

RAMAKRISHNA MISSION VIDYAMANDIRA

(Residential Autonomous College affiliated to University of Calcutta)

B.A./B.Sc. SIXTH SEMESTER EXAMINATION, MAY 2019

THIRD YEAR [BATCH 2016-19]

PHYSICS (Honours)

Paper : VIII

Date : 27/04/2019

Time : 11 am – 1 pm

Full Marks : 50

Answer any five questions of the following :

[5×10]

1. a) what is Curie Point? [1]
b) What is hysteresis? Explain its origin from domain theory. [1+3]
c) Using Langevin theory of diamagnetism, derive an expression for diamagnetic susceptibility of a material. [5]
2. a) The spacing between successive (100) planes in NaCl crystal is $2.82 \text{ \AA}$. A given x-ray, when shone upon the surface, is found to give rise to first order Bragg reflection at a grazing angle of $8^\circ 35'$. Find the wavelength of the x-ray and angle at which the second order Bragg reflection occur. [3]
b) Show that dipolar polarizability of a material is inversely proportional to the temperature. [4]
c) If an atom A has ionization energy 5eV and another atom B of electron affinity 4eV are at a distance $5\text{\AA}$, then find the bond dissociation energy of AB. [3]
3. a) A two-body interaction specified by the potential $V(r) = -\frac{a}{r^m} + \frac{b}{r^n}$
where, a and b are positive constants.
Show that the system is stable for $n > m$. Also find the equilibrium separation and the corresponding ratio of attractive to repulsive energy terms. [2+1+2]
b) What is the physical significance of effective mass of a carrier in a periodic lattice? [2]
c) Copper has fcc structure and the atomic radius is 0.1278 nm. Calculate the inter-planar spacing for (111) planes. [3]
4. a) The primitive translation vectors of the hexagonal space lattice is given by
$$\vec{a}_1 = \frac{a}{2}(\hat{i} + \sqrt{3}\hat{j}), \vec{a}_2 = \frac{a}{2}(-\hat{i} + \sqrt{3}\hat{j}), \vec{a}_3 = c\hat{k}$$
show that the lattice is its own reciprocal but with a rotation of axes. What is the volume of the unit cell in reciprocal space. [3+1]
b) Draw E–K diagram for free electron and electron in solid in same graph qualitatively. [1]
c) Show that the number of possible modes of vibration in a linear chain of atoms is equal to the number of vibrating atoms. [3]
d) What do you mean by density of electronic state? Find the relation between energy and density of electronic state for one-dimensional metal. [1+1]
5. a) Show that the electrical conductivity(σ) and Fermi surface area (S_F) are related as $\sigma = \frac{e^2 I S_F}{12\pi^2 \hbar}$, l being the mean free path of the electron. [5]
b) Show that at thermal equilibrium of Fermi level must be constant throughout the pn-diode. [3]

- c) Prove that the disappearance of resistivity and Meissner effect in a superconductor are mutually consistent. [2]
6. a) Kronig-Penny model gives a simplified solution of the form

$$P \frac{\sin \alpha a}{\alpha a} + \cos \alpha a = \cos Ka$$
, where the symbols have their usual significance. Discuss the formation of energy bands in a solid. [4]
- b) Show that the energy band gaps of band electron are consequence of Bragg reflection of the electrons at the zone boundaries. [2]
- c) Draw clearly the energy band diagram of a npn transistor. [2]
- d) A silicon pnp transistor of base width $2\mu\text{m}$ and base resistivity $10^{-3}\Omega\text{m}$. The emitter region has a thickness of $1\mu\text{m}$ and resistivity $10^{-5}\Omega\text{m}$. Calculate the emitter injection efficiency of the transistor. [2]
7. a) What are the basic features of Einstein's model for explanation of lattice specific heat of solids and what are its drawbacks? What is the concept of Debye for improvement of this model? [$1\frac{1}{2}+1+1\frac{1}{2}$]
- b) Assuming that in a solid of volume V , the number of modes of vibration (dN) having angular frequency between w and $w+dw$ is given by

$$dN = \frac{Vw^2dw}{2\pi^2c^3}$$

 where c is the velocity of sound in solids. Calculate the Debye cut-off frequency and write the physical significance of it. [2+1]
- c) A current of 5A is established in a slab of copper of 0.5 mm thick and 1 cm wide. The slab is placed in a magnetic field $B = 1.5\text{ T}$. The magnetic field is perpendicular to the plane of the slab and to the current. If free electron density of copper is $8.5 \times 10^{28}/\text{m}^3$, calculate the magnitude of Hall voltage across the width of the slab. [3]
8. a) what do you mean by carrier injection in a pn junction diode. Under low-level injection approximation find the expression for excess carrier at the edges of the pn junction. [1+3]
- b) Show that the number of energy state in each energy band is equal to the number of atoms in a crystal. [4]
- c) The electronic configuration of an ion is $4f^9 6s^0$. Calculate the magnetic susceptibility for a salt containing one mole of that ion at 300K. [2]

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