

CANDIDATE
NAME

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CENTRE
NUMBER

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CANDIDATE
NUMBER

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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 $\text{M}(\text{OH})_2$. You will then identify the metal **M**.



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

(a) Method

Experiment 1

- Weigh a crucible with its lid and record the mass.
- Add between 0.5 and 0.7g 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 1.0g 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 $\text{M}(\text{OH})_2$, calculate the relative formula mass of the metal oxide, **MO**.

M_r of **MO** = [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 $\text{M}(\text{OH})_2$ in your experiments was complete.

.....
..... [1]

- (ii) A student repeated the experiment using **FB 1** contaminated with MCO_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.



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

Calculations

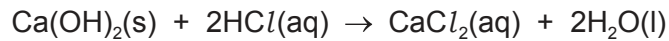
- (ii) Calculate the energy produced during this reaction.
[Assume that 4.2 J of heat energy changes the temperature of 1.0 cm³ of solution by 1.0 °C.]

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 .



$\Delta H_1 = \dots\dots\dots$ kJ mol⁻¹
(sign) (value) [1]

- (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.)



$$\Delta H_r = \dots\dots\dots \text{ kJ mol}^{-1}$$

(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 $4.0 \text{ mol dm}^{-3} \text{ HCl}$ was used instead of 30 cm^3 of $3.0 \text{ mol dm}^{-3} \text{ HCl}$.

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.

<i>test</i>	<i>observations</i>		
	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.			

<i>test</i>	<i>observations</i>		
	FB 5	FB 6	FB 7
Add a 1 cm depth of FB 5 .	X		
Add a 1 cm depth of FB 6 .	X	X	
Add a 1 cm depth of aqueous potassium iodide.	X	X	

[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

<i>ion</i>	<i>reaction</i>
carbonate, CO_3^{2-}	CO_2 liberated by dilute acids
chloride, $\text{Cl}^-(\text{aq})$	gives white ppt. with $\text{Ag}^+(\text{aq})$ (soluble in $\text{NH}_3(\text{aq})$)
bromide, $\text{Br}^-(\text{aq})$	gives cream ppt. with $\text{Ag}^+(\text{aq})$ (partially soluble in $\text{NH}_3(\text{aq})$)
iodide, $\text{I}^-(\text{aq})$	gives yellow ppt. with $\text{Ag}^+(\text{aq})$ (insoluble in $\text{NH}_3(\text{aq})$)
nitrate, $\text{NO}_3^-(\text{aq})$	NH_3 liberated on heating with $\text{OH}^-(\text{aq})$ and Al foil
nitrite, $\text{NO}_2^-(\text{aq})$	NH_3 liberated on heating with $\text{OH}^-(\text{aq})$ and Al foil
sulfate, $\text{SO}_4^{2-}(\text{aq})$	gives white ppt. with $\text{Ba}^{2+}(\text{aq})$ (insoluble in excess dilute strong acids)
sulfite, $\text{SO}_3^{2-}(\text{aq})$	gives white ppt. with $\text{Ba}^{2+}(\text{aq})$ (soluble in excess dilute strong acids)

3 Tests for gases

<i>gas</i>	<i>test and test result</i>
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	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">1 H hydrogen 1.0</div> <div style="border: 1px solid black; padding: 2px;">2 He helium 4.0</div> </div>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">3 Li lithium 6.9</div> <div style="border: 1px solid black; padding: 2px;">4 Be beryllium 9.0</div> </div>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">5 B boron 10.8</div> <div style="border: 1px solid black; padding: 2px;">6 C carbon 12.0</div> <div style="border: 1px solid black; padding: 2px;">7 N nitrogen 14.0</div> <div style="border: 1px solid black; padding: 2px;">8 O oxygen 16.0</div> <div style="border: 1px solid black; padding: 2px;">9 F fluorine 19.0</div> </div>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">11 Na sodium 23.0</div> <div style="border: 1px solid black; padding: 2px;">12 Mg magnesium 24.3</div> </div>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">13 Al aluminium 27.0</div> <div style="border: 1px solid black; padding: 2px;">14 Si silicon 28.1</div> <div style="border: 1px solid black; padding: 2px;">15 P phosphorus 31.0</div> <div style="border: 1px solid black; padding: 2px;">16 S sulfur 32.1</div> <div style="border: 1px solid black; padding: 2px;">17 Cl chlorine 35.5</div> </div>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">19 K potassium 39.1</div> <div style="border: 1px solid black; padding: 2px;">20 Ca calcium 40.1</div> </div>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">21 Sc scandium 45.0</div> <div style="border: 1px solid black; padding: 2px;">22 Ti titanium 47.9</div> <div style="border: 1px solid black; padding: 2px;">23 V vanadium 50.9</div> <div style="border: 1px solid black; padding: 2px;">24 Cr chromium 52.0</div> <div style="border: 1px solid black; padding: 2px;">25 Mn manganese 54.9</div> <div style="border: 1px solid black; padding: 2px;">26 Fe iron 55.8</div> <div style="border: 1px solid black; padding: 2px;">27 Co cobalt 58.9</div> <div style="border: 1px solid black; padding: 2px;">28 Ni nickel 58.7</div> <div style="border: 1px solid black; padding: 2px;">29 Cu copper 63.5</div> <div style="border: 1px solid black; padding: 2px;">30 Zn zinc 65.4</div> </div>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">37 Rb rubidium 85.5</div> <div style="border: 1px solid black; padding: 2px;">38 Sr strontium 87.6</div> </div>															
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		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">89–103 actinoids</div> <div style="border: 1px solid black; padding: 2px;">104 Rf rutherfordium —</div> <div style="border: 1px solid black; padding: 2px;">105 Db dubnium —</div> <div style="border: 1px solid black; padding: 2px;">106 Sg seaborgium —</div> <div style="border: 1px solid black; padding: 2px;">107 Bh bohrium —</div> <div style="border: 1px solid black; padding: 2px;">108 Hs hassium —</div> <div style="border: 1px solid black; padding: 2px;">109 Mt meitnerium —</div> <div style="border: 1px solid black; padding: 2px;">110 Ds darmstadtium —</div> <div style="border: 1px solid black; padding: 2px;">111 Rg roentgenium —</div> <div style="border: 1px solid black; padding: 2px;">112 Cn copernicium —</div> </div>															
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