Ex/BESUS/ ETC-406/ ***06***

B.E. (CST) Part-II 4th Semester Examination, 2006

Physical Electronics

(ETC-406)

Time : 3 hours **Full Marks : 100**

Use separate answerscript for each half.
Answer SIX questions, taking THREE from each half.
Two marks are reserved for neatness in each half.

FIRST HALF

(The questions are of equal value.)

1. An electron starting from rest is accelerated by a uniform electric potential V. Derive an expression for the velocity of the electron when V is small.

   Derive also the expression for velocity of the electron and its mass when accelerated by a electric potential V which is very large. Use the expressions to find the electron vel^ocitv^aiid^J^ mass of the electron when C i) V ~ 5 0^000 Volts, (ii) 1,00,000 Volts, (iii) 5,00,000 Volts.

2. A charged particle with electric charge + 18e and mass m_p = 1840 m_e (where e = electron charge = 1.6x10" Coulomb and m_e - electron rest mass = 9.11x10" kg) enters a uniform magnetic field B with a velocity v meters/sec corresponding to an accelerating potential of 3000 V in a direction at right angles to the field.

   Show that the path followed by the particle is a circle. Find the radius R and time period T if B = 10,000 Gauss.

3. a) What do you understand by the following terms :
   (i) Hole , (ii) Ionisation energy , (iii) amphoteric dopant.
   Define the term 'Fermi level'.

   b) Draw the energy band diagram of
   (i) p-type semiconductor , (ii) n-type semiconductor , (iii) compensated semiconductor having ionized and unionized donors and acceptors.

4. An electron is injected into a region of uniform crossed electric and magnetic fields and with a finite initial velocity normal to the magnetic field. Derive expressions for the trajectory of the electron and show that it is trochoidal in nature.

5. a) Find, from first principles, the expression for the thermal equilibrium electron concentration for the conduction band in silicon.

   b) Show that the Fermi level in an intrinsic semiconductor is located at the centre of the energy band gap.

SECOND HALF

6. a) Write two main differences between semiconductors and insulations. Give example of IV-VI, III-V and II-VI type compound semiconductors. Which type is suitable for infra red sensor?

   b) Draw typical E-K diagrams for direct and indirect band gap semiconductors and semimetals. What do you understand by 'K' here?

   c) What is effective mass? Calculate the approximate donor binding energy for Ge? [e_r= 16, m_n* = 0.12 m_0].

7. a) What is drift current? Consider a sample of silicon at T = 3 00°K doped at an impurity concentration of N^ = 10 cm and N_a = 10 cm . The electron and hole mobilities are u_n = 1350 cm^2/V-S and u_p = 480 cm^2/V-S, respectively. Calculate the drift current density if the applied electric field is E = 35 V/cm.

   b) An intrinsic Si-sample is doped with donors from one side such that N<j = NQ exp

   • (-ax). Find E(x) at equilibrium for N<j» Nj. Evaluate E(x) when a= 1 (^m)"^{1}.

8. a) Draw the band diagrams of a p-n junction for equilibrium, forward bias and reverse bias.

   b) What is Schottky barrier? Using band diagrams explain how a metal-semiconductor junction behaves like a diode.

   c) Draw the I-V characteristics curve of a photo-voltaic cell. What is fill factor? Draw the equivalent circuit of the photo-voltaic cell. [6+(l+4)+(2+l+2)]

9. a) Draw the I-V characteristics curve of a p-n junction diode. Consider a p-n junction at T = 300°K so that nj = 1.5x10^{10}cm"^{3}. Assume the n-type doping is 1 x 10^{16}cm~^{3} and assume that a forward bias of 0.6 V is applied to the p-n junction. Calculate the minority carrier hole concentration at the edge of the space charge region.

b) What do you understand by 'impact ionisation'? What are the main differences between Zener and Avalanche breakdown.

c) "Aluminium does not make good ohmic contact with n-silicon" - why? How to overcome this problem? [(2+6)+(2+4)+(l+l)]

10. a) Draw a p-n-p transistor and show the electron and hole flow at different regions.

b) A p-n-p transistor is doped such that the emitter doping is twelve times that in base, the minority carrier mobility in the emitter is one-half of that in base, and the base width is one-tenth the minority carrier diffusion length. The carrier lifetimes are equal. Calculate a and p.

c) Draw the simplified hybrid *n*- equivalent circuit of a transistor. For a BJT, if x_n = 2.5 kQ and c^ = 2pF, then calculate the cutoff frequency. [4+6+(2+4)]