Benha University
Faculty of Engineering- Shoubra
Electrical Engineering Department
First Year communications.

1st semester Exam
Date: 29-12-2014
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	$\varepsilon_o=8.85\text{x}10^{-14}$ F/cm
[Si] $n_i=1.5\text{x}10^{10}$ cm^{-3}	[Si] $\varepsilon_{rs}=11.7$	[Si] $E_g=1.12$ eV	[Ge] $n_i=2\text{x}10^{12}$ cm^{-3}	

Question 1 (18 marks)

For the following statements, mark (√) for true statement and (X) for wrong statement and ***correct*** it.

1 Fermi level is located above the intrinsic level in n-type Si and below it in p-type Si. ( )

2 In n-type Si, as doping concentration increases, Fermi level moves toward the conduction band edge. ( )

3 For a reverse biased pn junction, as the reverse bias voltage increases the depletion capacitance increases ( )

4 For the same doping level, the conductivity of the p-type Si is higher than that of n-type Si . ( )

5 Holes move in the opposite direction of the applied electric field. ( )

6 In a pn junction, depletion region extends more in lightly doped side than in heavily doped side. ( )

7 Forward biased pn junction can be used as a variable capacitor (varactor). ( )

8 Drift current arises when there is a change in carrier concentration. ( )

9 The intrinsic carrier concentration of a semiconductor decreases as its energy gap increases. ( )

10 The mass action law is valid at thermal equilibrium in intrinsic semiconductors only ( )

11 When an intrinsic semiconductor is doped with N_D donors, the new electron concentration is: $n = n_i + N_D$ ( )

12 At very high temperatures, doped semiconductors tend to be intrinsic ( )

13 With the rise in temp around 300 k the conductivity of an intrinsic semiconductor decrease ( )

14 The Hall effects occur only in (metals, intrinsic, and extrinsic) ( )

15 The depletion region in the pn junction is depleted of immobile charge ( )

16 The depletion region in the pn junction is reduced when the junction is forward bias ( )

17 When the diode is reveres bias it is equivalent to off switch ( )

18 As the time between collisions increases, the mobility decreases ( )

Question 2 (18 marks)

a- **(9 marks)** Silicon semiconductor at T = 300 K is doped with donors atoms of $N_D = 3 \times 10^{10}$ cm^{-3}.Assume ni = 1.5×10^{10} cm^{-3}. Calculate:

i- The thermal-equilibrium electron and hole concentrations in the sample.
ii- The Fermi energy level with respect to the intrinsic Fermi level at T = 300 k.

(P.T.O) >>>>

b- **(9 marks)** The electron concentration in Silicon at T = 300 K is given by: $n(x) = 10^{16} \exp\left(\frac{-x}{18}\right) \mathrm{Cm}^{-3}$ Where *x* is measured in **µm** and is limited to $0 \le x \le 25$ µm. The electron diffusion coefficient is D_n =25 cm^2/s. The electron current density through the semiconductor is constant and equal to J_n = - 40 A/cm^2. The electron current has both diffusion and drift current components. Determine the electric field as a function of x which must exist in the semiconductor.

Question 3 (18 marks)

a- **(9 marks)** Germanium is doped with 5 x 10^{17} **donor** atoms per cm^3 at T = 300 K. The dimensions of the Hall device shown in Figure. 1 are t = 5x10^{-3} cm, d = 2x10^{-2} cm. and W= 0.1 cm. The current is I_x = 250 µA. The applied voltage is V_x = 100 mV. The magnetic flux density is B_z = 5 x 10^{-2} tesla (Wb/m^2). Calculate:

- i- The Hall voltage.
- ii- The Hall Electric field.
- iii- The carrier mobility.

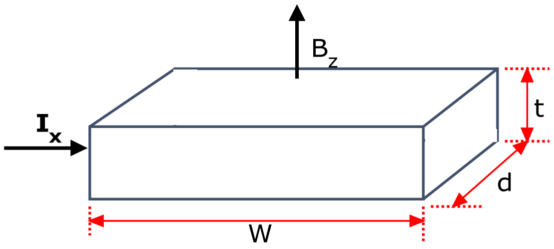

Figure 1

b- **(9 marks)** Silicon P$^+$n junction has N_A = 10^{18} cm^{-3} and N_D = 5 x 10^{15} cm^{-3}.The cross-sectional area of the junction is A = 5 x 10^{-5} cm^{-2}. Calculate

- i- The junction capacitance for V_R = 3V
- ii- Show that the curve ($[1/C]^2$ versus V_R) can be used to find N_D and V_o.

Question 4 (18 marks)

a- **(9 marks)** The charge distribution of an abrupt pn junction is shown in Figure. 2

- i- Derive an expressions for the electric field in the region $-x_p < x < x_n$.
- ii- By using Poisson's Equation find the expressions for the potential distribution in the region $-x_p < x < x_n$

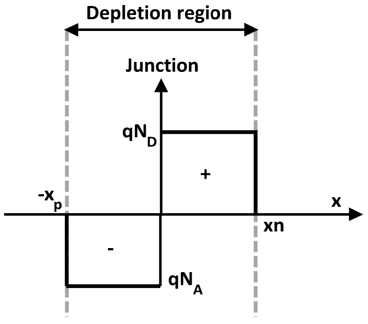

Figure 2

b- **(9 marks)** A silicon pn junction diode is doped such that $E_F = E_V + 5KT$ on the p-side and $E_F = E_C - 4KT$ on the n-side.

- i- Draw an equilibrium energy band diagram of this junction.
- ii- Calculate the built-in voltage at 300K. Given that Eg =1.12 eV
- iii- If the donor concentration N_D= 6.2x10^{17} cm^{-3}, Calculate N_A

Question 5 (18 marks)

a- **(6 marks)** Define: barrier potential, Static forward resistance, PIV, Reverse Stauration current.

b- **(6 marks)** Assuming an ideal diode, the dc output across the resistor V_{dc} =2 V.

- i- Sketch (**V_i, V_D, I_D**) for the half-wave rectifier of Figure. 3. The input is a sinusoidal waveform with a frequency of 50 Hz.
- ii- Determine the PIV of the diode.

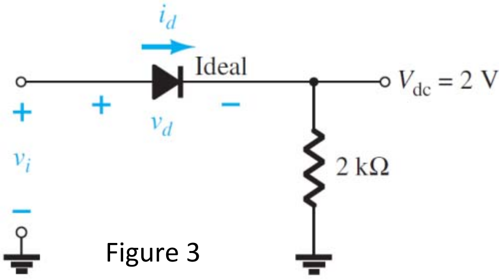

Figure 3

c- **(6 marks)** Consider a silicon pn junction with the following parameters.
$N_D = 10^{16}$ cm^{-3} N_A = 5x10^{16} cm^{-3}, n_i= 1.5x10^{10} cm^{-3}
$\tau_n = \tau_p$=5x10^{-7} S, D_p = 10 cm^2/S, D_n= 25 cm^2/S, ε_{rs}= 11.7, and the cross sectional area is 10^{-3} cm^2
Calculate the reverse saturation current I_o.

Good Luck

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