4.3 Stoichiometry
Worksheet

1) How many moles of hydrogen gas can be produced if 0.57 moles of hydrochloric acid, HCl, reacts with excess solid zinc according to the following chemical equation?

$$2\ HCl + Zn \rightarrow H_2 + ZnCl_2$$

2) Nitrogen gas will react with hydrogen gas to produce ammonia, NH_3. How many moles of hydrogen gas are required to produce 0.86 moles of NH_3?

3) N_2O_5 reacts with water to produce nitric acid, HNO_3. If 1.93 moles of N_2O_5 react with excess water, how many moles of nitric acid can be produced?

4) Suppose 1.65 moles of C_6H_6 react with excess oxygen gas to produce carbon dioxide and water.
   a. How many moles of carbon dioxide will be produced in this reaction?
   b. How many moles of water will be produced in this reaction?
   c. How many moles of oxygen gas will be consumed during the reaction?

5) How many grams of lithium are needed to produce 45.0 g of lithium nitride, Li_3N, according to the following process?

$$6\ Li_{(s)} + N_{2(g)} \rightarrow 2\ Li_3N_{(s)}$$

6) A 14.5 g sample of sodium chloride reacts with excess fluorine gas according to the following chemical equation.

$$2\ NaCl(s) + F_2(g) \rightarrow 2\ NaF(s) + Cl_2(g)$$

   a. How many grams of sodium fluoride are produced?
   b. How many grams of chlorine gas are produced?

7) What mass of P_2O_5 can be produced when a 172.1 g sample of phosphorus reacts with an excess of oxygen gas according to the following chemical equation.

$$4\ P + 5\ O_2 \rightarrow 2\ P_2O_5$$

8) Determine the mass if lithium hydroxide that is produced when 12.87 g of lithium nitride reacts with an excess of water according to the following process.

$$Li_3N + 3\ H_2O \rightarrow 3\ LiOH + NH_3$$

9) Suppose 31.4 g of antimony (III) oxide reacts with excess carbon according to the following process.

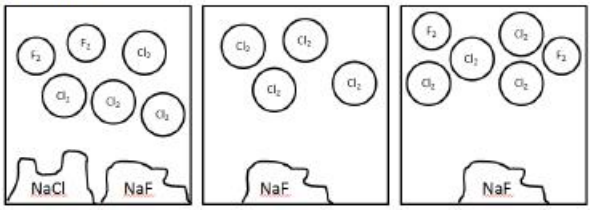
$$Sb_2O_3 + 3\ C \rightarrow 2\ Sb + 3\ CO$$

   a. What mass of antimony will be produced?
   b. What mass of CO will be produced?
   c. What mass of carbon is consumed during the reaction?

10) A 24.5 g sample of sodium chloride reacts with 41.3 g of fluorine gas according to the following chemical equation.

$$2\ NaCl_{(s)} + F_{2(g)} \rightarrow 2\ NaF_{(s)} + Cl_{2(g)}$$

a. What is the limiting reactant? Justify your answer.
b. How many grams of chlorine gas are produced?
c. Which particulate representation could be used to describe the species present in the reaction vessel after the process has gone to completion? Justify your answer.



11) A 84.1 gram sample of phosphorus reacts with 85.0 g of oxygen gas according to the following chemical equation.

$$4\ P_{(s)} + 5\ O_{2(g)} \rightarrow 2\ P_2O_5$$

a. Find the limiting reactant? Justify your answer.
b. How many grams of P_2O_5 are produced in theory?
c. If only 123 g of P_2O_5 are produced, what is the percentage yield?

12) Most nitrogen exists in a gaseous state. Plants require a soluble form of nitrogen so they can absorb it from the ground. Ammonia is a good fertilizer, as the mass percent of nitrogen in ammonia is very high. The following reaction is used to convert gaseous nitrogen into ammonia, which can be used as fertilizer.

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

Suppose 186.3 g of $N_2(g)$ react with 289.8 g of $H_2(g)$.

a. Which reactant is limiting? Justify your answer.
b. What mass of ammonia can be produced in theory?
c. If this reaction is know to have a 73.8% yield, what mass of ammonia could you expect to produce?

13) A 5.75 g sample of silicone dioxide reacts with 5.50 g of sodium hydroxide according to the following chemical equation.

$$SiO_2(s) + 2\ NaOH(aq) \rightarrow Na_2SiO_3(aq) + H_2O(l)$$

a. What is the limiting reactant? Justify your answer.
b. How many grams of $Na_2SiO_{3(aq)}$ are produced?
c. What is the % yield if only 7.24 g $Na_2SiO_{3(aq)}$ are produced.

14) The reaction between phosphorus and liquid bromine is outlined below.

$$2\ P(s) + 3\ Br_2(l) \rightarrow 2\ PBr_3(l)$$

a. Identify the limiting reactant when 5.78 g of phosphorus react with 27.9 g of liquid bromine. Justify your answer.
b. Based on your answer from part (a), determine the maximum mass of PBr_3 that can be produced in this reaction.
c. If the actual yield of PBr_3 is found to be 22.3 g, find the percent yield in this reaction.

15) The reaction between dihydrogen sulfide and sulfur dioxide is outlined below.

$$2\ H_2S(g) + SO_2(g) \rightarrow 3\ S(s) + 2\ H_2O(g)$$

a. Identify the limiting reactant when 3.89 g of dihydrogen sulfide react with 4.11 g of sulfur dioxide. Justify your answer.
b. Based on your answer from part (a), determine the maximum mass of sulfur that can be produced in this reaction.
c. If the actual yield of sulfur is found to be 4.89 g, find the percent yield in this reaction.

16) Air bags in cars operate according to the decomposition reaction below.

$$2\ Na_3N_{(s)} \rightarrow 6\ Na_{(s)} + N_{2(g)}$$

a. Use stoichiometric calculations to determine how many grams of nitrogen gas are produces during the decomposition of 6.22 g Na_3N?
b. Use stoichiometric calculations to determine how many grams of sodium are produced during the decomposition of 6.22 g Na_3N?
c. Use your finding from parts a. and b. to confirm that mass is conserved in chemical reactions.
d. Calculate the mass percent of each element in a pure sample of Na_3N.
e. Use your finding from parts a., b. and d. to confirm the law of definite proportions by showing that the mass percent of each element in Na_3N is equal to the mass percent of each species after the compound has decomposed.

17) What volume of CO_2 gas at 85°C and 795 mm Hg can be produced in the reaction below, when 43.0 g of methane react with excess oxygen?

$$CH_{4(g)} + 2\ O_{2(g)} \rightarrow CO_{2(g)} + 2\ H_2O_{(g)}$$

18) One of the problems with using hydrogen gas as a fuel to power cars is that it must be stored in high pressure tanks. The high pressure tanks that would be required to take a car a reasonable distances between refueling stops are often far too large for the average vehicle. What would be the necessary internal volume of a tank that stored $H_2(g)$ at 20.0 atm, if you needed to store enough hydrogen to react with 1435 g of oxygen gas at 32°C according to the chemical equation below?

$$2\ H_{2(g)} + O_{2(g)} \rightarrow 2\ H_2O_{(l)}$$

19) How many grams of CO_2 gas can be produced when 32.0 L of CH_4 gas at 25°C and 1.00 atm react with excess oxygen? (Note: This is not STP.)

$$CH_{4(g)} + 2\ O_{2(g)} \rightarrow CO_{2(g)} + 2\ H_2O_{(g)}$$

20) 13.74 L of hydrogen gas at 30.0°C and 801 torr and 6.55 L of oxygen gas at 25°C and 801 torr are drawn into a cylinder where the following reaction takes place.

$$2\ H_{2(g)} + O_{2(g)} \rightarrow 2\ H_2O_{(l)}$$

a. How many grams of water could be produced in this reaction?
b. What is the limiting reactant?
c. If 8.7 g of water are produced, what is the percent yield?

21) A rigid 11.7 L sealed vessel containing 3.3 mol of $O_{2(g)}$, 1.6 mol of $CH_{4(g)}$, and 2.3 mol of $He_{(g)}$ has an internal temperature of 78°C.

a. Calculate the partial pressure of each gas.
b. What is the total pressure in the vessel?
c. Find the mole fraction of each gas in the vessel.
d. A lab technician ignites the mixture in the flask and the following reaction occurs: $CH_{4(g)} + 2\ O_{2(g)} \rightarrow CO_{2(g)} + 2\ H_2O_{(g)}$. Find the mole fraction of each gas in the mixture after the reaction.

22) A rigid 4.50 L vessel contains 0.134 mol $H_{2(g)}$ at 28°C. A lab technician adds 0.092 mol $F_{2(g)}$, and a reaction proceeds where $HF_{(g)}$ is formed.

a. What is the balanced equation for the reaction that occurred in the vessel?
b. What is the limiting reactant?
c. How many moles of each gas are there after the reaction is complete? Assume the reaction goes to completion.
d. Find the partial pressure of each gas after the reaction?
e. What is the total pressure in the vessel after the reaction?

23) A 250.0 mL solution of 1.0 *M* NaOH is added to a 200.0 mL solution of 1.5 *M* $Al(NO_3)_3$ and a solid $Al(OH)_3$ precipitate forms.

a. What is the limiting reactant?
b. Find the maximum mass of $Al(OH)_3(s)$ that could be produced.