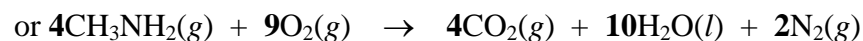
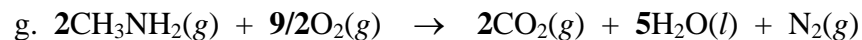
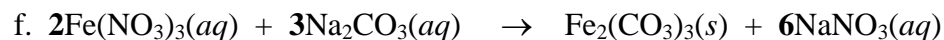
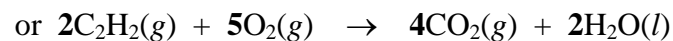
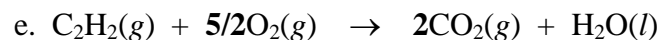
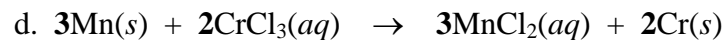
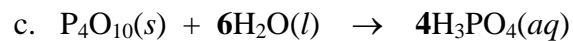
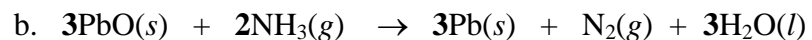
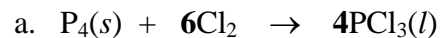
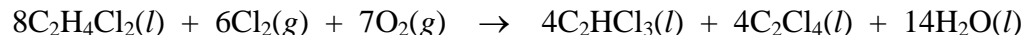


Chapter 4 Exercise Key

Exercise 4.1 – Balancing Chemical Equations: Balance the following chemical equations.



Exercise 4.2 – Mass-Mass Equation Stoichiometry: Tetrachloroethene, C_2Cl_4 , is a colorless liquid used in dry cleaning. Tetrachloroethene is often called perchloroethylene (perc). It can be formed in several steps from the reaction of dichloroethane, chlorine gas, and oxygen gas. The equation for the net reaction is below.



- a. Write fifteen different conversion factors that relate moles of one reactant or product to moles of another reactant or product.

$$\left(\frac{8 \text{ moles } C_2H_4Cl_2}{6 \text{ moles } Cl_2}\right) \text{ or } \left(\frac{8 \text{ moles } C_2H_4Cl_2}{7 \text{ moles } O_2}\right) \text{ or } \left(\frac{8 \text{ moles } C_2H_4Cl_2}{4 \text{ moles } C_2HCl_3}\right) \text{ or } \left(\frac{8 \text{ moles } C_2H_4Cl_2}{4 \text{ moles } C_2Cl_4}\right) \text{ or } \left(\frac{8 \text{ moles } C_2H_4Cl_2}{14 \text{ moles } H_2O}\right)$$

$$\text{or } \left(\frac{6 \text{ moles } Cl_2}{7 \text{ moles } O_2}\right) \text{ or } \left(\frac{6 \text{ moles } Cl_2}{4 \text{ moles } C_2HCl_3}\right) \text{ or } \left(\frac{6 \text{ moles } Cl_2}{4 \text{ moles } C_2Cl_4}\right) \text{ or } \left(\frac{6 \text{ moles } Cl_2}{14 \text{ moles } H_2O}\right) \text{ or } \left(\frac{7 \text{ moles } O_2}{4 \text{ moles } C_2HCl_3}\right)$$

$$\text{or } \left(\frac{7 \text{ moles } O_2}{4 \text{ moles } C_2Cl_4}\right) \text{ or } \left(\frac{7 \text{ moles } O_2}{14 \text{ moles } H_2O}\right) \text{ or } \left(\frac{4 \text{ moles } C_2HCl_3}{4 \text{ moles } C_2Cl_4}\right) \text{ or } \left(\frac{4 \text{ moles } C_2HCl_3}{14 \text{ moles } H_2O}\right) \text{ or } \left(\frac{4 \text{ moles } C_2Cl_4}{14 \text{ moles } H_2O}\right)$$

- b. What is the maximum mass of perchloroethylene, C_2Cl_4 , that can be formed from 23.75 megagrams of dichloroethane, $C_2H_4Cl_2$?

$$? \text{ Mg } C_2Cl_4 = 23.75 \text{ Mg } C_2H_4Cl_2 \left(\frac{10^6 \text{ g}}{1 \text{ Mg}}\right) \left(\frac{1 \text{ mole } C_2H_4Cl_2}{98.959 \text{ g } C_2H_4Cl_2}\right) \left(\frac{4 \text{ mole } C_2Cl_4}{8 \text{ mole } C_2H_4Cl_2}\right) \left(\frac{165.833 \text{ g } C_2Cl_4}{1 \text{ mole } C_2Cl_4}\right) \left(\frac{1 \text{ Mg}}{10^6 \text{ g}}\right)$$

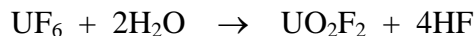
$$\text{or } ? \text{ Mg } C_2Cl_4 = 23.75 \text{ Mg } C_2H_4Cl_2 \left(\frac{4 \times 165.833 \text{ Mg } C_2Cl_4}{8 \times 98.959 \text{ Mg } C_2H_4Cl_2}\right) = \mathbf{19.90 \text{ Mg } C_2Cl_4}$$

- c. What is the maximum mass in tons of trichloroethene, C_2HCl_3 , formed with perchloroethylene, C_2Cl_4 , in the reaction of 23.75 megagrams of dichloroethylene, $C_2H_4Cl_2$? (Remember that we assume that a ton is an English short ton unless we are told otherwise.)

$$? \text{ tons } C_2HCl_3 = 23.75 \text{ Mg } C_2H_4Cl_2 \left(\frac{10^6 \text{ g}}{1 \text{ Mg}}\right) \left(\frac{1 \text{ mole } C_2H_4Cl_2}{98.959 \text{ g } C_2H_4Cl_2}\right) \left(\frac{4 \text{ mole } C_2HCl_3}{8 \text{ mole } C_2H_4Cl_2}\right) \left(\frac{131.388 \text{ g } C_2HCl_3}{1 \text{ mole } C_2HCl_3}\right) \left(\frac{1 \text{ lb}}{453.6 \text{ g}}\right) \left(\frac{1 \text{ ton}}{2000 \text{ lb}}\right)$$

$$\text{or } ? \text{ tons } C_2HCl_3 = 23.75 \text{ Mg } C_2H_4Cl_2 \left(\frac{4 \times 131.388 \text{ Mg } C_2HCl_3}{8 \times 98.959 \text{ Mg } C_2H_4Cl_2}\right) \left(\frac{10^6 \text{ g}}{1 \text{ Mg}}\right) \left(\frac{1 \text{ lb}}{453.6 \text{ g}}\right) \left(\frac{1 \text{ ton}}{2000 \text{ lb}}\right) = \mathbf{17.38 \text{ tons } C_2HCl_3}$$

Exercise 4.3 – Limiting Reactants: Uranium(IV) oxide, UO_2 , is used as fuel in nuclear power plants. The percentage of the fissionable isotope uranium-235 in the UO_2 used as fuel needs to be higher than that found in nature. To make fuel grade UO_2 , uranium oxides are first converted to uranium hexafluoride, UF_6 , which can be enriched in the fissionable isotope of uranium by gas diffusion. The UF_6 is then converted to UO_2 in a series of steps. The chemical equation for the first of these steps is below.



- a. What is the maximum mass in pounds of UO_2F_2 that can be formed from the reaction of 24.543 lb UF_6 with 8.0 lb of water?

$$? \text{ lb } \text{UO}_2\text{F}_2 = 24.543 \text{ lb } \text{UF}_6 \left(\frac{453.6 \text{ g}}{1 \text{ lb}} \right) \left(\frac{1 \text{ mole } \text{UF}_6}{352.019 \text{ g } \text{UF}_6} \right) \left(\frac{1 \text{ mole } \text{UO}_2\text{F}_2}{1 \text{ mole } \text{UF}_6} \right) \left(\frac{308.0245 \text{ g } \text{UO}_2\text{F}_2}{1 \text{ mole } \text{UO}_2\text{F}_2} \right) \left(\frac{1 \text{ lb}}{453.6 \text{ g}} \right)$$

$$\text{or } ? \text{ lb } \text{UO}_2\text{F}_2 = 24.543 \text{ lb } \text{UF}_6 \left(\frac{1 \times 308.0245 \text{ lb } \text{UO}_2\text{F}_2}{1 \times 352.019 \text{ lb } \text{UF}_6} \right) = \mathbf{21.476 \text{ lb } \text{UO}_2\text{F}_2}$$

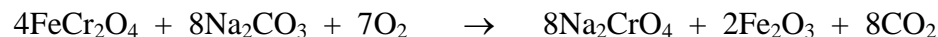
$$? \text{ lb } \text{UO}_2\text{F}_2 = 8.0 \text{ lb } \text{H}_2\text{O} \left(\frac{453.6 \text{ g}}{1 \text{ lb}} \right) \left(\frac{1 \text{ mole } \text{H}_2\text{O}}{18.0153 \text{ g } \text{H}_2\text{O}} \right) \left(\frac{1 \text{ mole } \text{UO}_2\text{F}_2}{2 \text{ mole } \text{H}_2\text{O}} \right) \left(\frac{308.0245 \text{ g } \text{UO}_2\text{F}_2}{1 \text{ mole } \text{UO}_2\text{F}_2} \right) \left(\frac{1 \text{ lb}}{453.6 \text{ g}} \right)$$

$$\text{or } ? \text{ lb } \text{UO}_2\text{F}_2 = 8.0 \text{ lb } \text{H}_2\text{O} \left(\frac{1 \times 308.0245 \text{ lb } \text{UO}_2\text{F}_2}{2 \times 18.0153 \text{ lb } \text{H}_2\text{O}} \right) = 68 \text{ lb } \text{UO}_2\text{F}_2$$

- b. Why do you think the reactant in excess was chosen to be in excess?

Water is much less toxic and less expensive than the radioactive and rare uranium compound. Water in the form of either liquid or steam is also very easy to separate from the solid product mixture.

Exercise 4.4 – Equation Stoichiometry and Percent Yield: The raw material for chromium and chromium compounds is a chrome-iron ore called chromite. Sodium chromate is made from the roasting of chromite ore. Roasting involves heating in the presence of air or oxygen. The following equation represents a simplified version of the net reaction. Typically, 75-85% of the chromium in the ore can be isolated as sodium chromate. What is the percent yield if 1.2 tons of Na_2CrO_4 are produced from ore that contains 1.0 ton of FeCr_2O_4 ?

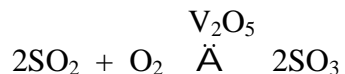
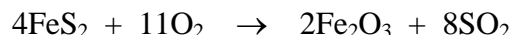


$$? \text{ tons Na}_2\text{CrO}_4 = 1.0 \text{ ton FeCr}_2\text{O}_4 \left(\frac{2000 \text{ lb}}{1 \text{ ton}} \right) \left(\frac{453.6 \text{ g}}{1 \text{ lb}} \right) \left(\frac{1 \text{ mol FeCr}_2\text{O}_4}{223.835 \text{ g FeCr}_2\text{O}_4} \right) \left(\frac{8 \text{ mol Na}_2\text{CrO}_4}{4 \text{ mol FeCr}_2\text{O}_4} \right) \left(\frac{161.9733 \text{ g Na}_2\text{CrO}_4}{1 \text{ mol Na}_2\text{CrO}_4} \right) \left(\frac{1 \text{ lb}}{453.6 \text{ g}} \right) \left(\frac{1 \text{ ton}}{2000 \text{ lb}} \right)$$

$$\text{or } ? \text{ tons Na}_2\text{CrO}_4 = 1.0 \text{ ton FeCr}_2\text{O}_4 \left(\frac{8 \times 161.9733 \text{ ton Na}_2\text{CrO}_4}{4 \times 223.835 \text{ ton FeCr}_2\text{O}_4} \right) = 1.4 \text{ ton Na}_2\text{CrO}_4$$

$$\text{Percent Yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100 = \frac{1.2 \text{ tons Na}_2\text{CrO}_4}{1.4 \text{ tons Na}_2\text{CrO}_4} \times 100 = \mathbf{86\% \text{ yield}}$$

Exercise 4.5 – Equation Stoichiometry and Mixtures: The FeS_2 found in pyrite ore is a source of sulfur for the production of sulfuric acid. The following equations describe the steps. First the sulfur in FeS_2 is converted to sulfur dioxide, which is converted to sulfur trioxide, which forms sulfuric acid when added to water.



- a. Consider the first step in this process. What is the maximum mass of iron(III) oxide, Fe_2O_3 , formed when 2.75 Mg of pyrite ore that is 92.6% FeS_2 is reacted with excess oxygen in air?

$$? \text{ Mg Fe}_2\text{O}_3 = 2.75 \text{ Mg ore} \left(\frac{92.6 \text{ Mg FeS}_2}{100 \text{ Mg ore}} \right) \left(\frac{10^6 \text{ g}}{1 \text{ Mg}} \right) \left(\frac{1 \text{ mole FeS}_2}{119.977 \text{ g FeS}_2} \right) \left(\frac{2 \text{ mole Fe}_2\text{O}_3}{4 \text{ mole FeS}_2} \right) \left(\frac{159.69 \text{ g Fe}_2\text{O}_3}{1 \text{ mole Fe}_2\text{O}_3} \right) \left(\frac{1 \text{ Mg}}{10^6 \text{ g}} \right)$$

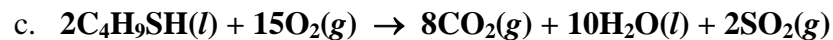
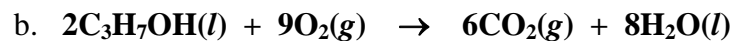
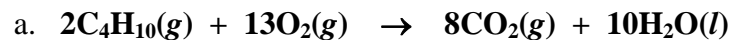
$$\text{or } ? \text{ Mg Fe}_2\text{O}_3 = 2.75 \text{ Mg ore} \left(\frac{92.6 \text{ Mg FeS}_2}{100 \text{ Mg ore}} \right) \left(\frac{2 \times 159.69 \text{ Mg Fe}_2\text{O}_3}{4 \times 119.977 \text{ Mg FeS}_2} \right) = \mathbf{1.69 \text{ Mg Fe}_2\text{O}_3}$$

- b. What is the minimum mass of pyrite ore that is 92.6% FeS_2 necessary to produce 1.00 Mg of iron(III) oxide, Fe_2O_3 ?

$$? \text{ Mg ore} = 1.00 \text{ Mg Fe}_2\text{O}_3 \left(\frac{10^6 \text{ g}}{1 \text{ Mg}} \right) \left(\frac{1 \text{ mole Fe}_2\text{O}_3}{159.69 \text{ g Fe}_2\text{O}_3} \right) \left(\frac{4 \text{ mole FeS}_2}{2 \text{ mole Fe}_2\text{O}_3} \right) \left(\frac{119.977 \text{ g FeS}_2}{1 \text{ mole FeS}_2} \right) \left(\frac{1 \text{ Mg}}{10^6 \text{ g}} \right) \left(\frac{100 \text{ Mg ore}}{92.6 \text{ Mg FeS}_2} \right)$$

$$\text{or } ? \text{ Mg ore} = 1.00 \text{ Mg Fe}_2\text{O}_3 \left(\frac{4 \times 119.977 \text{ g FeS}_2}{2 \times 159.69 \text{ Mg Fe}_2\text{O}_3} \right) \left(\frac{100 \text{ Mg ore}}{92.6 \text{ Mg FeS}_2} \right) = \mathbf{1.62 \text{ Mg ore}}$$

Exercise 4.6 – Writing Combustion Reactions: Write balanced equations for the complete combustion of (a) $\text{C}_4\text{H}_{10}(\text{g})$, (b) $\text{C}_3\text{H}_7\text{OH}(\text{l})$, and (c) $\text{C}_4\text{H}_9\text{SH}(\text{l})$.



Exercise 4.7 - Classification of Chemical Reactions: Classify each of these reactions as a combination reaction, a decomposition reaction, a combustion reaction, or a single-displacement reaction.

