SD

Test 1

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2K19/EP/005

1 a) Density of states is defined as no. of energy states available per unit volume.

Density of state function gives no. of energy states available for e^- to occupy in an energy band.

as, $E \xrightarrow[dE]{} E+dE$ $\quad Z(E)dE = \frac{\pi}{2} n^2 dn$ — ①

also, $E = \frac{n^2 h^2}{8mL^2}$, $n = \sqrt{\frac{8mL^2E}{h^2}}$

from ①

$2n\,dn = \frac{8mL^2}{h^2}dE$, $dn = \left(\frac{1}{2n}\right)\left(\frac{8mL^2}{h^2}\right)dE$

$dn = \frac{1}{2}\left(\frac{8mL^2}{h^2}\right)^{1/2} \frac{dE}{E^{1/2}}$

$\therefore$ $Z(E)\,dE = \frac{\pi}{2} \times \frac{8mL^2E}{h^2} \times \frac{1}{2}\left(\frac{8mL^2}{h^2}\right)^{1/2} \frac{dE}{E^{1/2}}$

$= \pi/4\,(2^2\,2m)^{3/2}\left(\frac{L}{h}\right)^3 E^{1/2}\,dE$

$$\boxed{Z(E)\,dE = \frac{2\pi}{h^3}(2m)^{3/2}L^3E^{1/2}\,dE}$$

b) no. of conduction e^- per m^3 = $\frac{\text{no. of } e^- \text{ per atom} \times N_A \times D}{\text{atomic wt.}}$

$= \frac{3 \times 6.025 \times 10^{26} \times 2.7 \times 10^3}{26.98}$

$= \underline{1.809 \times 10^{29}\ m^{-3}}$

mobility, $\mu = \dfrac{1}{1.809\times10^{29}\times1.6\times10^{-19}\times2.7\times10^{-8}}$ $\left(\because \mu = \dfrac{1}{ne\rho}\right)$.

$= \underline{\underline{0.00128}}\ m^2/Vs$

Drift velocity, $v_d = \left(\dfrac{eE}{m}\right)\tau$ $\left(\because E = \dfrac{IR}{L}\right)$.

$\sigma = \dfrac{ne^2\tau}{m}$.

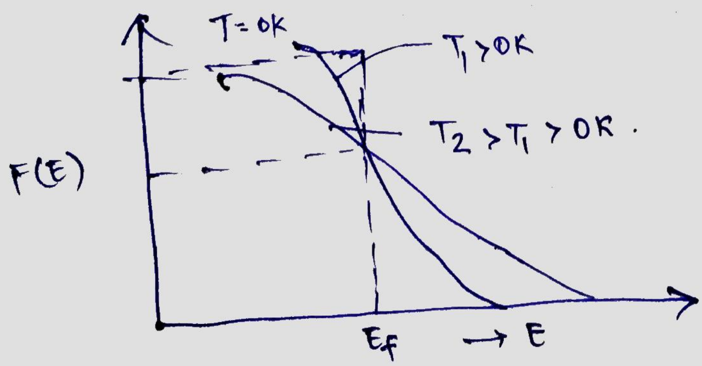
$= \dfrac{e}{m}\times\dfrac{IR}{L}\times\dfrac{m}{\rho ne^2}$

$= \dfrac{15\times0.06}{5\times2.7\times10^{-8}\times1.809\times10^{29}\times1.6\times10^{-19}}$

$= \underline{\underline{2.3\times10^{-4}}}\ m/s$

2 a) Fermi-Distribution function is a probability function used to define probability of occupying an energy state by the electron.

$$F(E) = \frac{1}{\left\{1+\exp\left(\frac{E-E_f}{KT}\right)\right\}}$$



at 0K,

$E < E_f \Rightarrow f(E) = 1$,

$E > E_f \Rightarrow f(E) = 0$.

fermi-Level → is the energy level at which probability of occupying an e^- in an energy state is $1/2$ at at all temperatures above 0K.

• It is the max energy of filled states at temp. equal to 0K.

b) $f(E) = \dfrac{1}{e^{\left(\frac{E-E_F}{KT}\right)}+1}$ $\qquad \dfrac{E-E_f}{KT} = \dfrac{0.5}{8.625\times10^{-5}\times300}$

$= 19.32$

$\dfrac{1}{100} = f(E) = \dfrac{1}{e^{19.32}+1}$

$\dfrac{1}{100} = 1+\exp\left[\dfrac{0.5}{8.61744\times10^{-5}\,T}\right]$

$100 = 1+\exp\left(\dfrac{5801.87}{T}\right)$

$\ln 100 = \dfrac{5801.87}{T}$ $\qquad \underline{T = 1259.98\ K}$.

3. a) for charge neutrality :

$n_0 + Na^- = P_0 + Na^+$

$n_0 + (Na - Pa) = P_0 + (Nd - nd)$

for complete Ionizatn, $\quad (nd = Pa = 0)$

$\Rightarrow \quad n_0 + Na = P_0 + Nd$ $\qquad$ as $n_0 P_0 = n_i^2$

$P_0 = \dfrac{n_i^2}{n_0}$

$n_0 + Na = \dfrac{n_i^2}{n_0} + Nd$

$n_0^2 - (Nd-Na)n_0 - n_i^2 = 0$ $\quad \therefore \quad n_0 = \left(\dfrac{Nd-Na}{2}\right) + \left(\sqrt{\left(\dfrac{Nd-Na}{2}\right)^2 + n_i^2}\right)$

A compensated semiconductor materials has both acceptors and donors. The process in which charged particles move because of an electric field in drift. It is in a way that their opposing electrical effects are partially cancelled.

b) $N_V = (1.04 \times 10^{19}) \left(\frac{400}{300}\right)^{3/2}$

$= 1.6 \times 10^{19}\ cm^{-3}$.

$KT = (0.0259)\left(\frac{400}{300}\right) = 0.03453\ eV$

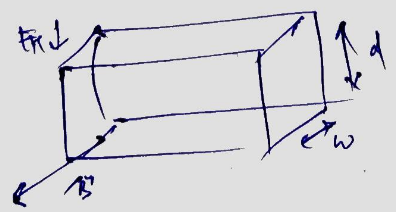
hole conc;

$p_0 = N_v \exp\left[\frac{E-E_f}{KT}\right]$

$= (1.6 \times 10^{19}) \exp\left(\frac{-0.27}{0.03453}\right)$

$p_0 = 6.43 \times 10^{15}\ cm^{-3}$.

$\boxed{4}$ The Hall effect is a consequence of the forces that are exerted on moving charges by $\vec{E}$ and $\vec{B}$ fields. Hall effect is the production of voltage difference (Hall voltage) across an electrical conductor.



$F_B = q(\vec{V} \times \vec{B})$

$F_E = E q_i$

At equilibrium, $F_B = F_E$

$q(\vec{V} \times \vec{B}) = Eq$

$E_H = V_d B$

$\left(\begin{array}{l} E = E_H \\ V = V_d \end{array}\right)$

$V_H = E_H \cdot d$

$V_H = V_d B \cdot d \Rightarrow V_d = \frac{V_H}{Bd}$

$J = \rho V_d$ ↳ charge density.

$J = \frac{i}{A} = \frac{i}{dw}$

$\frac{i}{dw} = \rho V_d \Rightarrow \rho = \frac{i}{dw\, V_d} = \frac{i}{dw \frac{V_H}{B\cancel{d}}}$

$$\boxed{\rho = \frac{iB}{V_H w}}$$

Hall coefficient,

$R_H = \frac{1}{\rho}$ $\quad R_H = \frac{V_H w}{iB}$. (charge density $\rho = ne$).

$n = \frac{1}{e} \times \frac{iB}{V_H w} = \frac{iB}{e V_H w}$.

b) $J = e p \mu_p E$

$\mu_p = \frac{IL}{e p V_H w d}$, $\mu_n = \frac{IL}{e n V_H w d}$.

b) $V = \frac{IBl}{neA}$

$= \frac{(50A)(1.5T)(0.5\ cm)}{(8.48 \times 10^{28})(1.6 \times 10^{-19})(1\ cm)}$

$= \cancel{7.9 \times 10^{-6}\ V}$

$= 1.1 \times 10^{-6}\ V$

$= 1.1\ \mu V$