($2\frac{1}{2}$ Hours) **Total Marks : 75**

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 of an electron: $e = 1.6021 \times 10^{-19}$ Coulomb

Mass of an electron: $m = 9.109 \times 10^{-31}$ Kg

Boltzmann constant: $K = 1.3805 \times 10^{-23}$ Joule/ Kelvin

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

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

Avogadro's number: $N_A = 6.023 \times 10^{26}$ /Kmole

1. (a) Attempt any **one:---**

(i) Describe the types of cubic crystal (SC) structures with neat diagram. Find the distance between the nearest neighbours and atomic packing factor of FCC system. **10**

(ii) Derive the expression for drift velocity of free electrons in metals. What are the drawbacks of classical theory for metals? **10**

(b) Attempt any **one:---**

(i) Define the terms: Coordination number, unit cell, basis, crystal structure and single crystal. **5**

(ii) Copper has fcc structure and its atomic radius is $0.1278\,nm$. Calculate its density. Take the atomic weight of copper as 63.5. **5**

2. (a) Attempt any **one:---**

(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) Derive the expression for density of energy states in metals. **10**

(b) Attempt any **one:---**

(i) Derive the expression for the mean energy of electron gas at absolute zero temperature. **5**

(ii) Show that the probability that a state ΔE above the Fermi level E_F is filled equals the probability that a state ΔE below E_F is empty. **5**

3. (a) Attempt any **one:**---
   (i) Derive the expression for Fermi level and electron concentration in n-type of semiconductor. **10**
   (ii) Apply the continuity equation to find the expression for injected minority carrier concentration in a bar of semiconductor subjected to radiation at one end as a function of distance under the state of equilibrium. **10**

   (b) Attempt any **one:**---
   (i) Derive the expression for barrier potential at an open circuited P-N junction in terms of dopping concentrations by using its energy band structure. **5**
   (ii) In an intrinsic semiconductor with forbidden energy gap E_g= 0.7 eV, determine the position of Fermi level at T= 300 K if $m_h^* = 6\, m_e^*$. **5**

4. (a) Attempt any **one:**---
   (i) Write down expression for reverse saturation current I_0 of a PN-diode and discuss it for Ge and Si diodes. Derive the relation for temperature co-efficient of I_0 which is defined as $(1/I_0)(dI_0/dT)$. **10**
   (ii) What is diamagnetism? Derive the expression for the diamagnetic susceptibility of a substance. **10**

   (b) Attempt any **one:**---
   (i) Explain the Meissner effect in superconductors. **5**
   (ii) A Ge PN junction has reverse saturation current I_0= 1 μA at 37˚C. Find its static and dynamic resistance for an applied bias of 0.3 V at 37˚C. **5**

5. (a) Attempt any **one:**---
   (i) Draw the lattice planes $(110), (231), (101)\ and\ (123)$. **4**
   (ii) Show that for simple cubic lattice $d_{100} : d_{110} : d_{111} = \sqrt{6} : \sqrt{3} : \sqrt{2}$ **4**

   (b) Attempt any **one:**---
   (i) Calculate the total number of energy states below $E = 5\ eV$ in a metal of volume $10^{-5}\ m^3$. Assume the electrons to be free. **4**
   (ii) Estimate the electronic specific heat of copper at $300K$. E_F for copper is 7 eV. **4**

(c) Attempt any **one:**---

(i) The Hall voltage for sodium metal is 0.001 mV measured at I= 100 mA, B_z= 2 Weber/ m^2. Thickness of specimen is 0.05 mm. Calculate the number of carriers per cubic meter in sodium. **4**

(ii) A germanium diode has 10^{22} donor atoms/m^3 in the n-region and 2×10^{21} acceptor atoms/m^3 in the p-region. Find the value of barrier potential developed across the unbiased junction at room temperature. Intrinsic carrier concentration (n_i) for germanium is 2.15 $\times 10^{19}/m^3$. **4**

(d) Attempt any **one:**---

(i) A superconducting material has critical temperature of 4.5K in zero magnetic field and critical field of 0.04 Wb/m^2 at 0 K. Find critical field at temperature 3 K. **3**

(ii) A magnetic material has magnetization of 3300 A/m and flux density of 0.0044 Wb/m^2. Calculate the magnetizing force. **3**
