

## Yield and Atom Economy

$$\text{percentage yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100$$





I'm worried about the environment and using up resources. How do manufacturers make sure they don't waste chemicals?

All manufacturers want reactions to be as **efficient** as possible. They don't want to waste resources or energy, and they want to make as much product as possible.



To figure out how efficient reactions are, scientists use **yield** and **atom economy**.

# What are the different types of yield?

The **percentage yield** of a chemical reaction shows how much product was actually made compared with the amount of product that was expected.

To calculate the percentage yield, you need to figure out the **theoretical yield** and the **actual yield**.

The **theoretical yield** is the maximum mass of product expected from the reaction, using reacting masses.

The **actual yield** is the mass of the product that is actually obtained from the real chemical reaction.

Why is the actual yield usually less than the theoretical yield?



# What factors affect the actual yield?

Do these factors reduce the yield of useful products or not?

reduce yield

do not reduce yield

The reactants may form other unexpected products.



solve



# How is percentage yield calculated?



The percentage yield of a reaction is the actual yield written as a percentage of the theoretical yield.

The equation for figuring out the percentage yield is:

$$\text{percentage yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100$$

The percentage yield is always less than 100%.

Why is the percentage yield never 100%?

What does it mean if the percentage yield of a reaction is 0%?



# Calculating percentage yield – example



I reacted copper sulphate solution with some iron. Using reacting masses, I figured out that the theoretical yield of the reaction was 50 grams of copper.

I lost some copper when I filtered the solution and ended up with 40 grams. What is the **percentage yield** of my reaction?

$$\text{percentage yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100$$

$$\text{percentage yield} = \frac{40 \text{ g}}{50 \text{ g}} \times 100 = 80\%$$

## What is the percentage yield?

$$\text{percentage yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100$$

1. A chemical factory was planning to make 500 tons of calcium oxide by heating calcium carbonate. They produced 450 tons. What was the percentage yield? **answer 1**
2. A pharmaceutical company carried out a test reaction, aiming to make 1 g of a new cancer drug. The reaction only produced 0.7 g of the drug. What was the percentage yield? **answer 2**
3. A teacher burned 24 g of magnesium in oxygen, hoping to make 40 g of magnesium oxide, but actually only produced 30 g of this product. What was the percentage yield? **answer 3**



# What is atom economy?



**Atom economy** is another measure of the efficiency of a chemical reaction.

It is the amount of starting materials that end up as useful products.

In an ideal chemical process, all the starting materials end up as useful products and no atom is wasted.

If most of the starting materials end up as useful products, the reaction is said to have a **high atom economy**.

Why is it important for sustainable development and for economical reasons to use reactions with high atom economy?





# Why is high atom economy important?

A chemical reaction with a **high percentage yield** has a **high atom economy**.

This is important for the chemical industry for many reasons:

- to minimize waste of non-renewable reactants
- to make as much useful product as possible
- to reduce pollution from waste products
- to minimize energy use in heating chemical reactions
- to minimize energy use in running factories
- to reduce use of water for cooling chemical reactions.



# Atom economy – true or false?

