U.G. 5th Semester Examination - 2023

PHYSICS

[HONOURS]

Course Code : PHY-H-CC-T-12

(Solid State Physics)

Full Marks : 40 Time : $2\frac{1}{2}$ Hours

The figures in the right-hand margin indicate marks.

Candidates are required to give their answers in their own words as far as practicable.

GROUP-A

1. Answer any **five** questions: 2×5=10

a) Compare the properties of amorphous and crystalline materials with example.

b) Explain the term "lattice translation vector" with proper diagram.

c) What piezoelectric effect? Give example of piezoelectric material. What are the applications of piezoelectric material?

d) What is complex dielectric constant?

e) How does Kronig Penny model lead to the concept of allowed and forbidden energy bands in solid?

f) What is electron mobility in a semiconductor?

[Turn over]

g) Sketch the variation of the magnetic susceptibility of a ferromagnetic material with the applied magnetic field above and below the Curie point.

h) What do you mean by type I and type II superconductor?

GROUP-B

2. Answer any **two** questions: 5×2=10

a) i) KBr crystal has a cubic structure. Assuming it to be an ionic crystal, calculate its lattice constant.
(Given density=2.75×10^3 $Kg.m^{-3}$, Molecular Weight=119.0)

ii) What are the Bravais lattices in orthorhombic lattice structure? Give diagram. 3+2

b) Briefly describe the experimental procedure for measuring Hall coefficient. What is the application of four-probe technique? 4+1

c) i) Consider a dielectric slab placed in an electric field E. Show that the Lorentz field due to the polarization charges is $\frac{P}{3\varepsilon_0}$, where P is the polarization and ε_0 is free space permittivity.

ii) Write down the relation between the dielectric constant and atomic polarizability. 4+1

d) What is Hysteresis? Discuss its occurrence on the basis of domain concept. Draw the B-H loop for a paramagnetic material .

$1\frac{1}{2}+2+1\frac{1}{2}$

GROUP-C

Answer any **two** questions: 10×2=20

3. a) Define reciprocal lattice.

b) The primitive translation vectors of a simple cubic lattice are $\overrightarrow{a_1} = a\hat{x}$, $\overrightarrow{a_2} = a\hat{y}$, $\overrightarrow{a_3} = a\hat{z}$ where x, y, z are orthogonal vectors of unit length. What are the primitive translation vectors of the reciprocal lattice?

c) What is five-fold symmetry? Why five fold symmetry is not possible in crystalline solids?

d) Obtain classical Langevin's formula for the susceptibility of the diamagnetic paramagnetic material. 2+2+2+4

4. a) Show that in one dimensional monoatomic lattice, the relation between frequency of vibration and the wave vector q is $\omega = \sqrt{\frac{4C}{M}}\left|\sin\frac{qa}{2}\right|$ where M is the mass of atom and C is the interatomic force constant, a is the interatomic equilibrium distance.

b) Calculate the phase and group velocity.

c) Show that in the long wavelength limit, phase velocity is independent of wave vector.

d) Briefly explain how BCS theory accounts for the superconducting state. 4+2+2+2

5. a) Find an expression for the number of modes with frequency between v and $v+dv$ in monoatomic lattice.

b) By considering Debye approximation derive the expression for specific heat capacity of solids. 4+6

6. a) Derive the expression for the dielectric constant as a function of ω, $\varepsilon(\omega)=1-\frac{\omega_p^2}{\omega^2}$, where $\omega_p^2 = \frac{ne^2}{\epsilon_0 m}$, n is the number density of free electron, m is the mass of electron and e is the charge of electron.

b) What is the significance of plasma frequency in case of optical phenomena in metal?

c) Explain the effect of structural phase transition in ferroelectric materials.

d) Derive the expression of AC conductivity from Drude model. 4+2+1+3
