'समानो मन्त्रः समितिः समानी'

UNIVERSITY OF NORTH BENGAL
B.Sc. Honours 5th Semester Examination, 2023

CC12-PHYSICS

SOLID STATE PHYSICS

Time Allotted: 2 Hours   Full Marks: 40

The figures in the margin indicate full marks.

GROUP-A

1. Answer any *five* questions from the following: $1 \times 5 = 5$

    (a) Define crystal planes in reciprocal lattice.

    (b) Differentiate between optical phonons and acoustic phonons.

    (c) Why does a semiconductor act as an insulator at 0K?

    (d) What are ferrites?

    (e) What is "Cooper pair"?

    (f) How does the plasma is formed?

    (g) Write down the expression relates dielectric constant and electric susceptibility.

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

GROUP-B

Answer any *three* questions from the following $5 \times 3 = 15$

2. (a) Define NaCl structure.   2

    (b) The lattice constant of an fcc lattice is 6.38 Å. Find the distance between a corner atom at the base and the atom at the centre of the top face.   2

    (c) What are symmetry operations in crystallography?   1

3. (a) Define electronic polarizability. Show that the electronic polarizability is directly proportional to the cube of the atomic radius.   1+2

    (b) A sample of phosphorus is uniformly polarized and polarization produced is 5×10^{-6} c/m^2. Find the total surface charge developed on an area of 6 m^2 inclined at an angle 30° with direction of polarization.   2

4. (a) Explain the difference between type I and type II superconductors using the Meissner effect.   2

    (b) The London penetration depth for a sample at 6K and 7K are 41.2 nm and 180.3 nm, respectively. Calculate its transition temperature as well as the penetration depth at 0K.   3

5. (a) "All materials are diamagnetic material" — Justify it. 2

   (b) Explain the term hysteresis and prove that hysteresis loss per cycle of magnetization is equal to the area of the B-H loop. 3

6. (a) Explain how the bands are formed in solids. 2

   (b) The Fermi level in certain semi-conducting material is 1.75 eV at a particular temperature. Calculate the number of free electrons per unit volume in the semiconductor at the same temperature. Given the lattice parameter $a = \pi/3$. 3

GROUP-C

Answer any *two* questions from the following $10 \times 2 = 20$

7. (a) Illustrate the Bragg's law of diffraction in reciprocal space. 3

   (b) Explain geometrical structure factor with mathematical expression. How is it related to the atomic structure factor? 3+1

   (c) The density of iron is 7080 kg. m^{-3} and its atomic weight is 56. Given that iron crystallises in BCC space lattice, find the lattice parameter of iron. 3

8. (a) Obtain the dispersion relation of monatomic linear chain of mass 'm' and lattice constant 'a'. Define the Brillouin zone boundaries in such a system. 4+2

   (b) Can we count number of phonons at fixed frequency? Justify your answer. 2

   (c) Write down the limitations of Debye theory of specific heat for solids. 2

9. (a) A copper strip 2 cm in breadth and 0.8 mm thick is placed in a magnetic field of induction 1 Tesla. If a current of 100 A is set up in the strip, how much Hall voltage develops across the strip? One cubic metre of copper strip contain 8.4×10^{28} electrons. 3

   (b) What is the main cause of failure of free electron theory in solids? Which type of charge has greater mobility and why? 2+1

   (c) What is polarization catastrophe? 2

   (d) What is 'isotope effect' in the field of superconductors? 2

10. (a) Sketch the M-H plot for diamagnetic, paramagnetic and ferromagnetic material in a single graph. 3

    (b) Calculate the diamagnetic susceptibility of atomic hydrogen in the ground state at RT using the wave-function, $\psi(r) = \dfrac{1}{(\pi a_0^3)^{1/2}} \exp(-r/a_0)$, where $a_0 = 0.46\,\text{Å}$. 6

    (c) What kind of magnetic material is preferred in electromagnet and why? 1

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