Stoichiometry

QUANTITATIVE RELATIONSHIPS IN CHEMISTRY

What Is Stoichiometry?

It is the study of the **quantitative** relationships among reactants and products in a chemical reaction

It's All in the Numbers!

The relationships among reactants and products in a chemical reaction are given by the **coefficients** in a balanced chemical equation

2 C_8H_{18} + **25** O_2 → **16** CO_2 + **18** H_2O

It's All in the Numbers!

The **coefficients** can be interpreted as the number of **molecules** or **moles** of each substance

2 C_8H_{18} + **25** O_2 → **16** CO_2 + **18** H_2O

It's All in the Numbers!

We will usually interpret coefficients as the amount of **moles** of each substance since that is more practical in lab work

2 C_8H_{18} + **25** O_2 → **16** CO_2 + **18** H_2O

It's All in the Numbers!

The balanced equation below shows that:

2 moles of octane need to react with 25 moles of oxygen to produce 16 moles of carbon dioxide and 18 moles of water

2 C_8H_{18} + **25** O_2 → **16** CO_2 + **18** H_2O

Stoichiometry Allows Predictions

How would the other coefficients change if you doubled the moles of octane to 4 instead of 2?

$$\cancel{2}\ C_8H_{18} + \cancel{25}\ O_2 \rightarrow \cancel{16}\ CO_2 + \cancel{18}\ H_2O$$
$$\underline{4} \qquad \_\_ \qquad \_\_ \qquad \_\_$$

Each Coefficient is Related to the Others

They would double also because every coefficient in a balanced chemical equation is proportionally related to the others

$$\cancel{2}\ C_8H_{18} + \cancel{25}\ O_2 \rightarrow \cancel{16}\ CO_2 + \cancel{18}\ H_2O$$
$$\underline{4} \qquad \underline{50} \qquad \underline{32} \qquad \underline{36}$$

In Chemistry, We Use "Mole Ratios"

A mole ratio is a fraction that allows us to compare **moles** of one substance to **moles** of another substance based on the coefficients

$$2\ C_8H_{18} + 25\ O_2 \rightarrow 16\ CO_2 + 18\ H_2O$$

$\frac{2 \text{ moles } C_8H_{18}}{25 \text{ moles } O_2}$ $\frac{18 \text{ moles } H_2O}{2 \text{ moles } C_8H_{18}}$ $\frac{2 \text{ moles } C_8H_{18}}{18 \text{ moles } H_2O}$ $\frac{25 \text{ moles } O_2}{16 \text{ moles } CO_2}$

What Do We Do With Mole Ratios?

We use mole ratios as conversion factors in dimensional analysis problems to help us predict…

how much product can be made or
how much reactant is needed
during a chemical reaction

Let's see how….

Example 1: A "Mole-to-Mole" Problem

How many **moles** of water are produced from burning 37.0 **moles** of octane?

Step 1: Write a **balanced** equation

$$2\ C_8H_{18} + 25\ O_2 \rightarrow 16\ CO_2 + 18\ H_2O$$

Example 1: A "Mole-to-Mole" Problem

How many **moles** of water are produced from burning 37.0 **moles** of octane?

Step 2: Convert moles of "substance A" into moles of "substance B" (Convert moles of octane into moles of water)

$$2\ C_8H_{18} + 25\ O_2 \rightarrow 16\ CO_2 + 18\ H_2O$$

$$37.0 \cancel{\text{mol } C_8H_{18}} \times \frac{18 \text{ mol } H_2O}{2 \cancel{\text{mol } C_8H_{18}}} = 333 \text{ mol } H_2O$$

This "mole ratio" allowed us to convert from octane to water

Example 2: A "Mass-to-Mass" Problem

How many **grams** of water are produced from burning 312 **grams** of octane?

The only difference with this problem is that:

1. You have to convert grams to moles before you can multiply by the "mole to mole ratio"
2. You have to convert moles to grams after you multiply by the "mole to mole ratio"

Summary of Stoichiometry Problems

1. Write a balanced chemical equation
2. Convert given substance "A" into moles
3. Convert moles of "A" into moles of "B" (mole/mole ratio)
4. Convert moles of substance "B" to desired units

Example 2: A "Mass-to-Mass" Problem

How many **grams** of water are produced from burning 312 **grams** of octane?

Step 1: Write a **balanced** equation

$$\mathbf{2\ C_8H_{18} + 25\ O_2 \rightarrow 16\ CO_2 + 18\ H_2O}$$

Example 2: A "Mass-to-Mass" Problem

How many **grams** of water are produced from burning 312 **grams** of octane?

Step 2: Convert given substance, "A" into moles

$$\mathbf{2\ C_8H_{18} + 25\ O_2 \rightarrow 16\ CO_2 + 18\ H_2O}$$

$$312\ \text{g}\ C_8H_{18} \times \frac{1\ \text{mol}\ C_8H_{18}}{114.26\ \text{g}} = 2.73\ \text{mol}\ C_8H_{18}$$

114.26 is the "molar mass" of octane
12.01g(8) + 1.01g(18) = 114.26g

Example 2: A "Mass-to-Mass" Problem

How many **grams** of water are produced from burning 312 **grams** of octane?

Step 3: Convert moles of "A" into moles of "B"

$$\mathbf{2\ C_8H_{18} + 25\ O_2 \rightarrow 16\ CO_2 + 18\ H_2O}$$

$$2.73\ \text{mol}\ C_8H_{18} \times \frac{18\ \text{mol}\ H_2O}{2\ \text{mol}\ C_8H_{18}} = 24.6\ \text{mol}\ H_2O$$

The mole-to-mole ratio allows you to compare moles of water to moles of octane

Example 2: A "Mass-to-Mass" Problem

How many **grams** of water are produced from burning 312 **grams** of octane?

Step 4: Convert moles of "B" to desired units (grams)

$$\mathbf{2\ C_8H_{18} + 25\ O_2 \rightarrow 16\ CO_2 + 18\ H_2O}$$

$$24.6\ \text{mol}\ H_2O \times \frac{18.02\ \text{g}\ H_2O}{1\ \text{mol}\ H_2O} = 443\ \text{g}\ H_2O$$

This is the "molar mass" of water.
1.01g(2) + 16.00(1) = 18.02g

In Summary

According to the balanced reaction,

$$2\ C_8H_{18} + 25\ O_2 \rightarrow 16\ CO_2 + 18\ H_2O$$

Burning 312 grams of octane will result in the production of 443 grams of water.

Summary of Stoichiometry Problems

1. Write a balanced chemical equation
2. Convert given substance "A" into moles
3. Convert moles of "A" into moles of "B" (mole/mole ratio)
4. Convert moles of substance "B" into desired units

Why Learn Stoichiometry?

It allows you to determine…

The amount of **reactant(s)** you need

and

The amount of **product(s)** you will make