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 → silicon + magnesium chloride ; $SiCl_{4\,(g)} + Mg_{\,(s)} \rightarrow Si_{\,(s)} + MgCl_{2\,(s)}$

10. magnesium + oxygen → 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 → potassium chloride + oxygen ; $KClO_3 \rightarrow KCl + O_2$; $2\ KClO_3 \rightarrow 2\ KCl + 3\ O_2$

(b) silver + sulfur → silver sulfide ; $Ag + S_8 \rightarrow Ag_2S$; $16\ Ag + S_8 \rightarrow 8\ Ag_2S$

(c) sodium hydrogen carbonate → 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 amu) + 1(32.00 amu) = 36.04 amu ; Product: 2 (18.02 amu) = 36.04 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) $4\ Li + O_2 \rightarrow 2\ Li_2O$

(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) $Cl_{2\,(g)} + 2\ NaBr_{\,(aq)} \rightarrow 2\ NaCl_{\,(aq)} + Br_{2\,(l)}$

(b) (synthesis) $CaO_{\,(s)} + H_2O_{\,(l)} \rightarrow Ca(OH)_{2\,(aq)}$

(c) (decomposition) $Ca(ClO_3)_{2\,(s)} \rightarrow CaCl_{2\,(s)} + 3\ O_{2\,(g)}$

(d) (double displacement) $2\ AgNO_{3\,(aq)} + K_2SO_{4\,(aq)} \rightarrow Ag_2SO_{4\,(s)} + 2\ KNO_{3\,(aq)}$

(e) (single displacement) $Zn_{\,(s)} + CuBr_{2\,(aq)} \rightarrow ZnBr_{2\,(aq)} + Cu_{\,(s)}$

(f) (hydrocarbon combustion) $2\ C_8H_{18\,(l)} + 25\ O_{2\,(g)} \rightarrow 16\ CO_{2\,(g)} + 18\ H_2O_{\,(g)}$

9. **(a)** no reaction

(b) (single displacement) $Mg_{\,(s)} + Cu(NO_3)_{2\,(aq)} \rightarrow Cu_{\,(s)} + Mg(NO_3)_{2\,(aq)}$

(c) (synthesis) $4\ Al_{\,(s)} + 3\ O_{2\,(g)} \rightarrow 2\ Al_2O_{3\,(s)}$

(d) (double displacement) $H_2SO_{4\,(aq)} + 2\ KOH_{\,(aq)} \rightarrow K_2SO_{4\,(aq)} + 2\ HOH_{\,(l)}$

10. **(a)** (decomposition) $2\ HgO \rightarrow 2\ Hg + O_2$

(b) (hydrocarbon combustion) $2\ C_3H_7OH + 10\ O_2 \rightarrow 6\ CO_2 + 8\ H_2O$

(c) (single displacement) $Zn + CuSO_4 \rightarrow Cu + ZnSO_4$

(d) (double displacement) $BaCl_2 + Na_2SO_4 \rightarrow 2\ NaCl + BaSO_4$

(e) (synthesis) $Zn + F_2 \rightarrow ZnF_2$

(f) (hydrocarbon combustion) $2\ C_5H_{10} + 15\ O_2 \rightarrow 10\ CO_2 + 10\ H_2O$

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, $NaCl_{\,(aq)}$ 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)** $Br_{2\,(l)} + 2\ Na^+_{(aq)} + 2\ I^-_{\,(aq)} \rightarrow 2\ Na^+_{(aq)} + 2\ Br^-_{(aq)} + I_{2\,(s)}$

(b) $Ca^{2+}_{(aq)} + 2\ OH^-_{\,(aq)} + 2\ H^+_{(aq)} + 2\ Cl^-_{(aq)} \rightarrow Ca^{2+}_{(aq)} + 2\ Cl^-_{(aq)} + 2\ H_2O_{\,(l)}$

(c) $Mg_{\,(s)} + 2\ Ag^+_{(aq)} + 2\ NO_3^-_{\,(aq)} \rightarrow 2\ Ag_{\,(s)} + Mg^{2+}_{(aq)} + 2\ NO_3^-_{\,(aq)}$

(d) $Ag^+_{(aq)} + NO_3^-_{\,(aq)} + K^+_{(aq)} + Br^-_{(aq)} \rightarrow AgBr_{\,(s)} + K^+_{(aq)} + NO_3^-_{\,(aq)}$

(e) $Ni_{\,(s)} + Pb^{2+}_{(aq)} + 2\ NO_3^-_{\,(aq)} \rightarrow Ni^{2+}_{(aq)} + 2\ NO_3^-_{\,(aq)} + Pb_{\,(s)}$

(f) $Ca_{\,(s)} + 2\ H_2O_{\,(l)} \rightarrow Ca^{2+}_{(aq)} + 2\ OH^-_{(aq)} + H_{2\,(g)}$

7. **(a)** (spectator ion = Na^+) $Br_{2\,(l)} + 2\ I^-_{\,(aq)} \rightarrow 2\ Br^-_{(aq)} + I_{2\,(s)}$

(b) (spectator ions = Ca^{2+} and Cl^-) $OH^-_{\,(aq)} + H^+_{(aq)} \rightarrow H_2O_{\,(l)}$

(c) (spectator ion = NO_3^-) $Mg_{\,(s)} + 2\ Ag^+_{(aq)} \rightarrow 2\ Ag_{\,(s)} + Mg^{2+}_{(aq)}$

(d) (spectator ions = K^+ and NO_3^-) $Ag^+_{(aq)} + Br^-_{(aq)} \rightarrow AgBr_{\,(s)}$

(e) (spectator ion = NO_3^-) $Ni_{\,(s)} + Pb^{2+}_{(aq)} \rightarrow Ni^{2+}_{(aq)} + Pb_{\,(s)}$

(f) (no spectator ions) $Ca_{\,(s)} + 2\ H_2O_{\,(l)} \rightarrow Ca^{2+}_{(aq)} + 2\ OH^-_{(aq)} + H_{2\,(g)}$

8. **(a)** (products = $Au_{\,(s)}$ and $AgCl_{\,(s)}$) $Au^{3+}_{(aq)} + 3\ Cl^-_{(aq)} + 3\ Ag_{\,(s)} \rightarrow Au_{\,(s)} + 3\ AgCl_{\,(s)}$

(b) (products = $AgCl_{\,(s)}$ and $Ca(NO_3)_{2\,(aq)}$)

$$2\ Ag^+_{(aq)} + 2\ NO_3^-_{\,(aq)} + Ca^{2+}_{(aq)} + 2\ Cl^-_{(aq)} \rightarrow 2\ AgCl_{\,(s)} + Ca^{2+} + 2\ NO_{3\,(aq)}$$

(c) (products = $Ni_{\,(s)}$ and $Al_2(SO_4)_{3\,(aq)}$)

$$2\ Al_{\,(s)} + 3\ Ni^{2+}_{(aq)} + 3\ SO_4^{2-}_{(aq)} \rightarrow 3\ Ni_{\,(s)} + 2\ Al^{3+}_{(aq)} + 3\ SO_4^{2-}_{(aq)}$$

(d) (products = $NaOH_{\,(aq)}$ and $H_{2\,(g)}$) $2\ Na_{\,(s)} + 2\ HOH_{\,(l)} \rightarrow 2\ Na^+_{(aq)} + 2\ OH^-_{(aq)} + H_{2\,(g)}$

(e) (products = $AgCl_{\,(s)}$ and $NaNO_{3\,(aq)}$)

$$Ag^+_{(aq)} + Cl^-_{(aq)} + Na^+_{(aq)} + NO_3^-_{\,(aq)} \rightarrow AgCl_{\,(s)} + Na^+_{(aq)} + NO_3^-_{\,(aq)}$$

9. **(a)** (no spectator ions) $Au^{3+}_{(aq)} + 3\ Cl^{-}_{(aq)} + 3\ Ag_{(s)} \rightarrow Au_{(s)} + 3\ AgCl_{(s)}$
(b) (spectator ions = Ca^{2+} and NO_3^{-}) $2\ Ag^{+}_{(aq)} + 2\ Cl^{-}_{(aq)} \rightarrow 2\ AgCl_{(s)}$
(c) (spectator ion = SO_4^{2-}) $2\ Al_{(s)} + 3\ Ni^{2+}_{(aq)} \rightarrow 3\ Ni_{(s)} + 2\ Al^{3+}_{(aq)}$
(d) (no spectator ions) $2\ Na_{(s)} + 2\ HOH_{(l)} \rightarrow 2\ Na^{+}_{(aq)} + 2\ OH^{-}_{(aq)} + H_{2\ (g)}$
(e) (spectator ion = Na^{+} and NO_3^{-}) $Ag^{+}_{(aq)} + Cl^{-}_{(aq)} \rightarrow AgCl_{(s)}$

10. **(a)** $2\ Ag^{+}_{(aq)} + 2\ NO_3^{-}{}_{(aq)} + 2\ Na^{+}_{(aq)} + SO_4^{2-}{}_{(aq)} \rightarrow 2\ Na^{+}_{(aq)} + 2\ NO_3^{-}{}_{(aq)} + Ag_2SO_{4\ (s)}$
(b) $2\ Al_{(s)} + 3\ Ni^{2+}_{(aq)} + 6\ I^{-}_{(aq)} \rightarrow 3\ Ni_{(s)} + 2\ Al^{3+}_{(aq)} + 6\ I^{-}_{(aq)}$
(c) $2\ K^{+}_{(aq)} + SO_4^{2-}{}_{(aq)} + Ca^{2+}_{(aq)} + 2\ Cl^{-}_{(aq)} \rightarrow CaSO_{4\ (s)} + 2\ K^{+}_{(aq)} + 2\ Cl^{-}_{(aq)}$
(d) $Mg_{(s)} + Cu^{2+}_{(aq)} + 2\ Br^{-}_{(aq)} \rightarrow Cu_{(s)} + Mg^{2+}_{(aq)} + 2\ Br^{-}_{(aq)}$
(e) $Pb^{2+}_{(aq)} + 2\ NO_3^{-}{}_{(aq)} + 2\ Na^{+}_{(aq)} + 2\ Cl^{-}_{(aq)} \rightarrow PbCl_{2\ (s)} + 2\ Na^{+}_{(aq)} + 2\ NO_3^{-}{}_{(aq)}$

11. **(a)** (spectator ions = NO_3^{-} and Na^{+}) $2\ Ag^{+}_{(aq)} + SO_4^{2-}{}_{(aq)} \rightarrow Ag_2SO_{4\ (s)}$
(b) (spectator ion = I^{-}) $2\ Al_{(s)} + 3\ Ni^{2+}_{(aq)} \rightarrow 3\ Ni_{(s)} + 2\ Al^{3+}_{(aq)}$
(c) (spectator ions = K^{+} and Cl^{-}) $Ca^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)} \rightarrow CaSO_{4\ (s)}$
(d) (spectator ion = Br^{-}) $Mg_{(s)} + Cu^{2+}_{(aq)} \rightarrow Cu_{(s)} + Mg^{2+}_{(aq)}$
(e) (spectator ions = NO_3^{-} and Na^{+}) $Pb^{2+}_{(aq)} + 2\ Cl^{-}_{(aq)} \rightarrow PbCl_{2\ (s)}$

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)** $H_2 + Cl_2 \rightarrow 2\ HCl$ **(b)** $2\ Al + Fe_2O_3 \rightarrow 2\ Fe + Al_2O_3$
(c) $Ba(ClO_3)_2 \rightarrow BaCl_2 + 3\ O_2$ **(d)** omit

27. **(a)** $Fe_2O_3 + 3\ Mg \rightarrow 3\ MgO + 2\ Fe$ **(b)** $3\ NO_2 + H_2O \rightarrow 2\ HNO_3 + NO$
(c) $SiCl_4 + 2\ H_2O \rightarrow SiO_2 + 4\ HCl$

28. **(a)** $4\ Fe + 3\ O_2 \rightarrow 2\ Fe_2O_3$ **(b)** $2\ H_2O_2 \rightarrow 2\ H_2O + O_2$
(c) $2\ C_8H_{18} + 25\ O_2 \rightarrow 16\ CO_2 + 18\ H_2O$ **(d)** $2\ Al + 3\ F_2 \rightarrow 2\ AlF_3$

29. **(a)** $2\ C_3H_7OH + 9\ O_2 \rightarrow 6\ CO_2 + 8\ H_2O$ **(b)** $2\ Al + 3\ Fe(NO_3)_2 \rightarrow 2\ Al(NO_3)_3 + 3\ Fe$
(c) $2\ PbO_2 \rightarrow 2\ PbO + O_2$

30. **(a)** $Zn + Pb(NO_3)_2 \rightarrow Pb + Zn(NO_3)_2$ **(b)** $H_2OOCCOO + 2\ NaOH \rightarrow Na_2OOCCOO + 2\ HOH$
(c) $2\ Al + 3\ CuSO_4 \rightarrow Al_2(SO_4) + 3\ Cu$

31. **(a)** $CuSO_4 + (NH_4)_2S \rightarrow CuS + (NH_4)_2SO_4$ **(b)** $2\ HNO_3 + Ba(OH)_2 \rightarrow 2\ HOH + Ba(NO_3)_2$
(c) $3\ BaCl_2 + 2\ H_3PO_4 \rightarrow Ba_3(PO_4)_2 + 6\ HCl$

32. **(a)** $2\ Zn + O_2 \rightarrow 2\ ZnO$ **(b)** $F_2 + Mg \rightarrow MgF_2$
(c) $Cl_2 + 2\ K \rightarrow 2\ KCl$ **(d)** $H_2 + I_2 \rightarrow 2\ HI$

33. **(a)** $2\ HgO \rightarrow 2\ Hg + O_2$ **(b)** $2\ H_2O \rightarrow 2\ H_2 + O_2$ **(c)** $2\ AgCl \rightarrow 2\ Ag + Cl_2$

34. **(a)** $2\ C_3H_6 + 9\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O$ **(b)** $C_5H_{12} + 8\ O_2 \rightarrow 5\ CO_2 + 6\ H_2O$
(c) $2\ CH_3OH + 3\ O_2 \rightarrow 2\ CO_2 + 4\ H_2O$ **(d)** $C_{12}H_{22}O_{11} + 12\ O_2 \rightarrow 12\ CO_2 + 11\ H_2O$

35. **(a)** (hydrocarbon combustion) $C_3H_8 + 5\ O_2 \rightarrow 3\ CO_2 + 4\ H_2O$
(b) (decomposition) $Na_2CO_3 \rightarrow Na_2O + CO_2$
(d) (combustion) $C_2H_5OH + 3\ O_2 \rightarrow 2\ CO_2 + 3\ H_2O$

36. **(a)** $Mg_{(s)} + CuCl_{2\ (aq)} \rightarrow MgCl_{2\ (aq)} + Cu_{(s)}$ **(b)** $Pb(NO_3)_{2\ (aq)} + Zn_{(s)} \rightarrow Zn(NO_3)_{2\ (aq)} + Pb_{(s)}$
(c) $2\ KI_{(aq)} + Cl_{2\ (g)} \rightarrow 2\ KCl_{(aq)} + I_{2\ (s)}$ **(d)** no reaction

37. **(a)** $2\ HOH_{(l)} + Ba_{(s)} \rightarrow Ba(OH)_{2\ (aq)} + H_{2\ (g)}$ **(b)** $4\ Ca_{(s)} + O_{2\ (g)} \rightarrow 2\ CaO_{(s)}$ **(c)** no reaction

38. **(a)** (combustion) $2\ C_2H_6 + 7\ O_2 \rightarrow 4\ CO_2 + 6\ H_2O$
(b) (single displacement) $3\ H_2SO_4 + 2\ Al \rightarrow Al_2(SO_4)_3 + 3\ H_2$
(c) (synthesis) $N_2 + 3\ Mg \rightarrow Mg_3N_2$
(e) (double displacement) no reaction

39. **(a)** (single displacement) $2\ HOH + 2\ Li \rightarrow 2\ LiOH + H_2$
(b) (double displacement) $AgNO_3 + HCl \rightarrow AgCl_{(s)} + HNO_3$
(c) (decomposition) $2\ HI \rightarrow H_2 + I_2$

40. **(a)** (hydrocarbon combustion) $C_2H_5OH + 3\ O_2 \rightarrow 2\ CO_2 + 3\ H_2O$
(b) (double displacement) $HNO_3 + LiOH \rightarrow LiNO_3 + HOH_{(l)}$
(c) (double displacement) $Pb(NO_3)_2 + Na_2CO_3 \rightarrow PbCO_{3\ (s)} + 2\ NaNO_3$

41. **(a)** Total Ionic: $H^+_{(aq)} + Cl^-_{(aq)} + Na^+_{(aq)} + OH^-_{(aq)} \rightarrow Na^+_{(aq)} + Cl^-_{(aq)} + HOH_{(l)}$
Net Ionic: $H^+_{(aq)} + Cl^-_{(aq)} \rightarrow H_2O_{(l)}$
(b) Total Ionic: $Mg_{(s)} + 2\ H^+_{(aq)} + 2\ Cl^-_{(aq)} \rightarrow Mg^{2+}_{(aq)} + 2\ Cl^-_{(aq)} + H_{2\ (g)}$
Net Ionic: $Mg_{(s)} + 2\ H^+_{(aq)} \rightarrow Mg^{2+}_{(aq)} + H_{2\ (g)}$
(c) Total Ionic: $Cd^{2+}_{(aq)} + 2\ Cl^-_{(aq)} + 2\ Na^+_{(aq)} + CO_3{}^{2-}_{(aq)} \rightarrow 2\ Na^+_{(aq)} + 2\ Cl^-_{(aq)} + CdCO_{3\ (s)}$
Net Ionic: $Cd^{2+}_{(aq)} + CO_3{}^{2-}_{(aq)} \rightarrow CdCO_{3\ (s)}$

42. **(a)** Na^+ and Cl^- **(b)** Cl^- **(c)** Na^+ and Cl^-

43. **(a)** (products = $KCl_{(aq)}$ and $CaCO_{3\ (s)}$) $CO_3{}^{2-}_{(aq)} + Ca^{2+}_{(aq)} \rightarrow CaCO_{3\ (s)}$
(b) (products = $NaNO_{3\ (aq)}$ and $Ag_2SO_{4\ (s)}$) $SO_4{}^{2-}_{(aq)} + 2\ Ag^+_{(aq)} \rightarrow Ag_2SO_{4\ (s)}$
(c) (products = $NH_4NO_{3\ (aq)}$ and $AgCl_{(s)}$) $Cl^-_{(aq)} + Ag^+_{(aq)} \rightarrow AgCl_{(s)}$

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.** $Mg_{(s)} + Zn^{2+}_{(aq)} \rightarrow Mg^{2+}_{(aq)} + Zn_{(s)}$

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. $Fe(NO_3)_3 + 3\ LiOH \rightarrow 3\ LiNO_3 + Fe(OH)_3$

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. $\frac{44.01\text{ g } CO_2}{1\text{ mol } CO_2}$, $\frac{6.022\times10^{23}\text{ particles}}{1\text{ mol}}$

4. **(a)** 5.48 mol BrCl **(b)** 780.0 g BrCl **(c)** 1.20×10^4 g Br_2

5. **(a)** 1.42 mol CO_2 **(b)** 47.2 mL CO_2

7. **(a)** $2\ LiOH + CO_2 \rightarrow Li_2CO_3 + H_2O$; $2\ NaOH + CO_2 \rightarrow Na_2CO_3 + H_2O$
(b) 524 g NaOH ; 313 g LiOH

9.2: Limiting Reactants and Percentage Yield

(Practice on pg. 314)

1. PCl_3 is excess, H_2O is limiting, theoretical yield = 109 g HCl

2. H_2O is excess, PCl_3 is limiting, theoretical yield = 59.7 g HCl

3. PCl_3 is excess, H_2O is limiting, theoretical yield = 101 g HCl

(Practice on pg.317)

1. N_2 is limiting, % yield = 85.3% **2.** C_2H_5OH is limiting, % yield = 80.0%

3. Br_2 is limiting, % yield = 90.9%

(Practice on pg. 318)

1. 1.04×10^3 g NH_3 **2.** 5.9×10^3 g CH_3OH **3.** 439 g BrCl

(Section Review on pg. 319)

6. Theoretical yield = 0.320 g H_2; % yield = 84.4%

7. **(a)** $P_4O_{10} + 6\ H_2O \rightarrow 4\ H_3PO_4$ **(b)** 138.1 g H_3PO_4 **(c)** % yield = 91.4%

8. $TiCl_4$ is limiting; 3.5 mol TiO_2 and 7.0 mol Cl_2 are produced, 1.0 mol O_2 left over

9. 3.70 g Cu **10.** % yield = 93.8%

11. **(a)** $Mg + 2\ HOH \rightarrow Mg(OH)_2 + H_2$ **(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 H_2, 10 mol O_2, and 20 mol H_2O

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 Fe_2O_3 **3.** 121 g $NaHCO_3$

4. **(a)** 168 g $NaHCO_3$ **(b)** 1.20×10^2 g $HC_2H_3O_2$

(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.** $2\ CH_3OH + 3\ O_2 \rightarrow 2\ CO_2 + 4\ H_2O$; 2.2×10^2 L of air

(Section Review on pg. 327)

5. 10.7 g Na_2O **6.** 1.20×10^2 g $NaHCO_3$

(Chapter Review on pg. 329 to 332)

21. **(a)** 6.6 mol H_2 **(b)** 3.36 mol O_2 **(c)** 8.12 mol H_2

22. **(a)** 1.6×10^3 mol H_2O **(b)** 2.90×10^3 mol N_2O_4 **(c)** 6.39×10^3 mol N_2

23. **(a)** 1.08 mol O_2 **(b)** 2.62 mol Al_2O_3
24. **(a)** 273 g H_2O **(b)** 58.1 g CaC_2 **(c)** 26.9 g H_2O
25. **(a)** 49.0 g O_2 **(b)** 748 g $KClO_3$ **(c)** 12.7 g KCl **26.** 73.3 g Al_2O_3
27. **(a)** 1.68 L O_2 **(b)** 0.153 g $KClO_3$ **(c)** 1.51×10^4 mL O_2
28. **(a)** 113 L O_2 **(b)** 25 L O_2
29. **(a)** 1.34×10^{24} molecules NO_2 **(b)** 9.67×10^{23} molecules NO **(c)** 1.88×10^{22} molecules O_2
30. **(a)** 4.61×10^{24} molecules H_2 **(b)** 4.31×10^{23} atoms Na **(c)** 3.30×10^{20} molecules H_2
31. **(a)** O_2 is excess; NO is limiting **(b)** 4.0 mol NO_2
32. **(a)** H_2O is excess; CaC_2 is limiting **(b)** 26 g C_2H_2 **(c)** 74 g $Ca(OH)_2$
33. **(a)** H_2 is excess; N_2 is limiting **(b)** 34 g NH_3 **(c)** 22 g H_2
34. % yield = 75.6 % **35.** % yield = 88.2 % **36.** % yield = 72.5%
37. 1.9×10^2 g $NaNO_2$ **38.** 4.7 g Al **39.** 2.8 kg Fe
40. 46.6 L CO_2 **41.** **(a)** 84.7 g NaN_3 **(b)** 43 L N_2 **(c)** 90 g NaN_3
42. $\frac{25 \text{ mol } O_2}{2 \text{ mol } C_8H_{18}}$ or 25 : 2 **43.** 2.41×10^3 g O_2 **44.** 1.71×10^3 L O_2
45. 4.75 g O_3 ; % yield = 96.4% **46.** 2.16×10^3 g CO_2 ; % yield = 88.0%
47. **(a)** 1.2×10^2 g CO_2 **(b)** 9.70 mL H_2O **(c)** 4.49×10^{22} molecules H_2O
48. 1.44 L N_2 **49.** 8.6×10^3 HNO_3 **50.** 1.74×10^3 g CO_2

(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. $2\ O_3 \rightarrow 3\ O_2$ **6.** 96 g O_2 **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