Recapitulation

5/9/2014

Excess Carriers due to photogeneration

$$\boxed{\frac{dp}{dt} = \frac{d(p_0+\delta p)}{dt} = \frac{d\,\delta p}{dt} = \underline{\underline{G_{th}}} - R + \underline{\underline{g_{op}}}}$$

$$\frac{d\,\delta p(t)}{dt} = \underline{G_{th}} - \underline{R} = -\alpha_r(n_0+p_0)\delta p \qquad g_{op} = 0$$

(low level generation)

$$\delta p(t) = \delta p(t=0)\, e^{-t/\tau_p} \qquad \tau_p = \frac{1}{\alpha_r(n_0+p_0)}$$

$$\frac{d}{dt}\delta p(t) = G_{th} - R + g_{op} = 0$$

Steady State

$$g_{op} = \frac{\delta p}{\tau_p}$$

$$g_{op} = \frac{\delta n}{\tau_n}$$

$$\delta p \uparrow, \delta n \uparrow \longrightarrow p \uparrow, n \uparrow \longrightarrow \sigma_p \uparrow, \sigma_n \uparrow$$

$$\Delta\sigma$$

Continuity Eqn

$$\nabla \times H = J_c + \frac{d}{dt} D .$$

$$D = \epsilon E$$

$$\nabla \cdot (\nabla \times H) = 0 = \nabla \cdot J_c + \frac{d}{dt}(\nabla \cdot D)$$

$$\nabla \cdot J_c + \frac{d}{dt}\rho = 0$$

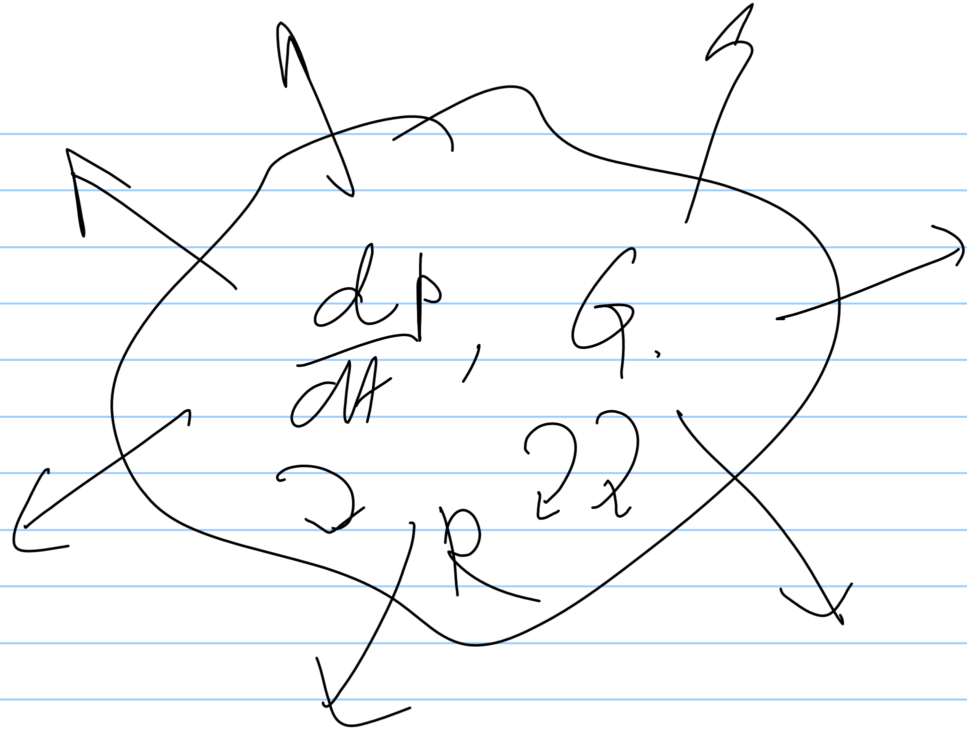
$$\boxed{\frac{d}{dt}\rho = -\nabla \cdot J_c} \rightarrow \text{Continuity Eqn.}$$

$$\frac{dp}{dt} = -\frac{1}{q} \nabla \cdot J_p \quad \text{---} \; (1)$$

$$\frac{dp}{dt} = G - R \quad \text{---} \; (2)$$

$$\boxed{\frac{dp}{dt} = -\frac{1}{q} \nabla \cdot J_p + G - R}$$

Continuity Eqn. of hole in semicond.



$$\frac{dn}{dt} = -\frac{1}{-q}\nabla\cdot J_n + \underline{\underline{G - R}}$$

$$n = n_0 + \delta n$$

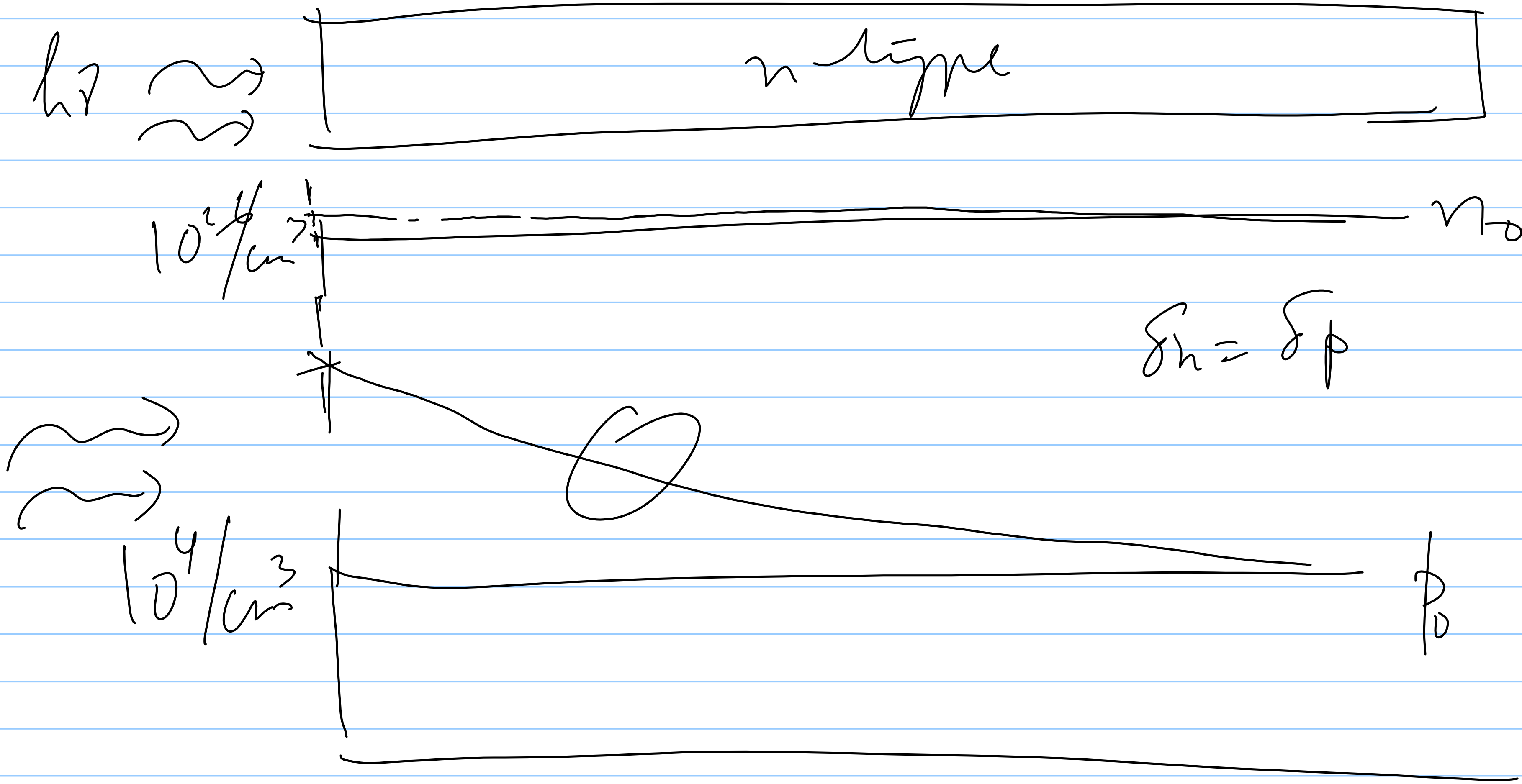
$$\boxed{\frac{d\delta n}{dt} = \frac{1}{q} \nabla \cdot J_n - \frac{\delta n}{\tau_n}}$$ Continuity Eqn. for electron

$$G_{th} - R = \alpha_r n_0 p_0 - \alpha_r (n_0 + \delta n)(p_0 + \delta p)$$

$$= -\alpha_r (n_0 + p_0)\delta n - \alpha_r \delta n^2$$

$$= -\frac{\delta n}{\tau_n}$$

$$\boxed{\frac{d\delta p}{dt} = -\frac{1}{q} \nabla \cdot J_p - \frac{\delta p}{\tau_p}}$$ → Continuity Eqn for hole


hν
n-type
$10^{16}/cm^3$
n_0
$\delta n = \delta p$
$10^4/cm^3$
p_0

$$0 = \frac{d}{dt}\delta p = -\frac{1}{q}\frac{d}{dx}J_p - \frac{\delta p}{\tau_p}.$$

steady state

$$\frac{d}{dx}\left(J_p/q\right) = -\frac{\delta p}{\tau_p}$$

$$J_p = -q D_p \frac{dp}{dx}$$

$$\frac{d^2}{dx^2}\left(D_p \delta p\right) = \frac{\delta p}{\tau_p}$$

$$\boxed{\frac{d^2\delta p(x)}{dx^2} = \frac{\delta p(x)}{(\tau_p \cdot D_p)} = \frac{\delta p}{L_p^2}}$$

$L_p \rightarrow$ Diffusion length $\qquad L_p = \sqrt{D_p \tau_p}$

$\mu_p = 500\ cm^2/V\text{-}s$

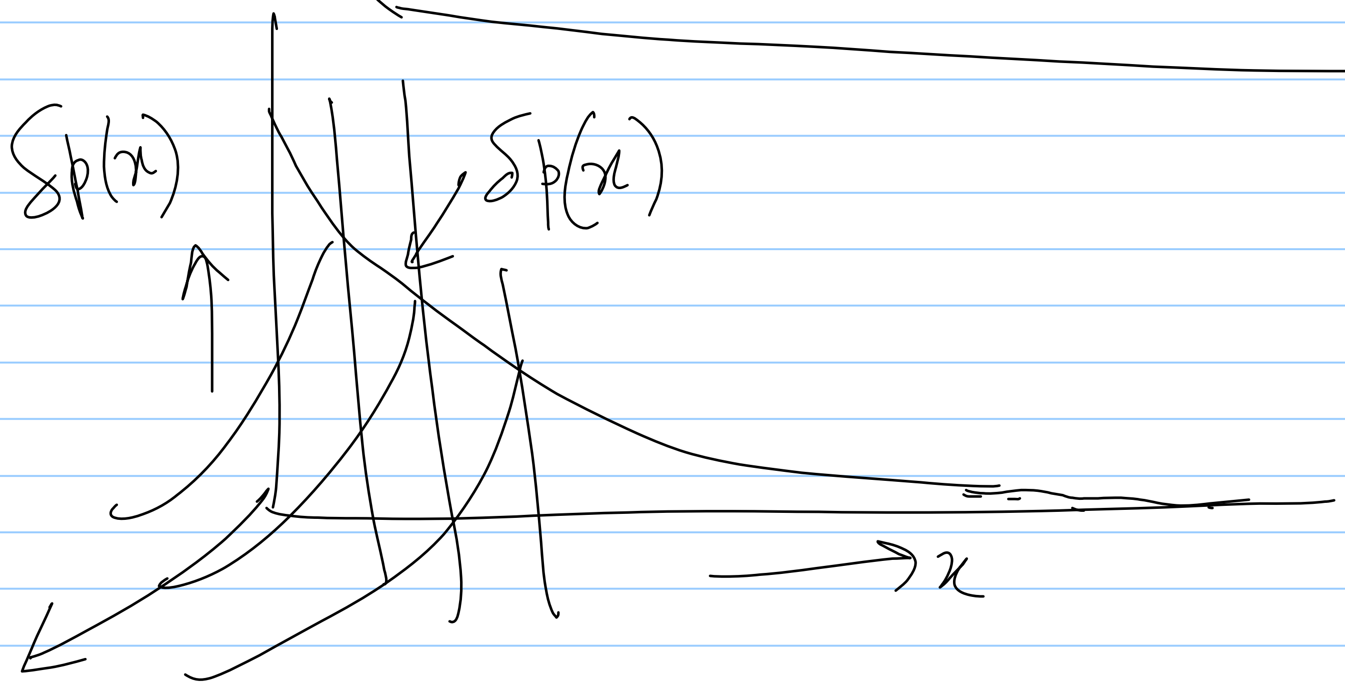
$D_p = V_T \cdot \mu_p = 0.0259 \times 500$

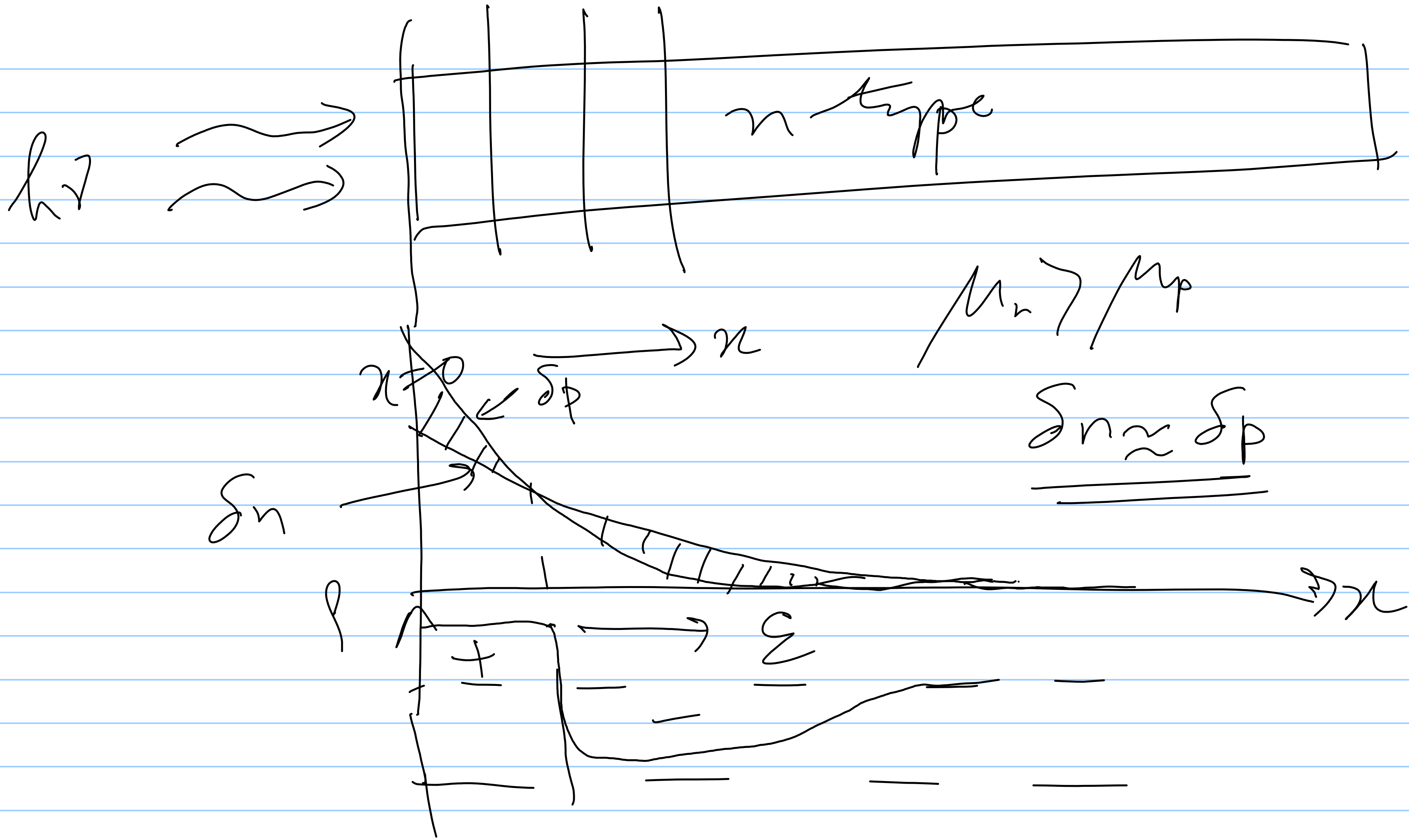
$\simeq 10\ cm^2/s$

$D_p \tau_p = 10\ cm^2 \cdot \times 10^{-6} = 10 \times 10^{-6}\ cm^2$

$$\delta p(x) = \delta p(x=0) \exp\left(-\frac{x}{L_p}\right)$$

$$\delta p(t) = \delta(t=0) \exp\left(-t/\tau_p\right)$$





$\mu_n > \mu_p$

$\delta n \approx \delta p$

J_{drift}

n.

p

J_{diff}

$\frac{dn}{dx}$

$\frac{dp}{dx}$

$\Longrightarrow J_{p, diff} =$

$\Longleftarrow J_{n, diff}$

$\longrightarrow J_{p, drift}$ X

$\longrightarrow J_{n, drift}$.

$$|J_{p\,diff}| = |J_{n\,diff}| - |J_{n, drift}|$$

$$J(x) = 0$$

$x = 0 \qquad \delta p(x=0) = 10^{16}/cm^3$

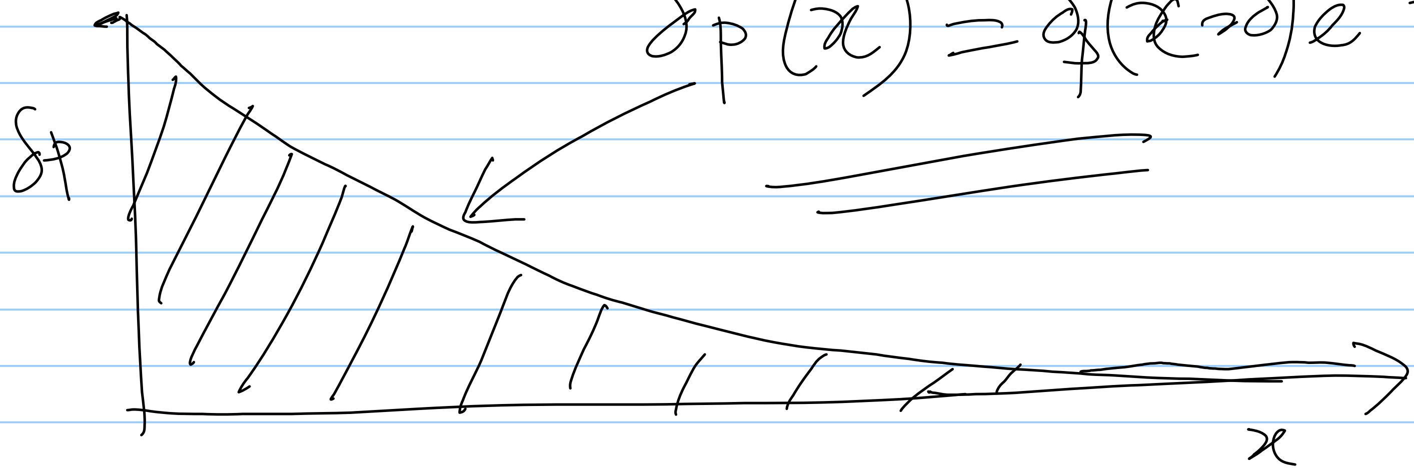
Cross-sectional Area $A = 10^{-3}\ cm^2$

$L_p = 10^{-3}\ cm$

$\tau_p = 10^{-6}\ sec.$

$$\delta p(x) = \delta p(x=0)\, e^{-x/L_p}$$

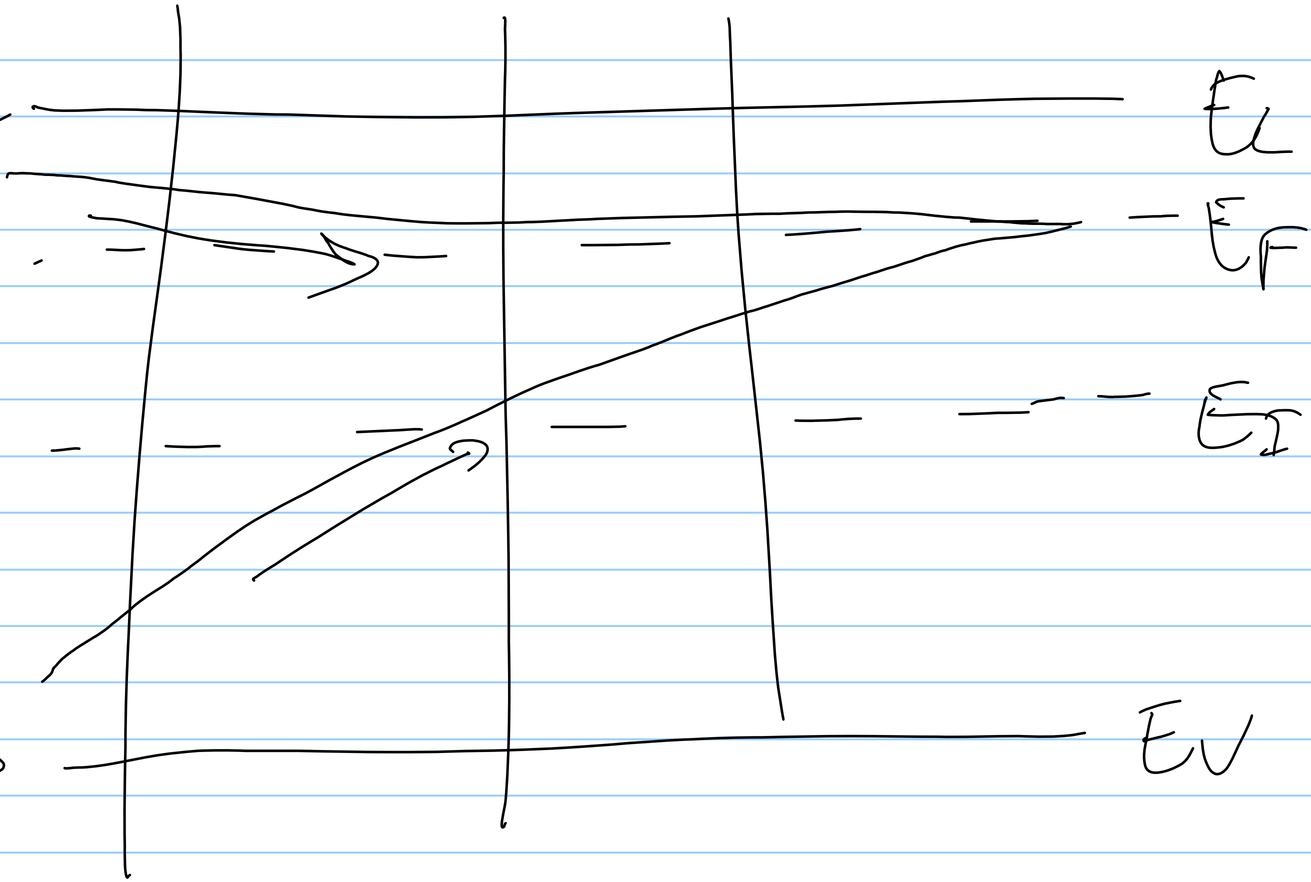
$\delta Q_p = ?$



$J_p = J_{p\,drift} + J_{p\,diff}$

$$\boxed{J_p = p\mu_p \frac{dE_{fp}}{dx}}$$

$$\boxed{J_n = n\mu_n \frac{dE_{fn}}{dx}}$$



$$J_p = p q \mu_p \mathcal{E} - q D_p \frac{dp}{dx}$$

$$p = n_i \exp\left(\frac{E_I - E_{fp}}{kT}\right)$$

$$\mathcal{E} = -\frac{dV}{dx} = +\frac{1}{q} \cdot \frac{d}{dx}(qV) = +\frac{1}{q}\frac{d}{dx}E_I$$

$$J_p = p q \mu_p \frac{1}{q}\frac{d}{dx}E_I - q D_p p \cdot \frac{1}{kT}\frac{d}{dx}(E_I - E_{fp})$$

$$= p \mu_p \frac{d}{dx}E_{fp}$$