Summer Project

Name: _____

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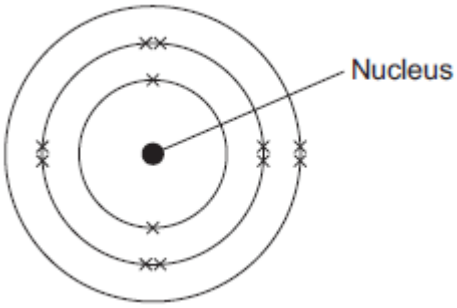
Q1. This question is about magnesium.

(a) (i) The electronic structure of a magnesium atom is shown below.



Which sub-atomic particles are found in the nucleus of a magnesium atom?

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Describe their relative charges and masses

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(4)

(ii) A magnesium atom reacts to produce a magnesium ion.

Draw a diagram to represent a magnesium ion

(2)

(b) Magnesium and dilute hydrochloric acid react to produce magnesium chloride solution and hydrogen.

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

(i) State **two** observations that could be made during the reaction.

1 .....

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2 .....

..... **(2)**

(ii) Describe a method for making pure, dry crystals of magnesium chloride from magnesium and dilute hydrochloric acid.

In your method you should name the apparatus you will use, and explain how you will maximise the purity of the magnesium chloride crystals produced

You do **not** need to mention safety.

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(6)
(Total 14 marks)

Q2. This question is about copper.

(a) Copper can be extracted by smelting copper-rich ores in a furnace.

The equation for one of the reactions in the smelting process is:

$$Cu_2S(s) + O_2(g) \longrightarrow 2\ Cu(s) + SO_2(g)$$

Explain why there would be an environmental problem if sulfur dioxide gas escaped into the atmosphere.

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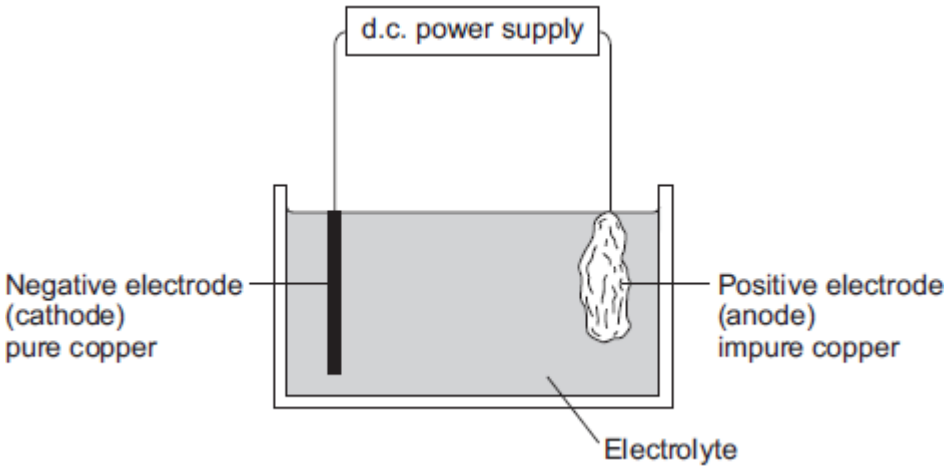
(2)

(b) The impure copper produced by smelting is purified by electrolysis, as shown below.



Copper atoms are oxidised at the positive electrode to Cu^{2+} ions, as shown in the half equation.

$$Cu(s) \longrightarrow Cu^{2+}(aq) + 2e^-$$

(i) How does the half equation show that copper atoms are oxidised?

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(1)

(ii) The Cu^{2+} ions are attracted to the negative electrode, where they are reduced to produce copper atoms.

Write a balanced half equation for the reaction at the negative electrode.

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(1)

(iii) Suggest a suitable electrolyte for the electrolysis.

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(1)

(c) Copper metal is used in electrical appliances.

Describe the bonding in a metal, and explain why metals conduct electricity.

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(4)

(d) Soil near copper mines is often contaminated with low percentages of copper compounds.

Phytomining is a new way to extract copper compounds from soil.

Describe how copper compounds are extracted by phytomining.

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(3)

(e) A compound in a copper ore has the following percentage composition by mass:

55.6% copper, 16.4% iron, 28.0% sulfur.

Calculate the empirical formula of the compound.

Relative atomic masses (A_r): S = 32; Fe = 56; Cu = 63.5

You must show all of your working.

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Empirical formula = ...

(4)

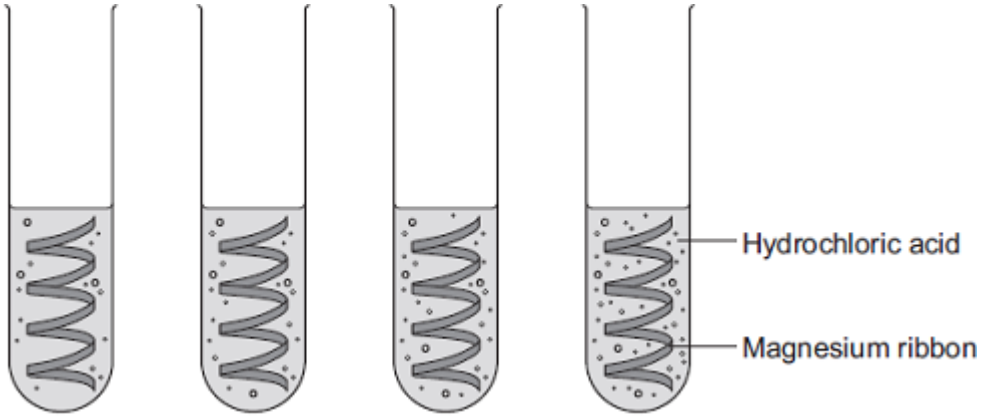
(Total 16 marks)

Q3. A student investigated the rate of reaction of magnesium and hydrochloric acid.

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

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

She measured the time for the magnesium to stop reacting.



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

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

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

1 .....

2 .....

(2)

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

Explain why.

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..... **(2)**

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

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..... **(3)**

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

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

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

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

Describe how she should use **titration** to obtain accurate results.

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(4)

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

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

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

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

Give your answer to three significant figures.

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

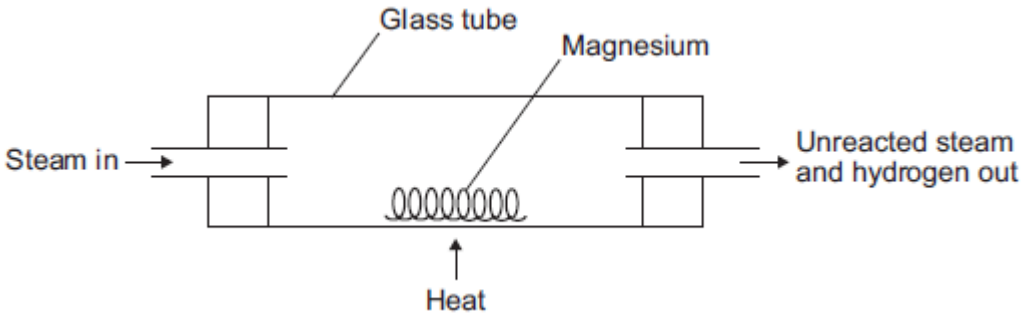
(3)

(Total 14 marks)

Q4. Magnesium reacts with steam to produce hydrogen gas and magnesium oxide.

A teacher demonstrated the reaction to a class.

The figure below shows the apparatus the teacher used.



(a) (i) The hydrogen produced was collected.

Describe how to test the gas to show that it is hydrogen.

Test .....

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Result .....

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(2)

(ii) Explain why the magnesium has to be heated to start the reaction.

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(2)

(b) The equation for the reaction is:

$$Mg(s) + H_2O(g) \longrightarrow MgO(s) + H_2(g)$$

(i) The teacher used 1.00 g of magnesium.

Use the equation to calculate the maximum mass of magnesium oxide produced.

Give your answer to three significant figures.

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

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Maximum mass = ... g **(3)**

(ii) The teacher's demonstration produced 1.50 g of magnesium oxide.

Use your answer from part (b)(i) to calculate the percentage yield.

If you could not answer part (b)(i), use 1.82 g as the maximum mass of magnesium oxide. This is **not** the answer to part (b)(i).

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Percentage yield = ... %

(2)

(iii) Suggest **one** reason why the percentage yield is less than 100%.

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(1)

(Total 10 marks)

Q5. 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.

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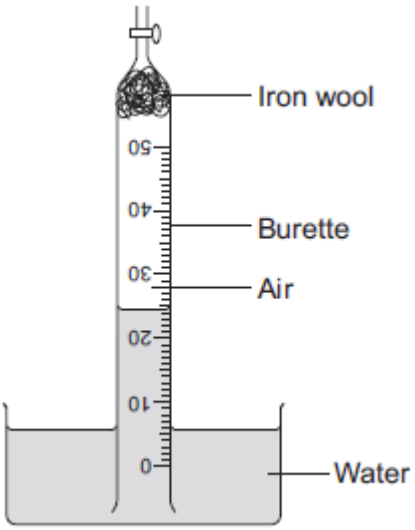
(1)

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

Figure 1

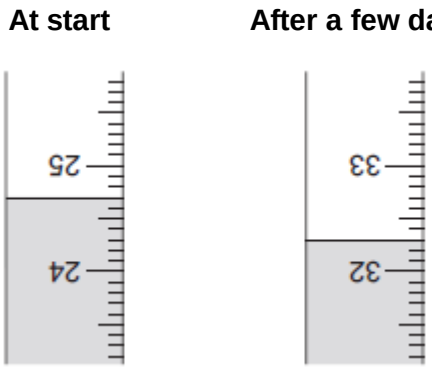


The student left the apparatus for a few days.

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

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

Figure 2



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

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

(1)

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

.....

Volume = ... cm^3

(1)

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

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

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

Explain why.

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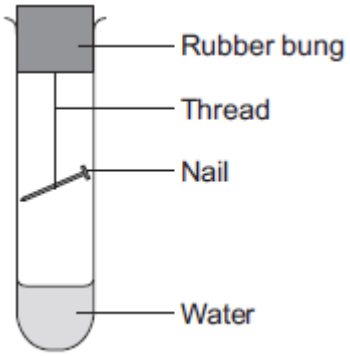
..... **(2)**

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

This is the method the student used:

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

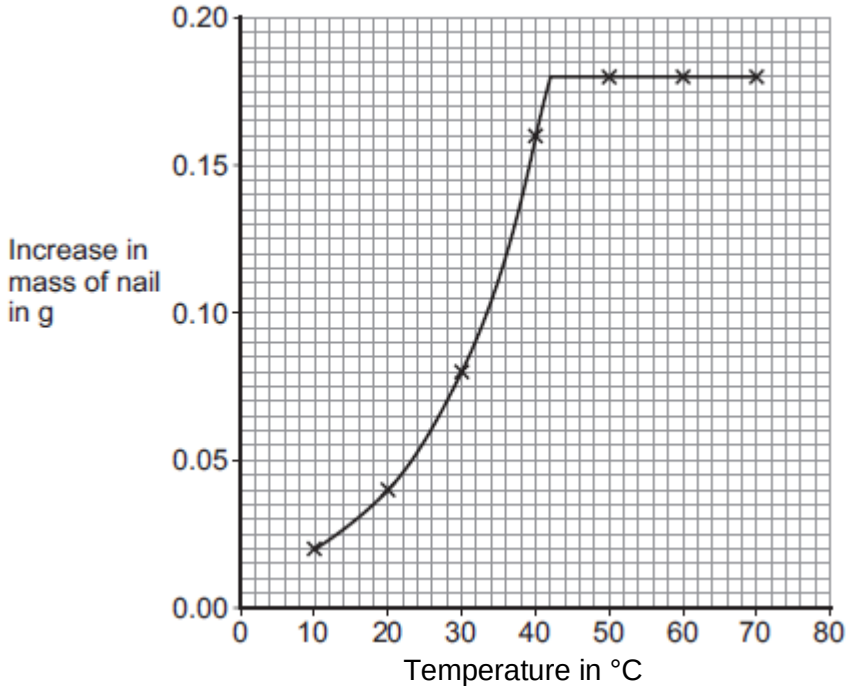
Figure 3



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

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

Figure 4



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

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..... **(1)**

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

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..... **(3)**

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

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

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

Give a reason for your answer.

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.....**(2)(Total 12 marks)**

Q6. Calcium chloride ($CaCl_2$) is a soluble salt.

Calcium chloride can be made by reacting dilute hydrochloric acid with either solid calcium oxide or solid calcium carbonate.

(a) Name the type of reaction that takes place when dilute hydrochloric acid reacts with calcium oxide.

..... **(1)**

(b) Write a balanced symbol equation for the reaction of dilute hydrochloric acid with calcium oxide.

..... **(2)**

(c) A student added solid calcium oxide to dilute hydrochloric acid in a beaker.

The student added solid calcium carbonate to dilute hydrochloric acid in another beaker.

Describe **one** difference between the two reactions that the student would **see**.

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..... **(1)**

(d) Describe how crystals of calcium chloride can be made from calcium carbonate and dilute hydrochloric acid.

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..... **(4)**

(Total 7 marks)

Q7.(a) Ethanol (C_2H_5OH) is an alcohol.

(i) Draw the displayed structure of ethanol.

(1)

(ii) Complete combustion of ethanol produces carbon dioxide and water.

Complete the balanced symbol equation for this reaction.

C_2H_5OH + ...

(3)

(iii) Explain, in terms of energy transferred, why the combustion of ethanol is exothermic.

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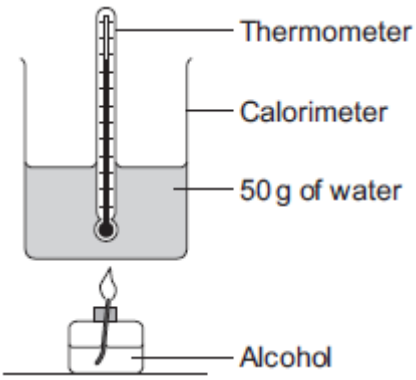
..... **(2)**

(b) A group of students investigated the amount of energy given out when different alcohols are burned. The students used the apparatus shown in the figure below.



In one experiment the temperature of 50 g of water increased from 22.5 °C to 38.3 °C. The mass of alcohol burned was 0.85 g.

(i) The energy used to heat the water, Q, can be found using the equation:

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

Where m = the mass of water, c = the specific heat capacity of water, and ΔT = the change in temperature

Calculate the heat energy, in joules, given out by burning 0.85 g of the alcohol.

Assume that all of the heat energy given out by burning the alcohol is used to heat the water (c = specific heat capacity of water = 4.2 J / g / °C).

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Heat energy = ... J **(2)**

(ii) Use your answer to part (b)(i)and the fact that 0.85 g of alcohol were burned to calculate the heat energy that would be given out by 1 g of alcohol.

If you could not answer part (b)(i), use 3000 J as the heat energy given out by burning 0.85 g of the alcohol. This is **not** the correct answer to part (b)(i).

.....

Heat energy = ... J

(1)

(c) Another group of students investigated the amount of heat energy given out when different alcohols are burned. They used a different, better, set of apparatus than the first group of students.

They used the results from their investigation to calculate the heat energy given out by burning 1 g of each alcohol.

They used a data book to find the theoretical amount of heat energy 1 g of each alcohol should have given out when burned completely.

The students recorded their experimental results and the theoretical values in the table below.

Name of alcohol	**Number of carbon atoms in one molecule of alcohol**	**Experimental amount of heat energy given out when 1 g is burned in kJ**	**Theoretical amount of heat energy given out when 1 g is burned completely in kJ**
Methanol	1	11.4	22.7
Ethanol	2	14.5	29.7
Propanol	3	16.0	33.7
Butanol	4	16.8	36.2
Pentanol	5	17.2	37.8
Hexanol	6	17.4	39.1

(i) What is the relationship between the number of carbon atoms in one molecule of the alcohol and the heat energy given out when the alcohol is burned?

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..... **(1)**

(ii) Suggest **one** reason why the students' experimental results are lower than the theoretical values.

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..... **(1)**

(iii) The students observed that as the number of carbon atoms in one molecule of the alcohol increased:

- the flame was more orange
- more carbon was left on the bottom of the calorimeter.

Suggest why.

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(1)

(iv) The heat energy given out when 1 g of ethanol (C_2H_5OH) is burned is 29.7 kJ.

Calculate the heat energy, in kilojoules, that will be given out when 1 mole of ethanol is burned.

Give your answer to three significant figures.

Relative atomic masses: H = 1; C = 12; O = 16

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Heat energy = ... kJ

(3)

(Total 16 marks)

Q8. Sodium thiosulfate solution reacts slowly with dilute hydrochloric acid.

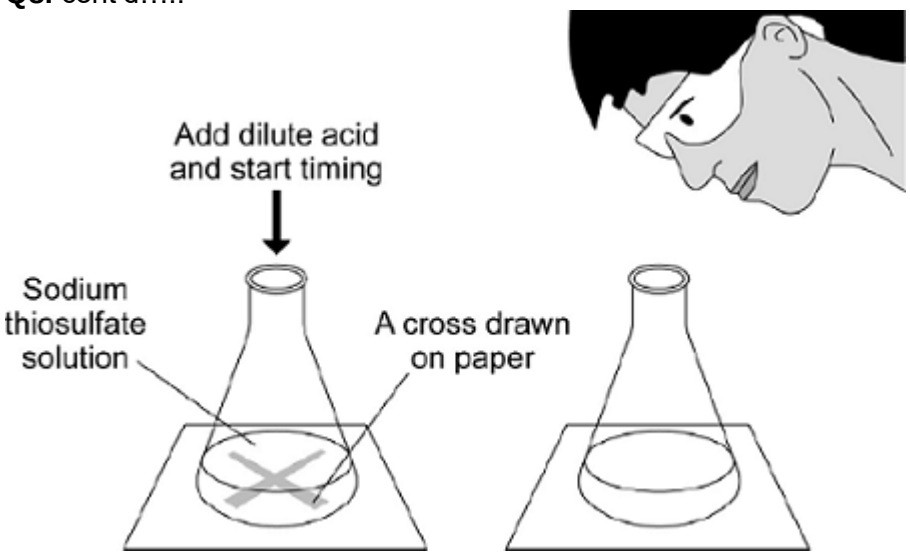
$$Na_2S_2O_3 + 2HCl \longrightarrow 2NaCl + S + SO_2 + H_2O$$

During the reaction a solid is made. This makes the reaction mixture become cloudy. The speed of the reaction can be followed by timing how long it takes for the reaction mixture to become too cloudy to be able to see through.

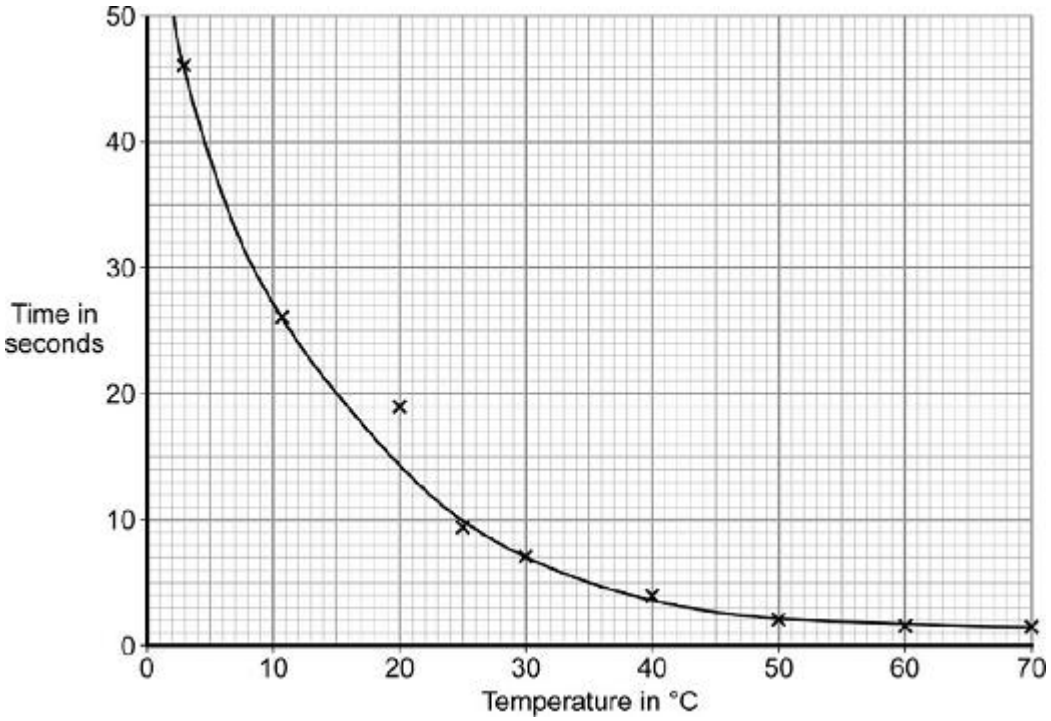
A student investigated how temperature affects the speed of the reaction.

- She used a measuring cylinder to measure out 10 cm^3 of sodium thiosulfate solution and 30 cm^3 of water. She mixed them together in a conical flask.
- She stood the conical flask on a cross drawn on a sheet of paper.
- She then added 5 cm^3 of dilute hydrochloric acid to the mixture and started her stopwatch.
- Once the mixture became so cloudy she could no longer see the cross, she recorded the time taken.
- She repeated the experiment at different temperatures by warming the reagents before she mixed them.

Q8. cont'd…..



(a) The student's results are shown on the graph.



(i) One of the points on the graph is anomalous. Draw a circle around this point. Suggest what could have happened in the experiment that may have caused this anomalous result.

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(2)

(ii) What conclusions can you draw from the graph?

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(2)

(iii) Use the graph to estimate how long it would have taken for the mark on the paper to no longer be visible at 15 °C.

..... seconds

(1)

(iv) Use the equation

rate = 1 ÷ time taken

to calculate the rate of reaction at 15 °C.

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Rate of reaction = ... s^{-1}

(1)

(v) For many reactions the rate of reaction doubles with every 10 °C increase in temperature.

Is this statement correct for this reaction? Justify your answer.

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(2)

(b) The teacher suggested that the student's results were less accurate at 60 °C than at 40 °C.

(i) Explain why the results may be less accurate at 60 °C.

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(2)

(ii) Suggest **one** change that the student could make to reduce error in this experiment.

Explain why this change would make the results more accurate.

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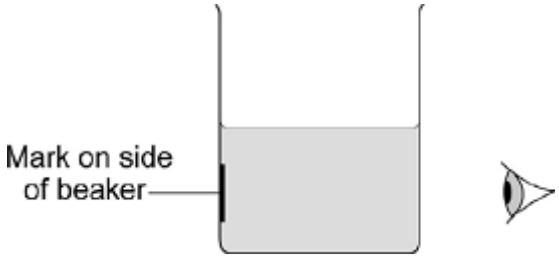
..... **(2)**

(c) A second student did the experiment, but used apparatus that was slightly different.



Both students timed how long it would take for the mark to become invisible at 20 °C. The results they obtained are given in the table.

	Time taken for mark to become invisible in s
first student using conical flask	18
second student using beaker	10

Both students then repeated the experiment using double the volume of all of the solutions.

(i) The student using the conical flask found that the time taken for the mark to become invisible was much shorter when the volumes were doubled.

Explain why the mark became invisible in a shorter time.

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..... **(1)**

(ii) What would happen to the result obtained by the student using the beaker when the volumes were doubled?

Explain your answer.

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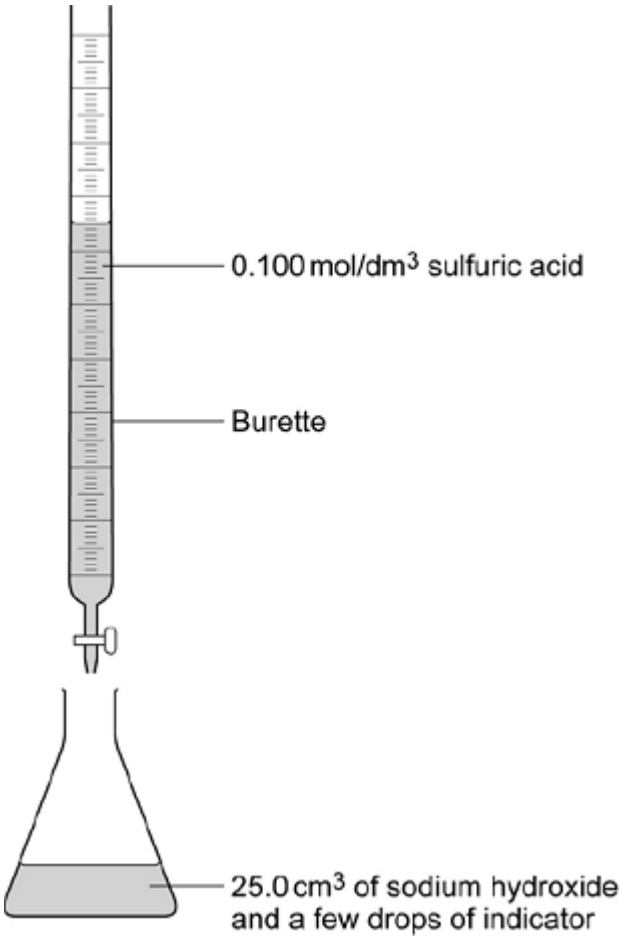
..... **(2)**

(Total 15 marks)

Q9. Some students were titrating sodium hydroxide solution against 0.100 mol/dm^3 sulfuric acid using the apparatus shown in the diagram.



(a) (i) A student first carried out a trial titration to find the approximate volume of 0.100 mol/dm^3 sulfuric acid needed to neutralise 25.0 cm^3 of sodium hydroxide solution.

Describe how the student would use the same apparatus to obtain an accurate value for the volume required to neutralise the sodium hydroxide.

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(6)

(ii) Give **one** safety precaution the student should use when doing the titration.

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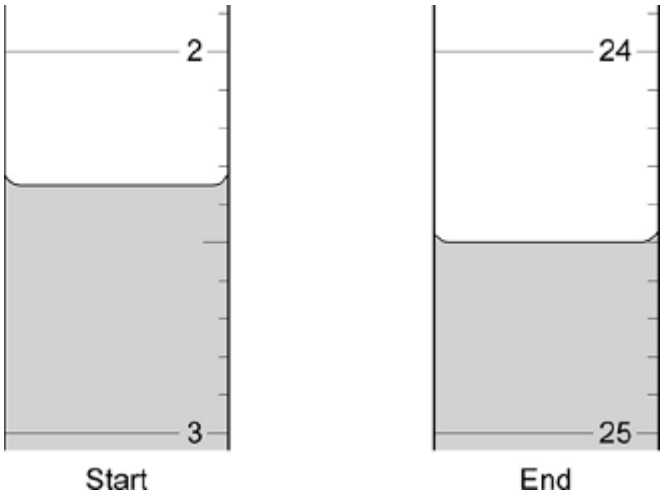
..... **(1)**

(b) The diagrams show the level of the sulfuric acid in the burette at the start and the end of one titration.



Use the diagrams to work out the volume of sulfuric acid added in the titration.

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..... cm^3 **(3)**

(c) The table shows the colours of some indicators that could be used in the titration.

Name of indicator	Colour in acid	Colour in alkali	Colour at end point
litmus	red	blue	purple
phenolphthalein	colourless	red	colourless
bromothymol blue	yellow	green	blue

Litmus is **not** a good choice for this titration.

Suggest why.

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..... **(1)**

(d) Another student obtained the following results.

end reading in cm^3	26.85	28.15	26.90	24.95
start reading in cm^3	1.75	4.85	3.65	1.65
volume added in cm^3	25.10	23.30	23.25	23.30

(i) Which results should the student use to calculate the mean volume of acid added?

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(1)

(ii) Calculate the mean from the results. Give your answer to 2 decimal places.

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Mean = ... cm^3

(2)

(e) One student found that 25.0 cm^3 of sodium hydroxide solution was neutralised by exactly 22.30 cm^3 of 0.100 mol/dm^3 sulfuric acid solution.

(i) Calculate the number of moles of sulfuric acid that this student used in the titration.

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number of moles = ...

(2)

(ii) The equation for the reaction of sulfuric acid with sodium hydroxide solution is:

$$H_2SO_4(aq) + 2\ NaOH(aq) \longrightarrow Na_2SO_4(aq) + 2\ H_2O(l)$$

Use your answer to (e)(i) and the equation to calculate the number of moles of sodium hydroxide that must have been used.

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number of moles = ...

(1)

(iii) Calculate the concentration, in mol/dm^3, of the sodium hydroxide solution used. Give your answer to 3 decimal places.

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Concentration = ... mol/dm^3

(2)

(Total 19 marks)