

Balancing Chemical Equations

How do you balance chemical equations?

●○○ Beginner

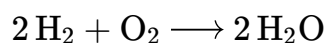
Reactions & Stoichiometry

Last reviewed 4 October 2026

Before you start: it helps to understand [Inside the Atom: Protons, Neutrons and Electrons](#).

What is it?

A **chemical equation** describes a reaction using formulas. **Reactants** go on the left of the arrow and **products** on the right:



An equation is **balanced** when every element has the **same number of atoms on both sides**. You balance an equation by placing whole-number **coefficients** (the big numbers in front of formulas).

💡 KEY IDEA

In a chemical reaction, atoms are **rearranged**, never created or destroyed (the **law of conservation of mass**). A balanced equation shows this: the atoms you start with are exactly the atoms you end with.

Why does it matter?

- **It obeys a law of nature.** Mass is conserved in every chemical reaction; an unbalanced equation describes something impossible.
- **It's the starting point for calculations.** The coefficients give the **mole ratios** used in stoichiometry. An unbalanced equation gives wrong answers.
- **It shows the recipe.** $2 \text{H}_2 + \text{O}_2 \longrightarrow 2 \text{H}_2\text{O}$ tells you hydrogen and oxygen react in a 2 : 1 ratio by molecules (and by moles).

How does it work?

1. Coefficients, not subscripts

- A **subscript** is part of the formula. It defines **which substance** it is: H_2O is water, H_2O_2 is hydrogen peroxide.
- A **coefficient** says **how many** units of that substance: $2 \text{H}_2\text{O}$ means two water molecules, containing 4 H and 2 O atoms in total.

Never change subscripts to balance an equation. That changes the substances, not the amounts.

2. Counting atoms

Multiply the coefficient by each subscript. Brackets multiply everything inside:

- 3CO_2 : 3 C and $3 \times 2 = 6\text{ O}$
- $\text{Ca}(\text{NO}_3)_2$: 1 Ca, 2 N and $2 \times 3 = 6\text{ O}$
- $2\text{Al}_2(\text{SO}_4)_3$: 4 Al, 6 S and $2 \times 3 \times 4 = 24\text{ O}$

3. The step-by-step method

1. **Write the correct formulas** of all reactants and products.
2. **Count the atoms** of each element on each side.
3. **Balance one element at a time** by changing coefficients. Start with an element that appears in **only one substance on each side**, usually a metal. Leave **hydrogen and oxygen until last**, and leave any **element on its own** (such as O_2 or Fe) to the very end.
4. **Re-count every element.** Changing one coefficient can unbalance another element.
5. **Check the coefficients are the smallest whole numbers.** If they all share a factor, divide by it.

4. Useful tricks

- **Polyatomic ions:** if an ion such as SO_4^{2-} or NO_3^- appears unchanged on both sides, balance it as **one unit** instead of counting S and O separately.
- **Odd-even trick:** if one side has an odd number of an atom and the other side must be even (as with O_2), double everything else first.
- **Fractions:** you can use a fraction such as $\frac{7}{2}$ temporarily, then multiply the whole equation to clear it.

THINK OF IT LIKE THIS

Balancing an equation is like checking a recipe for building toy models from Lego bricks. You can make **more copies** of a model (change a coefficient), but you can't change the design of a model (a subscript). When you're done, every brick you started with must be used, with none left over and none missing.

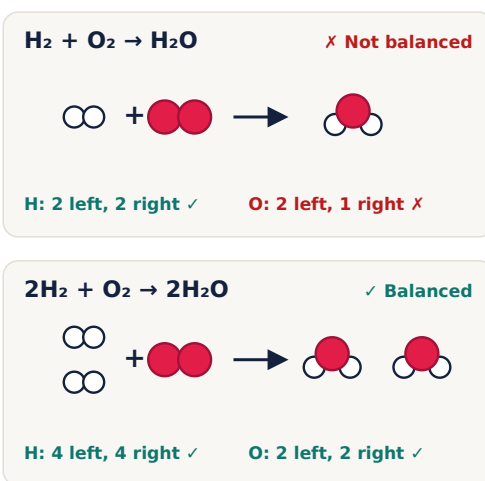
Q MORE PRECISELY

Coefficients count **particles** (molecules, atoms or formula units) and therefore also **moles**. They do not give the ratio of **masses**: in $2\text{H}_2 + \text{O}_2 \longrightarrow 2\text{H}_2\text{O}$, about 4 g of hydrogen reacts with 32 g of oxygen, not in a 2 : 1 ratio by mass. Equations can also include **state symbols**: (s) solid, (l) liquid, (g) gas and (aq) dissolved in water, e.g. $2\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \longrightarrow 2\text{H}_2\text{O}(\text{l})$. Ionic equations must also balance **charge**.

Visualise it

Balancing means counting atoms

Atoms are rearranged in a reaction, never created or destroyed



○ hydrogen atom ● oxygen atom

Adding coefficients makes the atom counts match on both sides.

Worked example

✏ WORKED EXAMPLE: Burning propane

Question: Balance $\text{C}_3\text{H}_8 + \text{O}_2 \longrightarrow \text{CO}_2 + \text{H}_2\text{O}$.

Step 1 **C:** 3 on the left, so put 3 in front of CO_2 : $\text{C}_3\text{H}_8 + \text{O}_2 \longrightarrow 3\text{CO}_2 + \text{H}_2\text{O}$

Step 2 **H:** 8 on the left, so put 4 in front of H_2O ($4 \times 2 = 8$):
 $\text{C}_3\text{H}_8 + \text{O}_2 \longrightarrow 3\text{CO}_2 + 4\text{H}_2\text{O}$

Step 3 **O (last, because O_2 is an element on its own):** right side has $3 \times 2 + 4 \times 1 = 10$ O, so put 5 in front of O_2 .

Step 4 **Balanced:** $\text{C}_3\text{H}_8 + 5\text{O}_2 \longrightarrow 3\text{CO}_2 + 4\text{H}_2\text{O}$. Check: C 3 = 3, H 8 = 8, O 10 = 10
✓

 WORKED EXAMPLE: A polyatomic ion

Question: Balance $\text{Pb}(\text{NO}_3)_2 + \text{KI} \longrightarrow \text{PbI}_2 + \text{KNO}_3$.

Step 1 Pb is already balanced ($1 = 1$).

Step 2 Treat NO_3 as one unit: 2 on the left, 1 on the right, so put 2 in front of KNO_3 .

Step 3 Now K is 2 on the right, so put 2 in front of KI. That also balances I ($2 = 2$).

Step 4 **Balanced:** $\text{Pb}(\text{NO}_3)_2 + 2 \text{KI} \longrightarrow \text{PbI}_2 + 2 \text{KNO}_3$ ✓

 WORKED EXAMPLE: Using the odd–even trick

Question: Balance $\text{Fe} + \text{O}_2 \longrightarrow \text{Fe}_2\text{O}_3$.

Step 1 O: 2 on the left but 3 on the right. Odd and even don't match, so make the right side even: put 2 in front of Fe_2O_3 (6 O).

Step 2 O: 6 on the right, so put 3 in front of O_2 .

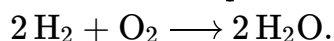
Step 3 Fe: $2 \times 2 = 4$ on the right, so put 4 in front of Fe.

Step 4 **Balanced:** $4 \text{Fe} + 3 \text{O}_2 \longrightarrow 2 \text{Fe}_2\text{O}_3$. Check: Fe $4 = 4$, O $6 = 6$ ✓

Common mistake

 COMMON MISTAKE: Changing a subscript

To “balance” $\text{H}_2 + \text{O}_2 \longrightarrow \text{H}_2\text{O}$, writing $\text{H}_2 + \text{O}_2 \longrightarrow \text{H}_2\text{O}_2$ makes the atoms match, but it turns the product into hydrogen peroxide. Change **coefficients** only:



 COMMON MISTAKE: Forgetting to multiply through brackets

$3 \text{Ca}(\text{OH})_2$ contains 3 Ca, **6 O and 6 H**, not 3 O and 3 H.

 COMMON MISTAKE: Stopping before re-counting everything

After each change, re-count **all** the elements. Fixing one element often unbalances another.

 COMMON MISTAKE: Leaving coefficients that can be simplified

$4 \text{H}_2 + 2 \text{O}_2 \longrightarrow 4 \text{H}_2\text{O}$ has equal atom counts, but it should be simplified to $2 \text{H}_2 + \text{O}_2 \longrightarrow 2 \text{H}_2\text{O}$. Use the smallest whole numbers.

NOTATION NOTE

- A coefficient of 1 is not written: $\text{CH}_4 + 2 \text{O}_2 \longrightarrow \text{CO}_2 + 2 \text{H}_2\text{O}$ has a coefficient of 1 in front of CH_4 and CO_2 .
- Some courses write "=" or " $\longrightarrow$ " instead of " $\rightarrow$ " in equations.

Remember this

REMEMBER THIS

- **Balanced** = same number of atoms of each element on both sides (conservation of mass).
- Change coefficients, **never subscripts**.
- Balance metals and other elements first, then H, then O; leave free elements (e.g. O_2) to last.
- Treat unchanged polyatomic ions as one unit; use the smallest whole-number coefficients.

References

1. Brown, T. L.; LeMay, H. E., Jr.; Bursten, B. E.; Murphy, C. J.; Woodward, P. M.; Stoltzfus, M. W. Chemistry: The Central Science, 15th ed.; Pearson, 2022.

Practise this topic with flashcards and a quiz at chemistryclarity.com/chemistry/balancing-equations/