

- 12.3 The parameters of the base region in a silicon npn bipolar transistor are $D_n = 18 \text{ cm}^2/\text{s}$, $n_{B0} = 4 \times 10^3 \text{ cm}^{-3}$, $x_B = 0.80 \text{ } \mu\text{m}$, and $A_{BE} = 5 \times 10^{-5} \text{ cm}^2$. (a) Comparing Equations (12.1) and (12.2), calculate the magnitude of I_S . (b) Calculate the collector current for (i) $v_{BE} = 0.58 \text{ V}$, (ii) $v_{BE} = 0.65 \text{ V}$, and (iii) $v_{BE} = 0.72 \text{ V}$.

a) From (12.1) & (12.2), $I_S = \frac{-e D_n A_{BE} n_{B0}}{x_B}$

$$I_S = \left| \frac{-1.6021766 \times 10^{-19} (18) 5 \times 10^{-5} (4 \times 10^3)}{0.8 \times 10^{-6} (100 \text{ cm/m})} \right|$$

$$\underline{\underline{I_S = 7.2098 \times 10^{-15} \text{ A}}}$$

b) Per (12.2), $i_c = I_S e^{V_{BE}/V_t}$

$$(7.10) V_t = \frac{k_B T}{e} = \frac{8.617333 \times 10^{-5} \text{ eV/K} (300 \text{ K})}{e} = 0.025852 \text{ V}$$

(i) $V_{BE} = 0.58 \text{ V}$

$$i_c = 7.21 \times 10^{-15} e^{\frac{0.58}{0.025852}} \Rightarrow \underline{\underline{i_c = 3.9948 \times 10^{-5} \text{ A}}}$$

(ii) $V_{BE} = 0.65 \text{ V}$

$$i_c = 7.21 \times 10^{-15} e^{\frac{0.65}{0.025852}} \Rightarrow \underline{\underline{i_c = 5.9902 \times 10^{-4} \text{ A}}}$$

(iii) $V_{BE} = 0.72 \text{ V}$

$$i_c = 7.21 \times 10^{-15} e^{\frac{0.72}{0.025852}} \Rightarrow \underline{\underline{i_c = 8.9824 \times 10^{-3} \text{ A}}}$$