Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME			
CENTRE NUMBER		CANDIDATE NUMBER	

2405188868

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, $(COOH)_2$, and sodium ethanedioate, $(COONa)_2$. 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, $(COO^-)_2$. These ions react with manganate(VII) ions as shown.

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

FB 1 is an aqueous solution of the mixture containing ethanedioic acid and sodium ethanedioate.
FB 2 is 0.0200 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 cm^3 of **FB 1** required .... cm^3 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 cm^3 of **FB 1**.

total moles of $(COO^-)_2$ = ... 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.

........$(COOH)_2(aq)$ + ...NaOH(aq) → .... + ...

[1]

FB 4 is 0.0400 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 cm^3 of **FB 1** required .... cm^3 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 cm^3 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 cm^3 of **FB 1**.

moles of $(COONa)_2$ = ... mol

(ii) Calculate the mass of sodium ethanedioate present in 25.0 cm^3 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 cm^3 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 $(COOH)_2.2H_2O$. This differs from the formula $(COOH)_2$ that you used in your calculations.

The **FB 1** you used was made from $(COOH)_2.2H_2O$ 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.

	test	*observations*
(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 10 s and then strongly for about 20 s.

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

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; NO liberated by dilute acids (colourless NO $\rightarrow$ (pale) brown NO_2 in air)
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 –