MS-1230 (Physics of Solids)

ASSIGNMENT

MS21BTECH11006

① (a) To do : Find and tabulate the 'd' spacings of different orientations of the given X-ray diffraction pattern.

Radiation used = Cu (K_α) with $\lambda = 1.5406\,\mathring{A}$

Bragg's Law : $\boxed{n\lambda = 2d\sin\theta}$

(i) $2\theta = 22.88° \Rightarrow \boxed{\theta = 11.44°}$

$\sin(11.44°) = 0.198$

So, $1 \times 1.5406 \times 10^{-10}\,m = 2 \times d \times \sin(11.44°)$

$\Rightarrow d = \dfrac{1.5406}{2 \times 0.198}\,\mathring{A} \Rightarrow \boxed{d = 3.89\,\mathring{A}}$

(ii) $2\theta = 32.54° \Rightarrow \boxed{\theta = 16.27°}$

$\sin(16.27°) = 0.28$

So, $1 \times 1.5406\,\mathring{A} = 2d\sin(16.27°)$

$\Rightarrow d = \dfrac{1.5406}{2 \times 0.28}\,\mathring{A} \Rightarrow \boxed{d = 2.75\,\mathring{A}}$

(iii) $2\theta = 40.10° \Rightarrow \boxed{\theta = 20.05°}$

$\sin(20.05°) = 0.342$

So, $1 \times 1.5406\,\mathring{A} = 2d\sin(20.05°)$

$\Rightarrow d = \dfrac{1.5406}{2 \times 0.342}\,\mathring{A} \Rightarrow \boxed{d = 2.25\,\mathring{A}}$

(iv) $2\theta = 46.60° \Rightarrow \boxed{\theta = 23.30°}$

$\sin(23.30°) = 0.395$

So, $1 \times 1.5406\,\mathring{A} = 2d\sin(23.30°)$

$\Rightarrow d = \dfrac{1.5406}{2 \times 0.395}\,\mathring{A} \Rightarrow \boxed{d = 1.95\,\mathring{A}}$

(v) $2\theta = 52.48^\circ \Rightarrow \boxed{\theta = 26.24^\circ}$

$\sin(26.24^\circ) = 0.442$

So, $1 \times 1.5406\ \text{Å} = 2d \sin(26.24^\circ)$

$\Rightarrow d = \dfrac{1.5406}{2 \times 0.442}\ \text{Å} \Rightarrow \boxed{d = 1.74\ \text{Å}}$

(vi) $2\theta = 57.92^\circ \Rightarrow \boxed{\theta = 28.96^\circ}$

$\sin(28.96^\circ) = 0.484$

So, $1 \times 1.5406\ \text{Å} = 2d \sin(28.96^\circ)$

$\Rightarrow d = \dfrac{1.5406}{2 \times 0.484}\ \text{Å} \Rightarrow \boxed{d = 1.59\ \text{Å}}$

(vii) $2\theta = 67.94^\circ \Rightarrow \boxed{\theta = 33.97^\circ}$

$\sin(33.97^\circ) = 0.558$

So, $1 \times 1.5406\ \text{Å} = 2d \sin(33.97^\circ)$

$\Rightarrow d = \dfrac{1.5406}{2 \times 0.558}\ \text{Å} \Rightarrow \boxed{d = 1.38\ \text{Å}}$

(viii) $2\theta = 72.68^\circ \Rightarrow \boxed{\theta = 36.34^\circ}$

$\sin(36.34^\circ) = 0.592$

So, $1 \times 1.5406\ \text{Å} = 2d \sin(36.34^\circ)$

$\Rightarrow d = \dfrac{1.5406}{2 \times 0.592} \Rightarrow \boxed{d = 1.30\ \text{Å}}$

(ix) $2\theta = 77.30^\circ \Rightarrow \boxed{\theta = 38.65^\circ}$

$\sin(38.65^\circ) = 0.624$

So, $1 \times 1.5406\ \text{Å} = 2d \sin(38.65^\circ)$

$\Rightarrow d = \dfrac{1.5406}{2 \times 0.624} \Rightarrow \boxed{d = 1.23\ \text{Å}}$

Table

S. No.	2θ	θ	'd' (in Å)
1	22.88°	11.44°	3.89 Å
2	32.54°	16.27°	2.75 Å
3	40.10°	20.05°	2.25 Å
4	46.60°	23.30°	1.95 Å
5	52.48°	26.24°	1.74 Å
6	57.92°	28.96°	1.59 Å
7	67.94°	33.97°	1.38 Å
8	72.68°	36.34°	1.30 Å
9	77.30°	38.65°	1.23 Å

(b) Radiation used = $Fe(K_\alpha)$ with $\lambda = 1.93604$ Å

(i) $1 \times 1.93604 \times \cancel{10^{-10}}\ m = 2 \times 3.89 \times \cancel{10^{-10}} \times \sin\theta$

$$\Rightarrow \sin\theta = \frac{1.93604}{2 \times 3.89} = 0.248$$

$$\Rightarrow \theta = \sin^{-1}(0.248) \Rightarrow \boxed{\theta = 14.35°}$$

(ii) 1×1.93604 Å $= 2 \times 2.75$ Å $\times \sin\theta$

$$\Rightarrow \sin\theta = \frac{1.93604}{5.5} = 0.352$$

$$\Rightarrow \theta = \sin^{-1}(0.352) \Rightarrow \boxed{\theta = 20.60°}$$

(iii) 1×1.92604 Å $= 2 \times 2.25$ Å $\times \sin\theta$

$$\Rightarrow \sin\theta = \frac{1.93604}{4.5} = 0.430$$

$$\Rightarrow \theta = \sin^{-1}(0.43) \Rightarrow \boxed{\theta = 25.46°}$$

(iv) $1 \times 1.93604\,\text{Å} = 2 \times 1.95\,\text{Å} \times \sin\theta$

$\Rightarrow \sin\theta = \dfrac{1.93604}{3.9} = 0.496$

$\Rightarrow \theta = \sin^{-1}(0.496) \Rightarrow \boxed{\theta = 29.73^\circ}$

(v) $1 \times 1.93604\,\cancel{\text{Å}} = 2 \times 1.74\,\cancel{\text{Å}} \times \sin\theta$

$\Rightarrow \sin\theta = \dfrac{1.93604}{3.48} = 0.556$

$\Rightarrow \theta = \sin^{-1}(0.556) \Rightarrow \boxed{\theta = 33.77^\circ}$

(vi) $1 \times 1.93604\,\cancel{\text{Å}} = 2 \times 1.59\,\cancel{\text{Å}} \times \sin\theta$

$\Rightarrow \sin\theta = \dfrac{1.93604}{3.18} = 0.6088$

$\Rightarrow \theta = \sin^{-1}(0.6088) \Rightarrow \boxed{\theta = 37.5^\circ}$

(vii) $1 \times 1.93604\,\cancel{\text{Å}} = 2 \times 1.38\,\cancel{\text{Å}} \times \sin\theta$

$\Rightarrow \sin\theta = \dfrac{1.93604}{2.76} = 0.701$

$\Rightarrow \theta = \sin^{-1}(0.701) \Rightarrow \boxed{\theta = 44.5^\circ}$

(viii) $1 \times 1.93604\,\cancel{\text{Å}} = 2 \times 1.30\,\cancel{\text{Å}} \times \sin\theta$

$\Rightarrow \sin\theta = \dfrac{1.93604}{2.6} = 0.744$

$\Rightarrow \theta = \sin^{-1}(0.744) \Rightarrow \boxed{\theta = 48.07^\circ}$

(ix) $1 \times 1.93604\,\cancel{\text{Å}} = 2 \times 1.23\,\cancel{\text{Å}} \times \sin\theta$

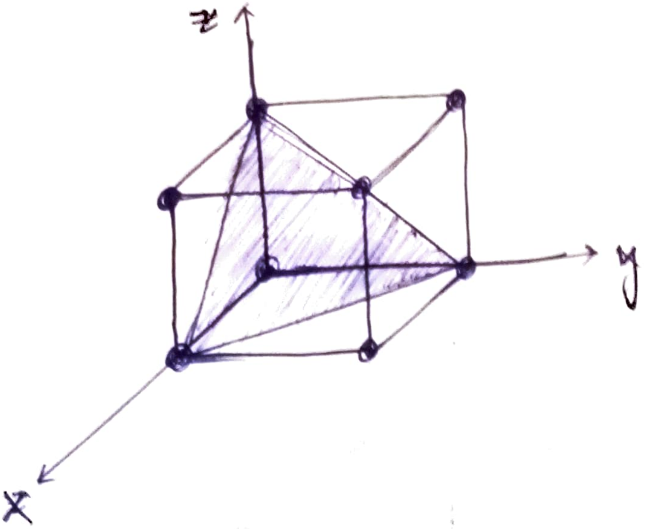
$\Rightarrow \sin\theta = \dfrac{1.93604}{2.46} = 0.787$

$\Rightarrow \theta = \sin^{-1}(0.787) \Rightarrow \boxed{\theta = 51.9^\circ}$

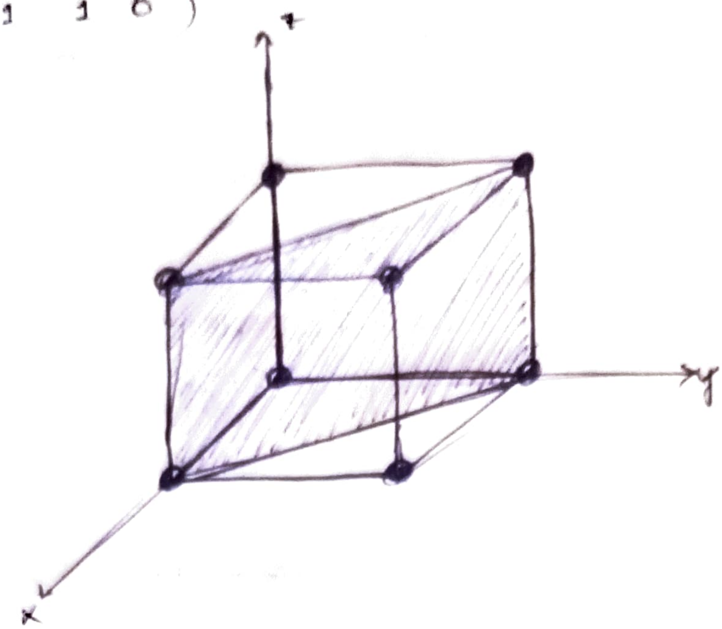
Table

S.No	d(in Å)	θ	2θ
1	3.89Å	14.35°	28.7°
2	2.75Å	20.60°	41.2°
3	2.25Å	25.46°	50.92°
4	1.95Å	29.73°	59.46°
5	1.74Å	33.77°	67.54°
6	1.57Å	37.5°	75°
7	1.38Å	44.5°	89°
8	1.30Å	48.07°	96.14°
9	1.23Å	51.9°	103.8°

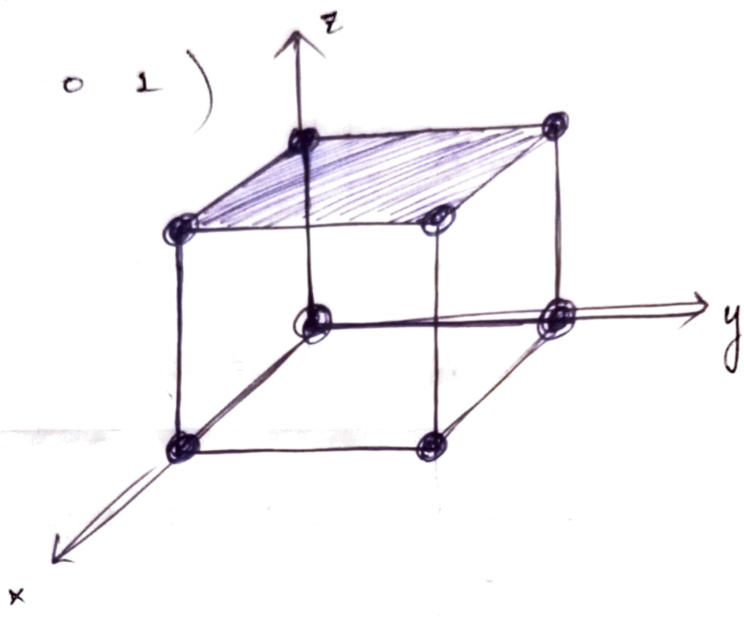
2 (a) (2 2 2) = 2 (1 1 1)



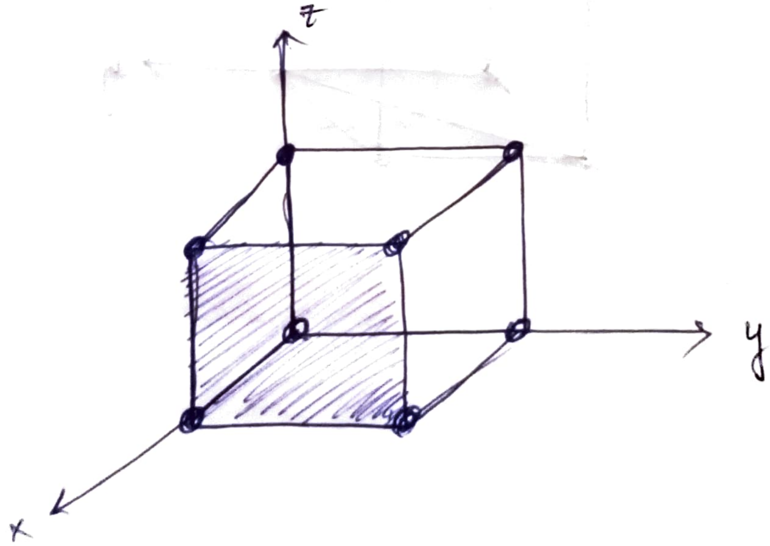
(b) (1 1 0)



(c) (0 0 1)



(d) (2 0 0) ≡ 2 (1 0 0)



(4) (a) When a coin is tossed once, the outcomes are either a head (H) or a tail (T).

Two eigen states = H, T

When 3 coins are tossed simultaneously the total no. of outcomes = 2^3

$= 8$

The eight eigen states are as follows

(H H H), (H H T), (H T H),

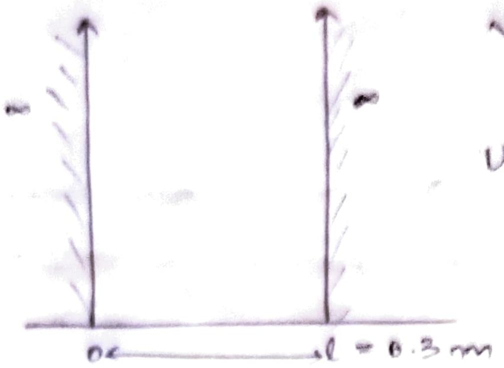
(T H H), (T T H), (H T T),

(T H T), (T T T).

(b) If 3 indistinguishable coins are tossed, there will be 2 degenerate states.

Degenerate states : (H H H), (T T T)

(5) Given: An e^- is confined in a 1-D potential well of width 0.3 nm.



$$V(x) = \begin{cases} 0, & \text{if } 0 < x < l \\ \infty, & \text{otherwise} \end{cases}$$

Using Schrödinger's eq^n

$$\boxed{\hat{H}\psi(x) = E\psi(x)}$$

$$\Rightarrow -\frac{\hbar^2}{2m} \cdot \frac{d^2\psi(x)}{dx^2} + \cancel{V(x)}^{\,0}\,\psi(x) = E\psi(x)$$

$$\Rightarrow -\frac{\hbar^2}{2m} \cdot \frac{d^2\psi(x)}{dx^2} = E\psi(x)$$

$$\Rightarrow \boxed{\frac{d^2\psi(x)}{dx^2} = -\frac{2mE}{\hbar^2} \cdot \psi(x)} \quad \text{--- (1)}$$

Now, solving the above differential eq^n, we have

$$\psi(x) = A\cos(kx) + B\sin(kx)$$

Using the boundary conditions,

$$\psi(x \leq 0) = 0 \rightarrow \psi(0) = 0$$

$$\psi(x \geq l) = 0 \rightarrow \psi(l) = 0.$$

So, $\psi(0) = A\cos(k.0) + B\sin(k.0)$

$$\Rightarrow \psi(0) = 0 = A \Rightarrow \boxed{A = 0}$$

and,

$$\psi(l) = B\sin(kl) = 0$$

$$\Rightarrow \sin(kl) = 0 \Rightarrow kl = n\pi$$

$$\Rightarrow \boxed{k = \frac{n\pi}{l}}, n \in \mathbb{Z}$$

So, $\boxed{\psi_n(x) = B\sin\left(\frac{n\pi x}{l}\right)}$ (3)

Now, on comparing

$$\frac{n\pi}{l} = k = \frac{p}{\hbar} = \frac{\sqrt{2mE}}{\hbar}$$

$$\Rightarrow \frac{n^2\pi^2}{l^2} = \frac{2mE}{\hbar^2}$$

$$\Rightarrow E = \frac{n^2\pi^2\hbar^2}{2m.l^2}$$

$$\Rightarrow \boxed{E_n = \frac{n^2h^2}{8ml^2}}$$ (2)

Electron at ground state $\Rightarrow n = 1$

So, $$E_1 = \frac{(1)^2 . h^2}{8 . m_e . (0.3\times10^{-9})^2}$$

$$\Rightarrow E_1 = \frac{(1)^2 . (6.63\times10^{-34})^2}{8.(9.31\times10^{-31}).(0.3\times10^{-9})^2}$$

$$\Rightarrow E_1 = \frac{43.9569\times10^{-68}}{6.7032\times10^{-49}} \text{ J}$$

$$\Rightarrow \boxed{E_1 = 6.557\times10^{-19}\text{ J} = 4.09\text{ eV}}$$

$\therefore$ The kinetic energy of the e^- when it is in the ground state $= 4.09$ eV

Now, the energy at ground state = 6.557×10^{-19} J

The energy at 2nd excited state

↳ $n = 3$

$$E_3 = \frac{(3)^2 \cdot h^2}{8 m_e (l)^2}$$

$$\Rightarrow E_3 = \frac{9 \times 43.9569 \times 10^{-68}}{8 \times 9.31 \times 10^{-31} \times 0.09 \times 10^{-18}}$$

$$\Rightarrow \boxed{E_3 = 59.01 \times 10^{-19} \text{ J}}$$

Now, $\Delta E = h\nu$

$$\Rightarrow E_3 - E_1 = h\nu$$

$$\Rightarrow (59.01 - 6.557) \times 10^{-19} \text{ J}$$

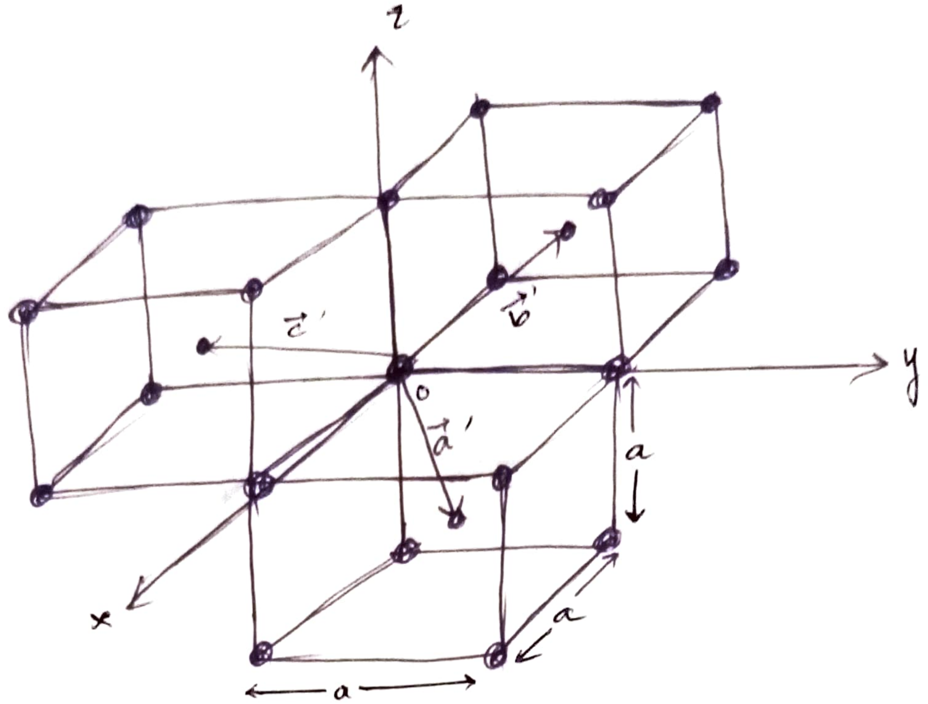
$$= 6.63 \times 10^{-34} \text{ Js} \cdot \nu$$

$$\Rightarrow \frac{52.453 \times 10^{-19}}{6.63 \times 10^{-34}} \text{ s}^{-1} = \nu$$

$$\Rightarrow \boxed{\nu = 7.911 \times 10^{15} \text{ Hz}}$$

∴ The special frequency resulting from a transition between the 2nd excited possible state to the ground level is 7.911×10^{15} Hz

(7)



To prove : The reciprocal lattice of BCC is FCC.

Let $\vec{a}', \vec{b}', \vec{c}'$ be the primitive translational vectors of BCC ~~crystal~~ lattice.
Let $\hat{i}, \hat{j}, \hat{k}$ be the orthogonal unit vectors along x, y and z axis respectively.

So, $\vec{a}' = \frac{a}{2}\hat{i} + \frac{a}{2}\hat{j} - \frac{a}{2}\hat{k} = \frac{a}{2}(\hat{i}+\hat{j}-\hat{k})$.

$$\Rightarrow \boxed{\vec{a}' = \frac{a}{2}(\hat{i}+\hat{j}-\hat{k})} \quad \text{--- (1)}$$

Similarly, $$\boxed{\vec{b}' = \frac{a}{2}(-\hat{i}+\hat{j}+\hat{k})} \quad \text{--- (2)}$$

and, $$\boxed{\vec{c}' = \frac{a}{2}(\hat{i}-\hat{j}+\hat{k})} \quad \text{--- (3)}$$

Let $\vec{a}^*$, $\vec{b}^*$ and $\vec{c}^*$ be the primitive translational vectors of reciprocal lattice

So, $\vec{a}^* = \dfrac{2\pi \cdot (\vec{b}' \times \vec{c}')}{\vec{a}' \cdot (\vec{b}' \times \vec{c}')}$ --- (4)

$\vec{b}^* = \dfrac{2\pi \cdot (\vec{c}' \times \vec{a}')}{\vec{a}' \cdot (\vec{b}' \times \vec{c}')}$ --- (5)

$\vec{c}^* = \dfrac{2\pi \cdot (\vec{a}' \times \vec{b}')}{\vec{a}' \cdot (\vec{b}' \times \vec{c}')}$ --- (6)

$\vec{b}' \times \vec{c}' = \left[\frac{a}{2}(-\hat{i} + \hat{j} + \hat{k})\right] \times \left[\frac{a}{2}(\hat{i} - \hat{j} + \hat{k})\right]$

$= \dfrac{a^2}{4} \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ -1 & 1 & 1 \\ 1 & -1 & 1 \end{vmatrix}$

$= \dfrac{a^2}{4}\left[\hat{i}(1+1) - \hat{j}(-1-1) + \cancel{\hat{k}(1-1)}\right]$

$= \dfrac{a^2}{4}\left[2\hat{i} + 2\hat{j}\right] = \dfrac{a^2}{2}(\hat{i} + \hat{j})$

$\Rightarrow \boxed{\vec{b}' \times \vec{c}' = \dfrac{a^2}{2}(\hat{i} + \hat{j})}$ --- (7)

So, $\vec{a}' \cdot (\vec{b}' \times \vec{c}')$

$= \left[\frac{a}{2}(\hat{i} + \hat{j} - \hat{k})\right] \cdot \left[\frac{a^2}{2}(\hat{i} + \hat{j})\right]$

$= \dfrac{a^3}{4}(1+1) = \dfrac{a^3}{2}$

$\Rightarrow \boxed{\vec{a}' \cdot (\vec{b}' \times \vec{c}') = \dfrac{a^3}{2}}$ --- (8)

Now using (7) and (8) in (4), we have

$$\vec{a}^* = \frac{2\pi \cdot \frac{a^2}{2}(\hat{i}+\hat{j})}{\frac{a^3}{2}}$$

$$\Rightarrow \boxed{\vec{a}^* = \frac{2\pi}{a}(\hat{i}+\hat{j})} \quad \text{--- (9)}$$

Similarly, $\boxed{\vec{b}^* = \frac{2\pi}{a}(\hat{j}+\hat{k})}$ --- (10)

and $\boxed{\vec{c}^* = \frac{2\pi}{a}(\hat{k}+\hat{i})}$ --- (11)

But these are the primitive translational vectors of FCC lattice. So, reciprocal lattice of BCC is FCC (Hence, proved)

(8) (a) The phase velocity is given by.

$$\boxed{V = V_g = \frac{d\omega}{dk}} \quad \text{--- (1)}$$

Now, $E = h\nu \Rightarrow E = \frac{h}{2\pi} \cdot 2\pi\nu$

$$\Rightarrow \boxed{E = \hbar\omega} \quad \text{--- (2)}$$

Diff. (2) w.r.t k, we have

$$\frac{dE}{dk} = \hbar \cdot \frac{d\omega}{dk} \Rightarrow \boxed{\frac{d\omega}{dk} = \frac{1}{\hbar} \cdot \frac{dE}{dk}} \quad (3)$$

Comparing (1) and (3), we have

$$\boxed{V = \frac{1}{\hbar} \cdot \frac{dE}{dk}} \quad \text{--- (4)}$$

We know that $E = \frac{p^2}{2m}$.

Using de-Broglie hypothesis

$$\lambda = \frac{h}{p} \Rightarrow p = \frac{h}{\lambda} = \frac{h}{2\pi} \cdot \frac{2\pi}{\lambda}$$

$$\Rightarrow \boxed{p = \hbar \cdot k}$$

So, $$\boxed{E = \frac{p^2}{2m} = \frac{\hbar^2 k^2}{2m}} \quad \text{--- (5)}$$

Diff. (5) w.r.t. k, we have

$$\boxed{\frac{dE}{dk} = \frac{\hbar^2}{2m} \cdot 2k = \frac{\hbar^2 \cdot k}{m}} \quad \text{--- (6)}$$

From (1), (4) and (6), we have

$$v = \frac{1}{\hbar} \cdot \frac{dE}{dk} = \frac{1}{\cancel{\hbar}} \cdot \frac{\hbar^2 k}{m}$$

$$\Rightarrow \boxed{v = \frac{\hbar k}{m}} \Longleftrightarrow v_e \propto k$$

On applying $\vec{E}$, the e^- gets accelerated

The Force acting on it is given by.

$$F = m^* a \Rightarrow \boxed{a = \frac{F}{m^*}} \quad \text{--- (7)}$$

Now, $a = \frac{dv}{dt}$

$$\Rightarrow a = \frac{d}{dt}\left(\frac{1}{\hbar} \cdot \frac{dE}{dk}\right)$$

$$\Rightarrow a = \frac{d}{dt}\left(\frac{1}{\hbar} \cdot \frac{dE}{dk}\right)\frac{dk}{dk}$$

$$\Rightarrow \boxed{a = \frac{1}{\hbar} \cdot \frac{dk}{dt} \cdot \frac{d^2E}{dk^2}} \quad \text{--- (8)}$$

Now, $p = \hbar k$

$$\Rightarrow \frac{dp}{dt} = \hbar \cdot \frac{dk}{dt}.$$

$$\Rightarrow \boxed{\frac{dk}{dt} = \frac{1}{\hbar} \cdot \frac{dp}{dt} = \frac{1}{\hbar} \cdot F} \quad \text{--- (9)}$$

So, $a = \frac{1}{\hbar} \cdot \frac{1}{\hbar} \cdot F \cdot \frac{d^2E}{dk^2}$

$$\Rightarrow \boxed{a = \frac{F}{\hbar^2} \cdot \frac{d^2E}{dk^2}} \quad \text{--- (10)}$$

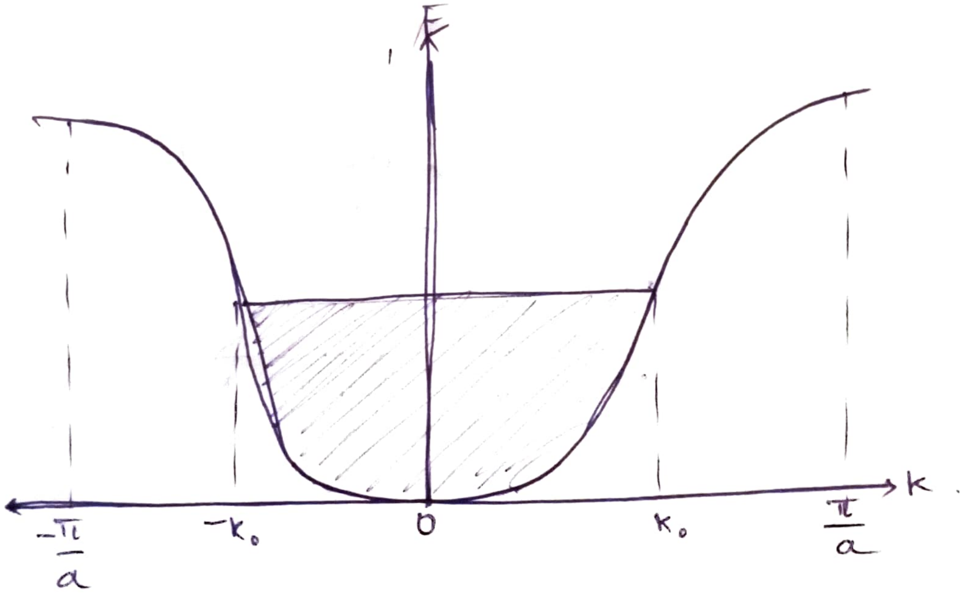
from (7) and (10), we have.

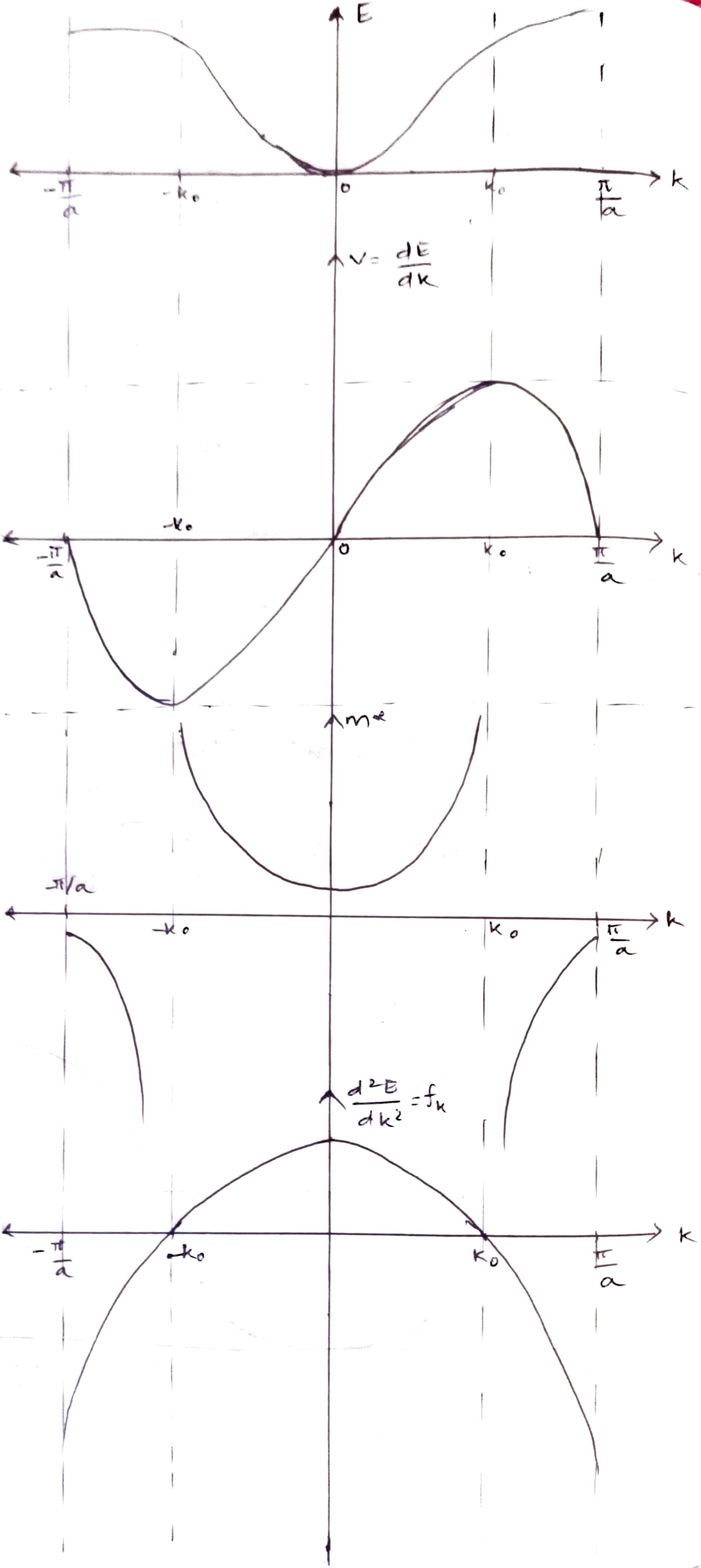
$$\frac{F}{m^*} = \frac{F}{\hbar^2} \cdot \frac{d^2E}{dk^2}$$

$$\Rightarrow \frac{1}{m^*} = \frac{1}{\hbar^2} \cdot \frac{d^2E}{dk^2}$$

$$\Rightarrow \boxed{m^* = \hbar^2 \cdot \left(\frac{d^2E}{dk^2}\right)^{-1}} \quad \text{--- (11)}$$

(b)




E
k
-π/a
-k₀
0
k₀
π/a
v = dE/dk
m*
d²E/dk² = f_k

(9) The effective mass is represented as a func of k $\left(m^* = \hbar^2 \left(\frac{d^2E}{dk^2} \right)^{-1} \right)$. In the lower portion of E-k graph, $\left(\frac{d^2E}{dk^2} \right)$ is positive. Hence m^* is positive. With increase in value of k, m^* attains a maximum value at the point of inflection (say k_0). Now, for higher values of k, $\left(\frac{d^2E}{dk^2} \right)$ becomes negative. As $k \rightarrow \frac{\pi}{a}$, the m^* approaches to a smaller negative value. At the point of inflection $\left[\left(\frac{d^2E}{dk^2} \right) = 0 \right]$, m^* becomes infinite.

As the electron approaches the zone boundary, the m^* becomes negative (can be seen from the graph). The External force is still positive, means that the acceleration on electron now becomes negative, i.e., the electron decelerates. The negative m^* tells us that the electron responds to the Electric field opposite to how a free electron would. Physically, the fact that the electron ~~responds~~ accelerates opposite to the direction of the force is because the electron must reflect off the zone boundary. As it approaches the boundary, the electron must decelerate.

(10) 1g of Li = $\frac{1}{7}$ mol atom Li

$= \frac{1}{7} \times 6.022 \times 10^{23}$ atom Li

The number density of conduction electron in Li is

$$n = \frac{\rho N_A}{M_{Li}} = \frac{0.534\ g\ cm^{-3} \times 6.022 \times 10^{23}\ mol^{-1}}{7\ g\ mol^{-1}}$$

$\Rightarrow n = 0.459 \times 10^{23}\ cm^{-3}$

$\Rightarrow \boxed{n = 45.9\ nm^{-3}}$

$$E_F = \left[\frac{(hc)^2}{8mc^2}\right]\left[\frac{3}{\pi}\right]^{2/3} \cdot n^{2/3}$$

on calculating $\left(\frac{3}{\pi}\right)^{2/3} \cdot \frac{1}{8} \approx 0.121$

So, $E_F = \frac{0.121\,(hc)^2}{m_e c^2} \cdot n^{2/3}$

Now, $hc = 1240$ eV nm

So, $E_F = \frac{(0.121) \cdot (1240)^2\ eV^2\ nm^2}{9.31 \times 10^{-31}\ kg\,(3 \times 10^8)^2\ m^2 s^{-2}} \times (45.9\ nm^{-3})^{2/3}$

$\Rightarrow E_F = \frac{(0.121)(1240)^2\ eV^2}{511 \times 10^3\ eV} \times (45.9)^{2/3}$

$\Rightarrow E_F = 0.364 \times (45.9)^{2/3}$ eV

$\Rightarrow E_F = 0.364 \times 12.5$ eV

$\Rightarrow \boxed{E_F = 4.55\ eV}$

1 g of Na = $\frac{1}{23}$ mol atom of Na

$= \frac{1}{23} \times 6.022 \times 10^{23}$ atom Na

The number density of conduction electron in Na is

$$n = \frac{\rho N_A}{M_{Na}} = \frac{0.968 \, g\,cm^{-3} \times 6.022 \times 10^{23} \, mol^{-1}}{23 \, g\,mol^{-1}}$$

$$\Rightarrow n = 0.253 \times 10^{23} \, cm^{-3}$$

$$\Rightarrow \boxed{n = 25.3 \, nm^{-3}}$$

Now, $E_F = \left[\frac{(hc)^2}{8 m_0 c^2}\right] \left[\frac{3}{\pi}\right]^{2/3} (n)^{2/3}$

$$\Rightarrow E_F = \frac{(0.121)(hc)^2}{511 \times 10^3 \, eV} \times (25.3 \, nm^{-3})^{2/3}$$

$$\Rightarrow E_F = \frac{(0.121)(1240)^2 \, eV^{\cancel{2}} \, \cancel{nm^2}}{511 \times 10^3 \, \cancel{eV}} \times (25.3)^{2/3} \, \cancel{nm^{-2}}$$

$$\Rightarrow E_F = (0.364) \times (8.34) \, eV$$

$$\Rightarrow \boxed{E_F = 3.035 \, eV}$$

$\therefore$ The Fermi energy of Li is 4.55 eV and that of Na is 3.035 eV.

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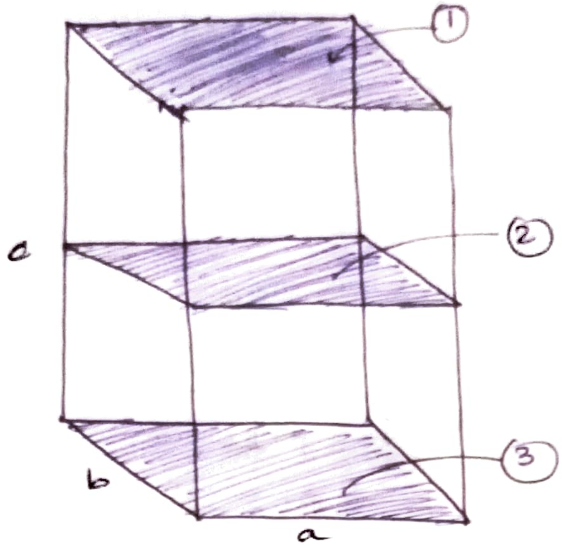
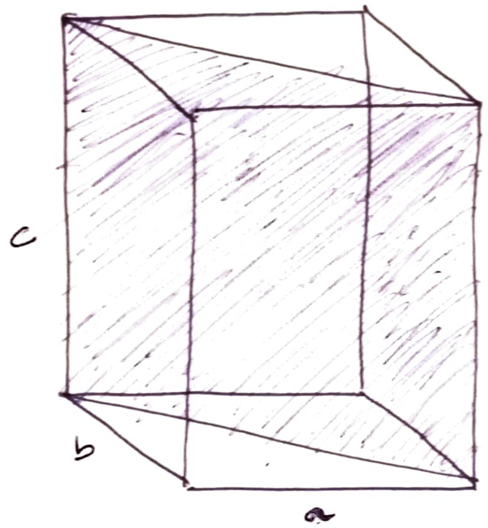


Miller Indices:

plane 1 = $(0\ 0\ 1)$

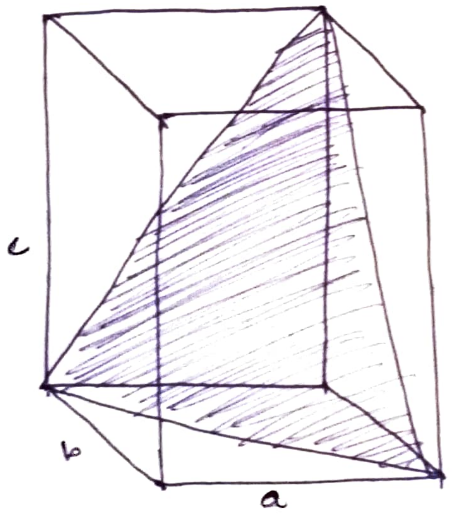
plane 2 = $(0\ 0\ 1)$

plane 3 = $(0\ 0\ \bar{1})$



Miller indices of the plane

$(1\ 1\ 0)$



Miller indices of the plane

$(1\ 1\ 1)$

(6) (a) Fermi energy of copper = 7 eV (given)

To find : Probability of finding electrons at energy = 8 eV at room T

Probability of finding electrons is given by,

$$f(E) = \frac{1}{e^{\frac{(E-E_F)}{kT}} + 1}$$

$$= \frac{1}{e^{\frac{(8-7)}{0.0259}} + 1}$$

(at room temp $KT = 0.0259$)

$$= \frac{1}{e^{1/0.0259} + 1}$$

Now, $e^{1/0.0259} = e^{38.61}$

$= 5.046 \times 10^{16} >> 1$

So, $f(E) = \frac{1}{5.046 \times 10^{16}}$

$= \frac{1}{5.046} \times 10^{-16}$

$= 0.198 \times 10^{-16}$

$\therefore$ Probability of finding electron at 8 eV at room T is 0.198×10^{-16} if fermi energy is 7 eV

(b) Energy = 8 eV

Probability = 0.3 = f(E)

So, A/Q

$$0.3 = \frac{1}{e^{(8-7)/kT} + 1}$$

$$\Rightarrow \frac{10}{3} = e^{1/kT} + 1$$

$$\Rightarrow e^{1/kT} = \frac{7}{3}$$

$$\Rightarrow \frac{1}{kT} = \ln\left(\frac{7}{3}\right) = 0.85$$

$$\Rightarrow T = \frac{1}{k \times 0.85}$$

$$\Rightarrow \boxed{T = 13675.338 \text{ K}}$$

∴ If the probability of finding an e^- at 8 eV is 0.3, then temperature should be 13675.338 K.