2024
M.Sc.
4th Semester Examination
PHYSICS
PAPER – PHS-404A
Full Marks: 50
Time: 2 Hours

Solid State Physics-II

ANSWER Q1, Q2, AND ANY TWO FROM Q3, Q4, Q5, AND Q6

1. Answer any four (04) from the following. 4×2=8

a) What is magnon? Write down its dispersion relation in case of ferromagnetic system.
b) What is Electron Spin Resonance (ESR)?
c) An antiferromagnetic material is exposed to an external magnetic field with magnetism of $M = 250\ mT$. After 15 minutes the external field is removed. If the temperature of the material remains below the Neel temperature, what is the magnetization of the material after the external field is removed?
d) What are the applications of NMR?
e) Calculate the Pauli's paramagnetic susceptibility from the following data: a paramagnetic substance contains 6.02×10^{28} atoms/m^3 and its Fermi energy is 11.63 eV.
f) Make a qualitative plot of effective susceptibility vs. the applied magnetic field for a long circular cylinder of a superconductor. The applied magnetic field is perpendicular to the cylinder axis.
g) How does the isotope effect provide evidence for the phonon-mediated pairing mechanism in conventional superconductors?
h) Calculate the wavelength of the photon, which will be required to break a Cooper pair in a superconducting Aluminium whose critical temperature is 1.2 K. For Aluminium, Δ is equal to $\frac{3.53}{2}kT_c$. The symbols have their usual meanings.

(Turn Over)

2. Answer any four (04) from the following. 4×4=16

a) Explain the formation of Cooper pair near absolute zero temperature. (4)
b) Discuss the process and significance of Andreev reflection at the interface of a normal metal and a superconductor. How can this phenomenon be used to study superconducting properties? (4)
c) Discuss the primary mechanisms that differentiate high-temperature superconductors (HTS) from conventional low-temperature superconductors. Include a brief overview of the structure of high-temperature superconducting materials, particularly focusing on cuprates, and explain how their electronic properties contribute to their high critical temperatures. (4)
d) What is the DC Josephson effect? Derive the expression for the Josephson current.
e) Explain the Heissenberg's exchange interaction in ferromagnetism. (4)
f) Express molecular field theory approximation in case of Antiferromagneism. (4)
g) Write down the spin Hamiltonian corresponding to the magnetic resonance. Explain each term contained in the spin Hamiltonian. (2+2)
h) The energy of a ferromagnet as a function of magnetization is

$$F(M) = F_0 + 2(T - T_c)M^2 + M^4, \quad F_0 > 0$$

Determine the number of minima in the function $F(M)$ for $T > T_c$. (4)

Answer any two (02) from the following 2×8= 16

3. From linearized Ginzburg–Landau equation derive the expression of upper critical field (B_{c2}) and define flux quantum (φ_0). What are their significance? (6+2)
4. Explain what is meant by coherence length. Derive an expression of coherence length. (2+6)
5. Explain the Langevin's classical theory of paramagnetism. Hence obtain an expression for paramagnetic susceptibility. (4+4)
6. State and prove van-Leeuen theorem in connection with the magnetism of a system. Derive Bloch's $T^{3/2}$ law of the specific heat for a ferromagnetic system at low temperature. (2+3+3)

(All the symbols have their usual meanings)

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Internal Assessment-10