Sem 5 T.Y.B.Sc Physics Nov 2022

[Time: 3 Hours] **[Marks:100]**

N.B. : (1) **All** questions are **compulsory**.
(2) **Figures** to the **right** indicate **full** marks.
(3) Draw **neat** diagrams wherever **necessary**.
(4) Symbols have usual meaning unless otherwise stated.
(5) Use of **non-programmable** calculator is allowed.

List of Constants:

Charge of an electron $e = 1.6021 \times 10^{-19}$ Coulomb, Mass of an electron $m_e = 9.109 \times 10^{-31}$ kg
Boltzmann constant $k_B = 1.38054 \times 10^{-23}$ Joule/Kelvin,
Planck's constant $h = 6.626 \times 10^{-34}$ joule sec
Permeability of free space $\mu_0 = 4 \times 10^{-7}$ Henry/m,
Avogadro's number $N_A = 6.023 \times 10^{26}$ /kg mole.

Q1. Attempt any **two:—**

(i) With the help of a neat diagram, explain the seven systems of the crystal. How will you differentiate them on the basis of the relation to length of axis and the angle between the axis of a unit cell in each case. **10**

(ii) Explain what you understand by miller indices of a lattice plane. Deduce the relation for interplanar spacing of a set of miller Planes in a simple cubic crystal in terms of lattice parameter. **10**

(iii) Define packing fraction. Determine packing fraction for a hcp-structure. **10**

(iv) What is crystal symmetry? Explain X-ray diffraction process through a crystal on the basis of Ewald's sphere of reflection and reciprocal lattice vector. **10**

Q2 Attempt any **two:—**

(i) Discuss classical free electron theory of metals and obtain the expression for electrical conductivity. **10**

(ii) a) Explain and derive expression for collision time. **10**
b) Explain the drawback of the classical free electron theory in terms of the heat capacity of metal.

(iii) Derive the expression of Fermi energy and average energy of electron gas at absolute zero. Assume the expression of density of states. **10**

(iv) Discuss the phenomenon of thermionic emission in metals. Obtain Richardson- Dushman equation for the thermionic emission current density at temperature T. **10**

Q3 Attempt any **two:—**

(i) Using Kronig Penney model, obtain solution of Schrodinger's equation for an electron in a periodic potential. **10**

(ii) Discuss the motion of an electron in one dimensional periodic potential under the influence of external electric field. Hence bring out the concept of effective mass of an electron. **10**

(iii) What is Hall effect? Derive the expression for the Hall voltage and Hall coefficient. Discuss significance of Hall coefficient. **10**

(iv) Derive the expression for the concentration of the holes in the valence band. **10**

Q4 Attempt any **two:—**

(i) Explain the band structure of an open circuited p-n junction with the help of a neat diagram. Derive expression for contact potential E_0 at the junction. **10**

(ii) Derive the law of junction for a low level injection for a p-n junction diode. **10**

(iii) a) Explain in brief the Meissner effect in superconductors. **10**
b) Explain Type I and Type II superconductors.

(iv) Discuss in brief BCS theory of superconductivity. **10**

Q5. Attempt any **four:—** **20**

(i) The Atomic radius of silver having fcc-structure is 0.152nm. Find the interplanar spacing of (2 3 1) and (1 1 0) planes. **05**

(ii) For a simple cubic lattice show that, the ratio of density of points in (1 1 1) and (1 1 0) planes is 0.82. **05**

(iii) The Fermi energy of silver is 5.51 eV. **05**
a) What is the average energy of the free electrons in silver at 0 K?
b) What is the speed of the electrons with this energy?

(iv) Calculate the probability that an allowed state occupied by an electron lies above the Fermi level by 6 k_BT. **05**

(v) Consider a two dimensional square lattice of side 0.3 nm. At what electron momentum values do the sides of the first Brillouin zone come? What is the energy of the free electron with this momentum? **05**

(vi) The energy band gap of an intrinsic semiconductor is 0.7 eV. Determine the position of the Fermi-level at 300 K, if the effective mass of electron is 1/6 times the effective mass of hole. (given kT = 0.026 eV) **05**

(vii) The conductivities of n-region and p-region of the germanium p-n junction are 200/Wm and 500/Wm respectively. The cross sectional area of crystal is 0.004cm^2. Dielectric constant for Germanium is 16. Calculate width of depletion region when p-n junction is unbiased. **05**
[$\epsilon_0 = 8.85 \times 10^{-12}$ S.I. units and $\epsilon_r = 16$ S.I. unit]
[$\mu_p = 0.18$ SI unit , $\mu_n = 0.39$ SI unit, $n_i = 2.20 \times 10^{19}$ /m^3]

(viii) Calculate the London penetration depth from the following data. **05**
[Given : Atomic weight = 118.7 , Density = 7.3×10^3 Kg/m^3, critical temperature =3.7K, Effective mass (m*) = 1.9m, mass of electron(m) = 9.1×10^{-31} Kg].

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