Time: 2 ½ hrs. **Marks: 75**

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: 1.38×10^{-23} J/K
Planck's Constants: 6.626×10^{-34} Js
Charge of electron $e = 1.6 \times 10^{-19}$ C
Mass of electron $m_e = 9.109 \times 10^{-31}$ kg
Avogadro's number $N_A = 3.023 \times 10^{26}$ /kg mole

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

(i) With the help of a neat labelled diagram, explain seven types of crystal systems of fourteen types of Bravais lattice? Explain Miller indices of lattice plane. **10**

(ii) Derive an expression for separation between the Miller planes in a simple cubic crystal in terms of Lattice parameter. **10**

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

(i) Explain the terms: **5**
a) Basis b) Coordination number c) Primitive cell

(ii) The atomic radius of Silver having FCC structure is 0.152 nm. Find the interplanar spacing of (2 3 1) and (1 1 0) planes. **5**

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

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

(ii) Explain quantum free electron theory and discuss the failure of Sommerfeld's free electron theory. **10**

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

(i) Discuss the Fermi distribution function in details. **5**

(ii) Show that heat capacity of the electron gas is $0.015R_u$. (where R_u is the universal gas constant) **5**

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

(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) With the help of schematic diagram of energy band structure for an intrinsic semiconductor. Derive the expression for electron concentration (n) in the intrinsic semiconductor at temperature T°K. Write down the expression for hole concentration (p). Obtain the expression for the Fermi energy in the semiconductor. **10**

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

(i) Write a short note on p-type and n-type semiconductors. **5**

(ii) The Hall voltage for the sodium metal is 0.001 mV measured at I = 100 mA and magnetic field 2 wb/m². Thickness of the specimen is 0.05 mm. Calculate the number of carriers per cubic m in sodium. **5**

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

(i) 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**

(ii) Explain Meissner effect and hence derive London equation in detail in case of superconductors. **10**

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

(i) Draw the volt-ampere characteristics of the p-n junction diode. Explain how they depend on the temperature. **5**

(ii) The lead material works as a superconductor at a temperature of 7.26 K. If the critical magnetic field at 0K if is 8×10^5 A/m then calculate the critical magnetic field in lead at 5 K. **5**

5. **Attempt any Five: -**

(i) Planes intercepts to the axis 6*a*, 2*b*, 4*c*. Find the Miller indices. **3**

(ii) For simple cubic lattice show that, the ratio of density of points in (111) and (110) plane is 0.82. **3**

(iii) Find the probability of an electronic state being occupied at 300 K temperature, if the energy of the state is 0.2 eV above fermi level. Does the probability remain the same for the state that is 0.2 eV below? **3**

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(iv) A uniform silver wire has a resistivity of 1.45×10^{-8} Ω-m at room temperature. For an electric field of 200 V/m along the wire, calculate the mobility and the average drift velocity of the electrons, assuming that there is 4.8×10^{28} conduction electrons/m^3. 3

(v) For a two-dimensional square lattice of side 0.4 nm, what will be the free electron momentum value of the first Brillouin zone? 3

(vi) Find the diffusion coefficients for holes of a silicon single crystal at 27°C, if the mobility of holes is 0.025 $m^2 V^{-1}s^{-1}$ respectively at 27°C. 3

(vii) Calculate the width of depletion region when p-n junction is forward biased by 0.1 volts. Relative dielectric constant for germanium is 16. Assume the junction to be abrupt one. 3

Given: $N_d = 3.2 \times 10^{21}$, $Na = 1.736 \times 10^{22}$ and barrier voltage $V_B = 0.131\ V$.

(viii) Calculate critical current through Tungsten wire of diameter 2.8 mm and $H_c = 8.51 \times 10^7$ A/m. 3

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