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: $2\times10 = 20$

(a) 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.

(b) Calculate the Einstein frequency (ν_E) for copper for which Einstein temperature (θ_E) is 230 K. [Given: $h = 6.6\times10^{-34}$ J. s., $k = 1.37\times10^{-23}$ JK^{-1}, the symbols having their usual meanings.].

(c) What is "Geometrical Structure Factor"?

(d) Explain briefly how the classical free electron theory leads to Ohm's law.

(e) Why diamagnetic materials have negative susceptibility? Give an example of such material.

(f) Define polarisation of a dielectric material. Which type of polarisation is most effective in the visible region?

(g) 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°23′, 7°25′ and 9°25′; respectively. Show that the KCl crystal has a simple cubic crystal structure.

(h) Explain briefly, why the inert gases do not exhibit paramagnetism.

(i) The thermal conductivity of aluminium at 20°C is 210 $Wm^{-1}K^{-1}$. Calculate the electrical resistivity of aluminium at this temperature. The Lorentz number for aluminium is 2.02×10^{-8} $W\Omega K^{-2}$.

(j) Discuss briefly the differences between Type I and Type II superconductors.

(k) What is Bloch Theorem? Explain the significance of this theorem.

(l) KBr crystal has cubic structure. Its density is 2.75×10^{3} kg/m^{3} and its molecular weight is 119.01. Calculate its lattice constant.

(m) Calculate the reciprocal lattice of FCC lattice.

(n) 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 $k\,(k \to 0)$ 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 $0.36\ m^2V^{-1}s^{-1}$ and $0.17\ m^2V^{-1}s^{-1}$ respectively. If the conductivity of the specimen is $2.12\ \Omega^{-1}m^{-1}$, estimate the intrinsic carrier density. 2

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