(8 pages) **Reg. No. :** .....

Code No. : 7807 **Sub. Code : WPHM 32**

M.Sc. (CBCS) DEGREE EXAMINATION, NOVEMBER 2024.

Third Semester

Physics – Core

CONDENSED MATTER PHYSICS

(For those who joined in July 2023 onwards)

Time : Three hours Maximum : 75 marks

PART A — (15 × 1 = 15 marks)

Answer ALL questions.

Choose the correct answer :

1. The reciprocal lattice is mathematically defined as:
   (a) The lattice that is the inverse of the direct lattice
   (b) The Fourier transform of the real-space lattice
   (c) The dual space of the direct lattice
   (d) The inverse of the wave vector

2. What are the units of the reciprocal lattice vectors?
   (a) Length (b) Area
   (c) Momentum (d) Inverse length

3. The reciprocal lattice is important in the study of:
   (a) Crystal defects (b) X-ray diffraction
   (c) Crystal vibrations (d) Atomic bonding

4. The First Brillouin zone is defined as:
   (a) The volume in reciprocal space enclosed by the Wigner-Seitz cell
   (b) The region in real space where all the electrons are localized
   (c) The region in reciprocal space closest to the origin
   (d) The region in real space farthest from the origin

5. The boundaries of the First Brillouin zone are determined by:
   (a) The unit cell in real space
   (b) The points where the energy is maximized
   (c) The planes that are perpendicular bisectors of the reciprocal lattice vectors
   (d) The electron density in the crystal

6. The First Brillouin zone is important because:
   (a) It contains all the possible positions of atoms
   (b) It contains all the distinct wavevectors k in reciprocal space
   (c) It defines the total energy of the crystal
   (d) It is the region of maximum potential

7. The Fermi surface in solid-state physics is defined as:
   (a) The surface in real space where atoms are arranged
   (b) The boundary in reciprocal space that separates occupied from unoccupied electron states at absolute zero
   (c) The plane in real space where electron probability is zero
   (d) The surface in reciprocal space where the electron spin is aligned

8. The Fermi energy E_F is:
   (a) The minimum energy of an electron in the crystal
   (b) The energy level at which the probability of occupation by an electron is 50% at absolute zero
   (c) The energy of the fastest electron in the crystal
   (d) The energy level where electrons are always unbound

9. The shape of the Fermi surface is determined by:
   (a) The atomic positions in real space
   (b) The crystal symmetry and the electron energy band structure
   (c) The temperature of the crystal
   (d) The pressure applied to the crystal

10. Ferromagnetic domains are:
   (a) Regions where magnetic moments are randomly oriented
   (b) Regions where magnetic moments are aligned in the same direction
   (c) Areas with no magnetic properties
   (d) Regions that only exist at high temperatures

11. The existence of ferromagnetic domains helps to:
   (a) Minimize the magnetic energy of the material
   (b) Maximize the external magnetic field
   (c) Prevent magnetization
   (d) Increase thermal conductivity

12. In ferromagnetic materials, the alignment of domains can be affected by:
   (a) Temperature changes
   (b) Applied magnetic fields
   (c) Mechanical stress
   (d) All of the above

13. The DC Josephson effect refers to:

(a) The generation of an alternating current across a Josephson junction without an applied voltage

(b) The flow of direct current across a Josephson junction when a constant voltage is applied

(c) The production of high-frequency electromagnetic radiation

(d) The thermal noise in a superconducting circuit

14. The AC Josephson effect occurs when:

(a) A constant voltage is applied across a Josephson junction

(b) No voltage is applied, but the junction is subjected to a magnetic field

(c) An alternating voltage is applied, leading to oscillations in the current

(d) The temperature of the junction is raised above the critical temperature

15. The Josephson junction consists of:

(a) Two normal conductors separated by an insulator

(b) Two superconductors separated by a thin insulating barrier

(c) A superconductor and a semiconductor

(d) Two superconductors in direct contact

PART B — (5 × 4 = 20 marks)

Answer ALL questions, choosing either (a) or (b).
Each answer should not exceed 250 words.

16. (a) Explain the important features of miller indices.

Or

(b) Copper has FCC structure and the atomic radius is 1.278 A°. Calculate the inter planner spacing for (111) planes.

17. (a) What are Brillouin Zones? Discuss the Construction of the first three Brillouin zones for a square Janice.

Or

(b) Explain the Umklapp processes.

18. (a) Derive Wieddmann - Franz law.

Or

(b) Explain Bloch function. Explain the origin of allowed and forbidden bands for electrons in solids.

19. (a) Explain diamagnetism. Why diamagnetic materials have negative susceptibility?

Or

(b) Give the Curie law of paramagnetism. What is the curie temperature?

20. (a) Explain the difference between type I and type II superconductors using the Meissner effect.

Or

(b) Explain the thermodynamics of super conducting transition.

PART C — (5 × 8 = 40 marks)

Answer ALL questions, choosing either (a) or (b)
Each answer should not exceed 600 words.

21. (a) Derive Laue's equation.

Or

(b) Describe the seven crystal systems with diagrams.

22. (a) Discuss the Debye model of lattice heat capacity and explain Debye T^3 law.

Or

(b) Explain the inelastic scattering by phonons.

23. (a) Using the Kroing-Penny model, Show that for P<<1, the energy of the lowest energy band is $E = \frac{\hbar^2}{ma^2}$.

Or

(b) Give the theory of Hall effect in the case of a semiconductor.

24. (a) Give an account for the quantum theory of paramagnetism and discuss the low and high temperature case.

Or

(b) Give the theory of antiferromagnetic material.

25. (a) Derive London equations and explain the term coherence length.

Or

(b) Discuss d.c and a.c Josephson's effects and explain their importance.

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