* 0000800000001 *

Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME	

CENTRE NUMBER						CANDIDATE NUMBER					

2035897765

CHEMISTRY **9701/33**

Paper 3 Advanced Practical Skills 1 **October/November 2024**

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 and use appropriate units.

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.
- Important values, constants and standards are printed in the question paper.
- Notes for use in qualitative analysis are provided in the question paper.

Session
Laboratory

For Examiner's Use	
1	
2	
3	
Total	

This document has **12** pages. Any blank pages are indicated.

DC (DE) 326174/3

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 the precision of the apparatus you used in the data you record.

Show your working and appropriate significant figures in the answer to **each** step of your calculations.

1 When a metal carbonate reacts with a suitable acid, carbon dioxide is produced. You will determine the relative formula mass, M_r, of a metal carbonate by reacting it with excess hydrochloric acid and measuring the mass of gas produced.

FA 1 is the metal carbonate.
FA 2 is 2.00 mol dm^{-3} hydrochloric acid, HC*l*.

(a) Method

- Use the measuring cylinder to transfer 30.0 cm^3 of **FA 2** into a conical flask.
- Weigh the conical flask containing **FA 2**. Record the mass.
- Weigh the container with **FA 1**. Record the mass.
- Tip all the **FA 1** slowly into the conical flask. When the reaction slows, swirl the flask gently.
- Weigh the container with any residual **FA 1**. Record the mass.
- Calculate the mass of **FA 1** added. Record the mass.
- Leave the conical flask and its contents for 15 minutes. Swirl the flask occasionally during this time.

During this period begin work on Question 2.

- After 15 minutes weigh the flask and its contents. Record the mass.

I	
II	
III	

[3]

(b) Calculations

(i) Use your readings to calculate the mass of carbon dioxide produced.

mass of CO_2 = ... g [1]

(ii) The ionic equation for the reaction of **FA 1** with **FA 2** is shown.

$$CO_3^{2-}(aq) + 2H^+(aq) \rightarrow CO_2(g) + H_2O(l)$$

Calculate the relative formula mass, M_r, of the metal carbonate **FA 1**. Show your working.

M_r of **FA 1** = ... [2]

(c) **(i)** A student carries out the experiment as described in **(a)**, except that the acid used is 15 °C colder than the acid you used. The student calculates the M_r correctly from the readings obtained.

State whether the value of the M_r calculated by the student is higher or lower than the value you calculated in **(b)(ii)**. Explain your answer.

....

....

....

.... [2]

(ii) Another student suggests that the experiment will be more accurate if the conical flask is tilted carefully to an almost horizontal position while the reaction is taking place.

Explain why the student is correct.

....

....

.... [1]

(d) State the uncertainty in a single balance reading.

uncertainty = ± .... g

Give an expression that would enable you to calculate the percentage error in your weighing of **FA 1**.

[1]

[Total: 10]

2 The relative formula mass, M_r, of metal carbonate **FA 1** can also be determined by titration of a solution of **FA 1** with an acid such as hydrochloric acid.

$$CO_3^{2-}(aq) + 2H^+(aq) \rightarrow CO_2(g) + H_2O(l)$$

FA 3 is an aqueous solution of **FA 1** containing 15.50 g dm^{-3} of the metal carbonate.
FA 4 is a solution of hydrochloric acid containing 4.02 g dm^{-3} of HC*l*.
FA 5 is bromophenol blue indicator.

(a) Method

- Fill the burette with **FA 4**.
- Pipette 25.0 cm^3 of **FA 3** into a conical flask.
- Add a few drops of **FA 5** into the same 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 results.
- Make sure any recorded results show the precision of your practical work.
- Record all your burette readings and the volume of **FA 4** added in each accurate titration.

I	
II	
III	
IV	
V	
VI	
VII	

[7]

(b) From your accurate titration results calculate a suitable mean value to be used in your calculations. Show clearly how you obtained the mean value.

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

DO NOT WRITE IN THIS MARGIN

(c) **Calculations**

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

(ii) Calculate the amount, in mol, of hydrochloric acid present in the volume of **FA 4** calculated in **(b)**.

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

(iii) Calculate the concentration, in $mol\,dm^{-3}$, of metal carbonate in **FA 3**.

concentration of metal carbonate in **FA 3** = ... $mol\,dm^{-3}$ [1]

(iv) Calculate the relative formula mass, M_r, of the metal carbonate in **FA 1**.

M_r of metal carbonate = ... [1]

(v) The metal carbonate in **FA 1** is hydrated sodium carbonate, Na_2CO_3•**x**H_2O.
Calculate the value of **x** to the nearest whole number. Show your working.

x = ... [1]

(d) Describe a different method to determine the value of **x** in **FA 1**.
This method should **not** involve the reaction of an acid. Explain how the method will ensure that the value of **x** is as accurate as possible.

....

....

....

....

....

.... [2]

[Total: 15]

Qualitative Analysis

For each test you should record all your observations in the spaces provided.

Examples of observations include:
- colour changes seen
- the formation of any precipitate and its solubility (where appropriate) in an excess of the reagent added
- the formation of any gas and its identification (where appropriate) by a suitable test.

You should record clearly at what stage in a test an observation is made.

Where no change is observed, you should write ‘no change’.

Where reagents are selected for use in a test, the name or correct formula of the element or compound must be given.

If any solution is warmed, a boiling tube must be used. If a solid is heated, a hard-glass test-tube must be used.

Rinse and reuse test-tubes and boiling tubes where possible.

No additional tests should be attempted.

3 **(a)** **(i)** **FA 6** contains one cation and one anion both of which are listed in the Qualitative analysis notes.

Heat a small spatula measure of **FA 6** in a hard-glass test-tube, until no further change occurs.

Record **all** your observations. Identify any gas produced.

....

....

....

....

.... [3]

(ii) Allow the residue to cool for 2 minutes. Then transfer a **small** quantity of the residue from **(a)(i)** into a test-tube containing a 2 cm depth of dilute sulfuric acid. Shake the test-tube.

Record your observations.

....

.... [1]

(iii) Give the equation for the reaction in **(a)(ii)**.
Include state symbols.

.... [1]

(b) **FA 7** is a sample of the solution produced by the experiment described in **(a)(ii)**.
FA 8 is a solution of a salt containing one anion.

(i) Use a 1 cm depth of **FA 7** in a test-tube for each of the following tests.
Record your observations in Table 3.1.

Table 3.1

test	*observations*
Test 1 Add aqueous sodium hydroxide.	
Test 2 Add aqueous ammonia, then	
add dilute hydrochloric acid.	
Test 3 Add aqueous sodium carbonate.	
Test 4 Add several drops of **FA 8**, then	
add a few drops of aqueous starch.	
Test 5 Add a small spatula measure of iron powder. Leave the test-tube to stand.	
Test 6 Add a few drops of aqueous barium nitrate **or** aqueous barium chloride.	

[6]

(ii) Carry out a different test from those you have already carried out in **(b)(i)** to confirm the identity of the anion in **FA 8**.
Record the reagent(s) used and your observations and give the formula of the anion.

The formula of the anion in **FA 8** is .... [2]

(iii) List **all** the numbered tests you carried out in **(b)(i)** which involved redox reactions.

.... [1]

(iv) Give the **ionic** equation for the reaction taking place in **Test 5** in **(b)(i)**.
Include state symbols.

.... [1]

[Total: 15]

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Qualitative analysis notes

1 Reactions of cations

cation	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 warming	–
barium, Ba^{2+}(aq)	faint white ppt. is observed unless [Ba^{2+}(aq)] is very low	no ppt.
calcium, Ca^{2+}(aq)	white ppt. unless [Ca^{2+}(aq)] is very low	no ppt.
chromium(III), Cr^{3+}(aq)	grey-green ppt. soluble in excess giving dark green solution	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

anion	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 / off-white ppt. with Ag^+(aq) (partially soluble in NH_3(aq))
iodide, I^-(aq)	gives pale 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; decolourises acidified aqueous $KMnO_4$
sulfate, SO_4^{2-}(aq)	gives white ppt. with Ba^{2+}(aq) (insoluble in excess dilute strong acids); gives white ppt. with high [Ca^{2+}(aq)]
sulfite, SO_3^{2-}(aq)	gives white ppt. with Ba^{2+}(aq) (soluble in excess dilute strong acids); decolourises acidified aqueous $KMnO_4$
thiosulfate, $S_2O_3^{2-}$(aq)	gives off-white/pale yellow ppt. slowly with H^+

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
hydrogen, H_2	'pops' with a lighted splint
oxygen, O_2	relights a glowing splint

4 Tests for elements

element	test and test result
iodine, I_2	gives blue-black colour on addition of starch solution

Important values, constants and standards

molar gas constant	$R = 8.31\,J\,K^{-1}\,mol^{-1}$
Faraday constant	$F = 9.65 \times 10^{4}\,C\,mol^{-1}$
Avogadro constant	$L = 6.022 \times 10^{23}\,mol^{-1}$
electronic charge	$e = -1.60 \times 10^{-19}\,C$
molar volume of gas	$V_m = 22.4\,dm^3\,mol^{-1}$ at s.t.p. (101 kPa and 273 K) $V_m = 24.0\,dm^3\,mol^{-1}$ at room conditions
ionic product of water	$K_w = 1.00 \times 10^{-14}\,mol^2\,dm^{-6}$ (at 298 K (25 °C))
specific heat capacity of water	$c = 4.18\,kJ\,kg^{-1}\,K^{-1}$ ($4.18\,J\,g^{-1}\,K^{-1}$)

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 –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –

lanthanoids	57 La lanthanum 138.9	58 Ce cerium 140.1	59 Pr praseodymium 140.9	60 Nd neodymium 144.2	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 –