8.7 An ideal germanium pn junction diode has the following parameters: $N_a = 4 \times 10^{15}$ cm^{-3}, $N_d = 2 \times 10^{17}$ cm^{-3}, $D_p = 48$ cm^2/s, $D_n = 90$ cm^2/s, $\tau_{p0} = \tau_{n0} = 2 \times 10^{-6}$ s, and $A = 10^{-4}$ cm^2. Determine the diode current for (*a*) a forward-bias voltage of 0.25 V and (*b*) a reverse-biased voltage of 0.25 V.

➢ First, calculate J_s.

(8.26) $J_s = \left[\frac{e D_p p_{no}}{L_p} + \frac{e D_n n_{po}}{L_n}\right]$ where $L_n = \sqrt{D_n \tau_{no}}$

$L_p = \sqrt{D_p \tau_{po}}$

Table B.4, $n_i = 2.4 \times 10^{13}$ cm^{-3} @ 300K

n region $n_{no} \approx N_d$. Per (4.43), $p_{no} = \frac{n_i^2}{n_{no}} = \frac{n_i^2}{N_d}$

p region $p_{po} \approx N_a$. Per (4.43), $n_{po} = \frac{n_i^2}{p_{po}} = \frac{n_i^2}{N_a}$

$$J_s = e n_i^2 \left[\frac{1}{N_a}\sqrt{\frac{D_p}{\tau_{po}}} + \frac{1}{N_d}\sqrt{\frac{D_n}{\tau_{no}}}\right]$$

$$= 1.6021766 \times 10^{-19} (2.4 \times 10^{13})^2 \left[\frac{1}{4 \times 10^{15}}\sqrt{\frac{48}{2 \times 10^{-6}}} + \frac{1}{2 \times 10^{17}}\sqrt{\frac{90}{2 \times 10^{-6}}}\right]$$

$$J_s = 1.57028 \times 10^{-4}\ \text{A/cm}^2 = 1.57028\ \text{A/m}^2$$

Per (8.27), $J = J_s\left[e^{V_a/V_t} - 1\right]$ where $V_t = \frac{k_B T}{e}$

and $I = J(A)$. $V_t = 8.617333 \times 10^{-5}(300) = 0.025852$ V @ 300K

a) $V_a = 0.25$ V

$$I = 1.57028 \times 10^{-4}\left[e^{\frac{0.25}{0.025852}} - 1\right]10^{-4} = 2.4875 \times 10^{-4}\ \text{A}$$

b) $V_a = -0.25$ V

$$I = 1.57028 \times 10^{-4}\left[e^{\frac{-0.25}{0.025852}} - 1\right]10^{-4} = -1.5703 \times 10^{-8}\ \text{A}$$