7.20 (*a*) The peak electric field in a reverse-biased silicon pn junction is $|E_{max}| = 3 \times 10^5$ V/cm. The doping concentrations are ~~$N_d = 4 \times 10^{15}$ cm^{-3}~~ and ~~$N_a = 4 \times 10^{17}$ cm^{-3}~~. Find the magnitude of the reverse-biased voltage. (*b*) Repeat part (*a*) for $N_d = 4 \times 10^{16}$ cm^{-3} and $N_a = 4 \times 10^{17}$ cm^{-3}.

Table B.4, $\epsilon_r = 11.7$ & $n_i = 1.5 \times 10^{10}$ cm^{-3} for Si @ 300K

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

$$V_{bi} = \frac{8.617333 \times 10^{-5}\,\text{eV/K}\,(300\text{K})}{e} \ln\left(\frac{4\times10^{17}(4\times10^{16})}{(1.5\times10^{10})^2}\right)$$

$$V_{bi} = 0.824556\ \text{V}$$

Per (7.36), $E_{max} = -\left\{\frac{2e(V_{bi}+V_R)}{\epsilon_s}\left(\frac{N_a N_d}{N_a + N_d}\right)\right\}^{1/2}$

$$|E_{max}|^2 = E_{max}^2 = \frac{2e(V_{bi}+V_R)}{\epsilon_s}\left(\frac{N_a N_d}{N_a + N_d}\right)$$

$$V_{bi} + V_R = \frac{\epsilon_s}{2e}\left(\frac{N_a + N_d}{N_a N_d}\right) E_{max}^2$$

$$V_R + 0.824556 = \frac{11.7(8.8542\times10^{-12})}{2(1.602176634\times10^{-19})} \frac{4\times10^{23} + 4\times10^{22}}{4\times10^{23}(4\times10^{22})} (3\times10^7)^2$$

$$= 8.00146\ \text{V}$$

$$V_R = 8.00146 - 0.824556$$

$$\underline{\underline{V_R = 7.1769\ \text{V}}}$$