UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education
Advanced Subsidiary Level and Advanced Level

CANDIDATE NAME

CENTRE NUMBER | | | | | |

CANDIDATE NUMBER | | | | |

3105748126

CHEMISTRY **9701/51**

Paper 5 Planning, Analysis and Evaluation **October/November 2009**

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs, or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions.
You are advised to show all working in calculations.
Use of Data Booklet is unnecessary.
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.

For Examiner's Use	
1	
2	
Total	

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

1 One method of studying the kinetics of a reaction is by the initial rates method.
To determine the initial rate we can time how long it takes to reach an identifiable point early in the reaction.

In solution, iodide ions, I^-, are oxidised by persulfate ions, $S_2O_8^{2-}$.

$$S_2O_8^{2-}(aq) + 2I^-(aq) \longrightarrow 2SO_4^{2-}(aq) + I_2(aq)$$

If sodium thiosulfate and starch are added to the reaction mixture, the blue-black colour of an iodine-starch complex appears suddenly. This occurs when all of the thiosulfate ions, $S_2O_3^{2-}$, present in the mixture have reacted with the iodine formed in the reaction above. This is the identifiable point in the reaction.

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

You are to plan an experiment to investigate how the rate of reaction between potassium persulfate and potassium iodide depends on the concentration of potassium persulfate.
A preliminary experiment, using approximate volumes of solution, indicates that the time taken for the iodine-starch complex to form doubles when the potassium persulfate is diluted with an equal amount of water.

(a) Using the results of the preliminary experiment predict the relationship between the concentration of potassium persulfate and the rate of reaction.

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Explain your prediction in terms of the particles (ions) present in the solution.

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(b) **(i)** Identify the independent variable in the investigation.

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(ii) Identify the dependent variable in the investigation.

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(c) Explain why it is important that the iodine formed by oxidation reacts with the sodium thiosulfate and is converted back to iodide ions.

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(d) Design a laboratory experiment that you would use to investigate your prediction in **(a)**.

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The following materials are to be used in your plan.

0.60 mol dm^{-3} potassium iodide
0.20 mol dm^{-3} potassium persulfate
0.01 mol dm^{-3} sodium thiosulfate
distilled water
starch indicator solution

A first experiment is carried out using the following quantities.

20 cm^3 potassium iodide
40 cm^3 potassium persulfate
20 cm^3 sodium thiosulfate
0 cm^3 distilled water
10 cm^3 starch indicator solution

Give a step-by-step description of the method you would use in further experiments. Include the following in your plan.

- the range of concentrations
- the volume of each solution to be used
- the method of measuring the volume of each solution
- how and when the solutions are to be mixed
- the way in which the dependent variable will be measured
- the control of all other variables

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(e) Explain why the volume of aqueous sodium thiosulfate should be measured precisely, using a burette, in each of the experiments.

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(f) Prepare a table in which to record all of the measurements from your experiment.
Indicate in your table how your measurements would be processed to enable you to confirm or reject your prediction in **(a)**.
Include appropriate units in the heading for each column.

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[2]

(g) Explain how the results of the experiment will confirm or reject your prediction in **(a)**.

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[Total: 15]

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2 A group of twelve students carried out the following experiment to confirm the formula of zinc iodide as ZnI_2. In the experiment an **excess** of powdered zinc reacts with a solution of iodine in ethanol.

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The instructions for the experiment given to each student are as follows.

- Weigh a dry, hard-glass test-tube.
- Put approximately 0.5 g of zinc powder in the test-tube and reweigh the tube.
- Add approximately 1.0 g of iodine and weigh the tube again.
- Cautiously add ethanol, drop by drop, until no further visible reaction takes place, and then add a further 1cm^3 of ethanol, an excess.
- Shake the tube gently until the brown colour of the dissolved iodine disappears. This indicates that the reaction is complete.
- Place the tube in a centrifuge and spin the tube and its contents for 30 seconds. The excess zinc will "pack" at the bottom of the tube.
- Pour off and discard the liquid above the layer of zinc. This liquid contains the zinc iodide formed in the reaction.
- Wash the zinc powder with 1 cm^3 of ethanol.
- Centrifuge the tube and pour off the liquid as before.
- Repeat the washing of the zinc several times to remove any remaining traces of zinc iodide.
- Dry the tube and its contents by laying the tube on a gauze, on top of a tripod, **gently** heated by a small Bunsen burner flame.
- Allow the tube to cool and reweigh the tube and its contents.

(a) The results of the experiment are shown in the table at the top of the next page.

Process the results in the table to produce values that will enable you to calculate the number of moles of zinc and iodine **reacting** in each student's experiment.

Record these values in the additional columns of the table. You may use some or all of the columns.
Label the columns you use. For each column, include the units and an expression to show how your values are calculated. You may use the column headings **A** to **G** in the expressions e.g. **C – B**.

You are reminded that an excess of zinc was used in each experiment.

[Turn over

Results

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	A	B	C	D	E	F	G
student	mass of empty test-tube /g	mass of test-tube and zinc powder /g	mass of test-tube, zinc powder and iodine /g	mass of test-tube + **excess** of zinc /g			
1	15.60	16.13	17.13	15.87			
2	14.73	15.24	16.23	14.99			
3	13.81	14.29	15.32	14.07			
4	16.67	17.16	18.17	16.90			
5	15.89	16.40	17.38	16.15			
6	16.32	16.84	17.79	16.60			
7	13.11	13.58	14.55	13.33			
8	17.86	18.35	19.39	18.05			
9	16.45	16.95	17.97	16.69			
10	15.77	16.31	17.27	16.06			
11	12.99	13.47	14.52	13.20			
12	14.48	14.98	16.02	14.71			

[3]

(b) (i) For each student calculate the number of moles of iodine atoms and number of moles of zinc that react together.
[A_r: I, 127; Zn, 65.4]

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student	moles of iodine	moles of zinc	
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

(ii) Process the values from **(i)** to enable you to confirm or reject the suggested formula of zinc iodide, ZnI_2. Use the blank column in the table above to record your results.

[4]

(c) By inspection of the values in **(b)**, identify any student(s) whose experimental results you consider to be anomalous.

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(d) In the light of your answer to **(c)** explain how you would process the values from **(b)** to find the formula of zinc iodide.

[2]

(e) For each anomalous result identified in **(c)** refer to the instructions for the experiment and suggest a possible reason for the anomaly.

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(f) Does the range of experimental values and your answer to **(d)** support the suggested formula, ZnI_2?
Explain your answer.

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(g) By referring to your calculated values in **(a)** identify any single weakness in the experimental method that could lead to errors in the results of the experiment.

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(h) A student suggests an alternative method with iodine in excess rather than zinc. Suggest a reagent that could be used, in a titration, to determine the amount of iodine remaining in solution after the reaction.

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[Total: 15]

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