



Cambridge International AS & A Level

CANDIDATE
NAME

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CHEMISTRY

9701/32

Paper 3 Advanced Practical Skills 2

May/June 2020

2 hours

You must answer on the question paper.

You will need: The materials and apparatus listed in the confidential instructions

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.

Session	
Laboratory	

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.

For Examiner's Use	
1	
2	
3	
Total	

This document has **12** pages. Blank pages are indicated.

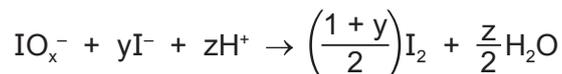
Quantitative Analysis

Read through the whole method before starting any practical work. Where appropriate, prepare a table for your results in the space provided.

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

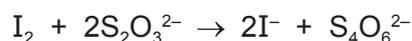
- 1 In this experiment you will determine the formula of the ion, IO_x^- . To do this you will first react IO_x^- ions with an excess of iodide ions, I^- , to form iodine, I_2 .

The equation for this reaction is:



where x, y and z are all integers.

The amount of iodine produced will then be determined by titration with thiosulfate ions, $\text{S}_2\text{O}_3^{2-}$.



FB 1 is a solution containing $0.0150 \text{ mol dm}^{-3}$ IO_x^- ions.

FB 2 is dilute sulfuric acid, H_2SO_4 .

FB 3 is $0.500 \text{ mol dm}^{-3}$ potassium iodide, KI.

FB 4 is $0.100 \text{ mol dm}^{-3}$ sodium thiosulfate, $\text{Na}_2\text{S}_2\text{O}_3$.

starch indicator

(a) Method

- Pipette 25.0 cm^3 of **FB 1** into a conical flask.
- Use the measuring cylinder to add 25 cm^3 of **FB 2** to the conical flask.
- Use the measuring cylinder to add 10 cm^3 of **FB 3** to the conical flask. The solution will turn brown as iodine is produced.
- Fill the burette with **FB 4**.
- Add **FB 4** from the burette until the solution in the conical flask turns yellow.
- Add 10–15 drops of starch indicator to the conical flask. The solution will turn blue-black.
- Continue to add more **FB 4** 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^3 .

- Carry out as many accurate titrations as you think necessary to obtain consistent results.
- Make sure that 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 **FB 4** added in each accurate titration.

Keep FB 3 and FB 4 for use in Question 3.

I	
II	
III	
IV	
V	
VI	
VII	

[7]

- (b) From your accurate titration results, obtain a value for the volume of **FB 4** to be used in your calculations. Show clearly how you obtained this value.

25.0 cm³ of **FB 1** required cm³ of **FB 4**. [1]

(c) Calculations

- (i) Give your answers to (c)(ii), (c)(iii) and (c)(iv) to the appropriate number of significant figures. [1]
- (ii) Use your answer to (b) and the relevant equation on page 2 to calculate the number of moles of iodine that form when 25.0 cm³ of **FB 1** react with 10 cm³ of **FB 3**.

moles of I₂ = mol [1]

- (iii) Calculate the number of moles of IO_x^- ions in 25.0 cm^3 of **FB 1**.

moles of IO_x^- ions = mol [1]

- (iv) Use the ratio of your answers to (c)(ii) and (c)(iii) along with the relevant equation given on page 2 to calculate the value of y . (Note that y is an odd integer such as 1, 3, 5, 7 etc.) Show your working.

$y = \dots\dots\dots$ [2]

- (v) Use your value of y to determine the formula of the IO_x^- ion.

formula = [1]

- (d) (i) The maximum error in the volume dispensed by the pipette is $\pm 0.06 \text{ cm}^3$.

Calculate the maximum percentage error in the volume of **FB 1** used.

maximum percentage error =% [1]

- (ii) A student suggested that a more accurate value of x could be obtained if a 10 cm^3 pipette is used to measure **FB 3** rather than the measuring cylinder.

State whether you agree with the student. Explain your answer.

.....

 [1]

[Total: 16]

- 2 In this experiment you will determine the enthalpy change of solution, ΔH_{sol} , for hydrated sodium thiosulfate, $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$. To do this you will measure the temperature change when a known mass of hydrated sodium thiosulfate is dissolved in a known volume of water.

FB 5 is hydrated sodium thiosulfate, $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$.

(a) Method

- Support the cup in the 250 cm³ beaker.
- Use the 25 cm³ measuring cylinder to transfer 20.0 cm³ of distilled water into the cup.
- Weigh the stoppered container of **FB 5** and record the mass.
- Measure and record the initial temperature of the water in the cup.
- Add all the **FB 5** to the water in the cup.
- Stir the mixture and record the minimum temperature that is reached.
- Reweigh the stoppered container. Record the mass.
- Calculate and record the mass of **FB 5** added to the water and the change in temperature.

I	
II	
III	
IV	

[4]

(b) Calculations

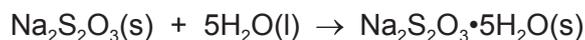
- (i) Calculate the energy change of the reaction.
(Assume that 4.2 J of heat energy changes the temperature of 1.0 cm³ of solution by 1.0 °C.)
Show your working.

energy change = J [1]

- (ii) Calculate the enthalpy change of solution, ΔH_{sol} , for hydrated sodium thiosulfate.

ΔH_{sol} for $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$ = kJ mol⁻¹
sign value [2]

- (iii) Assume that under the same conditions, the enthalpy change of solution, ΔH_{sol} , for anhydrous sodium thiosulfate, $\text{Na}_2\text{S}_2\text{O}_3$, is -7.7 kJ mol^{-1} . Construct a Hess's cycle and determine the enthalpy change for the following reaction. (If you were unable to calculate an answer to (b)(ii), assume a value of $+32.2 \text{ kJ mol}^{-1}$. Note this is not the correct value.)



$$\Delta H = \dots \dots \dots \text{ kJ mol}^{-1}$$

sign *value* [2]

- (c) How would your temperature change in (a) be affected if your sample of **FB 5** contained a small amount of anhydrous sodium thiosulfate? Explain your answer.

.....

.....

..... [1]

[Total: 10]

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) FB 6 is an aqueous solution containing one cation and one anion, both of which are listed in the Qualitative Analysis Notes.

- (i) Carry out tests to identify the cation in **FB 6**.
Record your tests and observations in the space below.

[2]

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

<i>test</i>	<i>observations</i>
Test 1 To a 2 cm depth of FB 6 in a test-tube, add a few drops of nitric acid, followed by a few drops of aqueous silver nitrate.	
Pour approximately half the contents of the test-tube into a clean test-tube.	
Test 2 To one of the test-tubes add aqueous ammonia.	
Test 3 To the other test-tube add FB 4 , $\text{Na}_2\text{S}_2\text{O}_3(\text{aq})$.	

[2]

(iii) Deduce the formula of **FB 6**.

..... [1]

(b) **FB 7** is acidified aqueous iron(III) chloride, FeCl_3 .

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

<i>test</i>	<i>observations</i>
Test 1 To a 1 cm depth of FB 7 in a test-tube, add a 1 cm depth of FB 3 , $\text{KI}(\text{aq})$, then	
add starch indicator.	

[1]

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

<i>test</i>	<i>observations</i>
Test 1 To a 1 cm depth of FB 7 in a test-tube, add a 1 cm depth of FB 4 , $\text{Na}_2\text{S}_2\text{O}_3(\text{aq})$. Leave to stand until there is no further change, then	
add aqueous sodium hydroxide.	

[2]

(iii) Explain your observation in (b)(ii) when aqueous sodium hydroxide is added.

.....

.....

..... [2]

(c) **FB 8** is acidified aqueous iron(II) sulfate, FeSO_4 .

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

<i>test</i>	<i>observations</i>	<i>conclusions</i>
Test 1 To a 1 cm depth of FB 8 in a boiling tube , add a 1 cm depth of hydrogen peroxide, then		X
add aqueous sodium hydroxide.		

[3]

(ii) Write an ionic equation for the reaction that occurs on addition of sodium hydroxide in (c)(i).

..... [1]

[Total: 14]

Qualitative Analysis Notes

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)	no ppt. ammonia produced on heating	–
barium, Ba ²⁺ (aq)	faint white ppt. is nearly always observed unless 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	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. turning brown on contact with air insoluble in excess	green ppt. turning brown on contact with air insoluble in excess
iron(III), Fe ³⁺ (aq)	red-brown ppt. insoluble in excess	red-brown 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. rapidly turning brown on contact with air insoluble in excess	off-white ppt. rapidly turning brown on contact with air insoluble in excess
zinc, Zn ²⁺ (aq)	white ppt. soluble in excess	white ppt. soluble in excess

2 Reactions of anions

<i>ion</i>	<i>reaction</i>
carbonate, CO_3^{2-}	CO_2 liberated by dilute acids
chloride, $\text{Cl}^-(\text{aq})$	gives white ppt. with $\text{Ag}^+(\text{aq})$ (soluble in $\text{NH}_3(\text{aq})$)
bromide, $\text{Br}^-(\text{aq})$	gives cream ppt. with $\text{Ag}^+(\text{aq})$ (partially soluble in $\text{NH}_3(\text{aq})$)
iodide, $\text{I}^-(\text{aq})$	gives yellow ppt. with $\text{Ag}^+(\text{aq})$ (insoluble in $\text{NH}_3(\text{aq})$)
nitrate, $\text{NO}_3^-(\text{aq})$	NH_3 liberated on heating with $\text{OH}^-(\text{aq})$ and Al foil
nitrite, $\text{NO}_2^-(\text{aq})$	NH_3 liberated on heating with $\text{OH}^-(\text{aq})$ and Al foil
sulfate, $\text{SO}_4^{2-}(\text{aq})$	gives white ppt. with $\text{Ba}^{2+}(\text{aq})$ (insoluble in excess dilute strong acids)
sulfite, $\text{SO}_3^{2-}(\text{aq})$	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, 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

