VE320 HW7 Solution

1.

(a) $V_{bi} = \phi_{B0} - \phi_n$

$$\phi_n = V_t \ln\left(\frac{N_c}{N_d}\right)$$

$$= (0.0259)\ln\left(\frac{2.8\times10^{19}}{5\times10^{15}}\right)$$

$$=0.2235 \text{ V}$$

$$V_{bi} = 0.65 - 0.2235 = 0.4265 \text{ V}$$

(b) $\phi_n = (0.0259)\ln\left(\frac{2.8\times10^{19}}{10^{16}}\right)$

$$= 0.2056 \text{ V}$$

$$V_{bi} = 0.65 - 0.2056 = 0.4444 \text{ V}$$

V_{bi} increases, ϕ_{B0} remains constant

(c) $\phi_n = (0.0259)\ln\left(\frac{2.8\times10^{19}}{10^{15}}\right)$

$$= 0.2652 \text{ V}$$

$$V_{bi} = 0.65 - 0.2652 = 0.3848 \text{ V}$$

V_{bi} decreases, ϕ_{B0} remains constant

2.

(a) $\phi_{B0} \cong 0.63 \text{ V}$

$$J_{sT} = (120)(300)^2 \exp\left(\frac{-0.63}{0.0259}\right)$$

$$= 2.948\times10^{-4} \text{ A/cm}^2$$

$$I_{sT} = (10^{-4})(2.948\times10^{-4}) = 2.948$$

(i) $V_a = V_t \ln\left(\frac{I}{I_{sT}}\right)$

$$= (0.0259)\ln\left(\frac{10\times10^{-6}}{2.948\times10^{-8}}\right)$$

$$= 0.151 \text{ V}$$

(ii) $V_a = (0.0259)\ln\left(\frac{100\times10^{-6}}{2.948\times10^{-8}}\right)$

$$= 0.211 \text{ V}$$

(iii) $V_a = (0.0259)\ln\left(\frac{10^{-3}}{2.948\times10^{-8}}\right)$

$$= 0.270 \text{ V}$$

(b) $kT = (0.0259)\left(\frac{350}{300}\right) = 0.030217 \text{ eV}$

$$I_{sT} = (10^{-4})(120)(350)^2 \exp\left(\frac{-0.63}{0.030217}\right)$$

$$= 1.296\times10^{-6} \text{ A}$$

(i) $I = I_{sT}\left[\exp\left(\frac{V_a}{V_t}\right) - 1\right]$

$$V_a = (0.030217)\ln\left[\frac{10\times10^{-6}}{1.296\times10^{-6}} + 1\right]$$

$$= 0.0654 \text{ V}$$

(ii) $V_a = (0.030217)\ln\left[\frac{100\times10^{-6}}{1.296\times10^{-6}} + 1\right]$

$$= 0.1317 \text{ V}$$

(iii) $V_a \cong (0.030217)\ln\left(\frac{10^{-3}}{1.296\times10^{-6}}\right)$

$$= 0.201 \text{ V}$$

3.

For the pn junction,

$$I_s = (8\times10^{-4})(8\times10^{-13}) = 6.4\times10^{-16} \text{ A}$$

(a) $V_a = (0.0259)\ln\left(\frac{150\times10^{-6}}{6.4\times10^{-16}}\right)$

$$= 0.678 \text{ V}$$

(b) $V_a = (0.0259)\ln\left(\frac{700\times10^{-6}}{6.4\times10^{-16}}\right)$

$$= 0.718 \text{ V}$$

(c) $V_a = (0.0259)\ln\left(\frac{1.2\times10^{-3}}{6.4\times10^{-16}}\right)$

$$= 0.732 \text{ V}$$

For the Schottky junction,

$$I_{sT} = (8\times10^{-4})(6\times10^{-9}) = 4.8\times10^{-12} \text{ A}$$

(a) $V_a = (0.0259)\ln\left(\frac{150\times10^{-6}}{4.8\times10^{-12}}\right)$

$$= 0.447 \text{ V}$$

(b) $V_a = (0.0259)\ln\left(\frac{700\times10^{-6}}{4.8\times10^{-12}}\right)$

$$= 0.487 \text{ V}$$

(c) $V_a = (0.0259)\ln\left(\frac{1.2\times10^{-3}}{4.8\times10^{-12}}\right)$

$$= 0.501 \text{ V}$$

4.

(a) $R = \dfrac{R_c}{A} = \dfrac{5 \times 10^{-5}}{10^{-5}} = 5\,\Omega$

(i) $V = IR = (1)(5) = 5\,\text{mV}$

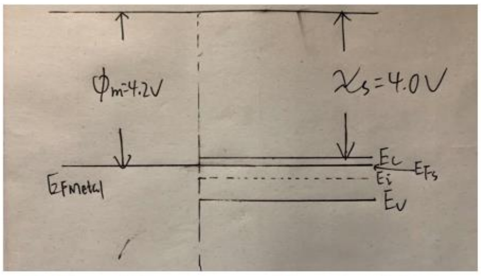
(ii) $V = IR = (0.1)(5) = 0.5\,\text{mV}$

(b) $R = \dfrac{5 \times 10^{-5}}{10^{-6}} = 50\ \Omega$

(i) $V = IR = (1)(50) = 50\,\text{mV}$

(ii) $V = IR = (0.1)(50) = 5\,\text{mV}$

5.



(b) We need $\phi_n = \phi_m - \chi = 4.2 - 4.0 = 0.20\ \text{V}$

And

$$\phi_n = V_t \ln\left(\frac{N_c}{N_d}\right)$$

or

$$0.20 = (0.0259)\ln\left(\frac{2.8 \times 10^{19}}{N_d}\right)$$

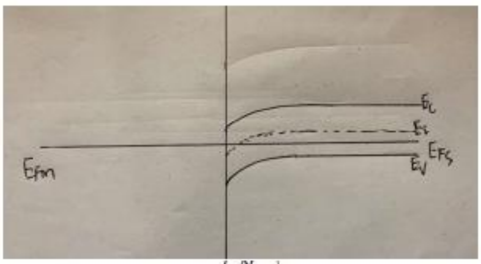
which yields

$$N_d = 1.24 \times 10^{16}\ \text{cm}^{-3}$$

(c)

Barrier height = 0.20 V

6.



(b) $\phi_{BO} = \phi_p = V_t \ln\left(\dfrac{N_v}{N_a}\right)$

$$= (0.0259)\ln\left(\frac{1.04 \times 10^{19}}{5 \times 10^{16}}\right)$$

or

$$\phi_{BO} = 0.138\ \text{V}$$