

Q.1.)

a.) steady-state, continuous injection $\Rightarrow \frac{\partial p}{\partial t} = 0$

$E=0 \Rightarrow$ no drift current

$$J_p = -q D_p \frac{dp}{dx} = -q D_p \frac{d\delta_p}{dx} \quad \text{for } x > 0$$

then from continuity equation:

$$0 = D_p \frac{d^2 \delta_p}{dx^2} = -\frac{\delta_p}{\tau_p}$$

$$\delta_p(x) = A e^{x/L_p} + B e^{-x/L_p}$$

$$\text{for } x \rightarrow \infty \Rightarrow \delta_p(x) \rightarrow 0 \Rightarrow A = 0$$

$$\text{at } x = 0 \Rightarrow \delta_p = \Delta p \Rightarrow \delta_p(x) = \Delta p e^{-x/L_p} \quad \text{for } x \geq 0$$

b.) steady-state, continuous injection $\Rightarrow \frac{\partial p}{\partial t} = 0$

$E=0 \Rightarrow$ no drift current.

$$J_p = -q D_p \frac{dp}{dx} = -q D_p \frac{d\delta_p}{dx} \Rightarrow 0 = D_p \frac{d^2 \delta_p}{dx^2} = -\frac{\delta_p}{\tau_p}$$

$$\delta_p(-x) = C e^{x/L_p} + D e^{-x/L_p}$$

$$\text{at } x=0^- \Rightarrow \delta_p(0^-) = C + D = \Delta p$$

$$\text{at } x = -w \Rightarrow \delta_p(-w) = 0 = C e^{w/L_p} + D e^{-w/L_p}$$

due to the ohmic contact

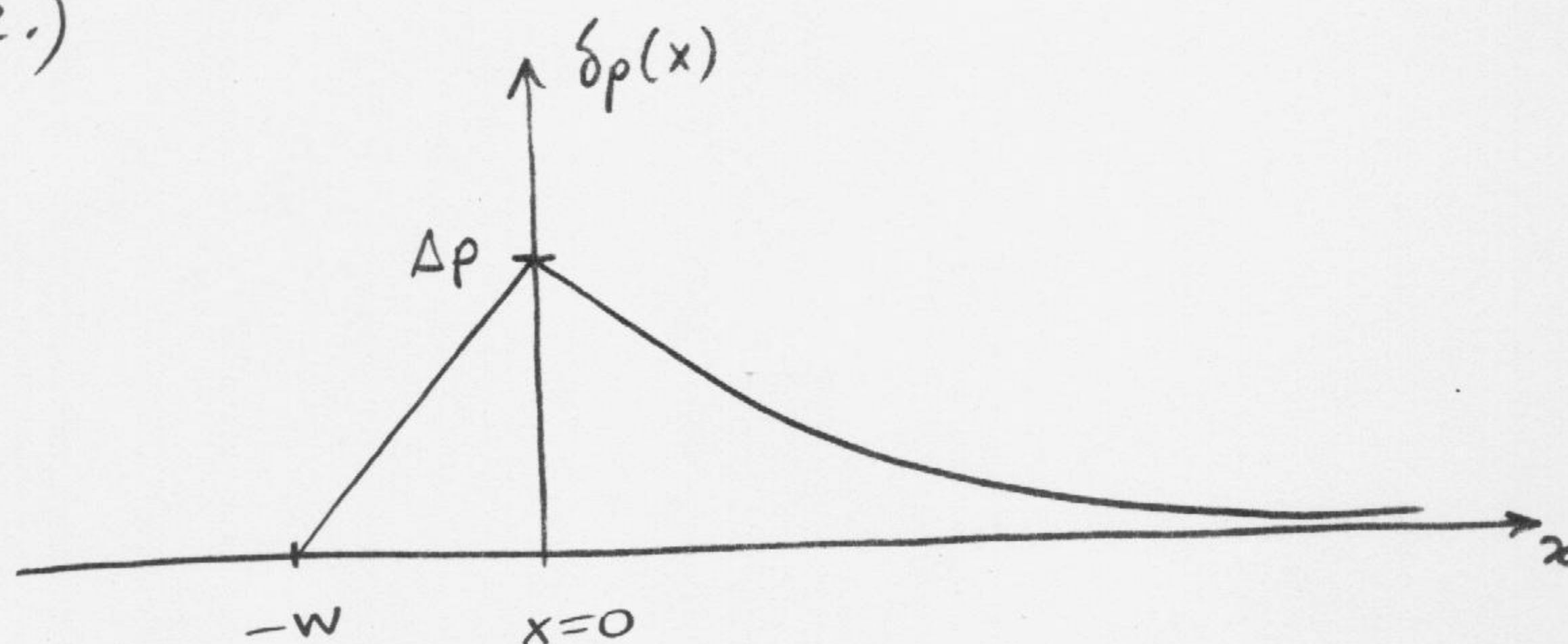
$$\Rightarrow \delta_p(-w) = 0 \Rightarrow C = 0 \quad \therefore D = \Delta p$$

$$\delta_p(-x) = \Delta p e^{-x/L_p} \quad \text{since } w \ll L_p$$

then the decrease with negative distance is

almost linear, starting from $\delta p(0^-) = \Delta p$
to $\delta p(-w) = 0$.

c.)



2.2.) $T = 300^\circ\text{K}$

$$N_D = 10^{14} \text{ atoms/cm}^3$$

$$N_A = 7 \times 10^{13} \text{ atoms/cm}^3$$

$$\mu_n = 3800 \text{ cm}^2/\text{Vsec.}$$

$$\mu_p = 1800 \text{ cm}^2/\text{Vsec.}$$

$$n_i = 10^{10} / \text{cm}^3 \text{ at } 300^\circ\text{K}$$

$$q = 1.6 \times 10^{-19} \text{ Coulombs}$$

mobilities are usually effected by doping. But here, it is assumed that mobilities does not change with doping.

a.) $n_0 = ?$, $p_0 = ?$ in the doped material at 300°K .

$$n_i^2 = n \cdot p$$

$$p = \frac{n_i^2}{n}$$

$$q(N_D + p - N_A - n) = 0 \quad \leftarrow \text{charge neutrality}$$

$$q\left(N_D + \frac{n_i^2}{n} - N_A - n\right) = 0$$

$$n N_D + n_i^2 - n N_A - n^2 = 0$$

$$n(N_D - N_A) + n_i^2 - n^2 = 0$$

$$n^2 - (N_D - N_A)n - n_i^2 = 0$$

$$n_0 = \frac{(N_D - N_A) \pm \sqrt{(N_D - N_A)^2 + 4n_i^2}}{2}$$

$$= \frac{(10^{14} - 7 \cdot 10^{13}) \pm \sqrt{(10^{14} - 7 \cdot 10^{13})^2 + 4 \cdot 10^{20}}}{2}$$

$$N_D - N_A \gg 2n_i$$

$$10^{14} - 0.7 \cdot 10^{14} \gg 2 \cdot 10^{10}$$

$$0.3 \cdot 10^{14} \gg 2 \cdot 10^{10}$$

$$n_0 = N_D - N_A$$

$$n_0 = 0.3 \cdot 10^{14} / \text{cm}^3$$

$$p_0 = \frac{n_i^2}{n_0} = \frac{10^{20}}{0.3 \cdot 10^{14}}$$

$$p_0 = 3.33 \times 10^6 / \text{cm}^3$$

$$\Rightarrow \begin{cases} n_0 = 0 / \text{cm}^3 \\ n_0 = 3 \cdot 10^{13} / \text{cm}^3 \end{cases} \quad \times$$

$$\Rightarrow p_0 = \frac{n_i^2}{n_0} = \frac{10^{20}}{3 \cdot 10^{13}} = 3.33 \times 10^6 / \text{cm}^3$$

b.) $J_T = ?$ for $E = 2 \text{ V/cm}$.

$$J_T = j_n + j_p = \underbrace{q(n \cdot \mu_n + p \cdot \mu_p)}_{\sigma} \cdot E$$

$$= (1.6 \times 10^{-19}) [3 \cdot 10^{13} (3800) + 3.33 \cdot 10^6 (1800)] \cdot 2$$

$$J_T = 0.03648 \text{ A/cm}^2 = 36.48 \frac{\text{mA}}{\text{cm}^2}$$

c.) $\sigma = q(n\mu_n + p\mu_p) = 18.2 \cdot 10^{-3} (\Omega \text{ cm})^{-1}$

as seen here by doping semiconductors conductivity is increased when compared with the conductivity of the intrinsic silicon which is,

$$\sigma = q(n_i \mu_n + n_i \mu_p) =$$

$$= (1.6 \times 10^{-19}) [10^{10} \cdot (3800) + 10^{10} (1800)]$$

$$= 8.96 \cdot 10^{-6} (\Omega \text{ cm})^{-1}$$