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Batch: F2

Tutorial-9

PHYSICS-2

1. (i) $a \neq b \neq c$
$\alpha \neq \beta \neq \gamma$
$\Rightarrow$ Triclinic

(ii) $a = b \neq c$
$\alpha = \beta = 90°, \gamma = 120°$
$\Rightarrow$ Hexagonal

(iii) $a = b = c$
$\alpha = \beta = \gamma = 90°$
$\Rightarrow$ Cubic

2. NaCl is FCC structure where contribution of all Corners Na^+ ions in unit cell will be -

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

And face centred Na^+ ions

$$N_f = 6 \times \frac{1}{2} = 3$$

Contribution of Cl^- ions in unit cell $= \left(\frac{1}{4} \times 12\right) + 1 \, (\text{bcc } Cl^-)$

so total no. of Na^+ ions $= 4$ and Cl^- ions $= 4$

Therefore total no. of NaCl molecules per unit cell will be

$$[4]Na^+ + [4]Cl^- = 4 \text{ molecules}$$

3. $\rho = 8.89 \text{ gm/cm}^3 = 8890 \text{ kg/m}^3$

$n = 4$

$M_A = 63.5 \text{ gm/mol} = 63.5 \text{ kg}$

$N_A = 6.02 \times 10^{26} \, (\text{kmol})^{-1}$

we know $\rightarrow$ $a = \left[\frac{n M_A}{N_A \rho}\right]^{1/3}$

$$= \left(\frac{4 \times 63.5}{8890 \times 6.02 \times 10^{26}}\right)^{1/3}$$

$$= 3.61 \text{ Å}$$

But Cu is fcc so →

$$2a^2 = (4r)^2 \Rightarrow r = a/2\sqrt{2}$$

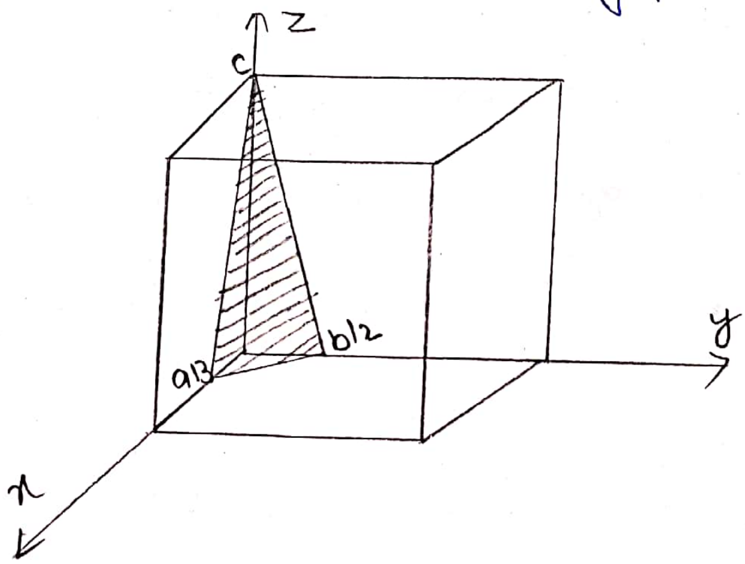
$$r = \frac{3.61}{2\sqrt{2}} = \boxed{1.28\,\mathring{A}}$$

4. Here the unit translations are →

$a = 3$, $b = 2$ and $c = 1$

(i) Intercepts	1	2	0.5
(ii) Division by unit translation	1/3	2/2	$\frac{0.5}{1}$
(iii) Reciprocals	3	1	2
(iv) After clearing fraction	Not Applicable		

The required Miller Indices of plane are (3 1 2)



5. Interplanar spacing for a simple cubic lattice is given by - $d_{hkl} = \frac{a}{\sqrt{h^2+k^2+l^2}}$

for (100) planes

$$d_{100} = \frac{a}{\sqrt{1+0+0}} = a$$

For (110) planes →

$$d_{110} = \frac{a}{\sqrt{1^2+1^2+0}} = \frac{a}{\sqrt{2}}$$

for (111) planes →

$$d_{111} = \frac{a}{\sqrt{1^2+1^2+1^2}} = \frac{a}{\sqrt{3}}$$

Now $\frac{1}{d_{100}} : \frac{1}{d_{110}} : \frac{1}{d_{111}} = 1 : \sqrt{2} : \sqrt{3}$

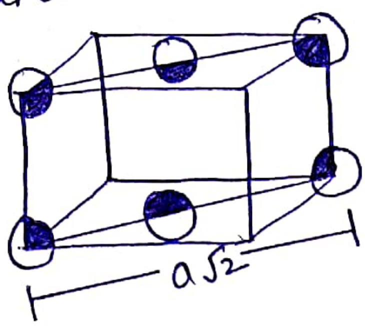
6. for fcc unit cell

d_{111} = same as d_{111} of simple cubic $= a/\sqrt{3}$

$d_{110} = \frac{1}{2}(d_{110})_{sc} = \frac{1}{2} \cdot \frac{a}{\sqrt{2}}$

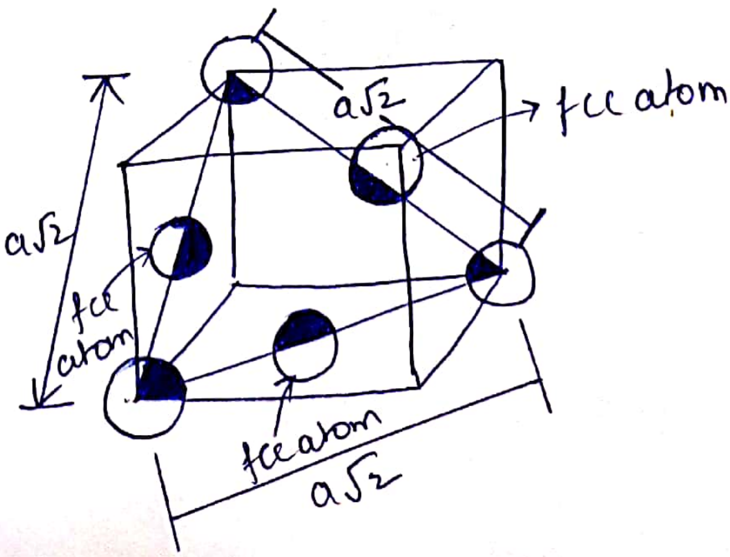
Planar density = $\frac{\text{No. of atoms in given plane}}{\text{area of that plane}}$

$$\rho_{110} = \frac{4\times\frac{1}{4} + 2\times\frac{1}{2}}{\sqrt{2}\,a^2} = \frac{\sqrt{2}}{a^2}$$



$$\rho_{111} = \frac{3\times\frac{1}{6} + 3\times\frac{1}{2}}{\frac{\sqrt{3}}{4}(a\sqrt{2})^2}$$

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



7. $a = 5\text{Å}$, $n = 1$, $\theta = 45°$

(110) plane →

$$d_{110} = \frac{a}{\sqrt{h^2+k^2+l^2}} = \frac{5}{\sqrt{2}} \text{Å}$$

using $2d_{hkl} \sin\theta = n\lambda$

$$\lambda = \frac{2\times5}{\sqrt{2}} \times \sin 45° = \frac{2\times5}{\sqrt{2}} \times \frac{1}{\sqrt{2}} = 5\text{Å}$$

8. $i = nA\,e\,V_d$

$$V_d = \frac{i}{nAe}$$

$$= \frac{1}{8.48\times10^{23}\times10^{-6}\times1.6\times10^{-19}}$$

$$= \boxed{7.37\times10^{-5}\ \text{m/s}}$$

here $n = \frac{\text{no. of atoms}}{m^3}$

$$= \frac{\text{Mass}/m^3}{\text{mass/atom}}$$

$$= \frac{8.49\times10^3\ \text{kg/m}^3}{63.5\times1.66\times10^{-27}\ \text{kg}}$$

$$= \boxed{8.48\times10^{28}\ e^-/m^3}$$

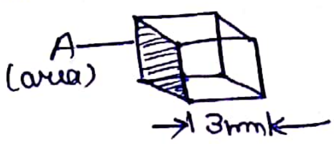
9. $\sigma = 6.17\times10^7$ mho/m , $\mu = 0.0056\ m^2/V.s$

(a) $V_d = 1$ mm/s

So $\mu = \frac{V_d}{E}$ or $E = \frac{V_d}{\mu} = 0.1786$ V/m

(b) $J = 10^7\ A/m^2$

using $J = \sigma E \Rightarrow E = \frac{J}{\sigma} = 0.1621$ V/m



(c) $I = 80$ Amp , $J = \frac{I}{A} = \sigma A$

$E = J/\sigma = .0.1441$ V/m

(d) $V = 50$ mV

$E = \frac{V}{d} \Rightarrow E = 1$ V/m

10. $V_{rms} = \sqrt{\frac{8k_BT}{m}} = \sqrt{\frac{3\times1.38\times10^{-23}\times293}{9.1\times10^{-31}}}$

$= 1.15\times10^{5}$ m/s

Relaxation time $\tau = \frac{m}{\rho n e^2} = 2.5\times10^{-14}$ sec

Mean free path $\lambda = V_{rms}\times\tau$

$= 2.8$ nm

Mobility $\mu = \frac{1}{ne\rho}$

or $= \frac{e\tau}{m}$

$= 4.34\times10^{-3}\ m^2/(V\cdot s)$

$\sigma = \frac{1}{\rho} = \frac{ne^2\tau}{m} = 5.92\times10^{7}$ mho/m

drift velocity. $V_d = \mu E = \boxed{4.84 \text{ mm/s}}$

here $\boxed{V_d << V_{rms}}$

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