

Ex/SC/PHY/UG/CORE/TH/12/2024

BACHELOR OF SCIENCE EXAMINATION, 2024

(3rd Year, 1st Semester)

PHYSICS

PAPER : Core/12

(Solid State Physics)

Time : Two Hours

Full Marks : 40

Use a separate answer script for each group.

GROUP—A

1. (a) How is amorphous solid different from polycrystalline solid? 2
- (b) Consider X-ray scattering from a material. Show that the scattered amplitude is the Fourier transform of electron density of the material. 4
- (c) Show that the every reciprocal lattice vector is perpendicular to the plane of direct lattice. 3
- (d) What is the Miller indices of the diagonal plane of a cube? (CO1) 1

(2)
(OR)

(a) Diffraction pattern of a crystal is a map of reciprocal lattice. Show that the significant value of a scattering amplitude can occur when scattering vector is equal to reciprocal vector (Most general diffraction condition). Hence derive Bragg's diffraction condition. 3+2=5

(b) Establish the concept of Brillouin zone from the most general diffraction condition. Calculate the volume of the Brillouin zone of a bcc lattice. (CO1) 2+3=5

2. (a) Frequency (ω) of vibration of a crystal with monoatomic

basis is given by the relation $\omega^2 = \frac{4c}{M} \sin^2 \frac{1}{2} ka$.

Show that group velocity of the wave at the boundary of the first Brillouin zone is zero. In the long wavelength limit, show that ω is directly proportional to the wave vector, i.e. velocity of the wave is independent of frequency. 2+2=4

(b) Consider an array of N similar atoms, separation between nearest neighbours being a . Discuss the specific heat of the system on the basis of the Debye approximation and determine the low temperature behaviour of the specific heat. (CO3) 4+2=6

(5)
(OR)

6 (a) Explain with reason, how the dielectric value of a dielectric material changes when AC currents of various frequencies are applied to it. 3

(b) Derive and explain Langevin-Debye equation for dielectric. 4

(c) Explain with diagram, the energy exchange process of copper pair so that it can move without any resistance. 3 (CO2)

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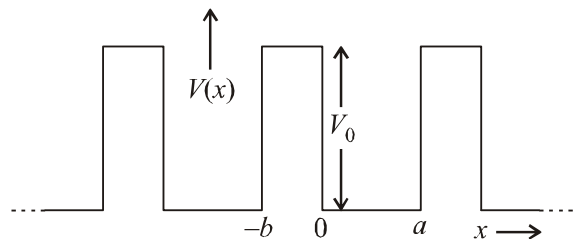
(3)
(OR)

- (a) State the Bloch theorem. Prove it for non-degenerate wave function. 2+3=5
- (b) Solution for the wave equations in the Kronig-Penney model (square-well periodic potential), as shown in figure

below, exist only if $p \frac{\sin \alpha a}{\alpha a} + \cos \alpha a = \cos ka$ ①

where $p = \frac{mV_0ba}{\hbar^2}$, m is the mass of the electrons.

$\alpha^2 = \frac{2mE}{\hbar^2}$ and k is the wave vector.



- (i) Under what condition, do you get the equation ①? 1
- (ii) By using the equation ①, show graphically the existence of band structure in a solid. 2
- (iii) Under what condition, does the energy spectrum become line spectrum? 1
- (iv) Draw the energy E vs k diagram for different Brillouin zones. (CO3) 1

(4)
GROUP—B

3. (a) Discuss diamagnetism in materials. Obtain the classical Langevin equation for diamagnetism. 5
- (b) With proper diagram, discuss the variation of magnetic susceptibility with temperature for dia-, para-and ferromagnetic materials. 3
- (c) What are the salient features of hard and soft magnetic materials? (CO4) 2

(OR)

4. (a) Give an account for the quantum theory of paramagnetism and discuss the low and high temperature cases. 5
- (b) Do all insulating materials show piezoelectric property? Explain in detail. 3
- (c) Explain with diagram, how polarization and stress change with applied electric field in piezoelectric material. (CO4) 2
5. (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
- (b) Explain Josephson effect in superconductor and discuss about its applications. (CO2) 4