

2008

PHYSICS

PAPER—PH 2204

Full Marks : 40

Time : 2 hours

Answer Q. No. 1 and any three from the rest

The figures in the right-hand margin indicate marks

Candidates are required to give their answers in their own words as far as practicable

Illustrate the answers wherever necessary

(Solid State Physics Spl. Paper)

1. Answer any five bits: 2 × 5

(a) Evaluate the penetration depth of a superconductor having superelectron density $4 \times 10^{28}/\text{m}^3$.

(Turn Over)

- (b) Estimate the intrinsic coherence length of Aluminium. Given the energy gap = 0.34 meV and $v_F = 2.02 \times 10^{16}$ m/s.
- (c) Define Cooper pairs on the basis of BCS theory.
- (d) What is isotope effect? What is its physical significance in the theory of superconductivity?
- (e) Estimate the frequency of the electromagnetic waves radiated by Josephson junction having a voltage of 650 μ V across its terminal.
- (f) What is the physical reason for the origin of a domain?
- (g) What is meant by irreversible domain wall motion?
- (h) Find the spectroscopic notation and effective no. of Bohr magneton in Cr^{2+} having $3d^4$ configuration in the outermost shell.

2. (a) Write the two London equations and find an expression for London penetration depth.
- (b) What do you mean by coherence length? Obtain an expression for the coherence length.
- (c) Derive conditions for positive and negative surface energy in the superconducting specimen. Using these conditions explain the occurrence of type I and type II superconductors. 10
3. (a) Discuss flux quantization in a superconductor. What do you mean by fluxon? Find its value.
- (b) Derive an expression for current in the DC Josephson tunnelling phenomena across superconducting junctions.
- (c) Derive an expression to show the periodic variation of critical current with the applied magnetic field in a superconducting quantum interferometer. 10

4. (a) Deduce the paramagnetic susceptibility of a Fermi gas of conduction electrons (Pauli model) and show it is independent of temperature for $k_B T \ll \epsilon_F$. State the limitations of assumptions of this model.
- (b) Why is the paramagnetic susceptibility exceptionally large in transition metals?
- (c) A paramagnetic salt contains 10^{28} ions/m³ with magnetic moment of one Bohr magneton. Calculate the paramagnetic susceptibility and the magnetization produced in a uniform magnetic field of 10^6 amp/m when the temperature is 27°C. (5 + 1) + 1 + 3
5. Assuming interaction between two hydrogen atoms according to Heitler and London scheme find an expression of exchange energy. Explain how exchange energy is responsible for ferromagnetism in a solid.

6. (a) What are spin waves? Derive an expression of the dispersion relation for 3d ferromagnetic spin waves. In which way does it differ from phonon dispersion relation?

(b) Calculate the molar diamagnetic susceptibility of atomic hydrogen. Assume the first Bohr radius 0.529 \AA . (2 + 4 + 1) + 3

