3 (Sem–5/CBCS) PHY HC2

2024

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 of the following questions from the given options : 1×7=7

   (a) Atomic packing factor of simple cubic structure is

   (i) π

   (ii) $\pi/2$

   (iii) $\pi/4$

   (iv) $\pi/6$

(b) A phonon does not have momentum but a phonam with wave vector k when interacts with other particles and fields, behaves as if it has a momentum

(i) $\hbar k$

(ii) hk

(iii) $\frac{1}{2}\hbar k$

(iv) $\frac{1}{2}hk$

(c) Two paramagnetic substances have susceptibilities χ_1 and χ_2 at absolute temperatures T_1 and T_2 respectively, then the ratio of χ_1 and χ_2 equals to

(i) $\frac{T_2}{T_1}$

(ii) $\frac{T_1}{T_2}$

(iii) $\frac{T_2^2}{T_1^2}$

(iv) $\frac{T_1^2}{T_2^2}$

(d) The polarisation which is observed in all kinds of materials is

(i) ionic polarisation

(ii) dipolar polarisation

(iii) electronic polarisation

(iv) space charge polarisation

(e) Piezoelectric coefficients of ferroelectrics are

(i) very small

(ii) small

(iii) large

(iv) very large

(f) For a sample having $8\times10^{28}/m^3$ numbers of electrons per unit volume, the Hall coefficient will be

(i) $0.078\times10^{-9}\,m^3/C$

(ii) $0.128\times10^{-9}\,m^3/C$

(iii) $0.081\times10^{-9}\,m^3/C$

(iv) $0.016\times10^{-9}\,m^3/C$

(g) The critical temperature of mercury with isotropic mass 199.5 *amu* is 4.185*K*. When its isotropic mass changes to 203.4 *amu*, the critical temperature will be

(i) 4.198*K*

(ii) 4.169*K*

(iii) 4.146*K*

(iv) None of the above

2. Answer the following questions : 2×4=8

(a) What is complex dielectric constant ?

(b) Explain, what do you mean by first-order and second order phase transition in case of ferroelectric crystals.

(c) Describe the significance of Block function.

(d) Draw the unit cell of simple cubic lattice showing clearly the Miller indices of all its six faces.

3. Answer ***any three*** of the following questions : 5×3=15

(a) Show that the reciprocal lattice of a bcc lattice is a fcc lattice.

(b) How lattice vibrations are quantized ? Name the various vibrational modes of a linear monoatomic lattice. Differentiate between normal processes and umklapp processes. 2+1+2=5

(c) What do you mean by ferromagnetic domain ? Explain the role of Block wall in case of domain formation. What is magnetic energy and anisotropic energy ? 1+2+2=5

(d) What do you mean by Fermi level ? What is Fermi sphare ? Write down the Fermi distribution function at temperature *T*. Give a schematic representation of this function at temperatures T_1 and T_2, where $T = 0^\circ K$ and $T_2 > T_1$. 1+1+1+2=5

(e) Differentiate between Type I and Type II superconductors showing their magnetisation curves. What is intermediate state ? 3+2=5

Contd.

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

(a) (i) Show that Bragg's law in vector form when obtained from Ewald construction in reciprocol lattice is given by

$$G^2 + 2\,\vec{k}.\vec{G} = 0$$

where $\vec{G}$ is reciprocal lattice vector. 7

(ii) When X-rays of wavelength 1.8 $\mathring{A}$ are used, the Bragg's angle corresponding to the first-order reflection from (1, 1, 1) planes in a crystal is 45°. Calculate the interatomic spacing for the crystal. 3

(b) (i) Obtain Debye's T^3 law of specific heat of solids. 7

(ii) Evaluate the Debye frequency of a crystal lattice corresponding to Debye temperature 350*K*. Given that Boltzmann constant is

$1.38\times10^{-23}\ m^2 kg\, s^{-2} K^{-1}$ 3

(c) (i) Use Langevin's classical theory to show that the paramagnetic susceptibility is inversely proportional to temperature. 7

(ii) The magnetic field of 20 CGS units produces a flux of 2400 CGS units in an iron bar of cross-section $0.2\,cm^2$. Calculate the permeability and susceptibility of this bar. 3

(d) (i) Establish Clausius-Mossotti relation between polarisability and dielectric constant of a material. 7

(ii) Calculate the induced dipole moment per unit volume of *He* gas placed in an electric field of $6\times10^5\ volt/m$. The molecular polarisability of *He* is 2.33×10^{-41} farrad$-m^2$ and the density of *He* is 20.6×10^{25} molecules$/m^3$. 3

(e) (i) Use free electron theory of metals to show that at constant temperature the ratio of thermal to electrical conductivity of metals is a constant. 7

(ii) For a semiconductor, the intrinsic carrier density is $1.5 \times 10^{16} m^{-3}$. If the mobility of electrons and holes are 0.13 and $0.5 m^2 V^{-1} s^{-1}$ respectively, calculate the conductivity. 3

(f) (i) State the Curie-Weiss law. What do you mean by Ferroelecrtic Curie temperature ? Explain in brief the significance of P-E hysteresis loop in case of ferroelectricity. 2+1+2=5

(ii) Write down the London equations of superconductivity. Show that Meissner effect contradicts the Maxwell's equation. 2+3=5
