



### Cambridge Assessment International Education

Cambridge International Advanced Subsidiary and Advanced Level

CENTRE	CANDIDATE	
NUMBER	NUMBER	0=01/01

CHEMISTRY

9701/31

Paper 3 Advanced Practical Skills 1

October/November 2019

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 14 and 15.

A copy of the Periodic Table is printed on page 16.

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.

	Session
La	boratory

For Examiner's Use	
1	
2	
3	
Total	

This document consists of 13 printed pages and 3 blank pages.



#### **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 concentration of a sample of hydrochloric acid. You will do this by measuring the volume of hydrogen produced when an excess of magnesium reacts with the acid.

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

**FA 1** is magnesium powder, Mg. **FA 2** is hydrochloric acid, HC *l*.

#### (a) Method

- Weigh the container with FA 1. Record the mass.
- Fill the tub with water to a depth of approximately 5 cm.
- Fill the 250 cm<sup>3</sup> measuring cylinder completely with water. Hold a piece of paper towel firmly over the top, invert the measuring cylinder and place it in the water in the tub.
- Remove the paper towel and clamp the inverted measuring cylinder so that the open end is just above the base of the tub.
- Use the 25 cm³ measuring cylinder to place 25.0 cm³ of **FA 2** into the reaction flask, labelled **X**.
- Check that the bung fits tightly in the neck of flask **X**, clamp flask **X**, and place the end of the delivery tube into the inverted 250 cm<sup>3</sup> measuring cylinder.
- Remove the bung from the neck of flask X. Tip all of FA 1 into flask X and replace the bung immediately. Remove the flask from the clamp and swirl to mix the contents.
- Swirl the flask occasionally until no more gas is evolved. Replace the flask in the clamp.
- Measure and record the final volume of gas in the measuring cylinder.
- Weigh and record the mass of the container with any residual solid.
- Calculate and record the mass of FA 1 used.

Keep FA 2 for use in Question 2.

	(i)	Calculate the number of moles of hydrogen gas produced. (Assume 1 mol of gas occupies 24.0 dm³ at this temperature.)
	an.	moles of $H_2(g) = \dots mol$ [1]
	(ii)	Calculate the concentration of hydrochloric acid in <b>FA 2</b> .
		concentration of HC $l$ in <b>FA 2</b> = mol dm <sup>-3</sup> [1]
(	(iii)	In this experiment the magnesium powder was in excess.
		Calculate the mass of magnesium powder needed for complete reaction with all the hydrochloric acid in $25.0\mathrm{cm^3}$ of <b>FA 2</b> .
		mass of Mg = g [1]
(c)		tudent suggested two modifications to the method in (a) to give a more accurate value for concentration.
	For	each suggestion, state whether you agree with the student and explain your answer.
	_	ggestion 1: Use magnesium ribbon rather than powdered magnesium; keep the rest of the periment the same.
	Sug	ggestion 2: Use twice the mass of magnesium powder; keep the rest of the experiment the ne.
		[2]

(d)	Another student carried out the experiment in <b>(a)</b> but used less magnesium than that calculate in <b>(b)(iii)</b> .			
	State and explain the effect this would have on the calculated concentration of hydrochloric acid in <b>FA 2</b> .			
	[Total: 8			

2 In this experiment you will determine the concentration of FA 2 by titration using aqueous sodium hydroxide.

$$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H2O(I)$$

**FA 2** is hydrochloric acid, HC*l.* **FA 3** is 0.100 mol dm<sup>-3</sup> sodium hydroxide, NaOH. methyl orange indicator

### (a) Method

#### Dilution of FA 2

- Fill the burette with **FA 2**.
- Run between 40.00 and 45.00 cm<sup>3</sup> from the burette into the 250 cm<sup>3</sup> volumetric flask.
- Record the volume used.
- Make the solution up to the 250 cm<sup>3</sup> mark by adding distilled water.
- Shake the flask thoroughly to ensure mixing.
- Label this solution of hydrochloric acid FA 4.

volume of **FA 2** used = ..... cm<sup>3</sup>

#### **Titration**

- Rinse the burette with distilled water and then with a little **FA 4**.
- Fill the burette with **FA 4**.
- Pipette 25.0 cm<sup>3</sup> of FA 3 into a conical flask.
- Add several drops of methyl orange indicator.
- Perform a rough titration and record your burette readings.

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

- Carry out as many accurate titrations as you think necessary to obtain consistent results.
- Make sure any recorded results show the precision of your practical work.
- Record in a suitable form all of your burette readings and the volume of **FA 4** added in each accurate titration.

I	
II	
III	
IV	
V	
VI	
VII	
VIII	

[8]

(b)		m your accurate titration results, obtain a value for the volume of <b>FA 4</b> to be used in your culations. Show clearly how you obtained this value.
		25.0 cm <sup>3</sup> of <b>FA 3</b> required cm <sup>3</sup> of <b>FA 4</b> .
		[1]
(c)	Cal	culations
	(i)	Give your answers to (ii), (iii) and (iv) to the appropriate number of significant figures. [1]
	(ii)	Calculate the number of moles of hydrochloric acid that reacted with 25.0 cm³ of <b>FA 3</b> .
		moles of $HCl = \dots mol$ [1]
	(iii)	Calculate the concentration of hydrochloric acid in <b>FA 4</b> .
		concentration of HC $l$ in <b>FA 4</b> = mol dm <sup>-3</sup>
	(iv)	[1] Calculate the concentration of hydrochloric acid in <b>FA 2</b> .
	(14)	Calculate the concentration of flydrochlone acid in TA 2.
		concentration of HC $l$ in <b>FA 2</b> = mol dm <sup>-3</sup>
		[1]
(d)		culate the maximum percentage error in the volume of FA 2 you added to the volumetric
	flas	k.
		maximum percentage error =%
		[1]

(e)	methods. Each method used has possible sources of error, for example in <b>Question 1</b> the largest source of error is escape of gas.
	Apart from this error, state and explain a source of error for each method.
	Question 1
	Question 2
	[2]
	[Total: 16]

### **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;

3

- 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.

<ul> <li>Place a small spatula measure of FA 5 in a</li> <li>Do not inhale the fumes.</li> <li>Record all your observations.</li> </ul>	hard-glass test-tube and heat <b>gently</b> .
Necold all your observations.	
carefully until the solid has dissolved. This s	solution is <b>FA</b> 6.
	solution is <b>FA</b> 6.
carefully until the solid has dissolved. This s Carry out the following tests on <b>FA 6</b> and re  test  To a 1 cm depth in a test-tube, add	solution is <b>FA 6</b> . cord your observations.
carefully until the solid has dissolved. This s Carry out the following tests on <b>FA 6</b> and re	solution is <b>FA 6</b> . cord your observations.

(a) FA 5 is a salt that contains two different cations and a single anion from those listed in the

test		observations
To a 1 cm depth in a test- aqueous barium nitrate o barium chloride, then		
add dilute hydrochloric ad nitric acid.	cid or dilute	
	l	[4]
(iii) Identify the three ions	in <b>FA 5</b> .	
, ,		
		and
		and[2]
FA 5 contains	itative Analysis tests on a h	
FA 5 contains	itative Analysis tests on a hyand $SO_4^{2-}$ . of <b>FA 7</b> is 499.3.	[2]
FA 5 contains	itative Analysis tests on a hyand $SO_4^{2-}$ . of <b>FA 7</b> is 499.3.	[2]
FA 5 contains	itative Analysis tests on a hyand $SO_4^{2-}$ . of <b>FA 7</b> is 499.3.	[2]
FA 5 contains	itative Analysis tests on a hyand $SO_4^{2-}$ . of <b>FA 7</b> is 499.3.	[2]
FA 5 contains  A student carried out Qual contained the ions K+, Cr³+ The relative formula mass  Determine the formula of I	itative Analysis tests on a hyand $SO_4^{2-}$ . of <b>FA 7</b> is 499.3.	[2] ydrated salt, <b>FA 7</b> , and concluded that it

(b)

Question 3 continues on page 10.

(c)	FA 8 is a solution containing a single cation and a single anion, both of which are listed in the
	Qualitative Analysis Notes.

/i	) Carr	v out the	following	tests and	record	vour	observations.
11	) Can	y Out tile	TOHOWING	เธอเอ สแน	1 <del>C</del> COIG	youi	uus <del>e</del> i valiulis.

test	observations
To a 1 cm depth in a test-tube, add a few drops of aqueous acidified potassium manganate(VII), then	
add starch indicator.	
To a 1 cm depth in a test-tube, add aqueous sodium hydroxide.	

<b>(ii)</b> Identify	the	two	ions	in	FA	8
----------------------	-----	-----	------	----	----	---

FA 8 contains	and
	[1]

(iii) Suggest an additional test you could carry out to confirm the presence of the anion in FA 8.

Carry out this test and record your result.

[2]

(iv) Give the ionic equation for the reaction you carried out using **FA 8** and sodium hydroxide. Include state symbols.

.....[1]

[Total: 16]

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# **Qualitative Analysis Notes**

## 1 Reactions of aqueous cations

ia la	react	ion with
ion	NaOH(aq)	NH <sub>3</sub> (aq)
aluminium, Al³+(aq)	white ppt. soluble in excess	white ppt. insoluble in excess
ammonium, NH₄⁺(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), Cr³+(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), Fe²+(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), Fe³+(aq)	red-brown ppt. insoluble in excess	red-brown ppt. insoluble in excess
magnesium, Mg²+(aq)	white ppt. insoluble in excess	white ppt. insoluble in excess
manganese(II), Mn²+(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

ion	reaction
carbonate, CO <sub>3</sub> <sup>2-</sup>	CO <sub>2</sub> liberated by dilute acids
chloride, C <i>l</i> <sup>-</sup> (aq)	gives white ppt. with Ag <sup>+</sup> (aq) (soluble in NH <sub>3</sub> (aq))
bromide, Br <sup>-</sup> (aq)	gives cream ppt. with Ag <sup>+</sup> (aq) (partially soluble in NH <sub>3</sub> (aq))
iodide, I <sup>-</sup> (aq)	gives yellow ppt. with Ag+(aq) (insoluble in NH <sub>3</sub> (aq))
nitrate, NO <sub>3</sub> -(aq)	NH <sub>3</sub> liberated on heating with OH <sup>-</sup> (aq) and A <i>l</i> foil
nitrite, NO <sub>2</sub> <sup>-</sup> (aq)	NH <sub>3</sub> liberated on heating with OH <sup>-</sup> (aq) and A <i>l</i> foil
sulfate, SO <sub>4</sub> <sup>2-</sup> (aq)	gives white ppt. with Ba <sup>2+</sup> (aq) (insoluble in excess dilute strong acids)
sulfite, SO <sub>3</sub> <sup>2-</sup> (aq)	gives white ppt. with Ba <sup>2+</sup> (aq) (soluble in excess dilute strong acids)

## 3 Tests for gases

gas	test and test result
ammonia, NH <sub>3</sub>	turns damp red litmus paper blue
carbon dioxide, CO <sub>2</sub>	gives a white ppt. with limewater (ppt. dissolves with excess CO <sub>2</sub> )
chlorine, Cl <sub>2</sub>	bleaches damp litmus paper
hydrogen, H <sub>2</sub>	'pops' with a lighted splint
oxygen, O <sub>2</sub>	relights a glowing splint

The Periodic Table of Elements

	18	2 He	nelium 4.0	10	Ne	neon 20.2	18	Ār	argon 39.9	36	궃	rrypton 83.8	54	Xe	xenon 131.3	86	Rn	radon -				
	17								chlorine 35.5													-
																					En.	-
	16			8	0	oxyge 16.0	16	ഗ	sulfur 32.1	34	Se	seleniu 79.0	52	Te	telluriu 127.(	84	Po	poloniu	116	_	livermori	
	15			7	z	nitrogen 14.0	15	۵	phosphorus 31.0	33	As	arsenic 74.9	51	Sp	antimony 121.8	83	Ξ	bismuth 209.0				
	14			9	ပ	carbon 12.0	14	S	silicon 28.1	32	Ge	germanium 72.6	20	Sn	tin 118.7	82	Pb	lead 207.2	114	Εl	flerovium	
	13			2	В	boron 10.8	13	Αl	aluminium 27.0	31	Ga	gallium 69.7	49	In	indium 114.8	81	11	thallium 204.4				
							_		12	30	Zu	zinc 65.4	48	g	cadmium 112.4	80	Нg	mercury 200.6	112	ပ်	copernicium	
									1	29	ŋ	copper 63.5	47	Ag	silver 107.9	62	Au	gold 197.0	111	Rg	roentgenium	
dn									10	28	z	nickel 58.7	46	Pd	palladium 106.4	78	₽	platinum 195.1	110	Ds	darmstadtium –	
Group									6	27	රි	cobalt 58.9	45	몬	rhodium 102.9	11	'n	iridium 192.2	109	¥	meitnerium	
		- I	hydrogen 1.0						80	26	Ь	iron 55.8	44	Ru	ruthenium 101.1	9/	SO	osmium 190.2	108	H	hassium	
				J					7	25	Mn	manganese 54.9	43	ပ	technetium -	75	Re	rhenium 186.2	107	B	bohrium	
					Ю	SS			9	24	ပ်	chromium 52.0	42	Mo	molybdenum 95.9	74	>	tungsten 183.8	106	Sg	seaborgium	
			Key	atomic number	atomic symbo	name relative atomic mass			2	23	>	vanadium 50.9	41	qN	niobium 92.9	73	д	tantalum 180.9	105	op O	dubnium	
				at	ator	relat			4	22	F	titanium 47.9	40	Zr	zirconium 91.2	72	Ξ	hafnium 178.5	104	쪼	rutherfordium -	
				<u> </u>			J		က	21	Sc	scandium 45.0	39	>	yttrium 88.9	57-71	lanthanoids		89-103	actinoids		
	2			4	Be	beryllium 9.0	12	Mg	magnesium 24.3	20	Ca	calcium 40.1	38	ഗ്	strontium 87.6	26	Ba	barium 137.3	88	Ra	radium	
	~			3	:=	lithium 6.9	1	Na	sodium 23.0	19	×	potassium 39.1	37	Rb	rubidium 85.5	55	Cs	caesium 132.9	87	ь́	francium	

71	3	lutetium 175.0	103	۲	lawrencium	1	
20	Υp	ytterbium 173.1	102	2	nobelium	_	
69	Tn	thulium 168.9	101	Md	mendelevium	1	
89	щ	erbium 167.3	100	Fm	fermium	I	
29	유	holmium 164.9	66	Es	einsteinium	_	
99	ò	dysprosium 162.5	86	₽	californium	1	
65	Ф	terbium 158.9	26	益	berkelium	ı	
64	В	gadolinium 157.3	96	Cm	curium	_	
63	En	europium 152.0	92	Am	americium	_	
62	Sm	samarium 150.4	94	Pu	plutonium	_	
61	Pm	promethium -	93	ď	neptunium	_	
09	PZ	neodymium 144.4	92	$\supset$	uranium	238.0	
59	Ą	praseodymium 140.9	91	Ра	protactinium	231.0	
58	Ce	cerium 140.1	06	٢	thorium	232.0	
22	Га	lanthanum 138.9	88	Ac	actinium	-	

lanthanoids actinoids

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