Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME										
CENTRE NUMBER						CANDIDATE NUMBER				

5247886750

CHEMISTRY **9701/34**

Paper 3 Advanced Practical Skills 2 **May/June 2023**

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.

DC (KN/JG) 310986/3

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

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

1 You will investigate the enthalpy change of neutralisation, ΔH_{neut}, between aqueous sodium hydroxide of known concentration and a dilute organic acid. You will use your results to suggest the identity of the organic acid. The acid is a halogenocarboxylic acid containing one halogen atom, **X**, per molecule.

$$NaOH(aq) + CH_3CH\mathbf{X}COOH(aq) \rightarrow CH_3CH\mathbf{X}COONa(aq) + H_2O(l)$$

FB 1 is 1.90 mol dm^{-3} sodium hydroxide, NaOH.
FB 2 is a solution containing 312.5 g dm^{-3} of the organic acid $CH_3CH\mathbf{X}COOH$.

(a) Method

- Support the cup in the 250 cm^3 beaker.
- Pipette 25.0 cm^3 of **FB 1** into the cup.
- Place the thermometer into **FB 1**. Record the temperature of **FB 1** in Table 1.1. This is the temperature when the volume of **FB 2** is 0.00 cm^3.

- Fill the burette with **FB 2**.
- Run 5.00 cm^3 of **FB 2** into the cup containing **FB 1**.
- Stir the mixture. Record the highest temperature observed.
- Run further 5.00 cm^3 portions of **FB 2** into the same cup.
- On each addition of **FB 2** stir the contents of the cup. Record the highest temperature after each addition.

I	
II	
III	

Results

Table 1.1

total volume of **FB 2** added / cm^3	0.00	5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00
temperature / °C									

[3]

(b) (i) Plot a graph of temperature (*y*-axis) against volume of **FB 2** added (*x*-axis) on the grid. Select a scale on the *y*-axis to include a temperature of 2 °C above your maximum thermometer reading. Label any points you consider to be anomalous.

Draw two lines of best fit, the first for the increase in temperature and the second for after the maximum temperature has been reached. Extrapolate the two lines so they intersect. This intersection corresponds to the volume of **FB 2** required to form a neutral solution.

I	
II	
III	
IV	

[4]

(ii) Use your graph to determine the volume of **FB 2** required to neutralise 25.0 cm^3 of **FB 1**.

25.0 cm^3 of **FB 1** required .... cm^3 of **FB 2**. [1]

(c) Calculations

(i) Calculate the energy change, in J, when the volume of **FB 2** recorded in **(b)(ii)** neutralises 25.0 cm^3 of **FB 1**.

energy change = ... J [1]

(ii) Calculate the amount, in mol, of sodium hydroxide, **FB 1**, pipetted into the cup.

amount of NaOH = ... mol [1]

(iii) Calculate the enthalpy change of neutralisation, ΔH_{neut}, in $kJ\,mol^{-1}$, for 1.00 mol of sodium hydroxide reacting with **FB 2**.

ΔH_{neut} = ... (*sign*) .... (*value*) $kJ\,mol^{-1}$ [1]

(iv) Use your answers to **(b)(ii)** and **(c)(ii)** and the information given on page 2 to calculate the relative formula mass, M_r, of the organic acid CH_3CH**X**$COOH$.
Show your working.

M_r of CH_3CH**X**$COOH$ = ... [1]

(v) The acid is known to be one of the following: $CH_3CHFCOOH$, $CH_3CHClCOOH$, $CH_3CHBrCOOH$ or $CH_3CHICOOH$.
Use your answer to **(c)(iv)** to identify the acid used to make solution **FB 2**.

The acid in **FB 2** is .... [1]

(vi) Calculate the percentage error in the relative formula mass, M_r, you calculated in **(c)(iv)**.

percentage error in M_r = ... % [1]

[Total: 14]

2 A gravimetric procedure can identify the metal in many metal carbonates. You will decompose a metal carbonate, **M**CO_3, by heating to produce the metal oxide and carbon dioxide. You may assume this metal forms a stable metal oxide on heating. **M** is **not** a transition metal.

$$\mathbf{M}CO_3(s) \rightarrow \mathbf{M}O(s) + CO_2(g)$$

FB 3 is the metal carbonate **M**CO_3.

(a) Method

- Weigh the crucible with its lid. Record the mass.
- Add between 0.90 g and 1.10 g of **FB 3** to the crucible.
- Weigh the crucible, lid and **FB 3**. Record the mass.
- Place the crucible on the pipe-clay triangle.
- Gently heat the crucible and contents for approximately 1 minute with the lid on.
- Remove the lid. Then heat the crucible and contents strongly for approximately 5 minutes.
- Replace the lid and leave the crucible to cool for at least 5 minutes.

While the crucible is cooling, 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.
- Calculate and record the mass of **FB 3** added to the crucible, the mass of residue obtained and the mass loss.

Keep the residue for use in 2(d).

Results

I	
II	
III	
IV	
V	

[5]

(b) Calculations

(i) Calculate the amount, in mol, of carbon dioxide lost on heating **FB 3**.

amount of CO_2 = ... mol [1]

(ii) Use your answer to **(b)(i)** and your data from **(a)** to calculate the relative formula mass, M_r, of **M**CO_3.

M_r of **M**CO_3 = ... [1]

(iii) Use your answer to **(b)(ii)** to suggest the identity of metal **M**.
Show your working.

M is .... [1]

(c) A student carrying out the same experiment as in **(a)** spills a small quantity of solid just before carrying out the final weighing.
State what effect this would have on the value of the M_r that is calculated for **M**CO_3.
Explain your answer.

....

....

.... [1]

(d) Normally, in this experiment, you would reheat and reweigh the crucible and contents until the mass is constant to ensure all the metal carbonate has decomposed.
Suggest a **chemical** test to determine whether all the metal carbonate has decomposed.

Record your test, observation and conclusion.

test ....

observation ....

conclusion ....
[2]

[Total: 11]

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.

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

No additional tests should be attempted.

3 Half fill the 250 cm^3 beaker with water and place it on a gauze on the tripod. Heat the water until boiling then switch off your Bunsen burner. This will be your hot water bath.

(a) **FB 4**, **FB 5** and **FB 6** are acids with the same concentration. Only one is an organic acid.

(i) Carry out the following tests and record your observations in Table 3.1.
Use a 1 cm depth of **FB 4**, **FB 5** or **FB 6** in a test-tube for each test.

Table 3.1

test	*observations*		
	FB 4	**FB 5**	**FB 6**
Test 1 Add 1 or 2 drops of acidified aqueous potassium manganate(VII), then			
place the test-tube in the hot water bath.			
Test 2 Add a few copper turnings and place the test-tube in the hot water bath for a few minutes.			
Test 3 Add a 1 cm strip of magnesium ribbon, then			
leave the test-tube for 3 minutes and then shake the test-tube gently.			
At the end of the experiments rinse the test-tubes thoroughly.			

[7]

(ii) Each of **FB 4**, **FB 5** and **FB 6** is one of the following acids: methanoic acid, nitric acid or sulfuric acid.
Use your observations to suggest the identity of each acid. Explain your answers.

FB 4 is ....

explanation ....

....

FB 5 is ....

explanation ....

....

FB 6 is ....

explanation ....

....
[3]

(b) The halogenocarboxylic acid in **FB 2** was hydrolysed by heating with excess aqueous sodium hydroxide. The resulting solution is **FB 7**.

(i) Carry out a test to check the identity of the halogen atom present in **FB 2**.
Use a 1 cm depth of **FB 7** in a test-tube for your test.
State your reagents and record your observations at each stage of your test.

From this test **only**, give the identity of the halogen present in **FB 2**.

The halogen is .... [3]

(ii) Give the equation for the hydrolysis reaction of the halogenocarboxylic acid, **FB 2**, with excess hot aqueous sodium hydroxide.
(If you were unable to identify the halogen in **(b)(i)**, then use the formula $CH_3CH\mathbf{X}COOH$.)

.... [2]

[Total: 15]

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

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 144.4	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 –