Solution

(1). Carrier concentration, $n = \dfrac{\text{Avagadro no.} \times \text{density}}{\text{Atomic weight}}$

$$= \frac{6.023 \times 10^{23} \times 10.5 \times 10^{3}}{107.9 \times 10^{-3}} = 5.86 \times 10^{28}/m^3$$

Conductivity, $\sigma = ne\mu \Rightarrow \mu = \dfrac{\sigma}{ne}$

$$\mu = \frac{6.8 \times 10^{7}}{5.86 \times 10^{28} \times 1.6 \times 10^{-19}} = 7.25 \times 10^{-3}\ m^2 V^{-1} s^{-1}$$

(2). Drift velocity $v_d = \dfrac{\sigma E}{ne} = \dfrac{E}{\rho n e}$

and mobility $\mu = \dfrac{v_d}{E}$

Now, No. of atoms per unit volume

$$= \frac{\text{Avogadro Number} \times \text{density}}{\text{Atomic weight}}$$

$$= \frac{6.02 \times 10^{23} \times 2700}{27} = 6.02 \times 10^{25}$$

As every atom gives 3 conduction electrons.

$\therefore$ No. of electrons $= 3 \times 6.02 \times 10^{25} = 18.06 \times 10^{25}$

Now $v_d = \dfrac{50}{2.6 \times 10^{-8} \times 18.06 \times 10^{25} \times 1.6 \times 10^{-19}}$

$$= 0.67 \times 10^{8-25+19} = 0.67 \times 10^{2} = 67\ m/sec.$$

and mobility $= \dfrac{67}{50} = 1.34\ m^2/Vs$

(3). $v_d = \dfrac{I}{A n_e e} = \dfrac{200}{5 \times 8.5 \times 10^{25} \times 1.6 \times 10^{-19}}$

$= 0.029 \times 10^{-3}$ m/s

(4). $v_d = \dfrac{I}{A n_e e} = \dfrac{5.4}{10^{-6} \times 8.4 \times 10^{28} \times 1.6 \times 10^{-19}}$

$= 0.4 \times 10^{-3}$ m/sec.

(5). $F(E) = \dfrac{1}{e^{(E-E_F)/kT} + 1}$ = Probability as asked

here, $E - E_F = 0.25$ eV $= 0.25 \times 1.6 \times 10^{-19}$ J

$k = 1.38 \times 10^{-23}\ m^2 kg\ s^{-2} K^{-1}$

$T = 300$ K

Put the values in formula and calculate.

*. Electron concentration $= n = N_c e^{-(E_c - E_F)/kT}$

Given that, $N_c = 2.8 \times 10^{19}\ cm^{-3}$

$T = 300K$, $E_c - E_F = 0.25$ eV

change the units and put in formula.

(6). $p = N_v e^{-(E_F - E_v)/kT}$

Given: $(E_F - E_v) = 0.27\,eV = 0.27 \times 1.6 \times 10^{-19}\,J$

$N_v = 1.04 \times 10^{19}\ cm^{-3}$ at 300K

$\therefore$ Now, $N_v = 2\left[\dfrac{2\pi m^* kT}{h^2}\right]^{3/2}$

$\therefore \dfrac{N_v \text{ at } T=400}{N_v \text{ at } T=300} = \left(\dfrac{400}{300}\right)^{3/2}$

$\Rightarrow N_v \text{ at } T=400 = 1.04 \times 10^{19} \left(\dfrac{4}{3}\right)^{3/2}$: calculate it

$\therefore p = (N_v \text{ at } T=400K)\, e^{-(0.27 \times 1.6 \times 10^{-19})/k \cdot 400}$

Solve and get answer.

(7). for Intrinsic semiconductors

$\sigma = n e [\mu_e + \mu_h]$

$= 1.41 \times 10^{16} \times 1.6 \times 10^{-19} [0.145 + 0.05]$

$=$ Answer.

Individual contribution in conductivity:

$\left.\begin{array}{l} \sigma_e = n e \mu_e \\ \sigma_h = p e \mu_h \end{array}\right]$ calculate and get answer.

here $n = p = 1.41 \times 10^{16}\ m^{-3}$

(8). Conductivity $\sigma = ne[\mu_e + \mu_h]$

Given resistivity $= 1500\ \Omega\ m$

$\therefore \sigma = \frac{1}{1500}$

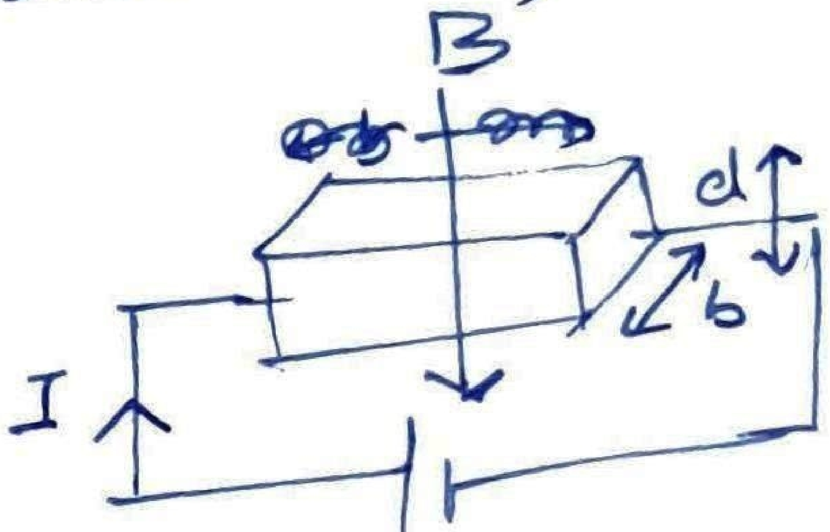
$\mu_e = 0.14\ m^2/V\text{-sec}$, $\mu_h = 0.05\ m^2/V\text{-sec}$.

Put the values and calculate $\boxed{n}$.

(9). $V_H = 20\,mV$, $I = 15\,mA$, $B = 0.4$ Tesla,

$\sigma = 0.36\ \frac{m^2}{V\text{-}Sec}$, $d = 0.4\ mm$, $b = 1\,mm$ (Not given in num.) (correct it)

Calculate Hall coeff., charge carrier conc., mobility.



$J = \frac{I}{bd} = \frac{15 \times 10^{-3}}{0.4 \times 10^{-3} \times 10^{-3}}$

$\therefore$ Hall coeff. $R_H = \frac{V_H\, d}{I B}$, calculate using given values

$R_H = \frac{1}{ne} \Rightarrow n = \frac{1}{e \cdot R_H}$ = Charge carrier concentration
* Calculate it!

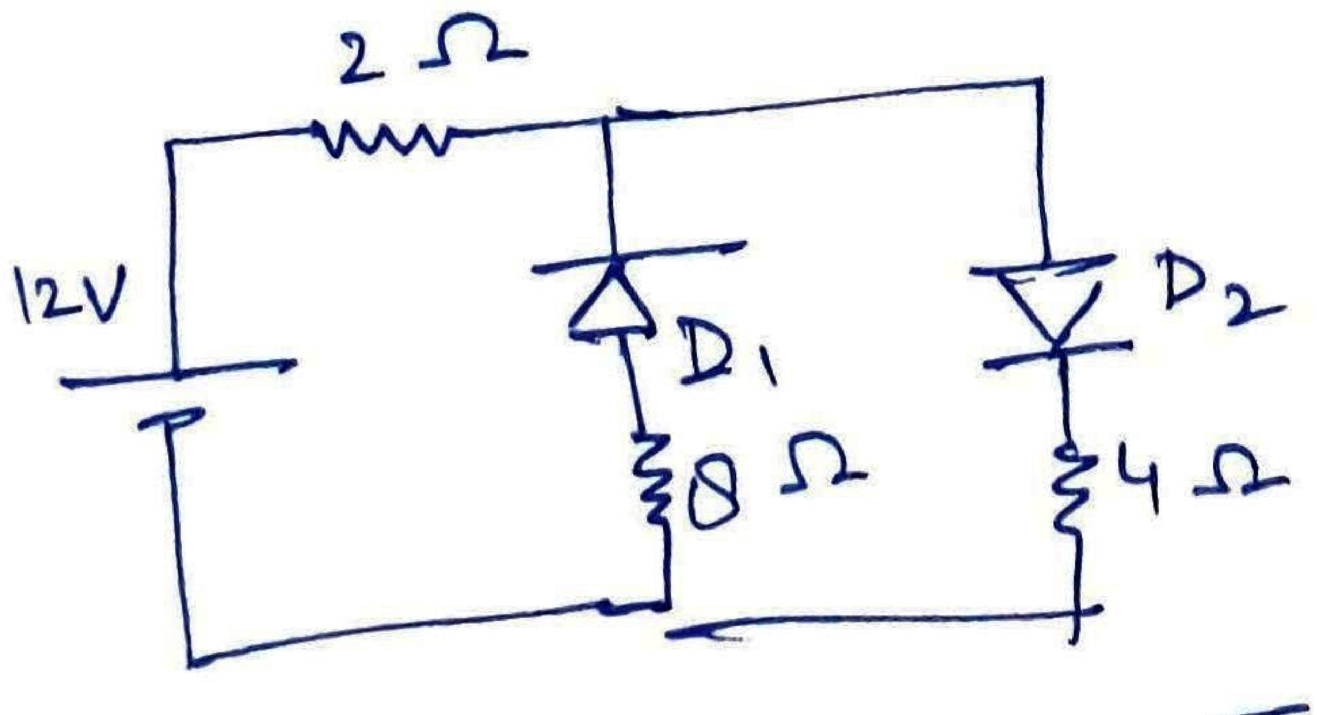
Mobility $\mu = \frac{R_H J}{E}$; calculate it!

(10). $R_H = 0.0125$ volt $- m^3/A$-weber

$R_H = \frac{1}{ne} \Rightarrow n = \frac{1}{R_H \cdot e}$

calculate n.

(11).



* D_1 is reverse biased so not conducting
* Due to Si diode, barrier Potential $= 0.7\ V$.

$\therefore$ effective voltage $= 12 - 0.7 = 11.3\ V$

Total resistance $= 2 + 4 = 6\ \Omega$

$\therefore I = V/R = 11.3/6 = 1.9\ A$

(12). (i) Not reverse biased. as $V_Z > V_{battery}$

(ii). Yes.

Effective potential difference across diode $= 12V - 10V = 2V$

$\therefore i = \frac{V}{R} = \frac{2}{500} = .004\ A$

(13). Properly biased.

$V_{AB} = V_Z = 12\ V$

$\therefore$ Drop across $R_1 = 18 - 12 = 6\ V$

$\Rightarrow I = 6/600 = 10\ mA$

$I_1 = \frac{12}{1800} = 6.7\ mA$

$\therefore I_Z = I - I_1 = 10 - 6.7 = 3.3\ mA$

as $I_Z < I_{Zmax}$, so properly biased.

$P = V_Z I_Z = 12 \times 3.3 \times 10^{-3} = 39.6 \times 10^{-3}\ W$

(14). $I = I_s\left[\exp\left(\frac{eV}{kT}\right) - 1\right]$

Here, $I = 50\ mA = 50 \times 10^{-3}\ A$

$I_s = 5\ \mu A = 5 \times 10^{-6}\ A$

and $T = 300\ K$

$\therefore \exp\left(\frac{eV}{kT}\right) = \frac{I}{I_s} + 1 = \frac{50 \times 10^{-3}}{5 \times 10^{-6}} + 1 = 10^4$

or $V = \frac{kT}{e} \ln 10^4 = \frac{1.38 \times 10^{-23} \times 300}{1.6 \times 10^{-19}} \times 2.303 \times 4$

$= \underline{0.238\ V}$ Ans.

(15). $I = I_s\left[\exp\left(\frac{eV}{kT}\right) - 1\right]$

Ratio of currents for forward bias (I_1) and reverse bias (I_2):

$$\frac{I_1}{I_2} = \frac{\exp\left(\frac{0.06\,e}{kT}\right) - 1}{\exp\left(\frac{-0.06\,e}{kT}\right) - 1}$$

Now $\frac{0.06\,e}{kT} = \frac{0.06 \times 1.6 \times 10^{-19}}{1.38 \times 10^{-23} \times (27+273)} = 2.319$

Hence. $\frac{I_1}{|I_2|} = \frac{e^{2.319} - 1}{|e^{-2.319} - 1|} = 10.16$ Ans.

(16). $I = I_s\left[\exp\left(\frac{eV}{kT}\right) - 1\right]$

$I_s = 30 \times 10^{-6}\,A$, $I = 2 \times 10^{-3}\,A$, $e/kT = 39/V$

$V = ?$

$$2 \times 10^{-3} = 30 \times 10^{-6}\left[\exp(39V) - 1\right]$$

$$\Rightarrow \exp(39V) = \frac{2 \times 10^{-3}}{30 \times 10^{-6}} + 1 = \frac{200}{3} + 1 = 66.7 + 1 = 67.7$$

$$\Rightarrow 39V = \ln(67.7) = 4.22$$

$$\Rightarrow V = \frac{4.22}{39} = 0.11\ V$$ Ans

(17) $T = 300K$, $I_s = 5 \times 10^{-6}\,A$, $I = 50\,mA$

$V = ?$,

Hint: use formula used in que. (16) and get answer.

18. Same as 15. Delete it

19. Solve it yourself using solution of 13.