Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME										
CENTRE NUMBER						CANDIDATE NUMBER				

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CHEMISTRY **9701/35**

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 Ethanedioic acid forms salts with Group 1 metals. In this experiment you will identify the Group 1 metal ion, Z^+, present in an ethanedioate salt, $(COO)_2Z_2$. You will titrate a solution of the salt with acidified aqueous potassium manganate(VII). The equation for the reaction between manganate(VII) ions and ethanedioate ions in acidic solution is shown.

$$2MnO_4^-(aq) + 16H^+(aq) + 5(COO)_2^{2-}(aq) \rightarrow 2Mn^{2+}(aq) + 8H_2O(l) + 10CO_2(g)$$

FA 1 is 0.0200 mol dm^{-3} potassium manganate(VII), $KMnO_4$.
FA 2 is a solution containing 8.06 g dm^{-3} of an ethanedioate salt, $(COO)_2Z_2$.
FA 3 is dilute sulfuric acid, H_2SO_4.

(a) Method

- Fill the burette with **FA 1**.
- Pipette 25.0 cm^3 of **FA 2** into a conical flask.
- Use the measuring cylinder to transfer 25 cm^3 of **FA 3** into the same conical flask.
- Place the conical flask on the tripod and gauze and heat the conical flask until the temperature of the solution is approximately 70 °C.
- **Carefully** remove the hot conical flask and place it on the white tile under the burette.
- During titrations, add **FA 1**, **slowly at first**, until a permanent pale pink colour is formed. (The pink colour on initial addition may take several seconds to disappear.) If the reaction mixture turns brown, reheat it to approximately 70 °C. If the brown colour disappears, continue with the titration. If the brown colour remains, discard the contents of the flask and begin a new titration.
- Perform a rough titration (the end-point is a permanent pale pink colour) 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 of your burette readings and the volume of **FA 1** added in each accurate titration.

I	
II	
III	
IV	
V	
VI	
VII	

[7]

(b) From your accurate titration results, obtain a suitable value for the volume of **FA 1** 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 1**. [1]

(c) **Calculations**

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

(ii) Calculate the number of moles of manganate(VII) ions in the volume of **FA 1** calculated in **(b)**.

moles of MnO_4^- = ... mol [1]

(iii) Use the equation on page 2 to calculate the number of moles of ethanedioate ions in 25.0 cm^3 of **FA 2**.

moles of $(COO)_2^{2-}$ = ... mol [1]

(iv) Calculate the relative formula mass, M_r, of the ethanedioate salt, $(COO)_2Z_2$.

M_r of ethanedioate salt = ... [1]

(v) Calculate the relative atomic mass, A_r, of the Group 1 metal, Z, in the ethanedioate salt.
Show your working.

A_r of Z = ...

Hence identify Z.

Z is ....
[2]

[Total: 14]

2 In this experiment you will determine the value of x in the formula for hydrated manganese(II) sulfate, $MnSO_4{\bullet}xH_2O$, where x is an integer. You will do this by measuring the mass lost when a sample of hydrated manganese(II) sulfate is heated.

$$MnSO_4{\bullet}xH_2O(s) \rightarrow MnSO_4(s) + xH_2O(g)$$

FA 4 is hydrated manganese(II) sulfate, $MnSO_4{\bullet}xH_2O$.

(a) Method

- Weigh the crucible with a lid and record the mass.
- Add all the **FA 4** to the crucible.
- Reweigh the crucible with the lid and **FA 4**. Record the mass. Describe the appearance of **FA 4**.

appearance of **FA 4** ....

- Place the crucible in the pipe-clay triangle on top of the tripod.
- Heat the crucible **gently** with the lid on for approximately 1 minute.
- Remove the lid and then heat more strongly for a further 4 minutes.
- Replace the lid and allow the crucible to cool.
- **While the crucible is cooling you may wish to begin work on Question 3.**
- Once the crucible has cooled, reweigh the crucible with the lid and contents. Record the mass.
- Calculate and record the mass of **FA 4** added to the crucible, the mass of the residue and the mass of water lost.
- Describe the appearance of the residue.

appearance of the residue ....

I	
II	
III	
IV	
V	
VI	

[6]

(b) Calculations

(i) Calculate the number of moles of manganese(II) sulfate present in the residue. You may assume all the water of crystallisation has been removed.

moles of $MnSO_4$ = ... mol [1]

(ii) Calculate the number of moles of water lost.

moles of water lost = ... mol [1]

(iii) Calculate the value of x in $MnSO_4•xH_2O$.

x = ... [1]

(c) It is possible that **FA 4** did not lose all of the water of crystallisation in your experiment.

(i) Explain how you could modify the experiment to ensure all water has been removed.

....

.... [1]

(ii) Explain why your calculated value of x might not change if a small amount of water of crystallisation remained in the residue.

....

....

.... [1]

[Total: 11]

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 250 cm^3 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 part **(b)**.

(a) **FA 5** is a solution of a salt which contains one cation and at least one anion, all of which are listed in the Qualitative Analysis Notes.
Sulfur is not present in **FA 5**.

(i) To a 1 cm depth of **FA 5** in a test-tube add aqueous sodium hydroxide.

observation ....

.... [1]

(ii) You are to carry out tests to allow you to determine the anion present in **FA 5**.

Identify reagents for these tests, carry out these tests and record these tests and observations in a table.

[3]

(iii) Use your results to identify the ions present in **FA 5**.

formulae of ions present in **FA 5** .... [1]

(iv) Write an ionic equation for the expected reaction between **FA 5** and aqueous ammonia. Include state symbols.

.... [1]

(v) Carry out the following tests and record your observations.

test	*observations*
Test 1 To a 1 cm depth of **FA 5** in a test-tube, add a 1 cm depth of hydrogen peroxide, then	
add aqueous sodium hydroxide.	

[2]

(vi) Suggest what type of reaction occurred when hydrogen peroxide was added to **FA 5**.

.... [1]

(b) **FA 6**, **FA 7** and **FA 8** are butan-1-ol, butan-2-ol and methylpropan-2-ol, but not necessarily in that order.

(i) Carry out the following tests and record your observations.

test	*observations*		
	FA 6	**FA 7**	**FA 8**
Test 1 To a 1 cm depth of dilute sulfuric acid in a test-tube, add 2 or 3 drops of **FA 1**, $KMnO_4$, then add a few drops of the alcohol. Shake the tube and place it in the hot water bath. Shake the tube occasionally until there is no further change.			
Test 2 To a 1 cm depth of aqueous iodine in a test-tube, add a few drops of the alcohol, then add drops of aqueous sodium hydroxide until the iodine colour **just** disappears or remains unchanged. Place the test-tube in the hot water bath.			

[3]

(ii) Use your observations from **(b)(i)** to identify the alcohols.

alcohol	**FA**….
butan-1-ol	**FA**………….
butan-2-ol	**FA**………….
methylpropan-2-ol	**FA**………….

[2]

(iii) Write an equation for the oxidation of one of these alcohols with acidified $KMnO_4$.
Use [O] to represent the oxidising agent.

.... [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	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 –