AQA GCSE Combined Science - Trilogy | 8464

SPECIFICATION POINT 5.6.1.3

Collision theory and activation energy

Past-paper questions

Tier	**Foundation**
Question groups	**9**
Available paper years	**2019–2025**

Using this booklet

1. Answer the questions in order and show your working.
2. Original question numbers and marks are retained.
3. Print at actual size (100%) for measuring questions.
4. Use the companion answer booklet to check your work.

Name: _____ **Date:** _____

Whole questions are retained for context, so some parts assess other specification points. Current and legacy sources are labelled. Continue on extra paper if needed.

5.6.1.3 Collision theory and activation energy

Question 01

June 2019 | 8464/C/1F | Original Q1

0 1 This question is about energy changes.

0 1 . 1 Which of these items uses an endothermic reaction?

[1 mark]

Tick (✓) **one** box.

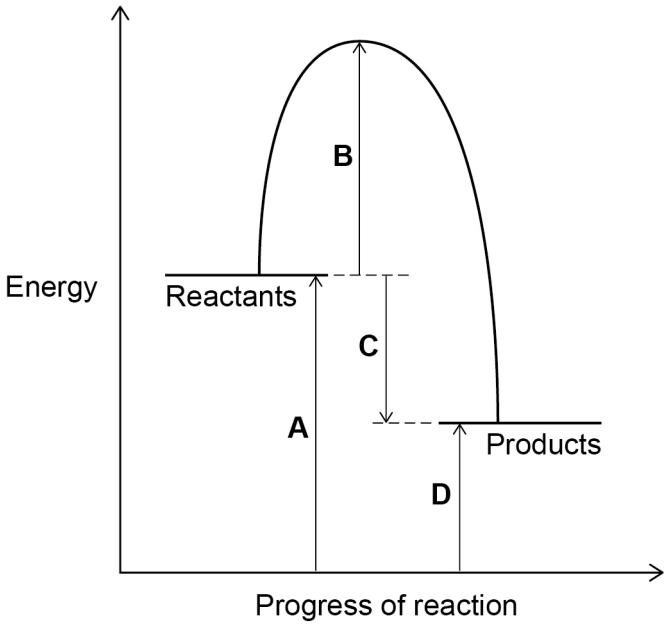
Hand warmer ☐

Sports injury pack ☐

Self-heating can ☐

Figure 1 shows the reaction profile for an exothermic reaction.

Figure 1



5.6.1.3 Collision theory and activation energy

Question 01 · continued

0 1 . 2 Which letter represents the activation energy for the reaction?

[1 mark]

Tick (✓) **one** box.

A ☐ **B** ☐ **C** ☐ **D** ☐

0 1 . 3 Which letter represents the overall energy change for the reaction?

[1 mark]

Tick (✓) **one** box.

A ☐ **B** ☐ **C** ☐ **D** ☐

0 1 . 4 Complete the sentence.

Choose the answer from the box.

[1 mark]

lower than	**the same as**	**higher than**

In an exothermic reaction the energy of the products

is _____ the energy of the reactants.

0 1 . 5 A student measured the temperature at the start and at the end of a reaction.

Name the apparatus used to measure the temperature.

[1 mark]

_____

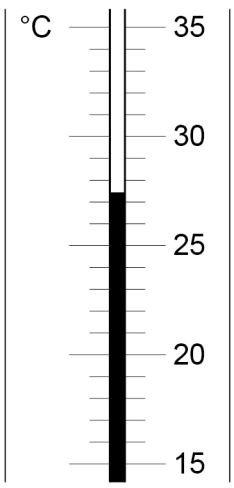
Question 1 continues on the next page

5.6.1.3 Collision theory and activation energy

Question 01 · continued

0 1 . 6 **Figure 2** shows the temperature at the end of the reaction.

Figure 2



Complete **Table 1**.

Use **Figure 2**.

[2 marks]

Table 1

Temperature at start in °C	14.3
Temperature at end in °C	
Change in temperature in °C	

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5.6.1.3 Collision theory and activation energy

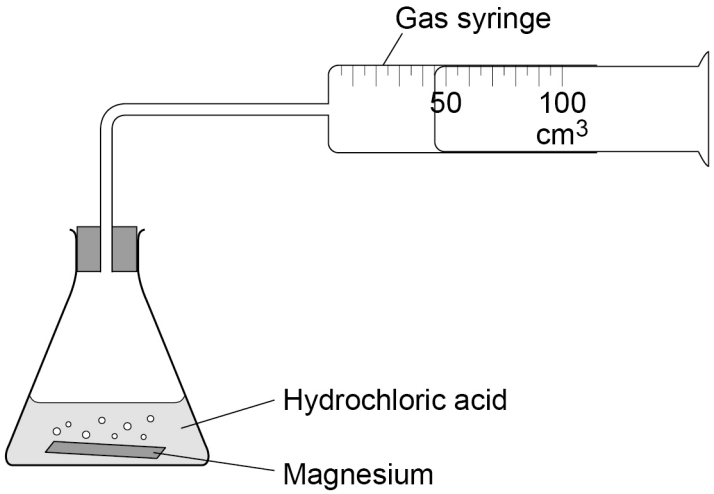
Question 02

June 2019 | 8464/C/2F | Original Q3

0 3 A student investigated the rate of the reaction between magnesium and hydrochloric acid.

Figure 4 shows the apparatus the student used.

Figure 4



0 3 . 1 Balance the equation for the reaction.

[1 mark]

$$Mg + ____ HCl \rightarrow MgCl_2 + H_2$$

0 3 . 2 The student used 50 cm^3 of hydrochloric acid.

Which apparatus would measure 50 cm^3 of hydrochloric acid with the greatest accuracy?

[1 mark]

Tick (✓) **one** box.

50 cm^3 beaker ☐

50 cm^3 conical flask ☐

50 cm^3 measuring cylinder ☐

5.6.1.3 Collision theory and activation energy

Question 02 · continued

0 3 . 3 The student measured the volume of gas produced every 20 seconds for 2 minutes.

The volume of gas was zero at the start of the experiment.

The measured volumes of gas were:

26 cm^3 38 cm^3 47 cm^3 55 cm^3 59 cm^3 60 cm^3

Complete **Table 2** to show these results.

[4 marks]

Table 2

0	0

0 3 . 4 The volumes of gas were lower than expected.

Suggest **one** reason.

[1 mark]

_____

_____

0 3 . 5 The student repeated the experiment using different concentrations of hydrochloric acid.

Give **two** variables the student should keep the same.

[2 marks]

1 _____

2 _____

5.6.1.3 Collision theory and activation energy

Question 02 · continued

0 3 . 6 Complete the sentences.

[3 marks]

As the concentration of the hydrochloric acid increased, the rate of the reaction _____ .

This is because there were more acid _____ in each cubic centimetre (cm^3).

So the collisions happened more _____ .

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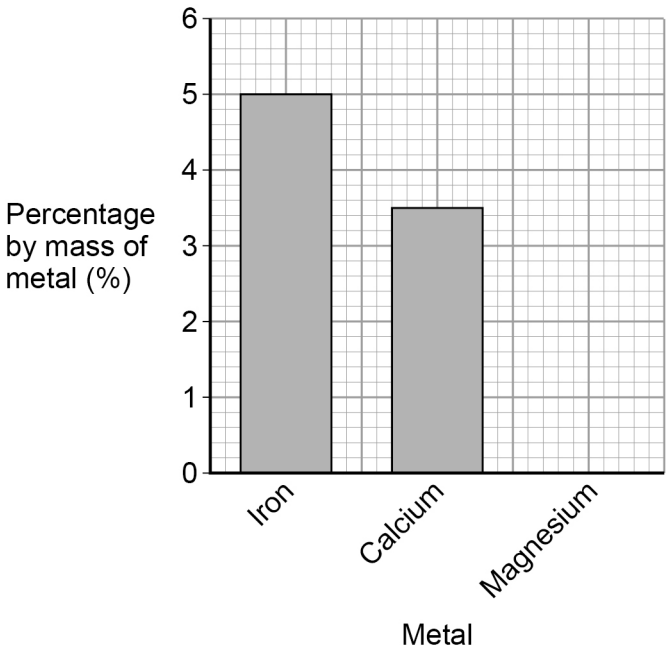
5.6.1.3 Collision theory and activation energy

Question 03

June 2019 | 8464/C/2F | Original Q5

0 5 **Figure 6** shows the percentage by mass of some metals in the Earth's crust.

Figure 6



0 5 . 1 What is the percentage by mass of calcium in the Earth's crust?

[1 mark]

Tick (✓) **one** box.

3.25% ☐ 3.50% ☐ 4.50% ☐ 5.00% ☐

0 5 . 2 The percentage by mass of magnesium in the Earth's crust is 2.1%

Draw the bar for magnesium on **Figure 6**.

[1 mark]

Question 5 continues on the next page

5.6.1.3 Collision theory and activation energy

Question 03 · continued

0 5 . 3 Copper sulfate is produced during the extraction of copper from the Earth's crust.

Copper is produced from copper sulfate solution using iron.

The word equation for the reaction is:

copper sulfate + iron → iron sulfate + copper

From the equation a company calculated that 648 kg of copper sulfate are needed to produce 617 kg of iron sulfate and 258 kg of copper.

Calculate the mass of iron needed to make 258 kg of copper.

[2 marks]

Mass = _____ kg

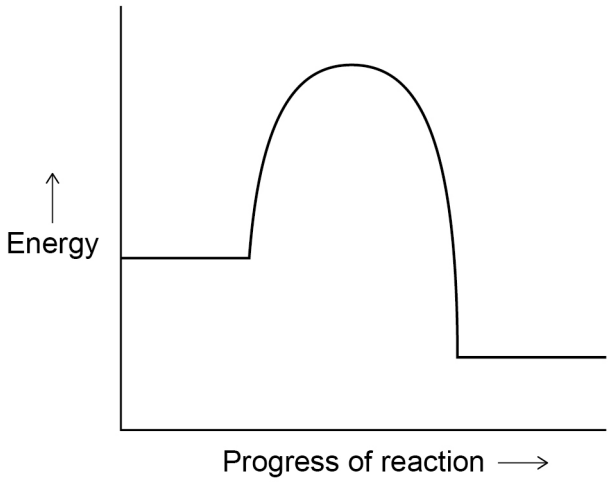
5.6.1.3 Collision theory and activation energy

Question 03 · continued

Copper is used as a catalyst.

0 5 . 4 **Figure 7** shows the reaction profile for a reaction without a catalyst.

Figure 7

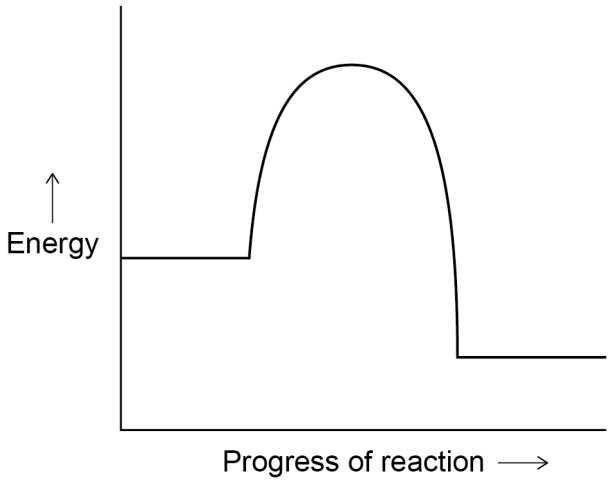


Draw an arrow on **Figure 7** to show the activation energy.

[1 mark]

0 5 . 5 The reaction profile for the reaction without a catalyst is shown again in **Figure 8.**

Figure 8



Draw a reaction profile on **Figure 8** for the same reaction with a catalyst.

[2 marks]

5.6.1.3 Collision theory and activation energy

Question 03 · continued

0 5 . 6 What are catalysts in biological systems called?

[1 mark]

Tick (✓) **one** box.

- Detergents ☐
- Enzymes ☐
- Polymers ☐
- Solvents ☐

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5.6.1.3 Collision theory and activation energy

Question 04

November 2020 | 8464/C/2F | Original Q4

0 4 This question is about hydrogen peroxide.

0 4 . 1 The symbol equation for the decomposition of hydrogen peroxide (H_2O_2) is:

$$2\ H_2O_2 \rightarrow 2\ H_2O + O_2$$

Complete the word equation for the decomposition of hydrogen peroxide.

[2 marks]

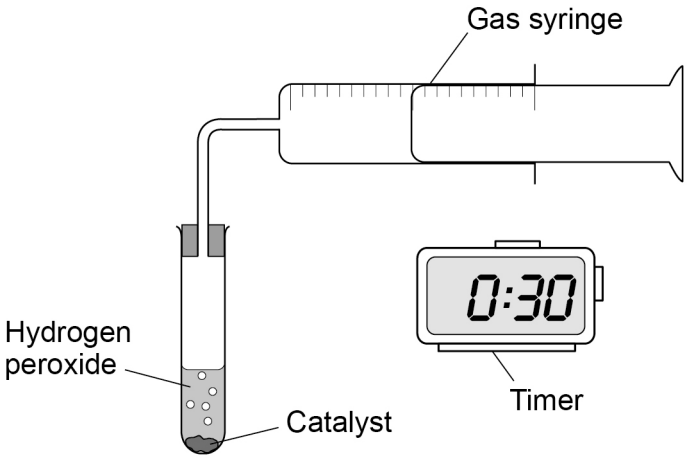
hydrogen peroxide → _____ + _____

A student investigated the effect of different catalysts on the decomposition of hydrogen peroxide.

The student measured the volume of gas collected every 30 seconds for 5 minutes.

Figure 5 shows the apparatus used.

Figure 5



5.6.1.3 Collision theory and activation energy

Question 04 · continued

0 4 . 2 Which **two** variables should the student keep the same to make the investigation a fair test?

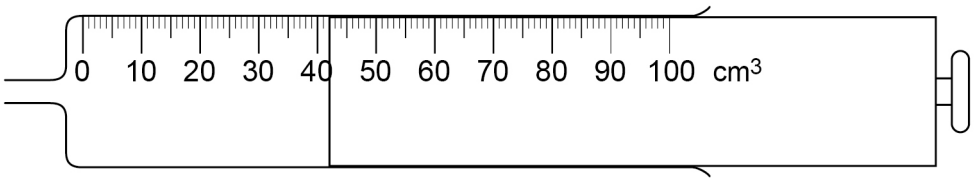
[2 marks]

Tick (✓) **two** boxes.

- Concentration of hydrogen peroxide ☐
- Mass of catalyst ☐
- Size of gas syringe ☐
- Type of catalyst ☐
- Volume of gas collected ☐

0 4 . 3 **Figure 6** shows a gas syringe.

Figure 6



What is the volume of gas in the syringe?

[1 mark]

Volume = _____ cm^3

Question 4 continues on the next page

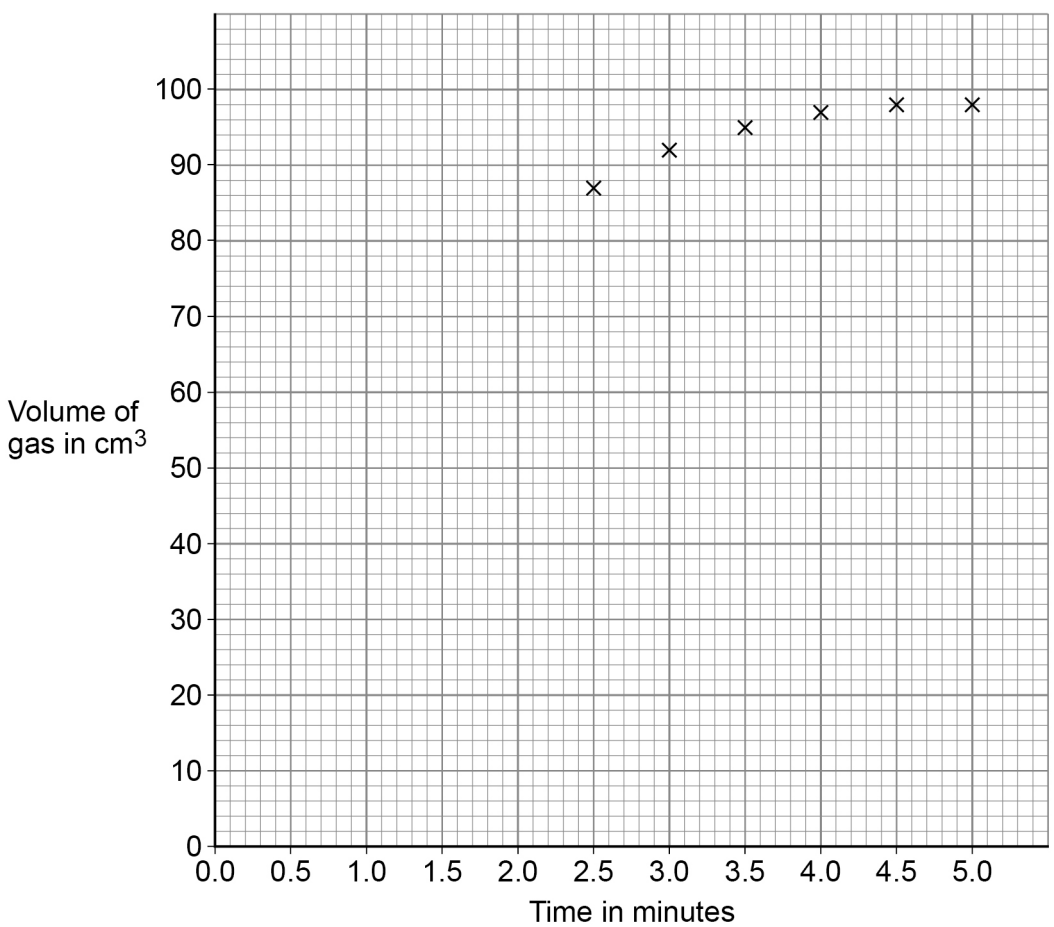
Table 3 shows the student's results for one catalyst.

Table 3

Time in minutes	0.0	0.5	1.0	1.5	2.0
Volume of gas in cm^3	0	34	54	68	78

0 4 . 4 Six of the other results have been plotted on **Figure 7**.

Figure 7



Complete the graph in **Figure 7**.

You should:

- plot the results from **Table 3**
- draw a line of best fit for all of the results.

[3 marks]

Question 04 · continued

The student repeated the experiment with other catalysts and plotted a graph for each of the catalysts used.

0 4 . 5 Suggest how the student could use these graphs to identify the best catalyst.

[1 mark]

0 4 . 6 All the graphs level off at the same volume of gas.

Suggest why.

[1 mark]

0 4 . 7 In another investigation, a student increased the temperature of the hydrogen peroxide.

Why is the rate of reaction faster when the temperature of the hydrogen peroxide is increased?

[2 marks]

Tick (✓) **two** boxes.

- The concentration of hydrogen peroxide decreases. ☐
- The particles are moving more slowly. ☐
- The particles have more energy. ☐
- There are more particle collisions per second. ☐
- There are more particles per unit volume. ☐

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5.6.1.3 Collision theory and activation energy

Question 05

November 2020 | 8464/C/2F | Original Q7

0 7 Some students investigated the effect of temperature on the rate of reaction.

0 7 . 1 The students reacted sodium thiosulfate solution with hydrochloric acid.

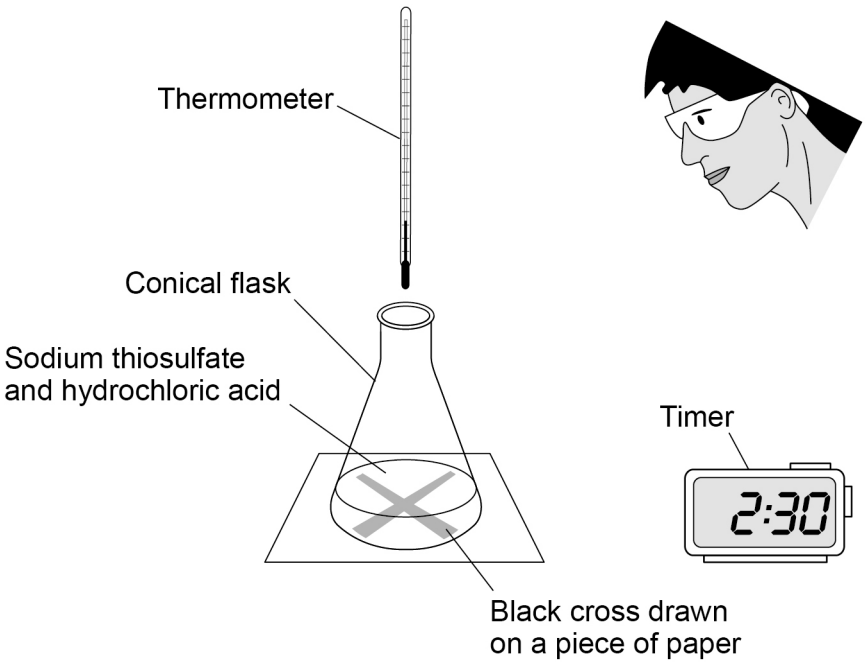
This is the method used.

1. Use a beaker to measure 50 cm^3 of heated sodium thiosulfate solution into a conical flask.
2. Measure the temperature of the room.
3. Put the conical flask on a black cross drawn on a piece of paper.
4. Start a timer.
5. Use the same beaker to measure 10 cm^3 of hydrochloric acid into the conical flask.
6. Stop the timer when the cross is no longer visible.

The students repeated the experiment at a different room temperature.

Figure 10 shows the apparatus.

Figure 10



5.6.1.3 Collision theory and activation energy

Question 05 · continued

The method contains errors and does **not** produce accurate results.

Describe a method the students should use to produce accurate results.

You do **not** need to write about safety precautions.

[6 marks]

Question 7 continues on the next page

5.6.1.3 Collision theory and activation energy

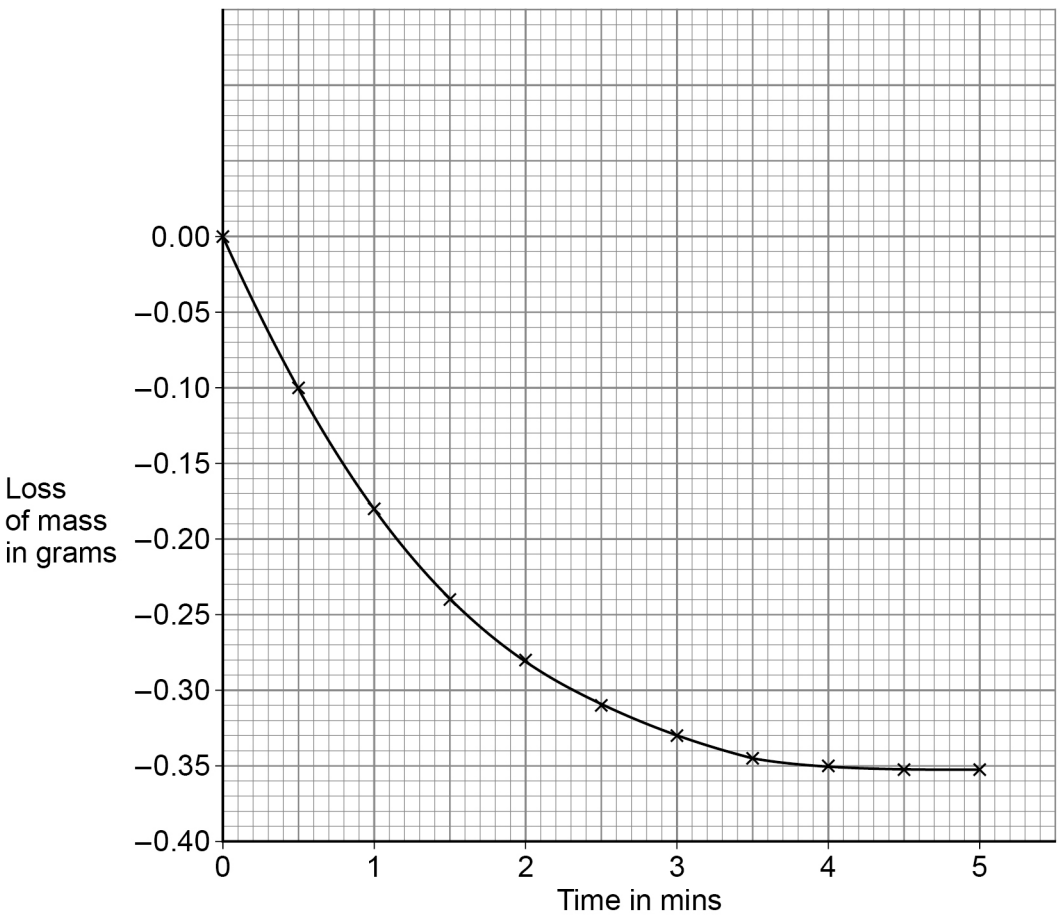
Question 05 · continued

Some students investigated the effect of temperature on the rate of a different reaction.

They recorded the loss of mass from their apparatus at 40 °C

Figure 11 shows the results.

Figure 11



5.6.1.3 Collision theory and activation energy

Question 05 · continued

0 7 . 2 Calculate the mean rate of reaction between 1 minute and 3 minutes at 40 °C

Use **Figure 11** and the equation:

$$\text{Mean rate of reaction} = \frac{\text{change in mass of gas in g}}{\text{time in mins}}$$

[3 marks]

Mean rate of reaction = _____ g/min

0 7 . 3 Draw a curve on **Figure 11** for the results you would expect at a temperature of 50 °C instead of 40 °C

[2 marks]

11

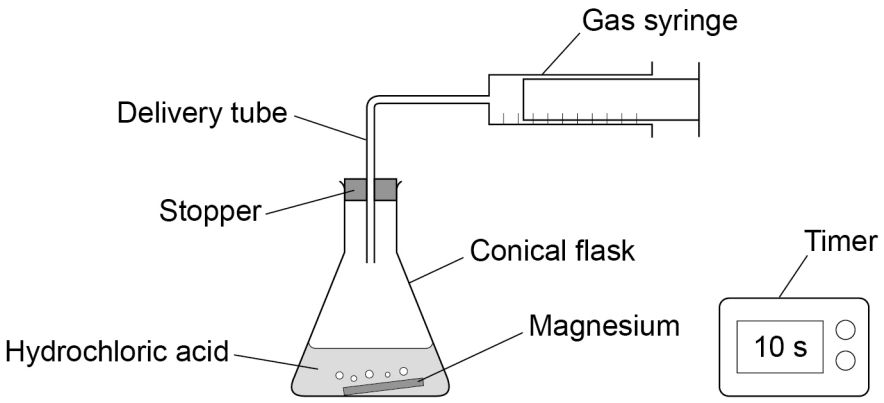
5.6.1.3 Collision theory and activation energy

Question 06

0 6 A student investigated the reaction between magnesium and excess hydrochloric acid.

Figure 5 shows the apparatus.

Figure 5



This is the method used.

1. Pour 50 cm^3 of hydrochloric acid into a conical flask.
2. Add a piece of magnesium.
3. Insert stopper and delivery tube and start a timer.
4. Collect the gas produced in a gas syringe.
5. Record the volume of gas produced every 20 seconds for 2 minutes.
6. Repeat steps 1 to 5 with higher concentrations of hydrochloric acid.

0 6 . 1 Give the independent variable and **one** control variable in this investigation.

[2 marks]

Independent variable _____

Control variable _____

Question 6 continues on the next page

Question 06 · continued

Table 3 shows the results from the first experiment using hydrochloric acid with a low concentration.

Table 3

Time in seconds	0	20	40	60	80	100	120
Volume of gas in cm³	0	48	72	90	97	98	98

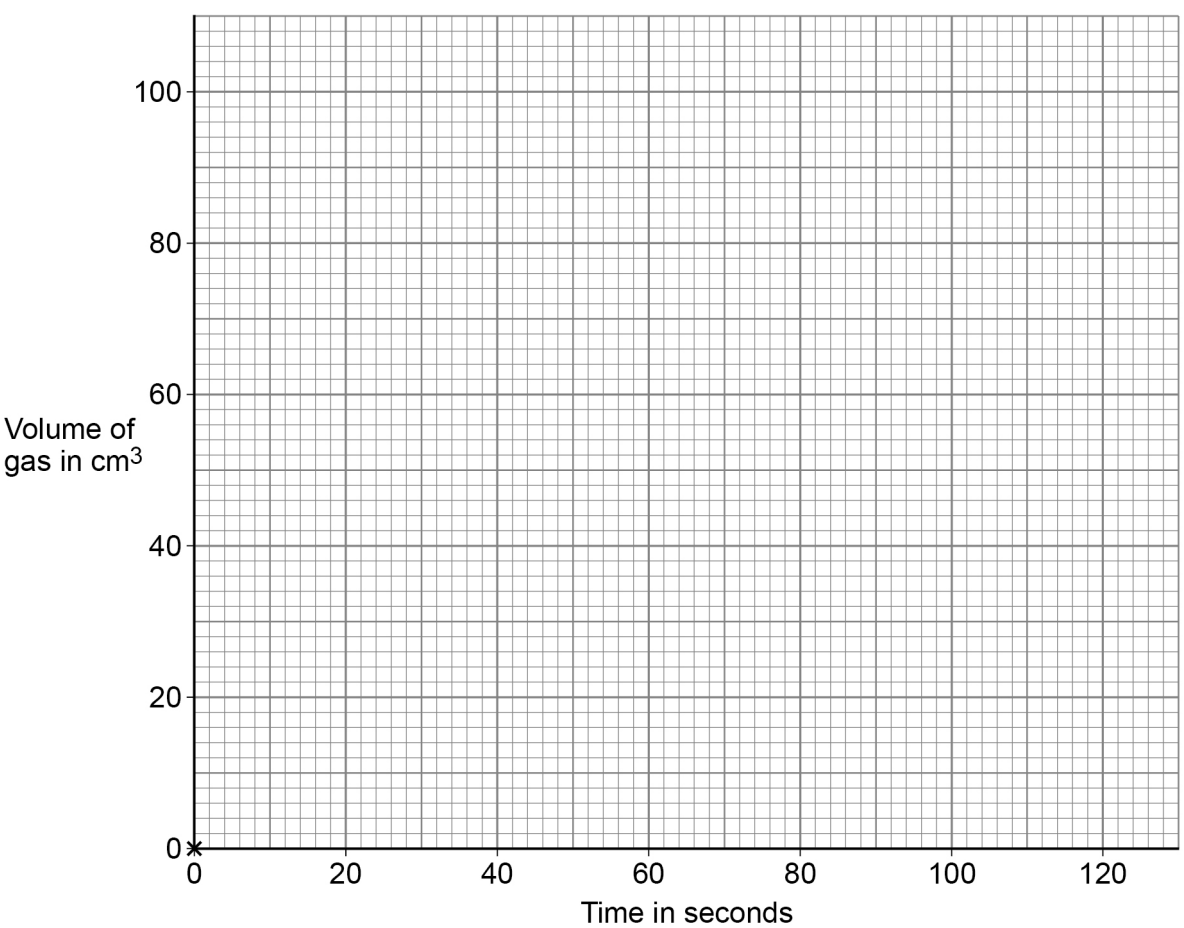
0 6 . 2 Complete **Figure 6**.

You should:

- plot the data from **Table 3** (the point 0,0 has been plotted for you)
- draw a line of best fit.

[3 marks]

Figure 6



5.6.1.3 Collision theory and activation energy

Question 06 · continued

0 6 . 3 How does the **rate** of this reaction change with time?

Use **Table 3**.

[1 mark]

Tick (✓) **one** box.

The rate decreases. ☐

The rate stays the same. ☐

The rate increases. ☐

0 6 . 4 The student repeated the experiment using hydrochloric acid with a higher concentration.

Which statement is correct?

[1 mark]

Tick (✓) **one** box.

The activation energy for the reaction was higher. ☐

The magnesium reacted more quickly. ☐

The reaction finished at the same time. ☐

The total volume of gas collected was smaller. ☐

Question 6 continues on the next page

5.6.1.3 Collision theory and activation energy

Question 06 · continued

0 6 . 5 Temperature also affects the rate of the reaction.

Explain how increasing the temperature affects the **rate** of the reaction.

You should refer to particles and collisions.

[3 marks]

10

5.6.1.3 Collision theory and activation energy

Question 07

June 2022 | 8464/C/2F | Original Q3

0 3 This question is about ammonia and its compounds.

A student heated a sample of ammonium chloride.

The equation for the reaction is:

$$\underset{\text{ammonium chloride}}{NH_4Cl} \rightleftharpoons \underset{\text{ammonia}}{NH_3} + HCl$$

0 3 . 1 One product is ammonia.

What is the name of the product with the formula HCl?

[1 mark]

0 3 . 2 Ammonia is a gas.

What is the state symbol for ammonia?

[1 mark]

Tick (✓) **one** box.

(aq) ☐ (g) ☐ (l) ☐ (s) ☐

0 3 . 3 How does the equation show that the reaction is reversible?

[1 mark]

0 3 . 4 Complete the sentence.

[1 mark]

The forward reaction is endothermic,

so the reverse reaction is _____ .

5.6.1.3 Collision theory and activation energy

Question 07 · continued

0 3 . 5 Complete the sentence.

Choose the answer from the box.

[1 mark]

concentration	**rate**	**temperature**

Equilibrium is reached when the forward and reverse reactions happen at exactly the same _____ .

Question 3 continues on the next page

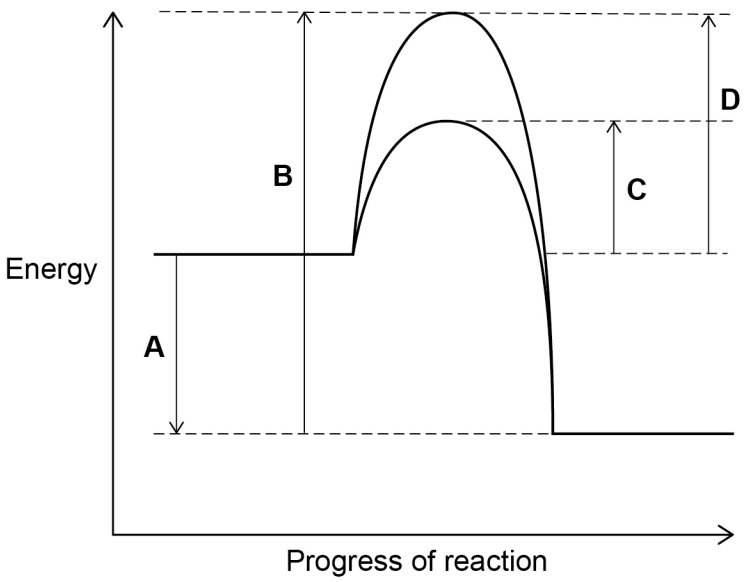
5.6.1.3 Collision theory and activation energy

Question 07 · continued

The industrial process to produce ammonia uses a catalyst.

0 3 . 6 **Figure 5** shows the reaction profile for the reaction with and without a catalyst.

Figure 5



Which letter represents the activation energy for the reaction with a catalyst?

[1 mark]

Tick (✓) **one** box.

A ☐ **B** ☐ **C** ☐ **D** ☐

5.6.1.3 Collision theory and activation energy

Question 07 · continued

0 3 . 7 Give **one** reason why using a catalyst reduces costs.

Do **not** answer in terms of activation energy.

[1 mark]

0 3 . 8 Ammonia is in a mixture that is used as a household cleaner.

What is a mixture that has been designed as a useful product called?

[1 mark]

8

Turn over for the next question

5.6.1.3 Collision theory and activation energy

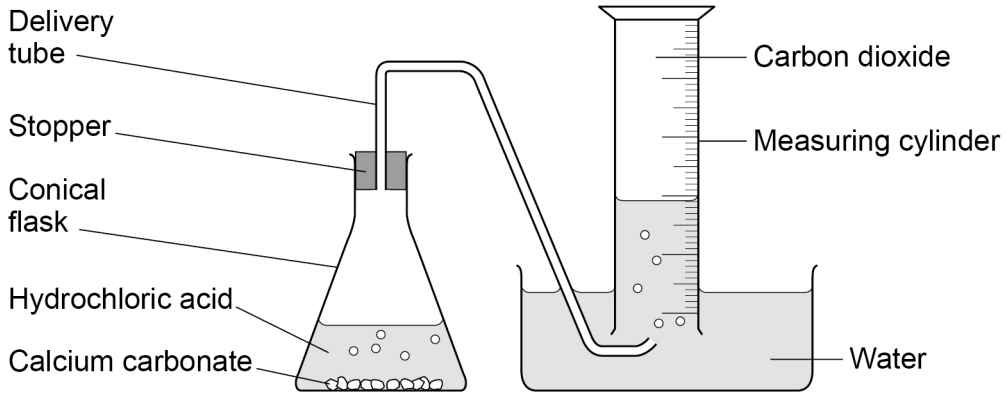
Question 08

0 7 Some factors affect the rates of chemical reactions.

0 7 . 1 A student investigated the effect of changing the particle size of calcium carbonate on the rate of reaction with hydrochloric acid.

Figure 6 shows the apparatus.

Figure 6



Describe a method the student could use to produce valid results.

[6 marks]

5.6.1.3 Collision theory and activation energy

Question 08 · continued

0 7 . 2 The student investigated the effect of increasing the temperature on the rate of a reaction.

Explain the effect of increasing the temperature on the rate of a reaction.

Refer to particles and collisions in your answer.

[3 marks]

5.6.1.3 Collision theory and activation energy

Question 08 · continued

Catalysts affect the rate of reactions.

0 7 . 3 What is meant by a 'catalyst'?

[2 marks]

0 7 . 4 What are catalysts in biological systems called?

[1 mark]

12

5.6.1.3 Collision theory and activation energy

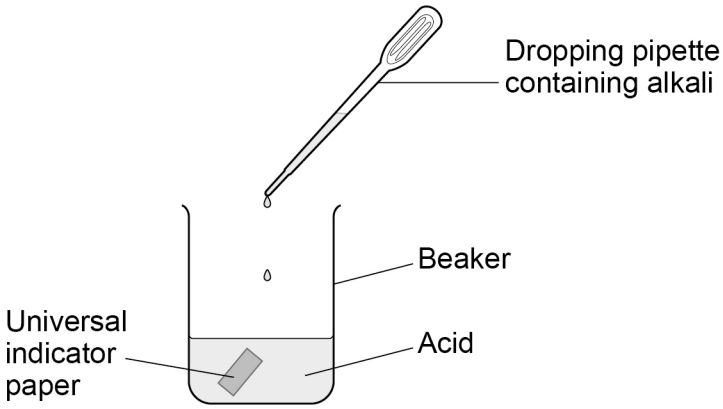
Question 09

0 5 This question is about acids.

A student investigated the volume of an alkali needed to react completely with 25 cm^3 of an acid.

Figure 10 shows the apparatus.

Figure 10



This is the method used.

1. Add 25 cm^3 of the acid to a beaker.

2. Add a piece of universal indicator paper to the acid.

3. Add the alkali drop by drop to the acid until the universal indicator paper changes colour to green.

4. Record the number of drops of alkali added.

0 5 . 1 The method does **not** give an accurate volume of alkali needed to react completely with the acid.

Suggest **two** improvements to the method.

[2 marks]

1 _____

_____

2 _____

_____

5.6.1.3 Collision theory and activation energy

Question 09 · continued

0 5 . 2 What is the pH of the solution when the universal indicator paper turns green?

[1 mark]

Tick (✓) **one** box.

1 ☐ 5 ☐ 7 ☐ 9 ☐

0 5 . 3 What name is given to the reaction between an acid and an alkali?

[1 mark]

Tick (✓) **one** box.

Combustion ☐

Displacement ☐

Neutralisation ☐

0 5 . 4 Which ion do all acids contain?

[1 mark]

Tick (✓) **one** box.

Cl^- ☐ H^+ ☐ Na^+ ☐

0 5 . 5 Name the acid that reacts with sodium hydroxide to produce sodium nitrate.

[1 mark]

_____

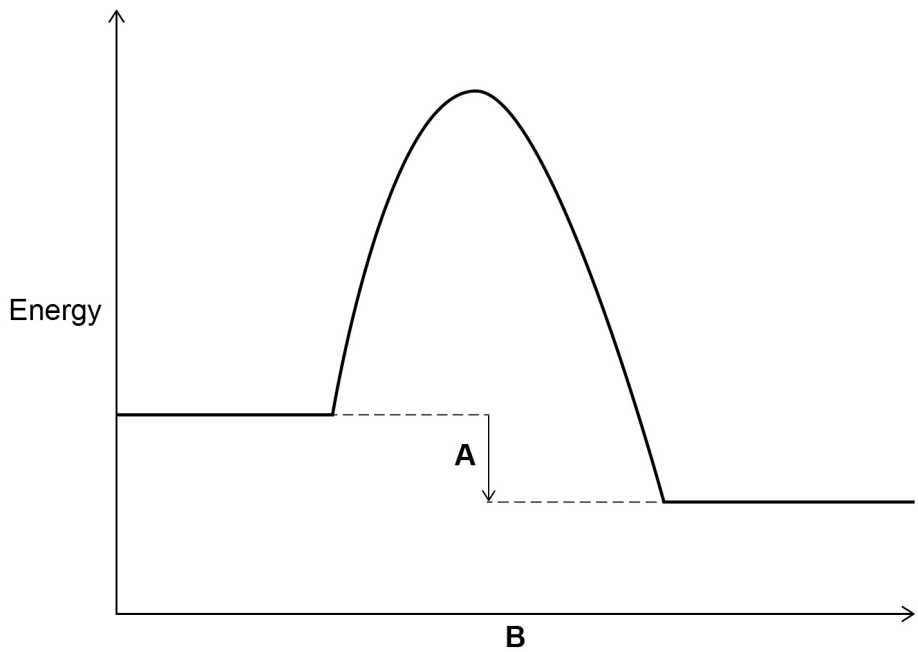
Question 5 continues on the next page

5.6.1.3 Collision theory and activation energy

Question 09 · continued

0 5 . 6 **Figure 11** shows a reaction profile for the reaction between an acid and an alkali.

Figure 11



What do labels **A** and **B** represent on **Figure 11**?

Choose the answers from the box.

[2 marks]

activation energy	**overall energy change**	**products**
progress of reaction	**reactants**	

A _____

B _____

5.6.1.3 Collision theory and activation energy

Question 09 · continued

Acids also react with insoluble solid substances to produce salt solutions.

0 5 . 7 When making a salt solution, excess solid is added to the acid.

Draw the apparatus used to separate the excess solid from the salt solution by filtration.

The apparatus should collect:

- the excess solid
- the salt solution.

[2 marks]

0 5 . 8 Solid **X** reacts with hydrochloric acid to produce zinc chloride and hydrogen gas.

Name solid **X**.

[1 mark]

11