



Cambridge Assessment International Education

Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME								
CENTRE NUMBER						CANDIDATE NUMBER		
CHEMISTRY								9701/33
Paper 3 Advan	ced Pract	ical Skills	: 1			Oc	tober/Nove	ember 2019
								2 hours
Candidates ans	swer on the	e Questio	on Paper.					
Additional Mate	erials:	As listed	in the Co	onfidential Ins	structions			

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.



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 solution of hydrochloric acid by titration with an alkali.

FA 1 is a solution containing $6.00\,\mathrm{g\,dm^{-3}}$ of sodium hydroxide, NaOH. **FA 2** is hydrochloric acid, HCl. (This solution is also used in **Questions 2** and **3**.) methyl orange indicator

(a) Method

Dilution of FA 2

- Pipette **10.0 cm³** of **FA 2** into the 250 cm³ volumetric flask.
- Make the solution up to the mark using distilled water.
- Shake the solution in the volumetric flask thoroughly.
- This solution of hydrochloric acid is **FA 3**. Label the volumetric flask **FA 3**.

Titration

VI

- Fill the burette with **FA 1**.
- Pipette 25.0 cm³ of FA 3 into a conical flask.
- Add several drops of methyl orange indicator.
- Perform a rough titration and record your burette readings in the space below.

Ι	•	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.
II	•	Record in a suitable form below all of your burette readings and the volume of FA 1 added in each accurate titration.
III		in each accurate itration.
IV		

© UCLES 2019 9701/33/O/N/19

[7]

The rough titre is cm³.

· ·	From your accurate titration results, obtain a suitable value for the volume of FA 1 to be used in your calculations. Show clearly how you obtained this value.
	25.0 cm ³ of FA 3 required cm ³ of FA 1 . [1]
(c)	Calculations
((i) Give your answers to (ii), (iii) and (iv) to the appropriate number of significant figures. [1]
(Calculate the number of moles of sodium hydroxide, NaOH, in the volume of FA 1 calculated in (b).
	moles of NaOH = mol [1]
(i	ii) Write the equation for the neutralisation of hydrochloric acid with sodium hydroxide. Include state symbols.
	Deduce the number of moles of hydrochloric acid that reacted with the sodium hydroxide in (ii).
	moles of hydrochloric acid = mol [1]
(i	v) Calculate the concentration, in mol dm ⁻³ , of hydrochloric acid in FA 2 .
	concentration of HC l in FA 2 =

[Total: 13]

2 In this experiment you will determine the enthalpy change, ΔH , for the reaction shown.

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

To do this, you will determine the enthalpy changes for the reactions of magnesium oxide and magnesium carbonate with hydrochloric acid. Excess hydrochloric acid will be used in each reaction.

You will then use Hess' Law to calculate the enthalpy change for the reaction.

FA 2 is hydrochloric acid, HC*l*.

FA 4 is magnesium oxide, MgO.

FA 5 is magnesium carbonate, MgCO₃.

(a) Determination of the enthalpy change for the reaction of magnesium oxide, FA 4, with hydrochloric acid, FA 2

Method

- Support a plastic cup in the 250 cm³ beaker.
- Use the measuring cylinder to transfer 40 cm³ of **FA 2** into the plastic cup.
- Measure and record the initial temperature of the solution.
- Weigh the container with FA 4. Record the mass.
- Add all the FA 4 from the container to the FA 2 in the plastic cup.
- Stir constantly until the maximum temperature is reached.
- Measure and record the maximum temperature.
- Weigh the container with any FA 4 remaining. Record the mass.
- Calculate and record the mass of FA 4 used.
- Calculate and record the temperature rise.

I III IIV

[4]

((b)) C	alc	ula	atio	ns
٨		, ~	uic	uic	4610	,,,,,

(i)	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.)
(ii)	energy produced =
(iii)	$moles \ of \ MgO = \ mol \ [1]$ Calculate the enthalpy change, in kJ mol ⁻¹ , for the reaction below.
` ,	$MgO(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2O(l)$
	enthalpy change = kJ mol ⁻¹ [1] sign value
	means of a calculation, use your answer to 1(c)(iv) to show that the hydrochloric acid, FA 2,

(c) was in excess for the reaction in **2(a)**.

(If you were unable to carry out the calculation in 1(c)(iv), you should assume that the concentration of HCl in **FA 2** is $3.75\,\text{mol\,dm}^{-3}$. This may not be the correct value.)

[1]

(d)	Determination of	the	enthalpy	change	for the	reaction	of	magnesium	carbonate,	FA 5	, with
	hydrochloric acid,	FA	2					-			

(i) Method

- Support the second plastic cup in the 250 cm³ beaker.
- Use the measuring cylinder to transfer 40 cm³ of **FA 2** into the plastic cup.
- Measure and record the initial temperature of the solution.
- Weigh the container with **FA 5**. Record the mass.
- Add approximately half of the FA 5 from the container to the FA 2 in the plastic cup.
- Stir constantly for approximately 30 seconds.
- Then add the remainder of the **FA 5**.
- Stir constantly until the maximum temperature is reached.
- Measure and record the maximum temperature.
- Weigh the container with any **FA 5** remaining. Record the mass.
- Calculate and record the mass of **FA 5** used.
- Calculate and record the temperature rise.

Calculate the enthalpy change for this reaction.

	[1]
(ii) Apart from the change in temperature, what observations did you make d	luring the reaction?

 $MgCO_3(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + CO_2(g) + H_2O(l)$

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

[2]

(e)	Use your values for the enthalpy changes calculated in (b)(iii) and (d)(iii) to calculate the enthalpy change for the reaction below.
	(If you were unable to calculate the enthalpy changes, assume that the magnitude of the enthalpy change in (b)(iii) is 110.3 kJ mol ⁻¹ and the magnitude of the enthalpy change in (d)(iii) is 65.9 kJ mol ⁻¹ .
	Note: these may not be the correct magnitudes and the signs have been deliberately omitted.)
	$MgO(s) + CO_2(g) \rightarrow MgCO_3(s)$
	enthalpy change = kJ mol ⁻¹ [1] sign value
(f)	Outline one improvement to the method that would lead to more accurate values for the enthalpy changes. Do not include a change to the apparatus used, such as the use of a lid.
	[1]
/a:\	Cive the error in a single belones reading
(9)	Give the error in a single balance reading.
	error = ± g
	Which is greater, the percentage error in the mass of magnesium oxide used or the percentage error in the mass of magnesium carbonate used?
	Percentage error is greater in
	Calculate the greater percentage error.
	greater % error = %
	greater % errer

[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;
- 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)	You	will investigate FA 6 .
		Add	r a 1 cm depth of hydrochloric acid, FA 2 , into a test-tube. a small spatula measure of FA 6 to the acid. ord your observations.
		VVh	at can you deduce from your observations? Explain your answer.
			[3]
	(b)	(i)	FA 7 is a sodium compound containing an anion listed in the Qualitative Analysis Notes.
			Heat a small spatula measure of FA 7 in a hard-glass test-tube. Heat strongly until no further change occurs, then leave the test-tube and contents to cool.
			Record all your observations below.
			rol

(ii) Dissolve the remaining FA 7 in a 5 cm depth of distilled water in a boiling tube. Label this solution FA 8.

FA 9 is a solution of a different sodium compound. The anion is listed in the Qualitative Analysis Notes.

Carry out the following tests on **FA 8** and **FA 9** and record your observations in the table.

test	observations with FA 8	observations with FA 9
To a 1 cm depth in a test-tube, add a few drops of aqueous acidified potassium manganate(VII).		
To a 1 cm depth in a test-tube, add a few drops of aqueous barium chloride or aqueous barium nitrate.		
To a 1 cm depth in a boiling tube, add an equal volume of aqueous sodium hydroxide. Warm carefully, then		
add aluminium foil.		

		[4]
(iii)	From your observations, suggest the anions present in FA 8 and FA 9.	
	anion in FA 8	
	anion in FA 9	[1]
(iv)	Give the ionic equation for any reaction observed in (b)(ii) . Include state symbols.	
		[1]
	[Total	: 11]

Qualitative Analysis Notes

1 Reactions of aqueous cations

inn	reaction with								
ion	NaOH(aq)	NH ₃ (aq)							
aluminium, Al³+(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), Cr³+(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), 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, Zn²+(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 A <i>l</i> foil
nitrite, NO ₂ ⁻ (aq)	NH ₃ liberated on heating with OH ⁻ (aq) and A <i>l</i> 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

				_						_			_						_				
	18	2	He	helium	10	Se	neon 20.2	18	Ā	argon 39.9	36	조	kryptor 83.8	54	×e	xenor 131.3	86	R	radon				
	17				6	ш	fluorine 19.0	17	Cl	chlorine 35.5	35	Ā	bromine 79.9	53	Н	iodine 126.9	85	Αţ	astatine -				
	16				80	0	oxygen 16.0	16	S	sulfur 32.1	34	Se	selenium 79.0	52	Те	tellurium 127.6	84	Ро	molouium -	116	۲<	livermorium	ı
	15				7	z	nitrogen 14.0	15	۵	phosphorus 31.0	33	As	arsenic 74.9	51	Sb	antimony 121.8	83	:E	bismuth 209.0				
	41				9	O	carbon 12.0	41	S	silicon 28.1	32	Ge	germanium 72.6	20	Sn	tin 118.7	82	Ъ	lead 207.2	114	Ll	flerovium	1
	13				2	В	boron 10.8	13	Ρl	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	В	cadmium 112.4	80	Ę	mercury 200.6	112	ပ်	copernicium	-
										7	29	ŋ	copper 63.5	47	Ag	silver 107.9	62	Αn	gold 197.0	111	Rg	roentgenium	1
dn										10	28	Z	nickel 58.7	46	Pd	palladium 106.4	78	చ	platinum 195.1	110	Ds	darmstadtium	-
Group										6	27	රි	cobalt 58.9	45	돈	rhodium 102.9	11	'n	iridium 192.2	109	¥	meitnerium	1
		_	I	hydrogen	2					80	26	Ъе	iron 55.8	44	Ru	ruthenium 101.1	9/	SO	osmium 190.2	108	Hs	hassium	-
					_					7	25	M	manganese 54.9	43	ပ	technetium -	75	Re	rhenium 186.2	107	뮵	pohrium	-
						Ю	S			9	24	ပ်	chromium 52.0	42	Mo	molybdenum 95.9	74	≥	tungsten 183.8	106	Sg	seaborgium	-
				Kev	atomic number	atomic symbo	name relative atomic mass			2	23	>	vanadium 50.9	41	qN	niobium 92.9	73	д	tantalum 180.9	105	Ор	dubnium	-
					at	ator	relat			4	22	F	titanium 47.9	40	Zr	zirconium 91.2	72	Ξ	hafnium 178.5	104	꿒	rutherfordium	-
								_		င	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	Š	strontium 87.6	56	Ba	barium 137.3	88	Ra	radium	
	_				8	=	lithium 6.9	=	Na	sodium 23.0	19	×	potassium 39.1	37	&	rubidium 85.5	55	S	caesium 132.9	87	ъ́	francium	-

Lu Lu	175.0	103	۲	lawrencium	ı
70 Yb	173.1	102	8	nobelium	ı
m Tm	168.9	101	Md	mendelevium	ı
88 正	167.3	100	Fm	ferminm	ı
67 Ho	164.9	66	Es	einsteinium	ı
Dy	162.5	86	Ç	californium	ı
65 Tb	158.9	26	Ř	perkelium	ı
Gd Gd	157.3	96	Cm	curium	ı
En Eu	152.0	92	Am	americium	ı
Sm	150.4	94	Pn	plutonium	ı
Pm		93	Νp	neptunium	ı
pN 09	144.4	95	⊃	uranium	238.0
Pr	140.9	91	Ра	protactinium	231.0
Ce Ce	140.1	06	Т	thorium	232.0
57 La	138.9	88	Ac	actinium	

lanthanoids

actinoids

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