Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME	
CENTRE NUMBER	
CANDIDATE NUMBER	

5616021708

CHEMISTRY **9701/35**

Paper 3 Advanced Practical Skills 1 **May/June 2021**

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. Any blank pages are indicated.

[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 carry out a titration to determine the relative formula mass, M_r, of a monoprotic acid, HX.

FA 1 is HX, the monoprotic acid.
FA 2 is 0.0450 mol dm^{-3} sodium carbonate, Na_2CO_3.
methyl orange indicator

(a) Method

Preparing a solution of FA 1

- Weigh the empty 250 cm^3 beaker. Record the mass.
- Transfer all the **FA 1** into the beaker.
- Weigh the beaker and **FA 1**. Record the mass.
- Calculate and record the mass of **FA 1** used.
- Add approximately 100 cm^3 of distilled water to the **FA 1** in the beaker.
- Stir the mixture with a glass rod until all the **FA 1** has dissolved.
- Transfer this solution into the 250 cm^3 volumetric flask.
- Wash the beaker with distilled water and transfer the washings to the volumetric flask.
- Rinse the 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 HX is **FA 3**. Label the flask **FA 3**.

Results

Titration

- Fill the burette with **FA 3**.
- Pipette 25.0 cm^3 of **FA 2** 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 3** added in each accurate titration.

I	
II	
III	
IV	
V	
VI	
VII	
VIII	

[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 2** required ..... cm^3 of **FA 3**. [1]

(c) Calculations

(i) Calculate the number of moles of sodium carbonate present in the volume of **FA 2** used in each titration.

moles of Na_2CO_3 = ... mol [1]

(ii) Give the equation for the reaction of **FA 2**, Na_2CO_3, with **FA 3**, HX.

.....Na_2CO_3 + ...HX $\rightarrow$ .....NaX + ... + ...

Use your answer to **(c)(i)** to deduce the number of moles of HX present in the volume you calculated in **(b)**.

moles of HX = ... mol [1]

(iii) Use your answer to **(c)(ii)** and your data recorded on page 2 to calculate the relative formula mass, M_r, of HX.
Show your working.

M_r of HX = ... [2]

(iv) One molecule of HX contains one nitrogen atom, three oxygen atoms, three hydrogen atoms and one atom of another element, **E**.
The identity of **E** can be found by calculation.

Show this calculation and identify **E**.

Element **E** is ..... . [1]

(d) What is the error in a single reading for the balance that you used?

error = ... g

Calculate the maximum percentage error in the mass of **FA 1** that you recorded on page 2.

maximum percentage error = ... %
[1]

(e) Suggest and carry out an experiment using aqueous silver nitrate to determine whether the compound AgX is soluble or insoluble in water.

method .....

.....

observations .....

conclusion .....
[2]

(f) Suggest why the use of methyl orange indicator might give an inaccurate titration result.

.....

..... [1]

[Total: 18]

2 You will determine the percentage by mass of water of crystallisation in a hydrated salt by thermal decomposition. When a hydrated salt is heated it loses its water of crystallisation.

FA 4 is the hydrated salt.

(a) Method

- Weigh the crucible with its lid. Record the mass.
- Transfer 2.0–2.2 g of **FA 4** from the container into the crucible.
- Weigh the crucible, lid and **FA 4**. Record the mass.
- Calculate and record the mass of **FA 4** used.
- Place the crucible and contents on the pipe-clay triangle.
- Heat gently, with the lid on, for approximately 1 minute.
- Heat strongly, with the lid off, for a further 4 minutes.
- Replace the lid and leave the crucible to cool for at least 5 minutes.

During the cooling period, you may wish to begin work on Question 3.

- When the crucible is cool, weigh the crucible with its lid and contents. Record the mass.
- Heat strongly, with the lid off, for a further 2 minutes.
- Replace the lid and leave the crucible to cool for at least 5 minutes.
- When it is cool, weigh the crucible with its lid and contents. Record the mass.
- Calculate and record the mass lost.

Keep FA 4 for use in Question 3.

Results

I	
II	
III	
IV	
V	

[5]

(b) (i) Calculate the percentage by mass of water of crystallisation in **FA 4**.

percentage by mass of H_2O in **FA 4** = ... % [1]

(ii) State what assumption you made about anhydrous **FA 4** in your calculation in **(b)(i)**.

.....

..... [1]

[Total: 7]

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 4** contains one cation and one anion both of which are listed in the Qualitative Analysis Notes.

Dissolve the remainder of the **FA 4** in approximately 20 cm^3 of water in the 100 cm^3 beaker.
Use a 1 cm depth of this solution in a test-tube for each of the tests.

(i) The anion in **FA 4** is chloride.

State which reagents you would use to identify this ion conclusively.

.....

Use your reagents to test your solution of **FA 4**.
Record your observations.

.....

.....

.....

In what way are your observations **not** consistent with the expected results for chloride?

.....

.....
[3]

(ii) Add an equal volume of dilute sulfuric acid to aqueous **FA 4**.

Record your observations and deduce the identity of the cation in **FA 4**.

observations .....

identity of cation .....

Give the ionic equation for this reaction. Include state symbols.

.....
[2]

(b) Use the conclusions in **(a)(i)** and **(a)(ii)** to calculate the relative formula mass of anhydrous **FA 4**.

M_r = ...

Use your results from **Question 2** to calculate the number of moles of water of crystallisation in one mole of hydrated **FA 4**.

moles of H_2O = ...
[3]

(c) **FA 5** contains one cation and one anion, both of which are listed in the Qualitative Analysis Notes.

(i) Heat a small spatula measure of **FA 5** in a hard-glass test-tube.
Keep heating until no further change is observed.
Record **all** your observations.

.....

.....

.....

..... [2]

(ii) To a 1 cm depth of dilute sulfuric acid in a test-tube, add a small spatula measure of **FA 5**. Record all your observations.

.....

.....

.....

.....

..... [3]

(iii) Place a small spatula measure of **FA 5** into a boiling tube. Add a 1 cm depth of aqueous sodium hydroxide and warm the mixture gently.
Record your observations.

.....

..... [1]

(iv) From the results of your tests, deduce the chemical formula of **FA 5**.

FA 5 is ..... . [1]

[Total: 15]

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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	pale 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 –