Cambridge International AS & A Level

CANDIDATE NAME	

CENTRE NUMBER		CANDIDATE NUMBER	

5423367051

CHEMISTRY **9701/31**

Paper 3 Advanced Practical Skills 1 **May/June 2020**

2 hours

You must answer on the question paper.

You will need: The materials and apparatus listed in the confidential instructions

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working, use appropriate units and use an appropriate number of significant figures.
- Give details of the practical session and laboratory, where appropriate, in the boxes provided.

Session
Laboratory

INFORMATION

- The total mark for this paper is 40.
- The number of marks for each question or part question is shown in brackets [ ].
- The Periodic Table is printed in the question paper.
- Notes for use in qualitative analysis are provided in the question paper.

For Examiner's Use	
1	
2	
3	
Total	

This document has **12** pages. Blank pages are indicated.

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 carry out a titration to determine the relative formula mass of a hydrated salt, **FA 1**.

FA 1 is a hydrated salt.
FA 2 is dilute sulfuric acid.
FA 3 is 0.0200 mol dm^{-3} potassium manganate(VII).

(a) Method

Preparing a solution of FA 1

- Weigh the stoppered container of **FA 1**. Record the mass in the space below.
- Tip all the **FA 1** into the beaker.
- Reweigh the container with its stopper. Record the mass.
- Calculate and record the mass of **FA 1** used.
- Add approximately 100 cm^3 of **FA 2** to the **FA 1** in the beaker.
- Stir the mixture until all the **FA 1** has dissolved.
- Transfer this solution into the 250 cm^3 volumetric flask.
- Rinse the beaker and glass rod with distilled water and transfer the washings to the volumetric flask.
- Make up the solution in the volumetric flask to the mark using distilled water.
- Shake the flask thoroughly.
- This solution of the hydrated salt is **FA 4**. Label the flask **FA 4**.

Titration

- Fill the burette with **FA 3**.
- Pipette 25.0 cm^3 of **FA 4** into a conical flask.
- Use the 25.0 cm^3 measuring cylinder to add 10 cm^3 of **FA 2** to the **FA 4** in the conical flask.
- 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 result
- 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 3** added in each accurate titration.

I	
II	
III	
IV	
V	
VI	
VII	
VIII	

Keep FA 3 and FA 4 for use in Question 3.

[8]

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

25.0 cm^3 of **FA 4** required .... cm^3 of **FA 3**. [1]

(c) Calculations

(i) Calculate the number of moles of potassium manganate(VII) present in the volume of **FA 3** calculated in **(b)**.

moles of $KMnO_4$ = ... mol [1]

(ii) 1 mol of $KMnO_4$ reacts with 5 mol of the hydrated salt, **FA 1**.

Calculate the concentration of the hydrated salt, in mol dm^{-3}, in **FA 4**.

concentration of **FA 4** = ... mol dm^{-3} [1]

(iii) Use your answer to **(c)(ii)**, and your data on page 2, to calculate an experimentally determined value for the relative formula mass of the hydrated salt, **FA 1**.
Show your working.

M_r of **FA 1** = ... [1]

[Total: 12]

2 In this experiment you will determine the enthalpy change of solution for anhydrou sodium carbonate.

FA 5 is anhydrous sodium carbonate, Na_2CO_3. (You are given approximately 11 g.)

(a) Method

Experiment 1

- Weigh a cup. Record the mass.
- Transfer 4.0–4.2 g of **FA 5** from the container into the cup.
- Reweigh and record the mass of the cup with **FA 5**.
- Calculate and record the mass of **FA 5** used.
- Support the cup in the 250 cm^3 beaker.
- Pour 30 cm^3 of distilled water into the 50 cm^3 measuring cylinder.
- Measure and record the temperature of the distilled water in the measuring cylinder.
- Add the 30 cm^3 of distilled water to the **FA 5** in the cup.
- Stir constantly until the maximum temperature is reached.
- Measure and record the maximum temperature.
- Calculate and record the temperature rise.

Experiment 2

- Repeat **Experiment 1** but this time use 5.0–5.2 g of **FA 5** and the other cup.
- Record all data from **both** experiments in one table.

I	
II	
III	
IV	

[4]

(b) Calculations

(i) Calculate the energy produced during **Experiment 1**.
(Assume that 4.2 J change the temperature of 1.0 cm^3 of solution by 1.0 °C.)

energy produced = ... J [1]

(ii) Calculate the number of moles of Na_2CO_3 used in **Experiment 1**.

moles of Na_2CO_3 = ... mol [1]

(iii) Use your answers to **(b)(i)** and **(b)(ii)** to calculate the enthalpy change, in kJ mol^{-1}, for the reaction below.
Show your working.

$$Na_2CO_3(s) + aq \rightarrow Na_2CO_3(aq)$$

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

(c) **(i)** A student suggested that by using the same thermometer, quantities of **FA 5**, and water, a more accurate value for the temperature rise could be calculated.

Suggest how the student could obtain a more accurate measurement.

....

....

.... [1]

(ii) State the maximum error in a single thermometer reading in your experiment in **(a)**.

maximum error = ...

Hence calculate the maximum percentage error in the measurement of the temperature rise in **Experiment 2**.

% error = ...
[2]

[Total: 10]

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)** **FA 6** is a hydrated salt. It contains two cations and one anion, all of which are listed in the Qualitative Analysis Notes.

(i) Describe and carry out tests to identify the cations in **FA 6**.

Record your tests and observations in the space below.

The cations in **FA 6** are .... and ....

[5]

(ii) The anion in **FA 6** is a sulfite, sulfate or a halide.

Carry out a test to identify the anion in **FA 6**.
Record your tests and observations in the space below.

The anion in **FA 6** is .... [2]

(iii) Give the ionic equation for **one** reaction you have carried out in **(a)(i)** or **(a)(ii)**.
Include state symbols.

.... [1]

(iv) The formula of **FA 6** is $\mathbf{XY_2Z_2 \cdot w}H_2O$ where

- **X** and **Y** are the cations present and **Z** is the anion present
- **w** is the number of moles of water of crystallisation in the hydrated salt.

The relative formula mass of this compound is 392.0.

Using your conclusions from **(a)(i)** and **(a)(ii)**, calculate the value of **w**, the number of moles of water of crystallisation.

w = ... [2]

(b) **FA 7** and **FA 8** are aqueous solutions of covalently bonded compounds.

Half fill the beaker with water and place it on a tripod and gauze. Heat until the water begins to boil and then turn off the Bunsen burner. This will be used as a hot water bath.

(i) Complete the table by carrying out the tests described.
Use a 1 cm depth of **FA 7** or **FA 8** in a test-tube for each test.

test	*observation(s)*	
	FA 7	**FA 8**
Test 1 Add an equal volume of dilute sulfuric acid and a **few** drops of **FA 3**, aqueous acidified potassium manganate(VII), then		
place in the hot water bath for several minutes.		
Test 2 Add an equal volume of dilute sulfuric acid and an equal volume of aqueous potassium iodide, then		
add a few drops of aqueous starch.		
Test 3 Add an equal volume of aqueous iodine, then add aqueous sodium hydroxide until no further change occurs. Leave the tube to stand.		
Test 4 Add a few drops of **FA 4**, then		
add aqueous ammonia.		

[5]

(ii) **FA 8** contains an organic compound.

From your observation(s), suggest one **possible** identity for this compound.
Explain your answer.

name ....

reason ....

....

.... [2]

(iii) State the type of reagent **FA 7** acts as in its reaction with aqueous potassium iodide.
Explain your answer.

....

....

.... [1]

[Total: 18]

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											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	3	4	5	6	7	8	9	10	11	12	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 –