

(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 /  $m^{20} k^2$ 

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 Bravais 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 Kronig 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. **05**  
 Calculate the spacing of the crystal; if the maximum reflection occurs at the glancing angle of 58 degree.
- (iii) Resistivity of an uniform Silver wire is  $1.54 \times 10^{-8} \Omega\text{-m}$ .at room **05**  
 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  $5.8 \times 10^{28}$  conduction electrons per meter cube.
- (iv) At what temperature we can expect a 10 % probability that electrons in **05**  
 a Silver possess an energy that is 1% above the Fermi-energy. Given Fermi-energy of Silver is 5.5 eV.
- (v) The minority carrier life time in p-type material is  $10^{-7}$  s. The mobility **05**  
 of electron in silicon is  $\mu_n = 0.15 \text{ m}^2/\text{VS}$ . Find the diffusion length of Si at 300K.
- (vi) Consider a two dimensional square lattice of side 0.3 nm. At what **05**  
 electron momentum values do the sides of the first Brillouin zone come? What is the energy of the free electron with this momentum?
- (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 **05**  
 27°C. Find its static and dynamic resistance for an applied forward bias of 0.3 V at 27°C.

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