2022

M.Sc.

Second Semester

CORE – 08

PHYSICS

Course Code: MPHC 2.41

(Condensed Matter Physics – I)

Total Mark: 70 *Pass Mark: 28*

Time: 3 hours

Answer five *questions, taking* one *from each unit.*

UNIT–I

1. Discuss the temperature dependence of a molar specific heat of solids according to Debye. What are the drawbacks of the above theory? Calculate the Debye frequency and Debye temperature for aluminium from the following data:

   Density of atoms in aluminium = $6.02 \times 10^{28}/m^3$

   Velocity of longitudinal wave, $v_l = 6374$ m/s

   Velocity of transverse wave, $v_t = 3111$ m/s 8+4+2=14

2. Obtain the expressions for the electrical and thermal conductivity of metal in free electron approximation and hence establish the Wiedemann-Franz law. How can the difference between electronic specific heat of metal according to classical and quantum theory of free electron be explained? Which value is correct? 10+4=14

UNIT–II

3. Using Kronig-Penney model, show that the energy spectrum of an electron consists of a number of allowed energy bands separated by forbidden region. Estimate the band gap of an insulator, if it absorbs electromagnetic radiation of all wavelengths below 3000 Å. 12+2=14

4. Discuss the motion of electrons in one dimension and the variation of energy, velocity, and effective mass as a function of wave vector. Discuss the formation of Brillouin zones for a two-dimensional lattice. 10+4=14

UNIT–III

5. Deduce expressions for the number density of electrons in the conduction band and holes in the valence band of an intrinsic semiconductor. Show that the product of these two quantities does not depend on E_f. Write down expression for conductivity of an intrinsic semiconductor. 12+1+1=14

6. Deduce an expression for the density of electrons in the conduction band of an n-type semiconductor. Show the variation of the position of the Fermi level. 10+4=14

UNIT–IV

7. Deduce an expression for the electronic polarizability of an atom on the basis of classical theory. The relative permittivity and square of refractive index of a dielectric material are 4.94 and 2.69 respectively. Find the relation between electronic and ionic polarizability of the material. 10+4=14

8. Discuss dipole theory of ferroelectricity. A solid dielectric has electronic polarizability of 10^{-40} Fm^2. If the internal electric field be a Lorentz field, what is the dielectric constant of the material? 10+4=14
(Given: density = 3×10^{28} atoms/m^3)

UNIT–V

9. Deduce quantum theory of paramagnetic susceptibility. A paramagnetic material has 10^{28} atoms/m^3. Its susceptibility at 350 K is 2.8×10^{-4}. Calculate the susceptibility at 300 K. 12+2=14

10. What is ferromagnetism? Discuss the Weiss-Field theory of ferromagnetism and explain how magnetic susceptibility varies with temperature. Find the order of magnitude of the exchange integral of a ferromagnet having Curie temperature 727°C. What is the internal field?
(Given: $\mu_B = 9.3 \times 10^{-21}$ ergs/gauss) 2+8+4=14
