M.Sc. Examination, 2018
Semester-I
Physics (Core)
Course Code: MPC-13
(Condensed Matter Physics)

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

Questions are of value as indicated in the margin
*Answer **any four** questions*

1. a) Distinguish between crystalline and amorphous solids. 2
   b) Discuss – '*Lattice + Basis = Crystal Structure*'. 2
   c) Define packing fraction and hence obtain the same for a bcc structure. 1+2
   d) What are Miller indices? Discuss the procedure to determine the Miller indices of a crystal plane with an example. 1+2

2. a) Write down the Laue equations describing each term. 2
   b) Why did Ewald put forward the concept of reciprocal lattice? How do we construct the reciprocal lattice? 2
   c) Derive the expression for reciprocal lattice vectors in terms of direct lattice vectors. 4
   d) Show that the reciprocal lattice of a bcc is fcc lattice. 2

3. Consider a one-dimensional monoatomic linear lattice with nearest neighbour interactions. Hence,
   a) obtain the dispersion $(\omega$ vs. $k)$ relation and draw a neat relevant diagram; 5+1
   b) using the dispersion relation, discuss the following cases: (i) ω is low and (ii) ω is high. 2+2

4. a) Obtain an expression for kinetic energy of electrons for a free electron gas in three dimensions. 6
   b) Derive an expression for the average kinetic energy of electrons at absolute zero. 4

5. a) Discuss – what is meant by the effective mass of an electron in an energy band and how does it account for the concept of 'hole'. 6
   b) What do you mean by Brillouin zone? Draw schematically the first three Brillouin zones. 4

6. a) What is antiferromagnetism? 1
   b) Under molecular field treatment of antiferromagnetism, derive expressions for
      i) the susceptibility when temperature is higher than Néel temperature, 3
      ii) the Néel temperature, and 2
      iii) the spontaneous sublattice magnetization below the Néel temperature. 4

7. a) What is Meissner effect. 2
   b) Obtain the second London equation for superconductivity and hence establish that the Meissner effect follows from this equation. 5
   c) What are Type-I and Type-II superconductors? 3

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