



# 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.

<b>Session</b>	
<b>Laboratory</b>	

**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.

<b>For Examiner's Use</b>	
<b>1</b>	
<b>2</b>	
<b>3</b>	
<b>Total</b>	

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

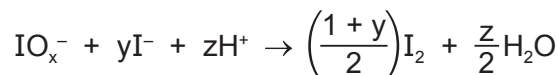
## Quantitative Analysis

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.

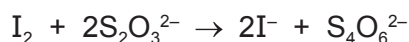
- 1 In this experiment you will determine the formula of the ion,  $\text{IO}_x^-$ . To do this you will first react  $\text{IO}_x^-$  ions with an excess of iodide ions,  $\text{I}^-$ , to form iodine,  $\text{I}_2$ .

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  $0.0150 \text{ mol dm}^{-3}$   $\text{IO}_x^-$  ions.

**FB 2** is dilute sulfuric acid,  $\text{H}_2\text{SO}_4$ .

**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  $25.0 \text{ cm}^3$  of **FB 1** into a conical flask.
- Use the measuring cylinder to add  $25 \text{ cm}^3$  of **FB 2** to the conical flask.
- Use the measuring cylinder to add  $10 \text{ cm}^3$  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 .....  $\text{cm}^3$ .

- 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 cm<sup>3</sup> of **FB 1** required ..... cm<sup>3</sup> 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 cm<sup>3</sup> of **FB 1** react with 10 cm<sup>3</sup> of **FB 3**.

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

- (iii) Calculate the number of moles of  $\text{IO}_x^-$  ions in  $25.0 \text{ cm}^3$  of **FB 1**.

moles of  $\text{IO}_x^-$  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  $\text{IO}_x^-$  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  $10 \text{ cm}^3$  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,  $\Delta H_{\text{sol}}$ , 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<sup>3</sup> beaker.
- Use the 25 cm<sup>3</sup> measuring cylinder to transfer 20.0 cm<sup>3</sup> 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**

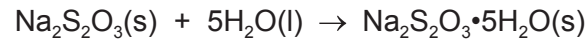
- (i) Calculate the energy change of the reaction.  
(Assume that 4.2 J of heat energy changes the temperature of 1.0 cm<sup>3</sup> of solution by 1.0 °C.)  
Show your working.

energy change = ..... J [1]

- (ii) Calculate the enthalpy change of solution,  $\Delta H_{\text{sol}}$ , for hydrated sodium thiosulfate.

$\Delta H_{\text{sol}}$  for  $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$  = ..... kJ mol<sup>-1</sup>  
sign value [2]

- (iii) Assume that under the same conditions, the enthalpy change of solution,  $\Delta H_{\text{sol}}$ , for anhydrous sodium thiosulfate,  $\text{Na}_2\text{S}_2\text{O}_3$ , is  $-7.7 \text{ kJ mol}^{-1}$ . 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>
<b>Test 1</b> To a 2 cm depth of <b>FB 6</b> 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.	
<b>Test 2</b> To one of the test-tubes add aqueous ammonia.	
<b>Test 3</b> To the other test-tube add <b>FB 4</b> , $\text{Na}_2\text{S}_2\text{O}_3(\text{aq})$ .	

[2]

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

..... [1]

(b) **FB 7** is acidified aqueous iron(III) chloride,  $\text{FeCl}_3$ .

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

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

[1]



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

<i>test</i>	<i>observations</i>
<b>Test 1</b> To a 1 cm depth of <b>FB 7</b> in a test-tube, add a 1 cm depth of <b>FB 4</b> , $\text{Na}_2\text{S}_2\text{O}_3(\text{aq})$ . 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,  $\text{FeSO}_4$ .

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

<i>test</i>	<i>observations</i>	<i>conclusions</i>
<b>Test 1</b> To a 1 cm depth of <b>FB 8</b> in a <b>boiling tube</b> , 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 <sub>3</sub> (aq)
aluminium, Al <sup>3+</sup> (aq)	white ppt. soluble in excess	white ppt. insoluble in excess
ammonium, NH <sub>4</sub> <sup>+</sup> (aq)	no ppt. ammonia produced on heating	–
barium, Ba <sup>2+</sup> (aq)	faint white ppt. is nearly always observed unless reagents are pure	no ppt.
calcium, Ca <sup>2+</sup> (aq)	white ppt. with high [Ca <sup>2+</sup> (aq)]	no ppt.
chromium(III), Cr <sup>3+</sup> (aq)	grey-green ppt. soluble in excess	grey-green ppt. insoluble in excess
copper(II), Cu <sup>2+</sup> (aq)	pale blue ppt. insoluble in excess	blue ppt. soluble in excess giving dark blue solution
iron(II), Fe <sup>2+</sup> (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 <sup>3+</sup> (aq)	red-brown ppt. insoluble in excess	red-brown ppt. insoluble in excess
magnesium, Mg <sup>2+</sup> (aq)	white ppt. insoluble in excess	white ppt. insoluble in excess
manganese(II), Mn <sup>2+</sup> (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 <sup>2+</sup> (aq)	white ppt. soluble in excess	white ppt. soluble in excess

## 2 Reactions of anions

<i>ion</i>	<i>reaction</i>
carbonate, $\text{CO}_3^{2-}$	$\text{CO}_2$ 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, $\text{NO}_3^-(\text{aq})$	$\text{NH}_3$ liberated on heating with $\text{OH}^-(\text{aq})$ and $\text{Al}$ foil
nitrite, $\text{NO}_2^-(\text{aq})$	$\text{NH}_3$ liberated on heating with $\text{OH}^-(\text{aq})$ and $\text{Al}$ 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, $\text{NH}_3$	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																				
1	2	<div style="text-align: center;"> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th colspan="2" style="text-align: left;">Key</th> </tr> <tr> <th style="width: 50%;">atomic number</th> <th style="width: 50%;">atomic symbol</th> </tr> <tr> <th>atomic name</th> <th>relative atomic mass</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">1</td> <td>H</td> </tr> <tr> <td>hydrogen</td> <td>1.0</td> </tr> </tbody> </table> </div>																Key		atomic number	atomic symbol	atomic name	relative atomic mass	1	H	hydrogen	1.0										
Key																																					
atomic number	atomic symbol																																				
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Li	Be	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe		
lithium	beryllium	scandium	titanium	vanadium	chromium	manganese	iron	cobalt	nickel	copper	zinc	gallium	germanium	arsenic	selenium	bromine	krypton	rubidium	strontium	yttrium	zirconium	niobium	molybdenum	technetium	ruthenium	rhodium	palladium	silver	cadmium	indium	tin	antimony	tellurium	iodine	xenon		
6.9	9.0	45.0	47.9	50.9	52.0	54.9	55.8	58.9	58.7	63.5	65.4	69.7	72.6	74.9	79.0	83.8	85.4	85.5	87.6	88.9	91.2	92.9	95.9	98.9	101.1	102.9	106.4	107.9	112.4	114.8	121.8	127.6	131.3	132.9			
11	12	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57–71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	
Na	Mg	lanthanoids	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn	Fr	Ra	actinoids	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Flerovium	Lv	livermorium	—	—			
23.0	24.3	lanthanoids	178.5	180.9	183.8	186.2	190.2	192.2	195.1	197.0	200.6	204.4	207.2	209.0	—	—	—	271	271	actinoids	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277

**lanthanoids**

57	La	lanthanum	138.9
58	Ce	cerium	140.1
59	Pr	praseodymium	140.9
60	Nd	neodymium	144.4
61	Pm	promethium	—
62	Sm	samarium	150.4
63	Eu	europlium	152.0
64	Gd	gadolinium	157.3
65	Tb	terbium	158.9
66	Dy	dysprosium	162.5
67	Ho	holmium	164.9
68	Er	erbium	167.3
69	Tm	thulium	168.9
70	Yb	ytterbium	173.1
71	Lu	lutetium	175.0

**actinoids**

89	Ac	actinium	—
90	Th	thorium	232.0
91	Pa	protactinium	231.0
92	U	uranium	238.0
93	Np	neptunium	—
94	Pu	plutonium	—
95	Am	americium	—
96	Cm	curium	—
97	Bk	berkelium	—
98	Cf	californium	—
99	Es	einsteinium	—
100	Fm	fermium	—
101	Md	mendeleevium	—
102	No	nobelium	—
103	Lr	lawrencium	—

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