Tutorial - 7

Q. resistivity of Al at room temp is $2.62 \times 10^{-8}\ \Omega m$. Calculate the drift velocity, mobility, relaxation time and mean free path of conduction e^- on the basis of classical free e^- theory in an applied field of 50 V/m. The density and atomic weight of trivalent Al are 2700 kg/m³ and 26.98 kg respectively.

Ans no. of free e^-/unit volume $= \dfrac{\text{Valency}(z) \times \text{density}(d) \times \text{Avogadro No}(N_A)}{\text{Atomic wt.}(M)}$

$$n = \frac{z \cdot \times d \times N_A}{M}$$

$$n = \frac{3 \times 2700 \times 6.026 \times 10^{26}}{26.98}$$

$$n = 18.08 \times 10^{28}/m^3$$

$$\sigma = \frac{1}{\rho} = \frac{ne^2\tau}{m}$$

$$\tau = \frac{m}{\rho n e^2} = \frac{9.1 \times 10^{-31}}{2.62 \times 10^{-8} \times 18.08 \times 10^{28} \times (1.6 \times 10^{-19})^2}$$

$$\tau = 7.508 \times 10^{-15}\ s$$

$$v_d = \frac{eE\tau}{m} = \frac{1.6 \times 10^{-19} \times 50 \times 7.508 \times 10^{-15}}{9.1 \times 10^{-31}}$$

$$= 6.593 \times 10^{-2}\ m/s$$

$$\mu = \frac{v_d}{E} = 1.319 \times 10^{-3}\ m^2 V^{-1} s^{-1}$$

$$\lambda = v_{th}\,\tau$$

$$v_{th} = \sqrt{\frac{3kT}{m}}$$

$T = 300K$

$v_{th} = 1.16 \times 10^{5}$ m/s

$\lambda_F = 1.16 \times 10^{5} \times 7.508 \times 10^{-15}$

$= 8.77 \times 10^{-10}$ m

2. A copper wire whose diameter is 0.16 cm carries a steady current of 10A. Assuming one free e^-/atom, calculate the density of e^-. Density of Cu is 8900 kg/m³, atomic mass is 63.54 kg and resistivity is 1.7×10^{-8} Ωm. Calculate the drift velocity and mean free path according to CFE theory

Ans

$d = 0.16 \times 10^{-2}$ m $\qquad I = 10$ A

$r = 0.08 \times 10^{-2}$ m $\qquad \rho = 1.7 \times 10^{-8}$ Ωm

$$n = \frac{Z \times d \times N_A}{M} = \frac{1 \times 8900 \times 6.026 \times 10^{26}}{63.54}$$

$= 8.44 \times 10^{28}$ /m³

$$\tau = \frac{m}{\rho n e^2} = \frac{9.1 \times 10^{-31}}{1.7 \times 10^{-8} \times 8.44 \times 10^{28} \times (1.6 \times 10^{-19})^2}$$

$= 2.477 \times 10^{-14}$ s

$I = A n e v_d$

$$v_d = \frac{I}{Ane} = \frac{10}{3.14 \times (0.08 \times 10^{-2})^2 \times 8.44 \times 10^{28} \times 1.6 \times 10^{-19}}$$

$= 3.684 \times 10^{-4}$ m/s

$\lambda = v_{th}\, \tau$

$= 1.16 \times 10^{5} \times 2.477 \times 10^{-14} = 2.877 \times 10^{-9}$ m

$$v_{th} = \sqrt{\frac{3kT}{m}}$$

$T = 300K$

$v_{th} = 1.16 \times 10^{5}\ m/s$

$\lambda_F = 1.16 \times 10^{5} \times 7.508 \times 10^{-15}$

$= 8.77 \times 10^{-10}\ m$

2. A copper wire whose diameter is 0.16 cm carries a steady current of 10A. Assuming one free e^-/atom, calculate the density of e^-. Density of Cu is 8900 kg/m³, atomic mass is 63.54 kg and resistivity is $1.7 \times 10^{-8}\ \Omega m$. Calculate the drift velocity and mean free path according to CFE theory

Ans $d = 0.16 \times 10^{-2}\ m$ $\qquad I = 10\ A$

$r = 0.08 \times 10^{-2}\ m$ $\qquad \rho = 1.7 \times 10^{-8}\ \Omega m$

$$n = \frac{Z \times d \times N_A}{M} = \frac{1 \times 8900 \times 6.026 \times 10^{26}}{63.54}$$

$= 8.44 \times 10^{28}\ /m^3$

$$\tau = \frac{m}{\rho n e^2} = \frac{9.1 \times 10^{-31}}{1.7 \times 10^{-8} \times 8.44 \times 10^{28} \times (1.6 \times 10^{-19})^2}$$

$= 2.477 \times 10^{-14}\ s$

$I = Ane v_d$

$$v_d = \frac{I}{Ane} = \frac{10}{3.14 \times (0.08 \times 10^{-2})^2 \times 8.44 \times 10^{28} \times 1.6 \times 10^{-19}}$$

$= 3.684 \times 10^{-4}\ m/s$

$\lambda = v_{th}\, \tau$

$= 1.16 \times 10^{5} \times 2.477 \times 10^{-14} = 2.897 \times 10^{-9}\ m$

conducting rod contains 8.5×10^{28} e^-/m^3. Calculate its resistivity and mobility of e^- at room temp if the mean ~~fr~~ collision time for e^- scattering is 2×10^{-14} s.

Ans

$$n = 8.5 \times 10^{28} /m^3$$

$$\tau = 2 \times 10^{-14} s$$

$$\sigma = \frac{1}{\rho} = \frac{ne^2\tau}{m}$$

$$\rho = \frac{m}{ne^2\tau} = \frac{9.1 \times 10^{-31}}{8.5 \times 10^{28} \times (1.6 \times 10^{-19})^2 \times 2 \times 10^{-14}}$$

$$= 2.09 \times 10^{-8} \ \Omega m$$

$$\mu = \frac{v_d}{E} = \frac{e\cancel{E}\tau}{m\cancel{E}} = \frac{e\tau}{m}$$

$$= 3.516 \times 10^{-3} \ m^2 V^{-1} s^{-1}$$

4. Fermi energy of silver is 5.5 eV. Calculate the probability of occupancy of state which is
(i) 0.1 eV below Fermi level
(ii) 0.1 eV above Fermi level
(iii) kT above Fermi level
(iv) 4kT above Fermi level at temp of 300K.

Ans

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

(i) 0.1 eV below Fermi level

so $E - E_F = -0.1$ eV

$$f(E) = \frac{1}{e^{\frac{-0.1 \times 1.6 \times 10^{-19}}{1.38 \times 10^{-23} \times 300}} + 1} = \frac{1}{e^{-3.8647} + 1}$$

$$= 0.979$$

(ii) 0.1 eV above E_F

so $E - E_F = 0.1\ eV$

$$f(E) = \frac{1}{e^{\frac{0.1 \times 1.6 \times 10^{-19}}{1.38 \times 10^{-23} \times 300}} + 1} = 0.0205$$

(iii) kT above E_F, so $E - E_F = kT$

$$f(E) = \frac{1}{e^{\frac{kT}{kT}} + 1} = \frac{1}{e+1} = 0.2689$$

(iv) At $4k$ above E_F, so $E - E_F = 4kT$

$$f(E) = \frac{1}{e^{\frac{4kT}{kT}} + 1} = \frac{1}{e^4 + 1} = 0.01798$$

5 Find the temperature at which there is 1% probability that a state lying above 0.5 eV above E_F will be occupied

$E - E_F = 0.5\ eV$

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

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

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

$$\frac{E-E_F}{kT} = \ln\left[\frac{1}{f(E)} - 1\right]$$

$$T = \frac{E - E_F}{k \ln\left[\frac{1}{f(E)} - 1\right]} = \frac{0.5 \times 1.6 \times 10^{-19}}{1.38 \times 10^{-23} \ln\left[\frac{1}{0.01} - 1\right]}$$

$$T = 1261.5\ K$$

/

...e Fermi level in silver is 5.5 eV. What are the energies for which the probabilities of occupancy at 300 k are 0.99 & 0.01.

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

$$\frac{E-E_F}{kT} = \ln\left[\frac{1}{f(E)} - 1\right]$$

$$E = E_F + kT \ln\left[\frac{1}{f(E)} - 1\right]$$

$T = 300k$ when $f(E) = 0.99$

$$E = 5.5 \times 1.6 \times 10^{-19} + 1.38 \times 10^{-23} \ln\left[\frac{1}{0.99} - 1\right]$$

$$= 8.61 \times 10^{-19}\ J$$

$$= 5.38\ eV$$

when $f(E) = 0.01$

$$E = 5.5 \times 1.6 \times 10^{-19} + 1.38 \times 10^{-23} \ln\left[\frac{1}{0.01} - 1\right]$$

$$= 5.61\ eV$$

7. Determine the temperature at which there is 1% probability that an energy state 0.3 eV below Fermi level is empty.

Given $E_F = 6.25\ eV$

Ans $$T = \frac{E - E_F}{k \ln\left[\frac{1}{f(E)} - 1\right]}$$

$E - E_F = -0.3\ eV$

$1 - f(E) = 1\%$ [Probability for unoccupation of state $= 1 - f(E)$]

$f(E) = 0.99$

$T = \dfrac{-0.3 \times 1.6 \times 10^{-19}}{1.38 \times 10^{-23} \ln\left[\frac{1}{0.99} - 1\right]}$

$T = 756.96\ K$

8. The Fermi energy of sodium is 3 eV at 0 K. Calculate electron density & Fermi velocity.

Ans

$E_F(0) = \dfrac{h^2}{8m}\left(\dfrac{3n}{\pi}\right)^{2/3}$

$E_F(0) = 5.85 \times 10^{-38}\ n^{2/3}$

$3 \times 1.6 \times 10^{-19} = 5.85 \times 10^{-38}\ n^{2/3}$

$n = \left[\dfrac{3 \times 1.6 \times 10^{-19}}{5.85 \times 10^{-38}}\right]^{3/2}$

$n = 2.35 \times 10^{28} / m^3$

$v_F = \sqrt{\dfrac{2E_F}{m}} = \sqrt{\dfrac{3 \times 1.6 \times 10^{-19}}{9.1 \times 10^{-31}}}$

$= 1.027 \times 10^{6}\ m/s$

9. Calculate the density of states between 0 and 2 eV in Cu cube of dimension 1 cm.

$$g\frac{(E)}{dE} = \frac{8\sqrt{2}\pi m^{3/2}}{h^3} \cancel{\frac{3}{2}} E^{1/2} \, dE$$

$$g(E) = \frac{8\sqrt{2}\pi m^{3/2}}{h^3} \times \int_0^{2\times1.6\times10^{-19}} E^{1/2} \, dE$$

$$= \frac{8\sqrt{2}\times3.14\times(9.1\times10^{-31})^{3/2}}{(6.63\times10^{-34})^3} \frac{2}{3}\left[E^{3/2}\right]_0^{2\times1.6\times10^{-19}}$$

$$= 1.063\times10^{56} \times \frac{2}{3}\left(2\times1.6\times10^{-19}\right)^{3/2}$$

$$= 1.28\times10^{+28} \,/m^3$$

$$= \frac{1.28\times10^{28}}{10^6} \,/cm^3$$

$$= 1.28\times10^{22} \,/cm^3$$

10 The relaxation time of e^- in trivalent Al is 7.3×10^{-15} s and atomic wt. and density are 26.98 kg and 2700 kg/m³ respectively. Calculate the Fermi energy, Fermi vel. & mean free path acc to QFE theory.

$\tau = 7.3 \times 10^{-15}$ s

$M = 26.98$ kg

$d = 2700$ kg/m^3

$$n = \frac{2 \times d \times N_A}{M} = \frac{3 \times 2700 \times 6.026 \times 10^{26}}{26.98}$$

$$= 18.08 \times 10^{28} /m^3$$

$$E_F(0) = \frac{h^2}{8m}\left(\frac{3n}{\pi}\right)^{2/3}$$

$$= 5.85 \times 10^{-38}\, n^{2/3}$$

$$= 5.85 \times 10^{-38} \left(18.08 \times 10^{28}\right)^{2/3}$$

$$= 1.87 \times 10^{-18}\ J$$

$$= 11.69\ eV$$

$$v_F = \sqrt{\frac{2E_F}{m}} = 2.027 \times 10^{6}\ m/s$$

$$\lambda = \tau v_F$$

$$= 7.3 \times 10^{-15} \times 2.027 \times 10^{6}$$

$$= 1.479 \times 10^{-8}\ m$$

Kalpana

Tutorial – 8 Semiconductors

1. The effective density of states for e^- and holes in Si at 300K are $2.8 \times 10^{19}/cm^3$ and $1.04 \times 10^{19}/cm^3$ respectively. If the energy gap of Si is 1.1eV, calculate the intrinsic carrier concentration.

Ans

$$n_i = \sqrt{N_c N_v}\, e^{-\frac{E_g}{2kT}}$$

$$= \sqrt{2.8\times10^{19} \times 1.04\times10^{19}}\; e^{-\frac{1.1\times1.6\times10^{-19}}{2\times1.38\times10^{-23}\times300}}$$

$$= 1.706\times10^{19} \times 5.869\times10^{-10}$$

$$= 1.001\times10^{10}/cm^3$$

[If E_g 1.12eV then $n_i = 6.803\times10^{9}/cm^3$ $= 6.803\times10^{15}/m^3$]

2. The following data corresponds to 300K

	$N_c\,(cm^{-3})$	$N_v\,(cm^{-3})$	m_e^*/m_0	m_h^*/m_0	Energy gap (eV)
Si	2.8×10^{19}	1.04×10^{19}	1.08	0.56	1.12
GaAs	4.7×10^{17}	7×10^{18}	0.067	0.48	1.42
Ge	1.04×10^{19}	6×10^{18}	0.55	0.37	0.67

(i) Calculate the intrinsic carrier concentration for Si at 400K

(ii) Calculate the intrinsic carrier concentration for Ge at 300K

(iii) Calculate the concentration of holes & e^- at 300K for GaAs.

(i)

$N_c \propto T^{3/2}$

$\dfrac{N_c(400k)}{N_c(300k)} = \left(\dfrac{400}{300}\right)^{3/2}$

$N_{c\,400k} = \left(\dfrac{400}{300}\right)^{3/2} \times N_c(300k)$

$N_{v\,400k} = \left(\dfrac{400}{300}\right)^{3/2} N_{v\,300k}$

$\cancel{N_c =}$

$$n_{i\,400k} = \sqrt{N_{c\,400k} N_{v\,400k}}\; e^{-\frac{E_g}{2kT}}\quad -\frac{1.12\times1.6\times10^{-19}}{2\times1.38\times10^{-23}\times400}$$

$$= \sqrt{2.8\times10^{19}\times\left(\frac{400}{300}\right)^{3/2}\times1.04\times10^{19}\left(\frac{400}{300}\right)^{3/2}}\; e^{-\frac{1.12\times1.6\times10^{-19}}{2\times1.38\times10^{-23}\times400}}$$

$$= \sqrt{2.8\times10^{19}\times1.04\times10^{19}}\; e^{-\frac{1.12\times1.6\times10^{-19}}{2\times1.38\times10^{-23}\times400}} \left(\frac{400}{300}\right)^{3/2}$$

$$= 1.706\times10^{19} \times \cancel{1.53395}\; 8.9244\times10^{-8} \times 1.5396$$

$$n_i = 2.34\times10^{12}/cm^3$$

(ii)

$$n_i = \sqrt{N_c N_v}\; e^{-\frac{E_g}{2kT}}$$

$$= \sqrt{1.04\times10^{19}\times6\times10^{18}}\; e^{-\frac{0.67\times1.6\times10^{-19}}{2\times1.38\times10^{-23}\times300}}$$

$$= 7.899\times10^{18}\times2.383\times10^{-6}$$

$$= 1.882\times10^{13}/cm^3$$

(iii)

$$\cancel{A}\; n = N_c\, e^{-\left(\frac{E_c-E_F}{kT}\right)}$$

$$n = N_c\, e^{-\frac{E_g}{2kT}}$$

$$= 4.7\times10^{17}\, e^{-\frac{1.42\times1.6\times10^{-19}}{2\times1.38\times10^{-23}\times300}}$$

$$= 4.7\times10^{17}\times1.2109\times10^{-12}$$

$$= 5.69\times10^{5}/cm^3$$

$$p = N_v\, e^{-\frac{E_g}{2kT}}$$

$$= 7\times10^{18}\, e^{-\frac{1.42\times1.6\times10^{-19}}{2\times1.38\times300}}$$

$$= 7\times10^{18}\times1.2109\times10^{-12}$$

$$= 8.476\times10^{6}/cm^3$$

(i) $$n_{i\,400K} = \sqrt{N_{c\,400K} N_{v\,400K}}\; e^{-\frac{E_g}{2kT}}$$

$$= \sqrt{2.8\times10^{19}\times\left(\frac{400}{300}\right)^{3/2}\times1.04\times10^{19}\left(\frac{400}{300}\right)^{3/2}}\; e^{-\frac{1.12\times1.6\times10^{-19}}{2\times1.38\times10^{-23}\times400}}$$

$$= \sqrt{2.8\times10^{19}\times1.04\times10^{19}}\; e^{-\frac{1.12\times1.6\times10^{-19}}{2\times1.38\times10^{-23}\times400}} \left(\frac{400}{300}\right)^{3/2}$$

$$= 1.706\times10^{19} \times \cancel{1.5395}\ 8.9244\times10^{-8} \times 1.5396$$

$$n_i = 2.374\times10^{12}/cm^3$$

$N_c \propto T^{3/2}$

$$\frac{N_c(400K)}{N_c(300K)} = \left(\frac{400}{300}\right)^{3/2}$$

$$N_{c\,400K} = \left(\frac{400}{300}\right)^{3/2}\times N_c(300K)$$

$$N_{v\,400K} = \left(\frac{400}{300}\right)^{3/2} N_{v\,300K}$$

(ii) $$n_i = \sqrt{N_c N_v}\; e^{-\frac{E_g}{2kT}}$$

$$= \sqrt{1.04\times10^{19}\times6\times10^{18}}\; e^{-\frac{0.67\times1.6\times10^{-19}}{2\times1.38\times10^{-23}\times300}}$$

$$= 7.899\times10^{18}\times2.383\times10^{-6}$$

$$= 1.882\times10^{13}/cm^3$$

(iii) $$n = N_c\, e^{-\left(\frac{E_c-E_F}{kT}\right)}$$

$$n = N_c\, e^{-\frac{E_g}{2kT}}$$

$$= 4.7\times10^{17}\; e^{-\frac{1.42\times1.6\times10^{-19}}{2\times1.38\times10^{-23}\times300}}$$

$$= 4.7\times10^{17}\times1.2109\times10^{-12}$$

$$= 5.69\times10^{5}/cm^3$$

$$p = N_v\, e^{-\frac{E_g}{2kT}}$$

$$= 7\times10^{18}\; e^{-\frac{1.42\times1.6\times10^{-19}}{2\times1.38\times300}}$$

$$= 7\times10^{18}\times1.2109\times10^{-12}$$

$$= 8.476\times10^{6}/cm^3$$

(3) Calculate the electron and hole concentration in Si at 300 K for the case when the fermi level is 0.22 eV below the conduction band energy E_c.

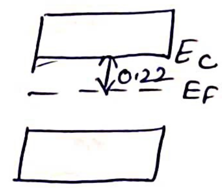
$E_c - E_F = 0.22$ eV
$E_V - E_F = 0.90$ eV

$$n = N_C \, e^{-\frac{E_c - E_F}{kT}}$$

$$= 2.8\times10^{19} \, e^{\frac{-0.22\times1.6\times10^{-19}}{1.38\times10^{-23}\times300}}$$

$$= 2.8\times10^{19} \times 2.029\times10^{-4}$$

$$= 5.683\times10^{15}/cm^3$$



$$p = 1.04\times10^{19} \, e^{\frac{-0.90\times1.6\times10^{-19}}{1.38\times10^{-23}\times300}}$$

$$= 8.49\times10^{3}/cm^3$$

4. Calculate the e^- and hole concentration in GaAs at 300 K for the case when Fermi energy level is 0.3 eV above the valence band energy E_v.

$E_F - E_V = 0.3$ eV
$E_g = 1.42$
$E_c - E_F = 1.12$ eV

$$n = 4.7\times10^{17} \, e^{\frac{-1.12\times1.6\times10^{-19}}{1.38\times10^{-23}\times300}}$$

$$= 4.7\times10^{17}\times1.59\times10^{-19} = 7.475\times10^{-2}/cm^3$$

$$p = 7\times10^{18} \times e^{\frac{-0.3\times1.6\times10^{-19}}{1.38\times10^{-23}\times300}}$$

$$= 7\times10^{18} \times 9.219\times10^{-6}$$

$$= 6.453\times10^{13}/cm^3$$

~~5. Determine the e^- & hole concentration in GaAs at 300 K for the case where~~

5. Calculate the density of states in conduction band of Si between E_c & $E_c + 3kT$ at 300K.

Ans.

$$g_c \, dE = \frac{8\sqrt{2}\pi m_e^{*3/2}}{h^3} (E - E_c)^{1/2} \, dE$$

$$g_c = \frac{8\sqrt{2}\pi (1.08 \times m_0)^{3/2}}{(6.63 \times 10^{-34})^3} \cancel{E_c + 3kT - E_c} \int_{E_c}^{E_c+3kT} (E - E_c)^{1/2} dE$$

$$= (1.08)^{3/2} \times 1.063 \times 10^{56} \times \frac{2}{3} \left[(E - E_c)^{3/2} \right]_{E_c}^{E_c+3kT}$$

$$= (1.08)^{3/2} \times 1.063 \times 10^{56} \times \frac{2}{3} \times [\cancel{E_c} + 3kT - \cancel{E_c}]^{3/2}$$

$$= 1.1009 \times 10^{26} / m^3$$

6. Calculate the density of states in valence band of Si b/w E_v & $E_v - kT$ at 300 k

$$g_v \, dE = \frac{8\sqrt{2}\pi m_h^{*3/2}}{h^3} \sqrt{E_v - E} \, dE$$

$$g_v = \frac{8\sqrt{2}\pi (0.56 \, m_0)^{3/2}}{h^3} \int_{E_v}^{E_v - kT} (E_v - E)^{1/2} dE$$

$$= (0.56)^{3/2} \times 1.063 \times 10^{56} \times \frac{2}{3} \left[(E_v - E)^{3/2} \right]_{E_v}^{E_v - kT}$$

$$= (0.56)^{3/2} \times 1.063 \times 10^{56} \times \frac{2}{3} (\cancel{E_v} - \cancel{E_v} + kT)^{3/2}$$

$$= 7.91 \times 10^{24} / m^3$$

6. The mobilities of e^- & holes for Ge are $\mu_n = 0.39\ m^2/V.s$ & $\mu_h = 0.19\ m^2/V.s$ Calculate resistivity at 300 K.
Given $n_i = 2.5 \times 10^{19}/m^3$

Ans
$$\sigma = e n_i (\mu_n + \mu_h)$$
$$= 1.6 \times 10^{-19} \times 2.5 \times 10^{19} (0.39 + 0.19)$$
$$= 2.32\ /\Omega m$$
$$\rho = \frac{1}{\sigma} = 0.431\ \Omega m$$

7. The energy gap of Si is 1.1 eV. Its e^- and hole mobilites at room temp are 0.48 and 0.013 $m^2 V^{-1} s^{-1}$ respectively. Evaluate its conductivity at 300K.

Ans
$$\sigma = e n_i (\mu_n + \mu_h)$$
$$n_i = \sqrt{N_c N_v}\ e^{\frac{-E_g}{2kT}}$$
$$= \cancel{9.974 \times} 10^{10}/cm^3 = 1.001 \times 10^{16}/m^3$$
$$1.001$$
$$\sigma = 1.6 \times 10^{-19} \times \cancel{9.974 \times} 1.001 \times 10^{16} (0.48 + 0.013)$$
$$= 7.895 \times 10^{-4}\ /\Omega m\ (1.1\ eV)$$
$$5.36 \times 10^{-4}\ (1.12\ eV)$$

8. An n-type Ge sample has dimensions $\overset{l}{10\,cm} \times \overset{w}{5\,cm} \times \overset{d}{1\,mm}$. The Hall voltage is measured across the width. The sample is placed in a magnetic field of strength 0.65 T and current density along the length is 250 A/m². If the e^- concentration is $10^{21}\ m^{-3}$, calculate the Hall field, Hall voltage and Hall coefficient.

Ans Hall coefficient

$$R_H = \frac{1}{ne}$$

$$= \frac{1}{10^{21} \times 1.6 \times 10^{-19}}$$

$$= 6.25 \times 10^{-3}\ m^3 C^{-1}$$

$$R_H = \frac{(E_H)_y}{(B)_z (J)_x}$$

$$E_H = B J R_H$$

$$= 0.65 \times 250 \times 6.25 \times 10^{-3}$$

$$= 1.015\ V/m$$

$$V_H = \frac{BI}{net}$$

$$= \frac{BJA}{net} = \frac{BJb\cancel{t}}{ne\cancel{t}}$$

$$= \frac{0.65 \times 250 \times 5 \times 10^{-2}}{10^{21} \times 1.6 \times 10^{-19}}$$

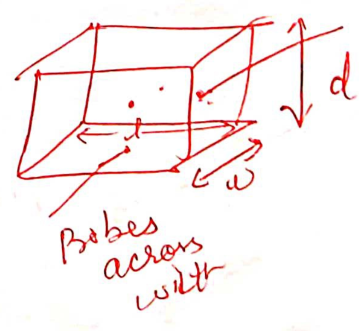
$$= 5.078 \times 10^{-2}\ V$$

$$E_y = \frac{V_y}{w} \quad [w = 5\,cm]$$

$$V_y = w E_y$$

$$= 5 \times 10^{-2} \times 1.015$$

$$= 5.078 \times 10^{-2}\ V$$



$= 1.479 \times 10^{-8}$ ... $\times 10^{6}$

9. The resistivity of a n-doped Si sample is $8.9 \times 10^{-3}\,\Omega m$. The Hall coefficient was measured to $3.6 \times 10^{-4}\ m^3/C$. Assuming single carrier conduction, calculate mobility & density of charge carriers.

Ans

$$R_H = 3.6 \times 10^{-4}$$

$$R_H = \frac{1}{ne}$$

$$n = \frac{1}{eR_H} = \frac{1}{3.6 \times 10^{-4} \times 1.6 \times 10^{-19}}$$

$$= 1.736 \times 10^{+22}\ /m^3$$

$$\sigma = ne\mu$$

$$\mu = \frac{\sigma}{ne} = \sigma R_H \leftarrow \mu_e = \sigma R_H = \frac{R_H}{\rho}$$

$$\mu = \frac{R_H}{\rho}$$

$$= \frac{3.6 \times 10^{-4}}{8.9 \times 10^{-3}}$$

$$= 4.044 \times 10^{-2}\ m^2 V^{-1} s^{-1}$$