

6.

$\delta p(0) = \Delta p$: excess hole concentration at the injection point.

$\delta p(w) = 0$: " " " " at $x=w$.

τ_p : hole-recombination life-time.

$w \gg L_p$, $\delta p(x) = ?$

SOLUTION:

$$\frac{\partial p(x,t)}{\partial t} = -\frac{1}{q} \frac{\partial J_p}{\partial x} - \frac{\delta p}{\tau_p} \quad : \text{continuity equation}$$

hole diffusion current: $J_p = -q \cdot D_p \frac{\partial p}{\partial x}$

$$p = p_0 + \delta p(x) \Rightarrow \frac{\partial p}{\partial x} = 0 + \frac{\partial \delta p(x)}{\partial x} \Rightarrow J_p = -q D_p \frac{\partial \delta p(x)}{\partial x}$$

$$\underbrace{\frac{\partial p(x,t)}{\partial t}}_{=0} = D_p \frac{\partial^2 \delta p}{\partial x^2} - \frac{\delta p}{\tau_p}$$

at steady-state

$$\Rightarrow \frac{\partial^2 \delta p}{\partial x^2} = \frac{\delta p}{D_p \tau_p} \quad ; \quad L_p = \sqrt{D_p \tau_p}$$

$$\Rightarrow \frac{\partial^2 \delta p}{\partial x^2} = \frac{\delta p}{L_p^2} \Rightarrow \text{solution has the form:}$$
$$\delta p(x) = C_1 e^{x/L_p} + C_2 e^{-x/L_p}$$

Constants C_1 and C_2 can be calculated using boundary conditions:

$$\text{at } x=0, \delta_p(x) = \Delta p$$

$$\delta_p(0) = \Delta p = C_1 + C_2 \quad \checkmark$$

$$\text{at } x=W, \delta_p(W) = 0$$

$$\delta_p(W) = 0 = C_1 e^{-W/L_p} + C_2 e^{W/L_p}$$

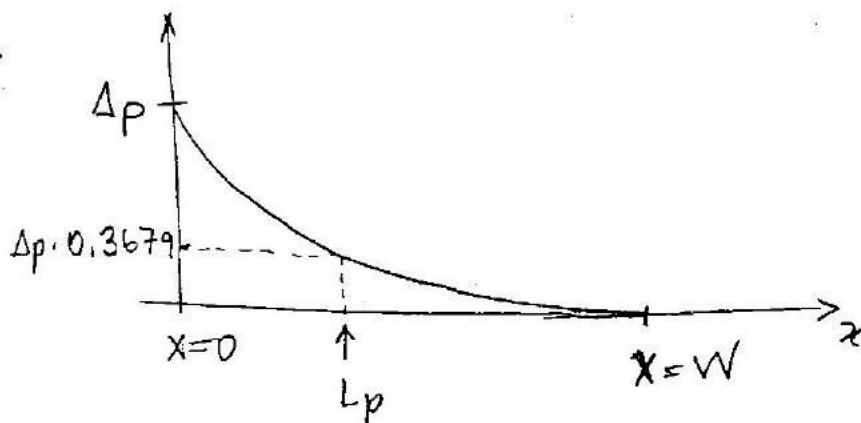
$$\text{since } W \gg L_p, e^{-W/L_p} = e^{-\infty} = 0$$

$$\text{and } C_2 e^{W/L_p} = C_2 e^{\infty} = 0 \Rightarrow C_2 = 0 \quad \checkmark$$

$$\Rightarrow C_1 = \Delta p \text{ and } C_2 = 0$$

Hence,

$$\delta_p(x) = \Delta p e^{-x/L_p}$$



where L_p is the mean diffusion length for holes.

5) SOLUTION:

a.) $\frac{\partial J_p}{\partial x} = 0$ since the bar is uniformly illuminated. There is no diffusion current. Drift current is zero since $\bar{E} = 0$.

$$\frac{\partial \delta_p(t)}{\partial t} = -\frac{\delta_p(t)}{\tau_p} \Rightarrow \delta_p(t) = \delta_p(0) e^{-t/\tau_p} \quad \delta_p(0) = \Delta p$$

$$\delta_p(t) = \Delta p e^{-t/\tau_p} \text{ cm}^{-3}$$

b) $\sigma = q(n \cdot \mu_n + p \cdot \mu_p)$ at $t = 5\tau_p$. $\delta_p(t)$ goes to almost zero therefore negligible,

hence: $\sigma = q(n_0 \mu_n + p_0 \mu_p) \Rightarrow \frac{1}{S} = \frac{1}{q(n_0 \mu_n + p_0 \mu_p)}$

$$n_0 \cong N_D \Rightarrow p_0 = \frac{n_i^2}{N_D} ; R_{\text{dark}} = \frac{S L}{w \cdot d} = \frac{L}{q w d (n_0 \mu_n + p_0 \mu_p)}$$

$$R_{\text{dark}} = \frac{L}{q w d (N_D \mu_n + \frac{n_i^2}{N_D} \cdot \mu_p)}$$

c.) $R(t) = \frac{S \cdot L}{w d} = \frac{L}{q(n \mu_n + p \mu_p) w d} ; \begin{cases} n = n_0 + \delta n \\ n = n_0 + \Delta p e^{-t/\tau_p} \\ p = p_0 + \Delta p e^{-t/\tau_p} \end{cases}$

$$R(t) = \frac{L}{q((N_D + \Delta p e^{-t/\tau_p}) \mu_n + (\frac{n_i^2}{N_D} + \Delta p e^{-t/\tau_p}) \mu_p) w d} \quad \Delta p = \Delta n, \quad \tau_p = \tau_n$$