

Roll No. ....

## **PHY–503**

### **Solid State Physics**

**M. Sc. PHYSICS (MSCPHY–12/13/16)**

**First Year, Examination, 2017**

**Time : 3 Hours**

**Max. Marks : 70**

**Note :** This paper is of **seventy (70)** marks containing **three (03)** sections A, B and C. Learners are required to attempt the questions contained in these sections according to the detailed instructions given therein.

### **Section–A**

#### **(Long Answer Type Questions)**

**Note :** Section ‘A’ contains four (04) long answer type questions of fifteen (15) marks each. Learners are required to answer *two* (02) questions only.

1. Show that the reciprocal lattice of a hexagonal lattice is a hexagonal lattice with a rotation of axis.
2. Explain the lattice dynamics of monoatomic two-dimensional lattices.
3. There are  $N$  atoms in a metal crystal and  $N_i$  interstitials in its structure. If  $\bar{E}$  and  $n$  are the average energy required to create one Frenkel defect and equilibrium number of defects respectively, then show that :

$$n = N/N_i^{1/2} \exp\left(-\frac{\bar{E}}{2 k_B T}\right)$$

where  $k_B$  is Boltzmann constant.

4. Give the quantum theory of paramagnetism and explain how it removes that shortcoming of Langevin's theory.

### Section-B

#### (Short Answer Type Questions)

**Note :** Section 'B' contains eight (08) short answer type questions of five (05) marks each. Learners are required to answer *six* (06) questions only.

1. With the help of diagram, calculate the packing fraction of a face centred cubic (fcc) structure.
2. Obtain the reciprocal lattice to a FCC lattice.
3. Explain Grain boundaries.
4. Give the limitation of Debye model.
5. In an intrinsic semiconductor, the effective mass of electron is  $0.07 m_e$  and that of hole is  $0.4 m_e$ , where  $m_e$  is the rest mass of electron. Calculate the intrinsic carrier concentration at 300 K.

Given that  $E_g = 0.7 \text{ eV}$ ,  $k_B = 1.38 \times 10^{-23} \text{ J/K}$ ,

$h = 6.67 \times 10^{-34} \text{ Js}$ ,  $m_e = 9.1 \times 10^{-31} \text{ kg}$ ,  $T = 300 \text{ K}$

6. What are Debye frequency and Debye temperature ? Give its physical significance.
7. The intrinsic carrier density of Ge at  $27^\circ\text{C}$  is  $2.4 \times 10^{17} \text{ m}^{-3}$ . Calculate its intrinsic resistivity, if the electron and hole mobilities are  $0.35 \text{ m}^2 \text{ V}^{-1} \text{ s}^{-1}$  and  $0.18 \text{ m}^2 \text{ V}^{-1} \text{ s}^{-1}$ .

8. What is piezoelectricity ? Give the application of piezoelectricity.

**Section-C**

**(Objective Type Questions)**

**Note :** Section 'C' contains ten (10) objective type questions of one (01) mark each. All the questions of this section are compulsory.

1. The Bravais lattice, formed by all points with Cartesian co-ordinates  $(n_1, n_2, n_3)$ , where  $n_1, n_2, n_3$  are either all odd or all even is :
  - (a) Simple cubic
  - (b) Body centered cubic
  - (c) Face centered cubic
  - (d) Hexagonal close packed
2. The nearest neighbour distance in a bcc structure with lattice constant  $a$  is :
  - (a)  $a$
  - (b)  $a / \sqrt{2}$
  - (c)  $a \sqrt{3} / 2$
  - (d)  $\sqrt{3} / 4 a$
3. X-ray of wavelength 10 picometer are scattered from a target. The maximum wavelength present in the scattered X-rays is :
  - (a) 10 picometer

- (b) 12.426 picometer
  - (c) 14.852 picometer
  - (d) not determined
4. Soft mode :
- (a) occurs in acoustical branch only
  - (b) occurs in optical branch when the frequency dips to almost zero
  - (c) occurs in alkali halides
  - (d) does not occur in ferroelectric materials
5. In an Umklapp process :
- (a) there is no conservation of momentum of the system electron plus phonon
  - (b) there is conservation of momentum of the system electrons plus phonon
  - (c) an electron does not absorb a phonon
  - (d) an electron does not arrive in a state at boundary of a Brillouin zone whereupon it suffers a reflection
6. At temperatures above absolute zero, for  $E \ll E_F$ , the Fermi-Dirac function approaches :
- (a)  $e^{-E/kT}$
  - (b) zero
  - (c) unit
  - (d) infinity
7. The effective mass of an electron :
- (a) can never be negative
  - (b) can never be infinity
  - (c) depends on its effective charge only
  - (d) can be positive, negative as well as infinity

8. In  $n$  type semiconductor, the position of Fermi level :
  - (a) is lower than the centre of energy gap
  - (b) at the centre of energy gap
  - (c) is higher than the centre of energy gap
  - (d) can be any where depending upon the doping concentration
9. The Hall effects occurs in :
  - (a) metals only
  - (b)  $n$ -type semiconductors only
  - (c) intrinsic semiconductors only
  - (d) All of the above
10. The electronic polarizability, at moderate temperature is :
  - (a) linearly depending on temperature
  - (b) independent of temperature
  - (c) inversely depending on temperature
  - (d) inversely depending on square of temperature

