TUTORIAL –7 UNIT-4: ELECTRICAL CONDUCTIVITY OF METALS

($e = 1.6 \times 10^{-19}$C; $m = 9.1 \times 10^{-31}$kg; $k = 1.38 \times 10^{-23}$ J/K; $N_A = 6.026 \times 10^{26}$/k.mol)

1. The resistivity of Aluminum at room temperature is 2.62×10^{-8}ohm-m. Calculate the drift velocity, mobility, relaxation time and mean free path of conduction electrons on the basis of classical free electron theory in an applied field of 50Vm^{-1}. The density and atomic weight of trivalent Al are 2700 kg/m^3 and 26.98 kg respectively.

2. A copper wire whose diameter is 0.16cm carries a steady current of 10A. Assuming one free electron/atom, calculate the density of electrons. Density of Cu is 8900 kg/m^3, atomic mass is 63.54 kg and resistivity is $1.7 \times 10^{-8}\Omega$m. Calculate the drift velocity and mean free path according to classical free electron theory.

3. A conducting rod contains 8.5×10^{28} electrons/m^3. Calculate its resistivity and mobility of electrons at room temperature if the mean collision time for electron scattering is 2×10^{-14}sec.

4. Fermi energy of silver is 5.5 eV. Calculate the probability of occupancy of a state which is (i) 0.1 eV below Fermi level, (ii) 0.1eV above the Fermi level (iii) kT above Fermi level and (iv) 4kT above Fermi level , at a temperature of 300 K.

5. Find the temperature at which there is 1% probability that a state lying ~~above~~ 0.5eV above Fermi energy will be occupied.

6. The Fermi level in silver is 5.5eV. What are the energies for which the probabilities of occupancy at 300K are 0.99 and 0.01.

7. Determine the temperature at which there is a 1% probability that an energy state 0.3eV below the Fermi level is empty. Given E_F=6.25eV.

8. The Fermi energy of sodium is 3eV at 0K. Calculate the electron density, Fermi velocity.

9. Calculate the density of states between 0 and 2 eV in a copper cube of dimension 1cm.

10. The relaxation time of electrons in trivalent Al is 7.3×10^{-15} s and atomic weight and density are 26.98 kg and 2700 kg/m^3 respectively. Calculate the Fermi energy, Fermi velocity and mean free path according to quantum free electron theory.

TUTORIAL —8 UNIT-4 : SEMICONDUCTORS

1. The effective density of states for electrons and holes in silicon at 300 K are 2.8×10^{19} cm^{-3} and 1.04×10^{19} cm^{-3} respectively and the energy gap of Si is 1.1 eV. Calculate the intrinsic carrier concentration.

2. The following data corresponds to 300 K

	$N_c(cm^{-3})$	$N_v(cm^{-3})$	m_e^* / m_0	m_h^* / m_0	Energy gap (eV)
Silicon	2.8×10^{19}	1.04×10^{19}	1.08	0.56	1.12
Ga As	4.7×10^{17}	7.0×10^{18}	0.067	0.48	1.42
Germanium	1.04×10^{19}	6.0×10^{18}	0.55	0.37	0.67

(i) Calculate the intrinsic carrier concentration for silicon at 400K.
(ii) Calculate the intrinsic carrier concentration for Germanium at 300 K.
(iii) Calculate the concentration of holes and electrons at 300 K for GaAs.

3. Calculate the electron and hole concentration in Si at 300K for the case when the Fermi level is 0.22eV below the conduction band energy E_c.

4. Determine the electron and hole concentration in GaAs at 300K for the case when the Fermi level is 0.3eV above the valence band energy E_v.

5. Calculate the density of states in conduction band of silicon between E_c and E_c+3kT at 300K.

6. The mobilities of electrons and holes for Germanium are: $\mu_n = 0.39\, m^2/Vs$ and $\mu_h = 0.19\, m^2/Vs$. Calculate intrinsic conductivity at 300 K. Given $n_i = 2.5 \times 10^{19}/m^3$.

7. The energy gap of Si is 1.1eV. Its electron and hole mobilities at room temperature are 0.48 and $0.013 m^2V^{-1}s^{-1}$ respectively. Evaluate its conductivity at 300K.

8. An n-type Ge sample has dimensions 10cm ×5cm ×1mm. The Hall voltage is measured across the width. The sample is placed in a magnetic field of strength 0.65 T and the current density along the length is 250 A/m^2. If the electron concentration is 10^{21} m^{-3}, calculate the Hall field, Hall voltage, Hall coefficient.

9. The resistivity of a n-doped Si sample is $8.9 \times 10^{-3} \Omega m$. The Hall coefficient was measured to be 3.6×10^{-4} m^3/C. Assuming single carrier conduction, calculate the mobility and density of charge carriers.