[Cheng P.5-8] A d-c voltage of 6 (V) applied to the ends of 1 (km) of a conducting wire of 0.5 (mm) radius results in a current of 1/6 (A). Find

(a) the conductivity of the sphere,

(b) the electric field intensity in the wire,

(c) the power dissipated in the wire,

(d) the electron drift velocity, assuming electron mobility in the wire to be 1.4×10^{-3} ($\mathrm{m}^2/\mathrm{V} \cdot \mathrm{s}$).

Solution:

(a)

$$R = \frac{l}{\sigma S} = \frac{V}{I} \rightarrow \sigma = \frac{lI}{SV} = 3.54 \times 10^7 \,[\mathrm{S/m}].$$

(b)

$$E = \frac{V}{l} = 6 \times 10^{-3} \,[\mathrm{V/m}].$$

(c)

$$P = VI = 1 \,[\mathrm{W}].$$

(d) The given electron mobility is that of a good conductor.

$$\rho_e = -\frac{\sigma}{\mu_e}$$
$$u = \mid \frac{J}{\rho_e} \mid = \mid \frac{\mu_e J}{\sigma} \mid = \mid \mu_e E \mid = 8.4 \times 10^{-6} [\mathrm{m/s}].$$

Answer:

1. $R = 3.54 \times 10^7 \,[\mathrm{S/m}]$
2. $E = 6 \times 10^{-3} \,[\mathrm{V/m}]$
3. $P = 1 \,[\mathrm{W}]$
4. $u = 8.4 \times 10^{-6} [\mathrm{m/s}]$