# Answers to Numerical Questions

**page 18, Practice Problems**

**1.** 1000×
**2.** 40×
**3.** 400×

**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) $Mg^{2+}$
(b) $Cl^{-}$
(c) $Fe^{2+}$
(d) $Fe^{3+}$
(e) $U^{6+}$
**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.** $Mg_3P_2$
**3.** $Ag_2S$
**4.** $FeBr_3$

**page 164, Practice Problems**

**1.** $Mg(OH)_2$
**2.** $Na_2SO_4$
**3.** $Pb(NO_3)_2$
**4.** $(NH_4)_2CO_3$

**page 168, Practice Problems**

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

**page 168, Practice Problems**

**1.** $SBr_6$
**2.** $CCl_4$
**3.** $N_2O_4$
**4.** $P_4O_{10}$

**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) $Ba(OH)_2$
(d) $NH_4I$
(e) $Mg_3(PO_4)_2$
(f) $Fe_2O_3$
(g) $Cu_2SO_4$
(h) $CrPO_4$
**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) $SBr_6$
(b) $NBr_3$
(c) $SCl_6$
(d) $P_2O_5$
(e) CO

**page 177, Learning Checkpoint**

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

**page 178, Practice Problems**

**1.** $4Na + O_2 \rightarrow 2Na_2O$
**2.** $6HCl + 2Al \rightarrow 2AlCl_3 + 3H_2$
**3.** $2KClO_3 \rightarrow 2KCl + 3O_2$

**page 179, Practice Problems**

**1.** $2HgO(s) \rightarrow 2Hg(l) + O_2(g)$

**2.** $2Al(s) + 3Br_2(l) \rightarrow 2AlBr_3(s)$

**3.** $Ca(s) + 2H_2O(l) \rightarrow Ca(OH)_2(s) + H_2(g)$

**page 180, Practice Problems**

**1.** $3H_2(g) + N_2(g) \rightarrow 2NH_3(g)$

**2.** $2NO(g) + O_2(g) \rightarrow 2NO_2(g)$

**3.** $Al(s) + 3HNO_3(aq) \rightarrow Al(NO_3)_3 + H_2(g)$

**4.** $PCl_3(g) + Cl_2 \rightarrow PCl_5(g)$

**page 181, Practice Problems**

**1.** $2Fe + 3Cl_2 \rightarrow 2FeCl_3$

**2.** $2Na + Ca(OH)_2 \rightarrow 2NaOH + Ca$

**3.** $2Na_3PO_4 + 3Mg(OH)_2 \rightarrow Mg_3(PO_4)_2 + 6NaOH$

**4.** $3H_2SO_4 + 2Ni(OH)_3 \rightarrow Ni_2(SO_4)_3 + 6H_2O$

**page 182, Practice Problems**

**1.** silver nitrate + copper → copper(II) nitrate + silver
$2AgNO_3(aq) + Cu(s) \rightarrow Cu(NO_3)_2(aq) + Ag(s)$

**2.** magnesium chloride + potassium phosphate → potassium chloride + magnesium phosphate
$MgCl_2(aq) + K_3PO_4(aq) \rightarrow KCl(aq) + Mg_3(PO_4)_2(s)$

**3.** hydrogen + carbon dioxide → carbon monoxide + water
$H_2(g) + CO_2(g) \rightarrow CO(g) + H_2O(l)$

**4.** potassium + oxygen → potassium oxide
$4K(s) + O_2(s) \rightarrow 2K_2O(s)$

**page 187, 4.3 Check and Reflect**

**4.** (a) aluminum + fluorine → aluminum fluoride
$2Al(s) + 3F_2(g) \rightarrow 2AlF_3(g)$

(b) potassium + oxygen → potassium oxide
$4K(s) + O_2(g) \rightarrow 2K_2O(s)$

(c) lithium sulphate + barium chloride → barium sulphate + lithium chloride
$Li_2SO_4(aq) + BaCl_2(aq) \rightarrow BaSO_4(s) + 2LiCl(aq)$

(d) aluminum chloride + sodium carbonate → aluminum carbonate + sodium chloride
$2AlCl_3(aq) + 3Na_2CO_3(aq) \rightarrow Al_2(CO_3)_3(s) + 6NaCl(aq)$

**5.** (a) $Al(s) + 3F_2(g) \rightarrow 2AlF_3(s)$

(b) $4K(s) + O_2(g) \rightarrow 2K_2O(s)$

(c) $C_6H_{12}O_6(s) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O(l)$

(d) $H_2SO_4(aq) + 6NaOH(s) \rightarrow Na_2SO_4(aq) + 6H_2O(l)$

(e) $Mg(CH_3COO)_2(aq) + 2AgNO_3(aq) \rightarrow Mg(NO_3)_2(aq) + 2AgCH_3COO(s)$

(f) $2H_2O_2(aq) \rightarrow O_2(g) + 2H_2O(l)$

(g) $2HCl(aq) + Ba(OH)_2(aq) \rightarrow BaCl_2(aq) + 2H_2O(l)$

**6.** (a) calcium + oxygen → calcium oxide
$2Ca(s) + O_2(g) \rightarrow 2CaO(s)$

(b) propane + oxygen → carbon dioxide + water
$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$

(c) fluorine + potassium chloride → potassium fluoride + chlorine
$F_2(g) + 2KCl(aq) \rightarrow 2KF(aq) + Cl_2(g)$

**page 190, Chapter 4 Review**

**6.** (a) sodium

(b) calcium

(c) iron(III)

(d) fluoride

(e) oxide

**13.** 45 atoms

**14.** (a) $O^{2-}$

(b) $Br^-$

(c) $S^{2-}$

(d) $Ca^{2+}$

(e) $Cu^+$

**15.** (a) $NH^{4+}$

(b) $CO_3^{2-}$

(c) $HCO_3^-$

(d) $PO_4^{3-}$

**16.** (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

**17.** (a) KI

(b) $Sr_3N_2$

(c) $MnCl_4$

(d) SnS

(e) $Mg(OH)_2$

(f) $Zn_3(PO_4)_2$

(g) $Ag_2O$

(h) $NH_4NO_3$

**18.** (a) OnO

(b) $OnCl_2$

(c) $On_3(PO_4)_2$

**19.** (a) $N_2O_3$

(b) CO

(c) $SF_6$

(d) phosphorus pentabromide

(e) carbon tetrachloride

(f) nitrogen tribromide

**20.** (a) $2Li(s) + F_2(g) \rightarrow 2LiF(s)$

(b) $2Be(s) + O_2(g) \rightarrow 2BeO(s)$

(c) $HCl(aq) + NaOH(s) \rightarrow NaCl(aq) + H_2O(l)$

(d) $Ca(CH_3COO)_2(aq) + 2AgNO_3(aq) \rightarrow Ca(NO_3)_2(aq) + 2AgCH_3COO(s)$

(e) $2NBr_3(l) \rightarrow 3N_2(g) + 3Br_2(g)$

(f) $2HF(aq) + Ba(OH)_2(aq) \rightarrow BaF_2(aq) + 2H_2O(l)$

**page 197, Learning Checkpoint**

**1.** basic

**2.** acidic

**3.** 7.0

**page 200, Learning Checkpoint**

**1.** (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.** $OH^-$, 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) $HNO_3(aq)$
(b) CsOH
(c) HCl(aq)
(d) $H_3PO_4$
(e) potassium hydroxide
(f) sulphuric acid

**9.** (a) magnesium hydroxide
(b) potassium hydroxide
(c) aluminum hydroxide

**10.** (a) $Mg(OH)_2$
(b) KOH
(c) $Al(OH)_3$

**page 206, 5.1 Practice Problems**

**1.** $HBr(aq) + KOH(aq) \rightarrow KBr + H_2O$

**2.** $H_2SO_4(aq) + Mg(OH)_2(aq) \rightarrow MgSO_4(aq) + H_2O(l)$

**3.** $H_3PO_4(aq) + 3NaOH(aq) \rightarrow Na_3PO_4(aq) + 3H_2O(l)$

**page 216, 5.2 Check and Reflect**

**8.** (a) water
(b) sodium bromide
(c) hydrogen chloride (or hydrochloric acid)

**9.** (a) $H_2SO_4 + Ca(OH)_2 \rightarrow H_2O + CaSO_4$
(b) $HBr + NaOH \rightarrow H_2O + NaBr$
(c) $HCl + NaOH \rightarrow H_2O + NaCl$

**10.** (a) $H_2SO_4 + Ca(OH)_2 \rightarrow 2H_2O + CaSO_4$
(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) $H_2SO_4$; acid
(b) $Ca(OH)_2$; base
(c) HBr; acid
(d) $Mg(OH)_2(aq)$; 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; $2Li + Cl_2 \rightarrow 2LiCl$

**2.** synthesis; $2Ca + O_2 \rightarrow 2CaO$

**3.** synthesis; $C(s) + O_2(g) \rightarrow CO_2(g)$

**page 227, Practice Problems**

**1.** decomposition; $8MgS \rightarrow 8Mg + S_8$

**2.** decomposition; $NaI \rightarrow Na + I_2$

**3.** decomposition; $2NaCl(l) \rightarrow 2Na(s) + Cl_2(g)$

**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) $KClO_3(s) \rightarrow KCl(s) + O_2(g)$
(c) $2KClO_3(s) \rightarrow 2KCl(s) + O_2(g)$

**7.** $2H_2O(l) \rightarrow 2H_2(g) + O_2(g)$

**8.** zinc nitride → zinc + nitrogen
$Zn_3N_2(s) \rightarrow 3Zn(s) + N_2(g)$

**9.** magnesium + chlorine → magnesium chloride
$Mg(s) + Cl_2(g) \rightarrow MgCl_2(s)$ (already balanced)

**page 233, Practice Problems**

**1.** single displacement; $Mg + Zn(NO_3)_2 \rightarrow Zn + Mg(NO_3)_2$

**2.** single displacement; $Fe(s) + AgNO_3(aq) \rightarrow Fe(NO_3)_2(aq) + Ag(s)$

**page 234, Practice Problems**

**1.** single displacement; $3F_2 + 2AlBr_3 \rightarrow 3Br_2 + 2AlF_3$

**2.** single displacement; $Cl_2$ and $2AgBr \rightarrow Br_2 + 2AgCl$

**3.** single displacement; $3Cl_2(g) + 2NiBr_3(aq) \rightarrow 2NiCl_3(aq) + 3Br_2(l)$

**page 235, Practice Problems**

**1.** double displacement; $AlCl_3(aq) + 3NaOH(aq) \rightarrow Al(OH)_3(s) + 3NaCl(aq)$

**2.** double displacement; $CuNO_3(aq) + KBr(aq) \rightarrow CuBr(s) + KNO_3(aq)$

**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; $FeCl_2(aq) + K_2S(aq) \rightarrow FeS(s) + 2KCl(aq)$
**16.** FeS(s)
**17.** (a) decomposition; $CaCl_2(s) \rightarrow Ca(s) + Cl_2(g)$
(b) decomposition; $2NaN_3(s) \rightarrow 2Na(s) + 3N_2(g)$
(c) double displacement; $Pb(NO_3)_2(aq) + Cu_2SO_4(aq) \rightarrow PbSO_4(s) + 2CuNO_3(aq)$
(d) decomposition; $2Ni_2O_3(s) \rightarrow 4Ni(s) + 3O_2(g)$
(e) combustion; $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$
(f) double displacement $3NaI(aq) + AlCl_3(aq) \rightarrow 3NaCl(aq) + AlI_3(s)$
**18.** (a) double displacement; $Na_2SO_4 + CaCl_2 \rightarrow 2NaCl + CaSO_4$
(b) synthesis; $3Mg + N_2 \rightarrow Mg_3N_2$
(c) double displacement; $Sr(OH)_2 + PbBr_2 \rightarrow SrBr_2 + Pb(OH)_2$
(d) synthesis; $4Na + O_2 \rightarrow 2Na_2O$
(e) synthesis; $N_2 + 3H_2 \rightarrow 2NH_3$
(f) decomposition; $2HCl \rightarrow H_2 + Cl_2$
(g) single displacement; $2AlI_3 + 3Br_2 \rightarrow 2AlBr_3 + 3I_2$
(h) neutralization; $HCl + NaOH \rightarrow NaCl + H_2O$
**19.** synthesis; $Ca + I_2 \rightarrow CaI_2$
**20.** single displacement; $Zn(s) + CuSO_4(aq) \rightarrow Cu(s) + ZnSO_4(aq)$
**21.** $Mg(s) + Br_2(l) \rightarrow MgBr_2(s)$
**22.** zinc bromide + silver nitrate → silver bromide + zinc nitrate $ZnBr_2(aq) + 2AgNO_3(aq) \rightarrow 2AgBr(s) + Zn(NO_3)_2(aq)$

**page 248, Unit B Review**

**2.** (a) $Cs^+$
(b) $O^{2-}$
(c) $Sn^{2+}$
(d) $Ni^{3+}$
(e) $Ti^{4+}$
**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) $2Na + Br_2 \rightarrow 2NaBr$
(b) $Mg + F_2 \rightarrow MgF_2$
(c) $2Al + 3Cl_2 \rightarrow 2AlCl_3$
(d) $6K + N_2 \rightarrow 2K_3N$
(e) $6Ca + P_4 \rightarrow 2Ca_3P_2$
**28.** single displacement
**29.** combustion
**32.** (a) 4
(b) 2
**34.** ammonium, $NH_4+$
**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) $Cu(NO_3)_2(aq) + Fe(s) \rightarrow Fe(NO_3)_2(aq) + Cu(s)$
(b) $2C_5H_{10}(l) + 15O_2(g) \rightarrow 10CO_2(g) + 10H_2O(l)$
(c) $Li_4C(s) + 2Ca(s) \rightarrow 4Li(s) + Ca_2C(s)$
(d) $2C_6H_{14}(g) + 19O_2(g) \rightarrow 12CO_2(g) + 14H_2O(l)$
(e) $3CsF(aq) + AlBr_3(aq) \rightarrow 3CsBr(aq) + AlF_3(s)$
**45.** calcium + bromine → calcium bromide
$Ca + Br_2 \rightarrow CaBr_2$
**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) NaBr
(b) $Be_3P_2$
(c) $Cu_2O$
(d) $Pd(NO_3)_4$
(e) $(NH_4)_2SO_4$
(f) $NH_4NO_3$
**51.** (a) disulphur trioxide
(b) diphosphorus pentasulphide
(c) oxygen difluoride
(d) dinitrogen trioxide
(e) carbon dioxide
**52.** (a) $SF_6$
(b) $CS_2$
(c) $N_2O$
(d) $CCl_4$
(e) 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; $2Ca + O_2 \rightarrow 2CaO$
**59.** (a) $CS_2 + 3O_2 \rightarrow CO_2 + 2SO_2$
(b) $Pb(NO_3)_2 + Na_2SO_4 \rightarrow PbSO_4 + 2NaNO_3$
(c) $KBr + AgNO_3 \rightarrow AgBr + KNO_3$
**60.** b, c
**61.** sulphuric acid + ammonium hydroxide → ammonium sulphate + water
$H_2SO_4 + 2NH_4OH \rightarrow (NH_4)_2SO_4 + 2H_2O$
**62.** benzene + oxygen → carbon dioxide + water
$2C_6H_6 + 15O_2 \rightarrow 12CO_2 + 6H_2O$

**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.** $h_i = 140$ cm or 1.40 m
**2.** $h_o = 0.80$ cm or 8.0 mm
**3.** $h_i = 12$ mm or 1.2 cm

**page 425, Practice Problems**
**1.** $d_o = 0.5$ cm
**2.** $d_i = 322$ cm or 3.22 m
**3.** $d_i = 120$ mm or 1.2 m

**page 433, 11.1 Check and Reflect**
**11.** $2.2 \times 10^2$ or about 220 times
**12.** 8.0 cm

**page 438, Practice Problems**
**1.** $n = 1.81$
**2.** $n = 1.43$
**3.** $n = 2.42$, diamond

**page 438, Practice Problems**
**1.** $2.21 \times 10^8$ m/s
**2.** $8.57 \times 10^7$ m/s
**3.** $1.69 \times 10^8$ m/s

**page 441, Practice Problems**
**1.** $\theta_2 = 22°$
**2.** $\theta_2 = 23°$
**3.** $\theta_2 = 35.5°$

**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°
**13.** 1.47, Pyrex glass
**14.** 1.13
**15.** 1.33, water
**16.** 17.0 m/s

**page 455, Practice Problems**
**1.** 3.5 mm
**2.** 30 mm
**3.** 2.86 mm

**page 456, Practice Problems**
**1.** larger, real, inverted, 60 cm
**2.** 0.06 cm
**3.** very far away

**page 457, Practice Problems**
**1.** 64 mm
**2.** 2.1 cm
**3.** 14 cm

**page 462, 11.3 Check and Reflect**
**6.** (a) $d_i = 12.0$ cm
(b) $h_i = 3.6$ cm
**7.** (a) $d_i = 60$ cm
(b) $M = 5.0$
**8.** $1.030 \times 10^5$ mm or about 103 m

**page 464, Chapter 11 Review**
**12.** (a) 14.6 mm or 1.46 cm
**14.** (a) 812 mm or 8.12 m
(b) 11 mm or 1.1 cm
**15.** 10°
**16.** 8.4°
**17.** 200 times
**18.** (a) 8.0 cm
(b) 1.5
**19.** 0.43 mm
**20.** 1.20
**21.** 0.0°
**25.** 8.0 mm

**page 477, Learning Checkpoint**
**1.** (a) less than 20°
(b) 180°

**page 504, Unit D Review**
**29.** 300 million m/s or $3.0 \times 10^8$ m/s
**67.** $3.4 \times 10^2$ or about 340 times
**68.** 0.241
**69.** $1.8 \times 10^7$
**70.** $1.97 \times 10^8$ m/s
**71.** 27.1°
**72.** $1.1 \times 10^{-4}$ m
**73.** 8.74 cm
**74.** 4.5 cm
**75.** 1.25 m

# Glossary

**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., $O_2$ (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 opposites 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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**Skills Reference**
p. 520; 521; 528; 534; 535; 536; 537; Ray Boudreau

**Charts**
p. 63; 92; 93; 340: IPCC, 2007: Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, Pachauri, R.K and Reisinger, A. (eds.)]. IPCC, Geneva, Switzerland, 104 pp.; p. 261; 343, 345 (c) Her Majesty the Queen in Right of Canada, Environment Canada, 2007. Reproduced with permission of the Minister of Public Works and Government Services Canada

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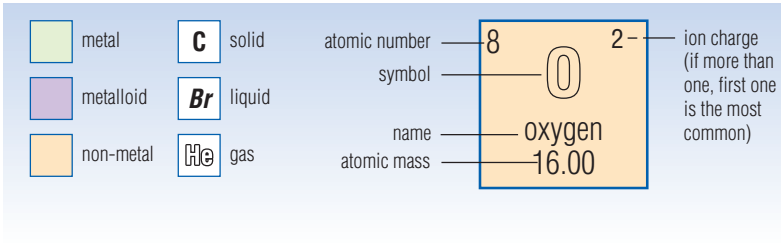
# Periodic Table of the Elements




| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 H 1+ hydrogen 1.01 | | | | | | | | |
| 2 | 3 Li 1+ lithium 6.94 | 4 Be 2+ beryllium 9.01 | | | | | | | |
| 3 | 11 Na 1+ sodium 22.99 | 12 Mg 2+ magnesium 24.31 | | | | | | | |
| 4 | 19 K 1+ potassium 39.10 | 20 Ca 2+ calcium 40.08 | 21 Sc 3+ scandium 44.96 | 22 Ti 4+ 3+ titanium 47.87 | 23 V 5+ 4+ vanadium 50.94 | 24 Cr 3+ 2+ chromium 52.00 | 25 Mn 2+ 4+ manganese 54.94 | 26 Fe 3+ 2+ iron 55.85 | 27 Co 2+ 3+ cobalt 58.93 |
| 5 | 37 Rb 1+ rubidium 85.47 | 38 Sr 2+ strontium 87.62 | 39 Y 3+ yttrium 88.91 | 40 Zr 4+ zirconium 91.22 | 41 Nb 5+ 3+ niobium 92.91 | 42 Mo 6+ molybdenum 95.94 | 43 Tc 7+ technetium (98) | 44 Ru 3+ 4+ ruthenium 101.07 | 45 Rh 3+ rhodium 102.91 |
| 6 | 55 Cs 1+ cesium 132.91 | 56 Ba 2+ barium 137.33 | 57–71 | 72 Hf 4+ hafnium 178.49 | 73 Ta 5+ tantalum 180.95 | 74 W 6+ tungsten 183.84 | 75 Re 7+ rhenium 186.21 | 76 Os 4+ osmium 190.23 | 77 Ir 4+ iridium 192.22 |
| 7 | 87 Fr 1+ francium (223) | 88 Ra 2+ radium (226) | 89–103 | 104 Rf rutherfordium (261) | 105 Db dubnium (262) | 106 Sg seaborgium (266) | 107 Bh bohrium (264) | 108 Hs hassium (277) | 109 Mt meitnerium (268) |

| | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|
| 6 | 57 La 3+ lanthanum 138.91 | 58 Ce 3+ cerium 140.12 | 59 Pr 3+ praseodymium 140.91 | 60 Nd 3+ neodymium 144.24 | 61 Pm 3+ promethium (145) | 62 Sm 3+ 2+ samarium 150.36 | 63 Eu 3+ 2+ europium 151.96 |
| 7 | 89 Ac 3+ actinium (227) | 90 Th 4+ thorium 232.04 | 91 Pa 5+ 4+ protactinium 231.04 | 92 U 6+ 4+ uranium 238.03 | 93 Np 5+ neptunium (237) | 94 Pu 4+ 6+ plutonium (244) | 95 Am 3+ 4+ americium (243) |

| 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | 2 **He** helium 4.00 |
| | | | 5 **B** boron 10.81 | 6 **C** carbon 12.01 | 7 **N** 3− nitrogen 14.01 | 8 **O** 2− oxygen 16.00 | 9 **F** 1− fluorine 19.00 | 10 **Ne** neon 20.18 |
| | | | 13 **Al** 3+ aluminum 26.98 | 14 **Si** silicon 28.09 | 15 **P** 3− phosphorus 30.97 | 16 **S** 2− sulphur 32.07 | 17 **Cl** 1− chlorine 35.45 | 18 **Ar** argon 39.95 |
| 28 **Ni** 2+ 3+ nickel 58.69 | 29 **Cu** 2+ 1+ copper 63.55 | 30 **Zn** 2+ zinc 65.41 | 31 **Ga** 3+ gallium 69.72 | 32 **Ge** 4+ germanium 72.64 | 33 **As** 3− arsenic 74.92 | 34 **Se** 2− selenium 78.96 | 35 ***Br*** 1− bromine 79.90 | 36 **Kr** krypton 83.80 |
| 46 **Pd** 2+ 4+ palladium 106.42 | 47 **Ag** 1+ silver 107.87 | 48 **Cd** 2+ cadmium 112.41 | 49 **In** 3+ indium 114.82 | 50 **Sn** 4+ 2+ tin 118.71 | 51 **Sb** 3+ 5+ antimony 121.76 | 52 **Te** 2− tellurium 127.60 | 53 **I** 1− iodine 126.90 | 54 **Xe** xenon 131.29 |
| 78 **Pt** 4+ 2+ platinum 195.08 | 79 **Au** 3+ 1+ gold 196.97 | 80 ***Hg*** 2+ 1+ mercury 200.59 | 81 **Tl** 1+ 3+ thallium 204.38 | 82 **Pb** 2+ 4+ lead 207.21 | 83 **Bi** 3+ 5+ bismuth 208.98 | 84 **Po** 2+ 4+ polonium (209) | 85 **At** 1− astatine (210) | 86 **Rn** radon (222) |
| 110 **Ds** darmstadtium (271) | 111 **Rg** roentgenium (272) | 112 **Uub** ununbium (285) | 113 **Uut** ununtrium (284) | 114 **Uuq** ununquadium (289) | 115 **Uup** ununpentium (288) | 116 **Uuh** ununhexium (293) | 117 **Uus** ununseptium (?) | 118 **Uuo** ununoctium (294) |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 64 **Gd** 3+ gadolinium 157.25 | 65 **Tb** 3+ terbium 158.93 | 66 **Dy** 3+ dysprosium 162.50 | 67 **Ho** 3+ holmium 164.93 | 68 **Er** 3+ erbium 167.26 | 69 **Tm** 3+ thulium 168.93 | 70 **Yb** 3+ 2+ ytterbium 173.04 | 71 **Lu** 2+ lutetium 174.97 | |
| 96 **Cm** 3+ curium (247) | 97 **Bk** 3+ 4+ berkelium (247) | 98 **Cf** 3+ californium (251) | 99 **Es** 3+ einsteinium (252) | 100 **Fm** 3+ fermium (257) | 101 **Md** 2+ 3+ mendelevium (258) | 102 **No** 2+ 3+ nobelium (259) | 103 **Lr** 3+ lawrencium (262) | |