

DECEMBER 2015

P/ID 40009/PPHJ

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Time : Three hours

Maximum : 100 marks

PART A — (10 × 2 = 20 marks)

Answer ALL questions.

1. Draw the structure of Zinc sulphide crystal and mention the equivalent positions.
2. Define atomic scattering factor and structure factor.
3. When the phase velocity will be independent of frequency and wavelength?
4. How the geometrical factors limit the mean free path length?
5. What is meant by degeneracy? Explain.
6. What is free electron Fermi gas? Explain.
7. What is the difference between spin ordering in a ferromagnet and a ferrimagnet?
8. What is a domain? What is its importance in ferromagnetic materials?
9. Explain the infrared properties of a typical superconducting material.
10. Define Cooper pairs. How the attraction between electrons arise in Cooper pairs?

PART B — (5 × 6 = 30 marks)

Answer ALL questions.

11. (a) Define Brillouin zone for a lattice. Explain how the Brillouin zone is constructed for a bcc lattice. Draw the necessary diagrams.

Or

- (b) Obtain an expression for the cohesive energy of inert gas crystals.

12. (a) Define the phonon momentum mathematically and explain the wave vector selection rules for allowed transitions between quantum states.

Or

- (b) Describe the classical theory of specific heat and mention its limitations.

13. (a) Discuss the energy levels and density of orbitals states in one dimension for a free electron gas.

Or

- (b) Explain the relation between electrical conductivity and Ohm's law with the Fermi sphere concept.

14. (a) Explain anti ferromagnetic order and discuss the susceptibility below the Neel temperature.

Or

- (b) Draw the B-H curve for a ferromagnetic material and explain retentivity, coercivity, hysteresis loss.

15. (a) Discuss the thermodynamics of a superconducting transition of a material with the theory.

Or

- (b) Show that London equation leads to Meissner effect and discuss the importance of London penetration depth.

PART C — (5 × 10 = 50 marks)

Answer ALL questions.

16. (a) Derive the geometrical structure factor for fcc structure in which all atoms are identical. Discuss the structure factor expression for all odd, all even and mixed indices.

Or

- (b) List the different types of bonding exists in single crystals. Discuss in detail the nature, properties and uses of any three with suitable examples.

17. (a) Explain Debye model and obtain the density of phonon modes in three dimensions. Discuss the low temperature lattice heat capacity.

Or

- (b) Distinguish between the Normal and Umklapp phonon collision processes. How Umklapp process is useful for the understanding of the thermal conductivity?

18. (a) Describe the method of calculation of energy bands using tight binding method with the necessary theory.

Or

- (b) Explain Hall effect with a neat diagram. Obtain expressions for Hall coefficient and Hall constant. Explain the various applications of Hall effect.

19. (a) Starting from the Heisenberg's 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 1 K. Discuss the mechanism with necessary diagram.

20. (a) Give a brief account of BCS theory of superconductivity. Explain, with necessary diagrams, how tunneling experiments support this theory.

Or

- (b) Explain ac Josephson effect. Derive an expression for the frequency of current oscillations in it.