Rate of Reactions 1

These practice questions can be used by students and teachers and is suitable for GCSE AQA Chemistry topic Questions 8462

Level: GCSE AQA Chemistry 8462

Subject: Chemistry

Exam board: GCSE AQA

Topic: Rate of Reactions 1

Q1.

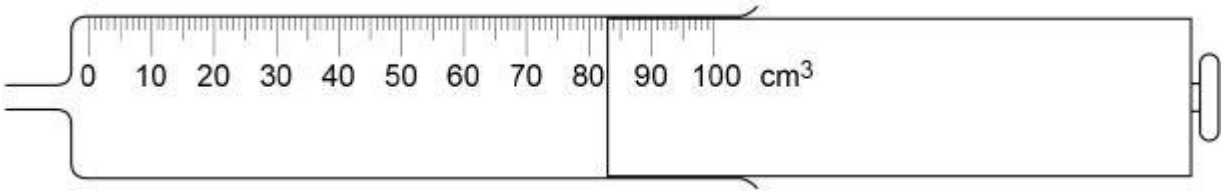
A student investigated how concentration affects the rate of reaction between magnesium and hydrochloric acid.

This is the method used.

1. Place hydrochloric acid in a conical flask.
2. Add magnesium powder.
3. Collect the gas produced in a gas syringe.
4. Measure the volume of gas every 40 seconds for 160 seconds.
5. Repeat steps 1-4 three more times.
6. Repeat steps 1-5 with hydrochloric acid of a higher concentration.

(a) **Figure 1** shows a gas syringe.

Figure 1



What is the volume of gas in the syringe?

Volume = _____ cm^3

(1)

(b) Which **two** variables should the student keep the same to make the investigation a fair test?

Tick **two** boxes.

Concentration of hydrochloric acid ☐

Mass of magnesium powder ☐

Temperature of hydrochloric acid ☐

Time for reaction to end ☐

Volume of gas collected 

(2)

The table below shows the student's results for the experiment with hydrochloric acid of a lower concentration.

Time in seconds	Volume of gas collected in cm^3				
	Test 1	**Test 2**	**Test 3**	**Test 4**	**Mean**
0	0	0	0	0	0
40	46	30	47	49	**X**
80	78	83	83	82	82
120	98	94	96	95	96
160	100	100	100	100	100

(c) Calculate mean value **X** in the table above.

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

Give your answer to 2 significant figures.

_____

_____

_____

_____

_____

_____

X = _____ cm^3

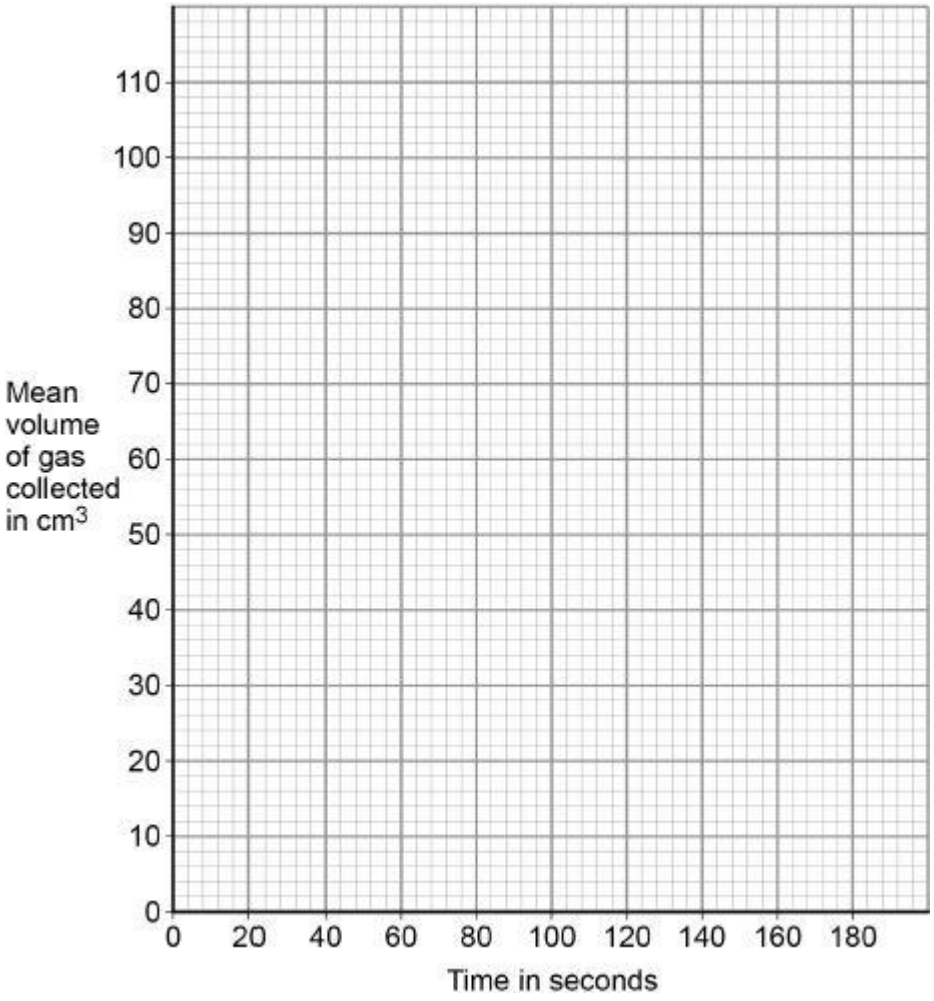
(2)

(d) Plot the data from the table above on **Figure 2**.

You should include your answer to Question **(c)**.

You do **not** need to draw a line of best fit.

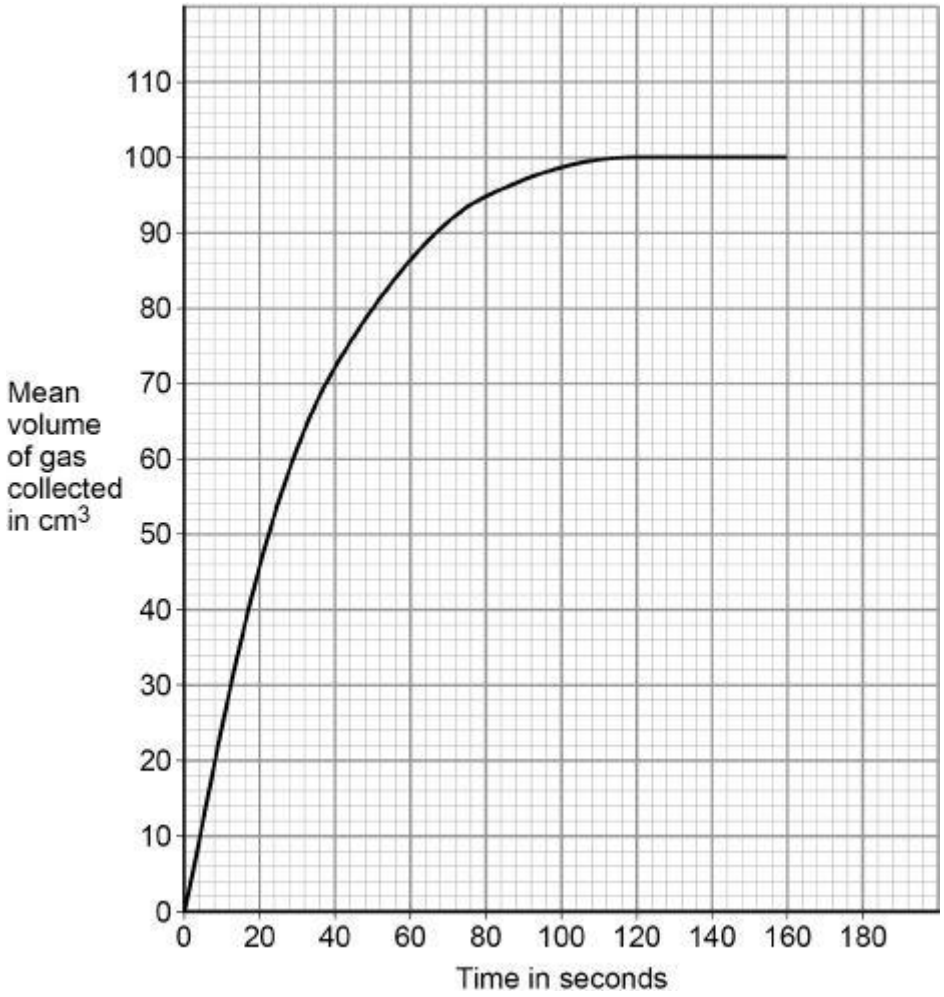
Figure 2



(2)

Figure 3 shows results of the experiment with the hydrochloric acid of a higher concentration.

Figure 3



(e) Calculate the mean rate of reaction between 0 and 50 seconds.

Use **Figure 3** and the equation:

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

Mean rate of reaction = _____ cm^3/s

(2)

(f) Describe how the **rate of reaction** changes between 0 and 160 seconds.

Use **Figure 3**.

_____

_____

_____

_____

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(3)

(g) The student concludes that the rate of reaction is greater when the concentration of hydrochloric acid is higher.

Why is the rate of reaction greater when the concentration of hydrochloric acid is higher?

Tick **two** boxes.

The particles are moving faster	☐
The particles have more energy	☐
The surface area of magnesium is smaller	☐
There are more particle collisions each second	☐
There are more particles in the same volume	☐

(2)

(h) The student tests the gas produced by bubbling it through limewater.

No change is seen in the limewater.

Give **one** conclusion the student can make about the gas.

_____

_____

_____

_____

(1)

(i) The student tests the gas produced using a burning splint.

Name the gas the student is testing for.

Give the result of a positive test for this gas.

Name of gas

_____

Result

_____

_____

_____

(2)

(Total 17 marks)

Q2.

Sodium thiosulfate solution reacts with dilute hydrochloric acid.

The solution becomes cloudy as the reaction takes place.

(a) The equation for the reaction is:

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

Explain why the solution becomes cloudy.

_____

_____

_____

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_____

(2)

(b) Plan an investigation to show how the concentration of the sodium thiosulfate solution affects the rate of the reaction with dilute hydrochloric acid.

Your plan should give valid results.

(6)

(Total 8 marks)

Q3.

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 °C 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 °C

(a) Explain why the contents of the conical flask lose mass.

(2)

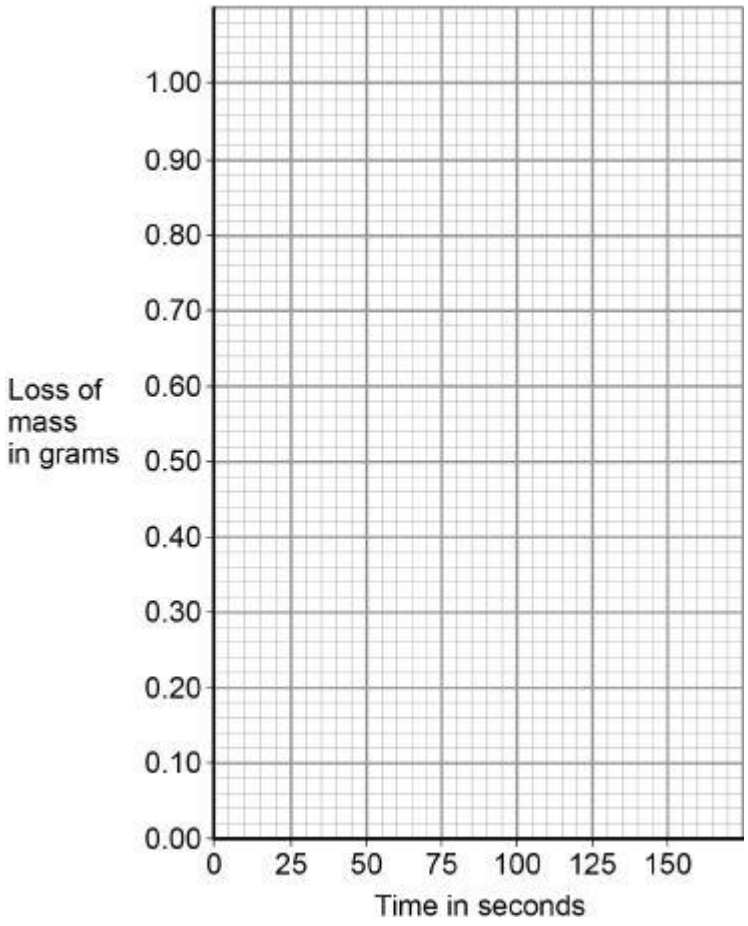
(b) The table below shows the student's results for hydrochloric acid at 30 °C

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

Plot the data from the table above on **Figure 1**.

Draw a line of best fit.

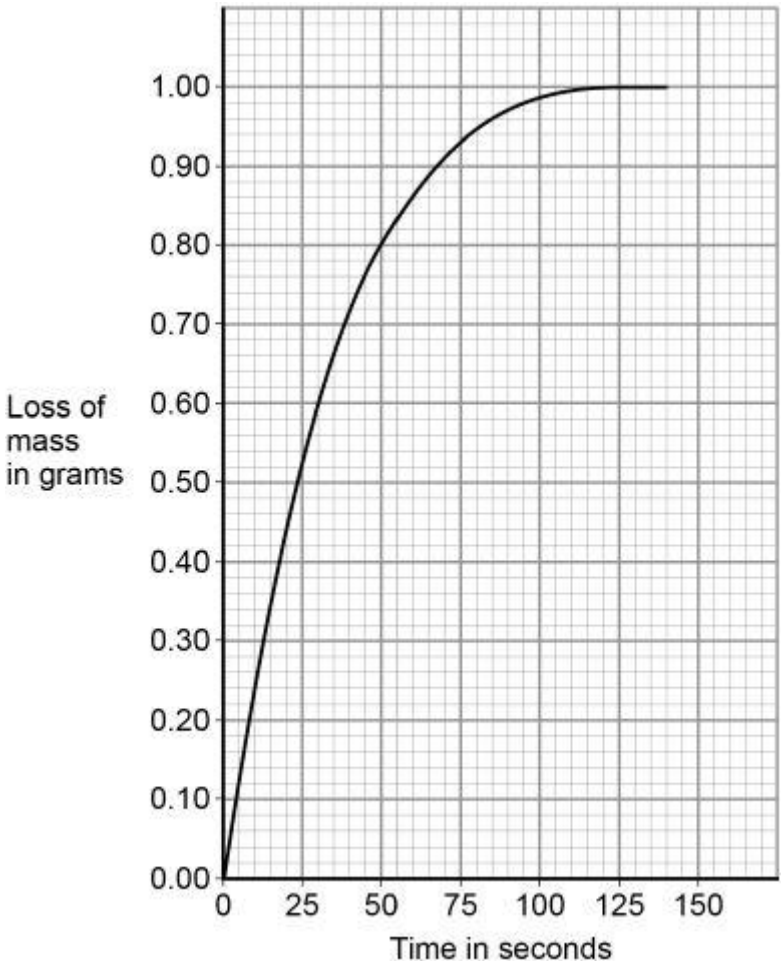
Figure 1



(3)

Figure 2 shows the student's results for hydrochloric acid at 50 °C

Figure 2



(c) Determine the rate of reaction at 50 °C when the loss of mass is 0.95 g

Show your working on **Figure 2**.

Give your answer to 2 significant figures.

_____

_____

_____

_____

_____

_____

_____

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_____

Rate of reaction = _____ g/s

(4)

(Total 9 marks)

Q4.

This question is about methanol.

(a) Methanol is broken down in the body during digestion.

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

Tick **one** box.

Amino acid	☐
Enzyme	☐
Ester	☐
Nucleotide	☐

(1)

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

The equation for the reaction is:

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

(b) How many moles of carbon monoxide react completely with 4.0×10^3 moles of hydrogen?

Tick **one** box.

1.0×10^3 moles	☐
2.0×10^3 moles	☐

4.0×10^3 moles ☐

8.0×10^3 moles ☐

(1)

(c) The reaction is carried out at a temperature of 250 °C 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 °C is used.

_____

_____

_____

_____

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_____

_____

(2)

(d) 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.

_____

_____

_____

_____

_____

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_____

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(4)

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

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

(2)

(f) Suggest why a catalyst is used in this industrial process.

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

(1)

(g) Suggest the effect of using the catalyst on the equilibrium yield of methanol.

_____

_____

_____

(1)

(Total 12 marks)

Q5.

A student investigates the effect of concentration on the rate of reaction.

The student reacts sodium thiosulfate solution with dilute hydrochloric acid.

This produces a cloudy mixture.

(a) The cloudiness is produced by the formation of solid sulfur.

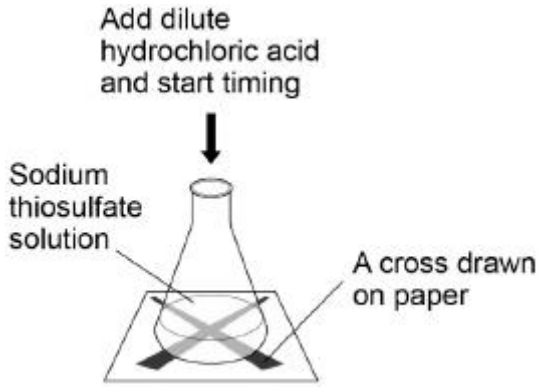
How should sulfur be written in the chemical equation for this reaction?

Tick (✓) **one** box.

S(aq) ☐ S(g) ☐ S(l) ☐ S(s) ☐

(1)

The diagram shows some of the apparatus the student uses.



This is the method used.

1. Measure 40 cm^3 sodium thiosulfate solution into a conical flask.
2. Stand the flask on a piece of paper with a cross drawn on it.
3. Add 10 cm^3 of dilute hydrochloric acid to the flask.
4. Time how long it takes the cross to become no longer visible.
5. Repeat steps 1–4 twice more.
6. Repeat steps 1–5 with sodium thiosulfate solutions of different concentrations.

(1)

(b) Which apparatus could be used to measure 10 cm^3 of dilute hydrochloric acid?

Tick (✓) **one** box.

- Beaker ☐
- Boiling tube ☐
- Measuring cylinder ☐
- Test tube ☐

(1)

(c) Draw **one** line from each type of variable to the description of the variable.

Type of variable	Description of the variable
	Concentration of sodium thiosulfate solution
Dependent variable	Size of conical flask
	Size of cross drawn on paper
Independent variable	Time for cross to become no longer visible
	Volume of hydrochloric acid

(2)

(d) The student draws a new cross for each experiment.

Suggest why this might give inaccurate results.

_____

_____

_____

_____

(1)

(e) The table shows the student's results for sodium thiosulfate solution with a concentration of 12 g / dm^3

Time for cross to become no longer visible in s			
Trial 1	**Trial 2**	**Trial 3**	**Mean**
43	78	41	**X**

Calculate value **X** in the tabble.

Do **not** use any anomalous results in your calculation.

_____

_____

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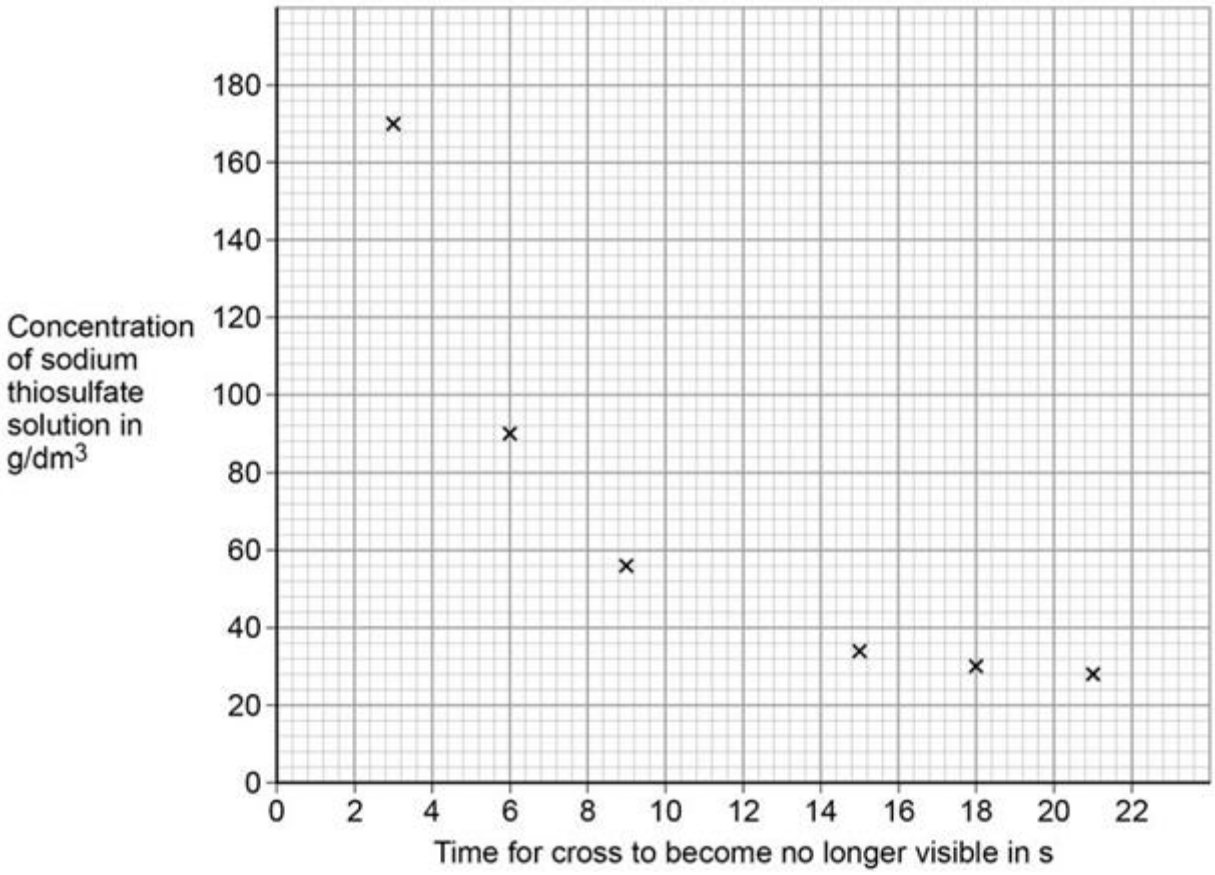
_____

X = _____ s

(2)

(f) The graph shows some of the student's results.



Draw a smooth curve of best fit on the graph above.

(1)

(g) Another student does the same investigation.

Both students have a similar pattern in their results.

Which word describes investigations performed by different students, which give a similar pattern of results?

Tick (✓) **one** box.

- Accurate ☐
- Precise ☐
- Reproducible ☐
- Valid ☐

(1)

(h) The more concentrated the sodium thiosulfate solution, the less time is taken for the cross to become no longer visible.

Give **two** reasons why.

Tick (✓) **two** boxes.

- Particles are more spread out ☐
- Particles collide more frequently ☐
- Particles have more energy ☐
- Particles move more quickly ☐
- There are more particles in a fixed volume ☐

(2)

(Total 11 marks)

Q6.

When sodium thiosulfate solution reacts with dilute hydrochloric acid, the solution becomes cloudy.

The equation for the reaction is:

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

(a) Why does the solution become cloudy?

_____

_____

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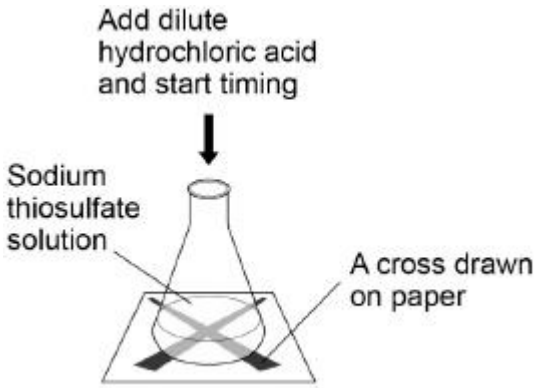
_____

_____

(2)

Some students used this reaction to investigate the effect of concentration on rate of reaction.

The diagram shows the apparatus used.



This is the method used.

1. Measure 25 cm^3 sodium thiosulfate solution into a conical flask.
2. Stand the conical flask on a cross drawn on paper.
3. Add 10 cm^3 of dilute hydrochloric acid.
4. Time how long it takes the cross to become no longer visible.

5. Repeat steps 1–4 with sodium thiosulfate solutions of different concentrations.

(b) The students used a measuring cylinder to measure 25 cm^3 of sodium thiosulfate solution.

Suggest a more accurate way of measuring 25 cm^3 of sodium thiosulfate solution.

_____

_____

_____

_____

(1)

(c) Name one control variable the students should use in this investigation.

_____

_____

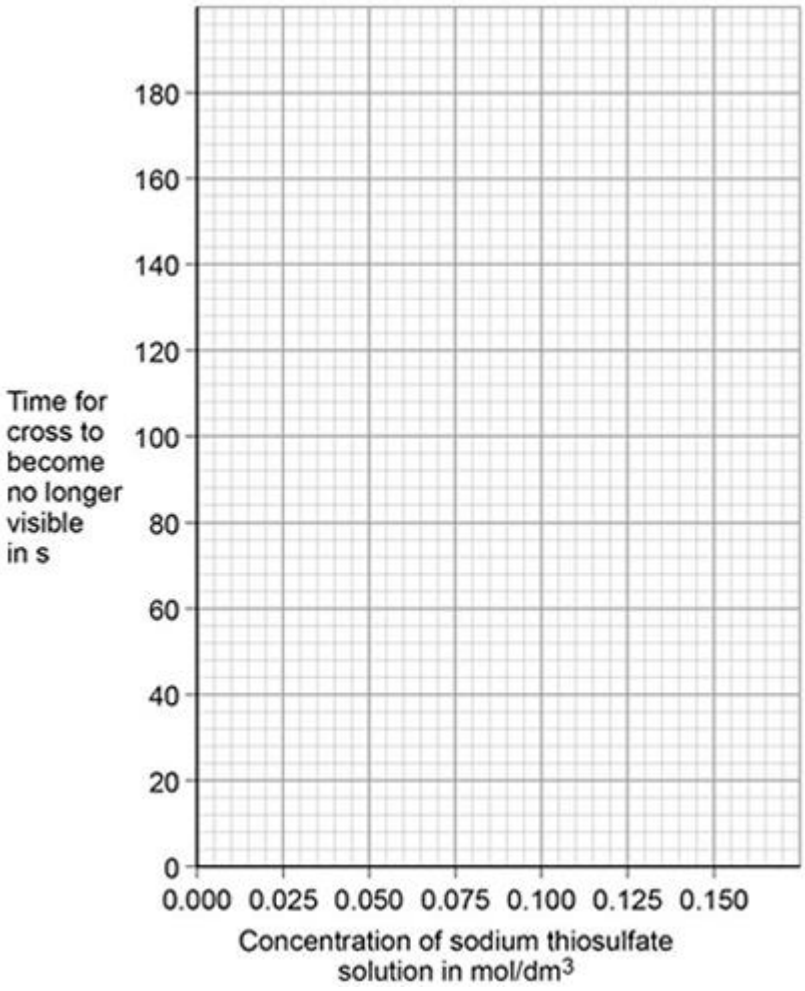
(1)

The table shows the students' results.

Concentration of sodium thiosulfate solution in mol / dm^3	**Time for cross to become no longer visible in s**
0.020	170
0.040	90
0.060	82
0.080	42
0.100	34
0.120	30
0.140	28

(d) Plot the data from the table above on the graph below.

Draw a line of best fit.



(3)

The students repeated the investigation two more times.

They obtained similar results each time.

(e) What word describes an investigation by the same students which gives similar results each time?

_____

(1)

(f) Describe how the students can use their results to improve the accuracy of the investigation.

_____

_____

_____

(2)

(g) The students analysed their results to give a conclusion and an explanation for their investigation.

Conclusion: 'The higher the concentration, the lower the rate of reaction.'

Explanation: 'At higher concentrations, the particles have more energy, so they are moving faster. Therefore the collisions are more energetic.'

The students are not correct.

Give a **correct** conclusion **and** explanation for the results of the investigation.

Conclusion

Explanation

(3)

(h) A solution containing 0.18 g of sodium thiosulfate reacts with dilute hydrochloric acid in 2 minutes.

Calculate the mean rate of reaction in g / s.

Give your answer in standard form.

Mean rate of reaction = _____ g / s

(3)

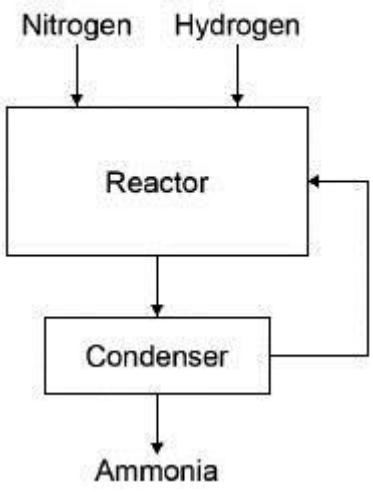
(Total 16 marks)

Q7.

Nitrogen and hydrogen react to produce ammonia in the Haber process.

Figure 1 shows the Haber process.

Figure 1



A gaseous mixture of ammonia, hydrogen and nitrogen leaves the reactor.

Table 1 shows the boiling points of the gases.

Table 1

Gas	Boiling point in °C
Ammonia	−33
Nitrogen	−196

Hydrogen	−253

(a) Suggest how ammonia is separated from the other gases.

(2)

(b) What happens to the unreacted hydrogen and nitrogen?

(1)

The equation for the reaction is:

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

The forward reaction is exothermic.

(c) Calculate the volume of ammonia produced from the complete reaction of 825 dm^3 of hydrogen.

Volume of ammonia = _____ dm^3

(2)

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

Why are these conditions used?

Tick **two** boxes.

- A higher pressure is maintained using less energy ☐
- A higher temperature would increase the equilibrium yield ☐
- A lower pressure would decrease the equilibrium yield ☐
- A lower temperature would make the reaction too slow ☐
- There are more product molecules than reactant molecules ☐

(2)

Most of the ammonia produced is used to make fertilisers.

Table 2 shows information about compounds used as fertilisers.

Table 2

Compound	Formula	Cost in £ / tonne
A	NH_4NO_3	220
B	$(NH_4)_2HPO_4$	350
C	KCl	235

(e) Which element in compound A improves agricultural productivity?

_____

_____

(1)

(f) Which **two** compounds can be mixed to make a fertiliser containing three elements that improve agricultural productivity?

Give a reason why you have chosen these compounds.

Compounds _____ and _____

Reason

_____

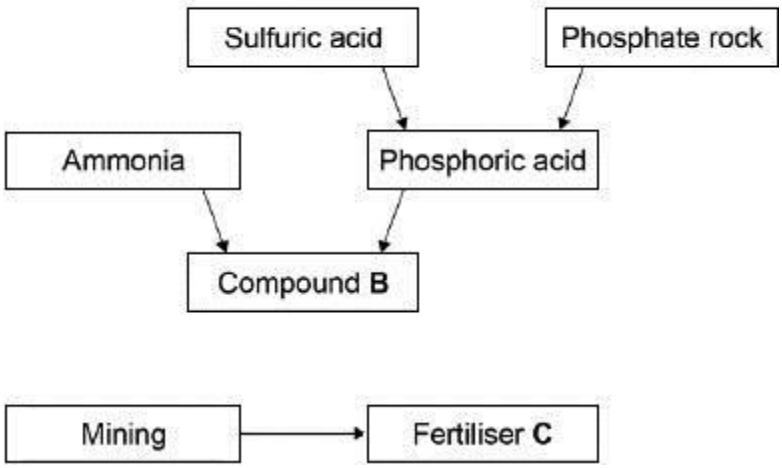
_____

_____

(2)

(g) **Figure 2** shows a flow chart for the production of compounds B and C.

Figure 2



Suggest **two** possible reasons for the difference in cost between compounds **B** and **C**.

1.

_____

_____

_____

2.

_____

_____

_____

_____

(2)

(Total 12 marks)

Q8.

Cobalt forms coloured compounds.

A pink cobalt compound reacts with hydrochloric acid.

The reaction can be represented as:

pink cobalt compound + hydrochloric acid ⇌ blue cobalt compound + water

The forward reaction is endothermic.

When both cobalt compounds are present in a solution at equilibrium, the equilibrium mixture is purple.

(a) What is meant by equilibrium?

(2)

(b) The equilibrium mixture is cooled.

Explain what happens to the concentration of the pink cobalt compound.

(3)

(c) More hydrochloric acid is added.

Explain what happens to the colour of the equilibrium mixture

_____

_____

_____

_____

_____

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_____

_____

(3)

(d) Why does cobalt form different coloured compounds?

_____

_____

(1)

(e) An oxide of cobalt has the formula Co_2O_3

Which cobalt ion is present in this oxide?

Tick (✓) **one** box.

Co^+ ☐

Co^{2+} ☐

Co^{3+} ☐

Co^{4+} ☐

(1)

(f) Cobalt compounds can act as catalysts.

Which two statements about cobalt compounds are correct?

Tick (✓) **two** boxes.

They allow reactions to reach equilibrium more quickly.	☐
They are reactants in reactions catalysed by cobalt compounds.	☐
They are used up when acting as catalysts.	☐
They increase the equilibrium yield of reactions.	☐
They provide a different reaction pathway.	☐

(2)

(g) The reaction of hydrogen with carbon monoxide is catalysed by cobalt metal.

Balance the equation for the reaction.

$$H_2 \quad + \quad CO \quad \longrightarrow \quad C_6H_{14} \quad + \quad H_2O$$

(1)

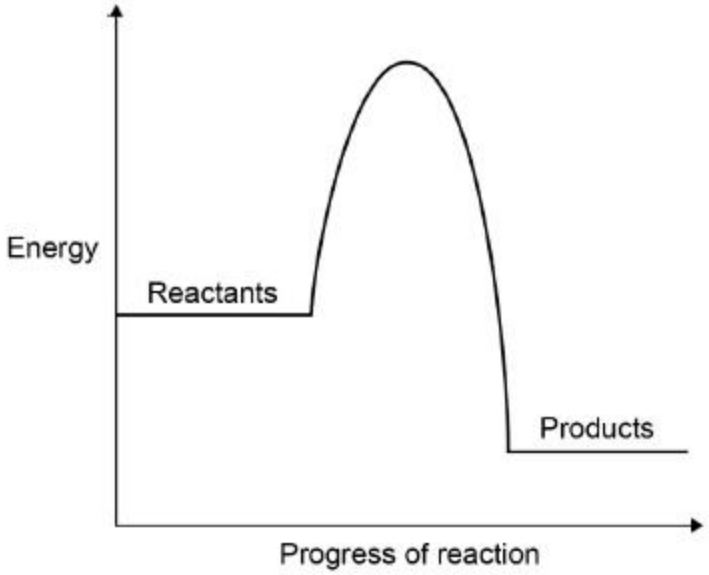
(h) C_6H_{14} is an alkane.

What is the formula of an alkane containing 18 hydrogen atoms?

_____

(1)

(i) The graph shows a reaction profile diagram for a reaction **without** a catalyst.



On the graph:

- draw the reaction profile diagram for a catalysed reaction
- draw and label an arrow to show the activation energy for the reaction **without** a catalyst.

(2)

(Total 16 marks)

Q9.

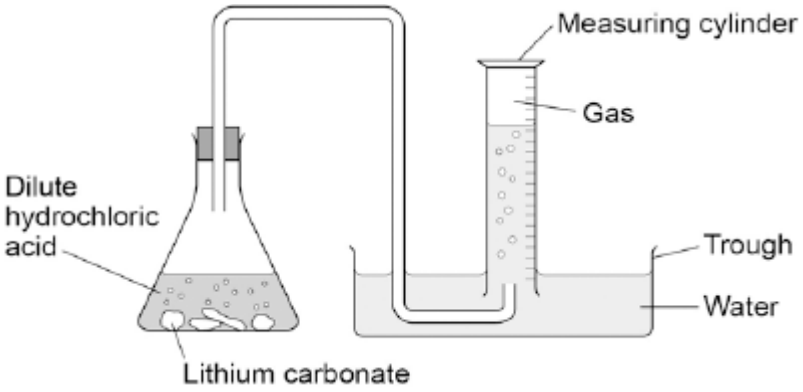
Lithium carbonate reacts with dilute hydrochloric acid.

A group of students investigated the volume of gas produced.

This is the method used.

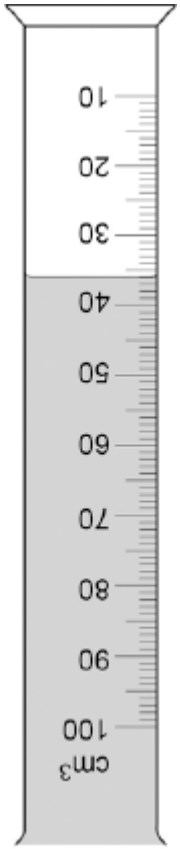
1. Place a known mass of lithium carbonate in a conical flask.
2. Measure 10 cm^3 of dilute hydrochloric acid using a measuring cylinder.
3. Pour the acid into the conical flask.
4. Place a bung in the flask and collect the gas as shown in **Figure 1**.

Figure 1



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

Figure 2



What volume of gas has been collected?

Volume = _____ cm^3

(1)

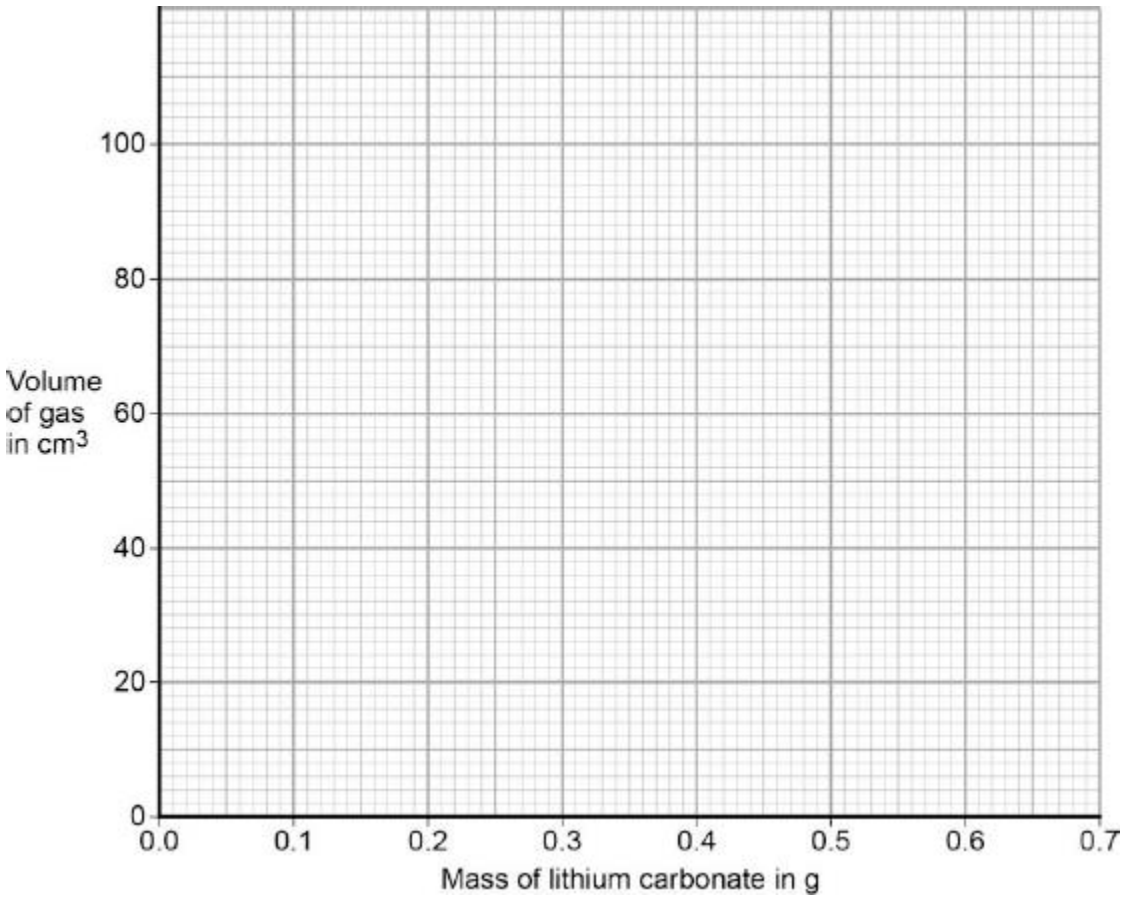
(b) The table below shows the students' results.

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.

_____

_____

_____

_____

_____

_____

_____

_____

(2)

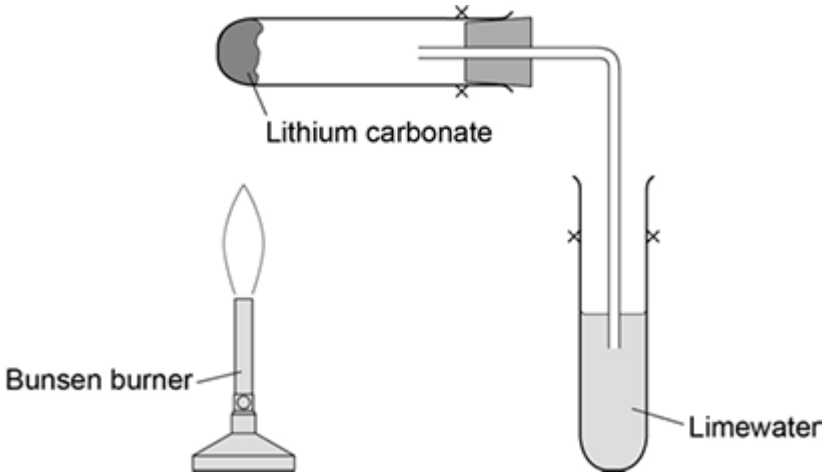
(e) Lithium carbonate decomposes when heated.

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?

_____

_____

_____

_____

(1)

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

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

_____

_____

_____

_____

(1)
(Total 11 marks)

Q10.

(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)

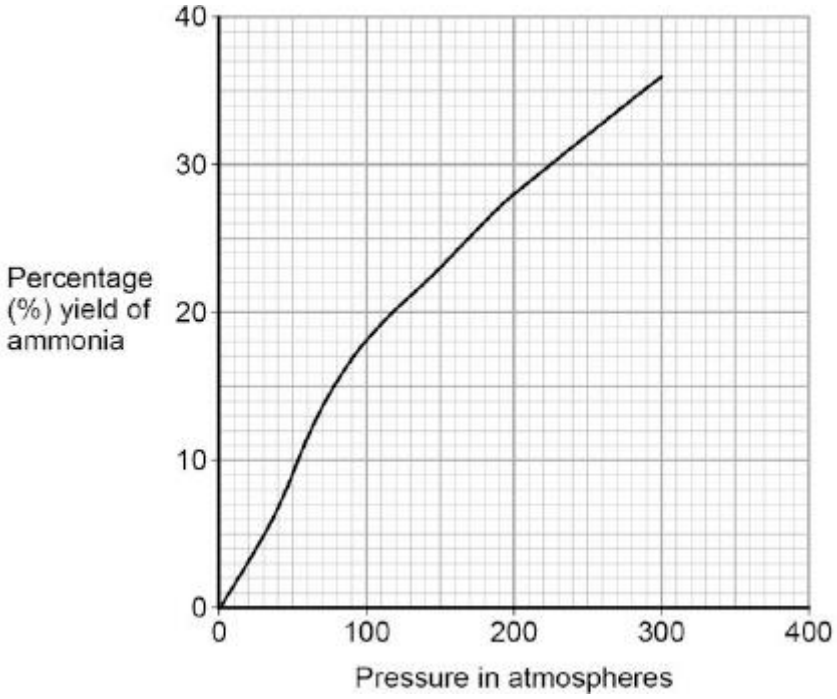
(b) What is iron used for in the Haber process?

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.

_____

_____

_____

_____

(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)

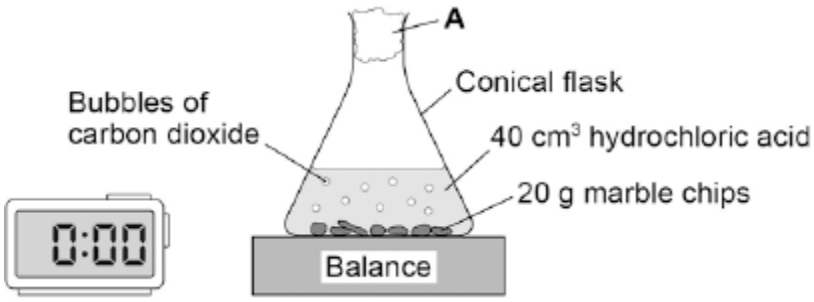
(Total 5 marks)

Q11.

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.

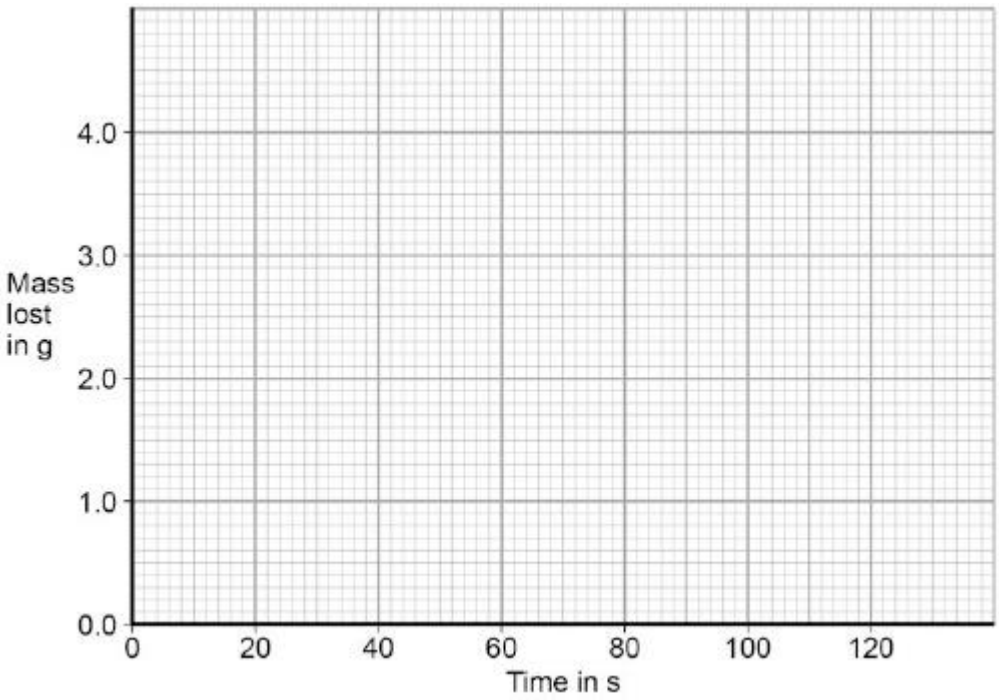
Table 1

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.

_____

_____

_____

_____

_____

_____

(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.

_____

_____

_____

_____

_____

_____

_____

_____

(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)

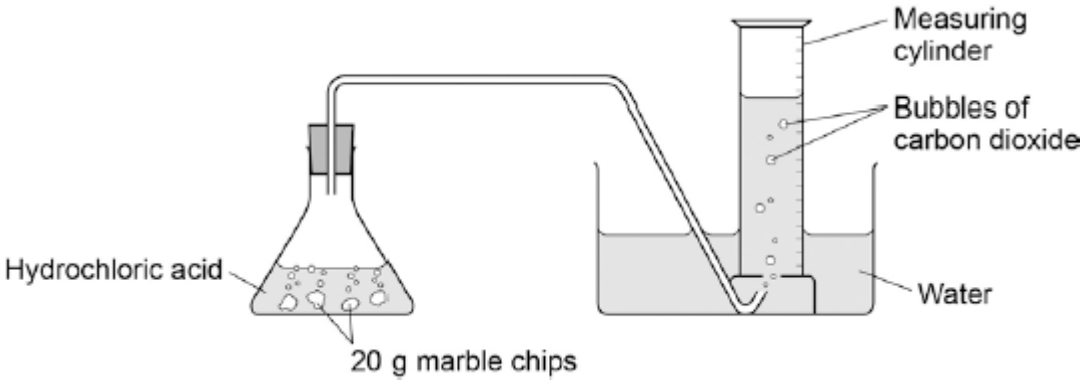
Q12.

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)

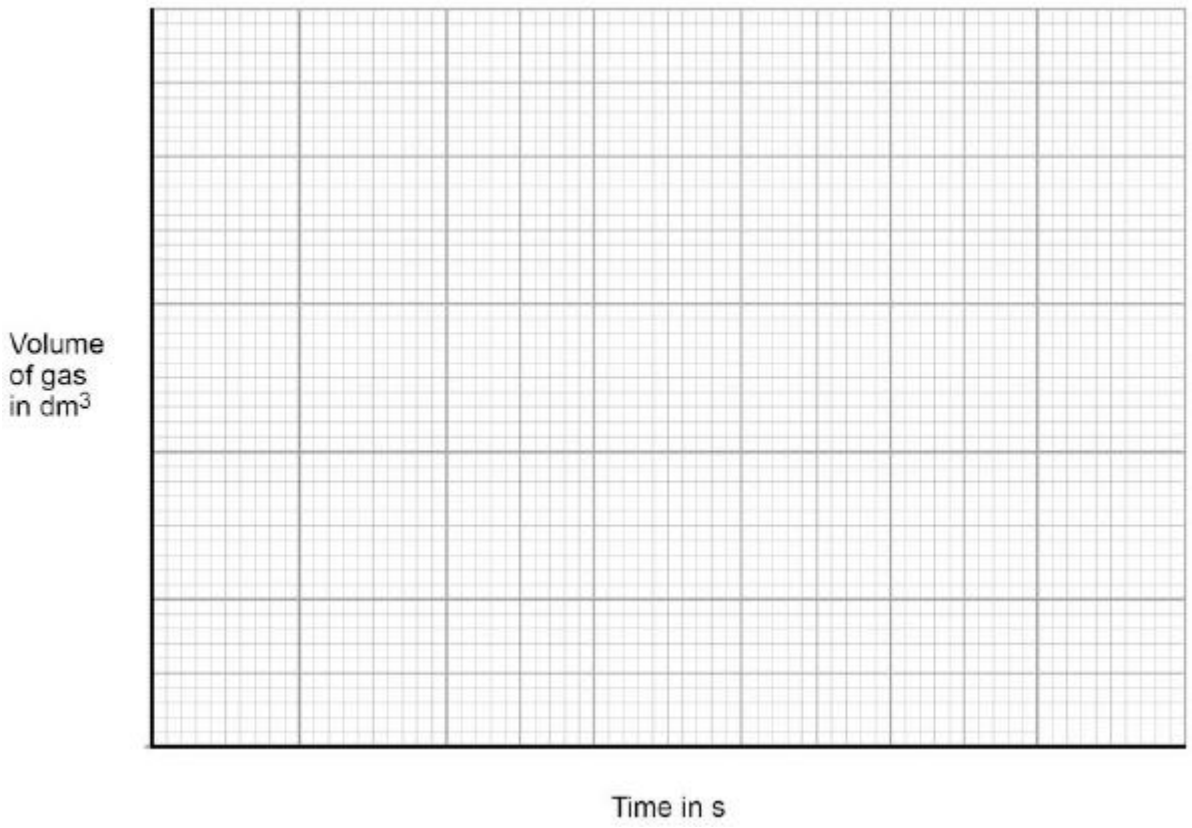
(b) The table below shows the student's results.

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)

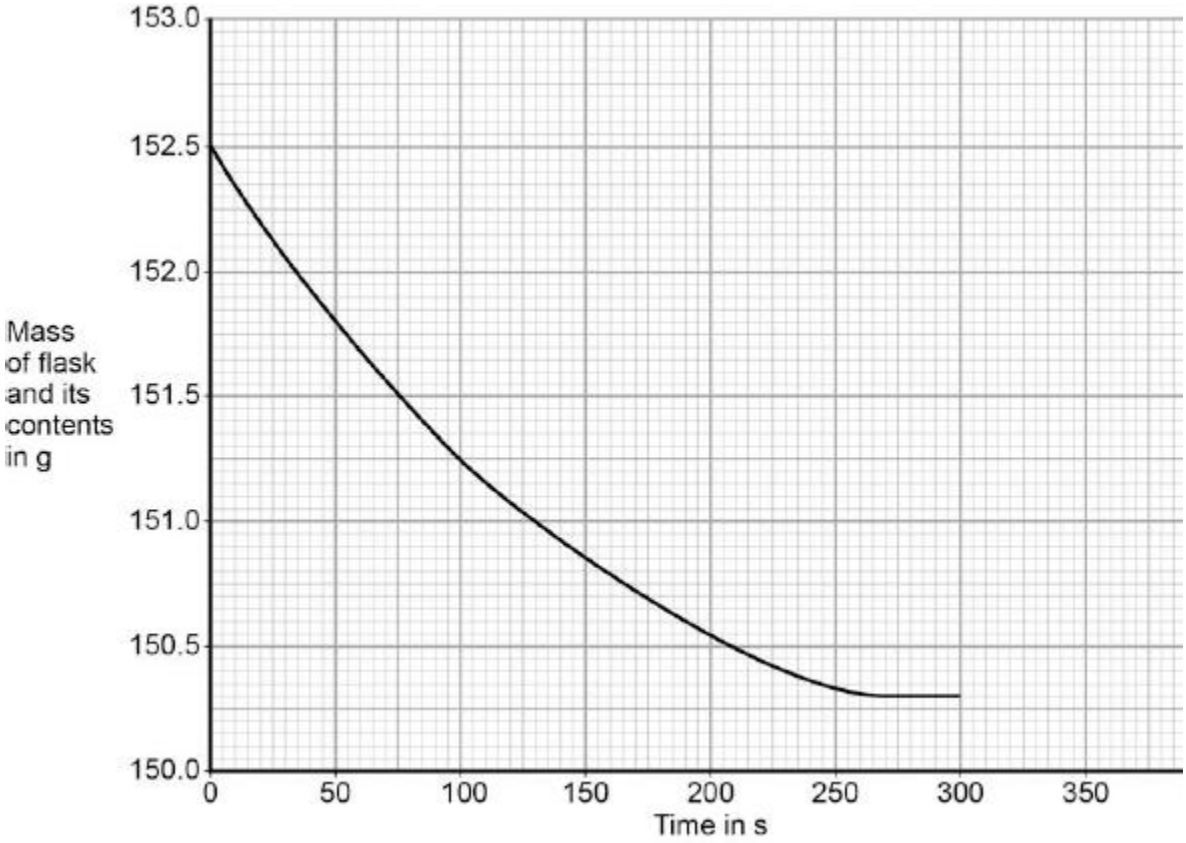
(d) Explain, in terms of particles, how and why the rate of reaction changes during the reaction of calcium carbonate with hydrochloric acid.

(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.

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.

Rate of reaction at 150 s = _____ g / s

(4)

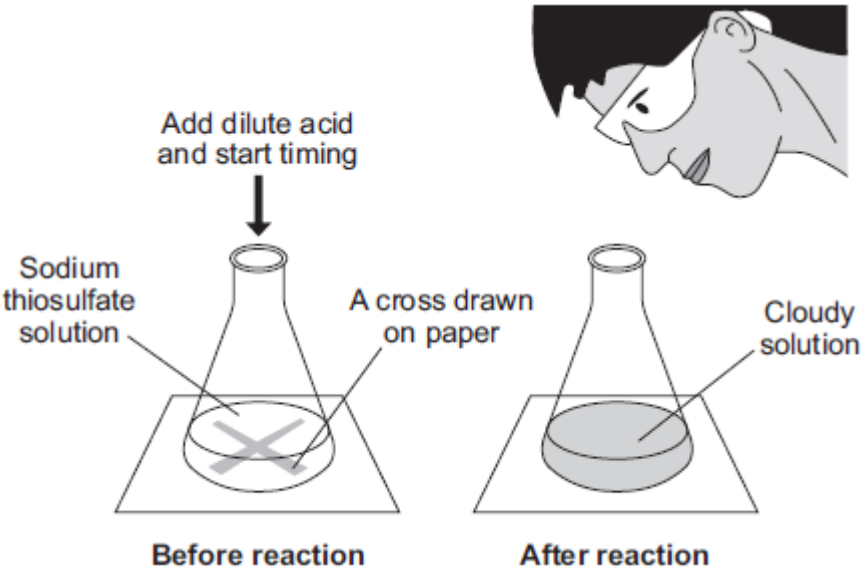
(Total 20 marks)

Q13.

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

Figure 1 shows an experiment.

Figure 1



The student:

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

The equation for the reaction is:

$$\underset{\text{sodium thiosulfate}}{Na_2S_2O_3(aq)} + \underset{\text{hydrochloric acid}}{2HCl(aq)} \longrightarrow \underset{\text{sodium chloride}}{2NaCl(aq)} + \underset{\text{water}}{H_2O(l)} + \underset{\text{sulfur dioxide}}{SO_2(g)} + \underset{\text{sulfur}}{S(s)}$$

(a) Which product is a gas?

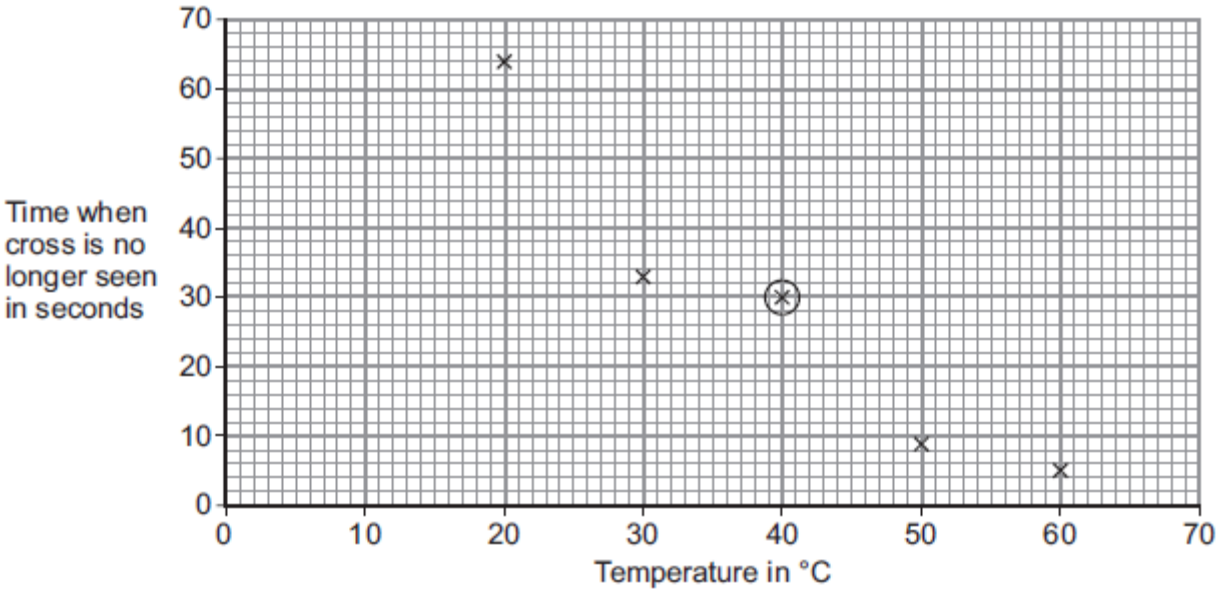
_____

(1)

(b) **Figure 2** shows the results of this experiment at five different temperatures.

The circled result point is anomalous.

Figure 2



(i) Draw a line of best fit on **Figure 2** to show how the reaction time varied with reaction temperature.

(1)

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

_____

_____

(1)

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

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

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

_____

_____

_____

_____

_____

_____

_____

_____

Rate of reaction = _____ grams per second

(2)

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

Tick (✓) **two** boxes.

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

(2)

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

activation	**collision**	**exothermic**

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

the _____ energy.

(1)

(Total 8 marks)

Q14.

This question is about atoms, molecules and nanoparticles.

(a) Different atoms have different numbers of sub-atomic particles.

(i) An oxygen atom can be represented as $^{16}_{8}O$

Explain why the mass number of this atom is 16.

You should refer to the numbers of sub-atomic particles in the nucleus of the atom.

_____

_____

_____

(2)

(ii) Explain why $^{12}_{6}C$ and $^{14}_{6}C$ are isotopes of carbon.

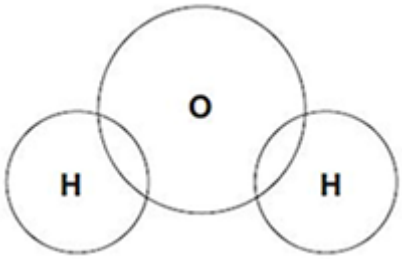
You should refer to the numbers of sub-atomic particles in the nucleus of each isotope.

(3)

(b) Hydrogen atoms and oxygen atoms chemically combine to produce water molecules.

(i) Complete the figure below to show the arrangement of the outer shell electrons of the hydrogen and oxygen atoms in a molecule of water.

Use dots (•) or crosses (×) to represent the electrons.



(2)

(ii) Name the type of bonding in a molecule of water.

_____

(1)

(iii) Why does pure water **not** conduct electricity?

_____

_____

_____

_____

(1)

(c) Nanoparticles of cobalt oxide can be used as catalysts in the production of hydrogen from water.

(i) How does the size of a nanoparticle compare with the size of an atom?

_____

_____

_____

_____

(1)

(ii) Suggest **one** reason why 1 g of cobalt oxide nanoparticles is a better catalyst than 1g of cobalt oxide powder.

_____

_____

_____

_____

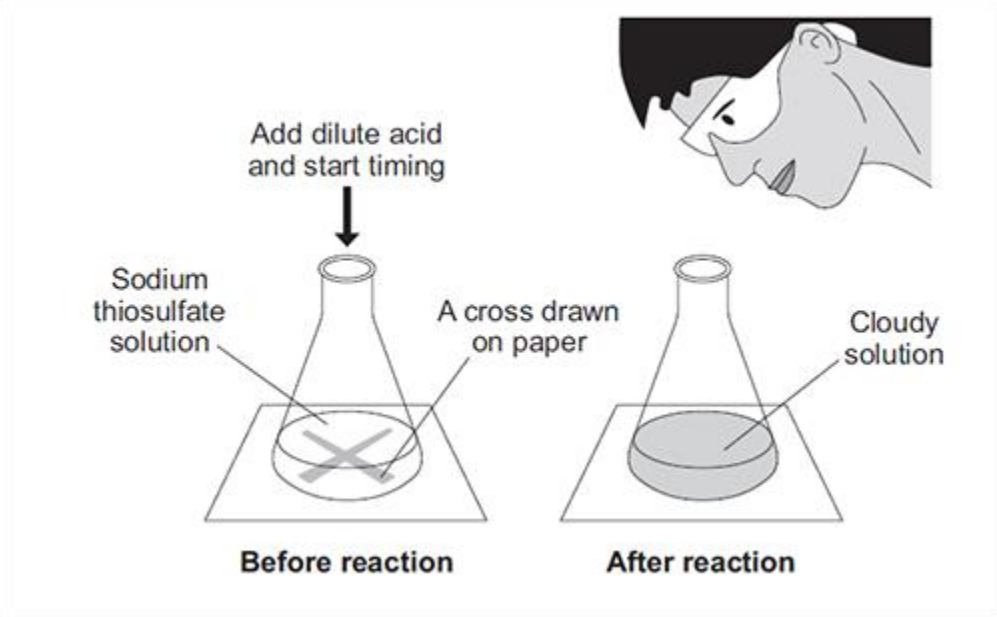
(1)

(Total 11 marks)

Q15.

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

The picture below shows an experiment.



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

(a) Explain why the solution goes cloudy.

_____

_____

_____

_____

_____

_____

_____

_____

(2)

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

1. _____

_____

2. _____

_____

(2)

(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.

_____

_____

_____

_____

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_____

(4)

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

_____

_____

_____

_____

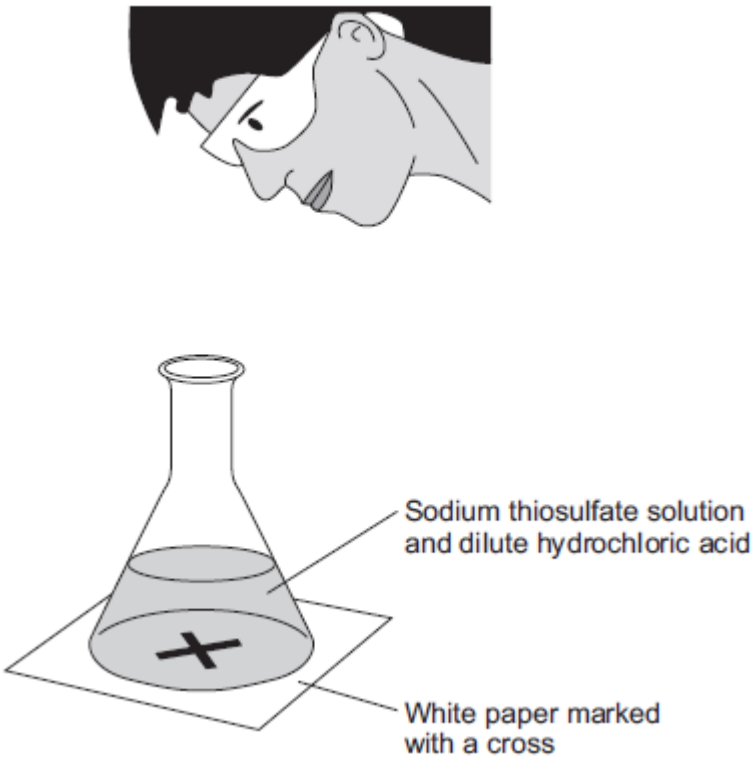
(1)

(Total 9 marks)

Q16.

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:

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

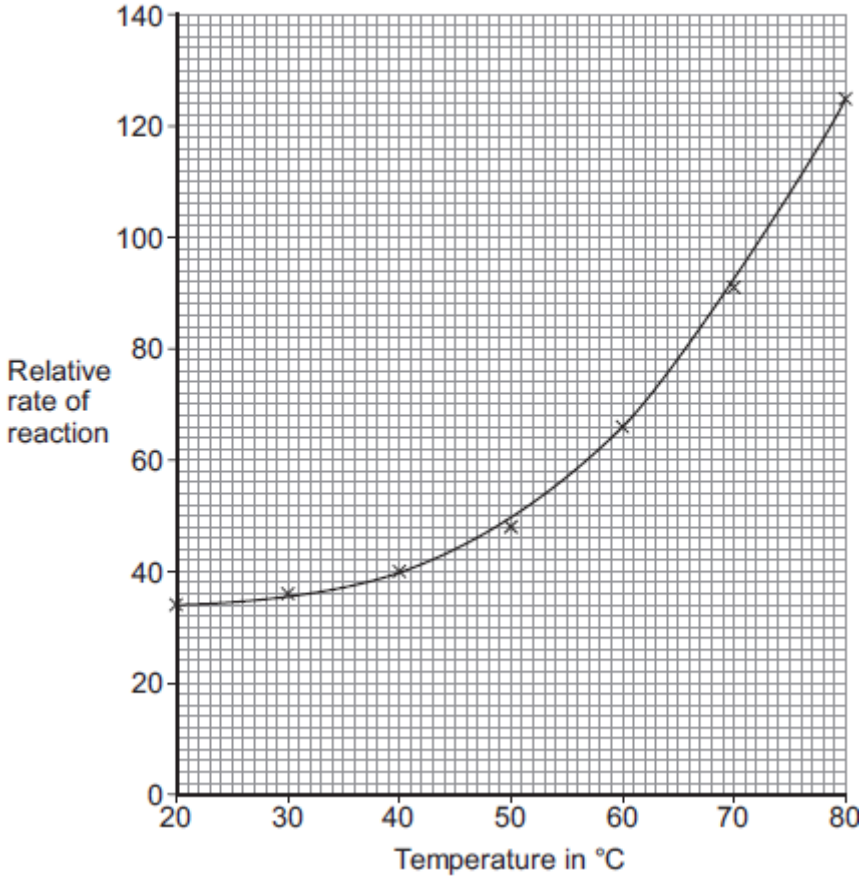
Name the product that made the mixture go cloudy.

(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.

(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.

(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.

(3)

(Total 8 marks)

Q17.

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.

_____

_____

_____

_____

(2)

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

_____

_____

_____

_____

_____

_____

_____

_____

(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

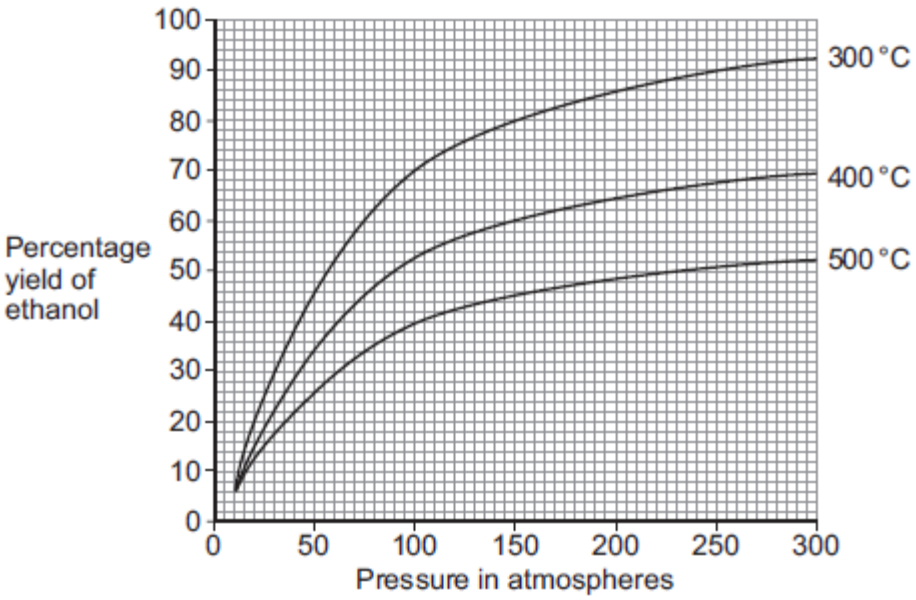
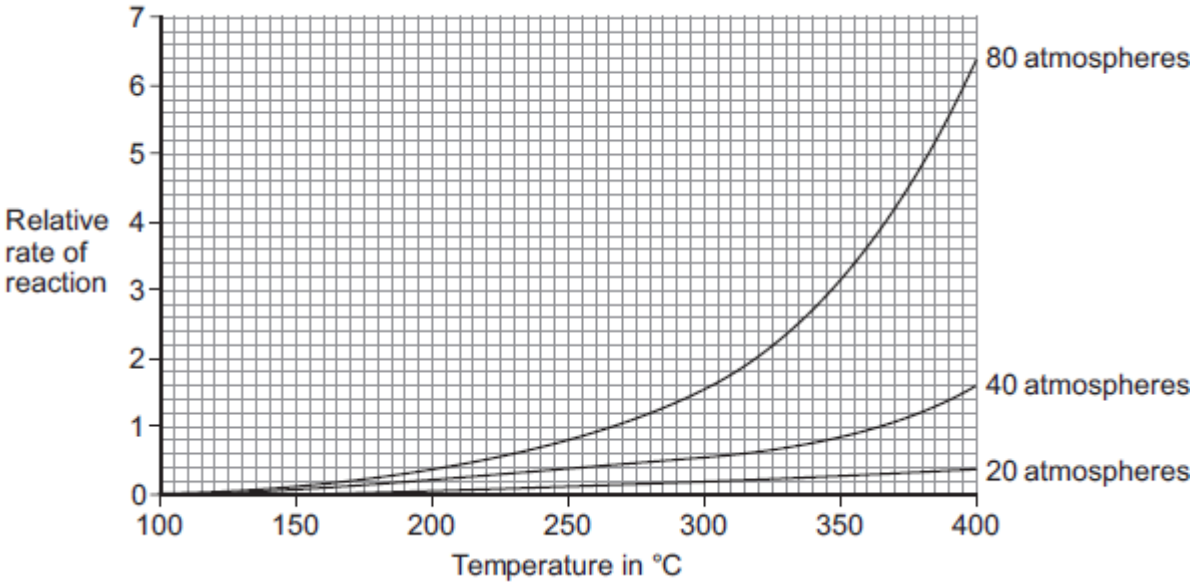


Figure 2 shows how the rate of reaction changes as the temperature changes at three different pressures.

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.

_____

_____

_____

_____

_____

_____

(6)

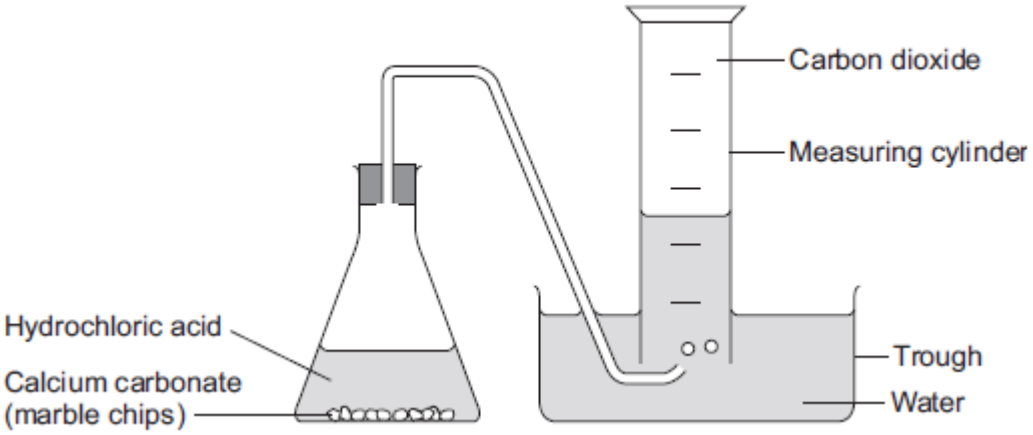
(Total 12 marks)

Q18.

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.

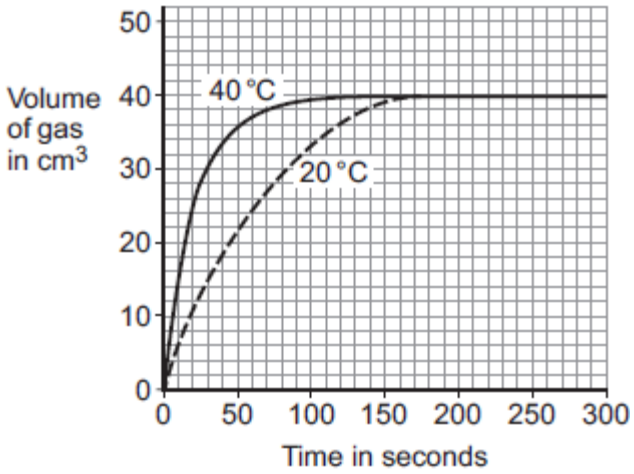
The equation for the reaction is:

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

(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.

_____

_____

_____

_____

(2)

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

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

_____

_____

(1)

(Total 8 marks)

Q19.

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.

_____

_____

_____

_____

(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.

(2)

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

Give a reason for your answer.

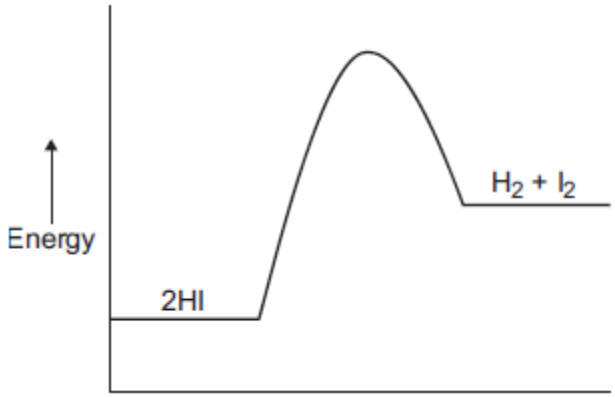
(2)

(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?

_____

_____

_____

_____

(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.

_____

_____

_____

_____

_____

_____

_____

_____

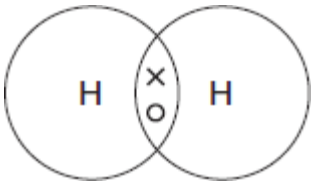
(2)

(Total 12 marks)

Q20.

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.

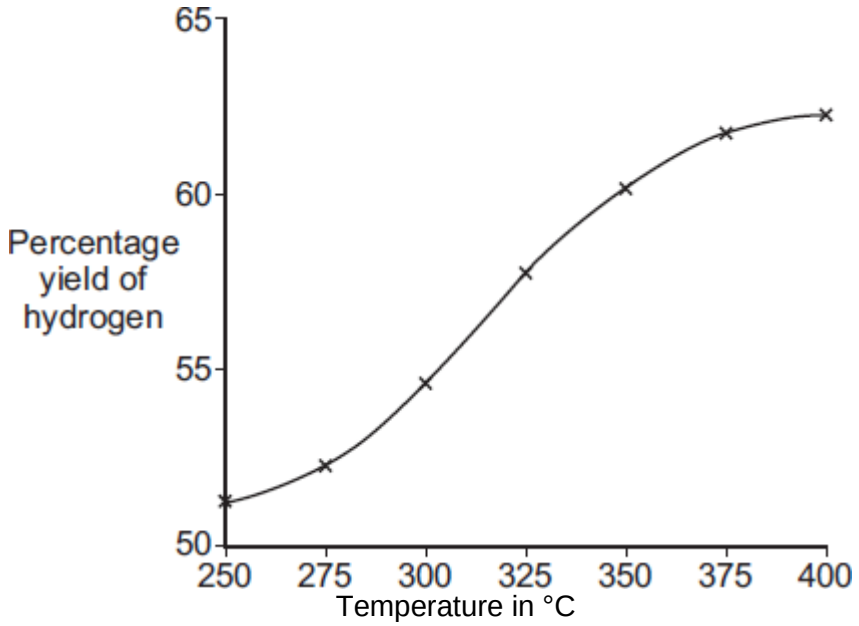
_____

_____

_____

(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?

(1)

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

(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.

Extra space

(6)

(Total 13 marks)

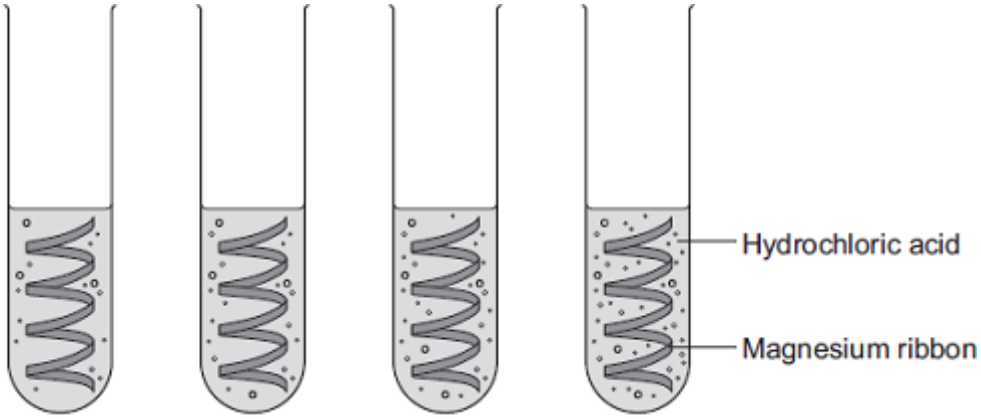
Q21.

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.

_____

_____

_____

_____

(2)

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

(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.

(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.

Concentration of hydrochloric acid = _____ moles per dm^3

(3)

(Total 14 marks)

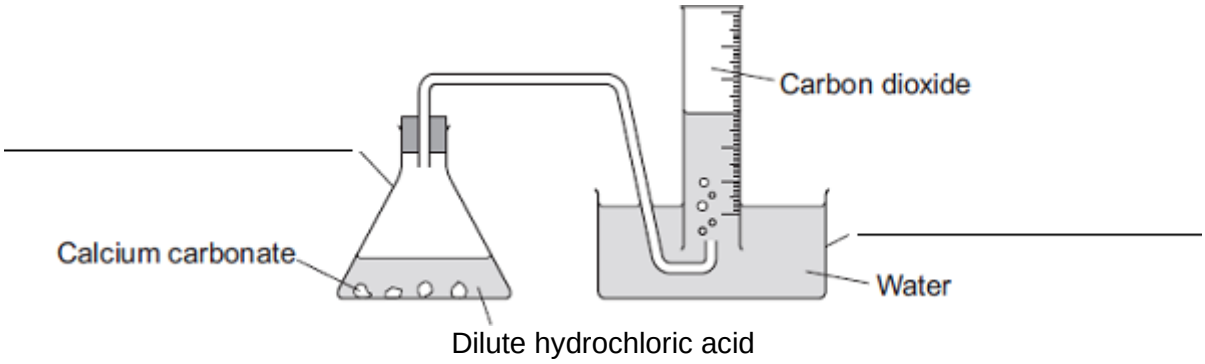
Q22.

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)

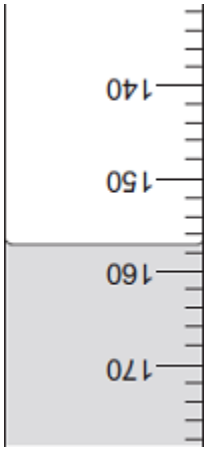
(b) The student measured the volume of gas collected every 30 seconds.

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

_____

_____

_____

_____

_____

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.

_____

_____

_____

_____

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.

(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.

(3)

(Total 17 marks)

Q23.

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**

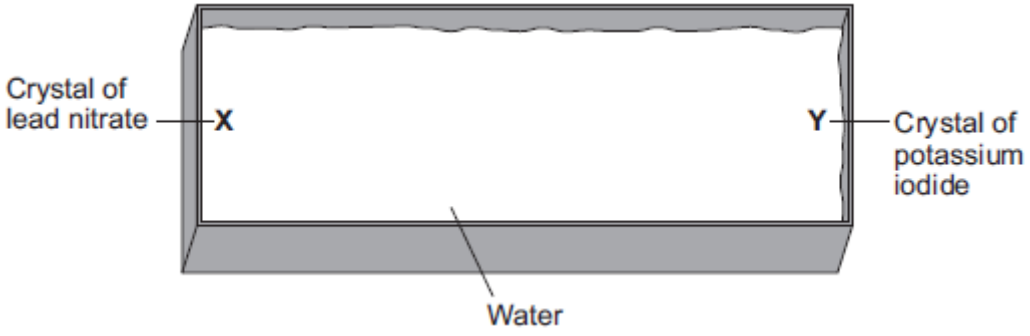
(1)

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

The students filled a container with water.

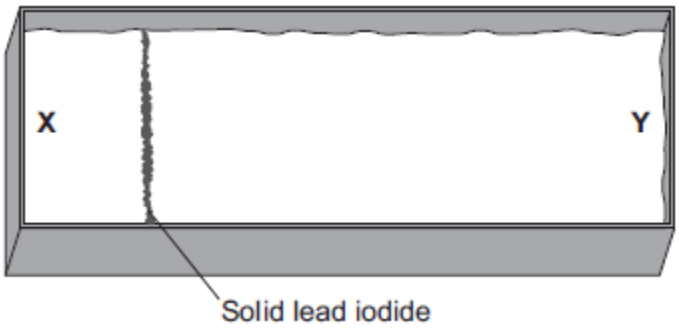
The students added a crystal of lead nitrate at position **X** and a crystal of potassium iodide at position **Y**, as shown in **Figure 2**.

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.

_____

_____

_____

_____

(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.

(2)

(Total 11 marks)

Q24.

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.

(3)

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

Give a reason for your answer.

(2)

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

Give a reason for your answer.

(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.

_____

(2)

(Total 9 marks)

Q25.

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.

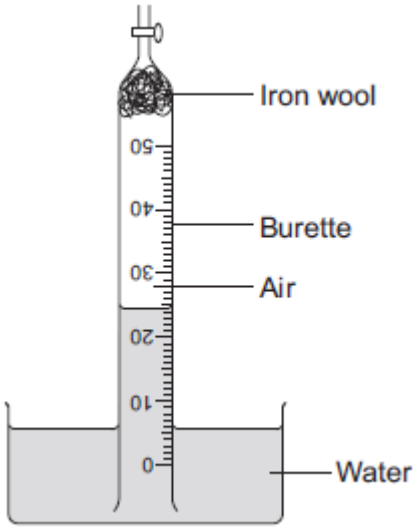
_____

_____

(1)

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

Figure 1

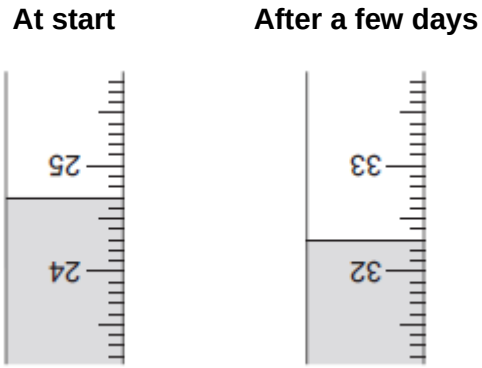


The student left the apparatus for a few days.

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.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

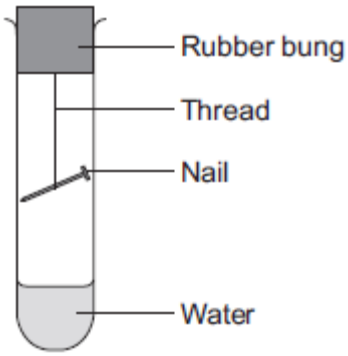
(2)

(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.

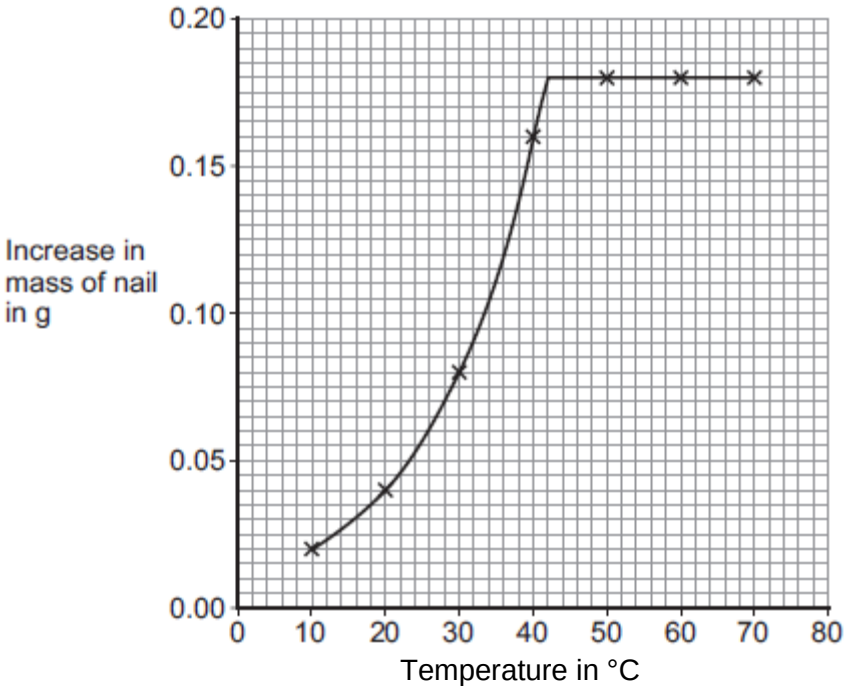
Figure 3



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?

_____

_____

_____

_____

(1)

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

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(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.

_____

_____

_____

_____

_____

_____

_____

_____

_____

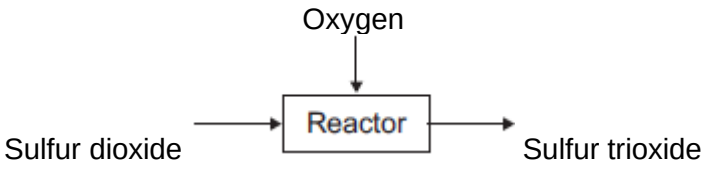
_____

(2)

(Total 12 marks)

Q26.

(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.

_____

_____

_____

_____

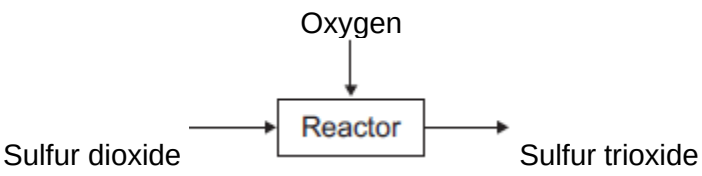
(1)

(Total 5 marks)

Q27.

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.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(3)

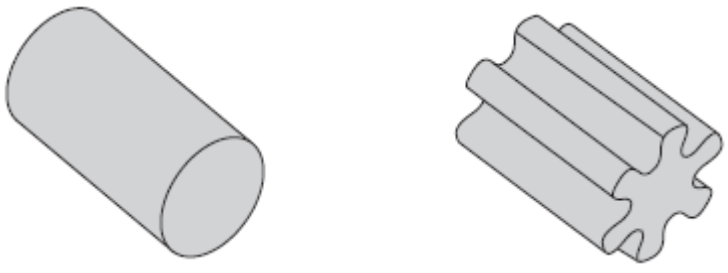
(ii) A catalyst is used for the reaction.

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**.

_____

_____

_____

_____

_____

_____

_____

_____

(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**?

_____

_____

_____

_____

_____

_____

(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.

_____

_____

_____

_____

_____

_____

_____

_____

(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.

_____

_____

_____

_____

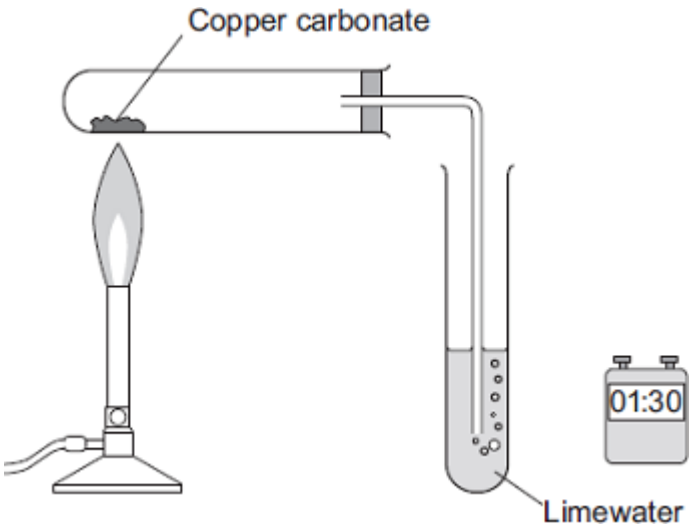
(1)

(Total 13 marks)

Q28.

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.

_____

_____

_____

_____

_____

_____

_____

_____

(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.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(2)

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

_____

_____

_____

_____

_____

_____

_____

(2)

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

_____

_____

_____

_____

_____

_____

_____

_____

(2)

Q29.

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)

Q30.

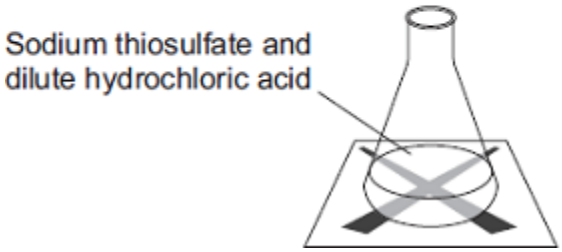
A student investigated the rate of reaction between sodium thiosulfate and dilute hydrochloric acid.

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:

$Na_2S_2O_3(aq) + 2\ HCl(aq) \rightarrow 2\ NaCl(aq) + H2O(l) + SO2(g) + S(s)$

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

(a) Explain why the solution goes cloudy.

_____

_____

_____

_____

(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.

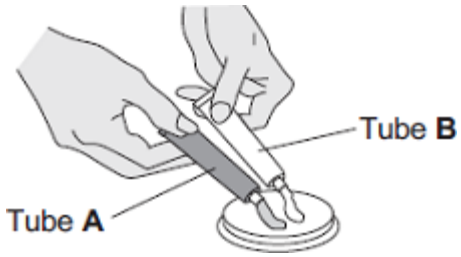
(3)

(Total 7 marks)

Q31.

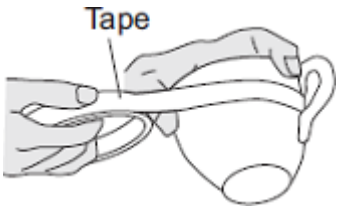
The following steps show how to use a type of glue.

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?

_____
_____

_____
_____

_____
_____

_____
_____

(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	

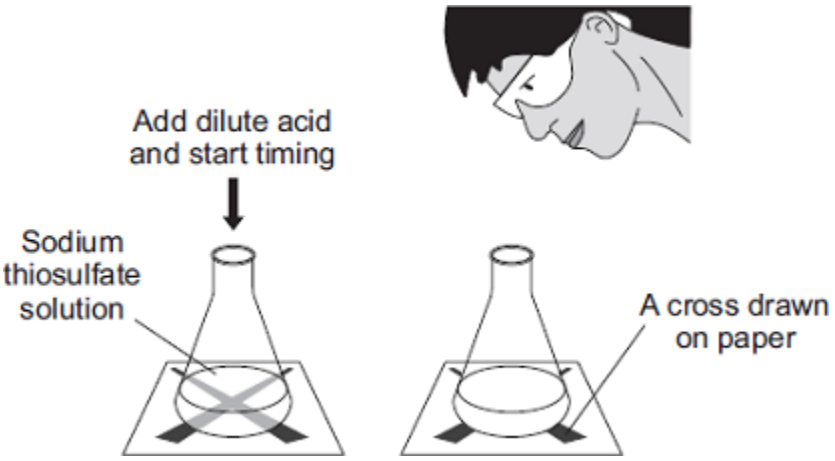
(2)

(Total 6 marks)

Q32.

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.

_____

_____

_____

_____

_____

_____

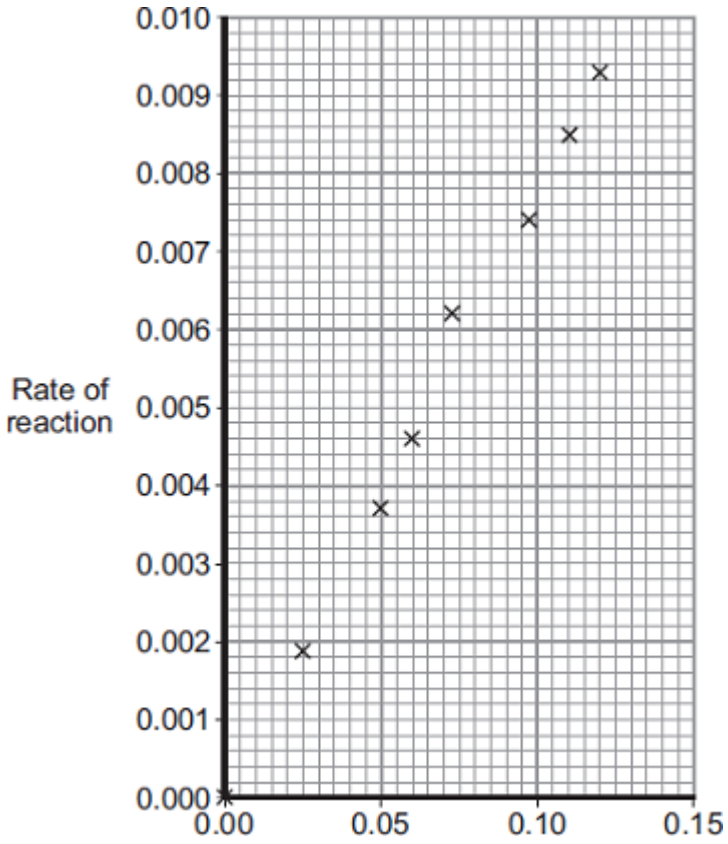
_____

_____

_____

_____

(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?

_____

_____

_____

_____

(1)

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

_____

_____

_____

_____

_____

_____

(2)

(Total 6 marks)

Q33.

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.

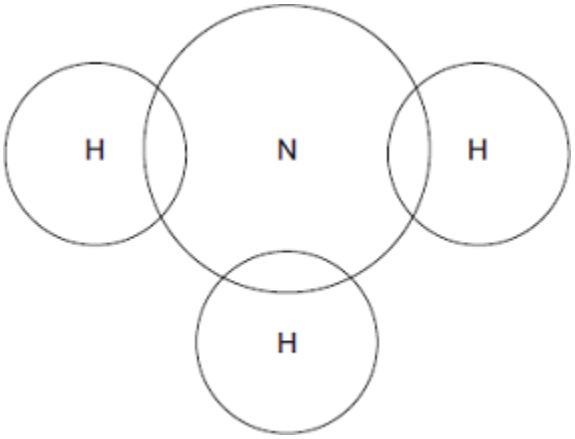
(2)

(Total 5 marks)

Q34.

(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.

_____

_____

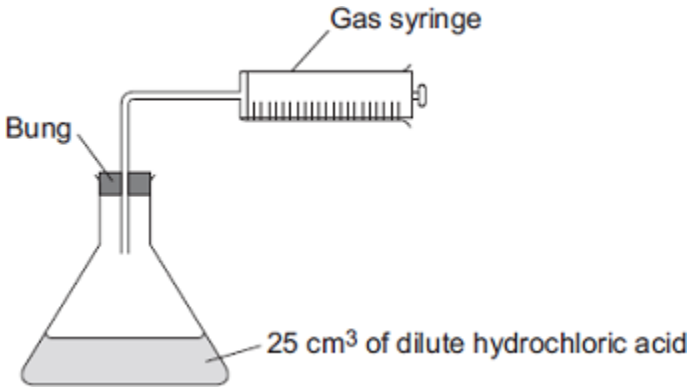
(6)

(Total 14 marks)

Q35.

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

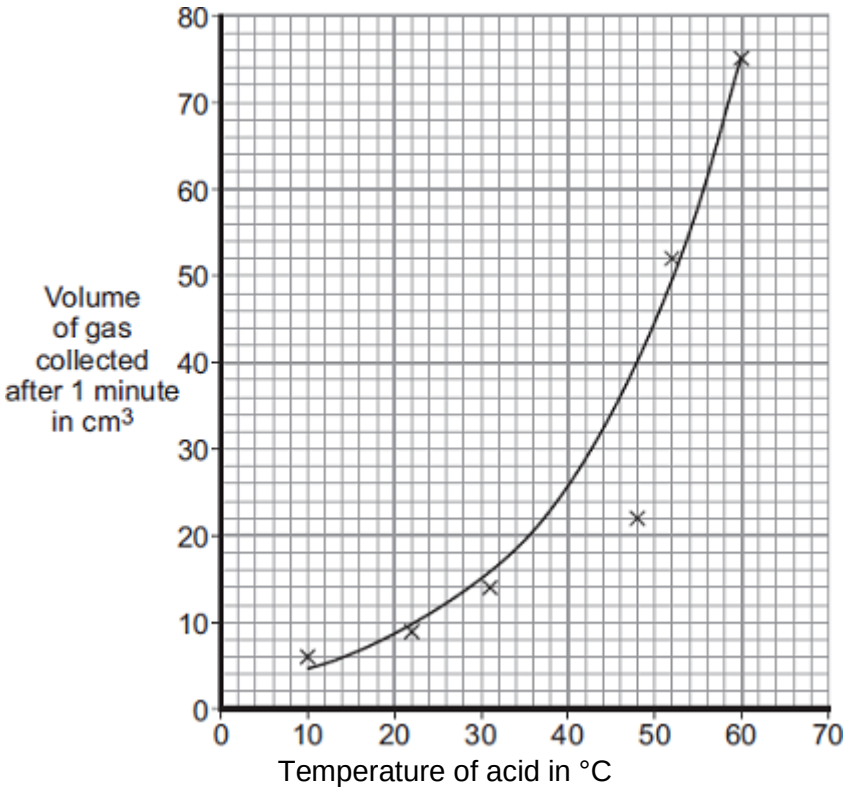
The student placed 25 cm^3 of dilute hydrochloric acid in a conical flask and set up the apparatus as shown in the diagram.



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.



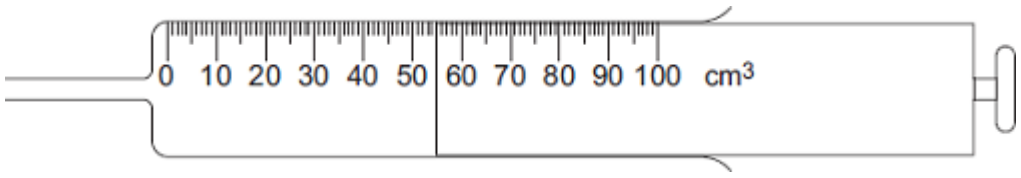
(a) Write the correct state symbols in the equation.

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

Mg (_____) + 2 HCl (_____) $\longrightarrow$ $MgCl_2$ (_____) + H_2 (_____)

(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.

_____

_____

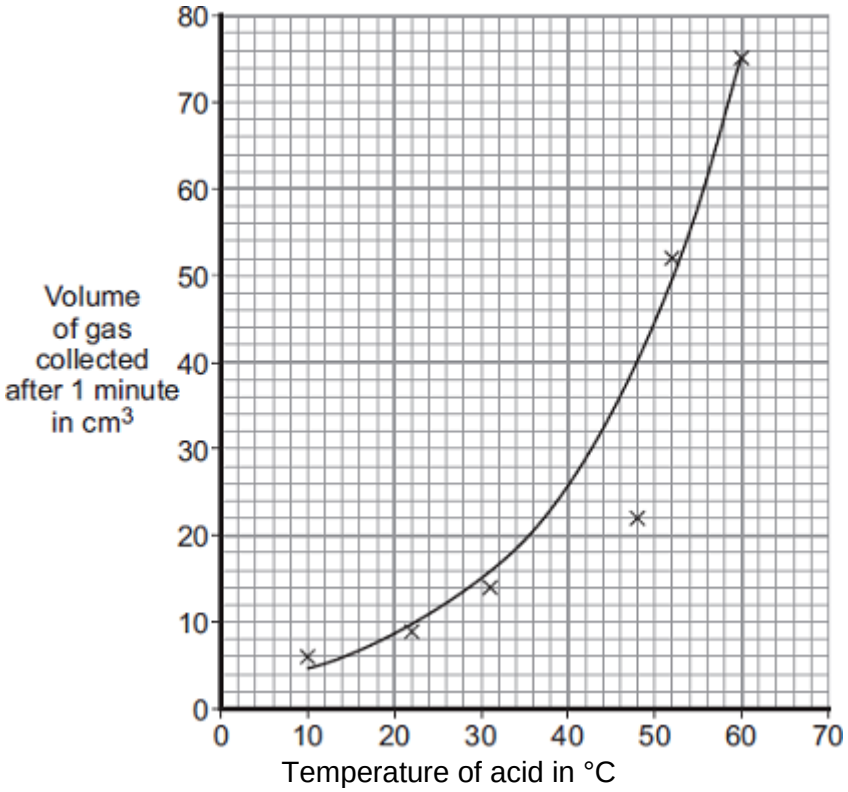
_____

_____

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.

_____

_____

_____

_____

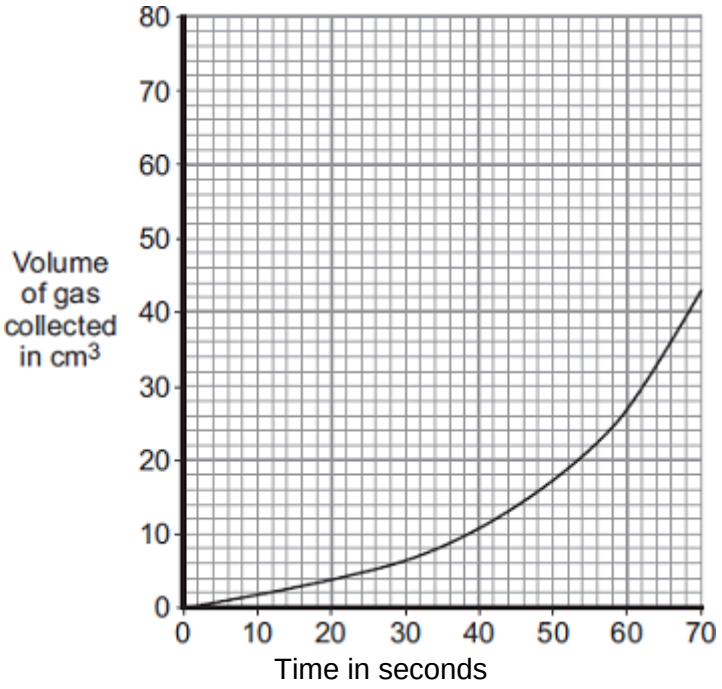
(2)

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

(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.

_____

_____

_____

_____

_____

_____

_____

_____

(2)

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

(2)

(Total 16 marks)

Mark schemes

Q1.

(a) 83 (cm^3)

allow 83.0 / 83.00

1

(b) mass of magnesium powder

1

temperature of hydrochloric acid

1

(c) $\frac{(46 + 47 + 49)}{3}$

*allow 47.3(333) (cm^3) for **1** mark*

1

= 47 (cm^3) (2 sf)

*an answer of 43 (cm^3) scores **1** mark*

1

*an answer of 47 (cm^3) scores **2** marks*

(d) all points plotted correctly
(inc 0,0)

allow a tolerance of ±½ a square
*allow ecf from question **(c)***
ignore line
*allow **1** mark for four points plotted correctly*

2

(e) $\frac{80}{50}$

allow 80 ± 2

1

= 1.6 (cm^3/s)

allow 1.60 ± 0.04

1

*an answer of 1.6 (cm^3/s) scores **2** marks*

(f) rate is greatest at start

allow rate is faster at start

1

(then) rate decreases

allow (then) rate slows down

1

reaction stops

1

(g) there are more particle collisions each second

1

there are more particles in the same volume

1

(h) (gas is) not carbon dioxide

ignore does not react with limewater

1

(i) hydrogen

allow H_2

1

pop sound

1

[17]

Q2.

(a) sulfur (formed)

allow S / S_8 (formed)

1

(which is a) precipitate

allow (which is a) solid
allow (which is) insoluble

1

(b) **Level 3:** The method would lead to the production of a valid outcome. All key steps are identified and logically sequenced.

5–6

Level 2: The method would not necessarily lead to a valid outcome. Most steps are identified, but the method is not fully logically sequenced.

3–4

Level 1: The method would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.

1–2

No relevant content

0

Indicative content

method

- measure (indicated) volume of sodium thiosulfate
- place sodium thiosulfate in (conical) flask
- measure (indicated) volume of hydrochloric acid
- place on cross or between light sensor
  or
  connect to a gas syringe
  or
  other suitable method for timing a change
- add hydrochloric acid to (conical) flask
- swirl
- start stopclock / stopwatch

- measure time for cross to become no longer visible
  or
  log light transmission over time
  or
  measure time for fixed volume of gas to be produced
- repeat and find mean
- repeat for different concentrations of sodium thiosulfate
  or change ratio of sodium thiosulfate volume : water volume

control variables
- concentration of hydrochloric acid
- volume of hydrochloric acid
- (total) volume of sodium thiosulfate solution

[8]

Q3.

(a) a gas is produced

allow carbon dioxide is produced
*do **not** accept an incorrect gas*

1

(which) escapes

***max 1** mark if evaporation mentioned*

1

(b) all eight points plotted correctly

allow a tolerance of ± half a small square.

*allow six or seven points plotted correctly for **1** mark*

2

line of best fit

1

(c) correctly drawn tangent at 0.95 g

1

correct value for x step **and** y step from tangent

allow evidence of use of two points on tangent either on the graph or in the text

1

$$(\text{rate} =) \frac{\text{value for y step}}{\text{value for x step}}$$

1

correctly evaluated and rounded to 2 sig figs

allow

$$(\text{rate} =) \frac{\text{value for x step}}{\text{value for y step}}$$

(i.e. inverted division)

correctly evaluated and rounded to 2 sig figs

1

an incorrect answer for one step does not prevent allocation of marks for subsequent steps

[9]

Q4.

(a) enzyme

1

(b) 2.0×10^3 moles

1

(c) smaller yield

allow less methanol is produced

1

(because) favours endothermic reaction

allow (because) favours reverse reaction
allow equilibrium / reaction shifts to the left
allow equilibrium / reaction shifts to reduce the temperature

ignore reference to forward reaction is exothermic
ignore references to rate

1

(d) (yield)
equilibrium position moves to the product side

allow equilibrium / reaction moves to the right
allow equilibrium / reaction shifts to reduce the pressure

1

(because) fewer molecules / moles / particles on product side

allow (because) fewer molecules / moles / particles on the right
allow (because) smaller volume on product side

1

(rate)
more collisions per unit time

allow increases collision frequency / rate

ignore more collisions alone
ignore faster collisions
*do **not** accept any indication of more energetic / forceful collisions*

1

(because) more molecules / particles per unit volume

allow (gas) molecules / particles closer together

ignore more molecules / particles alone

1

allow converse arguments

(e) provides different reaction pathway

allow provides a different mechanism / route

1

(which has a) lower activation energy

1

ignore references to collisions

(f) less energy is needed

allow reduces the temperature required
allow reduces costs

ignore references to pressure
ignore references to rate or time

1

(g) no effect / change

1

[12]

Q5.

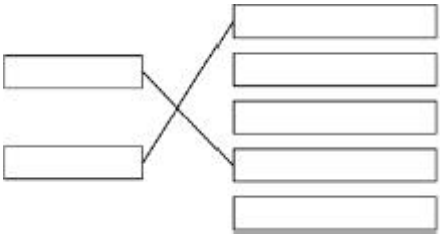
(a) S(s)

1

(b) measuring cylinder

1

(c)



1

*allow for **1** mark an answer of dependent variable --- concentration of sodium thiosulfate solution and independent variable --- time for cross to become no longer visible*

1

(d) cross might be darker or paler

allow cross may not be the same size / shape

1

(e) $\frac{43 + 41}{2}$

*an answer of 42 (s) scores **2** marks*

1

= 42 (s)

*an answer of 54 (s) scores **1** mark*

1

(f) smooth curve through all points

must touch all crosses

*do **not** allow straight lines between points*

*ignore attempt to plot **X***

1

(g) reproducible

1

(h) particles collide more frequently

1

there are more particles in a fixed volume

1

[11]

Q6.

(a) sulfur

1

precipitate

allow solid

1

(b) any **one** from:
- (volumetric) pipette
- burette

1

(c) any **one** from:
- concentration of hydrochloric acid
- volume of hydrochloric acid
- volume of sodium thiosulfate solution
- temperature (of solution)
- darkness of cross

allow same cross

- same stirring / swirling

1

(d) 7 points plotted correctly

allow tolerance of ± half a small square

*allow 5 or 6 points plotted correctly for **1** mark*

2

line of best fit

must avoid anomalous point

1

(e) repeatable

*do **not** accept reproducible*

1

(f) discard any anomalous results

1

calculate a mean

1

(g) **conclusion:**
the higher the concentration, the higher the rate of reaction

1

explanation:
(at higher concentrations) there are more particles in a fixed volume

1

(therefore the) collisions are more frequent

1

allow converse

(h) 120 (s)

1

0.18 / 120

allow 0.0015

1

= 1.5 × 10^{-3} (g / s)

*an answer of 9 × 10^{-2} scores **2** marks*
*allow an answer of 0.09 for **1** mark*

1

*an answer of 1.5 × 10^{-3} (g / s) scores **3** marks*

[16]

Q7.

(a) cool

1

to −34 °C

allow temperatures below −34 °C but above −196 °C

1

(b) recycled (to the reactor)

1

(c) $825 \times \frac{2}{3}$

1

= 550 (dm^3)

1

*an answer of 550 (dm^3) scores **2** marks*

(d) a lower pressure would decrease the equilibrium yield

1

a lower temperature would make the reaction too slow

1

(e) nitrogen / N

1

(f) **B** and **C**

1

contain nitrogen, phosphorus and potassium

1

(g) (**B**)

any **two** from:
- more stages
- uses more energy
- uses more raw materials
- takes longer

*allow converse for **C***

2

[12]

Q8.

(a) in a closed system

1

the rate of the forward and backward reactions are equal

1

(b) concentration increases

1

(because) reaction / equilibrium moves to the left / reactant side

1

(since the) reverse reaction is exothermic

allow (so that) temperature increases

1

(c) becomes blue

1

(because) reaction / equilibrium moves to the right / product side

1

(so) concentration of blue cobalt compound increases

allow (so that) concentration of hydrochloric acid decreases

1

(d) (cobalt has) ions with different charges

allow (cobalt is a) transition metal

1

(e) Co^{3+}

1

(f) they allow reactions to reach equilibrium more quickly

1

they provide a different reaction pathway

1

(g) $\mathbf{13}H_2 + \mathbf{6}CO \rightarrow C_6H_{14} + \mathbf{6}H_2O$

allow multiples

1

(h) C_8H_{18}

1

(i) curve below printed curve

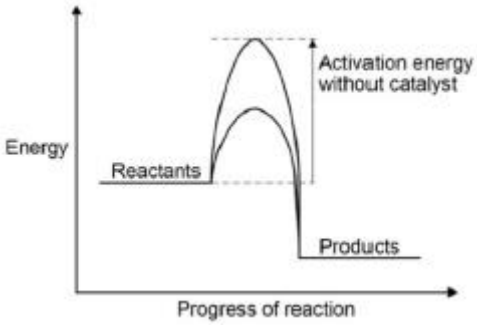
*do **not** accept different reactant or product levels*

1

vertical arrow from reactant level to peak of **printed** curve

1

an answer of:



scores **2** marks

[16]

Q9.

(a) 36 cm^3

1

(b) all points correct

± ½ small square

2

*allow **1** mark if 6 or 7 of the points are correct*

2 best fit lines drawn

must not deviate towards anomalous point

2

*allow **1** mark if 1 line correct*

(c) The bung was not pushed in firmly enough.

1

The measuring cylinder was not completely over the delivery tube.

1

(d) as mass of lithium carbonate increases volume of gas produced increases

1

linear / (directly) proportional

1

(e) A gas / carbon dioxide is produced.

allow because the air in the tube expands

1

(f) any **one** from:

- Potassium carbonate does not decompose to produce carbon dioxide / a gas.
- Potassium carbonate does not decompose at the temperature of the Bunsen burner **or** the Bunsen burner is not hot enough to decompose potassium carbonate.
- When potassium carbonate decomposes a gas is not formed.

1

[11]

Q10.

(a) $N_2 + 3\ H_2 \rightarrow 2\ NH_3$

1

(b) catalyst

1

(c) as pressure increases percentage yield increases

1

(d) 32−23

both readings correct

1

= 9 (%)

1

[5]

Q11.

(a) cotton wool

1

(b) all points correct

± ½ small square

2

*allow **1** mark if 5 or 6 of the points are correct*

best fit line

must not deviate towards anomalous point

1

(c) (mass)
2.1 (g)

allow ecf from drawn best fit line

1

(time)
100 (s)

1

(d) a gas is produced

1

which escapes from the flask

1

(e) $\frac{9.85}{150} = 0.0656$

1

0.07 (g / s)

allow ecf answer correctly calculated to 2 decimal places

1

(f) collect the gas in a gas syringe

1

measured the volume of gas

allow carbon dioxide for gas

1

*allow for **1** mark*
collected gas
or
counted bubbles

(g) The particles have more energy

1

The particles move faster

1

[14]

Q12.

(a) $CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$

2

*allow **1** mark for correct formulae*

(b) sensible scales, using at least half the grid for the points

1

all points correct

± ½ small square
*allow **1** mark if 8 or 9 of the points are correct*

2

best fit line

1

(c) steeper line to left of original

1

line finishes at same overall volume of gas collected

1

(d) acid particles used up

allow marble / reactant used up

1

so concentration decreases

allow surface area of marble decreases

1

so less frequent collisions / fewer collisions per second

*do **not** accept fewer collisions unqualified*

1

so rate decreases / reaction slows down

1

(e) mass lost of 2.2 (g)

1

time taken of
270 s

allow values in range 265 − 270

1

$\frac{2.2}{270} = 0.00814814$

allow ecf for values given for mass and time

1

0.00815 (g / s)

or

8.15×10^{-3}

*allow **1** mark for correct calculation of value to 3 sig figs*

*accept 0.00815 or 8.15×10^{-3} with no working shown for **4** marks*

1

(f) correct tangent

1

eg 0.35 / 50

1

0.007

allow values in range of 0.0065 − 0.0075

1

7×10^{-3}

1

*accept 7×10^{-3} with no working shown for **4** marks*

[20]

Q13.

(a) sulfur dioxide

accept SO_2

1

(b) (i) curved line of best fit between the 4 non-anomalous points

1

(ii) temperature was lower (than 40 °C)

accept student missed the moment when the cross

disappeared

accept smaller volume of acid or acid more dilute

1

(iii) 0.005 **or** 1/200

*correct answer with or without working gains **2** marks*

*if answer incorrect, allow **1** mark for 0.32 / 64*

2

(iv) The particles move faster.

1

The particles collide with more energy.

1

(v) activation

1

[8]

Q14.

(a) (i) (mass number = 16) because there are 8 protons and 8 neutrons (in the nucleus)

accept mass number is total number of protons and neutrons
*for **1** mark*

2

(ii) same number of protons **or** both have 6 protons

accept same atomic number

1

^{12}C has 6 neutrons

1

^{14}C has 8 neutrons

1

*accept different number of neutrons for **1** mark*

numbers, if given, must be correct

*incorrect reference to electrons = **max 2** marks*

(b) (i) 2 bonding pairs

1

additional unbonded electrons negates this mark

4 unbonded electrons around oxygen

1

accept dot, cross or e or – or any combination

(ii) covalent

1

(iii) any **one** from:

- no delocalised / free electrons
  ignore mobile electrons
- no overall electric charge
  accept no charge (carriers)
- no ions

1

*do **not** accept any implications of the presence of ions*

(c) (i) larger

accept the size of a few hundred atoms

accept atoms are smaller (than nanoparticles)

allow up to 1000 atoms)

1

(ii) (nanoparticles have) large(r) surface area

1

[11]

Q15.

(a) because sulfur / S (forms)

1

(which) is solid / insoluble / a precipitate / a suspension

1

(b) any **two** from:

- volume of sodium thiosulfate
  ignore amount of sodium thiosulfate
- volume of (hydrochloric) acid
  ignore amount of (hydrochloric) acid
- concentration of sodium thiosulfate
- concentration of (hydrochloric) acid

*if no other mark, allow **1** mark for same cross **or** same flask **or** unspecified volume **or** unspecified concentration*

ignore same person

*do **not** accept references to temperature*

2

(c) rate increases

1

because particles move faster

accept particles have more energy

1

so frequency of collisions increases

*accept particles are more likely to collide **or** more chance of collisions*

ignore more collisions

1

more particles / collisions have energy greater than (or equal to) the activation energy

1

(d) cool

*accept refrigerate **or** method to decrease temperature*

or

decrease the temperature (of the solutions)

1

[9]

Q16.

(a) sulfur / sulphur / S / S(s)

1

(b) as the temperature increases, the rate of reaction increases

allow two correct values for rate quoted (from graph) at different temperatures

1

the rate of increase increases **or** there is an exponential relationship

*accept the rate of reaction increases slowly (from 20 °C to 50 °C) then increases more rapidly for **2** marks*

answer MUST be based on rate / speed of reaction

1

(c) (i) any **two** from:

- temperature (of the reactants)
- concentration of hydrochloric acid
- volume of hydrochloric acid
- volume of sodium thiosulfate
- the (size / darkness / thickness of the) cross
- total volume of solution.

*if no other marks gained, allow **1** mark for:*

rate of stirring

OR

amount of hydrochloric acid / sodium thiosulfate

OR

volume of solution

2

(ii) (because as the concentration increases) the number of particles per unit volume increases **or** particles are closer together.

idea of more particles in a given space is required for the first mark.

ignore references to area.

1

(therefore) the frequency of (successful) collisions increases

allow increased chance / probability of collisions

number of collisions increases is insufficient here.

***must** mention per unit time or frequency.*

ignore speed of collisions.

if reference to space and time missing from M1 and M2 but they are otherwise correct, then award 1 mark.

1

so the number of particles (per unit volume) doubles **or** (the frequency of) collisions doubles.

*students can score **2** marks for a qualitative explanation; the third mark is for a quantitative explanation.*

1

[8]

Q17.

(a) (i) 25 °C

1

(ii) (fractional) distillation

1

(b) (i) (fertile) land is used to grow fuel crops **or** crops are grown for fuel **or** farmers get a better price for crops for fuel **or** crops for biofuels take up space

ignore biofuels are made from food or plants

1

less food grown **or** food prices rise **or** less (fertile) land to grow food

1

(ii) (crops / plants) take in carbon dioxide (while growing / during photosynthesis)

1

so the CO_2 given out was previously taken in

*do **not** accept burning biofuels does not release CO_2 or releases less CO_2 unqualified*

*if no other mark awarded, a statement of "carbon neutral" scores **1** mark*

1

(c) Marks awarded for this answer will be determined by the Quality of Communication (QC) as well as the standard of the scientific response. Examiners should also refer to the information in the Marking Guidance and apply a 'best–fit' approach to the marking.

0 marks
No relevant content

Level 1 (1−2 marks)
At least one statement about the effect of a condition on either rate **or** yield.

Level 2 (3−4 marks)
Correct statements about the effect of at least one condition on rate **and** yield.

Level 3 (5−6 marks)
Correct statements about the effect of at least one condition on rate and yield **and** at least one correct statement about compromise conditions.

Examples of the points made in the response

Temperature
- a higher temperature gives a lower yield
- a higher temperature gives a faster rate

Pressure
- a higher pressure gives a higher yield
- increase in yield gets less as pressure increases
- a higher pressure gives a faster rate
- increase in rate increases as pressure increases

Catalyst

- using a catalyst speeds up reaction
- catalysts allow a lower temperature to be used and so save energy / reduce energy costs

Compromise

- a higher pressure gives a greater yield but increases costs / (safety) risks
- a high pressure gives a faster rate but increases costs / risks
- a high temperature makes reaction faster but reduces yield
- a catalyst makes reaction faster so a lower temperature can be used which will increase the yield

6

[12]

Q18.

(a) (i) the higher the temperature, the greater the rate

or

at 40 °C rate is faster than at 20 °C

accept the higher the temperature, the faster the reaction

1

(ii) 40 °C curve is steeper

accept the 40 °C line becomes horizontal sooner

accept at higher temperatures the reaction finishes sooner

accept reaction finishes sooner at 40 °C

accept at higher temperatures the gas is produced faster

or

correct comparison of data from the graph

1

(iii) 2

1

(b) (i) Concentration of acid
Mass of marble chips

2

(ii) increases rate

*incorrect reference to energy = max **1***

1

(because of) more frequent collisions (between particles)

accept particles are more likely to collide

ignore more collisions

ignore more successful collisions

1

(c) any **one** from:

- increases rate of reaction
- reduces energy required

- lower temperature can be used
- catalyst is not used up.

1

[8]

Q19.

(a) (i) nothing can enter **and** nothing can leave the reaction

allow sealed reaction vessel

1

(ii) forward and backward reactions have same rate

1

so there is no (overall) change in quantities of reactants and products

allow concentrations of reactants and products

1

(b) (i) natural gas

allow methane / CH_4

allow fossil fuels / hydrocarbons

allow water

1

(ii) provides an alternative reaction pathway

1

which has a lower activation energy

ignore references to collisions

1

(iii) the amount (of ammonia) increases

allow yield increases

1

the equilibrium moves to the side (of the equation) with fewer (gaseous) molecules / moles

allow it favours the forward reaction

1

(c) (i) vertical arrow from reactants to maximum

1

(ii) (energy of) products higher than (energy of) reactants

allow converse

1

(iii) amount of hydrogen iodide decreases

1

equilibrium moves in the direction of the endothermic reaction

allow it favours the forward reaction

1

[12]

Q20.

(a) (i) covalent

1

(ii) increases the rate of reaction

1

(b) (i) the reaction is reversible

1

(ii) at lower pressure the molecules will be further apart

1

so there will be fewer collisions <u>per unit time</u>

accept frequency of collisions lower

1

(iii) as the temperature increases, the yield of the reaction increases

1

(iv) 2 molecules / volumes become 4 **or** more molecules / volumes **of** product than reactant

1

(c) Marks awarded for this answer will be determined by the Quality of Communication (QoC) as well as the standard of the scientific response. Examiners should also refer to the information on page 5, and apply a 'best-fit' approach to the marking.

0 marks
No relevant content

Level 1 (1 – 2 marks)
Candidate has written about some basic points from the table but has not added any extra knowledge. Candidate may have included advantages **or** disadvantages.

Level 2 (3 – 4 marks)
Candidate has attempted an evaluation using points from the table and their own knowledge. Candidate has included advantages **and** disadvantages.

Level 3 (5 – 6 marks)
Candidate has given an evaluation that includes both advantages and disadvantages. Candidate has clearly linked points from the table with their own knowledge and uses appropriate scientific terminology.

examples of the points made in the response

Advantages of using hydrogen:

- its combustion only produces water
- combustion of hydrogen does not produce carbon dioxide **or** does not contribute to climate change
- petrol requires much more oxygen to burn so partial combustion is possible producing carbon monoxide
- combustion of hydrogen does not produce any particulates **or** does not contribute to global dimming

- petrol comes from a non-renewable source **or** there are renewable ways of producing hydrogen, eg electrolysis of water.

Disadvantages of using hydrogen:

- hydrogen has to be stored at high pressure **or** risk of explosion or larger volume needed for storage.
- much less energy produced from the combustion of hydrogen **or** need to refuel more often
- most methods of producing hydrogen need fossil fuels.

6

[13]

Q21.

(a) any **two** from:

- temperature (of the HCl)
- mass or length of the magnesium
- surface area of the magnesium
- volume of HCl

2

(b) (i) (a greater concentration has) more particles per unit volume

allow particles are closer together

1

therefore more collisions per unit time **or** more frequent collisions.

1

(ii) particles move faster

allow particles have more (kinetic) energy

1

therefore more collisions per unit time **or** more frequent collisions

1

collisions more energetic (therefore more collisions have energy greater than the activation energy) **or** more productive collisions

1

(c) (i) add (a few drops) of indicator to the acid in the conical flask

allow any named indicator

1

add NaOH (from the burette) until the indicator changes colour **or** add the NaOH dropwise

candidate does not have to state a colour change but penalise an incorrect colour change.

1

repeat the titration

1

calculate the **average** volume of NaOH **or** repeat until concordant results are obtained

1

(ii) **moles of NaOH**

0.10 × 0.0272 = 0.00272 moles

*correct answer with or without working gains **3** marks*

1

Concentration of HCl

0.00272 / 0.005 = 0.544

allow ecf from mp1 to mp2

1

correct number of significant figures

1

[14]

Q22.

(a) left hand: (conical) flask

*do **not** accept round bottomed flask or container which is not a flask*

1

right hand: beaker / trough

accept plastic box

1

(b) (i) 157

1

(ii) all calcium carbonate used up **or** reaction stopped

*do **not** accept all acid used up*

1

(c) (i) 0.007(272727…)

*correct answer with or without working gains **2** marks*

*if answer incorrect, allow (0.32 / 44) for **1** mark*

2

(ii) 0.007(272727…)

*allow ecf from **(c)(i)***

1

(iii) (M_r = mass / moles = 1 / 0.00727…) = 137.5 or 138

*allow ecf from **(c)(ii)***

if use 0.00943 moles then = 106

if use 0.007 allow 143 (142.857)

1

(iv) (138) – 60 (= 78)

23 / 85

1

(78 / 2) = 39

1

potassium

sodium / rubidium

*identity of metal ecf on A_r, but **must** be Group 1*

*If no working max **1** mark*

1

(d) (i) (relative atomic mass) would decrease

1

because the mass lost greater

1

so moles carbon dioxide larger **or** moles metal carbonate greater

1

(ii) no change

1

because the acid (already) in excess

1

so the amount carbon dioxide lost is the same

1

[17]

Q23.

(a) (i) precipitation

1

(ii) (aq) on left hand side

1

(s) on right hand side

1

(iii) potassium iodide

1

potassium nitrate

1

(iv) filtration

1

(b) (i) diffusion

1

(ii) iodide ions move / diffuse faster than lead ions **or** travel further in the same time

Must be a comparison

Accept converse

1

because the lead iodide forms much closer to the lead nitrate (or **X**) than the potassium iodide (or **Y**).

allow because iodide ions are smaller than lead ions

allow references to potassium iodide and lead nitrate

1

(iii) the particles / ions move / diffuse faster

ignore which particles / ions the student refers to

1

because they have more energy **or** will collide / meet sooner

ignore reference to frequency of collisions

1

[11]

Q24.

(a) the forward and backward reactions occur

allow reversible

1

at (exactly) the same rate

1

in a closed system

allow therefore the concentrations / amounts of the reactants and products remain the same

1

(b) (i) increasing the temperature would lower the yield of ethanol **or** the (position of) equilibrium moves to the left

*if student has stated that increasing the temperature increases the yield then award **0** marks*

1

since the backwards reaction is endothermic **or** the forward reaction is exothermic

1

(ii) increasing the pressure would increase the yield of ethanol **or** the (position of) equilibrium moves to the right

*if student has stated that increasing the pressure decreases the yield then award **0** marks*

1

because the position (of equilibrium) moves in the direction of the lower number of moles (of gas)

2 (moles / molecules / volumes / particles) on lhs / 1 (mole / molecule / volume / particle) on rhs

1

(c) (a catalyst) provides an alternative pathway

1

with lower activation energy

or

(a catalyst) lowers the activation energy (1)

so less energy is needed to react **or** more particles react (1)

1

[9]

Q25.

(a) (i) brown

1

(ii) oxygen + iron + water ⟶ hydrated iron oxide / rust

allow correct symbol equation

ignore oxidation numbers for product

1

(b) (i) 32.3

1

(ii) 7.6

ecf from (b)(i)

1

(iii) do not know start volume of air

1

because the burette not graduated to the end

allow iron wool takes up some of the space

*if no other marks awarded accept all iron may have rusted (**1**) **or** still some oxygen left / not all used up (**1**)*

1

(c) (i) gains oxygen and water **or** oxygen and water are added

allow reacts with or gains oxygen

allow reacts with or gains water

allow reacts with or gains elements which add to mass

ignore iron oxide forms

1

(ii) as temperature increases (from 10 °C to 42 °C or to 50 °C) the increase in mass of nail increases

accept positive correlation

accept mass increases

1

rate of increase gets faster as temperature goes up

accept exponential

ignore non linear

1

no further increase at temperatures over 42 °C

accept no further increase at high temperatures

*exponential increase scores **2** marks*

1

(iii) use a (bigger) flask **or** let air into the tube **or** leave for less time **or**

ignore more water

1

to make sure sufficient oxygen / air **or** not all oxygen used up

accept converse

*if no other marks awarded allow change in surface area for rusting **or** change in number of nails for **1** mark*

1

[12]

Q26.

(a) (i) oxygen, sulfur trioxide

both needed for mark

1

(ii) compound

1

(b) increases

accept (goes) higher / (goes) up / (is) faster) / (are) more frequent

1

(c) activation

1

(d) catalyst **or** increase temperature

1

[5]

Q27.

(a) O_2 in correct space

1

correct balancing

accept multiples

1

(b) (i) rate increases

*incorrect reference to energy = max **2***

ignore references to equilibrium

1

because particles are closer together

accept because there are more particles (per unit volume)

allow particles have less space / room to move around

1

so frequency of collisions increases

accept particles are more likely to collide

ignore more collisions

ignore more successful collisions

1

(ii) has a greater surface area

1

so the reaction is faster

accept so more frequent collisions

1

(c) the (minimum) amount of energy (particles must have) to react ***or*** *to start a reaction*

accept the energy needed to break bonds

ignore references to heat

1

(d) (i) (potassium is) too / *very* reactive

ignore potassium is a Group 1 / alkali metal

1

so dangerous / *violent reaction*

accept hydrogen produced rapidly

1

(ii) $ZnSO_4$

accept products in either order

ignore names of substances

1

H_2

*do **not** accept brackets or charges in the formulae*

1

(iii) any **one** from:

- increase concentration (of sulfuric acid)
- increase temperature **or** heat it
- increase surface area of zinc

1

[13]

Q28.

(a) time from when the heating is started until

1

the limewater turns cloudy / milky

1

(b) (i) the temperature was not high enough

accept the copper carbonate had not started to decompose / react

accept it takes time to heat up the copper carbonate

1

the bubbles of gas were air

accept no carbon dioxide produced

1

(ii) the copper carbonate was decomposing / reacting

accept the temperature was high enough to cause decomposition / a reaction

1

so carbon dioxide was produced

allow correct word / symbol equation

1

(iii) copper oxide was produced

allow correct word / symbol equation

1

because the copper carbonate had <u>completely</u> decomposed / reacted

ignore all of the carbon dioxide had been given off

1

[8]

Q29.

(a) would melt

accept they have a low melting point
allow lose their shape
ignore would soften when hot
ignore boiling point

1

(b) to speed up the reaction

accept can use a lower temperature
accept less energy needed

1

(c) (i) mass spectrometer

allow mass spectroscopy

1

(ii) any **one** from:

ignore reliable
ignore more precise

- accurate
- sensitive
- rapid / quicker
- small amount of sample

1

(d) any **two** from:

allow concentration

- pressure

- temperature
- catalyst **or** initiator
- solvent

2

[6]

Q30.

(a) because sulfur / S forms

1

which is insoluble / a solid / a precipitate

1

(b) (i) 32

*correct answer with or without working gains **2** marks*
*accept evidence of 31 + 33 / 2 for **1** mark*
*allow 35 for **1** mark*

2

(ii) reaction rate increases

*if incorrect reference to energy = max **2***

1

because of more particles (per unit volume)

allow because particles are closer together

1

and because there is an increase in frequency of collisions

*accept because particles are more likely to collide **or** higher chance of collision*
ignore more (successful) collisions

1

[7]

Q31.

(a) heat / energy

1

given out / transfers to surroundings

the mark for given out / transfers to cannot be awarded without heat / energy
allow given off

1

(b) (i) decreases

1

increases

1

(ii) it gives the particles more energy

1

it makes the particles move faster

1

[6]

Q32.

(a) (i) a continuous <u>straight line</u> missing anomalous point

allow a line which does not start at zero / origin

1

(ii) any **two** sensible errors eg

*ignore systematic / zero error / weighing error **or** error unqualified*

- timing errors and / or example
- measurement errors and / or example
- apparatus errors and / or example
- human / experimental / reading / random error and / or example or 'did not do it right'

  *could be two from **same** category*
  eg two timing errors – watch not started at the same time plus difficulty in deciding when the cross has disappeared.
- temperature fluctuation
- anomalous point

  accept outlier / wrong result
- results not recorded correctly
- plotting error
- rate calculated incorrectly

  ignore 'not repeated'

2

(b) (i) <u>straight line</u>

*allow as concentration increases the rate goes up **or** converse*

allow numerical example

allow positive correlation

allow same gradient

ignore 'most points near / on line of best fit'

1

(ii) because of an increase in <u>frequency</u> of collisions

*max **1** if incorrect reference to energy **or** if subatomic particle specified*

accept because particles are more likely to collide or higher chance of collision

ignore more (successful) collisions

1

because there are more particles (per unit volume)

allow because particles are closer together

1

[6]

Q33.

(a) (i) In suntan creams

1

(ii) Much smaller

1

(b) (i) have a high surface area to volume ratio

1

(ii) because a catalyst provides an alternative / different pathway / mechanism / reaction route

accept adsorption or 'increases concentration <u>at the surface</u>'
ignore absorption

1

(that has) <u>lower</u> <u>activation energy</u>

allow weakens bonds

allow idea of increased successful collisions

*max **1** mark for incorrect chemistry eg increased energy of particles*

1

[5]

Q34.

(a) three bonding pairs

*do **not** allow non-bonding electrons in hydrogen*

ignore any inner shells on nitrogen

1

two non-bonding electrons

allow either dots and crosses or combination of both

1

(b) (i) nitric

1

(ii) fertilisers / explosives

ignore other uses

1

(iii) 80

*correct answer with or without working gains **2** marks*

*if answer incorrect, allow 14 + (1 × 4) + 14 + (16 × 3) for **1** mark*

2

(iv) 35

*allow ecf from **(b)(iii)***
*allow ecf for **1** mark for correct working but incorrect answer.*
*if answer incorrect, allow 28 / 80 × 100 for **1** mark*
*if answer is 17.5 % allow **1** mark*

2

(c) Marks awarded for this answer will be determined by the Quality of Communication (QoC) as well as the standard of the scientific response. Examiners should also refer to the information on page 5, and apply a 'best−fit' approach to the marking.

0 marks
No relevant content

Level 1 (1 − 2 marks)
There are statements about the conditions used. There is no correct explanation of the link between rate or yield and the conditions.

Level 2 (3 − 4 marks)
There is a correct explanation of the conditions used that links the conditions to rate **or** yield

Level 3 (5 − 6 marks)
There is an explanation covering at least temperature and pressure, which shows understanding of the compromise between rate **and** yield

examples of chemistry points made in the response:

200 atmospheres pressure
- high pressure gives a high yield of ammonia
- too high a pressure causes risk of explosion
- high pressure costly to maintain
- a high pressure will cause the rate to be higher
- 4 moles of gas become 2 (or fewer moles of gas in products)

450 °C
- high temperature increases the rate of reaction
- optimum temperature
- (forward reaction is exothermic so) a high yield of ammonia requires a low temperature
- but too low a temperature causes the rate of reaction to be too slow

iron catalyst
- a catalyst speeds up the reaction
- an iron catalyst allows a lower temperature to be used (saving energy and causing a higher yield)
- iron catalyst increases the rate of reaction equally in both reactions

others
- compromise conditions
- unreacted nitrogen and hydrogen is recycled

6

[14]

Q35.

(a) (s) (aq) (aq) (g)

must be in this order
2 *marks if all four correct*
1 *mark if 2 or 3 correct*

2

(b) (i) 55

ignore units

1

(ii) 54

allow ecf from ***(b)(i)***

1

(iii) 0.92

correct answer with or without working gains ***2*** *marks*
ecf from volume in ***(b)(i)***
accept 2 d.p. up to calculator value
if answer incorrect, allow rate = (b)(i) / 60 for ***1*** *mark*

2

(c) (i) circle round point at (48,22)

1

(ii) problem (1) and explanation (1)

explanation ***must*** *give lower volume of gas or slower reaction*
ignore human error unless qualified

problem with bung

e.g. bung not placed in firmly / quickly enough

so gas lost

or

problem with reagent

e.g. acid was diluted **or** acid not replaced

so reaction slower

or

problem with temperature

e.g. temperature was lower than recorded temperature

so reaction slower

or

problem with measurement

e.g. length of magnesium less than 8 cm **or** timed for less than a minute

so less gas produced

2

(d) repeat the experiment (several times)

1

because anomalous results could be excluded

1

and then the mean can be determined / calculated

*accept suggestion of alteration to method, which is explained as to why it would reduce the error, for **3** marks (e.g. place the magnesium in a container within the flask (1) so it can be tipped into the acid once the bung is in place (1). This will prevent anomalous results or gas loss (1))*

ignore idea of more accurate gas syringe
ignore shorter time intervals

1

(e) (i) use clean magnesium **or** use magnesium without oxide coating

1

compare results

1

(ii) **either**

measure the temperature of the acid before (adding magnesium)

1

and after adding magnesium

or

place the conical flask in a water bath (at 40 °C) (1)

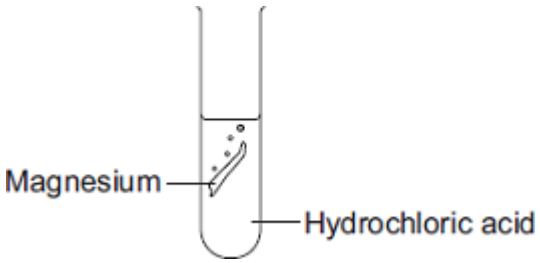
compare results (1)

1

[16]

Q1.

A student investigated the reaction between magnesium and hydrochloric acid.



The equation for the reaction is:

Mg(s) magnesium	+	2 HCl(aq) hydrochloric acid	⟶	$MgCl_2$(aq) magnesium chloride	+	H_2(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.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(6)

(Total 8 marks)

Q2.

(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**

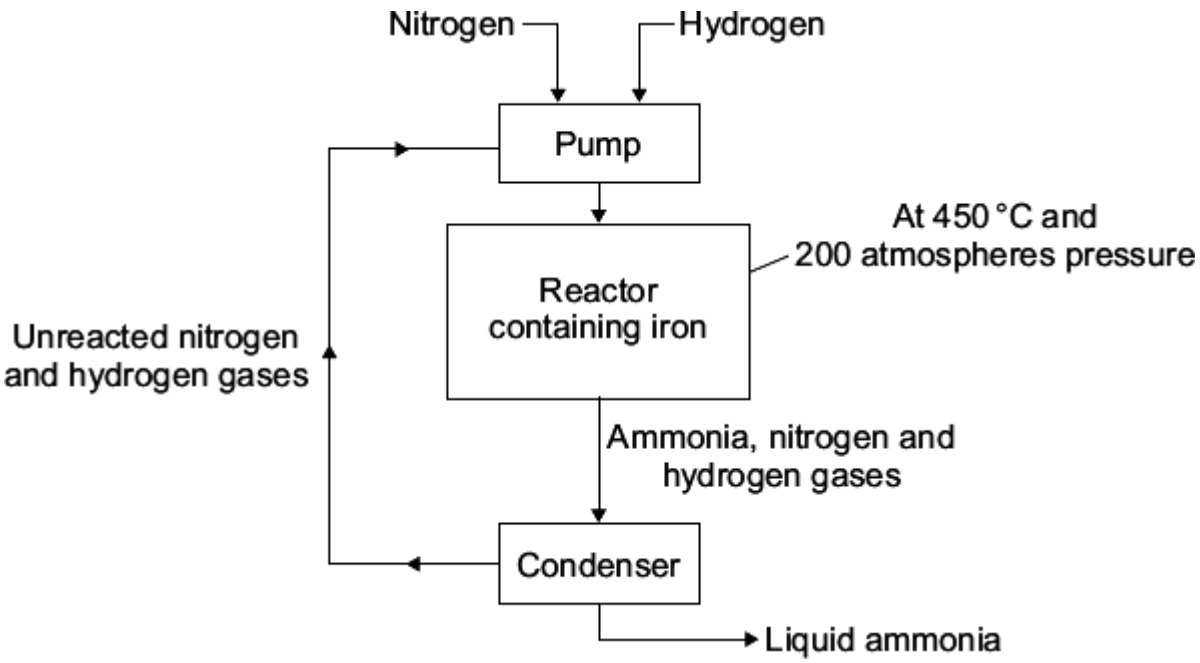
(1)

(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)

Q3.

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

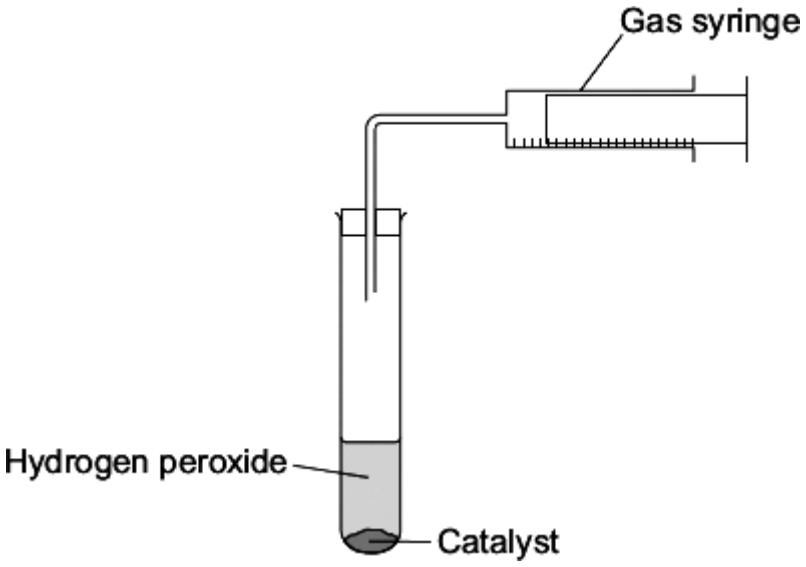
$$2H_2O_2 \rightarrow 2H_2O + O_2$$

Complete the word equation for the decomposition of hydrogen peroxide.

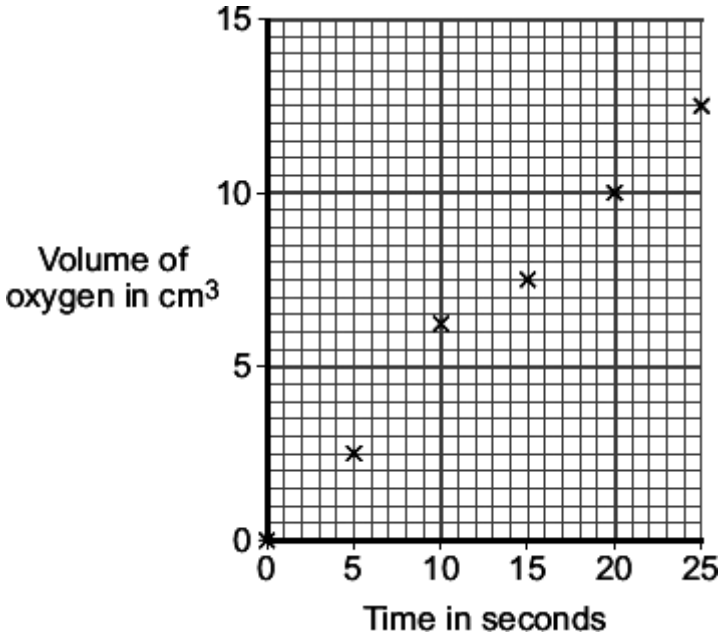
Hydrogen peroxide → _____ + _____

(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)

Q4.

The symbol equation for the decomposition of hydrogen peroxide is:

$2H_2O_2 \rightarrow 2H_2O + O_2$

(a) This reaction is *exothermic*.

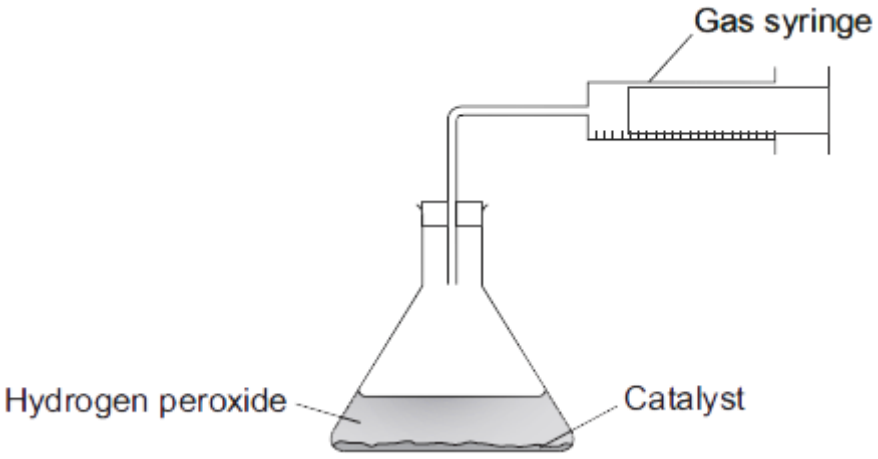
What is an *exothermic* reaction?

_____

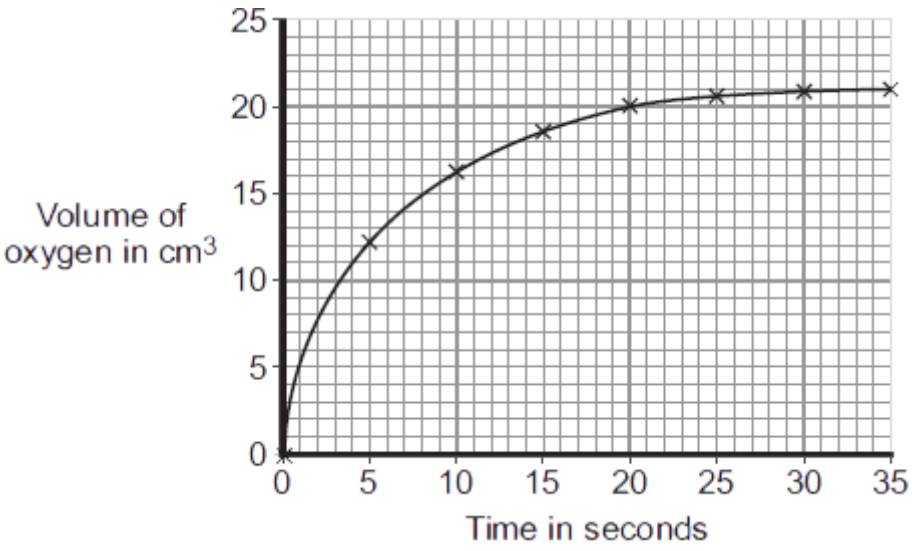
_____

(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)

Q5.

This question is about gold (Au).

(a) An atom of gold is represented as:

$$^{197}Au$$

79

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.

_____

_____

_____

_____

_____

_____

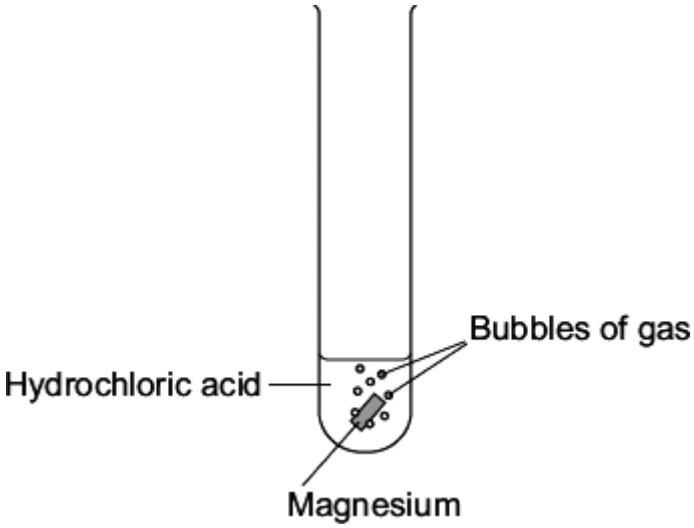
(3)

(Total 11 marks)

Q6.

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)

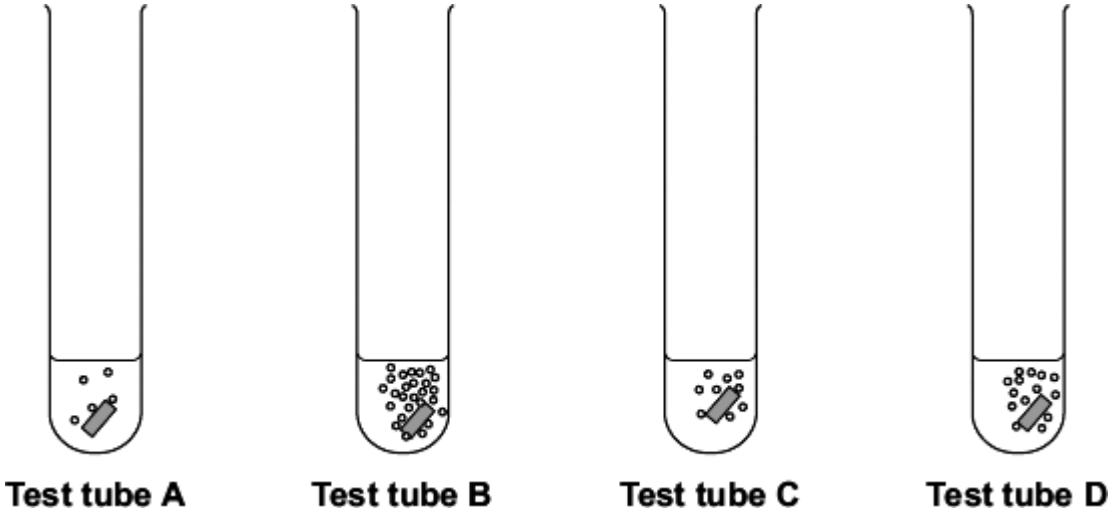
(ii) How would these measurements show that the reaction is exothermic?

_____

(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.

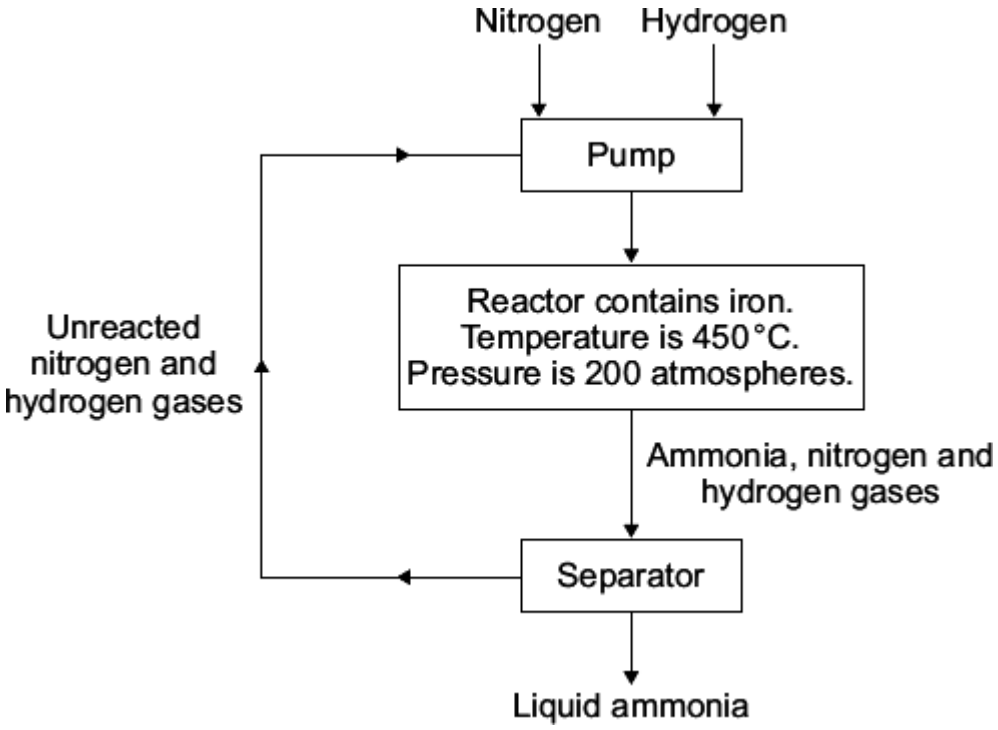
Statement	Tick (✓)
The particles move faster	
The particles collide with less energy	
The particles collide more often	
The particles are bigger	

(2)

(Total 8 marks)

Q7.

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.

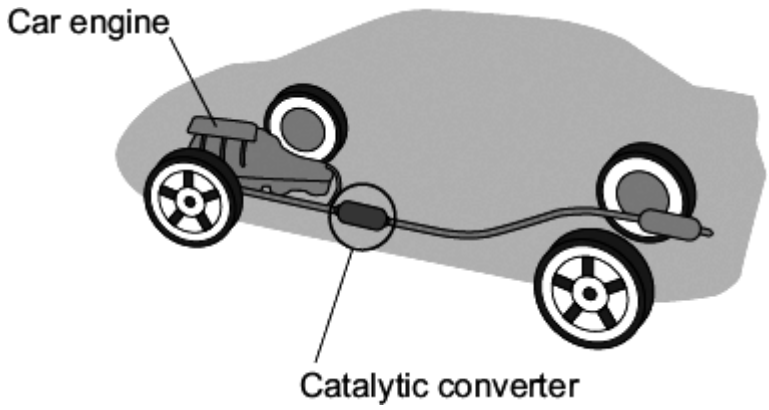
(2)

(Total 14 marks)

Q8.

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)

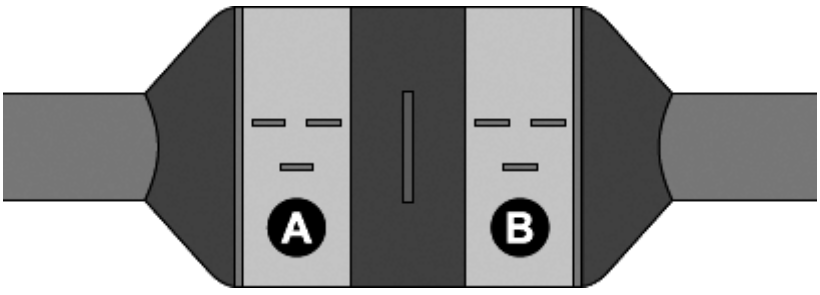
(ii) This is because during

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)

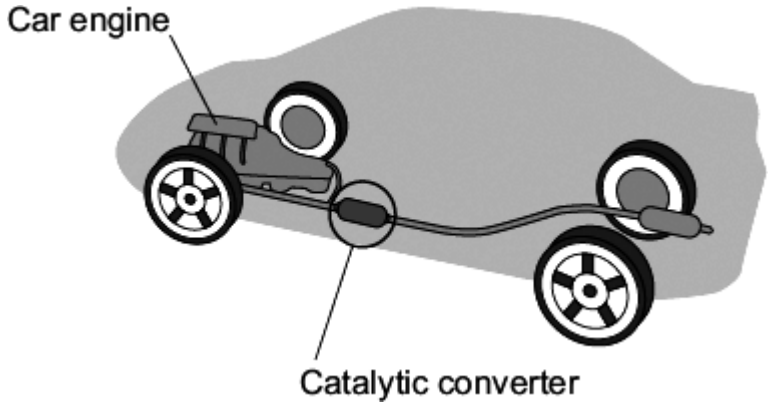
Q9.

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.



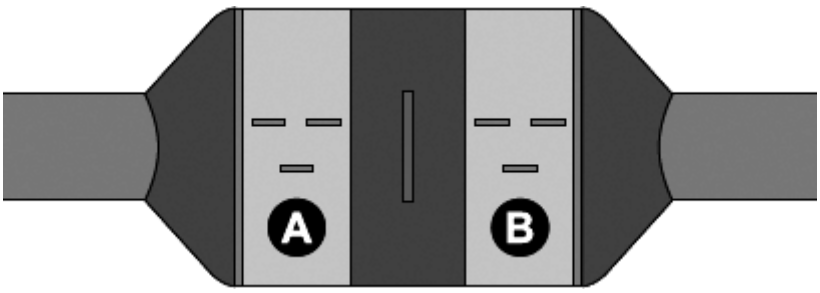
(a) The reaction is *exothermic*. What is the meaning of *exothermic*?

_____

_____

(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.

$$\_\_\_\_ CO + O_2 \rightarrow \_\_\_\_ CO_2$$

(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.

_____

_____

_____

_____

_____

_____

_____

(3)
(Total 9 marks)

Q10.

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)

Q11.

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)

Q12.

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.

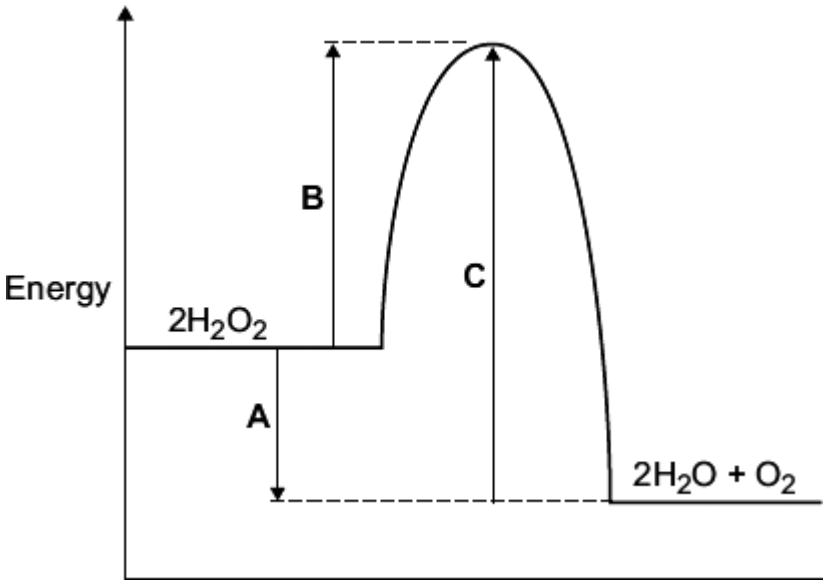
Draw a ring around the correct answer to complete the sentence.

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.

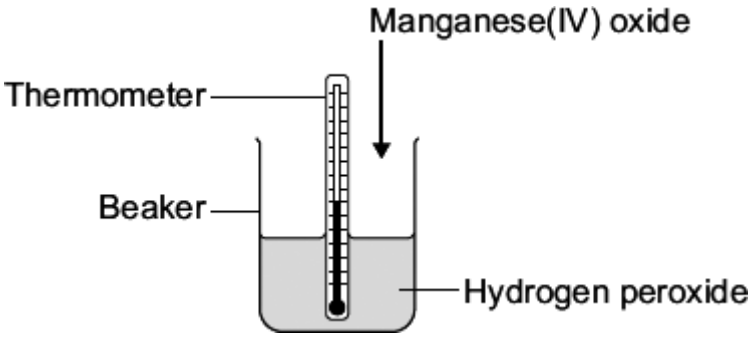
The manganese(IV) oxide has lowered the

- 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)

Q13.

Hydrogen peroxide decomposes to give water and oxygen.

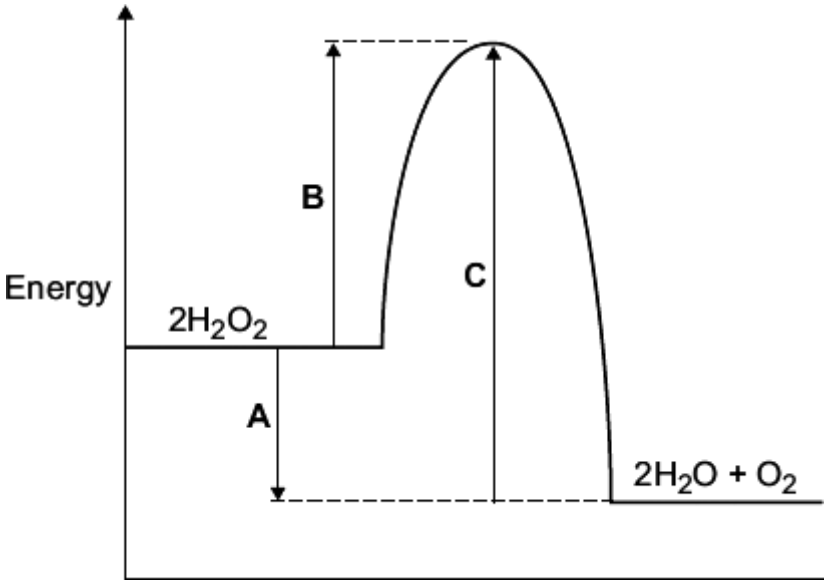
$$2H_2O_2 \rightarrow 2H_2O + O_2$$

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.

_____

_____

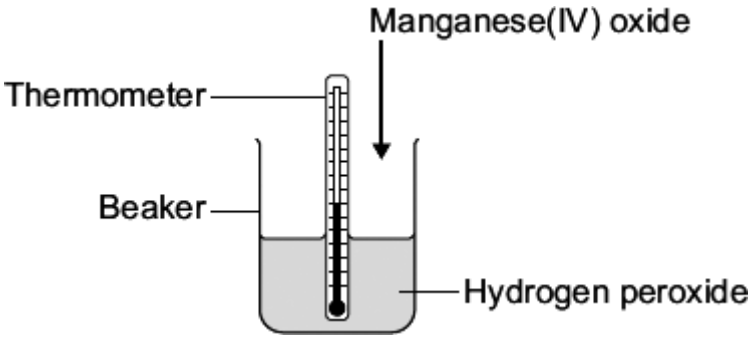
_____

_____

(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)

Q14.

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**:

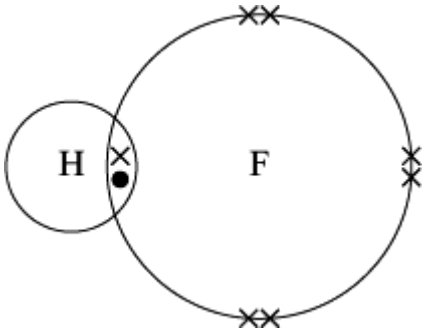
the temperature should be [higher / lower] so that the particles have [less / more] energy

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)

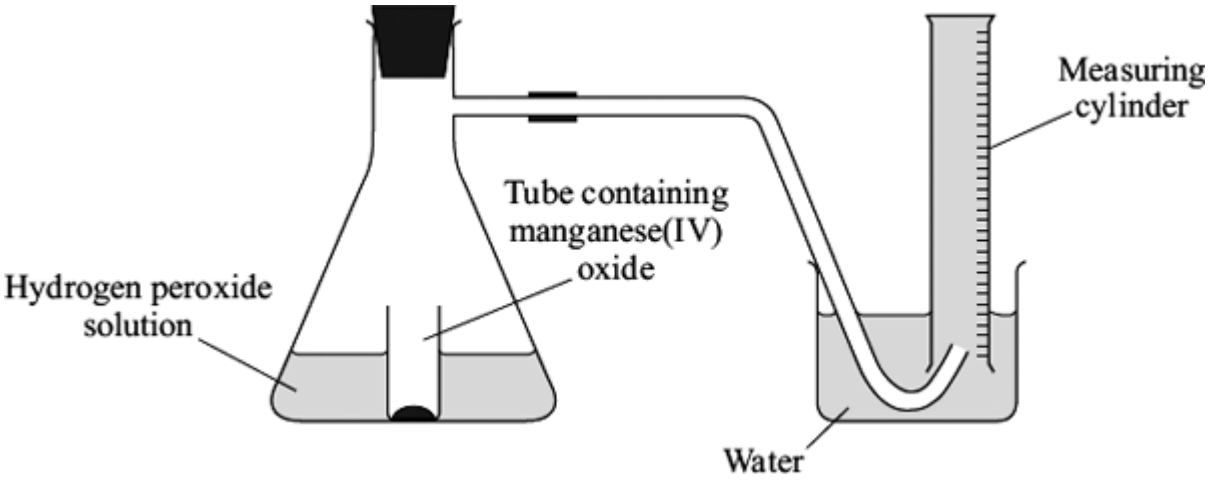
(Total 6 marks)

Q15.

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.

_____

_____

_____

_____

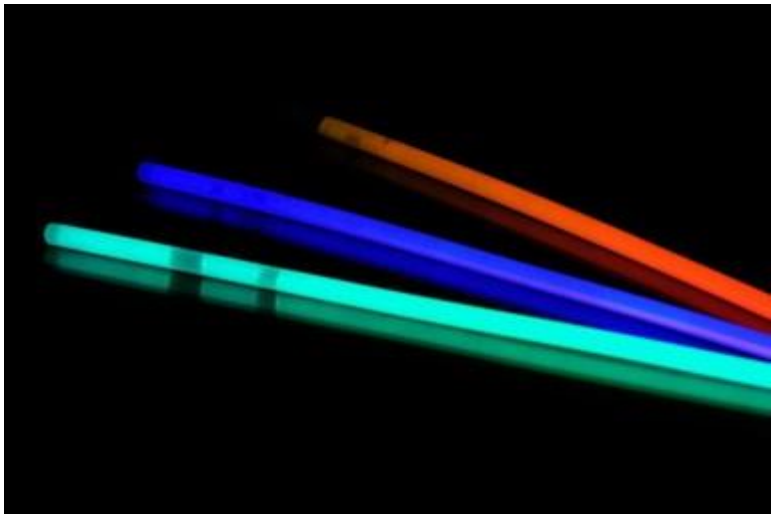
_____

(2)

(Total 5 marks)

Q16.

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)

Q17.

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)

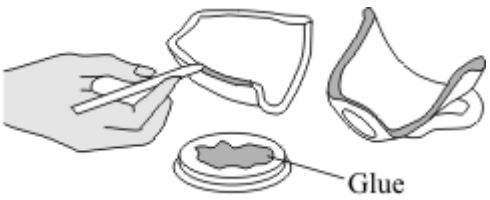
(Total 7 marks)

Q18.

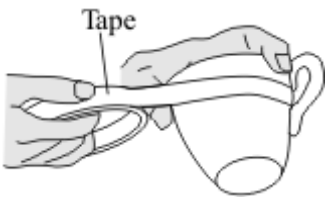
The following steps show how to use a type of glue.

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)

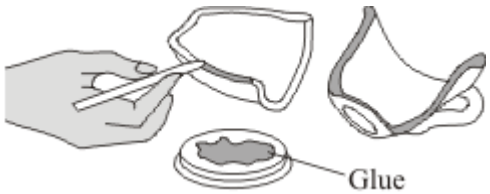
(Total 6 marks)

Q19.

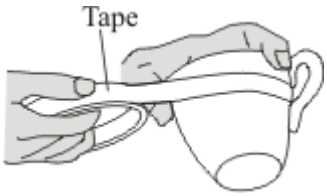
The following steps show how to use a type of glue.

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)

Q20.

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.

_____

_____

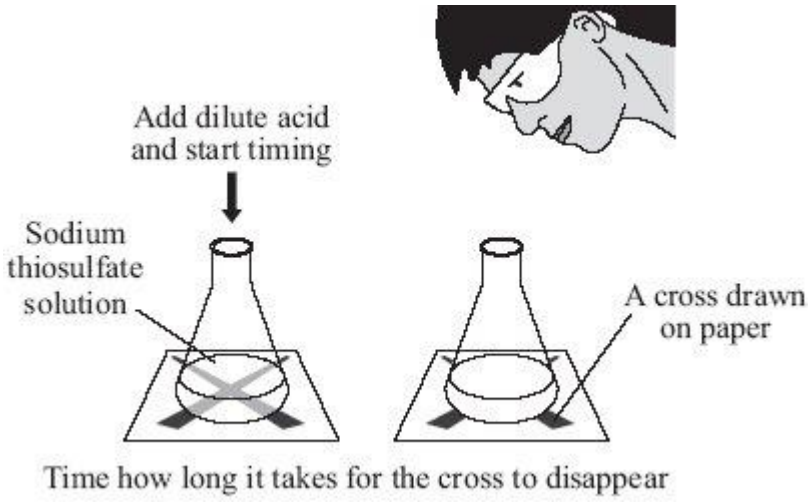
(1)

(Total 6 marks)

Q21.

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

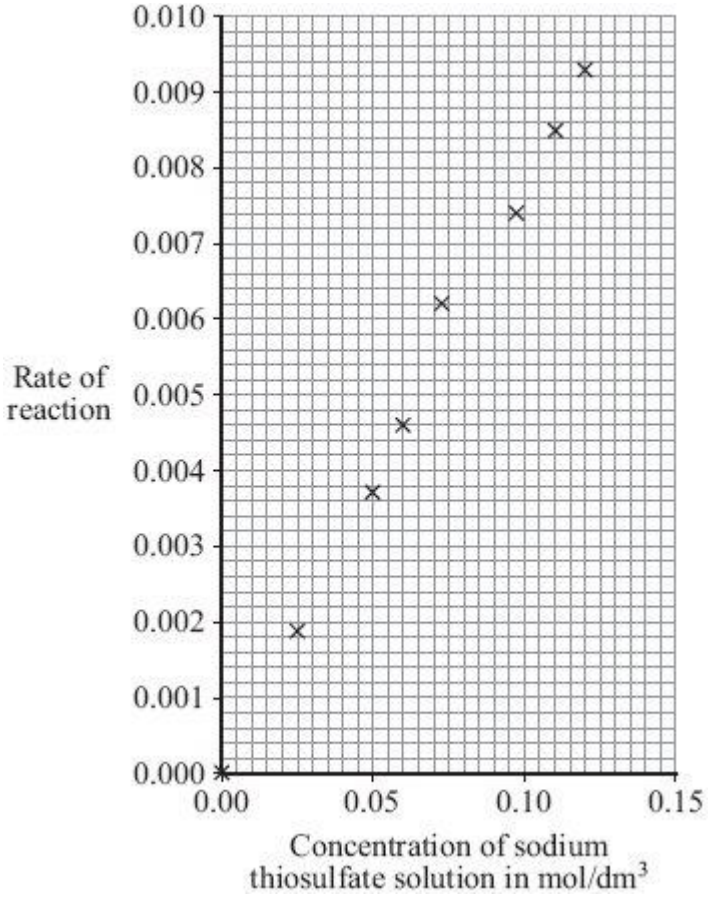
The diagram shows a method of measuring the rate of this reaction.



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

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

The results 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.

1. _____

_____

2. _____

_____

(2)

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

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

How does the graph support this conclusion?

_____

_____

(1)

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

(2)

(Total 6 marks)

Q22.

An airship caught fire when it was coming in to land in 1937. The airship was filled with hydrogen. A spark or flame ignited the hydrogen. The hydrogen reacted with oxygen in the air to produce water.

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

$$2\ H – H + O = O \rightarrow 2\ H – O – H$$

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

Bond	Bond energy in kJ per mole
H – H	436
O = O	498
O – H	464

Energy change = _____ kJ

(3)

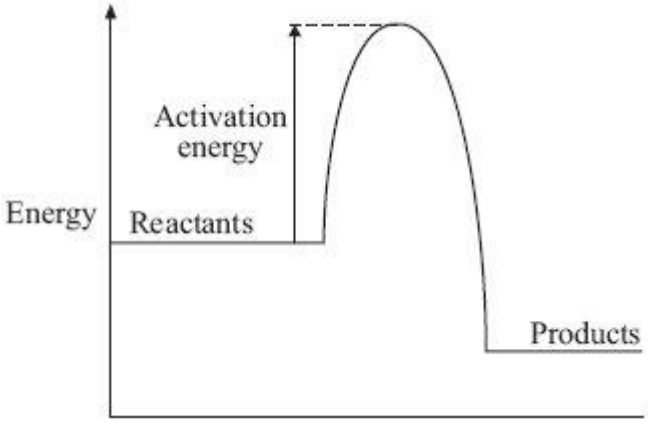
(b) Explain, in terms of making and breaking bonds, why this reaction is exothermic.

_____

_____

(1)

(c) Use the energy level diagram for this reaction to help you to answer these questions.



(i) The hydrogen did **not** burn until ignited by a spark or flame.

Explain why.

_____

_____

(1)

(ii) Platinum, a transition metal, causes hydrogen to ignite **without** using a spark or flame.

Explain why.

_____

_____

_____

_____

(2)

(Total 7 marks)

Q23.

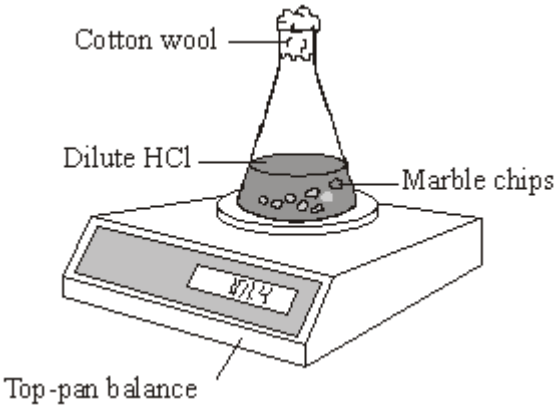
A student investigated the rate of reaction between marble and hydrochloric acid.

The student used an excess of marble.

The reaction can be represented by this equation.

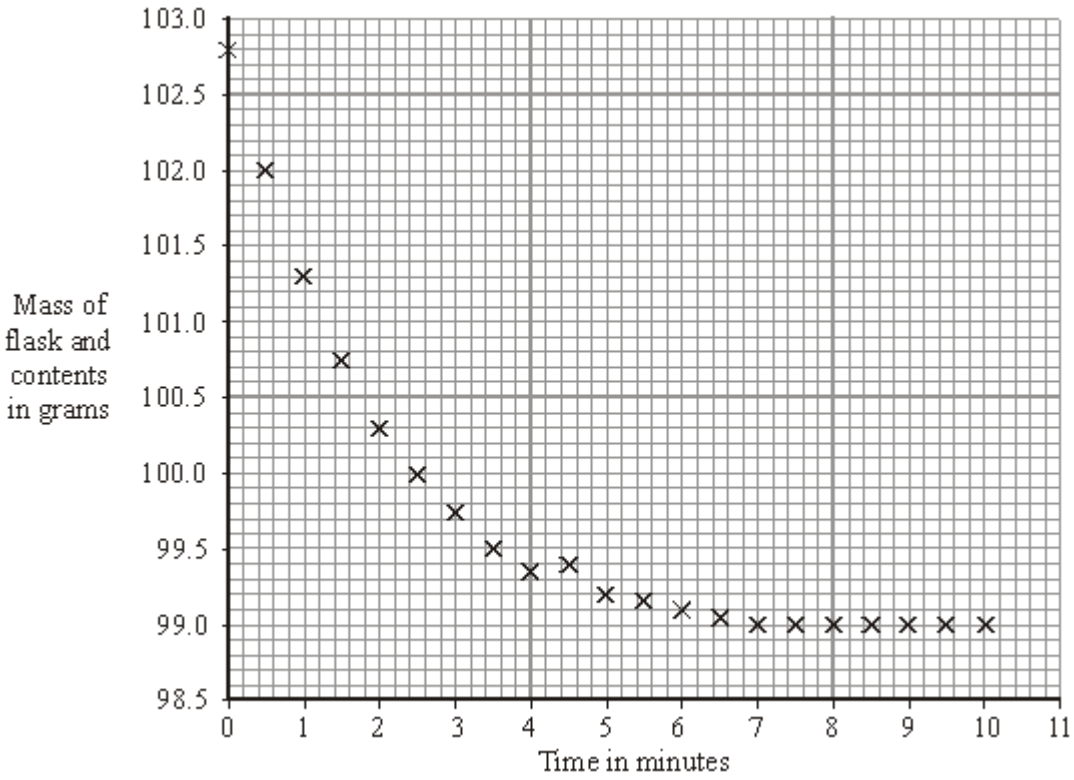
$CaCO_3$ (s) + 2HC1 (aq) → $CaC1_2$ (aq) + H_2O (l) + CO_2 (g)

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.



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

(1)

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

_____

_____

(1)

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

_____ minutes

(1)

(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** to show what the results for this second experiment might look like.

(2)

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

_____

_____

_____

_____

_____

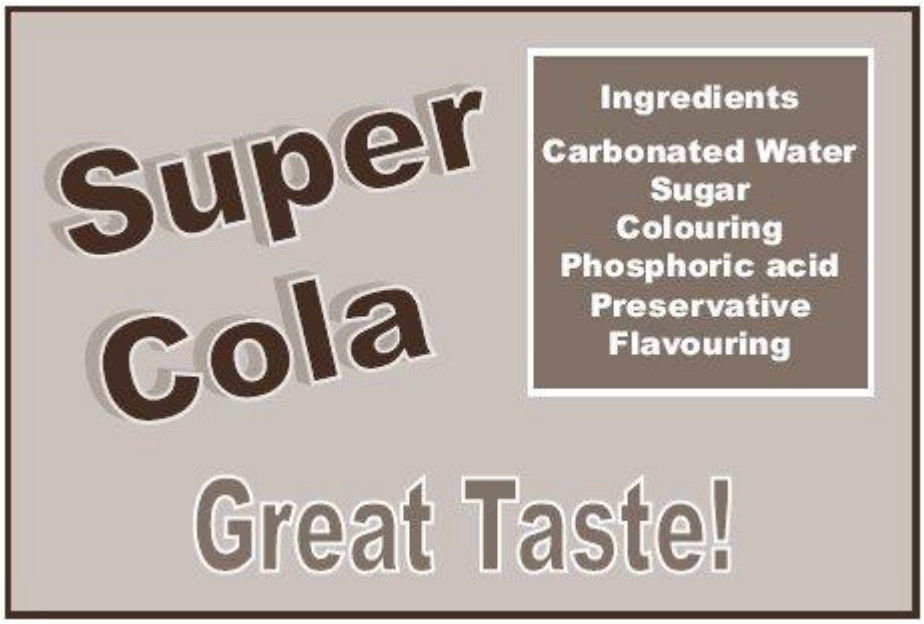
_____

(3)

(Total 8 marks)

Q24.

This label was taken from a cola drink.



The pH of this drink is 2.5.

(a) (i) Which **one** of the ingredients in the cola drink causes the low pH?

_____

(1)

(ii) Draw a ring around the name of the ion that gives the cola drink its low pH.

chloride **hydrogen** **hydroxide** **sodium**

(1)

(b) The preservative used in the cola drink is sodium benzoate.
Sodium benzoate is made using two chemical reactions.

Reaction 1
Methylbenzene is reacted with oxygen, with the help of a catalyst, to form benzoic acid.

Reaction 2
Benzoic acid is neutralised by sodium hydroxide solution to form sodium benzoate and water.

(i) How does the catalyst help **reaction 1**?

_____

_____

(1)

(ii) **Reaction 1** has a high atom economy.

The table lists several statements. Put a tick (✓) next to the **one** statement which best describes a high atom economy.

Statement	(✓)
All the atoms used are cheap.	
Most of the starting materials end up as useful products.	
Only a small number of atoms are used in the reaction.	

(1)

(iii) **Reaction 2** is a neutralisation reaction.

Complete the equation by writing the formula of the product.

$H^+ + OH^- \rightarrow$ _____

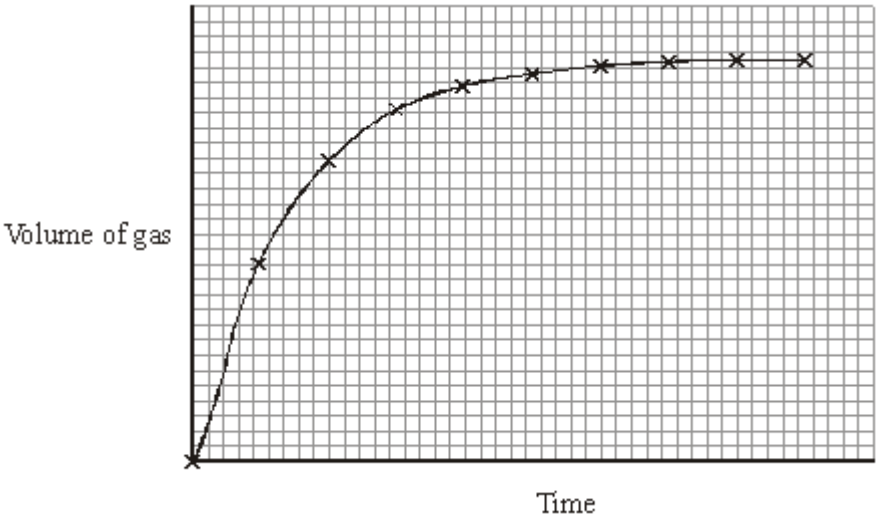
(1)

(Total 5 marks)

Q25.

Pieces of zinc react with dilute acid to form hydrogen gas.

The graph shows how the volume of hydrogen gas produced changes with time.



(a) Describe, as fully as you can, how the volume of gas produced changes with time.

_____

_____

_____

_____

(2)

(b) A student wants to make the reaction take place faster.

Some suggestions are given in the table.

Put ticks (✓) next to the **two** suggestions that would make the reaction take place faster.

Suggestions	(✓)
Use bigger pieces of zinc.	
Use a more concentrated acid.	
Use zinc powder.	
Decrease the temperature of the acid.	

(2)

(Total 4 marks)

Q26.

Copper sulfate ($CuSO_4$) is a salt that has many uses.

An aqueous solution of copper sulfate can be made by reacting copper oxide (CuO) with an acid.

(a) (i) Name this acid. _____

(1)

(ii) Write a balanced symbol equation, including state symbols, for this reaction.

_____

(2)

(b) Copper oxide reacts much faster with acid at 40 °C than at 20 °C.

Explain why in terms of particles.

_____

_____

_____

_____

(2)

(Total 5 marks)

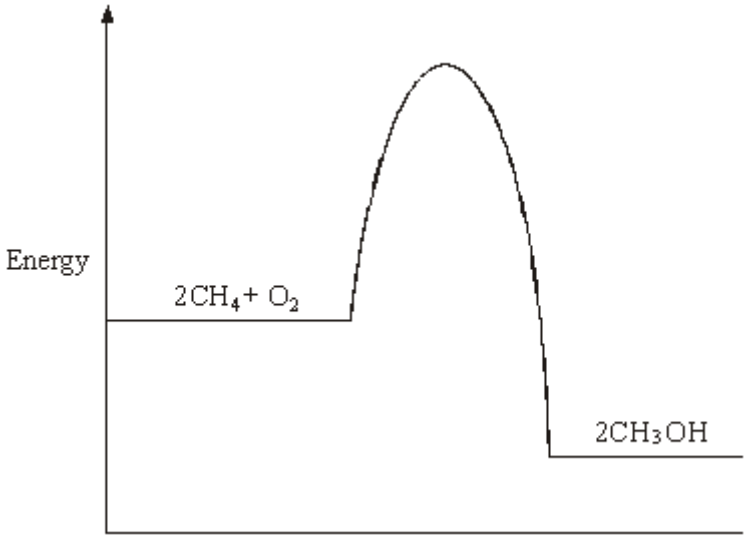
Q27.

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:

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

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



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

_____

_____

_____

(1)

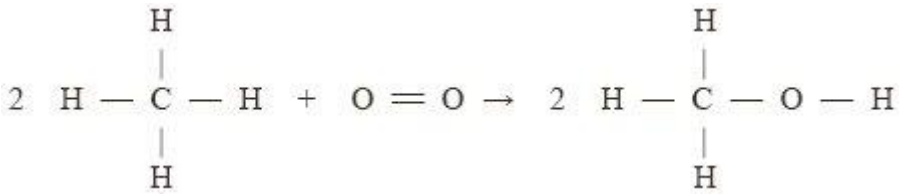
(ii) Explain, in terms of the energy level diagram, how the platinum catalyst increases the rate of this reaction.

_____

_____

(1)

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



(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

_____

_____

_____

_____

_____

Energy change = _____ kJ

(3)

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

_____

_____

(1)

(Total 6 marks)

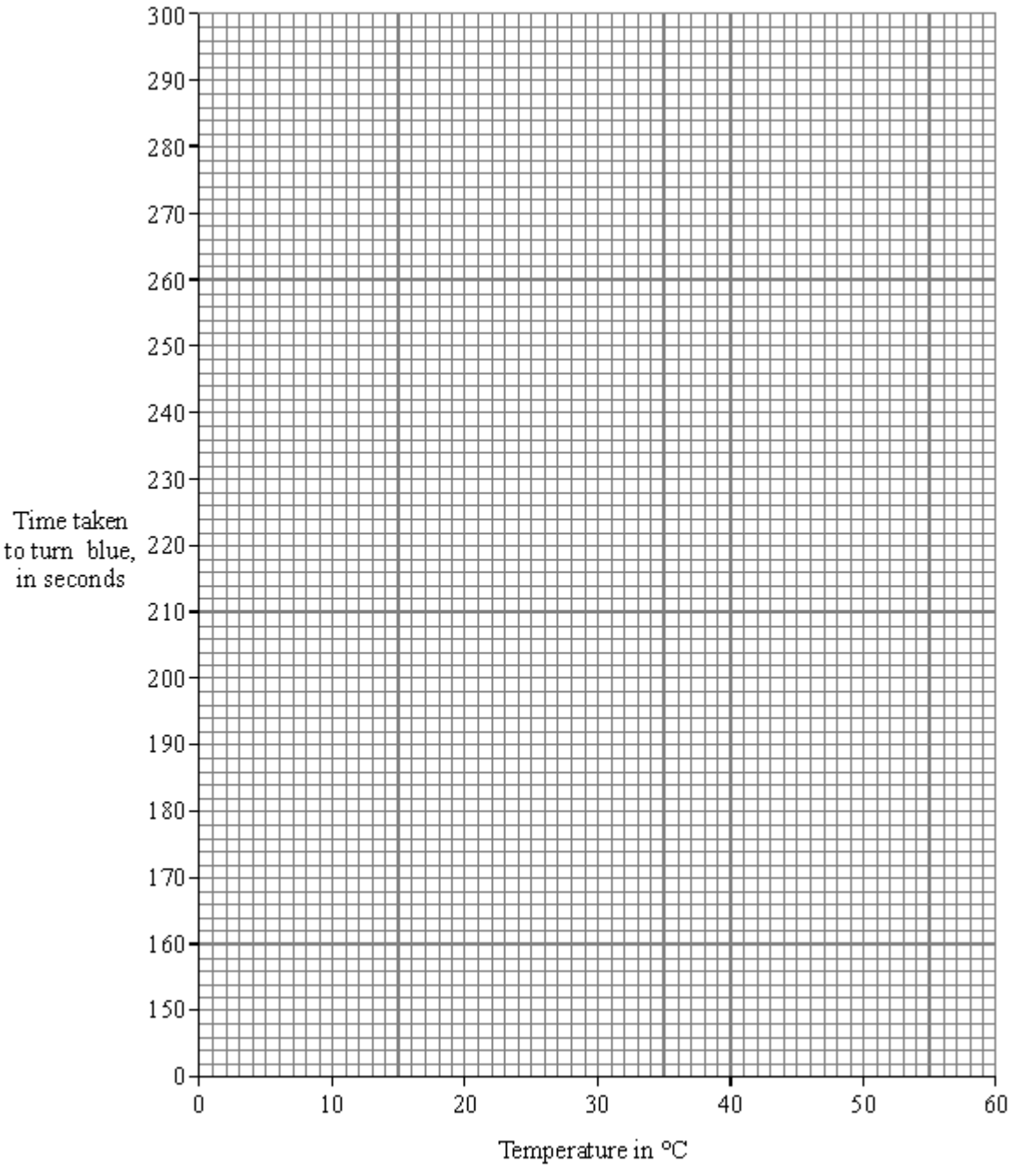
Q28.

Solutions **A** and **B** are colourless. When they are mixed, they react and turn blue after a period of time. A student investigated how temperature affected the rate of reaction between solutions **A** and **B**. The rate was measured by timing how long the mixture took to turn blue.

The results are shown in the table.

Temperature in °C	22	25	34	45	51
Time taken to turn blue, in seconds	290	250	200	170	160

(a) (i) Draw a graph for these results.



(3)

(ii) Use your graph to find how long it takes the solution to turn blue at 40°C.

Time = _____ s

(1)

(b) (i) How does the rate of reaction change as the temperature is increased?

_____

_____

(1)

(ii) Explain, in terms of particles, why temperature has this effect on the rate of reaction.

To gain full marks in this question you should write your ideas in good English. Put them into a sensible order and use the correct scientific words.

_____

_____

_____

_____

_____

_____

(3)

(c) State **one** variable that must be kept constant to make this experiment a fair test.

_____

(1)

(Total 9 marks)

Q29.

This label was on a bottle of stain remover.

When 'Simply Amazing' is mixed with water a reaction takes place which produces bubbles of oxygen gas.

(i) Suggest a method that you could use to measure how quickly this reaction takes place.

(2)

(ii) Read the instructions on the label and then suggest how increasing the temperature of the water affects the rate of this reaction.

(1)

(iii) Suggest **one** other way in which the rate of a reaction can be changed.

(1)

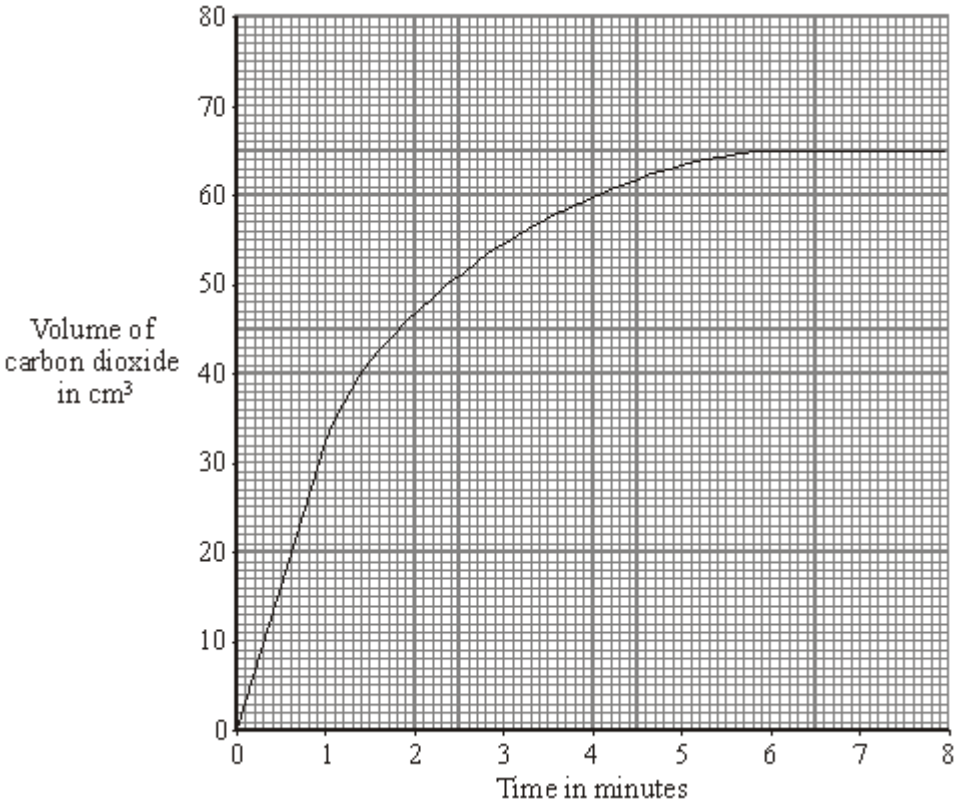
(Total 4 marks)

Q30.

A student studied the reaction between dilute hydrochloric acid and an **excess** of calcium carbonate.

calcium carbonate + hydrochloric acid → calcium chloride + water + carbon dioxide

The student measured the volume of carbon dioxide produced in the experiment. The results are shown on the graph.



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

_____ minutes

(1)

(b) The student wrote this conclusion for the experiment:

'The reaction gets slower and slower as the time increases.'

Explain why the reaction gets slower. Your answer should be in terms of particles.

_____

_____

_____

_____

(2)

(c) A second experiment was carried out at a higher temperature. All other factors were the same.

Draw a line on the graph above to show the results that you would expect.

(2)

(Total 5 marks)

Q31.

The monomer chloroethene is made from ethene in a two-stage process,

(a) The first stage is to convert ethene to 1,2-dichloroethane.

$$2C_2H_4(g) + 4HC1(g) + O_2(g) \rightleftharpoons 2C_2H_4Cl_2(g) + 2H_2O(g)$$

ethene 1,2-dichloroethane

State and explain the effect of increasing the pressure on:

(i) the yield of 1,2-dichloroethane;

_____

_____

(2)

(ii) the rate of reaction.

_____

_____

(2)

(b) In the second stage 1,2-dichloroethane is converted into chloroethene.

$C_2H_4C1_2 \rightarrow C_2H_3C1 + HCl$

This reaction is a thermal decomposition.

Suggest what would need to be done to decompose 1,2-dichloroethane.

_____

_____

(1)

(Total 5 marks)

Q32.

(a) Indigestion tablets called antacids can be taken to react with excess hydrochloric acid in the stomach. A student investigated two different antacid tablets labelled **X** and **Y**.

(i) Both tablets, **X** and **Y**, contained calcium carbonate. Give the chemical symbol for each of the three elements in calcium carbonate.

_____

_____

(3)

(ii) Name the gas formed when calcium carbonate reacts with hydrochloric acid.

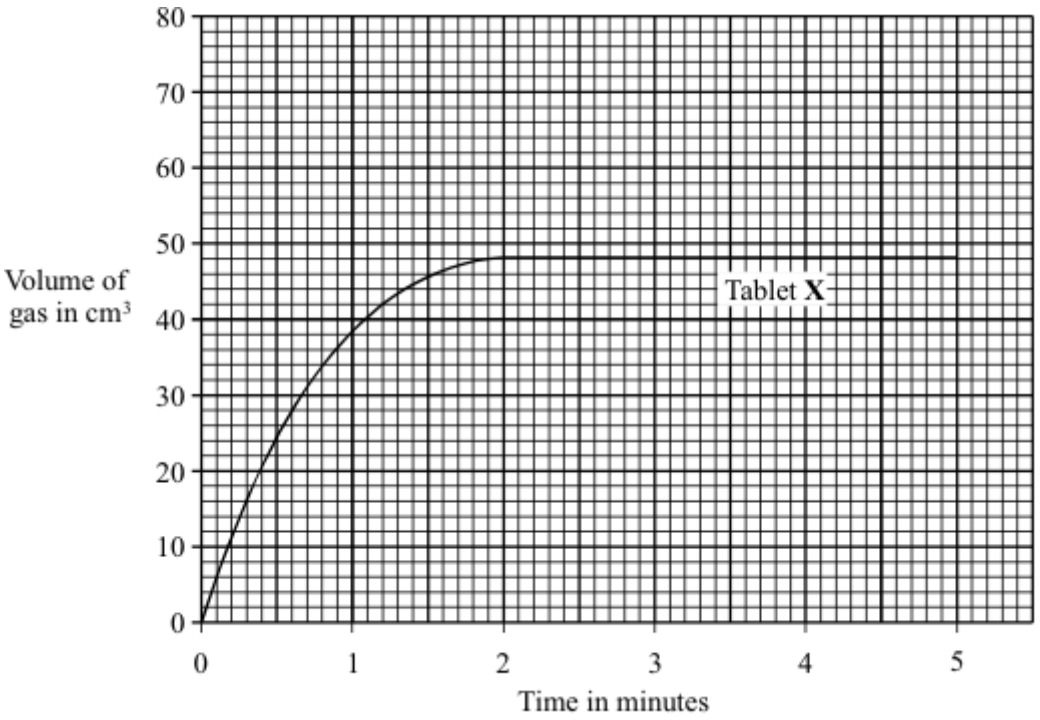
_____

(1)

(b) The student first reacted tablet **X** and then tablet **Y**, with 100 cm^3 of a hydrochloric acid solution. The student measured the volume of gas produced during the first five minutes. The results are shown in the table.

Time in minutes	0	1	2	3	4	5
Volume of gas in cm^3 Tablet X	0	38	48	48	48	48
Volume of gas in cm^3 Tablet Y	0	31	54	67	72	72

(i) Draw a graph of the results for tablet **Y**. (A graph of the results for tablet **X** has been drawn for you.)



(3)

(ii) Tablet **X** contains less calcium carbonate than tablet **Y**. How do the results show this?

_____

_____

(1)

(iii) Explain why the rate of reaction slows down for both tablets.

_____

_____

_____

(2)

(Total 10 marks)

Q33.

Hydrogen peroxide, H_2O_2, is often used as a bleach. It decomposes forming water and oxygen.

(a) (i) Write the balanced chemical equation for the decomposition of hydrogen peroxide.

_____

(3)

(ii) Give a test for oxygen.

Test _____

Result of test _____

_____

(2)

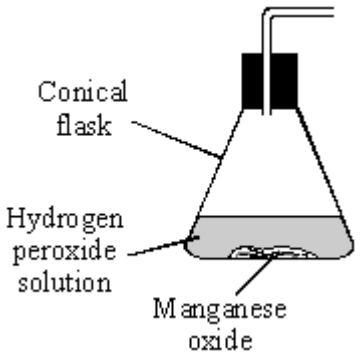
(b) The rate of decomposition of hydrogen peroxide at room temperature is very slow. Manganese oxide is a catalyst which can be used to speed up the decomposition. Complete the sentence.

A catalyst is a substance which speeds up a chemical reaction. At the end of the reaction, the catalyst is _____

(1)

(c) Two experiments were carried out to test if the amount of manganese oxide, MnO_2 affected the rate at which the hydrogen peroxide decomposed.

(i) Complete the diagram to show how you could measure the volume of oxygen formed during the decomposition.

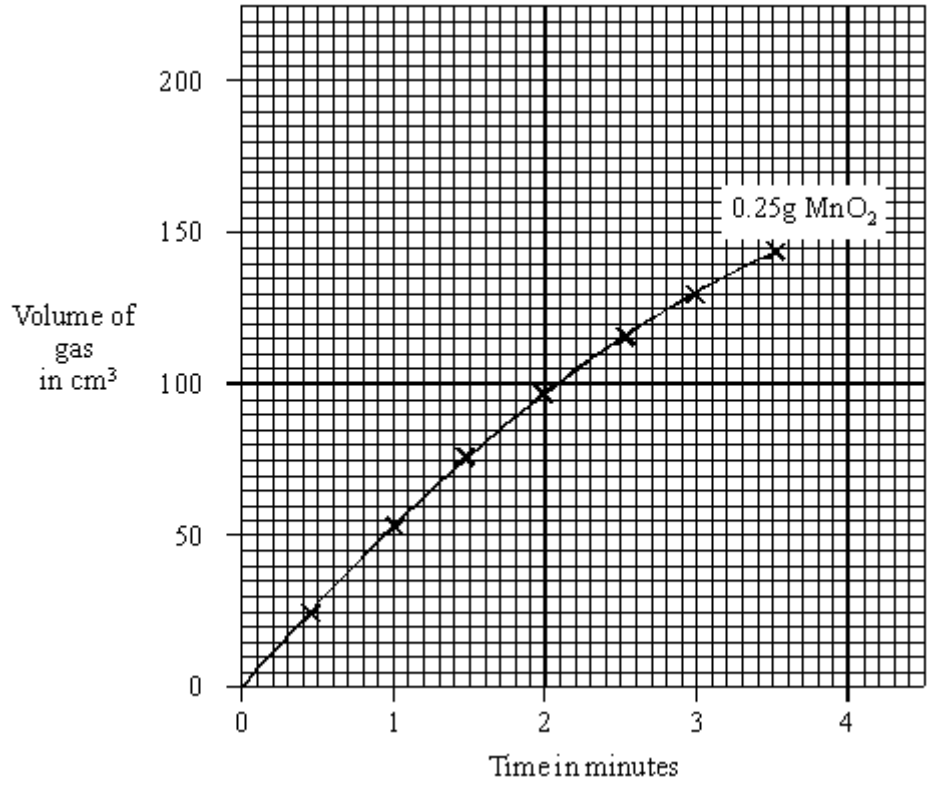


(2)

(ii) The results are shown in the table.

Time in minutes	0	0.5	1	1.5	2	2.5	3	3.5
Volume of gas in cm^3 using 0.25 g MnO_2	0	29	55	77	98	116	132	144
Volume of gas in cm^3 using 2.5 g MnO_2	0	45	84	118	145	162	174	182

Draw a graph of these results. The graph for 0.25 g MnO_2 has been drawn for you.



(3)

(iii) Explain why the slopes of the graphs become less steep during the reaction.

_____

_____

_____

(2)

(iv) The same volume and concentration of hydrogen peroxide solution was used for both experiments. What **two** other factors must be kept the same to make it a fair test?

1. _____

_____

2. _____

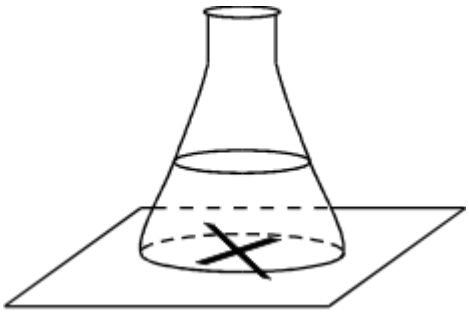
_____

(2)

(Total 15 marks)

Q34.

A student studied the effect of temperature on the rate of reaction between hydrochloric acid and sodium thiosulphate.



- The student mixed 50 cm^3 of a sodium thiosulphate solution and 5 cm^3 of hydrochloric acid in a flask.
- The flask was placed over a cross.
- The student timed how long after mixing the cross could no longer be seen.

(a) (i) Balance the chemical equation for this reaction.

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

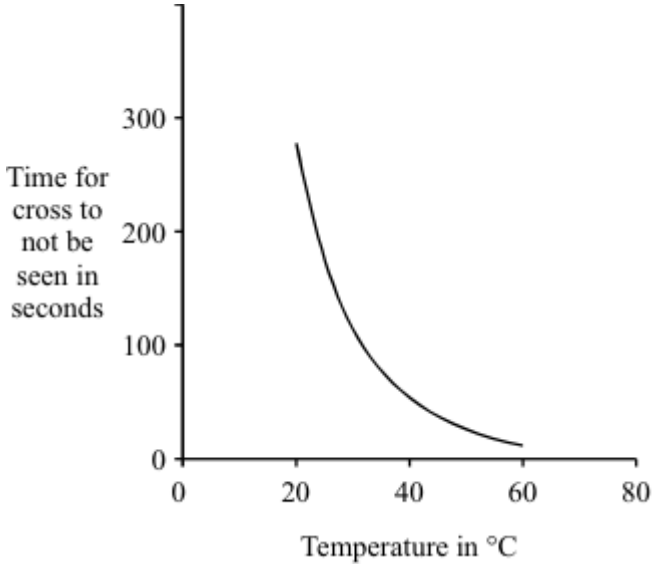
(1)

(ii) What causes the cross to be seen no longer?

_____

(1)

(b) A graph of the results is shown.



(i) What effect does temperature have on the rate of this reaction?

_____

(1)

(ii) Explain why temperature has this effect on the rate of reaction.

_____

_____

_____

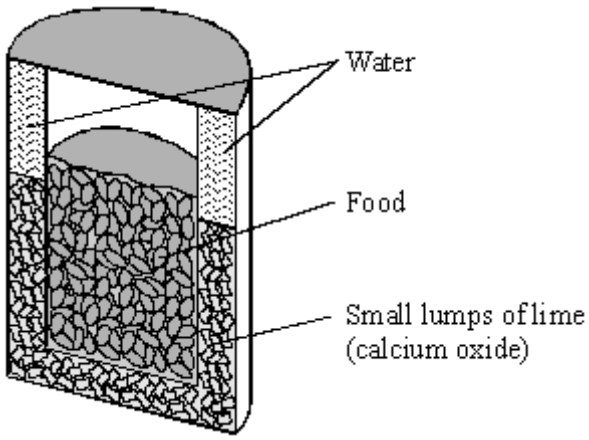
_____

(2)

(Total 5 marks)

Q35.

Mountaineers can warm their food in self-heating, sealed containers.



(a) The water is allowed to react with the lime. The heat from the reaction warms the food. What type of reaction causes a rise in temperature?

(1)

(b) Some students investigated the effect of adding different sized lumps of lime to water. The results of their investigation are shown.

Time in minutes	Temperature in °C		
	Large lumps of lime	Small lumps of lime	Powdered lime
0	18	18	18
1	19	20	28
2	21	23	43
3	24	27	63
4	28	32	88
5	33	38	100

What do these results show? Give an explanation for your answer.

(2)

(c) Suggest and explain **one** disadvantage of using powdered lime to heat food.

(2)

(Total 5 marks)

Mark schemes

Q1.

(a) any **two** from:

- effervescence / bubbles / fizzing
  allow gas / hydrogen is given off
  allow volume of gas
  allow magnesium floats

- magnesium disappears / dissolves
  allow change in mass of magnesium

- heat given off / exothermic
  allow temperature change
  *do **not** accept temperature decreases*

- change in pH
  *do **not** accept pH decreases*

2

(b) Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer to the information in the Marking guidance.

0 marks
No relevant content.

Level 1 (1-2 marks)
A simple plan without reference to changing any variable but should include an attempt at measuring rate **or** an attempt at fair testing

Level 2 (3-4 marks)
A plan including change of concentration / 'volume' of acid **and** should include an attempt at measuring rate **and / or** an attempt at fair testing

Level 3 (5-6 marks)
A workable plan including change of concentration **and** measurement of rate **and** fair testing

Examples of chemistry points made in the response could include:

Plan:

- add magnesium to acid

- time reaction / 'count bubbles' / measure volume of gas

- change concentration / 'volume' of acid

Control Variables:

- amount / mass / length / same 'size' of magnesium

- volume / amount of acid

6

[8]

Q2.

(a) (i) 10

1

(ii) OH^-

1

(b) (i) air

1

(ii) particles move faster

1

particles collide more often

1

(iii) catalyst(s)

1

(c) liquid

1

[7]

Q3.

(a) oxygen **and** water

both needed for mark
allow hydrogen oxide for water
in any order
ignore formulae

1

(b) (i) best fit line, omitting point at 10s

straight line drawn through all correct points

1

(ii) circle around point at 10 s

allow any indication

1

(iii) 7.5

allow ecf from candidate's line

1

(iv) increases (with time)

accept goes from 0 to 12.5

1

(c) (i) higher

1

(ii) more concentrated

1

(d) (i) share

1

(ii) covalent

1

(iii) simple molecules

1

(e) Water has a boiling point of 100°C

1

Water has a melting point lower than room temperature

1

[12]

Q4.

(a) gives out energy **or** heat

1

(b) (i) *accept qualified answers in terms of volume of gas related to time*

fast initially

1

slows down

1

reaction stops

accept reaction is now very slow

1

(b) (ii) 21

1

(iii) 84

*correct answer with or without working = **2** marks*
*allow ecf from (b)(ii) correctly calculated for **2** marks*
*allow evidence of 21/25 **or** (b)(ii)/25 for **1** mark*

2

(c) because they / particles have more energy / move faster

ignore particles move more / vibrate

1

(and so) particles collide more often / more frequently **or** particles more likely to collide

ignore collide faster
ignore more collisions

1

(and) more of the collisions are successful **or** particles collide with more energy /

harder **or** more of the particles have the activation energy

accept more successful collisions

1

[10]

Q5.

(a) 118

1

(b) it loses / transfers electrons

it = Au / gold atom

1

three electrons

*sharing / covalency = max **1** mark*

1

(c) (i) O_2

1

2 CO and **2** CO_2
or
correct balancing of equation from O

accept correct multiples / fractions throughout

1

(ii) *reference to incorrect bonding = **1** mark max*

because carbon dioxide is simple molecular / small molecules

1

there are <u>*intermolecular*</u> forces (between the molecules)

allow <u>intermolecular</u> bonds

1

so a small amount of energy needed (to separate molecules) **or** (*intermolecular forces*) are weak

1

(d) any **three** from:

- gold is the only catalyst for some reactions
- catalysts are not used up
- improves speed of reaction

reduces amount of energy **or** process needs low(er) temperature

*if no mark awarded, allow catalyst reduce costs (of the process) for **1** mark*

- only small quantities (of catalyst) needed

3

[11]

Q6.

(a) (i) the temperature at start

ignore reference to bubbles / heat

1

the temperature at end

*(measure) the temperature rise / change = **2** marks*

*(measure) the temperature **1** mark*

1

(ii) temperature would increase

allow it gets hot(ter) / warm(er) or heat given off

allow energy released / transferred

1

(b) any **one** from:

- volume of acid

  allow amount

  allow liquid

- temperature of acid

- size of magnesium ribbon

  allow volume / mass / amount

- surface area of magnesium

  ignore size of test tube and reference to water

1

(c) (i) (Test tube) B

1

(ii) produces bubbles faster

accept more bubbles

or

faster rate of reaction

allow most reactive

1

(d) The particles move faster

1

The particles collide more often

1

[8]

Q7.

(a) mixture is cooled / cooling

1

so ammonia / it condenses

or
so ammonia turns into a liquid (but nitrogen and hydrogen remain as gases)

1

(b) (i) exothermic reaction

accept reverse reaction is endothermic

or
equilibrium / reaction moves in the direction which raises the temperature

ignore answers based on rate or collisions

1

(ii) they / particles / molecules move faster **or** have more (kinetic) energy

allow atoms instead of particles

ignore particles move more / vibrate

*do **not** accept electrons (max1)*

1

any **one** from:

- particles / molecules collide more often / more frequently / more likely to collide

  ignore collide faster

  ignore more collisions

- more of the collisions are successful **or** particles collide with more energy / harder **or** more of the particles have the activation energy

  accept more successful collisions

1

(iii) more molecules / particles / moles / volumes on LHS (of equation than RHS)

accept 4 molecules / particles / moles / volumes on LHS and 2 molecules / particles / moles / volumes on RHS

or
greater volume on LHS (than RHS)
or
equilibrium / reaction moves in the direction which reduces the pressure / volume

accept converse

1

(iv) cost

or
difficulty in containing such a high pressure

allow risk of explosion

ignore dangerous

1

(c) (i) 60

1

(ii) 2.4(2857….)

*correct answer gains **3** marks with or without working*
accept any answer that rounds to 2.4
ignore units
if answer is incorrect look for evidence of correct working to a
*maximum of **2** marks.*
moles of N_2 = 2/28 = (0.0714)
moles of ammonia = 2 × 0.0714 = (0.1428)
mass of ammonia = 0.1428 × 17 = (2.4276)
or
28 → 34
1g →34/28
2g →2.4… ….

3

(d) (i) 15

1

(ii) unreacted gases are recycled

allow unreacted gases are reused

1

rate (of production) is fast

accept production is continuous
ignore compromise between rate and yield

1

[14]

Q8.

(a) (i) increase

1

(ii) energy is given out to the surroundings

1

(b) (i) NO

allow 2NO
ignore nitrogen oxide
*do **not** allow equations*

1

(ii) harmful / poisonous (owtte)

allow dangerous
ignore reference to pollution / global warming
*do **not** accept references to ozone layer*

1

(c) a catalyst can speed up a chemical reaction

1

different reactions need different catalysts

1

(d) (i) smaller

accept less / tiny / very small

allow 10^{-9}

*do **not** allow small unless qualified*

1

(ii) reduce cost (owtte) **or**

ignore references to energy

save resources / raw materials (owtte)

1

[8]

Q9.

(a) gives out heat / energy

allow release / loses

allow the products have less energy

or

energy / heat transferred to the surroundings

ignore temperature rises

allow more energy given out in forming bonds than taken in to break bonds

1

(b) (i) speed up the reaction (owtte)

accept changes the rate

accept lowers activation energy

accept increases successful collisions

accept allows reaction to take place at a lower temperature

1

(ii) nitrogen (N_2) / oxygen (O_2) / products are safe **or** not harmful / pollutant / toxic / dangerous / damaging

ignore releases nitrogen / oxygen unless qualified

or

(harmful) nitrogen monoxide / NO is not released into the air.

accept prevents / less acid rain

ignore greenhouse gas / ozone layer

1

(iii) 2 and 2

accept correct multiples or fractions

1

(iv) idea of catalyst not being used up

allow not changed by reaction

ignore catalyst does not take part

ignore catalyst not used in the reaction

1

(v) idea of different reactions (require different catalysts)

accept catalysts work for specific reactions

allow different gases

1

(c) • smaller / very small / or any indication of very small / 1–100 nanometres / a few (hundred) atoms

ignore just small

ignore size of the converter

1

• big(ger) surface area

1

• less (catalyst) needed / small amount of catalyst needed

1

[9]

Q10.

use a more concentrated solution of sulfuric acid

1

grind the phosphate rock into a powder before adding the acid

1

increase the temperature of the sulfuric acid

1

[3]

Q11.

(a) particles move faster

accept molecules / atoms / ions instead of particles

or

particles have more energy

ignore move / vibrate more

1

so they collide more often / frequently

allow particles collide harder / with more force

ignore collide quicker

or

more of the collisions are successful / have the activation energy

ignore collide more / more collisions

1

(b) any **one** from:

- increase surface area (of the rock)
  accept crush / powder the rock
- increase the concentration (of the acid)
  ignore increase the pressure / temperature
- add a catalyst
- stir / mix the mixture

1

[3]

Q12.

(a) goes up

1

(b) (i) B

1

(ii) A

1

(iii) a catalyst

1

activation energy

1

(c) (i) eg (ensures) complete reaction
allow spread heat / energy

or even heating
allow mixes properly or mix them together or to get correct temperature
ignore dissolves

1

(ii) lid (on beaker)
accept cover beaker

or

insulate (beaker) / use a plastic cup

1

[7]

Q13.

(a) energy released from making (new) bonds is greater than the energy needed to break (existing) bonds
accept the energy needed to break (existing) bonds is less than the energy released in making (new) bonds

*do **not** accept energy needed to make bonds*

1

(b) (i) energy / heat of products less than energy of reactants

accept products are lower than reactants

***or** reactants higher than products*

accept more energy / heat given out than taken in

***or** less energy / heat taken in than given out*

accept energy / heat is given out / lost (to the surroundings)

allow produce heat

ignore produce energy

accept ΔH is negative

***or** energy change / **A** is negative*

or B** is less than **C

1

(ii) **B** is (very) high / large

*it = **B***

*ignore energy change **C** is high*

1

(iii) *it = MnO_2*

(MnO_2) catalyst (is added)

accept it is a catalyst

or reaction catalysed (by MnO_2)

*do **not** accept MgO / magnesium oxide*

1

which lowers activation energy

accept provides alternative / lower energy pathway

or which lowers (energy change) **B**

if hydrogen peroxide is given as a catalyst instead of MnO_2 penalise once only in question

1

(c) any **two** from:

- (chemicals) not mixed / stirred
- heat / energy lost (from apparatus)
- (apparatus) not insulated **or** no lid
- low amount / mass / not enough MnO_2 **or** low concentration H_2O_2
- thermometer read incorrectly

ignore other experimental error

2

[7]

Q14.

(a) (i) mix (owtte)

accept to allow more collisions / helps particles to collide (owtte)

idea of more efficient heat transfer

*do **not** allow heat is a catalyst*

1

(ii) higher **and** more

1

powder **and** big

1

concentrated **and** more

1

(b) electrons

1

(c) H^+

1

[6]

Q15.

(a) (i) 0.2

*correct answer gains **2** marks with or without working*

accept answer in table

*if answer incorrect 5/25 gains **1** mark*

2

(ii) any **one** from:

- wider range of temperatures (owtte)
- (repeat at the same temperature) to improve accuracy / reliability
  allow to make it reliable / accurate
- reveal anomalous results (owtte)
  allow to eliminate random / human errors / to check results owtte
- so you can get an average / better average
  ignore to make it a fair test / to get better results
  ignore precision and validity

1

(b) any **two** from:

allow atoms / molecules / they instead of particles throughout

- particles gain energy / have more energy
  ignore increases particles activation energy

- particles move faster

  ignore move more / vibrate more

- particles collide more

- more of the particles have the activation energy **or** more of the collisions are successful (owtte)

  ignore increases / decreases activation energy

  or

  particles collide with more force / harder / more energy

  allow more successful collisions

  *alone for **1** mark*

2

[5]

Q16.

(a) the glow stick is brighter (owtte)

*accept glow stick is less bright **at low temperatures** (owtte)*

ignore references to rate / particles

1

(b) gave out light for less time

accept use of figures from table for comparison

allow reference to speed / rate eg quicker / faster reaction

1

(c) the particles will collide more often

1

the particles will move faster

1

the particles will have more energy

1

(d) any **one** from:

repeat

allow more glow sticks

measure brightness eg use light meter

more temperatures **or** wider range

improve precision

1

[6]

Q17.

(a) same number of (gaseous) molecules / moles / volume on both sides of the equation

allow particles for molecules
*do **not** accept atoms*
ignore amount

1

(b) (forward) reaction is exothermic
accept reverse answer

1

(c) any **three** from:

- particles gain energy
- particles move faster
  allow particles collide faster / quicker
  ignore move more / vibrate more
- particles collide more **or** more collisions
- more of the collisions are successful **or**
  more of the particles have the activation energy **or**
  particles collide with more force / energy

3

(d) any **two** from:

- more product (obtained in shorter time)
  accept better yield (of product)
- less fuel needed
  accept less energy / heat / electricity needed

  or

  lower fuel costs
  ignore cheaper unqualified
- less pollution caused by burning fuels

  or

  less specified type of pollution caused by producing heat / burning fuels
  *allow correct specified pollutants caused by burning fossil fuels eg CO_2 / greenhouse gases **or** correct effect of burning fossil fuels eg global warming*
  accept thermal / heat pollution
- using less fuel conserves resources
  accept sustainable
  accept fossil fuels are non-renewable

2

[7]

Q18.

(a) (i) increase

1

(ii) high melting point

1

(b) (i) decreases

1

increases

1

(ii) it gives the particles more energy

1

it makes the particles move faster

1

[6]

Q19.

(a) (i) increase (owtte) **or** gets hotter

ignore gives out heat / takes in heat

1

(ii) any **two** from:

- <u>bonds</u> are strong
  accept hard to break
- a lot of energy needed to break bonds
  allow heat for energy
- <u>all</u> atoms are joined by (covalent bonds
  accept forms lattice
- a large number of bonds would need to be broken
  *reference to ionic / metallic = **1** mark*
  *intermolecular forces /forces between molecules = max **1** mark*
  ignore electrostatic
  *many strong bonds need to be broken = **2** marks*
  accept 'double bonds' as equivalent to bonds

2

(b) any **two** from:

- particles have more energy
  ignore more vibrations
- particles move faster
  ignore move more

- particles collide more often **or**
  more collisions

  accept answers such as hit / bump

- more particles / particle collisions
  have the activation energy
  or
  more of the particles / particle collisions have
  enough energy to react
  or
  collisions are more energetic / harder (owtte)
  or
  more of the collisions are successful

  *if electrons rather than particles stated then max **1** mark*

  *there are more collisions and more of the collisions are successful = **2** marks*

  *accept more collisions per second / unit of time for **2** marks*

  *accept 'more successful collisions' for **1** mark*

2

[5]

Q20.

(a) 2.61 / range 2.5 to 2.7

*correct answer with **or** without **or** with wrong working gains **2** marks*

(accept answers between 2.5 and 2.7)

if answer incorrect moles of salicylic acid = 2/138 = 0.0145 moles
*ie 2/138 **or** 0.0145 gains **1** mark*
or
*(180/138) × 2 gains **1** mark*
or
*1 g → 180/138 = (1.304 g) gains **1** mark*
*(**not** 1.304g alone)*

2

(b) 42.1 range 40.7 to 42.3

*accept correct answer with **or** without **or** with wrong working for **2** marks*

*ecf ie (1.1 / their answer from (a)) × 100 correctly calculated gains **2** marks*

*if answer incorrect percentage yield = 1.1 / 2.61 × 100 gains **1** mark*

if they do not have an answer to part (a)
or
they choose not to use their answer then:

- yield = (1.1 / 2.5) × 100 (1)

- = 44

*accept 44 for **2** marks with no working*

2

(c) any **one** from:

- errors in weighing
- some (of the aspirin) lost
  *do **not** allow 'lost as a gas'*
- not all of the reactant may have been converted to product
  eg reaction didn't go to completion
  allow loss of some reactants
- the reaction is reversible
  accept other products / chemicals
- side reactions
  ignore waste products
- reactants impure
- not heated for long enough
- not hot enough for reaction to take place

1

(d) any **one** from:

- use lower temperature
- use less fuel / energy
  ignore references to use of catalyst
- produce product faster **or** speed up reaction
- more product produced in a given time (owtte)
- increased productivity
- lowers activation energy

1

[6]

Q21.

(a) (i) a continuous straight line missing anomalous point
allow a line which does not start at zero / origin

1

(ii) any **two** sensible errors eg

- timing errors and / or example(*)

- measurement errors and / or example(*)
- apparatus errors and / or example(*)
- human / experimental / random error and / or example or 'did not do it right'(*)

  *(*)could be two from **same** category eg two timing errors – watch not started at the same time plus difficulty in deciding when the cross has disappeared.*
- temperature fluctuation
- anomalous point

  accept outlier / wrong result
- results not recorded correctly
- plotting error
- rate calculated incorrectly

  ignore 'not repeated'

  *ignore systematic / zero error / weighing error **or** error unqualified*

2

(b) (i) straight line

or

as concentration increases the rate goes up **or** converse

accept numerical example

accept positive correlation

accept same gradient

ignore 'most points near / on line of best fit'

1

(ii) more collisions

accept greater chance of collisions

accept collide more successfully

accept alternative versions of collide eg 'bump / hit'

ignore references to energy / speed of particles / surface area

1

more particles (in each volume of solution)(i.e. an attempt at defining concentration)

accept 'particles are closer together'

allow ions / atoms / molecules for particles ignore reactants

*accept greater frequency of collisions **or** greater number of collisions per second for **2** marks*

1

[6]

Q22.

(a) (bonds broken) = 1370 (kJ)

1

(bonds made) = 1856 (kJ)

1

change in energy = (–) 486

ecf
ignore sign
*correct answer with **or** without working = **3** marks*

1

(b) energy released from forming new bonds is greater than the energy needed to break existing bonds

allow the energy needed to break bonds is less than the energy released in forming bonds
*do **not** accept energy needed to form bonds*

1

(c) (i) energy barrier needs to be overcome

or

activation energy supplied / needed

*allow energy needed to start reaction **or** energy needed to break bonds*
accept high activation energy

1

(ii) lowers activation energy(*)

or

provides lower energy pathway / route(*)

*(*)**2** mark answers*
*allow provides alternative pathway **or** platinum / it is a catalyst for **1** mark*

2

[7]

Q23.

(a) sensible line of best fit which goes through or close to all the points **except** the anomalous point

allow wobbly / short double lines
± ½ square

1

(b) loss of gas / loss of CO_2

idea of gas produced / formed

1

(c) 7

1

(d) (i) steeper line from around the same starting point and left of the points

*allow crosses if they are fully correct for **1** mark*

1

levelling off at 99

accept short level line at 99

± ½ square

1

(ii) any **three** from:

- particles / molecules / atoms/ ions have more energy

  allow given / gain / get energy

- move faster

  ignore move about more

  ignore vibrate more / faster

- collide more often

  or more chance of collisions

  or bump into each other more

  ignore collide quicker / faster

- collide with more force / energy

  or more particles have the activation energy

  or more collisions result in reaction

  or more collisions are successful

3

Q24.

(a) (i) (phosphoric) acid

allow phosphoric acid

1

(ii) hydrogen

1

(b) (i) faster / quicker / speeds it up (owtte)

allow answers based on activation energy

ignore helps it to react

1

(ii) most of the starting materials end up as useful products

1

(iii) H_2O

*allow HOH **or** OH_2*

1

[5]

Q25.

(a) any **two** from:

- increases

  owtte allow 'goes up'

- until reaches maximum / levels off

  owtte

- quickly at first

  owtte

- then more slowly / rate decreases

  allow reaction finished

  ignore rate increases

2

(b) use a more concentrated acid

list principle applies

use zinc powder

2

[4]

Q26.

(a) (i) sulfuric

accept H_2SO_4

accept sulphuric

allow phonetic spellings

1

(ii) $CuO + H_2SO_4 \rightarrow CuSO_4 + H_2O$

***1** mark for reactants*

***1** mark for products*

ignore state symbols

*max **1** mark for incorrect balancing*

2

(b) any **two** from:

- particles gain energy **or** particles have more energy

  allow have more activation energy

- particles move faster

  allow they collide faster / quicker

ignore move / vibrate more

- collide more often
  allow more collisions
- collide more energetically
- more of the collisions are successful
  or more particles have the activation energy
  ***NB** more successful collisions alone = **1** mark*
  *if particles are identified as electrons = max **1** mark*

2

[5]

Q27.

(a) (i) energy / heat of products less than energy of reactants
owtte
allow products are lower than reactants
allow more energy / heat given out than taken in
allow methanol is lower
allow converse
allow energy / heat is given out / lost allow ΔH is negative

1

(ii) lowers / less activation energy
owtte
allow lowers energy needed for reaction
***or** it lowers the peak/ maximum*
*do **not** allow just 'lowers the energy'*

1

(b) (i) bonds broken: (2 × 435) + 498 = 1368
allow: (8 × 435) + 498 = 3978

1

bonds made: (2 × 805) + (2 × 464) = 2538
allow: (6 × 435) + (2 × 805) + (2 × 464) = 5148

1

energy change: 1368 – 2538 = (–)1170
allow: 3978 – 5148 = (–)1170
ignore sign
allow ecf
*correct answer (1170) = **3** marks*

1

(ii) energy released forming new bonds is greater than energy needed to break existing bonds owtte
allow converse
*do **not** accept energy needed to form new bonds greater than energy needed to break existing bonds*

1

[6]

Q28.

(a) (i) accurate plotting of points ($\pm \frac{1}{2}$ square)

2 *marks for all points*
1 *mark for 3 or 4 points*

2

sensible smooth curve

reasonable attempt
*do **not** accept double lines **or** dot to dot*

1

(ii) accurately read from <u>their</u> graph to $\pm \frac{1}{2}$ square

1

(b) (i) (as temperature increases) rate <u>increases</u>

accept speeds up, gets faster, gets quicker
accept higher speed
*do **not** accept gets bigger / higher unqualified*
*do **not** accept answers about time on its own*

1

(ii) **Quality of Written Communication**
The answer to this question requires ideas in good English in a sensible order with correct use of scientific terms. Quality of written communication should be considered in crediting points in the mark scheme.

maximum 2 marks if ideas not expressed well

any **three** from:

for converse maximum 2 marks

particles have more energy

higher kinetic energy

particles move faster

*do **not** accept move more or vibrate more*

3

more collisions

accept greater rate of collisions

more energetic / successful / harder collisions

more particles have activation energy

(c) concentration (of solutions) **or** volume (of solutions)

accept 'how much of'

accept references to intensity of colour
accept same endpoint
accept rate of stirring / shaking
*do **not** accept reference to solids **or** catalysts etc*
ignore containers
*do **not** accept pH*

1

[9]

Q29.

(i) measure volume / mass of gas produced

1

in a certain time period

***1** mark is for a sensible way of measuring the amount of product produced and **1** mark is for the idea of timing*

e.g. measure volume of gas produced at regular time intervals
or time taken to fill a test tube with the gas
or collect a certain volume of gas

*(measuring the rate at which bubbles are produced e.g. number of bubbles in 30 seconds gains only **1** mark unless an enclosed system is used)*

or measure decrease in mass of flask and contents at regular time intervals

or time taken for the mass to decrease by certain amount

1

(ii) increases rate (owtte)

1

(ii) change the concentration **or** add a catalyst **or** change the surface area **or** lower the temperature

*accept 'expose to sunlight' (owtte) **or** change the amount of water / powder / solution used*

ignore 'stirring'

1

[4]

Q30.

(a) 6

accept 5.8 – 6

1

(b) hydrochloric acid used up / reacted / combined / **or** fewer particles (of hydrochloric acid) **or** fewer hydrogen ions owtte

accept reactants used up
*accept less calcium carbonate **or** smaller surface area of calcium carbonate*
accept lower concentration / less crowded

*do **not** accept atoms / molecules*
ignore references to energy
*do **not** accept references to atoms or molecules*

1

fewer collisions owtte

independent mark

1

(c) steeper curve initially

independent marks

1

levels out at same volume

- *must indicate levelling out*
- *if line goes higher than 66 do **not** award this mark*
- *diagonal line only = 0 marks*
- *if steeper initially and then crosses the line and finishes correctly, then loses one*

1

[5]

Q31.

(a) (i) yield increases

two marks are linked

1

because more (gaseous) reactant molecules / particles than (gaseous) product molecules / particles

accept 7 → 4 moles or volumes
ignore more reactants
accept fewer particles on the right

1

(ii) increased (rate) / faster / speeds up etc

two marks are linked

1

more collisions **or** increased concentration **or** particles closer together

greater chance of more successful collisions

1

(b) heat / high temperatures

*do **not** accept burn it ignore cracking / catalyst*

1

[5]

Q32.

(a) (i) ***must** be chemical symbol*

Ca

1

C

$CaCO_3$= 2 marks

1

O not O_2

1

(ii) carbon dioxide

***must** be name*

1

(b) (i) *points all correct 2 marks*
one point incorrect 1 mark
two points incorrect 0 marks

2

suitable line -narrow neat single curve

not dot to dot

1

(ii) reaction with X forms less gas

***must** include X or Y*
*do **not** penalise for H_2/O_2 if (a) (ii) already penalised*
*do **not** accept is finished in less time **or** slower/faster reaction **or** lower on graph*

1

(iii) any two from:

- concentration (of acid) decreases/less reacting particles/molecules
  ***not** acid/$CaCO_3$ runs out/is used up*
- surface area of calcium carbonate decreases
  ***not** strength of acid decreases*
- less collisions between reacting particles
  ***not** smaller (amount of) $CaCO_3$*

2

[10]

Q33.

(a) (i) H_2O_2 reactant correct

ignore any state symbols

1

$H_2O + O_2$ products correct

1

$2H_2O_2 \rightarrow 2H_2O + O_2$ balanced

accept correct multiple

1

(ii) glowing splint

1

relights

accept 'bursts into flame'

*do **not** accept a lighted splint burns brighter **or** faster*

1

(b) unchanged

*accept **not** used up **or** left (behind)*

1

(c) (i) gas syringe **or** measuring cylinder **either** with scale drawn **or** labelled

1

the apparatus as drawn would work

1

(ii) correct plotting of points

***one** mark to be deducted for each error*

2

best fit graph line drawn (single line drawn)

1

(iii) concentration of hydrogen peroxide decreases

accept less particles of hydrogen peroxide to collide

*do **not** accept hydrogen peroxide gets used up*

1

rate of reaction decreases

accept reaction gets slower

1

(iv) any two from:

- temperature
- pressure
- division of catalyst **or** manganese oxide

*do **not** accept any other factors*

2

[15]

Q34.

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

1

(ii) (formation of) sulphur

*accept precipitate **or** solid produced*

*do **not** accept goes cloudy **or** milky*

1

(b) (i) heat ≡ temperature increased temperature increases (the rate of reaction)
or decreased temperature decreases rate of reaction

may be gained in part (ii) if stated and not implied

1

(ii) (these ideas may be given in (i))

particles have more kinetic energy

accept particles move faster

1

more collisions (so more reactions)

*more energetic collisions **two** marks*

1

[5]

Q35.

(a) exothermic (reaction)

1

(b) smaller lumps react faster
or larger lumps react slower

*accept smaller lumps cause a more rapid rise in temperature **or** vice versa*

*do **not** accept higher temperature **or** more heat unless linked to time*

1

smaller lumps have a larger surface (area) or larger lumps have a smaller surface (area)

*more water can react at the same time **or** so less water can react at the same time*

1

(c) heats up (too) rapidly

accept temperature (too) high

1

burning the food **or** the hands

*accept danger of container exploding **or** splitting **or** food overheating*

do not accept reference to handling of powder

*do **not** accept a lot of powder needed **or** powder getting into food **or** too hot to eat **or** food would not cook properly **or** heat through properly*

1

[5]

Q1.

This question is about rates of reaction.

(a) Hydrogen peroxide (H_2O_2) decomposes very slowly at room temperature.

(i) Complete the balanced chemical equation for this reaction by writing in the formula of the missing product.

$2H_2O_2 \rightarrow 2$ _____ $+ O_2$

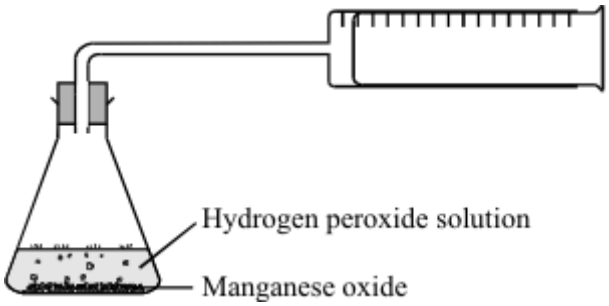
(1)

(ii) The decomposition is much faster if manganese oxide is mixed with the hydrogen peroxide. Complete the sentence.

Manganese oxide acts as a _____ for decomposition of hydrogen peroxide.

(1)

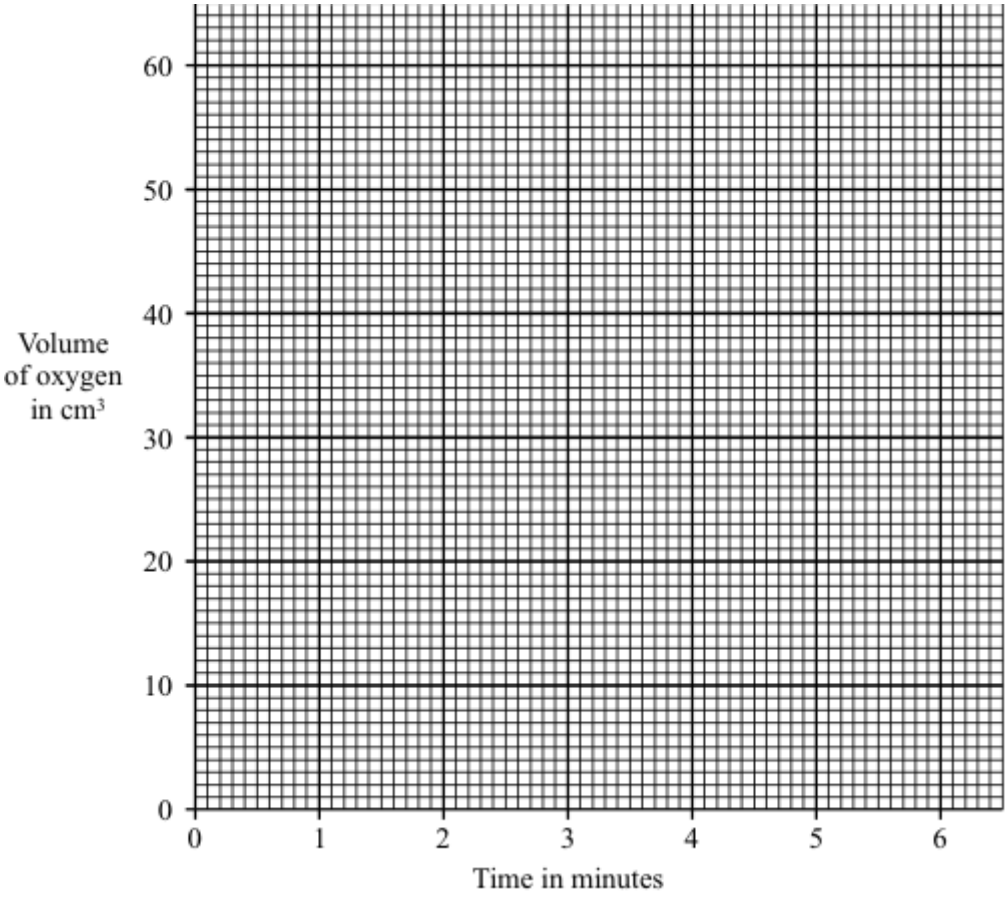
(b) In an experiment 1g of manganese oxide was mixed with 50 cm^3 of hydrogen peroxide solution.



The results show the volume of oxygen collected during six minutes.

Time in minutes	0	1	2	3	4	5	6
Volume of oxygen in cm^3	0	34.5	47.5	54.5	58.5	60.0	60.0

(i) Draw a graph of these results.



(3)

(ii) How long did it take for the decomposition to stop?

_____

(1)

(iii) Why did the decomposition stop?

_____

(1)

(c) In a second experiment water had been added to the hydrogen peroxide solution. Again 50 cm^3 of this hydrogen peroxide solution was mixed with 1g of manganese oxide.

(i) For this second experiment, sketch, on the same grid, a graph line you would expect to get.

(2)

(ii) In this second experiment, why would the rate of reaction be different to the first experiment?

_____

(1)

(Total 10 marks)

Q2.

Early atmospheres on Earth contained ammonia (NH_3).

(a) (i) Complete the sentence.

Our atmosphere today is made up of about _____ % nitrogen.

(1)

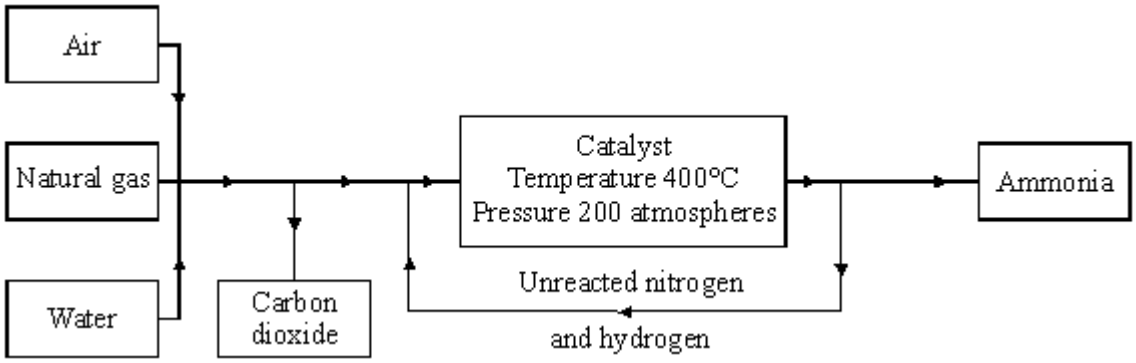
(ii) Today we convert nitrogen back to ammonia mainly for the production of fertilisers. What do plants convert the nitrogen in these fertilisers into?

_____

_____

(1)

(b) The conversion of nitrogen to ammonia is shown.



(i) When making ammonia, what is **one** source of hydrogen?

_____

(1)

(ii) Apart from ammonia, name **one** other product formed during this conversion.

_____

(1)

(c) The main reaction is the formation of ammonia from nitrogen and hydrogen.

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

_____(g) + _____(g) → _____NH_3(g)

(2)

(ii) Name the metal catalyst used in this reaction.

_____

(1)

(iii) This reaction does not work successfully at room temperature (20 °C) and needs a much higher temperature of 400 °C. Explain why.

_____

(2)

(d) Draw a diagram to show the arrangement of the electrons in a molecule of ammonia. The electron arrangement of each atom is hydrogen 1 and nitrogen 2.5.

(2)

(Total 11 marks)

Q3.

Calcium tablets are taken to build and maintain strong bones and teeth.

(a) These tablets react with hydrochloric acid in the stomach.

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

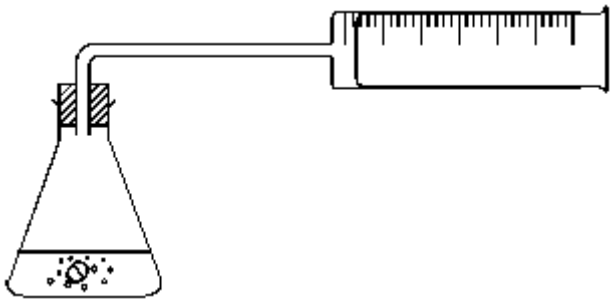
(i) Add all these missing state symbols aq g l s to the balanced chemical equation.

(2)

(ii) The calcium salt that is formed is absorbed during digestion. What is the name of the calcium salt?

(1)

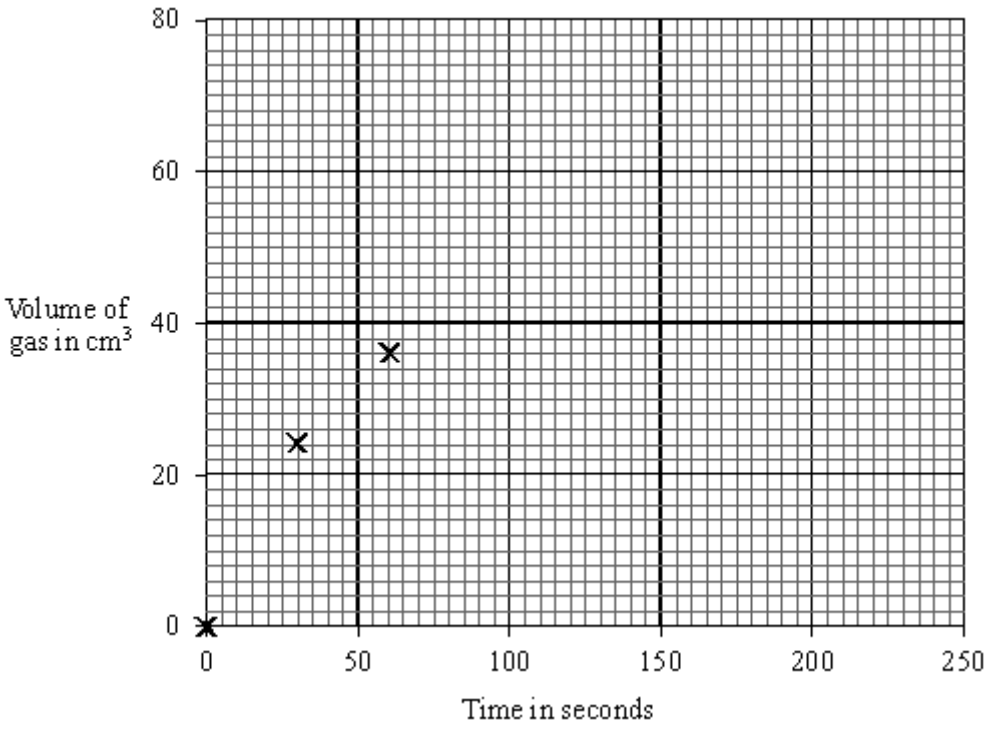
(b) The volume of carbon dioxide produced by one calcium tablet in the stomach can be found as shown.



The volume of carbon dioxide was recorded every 30 seconds until the reaction stopped.

Time in seconds	0	30	60	90	120	150	180	210	240
Volume of gas in cm^3	0	24	36	46	52	56	59	60	60

(i) Complete the graph of these results.



(3)

(ii) Describe **one** way in which this reaction can be made to go faster.

_____

_____

(1)

(iii) A calculation, using the mass of this tablet, showed that 80 cm^3 of carbon dioxide would be produced if the tablet was pure calcium carbonate. What do

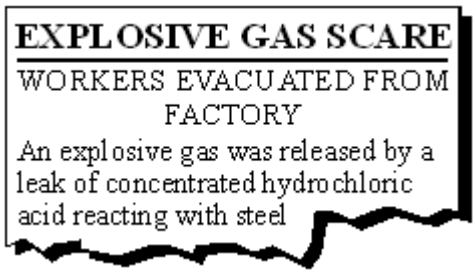
the results show about the purity of the tablet? Explain your answer by calculating the purity of this tablet.

(3)

(Total 10 marks)

Q4.

This article appeared in a newspaper.



(a) The balanced chemical equation shows the reaction between steel and hydrochloric acid.

$Fe(s) + 2HCl(aq) \rightarrow FeCl_2(aq) + H_2(g)$

(i) Which metal in steel reacted with the hydrochloric acid?

(1)

(ii) The gas released was described as explosive. Explain why.

(3)

(b) In the factory hydrogen chloride is manufactured by reacting hydrogen with chlorine. Hydrochloric acid is formed when hydrogen chloride forms a solution in water.

(i) Water was sprayed on the steel and hydrochloric acid. This slowed the rate of reaction. Explain why.

_____

_____

_____

_____

(2)

(ii) It would have been better to neutralise the acid with an alkali rather than to just add water. Hydrochloric acid can be neutralised by reaction with sodium hydroxide. Complete the ionic equation for the neutralisation reaction.

(aq) + (aq) → H_2O(l)

(2)

(iii) In the factory the acid leak was neutralised with slaked lime, $Ca(OH)_2$, and not sodium hydroxide, NaOH. Suggest why.

_____

_____

_____

_____

_____

(2)

(Total 10 marks)

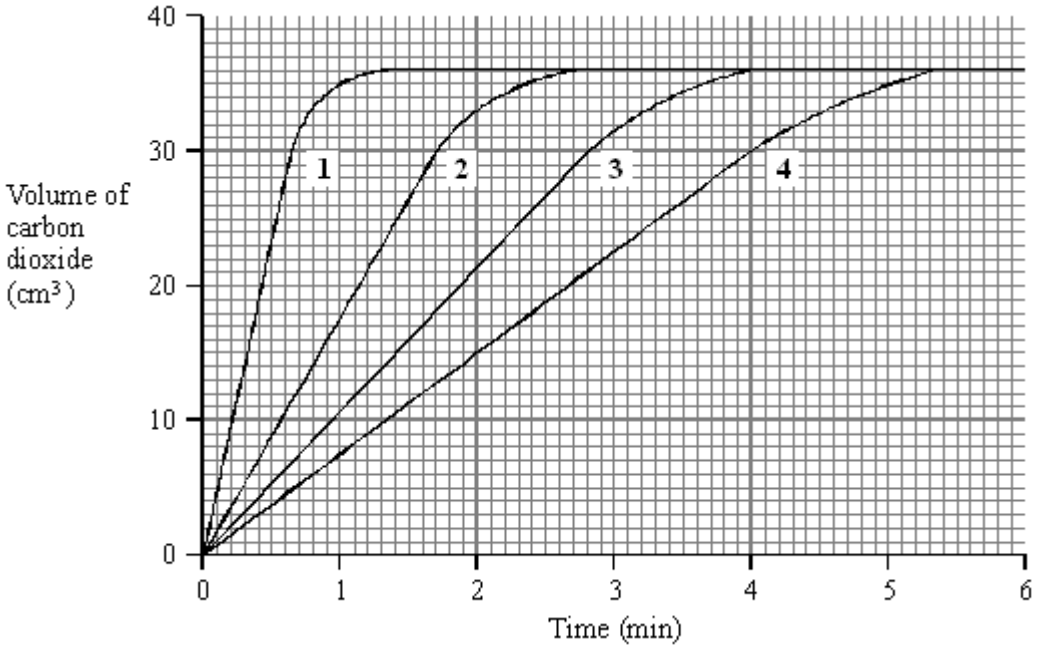
Q5.

Calcium carbonate reacts with dilute hydrochloric acid as shown in the equation below.

$CaCO_{3(s)} + 2HCl_{(aq)} \rightarrow CaCl_{2(aq)} + H_2O_{(l)} + CO_{2(g)}$

The rate at which this reaction takes place can be studied by measuring the amount of carbon dioxide gas produced.

The graph below shows the results of four experiments, 1 to 4. In each experiment the amount of calcium carbonate, the volume of acid and the concentration of the acid were kept the same but the temperature of the acid was changed each time. The calcium carbonate was in the form of small lumps of marble.



(a) Apart from altering the temperature, suggest **two** ways in which the reaction of calcium carbonate and hydrochloric acid could be speeded up.

1. _____

2. _____

(2)

(b) Which graph, 1 to 4, shows the results of the experiment in which the acid had the highest temperature?

Experiment _____

Explain fully how you know.

_____

_____

_____

_____

(2)

(c) (i) In experiment 2, how does the rate of reaction after one minute compare with the rate of reaction after two minutes?

_____

_____

(1)

(ii) Explain, as fully as you can, why the reaction rate changes during experiment 2.

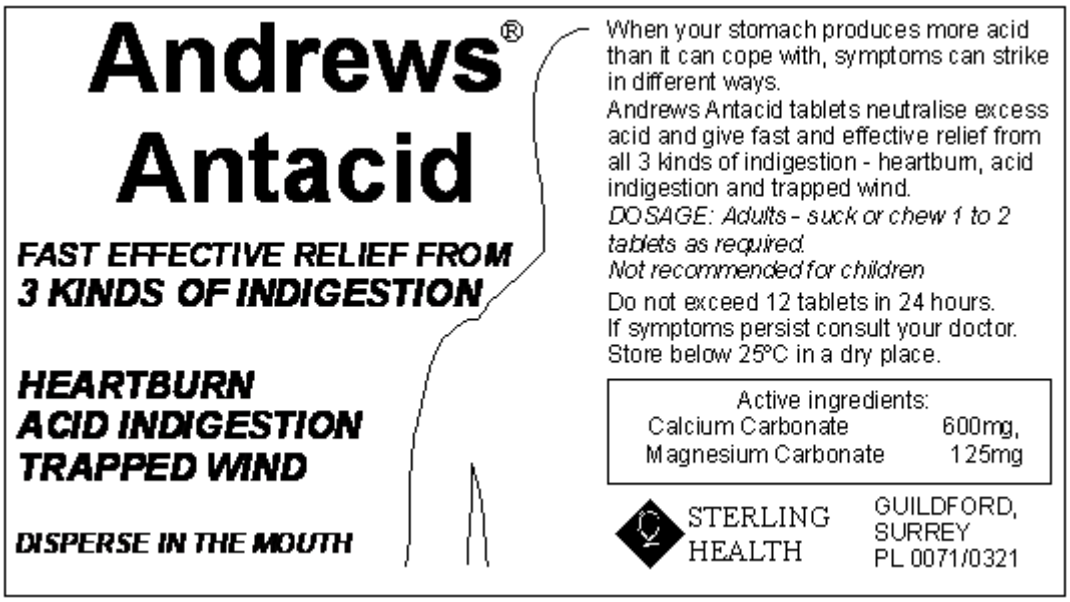
_____

(2)

(Total 7 marks)

Q6.

(a) This label has been taken from a packet of *Andrews Antacid*.



(i) Write the simplest ionic equation which represents a neutralisation reaction.

(1)

(ii) Chewing the tablet cures indigestion faster than swallowing the tablet whole. Explain why.

(1)

(b) The active ingredients in the *Antacid* react with hydrochloric acid in the stomach to give salts, water and carbon dioxide.

A student investigated how quickly the tablets react with **excess** hydrochloric acid.

40 cm^3 of dilute hydrochloric acid were placed in a conical flask. The flask was placed on a direct reading balance. Two *Antacid* tablets were quickly added to the

flask. The apparatus was weighed immediately. At the same time, a stop clock was started. The mass was recorded every half minute for 5 minutes.

The results are shown in the table below.

Mass of flask + contents (g)	92.0	90.0	89.0	88.3	87.8	87.5	87.3	87.1	87.0	87.0	87.0
Time (minutes)	0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0

The main active ingredient in *Andrews Antacid* is calcium carbonate.

(i) Balance the equation which represents the reaction between calcium carbonate and hydrochloric acid.

$CaCO_{3(s)}$ + _____ $HCl_{(aq)}$ → $CaCl_{2(aq)}$ + $H_2O_{(l)}$ + $CO_{2(g)}$

(1)

(ii) State the meaning of the symbol “(aq)”.

_____

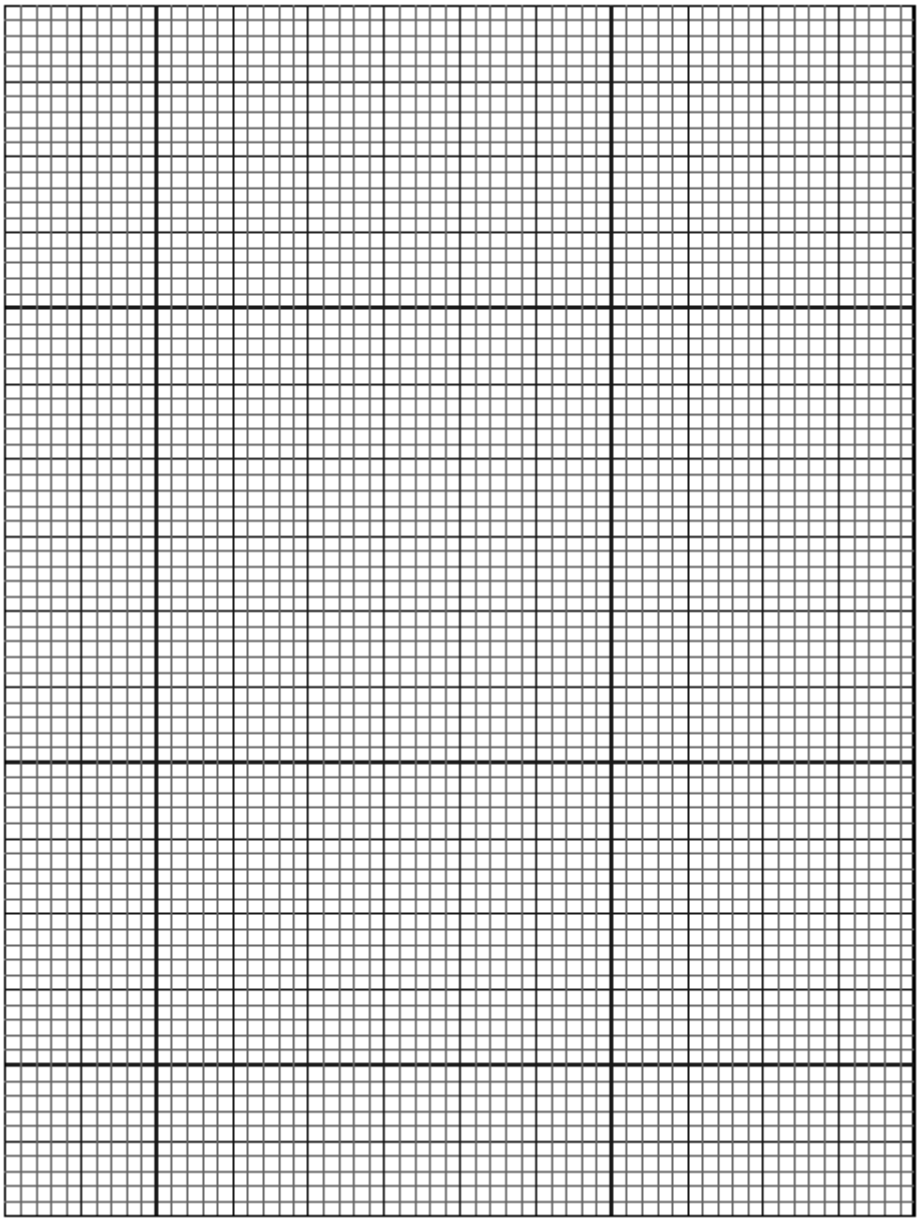
(1)

(iii) Why does the mass of the flask and contents decrease?

_____

(1)

(c) (i) Plot the results on the graph below and draw a smooth curve to show how the mass of the flask and its contents changes with time. Label this curve “A”.



(3)

(ii) One of the results does not appear to fit the pattern. Circle this result on the graph.

(1)

(d) The student did a second experiment. The only change was that the acid was twice as concentrated.

On the graph, sketch a second curve to show a possible result for this experiment. Label this curve “B”.

(2)

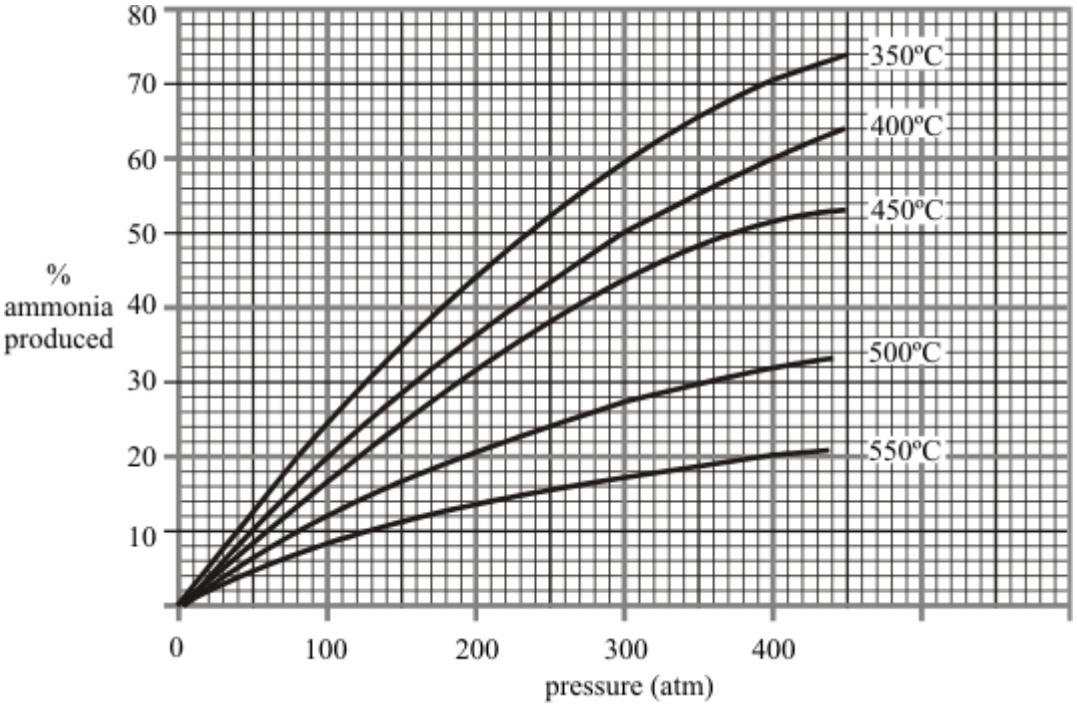
(Total 12 marks)

Q7.

Ammonia is produced by the Haber process. In the process nitrogen and hydrogen are mixed. The pressure is increased to about 200 atmospheres. The gases are passed over an iron catalyst at about 450°C. The equation for the reaction is:

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

The reaction between nitrogen and hydrogen is reversible. This affects the amount of ammonia that it is possible to obtain from the process. The graph below shows how the pressure and temperature affect the percentage of ammonia that can be produced.



Use this information, together with your knowledge of the process, to explain why many industrial ammonia plants operate at 200 atmospheres and 450°C.

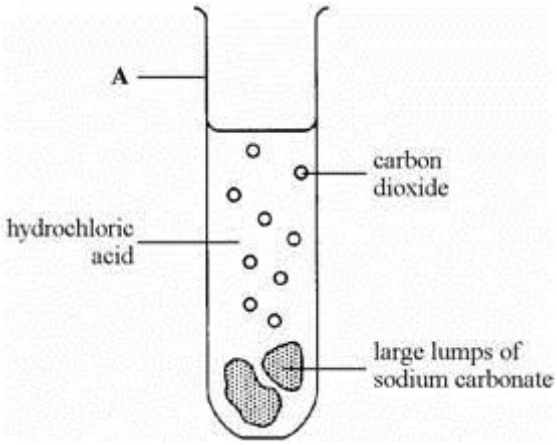
(Total 5 marks)

Q8.

Dilute hydrochloric acid reacts with sodium carbonate. The word equation for this reaction is:

sodium carbonate + hydrochloric acid → sodium chloride + water + carbon dioxide

(a) The diagram shows apparatus used by student X to investigate this reaction.



(i) Name the piece of apparatus labelled **A**.

_____

(1)

(ii) **$NaCO_3$** **NaCl** **Na_2CO_3** **Na_2Cl**

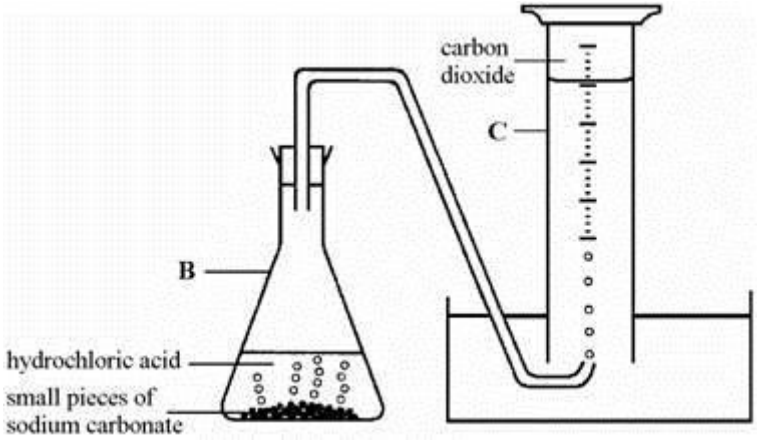
Use the Data Sheet to help you choose the correct formula from the list for:

sodium carbonate, _____

sodium chloride. _____

(2)

(b) The diagram below shows a different apparatus used by student Y to investigate the same reaction.



(i) Name the pieces of apparatus labelled **B** and **C**.

B _____

C _____

(2)

(ii) Both students X and Y used the same

- volume of acid

- concentration of acid
- temperature
- mass of sodium carbonate

Use information from the diagrams to explain why the reaction that student Y carried out was faster.

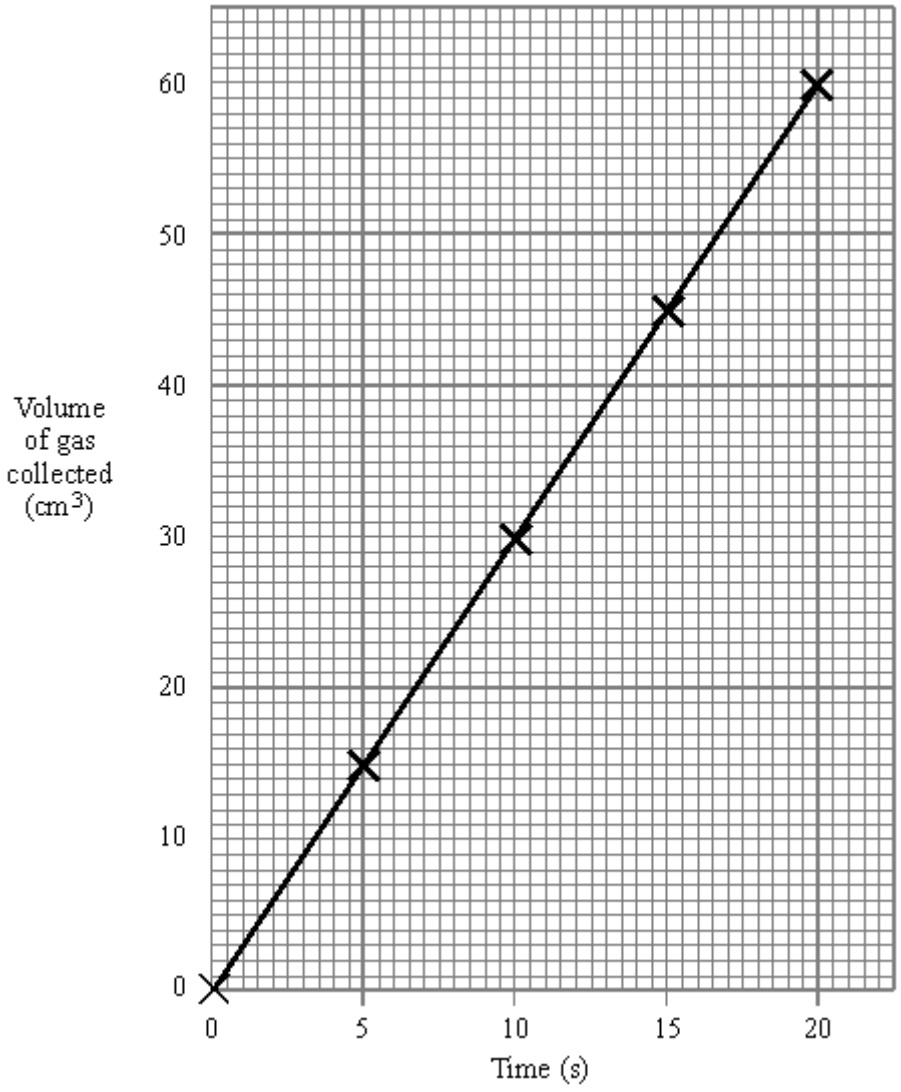
_____

_____

_____

(2)

(c) The results obtained by student Y were plotted as shown below.



(i) Student Y repeated the experiment exactly as before but used warmer acid. This made the reaction faster.
On the graph draw a line for this faster reaction.

(2)

(ii) Explain, in terms of particles, why the rate of the reaction is faster when warmer acid is used.

_____

_____

_____

(3)

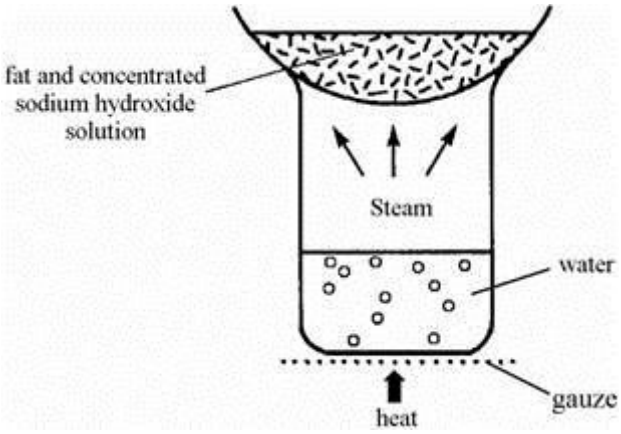
(Total 12 marks)

Q9.

Soap can be made by reacting fats with sodium hydroxide solution.

fat + sodium hydroxide → soap + glycerol

The diagram shows a laboratory experiment to make soap.



From the information in the diagram, give **two** factors which increase the rate of this reaction.
In each case explain, in terms of particles, why the rate of reaction increases.

Factor 1 _____

_____

Reason _____

_____

_____

_____

_____

Factor 2 _____

_____

Reason _____

_____

_____

_____

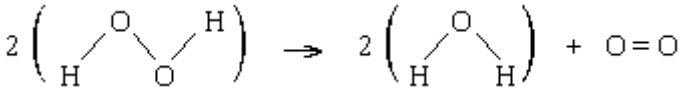
_____

(Total 7 marks)

Q10.

At room temperature, hydrogen peroxide decomposes very slowly to form water and oxygen.
The decomposition is speeded up when a catalyst is added.

(a) The following equation represents the decomposition of hydrogen peroxide.
The structural formulae of the chemicals involved are shown.



Use the following information about bond energies to answer this part of the question.

BOND	BOND ENERGY (kJ)
O = O	498
O – O	146
H – O	464

(i) Calculate the energy needed to break all the bonds in the reactants.

_____

_____

_____

_____ kJ

(2)

(ii) Calculate the energy released when new bonds are formed in the products.

_____

_____

_____

_____ kJ

(2)

(iii) Calculate the energy change for this reaction.

_____

_____ kJ

(1)

(iv) Is the reaction exothermic or endothermic?

_____

Explain why.

_____

_____

(1)

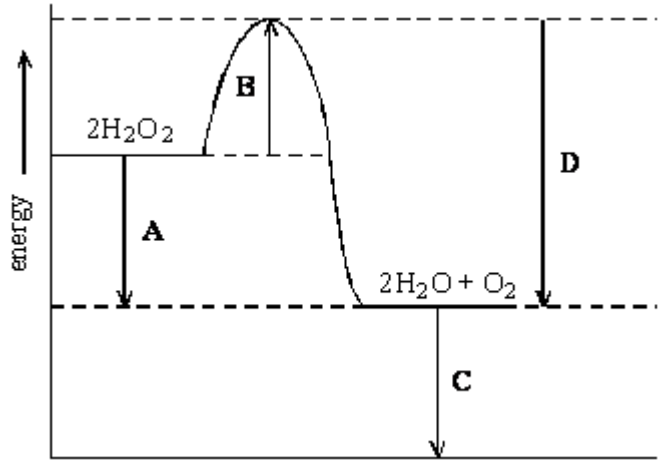
(b) (i) What is meant by 'activation energy'?

_____

_____

(1)

(ii) The energy level diagram for the decomposition of hydrogen peroxide into water and oxygen is shown below.



Which energy change, **A**, **B**, **C** or **D**, is the activation energy? _____

(1)

(iii) Explain, in terms of energy, how a catalyst makes hydrogen peroxide decompose more quickly.

_____

_____

_____

(1)

(Total 9 marks)

Q11.

This item appeared in the Wolverhampton *Express and Star* on October 31st, 1997. Read the passage and answer the questions that follow.

Fumes scare at factory

Workers were forced to flee a factory after a chemical alert. The building was evacuated when a toxic gas filled the factory.
It happened when nitric acid spilled on to the floor and mixed with magnesium metal powder.

(a) The equation which represents the reaction between magnesium and nitric acid is:

$Mg_{(s)} + 4HNO_{3(aq)} \rightarrow Mg(NO_3)_{2(aq)} + 2H_2O_{(1)} + 2NO_{2(g)}$

Give the formula of the toxic gas that was produced.

_____

(1)

(b) Explain, in terms of particles, how the toxic gas was able to fill the factory quickly.

_____

_____

_____

(2)

(c) The reaction of nitric acid with magnesium metal powder is more dangerous than if the acid had fallen on to the same mass of magnesium bars. Explain why.

_____

_____

_____

(1)

(d) (i) Water was sprayed on to the magnesium and nitric acid to slow down the reaction.
Explain, in terms of particles, why the reaction would slow down.

_____

_____

_____

(2)

(ii) Explain why it is better to add alkali, rather than just add water to the spillage.

_____

_____

(1)

(Total 7 marks)

Q12.

(a) You may find the Data Sheet helpful to complete the word equation.

These two gases react as shown in the balanced symbol equation.

$$2H_2 + O_2 \rightarrow 2H_2O$$

Complete the word equation for this reaction.

hydrogen + _____ → _____

(2)

(b) Complete this sentence by crossing out the **two** words in the box that are wrong.

This chemical reaction is much faster if a molecule if a

catalyst
molecule
solution

is used.

(1)

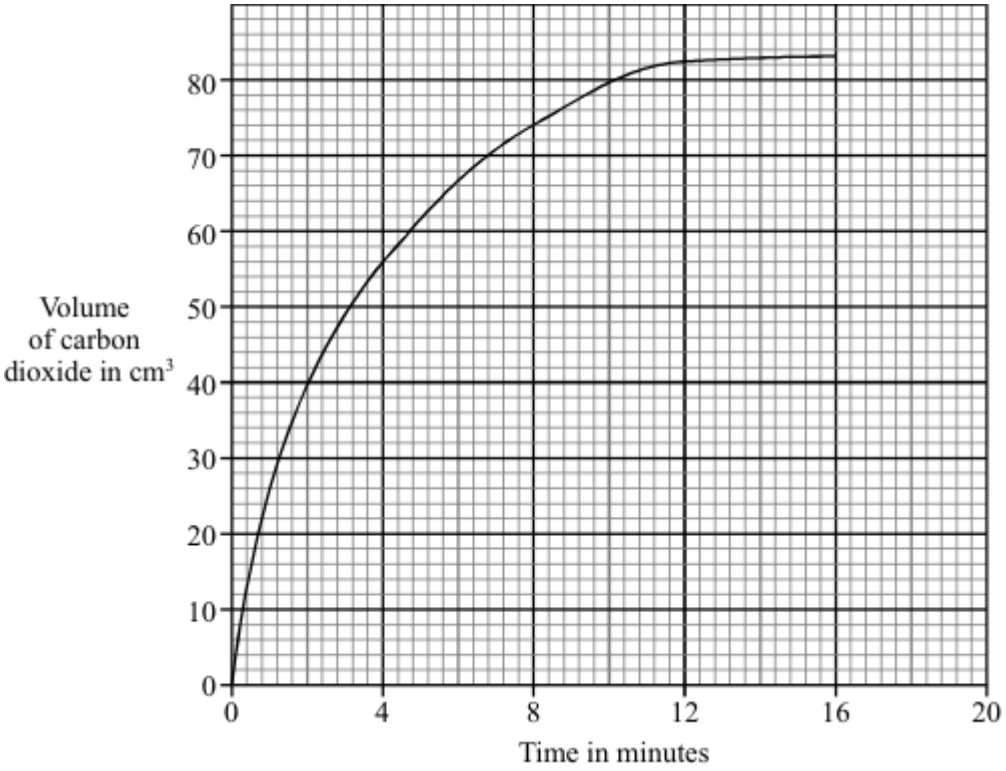
(Total 3 marks)

Q13.

Calcium carbonate reacts with nitric acid to produce carbon dioxide.

$$CaCO_3 + 2HNO_3 \rightarrow Ca(NO_3)_2 + H_2O + CO_2$$

A 10 g lump of calcium carbonate was reacted with 20 cm^3 of dilute nitric acid. When the reaction was finished, some of the calcium carbonate was left unreacted. The graph shows the volume of carbon dioxide made in each minute for sixteen minutes.



(a) The volume of carbon dioxide made in each minute decreases until it remains steady at 83 cm^3.
Explain why.

_____

_____

_____

_____

(2)

(b) Draw a graph line, on the axes above, for an experiment where 20 cm^3 of the same dilute nitric acid was reacted with 10 g of **powdered** calcium carbonate.

(2)

(c) Give **one** way of changing the rate of this reaction (other than using powdered calcium carbonate).

_____

_____

(1)

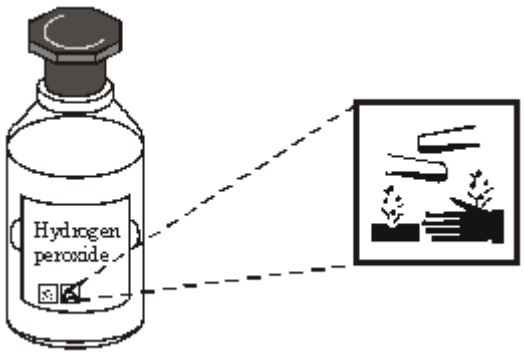
(Total 5 marks)

Q14.

Hydrogen peroxide (H_2O_2) contains the same elements as water (H_2O).

(a) Name the hazard symbol shown by using the correct word from the box.

corrosive	flammable	oxidising	toxic



.....

(1)

(b) Hydrogen peroxide decomposes in the presence of a catalyst.

$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$

(i) Complete the word equation for this chemical reaction.

hydrogen peroxide → water + _____

(1)

(ii) What does a catalyst do to a chemical reaction?

_____

_____

(1)

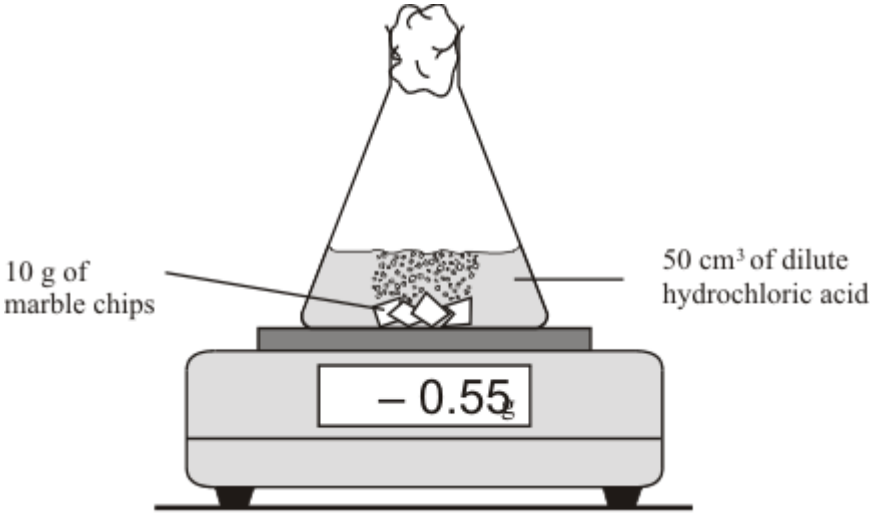
(Total 3 marks)

Q15.

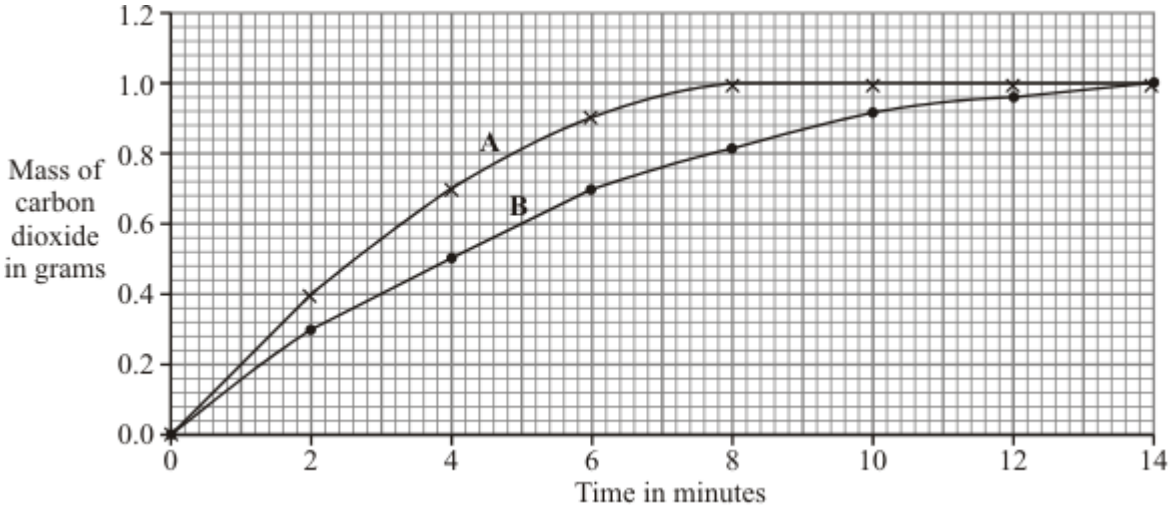
Marble is a rock that contains mainly calcium carbonate. This reacts with hydrochloric acid.

calcium carbonate + hydrochloric acid → calcium chloride + water + carbon dioxide

The rate of this reaction was followed by measuring the mass of carbon dioxide formed.



Two 10 g samples of marble, **A** and **B**, were each reacted with 50 cm^3 of dilute hydrochloric acid, at different temperatures. The mass of carbon dioxide formed in each reaction was recorded and plotted to produce the graph below.



Each reaction stopped when no more carbon dioxide was formed.
In both experiments some marble was left unreacted when the reaction stopped.

(a) Explain how you can tell which sample, **A** or **B**, reacted faster with the dilute hydrochloric acid.

(2)

(b) The faster rate of reaction was caused by using a higher temperature. Explain, in terms of particles, why a higher temperature causes a faster rate of reaction.

(3)

(Total 5 marks)

Q16.

In the Haber process, nitrogen and hydrogen react to make ammonia.

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

nitrogen + hydrogen $\rightleftharpoons$ ammonia

Pressure in atmospheres	% ammonia present at equilibrium				
	Temperature in ºC				
	100	**200**	**300**	**400**	**500**
10	88.2	50.7	14.7	3.9	1.2
25	91.7	63.6	27.4	8.7	2.9
50	94.5	74.0	39.5	15.3	5.6
100	96.7	81.7	52.5	25.2	10.6
200	98.4	89.0	66.7	38.8	18.3
400	99.4	94.6	79.7	55.4	31.9
1000	99.9	98.3	92.6	79.8	57.5

The actual conditions used in the Haber process are usually 450 °C and 200 atmospheres.

(a) What effect does increasing the pressure have on the percentage of ammonia made? Use the balanced symbol equation to explain why.

_____

(2)

(b) A lower temperature of 100 °C gives high percentages of ammonia at most pressures. Why is this temperature **not** used in the Haber process?

_____

_____

_____

(1)

(c) Describe and explain the effect of an increase in the temperature on the reaction between nitrogen and hydrogen in the Haber process.

_____

_____

_____

_____

_____

_____

_____

_____

(3)

(Total 6 marks)

Q17.

Hydrogen peroxide slowly decomposes into water and oxygen.

hydrogen peroxide → water + oxygen

The reaction can be speeded up by adding manganese dioxide.

(a) (i) What do we call a substance that speeds up a chemical reaction without being changed itself?

_____

(1)

(ii) Give **two** other ways of increasing the rate of this reaction.

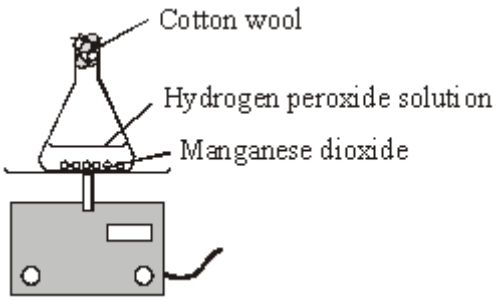
1. _____

2. _____

(2)

(b) The diagram shows how the rate of this reaction can be measured.

As the hydrogen peroxide decomposes, the mass of the flask and its contents decreases.



Why does this decrease in mass take place?

_____

_____

(1)

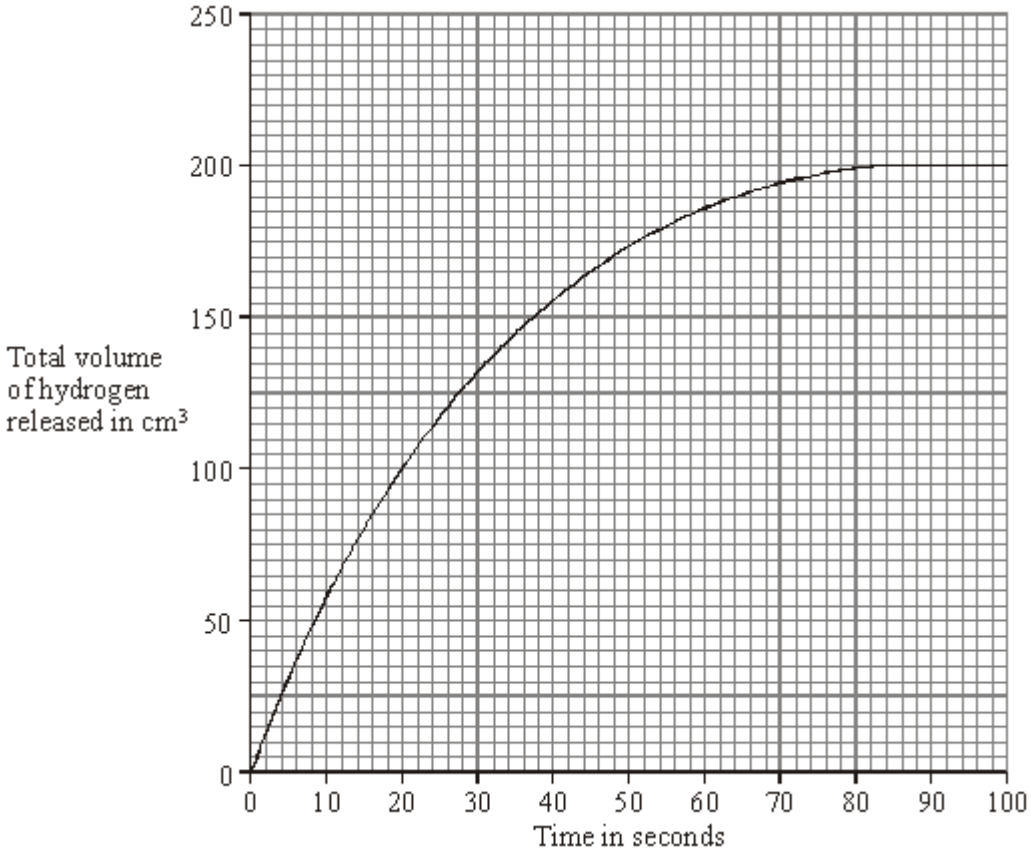
(Total 4 marks)

Q18.

Magnesium reacts with dilute sulphuric acid.

magnesium + sulphuric acid → magnesium sulphate + hydrogen

A student measured the volume of hydrogen given off every 10 seconds. The results are shown on the graph.



(a) The average rate of hydrogen production in the first 10 seconds is (60 cm^3 ÷ 10 s) = 6 cm^3/s.

(i) Calculate the average rate of production of hydrogen between 30 seconds and 50 seconds. Show clearly how you work out your answer.

_____

_____

_____

Rate _____ cm^3/s

(3)

(ii) Explain, as fully as you can, why the average rate between 30 and 50 seconds is different from the rate between 0 and 10 seconds.

_____

_____

_____

_____

(2)

(b) In industry, enzymes are used in both batch processes and continuous processes.

Give **one** reason why continuous processes are usually more profitable than batch processes.

_____

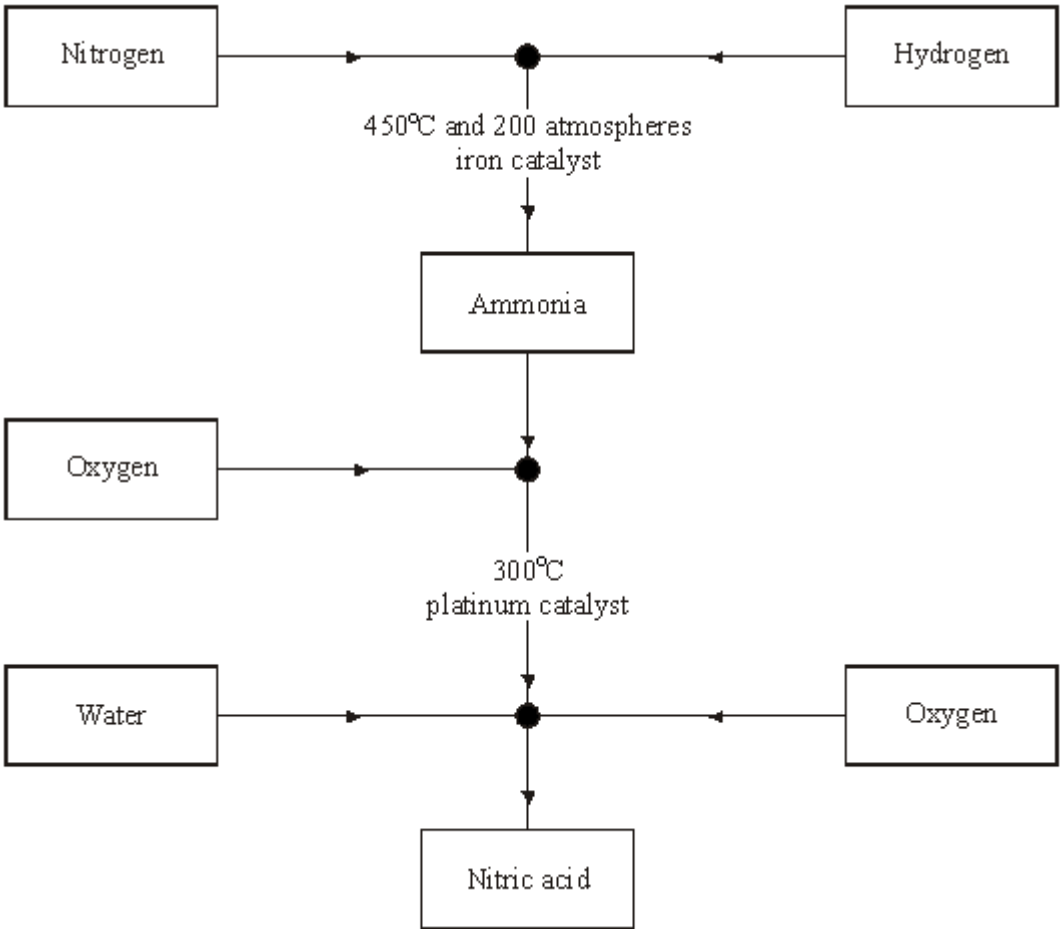
_____

(1)

(Total 6 marks)

Q19.

The flow diagram shows how to make ammonia and nitric acid from the nitrogen in the air.



(a) A fertiliser is made by neutralising ammonia with nitric acid. What is the name of this fertiliser?

_____

(1)

(b) In the flow diagram, why are two different catalysts used?

_____

_____

(1)

(c) What happens to catalysts at the end of a reaction?

_____

_____

(1)

(d) Explain why catalysts are used in many industrial chemical reactions.

_____

_____

_____

(2)

(e) Explain, in terms of collisions between molecules, why a high pressure is used in the reaction between nitrogen and hydrogen.

_____

_____

_____

_____

(2)

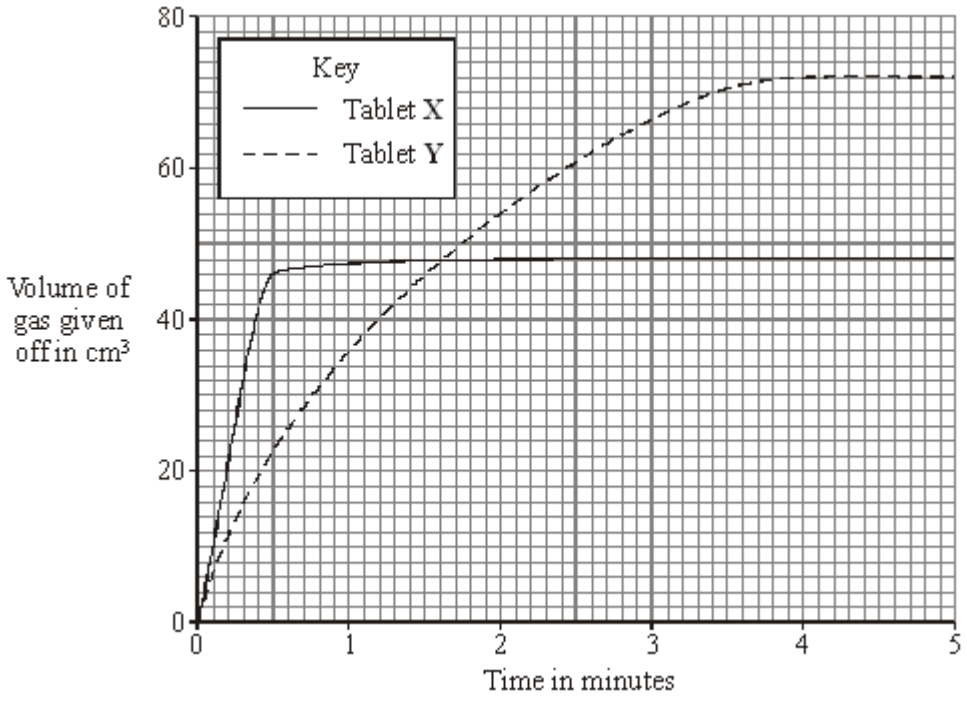
(Total 7 marks)

Q20.

Many indigestion tablets contain calcium carbonate as their only active ingredient. Calcium carbonate neutralises some of the hydrochloric acid in the stomach.

Two different indigestion tablets, **X** and **Y**, were separately reacted with excess hydrochloric acid. The volume of gas given off in each reaction was measured every minute.

The results are shown in the graph.



(i) Which tablet, **X** or **Y**, contained most calcium carbonate? _____

Explain the reason for your answer.

_____

_____

(1)

(ii) Which tablet, **X** or **Y**, reacted faster with hydrochloric acid?_____

Explain the reason for your answer.

_____

_____

(1)

(iii) Explain the shape of the graph for tablet **X** between 3 and 5 minutes.

_____

_____

_____

_____

(1)

(Total 3 marks)

Q21.

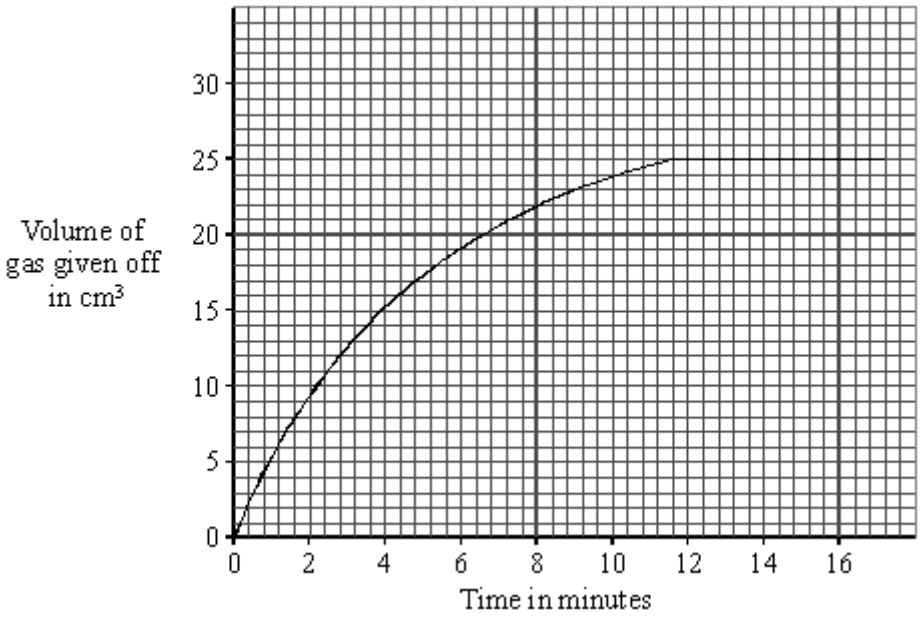
Zinc powder normally reacts slowly with hydrochloric acid.

(a) Balance the symbol equation for the reaction.

$Zn + HCl \rightarrow ZnC1_2 + H_2$

(1)

The graph shows the results from a reaction of 1.0 g of zinc powder with 20 cm^3 of dilute hydrochloric acid. It gives off a gas and forms zinc chloride, $ZnCl_2$. Some unreacted zinc is left at the end.



(b) Copper powder is a good catalyst for the reaction of zinc with hydrochloric acid.

(i) A mixture of 10 cm^3 of the same dilute hydrochloric acid and 1.0 g of copper powder was added to 1.0 g of zinc powder. What is the maximum volume of gas which could be given off?

_____ cm^3

(1)

(ii) Draw a graph, on the axes above, for an experiment where 20 cm^3 of the same dilute hydrochloric acid was added to 1.0 g of copper powder mixed with 1.0 g of zinc powder.

(2)

(iii) Give **two** other ways the reaction described in part (i) could be made to go faster.

1. _____

2. _____

(2)

(c) Copper powder can be formed by adding copper sulphate solution to the mixture of zinc powder and acid.

(i) Why does zinc react with copper sulphate solution to produce copper?

_____

_____

(1)

(ii) Write the word equation for the reaction.

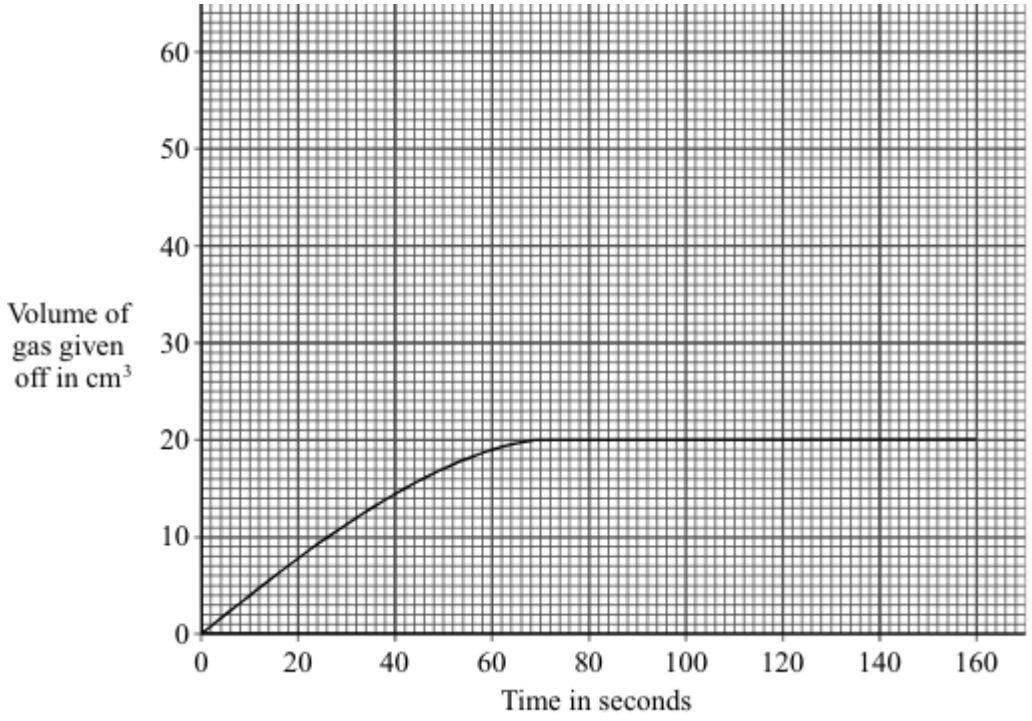
_____

(1)

(Total 8 marks)

Q22.

The graph shows the volume of gas given off during an experiment using hydrogen peroxide solution and manganese oxide.

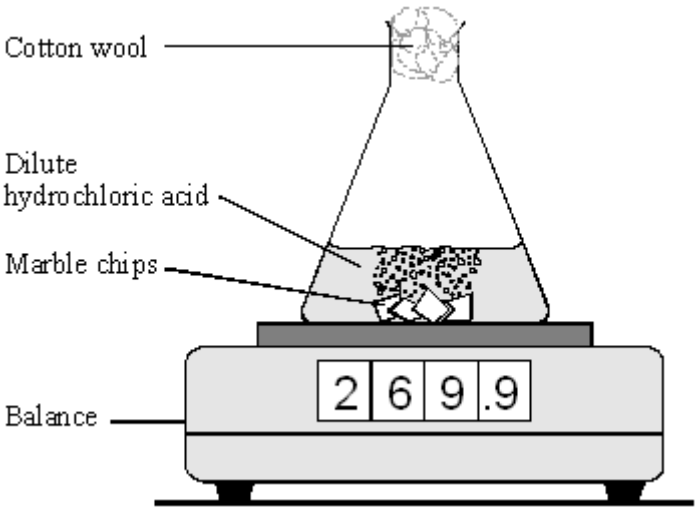


Draw, on the axes above, a graph to show the result you would expect if the volume of hydrogen peroxide solution had been the same, but it was **twice** as concentrated.

(Total 3 marks)

Q23.

The apparatus shown in the diagram was used to investigate the rate of reaction of excess marble chips with dilute hydrochloric acid, HCl. Marble is calcium carbonate, formula $CaCO_3$. The salt formed is calcium chloride, $CaCl_2$.



(a) Write a balanced equation for the reaction.

_____

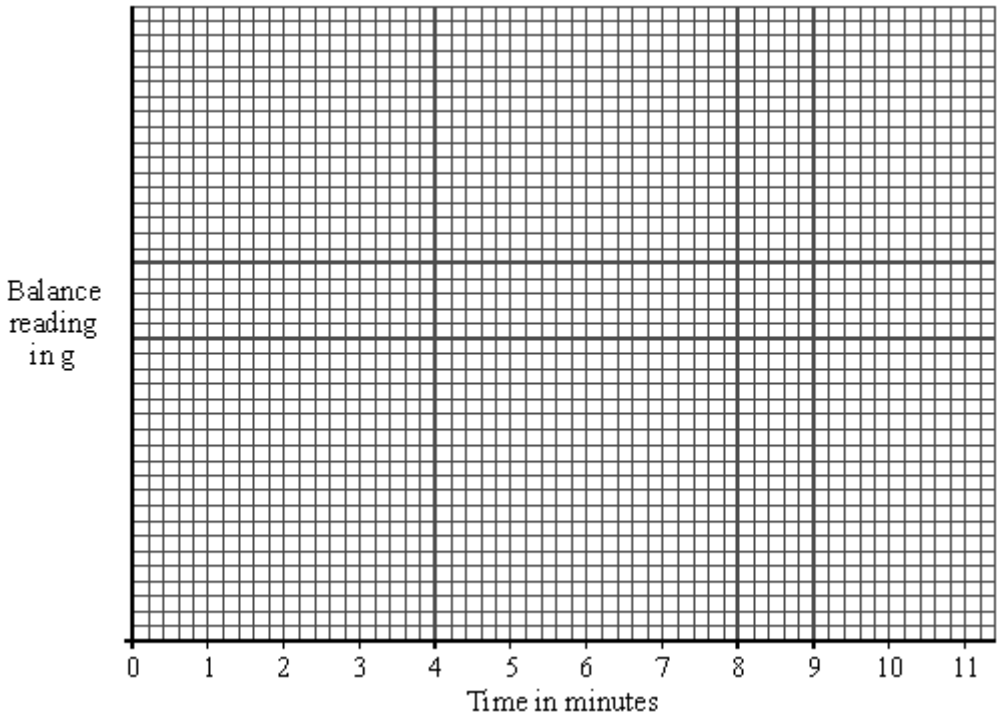
_____

(2)

The following results were obtained from the experiment.

Time in minutes	Reading on balance in g
0.5	269.6
1.0	269.3
2.0	269.0
3.0	268.8
5.0	268.7
9.0	268.6

(b) (i) Plot the results and draw a graph on the axes below.



(3)

(ii) Continue the graph you have drawn to show the expected reading after11 minutes.

(1)

(iii) On the axes above, sketch a graph of the result which would be obtained if in a similar experiment the same mass of powdered marble was used instead of marble chips.

(2)

(Total 8 marks)

Q24.

Potassium reacts violently with cold water.

It forms an alkaline solution of potassium hydroxide and hydrogen.

potassium + **water** → **potassium hydroxide** + **hydrogen**

(a) In what physical state is hydrogen given off?

Choose your answer from the words in the box.

gas	liquid	solid	solution

_____

(1)

(b) (i) What type of substance will neutralise potassium hydroxide solution?

_____

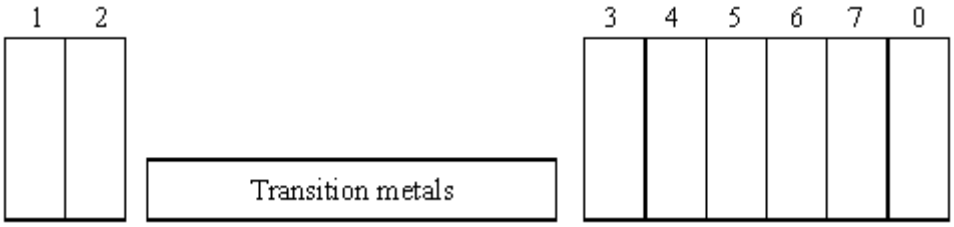
(1)

(ii) What is the pH of the neutral solution?

_____

(1)

(c) In the Periodic Table there are eight main groups.



What is the number of the group that has potassium in it?

_____

(1)

(d) Sodium is in the same group as potassium.

(i) How does sodium react with cold water and what is formed?

_____

_____

(2)

(ii) How can you prove that an alkaline solution is formed when sodium reacts with water?

_____

(2)

(e) Lithium reacts more slowly with cold water than sodium.

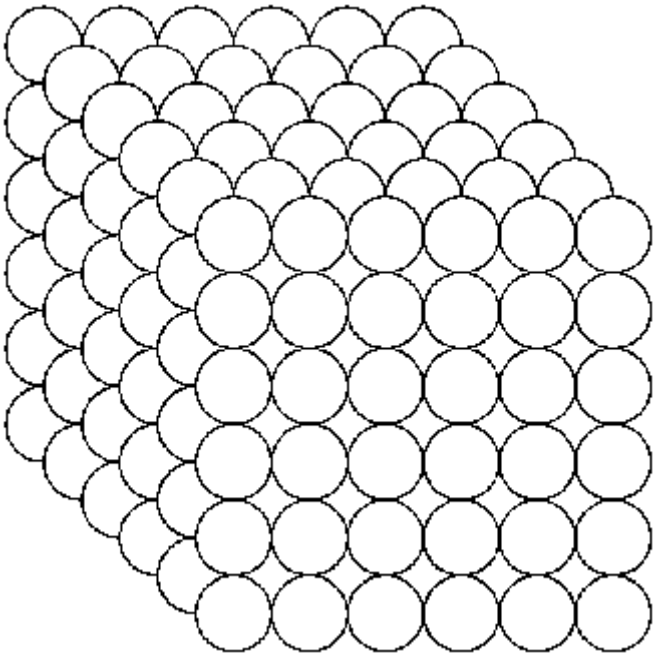
State **two** ways the reaction can be made to go faster.

(2)

(Total 10 marks)

Q25.

The diagram represents the particles in a piece of reactive metal.



The piece of reactive metal is added to dilute hydrochloric acid.

(a) (i) Which particle will probably react first?

Choose from:

- a particle inside the piece;
- a particle at the centre of a face;
- a particle on one of the corners.

(1)

(ii) Explain the reason for your choice.

(1)

(b) The reaction can be speeded up by making changes to the hydrochloric acid or the solid.

(i) State **two** ways to speed up the reaction by changing the hydrochloric acid. In each case explain in terms of particles why the reaction is faster.

1. _____

_____

_____

(2)

2. _____

_____

_____

(2)

(ii) What change can you make to the piece of solid to speed up the reaction? Explain in terms of the particles why the reaction is able to speed up.

_____

_____

(2)

(Total 8 marks)

Q26.

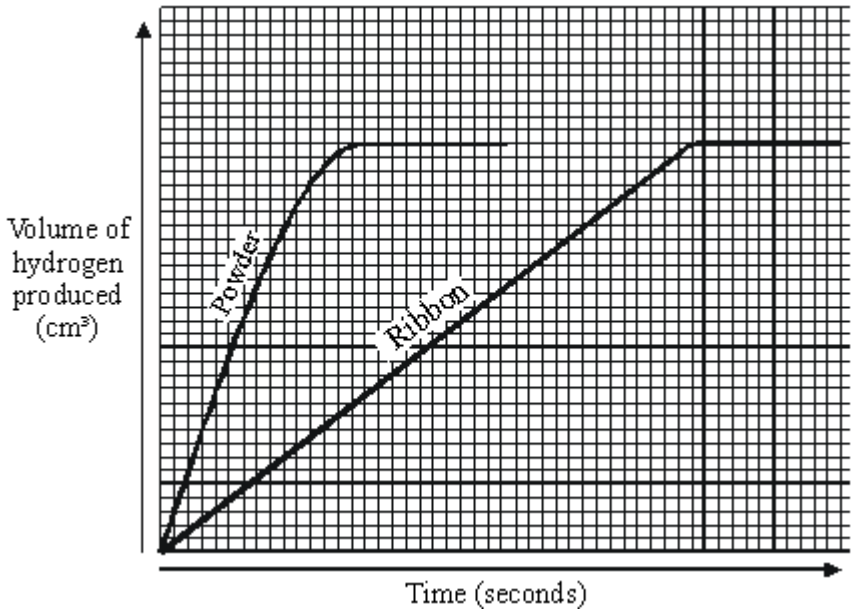
Some students were investigating how fast hydrogen gas is released in the reaction between magnesium and dilute hydrochloric acid.

To begin with they used 0.1 g of magnesium ribbon.

Next, they repeated the experiment using 0.1 g of magnesium powder.

In each case, they used enough acid to react with all the metal.

(a) Their results are shown on the graph below.



Hydrogen is produced in both the reactions.

Use the information on the graph to describe **two other** ways in which the two reactions are similar.

1. _____

_____

2. _____

_____

(2)

(b) Describe **one** way in which the reactions are different.

_____

_____

(1)

(Total 3 marks)

Q27.

Ammonia is manufactured by the Haber Process, where nitrogen and hydrogen react together as follows:

$N_2 + 3H_2 \Leftrightarrow 2NH_3$

The reaction is reversible. A balance is eventually reached when ammonia is being formed at the same rate at which it is decomposing.

This point is called 'equilibrium'.

	PERCENTAGE OF AMMONIA AT EQUILIBRIUM

PRESSURE (ATM)	100° C	300° C	500° C
25	91.7	27.4	2.9
100	96.7	52.5	10.6
400	99.4	79,7	31.9

(a) (i) What is meant by a 'reversible reaction'?

_____

_____

(1)

(ii) Which substances are present in the mixture at equilibrium?

_____

(1)

(b) (i) Under what conditions shown in the table is the maximum yield of ammonia obtained?

_____

_____

(2)

(ii) The Haber Process is usually carried out at a higher temperature than that which would produce the maximum yield. Suggest why.

_____

_____

_____

_____

(2)

(c) Ammonia can be converted into nitric acid in three stages:

Stage 1 Ammonia reacts with oxygen from the air to form nitrogen monoxide and water

$$4NH_3 + 5O_2 \longrightarrow 4NO + 6H_2O$$

Stage 2 On cooling, nitrogen monoxide reacts with oxygen from the air to form nitrogen dioxide.

Stage 3 Nitrogen dioxide reacts with water to form nitric acid and nitrogen monoxide.

(i) Describe the conditions under which the reaction in Stage 1 takes place.

_____

_____

_____

_____

(3)

(ii) Balance the equation for the reaction at Stage 2.

$NO + O_2 \longrightarrow NO_2$

(1)

(iii) Balance the equation for the reaction at Stage 3.

$NO_2 + H_2O \longrightarrow HNO_3 + NO$

(1)

(d) The chemical plant for manufacturing ammonia is often on the same site as plants manufacturing nitric acid and fertilisers.

(i) What advantages will this have for the manufacturing company?

_____

_____

_____

_____

(2)

(ii) Briefly describe **two** important ways in which it is possible to reduce the environmental impact of such plants on the surrounding area.

1. _____

_____

2. _____

_____

(2)

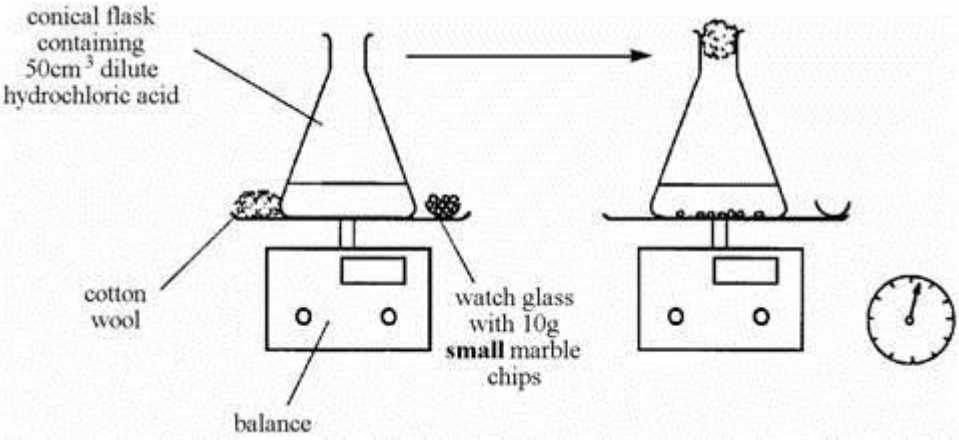
(Total 15 marks)

Q28.

Marble chips (calcium carbonate) react with dilute hydrochloric acid.

calcium carbonate + hydrochloric acid → calcium chloride + carbon dioxide + water

A student wanted to find out if the size of the marble chips made a difference to how fast the reaction took place.



(a) What readings should she take?

_____

_____

_____

(2)

(b) She repeated the experiment but this time used the same mass (10g) of **large** marble chips. In both experiments there was some marble left in the flask when the reaction stopped.

These are the results of the two experiments.

TIME (minutes)	0	2	4	6	8	10	12
Loss in mass (g), using small chips	0.00	0.40	0.72	0.91	1.04	1.04	1.04
Loss in mass (g), using large chips	0.00	0.28	0.52	0.70	0.84	0.94	1.04

(i) Explain the loss in mass in the two experiments.

_____

_____

_____

_____

(1)

(ii) What difference does the size of the chips make?

_____

_____

(1)

(c) A chemical reaction occurs when reacting particles collide with sufficient energy. The reaction between marble and hydrochloric acid is faster if the acid is at a higher

temperature. Explain why.

_____

_____

_____

_____

(3)

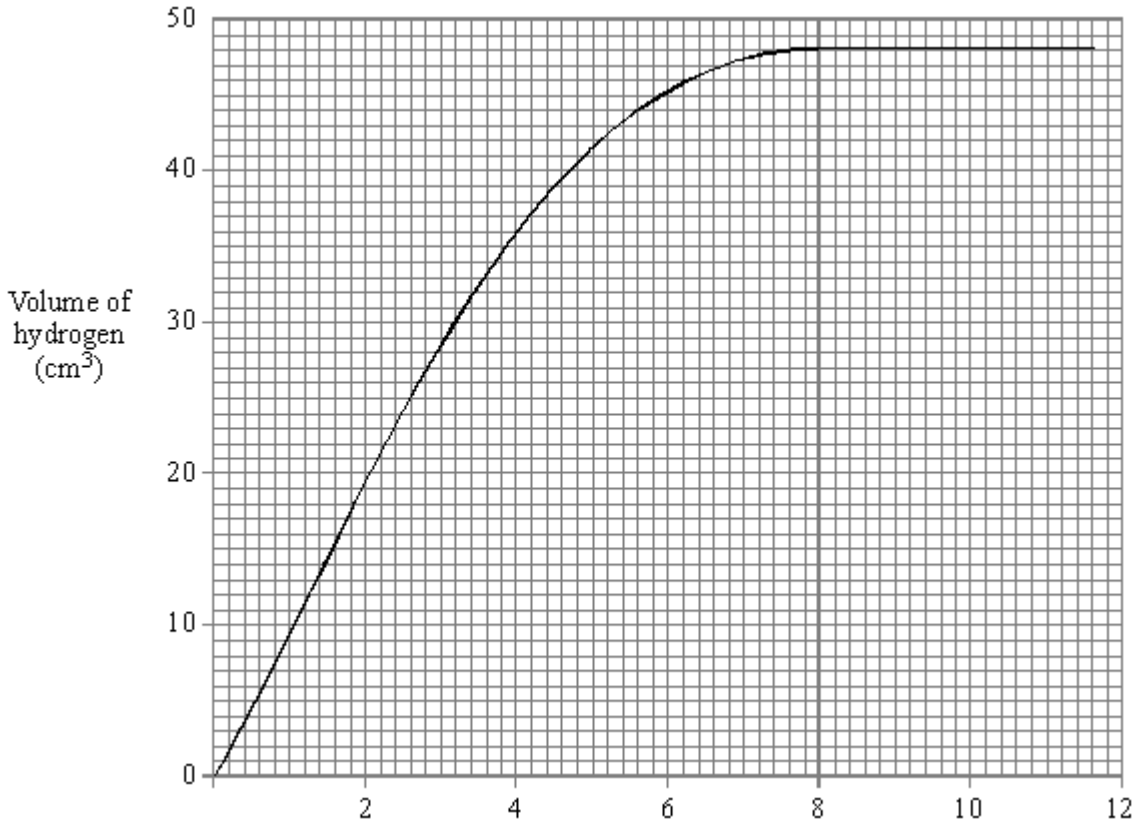
(Total 7 marks)

Q29.

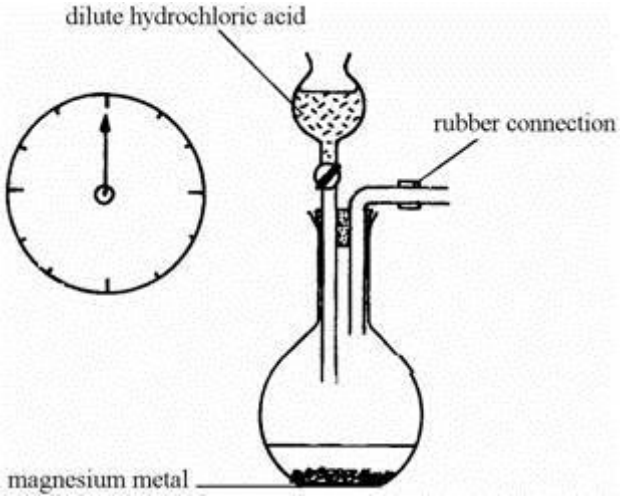
A student does an experiment to examine the rate of reaction between magnesium and dilute hydrochloric acid.
She adds 25 cm^3 of the acid to a weighed amount of the metal.
The reaction produces hydrogen gas.

Magnesium + hydrochloric acid ⟶ magnesium + hydrogen chloride

She collects the gas and measures the volume collected at one minute intervals.
All the metal reacted but there was some acid left unreacted.
Her results are shown on the graph.



(a) The diagram shows part of the apparatus she used for the experiment.
Complete the diagram to show how the student could collect the hydrogen produced and measure the volume after each minute.



(2)

(b) (i) When is the rate of reaction at its fastest?

_____

(1)

(ii) State **one** way in which she could increase the rate of reaction.

_____

(1)

(c) (i) What is the total volume of hydrogen collected in the experiment?

_____ cm^3

(1)

(ii) State **one** way in which she could increase the final volume of hydrogen collected.

_____

(1)

(Total 6 marks)

Mark schemes

Q1.

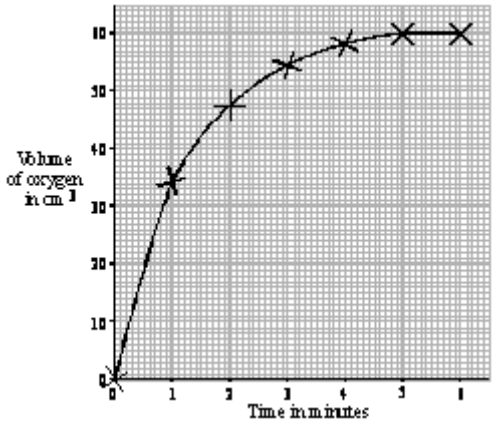
(a) (i) H_2O must be formula

1

(ii) catalyst

1

(b) (i)



correct plotting

2

1 *mark deducted per error to a maximum of* ***2***

do ***not*** *accept a complete dot-to-dot line*

do ***not*** *accept a bar chart if the (0,0) point is missing and line to one minute missing then maximum mark is* ***2***

best fit single line

if curve correct but no obvious points award ***3****marks*

1

(ii) 4.5 – 5

no units required

1

(iii) all <u>hydrogen peroxide</u> had reacted

accept all <u>hydrogen peroxide</u> had decomposed ***or*** *been used up*

accept no <u>hydrogen peroxide</u> (particles) left

1

(c) (i) remains lower than previous line

do ***not*** *accept bar chart*

1

line levels off lower than $60cm^3$

correct points but no line drawn then maximum ***1*** *mark*

1

(ii) decrease of (hydrogen peroxide) concentration

accept concentration is less

accept fewer collisions (of particles)

*do **not** accept weaker solutions **or** dilute solutions*

1

[10]

Q2.

(a) (i) 78-80%

1

(ii) proteins

accept amino acids

1

(b) (i) natural gas

accept methane (CH_4)

accept water (H_2O)

1

(ii) carbon dioxide

1

(c) (i) $N_2 + H_2$

1

correct balancing $1 + 3 \rightarrow 2$

award only if reactants are correct

1

(ii) iron

accept Fe

1

(iii) at low temperatures rate of reaction is too slow

accept very few collisions at low temperatures

accept converse

particles need enough (activation) energy to react

accept particles need enough energy for bonds to break

accept converse

1

(d) all three covalent bonds displayed correctly as electron pairs

1

two lone electrons displayed not necessarily as a pair

1

[11]

Q3.

(a) (i) (s) (aq) (l) (g)

*2 **or** 3 correct **1** mark*
*1 correct **0** marks*

2

(ii) calcium chloride

1

(b) (i) points

*deduct **1** mark for each error to a maximum of **2** marks*

2

line

accept a single line 'best fit' curve
accept reasonable attempt at curve

1

(ii) increase temperature **or** heat

*accept increase surface area **or***
*increase concentration **or** description*

1

(iii) 75% or ¾

not pure 1 mark
only 60 cm^3 (instead of 80 cm^3 of gas)

or $\frac{60}{80}$ × *100 **1** mark*

3

[10]

Q4.

(a) (i) iron **must** be named

*do **not** accept Fe*

1

(ii) hydrogen

1

and oxygen mixtures

1

burn rapidly

1

(b) (i) lowers concentration

accept dilutes the acid
*do **not** accept cooling*

1

less collisions (between particles)

1

(ii) H^+ (aq)

accept H_3O^+ only if 2 in front of H_2O

1

OH^- (aq)

*if spectator ions correctly included on both sides, maximum = **1** mark*

1

(iii) $Ca(OH_2)$ weak alkali

accept NaOH strong alkali

1

$Ca(OH)_2$ causes no problems

accept NaOH causes named problem
*(eg caustic **or** exothermic **or** burns **or** corrosive)*

1

[10]

Q5.

(a) increase concentration of acid;
increase surface area of solid
or grind up the solid;
add a catalyst

any two for 1 mark each

2

(b) 1;
it is the one that makes the gas fastest (steeper curve etc)
(second part is dependant on first)

for 1 mark each

2

(c) (i) faster after one minute, slower after 2 minutes

for 1 mark

1

(ii) the reactants get used up;
so concentration decreases/less chance of collision

for 1 mark each

2

[7]

Q6.

(a) (i) $H^+ + OH^- \rightarrow H_2O / H_3O^+ + OH^- \rightarrow 2H_2O$

for 1 mark

1

(ii) 1 point from e.g.
smaller bits
bigger surface area
faster reaction
dissolve faster
more particles open to attack by acid

any 1 for 1 mark

1

(iii) $MgCO_3$ or $MG^{2+}CO_3^{2-}$ or CO_3 Mg

for 1 mark

1

(b) (i) 2 HCl

for 1 mark

1

(ii) aqueous/<u>dissolved</u> in water (not in solution)

for 1 mark

1

(iii) CO_2/gas evolved/gas has mass

for 1 mark

1

(c) (i) plotting points
scales
curve
labelling axes including units

for 1 mark each

4

(d) faster
same final mass

for 1 mark each

2

[12]

Q7.

<u>Effect of pressure</u>

- high pressure increases yield

for 1 mark

- <u>either</u> because less product molecules (Le Chatelier)
<u>or</u> but high pressure increases cost/safety

for 1 mark

<u>Effect of temperature</u>

- low temperature increases yield

for 1 mark

- <u>either</u> because exothermic reaction (Le Chatelier)

for 1 mark

- <u>or</u> but at low temperature rate is slow/catalyst does not work

<u>Compromise</u>

- optimum conditions to balance rate and % yield

for 1 mark

- or rate is slow (at higher temperature) so need a catalyst
  or low percentage conversion so recycle untreated gases

[5]

Q8.

(a) (i) test tube / boiling tube

for 1 mark

1

(ii) Na_2CO_3
NaCl

each for 1 mark

2

(b) (i) flask
measuring cylinder

each for 1 mark

2

(ii) used smaller pieces

gains 1 mark

but larger surface area for reaction

gains 2 marks

2

(c) (i) steeper line
straight line

each for 1 mark

2

(ii) reaction occurs when particles collide
higher temperature, higher speed of particles
so harder collisions
more frequent collisions

any three for 1 mark each

3

[12]

Q9.

Factor 1

heating the solution / heat / increasing temperature / candidates can gain one mark here for the idea of the water evaporating faster with increased heat (so heating the reactants faster).

particles (of fat and sodium hydroxide) move faster (not vibration / not just move more) / more kinetic energy

collide more often / more collisions

have more energy when they collide / more successful collisions

Factor 2

concentrated (solution of alkali)

more (sodium hydroxide) particles (in a given volume) particles closer/ more crowded etc.

more collisions / greater chance of successful collisions

each for 1 mark

Possible alternative answer

size of fat pieces / small pieces of fat

have larger surface area

more collisions / greater chance of collisions

[7]

Q10.

(a) (i) 4 E (H-O) = 4 × 464 = 1856
2 E (O-O) = 2 × l46 = 292

gains 1 mark each

but Total = 2148 kJ
Deduct one mark for each mistake.
Answer of 1074 kJ gains 1 mark. (Candidate has ignored the 2 in front of the brackets.)

gains 2 marks

2

(ii) 4 E (H-O) = 4 × 464 = 1856
E (O=O) = 498

gains 1 mark each

but Total = 2354 kJ
Deduct one mark for each mistake.
Answer of 1426 kJ gains 1 mark. (Candidate has ignored the 2 in front of the brackets.)

gains 2 marks

2

(iii) 2354 – 2148 = 206 kJ (Ignore any signs)
Answer is consequential on their answers to (i) and (ii).

for 1 mark

1

(iv) exothermic because (more) heat is given out (than put it) / or
ΔH is negative /answer to (iii) is negative.).
(If the candidate gives the answer ‘endothermic because heat /energy is taken in’ then look back to their answers to (i) and (ii). If (i) is greater than (ii) then accept this answer.

for 1 mark

1

(b) (i) eg minimum energy for reaction
energy needed to start a reaction
energy needed to break bonds
energy needed to make two substances react
(Energy linked to starting a reaction.)
for 1 mark

1

(ii) B
for 1 mark

1

(iii) lowers activation energy / needs less energy to start reaction / less energetic route
for 1 mark

1

[9]

Q11.

(a) NO_2 / $2NO_{2(g)}$ / Nitrogen dioxide
for one mark

1

(b) particles of gas move / they move

reject spread out
particles move randomly / mix / go between air molecules / diffusion
any two for 1 mark each

2

(c) faster reaction / more surface area (*not* smaller pieces)
for one mark

1

(d) (i) **either** lower temperature / particles move slower
fewer collisions (owtte) / less energetic collisions / owtte
or acid diluted (owtte)
fewer collisions (owtte)
for 1 mark each

2

(ii) alkali <u>neutralises</u> the acid / stops the reaction
or water will only slow the reaction not stop it
either for 1 mark

1

[7]

Q12.

(a) oxygen
Ignore any numbers
accept hydrogen oxide / steam

1

water

1

(b) catalyst

1

[3]

Q13.

(a) the concentration of the (nitric) acid is decreasing

*accept the number of acid particles is decreasing **or** there are fewer collisions*

1

(the volume of carbon dioxide remains at 83 cm^3)
when the concentration of the (nitric) acid is zero

*accept no acid remains **or** all the acid is used up **or** no acid particles*

1

(b) line starts at origin is steeper **and** remains to the left of the original line

1

graph line levels off at 83 cm^3 **and** before 12 minutes

tolerance ± square

1

(c) change the temperature

*accept increase **or** decrease the temperature*
*accept change (increase **or** decrease) the concentration (of the nitric acid)*
*ignore amounts of reactants **or** changes in pressure **or** stirring **or** use of catalyst*

1

[5]

Q14.

(a) oxidising

1

(b) (i) oxygen

ignore any numbers

1

(ii) (catalyst) speeds up a (chemical reaction)

accept changes the rate (of reaction)

1

[3]

Q15.

(a) **A** faster because: the graph line steeper / the reaction had stopped earlier

*accept sample **B** slower because: the graph line was <u>less steep</u> / the reaction stopped later*

A because CO_2 given off faster / fizzes more for 1 mark

***B** because CO_2 given off slower / fizzes less for 1 mark*

2

(b) increases the speed / energy of the (hydrochloric acid) particles

1

collide more frequently

1

collide more energetically / successfully

accept more successful collisions = 2 marks

1

[5]

Q16.

(a) increases % / amount of ammonia

1

favours the forward reaction

1

(b) reaction(s) would be too slow

1

(c) any **three** from:

- rate increased
- decreases % / amount of ammonia
- the forward reaction is exothermic
- the backward reaction is endothermic
- backward reaction favoured / forward reaction not favoured
- yield / amount of nitrogen and hydrogen increased
- the relative amount (yield) of ammonia decreases as the equilibrium is changed
- the relative amount (yield) of nitrogen and hydrogen increases as the equilibrium is changed

explanations in terms of particles are neutral

3

[6]

Q17.

(a) (i) catalyst / enzyme

1

(ii) any **two** from

do not accept increase volume of peroxide

- heat
- stir / shake
- increase concentration of peroxide / catalyst

2

(b) oxygen lost

do not allow incorrect gas

1

[4]

Q18.

(a) (i) 2.25

correct answer gains three marks
if incorrect allow 1 mark for 2 correct readings (130 and 175) and further mark for 45 ÷ 20
allow e.c.f.

3

(ii) concentration of reactant(s) lower

1

fewer collisions per second / time unit

1

(b) labour costs lower / enzymes costs lower

not *stop and start*

1

[6]

Q19.

(a) ammonium nitrate

accept NH_4NO_3
do ***not*** *accept ammonia nitrate*

1

(b) different reactions need different catalysts

1

(c) they are used over and over again

accept they are reused
accept they are not used up
accept they are not changed
recycling is neutral

1

(d) any **two** from

they speed up reactions

they reduce energy requirements

accept allow reactions to take place at a lower temperature

they reduce costs

accept make process more economic

2

(e) (high pressure) increases the frequency of collisions

accept more collisions
move faster is neutral

1

this increases the rate of reaction

accept 'more successful collisions' for 2 marks

1

[7]

Q20.

(i) (Y)
more gas / carbon dioxide given off

1

(ii) (X)
curve / slope steeper

accept rises more rapidly / only took 30 seconds

1

(iii) (flat)
since calcium carbonate /
substrate all used up

accept the reaction has stopped /
no more gas is being produced *1*

1

[3]

Q21.

(a) $Zn + \mathbf{2}HC1 \rightarrow ZnC1_2 + H_2$

1

(b) (i) 12.5

1

(ii) steeper curve same volume of gas evolved

do not credit two intersects of straight lines
accept a sharp bend

2

(iii) any **two** from:

stir it

accept mix it better

heat it

accept warm it

use a more finely divided catalyst

accept use a better catalyst or more finely divided zinc

do not credit use acid of a higher

2

(c) (i) any **one** from

zinc is more reactive than copper

accept zinc is above copper in the reactivity series

zinc displaces copper

accept it is higher than copper in the reactivity series

1

(ii) zinc + copper sulphate → copper + zinc sulphate

*ignore the presence of acid **or** water*

accept a balanced equation

1

[8]

Q22.

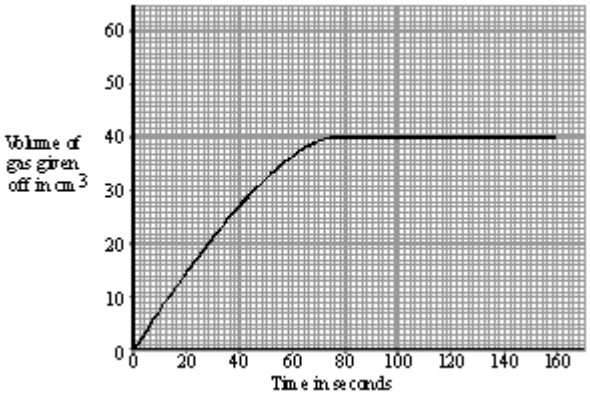
graph steeper

1

becomes horizontal

1

reaches twice the height, 40 cm^3 ± 1 cm^3



1

[3]

Q23.

(a) $CaCO_3$ + **2**HC1 → $CaC1_2$ + **CO_2 + H_2O**

*one mark for CO_2 and H_2O **or** H_2CO_3*

one mark for balancing the equation

2

(b) (i) linear suitable scale for y axis

± *one small square*

1

accurate plots

deduct one mark for each error plot

1

smooth curve through the points **or** a line of best fit

this mark requires a neat smooth curve

1

(ii) curve becomes almost horizontal at **or** above 268.5

do not credit a straight line reaching 268.5 at 11 mins

accept a plot at 268.6

1

(iii) steeper initial part to curve

1

becoming nearly horizontal between 268.6 and 268.4 g

1

[8]

Q24.

(a) gas

1

(b) (i) acid

ignore any reference to a particular kind of acid

1

(ii) 7

1

(c) 1

*credit potassium **or** K written into Group 1*

1

(d) (i) reacts rapidly **or** quickly **or** fast

*credit melts **or** fizzes **or** dissolves **or** violently **or** less violently (than K)*

1

sodium hydroxide **or** hydrogen

*credit NAOH **or** H2*

1

(ii) add universal indicator

*credit add indicator **or** litmus **or** use pH paper*

1

turns blue **or** purple

credit 'it goes purple' providing something has been added to the water

1

(e) any two from

heat **or** warm

cut it up **or** have smaller pieces or larger surface area
*do not accept more lithium **or** less water*

stir

2

[10]

Q25.

(a) (i) corners
accept an arrow to any corner

1

(ii) more (surface) exposed
*accept can be attacked from more directions **or** more space around it*

1

(b) (i) 1 any **two** pairs from

more concentrated
answers may be in either order
do not accept more acid
*do not accept more powerful **or** stronger (but stronger is neutral)*
a reference to sulphuric acid is neutral

1

more particles to hit the solid
accept more collisions per second
do not accept more collisions

1

2 hotter solution **or** increasing temperature

(faster) particles hit more often **or** harder
*accept particles have more energy **or** are more powerful **or** more successful collisions*

1

3 stirring

more surface area exposed **or** particles available
accept more collisions per second
do not accept more collisions

1

(ii) cut it up **or** increase the surface area

accept grind it up ***or*** *powder it*
or *flatten it do not accept make it smaller*
or *use a smaller piece*

1

more particles are exposed **or** available **or** can react

accept heat it and there are more
successful collisions for both marks

1

[8]

Q26.

(a) both reactions slow down with time;
both reactions produce same volume of hydrogen

each for 1 mark

2

(b) *idea* rate is faster with powder
or *idea* rate is slower with ribbon

(allow powder completed before ribbon) for 1 mark

1

[3]

-

Q27.

(a) (i) *idea that it is*

a reaction in which the products can themselves react to reform the original substance or a reaction that can go in either direction

(allow explanation in terms of the specific reaction in the question)

for 1 mark

1

(ii) nitrogen, hydrogen and ammonia
(allow formulae)

for 1 mark

1

(b) (i) high pressure/400 atm
low temperature/100 °C

for 1 mark each

2

(ii) higher rate of <u>reaction</u>
good rate of <u>production</u>
or *idea* that more economic (ally viable)
(allow catalyst more effective at higher temperature)

for 1 mark each

2

(c) (i) *ideas that it involves*

use of catalyst
gains 1 mark

but use of platinum catalyst
gains 2 marks

2

high temperature/900 °C
for 1 mark

1

(ii) $\underline{2}\ NO + O_2 \rightarrow \underline{2}NO_2$
for 1 mark each

1

(iii) $\underline{3}\ NO_2 + H_2O \rightarrow \underline{2H}NO_3 + NO$
for 1 mark each

1

(d) (i) references to

- transport reductions
- economic savings
- saves time
- guaranteed consumer/supplier

for 1 mark each

2

(ii)
- selection of site
- design of plant
- safe disposal of waste
- make gas emissions safe(r)
- monitoring/safety checks
- reduction of waste gas emissions
- research into more efficient processes
- research into energy savings/use of cooling water
- training of staff re: emergency procedures
- warning/evacuation procedures for the community

(or any two sensible suggestions)
any two for 1 mark each

2

[15]

Q28.

(a) *ideas that*

- ref to read the balance / read the mass / weight
- ref to read the stop clock / read the time
- 'readings' taken at the beginning and end / at regular intervals

for 1 mark each

2

(b) (i)
- loss of carbon dioxide (from the flask) }

(ii)
- smaller chips give faster reaction / reaction } **mark as a whole** finishes quicker /dissolved faster *[or reverse]* }
- smaller chips have a larger surface area }

any 2 for 1 mark each
[Allow converse answers]

2

(c) *ideas that*

- heating increases the speed / energy / vibration of the (acid) particles / marble particles
- (acid) particles <u>collide</u> (with marble chips / (particles)) more frequently / more likely to collide
- reacting particles collide with greater energy / collide faster
- so particles more likely to react *[do not accept* 'react faster'*]*

[Accept 'atoms', 'molecules' or 'ions' instead of 'particles' *in this question]*

any three for 1 mark each

3

[7]

Q29.

(a) (must be possible for the gas to enter and displace the water) **or** other suitable apparatus

- apparatus to collect the gas correctly assembled

for 1 mark

- **calibrated** collection vessel (award even if diagram is wrong)

for 1 mark

2

(b) (i) at the start / in the first 1/2 minutes (or any time within this range)

for 1 mark

1

(ii) increase the temperature / use smaller pieces of metal / use more metal / increase the surface area of the metal / add a catalyst / shake the flask / increase the concentration / strength of the acid

for 1 mark

1

(c) (i) 48

for 1 mark

1

(ii) increase the amount of magnesium used

for 1 mark
(do not allow increase the amount of acid used)

1

[6]