isaac Physics. You work it out.

What Affects Rate?

GCSE P P P A Level P P P

Part A Accelerating rate

There are three fundamental things at the atomic or molecular level that can be done to increase the rate of a given chemical reaction.

- Increasing the [ ] of the particles
- Increasing the [ ] of occurrence of collisions between particles
- Decreasing the [ ] [ ] required in a particle collision for a reaction to take place

Items:

symmetry **energy** **mass** **rotation** **activation** **frequency**

Part B Factor 1

Which one of the following changes would increase the rate of reaction **only** by increasing the frequency of collisions between particles?

- Giving the particles more kinetic energy
- Decreasing the temperature
- Increasing the temperature
- Increasing the concentrations of the reactants
- Decreasing the surface area of a solid reactant
- Introducing a catalyst

Part C Factor 2

Which of the following changes would increase the rate of a reaction, both by increasing the frequency of collisions between particles and by increasing the energy with which the particles collide?

- Carrying out the reaction at a lower pressure
- Carrying out the reaction at a lower temperature
- Carrying out the reaction at a higher temperature
- Increasing the concentrations of the reactants
- Decreasing the concentrations of the reactants

Part D Factor 3

Which of the following changes would increase the rate of reaction by decreasing the energy required in a particle collision for a reaction to take place (the activation energy)?

- Decreasing the concentrations of the reactants
- Adding an inert substance to the reaction mixture
- Increasing the surface area of a solid reactant
- Increasing the temperature
- Introducing a catalyst

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Calcium Carbonate Decomposition

GCSE A Level

A student investigated the reaction between calcium carbonate and excess dilute hydrochloric acid. The volume of gas released was measured at regular $5\,\mathrm{second}$ intervals. The equation for this reaction is:

$$\mathrm{CaCO_3\,(s) + 2\,HCl\,(aq) \longrightarrow CaCl_2\,(aq) + CO_2\,(g) + H_2O\,(l)}$$

The student plotted the results for $20\,^{\circ}\mathrm{C}$ and $40\,^{\circ}\mathrm{C}$ as shown on the following graphs.

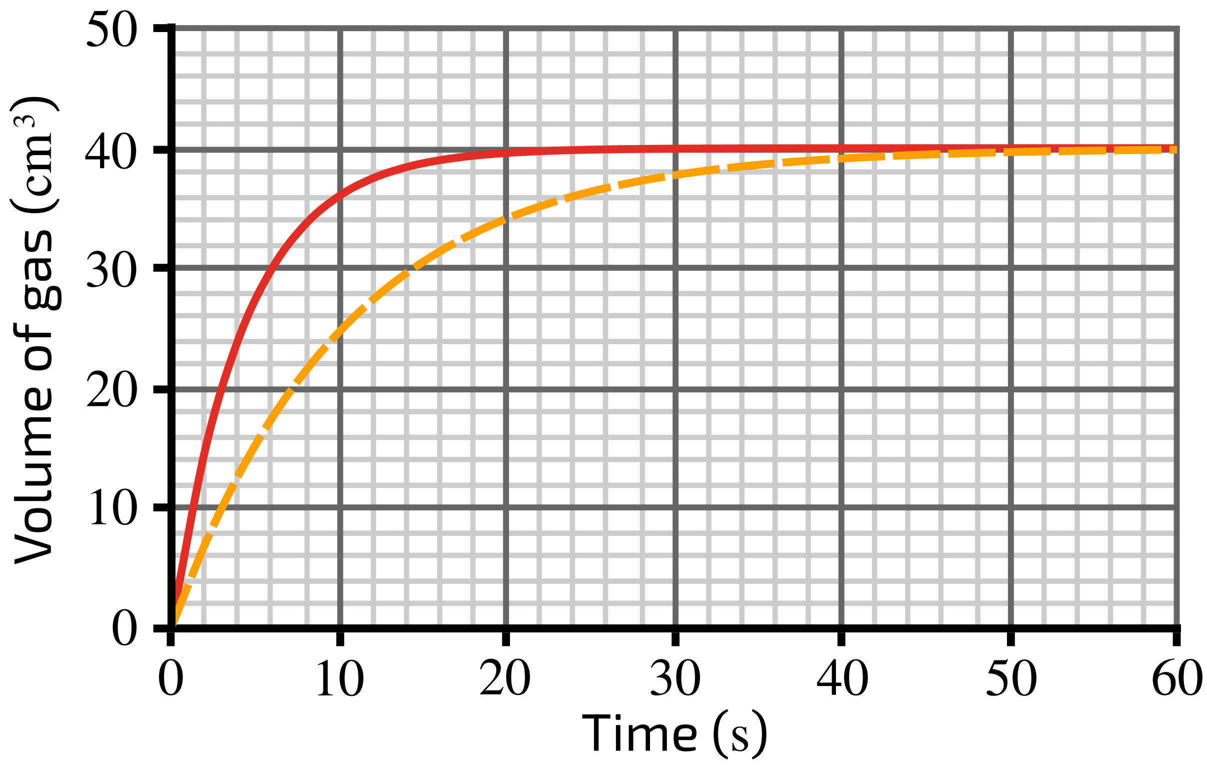

Figure 1: Volume of gas released during the reaction.

Part A Assigning the graph

The line on the graph indicating the progress of the reaction at $20\,^{\circ}\mathrm{C}$ is:

- Neither
- Dashed
- Solid

Part B Average rate

From the graph, calculate the average rate of reaction at $40\,^{\circ}\mathrm{C}$ over the first 30 seconds. Give your answer to 2 significant figures.

Part C Volume of $\mathrm{CO_2}$

If the initial amount of calcium carbonate used was doubled, assuming the hydrochloric acid remained in excess, what would the final volume of $\mathrm{CO_2}$ gas be?

Part D Surface area

The student then conducted a brief investigation into the effect of the surface area of the calcium carbonate on the rate of the reaction. What would be the result of doubling the surface area on the initial rate of reaction? The total mass of calcium carbonate is kept the same.

- ◯ It would halve
- ◯ It would stay the same
- ◯ There wouldn't be a reaction
- ◯ It would double
- ◯ There would be an explosion

Part E Final volume of gas

What would be the effect on the final volume of gas evolved?

- No gas would be evolved
- There wouldn't be a final volume, the gas would continue being produced at a consistent rate
- It would halve
- It would stay the same
- It would double

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Activation Energy

A Level

P P P

An energy diagram is shown below.

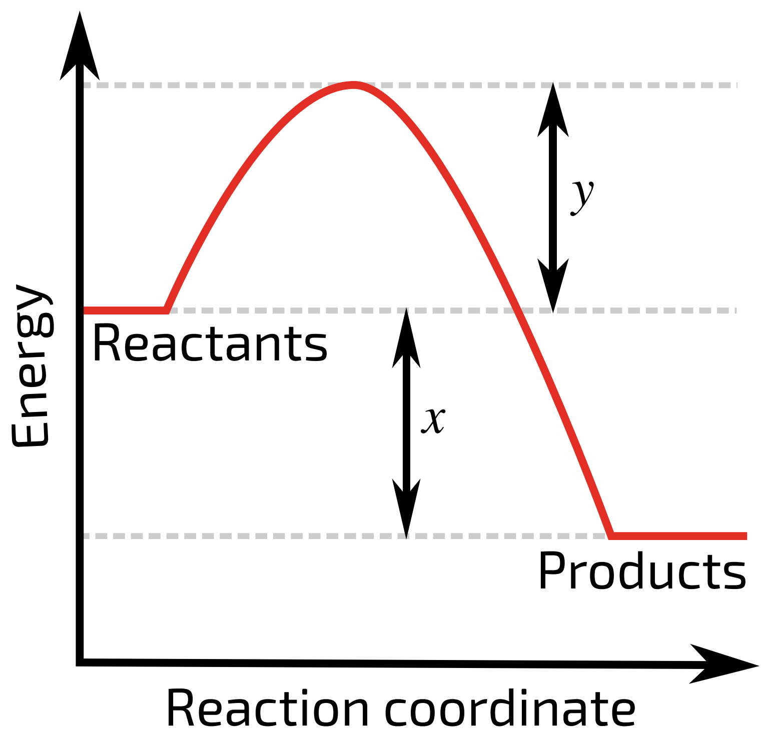

Figure 1: Energy diagram

Part A Reaction

What type of reaction is the forward reaction?

- Both
- Endothermic
- Exothermic
- Neither

Part B Forward activation energy

What is the activation energy for the forward reaction?

The following symbols may be useful: `x`, `y`

Part C Reverse activation energy

What is the activation energy for the reverse reaction?

The following symbols may be useful: `x`, `y`

Part D Altering the activation energy

What could be done to lower the activation energy for the reverse rection?

- Add a catalyst
- Decrease the temperature
- Increase the temperature
- Increase the concentration of all reactants

Adapted with permission from UCLES, A Level Chemistry, June 1987, Paper 3, Question 11

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Reaction Profiles

GCSE A Level

Shown below is a reaction profile diagram.

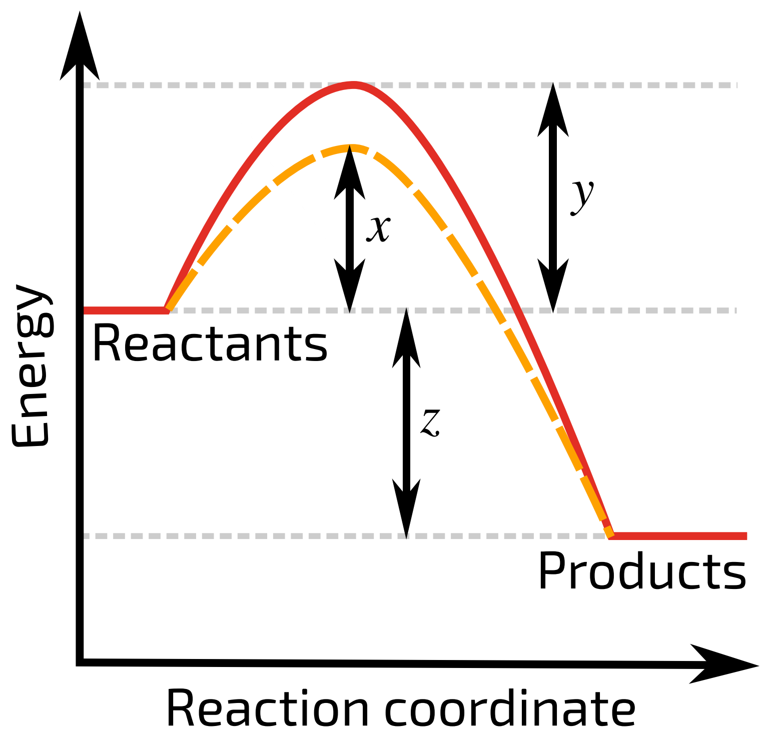

Figure 1: Reaction profile

Part A Activation energy

Which route of reaction has the lower activation energy?

- The dashed line
- The solid line

Part B Lowering the activation energy

What could be added to a reaction mixture to provide the route of reaction with lower activation energy?

- Catalyst
- Water
- Vanadium oxide
- Reactant
- Product

Part C Difference in activation energies

What is the difference between the activation energies for the forward reaction?

The following symbols may be useful: x, y

Part D Reverse reaction

What is the difference between the activation energies for the reverse reaction?

The following symbols may be useful: x, y, z

Part E Type of reaction

Is the forward reaction exothermic or endothermic?

- Exothermic
- Neither
- Endothermic

Part F Temperature and reaction rate

How would increasing the temperature affect the rate of reaction?

- It would decrease the rate
- It would increase the rate
- It would not affect the rate

Part G Temperature and yield

How would increasing the temperature affect the yield of the product?

- It would decrease the yield
- It would increase the yield
- It would not affect the yield

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Graphing Rates of Reaction

GCSE P P P A Level P P P

The following graph shows the volume of gas produced by a particular reaction over time. The reaction was carried out twice, under different conditions.

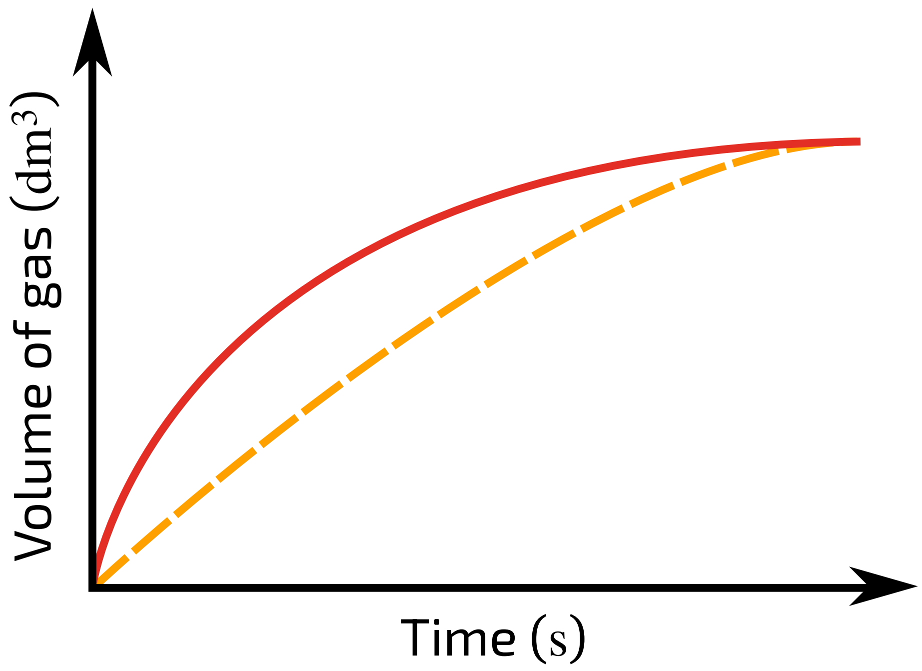

Figure 1: Graph showing the production of gas from a reaction under two different reaction conditions.

Part A Catalyst

One line shows the progress when carried out with a catalyst, and one without. Which line gives the gas produced by the reaction when carried out with a catalyst?

- The higher line
- The lower line
- Neither line

Part B Concentration

The reaction between two solutions, A and B produces a gas. Solution B is in excess. A plot of gas volume against time is made.

How would the plot of gas volume against time compare if the same volume of A was added, but with double the concentration?

- The line would have a similar gradient as the existing plots, and would reach a height double that of the other two.
- The plot would be steeper, and would reach the same height as the other two plots.
- The plot would be steeper, and would reach a height double that of the other two.
- The plot would be shallower, and would reach the same height as the other two plots.

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Catalyser

GCSE

Various metal oxides catalyse the decomposition of hydrogen peroxide, given by the reaction below.

$$2\,H_2O_2\,(aq) \longrightarrow 2\,H_2O\,(l) + O_2\,(g)$$

The catalysts PbO and MnO_2 are looked at in this question.

Part A Catalyst

What is the effect of a catalyst?

- It provides an alternative route for a reaction.
- It increases the yield of product at equilibrium
- It increases the equilibrium constant for the forward reaction
- It increases the speed of the reactant particles and therefore the rate of molecular collision
- It increases the rate constant for the forward reaction, but not for the reverse reaction

Part B Comparison of catalysts

The above reaction was performed in the presence first of MnO_2 and then of PbO and the following results were obtained.

Using 0.001 mol of MnO_2:

Time $/\mathrm{s}$	Extent of reaction
7	20%
16	43%
24	58%
30	67%

Using 0.001 mol of PbO:

Time $/\mathrm{s}$	Extent of reaction
11	24%
22	44%
34	62%
39	68%

Plot a graph of extent of reaction against time for both experiments and choose the more efficient catalyst.

- MnO_2
- PbO

Adapted with permission from UCLES, Additional Chemistry, June 1989, Paper 1, Question 5 and A Level Chemistry, June 1986, Paper 3, Question 12.

Decomposition of Hydrogen Peroxide

GCSE A Level

A solution of hydrogen peroxide was allowed to decompose into water and oxygen, and the oxygen gas given off was collected. The graph below shows the change in the total volume of oxygen evolved with time.

A black solid was added to the solution at $5\,\mathrm{minutes}$.

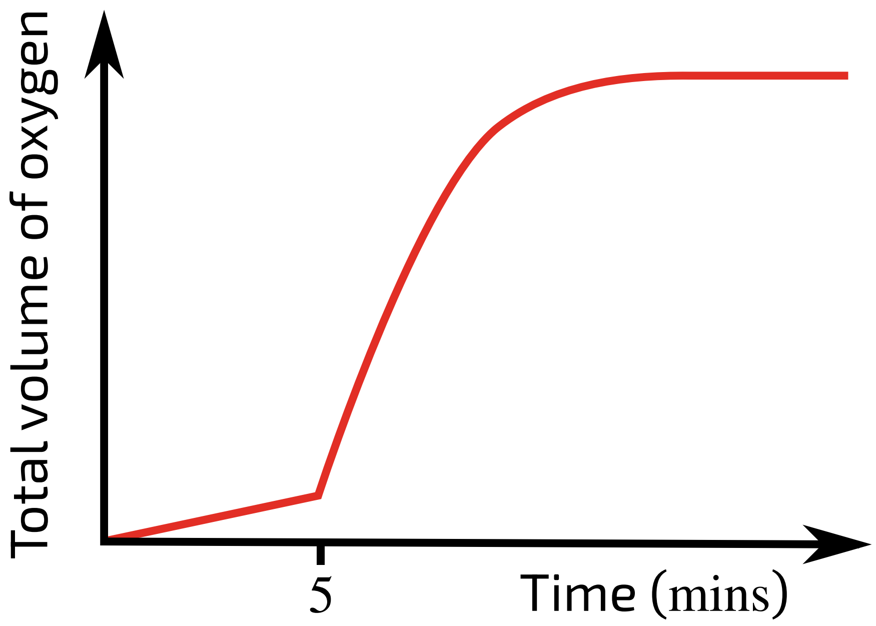

Figure 1: Graph showing total volume of oxygen with time

Part A Black solid

What effect has the black solid had on the rate of reaction?

- It increased the rate by 10.0 per cent
- It increased the rate
- It decreased the rate
- It did not change the rate
- It halted the progress of the reaction completely

Part B Naming

What is the general name given to compounds causing this effect?

- Manganese oxide
- Molecule
- Covalent
- Additive
- Catalyst

Part C Equation

Write the equation, including state symbols, for the decomposition of hydrogen peroxide.

Part D Maximum volume of oxygen

Calculate the maximum volume of oxygen, measured at room temperature and pressure, which can be obtained by this reaction from $1.7\,\mathrm{g}$ of hydrogen peroxide. Take the volume that $1\,\mathrm{mole}$ of gas occupies at room temperature and pressure to be $24\,\mathrm{dm}^3$.

Adapted with permission from UCLES, O Level Chemistry, November 1989, Paper 2, Question A7

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Altering H_2O_2 Decomposition

A Level

P P P

In the diagram, curve **X** was obtained by observing the decomposition of $100\,\mathrm{cm}^3$ of $1.0\,\mathrm{mol\,dm}^{-3}$ hydrogen peroxide, catalysed by manganese(IV) oxide.

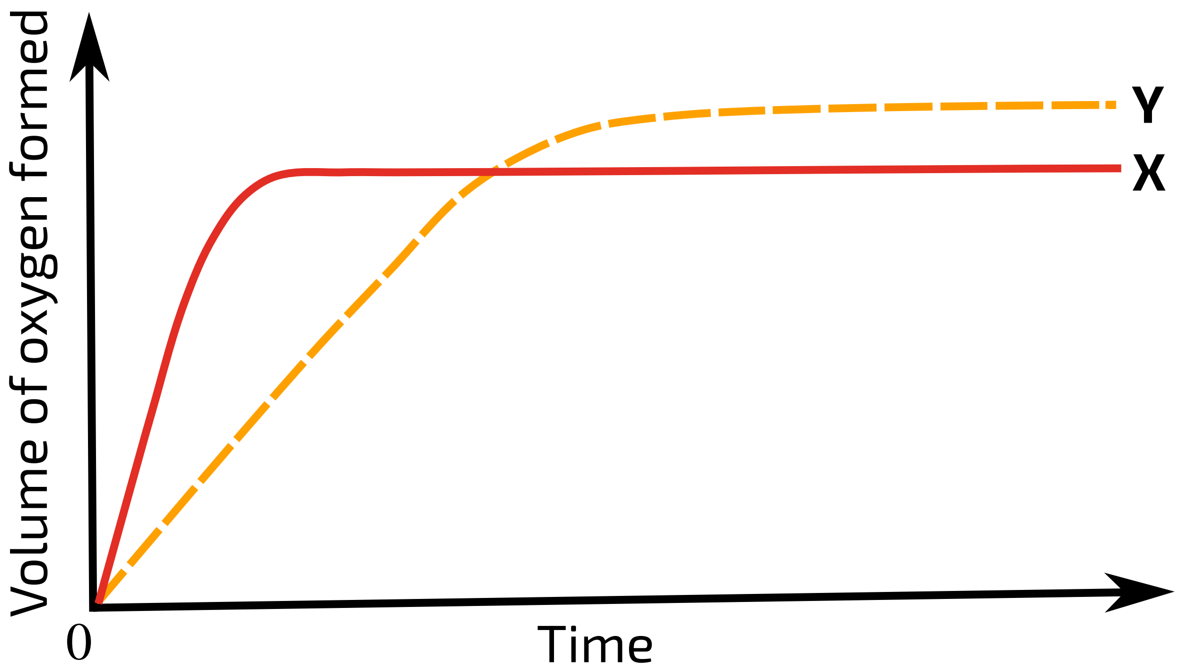

Figure 1: Graph showing the volume of oxygen evolved over time under two different reaction conditions.

Which alteration to the original experiment could produce curve **Y**?

- adding water
- adding some $0.1\,\mathrm{mol\,dm}^{-3}$ hydrogen peroxide
- using less manganese(IV) oxide
- lowering the temperature

Adapted with permission from UCLES, A Level Chemistry, November 1994, Paper 1, Question 16.

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Graphs and Rates

GCSE A Level

A certain reaction was repeated many times under different conditions. Three plots of the reaction's progress were made. The volume of gas produced by the reaction over time is given on the graph below.

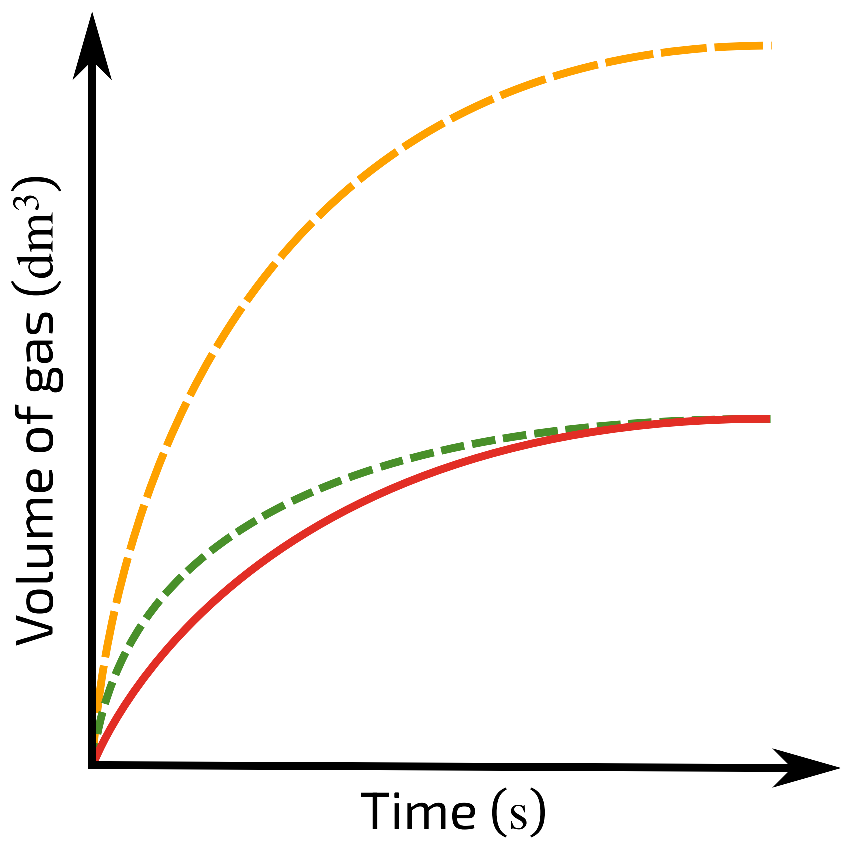

Figure 1: Graph showing the gas produced over time from three experiments

First reaction

The solid line plot was from the reaction between a $0.1\,\mathrm{g}$ piece of sodium, with surface area $1\,\mathrm{cm}^2$, and a $0.010\,\mathrm{mol\,dm^{-3}}$ solution of citric acid. The citric acid was in excess.

Other experiments

The reaction was also carried out under the following conditions:

Experiment	Sodium mass	Sodium surface area	Citric acid concentration	Catalyst
A	$0.1\,\mathrm{g}$	$0.5\,\mathrm{cm}^2$	$0.010\,\mathrm{mol\,dm^{-3}}$	Yes
B	$0.1\,\mathrm{g}$	Very large (fine strips)	$0.010\,\mathrm{mol\,dm^{-3}}$	No
C	$0.2\,\mathrm{g}$	$2\,\mathrm{cm}^2$	$0.010\,\mathrm{mol\,dm^{-3}}$	No
D	$0.1\,\mathrm{g}$	$1\,\mathrm{cm}^2$	$0.020\,\mathrm{mol\,dm^{-3}}$	No

Experiment	Sodium mass	Sodium surface area	Citric acid concentration	Catalyst
E	$0.2\,\mathrm{g}$	$0.5\,\mathrm{cm}^2$	$0.010\,\mathrm{mol\,dm}^{-3}$	No
F	$0.2\,\mathrm{g}$	$0.5\,\mathrm{cm}^2$	$0.010\,\mathrm{mol\,dm}^{-3}$	Yes
G	$0.05\,\mathrm{g}$	$2\,\mathrm{cm}^2$	$0.010\,\mathrm{mol\,dm}^{-3}$	No

Part A Yellow line

Which of the above experiment(s) *could* have produced the yellow (long-dashed) line? Choose the option with the most correct experiments.

- C, E, F
- D, F
- C
- A, B, C
- F, G
- C, F

Part B Green line

And which experiment(s) could have produced the green (short-dashed) line? Again, choose the option with the most correct experiments.

- A, B, D
- D, G
- A, D, F, G
- C, E, F
- B
- D, F

Gases and Rates

GCSE A Level

The **contact process** is the most common method of industrially producing sulfuric acid. The process, which replaced the previous lead chamber process, was patented in 1831 by British vinegar merchant Peregrine Phillips. The contact process was preferred to the existing lead chamber process as it was more economically viable, and it produces the useful by-products, sulfur trioxide and oleum.

Sulfur dioxide and oxygen react together to form sulfur trioxide in one of the steps of the contact process.

Part A Chemical equation

Write the chemical equation for this reversible reaction (sulfur dioxide and oxygen forming sulfur trioxide). Please include state symbols.

Part B Rate of reaction

The reaction was carried out at a higher pressure. What is the effect of this on the rate of reaction?

- The rate decreases, as the position of equilibrium shifts to the left, because there are more moles of gas on the left hand side.
- The rate decreases, as there are now less frequent collisions.
- The rate increases, as the position of equilibrium shifts to the right, because there are fewer moles of gas on the right hand side.
- The rate of reaction increases, as there would now be more particles per unit volume, so more frequent collisions.

Part C Catalyst

A particular catalyst, vanadium pentoxide, V_2O_5, is used to speed up the rate of this reaction.

How does a catalyst work?

- It reduces the activation energy of the existing reaction pathway.
- It increases the frequency of collisions.
- It increases the activation energy of the reaction.
- It provides an alternative pathway for the reaction to take, with a lower activation energy.
- It gives the reactants more energy.

Part D Maximising the yield

The forward reaction is an exothermic reaction. At what temperature should this reaction be carried out at to maximise the yield of sulfur trioxide?

- Very low temperature
- It does not matter
- Room temperature
- Very high temperature

Part E Maximising the rate

At what temperature should the reaction be carried out at to maximise the rate?

- Room temperature
- Very high temperature
- It does not matter
- Very low temperature

Part F Industrial temperature

To overcome this difficulty, the contact process is industrially carried out at a 'compromise' temperature. To 1 significant figure, what is this temperature?

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