Conservation of mass and balanced equations

4.3.1.1 · Quantitative chemistry · revision notes

The law of conservation of mass says that no atoms are lost or made in a chemical reaction, so the total mass of the products equals the total mass of the reactants. You use it to work out missing masses and to write and balance symbol equations. It is tested on Paper 1, and balancing equations is needed across both papers.

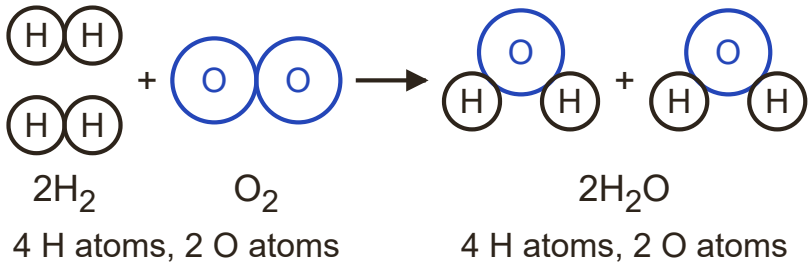
Key facts

- Law of conservation of mass: no atoms are lost or made, so mass of products = mass of reactants
- A small number multiplies the atom (or bracket) just before it
- Balance by changing the big numbers only, never the small numbers
- State symbols: (s) solid, (l) liquid, (g) gas, (aq) aqueous
- Missing mass = total mass on one side − known masses on the other side
- A big number in front multiplies the whole formula
- Diatomic elements: H_2, N_2, O_2, F_2, Cl_2, Br_2, I_2
- Grade 8+ only Ionic and half equations: atoms and charges both balance

Notes

The law of conservation of mass

- In a chemical reaction the atoms are **rearranged** to make new substances. No atoms are lost or made.
- So the **total mass of the products equals the total mass of the reactants**. This is the **law of conservation of mass**.



The atoms are rearranged, not lost or made, so the mass stays the same.

- Example: 12 g of magnesium reacts completely with 8 g of oxygen, so 20 g of magnesium oxide forms.
- If the mass seems to change in an open container, a gas has escaped or has been taken in from the air.

Reading formulae

- A small number after a symbol multiplies only that atom: CO_2 has 1 carbon atom and 2 oxygen atoms.
- A small number after a bracket multiplies everything inside it: $Mg(OH)_2$ has 1 Mg, 2 O and 2 H.
- A big number in front multiplies the whole formula: $3H_2O$ has 6 H and 3 O.
- Seven elements exist as molecules of two atoms: H_2, N_2, O_2, F_2, Cl_2, Br_2 and I_2.
- State symbols: (s) solid, (l) liquid, (g) gas, (aq) aqueous (dissolved in water).

Balancing symbol equations

- A balanced equation has the same number of atoms of each element on both sides.
- Only change the big numbers in front of formulae. Never change the small numbers: that would make a different substance.
- Balance one element at a time. Leave elements that appear on their own (such as O_2, H_2 or Fe) until last, then recount everything.
- Worked example: $Na + H_2O \rightarrow NaOH + H_2$. There are 2 H on the left but 3 on the right. Use $2H_2O$ and 2NaOH (4 H on each side), then 2Na. Result: $2Na + 2H_2O \rightarrow 2NaOH + H_2$.
- Higher tier: in ionic equations and half equations the charges must balance as well as the atoms, e.g. $2Cl^- \rightarrow Cl_2 + 2e^-$ (total charge 2− on each side). Grade 8+ only

How to answer each type of question

Calculate a missing mass 1 to 2 marks Grade 4

1. Write down: total mass of reactants = total mass of products.
2. Add up the masses on the side where you know them all.
3. Subtract the masses you know on the other side, and give the unit.

Example. Calcium carbonate breaks down when it is heated.
$CaCO_3 \rightarrow CaO + CO_2$
25.0 g of calcium carbonate was heated until it had all decomposed. 14.0 g of calcium oxide formed. Calculate the mass of carbon dioxide formed. [2 marks]

Model answer.

mass of CO_2 = 25.0 − 14.0 (1)
= 11.0 g (1)

Balance a symbol equation

1 mark | Grade 5

1. List each element and count its atoms on both sides.
2. Change the big numbers one at a time, leaving lone elements such as O_2 until last.
3. Recount every element on both sides before you move on.

Example. Balance the equation for the complete combustion of propane.
....C_3H_8 + ...O_2 → ....CO_2 + ...H_2O [1 mark]

Model answer.

$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$ (1)

Check: C 3 = 3; H 8 = 8; O 10 = 6 + 4.

Write a balanced symbol equation from a word equation

2 marks | Grade 6

1. Write the correct formula for every reactant and product (remember H_2, O_2, Cl_2).
2. Balance it by changing the big numbers only.
3. Add state symbols only if the question asks for them.

Example. Magnesium reacts with hydrochloric acid to produce magnesium chloride and hydrogen. Write a balanced symbol equation for this reaction. [2 marks]

Model answer.

Correct formulae: $Mg + HCl \rightarrow MgCl_2 + H_2$ (1)

Balanced: $Mg + 2HCl \rightarrow MgCl_2 + H_2$ (1)

Explain why the total mass stays the same

2 marks | Grade 5

1. Say that atoms are not lost or made, only rearranged.
2. Say that nothing can escape: no gas is made, or the container is sealed.

Example. A student mixed silver nitrate solution with sodium chloride solution in a beaker on a balance. A white solid formed. The total mass did not change.
Explain why. [2 marks]

Model answer. No atoms are lost or made in the reaction; they are only rearranged (1). No gas is produced, so nothing escapes from the beaker (1).

Don’t lose marks

- Changing the small numbers (e.g. writing H_2O_2 to balance oxygen) instead of the big numbers in front.
- Forgetting that a number after a bracket multiplies everything inside: $Ca(NO_3)_2$ has 6 oxygen atoms, not 3.

- Writing O, H or Cl on their own for oxygen, hydrogen or chlorine gas instead of O_2, H_2 or Cl_2.
- Writing only 'mass is conserved' when asked to explain. Say that no atoms are lost or made.
- Leaving a fraction such as $3½O_2$ in the final equation instead of whole numbers.

More tips

Memory tricks

- Make a tally table: list each element under both sides and tick it off when it balances.
- Leave lone elements (O_2, H_2, Fe) until last: changing them does not upset anything else.
- Stuck with an odd number of oxygen atoms? Double every balancing number, e.g. $2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$.
- The diatomic elements N, O, F, Cl, Br and I make a '7' shape on the periodic table. Add hydrogen and you have all seven.
- Quick check: mass in = mass out. A product mass bigger than the total reactant mass is wrong.

Exam technique

- After your last change, recount every element on both sides. One miscount loses the mark.
- In 'explain' questions about mass, use the word **atoms**: no atoms are lost or made, they are only rearranged.
- Show the subtraction in a missing-mass calculation so you can still get a method mark if you slip.
- If you add state symbols when they are not asked for, make sure they are correct.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3 — **State the law of conservation of mass**
No atoms are lost or made in a reaction, so the mass of the products equals the mass of the reactants.

Grade 3 — **Count the atoms in a formula**
Multiply the small numbers by the big number in front, e.g. $2H_2O$ contains 4 hydrogen atoms and 2 oxygen atoms.

Grade 4 — **Calculate a missing mass in a reaction**
Total mass of reactants = total mass of products, so subtract the known masses from the total.

Grade 5 — **Balance a symbol equation**
Change only the big numbers in front of formulae until every element has the same number of atoms on both sides.

Grade 6 — **Write balanced equations from word equations**
Write the correct formula for each substance (e.g. O_2, H_2, HCl, $MgCl_2$) and then balance it.

Grade 7 — **Balance equations with brackets in formulae**
Count atoms inside brackets carefully, e.g. $Ca(OH)_2 + 2HNO_3 \rightarrow Ca(NO_3)_2 + 2H_2O$.

Grade 8 — **Balance ionic and half equations**
Atoms and total charge must both be equal on each side, e.g. $Cu^{2+} + 2e^- \rightarrow Cu$.

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