Chemical reactions and rates

Teacher review edition. Ask your teacher if anything is unclear.

What happens in a chemical reaction, and why are some reactions faster?

What you will learn

- Identify reactants and products.
- Describe tests for oxygen, hydrogen and carbon dioxide.
- Explain how temperature, concentration, surface area and catalysts affect reaction rate.
- Calculate an average reaction rate.

Chemical reactions make new substances

Chemical reaction
A change that rearranges atoms to make new substances.

Reactant
A substance present at the start of a chemical reaction.

Product
A substance made in a chemical reaction.

- Reactants: starting substances. Products: substances made.
- The same types and numbers of atoms are present before and after.
- Word equation: reactants → products.

Signs of a reaction

Observations can suggest a reaction, but consider the substances involved too.

- Possible signs: colour change, temperature change, gas production or a new solid.
- A precipitate is a solid formed when solutions react.
- Bubbles alone do not prove a reaction: boiling water is a physical change.

Reactions that produce gases

Here are three examples of reactions studied in the laboratory. The arrow means “reacts to form”.

- Magnesium + hydrochloric acid → magnesium chloride + hydrogen.
- Calcium carbonate + hydrochloric acid → calcium chloride + water + carbon dioxide.
- Hydrogen peroxide → water + oxygen.

Identifying a gas

Different gases give different test results. These tests are carried out with small samples under teacher supervision.

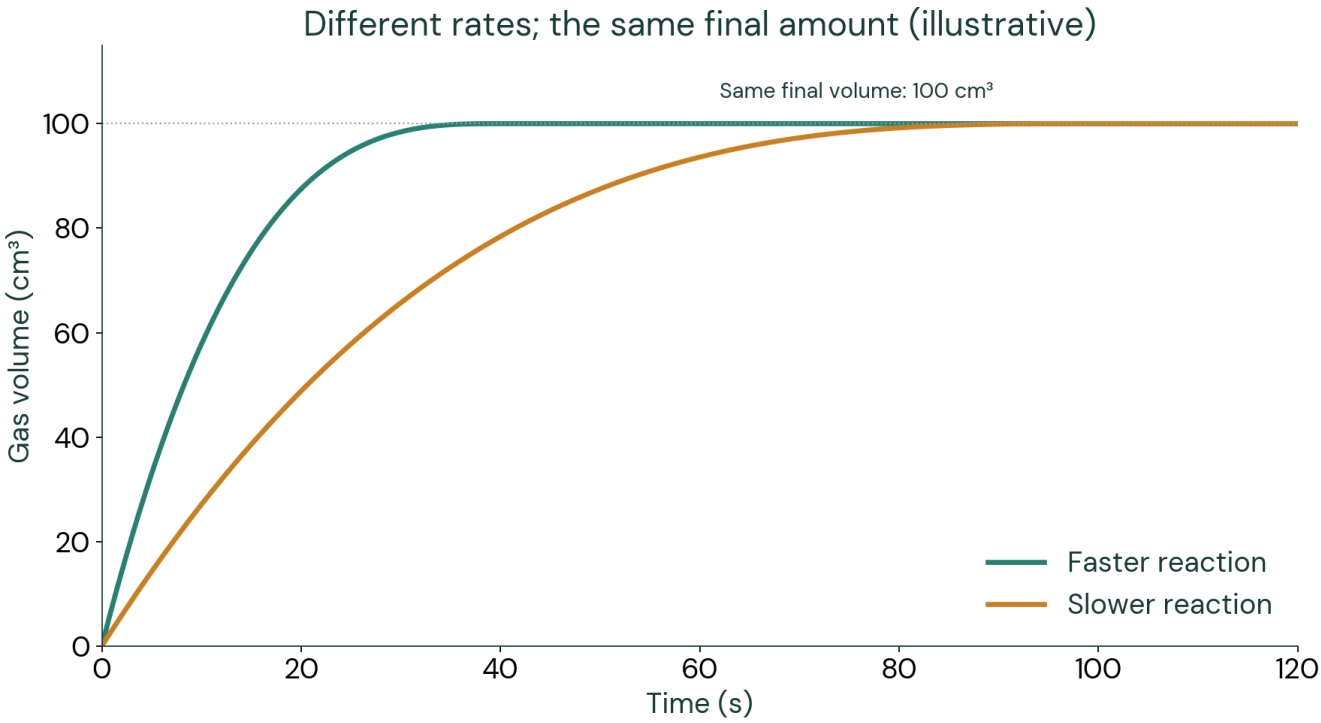
Gas	Test	Positive result
Oxygen	Use a glowing splint.	The splint relights.
Hydrogen	Use a lit splint at the mouth of a test tube.	A squeaky pop is heard.
Carbon dioxide	Bubble the gas through limewater.	The limewater turns milky.

Reaction rate

Reaction rate
How quickly a chemical reaction happens.

$$\text{average rate} = \frac{\text{volume of gas produced}}{\text{time taken}}$$

- For a gas-producing reaction, measure the volume collected over a given time.
- Average rate = gas volume ÷ time; a possible unit is cm^3/s.
- A faster reaction produces more gas in the same time.
- Two reactions can make the same final amount but finish at different times. Faster does not necessarily mean more product.



Illustrative curves: both reactions produce 100 cm³ of gas, but the faster one reaches that total sooner. A steeper curve means a greater rate.

Why do temperature and concentration matter?

Reacting particles must collide with enough energy for a reaction to happen.

- Higher temperature: particles move faster, collide more often and more collisions have enough energy. Rate usually increases.
- Higher concentration: more reacting particles in the same volume, so collisions happen more often and the reaction is often faster.

Why do smaller pieces react faster?

Breaking a solid into smaller pieces exposes more surface to the other reactant.

- Smaller marble chips react faster than one large piece of the same total mass.
- Keep acid concentration and temperature the same for a fair comparison.

Catalysts and enzymes

Catalyst
A substance that speeds up a reaction without being used up overall.

Enzyme
A biological catalyst that speeds up reactions in living things.

- It provides a reaction route needing less activation energy: the energy needed to start a reaction.
- An enzyme is a biological catalyst, such as those involved in digestion.

- Catalase speeds up the breakdown of hydrogen peroxide.
- Enzymes work within a suitable temperature range. Excess heat changes their shape so they no longer work properly: this is denaturing.

Worked examples

A reaction produces 48 cm³ of gas in the first 24 seconds. Find its average rate over this time.

Work through it

1. Write the relationship: average rate = gas volume ÷ time.
2. Substitute the values: average rate = $^{48}/_{24}$.
3. The average rate is 2 cm³/s over the first 24 seconds.

$$\text{average rate} = \frac{48}{24} = 2 \text{ cm}^3/\text{s}$$

Another example

1. A glowing splint relights in a sample of gas.
2. This is the positive test for oxygen.
3. Hydrogen is tested with a lit splint; carbon dioxide is tested with limewater.

Common mistakes

Common mistake: A faster reaction must produce more product overall.

Remember: Rate is how quickly product forms. Reactions can finish at different times but produce the same final amount.

Common mistake: Any bubbles prove that a chemical reaction has happened.

Remember: Boiling also makes bubbles. Use the substances involved and other evidence to decide whether new substances formed.

Answering questions

- For a gas-test answer, name the test and its positive result: for example, carbon dioxide turns limewater milky.
- For average rate, write volume ÷ time, substitute the values and include a matching unit such as cm³/s.

Try an investigation

Use gas-volume and time results to compare a reaction using large chips with one using small chips of the same substance. Keep the mass, acid concentration and temperature the same. Gas tests and flame tests must be supervised by your teacher.

Plan, record and review

- Question and prediction: What are you testing, and what do you think will happen? Give a reason.
- Change, measure, keep the same: What will you deliberately change? What will you measure, and in what units? What stays the same to make it a fair test? For an observation, say what you will record consistently instead.
- Record and look for a pattern: Use a table with headings and units. Look for a pattern or a result that does not fit.
- Conclude from evidence: Answer your question using a result or observation. Say if the evidence is unclear.
- Improve the investigation: What would you repeat or change, and how would that make the evidence better?

Do practical work with your teacher and follow the laboratory safety instructions.