AQA GCSE Chemistry | 8462

SPECIFICATION POINT 4.6.1.3

Collision theory and activation energy

Past-paper questions

Tier	**Foundation**
Question groups	**21**
Available paper years	**2008–2025**

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.

4.6.1.3 Collision theory and activation energy

Question 01

January 2008 | CHY2F | Original Q6 | Legacy

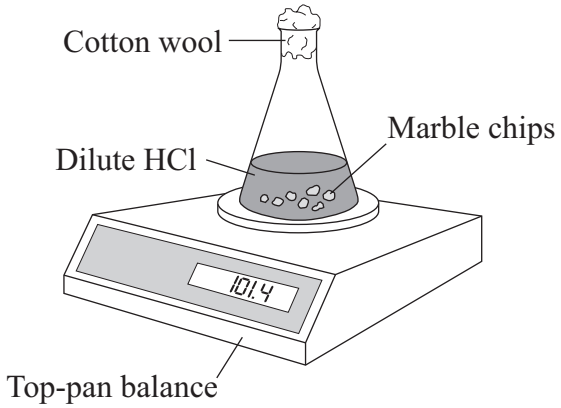
6 A student investigated the rate of reaction between marble and hydrochloric acid.

The student used an excess of marble.

The reaction can be represented by this equation.

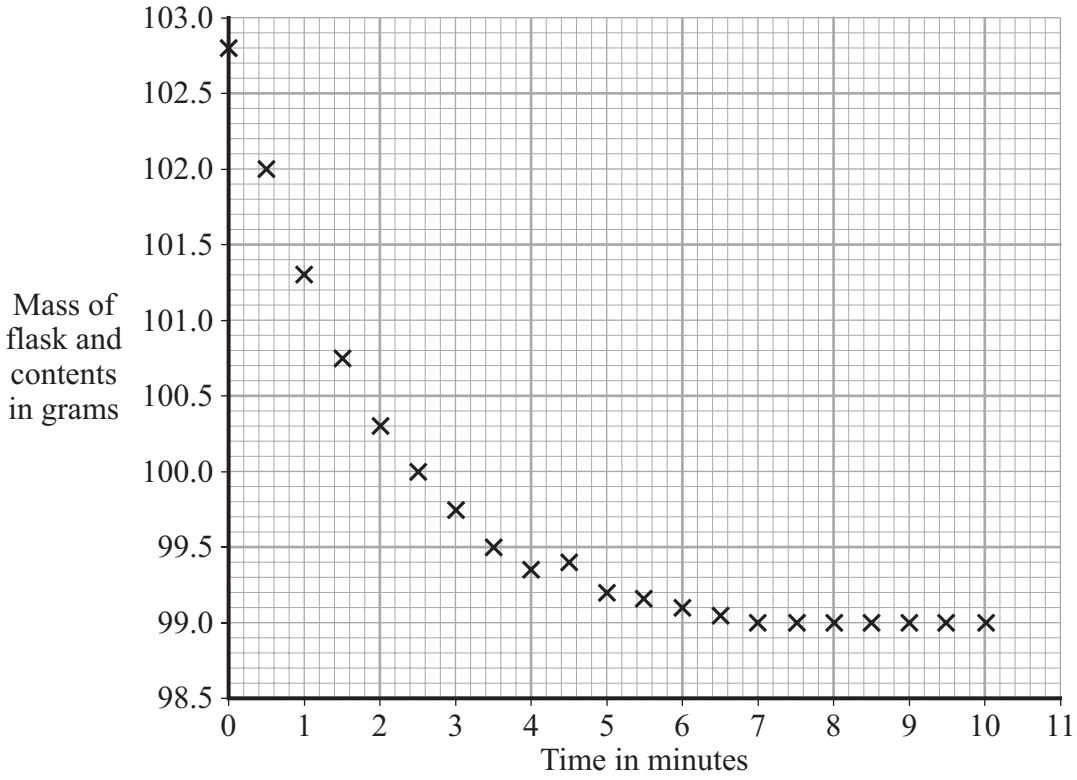
$CaCO_3$ (s) + 2HCl (aq) → $CaCl_2$ (aq) + H_2O (l) + CO_2 (g)

The student used the apparatus shown in the diagram.



The student measured the mass of the flask and contents every half minute for ten minutes.

The results are shown on the graph. Use the graph to answer the questions.



4.6.1.3 Collision theory and activation energy

Question 01 · continued

BLANK

(a) **Complete the graph** opposite by drawing a line of best fit.

(1 mark)

(b) Why did the mass of the flask and contents decrease with time?

.....

.....

(1 mark)

(c) After how many minutes had all the acid been used up?

..... minutes

(1 mark)

(d) The student repeated the experiment at a higher temperature. All other variables were kept the same as in the first experiment. The rate of reaction was much faster.

(i) Draw a line **on the graph** opposite to show what the results for this second experiment might look like.

(2 marks)

(ii) Why does an increase in temperature increase the rate of reaction?

.....

.....

.....

.....

.....

.....

(3 marks)

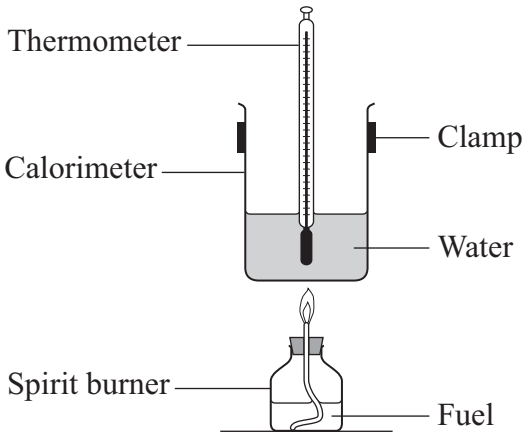
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4.6.1.3 Collision theory and activation energy

Question 02

5 A student burned four fuels and compared the amounts of energy they produced.

The student set up the apparatus as shown in the diagram.



The heat produced when each fuel was burned was used to raise the temperature of 100 g of water. The student noted the mass of fuel burned, the increase in temperature and whether the flame was smoky.

The results are shown in the table.

Fuel	Mass of fuel burned (g)	Temperature increase (°C)	Type of flame
Ethanol	4	24	Not smoky
Methanol	3	9	Not smoky
Peanut oil	2	20	Smoky
Vegetable oil	1	15	Smoky

(a) The student suggested that the vegetable oil was the best fuel for producing heat.

Explain why.

.....

.....

.....

.....

(2 marks)

4.6.1.3 Collision theory and activation energy

Question 02 · continued

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(b) Suggest an environmental problem that could be caused when large amounts of vegetable oil are burned. Suggest how the problem could be overcome.

.....

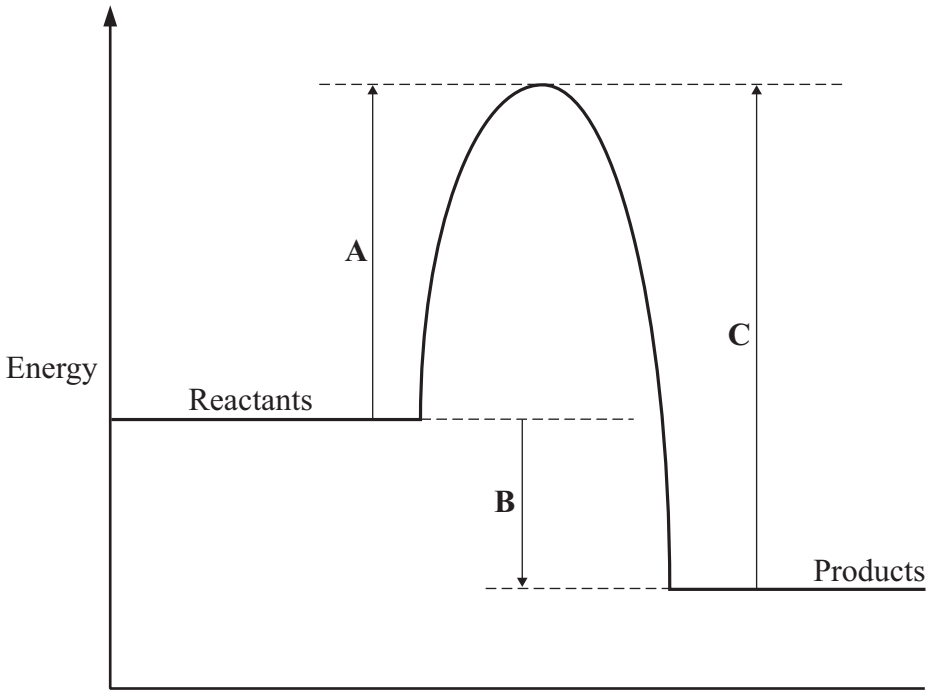
.....

.....

.....

(2 marks)

(c) An energy level diagram for the burning of vegetable oil is shown below.



Which of the energy changes **A**, **B** or **C**:

(i) represents the activation energy .....

(1 mark)

(ii) shows the amount of energy given out during the reaction? .....

(1 mark)

6

4.6.1.3 Collision theory and activation energy

Question 03

3 During a thunderstorm lightning strikes the Eiffel Tower.



In lightning the temperature can reach 30 000 °C. This causes nitrogen and oxygen in the air to react, producing nitrogen oxide. This reaction has a high *activation energy* and is *endothermic*.

3 (a) Nitrogen and oxygen in the air do not react easily.

What makes nitrogen and oxygen react during thunderstorms?

.....

(1 mark)

3 (b) Complete the word equation for the reaction of nitrogen with oxygen.

nitrogen + ... → .....

(1 mark)

3 (c) In an *endothermic* reaction, energy is taken in from the surroundings.

Draw a ring around the correct answer to complete the sentence.

In an *endothermic* reaction, the energy needed to break existing bonds is

less than
more than
the same as

the energy released from forming new bonds.

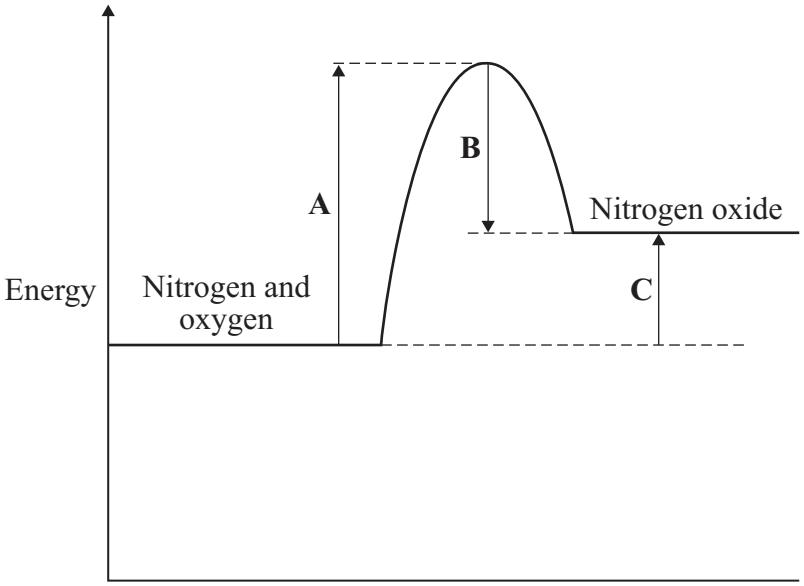
(1 mark)

4.6.1.3 Collision theory and activation energy

Question 03 · continued

for mark

3 (d) The energy level diagram for this reaction is shown.



Use the energy level diagram to help you to answer these questions.

3 (d) (i) Which energy change, **A**, **B** or **C**, represents the *activation energy*?

(1 mark)

3 (d) (ii) Which energy change, **A**, **B** or **C**, shows that this reaction is *endothermic*?

(1 mark)

5

4.6.1.3 Collision theory and activation energy

Question 04

3 The picture shows a student with two glow sticks.



Glow sticks contain several chemicals. When a glow stick is bent the chemicals mix. A chemical reaction takes place which causes light to be given out.

A student investigated three glow sticks. One was placed in water at 5 ºC, one in water at 40 ºC and one in water at 70 ºC.

The results are shown in the table.

Temperature in ºC	Effect on glow stick	
	Brightness of light	Time it gave out light, in hours
5	dim	7
40	bright	3
70	very bright	1

3 (a) How did increasing the temperature affect the brightness of the glow stick?

.....

.....

(1 mark)

3 (b) How did increasing the temperature affect the time it gave out light?

.....

.....

(1 mark)

4.6.1.3 Collision theory and activation energy

Question 04 · continued

3 (c) The student was asked why an **increase** in temperature changes the rate of the chemical reaction. The student listed five ideas. Only **three** of them are correct.

Put ticks (✓) next to the **three** correct ideas.

Ideas	Tick (✓)
The particles will collide more often.	
The particles will be more concentrated.	
The particles will move faster.	
The particles will have more energy.	
The particles will get bigger.	

(3 marks)

3 (d) Suggest **one** way the student could improve this investigation.

.....

.....

(1 mark)

6

4.6.1.3 Collision theory and activation energy

Question 05

2 Hydrogen peroxide decomposes slowly to give water and oxygen.

The reaction is *exothermic.*

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

2 (a) In an *exothermic* reaction, energy is given out.

Draw a ring around the correct answer to complete the sentence.

In an *exothermic* reaction, the temperature

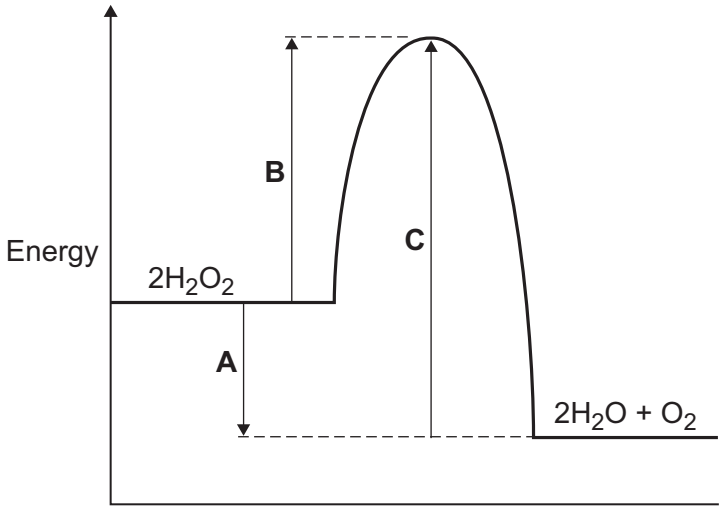
goes down.

goes up.

stays the same.

(1 mark)

2 (b) The energy level diagram for this reaction is shown below.



The energy changes, **A**, **B** and **C**, are shown on the diagram.

Use the diagram to help you answer these questions.

2 (b) (i) Which energy change, **A**, **B** or **C**, is the activation energy?

(1 mark)

2 (b) (ii) Which energy change, **A**, **B** or **C**, shows that this reaction is exothermic?

(1 mark)

4.6.1.3 Collision theory and activation energy

Question 05 · continued

2 (b) (iii) Hydrogen peroxide decomposes quickly when a small amount of manganese(IV) oxide is added.

Draw a ring around the correct answer to complete each sentence.

Hydrogen peroxide decomposes quickly because

manganese(IV) oxide is

- a catalyst.
- an element.
- a solid.

The manganese(IV) oxide has lowered the

- activation energy.
- boiling point.
- temperature.

(2 marks)

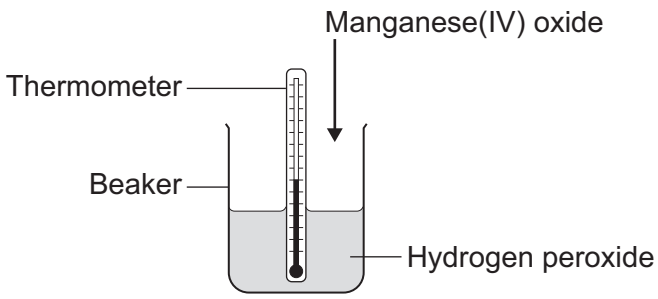
Question 2 continues on the next page

4.6.1.3 Collision theory and activation energy

Question 05 · continued

2 (c) A student did an experiment to find the amount of energy produced when hydrogen peroxide solution is decomposed using manganese(IV) oxide.

The apparatus the student used is shown in the diagram.



The student first measured the temperature of the hydrogen peroxide. Then the student added the manganese(IV) oxide, stirred the mixture and recorded the highest temperature.

2 (c) (i) Suggest why the student stirred the mixture before recording the highest temperature.

.....

.....

(1 mark)

2 (c) (ii) The biggest error in this experiment is heat loss.

Suggest how the student could change the apparatus so that less heat is lost.

.....

.....

(1 mark)

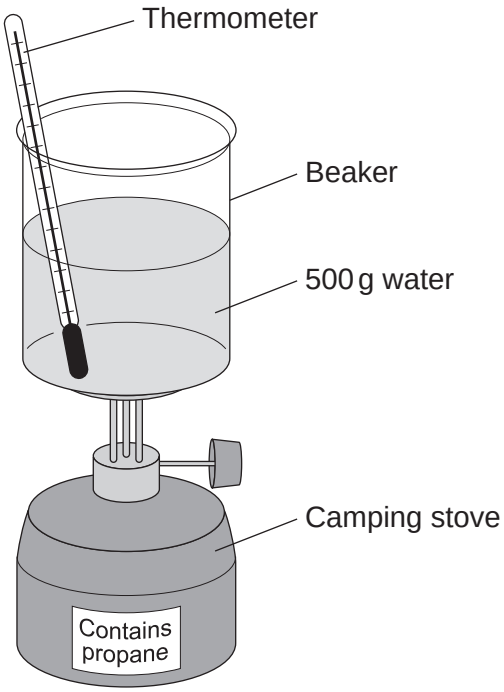
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4.6.1.3 Collision theory and activation energy

Question 06

June 2013 | CH3FP | Original Q4 | Legacy

4 A camping stove uses propane gas.



4 (a) A student did an experiment to find the energy released when propane is burned.

The student:

- put 500 g water into a beaker
- measured the temperature of the water
- heated the water by burning propane for 1 minute
- measured the temperature of the water again.

The student found the temperature change was 20 °C.

The student can calculate the energy released, in joules (J), using the equation:

energy released (J) = mass of water (g) × 4.2 × temperature change (°C)

4 (a) (i) Use the student's result to calculate the energy released in joules (J).

.....

.....

Energy released = ... J

(2 marks)

4.6.1.3 Collision theory and activation energy

Question 06 · continued

4 (a) (ii) State **two** safety precautions that the student should take during the experiment.

1 .....

.....

2 .....

.....

(2 marks)

4 (a) (iii) Tick (✓) **two** boxes which describe how the student could make his result more accurate.

	Tick (✓)
Stir the water before measuring the temperature.	
Heat the water until it boils.	
Place a lid on the beaker.	
Use a larger beaker for the water.	

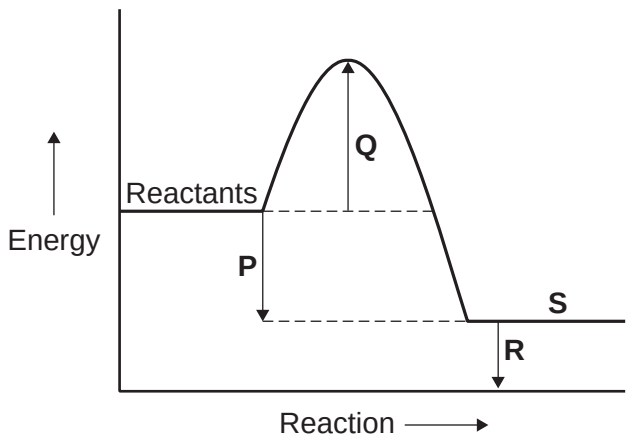
(2 marks)

Question 4 continues on the next page

4.6.1.3 Collision theory and activation energy

Question 06 · continued

4 (b) The change in energy when propane is burned can be shown in an energy level diagram.



Draw **one** line from each description to the correct letter.

Description	Letter
products	P
activation energy	Q
energy released by the reaction	R
	S

(3 marks)

4.6.1.3 Collision theory and activation energy

Question 06 · continued

4 (c) Propane and hydrogen are both used as fuels.

Some information about propane and hydrogen is given in the table.

Fuel	Resource	Products formed when fuel burned
propane	crude oil	carbon dioxide and water
hydrogen	water	water

Use the information in the table to suggest **two** disadvantages that propane has as a fuel compared to hydrogen.

1 .....

.....

2 .....

.....

(2 marks)

11

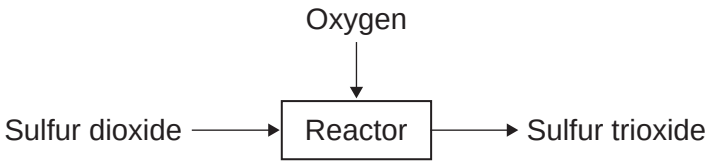
4.6.1.3 Collision theory and activation energy

Question 07

June 2014 | CH2FP | Original Q3 | Legacy

3 **Figure 4** represents the reaction of sulfur dioxide with oxygen.

Figure 4



3 (a) (i) Complete the word equation for the reaction of sulfur dioxide with oxygen.

[1 mark]

sulfur dioxide + ... → .....

3 (a) (ii) Draw a ring around the correct answer to complete the sentence.

[1 mark]

Sulfur dioxide (SO_2) is

- a compound.
- an element.
- a mixture.

3 (b) The reactants are gases.

When the pressure of the gases is increased, the reaction gets faster.

Complete the sentence.

[1 mark]

When the pressure of the gases is increased,

the frequency of the collisions ..... .

4.6.1.3 Collision theory and activation energy

Question 07 · continued

3 (c) The particles need energy to react.

Complete the sentence.

[1 mark]

The minimum amount of energy that particles need to react is called

the ..... energy.

3 (d) Give **one** way of increasing the rate of the reaction other than changing the pressure.

[1 mark]

.....

.....

5

Turn over for the next question

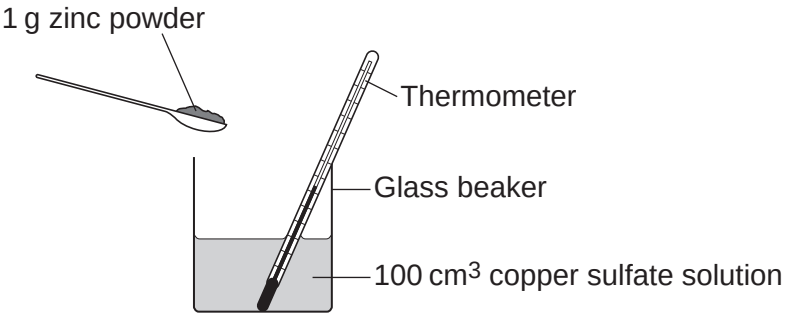
4.6.1.3 Collision theory and activation energy

Question 08

June 2015 | CH3FP | Original Q3 | Legacy

3 A student investigates the energy released when zinc powder reacts with copper sulfate solution. The student uses the apparatus shown in **Figure 3**.

Figure 3



The student:

- measures 100 cm^3 copper sulfate solution into a beaker
- measures the temperature of the copper sulfate solution
- puts 1 g zinc powder into the beaker
- stirs the mixture with a thermometer
- measures the highest temperature.

The student's results were:

Starting temperature = 21 °C
Highest temperature = 32 °C

3 (a) (i) Calculate the change in temperature.

[1 mark]

.....

Change in temperature = ... °C

3 (a) (ii) Calculate the energy released in the reaction.

Use the equation

$$\text{energy released in J} = \text{volume of solution in } cm^3 \times 4.2 \times \text{temperature change in °C}$$

[2 marks]

.....

.....

Energy released = ... J

4.6.1.3 Collision theory and activation energy

Question 08 · continued

3 (b) The reaction of zinc with copper sulfate is exothermic.

How can you tell from the student's results that the reaction is exothermic?

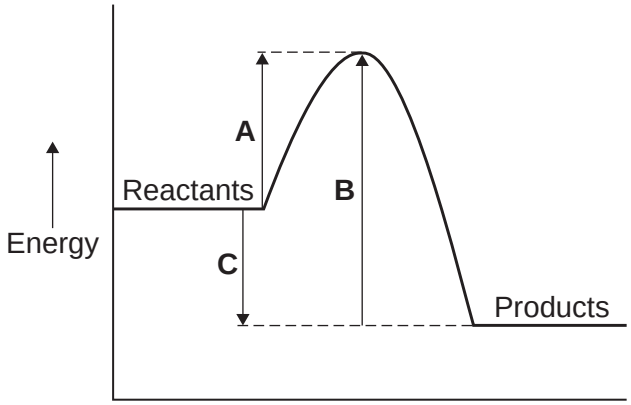
[1 mark]

.....

.....

3 (c) The energy diagram for the reaction is shown in **Figure 4**.

Figure 4



3 (c) (i) How can you tell from the energy diagram that the reaction is exothermic?

[1 mark]

.....

.....

3 (c) (ii) Which arrow shows the activation energy in **Figure 4**?

[1 mark]

Tick (✓) **one** box.

A ☐

B ☐

C ☐

6

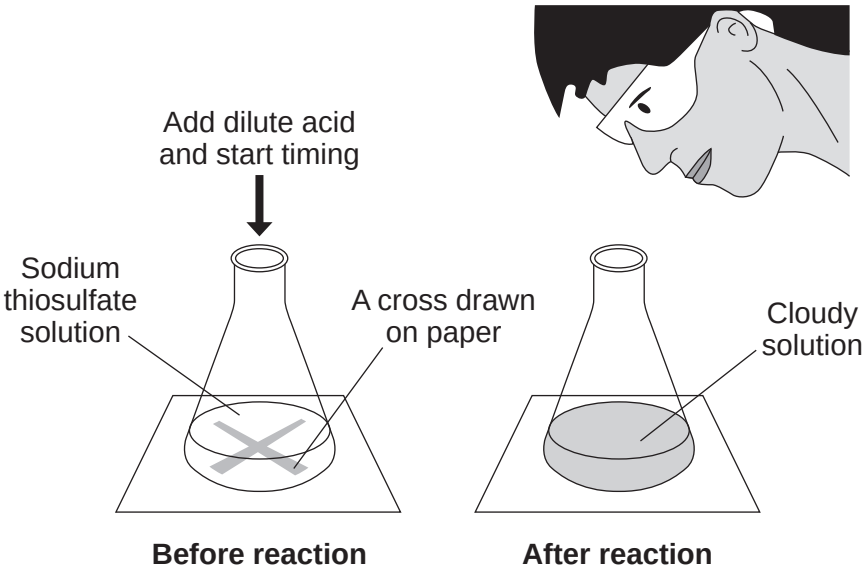
4.6.1.3 Collision theory and activation energy

Question 09

4 A student investigated the effect of temperature on the rate of a reaction.

Figure 9 shows an experiment.

Figure 9



The student:

- put 50 cm^3 sodium thiosulfate solution into a conical flask
- heated the sodium thiosulfate solution to the required temperature
- put the flask on a cross drawn on a piece of paper
- added 5 cm^3 dilute hydrochloric acid and started a stopclock
- stopped the stopclock when the cross could no longer be seen
- repeated the experiment at different temperatures.

4.6.1.3 Collision theory and activation energy

Question 09 · continued

The equation for the reaction is:

$$Na_2S_2O_3(aq) + 2HCl(aq) \longrightarrow 2NaCl(aq) + H_2O(l) + SO_2(g) + S(s)$$

sodium thiosulfate	hydrochloric acid	sodium chloride	water	sulfur dioxide	sulfur

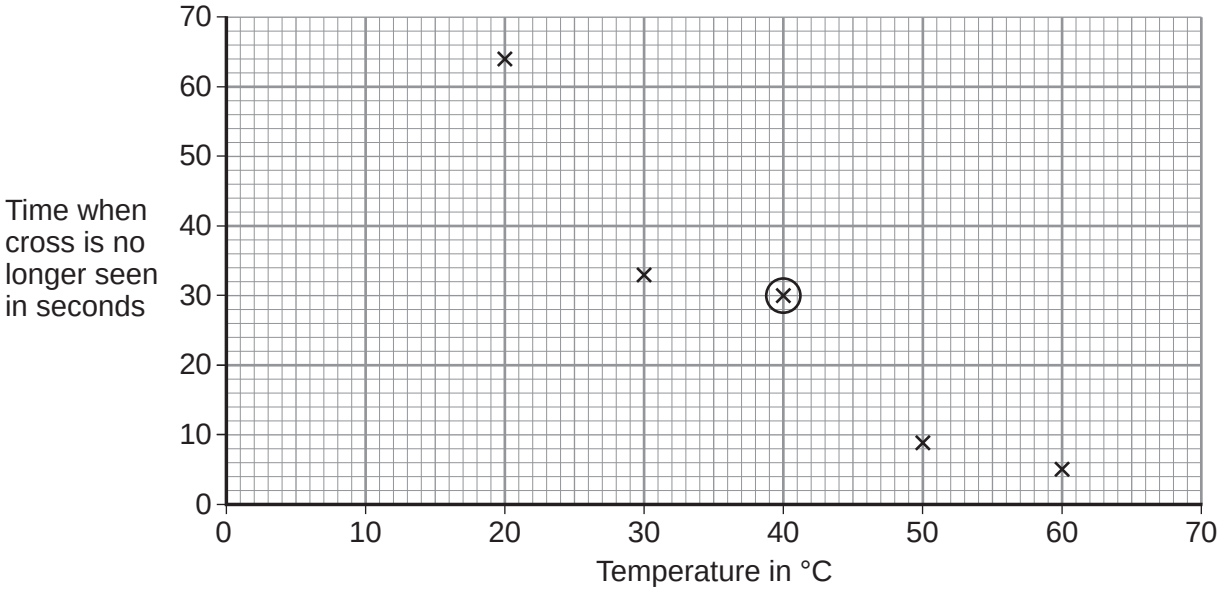
4 (a) Which product is a gas?

[1 mark]

_____

4 (b) **Figure 10** shows the results of this experiment at five different temperatures. The circled result point is anomalous.

Figure 10



4 (b) (i) Draw a line of best fit on **Figure 10** to show how the reaction time varied with reaction temperature.

[1 mark]

4 (b) (ii) Give a possible reason for the anomalous result at 40 °C.

[1 mark]

_____

_____

Question 4 continues on the next page

4.6.1.3 Collision theory and activation energy

Question 09 · continued

4 (b) (iii) The reaction at 20 °C produced 0.32 g of sulfur in 64 seconds.

Calculate the rate of the reaction at 20 °C using the equation:

$$\text{Rate of reaction} = \frac{\text{mass of sulfur}}{\text{time}}$$

[2 marks]

Rate of reaction = _____ grams per second

4 (b) (iv) Give **two** reasons why the rate of the reaction increases as the temperature increases.

[2 marks]

Tick (✓) **two** boxes.

- The particles move faster. ☐
- The particles collide less often. ☐
- All the particles have the same energy. ☐
- The particles collide with more energy. ☐
- The number of particles increases. ☐

4 (b) (v) Use the correct answer from the box to complete the sentence.

[1 mark]

activation	collision	exothermic

The minimum amount of energy particles must have to react is called

the _____ energy.

8

4.6.1.3 Collision theory and activation energy

Question 10

June 2016 | CH3FP | Original Q3 | Legacy

3 This question is about energy changes in chemical reactions.

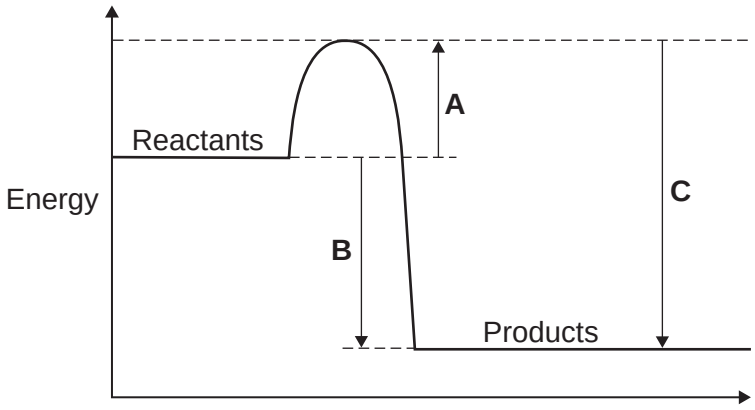
3 (a) Complete the word equation for the combustion of hydrogen.

[1 mark]

hydrogen + oxygen ⟶ _____

3 (b) **Figure 3** shows a simple energy level diagram.

Figure 3



3 (b) (i) Which arrow, **A**, **B** or **C**, shows the activation energy?

[1 mark]

Tick (✓) **one** box.

A ☐

B ☐

C ☐

3 (b) (ii) What type of reaction is shown by the energy level diagram in **Figure 3**?
Give a reason for your answer.

[2 marks]

Type of reaction _____

Reason _____

_____

4.6.1.3 Collision theory and activation energy

Question 10 · continued

3 (b) (iii) For a reaction, the value of **A** is 1370 kJ and **C** is 3230 kJ.
Calculate the value of **B**.

[1 mark]

_____

_____

B = _____ kJ

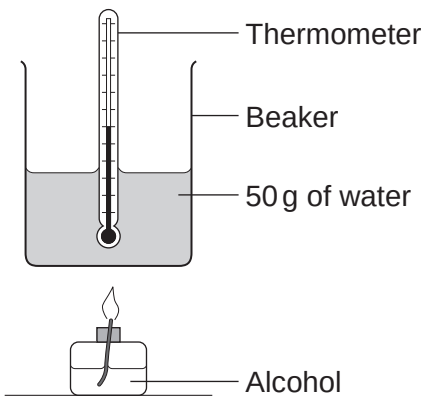
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Question 10 · continued

3 (c) Alcohols are used as fuels.

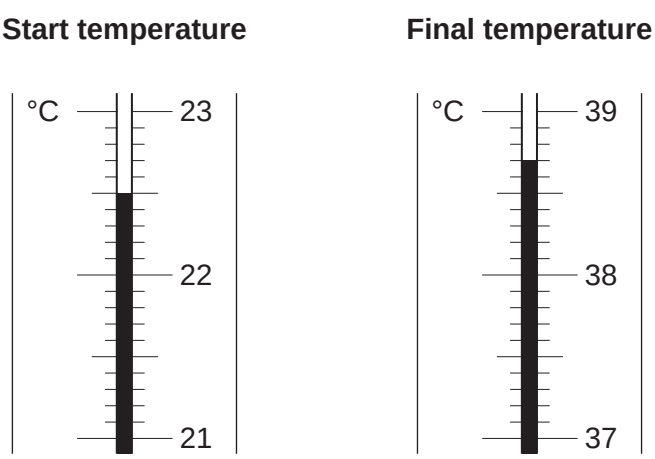
A group of students investigated the amount of energy released when different alcohols are burned.
The students used the apparatus shown in **Figure 4**.

Figure 4



3 (c) (i) **Figure 5** shows the start temperature and the final temperature of the water.

Figure 5



Write the start temperature and the final temperature of the water in **Table 1**.
Work out the increase in temperature to complete **Table 1**.

[3 marks]

Table 1

Start temperature of the water in °C	
Final temperature of the water in °C	
Increase in temperature in °C	

4.6.1.3 Collision theory and activation energy

Question 10 · continued

3 (c) (ii) The students worked out the heat energy released by burning 1 g of each alcohol. The students used the equation:

Heat energy released = m × 4.2 × increase in temperature

Look at **Figure 4**. What is the value of m?

[1 mark]

m = _____ g

3 (c) (iii) **Table 2** shows the students' results.

Table 2

Name of alcohol	Number of carbon atoms in one molecule of alcohol	Heat energy released when 1 g of alcohol is burned in kJ
Methanol	1	11.4
Ethanol	2	14.5
Propanol	3	20.1
Butanol	4	16.8
Pentanol	5	17.2

Which value of heat energy released is anomalous?

[1 mark]

_____

3 (c) (iv) Look at **Table 2**.
What is the relationship between the number of carbon atoms in one molecule of alcohol and the heat energy released when 1 g of the alcohol is burned?

[1 mark]

_____

_____

Question 3 continues on the next page

4.6.1.3 Collision theory and activation energy

Question 10 · continued

3 (c) (v) The value in a data book for the amount of heat energy released when 1 g of butanol is burned completely is 36.2 kJ.

Suggest **two** reasons why the students' result for butanol is lower than the data book value.

[2 marks]

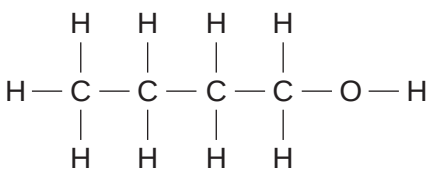
1 _____

_____

2 _____

_____

3 (c) (vi) The displayed structure of butanol is:



What is the functional group of the alcohol?

[1 mark]

Tick (✓) **one** box.

— C — C ☐

— C — H ☐

— O — H ☐

14

4.6.1.3 Collision theory and activation energy

Question 11

June 2018 | 8462/1F | Original Q6

0 6 A student investigated the temperature change in displacement reactions between metals and copper sulfate solution.

This is the method used.

1. Measure 50 cm^3 of the copper sulfate solution into a polystyrene cup.
2. Record the starting temperature of the copper sulfate solution.
3. Add the metal and stir the solution.
4. Record the highest temperature the mixture reaches.
5. Calculate the temperature increase for the reaction.
6. Repeat steps 1-5 with different metals.

0 6 . 1 Draw **one** line from each type of variable to the name of the variable in the investigation.

[2 marks]

Type of variable	Name of variable in the investigation
	Concentration of solution
Dependent variable	Particle size of solid
	Temperature change
Independent variable	Type of metal
	Volume of solution

4.6.1.3 Collision theory and activation energy

Question 11 · continued

0 6 . 2 The student used a polystyrene cup and **not** a glass beaker.

Why did this make the investigation more accurate?

[1 mark]

Tick **one** box.

- Glass is breakable ☐
- Glass is transparent ☐
- Polystyrene is a better insulator ☐
- Polystyrene is less dense ☐

Question 6 continues on the next page

Question 11 · continued

Table 5 shows the student's results.

Table 5

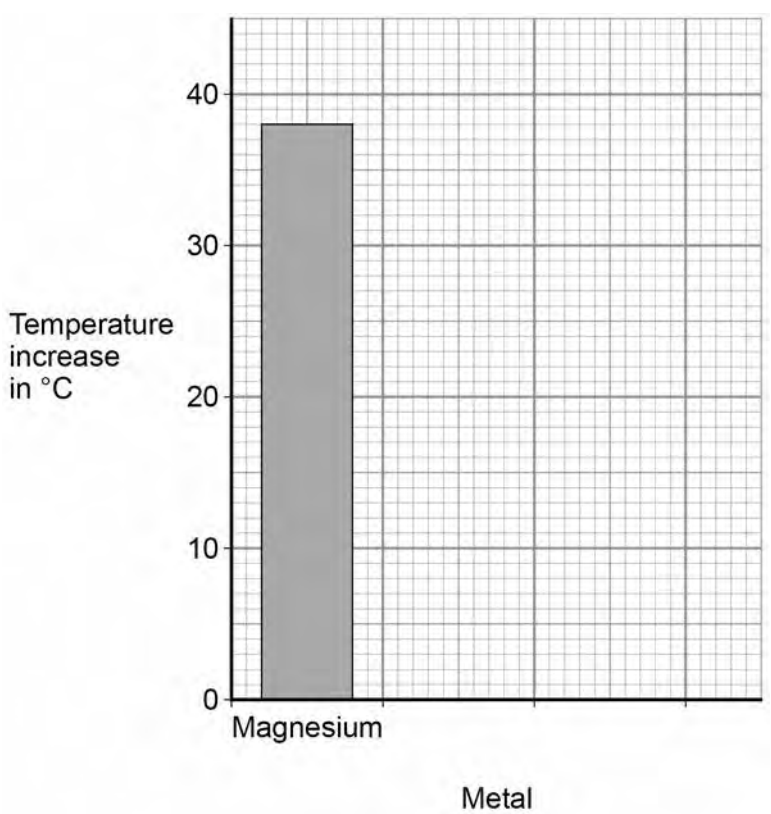
Metal	Temperature increase in °C
Magnesium	38
Nickel	8
Zinc	16

0 6 . 3 Complete **Figure 9**.

Use data from **Table 5**.

[2 marks]

Figure 9



4.6.1.3 Collision theory and activation energy

Question 11 · continued

0 6 . 4 The student concluded that the reactions between the metals and copper sulfate solution are endothermic.

Give **one** reason why this conclusion is **not** correct.

[1 mark]

0 6 . 5 The temperature increase depends on the reactivity of the metal.

Write the metals magnesium, nickel and zinc in order of reactivity.

Use **Table 5**.

[1 mark]

Most reactive _____

_____

Least reactive _____

0 6 . 6 **Y** is an unknown metal.

Describe a method to find the position of **Y** in the reactivity series in Question **06.5**

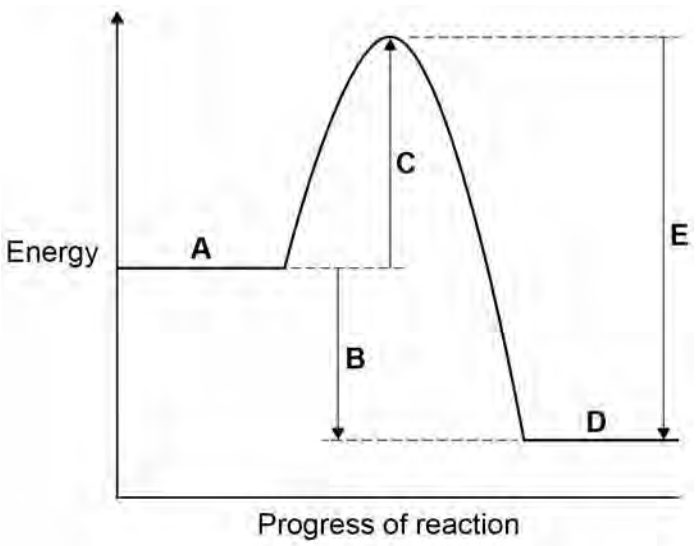
[3 marks]

4.6.1.3 Collision theory and activation energy

Question 11 · continued

Figure 10 shows the reaction profile for the reaction between zinc and copper sulfate solution.

Figure 10



0 6 . 7 Which letter represents the products of the reaction?

[1 mark]

Tick **one** box.

A		B		C		D		E	

0 6 . 8 Which letter represents the activation energy?

[1 mark]

Tick **one** box.

A		B		C		D		E	

12

4.6.1.3 Collision theory and activation energy

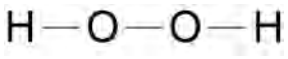
Question 12

June 2019 | 8462/1F | Original Q2

0 2 This question is about compounds of oxygen and hydrogen.

Figure 2 represents the structure of hydrogen peroxide.

Figure 2



0 2 . 1 What is the correct formula of hydrogen peroxide?

[1 mark]

Tick (✓) **one** box.

- H2O2 ☐
- HO_2 ☐
- H^2O^2 ☐
- H_2O_2 ☐

0 2 . 2 Which type of bonding is shown in **Figure 2**?

[1 mark]

Tick (✓) **one** box.

- Covalent ☐
- Ionic ☐
- Metallic ☐

4.6.1.3 Collision theory and activation energy

Question 12 · continued

0 2 . 3 Hydrogen peroxide decomposes in the presence of a catalyst.

Which elements are often used as catalysts?

[1 mark]

Tick (✓) **one** box.

Alkali metals ☐

Halogens ☐

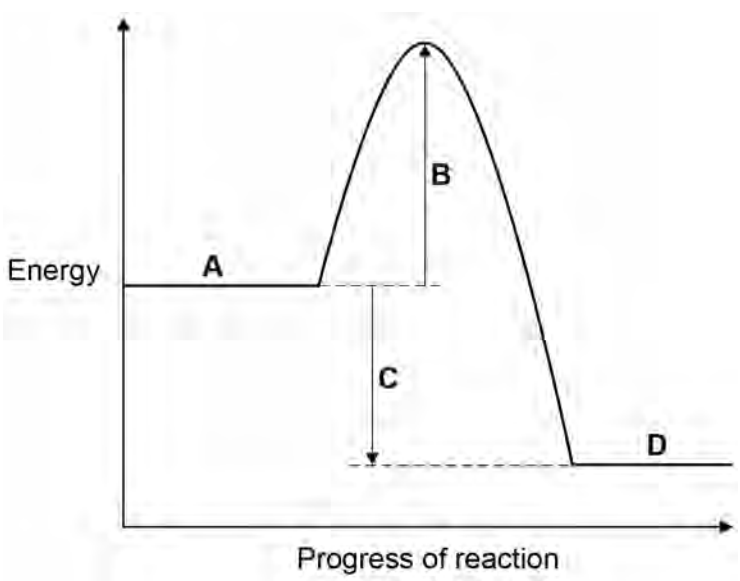
Transition metals ☐

Figure 3 shows the reaction profile for the decomposition of hydrogen peroxide.

The word equation for this reaction is:

hydrogen peroxide → water + oxygen

Figure 3



Question 12 · continued

Labels **A**, **B**, **C** and **D** each represent a different part of the reaction profile.

Use **Figure 3** to answer Questions **02.4** and **02.5**

0 2 . 4 Which label shows the activation energy?

[1 mark]

Tick (✓) **one** box.

A ☐ **B** ☐ **C** ☐ **D** ☐

0 2 . 5 Which label shows the energy of hydrogen peroxide?

[1 mark]

Tick (✓) **one** box.

A ☐ **B** ☐ **C** ☐ **D** ☐

0 2 . 6 The decomposition of hydrogen peroxide gives out energy to the surroundings.

What type of reaction is this?

[1 mark]

Tick (✓) **one** box.

Displacement ☐

Endothermic ☐

Exothermic ☐

Neutralisation ☐

Question 2 continues on the next page

4.6.1.3 Collision theory and activation energy

Question 12 · continued

0 2 . 7 Hydrogen and oxygen form water.

A hydrogen atom contains one electron.

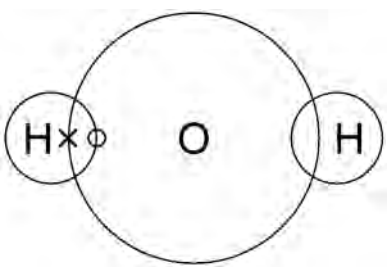
An oxygen atom contains six electrons in the outer shell.

Complete **Figure 4** to show a dot and cross diagram for a water molecule.

Show the outer electrons only.

[2 marks]

Figure 4



8

4.6.1.3 Collision theory and activation energy

Question 13

0 7 Some students investigated the rate of decomposition of hydrogen peroxide.

The equation for the reaction is:

hydrogen peroxide → water + oxygen

0 7 . 1 Complete the sentence.

Choose an answer from the box.

[1 mark]

a burning splint	**a glowing splint**
damp litmus paper	**limewater**

The students tested the gas produced to show that it was oxygen.

The students used _____ .

Student **A** investigated the effect of the particle size of a manganese dioxide catalyst on the rate of the reaction.

This is the method used.

1. Measure 25 cm^3 hydrogen peroxide solution into a conical flask.

2. Add some fine manganese dioxide powder to the conical flask.

3. Measure the volume of oxygen produced every 30 seconds for 10 minutes.

4. Repeat steps 1 to 3 two more times.

5. Repeat steps 1 to 4 with coarse manganese dioxide lumps.

4.6.1.3 Collision theory and activation energy

Question 13 · continued

0 7 . 2 The method student **A** used did **not** give repeatable results.

How could student **A** make the results repeatable?

[1 mark]

Tick (✓) **one** box.

- Student **A** should make measurements every 2 minutes. ☐
- Student **A** should measure the mass of manganese dioxide. ☐
- Student **A** should use 50 cm^3 hydrogen peroxide. ☐
- Student **A** should use a beaker instead of a conical flask. ☐

Student **B** used a method which gave repeatable results.

0 7 . 3 How could student **B** improve the accuracy of these results?

[1 mark]

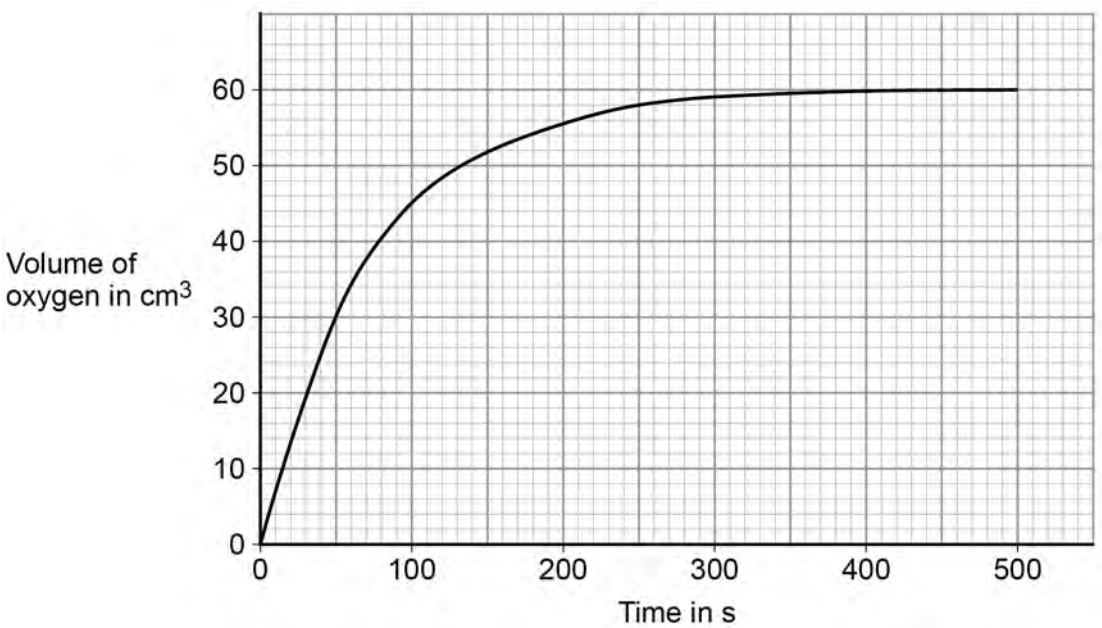
Tick (✓) **one** box.

- Calculate a mean but do not include any anomalous results. ☐
- Calculate a mean but do not include the first set of results. ☐
- Record the results in a table and plot the results on a bar chart. ☐
- Record the results in a table and plot the results on a line graph. ☐

Question 13 · continued

Figure 5 shows student **B**'s results for coarse manganese dioxide lumps.

Figure 5



0 7 . 4 Calculate the mean rate of reaction between 30 and 250 seconds for coarse manganese dioxide lumps.

Use **Figure 5** and the equation:

$$\text{Mean rate of reaction} = \frac{\text{Volume of oxygen formed}}{\text{Time taken}}$$

Give your answer to 3 significant figures.

[4 marks]

Volume of oxygen formed _____

Time taken _____

_____

_____

_____

_____

Mean rate of reaction = _____ cm^3/s

4.6.1.3 Collision theory and activation energy

Question 13 · continued

0 7 . 5 Fine manganese dioxide powder produces a higher rate of reaction than coarse manganese dioxide lumps.

Sketch on **Figure 5** the results you would expect for student **B**'s experiment with fine manganese dioxide powder.

[2 marks]

0 7 . 6 Hydrogen peroxide molecules collide with manganese dioxide particles during the reaction.

Why does fine manganese dioxide powder produce a higher rate of reaction than coarse manganese dioxide lumps?

[1 mark]

Tick (✓) **one** box.

Fine manganese dioxide powder has a larger surface area. ☐

Fine manganese dioxide powder has larger particles. ☐

Fine manganese dioxide powder produces less frequent collisions. ☐

4.6.1.3 Collision theory and activation energy

Question 14

November 2020 | 8462/1F | Original Q3

0 3 This question is about chemical reactions and energy.

Hydrogen reacts with oxygen to produce water.

This reaction releases energy.

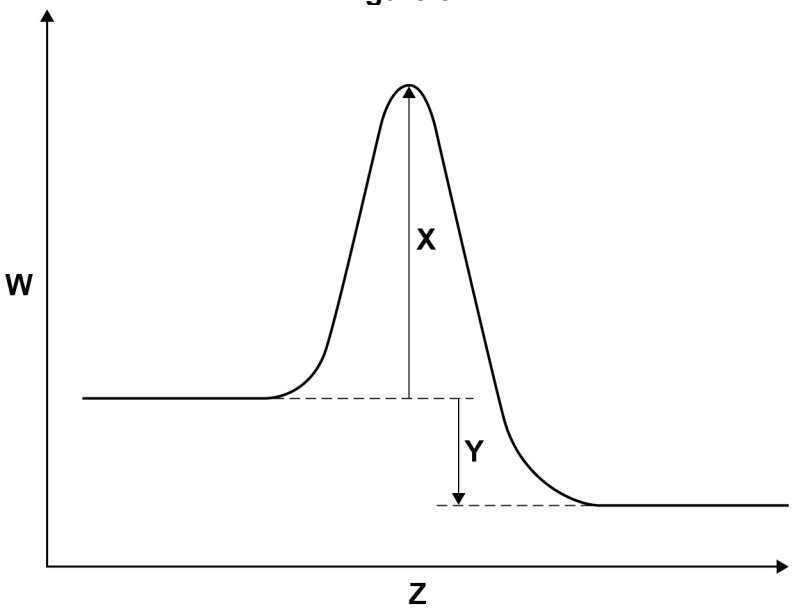
0 3 . 1 Complete the word equation for the reaction.

[1 mark]

hydrogen + oxygen → _____

0 3 . 2 **Figure 3** shows a reaction profile for the reaction between hydrogen and oxygen.

Figure 3



What do the labels **W**, **X**, **Y** and **Z** represent?

Choose answers from the box.

[4 marks]

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

W _____

X _____

Y _____

Z _____

4.6.1.3 Collision theory and activation energy

Question 14 · continued

0 3 . 3 The reaction between hydrogen and oxygen is used in a hydrogen fuel cell.

What is the reason for using this reaction in a fuel cell?

[1 mark]

Tick (✓) **one** box.

To produce a change of state ☐

To produce a potential difference ☐

To produce a temperature change ☐

0 3 . 4 A student investigated the voltage produced by a chemical cell.

The student used different metals as the electrodes in the cell.

The metals used were:

- copper
- iron
- magnesium.

Which **two** metal electrodes would produce the greatest voltage when used in the chemical cell?

Give **one** reason for your answer.

[2 marks]

Metals _____ and _____

Reason _____

_____

8

4.6.1.3 Collision theory and activation energy

Question 15

November 2020 | 8462/2F | Original Q3

0 3 This question is about the rate of the reaction between hydrochloric acid and calcium carbonate.

A student investigated the effect of changing the size of calcium carbonate lumps on the rate of this reaction.

This is the method used.

1. Pour hydrochloric acid into a conical flask up to the 50 cm^3 line.
2. Add 10.0 g of small calcium carbonate lumps to the conical flask.
3. Attach a gas syringe to the conical flask.
4. Measure the volume of gas produced every 20 seconds for 100 seconds.
5. Repeat steps 1 to 4 using 10.0 g of large calcium carbonate lumps.

0 3 . 1 The student used the 50 cm^3 line on the conical flask to measure the volume of hydrochloric acid.

Suggest a piece of equipment the student could use to make the measurement of volume more accurate.

[1 mark]

0 3 . 2 Carbon dioxide gas is produced in the reaction between hydrochloric acid and calcium carbonate.

Which test is used to identify carbon dioxide gas?

[1 mark]

Tick (✓) **one** box.

- A burning splint pops ☐
- A glowing splint relights ☐
- Damp litmus paper is bleached ☐
- Limewater turns milky ☐

4.6.1.3 Collision theory and activation energy

Question 15 · continued

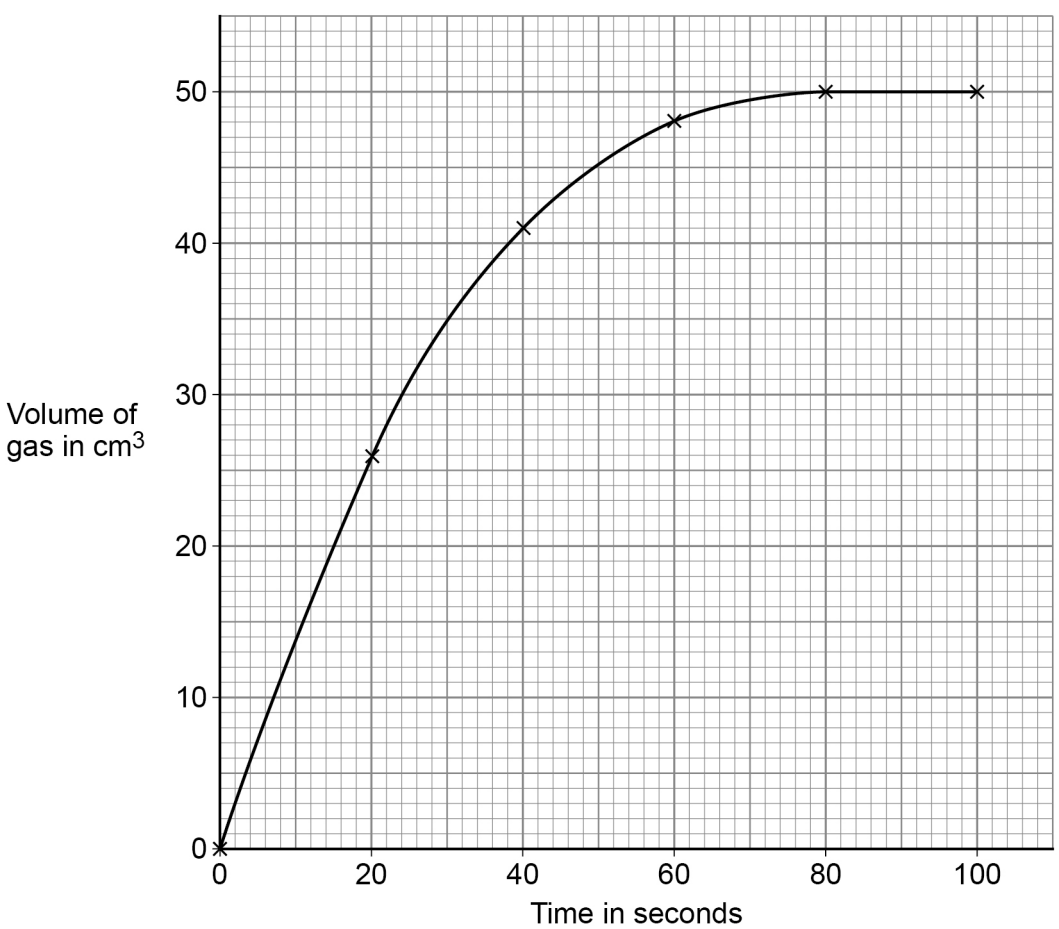
Table 2 shows the student's results for large calcium carbonate lumps.

Table 2

Time in seconds	Volume of gas in cm^3
0	0
20	16
40	30
60	40
80	46
100	48

Figure 4 shows the student's results for small calcium carbonate lumps.

Figure 4



4.6.1.3 Collision theory and activation energy

Question 15 · continued

0 3 . 3 Complete **Figure 4**.

You should:

- plot the data for large calcium carbonate lumps from **Table 2** on **Figure 4**
- draw a line of best fit for large calcium carbonate lumps.

[3 marks]

0 3 . 4 Determine the mean rate of reaction using **small** calcium carbonate lumps between 0 seconds and 60 seconds.

Use the equation:

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

Use **Figure 4**.

[3 marks]

Mean rate of reaction = _____ cm^3/s

0 3 . 5 Describe what happens to the volume of gas collected using **small** calcium carbonate lumps:

- between 0 and 20 seconds
- between 80 and 100 seconds.

Use **Figure 4**.

[2 marks]

Between 0 and 20 seconds _____

Between 80 and 100 seconds _____

Question 15 · continued

0 3 . 6 The balance used to weigh 10.0 g of calcium carbonate lumps caused an error.

The balance always read 0.2 g before being used.

What type of error was caused by the balance?

[1 mark]

Tick (✓) **one** box.

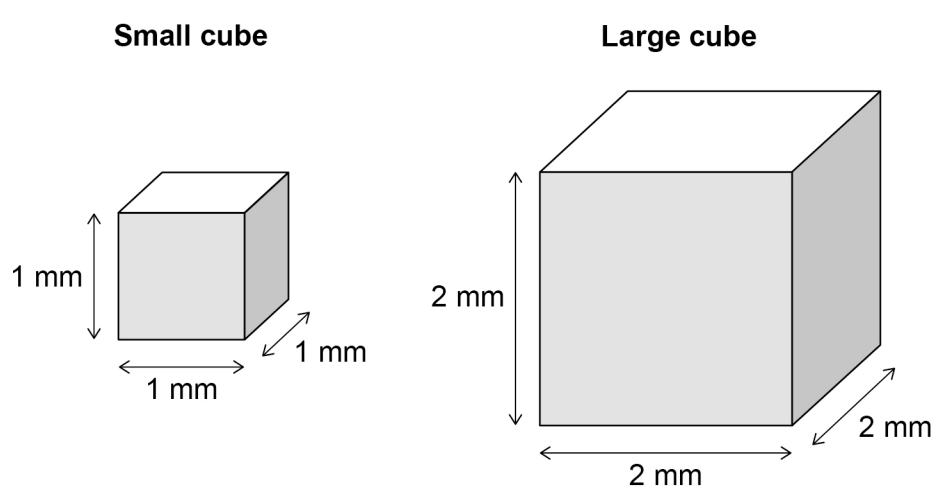
Human error ☐

Random error ☐

Systematic error ☐

Figure 5 shows the dimensions of two cubes of calcium carbonate.

Figure 5



Question 15 · continued

0 3 . 7 A cube of calcium carbonate has six faces.

Calculate the total surface area of the **large** cube of calcium carbonate.

Use **Figure 5**.

[3 marks]

Total surface area = _____ mm^2

0 3 . 8 The large cube of calcium carbonate was divided into eight smaller cubes.

The eight smaller cubes have a greater total surface area than the one large cube.

Compare the rate of reaction when using the eight smaller cubes with the rate of reaction when using the large cube.

Complete the sentence.

Choose the answer from the box.

[1 mark]

faster	**slower**	**the same**

The rate of reaction of the eight smaller cubes is _____.

15

4.6.1.3 Collision theory and activation energy

Question 16

November 2021 | 8462/1F | Original Q4

0 4 A student investigated the reactivity of metals with hydrochloric acid.

This is the method used.

1. Measure 50 cm^3 of hydrochloric acid into a polystyrene cup.
2. Measure the temperature of the hydrochloric acid.
3. Add one spatula of metal powder to the hydrochloric acid and stir.
4. Measure the highest temperature the mixture reaches.
5. Calculate the temperature increase for the reaction.
6. Repeat steps 1 to 5 three more times.
7. Repeat steps 1 to 6 with different metals.

Table 4 shows the student's results.

Table 4

Metal	Temperature increase in °C				Mean temperature increase in °C
	Trial 1	Trial 2	Trial 3	Trial 4	
Cobalt	6	7	5	9	7
Magnesium	54	50	37	55	**X**
Zinc	18	16	18	20	18

0 4 . 1 Calculate the mean temperature increase **X** for magnesium in **Table 4**.

Do **not** include the anomalous result in your calculation.

[2 marks]

X = _____ °C

4.6.1.3 Collision theory and activation energy

Question 16 · continued

0 4 . 2 Determine the order of reactivity for the metals cobalt, magnesium and zinc.

Use **Table 4**.

[1 mark]

Most reactive _____

_____

Least reactive _____

0 4 . 3 The range of measurements either side of the mean shows the uncertainty in the mean temperature increase.

Complete the sentence.

Use **Table 4**.

[1 mark]

The mean temperature increase for zinc is 18 ± _____ °C

0 4 . 4 What type of variable is the volume of hydrochloric acid in this investigation?

[1 mark]

Tick (✓) **one** box.

Control ☐

Dependent ☐

Independent ☐

0 4 . 5 Suggest **one** way of improving **step 3** in the method to give results which are more repeatable.

[1 mark]

_____

_____

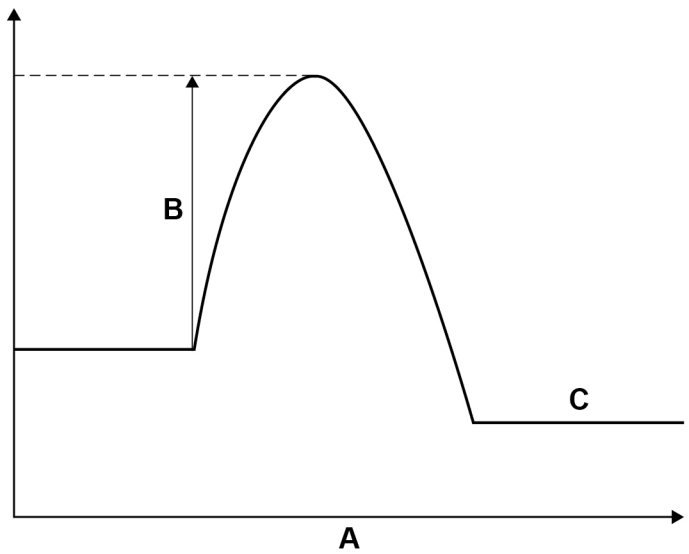
_____

4.6.1.3 Collision theory and activation energy

Question 16 · continued

0 4 . 6 **Figure 6** shows a reaction profile for the reaction of magnesium with hydrochloric acid.

Figure 6



What do labels **A**, **B** and **C** represent on **Figure 6**?

Choose answers from the box.

[3 marks]

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

A _____

B _____

C _____

9

4.6.1.3 Collision theory and activation energy

Question 17

November 2021 | 8462/2F | Original Q4

0 4 This question is about reactions between gases.

When hydrogen gas is heated with iodine gas, hydrogen iodide gas is produced.

The equation for this reversible reaction is:

hydrogen + iodine ⇌ hydrogen iodide

This reversible reaction reaches equilibrium in a sealed container.

0 4 . 1 How does the equation show that the reaction is reversible?

[1 mark]

0 4 . 2 Which **two** statements are correct when the reaction reaches equilibrium?

[2 marks]

Tick (✓) **two** boxes.

- The forward reaction and reverse reaction are both exothermic. ☐
- The gases have escaped from the container. ☐
- The hydrogen no longer reacts with iodine. ☐
- The mass of each substance does not change. ☐
- The rates of the forward reaction and reverse reaction are equal. ☐

4.6.1.3 Collision theory and activation energy

Question 17 · continued

0 4 . 3 The initial mixture of hydrogen and iodine in the sealed container is purple.

Hydrogen iodide is colourless.

How will the colour of the mixture in the sealed container have changed when equilibrium is reached?

[1 mark]

Tick (✓) **one** box.

The mixture will have become a deeper purple. ☐

The mixture will have become a paler purple. ☐

The mixture will have become colourless. ☐

0 4 . 4 The rate of reaction between gases is affected by changing the pressure.

Complete the sentences.

[3 marks]

When the pressure of the reacting gases is increased,

the rate of reaction _____.

This is because at higher pressures the distance

between the particles _____.

This means that the frequency of collisions _____.

0 4 . 5 Give **one** other way of changing the rate of reaction between gases.

You should **not** refer to pressure in your answer.

[1 mark]

_____

_____

8

4.6.1.3 Collision theory and activation energy

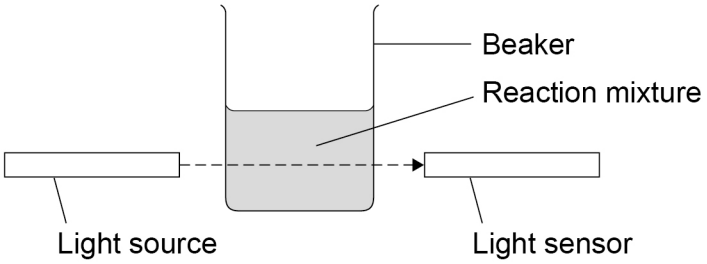
Question 18

June 2022 | 8462/2F | Original Q6

0 6 A student investigated the rate of reaction between sodium thiosulfate solution and hydrochloric acid.

Figure 7 shows the apparatus used.

Figure 7



When hydrochloric acid is added to sodium thiosulfate solution, the mixture gradually becomes cloudy.

A smaller percentage of light from the light source reaches the light sensor as the mixture becomes more cloudy.

This is the method used.

1. Measure 50 cm^3 of sodium thiosulfate solution into the beaker.

2. Add 10 cm^3 of hydrochloric acid to the sodium thiosulfate solution.

3. Immediately start a timer.

4. Record the percentage of light from the light source that reaches the light sensor every 20 seconds for 120 seconds.

0 6 . 1 Balance the equation for this reaction.

[1 mark]

$$Na_2S_2O_3 + 2\,HCl \rightarrow ____\ NaCl + H_2O + SO_2 + S$$

4.6.1.3 Collision theory and activation energy

Question 18 · continued

0 6 . 2 The mixture becomes cloudy because the sulfur produced is a solid.

What is the state symbol for a solid?

[1 mark]

Tick (✓) **one** box.

(aq) ☐

(g) ☐

(l) ☐

(s) ☐

0 6 . 3 The student monitored the cloudiness of the reaction mixture using a light sensor.

What other piece of equipment could be used to monitor the cloudiness of the reaction mixture?

[1 mark]

Tick (✓) **one** box.

A balance ☐

A cross on a piece of paper ☐

A gas syringe ☐

A thermometer ☐

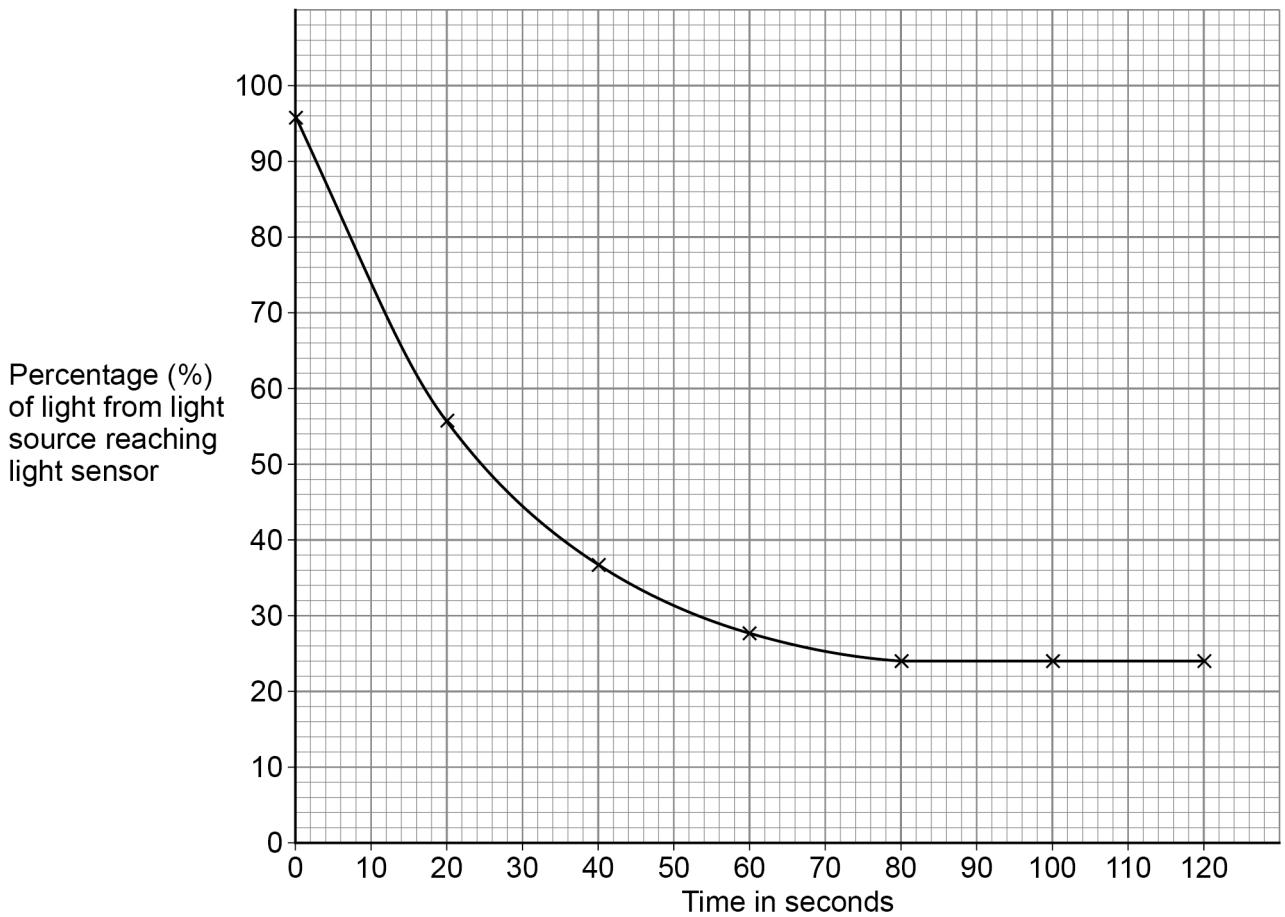
Question 6 continues on the next page

4.6.1.3 Collision theory and activation energy

Question 18 · continued

Figure 8 shows the results.

Figure 8



0 6 . 4 What happened to the rate of reaction between 40 and 60 seconds?

Use **Figure 8**.

[1 mark]

Tick (✓) **one** box.

The rate of reaction decreased. ☐

The rate of reaction stayed at zero. ☐

The rate of reaction increased. ☐

4.6.1.3 Collision theory and activation energy

Question 18 · continued

0 6 . 5 The student stopped taking measurements after 120 seconds because the percentage of light reaching the sensor stayed constant.

Why did the percentage of light reaching the sensor stay constant?

[1 mark]

Tick (✓) **one** box.

No light was reaching the sensor. ☐

One of the reactants was used up. ☐

The reaction was too vigorous. ☐

0 6 . 6 The student repeated the experiment using sodium thiosulfate solution of a higher concentration.

How would the line of best fit for sodium thiosulfate solution of a higher concentration compare with the line of best fit on **Figure 8**?

[1 mark]

Tick (✓) **one** box.

Initially the line of best fit would be less steep. ☐

Initially the line of best fit would be the same steepness. ☐

Initially the line of best fit would be steeper. ☐

Question 6 continues on the next page

4.6.1.3 Collision theory and activation energy

Question 18 · continued

0 6 . 7 The student then investigated the effect of changing the temperature on the rate of reaction.

The student used sodium thiosulfate solution and hydrochloric acid which had been kept in an ice bath.

Which are **two** effects of using reactants kept in an ice bath rather than at room temperature?

[2 marks]

Tick (✓) **two** boxes.

- Fewer reactant particles have the activation energy. ☐
- The reactant particles collide more frequently. ☐
- The reactant particles have more energy. ☐
- The reactant particles move more slowly. ☐
- There are fewer reactant particles in the same volume. ☐

8

4.6.1.3 Collision theory and activation energy

Question 19

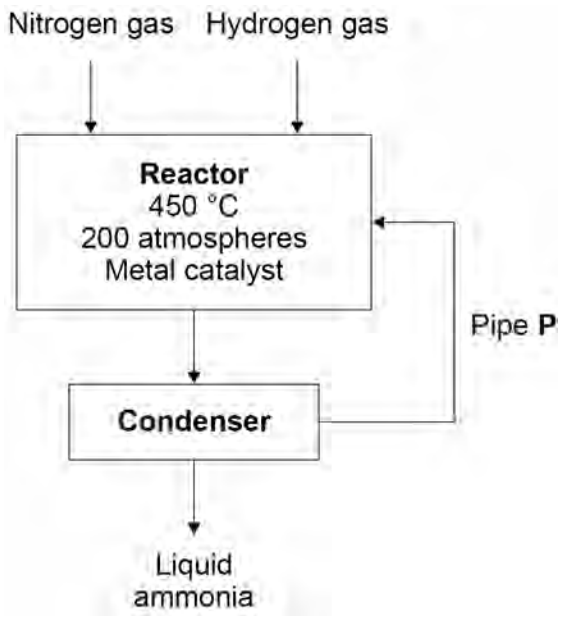
June 2024 | 8462/2F | Original Q9

0 9 This question is about ammonia and nitric acid.

In the Haber process ammonia is produced from nitrogen and hydrogen.

Figure 10 represents the Haber process.

Figure 10



0 9 . 1 Pipe **P** links the condenser to the reactor.

Why is the condenser linked to the reactor?

Use **Figure 10**.

[1 mark]

0 9 . 2 Which metal is used as a catalyst in this reaction?

[1 mark]

4.6.1.3 Collision theory and activation energy

Question 19 · continued

Nitric acid is produced by reacting ammonia with oxygen.

The word equation for the production of nitric acid is:

ammonia + oxygen → water + nitric acid

Platinum is a catalyst in this reaction.

0 9 . 3 Describe the test for oxygen gas.

Give the result if oxygen gas is present.

[2 marks]

Test _____

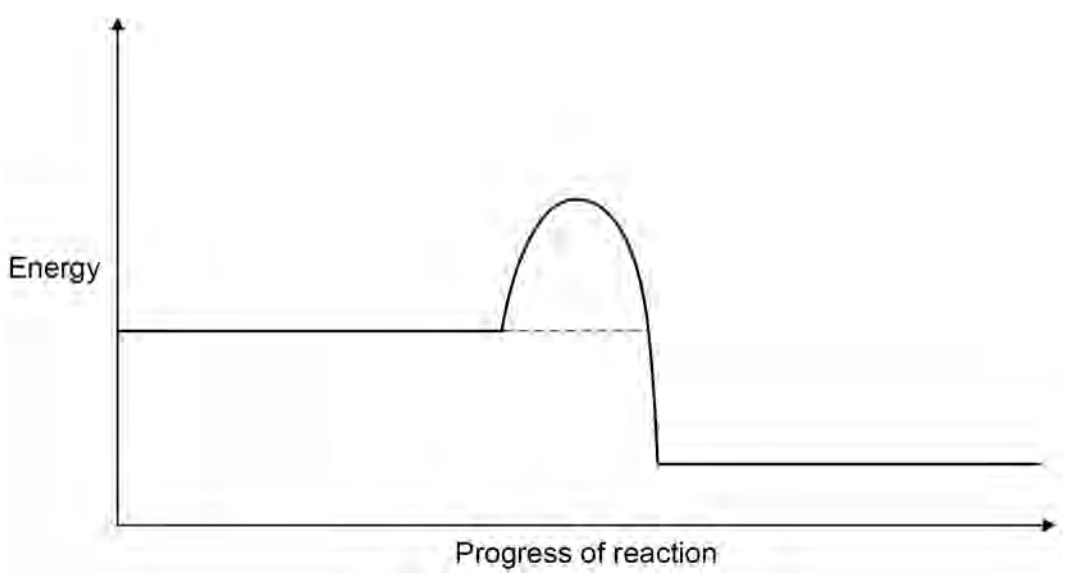
_____

Result _____

_____

Figure 11 represents the reaction profile of the catalysed reaction between ammonia and oxygen.

Figure 11



4.6.1.3 Collision theory and activation energy

Question 19 · continued

0 9 . 4 Complete the reaction profile for the catalysed reaction in **Figure 11**.

You should:

- label the activation energy
- label the reactants and products, using the names of the reactants and products.

[2 marks]

0 9 . 5 How would **Figure 11** be different if **no** catalyst was used?

[1 mark]

Tick (✓) **one** box.

The final energy level would be higher. ☐

The final energy level would be lower. ☐

The line would reach a higher peak. ☐

The line would reach a lower peak. ☐

0 9 . 6 Ammonia and nitric acid react to produce the salt, ammonium nitrate.

Ammonium ions and nitrate ions both contain nitrogen.

Suggest **one** use of ammonium nitrate.

[1 mark]

_____

_____

8

4.6.1.3 Collision theory and activation energy

Question 20

June 2025 | 8462/1F | Original Q2

0 2 Metals react with acids to produce a salt and a gas.

0 2 . 1 Which salt is produced when magnesium reacts with hydrochloric acid?

[1 mark]

Tick (✓) **one** box.

- Magnesium chloride ☐
- Magnesium nitrate ☐
- Magnesium sulfate ☐

0 2 . 2 Which gas is produced when magnesium reacts with hydrochloric acid?

[1 mark]

Tick (✓) **one** box.

- Carbon dioxide ☐
- Chlorine ☐
- Hydrogen ☐
- Oxygen ☐

Question 2 continues on the next page

Question 20 · continued

A student investigated the temperature change in the reaction between metals and hydrochloric acid.

This is the method used.

1. Measure 25 cm^3 of hydrochloric acid at 20 °C into a container.

2. Add 1 g of a metal.

3. Record the temperature change.

4. Repeat steps 1 to 3 using a different metal.

0 2 . 3 Draw **one** line from the type of variable to the name of the variable in the investigation.

[2 marks]

Type of variable	Name of variable
	Mass of metal
Dependent variable	Temperature change
Independent variable	Type of metal
	Volume of hydrochloric acid

4.6.1.3 Collision theory and activation energy

Question 20 · continued

0 2 . 4 Which container would be the most suitable to reduce energy transfer with the surroundings?

[1 mark]

Tick (✓) **one** box.

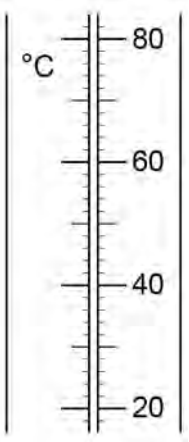
A copper can ☐

A glass beaker ☐

A polystyrene cup ☐

0 2 . 5 **Figure 1** shows part of the scale of the thermometer used in the investigation.

Figure 1



What is the resolution of the thermometer?

[1 mark]

Tick (✓) **one** box.

1 °C ☐ 2 °C ☐ 10 °C ☐ 20 °C ☐

4.6.1.3 Collision theory and activation energy

Question 20 · continued

0 2 . 6 The reaction between a metal and an acid is exothermic.

What happens to the temperature of the mixture during the reaction?

[1 mark]

Tick (✓) **one** box.

Decreases ☐

Stays the same ☐

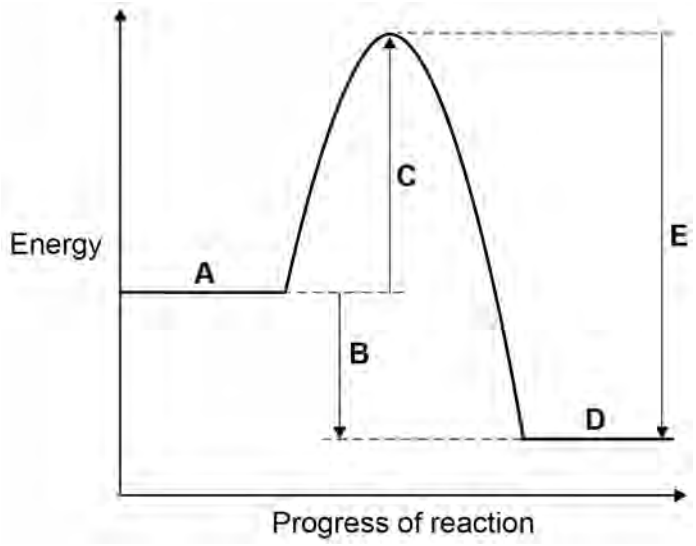
Increases ☐

4.6.1.3 Collision theory and activation energy

Question 20 · continued

Figure 2 shows the reaction profile for the reaction between a metal and an acid.

Figure 2



0 2 . 7 Which letter in **Figure 2** represents the reactants?

[1 mark]

Tick (✓) **one** box.

A ☐ **B** ☐ **C** ☐ **D** ☐ **E** ☐

0 2 . 8 Which letter in **Figure 2** represents the activation energy?

[1 mark]

Tick (✓) **one** box.

A ☐ **B** ☐ **C** ☐ **D** ☐ **E** ☐

0 2 . 9 Which letter in **Figure 2** represents the overall energy change?

[1 mark]

Tick (✓) **one** box.

A ☐ **B** ☐ **C** ☐ **D** ☐ **E** ☐

10

4.6.1.3 Collision theory and activation energy

Question 21

June 2025 | 8462/2F | Original Q2

0 2 Alkanes and alkenes are hydrocarbons.

Hydrocarbon molecules are made up of hydrogen and carbon atoms only.

An alkene has the formula C_3H_6

0 2 . 1 Which alkene has the formula C_3H_6?

[1 mark]

Tick (✓) **one** box.

Butene ☐

Ethene ☐

Propene ☐

0 2 . 2 How many atoms are there in a molecule of C_3H_6?

[1 mark]

Tick (✓) **one** box.

2 ☐ 3 ☐ 6 ☐ 9 ☐

0 2 . 3 Which is a use of C_3H_6?

[1 mark]

Tick (✓) **one** box.

Making a polymer ☐

Making ammonia ☐

Making glass ☐

Question 21 · continued

0 2 . 4 The percentage (%) by mass of each element in a molecule of C_3H_6 is:

- hydrogen 14%
- carbon 86%.

Figure 1 shows the percentage by mass of hydrogen in a molecule of C_3H_6

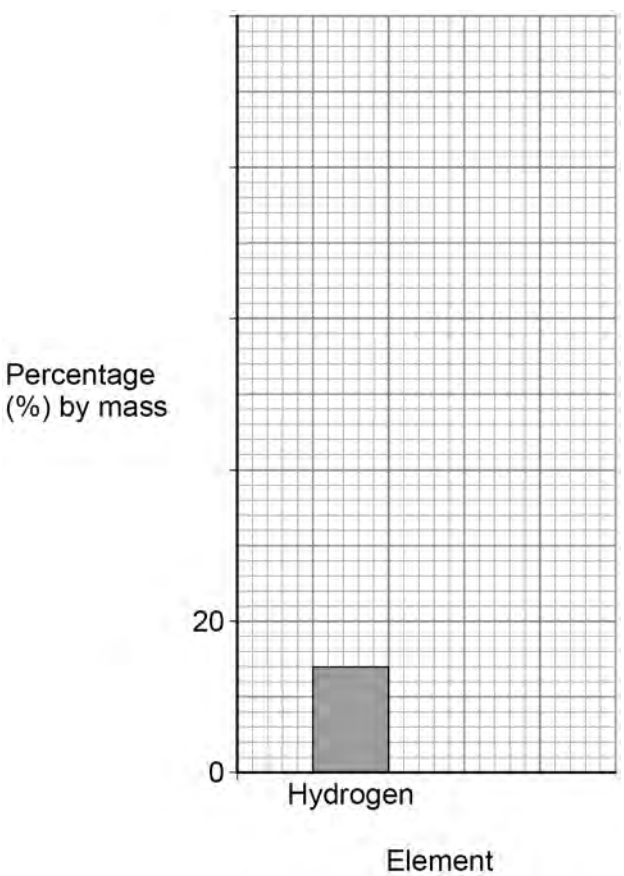
Complete **Figure 1**.

You should:

- complete the *y*-axis scale
- plot the percentage by mass of carbon as a bar
- label the bar plotted for carbon.

[3 marks]

Figure 1



4.6.1.3 Collision theory and activation energy

Question 21 · continued

Alkanes can be cracked to produce alkenes and smaller alkane molecules.

0 2 . 5 Describe a test for alkenes.

Give the result of the test.

[2 marks]

Test _____

_____

Result _____

_____

0 2 . 6 $C_{10}H_{22}$ can be cracked to produce C_3H_6 and an alkane.

Complete the equation for the reaction.

[1 mark]

$$C_{10}H_{22} \longrightarrow C_3H_6 + C ___ H_{16}$$

0 2 . 7 Complete the sentence.

Choose the answer from the box.

[1 mark]

ceramics	**fertilisers**	**fuels**

Smaller alkanes from cracking are useful as _____.

4.6.1.3 Collision theory and activation energy

Question 21 · continued

High temperatures between 450 °C and 750 °C are used in cracking reactions.

0 2 . 8 Which statement describes the molecules at 750 °C compared with the molecules at 450 °C?

[1 mark]

Tick (✓) **one** box.

- The molecules collide more frequently at 750 °C. ☐
- The molecules have less energy at 750 °C. ☐
- The molecules move more slowly at 750 °C. ☐

0 2 . 9 How does the rate of reaction at 750 °C compare with the rate of reaction at 450 °C?

[1 mark]

_____

_____

12