PEARSON EDEXCEL IGCSE CHEMISTRY · 4CH1

CHEMISTRY



EXAM QUESTION PACK

SECTION 3: PHYSICAL CHEMISTRY (PACK 3)

SCORE	PERCENTAGE
/232	%

STEMUP

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Q1.

This question is about metals.

(a) Metals can be arranged in a reactivity series based on their reactions with water and their reactions
with dilute hydrochloric acid.

The table shows how four metals, P, Q, R and S, react with water and with dilute hydrochloric acid.

Metal	Reaction with water	Reaction with dilute hydrochloric acid
P	no reaction	hydrogen gas forms very slowly
Q	no reaction	no reaction
R	hydrogen gas forms very quickly	not done
S	hydrogen gas forms quickly	hydrogen gas forms very quickly

(i) Identify which of the metals P, Q, R or S could be gold.

(1)

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(ii) Suggest why the reaction between metal R and dilute hydrochloric acid was not done.

(1)

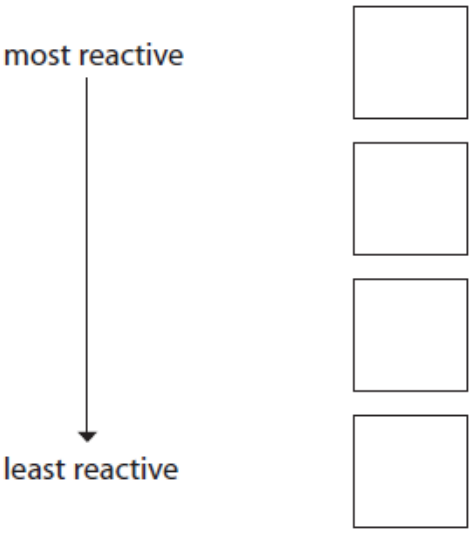
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(iii) Use the information in the table to place the metals in order of reactivity from most reactive to least reactive.

(1)



(b) Zinc is used to coat iron gates to prevent the iron from rusting.

(i) State the name of this method of preventing iron from rusting.

(1)

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(ii) State another method of preventing iron from rusting.

(1)

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(c) A mixture of zinc powder and copper(II) oxide is heated.

The chemical equation for the reaction that takes place is

$$Zn + CuO \rightarrow ZnO + Cu$$

(i) State how the reaction shows that zinc is more reactive than copper.

(1)

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(ii) Explain which substance is the oxidising agent.

(2)

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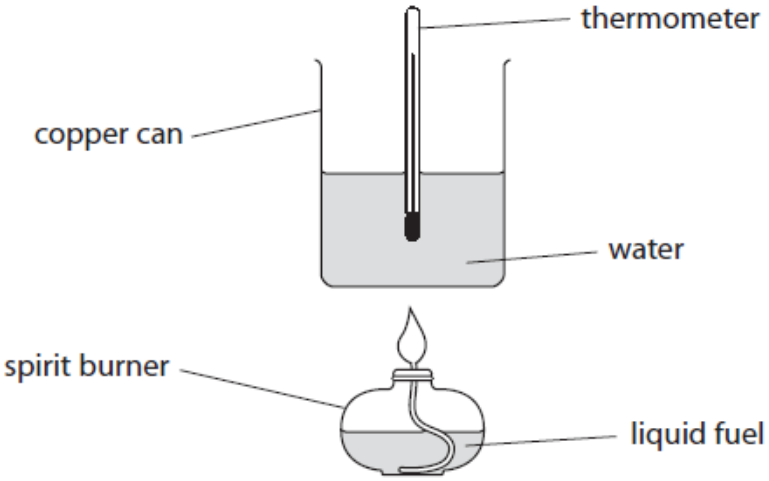
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(Total for question = 8 marks)

Q2.

A student uses this apparatus to investigate the heat energy released when a liquid fuel is burned.



This is the student's method.

- measure the mass of the spirit burner and fuel
- add 100 cm^3 of water to the copper can
- record the temperature of the water
- use the spirit burner to heat the water until the temperature rises by 30 °C
- immediately measure the new mass of the spirit burner and fuel

(a) Suggest why the student measures the mass of the spirit burner and fuel immediately after heating the water.

(1)

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(b) When the fuel is burned, the student notices that a black solid forms on the bottom of the copper can.

(i) Identify the black solid.

(1)

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(ii) Explain why the black solid forms.

(2)

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(c) (i) Show that the heat energy change, Q, to raise the temperature of 100 cm^3 of water by 30 °C is approximately 13 kJ.

[mass of 1.0 cm^3 of water = 1.0 g]

[c for water = 4.2 J/g/ °C]

(3)

(ii) The student burns 0.96 g of methanol, CH_3OH

Calculate the molar enthalpy change, ΔH, in kJ/mol, for the combustion of methanol.

Include a sign in your answer.

[M_r of methanol = 32]

(3)

ΔH = ... kJ/mol

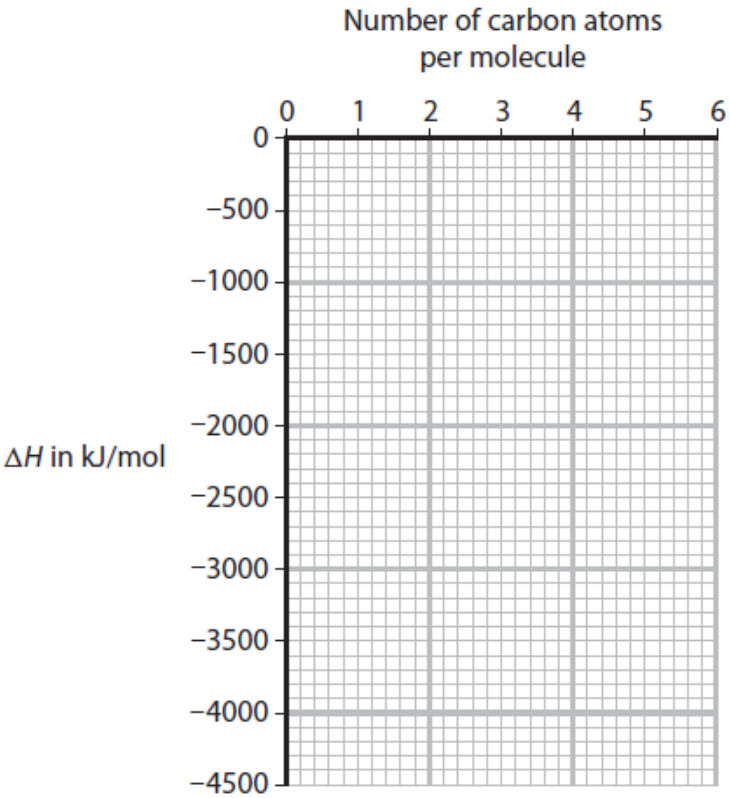
(d) The table shows data book values for the molar enthalpy change, ΔH, for the combustion of some alcohols with different numbers of carbon atoms per molecule.

Number of carbon atoms per molecule	1	2	3	4	5
Molar enthalpy change, ΔH, in kJ/mol	−730	−1370	−2020	−2680	−3320

(i) Plot the data values from the table on the grid.

Draw a straight line of best fit.

(2)



(ii) Deduce the value of Δ*H* for an alcohol with six carbon atoms per molecule.

Show on the graph how you obtained your answer.

(2)

Δ*H* = ... kJ/mol

(iii) State the relationship between Δ*H* and the number of carbon atoms per molecule.

(1)

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.....

(Total for question = 15 marks)

Q3.

This question is about nitrogen and some of its compounds.

(a) Nitrogen and oxygen do not react together at room temperature.

At the high temperatures in a car engine, nitrogen and oxygen react to form nitrogen monoxide, NO

(i) Give a chemical equation for this reaction.

(1)

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(ii) Give a reason why this reaction only occurs at high temperatures.

(1)

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.....

(iii) State why it is important that oxides of nitrogen are not released into the atmosphere.

(1)

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(b) Nitrogen monoxide gas can be removed from car exhaust fumes when it reacts with carbon monoxide gas.

(i) The rate of the reaction is increased by passing the gases over a catalyst.

Explain how a catalyst increases the rate of a reaction.

(2)

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(ii) Explain how increasing the pressure of gases increases the rate of reaction.

(3)

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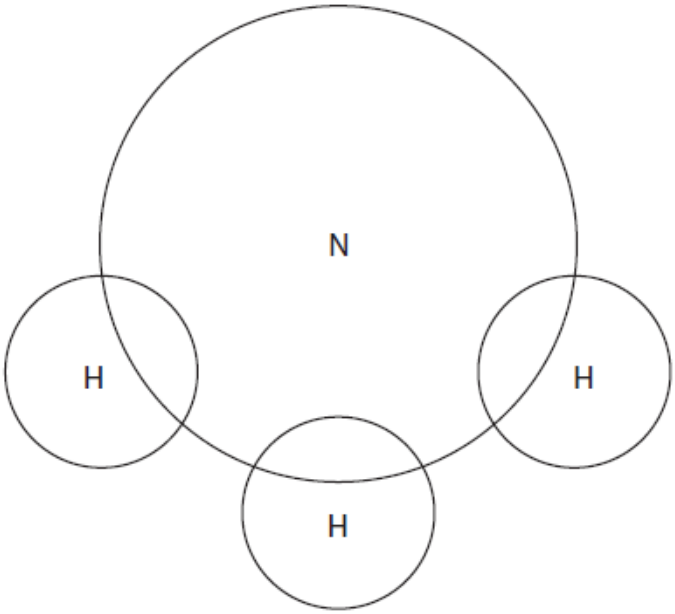
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(c) Ammonia is a simple molecule with the formula NH_3

(i) Complete the diagram to show the outer shell electrons in ammonia.

(2)



(ii) The bonds in ammonia are covalent.

Describe the forces of attraction in a covalent bond.

(2)

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(iii) Explain why ammonia has a low boiling point.

(2)

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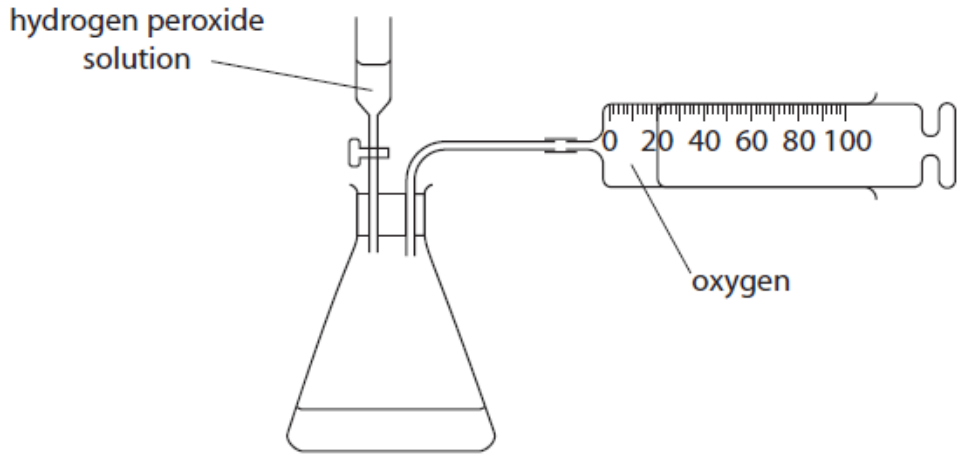
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(Total for question = 14 marks)

Q4.

A student uses this apparatus to investigate the rate of oxygen production by the decomposition of hydrogen peroxide solution, H_2O_2



(a) Give a test to show that the gas collected is oxygen.

(1)

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(b) This experiment is repeated with 1 g of a solid catalyst in the conical flask.

The rate of reaction is greater in this experiment.

Describe how the student can show that the solid is a catalyst and not a reactant.

(3)

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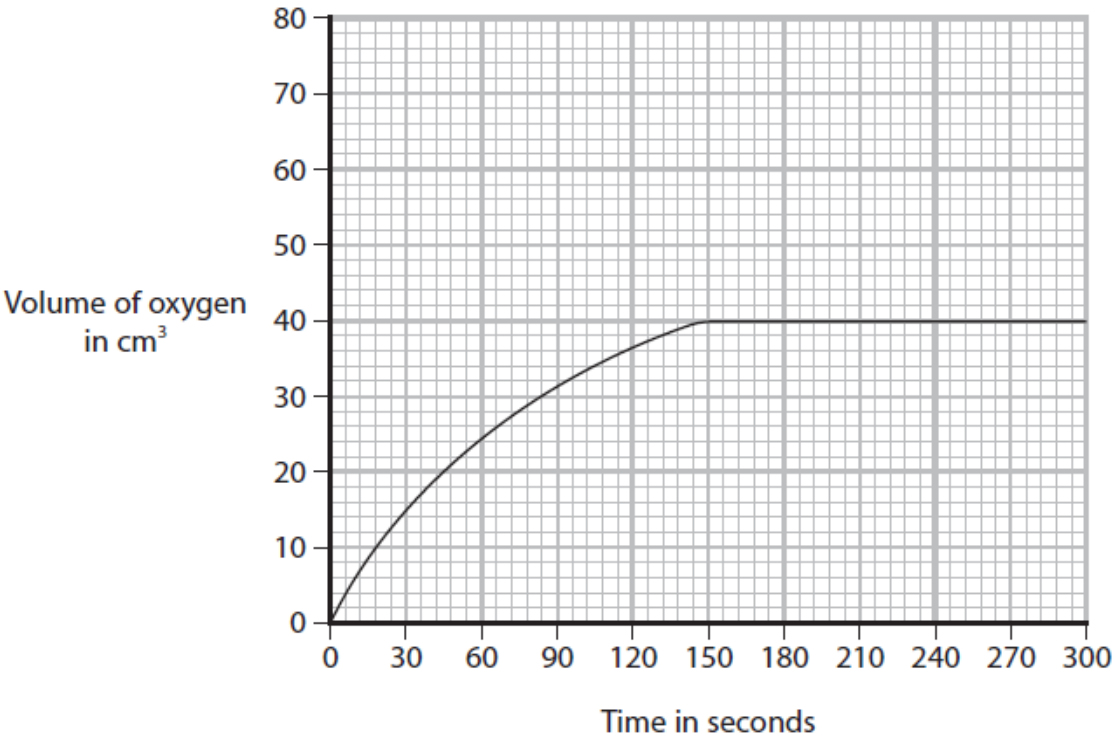
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(c) The graph shows the volume of oxygen collected at 20 °C.



The experiment is done at 40 °C using the same volume and the same concentration of hydrogen peroxide solution.

On the grid, sketch the curve you would expect to obtain.

(2)

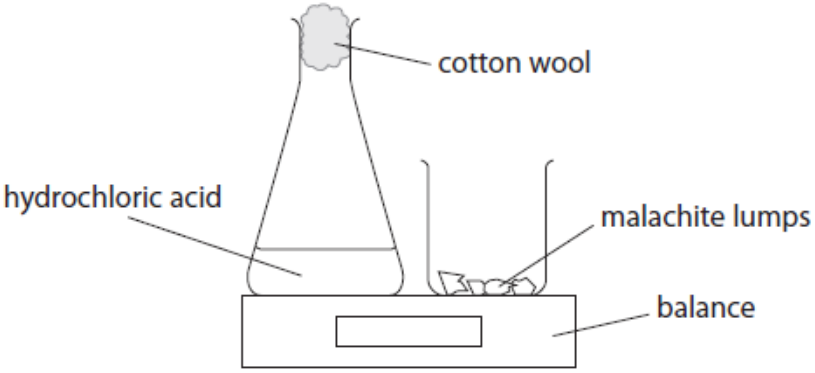
(Total for question = 6 marks)

Q5.

The copper(II) carbonate in the mineral, malachite, reacts with hydrochloric acid according to this equation.

$$CuCO_3(s) + 2HCl(aq) \rightarrow CuCl_2(aq) + H_2O(g) + CO_2(g)$$

Some students investigate the effect of changing the concentration of acid on the rate of this reaction. The diagram shows the apparatus they use.



This is the method they use:

- set the balance to zero
- add an excess of malachite lumps to the conical flask and replace the cotton wool
- start a timer and record the balance reading after one minute.

The experiment is repeated using different concentrations of hydrochloric acid. The mass and number of malachite lumps are kept the same in each experiment.

(a) The table shows the results obtained in one series of experiments.

concentration of hydrochloric acid / mol/dm^3	0.6	0.8	1.0	1.6	1.8	2.0
balance reading / g	−0.20	−0.27	−0.44	−0.54	−0.60	−0.67

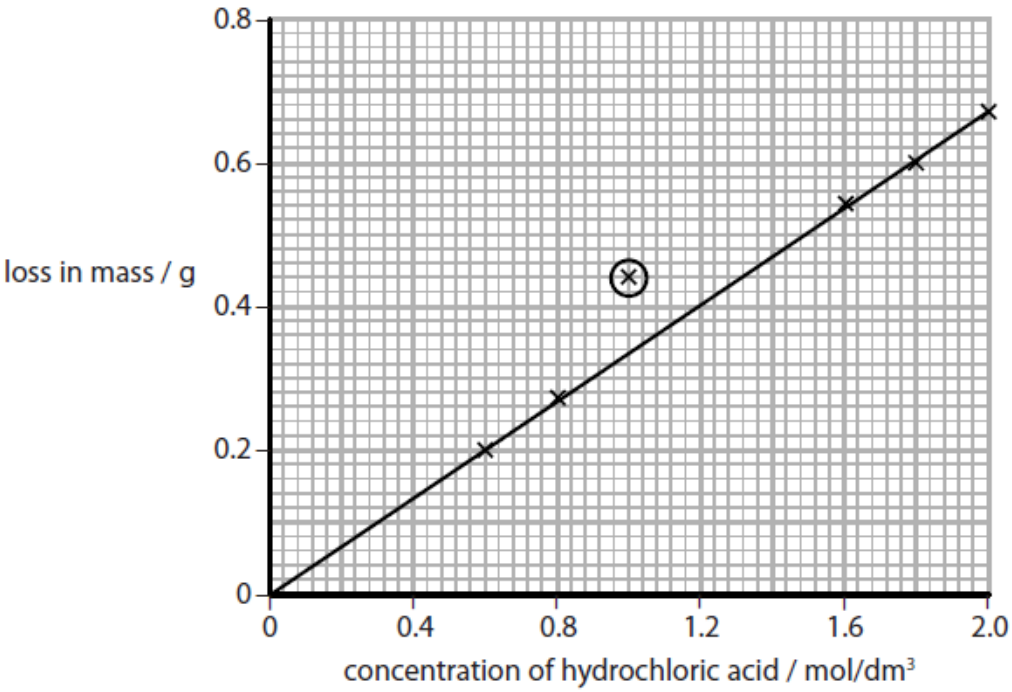
State why the balance readings have negative values.

(1)

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(b) The graph shows the results of this series of experiments.



The circled point indicates an anomalous result.

(i) Suggest **one** mistake the students could have made to produce this result.

(1)

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(ii) State the relationship shown by the graph.

(1)

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(c) Explain why an increase in the concentration of the acid causes an increase in the rate of the reaction. You should use the particle collision theory in your answer.

(2)

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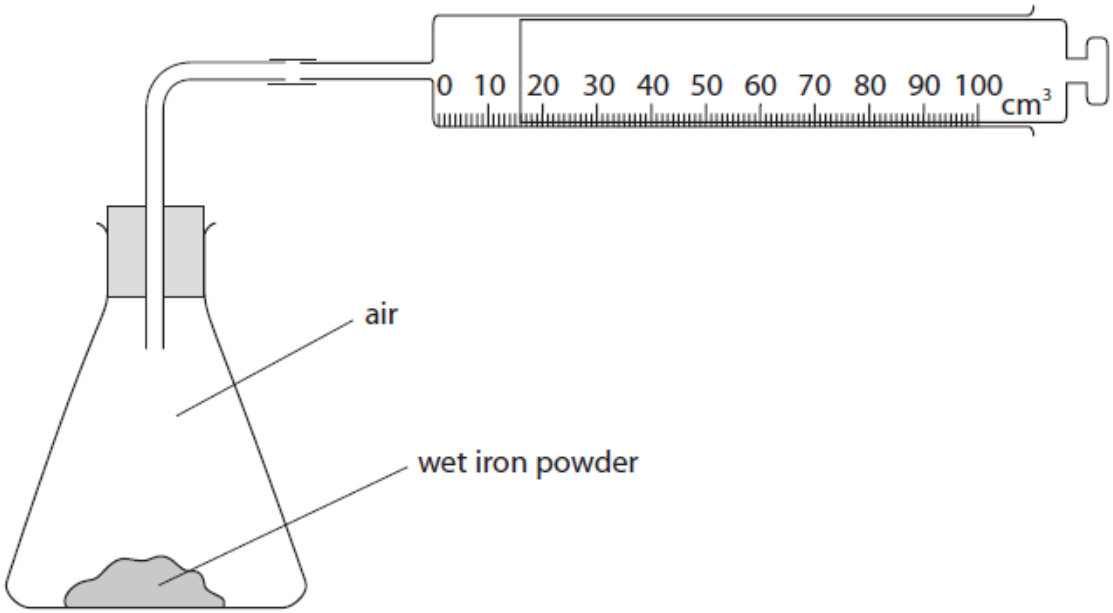
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(Total for question = 5 marks)

Q6.

A student uses the reaction between iron and oxygen to find the percentage of oxygen in air.

The diagram shows the apparatus the student uses.



(a) (i) State why the iron powder needs to be wet.

(1)

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(ii) State the colour of the compound formed in the reaction between iron and oxygen.

(1)

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(iii) Give the formula of the compound formed.

(1)

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(iv) Explain the advantage of using iron powder rather than pieces of iron.

(2)

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(b) The syringe in the diagram shows the reading at the end of the experiment.

Complete table 1 to show the readings on the syringe.

Give both values to the nearest 1 cm^3.

(2)

syringe reading at start	
syringe reading at end	
change in volume in cm^3	65

Table 1

(c) The student repeats the experiment and obtains a different set of results.

Table 2 shows these results.

volume of air in conical flask and glass tube in cm^3	260
syringe reading at start	90
syringe reading at end	22

Table 2

Use the results from table 2 to calculate the percentage by volume of oxygen in the air.

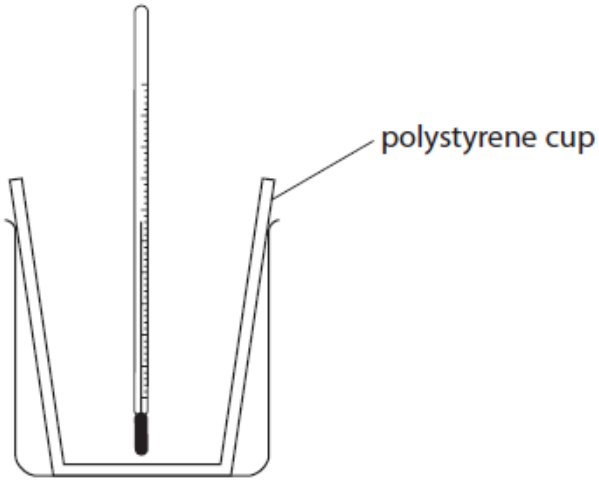
(3)

percentage by volume of oxygen in air = ... %

(Total for question = 10 marks)

Q7.

A student uses this apparatus to investigate the reaction between potassium hydroxide solution and dilute hydrochloric acid.



This is her method.

- pour 25 cm^3 of potassium hydroxide solution into a polystyrene cup and record the temperature of the solution
- pour 25 cm^3 of dilute hydrochloric acid into a measuring cylinder and record the temperature of the acid
- add the acid to the polystyrene cup and stir the mixture
- record the highest temperature reached

(a) (i) Give a word equation for the reaction between potassium hydroxide and hydrochloric acid.

(1)

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(ii) Explain why the student needs to stir the mixture.

(2)

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(b) The table gives the temperatures of the solutions before the student mixes them.

potassium hydroxide solution	17.8 °C
dilute hydrochloric acid	18.4 °C

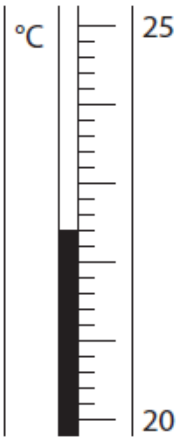
Calculate the mean (average) temperature of the two solutions.

(2)

mean temperature = ... °C

(c) The student repeats the experiment on a different day, using 25 cm^3 of potassium hydroxide solution and 25 cm^3 of
dilute hydrochloric acid.

The thermometer shows the highest temperature reached at the **end** of the experiment.



(i) Complete the table by giving the missing information.

Give both temperatures to the nearest 0.1 °C.

(2)

mean temperature at start in °C	
temperature at end in °C	
temperature rise in °C	5.2

(ii) Show that the heat energy change, *Q*, in the student's experiment is about 1100 J.

[for the mixture, c = 4.2 J/g/°C]

[mass of 1.0 cm^3 of mixture = 1.0 g]

(3)

(iii) The student uses 0.020 mol of potassium hydroxide in his experiment.

Calculate the enthalpy change (ΔH) in kJ/mol, for 1.0 mol of potassium hydroxide.

Include a sign in your answer.

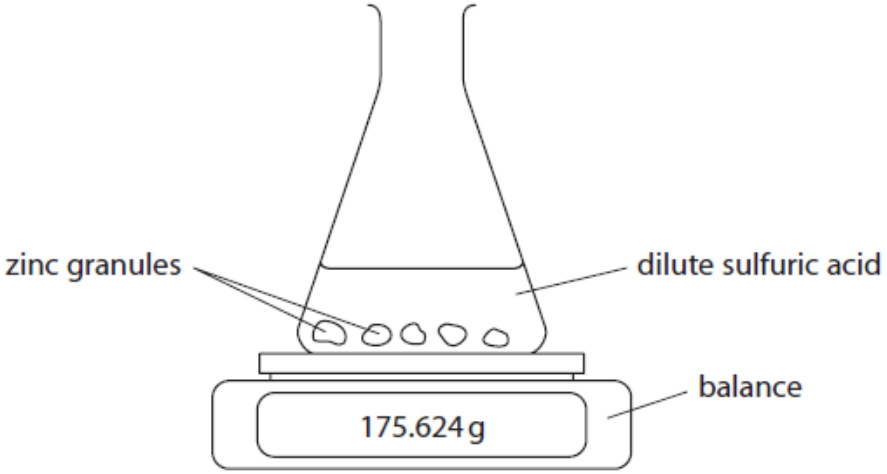
(3)

ΔH = ... kJ/mol

(Total for question = 13 marks)

Q8.

A student uses this apparatus in an experiment to study the rate of the reaction between zinc and dilute sulfuric acid.



This is the student's method.

- add a few zinc granules to a conical flask on a balance
- of dilute sulfuric acid to the flask, start a timer and immediately record the mass of the flask and contents
- record the mass of the flask and contents every minute until the mass remains constant

The mass of the flask and contents decreases because hydrogen gas is produced and leaves the flask.

The student uses the mass readings to calculate the total mass of hydrogen produced.

(1)

$$Zn\ (.....) + H_2SO_4\ (.....) \rightarrow ZnSO_4\ (.....) + H_2\ (.....)$$

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

Time in minutes	Total mass of hydrogen produced in mg
0	0
1	80
2	110
3	130
4	148
5	162
6	165
7	184
8	192
9	198
10	204
11	209
12	214
13	218
14	220
15	220

(i) Plot the student's results. The first three have been done for you.

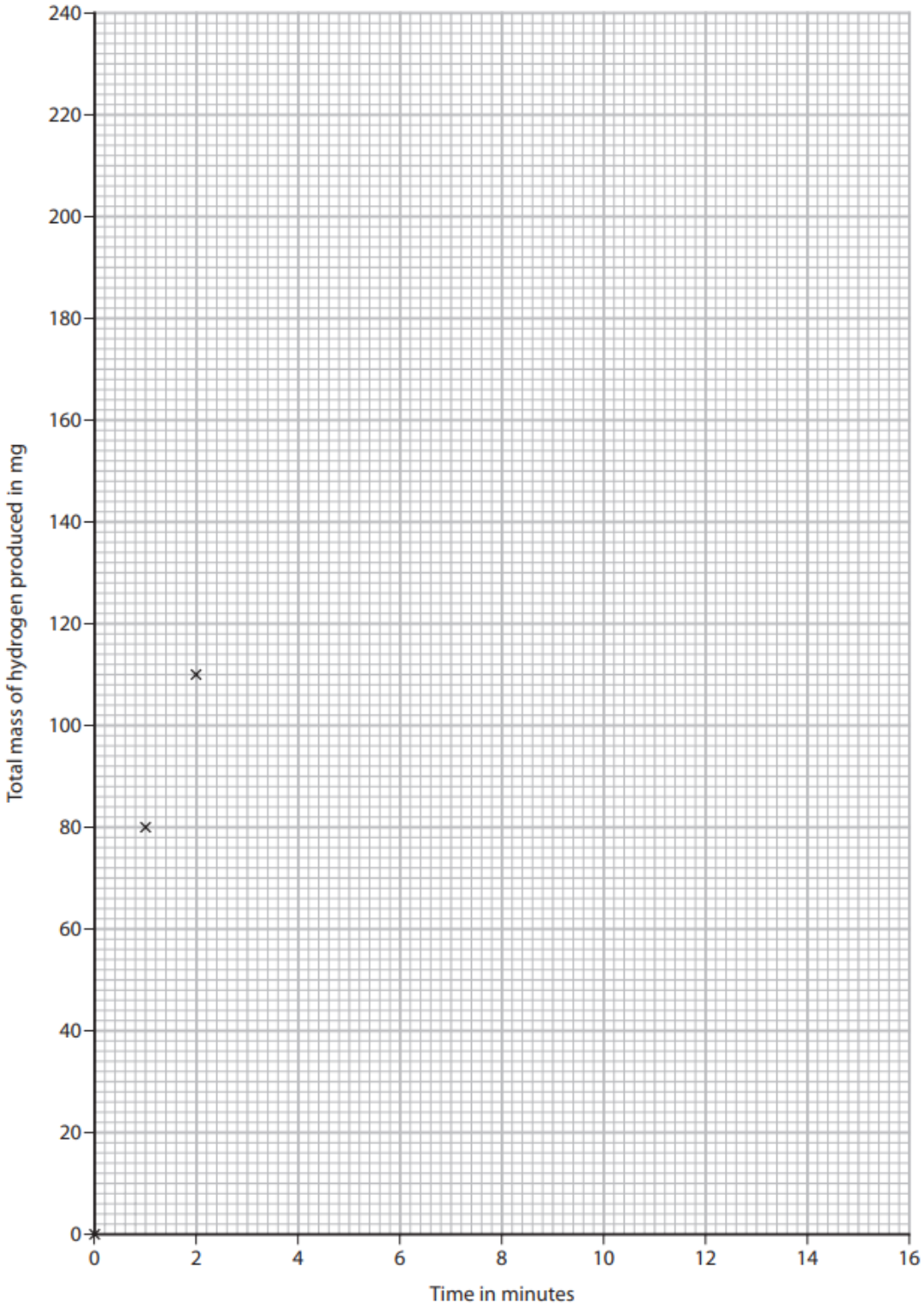
(1)

(ii) Draw a circle around the anomalous result.

(1)

(iii) Draw a curve of best fit.

(1)



(iv) Give a possible reason for the anomalous result.

(1)

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(v) Determine a more likely value for this result.

(1)

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(c) (i) Explain how the shape of the curve shows how the rate of the reaction changes as time increases.

(2)

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(ii) At the end of the experiment there is no zinc left in the flask.

Give a conclusion the student could make from this observation.

(1)

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(d) The student does another experiment using

- the same amount of similarly sized magnesium granules instead of zinc
- the same volume of sulfuric acid, but of a lower concentration

Explain why it is difficult to predict how the rate of reaction in this experiment compares with the rate of reaction in the first experiment.

(3)

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(e) Explain, in terms of particle collision theory, how increasing the temperature affects the rate of a reaction.

(3)

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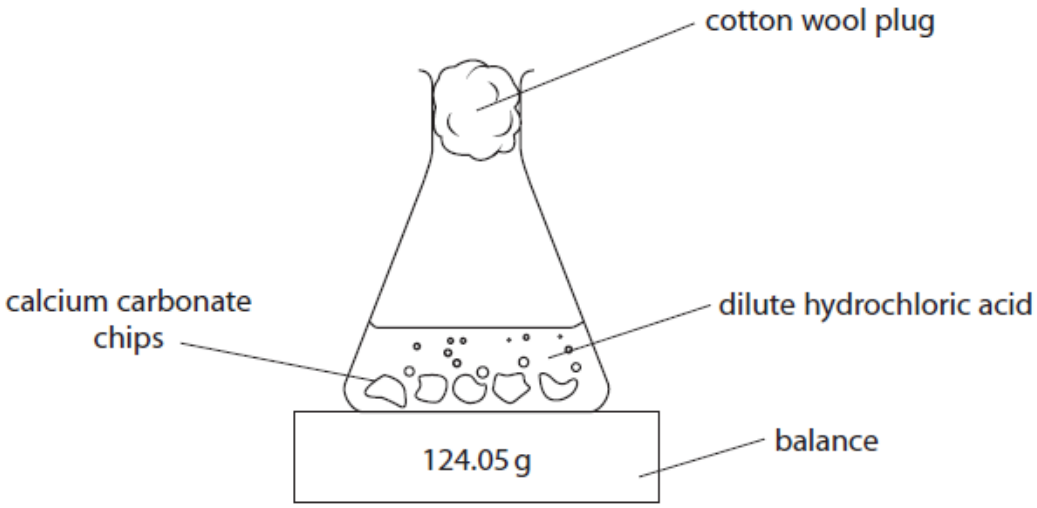
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(Total for question = 15 marks)

Q9.

A student uses this apparatus to investigate the rate of reaction between calcium carbonate chips and dilute hydrochloric acid.



Every 20 seconds the student records the reading on the balance.

(a) Explain why using a cotton wool plug increases the accuracy of the student's results.

(2)

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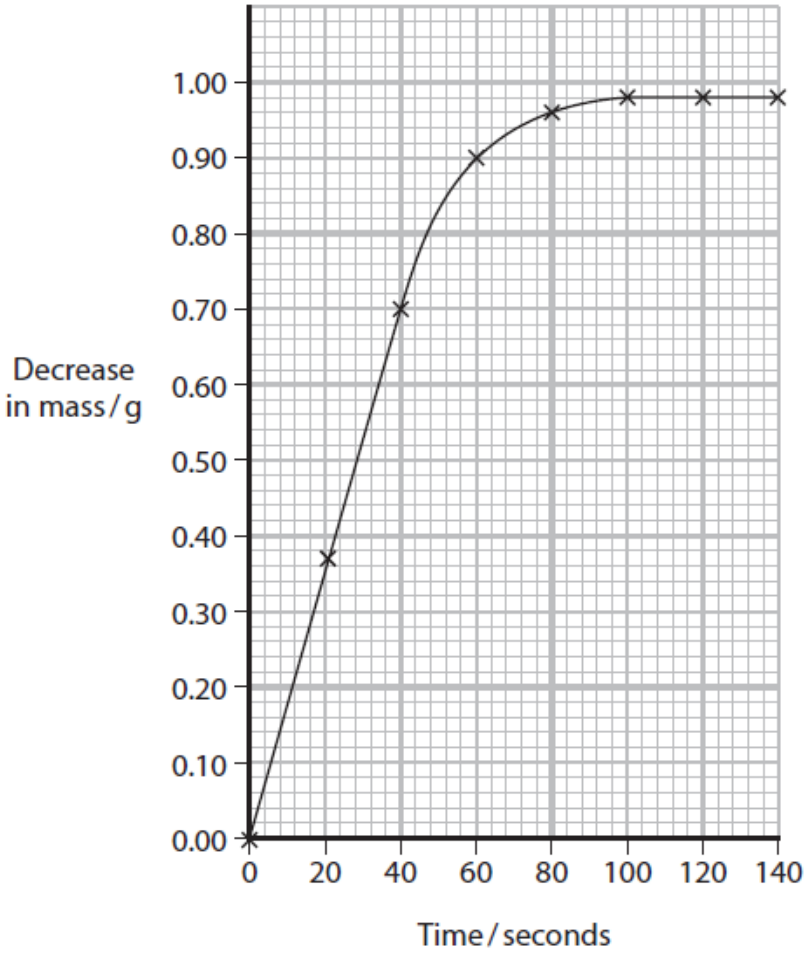
(b) Complete the equation for the reaction by adding the state symbols.

(2)

$CaCO_3$(.....) + 2HCl(.....) → $CaCl_2$(aq) + H_2O(.....) + CO_2(.....)

(c) The student uses the balance readings to find the decrease in mass of the flask and contents.

The graph shows the student's results.



(i) Give a reason why there are some calcium carbonate chips remaining in the flask when the reaction stops.

(1)

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(ii) State how the student would know when the reaction has stopped.

(1)

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(iii) Use the graph to determine the amount, in moles, of carbon dioxide produced during the reaction.

[M_r of CO_2 = 44]

(2)

amount = ... mol

(iv) Use the graph to calculate the rate of reaction, in grams per second, at time 60 seconds.

Show your working on the graph.

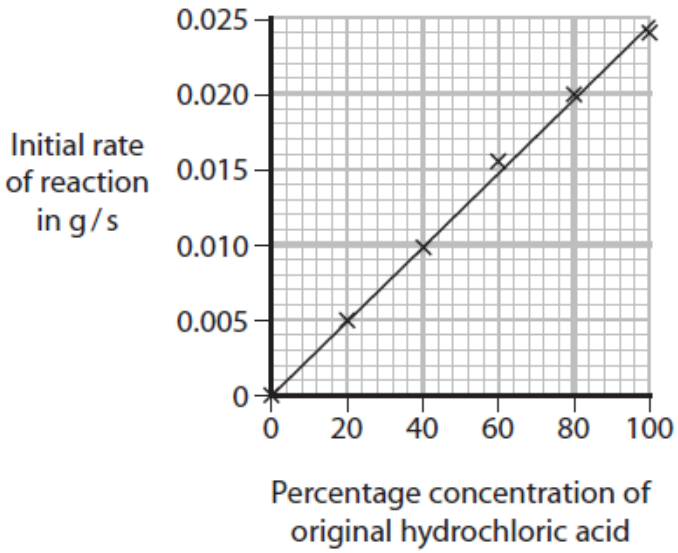
(3)

rate of reaction = ... g / s

(d) The student repeats the investigation by diluting the original hydrochloric acid.

The student then determines the initial rate of reaction at different percentage concentrations of the original hydrochloric acid.

The graph shows the student's results.



(i) Describe the relationship between the initial rate of reaction and percentage concentration of the original hydrochloric acid.

(2)

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(ii) Explain why changing the concentration of hydrochloric acid has an effect on the initial rate of reaction.

(2)

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(Total for question = 15 marks)

Q10.

This question is about rates of reaction.

(a) A student uses this method to investigate the rate of reaction between iron(III) nitrate solution and sodium thiosulfate solution.

- pour 50 cm^3 of iron(III) nitrate solution into a conical flask
- add one drop of catalyst solution
- add 50 cm^3 of sodium thiosulfate solution to the conical flask
- record the time for the mixture to become colourless

The student repeats the method using different catalysts and also with no catalyst.

The table shows the student's results.

Catalyst	Time for mixture to become colourless in s
no catalyst	55
cobalt(II) chloride solution	32
copper(II) sulfate solution	8
iron(II) sulfate solution	27
zinc nitrate solution	75

(i) Explain which is the best catalyst for the reaction.

(2)

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

(2)

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(b) The rate of a reaction can also be altered by changing the temperature or by changing the concentration of solutions.

(i) Explain, using the particle collision theory, how increasing the temperature affects the rate of a reaction.

(4)

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(ii) Explain why using a solution of a lower concentration decreases the rate of reaction.

(2)

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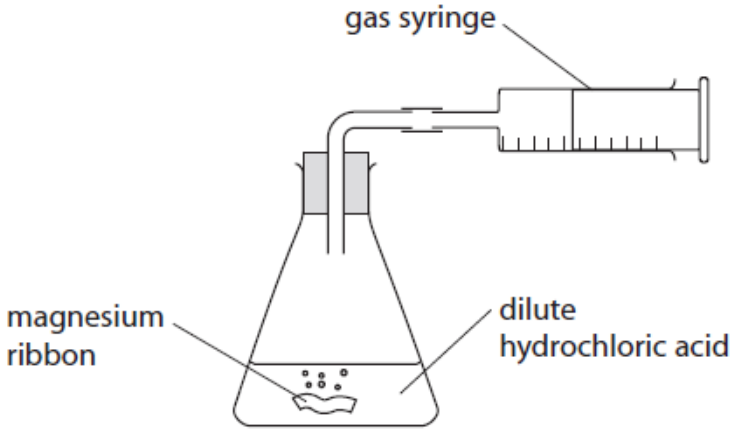
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(Total for question = 10 marks)

Q11.

A student uses this apparatus to investigate the reaction between magnesium and dilute hydrochloric acid.



(a) The word equation for the reaction is

magnesium + hydrochloric acid → magnesium chloride + hydrogen

(i) Complete the chemical equation for this reaction.

(1)

Mg + 2HCl → ..... + ...
...

(ii) Give the test for hydrogen.

(1)

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(iii) The student uses 0.090 g of magnesium and 0.025 mol of hydrochloric acid.

Show by calculation that the hydrochloric acid is in excess.

(2)

(b) The student measures the volume of hydrogen collected at regular intervals until the reaction stops.

The table shows the student's results.

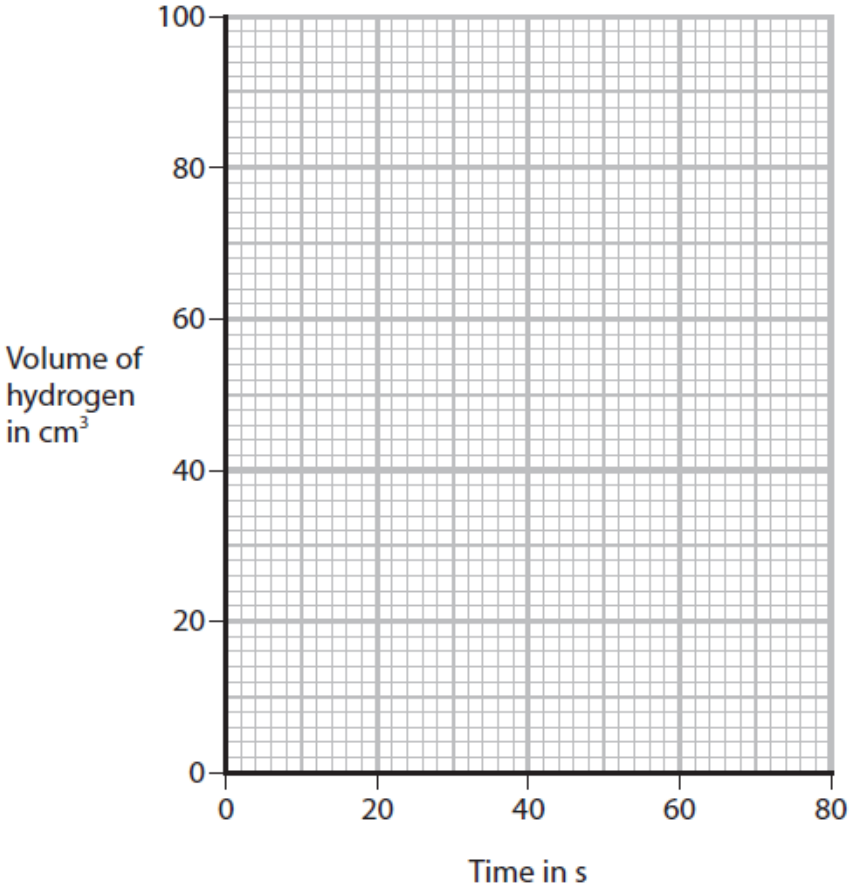
Time in s	0	15	30	45	60	75
Volume of hydrogen in cm^3	0	40	68	80	88	88

(i) Plot the student's results.

(1)

(ii) Draw a curve of best fit.

(1)



(iii) Determine the volume of hydrogen collected in the first 10 seconds.

Show on the graph how you obtained your answer.

(2)

volume of hydrogen = ... cm^3

(iv) Explain why the rate of reaction is greatest at the start of the reaction.

(2)

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(c) The student repeats the experiment at a temperature 5 °C higher than the original temperature.

All other conditions are kept the same.

(i) On the grid, draw the curve you would expect the student to obtain.

(2)

(ii) Explain, in terms of particle collision theory, how increasing the temperature affects the rate of reaction.

(3)

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(Total for question = 15 marks)

Q12.

Zinc reacts with dilute hydrochloric acid to form hydrogen.

(a) (i) Give a chemical equation for this reaction.

(2)

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(ii) Give a test for hydrogen gas.

(1)

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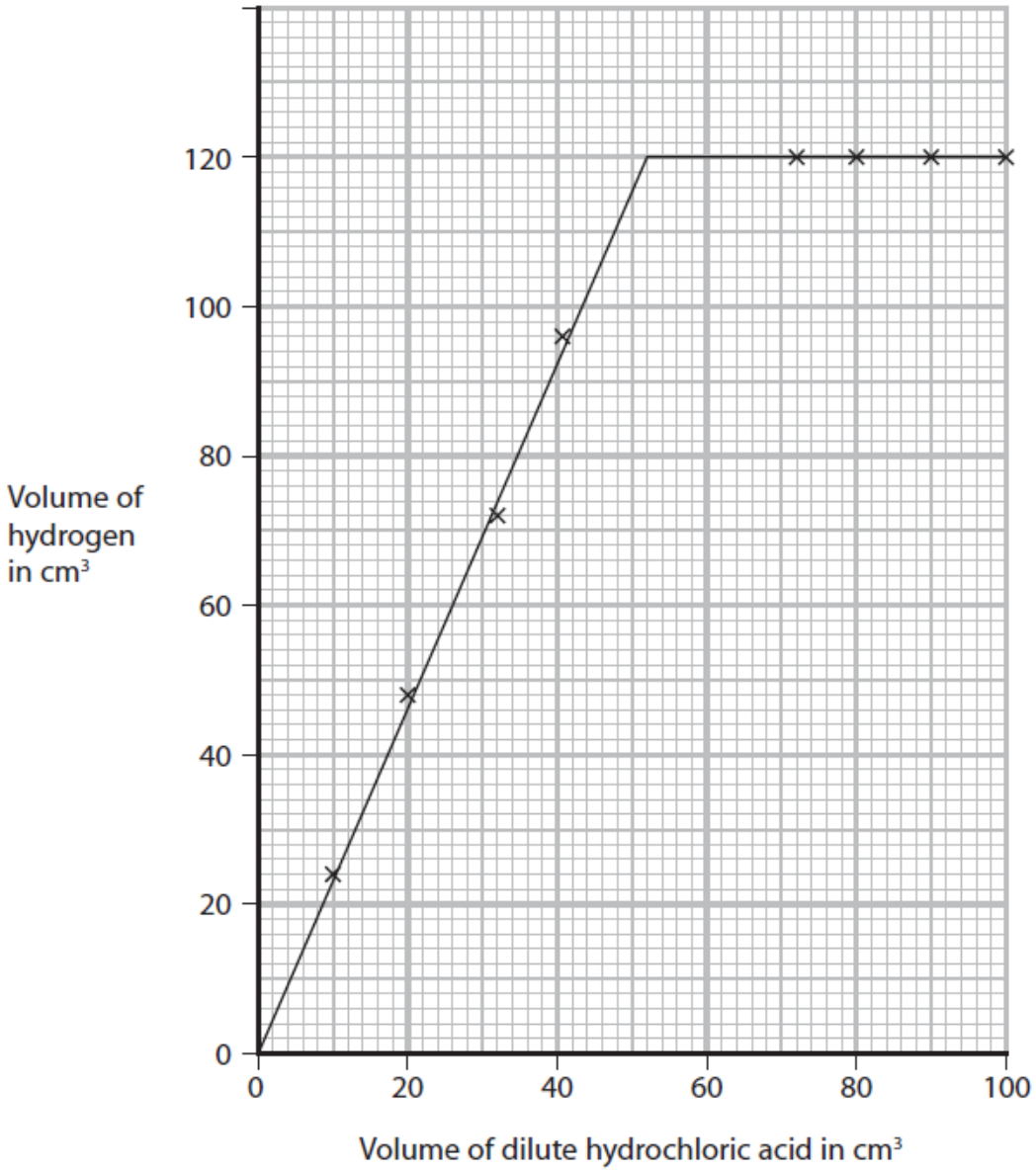
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(b) A student investigates the reaction between pieces of zinc and dilute hydrochloric acid.

In each experiment, he uses the same mass of zinc but a different volume of the acid.

He collects the hydrogen and measures its volume in each experiment.

The graph shows the student's results.



(i) Use the graph to find the minimum volume of acid needed to react with all of the zinc.

(1)

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(ii) The student repeats the investigation, using hydrochloric acid of double the original

concentration.

Determine the volume of hydrogen that would be collected using 15 cm^3 of this acid.

Show your working on the graph.

(2)

volume = ... cm^3

(c) Explain how increasing the concentration of the hydrochloric acid affects the rate of reaction.

(3)

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(d) The rate of reaction could also be affected by changing the temperature of the hydrochloric acid, or by using a catalyst.

Explain one other way in which the rate of reaction between zinc and hydrochloric acid can be affected.

(3)

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(Total for question = 12 marks)

Q13.

(a) A piece of magnesium ribbon is ignited and placed in a gas jar of oxygen.

The equation for the reaction is

$$2Mg + O_2 \rightarrow 2MgO$$

(i) Give two observations that would be made in this reaction.

(2)

1 .....

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2 .....

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(ii) State why this is an oxidation reaction.

(1)

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(b) A second piece of magnesium ribbon is ignited and placed in a gas jar of carbon dioxide.

A very exothermic reaction occurs, forming magnesium oxide and carbon.

(i) State what is meant by the term **exothermic**.

(1)

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(ii) Give the chemical equation for this reaction.

(1)

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(iii) A fire starts in a warehouse where magnesium is stored.

Suggest why it would **not** be suitable to use a carbon dioxide fire extinguisher to put out this fire.

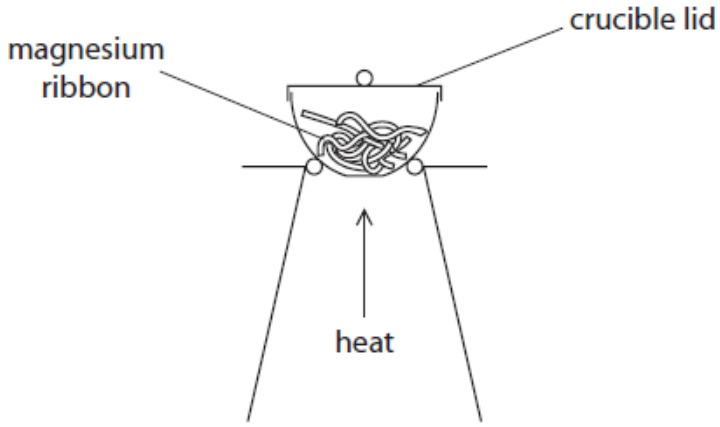
(1)

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(c) A student uses this apparatus to find the mass of magnesium oxide that forms when a known mass of magnesium
is heated.



This is his method.

- find the mass of the crucible and lid
- place some magnesium ribbon in the crucible
- find the mass of the crucible, lid and magnesium
- heat the crucible with the lid on for a few minutes
- find the mass of the crucible, lid and magnesium oxide

Using this method, the mass of magnesium oxide formed is less than expected.

Explain two changes that the student should make to his method to obtain a mass of magnesium oxide closer to the expected mass.

(4)

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2 .....

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(Total for question = 10 marks)

Q14.

This question is about reactions that form gases.

(a) Hydrogen peroxide decomposes to form water and oxygen.

The equation for the reaction is

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

25.0 cm^3 of hydrogen peroxide solution are poured into a conical flask and 1.00 g of solid manganese(IV) oxide is added.

Bubbles of oxygen gas are formed.

(i) Give the test for oxygen gas.

(1)

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(ii) Describe a method to show that solid manganese(IV) oxide is a catalyst in this reaction and not a reactant.

(3)

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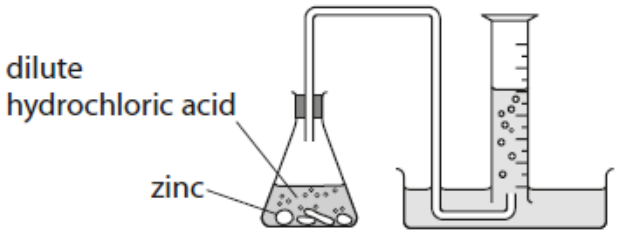
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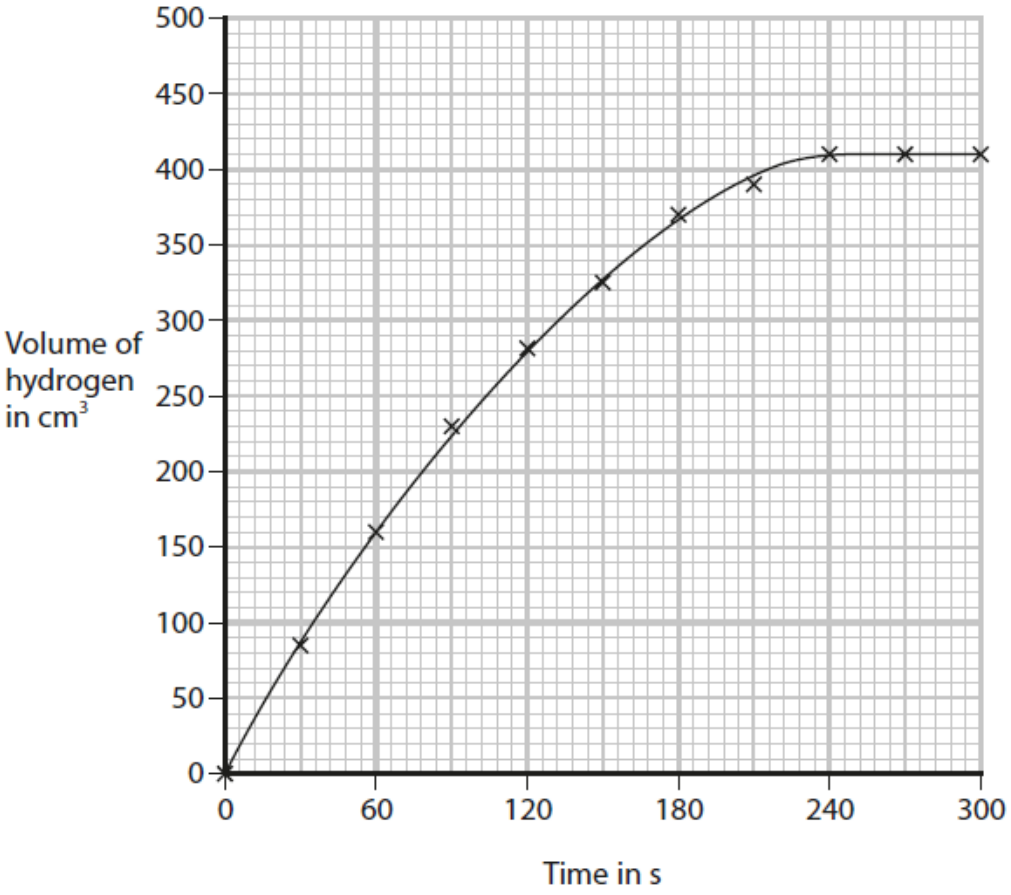
(b) A student uses this apparatus to investigate the rate of the reaction between zinc and an excess of dilute hydrochloric acid.



This is the student's method.

- pour 50 cm^3 of dilute hydrochloric acid into a conical flask
- add about 1.2 g of zinc lumps
- record the volume of hydrogen gas collected every 30 s until no more hydrogen is collected

The graph shows the student's results.



(i) Calculate the mean (average) rate of reaction, in cm^3 / s, in the first 120 s.

(2)

mean rate = ... cm^3 / s

(ii) The equation for the reaction between zinc and hydrochloric acid is

$$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$$

Use this equation and the particle collision theory to explain why the rate of reaction is greatest at the start of the reaction.

(3)

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(iii) The student repeats the experiment at a higher temperature but keeps all other conditions the same.

On the grid, draw the curve you would expect to see in this experiment.

(2)

(iv) Explain why the rate of reaction is greater if the same mass of zinc powder is used instead of zinc lumps. All other conditions are kept the same.

(2)

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(c) In another experiment, the student adds 0.55 g of zinc to a solution containing 2.50×10^{-2} moles of hydrochloric acid.

Use the equation to show that hydrochloric acid is in excess.

$$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$$

[Ar of Zn = 65]

(2)

(Total for question = 15 marks)

Q15.

Ammonium chloride decomposes in a reversible reaction. The equation for this reaction is

$$NH_4Cl(s) \rightleftharpoons NH_3(g) + HCl(g)$$

(a) State how the equation shows that the reaction is reversible.

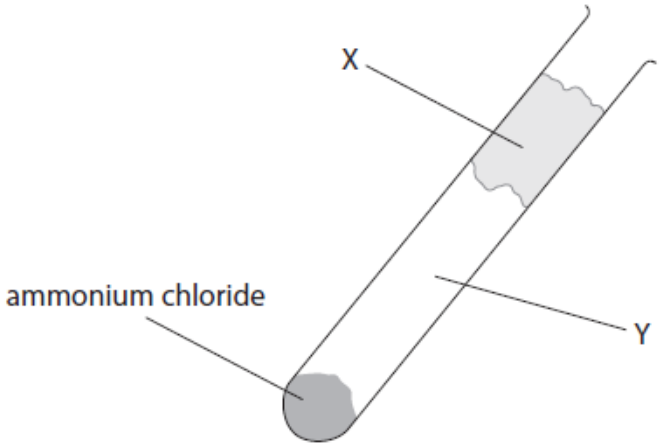
(1)

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(b) Some ammonium chloride is heated gently in a test tube.

The diagram shows the test tube after it has been heated gently for a short time.



(i) Identify solid **X** and the two gases formed in region Y of the test tube.

(2)

Solid **X** .....

Gases in region **Y** .....

.....

(ii) Which change of state occurs in the test tube during heating?

(1)

☒ **A** condensing

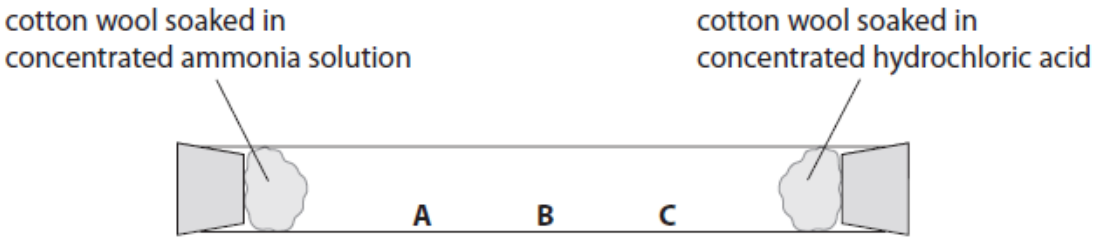
☒ **B** evaporating

☒ **C** melting

☒ **D** subliming

(c) An experiment involving ammonium chloride can be used to show the process of diffusion.

The diagram shows the apparatus at the start of the experiment.



At the end of the experiment, a white solid forms in the test tube.

Explain which position, **A**, **B** or **C**, shows where the white solid forms.

(3)

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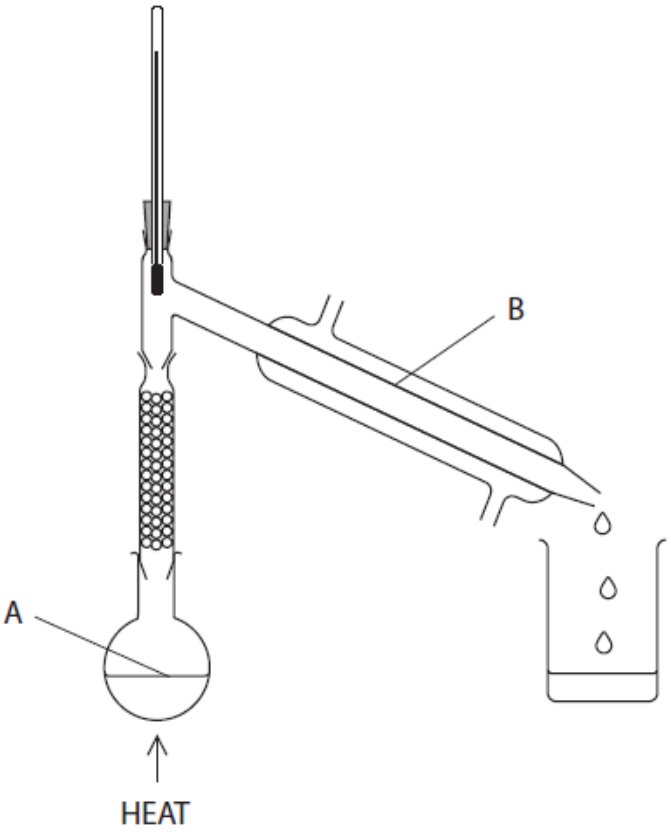
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(Total for question = 7 marks)

Q16.

A teacher uses this apparatus to separate a mixture of ethanol and water.



(a) (i) Name this method of separation.

(1)

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(ii) Name the change of state taking place at A.

(1)

.....

(iii) Name the change of state taking place at B.

(1)

.....

(b) The mixture contains 15.5 cm^3 of ethanol.

1.0 cm^3 of ethanol has a mass of 0.79 g.

One mole of ethanol contains 6.00×10^{23} molecules.

[M_r of ethanol = 46]

(i) Calculate the amount, in moles, of ethanol in 15.5 cm^3 of ethanol.

(2)

amount = ... mol

(ii) Calculate the number of molecules of ethanol in 15.5 cm^3 of ethanol.

(1)

number of molecules = ...

(c) After five minutes, the teacher collects a sample of colourless liquid in a new beaker.

(i) Describe a chemical test to show that the colourless liquid contains water.

(2)

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(ii) Describe a physical test to show if the colourless liquid is pure water.

(2)

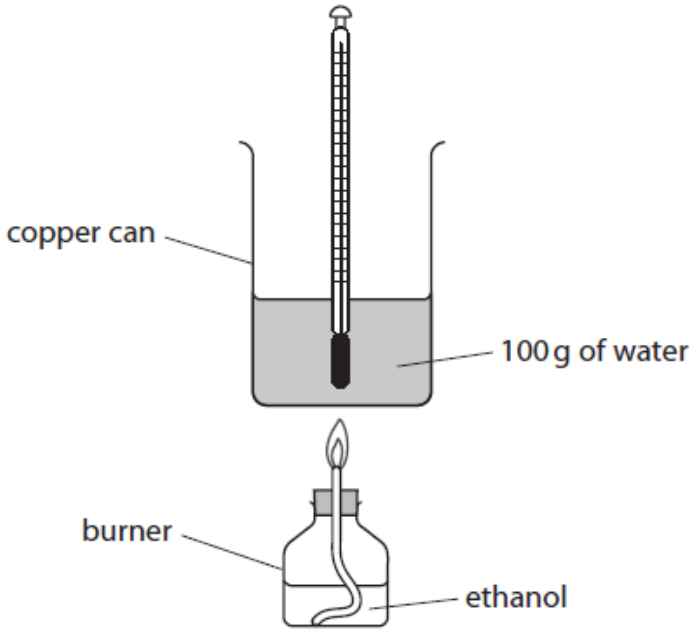
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(d) The teacher uses this apparatus to heat 100 g of water.



He records the temperature of the water before and after heating.

temperature of water before heating = 21.0 °C

temperature of water after heating = 70.5 °C

(i) Calculate the heat energy change (Q) in joules.

[specific heat capacity of water is 4.2 J /g/°C]

(3)

Q = ... J

(ii) The student burns 0.0200 mol of ethanol.

Use this information and your value for Q to calculate the molar enthalpy change (ΔH), in kJ/mol, for the combustion of ethanol.

Include a sign in your answer.

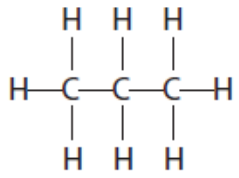
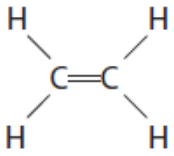
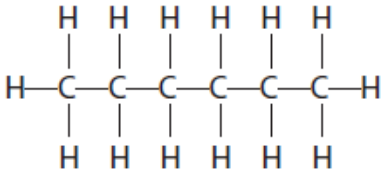
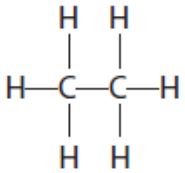
(2)

ΔH = ... kJ/mol

(Total for question = 15 marks)

Q17.

The table gives the displayed formulae of four hydrocarbons, P, Q, R and S.

P 	Q 
R 	S 

(a) (i) Explain why P, Q, R and S are all hydrocarbons.

(2)

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(ii) Give the name of hydrocarbon P.

(1)

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(iii) Give the molecular formula of hydrocarbon S.

(1)

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(iv) Describe a test to show that hydrocarbon Q is unsaturated.

(2)

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(b) Hydrocarbons P, Q, R and S have the same type of structure.

(i) Explain why P, Q, R and S all have low boiling points.

Refer to the type of structure in your answer.

(3)

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(ii) Suggest why the boiling point of hydrocarbon R is higher than the boiling point of hydrocarbon S.

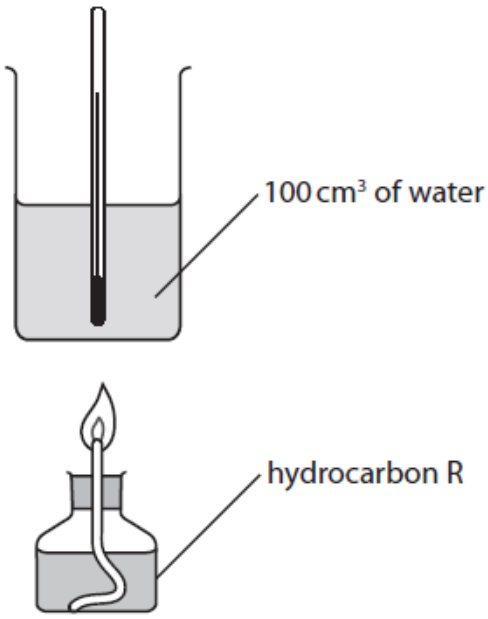
(1)

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(c) A teacher uses this apparatus to investigate the increase in temperature of 100 cm^3 of water when hydrocarbon R is burned.



The temperature of the water before heating is 19.7 °C.

The temperature of the water after heating is 57.2 °C.

The temperature rise is less than the teacher expected.

(i) One reason why the temperature rise is less than expected is that some of hydrocarbon R undergoes incomplete combustion.

Give another reason why the temperature rise is less than expected.

(1)

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(ii) Complete the equation for the incomplete combustion of hydrocarbon R.

(1)

$$C_6H_{14} + \text{.....} O_2 \rightarrow 3C + \text{.....} CO + \text{.....} H_2O$$

(iii) Explain why carbon monoxide (CO) should not be released into the laboratory.

(2)

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(iv) Calculate the heat energy change (Q), in joules, in this experiment.

[mass of 1.0 cm^3 of water = 1.0 g]

[for water, c = 4.2 J / g / °C]

(3)

Q = ... J

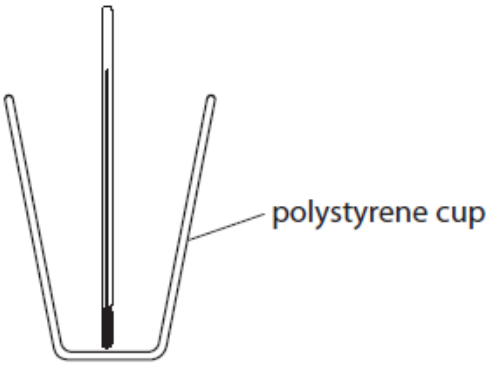
(Total for question = 17 marks)

Q18.

A student investigates the temperature change during the reaction between zinc metal and copper(II) sulfate solution.

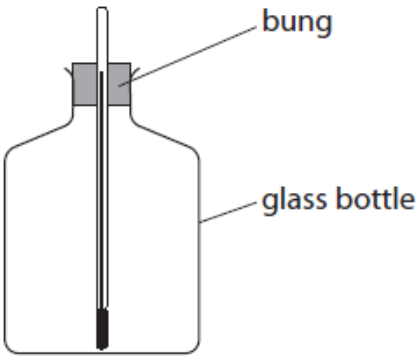
The student considers two different methods.

Method 1



- pour 50 cm^3 of copper(II) sulfate solution into the polystyrene cup
- record the temperature of the solution
- add 3 g of zinc powder
- stir using the thermometer and record the highest temperature reached

Method 2



- record the temperature of 50 cm^3 of copper(II) sulfate solution
- pour the 50 cm^3 of copper(II) sulfate solution into the glass bottle
- add 3 g of zinc powder
- push the bung and thermometer into the bottle and record the highest temperature reached

(a) Discuss the advantages and disadvantages of each method.

(6)

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(b) The equation for the reaction is

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

50 cm^3 of copper(II) sulfate solution contains 0.025 mol $CuSO_4$

A mass of 3 g of zinc is used.

Show that the zinc is in excess.

[A_r of zinc = 65]

(2)

(c) The student reacts a solution containing 0.025 mol $CuSO_4$ with an excess of zinc.

These are the student's results.

temperature of 50 cm^3 of copper(II) sulfate solution = 21.1 °C

highest temperature reached = 40.6 °C

(i) Show that the energy change Q for this reaction is about 4000 J

[mass of 1 cm^3 of solution = 1.0 g]

[for the solution, c = 4.2 J / g / °C]

(3)

(ii) Calculate the molar enthalpy change (ΔH), in kJ / mol, for the reaction.

(3)

(ΔH) = ... kJ / mol

(d) The ionic equation for the reaction is

$$Zn\ (s) + Cu^{2+}\ (aq) \rightarrow Zn^{2+}\ (aq) + Cu\ (s)$$

Explain what is oxidised and what is reduced in this reaction.

(2)

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(Total for question = 16 marks)

Q19.

In 1937 an airship full of hydrogen gas flew from Germany to America.



(Source: © Michael Rosskothen/Shutterstock)

(a) Which property of hydrogen makes it a suitable gas to use in an airship?

(1)

☒ **A** colourless

☒ **B** insoluble in water

☒ **C** low density

☒ **D** no smell

(b) Explain why helium is now used in airships instead of hydrogen.

(2)

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(c) Hydrogen is used to manufacture ammonia, NH_3

Hydrogen is reacted with nitrogen using an iron catalyst.

(i) Give a chemical equation for this reaction.

(1)

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(ii) State why a catalyst is used in this reaction.

(1)

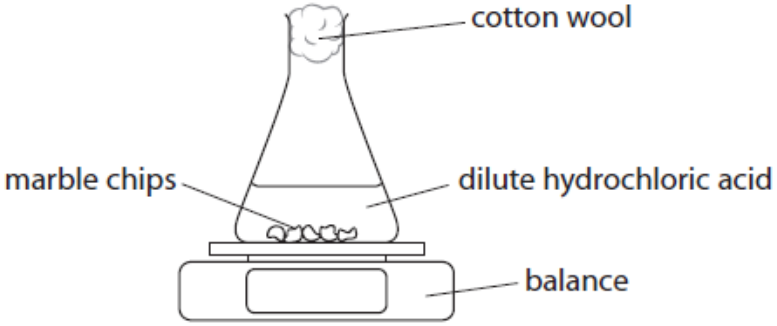
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(Total for question = 5 marks)

Q20.

A student uses this apparatus to investigate the rate of the reaction between marble chips and dilute hydrochloric acid.



(a) (i) Complete the equation for the reaction by adding the missing state symbols.

(1)

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

(ii) State why the mass of the contents of the flask decreases during the reaction.

(1)

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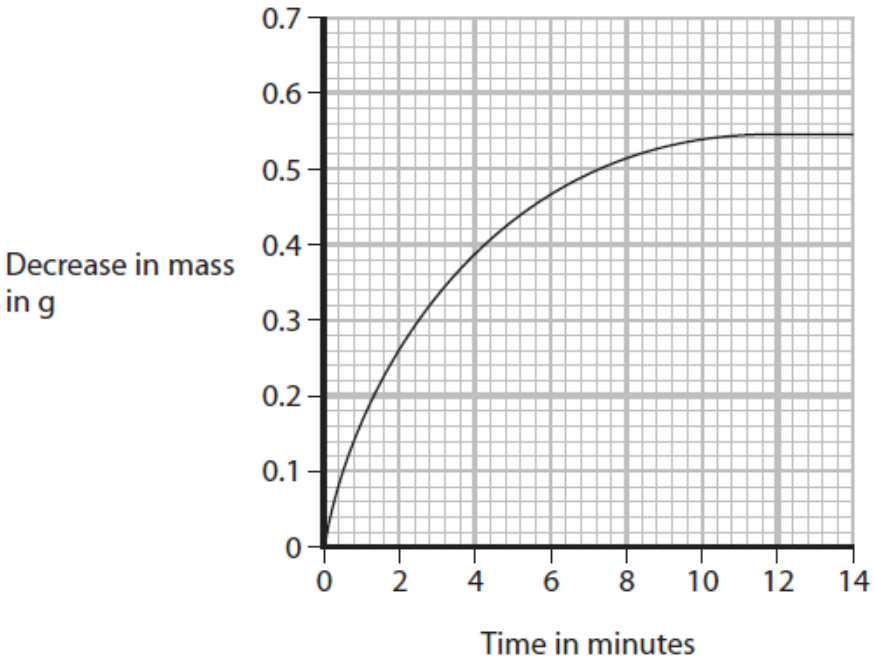
(iii) State the purpose of the cotton wool.

(1)

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(b) The graph shows the student's results.



In the investigation the marble chips are in excess.

(i) Explain the shape of the graph.

(4)

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(ii) On the grid, draw the curve the student would obtain if they used the same mass of smaller marble chips, keeping all other conditions the same.

(2)

(Total for question = 9 marks)