

- 1 Ethanedioic acid is used in some stain removal products.

In the solid crystals of ethanedioic acid, $\text{C}_2\text{H}_2\text{O}_4$, each molecule is combined with x molecules of water.

The formula of the crystals is $\text{C}_2\text{H}_2\text{O}_4 \cdot x\text{H}_2\text{O}$. x is a whole number.

In this experiment, you will determine the value of x .

Read all the instructions carefully before starting the experiment in Question 1.

Instructions

A is aqueous ethanedioic acid. 1.00 dm^3 of **A** contains 8.90 g of $\text{C}_2\text{H}_2\text{O}_4 \cdot x\text{H}_2\text{O}$.

B is 0.150 mol/dm^3 sodium hydroxide, NaOH .

C is thymolphthalein indicator.

- (a) (i)
- Fill the burette with **B**.
 - Use the pipette to transfer 25.0 cm^3 of **A** into the conical flask.
 - Add a few drops of indicator **C** to the conical flask. Ensure that the lid is placed back on the container of indicator **C** after use.
 - Add **B** from the burette to the conical flask whilst constantly swirling the flask.
The end-point of the titration is when one drop of **B** changes the colour of the solution to pale blue that does not change on swirling.
 - Record your results in an appropriate format in the space provided. Repeat the titration as many times as you consider to be necessary to achieve consistent results.

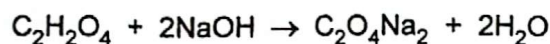
Results

[4]

- (ii) From your titration results, calculate the average volume of **B** required to reach the end-point of the titration. Show clearly how you obtained this volume.

average volume of **B** = cm^3 [1]

(b) The equation for the titration reaction is shown.



(i) B is 0.150 mol/dm³ sodium hydroxide.

Use your answer to (a)(ii) to calculate the amount of sodium hydroxide, in moles, used to reach the end-point of the titration. Use this amount and the equation for the reaction to calculate the number of moles of ethanedioic acid, C₂H₂O₄, present in 25.0 cm³ of A.

amount of NaOH in the average volume of B = mol

amount of ethanedioic acid, C₂H₂O₄, in 25.0 cm³ of A = mol
[2]

(ii) Use your answer to (b)(i) to calculate the amount, in moles, of ethanedioic acid, C₂H₂O₄, in 1.00 dm³ of A.

amount of ethanedioic acid, C₂H₂O₄, in 1.00 dm³ of A = mol [1]

(iii) Use your answer to (b)(ii) and the M_r of C₂H₂O₄ to calculate the mass of ethanedioic acid, C₂H₂O₄, in 1.00 dm³ of solution A.
[A_r: C, 12; H, 1; O, 16]

mass of ethanedioic acid in 1.00 dm³ of A = g [1]

- (iv) The mass of the ethanedioic acid crystals, $\text{C}_2\text{H}_2\text{O}_4 \cdot x\text{H}_2\text{O}$, dissolved in 1.00 dm^3 is 8.90 g .

Use your answer to (b)(iii) to calculate the amount, in moles, of water present in 8.90 g of $\text{C}_2\text{H}_2\text{O}_4 \cdot x\text{H}_2\text{O}$.

[A_r : H, 1; O, 16]

amount of water = mol [3]

- (v) Use your answers to (b)(ii) and (b)(iv) to calculate the value of x in the ethanedioic acid crystals, $\text{C}_2\text{H}_2\text{O}_4 \cdot x\text{H}_2\text{O}$.

value of x = [1]

- (c) (i) A student completes this experiment. Before each titration the student rinses the conical flask with deionised water. Some deionised water is left in the conical flask after rinsing.

State and explain the effect, if any, that this would have on the volume of **B** required to reach the end-point of the titration.

.....
.....
..... [1]

- (ii) Another student carries out this titration but consistently misses the end-point. The student's average volume of **B** added is slightly higher than it should be.

Explain why this error is unlikely to change the calculated whole number value of x .

.....
.....
..... [2]

[Total: 16]

- 2 You will investigate the reaction between magnesium and a dilute acid by measuring the volume of gas produced.

Read all the instructions carefully before starting the experiments in Question 2.

Instructions

D is 2.00 mol/dm^3 acid.

E is magnesium.

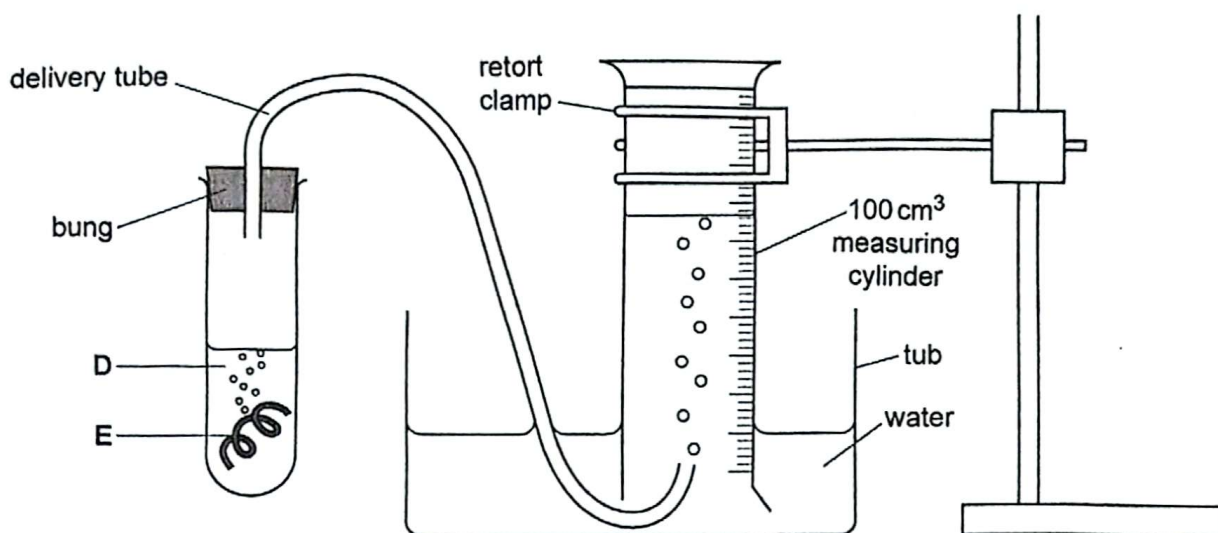


Fig. 2.1

- (a) (i)
- Fig. 2.1 shows how the apparatus is arranged.
 - Place a boiling tube into the test-tube rack.
 - Use the 25 cm^3 measuring cylinder to measure 15.0 cm^3 of the acid, D, and carefully pour it into the boiling tube.
 - Use the same 25 cm^3 measuring cylinder to measure 5.0 cm^3 of deionised water. Carefully add it to the acid in the boiling tube. Mix the acid and water using a glass rod.
 - Add tap water to the tub to half fill the tub (if this has not been done for you).
 - Fill the 100 cm^3 measuring cylinder **completely** with tap water. Hold a piece of paper towel firmly over the top, invert the measuring cylinder and place it in the water in the tub.
 - Remove the paper towel and clamp the inverted measuring cylinder so that the open end is in the water.
 - Check that the bung fits the boiling tube. Place the end of the delivery tube into the inverted 100 cm^3 measuring cylinder.
 - Use a dropper to introduce small amounts of air from the open end of the inverted measuring cylinder to adjust the water level until it reaches the 10 cm^3 mark.
 - You may fold or curl the piece of E so that it can easily be dropped into the boiling tube without getting stuck on the sides.
 - Carefully remove the bung from the boiling tube, drop E into the acid and quickly insert the bung into the boiling tube. Make sure that the only way gas can escape the boiling tube is through the delivery tube.
 - The experiment is complete when the volume of gas collected is no longer changing. Complete Table 2.1 to show your results.

Results

Table 2.1

volume of D /cm ³	
volume of deionised water added to D /cm ³	
volume of gas collected/cm ³	

[3]

- (ii) State which reactant, the acid or magnesium, is the limiting reactant. Explain your answer using observations from the experiment.

.....
.....
..... [1]

- (b) A student measures the volume of gas produced every 10 seconds during a reaction between magnesium and 0.50 mol/dm³ acid until the reaction is complete. The student's results are shown in Table 2.2. The acid is the limiting reactant in this reaction.

Table 2.2

time/s	0	10	20	30	40	50	60	70	80	90
volume of gas collected/cm ³	0	28	48	66	78	85	89	91	92	92

- (i) Plot a graph of the volume of gas collected against time on the grid.

Draw a line of best fit using all of the plotted points.

[4]

- (ii) Use your graph to calculate the average rate of gas production for the first 25 s of the reaction.

Give your answer to **three** significant figures.

Show all working.

average rate of gas production for the first 25 s = [2]

- (iii) Describe how the rate of reaction changes during the reaction. Refer to your graph in your answer.

.....
.....
..... [2]

- (iv) The same student carries out a second experiment using the same acid with a different concentration of 0.25 mol/dm^3 . All other conditions are the same and the reaction is complete by 90 s.

Sketch a line on the graph to show the results you would predict for this experiment. Label this line X.

[2]

- (c) (i) In this experiment, you will determine the identities of acids D and F.

D and F each contain one anion which is listed in the qualitative analysis notes on page 12. The 2 anions are **not** the same.

Select reagents to determine the identity of the anions in each of the acids, D and F. You should only use the bench reagents provided.

Carry out 3 tests on D and the same 3 tests on F. One of the tests has been provided for you in Table 2.3.

Use a 1 cm depth of either D or F for each test.

Record your tests and observations in Table 2.3. You should test any gas evolved.

If no observable change is observed for a test, write 'no observable change'.

If heating is required, a boiling tube must be used.

Table 2.3

test	observations for D	observations for F
Add about 1 cm depth of D in a clean boiling tube. Add about 2 cm depth of aqueous sodium hydroxide, shake the contents and then add a piece of aluminium foil. Heat the contents carefully. Repeat the test using F.		

[4]

(ii) Use your observations in Table 2.3 to deduce the formulae of the acids D and F.

D is

F is [1]

[Total: 19]

3 Amino acids are compounds that are essential for growth and repair of the body.

A food supplement powder states that it contains three different amino acids. A sample of the food supplement dissolves in water to form a colourless solution.

Describe a chromatography experiment to identify the three amino acids present in the food supplement.

The description should include:

- apparatus and method
- any measurements or observations
- how to analyse the results.

You can assume that all apparatus and reagents normally found in a school laboratory are available.

You may wish to include one or more labelled diagrams as part of your answer.

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..... [5]

[Total: 5]

- 1 Hydrochloric acid and sodium thiosulfate solution react as shown in the equation.



You will investigate how the rate of reaction changes when the concentration of sodium thiosulfate changes.

The rate of reaction can be determined by measuring the time taken for the solution to become so opaque that you cannot see through it.

Read all the instructions carefully before starting the experiments in Question 1.

Instructions

A is 1.0 mol/dm^3 hydrochloric acid.

B is 0.1 mol/dm^3 sodium thiosulfate.

Very small amounts of sulfur dioxide gas may be produced in this reaction. Take care not to inhale any gas. The reaction products should be disposed of into the container labelled **WASTE** immediately following each experiment.

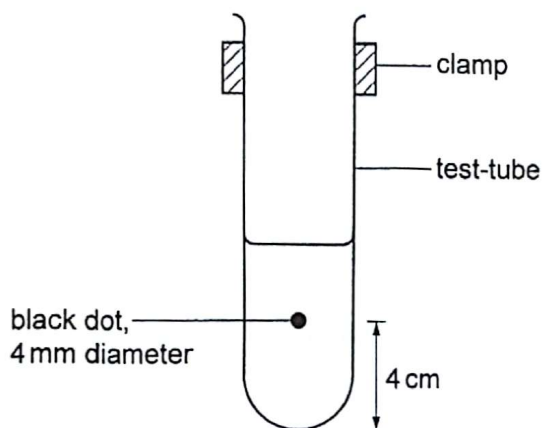


Fig. 1.1

(a) (i) Experiment 1

- Use the marker pen to draw a dot onto the test-tube, as shown in Fig. 1.1. The dot should be approximately 4 mm in diameter and positioned approximately 4 cm from the bottom of the test-tube. Repeat this process with 4 other clean and dry test-tubes. These 5 test-tubes should be used for **Experiments 1 to 5**.
- Use the 10 cm^3 measuring cylinder labelled **A** to transfer 1.0 cm^3 of **A** into a test-tube.
- Clamp the test-tube with the dot at the back so that you must look through the solution to see it.
- Use the other 10 cm^3 measuring cylinder to measure 10.0 cm^3 of **B**.
- Pour **B** into the test-tube and immediately start the stopwatch.
- Stop the stopwatch as soon as you can no longer see the dot through the reaction mixture. Record the time to the nearest second in the results table on page 4.
- Empty the contents of the test-tube into the **WASTE** container provided.

Experiment 2

- Use the 10 cm^3 measuring cylinder labelled **A** to add 1.0 cm^3 of **A** into another test-tube.
- Clamp the test-tube with the dot at the back so that you must look through the solution to see it.
- Use the other 10 cm^3 measuring cylinder to measure 2.0 cm^3 of **B**.
- Add 8.0 cm^3 of deionised water to the measuring cylinder to make the total volume 10.0 cm^3 .
- Pour the mixture of **B** and water into the test-tube and immediately start the stopwatch.
- Stop the stopwatch as soon as you can no longer see the dot through the reaction mixture. Record the time to the nearest second in the results table on page 4.
- Empty the contents of the test-tube into the **WASTE** container provided.

Experiments 3 to 5

- Choose 3 further volumes of **B** between 2.0 cm^3 and 10.0 cm^3 and deionised water. Record the volumes you have chosen in the results table provided on page 4.
- Follow the instructions for **Experiment 2** for each pair of volumes you have chosen. You should use a fresh test-tube, labelled using the instructions on page 2, in each experiment.

Results

experiment	volume of A/cm ³	volume of B/cm ³	volume of deionised water/cm ³	reaction time/s	rate of reaction/s ⁻¹
1	1.0	10.0	0.0		
2	1.0	2.0	8.0		
3	1.0				
4	1.0				
5	1.0				

[5]

- (ii) Calculate the rate of reaction in each experiment using the following equation.

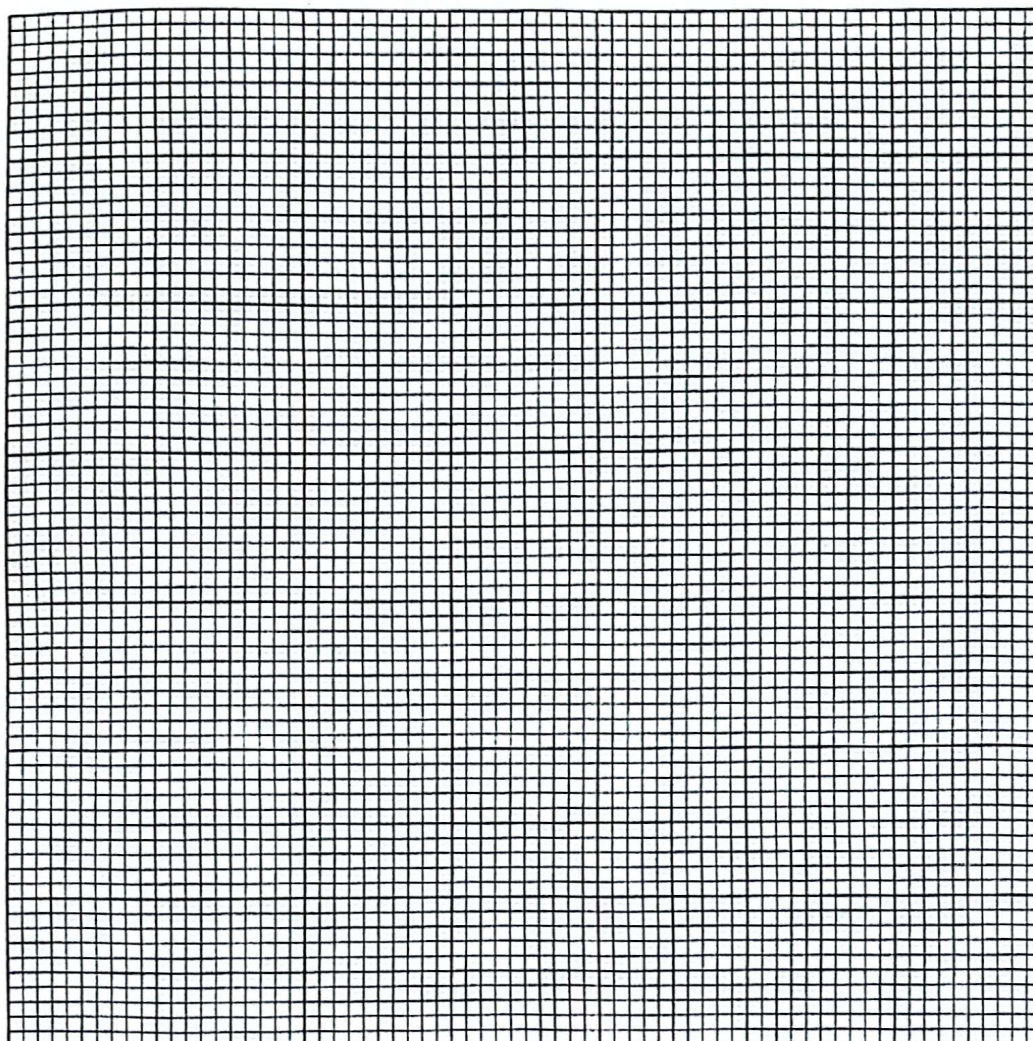
$$\text{rate of reaction} = \frac{1000}{\text{reaction time}}$$

Record each rate in the results table to **three** significant figures.

[2]

- (b) (i) Use your results to plot a graph of rate against volume of **B** on the grid. You should include the origin (0,0).

Draw a line of best fit. Circle anomalous points, if any.



[4]

- (ii) Use your graph to determine the rate of reaction if the volume of **B** used is 1.7 cm^3 . Show clearly **on the graph** how you obtained your answer.

rate = s^{-1} [1]

- (c) (i) Calculate the concentration of **B** in the reaction mixture at the start of Experiment 1.

concentration of **B** at the start of Experiment 1 = [1]

- (ii) Deduce the concentration of **B** in the reaction mixture at the start of Experiment 2.

concentration of **B** at the start of Experiment 2 = [2]

- (iii) Describe the relationship between concentration of **B** and rate of reaction.

Explain your answer using your graph and ideas about collisions between reacting particles.

.....
.....
.....
.....
..... [2]

- (iv) Explain why water was added to each reaction mixture for Experiments 2 to 5.

.....
.....
..... [2]

- (d) (i) A student uses a 10 cm³ measuring cylinder to measure out 10.0 cm³ of **B** in experiment 1. The measuring cylinder has an uncertainty of ± 0.2 cm³.

Calculate the percentage uncertainty in measuring 10 cm³ of **B** in experiment 1.

$$\text{percentage uncertainty} = \frac{\text{uncertainty}}{\text{measured value}} \times 100$$

Give your answer to **two** significant figures.

percentage uncertainty in measuring 10.0 cm³ of **B** = % [1]

- (ii) Suggest **one** change that could be made to the equipment used for the experiments to improve the accuracy of the results.

.....
.....
..... [1]

[Total: 21]

2 Read all the instructions carefully before starting the experiments in Question 2.

C is a powdered sample of an impure mineral ore.

- (a) The impure mineral ore **C** contains three ions. The ions are copper(II), carbonate and a third ion, the identity of which is unknown.

You are provided with two samples of **C**.

Instructions

- (i) Carry out the following tests on **C**. Test and identify any gases evolved. Record your observations in the table. If no change is observed for a test, write 'no observable changes'.

The volumes given below are approximate and should be estimated rather than measured.

<i>test</i>	<i>instructions</i>	<i>observations</i>
1	Remove the stopper from a sample of C in a test-tube. Heat the sample in the test-tube gently at first and then strongly for 1 min.	
2	Transfer the other provided 0.25 g measure of C to a boiling tube. Carefully add dilute nitric acid to a depth of approximately 5 cm. Keep the final solution for use in Tests 3–5.	
3	Add a 1 cm depth of the solution from Test 2 into a test-tube. Add aqueous ammonia slowly with shaking until no further change is seen.	
4	Add a 1 cm depth of the solution from Test 2 into a test-tube. Add a few drops of aqueous barium nitrate.	
5	Add a 1 cm depth of the solution from Test 2 into a test-tube. Add a few drops of aqueous silver nitrate.	

[5]

- (ii) Deduce the identity of the third ion in **C**. State which test provides evidence for your conclusion.

.....
..... [1]

- (b) **A** is 1.0 mol/dm^3 hydrochloric acid, HCl .
D is a 0.70 g sample of the same impure mineral ore as **C**.

You will determine the percentage by mass of copper(II) carbonate in a sample of **D** by measuring the loss in mass when **D** reacts with excess acid.

Instructions

- Use a 50 cm^3 measuring cylinder to add 50.0 cm^3 of **A** to the conical flask.
- Weigh the conical flask and **A** and record the mass.
- Carefully add all of sample **D** to the conical flask.
- Swirl the conical flask continuously until the reaction is complete.
- Reweigh the conical flask and its contents and record the mass.
- Record all your results in an appropriate format.

Results

[2]

(c) Calculations

- (i) Write the equation for the reaction between copper(II) carbonate and hydrochloric acid. Include state symbols.

..... [1]

- (ii) From your results determine the mass of gas lost during the reaction.

mass of gas lost during the reaction = g
[1]

- (iii) Use information given in the question and your answer to (c)(i) and (c)(ii) to calculate the mass of copper(II) carbonate present in the sample of **D** used.

[A_r : C, 12; Cu, 64; O, 16]

mass of copper(II) carbonate present = g [2]

- (iv) Use your answer to (c)(iii) and information given in the question to calculate the percentage by mass of copper(II) carbonate in **D**.

percentage by mass of copper(II) carbonate in **D** =% [1]

[Total: 13]

- 3 (a) Propanoic acid is produced by reacting propanol with potassium manganate(VII) and dilute sulfuric acid. This reaction can also produce another organic compound, propanal.

A student reacts propanol, potassium manganate(VII) and sulfuric acid. At the end of the reaction, the reaction flask contains propanoic acid, propanal and an aqueous solution containing ionic compounds. The student plans to collect pure propanal.

Describe a method the student can use to separate pure propanal from propanoic acid, water and ionic compounds.

Include a diagram of the apparatus required. You may assume that the apparatus normally found in a school laboratory are available.

[boiling points: propanoic acid, 141 °C; propanal, 49 °C]

.....

.....

.....

.....

.....

..... [4]

- (b) After collecting the propanal produced, the student tests it to check that it does **not** contain propanoic acid.

State a chemical reagent, other than an indicator, that may be used to test for propanoic acid.

Describe what is observed if propanoic acid is present.

.....

.....

..... [2]

[Total: 6]

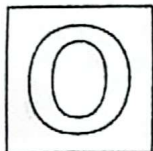
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6092/03/O/N/23

Oct/Nov 2023 Paper 3 (11)



MINISTRY OF EDUCATION, SINGAPORE
in collaboration with
CAMBRIDGE ASSESSMENT INTERNATIONAL EDUCATION
General Certificate of Education Ordinary Level

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CHEMISTRY

6092/03

Paper 3 Practical

October/November 2022

1 hour 50 minutes

Candidates answer on the Question Paper

Additional Materials: As listed in the Confidential Instructions

READ THESE INSTRUCTIONS FIRST

Write your Centre number, index number and name on all the work you hand in.
Give details of the practical shift and laboratory where appropriate, in the boxes provided.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO NOT WRITE ON ANY BARCODES.

Answer all questions in the spaces provided on the Question Paper.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.
Qualitative Analysis Notes are printed on page 12.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [] at the end of each question or part question.

Shift
Laboratory

For Examiner's Use	
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2	
Total	

This document consists of 12 printed pages.



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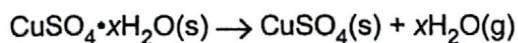


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1 Copper(II) sulfate, CuSO_4 , is used in agriculture to reduce leaf spots on fruit trees.

- (a) Copper(II) sulfate often occurs as a hydrated solid with the formula $\text{CuSO}_4 \cdot x\text{H}_2\text{O}$. In these crystals, one formula unit of copper(II) sulfate, CuSO_4 , combines with x molecules of water.

In this experiment, you will carry out a thermal decomposition to determine the value of x . The equation for the decomposition is shown.



Read all the instructions carefully before starting the experiments in Question 1.

Instructions

A is hydrated copper(II) sulfate, $\text{CuSO}_4 \cdot x\text{H}_2\text{O}$.

1. Use the balance to measure and record the mass of an empty boiling tube.
2. Transfer all solid A to the boiling tube. Measure and record the total mass of the boiling tube and A.
3. **Gently** heat the boiling tube for approximately 2 minutes. It is important that A is heated gently in order to achieve accurate results.
4. Record your observations in (a)(i).
5. Leave the boiling tube to cool to room temperature.

You may start working on Question 1(c) whilst waiting for the boiling tube to cool.

6. Reweigh the boiling tube and its contents and record the mass.
7. **Gently** heat the boiling tube again for approximately 1 minute.
8. Leave the boiling tube to cool to room temperature.
9. Reweigh the boiling tube and its contents and record the mass.
10. Record all your results in an appropriate format in (a)(ii).

(i) Observations

.....
..... [1]

(ii) Results

[4]

- (iii) The solid remaining after the second heating is anhydrous copper(II) sulfate, CuSO_4 . Calculate the mass, in g, of CuSO_4 remaining after the second heating.

mass of CuSO_4 = g [1]

- (iv) Calculate the amount, in mol, of anhydrous copper(II) sulfate, CuSO_4 , remaining after the second heating.

[A_r : Cu, 64; S, 32; O, 16]

amount of CuSO_4 = mol [1]

- (v) Calculate the **total** mass, in g, of water lost from the original sample of **A** after the second heating.

total mass of water lost = g [1]

- (vi) Calculate the total amount, in mol, of water lost during heating.

[A_r : H, 1; O, 16]

amount of water lost = mol [1]

- (vii) Use the equation for the decomposition and your answers to (iv) and (vi) to calculate the value of x .

Give your answer to the nearest whole number.

x = [1]

(b) (i) Explain why the sample of **A** is heated twice in (a).

In your answer, state and explain whether heating your sample of **A** for a third time would give a more accurate value for x .

.....

.....

.....

.....

..... [2]

(ii) Another student carried out the experiment in (a). The student heated the sample of **A** strongly causing it to decompose to give a black solid and a pungent gas.

State and explain the effect, if any, on the student's calculated value of x .

.....

.....

.....

.....

..... [2]

- (c) When anhydrous salts such as CuSO_4 are dissolved in water, there is sometimes a change in the temperature of the water as the salt dissolves.

In this experiment, you will determine the change in temperature when a sample of anhydrous CuSO_4 is dissolved in water.

Instructions

B is anhydrous copper(II) sulfate, CuSO_4 .

Place a polystyrene (Styrofoam) cup into a 250 cm^3 glass beaker.

Use a measuring cylinder to measure 20 cm^3 of deionised water into the polystyrene cup.

Measure and record the temperature of the deionised water.

Transfer all of **B** into the cup and use the thermometer to stir until the temperature no longer changes.

Measure and record the maximum temperature of the mixture.

Record your results in the table in (c)(i). Calculate the change in temperature in your experiment.

(i) Results

temperature of deionised water / $^{\circ}\text{C}$	
maximum temperature of mixture / $^{\circ}\text{C}$	
change in temperature / $^{\circ}\text{C}$	

[1]

- (ii) State whether ΔH , the enthalpy change that occurs when anhydrous copper(II) sulfate dissolves in water, has a positive or negative value. Explain how you used your experimental results to determine this.

.....
.....
.....
..... [1]

[Total: 16]

2 Many compounds of manganese are useful in industry.

You will carry out reactions using three compounds of manganese. The manganese has a different oxidation state in each of the three compounds.

C is aqueous potassium manganate(VII), $\text{KMnO}_4(\text{aq})$.

D is solid manganese(IV) oxide, $\text{MnO}_2(\text{s})$.

E is an aqueous manganese(II) salt.

You are also provided with hydrogen peroxide, $\text{H}_2\text{O}_2(\text{aq})$.

Read all the instructions carefully before starting the experiments in Question 2.

Instructions

- (a) Carry out the following tests. You should test and identify any gases evolved. Record your observations in the table.

The volumes given below are approximate and should be estimated rather than measured unless instructed otherwise.

test	observations
Test 1 Put about 1 cm depth of hydrogen peroxide in a clean test-tube. Add an equal volume of dilute sulfuric acid. Then add 10 drops of C with shaking. You do not need to test any gas evolved in Test 1.	
Test 2 Put about 1 cm depth of hydrogen peroxide in a clean test-tube. Use a spatula to carefully add a small amount of D .	
Test 3 Put about 1 cm depth of dilute sulfuric acid in a clean test-tube. Add an equal volume of aqueous potassium iodide. Then add 10 drops of C with shaking.	

test	observations
Test 4 Put about 2 cm depth of C in a clean test-tube. Add an equal volume of aqueous sodium hydroxide. Use a spatula to carefully add a small amount of D . Use a glass rod to stir the mixture for about 20 seconds. Filter the mixture and collect the filtrate in a clean test-tube. Then,	
put about 1 cm depth of the filtrate in a clean test-tube. Add dilute sulfuric acid slowly with shaking until no further change is seen.	
Test 5 Put about 1 cm depth of E in a clean test-tube. Add an equal volume of dilute nitric acid then add about 1 cm depth of aqueous silver nitrate.	
Test 6 Put about 1 cm depth of E in a clean test-tube. Add aqueous sodium hydroxide slowly with shaking until no further change is seen. Leave to stand for a few minutes.	

[9]

(b) Deduce the role of the hydrogen peroxide in **Test 1**. Explain your answer.

.....
.....
..... [2]

(c) Use the results of your tests to deduce the formula of **E**.

..... [1]

- (d) A student decides to investigate the effect of the concentration of **C**, aqueous potassium manganate(VII), on the rate of its reaction with acidified hydrogen peroxide. The student will determine the rate of the reaction by collecting the gas produced.

Describe the method the student should use. The method should include suitable apparatus and the measurements that need to be taken.

You may assume that the apparatus normally found in a school laboratory is available.

You may use a labelled diagram to illustrate your answer.

You do **not** need to explain how you would use your results to find the rate of the reaction.

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..... [4]

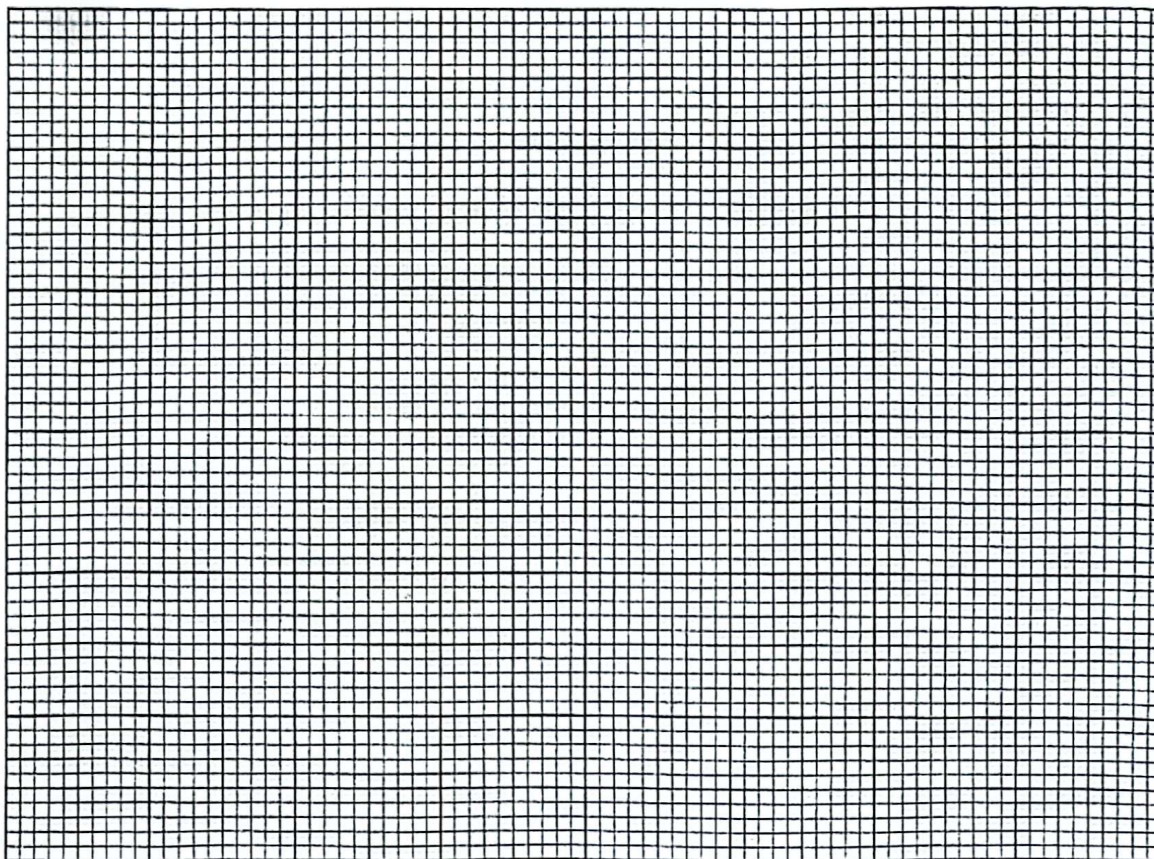
- (e) An experiment is carried out to determine how the rate of a similar reaction between potassium manganate(VII) and ethanedioic acid changes as time proceeds.

A mixture of the reactants is prepared. At 4-minute intervals, the concentration of potassium manganate(VII) is measured.

The results are shown in the table.

time / min	concentration of potassium manganate(VII) in mol/dm ³
0	10.0×10^{-4}
4	9.6×10^{-4}
8	7.8×10^{-4}
12	4.6×10^{-4}
16	—
20	0.6×10^{-4}
24	0.2×10^{-4}
28	0.1×10^{-4}

- (i) Use these results to plot a suitable graph on the grid below. Draw a line of best fit, using all of the plotted points.



[4]

- (ii) From your graph, determine the expected concentration of potassium manganate(VII) at 16 minutes.

concentration of KMnO_4 at 16 minutes = [2]

- (iii) Describe how the rate of the reaction changes during the experiment.
Use your graph to explain your answer.

.....

 [2]

[Total: 24]

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6092/03/O/N/22

Oct/Nov 2022 Paper 3 (10)

- 1 Mohr's salt is a compound used in chemical analysis. It contains **two** cations and **one** anion from those listed in the Qualitative Analysis notes.

You are provided with two samples of Mohr's salt, both labelled **X**.

You will carry out tests on **X** and identify the three ions present.

Read all the instructions carefully before starting the experiments in Question 1.

Instructions

- (a) Remove the stopper from the sample of **X** in a test-tube. Heat the sample in the test-tube gently for about 1 minute at first and then strongly for about 1 minute.

Record all your observations including testing the gas produced with damp red litmus paper.

.....

.....

.....

..... [2]

- (b) (i) Use a measuring cylinder to transfer about 30 cm³ of deionised water to the 100 cm³ beaker. Add the sample of **X** from the capped container to the beaker. Stir to ensure all the solid has dissolved, producing solution **X**.

Use solution **X** to carry out the following tests. You are also provided with **Y**, hydrogen peroxide.

You should test and identify any gases evolved. Record all your observations in the table.

The volumes given below are approximate and should be estimated rather than measured unless instructed otherwise.

test	observations
Test 1 Put about 1 cm depth of solution X in a clean test-tube. Add 1 cm depth of Y (hydrogen peroxide). Shake the test-tube. Keep this solution for Test 4.	
Test 2 Put about 1 cm depth of solution X in a clean test-tube. Add a few drops of aqueous sodium hydroxide with shaking, then add excess aqueous sodium hydroxide.	

test	observations
Test 3 Put about 1 cm depth of solution X in a clean boiling tube. Add an equal depth of aqueous sodium hydroxide and warm the mixture gently.	
Test 4 To the mixture from Test 1 add a few drops of aqueous sodium hydroxide with shaking, then	
add excess aqueous sodium hydroxide.	
Test 5 Put about 1 cm depth of solution X in a clean test-tube. Add an equal depth of dilute nitric acid and then add a few drops of aqueous barium nitrate.	

[5]

- (ii) Deduce the formulae of the **two** cations and **one** anion present in X.

cations and

anion

[2]

- (iii) State the type of reaction that occurs in **Test 1**.

Use your observations to explain how you have reached this conclusion.

.....
.....
..... [2]

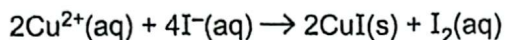
[Total: 11]

2 Brass is a copper alloy that is used to make screws.

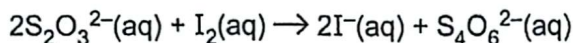
You are going to use titration to determine the percentage by mass of copper in a brass screw.

The brass screw has been dissolved in nitric acid to form a solution containing aqueous Cu^{2+} ions.

When excess aqueous potassium iodide is added to the aqueous Cu^{2+} ions, iodine and a white precipitate of copper(I) iodide are produced.



The amount of iodine produced is found by titration with aqueous thiosulfate ions, $\text{S}_2\text{O}_3^{2-}$.



Read all the instructions below carefully before starting the experiment in Question 2.

Instructions

P is 0.120 mol/dm^3 aqueous thiosulfate ions.

Q contains aqueous Cu^{2+} ions made from dissolving a 9.50 g brass screw in nitric acid and the solution is made up to 1.00 dm^3 .

R is aqueous 0.5 mol/dm^3 potassium iodide.

S is starch solution which you will use as an indicator.

(a) (i) Put **P** into the burette.

Pipette 25.0 cm^3 of **Q** into a conical flask.

Use a measuring cylinder to add 20 cm^3 of **R**, which is an excess, to **Q**. A white precipitate forms in a dark brown solution.

Add **P** from the burette to the flask until the solution turns light brown. Then use a measuring cylinder to add about 1 cm^3 of **S** to the flask. A dark-coloured solution forms.

Continue adding **P** slowly from the burette until one drop of **P** causes the dark colour to disappear leaving a white precipitate.

Record your titration results in an appropriate format in the space provided. Repeat the titration as many times as you consider necessary to achieve consistent results.

Results

[5]

- (ii) Use your titration results to obtain the average volume of P used.
Show clearly how you obtained this volume.

average volume of P = [1]

- (b) (i) Calculate the amount, in moles, of thiosulfate ions present in the average volume of P.

amount of thiosulfate ions = mol [1]

- (ii) Use the equations to determine the amount, in moles, of Cu^{2+} ions in 1.00 dm^3 of Q.

amount of Cu^{2+} ions in 1.00 dm^3 of Q = mol [2]

- (iii) Use your answer to (b)(ii) to calculate the mass of copper in the brass screw.

[A_r : Cu, 64]

mass of copper in the brass screw = [1]

- (iv) Calculate the percentage by mass of copper in the brass screw.

percentage by mass = [3]

- (c) A student repeats the experiment but adds a smaller volume of aqueous potassium iodide which is not in excess.
Describe and explain the effect this has on the calculated value for the percentage by mass of copper in the brass screw.

.....
.....
.....
..... [2]

[Total: 15]

- 3 Many metal ores contain carbonates of the metal. The amount of carbonate can be determined by reacting the ore with acid.

- (a) A student is investigating a metal ore. The method being used requires a solution of 0.100 mol/dm^3 hydrochloric acid.

The student is provided with a solution of hydrochloric acid that contains 36.5 g/dm^3 of acid.

Outline what the student should do to prepare 100 cm^3 of 0.100 mol/dm^3 hydrochloric acid from the solution provided. Include the names and volumes of any apparatus used and the volumes of solutions that are needed.

You can assume that all apparatus normally found in a school laboratory is available.

[M_r : HCl, 36.5]

.....

.....

.....

.....

.....

.....

.....

..... [3]

- (b) Calcium carbonate reacts with hydrochloric acid. This reaction is exothermic.



The student investigates the amount of heat released during this reaction by using the following method.

1. Weigh the container with the calcium carbonate.
2. Place 50.0 cm^3 of hydrochloric acid, which is an excess, in an insulated plastic cup and measure the temperature of the acid. Record the temperature in the table.
3. Start a stopwatch and measure the temperature of the acid every minute for 2 minutes. Record the temperatures.
4. At 3 minutes transfer the calcium carbonate from the container into the cup. Stir the contents and continue to measure, and record, the temperature every minute up to 8 minutes.
5. Reweigh the container with any residual solid.

The results the student obtains are shown.

time/min	0	1	2	3	4	5	6	7	8
temperature/ $^{\circ}\text{C}$	22.0	22.0	22.0		26.0	25.5	25.5	24.5	24.0

mass of container with calcium carbonate = 24.8 g

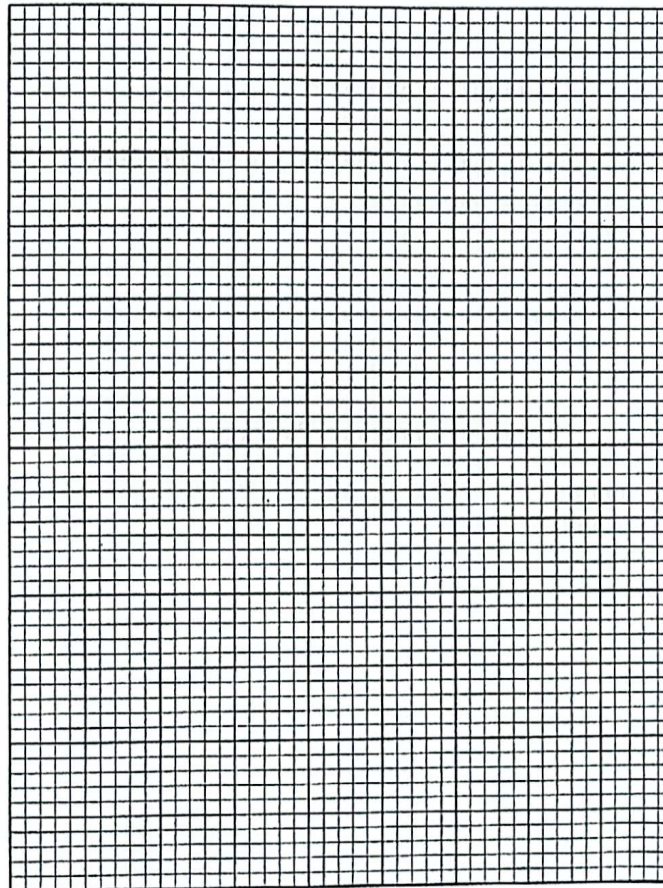
mass of container after adding calcium carbonate to the cup = 21.3 g

- (i) Plot the student's results on the grid with temperature on the y-axis and time on the x-axis.

Complete the graph by drawing **two** straight lines of best fit. One line should be drawn using data from 0 to 2 minutes and the other line should be drawn using data from 4 to 8 minutes.

Extend both of these lines to 3 minutes.

Draw a vertical line at 3 minutes to connect these lines.



[4]

- (ii) Use your lines from (b)(i) to calculate the maximum temperature rise in the experiment.

maximum temperature rise = °C [1]

- (iii) The amount of heat released in this experiment can be calculated using the expression shown.

heat released (in J) = mass of solution (in g) $\times$ maximum temperature rise (in $^{\circ}\text{C}$) $\times$ 4.2

Use this expression to calculate, in J, the amount of heat released.

Assume that 1.0cm^3 of solution has a mass of 1.0g.

amount of heat released = J [1]

- (iv) Calculate the number of moles of calcium carbonate used in the experiment.

[M_r : CaCO_3 , 100]

number of moles of CaCO_3 = mol [1]

- (v) Calculate the amount of heat released, in kJ/mol, when one mole of calcium carbonate reacts with hydrochloric acid.

amount of heat released = kJ/mol [1]

- (vi) Another student carries out the same experiment but only measures the initial temperature of the solution and the highest temperature reached in order to calculate the temperature rise.

Suggest why the student who uses a graph to calculate the temperature rise is able to obtain a more accurate value for the amount of heat released.

.....
.....
..... [1]

- (c) It is thought that the solid sample of calcium carbonate used in (b) is contaminated with zinc carbonate.

Describe briefly how the student can test to see if any zinc carbonate is present in the solid sample of calcium carbonate. Include expected observations in your answer.

.....

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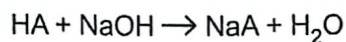
..... [2]

[Total: 14]

- 1 Some cleaning products contain a solution of sulfamic acid.

You are going to determine the concentration of sulfamic acid in a sample of a cleaning product by titration with sodium hydroxide.

The sulfamic acid can be represented by the formula, HA. The equation for the reaction occurring in the titration is shown.



Read all the instructions below carefully before starting the experiment in Question 1.

Instructions

P is 0.200 mol/dm^3 sodium hydroxide.

Q contains aqueous sulfamic acid. The solution was made by diluting a sample of 100 cm^3 of the cleaning product to 1.00 dm^3 by adding deionised water.

T is thymolphthalein indicator.

- (a) (i) Fill the burette with **P**.

Use the pipette to transfer 25.0 cm^3 of **Q** into a conical flask.

Add a few drops of the thymolphthalein indicator, **T**, to the solution in the conical flask.

Ensure the lid is placed back on the container of **T** after use.

Add **P** from the burette, swirling the flask constantly.

At the end-point, one drop of **P** produces a blue colour that does not disappear on swirling.

Record your titration results in the space provided. Repeat the titration as many times as you consider necessary to achieve consistent results.

Results

[5]

- (ii) From your titration results, obtain an average volume of P to be used in your calculations. Show clearly how you obtained this volume.

average volume of P cm^3 [1]

- (b) (i) P is 0.200 mol/dm^3 sodium hydroxide.

Use your answer from (a)(ii) and the equation for the reaction to calculate the number of moles of sulfamic acid in 25.0 cm^3 of Q.

number of moles of sulfamic acid in 25.0 cm^3 of Q mol [1]

- (ii) Use your answer from (b)(i) to calculate the concentration, in mol/dm^3 , of sulfamic acid in the sample of the cleaning product.

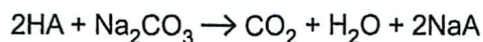
concentration of sulfamic acid in cleaning product mol/dm^3 [3]

(c) The label on the bottle of cleaning product gives the concentration of sulfamic acid in g/dm^3 .

To convert your answer from (b)(ii) into g/dm^3 , it is necessary to know the relative molecular mass, M_r , of sulfamic acid.

The M_r can be determined by reacting some **solid** sulfamic acid with aqueous sodium carbonate and measuring the volume of carbon dioxide produced.

The equation for the reaction is shown.



(i) Use this information to outline a method to determine the M_r of sulfamic acid.

Your method should use gas collection by the displacement of water.

In your method you should include:

- the apparatus you would use
- the measurements you would take
- an explanation of how you would use your results to determine the M_r of sulfamic acid.

You can assume the apparatus and reagents normally found in a school laboratory are available.

You may wish to use a labelled diagram to illustrate your answer.

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..... [5]

(ii) Carbon dioxide is soluble in water.

Suggest how this may cause your calculated value for the M_r of sulfamic acid to be different from its theoretical value.

Explain your answer.

.....
.....
..... [3]

(iii) Suggest and explain **one** change you could make to your experiment to improve the accuracy of your calculated value for M_r .

change

explanation

..... [1]

[Total: 19]

- 2 'Burgundy mixture' and 'Bordeaux mixture' are used as fungicides on some plants. They are both mixtures of **two** metal compounds.

R is a sample of Burgundy mixture.

S is a sample of Bordeaux mixture.

You will carry out tests on **R** and **S** to identify ions in both mixtures.

Read all the instructions carefully before starting the experiments in Question 2.

Instructions

- (a) Carry out the following tests on **R** and **S**. You should test and identify any gases evolved. Record your observations in the table.

The volumes given below are approximate and should be estimated rather than measured unless instructed otherwise.

test	observations for R	observations for S
Test 1 To the sample in the boiling tube, carefully add dilute nitric acid to a depth of approximately 6 cm. Use a glass rod to stir the mixture. Keep the final solution for use in Tests 2–4.		
Test 2 Put 1 cm depth of the solution from Test 1 in a clean test-tube. Add aqueous ammonia slowly with shaking until no further change is seen.		
Test 3 Put another 1 cm depth of the solution from Test 1 in a clean test-tube. Add aqueous sodium hydroxide slowly with shaking until no further change is seen.		

test	observations for R	observations for S
Test 4 Put 2 cm depth of the solution from Test 1 in a clean test-tube. Add an equal volume of aqueous barium nitrate. Keep the final solution for use in Test 5.		
Test 5 Filter the contents of the test-tube from Test 4 into a clean test-tube. Add an equal volume of aqueous silver nitrate to the filtrate.		

[8]

- (b) One of the compounds in **R** is the same as one of the compounds in **S**. Suggest the name of this compound and explain your reasoning.

compound present in both **R** and **S**

reasoning

.....

.....

[2]

- (c) Both compounds in **R** are soluble. Use this information and the results of your tests to suggest the other compound in **R**. Explain your reasoning.

other compound in **R**

reasoning

.....

.....

[2]

- (d) Use the results of your tests to identify the other anion in **S**.

..... [1]

[Total: 13]

- 3 A student investigates the effect of temperature on the rate of the reaction of zinc with dilute hydrochloric acid.

The student places a piece of zinc in a conical flask containing dilute hydrochloric acid. The student records the total mass of the flask and its contents at timed intervals.

The student repeats the experiment at different temperatures.

The student's results are shown.

Experiment 1 at 20 °C			Experiment 2 at 30 °C			Experiment 3 at 40 °C		
time /min	total mass/g	loss in mass/mg	time /min	total mass/g	loss in mass/mg	time /min	total mass/g	loss in mass/mg
0	81.130	0	0	81.132		0	81.129	0
2	81.116	14	2	81.114		2	81.100	29
5	81.099	31	5	81.094		5	81.075	54
10	81.082	48	10	81.076		10	81.065	64
15	81.071	59	15	81.069		15	81.063	66
20	81.066	64	20	81.067		20	81.063	66

- (a) Explain why there is a loss in mass as the reaction proceeds.

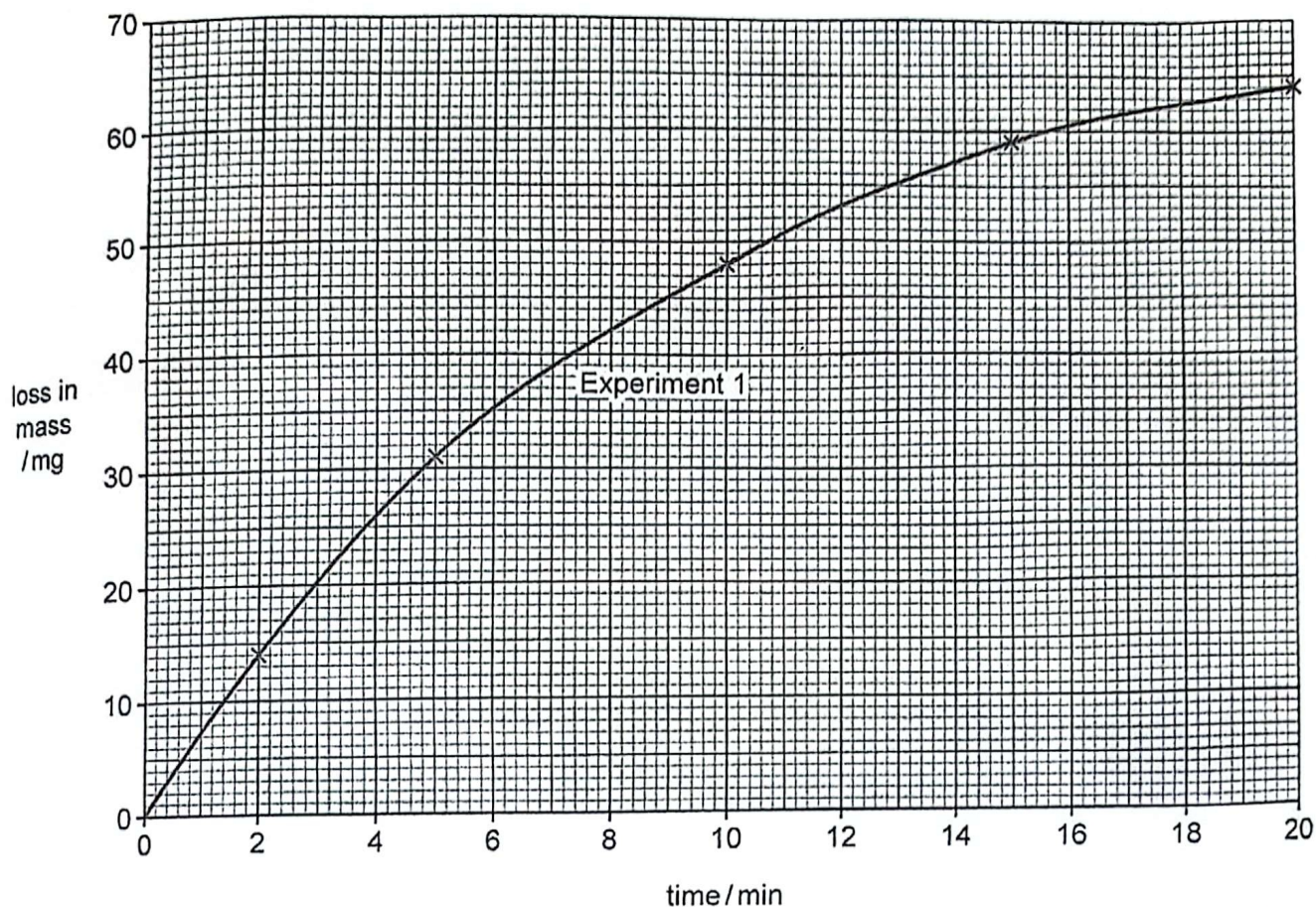
.....
..... [1]

- (b) Complete the table to show the loss in mass, in mg, for Experiment 2.

[1]

(c) (i) The results for Experiment 1 are plotted on the grid below.

Plot the results for Experiment 3 on the grid. Draw a line of best fit.



[2]

(ii) The average rate of this reaction can be calculated using:

$$\text{average rate of reaction} = \frac{\text{loss in mass}}{\text{time taken}}$$

For Experiment 1, calculate the average rate over the first 7 minutes of the reaction.

Give the units for your answer.

average rate of reaction [3]

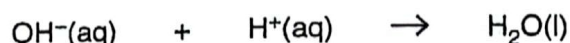
(d) The student concluded that the reaction in Experiment 3 had finished.

Suggest how the student reached this conclusion.

.....
..... [1]

[Total: 8]

- 1 The reaction of aqueous solutions of alkalis and strong acids is exothermic.



You are going to investigate the temperature rise when volumes of aqueous alkali and acid are mixed together.

Read all the instructions carefully before starting the experiments in Question 1.

Instructions

You are going to carry out seven experiments.

P is a 0.75 mol/dm^3 solution of a strong acid.

Q is 1.25 mol/dm^3 sodium hydroxide.

(a) Experiment 1

Place a Styrofoam cup into a 250 cm^3 glass beaker.

Put **P** into a burette and measure 40.00 cm^3 of **P** into the Styrofoam cup. Measure the temperature of **P** and record the value in the table.

Use a measuring cylinder to measure 10 cm^3 of **Q**. Pour this volume of **Q** into the Styrofoam cup containing **P**. Stir, using the thermometer, and measure the highest temperature reached. Record this temperature in the table.

Empty the Styrofoam cup and rinse it with water.

Experiments 2 to 7

Repeat Experiment 1 but use the different volumes of **P** and **Q** for each experiment given in the table.

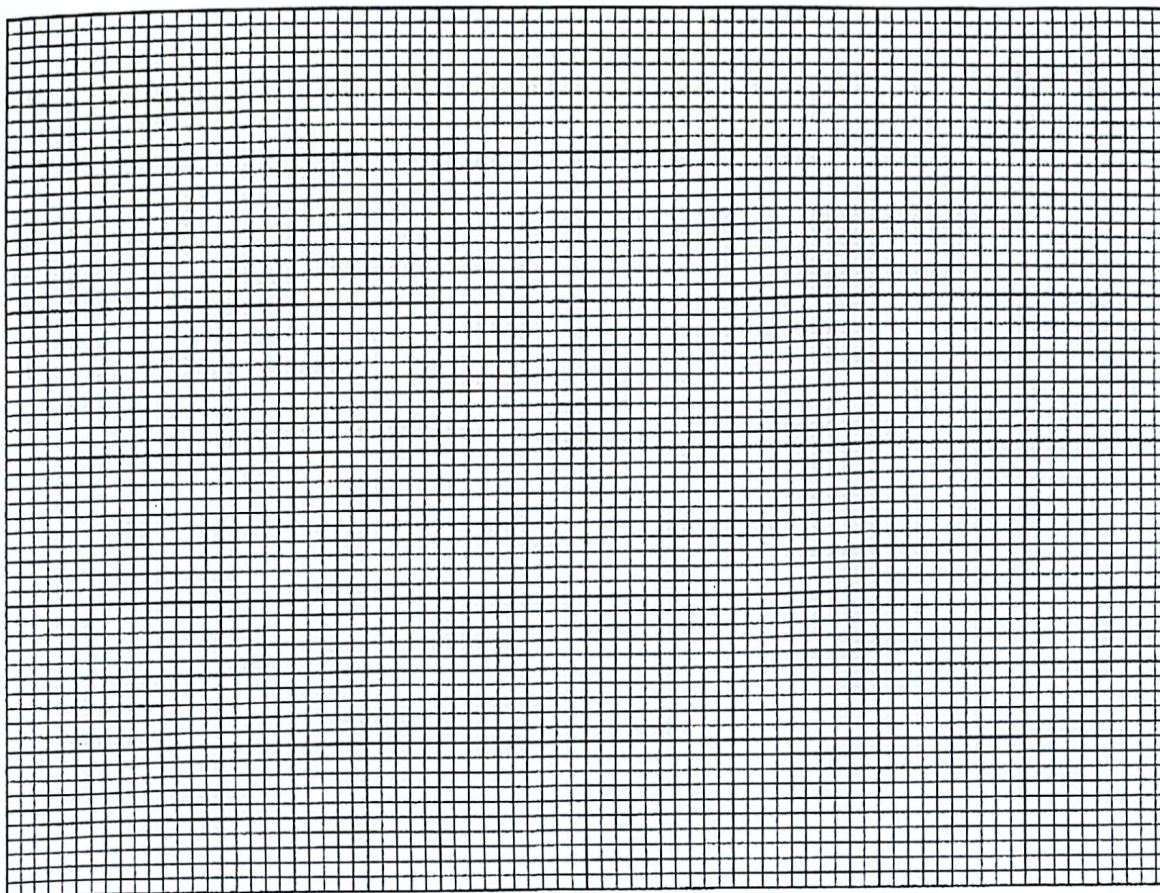
Complete the table by calculating the temperature rise for each experiment.

experiment	volume of P $/\text{cm}^3$	volume of Q $/\text{cm}^3$	initial temperature of P $/^\circ\text{C}$	highest temperature of mixture $/^\circ\text{C}$	temperature rise $/^\circ\text{C}$
1	40.00	10			
2	35.00	15			
3	30.00	20			
4	25.00	25			
5	20.00	30			
6	15.00	35			
7	10.00	40			

[4]

- (b) Plot a graph of temperature rise against volume of **Q** on the grid below.

Use these points to draw two intersecting straight lines of best fit.



[4]

- (c) From your graph, read the volume of **Q** where the two lines intersect.

..... cm³ [1]

- (d) Calculate the number of moles of sodium hydroxide present in the volume of **Q** in (c).

..... mol [1]

- (e) Calculate the volume of **P** required to neutralise the volume of **Q** in (c).

.....cm³ [1]

- (f) Calculate the concentration of hydrogen ions, H⁺, in **P**.

..... [2]

(g) Suggest the identity of the strong acid in **P** and explain your suggestion.

.....
..... [1]

(h) Suggest **two** changes that could be made to this experiment to improve the accuracy of the results.

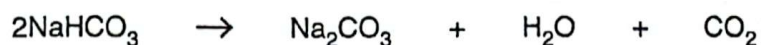
change 1
.....

change 2
.....

[2]

[Total: 16]

- 2 Sodium hydrogencarbonate decomposes on heating.



You are supplied with an impure sample of sodium hydrogencarbonate. The impurity is another sodium compound which is unaffected by heating. You are to determine the percentage by mass of sodium hydrogencarbonate present in the impure sample and identify the impurity.

Read all the instructions carefully before starting the experiment in Question 2.

Instructions

R is impure sodium hydrogencarbonate.

- (a) (i) Use the balance to find the mass of an empty test-tube.

Add about 1.5 g of **R** to the test-tube and then find the mass of the test-tube and its contents.

Gently heat the test-tube and contents for 3 minutes so that the sodium hydrogencarbonate decomposes.

Leave the test-tube and its contents to cool to room temperature before finding the mass of the test-tube and its contents.

You may begin the experiments in parts (d) and (e) on page 8 while you are waiting for the test-tube to cool.

Record your results in an appropriate format in the space provided.

Results

- (ii) From your results determine:

the mass of **R** before heating

the change in mass after heating.

[4]

[2]

- (b) (i) Use your answers from (a)(ii) and the equation for the decomposition of sodium hydrogencarbonate to calculate the mass of sodium hydrogencarbonate present in the mass of **R** heated.

[M_r : NaHCO_3 , 84.0; H_2O , 18.0; CO_2 , 44.0]

mass of sodium hydrogencarbonate present = [2]

- (ii) Calculate the percentage by mass of sodium hydrogencarbonate in **R**.

percentage by mass of sodium hydrogencarbonate in **R** = [2]

- (c) (i) Suggest why heating the sample once for 3 minutes may **not** give an accurate value for the percentage by mass of sodium hydrogencarbonate in **R**.

.....
..... [1]

- (ii) Suggest one way in which the experiment could be improved to obtain a more accurate value of the percentage by mass of sodium hydrogencarbonate in **R**.

.....
..... [1]

(d) **S** is the solid remaining after decomposing **R** by heating.

You are provided with a sample of S to use in parts (d) and (e).

Carry out the following test on the sample of **S** provided in a test-tube. Record your observations in the space provided. You should test and name any gas evolved.

Place the test-tube containing the sample of **S** in a test-tube rack and add dilute nitric acid, a little at a time, until no further reaction occurs.

Keep the final solution for use in (e).

.....
.....
..... [3]

(e) Carry out the following tests on the solution from (d). Record your observations in the space provided.

(i) To about 1 cm depth of the solution from (d) in a test-tube, add a few drops of aqueous silver nitrate.

..... [1]

(ii) To another 1 cm depth of the solution from (d) in a test-tube, add an equal volume of aqueous barium nitrate.

..... [1]

(f) Identify the impurity in **R**.

..... [1]

(g) (i) Why was excess acid added to **S** in (d) before carrying out the tests in (e)?

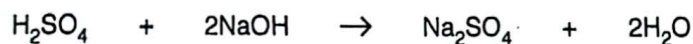
.....
..... [1]

(ii) Why was nitric acid used in (d) rather than hydrochloric or sulfuric acid?

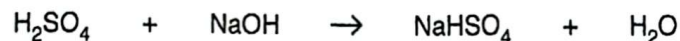
.....
..... [1]

[Total: 20]

- 3 Sodium sulfate, Na_2SO_4 , is the salt produced when sulfuric acid is neutralised by sodium hydroxide.



Sodium hydrogensulfate, NaHSO_4 , can also be produced from sulfuric acid and sodium hydroxide.



Both sodium sulfate and sodium hydrogensulfate are soluble in water.

Outline a method to obtain crystals of sodium hydrogensulfate using 1.0 mol/dm^3 sulfuric acid and aqueous sodium hydroxide of unknown concentration.

.....

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..... [4]

[Total: 4]

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6092/03/O/N/19

Oct/Nov 2019 Paper 3 (8)

- 1 The reaction of zinc with aqueous copper(II) ions is exothermic.

You are going to investigate the temperature change when an excess of zinc is added to aqueous solutions containing different amounts of copper(II) sulfate.

Read all the instructions below carefully before starting the experiments in Question 1.

Instructions

You are going to do five experiments.

P is 0.50 mol/dm^3 copper(II) sulfate.

You are provided with five samples of zinc powder each weighing between 0.5 and 0.6 g.

(a) Experiment 1

Using a 10 cm^3 measuring cylinder, pour 10 cm^3 of P into a boiling tube.
Measure the initial temperature of P in the boiling tube and record the value in the table.

Transfer the zinc powder from one of the five containers, labelled zinc powder, to P in the boiling tube. Stir the mixture gently with the thermometer.

Measure the highest temperature reached and record it in the table.

Wash the thermometer and boiling tube with water.

Experiments 2 to 5

Repeat Experiment 1, using the different volumes of P and water given in the table.
For example, in Experiment 2 measure 8 cm^3 of P into the measuring cylinder and then add water to P until the total volume in the measuring cylinder is 10 cm^3 .

Complete the table by calculating the change in temperature for each experiment.

experiment	volume of P/ cm^3	volume of water/ cm^3	initial temperature / $^{\circ}\text{C}$	highest temperature / $^{\circ}\text{C}$	change in temperature / $^{\circ}\text{C}$
1	10	0			
2	8	2			
3	6	4			
4	4	6			
5	2	8			

[4]

- (b) Give an observation made when zinc reacts with aqueous copper(II) sulfate and explain the observation.

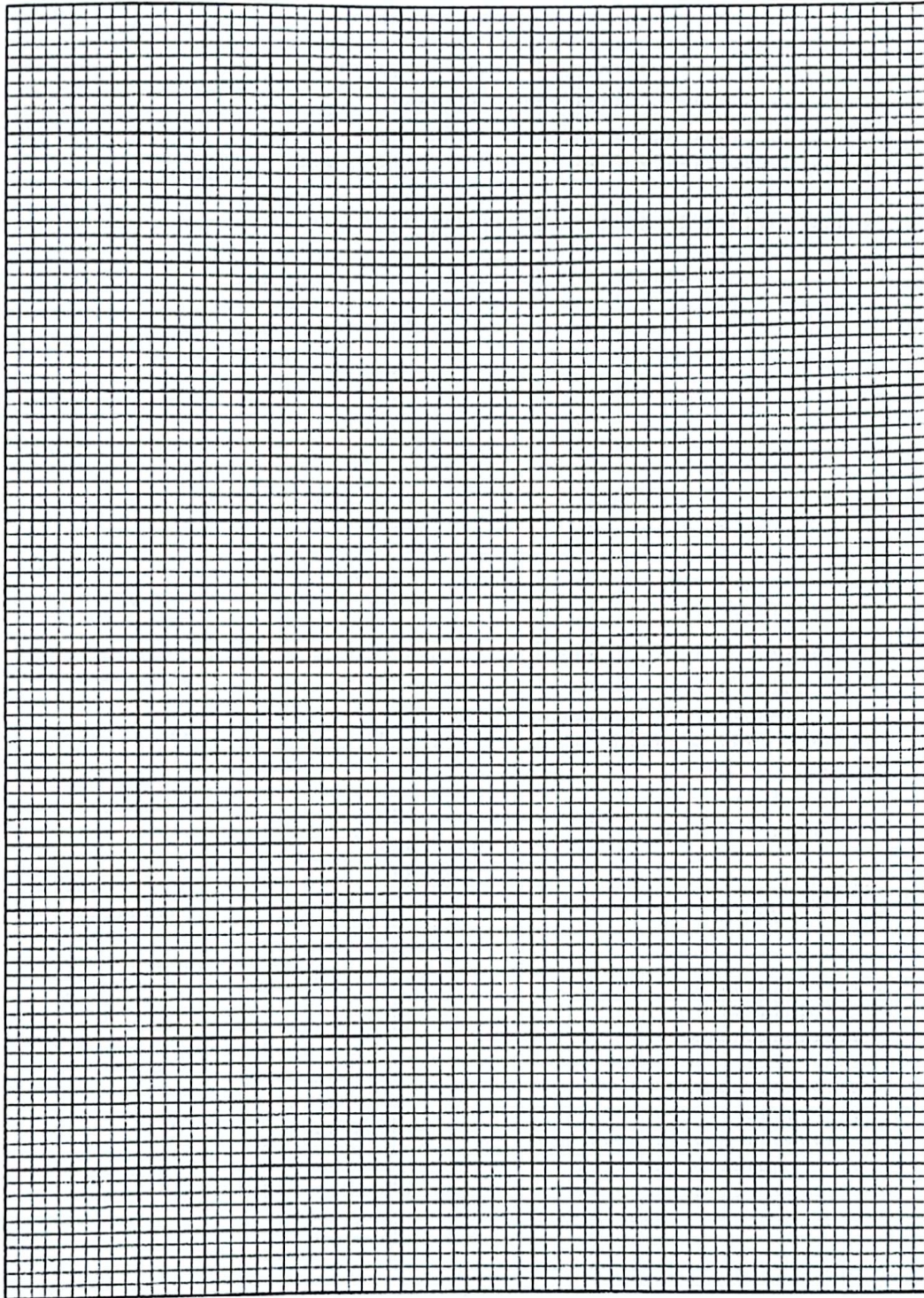
observation

explanation

[2]

(c) Use the results you have obtained to plot a suitable graph on the grid below.

Draw a straight line of best fit.



[4]

(d) Describe and explain the trend shown by your graph in (c).

.....
.....
.....[2]

(e) Determine the expected change in temperature if the experiment was repeated with 0.0035 mol of copper(II) sulfate in the 10 cm³ of solution.

Show clearly **on the graph** how you obtained your answer.

.....[2]

(f) Predict the change in temperature if an excess of zinc powder was added to 10 cm³ of 1.00 mol/dm³ copper(II) sulfate.

.....[1]

(g) The temperature change obtained in Experiment 2 is lower than the value given in a chemistry data book. The main source of error is likely to be heat loss.

(i) Suggest a reason, **other than heat loss**, why your result is different from the data book value.

.....[1]

(ii) Suggest an improvement you could make to the experiment in order to reduce this source of error.

.....[1]

- (h) If the same experiments were repeated using an excess of iron powder instead of zinc powder, predict the effect on the changes in temperature.

Explain your answer.

.....

.....

.....

..... [2]

[Total: 19]

- 2 Tablets taken for the prevention and treatment of iron deficiency contain an iron(II) compound.

You are going to determine the mass of iron present in a tablet by performing a titration using aqueous potassium manganate(VII).

No indicator is needed for this titration as the products of the reaction are almost colourless and one drop of aqueous potassium manganate(VII) in excess produces a pale pink colour.

Read all the instructions below carefully before starting the experiment in Question 2.

Instructions

Q is 0.0105 mol/dm^3 potassium manganate(VII).

R is an aqueous solution of iron(II) ions. The solution was made by dissolving nine tablets containing the iron(II) compound completely in sulfuric acid and making the final volume up to 250 cm^3 by adding water.

- (a) (i) Put **Q** into the burette.
The colour of **Q** makes it difficult to see the bottom of the meniscus so you should take all your readings using the top of the meniscus.

Pipette 25.0 cm^3 of **R** into a flask.

Add **Q** from the burette. At first the purple colour disappears quickly but as more **Q** is added the colour disappears less quickly. At the end-point, one drop of **Q** produces a pale pink colour that does not disappear on swirling.

Record your titration results in the space provided, repeating the titration as many times as you consider necessary to achieve consistent results.

Results

[5]

- (ii) From your titration results, obtain an average volume of **Q** to be used in your calculations. Show clearly how you obtained this volume.

average volume of **Q** [1]

- (b) (i) Q is 0.0105 mol/dm^3 aqueous potassium manganate(VII).

Calculate the number of moles of potassium manganate(VII) present in the average volume of Q.

number of moles of potassium manganate(VII) [1]

- (ii) In the reaction five moles of iron(II) ions react with one mole of potassium manganate(VII). Using your answer from (i), calculate the number of moles of iron(II) ions present in 25.0 cm^3 of R.

number of moles of iron(II) ions [1]

- (iii) Using your answer from (ii), calculate the number of moles of iron(II) ions in 250 cm^3 of R.

number of moles of iron(II) ions in 250 cm^3 of R [1]

- (iv) Using your answer from (iii), calculate the mass of iron in one tablet.
[A_r : Fe, 56]

mass of iron in one tablet [4]

- (c) One of the tablets containing the iron(II) compound is dissolved in nitric acid and a few drops of barium nitrate added. A white precipitate is observed.

Based on this observation, determine the formula of the iron(II) compound in the tablet.

.....[1]

- (d) A sample of a different brand of tablets containing an iron(II) compound is analysed. It is found that these tablets contain some solid impurities which are insoluble in water.

Describe how the impurities could be removed to leave a clear solution that contains all of the iron(II) ions present in the tablets.

.....

.....

.....[2]

[Total: 16]

3 Sea shells are used to make cement because of their high carbonate content.

Cockle shells, which are a type of sea shell, are said to contain nearly 60% carbonate, CO_3^{2-} , by mass.

Given 1 g of cockle shells, outline a method by which the percentage by mass of carbonate in the shells can be determined.

You can assume all the apparatus and reagents normally found in a school laboratory are available.

In your method you should note any assumptions that you make, include the measurements you would take and explain how you would use your results to determine the percentage by mass of carbonate in the cockle shells.

[A_r: C, 12; O, 16]

[5]

[Total: 5]

- 1 Sulfamic acid, $\text{H}_2\text{NSO}_3\text{H}$, is a white solid often used in descaling powders. Descaling powders are used to remove insoluble carbonates left in containers, like kettles, as a result of heating water in them.

You are to determine by titration the concentration of sulfamic acid in a solution made by dissolving a descaling powder in water.

P is a solution containing sulfamic acid prepared by dissolving 15.10g of the descaling powder in water and making the solution up to 1 dm^3 .

Q is 0.0510 mol/dm^3 sodium carbonate, Na_2CO_3 .

(a) Put **P** into the burette.

Pipette a 25.0 cm^3 (or 20.0 cm^3) portion of **Q** into a flask and titrate with **P**, using the indicator provided.

Record your results in the table, repeating the titration as many times as you consider necessary to achieve consistent results.

Results

titration number	1	2	
final burette reading / cm^3			
initial burette reading / cm^3			
volume of P used / cm^3			
best titration results (✓)			

Summary

Tick (✓) the best titration results.

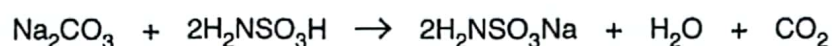
Using these results, the average volume of **P** required was cm^3 .

Volume of **Q** used was cm^3 .

[12]

- (b) **Q** is 0.0510 mol/dm^3 sodium carbonate.

Using your results from (a) and the equation below, calculate the concentration of sulfamic acid in **P**.



concentration of sulfamic acid in **P** mol/dm^3 [2]

- (c) Using your answer from (b), calculate the mass of sulfamic acid in 1 dm^3 of **P**.
(The relative molecular mass of sulfamic acid is 97.)

mass of sulfamic acid in 1 dm^3 of **P** g [1]

- (d) Using your answer from (c), calculate the percentage by mass of sulfamic acid in 15.10 g of the descaling powder.

percentage by mass of sulfamic acid in the descaling powder% [1]

- (e) Sulfamic acid reacts readily with dilute nitric acid at room temperature to produce the gas dinitrogen monoxide, N_2O , which is insoluble in water.



Describe a method based on this reaction that can be used to determine the percentage by mass of sulfamic acid in a sample of the descaling powder.

You can assume that all the apparatus and reagents normally found in a school laboratory are available. You should include the measurements you would take and how you would use your results to calculate the percentage by mass of sulfamic acid in the descaling powder.

You may not use a titration method.

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.....[4]

[Total: 20]

2 You are provided with three solutions R, S and T.

Carry out the following tests on each solution and record your observations in the tables on pages 6 and 7. You should test and name any gas evolved.

test no.	test	observations with solution R
1(a)	To 2 cm depth of the solution in a test-tube, add aqueous ammonia until a change is seen. Keep the final mixture for use in (b).	
1(b)	To the mixture from (a), add excess aqueous ammonia, with shaking, until no further change occurs. Keep the final mixture for use in (c).	
1(c)	To 1 cm depth of aqueous hydrogen peroxide in a boiling tube, add the final mixture from (b).	
2	To 1 cm depth of the solution in a test-tube, add an equal volume of aqueous potassium iodide and allow to stand for 2 minutes.	

test no.	observations with solution S	observations with solution T
1(a)		
1(b)		
1(c)		
2		

[17]

Conclusions

Identify the metal ion in each of the solutions.

The metal ion in **R** is

The metal ion in **S** is

The metal ion in **T** is

[3]

[Total: 20]

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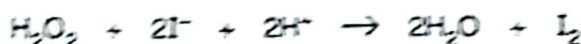
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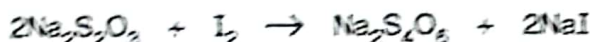
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- 1 Aqueous hydrogen peroxide is widely used as a germicide and bottles of the solution can be purchased all over the world.

The amount of hydrogen peroxide in an aqueous solution can be determined by reacting it with an excess of iodide ions to produce iodine.



The iodine is then titrated with aqueous sodium thiosulfate, $\text{Na}_2\text{S}_2\text{O}_3$, using starch solution as an indicator.



P is an aqueous solution of iodine produced by reacting all the hydrogen peroxide in 100cm^3 of the solution with excess iodide ions. The final solution was then made up to 1dm^3 by adding distilled water.

Q is 0.221mol/dm^3 sodium thiosulfate.

(a) Put **Q** into the burette.

Pipette a 25.0cm^3 (or 20.0cm^3) portion of **P** into a flask.

Add **Q** from the burette until the red-brown colour fades to pale yellow, then add a few drops of the starch indicator. This will give a dark blue solution.

Continue adding **Q** slowly from the burette until one drop of **Q** causes the blue colour to disappear, leaving a colourless solution.

Record your results in the table, repeating the titration as many times as you consider necessary to achieve consistent results.

Results

Burette readings

titration number	1	2	
final reading / cm^3			
initial reading / cm^3			
volume of Q used / cm^3			
best titration results (✓)			

Summary

Tick (✓) the best titration results.

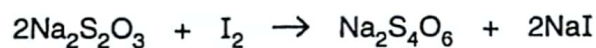
Using these results, the average volume of **Q** required was cm^3 .

Volume of **P** used was cm^3 .

[12]

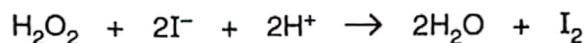
(b) Q is 0.221 mol/dm³ sodium thiosulfate.

Using your results from (a) and the equation below, calculate the concentration, in mol/dm³, of iodine in P.



concentration of iodine in P mol/dm³ [2]

(c) Using your answer from (b) and the equation below, deduce the number of moles of hydrogen peroxide in 100 cm³ of the solution.

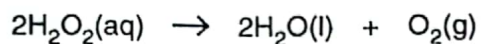


moles of hydrogen peroxide in 100 cm³ of the solution [1]

(d) Using your answer from (c), calculate the mass of hydrogen peroxide in 100 cm³ of the solution.
(The relative formula mass of hydrogen peroxide is 34.)

mass of hydrogen peroxide in 100 cm³ of the solution g [1]

- (e) An insoluble powder **X** is said to be a catalyst for the decomposition of aqueous hydrogen peroxide.



A catalyst is a substance which increases the rate of a reaction but is not used up in the reaction.

Given a sample of **X** and aqueous hydrogen peroxide, describe how you would show that both of the following statements are true.

- 1 **X** increases the rate of decomposition of aqueous hydrogen peroxide.
- 2 **X** is not used up in the decomposition of aqueous hydrogen peroxide.

You can assume all the apparatus normally found in a school laboratory is available.

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..... [4]

[Total: 20]

2 You are provided with element **R** and solution **S**.

Carry out the following tests and record your observations in the table.
You should test and name any gas evolved.

test no.	test	observations
1	To 2 cm depth of dilute hydrochloric acid in a test-tube, add a piece of R and warm the mixture until the reaction begins. Once the reaction is complete, keep the liquid for use in tests 2 and 3.	
2	To about half of the liquid from test 1 in a test-tube, add aqueous sodium hydroxide until no further change occurs.	
3	To the other portion of the liquid from test 1 in a test-tube, add aqueous ammonia until no further change occurs.	
4	To 1 cm depth of aqueous sodium hydroxide in a boiling tube, add a small amount of sodium nitrate powder and then heat the mixture until it just begins to boil. Place the hot boiling tube and its contents in a test-tube rack and then add a piece of R .	
5	To 2 cm depth of S in a test-tube, add a piece of R . Mix well and allow to stand for a few minutes.	

test no.	test	observations
6	To 2 cm depth of S in a test-tube, add a few drops of aqueous silver nitrate. Keep the mixture for use in tests 7 and 8.	
7	To about half of the mixture from test 6 in a test-tube, add an equal volume of dilute nitric acid.	
8	To the other portion of the mixture from test 6 in a test-tube, add aqueous ammonia until no further change occurs.	

[17]

Conclusions

Identify the element **R**.

The element **R** is

Identify the cation and anion in **S**.

The cation in **S** is and the anion in **S** is

[3]

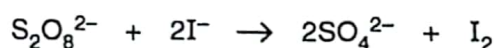
[Total: 20]

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- 1 **P** is an aqueous solution of ammonium peroxodisulfate, $(\text{NH}_4)_2\text{S}_2\text{O}_8$.
Q is an aqueous solution which contains iodide ions, I^- , and another substance.

When **P** and **Q** are mixed together, they react to produce iodine.



The addition of starch solution to the mixture allows the iodine to be detected as the solution turns blue-black.

In **Q** there is another substance present which rapidly converts iodine back into iodide ions and so the blue-black colour only appears when all of this substance is used up.

In each of the experiments 1–5, the same amount of iodine is produced before the mixture turns blue-black.

- (a) (i) Put **Q** into a burette and use it to measure 10cm^3 of **Q** into a conical flask. To **Q** in the flask, add 2cm^3 of starch solution using a 10cm^3 measuring cylinder. Place the flask and its contents on a white tile.
- (ii) Measure 25cm^3 of **P** as accurately as possible, using a 25cm^3 measuring cylinder. Pour this volume of **P** rapidly into the mixture of **Q** and starch solution in the flask. Start the stopwatch immediately and swirl the contents of the flask, then leave the mixture to stand. When the mixture first turns blue-black, stop the stopwatch. Record the time to the nearest second in column E of the table.
- (iii) Empty the conical flask and rinse it thoroughly with water.
- (iv) Repeat the procedure described in (i) – (iii) but in (ii) use the different volumes of **P** and water given in columns C and D of the table. For example in experiment 2, measure 20cm^3 of **P** as accurately as possible, using a measuring cylinder and then add water to **P** until the total volume of liquid in the measuring cylinder is 25cm^3 .

A	B	C	D	E
experiment number	volume of Q / cm^3	volume of P / cm^3	volume of water / cm^3	time taken for blue-black colour to appear / s
1	10	25	0	
2	10	20	5	
3	10	15	10	
4	10	10	15	
5	10	5	20	

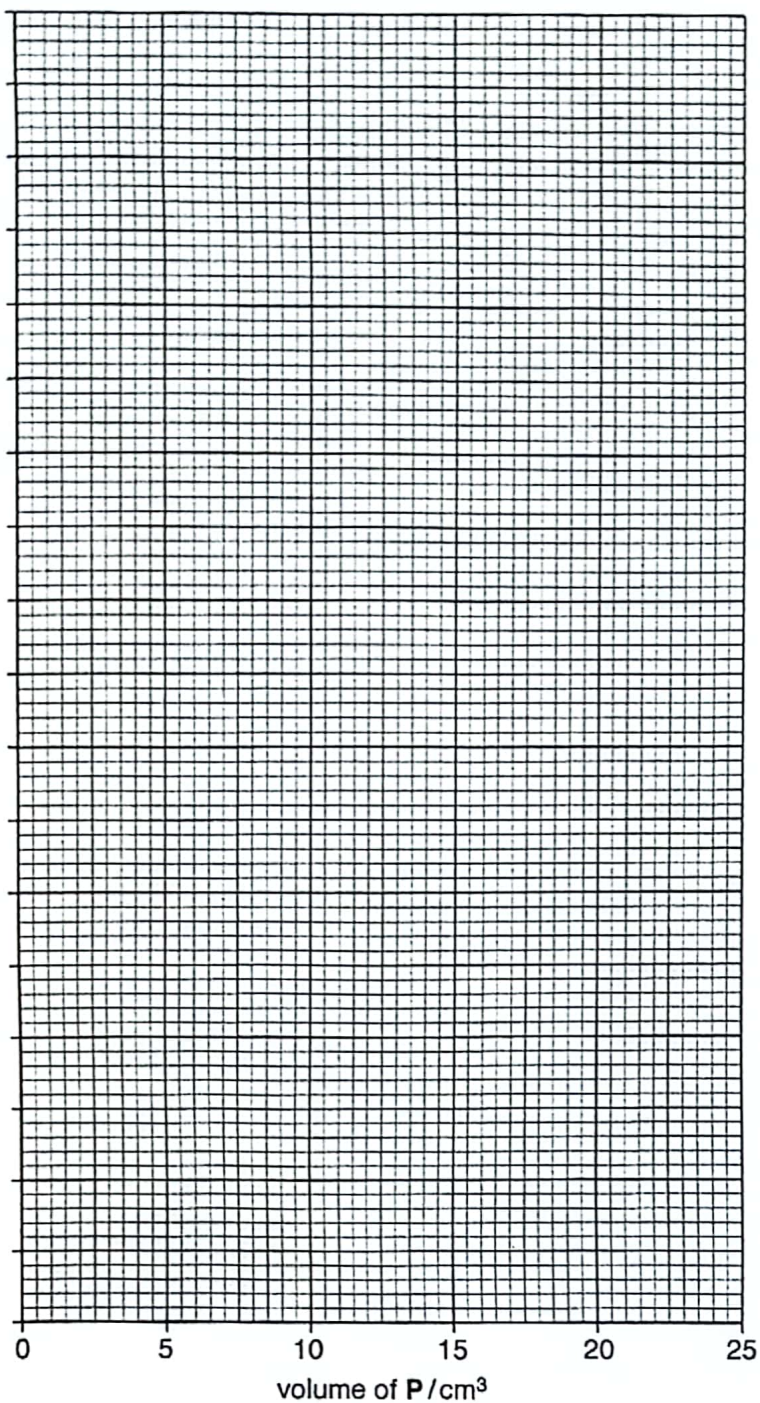
[10]

- (b) How exactly does the concentration of ammonium peroxodisulfate in experiment 2 compare with its concentration in experiment 4?

.....[1]

- (c) Plot a graph of time taken for the blue-black colour to appear (column E) against volume of **P** (column C) on the grid below. Using these points, draw the best fit curved line. [3]

time taken
for blue-black
colour to appear /s



- (d) Explain, in terms of collisions between reacting particles, why the time taken for the blue-black colour to appear increases as the volume of **P** decreases. [3]

.....
.....
.....

- (e) It has been suggested that for every 10°C rise in temperature the time taken for the blue-black colour to appear will be halved.

Given the same solutions P and Q, describe how you would investigate this suggestion by experiment.

You can assume that all the apparatus and reagents normally found in a school laboratory are available. You should include the measurements you would take and explain how you would use your results to confirm the suggestion.

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.....[4]

[Total: 21]

2 You are provided with solutions **R** and **S**.

Carry out the following tests and record your observations in the table. You should test and name any gas evolved.

test no.	test	observations
1	(a) To 1 cm depth of R in a test-tube, add a few drops of aqueous silver nitrate. (b) Add dilute nitric acid to the mixture from (a).	
2	To 1 cm depth of aqueous iron(III) chloride in a test-tube, add an equal volume of R .	
3	(a) To 1 cm depth of R in a test-tube, add an equal volume of dilute sulfuric acid and then one or two drops of S . (b) To the mixture from (a), add an equal volume of S and allow to stand for a few minutes.	
4	(a) To 1 cm depth of aqueous iron(II) sulfate in a boiling tube, add an equal volume of S . (b) Add aqueous sodium hydroxide to the mixture from (a) until no further change occurs.	
5	To 1 cm depth of aqueous acidified potassium manganate(VII) in a test-tube, add an equal volume of S .	
6	(a) To 1 cm depth of S in a test-tube, add a small amount of copper powder. (b) Add an equal volume of aqueous ammonia to the mixture from (a).	

[16]

Conclusions

Identify the anion present in R.

The anion in R is

In test 4(a), S is acting as

In test 5, S is acting as

(3)

[Total: 13]

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