Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME	

CENTRE NUMBER		CANDIDATE NUMBER	

* 7 1 2 7 8 9 3 7 0 9 *

CHEMISTRY **9701/34**

Paper 3 Advanced Practical Skills 2 **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 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.

CAMBRIDGE International Examinations

1 Strong acids, such as hydrochloric acid, HC*l*, are completely ionised in aqueous solution. Weak acids, such as ethanoic acid, CH_3COOH, 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, CH_3COOH.
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 cm^3 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 cm^3 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	$\frac{1}{2}$	1	$1\frac{1}{2}$	2	$2\frac{1}{2}$	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$	5
temperature / °C											

time / minutes	$5\frac{1}{2}$	6	$6\frac{1}{2}$	7	$7\frac{1}{2}$	8	$8\frac{1}{2}$	9	$9\frac{1}{2}$	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.

I	
II	
III	
IV	
V	

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]

(c) Calculations

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 4.2 J of heat energy raises the temperature of 1.0 cm^3 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, ΔH = ... kJ mol^{-1}
(sign) (value)

[3]

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

FB 3 is hydrochloric acid, HCl.
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 cm^3 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 cm^3 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) Calculations

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 $1.0\,cm^3$ of the mixture by 1.0 °C.]

enthalpy change, ΔH = ... $kJ\,mol^{-1}$
(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	ΔH / kJ 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** equation, including state symbols, for the reaction of magnesium with aqueous hydrochloric 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.

ΔH = ... 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	ΔH / kJ 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) Explain why the enthalpy change for reaction 3 is more exothermic than the enthalpy change for reaction 1.

....

....

(ii) Explain why the enthalpy change for reaction 3 is less exothermic than the enthalpy change for reaction 2.

....

....

[2]

[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*		
	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.			

(ii) What cation is present in **FB 5**, **FB 6** and **FB 7**?

....

(iii) Suggest another test that you could carry out to confirm the presence of the cation you identified in **(ii)**.

Carry out this test on one of **FB 5**, **FB 6** or **FB 7** and record your observation.

test ....

observation ....

(iv) Complete the table to identify, as far as possible, the anions present in **FB 5**, **FB 6** and **FB 7**. If you are not able to identify the anion from the tests you carried out in **(i)**, write 'unknown'.

	FB 5	**FB 6**	**FB 7**
ion present			

(v) For any **one** anion that you were unable to identify in **(iv)** you are to devise a test or tests that will enable you to identify it. You can assume that it is one of the anions listed in the Qualitative Analysis Notes.

Carry out the test(s), record the observation(s) you obtained and identify the unknown anion.

test(s) ....

....

....

observation(s) ....

....

....

Anion present in .... is ....

[10]

(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*	
	NaOH(aq)	NH_3(aq)
aluminium, Al^{3+}(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), Cr^{3+}(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), Fe^{3+}(aq)	red-brown ppt. insoluble in excess	red-brown ppt. insoluble in excess
magnesium, Mg^{2+}(aq)	white ppt. insoluble in excess	white ppt. insoluble in excess
manganese(II), Mn^{2+}(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^{2+}(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 Al foil
nitrite, NO_2^-(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_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

Group																	
1	2											13	14	15	16	17	18
							1 H hydrogen 1.0										2 He helium 4.0
3 Li lithium 6.9	4 Be beryllium 9.0			**Key** atomic number atomic symbol name relative atomic mass								5 B boron 10.8	6 C carbon 12.0	7 N nitrogen 14.0	8 O oxygen 16.0	9 F fluorine 19.0	10 Ne neon 20.2
11 Na sodium 23.0	12 Mg magnesium 24.3	3	4	5	6	7	8	9	10	11	12	13 Al aluminium 27.0	14 Si silicon 28.1	15 P phosphorus 31.0	16 S sulfur 32.1	17 Cl chlorine 35.5	18 Ar argon 39.9
19 K potassium 39.1	20 Ca calcium 40.1	21 Sc scandium 45.0	22 Ti titanium 47.9	23 V vanadium 50.9	24 Cr chromium 52.0	25 Mn manganese 54.9	26 Fe iron 55.8	27 Co cobalt 58.9	28 Ni nickel 58.7	29 Cu copper 63.5	30 Zn zinc 65.4	31 Ga gallium 69.7	32 Ge germanium 72.6	33 As arsenic 74.9	34 Se selenium 79.0	35 Br bromine 79.9	36 Kr krypton 83.8
37 Rb rubidium 85.5	38 Sr strontium 87.6	39 Y yttrium 88.9	40 Zr zirconium 91.2	41 Nb niobium 92.9	42 Mo molybdenum 95.9	43 Tc technetium –	44 Ru ruthenium 101.1	45 Rh rhodium 102.9	46 Pd palladium 106.4	47 Ag silver 107.9	48 Cd cadmium 112.4	49 In indium 114.8	50 Sn tin 118.7	51 Sb antimony 121.8	52 Te tellurium 127.6	53 I iodine 126.9	54 Xe xenon 131.3
55 Cs caesium 132.9	56 Ba barium 137.3	57–71 lanthanoids	72 Hf hafnium 178.5	73 Ta tantalum 180.9	74 W tungsten 183.8	75 Re rhenium 186.2	76 Os osmium 190.2	77 Ir iridium 192.2	78 Pt platinum 195.1	79 Au gold 197.0	80 Hg mercury 200.6	81 Tl thallium 204.4	82 Pb lead 207.2	83 Bi bismuth 209.0	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

lanthanoids	57 La lanthanum 138.9	58 Ce cerium 140.1	59 Pr praseodymium 140.9	60 Nd neodymium 144.4	61 Pm promethium –	62 Sm samarium 150.4	63 Eu europium 152.0	64 Gd gadolinium 157.3	65 Tb terbium 158.9	66 Dy dysprosium 162.5	67 Ho holmium 164.9	68 Er erbium 167.3	69 Tm thulium 168.9	70 Yb ytterbium 173.1	71 Lu lutetium 175.0
actinoids	89 Ac actinium –	90 Th thorium 232.0	91 Pa protactinium 231.0	92 U uranium 238.0	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –