Benha University Faculty of Engineering- Shoubra Electrical Engineering Department First Year communications.		1st semester Exam Date: 30-12-2013 ECE111: Electronic Engineering fundamentals Duration : 3 hours
▪ Answer all the following questions ▪ Illustrate your answers with sketches when necessary. ▪ The exam consists of two pages.		▪ No. of questions: 5 ▪ Total Marks: 90 Marks ▪ Examiners: Dr. Ehsan Abaas – Dr. Abdallah Hammad

$K=1.38\times10^{-23}$ J/K	$h=6.64\times10^{-34}$ J.s	$q=1.6\times10^{-19}$ C	$m_o=9.1\times10^{-31}$ Kg	$\varepsilon_o=8.85\times10^{-14}$ F/cm
[Si] $m_e=1.08\ m_o$	[Si] $m_h=0.81\ m_o$	[Si] $E_g=1.12$ eV	[Si] $n_i=1.5\times10^{10}$ cm^{-3}	[Si] $\varepsilon_{rs}=11.7$

Question 1 (18 marks)

* Use the given data in the table for the pure Silicon

a- **(5 marks)** Calculate the effective density of states for electrons and holes in silicon at T= 300 K.

b- **(5 marks)** Calculate the intrinsic carrier concentration at T=300 K (based on your results in part a)

c- **(4 marks)** Calculate the position of the intrinsic Fermi level relative to the mid energy gap.

d- **(4 marks)** Consider, the silicon is doped with donors, so that the Fermi energy level is shifted to be 0.2 eV below the edge of the conduction band, Calculate the thermal equilibrium electron and hole concentration.

Question 2 (18 marks)

a- **(10 marks)** A semiconductor material has electron and hole mobilities μ_n and μ_p respectively. When the conductivity is considered as a function of the hole concentration p_o:

i- Show that the corresponding hole concentration for the minimum conductivity is given by $p_0 = n_i\sqrt{\mu_n/\mu_p}$

ii- Show that the minimum value of conductivity σ_{min} can be written as $\sigma_{\min} = \dfrac{2\sigma_i\sqrt{\mu_n\mu_p}}{(\mu_n+\mu_p)}$ where σ_i is the intrinsic semiconductor conductivity.

b- **(8 marks)** The electron concentration in a semiconductor is given by $n = 10^{16}(1-x/L)$ cm^{-3} for $0 \le x \le L$ where L = 10 μm. The electron mobility is μ_n =1000 cm^2/V-s. An electric field is applied such that the total electron current density is a constant (J_n= -80 A/cm^2) over the given range of x. Determine and plot the required electric **field** as function of (x)

Question 3 (18 marks)

a- **(8 marks)** Consider a *p* type semiconductor that is exposed to the light for a long time ($t<0$). Suddenly (At $t=0$) the light source is removed. Derive and plot the excess of minority electrons as a function of time. (Assume that $\Delta n \ll p_o$)

b- **(10 marks)** An excess electron concentration of 10^{12} m^{-3} is maintained at one side of a bar of p-type semiconductor. The excess electron distribution along the bar is given by the solution of the diffusion equation. Calculate the diffusion current density at the side where the injection is maintained. Assume that the temperature is 300°K, the minority carriers mobility = 0.1 m^2/V.s and the minority carrier lifetime = 0.01 μs.

(P.T.O) >>>>

Question 4 (18 marks)

a- **(4 marks)** Define the barrier potential of the un-biased pn junction.
b- **(10 marks)** Derive and draw the relation between the applied voltage and the current in the *pn* junction, then discuss diode approximations.
c- **(4marks)** Draw the energy band diagram for the pn junction under
  i- Thermal equilibrium
  ii- Forward bias
  iii- Reverse bias

Question 5 (18 marks)

Consider a pn junction, both n and p sides are cube of side length 5 μm.
The properties of the ***p side*** at T=300 K are: $N_A=10^{14}$ cm^{-3}, τ_n= 20 μS, μ_p = 400 cm^2/V.S and μ_n = 1000 cm^2/V.S.
The properties of the ***n side*** at T=300 K are: $N_D=10^{18}$ cm^{-3}, τ_p=0.2 μS, μ_p = 300 cm^2/V.S and μ_n = 800 cm^2/V.S.

a- **(3 marks)** For the pn junction under thermal equilibrium, sketch the:
  i- Charge density
  ii- The electric field
  iii- The electric potential
b- **(8 marks)** For the pn junction under thermal equilibrium Calculate:
  i- The built in potential.
  ii- The depletion region width W.
  iii- The junction capacitance.
  iv- The peak electric field
c- **(7 marks)** Calculate the current passing through the junction when:
  i- The junction is forward biased by 0.4 V.
  ii- The junction is reverse biased by 2V.

Good Luck