53 (IE 303) EEMD

2017

ELECTRICAL ENGINEERING 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)* Discuss how the effect of temperature on resistance varies for the following types of materials — 10

   (i) Pure metals

   (ii) Insulators and semiconductors

   (iii) Alloys.

   Draw necessary diagrams.

(b) Two conductors, one of copper and the other of iron, are connected in parallel and carry equal currents at 25°C. What proportion of current will pass through each if the temperature is raised to 100°C ? The temperature co-efficients of resistance at 0°C are 0·0043/°C and 0·0063/°C for copper and iron respectively. 10

2. (a) What is drift velocity of electrons in a conductor material ? Derive an expression for drift velocity. Also obtain the relation between mobility and conductivity. 2+5+3=10

(b) A conduction wire has resistivity of $1{\cdot}54\times10^{-8}$ *ohm-m* at room temperature. There are $5{\cdot}8\times10^{28}$ conduction electrons per m^3. Calculate — 5

(i) The mobility and relaxation time of the electrons.

(ii) The average drift velocity of the electrons when the electric field applied to the conductor is $1\,volt.cm^{-1}$.

(c) How high resistivity materials are divided in groups according to their applications ? Discuss about *any one* application of high resistivity materials. 5

3. (a) From the concept of energy band, differentiate between insulator, conductor and semiconductor. 10

(b) The conductivity of an intrinsic semiconductor is given by —

$$\sigma_i = \eta_i e^2 \left(\tau_e / m_e + \tau_n / m_n \right)$$

Derive the above relation. 5

(c) Calculate the Hall voltage across the width of a semiconducting specimen from the following data — 5

Width of specimen = $0{\cdot}1m$,

thickness of the specimen = $0{\cdot}01m$,

field applied perpendicular to width and length = $0{\cdot}6T$,

Current flowing lengthwise = $10mA$,

Hall co-efficient = $3{\cdot}8 \times 10^{-4}\ m^3/C$.

4. *(a)* Make comparisons between ionic crystals and valence crystals. 5

(b) What are the quantities that determine the physical behaviour of a given material ? 5

(c) 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. 10

5. *(a)* Write and explain Gauss' Theorem. 5

(b) What is the difference between ionic and electronic polarization ? 5

(c) Consider two co-axial metal cylinders of radii R_1 and R_2. The space between them is filled with a dielectric with a relative dielectric constant ϵ_r. The potential difference applied between the two cylinders is *V volts*. Find the charge on the cylinders and the capacitance of the system per meter length. 10

6. *(a)* Derive the expression of complex polarizability. 10

(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 $\epsilon_r^* = \epsilon_r' - j\epsilon_r''$. 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 $i(t) = (\epsilon_0 \epsilon_r'' V_0)\cos \omega t - (\epsilon_0 \epsilon_r' V_0 \omega)\sin \omega t$. 10

7. (a) Classify the magnetic materials. 5

(b) What is remanent flux density ? 5

(c) The magnetic field strength in a piece of copper is $10^6 A/m$. Given that the magnetic susceptibility of copper is $-0{\cdot}5 \times 10^{-5}$, find the fluxdensity and the magnetization in the copper. 10