2021
B.A./B.Sc.
Fifth Semester
CORE – 12
PHYSICS
Course Code: PHC 5.21
(Solid State Physics)

Total Mark: 70 *Pass Mark: 28*
Time: 3 hours

Answer five *questions, taking* one *from each unit.*

UNIT–I

1. (a) A beam of X-ray is reflected from the (111) plane of an S.C. lattice with wavelength $\lambda = a$. If a is the lattice, find the Bragg angle. 2
   (b) Derive Bragg's law of X-ray diffraction, clearly stating the underlying assumptions. 5
   (c) Explain the procedure to draw Brillouin zone and hence draw 1st, 2nd and 3rd Brillouin zone. 7

2. (a) Find the Miller indices of crystal planes which cut through the axes at $(6a, 3b, 2c)$. 3
   (b) What is reciprocal lattice? Discuss its importance in solid state physics. 1+3= 4
   (c) A plane makes intercepts at 1, 2 and 1 for a cubic crystal with lattice parameter 0.5Å. Determine the inter-planar spacing of it. Show that the set of reciprocal lattice vectors G determines the possible X-ray reflections. 2+ 5=7

UNIT–II

3. (a) Show that, for low frequencies, phase velocity is equal to group velocity in a 1-D monoatomic lattice. 3

(b) What is a phonon? Give evidence for the existence of phonons. 1+3=4

(c) Define density of modes. Hence, find an expression to find the total number of vibrational modes 1+6=7

4. (a) Calculate Debye's frequency for copper, if it has Debye's temperature of 42°C. 2
   (b) Determine the direction of atoms for optical branch in a diatomic lattice. 5
   (c) Discuss Debye's model of lattice heat capacity. 7

UNIT–III

5. (a) If an unknown material is found to have magnetic permeability $4\pi \times 10^{-3}\, H/m$, identify the type of magnetism associated with it. 2
   (b) In an iron bar magnet of cross-section 2 mm^2, a magnetic intensity of $1.2\, Am^{-1}$ produces a magnetic flux of 3.2×10^{-5} weber. Calculate the permeability and susceptibility of the iron. 4
   (c) Discuss the Weiss theory of ferromagnetism and explain how magnetic susceptibility varies with temperature. 8

6. (a) What is superconductivity? Explain Meissner effect. Describe type-I and type-II superconductors. 1+3+3 =7
   (b) Mercury has critical temperature of –269°C at zero magnetic field and a critical field of 0.33 MAm^{-1} at absolute zero. Find the critical field at –266°C. 2
   (c) Explain the concept of penetration depth with the help of London's equation. 5

UNIT–IV

7. (a) Derive the general expression of Clausius-Mossotti relation for dielectric constant 3

(b) The atomic weight and density of sulphur are 32 and 2.08 gm/cm^3 respectively. The electronic polarizability of the atom is 3.28×10^{-40} Fm^2. If sulphur solid has cubic symmetry, what will be its relative permittivity? 4

(c) Derive the mathematical expression to explain the dominance of imaginary dielectric constant at certain frequencies in dispersion of solids. 7

8. (a) For an atomic site of cubic symmetry, a solid contains 1×10^{30} atoms per unit volume. Find the ratio of local field to the external field if the polarizability is 13.25×10^{-42} Fm^2. 3

(b) Find the frequency of positive and negative charges with the negative charge fluctuating about its equilibrium position. 4

(c) Discuss Langevin-Debye relation in dielectrics and the significance of real and imaginary parts of dielectric constants. 7

UNIT–V

9. What are ferroelectricity, piezoelectricity and pyroelectricity? What are the different groups of ferroelectric crystals? Derive the temperature dependence of the dielectric constant of the ferroelectric crystal.

3+4+7=14

10. (a) Calculate the Hall coefficient of sodium based on free electron model. Sodium has *BCC* structure and the side of the cube is 4.2Å 3

(b) Derive the relation $\sigma = en_i(\mu_n + \mu_p)$. Symbols have their usual meanings. 4

(c) How does the introduction of Kroning-Penny type of periodic potential explain the occurrence of bands and band gaps in solids? 7
