L.M.R Sheet for EP-1

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Superconductors and supercapacitors

1. Critical magnetic field:

$$H_c = H_0\left[1 - \frac{T^2}{T_c^2}\right]$$

$H_c \rightarrow$ critical field at any temp. T
$H_0 \rightarrow$ critical field at $0^\circ k$
$T_c \rightarrow$ critical temp. of the superconductor.

2. Energy density:

$$\text{Energy density} = \frac{\text{Energy}}{\text{Mass}}\left(\frac{W.hr}{Kg}\right) = \frac{\text{Energy}}{\text{Volume}}\left(\frac{W.hr}{l}\right)$$

3. Power density:

$$\text{Power density} = \frac{\text{Power}}{\text{Mass}}\left(\frac{KW}{Kg}\right) = \frac{\text{Power}}{\text{Volume}}\left(\frac{KW}{l}\right)$$

Quantum mechanics

1. De-broglie wavelength

$$\lambda = \frac{h}{p}$$

2. De-broglie wavelength in terms of K.E

$$\lambda = \frac{h}{\sqrt{2mE}}$$

3. De-broglie wavelength in terms of accelerating potential energy

$$\lambda = \frac{h}{\sqrt{2mqV}}$$

$h = 6.63 \times 10^{-34}$ JS
$M_e = 9.1 \times 10^{-31}$ kg
$M_p = 1.67 \times 10^{-27}$ kg

4. Phase velocity & group velocity & particle velocity

$V_{ph} = n\lambda$

$V_{ph} = \frac{c^2}{V_p} \Rightarrow c^2 = V_p \times V_{ph}$

5. uncertainty principle

$\Delta x \cdot \Delta p \geq \hbar$ position-momentum relation

$\Delta E \cdot \Delta t \geq \hbar$ Energy-time relation

$\Delta L \cdot \Delta \theta \geq \hbar$ Linear momentum - angular momentum relation

6. Particle trapped in 1-D infinite potential well

$$E = \frac{n^2 h^2}{8ma^2}$$

$n = 1, 2, 3, \ldots$
a = edge length
$h = 6.63 \times 10^{-34}$ JS
m = mass
E = energy

7. one dimension schrodinger's time dependent equation

$$i\hbar \frac{\partial \psi(x,t)}{\partial t} = \frac{-\hbar^2}{2m} \frac{\partial^2 \psi(x,t)}{\partial x^2} + V(x).\psi(x,t)$$

8. one dimension schrodinger's time independent equation

$$E\psi(x) = -\frac{\hbar^2}{2m} \frac{\partial^2 \psi(x)}{\partial x^2} + V(x)\psi(x)$$

Crystallography & x-rays

(1) Avg. no. of atoms per unit cell

$$N = \frac{N_C}{8} + \frac{N_f}{2} + \frac{N_B}{1}$$

(2) Packing efficiency $= \dfrac{n \times \frac{4}{3}\pi r^3}{a^3} \times 100$

(3) Density $(\rho) = \dfrac{Mn}{N_A a^3}$

(4) simple cubic crystal (sc)
(i) $N = 1$
(ii) $r = a/2$
(iii) coordination number $= 6$
(iv) packing efficiency $= 52\%$
(v) void space $= 48\%$

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(5) Body centred cubic crystal (BCC)

(i) $N = 2$
(ii) $r = \frac{\sqrt{3}a}{4}$

(iii) coordination number = 8
(iv) packing efficiency = 68%.
(v) void space = 32%.

(6) Face centered cubic crystal (FCC)

(i) $N = 4$
(ii) $r = \frac{a}{2\sqrt{2}}$

(iii) coordination number = 12
(iv) packing effeciency = 74%.
(v) void space = 26%.

For diamond

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

(7) Inter planar distance in cubic crystal

$$d = \frac{a}{\sqrt{h^2+k^2+l^2}}$$

(8) Bragg's law

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

$d \rightarrow$ interplanar distance
$\theta \rightarrow$ glancing angle
$\lambda \rightarrow$ wavelength
$n \rightarrow$ order of

Interference in thin film

A] Interference in thin parallel sided film.

(1) optical path difference

(i) For reflected ray

$$\Delta l = 2\mu t \cos r \pm \frac{\lambda}{2}$$

(ii) For transmitted ray

$$\Delta l = 2\mu t \cos r$$

⇨ General cases of maxima & minima

i maxima

$$\Delta l = n\lambda$$

ii minima

$$\Delta l = \left(n + \frac{1}{2}\right)\lambda \quad \text{OR} \quad \left(n - \frac{1}{2}\right)\lambda$$

(2) condition for maxima and minima

(i) Reflected

Maxima

$$2\mu t \cos r = (2n+1)\frac{\lambda}{2}$$

$$2\mu t \cos r = (2n-1)\frac{\lambda}{2}$$

Minima

$$2\mu t \cos r = n\lambda$$

(ii) Transmitted

Maxima

$$2\mu t \cos r = n\lambda$$

minima

$$2\mu t \cos r = (2n+1)\frac{\lambda}{2}$$

$$2\mu t \cos r = (2n-1)\frac{\lambda}{2}$$

B] Interference in wedge shaped film:

(1) condition for constructive interference

$$2\mu t \cos(r+\alpha) = (2n+1)\frac{\lambda}{2}$$

$$2\mu t \cos(r+\alpha) = (2n-1)\frac{\lambda}{2}$$

(2) condition for destructive interference

$$2\mu t \cos(r+\alpha) = n\lambda$$

(3) Fringe width

$$\beta = \frac{\lambda}{2\mu\alpha} \Rightarrow \alpha\beta\mu = \frac{\lambda}{2}$$

(4) wedge angle

$$\alpha = \frac{\lambda}{2\mu\beta}$$

(5) Determination of thickness of very thin wire or foil

$$\tan\alpha = \alpha = \frac{t}{l}$$

$$t = \frac{\lambda}{2\beta}$$

c] Newton ring:

(1) condition of constructive interference

$$2\mu t\cos(r+\alpha) = (2n+1)\frac{\lambda}{2}$$

$$2\mu t\cos(r+\alpha) = (2n-1)\frac{\lambda}{2}$$

(2) condition of destructive interference

$$2\mu t\cos(r+\alpha) = n\lambda$$

(3) Diameter of dark ring

$$D_n^2 = \frac{4Rn\lambda}{\mu}$$

(4) Diameter of bright ring

$$D_n^2 = \frac{2R\lambda(2n+1)}{\mu}$$

(5) wavelength of incident light

$\cancel{\lambda =}$

$$\text{slope} = \frac{D^2_{n+p} - D^2_n}{p} \qquad D^2_{n+p} - D^2_n = \frac{4Rp\lambda}{\mu}$$

$$\lambda = \text{Slope} \times \frac{1}{4R} = \frac{(D^2_{n+p} - D_n^2)\,\mu}{4P\cancel{R}}$$

(6) Radius of curvature

$$\cancel{R\times}\ R = \text{Slope} \times \frac{1}{4\cancel{R}\lambda} = \frac{(D^2_{n+p} - D^2_n)\,\mu}{4P\lambda}$$

(7) Refractive index of ~~water~~ medium

$$\cancel{\mu = \frac{D^2_{n+p} - D^2_n}{D_1{}^2_{n+p} - D_1{}^2_n}} \quad \cancel{\begin{matrix}\rightarrow \text{air} \\ \rightarrow \text{water}\end{matrix}}$$

$$\mu = \frac{4PR\lambda}{(D^2_{n+p} - D^2_n)} \rightarrow \text{Refractive index of any medium}$$

semiconductors

1. Fermi dirac distribution function

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

*** k should be in eV/K i.e 8.625×10^{-5} eV/K

$k \rightarrow$ Boltzmann constant $= 1.38 \times 10^{-23}$ J/K

$f(E)$ = probability that a particular energy level is occupied by electron

2. For intrinsic semiconductor

$n_i = n_e = n_h$

$\sigma = n_e \cdot e \cdot u_e + n_h \cdot e \cdot u_h$

$$E_f = \frac{E_c + E_v}{2}$$

n_i = intrinsic charge density
n_e = electron density
n_h = holes density
u_e = mobility of ~~hole~~ electrons
u_h = mobility of holes
E_f = fermi energy
σ = conductivity

3. For extrinsic semiconductor

$n_i^2 = n_h n_e$

4. Hall effect

(i) Hall voltage

$$V_H = \frac{BI}{pet} = \frac{-BI}{net} \quad \text{OR} \quad V_H = \frac{R_H BI}{t}$$

$B \rightarrow$ magnetic field
$R_H \rightarrow$ Hall coefficient
$I \rightarrow$ current
$p \rightarrow$ conc. of holes
$n \rightarrow$ conc. of electrons
$t \rightarrow$ thickness

(ii) Hall coefficient

$$R_H = \frac{E_H}{JB} \qquad R_H = \frac{-1}{ne} = \frac{1}{pe}$$

$E_H \rightarrow$ Hall field
$J \rightarrow$ current density
$B \rightarrow$ magnetic induction

$$R_H = \frac{V_H t}{BI}$$

(iii) Hall mobility

$$\sigma = u n e$$

$$u = \frac{\sigma}{ne}$$

$$u = \sigma R_H$$

(iv) carrier conc.

$$n = p = \left| \frac{1}{R_H e} \right|$$

(v) Hall angle

$$\theta_H = \tan^{-1}\left[\frac{E_H}{E_x}\right]$$