7.8 (*a*) Consider a uniformly doped ~~silicon~~ pn junction at $T = 300$ K. At zero bias, 25 percent of the total space charge region is in the n-region. The built-in potential barrier is ~~$V_{bi} = 0.710$ V~~. Determine (*i*) N_a, (*ii*) N_d, (*iii*) x_n, (*iv*) x_p, and (*v*) $|E_{max}|$. (*b*) Repeat part (*a*) for a GaAs pn junction with $V_{bi} = 1.180$ V.

b) From Table B.4, $n_i = 1.8 \times 10^6 \, \#/cm^3$ @ 300K

$\epsilon_r = 13.1$

Per (7.30), $W = x_n + x_p$

Given $x_n = 0.25W = 0.25(x_n + x_p)$

$\hookrightarrow x_p/x_n = 3 = \frac{N_d}{N_a}$ (7.17)

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

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

$V_{bi} = 1.180V = 0.025852 \ln\left(\frac{N_a (3N_a)}{(1.8 \times 10^6)^2}\right)$

$\hookrightarrow N_a = \left[\frac{(1.8 \times 10^6)^2}{3} e^{1.18/0.025852}\right]^{1/2}$

$N_a = 8.47765 \times 10^{15} \, \#/cm^3$

(ii) $N_d = 3N_a = 2.5433 \times 10^{16} \, \#/cm^3$

(iii) (7.28) $$x_n = \left\{ \frac{2\epsilon_s V_{bi}}{e} \left(\frac{N_a}{N_d}\right) \frac{1}{N_a + N_d} \right\}^{1/2}$$

$$x_n = \left\{ \frac{2(13.1)8.8541878\times10^{-12}(1.18)}{1.602176634\times10^{-19}} \left(\frac{1}{3}\right) \frac{1}{8.478\times10^{21} + 2.543\times10^{22}} \right\}^{1/2}$$

$$\underline{\underline{x_n = 1.29593\times10^{-7}\ m = 129.593\ nm}}$$

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

$$x_p = \left\{ \frac{2(13.1)8.8542\times10^{-12}(1.18)}{1.602176634\times10^{-19}} (3) \frac{1}{8.478\times10^{21} + 2.543\times10^{22}} \right\}^{1/2}$$

$$\underline{\underline{x_p = 3.8878\times10^{-7}\ m = 388.797\ nm}}$$

(v) $$E_{max} = \frac{-2V_{bi}}{W} \quad (7.37)$$

$$= \frac{-2(1.18)}{(129.593 + 388.797)\times10^{-9}} = -4.55271\times10^{6}\ V/m$$

$$\underline{\underline{|E_{max}| = 4.55271\ MV/m}}$$