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

1st semester Exam
Date: 3-01-2016
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
- Examiner: 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] $n_i=1.5\times10^{10}$ cm^{-3}	[Si] $\varepsilon_{rs}=11.7$	[Si] $E_g=1.12$ eV	[GaAS] $n_i=1.8\times10^{6} cm^{-3}$	[Ge] $n_i=2\times10^{12}$ cm^{-3}

Question 1 (18 marks)

a- Define each of the following (no more than 3 lines each) **(8 marks)**
Depletion region – Depletion Capacitance – Static resistance – dynamic resistance – PIV

b- In a semiconductor, the Fermi level is 250 meV below the conduction band edge. What is the probability of finding an electron in a state 1.5 KT below the valance band edge EV at room temperature [Eg=1.12ev]? **(5 marks)**

c- Silicon at T=300 K contains an acceptor impurity concentration of $N_A=10^{16}$ cm^{-3}. Determine the concentration of donor impurity atoms that must be added so that the silicon is n type and the Fermi energy is 0.20 eV below the conduction-band edge. **(5 marks)**

Question 2 (18 marks)

a- Draw the energy band diagram for Insulator – Semiconductor – Metals (indicate all the energy levels on you graph). **(5 marks)**

b- A silicon semiconductor is in the shape of a rectangular bar with a cross-section area of 100 μm^2. A length of 0.1 cm. and is doped with 5×10^{16} cm^{-3} arsenic atom. The temperature is T = 300 K. given that $\mu_n=1100$ $cm^2/V.s$ and $\mu_p=300$ $cm^2/V.s$ **(6 marks)**

- i- Determine the current if 5 V is applied across the length.
- ii- Calculate the average drift velocity of electrons, and holes

c- The Germanium sample in figure (1) is doped with 5×10^{15} donor atoms per cm^3 at T=300 K. The dimensions of the Hall device are $d = 5 \times 10^{-3}$ cm, $W = 2 \times 10^{-2}$ cm. and $L = 10^{-1}$ cm. The current $I_x = 250$ µA, the applied voltage $V_x = 100$ mV, and the magnetic flux density is $B_z = 5 \times 10^{-2}$ Tesla. ($n_i=2\times10^{12}$ cm^{-3}) **(7 marks)**

Calculate:

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

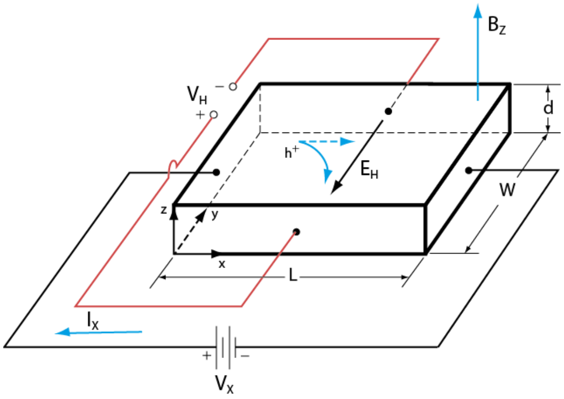

Figure 1

Question 3 (18 marks)

a- Compare between avalanche break down and Zener break down. **(7 marks)**

b- Consider a uniformly doped GaAs pn junction at T = 300 K. The junction capacitance at zero bias is C(0) and the junction capacitance with a 10V reverse bias voltage is C(10). The ratio of the two capacitances is 3.13. Also under reverse bias, the space charge width in to the p region is 0.2 of the total space charge width. Determine V_o N_D, N_A. **(6 marks)**

c- For a pn junction, if the reverse saturation current at T=300 K is 1.5×10^{-9} A. What will be its value at T=500 K. **(5 marks)**

>>> PTO >>>

Question 4 (18 marks)

a- With the help of figure (2) for the minority carrier distribution in the pn junction under external applied voltage *Va*, Show that $I = I_o(e^{\frac{qV_a}{KT}} - 1)$. **(9 marks)**

b- In the circuit shown in figure (3), the diode is a silicon diode, I is a dc current of 1 mA, and ***vs*** is a sinusoidal signal with a peak value of 10 mV. Capacitors C_1 and C_2 are very large, their function is to couple the signal to and from the diode but block the dc current from flowing into the signal source or the load (not shown). Let *Rs* = 1 kΩ. **(9 marks)**

- i- Determine the v_D, i_D.
- ii- Use the diode small-signal model to show that the ac signal component of the output voltage is:

$$v_o = v_s \frac{V_T}{V_T + IR_S}$$

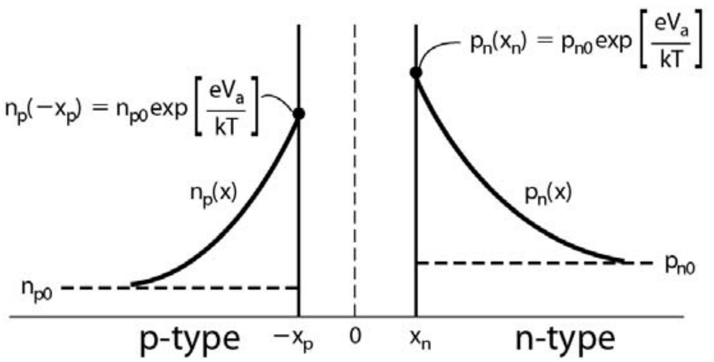

Figure 2

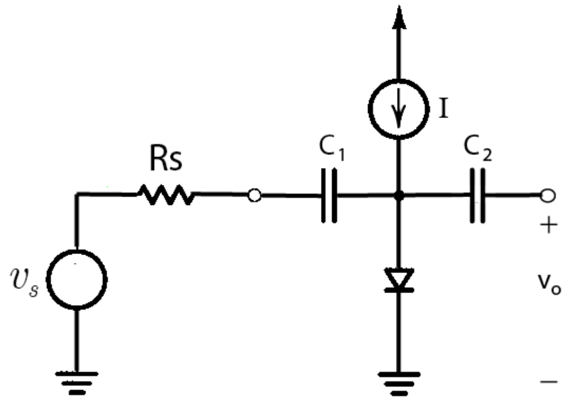

Figure 3

Question 5 (18 marks)

a- Mention the data-sheet specifications for the diode. **(5 marks)**

b- For the circuit shown in figure (4-a), both diodes have the same IV characteristics shown in figure (4-b).

- i- Identify where are the operating points of both diodes on the characteristics curve.
- ii- Calculate numerical values for V_{D1}, V_{D2} and I **(6 marks)**

c- For the full wave rectifier circuit shown in figure (5), if the diodes are silicon diodes and N_P:N_S = 10:1 **(7 marks)**

- i- Calculate Vs(p), Vo(p), V_{avg}, PIV, f_{out}.
- ii- Draw the waveforms I_{D1}, I_{D3}.
- iii- Calculate the average values for I_{D1}, I_{D3} and I_L.

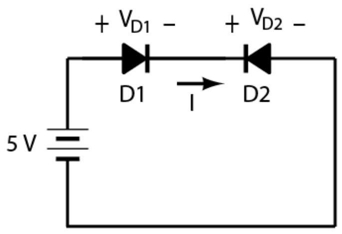

Figure 4-a

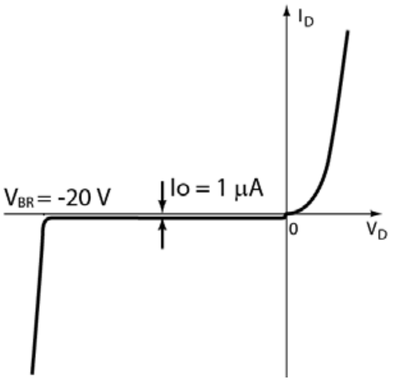

Figure 4-b

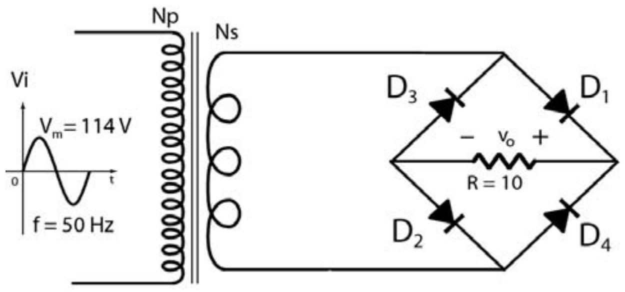

Figure 5

Good Luck