

CANDIDATE
NAME

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CENTRE
NUMBER

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CANDIDATE
NUMBER

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CHEMISTRY

9701/36

Paper 3 Advanced Practical Skills 2

October/November 2017

2 hours

Candidates answer on the Question Paper.

Additional Materials: As listed in the Confidential Instructions

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Give details of the practical session and laboratory where appropriate, in the boxes provided.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO NOT WRITE IN ANY BARCODES.

Answer **all** questions.
Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.
Use of a Data Booklet is unnecessary.

Qualitative Analysis Notes are printed on pages 10 and 11.
A copy of the Periodic Table is printed on page 12.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [] at the end of each question or part question.

Session	
Laboratory	

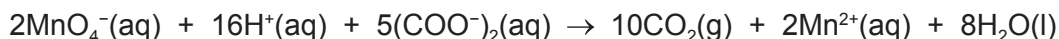
For Examiner's Use	
1	
2	
Total	

This document consists of **12** printed pages.

- 1 **FB 1** is a solution made by dissolving an unknown mass of a mixture of ethanedioic acid, $(\text{COOH})_2$, and sodium ethanedioate, $(\text{COONa})_2$. You will carry out two titrations to find the percentage by mass of ethanedioic acid in the mixture.

Titration 1

In aqueous solution both ethanedioic acid and sodium ethanedioate release all their ethanedioate ions, $(\text{COO}^-)_2$. These ions react with manganate(VII) ions as shown.



FB 1 is an aqueous solution of the mixture containing ethanedioic acid and sodium ethanedioate.

FB 2 is $0.0200 \text{ mol dm}^{-3}$ potassium manganate(VII), KMnO_4 .

FB 3 is 1.00 mol dm^{-3} sulfuric acid, H_2SO_4 .

(a) Method

- Fill a burette with **FB 2**.
- Pipette 25.0 cm^3 of **FB 1** into a conical flask.
- Use the measuring cylinder to add 30 cm^3 of **FB 3** to the same conical flask.
- Place the conical flask on the tripod and gauze and heat until the solution is at a temperature of approximately 70°C .
- **Carefully** remove the flask from the tripod and place it under the burette, ready for the titration.
- Add **FB 2** from the burette, slowly at first, until a permanent pale pink colour is formed. If the reaction mixture turns brown, reheat it to about 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 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 **FB 2** added in each accurate titration.

I	
II	
III	
IV	
V	
VI	

[6]

- (b) From your accurate titration results, obtain a suitable value for the volume of **FB 2** to be used in your calculations.

Show clearly how you obtained this value.

25.0 cm³ of **FB 1** required cm³ of **FB 2**. [1]

(c) Calculations

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

- (i) Calculate the number of moles of manganate(VII) ions in the volume of **FB 2** calculated in (b).

moles of MnO_4^- = mol

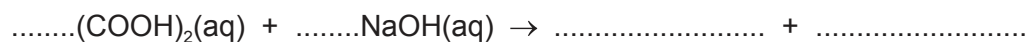
- (ii) Calculate the total number of moles of ethanedioate ions present in 25.0 cm³ of **FB 1**.

total moles of $(\text{COO}^-)_2$ = mol
[2]

Titration 2

Ethanedioic acid reacts with aqueous sodium hydroxide. In this reaction both the H^+ ions formed by the acid molecule react.

(d) Complete the equation showing the reaction between ethanedioic acid and sodium hydroxide including state symbols.



[1]

FB 4 is $0.0400 \text{ mol dm}^{-3}$ sodium hydroxide, NaOH.
thymol blue indicator

(e) Method

- Fill the second burette with **FB 4**.
- Pipette 25.0 cm^3 of **FB 1** into a conical flask.
- Add about 10 drops of thymol blue indicator.
- Add **FB 4** from the burette until the end-point has been reached.
- 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 **FB 4** added in each accurate titration.

[4]

(f) Calculations

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

- (i) From your accurate titration results, obtain a suitable value for the volume of **FB 4** to be used in your calculations.

25.0 cm³ of **FB 1** required cm³ of **FB 4**.

- (ii) Calculate the number of moles of sodium hydroxide in the volume of **FB 4** calculated in (i).

moles of NaOH = mol

- (iii) Use your equation from (d) to calculate the number of moles of ethanedioic acid present in 25.0 cm³ of **FB 1**.

moles of (COOH)₂ = mol
[1]

- (g) (i) Use your answers to (c)(ii) and (f)(iii) to calculate the number of moles of sodium ethanedioate, (COONa)₂, present in 25.0 cm³ of **FB 1**.

moles of (COONa)₂ = mol

- (ii) Calculate the mass of sodium ethanedioate present in 25.0 cm³ of **FB 1**.

mass of (COONa)₂ = g

- (iii) Use your answer to (f)(iii) to calculate the mass of ethanedioic acid present in 25.0 cm³ of **FB 1**.

mass of (COOH)₂ = g

- (iv) Calculate the percentage by mass of ethanedioic acid in the solid mixture used to prepare **FB 1**.

percentage by mass of (COOH)₂ = %
[5]

- (h) A student checked the formula of ethanedioic acid on the internet and found it to be (COOH)₂·2H₂O. This differs from the formula (COOH)₂ that you used in your calculations.

The **FB 1** you used was made from (COOH)₂·2H₂O and sodium ethanedioate.

State and explain the effect this knowledge has on;

- (i) the volume of **FB 4** needed for reaction in (e),

.....
.....
.....

- (ii) the calculated percentage by mass of (COOH)₂ in the solid mixture used to prepare **FB 1**.

.....
.....
.....

[2]

- (i) Another student suggested that the investigation could be improved by making the titrations more accurate. He said that the concentrations of **FB 2** and **FB 4** should be reduced.

State and explain whether or not this suggestion would make the titrations more accurate.

.....
..... [1]

[Total: 23]

2 Qualitative Analysis

At each stage of any test you are to record details of the following:

- colour changes seen;
- the formation of any precipitate;
- the solubility of such precipitates in an excess of the reagent added.

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

Where gases are released they should be identified by a test, **described in the appropriate place in your observations**.

You should indicate clearly at what stage in a test a change occurs.

No additional tests for ions present should be attempted.

If any solution is warmed, a boiling tube MUST be used.

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

FB 5, **FB 6** and **FB 7** are aqueous solutions that each have an ion containing one of the metals from those listed in the Qualitative Analysis Notes.

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

<i>test</i>	<i>observations</i>
(i) To a 1 cm depth of FB 5 in a test-tube add a 1 cm depth of aqueous sodium hydroxide, then	
add several drops of hydrogen peroxide.	
(ii) To a 1 cm depth of FB 6 in a test-tube add aqueous sodium hydroxide.	
(iii) To a 1 cm depth of FB 6 in a test-tube add several drops of hydrogen peroxide and then add aqueous sodium hydroxide.	
(iv) To a 1 cm depth of FB 6 in a test-tube add a 1 cm depth of dilute sulfuric acid and then add a few drops of FB 7 .	
(v) To a 1 cm depth of FB 6 in a test-tube add a 1 cm depth of FB 7 .	
(vi) To a 1 cm depth of aqueous potassium iodide in a test-tube add a few drops of FB 7 , then	
add a few drops of aqueous starch.	

[8]

(b) Identify the metal present in **FB 5**, **FB 6** and **FB 7**.

FB 5 contains

FB 6 contains

FB 7 contains

[3]

- (c) What do your observations in (a)(vi) tell you about what has happened to the iodide ions on addition of **FB 7** to KI(aq)?

You may give your answer in the form of an equation.

..... [1]

- (d) (i) **FB 8** is a solid sample of the compound present in aqueous solution **FB 7**.
Heat all of **FB 8** in a hard-glass test-tube gently for about 10s and then strongly for about 20s.

observations

.....

- (ii) Leave the test-tube and contents to cool completely.

To the cooled test-tube add a 1 cm depth of aqueous sodium hydroxide. Observe the appearance of the contents of the test-tube.

appearance

[2]

- (e) **FB 6** contains one of the anions Cl^- , Br^- , I^- , SO_4^{2-} or SO_3^{2-} .

- (i) Construct a table to show reagents you would use to identify which anion is present in **FB 6**. Include in your table space to record your observations and deductions.

- (ii) Carry out your tests on **FB 6** until you have identified the anion. Record your observations and deductions in your table.

anion in **FB 6** = [3]

[Total: 17]

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

<i>ion</i>	<i>reaction</i>
carbonate, CO_3^{2-}	CO_2 liberated by dilute acids
chloride, $\text{Cl}^-(\text{aq})$	gives white ppt. with $\text{Ag}^+(\text{aq})$ (soluble in $\text{NH}_3(\text{aq})$)
bromide, $\text{Br}^-(\text{aq})$	gives cream ppt. with $\text{Ag}^+(\text{aq})$ (partially soluble in $\text{NH}_3(\text{aq})$)
iodide, $\text{I}^-(\text{aq})$	gives yellow ppt. with $\text{Ag}^+(\text{aq})$ (insoluble in $\text{NH}_3(\text{aq})$)
nitrate, $\text{NO}_3^-(\text{aq})$	NH_3 liberated on heating with $\text{OH}^-(\text{aq})$ and Al foil
nitrite, $\text{NO}_2^-(\text{aq})$	NH_3 liberated on heating with $\text{OH}^-(\text{aq})$ and Al foil; NO liberated by dilute acids (colourless $\text{NO} \rightarrow$ (pale) brown NO_2 in air)
sulfate, $\text{SO}_4^{2-}(\text{aq})$	gives white ppt. with $\text{Ba}^{2+}(\text{aq})$ (insoluble in excess dilute strong acids)
sulfite, $\text{SO}_3^{2-}(\text{aq})$	gives white ppt. with $\text{Ba}^{2+}(\text{aq})$ (soluble in excess dilute strong acids)

3 Tests for gases

<i>gas</i>	<i>test and test result</i>
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

		Group															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">1 H hydrogen 1.0</div> <div style="border: 1px solid black; padding: 2px;">2 He helium 4.0</div> </div>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">3 Li lithium 6.9</div> <div style="border: 1px solid black; padding: 2px;">4 Be beryllium 9.0</div> </div>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">5 B boron 10.8</div> <div style="border: 1px solid black; padding: 2px;">6 C carbon 12.0</div> <div style="border: 1px solid black; padding: 2px;">7 N nitrogen 14.0</div> <div style="border: 1px solid black; padding: 2px;">8 O oxygen 16.0</div> <div style="border: 1px solid black; padding: 2px;">9 F fluorine 19.0</div> </div>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">11 Na sodium 23.0</div> <div style="border: 1px solid black; padding: 2px;">12 Mg magnesium 24.3</div> </div>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">13 Al aluminium 27.0</div> <div style="border: 1px solid black; padding: 2px;">14 Si silicon 28.1</div> <div style="border: 1px solid black; padding: 2px;">15 P phosphorus 31.0</div> <div style="border: 1px solid black; padding: 2px;">16 S sulfur 32.1</div> <div style="border: 1px solid black; padding: 2px;">17 Cl chlorine 35.5</div> </div>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">19 K potassium 39.1</div> <div style="border: 1px solid black; padding: 2px;">20 Ca calcium 40.1</div> </div>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">21 Sc scandium 45.0</div> <div style="border: 1px solid black; padding: 2px;">22 Ti titanium 47.9</div> <div style="border: 1px solid black; padding: 2px;">23 V vanadium 50.9</div> <div style="border: 1px solid black; padding: 2px;">24 Cr chromium 52.0</div> <div style="border: 1px solid black; padding: 2px;">25 Mn manganese 54.9</div> <div style="border: 1px solid black; padding: 2px;">26 Fe iron 55.8</div> <div style="border: 1px solid black; padding: 2px;">27 Co cobalt 58.9</div> <div style="border: 1px solid black; padding: 2px;">28 Ni nickel 58.7</div> <div style="border: 1px solid black; padding: 2px;">29 Cu copper 63.5</div> <div style="border: 1px solid black; padding: 2px;">30 Zn zinc 65.4</div> </div>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">37 Rb rubidium 85.5</div> <div style="border: 1px solid black; padding: 2px;">38 Sr strontium 87.6</div> </div>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">39 Y yttrium 88.9</div> <div style="border: 1px solid black; padding: 2px;">40 Zr zirconium 91.2</div> <div style="border: 1px solid black; padding: 2px;">41 Nb niobium 92.9</div> <div style="border: 1px solid black; padding: 2px;">42 Mo molybdenum 95.9</div> <div style="border: 1px solid black; padding: 2px;">43 Tc technetium —</div> <div style="border: 1px solid black; padding: 2px;">44 Ru ruthenium 101.1</div> <div style="border: 1px solid black; padding: 2px;">45 Rh rhodium 102.9</div> <div style="border: 1px solid black; padding: 2px;">46 Pd palladium 106.4</div> <div style="border: 1px solid black; padding: 2px;">47 Ag silver 107.9</div> <div style="border: 1px solid black; padding: 2px;">48 Cd cadmium 112.4</div> </div>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">55 Cs caesium 132.9</div> <div style="border: 1px solid black; padding: 2px;">56 Ba barium 137.3</div> </div>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">57–71 lanthanoids</div> <div style="border: 1px solid black; padding: 2px;">72 Hf hafnium 178.5</div> <div style="border: 1px solid black; padding: 2px;">73 Ta tantalum 180.9</div> <div style="border: 1px solid black; padding: 2px;">74 W tungsten 183.8</div> <div style="border: 1px solid black; padding: 2px;">75 Re rhenium 186.2</div> <div style="border: 1px solid black; padding: 2px;">76 Os osmium 190.2</div> <div style="border: 1px solid black; padding: 2px;">77 Ir iridium 192.2</div> <div style="border: 1px solid black; padding: 2px;">78 Pt platinum 195.1</div> <div style="border: 1px solid black; padding: 2px;">79 Au gold 197.0</div> <div style="border: 1px solid black; padding: 2px;">80 Hg mercury 200.6</div> </div>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">87 Fr francium —</div> <div style="border: 1px solid black; padding: 2px;">88 Ra radium —</div> </div>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">89–103 actinoids</div> <div style="border: 1px solid black; padding: 2px;">104 Rf rutherfordium —</div> <div style="border: 1px solid black; padding: 2px;">105 Db dubnium —</div> <div style="border: 1px solid black; padding: 2px;">106 Sg seaborgium —</div> <div style="border: 1px solid black; padding: 2px;">107 Bh bohrium —</div> <div style="border: 1px solid black; padding: 2px;">108 Hs hassium —</div> <div style="border: 1px solid black; padding: 2px;">109 Mt meitnerium —</div> <div style="border: 1px solid black; padding: 2px;">110 Ds darmstadtium —</div> <div style="border: 1px solid black; padding: 2px;">111 Rg roentgenium —</div> <div style="border: 1px solid black; padding: 2px;">112 Cn copernicium —</div> </div>															

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
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 —

lanthanoids

actinoids