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

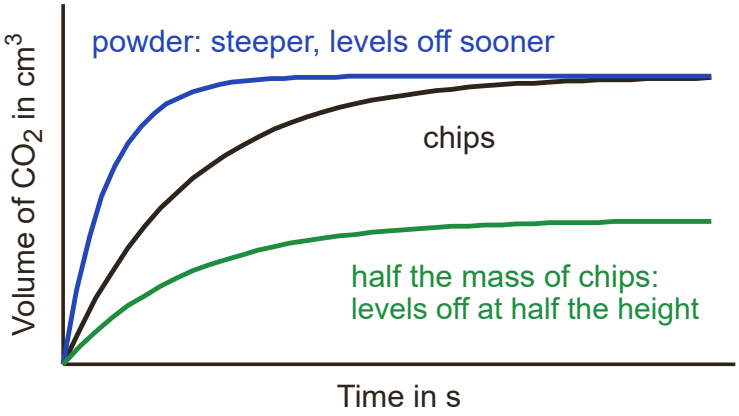
Notes

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.

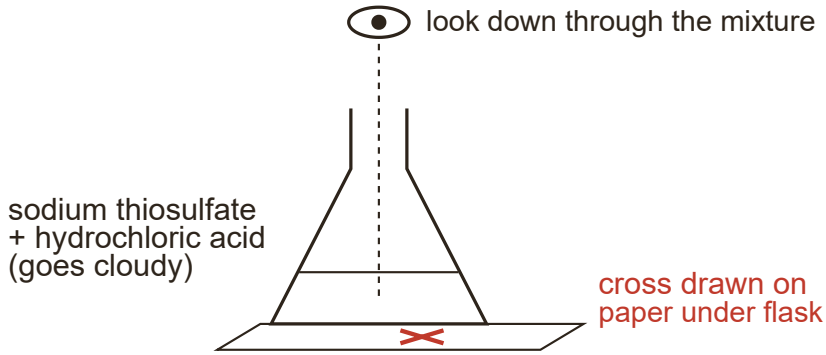


Same mass of marble: powder (blue) is faster than chips (black). Half the mass (green) gives half the gas.

- 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).
- Measure the acid with a measuring cylinder, put the bung in straight after adding the magnesium and start the timer at once. Gas that escapes before the bung is in makes the volume collected too low.
- 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 ÷ 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.

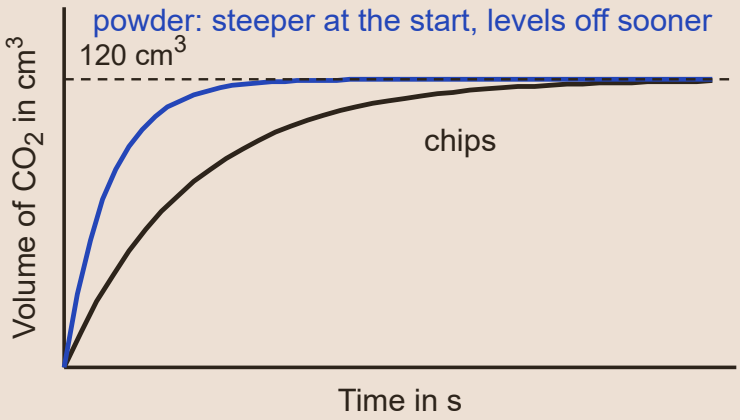
Describe or sketch the curve for changed conditions

2 marks **Grade 6**

1. Decide whether the change makes the reaction faster or slower: faster means a steeper start.
2. Decide whether the final amount changes: only if the amount of the reactant that runs out changes.
3. Draw the new curve from the origin, levelling off sooner (faster) or later (slower) at the correct height.

Example. A student reacted 0.5 g of large marble chips with excess hydrochloric acid at 20 °C and plotted the volume of carbon dioxide against time. The curve levelled off at 120 cm^3.
Describe how the curve would be different if the student used 0.5 g of powdered marble instead.

Model answer.



The curve would be steeper at the start / the initial rate is higher (1). It would level off sooner, but at the same final volume of 120 cm^3 (1).

6-mark: describe a method for the rates required practical

4 to 6 marks | **Grade 5**

1. Name the apparatus and exactly what you measure, with what, and how often.
2. Say what you change (the independent variable) and give a range, e.g. five concentrations.
3. List the control variables and how you keep them the same.
4. Say how you will process the results: repeat, find a mean, calculate the rate or 1 ÷ time.

Example. Sodium thiosulfate solution reacts with dilute hydrochloric acid to form a precipitate of sulfur, which makes the mixture cloudy.
Describe a method to investigate how the concentration of sodium thiosulfate solution affects the rate of this reaction.

Model answer.

Marked in levels: a clear, logical and complete method reaches the top level. Creditworthy points:

Use a measuring cylinder to put 10 cm^3 of sodium thiosulfate solution into a conical flask (1).

Stand the flask on a piece of paper with a black cross drawn on it (1). Add 10 cm^3 of hydrochloric acid, swirl, and start a stopwatch at the same time (1). Look down through the flask and stop the stopwatch when the cross can no longer be seen (1). Repeat with at least four other concentrations, made by diluting the sodium thiosulfate solution with water to the same total volume, keeping the volume and concentration of acid and the temperature the same (1).

Repeat each concentration, calculate a mean time and use 1 ÷ time as the rate (1).

Suggest an improvement to the method

2 marks | **Grade 5**

1. Find the weakness: often a judgement by eye, gas escaping, or a variable not controlled.
2. Suggest a specific fix and say why it helps.

Example. Two students did the disappearing-cross experiment with the same solutions but recorded different times.
Suggest why, and suggest how the method could be improved.

Model answer. Different people judge the moment the cross disappears differently / the end point is a matter of judgement (1). Use a light sensor and data logger to measure when the mixture reaches the same cloudiness, or have the same person judge every run using the same cross (1).

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 4 — **Identify and control the variables**
Independent: concentration; dependent: time taken or volume of gas; control: temperature, volumes, and mass and size of solid.

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.

Grade 6 — **Sketch rate curves for changed conditions**
A faster reaction has a steeper start and levels off sooner, at the same height if the amounts of reactants are the same.

Grade 8 — **Plan a rates investigation from a hypothesis**
Give a testable hypothesis, a step-by-step method with a range of values and repeats, and say how the results test it.

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