AQA GCSE Combined Science - Trilogy | 8464

SPECIFICATION POINT 5.5.1.1

Energy transfer during exothermic and endothermic reactions

Past-paper questions

Tier	**Higher**
Question groups	**20**
Available paper years	**2018–2025**

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.

5.5.1.1 Energy transfer during exothermic and endothermic reactions

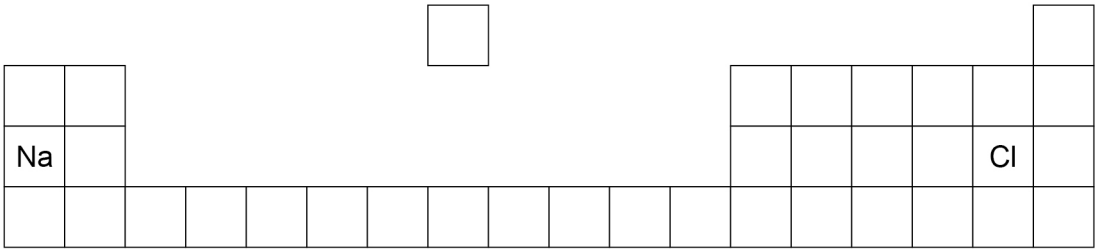
Question 01

June 2018 | 8464/C/1H | Original Q2

0 2 This question is about sodium and chlorine.

Figure 2 shows the positions of sodium and chlorine in the periodic table.

Figure 2



0 2 . 1 State **one** difference and **one** similarity in the electronic structure of sodium and of chlorine.

[2 marks]

Difference _____

_____

Similarity _____

_____

0 2 . 2 Sodium atoms react with chlorine atoms to produce sodium chloride (NaCl).

Describe what happens when a sodium atom reacts with a chlorine atom.

Write about electron transfer in your answer.

[4 marks]

_____

_____

_____

_____

_____

_____

_____

_____

5.5.1.1 Energy transfer during exothermic and endothermic reactions

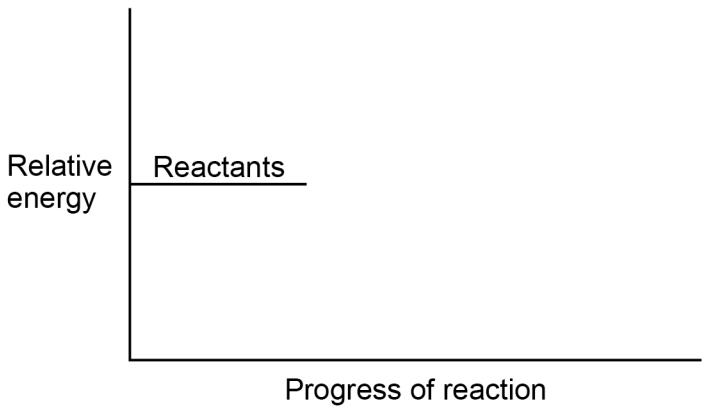
Question 01 · continued

0 2 . 3 The reaction between sodium and chlorine is an exothermic reaction.

Complete the reaction profile for the reaction between sodium and chlorine.

[2 marks]

Figure 3



8

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 02

June 2018 | 8464/C/2H | Original Q6

0 6 Bleach is a solution of sodium hypochlorite (NaClO).

Chlorine gas is produced when bleach reacts with hydrochloric acid.

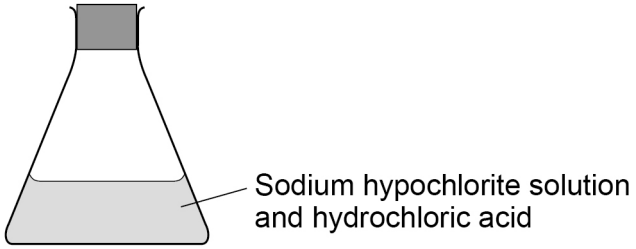
$$NaClO(aq) + 2HCl(aq) \rightleftharpoons NaCl(aq) + H_2O(l) + Cl_2(g)$$

0 6 . 1 Give the test and result for chlorine gas.

[2 marks]

Figure 8 shows a sealed flask of sodium hypochlorite and hydrochloric acid at equilibrium.

Figure 8



0 6 . 2 Explain why equilibrium is reached in this reaction.

[2 marks]

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 02 · continued

0 6 . 3 The stopper in **Figure 8** is removed and hydrochloric acid is added.

The stopper is replaced.

Explain what happens to the equilibrium.

[4 marks]

Question 6 continues on the next page

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 02 · continued

Chlorine gas is also produced when hydrogen chloride decomposes.

$$2HCl(g) \rightleftharpoons H_2(g) + Cl_2(g)$$

The forward reaction is endothermic.

0 6 . 4 Predict the effect of increasing the temperature on the amount of chlorine gas produced at equilibrium.

Explain your answer using Le Chatelier's Principle.

[2 marks]

0 6 . 5 Explain the effect of increasing the pressure on this equilibrium.

[2 marks]

12

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 03

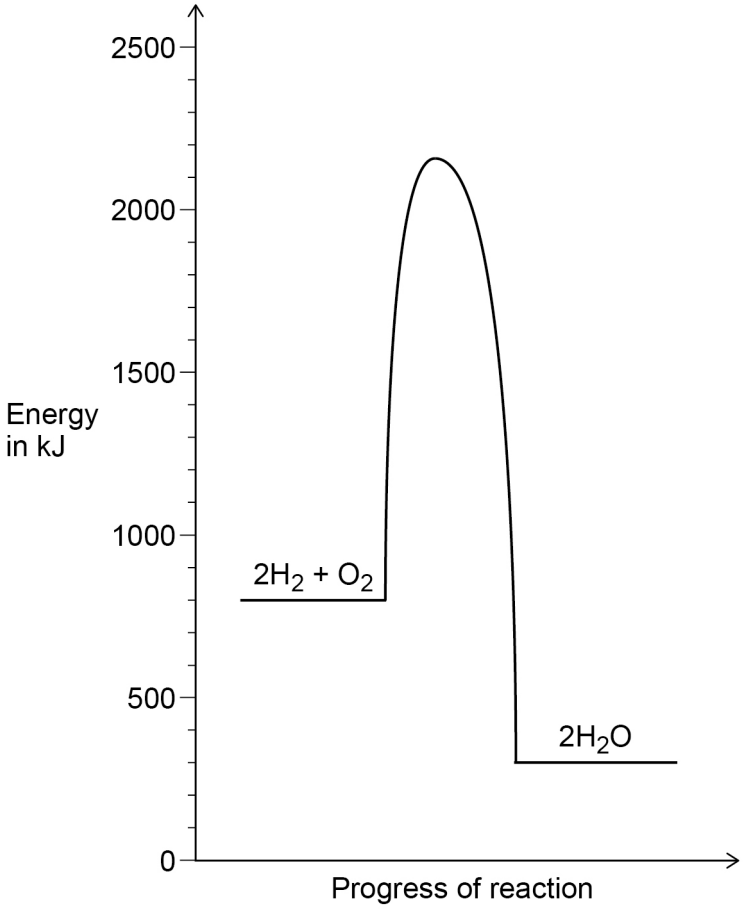
0 3 This question is about oxygen.

0 3 . 1 Hydrogen reacts with oxygen.

$$2\,H_2\,(g) + O_2\,(g) \rightarrow 2\,H_2O\,(g)$$

Figure 2 shows the relative energies of the reactants and products at a certain temperature.

Figure 2



Label the activation energy on **Figure 2**.

[1 mark]

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 03 · continued

0 3 . 2 Determine the overall energy change for the reaction between hydrogen and oxygen shown in Question **03.1**

Use **Figure 2**.

[2 marks]

Energy change = _____ kJ

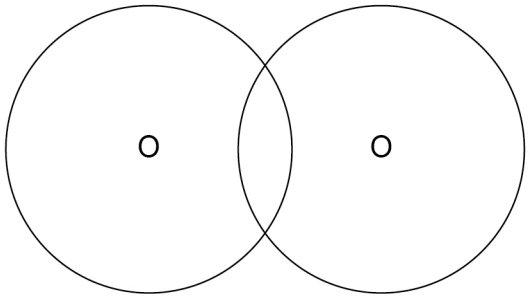
0 3 . 3 Oxygen is in Group 6 of the periodic table.

Figure 3 shows the outer energy levels in one molecule of oxygen (O_2).

Draw the electrons in the outer energy levels in **Figure 3**.

[2 marks]

Figure 3



Question 3 continues on the next page

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 03 · continued

0 3 . 4 The equation shows the decomposition of hydrogen peroxide.

$$2\ H{-}O{-}O{-}H \rightarrow 2\ H{-}O{-}H + O{=}O$$

Table 1 shows the bond energies.

Table 1

Bond	**O–O**	**O=O**	**O–H**
Bond dissociation energy in kJ per mole	138	496	463

Calculate the overall energy change for the reaction.

[3 marks]

Energy change = _____ kJ

8

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 04

November 2020 | 8464/C/1H | Original Q5

0 5 A student investigated the temperature change when magnesium was added to copper sulfate solution.

This is the method used.

1. Pour 30 cm^3 of copper sulfate solution into a polystyrene cup.
2. Measure the temperature of copper sulfate solution every minute for 3 minutes.
3. Add magnesium on the fourth minute.
4. Measure the temperature of the mixture at 5 minutes and then every minute up to 14 minutes.

0 5 . 1 What is the dependent variable in this investigation?

[1 mark]

Question 5 continues on the next page

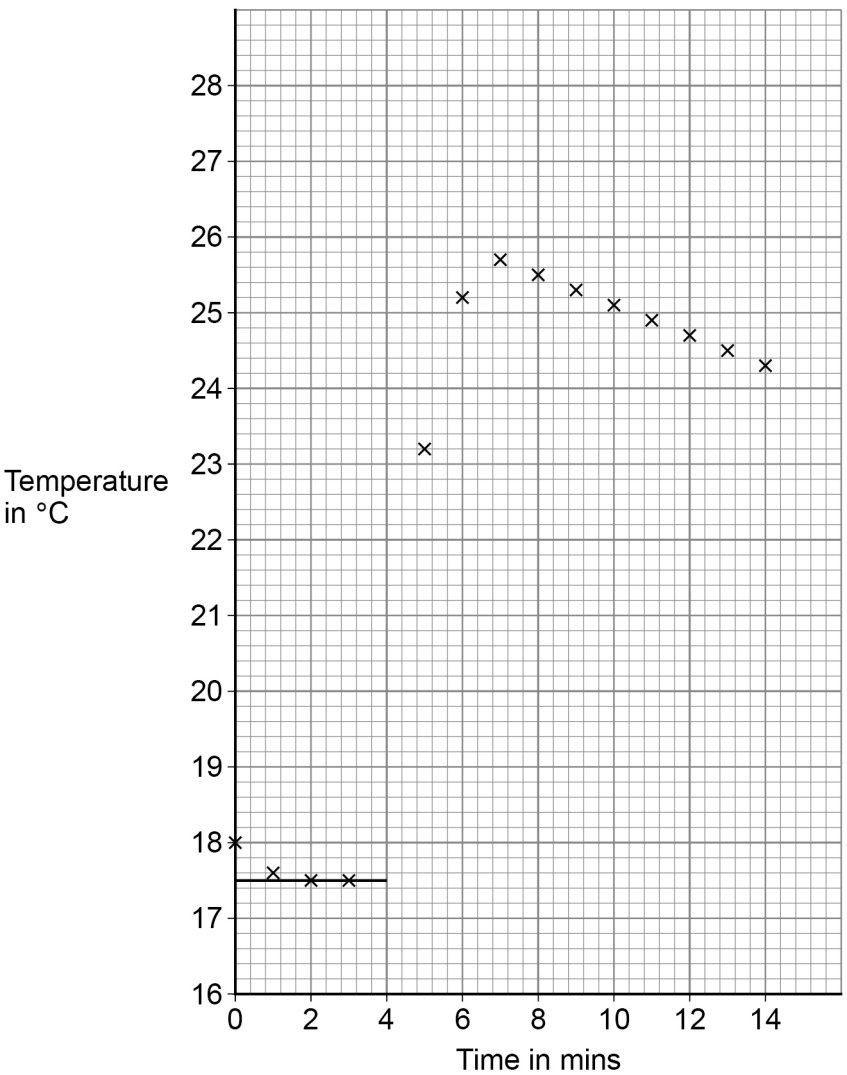
5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 04 · continued

The student used the results to plot a graph.

Figure 4 shows the graph.

Figure 4



5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 04 · continued

0 5 . 2 Suggest why the copper sulfate solution was left for four minutes before adding the magnesium.

[1 mark]

0 5 . 3 Complete **Figure 4** by:

- drawing a line of best fit through all the points after 7 minutes
- extending the line back to 4 minutes.

[2 marks]

0 5 . 4 The temperature change for the reaction is the temperature difference between the two graph lines at 4 minutes.

Determine the temperature change for the reaction.

Use **Figure 4**.

[2 marks]

Temperature change = _____ °C

0 5 . 5 Explain why the temperature of the mixture decreases after 7 minutes.

[2 marks]

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 04 · continued

0 5 . 6 The student repeated the experiment with an unknown metal **Q** instead of magnesium.

All the other variables were kept the same.

The student recorded a smaller temperature change.

Suggest the identity of metal **Q**.

Give **one** reason for your answer.

[2 marks]

Metal **Q** _____

Reason _____

_____

0 5 . 7 A copper sulfate solution contained 0.100 moles of copper sulfate dissolved in 0.500 dm^3 of water.

Calculate the mass of copper sulfate in 30.0 cm^3 of this solution.

Relative formula mass (M_r): $CuSO_4$ = 159.5

[4 marks]

_____

_____

_____

_____

_____

_____

Mass = _____ g

14

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 05

0 2 Some students investigated the effect of temperature on the rate of reaction.

0 2 . 1 The students reacted sodium thiosulfate solution with hydrochloric acid.

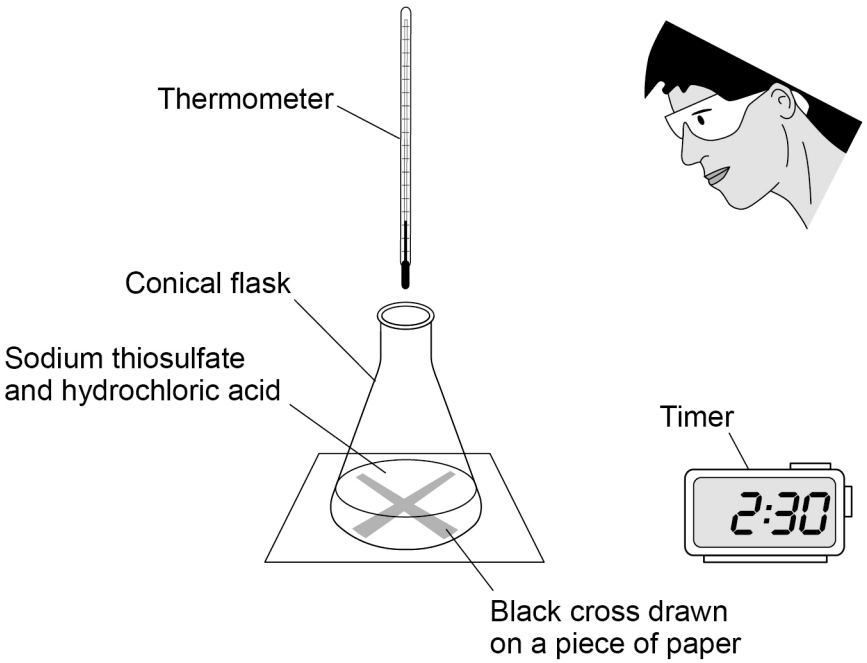
This is the method used.

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 1 shows the apparatus.

Figure 1



5.5.1.1 Energy transfer during exothermic and endothermic reactions

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 2 continues on the next page

5.5.1.1 Energy transfer during exothermic and endothermic reactions

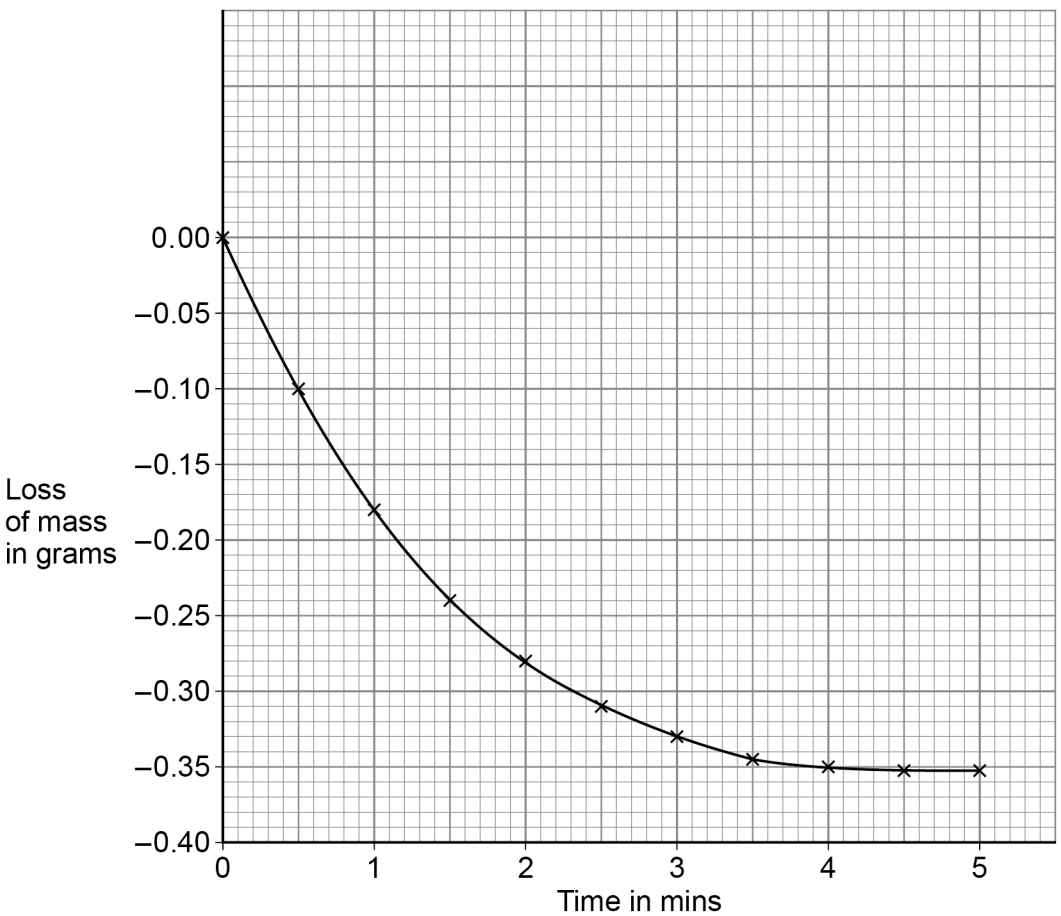
Question 05 · continued

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 2 shows the results.

Figure 2



5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 05 · continued

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

Use **Figure 2** 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 2 . 3 Draw a curve on **Figure 2** for the results you would expect at a temperature of 50 °C instead of 40 °C

[2 marks]

11

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 06

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

0 7 This question is about equilibrium.

0 7 . 1 Describe how a reaction reaches equilibrium.

[2 marks]

Nitrogen dioxide gas reacts to form dinitrogen tetraoxide gas.

The reaction is reversible.

The equation for the reaction is:

$$2\ NO_2(g) \rightleftharpoons N_2O_4(g)$$

0 7 . 2 Explain the effect on the equilibrium position of increasing the pressure.

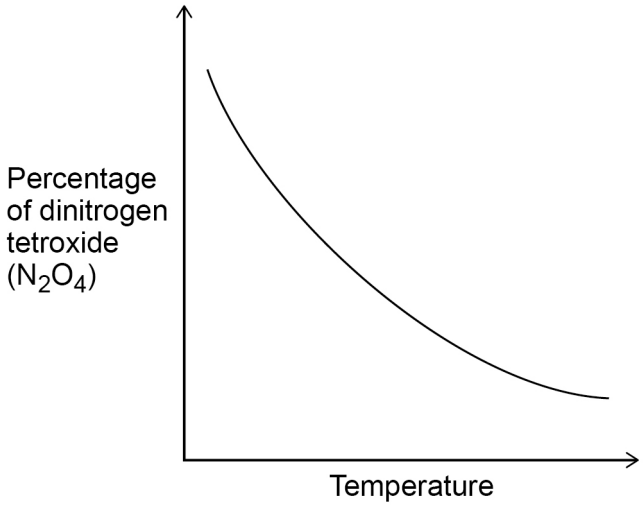
[2 marks]

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 06 · continued

0 7 . 3 **Figure 7** shows the change in the percentage of dinitrogen tetroxide (N_2O_4) in the equilibrium mixture as the temperature of the equilibrium mixture is changed.

Figure 7



Explain the effect on the equilibrium position of increasing the temperature.

Use **Figure 7**.

[3 marks]

7

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 07

November 2021 | 8464/C/1H | Original Q3

0 3 This question is about energy change.

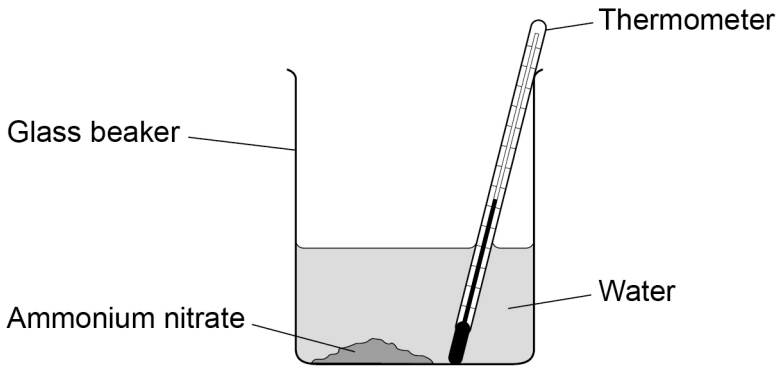
A student investigated the temperature change when 10 g of ammonium nitrate was added to 100 cm^3 of water.

This is the method used.

1. Measure the temperature of 100 cm^3 of water.
2. Add 10 g of ammonium nitrate.
3. Stir once.
4. Measure the temperature of the solution every minute for 7 minutes.

Figure 3 shows the apparatus.

Figure 3



0 3 . 1 What is the dependent variable in this investigation?

[1 mark]

0 3 . 2 Give **three** improvements to the investigation to make the results more accurate.

[3 marks]

1

2

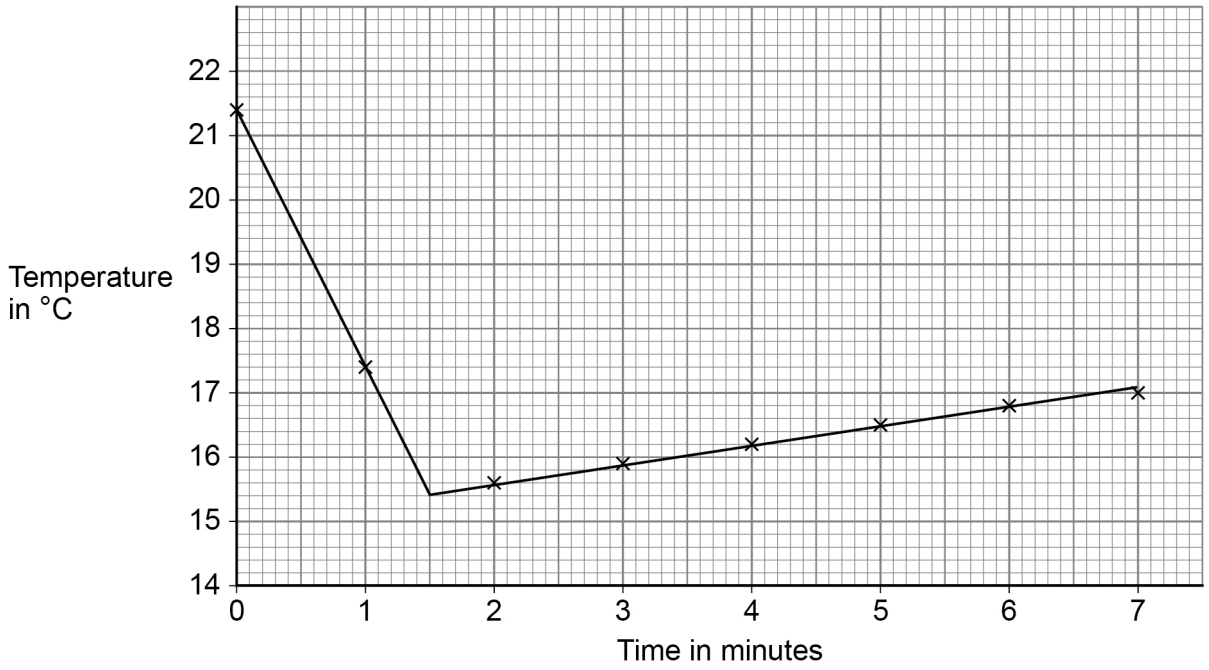
3

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 07 · continued

0 3 . 3 **Figure 4** shows the results.

Figure 4



Explain the results.

[4 marks]

Question 3 continues on the next page

5.5.1.1 Energy transfer during exothermic and endothermic reactions

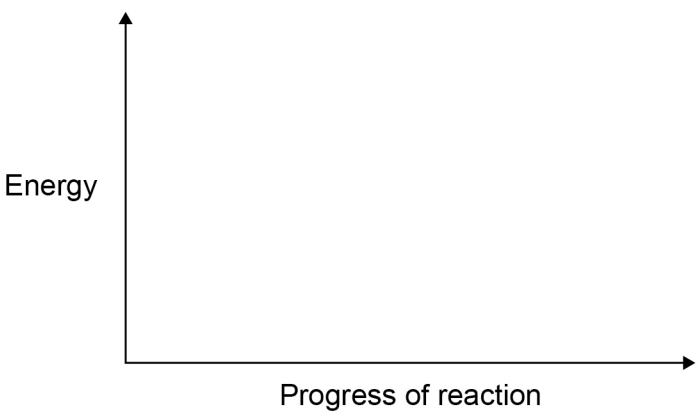
Question 07 · continued

0 3 . 4 Draw a reaction profile for an exothermic reaction.

You should label:

- the energy level of the reactants and of the products
- the activation energy
- the overall energy change.

[4 marks]



12

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 08

November 2021 | 8464/C/1H | Original Q7

0 7 Methane, ethane, propane and butane all react with oxygen to produce carbon dioxide and water.

0 7 . 1 Suggest why a mixture of methane and oxygen does **not** react at room temperature.

Answer in terms of particles.

[2 marks]

0 7 . 2 **Table 3** shows the energy released when methane, ethane and propane react with oxygen to produce carbon dioxide and water.

Table 3

	Compound reacted with oxygen		
	Methane	Ethane	Propane
Formula of compound	CH_4	C_2H_6	C_3H_8
Energy released in kJ/mol	680	1160	1640

Predict the energy released when butane (C_4H_{10}) reacts with oxygen to produce carbon dioxide and water.

[1 mark]

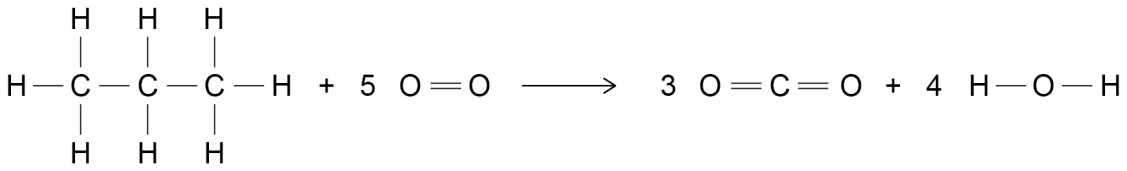
Energy released = _____ kJ/mol

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 08 · continued

0 7 . 3 Propane reacts with oxygen to produce carbon dioxide and water.

The displayed formula equation for the reaction is:



The reaction is exothermic.

In the reaction, the energy released when forming new bonds is 1640 kJ/mol greater than the energy needed when breaking bonds.

Table 4 shows bond energies.

Table 4

Bond	**H–C**	**C–C**	**O=O**	**C=O**	**O–H**
Bond energy in kJ/mol	410	**X**	500	740	460

Calculate the C—C bond energy (**X**).

[5 marks]

X = _____ kJ/mol

8

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 09

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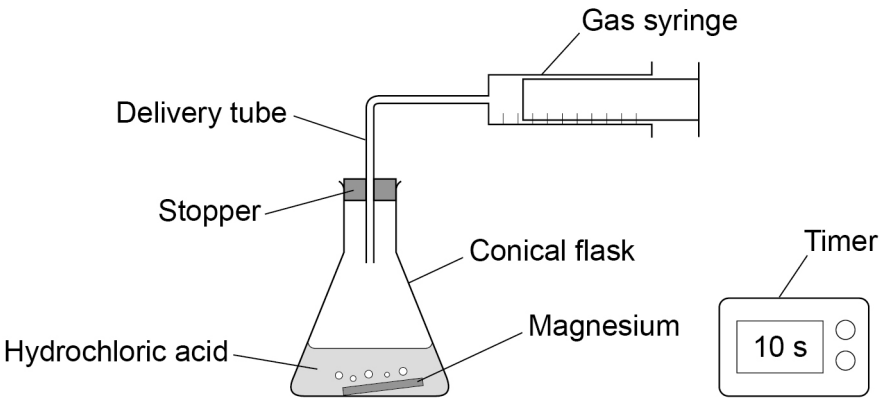
bo

0 1 A student investigated the reaction between magnesium and excess hydrochloric acid.

Figure 1 shows the apparatus.

Figure 1



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

[2 marks]

Independent variable _____

Control variable _____

Question 1 continues on the next page

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 09 · continued

Table 1 shows the results from the first experiment using hydrochloric acid with a low concentration.

Table 1

Time in seconds	0	20	40	60	80	100	120
Volume of gas in cm^3	0	48	72	90	97	98	98

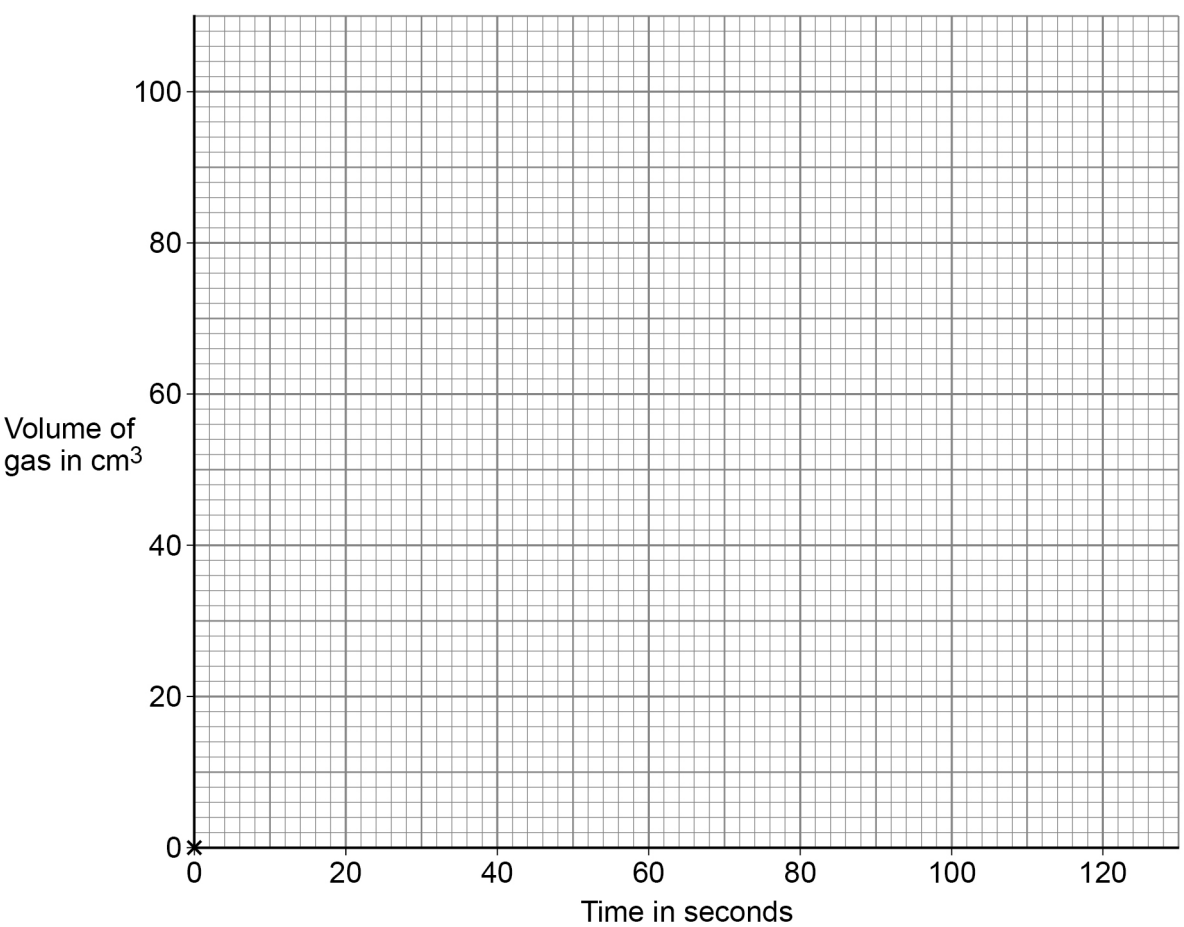
0 1 . 2 Complete **Figure 2**.

You should:

- plot the data from **Table 1** (the point 0,0 has been plotted for you)
- draw a line of best fit.

[3 marks]

Figure 2



5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 09 · continued

0 1 . 3 How does the **rate** of this reaction change with time?

Use **Table 1**.

[1 mark]

Tick (✓) **one** box.

The rate decreases. ☐

The rate stays the same. ☐

The rate increases. ☐

0 1 . 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 1 continues on the next page

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 09 · continued

0 1 . 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

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 10

November 2021 | 8464/C/2H | Original Q6

0 6 Ammonia is produced when a mixture of nitrogen and hydrogen reacts.

The equation for the reaction is:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

0 6 . 1 Nitrogen is obtained from the air.

The mixture of nitrogen and hydrogen must **not** contain carbon dioxide and oxygen.

Explain how a sample can be tested to show that carbon dioxide is **not** present in the mixture.

[2 marks]

0 6 . 2 A catalyst is used in the reaction.

Explain how a catalyst increases the rate of a reaction.

[2 marks]

Question 6 continues on the next page

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 10 · continued

The equation for the reaction to produce ammonia is repeated here.

$$N_2\,(g) + 3\,H_2\,(g) \rightleftharpoons 2\,NH_3\,(g)$$

0 6 . 3 The reaction reaches equilibrium.

Explain how an equilibrium is reached.

[2 marks]

0 6 . 4 Suggest how the catalyst affects the equilibrium position.

Give **one** reason for your answer.

[2 marks]

0 6 . 5 What is the effect of increasing the pressure on the reaction to produce ammonia?

[1 mark]

Tick (✓) **one** box.

The yield of ammonia decreases. ☐

The yield of ammonia stays the same. ☐

The yield of ammonia increases. ☐

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 10 · continued

November 2021 | 8464/C/2H | Original Q6

0 6 . 6 The forward reaction is exothermic.

Explain the effect of increasing the temperature on the yield of ammonia gas produced at equilibrium.

[2 marks]

11

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 11

June 2022 | 8464/C/1H | Original Q1

0 1 This question is about salts.

Green copper carbonate and sulfuric acid can be used to produce blue copper sulfate crystals.

0 1 . 1 **Excess** copper carbonate is added to sulfuric acid.

Give **three** observations you would make.

[3 marks]

1 _____

_____

2 _____

_____

3 _____

_____

0 1 . 2 How can the excess copper carbonate be removed?

[1 mark]

_____

_____

0 1 . 3 The pH of the solution changes during the reaction.

What is the pH of the solution at the end of the reaction?

[1 mark]

pH = _____

0 1 . 4 Copper carbonate and sulfuric acid react to produce copper sulfate.

What type of reaction is this?

[1 mark]

_____

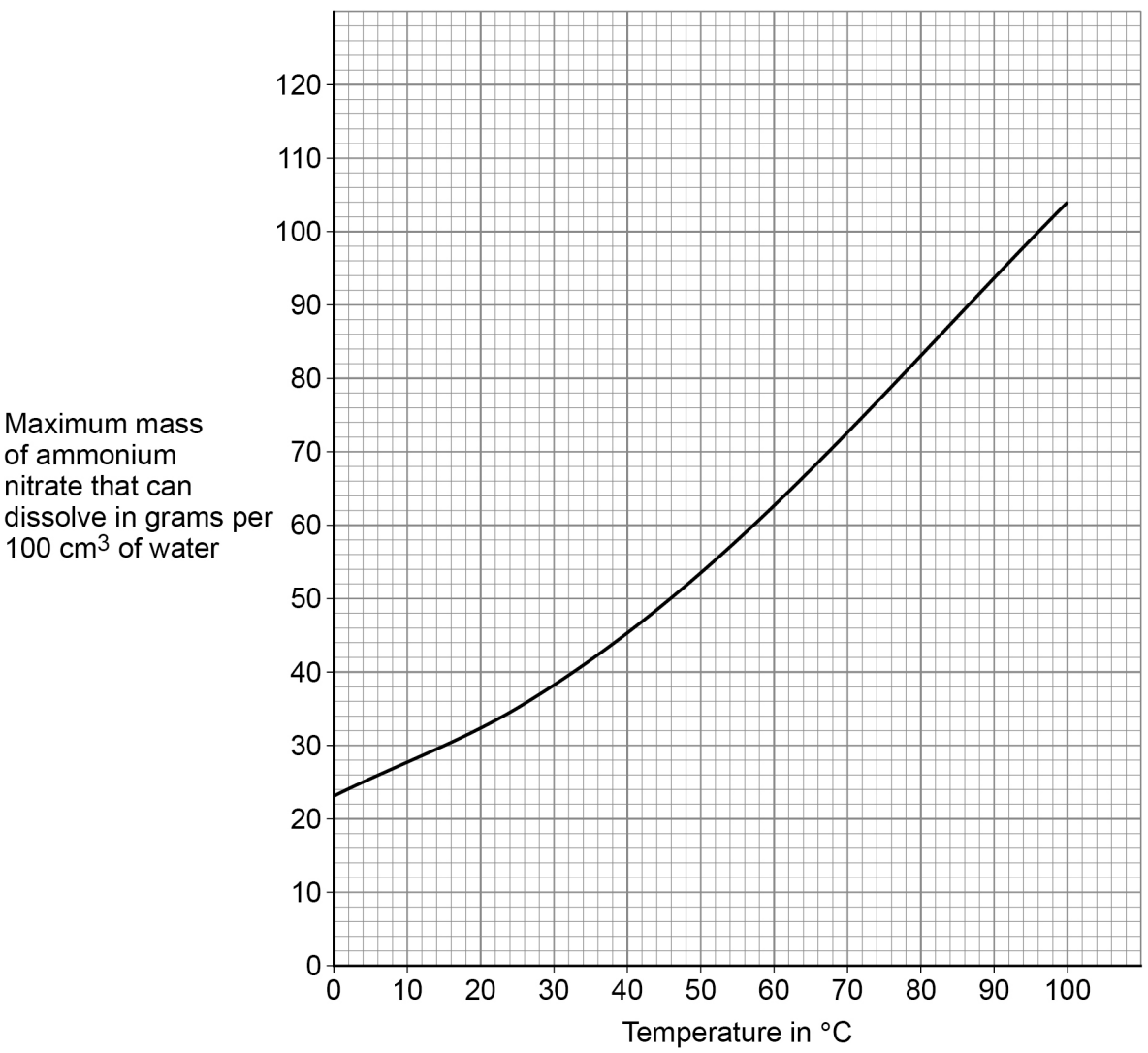
5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 11 · continued

0 1 . 5 Ammonium nitrate is a salt.

Figure 1 shows the maximum mass of ammonium nitrate that can dissolve in 100 cm^3 of water at different temperatures.

Figure 1



5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 11 · continued

A student adds ammonium nitrate to water at 80 °C until no more dissolves.

The student cools 100 cm^3 of this solution of ammonium nitrate from 80 °C to 20 °C to produce crystals of ammonium nitrate.

Determine the mass of ammonium nitrate that crystallises on cooling 100 cm^3 of this solution from 80 °C to 20 °C

[3 marks]

Mass = _____ g

9

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 12

June 2022 | 8464/C/1H | Original Q3

0 3 Plan an investigation to find the order of reactivity of three metals.

You should use the temperature change when each metal reacts with hydrochloric acid.

[6 marks]

6

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 13

June 2022 | 8464/C/1H | Original Q6

0 6 This question is about hydrogen chloride and hydrochloric acid.

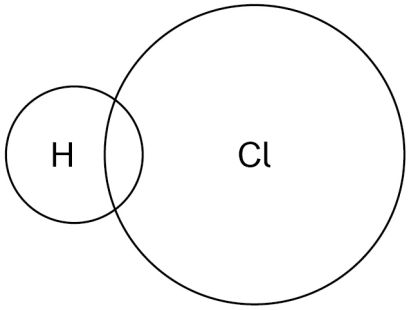
0 6 . 1 Complete the dot and cross diagram to represent the bonding in hydrogen chloride on **Figure 7**.

Use dots (o) and crosses (x) to represent electrons.

You should show only the electrons in the outer shells.

[2 marks]

Figure 7



0 6 . 2 Hydrogen chloride dissolves in water to produce hydrochloric acid.

Hydrochloric acid is a strong acid.

What is meant by the term strong acid?

[1 mark]

0 6 . 3 Describe how magnesium can be used to distinguish between a strong acid and a weak acid of the same concentration.

[2 marks]

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 13 · continued

0 6 . 4 The concentration of hydrochloric acid is increased by a factor of 100

What is the change in pH?

[2 marks]

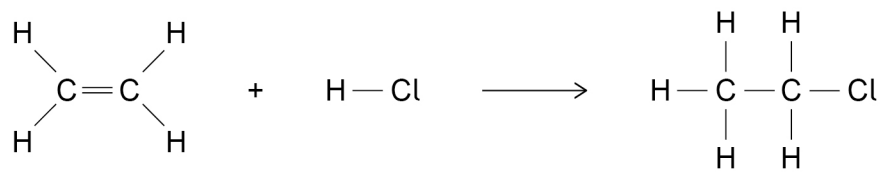
Question 6 continues on the next page

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 13 · continued

0 6 . 5 Ethene and hydrogen chloride react to produce chloroethane.

The displayed formulae equation for the reaction is:



The reaction is exothermic.

In the reaction the energy released forming new bonds is 56 kJ/mol greater than the energy needed to break existing bonds.

Table 1 shows some bond energies.

Table 1

Bond	H–C	C=C	H–Cl	C–C	C–Cl
Bond energy in kJ/mol	413	**X**	431	346	339

Calculate the bond energy **X**.

[4 marks]

X = _____ kJ/mol

11

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 14

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

0 3 This question is about the reaction between sodium thiosulfate solution and hydrochloric acid.

The equation for the reaction is:

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

0 3 . 1 The mass of the conical flask and contents was greater at the start of the reaction than at the end.

Explain why.

[2 marks]

Question 3 continues on the next page

5.5.1.1 Energy transfer during exothermic and endothermic reactions

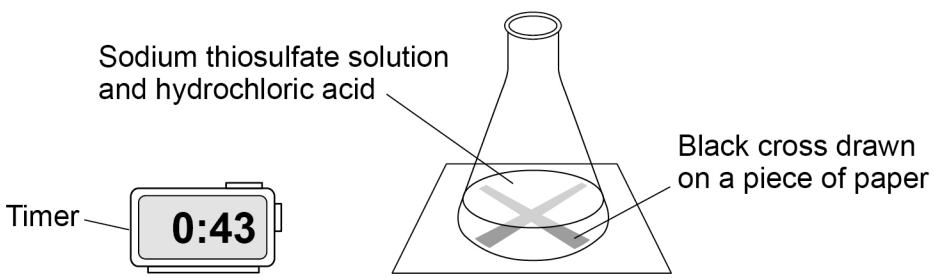
Question 14 · continued

A teacher demonstrated the reaction between sodium thiosulfate solution and hydrochloric acid.

Figure 3 shows the experiment.

The experiment was done in a fume cupboard.

Figure 3



This is the method the teacher used.

1. Pour 50 cm^3 of sodium thiosulfate solution into a conical flask.
2. Put the conical flask on a black cross drawn on a piece of paper.
3. Pour 10 cm^3 of hydrochloric acid into the conical flask and start a timer.
4. Stop the timer when the cross can no longer be seen.
5. Repeat the experiment at different temperatures.

0 3 . 2 What type of variable is time in this reaction?

[1 mark]

Tick (✓) **one** box.

Control ☐

Dependent ☐

Independent ☐

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 14 · continued

0 3 . 3 **Table 1** shows the results.

Table 1

Temperature in °C	Time in seconds
19	82
32	48
45	43
52	15
63	7
73	3

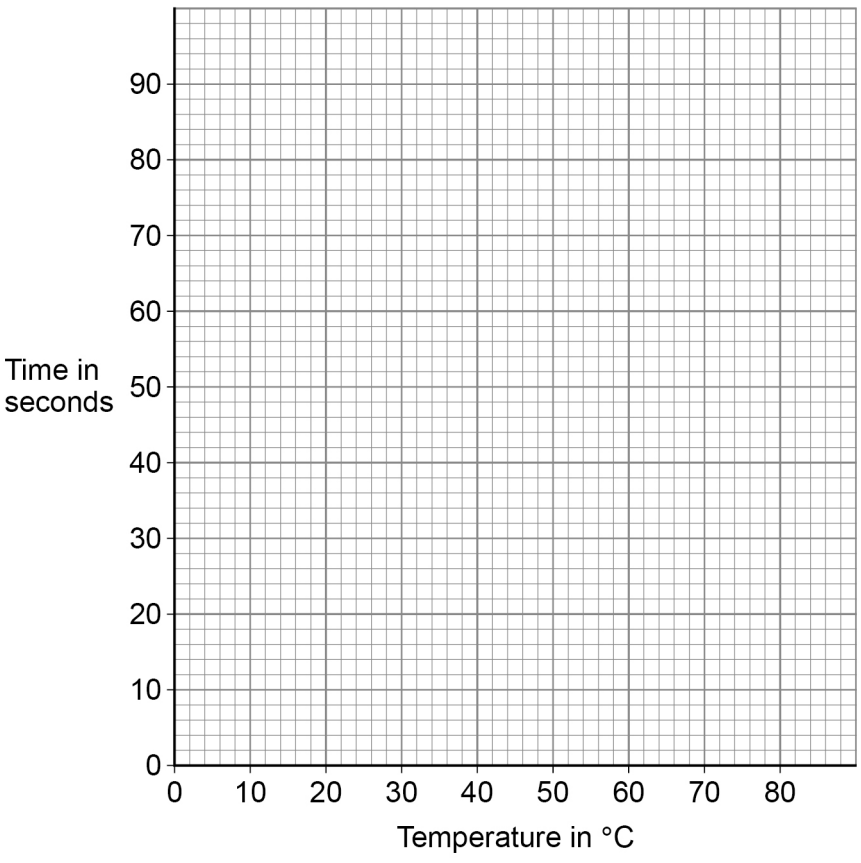
Complete **Figure 4**.

You should:

- plot the data from **Table 1** on **Figure 4**
- draw a line of best fit.

[3 marks]

Figure 4



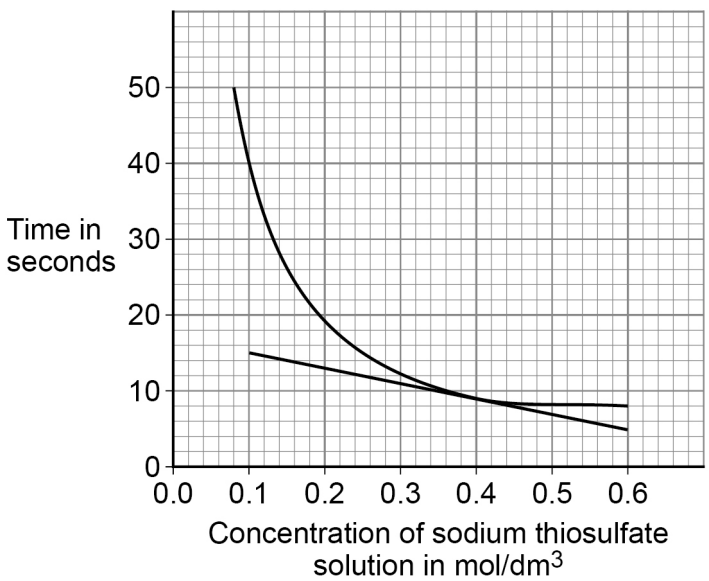
5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 14 · continued

0 3 . 4 A student investigated the effect of concentration of sodium thiosulfate on the time taken for the reaction at room temperature.

Figure 5 shows the results with a tangent drawn at 0.4 mol/dm^3

Figure 5



Calculate the gradient (slope) of the tangent at 0.4 mol/dm^3

Give the unit.

[4 marks]

Gradient = _____

Unit = _____

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 14 · continued

0 3 . 5 The student determined the **rate** of the reaction at regular time intervals during an experiment.

Explain why the **rate** decreased during the reaction.

You should give your answer in terms of particles.

[2 marks]

12

Turn over for the next question

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 15

June 2022 | 8464/C/2H | Original Q6

0 6 This question is about catalysts and equilibrium.

0 6 . 1 What type of substance is a catalyst in biological systems?

[1 mark]

Tick (✓) **one** box.

- Algae ☐
- Alkene ☐
- Enzyme ☐
- Formulation ☐

0 6 . 2 Explain how a catalyst increases the rate of a reaction.

[2 marks]

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 15 · continued

The reversible reaction for the production of ammonia is:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

0 6 . 3 What can scientists predict using Le Chatelier's Principle?

[1 mark]

0 6 . 4 Describe how a reversible chemical reaction is able to reach equilibrium.

[2 marks]

0 6 . 5 Explain the effect of increasing the pressure on the yield of ammonia.

[2 marks]

0 6 . 6 The forward reaction to produce ammonia is exothermic.

Explain the effect of increasing the temperature on the yield of ammonia.

[2 marks]

10

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 16

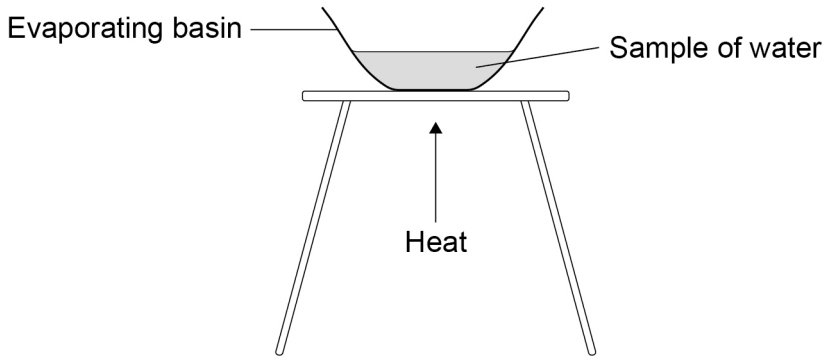
June 2023 | 8464/C/2H | Original Q4

0 4 Some types of water contain dissolved substances.

A student investigated the mass of dissolved solids in distilled water and in sea water.

Figure 1 shows the apparatus.

Figure 1



This is the method used.

1. Weigh an evaporating basin.
2. Add 20 cm^3 of distilled water to the evaporating basin.
3. Weigh the evaporating basin and the water sample.
4. Heat the water sample for 2 minutes.
5. Weigh the evaporating basin and contents.
6. Repeat steps 1 to 5 two more times.
7. Repeat steps 1 to 6 with sea water.

0 4 . 1 The method used by the student did **not** give valid results.

Describe **one** improvement the student could make to obtain valid results.

[1 mark]

Question 16 · continued

A different student used a method which gave valid results.

0 4 . 2 **Table 2** shows the results.

Table 2

	Mass of dissolved solids in grams			
Type of water	**Test 1**	**Test 2**	**Test 3**	**Mean**
Distilled water	0.00	0.00	0.00	0.00
Sea water	0.30	**X**	0.26	0.29

Calculate the value **X** for the mass of dissolved solids in sea water in **Test 2**.

[2 marks]

Mass **X** = _____ g

0 4 . 3 The student concludes that distilled water is pure.

Describe a test to confirm that distilled water is pure.

[2 marks]

Test _____

Result _____

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 16 · continued

Tap water is potable.

A stage in the production of potable water is sterilising.

A gas is used to sterilise water.

The equation for the reaction is:

$$Cl_2(g) + H_2O(l) \rightleftharpoons HOCl(aq) + HCl(aq)$$

0 4 . 4 What is meant by the symbol ⇌?

[1 mark]

0 4 . 5 The reaction is at equilibrium.

The reaction is exothermic.

What happens to the equilibrium position when the temperature is increased?

[1 mark]

Tick (✓) **one** box.

- Shifts towards the left-hand side ☐
- Stays in the same place ☐
- Shifts towards the right-hand side ☐

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 16 · continued

0 4 . 6 Describe a test to identify the gas used to sterilise water.

[2 marks]

Test _____

_____

Result _____

_____

0 4 . 7 Another stage in the production of potable water is filtering.

Explain why potable water contains dissolved solids after filtering.

[2 marks]

_____

_____

_____

_____

11

5.5.1.1 Energy transfer during exothermic and endothermic reactions

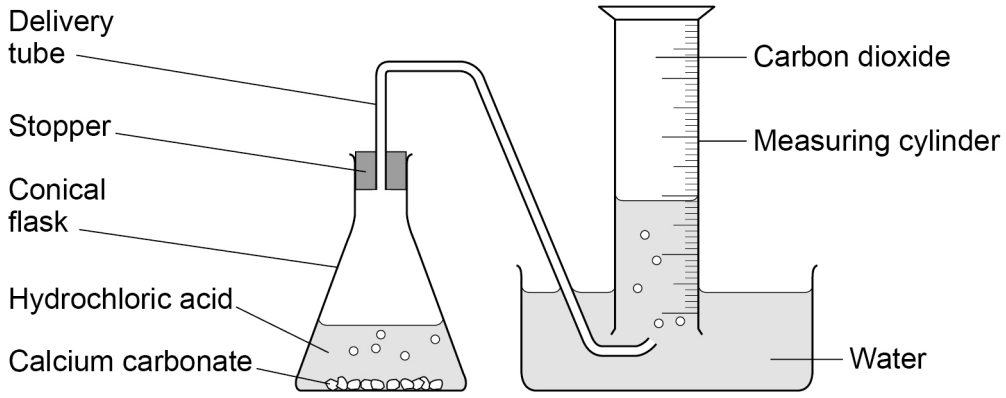
Question 17

0 2 Some factors affect the rates of chemical reactions.

0 2 . 1 A student investigated the effect of changing the particle size of calcium carbonate on the rate of reaction with hydrochloric acid.

Figure 3 shows the apparatus.

Figure 3



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

[6 marks]

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 17 · continued

0 2 . 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]

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 17 · continued

Catalysts affect the rate of reactions.

0 2 . 3 What is meant by a 'catalyst'?

[2 marks]

0 2 . 4 What are catalysts in biological systems called?

[1 mark]

12

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 18

June 2024 | 8464/C/2H | Original Q5

0 5 Sulfuric acid is produced by an industrial process.

In the process, sulfur dioxide (SO_2) reacts with oxygen (O_2) to produce sulfur trioxide (SO_3).

The equation for the reversible reaction is:

$$2\,SO_2(g) + O_2(g) \rightleftharpoons 2\,SO_3(g)$$

The forward reaction releases 198 kJ/mol of energy.

0 5 . 1 What is the amount of energy transferred during the reverse reaction?

[1 mark]

Tick (✓) **one** box.

< 198 kJ/mol ☐

= 198 kJ/mol ☐

> 198 kJ/mol ☐

0 5 . 2 The concentration of oxygen is increased.

What is the effect on the position of the equilibrium?

[1 mark]

Tick (✓) **one** box.

Equilibrium position shifts to the left ☐

Equilibrium position does not change ☐

Equilibrium position shifts to the right ☐

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 18 · continued

0 5 . 3 The pressure is decreased.

What is the effect on the position of the equilibrium?

[1 mark]

Tick (✓) **one** box.

- Equilibrium position shifts to the left ☐
- Equilibrium position does not change ☐
- Equilibrium position shifts to the right ☐

0 5 . 4 The temperature is increased.

What is the effect on the position of the equilibrium?

[1 mark]

Tick (✓) **one** box.

- Equilibrium position shifts to the left ☐
- Equilibrium position does not change ☐
- Equilibrium position shifts to the right ☐

0 5 . 5 A catalyst is used in the reaction.

Suggest what effect the catalyst has on the position of the equilibrium.

Give **one** reason for your answer.

[2 marks]

Effect _____

_____

Reason _____

_____

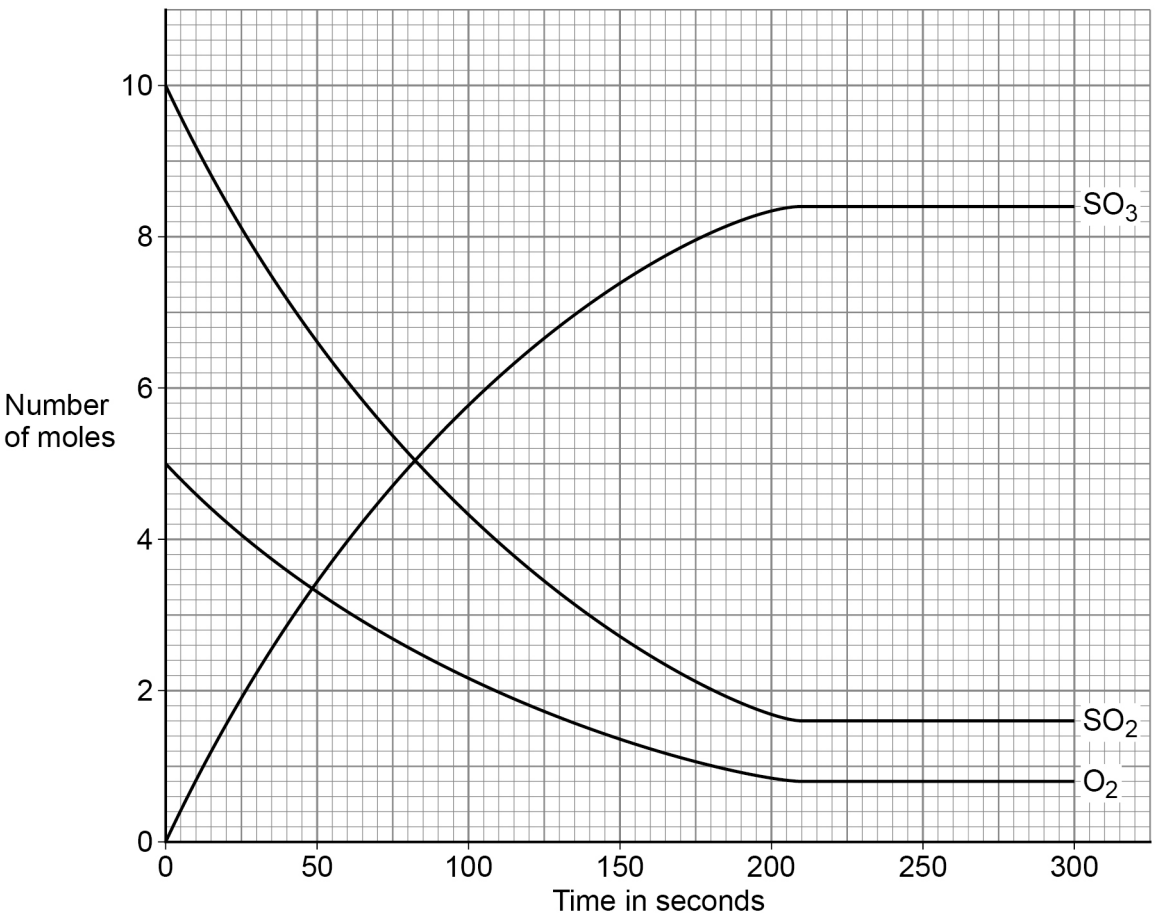
5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 18 · continued

A scientist measured how the number of moles of sulfur dioxide, oxygen and sulfur trioxide varied with time during the reaction.

Figure 5 shows the results.

Figure 5



0 5 . 6 Determine the time taken for the reaction to reach equilibrium.

Explain your answer.

Use **Figure 5**.

[3 marks]

Time _____ s

Explanation _____

_____

_____

_____

_____

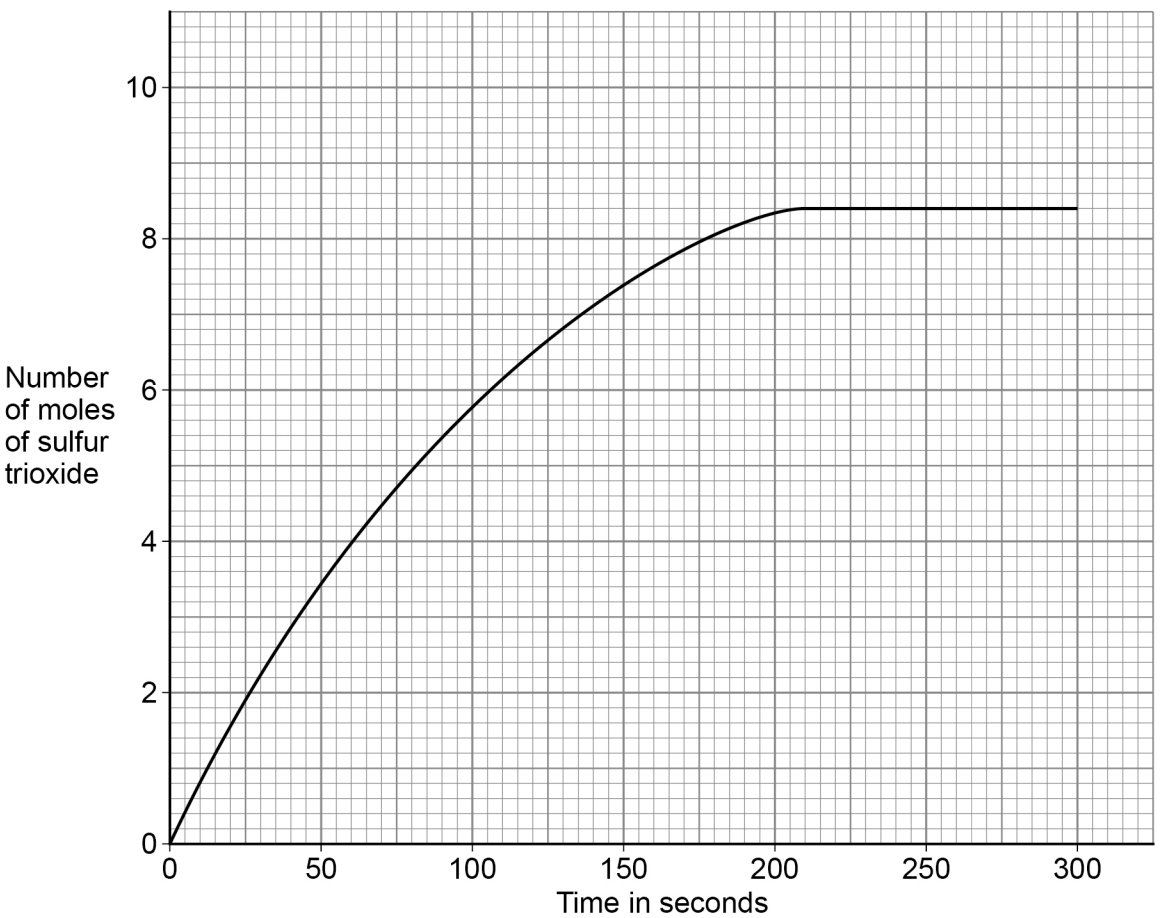
Question 5 continues on the next page

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 18 · continued

0 5 . 7 **Figure 6** shows the results for sulfur trioxide.

Figure 6



Determine the rate of reaction at 60 seconds.

[4 marks]

Rate = _____ mol/s

13

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 19

June 2025 | 8464/C/1H | Original Q2

0 2 A student investigated an exothermic reaction.

The student reacted solid calcium oxide with water to produce calcium hydroxide.

0 2 . 1 What is meant by an 'exothermic' reaction?

[1 mark]

0 2 . 2 The formula of calcium hydroxide is $Ca(OH)_2$

Calculate the percentage by mass of oxygen in calcium hydroxide.

Relative atomic mass (A_r): O = 16

Relative formula mass (M_r): $Ca(OH)_2$ = 74

[3 marks]

Percentage = _____ %

Question 2 continues on the next page

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 19 · continued

0 2 . 3 When solid calcium oxide is added to water, the temperature of the reaction mixture changes.

Plan a method to investigate how changing the mass of calcium oxide affects the temperature change of the reaction mixture.

[6 marks]

Extra space

10

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 20

June 2025 | 8464/C/2H | Original Q4

0 4 This question is about methanol.

0 4 . 1 Methanol is used in screenwash.

Screenwash is used to keep car windscreens clean.

Screenwash is a formulation.

Define the term 'formulation'.

[1 mark]

Question 4 continues on the next page

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 20 · continued

Carbon monoxide and hydrogen are used to produce methanol.

The conditions used in the production of methanol are:

- high temperature
- high pressure
- a catalyst.

The equation for the reaction is:

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$$

91 kJ/mol of energy is transferred during the exothermic forward reaction.

0 4 . 2 How much energy is transferred when methanol is decomposed into carbon monoxide and hydrogen?

[1 mark]

Tick (✓) **one** box.

< 91 kJ/mol ☐

91 kJ/mol ☐

> 91 kJ/mol ☐

0 4 . 3 A scientist developed a principle to predict the effect of changing conditions on a system at equilibrium.

What was the name of the scientist?

[1 mark]

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 20 · continued

0 4 . 4 What is the effect of increasing the temperature on the proportion of methanol in the equilibrium mixture?

[1 mark]

Tick (✓) **one** box.

The proportion of methanol decreases. ☐

The proportion of methanol stays the same. ☐

The proportion of methanol increases. ☐

0 4 . 5 What is the effect of using a catalyst on the proportion of methanol in the equilibrium mixture?

[1 mark]

Tick (✓) **one** box.

The proportion of methanol decreases. ☐

The proportion of methanol stays the same. ☐

The proportion of methanol increases. ☐

0 4 . 6 Explain the effect of increasing the pressure on the proportion of methanol in the equilibrium mixture.

[3 marks]

5.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 20 · continued

0 4 . 7 Explain the effect of using a catalyst on the **rate** of production of methanol.

[3 marks]

0 4 . 8 The catalyst allows the reaction to take place at a lower temperature.

Explain **one** advantage of using a lower temperature in the production of methanol.

Do **not** refer to the position of equilibrium in your answer.

[2 marks]

0 4 . 9 Methanol (CH_3OH) can also be produced by reacting carbon dioxide with hydrogen.

Water is the other product of the reaction.

Write a balanced equation for the reaction.

[2 marks]

_____ + _____ → _____ + _____

15