(5) what is the concentration of holes in Si crystals having donor concentration of $1.4 \times 10^{24}/m^3$ when the intrinsic carrier concentration is $1.4 \times 10^{18}/m^3$? find the ratio of electron to hole concentration.

<u>Sol<sup></sup></u>

Sol$^n$ Intrinsic carrier concentration $n_i = 1.4 \times 10^{18}/m^3$

Donor concentration $N_D = 1.4 \times 10^{24}/m^3$

Concentration of electrons $n \approx N_D = 1.4 \times 10^{24}/m^3$

Concentration of hole $P = \dfrac{n_i^2}{n}$

$$= \frac{(1.4 \times 10^{18})^2}{1.4 \times 10^{24}} = 1.4 \times 10^{12}/m^3 \quad \text{ANS}$$

Ratio of electron to hole concentration

$$\frac{n}{p} = \frac{1.4 \times 10^{24}}{1.4 \times 10^{12}} = 1 \times 10^{12} \quad \text{ANS}$$

# Shockley Equation

## Diode Equation

Volt equivalent of temperature $= V_T = k'T/e = T/11600 = 26\text{ mV} = 0.026\text{ V}$

$\eta = 1$ for Germanium

$\eta = 2$ for Silicon

$$\boxed{I = I_o\left(e^{\frac{V}{\eta V_T}} - 1\right)}$$

1. The current flowing through a certain p-n junction diode at room temperature when reversed biased is 0.15µA. Determine the current flowing through the diode when the applied voltage is 0.12V.

2. A Si diode has reverse saturation current of 2.5µA at 300k. Find forward voltage for a forward current of 10 mA.

(1) The diode current is given as $I = I_o(e^{V/\eta V_T} - 1)$

Large reverse biase current $I \simeq I_o = 0.15 \times 10^{-6}$ A

Applied Voltage $V = 0.12$ V

$V_T = 26$ mV $= 0.026$ V at room temp.

$$I = 0.15 \times 10^{-6}\left(e^{0.12/0.026} - 1\right)$$

$$\boxed{I = 15\,\mu A}$$ ANS

(2) $$I = I_o\left(e^{V/\eta V_T} - 1\right)$$

$I = 10\text{ mA} = 0.01\text{ A}$, $I_o = 2.5 \times 10^{-6}$ A

$$0.01 = 2.5 \times 10^{-6}\left(e^{V/\eta V_T} - 1\right)$$

$$e^{V/\eta V_T} = \frac{0.01}{2.5 \times 10^{-6}} + 1 = 4 \times 10^3 + 1 = 4001$$

or $$\frac{V}{\eta V_T} = \log_e 4001$$

$$V = \eta \times V_T \log_e 4001 = 2 \times 0.026 \times \log_e 4001$$

$$\boxed{V = 0.43\text{ V}}$$ ANS

$$\boxed{\log_e 4001 \approx 8.3}$$