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Roll No. | | | | | | | | | | |

S. No. of Question Paper : **1602**

Unique Paper Code : **222603** **C**

Name of the Paper : **Solid State Physics (PHHT-621)**

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

Semester : **VI**

Duration : **3 Hours** Maximum Marks : **75**

(Write your Roll No on the top immediately on receipt of this question paper.)

Attempt *five* questions in all. Question No. **1** is compulsory.

All questions carry equal marks.

1. Attempt any *five* questions of the following : 3×5=15

   (*a*) What is the number of nearest neighbours for the three types of cubic lattices ? What are their nearest neighbour distances ?

   (*b*) Discuss the structure of Diamond cubic unit cell.

   (*c*) Show that the reciprocal lattice of a bcc lattice is a fcc lattice.

   (*d*) Name the seven crystal systems in a 3-D lattice. Give the relation between the length and angles of the axes of unit cell in each type.

   (*e*) Prove that 5-fold rotation axis cannot exist in a crystal lattice.

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(*f*) How does the dielectric constant of a polar dielectric (like water) vary from zero to optical frequencies of an applied electric field ?

(*g*) Discuss the concept of effective mass. How does it vary with wave-vector ?

(*h*) Distinguish between dia, para, and ferromagnetic materials on the basis of susceptibility.

(*i*) How do entropy and specific heat vary with temperature for a superconductor ?

2. (*a*) Given the basis vector of hcp structure :

$$\boldsymbol{a} = (\sqrt{3/2}\, a)\boldsymbol{i} + (a/2)\boldsymbol{j}, \quad \boldsymbol{b} = (-\sqrt{3/2}\, a)\boldsymbol{i} + (a/2)\boldsymbol{j}\ , c = c\boldsymbol{k}$$

Find its reciprocal lattice and to which crystal class it belongs. 5

(*b*) Explain how the planes of a crystal are specified. Prove for an orthorhombic system, the interplanar distance is :

$$d_{hkl} = 1/(h^2/a^2 + k^2/b^2 + l^2/c^2)^{1/2}$$

Find the value of d_{210} for a cubic crystal with side '*a*'. 5

(*c*) Deduce the Bragg's sine law from the diffraction condition $2\mathbf{K} \cdot \mathbf{G} + G^2 = 0$ and show that its geometrical interpretation leads to the concept of Brillouin Zones in crystals. 5

3. (*a*) Derive the dispersion relation for a linear diatomic lattice, stating the assumptions involved. Discuss the salient features of various branches in the dispersion curve. Under what condition a diatomic lattice behaves as a monatomic lattice ? 12

(*b*) Give the qualitative description of the dispersion curves in a 3-dimensional diatomic lattice. 3

4. (*a*) Discuss the failure of classical theory in explaining the observed temperature dependence of specific heat of a solid. 3

(*b*) Give the modifications incorporated by Debye and derive T^3 law. Calculate the vibrational frequency of carbon whose Debye's temperature is 1650 K. Given $h = 6.6 \times 10^{-34}$ Js, $k_B = 1.38 \times 10^{-23}$ J/K. 12

5. (*a*) Obtain the Lorentz relation for local field at a point inside a dielectric. How is local field different from Maxwell field ? 5

(*b*) Derive an expression for the electronic polarizability in a varying electric field. What is the implication of complex dielectric constant ? 10

6. (*a*) What is hysteresis ? Discuss its occurrence on the basis of domain concept. 5

(*b*) What is the origin of magnetic properties in a material ? Obtain an expression for paramagnetic susceptibility on the basis of Langevin's theory. Explain briefly an experimental method used to measure paramagnetic susceptibility. 10

7. (*a*) State Block Theorem. Obtain the energy spectrum of an electron in a one-dimensional periodic potential. Show that in the limiting case of vanishing potential barrier leads to the results obtained in a free electron model. 12

(*b*) Discuss the symmetry properties of the energy spectrum as obtained from the reduced zone scheme. 3

8. (*a*) Starting with expressions of electron and holes densities, show that the Fermi level lies midway between the band gap for an intrinsic semiconductor. How does its position change with doping concentration and temperature for an extrinsic semiconductor ? 5

(*b*) What is Meisener effect in superconductors ? Enumerate the properties of type I and type II superconductors. 6

(*c*) Discuss 'isotope effect' and 'critical field' in superconductors. 4