Types of Chemical Reactions

2. Sample answers:

Type of Chemical Reaction	Reactants	Products	Descriptions (include general equations)
Synthesis (page 156)	2 or more elements (or simple compounds)	1 compound (larger compound)	$A + B \longrightarrow AB$ • reverse of decomposition • most are exothermic
Decomposition (page 158)	1 compound (larger compound)	2 or more elements (or simple compounds)	$AB \longrightarrow A + B$ • reverse of synthesis • most are endothermic
Single replacement (page 160)	element and compound	element and compound	Element is metal: $A + BX \longrightarrow AX + B$ Element is non-metal: $AX + Y \longrightarrow AY + X$
Double replacement (page 163)	2 compounds	2 compounds	$AX + BY \longrightarrow AY + BX$ • common product: insoluble solid (precipitate)
Combustion (pages 165 and 167)	element and oxygen or hydrocarbon and oxygen	carbon dioxide and water	Element: $A + O_2 \longrightarrow AO_x$ Hydrocarbon: $C_xH_y + O_2 \longrightarrow CO_2 + H_2O$ • rapid exothermic reaction
Neutralization (page 171)	acid and base	salt and water	$HA + BOH \longrightarrow BA + H_2O$ • salt is formed from the cation of the base and anion of the acid

Classifying Chemical Reactions

1. a) synthesis; 2, 1, 2

b) single replacement; already balanced

c) neutralization; 1, 2, 1, 2

d) double replacement; already balanced

e) decomposition; 2, 2, 1

f) combustion; 1, 2, 1, 2

g) single replacement; 4, 1, 2, 2

h) combustion; 1, 8, 5, 6

i) synthesis; already balanced

j) double replacement; 2, 3, 1, 6

k) neutralization; 1, 2, 1, 2

l) decomposition; 2, 2, 1

2. a) iodine monochloride ⟶ iodine + chlorine; decomposition;
$2ICl(g) + \text{energy} \longrightarrow I_2(g) + Cl_2(g)$

b) bromine + sodium iodide ⟶ iodine + sodium bromide; single replacement;
$Br_2(\ell) + 2NaI(s) \longrightarrow I_2(s) + 2NaBr(aq)$

c) sodium azide ⟶ sodium + nitrogen; decomposition;
$2NaN_3(s) \longrightarrow 2Na(s) + 3N_2(g)$

d) naphthalene + oxygen ⟶ carbon dioxide + water + energy; combustion;
$C_{10}H_8(s) + 12O_2(g) \longrightarrow 10CO_2(g) + 4H_2O(\ell) + \text{energy}$

e) phosphoric acid + barium hydroxide ⟶ barium phosphate + water;
neutralization; $2H_3PO_4(aq) + 3Ba(OH)_2(aq) \longrightarrow Ba_3(PO_4)_2(s) + 6H_2O(\ell)$

f) iron(III) nitrate + magnesium sulfide ⟶ iron(III) sulfide + magnesium nitrate;
double replacement; $2Fe(NO_3)_3(aq) + 3MgS(aq) \longrightarrow Fe_2S_3(s) + 3Mg(NO_3)_2(aq)$

g) tin(IV) hydroxide + hydrogen bromide ⟶ water + tin(IV) bromide;
neutralization; $Sn(OH)_4(aq) + 4HBr(aq) \longrightarrow 4H_2O(\ell) + SnBr_4(aq)$

h) sodium carbonate + aluminum chloride ⟶ aluminum carbonate + sodium chloride; double replacement; $3Na_2CO_3(aq) + 2AlCl_3(aq) \longrightarrow Al_2(CO_3)_3(s) + 6NaCl(aq)$

i) dinitrogen monoxide ⟶ nitrogen + oxygen; decomposition;
$2N_2O(g) \longrightarrow 2N_2(g) + O_2(g)$

j) iron + iodine ⟶ iron(II) iodide; synthesis; $Fe(s) + I_2(g) \longrightarrow FeI_2(g)$

k) glucose + oxygen ⟶ carbon dioxide + water + energy; combustion;
$C_6H_{12}O_6(s) + 6O_2(g) \longrightarrow 6CO_2(g) + 6H_2O(\ell) + \text{energy}$

l) chromium + tin(IV) chloride ⟶ tin + chromium(III) chloride;
single replacement; $4Cr(s) + 3SnCl_4(aq) \longrightarrow 3Sn(s) + 4CrCl_3(aq)$

Predicting Products

1. a) $2C_2H_2 + 5O_2 \longrightarrow 4CO_2 + 2H_2O$; combustion

b) $Cl_2 + 2KI \longrightarrow 2KCl + I_2$; single replacement

c) $4Al + 3O_2 \longrightarrow 2Al_2O_3$; synthesis

d) $2AgNO_3 + Li_2CrO_4 \longrightarrow Ag_2CrO_4 + 2LiNO_3$; double replacement

e) $2HgO \longrightarrow 2Hg + O_2$; decomposition

f) $2HNO_3 + Ba(OH)_2 \longrightarrow Ba(NO_3)_2 + 2H_2O$; neutralization

g) $Zn + H_2SO_4 \longrightarrow ZnSO_4 + H_2$; single replacement

h) $2Ca + O_2 \longrightarrow 2CaO$; synthesis

i) $NaOH + CH_3COOH \longrightarrow NaCH_3COO + H_2O$; neutralization

j) $45O_2 + 2C_{15}H_{30} \longrightarrow 30CO_2 + 30H_2O$; combustion

k) $Rb_2SO_4 + 2KF \longrightarrow K_2SO_4 + 2RbF$; double replacement

l) $8ZnS \longrightarrow 8Zn + S_8$; decomposition

2. a) hydrogen carbonate $\longrightarrow$ carbon dioxide + water; decomposition; $H_2CO_3(aq) \longrightarrow CO_2(g) + H_2O(\ell)$

b) fluorine + potassium chloride $\longrightarrow$ chlorine + potassium fluoride; single replacement; $F_2(g) + 2KCl(aq) \longrightarrow Cl_2(g) + 2KF(s)$

c) lead(II) chlorate + potassium iodide $\longrightarrow$ lead(II) iodide + potassium chlorate; double replacement; $Pb(ClO_3)_2(aq) + 2KI(aq) \longrightarrow PbI_2(s) + 2KClO_3(aq)$

d) sodium + iodine $\longrightarrow$ sodium iodide; synthesis; $2Na(s) + I_2(g) \longrightarrow 2NaI$

e) benzene + oxygen $\longrightarrow$ carbon dioxide + water (+ energy); combustion; $2C_6H_6(\ell) + 15O_2(g) \longrightarrow 12CO_2(g) + 6H_2O(\ell)$ (+ energy)

f) ammonium hydroxide + hydrogen chloride $\longrightarrow$ ammonium chloride + water; neutralization; $NH_4OH(aq) + HCl(aq) \longrightarrow NH_4Cl(aq) + H_2O(\ell)$

g) cobalt(II) bromide (+ energy) $\longrightarrow$ cobalt + bromine; decomposition; $CoBr_2(s)$ (+ energy) $\longrightarrow Co(s) + Br_2(g)$

h) aluminum + iron(III) oxide (+ energy) $\longrightarrow$ aluminum oxide + iron; single replacement; $2Al(s) + Fe_2O_3(s)$ (+ energy) $\longrightarrow Al_2O_3(s) + 2Fe(s)$

i) hydrogen + oxygen $\longrightarrow$ water; synthesis; $2H_2(g) + O_2(g) \longrightarrow 2H_2O(\ell)$

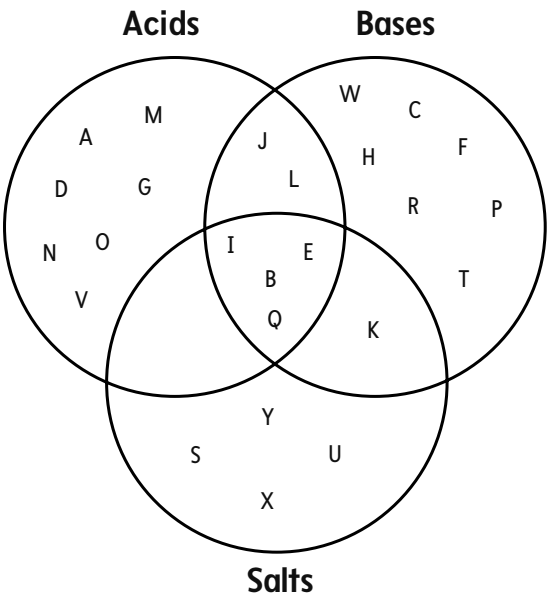
j) lithium sulfate + barium chloride $\longrightarrow$ barium sulfate + lithium chloride; double replacement; $Li_2SO_4(aq) + BaCl_2(aq) \longrightarrow BaSO_4(s) + 2LiCl(aq)$

k) aluminum hydroxide + gastric juice $\longrightarrow$ aluminum chloride + water; neutralization; $Al(OH)_3(s) + 3HCl(aq) \longrightarrow AlCl_3(aq) + 3H_2O(\ell)$

l) propane + oxygen $\longrightarrow$ carbon dioxide + water; combustion; $C_3H_8(g) + 5O_2(g) \longrightarrow 3CO_2(g) + 4H_2O(\ell)$

Acids, Bases, and Salts

1.



2. **a)** salt
b) acid
c) base
d) acid
e) salt
f) none
g) none
h) base
i) acid
j) salt
k) none
l) acid
m) base
n) none

3. They are substances that consist of atoms of non-metal elements joined together by covalent bonds. They are either molecules or covalent compounds.

4. **a)** hydrochloric acid, HCl(aq)
b) sulfuric acid, H_2SO_4(aq)
c) sodium chloride, NaCl
d) carbonic acid, H_2CO_3(aq)
e) NaOH(aq)

5. Bicarbonate is a base that reacts and neutralizes the hydrochloric acid in our stomach.

6. Student answers may vary. Some examples:

Test 1: Litmus paper test.

Result: If the solution is acidic, red litmus paper will remain red and blue litmus paper will turn red.

Test 2: Metal (magnesium) test.

Result: If the solution is acidic, the small magnesium strip will react with the solution, and H_2 gas bubbles should form.

Test 3: Reaction with base (baking soda).

Result: If the solution is acidic, it will neutralize and react with baking soda to produce carbon dioxide gas (bubbles).

pH Scale

1. stomach acid, pH = 1

2. oven cleaner, pH = 13

3. pure water, pH = 7

4. grapes (pH = 3), tomato (pH = 4), water (pH = 7), egg (pH = 8), baking soda (pH = 9), bleach (pH = 13). The lower the pH, the more acidic it is. The higher the pH, the less acidic (more basic) it is.

5. a) banana (pH = 5) and milk (pH = 6); banana is more acidic

b) Banana has a higher concentration of hydrogen ions and a lower concentration of hydroxide ions than milk.

6. a) Solution B is more acidic by 10^2 (or 100) times.

b) Concentration of hydrogen ions in Solution A is 100 times less than that of Solution B.

7. a) bleach

b) pH = 12 (3 units higher than the pH value of baking soda, pH = 9)

8. a) grapes

b) pH = 3 (3 units lower than the pH value of milk, pH = 6)

9. a) Student sketches of pH scale should be similar to pH scale on workbook page 110 and Figure 2.40 on page 170 of the student textbook.

b) Sea water, pH = 8
Liquid drain cleaner, pH = 14
Soft drink, pH = 3
Blood, pH = 7.3
Soap, pH = 10
Human saliva, pH = 6
Black coffee, pH = 5

Apples, pH = 3
Normal rain, pH = 5.6
Orange juice, pH = 3
Battery acid, pH = 0

pH Indicators

1. a) red

b) orange

c) yellow

d) colourless

e) blue

f) red

2. a) carbonic acid, $H_2CO_3(aq)$

b) Student answers may vary. Answers may include: similar pH value of 2 (low pH), taste sour, good conductors of electric current, good electrolytes, turn litmus red, have more hydrogen ions than hydroxide ions, ionic compounds.

c) Red. Soft drink is comparable to the acidity of lemon juice (pH 2). Solutions with pH values less than 4.8 cause methyl red to turn red.

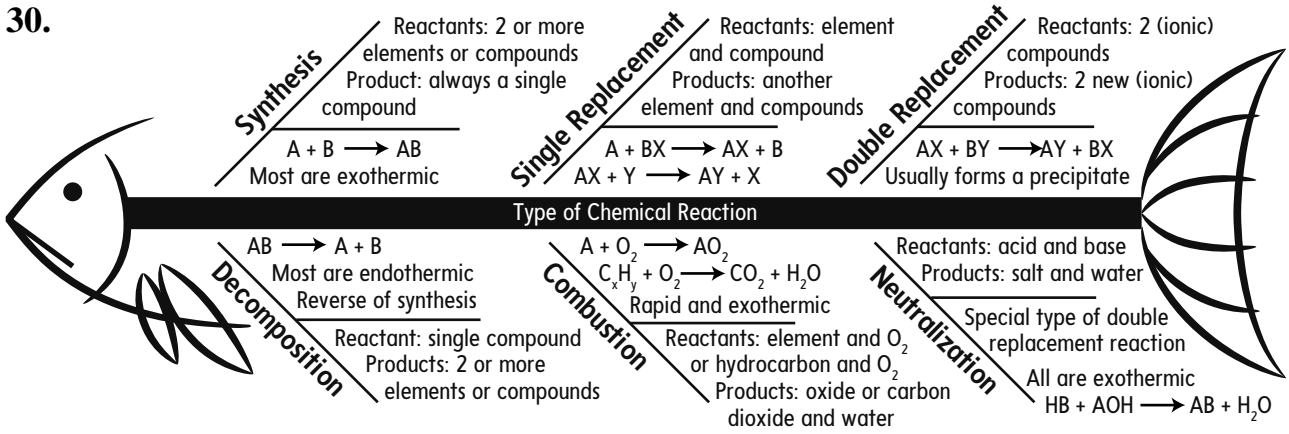
3. Examples of natural acid-base indicators that students might cite include grape juice, red cabbage juice, rose petals, hibiscus, and herbal tea.

2.4 Assessment

1. C
2. E
3. F
4. B
5. D
6. A
7. E
8. C
9. B
10. D
11. A
12. F
13. D
14. B
15. C
16. C
17. A
18. D
19. A
20. C
21. D
22. A
23. B
24. B
25. C
26. C
27. A

28. A **29.** C

30.


Synthesis
Reactants: 2 or more elements or compounds
Product: always a single compound
A + B → AB
Most are exothermic
Single Replacement
Reactants: element and compound
Products: another element and compounds
A + BX → AX + B
AX + Y → AY + X
Double Replacement
Reactants: 2 (ionic) compounds
Products: 2 new (ionic) compounds
AX + BY → AY + BX
Usually forms a precipitate
Type of Chemical Reaction
Decomposition
AB → A + B
Most are endothermic
Reverse of synthesis
Reactant: single compound
Products: 2 or more elements or compounds
Combustion
A + O2 → AO2
CxHy + O2 → CO2 + H2O
Rapid and exothermic
Reactants: element and O2 or hydrocarbon and O2
Products: oxide or carbon dioxide and water
Neutralization
Reactants: acid and base
Products: salt and water
Special type of double replacement reaction
All are exothermic
HB + AOH → AB + H2O