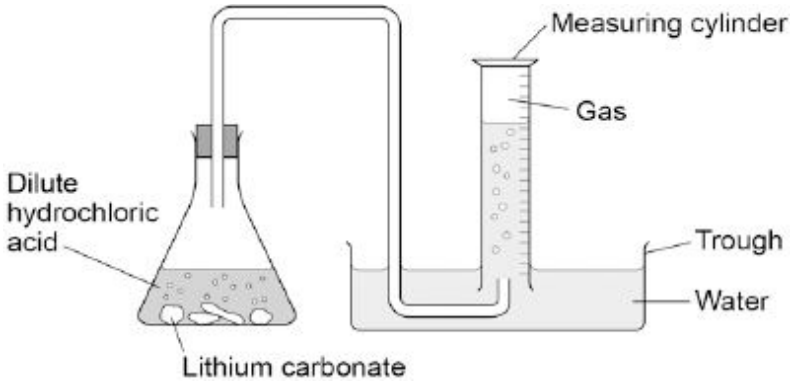
1 Lithium carbonate reacts with dilute hydrochloric acid.

A group of students investigated the volume of gas produced.

This is the method used.

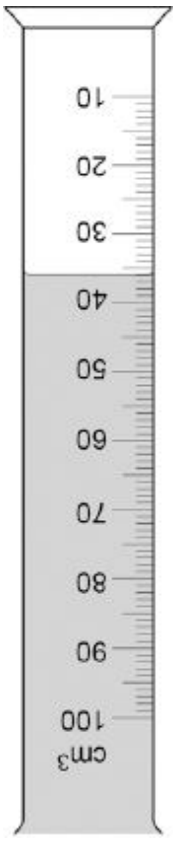
1. Place a known mass of lithium carbonate in a conical flask.
2. Measure 10 cm^3 of dilute hydrochloric acid using a measuring cylinder.
3. Pour the acid into the conical flask.
4. Place a bung in the flask and collect the gas as shown in **Figure 1**.

Figure 1



(a) **Figure 2** shows the measuring cylinder.

Figure 2



What volume of gas has been collected?

Volume = ... cm^3

(1)

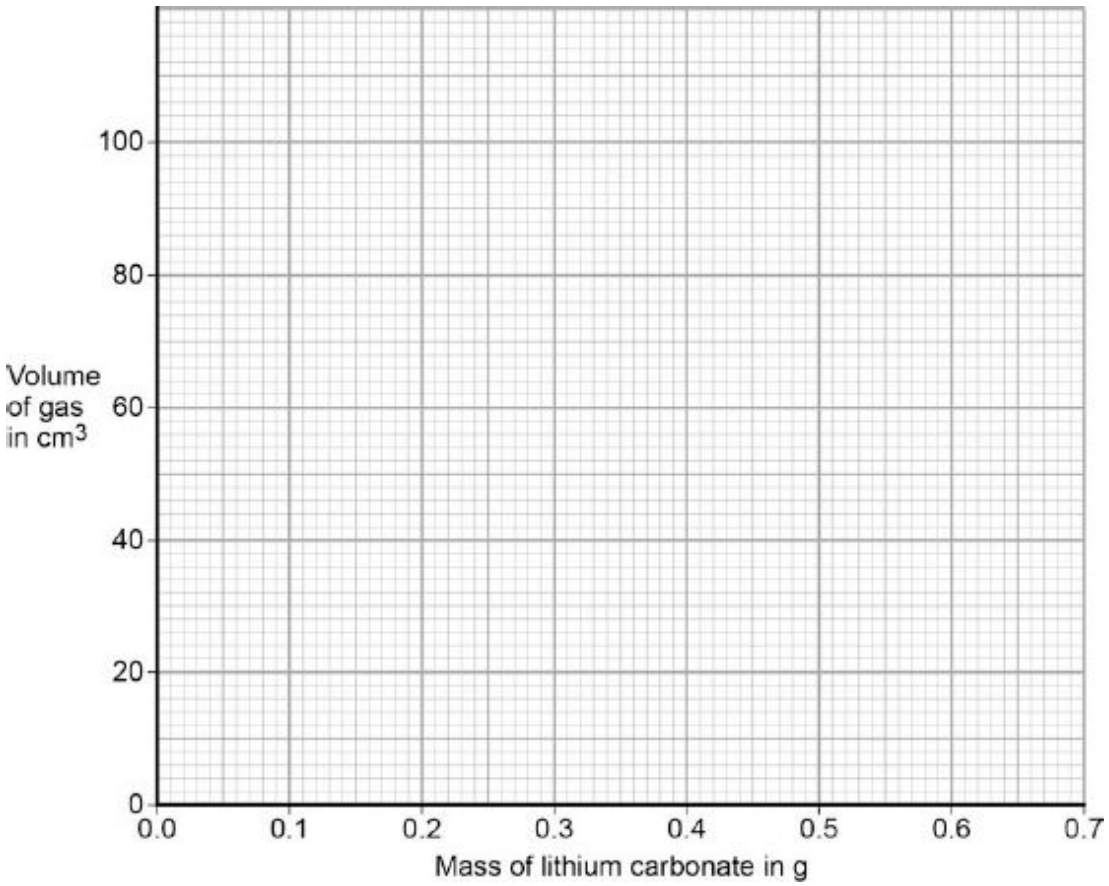
(b) The table below shows the students' results.

Mass of lithium carbonate in g	**Volume of gas in cm^3**
0.0	0
0.1	22
0.2	44
0.3	50
0.4	88
0.5	96
0.6	96
0.7	96

On **Figure 3**:

- Plot these results on the grid.
- Complete the graph by drawing **two** straight lines of best fit.

Figure 3



(4)

(c) What are **two** possible reasons for the anomalous result?

Tick **two** boxes.

- Too much lithium carbonate was added. ☐
- The bung was not pushed in firmly enough. ☐
- There was too much water in the trough. ☐
- The measuring cylinder was not completely over the delivery ☐
- The conical flask was too small. ☐

(2)

(d) Describe the pattern the graph shows up to 0.4 g of lithium carbonate added.

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(2)

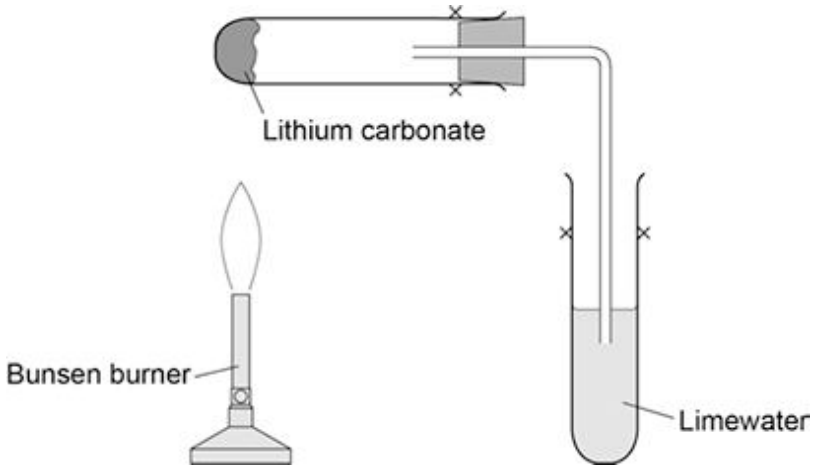
(e) Lithium carbonate decomposes when heated.

The equation shows the decomposition of lithium carbonate.

Li_2CO_3 (s) → Li_2O (s) + CO_2 (g)

Figure 4 shows the apparatus a student used to decompose lithium carbonate.

Figure 4



Why does the limewater bubble?

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(1)

(f) The student repeated the experiment with potassium carbonate.
The limewater did not bubble.

Suggest why there were **no** bubbles in the limewater.

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(1)
(Total 11 marks)

2 (a) Nitrogen and hydrogen are passed over iron to produce ammonia in the Haber Process.

Balance the equation for the reaction.

N_2 + H_2 → NH_3

(1)

(b) What is iron used for in the Haber process?

Tick **one** box.

catalyst ☐

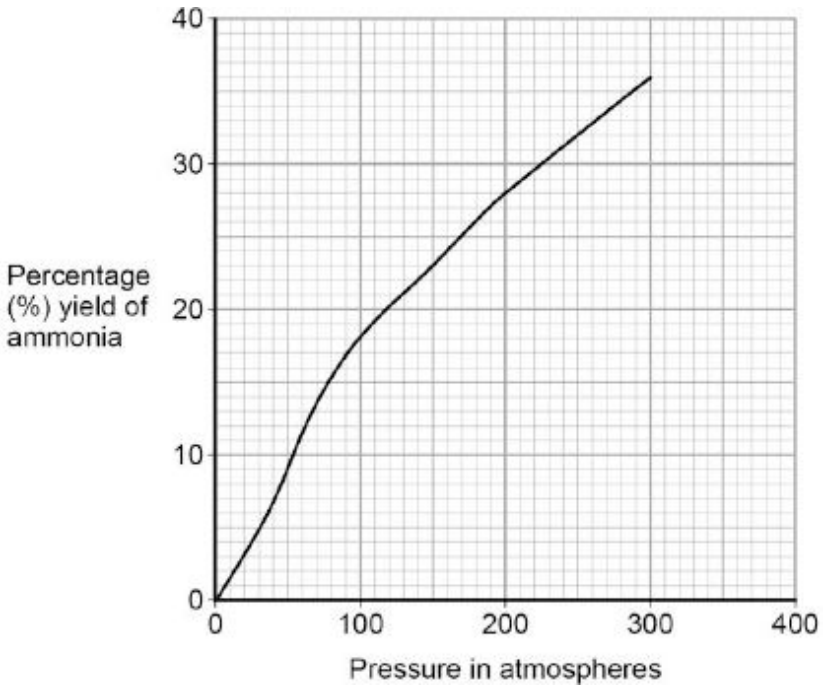
fuel ☐

monomer ☐

reactant ☐

(1)

(c) The figure below shows how the percentage yield of ammonia changes with pressure.



Describe the trend shown in the figure above.

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.....

(1)

(d) Use the figure above to determine the difference in percentage yield of ammonia at 150 atmospheres pressure and 250 atmospheres pressure.

Difference in percentage yield of ammonia = ... %

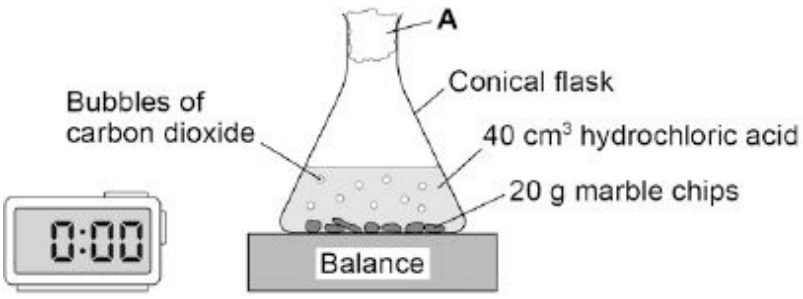
(2)

(Total 5 marks)

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

Figure 1 shows the apparatus the student used.

Figure 1



(a) What is **A**?

Tick **one** box.

cotton wool ☐

limestone ☐

poly(ethene) ☐

rubber bung ☐

(1)

(b) **Table 1** shows the student's results for one investigation.

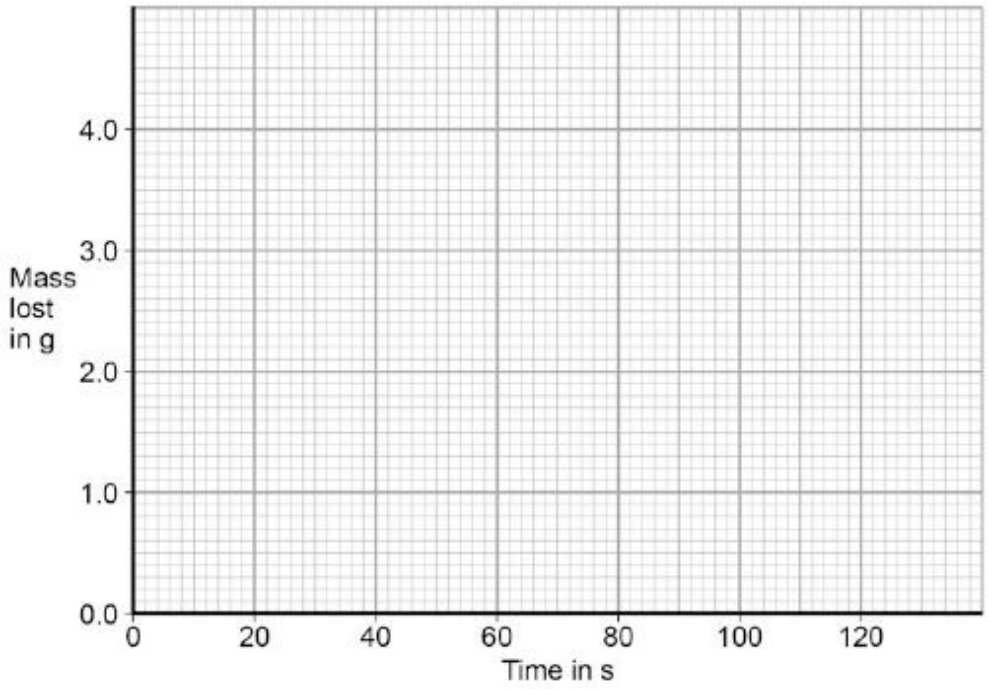
Table 1

Time in s	Mass lost in g
0	0.0
20	1.6
40	2.6
60	2.9
80	3.7
100	4.0
120	4.0

On **Figure 2**:

- Plot these results on the grid.
- Draw a line of best fit.

Figure 2



(3)

(c) Use **Figure 2** to complete **Table 2**.

Table 2

Mass lost after 0.5 minutes	..... g
Time taken to complete the reaction	..... s

(2)

(d) The equation for the reaction is:

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

Explain why there is a loss in mass in this investigation.

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(2)

(e) Another student investigated the rate of a different reaction.

Table 3 shows the results from the different reaction.

Table 3

Mass lost when the reaction was complete	9.85 g
Time taken to complete the reaction	2 minutes 30 seconds

Calculate the mean rate of the reaction using **Table 3** and the equation:

$$\text{mean rate of reaction} = \frac{\text{mass lost in g}}{\text{time taken in s}}$$

Give your answer to two decimal places.

.....

.....

Mean rate of reaction = ... g / s

(2)

(f) The student measured the change in mass of the reactants.

Describe another method, other than measuring the change in mass of the reactions, that the student could have used to find the rate of the reaction between marble chips and hydrochloric acid.

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(2)

(g) Another student planned to investigate the effect of temperature on the rate of reaction. The student predicted that the rate of reaction would increase as the temperature was increased.

Give **two** reasons why the student's prediction is correct.

Tick **two** boxes.

The particles are more concentrated. ☐

The particles have a greater mass. ☐

The particles have a larger surface area. ☐

The particles have more energy. ☐

The particles move faster. ☐

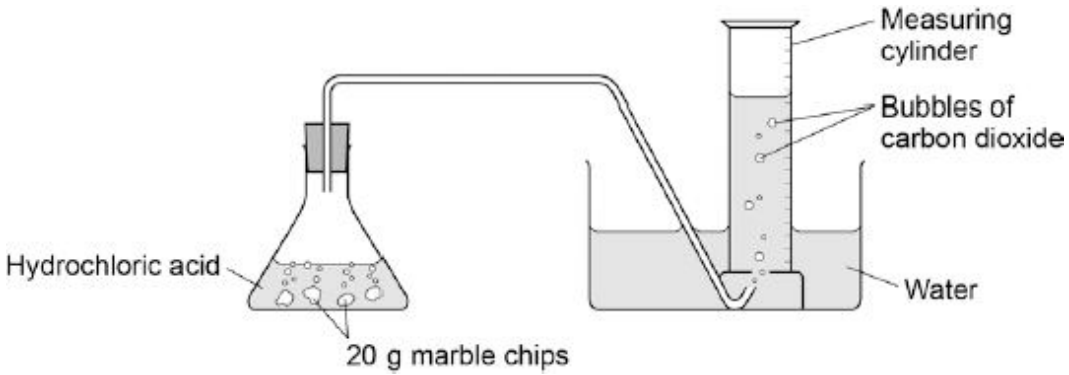
(2)
(Total 14 marks)

4 Marble chips are mainly calcium carbonate ($CaCO_3$).

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

Figure 1 shows the apparatus the student used.

Figure 1



(a) Complete and balance the equation for the reaction between marble chips and hydrochloric acid.

..... + ... → $CaCl_2$ + ... + ...

(2)

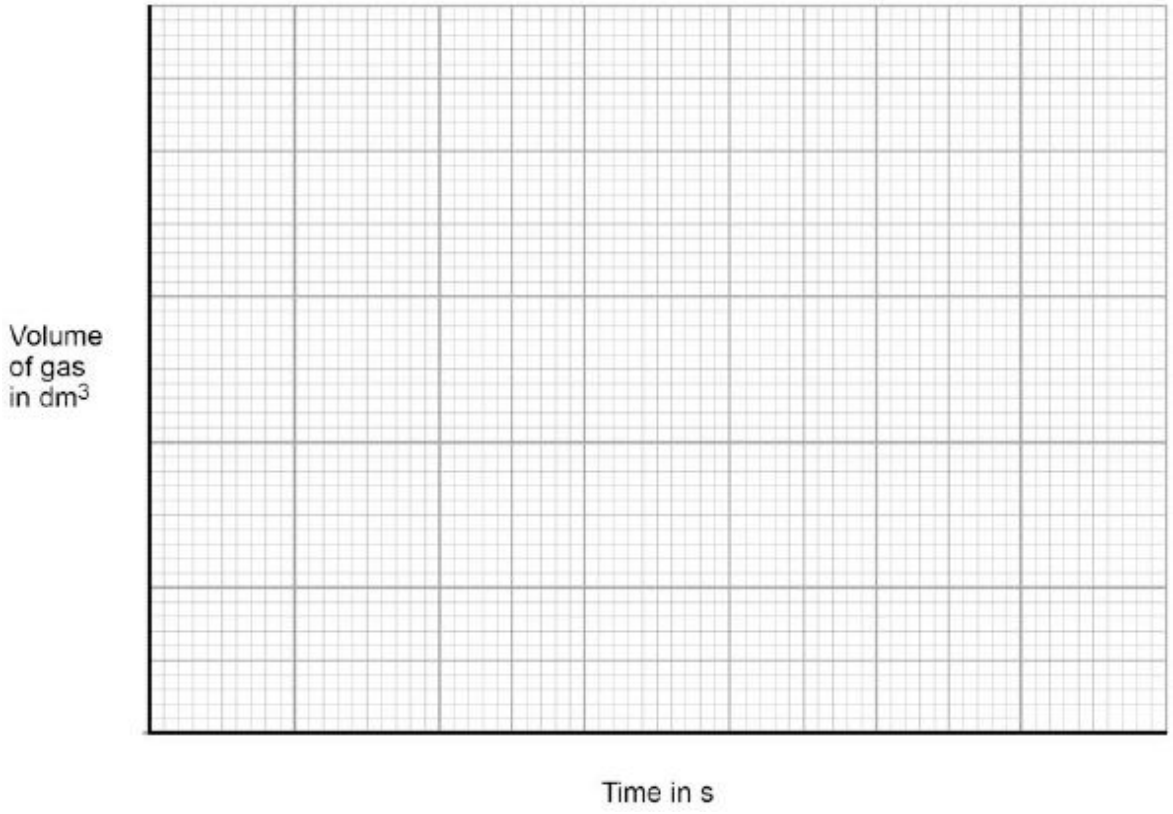
(b) The table below shows the student's results.

Time in s	Volume of gas in dm^3
0	0.000
30	0.030
60	0.046
90	0.052
120	0.065
150	0.070
180	0.076
210	0.079
240	0.080
270	0.080

On **Figure 2**:

- Plot these results on the grid.
- Draw a line of best fit.

Figure 2



(4)

(c) Sketch a line on the grid in **Figure 2** to show the results you would expect if the experiment was repeated using 20 g of smaller marble chips.

Label this line **A**.

(2)

(d) Explain, in terms of particles, how and why the rate of reaction changes during the reaction of calcium carbonate with hydrochloric acid.

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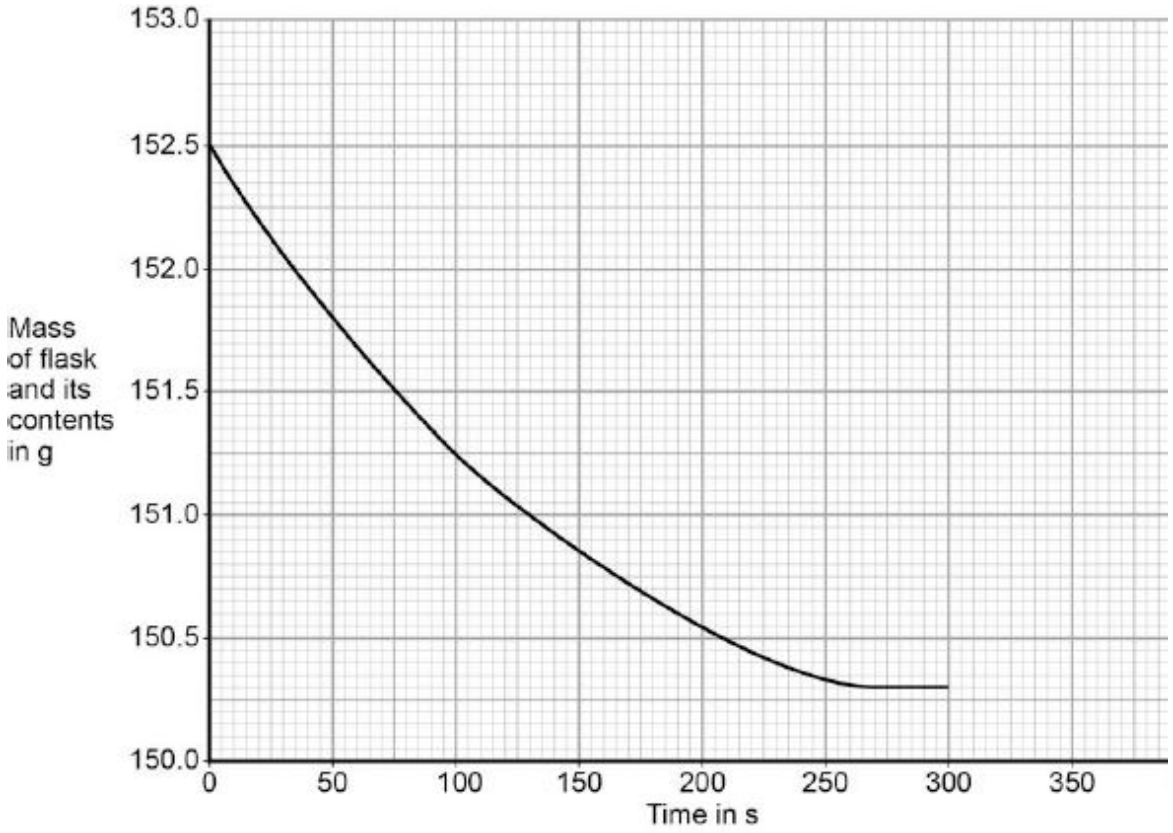
(4)

(e) Another student investigated the rate of reaction by measuring the change in mass.

Figure 3 shows the graph plotted from this student's results.

Figure 3



Use **Figure 3** to calculate the mean rate of the reaction up to the time the reaction is complete.

Give your answer to three significant figures.

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Mean rate of reaction = ... g / s

(4)

(f) Use **Figure 3** to determine the rate of reaction at 150 seconds.

Show your working on **Figure 3**.

Give your answer in standard form.

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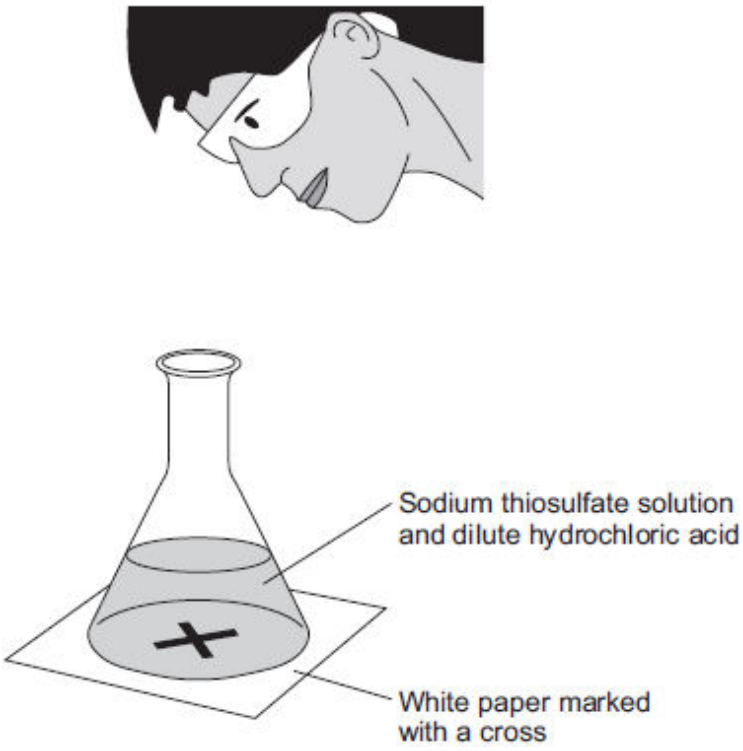
Rate of reaction at 150 s = ... g / s

(4)

(Total 20 marks)

5 A student investigated the rate of reaction between sodium thiosulfate solution and dilute hydrochloric acid, as shown in **Figure 1**.

Figure 1



The reaction produced a precipitate, which made the mixture turn cloudy.

The student timed how long it took until she could no longer see the cross.

She calculated the rate of the reaction.

(a) The equation for the reaction is:

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

Name the product that made the mixture go cloudy.

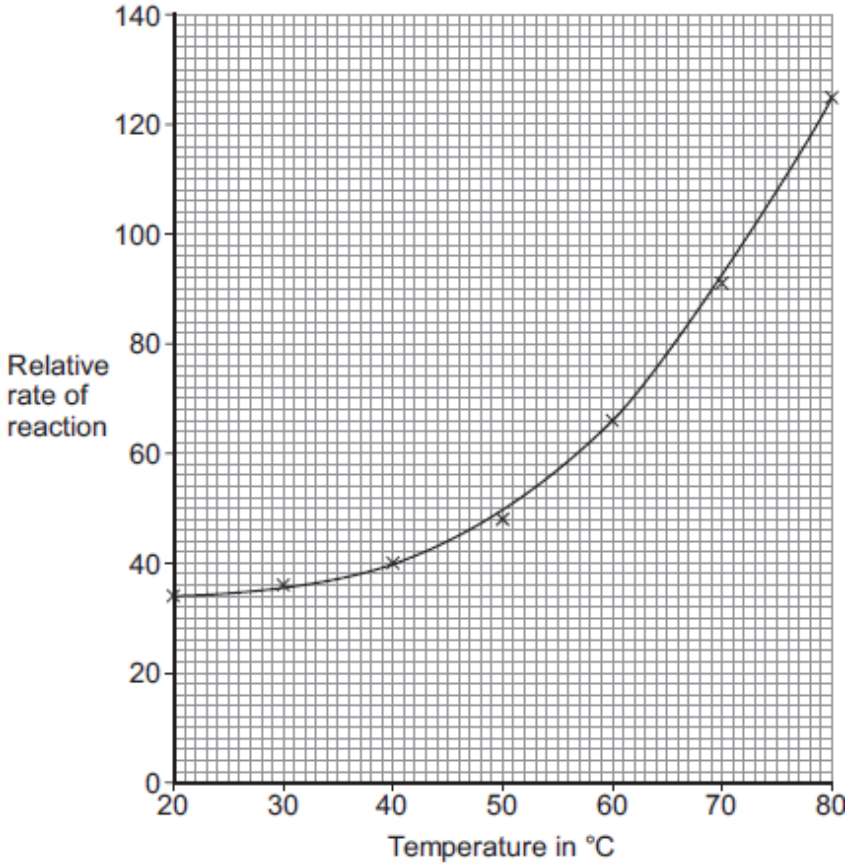
.....

(1)

(b) The student investigated the effect of changing the temperature of the sodium thiosulfate solution on the rate of reaction.

She plotted her results on a graph, as shown in **Figure 2**.

Figure 2



Describe the trends shown in the student's results.

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(2)

(c) The student then investigated the effect of changing the concentration of sodium thiosulfate solution on the rate of the reaction.

(i) Suggest **two** variables the student would need to control to make sure that her results were valid.

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(2)

(ii) From this investigation the student correctly concluded:

'As the concentration of sodium thiosulfate solution doubles, the rate of reaction doubles.'

Explain the student's conclusion in terms of particles.

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(3)
(Total 8 marks)

6 This question is about ethanol.

(a) Ethanol can be made by fermentation of sugars from plants.

(i) What is a suitable temperature for fermentation?

Draw a ring around the correct answer.

0 °C **25 °C** **450 °C**

(1)

(ii) Fermentation produces a dilute solution of ethanol in water.

Name the process used to obtain ethanol from this dilute solution.

.....

(1)

(b) Ethanol made by fermentation can be used as a biofuel.

(i) Explain why increasing the use of biofuels may cause food shortages.

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(2)

(ii) Explain why burning biofuels contributes less to climate change than burning fossil fuels.

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(2)

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

Ethanol can also be made by reacting ethene with steam in the presence of a catalyst.

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

Figure 1 shows how the percentage yield of ethanol changes as the pressure is changed at three different temperatures.

Figure 1

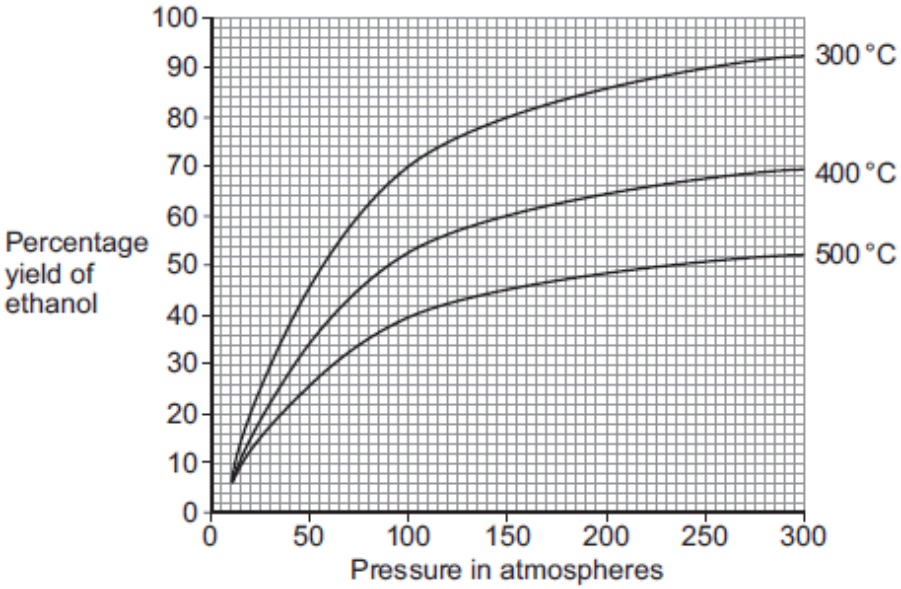
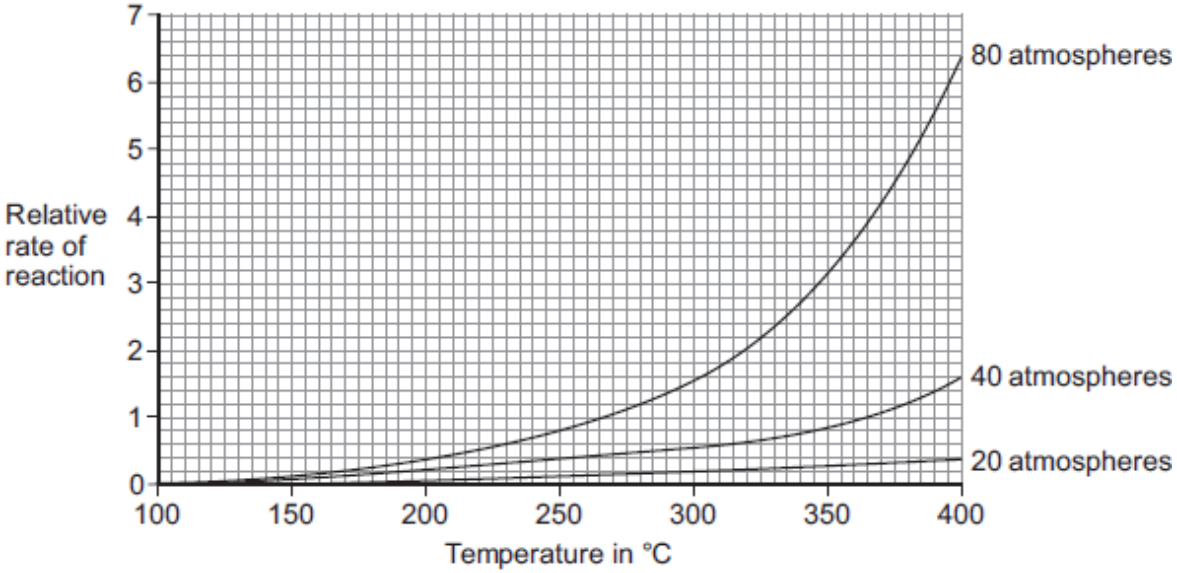


Figure 2 shows how the rate of reaction changes as the temperature changes at three different pressures.

Figure 2



In one process for the reaction of ethene with steam the conditions are:

- 300 °C

- 65 atmospheres
- a catalyst.

Use the information in **Figure 1** and **Figure 2**, and your own knowledge, to justify this choice of conditions.

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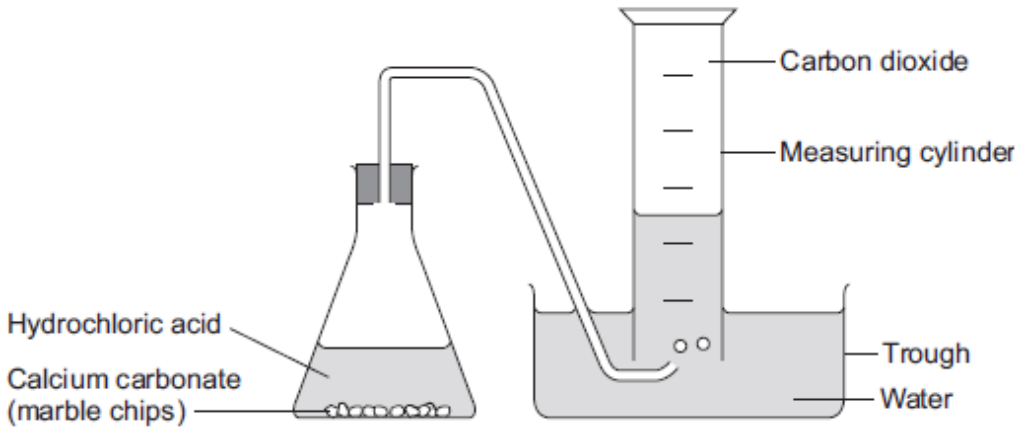
(6)
(Total 12 marks)

7 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.

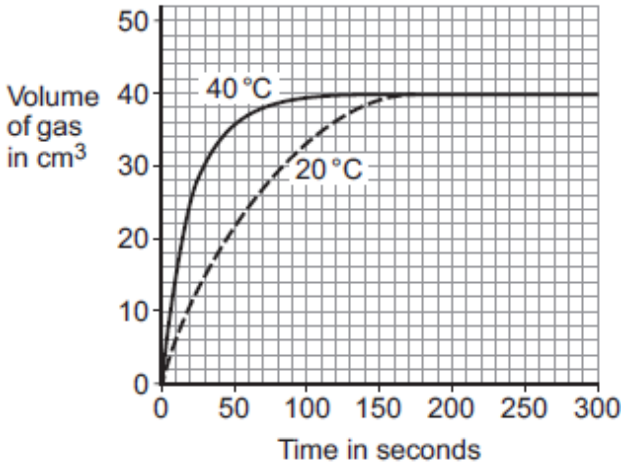
The equation for the reaction is:

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

(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.

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

.....

.....

(1)

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

.....

.....

(1)

(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.

.....

.....

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

(1)

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

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

Tick (✓) **two** boxes.

Amount of water in the trough ☐

Concentration of acid ☐

Mass of marble chips ☐

Size of marble chips ☐

Volume of measuring cylinder ☐

(2)

(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.

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(2)

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

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

.....

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(1)
(Total 8 marks)

8 This question is about reversible reactions and chemical equilibrium.

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

(i) What is meant by a closed system?

.....

.....

(1)

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

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(2)

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

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

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

.....

(1)

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

Explain how a catalyst speeds up a reaction.

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(2)

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

Give a reason for your answer.

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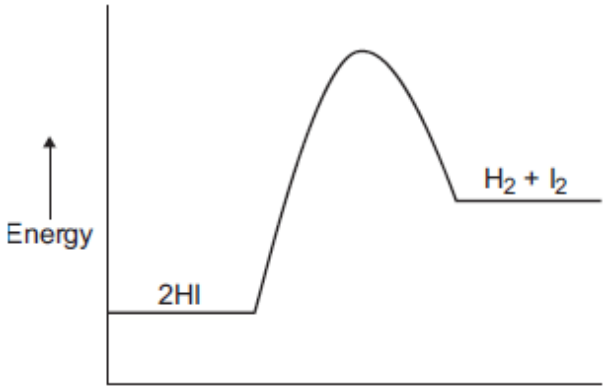
(2)

(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 shown below is for the forward reaction.



(i) Draw an arrow to show the activation energy on the diagram.

(1)

(ii) How does the diagram show that the reaction is endothermic?

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.....

(1)

(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.

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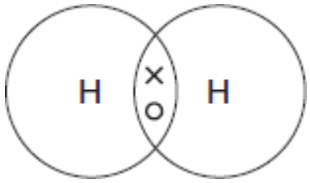
(2)
(Total 12 marks)

9 Hydrogen gas is produced by the reaction of methane and steam.

(a) The diagram represents a molecule of hydrogen.



(i) What type of bond joins the atoms of hydrogen?

Tick (✓) **one** box.

Covalent ☐

Metallic ☐

Ionic ☐

(1)

(ii) A catalyst is used in the reaction.

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

A catalyst

increases the rate of reaction.

increases the temperature.

increases the yield of a reaction.

(1)

(b) The equation for the reaction of methane and steam is:

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

(i) What is meant by the symbol $\rightleftharpoons$?

.....

(1)

(ii) Lowering the pressure reduces the rate of reaction.

Explain why, in terms of particles.

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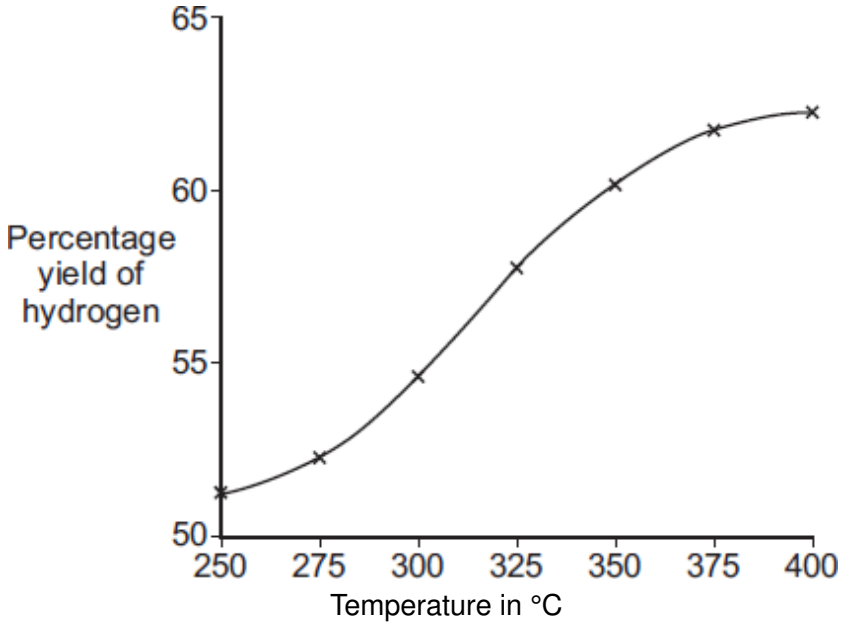
(2)

(iii) The graph shows the yield of hydrogen at different temperatures.



The forward reaction is endothermic.

How does the graph show that the forward reaction is endothermic?

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(1)

(iv) Why is a higher yield produced if the reaction is repeated at a lower pressure?

.....

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(1)

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

Car engines are being developed that use hydrogen gas as a fuel instead of petrol.

The table compares the two fuels.

	Hydrogen	**Petrol**
Energy	5700 kJ per litre	34 000 kJ per litre
State	Gas	Liquid
Equation for combustion	$2H_2 + O_2 \rightarrow 2H_2O$	$2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O$
How the fuel is obtained	Most hydrogen is produced from coal, oil or natural gas. Hydrogen can be produced by the electrolysis of water or the solar decomposition of water.	Fractional distillation of crude oil.

Use the information in the table and your knowledge of fuels to evaluate the use of hydrogen instead of petrol as a fuel.

You should describe the advantages and disadvantages of using hydrogen instead of petrol.

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Extra space .....

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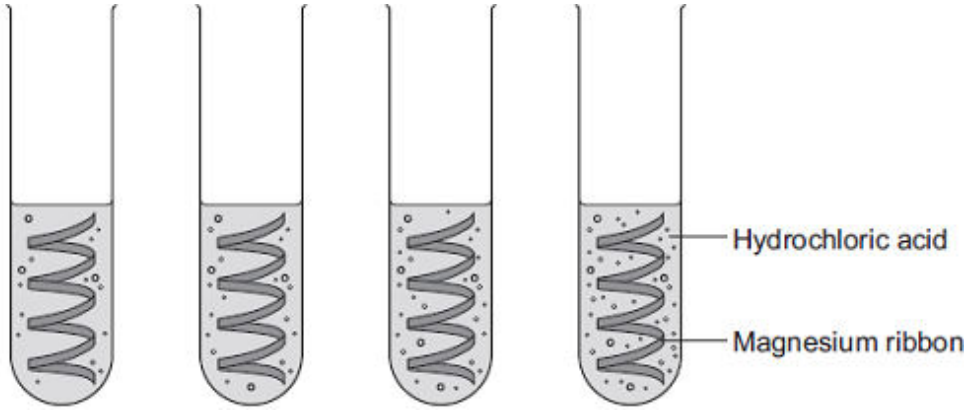
(6)
(Total 13 marks)

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

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

The student studied the effect of changing the concentration of the hydrochloric acid.

She measured the time for the magnesium to stop reacting.



Concentration of hydrochloric acid in moles per dm^3	0.5	1.0	1.5	2.0

(a) The student changed the concentration of the hydrochloric acid.

Give **two** variables that the student should control.

1 .....

2 .....

(2)

(b) (i) The rate of reaction increased as the concentration of hydrochloric acid increased.

Explain why.

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(2)

(ii) Explain why increasing the temperature would increase the rate of reaction.

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(3)

(c) (i) The student had a solution of sodium hydroxide with a concentration of 0.100 moles per dm^3.

She wanted to check the concentration of a solution of hydrochloric acid.

She used a pipette to transfer 5.00 cm^3 of the hydrochloric acid into a conical flask.

She filled a burette with the 0.100 moles per dm^3 sodium hydroxide solution.

Describe how she should use titration to obtain accurate results.

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(4)

(ii) Sodium hydroxide neutralises hydrochloric acid as shown in the equation:

$$NaOH(aq) + HCl(aq) \longrightarrow NaCl(aq) + H_2O(l)$$

The student found that 27.20 cm^3 of 0.100 moles per dm^3 sodium hydroxide neutralised 5.00 cm^3 of hydrochloric acid.

Calculate the concentration of the hydrochloric acid in moles per dm^3.

Give your answer to three significant figures.

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Concentration of hydrochloric acid = ... moles per dm^3

(3)

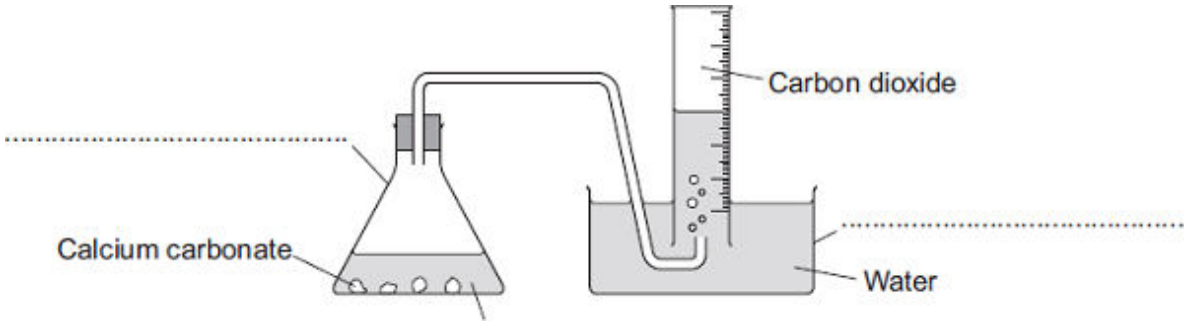
(Total 14 marks)

11 Some students were investigating the rate at which carbon dioxide gas is produced when metal carbonates react with an acid.

One student reacted 1.00 g of calcium carbonate with 50 cm^3, an excess, of dilute hydrochloric acid.

The apparatus used is shown in **Diagram 1**.

Diagram 1



(a) Complete the **two** labels for the apparatus on the diagram.

(2)

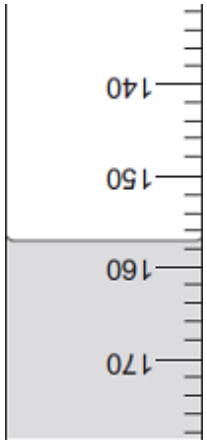
(b) The student measured the volume of gas collected every 30 seconds.

The table shows the student's results.

Time in seconds	Volume of carbon dioxide collected in cm^3
30	104
60	
90	198
120	221
150	232
180	238
210	240
240	240

(i) **Diagram 2** shows what the student saw at 60 seconds.

Diagram 2



What is the volume of gas collected?

Volume of gas = ... cm^3

(1)

(ii) Why did the volume of gas stop changing after 210 seconds?

.....

.....

(1)

(c) Another student placed a conical flask containing 1.00 g of a Group 1 carbonate (M_2CO_3) on a balance.

He then added 50 cm^3, an excess, of dilute hydrochloric acid to the flask and measured the mass of carbon dioxide given off.

The equation for the reaction is:

$$M_2CO_3 + 2HCl \longrightarrow 2MCl + H_2O + CO_2$$

The final mass of carbon dioxide given off was 0.32 g.

(i) Calculate the amount, in moles, of carbon dioxide in 0.32 g carbon dioxide.

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

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Moles of carbon dioxide = ... moles

(2)

(ii) How many moles of the metal carbonate are needed to make this number of moles of carbon dioxide?

.....

.....

Moles of metal carbonate = ... moles

(1)

(iii) The mass of metal carbonate used was 1.00 g.

Use this information, and your answer to part **(c) (ii)**, to calculate the relative formula mass (M_r) of the metal carbonate.

If you could not answer part **(c) (ii)**, use 0.00943 as the number of moles of metal carbonate. This is **not** the answer to part **(c) (ii)**.

.....

.....

Relative formula mass (M_r) of metal carbonate = ...

(1)

(iv) Use your answer to part **(c) (iii)** to calculate the relative atomic mass (A_r) of the metal in the metal carbonate (M_2CO_3) and so identify the Group 1 metal in the metal carbonate.

If you could not answer part **(c) (iii)**, use 230 as the relative formula mass of the metal carbonate. This is **not** the answer to part **(c) (iii)**.

To gain full marks, you must show your working.

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Relative atomic mass of metal is .....

Identity of metal .....

(3)

(d) Two other students repeated the experiment in part **(c)**.

(i) When the first student did the experiment some acid sprayed out of the flask as the metal carbonate reacted.

Explain the effect this mistake would have on the calculated relative atomic mass of the metal.

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(3)

(ii) The second student used 100 cm^3 of dilute hydrochloric acid instead of 50 cm^3.

Explain the effect, if any, this mistake would have on the calculated relative atomic mass of the metal.

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(3)
(Total 17 marks)

12 Lead nitrate solution reacts with potassium iodide solution.

The reaction produces a solid.

Figure 1 shows the reaction occurring.

Figure 1

Lead Iodide By Der Kreole (own work) (CC-BY-3.0) via Wikimedia Commons

(a) (i) Give the name of this type of reaction.

Tick (✓) **one** box.

Combustion ☐

Neutralisation ☐

Precipitation ☐

(1)

(ii) Write the missing state symbols in the chemical equation.

$Pb(NO_3)_2(aq) + 2KI(.....) \longrightarrow PbI_2(.....) + 2KNO_3(aq)$

(2)

(iii) Complete the word equation for the reaction.

lead nitrate + ... ⟶ lead iodide + ...

(2)

(iv) How is solid lead iodide separated from the solution?

Draw a ring around the correct answer.

Distillation **Electrolysis** **Filtration**

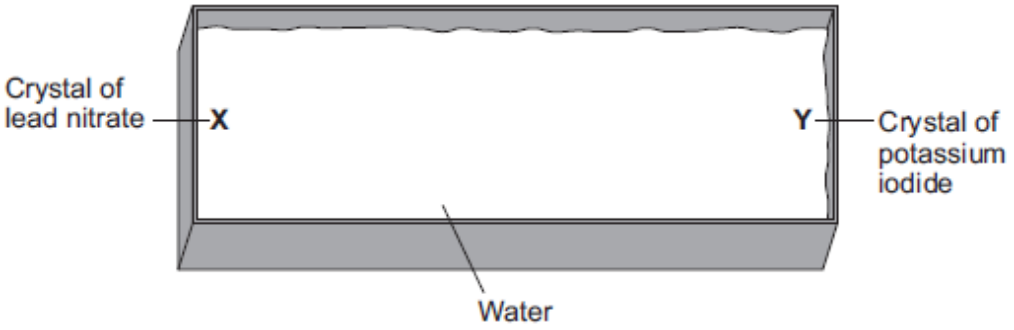
(1)

(b) A group of students investigated the movement of particles.

The students filled a container with water.

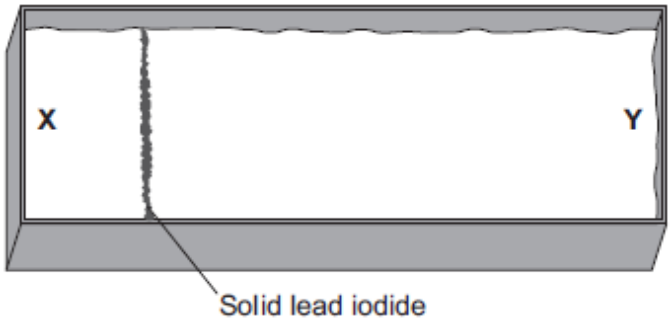
The students added a crystal of lead nitrate at position **X** and a crystal of potassium iodide at position **Y**, as shown in **Figure 2**.

Figure 2 – view from above



After 3 minutes solid lead iodide started to form at the position shown in **Figure 3**.

Figure 3 – view from above



(i) Tick (✓) the correct box to complete the sentence.

Lead ions and iodide ions move through the water by

diffusion. ☐

evaporation. ☐

neutralisation. ☐

(1)

(ii) What conclusion can you make about the speed of movement of lead ions compared with iodide ions?

Give a reason for your answer.

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(2)

(iii) The students repeated the experiment at a higher temperature.

The solid lead iodide formed after a shorter period of time.

Explain why, in terms of particles.

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(2)
(Total 11 marks)

13 A company manufactures ethanol (C_2H_5OH).

The reaction for the process is:

$$C_2H_4(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g) \qquad \Delta H = -45 \text{ kJ per mole}$$

The temperature and pressure can be changed to increase the yield of ethanol at equilibrium.

(a) Explain what is meant by equilibrium.

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(3)

(b) (i) How would increasing the temperature change the **yield** of ethanol at equilibrium?

Give a reason for your answer.

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(2)

(ii) How would increasing the pressure change the **yield** of ethanol at equilibrium?

Give a reason for your answer.

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(2)

(c) A catalyst is added to increase the rate of the reaction.

Explain how adding a catalyst increases the rate of a chemical reaction.

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(2)
(Total 9 marks)

14 Iron will rust in damp air.

(a) Iron reacts with water and oxygen to produce rust.

(i) As iron rusts there is a colour change.

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

During the reaction iron changes from grey to

blue **brown** **green**

(1)

(ii) Rust is hydrated iron oxide.

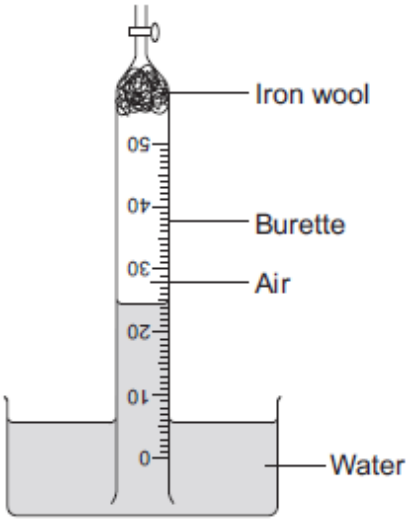
Write a word equation for the reaction of iron with oxygen and water.

.....

(1)

(b) A student set up the apparatus shown in **Figure 1**.

Figure 1

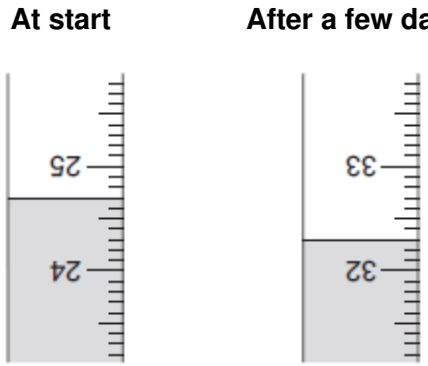


The student left the apparatus for a few days.

The water level in the burette slowly went up and then stopped rising.

Figure 2 shows the water level in the burette at the start of the experiment and after a few days.

Figure 2



(i) Complete the table below to show the reading on the burette after a few days.

Burette reading at start	24.7 cm^3
Burette reading after a few days	.....cm^3

(1)

(ii) Calculate the volume of oxygen used up in the reaction.

.....

Volume = ... cm^3

(1)

(iii) The percentage of air that is oxygen can be calculated using the equation:

$$\text{percentage of air that is oxygen} = \frac{\text{volume of oxygen used up}}{\text{volume of air at start}} \times 100$$

The student **cannot** use his results to calculate the correct percentage of air that is oxygen.

Explain why.

.....

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.....

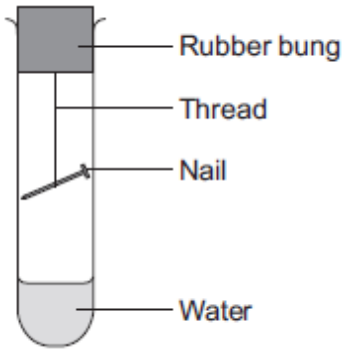
(2)

(c) A student investigated the rusting of an iron nail at different temperatures.

This is the method the student used:

- measure the mass of a nail
- set up apparatus as shown in **Figure 3**
- leave for 3 days
- measure the mass of the rusted nail.

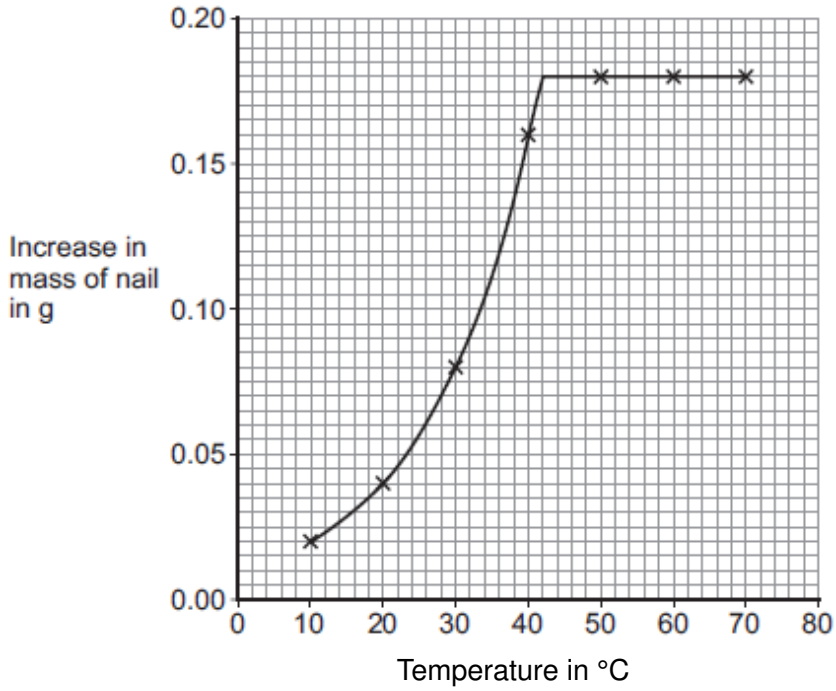
Figure 3



The student repeated the experiment at different temperatures using a new, identical, nail each time.

The student's results are shown on the graph in **Figure 4**.

Figure 4



(i) Why does the mass of the nail increase when it rusts?

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(1)

(ii) Use the graph to describe the relationship between the temperature and the increase in mass of the nail.

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(3)

(iii) The increase in mass of the nail after 3 days is a measure of the rate of rusting.

The student's graph does **not** correctly show how increasing the temperature above 42 °C changes the rate of rusting.

How could the experiment be changed to show the effect of temperatures above 42 °C on the rate of rusting?

Give a reason for your answer.

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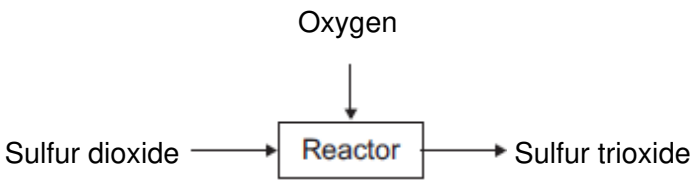
(2)
(Total 12 marks)

15 (a) The figure below represents the reaction of sulfur dioxide with oxygen.



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

sulfur dioxide + ... ⟶ .....

(1)

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

Sulfur dioxide (SO_2) is

a compound.
an element.
a mixture.

(1)

(b) The reactants are gases.

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

Complete the sentence.

When the pressure of the gases is increased,

the frequency of the collisions ..... .

(1)

(c) The particles need energy to react.

Complete the sentence.

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

the ..... energy.

(1)

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

.....

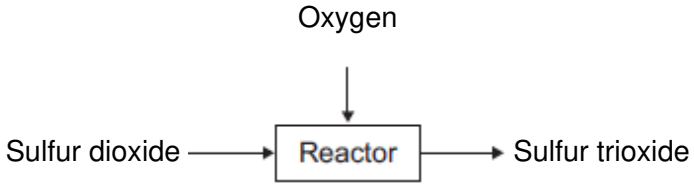
.....

(1)

(Total 5 marks)

16 **Figure 1** represents a reaction in the production of sulfuric acid.

Figure 1



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

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

(2)

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

(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.

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(3)

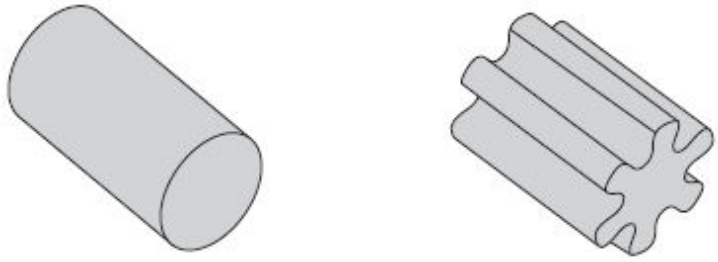
(ii) A catalyst is used for the reaction.

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

Figure 2 shows the shapes of pieces of catalyst.

Figure 2

A **B**



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

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(2)

(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**?

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(1)

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

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

Explain why.

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.....

(2)

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

Complete the equation for this reaction.

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

(2)

(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.

.....

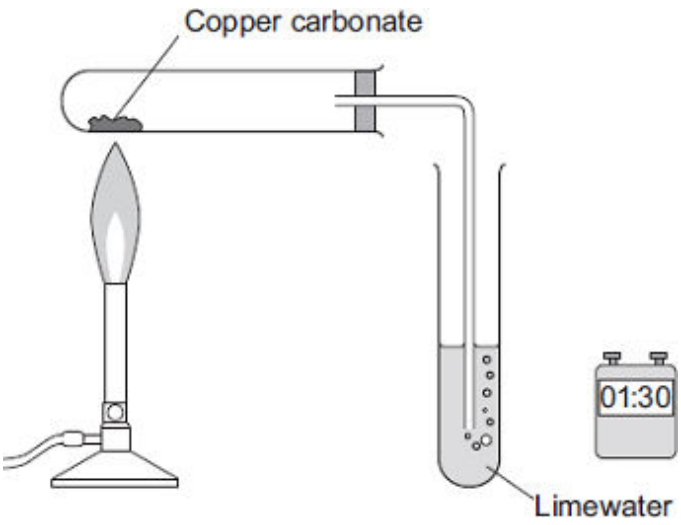
.....

(1)

(Total 13 marks)

17 Carbon dioxide is produced when copper carbonate is heated.

A student investigated heating copper carbonate.
The student used the apparatus to measure how long it took for carbon dioxide to be produced.
The student also noted what happened during each minute for three minutes.



(a) The student used changes to the limewater to measure how long it took for carbon dioxide to be produced.

Describe how.

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(2)

(b) The student wrote down her observations.

Time interval in minutes	Observations
Between 0 and 1	A slow release of gas bubbles. The limewater did not change. The solid in the test tube was green.
Between 1 and 2	A fast release of gas bubbles. The limewater changed at 1 minute 10 seconds.
Between 2 and 3	No release of gas bubbles. The solid in the test tube was black.

(i) Suggest the reason for the student's observations between 0 and 1 minute.

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(2)

(ii) Explain the student's observations between 1 and 2 minutes.

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(2)

(iii) Explain the student's observations between 2 and 3 minutes.

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(2)

18 Thermosoftening polymers can be used to make plastic bottles and food packaging.

(a) Why are thermosoftening polymers **not** suitable for storing very hot food?

.....

.....

(1)

(b) The reaction to produce the polymers uses a catalyst.

Why are catalysts used in chemical reactions?

.....

.....

(1)

(c) Compounds from food packaging must not get into food.

Gas chromatography can be used to separate compounds in food.

The output from the gas chromatography column can be linked to an instrument which can identify the compounds.

(i) Name the instrument used to identify the compounds.

.....

.....

(1)

(ii) Give **one** reason why instrumental methods of analysis are used to identify the compounds.

.....

.....

(1)

(d) Poly(ethene) is a thermosoftening polymer.

Poly(ethene) can be made with different properties. The properties depend on the conditions used when poly(ethene) is made.

Suggest **two** conditions which could be changed when poly(ethene) is made.

.....

.....

(2)

(Total 6 marks)

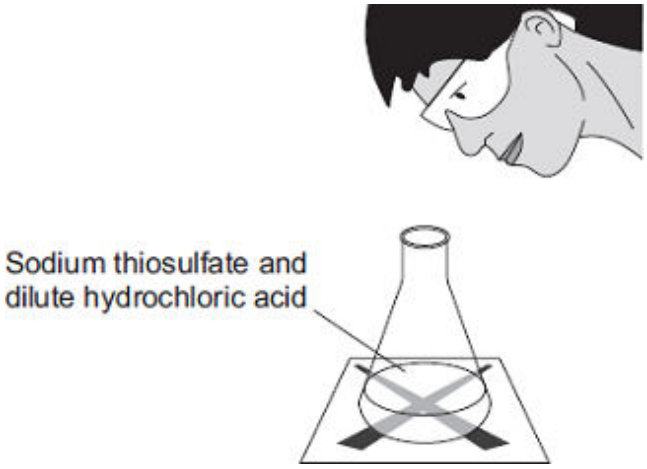
19 A student investigated the rate of reaction between sodium thiosulfate and dilute hydrochloric acid.

The student placed a conical flask over a cross on a piece of paper.

The student mixed the solutions in the flask.

The solution slowly went cloudy.

The student timed how long it took until the cross could not be seen.



The equation for the reaction is:

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

sodium thiosulfate + hydrochloric acid → sodium chloride + water + sulfur dioxide + sulfur

(a) Explain why the solution goes cloudy.

.....

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(2)

(b) The student repeated the experiment with different concentrations of sodium thiosulfate.

Concentration of sodium thiosulfate in moles per dm^3	Time taken until the cross could not be seen in seconds			
	Trial 1	Trial 2	Trial 3	Mean
0.040	71	67	69	69
0.060	42	45	45	44
0.080	31	41	33	

(i) Calculate the mean time for 0.080 moles per dm^3 of sodium thiosulfate.

.....

.....

.....

Mean = ... seconds

(2)

(ii) Describe and explain, in terms of particles and collisions, the effect that increasing the concentration of sodium thiosulfate has on the rate of the reaction.

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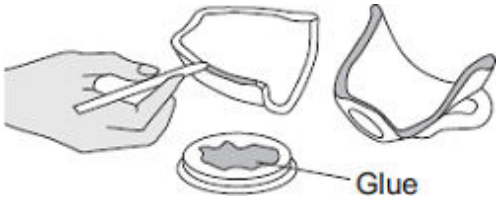
(3)
(Total 7 marks)

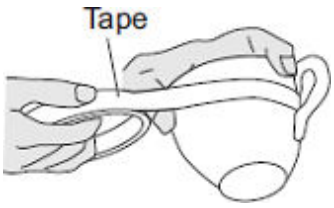
20 The following steps show how to use a type of glue.

Step 1 Measure out equal amounts of the liquids from tubes **A** and **B**.

Step 2 Mix the liquids to make the glue.
Put a thin layer of the glue onto each of the surfaces to be joined.



Step 3 Put the pieces together and hold them with tape.



Step 4 Leave the glue to set.

(a) When liquids **A** and **B** are mixed a chemical reaction takes place.

This reaction is *exothermic*.

What does *exothermic* mean?

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(2)

(b) The time taken for the glue to set at different temperatures is given in the table below.

Temperature in°C	Time taken for the glue to set
20	3 days
60	6 hours
90	1 hour

(i) Use the correct answer from the box to complete each sentence.

decreases	increases	stays the same

When the temperature is increased the time taken for the glue to set

.....

When the temperature is increased the rate of the setting reaction

.....

(2)

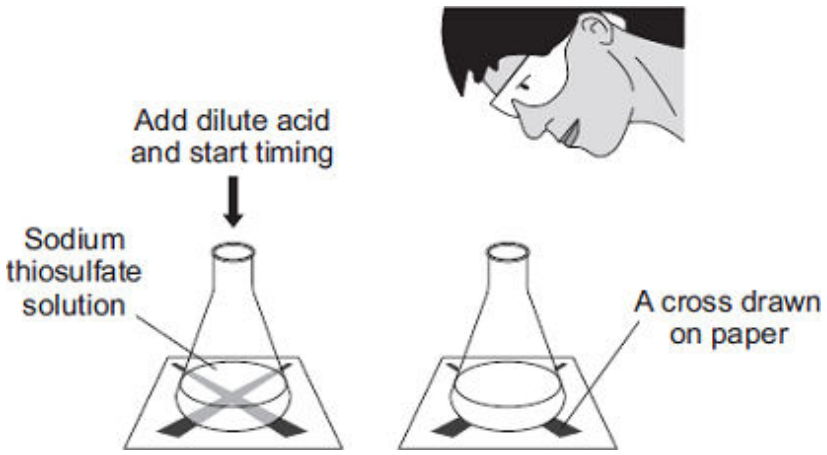
(ii) Tick (✓) **two** reasons why an increase in temperature affects the rate of reaction.

Reason	Tick (✓)
It gives the particles more energy	
It increases the concentration of the particles	
It increases the surface area of the particles	
It makes the particles move faster	

(2)
(Total 6 marks)

21 Sodium thiosulfate solution reacts with hydrochloric acid. As the reaction takes place the solution slowly turns cloudy.

The diagram shows a method of measuring the rate of this reaction.



A student used this method to study how changing the concentration of the sodium thiosulfate solution alters the rate of this reaction.

The student used different concentrations of sodium thiosulfate solution. All the other variables were kept the same.

The results of the experiments are shown on the graph below.

(a) (i) Draw a line of best fit on the graph.

(1)

(ii) Suggest **two** reasons why all of the points do not lie on the line of best fit.

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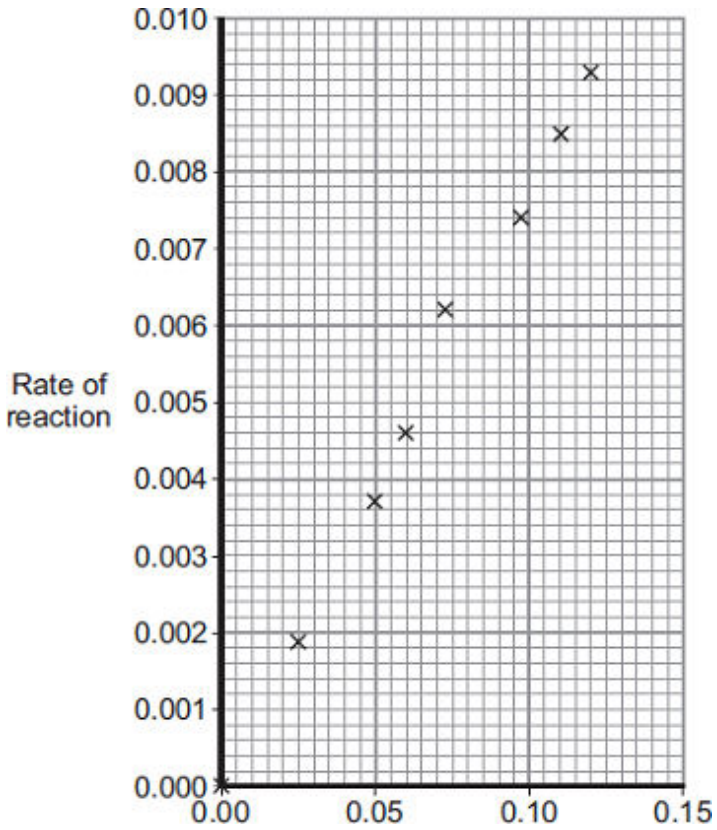
(2)



(b) (i) In a conclusion to the experiment the student stated that:

'The rate of this reaction is directly proportional to the concentration of the sodium thiosulfate.'

How does the graph support this conclusion?

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.....

(1)

(ii) Explain, in terms of particles, why the rate of reaction increases when the concentration of sodium thiosulfate is increased.

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(2)
(Total 6 marks)

22 Nanoparticles have many uses.

(a) (i) Tick (✓) **one** use of nanoparticles.

In the extraction of iron ☐

In suntan creams ☐

In the test for oxygen ☐

(1)

(ii) How is the size of nanoparticles different from normal-sized particles?

Draw a ring around the correct answer.

much smaller **same size** **much larger**

(1)

(b) Very small amounts of cerium oxide nanoparticles can be added to diesel fuel.

The cerium oxide is a catalyst.

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

Only a very small amount of cerium oxide nanoparticles is needed because

the nanoparticles

are elements.
are very reactive.
have a high surface area to volume ratio.

(1)

(ii) Explain how a catalyst increases the rate of a reaction.

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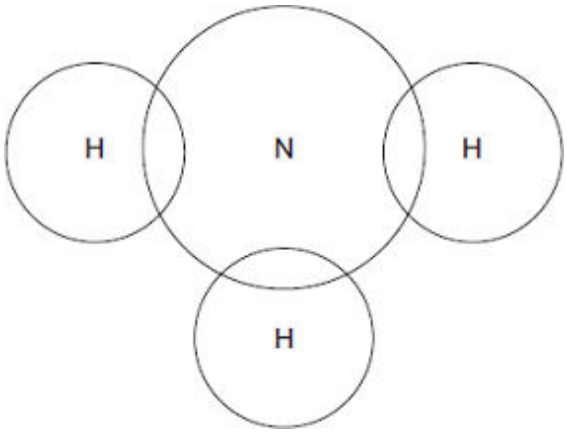
(2)
(Total 5 marks)

23 (a) Complete the dot and cross diagram to show the electrons in the outer energy levels of ammonia (NH_3).

You may use the periodic table to help you.



(2)

(b) Ammonia can be used to make ammonium nitrate (NH_4NO_3).

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

Ammonium nitrate can be made by reacting ammonia with | ethanoic / hydrochloric / nitric | acid.

(1)

(ii) State **one** use of ammonium nitrate.

.....

(1)

(iii) Calculate the relative formula mass (M_r) of ammonium nitrate (NH_4NO_3).

Relative atomic masses: H = 1; N = 14; O = 16.

.....

.....

Relative formula mass (M_r) = ...

(2)

(iv) Calculate the percentage by mass of nitrogen in ammonium nitrate.

.....

.....

.....

.....

Percentage by mass of nitrogen = ... %

(2)

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

Ammonia is manufactured from nitrogen and hydrogen by the Haber process:

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

The forward reaction is exothermic.

The conditions used in the Haber process are:

- 200 atmospheres pressure
- 450 °C
- iron catalyst.

Use the equation and your knowledge of reversible reactions to explain why these conditions are used in the Haber process.

To get full marks you must consider **both** yield **and** rate of reaction in your answer.

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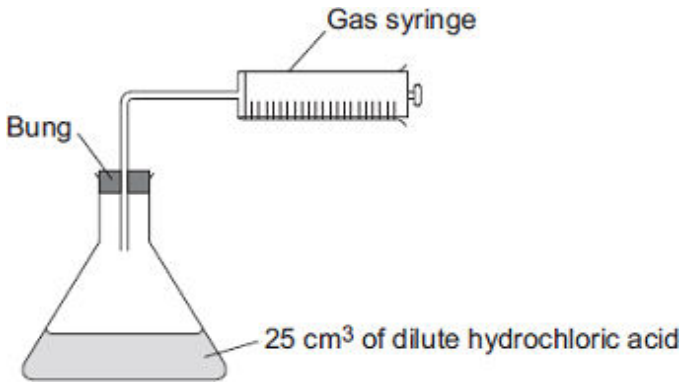
(6)
(Total 14 marks)

24 A student investigated the reaction between magnesium metal and dilute hydrochloric acid.

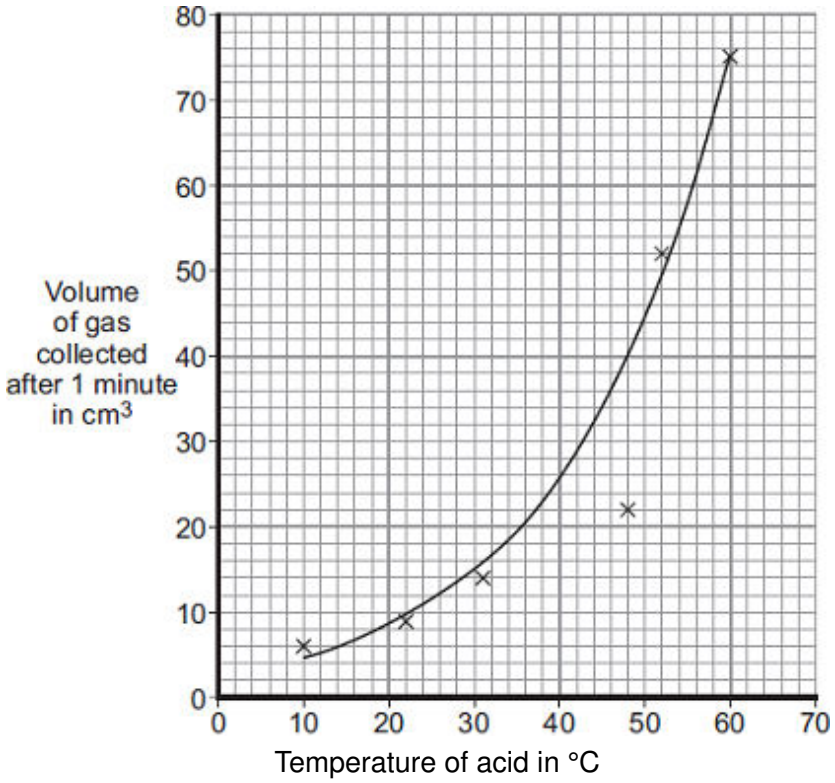
The student placed 25 cm^3 of dilute hydrochloric acid in a conical flask and set up the apparatus as shown in the diagram.



The student:

- took the bung out of the flask and added a single piece of magnesium ribbon 8 cm long
- put the bung back in the flask and started a stopwatch
- recorded the volume of gas collected after 1 minute
- repeated the experiment using different temperatures of acid.

The student plotted his results on a graph.



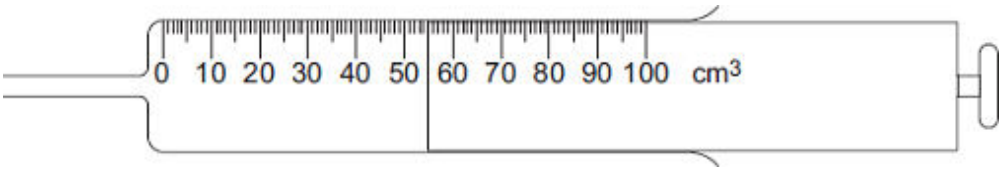
(a) Write the correct state symbols in the equation.

Choose from (s) for solid, (l) for liquid, (g) for gas and (aq) for aqueous.

$Mg(\ldots.) + 2\,HCl(\ldots.) \longrightarrow MgCl_2(\ldots.) + H_2(\ldots.)$

(2)

(b) The diagram shows a gas syringe after 1 minute.



(i) What volume of gas has been collected in the gas syringe after 1 minute?

Volume = ... cm^3

(1)

(ii) Use the graph to determine the temperature of the acid used in this experiment.

Temperature = ... °C

(1)

(iii) Calculate the average rate of reaction, in cm^3 of hydrogen made per second (cm^3/s), for this experiment.

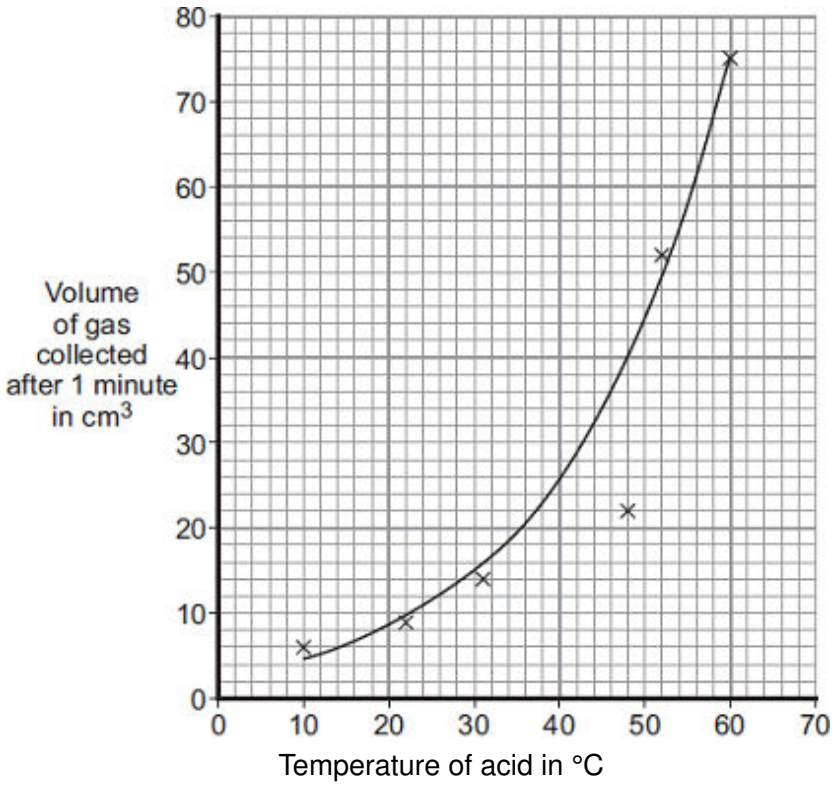
.....

.....

Rate of reaction = ... cm^3/s

(2)

(c) The student's graph has been reprinted to help you answer this question.



One of the results on the graph is anomalous.

(i) Draw a circle on the graph around the anomalous point.

(1)

(ii) Suggest what may have happened to cause this anomalous result.

Explain your answer.

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(2)

(d) Explain how the student could improve the accuracy of the volume of gas recorded at each temperature.

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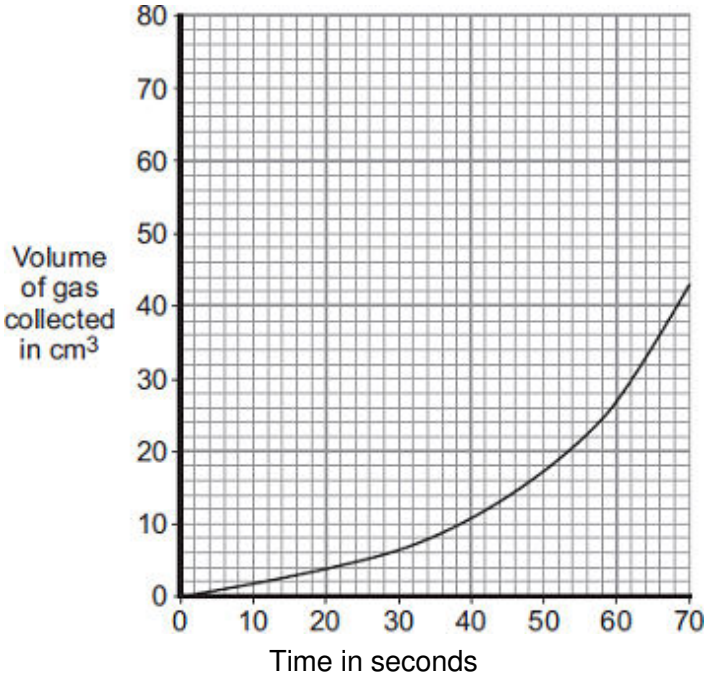
.....

(3)

(e) The student then used the same apparatus to measure the volume of gas produced every 10 seconds at 40 °C.

The student's results are shown on the graph.



The rate at which the gas was produced got faster over the first 60 seconds.

The student's teacher gave two possible explanations of why the reaction got faster.

Explanation 1
There was a layer of magnesium oxide on the surface of the magnesium.
The layer of magnesium oxide prevented the magnesium reacting with the acid.
As the magnesium oxide reacted slowly with the acid, the magnesium was exposed to the acid and hydrogen gas was produced.

Explanation 2
The reaction is exothermic, and so the temperature of the acid increased during the reaction.

(i) Describe further experimental work the student could do to see if **Explanation 1** is correct.

.....

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.....

(2)

(ii) Describe further experimental work the student could do to see if **Explanation 2** is correct.

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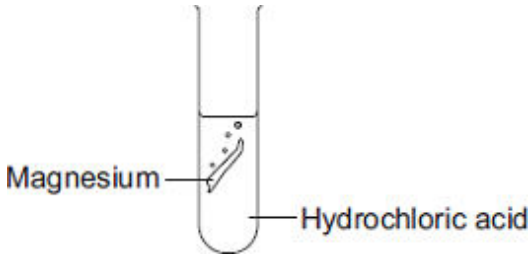
(2)
(Total 16 marks)

25 A student investigated the reaction between magnesium and hydrochloric acid.



The equation for the reaction is:

Mg(s) magnesium	+	2 HCl(aq) hydrochloric acid	⟶	MgCl2(aq) magnesium chloride	+	H2(g) hydrogen

(a) Give **two** observations the student could make during the reaction.

1 .....

.....

2 .....

.....

(2)

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

The student investigated how the rate of this reaction changed when the concentration of hydrochloric acid was changed.

Write a plan the student could use.

In your plan you should:

- describe how you would carry out the investigation and make it a fair test
- describe the measurements you would make.

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(6)
(Total 8 marks)

26 (a) Ammonia solution is used in cleaning products to remove grease from kitchen surfaces.

Ammonia solution is alkaline.

(i) Draw a ring around the number most likely to be the pH of ammonia solution.

1 **3** **7** **10**

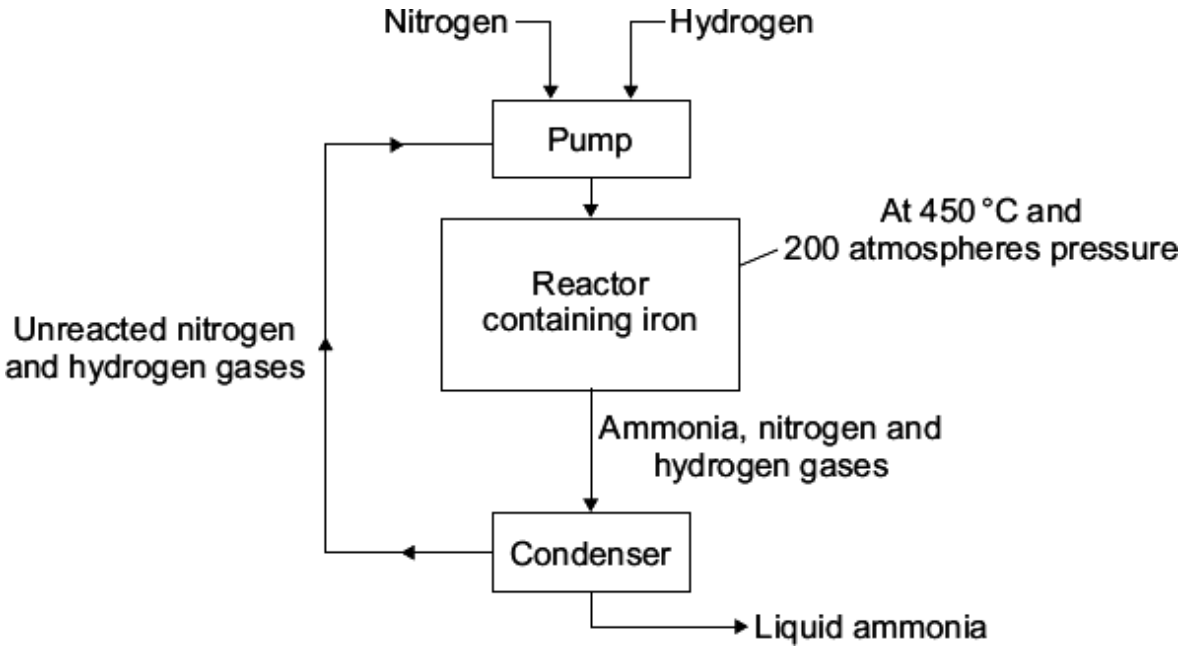
(1)

(ii) Draw a ring around the ion in ammonia solution which makes it alkaline.

Cl^- **H^+** **Na^+** **OH^-**

(1)

(b) Ammonia is made using the Haber process.



(i) Where does the nitrogen used in the Haber process come from?

Draw a ring around your answer.

air **natural gas** **water**

(1)

(ii) A high temperature of 450 °C is used in the reactor.

Tick (✓) **two** reasons in the table which explain why high temperatures make reactions faster.

Reasons	**Tick (✓)**
Particles move faster	
Particles are closer together	
Particles collide more often	
Particles have less energy	

(2)

(iii) The iron in the reactor speeds up the reaction but is not used up.

What is the name given to substances that speed up the chemical reaction but which are not used up during the reaction?

.....

(1)

(c) Complete the sentence.

The condenser separates the ammonia from the unreacted nitrogen and hydrogen by

turning the ammonia into a .....

(1)

(Total 7 marks)

27 (a) The symbol equation for the decomposition of hydrogen peroxide is:

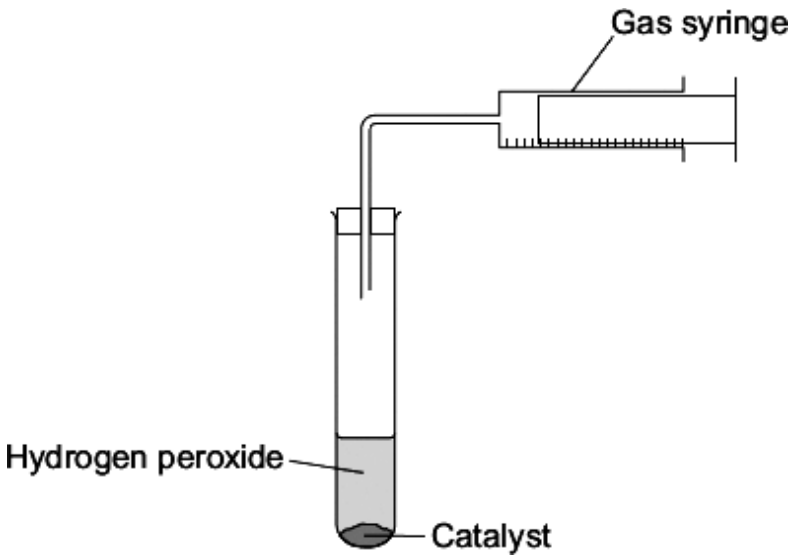
$$2H_2O_2 \rightarrow 2H_2O + O_2$$

Complete the word equation for the decomposition of hydrogen peroxide.

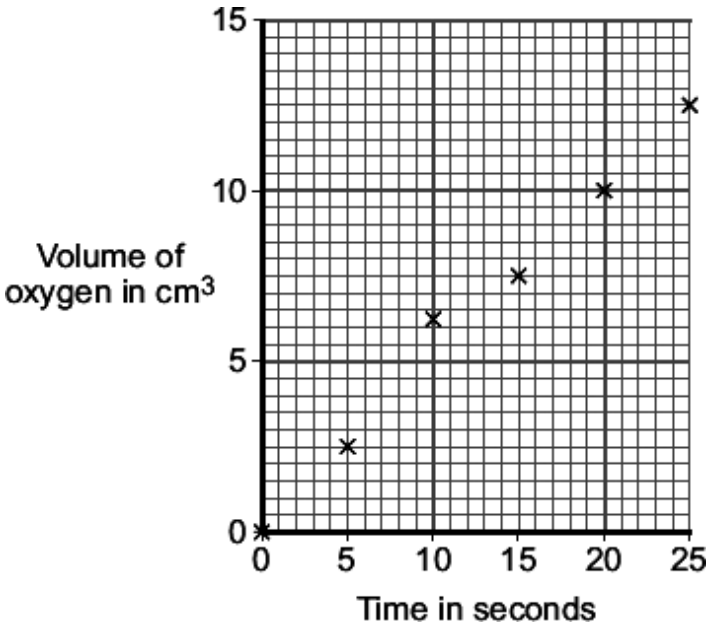
Hydrogen peroxide → ..... + ...

(1)

(b) A student did an experiment to see how quickly hydrogen peroxide decomposes.
The student used the apparatus shown below to measure the volume of oxygen.



(i) Draw a straight line of best fit to complete the graph.



(1)

(ii) Draw a circle around the anomalous point on the graph.

(1)

(iii) What is the volume of oxygen given off after 15 seconds?

..... cm^3

(1)

(iv) How did the volume of oxygen change between 0 and 25 seconds?

.....

(1)

(c) The student wanted to make the reaction faster.

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

(i) To make the reaction faster, the temperature should be

higher.

lower.

the same.

(1)

(ii) To make the reaction faster, the hydrogen peroxide should be

more dilute.

more concentrated.

the same.

(1)

(d) The diagram represents the bonding in oxygen.

O=O

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

(i) When two oxygen atoms bond, the atoms [share / transfer / delocalise] electrons.

(1)

(ii) The oxygen atoms are joined by [ionic / metallic / covalent] bonds.

(1)

(iii) Oxygen is made of [simple molecules. / a giant lattice. / macromolecules.]

(1)

(e) When hydrogen peroxide decomposes water is produced.
Which **two** statements in the table explain why water is a liquid at room temperature?

Tick (✓) the **two** statements.

Statement	Tick (✓)
Water has a boiling point of 100 °C.	
Water is made of ions.	
Water has a melting point lower than room temperature.	
Water has a giant covalent structure.	

(2)
(Total 12 marks)

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

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

(a) This reaction is *exothermic*.

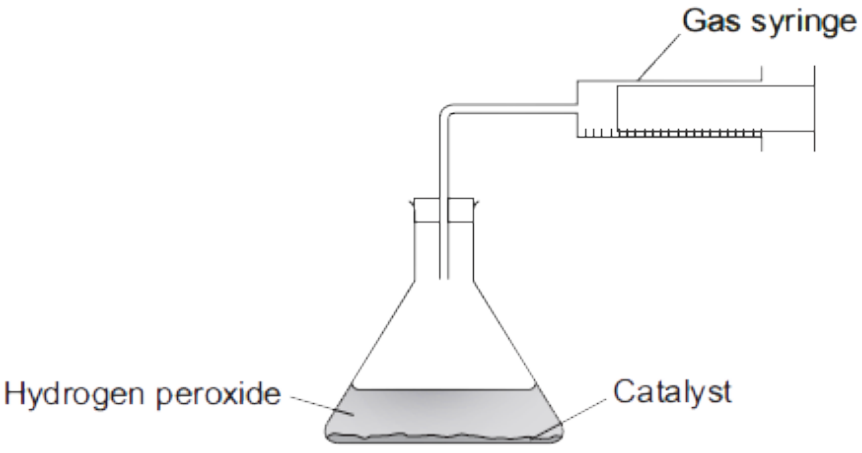
What is an *exothermic* reaction?

.....

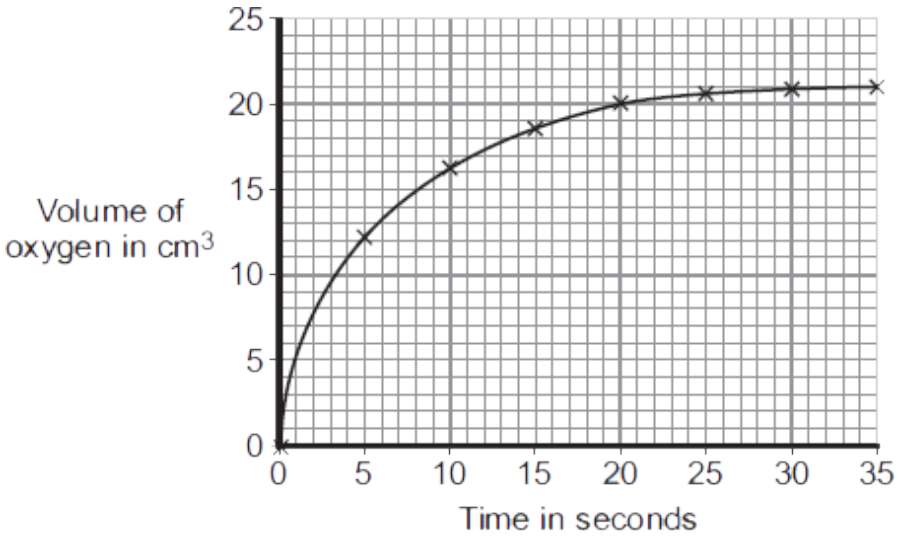
.....

(1)

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



The graph shows the results.



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

.....

.....

.....

.....

.....

.....

(3)

(ii) What was the total volume of oxygen gas collected?

..... cm^3

(1)

(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)

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

Use your knowledge of particles to explain why.

.....

.....

.....

.....

.....

.....

(3)
(Total 10 marks)

29 This question is about gold (Au).

(a) An atom of gold is represented as:

$$^{197}_{79}Au$$

How many neutrons are in this atom of gold? .....

(1)

(b) Gold ions are used as a catalyst.

How does a gold atom (Au) become a gold ion (Au^{3+})?

.....

.....

.....

.....

(2)

(c) A gold catalyst can be used when carbon monoxide reacts with oxygen to make carbon dioxide.

(i) Complete and balance the equation for this reaction.

.... CO + ... → ..... CO_2

(2)

(ii) Carbon dioxide has a very low boiling point.

Explain why.

.....

.....

.....

.....

.....

.....

(3)

(d) Gold is used as a catalyst in industrial processes. Gold is rare and increasingly expensive.

Suggest **three** reasons why gold is still used in industrial processes.

.....

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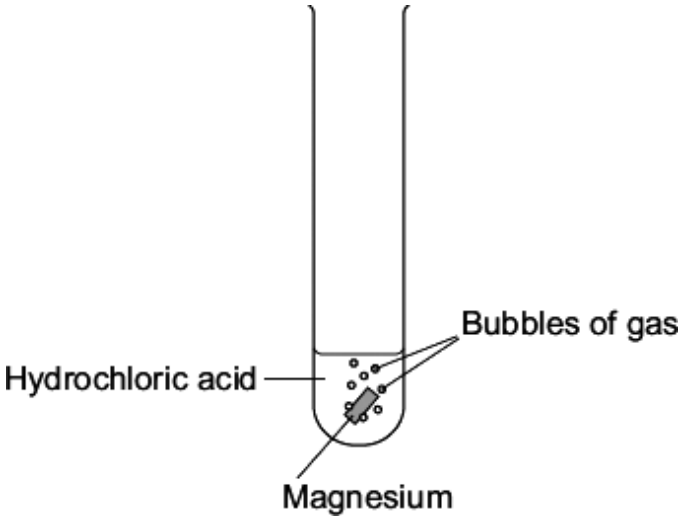
(3)
(Total 11 marks)

30 A student investigated the reaction of magnesium with hydrochloric acid.

(a) A piece of magnesium was dropped into the hydrochloric acid.



Bubbles of gas were produced and the magnesium disappeared.

The reaction is exothermic.

(i) What measurements would the student make to show that the reaction is exothermic?

.....

.....

.....

.....

(2)

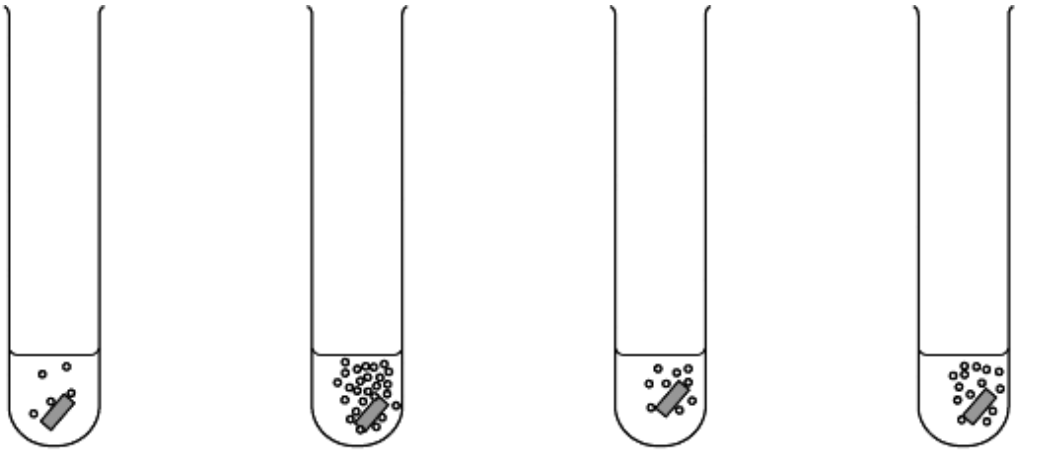
(ii) How would these measurements show that the reaction is exothermic?

.....

(1)

The student investigated how changing the concentration of the hydrochloric acid affects this reaction.

Each test tube contained a different concentration of hydrochloric acid.
The diagrams show the results of this experiment.



(b) Suggest **one** control variable in this investigation.

.....

.....

(1)

(c) (i) Which test tube, **A**, **B**, **C** or **D**, contained the greatest concentration of hydrochloric acid?

Test tube ☐

(1)

(ii) Why did you choose this test tube?

.....

.....

(1)

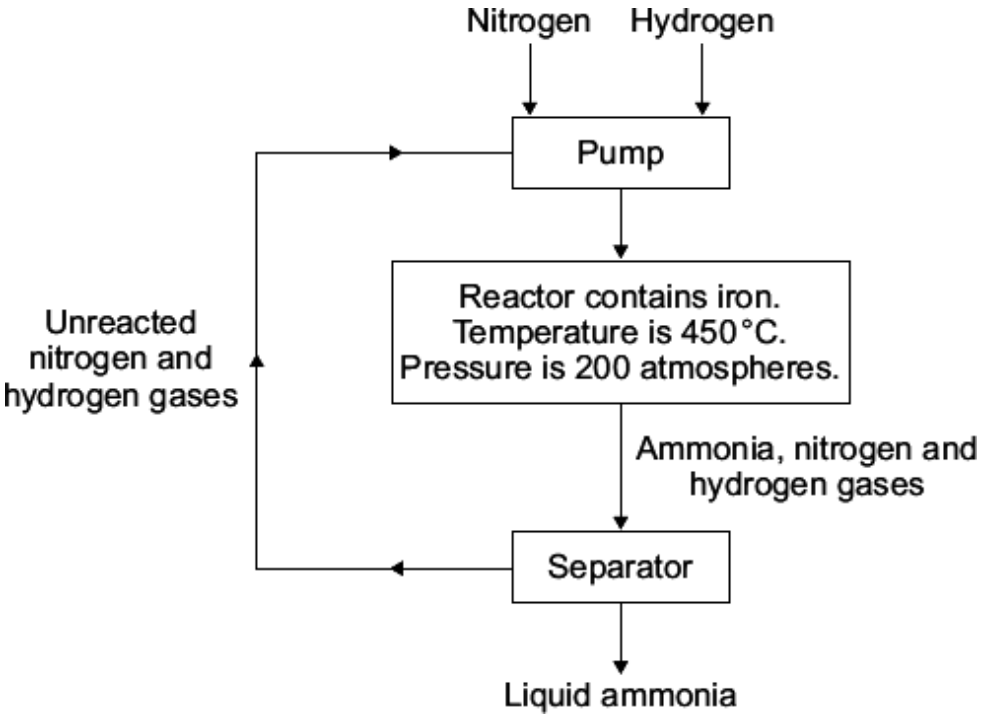
(d) The student predicted that if the temperature of the acid was increased the reaction would take place faster.

Tick (✓) **two** statements in the table which explain why.

Statement	Tick (✓)
The particles move faster	
The particles collide with less energy	
The particles collide more often	
The particles are bigger	

(2)
(Total 8 marks)

31 Ammonia is made using the Haber process.



(a) How is ammonia separated from unreacted nitrogen and hydrogen in the separator?

.....

.....

.....

.....

(2)

(b) The equation shows the reaction which takes place in the reactor:

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

(i) Why does the yield of ammonia at equilibrium increase as the temperature is decreased?

.....

.....

(1)

(ii) A temperature of 450 °C is used in the reactor to make the reaction take place quickly.

Explain, in terms of particles, why increasing the temperature makes a reaction go faster.

.....

.....

.....

.....

(2)

(iii) Why does the yield of ammonia at equilibrium increase as the pressure is increased?

.....

.....

(1)

(iv) The pressure used in the reactor is 200 atmospheres.
Suggest why a much higher pressure is **not** used.

.....

.....

(1)

(c) Use the equation for the reaction in the reactor to help you to answer these questions.

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

(i) It is important to mix the correct amounts of hydrogen and nitrogen in the reactor.

20 m^3 of nitrogen is reacted with hydrogen.

What volume of hydrogen (measured at the same temperature and pressure as the nitrogen) is needed to have the correct number of molecules to react with the nitrogen?

Volume of hydrogen needed = ... m^3

(1)

(ii) Calculate the maximum mass of ammonia that can be made from 2 g of nitrogen.

Relative atomic masses: H = 1; N = 14.

.....

.....

.....

.....

.....

.....

Maximum mass of ammonia = ... g

(3)

(d) The expected maximum mass of ammonia produced by the Haber process can be calculated.

(i) In one process, the maximum mass of ammonia should be 80 kg.

The actual mass of ammonia obtained was 12 kg.

Calculate the percentage yield of ammonia in this process.

.....

.....

Percentage yield of ammonia = ... %

(1)

(ii) Give **two** reasons why it does **not** matter that the percentage yield of ammonia is low.
Use the flow diagram at the start of this question to help you.

.....

.....

.....

.....

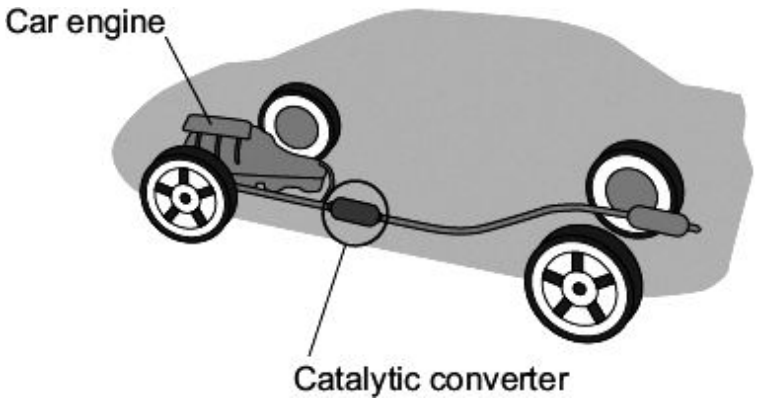
(2)
(Total 14 marks)

32 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.



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

(i) The exothermic reaction makes the temperature of the engine

decrease.

increase.

stay the same.

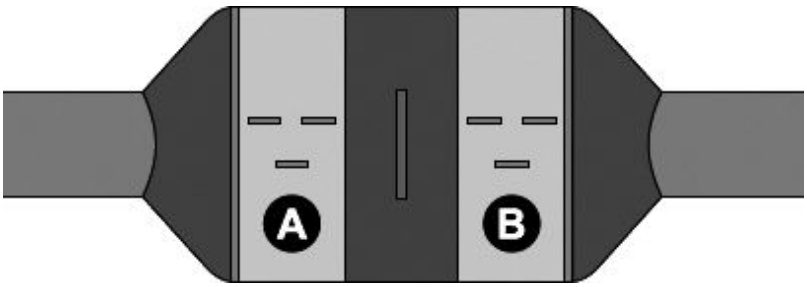
(1)

(ii) This is because during exothermic reactions

energy is taken in from the surroundings.
energy is given out to the surroundings.
there is no energy change.

(1)

(b) The diagram shows a catalytic converter which removes harmful substances.
The catalytic converter has two parts, **A** and **B**, which contain different catalysts.



(i) The equation for the reaction that takes place in part **A** is:

$$2NO \rightarrow N_2 + O_2$$

Which **one** of the substances shown in the equation is a compound?

Give the formula of this compound.

.....

(1)

(ii) The equation for the reaction that takes place in part **B** is:

$$2CO + O_2 \rightarrow 2CO_2$$

Why is it important to stop carbon monoxide (CO) from being released into the air?

.....

.....

(1)

(c) The table lists some statements about catalysts. Only **two** statements are correct.

Tick (✓) the **two** correct statements.

Statement	Tick (✓)
A catalyst can speed up a chemical reaction.	
A catalyst is used up in a chemical reaction.	
Different reactions need different catalysts.	
A catalyst does **not** change the rate of a chemical reaction.	

(2)

(d) Modern catalytic converters contain nanosized particles of catalyst.
Less catalyst is needed when nanosized catalyst particles are used.

(i) Complete the sentence.

The size of nanosized particles is ..... than normal sized particles.

(1)

(ii) The catalysts contain platinum.

Suggest why a manufacturer of catalytic converters would want to use less catalyst.

.....

.....

(1)

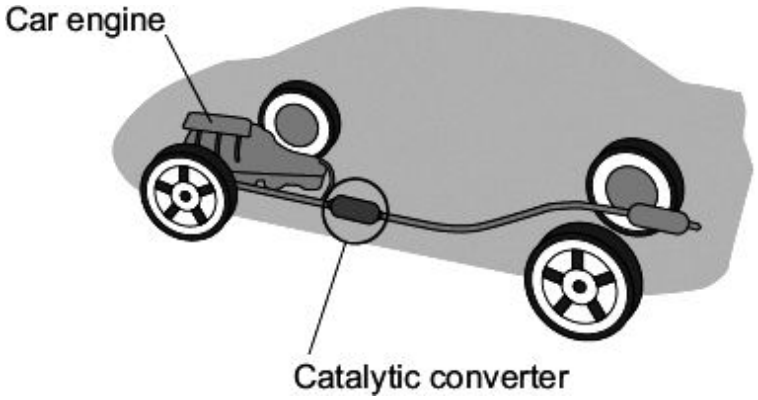
(Total 8 marks)

33 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.



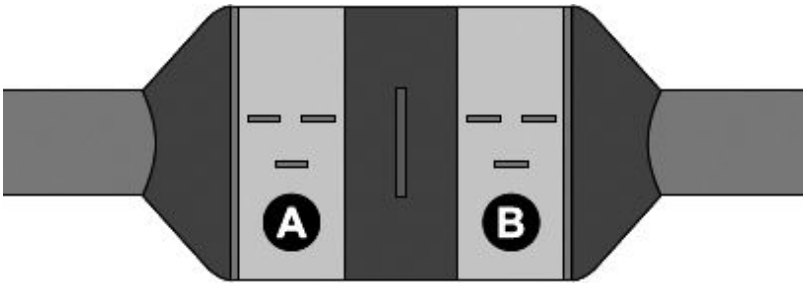
(a) The reaction is *exothermic*. What is the meaning of *exothermic*?

.....

.....

(1)

(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.

(i) Why are catalysts used in chemical reactions?

.....

.....

(1)

(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)

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

Balance this equation.

..... CO + O_2 → ..... CO_2

(1)

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

Explain why the catalyst does not need to be replaced.

.....

.....

(1)

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

.....

.....

(1)

(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)

(Total 9 marks)

34 The picture shows a lump of phosphate rock.

Rob Lavinsky, iRocks.com – CC-BY-SA-3.0 [CC-BY-SA-3.0], via Wikimedia Commons

Phosphoric acid is made by reacting phosphate rock with sulfuric acid.

Only **three** of the methods shown below will **increase** the rate of this reaction.

Put a **tick (✓)** next to each of the **three** methods that will **increase** the rate of this reaction.

Method	**Tick (✓)**
Use a more concentrated solution of sulfuric acid	
Use larger lumps of phosphate rock	
Cool the mixture of phosphate rock and sulfuric acid	
Grind the phosphate rock into a powder before adding the acid	
Increase the temperature of the sulfuric acid	
Dilute the sulfuric acid solution with water	

(3)
(Total 3 marks)

35 The picture shows a lump of phosphate rock.

Rob Lavinsky, iRocks.com – CC-BY-SA-3.0 [CC-BY-SA-3.0], via Wikimedia Commons

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

(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)

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

.....

.....

(1)
(Total 3 marks)

36 Hydrogen peroxide decomposes slowly to give water and oxygen.

The reaction is *exothermic*.

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

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

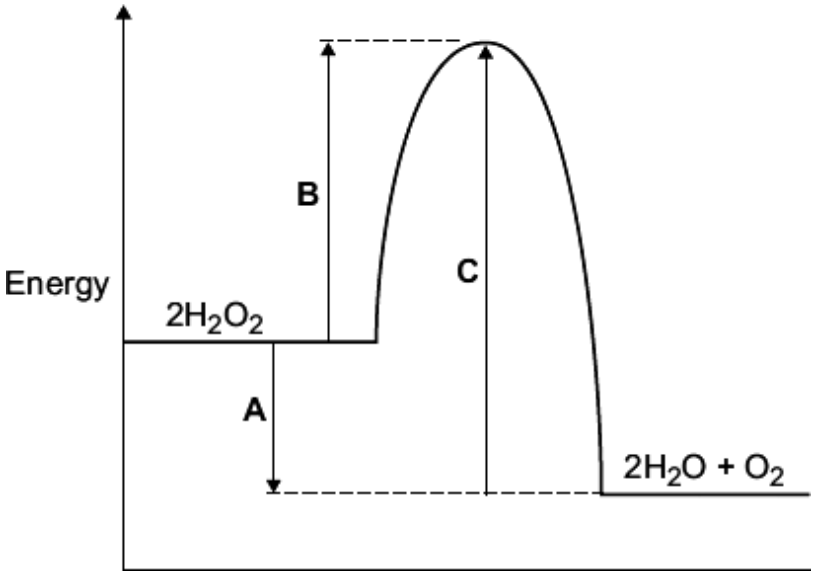
Draw a ring around the correct answer to complete the sentence.

In an *exothermic* reaction, the temperature

- goes down.
- goes up.
- stays the same.

(1)

(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.

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

(1)

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

(1)

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

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

Hydrogen peroxide decomposes quickly because

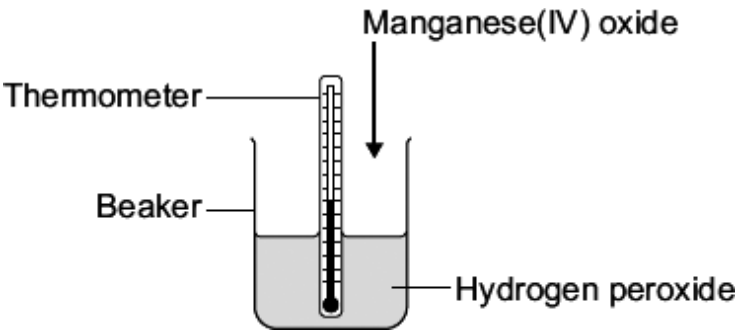
manganese(IV) oxide is	a catalyst.
	an element.
	a solid.

The manganese(IV) oxide has lowered the	activation energy.
	boiling point.
	temperature.

(2)

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

The apparatus the student used is shown in the diagram.



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

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

.....

.....

(1)

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

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

.....

.....

(1)

(Total 7 marks)

37 Hydrogen peroxide decomposes to give water and oxygen.

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

The reaction is *exothermic*.

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

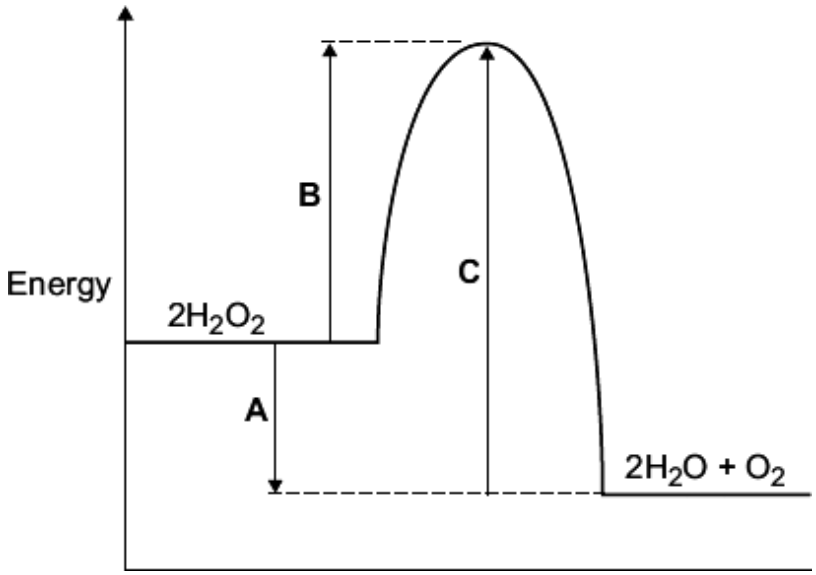
.....

.....

.....

(1)

(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.

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

.....

.....

.....

(1)

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

.....

.....

.....

(1)

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

Explain why.

.....

.....

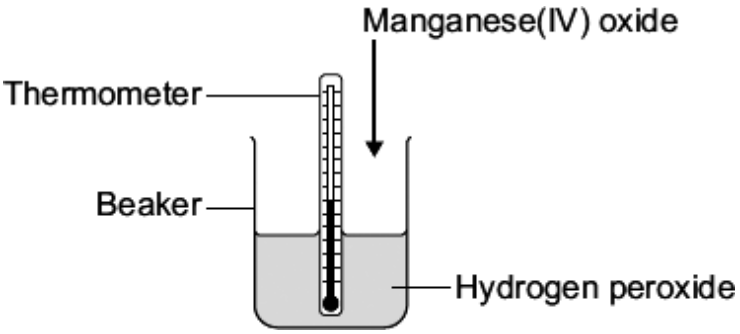
.....

.....

(2)

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

The apparatus the student used is shown in the diagram.



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

The temperature rise was smaller than expected.

Suggest why.

.....

.....

.....

.....

.....

(2)
(Total 7 marks)

38 Hydrogen fluoride is used to make hydrofluoric acid.

(a) A company makes hydrogen fluoride by reacting solid calcium fluoride with sulfuric acid. The reaction takes place in a rotating kiln.

calcium fluoride + sulfuric acid → calcium sulfate + hydrogen fluoride

The company want this reaction to take place quickly.

(i) Rotating the kiln makes the reaction take place faster.

Suggest why.

.....

.....

(1)

(ii) Draw a ring around the correct word in each box.

To make the reaction take place **faster**:

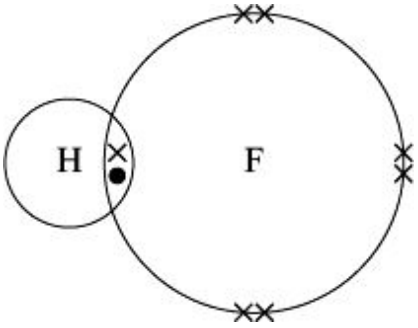
the temperature should be [higher / lower] so that the particles have [less / more] energy

the solid calcium fluoride should be [powder / lumps] to give a [small / big] surface area

the sulfuric acid solution should be [dilute / concentrated] to give [less / more] collisions between the particles each second.

(3)

(b) The diagram represents a molecule of hydrogen fluoride.



The hydrogen and fluorine atoms are joined by a covalent bond.

Use the correct word from the box to complete the sentence.

electrons	**neutrons**	**protons**

In a covalent bond the atoms share ..... .

(1)

(c) Hydrogen fluoride is dissolved in water to make an acidic solution of hydrofluoric acid.

Draw a ring around the symbol of the ion that makes the solution acidic.

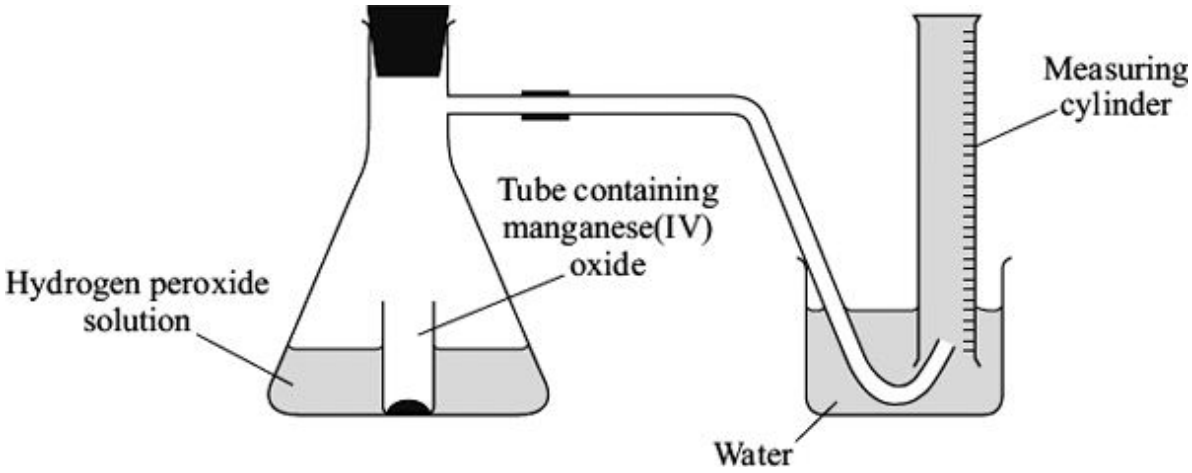
H^+ **OH^-** **F^-**

(1)
(Total 6 marks)

39 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	

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

.....

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

(2)

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

Suggest why.

.....

.....

(1)

(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.

.....

.....

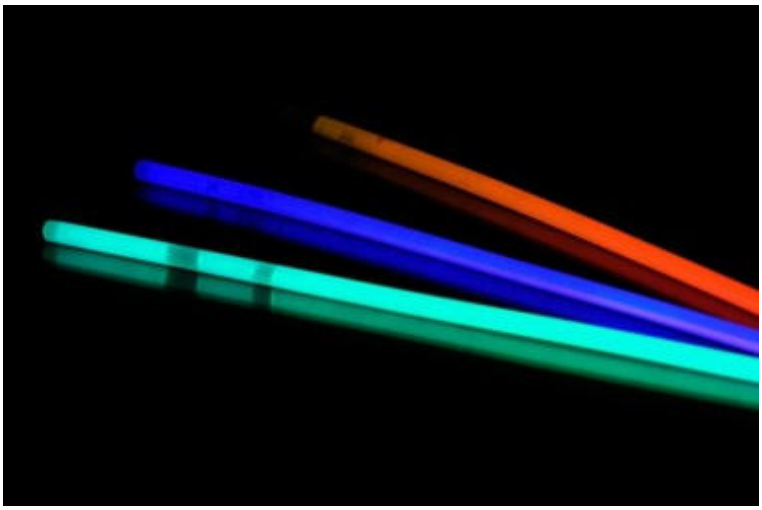
.....

.....

.....

(2)
(Total 5 marks)

40 The picture shows three glowsticks.



Photograph supplied by iStockphoto/Thinktsock

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

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

The results are shown in the table.

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

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

.....

.....

(1)

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

.....

.....

(1)

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

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

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

(3)

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

.....

.....

(1)

(Total 6 marks)

41

The equation for a reaction to produce hydrogen is:

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

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

.....

.....

(1)

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

.....

.....

(1)

(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.

.....

.....

.....

.....

.....

.....

(3)

(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?

.....

.....

.....

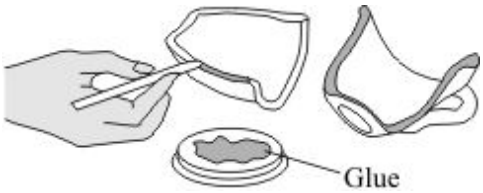
.....

(2)
(Total 7 marks)

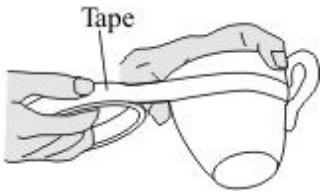
42 The following steps show how to use a type of glue.

Step 1 Measure out equal amounts of the liquids from tubes **A** and **B**.

Step 2 Mix the liquids to make the glue.
Put a thin layer of the glue onto each of the surfaces to be joined.



Step 3 Assemble the pieces to be joined and then hold them together with tape.



Step 4 Leave the glue to set.

(a) When liquids **A** and **B** are mixed a chemical reaction takes place.

(i) This reaction is exothermic.

Complete the sentence below using a word or phrase from the box.

decrease	**increase**	**stay the same**

During the reaction the temperature of the mixture will ..... .

(1)

(ii) When the glue sets it forms a giant covalent structure.

Draw a ring around **one** property that you would expect the set glue to have.

good conductor of electricity **low melting point** **high melting point**

(1)

(b) The time taken for the glue to set at different temperatures is given in the table below.

Temperature in °C	Time taken for the glue to set
20	3 days
60	6 hours
90	1 hour

(i) Complete the sentences below using words or phrases from the box.

decrease	**increase**	**stay the same**

When the temperature is increased the time taken for the glue to set

..... .

When the temperature is increased the rate of the setting reaction

..... .

(2)

(ii) Put a tick (✓) next to the **two** reasons why an increase in temperature affects the rate of reaction.

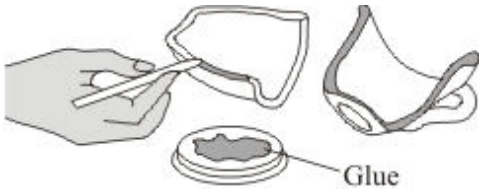
Reason	(✓)
It gives the particles more energy.	
It increases the concentration of the particles.	
It increases the surface area of the particles.	
It makes the particles move faster.	

(2)
(Total 6 marks)

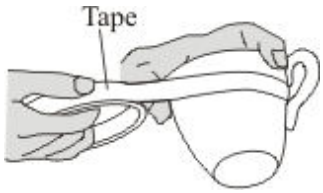
43 The following steps show how to use a type of glue.

Step 1 Measure out equal amounts of the liquids from tubes **A** and **B**.

Step 2 Mix the liquids to make the glue.
Put a thin layer of the glue onto each of the surfaces to be joined.



Step 3 Assemble the pieces to be joined and then hold them together with tape.



Step 4 Leave the glue to set.

(a) When liquids **A** and **B** are mixed a chemical reaction takes place.

(i) This reaction is exothermic.

State how the temperature of the mixture will change as the glue is mixed.

.....

.....

(1)

(ii) When the glue sets it forms a giant covalent structure.

Explain why substances with giant covalent structures have high melting points.

.....

.....

.....

.....

(2)

(b) The time taken for the glue to set at different temperatures is given in the table below.

Temperature in °C	Time taken for the glue to set
20	3 days
60	6 hours
90	1 hour

Explain, in terms of particles, why increasing the temperature changes the rate of the reaction which causes the glue to set.

.....

.....

.....

.....

.....

(2)
(Total 5 marks)

44 Aspirin tablets have important medical uses.

A student carried out an experiment to make aspirin. The method is given below.

1. Weigh 2.00 g of salicylic acid.
2. Add 4 cm^3 of ethanoic anhydride (an excess).
3. Add 5 drops of concentrated sulfuric acid.
4. Warm the mixture for 15 minutes.
5. Add ice cold water to remove the excess ethanoic anhydride.
6. Cool the mixture until a precipitate of aspirin is formed.
7. Collect the precipitate and wash it with cold water.
8. The precipitate of aspirin is dried and weighed.

(a) The equation for this reaction is shown below.

$C_7H_6O_3$ + $C_4H_6O_3$ → $C_9H_8O_4$ + CH_3COOH
salicylic acid aspirin

Calculate the maximum mass of aspirin that could be made from 2.00 g of salicylic acid.

The relative formula mass (M_r) of salicylic acid, $C_7H_6O_3$, is 138

The relative formula mass (M_r) of aspirin, $C_9H_8O_4$, is 180

.....

.....

.....

.....

Maximum mass of aspirin = ... g

(2)

(b) The student made 1.10 g of aspirin from 2.00 g of salicylic acid.

Calculate the percentage yield of aspirin for this experiment.

(If you did not answer part (a), assume that the maximum mass of aspirin that can be made from 2.00 g of salicylic acid is 2.50 g. This is **not** the correct answer to part (a).)

.....

.....

.....

.....

Percentage yield of aspirin = ... %

(2)

(c) Suggest **one** possible reason why this method does **not** give the maximum amount of aspirin.

.....

.....

(1)

(d) Concentrated sulfuric acid is a catalyst in this reaction.

Suggest how the use of a catalyst might reduce costs in the industrial production of aspirin.

.....

.....

(1)

(Total 6 marks)