(6 pages)

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Time : Three hours                    Maximum : 100 marks

PART A — (10 × 2 = 20 marks)

Answer ALL questions.

All questions carry equal marks.

1.  Define packing fraction of fcc lattice.

2.  List the different symmetry elements in two dimensions.

3.  Define phase velocity.

4.  Write down the selection rule for the scattering of photon by a crystal.

5.  Show that the chemical potential at absolute zero is equal to the Fermi energy.

6.  What is the physical basis for effective mass?

7.  What is the method to cool a material below 1 K?

8. What is the reason for the negative susceptibility in a diamagnetic material?

9. What are the two most important characteristics of the superconducting state?

10. What are high temperature superconductors?

PART B — (5 × 6 = 30 marks)

Answer ALL questions.

All questions carry equal marks.

11. (a) Is five fold symmetry possible? Prove your statement. Mention recent findings about five fold symmetry.

Or

(b) Explain how the Brillouin zone is constructed for a bcc lattice.

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

Or

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(b) Derive an expression for the thermal conductivity coefficient of a solid from the phonon gas model.

13. (a) Describe the free electron theory of metals. Mention its merits and demerits.

Or

(b) What is a semimetal? Give an example. Explain the allowed energy band for a semimetal with a neat diagram.

14. (a) Outline Weiss mean field theory of ferromagnetism. What are its success and failures?

Or

(b) Discuss ferromagnetic domains. Show that the domain structure has always its origin in the principle of minimum energy.

15. (a) Distinguish between Giavier tunneling and Josphson tunneling.

Or

(b) Define the stabilization energy of a superconductor and derive an expression for it.

PART C — ($5 \times 10 = 50$ marks)

Answer ALL questions.

All questions carry equal marks.

16. (a) Define atomic scattering factor and structure factor. Obtain an expression for the geometrical structure factor for a fcc lattice. Discuss about the absent reflection.

Or

(b) Explain the energy of formation of NaCl molecule. Obtain an expression for the Madelung constant and discuss its significance in NaCl crystal.

17. (a) Derive an expression for the lattice heat capacity on the basis of Debye model. How does this compare with the experiment? Draw a graph to illustrate it.

Or

(b) Explain the experimental techniques for the study of electrical and thermal conductivity of metallic elements.

18. (a) Obtain Kronig-Penny model and explain its salient features.

Or

(b) 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.

19. (a) Explain exchange interaction. Obtain an expression for exchange integral using Heisenberg's theory.

Or

(b) Discuss the quantum theory of paramagnetism and obtain Curie-Weiss law. Write down the Hund's rule and discuss its importance

20. (a) Explain Meissner effect with a neat diagram. Discuss how the Meissner effect result contradicts Maxwell's equation. Discuss in detail the importance of penetration depth in a superconducting material.

Or

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(b) What is Josephson effect? Explain how tunneling experiments give useful information about superconductors.

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