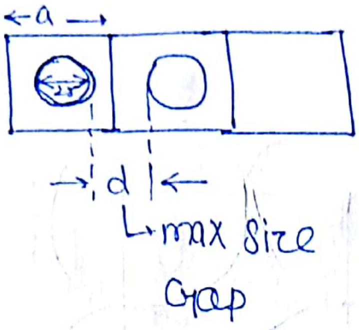
$4r = a\sqrt{3}$

$APF = \dfrac{2 \times \frac{4}{3}\pi r^3}{a^3} = 0.68$

$$\boxed{C.N. = 8}$$

Q What is the diameter of largest sphere that can fill ~~at~~ in bcc, take size of unit cell a.

Sol^n



$d = a - 2r$

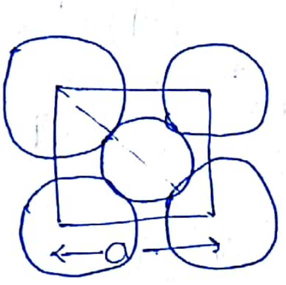
$d = a - \frac{\sqrt{3}}{2} a$

$d = 0.133\, a$

③ Face Centered Cube (FCC) :-

No. of atom $= \frac{1}{8} \times 8 + \frac{1}{2} \times 6 \Rightarrow \boxed{n = 4}$

Facial structure



$4r = a\sqrt{2}$

$APF = \frac{4 \times 4/3\, \pi r^3}{a^3}$

$\boxed{APF = 0.74}$

$\boxed{C.N. = 12}$

✰ If material is ductile it will be - FCC

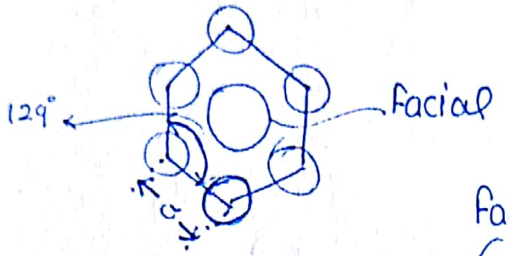
~~Ques~~ if material is brittle it will be - HCP

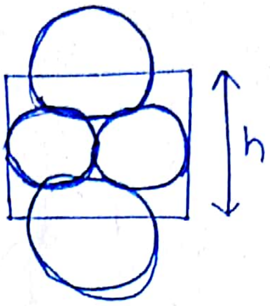
Ques If atomic radius is r what will be its unit Volume (Aluminium) Al - FCC

Sol^n $\cancel{V = \frac{4}{3}\pi r^3}$ $4r = a\sqrt{2} \Rightarrow a = \left(\frac{4r}{\sqrt{2}}\right)$

$\text{Volume} = a^3 = \left(\frac{4r}{\sqrt{2}}\right)^3 = 22.62\, r^3$

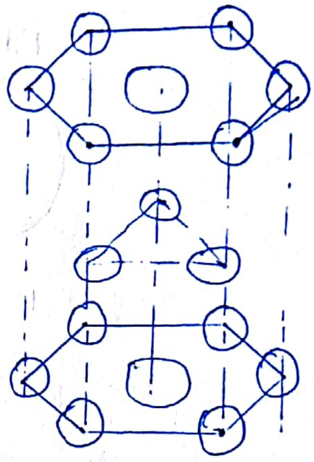
Hexagonal Close Pack :-





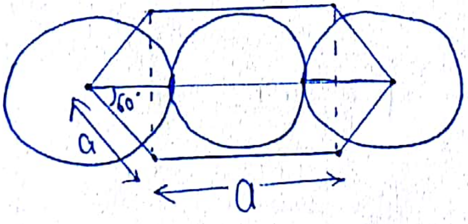
$$n = \frac{1}{6}\times 12 + \overset{\text{facial}}{\frac{1}{2}\times 2} + \overset{\text{inside}}{3}$$

$$\boxed{n = 6} \qquad \boxed{C.N. = 12}$$



Atomic packing Factor of HCP

$$APF = \frac{6\times \frac{4}{3}\pi r^3}{(\text{Area of Hexagon} \times h)}$$



$$4r = a + 2\times a\cos 60^\circ$$

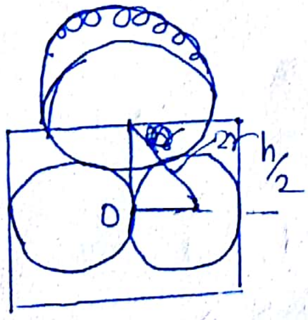
$$4r = 2a$$

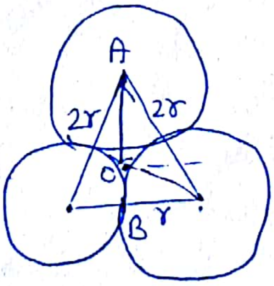
Area of hexagon

$$A = a\times(2a\sin 60^\circ) + \frac{2}{2}\left[\frac{1}{2}\left(a\cos 60^\circ \times 2a\sin 6\right.\right.$$

$$A = \cancel{2}a^2\times\frac{\sqrt{3}}{\cancel{2}} + \cancel{2}\times\frac{1}{\cancel{2}}\left(a\times\frac{1}{2}\times 2\times a\times\frac{\sqrt{3}}{\cancel{2}}\right)$$

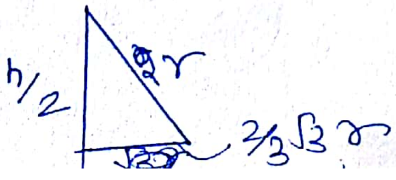
$$A = a^2\sqrt{3} + a^2\frac{\sqrt{3}}{2} = \frac{3\sqrt{3}}{2}a^2$$





$$AB = \sqrt{(2r)^2 - r^2} = \sqrt{3}r$$

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



$$\frac{h^2}{4} = 4r^2 - \frac{4}{9} \times 3r^2 = \frac{8}{3} r^2$$

$$h^2 = \frac{32}{3} r^2$$

$$h = \frac{4\sqrt{2}\, r}{\sqrt{3}}$$

So $$\text{A.P.F} = \frac{6 \times \frac{4}{3} \pi r^3}{\frac{3\sqrt{3}}{2} a^2 \times \frac{4\sqrt{2}}{\sqrt{3}} r}$$

$$\text{A.P.F} = \frac{8 \pi a^3/8}{6a^2\sqrt{2} \times a/2} = \frac{\pi}{3\sqrt{2}} = 0.74$$

$$\text{A.P.F.} = 0.74$$

Now $$h = \frac{4\sqrt{2}}{\sqrt{3}} \times a/2$$

$$\frac{h}{a} = \frac{2\sqrt{2}}{\sqrt{3}} \Rightarrow h = 1.63\, a$$

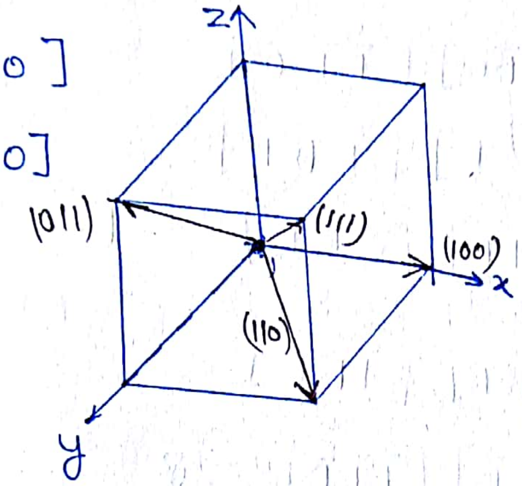
crystal Direction! -

[x y z]

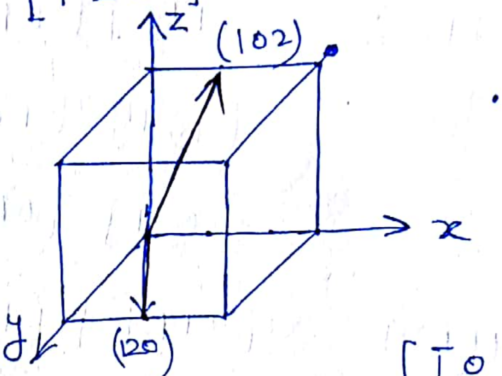
whatever is written in braket of crystal direction is the 3-D coordinate system and by joining it with origion we get the direction. Max. No. appearing in the braket can be considerd as size of unit cell

[1 0 0]

[1 1 0]



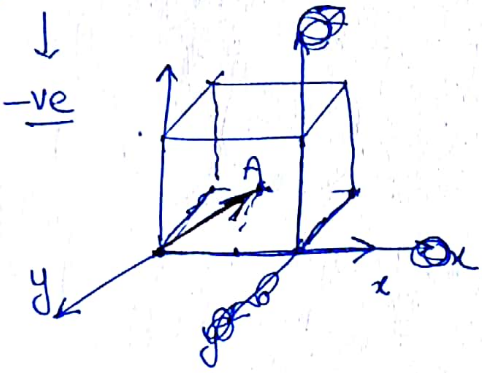
[1 2 0]

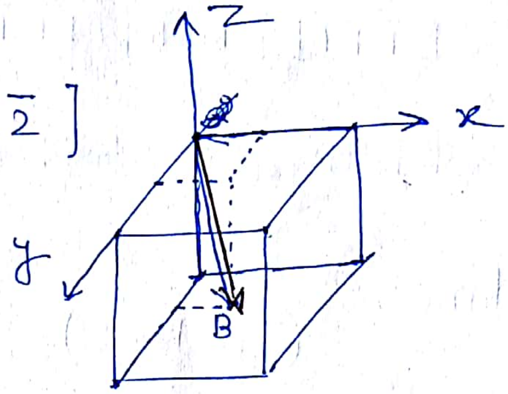


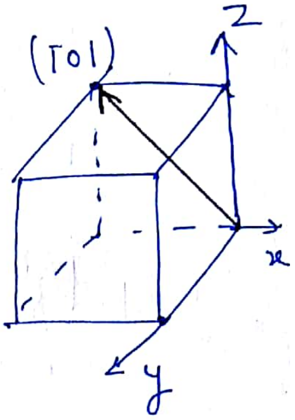
A$[1\bar{2}0]$
↓
-ve

B$[1\,1\,\bar{2}]$

$[\bar{1}01]$







Linear density :-

$$\text{linear density} = \frac{\text{No. of atoms in crystal direction}}{\text{length of direction}}$$

$$SC\,[100] = \frac{1}{a}$$

$$BCC\,[110] = \frac{2}{a\sqrt{2}} \qquad FCC\,[111] = \frac{2}{a\sqrt{3}}$$

* All those possible crystal direction within the crystal having the same linear density is Called Family of direction

Cubic

$\langle 100 \rangle = [100][\bar{1}00][010][0\bar{1}0]\underline{[001][00\bar{1}]} = 6$ tetrogonal मे हटादे

$\langle 110 \rangle = [110][\bar{1}10][1\bar{1}0][\bar{1}\bar{1}0]$
$[101][\bar{1}01][10\bar{1}][\bar{1}0\bar{1}]$
$[011][0\bar{1}1][01\bar{1}][0\bar{1}\bar{1}] = 12$

$\langle 111 \rangle = [111][\bar{1}11][1\bar{1}1][11\bar{1}]$
$[\bar{1}\bar{1}1][\bar{1}1\bar{1}][1\bar{1}\bar{1}][\bar{1}\bar{1}\bar{1}] = 8$

* if it is ~~a~~ tetrogonal don't Consider Z dir^n

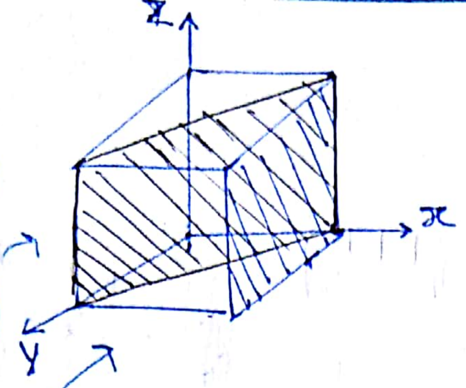
Crystal planes $(\underbrace{h\ k\ l})$

miller indicess (Resiprocal of intercepts)

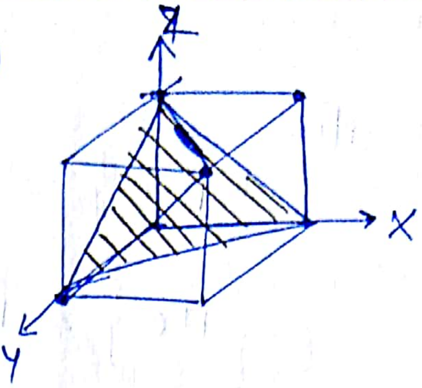
What is written in braket of Crystal plane are not intercepts on x, y, z axis these are miller indicees reciprocal of intercepts. While constructing crystal plane size of unit cell always taken 1.

eg.
(100)
x = 1
y = ∞
z = ∞

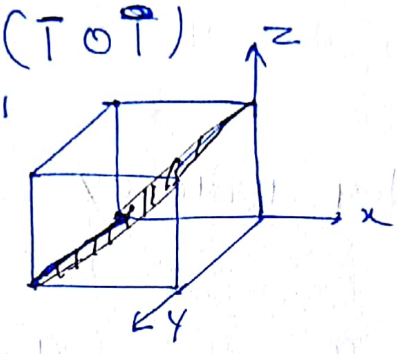
(110)
x = 1
y = 1
z = ∞



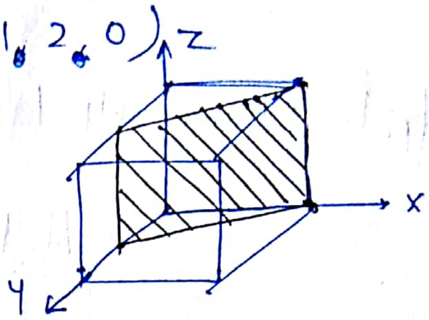
(111)
x = 1
y = 1
z = 1



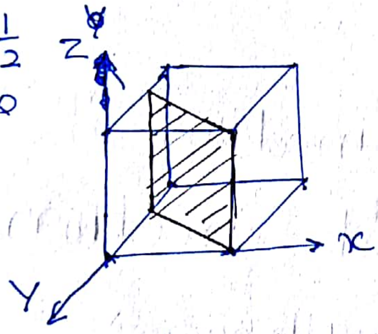
eg $(\bar{1}0\bar{1})$
x = -1
y = ∞
z = 1



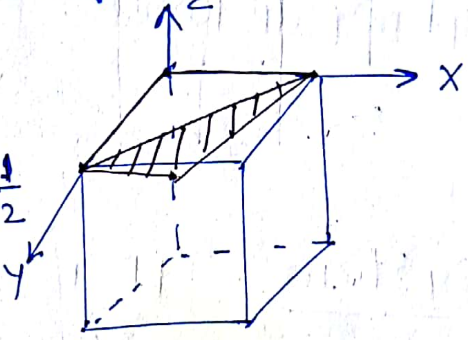
(1, 2, 0)
x = 1
$y = \frac{1}{2}$
z = 0



eg. $(1\bar{2}0)$
x = 1
$y = -\frac{1}{2}$
z = ∞



$(1, 1, \bar{2})$
x = 1
y = 1
$z = -\frac{1}{2}$



Planer density! *

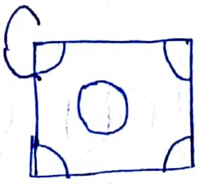
$$\text{Planer density} = \frac{\text{no. of atoms in Plane}}{\text{Area of Plane}}$$

$$SC(100) = \frac{1}{a^2}$$

$$FCC(100) = \frac{2}{a^2}$$

$$BCC(110) = \frac{2}{\sqrt{2}a^2}$$

* All those plane within the unit cell having the same planer density is called a family



Family $\{100\} = 6$ $\{111\} = 8$

$\{110\} = 12$

Interplaner distance :-

(hkl) miller indicees

Interplaner distance $= \dfrac{a}{\sqrt{h^2+k^2+l^2}}$ a - Size of unit cell

Slip System :- It is the combination of crystal plane and direction along with dislocation moves with ease.

FCC → $\{111\}<110> = 12$

BCC → 12 - 24

HCP → 3 or 6

* In FCC structure No. of slip System are 12 and APF is also a high so dislocation will move with an ease so such crystal structure with always be ductile.

* Although in BCC Crystal No. of slip System

are more so failure will ~~be~~ always be in ductile more but its atomic packing factor (APF) is low. so dislocation have difficulty move through, so such crystal ~~are~~ be strong.

☆ In HCP material since no. of slip system are very low so failure will always be in brittle more.

critical Resolved shear stress

$$\boxed{\tau_R = \sigma \cos\phi \cos\lambda}$$

ϕ = Angle between normal to slip plane & applied stress.

λ = Angle b/w slip and stress direcn

FCC - Ductile
BCC - more ductile (strong)
HCP - Brittle

Question
IES
2015

Copper - FCC
$r = 1.28$ A°

Atomic mass = 63.5
density of Cu $\rho = ?$

FCC ⇒ 4 atom/unit cell

$4r = a\sqrt{2}$

$$\frac{\text{Atomic wt (g/mole)}}{\text{Avgrado no (atom/mole)}} \Rightarrow \text{g/atom}$$

$$\text{Vol. } a^3 = \left(\frac{4r}{\sqrt{2}}\right)^3$$

$$\text{Vol.} = 8.9\times10^{3}\ \text{kg/m}^3$$

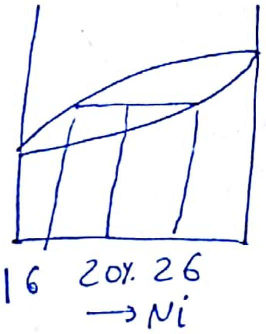
$$\frac{\text{wt/unit cell}}{~~\rho(g/cm^3)~~} = \text{g/atom} \times 4$$

$$\frac{\text{wt/unit cell}}{\rho(\text{g/cm}^3)} = \text{Volume of unit cell}$$

$$\rho = \frac{\text{wt}}{\text{Vol.}} = \frac{63.5\times4}{6.022\times10^{3}\times8.9\times10^{3}}$$

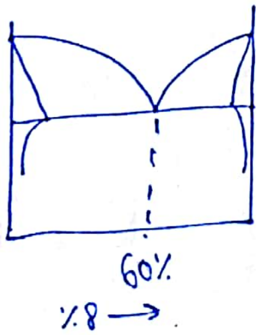
$$\rho =$$

Q



$$\frac{m_s}{m_e} = \frac{\frac{20-16}{26-16}}{\frac{26-20}{26-16}} = 4/6 = 2/3$$

Q



$$\frac{60-x}{y-x} = \frac{y-60}{y-x}$$

$$x+y = 120$$