



Cambridge International AS & A Level

CANDIDATE
NAME

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CENTRE
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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.

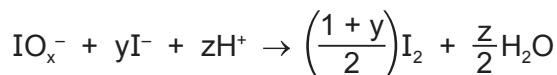
Quantitative Analysis

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 = [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 cm^3 beaker.
- Use the 25 cm^3 measuring cylinder to transfer 20.0 cm^3 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.

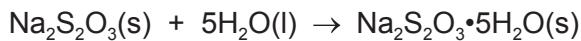
energy change = J [1]

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

$$\Delta H_{\text{sol}} \text{ for } \text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O} = \dots \text{ kJ mol}^{-1}$$

<i>sign</i>	<i>value</i>	[2]
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(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.)



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

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 , $\text{Na}_2\text{S}_2\text{O}_3$ (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 , KI (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 , $\text{Na}_2\text{S}_2\text{O}_3$ (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

ion	reaction
carbonate, CO_3^{2-}	CO_2 liberated by dilute acids
chloride, Cl^- (aq)	gives white ppt. with Ag^+ (aq) (soluble in NH_3 (aq))
bromide, Br^- (aq)	gives cream ppt. with Ag^+ (aq) (partially soluble in NH_3 (aq))
iodide, I^- (aq)	gives yellow ppt. with Ag^+ (aq) (insoluble in NH_3 (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
sulfate, SO_4^{2-} (aq)	gives white ppt. with Ba^{2+} (aq) (insoluble in excess dilute strong acids)
sulfite, SO_3^{2-} (aq)	gives white ppt. with Ba^{2+} (aq) (soluble in excess dilute strong acids)

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

The Periodic Table of Elements

1		2		Group																									
				1								13								14		15		16		17		18	
				Key																									
				atomic number				atomic symbol																					
				name				relative atomic mass																					
3	Li	4	Be	benzillium	9.0			1	H	hydrogen	1.0									2		He		helium					
11	Na	12	Mg	magnesium	24.3			2												4.0		He		neon					
19	K	20	Ca	Scandium	45.0			3												10.8		B		C					
37	Rb	38	Sr	Yttrium	88.9			4												10.8		Al		Aluminum					
55	Cs	56	Ba	Lanthanoids	137.3			5												27.0		Si		silicon					
87	Fr	88	Ra	actinoids	232.0			6												28.1		P		phosphorus					
								7												31.0		S		sulfur					
								8												32.1		Cl		chlorine					
								9												35.5		F		fluorine					
								10												16.0		O		oxygen					
								11												14.0		N		nitrogen					
								12												12.0		C		carbon					
																				10.8		B		boron					
																				10.8		As		arsenic					
																				72.6		Ge		germanium					
																				69.7		Ga		gallium					
																				65.4		Zn		zinc					
																				48		Cd		cadmium					
																				47.9		In		indium					
																				114.8		Ag		silver					
																				107.9		Pd		palladium					
																				106.4		Ru		rhodium					
																				102.9		Rh		rhodium					
																				101.1		Tc		technetium					
																				95.9		Mo		molybdenum					
																				92.9		Nb		niobium					
																				91.2		Zr		zirconium					
																				72		Tc		tantalum					
																				73		Re		rheneium					
																				74		W		tungsten					
																				183.8		Sg		seaborgium					
																				186.2		Db		dubnium					
																				180.9		Bh		bohrium					
																				178.5		Rf		rutherfordium					
																				104		Pu		plutonium					
																				92		U		uranium					
																				231.0		Pa		protactinium					
																				232.0		Th		thorium					
																				91		Ce		cerium					
																				140.1		Pr		praseodymium					
																				144.4		Nd		neodymium					
																				150.4		Sm		samarium					
																				152.0		Eu		europium					
																				157.3		Gd		gadolinium					
																				158.9		Tb		terbium					
																				162.5		Ho		holmium					