PEARSON EDEXCEL IGCSE CHEMISTRY · 4CH1

CHEMISTRY



EXAM QUESTION PACK

SECTION 3: PHYSICAL CHEMISTRY (PACK 2)

SCORE	PERCENTAGE
/223	%

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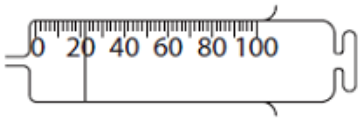
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Q1.

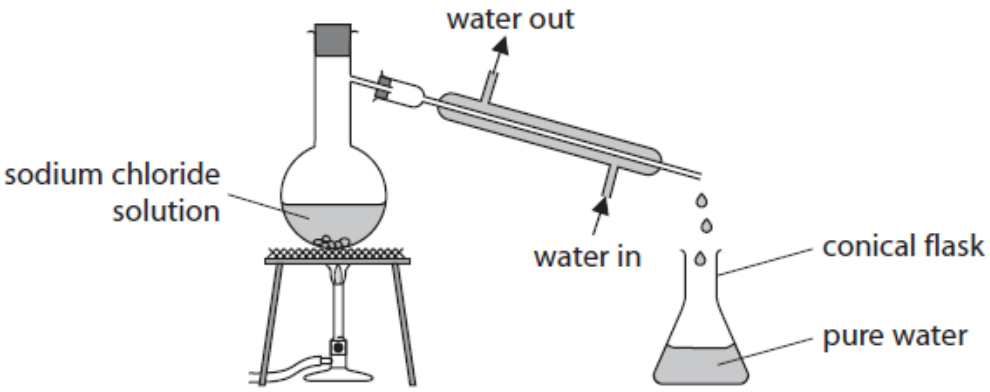
This question is about apparatus used in the laboratory.

(a) Complete the table by giving the name of each piece of apparatus and a unit used for the quantity it measures.

(2)

Apparatus	Name	Unit
		
		

(b) The diagram shows apparatus used to obtain pure water from sodium chloride solution by simple distillation.



(i) Explain why it is necessary for water to flow continuously in and out of the apparatus.

(2)

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(ii) Describe a chemical test to show that the sodium chloride solution contains chloride ions.

(2)

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(iii) Describe a physical test to show that the liquid in the conical flask is pure water.

(2)

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(Total for question = 8 marks)

Q2.

Nitric acid (HNO_3) is used in the production of fertilisers.

Nitric acid is manufactured in three stages.

Stage 1 ammonia reacts with oxygen in the presence of a platinum catalyst to produce nitrogen monoxide gas, NO, and water.

Stage 2 nitrogen monoxide gas reacts with more oxygen to produce nitrogen dioxide gas, NO_2.

Stage 3 nitrogen dioxide gas reacts with water to produce nitric acid and more nitrogen monoxide gas.

(a) (i) Complete the chemical equation for the reaction in stage 1.

(1)

.....NH_3 + ...O_2 $\rightleftharpoons$ .....NO + ...H_2O

(ii) Give the meaning of the symbol $\rightleftharpoons$

(1)

.....

.....

(iii) State the purpose of the platinum catalyst.

(1)

.....

.....

(b) Give a chemical equation for the reaction of nitrogen monoxide and oxygen in stage 2.

(1)

.....

(c) (i) The equation for the reaction in stage 3 is

$$3NO_2 + H_2O \rightarrow 2HNO_3 + NO$$

Calculate the maximum mass, in tonnes, of nitric acid that could be produced in this reaction from 11.5 tonnes of nitrogen dioxide.

[1 tonne = 1.0×10^6g]

(4)

mass of nitric acid = ... tonnes

(ii) Suggest what use can be made of the nitrogen monoxide gas formed in stage 3.

(1)

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.....

.....

(d) When copper(II) oxide reacts with dilute nitric acid, copper(II) nitrate is produced.

The equation for the reaction is

$$CuO + 2HNO_3 \rightarrow Cu(NO_3)_2 + H_2O$$

0.200 mol of nitric acid reacts with excess copper(II) oxide.

A mass of 15.3 g of copper(II) nitrate is produced.

Calculate the percentage yield of copper(II) nitrate.

[M_r of copper(II) nitrate = 187.5]

(3)

percentage yield = ... %

(Total for question = 12 marks)

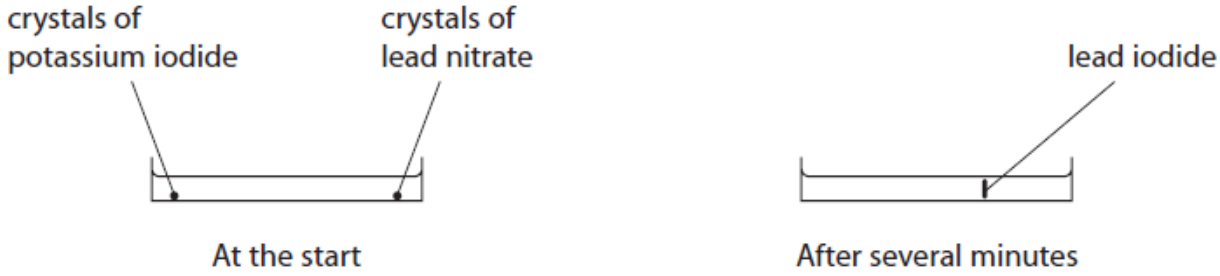
Q3.

Lead nitrate and potassium iodide react to form the insoluble solid lead iodide.

Crystals of lead nitrate and potassium iodide are placed at opposite ends of a container of water.

Solid lead iodide forms after several minutes.

The diagram shows the container at the start and after several minutes.



(a) Name the two processes that occur before the solid lead iodide forms.

(2)

1 .....

2 .....

(b) Explain why solid lead iodide takes less time to form when the reaction is repeated using water at a higher temperature.

(2)

.....

.....

.....

.....

(c) The formula for lead nitrate is $Pb(NO_3)_2$

(i) Give the number of different elements in lead nitrate.

(1)

.....

.....

(ii) Give the charge on the lead ion in $Pb(NO_3)_2$

(1)

.....

(d) Complete the chemical equation for the reaction between lead nitrate and potassium iodide.

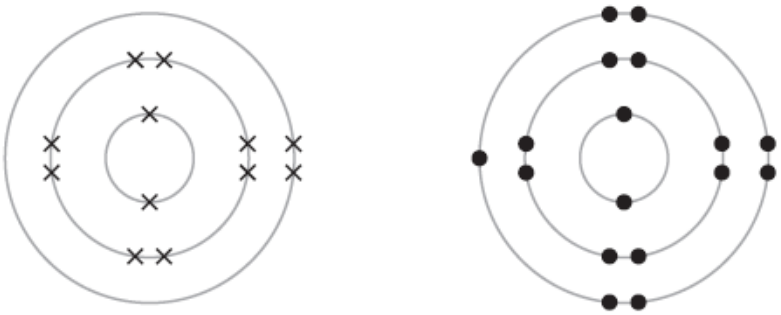
(1)

$Pb(NO_3)_2(aq)$ + ... $KI(aq) \rightarrow PbI_2(s)$ + ... $KNO_3(aq)$

(Total for question = 7 marks)

Q4.

(a) The diagram shows the electronic configuration of an atom of magnesium and an atom of chlorine.



Magnesium Chlorine

Describe the changes in the electronic configurations of magnesium and chlorine when they react to form magnesium chloride, $MgCl_2$

(2)

.....

.....

.....

.....

.....

(b) A sample of chlorine contains these percentages of two isotopes.

Cl-35 = 70% Cl-37 = 30%

(i) Use this information to calculate the relative atomic mass (A_r) of this sample of chlorine.

(2)

A_r = ...

(ii) Both chlorine isotopes react with magnesium in the same way.

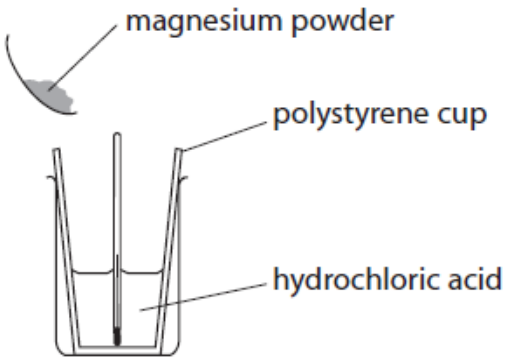
Give a reason why both isotopes react in the same way.

(1)

.....

.....

(c) A student uses this apparatus to investigate the temperature change when magnesium powder reacts with hydrochloric acid.



The student uses this method.

- pour 100 cm^3 of hydrochloric acid into a polystyrene cup
- measure the initial temperature of the acid
- add the magnesium powder and stir
- measure the highest temperature reached by the mixture

The table shows the student's results.

Initial temperature of the acid in °C	18.1
Highest temperature of the mixture in °C	45.6

(i) Use the student's results to explain the type of reaction that occurs when magnesium is added to hydrochloric acid.

(2)

.....

.....

.....

.....

(ii) Give a reason why the student uses a polystyrene cup.

(1)

.....

.....

(iii) Use the student's results to calculate the heat energy change (Q), in joules, for this reaction.

[for 1.00 cm^3 of the mixture, mass = 1.00 g]

[for the mixture, c = 4.2 J / g / °C]

(3)

Q = ... J

(Total for question = 11 marks)

Q5.

A solution of hydrogen peroxide decomposes when a catalyst of manganese(IV) oxide is added.

The products of the reaction are water and oxygen.

(a) Complete the chemical equation for this reaction.

(1)

..... H_2O_2 → ..... H_2O + ... O_2

(b) Give a test for oxygen.

(1)

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.....

(c) State the reason for adding a catalyst.

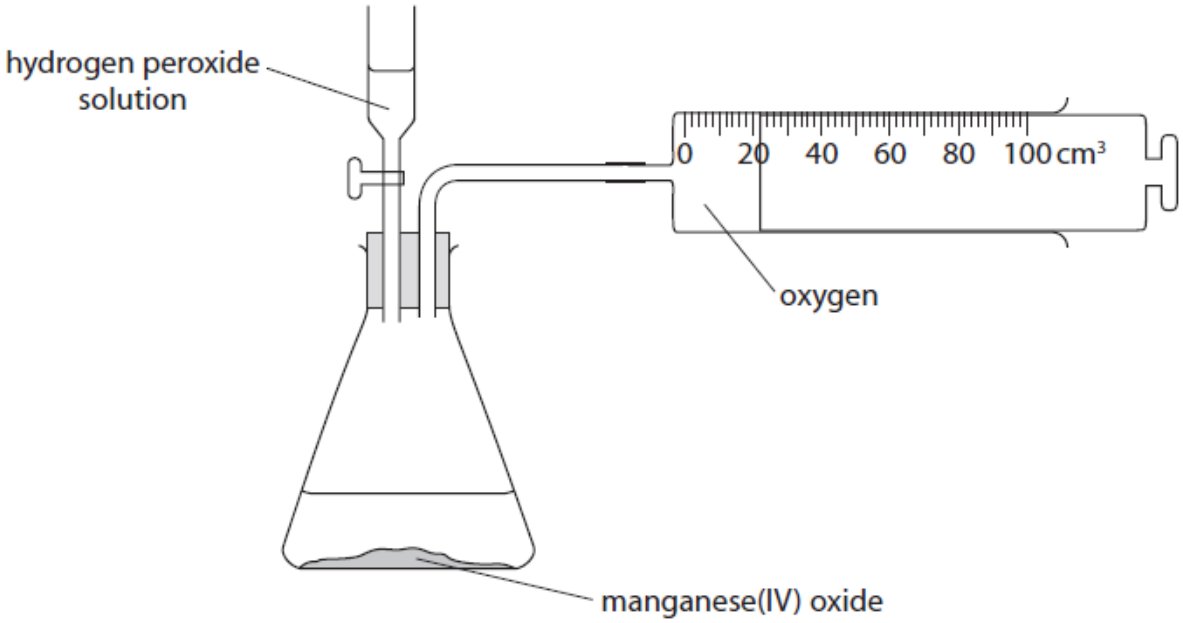
(1)

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(d) A student investigates how changing the concentration of the hydrogen peroxide solution affects the rate of this reaction.

She uses this apparatus.



The student records the volume of oxygen that collects every 2 minutes for 16 minutes.

The table shows her results.

Time in minutes	0	2	4	6	8	10	12	14	16
Volume of oxygen in cm³	0	22	38	50	55	69	76	80	80

(i) Plot the student's results on the grid.

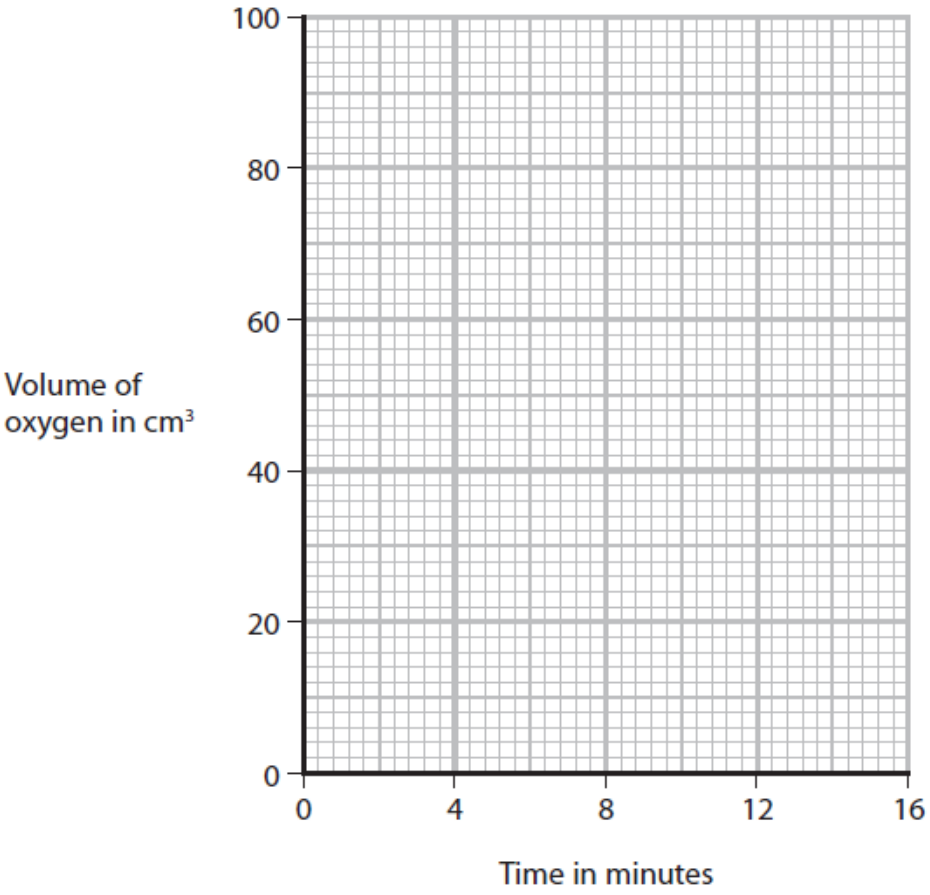
(1)

(ii) Draw a circle on the grid around the anomalous result.

(1)

(iii) Draw a curve of best fit through the points, ignoring the anomalous result.

(1)



(iv) Suggest a mistake that the student might have made to cause the anomalous result.

(1)

.....

.....

.....

(v) Determine the volume of oxygen collected during the first 3 minutes.

Show on your graph how you obtain your answer.

(2)

volume of oxygen = ... cm^3

(e) The student repeats the experiment using hydrogen peroxide solution of half the concentration of the original solution.

She keeps the volume of the hydrogen peroxide solution and all other conditions the same.

(i) Draw on the grid the curve you would expect the student to obtain.

(2)

(ii) Explain how using hydrogen peroxide solution of half the concentration affects the rate of the reaction.

Refer to particle collision theory in your answer.

(3)

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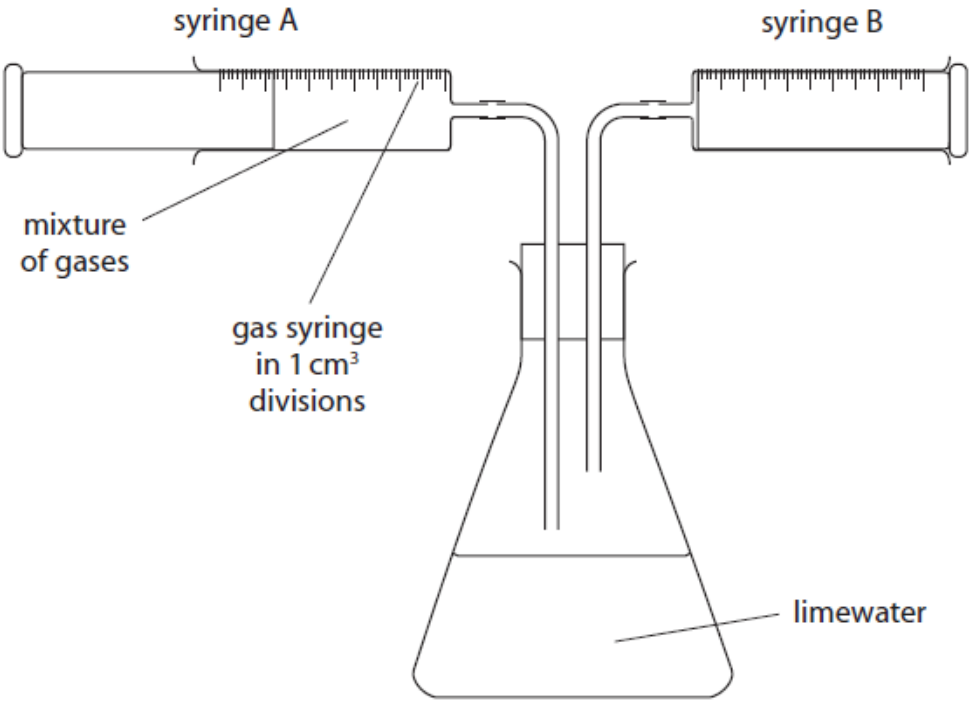
(Total for question = 14 marks)

Q6.

Two experiments are done to determine the percentage composition by volume of a mixture of three gases, carbon dioxide, oxygen and argon.

(a) In experiment 1, a student bubbles the mixture of gases through limewater. Carbon dioxide reacts with limewater.

The diagram shows the apparatus the student uses.



The student pushes the mixture of gases out of syringe A, but no gas bubbles appear in the limewater.

Give one change the student needs to make to the apparatus for gas bubbles to appear in the limewater.

(1)

.....

.....

(b) When the apparatus in experiment 1 is set up correctly, the mixture of gases is bubbled gently through the limewater so that all the carbon dioxide is removed.

The volume of the mixture of gases in syringe A at the start is 76 cm^3.

The volume of the mixture of gases in syringe B at the end is 66 cm^3.

(i) Calculate the percentage by volume of carbon dioxide in the mixture of gases in syringe A.

(2)

percentage of carbon dioxide = ... %

(ii) Give the change in the appearance of the limewater.

(1)

.....

.....

(iii) Explain why the gas syringes in experiment 1 cannot be used to find the percentage of carbon dioxide in a typical sample of air.

(2)

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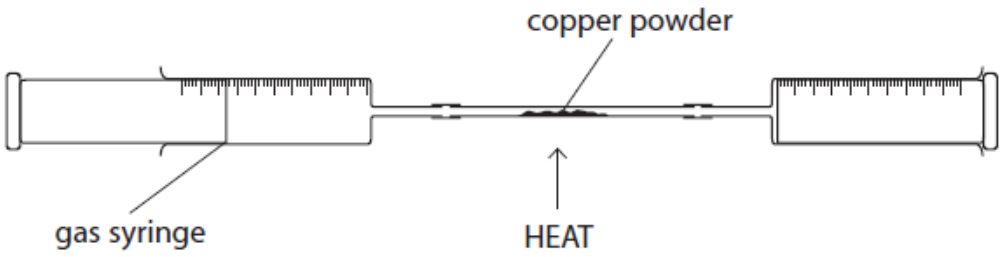
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In experiment 2, a teacher pushes the remaining gases over hot copper powder.

The diagram shows the apparatus the teacher uses.



The copper powder turns black as it reacts with oxygen.

Argon is extremely unreactive, so it does not react with copper.

(i) Name the black substance that forms on the copper powder.

(1)

.....

(ii) Suggest why the teacher uses copper powder instead of the same mass of large pieces of copper.

(1)

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(iii) Explain why argon is extremely unreactive.

(2)

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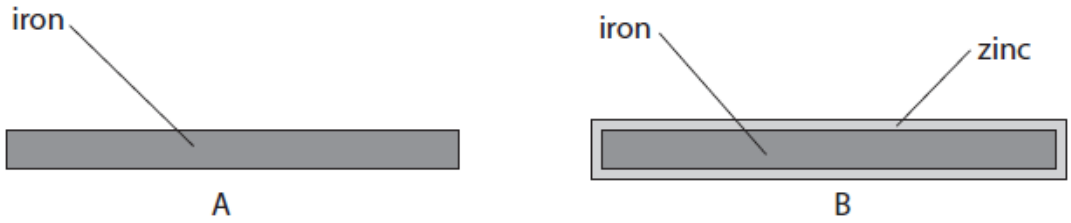
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(Total for question = 10 marks)

Q7.

The diagram shows two samples of iron, A and B.



Sample B is coated with a thin layer of zinc.

(a) Name the process used to coat iron with zinc.

(1)

.....

(b) The two samples of iron are left outside for several weeks.

A brown solid containing hydrated iron(III) oxide forms on sample A.

(i) Give the common name for the brown solid.

(1)

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(ii) Give the names of the two substances that react with the iron to form the brown solid.

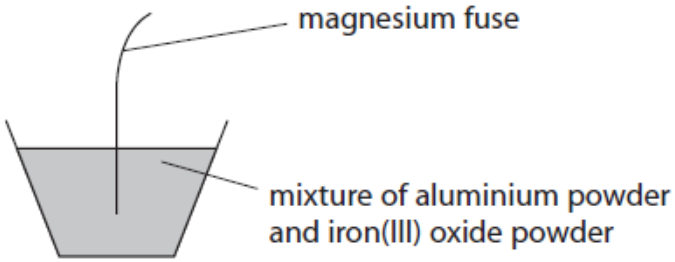
(2)

1 .....

2 .....

(c) Iron can be formed by reacting aluminium powder with iron(III) oxide.

The diagram shows how this reaction can be demonstrated.



When the magnesium fuse is lit, a very exothermic reaction occurs.

(i) State the meaning of the term **exothermic**.

(1)

.....

.....

(ii) The equation for the reaction between aluminium and iron(III) oxide is

$$2Al + Fe_2O_3 \rightarrow 2Fe + Al_2O_3$$

Explain what this reaction shows about the relative reactivities of aluminium and iron.

(2)

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(iii) Explain why the reaction between aluminium and iron(III) oxide is a redox reaction.

(3)

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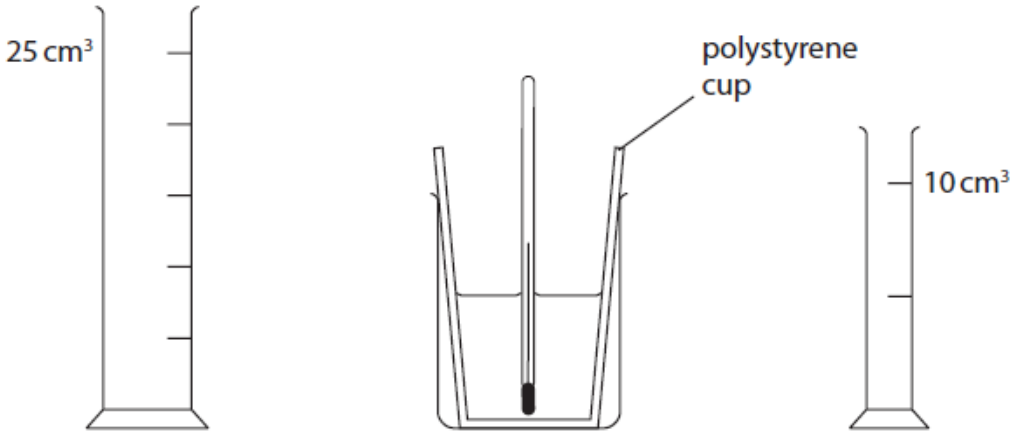
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(Total for question = 10 marks)

Q8.

When aqueous solutions of potassium hydroxide and nitric acid are mixed together, an exothermic reaction occurs.

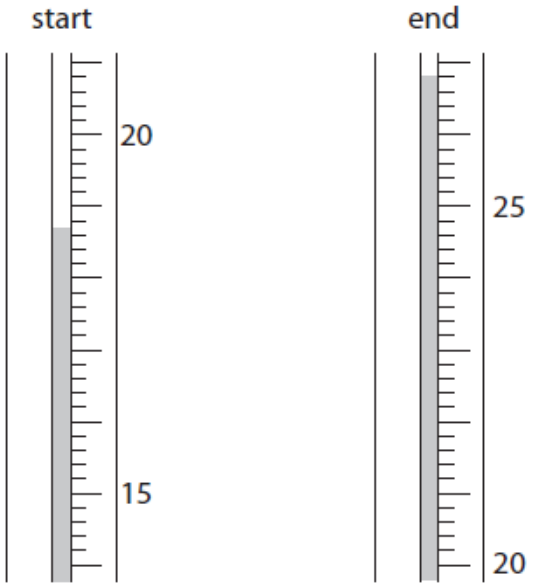
The diagram shows the apparatus used in an experiment to measure the temperature increase.



This is the student's method.

- use the larger measuring cylinder to add 25 cm^3 of aqueous potassium hydroxide to the polystyrene cup.
- record the steady temperature.
- use the smaller measuring cylinder to add 5 cm^3 of dilute nitric acid to the cup, stir the mixture with the thermometer.
- record the highest temperature of the mixture.
- continue adding further 5 cm^3 portions of dilute nitric acid to the cup, stirring and recording the temperature, until a total volume of 35 cm^3 has been added.

(a) The diagram shows the thermometer readings at the start and at the end of one experiment.



Complete the table to show:

- the thermometer reading at the start of the experiment
- the temperature rise in the experiment.

(2)

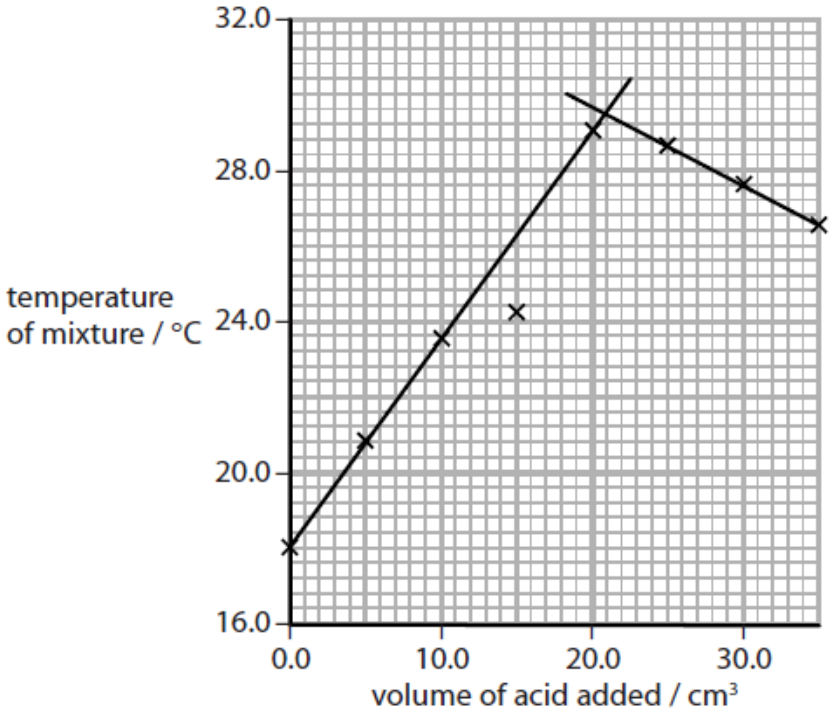
thermometer reading at end / °C	26.8
thermometer reading at start / °C	
thermometer rise / °C	

(b) Another student uses the same method, adding the dilute nitric acid from a burette.

The table shows his results.

volume of acid added / cm^3	0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0
temperature of mixture / °C	18.0	20.8	23.5	24.2	29.0	28.6	27.6	26.5

This is the student's graph.



The point where the lines cross represents complete neutralisation.

(i) Identify the maximum temperature reached during the experiment.

(1)

maximum temperature = ... °C

(ii) Identify the volume of dilute nitric acid that exactly neutralises the 25 cm^3 of aqueous potassium hydroxide.

(1)

volume = ... cm^3

(c) Another student records these results.

volume of aqueous potassium hydroxide	= 20.0 cm^3
starting temperature of aqueous potassium hydroxide	= 18.5 °C
maximum temperature of mixture	= 30.0 °C
volume of dilute nitric acid	= 20.0 cm^3

Calculate the heat energy released in this experiment.

c = 4.2 J/g / °C

mass of 1 cm^3 of mixture = 1 g

(4)

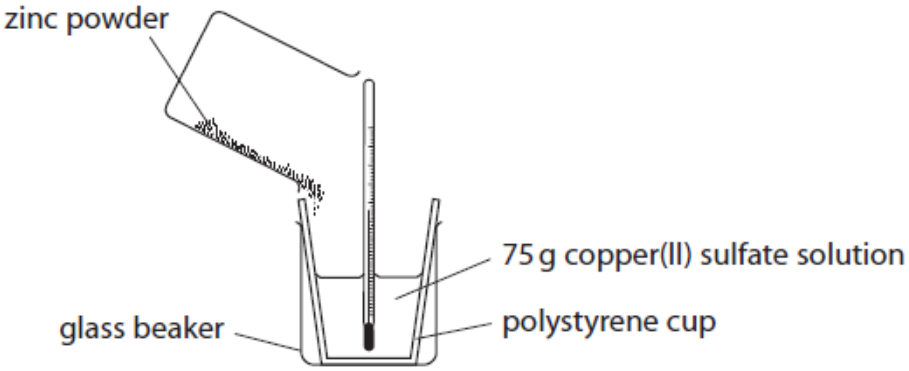
heat energy = ... J

(Total for question = 8 marks)

Q9.

This question is about exothermic reactions.

(a) A student uses this apparatus to measure the temperature increase when an excess of zinc powder is added to copper(II) sulfate solution.



(i) Complete the word equation for the reaction.

(1)

zinc + copper(II)
sulfate → ..... + ...

(ii) Give a reason why the student uses a polystyrene cup inside a glass beaker.

(1)

.....

.....

(iii) State why zinc reacts with copper(II) sulfate solution.

(1)

.....

.....

(iv) The temperature at the start of the reaction is 19.7 °C.

The temperature at the end of the reaction is 48.3 °C.

Calculate the heat energy change, in joules, for the reaction.

[for the mixture, c = 4.2 J/g/°C]

(2)

heat energy change = ... J

(b) (i) The reaction between zinc and silver nitrate solution is exothermic.

A mass of 0.65 g of zinc is added to excess silver nitrate solution.

The heat energy change is 800 J.

Calculate the molar enthalpy change, ΔH, in kJ/mol.

Include a sign in your answer.

(3)

ΔH = ... kJ/mol

(ii) This is the ionic equation for the reaction between zinc and silver nitrate solution.

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

Explain, in terms of electrons, why this is a redox reaction.

(2)

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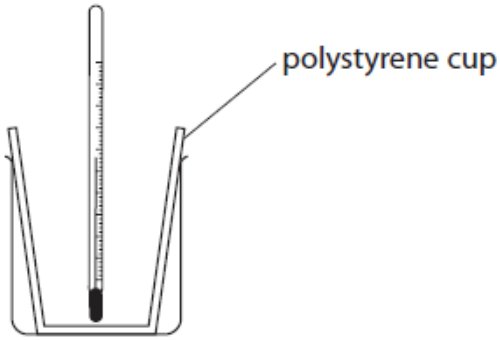
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(Total for question = 10 marks)

Q10.

A student uses this apparatus to find the temperature change when sodium hydroxide solution reacts with dilute hydrochloric acid.



This is the student's method.

- pour 20 cm^3 of sodium hydroxide solution into a polystyrene cup
- record the temperature of the sodium hydroxide solution
- add 20 cm^3 of dilute hydrochloric acid and stir the mixture
- record the highest temperature of the mixture

(a) (i) Give the formula of the ion that causes sodium hydroxide solution to be alkaline.

(1)

.....

(ii) Suggest a pH value for the dilute hydrochloric acid.

(1)

.....

(b) Explain why a polystyrene cup is used in this experiment.

(2)

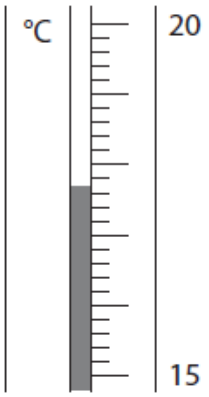
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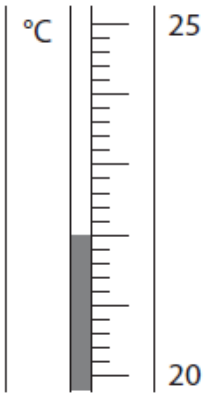
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(c) The diagram shows the thermometer readings at the start and at the end of the experiment.



start



end

Use the readings to complete the table, giving all values to the nearest 0.1 °C.

(3)

temperature in °C at end	
temperature in °C at start	
temperature change in °C	

(d) Another student does the experiment, but uses 25 cm^3 of sodium hydroxide solution and 25 cm^3 of dilute hydrochloric acid.

She records a temperature change of 5.2 °C.

Calculate the heat energy (Q) in kilojoules (kJ) released in this reaction.

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

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

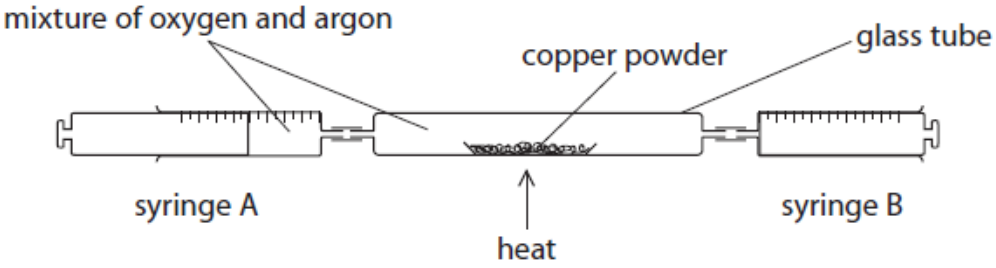
(4)

Q = ... kJ

(Total for question = 11 marks)

Q11.

A teacher uses this apparatus to find the percentage of oxygen in a gaseous mixture of oxygen and argon.



This is the teacher's method.

Step 1 heat the copper powder

Step 2 push the plunger on syringe A to pass the mixture of oxygen and argon over the hot copper so that the mixture moves into syringe B

Step 3 push the plunger on syringe B to pass the mixture of oxygen and argon over the hot copper so that the mixture moves into syringe A

Step 4 record the reading on syringe A

Step 5 repeat Steps 2, 3 and 4 a number of times

The volume of gas decreases as the oxygen reacts with the copper.

Argon is unreactive so does not react with the copper.

The copper powder turns black.

(a) (i) Give a reason why the copper powder is heated.

(1)

.....

.....

(ii) State why argon is unreactive.

(1)

.....

.....

(iii) Give the name of the black powder that forms when the oxygen reacts with the copper.

(1)

.....

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

Reading number	Reading on syringe A in cm^3
Start	78
1	70
2	67
3	65
4	63
5	61
6	60
7	59
8	58
9	58
10	58

(i) State how the results show that all the oxygen has reacted.

(1)

.....

.....

(ii) The volume of gas in the glass tube and connecting tubes is 175 cm^3.

Use this value and the results table to calculate the percentage of oxygen in the mixture of oxygen and argon.

(3)

percentage of oxygen = ... %

(iii) Suggest one reason why the calculated percentage of oxygen in the mixture may not be accurate.

(1)

.....

.....

(Total for question = 8 marks)

Q12.

Lithium, sodium and potassium are the first three elements in Group 1 of the Periodic Table.

(a) Suggest why these three elements are all stored in paraffin oil.

(1)

.....

.....

.....

(b) Caesium, Cs, is below potassium in Group 1.

(i) Give a similarity and a difference between the reactions of potassium with water and caesium with water.

(2)

similarity.....

.....

difference.....

.....

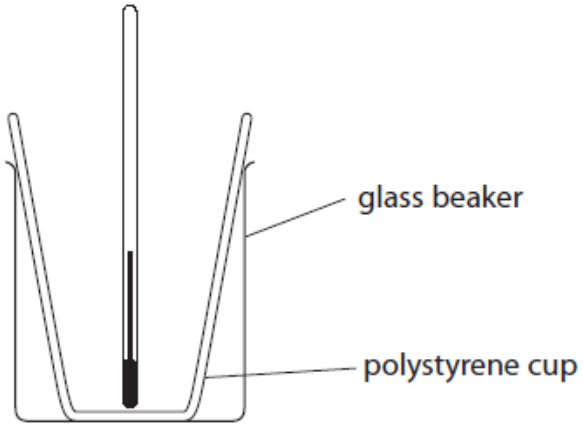
(ii) Give the chemical equation for the reaction between caesium and water.

(2)

.....

(c) A student investigates the temperature change in the reaction between dilute acids and solutions of Group 1 hydroxides.

He uses this apparatus.



This is the student's method.

- measure the temperature of 50 cm^3 of hydrochloric acid
- pour the acid into a polystyrene cup
- add 50 cm^3 of sodium hydroxide solution to the acid
- measure the maximum temperature of the mixture

(i) Suggest what could be added to the apparatus to improve the experiment.

(1)

.....

.....

(ii) Explain a change to the method that would improve the accuracy of the experiment.

(2)

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.....

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(d) These are the student's results.

temperature of hydrochloric acid = 19.9 °C

maximum temperature of mixture = 26.5 °C

(i) Calculate the energy change, Q, in joules for this reaction.

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

[for the mixture, c = 4.2 J/g/°C]

(3)

Q = ... J

(ii) In the student's reaction between hydrochloric acid and sodium hydroxide, 0.050 mol of water forms.

Calculate the molar enthalpy change, ΔH, in kJ/mol for this reaction.

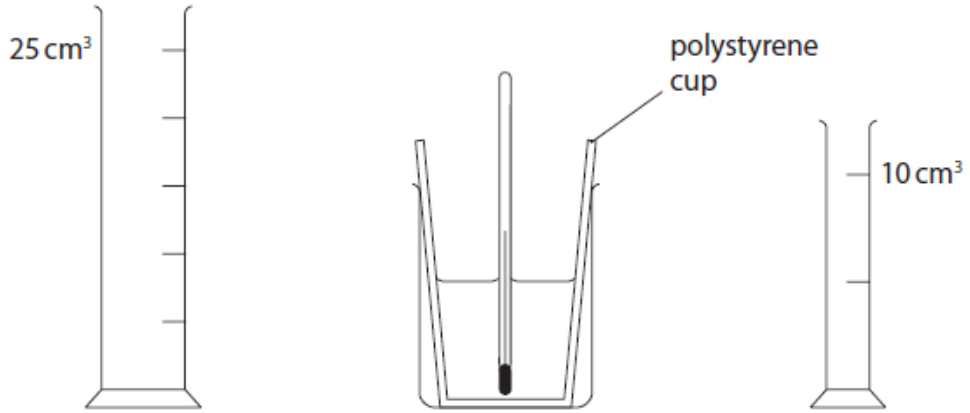
(2)

ΔH = ... kJ/mol

(Total for question = 13 marks)

Q13.

When aqueous solutions of potassium hydroxide and nitric acid are mixed together, an exothermic reaction occurs. The diagram shows the apparatus used in an experiment to measure the temperature increase.



This is the student's method;

- use the larger measuring cylinder to add 25 cm^3 of aqueous potassium hydroxide to the polystyrene cup
- record the steady temperature
- use the smaller measuring cylinder to add 5 cm^3 of dilute nitric acid to the cup, stir the mixture with the thermometer
- record the highest temperature of the mixture
- continue adding further 5 cm^3 portions of dilute nitric acid to the cup, stirring and recording the temperature, until a total volume of 35 cm^3 has been added.

(a) A teacher advises the student to use a 50 cm^3 burette instead of the 10 cm^3 measuring cylinder.

Suggest **two** reasons why it would be better to use a burette instead of a measuring cylinder to add the acid in this experiment.

(2)

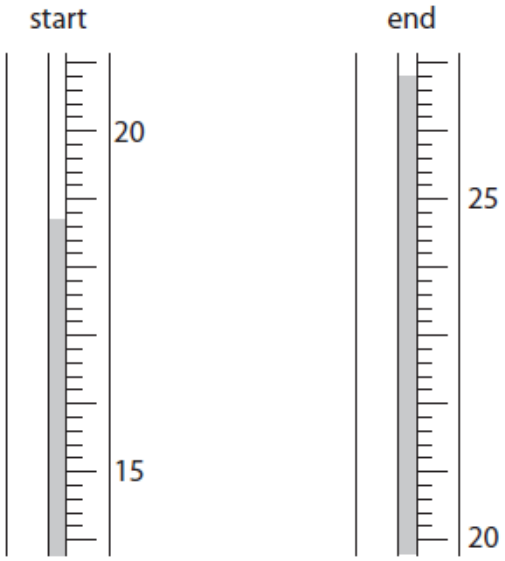
1 .....

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2 .....

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(b) The diagram shows the thermometer readings at the start and at the end of one experiment.



Complete the table to show:

- the thermometer reading at the start of the experiment
- the temperature rise in the experiment.

(2)

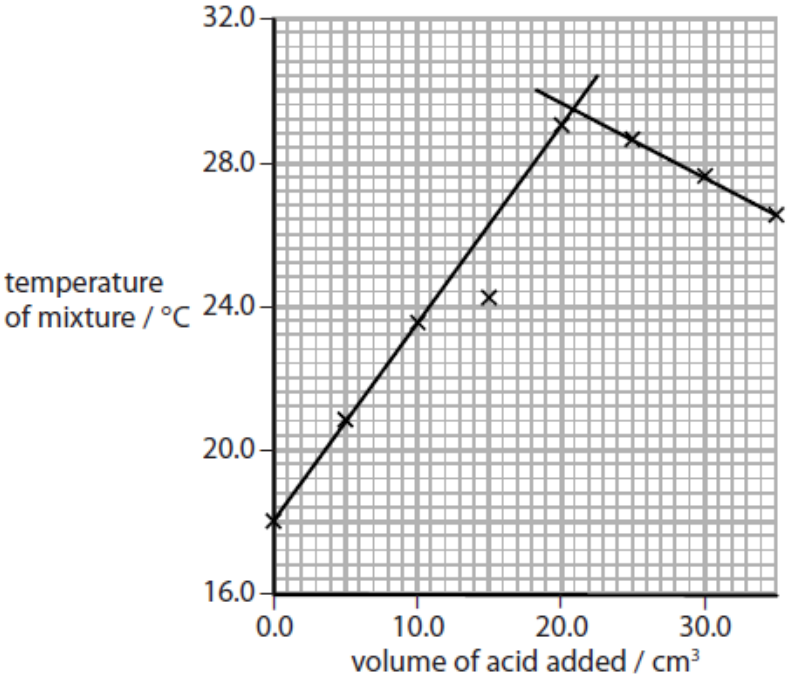
thermometer reading at end / °C	26.8
thermometer reading at start / °C	
thermometer rise / °C	

(c) Another student uses the same method, adding the dilute nitric acid from a burette.

The table shows his results.

volume of acid added / cm^3	0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0
temperature of mixture / °C	18.0	20.8	23.5	24.2	29.0	28.6	27.6	26.5

This is the student's graph.



The point where the lines cross represents complete neutralisation.

(i) Identify the maximum temperature reached during the experiment.

(1)

maximum temperature = ... °C

(ii) Identify the volume of dilute nitric acid that exactly neutralises the 25 cm^3 of aqueous potassium hydroxide.

(1)

volume = ... cm^3

(d) Another student records these results.

volume of aqueous potassium hydroxide	= 20.0 cm^3
starting temperature of aqueous potassium hydroxide	= 18.5 °C
maximum temperature of mixture	= 30.0 °C
volume of dilute nitric acid	= 20.0 cm^3

Calculate the heat energy released in this experiment.

c = 4.2 J/g / °C

mass of 1 cm^3 of mixture = 1 g

(4)

heat energy = ... J

(e) In another experiment, the heat energy released is 1600 J when 0.040 mol of potassium hydroxide is neutralised.

Calculate the value of ΔH, in kJ/mol, for the neutralisation of potassium hydroxide.

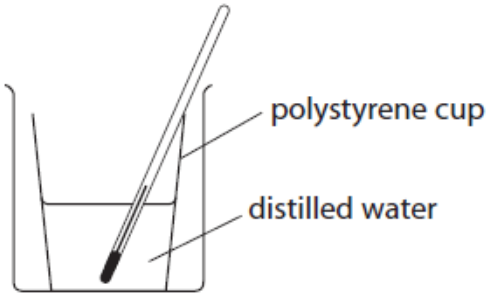
(2)

ΔH = ... kJ/mo

(Total for question = 12 marks)

Q14.

A student uses this apparatus to investigate the heat energy change when a salt dissolves in water to form a solution.



This is the student's method.

- add 50 cm^3 of distilled water to a polystyrene cup
- record the initial temperature of the water
- add a known mass of solid anhydrous copper(II) sulfate to the polystyrene cup and stir the solution with the thermometer until all the solid has dissolved
- record the maximum temperature of the copper(II) sulfate solution

(a) (i) Name the piece of apparatus the student should use to add the distilled water to the polystyrene cup.

(1)

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(ii) The student stirs the solution to help the solid dissolve more quickly.

Suggest another reason why the student stirs the solution.

(1)

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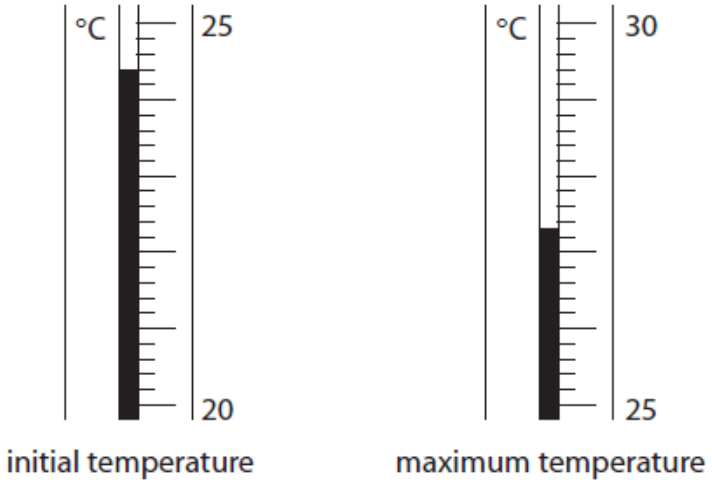
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(iii) State the colour of the copper(II) sulfate solution.

(1)

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(b) The diagram shows the temperatures in one experiment.



Complete the table, giving all values to the nearest 0.1 °C.

(3)

maximum temperature in °C	
initial temperature in °C	
increase in temperature in °C	

(c) In a second experiment, when a student dissolves the anhydrous copper(II) sulfate in 50 cm^3 of distilled water, the
increase in temperature is 3.3 °C.

(i) Show that the heat energy change (Q) in this second experiment is approximately 700 J.

[for water, c = 4.2 J/g/°C]

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

(2)

(ii) In this experiment the student uses 1.70 g of the anhydrous copper(II) sulfate.

Calculate the molar enthalpy change (ΔH) in kJ/mol.

Include a sign in your answer.

[M_r of $CuSO_4$ = 159.5]

(4)

ΔH = ... kJ/mol

(d) Another student does a similar experiment but uses hydrated copper(II) sulfate instead of anhydrous copper(II) sulfate.

The table shows his results.

initial temperature in °C	23.8
final temperature in °C when all solid dissolves	22.7

Explain what the results show about the type of energy change that occurs when hydrated copper(II) sulfate dissolves.

(2)

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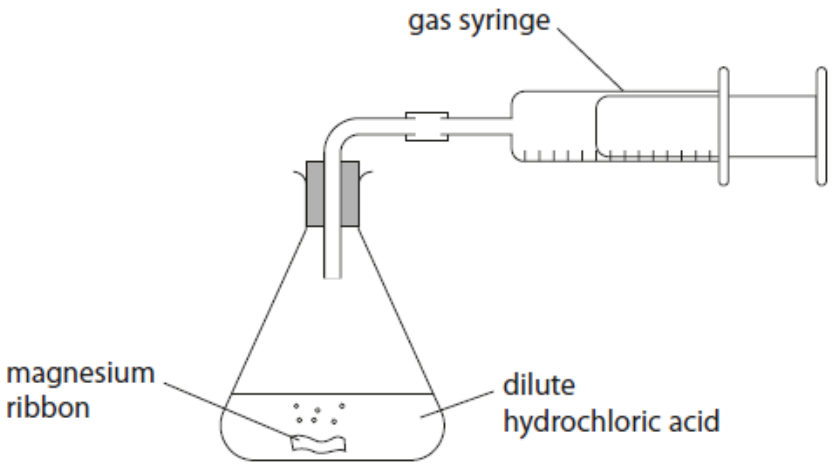
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(Total for question = 14 marks)

Q15.

A student uses this apparatus to investigate the rate of reaction between magnesium and an **excess** of dilute hydrochloric acid.



She uses this method.

- use a graduated beaker to pour 50 cm^3 of dilute hydrochloric acid of concentration 2.00 mol/dm^3 into the conical flask
- add a piece of magnesium ribbon of mass 0.086 g to the acid and put the bung into the

neck of the flask

- measure the total volume of gas collected every ten seconds until the reaction stops

The table shows the student's results.

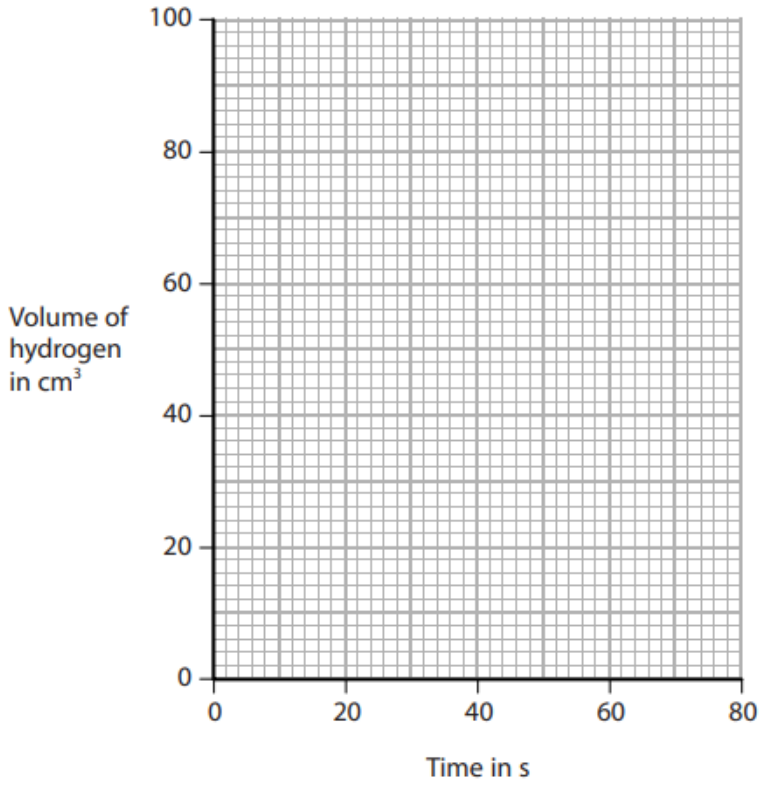
Time in s	Volume of hydrogen in cm^3
0	0
10	29
20	52
30	67
40	76
50	81
60	84
70	84
80	84

(a) (i) Plot the student's results on the grid.

(1)

(ii) Draw a curve of best fit.

(1)



(b) (i) The student repeats the experiment using

- 0.043 g of magnesium ribbon
- 50 cm^3 of 2.00 mol/dm^3 hydrochloric acid

Draw, on the grid in part (a), the curve you would expect in this experiment.

Label this curve Y.

(2)

(ii) The student repeats the experiment again, using

- 0.086 g of magnesium ribbon
- 50 cm^3 of 2.00 mol/dm^3 hydrochloric acid
- a slightly higher temperature than the first experiment

Draw, on the grid in part (a), the curve you would expect in this experiment.

Label this curve Z.

(2)

(c) The expected volume of gas produced in the first experiment is 86 cm^3.

Suggest why the volume collected is less than the expected volume.

(1)

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(d) The student uses a graduated beaker to measure the volume of dilute hydrochloric acid.

Explain why it is **not** necessary to use a measuring cylinder in this experiment.

(2)

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(e) The ionic equation for the reaction between magnesium and hydrochloric acid is

$$Mg(s) + 2H^+(aq) \rightarrow Mg^{2+}(aq) + H_2(g)$$

Use the information in this equation, and the particle collision theory, to explain why the rate of reaction decreases during each of the experiments.

(3)

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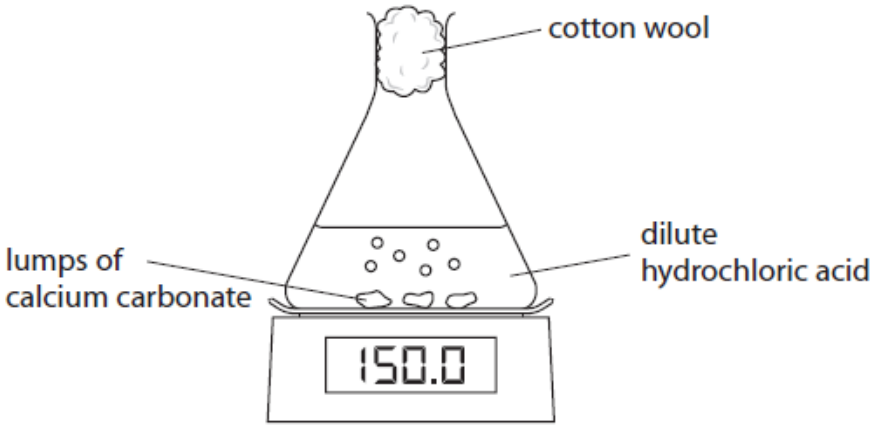
(Total for question = 12 marks)

Q16.

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

The equation for the reaction is

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



(a) Give a reason why the student puts cotton wool in the top of the flask.

(1)

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.....

(b) The student records the mass of the flask and its contents every 20 seconds for two minutes.

The table shows her results.

Time in s	Mass in g
0	150.0
20	148.2
40	147.2
60	146.6
80	146.2
100	146.0
120	146.0

(i) The mean (average) rate of reaction can be calculated using the expression

$$\text{mean rate of reaction} = \frac{\text{mass lost}}{\text{time taken to lose this mass}}$$

Calculate the mean rate of reaction during the first 20 seconds.

Give a unit.

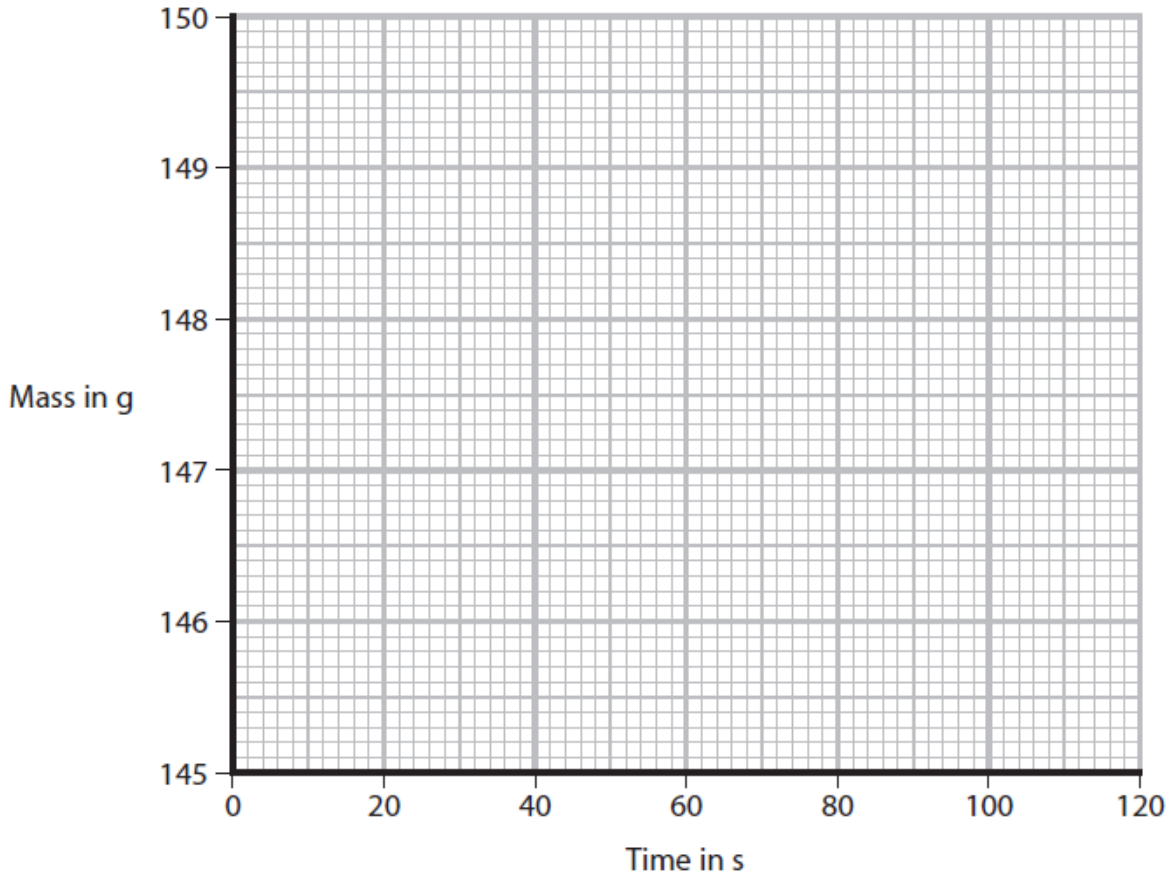
(2)

mean rate of reaction = ... unit

(ii) Plot the student's results.

Draw a curve of best fit.

(2)



(iii) Explain why the rate of reaction decreases during the experiment.

(2)

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(iv) Give a reason why the last two mass readings are the same.

(1)

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(c) The student repeats the experiment using the same mass of calcium carbonate, but in powdered form instead of lumps.

(i) Give two other variables that she should control.

(2)

1 .....

2 .....

(ii) Explain why the rate of reaction is greater when using powder instead of lumps of calcium carbonate.

(2)

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(iii) Suggest how the graph would be different when the reaction is repeated using the same mass of calcium
carbonate, but in powdered form instead of lumps.

(1)

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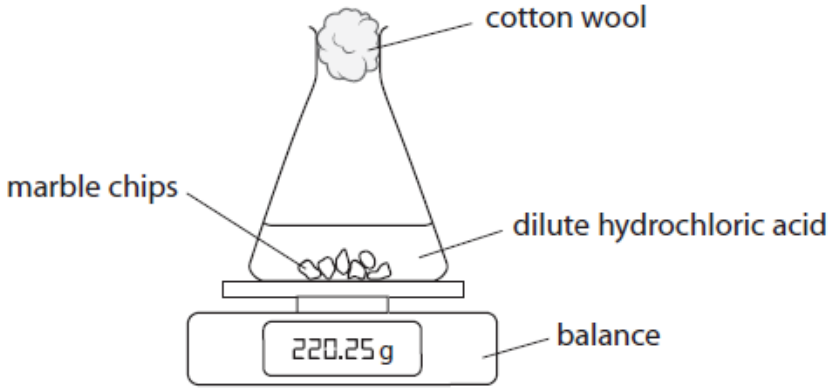
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(Total for question = 13 marks)

Q17.

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



The equation for the reaction is

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$$

(a) During the reaction the mass of the contents of the flask decreases.

(i) State why the mass of the contents of the flask decreases.

(1)

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(ii) State the purpose of the cotton wool.

(1)

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(iii) Explain why sulfuric acid is not a suitable acid to use in this investigation.

(2)

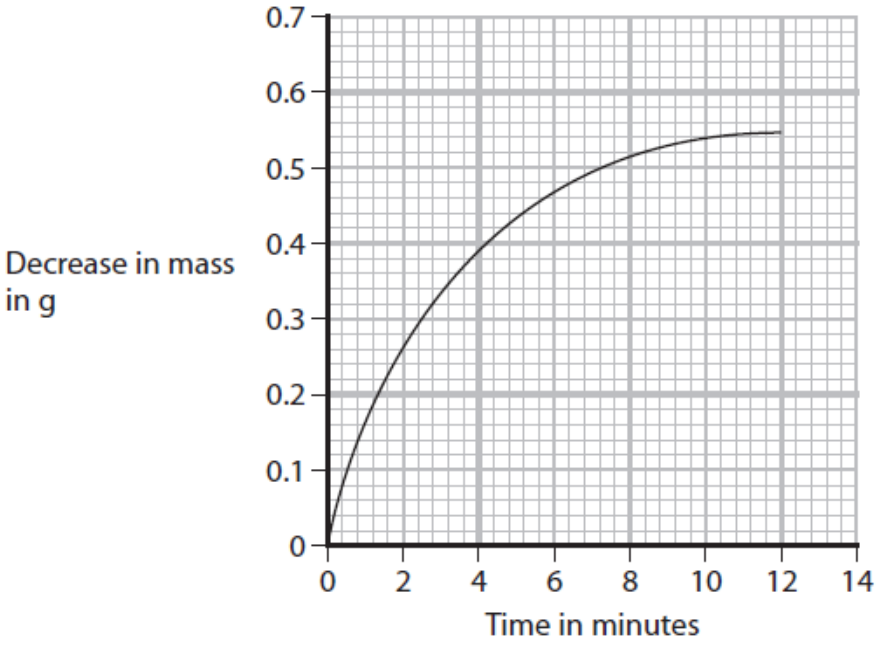
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(b) The graph shows the student's results.



(i) In the investigation the marble chips are in excess.

Explain the shape of the graph.

(4)

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(ii) The student repeats the experiment using the same volume of hydrochloric acid but of half the concentration of
the original acid. All other conditions are kept the same.

On the grid, draw the curve the student would obtain.

(2)

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

(4)

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(Total for question = 14 marks)

Q18.

A student investigates the reaction between magnesium and hydrochloric acid.

He uses this method.

Step 1 add 25 cm^3 of dilute hydrochloric acid to a polystyrene cup

Step 2 record the temperature of the acid

Step 3 find the mass of a 10 cm strip of magnesium ribbon

Step 4 add the magnesium ribbon to the hydrochloric acid

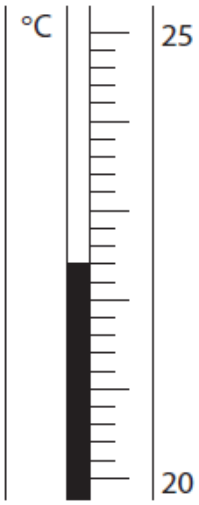
Step 5 when all the magnesium has reacted, record the highest temperature reached

(a) Complete the word equation for the reaction.

(1)

magnesium + hydrochloric acid → ..... + ...

(b) The thermometer shows the temperature of the acid at the start of the experiment.



(i) Complete the table by giving the temperatures to the nearest 0.1 °C.

(2)

temperature of the acid at the start in °C	
highest temperature reached in °C	
temperature rise in °C	20.8

(ii) Show that the heat energy change (Q) for this reaction is about 2200 J.

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

[for the solution, c = 4.2 J/g/°C]

(2)

(iii) The mass of magnesium used by the student was 0.12 g.

Calculate the value of the enthalpy change (ΔH), in kilojoules per mole of magnesium, for the reaction between magnesium and hydrochloric acid.

Include a sign in your answer.

(4)

ΔH = ... kJ/mol

(Total for question = 9 marks)

Q19.

A student investigates the reaction between solid hydrated sodium carbonate and dilute hydrochloric acid.

(a) She uses this method to investigate the temperature change during the reaction.

Step 1 pour 25.0 cm^3 of dilute hydrochloric acid into a polystyrene cup

Step 2 record the temperature of the dilute hydrochloric acid

Step 3 add 0.5 g of sodium carbonate and stir the mixture

Step 4 record the lowest temperature of the mixture

Step 5 add further 0.5 g portions of sodium carbonate, one portion at a time, stir the mixture and record the lowest temperature each time

The table shows the student's results.

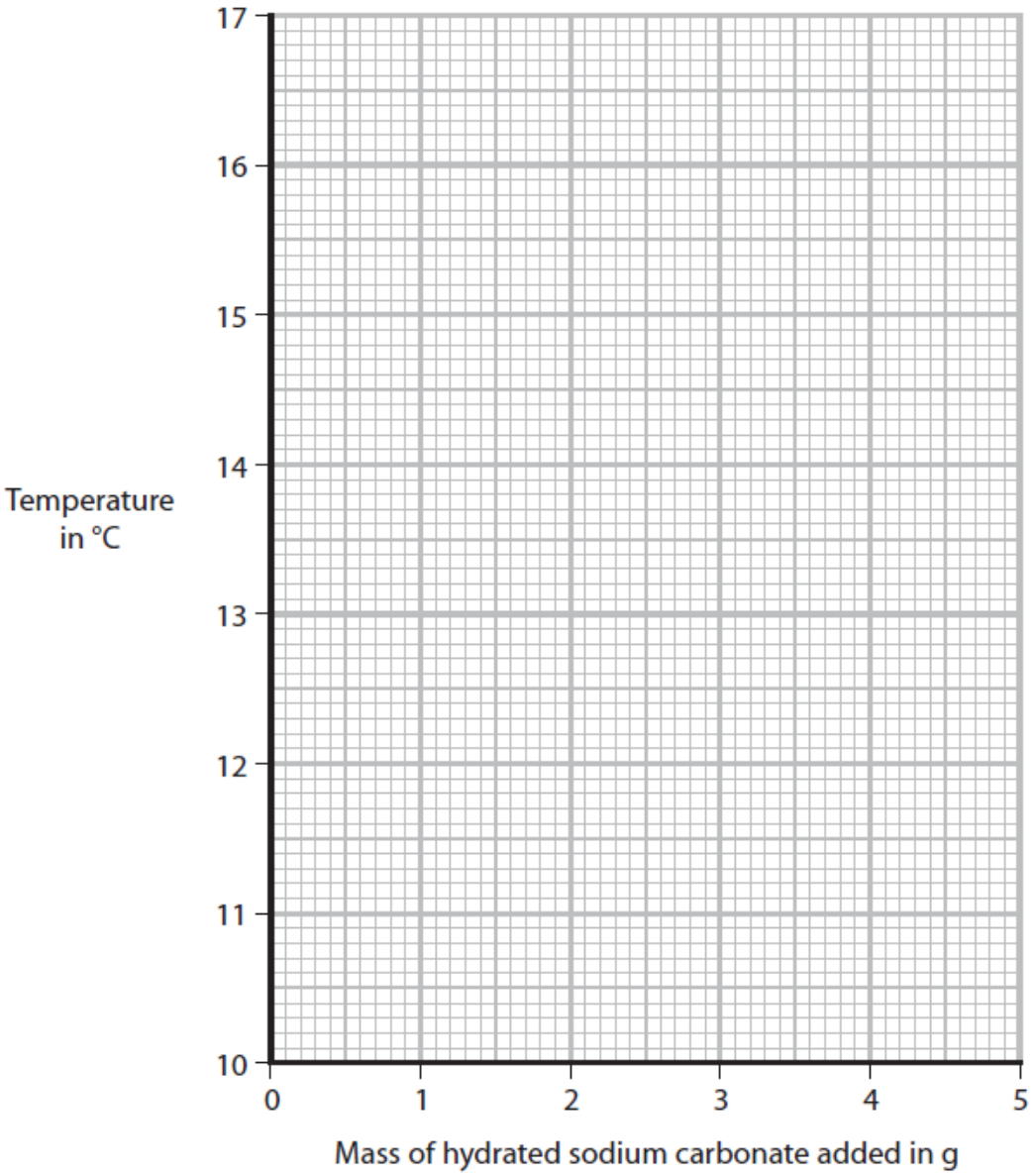
Mass of sodium carbonate added in g	Temperature in °C
0.0	17.0
0.5	15.6
1.0	14.1
1.5	13.0
2.0	12.9
2.5	12.2
3.0	11.8
3.5	11.5
4.0	11.2
4.5	11.0
5.0	11.0

(i) Plot the student's results on the grid.

(2)

(ii) Draw a curve of best fit, ignoring the anomalous result.

(1)



(iii) Explain why it is better to use a polystyrene cup instead of a glass beaker in this experiment.

(2)

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.....

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.....

(iv) Suggest a reason for the anomalous result.

(1)

.....

.....

(v) State how the results show that all the dilute hydrochloric acid has reacted.

(1)

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.....

(vi) Use the results of the experiment to explain the type of reaction that occurs when sodium carbonate is added to dilute hydrochloric acid.

(2)

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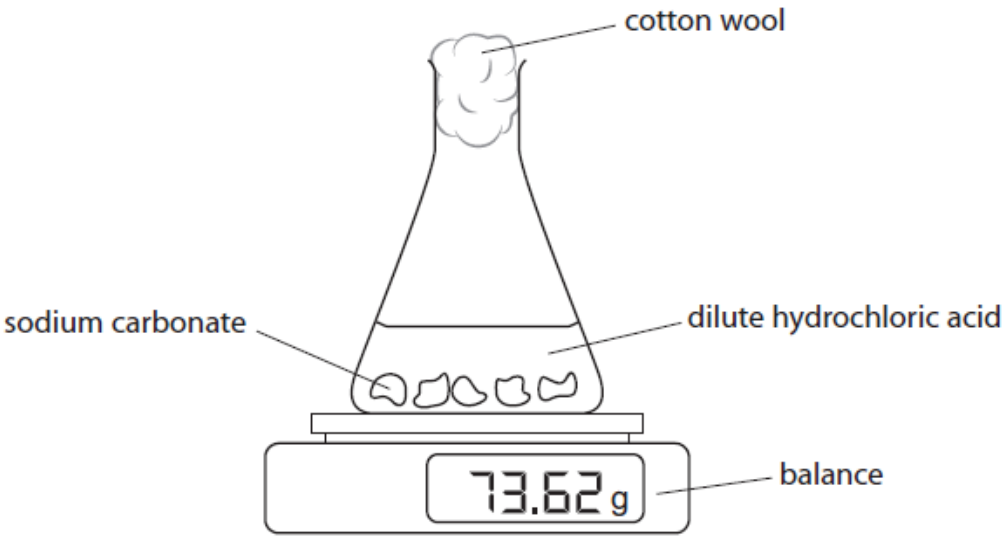
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(b) The student does another experiment using the same reaction.

The diagram shows the student's apparatus.



The mass on the balance decreases as carbon dioxide gas escapes.

(i) Give a reason for the cotton wool plug in the conical flask.

(1)

.....

.....

(ii) The student adds 2.12 g of sodium carbonate to an excess of dilute hydrochloric acid.

The chemical equation for the reaction is

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

Calculate the maximum mass, in g, of carbon dioxide formed in the reaction.

(3)

mass = ... g

(iii) Suggest why the mass of carbon dioxide produced is less than the calculated maximum mass.

(1)

.....

.....

(Total for question = 14 marks)

Q20.

This question is about lithium oxide.

(a) The diagram shows the electron configurations of an atom of lithium and an atom of oxygen.



lithium oxygen

Describe the changes in electronic configuration when lithium and oxygen react to form lithium oxide, Li_2O

(3)

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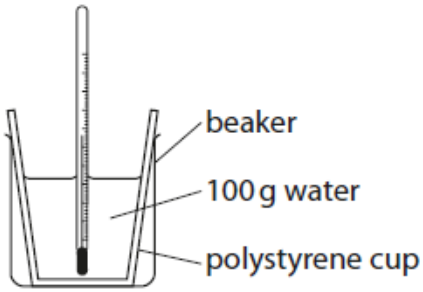
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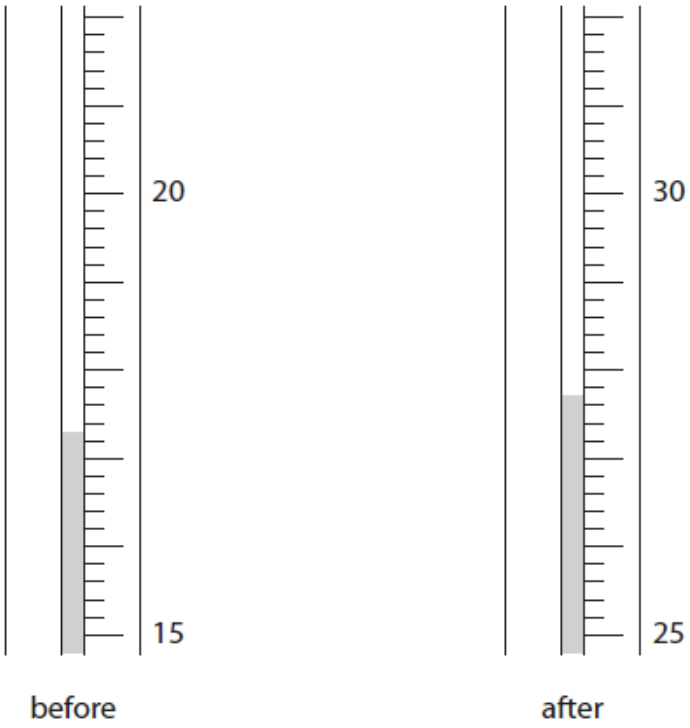
(b) Lithium oxide reacts with water to form lithium hydroxide as the only product.
A scientist uses this apparatus to measure the temperature change of the reaction.



This is the scientist's method.

- pour 100 g of water into a polystyrene cup
- record the temperature of the water
- add the lithium oxide and stir the mixture
- record the maximum temperature reached

The diagram shows the thermometer readings before and after adding the lithium oxide.



(i) Complete the table, giving all values to the nearest 0.1 °C.

(2)

temperature in °C after adding the lithium oxide	
temperature in °C before adding the lithium oxide	17.3
temperature rise in °C	

(ii) Calculate the heat energy change in the reaction.

Give your answer to two significant figures.

[c = 4.2 J / g / °C]

(4)

heat energy change = ... J

(iii) In another experiment the scientist obtains these results.

amount of lithium oxide in mol	0.0580
heat energy change in J	5210

Calculate the molar enthalpy change (ΔH) in kJ / mol.

Include a sign in your answer.

(3)

ΔH = ... kJ / mol

(iv) Give a reason why the scientist does the experiment in a polystyrene cup.

(1)

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(Total for question = 13 marks)

Q1.