This question paper contains 4 printed pages.]

Your Roll No. ....

1387

B.Sc. (H) ELECTRONICS / II Sem. A

Paper – ELHT-202

Semiconductor Devices

(Admission of 2010 and onwards)

Time : 3 Hours **Maximum Marks : 75**

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt **five** questions in all.
Question No. **1** is compulsory.
Attempt **two** questions from each Section.
Use of Scientific Calculators is allowed.

1. Attempt any **five** of the following : **3 × 5**

   (a) Show that the probability that a state ΔE above the Fermi level E_f is filled equals the probability that a state ΔE below is empty.

   (b) The effective mass of a conduction band electron in a semiconductor is 0.1 m_0. Calculate the energy of this electron measured from the bottom of the conduction band edge if the K vector is 0.3 A^{-1}.

(c) Sketch the space charge, electric field and energy band diagram for an abrupt p-n junction at equilibrium.

(d) A n-p-n transistor with $\alpha = 0.98$ is operated in common base configuration. If the emitter current is 3 mA and the reverse saturation current is 10 μA. Find the value of base and collector current.

(e) What is the meaning of intrinsic stand off ratio in UJT ?

(f) Which device has the highest drain current in saturation at zero gate voltage – p-type enhancement MOSFET or n-type depletion MOSFET ? What is the reason for high input resistance of ☐ MOSFET ?

(g) State Moore's law. Define MSI, LSI, VLSI, ULSI and GSI technologies.

SECTION – A

2. (a) Show that the density of state for conduction band is given by **8**

$$N(E) = 4\pi \left(\frac{2\,m_n}{h^2}\right)^{3/2} (E - E_C)^{1/2}$$

per unit volume. Using this expression, determine the electron density in the conduction band.

(b) Describe the temperature dependence of the carrier density in an extrinsic semiconductor. Intrinsic semiconductor material A has an energy gap of 0.36 eV while material B has an energy gap of 0.72 eV. Compare the intrinsic densities of carriers in these two semiconductors at 300 K. Assume that the effective masses of all the electrons and holes are equal to the free electron mass. **4 + 3**

3. (a) Derive the ideal diode equation for an abrupt p-n junction. 8

(b) Explain the working of silicon controlled rectifier (SCR) using two transistor equivalent circuit. Explain the function of gate. 7

4. (a) Discuss different modes of operation of a BJT. Draw the minority carrier profile for these modes. Explain the input and output characteristics of p-n-p transistor in common-emitter (CE) configuration. What do you understand by base width modulation ? Explain its consequences. 8

(b) Show that capacitance of an abrupt p-n junction varies inversely with the square root of junction potential. 7

SECTION – B

5. (a) Explain the working of a uni-junction transistor (UJT). What is negative resistance region ? 8

(b) An abrupt Si ($n_i = 10^{10}$ cm^{-3}) p-n junction consists of a p-type region containing 10^{16} cm^{-3} acceptors and an n-type region containing 5×10^{16} cm^{-3} donors. Given $E_s = 11.8 \in_0$.

(i) Calculate the built in potential of this p-n junction.

(ii) Calculate the total width of the depletion region if the applied voltage $V_a = 0$ V, 0.5 V, + 0.5 V.

(iii) Calculate maximum electric field in the depletion region at 1.0 V.

(iv) Calculate the potential across the depletion region in the n-type semiconductor at – 2.5 V. **(2, 3, 1, 1)**

6. (a) Why do bands bend near the semiconductor surface for the ideal MOS structure under different biasing conditions ? Explain accumulation, depletion and inversion. **8**

   (b) Describe the different steps involved in wafer fabrication. **7**

7. (a) Explain various steps involved in the fabrication of n-p-n transistor. What is the significance of burried layer in BJT fabrication ? **8**

   (b) Define transconductance (g_m) and channel conductance (g_d) of a JFET. Find the pinch off voltage of a Si p-channel FET having half channel height of 2 μm and channel resistivity of 10 Ω cm. The dielectric constant of Si is 12 ϵ_0 and the mobility of holes is 500 cm^2/V-S. **4 + 3**

   $\epsilon_0 = 8.854 \times 10^{-12}$ F/cm
