

Unit 5: Chemical Equations and Reactions & Stoichiometry**Chapter 8: Chemical Equations and Reactions****8.1: Describing Chemical Reactions**

(Section Review on pg. 266)

5. $C_3H_8 + O_2 \rightarrow CO_2 + H_2O$ 6. $C_3H_8(g) + O_2(g) \rightarrow CO_2(g) + H_2O(l)$
 9. silicon tetrachloride + magnesium \rightarrow silicon + magnesium chloride ; $SiCl_4(g) + Mg(s) \rightarrow Si(s) + MgCl_2(s)$
 10. magnesium + oxygen \rightarrow magnesium oxide ; $Mg(s) + O_2(g) \rightarrow MgO(s)$

8.2: Balancing Chemical Equations

(Practice on pg. 269)

1. $P_4 + 5 O_2 \rightarrow 2 P_2O_5$ 2. $C_3H_8 + 5 O_2 \rightarrow 3 CO_2 + 4 H_2O$
 3. $Ca_2Si + 4 Cl_2 \rightarrow 2 CaCl_2 + SiCl_4$ 4. $2 Si + CO_2 \rightarrow SiC + SiO_2$

(Practice on pg. 271)

1. $2 C_2H_2 + 5 O_2 \rightarrow 4 CO_2 + 2 H_2O$ 2. $2 Fe(OH)_2 + H_2O_2 \rightarrow 2 Fe(OH)_3$
 3. $2 FeS_2 + 5 Cl_2 \rightarrow 2 FeCl_3 + 2 S_2Cl_2$

(Practice on pg. 273)

1. $HgCl_2 + 2 AgNO_3 \rightarrow Hg(NO_3)_2 + 2 AgCl$ 2. $2 Al + 3 Hg(CH_3COO)_2 \rightarrow 2 Al(CH_3COO)_3 + 3 Hg$
 3. $3 Ca(OH)_2 + 2 H_3PO_4 \rightarrow Ca_3(PO_4)_2 + 6 H_2O$

(Section Review on pg. 274)

4. (a) potassium chlorate \rightarrow potassium chloride + oxygen ; $KClO_3 \rightarrow KCl + O_2$; $2 KClO_3 \rightarrow 2 KCl + 3 O_2$
 (b) silver + sulfur \rightarrow silver sulfide ; $Ag + S_8 \rightarrow Ag_2S$; $16 Ag + S_8 \rightarrow 8 Ag_2S$
 (c) sodium hydrogen carbonate \rightarrow sodium carbonate + carbon dioxide + water ;
 $NaHCO_3 \rightarrow Na_2CO_3 + CO_2 + H_2O$; $2 NaHCO_3 \rightarrow Na_2CO_3 + CO_2 + H_2O$
 5. (a) $2 ZnS + 3 O_2 \rightarrow 2 ZnO + 2 SO_2$ (b) $Fe_2O_3 + 3 CO \rightarrow 2 Fe + 3 CO_2$
 (c) $3 AgNO_3 + AlCl_3 \rightarrow 3 AgCl + Al(NO_3)_3$ (d) $Ni(ClO_3)_2 \rightarrow NiCl_2 + 3 O_2$
 6. (a) $(NH_4)_2Cr_2O_7 \rightarrow Cr_2O_3 + N_2 + 4 H_2O$ (b) $2 NH_3 + 3 CuO \rightarrow N_2 + 3 Cu + 3 H_2O$
 (c) $Na_2SiF_6 + 4 Na \rightarrow Si + 6 NaF$ (d) $2 C_4H_{10} + 13 O_2 \rightarrow 8 CO_2 + 10 H_2O$
 7. $P_4 + 3 O_2 \rightarrow 2 P_2O_3$ (Given only 4 atoms of phosphorus – or 1 molecule of P_4 , even if there are more than 3 molecules of oxygen, there can only be two molecules of P_2O_3 . This is because the number of phosphorus atoms limits how many P_2O_3 molecules can form.)
 9. $2 H_2 + O_2 \rightarrow 2 H_2O$
 Reactants: $2(2.02 \text{ amu}) + 1(32.00 \text{ amu}) = 36.04 \text{ amu}$; Product: $2(18.02 \text{ amu}) = 36.04 \text{ amu}$
 10. The correct equation should be $2 Fe(s) + 3 Cl_2(g) \rightarrow 2 FeCl_3(s)$; Chlorine is a diatomic element (Cl_2).

8.3: Classifying Chemical Reactions

(Practice on pg. 279)

1. (Hydrocarbon Combustion) $2 C_4H_{10} + 13 O_2 \rightarrow 8 CO_2 + 10 H_2O$ 2. (Synthesis) $H_2O + CaO \rightarrow Ca(OH)_2$
 3. (Synthesis) $4 Li + O_2 \rightarrow 2 Li_2O$ 4. (Decomposition) $H_2CO_3 \rightarrow H_2O + CO_2$

(Practice on pg. 282)

1. $2 Al + 3 Zn(NO_3)_2 \rightarrow 2 Al(NO_3)_3 + 3 Zn$ 2. $2 Na + 2 H_2O \rightarrow 2 NaOH + H_2$ 3. No reaction

(Section Review on pg. 285)

4. water and carbon dioxide 7. a solid precipitate, a gas, or a molecular compound, such as water
8. (a) (single displacement) $\text{Cl}_2(g) + 2 \text{NaBr}(aq) \rightarrow 2 \text{NaCl}(aq) + \text{Br}_2(l)$
 (b) (synthesis) $\text{CaO}(s) + \text{H}_2\text{O}(l) \rightarrow \text{Ca(OH)}_2(aq)$
 (c) (decomposition) $\text{Ca(ClO}_3)_2(s) \rightarrow \text{CaCl}_2(s) + 3 \text{O}_2(g)$
 (d) (double displacement) $2 \text{AgNO}_3(aq) + \text{K}_2\text{SO}_4(aq) \rightarrow \text{Ag}_2\text{SO}_4(s) + 2 \text{KNO}_3(aq)$
 (e) (single displacement) $\text{Zn}(s) + \text{CuBr}_2(aq) \rightarrow \text{ZnBr}_2(aq) + \text{Cu}(s)$
 (f) (hydrocarbon combustion) $2 \text{C}_8\text{H}_{18}(l) + 25 \text{O}_2(g) \rightarrow 16 \text{CO}_2(g) + 18 \text{H}_2\text{O}(g)$
9. (a) no reaction
 (b) (single displacement) $\text{Mg}(s) + \text{Cu(NO}_3)_2(aq) \rightarrow \text{Cu}(s) + \text{Mg(NO}_3)_2(aq)$
 (c) (synthesis) $4 \text{Al}(s) + 3 \text{O}_2(g) \rightarrow 2 \text{Al}_2\text{O}_3(s)$
 (d) (double displacement) $\text{H}_2\text{SO}_4(aq) + 2 \text{KOH}(aq) \rightarrow \text{K}_2\text{SO}_4(aq) + 2 \text{HOH}(l)$
10. (a) (decomposition) $2 \text{HgO} \rightarrow 2 \text{Hg} + \text{O}_2$
 (b) (hydrocarbon combustion) $2 \text{C}_3\text{H}_7\text{OH} + 9 \text{O}_2 \rightarrow 6 \text{CO}_2 + 8 \text{H}_2\text{O}$
 (c) (single displacement) $\text{Zn} + \text{CuSO}_4 \rightarrow \text{Cu} + \text{ZnSO}_4$
 (d) (double displacement) $\text{BaCl}_2 + \text{Na}_2\text{SO}_4 \rightarrow 2 \text{NaCl} + \text{BaSO}_4$
 (e) (synthesis) $\text{Zn} + \text{F}_2 \rightarrow \text{ZnF}_2$
 (f) (hydrocarbon combustion) $2 \text{C}_5\text{H}_{10} + 15 \text{O}_2 \rightarrow 10 \text{CO}_2 + 10 \text{H}_2\text{O}$
14. Yes, copper is higher than silver on the activity series and will replace the silver in silver nitrate.

8.4: Writing Net-Ionic Equations

(Section Review on pg. 289)

3. No, $\text{NaCl}(aq)$ is an ionic solution and should be written as Na^+ and Cl^- . Since both ions are shown on both sides of the equation, they are all spectator ions.
4. Mg^{2+} and NO_3^-
6. (a) $\text{Br}_2(l) + 2 \text{Na}^+(aq) + 2 \text{I}^-(aq) \rightarrow 2 \text{Na}^+(aq) + 2 \text{Br}^-(aq) + \text{I}_2(s)$
 (b) $\text{Ca}^{2+}(aq) + 2 \text{OH}^-(aq) + 2 \text{H}^+(aq) + 2 \text{Cl}^-(aq) \rightarrow \text{Ca}^{2+}(aq) + 2 \text{Cl}^-(aq) + 2 \text{H}_2\text{O}(l)$
 (c) $\text{Mg}(s) + 2 \text{Ag}^+(aq) + 2 \text{NO}_3^-(aq) \rightarrow 2 \text{Ag}(s) + \text{Mg}^{2+}(aq) + 2 \text{NO}_3^-(aq)$
 (d) $\text{Ag}^+(aq) + \text{NO}_3^-(aq) + \text{K}^+(aq) + \text{Br}^-(aq) \rightarrow \text{AgBr}(s) + \text{K}^+(aq) + \text{NO}_3^-(aq)$
 (e) $\text{Ni}(s) + \text{Pb}^{2+}(aq) + 2 \text{NO}_3^-(aq) \rightarrow \text{Ni}^{2+}(aq) + 2 \text{NO}_3^-(aq) + \text{Pb}(s)$
 (f) $\text{Ca}(s) + 2 \text{H}_2\text{O}(l) \rightarrow \text{Ca}^{2+}(aq) + 2 \text{OH}^-(aq) + \text{H}_2(g)$
7. (a) (spectator ion = Na^+) $\text{Br}_2(l) + 2 \text{I}^-(aq) \rightarrow 2 \text{Br}^-(aq) + \text{I}_2(s)$
 (b) (spectator ions = Ca^{2+} and Cl^-) $\text{OH}^-(aq) + \text{H}^+(aq) \rightarrow \text{H}_2\text{O}(l)$
 (c) (spectator ion = NO_3^-) $\text{Mg}(s) + 2 \text{Ag}^+(aq) \rightarrow 2 \text{Ag}(s) + \text{Mg}^{2+}(aq)$
 (d) (spectator ions = K^+ and NO_3^-) $\text{Ag}^+(aq) + \text{Br}^-(aq) \rightarrow \text{AgBr}(s)$
 (e) (spectator ion = NO_3^-) $\text{Ni}(s) + \text{Pb}^{2+}(aq) \rightarrow \text{Ni}^{2+}(aq) + \text{Pb}(s)$
 (f) (no spectator ions) $\text{Ca}(s) + 2 \text{H}_2\text{O}(l) \rightarrow \text{Ca}^{2+}(aq) + 2 \text{OH}^-(aq) + \text{H}_2(g)$
8. (a) (products = $\text{Au}(s)$ and $\text{AgCl}(s)$) $\text{Au}^{3+}(aq) + 3 \text{Cl}^-(aq) + 3 \text{Ag}(s) \rightarrow \text{Au}(s) + 3 \text{AgCl}(s)$
 (b) (products = $\text{AgCl}(s)$ and $\text{Ca(NO}_3)_2(aq)$)
 $2 \text{Ag}^+(aq) + 2 \text{NO}_3^-(aq) + \text{Ca}^{2+}(aq) + 2 \text{Cl}^-(aq) \rightarrow 2 \text{AgCl}(s) + \text{Ca}^{2+} + 2 \text{NO}_3^-(aq)$
 (c) (products = $\text{Ni}(s)$ and $\text{Al}_2(\text{SO}_4)_3(aq)$)
 $2 \text{Al}(s) + 3 \text{Ni}^{2+}(aq) + 3 \text{SO}_4^{2-}(aq) \rightarrow 3 \text{Ni}(s) + 2 \text{Al}^{3+}(aq) + 3 \text{SO}_4^{2-}(aq)$
 (d) (products = $\text{NaOH}(aq)$ and $\text{H}_2(g)$) $2 \text{Na}(s) + 2 \text{HOH}(l) \rightarrow 2 \text{Na}^+(aq) + 2 \text{OH}^-(aq) + \text{H}_2(g)$
 (e) (products = $\text{AgCl}(s)$ and $\text{NaNO}_3(aq)$)
 $\text{Ag}^+(aq) + \text{Cl}^-(aq) + \text{Na}^+(aq) + \text{NO}_3^-(aq) \rightarrow \text{AgCl}(s) + \text{Na}^+(aq) + \text{NO}_3^-(aq)$

9. (a) (no spectator ions) $\text{Au}^{3+}_{(aq)} + 3 \text{Cl}^{-}_{(aq)} + 3 \text{Ag}_{(s)} \rightarrow \text{Au}_{(s)} + 3 \text{AgCl}_{(s)}$
 (b) (spectator ions = Ca^{2+} and NO_3^{-}) $2 \text{Ag}^{+}_{(aq)} + 2 \text{Cl}^{-}_{(aq)} \rightarrow 2 \text{AgCl}_{(s)}$
 (c) (spectator ion = SO_4^{2-}) $2 \text{Al}_{(s)} + 3 \text{Ni}^{2+}_{(aq)} \rightarrow 3 \text{Ni}_{(s)} + 2 \text{Al}^{3+}_{(aq)}$
 (d) (no spectator ions) $2 \text{Na}_{(s)} + 2 \text{HOH}_{(l)} \rightarrow 2 \text{Na}^{+}_{(aq)} + 2 \text{OH}^{-}_{(aq)} + \text{H}_2_{(g)}$
 (e) (spectator ion = Na^{+} and NO_3^{-}) $\text{Ag}^{+}_{(aq)} + \text{Cl}^{-}_{(aq)} \rightarrow \text{AgCl}_{(s)}$
10. (a) $2 \text{Ag}^{+}_{(aq)} + 2 \text{NO}_3^{-}_{(aq)} + 2 \text{Na}^{+}_{(aq)} + \text{SO}_4^{2-}_{(aq)} \rightarrow 2 \text{Na}^{+}_{(aq)} + 2 \text{NO}_3^{-}_{(aq)} + \text{Ag}_2\text{SO}_4_{(s)}$
 (b) $2 \text{Al}_{(s)} + 3 \text{Ni}^{2+}_{(aq)} + 6 \text{I}^{-}_{(aq)} \rightarrow 3 \text{Ni}_{(s)} + 2 \text{Al}^{3+}_{(aq)} + 6 \text{I}^{-}_{(aq)}$
 (c) $2 \text{K}^{+}_{(aq)} + \text{SO}_4^{2-}_{(aq)} + \text{Ca}^{2+}_{(aq)} + 2 \text{Cl}^{-}_{(aq)} \rightarrow \text{CaSO}_4_{(s)} + 2 \text{K}^{+}_{(aq)} + 2 \text{Cl}^{-}_{(aq)}$
 (d) $\text{Mg}_{(s)} + \text{Cu}^{2+}_{(aq)} + 2 \text{Br}^{-}_{(aq)} \rightarrow \text{Cu}_{(s)} + \text{Mg}^{2+}_{(aq)} + 2 \text{Br}^{-}_{(aq)}$
 (e) $\text{Pb}^{2+}_{(aq)} + 2 \text{NO}_3^{-}_{(aq)} + 2 \text{Na}^{+}_{(aq)} + 2 \text{Cl}^{-}_{(aq)} \rightarrow \text{PbCl}_2_{(s)} + 2 \text{Na}^{+}_{(aq)} + 2 \text{NO}_3^{-}_{(aq)}$
11. (a) (spectator ions = NO_3^{-} and Na^{+}) $2 \text{Ag}^{+}_{(aq)} + \text{SO}_4^{2-}_{(aq)} \rightarrow \text{Ag}_2\text{SO}_4_{(s)}$
 (b) (spectator ion = I^{-}) $2 \text{Al}_{(s)} + 3 \text{Ni}^{2+}_{(aq)} \rightarrow 3 \text{Ni}_{(s)} + 2 \text{Al}^{3+}_{(aq)}$
 (c) (spectator ions = K^{+} and SO_4^{2-}) $\text{Ca}^{2+}_{(aq)} + 2 \text{Cl}^{-}_{(aq)} \rightarrow \text{CaSO}_4_{(s)}$
 (d) (spectator ion = Br^{-}) $\text{Mg}_{(s)} + \text{Cu}^{2+}_{(aq)} \rightarrow \text{Cu}_{(s)} + \text{Mg}^{2+}_{(aq)}$
 (e) (spectator ions = NO_3^{-} and Na^{+}) $\text{Pb}^{2+}_{(aq)} + 2 \text{Cl}^{-}_{(aq)} \rightarrow \text{PbCl}_2_{(s)}$
12. All potassium compounds are soluble. Hence K^{+} will always be a spectator ion in double displacement reactions.
15. If a double-displacement reaction has four spectator ions, then both reactants and products are soluble. All four ions are spectator ions and no reaction (as well as no observations of chemical change) will happen.

(Chapter Review on pg. 293 to 295)

26. (a) $\text{H}_2 + \text{Cl}_2 \rightarrow 2 \text{HCl}$ (b) $2 \text{Al} + \text{Fe}_2\text{O}_3 \rightarrow 2 \text{Fe} + \text{Al}_2\text{O}_3$
 (c) $\text{Ba}(\text{ClO}_3)_2 \rightarrow \text{BaCl}_2 + 3 \text{O}_2$ (d) omit
27. (a) $\text{Fe}_2\text{O}_3 + 3 \text{Mg} \rightarrow 3 \text{MgO} + 2 \text{Fe}$ (b) $3 \text{NO}_2 + \text{H}_2\text{O} \rightarrow 2 \text{HNO}_3 + \text{NO}$
 (c) $\text{SiCl}_4 + 2 \text{H}_2\text{O} \rightarrow \text{SiO}_2 + 4 \text{HCl}$
28. (a) $4 \text{Fe} + 3 \text{O}_2 \rightarrow 2 \text{Fe}_2\text{O}_3$ (b) $2 \text{H}_2\text{O}_2 \rightarrow 2 \text{H}_2\text{O} + \text{O}_2$
 (c) $2 \text{C}_8\text{H}_{18} + 25 \text{O}_2 \rightarrow 16 \text{CO}_2 + 18 \text{H}_2\text{O}$ (d) $2 \text{Al} + 3 \text{F}_2 \rightarrow 2 \text{AlF}_3$
29. (a) $2 \text{C}_3\text{H}_7\text{OH} + 9 \text{O}_2 \rightarrow 6 \text{CO}_2 + 8 \text{H}_2\text{O}$ (b) $2 \text{Al} + 3 \text{Fe}(\text{NO}_3)_2 \rightarrow 2 \text{Al}(\text{NO}_3)_3 + 3 \text{Fe}$
 (c) $2 \text{PbO}_2 \rightarrow 2 \text{PbO} + \text{O}_2$
30. (a) $\text{Zn} + \text{Pb}(\text{NO}_3)_2 \rightarrow \text{Pb} + \text{Zn}(\text{NO}_3)_2$ (b) $\text{H}_2\text{OOC}(\text{COO}) + 2 \text{NaOH} \rightarrow \text{Na}_2\text{OOC}(\text{COO}) + 2 \text{HOH}$
 (c) $2 \text{Al} + 3 \text{CuSO}_4 \rightarrow \text{Al}_2(\text{SO}_4)_3 + 3 \text{Cu}$
31. (a) $\text{CuSO}_4 + (\text{NH}_4)_2\text{S} \rightarrow \text{CuS} + (\text{NH}_4)_2\text{SO}_4$ (b) $2 \text{HNO}_3 + \text{Ba}(\text{OH})_2 \rightarrow 2 \text{HOH} + \text{Ba}(\text{NO}_3)_2$
 (c) $3 \text{BaCl}_2 + 2 \text{H}_3\text{PO}_4 \rightarrow \text{Ba}_3(\text{PO}_4)_2 + 6 \text{HCl}$
32. (a) $2 \text{Zn} + \text{O}_2 \rightarrow 2 \text{ZnO}$ (b) $\text{F}_2 + \text{Mg} \rightarrow \text{MgF}_2$
 (c) $\text{Cl}_2 + 2 \text{K} \rightarrow 2 \text{KCl}$ (d) $\text{H}_2 + \text{I}_2 \rightarrow 2 \text{HI}$
33. (a) $2 \text{HgO} \rightarrow 2 \text{Hg} + \text{O}_2$ (b) $2 \text{H}_2\text{O} \rightarrow 2 \text{H}_2 + \text{O}_2$
 (c) $2 \text{AgCl} \rightarrow 2 \text{Ag} + \text{Cl}_2$ (d) $2 \text{KOH} \rightarrow \text{K}_2\text{O} + \text{HOH}$
34. (a) $2 \text{C}_3\text{H}_6 + 9 \text{O}_2 \rightarrow 6 \text{CO}_2 + 6 \text{H}_2\text{O}$ (b) $\text{C}_5\text{H}_{12} + 8 \text{O}_2 \rightarrow 5 \text{CO}_2 + 6 \text{H}_2\text{O}$
 (c) $2 \text{CH}_3\text{OH} + 3 \text{O}_2 \rightarrow 2 \text{CO}_2 + 4 \text{H}_2\text{O}$ (d) $\text{C}_{12}\text{H}_{22}\text{O}_{11} + 12 \text{O}_2 \rightarrow 12 \text{CO}_2 + 11 \text{H}_2\text{O}$
35. (a) (hydrocarbon combustion) $\text{C}_3\text{H}_8 + 5 \text{O}_2 \rightarrow 3 \text{CO}_2 + 4 \text{H}_2\text{O}$
 (b) (decomposition) $\text{Na}_2\text{CO}_3 \rightarrow \text{Na}_2\text{O} + \text{CO}_2$
 (c) (decomposition) $\text{Ba}(\text{OH})_2 \rightarrow \text{BaO} + 2 \text{H}_2\text{O}$
 (d) (combustion) $\text{C}_2\text{H}_5\text{OH} + 3 \text{O}_2 \rightarrow 2 \text{CO}_2 + 3 \text{H}_2\text{O}$
36. (a) $\text{Mg}_{(s)} + \text{CuCl}_2_{(aq)} \rightarrow \text{MgCl}_2_{(aq)} + \text{Cu}_{(s)}$ (b) $\text{Pb}(\text{NO}_3)_2_{(aq)} + \text{Zn}_{(s)} \rightarrow \text{Zn}(\text{NO}_3)_2_{(aq)} + \text{Pb}_{(s)}$
 (c) $2 \text{KI}_{(aq)} + \text{Cl}_2_{(g)} \rightarrow 2 \text{KCl}_{(aq)} + \text{I}_2_{(s)}$ (d) no reaction

37. (a) $2 \text{HOH}_{(l)} + \text{Ba}_{(s)} \rightarrow \text{Ba}(\text{OH})_{2(aq)} + \text{H}_{2(g)}$ (b) $4 \text{Ca}_{(s)} + \text{O}_{2(g)} \rightarrow 2 \text{CaO}_{(s)}$ (c) no reaction
38. (a) (combustion) $2 \text{C}_2\text{H}_6 + 7 \text{O}_2 \rightarrow 4 \text{CO}_2 + 6 \text{H}_2\text{O}$
 (b) (single displacement) $3 \text{H}_2\text{SO}_4 + 2 \text{Al} \rightarrow \text{Al}_2(\text{SO}_4)_3 + 3 \text{H}_2$
 (c) (synthesis) $\text{N}_2 + 3 \text{Mg} \rightarrow \text{Mg}_3\text{N}_2$
 (d) (decomposition) $\text{Na}_2\text{CO}_3 \rightarrow \text{Na}_2\text{O} + \text{CO}_2$
 (e) (double displacement) no reaction
39. (a) (single displacement) $2 \text{HOH} + 2 \text{Li} \rightarrow 2 \text{LiOH} + \text{H}_2$
 (b) (double displacement) $\text{AgNO}_3 + \text{HCl} \rightarrow \text{AgCl}_{(s)} + \text{HNO}_3$
 (c) (decomposition) $2 \text{HI} \rightarrow \text{H}_2 + \text{I}_2$
40. (a) (hydrocarbon combustion) $\text{C}_2\text{H}_5\text{OH} + 3 \text{O}_2 \rightarrow 2 \text{CO}_2 + 3 \text{H}_2\text{O}$
 (b) (double displacement) $\text{HNO}_3 + \text{LiOH} \rightarrow \text{LiNO}_3 + \text{HOH}_{(l)}$
 (c) (double displacement) $\text{Pb}(\text{NO}_3)_2 + \text{Na}_2\text{CO}_3 \rightarrow \text{PbCO}_3_{(s)} + 2 \text{NaNO}_3$
41. (a) Total Ionic: $\text{H}^+_{(aq)} + \text{Cl}^-_{(aq)} + \text{Na}^+_{(aq)} + \text{OH}^-_{(aq)} \rightarrow \text{Na}^+_{(aq)} + \text{Cl}^-_{(aq)} + \text{HOH}_{(l)}$
 Net Ionic: $\text{H}^+_{(aq)} + \text{Cl}^-_{(aq)} \rightarrow \text{H}_2\text{O}_{(l)}$
 (b) Total Ionic: $\text{Mg}_{(s)} + 2 \text{H}^+_{(aq)} + 2 \text{Cl}^-_{(aq)} \rightarrow \text{Mg}^{2+}_{(aq)} + 2 \text{Cl}^-_{(aq)} + \text{H}_{2(g)}$
 Net Ionic: $\text{Mg}_{(s)} + 2 \text{H}^+_{(aq)} \rightarrow \text{Mg}^{2+}_{(aq)} + \text{H}_{2(g)}$
 (c) Total Ionic: $\text{Cd}^{2+}_{(aq)} + 2 \text{Cl}^-_{(aq)} + 2 \text{Na}^+_{(aq)} + \text{CO}_3^{2-}_{(aq)} \rightarrow 2 \text{Na}^+_{(aq)} + 2 \text{Cl}^-_{(aq)} + \text{CdCO}_3_{(s)}$
 Net Ionic: $\text{Cd}^{2+}_{(aq)} + \text{CO}_3^{2-}_{(aq)} \rightarrow \text{CdCO}_3_{(s)}$
42. (a) Na^+ and Cl^- (b) Cl^- (c) Na^+ and Cl^-
43. (a) (products = $\text{KCl}_{(aq)}$ and $\text{CaCO}_3_{(s)}$) $\text{CO}_3^{2-}_{(aq)} + \text{Ca}^{2+}_{(aq)} \rightarrow \text{CaCO}_3_{(s)}$
 (b) (products = $\text{NaNO}_3_{(aq)}$ and $\text{Ag}_2\text{SO}_4_{(s)}$) $\text{SO}_4^{2-}_{(aq)} + 2 \text{Ag}^+_{(aq)} \rightarrow \text{Ag}_2\text{SO}_4_{(s)}$
 (c) (products = $\text{NH}_4\text{NO}_3_{(aq)}$ and $\text{AgCl}_{(s)}$) $\text{Cl}^-_{(aq)} + \text{Ag}^+_{(aq)} \rightarrow \text{AgCl}_{(s)}$
44. (a) K^+ and Cl^- (b) Na^+ and NO_3^- (c) NH_4^+ and NO_3^-

(Standardize Test Prep on pg. 298 & 299)

1. D 2. G 3. A 4. $\text{Mg}_{(s)} + \text{Zn}^{2+}_{(aq)} \rightarrow \text{Mg}^{2+}_{(aq)} + \text{Zn}_{(s)}$
5. Formula equations give only the identity of the reactants and the products but a balanced equation shows equal numbers of atoms of each element on both sides.
6. $\text{Fe}(\text{NO}_3)_3 + 3 \text{LiOH} \rightarrow 3 \text{LiNO}_3 + \text{Fe}(\text{OH})_3$
7. The gas that burns is a different chemical substance than any of the reactants, indicating a chemical reaction.
8. F 9. C 10. H 11. D 12. I

Chapter 9: Stoichiometry**9.1: Calculating Quantities in Reactions**

(Practice on pg. 304)

1. (a) 0.670 mol O_2 (b) 1.34 mol H_2O
2. (a) 6.60 mol Al (b) 6.60 mol Fe (c) 3.30 mol Al_2O_3

(Practice on pg. 307)

1. 45.6 g Al 2. 44.6 g Al_2O_3 3. 679 g Fe_2O_3 4. 107 g Fe

(Practice on pg. 309)

1. 315 mL C_3H_8 2. 2.03×10^3 L H_2 3. 113 mL C_5H_{12} 4. 7.64×10^5 mL H_2

(Practice on pg. 311)

1. 2.89×10^{24} molecules BrF_5 2. 2.22×10^{19} molecules Br_2

(Section Review on pg. 311)

2. the molar mass of the substance; Avogadro's number, $\frac{6.022 \times 10^{23} \text{ particles}}{1 \text{ mol}}$
3. $\frac{44.01 \text{ g CO}_2}{1 \text{ mol CO}_2}$, $\frac{6.022 \times 10^{23} \text{ particles}}{1 \text{ mol}}$
4. (a) 5.48 mol BrCl (b) 780.0 g BrCl (c) 1.20×10^4 g Br₂
5. (a) 1.42 mol CO₂ (b) 47.2 mL CO₂
7. (a) $2 \text{ LiOH} + \text{CO}_2 \rightarrow \text{Li}_2\text{CO}_3 + \text{H}_2\text{O}$; $2 \text{ NaOH} + \text{CO}_2 \rightarrow \text{Na}_2\text{CO}_3 + \text{H}_2\text{O}$
(b) 524 g NaOH ; 313 g LiOH

9.2: Limiting Reactants and Percentage Yield

(Practice on pg. 314)

1. PCl₃ is excess, H₂O is limiting, theoretical yield = 109 g HCl
2. H₂O is excess, PCl₃ is limiting, theoretical yield = 59.7 g HCl
3. PCl₃ is excess, H₂O is limiting, theoretical yield = 101 g HCl

(Practice on pg. 317)

1. N₂ is limiting, % yield = 85.3% 2. C₂H₅OH is limiting, % yield = 80.0%
3. Br₂ is limiting, % yield = 90.9%

(Practice on pg. 318)

1. 1.04×10^3 g NH₃ 2. 5.9×10^3 g CH₃OH 3. 439 g BrCl

(Section Review on pg. 319)

6. Theoretical yield = 0.320 g H₂; % yield = 84.4%
7. (a) $\text{P}_4\text{O}_{10} + 6 \text{ H}_2\text{O} \rightarrow 4 \text{ H}_3\text{PO}_4$ (b) 138.1 g H₃PO₄ (c) % yield = 91.4%
8. TiCl₄ is limiting; 3.5 mol TiO₂ and 7.0 mol Cl₂ are produced, 1.0 mol O₂ left over
9. 3.70 g Cu 10. % yield = 93.8%
11. (a) $\text{Mg} + 2 \text{ HOH} \rightarrow \text{Mg}(\text{OH})_2 + \text{H}_2$ (b) % yield = 86.8% (c) 55 g Mg(OH)₂
12. (a) CuO is limiting (b) % yield = 94.3% (c) 15.0 g Cu
13. 0 mol H₂, 10 mol O₂, and 20 mol H₂O
14. Theoretical yield = 23 g CaO. The actual yield reported is 27 g, which gives a % yield of 120%. The result can be explained by the possibility that there were impurities in the reactant samples, or the measurement of the mass of the reactant is less than its actual mass. In addition, the decomposition reaction might not have reached completion and some of the reactants remained behind.

9.3: Stoichiometry and Cars

(Practice on pg. 322)

1. 33 g Na 2. 40.9 g Fe₂O₃ 3. 121 g NaHCO₃
4. (a) 168 g NaHCO₃ (b) 1.20×10^2 g HC₂H₃O₂

(Practice on pg. 324)

1. 2.17 cycles; After 3 full cycles, all of the 1.00 mL of isooctane will have reacted.
2. 8.65 mL of isooctane 3. $2 \text{ CH}_3\text{OH} + 3 \text{ O}_2 \rightarrow 2 \text{ CO}_2 + 4 \text{ H}_2\text{O}$; 2.2×10^2 L of air

(Section Review on pg. 327)

5. 10.7 g Na₂O 6. 1.20×10^2 g NaHCO₃

(Chapter Review on pg. 329 to 332)

21. (a) 6.6 mol H₂ (b) 3.36 mol O₂ (c) 8.12 mol H₂
 22. (a) 1.6×10^3 mol H₂O (b) 2.90×10^3 mol N₂O₄ (c) 6.39×10^3 mol N₂
 23. (a) 1.08 mol O₂ (b) 2.62 mol Al₂O₃
 24. (a) 273 g H₂O (b) 58.1 g CaC₂ (c) 26.9 g H₂O
 25. (a) 49.0 g O₂ (b) 748 g KClO₃ (c) 12.7 g KCl 26. 73.3 g Al₂O₃
 27. (a) 1.68 L O₂ (b) 0.153 g KClO₃ (c) 1.51×10^4 mL O₂
 28. (a) 113 L O₂ (b) 25 L O₂
 29. (a) 1.34×10^{24} molecules NO₂ (b) 9.67×10^{23} molecules NO (c) 1.88×10^{22} molecules O₂
 30. (a) 4.61×10^{24} molecules H₂ (b) 4.31×10^{23} atoms Na (c) 3.30×10^{20} molecules H₂
 31. (a) O₂ is excess; NO is limiting (b) 4.0 mol NO₂
 32. (a) H₂O is excess; CaC₂ is limiting (b) 26 g C₂H₂ (c) 74 g Ca(OH)₂
 33. (a) H₂ is excess; N₂ is limiting (b) 34 g NH₃ (c) 22 g H₂
 34. % yield = 75.6 % 35. % yield = 88.2 % 36. % yield = 72.5%
 37. 1.9×10^2 g NaNO₂ 38. 4.7 g Al 39. 2.8 kg Fe
 40. 46.6 L CO₂ 41. (a) 84.7 g NaN₃ (b) 43 L N₂ (c) 90 g NaN₃
 42. $\frac{25 \text{ mol O}_2}{2 \text{ mol C}_8\text{H}_{18}}$ or 25 : 2 43. 2.41×10^3 g O₂ 44. 1.71×10^3 L O₂
 45. 4.75 g O₃ ; % yield = 96.4% 46. 2.16×10^3 g CO₂ ; % yield = 88.0%
 47. (a) 1.2×10^2 g CO₂ (b) 9.70 mL H₂O (c) 4.49×10^{22} molecules H₂O
 48. 1.44 L N₂ 49. 8.6×10^3 HNO₃ 50. 1.74×10^3 g CO₂

(Standardize Test Prep on pg. 334 & 335)

1. D 2. I 3. D 4. The limiting reactant is nitrogen dioxide and the excess is water.
 5. $2 \text{ O}_3 \rightarrow 3 \text{ O}_2$ 6. 96 g O₂ 7. H 8. C
 9. In general, the products of an explosion are much more stable than the reactants. 10. H
 11. The Stoichiometry of the reaction is needed in order to calculate the amount of gas produced. If the wrong amount of reactant is used, the airbag might over-inflate or under-inflate, making it ineffective.
 12. A 13. 7.5 mol