

**D 70986**

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**Name.....**

**Reg. No.....**

**THIRD SEMESTER M.Sc. DEGREE (REGULAR) EXAMINATION  
NOVEMBER 2019**

**Physics**

**PHY 3C 11—SOLID STATE PHYSICS**

**(2017 Admissions)**

**Time : Three Hours**

**Maximum : 36 Weightage**

**Part A**

*Answer all questions.*

*Each question carries 1 weightage.*

1. What is a symmetry operation ? Mention different types of symmetry elements and symmetry operations in a cubic crystal.
2. What are Brillouin zones ? Construct first Brillouin zone for a two dimensional square lattice.
3. Show that the group velocity for elastic waves of lattice vibrations are zero at the edges of Brillouin zones.
4. Discuss the limitations of Einstein model for lattice heat capacity in solids.
5. What is the limitation of free electron model in explaining Hall coefficients of metals ?
6. Explain the concept of holes in semiconductors.
7. What is effective mass of a charge carrier ? What is its importance ?
8. Distinguish between paramagnetic and ferromagnetic materials.
9. Briefly explain the concept of magnons in ferromagnetic materials.
10. Briefly explain the origin of ferrimagnetic moments.
11. What are superconductors ? What is the importance of transition temperature of superconductors ?
12. Certain superconductor has an energy gap of  $10^{-4}$  eV. Calculate the wavelength of electromagnetic radiation to which this superconductor respond.

(12 × 1 = 12 weightage)

**Part B**

*Answer any two questions.*

*Each question carries 6 weightage.*

13. What are reciprocal lattices ? Show that reciprocal lattice to BCC lattice is an FCC lattice and reciprocal lattice to FCC lattice is BCC lattice.

**Turn over**

14. Derive an expression for lattice heat capacity using Debye model. Discuss how this model differs from Einstein model.
15. Derive Curie-Weiss law for ferromagnetism.
16. Explain flux quantization in superconductors and use it to explain the principle of macroscopic quantum interference.

(2 × 6 = 12 weightage)

### Part C

Answer any four questions.

Each question carries 3 weightage.

17. An orthorhombic crystal has a ratio  $a : b : c = 0.429 : 1 : 0.377$ . find the Miller indices of the faces whose intercepts are (i)  $0.214 : 1 : 0.188$  and (ii)  $0.429 : \infty : 0.126$ .
18. If phonon mean free path length in quartz crystal is  $30 \text{ \AA}$  and the specific heat capacity per unit volume is  $4 \times 10^3 \text{ J m}^{-3}\text{K}^{-1}$  at 300 K, calculate lattice thermal conductivity in quartz, (assume phonon velocity =  $5 \times 10^3 \text{ ms}^{-1}$ ).
19. Valence electron density for monovalent potassium is,  $N/V = 1.402 \times 10^{28} \text{ m}^{-3}$ . For a typical current density of  $10^6 \text{ Am}^{-2}$ , obtain the drift velocity in terms of Fermi velocity for electrons in potassium.
20. Prove that the Fermi level in an intrinsic semiconductor lies in the middle of the forbidden gap if the effective masses of electrons and holes are equal.
21. Calculate the value of magnetic susceptibility for a paramagnetic material ( $N = 9 \times 10^{28} \text{ m}^{-3}$ ,  $\mu_B = 9.27 \times 10^{-24} \text{ JT}^{-1}$ ) at 0.1 K.
22. A superconducting material has a transition temperature of 3.7 K at zero magnetic field and a critical field of  $3 \times 10^5 \text{ A/m}$  at 0 K. Find the critical field at 2K.

(4 × 3 = 12 weightage)