Date:

Registration number:

ST. JOSEPH'S COLLEGE (AUTONOMOUS), BENGALURU-27
M.Sc. PHYSICS - IV SEMESTER
SEMESTER EXAMINATION: APRIL 2022
(Examination conducted in July 2022)

PH0120 – SOLID STATE PHYSICS

Time- 2 ½ hrs   Max Marks-70

This question paper contains Two printed pages and Two parts

Part A
Answer any FIVE questions. Each question carries 10 marks

[5 x 10 = 50]

1. Define reciprocal lattice. Calculate the reciprocal lattice for the following systems (i). simple cubic (SC) and (ii). body centered cubic system (BCC).
2. Derive the expression for the specific heat of a linear continuous chain of molecules based on the Debye Theory for the specific heat of a linear continuous chain. Discuss the higher and lower temperature limit.
3. Define density of states. Derive the expression for the density of energy states in a metal. Plot the density of states as a function of electron energy at different temperatures. [2+8]
4. (a). Deduce the Clausius- Mosotti relation and explain its use in predicting the dielectric constant of solids.
   (b). With a neat sketch, describe ionic polarization and orientation polarization. [6+4]
5. (a). Explain the domain theory of ferromagnetic material with a suitable diagram.
   (b). Compare the characteristic of soft Magnetic and hard magnetic materials with a necessary diagram. [4+6]
6. (a). Define superconductivity. Describe the effect of magnetic field on superconducting substance with suitable diagram.
   (b). Enumerate the properties of type I and Type II superconductors. [5+5]
7. (a). Define coordination number. With a neat sketch, determine the coordination number for simple cubic, BCC and FCC systems.
   (b). Describe thermal expansion of solids? Obtain the expression for linear coefficient of solids. [6+4]

Part B

Answer any Four questions. Each question carries 5 marks

[4 x 5 = 20]

8. Find the Miller indices of a set of parallel planes which make intercepts in the ratio 3a:4b on the X and Y axes and parallel to the Z-axis. a, b, and c are primitive vectors of the lattice. Also, calculate the interplanar distance of the planes taking the lattice to be a cubic with $a = b = c = 2\text{Å}$.
9. The penetration depth of mercury at 3.5 K is about 750 Å. Estimate the penetration depth at 0 K. Calculate the superconducting electron density.
10. The atomic weight and density of Sulphur are 32 and 2.08 x 10^3 kg m^{-3}, respectively. The electronic polarizability of the atom is 3.28 x 10^{-40} F m^2. If Sulphur solid has a cubic structure, calculate its dielectric constant.
11. For Nickel, the magnetic moment per atom is 0.6 Bohr magnetron. The density and atomic weight are 8900 kgm^{-3} and 58.71 respectively. Calculate the saturation magnetization and the saturation flux density.
12. While silver metal obeys the Dulong Petit's Law at room temperature, diamond does not explain.
13. The lattice parameter of KCl is 0.629 nm. It crystallizes like the NaCl crystal structure. The electronic polarizability of K^+ is 1.264 x 10^{-40} Fm^2 and $Cl^-$is 3.408 x 10^{-40} Fm^2. Calculate the relative permittivity of KCl crystal at optical frequencies.

List of Physics Constants

Speed of light in vacuum (c)	2.997925 x 10^8 ms^{-1}
Charge of electron (e)	1.6021 x 10^{-19} C
Rest mass of electron (m)	9.109 x 10^{-31} kg
Atomic mass unit (m_u)	1.6604 x 10^{-27} kg
Electron radius (r_e)	2.828 x 10^{-15} m
1 Angstrom unit (Å)	10^{-10} m
Avogadro's number (N_A)	6.02252 x 10^{26} $kmol^{-1}$
Boltzmann constant (k_B)	1.38054 x 10^{-23} jK^{-1}
Thermal energy at 300K (k_BT)	0.0258 J
Planck's constant (h)	6.626 x 10^{-34} Js
Permeability of free space (μ_o)	4π x 10^{-7} Hm^{-1}
Permittivity of free space (ε_o)	8.854 x 10^{-12} Fm^{-1}
Rydberg constant for Hydrogen (R_H)	1.0967758 x 10^7 m^{-1}
Universal gas constant (Ru = N_Ak_B)	8.3143 x 10^3 $Jkmol^{-1}K$