Total No. of printed pages = 4

17/1/19

EE 131303

Roll No. of candidate

2019

B.Tech. (EE) 3rd Semester End-Term Examination

MATERIAL SCIENCE

(New Regulation)

(w.e.f. 2017-2018)

Full Marks – 70 Time – Three hours

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

Answer question No. 1 and any *four* from the rest.

1. Fill in the blanks : (10 × 1 = 10)

   (i) In dielectric materials the spontaneous polarization vanishes above a certain temperature and the material becomes ————

   (ii) A ———— material has negative magnetic susceptibility.

   (iii) The relative permeability of a diamagnetic material always approaches ————.

   (iv) The net magnetic moment is zero for ———— materials.

   (v) ———— Rule indicates that the various contributions to the resistivity of metals are independently additive.

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(vi) The hysteresis loop of a ferroelectric material changes its shape with increase in ————.

(vii) The atomic packing fraction for B.C.C cubic crystal is ————.

(viii) A state of material in which it has zero resistivity is called ————.

(ix) The ferromagnetic materials show spontaneous magnetization below ———— temperature.

(x) The density of charge carriers in an extrinsic semiconductor can be found by measurement of the ———— of the material.

2. (a) What is crystal lattice? Calculate the packing fraction for Simple Cubic (SC), Body-Centred Cubic (BCC) and Face-Centred Cubic (FCC) crystal structures. (2 + 6 = 8)

(b) State the Bragg's law. Gold with atomic radius 1.44 A and face-centred cubic structure is used to determine the wavelength of X-rays. Calculate the wavelength of X-rays if the (111) plane diffracts the beam by 32.1°. Assume first order diffraction. (2+5=7)

3. (a) Define electronic polarization and orientational polarization in a dielectric material. Derive an expression for the static dielectric constant of a monoatomic gas. (2+5=7)

(b) Assuming a Lorentz internal field, deduce Clausius-Mosotti relation for a solid containing N atoms/m^3, each atom having polarizability ct. farad m^2. (5)

(c) Find the total polarizability of CO_2 at 273 K and 1 atmospheric pressure if its susceptibility is 0.985×10^{-3} and $N = 27 \times 10^{25}$ atoms/m^3. (3)

4. (a) Define the terms Diamagnetism, Paramagnetism, Ferro-magnetism, Anti-ferromagnetism and Ferrimagnetism with reference to magnetic dipoles of the atoms. (5)

(b) Derive an expression to show the relationship between susceptibility and temperature for Anti-ferromagnetic materials above the Neel temperature. (7)

(c) Write a short note on Magnetic Anisotropy. (3)

5. (a) Explain the Meissner Effect in superconductors. (3)

(b) Deduce an expression for the current density in a conductor with the help of the free electron theory of metals. (5)

(c) A conducting wire has resistivity of 1.54×10^{-18} ohm-m at room temperature. There are 5.8×10^{28} conduction electrons per m^3 and the Fermi energy is 5.5 eV. Calculate the mobility and mean free path of the electrons. (4)

(d) What are the factors affecting the resistivity of conductive materials? (3)

6. (a) What are n-type and p-type semiconductors? Derive an expression for the concentration of charge carriers in n-type and p-type semiconductors. (2 + 5 = 7)

(b) Find the diffusion coefficients of electrons and holes of a silicon single crystal at 27°C, if the mobilities of electrons and holes are 0.17 and 0.025 m^2 $volt^{-1}$ sec^{-1} respectively at 27°C. (4)

(c) Explain in brief the fabrication process of bipolar junction transistors. (4)

7. (a) Define piezoelectric, pyroelectric and ferroelectric materials. (3)

(b) What is dielectric loss? Deduce an expression for the loss angle of a dielectric. (2 + 4 = 6)

(c) What is crystal imperfection? Explain the various types of defects in solids. (6)
