3.12 Using Eq. (3.22) and $N_A = N_D$

$= 5 \times 10^{16}\ \text{cm}^{-3}$ and $n_i = 1.5 \times 10^{10}\ \text{cm}^{-3}$,

we have $V_0 = 778$ mV.

Using Eq. (3.26) and
$\epsilon_s = 11.7 \times 8.854 \times 10^{-14}$ F/cm, we have
$W = 2 \times 10^{-5}\ \text{cm} = 0.2\ \mu\text{m}$. The extension of

the depletion width into the n and p regions is given in Eqs. (3.27) and (3.28), respectively:

$$x_n = W \cdot \frac{N_A}{N_A + N_D} = 0.1\ \mu\text{m}$$

$$x_p = W \cdot \frac{N_D}{N_A + N_D} = 0.1\ \mu\text{m}$$

Since both regions are doped equally, the depletion region is symmetric.

Using Eq. (3.29) and
$A = 20\ \mu\text{m}^2 = 20 \times 10^{-8}\ \text{cm}^2$, the charge magnitude on each side of the junction is

$Q_J = 1.6 \times 10^{-14}$ C.

3.15 Equation (3.26):

$$W = \sqrt{\frac{2\epsilon_s}{q}\left(\frac{1}{N_A} + \frac{1}{N_D}\right)V_0},$$

Since $N_A \gg N_D$, we have

$$W \simeq \sqrt{\frac{2\epsilon_s}{q}\frac{1}{N_D}\,V_0}$$

$$V_0 = \frac{qN_D}{2\epsilon_s}.W^2$$

Here $W = 0.2\ \mu\text{m} = 0.2 \times 10^{-4}$ cm

$$\text{So } V_0 = \frac{1.6 \times 10^{-19} \times 10^{16} \times \left(0.2 \times 10^{-4}\right)^2}{2 \times 1.04 \times 10^{-12}}$$

$= 0.31$ V

$$Q_J = Aq\left(\frac{N_A N_D}{N_A + N_D}\right)W \cong AqN_D W$$

since $N_A \gg N_D$, we have $Q_J = 3.2$ fC.

3.19 Equation (3.39):

$$I = Aqn_i^2\left(\frac{D_p}{L_pN_D} + \frac{D_n}{L_nN_A}\right)\left(e^{V/V_T} - 1\right)$$

Here $I_p = Aqn_i^2\dfrac{D_p}{L_pN_D}\left(e^{V/V_T} - 1\right)$

$$I_n = Aqn_i^2\frac{D_n}{L_nN_A}\left(e^{V/V_T} - 1\right)$$

$$\frac{I_p}{I_n} = \frac{D_p}{D_n}\cdot\frac{L_n}{L_p}\cdot\frac{N_A}{N_D}$$

$$= \frac{10}{20} \times \frac{10}{5} \times \frac{10^{18}}{10^{16}}$$

$$\frac{I_p}{I_n} = 100$$

Now $I = I_p + I_n = 100\, I_n + I_n \equiv 1 \text{ mA}$

$$I_n = \frac{1}{101} \text{ mA} = 0.0099 \text{ mA}$$

$$I_p = 1 - I_n = 0.9901 \text{ mA}$$

3.21 $n_i = BT^{3/2}e^{-E_g/2kT}$

At 300 K,

$$n_i = 7.3 \times 10^{15} \times (300)^{3/2} \times e^{-1.12/(2\times 8.62\times 10^{-5}\times 300)}$$

$$= 1.4939 \times 10^{10}/\text{cm}^2$$

$$n_i^2 \text{ (at 300 K)} = 2.232 \times 10^{20}$$

At 305 K,

$$n_i = 7.3 \times 10^{15} \times (305)^{3/2} \times e^{-1.12/(2\times 8.62\times 10^{-5}\times 305)}$$

$$= 2.152 \times 10^{10}$$

$$n_i^2 \text{ (at 305 K)} = 4.631 \times 10^{20}$$

$$\text{so } \frac{n_i^2 \text{ (at 305 K)}}{n_i^2 \text{ (at 300 K)}} = 2.152$$

Thus I_S approximately doubles for every 5°C rise in temperature.

3.25 Equation (3.49), $C_j = \dfrac{C_{j0}}{\left(1 + \dfrac{V_R}{V_0}\right)^m}$

For $V_R = 1$ V, $C_j = \dfrac{0.4 \text{ pF}}{\left(1 + \dfrac{1}{0.75}\right)^{1/3}}$

$= 0.3$ pF

For $V_R = 10$ V, $C_j = \dfrac{0.4 \text{ pF}}{\left(1 + \dfrac{10}{0.75}\right)^{1/3}}$

$= 0.16$ pF