ECE 305 Spring 2018

Homework 3 solution

1. a. p≈N_A≈ 4×10^{16} cm^{-3}

b. $n = \frac{n_i^2}{p} = \frac{10^{20}}{4\times10^{16}} = 2500$ cm^{-3}

c. Assuming p varies linearly: dp/dx=Δp/Δx=$(8 \times 10^{16} - 4 \times 10^{16})/(300 \times 10^{-4})$=1.333× 10^{18} cm^{-4}

$J_{p,diff} = -qD_p \frac{dp}{dx}$ = -2.56 A cm^{-2} (using Diffusion coefficient, or mobility, of holes in Si from literature)

d. Total current zero, so $J_{p,drift} = -J_{p,diff} = 2.56$ A cm^{-2}

$J_{p,drift} = pq\mu_p\mathcal{E}_x$, so

$\mathcal{E}_x(x) = \frac{J_{p,drift}}{p(x)q\mu_p}$, where $p(x)$ is approximated to be linearly varying with x, such that:

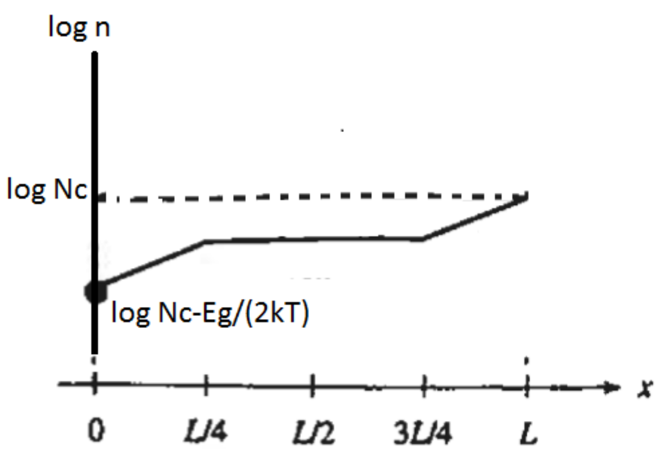
$p(x) = 8 \times 10^{16} - \frac{(4\times10^{16})}{300\times10^{-4}} (x)$ cm^{-3}, if $x = 0$ at top.

2.

a. $n = N_C e^{(E_F - E_C)/kT}$

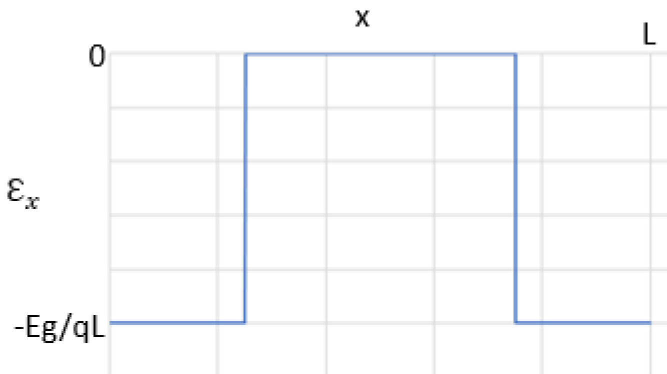
log n= log N_C + $(E_F - E_C)/kT$

$E_F - E_C: -\frac{Eg}{2} at\ x = 0$, linearly varying to $-\frac{Eg}{4}$ at x=L/4, remaining constant until x=L/4, then linearly varying to 0 at x=L



b. $\mathcal{E}_x$=$\frac{1}{q}$dE_c/dx

$$\mathcal{E}_x = \begin{cases} (-\frac{\mathrm{Eg}}{4})/(\frac{\mathrm{qL}}{4}) = -\mathrm{Eg}/(\mathrm{qL})\ 0 < \mathrm{x} < \mathrm{L}/4 \\ 0 \quad \mathrm{L}/4 < \mathrm{x} < 3\mathrm{L}/4 \\ -\mathrm{Eg}/(\mathrm{qL}) \quad 3\mathrm{L}/4 < \mathrm{x} < \mathrm{L} \end{cases}$$



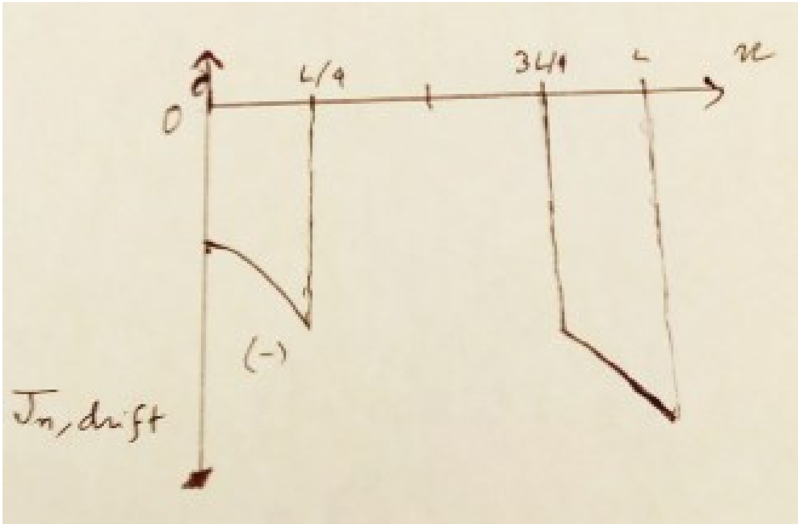
$J_{n,drift} = nq\mu_n\mathcal{E}_x$, where $n = N_C e^{(E_F - E_C)/kT}$

$$E_F - E_C = \begin{cases} -\frac{Eg}{2}\left(1 - \frac{2x}{L}\right) \quad 0 < x < L/4 \\ -\frac{Eg}{4} \quad \frac{L}{4} < x < \frac{3L}{4} \\ \frac{Eg}{L}(x - L) \quad \frac{3L}{4} < x < L \end{cases}$$

Therefore,

$J_{n,drift} =$

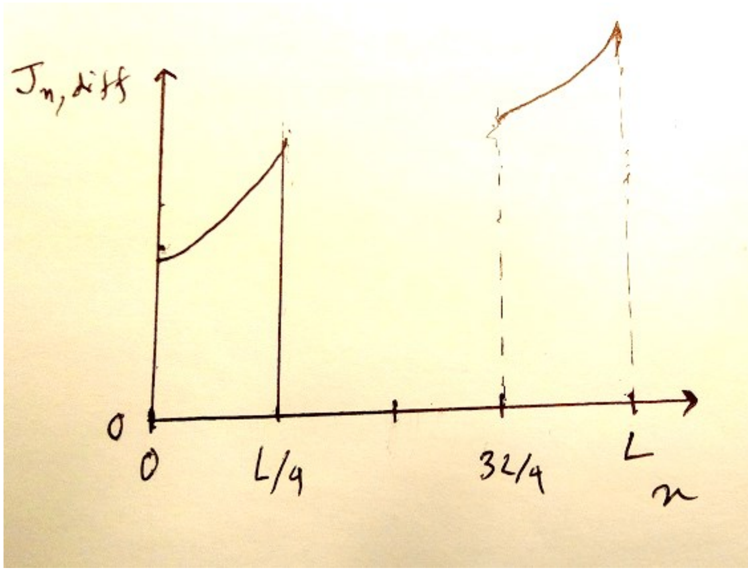
$$\begin{cases} -\frac{Eg}{qL} nq\mu_n N_C e^{\left(-\frac{Eg}{2}\left(1-\frac{2x}{L}\right)\right)/kT} \quad 0 < x < L/4 \\ 0 \quad \frac{L}{4} < x < \frac{3L}{4} \\ -\frac{Eg}{qL} nq\mu_n N_C e^{\left(\frac{Eg}{L}(x-L)\right)/kT} \quad \frac{3L}{4} < x < L \end{cases} = \begin{cases} -\frac{Eg}{L} n\mu_n N_C e^{\left(-\frac{Eg}{2}\left(1-\frac{2x}{L}\right)\right)/kT} \quad 0 < x < L/4 \\ 0 \quad \frac{L}{4} < x < \frac{3L}{4} \\ -\frac{Eg}{L} n\mu_n N_C e^{\left(\frac{Eg}{L}(x-L)\right)/kT} \quad \frac{3L}{4} < x < L \end{cases}$$



$J_{n,diff} = qD_n \frac{dn}{dx} = kT\mu_n \frac{dn}{dx}$ where $n = N_C e^{(E_F - E_C)/kT}$

$$E_F - E_C = \begin{cases} -\frac{Eg}{2}\left(1 - \frac{2x}{L}\right) & 0 < x < L/4 \\ -\frac{Eg}{4} & \frac{L}{4} < x < \frac{3L}{4} \\ \frac{Eg}{L}(x - L) & \frac{3L}{4} < x < L \end{cases}$$

$$J_{n,diff} = \begin{cases} \frac{Eg\mu_n}{L}\left(N_C e^{\left(-\frac{Eg}{2}\left(1-\frac{2x}{L}\right)\right)/kT}\right) & 0 < x < L/4 \\ 0 & \frac{L}{4} < x < \frac{3L}{4} \\ \frac{Eg\mu_n}{L}\left(N_C e^{\left(\frac{Eg}{L}(x-L)\right)/kT}\right) & \frac{3L}{4} < x < L \end{cases}$$



$J_{n,diff}$ *and* $J_{n,drift}$ add upto 0, thus the system is in equilibrium. This is consistent with the fact that Fermi Level remains at the same energy throughout the length.