Stoichiometry: Predicting Amounts in Reactions

Stoichiometry is the process of determining how much product is made or how much reactant is needed during a chemical reaction. As we know, in chemical reactions atoms are **conserved**. We show this in a balanced chemical equation.

The balanced chemical equation tells us two things:

1. **Which substances** begin with (reactants) and end with (products) during the rearrangement process.
2. The **ratio of particles** involved. This ratio can be seen either as a ratio of individual particles OR as a ratio of moles.

In the lab it is only practical to work with **moles** of substances rather than individual atoms or molecules, and so we interpret our equations as a ratio of moles, or a **mole ratio.**

Example: $\boldsymbol{2}\ Mg + \boldsymbol{1}O_2 \rightarrow \boldsymbol{2}\ MgO$ means
for every *2 moles of Mg* burned, *1 mole of O_2* is required to produce *2 moles of MgO*, or a ratio of $\boldsymbol{2}$ *moles Mg* : $\boldsymbol{1}$ *mole* O_2 : $\boldsymbol{2}$ *moles MgO*

We can use this mole ratio relationship to make predictions about how much we need of something, or how much we can make from what we have.

Making Predictions
In every reaction, there are three stages we need to consider to make good predictions:

1. **Before**: What we have before the reaction takes place.
2. **Change**: How much of each substance *actually changes* during the reaction
3. **After**: How much of each substance is present after the reaction is complete.

Some good organization can help us in making good predictions. We have an organizational table that can help us track the Before-Change-After for a reaction. Below is an example of a problem involving a chemical reaction.

> Sample Problem: Hydrogen sulfide gas, which smells like rotten eggs, burns in air to produce sulfur dioxide and water. How many moles of oxygen gas would be needed to completely burn 2.4 moles of hydrogen sulfide?

Step 1- Write and Balance the equation (describe the reaction and its mole ratio)

$$\boldsymbol{2\ H_2S + 3\ O_2 \rightarrow 2\ SO_2 + 2\ H_2O}$$

Before:

Change

After

Step 2: Fill in the *Before* line with the Given information; mark what you must Find on the table (with units)

$2\ H_2S + 3\ O_2 \rightarrow 2\ SO_2 + 2\ H_2O$

Before:	***2.4moles***	***xs moles***	***0 moles***	***0 moles***
Change	***__ moles***			
After				

NOTE: Assume reactants you don't have amounts for are present with more than enough available (**excess**, or "**xs"**) for the reaction to be completed.

Step 3: Use ratio of coefficients to determine the *Change* made

$\mathbf{2}\ H_2S + \mathbf{3}\ O_2 \rightarrow \mathbf{2}\ SO_2 + \mathbf{2}\ H_2O$

Before:	2.4moles	xs moles	0 moles	0 moles
Change:	***–2.4 moles***	***–3.6 moles***	***+2.4 moles***	***+2.4 moles***
After				

NOTE: Reactants are consumed/decrease (-), products accumulate/increase (+)

Step 4: Complete the table for what remains *After* the reaction is complete

$2\ H_2S + 3\ O_2 \rightarrow 2\ SO_2 + 2\ H_2O$

Before:	2.4 moles	xs moles	0 moles	0 moles
Change:	–2.4 moles	–3.6 moles	+2.4 moles	+2.4 moles
After:	***0 moles***	***xs moles***	***2.4 moles***	***2.4 moles***

- In this case, desired answer is in moles
  Answer (in moles): 3.6 moles O_2 are needed to burn 2.4 moles H_2S.

- If mass is required, convert moles to grams in the usual way
  $3.6 moles\ O_2 * \frac{32\ grams}{1\ mole} = 115\ grams\ O_2$
  Answer (in grams): 115 grams O_2 are needed to burn 2.4 moles H_2S.