## 3 (Sem-5/CBCS) PHY HC 2

## 2023

## **PHYSICS**

(Honours Core)

Paper: PHY-HC-5026

(Solid State Physics)

Full Marks: 60

Time: Three hours

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

- 1. Choose the correct answer from the following:  $1 \times 7 = 7$ 
  - (a) If N is the number of primitive cells in a specimen, the number of orbitals in the band will be
    - (i) N
      - (ii) 2N
      - (iii) 3N
      - (iv) 4N

- A superconductor exhibits (b) infinite conductivity (i) finite conductivity (ii) zero conductivity (iii) negative conductivity (iv) First Brillouin zone of a body-centred (c) cubic latice is (i) cube (ii) sphere rhombic dodecahedron (iii) (iv)truncated octahedron Packing fraction of simple cubic cell is (d) (i) 0.52 (ii) 0.68
  - (iv) 1

(iii)

0.74

- (e) The material that does not have permanent magnetic dipoles is
  - (i) anti-ferromagnetic
  - (ii) ferromagnetic
  - (iii) diamagnetic
  - (iv) paramagnetic
- (f) Four probe method is used for the experimental measurement of
  - (i) conductivity of semiconductor
  - (ii) charge carrier density
  - (iii) energy band gap of semiconductor
  - (iv) band gap and conductivity of semiconductor
- (g) The electron pairs in a superconductor are called
  - (i) Cooper pair
  - (ii) BCS pair
- (iii) positron pair
  - (iv) electron-hole pair

- 2. Answer the following questions:  $2\times4=8$ 
  - (a) What is reciprocal lattice vector? and equal mag
     (b) What is the energy eigenvalue for a phonon of frequency ω? What is its zero point energy?
  - (c) Draw a simple energy band diagram of n-type semiconductor showing conduction band, valence band, donor level and Fermi level.
  - (d) Explain how Meissner effect may be used to distinguish between type I and type II superconductors.
  - 3. Answer **any three** of the following questions:  $5\times 3=15$ 
    - Show that reciprocal of the reciprocal lattice is the direct lattice.
    - (b) Deduce the vibrational modes of a diatomic lattice stating the acoustic and optical modes.
    - Elaborate the basic features of Debye model of lattice heat capacity.
    - (d) What is ferromagnetic domain?

      Discuss in brief the domain theory of ferromagnetism.

(e) Obtain an expression for conductivity of an intrinsic semiconductor.

4. Answer any three of the following questions: 10×3=30

Write down the Bragg's law of X-ray diffraction. Calculate the glancing angle for (100) plane of cubic structured crystal with a = 2.814Å corresponding to second order X-ray diffraction maximum of wavelength 0.710Å.

1+3=4

What are the various symmetry elements associated with a crystal? The Symmetry 2

What do you mean by atomic scattering factor and geometrical structure factor? 2+2=4

Obtain the classical Langevien equation for diamagnetism to show that diamagnetic susceptibility is independent of temperature and field strength. 6

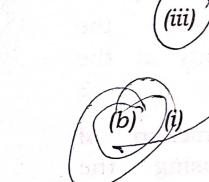
Write down the Curie law for a paramagnetic substance. What is Curie temperature?

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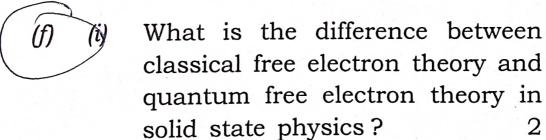
(i)

- (iii) What do you mean by hysteresis of a ferromagnetic material? Why hysteresis loop of a ferromagnetic material is important in practical application of the material? 2
- Use the basic idea of Kronig-(c) (i) Penney model to show that the motion of electrons in the periodic potential of solids give rise to the formation of allowed and forbidden energy bands. 7
  - (ii) The intrinsic resistivity of silicon at  $27^{\circ}C$  is  $2.8\times10^{3}$   $\Omega m_{\odot}$  The electron and hole mobilities are 0.38  $m^2v^{-1}s^{-1}$  and 0.18  $m^2v^{-1}s^{-1}$ respectively. Calculate the intrinsic carrier density at the given temperature.
- (d) Explain the phenomenon super-conductivity using elementary idea of BCS theory. 3
  - Define Critical temperature, Critical magnetic field and Isotope effect related to superconductivity. makratanon!

- (iii) Show that in case of a superconductor magnetic field decreases rapidly with distance from the surface.
- (e) (i) Differentiate between ferroelectricity and piezoelectricity. 2
  - (ii) Consider an electron of charge '-e' rotating in a circular orbit of radius r in a field directed at right angles to the plane of the orbit. Show that polarizability

$$\alpha = 4\pi \,\varepsilon_0 r^3 \tag{4}$$

(iii) What do you mean by normal and anomalous dispersion? 2+2=4



(ii) Copper has electrical conductivity at 300K as  $6.4 \times 10^7$  mho/m. Calculate the thermal conductivity of copper. Lorentz number  $L = 2.45 \times 10^{-8} W\Omega K^{-2}$ . 2

- (iii) What is Hall effect? Derive an expression for Hall co-efficient of a semiconductor. 1+3=4
  - (iv) A silicon plate of thickness 2 mm, breadth 8 mm and length 80 cm is placed in a magnetic field of 0.5 Wb/m² acting perpendicular to its thickness. If 10-2A current flows along its length, calculate the Hall voltage developed if the Hall co-efficient is 3.66×10-4 m³/coulomb.