[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 = 1.6021×10^{-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) What do you mean by primitive and non –primitive unit cells? With the help of a diagram explain fourteen Bravais Lattice with a suitable relation between the length of axis and angle between them. **10**

(ii) Show that for a simple cubic lattice the interplanar spacing between two parallel planes with miller indices (h k l) is $d_{hkl}=a/\sqrt{h^2+k^2+l^2}$ **10**

(iii) Explain the X-ray diffraction through a crystal. **10**
Determine the Wavelength of X-ray for first order diffraction at a glancing angle of 9º. The spacing between adjacent planes is 2.51AU

(iv) Explain hcp structure and show that a packing fraction of hcp-structure is 0.74 **10**

Q2 Attempt any **two:---**

(i) Derive the expression for the drift velocity of free electrons in metals. **10**
Specify any two drawbacks of classical theory for metals?

(ii) Write down one main feature of the 'Sommerfeld free electron model'. Hence obtain an expression for the density of states for the potential energy box of depth E. **10**

(iii) Derive the expression for the electrical conductivity of metal on the basis of quantum theory of metals. **10**

(iv) Explain the variation of Fermi distribution function with temperature and define Fermi energy of a metal. **10**
The Fermi energy of a metal is 10 eV. Calculate the average energy of free electrons in the metal at 0 ^{o} K.

Q3 Attempt any **two:---**

(i) Explain the Brillouin zones in one dimension and two dimensions with neat diagram. How are they related to the energy levels of an electron in a metal? **10**

(ii) What is Kronig-Penney model? Write the solution of Schrodinger's equation for this model. Discuss the conclusions derived. **10**

(iii) Derive the continuity equation for charge carriers in a semiconductor. **10**

(iv) Derive an expression for the concentration of electrons in an intrinsic semiconductor. **10**

Q4 Attempt any **two:---**

(i) For a p-n junction diode show that reverse saturation current is equal to **10**

$$I_o = A.e.[\frac{D_p}{L_p.N_d} + \frac{D_n}{L_n.N_a}]\, n_i^2$$

(ii) For a p-n junction in equilibrium show that $Vo = V_T \ln (\frac{Ppo}{Pno})$ where symbols have their usual meaning. **10**

(iii) What is superconductivity? Explain any four characteristics of a superconductor. **10**

(iv) (a) Explain in brief the Meissner effect in superconductors. **10**
(b) Discuss the effect of temperature on critical magnetic fired.

Q5. Attempt any **four:---** **20**

(i) Give one importance of miller indices. **05**
Find the miller indices of a plane parallel to Z-Axis and cut intercepts of 2 and 3/2 along the X-and Y-axis respectively.

(ii) The Lattice constant of Aluminium is 4.05AU. How many unit cells are there in an Aluminium foil 0.1mm thick and side 20 cm? If the foil weight is 10gm how many atoms are present? [Atomic weight of Al = 26.9] **05**

(iii) The Fermi temperature of Potassium is 2460^0K. Calculate the Fermi velocity of electron in Potassium. **05**

(iv) Calculate the probability that an allowed state occupied by an electron lies above the Fermi level by 8 K_BT. **05**

(v) The conductivity of Germanium at 20^0C is 2 /Ωm. Calculate its conductivity at 40^0C. Eg= 0.72eV. **05**

(vi) An electric field of 50 V/m is applied to a sample of n-type semiconductor whose Hall coefficient is -0.0125 m^3/C. Determine the current density in the sample, assuming $\mu_n = 0.40\ m^2V^{-1}s^{-1}$. **05**

(vii) A germanium p-n junction has reverse saturation current, $I_0 = 2\mu A$ at 27°C. Find its static and dynamic resistance for an applied forward bias of 0.3 V at 27°C. **05**

(viii) Calculate the critical current density of 1mm diameter wire of lead at 7K. Given Tc for lead is 7.18Kand Ho= 6.5 x 10^4 ampere/meter. **05**

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