Semiconductor

1) Einstein showed that parameters describing drift and diffusion constant D respectively are directly related. Einstein relates the diffusion cofficient to the mobility and is frequently used in semiconductor -

$$\Delta n e E \mu_n = e D_n \frac{\partial \Delta n}{\partial x}$$

$$f = (\Delta n e E) - \frac{e D_n}{\mu_n} \frac{\partial \Delta n}{\partial x}$$

As, $KT = \frac{e D_n}{\mu_n}$ $\boxed{D_n = \frac{\mu_n KT}{e}}$

$||^{ly}$ for holes,

$$\boxed{D_p = \frac{\mu_p KT}{e}}$$

$$\rightarrow \frac{D_n}{D_p} = \frac{\mu_e}{\mu_p}$$

$$\mu_p = \frac{D_p e}{KT}$$

$$= \frac{20 \times 10^{-4} \times 1.6 \times 10^{-19}}{1.38 \times 10^{-23} \times 298} = 0.078 \ m^2/sec$$

2) $$n = 2\left(\frac{2\pi m^*_e KT}{h^2}\right)^{3/2} \exp\left(\frac{E_F - E_C}{KT}\right)$$

$$P = 2\left(\frac{2\pi m^*_e KT}{h^2}\right)^{3/2} \exp\left(\frac{E_V - E_F}{KT}\right)$$

$n_i^2 = np.$

$$n_i^2 = 4\left(\frac{2\pi KT}{h^2}\right)^3 \left(m_e^* m_h^*\right)^{3/2} \exp\left(\frac{E_v - E_c}{KT}\right)$$

$E_g = \underline{E_c - E_v}.$

3) $n = p$

$$2\left(\frac{2\pi m_e^* KT}{h^2}\right)\exp\left(\frac{E_F - E_c}{KT}\right) = 2\left(\frac{2\pi m_h^* KT}{h^2}\right)\exp\left(\frac{E_v - E_c}{KT}\right)$$

$$\exp\left(\frac{2E_F}{KT}\right) = \left(\frac{m_h^*}{m_e^*}\right)^{3/2}\exp\left(\frac{E_v + E_c}{KT}\right)$$

Taking log on both side,

$$\frac{2E_F}{KT} = \frac{3}{2}\log\left(\frac{m_h^*}{m_e^*}\right) + \frac{E_v + E_c}{2}$$

for $m_h^* = m_e^*$ $\boxed{E_F = \frac{E_c + E_v}{2}}$.

4) i) $\sigma = en(\mu_n + \mu_p)$

$$= 1.6\times10^{-19}\times1.5\times10^{16}\,(0.135 + 0.048)$$

$$= 4.4\times10^{4}\ C/_{mVs}$$

$$\rho = \frac{1}{\sigma} = \frac{1}{4.4\times10^{4}} = 2272.7$$

$$R = \rho\frac{l}{A} = 2273\times10^{-2}.$$

2)

$n = 8 \times 10^{13}\ cm^{-3}$

$n_i^2 = np$

$(1.5 \times 10^{16})^2 = (8 \times 10^{19})\, p$

$p = 2.81 \times 10^{13}\ m^{-3}$

$\sigma = e(n\mu_n + p\mu_p)$

$= 1.6 \times 10^{-19}((8 \times 10^{13} \times 0.135) + 0.281 \times 10^{13} \times 0.048)$

$= 1.7 \times 10^{-6}$.

$R = \rho \frac{l}{A} = \frac{1}{1.7 \times 10^{-6}} \times \frac{10^{-3} \times 10}{0.1 \times 10^{-6}}$

$= 5.717 \times 10^{9}\ \Omega$.

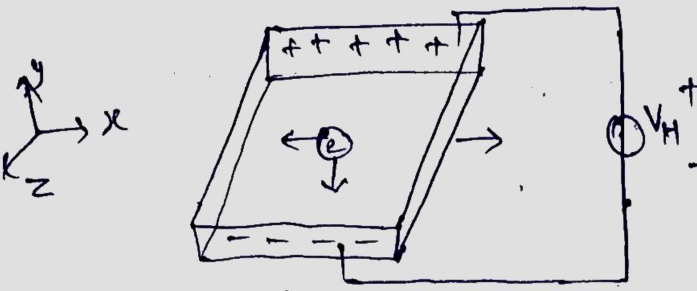
5) → The population of the electrons is an experimental function of the difference b/w the conduction band energy and fermi energy.

$E_F = E_i + KT \ln\left(\frac{N_D}{n_i}\right)$

as donor concn increases, N_D increases, so E_F also increases.

→ At higher temp, fermi level get a finite probability to be occupied and states below to be empty. But to maintain; fermi levels shifts towards conduction band.

6) When a current carrying conductor (metal or semiconductor) is placed in a magnetic field ⊥ to the direction of current, a voltage (called Hall Voltage) is developed across the conductors in a direction ⊥ to both current and magnetic field.



$$e E_H = BeV$$

$$\boxed{E_H = BV}$$

J, current density = nev

Hall's coefficient $= \frac{1}{ne}$

$V = \frac{J}{ne}$, $E_H = \frac{BJ}{ne} = R_H BJ$

$$\underline{V_H = R_H BJ t}$$ → thickness

7) $\sigma = e(n\mu_n + P\mu_p)$

$= 1.6 \times 10^{-19} (2.5 \times 10^{19} \times 0.375 + 2.5 \times 10^{19} \times 0.175)$

$= 2.2$

Resistivity, $\frac{1}{\sigma} = \frac{1}{2.2} = \underline{0.45}$

8) $E_g = \frac{hc}{\lambda}$ → $\lambda = \frac{hc}{2.29 \times 10^{-19}} = \underline{867 \text{ nm}}$.