Q. Consider a si PIN Diode with an Intrinsic Region width of $W = 20\,\mu m$. Assume that the photon flux is $10^{17}/cm^2/sec$ & Absorption Coefficient is $\alpha = 10^3/cm$. Then photo current density is : ______ mA/cm^2?

2M

Sol:- Here Examiner Not Specified G_L ⇒ We Can't Consider Uniform generation Rate.

So, G_{L_1} @ front Edge of Intrinsic region $G_{L_1} = \alpha \phi_0 = 10^{20}/cm^3/sec$.

G_{L_2} @ back Edge of Intrinsic region $G_{L_2} = \alpha \phi_0 e^{-\alpha W} = 0.135 \times 10^{12}/cm^3/sec$.

→ For Testing → It Clearly shows G_L → Non Uniform throughout Intrinsic region.

Hence, photo Current density,

$$J_L = q\phi_0(1-e^{-\alpha w})$$

$$= (1.6\times10^{-19})(10^{17})(1-\exp(-10^3(20\times10^{-4})))$$

$$= 13.8\,mA/cm^2.$$

Q: Consider GaAs @ $T = 300^\circ K$, Assume the photon Intensity @ a Particular point is $I_\nu(x) = 0.05 W/cm^2$ at a Wave length

1M: $\lambda = 0.75 \mu m$. Then the Generation rate of Electron hole pair where Intensity is typical of Sunlight is ___ $\times 10^{21} cm^{-3} s^{-1}$?

[Let Absorbtion coefficient for GaAs, $\alpha \simeq 0.9 \times 10^4 /cm$].

Sol:- As $G_L = \dfrac{\alpha I_\nu(x)}{h\nu}$, where $E = h\nu = \dfrac{1.24}{0.75} = 1.65 eV$.

$$\Rightarrow G_L = \frac{0.9 \times 10^4 \times 0.05}{1.6 \times 10^{-19} \times 1.65} = 1.70 \times 10^{21} cm^{-3} s^{-1}.$$

Q. Consider a Silicon Semiconductor @ T = 300°K in which $N_A = 10^{16}/cm^3$ & $N_D = 3 \times 10^{15}/cm^3$. Calculate Thermal Equilibrium Concentration of Majority Carriers ______ $\times 10^{15}/cm^3$?

Sol:- Since both N_A & N_D Exist $\Rightarrow$ Compensated Semiconductor.

Since $N_A > N_D \Rightarrow$ p-type.

$$\therefore \quad p_0 = \frac{N_A - N_D}{2} + \sqrt{\left(\frac{N_A - N_D}{2}\right)^2 + n_i^2}$$

$$\therefore \quad p_0 = \frac{10^{16} - 3 \times 10^{15}}{2} + \sqrt{\left(\frac{10^{16} - 3 \times 10^{15}}{2}\right)^2 + (1.5 \times 10^{10})^2} \simeq 7 \times 10^{15}/cm^3.$$

Q: In a BJT of npn Transistor, Emitter is doped with Phosporous of $N_D = 10^{16}/cm^3$. If Device Maintained @ 300°K, Determine the fraction of total Electrons Still in the Donar State @ $T = 300°K$? (Consider $N_c = 2.8 \times 10^{19}/cm^3$).

a). 41%. b). 0.41%. c). 38%. d). 0.38%.

Sol:- Since,

$$\frac{n_d}{n_0 + n_d} = \frac{1}{1 + \frac{N_c}{2N_D}\exp\left(\frac{E_D - E_c}{kT}\right)}$$

$$\Rightarrow \frac{n_d}{n_0 + n_d} = \frac{1}{1 + \frac{2.8 \times 10^{19}}{2 \times 10^{16}}\exp\left(\frac{-0.045}{0.026}\right)} = 0.0041 = 0.41\%$$

option b.

Q. A MOSFET @ 300°K Contains an Acceptor Impurity $N_A = 10^{16}/cm^3$. Determine the Concentration of Donar Impurity atoms that must be added ($\_\_ \times 10^{16}/cm^3$) for a Specific Application so that the silicon is n-type & Fermi level is 0.20eV below Conduction band Edge?

Sol:- For n-type (Non Compensated) As we know,

$$E_C - E_F = kT \log_e \left| N_C / N_D \right| \quad [\text{for } n_0 \simeq N_D].$$

Now for n-type Compensated,

$$E_C - E_F = kT \log_e \left| \frac{N_C}{N_D - N_A} \right| \Rightarrow N_D - N_A = N_C \exp\left(\frac{E_F - E_C}{kT}\right)$$

$$\Rightarrow N_D - N_A = 2.8 \times 10^{19} \exp\left[\frac{-0.20}{0.026}\right]$$

[$\because$ we know, N_C for si @ $300^\circ K$ is $2.8 \times 10^{19}/cm^3$].

$$\Rightarrow N_D - N_A = 1.24 \times 10^{16}/cm^3.$$

$$\Rightarrow N_D = 1.24 \times 10^{16} + N_A$$

$$\Rightarrow N_D = 2.24 \times 10^{16}/cm^3.$$