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B12

Physics tut-9

(1)

(i) Triclinic
(ii) Hexagonal
(iii) Cubic

(2) NaCl has FCC structure

$\therefore$ No. of Cl^- $= 6 \times \frac{1}{2} + 8 \times \frac{1}{8} = 4$ atoms

similarly 4 atoms of Na^+

$\therefore$ total 4 molecules of NaCl in each unit cell.

(3) $d = \dfrac{Z \times M}{V \times N_A} = \dfrac{4 \times 63.5}{a^3 \times 6.022 \times 10^{23}}$

$\cancel{8.89 = \dfrac{4 \times 63.5}{\frac{4}{3}\pi r^3 \times 6.022 \times 10^{23}}}$

$\cancel{r^3 = 8.89 \times 3.14 \times 6.022 \times 10^{23}}$

$\cancel{r^3 = \dfrac{3 \times 63.5}{8.89 \times 3.14 \times 6.022 \times 10^{23}} = 1.133 \times 10^{-23}}$

$\cancel{r = 2.24 \times 10^{-8}\ m = 224\ \text{Å}}$

$8.89 = \dfrac{4 \times 63.5}{\left(\frac{\sqrt{3}}{4} r\right)^3 \times 6.022 \times 10^{23}}$

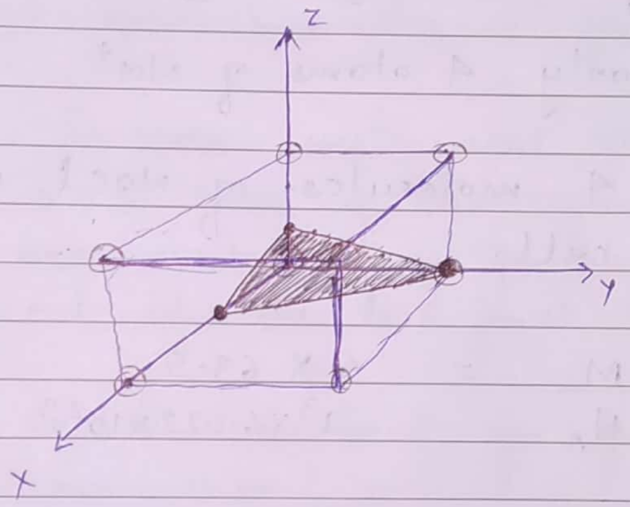
$r = 156.23$ pm

④ intercept ~~indices~~ are 1, 2 & 0.5

→ reciprocal : $1, \frac{1}{2}, 2$

→ lowest integer form (x2): 2, 1, 4

∴ Miller indices are 2,1,4



on x-axis, move $\frac{3}{2}$

on y-axis, move $\frac{2}{1}$

on z-axis, move, $\frac{1}{4}$

⑤ for cubic system

$$\left(\frac{1}{d_{hkl}}\right)^2 = (h^2+k^2+l^2) \div a^2$$

$$\frac{1}{d_{100}} = \sqrt{\frac{1}{a^2}}$$

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

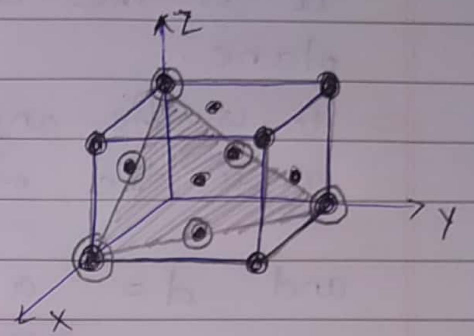
$$\frac{1}{d_{111}} = \sqrt{\frac{3}{a^2}}$$

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

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

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

(6) In FCC, $a = \frac{4}{\sqrt{2}} r = 2\sqrt{2}\, r$



Area of the plane$^{(111)}$ $= \frac{1}{2} \times$ height $\times$ base

$$= \frac{1}{2} \times a\sqrt{2} \times h$$

height of plane :-

$$h^2 = a^2 + \left(\frac{a\sqrt{2}}{2}\right)^2 = a\sqrt{\frac{3}{2}}$$

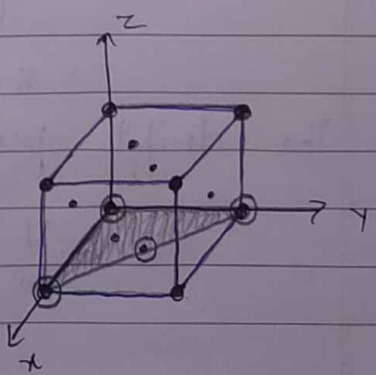
$$\therefore \text{area}^{(111)} = \frac{1}{2} \times a\cancel{\sqrt{2}} \times a\frac{\sqrt{3}}{\cancel{\sqrt{2}}} = \frac{a^2\sqrt{3}}{2} = 4\sqrt{3}\, r^2$$

number of atoms in (111) plane $= \left(3\times\frac{1}{8} + 3\times\frac{1}{2}\right)$

surface of each of them $= \pi r^2$

$$\therefore \text{planar density}^{(111)} = \frac{(3\times 1/8 + 3\times\frac{1}{2})\times\pi \cancel{r^2}}{4\cancel{r^2}\sqrt{3}} = \frac{\pi}{2\sqrt{3}} = 0.906$$

Similarly, for (110) :-



$$\text{area}^{(110)} = \frac{1}{2} \times a\sqrt{2} \times \frac{a\sqrt{2}}{2} = a^2/2 = \frac{8r^2}{2} = 4r^2$$

no. of atoms $= 3\times\frac{1}{8} + 1\times\frac{1}{2} = 7/8$

$$\text{planar density}^{(110)} = \frac{7/8 \times \pi r^2}{a^2/2} = \frac{7\times\pi \cancel{r^2}}{32\cancel{r^2}} = 0.68$$

(7) Bragg's eq^n as follows:-

$$n\lambda = 2d\sin\theta$$

d is the distance b/w the scattering plane.
θ is the angle of diffraction
n is the order of diffraction

and $d = \dfrac{a}{\sqrt{h^2+k^2+l^2}}$ a → edge length
h, k, l → miller indices

$$\therefore \quad 1 \times \lambda = 2 \times \frac{5\times10^{-10}}{\sqrt{2}} \times \sin 45^\circ \ m$$

$$\lambda = \frac{\cancel{2} \times 5\times10^{-10}}{\cancel{\sqrt{2}} \times \cancel{\sqrt{2}}} \ m = 5\times10^{-10} \ m \text{ or } 5\,\mathring{A}$$

(8) The volume occupied by 63.5g of copper is

$$V = \frac{M}{\rho} = \frac{63.5}{8.94} = 7.09 \ cm^3 \ mol^{-1}$$

as each cu atom contributes 1 e^- to the body of the material, density of free e^- is

$$n = \frac{6.02\times10^{23}}{7.09\times10^{-6}} \ e^-/m^3$$

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

The drift speed is

$$V_d = \frac{I}{neA} = \frac{1}{8.48\times10^{28}\times1.6\times10^{-19}\times1\times10^{-6}}$$

$$= 7.38\times10^{-5} \ ms^{-1}$$

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(a) $V_d = -\mu_e E$

$1\times10^{-3} = 0.0056 \times E$

$E = \frac{10}{56} = 0.178$

(b) $J = \sigma E$

$\cancel{10}^7 = 6.17\times\cancel{10}^7 \times E$

$E = \frac{1}{6.17} = 0.162$

(c) $J = \frac{I}{S} = \sigma E = \sigma \frac{V}{L}$

$\frac{80}{9\times10^{-6}} = 6.17\times10^{7} \times E$

$E = \frac{8\cancel{0}}{9\times6.17\times1\cancel{0}} = 0.144$

(d) $E = \frac{V}{L} = \frac{5\cancel{0}\times\cancel{10}^{-3}}{\cancel{5}\times\cancel{10}^{-2}} = 1$

$= \cancel{\frac{0.5\times10^{-3}}{3\times10^{-3}}} \cancel{=} \cancel{0.16}$

(10) $\rho = \cancel{1.53}\ 1.69\times10^{-8}\ \Omega\cdot m$

$n = 8.5\times10^{28}$

relaxation time, $\tau = \frac{m_e}{ne^2\rho} = \frac{9.11\times10^{-31}}{8.5\times10^{28}\times(1.6\times10^{-19})^2\times1.69\times10^{-8}}$

$= \frac{9.11\times10^{-13}}{8.5\times\cancel{1.6}\ 2.56\times1.69} = 0.24\times10^{-13}\ s$

$$\text{Mobility}, \ \mu = \frac{e}{m_e} \times \tau$$

$$= \frac{1.6 \times \cancel{10^{-19}}}{9.11 \times \cancel{10^{-31}}} \times 0.24 \times \cancel{10^{-13}} \times 10$$

$$= 0.421$$

$$\text{conductivity}, \ \sigma = \frac{ne^2 \tau}{m}$$

$$= \frac{8.5 \times 10^{28} \times (1.6 \times 10^{-19})^2 \times 0.24 \times 10^{-13}}{9.11 \times 10^{-31}}$$

$$= \frac{8.5 \times 0.24 \times}{9.11} 10^8 \simeq 0.223 \times 10^8$$

$$\text{Mean free path}, \ \lambda = V_F \tau = \sqrt{\frac{2E_f}{m}} \ \tau$$

$$E_f = \left(\frac{h^2}{8m_e}\right)\left(\frac{3}{\pi}\right)^{2/3} n^{2/3}$$

$$= \frac{(6.63 \times 10^{-34})^2}{8 \times 9.11 \times 10^{-31}} \times \left(\frac{3 \times 7}{22}\right)^{3/2} \times (8.5 \times 10^{28})^{2/3}$$

$$= 0.603 \times 10^{-37} \times 0.932 \times 1.93 \times 10^{19}$$

$$= 1.08 \times 10^{-18}$$

for copper wire

applied $E = 1 \ \text{v/cm} = 10^2 \ \text{v/m}$

$$\text{drift velocity}, \ V_d = \left(\frac{eE}{m}\right) \times \tau = \left[\frac{1.60 \times \cancel{10^{-19}} \times \cancel{10^{2}}}{9.11 \times \cancel{10^{-31}}}\right] \times 0.24 \times \cancel{10^{-13}}$$

$$= \frac{1.6 \times 0.24 \times 10}{9.11}$$

$$= 0.42$$

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$$V_{rms} = \sqrt{\frac{3KT}{m}} = \sqrt{\frac{3 \times 1.38 \times 10^{-23} \times 293 \times 10^{8}}{9.11 \times 10^{-31}}} = 11.53 \times 10^{4}$$

$$= 1.153 \times 10^{5}$$