Cambridge Pre-U

**Cambridge International Examinations**
Cambridge Pre-U Certificate

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

*6560580235*

**CHEMISTRY (PRINCIPAL)** **9791/04**

Paper 4 Practical **May/June 2015**

**2 hours**

Candidates answer on the Question Paper.

Additional Materials: As listed in the Confidential Instructions
Data Booklet

**READ THESE INSTRUCTIONS FIRST**

Write your Centre number, candidate number and name on all the work you hand in.
Give details of the practical session 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 IN ANY BARCODES.

Answer **all** questions.
Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.
A Data Booklet is provided.

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.

| Session |
|---|
| |
| **Laboratory** |
| |

| For Examiner's Use | |
|---|---|
| 1 | |
| 2 | |
| 3 | |
| Total | |

The syllabus is approved for use in England, Wales and Northern Ireland as a Cambridge International Level 3 Pre-U Certificate.

This document consists of **10** printed pages and **2** blank pages.




CAMBRIDGE International Examinations

**1** In the presence of acid, hydrogen peroxide, $H_2O_2$, can oxidise iodide ions, $I^-$, to iodine, $I_2$.

$$H_2O_2(aq) + 2H^+(aq) + 2I^-(aq) \longrightarrow 2H_2O(l) + I_2(aq)$$

You will investigate how the rate of this reaction is affected by the concentration of the iodide ions. In order to measure the rate of reaction you will add a fixed amount of thiosulfate ions, $S_2O_3^{2-}$. The thiosulfate ions react immediately with the iodine as it is formed, reducing the iodine back to iodide ions.

$$I_2(aq) + 2S_2O_3^{2-}(aq) \longrightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$$

Only when all the thiosulfate ions have reacted does the iodine appear in the reaction mixture. The presence of iodine is shown by starch indicator turning blue-black.

The following reagents are provided.

**FA 1**, 1.00 mol dm$^{-3}$ potassium iodide, KI
**FA 2**, 0.100 mol dm$^{-3}$ sodium thiosulfate, $Na_2S_2O_3$
**FA 3**, 0.100 mol dm$^{-3}$ hydrogen peroxide, $H_2O_2$
**FA 4**, 1.00 mol dm$^{-3}$ sulfuric acid, $H_2SO_4$
starch indicator
distilled water

**(a) Method**

**Before starting any practical work, read through all the instructions for experiments 1–5 and prepare a table for your results in the space opposite.**

**Experiment 1**

1. Fill the burette labelled **FA 1** with **FA 1**.
2. Run 20.00 cm$^3$ of **FA 1** from the burette into a 100 cm$^3$ beaker.
3. Use the 25 cm$^3$ measuring cylinder to add 15 cm$^3$ of **FA 2** to the same beaker.
4. Use the 50 cm$^3$ measuring cylinder to transfer 20 cm$^3$ of **FA 3** into a **second** 100 cm$^3$ beaker.
5. Use the same measuring cylinder to add 20 cm$^3$ of **FA 4** to the second beaker.
6. Add 10 drops of starch indicator to the second beaker.
7. Add the contents of the first beaker to the second beaker and immediately start timing. Stir the mixture once with a glass rod and place the beaker with the reaction mixture on a white tile.
8. Record the time to the **nearest second** when the mixture turns blue-black.
9. Rinse out both beakers and drain.
10. Rinse the glass rod and dry with a paper towel.

**Experiment 2**

1. Fill the second burette with distilled water.
2. Run 10.00 cm$^3$ of distilled water from the burette into one of the drained 100 cm$^3$ beakers.
3. Add 10.00 cm$^3$ of **FA 1** to the distilled water in the beaker.
4. Use the 25 cm$^3$ measuring cylinder to add 15 cm$^3$ of **FA 2** to the same beaker.
5. Use the 50 cm$^3$ measuring cylinder to transfer 20 cm$^3$ of **FA 3** into the **second** 100 cm$^3$ beaker.
6. Use the same measuring cylinder to add 20 cm$^3$ of **FA 4** to the second beaker.
7. Add 10 drops of starch indicator to the second beaker.
8. Add the contents of the first beaker to the second beaker and immediately start timing. Stir the mixture once with a glass rod and place the beaker with the reaction mixture on a white tile.
9. Record the time to the **nearest second** when the mixture turns blue-black.
10. Rinse out both beakers and drain.
11. Rinse the glass rod and dry with a paper towel.

**Experiments 3–5**

Carry out **three** further experiments to investigate how the reaction time varies with the concentration of iodide ions.

For all your experiments the total volume of the solution must be constant.

Do not use a volume of **FA 1** that is less than 5.00 $cm^3$.

Record your results from Experiments 1–5 in a **single** table showing the volume of **FA 1**, the volume of distilled water and the reaction time to the **nearest second** for each experiment.

**Keep FA 3 for use in Question 3.**

**Results**

| | |
|---|---|
| I | |
| II | |
| III | |
| IV | |
| V | |
| VI | |
| VII | |
| VIII | |

[8]

**(b)** Assume that the rate of reaction is given by:

$$\text{rate} = \frac{\text{“concentration of iodine” at the reaction time}}{\text{reaction time}}$$

where,

- the reaction time is the time taken for the mixture to turn blue-black,
- the “concentration of iodine” at the reaction time is the concentration that would have been present if the same volume of distilled water had been added to the reaction mixture instead of sodium thiosulfate solution.

**(i)** Show that the “concentration of iodine” at the reaction time = $0.0100\,\text{mol}\,\text{dm}^{-3}$. Ignore the volume of the starch indicator.

[2]

**(ii)** In each of your experiments the initial concentration of the iodide is given by the following expression. The volume of the starch indicator is ignored.

$$\text{initial concentration of iodide ions} = \frac{\text{volume of } \textbf{FA 1} \text{ in cm}^3}{75\,\text{cm}^3} \times 1.00\,\text{mol}\,\text{dm}^{-3}$$

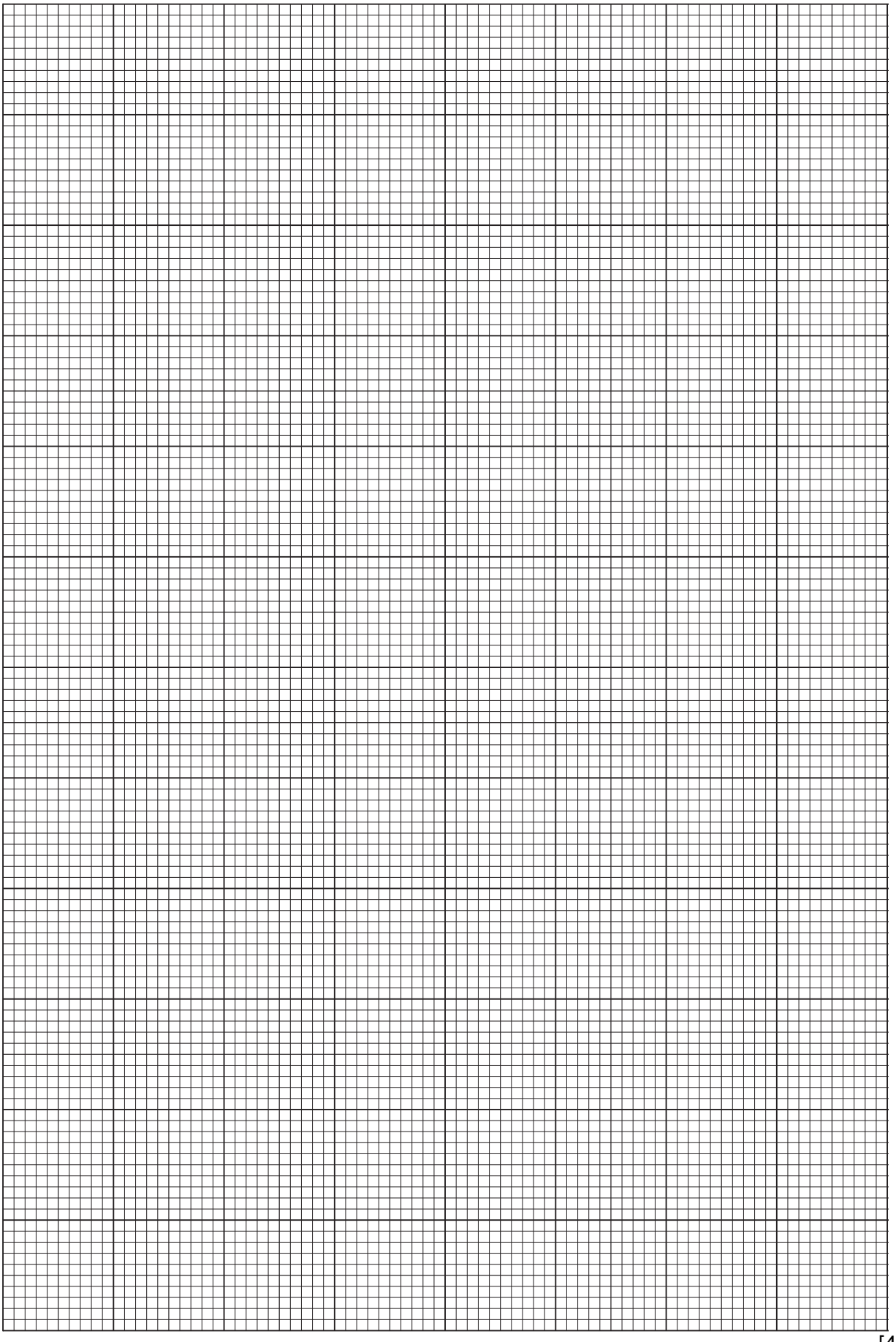
You have shown in **(i)** that the rate of reaction is given by the following expression.

$$\text{rate} = \frac{0.0100\,\text{mol}\,\text{dm}^{-3}}{\text{reaction time}}$$

Use these expressions to draw up a table in the space below showing the rate of reaction and the initial concentration of iodide ions in each of your five experiments.

[1]

**(c)** On the grid below, plot a graph of the rate of reaction on the *y*-axis against the initial concentration of iodide ions on the *x*-axis.
Draw a line of best fit through the points you have plotted.



[4]

| | |
|---|---|
| I | |
| II | |
| III | |
| IV | |

**(d) (i)** Use your graph to determine the order of reaction with respect to the concentration of iodide ions. Explain your answer.

.....

.....

..... [1]

**(ii)** In a series of experiments a student determined that the reaction was first order with respect to the concentration of $H_2O_2$ and also first order with respect to the concentration of $H^+$ ions.

Use your answer from **(d)(i)** and this information to give the rate equation for this reaction.

..... [1]

**(iii)** Calculate the gradient of the best-fit line you have drawn on your graph.

gradient = ..... $s^{-1}$ [1]

**(iv)** Assume that the initial concentration of $H^+$ ions is 0.276 mol $dm^{-3}$. Use this value to determine the value of the rate constant, *k*, in your rate equation. Give its units.

*k* = ..... ..... [3]
*value* *units*

**(v)** Explain why it is difficult to calculate the initial concentration of the $H^+$ ions.

.....

.....

..... [1]

**(e)** A student suggested that the measurement of the reaction time in these experiments could be made more accurate by using 2.00 mol $dm^{-3}$ sulfuric acid rather than **FA 4**.

Discuss whether you agree with the student.

.....

.....

..... [1]

[Total: 23]

**2** **FA 5** contains a mixture of two solids, only one of which is soluble in water.

**(a)**
- Place all of **FA 5** in a boiling tube and fill with distilled water to a depth of approximately one third of the tube.
- Stir the mixture carefully to dissolve one of the solids.
- Filter the mixture into a second boiling tube.
- Carry out the following tests on the filtrate and the solid residue. Test and identify any gases given off.

| test | observations |
|---|---|
| **(i)** To a 1 cm depth of the filtrate in a test-tube add aqueous sodium hydroxide. | |
| **(ii)** Use a spatula to transfer some of the solid residue from the filter paper to a test-tube.<br>Add a 1 cm depth of hydrochloric acid to the test-tube, then | |
| add aqueous sodium hydroxide to the test-tube. | |

[4]

**(b)** Use your results to identify as many of the ions as you can that are present in the two solids. Give the formula of each ion.

The soluble salt contains ..... .

The insoluble salt contains ..... . [2]

**(c)** The soluble salt contains either the chloride ion or the bromide ion.
State which pair of reagents you would usually use to determine whether chloride or bromide is present and explain why this would be difficult in this case.
**Do not carry out this test.**

.....

.....

..... [2]

[Total: 8]

**3** **FA 6** is a salt with a single anion.
**FA 7** is aqueous potassium manganate(VII).

**(a)**
- Rinse one of the 100 $cm^3$ beakers with distilled water.
- Place all of the sample of **FA 6** into the beaker and use the 50 $cm^3$ measuring cylinder to add 40 $cm^3$ of distilled water.
- Stir the mixture until the solid has dissolved.
- Use this solution to carry out the following tests.

| test | observations |
|---|---|
| **(i)** To a 1 cm depth of the solution of **FA 6** in a test-tube add a 1 cm depth of aqueous barium chloride (or aqueous barium nitrate), then | |
| add excess hydrochloric acid. | |
| **(ii)** To a 1 cm depth of the solution of **FA 6** in a test-tube add a 1 cm depth of **FA 3**, hydrogen peroxide, then | no observations required |
| add a 1 cm depth of aqueous barium chloride (or aqueous barium nitrate), then | |
| add excess hydrochloric acid. | |
| **(iii)** To a 1 cm depth of the solution of **FA 6** in a test-tube add a 1 cm depth of **FA 7**, then | |
| add excess sulfuric acid. | |
| **(iv)** To a 1 cm depth of the solution of **FA 6** in a **boiling tube** add a 1 cm depth of sulfuric acid and warm gently.<br><br>Test the gas given off using filter paper dipped in **acidified** aqueous potassium manganate(VII). Identify the gas. | |

[6]

**(b)** From your results, suggest the identity of the anion in **FA 6**.

The formula of the anion in **FA 6** is ..... . [1]

**(c)** Explain the observations that you made in tests **(a)(i)** and **(ii)**.

.....

.....

.....

..... [2]

[Total: 9]

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