Total number of printed pages = 8

63/1(SEM-5)CC12/PHYHC5126

2024

PHYSICS

Paper : PHYHC5126

(Solid State Physics)

Full Marks : 60

Pass Marks : 24

Time : 2 hours

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

1. Choose the correct answer: ***(any five)*** 1×5=5

   (a) Lattice + basis is

   (i) atomic structure

   (ii) crystal structure

   (iii) unit cell

   (iv) Miller indices

(b) Every reciprocal lattice vector is

(i) parallel to lattice plane

(ii) perpendicular to lattice plane

(iii) inclined at an angle of 45°

(iv) inclined at an angle of 60°

(c) The diamagnetic susceptibility is

(i) negative and does not depend on temperature

(ii) positive and does not depend on temperature.

(iii) negative and depends on temperature.

(iv) positive and depends on temperature

(d) Basically the dielectric materials are

(i) semiconductors

(ii) conductors

(iii) superconductors

(iv) insulators

(e) The expression $C_V=3R$ (the symbols have their usual meanings) represents

(i) Debye's law

(ii) Wein's law

(iii) Dulong and Petit's law

(iv) Planck's law

(f) The current density is given by

(i) $J=\frac{1}{neV_d}$

(ii) $J=neV_d$

(iii) $J=\frac{e}{nV_d}$

(iv) $J=\frac{V_d}{ne}$

(g) Magnetic permeability of a paramagnetic material is

(i) equal to 1

(ii) less than 1

(iii) slightly greater than 1

(iv) equal to zero

(h) Piezoelectricity is a phenomenon in which

(i) electrical energy is converted into thermal energy

(ii) electrical energy is converted into mechanical energy

(iii) mechanical energy is converted into electrical energy

(iv) mechanical energy is converted into thermal energy

(i) The band gap between the valence band and the conduction band in an insulator is

(i) high

(ii) low

(iii) very low

(iv) zero

(j) The superconducting state in perfectly

(i) paramagnetic state

(ii) ferromagnetic state

(iii) diamagnetic state

(iv) anti-ferromagnetic state

2. Answer the following questions : ***(any five)*** 2×5=10

(a) What do you mean by crystal lattice?

(b) Explain why X-rays are useful for crystal analysis.

(c) Define magnetic susceptibility "Magnetic susceptibility is a dimension less quantity."- true *or* false? 1+1=2

(d) What is plasma state of matter and how it can be artificially generated? 1+1=2

(e) What is ferro electric effect? Define Curie temperature in ferro electricity. 1+1=2

(f) Define mobility of charge carriers. Write the relation between current density and mobility. 1+1=2

(g) Define critical magnetic field for a superconductor. 1+1=2

Draw a graph to show the variation of critical magnetic field with temperature. 1+1=2

3. Answer the following questions : ***(any five)***

(a) What are crystal planes? Draw the crystal plane with intercepts (1,1,1)

Calculate the Miller indices of the plane having intercepts 2a,3b,2c. 1+1+3=5

(b) Show that the reciprocal lattice of a *bcc* lattice is an *fcc* lattice. 5

(c) Define atomic heat capacity of a substance.

State and prove Dulong and Petit's law. 1+4=5

(d) Define relative permeability and magnetic susceptibility.

Deduce a relation between them. 2+3=5

(e) What do you mean by hysteresis? Show that hysterasis loss is equal to the area of the B-H loop. 1+4=5

(f) What is plasma oscillation? Discuss the mechanism of electron oscillation. What is plasma frequency? 1+3+1=5

(g) What is ferroelectric effect? What are ferroelectric domains and how they behave in presence of an external electric field ? 5

(h) Describe the two types of extrinsic semiconductors with proper energy band diagrams? 5

(i) What is Hall effect ? Deduce a relation between Hall co-efficient and Hall field. 1+4=5

4. Answer the following question: ***(any two)*** 10×2=10

(a) Consider the vibrations of an infinitely long one-dimensional chain of atoms of mass 'M' separated by a distance 'a'. Let U_n denote the displacement of the n^{th} atom from its equilibrium position.

Suppose each atom interact only interact with its nearest neighbours and the interaction is harmonic. That is the potential for the n^{th} atom is

$$u_n = \frac{r}{2}(u_{n-1} - u_n)^2 + \frac{r}{2}(u_n - u_{n+1})^2, r > 0$$

Show that the phonon dispersion relation is given by

$$w(K) = 2\sqrt{\frac{r}{M}} \left| \sin\frac{Ka}{2} \right|$$

Clearly explain every step in your derivation. 5+5=10

(b) Calculate and plot the phonon group velocity as a function of the wave vector '*K*'. 2+8=10

Or

What is diamagnetism? Discuss the Langevins theory of diamagnetism.

2+8=10

(c) Define molecular polarizability. Deduce Langevin-Debye equation of polarisation in polar dielectrics.

1+9=10

(d) Derive the Loudon equations of Superconductivity and then find an expression for penetration depth.

5+5=10
