Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME			
CENTRE NUMBER		CANDIDATE NUMBER	

9693421101

CHEMISTRY **9701/32**

Paper 3 Advanced Practical Skills 2 **May/June 2018**

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 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 Many metal hydroxides decompose when heated to produce water vapour and the metal oxide as residue.

In this experiment, you will heat a metal hydroxide **M**$(OH)_2$. You will then identify the metal **M**.

$$\mathbf{M}(OH)_2(s) \rightarrow \mathbf{M}O(s) + H_2O(g)$$

FB 1 is the hydroxide of a metal in Group 2 of the Periodic Table, **M**$(OH)_2$.
You are supplied with approximately 2 g of **FB 1**.

(a) Method

Experiment 1

- Weigh a crucible with its lid and record the mass.
- Add between 0.5 and 0.7 g of **FB 1** to the crucible. Weigh the crucible with **FB 1** and lid and record the mass.
- Place the crucible on the pipe-clay triangle and remove the lid.
- Heat the crucible and contents strongly for about four minutes.
- Replace the lid and leave the crucible and residue to cool.
- While the crucible is cooling, begin work on a different question.
- Once the crucible is cool, reweigh the crucible and contents with the lid on. Record the mass.
- Calculate and record the mass of **FB 1** used and the mass of residue obtained.

Experiment 2

- Repeat the method used in **Experiment 1**, using between 0.8 and 1.0 g of **FB 1** in the second crucible.
- Calculate and record the mass of **FB 1** used and the mass of residue obtained.

Results

I	
II	
III	
IV	
V	

[5]

(b) Calculations

(i) Calculate the mean mass of **FB 1** used in your experiments and calculate the mean mass of residue obtained.
Express both answers to **two** decimal places.

mean mass of **FB 1** = ... g

mean mass of residue = ... g
[1]

(ii) Calculate the mean number of moles of water lost during your experiments.

mean moles of H_2O = ... mol [1]

(iii) Using your answer to **(ii)** and the equation for the decomposition of **M**$(OH)_2$, calculate the relative formula mass of the metal oxide, **M**O.

M_r of **M**O = ... [1]

(iv) Calculate the relative atomic mass of **M**.
M is in Group 2 of the Periodic Table. Suggest the identity of **M**.

A_r of **M** = ...

M is ....
[1]

(c) (i) State how you could ensure that the decomposition of **M**$(OH)_2$ in your experiments was complete.

....

.... [1]

(ii) A student repeated the experiment using **FB 1** contaminated with **M**CO_3.

State and explain what effect this impurity would have on the value of the relative atomic mass of **M** that this student would calculate.

....

....

.... [2]

[Total: 12]

2 In this experiment you will determine the enthalpy change, ΔH_r, for the decomposition of calcium hydroxide to calcium oxide.

$$Ca(OH)_2(s) \rightarrow CaO(s) + H_2O(l)$$

To do this, you will determine the enthalpy changes for the reactions of calcium hydroxide and calcium oxide with hydrochloric acid. Excess acid will be used for both experiments.

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

FB 2 is 3.0 mol dm^{-3} hydrochloric acid, HCl.
FB 3 is calcium hydroxide, $Ca(OH)_2$.
FB 4 is calcium oxide, CaO.

(a) Determination of the enthalpy change for the reaction of calcium hydroxide, **FB 3**, with hydrochloric acid, **FB 2**.

(i) Method

- Support a plastic cup in the 250 cm^3 beaker.
- Weigh the container with **FB 3**. Record the mass.
- Use the measuring cylinder to transfer 30 cm^3 of **FB 2** into the 100 cm^3 beaker.
- Place the beaker on the tripod and gauze and heat **FB 2** gently until its temperature is between 35 °C and 40 °C. Turn off the Bunsen burner.
- Carefully transfer all **FB 2** from the 100 cm^3 beaker into the plastic cup.
- Measure and record the temperature of **FB 2** in the plastic cup in the space below.
- Immediately add all the **FB 3** from the container to the **FB 2** in the plastic cup.
- Stir constantly until the maximum temperature is reached.
- Measure and record the maximum temperature.
- Weigh and record the mass of the container with any residual solid.
- Calculate and record the mass of **FB 3** used.
- Calculate and record the temperature rise.

Results

[4]

Calculations

(ii) Calculate the energy produced during this reaction.
[Assume that 4.2 J of heat energy changes the temperature of 1.0 cm^3 of solution by 1.0 °C.]

energy produced = ... J [1]

(iii) Calculate the number of moles of calcium hydroxide, **FB 3**, used in the experiment.

moles of $Ca(OH)_2$ = ... mol [1]

(iv) Calculate the enthalpy change, in kJ mol^{-1}, for reaction 1 below, ΔH_1.

$$Ca(OH)_2(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + 2H_2O(l)$$

ΔH_1 = ... kJ mol^{-1}
(sign) (value)

[1]

(b) Determination of the enthalpy change for the reaction of calcium oxide, **FB 4**, with hydrochloric acid, **FB 2**.

(i) Method

- Support the second plastic cup in the 250 cm^3 beaker.
- Weigh the container with **FB 4**. Record the mass.
- Use the measuring cylinder to transfer 30 cm^3 of **FB 2** into the 100 cm^3 beaker.
- Place the beaker on the tripod and gauze and heat **FB 2** gently until its temperature is approximately 35 °C.
- Carefully transfer all **FB 2** from the 100 cm^3 beaker into the plastic cup.
- Measure and record the temperature of **FB 2** in the plastic cup in the space below.
- Immediately add all the **FB 4** from the container to the **FB 2** in the plastic cup.
- Stir constantly until the maximum temperature is reached.
- Measure and record the maximum temperature.
- Weigh and record the mass of the container with any residual solid.
- Calculate and record the mass of **FB 4** used.
- Calculate and record the temperature rise.

Results

[2]

Calculation

(ii) Calculate the enthalpy change, in kJ mol^{-1}, for reaction 2 below, ΔH_2.

$$CaO(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l)$$

ΔH_2 = ... kJ mol^{-1}
(sign) (value)

[2]

(c) Use your values for ΔH_1 and ΔH_2 to calculate the enthalpy change for the decomposition of calcium hydroxide, ΔH_r.

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 ΔH_1 is $-129\,kJ\,mol^{-1}$ and ΔH_2 is $-150\,kJ\,mol^{-1}$. Note: these are not the correct values.)

$$Ca(OH)_2(s) \rightarrow CaO(s) + H_2O(l)$$

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

[2]

(d) (i) Give a reason why **FB 2** was heated before **FB 3** or **FB 4** were added to it.

....

.... [1]

(ii) The procedure in **(b)** was repeated using the same mass of calcium oxide, **FB 4**. However, $30\,cm^3$ of $4.0\,mol\,dm^{-3}$ HCl was used instead of $30\,cm^3$ of $3.0\,mol\,dm^{-3}$ HCl.

How would the temperature rise compare with the one you obtained in the experiment in **(b)**?
Explain your answer.

....

....

.... [1]

[Total: 15]

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) **FB 5**, **FB 6** and **FB 7** are all aqueous solutions.
Each solution contains one cation and one anion.
The cation in **FB 6** is listed in the Qualitative Analysis Notes, but the other cations are not.
The anions present are chloride, nitrate and sulfate (but not necessarily in that order).

Use a 1 cm depth of each solution in a test-tube for the following tests.
Record all your observations in the table.

test	*observations*		
	FB 5	**FB 6**	**FB 7**
Add a 2 cm strip of magnesium ribbon.			
Add several drops of aqueous sodium carbonate.			
Add aqueous sodium hydroxide.			
Add several drops of aqueous barium chloride or aqueous barium nitrate.			

test	*observations*		
	FB 5	**FB 6**	**FB 7**
Add a 1 cm depth of **FB 5**.			
Add a 1 cm depth of **FB 6**.			
Add a 1 cm depth of aqueous potassium iodide.			

[9]

(b) **(i)** From your observation of the reaction of **FB 7** with aqueous potassium iodide, suggest the identity of the cation in **FB 7**.

.... [1]

(ii) Give the ionic equation for the reaction of magnesium with **FB 5**.
Include state symbols.

.... [1]

(iii) What **type** of reaction takes place when **FB 6** reacts with sodium carbonate?

.... [1]

(iv) Give the ionic equation for the reaction between **FB 6** and **FB 7**.
Include state symbols.

.... [1]

[Total: 13]

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
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 A*l* aluminium 27.0	14 Si silicon 28.1	15 P phosphorus 31.0	16 S sulfur 32.1	17 C*l* 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 T*l* 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 F*l* 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 –