Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME	

CENTRE NUMBER		CANDIDATE NUMBER	

3068627395

CHEMISTRY **9701/33**

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.

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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 **FA 1** is an aqueous solution of a monoprotic organic acid. You will investigate the identity of **FA 1** by using a titration method to find its relative molecular mass, M_r.

FA 1 is an aqueous solution containing 6.20 $g\,dm^{-3}$ of a monoprotic organic acid.
FA 2 is 0.105 $mol\,dm^{-3}$ sodium hydroxide, NaOH.
thymol blue indicator

(a) Method

- Pipette 25.0 cm^3 of **FA 1** into a conical flask.
- Fill the burette with **FA 2**.
- Add several drops of thymol blue indicator to the conical flask.
- Carry out 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 accuracy of your practical work.
- Record in a suitable form below all of your burette readings and the volume of **FA 2** added in each accurate titration.

I	
II	
III	
IV	
V	
VI	
VII	

[7]

(b) From your accurate titration results, obtain a suitable value to be used in your calculations. Show clearly how you obtained this value.

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

(c) Calculations

(i) Calculate the number of moles of sodium hydroxide present in the volume of **FA 2** calculated in **(b)**.

moles of NaOH = ... mol [1]

(ii) Deduce the number of moles of the organic acid present in 25.0 cm^3 of **FA 1**.

moles of organic acid = ... mol

Hence calculate the concentration, in $mol\,dm^{-3}$, of the organic acid in **FA 1**.
Show your working.

concentration of the organic acid = ... $mol\,dm^{-3}$ [1]

(iii) Calculate the relative molecular mass, M_r, of the organic acid in **FA 1**.

M_r of the organic acid = ... [1]

(iv) From another experiment it is found that **FA 1** contains one of the following.

CH_3COOH HCOOH $C_2H_4C\mathit{l}COOH$ $CH_2CHCOOH$

NaOH(aq) reacts only with the COOH group in the acid.

Deduce which of these acids is present in **FA 1**. Explain your answer.

....

.... [1]

(d) This method of investigation uses the relative molecular mass of the acid. The relative molecular masses of C_2H_5COOH and $CH_2CHCOOH$ are similar so that any inaccuracy in the practical procedure could lead to an incorrect conclusion.

Suggest a chemical test that would enable you to distinguish between C_2H_5COOH and $CH_2CHCOOH$. Include the test and the results expected but do **not** carry out this test.

....

.... [1]

(e) A student is given a solution of another organic acid containing the same concentration, in $mol\,dm^{-3}$, as that used in **(a)**. The student assumes this acid is monoprotic but it is diprotic.

Explain the effect the student's assumption has on the value of the relative molecular mass that the student calculates.

....

....

.... [2]

[Total 15]

2 When an organic acid, RCOOH, is neutralised by an alkali an exothermic reaction takes place. You will determine the enthalpy change of neutralisation, ΔH, for the following reaction.

$$RCOOH(aq) + NaOH(aq) \rightarrow RCOONa(aq) + H_2O(l)$$

In this equation R is an alkyl group.

FA 3 is a solution containing 120.1 $g\,dm^{-3}$ of RCOOH.
FA 4 is aqueous sodium hydroxide, NaOH.

(a) Method

Experiment 1

- Support the cup in the 250 cm^3 beaker.
- Use the 25 cm^3 measuring cylinder to transfer 25.0 cm^3 of **FA 3** into the cup.
- Measure and record the temperature of this **FA 3**. Rinse the thermometer.
- Place 25.0 cm^3 of **FA 4** into the 50 cm^3 measuring cylinder.
- Measure and record the temperature of the **FA 4** in the measuring cylinder. Rinse the thermometer.
- Tip the **FA 4** from the measuring cylinder into the cup. Stir, then measure and record the highest temperature reached.
- Calculate and record the average initial temperature of **FA 3** and **FA 4**.
- Calculate and record the difference between the average initial temperature and the highest temperature reached.
- Rinse and dry the cup for use in **Experiment 2**.

Experiment 2

- Repeat **Experiment 1** using 50.0 cm^3 of **FA 3** and **FA 4**. You will need to use the 25 cm^3 measuring cylinder twice to measure the **FA 3**.
- Calculate and record the average initial temperature of **FA 3** and **FA 4**.
- Calculate and record the difference between the average initial temperature and the highest temperature reached.

[4]

(b) Calculations

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

energy released = ... J [1]

(ii) Calculate the number of moles of RCOOH used in **Experiment 1**. Assume that the relative molecular mass, M_r, of RCOOH is 122.
Show your working.

moles of RCOOH = ... mol [2]

(iii) Calculate the enthalpy change of neutralisation, ΔH, of RCOOH. Assume that the sodium hydroxide is in excess.

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

(c) Each measuring cylinder can be read to an accuracy of ± 0.5 cm^3.

Calculate the total maximum percentage error in the volumes of solution measured in each of **Experiments 1** and **2**.

Experiment 1

total maximum percentage error = ... %

Experiment 2

total maximum percentage error = ... %
[2]

(d) A student repeated both experiments in **(a)** using hydrochloric acid in place of RCOOH.

Suggest how the temperature rise when using HCl would compare to the temperature rise recorded in **(a)**. Assume all volumes and concentrations of solutions, in mol dm^{-3}, are the same.

Explain your answer by considering the chemical bonds involved.

....

....

.... [2]

[Total: 12]

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 Half fill the beaker with water and place it on a tripod and gauze. Heat until the water begins to boil then switch off your Bunsen burner. This is the hot water bath.

For a test in **(a)(i)** you will need Tollens' reagent. Place a 2–3 cm depth of silver nitrate in a test-tube, add aqueous sodium hydroxide drop by drop until a small amount of brown precipitate is formed and then add aqueous ammonia drop by drop with shaking until the precipitate just dissolves. This is Tollens' reagent. When Tollens' reagent is used, ensure that all test-tubes are thoroughly rinsed immediately after use.

(a) **FA 5**, **FA 6** and **FA 7** are organic compounds each of which contains carbon, hydrogen and oxygen only.

(i) Carry out the following tests on **FA 5**, **FA 6** and **FA 7**. Use a 1 cm depth of organic compound in a test-tube for each test. One test has been done for you.

test	*observations*		
	FA 5	**FA 6**	**FA 7**
Test 1 Add 2,4-dinitrophenylhydrazine.	no visible reaction	orange precipitate formed	orange precipitate formed
Test 2 Add a 1 cm length of magnesium ribbon.			
Test 3 Add a 1 cm depth of Tollens' reagent, place the tube in the hot water bath and leave for a few minutes.			
Test 4 Add a few drops of acidified potassium manganate(VII), place the tube in the hot water bath and leave for a few minutes.			

[5]

(ii) Identify the organic functional group present in each of **FA 5**, **FA 6** and **FA 7**.

FA 5 contains the functional group ....

FA 6 contains the functional group ....

FA 7 contains the functional group ....

[3]

(b) **FA 8** contains one anion and one cation from those listed in the Qualitative Analysis Notes.

(i) In a hard-glass test-tube heat a spatula measure of **FA 8** gently at first and then more strongly. Record all your observations.

....

....

.... [1]

(ii) Describe tests that will allow you to identify the cation in **FA 8**.
Carry out these tests and record the tests and your observations in the space below.

[3]

(iii) Give the formula of the cation present in **FA 8**.

.... [1]

[Total: 13]

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 –