Chemistry: *Quantitative Relationships in Chemical Equations*

When we balance a chemical equation, we are satisfying the law of conservation of mass; that is, we are making sure that there are the same number of atoms of each element on both sides of the equation. The coefficients we place in front of the substances in an equation are very important because they tell us the mole ratio of the substances in that reaction. For instance, the balanced equation…

\[
\text{hydrogen gas} + \text{oxygen gas} \rightarrow \text{liquid water}
\]

\[2 \ H_2(g) + O_2(g) \rightarrow 2 \ H_2O(l)\]

can be thought of in terms of…

\[2 \ \text{moles} \ H_2(g) + 1 \ \text{mole} \ O_2(g) \rightarrow 2 \ \text{moles} \ H_2O(l)\]

**Directions:**

A. Balance each equation.

B. Solve the problems, assuming that you have excess of the other reactant(s).

1. \[____ \ Ca(s) + ____ \ N_2(g) \rightarrow ____ \ Ca_3N_2(s)\]
   a. How many moles of \( Ca_3N_2\) can be made from 16.8 moles of \( Ca\)?

   b. If you need to make 34.4 moles of \( Ca_3N_2\), how many moles of \( N_2\) will you need?

2. \[____ \ Fe(s) + ____ \ O_2(g) \rightarrow ____ \ Fe_3O_4(s)\]
   a. How many moles of \( O_2\) will react with 42.5 moles of \( Fe\)?

   b. If you need to make 1.56 moles of \( Fe_3O_4\), how many moles of \( Fe\) will you need?

3. \[____ \ FeCl_2(aq) + ____ \ KOH(aq) \rightarrow ____ \ Fe(OH)_2(s) + ____ \ KCl(aq)\]
   a. How many moles of \( KOH\) will react with 86.2 moles of \( FeCl_2\)?

   b. If you need to make 12.4 moles of \( KCl\), how many moles of \( FeCl_2\) will you need?
4. \( \underline{\text{Cu(s)}} + \underline{\text{O}_2(g)} \rightarrow \underline{\text{Cu}_2\text{O(s)}} \)
   a. How many moles of \( \text{Cu}_2\text{O} \) can be made from 25.6 moles of \( \text{Cu} \)?

   b. How many moles of \( \text{O}_2 \) does it take to produce 214 moles of \( \text{Cu}_2\text{O} \)?

5. \( \underline{\text{K(s)}} + \underline{\text{Cl}_2(g)} + \underline{\text{O}_2(g)} \rightarrow \underline{\text{KClO}_3(s)} \)
   a. How many moles of \( \text{KClO}_3 \) can be made from 89 moles of \( \text{O}_2 \)?

   b. If you have 24.6 moles of \( \text{Cl}_2 \), how many moles of \( \text{KClO}_3 \) can you produce?

6. \( \underline{\text{NH}_3(g)} + \underline{\text{H}_2\text{S(g)}} \rightarrow \underline{\text{(NH}_4\text{)}_2\text{S(s)}} \)
   a. How many moles of \( \text{(NH}_4\text{)}_2\text{S} \) can be made from 15.8 moles of \( \text{NH}_3 \)?

   b. If you have 462 moles of \( \text{NH}_3 \), how many moles of \( \text{H}_2\text{S} \) do you need?

7. \( \underline{\text{Al}_2\text{O}_3(s)} + \underline{\text{H}_2\text{SO}_4(aq)} \rightarrow \underline{\text{Al}_2\text{(SO}_4\text{)}_3(aq)} + \underline{\text{H}_2\text{O(l)}} \)
   a. How many moles of \( \text{Al}_2\text{(SO}_4\text{)}_3 \) can be made from 6.3 moles of \( \text{H}_2\text{SO}_4 \)?

   b. How many moles of \( \text{Al}_2\text{O}_3 \) does it take to make 7.2 moles of \( \text{H}_2\text{O} \)?

   c. If you have 588 moles of \( \text{Al}_2\text{O}_3 \), how many moles of \( \text{Al}_2\text{(SO}_4\text{)}_3 \) can you produce?

**Answers:**

1a. 5.6 mol \( \text{Ca}_3\text{N}_2 \)
1b. 34.4 mol \( \text{N}_2 \)
2a. 29.3 mol \( \text{O}_2 \)
2b. 4.68 mol \( \text{Fe} \)
3a. 172.4 mol \( \text{KOH} \)
3b. 6.2 mol \( \text{FeCl}_3 \)
4a. 12.8 mol \( \text{Cu}_2\text{O} \)
4b. 107 mol \( \text{O}_2 \)
5a. 59.3 mol \( \text{KClO}_3 \)
5b. 49.2 mol \( \text{KClO}_3 \)
6a. 7.9 mol \( \text{(NH}_4\text{)}_2\text{S} \)
6b. 231 mol \( \text{H}_2\text{S} \)
7a. 2.1 mol \( \text{Al}_2\text{(SO}_4\text{)}_3 \)
7b. 2.4 mol \( \text{Al}_2\text{O}_3 \)
7c. 588 mol \( \text{Al}_2\text{(SO}_4\text{)}_3 \)
Chemistry: *Quantitative Relationships in Chemical Equations*

When we balance a chemical equation, we are satisfying the law of conservation of mass; that is, we are making sure that there are the same number of atoms of each element on both sides of the equation. The coefficients we place in front of the substances in an equation are very important because they tell us the mole ratio of the substances in that reaction. For instance, the balanced equation…

$$\text{hydrogen gas} + \text{oxygen gas} \rightarrow \text{liquid water}$$

$$2 \text{H}_2(\text{g}) + 1 \text{O}_2(\text{g}) \rightarrow 2 \text{H}_2\text{O}(\text{l})$$

can be thought of in terms of…

$$2 \text{ moles H}_2(\text{g}) + 1 \text{ mole O}_2(\text{g}) \rightarrow 2 \text{ moles H}_2\text{O}(\text{l})$$

**Directions:**

C. Balance each equation.

D. Solve the problems, assuming that you have excess of the other reactant(s).

1. $$\underline{3} \text{Ca(s)} + \underline{2} \text{N}_2(\text{g}) \rightarrow \underline{5} \text{Ca}_3\text{N}_2(\text{s})$$
   a. How many moles of Ca$_3$N$_2$ can be made from 16.8 moles of Ca?

   \[
x \text{ mol Ca}_3\text{N}_2 = 16.8 \text{ mol Ca} \times \left(\frac{1 \text{ mol Ca}_3\text{N}_2}{3 \text{ mol Ca}}\right) = 5.6 \text{ mol Ca}_3\text{N}_2
\]

   b. If you need to make 34.4 moles of Ca$_3$N$_2$, how many moles of N$_2$ will you need?

   \[
x \text{ mol N}_2 = 34.4 \text{ mol Ca}_3\text{N}_2 \times \left(\frac{1 \text{ mol N}_2}{1 \text{ mol Ca}_3\text{N}_2}\right) = 34.4 \text{ mol N}_2
\]

2. $$\underline{3} \text{Fe(s)} + \underline{2} \text{O}_2(\text{g}) \rightarrow \underline{5} \text{Fe}_3\text{O}_4(\text{s})$$
   a. How many moles of O$_2$ will react with 42.5 moles of Fe?

   \[
x \text{ mol O}_2 = 42.5 \text{ mol Fe} \times \left(\frac{2 \text{ mol O}_2}{3 \text{ mol Fe}}\right) = 28.3 \text{ mol O}_2
\]

   b. If you need to make 1.56 moles of Fe$_3$O$_4$, how many moles of Fe will you need?

   \[
x \text{ mol Fe} = 1.56 \text{ mol Fe}_3\text{O}_4 \times \left(\frac{3 \text{ mol Fe}}{1 \text{ mol Fe}_3\text{O}_4}\right) = 4.68 \text{ mol Fe}
\]

3. $$\underline{3} \text{FeCl}_2(\text{aq}) + \underline{2} \text{KOH(aq)} \rightarrow \underline{5} \text{Fe(OH)}_2(\text{s}) + \underline{2} \text{KCl(aq)}$$
   a. How many moles of KOH will react with 86.2 moles of FeCl$_2$?

   \[
x \text{ mol KOH} = 86.2 \text{ mol FeCl}_2 \times \left(\frac{2 \text{ mol KOH}}{1 \text{ mol FeCl}_2}\right) = 172.4 \text{ mol KOH}
\]

   b. If you need to make 12.4 moles of KCl, how many moles of FeCl$_2$ will you need?

   \[
x \text{ mol FeCl}_2 = 12.4 \text{ mol KCl} \times \left(\frac{1 \text{ mol FeCl}_2}{2 \text{ mol KCl}}\right) = 6.2 \text{ mol FeCl}_2
\]
4. \[ \text{Cu(s)} + \_ \_ \_ \text{O}_2(g) \rightarrow \_ \_ \_ \text{Cu}_2\text{O(s)} \]

a. How many moles of \( \text{Cu}_2\text{O} \) can be made from 25.6 moles of \( \text{Cu} \)?

\[
x \text{ mol Cu}_2\text{O} = 25.6 \text{ mol Cu} \left( \frac{2 \text{ mol Cu}_2\text{O}}{4 \text{ mol Cu}} \right) = 12.8 \text{ mol Cu}_2\text{O}
\]

b. How many moles of \( \text{O}_2 \) does it take to produce 214 moles of \( \text{Cu}_2\text{O} \)?

\[
x \text{ mol } \text{O}_2 = 214 \text{ mol Cu}_2\text{O} \left( \frac{1 \text{ mol } \text{O}_2}{2 \text{ mol Cu}_2\text{O}} \right) = 107 \text{ mol } \text{O}_2
\]

5. \[ \_ \_ \_ \text{K(s)} + \_ \_ \_ \text{Cl}_2(g) + \_ \_ \_ \text{O}_2(g) \rightarrow \_ \_ \_ \text{KClO}_3(s) \]

a. How many moles of \( \text{KClO}_3 \) can be made from 89 moles of \( \text{O}_2 \)?

\[
x \text{ mol } \text{KClO}_3 = 89 \text{ mol } \text{O}_2 \left( \frac{2 \text{ mol } \text{KClO}_3}{3 \text{ mol } \text{O}_2} \right) = 59.3 \text{ mol } \text{KClO}_3
\]

b. If you have 24.6 moles of \( \text{Cl}_2 \), how many moles of \( \text{KClO}_3 \) can you produce?

\[
x \text{ mol } \text{KClO}_3 = 24.6 \text{ mol } \text{Cl}_2 \left( \frac{2 \text{ mol } \text{KClO}_3}{1 \text{ mol } \text{Cl}_2} \right) = 49.2 \text{ mol } \text{KClO}_3
\]

6. \[ \_ \_ \_ \text{NH}_3(g) + \_ \_ \_ \text{H}_2\text{S(g)} \rightarrow \_ \_ \_ (\text{NH}_4)_2\text{S(s)} \]

a. How many moles of \( (\text{NH}_4)_2\text{S} \) can be made from 15.8 moles of \( \text{NH}_3 \)?

\[
x \text{ mol } (\text{NH}_4)_2\text{S} = 15.8 \text{ mol } \text{NH}_3 \left( \frac{1 \text{ mol } (\text{NH}_4)_2\text{S}}{2 \text{ mol } \text{NH}_3} \right) = 7.9 \text{ mol } (\text{NH}_4)_2\text{S}
\]

b. If you have 462 moles of \( \text{NH}_3 \), how many moles of \( \text{H}_2\text{S} \) do you need?

\[
x \text{ mol } \text{H}_2\text{S} = 462 \text{ mol } \text{NH}_3 \left( \frac{1 \text{ mol } \text{H}_2\text{S}}{2 \text{ mol } \text{NH}_3} \right) = 231 \text{ mol } \text{H}_2\text{S}
\]

7. \[ \_ \_ \_ \text{Al}_2\text{O}_3(s) + \_ \_ \_ \text{H}_2\text{SO}_4(aq) \rightarrow \_ \_ \_ \text{Al}_2(\text{SO}_4)_3(aq) + \_ \_ \_ \text{H}_2\text{O(l)} \]

a. How many moles of \( \text{Al}_2(\text{SO}_4)_3 \) can be made from 6.3 moles of \( \text{H}_2\text{SO}_4 \)?

\[
x \text{ mol } \text{Al}_2(\text{SO}_4)_3 = 6.3 \text{ mol } \text{H}_2\text{SO}_4 \left( \frac{1 \text{ mol } \text{Al}_2(\text{SO}_4)_3}{3 \text{ mol } \text{H}_2\text{SO}_4} \right) = 2.1 \text{ mol } \text{Al}_2(\text{SO}_4)_3
\]

b. How many moles of \( \text{Al}_2\text{O}_3 \) does it take to make 7.2 moles of \( \text{H}_2\text{O} \)?

\[
x \text{ mol } \text{Al}_2\text{O}_3 = 7.2 \text{ mol } \text{H}_2\text{O} \left( \frac{1 \text{ mol } \text{Al}_2\text{O}_3}{3 \text{ mol } \text{H}_2\text{O}} \right) = 2.4 \text{ mol } \text{Al}_2\text{O}_3
\]

c. If you have 588 moles of \( \text{Al}_2\text{O}_3 \), how many moles of \( \text{Al}_2(\text{SO}_4)_3 \) can you produce?

\[
x \text{ mol } \text{Al}_2(\text{SO}_4)_3 = 588 \text{ mol } \text{Al}_2\text{O}_3 \left( \frac{1 \text{ mol } \text{Al}_2(\text{SO}_4)_3}{1 \text{ mol } \text{Al}_2\text{O}_3} \right) = 588 \text{ mol } \text{Al}_2(\text{SO}_4)_3
\]