U.G. 5th Semester Examination - 2021

PHYSICS

[HONOURS]

Course Code : PHY-H-CC-T-12

(Solid State Physics)

Full Marks : 40 Time : $2\frac{1}{2}$ Hours

The figures in the right-hand margin indicate marks.

Candidates are required to give their answers in their own words as far as practicable.

1. Answer any **five** questions: 2×5=10

   a) What is the number of second nearest neighbors in a fcc structure?

   b) Calculate the glancing angle on the plane (110) of a cube of rock salt (a=0.281nm) corresponding to the second order diffraction maximum for X-ray of wavelength 0.710. Å.

   c) What is atomic packing fraction? Find it for bcc lattice.

   d) Find the ratio of the susceptibility (χ_{200}) measured at T=200K and that measured at T=300K for a ferromagnetic material having the Curie temperature equal to 100K.

   e) The static dielectric constant of water is 8.1 and its refractive index is 1.33. Calculate the percentage contribution of ionic polarizability.

   f) Superconducting tin has a critical temperature of 3.7K at zero magnetic field and a critical field of 0.0306T at 0K. What is the critical field at 2K?

   g) The energy E (K) of electron of wave vector k in a solid is given by $E(K)= AK^2 +BK^4$, where A and B are constants. Evaluate the effective mass of the electron at $K=K_0$

   h) A crystal belongs to a. fcc lattice with four atoms in the unit cell. The size of the crystal is 1cm and the unit cell dimension is 1nm. Determine the scattering factor (*f*) for (010) and (200) reflection plain.

2. Answer any **two** questions from the following: 5×2=10

   a) In a unit cell of simple cubic structure, find the angle between the normal to pair of planes whose Miller indices are (i) (100) and (010) (ii) (121) and (111).

   A three-dimensional lattice has the basis vectors a=2x; b=x+2y; c=z. Find the reciprocal

lattice vectors. 2+3

b) Explain the orientational polarization in dielectrics. Derive an expression of the same using Langevin's theory. 1+4

c) Show graphically the variation of the energy with the wavenumber k for the first allowed band in a solid. Hence explain the variation in the sign of the effective mass for an electron in the band. 1+4

d) What is Hall effects? Obtain an expression for Hall coefficient in a metal when the carriers are only electrons. 1+4

3. Answer any **two** questions from the following: 10×2=20

a) What is ferromagnetism? Discuss the Weiss theory of ferromagnetism. Explain how the susceptibility of a ferromagnetic material varies with temperature.

Calculate the Lande's g factor and effective number of Bohr magnetism of a paramagnetic gas with L=0 and S = $\frac{1}{2}$. 2+4+2+2

b) State the difference between the Einstein model and Debye model in explaining the specific heat of solids. Calculate the number

of vibrational modes of monoatomic solid in the frequency range ω and $\omega+d\omega$. Hence obtain an expression for Debye temperature and explain the significance of Debye cutoff frequency. Explain the variation of specific heat with temperature according to the Debye model. 2+(4+3)+1

c) Show that the perpendicular distance between two adjacent planes of set (h, k, 1) in a cubic lattice constant a is $d = \frac{a}{\sqrt{h^2 + k^2 + l^2}}$.

Show that the reciprocal lattice to a face centred cubic (*fcc*) lattice is body centred cubic (*bcc*) lattice. 5+5

d) What is Meissner effects? Show that a superconductor behaves as a diamagnetic body. Deduce first and second London equations. What do you mean by London penetration depth? 3+5+2

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