

Cambridge	
International	
AS & A Level	

### Cambridge International Examinations

Cambridge International Advanced Subsidiary and Advanced Level

CHEMISTRY		9701/33
CENTRE NUMBER	CANDIDATE NUMBER	
CANDIDATE NAME		

Paper 3 Advanced Practical Skills 1

May/June 2017

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 10 and 11.

A copy of the Periodic Table is printed on page 12.

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 12 printed pages.



1 Sodium hydrogencarbonate, NaHCO<sub>3</sub>, is used as baking soda in cooking. Baking soda may also contain small amounts of other chemicals.

In this experiment, you will determine the percentage purity by mass of an impure sample of NaHCO<sub>3</sub> by titration with sulfuric acid.

**FA 1** is  $0.0500 \, \text{mol dm}^{-3}$  sulfuric acid,  $H_2SO_4$ . **FA 2** is impure NaHCO $_3$ . methyl orange

### (a) Method

### Preparing a solution of FA 2

- Weigh the stoppered container of FA 2. Record the mass in the space below.
- Tip all the FA 2 into the beaker.
- Reweigh the container with its stopper. Record the mass.
- Calculate and record the mass of FA 2 used.
- Add approximately 100 cm<sup>3</sup> of distilled water to the **FA 2** in the beaker.
- Stir the mixture with a glass rod until all the FA 2 has dissolved.
- Transfer this solution into the 250 cm<sup>3</sup> volumetric flask.
- Wash the beaker with distilled water and transfer the washings to the volumetric flask.
- Rinse the glass rod with distilled water and transfer the washings to the volumetric flask.
- Make up the solution in the volumetric flask to the mark using distilled water.
- Shake the flask thoroughly.
- This solution of impure NaHCO<sub>3</sub> is FA 3. Label the flask FA 3.

#### Results

#### **Titration**

- Fill the burette with **FA 1**.
- Pipette 25.0 cm³ of **FA3** into a conical flask.
- Add several drops of methyl orange.
- Perform a rough titration and record your burette readings in the space below.

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

	3	
•	Carry out as many accurate titrations as you think necessary to obtain consistent results which 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 <b>FA 1</b> actin each accurate titration.	
	Keep FA 1 for use in Question 2.	I
		II
		III
		IV
		V
		VI
		VII
		VIII
		[8]
in y	om your accurate titration results, obtain a suitable value for the volume of <b>FA 1</b> to be upour calculations.  ow clearly how you obtained this value.  25.0 cm <sup>3</sup> of <b>FA 3</b> required	
	20.0011 011710 10401100	. [.]
Cal	Iculations	
	ow your working and appropriate significant figures in the final answer to <b>each</b> step of culations.	your
(i)	Calculate the number of moles of sulfuric acid present in the volume of <b>FA1</b> calculate in <b>(b)</b> .	ated
	moles of H <sub>2</sub> SO <sub>4</sub> =	mol

(ii) Balance the equation for the reaction of sulfuric acid and sodium hydrogencarbonate.

 $......\mathsf{NaHCO}_3 \ + \ .......\mathsf{H}_2\mathsf{SO}_4 \ \to \ .......\mathsf{Na}_2\mathsf{SO}_4 \ + \ .......\mathsf{CO}_2 \ + \ .......\mathsf{H}_2\mathsf{O}$ 

State symbols are not required.

(iii) Using your answers to (i) and (ii), calculate the number of moles of sodium hydrogencarbonate used in each titration.

moles of NaHCO<sub>3</sub> = ..... mol

(b)

(c)

(iv)	Using your answer to (iii), calculate the mass of sodium hydrogencarbonate present in the mass of FA 2 used to prepare FA 3.
	mass of NaHCO <sub>3</sub> =g
(v)	Calculate the percentage purity by mass of the impure sodium hydrogencarbonate sample. FA 2.
	percentage purity by mass of impure NaHCO <sub>3</sub> , <b>FA 2</b> =%
(vi)	What did you assume about the impurities in <b>FA 2</b> when you calculated the percentage purity?
(vii)	A volumetric flask was labelled 250.0 ±0.10 cm <sup>3</sup> .
	Calculate the maximum percentage error when using this volumetric flask.
	maximum percentage error =%
	[Total: 16]

2 When baking soda is heated, carbon dioxide is produced. In this experiment you will investigate the reaction taking place when the sodium hydrogencarbonate in baking soda is thermally decomposed.

**FA 4** is baking soda (impure NaHCO<sub>3</sub>). Its composition is the same as that of **FA 2**.

#### (a) Method

Record all your readings in the space below.

- Weigh the crucible with its lid.
- Transfer all the **FA 4** from the container into the crucible.
- Weigh the crucible, lid and FA 4.
- Calculate and record the mass of FA 4 used.
- Place the crucible and contents on a pipe-clay triangle.
- Heat gently, with the lid on, for approximately one minute.
- Heat strongly, with the lid off, for a further three minutes.
- Replace the lid and leave the crucible to cool for at least five minutes.

## While the crucible is cooling you may wish to begin work on Question 3.

- When it is cool, weigh the crucible with its lid and contents.
- Heat strongly, with the lid off, for a further two minutes.
- Replace the lid and leave the crucible to cool for at least five minutes.
- When it is cool, weigh the crucible with its lid and contents.
- Calculate and record the mass of residue obtained.
- This residue is FA 5. Keep this for use in 2(d).

#### Results

I	
II	
III	
IV	

[4]

1	(h)	C	alc	ula	tic	ne
١	W.		aıc	uia	ILIU	כווי

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

(i) Use the percentage purity by mass of FA 2 you calculated in 1(c)(v), to calculate the mass of sodium hydrogencarbonate in the sample of FA 4 that you weighed out.

(If you were unable to carry out the calculation in **1(c)(v)**, assume that the percentage purity by mass of **FA 2** is 95.8%.)

mass of NaHCO<sub>3</sub> in **FA 4** weighed out = ...... g

(ii) Calculate the mass of impurity present in your sample of FA 4.

mass of impurity = ......g

(iii) The impurity in **FA 4** does not decompose when it is heated.

This means that the residue, **FA 5**, contains the mass of impurity calculated in (ii) together with the solid decomposition product of sodium hydrogencarbonate.

Calculate the mass of the solid decomposition product.

mass of solid decomposition product = ...... g

(iv) Use your answers to (i) and (iii) to calculate the mass of solid decomposition product that would be obtained if 84.0 g of **pure** sodium hydrogencarbonate were heated.

mass of solid decomposition product = ...... g

(v) A student carried out the experiment by heating to constant mass and calculated that heating  $84.0\,\mathrm{g}$  of pure  $\mathrm{NaHCO_3}$  would produce  $52.3\,\mathrm{g}$  of the solid decomposition product. The student then suggested the following equation for the thermal decomposition of sodium hydrogencarbonate.

$$NaHCO_3(s) \rightarrow NaOH(s) + CO_2(g)$$

Use data from the Periodic Table on page 12 to explain why the student's suggestion cannot be correct.

.....

[4]

(c) (i)	Why was the lid put on while the crucible and its contents cooled?
(ii)	The experiment could be made more accurate by heating to constant mass or using a more accurate balance. Suggest a further improvement to make the experiment more accurate.
	[2]
(d) (i)	Pour a 1 cm depth of sulfuric acid, <b>FA 1</b> , into a test-tube.  Add some <b>FA 5</b> from the crucible to the acid in the test-tube.  Record all your observations.
(ii)	Use your observation(s) in (i) to identify an anion present in <b>FA 5</b> . Explain your answer.
	identity
	explanation
(iii)	Steam is one of <b>three</b> products obtained when sodium hydrogencarbonate is thermally decomposed.
	Use your answer in (ii) to complete and balance the equation for the thermal decomposition of sodium hydrogencarbonate. Include state symbols.
	NaHCO $_3$ (s) $\rightarrow$ H $_2$ O(g) +CO $_2$ (g) +
(iv)	State whether the balanced equation in (iii) agrees with the student's results given in 2(b)(v).  Show working in order to explain your answer.
	[4]

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

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.

## (a) (i) FA 6 and FA 7 are aqueous solutions.

Each solution contains one cation and one anion from those listed in the Qualitative Analysis Notes.

Use 1 cm depths of **FA 6** or **FA 7** in test-tubes for the following tests. Complete the table by recording your observations.

40.04	observations		
test	FA 6	FA 7	
Add a few drops of aqueous barium chloride or aqueous barium nitrate, then			
add dilute nitric acid.			
Add a few drops of aqueous silver nitrate.			
Add a small spatula measure of sodium carbonate. Shake the mixture.			

	mixture.		
(ii)	From your observations, of Give your evidence.	educe which solution, FA 6 or F	FA 7, has the lower pH.
	solution with lower pH		
	evidence		
			[4

(b)	Choose <b>two</b> reagents that would allow you to identify the cations in <b>FA 6</b> and <b>FA 7</b> .		
	reagents ar	nd	
	Use these reagents to test solutions <b>FA 6</b> and <b>FA 7</b> Record all your observations in the space below.		
		[4]	
(c)	Deduce the chemical <b>formulae</b> of <b>FA 6</b> and <b>FA 7</b> .		
	FA 6		
	FA 7	[2]	
		[Total: 10]	
		· seem so	

# **Qualitative Analysis Notes**

# 1 Reactions of aqueous cations

ion	reaction with									
ion	NaOH(aq)	NH <sub>3</sub> (aq)								
aluminium, Al³+(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 [Ca²+(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, Mg <sup>2+</sup> (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-(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> <sup>-</sup> (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

				E			- <b>^</b>						5 ~		-	<u>-</u> ω		_					
	18	2	He	heliui 4.0	10	Ne	neor 20.2	18	Ā	argon 39.9	36	궃	kryptc 83.8	25	×e	xeno 131.	86	쪼	rado				
	17				6	ш	fluorine 19.0	17	Cl	chlorine 35.5	35	Ā	bromine 79.9	53	П	iodine 126.9	85	¥	astatine -				
	16				80	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	_	livermorium —	
	15				7	z	nitrogen 14.0	15	۵	phosphorus 31.0	33	As	arsenic 74.9	51	Sb	antimony 121.8	83	<u>B</u>	bismuth 209.0				
	4				9	ပ	carbon 12.0	41	S	silicon 28.1	32	Ge	germanium 72.6	50	Sn	tin 118.7	82	Pp	lead 207.2	114	Fl	flerovium	
	13				2	Ф	boron 10.8	13	Ρl	aluminium 27.0	31	Ga	gallium 69.7	49	In	indium 114.8	81	<i>1</i> L	thallium 204.4				
										12	30	Zu	zinc 65.4	48	ပ္ပ	cadmium 112.4	80	Нg	mercury 200.6	112	ပ်	copernicium	
dı										7	29	Cn	copper 63.5	47	Ag	silver 107.9	62	Αu	gold 197.0	111	Rg	roentgenium -	
	-								10	28	Ē	nickel 58.7	46	Pd	palladium 106.4	78	చ	platinum 195.1	110	Ds	darmstadtium -		
Group											6	27	ပိ	cobalt 58.9	45	돈	rhodium 102.9	77	'n	iridium 192.2	109	¥	meitnerium -
		-	I	hydrogen 1.0						œ	26	Ьe	iron 55.8	44	Ru	ruthenium 101.1	92	SO	osmium 190.2	108	H	hassium -	
				_					7	25	Mn	manganese 54.9	43	ည	technetium -	75	Re	rhenium 186.2	107	В	bohrium –		
					00	SS			9	24	ပ်	chromium 52.0	42	Mo	molybdenum 95.9	74	>	tungsten 183.8	106	Sg	seaborgium -		
				Key	Key	atomic number	atomic symbo	name relative atomic mass			2	23	>	vanadium 50.9	41	g	niobium 92.9	73	д	tantalum 180.9	105	9	dubnium -
							a	ator	relat			4	22	F	titanium 47.9	40	Zr	zirconium 91.2	72	Ξ	hafnium 178.5	104	꿆
								J		ဇ	21	Sc	scandium 45.0	39	>	yttrium 88.9	57-71	lanthanoids		89–103	actinoids		
	7				4	Be	beryllium 9.0	12	Mg	magnesium 24.3	20	Ca	calcium 40.1	38	Š	strontium 87.6	56	Ba	barium 137.3	88	Ra	radium	
	_				3	:-	lithium 6.9	#	Na	sodium 23.0	19	メ	potassium 39.1	37	Rb	rubidium 85.5	55	S	caesium 132.9	87	Ļ	francium -	

71	P	lutetium 175.0	103	۲	lawrencium	ı	
20	ХÞ	ytterbium 173.1	102	Š	nobelium	ı	
69	T	thulium 168.9	101	Md	mendelevium	ı	
89	щ	erbium 167.3	100	Fm	ferminm	I	
29	웃	holmium 164.9	66	Es	einsteinium	I	
99	Ο̈́	dysprosium 162.5	86	Ç	californium	ı	
65	Д	terbium 158.9	6	Ř	berkelium	ı	
49	9 G	gadolinium 157.3	96	Cm	curium	ı	
63	En	europium 152.0	92	Am	americium	ı	
62	Sm	samarium 150.4	94	Pu	plutonium	ı	
61	Pm	promethium —	93	ď	neptunium	ı	
09	PZ	neodymium 144.4	92	$\supset$	uranium	238.0	
69	Ą	praseodymium 140.9	91	Ра	protactinium	231.0	
58	O	cerium 140.1	06	T	thorium	232.0	
22	Га	lanthanum 138.9	89	Ac	actinium	ı	

lanthanoids

actinoids

To avoid the issue of disclosure of answer-related information to candidates, all copyright acknowledgements are reproduced online in the Cambridge International Examinations Copyright Acknowledgements Booklet. This is produced for each series of examinations and is freely available to download at www.cie.org.uk after the live examination series.