8.2 A silicon pn junction has impurity doping concentrations of $N_d = 2 \times 10^{15}$ cm^{-3} and $N_a = 8 \times 10^{15}$ cm^{-3}. Determine the minority carrier concentrations at the edges of the space charge region for (*a*) $V_a = 0.45$ V, (*b*) $V_a = 0.55$ V, and (*c*) $V_a = -0.55$ V.

- First, calculate the thermal equilibrium minority carrier concentrations for the n & p regions.

Per Table B.4, $n_i = 1.5 \times 10^{10}\ \text{cm}^{-3}$ @ 300 K

n region $n_{no} \simeq N_d = 2 \times 10^{15}\ \text{cm}^{-3}$

Per (4.43), $p_{no} = \frac{n_i^2}{n_{no}} = \frac{(1.5\times10^{10})^2}{2\times10^{15}} \Rightarrow p_{no} = 1.125 \times 10^{5}\ \text{cm}^{-3}$

p region $p_{po} \simeq N_a = 8 \times 10^{15}\ \text{cm}^{-3}$

(4.43) $n_{po} = \frac{n_i^2}{p_{po}} = \frac{(1.5\times10^{10})^2}{8\times10^{15}} \Rightarrow n_{po} = 2.8125 \times 10^{4}\ \text{cm}^{-3}$

(8.6) $n_p = n_p(-x_p) = n_{po}\, e^{V_a/V_t}$ where $V_t = \frac{k_B T}{e}$

(8.7) $p_n = p_n(x_n) = p_{no}\, e^{V_a/V_t}$

$= 8.617333\times10^{-5}(300)$

$= 0.025852\ V$

a) $V_a = 0.45\ V$ $n_p = 28125\, e^{\frac{0.45}{0.025852}} = 1.0204 \times 10^{12}\ \text{cm}^{-3}$

$p_n = 1.125\times10^{5}\, e^{\frac{0.45}{0.025852}} = 4.0815 \times 10^{12}\ \text{cm}^{-3}$

b) $V_a = 0.55\ V$ $n_p = 28125\, e^{\frac{0.55}{0.025852}} = 4.883 \times 10^{13}\ \text{cm}^{-3}$

$p_n = 1.125\times10^{8}\, e^{\frac{0.55}{0.025852}} = 1.953 \times 10^{14}\ \text{cm}^{-3}$

c) $V_a = -0.55\ V$ $n_p = 28125\, e^{-\frac{0.55}{0.025852}} = 1.62 \times 10^{-5}\ \text{cm}^{-3}$

$p_n = 1.125\times10^{8}\, e^{\frac{-0.55}{0.025852}} = 6.48 \times 10^{-5}\ \text{cm}^{-3}$