Cambridge International AS & A Level

Cambridge Assessment International Education
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

5034283225

CHEMISTRY **9701/36**

Paper 3 Advanced Practical Skills 2 **October/November 2019**

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.

Cambridge Assessment International Education

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 Limewater is a saturated solution of calcium hydroxide, $Ca(OH)_2$, in water. In this experiment you will determine the concentration of limewater by titration with hydrochloric acid.

FB 1 is limewater.
FB 2 is 0.500 mol dm^{-3} hydrochloric acid, HC*l*.
bromophenol blue indicator

(a) Method

Dilution of FB 2

- Pipette 25.0 cm^3 of **FB 2** into the 250 cm^3 volumetric flask.
- Make the solution up to the mark using distilled water.
- Shake the solution in the volumetric flask thoroughly.
- This solution of hydrochloric acid is **FB 3**. Label the volumetric flask **FB 3**.
- Rinse the pipette thoroughly.

Titration

- Fill the burette with **FB 3**.
- Pipette 25.0 cm^3 of **FB 1** into a conical flask.
- Add a few drops of bromophenol blue.
- 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 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 **FB 3** added in each accurate titration.

I	
II	
III	
IV	
V	
VI	
VII	

[7]

(b) From your accurate titration results, obtain a suitable value for the volume of **FB 3** to be used in your calculations.
Show clearly how you obtained this value.

25.0 cm^3 of **FB 1** required ..... cm^3 of **FB 3**. [1]

(c) Calculations

(i) Give your answers to **(ii)**, **(iii)**, **(iv)** and **(v)** to the appropriate number of significant figures.
[1]

(ii) Calculate the number of moles of hydrochloric acid, HC*l*, in the volume of **FB 3** calculated in **(b)**.

moles of HC*l* = ... mol
[1]

(iii) Give the equation for the reaction of calcium hydroxide with hydrochloric acid.

.....

Deduce the number of moles of calcium hydroxide that reacted with the hydrochloric acid in **(c)(ii)**.

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

(iv) Calculate the concentration, in mol dm^{-3}, of calcium hydroxide in **FB 1**.

concentration of $Ca(OH)_2$ in **FB 1** = ... mol dm^{-3}
[1]

(v) Calculate the mass of calcium hydroxide dissolved in 1.00 dm^3 of limewater, **FB 1**.

mass of $Ca(OH)_2$ = ... g
[1]

[Total: 13]

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

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

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.

Then you will use Hess' Law to calculate the enthalpy change for the reaction.

FB 4 is calcium hydroxide, $Ca(OH)_2$.
FB 5 is calcium oxide, CaO.
FB 6 is 2.50 mol dm^{-3} hydrochloric acid, HC*l*.

(a) Determination of the enthalpy change for the reaction of calcium hydroxide, **FB 4**, with hydrochloric acid, **FB 6**

(i) Method

- Support a plastic cup in the 250 cm^3 beaker.
- Use the measuring cylinder to transfer 40 cm^3 of **FB 6** into the plastic cup.
- Measure and record the temperature of **FB 6**.
- Weigh the container with **FB 4**. Record the mass.
- Add all **FB 4** from the container to **FB 6** 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.

Keep FB 6 for use in Question 3.

Results

[3]

(ii) Calculations

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 4**, used in the experiment.

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

(iv) Calculate the enthalpy change, in kJ mol^{-1}, for the reaction in which 1.00 mol of solid calcium hydroxide is neutralised by aqueous hydrochloric acid.

enthalpy change = ... kJ mol^{-1}
sign *value*
[1]

(b) Determination of the enthalpy change for the reaction of calcium oxide, **FB 5**, with hydrochloric acid, **FB 6**

(i) Method

- Support the second plastic cup in the 250 cm^3 beaker.
- Use the measuring cylinder to transfer 40 cm^3 of **FB 6** into the plastic cup.
- Measure and record the temperature of **FB 6**.
- Weigh the container with **FB 5**. Record the mass.
- Add all **FB 5** from the container to **FB 6** 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 5** used.
- Calculate and record the temperature rise.

Results

[3]

(ii) Calculation

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

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

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

[1]

(c) Use your values for the enthalpy changes calculated in **(a)(iv)** and **(b)(ii)** to calculate the enthalpy change for the decomposition of calcium hydroxide.

Show clearly how you obtained your answer.

(If you were unable to calculate the enthalpy changes, assume that the magnitude of the enthalpy change in **(a)(iv)** is 164 kJ mol^{-1} and the magnitude in **(b)(ii)** is 191 kJ mol^{-1}.
Note: these may not be the correct magnitudes and the signs have been deliberately omitted.)

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

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

[2]

(d) (i) The experiment in **(b)** was repeated, using the same mass of calcium oxide, **FB 5**.
However, 40 cm^3 of 3.0 mol dm^{-3} HC*l* was used instead of 40 cm^3 of 2.5 mol dm^{-3} HC*l*.

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

.....

.....

..... [1]

(ii) A student suggested that the experiment in **(a)** would be more accurate if a taller plastic cup of the same diameter was used.

Do you agree with the student? Explain your answer.

.....

..... [1]

[Total: 14]

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 7** is a solid containing one of the anions listed in the Qualitative Analysis Notes.
Place a small spatula measure of **FB 7** in a hard-glass test-tube.
Heat it gently at first and then more strongly. Identify the gas produced.
Leave the contents of the tube to cool.

Record **all** your observations.

.....

.....

.....

.....

.....

..... [3]

(b) **FB 8** and **FB 9** are both solutions of potassium compounds.
Each contains one anion which is listed in the Qualitative Analysis Notes.

(i) Carry out the following tests and record your observations.

test	*observations with **FB 8***	*observations with **FB 9***
To a 1 cm depth in a test-tube, add a few drops of aqueous acidified potassium manganate(VII).		
To a 1 cm depth in a test-tube, add an equal volume of dilute nitric acid followed by a few drops of aqueous barium nitrate, then		
add a few drops of aqueous silver nitrate.		
To a 1 cm depth in a boiling tube, add an equal volume of aqueous sodium hydroxide and warm **carefully**, then		
add a strip of aluminium foil.		

[5]

(ii) Give the ionic equation for the reaction of silver nitrate with **FB 8**. Include state symbols.

..... [1]

(iii) The reaction of aluminium with **FB 9** involves a redox reaction.

What species are oxidised and reduced in this reaction?

species oxidised .....

species reduced .....
[1]

(c) (i) In a test-tube, mix together 1 cm depths of **FB 8** and **FB 9**. Record your observation.

observation .....

Then add **one drop** of **FB 6**, hydrochloric acid, and record your observation.

observation .....
[1]

(ii) From your knowledge of **FB 8**, suggest the formula of the chemical you observed at the **end** of the experiment in **(c)(i)**.

formula ..... [1]

(iii) How would you test to confirm that the identification you made in **(c)(ii)** is correct?
Name the reagent you would use.
Carry out your test and record your observation.

reagent used .....

observation .....
[1]

[Total: 13]

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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
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 –