



WEST BENGAL STATE UNIVERSITY
B.Sc. Honours 5th Semester Examination, 2022-23

PHSACOR12T-PHYSICS (CC12)

SOLID STATE PHYSICS

Time Allotted: 2 Hours

Full Marks: 40

*The figures in the margin indicate full marks.
Candidates should answer in their own words and adhere to the word limit as practicable.
All symbols are of usual significance.*

Question No. 1 is compulsory and answer any two from the rest

1. Answer any *ten* questions from the following: 2×10 = 20
- A plane makes intercepts of 1Å , 2Å , 3Å on the crystallographic axes of an orthorhombic crystal with $a : b : c = 3 : 2 : 1$. Determine the Miller indices of the plane.
 - Calculate the Einstein frequency (ν_E) for copper for which Einstein temperature (θ_E) is 230 K. [Given: $h = 6.6 \times 10^{-34}$ J. s., $k = 1.37 \times 10^{-23}$ JK⁻¹, the symbols having their usual meanings.].
 - What is "Geometrical Structure Factor"?
 - Explain briefly how the classical free electron theory leads to Ohm's law.
 - Why diamagnetic materials have negative susceptibility? Give an example of such material.
 - Define polarisation of a dielectric material. Which type of polarisation is most effective in the visible region?
 - Bragg found that for a KCl crystal, strong reflection from the sets of planes (100); (110) and (111) are obtained at the same order for angles $5^\circ 23'$, $7^\circ 25'$ and $9^\circ 25'$; respectively. Show that the KCl crystal has a simple cubic crystal structure.
 - Explain briefly, why the inert gases do not exhibit paramagnetism.
 - The thermal conductivity of aluminium at 20°C is $210 \text{ Wm}^{-1}\text{K}^{-1}$. Calculate the electrical resistivity of aluminium at this temperature. The Lorentz number for aluminium is $2.02 \times 10^{-8} \text{ W}\Omega\text{K}^{-2}$.
 - Discuss briefly the differences between Type I and Type II superconductors.
 - What is Bloch Theorem? Explain the significance of this theorem.
 - KBr crystal has cubic structure. Its density is $2.75 \times 10^3 \text{ kg/m}^3$ and its molecular weight is 119.01. Calculate its lattice constant.
 - Calculate the reciprocal lattice of FCC lattice.
 - Why semiconductor acts as an insulator at 0 K?

2. (a) Energy $E(k)$ of electron of wave vector \vec{k} in a solid is given by $E(k) = Ak^2 + Bk^4$, where A and B are positive non-zero constant. Find the effective mass of the electron at $|\vec{k}| = k_0$. 2
- (b) Derive the expression for paramagnetic susceptibility on the basis of Langevin's theory. 4
- (c) Explain the Meissner effect from the second London equation, using the Maxwell's relation $\vec{\nabla} \times \vec{B} = \mu_0 \vec{J}_s$. 4
3. (a) Consider the model of one dimensional monoatomic lattice chain of N atoms, equally spaced with lattice separation a , and each with the same mass m . Find the following: 2+2+2
- (i) Derive an expression for the group velocity v_g with the wave vector k .
- (ii) Using the result of (i) Evaluate v_g at small values of k ($k \rightarrow 0$) and briefly discuss the physical significance of this low k group velocity.
- (b) Show that in vector form, the Bragg's Law is given by $G^2 + 2\vec{k} \cdot \vec{G} = 0$, where \vec{k} represents the wave vector and \vec{G} is the reciprocal lattice vector. 4
4. (a) Distinguish between Pyroelectric and Piezoelectric materials. Give proper examples. 3
- (b) Using Kronig Penney model discuss briefly how this model led to the formation of energy bands inside a solid. 3
- (c) What is Hall effect? Deduce the expression for Hall Coefficient in the case of a semiconductor. 1+3
5. (a) What are Bravais lattices and crystal system? 2
- (b) What is the packing fraction of FCC crystal? 3
- (c) The primitive translation vectors of the space lattice are: 3
- $$\vec{a} = 2\hat{i} + \hat{j}, \vec{b} = 2\hat{j}, \vec{c} = \hat{k}$$
- Find the primitive translation of the reciprocal lattice.
- (d) Mobilities of electrons and holes in a sample of intrinsic Germanium at 300 K are $0.36 \text{ m}^2\text{V}^{-1}\text{s}^{-1}$ and $0.17 \text{ m}^2\text{V}^{-1}\text{s}^{-1}$ respectively. If the conductivity of the specimen is $2.12 \text{ } \Omega^{-1}\text{m}^{-1}$, estimate the intrinsic carrier density. 2

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