53 (IE 303) EEMD

2018

ELECTRICAL ENGG. MATERIALS AND DEVICES

Paper : IE 303

Full Marks : 100

Time : Three hours

The figures in the margin indicate full marks for the questions.

Answer ***any five*** *questions.*

1. *(a)* Write the names of the important properties of a material used in electrical engineering. What is the value of the mass of an electron ? 3+2=5

   (b) Assume the energy of two particles in the field of each other is given by the following function of the distance r between the centres of the particles :

   $$W(r) = -(\alpha / r) + (\beta / r^{\delta})$$

   where α and β are constants. Determine the value of r to form a stable compound with these two particles.

5

(c) An electron in a hydrogen atom makes a transition from a quantum state of principal quantum number $n = 2$ to the ground state. What is the energy and what is the frequency f of the emitted light quantum? 10

2. (a) Write Gauss theorem and its mathematical expression. 5

(b) What is elemental dielectric? 5

(c) With reference to a two-dimensional Cartesian coordinate system x, y, four point charges are located as follows : a charge of Q coulombs in the point $(0, 0)$; $-Q$ in $(1, 0)$; $2Q$ in $(1, 1)$; and $-2Q$ in $(0, 1)$; the numbers refer to meters. Find the magnitude and direction of the dipole moment of the system. 10

3. (a) What is the difference between ionic and electronic polarization? Discuss with the help of diagrams of string of ions. 5

(b) Discuss the decay of the orientational polarization of a liquid upon switching-off the electric field. 5

(c) Consider a parallel plate condenser with a lossy dielectric between them. At an angular frequency ω let the dielectric be characterised by a complex dielectric constant $\epsilon_r^* = \epsilon_r' - j\epsilon_r''$. The area of the plates is $1m^2$, the distance between them $1m$. For an applied voltage $V(t) = V_0 \cos \omega t$ show that the current through the lossy condenser is given by

$$i(t) = (\epsilon_0 \epsilon_r'' \omega V_0)\cos \omega t - (\epsilon_0 \epsilon_r' V_0 \omega)\sin \omega t$$

10

4. (a) What is Circular Bohr Orbit model? Derive the magnetic dipole moment of this model. 5

(b) Discuss the classification of magnetic materials. 5

(c) Show that an electron with a velocity perpendicular to the direction of a homogeneous magnetic field of flux density B describes a circular path with an angular velocity of rotation equal to eB/m where e is electron charge, m is mass of electron. 10

5. *(a)* What is Hall-effect and who observed this phenomenon for the first time? Find an expression for Hall voltage generated in a rectangular piece of semiconductor material. 2+8=10

(b) Explain how *p*-type and *n*-type semiconductors are formed from intrinsic semiconductors. 5+5=10

6. *(a)* What do you mean by diffusion current? How does it differ from drift current of electrons? Derive the Einstein's relation related to diffusion current for a semiconductor material. 2+8=10

(b) How the concentration of charge carriers can be found in semiconductors from mass-action law? 6

(c) The resistivity of intrinsic Germanium at 300*K* is 0·47 *ohm-m*. If the electron and hole mobilities are 0·38 and $0 \cdot 18 m^2 . volt^{-1} sec^{-1}$, calculate the intrinsic carrier density at 300*K*. 4

7. *(a)* What do you mean by superconductivity? Briefly explain. Also write some application of superconductivity. 6+4=10

(b) A conduction wire has resistivity of $1{\cdot}54 \times 10^{-8}$ *ohm-m* at room temperature. There are $5{\cdot}8 \times 10^{+28}$ conduction electrons per m^3. Calculate

(i) the mobility and relaxation time of electrons

(ii) the average drift velocity of the electrons when the electric field applied to the conductor is 1 *volt/cm*. 5

(c) The resistivity of a doped silicon sample is $8{\cdot}90 \times 10^{-3}$ *ohm-m*. The hole-coefficient was measured to be $3{\cdot}6 \times 10^{-4}\ m^3$ */coloumb*. Assuming single carrier conduction, find the mobility and density of charge carriers. 5