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**1 (Sem-5/FYUGP) PHY02MJ**

**2025**

**PHYSICS**

(Major)

Paper : PHY0500204

**(Condensed Matter Physics)**

Full Marks : 45

Time : 2 hours

***The figures in the margin indicate full marks for the questions.***

1. Answer the following questions :  $1 \times 5 = 5$

(a) Number of atoms per unit cell in an f.c.c. lattice is

(i) 1

(ii) 2

(iii) 3

(iv) 4

- (b) If temperature increases, the electrical conductivity of semiconductor
- (i) increases
  - (ii) decreases
  - (iii) remains constant
  - (iv) reduces to zero
- (c) Above Curie temperature a ferromagnetic material becomes
- (i) antiferromagnetic
  - (ii) diamagnetic
  - (iii) paramagnetic
  - (iv) ferrimagnetic
- (d) What is a phonon?
- (e) The magnetic susceptibility of superconductor is
- (i) zero
  - (ii) positive
  - (iii) negative
  - (iv) infinite

2. Give very short answers of the following questions : **(any five)**  $2 \times 5 = 10$

- (a) Draw unit cells of simple cubic lattice showing (111) and (210) planes.
- (b) State Curie-Weiss law and Curie law.
- (c) A crystalline solid diffracts X-ray. Can the solid also diffract  $\gamma$ -rays and visible light? Justify.
- (d) Write the names of bondings which are available in  $\text{NaCl}$ , diamond, ice and  $\text{Cu}$  molecules.
- (e) Define polarisation.
- (f) What are primitive and non-primitive unit cells?
- (g) Define Fermi energy and density of states.
- (h) An insulator has an optical absorption which occurs for all wavelengths lesser than  $1400\text{\AA}$ . Find the width of the forbidden energy band for insulator.

(i) Write *two* differences between nano-materials and bulk materials.

(j) Find out the relation  $\mu_r = 1 + \chi_m$  for magnetic substance, where  $\mu_r$  and  $\chi_m$  are the relative permeability and magnetic susceptibility of the substance respectively.

3. Give answers of the following questions :  
**(any four)** 5×4=20

(a) What do you mean by Miller indices? How are Miller indices determined? Write its *four* important features.

1+2+2=5

(b) Write Wiedmann-Franz law and its limitations.

(c) Discuss the properties of nano-materials.

(d) (i) Calculate the cohesive energy of ionic crystal. 3

(ii) Define electron affinity and ionisation energy. 2

(e) Write the assumptions of linear monoatomic vibration and find out its dispersion relation. 2+3=5

(f) (i) Find out relation between electric field, displacement vector and polarisation vector of dielectric. 3

(ii) The electric susceptibility of a material is

$25.4 \times 10^{-12} \frac{c^2}{nt \cdot m^2}$ . What are the

values of dielectric constant and permittivity of the material? 2

(g) (i) What is Meissner effect? Write the difference between type-I and type-II superconductors using Meissner effect. 1+2=3

(ii) A superconductor has a critical temperature of 2.5K at zero magnetic field and a critical field of 0.04T at 0K. Determine the critical field at 3K. 2

(h) (i) Write the differences between diamagnetic and paramagnetic substances. 3

- (ii) Calculate the glancing angle on the plane (110) of a crystal ( $a = 2.5\text{\AA}$ ) corresponding to second order diffraction maxima of wavelength  $0.7\text{\AA}$ . 2

4. Answer **any one** of the following questions :

10×1=10

(a) Write short notes on **any two** of the following :

(i) Free electron theory

(ii) Covalent bond

(iii) Bravais lattice

(iv) B-H curve and Hysteresis loss

(b) (i) Derive classical Langevin theory of diamagnetism. 8

(ii) How magnetic behaviour of magnetic substance changes with temperature? 2

(c) (i) Discuss Kronig-Penny model. 7

- (ii) Calculate the conductivity of germanium. Given mobilities of electron and holes in a sample of germanium at room temperature are  $0.54\text{m}^2\text{v}^{-1}\text{s}^{-1}$  and  $0.18\text{m}^2\text{v}^{-1}\text{s}^{-1}$  respectively. Assuming that electron and hole densities are each equal to  $3.6 \times 10^{19}$  per  $\text{m}^3$ . If a potential difference of 2 volts is applied across the germanium plate of thickness  $0.2\text{mm}$  and area  $1\text{cm}^2$ , calculate the current produced in the plate. 3

(d) (i) Derive Einstein's theory of specific heat. 7

(ii) What are the limitations of Dulong and Petit's law? 3