(b) Write short notes on (i) Critical temperature (ii) Critical magnetic field and its variation with temperature. (5)

(c) The penetration depth for lead is 396Å and 1730Å at 3K and 7.1 K respectively. Calculate the critical temperature for lead. (5)

6. (a) Discuss the Langevin's theory of para-magnetism. How does the quantum theory remove the shortcomings of classical Langevin's theory. (8)

(b) A paramagnetic salt contains 10^{28} ions/m^3 with magnetic moment of one Bohr magneton. Calculate the paramagnetic susceptibility and the magnetization produced in a uniform magnetic field of 10^6 A/m at room temperature (Given 1 bohr magneton = $9.27 \times 10^{-24} A/m^2$. (7)

7. (a) Discuss the formation of allowed and forbidden energy band gap on the basis of Kronig-Penny model. (10)

(b) The energy near the valence band edge of a crystal is given by: $E = -A K^2$ where $A = 10^{-39} Jm^2$. An electron with wave vector $k = 10^{10} i\ m^{-1}$ is removed from an orbital in a completely filled valence band. Determine the effective mass and energy of the electron. (5)

[This question paper contains 4 printed pages.]

01.01.2024 (M)

Your Roll No.....

Sr. No. of Question Paper : 4388 **G**

Unique Paper Code : 32221502

Name of the Paper : Solid State Physics

Name of the Course : **B.Sc. (Hons.) Physics**

Semester : V

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt any **five** of the following questions.
3. Question no. **1** is compulsory.

1. Attempt any **Five** of the following : (3×5=15)

(a) What are point groups. Mention which are the two symmetry operations permissible in 2-D lattice? How many point groups are possible in 2-D lattice?

(b) What type of lattice and basis do the following structures have: (a) Sodium Chloride (b) Diamond Cubic (c) Zinc sulphide?

(c) What is Ewald's construction? Give its significance

(d) For Cu, Einstein's temperature is 230°K. Calculate Einstein's frequencies of atoms in the solids. Given that $h = 6.6 \times 10^{-34}$Js and $k_B = 1.38 \times 10^{-23}$ J/K.

(e) What are phonons? Mention one experimental fact which suggests the existence of phonons.

(f) How does the Debye model differ from the Einsteins model of specific heat?

(g) What are the shortcomings of the free electron theory? Does this theory account for the validity of ohm's law?

(h) What is ferroelectricity? Draw the graph showing variation of polarization with electric field in the ferroelectric materials. Give one example of compound /element which show ferroelectricity.

2. (a) The primitive translation lattice vectors of a crystal are :

$\vec{a} = \frac{a}{2}(\hat{\imath} + \hat{\jmath} - \hat{k}), \vec{b} = \frac{a}{2}(-\hat{\imath} + \hat{\jmath} + \hat{k})$ and

$\vec{c} = \frac{a}{2}(\hat{\imath} - \hat{\jmath} + \hat{k})$

Determine the reciprocal lattice vectors and name the structure obtained. (5)

(b) What are Miller Indices? What is the purpose of taking reciprocal of intercepts in order to find out Miller indices? (5)

(c) Sketch (120), (101) and [100] in a cubic crystal. (5)

3. (a) Derive an expression for the dispersion relation for a mono-atomic lattice vibration in one dimension. Draw the dispersion curve for wave vector k lying between $-\pi/a$ to $+\pi/a$. (5)

(b) Show that for very long wavelength limit, crystal behave as a continuous medium. (5)

(c) Prove that crystal medium behave as low pass filter. (5)

4. (a) Derive Clausius-Mossotti relation between polarizability and dielectric constant of the dielectric material and discuss the significance of this relation. (8)

(b) Draw a diagram showing variation of total polarizability with frequency ranging from static to ultraviolet and explain why the dielectric constant of water is 81 at zero frequency while it is 1.8 at optical frequencies. (7)

5. (a) Discuss difference between Type I and Type II superconductors using Meissner's effect. (5)