

B.Sc. Semester V (Honours) Examination, 2021 (CBCS)

Subject: Physics

Paper: CC-XII (Solid State Physics)

Full marks: 40

Time: 2 hours

The questions are of equal value. Candidates are required to give their answers in their own words as far as practicable.

Answer any eight of the following questions:

5x8=40

1. Define linear atomic number density. Calculate linear packing fraction of *BCC* crystal along (100), (110) and (111) direction.

2. a) If V is the volume of a primitive unit cell in the direct lattice, show that the volume of a primitive unit cell in the reciprocal lattice is $8\pi^3/V$.

b) Define geometrical structure factor. Show that for *FCC* crystals only all odd or all even values of h , k , l are allowed for reflections.

3. How does internal field (Weiss field) arise in ferromagnetic crystals? Show that for ferromagnetic materials, Curie temperature is proportional to the Weiss field constant, λ .

4. Discuss the Debye's theory of specific heat of a crystalline solid and show that in suitable limits, it gives Dulong and Petit's law and the T^3 law.

5.a) What do you mean by electronic polarization of an atom?

b) One gm mole of a certain polar substance is dissolved into 1000cc of a non-polar liquid. The liquid itself has a dielectric constant 3 at 27°C , whereas the solution has a dielectric constant of 3.2 at the same temperature. Calculate the dipole moment of the polar molecules considering volume remains constant.

6. Deduce an expression for the electronic polarizability of an atom on the basis of classical theory and hence calculate electronic polarization.

7. a) Define Hall coefficient and how does it help to identify the carrier type of a semiconductor?

b) Show that the ratio of maximum resistivity to intrinsic resistivity is expressed as

$$\rho_m/\rho_i = (\mu_e + \mu_h) / 2\sqrt{(\mu_e \mu_h)}$$
, where μ_e and μ_h denote the mobilities of electron and hole respectively.

8. The wave function of the hydrogen atom in its ground state is given by

$$\Psi(r) = \exp(-r/a_0) / (\pi a_0^3)^{1/2}$$

Show that $\langle r^2 \rangle = 3a^2$ and calculate the molar diamagnetic susceptibility of atomic hydrogen at STP, where $a_0 = \text{atomic radius} = 0.46 \text{ \AA}$.

9. Define London penetration depth and find an expression for it. If the penetration depths for lead are 396 \AA and 1730 \AA at 3K and 7.1K respectively, calculate the critical temperature of lead.

10. State Bloch theorem. What is the outcome of the theory? Find the lowest energy band using Kronig-Penny model for $P \ll 1$.