DEPARTMENT OF PHYSICS AND NANOTECHNOLOGY
SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

18PYB103J –Semiconductor Physics

Lecture-4

SOLVING PROBLEMS

SRM Institute of Science and Technology

1. The electrical resistivity of copper at 27^0 C is 1.72×10^{-8} Ohm m. Compute its thermal conductivity if the Lorentz number is 2.26×10^{-8} W Ohm K^{-2}

Given $(\rho) = 1.72 \times 10^{-8}\ \Omega m$

$T = 27°c \Rightarrow 273 + 27 = 300k$

$L = 2.26 \times 10^{-8}\ W \Omega K^{-2}$

According to Wiedemann - Franz law using classical free electron theory

$$\frac{k}{\sigma} = LT$$

(or) $k = \sigma LT$

$$k = \frac{LT}{\rho} \qquad \left[\because \sigma = \frac{1}{\rho}\right]$$

Therefore thermal Conductivity $k = \dfrac{2.26 \times 10^{-8} \times 300}{1.72 \times 10^{-8}}$

$$k = \boxed{394.18\ Wm^{-1}k^{-1}}$$

2. Calculate the drift velocity of electrons in copper and current density in wire of diameter 0.16 cm which carries a steady current of 10 A. Given $n = 8.46 \times 10^{28}\ m^{-3}$.

Solution:

Given:

Diameter of the wire $d = 0.16$ cm

Current flowing $= 10$ A

$$\text{Current density} \quad J = \frac{\text{Current}}{\text{Area of cross section } (A^2)}$$

$$= \frac{10}{\pi r^2} = \frac{10}{\pi (d/2)^2} \qquad \left[\because r = \frac{d}{2}\right]$$

$$= \frac{10}{3.14 \times \left[0.16 \times 10^{-2}/2\right]^2}$$

$$J = 4.976 \times 10^{6}\ Am^{-2}$$

$$J = neV_d$$

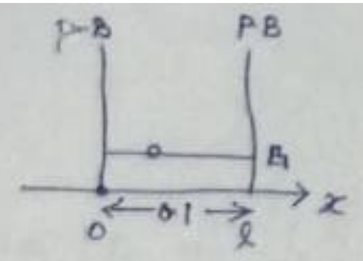
$$V_d = \frac{J}{ne}$$

$$= \frac{4.97 \times 10^{6}}{8.46 \times 10^{28} \times 1.6 \times 10^{-19}}$$

$$\text{Drift velocity } V_d = 3.67 \times 10^{-4}\ m\ s^{-1}$$

3. Find the lowest energy of an electron confined in one dimensional potential box separated by distance 0.1 nm.

Given $l = 0.1$ nm & we know $h = 6.62 \times 10^{-34}$



We know Energy of electron in 1-D Box is

$$E_n = \frac{n^2 h^2}{8 m l^2}$$

To find, Lowest energy of an electron $(n=1)$

$$E_1 = \frac{(1)^2 \times (6.62 \times 10^{-34})^2}{8 \times (9.1 \times 10^{-31}) \times (0.1 \times 10^{-9})^2}$$

$$E_1 = \frac{4.38244 \times 10^{-67}}{7.28 \times 10^{-31} \times 10^{-18}} = \frac{4.38244 \times 10^{-67}}{7.28 \times 10^{-49}}$$

$$\boxed{E_1 = 6.0198 \times 10^{-19}\ J}$$

4. An electron is bound in one dimensional infinite well of width 1×10^{-10}m. Find the energy value in the ground state, first and second excited states.

We know $E_n = \frac{n^2 h^2}{8 m l^2}$

To find lowest energy of an electron $(n=1)$

$$E_1 = \frac{(1)^2 \times (6.62 \times 10^{-34})^2}{8 \times (9.1 \times 10^{-31}) \times (1 \times 10^{-10})^2}$$

$$E_1 = 0.6031 \times 10^{-17}\ J$$

Energy of first excited state $= 4 \times 0.6031 \times 10^{-17}$
$= 2.412 \times 10^{-17}\ J$

Energy of second excited state $= 9 \times 0.6031 \times 10^{-17}$
$\boxed{= 5.428 \times 10^{-17}\ J}$

SRM Institute of Science and Technology

5. Find the least energy of an electron moving in one-dimensional potential box (infinite height) of width 0.05nm.

$$E_n = \frac{n^2 h^2}{8mL^2} \qquad L = 0.05\ \text{nm} = 0.05 \times 10^{-9}\ \text{m}$$

$$E_1 = \frac{h^2}{8mL^2} = \frac{\left(6.63\times10^{-34}\right)^2}{8\times9.1\times10^{-31}\times0.5\times10^{-10}\times0.5\times10^{-10}}\ \text{J}$$

$$= \frac{6.63\times6.63}{8\times9.1\times0.25}\times10^{-17}\ \text{J} = 2.4\times10^{-17}\ \text{J}$$

$$= \frac{2.4\times10^{-17}}{1.6\times10^{-19}} = 150.95\ \text{eV}$$