53 (IE 303) EEMD

2014

ELECTRICAL ENGG. MATERIALS AND DEVICES

Paper : IE 303

Full Marks : 100

Pass Marks : 30

Time : Three hours

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

*Answer **any five** questions.*

1. *(a)* What are the quantities that determine the physical behaviour of a given material ? 3

   (b) What is continuous charge distribution ? 2

   (c) Write the names of the *three* quantum numbers. Also write the relation between them. What is the electronic configuration of potassium $(z = 19)$? 6

(d) Calculate the kinetic energy, the potential energy and the total energy of an electron in the ground state of a hydrogen atom according to the theory of Bohr. 9

2. (a) What is the difference between ionic and electronic polarization ? 3

(b) Show that in a dielectric subjected to an electric field E, each volume element may be thought of as carrying an electric dipole moment which is proportional to the field strength. 7

(c) A condenser of 1 *microfarad* contains titanium oxide (TiO_2) as a dielectric with $\in_r = 100$. For an applied *d-c* voltage of 1000 *volts*, find the energy stored in the condenser as well as the energy stored in polarizing the titanium oxide. Answer the same questions for a 1-*microfarad* mica condenser, assuming a dielectric constant $\in_r = 5{\cdot}4$ for mica. 10

3. *(a)* State Bio Savart's law with an example. 3

(b) Write the classification of magnetic materials. 5

(c) What is ferromagnetic Curie temperature ? 2

(d) Two infinite parallel conductors carry parallel currents of 10 *amperes* each. Find the magnitude and direction of the force between the conductors per meter length if the distance between them is 20*cm*. 10

4. *(a)* Define relaxation time of the electrons. Derive the expression of the mobility of the electrons. 8

(b) Write the relation between relaxation time of the electron and the resistivity of the metal. 2

(c) A uniform silver wire has a resistivity of $1{\cdot}54\times10^{-8}$ *ohm m* at room temperature. For an electric field along the wire of 1 *volt* cm^{-1} compute the average drift velocity of the electrons, assuming there are $5{\cdot}8\times10^{28}$ conduction electrons per m^3. Also calculate the mobility and relaxation time of the electrons. 10

5. *(a)* Write on the following : 10

(i) alternating field

(ii) restoring force

(iii) damping

(iv) natural or resonance angular frequency

(b) Consider a parallel plate condenser with a lossy dielectric between them. At an angular frequency ω let the dielectric be characterized by a complex dielectric constant $\in_r^* = \in_r' - j \in_r''$. 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

$$i(t) = (\in_0 \in_r'' v_0) \cos \omega t - (\in_0 \in_r' v_0 \omega) \sin \omega t$$ 10

6. *(a)* Write the differences between metals and semiconductors. 3

(b) What is the difference between intrinsic semiconductors and extrinsic semiconductors ? 3

(c) What is energy gap ? 4

(d) The resistivity of intrinsic germanium at $27°C$ is equal to $0{\cdot}47 ohm\ m$. Assuming electron and hole mobilities of respectively $0{\cdot}38$ and $0{\cdot}18 m^2\ volt^{-1} sec^{-1}$, calculate the intrinsic carrier density ni at $27°C$. 10

7. (a) A charge of Q coulombs is distributed homogeneously throughout the volume of a sphere of radius R meters ; the sphere is in vacuum. Find the flux density D, the field strength E and the potential V as a function of the distance from the center of the sphere for $O \leq R \leq \alpha$; assume $V(\alpha)=0$. 10

(b) Consider a parallel arrangement of a capacitance C and a resistance R. An external voltage $V(t)=V_0 \cos \omega t$ is applied to this arrangement. Show that the total current $i(t)$ is given by $i(t)=(V_0/R)\cos \omega t - e_\omega V_0 \sin \omega t$.

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