[CO2]

(b) Explain Josephson effect in superconductor and discuss its application. 4

(OR)

[CO4]

8. *(a)* How does polarisability related with *(i)* radius of the atom, *(ii)* mass of the atom and *(iii)* temperature? 6

(b) Explain dielectric loss. How does dielectric loss change with *(i)* frequency and voltage of the applied voltage, *(ii)* temperature and humidity. Also explain the reason. 4

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B. Sc. Physics (Hons.) Examination, 2025

(3rd Year, 1st Semester)

PHYSICS

Paper : CORE/TH/12

(Solid State Physics)

Time : 2 *Hours* *Full Marks* : 40

Use a separate answer script for each Group.

GROUP—A

[CO1]

1. *(a)* The electron density of a crystalline solid results from the convolution of the lattice structure and the basis. Using this concept, define the form factor and the structure factor of a solid. Explain their significances in the light of the diffraction pattern from a crystal. 3+2=5

(b) Consider a metal with an fcc structure and an atomic weight of 92·9. When monochromatic X-ray of wavelength 1·54 Å strikes the crystal, the angle of diffraction (2θ) for the (311) set of planes in the metal occurs at 72 degrees (For the first order reflection).

- Calculate the interplanar spacing for the set of planes (311).
- Determine the lattice parameter for the metal.
- Estimate the density of the metal. 5

(OR)

[CO1]

2. *(a)* Determine the Miller indices of a plane that makes intercepts of 4 Å, 3 Å and 8 Å on the coordinate axes of an orthorhombic lattice with the ratio of the axial lengths as $a : b : c = 2 : 3 : 1$. 3

(b) Starting from the scattered amplitude from a unit cell derive the expression for atomic form factor. 3

(c) Calculate the structure factor of fcc lattice and hence show that structure factor vanishes if one of the integers (h, k, l) is either odd or even. 2+2=4

[CO3]

3. *(a)* The dispersion relation can be obtained for the lattice with two atoms per primitive basis (Diatomic lattice) from the following equation :

$M_1 M_2 \omega^4 - 2C(M_1 + M_2)\omega^2 + 2C^2(1 - \cos ka) = 0$

where symbols have their usual meanings. Examine the solution of the above equation in the limit $ka << 1$ and $ka = \pm\pi$. Plot the dispersion curve in the 1st Brillouin zone. Indicate the optical and acoustical branches. Draw a schematic picture to show vibration of atoms in the optical and acoustical modes. 4+2+2=8

(b) Why did Einstein's theory of lattice vibration fail to explain empirical behaviour of specific heat? 2

(OR)

[CO3]

4. *(a)* What are the basic assumptions in the Debye model in the context of specific heat of a solid? Following the

Debye assumptions, estimate the density of states in three-dimension and hence calculate the Debye cut off frequency. 2+3+2=7

(b) Show that Debye assumption may be fault in the high frequency region. (Hints: Debye frequency $\sim 10^{13}$ Hz, Velocity of the elastic wave $\sim 10^5$ cm/s). 3

GROUP—B

[CO2]

5. *(a)* What is magnetic susceptibility? How does magnetic suceptibility of a paramagnetic substance vary with temperature? 1+3=4

(b) What is Curie-Weiss law? Discuss the domain structure in ferromagnetic materials. 6

(OR)

[CO2]

6. *(a)* What force exists in the flow of electron in the super-conductor? Why does a superconductor show zero resistance? Why does superconductor behave as a perfect diamagnetic material? 3+2+2=7

(b) Why superconductivity can be achieved only at low temperature? What is superconducting state? Explain the importance of superconducting state. 1+1+1=3

[CO4]

7. *(a)* Explain the difference between hard and soft superconductors. How does superconductor behave in presence of external magnetic field, electric current, temperature and pressure? 2+4=6