Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME	

CENTRE NUMBER		CANDIDATE NUMBER	

* 8 7 2 2 3 8 9 7 8 9 *

CHEMISTRY **9701/35**

Paper 3 Advanced Practical Skills 1 **May/June 2016**

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	
3	
Total	

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

IB16 06_9701_35/4RP

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

FA 1 is sulfuric acid, H_2SO_4.
FA 2 is aqueous sodium hydroxide, containing 4.20 g NaOH dissolved in 1.00 dm^3 of water.
thymolphthalein indicator

(a) Method

Dilution of FA 1

- Pipette **10.0 cm^3** of **FA 1** into the 250 cm^3 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^3** 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^3.

- 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 used in your calculations.
Show clearly how you obtained this value.

25.0 cm^3 of **FA 3** required .... cm^3 of **FA 2**. [1]

(c) Calculations

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

(i) Calculate the number of moles of sodium hydroxide present in the volume of **FA 2** calculated in **(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 = ... mol

(iv) Calculate the concentration, in mol dm^{-3}, of sulfuric acid in **FA 3**.

concentration of H_2SO_4 in **FA 3** = ... mol dm^{-3}

(v) Calculate the concentration, in mol dm^{-3}, of sulfuric acid in **FA 1**.

concentration of H_2SO_4 in **FA 1** = ... mol dm^{-3}
[5]

[Total: 13]

2 In this experiment you will determine the enthalpy change, ΔH, 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_2SO_4.
FA 4 is magnesium carbonate, $MgCO_3$.
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^3 beaker.
- Use a measuring cylinder to transfer 25 cm^3 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 cm^3 of solution by 1.0 °C.]

energy produced = ... J

(iii) Use your answer to **1(c)(v)** to calculate the number of moles of sulfuric acid in 25 cm^3 of **FA 1**.
(If you were unable to calculate the concentration of sulfuric acid in **FA 1**, assume that it is 1.27 mol dm^{-3}. This is not the true value.)

moles of H_2SO_4 = ... mol

(iv) Calculate the enthalpy change, in kJ mol^{-1}, for the reaction below.

$$MgCO_3(s) + H_2SO_4(aq) \rightarrow MgSO_4(aq) + CO_2(g) + H_2O(l)$$

enthalpy change = ... kJ 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 cm^3 of **FA 1** into the **100 cm^3** 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^3** beaker.
- Use the measuring cylinder to transfer 25 cm^3 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 cm^3 of solution by 1.0 °C.]

energy produced = ... J

(iii) Use your answer to **(a)(iii)** to calculate the enthalpy change, in kJ mol^{-1}, for the reaction below.

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

enthalpy change = ... kJ mol^{-1}
(sign) (value)

[4]

(c) Use your values for the enthalpy changes calculated in **(a)(iv)** and **(b)(iii)** to calculate the enthalpy change for the reaction below.

Show clearly how you obtained your answer by drawing a Hess' Law energy cycle.

(If you were unable to calculate the enthalpy changes, assume that the value of the enthalpy change in **(a)(iv)** is $-58.7\,kJ\,mol^{-1}$ and the value in **(b)(iii)** is $-140.3\,kJ\,mol^{-1}$. Note: these are not the correct values.)

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

enthalpy change = ... $kJ\,mol^{-1}$
(sign) (value)

[2]

(d) **(i)** Calculate the maximum percentage error in the temperature **rise** in **(b)(i)**.

percentage error = ... %

(ii) The magnesium oxide, **FA 5**, was weighed with a balance measuring to one decimal place. A student suggested that the accuracy of the experiment in **(b)(i)** would be improved by weighing **FA 5** using a balance measuring to two decimal places.
State and explain whether or not the student is correct.

....

....

....

[2]

[Total: 14]

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) **FA 6** is a salt containing one cation and one anion from those listed on pages 14 and 15.
Transfer a **small** spatula measure of **FA 6** into a hard-glass test-tube.
Heat gently at first, then heat strongly until no further change occurs.

Record **all** 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 **FA 6** in a test-tube, add an equal volume of **FA 1**, aqueous sulfuric acid.	
To a 1 cm depth of the solution of **FA 6** in a test-tube, add aqueous ammonia.	
To a 1 cm depth of the solution of **FA 6** 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.	

(iii) Give the chemical formula of **FA 6**.

....

Give the ionic equation for the reaction of **FA 6** with cold sodium hydroxide.
Include state symbols.

....

[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 **FA 7** in a test-tube, add aqueous sodium hydroxide.	
To a 1 cm depth of **FA 7** in a test-tube, add aqueous ammonia.	
To a 1 cm depth of **FA 7** in a test-tube, add a few drops of acidified potassium manganate(VII), followed by a few drops of aqueous starch.	

(ii) Identify **FA 7**.

FA 7 is ....

(iii) Carry out **one** further test of your choice to confirm the identity of the **anion** in **FA 7**.

reagent(s) used ....

observation(s) ....

....

[5]

[Total: 13]

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Qualitative Analysis Notes

Key: [ppt. = precipitate]

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 giving dark green solution	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

Key

atomic number
atomic symbol
name
relative atomic mass

Group 1	2	3	4	5	6	7	8	9	10	11	12	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											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											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 –