Cambridge International AS & A Level

Cambridge Assessment International Education
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME			
CENTRE NUMBER		CANDIDATE NUMBER	

8811663269

CHEMISTRY **9701/33**

Paper 3 Advanced Practical Skills 1 **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 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.

Cambridge Assessment International Education

[Turn over

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 In this experiment you will determine the concentration of a solution of hydrochloric acid by titration with an alkali.

FA 1 is a solution containing 6.00 g dm^{-3} of sodium hydroxide, NaOH.
FA 2 is hydrochloric acid, HCl. (This solution is also used in **Questions 2** and **3**.)
methyl orange indicator

(a) Method

Dilution of FA 2

- Pipette **10.0 cm^3** of **FA 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 **FA 3**. Label the volumetric flask **FA 3**.

Titration

- Fill the burette with **FA 1**.
- Pipette **25.0 cm^3** of **FA 3** into a conical flask.
- Add several drops of methyl orange indicator.
- 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 **FA 1** 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 **FA 1** 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 1**. [1]

(c) Calculations

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

(ii) Calculate the number of moles of sodium hydroxide, NaOH, in the volume of **FA 1** calculated in **(b)**.

moles of NaOH = ... mol [1]

(iii) Write the equation for the neutralisation of hydrochloric acid with sodium hydroxide. Include state symbols.

....

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

moles of hydrochloric acid =..................... mol [1]

(iv) Calculate the concentration, in mol dm^{-3}, of hydrochloric acid in **FA 2**.

concentration of HCl in **FA 2** = ... mol dm^{-3} [2]

[Total: 13]

2 In this experiment you will determine the enthalpy change, ΔH, for the reaction shown.

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

To do this, you will determine the enthalpy changes for the reactions of magnesium oxide and magnesium carbonate with hydrochloric acid. Excess hydrochloric acid will be used in each reaction.

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

FA 2 is hydrochloric acid, HCl.
FA 4 is magnesium oxide, MgO.
FA 5 is magnesium carbonate, $MgCO_3$.

(a) Determination of the enthalpy change for the reaction of magnesium oxide, **FA 4**, with hydrochloric acid, **FA 2**

Method

- Support a plastic cup in the 250 cm^3 beaker.
- Use the measuring cylinder to transfer 40 cm^3 of **FA 2** into the plastic cup.
- Measure and record the initial temperature of the solution.
- Weigh the container with **FA 4**. Record the mass.
- Add all the **FA 4** from the container to the **FA 2** in the plastic cup.
- Stir constantly until the maximum temperature is reached.
- Measure and record the maximum temperature.
- Weigh the container with any **FA 4** remaining. Record the mass.
- Calculate and record the mass of **FA 4** used.
- Calculate and record the temperature rise.

I	
II	
III	
IV	

[4]

(b) Calculations

(i) 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 [1]

(ii) Calculate the number of moles of MgO used.

moles of MgO = ... mol [1]

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

$$MgO(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2O(l)$$

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

(c) By means of a calculation, use your answer to **1(c)(iv)** to show that the hydrochloric acid, **FA 2**, was in excess for the reaction in **2(a)**.

(If you were unable to carry out the calculation in **1(c)(iv)**, you should assume that the concentration of HCl in **FA 2** is 3.75 $mol\,dm^{-3}$. This may not be the correct value.)

[1]

(d) Determination of the enthalpy change for the reaction of magnesium carbonate, **FA 5**, with hydrochloric acid, **FA 2**

(i) Method

- Support the second plastic cup in the 250 cm^3 beaker.
- Use the measuring cylinder to transfer 40 cm^3 of **FA 2** into the plastic cup.
- Measure and record the initial temperature of the solution.
- Weigh the container with **FA 5**. Record the mass.
- Add approximately **half** of the **FA 5** from the container to the **FA 2** in the plastic cup.
- Stir constantly for approximately 30 seconds.
- Then add the remainder of the **FA 5**.
- Stir constantly until the maximum temperature is reached.
- Measure and record the maximum temperature.
- Weigh the container with any **FA 5** remaining. Record the mass.
- Calculate and record the mass of **FA 5** used.
- Calculate and record the temperature rise.

[2]

(ii) Apart from the change in temperature, what observations did you make during the reaction?

....

.... [1]

(iii) Calculation

Calculate the enthalpy change for this reaction.

$$MgCO_3(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + CO_2(g) + H_2O(l)$$

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

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

(If you were unable to calculate the enthalpy changes, assume that the magnitude of the enthalpy change in **(b)(iii)** is 110.3 kJ mol^{-1} and the magnitude of the enthalpy change in **(d)(iii)** is 65.9 kJ mol^{-1}.
Note: these may not be the correct magnitudes and the signs have been deliberately omitted.)

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

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

(f) Outline one improvement to the **method** that would lead to more accurate values for the enthalpy changes. Do **not** include a change to the apparatus used, such as the use of a lid.

....

....

.... [1]

(g) Give the error in a single balance reading.

error = ± .... g

Which is greater, the percentage error in the mass of magnesium oxide used or the percentage error in the mass of magnesium carbonate used?

Percentage error is greater in ....

Calculate the **greater** percentage error.

greater % error = ... %
[2]

[Total: 16]

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)** You will investigate **FA 6**.

Pour a 1 cm depth of hydrochloric acid, **FA 2**, into a test-tube.
Add a small spatula measure of **FA 6** to the acid.
Record your observations.

....

....

....

....

What can you deduce from your observations? Explain your answer.

....

....
[3]

(b) **(i)** **FA 7** is a sodium compound containing an anion listed in the Qualitative Analysis Notes.

Heat a **small** spatula measure of **FA 7** in a hard-glass test-tube.
Heat strongly until no further change occurs, then leave the test-tube and contents to cool.

Record **all** your observations below.

....

....

....

....

.... [2]

(ii) Dissolve the remaining **FA 7** in a 5 cm depth of distilled water in a boiling tube. Label this solution **FA 8**.

FA 9 is a solution of a different sodium compound. The anion is listed in the Qualitative Analysis Notes.

Carry out the following tests on **FA 8** and **FA 9** and record your observations in the table.

test	*observations with **FA 8***	*observations with **FA 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 a few drops of aqueous barium chloride or aqueous barium nitrate.		
To a 1 cm depth in a boiling tube, add an equal volume of aqueous sodium hydroxide. Warm **carefully**, then		
add aluminium foil.		

[4]

(iii) From your observations, suggest the anions present in **FA 8** and **FA 9**.

anion in **FA 8** ....

anion in **FA 9** ....

[1]

(iv) Give the ionic equation for any reaction observed in **(b)(ii)**. Include state symbols.

.... [1]

[Total: 11]

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 –