8.3 The doping concentrations in a GaAs pn junction are $N_d = 10^{16}$ cm^{-3} and $N_a = 4 \times 10^{16}$ cm^{-3}. Find the minority carrier concentrations at the edges of the space charge region for (*a*) $V_a = 0.90$ V, (*b*) $V_a = 1.10$ V, and (*c*) $V_a = -0.95$ V.

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

From Table B.4, $n_i = 1.8 \times 10^6$ cm^{-3} for GaAs @ 300K.

<u>n region</u> $n_{no} \simeq N_d = 10^{16}$ cm^{-3} (majority)

Per (4.43), $p_{no} = \frac{n_i^2}{n_{no}} = \frac{(1.8\times10^6)^2}{10^{16}} \Rightarrow p_{no} = 3.24 \times 10^{-4}$ cm^{-3} (minority)

<u>p region</u> $p_{po} \simeq N_a = 4\times10^{16}$ cm^{-3} (majority)

Per (4.43), $n_{po} = \frac{n_i^2}{p_{po}} = \frac{(1.8\times10^6)^2}{4\times10^{16}} \Rightarrow n_{po} = 8.1\times10^{-5}$ cm^{-3} (minority)

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

& (8.7) $p_n = p_n(x=x_n) = p_{no} e^{V_a/V_t}$ $V_t = 0.025852$ V

a) $V_a = 0.90$V $n_p = 8.1\times10^{-5} e^{0.9/0.025852} \Rightarrow n_p = 1.066\times10^{11}$ cm^{-3}

$p_n = 3.24\times10^{-4} e^{0.9/0.025852} \Rightarrow p_n = 4.265\times10^{11}$ cm^{-3}

b) $V_a = 1.10$V $n_p = 8.1\times10^{-5} e^{1.1/0.025852} \Rightarrow n_p = 2.442\times10^{14}$ cm^{-3}

$p_n = 3.24\times10^{-4} e^{1.1/0.025852} \Rightarrow p_n = 9.766\times10^{14}$ cm^{-3}

c) $V_a = -0.95$V $n_p = 8.1\times10^{-5} e^{-0.95/0.025852} \Rightarrow n_p = 8.896\times10^{-21}$ cm^{-3}

$p_n = 3.24\times10^{-4} e^{\frac{-0.95}{0.025852}} \Rightarrow p_n = 3.558\times10^{-20}$ cm^{-3}