Homework 1 Solutions

Posted Monday, September19th , 2016

Each homework problem is worth 10 points unless otherwise stated.

1.4

(a) n-type; $n_o = 10^{15}\ \text{cm}^{-3}$; $p_o = \dfrac{n_i^2}{n_o} = \dfrac{(2.4\times10^{13})^2}{10^{15}} = 5.76\times10^{11}\ \text{cm}^{-3}$

(b) n-type; $n_o = 10^{15}\ \text{cm}^{-3}$; $p_o = \dfrac{n_i^2}{n_o} = \dfrac{(1.5\times10^{10})^2}{10^{15}} = 2.25\times10^{5}\ \text{cm}^{-3}$

1.12

$$J = \sigma \mathrm{E} \Rightarrow \sigma = \frac{J}{\mathrm{E}} = \frac{120}{18} = 6.67(\Omega - cm)^{-1}$$

$$\sigma \cong e\mu_n N_d \Rightarrow N_d = \frac{\sigma}{e\mu_n} = \frac{(6.67)}{(1.6\times10^{-19})(1250)} = 3.33\times10^{16}\ \text{cm}^{-3}$$

1.20

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

or

$$N_a = \frac{(n_i^2)}{N_d}\exp\left(\frac{V_{bi}}{V_T}\right) = \frac{(1.5\times10)^2}{10^{16}}\exp\left(\frac{0.712}{0.026}\right) = 1.76\times10^{16}\ \text{cm}^{-3}$$

1.34

(a) $1.5\times10^{-3} = I_S \exp\left(\dfrac{0.30}{0.026}\right) \Rightarrow I_S = 1.46\times10^{-8}\ A$

(b) (i) $I_D = (1.462\times10^{-8})\exp\left(\dfrac{0.35}{0.026}\right) \Rightarrow I_D = 10.3\ \text{mA}$

(ii) $I_D = (1.462\times10^{-8})\exp\left(\dfrac{0.25}{0.026}\right) \Rightarrow I_D = 0.219\ \text{mA}$

1.38

(a) $V_{PS} = I_D R + V_D$

$$2.8 = I_D(10^6) + V_D; \quad I_D = (5\times10^{-11})\exp\left(\frac{V_D}{0.026}\right)$$

By trial and error,

$V_D = 0.282\ \text{V}$, $I_D = 2.52\,\mu\text{A}$

(b)

$I_D \cong -5\times10^{-11}\ \text{A}$, $V_D = -2.8\ \text{V}$