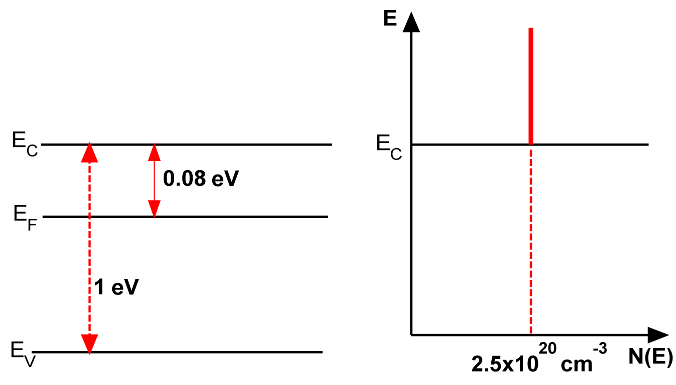
Faculty of Engineering – Shoubra Department: **Electrical Eng.** Semester: **Fall 2013**		**Course: ECE 111:** **Electronic Engineering Fundamentals** **Instructor**: **Dr.** Abdallah Hammad
Total Grade: **20**	**Mid Term Exam solution**	Number of questions: **4** - Time allowed: **90 Min**

***Answer all questions*: write each question number and part number ahead of your answer**

$K=1.38\times10^{-23}$ J/K $h=6.64\times10^{-34}$ J.s $q=1.6\times10^{-19}$ C $m_o=9.1\times10^{-31}$ Kg

(1) A semiconductor has the energy band diagram shown in figure 1-a. Assume that the density of states in the conduction band is represented by figure 1-b. Calculate the free electrons concentration. (T = 300 K)



(a) Figure 1 (b)

$$n=\int_{Ec}^{\infty}F(E)N(E)dE$$

$$n=\int_{Ec}^{\infty}\frac{1}{1+e^{\frac{E-E_F}{KT}}}2.5\times10^{20}dE$$

$$n=\int_{Ec}^{\infty}e^{-\frac{E-E_F}{KT}}\,2.5\times10^{20}dE$$

$$n=\int_{Ec}^{\infty}e^{-\frac{E-E_F}{KT}}\,2.5\times10^{20}dE$$

$$n=2.5\times10^{20}\int_{Ec}^{\infty}e^{-\frac{E-E_F}{KT}}dE$$

$$n=-2.5\times10^{20}KT\left[e^{-\frac{E-E_F}{KT}}\right]_{E_c}^{\infty}=2.5\times10^{20}KT\left[e^{-\frac{E-E_F}{KT}}\right]_{\infty}^{E_c}$$

$$n=2.5\times10^{20}KTe^{-\frac{E_c-E_F}{KT}}=2.5\times10^{20}\times0.026\times e^{-\frac{0.08}{0.026}}=2.99\times10^{17}\ \ \text{cm}^{-3}$$

(2) A Si sample in figure 2 is doped with $2x10^{17}$ cm^{-3} donors. (Given: μ_n=1350 cm^2/V.s, μ_p= 400 cm^2/V.s n_i =1.5x 10^{10} cm^{-3}, T = 300 K, L = 0.5 cm, d = 0.6 mm, W = 0.4mm and V= 1V).

Calculate:

a) The drift velocity of electrons
b) The total drift current
c) The resistance of the bar.

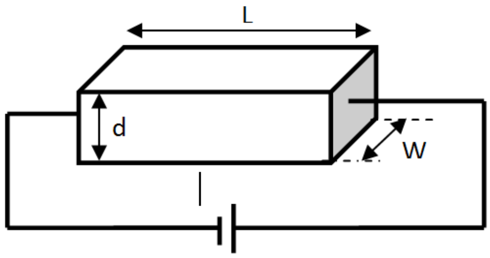


Figure 2

(3) A bar of silicon of length 0.5 x 10^{-3}cm is illuminated at one end creating $\Delta n = \Delta p = 10^{13}$ cm^{-3} excess electrons and holes. If the diffusion length L_p for the minority holes is 5 x 10^{-3} cm and if all the excess electrons and holes recombine at the other end of the bar. Calculate and plot the steady-state excess minority hole distribution $\delta p(x)$ as function of the distance along the bar.

(Hint Use the approximation, $e^y = 1+y$, for $y \ll 1$)

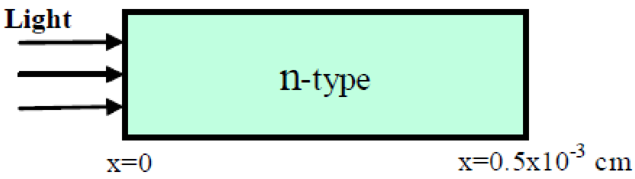


Figure 3

(4)

a- **Drive an expression for the mobility of carriers in semiconductor.**

b- **The hole concentration in a semiconductor specimen is shown in figure (4).**
Find an expression and plot the hole current density Jp(x) for the case in which, there is no externally applied electric field.

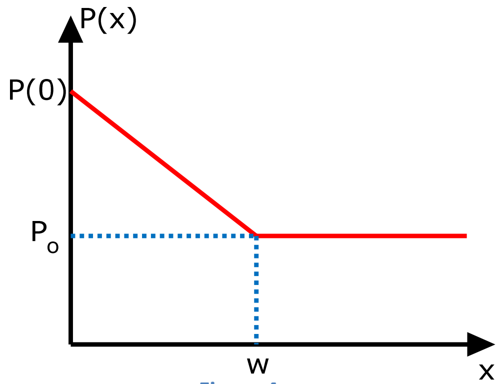


Figure 4

Good Luck