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

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER				

3318230628

CHEMISTRY **9701/31**

Paper 31 Practical Test **October/November 2007**

2 hours

Candidates answer on the Question Paper.

Additional Materials: As listed in the Instructions to Supervisors

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 a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

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

Qualitative Analysis Notes are printed on pages 11 and 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.

Session
Laboratory

For Examiner's Use	
1	
2	
Total	

This document consists of **12** printed pages and **1** Insert.

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1 Read through question 1 before starting any practical work.

You are provided with the following reagents.

FA 1 containing 37.0 g dm^{-3} of hydrated sodium thiosulphate, $Na_2S_2O_3.5H_2O$
FA 2 2.0 mol dm^{-3} hydrochloric acid, HC*l*
distilled water

Aqueous thiosulphate ions, $S_2O_3^{2-}$, decompose in the presence of hydrogen ions, H^+.

$$S_2O_3^{2-}(aq) + 2H^+(aq) \longrightarrow S(s) + SO_2(g) + H_2O(l)$$

The rate of reaction can be followed by observing the formation of a fixed amount of sulphur as a fine suspension of solid particles in the solution.

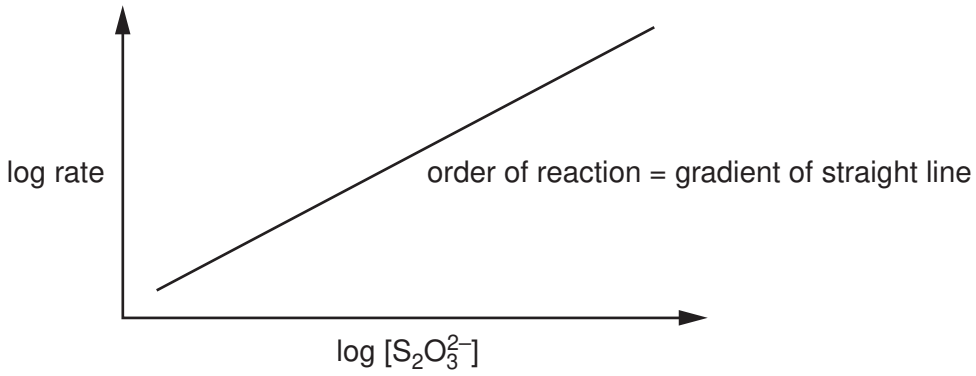
The rate of decomposition at a fixed temperature is affected by

- the concentration of thiosulphate ions, $[S_2O_3^{2-}]$;
- the concentration of hydrogen ions, $[H^+]$.

In a series of experiments where the concentration of a reagent is changed

- 1/time can be used as a measure of rate,
- the volume of the reagent used can be taken as a measure of its concentration, providing the total volume of the mixture is kept constant in each experiment.

The order of reaction with respect to thiosulphate ions can be obtained by plotting a graph of log rate against log $[S_2O_3^{2-}]$.



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(a) Method

Experiment 1

- Fill the burette **labelled FA 1** with **FA 1**.
- Run 50.00 cm^3 of **FA 1** from the burette into a 250 cm^3 beaker.
- Measure 5 cm^3 of **FA 2** in a measuring cylinder.
- Tip the acid **FA 2** from the measuring cylinder into the beaker and **immediately** start a stop-clock or note the start time on a clock with a second hand.
- Swirl the beaker to mix the reagents and place the beaker over the printing on the insert provided.
- Observe the printing by looking down through the solution in the beaker.
- Stop the clock or note the time when the printing is **just** no longer visible.
- Record the time taken to the nearest second.

The time taken is ..... s.

Experiment 2

- Empty and rinse the beaker used in experiment 1. Carefully dry the beaker with a paper towel.
- Refill the burette **labelled FA 1** with **FA 1**.
- Fill the second burette, **labelled water**, with distilled water.
- Run 10.00 cm^3 of **FA 1** and 40.00 cm^3 of distilled water from the burettes into the 250 cm^3 beaker.
- Measure 5 cm^3 of **FA 2** in a measuring cylinder.
- Tip the acid **FA 2** into the beaker, start the clock or note the time, mix the reagents and place over the printing as in experiment 1.
- Stop the clock or note the time when the printing is **just** no longer visible.
- Record the time taken to the nearest second.

The time taken is ..... s.

[2]

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[Turn over

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(b) In experiment 1 you will have obtained the time taken for a 'fast' reaction and in experiment 2 the time taken for a 'slow' reaction.

You are to repeat the experiment with further mixtures in which **only** the concentration of thiosulphate ions is varied.
In selecting the mixtures to be used you should consider

- how many mixtures need to be used,
- what concentrations of thiosulphate ion should be used,
- what range these concentrations should cover,
- that only the concentration of thiosulphate ion must change.

Remember – you already have reaction times for two mixtures with different concentrations of thiosulphate ion.

In the space below prepare to record, in an appropriate form, the results of the experiments you will perform and the results of experiments 1 and 2.

Your recorded results should include calculated values to enable you to plot

log (1/time) against **log (volume of FA 1)**.

Carry out the additional experiments and record your results.

i	
ii	
iii	
iv	
v	
vi	
vii	
viii	
ix	
x	
xi	

[11]

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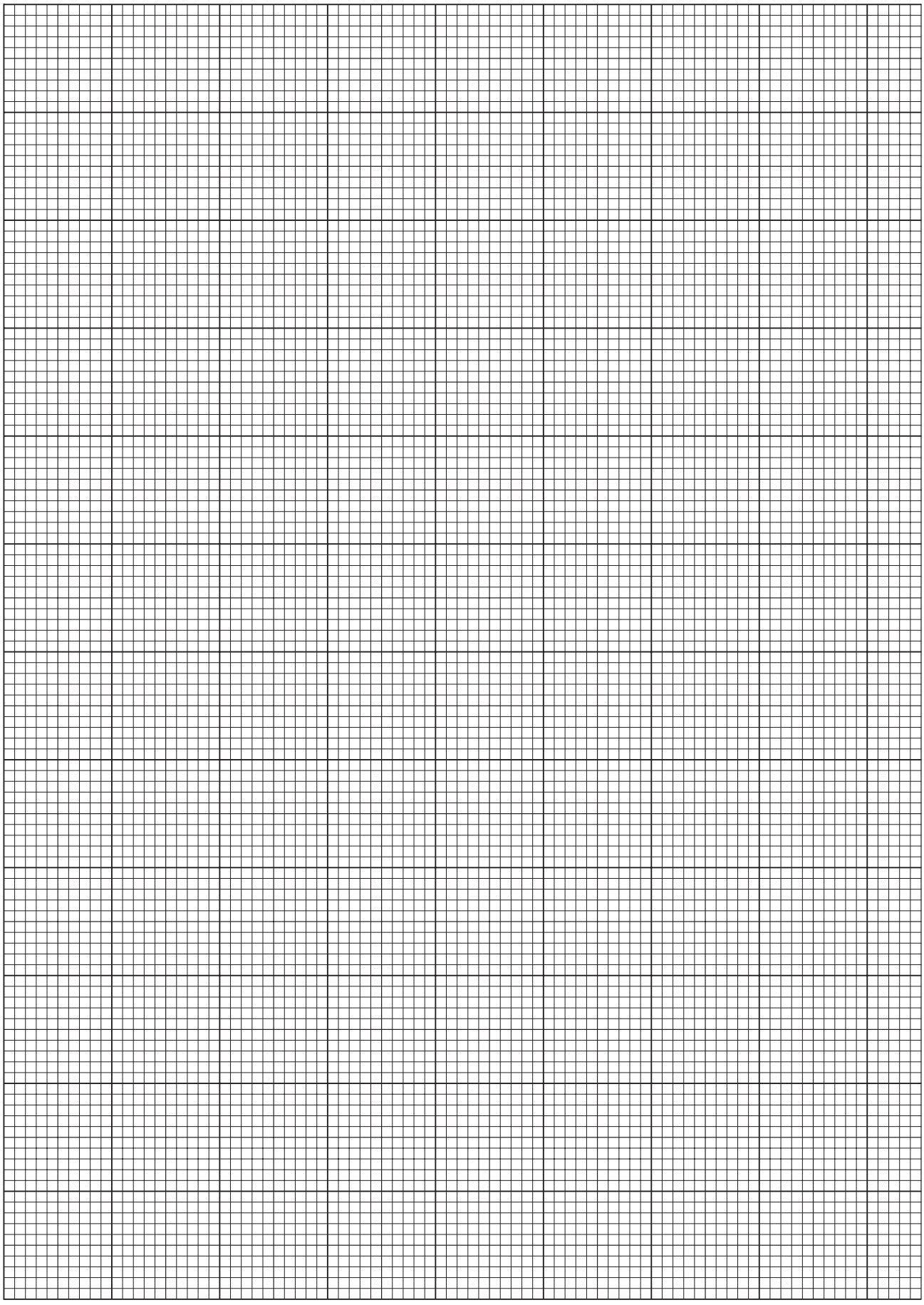
(c) Use the grid below to plot a graph of **log (1/time)** against **log (volume of FA 1)**. Draw an appropriate straight line through the points plotted.



[4]

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(d) Draw construction lines on your graph and obtain data from them to enable you to calculate the gradient of the graph.

Calculate the gradient of the line drawn, which is the order of reaction with respect to thiosulphate ions.

The reaction is ..... order with respect to thiosulphate ions, $S_2O_3^{2-}$. [3]

(e) The moment at which the printing is just obscured can be difficult to judge and will vary from person to person.

Explain why this uncertainty for experiment 1 in section **(a)** will be less than the uncertainty for experiment 2 in section **(a)**.

.....

.....

.....

Estimate a value (± seconds) for the uncertainty in each of experiments 1 and 2 and express this uncertainty as a percentage of the time for the reaction.

	experiment 1	experiment 2
reaction time / s		
uncertainty / s	±	±
percentage uncertainty		

[3]

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(f) The experimental method can be modified to enable the rate of reaction with respect to hydrogen ions, H^+, to be investigated.

You will perform two further experiments **using the method for experiment 2 in section (a).** You will keep the concentration of thiosulphate ions constant and vary the concentration of hydrogen ions.

First copy the reaction time from your results to experiment 2 in section **(a)** into the table below. Then complete the table below to show the volumes of **FA 1**, **FA 2**, and distilled water you will use in these two further experiments.

Carry out each experiment as before and record the time taken in each case.

	volume of **FA 1** /cm^3	volume of **FA 2** /cm^3	volume water /cm^3	reaction time /s
experiment 2 in section **(a)**	10.00	5	40.00	
experiment **i**				
experiment **ii**				

[1]

(g) Use the experimental results from the three experiments to draw a conclusion as to how the rate of reaction is affected by changing the concentration of hydrogen ions.

.....

.....

.....

.....

.....[1]

[Total: 25]

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2 The four solutions **FA 3**, **FA 4**, **FA 5** and **FA 6 each** contain **one** of the following anions.

nitrate, NO_3^-
nitrite, NO_2^-
sulphate, SO_4^{2-}
sulphite, SO_3^{2-}

(a) Use information from the Qualitative Analysis Notes on page 12 to answer the following questions.

What single reagent could you use to identify the solution containing the nitrite ion?

.....

What reagents could you use to identify the sulphate and sulphite ions?

..... and .....

[1]

(b) Use the reagents selected in **(a)** to test each of the four solutions.

Record in the space below, the reagents used and the observations made.

From your observations identify the solutions containing nitrite, sulphate and sulphite ions.

Solution ..... contains the nitrite ion.

supporting evidence .....

Solution ..... contains the sulphate ion.

supporting evidence .....

Solution ..... contains the sulphite ion.

supporting evidence .....

[7]

(c) You are to perform the tests given in the table below with each of the solutions **FA 3**, **FA 4**, **FA 5** and **FA 6** to identify **three** of the cations present. One of these cations is the Ba^{2+} ion.

Record details of colour changes seen, the formation of any precipitate and the solubility of any such precipitate in an excess of the reagent added.

Where gases are released they should be identified by a test, **described in the appropriate place in the table.**

You should indicate clearly at what stage in a test a change occurs.

Marks are **not** given for chemical equations.
No additional tests should be attempted.

test	observations			
	FA 3	**FA 4**	**FA 5**	**FA 6**
(i) To 1 cm depth of solution in a boiling-tube, add aqueous sodium hydroxide a little at a time until there is no further change.				
If no precipitate forms, carefully warm the solution. **CARE** - heated solutions containing sodium hydroxide can be ejected from the boiling-tube.				
(ii) To 1 cm depth of solution in a test-tube, add aqueous ammonia a little at a time until there is no further change.				
(iii) To 1 cm depth of solution in a test-tube add 1 cm depth of dilute sulphuric acid.				
(iv) To 1 cm depth of solution in a test-tube add 1 cm depth of aqueous sodium sulphite.				
If a precipitate forms, add 2 cm depth of dilute hydrochloric acid.				

[3]

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[Turn over

(d) From your observations in **(c)** you should be able to identify the cation present in three of the solutions.

Solution ..... contains the ..... ion.

supporting evidence .....

.....

Solution ..... contains the ..... ion.

supporting evidence .....

.....

Solution ..... contains the ..... ion.

supporting evidence .....

.....

[3]

(e) Do not carry out this test.

What other reagent could you use to confirm the presence of Ba^{2+} in one of the solutions?

.....[1]

[Total: 15]

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Qualitative Analysis Notes

Key: [ppt. = precipitate]

1 Reactions of aqueous cations

ion	*reaction with*	
	NaOH(aq)	NH_3(aq)
aluminium, Al^{3+}(aq)	white ppt. soluble in excess	white ppt. insoluble in excess
ammonium, NH_4^+(aq)	ammonia produced on heating	
barium, Ba^{2+}(aq)	no ppt. (if reagents are pure)	no ppt.
calcium, Ca^{2+}(aq)	white ppt. with high [Ca^{2+}(aq)]	no ppt.
chromium(III), Cr^{3+}(aq)	grey-green ppt. soluble in excess giving dark green solution	grey-green ppt. insoluble in excess
copper(II), Cu^{2+}(aq)	pale blue ppt. insoluble in excess	blue ppt. soluble in excess giving dark blue solution
iron(II), Fe^{2+}(aq)	green ppt. insoluble in excess	green ppt. insoluble in excess
iron(III), Fe^{3+}(aq)	red-brown ppt. insoluble in excess	red-brown ppt. insoluble in excess
lead(II), Pb^{2+}(aq)	white ppt. soluble in excess	white ppt. insoluble in excess
magnesium, Mg^{2+}(aq)	white ppt. insoluble in excess	white ppt. insoluble in excess
manganese(II), Mn^{2+}(aq)	off-white ppt. insoluble in excess	off-white ppt. insoluble in excess
zinc, Zn^{2+}(aq)	white ppt. soluble in excess	white ppt. soluble in excess

[Lead(II) ions can be distinguished from aluminium ions by the insolubility of lead(II) chloride.]

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2 Reactions of anions

ion	*reaction*
carbonate, CO_3^{2-}	CO_2 liberated by dilute acids
chromate(VI), CrO_4^{2-} (aq)	yellow solution turns orange with H^+(aq); gives yellow ppt. with Ba^{2+}(aq); gives bright yellow ppt. with Pb^{2+}(aq)
chloride, Cl^-(aq)	gives white ppt. with Ag^+(aq) (soluble in NH_3(aq)); gives white ppt. with Pb^{2+}(aq)
bromide, Br^-(aq)	gives cream ppt. with Ag^+(aq) (partially soluble in NH_3(aq)); gives white ppt. with Pb^{2+}(aq)
iodide, I^- (aq)	gives yellow ppt. with Ag^+(aq) (insoluble in NH_3(aq)); gives yellow ppt. with Pb^{2+}(aq)
nitrate, NO_3^- (aq)	NH_3 liberated on heating with OH^-(aq) and Al foil
nitrite, NO_2^-(aq)	NH_3 liberated on heating with OH^-(aq) and Al foil; NO liberated by dilute acids (colourless NO → (pale) brown NO_2 in air)
sulphate, SO_4^{2-} (aq)	gives white ppt. with Ba^{2+}(aq) or with Pb^{2+}(aq) (insoluble in excess dilute strong acid)
sulphite, SO_3^{2-} (aq)	SO_2 liberated with dilute acids; gives white ppt. with Ba^{2+}(aq) (soluble in excess dilute strong acid)

3 Tests for gases

gas	*test and test result*
ammonia, NH_3	turns damp red litmus paper blue
carbon dioxide, CO_2	gives a white ppt. with limewater (ppt. dissolves with excess CO_2)
chlorine, Cl_2	bleaches damp litmus paper
hydrogen, H_2	'pops' with a lighted splint
oxygen, O_2	relights a glowing splint
sulphur dioxide, SO_2	turns potassium dichromate(VI) (aq) from orange to green

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