



COLLEGE OF ENGINEERING & TECHNOLOGY

Department : Electronics & Communications Engineering
Lecturer : Dr. Mohamed Al Amir
T. Assistant : Eng. Mohammed Bedier
Course : Electronic Materials
Course Code : EC311

Sheet 1

Free Electron Gas Model

[1] In silver, the number of free electrons per unit volume is $5.8 \times 10^{28} \text{ m}^{-3}$. What is the Fermi energy for the free electron gas in silver? Also, what is the speed of an electron with this energy?

[2] The electron concentration in sodium, copper and aluminum are 2.5, 8.5 and $18 \times 10^{22} \text{ cm}^{-3}$ respectively. The Fermi energy of Sodium is 3.1 electron volts. Calculate the Fermi energy level and Fermi velocities for all materials in cm/sec.

[3] Show that the kinetic energy of a 3-dimension of N free electrons at 0 Kelvin is $U = \frac{3}{5} NE_f$.

[4] Derive a relation connecting the pressure and volume of an electron gas at 0 Kelvin.

[5] If the Fermi temperature is defined as $T_f = 2E_f / 3K_B$, which is not a temperature but a theoretical temperature, where $N/V = 5.6 \times 10^{28} \text{ m}^{-3}$ and $K_B = 1.38 \times 10^{-23} \text{ J/k}$

a. What is the Fermi temperature of the free electron silver?

b. Show that the Fermi momentum $P_f = (2m_e E_f)^{1/2}$

[6] Silver (its molecular weight is 108) has a mass density of 10.5 gm/cm^{-3} and an electrical resistivity of $1.55 \times 10^{-8} \Omega \cdot \text{m}$ at room temperature.

Find:

1. The concentration of the conduction electrons (Hint: Concentration = $A_{vo} \cdot \text{density} / \text{molecular weight}$).
2. The relaxation time.
3. Fermi energy.
4. Fermi velocity.

[7] The resistance of a copper wire (diameter = 1.03 mm) is 6.51Ω for 1000m lengths. The concentration of free electron in copper is $8.4 \times 10^{28} \text{ electrons/m}^3$. If the current is 2A, find:

1. Drift velocity.
2. Conductivity.
3. Mobility.