(*Time*: 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.
          (5) Symbols have usual meaning unless otherwise stated.
          (5) Use of non-programmable calculator is allowed.

List of Constants:

Charge on electron	$e = 1.6 \times 10^{-19}$ C
Electron mass	$m = 9.1 \times 10^{-31}$ Kg
Planck's constant	$h = 6.62 \times 10^{-34}$ js
Velocity of light in vacuum	$c = 3 \times 10^{8}$ m/s
Permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}$ C^2/ N·m^2
Avogadro 's number	$N_A = 6.02 \times 10^{26}$ Kg- mol^{-1}
Boltzmann constant	$k = 1.38 \times 10^{-23}$ J/K
	$= 8.625 \times 10^{-5}$ eV/K

1.   Attempt **any two**:---

  (a) What are Miller indices? With example explain how they are obtained?   10
       Sketch the (0 1 0), (1 1 0) and (1 1 1) planes in a cubic crystal.

  (b) Discuss fcc and bcc crystal structures and hence explain crystal structure of   10
       sodium chloride and cesium chloride.

  (c) Explain the seven systems of the crystal with the help of a neat diagram.   10
       Give the relation to lengths of axes and the angle between the axes of a unit
       cell in each type.

2   Attempt **any two**:---

  (a) Define Fermi energy. Write down the expression for Fermi-Dirac   10
       distribution law. Discuss the variation of Fermi-distribution graphically.

  (b) What is meant by thermionic emission? Obtain an expression for the   10
       emitted current density.

  (c) What is relaxation time ? Derive an expression for it.   10
       According to classical theory of free electron of metals show that
       the root mean square velocity of electron is proportional to the square root
       of the absolute temperature of metal.

3.   Attempt **any two**:---

  (a) What is Kronig-Penny model?. Discuss the solution of Schrödinger's   10
       equation for this model. State the conclusions derived.

  (b) What is Hall effect? Derive the expression for the Hall voltage and Hall   10
       coefficient.

(c) Explain mechanism of generation and recombination of charge carriers in semiconductors. Explain the concept of mean life time and derive the expression for the same.   10

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

(a) Explain the term 'reverse saturation current' I_0 in the junction diode. Write down expression for I_0 and discuss it for Ge and Si diodes. Derive the relation for fractional increase in I_0 with temperature, $(1/I_0)(dI_0/dT)$.   10

(b) Explain the depletion layer and barrier potential at a P-N junction. Obtain an expression for the potential barrier developed across an unbiased P-N junction in terms of the doping concentrations.   10

(c) Explain the Meissner effect in superconductors. Explain how the critical temperature of a superconductor varies with magnetic field.   10

5.   Attempt **any four**:---

(i) Lattice constant of copper is 0.38 nm. Calculate the distance between (110) planes.   05

(ii) Explain the symmetry elements in a crystal   05

(iii) Calculate the density of states for a free electron per unit volume with energies between 0 and 1eV.   05

(iv) A uniform copper wire of diameter 0.16 cm carries a steady current of 10 A. Find the current density and the drift velocity of the electrons in copper.
[Given : density and atomic weight of copper are 8920 Kg/m^3 and 63.5 respectively].   05

(v) Write a note on p-type and n-type semiconductors.   05

(vi) What is Brillouin zone? Explain with diagram Brillouin zone in two dimensional square lattice.   05

(vii) For what voltage will the reverse current in a p-n junction germanium diode attain a value of 80% of its saturation value at room temperature?   05

(viii) Explain the 'penetration depth' with reference to superconductors.   05

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