



# Cambridge International AS & A Level

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## CHEMISTRY

9701/35

Paper 3 Advanced Practical Skills 1

October/November 2020

2 hours

You must answer on the question paper.

You will need: The materials and apparatus listed in the confidential instructions  
Insert (enclosed)

## INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working, use appropriate units and use an appropriate number of significant figures.
- Give details of the practical session and laboratory, where appropriate, in the boxes provided.

## INFORMATION

- The total mark for this paper is 40.
- The number of marks for each question or part question is shown in brackets [ ].
- The Periodic Table is printed in the question paper.
- Notes for use in qualitative analysis are provided in the question paper.
- The insert contains printed text for use in your practical.

Session

Laboratory

For Examiner's Use

1

2

3

Total

This document has **16** pages. Blank pages are indicated.

Show your working and appropriate significant figures in the final answer to **each** step of your calculations.

- $$2\text{S}_2\text{O}_3^{2-}(\text{aq}) + \text{I}_2(\text{aq}) \rightarrow \text{S}_4\text{O}_6^{2-}(\text{aq}) + 2\text{I}^{-}(\text{aq})$$

starch indicator

### Preparation of salt solution

- [illegible]

**Titration**

- Fill a burette with **FA 2**.
- Pipette 25.0 cm<sup>3</sup> of **FA 3** into the conical flask.
- Add **FA 2** from the burette until the solution in the flask turns yellow.
- Add 10 drops of starch indicator to the conical flask. The solution will turn blue-black.
- Continue to add more **FA 2** from the burette until the blue-black colour just disappears. This is the end-point of the titration.
- Carry out a rough titration and record your burette readings in the space below.

The rough titre is ..... cm<sup>3</sup>.

- Carry out as many accurate titrations as you think necessary to obtain consistent results.
- Make sure your recorded results show the precision of your practical work.
- Record, in a suitable form in the space below, all of your burette readings and the volume of **FA 2** added in each accurate titration.

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

[8]

- (b) From your accurate titration results, obtain a value for the volume of **FA 2** to be used in your calculations. Show clearly how you obtained this value.

25.0 cm<sup>3</sup> of **FA 3** required ..... cm<sup>3</sup> of **FA 2**. [1]

**(c) Calculations**

(i) Give your answers to **(c)(ii)** and **(c)(iii)** to the appropriate number of significant figures. [1]

(ii) Calculate the number of moles of iodine in 25.0 cm<sup>3</sup> of **FA 3**.

moles of I<sub>2</sub> = ..... mol [1]

(iii) Calculate the number of moles of thiosulfate ions in the volume recorded in **(b)**.

moles of S<sub>2</sub>O<sub>3</sub><sup>2-</sup> = ..... mol

Hence calculate the number of moles of hydrated sodium thiosulfate in the mass weighed in **(a)**.

moles of Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub>•xH<sub>2</sub>O = ..... mol [1]

(iv) Calculate the value for x in the formula of hydrated sodium thiosulfate, Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub>•xH<sub>2</sub>O. Show your working.

x = ..... [3]

- (d) (i) State the maximum error in a single reading on the balance used in (a).

maximum error =  $\pm$  ..... g

Calculate the maximum percentage error in the mass of **FA 1** used in (a).  
Show your working.

maximum percentage error =  $\pm$  ..... %  
[1]

- (ii) Assume that the uncertainty in the mass of **FA 1** is the only source of error in your experiment.

Calculate the minimum value for the relative formula mass of **FA 1**.  
Show your working.

minimum value for the relative formula mass of **FA 1** = ..... [1]

- (e) A student prepares **FA 2** using anhydrous sodium thiosulfate salt and the same mass of salt that you used in (a).

State how the student's titre would compare with the average titre value you obtained in (b).  
Explain your answer.

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

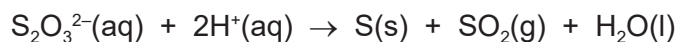
- (f) In many titrations it is usual to fill the burette with the solution of known concentration.

Suggest why this was not done in (a).

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

[Total: 19]

- 2 When a solution containing thiosulfate ions,  $\text{S}_2\text{O}_3^{2-}$ , is acidified the following reaction occurs.



The solid sulfur that is formed makes the mixture become cloudy. The rate of reaction can then be measured by timing how long it takes for the mixture to become too cloudy to see through.

You will investigate how changing the concentration of the thiosulfate ions affects the rate of reaction.

**Throughout these experiments care must be taken to avoid inhaling the  $\text{SO}_2$  that is produced. It is very important that as soon as each experiment is complete the contents of the beaker are emptied into the quenching bath.**

**FA 4** is  $2.00 \text{ mol dm}^{-3}$  hydrochloric acid,  $\text{HCl}$ .

**FA 5** is a solution of sodium thiosulfate,  $\text{Na}_2\text{S}_2\text{O}_3$ .  
distilled water

### (a) Method

#### Experiment 1

- Use the  $50 \text{ cm}^3$  measuring cylinder to transfer  $40.0 \text{ cm}^3$  of **FA 5** into the  $100 \text{ cm}^3$  beaker.
- Use the  $25 \text{ cm}^3$  measuring cylinder to measure  $20.0 \text{ cm}^3$  of **FA 4**.
- Add the  $20.0 \text{ cm}^3$  of **FA 4** to **FA 5** in the beaker and start timing immediately.
- Stir the mixture once and place the beaker on the printed insert.
- View the printed text on the insert from above through the mixture in the beaker.
- Note the time when the print on the insert becomes obscured.
- Record this reaction time to the nearest second.
- Empty the contents of the beaker into the quenching bath.
- Rinse and dry the beaker so it is ready for use in **Experiment 2**.

#### Experiment 2

- Use the  $50 \text{ cm}^3$  measuring cylinder to transfer  $20.0 \text{ cm}^3$  of **FA 5** into the  $100 \text{ cm}^3$  beaker.
- Use the  $50 \text{ cm}^3$  measuring cylinder to transfer  $20.0 \text{ cm}^3$  of distilled water into the same beaker.
- Use the  $25 \text{ cm}^3$  measuring cylinder to measure  $20.0 \text{ cm}^3$  of **FA 4**.
- Add the  $20.0 \text{ cm}^3$  of **FA 4** to **FA 5** in the beaker and start timing immediately.
- Stir the mixture once and place the beaker on the printed insert.
- View the printed text on the insert from above through the mixture in the beaker.
- Note the time when the print on the insert becomes obscured.
- Record this reaction time to the nearest second.
- Empty the contents of the beaker into the quenching bath.
- Rinse the beaker thoroughly.

**Keep FA 5 for use in Question 3.**

Record all your results in a table. You should include the volume of **FA 5**, the volume of distilled water, the reaction time and the rate of reaction for both experiments.

The rate of reaction can be calculated using the following formula.

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

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

[4]

- (b) A student suggested that the rate of the reaction is directly proportional to the concentration of the thiosulfate ions.

State whether your results support this suggestion.  
Explain your answer.

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

- (c) The student's suggestion in (b) could be made more reliable by carrying out further experiments.

Prepare a table to show three further experiments you could carry out. Show clearly the volumes of **FA 4**, **FA 5** and distilled water that you would use in each of these experiments. Do not suggest a volume of **FA 5** that is greater than 40.0 cm<sup>3</sup> or less than 20.0 cm<sup>3</sup>.

**DO NOT CARRY OUT THESE ADDITIONAL EXPERIMENTS.**

[2]

[Total: 7]

## Qualitative Analysis

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

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

- colour changes seen
- the formation of any precipitate and its solubility in an excess of the reagent added
- the formation of any gas and its identification by a suitable test.

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

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

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

**No additional tests for ions present should be attempted.**

- 3 (a) **FA 6** is a salt containing one cation and one anion. The anion is listed in the Qualitative Analysis Notes.

Add all the sample of **FA 6** to the 100 cm<sup>3</sup> beaker. Dissolve the solid in approximately 50 cm<sup>3</sup> of distilled water.

Label this solution **FA 7**.

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

| <i>test</i>                                                                                                 | <i>observations</i> |
|-------------------------------------------------------------------------------------------------------------|---------------------|
| <b>Test 1</b><br>To a 1 cm depth of <b>FA 7</b> in a test-tube, add a 3 cm depth of aqueous silver nitrate. |                     |
| Pour approximately half the contents of the test-tube into a clean test-tube.                               |                     |
| <b>Test 2</b><br>To the first test-tube add aqueous ammonia.                                                |                     |
| <b>Test 3</b><br>To the second test-tube add <b>FA 5</b> , aqueous sodium thiosulfate.                      |                     |

[2]

- (ii) From the results of your tests in (a)(i) suggest which anion is present in **FA 6**.

..... [1]

- (iii) It is suggested that **FA 6** could be sodium sulfite,  $\text{Na}_2\text{SO}_3$ , or sodium sulfate,  $\text{Na}_2\text{SO}_4$ .

Carry out tests using solution **FA 7** in order to decide whether **FA 6** is sodium sulfite or sodium sulfate.

Record the reagents selected, the results of your tests and your conclusions in the space below.

**FA 6** is sodium ..... [2]

- (iv) Using your conclusion from (a)(iii), write an ionic equation for the reaction between silver nitrate and **FA 7**.  
Include state symbols.

..... [1]

- (b) **FA 8** is a solution containing one of the cations listed in the Qualitative Analysis Notes.

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

| <i>test</i>                                                                                                                | <i>observations</i> |
|----------------------------------------------------------------------------------------------------------------------------|---------------------|
| <b>Test 1</b><br>To a 1 cm depth of <b>FA 8</b> in a test-tube, add aqueous ammonia until there is no further change, then |                     |
| pour the contents into a boiling tube and add a few drops of aqueous hydrogen peroxide.                                    |                     |

[3]

- (ii) Identify the cation in **FA 8**.

cation = ..... [1]

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

| <i>test</i>                                                                                                              | <i>observations</i> |
|--------------------------------------------------------------------------------------------------------------------------|---------------------|
| <b>Test 1</b><br>To a 1 cm depth of <b>FA 8</b> in a test-tube,<br>add a 1 cm depth of aqueous<br>potassium iodide, then |                     |
| add <b>FA 5</b> , aqueous sodium thiosulfate.                                                                            |                     |

[2]

(iv) Explain your observations in (b)(iii).

.....

.....

..... [2]

[Total: 14]







## 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           |
| 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                       | 1<br>H<br>hydrogen<br>1.0                                      |  |  |  |  |  |  |  |  |  |  |  |  |  | 17 | 18 |
|                        |                         | Key                                                            |  |  |  |  |  |  |  |  |  |  |  |  |  |    |    |
|                        |                         | atomic number<br>atomic symbol<br>name<br>relative atomic mass |  |  |  |  |  |  |  |  |  |  |  |  |  |    |    |
| 3                      | 4                       |                                                                |  |  |  |  |  |  |  |  |  |  |  |  |  |    |    |
| Li<br>lithium<br>6.9   | Be<br>beryllium<br>9.0  |                                                                |  |  |  |  |  |  |  |  |  |  |  |  |  |    |    |
| 11                     | 12                      |                                                                |  |  |  |  |  |  |  |  |  |  |  |  |  |    |    |
| Na<br>sodium<br>23.0   | Mg<br>magnesium<br>24.3 |                                                                |  |  |  |  |  |  |  |  |  |  |  |  |  |    |    |
| 19                     | 20                      |                                                                |  |  |  |  |  |  |  |  |  |  |  |  |  |    |    |
| K<br>potassium<br>39.1 | Ca<br>calcium<br>40.1   |                                                                |  |  |  |  |  |  |  |  |  |  |  |  |  |    |    |
| 37                     | 38                      |                                                                |  |  |  |  |  |  |  |  |  |  |  |  |  |    |    |
| Rb<br>rubidium<br>85.5 | Sr<br>strontium<br>87.6 |                                                                |  |  |  |  |  |  |  |  |  |  |  |  |  |    |    |
| 55                     | 56                      |                                                                |  |  |  |  |  |  |  |  |  |  |  |  |  |    |    |
| Cs<br>caesium<br>132.9 | Ba<br>barium<br>137.3   |                                                                |  |  |  |  |  |  |  |  |  |  |  |  |  |    |    |
| 87                     | 88                      |                                                                |  |  |  |  |  |  |  |  |  |  |  |  |  |    |    |
| Fr<br>francium<br>—    | Ra<br>radium<br>—       |                                                                |  |  |  |  |  |  |  |  |  |  |  |  |  |    |    |
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lanthanoids

actinoids

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