Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME	
CENTRE NUMBER	
CANDIDATE NUMBER	

8542704584

CHEMISTRY **9701/32**

Paper 3 Advanced Practical Skills 2 **May/June 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 14 and 15.
A copy of the Periodic Table is printed on page 16.

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	
3	
Total	

This document consists of **14** printed pages and **2** blank pages.

IB17 06_9701_32/4RP

CAMBRIDGE International Examinations

[Turn over

1 HA is an organic acid where A^- is the anion. You will determine the relative formula mass, M_r, of HA by titration with sodium hydroxide of known concentration and so identify the anion, A^-. The equation for the reaction is shown.

$$HA(aq) + NaOH(aq) \rightarrow NaA(aq) + H_2O(l)$$

FB 1 is a solution of organic acid, HA, containing 12.60 g dm^{-3}.
FB 2 is 0.100 mol dm^{-3} sodium hydroxide, NaOH.
thymol blue indicator

(a) Method

- Fill the burette with **FB 1**.
- Pipette 25.0 cm^3 of **FB 2** into a conical flask.
- Add approximately 10 drops of thymol blue indicator. This indicator is blue in alkaline solutions and yellow in acidic solutions.
- 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 certain that 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 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 **FB 1** to be used in your calculations. Show clearly how you obtained this value.

25.0 cm^3 of **FB 2** required .... cm^3 of **FB 1**.
[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 sodium hydroxide present in 25.0 cm^3 of **FB 2** pipetted into the conical flask.

moles of NaOH = ... mol

(ii) Use your answers to **(b)** and **(c)(i)** to determine the concentration of the organic acid HA, in **FB 1**, in mol dm^{-3}.

concentration of HA in **FB 1** = ... mol dm^{-3}

(iii) Use your answer to **(ii)** and the information given on page 2 to determine the relative formula mass, M_r, of the organic acid, HA.

M_r of HA = ...

(iv) The organic acid was known to have one of the following structural formulae.

CH_3COOH $CH_2ClCOOH$ $CHCl_2COOH$ CCl_3COOH

Use your answer to **(iii)** and the Periodic Table on page 16 to identify the anion, A^-.

anion, A^- = ...

[4]

(d) A student carried out the same procedure accurately but was supplied with a solution of less concentrated sodium hydroxide by mistake.

(i) What effect would this have on the calculated value of the relative formula mass, M_r? Explain your answer.

....

....

(ii) Explain how this would affect the identification of the acid.

....

....
[2]

[Total: 14]

2 You are to determine the enthalpy change of neutralisation for a different acid from that used in **Question 1**. The acid is represented by HB where B^- represents the anion.

$$HB(aq) + NaOH(aq) \rightarrow NaB(aq) + H_2O(l)$$

FB 3 is 2.00 mol dm^{-3} acid, HB.
FB 4 is 72.00 g dm^{-3} sodium hydroxide, NaOH.

(a) Method

Read through the method before starting your practical work and prepare a table below for recording your results.

Experiment 1

- Place the plastic cup in the 250 cm^3 beaker.
- Pour 25 cm^3 of **FB 3** into the larger measuring cylinder.
- Measure and record the temperature of **FB 3**.
- Rinse and dry the thermometer.
- Use the smaller measuring cylinder to transfer 25 cm^3 of **FB 4** into the plastic cup.
- Measure and record the temperature of **FB 4**.
- Add the 25 cm^3 of **FB 3** to **FB 4** in the plastic cup and stir the mixture. Measure and record the highest temperature reached.
- Calculate and record the average initial temperature of the solutions.
- Calculate and record the temperature rise.
- Empty the plastic cup, rinse it with water and shake it to remove excess water.

Experiment 2

- Repeat the method given for **Experiment 1** using 50 cm^3 of each solution.
- Use the larger measuring cylinder for **FB 3** and the smaller measuring cylinder for **FB 4**.

Results

I	
II	
III	
IV	

[4]

(b) Calculations

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

(i) Show by calculation that in **Experiment 1**, the number of moles of acid was in excess of the number of moles of sodium hydroxide.

(ii) Calculate the heat energy evolved in **Experiment 1**.
[Assume that 4.2 J of heat energy changes the temperature of 1.0 cm^3 of solution by 1.0 °C.]

heat energy evolved = ... J

(iii) Calculate the enthalpy change, in $kJ\,mol^{-1}$, for **Experiment 1**.

enthalpy change = ... (sign) .... (value) $kJ\,mol^{-1}$

(iv) Calculate the number of moles of sodium hydroxide neutralised in **Experiment 2**.

moles of NaOH = ... mol

(v) Calculate the enthalpy change, in $kJ\,mol^{-1}$, for **Experiment 2**.

enthalpy change = ... (sign) .... (value) $kJ\,mol^{-1}$

[5]

(c) (i) The accuracy of the larger measuring cylinder is ± 0.5 cm^3.
The accuracy of the smaller measuring cylinder is ± 0.25 cm^3.

Calculate the maximum percentage error in the measurement of the volume of **FB 3** used in **Experiment 2** and the measurement of the volume of **FB 4** used in **Experiment 2**.

Show your working.

maximum % error in volume of **FB 3** ....

maximum % error in volume of **FB 4** ....

(ii) Suggest a change to the method used in **(a)** that would improve the accuracy of your results.

....

....
[3]

[Total: 12]

3 **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.

(a) **FB 5** and **FB 6** are solutions of acids of equal concentration in $mol\,dm^{-3}$. One solution is a weak acid and the other is a strong acid.

(i) Devise and carry out a chemical test to find out which of **FB 5** and **FB 6** is the weak acid. Record your test, observations and conclusion in the space below.

(ii) Another acid, **FB 7**, is a dilute solution of one of hydrochloric, nitric or sulfuric acids.

Carry out the tests in the order given in the table below until you are able to identify **FB 7**. Record your observations. If any test is unnecessary write 'not needed'.

test	*observations*
To a 1 cm depth of **FB 7** in a test-tube add aqueous silver nitrate.	
To a 0.5 cm depth of **FB 7** in a boiling tube add a 1 cm depth of aqueous sodium hydroxide and a small piece of aluminium foil and warm.	
To a 1 cm depth of **FB 7** in a test-tube add aqueous barium chloride or aqueous barium nitrate.	

FB 7 is .... acid.

[6]

(b) **FB 8** contains a cation listed in the Qualitative Analysis Notes. **FB 9** is a solution of an organic salt. Carry out the following tests and record your observations.

test	*observations*
(i) To a 1 cm depth of **FB 8** in a test-tube add aqueous sodium carbonate.	
(ii) To a 1 cm depth of **FB 8** in a test-tube add a 1 cm depth of aqueous potassium iodide, then	
add aqueous sodium thiosulfate until in excess.	
(iii) To a 2 cm depth of **FB 8** in a test-tube add a 1 cm depth of concentrated hydrochloric acid **(CARE)**. Keep this solution for test **(iv)**.	
(iv) To a 2 cm depth of distilled water in a boiling tube add all the contents of the test-tube from test **(iii)**. Keep this solution for tests **(v)** and **(vi)**.	
Pour a 1 cm depth of the contents of the boiling tube into three separate test-tubes for use in tests **(v)** and **(vi)**. **One tube is to be used for comparing colours in your observations.**	
(v) To one of the test-tubes add aqueous ammonia until in excess.	
(vi) To a second test-tube add **FB 9** until in excess.	

(vii) Identify the cation in **FB 8**.

cation ....

(viii) Write an **ionic** equation for a precipitation reaction you observed during your experiments with this cation.
Include state symbols.

....

[8]

[Total: 14]

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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; 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											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	3	4	5	6	7	8	9	10	11	12	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 –