



#### **Cambridge International Examinations**

Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER			
CHEMISTRY								9701	/35
Paper 3 Advance	ced Prac	tical Skill	s 1				May/J	une 20	16
								2 hou	ırs
Candidates ans	wer on th	ne Quest	ion Pap	er.					
Additional Mater	rials:	As liste	d in the	Con	fidential 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
Laboratory

For Examiner's Use	
1	
2	
3	
Total	

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



1 In this experiment you will determine the concentration of a solution of sulfuric acid by titration.

**FA 1** is sulfuric acid, H<sub>2</sub>SO<sub>4</sub>.

**FA 2** is aqueous sodium hydroxide, containing 4.20 g NaOH dissolved in 1.00 dm³ of water. thymolphthalein indicator

### (a) Method

#### Dilution of FA 1

- Pipette **10.0 cm³** of **FA 1** into the 250 cm³ volumetric flask.
- Make the solution up to the mark using distilled water.
- Shake the flask thoroughly.
- This diluted solution of sulfuric acid is FA 3. Label the flask FA 3.

#### **Titration**

- Fill the burette with **FA 2**.
- Pipette **25.0 cm**<sup>3</sup> of **FA 3** into a conical flask.
- Add a few drops of thymolphthalein indicator.
- Perform a rough titration and record your burette readings in the space below. The end point is reached when the solution turns a permanent pale blue colour.

The rough titre	is		cm <sup>3</sup>
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- 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 below all of your burette readings and the volume of FA 2 added in each accurate titration.

Keep solution FA 1 for use in Questions 2 and 3.

I	
II	
III	
IV	
V	
VI	
VII	

[7]

(b)	From your accurate titration results, obtain a suitable value for the volume of FA 2 to be us in your calculations. 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 2</b> . [1]
(c)	Cal	culations
		ow your working and appropriate significant figures in the final answer to <b>each</b> step of your culations.
	(i)	Calculate the number of moles of sodium hydroxide present in the volume of <b>FA 2</b> calculated in <b>(b)</b> .
		Use the data in the Periodic Table on page 16.
		moles of NaOH = mol
	(ii)	Complete the equation for the reaction of sulfuric acid with sodium hydroxide. State symbols are required.
		+ $\rightarrow$ $Na_2SO_4(aq)$ +
(	(iii)	Use your answers to (i) and (ii) to calculate the number of moles of sulfuric acid used in each titration.
		moles of $H_2SO_4 = \dots mol$
(	(iv)	Calculate the concentration, in mol dm <sup>-3</sup> , of sulfuric acid in <b>FA 3</b> .
		concentration of H <sub>2</sub> SO <sub>4</sub> in <b>FA 3</b> = mol dm <sup>-3</sup>
	(v)	Calculate the concentration, in mol dm <sup>-3</sup> , of sulfuric acid in <b>FA 1</b> .
		concentration of U.S.O. in EA.4.—
		concentration of $H_2SO_4$ in <b>FA 1</b> = mol dm <sup>-3</sup> [5]
		[Total: 13]

2 In this experiment you will determine the enthalpy change,  $\Delta H$ , for the decomposition of magnesium carbonate to magnesium oxide.

$$MgCO_3(s) \rightarrow MgO(s) + CO_2(g)$$

In order to do this, you will determine the enthalpy changes for the reactions of magnesium carbonate and magnesium oxide with sulfuric acid. Excess of the two magnesium compounds will be used in each experiment.

Then you will use Hess' Law to calculate the enthalpy change for the reaction above.

**FA 1** is sulfuric acid, H<sub>2</sub>SO<sub>4</sub>.

FA 4 is magnesium carbonate, MgCO<sub>3</sub>.

**FA 5** is magnesium oxide, MgO.

(a) Determination of the enthalpy change for the reaction of magnesium carbonate, FA 4, with sulfuric acid, FA 1

### (i) Method

- Support the plastic cup inside the 250 cm<sup>3</sup> beaker.
- Use a measuring cylinder to transfer 25 cm<sup>3</sup> of **FA 1** into the plastic cup.
- Measure and record the initial temperature of the **FA 1** in the space below.
- Add all the **FA 4** from the container to the **FA 1** in the plastic cup.
- Stir constantly until the maximum temperature is reached.
- Measure and record the maximum temperature of the contents of the cup.
- Rinse out the plastic cup and shake to dry for use in (b).
- Calculate and record the temperature rise.

#### **Calculations**

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

(ii)	Calculate the energy produced during this reaction.
	[Assume that 4.2 J are needed to raise the temperature of 1.0 cm³ of solution by 1.0 °C.]

(iii) Use your answer to 1(c)(v) to calculate the number of moles of sulfuric acid in 25 cm³ of FA 1.

(If you were unable to calculate the concentration of sulfuric acid in **FA 1**, assume that it is  $1.27 \, \text{mol dm}^{-3}$ . This is not the true value.)

moles of 
$$H_2SO_4$$
 = ..... mol

(iv) Calculate the enthalpy change, in kJ mol<sup>-1</sup>, for the reaction below.

$$\label{eq:mgCO3} MgCO_3(s) \ + \ H_2SO_4(aq) \ \rightarrow \ MgSO_4(aq) \ + \ CO_2(g) \ + \ H_2O(l)$$

enthalpy change = ..... 
$$kJ \text{ mol}^{-1}$$
 (sign) (value) [6]

(b) Determination of the enthalpy change for the reaction of magnesium oxide, FA 5, with sulfuric acid, FA 1

#### (i) Method

- Use the measuring cylinder to transfer approximately 40 cm³ of **FA 1** into the **100 cm³** beaker.
- Place the beaker on a tripod and gauze.
- Heat FA 1 in the beaker until the temperature is between 40°C and 50°C.
- Support the plastic cup in the **250 cm**<sup>3</sup> beaker.
- Use the measuring cylinder to transfer 25 cm³ of hot **FA 1** into the plastic cup. **CARE.**
- Measure and record, in the space below, the initial temperature of FA 1 in the plastic cup.
- Immediately, add all the **FA 5** from the container to the **FA 1** in the plastic cup.
- Stir constantly until the maximum temperature is reached.
- Measure and record the maximum temperature.
- Calculate and record the temperature rise.

#### **Calculations**

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

(ii) Calculate the energy produced during this reaction.

[Assume that 4.2 J are needed to raise the temperature of 1.0 cm³ of solution by 1.0 °C.]

energy produced = ...... J

(iii) Use your answer to (a)(iii) to calculate the enthalpy change, in kJ mol<sup>-1</sup>, for the reaction below.

$$MgO(s) + H_2SO_4(aq) \rightarrow MgSO_4(aq) + H_2O(l)$$

enthalpy change = ..... kJ mol<sup>-1</sup> (sign) (value)

[4]

(c)		e your values for the enthalpy changes calculated in <b>(a)</b> halpy change for the reaction below.	)(iv) and (b	o)(iii) to cald	ulate the
	Sho	ow clearly how you obtained your answer by drawing a He	ess' Law en	ergy cycle.	
	cha	you were unable to calculate the enthalpy changes, assuringe in <b>(a)(iv)</b> is -58.7 kJ mol <sup>-1</sup> and the value in <b>(b)(iii)</b> is the correct values.)			
		$MgCO_3(s) \rightarrow MgO(s) + CO_2(g)$			
		enthalpy change =	: (sign)	(value)	kJ mol <sup>-1</sup> [2]
(d)	(i)	Calculate the maximum percentage error in the temperat	ture <b>rise</b> in	(b)(i).	
		noreo	ntaga arrar	=	0/
		·			
	(ii)	The magnesium oxide, <b>FA 5</b> , was weighed with a balance A student suggested that the accuracy of the experiment weighing <b>FA 5</b> using a balance measuring to two decima State and explain whether or not the student is correct.	nt in <b>(b)(i)</b> v		

[Total: 14]

[2]

#### 3 Qualitative Analysis

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

- colour changes seen
- the formation of any precipitate
- the solubility of such precipitates in an excess of the reagent added

Where gases are released they should be identified by a test, **described in the appropriate place in your observations**.

You should indicate clearly at what stage in a test a change occurs. **No additional tests for ions present should be attempted.** 

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

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

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

(a)	(i)	<b>FA 6</b> is a salt containing one cation and one anion from those listed on pages 14 and 15 Transfer a <b>small</b> spatula measure of <b>FA 6</b> into a hard-glass test-tube. Heat gently at first, then heat strongly until no further change occurs.
		Record <b>all</b> your observations below.

(ii) Dissolve the remainder of **FA 6** in an approximate depth of 5 cm of distilled water in a boiling tube for use in the following tests. Record your observations in the table below.

test	observations
To a 1 cm depth of the solution of <b>FA 6</b> in a test-tube, add an equal volume of <b>FA 1</b> , aqueous sulfuric acid.	
To a 1 cm depth of the solution of <b>FA 6</b> in a test-tube, add aqueous ammonia.	
To a 1 cm depth of the solution of <b>FA 6</b> in a boiling tube, add aqueous sodium hydroxide, then	
heat the mixture, gently and carefully, then	
place the boiling tube in a rack and add aluminium foil.	
ii) Give the chemical formula of FA 6.	
Give the ionic equation for the reaction include state symbols.	n of <b>FA 6</b> with cold sodium hydroxide.

[8]

(b) (i) FA 7 is a solution containing one cation and one anion from the list on pages 14 and 15.Carry out the following tests and record your observations in the table below.

	test	observations				
	To a 1 cm depth of <b>FA 7</b> in a test-tube, add aqueous sodium hydroxide.					
	To a 1 cm depth of <b>FA 7</b> in a test-tube, add aqueous ammonia.					
	To a 1 cm depth of <b>FA 7</b> in a test-tube, add a few drops of acidified potassium manganate(VII), followed by a few drops of aqueous starch.					
(	(ii) Identify <b>FA 7</b> .					
	<b>FA 7</b> is					
(i	iii) Carry out one further test of your ch	Carry out <b>one</b> further test of your choice to confirm the identity of the <b>anion</b> in <b>FA 7</b> .				
	reagent(s) used	reagent(s) used				
	observation(s)					

[Total: 13]

[5]

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# **Qualitative Analysis Notes**

Key: [ppt. = precipitate]

# 1 Reactions of aqueous cations

ion	reaction with				
ion	NaOH(aq)	NH <sub>3</sub> (aq)			
aluminium, A $l^{3+}$ (aq)	white ppt. soluble in excess	white ppt. insoluble in excess			
ammonium, NH <sub>4</sub> +(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 giving dark green solution	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), 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, Zn²+(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 <sup>+</sup> (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> -(aq)	$NH_3$ liberated on heating with $OH^-(aq)$ and $Al$ foil; NO liberated by dilute acids (colourless $NO \rightarrow$ (pale) brown $NO_2$ in air)
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	helium 4.0	10	Ne	neon 20.2	18	Ā	argon 39.9	36	궃	krypton 83.8	22	×e	xenon 131.3	98	R	radon			
	17				6	ш	fluorine 19.0	17	Cl	chlorine 35.5	35	Ŗ	bromine 79.9	53	П	iodine 126.9	85	Ą	astatine -			
	16				8	0	oxygen 16.0	16	S	sulfur 32.1	34	Se	selenium 79.0	52	<u>e</u>	tellurium 127.6	84	Ъо	polonium	116		vermorium -
	15									shosphorus 31.0												_
	14									silicon pl										114	Fl	erovium -
	13									aluminium 27.0												_
																cadmium 112.4				112	ن ت	ernicium -
																silver ca 107.9 1						_
																palladium s 106.4 10						Ε
Group																						_
					]					0	27	ပိ	cobal 58.9	45	듄	rhodium 102.9	77	ŗ	iridiur 192.	109	Ĭ	meitner
		1	I	hydrogen 1.0						80	26	Fe	iron 55.8	44	Ru	ruthenium 101.1	92	Os	osmium 190.2	108	H <sub>s</sub>	hassium
										7	25	Mn	manganese 54.9	43	ပ	technetium -	75	Re	rhenium 186.2	107	В	bohrium –
						loc	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	14	Q N	niobium 92.9	73	Щ	tantalum 180.9	105	o O	dubnium –
					ø	ator	relat			4	22	ı=	titanium 47.9	40	Zr	zirconium 91.2	72	Ξ	hafnium 178.5	104	꿒	rutherfordium -
								_		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	တ်	strontium 87.6	56	Ba	barium 137.3	88	Ra	radium
	1				3	:=	lithium 6.9	1	Na	sodium 23.0	19	¥	potassium 39.1	37	Rb	rubidium 85.5	55	S	caesium 132.9	87	ъ́	francium -

71 Lu	lutetium 175.0	103	ב	lawrencium	ı
oz Yb	ytterbium 173.1	102	Š	nobelium	ı
e9 Tm	thulium 168.9	101	Md	mendelevium	ı
<sub>88</sub> 正	erbium 167.3	100	Fm	fermium	ı
67 Ho	holmium 164.9	66	Es	einsteinium	1
ee Dy	dysprosium 162.5	86	ర్	californium	ı
e5 Tb	terbium 158.9	26	Ř	berkelium	ı
<sup>2</sup> Gd	gadolinium 157.3	96	Cm	curium	ı
63 Eu	europium 152.0	98	Am	americium	ı
ss Sm	samarium 150.4	94	Pn	plutonium	ı
Pm	promethium -	93	ď	neptunium	ı
 9 V	neodymium 144.4	92	$\supset$	uranium	738.0
88 <b>ન</b>	praseodymium 140.9	91	Ра	protactinium	231.0
Se Ce	cerium 140.1	06	T	thorium	73Z.U
57 <b>La</b>	lanthanum 138.9	89	Ac	actinium	ı

lanthanoids

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