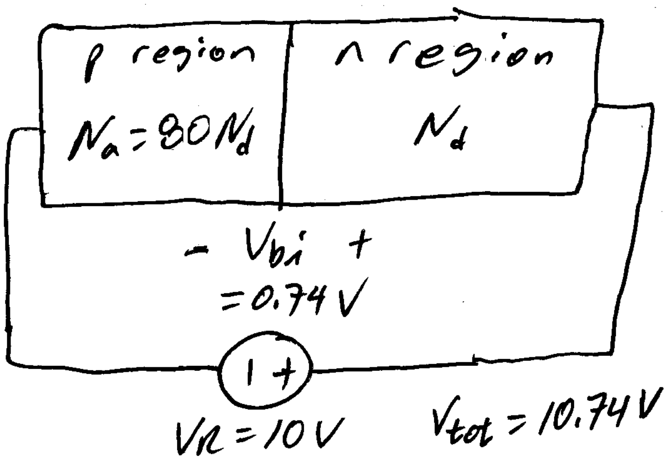
7.18 An ideal one-sided silicon p^+n junction at $T = 300$ K is uniformly doped on both sides of the metallurgical junction. It is found that the doping relation is $N_a = 80\,N_d$ and the built-in potential barrier is $V_{bi} = 0.740$ V. A reverse-biased voltage of $V_R = 10$ V is applied. Determine (*a*) N_a, N_d; (*b*) x_p, x_n; (*c*) $|E_{max}|$; and (*d*) C'.



From Table B.4

$\epsilon_r = 11.7$

$n_i = 1.5 \times 10^{10}\ \text{cm}^{-3}$

for Si @ 300K

a) Per (7.10), $V_{bi} = \frac{k_B T}{e} \ln\left(\frac{N_a N_d}{n_i^2}\right) = V_t \ln\left(\frac{N_a N_d}{n_i^2}\right)$

$$V_t = \frac{8.617333 \times 10^{-5}\ \text{eV/K}\,(300\text{K})}{e} = 0.025852\ \text{V}$$

$$0.74 = 0.025852 \ln\left(\frac{80 N_d^2}{(1.5 \times 10^{10})^2}\right)$$

$$N_d = \sqrt{\frac{(1.5 \times 10^{10})^2}{80} e^{0.74/0.025852}}$$

$$\underline{\underline{N_d = 2.756 \times 10^{15}\ \text{cm}^{-3}}}$$

$$\underline{\underline{N_a = 80(2.756 \times 10^{15}) = 2.20477 \times 10^{17}\ \text{cm}^{-3}}}$$

b) Per (7.28), $x_n = \left\{\frac{2 \epsilon_s V_{tot}}{e}\left(\frac{N_a}{N_d}\right)\frac{1}{N_a + N_d}\right\}^{1/2}$

$$x_n = \left\{\frac{2(11.7)8.8542 \times 10^{-12}(10.74)}{1.602176634 \times 10^{-19}}\left(\frac{80 N_d}{N_d}\right)\frac{1}{2.756 \times 10^{21} + 2.048 \times 10^{23}}\right\}^{1/2}$$

b) cont.

$$\underline{\underline{x_n = 2.231 \times 10^{-6}\,m = 2.231\,\mu m}}$$

Per (7.29), $x_p = \left\{ \frac{2\epsilon_s V_{tot}}{e} \left(\frac{N_d}{N_a} \right) \frac{1}{N_a + N_d} \right\}^{1/2}$

$$x_p = \left\{ \frac{2(11.7)\,8.8542 \times 10^{-12}(10.74)}{1.602176634 \times 10^{-19}} \left(\frac{N_d}{80 N_d} \right) \frac{1}{2.756 \times 10^{21} + 2.2048 \times 10^{23}} \right\}^{1/2}$$

$$\underline{\underline{x_p = 2.7887 \times 10^{-8}\,m = 0.027887\,\mu m}}$$

c) Per (7.37), $E_{max} = \frac{-2(V_{bi} + V_R)}{W}$

$$|E_{max}| = \frac{2(10.74)}{(2.231 + 0.027887) \times 10^{-6}}$$

$$\underline{\underline{|E_{max}| = 9.5092 \times 10^{6}\,V/m = 9.5092\,\frac{MV}{m}}}$$

d) Per (7.42), $C' = \left\{ \frac{e\,\epsilon_s N_a N_d}{2(V_{bi} + V_R)(N_a + N_d)} \right\}^{1/2}$

$$C' = \left\{ \frac{1.6022 \times 10^{-9}(11.7)\,8.8542 \times 10^{-12}(2.2048 \times 10^{23})(2.756 \times 10^{21})}{2(10.74)(2.2048 \times 10^{23} + 2.756 \times 10^{21})} \right\}^{1/2}$$

$$\underline{\underline{C' = 4.5861 \times 10^{-5}\,F/m^2 = 4.5861 \times 10^{-9}\,F/cm^2}}$$