(3 hrs) **Total 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 $= 1.3805 \times 10^{-23}$ Joule/kelvin.

Planck's constant h $= 6.626 \times 10^{-34}$ Joule sec.

Permeability of free space $\mu_0 = 4\pi \times 10^{-7}$ Henry/m.

Avogadro's Number $N_A = 6.023 \times 10^{26}$ /kg mole.

Universal Constant = $A_0 = 1.2 \times 10^6$ Amp / $m^{2\,0}$ k^2

1. Attempt any two:---
   (a) For a cubical crystal, deduce an expression for interplanar distance for planes of Miller indices (h k l). **10**
   (b) Define 'Primitive cell' and ' Non-primitive cell'. Explain the terms 'Atomic-radius' and 'Atomic packing fraction'. Obtain packing fraction for a body centered cubic cell. **10**
   (c) With the help of a neat diagram, explain seven crystal systems and fourteen Brais space lattice. **10**

2 Attempt any two:---
   (a) 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**
   (b) On the basis of quantum theory, derive an expression for the electrical conductivity of metal. Modify it on the basis of band theory. **10**
   (c) What is meant by ' Thermionic emission'? derive Richardson-Dushman equation. **10**

3. Attempt any two:---
   (a) Derive an expression for the concentration of electrons in an intrinsic semiconductor. **10**
   (b) Using Kroning Penney model, obtain solution of Schrodinger's equation for an electron in a periodic potential. **10**
   (c) Set up the continuity equation for the charge carriers in a semiconductors. **10**

4. Attempt any two**:---**

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

(b) What is superconductivity? Explain and distinguish between Type I and Type II superconductors. **10**

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

5. Attempt any **Four:**---

(i) Show that for a cubic fcc crystal, the lattice constant is given by **05**

$$a = (4M/Nd)^{1/3}$$

where M is the molecular weight of molecules at lattice points, d is the density of a crystal and N is Avogadro's number.

(ii) Electrons are accelerated by 844 V and are reflected from a crystal. Calculate the spacing of the crystal; if the maximum reflection occurs at the glancing angle of 58 degree. **05**

(iii) Resistivity of an uniform Silver wire is 1.54×10^{-8} Ω-m.at room temperature. Compute the average drift velocity of an electrons, their mobility and also relaxation time. Assume an electric field is of 1V/cm. along the wire and there are 5.8×10^{28} conduction electrons per meter cube. **05**

(iv) At what temperature we can expect a 10 % probability that electrons in a Silver possess an energy that is 1% above the Fermi-energy. Given Fermi-energy of Silver is 5.5 eV. **05**

(v) The minority carrier life time in p-type material is 10^{-7} s. The mobility of electron in silicon is $\mu_n = 0.15\ m^2\ /VS$. Find the diffusion length of Si at 300K. **05**

(vi) 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**

(vii) The lead material works as a superconductor at a temperature of **05**

T_C = 7.26 K. If the constant characteristics field of the lead material at

0 K is $H_0 = 8 \times 10^5$ A/m. Calculate the critical magnetic field at 5K.

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

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