

U.G. 6th Semester Examination-2025

PHYSICS**[HONOURS]**

Course Code : PHY-H-CC-T-14

(Solid State Physics)

[New Syllabus]

Full Marks : 40

Time : $2\frac{1}{2}$ Hours*The figures in the right-hand margin indicate marks.**Candidates are required to give their answers in their own words as far as practicable.***GROUP-A**

1. Answer any five questions: $2 \times 5 = 10$
- Calculate the interplanar spacing for the (2 1 1) plane in a cubic crystal with lattice constant $a = 4\text{\AA}$.
 - State and explain Bragg's Law.
 - Differentiate between acoustic and optical phonons.
 - State Debye's T^3 law.
 - What is hysteresis loss in ferromagnetic materials?
 - What are Plasmons?
 - Explain the Meissner effect.
 - What is the Hall Effect? Write down the expression for Hall coefficient.

[Turn Over]

GROUP-B

2. Answer any two questions: $5 \times 2 = 10$
- Explain the Weiss's theory of ferromagnetism. What do you mean by ferromagnetic Domains. $3+2$
 - Derive the expression for the Clausius-Mossotti equation.
 - Explain the concept of Brillouin zone. Define Brillouin Zone for a simple cubic crystal.
 - Derive the expression for plasma frequency (ω_p) of free electrons in a conductor. Then calculate ω_p and the corresponding plasma wavelength (λ_p) for a metal with electron density $n = 5.9 \times 10^{23} \text{m}^{-3}$. (Use $m_e = 9.11 \times 10^{-31} \text{kg}$, $e = 1.6 \times 10^{-19} \text{C}$).

GROUP-C

3. Answer any two questions: $10 \times 2 = 20$
- Using the Einstein model of specific heat, show how the specific heat C_v approaches the classical Dulong-Petit limit at high temperatures.
 - Calculate the frequency ratio of optical to acoustical phonons in a diatomic linear chain, assuming masses m_1 and m_2 and spring constant K .

- Using the Sellmeier equation: $n^2(\lambda) = 1 + \left(B\lambda^2 / (\lambda^2 - C) \right)$, with $B = 1.04$ and $C = 0.006 \mu\text{m}^2$, calculate the refractive index n at wavelength $\lambda = 0.5 \mu\text{m}$. (Give n to three decimal places). $4+3+3$
 - Discuss Type I and Type II superconductors and explain London's equations qualitatively.
 - What are Cooper pairs in the context of superconductivity?
 - What are ferroelectric materials? Discuss the PE hysteresis loop. $3+3+4$
- Show that, if in the potential model used in connection with the Kronig-Penny calculation, V_0 is allowed to become infinitely large and b is allowed to approach zero, such that the product remains fixed, then the allowed energy values are given by the solutions of the equation. Also show that this leads to allowed and forbidden energy bands.
 - Why is the four-probe method preferred over the two-probe method in measuring resistivity of semiconductors? $5+2+3$

- iv) a) Derive Curie's law for a paramagnetic material using the quantum mechanical treatment of magnetic dipoles.
- b) A sample of paramagnetic salt has a magnetic moment of 2.2×10^{23} A.m² per molecule and a number density of 4×10^2 molecules/m³. Calculate its magnetization at 300 K in an external field of 0.1 T. (Use $k_B = 1.38 \times 10^{23}$ J/K and $\mu = 4\pi \times 10^{-7}$ H/m).
- c) Show that the pyroelectric coefficient is related to the rate of change of spontaneous polarization with temperature. 5+2+3
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