UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education
Advanced Subsidiary Level and Advanced Level

CANDIDATE NAME	

CENTRE NUMBER						CANDIDATE NUMBER					

0117392783

CHEMISTRY **9701/33**

Advanced Practical Skills 1 **May/June 2013**

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 a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, 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 12 and 13.
A 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 **14** printed pages and **2** blank pages.

IB13 06_9701_33/4RP

CAMBRIDGE International Examinations

[Turn over

1 You are to determine the enthalpy change of the reaction between hydrochloric acid and sodium hydroxide by adding various volumes of acid and alkali and measuring the change in temperature.

FA 1 is 0.950 mol dm^{-3} hydrochloric acid, HCl.
FA 2 is aqueous sodium hydroxide, NaOH.

(a) Method

- Support the plastic cup in a 250 cm^3 beaker.
- Using a measuring cylinder, transfer 25 cm^3 of **FA 1** into the cup and measure the temperature of the acid. Tilt the cup if necessary to cover the bulb of the thermometer.
- Record this initial temperature.

initial temperature of **FA 1** = ... °C

- Use a second measuring cylinder to transfer 10 cm^3 of **FA 2** and 25 cm^3 of water into a 100 cm^3 beaker.
- Add this mixture to the plastic cup and stir.
- Measure the maximum temperature reached and record this maximum temperature in the table below.
- Rinse out the plastic cup and shake it to remove excess water.
- Repeat the experiment, using the volumes of **FA 1**, **FA 2** and water shown in the table. Record the maximum temperature for each experiment.

volume **FA 1** / cm^3	volume **FA 2** / cm^3	volume water / cm^3	maximum temperature / °C
25	10	25	
25	15	20	
25	20	15	
25	25	10	
25	30	5	
25	35	0	

You are going to plot a graph using these results to find the volume of **FA 2** that gives the greatest maximum temperature.

Before you plot the graph, choose two further volumes of **FA 2** that will allow you to find more precisely the volume that gives the greatest maximum temperature.

Record the volumes you choose, carry out the experiments and record the corresponding maximum temperatures, in the table. [2]

For Examiner's Use

(b) **(i)** On the grid below, plot the maximum temperature on the *y*-axis against the volume of **FA 2** on the *x*-axis.

(ii) Draw two straight lines of best fit on your graph, one to show where the temperature was increasing and the other after the greatest maximum temperature had been reached.

(iii) Using your graph and the initial temperature recorded in **(a)**, determine the maximum temperature **change** that could occur when 25 cm^3 of **FA 1** react with **FA 2**.

maximum temperature **change** = ... °C

[5]

For Examiner's Use

(c) Calculation

(i) Calculate the energy needed to produce the temperature change in **(b)(iii)**.
(Assume that 4.3 J of heat energy changes the temperature of 1.0 cm^3 of solution by 1.0 °C.)

energy needed = ... J

(ii) Calculate the number of moles of HCl used in each experiment.

moles of HCl = ... mol

(iii) Calculate the enthalpy change, in $kJ\,mol^{-1}$, when 1 mole of HCl reacts with NaOH.

enthalpy change = ... $kJ\,mol^{-1}$
(sign) (value) [3]

[Total: 10]

For Examiner's Use

2 The identity of a metal, M, can be found by titrating a solution of its carbonate with hydrochloric acid of known concentration.

FA 3 is a solution of the metal carbonate, M_2CO_3, of concentration 6.90 g dm^{-3}.

You are to dilute the hydrochloric acid that you used in **Question 1** and then titrate the carbonate solution with this acid.

(a) Method

Dilution of the acid

- Pipette 25.0 cm^3 of **FA 1** into the 250 cm^3 volumetric (graduated) flask labelled **FA 4**.
- Add distilled water to make the total volume 250 cm^3.
- Stopper the flask and mix the contents thoroughly.

Titration

- Fill the burette with diluted hydrochloric acid, **FA 4**.
- Use a clean pipette to transfer 25.0 cm^3 of **FA 3** into a conical flask.
- Titrate **FA 3** with **FA 4** using the indicator provided.
- Perform a rough titration and record your burette readings in the space below.

The rough titre is .... cm^3.

- Carry out as many accurate titrations as you think necessary to obtain consistent results.
- Make certain 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 4** added in each accurate titration.

I	
II	
III	
IV	
V	
VI	
VII	

[7]

For Examiner's Use

(b) From your accurate titration results, obtain a suitable value 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 4**
[1]

(c) Calculation

The equation for the reaction between hydrochloric acid and the metal carbonate is given below.

$$M_2CO_3 + 2HCl \rightarrow 2MCl + CO_2 + H_2O$$

(i) Calculate the number of moles of hydrochloric acid present in the volume in **(b)**.

moles of HCl = ... mol

(ii) Hence, calculate the number of moles of M_2CO_3 present in 25.0 cm^3 of **FA 3**.

moles of M_2CO_3 = ... mol

(iii) Calculate the concentration of M_2CO_3 in **FA 3** in mol dm^{-3}.

concentration of M_2CO_3 = ... mol dm^{-3}

(iv) Use your answer to **(iii)**, and the fact that **FA 3** contains 6.90 g dm^{-3}, to determine the relative atomic mass, A_r, of M.

A_r of M = ...

(v) Use your answer to **(iv)** and the Periodic Table on page 16 to suggest the identity of M.

M is .... [5]

For Examiner's Use

(d) The concentration of a carbonate solution could be found using either the method in **Question 1** or that in **Question 2**.

(i) Suggest, and explain, which of the methods is more accurate.

....

....

(ii) For the method that you think is less accurate, suggest an improvement to the practical procedure that could be made to improve the accuracy.

....

.... [2]

[Total: 15]

For Examiner's Use

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.
Marks are **not** given for chemical equations.
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) You are provided with a solid, **FA 5**. **FA 5** is a mixture that contains two anions and two cations.

To all your sample of **FA 5** in a boiling tube add 3 cm depth of distilled water. Shake the tube and filter the contents. Keep the solid residue for tests in **(b)** and the filtered solution for tests in **(c)**.

(b) **(i)** Open up the filter paper and scrape the residue into a boiling tube. Add dilute nitric acid, HNO_3, using a dropping pipette until the solid **just** disappears. Record your observations and keep the solution for tests in **(ii)**.

observations ....

....

(ii) Divide the solution from test **(i)** equally into **three** test-tubes.

To the first test-tube add aqueous sodium hydroxide, NaOH, until in excess. Record your observations.

observations ....

....

Which cations, from those listed in the Qualitative Analysis Notes on page 12, would give these observations?

....

For Examiner's Use

(iii) You are to devise tests that will positively identify which one of the cations you have suggested in **(ii)** is present. For each of the possible ions you should indicate the test and the expected result for each test in a suitable table in the space below.

Use the solutions in the second and third test-tubes to carry out these tests and record your observations in the space below.

Identify the cation present.

The cation present is .... [7]

For Examiner's Use

(c) To 1 cm depth of filtered solution from **(a)** in a test-tube add 1 cm depth of dilute nitric acid followed by a few drops of aqueous silver nitrate. Record your observation.

observation ....

Which further reagent could be added to this test-tube to help you to confirm the nature of the anion present?

reagent ....

Carry out a test using this additional reagent. Record your observation and conclusion about the anion present.

observation ....

The anion present is .... [2]

(d) Using your observation in **(b)(i)** state which other anion is present in **FA 5**.

The anion present is .... [1]

For Examiner's Use

(e) Solutions **FA 6** and **FA 7** each contain one of the ions sulfite, SO_3^{2-}, sulfate, SO_4^{2-}, nitrite, NO_2^-, or nitrate, NO_3^-.

(i) Carry out the tests in the table below to identify which ion is present in each solution.

test	*observations*	
	FA 6	**FA 7**
To 1 cm depth of solution in a **boiling** tube, add a small piece of aluminium foil and 1 cm depth of aqueous sodium hydroxide. Warm the mixture **with care**.		
To 1 cm depth of solution in a test-tube, add a few drops of aqueous barium chloride or barium nitrate, then		
add dilute hydrochloric acid.		
To 1 cm depth of solution in a test-tube, add 1 cm depth of dilute hydrochloric acid.		

(ii) From your observations, identify the anion present in each solution.

FA 6 contains ....

FA 7 contains ....

(iii) What type of reaction takes place when a positive observation is seen with aluminium foil and aqueous sodium hydroxide in **(i)**?

....

[5]

[Total: 15]

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)	no ppt. (if 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
lead(II), Pb^{2+}(aq)	white ppt. soluble in excess	white 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

[Lead(II) ions can be distinguished from aluminium ions by the insolubility of lead(II) chloride.]

2 Reactions of anions

ion	*reaction*
carbonate, CO_3^{2-}	CO_2 liberated by dilute acids
chromate(VI), $CrO_4^{2-}(aq)$	yellow solution turns orange with $H^+(aq)$; gives yellow ppt. with $Ba^{2+}(aq)$; gives bright yellow ppt. with $Pb^{2+}(aq)$
chloride, $Cl^-(aq)$	gives white ppt. with $Ag^+(aq)$ (soluble in $NH_3(aq)$); gives white ppt. with $Pb^{2+}(aq)$
bromide, $Br^-(aq)$	gives cream ppt. with $Ag^+(aq)$ (partially soluble in $NH_3(aq)$); gives white ppt. with $Pb^{2+}(aq)$
iodide, $I^-(aq)$	gives yellow ppt. with $Ag^+(aq)$ (insoluble in $NH_3(aq)$); gives yellow ppt. with $Pb^{2+}(aq)$
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 $Ba^{2+}(aq)$ or with $Pb^{2+}(aq)$ (insoluble in excess dilute strong acids)
sulfite, $SO_3^{2-}(aq)$	SO_2 liberated with dilute acids; 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
sulfur dioxide, SO_2	turns acidified aqueous potassium dichromate(VI) from orange to green

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The Periodic Table of the Elements

Group																	
I	II											III	IV	V	VI	VII	0
							1.0 **H** Hydrogen 1										4.0 **He** Helium 2
6.9 **Li** Lithium 3	9.0 **Be** Beryllium 4											10.8 **B** Boron 5	12.0 **C** Carbon 6	14.0 **N** Nitrogen 7	16.0 **O** Oxygen 8	19.0 **F** Fluorine 9	20.2 **Ne** Neon 10
23.0 **Na** Sodium 11	24.3 **Mg** Magnesium 12											27.0 **Al** Aluminium 13	28.1 **Si** Silicon 14	31.0 **P** Phosphorus 15	32.1 **S** Sulfur 16	35.5 **Cl** Chlorine 17	39.9 **Ar** Argon 18
39.1 **K** Potassium 19	40.1 **Ca** Calcium 20	45.0 **Sc** Scandium 21	47.9 **Ti** Titanium 22	50.9 **V** Vanadium 23	52.0 **Cr** Chromium 24	54.9 **Mn** Manganese 25	55.8 **Fe** Iron 26	58.9 **Co** Cobalt 27	58.7 **Ni** Nickel 28	63.5 **Cu** Copper 29	65.4 **Zn** Zinc 30	69.7 **Ga** Gallium 31	72.6 **Ge** Germanium 32	74.9 **As** Arsenic 33	79.0 **Se** Selenium 34	79.9 **Br** Bromine 35	83.8 **Kr** Krypton 36
85.5 **Rb** Rubidium 37	87.6 **Sr** Strontium 38	88.9 **Y** Yttrium 39	91.2 **Zr** Zirconium 40	92.9 **Nb** Niobium 41	95.9 **Mo** Molybdenum 42	**Tc** Technetium 43	101 **Ru** Ruthenium 44	103 **Rh** Rhodium 45	106 **Pd** Palladium 46	108 **Ag** Silver 47	112 **Cd** Cadmium 48	115 **In** Indium 49	119 **Sn** Tin 50	122 **Sb** Antimony 51	128 **Te** Tellurium 52	127 **I** Iodine 53	131 **Xe** Xenon 54
133 **Cs** Caesium 55	137 **Ba** Barium 56	139 **La** Lanthanum 57 *	178 **Hf** Hafnium 72	181 **Ta** Tantalum 73	184 **W** Tungsten 74	186 **Re** Rhenium 75	190 **Os** Osmium 76	192 **Ir** Iridium 77	195 **Pt** Platinum 78	197 **Au** Gold 79	201 **Hg** Mercury 80	204 **Tl** Thallium 81	207 **Pb** Lead 82	209 **Bi** Bismuth 83	**Po** Polonium 84	**At** Astatine 85	**Rn** Radon 86
Fr Francium 87	**Ra** Radium 88	**Ac** Actinium 89 †	**Rf** Rutherfordium 104	**Db** Dubnium 105	**Sg** Seaborgium 106	**Bh** Bohrium 107	**Hs** Hassium 108	**Mt** Meitnerium 109	**Uun** Ununnilium 110	**Uuu** Unununium 111	**Uub** Ununbium 112		**Uuq** Ununquadium 114		**Uuh** Ununhexium 116		**Uuo** Ununoctium 118

*	140 **Ce** Cerium 58	141 **Pr** Praseodymium 59	144 **Nd** Neodymium 60	**Pm** Promethium 61	150 **Sm** Samarium 62	152 **Eu** Europium 63	157 **Gd** Gadolinium 64	159 **Tb** Terbium 65	163 **Dy** Dysprosium 66	165 **Ho** Holmium 67	167 **Er** Erbium 68	169 **Tm** Thulium 69	173 **Yb** Ytterbium 70	175 **Lu** Lutetium 71
†	**Th** Thorium 90	**Pa** Protactinium 91	**U** Uranium 92	**Np** Neptunium 93	**Pu** Plutonium 94	**Am** Americium 95	**Cm** Curium 96	**Bk** Berkelium 97	**Cf** Californium 98	**Es** Einsteinium 99	**Fm** Fermium 100	**Md** Mendelevium 101	**No** Nobelium 102	**Lr** Lawrencium 103

*58-71 Lanthanides
†90-103 Actinides

Key

a	a = relative atomic mass
X	**X** = atomic symbol
b	b = proton (atomic) number