Q.5] A p-n junction is doped with $N_A = 2 \times 1016\ cm^{-3}$ and $N_D = 9 \times 1015\ cm^{-3}$. Determine the capacitance of the device with $V_R = 0V$ and $V_R = 1V$.

→ We first obtain the built-in potential.

$$V_0 = V_T \cdot \ln\left(\frac{N_A N_D}{n_i^2}\right)$$

$$V_0 = 0.73\ V$$

Thus for $V_R = 0$ and $q = 1.6 \times 10^{-19}\ C$, we have

$$C_{j0} = \sqrt{\frac{\varepsilon_{si} q}{2} \cdot \frac{N_A N_D}{N_A + N_D} \cdot \frac{1}{V_0}}$$

$\varepsilon_{si} = 11.7 \times 8.85 \times 10^{-14}\ F/cm^{10}$

represents dielectric constant of silicon.

$$= \sqrt{\frac{11.7 \times 8.85 \times 10^{-14} \times 1.6 \times 10^{-19} \times 2 \times 1016 \times 9 \times 1015}{2 \times 2 \times 1016 \times 9 \times 1015 \times 0.73}}$$

$$= 2.65 \times 10^{-8}\ F/cm^2$$

$$\therefore C_{j0} = 0.265\ FF/\mu m^2$$

where 1 FF (Femto Farad) $= 10^{-15}\ F$.

For $V_R = 1V$

$$C_j = \frac{C_{j0}}{\sqrt{1 + \frac{V_R}{V_0}}}$$

$$= \frac{0.265}{\sqrt{1 + \frac{1}{0.73}}}$$

$$= \frac{0.265}{1.539}$$

$$\therefore C_j = 0.172\ FF/\mu m^2$$