

EE 362 Electronic, Magnetic, & Opt. Prop. of Mat'ls Quiz 7 (Spring 2026)

Name KEY A

Instructions: Open book/notes. Place answers in indicated spaces and **show all** work for credit. Carry *at least 6* significant figures on constants/parameters in calculations. Give answers with **3-4** significant figures.

At 400 K, a semiconductor has $n_i = 6 \times 10^{11} \text{ #/cm}^3$, carrier lifetimes of $\tau_{n0} = 4 \times 10^{-7} \text{ s}$ & $\tau_{p0} = 8 \times 10^{-8} \text{ s}$, and diffusion coefficients $D_n = 28 \text{ cm}^2/\text{s}$ & $D_p = 12 \text{ cm}^2/\text{s}$. A pn junction is formed with acceptor concentration $7 \times 10^{17} \text{ #/cm}^3$ and donor concentration $6 \times 10^{16} \text{ #/cm}^3$. On the p-side, find the thermal equilibrium hole p_{p0} and electron concentrations n_{p0} (#/cm^3). Then, find the thermal voltage and electron diffusion length L_n (cm). At the edge of the depletion region $x = -x_p$, find the minority electron concentration n_p and diffusion current density J_n (A/cm^2) when a voltage of 0.5 V is applied.

$$\text{Since } N_a \gg n_i, p_{p0} \cong N_a \quad \Rightarrow \quad \underline{p_{p0} = 7 \times 10^{17} \text{ cm}^{-3}}.$$

$$\text{Per (4.43), } n_{p0} = n_i^2 / p_{p0} = (6 \times 10^{11})^2 / 7 \times 10^{17} \quad \Rightarrow \quad \underline{n_{p0} = 5.14286 \times 10^5 \text{ cm}^{-3}}.$$

$$\text{Per (7.10), } V_t = \frac{k_B T}{e} = \frac{8.617333 \times 10^{-5} \text{ eV/K (400K)}}{e} \quad \Rightarrow \quad \underline{V_t = 0.03446933 \text{ V}}.$$

$$\text{From p. 283, } L_n = \sqrt{D_n \tau_{n0}} = \sqrt{28 (4 \times 10^{-7})} \quad \Rightarrow \quad \underline{L_n = 0.00334664 \text{ cm}}.$$

$$\text{Per (8.6), } n_p = n_p(-x_p) = n_{p0} e^{V_a/V_t} = 5.14286 \times 10^5 e^{0.5/0.03446933} \quad \Rightarrow \quad \underline{n_p = 1.02548 \times 10^{12} \text{ cm}^{-3}}.$$

$$\begin{aligned} \text{Per (8.24), } J_n(-x_p) &= \frac{e D_n n_{p0}}{L_n} (e^{V_a/V_t} - 1) \\ &= \frac{1.602176634 \times 10^{-19} (28) 5.14286 \times 10^5}{0.00334664} (e^{0.5/0.03446933} - 1) \\ &\Rightarrow \underline{J_n = 0.001374634 \text{ A/cm}^2}. \end{aligned}$$

$$p_{p0} = \underline{7 \times 10^{17} \text{ cm}^{-3}} \quad n_{p0} = \underline{5.14286 \times 10^5 \text{ cm}^{-3}} \quad V_t = \underline{0.034469 \text{ V}}$$

$$L_n = \underline{0.0033466 \text{ cm}} \quad n_p = \underline{1.02548 \times 10^{12} \text{ cm}^{-3}} \quad J_n = \underline{0.0013746 \text{ A/cm}^2}$$

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Name KEY B

Instructions: Open book/notes. Place answers in indicated spaces and **show all** work for credit. Carry *at least 6* significant figures on constants/parameters in calculations. Give answers with **3-4** significant figures.

At 425 K, a semiconductor has $n_i = 8 \times 10^{11} \text{ \#/cm}^3$, carrier lifetimes $\tau_{n0} = 3 \times 10^{-7} \text{ s}$ & $\tau_{p0} = 7 \times 10^{-8} \text{ s}$, and diffusion coefficients $D_n = 29 \text{ cm}^2/\text{s}$ & $D_p = 13 \text{ cm}^2/\text{s}$. A pn junction is formed with acceptor concentration $7 \times 10^{17} \text{ \#/cm}^3$ and donor concentration $6 \times 10^{16} \text{ \#/cm}^3$. On the n-side, find the thermal equilibrium hole p_{n0} and electron concentrations n_{n0} (\#/cm^3). Then, find the thermal voltage and hole diffusion length L_p (cm). At the edge of the depletion region $x = x_n$, find the minority hole concentration p_n and diffusion current density J_p (A/cm^2) when a voltage of 0.5 V is applied.

$$\text{Since } N_d \gg n_i, n_{n0} \cong N_d \quad \Rightarrow \quad \underline{n_{n0} = 6 \times 10^{16} \text{ cm}^{-3}}.$$

$$\text{Per (4.43), } p_{n0} = n_i^2 / n_{n0} = (8 \times 10^{11})^2 / 6 \times 10^{16} \quad \Rightarrow \quad \underline{p_{n0} = 1.06667 \times 10^7 \text{ cm}^{-3}}.$$

$$\text{Per (7.10), } V_t = \frac{k_B T}{e} = \frac{8.617333 \times 10^{-5} \text{ eV/K} (425 \text{ K})}{e} \quad \Rightarrow \quad \underline{V_t = 0.036623665 \text{ V}}.$$

$$\text{From p. 283, } L_p = \sqrt{D_p \tau_{p0}} = \sqrt{13 (7 \times 10^{-8})} \quad \Rightarrow \quad \underline{L_p = 0.000953939 \text{ cm}}.$$

$$\text{Per (8.7), } p_n = p_n(x_n) = p_{n0} e^{V_a/V_t} = 1.066667 \times 10^7 e^{0.5/0.036623665} \quad \Rightarrow \quad \underline{p_n = 9.0610755 \times 10^{12} \text{ cm}^{-3}}.$$

$$\begin{aligned} \text{Per (8.22), } J_p(x_n) &= \frac{e D_p p_{n0}}{L_p} (e^{V_a/V_t} - 1) \\ &= \frac{1.602176634 \times 10^{-19} (13) 1.06667 \times 10^7}{0.000953939} (e^{0.5/0.036623665} - 1) \\ &\Rightarrow \quad \underline{J_p = 0.01978398 \text{ A/cm}^2}. \end{aligned}$$

$$p_{n0} = \underline{1.06667 \times 10^7 \text{ cm}^{-3}} \quad n_{n0} = \underline{6 \times 10^{16} \text{ cm}^{-3}} \quad V_t = \underline{0.0366237 \text{ V}}$$

$$L_p = \underline{0.00095394 \text{ cm}} \quad p_n = \underline{9.06108 \times 10^{12} \text{ cm}^{-3}} \quad J_p = \underline{0.019784 \text{ A/cm}^2}$$