'समानो मन्त्रः समितिः समानी'

UNIVERSITY OF NORTH BENGAL

B.Sc. Honours 5th Semester Examination, 2021

CC12-PHYSICS

SOLID STATE PHYSICS

Time Allotted: 2 Hours | Full Marks: 40

The figures in the margin indicate full marks.
All symbols are of usual significance.

GROUP-A

1. Answer any ***five*** questions: 1×5 = 5

   (a) Determine the reciprocal lattice vectors of a 2-*D* square lattice of side '*a*'.

   (b) What are the major characteristics of ferroelectric materials?

   (c) Explain in clear terms why the Hall voltage develops when a current is passed through and a magnetic field is applied across a material.

   (d) Draw the schematic band diagrams for *p*-type and *n*-type semiconductors.

   (e) Obtain the Miller indices of a crystal plane that makes intercepts of $(a, \frac{b}{2}, \infty)$ on the three crystallographic axes.

   (f) Determine the dimension of magnetic susceptibility in terms of *M*, *L* and *T*.

   (g) Explain the term critical magnetic field in superconductor.

   (h) What is the significance of effective mass of an electron?

GROUP-B

Answer any *three* questions 5×3 = 15

2. Describe the crystal structure of KCl and determine the Geometrical structure factor. 3+2

3. Discuss the Curie-Weiss law of ferroelectricity. 5

4. Explain the different contributions for the formation of domains in ferromagnetic material and show how the hysteresis curve is explained on the basis of the domain theory. 1+4

5. Show that the London's equation for the supercurrent 4+1

$$j_s = \frac{-n_s e^2}{m_{e^c}} \vec{A}$$

leads to the Meissner effect. [j_s = Super-current, $\vec{A}$ = Magnetic vector potential, m_e = electronic mass].

What is the London penetration depth?

6. (a) Define the polarization vector and polarizability of a dielectric material. 2+3

(b) Silicon has dielectric constant 12 and the dimension of the conventional cubic cell of a silicon lattice is 5.43Å. If the conventional cell contains 8 atoms, calculate the electric polarizability of silicon atom.

GROUP-C

Answer any *two* questions 10×2 = 20

7. Discuss the reasons for the failure of Dulong and Petit's law to predict the specific heat at low temperature. Why should the law be valid at high temperatures? Find an expression for the specific heat of a solid on the basis of Einstein's model and show that it converges to 3*R* at high temperatures. 1+1+(5+1)+2

Show that from Debye's theory, at lower temperature C_V varries directly as T^3 law.

8. (a) "The basic principle of diamagnetic behaviour may be shown to follow directly from the familiar Lenz's law of electromagnetic theory" —Discuss the Langevin theory of diamagnetism to support this statement. 5+2+3

(b) Explain how the bands are formed in solids.

(c) On the basis of band theory of solids distinguish between metals, insulators and semiconductors.

9. (a) Discuss in detail the variation of effective mass of an electron as a function of wave vector *R* when it moves through a periodic potential. 6+4

(b) Discuss the motion of an electron in a periodic potential lattice and draw a ε - k diagram to identify the Brillouin zones.

10. (a) Show that the orientational polarizability is inversely proportional to the absolute temperature of the dielectric material. 3+(5+2)

(b) Using Fermi distribution find out the electron number density in the conduction band of an intrinsic semiconductor of temperature *T*. Hence Obtain an expression for the electrical conductivity of an extrinsic semiconductor.

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