PHYSICS ASSIGNMENT - III

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1. The fermi temperature of a metal is 24600 K. Calculate the Fermi velocity.

Soln:- Given, $T_F = 24600K$

we have, mass of an electron, $m = 9.11 \times 10^{-31}$ kg

So,

$$\text{Fermi Velocity}, V_F = \sqrt{\frac{2kT_f}{m}}$$

$$= \sqrt{\frac{2 \times 1.38 \times 10^{-23} \times 24600}{9.11 \times 10^{-31}}}$$

$$\therefore V_F = 0.8633 \times 10^6 \; ms^{-1}$$

2. Free electron density of aluminium is $18.1 \times 10^{28} m^{-3}$. Calculate its fermi energy at 0K.

Soln:- Given, Electron density of Al, $n = 18.1 \times 10^{28} m^{-3}$

we know, Plank's Constant, $h = 6.62 \times 10^{-34}$ Js

and Mass of an electron, $m = 9.1 \times 10^{-31}$ kg

So,

$$\text{At 0K, fermi energy}, E_{F_0} = \left(\frac{3n}{8\pi}\right)^{2/3} \times \frac{h^2}{2m}$$

$$= \left(\frac{3 \times 18.10 \times 10^{28}}{8 \times 3.14}\right)^{2/3} \times \frac{(6.62 \times 10^{-34})^2}{2 \times 9.1 \times 10^{-31}}$$

$$= 1.8689 \times 10^{-18} J$$

$$= \frac{1.8689 \times 10^{-18}}{1.6 \times 10^{-19}} eV$$

$$\therefore E_{F_0} = 11.68 \; eV$$

3. The resistivity of a piece of silver at room temperature 1.6×10^{-8} m. The effective number of conduction electrons is 0.9 per atom and the fermi energy is 5.5eV. Estimate the mean free path of the conduction electrons. Calculate the electronic relaxation time and the electronic drift velocity in a field of $100\ Vm^{-1}$. The density of silver is $1.05\times10^{4}\ Kgm^{-3}$.

Soln: Given, Resistivity of silver, $\rho = 1.6\times10^{-8}\ \Omega m$

Electric field, $E = 100\ Vm^{-1}$

So, Conductivity of silver, $\sigma = \frac{1}{\rho} = \frac{1}{1.6\times10^{-8}} = 6.25\times10^{7}\ \Omega^{-1}m^{-1}$

We know,

The carrier Concentration, $n = \frac{\text{Avagadro Number} * \text{Density}}{\text{Atomic weight}}$

$$= \frac{6.023\times10^{23}\times1.05\times10^{4}}{107.9}$$

$$\therefore n = 5.86\times10^{25}\ m^{-2}$$

Now, Relaxation time, $\tau = \frac{\sigma m}{ne^2}$

$$= \frac{6.25\times10^{7}\times9.11\times10^{-31}}{5.86\times10^{25}\times(1.6\times10^{-19})^2}$$

$$\therefore \tau = 3.79\times10^{-11}\ \text{sec}$$

Finally, Mean free path, $\lambda = c\tau$

$$= 3\times10^{8}\times3.78\times10^{-11}$$

$$\therefore \lambda = 1.134\times10^{-3}\ m$$

Also, Electronic drift velocity, $V_d = \frac{J}{ne} = \frac{\sigma E}{ne} = \frac{6.25\times10^{7}\times100}{5.86\times10^{25}\times1.6\times10^{-19}}$

$$\therefore V_d = 0.666\times10^{2}\ ms^{-1}$$

4. The intrinsic carrier density is $1.5 \times 10^{16}\ m^{-3}$. If the mobility of an electron and a hole are 0.13 and 0.05 $m^2 V^{-1} s^{-1}$, calculate the conductivity.

Soln:- Given, $n_i = 1.5 \times 10^{16}\ m^{-3}$

$\mu_e = 0.13\ m^2 V^{-1} s^{-1}$

$\mu_h = 0.05\ m^2 V^{-1} s^{-1}$

So, Conductivity, $\sigma = n_i e(\mu_e + \mu_h)$

$= 1.5 \times 10^{16} \times 1.6 \times 10^{-19} \times (0.13 + 0.05)$

$\therefore \sigma = 4.32 \times 10^{-4}\ \Omega^{-1} m^{-1}$

5. A semiconducting crystal with 12 mm long, 5 mm wide and 1 mm thick has a magnetic density of $0.5\ Wbm^{-2}$ applied from front to back perpendicular to largest faces. When a current of 20mA flows through the specimen, the voltage measured across its width is found to be $37\ \mu V$. Whis is the Hall coefficient of this semiconductor?

Soln:- Given, Hall Voltage, $V_H = 37\ \mu V = 37 \times 10^{-6}\ V$

Breath of the material, $t = 1\ mm = 1 \times 10^{-3}\ m$

Current, $I_H = 20 mA = 20 \times 10^{-3} A$

Magnetic flow density, $B = 0.5\ Wbm^{-2}$

So,

Hall coefficient, $R_H = \dfrac{V_H t}{I_H B}$

$= \dfrac{37 \times 10^{-6} \times 10^{-3}}{20 \times 10^{-3} \times 0.5}$

$\therefore R_H = 3.7 \times 10^{-6}\ C^{-1} m^3$