[This question paper contains 6 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 1670 **A**

Unique Paper Code : 42227637

Name of the Paper : DSE: Solid State Physics

Name of the Course : **CBCS: B.Sc. (Prog.) – DSE**

Semester : VI

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. Answer **five** questions in all.
3. Question No. **1** is compulsory.
4. **All** questions carry equal marks.
5. Non-programmable scientific calculator is allowed.

1. Attempt any **five** : (3×5)

   (a) Mention the lattice type and bases in CsCl structure with diagram.

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(b) Obtain the Miller indices of a plane which makes an intercepts at a/2, b/2 and 3c along the primitive axes of the simple cubic unit cell. Draw a neat diagram of the plane.

(c) Determine the number of normal modes of vibration in a linear mono-atomic lattice of finite length in first Brillouin zone.

(d) Describe low temperature behavior of Einstein's theory of specific heat of solids.

(e) Calculate the Hall Coefficient when number of holes in a semiconductor is 10^{20} m^{-3}. Given that e = 1.6×10^{-19} coulomb.

(f) Distinguish between dia, para and ferro-magnetic materials on the basis of magnetic susceptibility.

(g) Discuss the variation of polarizability with frequency.

(h) Differentiate a superconductor with a perfect conductor.

2. (a) Mention the names of seven crystal systems in three dimensions with fourteen Bravais lattices included in them. Mention the unit cell characteristics of each system. (10)

(b) For a bee lattice, determine the diffraction angle for 1st order diffraction maximum from the (220) set of planes with interplanar spacing 1.013 Å with monochromatic X- rays of wavelength 1.790 Å. (5)

3. (a) Discuss the importance of reciprocal lattice space in understanding the structure of a crystal. (5)

(b) Prove that the reciprocal lattice vector $\vec{G}_{hkl}$ is perpendicular to the crystal plane (hkl) of a cubic crystal and that the interplanar spacing d_{hkl} is given as

$$d_{hkl} = \frac{2\pi}{|\vec{G}_{hkl}|}$$ (5)

(c) A direct lattice has the following primitive translation vectors: $\vec{a} = 2(i + j)$, $\vec{b} = 2(j + k)$, $\vec{c} = 2(k + i)$. Find out the reciprocal lattice vectors and type of lattice. (5)

4. The dispersion relation for the vibrational modes of diatomic linear lattice having masses m and M(m < M) is

$$\omega^4 - 2\alpha\left(\frac{1}{M}+\frac{1}{m}\right)\omega^2 + \frac{4\alpha^2}{mM}\sin^2 Ka = 0$$

where the symbols have their usual meanings.

(a) Obtain expressions for acoustical and optical curves. Draw the dispersion curves. (4,2)

(b) Explain its behaviors observed in acoustical and optical branches when

(i) m becomes equal to M.

(ii) m reduces to zero.

(iii) M increases to infinity. (2,2,2)

(c) Determine the smallest possible wavelength allowed by this diatomic lattice in the first Brillouin zone. (3)

5. (a) Describe qualitatively the Einstein's theory of specific heat of solids. Describe its shortcomings. (5,2)

(b) Describe how Debye improved the Einstein's theory? Discuss qualitatively Debye's theory of specific heat. (6)

(c) The Debye temperature for Aluminum is 418 K. Calculate the frequency of the highest possible lattice vibration in Aluminum. (2)

6. (a) Describe in detail n- type and p- type semiconductors. (6)

(b) Define conductivity and mobility. Obtain expressions for conductivity and mobility for a highly doped n-type semiconductor. (6)

(c) What will be the mobility of electrons in Cu if it has 9×10^{28} valence electrons per cubic meter and its conductivity is 6×10^{7} ohm^{-1}meter^{-1}? (3)

7. (a) Describe Langevin theory of paramagnetism and hence, obtain expression of magnetic susceptibility. (10)

(b) Assuming the existence of Weiss molecular field, obtain modified expression of magnetic susceptibility for a paramagnetic substance. (5)

8. (a) Obtain an expression for the local electric field at an atom in a dielectric medium. (8)

P.T.O.

(b) Explain Meissner effect in superconductors. (5)

(c) For a given specimen of a superconductor, the critical fields are 1.4×10^5 A/m and 4.2×10^7 A/m respectively for 14K and 13 K. What will be the critical field at 4.2 K? (2)