2021
M.Sc. (Physics)-3rd Semester
PHY-7004: Condensed Matter Physics-I

Time allowed: 3 Hours

Max. Marks: 60

NOTE: Attempt _five_ questions in all including Q. No.-IX (Unit-V) which is compulsory and select _one_ question each from Unit I-IV.

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UNIT-I

I. (a) Explain why it is necessary to include the anharmonic interactions to understand the thermal expansion?

(b) Derive the wave equations for elastic waves in a cubic crystal. Solve it for a longitudinal and transverse waves moving in the [100] direction. (6+6)

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

(b) Define and derive the structure factor. Is it a real quantity? Determine the structure factor for FCC Lattice. (6+6)

UNIT-II

III. (a) Show that the behavior of an electron in a periodic potential. Derive the dispersion relation for a one-dimensional diatomic crystal and show that group velocity vanishes at the zone boundary.

(b) Derive an expression for the position of Fermi-level in the doped semiconductor. (7+5)

IV. (a) Prove that for the Kronig-Penny potential with $P \ll 1$, the energy of lowest energy band at K=0 is $\dfrac{h^2 p}{4\pi^2 ma^2}$.

(b) What is Block function? Find the expression for energy bands in the Tight Binding Approximation. (7+5)

UNIT-III

V. (a) Find the expression for the thermal conductivity of metals and insulators.

(b) Apply Baltzman Transport equation to prove Widemann-Franz Law. (7+5)

VI. (a) Find the expression for the electrical conductivity of metals by using the transport equation.

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(b) Define magnetoresistance and its type. What is the two-band model of magnetoresistance for the calculation of Hall-Coefficient? (6+6)

UNIT-IV

VII. (a) Discuss various polarization methanisms and the classical theory of electronic polarizability.

(b) Deduce Clausius-Massotti relation and explain its use in predicting the dielectric constant of a solid. (6+6)

VIII. (a) Derive Kramer's-Kronig relations and discuss their importance.

(b) What is menat by local field in a dielectric and how it is calculated for a cubic structure? (6+6)

UNIT-V

IX. (a) Describe the Umklapp and N-processes.

(b) What is the difference between acoustical and optical phonons?

(c) What are main characteristics of ferroelectric materials?

(d) Explain the concept of effective mass.

(e) Define mobility. How it is related to Relaxation time?

(f) Explain the phenomenon of antiferroelectricity. (6×2)

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