

Chapter 12

Current electricity

1. After leaving the negative terminal, the electron is able to move freely through the conductor. When it reaches the globe, the type of material through which it is travelling (most likely tungsten) changes. The path becomes narrower and the electron makes repeated collisions with atoms in the filament, converting electrical potential energy into internal energy, increasing the temperature of the filament. After leaving the filament, the electron travels freely back to the cell's positive terminal.

In the cell, the electron is absorbed into the chemicals in the cell while other electrons are forced out of the chemicals and into the circuit.

2. Conventional current is in the direction that positive charges would flow if they were free to do so. Electron current is in the direction that electrons would flow, i.e. from the negative terminal of a cell.

3. *Direct current:* the charge carriers move in only one direction.

Alternating current: the charge carriers periodically change direction (backwards and forwards).

4. Dry cells, photovoltaic cells, capacitors, power packs, thermocouples.

$$5. \quad Q = It \\ = 2.5 \times 15 \\ = 37.5 \text{ C}$$

$$6. \quad 45 \text{ mA} = \frac{45}{1000} \\ = 0.045 \text{ A}$$

$$7. \quad 2.3 \times 10^{-4} \text{ A} = 2.3 \times 10^{-4} \times 10^3 \\ = 2.3 \times 10^{-1} \\ = 0.23 \text{ mA}$$

$$8. \quad 450 \text{ } \mu\text{A} = 450 \times 10^{-6} \\ = 4.5 \times 10^{-4} \text{ A}$$

9. No. Electrons cannot be destroyed. They transform energy as they pass through the filament of the globe. Current electricity is the movement of charged particles along a path. Current is *not* used up in a light globe. The current flowing into a globe is equal to the current flowing out of it.

10. (a) 160 mA
(b) 16 mA
(c) 1.6 A

$$11. \quad E = \frac{\text{energy}}{Q} \\ = \frac{1.05 \text{ J}}{0.70 \text{ C}} \\ = 1.5 \text{ V}$$

Voltage drop	Energy	Charge
3.3 V	32 J	9.6 C
6.0 V	4 J	670 mC
9.0 V	31.5 J	3.5 C
12 V	1.02 J	85 mC
4.5 V	12 J	2.7 C
240 V	7.5 kJ	31.25 C

$$13. \quad \text{Energy} = QV \\ = 5.7 \times 10^{-6} \times 6.0 \\ = 3.42 \times 10^{-5} \text{ J}$$

$$14. \quad \text{Energy} = QV \\ \Rightarrow Q = \frac{\text{Energy}}{V} \\ = \frac{3.6 \times 10^{-4}}{6.0} \\ = 6.0 \times 10^{-5} \text{ C} \\ = 60 \text{ } \mu\text{C}$$

$$15. \quad (a) \quad I = \frac{P}{V} \\ = \frac{60}{240} \\ = 0.25 \text{ A}$$

$$(b) \quad I = \frac{P}{V} \\ = \frac{40}{12} \\ = 3.3 \text{ A}$$

$$(c) \quad I = \frac{P}{V} \\ = \frac{6.3}{6.0} \\ = 1.05 \text{ A}$$

$$(d) \quad I = \frac{P}{V} \\ = \frac{1200}{240} \\ = 5.0 \text{ A}$$

16. (a) 2.3 V
(b) 11.5 V
(c) 23 V

$$17. \quad E = \frac{\text{Energy}}{Q} \\ = \frac{9.0 \text{ J}}{6.0 \text{ C}} \\ = 1.5 \text{ V}$$

$$18. \quad \text{Energy} = VIt \\ = 6.0 \text{ V} \times 3.0 \text{ A} \times 60 \text{ s} \\ = 1080 \text{ J or } 1.08 \times 10^3 \text{ J}$$

19.

Voltage drop	Current	Resistance
32 V	8.0 A	4.0 Ω
48.4 V	22 mA	2.2 kΩ
12 V	2.0 A	6.0 Ω
240 V	3.0 × 10 ⁻³ A	8.0 × 10 ⁴ Ω
9.0 V	6.0 A	1.5 Ω
1.5 V	45 mA	33.3 Ω

20. (a) orange = 3
white = 9
black = 0
gold = ±5%
 $R = 39 \Omega \pm 5\%$
 $= 39 \pm 2 \Omega$

- (b) green = 5
blue = 6
orange = 3
silver = ±10%
 $R = 56\,000 \Omega \pm 10\%$
 $= 56\,000 \pm 5600 \Omega$

- (c) violet = 7
green = 5
yellow = 4
gold = ±5%
 $R = 750\,000 \Omega \pm 5\%$
 $= 750 \pm 37.5 \text{ k}\Omega$

21. (a) Non-ohmic. The graph of I vs V is non-linear.

(b) 0

(c) $R = \frac{V}{I}$
 $= \frac{0.5}{0}$
 $= \infty$ (infinity)

(d) $I = 20 \text{ mA}$
 $\Rightarrow V = 0.65 \text{ V}$

$$R = \frac{V}{I}$$

$$= \frac{0.65}{0.020}$$

$$= 32.5 \Omega$$

22. $P = VI$

or $P = I^2R$
 $= (0.30 \text{ A})^2 \times 5.0 \Omega$
 $= 0.45 \text{ W}$

23. $P = \frac{V^2}{R}$

$$\Rightarrow R = \frac{V^2}{P}$$

(a) $R = \frac{(240)^2}{60}$
 $= 960 \Omega$

(b) $R = \frac{6.0^2}{6.3}$
 $= 5.7 \Omega$

(c) $R = \frac{12^2}{40}$
 $= 3.6 \Omega$

24. $Q = It$
 $I = 3.5 \text{ A}$
 $t = 20 \times 60 = 1200 \text{ s}$
 $Q = 3.5 \times 1200$
 $= 4.2 \times 10^3 \text{ C}$

25. $I = \frac{Q}{t}$
 $= \frac{15}{50}$
 $= 0.30 \text{ A}$

26. (a) Each coulomb of charge passing through the heater will transform 240 J of energy.

(b) Energy = QV
 $= 25 \times 240$
 $= 6.0 \times 10^3 \text{ J}$

27. Energy = VIt
 $= 12 \times 2.0 \times 30 \times 60$
 $= 43\,200 \text{ J}$
 $= 4.3 \times 10^4 \text{ J}$

28. $P = VI$
 $= 12 \times 2$
 $= 24 \text{ W}$

29. Energy = Pt
 $\Rightarrow t = \frac{\text{Energy}}{P}$
 $= \frac{5.4 \times 10^4}{600}$
 $= 90 \text{ s}$

30. $P = VI$
 $= 240 \times 10$
 $= 2400$
 $= 2.4 \text{ kW}$

31. $V = 240 \text{ V}$
 $I = 3.3 \text{ A}$
Energy = $3.2 \times 10^4 \text{ W}$
 $t = ?$

Energy = VIt
 $\Rightarrow t = \frac{\text{Energy}}{VI}$
 $= \frac{3.2 \times 10^4}{240 \times 3.3}$
 $= 40.4 \text{ s}$

32. $P = \frac{V^2}{R}$
 $= \frac{240^2}{48}$
 $= 1200 \text{ W}$

33. Halve the current \Rightarrow halve the velocity. Therefore, $8.0 \times 10^{-5} \text{ m s}^{-1}$.

34. (a) $A = \frac{\pi d^2}{4}$
 $= \frac{3.142 \times (1.63 \times 10^{-3} \text{ m})^2}{4}$
 $= 2.1 \times 10^{-6} \text{ m}^2$

$$(b) \quad R = \frac{\rho L}{A}$$

$$\Rightarrow \rho = \frac{RA}{L}$$

$$(c) \quad \rho = \frac{5.00 \, \Omega \times 2.1 \times 10^{-6} \, \text{m}^2}{41.5 \, \text{m}}$$

$$= 2.5 \times 10^{-7} \, \Omega \, \text{m}$$

$$(d) \quad R \propto L$$

double $L \Rightarrow$ double R
Therefore, $10.0 \, \Omega$.

$$(e) \quad R \propto \frac{1}{A} \quad A = \frac{\pi d^2}{4}$$

$$\Rightarrow R \propto \frac{1}{d^2}$$

If d is halved $\Rightarrow R$ is multiplied by 4.
Therefore, $20.0 \, \Omega$.

$$(b) \quad R_{\text{eff}} = R_1 + R_2 + R_3$$

$$= 12 + 20 + 30$$

$$= 62 \, \Omega$$

$$(c) \quad R_{\text{eff}} = R_1 + R_2 + R_3$$

$$= 1.2 + 3.2 + 11$$

$$= 15.4 \, \text{k}\Omega$$

5. $I_a = 1.0 \, \text{A}$ (series circuit)

$$V_1 = IR_1$$

$$= 1.0 \times 4.0$$

$$= 4.0 \, \text{V}$$

$$V_2 = 2.0 \, \text{V} \quad (E = V_1 + V_2)$$

$$R_2 = \frac{V_2}{I}$$

$$= \frac{2.0}{1.0}$$

$$= 2.0 \, \Omega$$

6. (a) In a series circuit,

$$I_a = I_b$$

$$I_a = 2.0 \, \text{A}$$

$$\Rightarrow I_b = 2.0 \, \text{A}$$

$$(b) \quad V_{bc} = IR_2$$

$$= 2.0 \times 30$$

$$= 60 \, \text{V}$$

$$(c) \quad R_1 = \frac{V_{ab}}{I}$$

$$= \frac{20}{2.0}$$

$$= 10 \, \Omega$$

$$(d) \quad R_{\text{eff}} = R_1 + R_2$$

$$= 10 \, \Omega + 30 \, \Omega$$

$$= 40 \, \Omega$$

$$(e) \quad E = V_{ab} + V_{bc}$$

$$= 20 \, \text{V} + 60 \, \text{V}$$

$$= 80 \, \text{V}$$

$$7. (a) \quad \frac{1}{R_{\text{eff}}} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$= \frac{1}{30} + \frac{1}{20}$$

$$= \frac{2}{60} + \frac{3}{60}$$

$$= \frac{5}{60}$$

$$\Rightarrow R_{\text{eff}} = \frac{60}{5} = 12 \, \Omega$$

$$(b) \quad \frac{1}{R_{\text{eff}}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$= \frac{1}{5} + \frac{1}{10} + \frac{1}{30}$$

$$= \frac{6}{30} + \frac{3}{30} + \frac{1}{30}$$

$$= \frac{10}{30}$$

$$\Rightarrow R_{\text{eff}} = \frac{30}{10} = 3.0 \, \Omega$$

Chapter 13

Circuit analysis

1. (a) *Junction*: a connection between two or more conducting paths.

(b) *Open circuit*: a circuit in which the conducting path is broken so that no current flows.

(c) *Voltage drop*: the amount of electrical potential energy converted in a load for every coulomb of charge passing through it.

(d) *Earth*: a connection of part of the circuit to the earth, making that part of the circuit be at zero volt.

(e) *Series*: circuit elements connected one after the other.

(f) *Parallel*: circuit elements connected side by side.

(g) *Short circuit*: the bypassing of a circuit element by the connection of a conductor in parallel with the element.

2. (a) Into = $3.0 \, \text{A}$

$$\text{Away} = 1.5 \, \text{A} + I_a$$

$$\Rightarrow I_a = 1.5 \, \text{A} \text{ away from junction.}$$

(b) Into = $2.5 \, \text{A} + I_b$

$$\text{Away} = 7.3 \, \text{A}$$

$$\Rightarrow I_b = 4.8 \, \text{A} \text{ into the junction.}$$

(c) Into = $1.3 \, \text{A} + 4.2 \, \text{A} + I_c$

$$\text{Away} = 2.9 \, \text{A} + 3.7 \, \text{A}$$

$$\Rightarrow I_c = 6.6 \, \text{A} + 5.5 \, \text{A}$$

$$= 1.1 \, \text{A} \text{ into the junction.}$$

3. $V_a = 9.0 \, \text{V}$

$$V_b = 9.0 \, \text{V}$$

$$V_c = V_b - V_{bc}$$

$$= 9.0 - 5.0 \, \text{V}$$

$$= 4.0 \, \text{V}$$

$$V_d = 0.0 \, \text{V} \text{ (earthed)}$$

4. (a) $R_{\text{eff}} = R_1 + R_2$

$$= 2.7 + 9.8$$

$$= 12.5 \, \Omega$$

$$\begin{aligned}
 \text{(c)} \quad \frac{1}{R_{\text{eff}}} &= \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \\
 &= \frac{1}{15} + \frac{1}{60} + \frac{1}{60} \\
 &= \frac{4}{60} + \frac{1}{60} + \frac{1}{60} \\
 &= \frac{6}{60} \\
 \Rightarrow R_{\text{eff}} &= \frac{60}{6} = 10 \, \Omega
 \end{aligned}$$

$$\begin{aligned}
 \text{(d)} \quad \frac{1}{R_{\text{eff}}} &= \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \\
 &= \frac{1}{20} + \frac{1}{50} + \frac{1}{80} \\
 &= \frac{20}{400} + \frac{8}{400} + \frac{5}{400} \\
 &= \frac{33}{400} \\
 \Rightarrow R_{\text{eff}} &= \frac{400}{33} \\
 &= 12.1 \, \Omega
 \end{aligned}$$

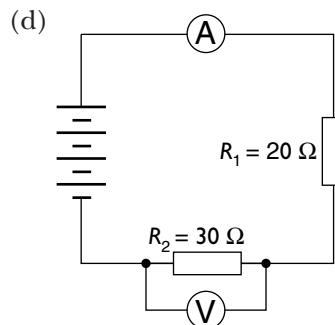
$$\begin{aligned}
 8. \quad I_a &= 1.5 \, \text{A} \\
 V_1 &= 6.0 \, \text{V} \\
 V_2 &= 6.0 \, \text{V} \\
 I_1 &= \frac{V_1}{R_1} \\
 &= \frac{6.0 \, \text{V}}{6.0 \, \Omega} \\
 &= 1.0 \, \text{A} \\
 I_2 &= I_a - I_1 \\
 &= 1.5 \, \text{A} - 1.0 \, \text{A} \\
 &= 0.5 \, \text{A} \\
 R_2 &= \frac{V_2}{I_2} \\
 &= \frac{6.0}{0.5} \\
 &= 12 \, \Omega
 \end{aligned}$$

$$\begin{aligned}
 9. \quad \text{(a)} \quad V_{\text{ab}} &= I_1 R_1 \\
 &= 0.20 \, \text{A} \times 60 \, \Omega \\
 &= 12 \, \text{V} \\
 \text{(b)} \quad V_{\text{cd}} &= 12 \, \text{V} \\
 \text{(c)} \quad E &= 12 \, \text{V} \\
 \text{(d)} \quad I_2 &= I_T - I_1 \\
 &= 0.50 \, \text{A} - 0.20 \, \text{A} \\
 &= 0.30 \, \text{A} \\
 \text{(e)} \quad R_2 &= \frac{V_{\text{cd}}}{I_2} \\
 &= \frac{12 \, \text{V}}{0.30 \, \text{A}} \\
 &= 40 \, \Omega
 \end{aligned}$$

$$\begin{aligned}
 10. \quad \text{(a)} \quad R_{\text{eff}} &= R_1 + R_2 \\
 &= 20 + 30 \\
 &= 50 \, \Omega
 \end{aligned}$$

$$\begin{aligned}
 \text{(b)} \quad I &= \frac{E}{R_{\text{eff}}} \\
 &= \frac{100}{50} \\
 &= 2.0 \, \text{A}
 \end{aligned}$$

$$\begin{aligned}
 \text{(c)} \quad 20 \, \Omega &\Rightarrow V = IR \\
 &= 2.0 \times 20 \\
 &= 40 \, \text{V} \\
 30 \, \Omega &\Rightarrow V = IR \\
 &= 2.0 \times 30 \\
 &= 60 \, \text{V}
 \end{aligned}$$



$$\begin{aligned}
 11. \quad \text{(a)} \quad R_{\text{eff}} &= R_1 + R_2 + R_3 \\
 &= 3.0 + 5.0 + 4.0 \\
 &= 12.0 \, \Omega
 \end{aligned}$$

$$\begin{aligned}
 \text{(b)} \quad I &= \frac{E}{R_{\text{eff}}} \\
 &= \frac{12}{12.0} \\
 &= 1.0 \, \text{A}
 \end{aligned}$$

$$\begin{aligned}
 \text{(c)} \quad 3.0 \, \Omega &\Rightarrow V = IR \\
 &= 1.0 \times 3.0 \\
 &= 3.0 \, \text{V} \\
 5.0 \, \Omega &\Rightarrow V = IR \\
 &= 1.0 \times 5.0 \\
 &= 5.0 \, \text{V} \\
 4.0 \, \Omega &\Rightarrow V = IR \\
 &= 1.0 \times 4.0 \\
 &= 4.0 \, \text{V}
 \end{aligned}$$

$$\begin{aligned}
 \text{(d)} \quad V_T &= V_1 + V_2 + V_3 \\
 &= 3.0 \, \text{V} + 5.0 \, \text{V} + 4.0 \, \text{V} \\
 &= 12.0 \, \text{V}
 \end{aligned}$$

$$\begin{aligned}
 12. \quad \text{(a)} \quad R_{\text{eff}} &= 1000 + 1500 \\
 &= 2500 \, \Omega \\
 I &= \frac{E}{R_{\text{eff}}} \\
 &= \frac{25}{2500} \\
 &= 0.010 \, \text{A}
 \end{aligned}$$

$$\begin{aligned}
 \text{(b)} \quad \text{First person} \quad V_1 &= IR_1 \\
 &= 0.010 \times 1000 \\
 &= 10 \, \text{V} \\
 \text{Second person} \quad V_2 &= IR_2 \\
 &= 0.010 \times 1500 \\
 &= 15 \, \text{V}
 \end{aligned}$$

$$13. (a) \frac{1}{R_{\text{eff}}} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$= \frac{1}{10} + \frac{1}{10}$$

$$= \frac{2}{10}$$

$$\Rightarrow R_{\text{eff}} = 5.0 \Omega$$

$$(b) I_{\text{eff}} = \frac{E}{R_{\text{eff}}}$$

$$= \frac{15}{5.0}$$

$$= 3.0 \text{ A}$$

$$(c) I_1 = \frac{E}{R_1}$$

$$= \frac{15}{10}$$

$$= 1.5 \text{ A}$$

Similarly $I_2 = 1.5 \text{ A}$

$$14. (a) \frac{1}{R_{\text{eff}}} = \frac{1}{60} + \frac{1}{30} + \frac{1}{20}$$

$$= \frac{1}{60} + \frac{2}{60} + \frac{3}{60}$$

$$= \frac{6}{60}$$

$$\Rightarrow R_{\text{eff}} = \frac{60}{6}$$

$$= 10 \Omega$$

$$(b) I = \frac{E}{R_{\text{eff}}}$$

$$= \frac{90}{10}$$

$$= 9.0 \text{ A}$$

$$(c) 60 \Omega \Rightarrow I = \frac{V}{R}$$

$$= \frac{90 \text{ V}}{60 \Omega}$$

$$= 1.5 \text{ A}$$

$$30 \Omega \Rightarrow I = \frac{V}{R}$$

$$= \frac{90 \text{ V}}{30 \Omega}$$

$$= 3.0 \text{ A}$$

$$20 \Omega \Rightarrow I = \frac{V}{R}$$

$$= \frac{90 \text{ V}}{20 \Omega}$$

$$= 4.5 \text{ A}$$

$$15. (a) R_1 = 6.0 \Omega \Rightarrow I_1 = \frac{V}{R_1}$$

$$= \frac{36 \text{ V}}{6.0 \Omega}$$

$$= 6.0 \text{ A}$$

$$R_2 = 18 \Omega \Rightarrow I_2 = \frac{V}{R_2}$$

$$= \frac{36 \text{ V}}{18 \Omega}$$

$$= 2.0 \text{ A}$$

$$R_3 = 9.0 \Omega \Rightarrow I_3 = \frac{V}{R_3}$$

$$= \frac{36 \text{ V}}{9.0 \Omega}$$

$$= 4.0 \text{ A}$$

$$(b) I_T = I_1 + I_2 + I_3$$

$$= 6.0 \text{ A} + 2.0 \text{ A} + 4.0 \text{ A}$$

$$= 12 \text{ A}$$

$$(c) R_{\text{eff}} = \frac{E}{I}$$

$$= \frac{36 \text{ V}}{12 \text{ A}}$$

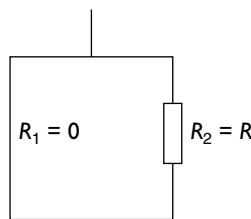
$$= 3.0 \Omega$$

$$16. (a) G_1, G_2, G_3$$

$$(b) G_1, G_3$$

$$(c) G_1$$

17.



$$\frac{1}{R_{\text{eff}}} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$= \frac{1}{0} + \frac{1}{R}$$

$$= \infty$$

$$\Rightarrow R_{\text{eff}} = \frac{1}{\infty} = 0$$

$$18. (a) 6 \text{ mA}$$

$$(b) 140 \text{ V}$$

$$(c) R = \frac{V}{I}$$

$$= \frac{140 \text{ V}}{16 \times 10^{-3} \text{ A}}$$

$$= 8.75 \text{ k}\Omega$$

$$19. (a) V = IR$$

$$= 6.0 \times 10^{-3} \text{ A} \times 5.0 \times 10^3 \Omega$$

$$= 30 \text{ V}$$

$$(b) 6.0 \text{ mA}$$

$$(c) 100 \text{ V (from graph)}$$

$$(d) V_T = V_1 + V_2$$

$$= 100 \text{ V} + 30 \text{ V}$$

$$= 130 \text{ V}$$

$$20. (a) V = IR$$

$$= 20 \times 10^{-3} \text{ A} \times 5.0 \times 10^3 \Omega$$

$$= 100 \text{ V}$$

$$(b) 100 \text{ V}$$

$$(c) 6 \text{ mA}$$

$$(d) I_T = 20 \text{ mA} + 6 \text{ mA}$$

$$= 26 \text{ mA}$$

21. (a) The emf of a power supply is a measure of the amount of electrical potential energy provided to the circuit for every coulomb of charge passing through the supply.

A voltage drop is a measure of the amount of energy converted in a load for every coulomb of charge passing through it.

(b) The emf of a battery is greater than its terminal voltage when there is a current flowing through the battery and it has an internal resistance.

22. (a) Internal resistance in a cell is caused by:
- a build-up of the products of the chemical reaction that produces electricity
 - the conductivity of the electrolyte in the cell
 - the temperature of the cell.

(b) As a cell gets older, its internal resistance rises.

23.

$$E = V_{\text{ext}} - I_r$$

$$I = 0 \Rightarrow E = V_{\text{ext}}$$

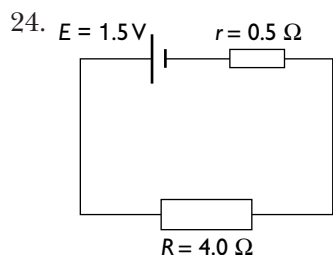
$$\Rightarrow E = 9.0 \text{ V}$$

$$V_{\text{ext}} = 8.0 \text{ V when } I = 1.0 \text{ A}$$

$$E = V_{\text{ext}} - I_r$$

$$\Rightarrow 9.0 \text{ V} = 8.0 \text{ V} - 1.0 \times r$$

$$\Rightarrow r = 1.0 \Omega$$



(a) $R_{\text{eff}} = 4.5 \Omega$

$$I = \frac{E}{R_{\text{eff}}}$$

$$= \frac{1.5}{4.5}$$

$$= 0.33 \text{ A}$$

(b) $V_{\text{ext}} = IR$

$$= 0.33 \times 4.0$$

$$= 1.33 \text{ V}$$

25. (a) $E_{\text{eff}} = 3.0 \text{ V}$

$$r_{\text{eff}} = r_1 + r_2$$

$$= 0.5 + 0.5$$

$$= 1.0 \Omega$$

(b) $E = 1.5 \text{ V}$

$$\frac{1}{r_{\text{eff}}} = \frac{1}{r_1} + \frac{1}{r_2}$$

$$= \frac{1}{0.5} + \frac{1}{0.5}$$

$$\Rightarrow r_{\text{eff}} = 0.25 \Omega$$

26. (a) $R_{\text{eff}} = R_1 + R_2 + R_3$

$$= 25 + 15 + 10$$

$$= 50 \Omega$$

$$I = \frac{E}{R_{\text{eff}}}$$

$$= \frac{10}{50}$$

$$= 0.20 \text{ A}$$

(b) $25 \Omega \Rightarrow V = IR$

$$= 0.2 \times 25$$

$$= 5.0 \text{ V}$$

$$15 \Omega \Rightarrow V = IR$$

$$= 0.2 \times 15$$

$$= 3.0 \text{ V}$$

$$10 \Omega \Rightarrow V = IR$$

$$= 0.2 \times 10$$

$$= 2.0 \text{ V}$$

(c) $25 \Omega \Rightarrow P = VI$

$$= 5.0 \times 0.2$$

$$= 1.0 \text{ W}$$

$$15 \Omega \Rightarrow P = VI$$

$$= 3.0 \times 0.2$$

$$= 0.6 \text{ W}$$

$$10 \Omega \Rightarrow P = VI$$

$$= 2.0 \times 0.2$$

$$= 0.4 \text{ W}$$

(d) $P_T = P_1 + P_2 + P_3$

$$= 1.0 + 0.6 + 0.4$$

$$= 2.0 \text{ W}$$

27. (a) $\frac{1}{R_{\text{eff}}} = \frac{1}{25} + \frac{1}{15} + \frac{1}{10}$

$$= \frac{6}{150} + \frac{10}{150} + \frac{15}{150}$$

$$= \frac{31}{150}$$

$$\Rightarrow R_{\text{eff}} = \frac{150}{31}$$

$$= 4.8 \Omega$$

$$I = \frac{E}{R_{\text{eff}}}$$

$$= \frac{10}{1} \times \frac{31}{150}$$

$$= 2.1 \text{ A}$$

(b) V across each resistor = 10 V

(c) $25 \Omega \Rightarrow P = \frac{V^2}{R}$

$$= \frac{(10 \text{ V})^2}{25 \Omega}$$

$$= 4.0 \text{ W}$$

$$15 \Omega \Rightarrow P = \frac{V^2}{R}$$

$$= \frac{(10 \text{ V})^2}{15 \Omega}$$

$$= 6.7 \text{ W}$$

$$10 \Omega \Rightarrow P = \frac{V^2}{R}$$

$$= \frac{(10 \text{ V})^2}{10 \Omega}$$

$$= 10 \text{ W}$$

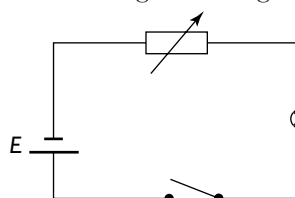
(d) $P_T = P_1 + P_2 + P_3$

$$= 4.0 + 6.7 + 10$$

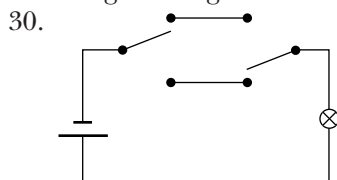
$$= 21.7 \text{ W}$$

28. The voltage provided by the supply is constant. The power provided by the supply is equal to the current through the supply multiplied by the voltage provided. So the larger the current, the larger the power provided. Henrietta is correct since a smaller resistance gives a larger current.

29.



The circuit consumes/dissipates more power when the light is bright since the current flowing through the globe is greater and for the circuit $P = EI$.



A current will flow through the globe only when both switches are up or down.

Chapter 14

Using electrical energy

- It is an alternating current.
 - The voltage varies between +340 V and -340 V.
 - The voltage oscillates 50 times per second.
 - The voltage provides heating effects equivalent to a DC voltage of 240 V.
 - An overload is when too many appliances are connected to a circuit. The overall effect is to draw too much current. This can cause wires to melt or materials surrounding the wires to catch fire.
 - An electric shock is a violent disturbance of the nervous system caused by an electrical discharge or current through the body. Electrocutation is death resulting from an electric shock.
 - Active — brown; neutral — blue; earth — green-and-yellow striped
 - Active — red; neutral — black; earth — green. Colourblind electricians can't distinguish between red and green.
- 6.
- The neutral wire is used to provide an insulated path for the electricity to return to the generator. The earth wire connects the metal case of the appliance to earth so that if a live active wire accidentally contacts the outer case, a low resistance path for the electricity to return to earth is provided.
 - The earth wire is used in household lighting circuits when the light fittings have a metal case. Plastic and glass fittings do not need to be earthed.
 - Breaks or cuts in the skin; water
 - Nerve impulses are electrical in nature. The size of the current will influence the size and type of muscle contraction.
 - Fibrillation is the disorganised rapid contraction of separate parts of the heart so that it pumps no blood.
 - Your muscles would contract and you could grip onto the victim and not be able to let go.
 - The longer the time of exposure, the more severe the shock.
 - Double insulation is a way to protect the user of hand-held appliances. There are two separate layers of insulation between the functional parts of the appliance and the user.

- Lead-acid batteries can be recharged. They can give a high current with little drop in output voltage.
- The loom contains wires which form a part of every circuit in an automobile. The loom is connected to the positive terminal of the battery. The other side of the load is connected to the car body which is connected to the negative terminal of the battery.
- Energy in kW.h = power rating (in kW) × time (h)

$$\text{time} = 365 \times 12 = 4380 \text{ h}$$

$$\text{power rating} = 0.300 \text{ kW}$$

$$\text{Energy} = 0.300 \text{ kW} \times 4380 \text{ h}$$

$$= 1314 \text{ kW.h}$$

$$\text{Cost} = \text{energy} \times \text{rate}$$

$$= 1314 \times 11.87$$

$$= 15\,597.18 \text{ cents}$$

$$= \$155.97$$

$$= \$156 \text{ (to three significant figures)}$$
- $$V = 240 \text{ V} \quad R = 24 \, \Omega$$

(a)
$$\text{Power} = \frac{V^2}{R}$$

$$= \frac{240^2}{24}$$

$$= 2400 \text{ W}$$

$$= 2.4 \text{ kW}$$

(b)
$$I = \frac{V}{R}$$

$$= \frac{240}{24}$$

$$= 10 \text{ A}$$

(c)
$$\text{Energy} = P \text{ (kW)} \times t \text{ (h)}$$

$$= 2.4 \times 5$$

$$= 12 \text{ kW.h}$$

$$\text{Cost} = \text{energy} \times \text{rate}$$

$$= 12 \text{ kW.h} \times \$0.12$$

$$= \$1.44$$
- (a)
$$V_{\text{ext}} = E - Ir$$

$$= 12 - 50 \times 0.04$$

$$= 10 \text{ V}$$

(b)
$$P = EI$$

$$= 12 \times 50$$

$$= 600 \text{ W}$$

(c)
$$P = I^2 r$$

$$= 50^2 \times 0.04$$

$$= 100 \text{ W}$$

(d)
$$t = \frac{\text{capacity}}{\text{current}}$$

$$= \frac{80}{50}$$

$$= 1.6 \text{ h (1 hour 36 minutes)}$$
- (a)
$$\text{time} = \frac{\text{capacity}}{\text{current}}$$

$$= \frac{120}{400}$$

$$= 0.30 \text{ h}$$

$$= 18 \text{ min}$$

(b)
$$Q = It \quad t = 18 \times 10 = 1080 \text{ s}$$

$$= 400 \times 1080$$

$$= 432\,000$$

$$= 4.32 \times 10^5 \text{ C}$$

(c) The chemical reaction that produces the emf produces products that increase the internal resistance of the battery. Also, the chemicals involved in the reaction are used up.

21. (a) $P = VI$

$$\Rightarrow I = \frac{P}{V}$$

$$= \frac{360 \text{ W}}{12 \text{ V}}$$

$$= 30 \text{ A}$$

(b) Energy = $P \times t$ $t = 4.0 \times 3600 \text{ s} = 14\,400 \text{ s}$

$$= 360 \times 14\,400$$

$$= 5.2 \times 10^6 \text{ J}$$

(c) Current capacity = current \times time

$$= 30 \text{ A} \times 4.0 \text{ h}$$

$$= 120 \text{ A.h}$$

22. $V = IR$

$$R = \frac{\rho L}{A}$$

$$\Rightarrow V = \frac{I\rho L}{A}$$

$$I = 500 \text{ A}$$

$$A = 2.0 \times 10^{-4} \text{ m}^2$$

$$L = 2.0 \times 10^{-2} \text{ m}$$

$$\rho = 2.65 \times 10^{-8} \Omega \text{ m}$$

$$\Rightarrow V = \frac{500 \times 2.65 \times 10^{-8} \times 2.0 \times 10^{-2}}{2.0 \times 10^{-4}}$$

$$= 1.3 \times 10^{-3} \text{ V}$$

23. Voltage doesn't flow, current does. The paper should have reported that there was a voltage drop across his body of 50 000 V.

It is the size of the current that determines the amount of injury. It is not the voltage that kills.