(6 pages)

OCTOBER 2011 **P/ID 40009/PPHJ**

Time : Three hours Maximum : 100 marks

PART A — (10 × 2 = 20 marks)

Answer ALL questions.

All questions carry equal marks.

1. Write down the various symmetry elements in crystalline solids.

2. Name at least four different covalent bonded crystals.

3. Explain group velocity with an example.

4. What are the normal modes of vibrations?

5. What is meant by degeneracy?

6. Explain the Wiedmann and Franz's law.

7. What are magnons?

8. State Hund's rule for the ground state.

9. Explain the isotope effect in superconductors.

10. Define dc Josephson effect.

PART B — (5 × 6 = 30 marks)

Answer ALL questions.

All questions carry equal marks.

11. (a) Explain the reciprocal lattice concept and obtain Bragg's diffraction conditions in terms of reciprocal lattice.

Or

(b) Draw neatly the structure of NaCl, Diamond and CsCl crystal and explain their structure.

12. (a) Distinguish between heat capacity of a lattice and that of an electron gas.

Or

(b) Describe the classical theory of specific heat. What are its limitations?

13. (a) Prove that the Fermi energy of a free electron gas in three dimension is a function of its electron concentration.

Or

(b) Obtain suitable expressions for the motion of an electron in a magnetic field and explain the importance of cyclotron frequency.

14. (a) What is the origin of diamagnetism in solids? Outline the Langevin theory of diamagnetism and obtain an expression for susceptibility.

Or

(b) Explain the various characteristics of hysteresis loop that one would look for in choosing a suitable material for making a permanent magnet.

15. (a) Obtain London equation. Show that London equation leads to Meissner effect and discuss the importance of London penetration depth.

Or

(b) Describe the flux quantization in a superconducting ring and obtain an expression for the flux through the ring.

PART C — (5 × 10 = 50 marks)

Answer ALL questions.

All questions carry equal marks.

16. (a) What are the different types of bonding exists in single crystals? List them. Explain in detail the nature, properties and uses of any three with examples. Draw diagrams wherever it is necessary.

Or

(b) Define primitive lattice and Bravais lattice. How many crystal systems are there? List them. How many Bravais lattices are there in three dimensions? List them and explain their equivalence in a, b, c, α, β and γ with diagrams for each.

17. (a) Discuss the vibrations of one dimensional diatomic linear lattice and obtain the dispersion relation. Explain the acoustical branch and optical branch.

Or

(b) Using Debye model, obtain the density of phonon modes in three dimensions explain the low temperature lattice heat capacity.

18. (a) Derive an expression for the free electron density of state of a three dimensional Fermi gas and discuss the effect of temperature on density of states.

Or

(b) Calculate the number of orbitals in each energy band. Describe the condition for a crystal to be an insulator or a metal in terms of the number of valence electrons per primitive cell.

19. (a) Starting from the Heisenberg Hamiltonian, obtain the magnon dispersion relation for a linear chain ferromagnet. Hence derive the Bloch's $T^{3/2}$ law.

Or

(b) Explain in detail the adiabatic demagnetization process of cooling a material below 1K. Discuss the mechanism with necessary diagram.

20. (a) In a circuit with two Josephson junctions in parallel, a small magnetic field but no voltage is applied. Sketch and show that the total current flowing in the circuit is proportional to the flux due to the applied magnetic field.

Or

(b) Discuss in detail BCS theory of superconductivity. Explain, with necessary diagrams how tunneling experiments support this theory.

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