53 (IE 303) EEMD

2016

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)* What is the objective of studying the subject Electrical Engineering Materials and Devices ? 3

   (b) Write the quantum condition postulated by Bohr. 3

(c) What is transition elements? 2

(d) What is the resemblance between valence crystals and metals? 2

(e) According to wave mechanics, the wavelength λ of an electron is related to the momentum p of the electron by means of the so-called de Broglie formula $\lambda = h/p$, where h is Planck's constant. Show that the wavelength of an electron with kinetic energy of V electron volts is given by $\lambda = (150/V)^{1/2}$ angstroms. 10

2. (a) Define dipole moment. 3

(b) What is the difference between ionic and electronic polarization? 3

(c) For monoatomic gases, derive the relationship between dielectric constant and the electronic polarizability. 6

(d) 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. 8

3. (a) What is alternating field ? 2

(b) Derive the expression for complex polarizability. 8

(c) 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

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

10

4. (a) Write and discuss the law of Biot and Savart. 4

(b) What is ferromagnetic Curie temperature? 3

(c) Define coercive force. 3

(d) The magnetic field strength in a piece of Fe_2O_3 is 10^6 ampere m^{-1}. Given that the susceptibility of Fe_2O_3 at room temperature is $1{\cdot}4 \times 10^{-3}$, find the flux density and the magnetization in the material. 10

5. *(a)* Write the differences between drift current and diffusion current and derive the Einstein relation for electrons and holes. 2+8=10

(b) Explain the mass-action law and how the concentration of charge carriers can be found with the help of it. 8

(c) In a *p*-type semiconductor the acceptor density is $10^{20}\ atoms/m^3$. Intrinsic concentration is $2{\cdot}5\times10^{19}/m^3$ at 300*K*. Calculate the hole and electron concentration. 2

6. *(a)* Discuss some application of conductor materials in — 8

(i) Transmission lines/cables

(ii) Transformers

(iii) DC machines

(iv) 3-ϕ induction motors

(b) What is the Meissner Effect? 2

(c) What is Hall-effect and write some applications of this effect.

An N-type germanium sample has a donor density of $10^{21}/m^3$. It is arranged in a Hall experiment having magnetic field of $0{\cdot}2T$ and the current density is $600\,A/m^2$. Determine the Hall voltage if $d = 4mm$. 1+3+6=10

7. (a) Define the temperature co-efficient of resistance. How α is determine graphycally? Is it temperature dependent? Also prove that —

$$R_2 = R_1\left[1+\alpha_1(t_2-t_1)\right]$$

Where R_1 and R_2 are the resistances of a conductor at $t_1^{\circ}C$ and $t_2^{\circ}C$ respectively and α_1 is the temperature co-efficient at $t_1^{\circ}C$. 1+3+1+5=10

(b) Two materials *A* and *B* have resistance temperature co-efficients of 0·004 and 0·0004 respectively at a given temperature. In what proportion must *A* and *B* be joined in series to produce a circuit having a temperature co-efficient of 0·001 ? 10