

# 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:**  $2 \text{Mg} + 1 \text{O}_2 \rightarrow 2 \text{MgO}$  means  
for every 2 moles of Mg burned, 1 mole of O<sub>2</sub> is required to produce 2 moles of MgO, or a ratio  
of  $2 \text{ moles Mg} : 1 \text{ mole O}_2 : 2 \text{ moles MgO}$

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

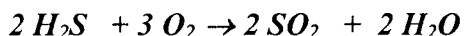
In every reaction, there are three stages we need to consider to make good predictions:

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)



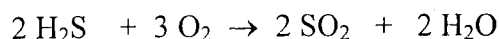
Before:

Change

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After

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



*Before:*     2.4 moles     *xs moles*     0 moles     0 moles

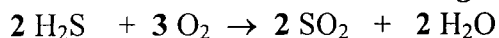
Change                          moles

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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**



Before:     2.4 moles     *xs moles*     0 moles     0 moles

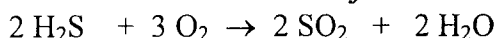
*Change:*   -2.4 moles   -3.6 moles   +2.4 moles   +2.4 moles

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After

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

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



Before:     2.4 moles     *xs moles*     0 moles     0 moles

Change:   -2.4 moles   -3.6 moles   +2.4 moles   +2.4 moles

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*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<sub>2</sub> are needed to burn 2.4 moles H<sub>2</sub>S.
- If mass is required, convert moles to grams in the usual way  

$$3.6 \text{ moles O}_2 * \frac{32 \text{ grams}}{1 \text{ mole}} = 115 \text{ grams O}_2$$
Answer (in grams): 115 grams O<sub>2</sub> are needed to burn 2.4 moles H<sub>2</sub>S.

## Unit 7 Worksheet 1: Mole relationships

For each of the problems below:

- Write the balanced chemical equation
- Identify what is given (with units) and what you want to find (with units)
- Use coefficients from balanced equation to determine mole ratio.
- Show set up (organize it!).

- 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 8 moles of hydrogen sulfide?

Equation:      \_\_\_  $\text{H}_2\text{S}_{(g)}$  + \_\_\_  $\text{O}_{2(g)}$   $\rightarrow$  \_\_\_  $\text{SO}_{2(g)}$  +      \_\_\_  $\text{H}_2\text{O}_{(g)}$

Before:            \_\_\_                    \_\_\_                    \_\_\_                    \_\_\_

Change            \_\_\_                    \_\_\_                    \_\_\_                    \_\_\_

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After                \_\_\_                    \_\_\_                    \_\_\_                    \_\_\_

- Propane,  $\text{C}_3\text{H}_8$ , burns in air to form carbon dioxide and water. If 12 moles of carbon dioxide are formed, how many moles of propane were burned?

Equation:

Before:

Change

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After

- Ammonia,  $\text{NH}_3$ , for fertilizer is made by causing hydrogen and nitrogen to react at high temperature and pressure. How many moles of ammonia can be made from 0.15 moles of nitrogen gas?

Equation:

Before:

Change

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After



## Mole Ratios

1. Lead will react with hydrochloric acid to produce lead chloride and hydrogen gas. How many moles of hydrochloric acid are needed to completely react with 4.0 mole of lead?

Equation:

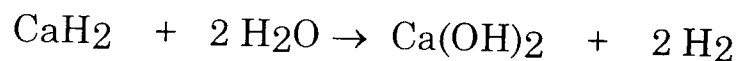
Before:

Change

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After

2. How many moles of hydrogen gas will be produced if 2.5 moles of calcium hydride react according to the following equation?



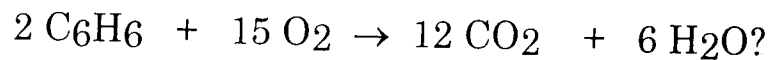
Before:

Change

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After

3. How many moles of water will be produced if 0.45 mol of oxygen reacts according to the following equation?



Before:

Change

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After