4.34 Determine the equilibrium electron and hole concentrations in silicon for the following conditions:

(*a*) $T = 300$ K, $N_d = 10^{15}$ cm^{-3}, $N_a = 4 \times 10^{15}$ cm^{-3}

(*b*) $T = 300$ K, $N_d = 3 \times 10^{16}$ cm^{-3}, $N_a = 0$

Table B.4, $n_i = 1.5 \times 10^{10}$ #/cm³

a) For $N_a > N_d$ and assuming complete ionization, we can use (4.62)

$$p_o = \frac{N_a - N_d}{2} + \sqrt{\left(\frac{N_a - N_d}{2}\right)^2 + n_i^2} = \frac{3\times10^{15}}{2} + \sqrt{\left(\frac{3\times10^{15}}{2}\right)^2 + (1.5\times10^{10})^2}$$

$$p_o = 3\times10^{15} \text{ \#/cm}^3$$

(4.43) $n_o p_o = n_i^2 \Rightarrow n_o = \frac{n_i^2}{p_o}$

$$n_o = \frac{(1.5\times10^{10})^2}{3\times10^{15}} \Rightarrow n = 7.5\times10^4 \text{ \#/cm}^3$$

b) Assuming complete ionization and noting $N_d > N_a$, we can use (4.60)

$$n_o = \frac{N_d - N_a}{2} + \sqrt{\left(\frac{N_d - N_a}{2}\right)^2 + n_i^2}$$

$$= \frac{3\times10^{16}}{2} + \sqrt{\left(\frac{3\times10^{16}}{2}\right)^2 + (1.5\times10^{10})^2}$$

$$n_o = 3\times10^{16} \text{ \#/cm}^3$$

(4.43) $n_o p_o = n_i^2 \rightarrow p_o = \frac{n_i^2}{n_o}$

$$p_o = \frac{(1.5\times10^{10})^2}{3\times10^{16}} \Rightarrow p_o = 7.5\times10^3 \text{ \#/cm}^3$$