7.2 Calculate the built-in potential barrier, V_{bi}, for Si pn junctions if they have the following dopant concentrations at $T = 300$ K:

(*a*) $N_d = 10^{14}\ \text{cm}^{-3}$ $N_a = 10^{17}\ \text{cm}^{-3}$

(*b*) $N_d = 5 \times 10^{16}$ $N_a = 5 \times 10^{16}$

(*c*) $N_d = 10^{17}$ $N_a = 10^{17}$

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

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

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

a) $$V_{bi} = 0.025852 \ln\left[\frac{10^{17}(10^{14})}{(1.5 \times 10^{10})^2}\right]$$

$$\underline{V_{bi} = 0.63383\ \text{V}}$$

b) $$V_{bi} = 0.025852 \ln\left[\frac{(5 \times 10^{16})^2}{(1.5 \times 10^{10})^2}\right]$$

$$\underline{V_{bi} = 0.77657\ \text{V}}$$

c) $$V_{bi} = 0.025852 \ln\left[\frac{(10^{17})^2}{(1.5 \times 10^{10})^2}\right]$$

$$\underline{V_{bi} = 0.81241\ \text{V}}$$