Total number of printed pages–7

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 :   1×5=5

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

   (i)   1

   (ii)   2

   (iii)   3

   (iv)   4

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(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)* 2×5=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 γ-rays and visible light ? Justify.

(d) Write the names of bondings which are available in *NaCl*, diamond, ice and *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 $1400 \mathring{A}$. 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 μ_r and χ_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

$$25 \cdot 4 \times 10^{-12} \frac{c^2}{nt \cdot m^2}.$$ 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 $2 \cdot 5K$ at zero magnetic field and a critical field of $0 \cdot 04T$ at $0K$. Determine the critical field at $3K$. 2

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

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(ii) Calculate the glancing angle on the plane (110) of a crystal ($a = 2 \cdot 5 \mathring{A}$) corresponding to second order diffraction maxima of wavelength $0 \cdot 7 \mathring{A}$. 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

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

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