

Chapter 1

Exercise Solutions

E1.1

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

GaAs:

$$n_i = (2.1 \times 10^{14})(300)^{3/2} \exp\left(\frac{-1.4}{2(86 \times 10^{-6})(300)}\right)$$

$$\underline{n_i = 1.8 \times 10^5 \text{ cm}^{-3}}$$

Ge:

$$n_i = (1.66 \times 10^{15})(300)^{3/2} \exp\left(\frac{-0.66}{2(86 \times 10^{-6})(300)}\right)$$

$$\underline{n_i = 2.40 \times 10^{13} \text{ cm}^{-3}}$$

E1.2

Si:

$$n_i = (5.23 \times 10^{12})(400)^{3/2} \exp\left(\frac{-1.1}{2(86 \times 10^{-6})(400)}\right)$$

$$\underline{n_i = 4.76 \times 10^{12} \text{ cm}^{-3}}$$

GaAs:

$$n_i = (2.1 \times 10^{14})(400)^{3/2} \exp\left(\frac{-1.4}{2(86 \times 10^{-6})(400)}\right)$$

$$\underline{n_i = 2.44 \times 10^7 \text{ cm}^{-3}}$$

Ge:

$$n_i = (1.66 \times 10^{15})(400)^{3/2} \exp\left(\frac{-0.66}{2(86 \times 10^{-6})(400)}\right)$$

$$\underline{n_i = 9.06 \times 10^{14} \text{ cm}^{-3}}$$

E1.3

- a. majority carrier: $p_0 = 10^{17} \text{ cm}^{-3}$
 minority carrier:

$$\underline{n_0 = \frac{n_i^2}{p_0} = \frac{(1.5 \times 10^{10})^2}{10^{17}} = 2.25 \times 10^3 \text{ cm}^{-3}}$$

- b. $n_0 = N_d - N_a = 5 \times 10^{15}$

majority carrier: $p_0 = 5 \times 10^{15} \text{ cm}^{-3}$

minority carrier:

$$\underline{p_0 = \frac{n_i^2}{n_0} = \frac{(1.5 \times 10^{10})^2}{5 \times 10^{15}} = 4.5 \times 10^4 \text{ cm}^{-3}}$$

E1.4

- (a) $n_0 = 5 \times 10^{15} \text{ cm}^{-3}$, $p_0 \ll n_0$

$$\sigma \approx e\mu_n n_0 = (1.6 \times 10^{-19})(1350)(5 \times 10^{15}) \Rightarrow$$

$$\underline{\sigma = 10.8 (\Omega \cdot \text{cm})^{-1}}$$

- (b) $p_0 = 5 \times 10^{15} \text{ cm}^{-3}$, $n_0 \ll p_0$

$$\sigma \approx e\mu_p p_0 = (1.6 \times 10^{-19})(480)(5 \times 10^{15}) \Rightarrow$$

$$\underline{\sigma = 3.84 (\Omega \cdot \text{cm})^{-1}}$$

E1.5

- a. $n_0 = N_d = 8 \times 10^{15} \text{ cm}^{-3}$

$$p_0 = \frac{n_i^2}{n_0} = \frac{(1.5 \times 10^{10})^2}{8 \times 10^{15}} \Rightarrow$$

$$\underline{p_0 = 2.81 \times 10^4 \text{ cm}^{-3}}$$

- b. $n = n_0 + \delta n = 8 \times 10^{15} + 0.1 \times 10^{15} \Rightarrow$

$$\underline{n = 8.1 \times 10^{15} \text{ cm}^{-3}}$$

$$p = p_0 + \delta p \Rightarrow$$

$$\underline{p \approx 10^{15} \text{ cm}^{-3}}$$

E1.6

$$J = eE = (10)(10) \Rightarrow$$

$$\underline{J = 100 \text{ A/cm}^2}$$

E1.7

$$\text{a. } V_{bi} = V_T \ln\left(\frac{N_a N_d}{n_i^2}\right)$$

$$V_{bi} = (0.026) \ln\left[\frac{(10^{15})(10^{17})}{(1.5 \times 10^{10})^2}\right]$$

$$\underline{V_{bi} = 0.897 \text{ V}}$$

$$\text{c. } V_{bi} = (0.026) \ln\left[\frac{(10^{17})(10^{17})}{(1.5 \times 10^{10})^2}\right]$$

$$\underline{V_{bi} = 0.817 \text{ V}}$$

Donald Neamen Solution Manual

LL Leslie



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