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

- $I = 0.50$ A, $t = 2.0$ min $= 120$ s
- $Q = It$

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

2.3

- $e = \mathbf{1.60 \times 10^{-19}}$ 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 $t = 100$ s

3.2

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

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

3.3

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

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

3.4

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

3.5

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

- $V = IR$

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

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

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

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

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

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

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

- 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**