

Balancing equations and conserving atoms

Grade 8 science (Year 9 · Class 8) · Lesson

Quick answer: A chemical equation shows reactants turning into products. Atoms are only rearranged, never created or destroyed, so a balanced equation has the same number of each kind of atom on both sides. To balance it, change coefficients in front of formulas, never the small subscripts.

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What happens to atoms in a chemical reaction?

When wood burns, iron rusts or a tablet fizzes in water, new substances form. A **chemical reaction** turns the starting substances, called **reactants**, into different substances, called **products**. The bonds in the reactants break, the atoms move around, and new bonds form in the products.

Definition

A **chemical equation** is a short way of showing a reaction, with the reactants on the left, the products on the right and an arrow meaning "produces" between them.

Key law

Atoms are never created or destroyed in a chemical reaction; they are only rearranged. So every element has the same number of atoms on both sides of a correct equation, and the total mass does not change.

How do you write a chemical equation?

Start with a word equation, such as *hydrogen + oxygen → water*. Then replace each name by its formula: $\text{H}_2 + \text{O}_2 \rightarrow \text{H}_2\text{O}$. Hydrogen and oxygen are written as molecules with two atoms (H_2 and O_2). Often extra letters in brackets, called **state symbols**, show the physical state.

State symbol	Meaning	Example
(s)	solid	Mg(s)
(l)	liquid	$\text{H}_2\text{O(l)}$
(g)	gas	$\text{H}_2\text{(g)}$
(aq)	dissolved in water	HCl(aq)

How do you balance an equation?

$\text{H}_2 + \text{O}_2 \rightarrow \text{H}_2\text{O}$ is not yet correct, because there are two oxygen atoms on the left but only one on the right. We fix it using **coefficients**, the big numbers in front of formulas. The balanced version is $2 \text{H}_2 + \text{O}_2 \rightarrow 2 \text{H}_2\text{O}$. The picture shows how the atoms are simply regrouped.

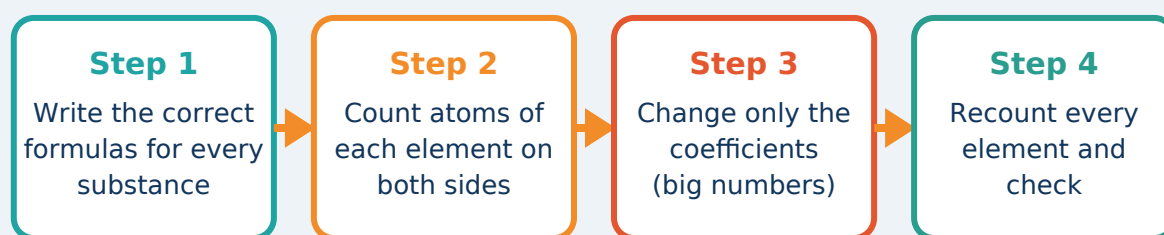


Left: 4 H atoms, 2 O atoms



Right: 4 H atoms, 2 O atoms

The same atoms appear on both sides: they are only rearranged into new molecules.



Never change the small subscripts.

The four steps of balancing a chemical equation.

Worked example 1

Balance: $\text{Mg} + \text{O}_2 \rightarrow \text{MgO}$ (burning magnesium ribbon).

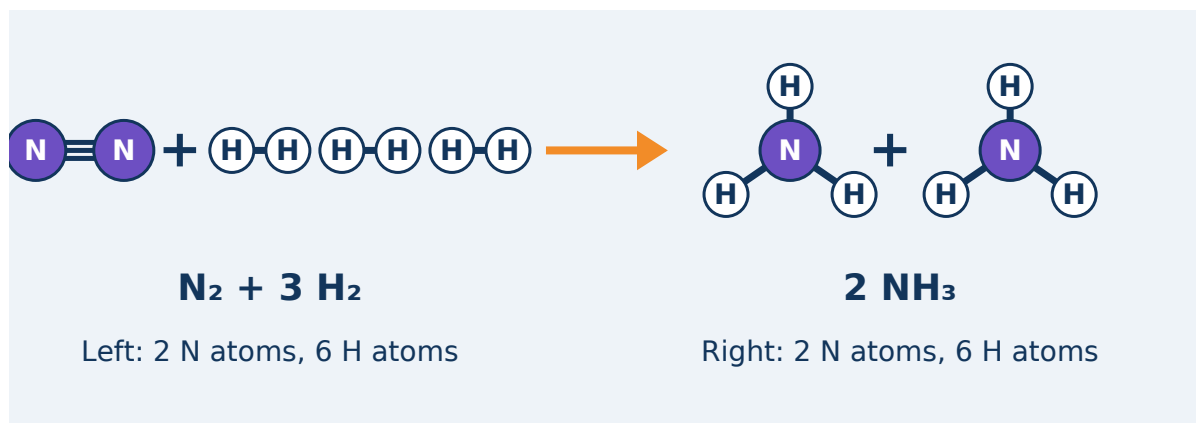
Count atoms. Left: Mg 1, O 2. Right: Mg 1, O 1.

Put 2 before MgO to make 2 oxygen atoms: Mg 1 on the left but 2 on the right. Put 2 before Mg to match.

Recount: left Mg 2, O 2; right Mg 2, O 2. **$2 \text{Mg} + \text{O}_2 \rightarrow 2 \text{MgO}$** .

Common mistake

Do not change a subscript to make the numbers match. Writing H_2O_2 instead of H_2O would make a different substance (hydrogen peroxide). Only the coefficient in front of a formula may be changed.



$N_2 + 3 H_2 \rightarrow 2 NH_3$ is balanced: each side has 2 nitrogen atoms and 6 hydrogen atoms.

Atom	Left side: $N_2 + 3 H_2$	Right side: $2 NH_3$	Equal?
N	2	2	yes
H	$3 \times 2 = 6$	$2 \times 3 = 6$	yes

Worked example 2

Balance: $N_2 + H_2 \rightarrow NH_3$ (making ammonia for fertiliser).

Nitrogen: 2 on the left, 1 on the right, so put 2 before NH_3 . Now the right has 2 N and 6 H.

Hydrogen: 6 needed on the left, and each H_2 has 2, so put 3 before H_2 .

$N_2 + 3 H_2 \rightarrow 2 NH_3$.

How is mass conserved in a reaction?

Because every atom survives, the total mass of the reactants equals the total mass of the products. If a gas escapes from an open container, the balance reading may drop, but the missing mass is still there in the gas.

Worked example 3

In a lime kiln in Rajasthan, limestone breaks down: $CaCO_3 \rightarrow CaO + CO_2$. If 100 g of $CaCO_3$ gives 56 g of CaO , what mass of CO_2 forms?

Mass of products = mass of reactants, so $CO_2 = 100 - 56 = \mathbf{44\text{ g}}$.

Lina's tip

Balance the elements that appear in only one substance on each side first, and leave elements such as oxygen or hydrogen, which often appear in several substances, until last.

Key points to remember

- Reactants turn into products; bonds break and new bonds form.
- Atoms are conserved, so each element has equal numbers of atoms on both sides.

- Balance by changing coefficients only, never subscripts.
- Example: $\text{N}_2 + 3 \text{H}_2 \rightarrow 2 \text{NH}_3$ has 2 N and 6 H on each side.
- Total mass of reactants = total mass of products in a closed system.

Balancing equations and conserving atoms: frequently asked questions

What is a balanced chemical equation?

It is an equation with the same number of atoms of every element on both sides. This reflects the fact that atoms are not created or destroyed in a reaction, only rearranged.

Why can you not change the subscripts when balancing?

The subscripts are part of the identity of the substance. Changing H_2O to H_2O_2 makes a different compound, so you would no longer be describing the same reaction. Only coefficients can change.

What are reactants and products?

Reactants are the substances that react and are written on the left of the arrow. Products are the new substances formed and are written on the right.

How do state symbols help?

They show whether each substance is a solid (s), liquid (l), gas (g) or dissolved in water (aq). They tell you, for example, whether a gas is released.

Does mass change in a chemical reaction?

The total mass of all reactants equals the total mass of all products. A balance may show a loss if a gas escapes from an open container, but the mass is still accounted for in that gas.