M.Sc. Examination, 2019

Semester-IV

Physics

Special Paper: MPC-462

(Condensed Matter Physics-III)

Time: Three Hours **Full Marks: 40**

Questions are of value as indicated in the margin.

Answer ***any four*** questions.

1. a) Considering a lattice with two atoms per primitive cell, obtain the dispersion relations for optical and acoustical branch mode of phonons. Discuss the physical significance of these two modes of lattice vibrations.
   b) What do you mean by 3-D, 2-D, 1-D and 0-D structures? Considering an infinitely deep one-dimensional potential well, briefly discuss quantum confinement effect and hence size effect. (3+2)+(3+2)=10

2. a) What are electronic and lattice heat capacity of solids? Discuss briefly.
   b) Explain lattice thermal expansion of solid considering anharmonic crystal interactions.
   c) What is Umklapp Process? Explain lattice thermal resistivity of solid considering it? 2+4+4=10

3. a) Considering electrons (e) and holes (h) in a semiconductor, explain the following:
   (i) $\boldsymbol{k}_h = -\boldsymbol{k}_e$, (ii) $\varepsilon_h(k_h) - \varepsilon_e(k_e)$ and (iii) $m_h > m_e$
   where k, ε and m stand for wave vector, energy and effective mass, respectively.
   b) What is diffusion of atoms in a solid crystal? Discuss with possible mechanisms. Show that the diffusivity $D = D_0 \exp(-E/k_B T)$, symbols have their usual meanings. (2+2+2)+(2+2)=10

4. a) Obtain magnon dispersion relation for ferromagnets considering Heisenberg's exchange interaction. Compare it with phonon dispersion relation in the longer wavelength limit.
   b) Considering the specific heat, establish the Bloch's law for ferromagnetic magnons at low excitations. (5+1)+4=10

5. a) What do you understand by nuclear resonance fluorescence?
   b) Deduce an expression for recoil energy of an atom emitting gamma ray and discuss its role in observing nuclear resonance fluorescence.
   c) Doppler broadening in general makes the observation of resonance fluorescence possible for atomic transitions, but not for nuclear transitions. – Explain. 2+4+4=10

6. a) Using the BCS Hamiltonian under Bogoliubov-Valentin transformation obtain an expression for the superconducting energy gap.
   b) Derive an expression showing the temperature dependence of superconducting energy gap. 6+4=10

7. a) Considering optical branch mode of lattice vibration in the long wavelength limit, obtain Lyddane-Sachs-Teller relation.
   b) Discuss the origin of ferromagnetic states in iron, cobalt and nickel in the light of zone theory. 5+5=10
