'समानो मन्त्रः समितिः समानी'

UNIVERSITY OF NORTH BENGAL

B.Sc. Honours 5th Semester Examination, 2022

CC12-PHYSICS

SOLID STATE PHYSICS

Time Allotted: 2 Hours | Full Marks: 40

GROUP-A

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

   (a) Explain why the conductivity of a pure semiconductor increases with temperature. 1

   (b) Which of the following reflections would be missing in a bcc lattice: 1

   (100), (110), (111), (200), (210), (220), (211)?

   —Explain your answer.

   (c) What is the first Brillouin zone? 1

   (d) Draw the variation of magnetic susceptibility with temperature for 1

   (i) paramagnetic and (ii) ferromagnetic materials.

   (e) What is a phonon? 1

   (f) State Bloch's theorem. 1

   (g) What is Meissner effect? 1

   (h) What kind of susceptibility exists in N_2 molecule? 1

GROUP-B

Answer any *three* questions 5×3 = 15

2. (a) Find the lattice vectors for an fcc crystal. 2

   (b) Prove that any reciprocal lattice vector is normal to a lattice plane of the crystal lattice. 3

3. (a) Why is the Debye theory of specific heat more acceptable than the Einstein theory? Explain your answer. 3

   (b) Define Einstein's temperature and explain its significance. 2

4. (a) Derive London equations. 3

   (b) The critical field H_c of Niobium at 0 K is 1.55×10^{-5} A/m. What is the minimum current that can be carried by a Niobium wire of diameter 0.1 mm at 0 K? 2

5. (a) Plot the energy E against wave number k for the first allowed energy band in a crystalline solid. How do you account for the negative effective mass of an electron from this (E-k) curve? 1+2

   (b) Show that the effective mass of a hole is more than that of a free electron. 2

6. (a) Distinguish between p-type and n-type semiconductors. 2

(b) The Hall coefficient of certain silicon specimen is found to be $-7.35\times10^{-5}\ \mathrm{m^3\ C^{-1}}$. 1+2

(i) Determine the nature of the semiconductor.

(ii) If the conductivity of the semiconductor is $200\ \mathrm{m^{-1}\ \Omega^{-1}}$, calculate the number density and the mobility of the charge carriers.

GROUP-C

Answer any *two* questions $10\times2 = 20$

7. (a) What do you mean by the dispersion relation? Obtain the dispersion relation for a linear diatomic lattice and show that its vibration spectrum consists of two branches. 1+5

(b) The Bragg's angle for reflection from the (111) plane in a fcc crystal is 19.2° for an X-ray of wavelength 1.54 Å. Calculate the cube edge length of the unit cell. What will be the volume of the Primitive cell of that fcc crystal? 3+1

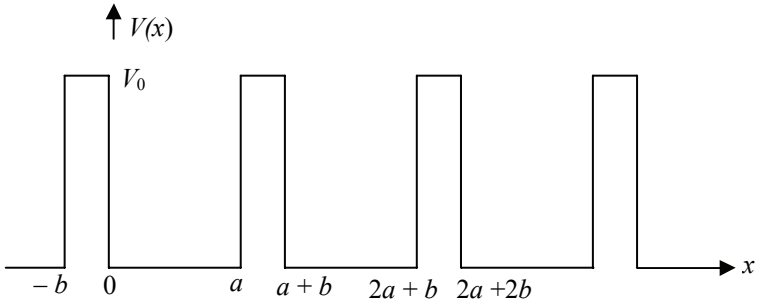
8. (a) Discuss briefly the Kronig-Penny model for the motion of an electron in a periodic potential. 5

(b) Derive the expression for the density of states in 1-D. 2

(c) Using the Kronig-Penny model, show that for $P \ll 1$, the energy of the lowest energy band is 3

$$E = \frac{\hbar^2 P}{ma^2}$$

where $P = \dfrac{mV_0ab}{\hbar^2}$ and the electron of mass 'm' is subjected to the following potential:



9. (a) Derive the Clausius-Mossotti relation showing the relationship between dielectric constant and atomic polarizability. 5

(b) Determine the percentage of ionic polarizability in the sodium chloride crystal which has the optical index of refraction and the static dielectric constant as 1.5 and 5.6 respectively. 3

(c) What is polarization catastrophe? 2

10. (a) Find an expression of the paramagnetic susceptibility using quantum theory. 5

(b) What is Pauli's paramagnetism? 2

(c) The magnetic field strength in vacuum is 10^6 ampere per metre. Find the flux density and the magnetisation in the material. Assume that the magnetic susceptibility of the material is 0.5×10^{-5}. 3

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