

Solutions

Each answer shows the steps, then the **result**.

2.1

- a current is a **flow of charge carriers** (the rate of flow of charge)

2.2

- $I = 0.50 \text{ A}$, $t = 2.0 \text{ min} = 120 \text{ s}$
- $Q = It$

$$Q = (0.50 \text{ A})(120 \text{ s}) = \mathbf{60 \text{ C}}$$

2.3

- $e = \mathbf{1.60 \times 10^{-19} \text{ C}}$

2.4

- **opposite** to the electron flow (the direction positive charge would move)

3.1 C

- $Q = It$

$$Q = (3.0 \text{ A})(10 \text{ s}) = \mathbf{30 \text{ C}}$$

- **A** divides instead of multiplying; **B** drops a factor of 10; **D** uses $t = 100 \text{ s}$

3.2

- $Q = 60 \text{ C}$, $e = 1.60 \times 10^{-19} \text{ C}$
- $N = Q/e$

$$N = \frac{60 \text{ C}}{1.60 \times 10^{-19} \text{ C}} = \mathbf{3.75 \times 10^{20}}$$

3.3

- $I = 5.0 \text{ A}$, $A = 1.0 \times 10^{-6} \text{ m}^2$, $n = 8.5 \times 10^{28} \text{ m}^{-3}$, $q = e = 1.6 \times 10^{-19} \text{ C}$
- $I = Anvq$, so $v = I/(Anq)$

$$v = \frac{5.0 \text{ A}}{(1.0 \times 10^{-6} \text{ m}^2)(8.5 \times 10^{28} \text{ m}^{-3})(1.6 \times 10^{-19} \text{ C})} = \mathbf{3.7 \times 10^{-4} \text{ m s}^{-1}}$$

3.4

- charge comes only in **whole-number multiples** of the elementary charge e

3.5

(a) $I = 0.75 \text{ A}$, $R = 4.4 \text{ m}\Omega = 4.4 \times 10^{-3} \Omega$

- $V = IR$

$$V = (0.75 \text{ A})(4.4 \times 10^{-3} \Omega) = \mathbf{3.3 \times 10^{-3} \text{ V}}$$

(b) $R = \rho L/A$, so $A = \rho L/R$

$$A = \frac{(1.8 \times 10^{-8} \, \Omega \text{ m})(0.32 \text{ m})}{4.4 \times 10^{-3} \, \Omega} = 1.31 \times 10^{-6} \text{ m}^2 \approx \mathbf{1.3 \times 10^{-6} \text{ m}^2}$$

(c) number density = total number / volume, and $V = AL$

$$n = \frac{3.1 \times 10^{22}}{(1.31 \times 10^{-6} \text{ m}^2)(0.32 \text{ m})} = \mathbf{7.4 \times 10^{28} \text{ m}^{-3}}$$

(d) $I = nAvq$, so $v = I/(nAq)$

$$v = \frac{0.75 \text{ A}}{(7.4 \times 10^{28} \text{ m}^{-3})(1.31 \times 10^{-6} \text{ m}^2)(1.6 \times 10^{-19} \text{ C})} = \mathbf{4.8 \times 10^{-5} \text{ m s}^{-1}}$$

- about 0.2 mm every four seconds: the electrons crawl, while the *signal* travels near c

(e) Q has the **same volume**, so making it longer forces it to be thinner: L **increases** and A **decreases**

- $R = \rho L/A$, so both changes raise R
- **Q has a greater resistance than P**