



Cambridge International Examinations

Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER			
CHEMISTRY								97	01/34
Paper 3 Advan	ced Pra	ctical Skill	s 2				Ma	ay/June	2017
								2	hours
Candidates ans	swer on	the Quest	ion Pape	r.					
Additional Mate	erials:	As liste	d in the C	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	
Laboratory	

For Examiner's Use						
1						
2						
Total						

This document consists of 14 printed pages and 2 blank pages.



1 Strong acids, such as hydrochloric acid, HCl, are completely ionised in aqueous solution. Weak acids, such as ethanoic acid, CH₃COOH, are partially ionised in aqueous solution.

You will investigate the enthalpy change for the reaction of an excess of each of these acids with magnesium and hence determine the energy needed to cause the weak acid to ionise completely.

(a) Reaction 1 Enthalpy change of a weak acid

FB 1 is ethanoic acid, CH₃COOH.

FB 2 is magnesium, Mg.

Method 1

- Weigh the strip of magnesium and record the balance reading in the space below.
- Support the plastic cup in the 250 cm³ beaker.
- Coil the magnesium ribbon loosely so that it fits into the bottom of the plastic cup and then remove the ribbon.
- Use the measuring cylinder to transfer 25 cm³ of the acid, **FB 1**, into the plastic cup.
- Place the thermometer in the acid and read the initial temperature. This is the temperature at time zero (t = 0).
- Start timing and do not stop the clock until the whole experiment has been completed.
- Read the temperature of the acid every half minute for two minutes.
- At time $t = 2\frac{1}{2}$ minutes drop the magnesium, **FB 2**, into the acid and stir the mixture.
- Measure and record, in the table below, the temperature of the mixture at t = 3 minutes and then every half minute until t = 10 minutes. Stir the mixture continuously between thermometer readings.
- Rinse the plastic cup for use in **Method 2**. Shake to remove excess water.

Results

Mass of magnesium

Temperature

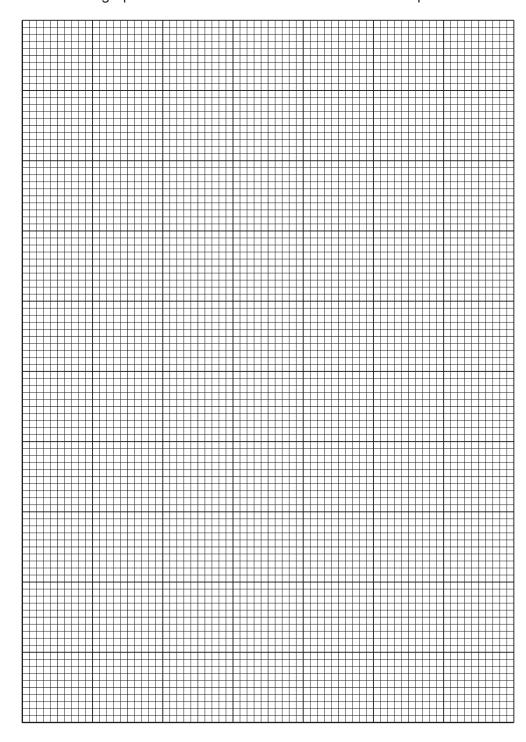
time/minutes	0	1/2	1	1 1 2	2	2 1 /2	3	3 1/2	4	4 1/2	5
temperature/°C											
				1				1			ı
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time/minutes	5 ¹ / ₂	6	6 1 / ₂	7	$7\frac{1}{2}$	8	8 1/2	9	91/2	10
temperature/°C										

[4]

I	
II	
III	
IV	

(b) Plot a graph of temperature on the *y*-axis against time on the *x*-axis on the grid below. The scale for temperature should extend 10° C above your highest recorded temperature. You will use this graph to determine the theoretical maximum temperature rise at $2\frac{1}{2}$ minutes.





Draw two lines of best fit through the points on your graph. The first line should be for the temperature before adding **FB 2** and the second for the cooling of the mixture once the reaction is complete.

Extrapolate the two lines to $2\frac{1}{2}$ minutes, draw a vertical line between the two and determine the theoretical rise in temperature at this time.

theoretical rise in temperature at $2\frac{1}{2}$ minutes =°C [5]

1	(C)	Cal	lcu	lati	ons
l	C) Cai	ıcu	ıau	OHS

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

Magnesium reacts with ethanoic acid according to the equation shown.

$$Mg(s) + 2CH_3COOH(aq) \rightarrow Mg(CH_3COO)_2(aq) + H_2(g)$$

(i) Use your answer to (b) to calculate the heat energy, in joules, given out when **FB 2** is added to the acid.

[Assume 4.2J of heat energy raises the temperature of 1.0 cm³ of the mixture by 1.0 °C.]

heat energy evolved = J

(ii) Use the Periodic Table on page 16 and your answer to (i) to calculate the enthalpy change, in kJ mol⁻¹, when 1 mole of **FB 2**, Mg, reacts with ethanoic acid.

enthalpy change, $\Delta H = \dots kJ \text{ mol}^{-1}$ (sign) (value)

[3]

(d) Reaction 2 Enthalpy change of a strong acid.

FB 3 is hydrochloric acid, HC*l*.

The tube labelled **FB 4** contains two strips of magnesium, Mg. One strip is longer than the other strip.

Method 2

Read the whole method before starting any practical work and prepare a table for your results in the space below.

- Weigh the longer strip of magnesium and record the balance reading.
- Support the plastic cup in the 250 cm³ beaker.
- Coil the magnesium ribbon loosely so that it fits into the bottom of the plastic cup and then remove the ribbon.
- Use the measuring cylinder to transfer 25 cm³ of the acid, **FB 3**, into the plastic cup.
- Place the thermometer in the acid and measure and record the initial temperature of the acid.
- Add the piece of magnesium into the acid in the cup.
- Stir constantly until the maximum temperature is reached.
- Measure and record the maximum temperature.
- Rinse the plastic cup for use in the next experiment.
- Calculate and record the temperature rise.
- Repeat this experiment using the shorter strip of magnesium and record all results.

[3]

(e)) (Ca	lc	ul	aí	ic	on	ıs
•	•	,	vч	-	~ :	u			•

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

Use your results from **(d)** for the **longer strip** of magnesium and the Periodic Table on page 16 to calculate the enthalpy change, in kJ mol⁻¹, when 1 mole of **FB 4**, Mg, reacts with hydrochloric acid.

[Assume 4.2 J of heat energy changes the temperature of 1.0 cm³ of the mixture by 1.0 °C.]

		enthalpy change, $\Delta H = \dots \dots \dots kJ \text{ mol}^{-1}$
		(sign) (value) [2]
(f)	(i)	A student suggested that the experiment carried out in (d) could be improved by using a catalyst.
		Would the use of a catalyst improve the accuracy of the results in this experiment? Give a reason for your answer.
	(ii)	Another student could not find the hydrochloric acid, FB 3 , so used sulfuric acid, H_2SO_4 , instead. He used the same volume and the same concentration as the hydrochloric acid in FB 3 .
		What effect would this change have on the temperature rise in the experiment? Give a reason for your answer.

[2]

(g) Ethanoic acid is a weak acid. It is partially ionised in aqueous solution.

$$CH_3COOH(aq) \rightleftharpoons CH_3COO^-(aq) + H^+(aq)$$

You are to determine the energy needed to cause the molecules of ethanoic acid to ionise completely.

$$CH_3COOH(aq) \rightarrow CH_3COO^-(aq) + H^+(aq)$$

Hydrochloric acid is a strong acid; it is fully ionised in aqueous solution.

The values for the enthalpy changes you obtained in (c)(ii) and (e) could be used to calculate the energy change for the ionisation **but** more accurate experiments give the results in Table 1.

Table 1

reaction	equation	$\Delta H/\text{kJ}\text{mol}^{-1}$
1	$Mg(s) + 2CH_3COOH(aq) \rightarrow Mg(CH_3COO)_2(aq) + H_2(g)$	-460.3
2	$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$	-464.1

(i)	Write the ionic equa	ation, ir	ncluding	state	symbols,	for	the	reaction	of	magnesium	with
	aqueous hydrochloric	c acid.									

(ii) Use the data in **Table 1** to calculate the enthalpy change for the ionisation of ethanoic acid.

$$CH_3COOH(aq) \rightarrow CH_3COO^-(aq) + H^+(aq)$$

Show clearly how you obtained your answer.

$$\Delta H =$$
 kJ mol⁻¹ (sign) (value) [4]

(h) The experiment in (a) was repeated using trichloroethanoic acid instead of ethanoic acid.

$$Mg(s) + 2CCl_3COOH(aq) \rightarrow Mg(CCl_3COO)_2(aq) + H_2(g)$$
 reaction 3

Trichloroethanoic acid, CCl_3COOH , is a weak acid that is however stronger than ethanoic acid.

The enthalpy change for reaction 3 is between the two values given in Table 1.

Table 1

reaction	equation	$\Delta H/\text{kJ}\text{mol}^{-1}$
1	$Mg(s) + 2CH3COOH(aq) \rightarrow Mg(CH3COO)2(aq) + H2(g)$	-460.3
2	$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$	-464.1

(i)	Explain why the enthalpy change for reaction 3 is more exothermic than the enthal change for reaction 1.	.py
(ii)	Explain why the enthalpy change for reaction 3 is less exothermic than the enthal change for reaction 2.	py

[Total: 25]

2 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) FB 5, FB 6 and FB 7 each contain one anion and one cation.

Carry out the following tests and record your observations.

test		observations	
lest	FB 5	FB 6	FB 7
To a 1 cm depth of solution in a test-tube, add a few drops of aqueous silver nitrate, then			
add aqueous ammonia.			
To a 1 cm depth of solution in a test-tube, add a few drops of aqueous barium nitrate, or barium chloride, then			
add dilute nitric acid.			
To a 1 cm depth of solution in a test-tube, add a spatula measure of solid sodium carbonate.			

Suggest another test that you could carry out to confirm the presence of the cation yieldentified in (ii).								
	Carry out this tes	st on one of FB 5 , FI	B 6 or FB 7 and red	ord your observatio	n.			
	test							
	observation							
		ble to identify, as fa not able to identify						
			ED 0	ED 7				
		FB 5	FB 6	FB 7				
	ion present	FB 5	FB 6	FB /				
	For any one anion that will enable you Qualitative Analy	on that you were una	able to identify in (iv u can assume that i	') you are to devise t is one of the anior	ıs liste			
	For any one anion that will enable y Qualitative Analy Carry out the teanion.	on that you were una you to identify it. You ysis Notes.	able to identify in (iv u can assume that in servation(s) you ob	y) you are to devise t is one of the anior otained and identify	the u			
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(b) FB 8 is an aqueous solution of a mixture containing two anions and two cations.

Carry out the following tests and record your observations.

test	observations
To a 1 cm depth of FB 8 in a test-tube, add a 1 cm depth of dilute hydrochloric acid, then	
add a few drops of hydrogen peroxide, then	
add a few drops of starch.	
To a 1 cm depth of FB 8 in a test-tube, add aqueous sodium hydroxide.	
To a 1 cm depth of FB 8 in a test-tube, add a 3 cm depth of aqueous copper(II) sulfate, then	
add a 1 cm depth of dilute hydrochloric acid, then	
add aqueous sodium thiosulfate.	

From these observations, identify two ions present in FB 8 .	
ions present in FB 8 and	
•	[5]

[Total: 15]

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Qualitative Analysis Notes

1 Reactions of aqueous cations

ion	reaction with								
ion	NaOH(aq)	NH ₃ (aq)							
aluminium, Al³+(aq)	white ppt. soluble in excess	white ppt. insoluble in excess							
ammonium, NH₄⁺(aq)	no ppt. ammonia produced on heating	_							
barium, Ba²+(aq)	faint white ppt. is nearly always observed unless reagents are pure	no ppt.							
calcium, Ca²+(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 ²⁺ (aq)	pale blue ppt. insoluble in excess	blue ppt. soluble in excess giving dark blue solution							
iron(II), Fe ²⁺ (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, C <i>l</i> ⁻ (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)	$\mathrm{NH_3}$ liberated on heating with $\mathrm{OH^-}(\mathrm{aq})$ and $\mathrm{A}\mathit{l}$ foil; NO liberated by dilute acids (colourless $\mathrm{NO} \to (\mathrm{pale})$ brown $\mathrm{NO_2}$ in air)
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

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18	2	He	heliun 4.0	10	Ne	neon 20.2	18	Ā	argor 39.9	36	궃	krypto. 83.8	72	×e	xenor 131.3	86	R	rador			
17				6	Щ	fluorine 19.0	17	Cl	chlorine 35.5	35	Ā	bromine 79.9	53	П	iodine 126.9	82	¥	astatine -			
16				00	0	oxygen 16.0	16	ഗ	sulfur 32.1	34	Se	selenium 79.0	52	<u>e</u>	tellurium 127.6	84	Ъ	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	Ξ	bismuth 209.0			
14				9	ပ	carbon 12.0	14	S	silicon 28.1	32	Ge	germanium 72.6	90	Sn	tin 118.7	82	Pb	lead 207.2	114	Εl	flerovium
13				5	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	පි	cadmium 112.4	80	å	mercury 200.6	112	ပ်	copernicium
									7	29	D O	copper 63.5	47	Ag	silver 107.9	62	Αu	gold 197.0	111	Rg	roentgenium -
									10	28	z	nickel 58.7	46	Pd	palladium 106.4	78	చ	platinum 195.1	110	Ds	darmstadtium -
									6	27	රි	cobalt 58.9	45	뫈	rhodium 102.9	77	٦	iridium 192.2	109	¥	meitnerium -
	1	I	hydrogen 1.0						80	26	Ъе	iron 55.8	44	Ru	ruthenium 101.1	9/	SO	osmium 190.2	108	£	hassium
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				to	ato	rela			4	22	F	titanium 47.9	40	Zr	zirconium 91.2	72	Ξ	hafnium 178.5	104	짪	rutherfordium -
							_		ဇ	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
_				က	:=	lithium 6.9	=	Na	sodium 23.0	19	¥	potassium 39.1	37	Rb	rubidium 85.5	55	S	caesium 132.9	87	ъ.	francium
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Lu Lu	lutetium 175.0	103	۲	lawrencium -	
o ² AY	ytterbium 173.1	102	Š	nobelium	
e9 Tm	thulium 168.9	101	Md	mendelevium -	
₈₈ 正	erbium 167.3	100	Fm	fermium -	
67 Ho	holmium 164.9	66	Es	einsteinium -	
ee Dy	dysprosium 162.5	86	ర్	californium -	
e5 Tb	terbium 158.9	26	Ř	berkelium	
² Gd	gadolinium 157.3	96	CH	curium	
63 Eu	europium 152.0	98	Am	americium	
ss Sm	samarium 150.4	94	Pn	plutonium	
Pm	promethium -	93	ď	neptunium	
 9 V	neodymium 144.4	92	\supset	uranium 238.0	
.g	praseodymium 140.9	91	Ра	protactinium 231.0	
58 Ce	cerium 140.1	06	H	thorium 232.0	
57 La	lanthanum 138.9	89	Ac	actinium -	

lanthanoids

actinoids

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