AQA GCSE Chemistry | 8462

SPECIFICATION POINT 4.5.1.1

Energy transfer during exothermic and endothermic reactions

Past-paper questions

Tier	**Higher**
Question groups	**76**
Available paper years	**2007–2025**

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.

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 01

March 2007 | CHY1A | Original Q7 | Legacy

QUESTION SEVEN

In the engine cylinders of petrol-driven cars, a mixture of petrol and air is ignited.

- Petrol consists mainly of alkanes in the $C_5 - C_{10}$ range.
- Air consists of nitrogen (79 %), oxygen (20 %) and small amounts of other gases.

The petrol/air mixture is ignited by an electrical spark causing an explosive reaction to drive the pistons in the cylinders.

Some of the elements in the petrol/air mixture combine with oxygen at the very high temperatures reached.

Modern engines are very efficient but are still not capable of complete combustion. The gases produced during combustion are released as exhaust gases.

The table shows some of the exhaust gases from a typical petrol engine.

Gas	Percentage
carbon dioxide	15.0
carbon monoxide	1.0
oxygen	0.7
hydrocarbons	0.05
nitrogen oxides	0.2
sulfur dioxide	0.007

7A The gases in the table make up less than 20 % of the exhaust gases.

Which substance will make up most of the remainder of the exhaust gases?

1 hydrogen

2 methane

3 nitrogen

4 water vapour

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 01 · continued March 2007 | CHY1A | Original Q7 | Legacy

7B One piece of evidence that suggests there is incomplete combustion is . . .

1 the high percentage of carbon dioxide.

2 the presence of carbon monoxide.

3 the presence of nitrogen oxides.

4 the low percentage of sulfur dioxide.

Nitrogen oxides are acidic oxides.
The equation shows how nitrogen monoxide is formed in the cylinders.

$$N_2 + O_2 \rightarrow 2NO$$

7C Nitrogen monoxide reacts with more oxygen to produce nitrogen dioxide.

Which is the correct equation for this reaction?

1 $N_2 + O_2 \rightarrow NO_2$

2 $NO + O_2 \rightarrow NO_2$

3 $2NO + O_2 \rightarrow 2NO_2$

4 $2NO + 2O_2 \rightarrow 2NO_2$

7D Why is it important to remove nitrogen oxides from the exhaust gases?

1 They are brown gases.

2 They can cause global dimming.

3 They can cause acid rain.

4 They cause carbon deposits in the exhaust pipe.

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 02

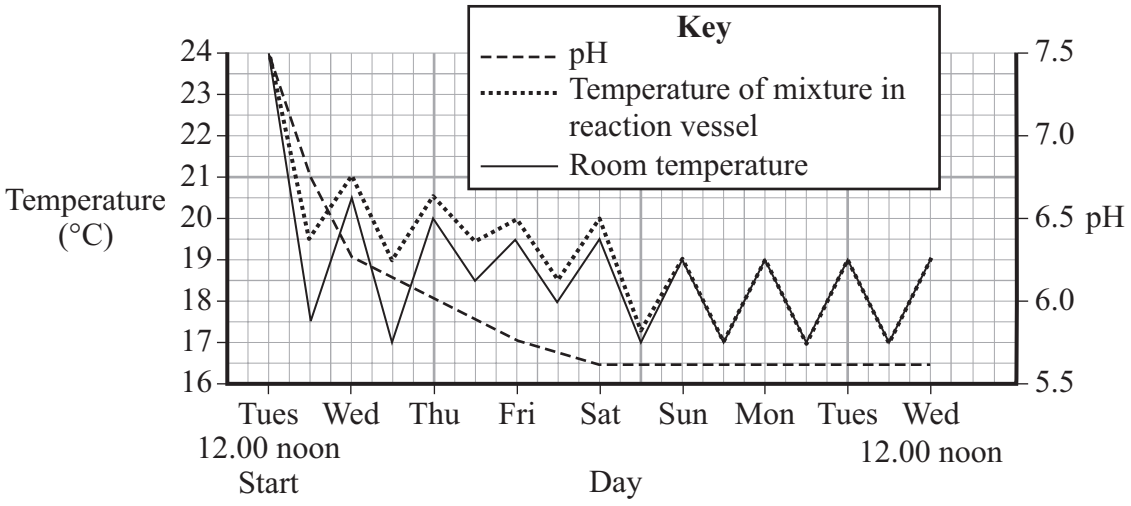
November 2007 | CHY1B | Original Q8 | Legacy

QUESTION EIGHT

Ethanol can be made by the action of yeast on a solution of sugar. This is called fermentation. The sugar is converted to ethanol and carbon dioxide. Carbon dioxide is a slightly acid gas. During fermentation, some of the energy is transferred as thermal energy.

A sugar solution and yeast were put into a reaction vessel.
The temperature of the mixture, the pH of the mixture and the room temperature were recorded over an eight-day period.

The results are shown on the graph.



8A There is a larger difference between the temperature of the mixture and the room temperature during the first few days than there is later.

The probable reason is that . . .

1 fermentation is quicker at the start.

2 the room temperature is steadily decreasing.

3 the pH value of the mixture is decreasing.

4 the room temperature fluctuates.

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 02 · continued

8B From the information on the graph, . . .

1 fermentation is completed after 4 days.

2 fermentation is completed after 5 days.

3 fermentation is completed after 6 days.

4 fermentation continues after 8 days.

8C A general conclusion from the graph is that . . .

1 the yeast cannot survive for more than 8 days.

2 the acidity of the mixture increases in the first 4 days.

3 the acidity of the mixture is greater at the start than when fermentation is completed.

4 the temperature of the mixture does not fall below 18.0 °C.

8D One advantage of producing ethanol by fermentation rather than from ethene is that . . .

1 less carbon dioxide is produced in fermentation.

2 there are no waste products.

3 the raw materials are renewable.

4 the ethanol does not need further processing.

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 03

January 2008 | CHY2H | Original Q1 | Legacy

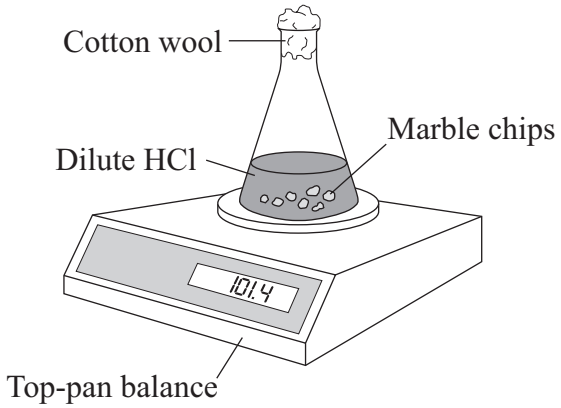
1 A student investigated the rate of reaction between marble and hydrochloric acid.

The student used an excess of marble.

The reaction can be represented by this equation.

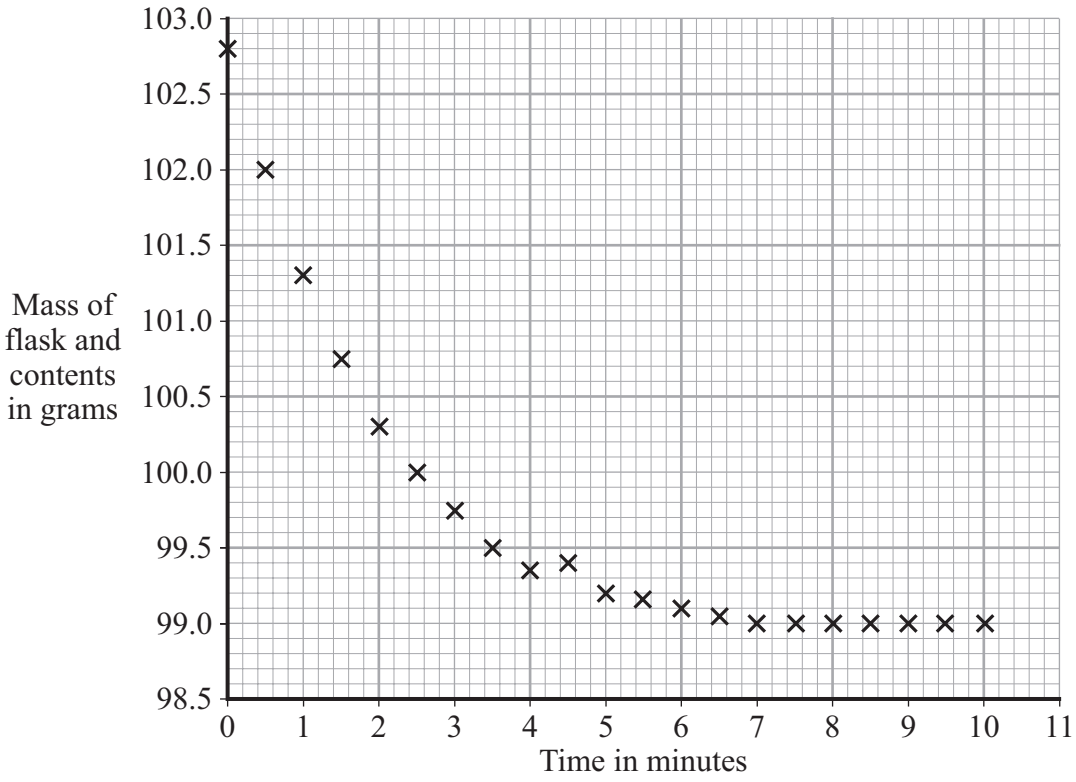
$CaCO_3$ (s) + 2HCl (aq) → $CaCl_2$ (aq) + H_2O (l) + CO_2 (g)

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.



4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 03 · continued

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(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?

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.....

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.....

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(3 marks)

8

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 04

January 2008 | CHY2H | Original Q5 | Legacy

5 Distress flares are used to attract attention in an emergency.



Flares often contain the element magnesium. Magnesium burns to form magnesium oxide.

(a) The distress flare burns with a bright flame because the reaction is very *exothermic*.

State the meaning of *exothermic*.

.....

.....

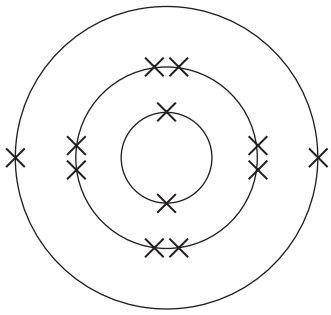
(1 mark)

(b) Write a balanced symbol equation for the reaction between magnesium (Mg) and oxygen (O_2) to form magnesium oxide (MgO).

.....

(1 mark)

(c) The diagram shows the electronic structure of a magnesium atom.
The atomic (proton) number of magnesium is 12.



Magnesium atom

Draw a similar diagram to show the electronic structure of an oxygen atom.
The atomic (proton) number of oxygen is 8.

(1 mark)

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 04 · continued

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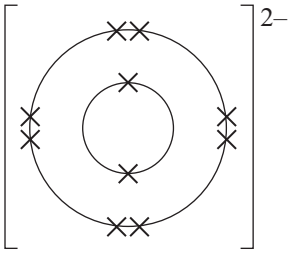
(d) Magnesium ions and oxide ions are formed when magnesium reacts with oxygen.

The diagram shows the electronic structure of an oxide ion.



Oxide ion

Draw a similar diagram to show the electronic structure of a magnesium ion.

(1 mark)

(e) Magnesium oxide is a white solid with a high melting point.

Explain how the ions are held together in solid magnesium oxide.

.....

.....

.....

.....

(2 marks)

(f) Indigestion tablets can be made from magnesium oxide. The magnesium oxide neutralises some of the hydrochloric acid in the stomach.

Complete the word equation for the reaction between magnesium oxide and hydrochloric acid.

hydrochloric acid + magnesium oxide → ..... + water.

(1 mark)

7

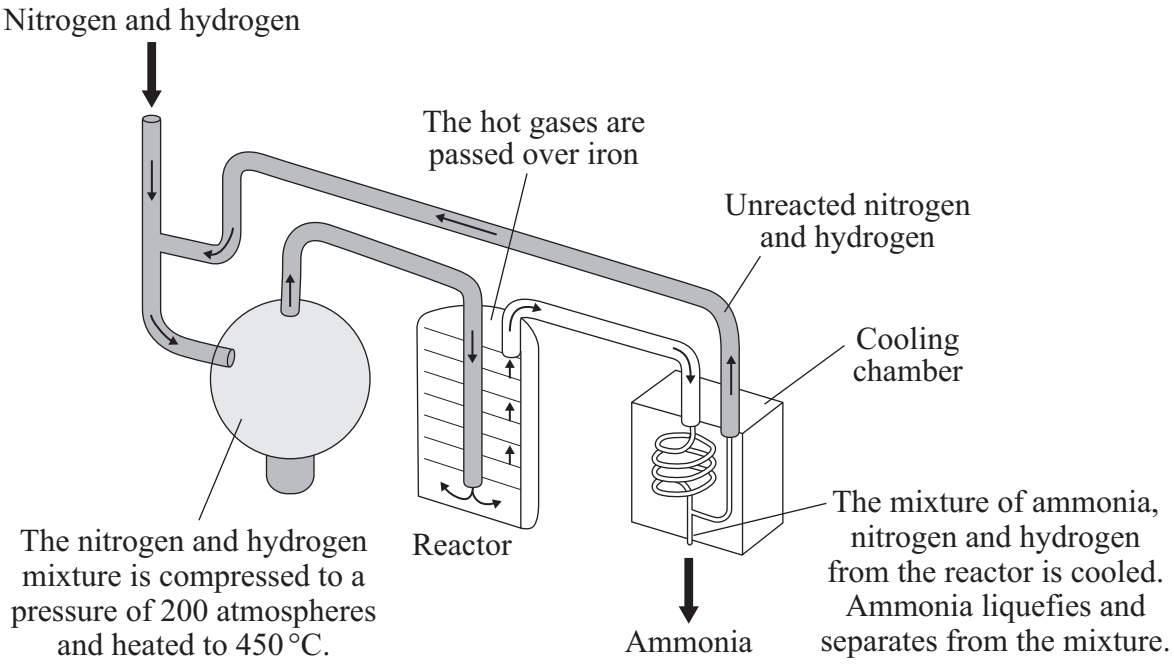
4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 05

January 2008 | CHY2H | Original Q7 | Legacy

7 The Haber process is named after the German chemist, Fritz Haber.

The diagram shows the main stages in the Haber process.



An exothermic reaction takes place when nitrogen reacts with hydrogen to make ammonia. The reaction can be represented by this equation.

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

(a) Calculate the maximum mass of ammonia that could be made from 1000 g of nitrogen.

Relative atomic masses: H = 1; N = 14

.....

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.....

.....

Mass .....g

(3 marks)

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 05 · continued

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(b) At a temperature of 450 °C and 200 atmospheres the actual mass of ammonia produced when 1000 g of nitrogen is passed through the reactor is 304 g.

Calculate the percentage yield of ammonia produced in the reactor.

(If you did not answer part (a), then assume that the maximum mass of ammonia that can be made from 1000 g of nitrogen is 1100 g. This is **not** the correct answer to part (a).)

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.....

Percentage yield of ammonia = ... %

(2 marks)

(c) State **and** explain:

(i) how a **decrease** in temperature would affect the yield of ammonia

.....

.....

.....

.....

(2 marks)

(ii) how an **increase** in pressure would affect the yield of ammonia.

.....

.....

.....

.....

(2 marks)

Question 7 continues on the next page

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 05 · continued

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(d) Factories that make ammonia are often near to large towns.

Discuss the economic, safety and environmental factors to be considered when there is an ammonia factory near a town.

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(3 marks)

12

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 06

June 2008 | CHY1H | Original Q1 | Legacy

1 Limestone is mainly calcium carbonate.

1 (a) Quicklime is produced by heating limestone.

1 (a) (i) Complete the word equation for this reaction by writing the chemical name of the solid and the gas produced.

calcium carbonate → ..... + ...

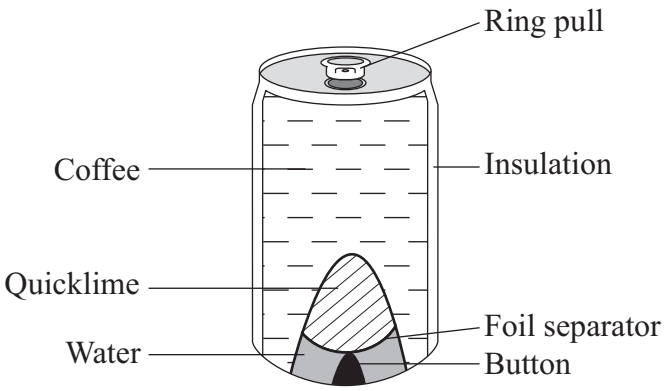
(2 marks)

1 (a) (ii) What is the name for this type of chemical reaction?

.....

(1 mark)

1 (b) Quicklime is used in self-heating cans.
The diagram shows a self-heating can designed to raise the temperature of coffee to 60 °C.



The button on the base of the can is pushed. The foil separator breaks, allowing water to mix with the quicklime. After about 3 minutes, the can is opened by the ring pull. Insulating materials are used inside the walls of the can to prevent either the lips or the fingers from being burned.

1 (b) (i) Explain why the coffee becomes hot.

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.....

.....

(2 marks)

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 06 · continued

for mark

1 (b) (ii) Suggest **two** reasons why it is **not** possible to re-use this self-heating can.

1 .....

.....

2 .....

.....

(2 marks)

7

Turn over for the next question

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 07

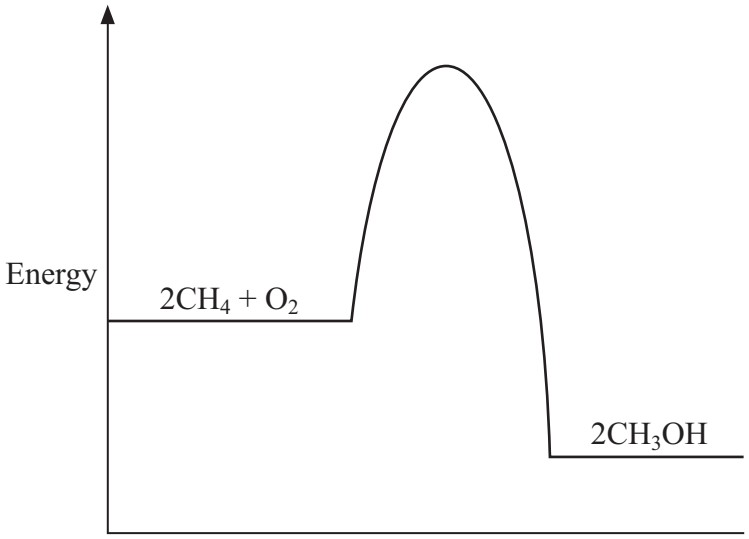
June 2008 | CHY3H | Original Q7 | Legacy

7 Methanol (CH_3OH) can be made by reacting methane (CH_4) and oxygen (O_2) in the presence of a platinum catalyst. The reaction is exothermic.

An equation that represents the reaction is:

$$2CH_4 + O_2 \rightarrow 2CH_3OH$$

7 (a) The energy level diagram for this reaction is given below.



7 (a) (i) Use the diagram to explain how you know that this reaction is exothermic.

.....

.....

.....

(1 mark)

7 (a) (ii) Explain, in terms of the energy level diagram, how the platinum catalyst increases the rate of this reaction.

.....

.....

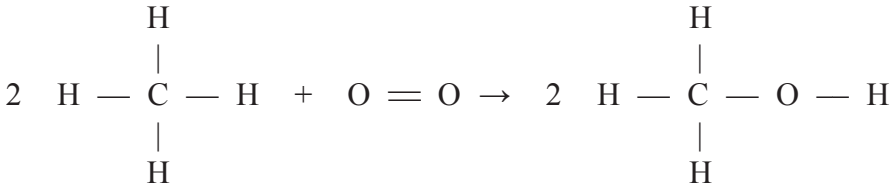
(1 mark)

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 07 · continued

for mark

7 (b) The equation can also be written showing the structural formulae of the reactants and the product.



7 (b) (i) Use the bond energies given in the table to help you to calculate the energy change for this reaction.

Bond	Bond energy in kJ
C — H	435
O = O	498
C — O	805
O — H	464

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Energy change = ... kJ

(3 marks)

7 (b) (ii) In terms of the bond energies, explain why this reaction is exothermic.

.....

.....

(1 mark)

6

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 08

March 2009 | CHY1AP | Original Q7 | Legacy

QUESTION SEVEN

Calcium carbonate decomposes on heating to give calcium oxide and carbon dioxide.

$$CaCO_3 \rightarrow CaO + CO_2$$

100 g of calcium carbonate, on complete decomposition, produces 56 g of calcium oxide.

If the carbon dioxide is not allowed to escape, it will recombine with the calcium oxide. This can happen at any temperature.

The carbon dioxide formed could be:

- used by oil companies
- used by ice-cream companies
- reacted with sodium hydroxide to make sodium carbonate for glass-making.

7A Calculate the mass of carbon dioxide that would be released by completely decomposing 400 tonnes of calcium carbonate.

(1 tonne = 1 000 000 g)

1 17.6 tonnes

2 22.4 tonnes

3 176.0 tonnes

4 224.0 tonnes

7B If calcium oxide is left exposed to the air, it will increase in mass.

Which of the following could **not** be the reason for this?

1 The calcium oxide is recombining with carbon dioxide from the air.

2 The calcium oxide is reacting with water from the air.

3 The calcium oxide is still thermally decomposing.

4 The calcium oxide is reverting back to calcium carbonate.

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 08 · continued

7C A company makes calcium oxide from calcium carbonate.

The best way for this company to benefit economically, and at the same time reduce environmental damage, is to . . .

1 store the carbon dioxide in holes in the ground made by oil companies.

2 offer the carbon dioxide to oil companies so that they can use it to flush oil out of the ground.

3 sell solid carbon dioxide to ice-cream companies for keeping ice-cream cold.

4 sell the carbon dioxide to glass-making companies for conversion into sodium carbonate.

7D Graphs of global temperatures compared with the amount of carbon dioxide in the atmosphere over the past 50 years follow each other very closely.

The best conclusion that can be drawn from this is that . . .

1 burning fossil fuels causes global warming.

2 decomposing limestone causes global warming.

3 the heat from processing limestone causes global warming.

4 rising levels of carbon dioxide probably add to global warming.

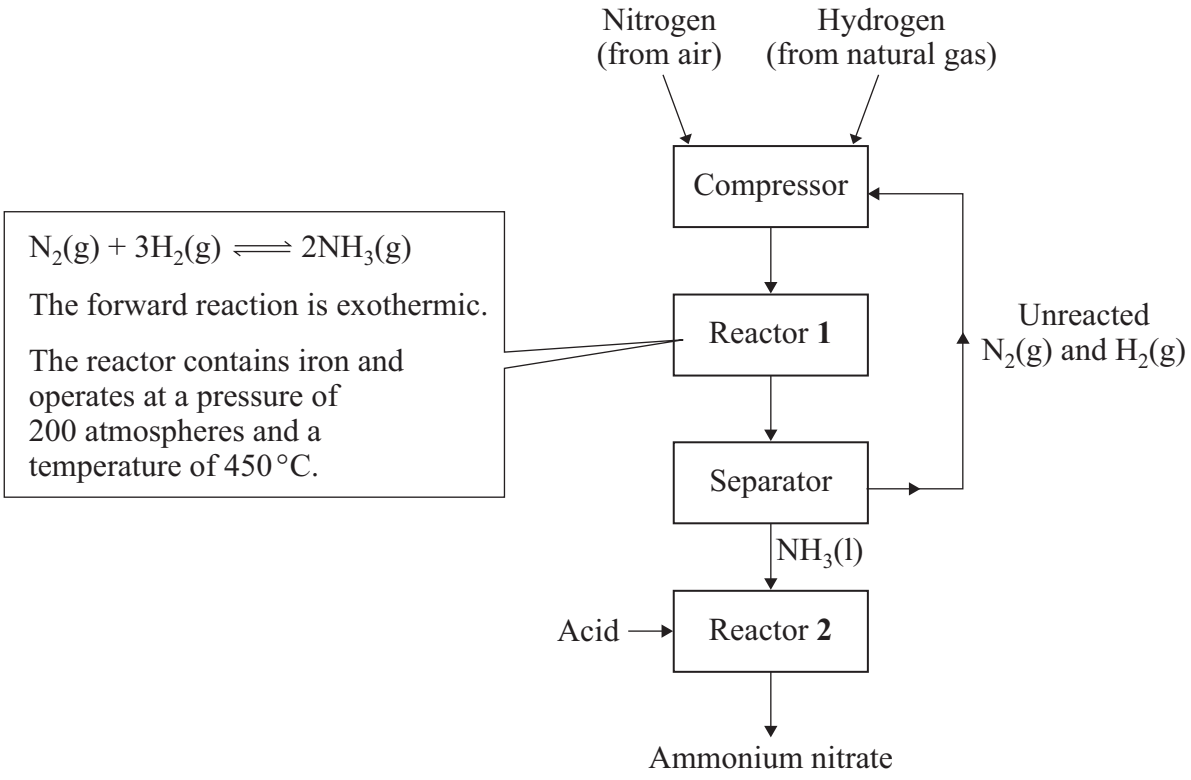
4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 09

June 2009 | CHY2H | Original Q3 | Legacy

3 Ammonium nitrate is an important chemical. The diagram shows the main stages in the manufacture of ammonium nitrate.

Study the diagram and then answer the question.



3 (a) What is the purpose of the iron in reactor **1**?

.....

.....

(1 mark)

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 09 · continued

for mark

3 (b) Explain why the best yield of ammonia at equilibrium is obtained:

3 (b) (i) at low temperature

.....

.....

(1 mark)

3 (b) (ii) at high pressure.

.....

.....

(1 mark)

3 (c) The temperature used in reactor **1** is 450 °C.

Explain why a much lower temperature is **not** used.

.....

.....

(1 mark)

3 (d) A mixture of ammonia, nitrogen and hydrogen leaves reactor **1**.

In the separator, what is done to the mixture to separate the ammonia from the other gases?

.....

.....

(1 mark)

3 (e) Name the acid that reacts with ammonia in reactor **2** to make ammonium nitrate.

.....

.....

(1 mark)

6

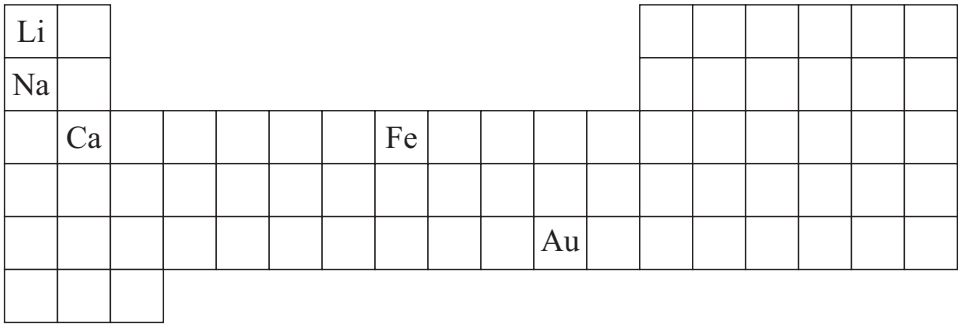
4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 10

November 2009 | CHY1AP | Original Q1 | Legacy

QUESTION ONE

The diagram shows part of the periodic table.



Match elements, **A**, **B**, **C** and **D**, with the numbers **1–4** in the table below.

A Calcium (Ca)

B Lithium (Li)

C Gold (Au)

D Iron (Fe)

1	It will not react with oxygen or water even at high temperatures.
2	It forms the oxide known as quicklime.
3	It has properties most similar to those of sodium (Na).
4	It is a transition element found in the Earth as an oxide.

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 11

November 2009 | CHY1BP | Original Q7 | Legacy

QUESTION SEVEN

Usually, the lower the melting point of a fat, the more unsaturated it is.

A student measured the melting points of four fats so that he could later compare the amount of unsaturation.

He used four boiling tubes, each half-filled with a different fat. A thermometer was used to measure the melting point of each fat.

The student repeated the measurement of the melting point for each fat either once or twice.

Fat	Melting point in °C		
	Attempt 1	Attempt 2	Attempt 3
Coconut	25	26	
Lard	33	33	
Frying fat	41	49	42
Pastry fat	46	44	

7A Which statement is correct about the way he carried out the test?

1 It was **not** a fair test because he did not repeat each measurement the same number of times.

2 It was a fair test because everything used except the fat, was the same.

3 It was **not** a fair test because he used different fats.

4 It was a fair test because they were all fats.

7B What is the mean value that the student should use for the melting point of frying fat?

1 41.5 °C

2 43.0 °C

3 44.5 °C

4 45.0 °C

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 11 · continued

7C If it is true that the lower the melting point of a fat, the more unsaturated it is, then . . .

1 coconut fat should react with the most bromine in a fair test.

2 pastry fat should react with the most bromine in a fair test.

3 coconut fat should contain the highest number of carbon carbon single bonds.

4 pastry fat should contain the highest number of carbon carbon double bonds.

7D Which row in the table shows the conditions that would be required to harden the coconut oil?

	React with	Temperature in °C	Catalyst
1	oxygen	60	nickel
2	hydrogen	60	nickel
3	hydrogen	100	iron
4	oxygen	100	iron

4.5.1.1 Energy transfer during exothermic and endothermic reactions

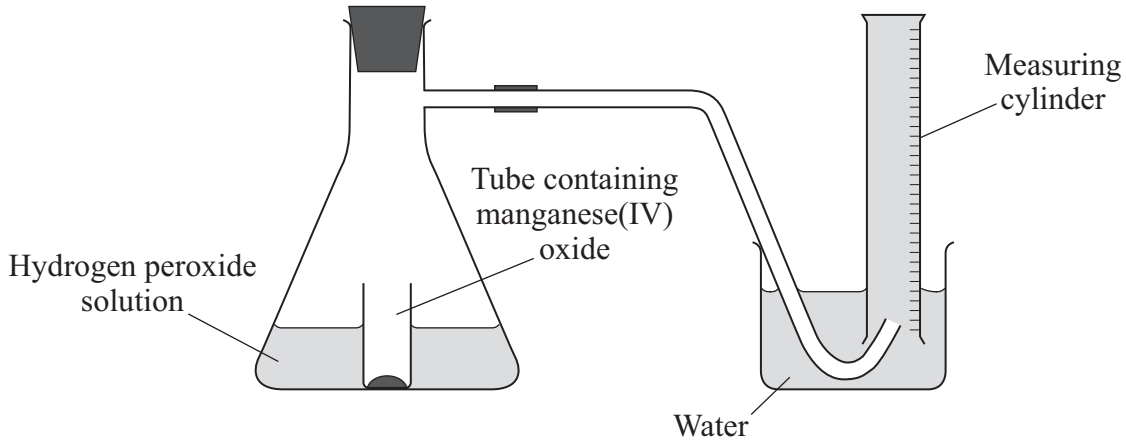
Question 12

January 2010 | CHY2H | Original Q5 | Legacy

5 A student investigated the effect of temperature on the decomposition of hydrogen peroxide. Hydrogen peroxide decomposes to oxygen and water when a manganese(IV) oxide catalyst is added.

The student measured the time taken to collect 5 cm^3 of oxygen gas.

The apparatus shown below was used for the investigation. The reaction was started by shaking the flask so that the manganese(IV) oxide and hydrogen peroxide were mixed.



The student did the investigation at two different temperatures. All the other variables were kept constant.

The student's results are shown in the table.

Temperature of the hydrogen peroxide solution in °C	Volume of oxygen collected in cm^3	Time taken to collect the oxygen in seconds	Rate of reaction in cm^3 per second
20	5	40	0.125
25	5	25	

5 (a) (i) Calculate the rate of reaction at 25 °C.

.....

Rate of reaction = ... cm^3 per second
(2 marks)

5 (a) (ii) The teacher said that the student should repeat the investigation to get more results.

Suggest why.

.....

.....
(1 mark)

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 12 · continued

for mark

5 (b) The student concluded that:

'the rate of reaction increases when the temperature is increased'.

Explain, in terms of particles, why the rate of reaction increases.

.....

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.....

(2 marks)

5

Turn over for the next question

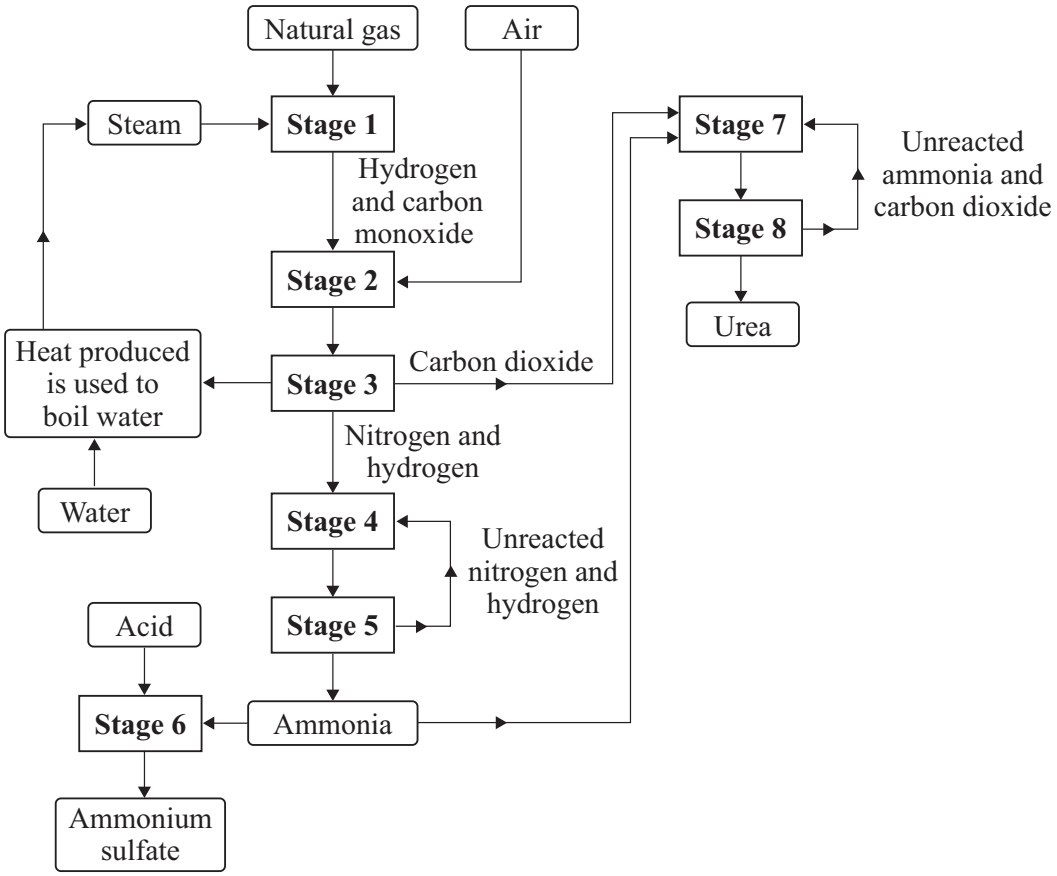
4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 13

January 2010 | CHY2H | Original Q6 | Legacy

6 Ammonium sulfate and urea are made from ammonia.
These compounds are used by farmers.

The flow diagram shows the stages to make ammonium sulfate and urea.



6 (a) Give **two** examples from the flow diagram of efficient use of energy or materials.

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(2 marks)

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 13 · continued

for mark

6 (b) Why do farmers use ammonium compounds?

.....

.....

(1 mark)

6 (c) The equation for a reaction that takes place in **Stage 1** is given below.

Balance this equation by putting the correct number on the dotted line.

$$CH_4 + H_2O \rightarrow CO + \ldots\ldots H_2$$

(1 mark)

6 (d) The equation for the reaction in **Stage 4** is shown below.

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

The forward reaction is exothermic.

6 (d) (i) Explain why, at equilibrium, the yield of ammonia for this reaction is greater at **low** temperatures.

.....

.....

(1 mark)

6 (d) (ii) Explain why a high temperature, 450 °C, is used in **Stage 4**.

.....

.....

(1 mark)

6 (e) Name the acid used in **Stage 6** to make ammonium sulfate.

..... acid

(1 mark)

Question 6 continues on the next page

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 13 · continued

for mark

6 (f) **Stage 7** can be represented by this equation.

$$\underset{\text{ammonia}}{2NH_3} + CO_2 \rightarrow \underset{\text{urea}}{NH_2CONH_2} + H_2O$$

The table gives the relative formula masses (M_r) of the reactants and the products for this reaction.

Formula of reactant or product	Relative formula masses (M_r)
NH_3	17
CO_2	44
NH_2CONH_2	60
H_2O	18

Use information from the table to help you answer (f)(i) and (f)(ii).

6 (f) (i) One factory produces 6000 g of urea each second. Calculate the mass of ammonia needed to make 6000 g of urea.

.....

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.....

Mass of ammonia needed = ... g

(3 marks)

6 (f) (ii) Percentage atom economy can be calculated using:

$$\text{Percentage atom economy} = \frac{M_r \text{ of useful product}}{\text{total } M_r \text{ of all reactants added together}} \times 100\%$$

Calculate the percentage atom economy for the reaction in **Stage 7**

.....

.....

.....

Percentage atom economy = ... %

(2 marks)

12

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 14

January 2010 | CHY3H | Original Q6 | Legacy

6 During a thunderstorm lightning strikes the Eiffel Tower.

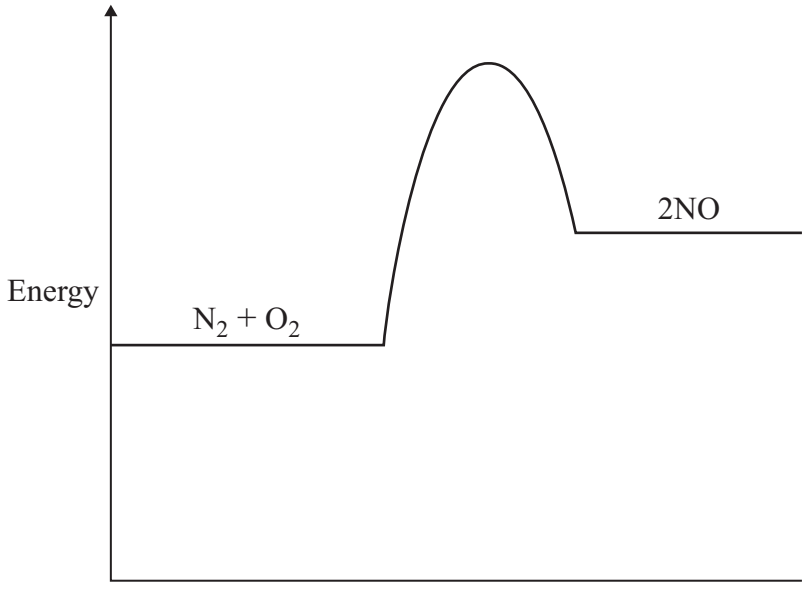


In lightning the temperature can reach 30 000 °C. This causes nitrogen and oxygen in the air to react, producing nitrogen oxide. This reaction has a high *activation energy* and is *endothermic*.

An equation that represents this endothermic reaction is:

$$N_2 + O_2 \rightarrow 2NO$$

The energy level diagram for this reaction is given below.



6 (a) The energy level diagram shows that this reaction is *endothermic*.

Explain how.

.....

.....

(1 mark)

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 14 · continued

for mark

6 (b) What is meant by the term *activation energy*?

.....

.....

(1 mark)

6 (c) The equation showing the structural formulae of the reactants and products is

$$N \equiv N \quad + \quad O = O \quad \rightarrow \quad 2\ N = O$$

Bond	Bond energy in kJ
N ≡ N	945
O = O	498
N = O	630

6 (c) (i) Use the bond energies in the table to calculate the energy change for this reaction.

.....

.....

.....

.....

Energy change = ... kJ

(3 marks)

6 (c) (ii) In terms of bond energies, explain why this reaction is endothermic.

.....

.....

.....

(1 mark)

6

4.5.1.1 Energy transfer during exothermic and endothermic reactions

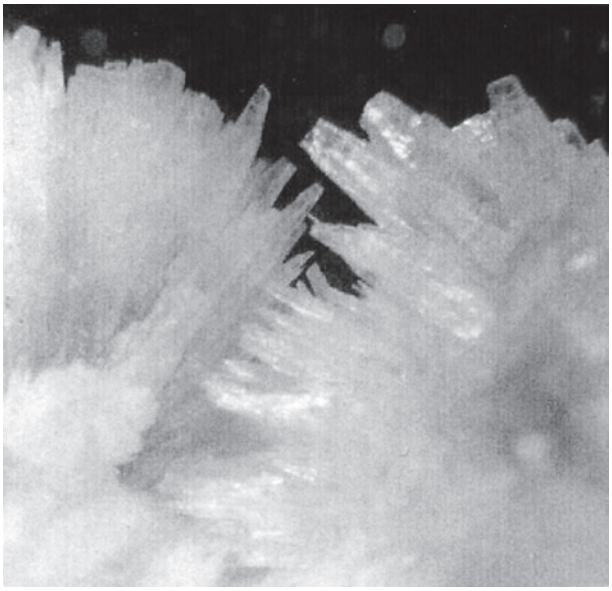
Question 15

June 2010 | CHY2H | Original Q2 | Legacy

2 (a) Read the article about the mineral strontianite.

Strontianite is a mineral that was discovered near the village of Strontian in Scotland. At first some scientists thought that strontianite was barium carbonate.

Strontianite



In 1790, Professor Adair Crawford and William Cruikshank were both lecturers in chemistry and doctors of medicine. They investigated the properties of strontianite. They found that strontianite had different properties from barium carbonate. They concluded that strontianite contained a new element.

After this, other scientists also showed that strontianite and barium carbonate had different properties. Strontianite is now known to be strontium carbonate.

2 (a) (i) What evidence did Crawford and Cruikshank use to prove that strontianite was **not** barium carbonate?

.....

.....

(1 mark)

2 (a) (ii) Crawford and Cruikshank's conclusion was immediately accepted by other scientists. Suggest why.

.....

.....

(1 mark)

2 (a) (iii) How was the reliability of the work of Crawford and Cruikshank confirmed?

.....

.....

(1 mark)

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 15 · continued

2 (b) One of Crawford and Cruikshank's experiments was repeated in a school laboratory. Samples of strontianite and barium carbonate were reacted with hydrochloric acid to produce strontium chloride and barium chloride.

Solid strontium chloride and solid barium chloride were separately added to water. The change in temperature of the water was measured.

The results of the experiments are shown below.

	Experiment 1 Strontium chloride dissolved in water	**Experiment 2** Barium chloride dissolved in water
Temperature of water before adding the chloride in ºC	19.5	19.6
Temperature of water after adding the chloride in ºC	21.2	17.5

2 (b) (i) State **one** variable that should be controlled to make it a fair test.

.....

.....

(1 mark)

2 (b) (ii) Which experiment, **1** or **2**, is endothermic?

Explain how you know.

Experiment ☐ because .....

.....

(1 mark)

2 (b) (iii) The results prove that strontium chloride and barium chloride must be different even if all of the variables had not been controlled when they were dissolved. Explain why.

.....

.....

(1 mark)

2 (c) In 1808, Humphry Davy was the first person to extract strontium. He did this by the electrolysis of molten strontium chloride. Strontium formed at the negative electrode.

Suggest why strontium ions are attracted to the negative electrode.

.....

.....

(1 mark)

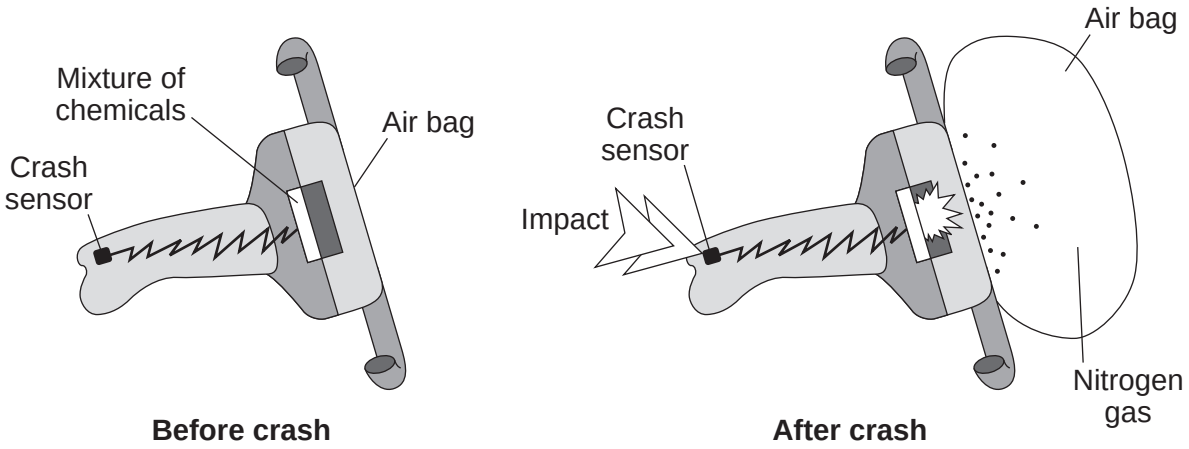
7

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 16

June 2010 | CHY2H | Original Q4 | Legacy

4 Air bags are used to protect the passengers in a car during an accident. When the crash sensor detects an impact it causes a mixture of chemicals to be heated to a high temperature. Reactions take place which produce nitrogen gas. The nitrogen fills the air bag.



4 (a) The mixture of chemicals contains sodium azide (NaN_3) which decomposes on heating to form sodium and nitrogen.

$$2NaN_3 \rightarrow 2Na + 3N_2$$

A typical air bag contains 130 g of sodium azide.

4 (a) (i) Calculate the mass of nitrogen that would be produced when 130 g of sodium azide decomposes.

Relative atomic masses (A_r): N = 14; Na = 23

.....

.....

.....

.....

Mass of nitrogen = ... g

(3 marks)

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 16 · continued

4 (a) (ii) 1 g of nitrogen has a volume of 0.86 litres at room temperature and pressure.

What volume of nitrogen would be produced from 130 g of sodium azide?

(If you did not answer part (a)(i), assume that the mass of nitrogen produced from 130 g of sodium azide is 80 g. This is **not** the correct answer to part (a)(i).)

.....

Volume = ... litres

(1 mark)

4 (b) The sodium produced when the sodium azide decomposes is dangerous.
The mixture of chemicals contains potassium nitrate and silicon dioxide which help to make the sodium safe.

4 (b) (i) Sodium reacts with potassium nitrate to make sodium oxide, potassium oxide and nitrogen. Complete the balancing of the equation for this reaction.

$$10Na + ...KNO_3 \rightarrow .....Na_2O + K_2O + N_2$$

(1 mark)

4 (b) (ii) The silicon dioxide reacts with the sodium oxide and potassium oxide to form silicates.

Suggest why sodium oxide and potassium oxide are dangerous in contact with the skin.

.....

.....

(1 mark)

6

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 17

June 2010 | CHY2H | Original Q6 | Legacy

6 The equation for a reaction to produce hydrogen is:

$$CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$$

6 (a) Explain why changing the pressure does **not** affect the yield of hydrogen at equilibrium.

.....

.....

(1 mark)

6 (b) Suggest why the best yield of hydrogen at equilibrium is obtained at **low** temperatures.

.....

.....

(1 mark)

6 (c) The temperature used in industry needs to be high enough for the reaction to take place quickly. Explain, in terms of particles, why the rate of reaction increases when the temperature is increased.

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.....

(3 marks)

6 (d) Scientists have developed catalysts which allow the reaction to take place quickly at lower temperatures. How could this be good for the manufacturer and for the environment?

.....

.....

.....

.....

(2 marks)

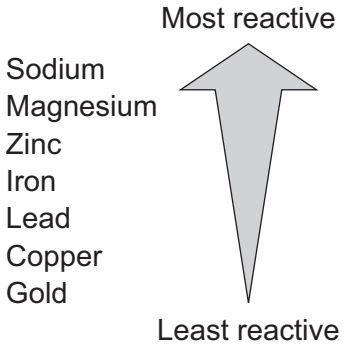
7

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 18

QUESTION EIGHT

A metal will displace a less reactive metal from its compounds.



If a reaction occurs, it releases heat. The reactivity of metals can be investigated by measuring the temperature rise if a fair test is carried out between metals and metal compounds.

Metal	Metal compound	Temperature rise in °C
Zinc	Lead nitrate	10
Iron	Lead nitrate	6
Zinc	Copper sulfate	19
Magnesium	Copper sulfate	48
Copper	Zinc sulfate	0

8A The results in the table suggest that the largest rise in temperature occurs when . . .

1 a metal reacts with a metal compound that is a sulfate.

2 a transition metal is used with a metal compound.

3 there is a large difference in reactivity between the metal used and the metal in the metal compound.

4 a Group 1 metal reacts with a transition metal compound.

8B Using copper and zinc sulfate does **not** cause a temperature rise.

This is because . . .

1 not enough copper is used.

2 zinc is more reactive than copper.

3 copper corrodes easily.

4 too much zinc sulfate is added.

8C Which of the following metals will cause the largest temperature rise when added to iron nitrate solution?

1 gold

2 sodium

3 lead

4 zinc

8D
- Carbon can reduce zinc oxide.
- Magnesium can react with carbon dioxide.
- Carbon can produce iron from iron oxide.

Where should carbon be placed in the reactivity series?

1 above magnesium but below sodium

2 above zinc but below magnesium

3 below iron but above lead

4 below lead but above copper

4.5.1.1 Energy transfer during exothermic and endothermic reactions

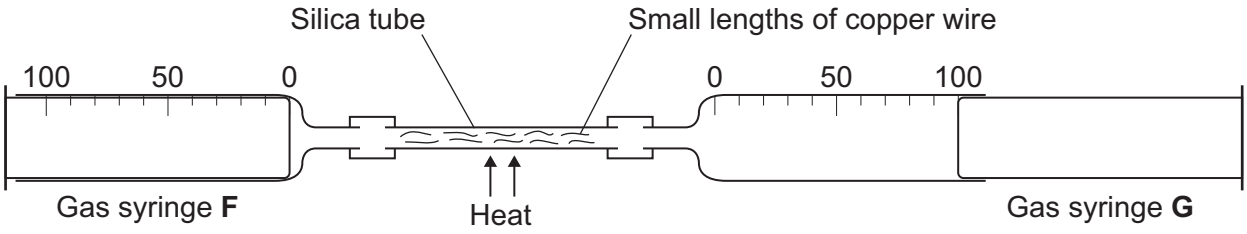
Question 19

November 2010 | CHY1BP | Original Q8 | Legacy

QUESTION EIGHT

Some students used this equipment to find the answer to the question:

What percentage (%) of the air is oxygen?



The students heated the copper wire inside the silica tube. The syringes were used to push air backwards and forwards between the two syringes, until the volume of gases in the syringes stopped changing.

The equation for the reaction is:

$$\underset{\text{(Pink)}}{2Cu} + O_2 \longrightarrow \underset{\text{(Black)}}{2CuO}$$

They pushed all the gas that remained into gas syringe **G**. When the gas had cooled to room temperature, they measured its final volume.

8A The equipment was cooled to room temperature before the final volume was measured . . .

1 to make sure that there were no other variables affecting the measurements.

2 to make sure that all of the oxygen in the sample was used up.

3 to make the measurements more precise.

4 to stop any further reaction.

8B The most accurate answer to the question 'What percentage (%) of the air is oxygen?' would be obtained . . .

1 by weighing the amount of solid product that remained at the end of the experiment.

2 by repeating the experiment using different diameters of copper wire.

3 when all the copper in the silica tube had turned black by the end of the experiment.

4 when there was still some pink copper left in the silica tube at the end of the experiment.

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 19 · continued

8C In the students' first experiment, the final volume they recorded was 82 cm^3. When the students repeated the experiment with a new 100 cm^3 sample of air, the final volume was 72 cm^3.

The difference in final volume was because . . .

1 there was a leak from the apparatus.

2 the students did not put enough new copper in the tube in the repeat experiment.

3 there was more oxygen in the second sample.

4 the students did not heat the copper for long enough in the repeat experiment.

8D If the experiment could be carried out with an air sample similar to that of the Earth's early atmosphere, we would expect . . .

1 a larger decrease in the volume of the air sample.

2 an increase in the volume of the air sample.

3 no change in the volume of the air sample.

4 more copper wire would be needed to use all the oxygen in the air sample.

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 20

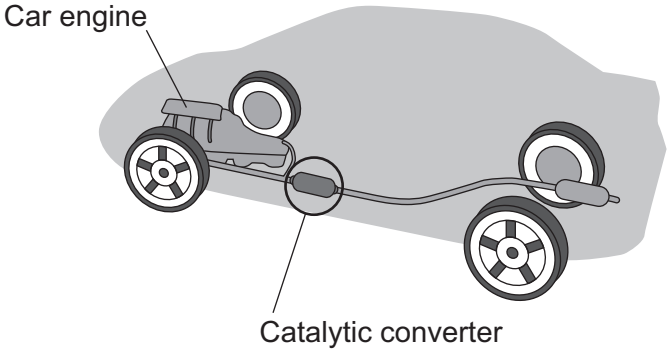
January 2011 | CHY2H | Original Q4 | Legacy

4 Read the information about car engines.

Burning petrol in air is an *exothermic* reaction. This reaction is used in car engines.

When petrol burns it produces harmful substances such as nitrogen oxides and carbon monoxide.

A catalytic converter stops these harmful substances being released into the air.



4 (a) The reaction is *exothermic*. What is the meaning of *exothermic*?

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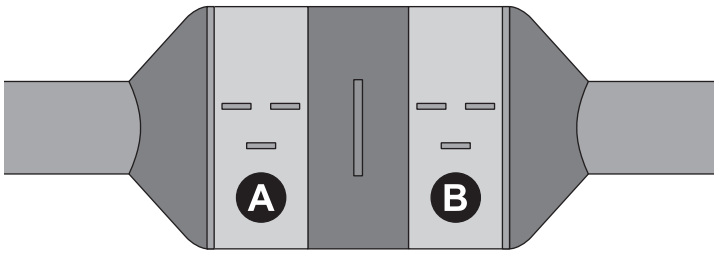
.....

(1 mark)

4 (b) The catalytic converter has two parts shown as **A** and **B** in the diagram.



Part **A** contains a catalyst made from platinum and rhodium.

Part **B** contains a catalyst made from platinum and palladium.

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 20 · continued

4 (b) (i) Why are catalysts used in chemical reactions?

.....

.....

(1 mark)

4 (b) (ii) One reaction in part **A** is shown by this equation.

$$2NO \rightarrow N_2 + O_2$$

Suggest why this reaction helps the environment.

.....

.....

(1 mark)

4 (b) (iii) The equation for one of the reactions in part **B** is shown below.

Balance this equation.

..... CO + O_2 → ..... CO_2

(1 mark)

4 (b) (iv) The catalytic converter works for many years without replacing the catalyst.

Explain why the catalyst does not need to be replaced.

.....

.....

(1 mark)

4 (b) (v) Suggest why different catalysts are used in parts **A** and **B**.

.....

.....

(1 mark)

Question 4 continues on the next page

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 20 · continued

4 (c) Modern catalytic converters contain nanosized particles of catalyst. Using nanosized particles reduces the cost of the catalytic converter.

Suggest and explain why the use of nanosized catalyst particles reduces the cost of the catalytic converter.

Your answer should include information about the size and surface area of the particles.

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(3 marks)

9

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 21

January 2011 | CHY2H | Original Q6 | Legacy

6 The picture shows a wooden bowl.
The pieces of wood used for this bowl were dyed different colours.



The artist who made the bowl explained why he dissolved the coloured dyes in methanol.

> I use different coloured dyes dissolved in methanol.
> I use methanol because with dyes dissolved in water the wood needs to be soaked for a longer time.
> The bowl dries more quickly if I use methanol instead of water.

6 (a) (i) Why is using methanol an advantage to the artist?

.....

.....

(1 mark)

6 (a) (ii) The bonds within a methanol molecule are strong, covalent bonds.

Explain why methanol has a low boiling point.

.....

.....

.....

.....

.....

(2 marks)

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 21 · continued

6 (b) Methanol is made by reacting carbon monoxide with hydrogen.

The equation for this reaction is:

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

The forward reaction is exothermic.

The best equilibrium yield of methanol is obtained when the temperature is low and when the pressure is high.

Explain why the best equilibrium yield is obtained:

6 (b) (i) when the temperature is low

.....

.....

(1 mark)

6 (b) (ii) when the pressure is high.

.....

.....

(1 mark)

6 (b) (iii) In industry a high temperature is used for this reaction. This gives a fast rate of reaction. The increase in temperature gives the particles more energy.

Explain, in terms of particles, why this makes the reaction go faster.

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(2 marks)

Question 6 continues on the next page

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 21 · continued January 2011 | CHY2H | Original Q6 | Legacy

6 (c) (i) Calculate the maximum mass of methanol that could be made from 14 g of carbon monoxide.

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

Relative formula masses (M_r): CO = 28; CH_3OH = 32.

.....

.....

.....

.....

.....

Maximum mass of methanol = ... g
(2 marks)

6 (c) (ii) In an experiment the actual mass of methanol made from 14 g of carbon monoxide was 12 g. Use this information and your answer from part (c)(i) to calculate the percentage yield of methanol in this experiment.

(If you did not get an answer to part (c)(i) then assume that the maximum yield is 18 g. This is **not** the correct answer to part (c)(i).)

.....

.....

Percentage yield of methanol = ...%
(2 marks)

6 (c) (iii) Suggest **one** reason why the yield obtained is less than the maximum yield.

.....

.....
(1 mark)

12

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 22

January 2011 | CHY3H | Original Q7 | Legacy

7 Hydrogen peroxide is often used to bleach or lighten hair.

Hydrogen peroxide slowly decomposes to produce water and oxygen.

7 (a) The equation for the reaction can be represented using structural formulae.

$$2\ H-O-O-H \longrightarrow 2\ H-O-H + O=O$$

Use the bond energies in the table to help you to calculate the energy change for this reaction.

Bond	Bond energy in kJ per mole
H – O	464
O – O	146
O = O	498

.....

.....

.....

.....

Energy change = ... kJ

(3 marks)

7 (b) Explain, in terms of bond making and bond breaking, why the reaction is exothermic.

.....

.....

.....

(1 mark)

4

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 23

March 2011 | CHY1AP | Original Q8 | Legacy

QUESTION EIGHT

Zinc is a reactive metal that will react with oxygen at high temperatures. Its two main ores are zinc sulfide (ZnS) and zinc carbonate ($ZnCO_3$). The relative abundance of each ore is about the same throughout the world.

To extract zinc, the ores are first heated to produce zinc oxide:

$$2ZnS + 3O_2 \xrightarrow{\text{heat}} 2ZnO + 2SO_2$$

$$ZnCO_3 \xrightarrow{\text{heat}} ZnO + CO_2$$

The zinc oxide is mixed with carbon (C) and heated in a furnace.

In the furnace, these reactions occur:

$$C + O_2(air) \xrightarrow{\text{heat}} CO_2$$

$$CO_2 + C \longrightarrow 2CO$$

Zinc is extracted by the following reaction:

$$ZnO + CO \longrightarrow Zn + CO_2$$

8A An advantage of using zinc carbonate instead of zinc sulfide is that. . .

1 zinc carbonate is more common and therefore cheaper.

2 only one waste product is formed.

3 less zinc is lost during the reaction.

4 zinc is formed directly without another chemical being used.

8B The atmosphere inside the furnace is kept rich in carbon monoxide (CO).

This is to . . .

1 prevent zinc oxide from reacting with carbon (C).

2 stop the zinc from re-forming zinc oxide.

3 remove carbon (C) from the furnace.

4 make carbon dioxide (CO_2).

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 23 · continued

8C Zinc ores also contain lead compounds. Lead is produced with the zinc in the furnace. The temperature inside the furnace is about 1500 °C.

	Boiling point in °C	Density in g per cm^3	Reactivity
Lead	1749	11.3	Low
Zinc	907	7.1	High

Pure zinc is obtained from the furnace because . . .

1 zinc leaves the furnace as vapour, and liquid lead remains in the furnace.

2 liquid zinc floats on liquid lead in the furnace.

3 lead leaves the furnace as vapour, and liquid zinc remains in the furnace.

4 lead is more reactive than zinc and reacts with oxygen to form lead oxide.

8D Limestone is added to the furnace because . . .

1 it provides energy for the reaction.

2 it removes any acidic impurities.

3 it is the only source of the carbon dioxide in the furnace.

4 it is thermally stable.

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 24

June 2011 | CHY2H | Original Q3 | Legacy

3 The picture shows lumps of phosphate rock.



Phosphoric acid is made by adding sulfuric acid to phosphate rock.

3 (a) The rate of reaction between sulfuric acid and phosphate rock can be increased if the mixture is heated to a higher temperature.

Explain, in terms of particles, why an increase in temperature increases the rate of reaction.

.....

.....

.....

.....

.....

.....

(2 marks)

3 (b) State **one** other way in which the rate of reaction between sulfuric acid and phosphate rock can be increased.

.....

.....

(1 mark)

3

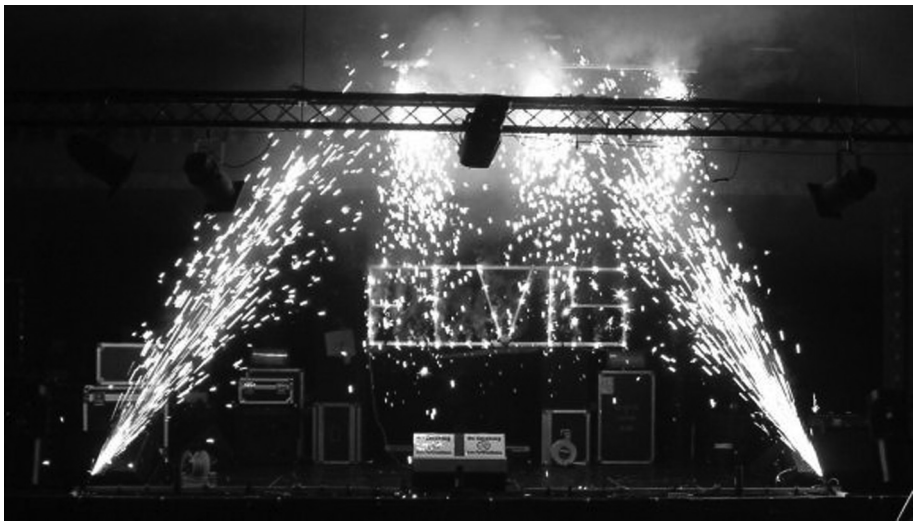
4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 25

June 2011 | CHY2H | Original Q4 | Legacy

4 Read the information in the box.

Flash powder is used to produce special effects at pop concerts.



Flash powder contains aluminium. The powder burns with a bright white flame and gives out lots of heat and light. It also produces white smoke.

The flash powder is placed on stage in a special container. At the bottom of the container there is a thin piece of wire. When the flash is needed, electricity is passed through the wire. The wire gets hot and starts the aluminium burning.

4 (a) When aluminium burns the reaction is *exothermic*.

What is the meaning of *exothermic?*

.....

.....

(1 mark)

4 (b) The hot wire provides energy to start the aluminium burning.

What is the name given to the heat energy needed to start a chemical reaction?

..... energy

(1 mark)

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 25 · continued

4 (c) The white smoke produced is aluminium oxide.

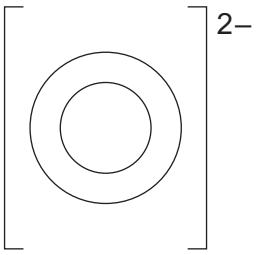
Aluminium oxide contains aluminium ions (Al^{3+}) and oxide ions (O^{2-}).

4 (c) (i) Complete the diagram to show the electronic structure of an oxide ion.

The atomic number of oxygen = 8

Use crosses (x) to represent the electrons.

oxide ion



(1 mark)

4 (c) (ii) The bonding in aluminium oxide is ionic.

What causes the aluminium ions and oxide ions to be held together strongly?

.....

.....

(1 mark)

4

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 26

June 2011 | CHY2H | Original Q7 | Legacy

7 Humberstone was a town in the desert of Northern Chile in South America. It was built for the people who worked in the nearby sodium nitrate mines.

The sodium nitrate was used as a fertiliser.

The sodium nitrate was exported by ship to countries all around the world.

Today the mines have closed and nobody lives in Humberstone.

One of the reasons for the mines closing was the invention of the Haber process.



7 (a) The Haber process is used to make ammonia (NH_3).

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

The forward reaction is exothermic.

7 (a) (i) Name the raw materials that are used to supply the nitrogen and hydrogen.

Nitrogen .....

Hydrogen .....

(2 marks)

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 26 · continued

7 (a) (ii) The Haber process uses a temperature of 450 °C.

Explain, as fully as you can, why a temperature of 450 °C is used rather than a much higher temperature or a much lower temperature.

.....

.....

.....

.....

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.....

.....

(3 marks)

7 (a) (iii) Ammonia can be converted to ammonium nitrate by adding an acid.

Name this acid.

.....

(1 mark)

7 (b) Suggest and explain why the invention of the Haber process caused the closure of the Humberstone mines in Chile.

.....

.....

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.....

.....

(2 marks)

8

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 27

June 2011 | CHY3H | Original Q4 | Legacy

4 Hydrogen peroxide decomposes to give water and oxygen.

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

The reaction is *exothermic.*

4 (a) Explain, in terms of bond breaking and bond making, why the decomposition of hydrogen peroxide is *exothermic*.

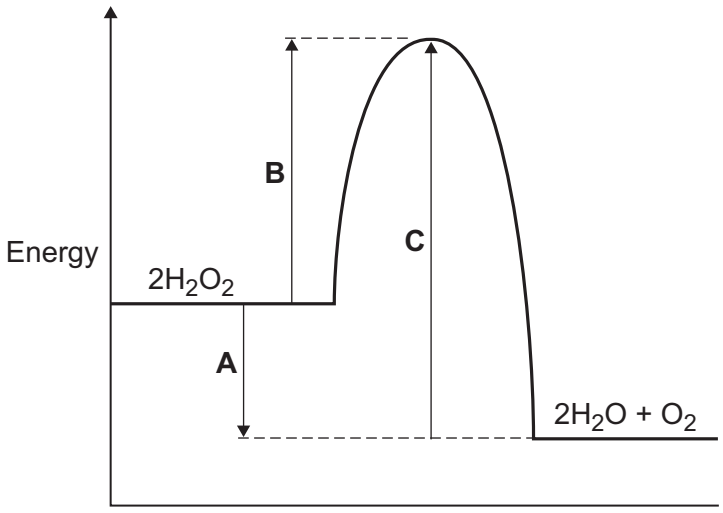
.....

.....

.....

(1 mark)

4 (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.

4 (b) (i) How do you know that this reaction is *exothermic*?

.....

.....

.....

(1 mark)

4 (b) (ii) The decomposition of hydrogen peroxide is slow.
What does this suggest about energy change **B**?

.....

.....

.....

(1 mark)

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 27 · continued

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

Explain why.

.....

.....

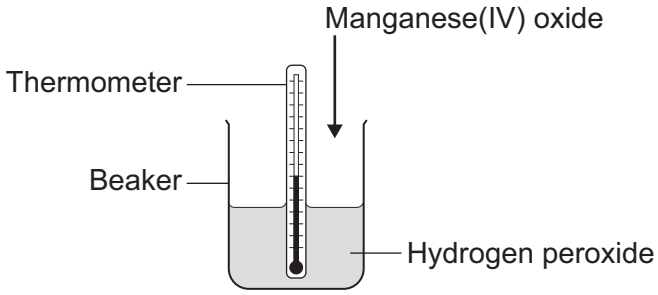
.....

.....

(2 marks)

4 (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 and recorded the highest temperature.

The temperature rise was smaller than expected.

Suggest why.

.....

.....

.....

.....

.....

(2 marks)

7

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 28

November 2011 | CHY1AP | Original Q7 | Legacy

QUESTION SEVEN

Titanium (Ti) is extracted from the ore called rutile. Rutile is mainly made up of titanium oxide (TiO_2). Titanium is not very reactive so it should be possible to displace titanium from its oxide with carbon. But carbon reacts with titanium, making it very brittle.

Therefore, titanium is extracted by reacting titanium chloride ($TiCl_4$) with sodium. Titanium chloride is produced by reacting titanium oxide with chlorine. The sodium used for the reaction is obtained by electrolysis.

The titanium chloride is added to a reactor in which sodium has been heated to about 550 °C in an inert argon atmosphere. During the reaction, the temperature increases to about 1000 °C.
After the reaction is complete, and everything has cooled, which can take several days, the mixture is crushed and washed with water to remove the sodium chloride (NaCl).

7A Which row in the table is the correct order of reactivity for carbon, sodium and titanium?

	Most reactive ⟶		Least reactive
1	sodium	carbon	titanium
2	carbon	titanium	sodium
3	titanium	carbon	sodium
4	sodium	titanium	carbon

7B The equation for the reaction of titanium chloride with sodium is shown below.

$$TiCl_4 + 4Na \rightarrow Ti + 4NaCl$$

When 190 g of titanium chloride were reacted with sodium, 48 g of titanium and 234 g of sodium chloride were produced.

How much sodium is required to produce 48 g of titanium?

1 23 g

2 92 g

3 190 g

4 234 g

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 28 · continued

7C A student suggested that there are four possible reasons why titanium is expensive.

J the cost of the process used to remove the sodium chloride
K large amounts of energy are needed to produce the sodium
L it takes several days to complete the process of separating the mixture
M the reacting mixture needs to be cooled to a low temperature

Which two of these reasons are correct?

1 **J** and **M**

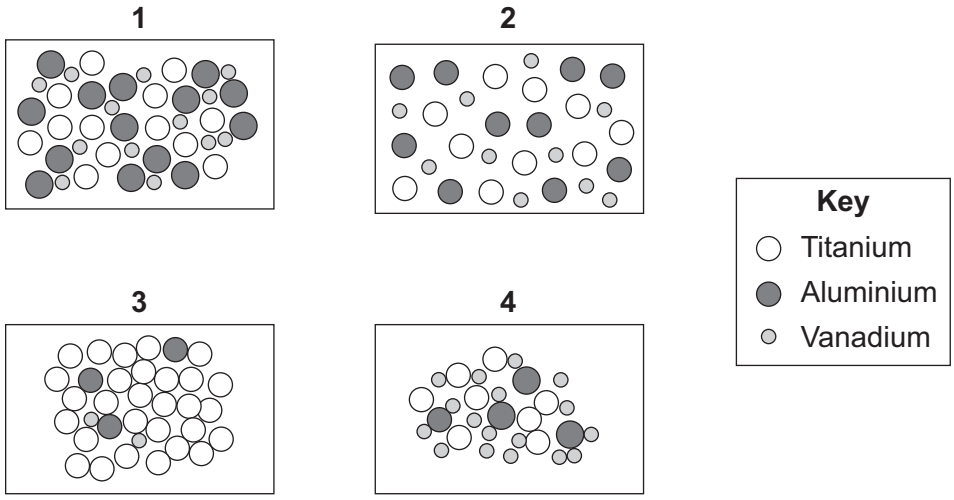
2 **K** and **L**

3 **J** and **K**

4 **L** and **M**

7D Titanium is often alloyed with small amounts of vanadium (4 %) and aluminium (6 %). This makes the titanium harder and stronger.

Which of the diagrams below shows the atoms in a sample of this titanium alloy?



4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 29

November 2011 | CHY1BP | Original Q6 | Legacy

QUESTION SIX

The atmosphere is made up of many different gases.

The abundance, melting points, and the boiling points of the noble gases are given in the table.

Noble gas	Abundance (percentage in the atmosphere by volume)	Melting point in °C	Boiling point in °C
Helium	0.0005	–272	–269
Neon	0.0018	–248	–229
Argon	0.93	–189	–186
Krypton	0.0001	–157	–153
Xenon	0.000009	–112	–108

6A Which of the following statements about the gases in the atmosphere is correct?

1 There is about 10 times as much argon as krypton.

2 There is about 20 times as much oxygen as argon.

3 There is about 4 times as much oxygen as nitrogen.

4 There is about 5 times as much nitrogen as oxygen.

6B Which noble gas is liquid over the largest temperature range?

1 neon

2 krypton

3 helium

4 argon

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 29 · continued

6C Which row in the table below correctly describes the properties of the noble gases?

	Melting point/boiling point	Use	Position in the periodic table
1	Melting point above room temperature (20 °C)	Provides a reactive atmosphere	In group 0
2	Melting point below room temperature (20 °C)	Provides an unreactive atmosphere	In group 7
3	Boiling point below room temperature	Provides a reactive atmosphere	In group 1
4	Boiling point is higher than the melting point	Provides an unreactive atmosphere	In group 0

6D The average concentration of carbon dioxide in the atmosphere is about 390 parts per million (0.039 %).

Which row in the table below shows the best way to measure this amount?

	Instrument reading to . . .	How readings are taken and used
1	10 parts per million	In several locations in a small area and take an average
2	2 parts per million	Average the highest and lowest values obtained
3	10 parts per million	Take values from industrialised areas and take an average
4	2 parts per million	Average the values taken over a large number of randomly selected locations

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 30

June 2012 | CH2HP | Original Q3 | Legacy

3 The symbol equation for the decomposition of hydrogen peroxide is:

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

3 (a) This reaction is *exothermic*.

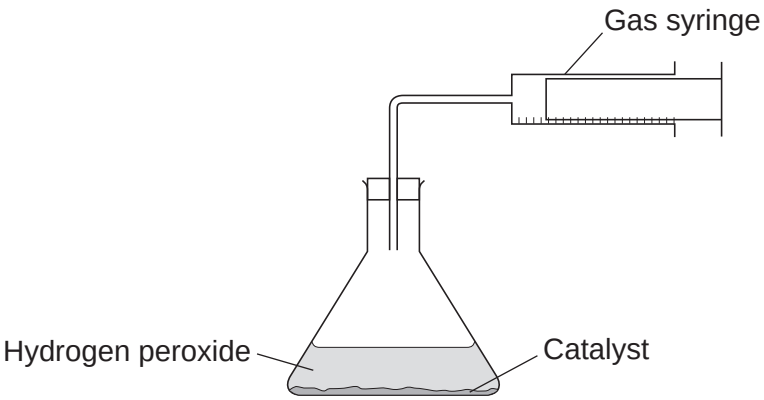
What is an *exothermic* reaction?

.....

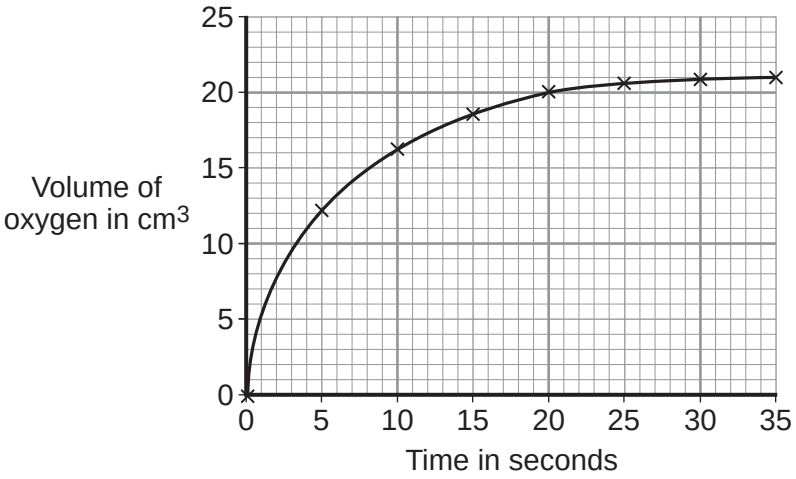
.....

(1 mark)

3 (b) A student measured the volume of oxygen produced by 50 cm^3 of hydrogen peroxide.



The graph shows the results.



4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 30 · continued

3 (b) (i) Use the graph to describe the changes in the rate of the reaction from 0 to 35 seconds.

.....

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.....

.....

(3 marks)

3 (b) (ii) What was the total volume of oxygen gas collected? ..... cm^3

(1 mark)

3 (b) (iii) The student had calculated that the hydrogen peroxide used should produce 25 cm^3 of oxygen.

Calculate the percentage yield of oxygen.

.....

.....

.....

Answer = ... %

(2 marks)

3 (c) An increase in the temperature of the hydrogen peroxide increases the rate of the reaction.

Use your knowledge of particles to explain why.

.....

.....

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.....

.....

.....

(3 marks)

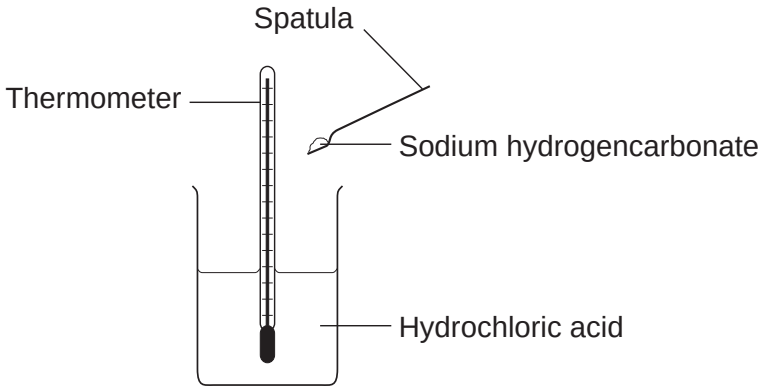
10

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 31

June 2013 | CH2HP | Original Q1 | Legacy

1 (a) Some students did an experiment to find the temperature change when hydrochloric acid reacts with sodium hydrogencarbonate.



The results are in the table.

Number of spatula measures of sodium hydrogencarbonate	Start temperature in °C	Final temperature in °C	Change in temperature in °C
2	20	16	4
4	20	14	6
6	19	11	8
8	20	10	10
10	19	9	10
12	20	10	10

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 31 · continued

1 (a) (i) Describe, as fully as you can, the trends shown in the students' results.

.....

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(3 marks)

1 (a) (ii) State the type of energy transfer for this reaction.

.....

.....

(1 mark)

Question 1 continues on the next page

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 31 · continued

1 (b) Sodium hydrogencarbonate is used as baking powder for making cakes.

When the cake mixture is baked the sodium hydrogencarbonate decomposes.

The equation for the reaction is:

$$2\,NaHCO_3(s) \xrightarrow{\text{Heat}} Na_2CO_3(s) + H_2O(g) + CO_2(g)$$

1 (b) (i) The cake mixture rises when baked.



Use the equation to suggest why.

.....

.....

(1 mark)

1 (b) (ii) The same reaction can be reversed to produce sodium hydrogencarbonate from sodium carbonate.

$$Na_2CO_3 + H_2O + CO_2 \longrightarrow 2\,NaHCO_3$$

Do the reactants need to be heated?

Give a reason for your answer.

.....

.....

(1 mark)

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 31 · continued

1 (c) (i) Calculate the relative formula mass of sodium hydrogencarbonate ($NaHCO_3$).

Relative atomic masses (A_r): H=1; C=12; O=16; Na=23

.....

.....

.....

Relative formula mass (M_r) = ...

(2 marks)

1 (c) (ii) Calculate the percentage by mass of carbon in sodium hydrogencarbonate.

.....

.....

Percentage of carbon = ... %

(1 mark)

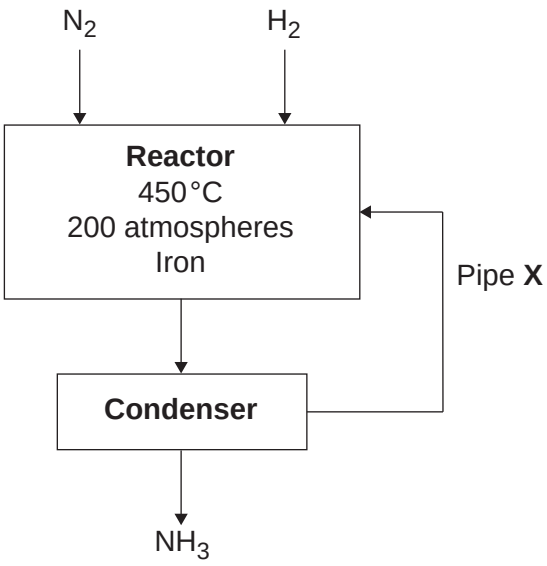
9

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 32

June 2013 | CH3HP | Original Q6 | Legacy

6 The flow diagram shows the Haber process. In the Haber process, ammonia (NH_3) is produced from nitrogen (N_2) and hydrogen (H_2).



6 (a) Which raw material is nitrogen obtained from?

.....

(1 mark)

6 (b) What is the purpose of Pipe **X**?

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.....

(2 marks)

6 (c) Balance the chemical equation below for the production of ammonia.

N_2 + ...H_2 $\rightleftharpoons$ .....NH_3

(1 mark)

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 32 · continued

6 (d) A temperature of 450 °C is used in the reactor.
The reaction of nitrogen with hydrogen is reversible.
The forward reaction is exothermic.

Explain why a temperature of 450 °C is the optimum temperature for the Haber process.

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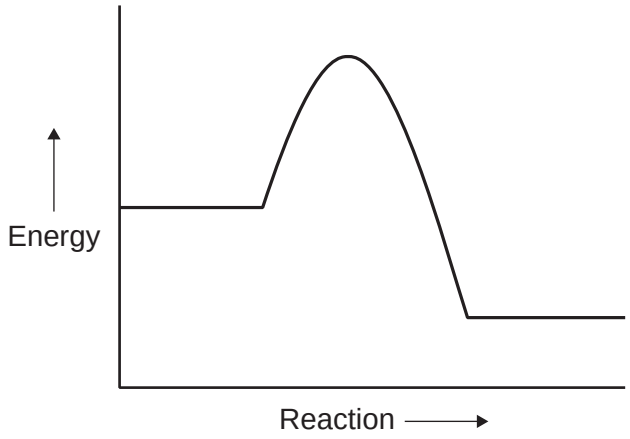
(2 marks)

6 (e) An energy level diagram for the reaction between nitrogen and hydrogen is shown below.



6 (e) (i) How does the energy level diagram show this reaction is exothermic?

.....

.....

(1 mark)

6 (e) (ii) In the Haber process iron is used as a catalyst.

Draw a line on the energy level diagram to show the effect of adding a catalyst.

(1 mark)

8

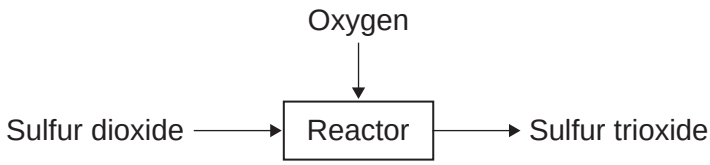
4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 33

June 2014 | CH2HP | Original Q3 | Legacy

3 **Figure 2** represents a reaction in the production of sulfuric acid.

Figure 2



3 (a) Complete and balance the equation for the reaction.

[2 marks]

..... $SO_2(g)$ + ... (g) $\rightleftharpoons$ ..... $SO_3(g)$

3 (b) The conditions can affect the rate of the reaction.

3 (b) (i) The pressure of the reacting gases was increased.

State the effect of increasing the pressure on the rate of reaction.

Explain your answer in terms of particles.

[3 marks]

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4.5.1.1 Energy transfer during exothermic and endothermic reactions

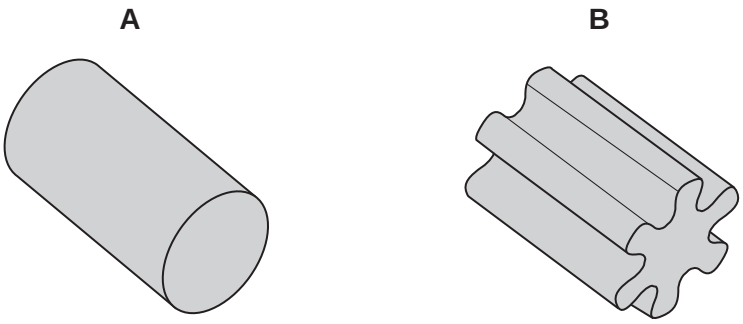
Question 33 · continued

3 (b) (ii) A catalyst is used for the reaction.

The gases pass through a layer containing pieces of the catalyst.

Figure 3 shows the shapes of pieces of catalyst.

Figure 3



Suggest and explain why shape **B** is more effective as a catalyst than shape **A**.

[2 marks]

.....

.....

.....

.....

3 (c) The reaction is carried out at a high temperature to provide the reactants with the **activation energy**.

What is meant by the **activation energy**?

[1 mark]

.....

.....

.....

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 33 · continued

3 (d) Sulfuric acid reacts with metals to produce salts.

3 (d) (i) A student concluded that potassium would **not** be a suitable metal to react with sulfuric acid.

Explain why.

[2 marks]

.....

.....

.....

.....

3 (d) (ii) A student reacted zinc metal with sulfuric acid to produce a salt and another product.

Complete the equation for this reaction.

[2 marks]

$Zn + H_2SO_4 \longrightarrow$ ..... + ...

3 (d) (iii) The student wanted to increase the rate of the reaction between the zinc and sulfuric acid.

State **one** way, other than using a catalyst, that the student could increase the rate of the reaction.

[1 mark]

.....

.....

13

4.5.1.1 Energy transfer during exothermic and endothermic reactions

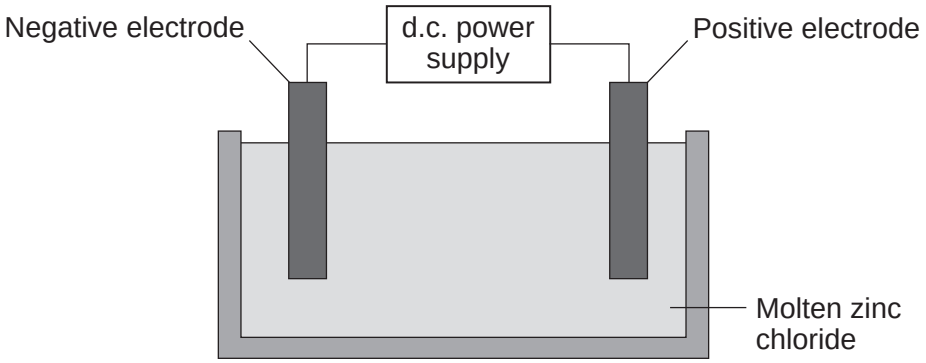
Question 34

June 2014 | CH2HP | Original Q4 | Legacy

4 This question is about zinc and magnesium.

Zinc is produced by electrolysis of molten zinc chloride, as shown in **Figure 4**.

Figure 4



4 (a) (i) Why must the zinc chloride be molten for electrolysis?

[1 mark]

.....

.....

4 (a) (ii) Describe what happens at the negative electrode.

[3 marks]

.....

.....

.....

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.....

.....

4 (a) (iii) Complete the half equation for the reaction at the positive electrode.

[1 mark]

..... $\longrightarrow$ Cl_2 + ... e^-

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 34 · continued

4 (b) Magnesium can be produced from magnesium oxide.

The equation for the reaction is:

$$Si(s) + 2\,MgO(s) \rightleftharpoons SiO_2(s) + 2\,Mg(g)$$

4 (b) (i) How can you tell from the equation that the reaction is done at a high temperature?

[1 mark]

.....

.....

4 (b) (ii) This reaction to produce magnesium from magnesium oxide is **endothermic**.

What is meant by an **endothermic** reaction?

[1 mark]

.....

.....

4 (b) (iii) A company made magnesium using this reaction.

Calculate the mass of magnesium oxide needed to produce 1.2 tonnes of magnesium.

Relative atomic masses (A_r): O = 16; Mg = 24

[3 marks]

.....

.....

.....

.....

Mass of magnesium oxide needed = ... tonnes

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 34 · continued

4 (b) (iv) The company calculated that they would produce 1.2 tonnes of magnesium, but only 0.9 tonnes was produced.

Calculate the percentage yield.

[1 mark]

.....

.....

Percentage yield = ... %

4 (b) (v) Give **one** reason why the calculated yield of magnesium might not be obtained.

[1 mark]

.....

.....

12

Turn over for the next question

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 35

June 2014 | CH3HP | Original Q6 | Legacy

6 Some cars are powered by hydrogen fuel cells.

Figure 6



6 (a) What type of energy is released by hydrogen fuel cells?

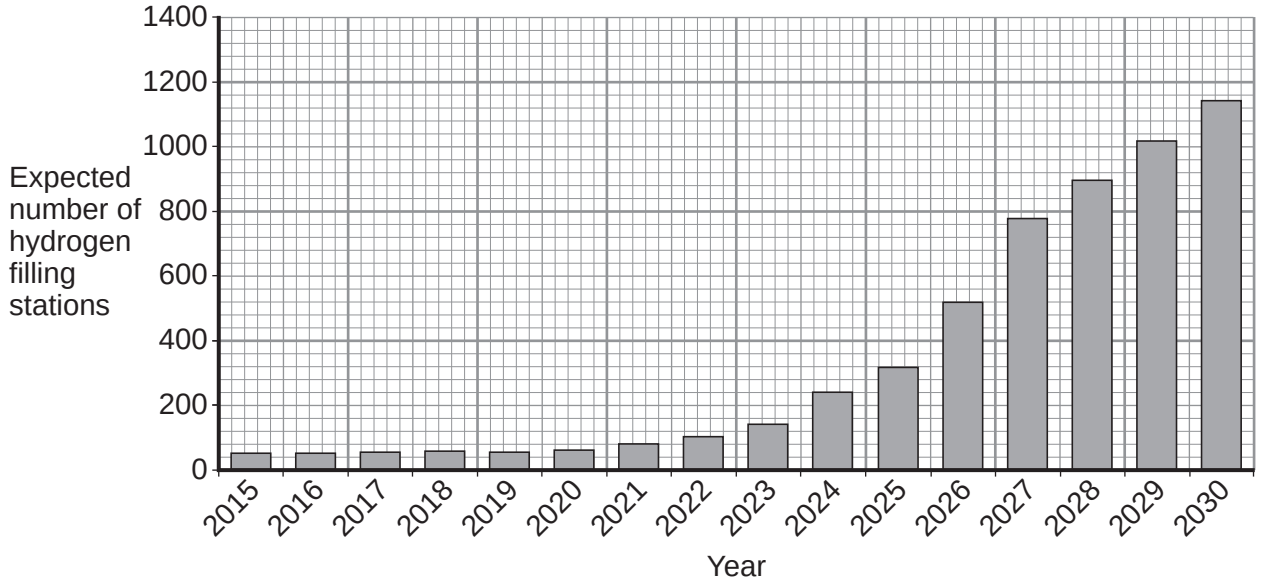
[1 mark]

.....

6 (b) Owners of cars powered by fuel cells buy hydrogen from hydrogen filling stations.

Figure 7 shows how the number of hydrogen filling stations in the UK is expected to increase up to the year 2030.

Figure 7



4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 35 · continued

Use the information in **Figure 7** and your own knowledge to answer this question.

Suggest **two** reasons why the UK government might encourage the building of more hydrogen filling stations.

[2 marks]

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Question 6 continues on the next page

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 35 · continued

6 (c) The equation for the reaction of hydrogen with oxygen is:

$$2H_2 + O_2 \longrightarrow 2H_2O$$

During the reaction, energy is used to break the bonds of the reactants.

Energy is released when new bonds are made to form the product.

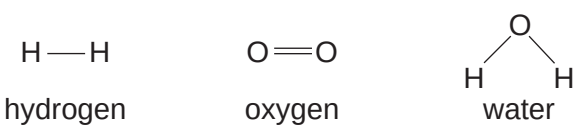
Bond energies for the reaction are given in **Table 1**.

Table 1

Bond	Bond energy in kJ
H—H	436
O=O	498
O—H	464

The structures of the reactants and product are shown in **Figure 8**.

Figure 8



6 (c) (i) Calculate the energy change for the reaction:

$$2H_2 + O_2 \longrightarrow 2H_2O$$

[3 marks]

.....

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.....

Energy change = ... kJ

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 35 · continued

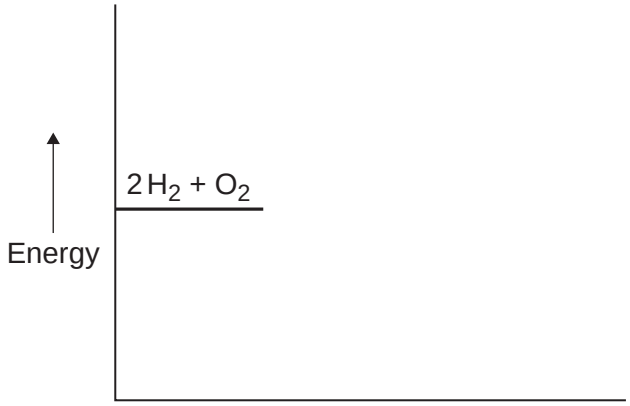
6 (c) (ii) The reaction of hydrogen with oxygen is exothermic.

Complete the energy level diagram for this reaction on **Figure 9**.

Clearly label the activation energy.

[3 marks]

Figure 9



9

4.5.1.1 Energy transfer during exothermic and endothermic reactions

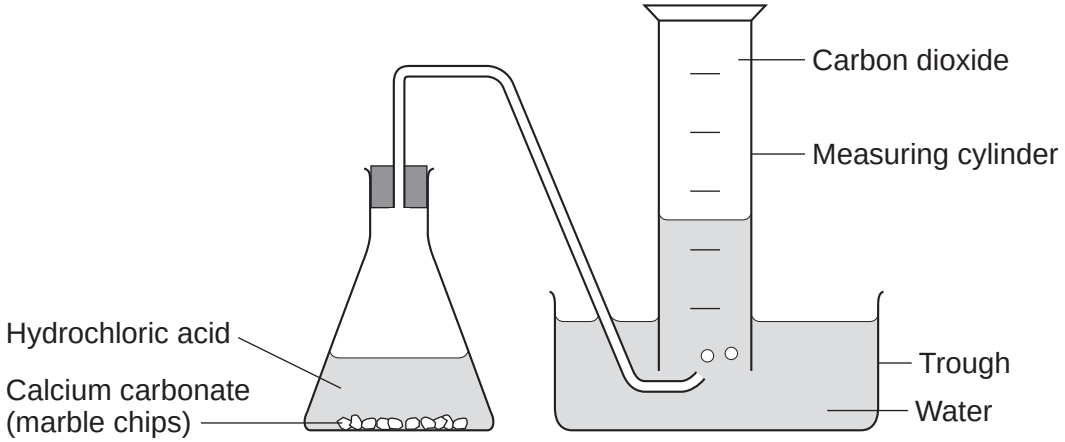
Question 36

June 2015 | CH2HP | Original Q1 | Legacy

1 A student investigated the rate of reaction between calcium carbonate (marble chips) and hydrochloric acid.

The student used the apparatus shown in **Figure 1**.

Figure 1



The student:

- recorded the volume of gas collected every 5 seconds
- repeated the experiment using hydrochloric acid at different temperatures.

The equation for the reaction is:

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

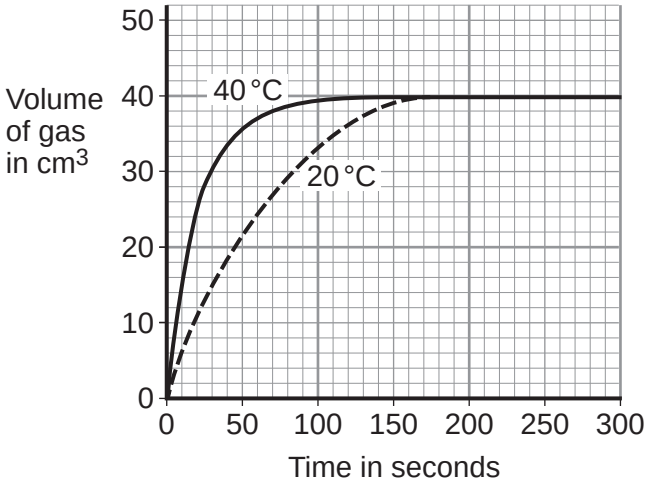
4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 36 · continued

1 (a) The student plotted results for the hydrochloric acid at 20 °C and 40 °C on a graph.

Figure 2 shows the student's graph.

Figure 2



Use information from **Figure 2** to answer these questions.

1 (a) (i) State **one** conclusion the student could make about the effect of temperature on the rate of the reaction.

[1 mark]

.....

.....

1 (a) (ii) Give **one** reason why the student could make this conclusion.

[1 mark]

.....

.....

1 (a) (iii) For the hydrochloric acid at 60 °C the student had collected 30 cm^3 after 15 seconds.

Calculate the average rate of reaction from 0 to 15 seconds.

[1 mark]

.....

.....

Rate of reaction = ... cm^3 per second

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 36 · continued

1 (b) The student then investigated how the surface area of marble chips affected the rate of reaction.

1 (b) (i) Which **two** variables should the student keep constant?

[2 marks]

Tick (✓) **two** boxes.

- Amount of water in the trough ☐
- Concentration of acid ☐
- Mass of marble chips ☐
- Size of marble chips ☐
- Volume of measuring cylinder ☐

1 (b) (ii) Explain, in terms of particles and collisions, the effect that increasing the surface area of the marble chips has on the rate of reaction.

[2 marks]

.....

.....

.....

.....

1 (c) Calcium carbonate is a catalyst for the industrial production of biodiesel.

Give **one** reason why using a catalyst reduces costs.

[1 mark]

.....

.....

8

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 37

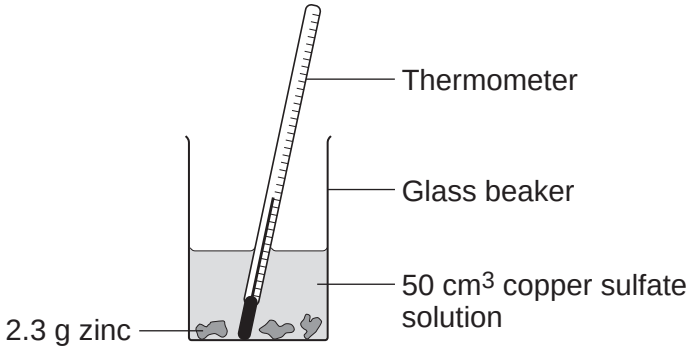
June 2015 | CH2HP | Original Q2 | Legacy

2 A student investigated the temperature change when zinc reacts with copper sulfate solution.

The student used a different concentration of copper sulfate solution for each experiment.

The student used the apparatus shown in **Figure 3**.

Figure 3



The student:

- measured 50 cm^3 copper sulfate solution into a glass beaker
- measured the temperature of the copper sulfate solution
- added 2.3 g zinc
- measured the highest temperature
- repeated the experiment using copper sulfate solution with different concentrations.

The equation for the reaction is:

$$Zn(s) + CuSO_4(aq) \longrightarrow Cu(s) + ZnSO_4(aq)$$

zinc + copper sulfate solution ⟶ copper + zinc sulfate solution

2 (a) The thermometer reading changes during the reaction.

Give **one** other change the student could **see** during the reaction.

[1 mark]

.....

.....

Question 2 continues on the next page

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 37 · continued

2 (b) Suggest **one** improvement the student could make to the apparatus in **Figure 3**.

Give a reason why this improves the investigation.

[2 marks]

Improvement .....

.....

Reason .....

.....

2 (c) **In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.**

The student's results are shown in **Table 1**.

Table 1

Experiment number	Concentration of copper sulfate in moles per dm^3	Increase in temperature in °C
1	0.1	5
2	0.2	10
3	0.3	12
4	0.4	20
5	0.5	25
6	0.6	30
7	0.7	35
8	0.8	35
9	0.9	35
10	1.0	35

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 37 · continued

Describe **and** explain the trends shown in the student's results.

[6 marks]

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Extra space .....

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4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 38

June 2015 | CH3HP | Original Q6 | Legacy

6 This question is about reversible reactions and chemical equilibrium.

6 (a) Reversible reactions can reach equilibrium in a closed system.

6 (a) (i) What is meant by a closed system?

[1 mark]

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.....

6 (a) (ii) Explain why, when a reversible reaction reaches equilibrium, the reaction appears to have stopped.

[2 marks]

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4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 38 · continued

6 (b) In the Haber process, the reaction of nitrogen with hydrogen to produce ammonia is reversible.

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

6 (b) (i) Name a natural resource from which hydrogen is produced.

[1 mark]

.....

6 (b) (ii) The Haber process uses a catalyst to speed up the reaction.

Explain how a catalyst speeds up a reaction.

[2 marks]

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6 (b) (iii) What happens to the amount of ammonia produced at equilibrium if the pressure is increased?

Give a reason for your answer.

[2 marks]

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Question 6 continues on the next page

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 38 · continued

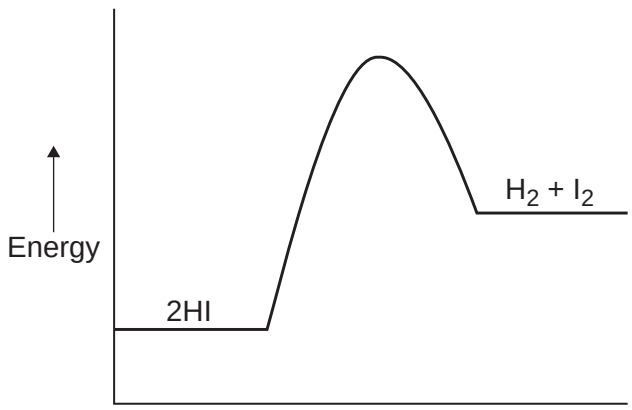
6 (c) The decomposition of hydrogen iodide into hydrogen and iodine is reversible.

$$2HI(g) \rightleftharpoons H_2(g) + I_2(g)$$

The forward reaction is endothermic.

The energy level diagram in **Figure 3** is for the forward reaction.

Figure 3



6 (c) (i) Draw an arrow to show the activation energy on the diagram in **Figure 3**.

[1 mark]

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 38 · continued

6 (c) (ii) How does the diagram in **Figure 3** show that the reaction is endothermic?

[1 mark]

.....

.....

6 (c) (iii) Suggest what effect, if any, increasing the temperature will have on the amount of hydrogen iodide at equilibrium.

Give a reason for your answer.

[2 marks]

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12

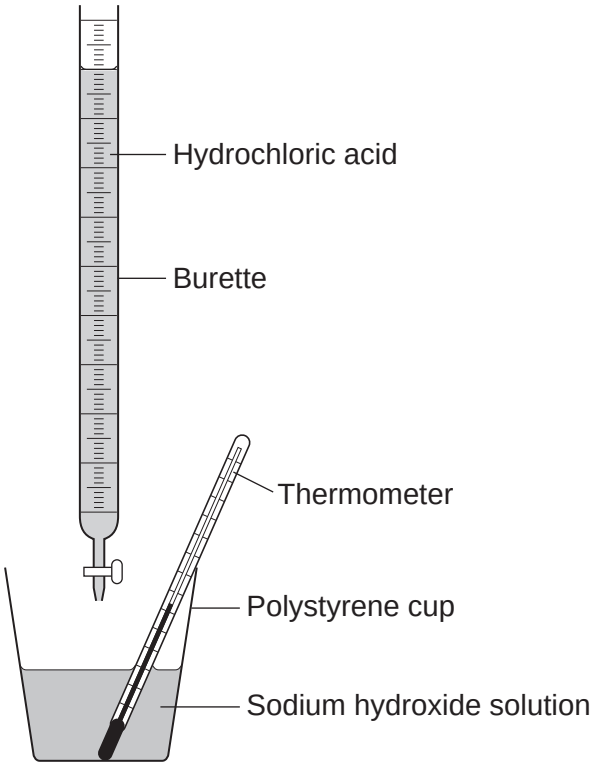
4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 39

June 2015 | CH3HP | Original Q8 | Legacy

8 A student investigates the energy released when hydrochloric acid completely neutralises sodium hydroxide solution.
The student uses the apparatus shown in **Figure 4**.

Figure 4



The student:

- measures 25 cm^3 sodium hydroxide solution into a polystyrene cup
- fills a burette with hydrochloric acid
- measures the temperature of the sodium hydroxide solution
- adds 5 cm^3 hydrochloric acid to the sodium hydroxide solution in the polystyrene cup
- stirs the mixture and measures the highest temperature of the mixture
- continues to add 5 cm^3 portions of hydrochloric acid, stirring and measuring the highest temperature of the mixture after each addition.

Question 8 continues on the next page

4.5.1.1 Energy transfer during exothermic and endothermic reactions

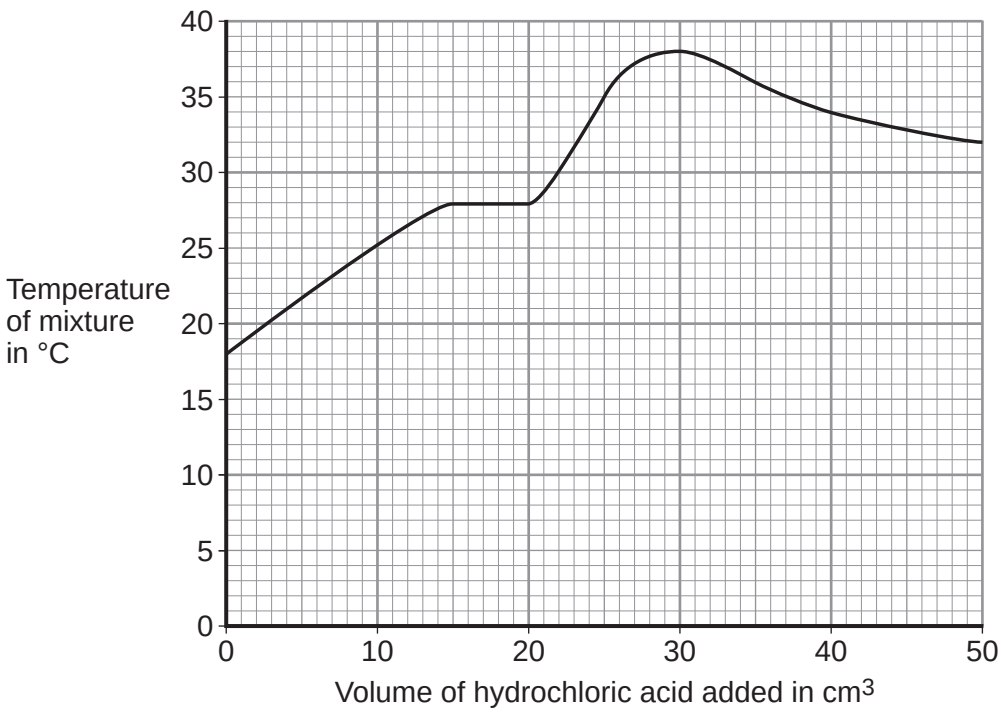
Question 39 · continued

8 (a) The student has plotted a graph of the results.

The graph line has been incorrectly drawn by including an anomalous result.

The graph is shown in **Figure 5**.

Figure 5



8 (a) (i) Suggest a cause for the anomalous result when 20 cm^3 of hydrochloric acid is added.

[1 mark]

.....

.....

8 (a) (ii) Suggest the true value of the temperature of the anomalous point.

[1 mark]

Temperature = ... °C

8 (a) (iii) What was the **total** volume of the mixture when the maximum temperature was reached?

[1 mark]

.....

Total volume of the mixture = ... cm^3

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 39 · continued

8 (a) (iv) Calculate the overall temperature increase in this experiment.

[1 mark]

.....

Overall temperature increase = ... °C

8 (a) (v) Use your answers to **8(a)(iii)** and **8(a)(iv)** and the equation to calculate the energy released in the reaction. Give the unit.

[2 marks]

Assume the volume in cm^3 is equivalent to the mass of solution in grams.

Equation: $Q = mc\Delta T$

where:
Q = energy released
m = mass of solution (g)
c = 4.2 (J per g per °C)
ΔT = change in temperature (°C)

.....

.....

Energy released = ... Unit = ...

8 (b) The student did the experiment on page 19 again, starting with 50 cm^3 of sodium hydroxide solution instead of 25 cm^3.

Explain why this would make no difference to the overall temperature increase.

[2 marks]

.....

.....

.....

.....

8

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 40

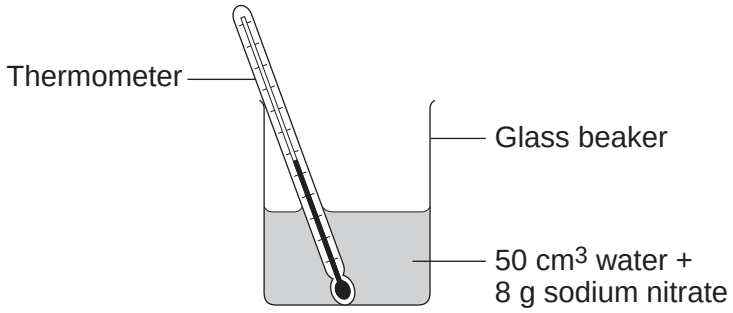
June 2016 | CH2HP | Original Q1 | Legacy

1 This question is about temperature changes.

1 (a) A student investigated the temperature change when 8 g of sodium nitrate dissolves in 50 cm^3 of water.

Figure 1 shows the apparatus the student used.

Figure 1



The student did the experiment five times.
Table 1 shows the results.

Table 1

Experiment	Decrease in temperature of water in °C
1	5.9
2	5.7
3	7.2
4	5.6
5	5.8

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 40 · continued

1 (a) (i) Calculate the mean decrease in temperature.
Do not use the anomalous result in your calculation.

[2 marks]

Mean decrease in temperature = _____ °C

1 (a) (ii) Suggest **one** change in the apparatus in **Figure 1** which would improve the accuracy of the results.
Give a reason for your answer.

[2 marks]

Question 1 continues on the next page

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 40 · continued

1 (b) The student investigated the temperature change when different masses of sodium carbonate were added to 50 cm^3 of water at 20 °C.

Table 2 shows the results.

Table 2

Mass of sodium carbonate in g	Final temperature of solution in °C
2.0	21.5
4.0	23.0
6.0	24.5
8.0	26.0
10.0	26.6
12.0	26.6
14.0	26.6

Describe the relationship between the mass of sodium carbonate added and the final temperature of the solution.

Use values from **Table 2** in your answer.

[3 marks]

7

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 41

June 2016 | CH2HP | Original Q2 | Legacy

2 This question is about ammonia and fertilisers.

2 (a) Ammonia is produced by a reversible reaction.

The equation for the reaction is:

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

Complete the sentence.

[1 mark]

The forward reaction is exothermic, so the reverse reaction is _____ .

2 (b) Calculate the percentage by mass of nitrogen in ammonia (NH_3).
Relative atomic masses (A_r): H = 1; N = 14
You **must** show how you work out your answer.

[3 marks]

_____

_____

_____

_____

_____

_____

Percentage by mass of nitrogen = _____ %

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 41 · continued

2 (c) A neutral solution can be produced when ammonia reacts with an acid.

2 (c) (i) Give the pH of a neutral solution.

[1 mark]

pH _____

2 (c) (ii) Which of these ionic equations shows a neutralisation reaction?

[1 mark]

Tick (✓) **one** box.

$H^+ + OH^- \longrightarrow H_2O$ ☐

$NH_4^+ + OH^- \longrightarrow NH_4OH$ ☐

$H^+ + Cl^- \longrightarrow HCl$ ☐

$H^+ + H_2O \longrightarrow H_3O^+$ ☐

2 (c) (iii) Name the salt produced when ammonia reacts with hydrochloric acid.

[1 mark]

_____

Question 2 continues on the next page

Question 41 · continued

2 (d) **In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.**

Farmers use ammonium nitrate as a fertiliser for crops.

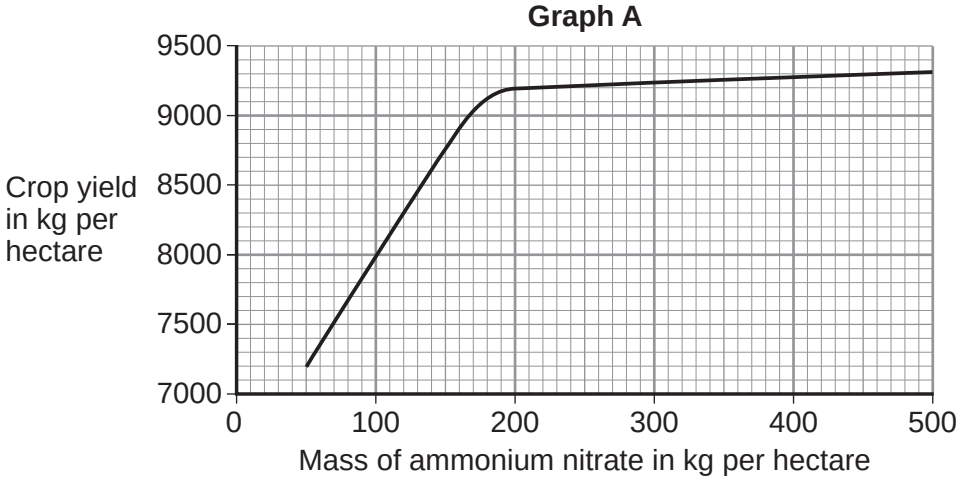
Rainwater dissolves ammonium nitrate in the soil.

Some of the dissolved ammonium nitrate runs off into rivers and lakes.

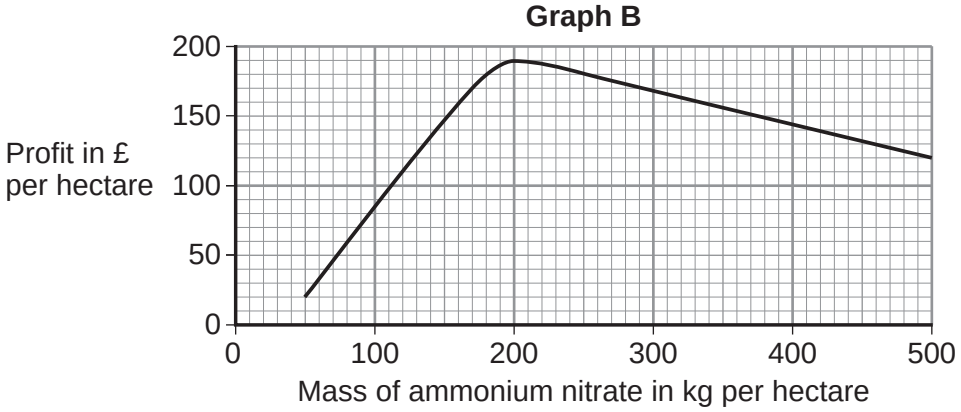
Figure 2 shows three graphs **A**, **B** and **C**. The graphs show information about the use of ammonium nitrate as a fertiliser. A hectare is a measurement of an area of land.

Figure 2

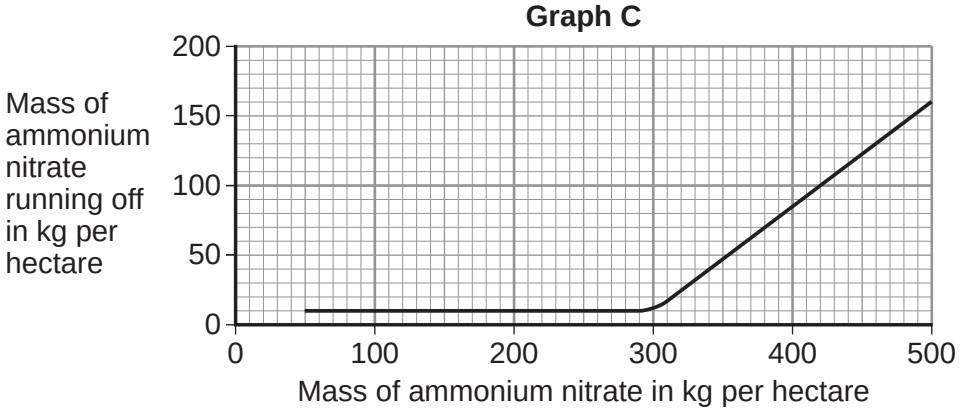
Graph A



Graph B



Graph C



4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 41 · continued

Suggest how much ammonium nitrate farmers should use per hectare.
Give reasons for your answer.
Use information from graphs **A**, **B** and **C**.

[6 marks]

Extra space

13

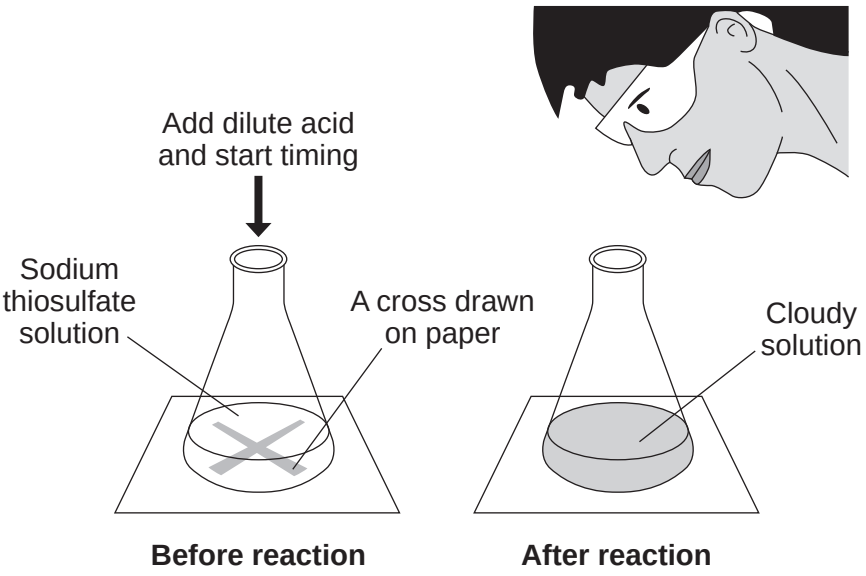
4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 42

June 2016 | CH2HP | Original Q4 | Legacy

4 A student investigated the effect of temperature on the rate of a reaction.
Figure 4 shows an experiment.

Figure 4



The student:

- put 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 dilute hydrochloric acid and started a stopclock
- stopped the stopclock when the cross could no longer be seen
- repeated the experiment at different temperatures.

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

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 42 · continued

4 (a) Explain why the solution goes cloudy.

[2 marks]

4 (b) Give **two** variables the student must control to make the investigation a fair test.

[2 marks]

1 _____

2 _____

4 (c) State the effect that increasing the temperature of the sodium thiosulfate solution has on the rate of the reaction.
Explain this effect in terms of particles and collisions.

[4 marks]

4 (d) Suggest how the student should change the method to investigate the rate of reaction at 5 °C.

[1 mark]

9

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 43

June 2016 | CH3HP | Original Q5 | Legacy

5 This question is about energy changes in chemical reactions.

5 (a) Balance the chemical equation for the combustion of methane.

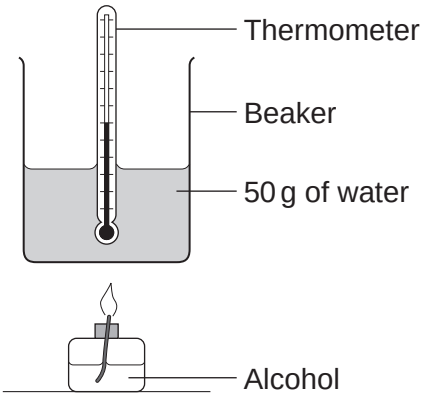
[1 mark]

$$CH_4 \quad + \quad O_2 \quad \longrightarrow \quad CO_2 \quad + \quad H_2O$$

5 (b) Alcohols are used as fuels.

A group of students investigated the amount of energy released when an alcohol was burned. The students used the apparatus shown in **Figure 5**.

Figure 5



In one experiment the temperature of 50 g of water increased from 22.0 °C to 38.4 °C. The mass of alcohol burned was 0.8 g.

Calculate the heat energy (Q) in joules, released by burning 0.8 g of the alcohol.
Use the equation:

$$Q = m \times c \times \Delta T$$

Specific heat capacity (c) = 4.2 J/g/°C

[3 marks]

Heat energy (Q) = _____ J

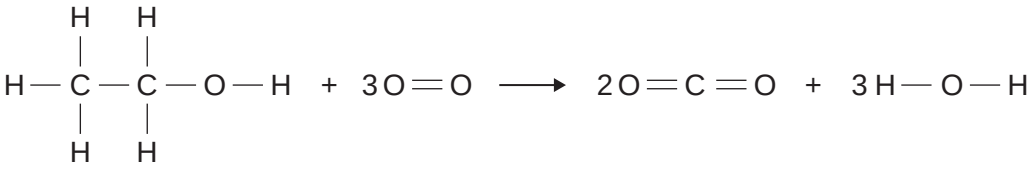
4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 43 · continued

5 (c) The chemical equation for the combustion of ethanol is:

$$C_2H_5OH + 3O_2 \longrightarrow 2CO_2 + 3H_2O$$

5 (c) (i) The equation for the reaction can be shown as:



Bond	Bond energy in kJ per mole
C — H	413
C — C	347
C — O	358
C = O	799
O — H	467
O = O	495

Use the bond energies to calculate the overall energy change for this reaction.

[3 marks]

Overall energy change = _____ kJ per mole

Question 5 continues on the next page

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 43 · continued

5 (c) (ii) The reaction is exothermic.
Explain why, in terms of bonds broken and bonds formed.

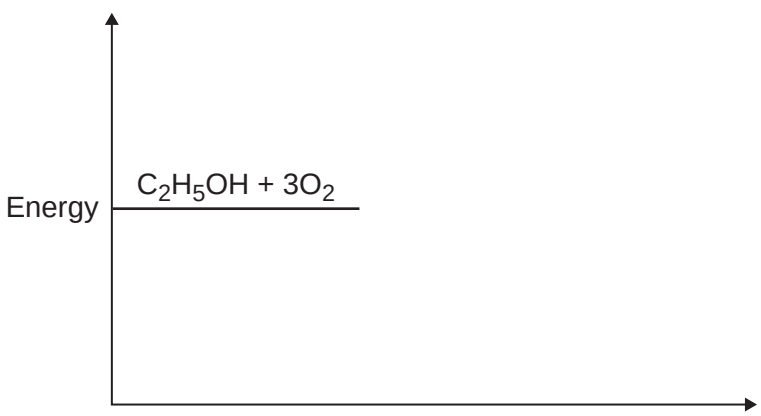
[2 marks]

5 (c) (iii) Complete the energy level diagram for the combustion of ethanol.

[3 marks]

On the completed diagram, label:

- activation energy
- overall energy change.



12

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 44

June 2017 | CH2HP | Original Q6 | Legacy

6 This question is about sodium chloride.

6 (a) A student reacted hydrochloric acid and sodium hydroxide solution to produce sodium chloride solution.

The student:

- measured 50 cm^3 of hydrochloric acid into a glass beaker
- measured the initial temperature of the hydrochloric acid
- added 50 cm^3 of sodium hydroxide solution
- stirred the mixture and measured the highest temperature of the solution.

6 (a) (i) The hydrochloric acid and sodium hydroxide solution were the same concentration.

Suggest **one** reason why the temperature change could be greater than expected.

[1 mark]

Tick (✓) **one** box.

The volume of the sodium hydroxide solution was more than 50 cm^3. ☐

The volume of the hydrochloric acid was more than 50 cm^3. ☐

The initial temperature reading was too low. ☐

The highest temperature reading was too low. ☐

6 (a) (ii) The student did the investigation three times.

Table 2 shows the results.

Table 2

Experiment number	Initial temperature of the acid in °C	Highest temperature of solution in °C
1	20	33
2	19	30
3	20	32

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 44 · continued

What conclusion can you make about the reaction from the results in **Table 2**?

[1 mark]

6 (b) The student electrolysed sodium chloride solution.

6 (b) (i) Explain what happens at the negative electrode and why sodium is **not** produced.

[3 marks]

6 (b) (ii) Chlorine gas is produced at the positive electrode.
Complete the half equation.

[1 mark]

$$____\ Cl^- \longrightarrow _____ + _____$$

6 (b) (iii) Explain why the pH of the solution after electrolysis was 14

[2 marks]

8

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 45

June 2017 | CH3HP | Original Q5 | Legacy

5 This question is about sulfuric acid and sulfates.

5 (a) One reaction in the industrial production of sulfuric acid is:

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

The forward reaction is exothermic.

5 (a) (i) Explain why a moderately high temperature, instead of a low temperature, is used for this reaction.

Use the information above and your knowledge.

[3 marks]

5 (a) (ii) Explain why you would expect this reaction to be carried out at high pressure.

[2 marks]

5 (a) (iii) This reaction is carried out at atmospheric pressure.

Suggest **one** advantage, other than cost, of using atmospheric pressure and **not** a high pressure for this reaction.

[1 mark]

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 45 · continued

5 (b) Sulfuric acid is used to produce sulfates.

Describe how sodium hydroxide solution is used to distinguish between a solution of magnesium sulfate and a solution of aluminium sulfate.

[2 marks]

_____

_____

_____

_____

8

Turn over the for the next question

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 46

June 2017 | CH3HP | Original Q6 | Legacy

6 This question is about ammonia and a compound produced from ammonia.

6 (a) Ammonia is produced by the Haber process.

6 (a) (i) The reactants in the Haber process are nitrogen and hydrogen.

Give the source of the hydrogen used for the Haber process.

[1 mark]

_____

6 (a) (ii) The Haber process produces a mixture of the gases ammonia, hydrogen and nitrogen.

Table 3 shows boiling points for ammonia, hydrogen and nitrogen.

Table 3

	Boiling point in °C
Ammonia	–33
Hydrogen	–260
Nitrogen	–196

Explain how to separate ammonia from the mixture of gases.

Use the information in **Table 3** to help you.

[2 marks]

_____

_____

_____

_____

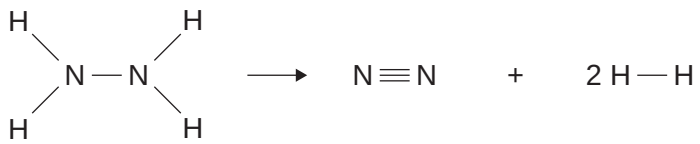
Question 6 continues on the next page

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 46 · continued

6 (b) Ammonia is used to produce hydrazine (N_2H_4).

6 (b) (i) The equation for the decomposition of hydrazine is:



Bond energies are given in **Table 4**.

Table 4

Bond	Bond energy in kJ
N — N	160
N — H	391
N ≡ N	941
H — H	432

Calculate the energy change for the decomposition of hydrazine.

[3 marks]

Energy change = _____ kJ

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 46 · continued

6 (b) (ii) The decomposition of hydrazine is exothermic.

Explain why, in terms of bond making and bond breaking.

[2 marks]

8

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 47

June 2018 | 8462/1H | Original Q5

0 5 A student investigated the temperature change in displacement reactions between metals and copper sulfate solution.

Table 2 shows the student's results.

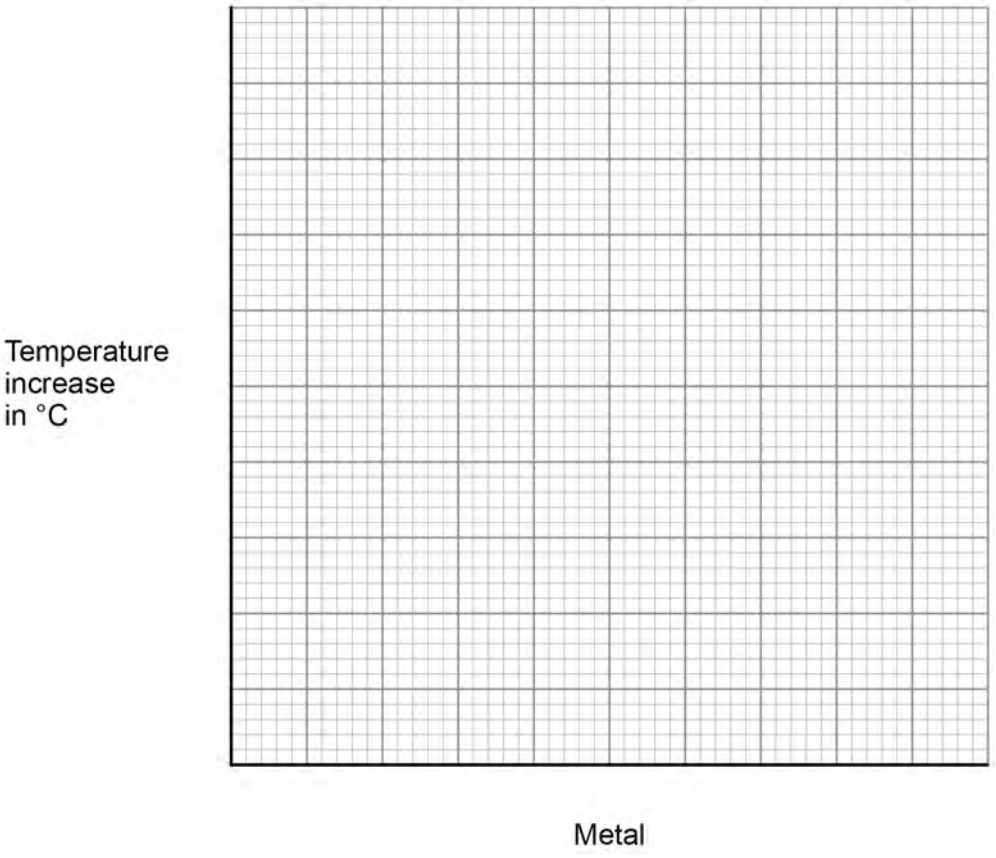
Table 2

Metal	Temperature increase in °C
Copper	0
Iron	13
Magnesium	43
Zinc	17

0 5 . 1 Plot the data from **Table 2** on **Figure 4** as a bar chart.

[2 marks]

Figure 4



4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 47 · continued

0 5 . 2 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 5 . 3 The temperature change depends on the reactivity of the metal.

The student's results are used to place copper, iron, magnesium and zinc in order of their reactivity.

Describe a method to find the position of an unknown metal in this reactivity series.

Your method should give valid results.

[4 marks]

Question 5 continues on the next page

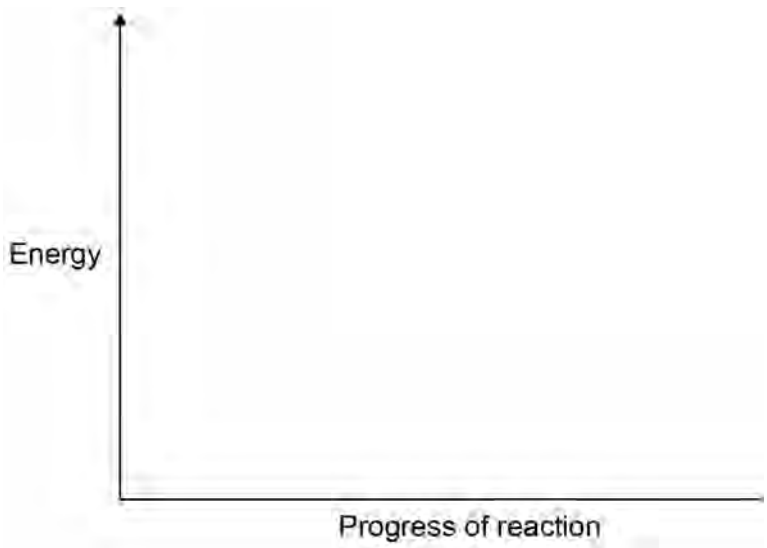
4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 47 · continued

0 5 . 4 Draw a fully labelled reaction profile for the reaction between zinc and copper sulfate solution on **Figure 5**.

[3 marks]

Figure 5



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4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 48

June 2018 | 8462/1H | Original Q7

0 7 This question is about Group 7 elements.

Chlorine is more reactive than iodine.

0 7 . 1 Name the products formed when chlorine solution reacts with potassium iodide solution.

[1 mark]

0 7 . 2 Explain why chlorine is more reactive than iodine.

[3 marks]

0 7 . 3 Chlorine reacts with hydrogen to form hydrogen chloride.

Explain why hydrogen chloride is a gas at room temperature.

Answer in terms of structure and bonding.

[3 marks]

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 48 · continued

0 7 . 4 Bromine reacts with methane in sunlight.

Figure 9 shows the displayed formulae for the reaction of bromine with methane.

Figure 9

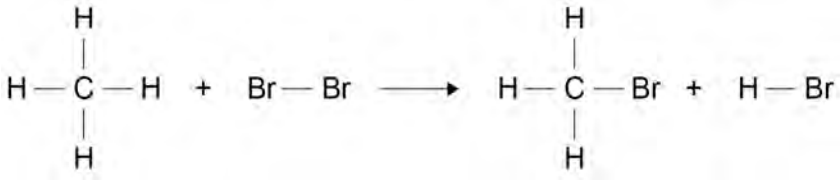


Table 3 shows the bond energies and the overall energy change in the reaction.

Table 3

	C—H	Br—Br	C—Br	H—Br	Overall energy change
Energy in kJ/mol	412	193	**X**	366	– 51

Calculate the bond energy **X** for the C—Br bond.

Use **Figure 9** and **Table 3**.

[4 marks]

Bond energy **X** = _____ kJ/mol

1

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 49

June 2018 | 8462/1H | Original Q8

0 8 Titanium is a transition metal.

Titanium is extracted from titanium dioxide in a two stage industrial process.

Stage 1 $TiO_2 + 2\,C + 2\,Cl_2 \rightarrow TiCl_4 + 2\,CO$

Stage 2 $TiCl_4 + 4\,Na \rightarrow Ti + 4\,NaCl$

0 8 . 1 Suggest **one** hazard associated with **Stage 1**.

[1 mark]

0 8 . 2 Water must be kept away from the reaction in **Stage 2**.

Give **one** reason why it would be hazardous if water came into contact with sodium.

[1 mark]

0 8 . 3 Suggest why the reaction in **Stage 2** is carried out in an atmosphere of argon and **not** in air.

[2 marks]

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 49 · continued

0 8 . 4 Titanium chloride is a liquid at room temperature.

Explain why you would **not** expect titanium chloride to be a liquid at room temperature.

[3 marks]

In **Stage 2**, sodium displaces titanium from titanium chloride.

0 8 . 5 Sodium atoms are oxidised to sodium ions in this reaction.

Why is this an oxidation reaction?

[1 mark]

0 8 . 6 Complete the half equation for the oxidation reaction.

[1 mark]

Na → _____ + _____

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 49 · continued

0 8 . 7 In **Stage 2**, 40 kg of titanium chloride was added to 20 kg of sodium.

The equation for the reaction is:

$$TiCl_4 + 4\,Na \rightarrow Ti + 4\,NaCl$$

Relative atomic masses (A_r): Na = 23 Cl = 35.5 Ti = 48

Explain why titanium chloride is the limiting reactant.

You **must** show your working.

[4 marks]

0 8 . 8 For a **Stage 2** reaction the percentage yield was 92.3%

The theoretical maximum mass of titanium produced in this batch was 13.5 kg.

Calculate the actual mass of titanium produced.

[2 marks]

Mass of titanium = _____ kg

15

4.5.1.1 Energy transfer during exothermic and endothermic reactions

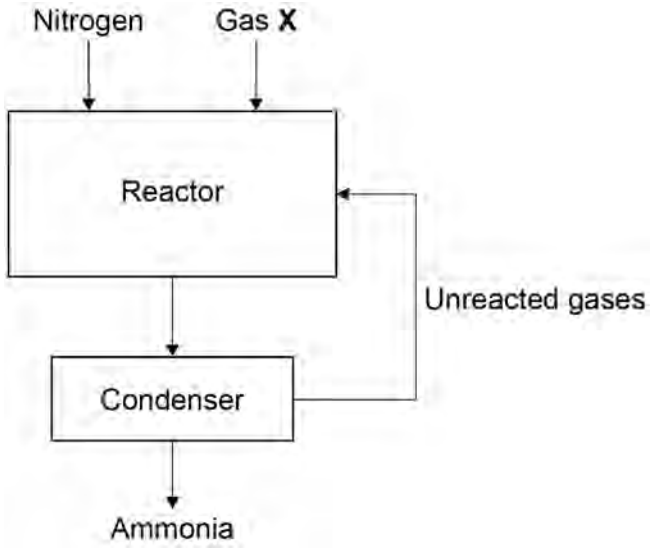
Question 50

June 2018 | 8462/2H | Original Q3

0 3 This question is about gases.

Figure 3 shows how nitrogen is used in the Haber Process to produce ammonia.

Figure 3



0 3 . 1 Gas **X** in **Figure 3** is obtained from methane.

Name gas **X**.

[1 mark]

_____

0 3 . 2 Give the approximate temperature and pressure used in the reactor.

[2 marks]

Temperature _____

Pressure _____

0 3 . 3 The mixture of gases from the reactor cools in the condenser.

Suggest why ammonia condenses but the other gases do not.

[1 mark]

_____

_____

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 50 · continued

The Earth's early atmosphere was different to Earth's atmosphere today.

Scientists think that the Earth's early atmosphere was like the atmosphere found on Venus today.

Table 2 shows the amounts of carbon dioxide and oxygen in the atmospheres of Venus and Earth today.

Table 2

Gas	Percentage (%) in Venus' atmosphere today	Percentage (%) in Earth's atmosphere today
Carbon dioxide	96.50	0.04
Oxygen	0.00	20.95

0 3 . 4 The percentages of carbon dioxide and oxygen have changed from Earth's early atmosphere to Earth's atmosphere today.

Explain the processes that led to these changes.

[6 marks]

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 50 · continued

0 3 . 5 Why are scientists **not** certain about the percentage of each gas in the Earth's early atmosphere?

[1 mark]

11

Turn over for the next question

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 51

June 2018 | 8462/2H | Original Q8

0 8 A student investigated how temperature affects the rate of reaction between magnesium carbonate and dilute hydrochloric acid.

This is the method used.

1. Heat hydrochloric acid to 30 ºC in a conical flask.
2. Add magnesium carbonate powder to the conical flask.
3. Measure the loss in mass of the flask and contents every 20 seconds for 140 seconds.
4. Repeat steps 1-3 with hydrochloric acid heated to 50 ºC

0 8 . 1 Explain why the contents of the conical flask lose mass.

[2 marks]

0 8 . 2 **Table 5** shows the student's results for hydrochloric acid at 30 ºC

Table 5

Time in seconds	Loss of mass in grams
0	0.00
20	0.26
40	0.48
60	0.67
80	0.82
100	0.91
120	0.96
140	0.99

4.5.1.1 Energy transfer during exothermic and endothermic reactions

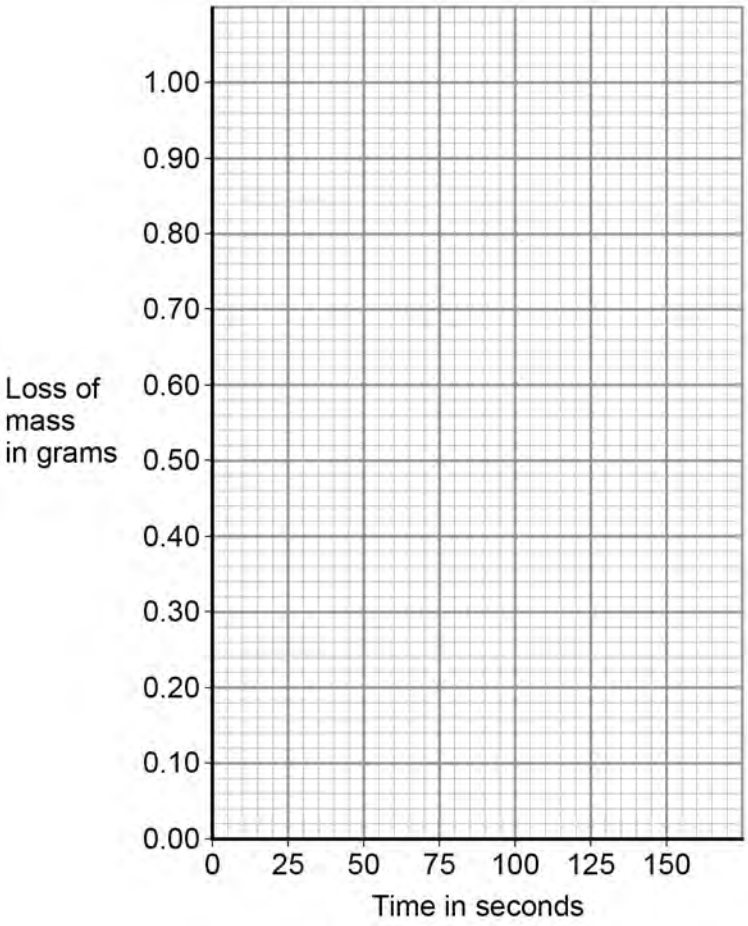
Question 51 · continued

Plot the data from **Table 5** on **Figure 6**.

Draw a line of best fit.

[3 marks]

Figure 6



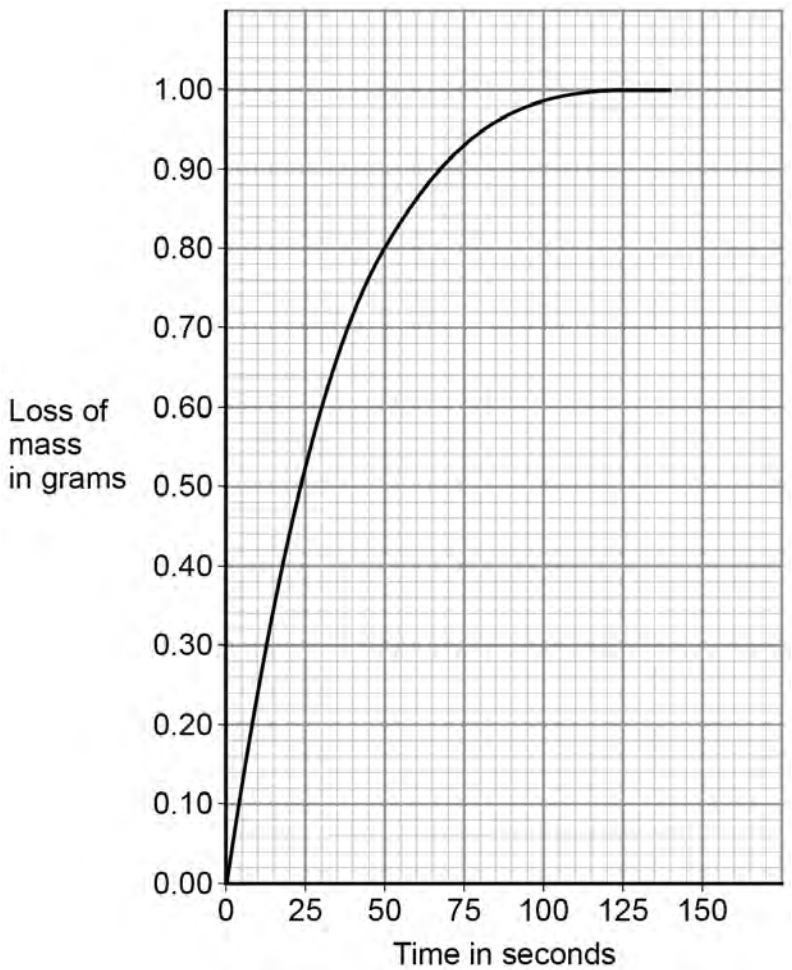
Question 8 continues on the next page

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 51 · continued

Figure 7 shows the student's results for hydrochloric acid at 50 ºC

Figure 7



0 8 . 3 Determine the rate of reaction at 50 °C when the loss of mass is 0.95 g

Show your working on **Figure 7**.

Give your answer to 2 significant figures.

[4 marks]

Rate of reaction = _____ g/s

9

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 52

June 2018 | 8462/2H | Original Q9

0 9 This question is about methanol.

0 9 . 1 Methanol is broken down in the body during digestion.

What type of substance acts as a catalyst in this process?

[1 mark]

Tick **one** box.

- Amino acid ☐
- Enzyme ☐
- Ester ☐
- Nucleotide ☐

In industry, methanol is produced by reacting carbon monoxide with hydrogen.

The equation for the reaction is:

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

0 9 . 2 How many moles of carbon monoxide react completely with 4.0×10^3 moles of hydrogen?

[1 mark]

Tick **one** box.

- 1.0×10^3 moles ☐
- 2.0×10^3 moles ☐
- 4.0×10^3 moles ☐
- 8.0×10^3 moles ☐

Question 52 · continued

0 9 . 3 The reaction is carried out at a temperature of 250 ºC and a pressure of 100 atmospheres.

The forward reaction is exothermic.

Explain what happens to the yield of methanol if a temperature higher than 250 ºC is used.

[2 marks]

0 9 . 4 A pressure of 100 atmospheres is used instead of atmospheric pressure.

The higher pressure gives a greater yield of methanol **and** an increased rate of reaction.

Explain why.

[4 marks]

Question 9 continues on the next page

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 52 · continued

A catalyst is used in the reaction to produce methanol from carbon monoxide and hydrogen.

0 9 . 5 Explain how a catalyst increases the rate of a reaction.

[2 marks]

0 9 . 6 Suggest why a catalyst is used in this industrial process.

Do **not** give answers in terms of increasing the rate of reaction.

[1 mark]

0 9 . 7 Suggest the effect of using the catalyst on the equilibrium yield of methanol.

[1 mark]

12

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 53

June 2019 | 8462/1H | Original Q1

0 1 This question is about the periodic table.

In the 19th century, some scientists tried to classify the elements by arranging them in order of their atomic weights.

Figure 1 shows the periodic table Mendeleev produced in 1869.

His periodic table was more widely accepted than previous versions.

Figure 1

	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7
Period 1	H						
Period 2	Li	Be	B	C	N	O	F
Period 3	Na	Mg	Al	Si	P	S	Cl
Period 4	K Cu	Ca Zn	* *	Ti *	V As	Cr Se	Mn Br
Period 5	Rb Ag	Sr Cd	Y In	Zr Sn	Nb Sb	Mo Te	* I

0 1 . 1 The atomic weight of tellurium (Te) is 128 and that of iodine (I) is 127

Why did Mendeleev reverse the order of these two elements?

[1 mark]

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 53 · continued

0 1 . 2 Mendeleev left spaces marked with an asterisk *

He left these spaces because he thought missing elements belonged there.

Why did Mendeleev's periodic table become more widely accepted than previous versions?

[3 marks]

0 1 . 3 Mendeleev arranged the elements in order of their atomic weight.

What is the modern name for atomic weight?

[1 mark]

Tick (✓) **one** box.

- Atomic number ☐
- Mass number ☐
- Relative atomic mass ☐
- Relative formula mass ☐

0 1 . 4 Complete the sentence.

[1 mark]

In the modern periodic table, the elements are arranged in order of

_____.

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 53 · continued

Chlorine, iodine and astatine are in Group 7 of the modern periodic table.

0 1 . 5 Astatine (At) is below iodine in Group 7.

Predict:

- the formula of an astatine molecule
- the state of astatine at room temperature.

[2 marks]

Formula of astatine molecule _____

State at room temperature _____

0 1 . 6 Sodium is in Group 1 of the modern periodic table.

Describe what you would see when sodium reacts with chlorine.

[2 marks]

_____

_____

_____

_____

10

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 54

June 2019 | 8462/1H | Original Q5

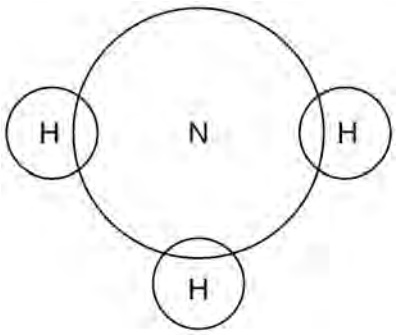
0 5 This question is about ammonia, NH_3

0 5 . 1 Complete the dot and cross diagram for the ammonia molecule shown in **Figure 6**.

Show only the electrons in the outer shell of each atom.

[2 marks]

Figure 6



0 5 . 2 Give **one** limitation of using a dot and cross diagram to represent an ammonia molecule.

[1 mark]

0 5 . 3 Explain why ammonia has a low boiling point.

You should refer to structure and bonding in your answer.

[3 marks]

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 54 · continued

Ammonia reacts with oxygen in the presence of a metal oxide catalyst to produce nitrogen and water.

0 5 . 4 Which metal oxide is most likely to be a catalyst for this reaction?

[1 mark]

Tick (✓) **one** box.

- CaO ☐
- Cr_2O_3 ☐
- MgO ☐
- Na_2O ☐

Figure 7 shows the displayed formula equation for the reaction.

Figure 7

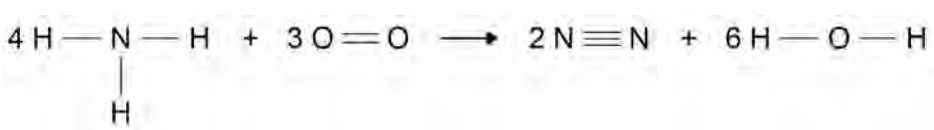


Table 3 shows some bond energies.

Table 3

Bond	N — H	O = O	N ≡ N	O — H
Bond energy in kJ/mol	391	498	945	464

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 54 · continued

0 5 . 5 Calculate the overall energy change for the reaction.

Use **Figure 7** and **Table 3**.

[3 marks]

Overall energy change = _____ kJ

0 5 . 6 Explain why the reaction between ammonia and oxygen is exothermic.

Use values from your calculation in Question **05.5**

[2 marks]

Question 5 continues on the next page

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 54 · continued

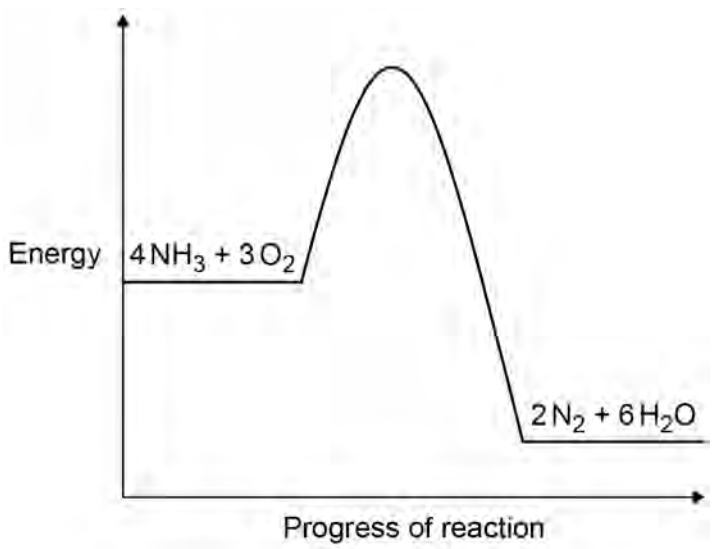
0 5 . 7 **Figure 8** shows the reaction profile for the reaction between ammonia and oxygen.

Complete **Figure 8** by labelling the:

- activation energy
- overall energy change.

[2 marks]

Figure 8



14

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 55

June 2019 | 8462/1H | Original Q9

0 9 A student investigated the temperature change in the reaction between dilute sulfuric acid and potassium hydroxide solution.

This is the method used.

1. Measure 25.0 cm^3 potassium hydroxide solution into a polystyrene cup.

2. Record the temperature of the solution.

3. Add 2.0 cm^3 dilute sulfuric acid.

4. Stir the solution.

5. Record the temperature of the solution.

6. Repeat steps 3 to 5 until a total of 20.0 cm^3 dilute sulfuric acid has been added.

0 9 . 1 Suggest why the student used a polystyrene cup rather than a glass beaker for the reaction.

[2 marks]

Question 9 continues on the next page

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 55 · continued

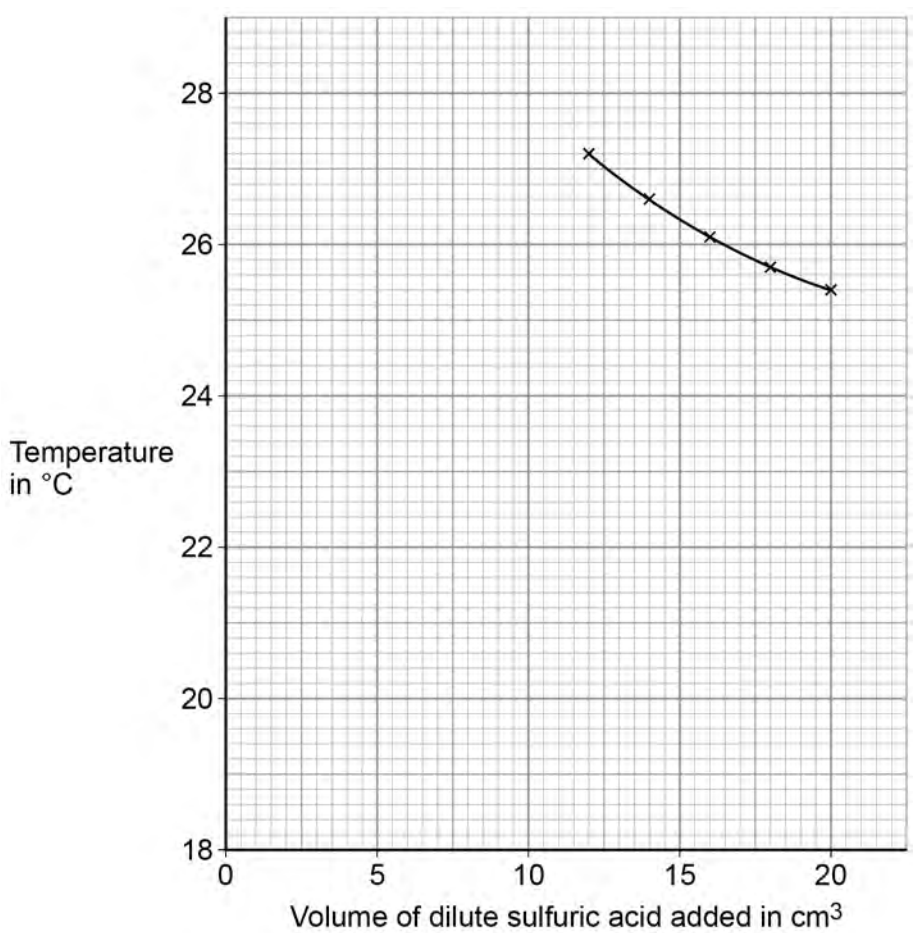
Table 6 shows some of the student's results.

Table 6

Volume of dilute sulfuric acid added in cm^3	Temperature in °C
0.0	18.9
2.0	21.7
4.0	23.6
6.0	25.0
8.0	26.1
10.0	27.1

Figure 11 shows some of the data from the investigation.

Figure 11



4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 55 · continued

0 9 . 2 Complete **Figure 11**:

- plot the data from **Table 6**
- draw a line of best fit through these points
- extend the lines of best fit until they cross.

[4 marks]

0 9 . 3 Determine the volume of dilute sulfuric acid needed to react completely with 25.0 cm^3 of the potassium hydroxide solution.

Use **Figure 11**.

[1 mark]

Volume of dilute sulfuric acid to react completely = _____ cm^3

0 9 . 4 Determine the overall temperature change when the reaction is complete.

Use **Figure 11**.

[1 mark]

_____

_____

Overall temperature change = _____ °C

Question 9 continues on the next page

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 55 · continued

0 9 . 5 The student repeated the investigation.

The student used solutions that had different concentrations from the first investigation.

The student found that 15.5 cm^3 of 0.500 mol/dm^3 dilute sulfuric acid completely reacted with 25.0 cm^3 of potassium hydroxide solution.

The equation for the reaction is:

$$2\,KOH + H_2SO_4 \rightarrow K_2SO_4 + 2\,H_2O$$

Calculate the concentration of the potassium hydroxide solution in mol/dm^3 and in g/dm^3

Relative atomic masses (A_r): H = 1 O = 16 K = 39

[6 marks]

Concentration in mol/dm^3 = _____ mol/dm^3

Concentration in g/dm^3 = _____ g/dm^3

14

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 56

June 2019 | 8462/2H | Original Q3

0 3 This question is about rate of reaction.

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

The equation for the reaction is:

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

0 3 . 1 Which state symbol in the equation for the reaction does **not** represent one of the three states of matter?

[1 mark]

The student determined the rate of production of hydrogen gas.

0 3 . 2 What **two** pieces of measuring apparatus could the student use to find the rate of production of hydrogen gas?

[2 marks]

1 _____

2 _____

Question 3 continues on the next page

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 56 · continued

Table 2 shows the results of the investigation.

Table 2

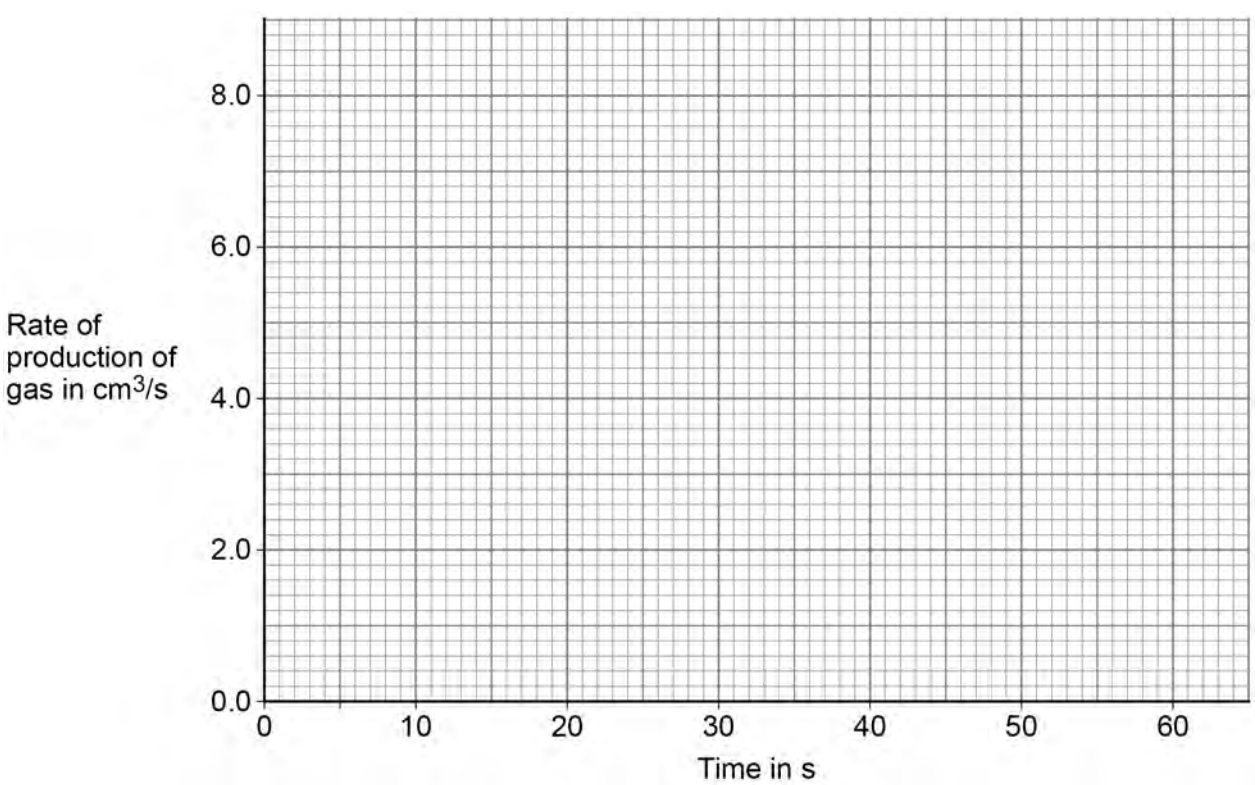
Time in s	Rate of production of gas in cm^3/s
10	6.9
20	3.9
30	2.0
40	0.9
50	0.3
60	0.0

0 3 . 3 Plot the data from **Table 2** on **Figure 3**.

You should draw a line of best fit.

[3 marks]

Figure 3



4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 56 · continued

0 3 . 4 Give **three** conclusions that can be drawn about the rate of reaction between magnesium and dilute hydrochloric acid in this investigation.

Use data from **Figure 3** and **Table 2**.

[3 marks]

1 _____

_____

2 _____

_____

3 _____

_____

0 3 . 5 The student repeated the investigation using dilute hydrochloric acid at a higher temperature.

All the other variables were kept the same.

Which **two** statements are correct?

[2 marks]

Tick (✓) **two** boxes.

More bubbles were produced in the first 10 seconds. ☐

The activation energy for the reaction was higher. ☐

The magnesium was used up more quickly. ☐

The reaction finished at the same time. ☐

The total volume of gas collected was greater. ☐

11

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 57

June 2019 | 8462/2H | Original Q10

1 0 This question is about reversible reactions and equilibrium.

Hydrogen is used to produce ammonia in the Haber process.

The hydrogen is made in two stages.

Stage 1 is the reaction of methane and steam to produce carbon monoxide and hydrogen.

The equation for the reaction is:

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$$

1 0 . 1 Calculate the atom economy for the formation of hydrogen in **stage 1**.

Relative atomic masses (A_r): H = 1 C = 12 O = 16

[2 marks]

Atom economy = _____ %

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 57 · continued

1 0 . 2 Explain why a low pressure is used in **stage 1**.

Give your answer in terms of equilibrium.

[2 marks]

1 0 . 3 **Stage 2** uses the carbon monoxide produced in **stage 1**.

The carbon monoxide is reacted with more steam to produce carbon dioxide and more hydrogen.

The equation for the reaction in **stage 2** is:

$$CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$$

What is the effect of increasing the pressure on the equilibrium yield of hydrogen in **stage 2**?

[1 mark]

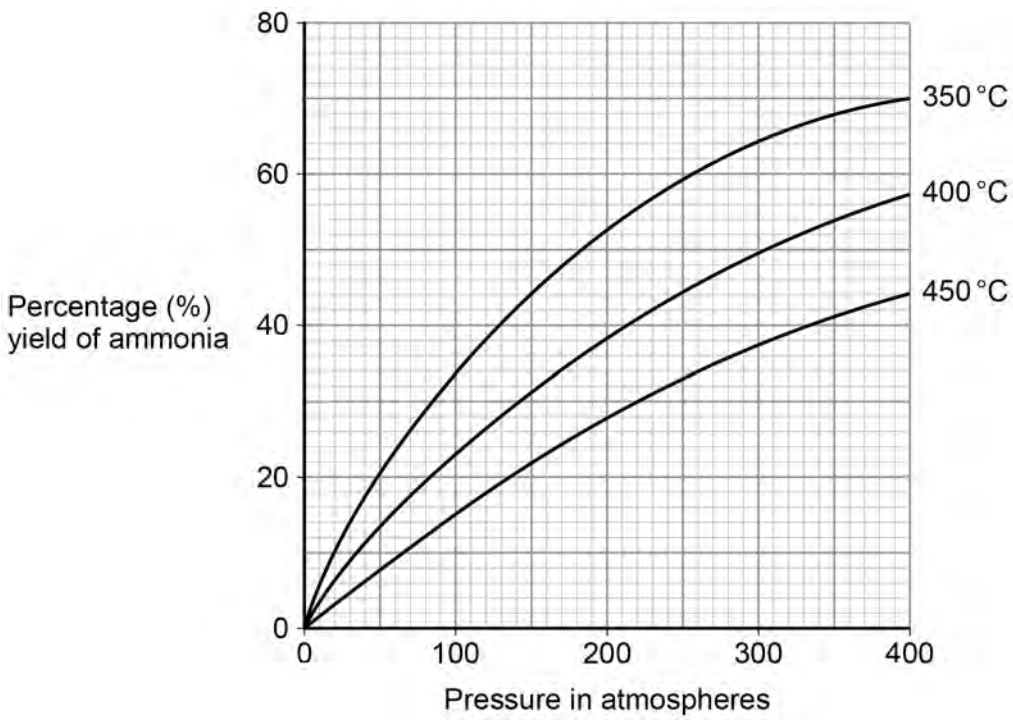
Question 10 continues on the next page

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 57 · continued

Figure 10 shows the percentage yield of ammonia produced at different temperatures and pressures in the Haber process.

Figure 10



A temperature of 450 °C and a pressure of 200 atmospheres are used in the Haber process.

1 0 . 4 A student suggested that a temperature of 350 °C and a pressure of 285 atmospheres could be used instead of those used in the Haber process.

Determine how many times greater the percentage yield of ammonia obtained would be.

Use **Figure 10**.

[3 marks]

Percentage yield = _____ times greater

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 57 · continued

June 2019 | 8462/2H | Original Q10

10.5 A pressure of 285 atmospheres is **not** used in the Haber process instead of 200 atmospheres.

Give **one** reason why.

[1 mark]

10.6 How does **Figure 10** show that the forward reaction in the Haber process is exothermic?

[1 mark]

10.7 World production of ammonia is now about 30 times greater than it was in 1950.

Suggest why the demand for ammonia has increased.

[2 marks]

12

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 58

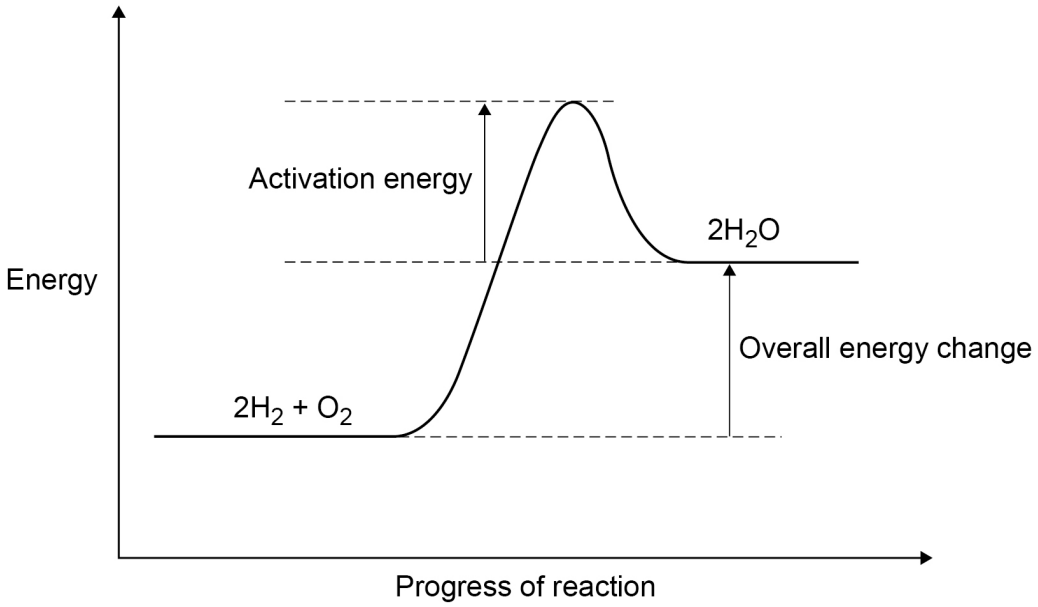
November 2020 | 8462/1H | Original Q7

0 7 The reaction between hydrogen and oxygen releases energy.

0 7 . 1 A student drew a reaction profile for the reaction between hydrogen and oxygen.

Figure 3 shows the student's reaction profile.

Figure 3



The student made **two** errors when drawing the reaction profile.

Describe the **two** errors.

[2 marks]

1 _____

_____

2 _____

_____

Question 58 · continued

0 7 . 2 The reaction between hydrogen and oxygen in a hydrogen fuel cell is used to produce electricity.

Hydrogen fuel cells and rechargeable cells are used to power some cars.

Give **two** advantages of using hydrogen fuel cells instead of using rechargeable cells to power cars.

[2 marks]

1 _____

_____

2 _____

_____

0 7 . 3 Reactions occur at the positive electrode and at the negative electrode in a hydrogen fuel cell.

Write a half equation for **one** of these reactions.

[1 mark]

_____

Question 7 continues on the next page

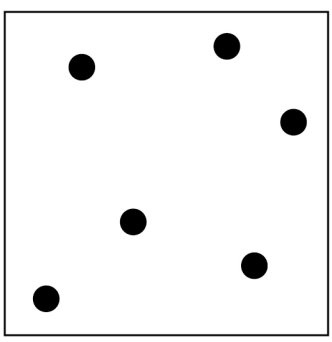
4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 58 · continued

0 7 . 4 The three states of matter can be represented by a simple particle model.

Figure 4 shows a simple particle model for hydrogen gas.

Figure 4



Give **two** limitations of this simple particle model for hydrogen gas.

[2 marks]

1 _____

_____

2 _____

_____

0 7 . 5 The hydrogen gas needed to power a car for 400 km would occupy a large volume.

Suggest **one** way that this volume can be reduced.

[1 mark]

_____

_____

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 58 · continued

0 7 . 6 The energy needed for a car powered by a hydrogen fuel cell to travel 100 km is 58 megajoules (MJ).

The energy released when 1 mole of hydrogen gas reacts with oxygen is 290 kJ

The volume of 1 mole of a gas at room temperature and pressure is 24 dm^3

Calculate the volume of hydrogen gas at room temperature and pressure needed for the car to travel 100 km

[4 marks]

Volume of hydrogen gas = _____ dm^3

12

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 59

November 2020 | 8462/1H | Original Q9

0 9 This question is about citric acid ($C_6H_8O_7$).

Citric acid is a solid.

A student investigated the temperature change during the reaction between citric acid and sodium hydrogencarbonate solution.

This is the method used.

1. Pour 25 cm^3 of sodium hydrogencarbonate solution into a polystyrene cup.

2. Measure the temperature of the sodium hydrogencarbonate solution.

3. Add 0.20 g of citric acid to the polystyrene cup.

4. Stir the solution.

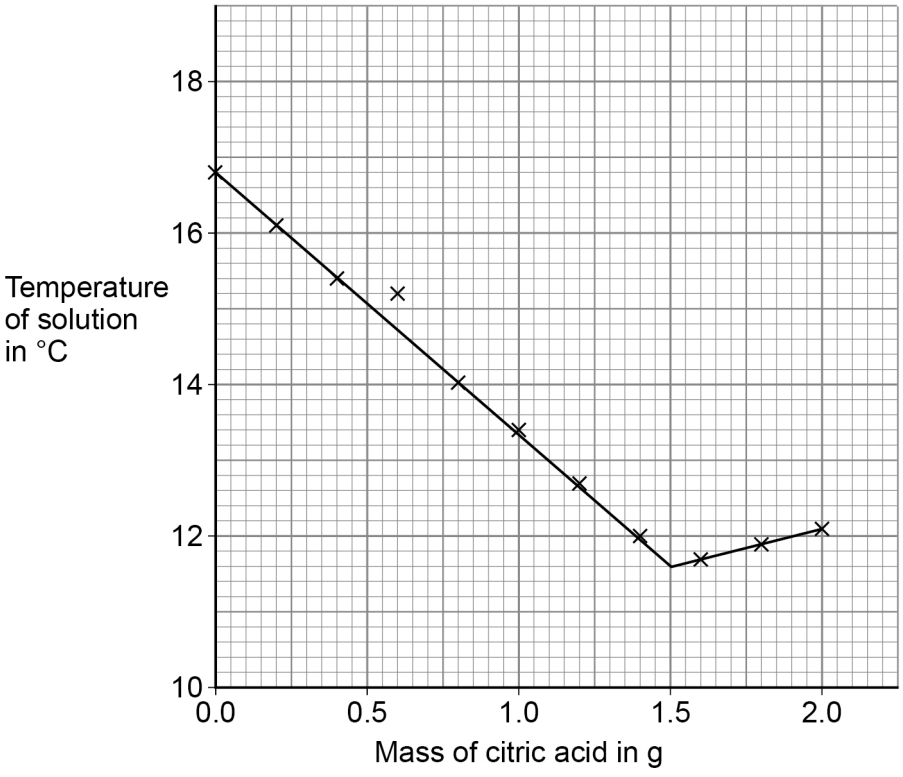
5. Measure the temperature of the solution.

6. Repeat steps 3 to 5 until a total of 2.00 g of citric acid has been added.

The student plotted the results on a graph.

Figure 6 shows the student's graph.

Figure 6



4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 59 · continued

0 9 . 1 **Figure 6** shows an anomalous point when 0.60 g of citric acid was added. This was caused by the student making an error.

The student correctly:

- measured the mass of the citric acid
- read the thermometer
- plotted the point.

Suggest **one** reason for the anomalous point.

[1 mark]

0 9 . 2 Explain the shape of the graph in terms of the energy transfers taking place.

You should use data from **Figure 6** in your answer.

[3 marks]

0 9 . 3 A second student repeated the investigation using a metal container instead of the polystyrene cup. The container and the cup were the same size and shape.

Sketch a line on **Figure 6** to show the second student's results until 1.00 g of citric acid had been added. The starting temperature of the solution was the same.

Explain your answer.

[3 marks]

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 59 · continued

The student used a solution of citric acid to determine the concentration of a solution of sodium hydroxide by titration.

0 9 . 4 The student made 250 cm^3 of a solution of citric acid of concentration 0.0500 mol/dm^3

Calculate the mass of citric acid ($C_6H_8O_7$) required.

Relative atomic masses (A_r): H = 1 C = 12 O = 16

[3 marks]

Mass = _____ g

This is part of the method the student used for the titration.

1. Measure 25.0 cm^3 of the sodium hydroxide solution into a conical flask using a pipette.
2. Add a few drops of indicator to the flask.
3. Fill a burette with citric acid solution.

0 9 . 5 Describe how the student would complete the titration.

[3 marks]

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 59 · continued

0 9 . 6 Give **two** reasons why a burette is used for the citric acid solution.

[2 marks]

1 _____

_____

2 _____

_____

0 9 . 7 13.3 cm^3 of 0.0500 mol/dm^3 citric acid solution was needed to neutralise 25.0 cm^3 of sodium hydroxide solution.

The equation for the reaction is:

$$3\,NaOH + C_6H_8O_7 \rightarrow C_6H_5O_7Na_3 + 3\,H_2O$$

Calculate the concentration of the sodium hydroxide solution in mol/dm^3

[3 marks]

_____

_____

_____

_____

_____

_____

Concentration = _____ mol/dm^3

18

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 60

November 2020 | 8462/2H | Original Q10

1 0 This question is about a reversible reaction.

The reaction between solutions of iron(III) ions (Fe^{3+}) and thiocyanate ions (SCN^-) is reversible.

The ionic equation for the reaction is:

	$Fe^{3+}(aq)$	+	$SCN^-(aq)$	$\rightleftharpoons$	$FeSCN^{2+}(aq)$
Colour of solution:	yellow		colourless		red

The colour of the equilibrium mixture is orange at room temperature.

1 0 . 1 Give the name of the solvent used to dissolve the ions in this reaction.

[1 mark]

1 0 . 2 A few drops of a colourless solution containing a high concentration of thiocyanate ions (SCN^-) are added to the orange equilibrium mixture.

Explain the colour change observed.

[3 marks]

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 60 · continued

1 0 . 3 A water bath is set up at a temperature above room temperature.

When a test tube containing the orange equilibrium mixture is placed in the water bath, the mixture becomes more yellow.

Explain what this shows about the energy change for the forward reaction.

[3 marks]

1 0 . 4 Explain why a change in pressure does **not** affect the colour of the equilibrium mixture.

[2 marks]

1 0 . 5 Other metal ions form coloured equilibrium mixtures with thiocyanate ions.

Which metal ion could form a coloured equilibrium mixture with thiocyanate ions?

[1 mark]

Tick (✓) **one** box.

Al^{3+} ☐

Co^{2+} ☐

Mg^{2+} ☐

Na^{+} ☐

10

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 61

November 2021 | 8462/1H | Original Q8

0 8 This question is about the reaction between hydrogen sulfide (H_2S) and oxygen.

The equation for the reaction is:

$$2\,H_2S(g) + 3\,O_2(g) \rightarrow 2\,H_2O(g) + 2\,SO_2(g)$$

0 8 . 1 What does $H_2O(g)$ represent?

[1 mark]

0 8 . 2 Calculate the volume of oxygen required to react with 50 cm^3 of hydrogen sulfide.

[1 mark]

Volume = _____ cm^3

0 8 . 3 **Figure 6** shows part of the reaction profile for the reaction.

The reaction is exothermic.

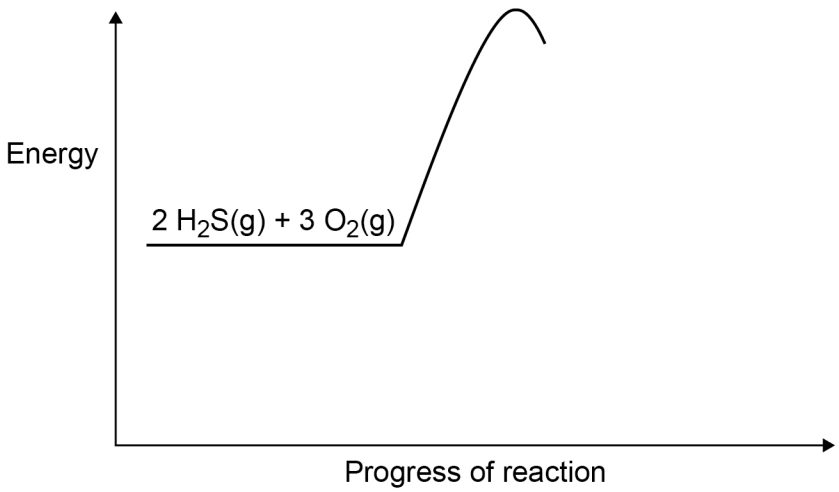
Complete **Figure 6**.

You should:

- complete the profile line
- label the activation energy
- label the overall energy change.

[3 marks]

Figure 6



Question 61 · continued

0 8 . 4 **Figure 7** shows the displayed formula equation for the reaction of hydrogen sulfide with oxygen.

Figure 7

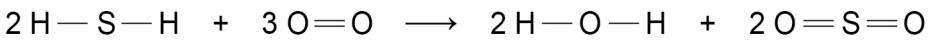


Table 5 shows some of the bond energies.

Table 5

Bond	H — S	O = O	H — O	S = O
Energy in kJ/mol	364	498	464	**X**

In the reaction the energy released forming new bonds is 1034 kJ/mol greater than the energy needed to break existing bonds.

Calculate the bond energy **X** for the S = O bond.

Use **Figure 7** and **Table 5.**

[5 marks]

X = _____ kJ/mol

10

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 62

November 2021 | 8462/2H | Original Q10

1 0 This question is about alkenes and alcohols.

Ethene is an alkene produced from large hydrocarbon molecules.

Large hydrocarbon molecules are obtained from crude oil by fractional distillation.

1 0 . 1 Name the process used to produce ethene from large hydrocarbon molecules.

[1 mark]

1 0 . 2 Describe the conditions used to produce ethene from large hydrocarbon molecules.

[2 marks]

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 62 · continued

10.3 Ethanol can be produced from ethene and steam.

The equation for the reaction is:

$$C_2H_4(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g)$$

The forward reaction is exothermic.

Explain how the conditions for this reaction should be chosen to produce ethanol as economically as possible.

[6 marks]

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 62 · continued

10.4 Ethanol can also be produced from sugar solution by adding yeast.

Name this process.

[1 mark]

10.5 Butanol can be produced from sugar solution by adding bacteria.

Sugar solution is broken down in similar ways by bacteria and by yeast.

Suggest the reaction conditions needed to produce butanol from sugar solution by adding bacteria.

[2 marks]

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 62 · continued

Ethanol and butanol can be used as fuels for cars.

10.6 A car needs an average of 1.95 kJ of energy to travel 1 m

Ethanol has an energy content of 1300 kilojoules per mole (kJ/mol).

Calculate the number of moles of ethanol needed by the car to travel 200 km

[3 marks]

Number of moles = _____ mol

10.7 When butanol is burned in a car engine, complete combustion takes place.

Write a balanced equation for the complete combustion of butanol.

You do **not** need to include state symbols.

[2 marks]

17

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 63

June 2022 | 8462/1H | Original Q2

0 2 Sodium carbonate reacts with hydrochloric acid in an exothermic reaction.

The equation for the reaction is:

$$Na_2CO_3(s) + 2\,HCl(aq) \rightarrow 2\,NaCl(aq) + CO_2(g) + H_2O(l)$$

A student investigated the effect of changing the mass of sodium carbonate powder on the highest temperature reached by the reaction mixture.

0 2 . 1 Plan a method to investigate the effect of changing the mass of sodium carbonate powder on the highest temperature reached.

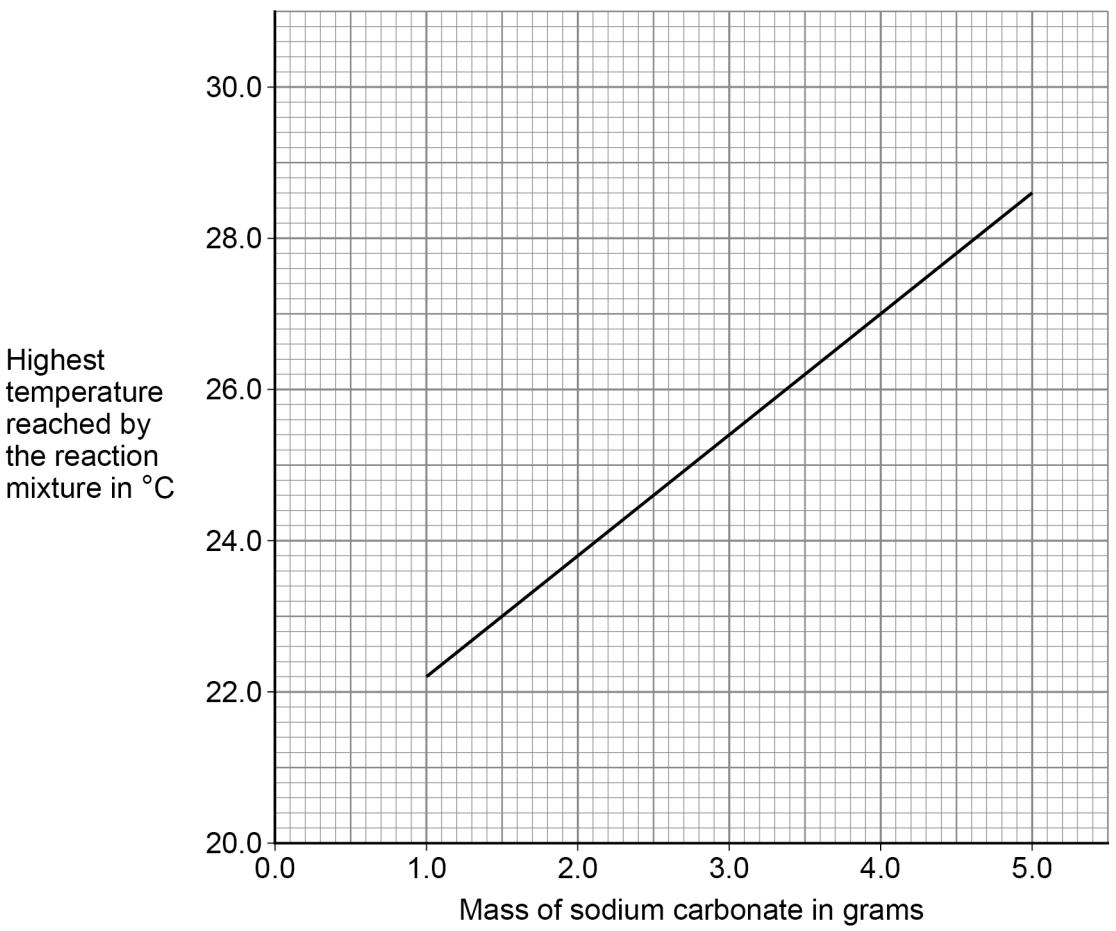
[6 marks]

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 63 · continued

Figure 3 shows a line of best fit drawn through the student's results.

Figure 3



4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 63 · continued

0 2 . 2 Determine the gradient of the line of best fit in **Figure 3**.

Use the equation:

$$\text{Gradient} = \frac{\text{Change in highest temperature}}{\text{Change in mass}}$$

Give the unit.

[5 marks]

Gradient = _____ Unit _____

0 2 . 3 The initial temperature of the reaction mixture is where the line of best fit would meet the *y*-axis.

Determine the initial temperature of the reaction mixture.

Show your working on **Figure 3**.

[2 marks]

Initial temperature of the reaction mixture = _____ °C

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 63 · continued

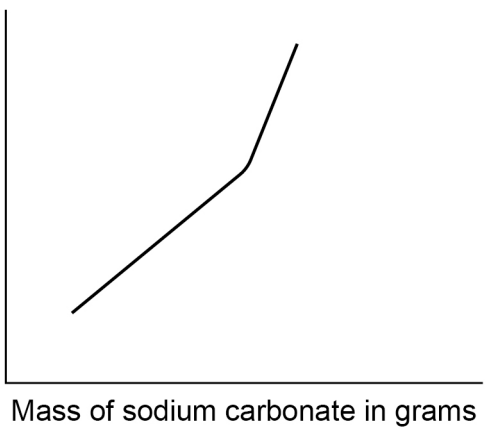
0 2 . 4 Another student repeated the investigation but added sodium carbonate until the sodium carbonate was in excess.

Which sketch graph shows the results obtained when sodium carbonate was added until in excess?

[1 mark]

Tick (✓) **one** box.

A



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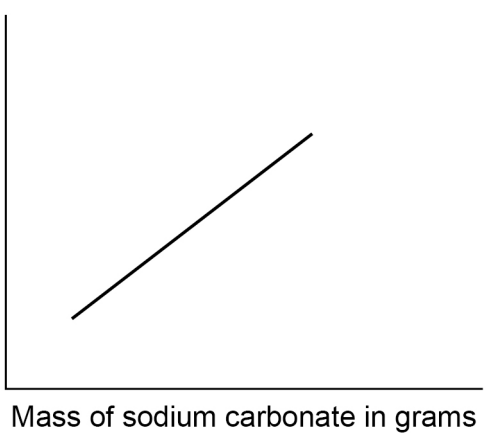
B



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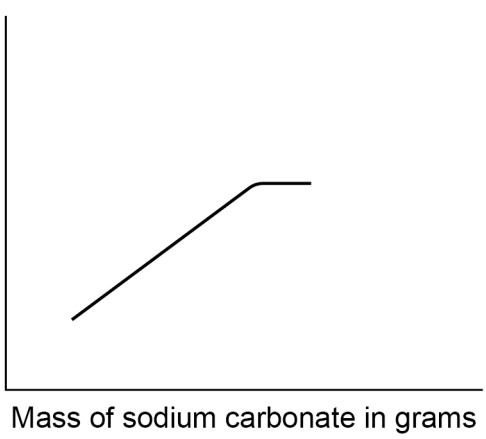
C



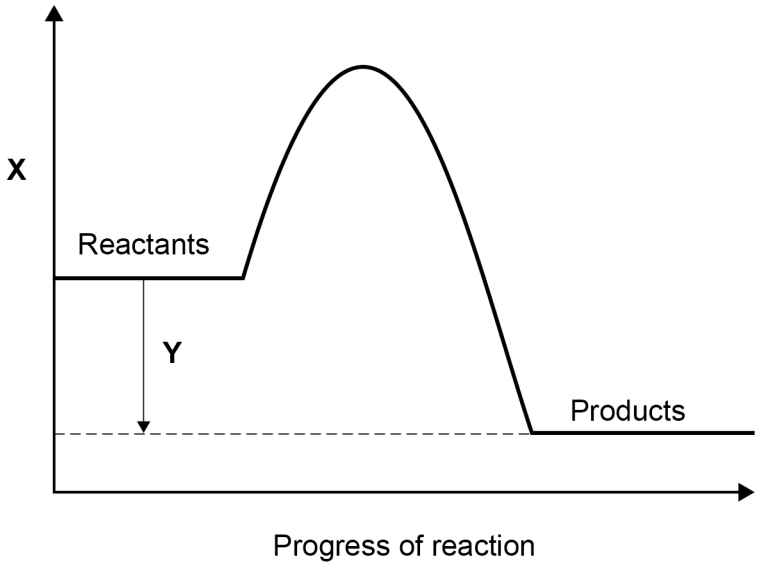
☐

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 63 · continued

Figure 4 shows a reaction profile for the reaction of sodium carbonate with hydrochloric acid.

Figure 4



0 2 . 5 What do labels **X** and **Y** represent on **Figure 4**?

[2 marks]

X _____

Y _____

0 2 . 6 How does the reaction profile show that the reaction is exothermic?

Use **Figure 4**.

[1 mark]

_____

_____

17

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 64

June 2022 | 8462/1H | Original Q7

0 7 This question is about silicon and compounds of silicon.

0 7 . 1 The reactivity series sometimes includes non-metals such as carbon, hydrogen and silicon.

Silicon can be extracted by reducing silicon dioxide with different substances.

The equation for one possible reaction is:

$$2\,C(s) + SiO_2(s) \rightarrow Si(s) + 2\,CO(g)$$

Explain what this reaction shows about the position of silicon in the reactivity series.

[2 marks]

0 7 . 2 Aluminium also reduces silicon dioxide.

Carbon is used rather than aluminium to reduce silicon dioxide because carbon is cheaper than aluminium.

Carbon can be obtained by heating coal.

Aluminium is obtained from aluminium oxide.

Explain why aluminium is more expensive than carbon.

[2 marks]

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 64 · continued

Magnesium also reduces silicon dioxide.

The equation for the reaction is:

$$2\,Mg(s) + SiO_2(s) \rightarrow Si(s) + 2\,MgO(s)$$

0 7 . 3 Give **one** reason why the products are difficult to separate if magnesium is used to reduce silicon dioxide.

[1 mark]

0 7 . 4 Calculate the minimum mass in grams of magnesium needed to completely reduce 1.2 kg of silicon dioxide.

Relative atomic masses (A_r): O = 16 Mg = 24 Si = 28

[5 marks]

Minimum mass of magnesium = _____ g

4.5.1.1 Energy transfer during exothermic and endothermic reactions

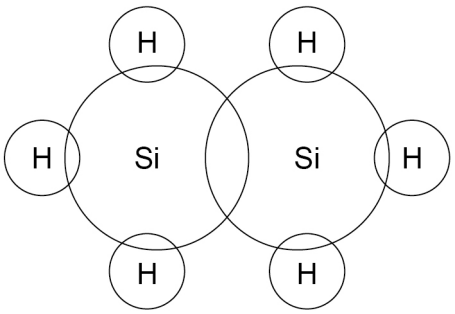
Question 64 · continued

Si_2H_6 is a covalent compound of silicon and hydrogen.

0 7 . 5 Complete **Figure 9** to show the outer shell electrons in a molecule of Si_2H_6

[1 mark]

Figure 9



0 7 . 6 Si_2H_6 reacts with oxygen.

The equation for the reaction is:

$$2\,Si_2H_6(g) + 7\,O_2(g) \rightarrow 4\,SiO_2(s) + 6\,H_2O(g)$$

30 cm^3 of Si_2H_6 is reacted with 150 cm^3 (an excess) of oxygen.

Calculate the total volume of gases present after the reaction.

All volumes of gases are measured at the same temperature and pressure.

[4 marks]

Volume of gases = _____ cm^3

15

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 65

June 2022 | 8462/2H | Original Q7

0 7 Ammonia is produced in the Haber process.

The raw materials for the Haber process are nitrogen and hydrogen.

The equation for the reaction is:

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

0 7 . 1 Give the sources of the nitrogen and of the hydrogen used in the Haber process.

[2 marks]

Nitrogen _____

Hydrogen _____

0 7 . 2 How does the equation for the reaction show that the atom economy of the forward reaction is 100%?

[1 mark]

_____

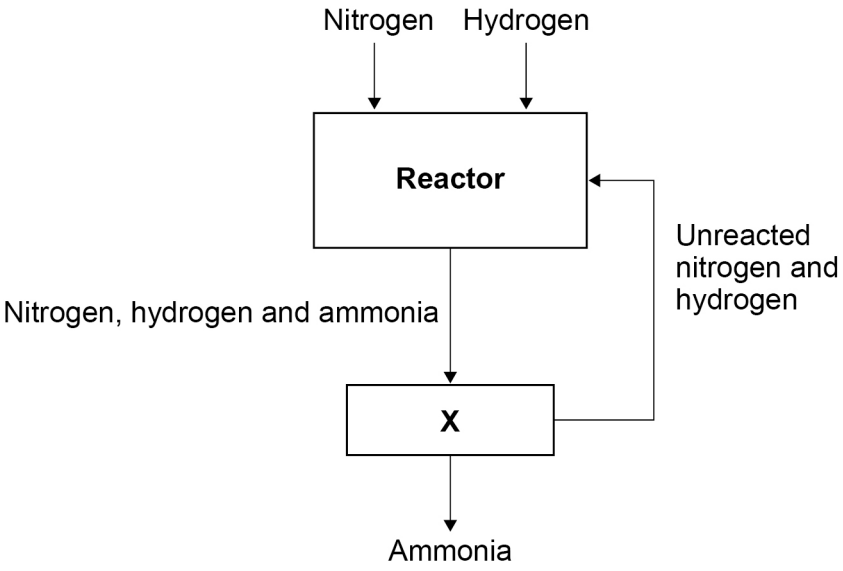
_____

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 65 · continued

0 7 . 3 **Figure 4** represents the Haber process.

Figure 4



Explain how the ammonia produced is separated from the unreacted nitrogen and hydrogen in **X**.

[2 marks]

Question 7 continues on the next page

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 65 · continued

The Haber process uses a temperature of 450 °C and a pressure of 200 atmospheres.

Table 6 shows the percentage yield of ammonia produced at 450 °C using different pressures.

Table 6

Pressure in atmospheres	Percentage (%) yield of ammonia
60	9
120	18
180	25
240	31
300	36
360	40
420	43

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 65 · continued

0 7 . 4 Complete **Figure 5**.

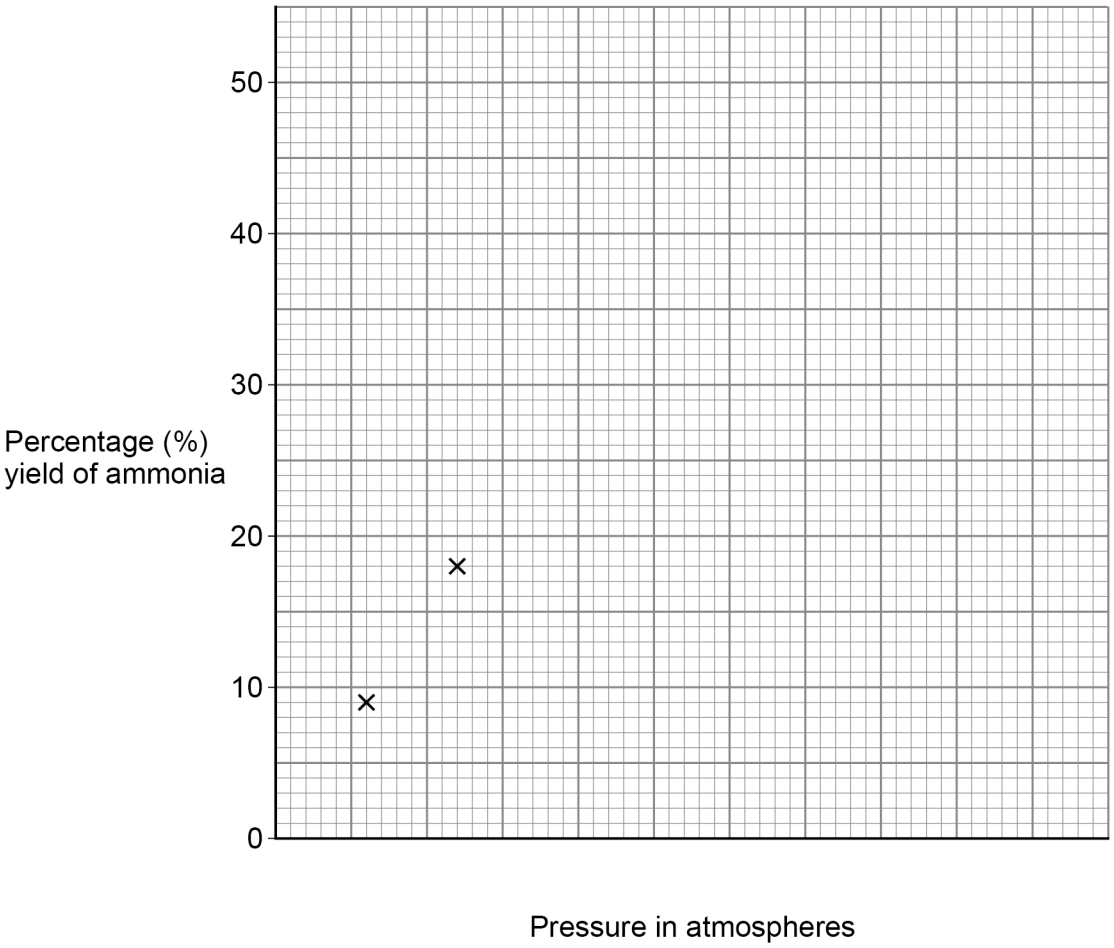
The first two points have been plotted.

You should:

- use a suitable scale for the *x*-axis
- plot the remaining data from **Table 6**
- draw a line of best fit.

[4 marks]

Figure 5



0 7 . 5 Determine the percentage yield of ammonia at 450 °C and 500 atmospheres.

Show your working on **Figure 5**.

[2 marks]

Percentage yield = _____ %

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 65 · continued

0 7 . 6 The equation for the production of ammonia in the Haber process is:

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

The forward reaction is exothermic.

The conditions used are:

- a temperature of 450 °C
- a pressure of 200 atmospheres
- the presence of an iron catalyst.

Explain why these conditions are chosen for economical production of ammonia in the Haber process.

You should include references to the rate of reaction and the position of equilibrium.

[6 marks]

17

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 66

June 2023 | 8462/1H | Original Q2

0 2 This question is about temperature changes.

A student investigated the change in temperature of a solution when different masses of ammonium nitrate were dissolved in water.

This is the method used.

1. Measure 200 cm^3 of water into a polystyrene cup.

2. Measure the temperature of the water.

3. Add 4.0 g of ammonium nitrate to the water.

4. Stir the solution until all the ammonium nitrate has dissolved.

5. Measure the lowest temperature reached by the solution.

6. Repeat steps 1 to 5 with different masses of ammonium nitrate.

0 2 . 1 Give the independent variable and the dependent variable in the investigation.

[2 marks]

Independent variable _____

Dependent variable _____

Table 2 shows the results.

Table 2

Mass of ammonium nitrate added in grams	Lowest temperature of solution in °C
4.0	18.2
8.0	16.2
12.0	15.2
16.0	13.6
20.0	12.4
24.0	10.6

4.5.1.1 Energy transfer during exothermic and endothermic reactions

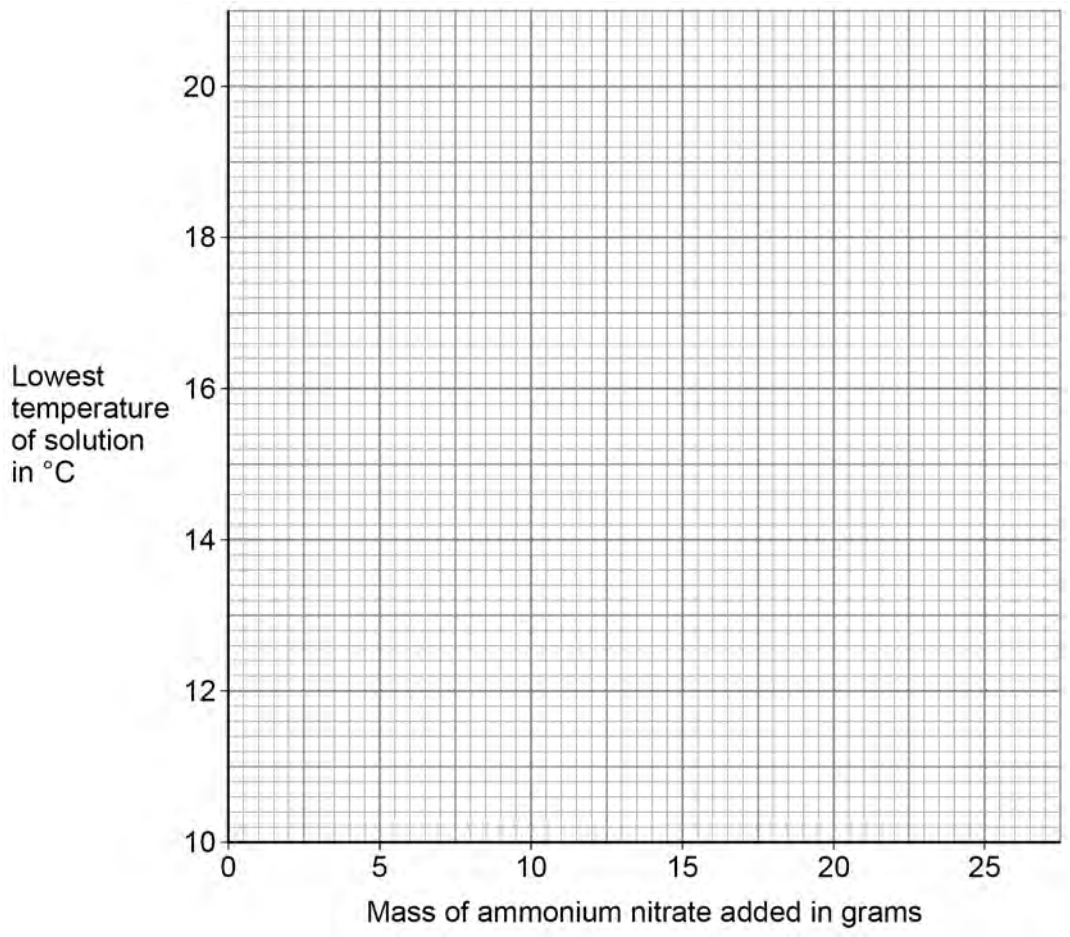
Question 66 · continued

0 2 . 2 Plot the data from **Table 2** on **Figure 2**.

Draw a line of best fit.

[3 marks]

Figure 2



0 2 . 3 Determine the initial temperature of the water.

You should extend your line of best fit on **Figure 2**.

[2 marks]

Initial temperature of the water = _____ °C

0 2 . 4 How do the results show that dissolving ammonium nitrate in water is endothermic?

[1 mark]

_____

_____

Question 66 · continued

The student repeated the experiment three more times.

Table 3 shows the results for 8.0 g of ammonium nitrate.

Table 3

	Trial 1	Trial 2	Trial 3	Trial 4	Mean
Lowest temperature of solution in ºC	16.2	16.6	16.8	16.4	16.5

0 2 . 5 The student recorded the mean lowest temperature of the solution for 8.0 g of ammonium nitrate as 16.5 ± 0.3 ºC.

Explain why the student included ± 0.3 ºC after the mean lowest temperature.

[2 marks]

0 2 . 6 What type of error is shown by the results in **Table 3**?

[1 mark]

Tick (✓) **one** box.

Random error ☐

Systematic error ☐

Zero error ☐

11

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 67

June 2023 | 8462/2H | Original Q9

0 9 This question is about reversible reactions.

When 4.68 g of hydrated copper sulfate changes into anhydrous copper sulfate:

- 2.99 g of anhydrous copper sulfate is produced
- 1.47 kJ of energy is taken in from the surroundings.

The equation for the reversible reaction is:

hydrated copper sulfate ⇌ anhydrous copper sulfate + water

0 9 . 1 Calculate the maximum mass of water that can be produced from 11.7 g of hydrated copper sulfate.

[3 marks]

Mass = _____ g

0 9 . 2 15.0 g of anhydrous copper sulfate completely changes into hydrated copper sulfate when water is added.

Calculate the amount of energy transferred to the surroundings.

[2 marks]

Energy = _____ kJ

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 67 · continued

The gases nitrogen dioxide and dinitrogen tetroxide reach dynamic equilibrium in a sealed container.

The equation for the reaction is:

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

nitrogen dioxide (brown) — dinitrogen tetroxide (colourless)

The forward reaction is exothermic.

0 9 . 3 What happens to the position of the equilibrium in this reaction if the temperature is increased?

[1 mark]

Tick (✓) **one** box.

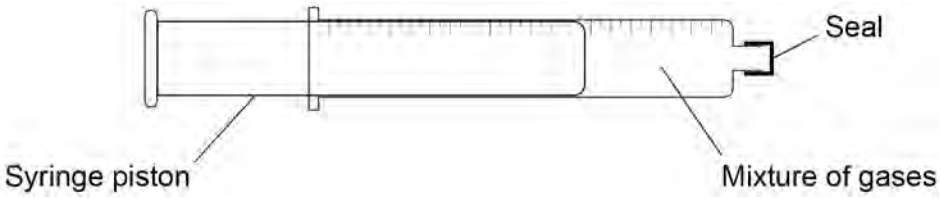
- Shifts to the left ☐
- Stays the same ☐
- Shifts to the right ☐

Question 67 · continued

0 9 . 4 A teacher seals a brown-coloured mixture of nitrogen dioxide and dinitrogen tetroxide in a gas syringe.

Figure 8 shows the sealed gas syringe.

Figure 8



The teacher pushes the syringe piston in.

This increases the pressure in the gas syringe.

What is the colour of the mixture when a new equilibrium position is reached?

[1 mark]

Tick (✓) **one** box.

The mixture is a darker shade of brown. ☐

The mixture is the same shade of brown. ☐

The mixture is a lighter shade of brown. ☐

Question 9 continues on the next page

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 67 · continued

Hydrogen iodide gas decomposes into hydrogen gas and iodine gas at high temperatures.

The equation for the reaction is:

$$2\,HI(g) \rightleftharpoons H_2(g) + I_2(g)$$

0 9 . 5 Explain the effect of increasing the pressure on the equilibrium position of this reaction.

[2 marks]

0 9 . 6 Suggest the effect of adding a catalyst on the equilibrium position of this reaction.

[1 mark]

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 67 · continued

Copper forms coloured compounds.

Hydrochloric acid is added to an aqueous solution of copper compound **A**.

The word equation for the reaction is:

copper compound **A** (blue) + hydrochloric acid ⇌ copper compound **B** (yellow) + water

0 9 . 7 The reaction mixture is green when both copper compounds are present in a solution at equilibrium.

How can the equilibrium position be shifted to make the reaction mixture more yellow?

[1 mark]

Tick (✓) **one** box.

- Add more hydrochloric acid ☐
- Add more water ☐
- Leave the reaction mixture for 30 minutes ☐

0 9 . 8 The concentrations of the substances in this reaction do **not** change at dynamic equilibrium.

Explain why.

[2 marks]

13

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 68

June 2024 | 8462/1H | Original Q4

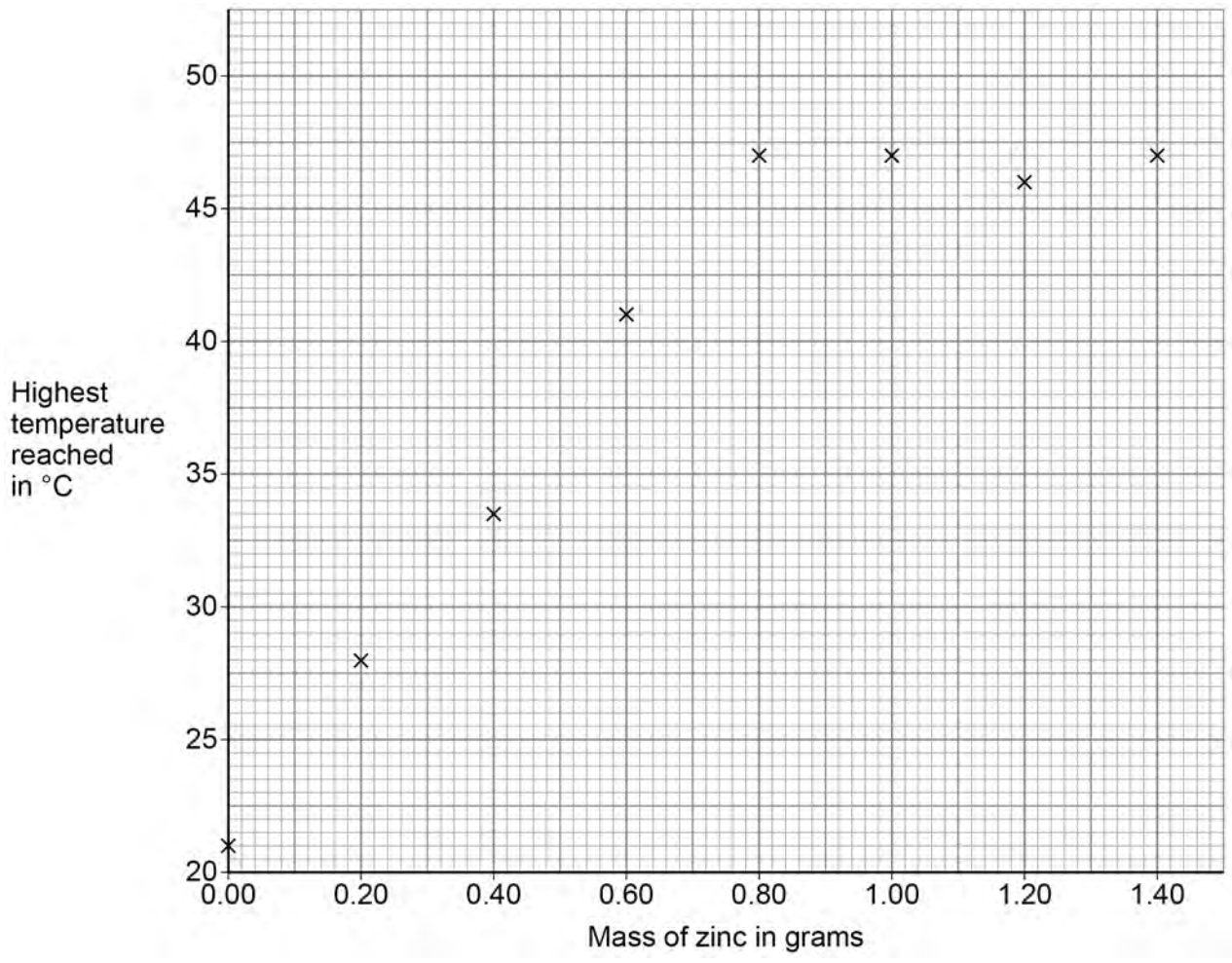
0 4 A student investigated the energy change of the reaction between zinc and copper sulfate solution.

This is the method used.

1. Measure 25 cm^3 of copper sulfate solution into a polystyrene cup.
2. Measure the temperature of the copper sulfate solution.
3. Add 0.20 g of zinc powder to the copper sulfate solution.
4. Stir the reaction mixture.
5. Record the highest temperature reached.
6. Repeat steps 1 to 5 with different masses of zinc powder.

Figure 3 shows the results.

Figure 3



4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 68 · continued

0 4 . 1 Draw **two** lines of best fit on **Figure 3**.

The lines should cross.

[2 marks]

0 4 . 2 Explain the results shown in **Figure 3**.

Do **not** refer to anomalous points.

Use data from **Figure 3**.

[4 marks]

0 4 . 3 Explain why using a polystyrene cup gives more accurate results than using a glass beaker.

[2 marks]

0 4 . 4 Complete the ionic equation for the reaction between zinc and copper sulfate solution.

Include state symbols.

[2 marks]

$$Zn(s) + Cu^{2+}(aq) \rightarrow ____(__) + ____(__)$$

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 68 · continued

A different student repeated steps 1 to 5 of the method four times using 0.50 g of zinc powder.

Table 2 shows the results.

Table 2

	Trial 1	Trial 2	Trial 3	Trial 4
Highest temperature reached in °C	37.6	37.2	37.8	37.4

0 4 . 5 Calculate the mean highest temperature reached.

Include the uncertainty in your answer.

[3 marks]

Mean highest temperature reached = _____ ± _____ °C

0 4 . 6 The results show random errors.

The student did not make any measuring errors.

Suggest **one** reason for the random errors in this experiment.

[1 mark]

14

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 69

June 2024 | 8462/1H | Original Q7

0 7 This question is about iron.

0 7 . 1 Iron is a metal.

Describe how iron conducts thermal energy.

[2 marks]

0 7 . 2 Pure iron is too soft for many uses.

Explain why mixing iron with other metals makes alloys which are harder than pure iron.

[3 marks]

Question 7 continues on the next page

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 69 · continued

0 7 . 3 When iron reacts with chlorine, 0.12 mol of iron reacts with 0.18 mol of chlorine (Cl_2).

Which is the correct equation for the reaction?

[1 mark]

Tick (✓) **one** box.

$Fe + Cl_2 \rightarrow FeCl_2$ ☐

$Fe + 3Cl_2 \rightarrow FeCl_6$ ☐

$2Fe + Cl_2 \rightarrow 2FeCl$ ☐

$2Fe + 3Cl_2 \rightarrow 2FeCl_3$ ☐

The most common oxides of iron are Fe_2O_3 and Fe_3O_4

0 7 . 4 What is the ratio of the numbers of ions in Fe_3O_4?

[1 mark]

Tick (✓) **one** box.

$2\ Fe^{2+} : 1\ Fe^{3+} : 4\ O^{2-}$ ☐

$1\ Fe^{2+} : 2\ Fe^{3+} : 4\ O^{2-}$ ☐

$3\ Fe^{2+} : 4\ O^{2-}$ ☐

$3\ Fe^{3+} : 4\ O^{2-}$ ☐

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 69 · continued

0 7 . 5 Calculate the percentage (%) by mass of iron in Fe_3O_4

Relative atomic masses (A_r): O = 16 Fe = 56

[3 marks]

Percentage by mass of iron = _____ %

0 7 . 6 Fe_2O_3 reacts with carbon to produce carbon dioxide.

The equation for the reaction is:

$$2\,Fe_2O_3(s) + 3\,C(s) \rightarrow 4\,Fe(s) + 3\,CO_2(g)$$

Calculate the volume of carbon dioxide gas at room temperature and pressure that is produced from 40.0 kg of Fe_2O_3 using excess carbon.

Relative formula mass (M_r): Fe_2O_3 = 160

The volume of 1 mole of any gas at room temperature and pressure is 24 dm^3.

[5 marks]

Volume of carbon dioxide = _____ dm^3

15

4.5.1.1 Energy transfer during exothermic and endothermic reactions

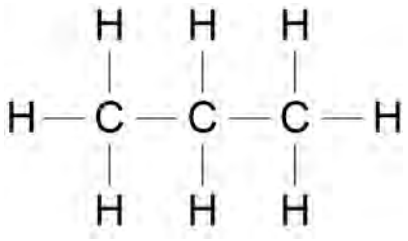
Question 70

June 2024 | 8462/1H | Original Q8

0 8 This question is about propane (C_3H_8).

Figure 7 shows the displayed structural formula of propane.

Figure 7



0 8 . 1 Explain why propane has a low boiling point.

[3 marks]

4.5.1.1 Energy transfer during exothermic and endothermic reactions

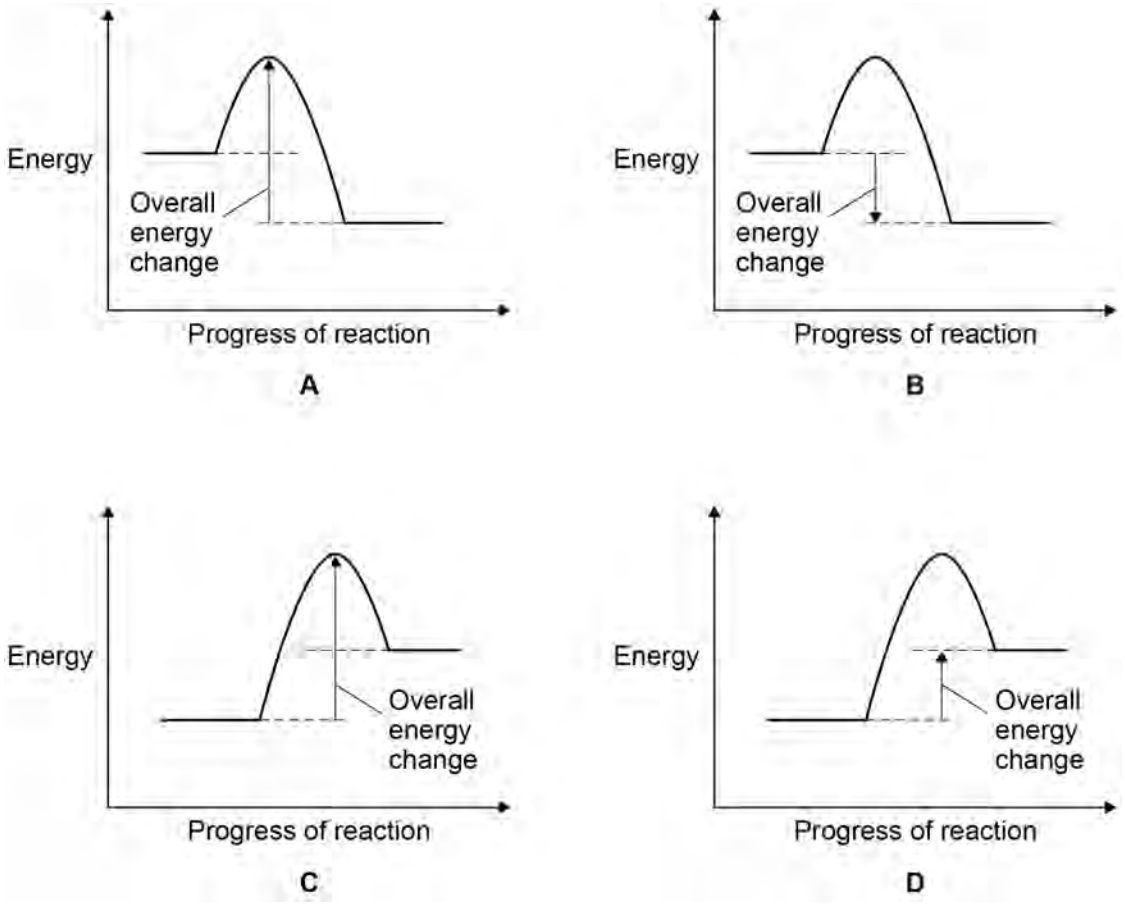
Question 70 · continued

Propane reacts with oxygen to produce carbon dioxide and water.

The reaction is exothermic.

0 8 . 2 **Figure 8** shows four reaction profiles.

Figure 8



Which is the correct reaction profile and labels for the reaction between propane and oxygen?

Tick (✓) **one** box.

[1 mark]

A ☐ B ☐ C ☐ D ☐

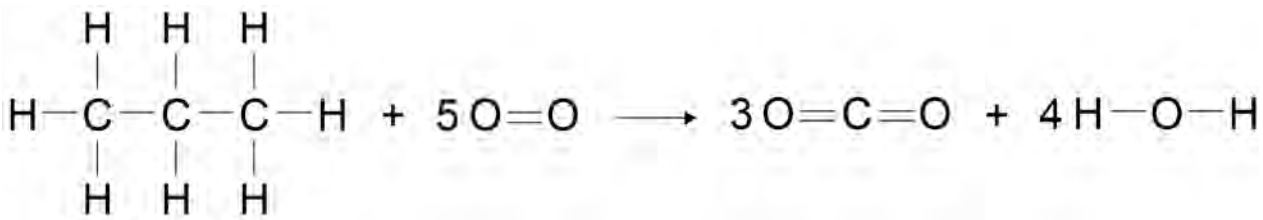
Question 8 continues on the next page

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 70 · continued

0 8 . 3 **Figure 9** shows the displayed formula equation for the reaction between propane and oxygen.

Figure 9



The overall energy change of this exothermic reaction is 2219 kJ/mol.

Table 4 shows the bond energies of the bonds in the reaction.

Table 4

	C — C	C — H	O = O	C = O	O — H
Energy in kJ/mol	347	**X**	498	805	464

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

[5 marks]

Bond energy of the C — H bond (**X**) = _____ kJ/mol

9

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 71

0 7 This question is about sulfuric acid.

0 7 . 1 Sulfuric acid contains sulfate ions.

Describe the test for the presence of sulfate ions in sulfuric acid.

Give the result of the test.

[2 marks]

Test _____

_____

Result _____

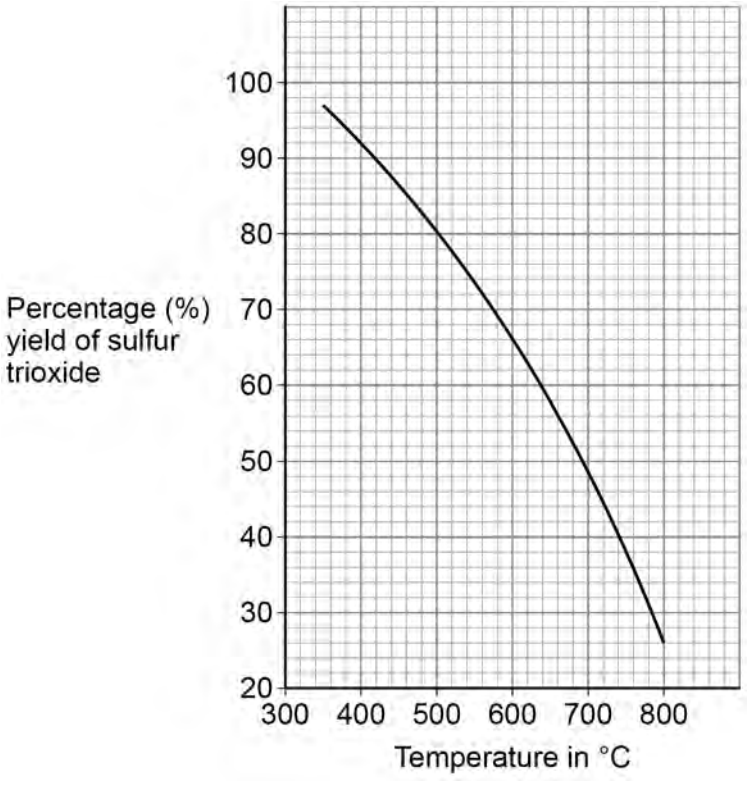
_____

One stage in the industrial production of sulfuric acid is the reaction of sulfur dioxide with oxygen to produce sulfur trioxide.

This reversible reaction reaches dynamic equilibrium.

Figure 7 shows the percentage yield of sulfur trioxide in this reaction at different temperatures.

Figure 7



4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 71 · continued

0 7 . 2 Which statement about the forward reaction is correct?

Use **Figure 7**.

[1 mark]

Tick (✓) **one** box.

- The yield is greater at higher temperatures because the reaction is exothermic. ☐
- The yield is greater at higher temperatures because the reaction is endothermic. ☐
- The yield is smaller at higher temperatures because the reaction is exothermic. ☐
- The yield is smaller at higher temperatures because the reaction is endothermic. ☐

The equation for the reaction is:

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

0 7 . 3 Explain why the percentage yield of sulfur trioxide in this reaction is greater if the pressure is higher.

[2 marks]

0 7 . 4 In industry, the reaction is done at 450 °C and atmospheric pressure.

Under these conditions the yield of sulfur trioxide is 86%.

Suggest **two** reasons why a higher pressure is **not** used.

[2 marks]

1

2

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 71 · continued

0 7 . 5 This reaction uses a catalyst to increase the rate of the reaction.

The catalyst is a metal oxide.

Which is the most likely metal in the metal oxide catalyst?

Use the periodic table.

[1 mark]

Tick (✓) **one** box.

Aluminium (Al) ☐

Barium (Ba) ☐

Potassium (K) ☐

Vanadium (V) ☐

8

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 72

June 2024 | 8462/2H | Original Q9

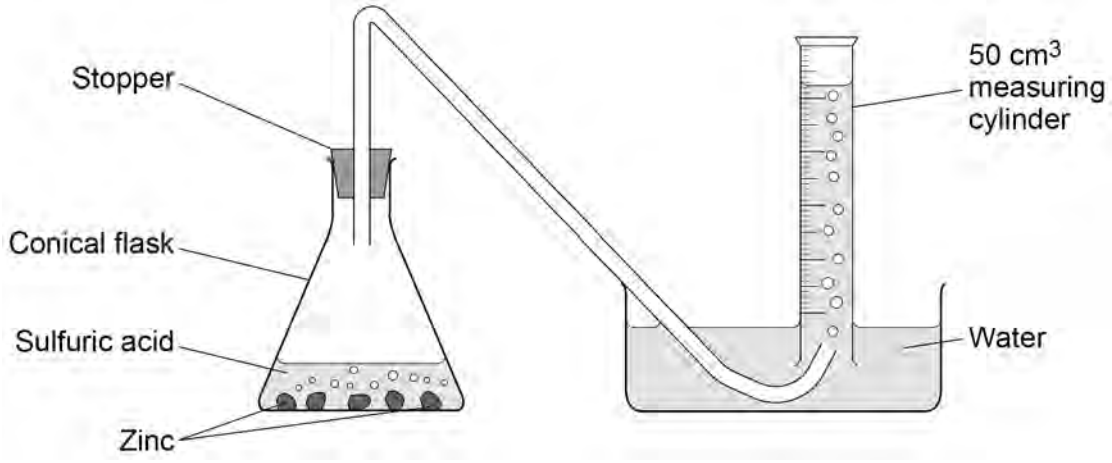
0 9 A student investigated the rate of the reaction between zinc and sulfuric acid.

The equation for the reaction is

$$Zn(s) + H_2SO_4(aq) \rightarrow ZnSO_4(aq) + H_2(g)$$

Figure 10 shows the apparatus.

Figure 10



This is the method used.

1. Pour 50 cm^3 of sulfuric acid into the conical flask.
2. Add excess zinc to the conical flask.
3. Insert the stopper and start a timer.
4. Measure the volume of hydrogen collected in the 50 cm^3 measuring cylinder every 20 seconds for 180 seconds.

0 9 . 1 Explain why the volume of hydrogen collected in the 50 cm^3 measuring cylinder is less than the volume of hydrogen produced.

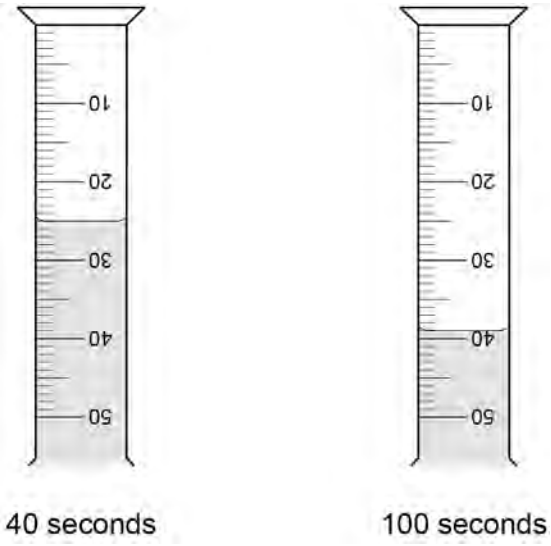
[2 marks]

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 72 · continued

Figure 11 shows the volumes of hydrogen collected in the 50 cm^3 measuring cylinder after 40 seconds and after 100 seconds.

Figure 11



0 9 . 2 Determine the number of moles of hydrogen collected between 40 seconds and 100 seconds.

The volume of one mole of any gas at room temperature and pressure is 24 dm^3.

[4 marks]

Moles of hydrogen = _____

Question 9 continues on the next page

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 72 · continued

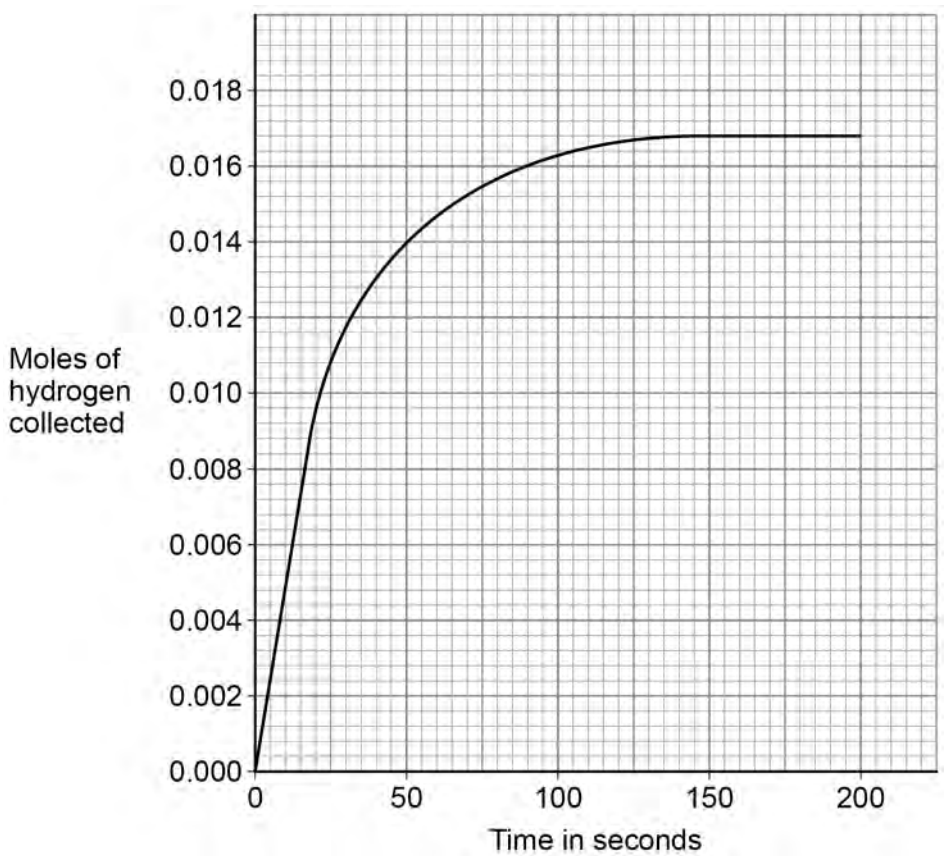
A different student investigated how the concentration of sulfuric acid affected the rate of the reaction.

0 9 . 3 The student did a different experiment using sulfuric acid of concentration 0.40 mol/dm^3.

The student calculated the number of moles of hydrogen collected after every 20 seconds.

Figure 12 shows the results.

Figure 12



4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 72 · continued

Determine the rate of reaction at 45 seconds.

You should draw a tangent on **Figure 12**.

Give your answer in standard form.

[5 marks]

Rate of reaction (in standard form) = _____ mol/s

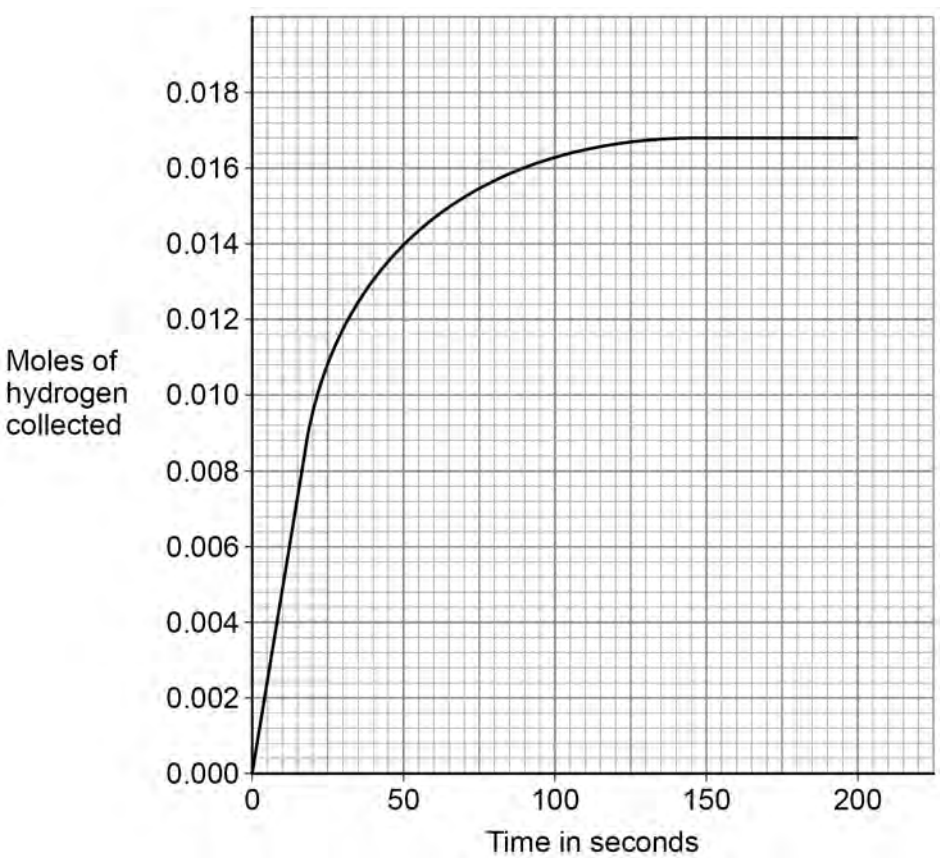
Question 9 continues on the next page

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 72 · continued

0 9 . 4 **Figure 13** shows the results for 0.40 mol/dm^3 sulfuric acid.

Figure 13



The student repeated the experiment using 0.20 mol/dm^3 sulfuric acid instead of 0.40 mol/dm^3 sulfuric acid.

Excess zinc was used in each experiment.

Sketch a line on **Figure 13** to show the results you would expect.

[2 marks]

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 72 · continued

June 2024 | 8462/2H | Original Q9

0 9 . 5 Explain how increasing the temperature would affect the rate of reaction between zinc and sulfuric acid.

[3 marks]

16

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 73

June 2025 | 8462/1H | Original Q7

0 7 Hydrazine (N_2H_4) is a compound of nitrogen and hydrogen.

0 7 . 1 Scientists are researching the use of hydrazine in fuel cells.

Table 2 gives some information about the use of hydrogen and hydrazine in fuel cells.

Table 2

	Hydrogen	**Hydrazine**
State at room temperature	Gas	Liquid
Hazards	Explosive	Toxic
Equation for fuel cell reaction	$2\ H_2\ +\ O_2\ \longrightarrow\ 2\ H_2O$	$N_2H_4\ +\ O_2\ \longrightarrow\ N_2\ +\ 2\ H_2O$
Voltage produced in volts	1.23	1.61
Catalyst needed for reaction	Platinum	None

Evaluate the use of hydrazine instead of hydrogen in a fuel cell.

[4 marks]

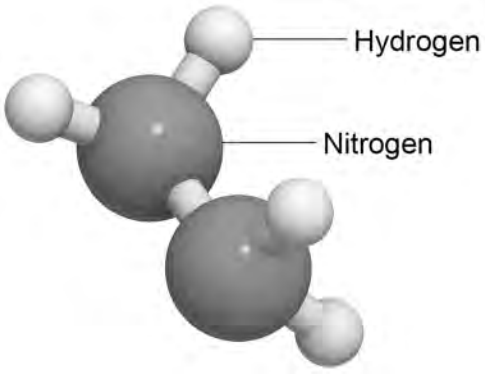
Extra space

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 73 · continued

Figure 6 shows a model of the hydrazine molecule.

Figure 6

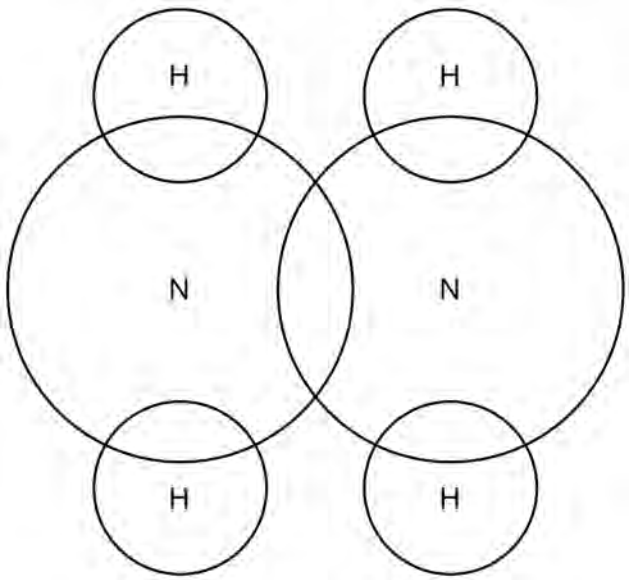


0 7 . 2 Complete the dot and cross diagram for hydrazine in **Figure 7**.

Show the outer shell electrons only.

[2 marks]

Figure 7



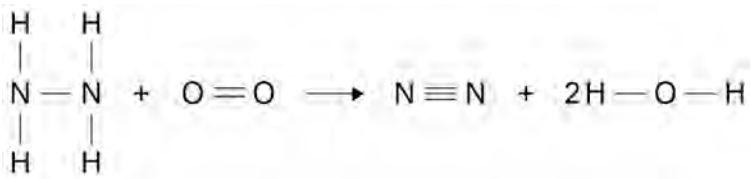
0 7 . 3 Give **one** advantage of the ball and stick model in **Figure 6** compared to the dot and cross diagram.

[1 mark]

Question 73 · continued

0 7 . 4 **Figure 8** shows the displayed formula equation for the reaction of hydrazine with oxygen.

Figure 8



The reaction is exothermic.

The energy released forming new bonds is 581 kJ/mol greater than the energy needed to break existing bonds.

Table 3 shows some bond energies.

Table 3

Bond	N — N	N — H	O = O	N ≡ N	O — H
Bond energy in kJ/mol	X	391	498	945	464

Calculate the bond energy (**X**) of the N — N bond.

[4 marks]

X = _____ kJ/mol

11

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 74

0 5 This question is about unsaturated hydrocarbons.

0 5 . 1 **Table 6** shows the boiling points of some unsaturated hydrocarbons.

Table 6

Formula of unsaturated hydrocarbon	Boiling point in °C
C_2H_4	– 104
C_3H_6	– 47
C_4H_8	**X**
C_5H_{10}	30
C_6H_{12}	63

Estimate the boiling point **X** in **Table 6**.

[1 mark]

_____ °C

0 5 . 2 C_2H_4 reacts with water vapour (steam).

Name the compound produced when C_2H_4 reacts with water vapour.

[1 mark]

_____

Question 5 continues on the next page

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 74 · continued

C_4H_8 reacts with chlorine (Cl_2).

0 5 . 3 Describe the test for chlorine.

Give the result of the test.

[2 marks]

Test _____

_____

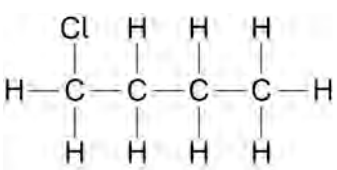
Result _____

_____

0 5 . 4 Which is the displayed formula of the organic compound produced when C_4H_8 reacts with chlorine?

[1 mark]

Tick (✓) **one** box.



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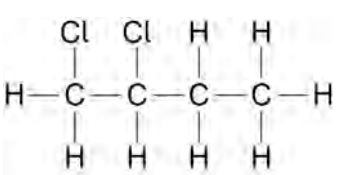

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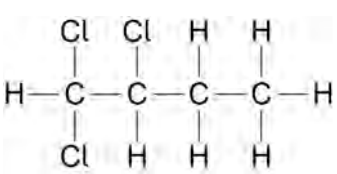

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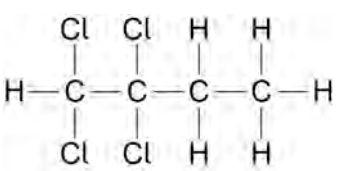


☐

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 74 · continued

0 5 . 5 Name the unsaturated hydrocarbon with the formula C_3H_6

[1 mark]

0 5 . 6 Why does C_3H_6 tend to burn in air with a smoky flame?

[1 mark]

0 5 . 7 C_3H_6 is a gas at room temperature and pressure.

Calculate the volume of 2.1 g of C_3H_6 at room temperature and pressure.

Give your answer in cm^3.

The volume of one mole of any gas at room temperature and pressure is 24 dm^3.

Relative atomic masses (A_r): H = 1 C = 12

[5 marks]

Volume = _____ cm^3

12

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 75

0 8 Hydrogen peroxide decomposes into water and oxygen.

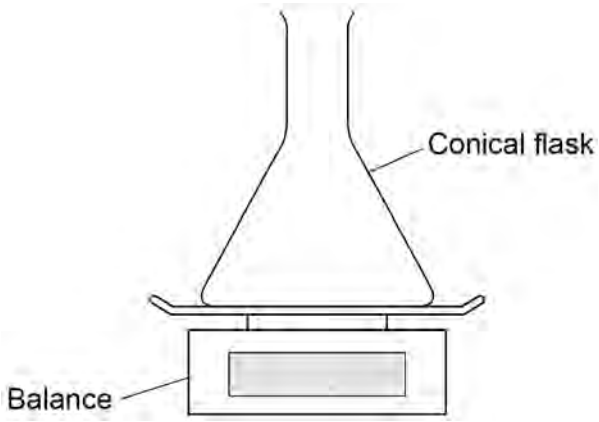
The equation for the reaction is:

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

A student investigated the effect of catalyst **A** and of catalyst **B** on the rate of this reaction.

Figure 6 shows the apparatus.

Figure 6



This is the method used.

1. Put the conical flask on the balance.
2. Add 50 cm^3 of 1.5 mol/dm^3 hydrogen peroxide solution to the conical flask.
3. Add 1.00 g of catalyst **A** to the conical flask.
4. Start a timer.
5. Record the loss in mass of the conical flask and contents every 30 seconds for 3 minutes.
6. Repeat steps 1 to 5 using catalyst **B**.

0 8 . 1 Explain why the conical flask and contents lost mass.

[2 marks]

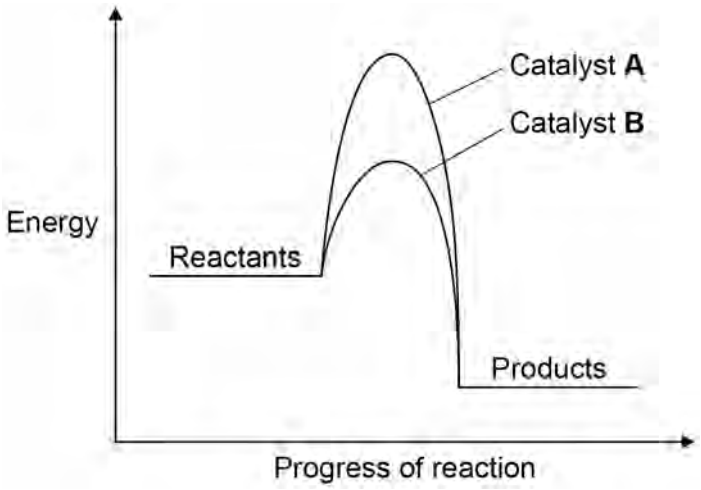
4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 75 · continued

0 8 . 2 **Figure 7** shows the reaction profile for the decomposition of hydrogen peroxide using:

- catalyst **A**
- catalyst **B**.

Figure 7



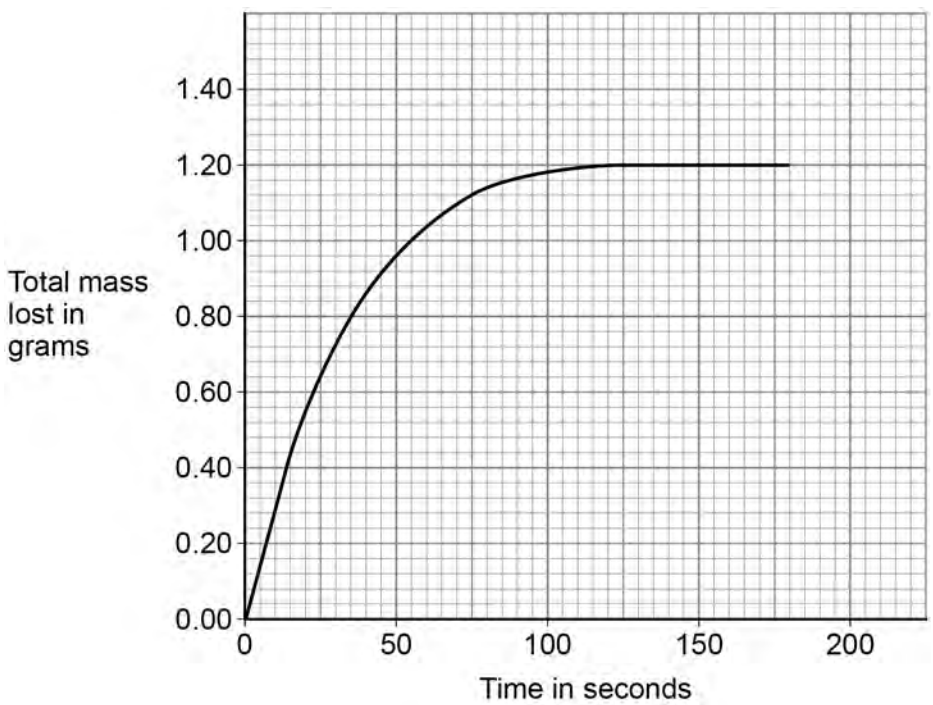
Explain why catalyst **A** and catalyst **B** give different rates of reaction for the decomposition of hydrogen peroxide.

[3 marks]

Question 8 continues on the next page

0 8 . 3 **Figure 8** shows the results for catalyst **A**.

Figure 8



Determine the rate of the reaction when the time was 60 seconds.

Give your answer in standard form.

[5 marks]

Rate (standard form) = _____ g/s

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 75 · continued

0 8 . 4 Explain how the rate of decomposition of hydrogen peroxide depends on the temperature of the solution.

[3 marks]

13

Turn over for the next question

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 76

June 2025 | 8462/2H | Original Q9

0 9 This question is about ammonia.

Ammonia is produced from nitrogen and hydrogen in the Haber process.

Hydrogen is produced from methane and steam.

The equation for one of the reactions in the production of hydrogen is:

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3\,H_2(g)$$

The forward reaction absorbs energy from the surroundings.

0 9 . 1 Explain why a high temperature is used in this reaction.

[3 marks]

0 9 . 2 Explain why as low a pressure as possible is used in this reaction.

[2 marks]

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 76 · continued

0 9 . 3 A nickel catalyst is used in this reaction.

What is the effect of the nickel catalyst on the position of equilibrium?

[1 mark]

Tick (✓) **one** box.

Equilibrium position shifts to the left. ☐

No effect on equilibrium position. ☐

Equilibrium position shifts to the right. ☐

0 9 . 4 The nitrogen needed in the Haber process is obtained from air.

Calculate the approximate volume of air required to obtain 50 dm^3 of nitrogen.

[2 marks]

Volume ~ _____ dm^3

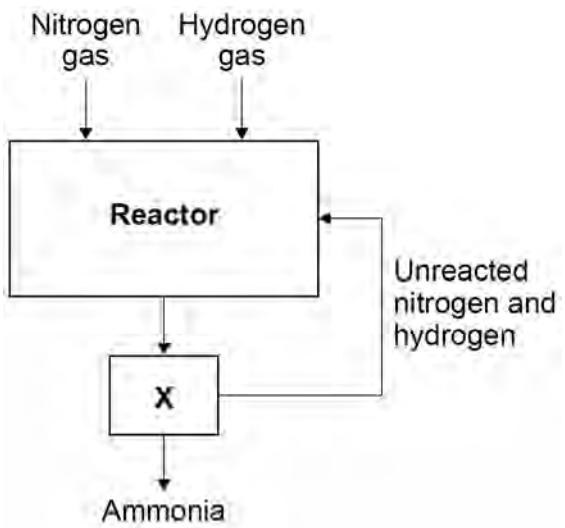
Question 9 continues on the next page

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 76 · continued

0 9 . 5 **Figure 9** shows how ammonia is produced from nitrogen and hydrogen.

Figure 9



Explain how the mixture of ammonia, nitrogen and hydrogen is separated at **X**.

[3 marks]

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 76 · continued

0 9 . 6 Ammonia is used to produce fertilisers.

Nitrogen is released into the air when bacteria break down fertilisers and dead plant matter.

One of the reactions during the production of hydrogen from methane (natural gas) releases carbon dioxide into the air.

The use of nitrogen to produce ammonia is more sustainable than the use of hydrogen to produce ammonia.

Give **three** reasons why.

[3 marks]

1 _____

_____

2 _____

_____

3 _____

_____

14