Ch 9 – Worksheet 1 Using Stoichiometry

From the equation:  \( \text{NaOH} + \text{HCl} \rightarrow \text{NaCl} + \text{H}_2\text{O} \)

1. How many grams of NaCl could be made from 150.0 grams of HCl?

\[
150.0 \text{ g HCl} \times \frac{1 \text{ mol HCl}}{36.46 \text{ g HCl}} \times \frac{1 \text{ mol NaCl}}{1 \text{ mol HCl}} \times \frac{58.45 \text{ g NaCl}}{1 \text{ mol NaCl}} = 240.5 \text{ g NaCl}
\]

2. How many grams of NaOH would be needed to produce 11.7 grams of NaCl?

\[
11.7 \text{ g NaCl} \times \frac{1 \text{ mol NaCl}}{58.45 \text{ g NaCl}} \times \frac{1 \text{ mol NaOH}}{1 \text{ mol NaCl}} \times \frac{40.0 \text{ g NaOH}}{1 \text{ mol NaOH}} = 8.01 \text{ g NaOH}
\]

From the equation:  \( \text{FeCl}_3 + 3 \text{ KOH} \rightarrow \text{Fe(OH)}_3 + 3 \text{ KCl} \)

3. How many grams of FeCl_3 would be required to produce 28.0 grams of KCl?

\[
28.0 \text{ g KCl} \times \frac{1 \text{ mol KCl}}{74.55 \text{ g KCl}} \times \frac{1 \text{ mol FeCl}_3}{3 \text{ mol KCl}} \times \frac{162.2 \text{ g FeCl}_3}{1 \text{ mol FeCl}_3} = 20.3 \text{ g FeCl}_3
\]

4. How many grams of KCl will be produced from 4.0 moles of FeCl_3?

\[
4.0 \text{ mol FeCl}_3 \times \frac{3 \text{ mol KCl}}{1 \text{ mol FeCl}_3} \times \frac{74.55 \text{ g KCl}}{1 \text{ mol KCl}} = 895.2 \text{ g KCl} \rightarrow 890 \text{ g KCl}
\]

5. How many moles of KCl would be formed from 16.1 grams of KOH?

\[
16.1 \text{ g KOH} \times \frac{1 \text{ mol KOH}}{56.11 \text{ g KOH}} \times \frac{3 \text{ mol KCl}}{3 \text{ mol KOH}} = 0.287 \text{ mol KCl}
\]

From the equation:  \( \text{CaCO}_3 + 2 \text{ NaCl} \rightarrow \text{Na}_2\text{CO}_3 + \text{CaCl}_2 \)

6. How many grams of NaCl will react with 1.00 Kg of CaCO_3?

\[
1.00 \text{ kg CaCO}_3 \times \frac{1000 \text{ g}}{1 \text{ Kg}} \times \frac{1 \text{ mol CaCO}_3}{100.09 \text{ g CaCO}_3} \times \frac{2 \text{ mol NaCl}}{1 \text{ mol CaCO}_3} \times \frac{58.45 \text{ g NaCl}}{1 \text{ mol NaCl}} = 1168 \text{ g NaCl}
\]

7. How many grams of Na_2CO_3 will be formed in question #6?

\[
1 \text{ kg} = 1000 \text{ g}
\]

\[
1000 \text{ g CaCO}_3 \times \frac{1 \text{ mol CaCO}_3}{100.09 \text{ g CaCO}_3} \times \frac{1 \text{ mol Na}_2\text{CO}_3}{1 \text{ mol CaCO}_3} \times \frac{106.0 \text{ g Na}_2\text{CO}_3}{1 \text{ mol Na}_2\text{CO}_3} = 1059 \text{ g Na}_2\text{CO}_3
\]
If potassium chlorate is heated, it gives off oxygen and potassium chloride remains.

8. Write a balanced equation for this reaction.

\[ 2 \text{K ClO}_3 \xrightarrow{\Delta} 3\text{O}_2 + 2\text{KCl} \]

9. How many moles of potassium chlorate are needed to produce 48.0 grams of \( \text{O}_2 \)?

\[
\frac{48.0 \text{ g O}_2}{32.0 \text{ g O}_2} \times \frac{1 \text{ mol O}_2}{3 \text{ mol O}_2} = 1.00 \text{ mol KClO}_3
\]

10. How many moles of potassium chloride could be formed from 7.00 moles of potassium chlorate?

\[
7.0 \text{ mol KClO}_3 \times \frac{2 \text{ mol KCl}}{2 \text{ mol KClO}_3} = 7.00 \text{ mol KCl}
\]

11. How many grams of oxygen gas would be given off by 122.6 grams of potassium chlorate?

\[
\frac{122.6 \text{ g KClO}_3}{122.6 \text{ g KClO}_3} \times \frac{1 \text{ mol KClO}_3}{122.6 \text{ g KClO}_3} \times \frac{3 \text{ mol O}_2}{2 \text{ mol KClO}_3} \times \frac{32.0 \text{ g O}_2}{1 \text{ mol O}_2} = 48.0 \text{ g O}_2
\]

Pentane \((\text{C}_5\text{H}_{12})\) reacts with oxygen to form carbon dioxide and water vapor.

12. Write the balanced equation for this reaction.

\[ \text{C}_5\text{H}_{12} + 8\text{O}_2 \rightarrow 5\text{CO}_2 + 6\text{H}_2\text{O} \]

13. How many moles of \( \text{O}_2 \) would be required for the complete reaction of 3.50 moles of pentane?

\[
3.50 \text{ mol C}_5\text{H}_{12} \times \frac{8 \text{ mol O}_2}{1 \text{ mol C}_5\text{H}_{12}} = 28.0 \text{ mol O}_2
\]

14. How many grams of \( \text{H}_2\text{O(g)} \) would be produced starting with 2.00 moles of pentane?

\[
2.00 \text{ mol C}_5\text{H}_{12} \times \frac{6 \text{ mol H}_2\text{O}}{1 \text{ mol C}_5\text{H}_{12}} \times \frac{18.02 \text{ g H}_2\text{O}}{1 \text{ mol H}_2\text{O}} = 216 \text{ g H}_2\text{O}
\]

15. How many grams of \( \text{O}_2 \) would be required to burn enough pentane to produce 112.0 grams \( \text{CO}_2 \)?

\[
112.0 \text{ g CO}_2 \times \frac{1 \text{ mol CO}_2}{44.0 \text{ g CO}_2} \times \frac{8 \text{ mol O}_2}{5 \text{ mol CO}_2} \times \frac{32.0 \text{ g O}_2}{1 \text{ mol O}_2} = 130.3 \text{ g O}_2
\]
1) Chlorine is used by textile manufacturers to bleach cloth. Excess chlorine is destroyed by its reaction with sodium thiosulfate, Na₂S₂O₃:

\[ \underline{Na_2S_2O_3(aq)} + \frac{4}{5} Cl_2(g) + \frac{5}{6} H_2O(aq) \rightarrow 2 NaHSO_4(aq) + 8 HCl(aq) \]

(Balance the equation)

a. How many moles of Na₂S₂O₃ are needed to react with 0.12 mol of Cl₂?

\[ 0.12 \text{ mol Cl}_2 \times \frac{1 \text{ mol Na}_2S_2O_3}{4 \text{ mol Cl}_2} = 0.03 \text{ mol Na}_2S_2O_3 \]

b. How many moles of HCl can form from 0.12 mol of Cl₂?

\[ 0.12 \text{ mol Cl}_2 \times \frac{8 \text{ mol HCl}}{4 \text{ mol Cl}_2} = 0.24 \text{ mol HCl} \]

c. How many moles of H₂O are required for the reaction of 5.19 g of Cl₂?

\[ 5.19 \text{ g Cl}_2 \times \frac{1 \text{ mol Cl}_2}{70.90 \text{ g Cl}_2} \times \frac{5 \text{ mol H}_2O}{4 \text{ mol Cl}_2} = 0.0915 \text{ mol H}_2O \]

d. How many grams of H₂O react if 10.24 grams of HCl is formed?

\[ 10.24 \text{ g HCl} \times \frac{1 \text{ mol HCl}}{36.46 \text{ g HCl}} \times \frac{5 \text{ mol H}_2O}{8 \text{ mol HCl}} \times \frac{18.01 \text{ g H}_2O}{1 \text{ mol H}_2O} = 3.161 \text{ g} \]

2.) The incandescent white of a fireworks display is caused by the reaction of Phosphorous with Oxygen to give Tetraphosphorus decaoxide.

a. Write the balanced chemical equation for the reaction.

\[ 4 P + 5 O_2 \rightarrow P_4O_{10} \]

b. How many grams of O₂ are needed to combine with 6.85 g of P?

\[ 6.85 \text{ g P} \times \frac{1 \text{ mol P}}{30.97 \text{ g P}} \times \frac{5 \text{ mol O}_2}{1 \text{ mol P}} \times \frac{32.00 \text{ g O}_2}{1 \text{ mol O}_2} = 8.85 \text{ g} \]

c. How many grams of P₄O₁₀ can be made from 8.75 g of O₂?

\[ 8.75 \text{ g O}_2 \times \frac{1 \text{ mol O}_2}{32.00 \text{ g O}_2} \times \frac{1 \text{ mol P}_4O_{10}}{5 \text{ mol O}_2} \times \frac{283.88 \text{ g P}_4O_{10}}{1 \text{ mol P}_4O_{10}} = 15.5 \text{ g} \]

d. How many grams of P are needed to make 7.46 g P₄O₁₀?

\[ 7.46 \text{ g P}_4O_{10} \times \frac{1 \text{ mol P}_4O_{10}}{283.88 \text{ g P}_4O_{10}} \times \frac{4 \text{ mol P}}{1 \text{ mol P}_4O_{10}} \times \frac{30.97 \text{ g P}}{1 \text{ mol P}} = 3.83 \text{ g} \]
3. In dilute nitric acid, HNO₃, copper metal dissolves according to the following equation:

\[ 3\text{Cu(s)} + 8\text{HNO}_3(\text{aq}) \rightarrow 3\text{Cu(NO}_3)_2(\text{aq}) + 2\text{NO}_2(\text{g}) + 4\text{H}_2\text{O(aq)} \]

a. How many grams of HNO₃ are needed to dissolve 11.45g of Cu?

\[
11.45\text{g Cu} \times \frac{1\text{mol Cu}}{63.54\text{g Cu}} \times \frac{8\text{mol HNO}_3}{3\text{mol Cu}} \times \frac{63.02\text{g HNO}_3}{1\text{mol HNO}_3} = 30.28\text{g}
\]

b. If a chemist has 15.84 grams of nitric acid available, how many grams of copper can she dissolve?

\[
15.84\text{g HNO}_3 \times \frac{1\text{mol HNO}_3}{63.02\text{g HNO}_3} \times \frac{3\text{mol Cu}}{8\text{mol HNO}_3} \times \frac{63.54\text{g Cu}}{1\text{mol Cu}} = 5.98\text{g}
\]

c. State the name of each of the products formed.

- \(\text{Cu(NO}_3)_2\) = copper (II) nitrate
- NO = nitrogen monoxide
- \(\text{H}_2\text{O}\) = water
1. The industrial solvent carbon disulfide (CS₂) is produced through the following reaction between coke (C) and sulfur dioxide (SO₂):

\[ 5C + 2SO_2 \rightarrow CS_2 + 4CO \] (unbalanced)

If 8.00 g SO₂ reacts, how many moles of CS₂ are formed?

\[ \frac{8.00 \text{ g SO}_2}{64.10 \text{ g SO}_2} \times \frac{1 \text{ mol SO}_2}{2 \text{ mol SO}_2} = 0.125 \text{ mol} \]

If 8.00 g SO₂ reacts, how many moles of CO are formed?

\[ \frac{8.00 \text{ g SO}_2}{64.10 \text{ g SO}_2} \times \frac{1 \text{ mol SO}_2}{2 \text{ mol SO}_2} \times \frac{4 \text{ mol CO}}{1 \text{ mol SO}_2} = 0.250 \text{ mol} \]

2. In photosynthesis, plants use energy from sun to combine carbon dioxide and water, forming glucose (C₆H₁₂O₆) and oxygen. What mass in grams of glucose is produced when 3.00 mole of water reacts with carbon dioxide? (Hint: your first step is to write the formula equation)

\[ 6\text{CO}_2 + 6\text{H}_2\text{O} \rightarrow C_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 \]

\[ \frac{3.00 \text{ mol H}_2\text{O}}{6 \text{ mol H}_2\text{O}} \times \frac{1 \text{ mol C}_6\text{H}_{12}\text{O}_6}{6 \text{ mol H}_2\text{O}} \times \frac{180.12 \text{ g C}_6\text{H}_{12}\text{O}_6}{1 \text{ mol C}_6\text{H}_{12}\text{O}_6} = 90.06 \text{ g C}_6\text{H}_{12}\text{O}_6 \]

3. Laughing gas (N₂O) is sometimes used as an anesthetic in dental work. It is produced when ammonium nitrate is decomposed according to the reaction:

\[ \text{NH}_4\text{NO}_3 \rightarrow N_2\text{O} + 2\text{H}_2\text{O} \] (unbalanced)

How many grams of NH₄NO₃ are required to produce 33.0 g N₂O?

\[ \frac{33.0 \text{ g N}_2\text{O}}{44 \text{ g N}_2\text{O}} \times \frac{1 \text{ mol N}_2\text{O}}{1 \text{ mol N}_2\text{O}} \times \frac{80.04 \text{ g NH}_4\text{NO}_3}{1 \text{ mol NH}_4\text{NO}_3} = 60.03 \text{ g} \]
4. The decomposition of potassium chlorate is used as a source of oxygen in the laboratory. How many moles of potassium chlorate are needed to produce 15 moles of oxygen (O$_2$)?

\[ 2 \text{KClO}_3 \rightarrow 2 \text{KCl} + 3 \text{O}_2 \quad \text{(unbalanced)} \]

\[
15 \text{ mol O}_2 \times \frac{2 \text{ mol KClO}_3}{3 \text{ mol O}_2} = 10 \text{ mol KClO}_3
\]

5. Tin (II) fluoride, or stannous fluoride, is used in some home dental treatment products. It is made by the reaction of tin with hydrogen fluoride.

\[ \text{Sn} + 2\text{HF} \rightarrow \text{SnF}_2 + \text{H}_2 \quad \text{(unbalanced)} \]

How many grams of SnF$_2$ are produced from the reaction of 35.0 g of hydrogen fluoride with tin?

\[
35.0 \text{ g HF} \times \frac{1 \text{ mol HF}}{20.01 \text{ g HF}} \times \frac{1 \text{ mol SnF}_2}{2 \text{ mol HF}} \times \frac{156.69 \text{ g SnF}_2}{1 \text{ mol SnF}_2} = 137.8 \text{ g SnF}_2
\]
Ch 9 – Worksheet 3 – Limiting Reactant

1. Silicon dioxide (quartz) is usually quite stable but reacts with hydrogen fluoride according to the following equation:
   \[ \text{SiO}_2 (s) + 4 \text{HF} (g) \rightarrow \text{SiF}_4 (g) + 2 \text{H}_2\text{O} (l) \]

   (a) If 2.0 mol of HF is combined with 4.5 mol of SiO_2, how many moles of SiF_4 will be produced?
   \[ 2.0 \ 	ext{mol HF} \times \frac{1 \ 	ext{mol SiF}_4}{4 \ 	ext{mol HF}} = 0.5 \ 	ext{mol SiF}_4 \]

   (b) What is the limiting reactant?
   \[ \text{HF is lim. react.} \]

2. Some rocket engines use a mixture of hydrazine (N_2H_4) and hydrogen peroxide (H_2O_2) as the propellant system. The reaction is given by the equation
   \[ \text{N}_2\text{H}_4 + 2 \text{H}_2\text{O}_2 \rightarrow \text{N}_2 + 4 \text{H}_2\text{O} \]

   (a) Which is the limiting reactant in this reaction when 0.750 mol N_2H_4 reacts with 0.500 mol H_2O_2?
   \[ 0.750 \ 	ext{mol N}_2\text{H}_4 \times \frac{1 \ 	ext{mol N}_2}{1 \ 	ext{mol N}_2\text{H}_4} = 0.75 \ 	ext{mol N}_2 \]
   \[ 0.500 \ 	ext{mol H}_2\text{O}_2 \times \frac{2 \ 	ext{mol N}_2}{2 \ 	ext{mol H}_2\text{O}_2} = 0.25 \ 	ext{mol N}_2 \]

   (b) How many moles of N_2 are formed?
   \[ 0.25 \ 	ext{mol} \]

3. From the equation: \[ 2 \text{HCl} + \text{Zn} \rightarrow \text{ZnCl}_2 + \text{H}_2 \]

   (a) How many grams of H_2 can be produced starting with 20.0 grams of Zn and 25.5 grams of HCl?
   \[ 20.0 \ 	ext{g Zn} \times \frac{1 \ 	ext{mol Zn}}{65.38 \ 	ext{g Zn}} \times \frac{1 \ 	ext{mol H}_2}{2 \ 	ext{mol Zn}} \times \frac{2.02 \ 	ext{g H}_2}{22.01 \ 	ext{mol H}_2} = 0.618 \ 	ext{g H}_2 \]
   \[ 25.5 \ 	ext{g HCl} \times \frac{1 \ 	ext{mol HCl}}{36.46 \ 	ext{g HCl}} \times \frac{1 \ 	ext{mol H}_2}{2 \ 	ext{mol HCl}} \times \frac{2.02 \ 	ext{g H}_2}{22.01 \ 	ext{mol H}_2} = 0.706 \ 	ext{g H}_2 \]

   (b) Identify the limiting reactant.
   \[ \text{Zn is lim. reactant} \]
4. From the equation: \(3\text{H}_2\text{SO}_4 + 2\text{Fe(OH)}_3 \rightarrow \text{Fe}_2\text{(SO}_4)_3 + 6\text{H}_2\text{O}\)

(a) How many grams of \(\text{Fe}_2\text{(SO}_4)_3\) would be produced from 25.0 grams of \(\text{Fe(OH)}_3\) and an excess of \(\text{H}_2\text{SO}_4\)?

\[
25.0 \text{g Fe(OH)}_3 \times \frac{1 \text{mol Fe(OH)}_3}{106.88 \text{g Fe(OH)}_3} \times \frac{1 \text{mol Fe}_2\text{(SO}_4)_3}{2 \text{mol Fe(OH)}_3} \times \frac{399.88 \text{g Fe}_2\text{(SO}_4)_3}{1 \text{mol Fe}_2\text{(SO}_4)_3} = 76.8 \text{g Fe}_2\text{(SO}_4)_3
\]

(b) How many moles of water would be produced in the reaction of 15.0 grams of \(\text{H}_2\text{SO}_4\) with 15.0 grams of \(\text{Fe(OH)}_3\)?

\[
15.0 \text{g H}_2\text{SO}_4 \times \frac{1 \text{mol H}_2\text{SO}_4}{98.08 \text{g H}_2\text{SO}_4} \times \frac{6 \text{mol H}_2\text{O}}{3 \text{mol H}_2\text{SO}_4} = 0.306 \text{mol H}_2\text{O}
\]

5. From the equation: \(2\text{HCl} + \text{MgO} \rightarrow \text{MgCl}_2 + \text{H}_2\text{O}\) (not balanced)

Starting with 450.0 grams of \(\text{HCl}\) gas and an excess of \(\text{MgO}\), how many moles of \(\text{H}_2\text{O}\) could be produced?

\[
450.0 \text{g HCl} \times \frac{1 \text{mol HCl}}{36.46 \text{g HCl}} \times \frac{1 \text{mol H}_2\text{O}}{2 \text{mol HCl}} = 6.171 \text{mol H}_2\text{O}
\]

6. From the equation: \(2\text{SO}_2 + \text{O}_2 \rightarrow 2\text{SO}_3\) (not balanced)

(a) How many moles of \(\text{SO}_2\) will react with 10.0 moles of \(\text{O}_2\)?

\[
10.0 \text{mol O}_2 \times \frac{2 \text{mol SO}_2}{1 \text{mol O}_2} = 20.0 \text{mol SO}_2
\]

(b) How many grams of \(\text{SO}_3\) will be produced by reacting 9.62 grams \(\text{SO}_2\) with 1.35 grams \(\text{O}_2\)? Which substance is the limiting reactant?

\[
9.62 \text{g SO}_2 \times \frac{1 \text{mol SO}_2}{64.06 \text{g SO}_2} \times \frac{2 \text{mol SO}_3}{2 \text{mol SO}_2} \times \frac{80.06 \text{g SO}_3}{1 \text{mol SO}_3} = 12.0 \text{g SO}_3
\]

\[
1.35 \text{g O}_2 \times \frac{1 \text{mol O}_2}{32.0 \text{g O}_2} \times \frac{2 \text{mol SO}_3}{1 \text{mol O}_2} \times \frac{80.06 \text{g SO}_3}{1 \text{mol SO}_3} = 6.76 \text{g SO}_3
\]

\(\text{O}_2\) is the limiting reactant.
From the equation: \( \text{Zn} + 2\text{HCl} \rightarrow \text{ZnCl}_2 + \text{H}_2 \) (not balanced)

1. (a) If 50.0 grams zinc and 50.0 grams HCl are reacted, how many grams of \( \text{ZnCl}_2 \) will result?

\[
50.0 \text{g Zn} \times \frac{1 \text{mol Zn}}{65.37 \text{g Zn}} \times \frac{1 \text{mol ZnCl}_2}{1 \text{mol Zn}} \times \frac{136.3 \text{g ZnCl}_2}{1 \text{mol ZnCl}_2} = 104.8 \text{g}
\]

\[
50.0 \text{g HCl} \times \frac{1 \text{mol HCl}}{36.46 \text{g HCl}} \times \frac{1 \text{mol ZnCl}_2}{2 \text{mol HCl}} \times \frac{136.3 \text{g ZnCl}_2}{1 \text{mol ZnCl}_2} = 93.5 \text{g}
\]

(b) If 70.0 grams \( \text{ZnCl}_2 \) are actually produced, calculate the % yield.

\[
\% \text{ yield} = \frac{\text{act. yield}}{\text{theo. yield}} \times 100
\]

\[
= \frac{70.0 \text{g}}{93.5 \text{g}} \times 100 = 74.9 \%
\]

From the equation: \( \text{H}_2 + \text{Cl}_2 \rightarrow 2\text{HCl} \) (not balanced)

2. How many grams HCl are formed by reacting 10.0 grams \( \text{H}_2 \) with 10.0 grams \( \text{Cl}_2 \) if the yield is 82.5%?

\[
10.0 \text{g H}_2 \times \frac{1 \text{mol H}_2}{2.02 \text{g H}_2} \times \frac{2 \text{mol HCl}}{1 \text{mol H}_2} \times \frac{36.46 \text{g HCl}}{1 \text{mol HCl}} = 360.99 \text{g HCl}
\]

\[
10.0 \text{g Cl}_2 \times \frac{1 \text{mol Cl}_2}{70.9 \text{g Cl}_2} \times \frac{2 \text{mol HCl}}{1 \text{mol Cl}_2} \times \frac{36.46 \text{g HCl}}{1 \text{mol HCl}} = 10.3 \text{g HCl}
\]

\[
\% = \frac{\text{act. yield}}{\text{theo. yield}} \times 100
\]

\[
82.5 = \frac{\text{act. yield}}{10.3} \quad \text{act. yield} = 8.50 \text{g HCl}
\]

3. Carbon monoxide will react with oxygen to form carbon dioxide. How many grams of carbon monoxide may be converted by this process if 10.0 grams of \( \text{O}_2 \) is available?

\[
2\text{CO} + \text{O}_2 \rightarrow 2\text{CO}_2
\]

\[
10.0 \text{g O}_2 \times \frac{1 \text{mol O}_2}{32.0 \text{g O}_2} \times \frac{2 \text{mol CO}}{1 \text{mol O}_2} \times \frac{28.01 \text{g CO}}{1 \text{mol CO}} = 17.5 \text{g CO}
\]
4. How many moles of magnesium sulfate are needed to react completely with 14.50 grams sodium chloride?

\[ \text{MgSO}_4 + 2\text{NaCl} \rightarrow \text{MgCl}_2 + \text{Na}_2\text{SO}_4 \]

\[
\frac{14.50 \text{ g NaCl}}{58.45 \text{ g NaCl}} \times \frac{1 \text{ mol NaCl}}{2 \text{ mol NaCl}} \times \frac{1 \text{ mol MgSO}_4}{1 \text{ mol NaCl}} = 0.1240 \text{ mol MgSO}_4
\]

5. An excess of potassium hydroxide is reacted with 50.0 grams hydrogen chloride. If 64.8 grams potassium chloride are actually produced, what is the % yield?

\[ \text{KOH} + \text{HCl} \rightarrow \text{KCl} + \text{H}_2\text{O} \]

\[
\frac{50.0 \text{ g HCl}}{36.46 \text{ g HCl}} \times \frac{1 \text{ mol HCl}}{1 \text{ mol KCl}} \times \frac{74.55 \text{ g KCl}}{1 \text{ mol KCl}} = 102.2 \text{ g KCl}
\]

\[
\% \text{ yield} = \frac{64.8 \text{ g}}{102.2 \text{ g}} \times 100 = 63.14\%
\]

6. How many grams silver bromide can be produced by the reaction 15.0 grams silver nitrate with an excess sodium bromide if the yield is 71.4%?

\[ \text{AgNO}_3 + \text{NaBr} \rightarrow \text{AgBr} + \text{NaNO}_3 \]

\[
\frac{15.0 \text{ g AgNO}_3}{169.91 \text{ g AgNO}_3} \times \frac{1 \text{ mol AgNO}_3}{1 \text{ mol AgBr}} \times \frac{187.89 \text{ g AgBr}}{1 \text{ mol AgBr}} = 16.06 \text{ g AgBr}
\]

\[
\% \text{ yield} = \frac{16.06 \text{ g}}{15.0 \text{ g}} \times 100 = 107.11
\]

7. From the equation: \( \text{N}_2 + \text{O}_2 \rightarrow 2\text{NO} \) (not balanced)
What is the minimum moles \( \text{N}_2 \) needed to form 25.0 moles NO?

25.0 mol NO \times \frac{1 \text{ mol } \text{N}_2}{2 \text{ mol NO}} = 12.5 \text{ mol } \text{N}_2

8. Zinc and sulfur react to form zinc sulfide according to the following:

\[ 8 \text{Zn} + 8\text{S}_8 \rightarrow 8\text{ZnS} \]

(a) If 2.00 moles of Zn are heated with 1.00 mole of \( \text{S}_8 \), identify the limiting reactant.

\[
2.00 \text{ mol Zn} \times \frac{8 \text{ mol ZnS}}{8 \text{ mol Zn}} = 2.0 \text{ mol ZnS}
\]

\[
1.0 \text{ mol } \text{S}_8 \times \frac{8 \text{ mol ZnS}}{1 \text{ mol } \text{S}_8} = 8.0 \text{ mol ZnS}
\]

(\textbf{Zn} = \text{Lim React.})

(b) How many moles of product are formed?

\[
2.0 \text{ mol ZnS}
\]
1. If 20.0 grams of sodium hydroxide react with 30 grams hydrogen sulfate, which reactant is limiting?

\[ 2\text{NaOH} + \text{H}_2\text{SO}_4 \rightarrow \text{Na}_2\text{SO}_4 + 2\text{H}_2\text{O} \]

\[
30 \text{ g H}_2\text{SO}_4 \times \frac{1 \text{ mol H}_2\text{SO}_4}{98.08 \text{ g H}_2\text{SO}_4} \times \frac{1 \text{ mol Na}_2\text{SO}_4}{2 \text{ mol H}_2\text{SO}_4} = 0.3 \text{ mol Na}_2\text{SO}_4
\]

\[
20.0 \text{ g NaOH} \times \frac{1 \text{ mol NaOH}}{40.00 \text{ g NaOH}} = 0.5 \text{ mol NaOH}
\]

\[
\frac{1 \text{ mol Na}_2\text{SO}_4}{2 \text{ mol NaOH}} = 0.25 \text{ mol NaOH}
\]

\[ \text{NaOH is limiting} \]

2. If 20.0 grams of KOH react with 15.0 grams of (NH₄)₂SO₄, determine the mass of each product.

\[
\frac{2\text{KOH} + (\text{NH}_4)_2\text{SO}_4 \rightarrow \text{K}_2\text{SO}_4 + 2\text{NH}_4\text{OH}}{	ext{20.0 g KOH} \times \frac{1 \text{ mol KOH}}{56.17 \text{ g KOH}} \times \frac{1 \text{ mol K}_2\text{SO}_4}{2 \text{ mol KOH}}} = \frac{20.0 \text{ g K}_2\text{SO}_4}{19.78} = \frac{31.05}{\text{g K}_2\text{SO}_4}
\]

\[
\frac{15.0 \text{ g (NH}_4)_2\text{SO}_4 \times \frac{1 \text{ mol (NH}_4)_2\text{SO}_4}{132.14 \text{ g (NH}_4)_2\text{SO}_4} \times \frac{1 \text{ mol K}_2\text{SO}_4}{1 \text{ mol (NH}_4)_2\text{SO}_4}}{147.85} = 19.78 \text{ g K}_2\text{SO}_4
\]

\[
\frac{15.0 \text{ g (NH}_4)_2\text{SO}_4 \times \frac{1 \text{ mol (NH}_4)_2\text{SO}_4}{132.14 \text{ g (NH}_4)_2\text{SO}_4} \times \frac{2 \text{ mol NH}_4\text{OH}}{1 \text{ mol (NH}_4)_2\text{SO}_4}}{35.05 \text{ g NH}_4\text{OH}} = 7.96 \text{ g NH}_4\text{OH}
\]

3. If the percent yield of a reaction between 50.0 g of CaCl₂ and 35.0 g of AgNO₃ is 82.0%, determine the grams of AgCl produced.

\[
\text{CaCl}_2 + 2\text{AgNO}_3 \rightarrow 2\text{AgCl} + \text{Ca(NO}_3)_2
\]

**Assume Cu²⁺**

**1. Limiting Reactant derivation:**

\[
\text{50.0 g CaCl}_2 \times \frac{1 \text{ mol CaCl}_2}{111.0 \text{ g CaCl}_2} \times \frac{2 \text{ mol AgCl}}{1 \text{ mol CaCl}_2} = 12.9 \text{ g AgCl}
\]

\[
\text{35.0 g AgNO}_3 \times \frac{1 \text{ mol AgNO}_3}{169.9 \text{ g AgNO}_3} \times \frac{2 \text{ mol AgCl}}{1 \text{ mol AgNO}_3} = 29.5 \text{ g AgCl}
\]

**2. Percent Yield Formula:**

\[
\% \text{ yield} = \frac{\text{act. mg AgCl}}{\text{th. mg AgCl}} \times 100 \%
\]

\[
\% \text{ yield} = \frac{20.0}{49.5} \times 100 \% = 82.0 \%
\]

**4. If 5.00 grams of copper reacted with an excess amount of silver nitrate to produce 1.00 grams of silver, what was the percent yield?**

\[
\text{Cu} + 2\text{AgNO}_3 \rightarrow 2\text{Ag} + \text{Cu(NO}_3)_2
\]

\[
\text{5.00 g Cu} \times \frac{1 \text{ mol Cu}}{63.54 \text{ g Cu}} \times \frac{2 \text{ mol Ag}}{1 \text{ mol Cu}} \times \frac{107.87 \text{ g Ag}}{1 \text{ mol Ag}} = 17.0 \text{ g Ag}
\]

\[
\% \text{ yield} = \frac{1.00 \text{ g Ag}}{17.0 \text{ g Ag}} \times 100 \% = 5.88 \%
\]
Write complete balanced reactions for each.

5. sodium iodide + chlorine →
   \[ 2NaI + Cl_2 \rightarrow 2NaCl + I_2 \]

6. aluminum hydroxide + hydrogen chloride →
   \[ Al(OH)_3 + 3HCl \rightarrow AlCl_3 + 3H_2O \]

7. hydrogen + oxygen →
   \[ 2H_2 + O_2 \rightarrow 2H_2O \]

8. aluminum oxide →
   \[ 2Al_2O_3 \rightarrow 4Al + 3O_2 \]

9. tin (IV) oxide + carbon →
   \[ SnO_2 + C \rightarrow Sn + CO_2 \]

10. lithium + water →
    \[ Li + 2H_2O \rightarrow 2LiOH + H_2 \]

11. aluminum hydroxide + hydrogen sulfate →
    \[ 2Al(OH)_3 + 3H_2SO_4 \rightarrow Al_2(SO_4)_3 + 6H_2O \]

12. C₄H₁₀ + O₂ →
    \[ 2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 16H_2O \]
1. Oxygen was discovered by Joseph Priestly in 1774 when he decomposed mercury (II) oxide to its constituent elements by heating it. Ideally, how many moles of mercury (II) oxide are needed to produce 125 g $O_2$?

\[
2HgO \xrightarrow{\Delta} 2Hg + O_2
\]

\[
125 \text{ g } O_2 \times \frac{1 \text{ mol } O_2}{32.0 \text{ g } O_2} \times \frac{2 \text{ mol } HgO}{1 \text{ mol } O_2} = 7.81 \text{ mol } HgO
\]

2. Chlorobenzene ($C_6H_5Cl$) is used in the production of many important chemicals such as aspirin, dyes, and disinfectants. One industrial method of preparing chlorobenzene, is the reaction between benzene ($C_6H_6$) and chlorine, represented by the equation

\[
C_6H_6 + Cl_2 \rightarrow C_6H_5Cl + HCl \quad \text{unbalanced}
\]

When 36.8 g $C_6H_6$ react with an excess of $Cl_2$, the actual yield of $C_6H_5Cl$ is 38.8 g. What is the percent yield of $C_6H_5Cl$?

\[
\begin{align*}
\text{1st mole ratio} & \quad \frac{36.8 \text{ g } C_6H_6}{78.12 \text{ g } C_6H_6} \times \frac{1 \text{ mol } C_6H_6}{1 \text{ mol } C_6H_5Cl} = 0.473 \text{ mol } C_6H_5Cl \\
\text{2nd mole ratio} & \quad \frac{112.56 \text{ g } C_6H_5Cl}{1 \text{ mol } C_6H_5Cl} = 53.02 \text{ g } C_6H_5Cl \\
\%	ext{ yield} & \quad \frac{38.8 \text{ g } C_6H_5Cl}{53.02 \text{ g } C_6H_5Cl} \times 100 = 73.27\%
\end{align*}
\]

3. Aluminum reacts with hydrochloric acid according to the following single replacement equation:

\[
2 \text{Al} + 6\text{HCl} \rightarrow 2\text{AlCl}_3 + 3\text{H}_2
\]

If 18 g Al are combined with 50 g HCl, which reactant is the limiting reactant? What mass of each product is formed?

\[
\begin{align*}
\text{Al mass} & \quad \frac{18 \text{ g Al}}{26.98 \text{ g Al}} \times \frac{2 \text{ mol Al}}{2 \text{ mol AlCl}_3} \times \frac{133.3 \text{ g AlCl}_3}{1 \text{ mol AlCl}_3} = 89 \text{ g AlCl}_3 \\
\text{HCl mass} & \quad \frac{50.0 \text{ g HCl}}{36.46 \text{ g } HCl} \times \frac{2 \text{ mol } AlCl_3}{6 \text{ mol } HCl} \times \frac{133.3 \text{ AlCl}_3}{1 \text{ mol } AlCl_3} = 60.9 \text{ g AlCl}_3
\end{align*}
\]

HCl is Lim. React.

\[
\begin{align*}
\text{H}_2 \text{ mass} & \quad \frac{50.0 \text{ g } HCl}{36.46 \text{ g } HCl} \times \frac{3 \text{ mol } H_2}{6 \text{ mol } HCl} \times \frac{2.02 \text{ g } H_2}{1 \text{ mol } H_2} = 1.39 \text{ g } H_2
\end{align*}
\]
1) Given the reaction:

\[ 2\text{C}_8\text{H}_{18} + 25\text{O}_2 \rightarrow 16\text{CO}_2 + 18\text{H}_2\text{O} \] (not balanced)

a. How many moles of \( \text{O}_2 \) are needed to react with 0.12 mol of \( \text{C}_8\text{H}_{18} \)?

\[ 0.12 \text{ mol C}_8\text{H}_{18} \times \frac{25 \text{ mol O}_2}{2 \text{ mol C}_8\text{H}_{18}} = 1.5 \text{ mol O}_2 \]

b. How many moles of \( \text{H}_2\text{O} \) can form from 0.12 mol of \( \text{C}_8\text{H}_{18} \)?

\[ 0.12 \text{ mol C}_8\text{H}_{18} \times \frac{18 \text{ mol H}_2\text{O}}{2 \text{ mol C}_8\text{H}_{18}} = 1.08 \text{ mol H}_2\text{O} \]

c. How many moles of \( \text{H}_2\text{O} \) are produced from the reaction of 5.19 g of \( \text{O}_2 \)?

\[ 5.19 \text{ g O}_2 \times \frac{1 \text{ mol O}_2}{32.0 \text{ g O}_2} \times \frac{18 \text{ mol H}_2\text{O}}{25 \text{ mol O}_2} = 0.117 \text{ mol H}_2\text{O} \]

d. How many grams of \( \text{O}_2 \) react if 10.24 grams of \( \text{H}_2\text{O} \) is formed?

\[ 10.24 \text{ g H}_2\text{O} \times \frac{1 \text{ mol H}_2\text{O}}{18.02 \text{ g H}_2\text{O}} \times \frac{1 \text{ mol O}_2}{18 \text{ mol H}_2\text{O}} \times 32 \text{ g O}_2 = 25.26 \text{ g O}_2 \]

2.) Magnesium phosphate will react with Copper (II) nitrate.

a. Write the balanced chemical equation for the reaction.

\[ \text{Mg}_3(\text{PO}_4)_2 + 2\text{Cu(NO}_3)_2 \rightarrow 2\text{Mg(NO}_3)_2 + \text{Cu}_3(\text{PO}_4)_2 \]

b. How many grams of magnesium nitrate are needed to combine with 6.85 g of copper (II) nitrate?

\[ 6.85 \text{ g Cu(NO}_3)_2 \times \frac{1 \text{ mol Cu(NO}_3)_2}{187.56 \text{ g Cu(NO}_3)_2} \times \frac{3 \text{ mol Mg(NO}_3)_2}{3 \text{ mol Cu(NO}_3)_2} \times \frac{148.3 \text{ g Mg(NO}_3)_2}{1 \text{ mol Mg(NO}_3)_2} = 5.42 \text{ g} \]

c. How many grams of magnesium nitrate can be made from 8.75 g of magnesium phosphate?

\[ 8.75 \text{ g Mg}_3(\text{PO}_4)_2 \times \frac{1 \text{ mol Mg}_3(\text{PO}_4)_2}{248.86 \text{ g Mg}_3(\text{PO}_4)_2} \times \frac{3 \text{ mol Mg(NO}_3)_2}{1 \text{ mol Mg}_3(\text{PO}_4)_2} \times \frac{148.3 \text{ g Mg(NO}_3)_2}{1 \text{ mol Mg(NO}_3)_2} = 14.8 \text{ g} \]

d. How many moles of copper (II) nitrate are needed to make 7.46 g copper (II) phosphate?

\[ 7.46 \text{ g Cu}_3(\text{PO}_4)_2 \times \frac{1 \text{ mol Cu}_3(\text{PO}_4)_2}{380.58 \text{ g Cu}_3(\text{PO}_4)_2} \times \frac{3 \text{ mol Cu(NO}_3)_2}{1 \text{ mol Cu}_3(\text{PO}_4)_2} = 0.058 \text{ mol Cu(NO}_3)_2 \]
3. A 50.6 g sample of Mg(OH)\textsubscript{2} is reacted with 45.0 g of HCl according to the reaction:

\[
\text{Mg(OH)}_2 + 2 \text{HCl} \rightarrow \text{MgCl}_2 + 2 \text{H}_2\text{O}
\]

a. Determine the limiting reactant.

\[
\frac{50.6 \text{ g Mg(OH)}_2 \times \frac{1 \text{ mol Mg(OH)}_2}{58.32 \text{ g Mg(OH)}_2} \times \frac{2 \text{ mol H}_2\text{O}}{1 \text{ mol Mg(OH)}_2}}{1 \text{ mol H}_2\text{O}} = 31.3 \text{ g H}_2\text{O}
\]

\[
\frac{45.0 \text{ g HCl} \times \frac{1 \text{ mol HCl}}{36.47 \text{ g HCl}} \times \frac{2 \text{ mol H}_2\text{O}}{2 \text{ mol HCl}}}{1 \text{ mol H}_2\text{O}} = 22.8 \text{ g H}_2\text{O}
\]

b. How many grams of each product will be formed?

\[
\frac{45.0 \text{ g HCl} \times \frac{1 \text{ mol MgCl}_2}{36.47 \text{ g HCl}} \times \frac{1 \text{ mol MgCl}_2}{2 \text{ mol HCl}}}{1 \text{ mol MgCl}_2} = 58.76 \text{ g MgCl}_2
\]

4. According to the following equation, Calculate the percentage yield if 550.0 g of toluene (C\textsubscript{7}H\textsubscript{8}) added to an excess of nitric acid (HNO\textsubscript{3}) provides 305 g of the p-nitrotoluene (C\textsubscript{7}H\textsubscript{7}NO\textsubscript{2}) product.

\[
\text{C}_7\text{H}_8 + \text{HNO}_3 \rightarrow \text{C}_7\text{H}_7\text{NO}_2 + \text{H}_2\text{O}
\]

\[
\frac{550.0 \text{ g C}_7\text{H}_8 \times \frac{1 \text{ mol C}_7\text{H}_8}{92.14 \text{ g C}_7\text{H}_8} \times \frac{1 \text{ mol C}_7\text{H}_7\text{NO}_2}{1 \text{ mol C}_7\text{H}_8}}{1 \text{ mol C}_7\text{H}_7\text{NO}_2} = 818.6 \text{ g}
\]

\[
\% \text{ yield} = \frac{305 \text{ g}}{818.6 \text{ g}} \times 100 = 37.39\%
\]

5. Chloroform, CHCl\textsubscript{3}, reacts with chlorine to form carbon tetrachloride and hydrogen chloride. In an experiment 25 grams of chloroform and 25 grams of chlorine were mixed. If 5.75 grams of water are formed, what is the percent yield?

\[
\text{CHCl}_3 + \text{Cl}_2 \rightarrow \text{CCl}_4 + \text{HCl} \quad \text{(balanced)}
\]

\[
\frac{25 \text{ g CHCl}_3 \times \frac{1 \text{ mol CHCl}_3}{119.4 \text{ g CHCl}_3} \times \frac{1 \text{ mol CCl}_4}{1 \text{ mol CHCl}_3}}{1 \text{ mol CCl}_4} = 32.8 \text{ g CCl}_4
\]

\[
25 \text{ g Cl}_2 \times \frac{1 \text{ mol Cl}_2}{70.9 \text{ g Cl}_2} \times \frac{1 \text{ mol CCl}_4}{1 \text{ mol Cl}_2} \times \frac{153.8 \text{ g CCl}_4}{1 \text{ mol CCl}_4} = 54.8 \text{ g CCl}_4
\]

\[
\% \text{ yield} = \frac{5.75 \text{ g}}{32.8 \text{ g}} \times 100 = 17.97\%
\]