

Cambridge  
International  
AS & A Level

**Cambridge International Examinations**  
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE  
NAME

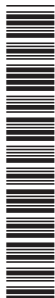
CENTRE  
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**CHEMISTRY**

**9701/34**

Paper 3 Advanced Practical Skills 2

**October/November 2017**

**2 hours**

Candidates answer on the Question Paper.

Additional Materials: As listed in the Confidential Instructions

**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.  
Use of a Data Booklet is unnecessary.

Qualitative Analysis Notes are printed on pages 10 and 11.  
A copy of the Periodic Table is printed on page 12.

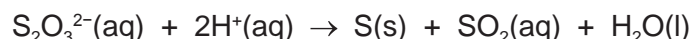
At the end of the examination, fasten all your work securely together.  
The number of marks is given in brackets [ ] at the end of each question or part question.

|                   |
|-------------------|
| <b>Session</b>    |
|                   |
| <b>Laboratory</b> |
|                   |

|                           |  |
|---------------------------|--|
| <b>For Examiner's Use</b> |  |
| <b>1</b>                  |  |
| <b>2</b>                  |  |
| <b>Total</b>              |  |

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

- 1 Sodium thiosulfate reacts with acid to produce a pale yellow precipitate of sulfur.



You will investigate how the rate of this reaction varies with the concentration of thiosulfate ions. To do this you will measure the time taken for a fixed amount of sulfur to be formed.

**FB 1** is  $0.10 \text{ mol dm}^{-3}$  sodium thiosulfate,  $\text{Na}_2\text{S}_2\text{O}_3$ .

**FB 2** is  $1.00 \text{ mol dm}^{-3}$  hydrochloric acid,  $\text{HCl}$ .

### (a) Method

Read through the instructions and prepare a table on page 3 for your results before starting any practical work. You will need to include volume of **FB 1**, volume of water, reaction time and rate of reaction for each of the five experiments.

#### Experiment 1

- Use the larger measuring cylinder to transfer  $40 \text{ cm}^3$  of **FB 1** into the  $100 \text{ cm}^3$  beaker.
- Use the smaller measuring cylinder to measure  $25 \text{ cm}^3$  of **FB 2**.
- Pour the **FB 2** into the **FB 1** in the beaker and start timing **immediately**.
- Stir the mixture in the beaker once and place the beaker on top of the printed insert provided.
- Look down through the solution in the beaker at the print on the insert.
- Stop timing as soon as the precipitate of sulfur makes the print on the insert **just** invisible.
- Record the reaction time to the nearest second.
- Empty, rinse and dry the beaker so it is ready for use in **Experiment 2**.
- Rinse the sink with tap water to wash away the products of the reaction.

#### Experiment 2

- Use the larger measuring cylinder to transfer  $30 \text{ cm}^3$  of **FB 1** into the  $100 \text{ cm}^3$  beaker.
- Use the same measuring cylinder to add  $10 \text{ cm}^3$  of distilled water to the beaker.
- Use the smaller measuring cylinder to add  $25 \text{ cm}^3$  of **FB 2** to the mixture in the beaker and start timing **immediately**.
- Stir the mixture in the beaker once and place the beaker on top of the printed insert provided.
- Look down through the solution in the beaker at the print on the insert.
- Stop timing as soon as the precipitate of sulfur makes the print on the insert **just** invisible.
- Record the reaction time to the nearest second.
- Empty, rinse and dry the beaker so it is ready for use in **Experiment 3**.
- Rinse the sink with tap water to wash away the products of the reaction.

**Experiment 3**

Repeat **Experiment 2** using 20 cm<sup>3</sup> of **FB 1**, 20 cm<sup>3</sup> of distilled water and 25 cm<sup>3</sup> of **FB 2**.

**Experiments 4 and 5**

Choose suitable volumes that will enable you to investigate further the effect of changing the concentration of thiosulfate ions on the rate of the reaction. You should not use a volume of less than 10 cm<sup>3</sup> of **FB 1**.

**Results**

The rate of the reaction can be calculated as shown.

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

Calculate the rate of reaction for each experiment and complete the table.

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

[10]

- (b) On the grid plot a graph of rate of reaction ( $y$ -axis) against volume of **FB 1** ( $x$ -axis). Circle any points that you consider anomalous and draw a line of best fit to show how the rate of the reaction depends on the volume of **FB 1**.

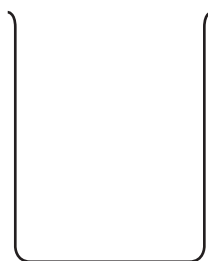


[3]

- (c) Use your graph to calculate the time that the reaction would have taken if  $8\text{ cm}^3$  of **FB 1** had been used. Show **on the grid** how you obtained your answer.

time = ..... s [2]

- (d) (i) A student broke the 100 cm<sup>3</sup> beaker when carrying out the experiment and decided to use a petri dish instead. This has a different shape.



beaker



petri dish

State and explain what effect this would have on the student's results.

.....

.....

.....

- (ii) Another student suggested that the experiment could be improved by using a less concentrated solution of sodium thiosulfate.

Explain whether this suggestion would improve the accuracy of the results.

.....

.....

.....

[4]

- (e) Calculate the maximum percentage error in the reaction time for **Experiment 1**. Show how you obtained your answer.

maximum percentage error = ..... % [1]

- (f) Using a similar method to (a), explain how you would investigate how the rate of the reaction varies with changes in the concentration of hydrochloric acid.

.....

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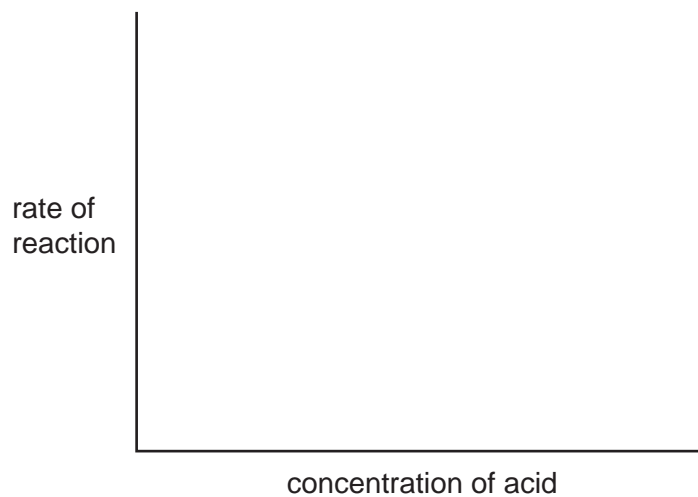
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..... [3]

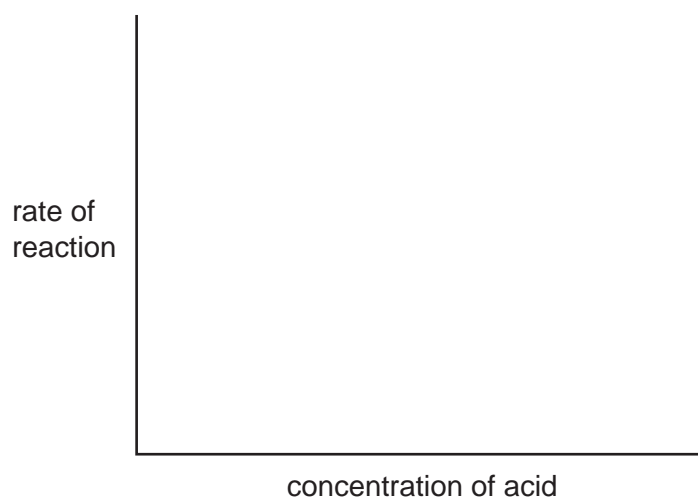
- (g) An experiment to investigate the effect of changing the concentration of hydrochloric acid gave results that could be plotted to produce a graph.

On the axes, sketch the graph that would show that:

- (i) the rate of reaction was directly proportional to the concentration of acid,



- (ii) the rate of reaction did **not** depend on the concentration of acid.



[2]

[Total: 25]

## 2 Qualitative Analysis

At each stage of any test you are to record details of the following:

- colour changes seen;
- the formation of any precipitate;
- the solubility of such precipitates in an excess of the reagent added.

Where reagents are selected for use in a test, the **name** or **correct formula** of the element or compound must be given.

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

You should indicate clearly at what stage in a test a change occurs.  
**No additional tests for ions present should be attempted.**

**If any solution is warmed, a boiling tube MUST be used.**

Rinse and reuse test-tubes and boiling tubes where possible.

**(a) FB 3, FB 4, FB 5 and FB 6** are aqueous solutions each containing one cation and one anion.

- (i)** Carry out the following tests by adding, to a 1 cm depth of each solution in a test-tube, a 1 cm depth of the other solution. Record your observations in the table.

| test | observations |      |      |
|------|--------------|------|------|
|      | FB 4         | FB 5 | FB 6 |
| FB 3 |              |      |      |
| FB 4 |              |      |      |
| FB 5 |              |      |      |

- (ii) **FB 3** and **FB 4** both contain the same anion.

Use your observations from (i) to suggest the identity of this anion.

anion: .....

- (iii) Suggest and carry out a test to confirm the identity of the anion you identified in (ii). You should include the test and your result.

test .....

result .....

- (iv) **FB 5** contains one cation from those listed in the Qualitative Analysis Notes.

Use your observations in (i) to suggest **two** cations that could be present in **FB 5**.

cations present ..... or .....

- (v) Suggest and carry out a test to identify which of the cations you suggested in (iv) is present in **FB 5**.

test .....

result .....

cation present in **FB 5** .....

[9]



(b) **FB 7**, **FB 8** and **FB 9** are aqueous solutions.

(i) Carry out the following tests and record your observations.

| test   | observations |      |      |
|--|--------------|------|------|
|  | FB 7         | FB 8 | FB 9 |
| To a 1 cm depth of solution in a test-tube add a 1 cm depth of aqueous potassium iodide, then                    |              |      |      |
| add aqueous starch.  |              |      |      |
| To a 1 cm depth of solution in a test-tube add a 1 cm depth of aqueous iodine.                                   |              |      |      |
| To a 1 cm depth of solution in a test-tube add a few drops of aqueous barium nitrate or aqueous barium chloride. |              |      |      |

(ii) From your observations in (i) suggest **two** anions from those listed in the Qualitative Analysis Notes that could be present in **FB 9**.

anions present ..... or .....

(iii) Suggest and carry out a test to identify which of the anions you suggested in (ii) is present in **FB 9**.

test .....

result .....

anion present in **FB 9** .....

[6]

[Total: 15]

## Qualitative Analysis Notes

## 1 Reactions of aqueous cations

| ion  | reaction with  |  |
|--|--|--|
|  | NaOH(aq)   | NH <sub>3</sub> (aq)   |
| aluminium,<br>Al <sup>3+</sup> (aq)            | white ppt.<br>soluble in excess  | white ppt.<br>insoluble in excess  |
| ammonium,<br>NH <sub>4</sub> <sup>+</sup> (aq) | no ppt.<br>ammonia produced on heating   | –  |
| barium,<br>Ba <sup>2+</sup> (aq)               | faint white ppt. is nearly always<br>observed unless reagents are pure             | no ppt.  |
| calcium,<br>Ca <sup>2+</sup> (aq)              | white ppt. with high [Ca <sup>2+</sup> (aq)]                                       | no ppt.  |
| chromium(III),<br>Cr <sup>3+</sup> (aq)        | grey-green ppt.<br>soluble in excess   | grey-green ppt.<br>insoluble in excess   |
| copper(II),<br>Cu <sup>2+</sup> (aq)           | pale blue ppt.<br>insoluble in excess  | blue ppt. soluble in excess<br>giving dark blue solution                           |
| iron(II),<br>Fe <sup>2+</sup> (aq)             | green ppt. turning brown on contact<br>with air<br>insoluble in excess             | green ppt. turning brown on contact<br>with air<br>insoluble in excess             |
| iron(III),<br>Fe <sup>3+</sup> (aq)            | red-brown ppt.<br>insoluble in excess  | red-brown ppt.<br>insoluble in excess  |
| magnesium,<br>Mg <sup>2+</sup> (aq)            | white ppt.<br>insoluble in excess  | white ppt.<br>insoluble in excess  |
| manganese(II),<br>Mn <sup>2+</sup> (aq)        | off-white ppt. rapidly turning brown<br>on contact with air<br>insoluble in excess | off-white ppt. rapidly turning brown<br>on contact with air<br>insoluble in excess |
| zinc,<br>Zn <sup>2+</sup> (aq)                 | white ppt.<br>soluble in excess  | white ppt.<br>soluble in excess  |

## 2 Reactions of anions

| <i>ion</i>                                | <i>reaction</i>   |
|---|---|
| carbonate,<br>$\text{CO}_3^{2-}$          | $\text{CO}_2$ liberated by dilute acids   |
| chloride,<br>$\text{Cl}^-(\text{aq})$     | gives white ppt. with $\text{Ag}^+(\text{aq})$ (soluble in $\text{NH}_3(\text{aq})$ )   |
| bromide,<br>$\text{Br}^-(\text{aq})$      | gives cream ppt. with $\text{Ag}^+(\text{aq})$ (partially soluble in $\text{NH}_3(\text{aq})$ )   |
| iodide,<br>$\text{I}^-(\text{aq})$        | gives yellow ppt. with $\text{Ag}^+(\text{aq})$ (insoluble in $\text{NH}_3(\text{aq})$ )  |
| nitrate,<br>$\text{NO}_3^-(\text{aq})$    | $\text{NH}_3$ liberated on heating with $\text{OH}^-(\text{aq})$ and $\text{Al}$ foil   |
| nitrite,<br>$\text{NO}_2^-(\text{aq})$    | $\text{NH}_3$ liberated on heating with $\text{OH}^-(\text{aq})$ and $\text{Al}$ foil;<br>$\text{NO}$ liberated by dilute acids<br>(colourless $\text{NO} \rightarrow$ (pale) brown $\text{NO}_2$ in air) |
| sulfate,<br>$\text{SO}_4^{2-}(\text{aq})$ | gives white ppt. with $\text{Ba}^{2+}(\text{aq})$ (insoluble in excess dilute strong acids)   |
| sulfite,<br>$\text{SO}_3^{2-}(\text{aq})$ | gives white ppt. with $\text{Ba}^{2+}(\text{aq})$ (soluble in excess dilute strong acids)   |

## 3 Tests for gases

| <i>gas</i>                    | <i>test and test result</i>   |
|-------------------------------|---|
| ammonia, $\text{NH}_3$        | turns damp red litmus paper blue  |
| carbon dioxide, $\text{CO}_2$ | gives a white ppt. with limewater (ppt. dissolves with excess $\text{CO}_2$ ) |
| chlorine, $\text{Cl}_2$       | bleaches damp litmus paper  |
| hydrogen, $\text{H}_2$        | 'pops' with a lighted splint  |
| oxygen, $\text{O}_2$          | relights a glowing splint   |

The Periodic Table of Elements

|                              |                               | Group  |                               |                               |                                |                              |                                |                              |                                |                               |                              |                               |                            |                               |                                |                             |                               |                              |                              |                             |                                 |                           |                              |                           |                           |                              |                                |                               |                               |                            |                             |                             |                               |                              |                            |
|------------------------------|-------------------------------|--|-------------------------------|-------------------------------|--------------------------------|------------------------------|--------------------------------|------------------------------|--------------------------------|-------------------------------|------------------------------|-------------------------------|----------------------------|-------------------------------|--------------------------------|-----------------------------|-------------------------------|------------------------------|------------------------------|-----------------------------|---------------------------------|---------------------------|------------------------------|---------------------------|---------------------------|------------------------------|--------------------------------|-------------------------------|-------------------------------|----------------------------|-----------------------------|-----------------------------|-------------------------------|------------------------------|----------------------------|
| 1                            | 2                             | 3  | 4                             | 5                             | 6                              | 7                            | 8                              | 9                            | 10                             | 11                            | 12                           | 13                            | 14                         | 15                            | 16                             | 17                          | 18                            |                              |                              |                             |                                 |                           |                              |                           |                           |                              |                                |                               |                               |                            |                             |                             |                               |                              |                            |
|                              |                               | <div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">1<br/>H<br/>hydrogen<br/>1.0</div> <div style="border: 1px solid black; padding: 2px;"> <b>Key</b><br/>                     atomic number<br/>                     atomic symbol<br/>                     name<br/>                     relative atomic mass                 </div> </div> |                               |                               |                                |                              |                                |                              |                                |                               |                              |                               |                            |                               |                                |                             |                               |                              |                              |                             |                                 |                           |                              |                           |                           |                              |                                |                               |                               |                            |                             |                             |                               |                              |                            |
| 3<br>Li<br>lithium<br>6.9    | 4<br>Be<br>beryllium<br>9.0   | 11<br>Na<br>sodium<br>23.0   | 12<br>Mg<br>magnesium<br>24.3 | 19<br>K<br>potassium<br>39.1  | 20<br>Ca<br>calcium<br>40.1    | 21<br>Sc<br>scandium<br>45.0 | 22<br>Ti<br>titanium<br>47.9   | 23<br>V<br>vanadium<br>50.9  | 24<br>Cr<br>chromium<br>52.0   | 25<br>Mn<br>manganese<br>54.9 | 26<br>Fe<br>iron<br>55.8     | 27<br>Co<br>cobalt<br>58.9    | 28<br>Ni<br>nickel<br>58.7 | 29<br>Cu<br>copper<br>63.5    | 30<br>Zn<br>zinc<br>65.4       | 31<br>Ga<br>gallium<br>69.7 | 32<br>Ge<br>germanium<br>72.6 | 33<br>As<br>arsenic<br>74.9  | 34<br>Se<br>selenium<br>79.0 | 35<br>Br<br>bromine<br>79.9 | 36<br>Kr<br>krypton<br>83.8     |                           |                              |                           |                           |                              |                                |                               |                               |                            |                             |                             |                               |                              |                            |
| 37<br>Rb<br>rubidium<br>85.5 | 38<br>Sr<br>strontium<br>87.6 | 39<br>Y<br>yttrium<br>88.9   | 40<br>Zr<br>zirconium<br>91.2 | 41<br>Nb<br>niobium<br>92.9   | 42<br>Mo<br>molybdenum<br>95.9 | 43<br>Tc<br>technetium<br>—  | 44<br>Ru<br>ruthenium<br>101.1 | 45<br>Rh<br>rhodium<br>102.9 | 46<br>Pd<br>palladium<br>106.4 | 47<br>Ag<br>silver<br>107.9   | 48<br>Cd<br>cadmium<br>112.4 | 49<br>In<br>indium<br>114.8   | 50<br>Sn<br>tin<br>118.7   | 51<br>Sb<br>antimony<br>121.8 | 52<br>Te<br>tellurium<br>127.6 | 53<br>I<br>iodine<br>126.9  | 54<br>Xe<br>xenon<br>131.3    | 55<br>Cs<br>caesium<br>132.9 | 56<br>Ba<br>barium<br>137.3  | 57<br>Fr<br>francium<br>—   | 58<br>Ra<br>radium<br>—         |                           |                              |                           |                           |                              |                                |                               |                               |                            |                             |                             |                               |                              |                            |
| 87<br>Fr<br>francium<br>—    | 88<br>Ra<br>radium<br>—       | 89–103<br>actinoids  | 72<br>Hf<br>hafnium<br>178.5  | 73<br>Ta<br>tantalum<br>180.9 | 74<br>W<br>tungsten<br>183.8   | 75<br>Re<br>rhenium<br>186.2 | 76<br>Os<br>osmium<br>190.2    | 77<br>Ir<br>iridium<br>192.2 | 78<br>Pt<br>platinum<br>195.1  | 79<br>Au<br>gold<br>197.0     | 80<br>Hg<br>mercury<br>200.6 | 81<br>Tl<br>thallium<br>204.4 | 82<br>Pb<br>lead<br>207.2  | 83<br>Bi<br>bismuth<br>209.0  | 84<br>Po<br>polonium<br>—      | 85<br>At<br>astatine<br>—   | 86<br>Rn<br>radon<br>—        | 87<br>Fr<br>francium<br>—    | 88<br>Ra<br>radium<br>—      | 89–103<br>actinoids         | 104<br>Rf<br>rutherfordium<br>— | 105<br>Db<br>dubnium<br>— | 106<br>Sg<br>seaborgium<br>— | 107<br>Bh<br>bohrium<br>— | 108<br>Hs<br>hassium<br>— | 109<br>Mt<br>meitnerium<br>— | 110<br>Ds<br>darmstadtium<br>— | 111<br>Rg<br>roentgenium<br>— | 112<br>Cn<br>copernicium<br>— | 113<br>Nh<br>nihonium<br>— | 114<br>Fl<br>flerovium<br>— | 115<br>Mc<br>moscovium<br>— | 116<br>Lv<br>livermorium<br>— | 117<br>Ts<br>tennessine<br>— | 118<br>Og<br>oganeson<br>— |

|             |                                |                              |                                   |                                |                             |                               |                               |                                 |                              |                                 |                              |                             |                               |                                |                               |
|-------------|--------------------------------|------------------------------|-----------------------------------|--------------------------------|-----------------------------|-------------------------------|-------------------------------|---------------------------------|------------------------------|---------------------------------|------------------------------|-----------------------------|-------------------------------|--------------------------------|-------------------------------|
| lanthanoids | 57<br>La<br>lanthanum<br>138.9 | 58<br>Ce<br>cerium<br>140.1  | 59<br>Pr<br>praseodymium<br>140.9 | 60<br>Nd<br>neodymium<br>144.4 | 61<br>Pm<br>promethium<br>— | 62<br>Sm<br>samarium<br>150.4 | 63<br>Eu<br>europium<br>152.0 | 64<br>Gd<br>gadolinium<br>157.3 | 65<br>Tb<br>terbium<br>158.9 | 66<br>Dy<br>dysprosium<br>162.5 | 67<br>Ho<br>holmium<br>164.9 | 68<br>Er<br>erbium<br>167.3 | 69<br>Tm<br>thulium<br>168.9  | 70<br>Yb<br>ytterbium<br>173.1 | 71<br>Lu<br>lutetium<br>175.0 |
| actinoids   | 89<br>Ac<br>actinium<br>—      | 90<br>Th<br>thorium<br>232.0 | 91<br>Pa<br>protactinium<br>231.0 | 92<br>U<br>uranium<br>238.0    | 93<br>Np<br>neptunium<br>—  | 94<br>Pu<br>plutonium<br>—    | 95<br>Am<br>americium<br>—    | 96<br>Cm<br>curium<br>—         | 97<br>Bk<br>berkelium<br>—   | 98<br>Cf<br>californium<br>—    | 99<br>Es<br>einsteinium<br>— | 100<br>Fm<br>fermium<br>—   | 101<br>Md<br>mendelevium<br>— | 102<br>No<br>nobelium<br>—     | 103<br>Lr<br>lawrencium<br>—  |