HW # 6

2.11.

$$N_D = 10^{18} - 10^{16} = 9.9 \times 10^{17} \ cm^{-3}$$

$$n_o p_o = n_i^2 \Rightarrow 9.9 \times 10^{17} \times p_o = (1.062 \times 10^{10})^2$$

$$p_o = 114 \ cm^{-3}$$

2.13.

$$p_o = 4 \times 10^{6} \ cm^{-3}$$

$$N_D - N_A = 4.99 \times 10^{18}$$

$$p_o = \frac{n_i^2}{N_D - N_A} \Rightarrow n_i = \sqrt{p_o(N_D - N_A)} = 4.468 \times 10^{12} \ cm^{-3}$$

$$n_i = BT^{3/2} e^{\frac{-E_g}{2kT}}$$

$$B = 5.23 \times 10^{15} \qquad E_g = 1.12 \ eV \qquad k = 86.17 \ \frac{\mu eV}{K}$$

$$\Rightarrow 4.468 \times 10^{12} = 5.23 \times 10^{15} \ T^{3/2} \exp\left(-\frac{1.12}{2kT}\right)$$

$$T = 404.43 \ K$$

2.15

a) $E = \frac{V}{d} = \frac{1 \, V}{20 \times 10^{-4} cm} = 500 \ \frac{V}{cm}$

b) $n_o p_o = n_i^2$

$$n_i = BT^{3/2} e^{\left(-\frac{E_g}{2kT}\right)}$$

$$n_i = 5.23\times10^{15}\times(280)^{3/2}\cdot e^{\left(-\frac{1.12}{2\times8617\times280}\right)} = 2.04\times10^{9}\ cm^{-3}$$

$$n_o = \frac{n_i^2}{P_o} = \frac{(2.04\times10^{9})^2}{10^{18}} = 4.16\ cm^{-3}$$

c) $J = \mu_n q E n_o + \mu_p q E P_o$

$$= 1500\times1.6\times10^{-19}\times500\times4.16 + 500\times1.6\times10^{-19}\times500\times10^{18}$$

$$J = 40050\ A/cm^2$$

d)

$$J = 40050\ \frac{A}{cm^2}\times\left(10^{-4}\ \frac{cm}{\mu}\right)^2 = 400.5\ \mu A/\mu m^2$$

2.20.

$$J_{n\,diff} = q D_n \frac{dn_o}{dx} \qquad J_{p\,diff} = q D_p \frac{dP_o}{dx}$$

$$J = q D_n \frac{dn_o}{dx} + q D_p \frac{dP_o}{dx}$$

$$\frac{dn_o}{dx} = 3\frac{dP_o}{dx}$$

$$J = q D_n \cdot 3\frac{dP_o}{dx} + q D_p \frac{dP_o}{dx} = q D_n \frac{dn_o}{dx} + q D_p \frac{1}{3}\frac{dn_o}{dx}$$

$$15\ \frac{mA}{cm^2} = 1.6\times10^{-19}\times35\times3\frac{dP_o}{dx} + 1.6\times10^{-19}\times12\times\frac{dP_o}{dx}$$

$$\frac{dP_o}{dx} = 8.013\times10^{14}\ cm^{-1}$$

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$$15\ \frac{mA}{cm^2} = 1.6\times10^{-19}\times 35\times\frac{dn_0}{dx} + 1.6\times10^{-19}\times 12\times\frac{1}{3}\frac{dn_0}{dx}$$

$$\frac{dn_0}{dx} = 2.404\times10^{15}\ cm^{-1}$$

2.24

a) $$V_{bi} = \frac{kT}{q}\ln\left(\frac{N_A N_D}{n_i^2}\right) \qquad T = 300\ k$$

$$V_{bi} = \frac{1.38066\times10^{-23}\times 300}{1.6\times10^{-19}}\ln\left(\frac{10^{16}\times10^{18}}{(1.062\times10^{10})^2}\right) = .831\ mV$$

b) $T = 400\ k$

$$n_i = BT^{3/2}e^{-\frac{E_g}{2kT}} = 5.23\times10^{15}\times400^{3/2}\exp\left(-\frac{1.12}{2k\times400}\right)$$

$$n_i = 3.678\times10^{12}$$

$$V_{bi} = \frac{kT}{q}\ln\left(\frac{N_A\cdot N_D}{n_i^2}\right)$$

$$V_{bi} = \frac{1.38066\times10^{-23}\times400}{1.6\times10^{-19}}\ln\left(\frac{10^{16}\times10^{18}}{(3.678\times10^{12})^2}\right) = 0.705\ V$$

2.28.

$$I_D = I_S\left(e^{\frac{qV_D}{kT}} - 1\right)$$

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2.28

$$I_D = 10\ pA\left(e^{\frac{1.6\times10^{-19}\times0.625}{1.38066\times10^{-23}}} - 1\right) = 275\ mA$$

2.30

$$I_D = I_S\left(e^{\frac{V_D}{V_{th}}} - 1\right) \simeq I_S \cdot e^{\frac{V_D}{V_{th}}}$$

$$\frac{I_{D_1}}{I_{D_2}} = e^{\frac{V_{D_1} - V_{D_2}}{V_{th}}} = e^{\frac{\Delta V}{V_{th}}}$$

$$\Delta V = V_{th} \cdot \ln\left(\frac{I_{D_1}}{I_{D_2}}\right) = 25.9\ mV \times \ln(100) = 0.119\ V$$

35500