Registration Number:

Date & Session:

ST. JOSEPH'S COLLEGE (AUTONOMOUS), BENGALURU -27

M.Sc. Physics – IV SEMESTER

SEMESTER EXAMINATION: April 2023

PH0120/PH0122 – Solid State Physics

Time: 2 ½ Hours **Max Marks: 70**

This paper contains TWO printed pages and TWO parts

PART-A

Answer any FIVE questions. Each question carries TEN Marks.

[5 x 10 = 50]

1. (a). Define reciprocal lattice. Show that the reciprocal lattice for a body centred cubic is a face centred cubic.
   (b). In a crystal, a plane cuts intercepts of 2a, 3b and 6c along three crystallographic axes. Determine the Miller indices of the plane.
   (c). Draw the three Brillouin zones for a two-dimensional square lattice. [5+3+2]
2. Sate Dulong- Petit's law and show how the departure from this law at lower temperatures has been explained by Einstein theory.
3. (a). Obtain the expression of Lorentz number on the basis of quantum theory. Compare it with the one predicted on the basis of classical theory.
   (b). Demonstrate the Fermi- Dirac distribution function for T> 0K and T = 0k.
   (c). With a neat sketch, describe the intrinsic and extrinsic semiconducting properties of silicon using band and bond model. [4+2+4]
4. Obtain an expression for the local electric field acting at an atom in SI system.
5. Draw a typical B-H curve for a ferromagnetic material and explain the different stages of magnetization process on the basis of domain theory.
6. (a). Using Langevin's theory, obtain an expression for diamagnetic susceptibility.
   (b). Compare paramagnetic and ferromagnetic substances with necessary examples and diagrams. [7+3]
7. Explain the single-particle tunneling effect for the given system using the current-voltage (I-V) curve. (i). Metal- Insulator-Metal, (ii). Metal-Insulator-superconductor and (iii). Superconductor-Insulator-Superconductor (SIS) system.
   (b). Prove that superconductors have perfect diamagnetic nature using Meissner effect. [7+3]

PART-B

Answer any FOUR questions. Each question carries FIVE Marks.

[4 x 5 = 20]

8. A parallel plate capacitor consists of 2 plates each of area 5×10^{-4} m^2. They are separated by a distance of 1.5×10^{-3} m and filled with a dielectric of relative permittivity 6. Calculate the charge on the capacitor if it is connected to a 100 volts DC supply.
9. Calculate the electronic polarizability of an isolated Se atom. The atomic radius of an Se atom is 0.12 nm.
10. Calculate the steady state transfer rate (in $Jm^{-2}s^{-1}$) through a sheet of cooper 10 mm thickness if there is a temperature drop from 823 to 773K across the sheet.
11. A magnetic field of 1800 ampere/metre produces a magnetic flux of 3×10^{-5} weber in an iron bar of cross – sectional area 0.2 cm^2. Calculate permeability.
12. The penetration depth of Mercury at 3.5 K is about 750 Å. Estimate the penetration depth at 0 K. Also calculate the superconducting electron density.
13. Superconducting tin has a critical temperature of 3.7 K at magnetic field and a critical field of 0.0306 Tesla. Find the critical field at 2K.

List of Physics Constants

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