# RAMAKRISHNA MISSION VIDYAMANDIRA

**(Residential Autonomous College affiliated to University of Calcutta)**

**B.A./B.Sc. FIFTH SEMESTER EXAMINATION, DECEMBER 2019**

**THIRD YEAR [BATCH 2017-20]**

Date : 16/12/2019 **PHYSICS (Honours)**

Time : 11 am – 1 pm **Paper : VI [Gr. B]** Full Marks : 50

## Answer <u>any five</u> questions of the following: [5×10]

1. a) What is Weiss molecular field? Derive a relation between curie temperature and the molecular field constant of a ferromagnet. Assume the relation for paramagnetization:

   $M = Ng\mu_B JB_J(x)$, symbols having usual meaning. (2+3)

   b) Deduce a relation between mobility and the diffusion constant of carrier in a semiconductor. (3)

   c) Calculate the volume density of a FCC lattice of lattice constant $4\,\mathring{A}$. Calculate the atomic surface density on the (110) plane. (2)

2. a) What are phonons? Derive an expression for the energy and the momentum of phonon? (1+2)

   b) The energy ($E$)-wave vector ($K$) relation of one dimensional crystal of lattice constant $a$ is $E = E_0 - E_p cosKa\left(E_0 > E_p\right)$. Draw the variation of $E$, group velocity and effective mass as a function of $K$. (1+1+2)

   c) For a BCC lattice of identical atom with a lattice constant of $5\,\mathring{A}$. Calculate the maximum packing fraction and the radius of the atoms treated as hard spheres with the nearest neighbours touching. (3)

3. a) Assuming a dipolar interaction energy inside a molecular solid containing N molecules per unit volume with permanent dipole-moment $\vec{P_0}$, find the contribution of orientational polarization to the electrical susceptibility. (5)

   b) Why do Einstein's and Debye functions differ? (2)

   c) Find the temperature at which the lattice specific heat and electronic specific heat are equal. (3)

4. a) Find an expression for Hall coefficient of a solid. Can the hall coefficient be zero? Explain. (3+1)

   b) Show that at thermal equilibrium the Fermi level must be constant throughout the pn junction. (3)

   c) A solid dielectric of dielectric constant 6, the length of the edge of its cubic is $4.2\,^{\circ}A$. Find the electric polarization of dielectric atoms. [Number of atoms per unit cell is 8] (3)

5. a) What is superconductivity? What are the difference between perfect conductor and super conductor? Show that London equation leads to Meisserner effect. (1+1+3)

   b) Deduce the law of mass action in a semiconductor. (2)

   c) For a semiconductor with a band gap of $1eV$, calculate the position of Fermi level at $T = 0K$ and at $T = 300K$ in $m_h^* = 6m_e^*$ where $m_h^*$, and $m_e^*$ are effective masses of hole and electron respectively. (3)

6. a) What do you mean by Miller indices? Deduce an expression for the distance between adjacent planes with miller indices (*hkl*). (1+2)

   b) Show that barrier potential of pn junction with doping concentration $N_a$ and $N_d$ can be written as $V_{bi} = \frac{kT}{e}\left(\frac{N_a N_d}{n_i^2}\right)$, where symbols have their usual meaning. (4)

   c) Calculate the number of energy state for free electrons in a cubic box of silver of side 0.02m lying between an energy of 0 to 3*eV*. [Fermi Energy of silver is 5*eV*] (3)

7. a) What is Debye cutoff frequency. Find an expression for Debye cut off frequency in terms of atomic density and velocity of transmitted wave of a solid. (1+3)

   b) Show that a crystalline solid can not process a five-fold rotational symmetry. (3)

   c) Construct the reciprocal lattice for a two dimensional lattice in which $\vec{a} = a_0\hat{x}$, where $a_0 = 1.2\ \mathring{A}$ and $b_0 = 2.4\ \mathring{A}$ and $\gamma = 120^0$. (3)

8. a) Show that the structure factor for reflection(*hkl*) can be written as

$$F(hkl) = \sum_j^N f_j e^{i2\pi(hu_j + kv_j + lw_j)}$$

   Where symbols have their usual meaning. (4)

   b) The paramagnetic susceptibility of metal is $\chi = \frac{n\mu_B^2}{3kT_F}$, where *n* is electron concentration, $\mu_B$ is Bohr magneton, *k* Boltzmann constant. Establish the relation. (2)

   c) What do you mean by first Brillouin zone? Find the number of possible energy state in the first Brillouin zone. (1+3)

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