

Factors which affect the rate of reaction

4.6.1.2 · The rate and extent of chemical change · revision notes

The five factors that change the rate of a reaction: concentration, pressure of gases, surface area, temperature and catalysts. You must recall their effects, compare rate graphs for different conditions, and describe the rates required practical, which investigates how concentration affects the rate.

Key facts

- Rate increases with: higher concentration, higher pressure (gases), larger surface area, higher temperature, a catalyst
- Smaller pieces or powder = larger surface area = faster reaction
- Faster reaction: steeper start, levels off sooner
- The final amount of product depends on the amount of the reactant that runs out, not on the rate
- Disappearing cross: sodium thiosulfate + hydrochloric acid gives a cloudy precipitate of sulfur
- Rate can be measured as $1 \div \text{time taken}$ (shorter time = faster)
- Gas collection: gas syringe, or upturned measuring cylinder filled with water

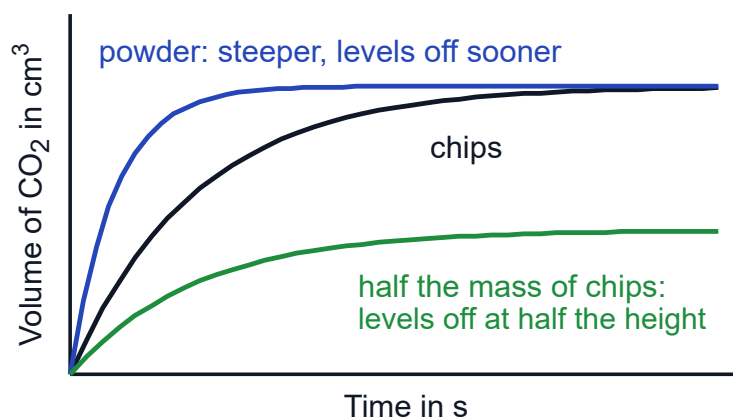
Notes

The five factors

- Increasing the **concentration** of a reactant in solution increases the rate.
- Increasing the **pressure** of reacting gases increases the rate.
- Increasing the **surface area** of a solid reactant (smaller pieces, or a powder) increases the rate.
- Increasing the **temperature** increases the rate.
- Adding a **catalyst** increases the rate, and the catalyst is not used up.
- Changing the temperature or surface area, or adding a catalyst, changes how fast the product forms, not how much forms in the end. The total amount of product only changes if the amount of the reactant that runs out changes.

Comparing rate graphs

- A faster reaction gives a steeper curve at the start, and it levels off sooner.
- With the same amounts of reactants, both curves level off at the same final volume or mass.
- If you halve the amount of the reactant that runs out, the curve levels off at half the height.

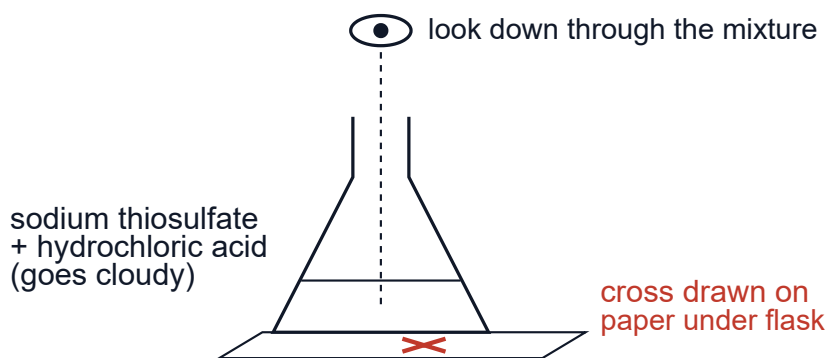


Same mass of marble: powder (blue) is faster than chips (black). Half the mass (green) gives half the gas.

- Example: the same mass of marble as a powder instead of chips gives a steeper curve that reaches the same final volume of carbon dioxide sooner.

Required practical: effect of concentration

- Gas-volume method: react magnesium ribbon with hydrochloric acid of different concentrations, and measure the volume of hydrogen in a gas syringe at regular intervals (e.g. every 10 s).
- Turbidity method: mix sodium thiosulfate solution with hydrochloric acid in a flask standing on a paper cross. A pale yellow precipitate of sulfur makes the mixture cloudy. Time how long until you can no longer see the cross.



Time how long it takes until you can no longer see the cross.

- Make different concentrations by mixing the sodium thiosulfate solution with different volumes of water, keeping the total volume the same.
- A shorter time means a faster rate. You can use $1 \div \text{time}$ as a measure of the rate.
- Control variables: temperature, volumes of solutions, concentration of the other reactant, mass and length of magnesium, and the same cross viewed by the same person.
- The thiosulfate reaction gives off sulfur dioxide, so work in a well-ventilated room and wear eye protection.

How to answer each type of question

Recall: give ways to increase the rate

1 to 2 marks

Grade 3

1. Pick changes that apply to the reaction given: surface area only for solids, pressure only for gases, concentration only for solutions.
2. Use comparatives: 'higher temperature', 'more concentrated acid', 'smaller pieces'.

Example. Calcium carbonate lumps react with dilute hydrochloric acid.

Give **two** changes that would increase the rate of this reaction.

Model answer. Any two from: use powdered calcium carbonate or smaller lumps (1); use more concentrated acid (1); increase the temperature (1). Maximum 2 marks.

Don't lose marks

- ✗ Saying a catalyst or a higher temperature makes *more* product. It makes the same amount of product, faster.
- ✗ Saying bigger pieces have a bigger surface area. For the same mass, smaller pieces have the larger total surface area.
- ✗ Drawing the curve for a faster reaction levelling off higher than the original.
- ✗ Writing 'more acid' when you mean 'more concentrated acid'.
- ✗ In the cross method, forgetting that a longer time means a slower rate.

More tips

Memory tricks

- Five factors mnemonic: 'Cats Prefer Sunny Toasty Corners' = Concentration, Pressure, Surface area, Temperature, Catalyst.
- Race picture: the faster reaction reaches the top of the graph first, but if the same amount of reactant runs out it stops at the same finish line.
- Disappearing cross: long time = slow reaction; short time = fast reaction.
- Break it up to speed it up: grinding a solid into a powder increases its surface area.

Exam technique

- When comparing conditions, use comparatives: 'the higher the temperature, the faster the rate', not just 'temperature affects the rate'.
- In method questions, name the apparatus (measuring cylinder, gas syringe, stopwatch), give volumes, and say what is kept the same.
- 6-mark method questions are marked by levels: write the steps in a logical order that someone else could follow.
- If asked for a hypothesis, make it testable, e.g. 'The higher the concentration of acid, the faster the rate of reaction.'

What each grade needs

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

Grade 3**Name the five factors that affect rate**

Concentration of solutions, pressure of gases, surface area of solids, temperature and the presence of a catalyst.

Grade 4**State how each factor changes the rate**

Increasing the concentration, pressure, surface area or temperature, or adding a catalyst, increases the rate.

Grade 5**Describe the gas-volume method for rates**

Measure the volume of gas given off at regular time intervals with a gas syringe or an upturned measuring cylinder.

Grade 5**Describe the disappearing-cross (turbidity) method**

Time how long it takes for a cross under the flask to disappear as a cloudy precipitate forms.

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