FE ALL BRANCHES.

IAT - I , APPLIED PHYSICS-I.

Q.1. Solve any three.

a) Data

$T = 500K$

$E_p = 1.5\ eV$

$\frac{n}{N} = ?$ for Schottky defect in KCl crystal.

Solution :

For Schottky defect

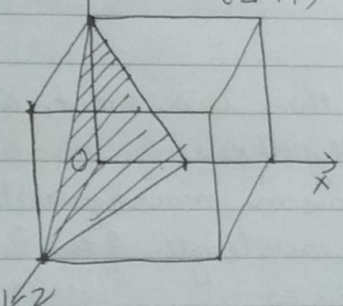
$n = N\, e^{-E_p/2kT}$ —— 1M

$\frac{n}{N} = e^{-E_p/2kT}$

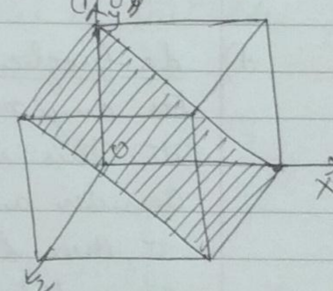
$= e^{-1.5 \times 1.6\times10^{-19} J / 2\times 1.38\times10^{-23} \frac{J}{K} \cdot 500K}$ — ½M

$= \underline{\underline{2.79 \times 10^{-8}}}$ — ½M

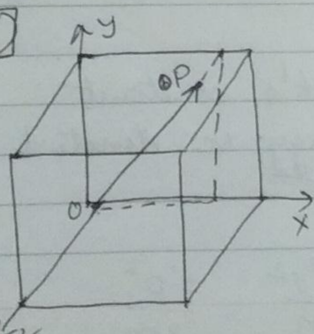
b) (2 1 1)



(1 1 0)



[2 3 1]



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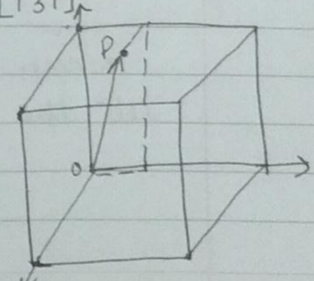

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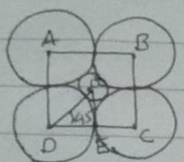
c) Critical Radius Ratio for Ligancy 6.



Consider six anions touching the cation and touching with each other.
Let r_c be the radius of cation and r_a be the radius of anion. 1M

From the figure.

$$\cos 45^\circ = \frac{DE}{DO}$$

$$\frac{1}{\sqrt{2}} = \frac{r_a}{r_c + r_a}$$

$$\sqrt{2} = \frac{r_c + r_a}{r_a}$$

$$\sqrt{2} = 1 + \frac{r_c}{r_a}$$

½M

$$\therefore \frac{r_c}{r_a} = \sqrt{2} - 1 = 0.414.$$

→ ½M.

d) de-Broglie Hypothesis:

For any moving particle there is a wave associated it. This is de-Broglie Hypothesis.
Consider a particle of mass m, moving with velocity v, then the de-Broglic wavelength of the waves associated with it is given as

$$\lambda = \frac{h}{mv}.$$

1M

where h is planck's constant.
Let the kinetic energy be denoted as E_k

$$E_k = \frac{1}{2} mv^2$$

$$= \frac{1}{2} \frac{m^2 v^2}{m} = \frac{p^2}{2m}.$$

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$$p^2 = 2mE_k$$
$$p = \sqrt{2mE_k}$$

$$\therefore \lambda = \frac{h}{\sqrt{2mE_k}}$$ — ½M

For a charged particle, if its accelerated by a potential V ~~and its~~, then its potential energy is eV

$\therefore$ Kinetic energy = potential energy

$$E_k = eV$$

$$\therefore \lambda = \frac{h}{\sqrt{2meV}}$$ — ½M

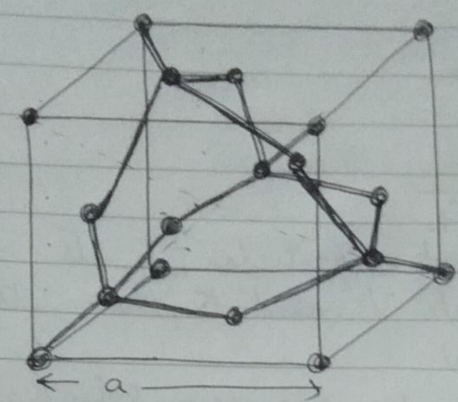
e * X-Rays are radiations of very short wavelength of the order of 1Å. In a crystalline solid atoms are very closely distributed in atomic planes which are spread in three dimensions. The crystal planes form a three dimensional grating system with a spacing between them of order of X-Ray wavelength. Hence a natural crystal is suitable grating for X-ray diffraction. 1M

* Phases of liquid crystals:

a) Nematic
b) Smectic A and Smectic C
c) Cholestric or Chiral
d) Twisted Nematic
e) Discotic.

1M for any two

2a)

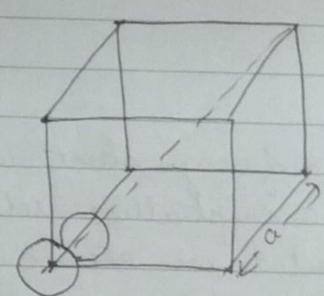


$a = b = c$

$\alpha = \beta = \gamma = 90^\circ$

— 2M

Radius (r)



From the figure

$$2r = \frac{\sqrt{3}a}{4}$$

$$\therefore r = \frac{\sqrt{3}a}{8}$$ — 1M

Coordination No: 4 — ½M

$$APF = \frac{nv}{V}$$

, here $n \rightarrow$ no. of atoms/cell

$v \rightarrow$ volume of each atom

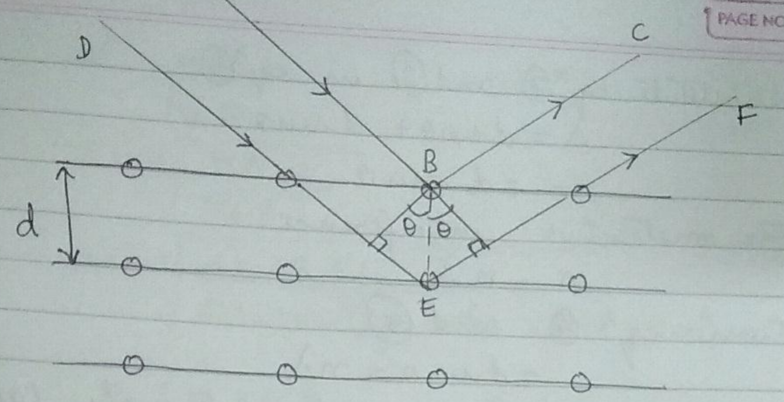
$V \rightarrow$ Volume of cell.

$$APF = \frac{8 \times \frac{4}{3}\pi r^3}{a^3}$$ — ½M

$$= \frac{8 \times \frac{4}{3}\pi \left(\frac{\sqrt{3}a}{8}\right)^3}{a^3}$$ — ½M

$$= \underline{\underline{0.34}}$$ — ½M

2b)



2M

Consider a set of parallel atomic planes with inter planar spacing d. The figure shows the row of atoms as a single horizontal line. Let a parallel beam of monochromatic X-rays of wavelength λ, represented by the parallel line AB and DE, be incident on these planes at a glancing angle θ. The scattered beam emerges along BC and EF. The rays BC and EF interfere either constructively and destructively, which depends on the path difference between them.

The path difference Δ between these rays is given by

$$\Delta = GE + HE \quad \cdots \quad (1)$$ →1M

Consider ΔGBE

$$\sin\theta = \frac{GE}{BE}$$

$$GE = BE \sin\theta$$
$$= d \sin\theta \quad \cdots \quad (2)$$

Consider ΔBEH

$$\sin\theta = \frac{HE}{BE}$$

$$HE = BE \sin\theta \quad \cdots \quad (3)$$
$$= d \sin\theta$$

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Substitute eq^n 2 and 3 in eq^n 1

$$\Delta = d\sin\theta + d\sin\theta$$

$$= 2d\sin\theta \quad \text{--- --- (4)}$$

— 1m

For constructive interference

$$\Delta = n\lambda \quad \text{--- --- (5)}$$

From eq^n 4 and 5

$$2d\sin\theta = n\lambda \quad \text{--- --- (6)}$$ — 1m

This equation is called as Bragg's law.
where n is the order of diffraction.

3a) Data FCC copper crystal.

$\lambda = 1.54\,\mathring{A}$

$A = 63.54$

$\rho = 8.96\ g/cm^3$

$n = 2$

$(hkl) = (101)$

$\theta = ?$

Solution:

By using Bragg's law

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

$$\sin\theta = \frac{n\lambda}{2d}$$

$$\therefore \theta = \sin^{-1}\left[\frac{n\lambda}{2d}\right] \quad \text{--- --- (1)}$$

We know

$$d = \frac{a}{\sqrt{h^2+k^2+l^2}} \quad \text{--- --- (2)}$$

Also. $$\rho = \frac{nA}{N_A a^3}$$ —

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$$a^3 = \frac{nA}{N_A \rho}$$

$$a = \sqrt[3]{\frac{nA}{N_A \rho}}$$

$$= \sqrt[3]{\frac{4 \times 63.54}{6.023 \times 10^{23}/\text{gm-mole} \times 8.96\ g/cm^3}}$$ [For FCC $n=4$]

$$= 3.61 \times 10^{-8}\ cm = 3.61\ \mathring{A}$$ — 2M

Putting it in eq^n ② we have.

$$d = \frac{3.61 \times 10^{-8}\ cm}{\sqrt{1^2 + 0^2 + 1^2}}$$

$$= \frac{\quad}{\sqrt{2}}$$

$$= 2.55 \times 10^{-8}\ cm = 2.55\ \mathring{A}$$ (1/2 + 1/2) — 1M

Putting it in eq^n ①

$$\theta = \sin^{-1}\left[\frac{2 \times 1.54 \times 10^{-8}\ cm}{2 \times 2.55 \times 10^{-8}\ cm}\right]$$ (1/2 + 1/2)

$$= \underline{\underline{37.15^\circ}}$$ — 1M

3b) Data

Electron

$m_e = 9.1 \times 10^{-31}\ kg$

$V = 100\ V$

λ_e = de broglie wavelength of electron

Proton

$m_p = 1.67 \times 10^{-27}\ kg$

$E_K = ?$

λ_p = de Broglie wavelength of proton

$$\lambda_e = \lambda_p$$

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Solution:

For electron

$$\lambda_e = \frac{h}{\sqrt{2meV}}$$ — ½M

$$= \frac{6.63 \times 10^{-34}\,Js}{\sqrt{2 \times 9.1 \times 10^{-31}\,kg \times 1.6 \times 10^{-19}\,C \times 100\,V}}$$ — ½M

$$= 1.22 \times 10^{-10}\,m$$

$$= 1.22\,\mathring{A}$$ — ½M

For proton

$$\lambda_p = \lambda_e = 1.22 \times 10^{-10}\,m$$ ½M

$$\lambda_p = \frac{h}{\sqrt{2mE_k}}$$ — ½M

$$\lambda_p^2 = \frac{h^2}{2mE_k}$$

$$E_k = \frac{h^2}{2m\lambda_p^2}$$ — ½M

$$= \frac{(6.63 \times 10^{-34})^2}{2 \times 1.67 \times 10^{-27}\,kg \times (1.22 \times 10^{-10}\,m)^2}$$

$$= 8.84 \times 10^{-21}\,J$$ — 1M