

Attempt any **FOUR** Questions, selecting at least one from each section.
 All questions carry equal marks

Section-I

- 1- a) Give a detailed description of STRUCTURE FACTOR. 5
 b) Draw unit cell structure of CUBIC ZINC SULFIDE and discuss it w.r.t. basis, nearest neighbour distance and lattice parameters. 2.5
 c) Evaluate Structure Factor for a bcc lattice. 5
- 2- a) What is the role of VAN DER WAALS Interactions in Inert Gas Crystals? 5
 b) For H_2 , the Lennard-Jones parameters are $\epsilon = 50 \times 10^{-16}$ erg and $\sigma = 2.96 \text{ \AA}$. Find the cohesive energy in KJ per moles of H_2 . Consider fcc structure and H_2 molecules as a sphere. 2.5
 c) Discuss the Formation and Characteristics of COVALENT BONDS in COVALENT CRYSTALS. 5
- 3- a) Find the Dispersion relation for a MONATOMIC LINEAR LATTICE. 5
 b) Derive Force Constants from experiments using the dispersion relation for a Monatomic Linear Lattice. 5
 c) Consider point ions of mass M and charge e immersed in a uniform sea of conduction electrons. The ions are imagined to be in stable equilibrium when at regular lattice points. If one ion is displaced a distance r from its equilibrium position, the restoring force is due to electric charge within the sphere of radius r centered at equilibrium position. Take the number density of ions as $\frac{3}{4} \pi R^3$, which defines R. Show that the frequency of a single ion set into oscillation is $\omega = \left(\frac{e^2}{MR^3} \right)^{1/2}$. 2.5

Section-II

- 4- a) How DEBYE Model for Density of States can be used to derive DEBYE T^3 LAW? Discuss in detail. 5
 b) From the dispersion relation for a Monatomic Linear Lattice of N atoms with nearest neighbor interactions, Show that density of modes is:

$$D(\omega) = \frac{2N}{\pi} \cdot \frac{1}{(\omega_m^2 - \omega^2)^{1/2}}, \text{ where } \omega_m \text{ is maximum frequency.}$$
 2.5
 c) Describe the effect of ANHARMONIC CRYSTAL Interactions on the THERMAL EXPANSION of a CRYSTAL. 5
- 5- a) Why thermal properties of an Amorphous Solid are unexpected and different from Crystalline Solids? Determine expressions for Heat Capacity of an Amorphous solid by considering a Two-Level System. 5
 b) Suppose that the energy required to remove a sodium atom from inside of a sodium crystal to the boundary is 1 eV. Calculate the concentration of SCHOTTKY VACANCIES at 300K. Given that $N = 2.5 \times 10^{22}$ atoms/cm³ for Sodium. 2.5
 c) Clearly distinguish between SCHOTTKY and FRENKEL DEFECTS. What are the effects of these defects on various Crystals? 5
- 6- a) How Dislocations affect CRYSTAL GROWTH? Discuss briefly, also explain the growth of Whiskers. 5
 b) How Hardness of a Material can be measured? 2.5
 c) Discuss various factors which can enhance the STRENGTH OF AN ALLOY. 5
- 7- Write notes on any Two of the following: 6, 6.5
 - a) BRILLOUIN ZONE
 - b) PHONON MOMENTUM
 - c) GLASSES
 - d) COLOR CENTRES