Drift velocity Solved example

Example

1. Find the approximate current density when an electric field of 5 V/m is applied to a copper conductor. The conductivity of copper is $59.6x10^6 \frac{S}{m}$.

Solution

$$J = \sigma E = 59.6x10^6 \frac{S}{m}\left(5\frac{V}{m}\right) = 298x10^6 \frac{A}{m^2} = 2.98x10^8 \frac{A}{m^2}$$

2. Find the number of charge carriers per unit volume in a copper wire of cross sectional area $1mm^2$ carrying a current of 3 A if the drift velocity of the charge carriers is 0.00028 m/s. (The elementary charge is $1.6x10^{-19}C$)

Solution

$$J = nqv_d$$

$$n = \frac{J}{v_d q}$$

$$J = \frac{I}{A} = \frac{3A}{1mm^2} = \frac{3A}{1x10^{-6}m^2} = 3x10^6 \frac{A}{m^2}$$

$$n = \frac{3x10^6 \frac{A}{m^2}}{0.00028\ \mathrm{m/s}(1.6x10^{-19}C)} = \frac{3x10^6 \frac{A}{m^2}}{0.000448\ x10^{-19}\mathrm{m/s}C} = 6696.42x10^{25} = 6.7x10^{28}$$

Exercise:

1. Find the approximate current density when an electric field of 12 V/m is applied to a copper conductor. The conductivity of copper is $63.0x10^6 \frac{S}{m}$.
2. Find the number of charge carriers per unit volume in a copper wire of cross sectional area $2mm^2$ carrying a current of 6 A if the drift velocity of the charge carriers is 0.00028 m/s. (The elementary charge is $1.6x10^{-19}C$)
3. A wire with a circular cross-sectional area 10^{-6} m^2 carries current of 1A. Find the drift speed of electrons if the number of mobile charge carriers is 10^{28} electrons per cubic meter.