

# Answers to Numerical Questions

## page 18, Practice Problems

1.  $1000\times$
2.  $40\times$
3.  $400\times$

## page 146, Learning Checkpoint

1. proton (1+), neutron (0), electron (1-)
2. proton and neutron
3. proton

## page 148, Learning Checkpoint

1. lithium, beryllium, boron, carbon, nitrogen, oxygen, fluorine, neon
2. silicon, germanium, tin, lead, ununquadium
3. (a) helium  
(b) magnesium  
(c) bromine  
(d) oxygen
4. (a) period 2  
(b) carbon, nitrogen, oxygen, fluorine, neon
5. (a) Group 18 (noble gases)  
(b) for example: colourless, unreactive, gases

## page 149, Learning Checkpoint

1. (a) hydrogen, H  
(b) sodium, Na  
(c) chlorine, Cl  
(d) copper, Cu  
(e) uranium, U
2. Answers are approximate:  
(a) 4.0  
(b) 12.0  
(c) 16.0  
(d) 207.2  
(e) 197.0
3. (a) 1+  
(b) 2-  
(c) 1-  
(d) 2+, 3+

## page 150, Learning Checkpoint

1. (a) 3, 1  
(b) 7, 5  
(c) 10, 8  
(d) 14, 4  
(e) 20, 2

2. valence electrons are in the same shell
3. for example: helium, 2; neon, 10; argon, 18

## page 158, Learning Checkpoint

1. (a)  $\text{Mg}^{2+}$   
(b)  $\text{Cl}^-$   
(c)  $\text{Fe}^{2+}$   
(d)  $\text{Fe}^{3+}$   
(e)  $\text{U}^{6+}$
2. (a) zinc  
(b) nitride  
(c) cobalt(II)  
(d) cobalt(III)  
(e) lead(IV)

## page 159, Practice Problems

1. lithium bromide
2. calcium iodide
3. aluminum oxide
4. magnesium nitride

## page 160, Practice Problems

1. iron(II) chloride
2. iron(III) chloride
3. copper(II) nitride
4. nickel(III) oxide

## page 161, Practice Problems

1. aluminum sulphate
2. calcium phosphate
3. iron(II) hydroxide
4. ammonium sulphide

## page 163, Practice Problems

1. KI
2.  $\text{Mg}_3\text{P}_2$
3.  $\text{Ag}_2\text{S}$
4.  $\text{FeBr}_3$

## page 164, Practice Problems

1.  $\text{Mg}(\text{OH})_2$
2.  $\text{Na}_2\text{SO}_4$
3.  $\text{Pb}(\text{NO}_3)_2$
4.  $(\text{NH}_4)_2\text{CO}_3$

## page 168, Practice Problems

1. sulphur trioxide
2. tetraphosphorus decasulphide
3. nitrogen trifluoride
4. dinitrogen monoxide

## page 168, Practice Problems

1.  $\text{SBr}_6$
2.  $\text{CCl}_4$
3.  $\text{N}_2\text{O}_4$
4.  $\text{P}_4\text{O}_{10}$

## page 171, 4.2 Check and Reflect

6. (a) aluminum  
(b) calcium  
(c) bromide  
(d) sulphide  
(e) sulphate  
(f) phosphate
7. (a) BeO  
(b) RbBr  
(c)  $\text{Ba}(\text{OH})_2$   
(d)  $\text{NH}_4\text{I}$   
(e)  $\text{Mg}_3(\text{PO}_4)_2$   
(f)  $\text{Fe}_2\text{O}_3$   
(g)  $\text{Cu}_2\text{SO}_4$   
(h)  $\text{CrPO}_4$
8. (a) zinc chloride  
(b) calcium sulphide  
(c) potassium sulphate  
(d) ammonium nitrate  
(e) strontium phosphate  
(f) gold(III) chloride  
(g) nickel(III) sulphide  
(h) lead(IV) fluoride
12. (a) sulphur dioxide  
(b) sulphur trioxide  
(c) phosphorus triiodide  
(d) oxygen difluoride  
(e) sulphur hexaiodide  
(f) diphosphorus tetrasulphide
13. (a)  $\text{SBr}_6$   
(b)  $\text{NBr}_3$   
(c)  $\text{SCl}_6$   
(d)  $\text{P}_2\text{O}_5$   
(e) CO

## page 177, Learning Checkpoint

3. 3.5 g
5. 4 K, 2 O on both sides

## page 178, Practice Problems

1.  $4\text{Na} + \text{O}_2 \rightarrow 2\text{Na}_2\text{O}$
2.  $6\text{HCl} + 2\text{Al} \rightarrow 2\text{AlCl}_3 + 3\text{H}_2$
3.  $2\text{KClO}_3 \rightarrow 2\text{KCl} + 3\text{O}_2$

**page 179, Practice Problems**

- $2\text{HgO}(s) \rightarrow 2\text{Hg}(l) + \text{O}_2(g)$
- $2\text{Al}(s) + 3\text{Br}_2(l) \rightarrow 2\text{AlBr}_3(s)$
- $\text{Ca}(s) + 2\text{H}_2\text{O}(l) \rightarrow \text{Ca}(\text{OH})_2(s) + \text{H}_2(g)$

**page 180, Practice Problems**

- $3\text{H}_2(g) + \text{N}_2(g) \rightarrow 2\text{NH}_3(g)$
- $2\text{NO}(g) + \text{O}_2(g) \rightarrow 2\text{NO}_2(g)$
- $\text{Al}(s) + 3\text{HNO}_3(\text{aq}) \rightarrow \text{Al}(\text{NO}_3)_3 + \text{H}_2(g)$
- $\text{PCl}_3(g) + \text{Cl}_2 \rightarrow \text{PCl}_5(g)$

**page 181, Practice Problems**

- $2\text{Fe} + 3\text{Cl}_2 \rightarrow 2\text{FeCl}_3$
- $2\text{Na} + \text{Ca}(\text{OH})_2 \rightarrow 2\text{NaOH} + \text{Ca}$
- $2\text{Na}_3\text{PO}_4 + 3\text{Mg}(\text{OH})_2 \rightarrow \text{Mg}_3(\text{PO}_4)_2 + 6\text{NaOH}$
- $3\text{H}_2\text{SO}_4 + 2\text{Ni}(\text{OH})_3 \rightarrow \text{Ni}_2(\text{SO}_4)_3 + 6\text{H}_2\text{O}$

**page 182, Practice Problems**

- silver nitrate + copper  $\rightarrow$  copper(II) nitrate + silver  
 $2\text{AgNO}_3(\text{aq}) + \text{Cu}(s) \rightarrow \text{Cu}(\text{NO}_3)_2(\text{aq}) + \text{Ag}(s)$
- magnesium chloride + potassium phosphate  $\rightarrow$  potassium chloride + magnesium phosphate  
 $\text{MgCl}_2(\text{aq}) + \text{K}_3\text{PO}_4(\text{aq}) \rightarrow \text{KCl}(\text{aq}) + \text{Mg}_3(\text{PO}_4)_2(s)$
- hydrogen + carbon dioxide  $\rightarrow$  carbon monoxide + water  
 $\text{H}_2(g) + \text{CO}_2(g) \rightarrow \text{CO}(g) + \text{H}_2\text{O}(l)$
- potassium + oxygen  $\rightarrow$  potassium oxide  
 $4\text{K}(s) + \text{O}_2(s) \rightarrow 2\text{K}_2\text{O}(s)$

**page 187, 4.3 Check and Reflect**

- (a) aluminum + fluorine  $\rightarrow$  aluminum fluoride  
 $2\text{Al}(s) + 3\text{F}_2(g) \rightarrow 2\text{AlF}_3(g)$   
 (b) potassium + oxygen  $\rightarrow$  potassium oxide  
 $4\text{K}(s) + \text{O}_2(g) \rightarrow 2\text{K}_2\text{O}(s)$

- (c) lithium sulphate + barium chloride  $\rightarrow$  barium sulphate + lithium chloride  
 $\text{Li}_2\text{SO}_4(\text{aq}) + \text{BaCl}_2(\text{aq}) \rightarrow \text{BaSO}_4(s) + 2\text{LiCl}(\text{aq})$   
 (d) aluminum chloride + sodium carbonate  $\rightarrow$  aluminum carbonate + sodium chloride  
 $2\text{AlCl}_3(\text{aq}) + 3\text{Na}_2\text{CO}_3(\text{aq}) \rightarrow \text{Al}_2(\text{CO}_3)_3(s) + 6\text{NaCl}(\text{aq})$

- (a)  $\text{Al}(s) + 3\text{F}_2(g) \rightarrow 2\text{AlF}_3(s)$   
 (b)  $4\text{K}(s) + \text{O}_2(g) \rightarrow 2\text{K}_2\text{O}(s)$   
 (c)  $\text{C}_6\text{H}_{12}\text{O}_6(s) + 6\text{O}_2(g) \rightarrow 6\text{CO}_2(g) + 6\text{H}_2\text{O}(l)$   
 (d)  $\text{H}_2\text{SO}_4(\text{aq}) + 6\text{NaOH}(s) \rightarrow \text{Na}_2\text{SO}_4(\text{aq}) + 6\text{H}_2\text{O}(l)$   
 (e)  $\text{Mg}(\text{CH}_3\text{COO})_2(\text{aq}) + 2\text{AgNO}_3(\text{aq}) \rightarrow \text{Mg}(\text{NO}_3)_2(\text{aq}) + 2\text{AgCH}_3\text{COO}(s)$   
 (f)  $2\text{H}_2\text{O}_2(\text{aq}) \rightarrow \text{O}_2(g) + 2\text{H}_2\text{O}(l)$   
 (g)  $2\text{HCl}(\text{aq}) + \text{Ba}(\text{OH})_2(\text{aq}) \rightarrow \text{BaCl}_2(\text{aq}) + 2\text{H}_2\text{O}(l)$
- (a) calcium + oxygen  $\rightarrow$  calcium oxide  
 $2\text{Ca}(s) + \text{O}_2(g) \rightarrow 2\text{CaO}(s)$   
 (b) propane + oxygen  $\rightarrow$  carbon dioxide + water  
 $\text{C}_3\text{H}_8(g) + 5\text{O}_2(g) \rightarrow 3\text{CO}_2(g) + 4\text{H}_2\text{O}(g)$   
 (c) fluorine + potassium chloride  $\rightarrow$  potassium fluoride + chlorine  
 $\text{F}_2(g) + 2\text{KCl}(\text{aq}) \rightarrow 2\text{KF}(\text{aq}) + \text{Cl}_2(g)$

**page 190, Chapter 4 Review**

- (a) sodium  
 (b) calcium  
 (c) iron(III)  
 (d) fluoride  
 (e) oxide
- 45 atoms
- (a)  $\text{O}^{2-}$   
 (b)  $\text{Br}^-$   
 (c)  $\text{S}^{2-}$   
 (d)  $\text{Ca}^{2+}$   
 (e)  $\text{Cu}^+$

- (a)  $\text{NH}_4^+$   
 (b)  $\text{CO}_3^{2-}$   
 (c)  $\text{HCO}_3^-$   
 (d)  $\text{PO}_4^{3-}$
- (a) sodium nitride  
 (b) calcium fluoride  
 (c) aluminum hydroxide  
 (d) iron(II) chloride  
 (e) lead(IV) oxide  
 (f) potassium permanganate  
 (g) ammonium phosphate  
 (h) chromium(II) nitrate
- (a) KI  
 (b)  $\text{Sr}_3\text{N}_2$   
 (c)  $\text{MnCl}_4$   
 (d) SnS  
 (e)  $\text{Mg}(\text{OH})_2$   
 (f)  $\text{Zn}_3(\text{PO}_4)_2$   
 (g)  $\text{Ag}_2\text{O}$   
 (h)  $\text{NH}_4\text{NO}_3$
- (a) OnO  
 (b) OnCl<sub>2</sub>  
 (c) On<sub>3</sub>(PO<sub>4</sub>)<sub>2</sub>
- (a) N<sub>2</sub>O<sub>3</sub>  
 (b) CO  
 (c) SF<sub>6</sub>  
 (d) phosphorus pentabromide  
 (e) carbon tetrachloride  
 (f) nitrogen tribromide
- (a)  $2\text{Li}(s) + \text{F}_2(g) \rightarrow 2\text{LiF}(s)$   
 (b)  $2\text{Be}(s) + \text{O}_2(g) \rightarrow 2\text{BeO}(s)$   
 (c)  $\text{HCl}(\text{aq}) + \text{NaOH}(s) \rightarrow \text{NaCl}(\text{aq}) + \text{H}_2\text{O}(l)$   
 (d)  $\text{Ca}(\text{CH}_3\text{COO})_2(\text{aq}) + 2\text{AgNO}_3(\text{aq}) \rightarrow \text{Ca}(\text{NO}_3)_2(\text{aq}) + 2\text{AgCH}_3\text{COO}(s)$   
 (e)  $2\text{NBr}_3(l) \rightarrow 3\text{N}_2(g) + 3\text{Br}_2(g)$   
 (f)  $2\text{HF}(\text{aq}) + \text{Ba}(\text{OH})_2(\text{aq}) \rightarrow \text{BaF}_2(\text{aq}) + 2\text{H}_2\text{O}(l)$

**page 197, Learning Checkpoint**

- basic
- acidic
- 7.0

**page 200, Learning Checkpoint**

- (a) hydrochloric acid  
 (b) nitric acid  
 (c) acetic acid (or ethanoic acid)

2. (a) phosphate  
(b) nitrate

## page 201, Learning Checkpoint

1. (a) potassium hydroxide  
(b) calcium hydroxide  
(c) magnesium hydroxide  
(d) ammonium hydroxide  
2. OH<sup>-</sup>, hydroxide

## page 203, 5.1 Check and Reflect

3. (a) basic  
(b) acidic  
(c) acidic  
(d) acidic  
(e) basic  
7. (a) basic  
(b) salt  
(c) acidic  
(d) acidic  
8. (a) HNO<sub>3</sub>(aq)  
(b) CsOH  
(c) HCl(aq)  
(d) H<sub>3</sub>PO<sub>4</sub>  
(e) potassium hydroxide  
(f) sulphuric acid  
9. (a) magnesium hydroxide  
(b) potassium hydroxide  
(c) aluminum hydroxide  
10. (a) Mg(OH)<sub>2</sub>  
(b) KOH  
(c) Al(OH)<sub>3</sub>

## page 206, 5.1 Practice Problems

1. HBr(aq) + KOH(aq) → KBr + H<sub>2</sub>O  
2. H<sub>2</sub>SO<sub>4</sub>(aq) + Mg(OH)<sub>2</sub>(aq) → MgSO<sub>4</sub>(aq) + H<sub>2</sub>O(l)  
3. H<sub>3</sub>PO<sub>4</sub>(aq) + 3NaOH(aq) → Na<sub>3</sub>PO<sub>4</sub>(aq) + 3H<sub>2</sub>O(l)

## page 216, 5.2 Check and Reflect

8. (a) water  
(b) sodium bromide  
(c) hydrogen chloride (or hydrochloric acid)  
9. (a) H<sub>2</sub>SO<sub>4</sub> + Ca(OH)<sub>2</sub> → H<sub>2</sub>O + CaSO<sub>4</sub>  
(b) HBr + NaOH → H<sub>2</sub>O + NaBr  
(c) HCl + NaOH → H<sub>2</sub>O + NaCl

10. (a) H<sub>2</sub>SO<sub>4</sub> + Ca(OH)<sub>2</sub> → 2H<sub>2</sub>O + CaSO<sub>4</sub>  
(b) already balanced  
(c) already balanced

## page 218, Chapter 5 Review

4. (a) acidic  
(b) neutral  
(c) neutral  
(d) basic  
(e) basic  
9. (a) acid  
(b) acid  
(c) base  
10. (a) H<sub>2</sub>SO<sub>4</sub>; acid  
(b) Ca(OH)<sub>2</sub>; base  
(c) HBr; acid  
(d) Mg(OH)<sub>2</sub>(aq); base  
11. (a) hydrofluoric acid; acid  
(b) nitric acid; acid  
(c) sodium hydroxide; base  
(d) ammonium hydroxide; base  
(e) acetic acid (ethanoic acid); acid  
(f) phosphoric acid; acid  
(g) calcium hydroxide; base

## page 226, Practice Problems

1. synthesis; 2Li + Cl<sub>2</sub> → 2LiCl  
2. synthesis; 2Ca + O<sub>2</sub> → 2CaO  
3. synthesis; C(s) + O<sub>2</sub>(g) → CO<sub>2</sub>(g)

## page 227, Practice Problems

1. decomposition; 8MgS → 8Mg + S<sub>8</sub>  
2. decomposition; NaI → Na + I<sub>2</sub>  
3. decomposition; 2NaCl(l) → 2Na(s) + Cl<sub>2</sub>(g)

## page 229, 6.1 Check and Reflect

1. synthesis and decomposition  
4. (a) decomposition  
(b) decomposition  
(c) synthesis  
(d) synthesis  
(e) decomposition  
(f) decomposition  
5. (a) synthesis  
(b) iron(II)

6. (a) potassium chlorate → potassium chloride + oxygen  
(b) KClO<sub>3</sub>(s) → KCl(s) + O<sub>2</sub>(g)  
(c) 2KClO<sub>3</sub>(s) → 2KCl(s) + O<sub>2</sub>(g)  
7. 2H<sub>2</sub>O(l) → 2H<sub>2</sub>(g) + O<sub>2</sub>(g)  
8. zinc nitride → zinc + nitrogen  
Zn<sub>3</sub>N<sub>2</sub>(s) → 3Zn(s) + N<sub>2</sub>(g)  
9. magnesium + chlorine → magnesium chloride  
Mg(s) + Cl<sub>2</sub>(g) → MgCl<sub>2</sub>(s)  
(already balanced)

## page 233, Practice Problems

1. single displacement; Mg + Zn(NO<sub>3</sub>)<sub>2</sub> → Zn + Mg(NO<sub>3</sub>)<sub>2</sub>  
2. single displacement; Fe(s) + AgNO<sub>3</sub>(aq) → Fe(NO<sub>3</sub>)<sub>2</sub>(aq) + Ag(s)

## page 234, Practice Problems

1. single displacement; 3F<sub>2</sub> + 2AlBr<sub>3</sub> → 3Br<sub>2</sub> + 2AlF<sub>3</sub>  
2. single displacement; Cl<sub>2</sub> and 2AgBr → Br<sub>2</sub> + 2AgCl  
3. single displacement; 3Cl<sub>2</sub>(g) + 2NiBr<sub>3</sub>(aq) → 2NiCl<sub>3</sub>(aq) + 3Br<sub>2</sub>(l)

## page 235, Practice Problems

1. double displacement; AlCl<sub>3</sub>(aq) + 3NaOH(aq) → Al(OH)<sub>3</sub>(s) + 3NaCl(aq)  
2. double displacement; CuNO<sub>3</sub>(aq) + KBr(aq) → CuBr(s) + KNO<sub>3</sub>(aq)

## page 240, 6.2 Check and Reflect

4. (a) double displacement  
(b) neutralization  
(c) combustion  
(d) single displacement  
(e) decomposition  
(f) synthesis  
7. (a) single displacement  
(b) double displacement  
(c) combustion  
(d) double displacement

**page 242, Chapter 6 Review**

1. synthesis
7. neutralization, combustion
8. (a) double displacement  
(b) neutralization
10. (a) potassium iodide  
(b) cesium chloride
12. carbon dioxide, water
14. (a) synthesis  
(b) decomposition  
(c) single displacement  
(d) double displacement  
(e) combustion  
(f) double displacement  
(g) decomposition
15. double displacement;  $\text{FeCl}_2(\text{aq}) + \text{K}_2\text{S}(\text{aq}) \rightarrow \text{FeS}(\text{s}) + 2\text{KCl}(\text{aq})$
16.  $\text{FeS}(\text{s})$
17. (a) decomposition;  $\text{CaCl}_2(\text{s}) \rightarrow \text{Ca}(\text{s}) + \text{Cl}_2(\text{g})$   
(b) decomposition;  $2\text{NaN}_3(\text{s}) \rightarrow 2\text{Na}(\text{s}) + 3\text{N}_2(\text{g})$   
(c) double displacement;  
 $\text{Pb}(\text{NO}_3)_2(\text{aq}) + \text{Cu}_2\text{SO}_4(\text{aq}) \rightarrow \text{PbSO}_4(\text{s}) + 2\text{CuNO}_3(\text{aq})$   
(d) decomposition;  $2\text{Ni}_2\text{O}_3(\text{s}) \rightarrow 4\text{Ni}(\text{s}) + 3\text{O}_2(\text{g})$   
(e) combustion;  $\text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{g})$   
(f) double displacement  
 $3\text{NaI}(\text{aq}) + \text{AlCl}_3(\text{aq}) \rightarrow 3\text{NaCl}(\text{aq}) + \text{AlI}_3(\text{s})$
18. (a) double displacement;  
 $\text{Na}_2\text{SO}_4 + \text{CaCl}_2 \rightarrow 2\text{NaCl} + \text{CaSO}_4$   
(b) synthesis;  $3\text{Mg} + \text{N}_2 \rightarrow \text{Mg}_3\text{N}_2$   
(c) double displacement;  
 $\text{Sr}(\text{OH})_2 + \text{PbBr}_2 \rightarrow \text{SrBr}_2 + \text{Pb}(\text{OH})_2$   
(d) synthesis;  $4\text{Na} + \text{O}_2 \rightarrow 2\text{Na}_2\text{O}$   
(e) synthesis;  $\text{N}_2 + 3\text{H}_2 \rightarrow 2\text{NH}_3$   
(f) decomposition;  $2\text{HCl} \rightarrow \text{H}_2 + \text{Cl}_2$   
(g) single displacement;  $2\text{AlI}_3 + 3\text{Br}_2 \rightarrow 2\text{AlBr}_3 + 3\text{I}_2$

(h) neutralization;  $\text{HCl} + \text{NaOH} \rightarrow \text{NaCl} + \text{H}_2\text{O}$

19. synthesis;  $\text{Ca} + \text{I}_2 \rightarrow \text{CaI}_2$
20. single displacement;  $\text{Zn}(\text{s}) + \text{CuSO}_4(\text{aq}) \rightarrow \text{Cu}(\text{s}) + \text{ZnSO}_4(\text{aq})$
21.  $\text{Mg}(\text{s}) + \text{Br}_2(\text{l}) \rightarrow \text{MgBr}_2(\text{s})$
22. zinc bromide + silver nitrate  $\rightarrow$  silver bromide + zinc nitrate  
 $\text{ZnBr}_2(\text{aq}) + 2\text{AgNO}_3(\text{aq}) \rightarrow 2\text{AgBr}(\text{s}) + \text{Zn}(\text{NO}_3)_2(\text{aq})$

**page 248, Unit B Review**

2. (a)  $\text{Cs}^+$   
(b)  $\text{O}^{2-}$   
(c)  $\text{Sn}^{2+}$   
(d)  $\text{Ni}^{3+}$   
(e)  $\text{Ti}^{4+}$
3. (a) magnesium  
(b) fluoride  
(c) gold(I)  
(d) silver  
(e) nitride
4. (a) positive  
(b) negative
8. two
9. metals and non-metals
10. non-metals and other non-metals
15. 0 to 14
16.  $> 7$
17.  $< 7$
19. neutralization
22. 7
25. decomposition
26. (a) synthesis  
(b) combustion
27. (a)  $2\text{Na} + \text{Br}_2 \rightarrow 2\text{NaBr}$   
(b)  $\text{Mg} + \text{F}_2 \rightarrow \text{MgF}_2$   
(c)  $2\text{Al} + 3\text{Cl}_2 \rightarrow 2\text{AlCl}_3$   
(d)  $6\text{K} + \text{N}_2 \rightarrow 2\text{K}_3\text{N}$   
(e)  $6\text{Ca} + \text{P}_4 \rightarrow 2\text{Ca}_3\text{P}_2$
28. single displacement
29. combustion
32. (a) 4  
(b) 2
34. ammonium,  $\text{NH}_4^+$
40. (a) sulphur  
(b) hydrogen, chlorine  
(c) nitrogen  
(d) phosphorus
43. (a) single displacement  
(b) combustion  
(c) single displacement  
(d) combustion  
(e) double displacement
44. (a)  $\text{Cu}(\text{NO}_3)_2(\text{aq}) + \text{Fe}(\text{s}) \rightarrow \text{Fe}(\text{NO}_3)_2(\text{aq}) + \text{Cu}(\text{s})$   
(b)  $2\text{C}_5\text{H}_{10}(\text{l}) + 15\text{O}_2(\text{g}) \rightarrow 10\text{CO}_2(\text{g}) + 10\text{H}_2\text{O}(\text{l})$   
(c)  $\text{Li}_4\text{C}(\text{s}) + 2\text{Ca}(\text{s}) \rightarrow 4\text{Li}(\text{s}) + \text{Ca}_2\text{C}(\text{s})$   
(d)  $2\text{C}_6\text{H}_{14}(\text{g}) + 19\text{O}_2(\text{g}) \rightarrow 12\text{CO}_2(\text{g}) + 14\text{H}_2\text{O}(\text{l})$   
(e)  $3\text{CsF}(\text{aq}) + \text{AlBr}_3(\text{aq}) \rightarrow 3\text{CsBr}(\text{aq}) + \text{AlF}_3(\text{s})$
45. calcium + bromine  $\rightarrow$  calcium bromide  
 $\text{Ca} + \text{Br}_2 \rightarrow \text{CaBr}_2$
49. (a) beryllium oxide  
(b) potassium chloride  
(c) strontium bromide  
(d) aluminum sulphide  
(e) calcium phosphide  
(f) manganese(II) chloride  
(g) potassium sulphate  
(h) lithium phosphate  
(i) chromium hydroxide  
(j) ammonium hydrogen carbonate
50. (a)  $\text{NaBr}$   
(b)  $\text{Be}_3\text{P}_2$   
(c)  $\text{Cu}_2\text{O}$   
(d)  $\text{Pd}(\text{NO}_3)_4$   
(e)  $(\text{NH}_4)_2\text{SO}_4$   
(f)  $\text{NH}_4\text{NO}_3$
51. (a) disulphur trioxide  
(b) diphosphorus pentasulphide  
(c) oxygen difluoride  
(d) dinitrogen trioxide  
(e) carbon dioxide
52. (a)  $\text{SF}_6$   
(b)  $\text{CS}_2$   
(c)  $\text{N}_2\text{O}$   
(d)  $\text{CCl}_4$   
(e)  $\text{CO}$
53. (a) combustion  
(b) synthesis  
(c) single displacement  
(d) decomposition  
(e) double displacement  
(f) neutralization

54. KCl

56. (a) single displacement  
 (b) neutralization  
 (c) decomposition  
 (d) single displacement  
 (e) synthesis  
 (f) double displacement  
 (g) neutralization

58. synthesis;  $2\text{Ca} + \text{O}_2 \rightarrow 2\text{CaO}$

59. (a)  $\text{CS}_2 + 3\text{O}_2 \rightarrow \text{CO}_2 + 2\text{SO}_2$   
 (b)  $\text{Pb}(\text{NO}_3)_2 + \text{Na}_2\text{SO}_4 \rightarrow \text{PbSO}_4 + 2\text{NaNO}_3$   
 (c)  $\text{KBr} + \text{AgNO}_3 \rightarrow \text{AgBr} + \text{KNO}_3$

60. b, c

61. sulphuric acid + ammonium hydroxide  $\rightarrow$  ammonium sulphate + water  
 $\text{H}_2\text{SO}_4 + 2\text{NH}_4\text{OH} \rightarrow (\text{NH}_4)_2\text{SO}_4 + 2\text{H}_2\text{O}$
62. benzene + oxygen  $\rightarrow$  carbon dioxide + water  
 $2\text{C}_6\text{H}_6 + 15\text{O}_2 \rightarrow 12\text{CO}_2 + 6\text{H}_2\text{O}$

page 395, Learning Checkpoint

2. 5%

page 401, 10.2 Check and Reflect

6. (a) 5%  
 (b) 20%

page 424, Practice Problems

1.  $M = 250$   
 2.  $M = 4.6$   
 3.  $M = 4.68 \times 10^{-4}$

page 424, Practice Problems

1.  $M = 0.667$   
 2.  $M = 1$   
 3.  $M = 7.5 \times 10^{-4}$

page 425, Practice Problems

1.  $h_i = 140 \text{ cm}$  or  $1.40 \text{ m}$   
 2.  $h_o = 0.80 \text{ cm}$  or  $8.0 \text{ mm}$   
 3.  $h_i = 12 \text{ mm}$  or  $1.2 \text{ cm}$

page 425, Practice Problems

1.  $d_o = 0.5 \text{ cm}$   
 2.  $d_i = 322 \text{ cm}$  or  $3.22 \text{ m}$   
 3.  $d_i = 120 \text{ mm}$  or  $1.2 \text{ m}$

page 433, 11.1 Check and Reflect

11.  $2.2 \times 10^2$  or about 220 times  
 12.  $8.0 \text{ cm}$

page 438, Practice Problems

1.  $n = 1.81$   
 2.  $n = 1.43$   
 3.  $n = 2.42$ , diamond

page 438, Practice Problems

1.  $2.21 \times 10^8 \text{ m/s}$   
 2.  $8.57 \times 10^7 \text{ m/s}$   
 3.  $1.69 \times 10^8 \text{ m/s}$

page 441, Practice Problems

1.  $\theta_2 = 22^\circ$   
 2.  $\theta_2 = 23^\circ$   
 3.  $\theta_2 = 35.5^\circ$

page 442, Practice Problems

1. 1.50  
 2. 1.9  
 3. 1.48

page 447, 11.2 Check and Reflect

11. 2.5  
 12.  $38^\circ$   
 13. 1.47, Pyrex glass  
 14. 1.13  
 15. 1.33, water  
 16.  $17.0 \text{ m/s}$

page 455, Practice Problems

1.  $3.5 \text{ mm}$   
 2.  $30 \text{ mm}$   
 3.  $2.86 \text{ mm}$

page 456, Practice Problems

1. larger, real, inverted,  $60 \text{ cm}$   
 2.  $0.06 \text{ cm}$   
 3. very far away

page 457, Practice Problems

1.  $64 \text{ mm}$   
 2.  $2.1 \text{ cm}$   
 3.  $14 \text{ cm}$

page 462, 11.3 Check and Reflect

6. (a)  $d_i = 12.0 \text{ cm}$   
 (b)  $h_i = 3.6 \text{ cm}$   
 7. (a)  $d_i = 60 \text{ cm}$   
 (b)  $M = 5.0$   
 8.  $1.030 \times 10^5 \text{ mm}$  or about  $103 \text{ m}$

page 464, Chapter 11 Review

12. (a)  $14.6 \text{ mm}$  or  $1.46 \text{ cm}$   
 14. (a)  $812 \text{ mm}$  or  $8.12 \text{ m}$   
 (b)  $11 \text{ mm}$  or  $1.1 \text{ cm}$   
 15.  $10^\circ$   
 16.  $8.4^\circ$   
 17. 200 times  
 18. (a)  $8.0 \text{ cm}$   
 (b) 1.5  
 19.  $0.43 \text{ mm}$   
 20. 1.20  
 21.  $0.0^\circ$   
 25.  $8.0 \text{ mm}$

page 477, Learning Checkpoint

1. (a) less than  $20^\circ$   
 (b)  $180^\circ$

page 504, Unit D Review

29. 300 million  $\text{m/s}$  or  $3.0 \times 10^8 \text{ m/s}$   
 67.  $3.4 \times 10^2$  or about 340 times  
 68. 0.241  
 69.  $1.8 \times 10^7$   
 70.  $1.97 \times 10^8 \text{ m/s}$   
 71.  $27.1^\circ$   
 72.  $1.1 \times 10^{-4} \text{ m}$   
 73.  $8.74 \text{ cm}$   
 74.  $4.5 \text{ cm}$   
 75.  $1.25 \text{ m}$

**Notes:** The numbers in parentheses at the end of each definition indicates the page number in this book where the term is defined. A pronunciation guide, using the key below, appears in square brackets after selected words.

a = tack, cat  
 ae = day, clay  
 ah = car, farther  
 aw = dawn, hot  
 e = bed, less  
 ee = leaf, clean  
 ih = idea, life

i = simple, this  
 oh = home, loan  
 oo = mood, root  
 u = wonder, Sun  
 uh = taken, traveller  
 uhr = insert, turn

## A

**absorption** process by which food that has already been broken down passes through the walls of the intestine into the bloodstream

**acid** substance that has a pH less than 7 when it is in aqueous solution (196)

**acid leaching** process in which acids dissolve metals found in soil; as the pH falls, heavy metals begin to dissolve (211)

**acid precipitation** rain, snow, fog, or dew that has a pH less than 5.6 (208)

**acid-base indicator** substance that changes colour in the presence of an acid or a base (197)

**additive colour theory** theory of light stating that white light is composed of different colours (wavelengths) of light (387)

**albedo** [al-BEE-doh] percent of incoming solar radiation reflected by a surface (278)

**alkali metal** member of the family of elements composed of soft, silver-grey metals that react easily with water and with oxygen in the air; group 1 on the periodic table (148)

**alkaline earth metal** member of the family of elements composed of silver-grey metals that are harder and more reactive than alkali metals; group 2 on the periodic table (148)

**amplitude** wave height from the rest position to the crest, or wave depth from the rest position to the trough; the larger the amplitude, the more energy that is carried (382)

**anaphase** [a-nuh-FAEZ] third phase of mitosis; phase in which the sister chromatids separate into individual chromosomes and move to opposite poles (32)

**angle of incidence** (*i*) angle between the incident ray and the normal (418)

**angle of reflection** (*r*) angle between the reflected ray and the normal (418)

**anthropogenic greenhouse effect** enhancement of the natural greenhouse effect due to increased greenhouse gas emissions caused by human activities (300)

**aperture** in a camera, opening that the light passes through (484)

**apoptosis** [AE-pawp-TOH-sis] controlled death of a cell that is no longer useful (33)

**astigmatism** condition in which the eye is unable to form a clear image because of an irregularly shaped cornea or lens (474)

**atmosphere** layer of gases that extends outward about 300 km from the surface of Earth (265)

**atom** smallest particle in matter (144)

**atomic mass** measure of the average mass of an atom of an element (149)

**atomic number** number of protons in an atom of an element (149)

**atomic theory** study of the nature of atoms and how atoms combine to form all types of matter (144)

**axis of symmetry** imaginary vertical line drawn through the optical centre of a lens (450)

## B

**base** substance that has a pH greater than 7 when it is in aqueous solution (197)

**binoculars** two short refracting telescopes attached together (489)

**bioluminescence** [bi-oh-loo-min-ES-uhns] ability of a plant or animal to produce light (392)

**biome** [BIH-ohm] large geographical region with a defined climate (range of temperature and precipitation) (268)

**biosphere** [BIH-uh-sfeer] relatively thin layer of Earth that has conditions suitable for supporting life; includes the lithosphere, hydrosphere, and atmosphere (264)

**blind spot** place where the optic nerve attaches to the retina (472)

**Bohr diagram** illustration of an atom that shows the arrangement and number of electrons in each shell (145)

**boiling point** (condensation point) temperature of boiling (or condensing) (142)

## C

**camera** lightproof box with a lens at one end to form a real, inverted image on a light detector or on a light-sensitive plate or film (484)

**cancer cell** cell that divides uncontrollably; develops when a mutation occurs in the cell that affects how that cell divides (34)

**capillary** thin-walled blood vessel (57)

**carbon footprint** total amount of greenhouse gas emissions caused directly and indirectly by an individual, community, industry, or country (350)

**carbon offset** contribution of money to a carbon sink to compensate for an individual's or company's greenhouse gas emissions (353)

**carbon sink** process that takes carbon dioxide from the atmosphere and stores it (302)

**carbon source** process that releases carbon dioxide to the atmosphere (301)

**carbon tax** charge to an individual or company for creating greenhouse gas emissions either directly or by purchasing a fossil fuel (354)

**cell** basic unit of life for all living things (10)

**cell cycle** repeating cycle of events in the life of a cell in which it grows and prepares for division (28)

**cell membrane** protective barrier formed around every cell; made of a double layer of lipids (12)

**cell specialization** process in which cells develop in different ways to perform particular functions (40)

**cell wall** rigid frame around a plant cell that provides strength, protection, and support (14)

**centriole** pair of structures involved in cell division in animal cells (16)

**chemical change** transformation of one or more substances into new substances with new properties (174)

**chemical equation** words, or symbols and formulas, that describe the changes that occur during a chemical reaction (175)

**chemical property** property related to the ability of a substance to change into a new substance or substances (142)

**chemical reaction** process by which chemical change happens; all chemical reactions are also accompanied by changes in energy (174)

**chemiluminescence** [KEM-i-loo-min-ES-uhns] light produced from a chemical reaction without a rise in temperature (395)

**chloroplast** organelle that contains a green substance called chlorophyll; found only in plant cells and some algae (15)

**chromosome** long piece of coiled DNA and proteins; only visible during mitosis (28)

**circulatory system** organ system that includes the heart, blood, veins, arteries, and capillaries; transports blood around the body (70)

**climate** average weather conditions that occur in a region over a long period of time, usually a minimum of 30 years (262)

**climate change** significant long-term change in expected climate patterns (303)

**cloning** creation of a genetically identical organism that is an exact copy of a gene, cell, tissue, or organism (115)

**colour blindness** ability to see only shades of grey; very rare, occurring in about 1 in 40 000 people (477)

**colour vision deficiency** ability to distinguish some colours but not others (477)

**combustion** chemical reaction in which a compound or element rapidly combines with oxygen gas (232)

**compound** pure substance made from two or more elements that are combined together chemically (143)

**compound microscope** type of light microscope in which a pair of convex lenses causes a small object to appear magnified when viewed through the eyepiece (487)

**concave lens** lens that is thinner at the centre than at the edges; also called a diverging lens (451)

**concave mirror** reflecting surface that curves inward like a bowl; also called a converging mirror (421)

**concentration** amount of a substance that has been dissolved in solution (12)

**conduction** transfer of thermal energy through direct contact between the particles of a substance without moving the particles to a new location (279)

**conductivity** ability to conduct heat or electricity (142)

**cone cells** photoreceptor cells in the eye that detect colour (472)

**confidence level** degree of confidence in predictions about a particular event (340)

**convection** transfer of thermal energy through the movement of particles from one location to another (280)

**converging lens** lens that is thicker at the centre than at the edges; also called a convex lens (452)

**converging mirror** reflecting surface that curves inward like a bowl; also called a concave mirror (421)

**convex lens** lens that is thicker at the centre than at the edges; also called a converging lens (452)

**convex mirror** reflecting surface that curves outward; also called a diverging mirror (426)

**Coriolis effect** [kor-ee-OH-luhs] deflection of any object from a straight-line path by the rotation of Earth (281)

**cornea** transparent layer of tissue on the outer surface of the eye covering the iris and pupil; refracts light entering the eye (470)

**covalent bond** connection, usually between the atoms of non-metals, in which the two atoms share a pair of electrons (164)

**crest** highest point in a wave (382)

**crystal formation** forming of particles with a crystalline appearance (142)

**cytokinesis** [sih-toh-kin-EE-suhs] division of the cytoplasm during mitosis (32)

**cytoplasm** [SIH-toh-plaz-uhm] jelly-like substance that fills the cell and surrounds the organelles (12)

**cytoskeleton** internal network of fibres within a cell; made up of protein filaments (14)

## D

**decomposition reaction** chemical reaction in which a compound is broken apart into two or more elements and/or simpler compounds (226)

**diaphragm** in a camera, an adjustable opening that controls the aperture (484)

**diatomic molecule** molecule made from two atoms (164)

**differentiation** process in which stem cells become specialized so that they can perform different functions (40)

**diffuse reflection** reflection in which parallel light rays are scattered in different directions when reflected from an irregular surface (406)

**diffusion** process for moving substances across a cell membrane (12)

**digestive system** organ system made up of the mouth, esophagus, stomach, small and large intestine, and rectum; transports and absorbs nutrients in the body (68)

**dispersion** refraction of white light into separate wavelengths, or colours (440)

**diverging lens** lens that is thinner at the centre than at the edges; also called a concave lens (451)

**diverging mirror** reflecting surface that curves outward; also called a convex mirror (426)

**DNA screening** test in which DNA is analyzed to see if an individual has a series of genes related to certain diseases, such as heart disease and types of cancer (108)

**double-displacement reaction** chemical reaction in which the positive or negative ions in two dissolved ionic compounds switch places (235)

**ductility** ability to be stretched without breaking (142)

## E

**economic system** organized way in which a country or region sets up activities related to how goods and services are produced, distributed, and consumed (322)

**electric discharge** method for producing light in which an electric current passes through the air or another gas (396)

**electroluminescence** process of transforming electrical energy directly into light energy (397)

**electromagnetic radiation** energy that can travel through

empty space in the form of waves (385)

**electromagnetic spectrum** entire range of wavelengths or frequencies of electromagnetic radiation extending from the shortest gamma rays to the longest radio waves and including light (385)

**electron** subatomic particle that has a negative charge of 1– (144)

**element** substance that cannot be broken down into any simpler substance by chemical means (143)

**emissions trading** system by which a company that reduces its emissions by more than the government limit can trade the extra amount to another company that has exceeded its maximum; also called “cap and trade” (354)

**esophagus** tube that allows food to travel from the mouth to the stomach (58)

**excretory system** organ system that includes the kidneys, ureters, urinary bladder, urethra, and skin; filters waste products from the blood and maintains the proper levels of water and electrolytes in the body (71)

## F

**family** vertical column of the periodic table; elements in the same family in the periodic table have similar physical and chemical properties; also called a group (146)

**far-sighted** able to see distant objects clearly but not near objects clearly (473)

**fluorescent** describes light emitted by some substances when they are exposed to electromagnetic radiation (394)

**focal length** distance from the vertex to the focal point of a curved mirror (420)

**focal point** point where light rays meet or appear to meet (420)

**formula equation** chemical equation that uses formulas of the reactants and products (175)

**fossil fuels** hydrocarbons formed underground over millions of years from the remains of once-living organisms; fossil fuels are coal, oil, and natural gas (232, 301)

**frequency** ( $f$ ) rate of repetition of a wave; measured in hertz (Hz), which is cycles per second (382)

## G

**gamma rays** extremely high-energy electromagnetic radiation that can penetrate human tissue (385)

**gene** each section of DNA that codes for a particular protein (108)

**gene therapy** therapy in which healthy genes are inserted into cells so that cells function normally (114)

**general chemical equation** (GCE) equation that uses letters of the alphabet (A, B, C, D) in place of symbols for elements (224)

**geometric optics** science of how light reflects and refracts (417)

**global warming** observed increases in Earth's average annual temperature (303)

**global warming potential** measure of the ability of a greenhouse gas to trap thermal energy in the atmosphere (298)

**Golgi apparatus** [GOHL-jee] structure that receives proteins from the endoplasmic reticulum; modifies, sorts, and packages these proteins for delivery throughout the cell or outside the cell (14)

**granum** [GRAE-nuhm] stack of thylakoids (15)

**greenhouse gas** gas that contributes to the natural greenhouse effect, such as water vapour, carbon dioxide, nitrous oxide, or methane; last three also contribute to the anthropogenic greenhouse effect (276)

**group** vertical column of the periodic table; elements in the same family in the periodic table have similar physical and chemical properties; also called a family (146)

## H

**halogen** member of the family of elements composed of very reactive, coloured non-metals; group 17 on the periodic table (148)

**heart** muscular pump that supplies blood to all parts of the body (57)

**heterogeneous mixture** mixture in which different parts of the mixture are visible (143)

**homeostasis** tendency of an organism to maintain a steady state; an acceptable range of physical and chemical conditions in which body cells, tissues, and organs can operate efficiently (79)

**homogeneous mixture** mixture that looks the same throughout and the separate components are not visible; sugar water is a solution of sugar dissolved in water (143)

**hydrocarbon** compound made of only carbon and hydrogen (232)

**hydrosphere** includes all of the water on Earth, with about 97 percent of this water being salt water in the Earth's oceans (267)

## I

**image** in optics, reproduction of an object seen in reflective surfaces such as calm water or glass (418)

**immunization** making a person resistant to infection through vaccination (105)

**incandescent** describes light produced by an object, such as a metal, that is at a very high temperature (394)

**incident ray** ray that strikes a reflecting or refracting surface (418)

**index of refraction** amount by which a transparent material decreases the speed of light; indicated by a number; also called refractive index (437)

**infrared waves** electromagnetic radiation that has wavelengths shorter than microwaves but longer than the visible spectrum (384)

**insolation** amount of solar energy received by a region of Earth's surface (276)

**integumentary system** [in-TEG-yoo-MEN-tuh-ree] organ system made up of skin and accessory structures (68)

**interdependant** connection between parts so that one part contributes to the action of another part; e.g., body systems are interdependent because the action of each system contributes to the actions of the other systems (80)

**interphase** stage in the cell cycle in which the cell grows and prepares for cell division (28)

**intestine** area of chemical digestion and removal of wastes (58)

**ion** atom or group of atoms with a negative charge or a positive charge (149)

**ionic compound** compound formed from one or more positively charged ion(s) and one or more negatively charged ion(s) (156)

**iris** circular coloured band of muscle in the eye that controls the size of the pupil and the amount of light that enters the eye (470)

## K

**Kyoto Protocol** UNFCCC agreement among countries to reduce their greenhouse gas emissions (342)

## L

**laser** light in which all the light rays are almost perfectly parallel, all have the same wavelength, and all wave crests and troughs are exactly lined up (490)

**law of conservation of mass** scientific law stating that the mass of the products always equals the mass of the reactants in a chemical reaction (176)

**law of reflection** scientific law stating that when light reflects off a surface, the angle of incidence always equals the angle of reflection; refers to the predictable behaviour of reflected light (418)

**lens** curved transparent object that is smooth and regularly shaped, so that when light strikes it, the light refracts in a predictable and useful way (450)

**light-emitting diode** (LED) electroluminescent light source made from a semiconductor (397)

**liquid crystal** solid that can change the orientation of its molecules like a liquid, but only when electricity is applied (398)

**liquid crystal display** (LCD) light source in which white light, such as a fluorescent light or light-emitting diode, shines behind a liquid crystal (398)

**lithosphere** solid portion of Earth that floats on the semi-fluid portion of the upper mantle (266)

**lung** one of a pair of organs involved in respiration (57)

**lysosome** small organelle filled with enzymes; where digestion takes place (13)

## M

**magnification** measure of how much larger or smaller an image is compared with the object itself (423)

**malleability** ability to be beaten or rolled into sheets without crumbling (142)

**matter** anything that has mass and takes up space (has volume) (142)

**mechanical mixture** mixture that may contain several solids combined together (143)

**medical imaging** taking images of organs and tissues within the body for use in diagnosis and treatment (93)

**medium** material that is being used or is undergoing a process; plural is media (436)

**melting point** (freezing point) temperature of melting (or freezing) (142)

**meristematic cells** [mer-i-stuhm-AT-ik] stem cells that are found in plants and can become specialized (41)

**meristematic tissue** plant tissue formed from groups of meristematic cells (43)

**mesophyll** [ME-zuh-fil] specialized ground tissue in which photosynthesis and gas exchange occurs (44)

**metal** element that is ductile, malleable, shiny, usually silver, and generally a good conductor of heat and electricity; metals are found on the left and in the centre of the periodic table (146)

**metalloid** element with properties intermediate between the properties of metals and non-metals; on the periodic table, metalloids are arranged in a staircase that separates metals from non-metals (146)

**metaphase** second stage of mitosis; phase at which each chromosome lines up at the centre of the cell and the mitotic spindle forms (32)

**microwaves** electromagnetic radiation that has shorter wavelengths and higher frequency and carries more energy than radio waves (384)

**mirage** image of a distant object produced when light refracts through air of different densities (443)

**mitigation** making something milder or less severe (350)

**mitochondria** [mih-toh-KAWN-dree-uh] organelles that convert the chemical energy in sugar into energy that the cell can use; known as the power houses of the cell; singular is mitochondrion (13)

**mitosis** [mih-TOH-sis] stage of the cell cycle in which the cell divides into two new daughter cells (28)

**mixture** combination of pure substances; proportions of the pure substances in a mixture can vary, so the properties of the mixture vary as well (143)

**model** representation of an object, event, or process based on what we observe about the characteristics and properties (386)

**molecular compound** compound formed when atoms of non-metals combine (165)

**molecular element** element that exists as a molecule of two or more atoms joined by a covalent bond(s); e.g., O<sub>2</sub> (164)

**molecule** combination of two or more atoms held together by covalent bonds (164)

**multivalent element** element that can form an ion in more than one way (158)

## N

**natural greenhouse effect** absorption of thermal energy by the atmosphere, maintaining Earth at an average temperature suitable for life (276)

**near-sighted** able to see near objects clearly but not distant objects clearly (474)

**net radiation budget** difference between the amount of incoming radiation and amount of outgoing radiation (277)

**neutral** describes a substance with a pH of 7 when in aqueous solution; a neutral substance, such as pure water, is neither an acid nor a base (196)

**neutralization** chemical reaction between an acid and a base that produces water and a salt (206)

**neutron** subatomic particle that is neutral; neutrons have a charge of 0 (144)

**noble gas** member of the family of non-metal gases that are colourless, odourless, and unreactive; group 18 on the periodic table (148)

**non-metal** element that is not a metal and usually is a poor conductor of heat and electricity; non-metals are located on the right-hand side of the periodic table (146)

**normal** in optics, an imaginary dashed line drawn perpendicular to a reflecting or refracting surface at the point of reflection or refraction (418)

**nucleus** (atomic) central core in an atom, composed of protons and neutrons (144)

**nucleus** (cell) control centre organelle of a cell (12)

## O

**opaque** absorbing and reflecting light but not transmitting it (404)

**ophthalmologist** [off-thal-MAWL-uh-jist] physician who specializes in eye care (469)

**optic nerve** nerve that connects the eye to the brain (472)

**optical device** technology that uses light (418)

**optical fibre** solid strand of glass that can transmit light, even around corners (434)

**optometrist** trained professional in vision testing (469)

**organ** organized group of tissues that work together to perform a specific function (54)

**organ system** group of organs that work together to carry out specific duties in the body (65)

**organelle** small cell part that maintains life processes of the cell (10)

**organic light-emitting display** (OLED) light source in which several extremely thin layers of organic molecules use an electric current to create light (397)

## P

**penumbra** area of partial shadow from a non-point light source (405)

**period** horizontal row of the periodic table (146)

**persistence** length of time a greenhouse gas remains in the atmosphere (298)

**pH scale** number scale that indicates how acidic or basic a solution is (196)

**phloem** [FLOH-em] vascular tissue in a plant that transports the sugar produced during photosynthesis from the leaves to the other parts of the plant (45)

**phosphor** [FAWS-fohr] substance that glows after being exposed to energized particles (394)

**phosphorescence** ability to store the energy from a source of light and then emit it slowly over a long period (395)

**photon** tiny packet of light energy, according to one model of how light travels; in this model, the colour of light is related to the amount of energy carried by each photon (491)

**photonics** technologies that make use of the way in which light travels as photons (491)

**photoreceptors** cells in the retina that are sensitive to light, called rod cells and cone cells (472)

**physical property** property related to the physical appearance and composition of a substance (142)

**pixels** tiny picture elements in an image assigned a single colour and brightness (485)

**plane mirror** mirror that has a flat reflective surface (419)

**plasma display** light source including tiny fluorescent lights in which an electrical signal causes a gas, such as neon, to release ultraviolet radiation (398)

**polyatomic ion** group of atoms, usually of different elements, that act as a single ion (160)

**positive feedback loop** sequence of events that cycles back to one of the earlier events in the sequence and enhances the outcome (326)

**precipitate** suspension of small, solid particles formed during a chemical reaction (206)

**prism** transparent glass or plastic object with flat polished sides that separates light into its component colours (386)

**product** new substance formed during a chemical reaction (174)

**property** attribute common to all substances or objects of the same group (386)

**prophase** first phase of mitosis, when the chromatin condenses to form chromosomes, and the centrioles separate and move to opposite sides of the nucleus (31)

**proton** subatomic particle that has a positive charge of 1+ (144)

**public health strategies** programs for health promotion and disease prevention; e.g., immunization programs, programs to promote healthy lifestyles, health education programs, and screening services (104)

**pupil** transparent area in the centre of the eye that allows light to pass into the eye (470)

**pure substance** substance composed of only one kind of matter and having a unique set of properties, such as colour, hardness, melting point, and conductivity; may be either an element or a compound (143)

## R

**radiation** emission of energy as waves (279)

**radio waves** electromagnetic radiation that has the longest wavelength and lowest frequency (384)

**ray model of light** model representing light as straight lines, called rays, that show the direction in which light travels (404)

**reactant** starting substance in a chemical reaction (174)

**real image** image formed by rays that come from the location of the image (420)

**red blood cell** blood cell that contains hemoglobin, a protein that can absorb and release oxygen (42)

**reflect** to bounce off an object, such as when a light wave strikes an object (388)

**reflecting telescope** telescope in which light enters from one end of a tube and then reflects off a concave mirror toward a small plane mirror (489)

**refracting telescope** telescope that has two convex lenses, one on each end of a long tube (488)

**refraction** bending of light rays as they pass from one medium into another (436)

**regeneration** process in which a body part is replaced or regrown (38)

**regular reflection** reflection in which parallel light rays strike a smooth surface and stay parallel (406)

**respiratory system** system made up of various organs including the nose, mouth, trachea, lungs, bronchi, bronchioles, and diaphragm; function is to obtain oxygen and release carbon dioxide (69)

**rest position** in water, the level of the water when there are no waves (382)

**retina** inner lining at the back of the eye that acts as a projection screen for light rays entering the eye (471)

**ribosome** [RIH-buh-sohm] small dense-looking organelle that is attached to rough endoplasmic reticulum or free in the cytoplasm (14)

**rod cells** cells located in the retina that help to detect shapes and movement in low light situations (472)

**rough endoplasmic reticulum** organelle that is made of a series of interconnected small tubes and that carries materials through the cell; has ribosomes attached; associated with making proteins (14)

**runaway positive feedback loop** feedback loop in which the sequence of events appears to speed up with each cycle (327)

## S

**salinity** [sa-LIN-i-tee] salt content of water (314)

**sequester** [suh-KWES-tuhr] to store permanently (350)

**shell** cloud-like energy level that surrounds the nucleus of an atom; occupied by one or more electrons (144)

**shutter** in a camera, device that controls the length of time light is allowed in to the lens (484)

**single-displacement reaction** chemical reaction in which an element reacts with an ionic compound; during the reaction, the element becomes part of the ionic compound, while one of the elements in the ionic compound becomes an element by itself (233)

**sister chromatid** [KROH-muh-tid] one of two identical copies of a chromosome (29)

**skeleton equation** chemical equation that is complete except for coefficients; also called an unbalanced equation (178)

**skin** largest organ in the body; made up of two layers of tissues, the epidermis and the dermis; protects the inner cells from damage, acts as a defence against disease organisms, insulates, releases heat, and excretes bodily wastes (56)

**smooth endoplasmic reticulum** organelle made of a series of interconnected small tubes that carry materials through the cell; associated with the production of fats and oils (14)

**Snell's law** formula that states the relationship between the angle of incidence and the angle of refraction:  $n_1 \sin \theta_1 = n_2 \sin \theta_2$  (441)

**solar oven** cooking device that uses light from the Sun as its energy source; also called a solar cooker (423)

**solar radiation** radiant energy given off by the Sun (264)

**solubility** ability to dissolve in a liquid (142)

**state** phase of matter: solid, liquid, or gas (142)

**stem cell** unspecialized cell that can form specialized cells (40)

**stomach** organ made of epithelial, connective, nervous, and muscle tissues; churns food and mixes it with digestive juices and enzymes (58)

**stomate** [STOH-maet] tiny opening, or pore, in the underside of a leaf that allows carbon dioxide, water vapour, and oxygen to move into or out of the leaf easily; plural is stomata (44)

**subtractive colour theory** theory of light stating that coloured matter selectively absorbs different colours, or wavelengths, of light; colours that are absorbed are "subtracted" from the reflective light seen by the eye (388)

**suspension** cloudy mixture formed when tiny particles of one substance are held within another substance (143)

**sustainable development** use of the world's resources in ways that maintain these resources for future generations with minimal environmental impact (342)

**synthesis reaction** chemical reaction in which two elements combine to form a compound; the reactants may be a metal element and a non-metal element or two non-metal elements (225)

## T

**telephoto lens** in a camera, lens that increases the amount of light that is collected and magnifies a distant object (485)

**telescope** optical device that provides enlarged images of distant objects (488)

**telophase** fourth and final phase of mitosis, when the cell divides the cytoplasm into two portions (32)

**thermal energy** total kinetic energy of the molecules or atoms in a substance (264)

**thin lens** lens whose thickness is slight compared to its focal length (452)

**thin lens equation** equation that states the relationship of the distance of an object from the lens ( $d_o$ ), the distance of the image from the lens ( $d_i$ ), and the focal length of the lens ( $f$ ):  $\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$  (454)

**thylakoid** [THIH-luh-koyd] one of the little sacs that make up a chloroplast; collects light energy from the Sun, which is used in photosynthesis (15)

**tissue** group of cells that function together to perform a specialized task (42)

**total internal reflection** type of reflection in which light reflects completely off the inside wall of a denser medium, rather than passing through the wall into a less dense medium (442)

**transgenic organism** [tranz-JEN-ik] organism that contains genes from other species (116)

**translucent** transmitting some, but not all, light rays (404)

**transparent** transmitting light rays freely, as in clear glass or clear plastic (404)

**transpiration** the evaporation of water through the stomata in leaves (72)

**triboluminescence** [TRIH-boh-loo-min-ES-ens] light produced from friction (396)

**trough** lowest point in a wave (382)

## U

**ultraviolet** electromagnetic radiation that carries more energy than the visible spectrum but less energy than X-rays (385)

**umbra** part of a shadow in which all light rays from the light source are blocked (405)

**universal indicator** mixture of chemicals that changes colour through a wide range of pH values (197)

## V

**vacuole** [VAK-yoo-ohl] membrane-bound organelle that stores nutrients, wastes, and other substances used by a cell; in plant cells, the central vacuole stores water for the cell (13)

**valence electron** electron in the valence shell of an atom (145)

**valence shell** outermost shell of an atom (145)

**vertex** middle point of a curved mirror (420)

**vesicle** membrane-bound organelle that transports substances throughout the cell (13)

**virtual image** image formed by rays that do not come from the location of the image (419)

**visible spectrum** range of wavelengths of light that can be detected by the human eye (386)

## W

**wave** disturbance that transfers energy from one point to another without transferring matter (382)

**wave model of light** model of light comparing light to water waves; in this model, similarities between light and the movement of waves on the surface of water are used to explain several properties of visible light (386)

**wavelength** ( $\lambda$ ) distance from one place in a wave to the next similar place on the wave, such as from crest to crest; measured in metres (382)

**weather** environmental conditions that occur in a particular place at a particular time (262)

**wide-angle lens** in a camera, lens that captures a wider angle of view than a regular lens or telephoto lens (485)

**wind** movement of air from areas of high pressure to areas of low pressure (281)

**word equation** chemical equation that uses the names of the reactants and products (175)

## X

**X-rays** very high-energy electromagnetic radiation that can penetrate human tissue (385)

**xylem** [ZIH-lem] vascular tissue in a plant that carries water and minerals from the roots up the stem to the leaves (45)

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