EE 207 (MBP): Question Set 3

1. For a silicon *pnp* transistor, the base doping density is $N_{dB} = 10^{16}\,\text{cm}^{-3}$, the width of the neutral base region is $W = 1.2\,\mu\text{m}$, $\mu_p = 300\,\text{cm}^2/\text{V-s}$, $\tau_p = 0.1\,\mu\text{s}$, and cross-sectional area is $A = 5 \times 10^{-4}\,\text{cm}^2$. The transistor is biased in the active region with $V_{BE} = 0.65\,\text{V}$ at $300\,\text{K}$. What is Δp in the base region at the edge of the B-E depletion region? $(n_i = 1.5 \times 10^{10}\,\text{cm}^{-3})$

   (A) $2.23 \times 10^{16}\,\text{cm}^{-3}$
   (B) $7.85 \times 10^{16}\,\text{cm}^{-3}$
   (C) $9.60 \times 10^{15}\,\text{cm}^{-3}$
   (D) $1.87 \times 10^{15}\,\text{cm}^{-3}$

2. For the conditions given in Q-1, assume Δp in the neutral base region to be linear. What is I_C?

   (A) 1.5 mA   (B) 4.6 mA   (C) 9.7 mA   (D) 13.3 mA

3. For the conditions given in Q-1, what is the base transport factor α_T?

   (A) 0.991   (B) 0.956   (C) 0.936   (D) 0.982

4. If the injection efficiency of the BJT in Q-1 is 0.985 (for the same bias conditions), what is the transistor β?

   (A) 116   (B) 90   (C) 73   (D) 40

5. An *npn* silicon transistor has the following parameters: $N_{dE} = 10^{18}\,\text{cm}^{-3}$, $N_{aB} = 5 \times 10^{16}\,\text{cm}^{-3}$, $N_{dC} = 5 \times 10^{15}\,\text{cm}^{-3}$, $\mu_{nB} = 1000\,\text{cm}^2/\text{V-s}$, $\tau_{nB} = 0.1\,\mu\text{s}$, area $A = 5 \times 10^{-4}\,\text{cm}^2$. The metallurgical base width is $1.2\,\mu\text{m}$. The BJT is biased in the active mode, with $V_{BE} = 0.65\,\text{V}$ and $V_{CE} = 5\,\text{V}$ at $300\,\text{K}$. What is the width of the B-E depletion region? $(n_i = 1.5 \times 10^{10}\,\text{cm}^{-3}$ at $300\,\text{K}.)$

   (A) $0.095\,\mu\text{m}$ (B) $0.0744\,\mu\text{m}$ (C) $0.0528\,\mu\text{m}$ (D) $0.142\,\mu\text{m}$

6. In the BJT described in Q-5 (for the same bias conditions), what is the width of the B-C depletion region?

   (A) $1.2\,\mu\text{m}$ (B) $0.76\,\mu\text{m}$ (C) $0.57\,\mu\text{m}$ (D) $0.90\,\mu\text{m}$

7. In the BJT described in Q-5 (for the same bias conditions), what is the width of the neutral base region?

   (A) $0.92\,\mu\text{m}$ (B) $0.76\,\mu\text{m}$ (C) $1.02\,\mu\text{m}$ (D) $0.65\,\mu\text{m}$

8. In the BJT described in Q-5 (for the same bias conditions), what is the base transport factor α_T?

   (A) 0.992   (B) 0.998   (C) 0.989   (D) 0.985

9. In the BJT described in Q-5 (for the same bias conditions), $\mu_{pE} = 250\,\text{cm}^2/\text{V-s}$, and $\tau_{pE} = 0.2\,\mu\text{s}$. What is the emitter injection efficiency γ?.

   (A) 0.9924   (B) 0.9971   (C) 0.9896   (D) 0.9988

10. Consider a *pnp* silicon transistor at $300\,\text{K}$ with $N_{aE} = 10^{18}\,\text{cm}^{-3}$, $N_{dB} = 2 \times 10^{16}\,\text{cm}^{-3}$, $N_{aC} = 2 \times 10^{15}\,\text{cm}^{-3}$. The BJT is biased in the active mode, with $V_{EB} = 0.68\,\text{V}$. The other device parameters are $\mu_{pB} = 400\,\text{cm}^2/\text{V-s}$, area $A = 20 \times 10^{-4}\,\text{cm}^2$, and the metallurgical base width is $1.2\,\mu\text{m}$. What is the excess hole concentration at the B-E depletion region edge on the base side?

    $(n_i = 1.5 \times 10^{10}\,\text{cm}^{-3}$ at $300\,\text{K}$.)

    (A) $1.5 \times 10^{16}\,\text{cm}^{-3}$
    (B) $6.7 \times 10^{16}\,\text{cm}^{-3}$
    (C) $3.0 \times 10^{15}\,\text{cm}^{-3}$
    (D) $8.5 \times 10^{15}\,\text{cm}^{-3}$

11. For the BJT described in Q-10, what is W, the width of the neutral base region, for $V_{EC} = 5\,\text{V}$?

    (A) $1.02\,\mu\text{m}$ (B) $0.78\,\mu\text{m}$ (C) $0.81\,\mu\text{m}$ (D) $0.93\,\mu\text{m}$

12. For the BJT described in Q-10 with $V_{EC} = 5\,\text{V}$, what is I_C as given by the straight line approximation for $\Delta p(x)$ in the neutral base region?

    (A) 106 mA   (B) 54 mA   (C) 125 mA   (D) 71 mA

13. For a silicon *npn* transistor operating in the active mode at $300\,\text{K}$, $N_{dE} = 5 \times 10^{18}\,\text{cm}^{-3}$, $\mu_{pE} = 250\,\text{cm}^2/\text{V-s}$, $\mu_{nB} = 1000\,\text{cm}^2/\text{V-s}$, $\tau_{pE} = 0.1\,\mu\text{s}$, $\tau_{nB} = 0.05\,\mu\text{s}$, and the width of the neutral base region is $W = 0.8\,\mu\text{m}$. For an injection efficiency γ of 0.998, what value of N_{aB} is required?

    (A) $1.5 \times 10^{16}\,\text{cm}^{-3}$
    (B) $6.7 \times 10^{16}\,\text{cm}^{-3}$
    (C) $4.0 \times 10^{17}\,\text{cm}^{-3}$
    (D) $8.5 \times 10^{17}\,\text{cm}^{-3}$

14. For the BJT described in Q-13, what is the base transport factor α_T?

    (A) 0.991   (B) 0.9827   (C) 0.9934   (D) 0.9975

15. For the BJT described in Q-13, what is β?

    (A) 223   (B) 120   (C) 186   (D) 260