Time: 3 hrs. **M. M.: 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.

Constants: Boltzmann Constant:K_B= 1.38 x 10^{-23}J/K
Planck's Constants: h=6.63 x 10^{-34}Js
Electron charge: e=1.6 x 10^{-19}C
Permeability of free space $\mu_0 = 4\pi \times 10^{-7}$ Henry/m,
Avogadro's number NA = 6.023×10^{26} /kg mole

Q1. Attempt any **two**

(i) Explain the terms: **10**
i) Lattice
ii) Basis
iii) Coordination number
iv) Nearest neighbor distance
v) Primitive cell

(ii) Explain the seven types of crystal systems with the help of a neat diagram. Derive the relation of length of axes and the angle between the axes of a unit cell in each type? **10**

(iii) In a cubic crystal, derive an expression for separation between the planes? **10**

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

Q2 Attempt any **two**

(i) Discuss classical free electron theory of metals and hence obtain the relation between resistivity of metals and absolute temperature. **10**

(ii) What is Wiedemann-Franz law? Obtain the relation between electrical conductivity and the thermal conductivity using classical free electron theory. **10**

(iii) Derive the expression for density of states between E and E+dE for electrons in metals at a particular temperature. **10**

(iv) Describe the Fermi distribution function in details and show that heat capacity of the electron gas is $0.015R_u$. (where R_u is the universal gas constant) **10**

Q3 Attempt any **two**

(i) Explain how materials can be classified into conductors, insulators and semiconductors on the basis of the E-K curve for the material. **10**

(ii) State the assumptions made, write Schrodinger's equations for the motion of electrons in one dimensional periodic potential. Explain the condition for the satisfactory solution of these equations. With the help of a suitable sketch explain the conclusions drawn. **10**

(iii) Derive the expression for electron concentration in intrinsic semiconductor. **10**

(iv) Explain the Hall effect and derive the expressions for the Hall voltage and Hall coefficient **10**

Q4 Attempt any **two**

(i) Explain BCS theory of superconductors, highlighting the cooper pair formation. **10**

(ii) Write a detailed note on London equation in case of superconductors, explaining the concept of penetration depth . **10**

(iii) Write a detailed note on total current in p-n junction diode, discussing the different components involved in total current of p-n junction. **10**

(iv) Discuss p-n junction in equilibrium. Obtain the relation between barrier height and the thickness of depletion layer at the junction. **10**

Q5. Attempt any **four**

(i) When a monochromatic X-ray of wavelength 1.54 A.U. is incident on a simple cubic crystal of lattice constant 3.16 A.U., a diffraction pattern is observed. What are the interplanar spacing and Miller indices of the reflecting planes if the first line of diffraction is observed at 20.3 degree? **05**

(ii) Determine the Miller indices having planes intercepts on the axis -2*a*, b, -4c. **05**

(iii) A uniform silver wire has a resistivity of 1.54×10^{-8} Ω-m at room temperature. For an electric field of 100 V/m, along the wire calculate the mobility and the average drift velocity of the electrons, assuming that there are 5.2×10^{28} conduction electrons/m^3. **05**

(iv) The Fermi energy of silver is 5.49 eV. What are the average energy and the speed of free electrons in silver at 0 K? **05**

(v) Consider a grain dust having mass 1μgm confined to move between two rigid walls separated by 0.1mm. At what grain momentum values of the sides of the first Brillouin zone come? What is the energy of the grain particle with this momentum? **05**

(vi) An electric field of 50V/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 $\mu_n = 0.40 m^2/Vs$ **05**

(vii) The critical field for niobium is 1×10^5 *amp/m* at 8 *K* and 2×10^5 *amp/m* at absolute zero. Find the transition temperature of the element. **05**

(viii) A germanium p-n junction has reverse saturation current, $I_0 = 2\ \mu A$ at 27^0C. Find its dynamic resistance for an applied forward bias of 0.3 V at 27^0C. **05**
