53 (IE 303) EEMD

2015

ELECTRICAL ENGG. MATERIAL & 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)* Make comparisons between ionic crystals and valence crystals. 5

(b) Write the names of the three quantum numbers. Also write the relation between them. What is the electronic configuration of potassium $(Z = 19)$? 7

(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. 8

2. *(a)* What is Gauss Theorem ? 3

(b) Write a method for measuring ϵ_r for a particular material considering a parallel plate condenser. 4

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

(d) A condenser of 1 microfarad contains. titanium oxide (TiO_2) as a dielectric with $\epsilon_r = 100$. 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 $\epsilon_r = 5{\cdot}4$ for mica. 10

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

(b) Compare Circular Bohr Orbit model and spherical charge Cloud Model of atom. 4

(c) Write the classification of magnetic materials. 5

(d) Show by means of Biot Savart's law that the flux density produced by an infinitely long straight wire, carrying a current I, in a point at a distance 'a' normal to the wire is given by $\mu_0 \mu_r I / 2\pi a$. 8

4. (a) Derive the expression of complex polarizability. Derive the maximum and minimum value of the real part of complex polarizability. 7+3=10

(b) Consider a parallel plate condenser with a lossy dielectric between them. At an angular frequency w 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 $v(t) = v_0 \cos wt$ show that the current through the lossy condenser is given by

$$i(t) = \left(\epsilon_0 \epsilon_r'' \, w V_0\right) \cos wt = \left(\epsilon_r' \epsilon_0 \, V_0 w\right) \sin wt$$

10

5. *(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

(e) A copper wire has a resistivity of $1{\cdot}8 \times 10^{-8}$ *ohm m* at room temperature $(300°K)$. Assuming Copper is very pure, estimate the resistivity at $700°C$ and the percentage change in the resistivity from room temperature to $700°C$. 10

6. *(a)* Write the positions of the Silicon and germanium in the periodic table. 2

(b) Write the difference between metals and semiconductors. 3

(c) What are the differences between intrinsic semiconductors and extrinsic semiconductors ? 5

(d) The resistivity of intrinsic germanium at $27°C$ is equal to $0{\cdot}47 ohm\ m$. Assuming electron and hole mobilities of respectively 0·38 and $0{\cdot}18 m^2 volt^{-1}/sec^{-1}$, calculate the intrinsic carrier density n : 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 $0 \le r \le \infty$; assume $V(\infty) = 0$. 10

(b) The Hall coefficient of a specimen of doped silicon is found to be $3{\cdot}66 \times 10^{-4} m^3$ coulomb^{-1}; the resistivity of the specimen is $8{\cdot}93 \times 10^{-3} ohm\ m$. Find the mobility and density of the charge carriers, assuming single carrier conduction. 10
