

B. SC. PHYSICS (HONS.) EXAMINATION, 2023

(3rd Year, 1st Semester)

SOLID STATE PHYSICS

PAPER – UG/SC/CORE/PHY/TH/12

Time : Two hours

Full Marks : 40

Group – A

Answer *any two* questions.

1. a) In a typical x-ray diffraction of a crystalline solid, what determines the positions of the peak and intensity of each peak? 2
- b) Positions of the atoms in the fcc lattice are at $(0,0,0)$, $(0, \frac{1}{2}, \frac{1}{2})$, $(\frac{1}{2}, 0, \frac{1}{2})$ and $(\frac{1}{2}, \frac{1}{2}, 0)$. Calculate the structure factor. Show that in the fcc lattice no reflection can occur for which the indices are partly even and partly odd. 3+2
- c) Show that the bcc lattice is reciprocal to the fcc lattice. 3
2. a) Calculate the atomic form factor. Show that in the forward scattering the atomic form factor reduces to the number of atomic electrons. 4+1
- b) The primitive translation vectors of the hexagonal space lattice are given by

$$\vec{a}_1 = \frac{\sqrt{3}a}{2}\hat{x} + \frac{a}{2}\hat{y}$$

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$$\vec{a}_2 = -\frac{\sqrt{3}a}{2}\hat{x} + \frac{a}{2}\hat{y}$$

$$\vec{a}_3 = c\hat{z}$$

Calculate the primitive translation vectors in the reciprocal lattice. Is there any specific relation of the reciprocal lattice with its own lattice? 4+1

3. a) For a diatomic linear chain, the phonon dispersion relation is given by

$$\omega^2 = f\left(\frac{1}{M_1} + \frac{1}{M_2}\right) \pm f\left[\left(\frac{1}{M_1} + \frac{1}{M_2}\right)^2 - \frac{4}{M_1M_2}\sin^2\frac{ka}{2}\right]^{\frac{1}{2}}$$

There are two atoms in the unit cell of masses M_1 and M_2 , and the force constant of nearest neighbour interaction is given by f .

- Calculate the sound velocity. 3
 - Show that for $M_1 = M_2$ the result is equivalent to the dispersion curve of single atom chain. 2
- b) A monatomic, cubic material has lattice spacing of a . The sound velocity for longitudinal and transverse phonons is approximately equal, $c_T = c_L = c$, is isotropic, and the highest frequency is ω^* . What is the Debye frequency? 5

[3]

Group – B

Answer *any two* questions.

4. a) Explain the distinguishing features of ferromagnetism. 2
- b) Give an account of the Langevin's theory of paramagnetism. 6
- c) Discuss the temperature variation of saturation magnetization of ferromagnetic materials. 2
5. a) Explain various polarization processes in dielectric material. 3
- b) Explain piezoelectric effect in quartz crystal and its application in clock. 4
- c) What is Cooper pair and discuss about the BCS theory. 3
6. a) Explain Normal and Anomalous Dispersion in dielectric materials. 3
- b) Derive Clausius-Mossotti relation and explain its importance. 7