Exam.Code:0474
Sub. Code: 3718

2022

M.Sc. (Physics), Third Semester

PHY-8033: Condensed Matter Physics - I

Time allowed: 3 Hours Max. Marks: 60

***NOTE**: Attempt <u>five</u> questions in all, including Question No. 9 (Unit-V) which is compulsory and selecting one question each from Unit I - IV.*

x-x-x

Unit I

1. (a) Derive the wave equation for elastic waves in a cubic crystal. Solve it for longitudinal and transverse waves moving in [110] direction. 7

(b) What are ionic crystals? Explain the formation of an ionic crystal and obtain an expression for its cohesive energy. 5

2. (a) Define elastic constants for a crystal. Prove that elastic stiffness constants are symmetrical i.e. $C_{ij} = C_{ji}$. 7

(b) Explain why is it necessary to include anharmonic interactions to understand thermal expansion. 5

Unit II

3. (a) Prove that for the Kronig Penny potential with P<<1, the energy of the lowest band at k=0 is $\frac{h^2P}{4\pi^2ma^2}$. 7

(b) Distinguish between reduced zone, extended zone and periodic zone schemes of representing energy bands. 5

4. (a) Show that in the tight binding approximation, the energy E(k) for b.c.c. lattice is given by $E(\vec{k}) = E_a - \beta - 8\gamma \cos(a/2)\, k_x \cos(a/2)\, k_y \cos(a/2)\, k_z$ 8

Discuss the shape of constant energy surface in k space.

(b) In an extrinsic semiconductor, the effective mass of the electron is 0.07 m_o and that of hole is 0.4 m_o, where m_o is the rest mass of electron.Calculate the intrinsic concentration of charge carriers at 300 K. Given the energy gap E_g=0.7 eV. 4

Unit III

5. (a) Explain Magnetoresistance. If the applied magnetic field is H, show that the change in resistance of a crystal is proportional to H^2. 8

(b) Derive an expression for electrical conductivity of semiconductors. 4

6. (a) Derive an expression for Hall coefficient and Hall field using Boltzmann transport equation. 8

(b) A Cu strip 4.0 cm wide and 1mm thick is placed in magnetic field with B=2.5 Wb/m^2 perpendicular to strip. If 300 Amp current is set up in the strip, what Hall potential difference appears across the strip? Atomic weight of Cu is 64 gm/mole and density is 9.0 gm/cm^3. 4

Unit IV

7. (a) Discuss the different polarization mechanisms in dielectric and explain their temperature dependence. 6

(b) Discuss Weiss theory of Ferroelectricity. Give some applications of Ferroelectric materials. 6

P.T.O.

8. (a) Derive Clausius Mossotti equation. Discuss the variation of dielectric constant of ferroelectric material above Curie temperature. 8

(b) The Bakelite is found to have the real part of its complex relative dielectric constant as 4.36 with a loss tangent of 2.8×10^{-2} at a frequency of 1 Hz. Calculate the complex polarizability of the materials assuming Lorentz field. (Given $N=4\times10^{28}/m^3$). 4

Unit V

9. **Short questions:**

(a) Define Gruneisen parameter and discuss its relationship with anharmonicity in the lattice.

(b) Differentiate between antiferroelectricity and ferrielectricity.

(c) Define cohesive energy.

(d) Define mobility. How is it related to relaxation time?

(e) Explain metallic bonding in solids.

(f) What are elastic waves? (2×6=12)

x-x-x