Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME	
CENTRE NUMBER	
CANDIDATE NUMBER	

9648031486

CHEMISTRY **9701/33**

Paper 3 Advanced Practical Skills 1 **May/June 2018**

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	
3	
Total	

This document consists of **11** printed pages and **1** blank page.

CAMBRIDGE International Examinations

[Turn over

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 Acids are defined as substances that can donate hydrogen ions, H^+, to bases. Monoprotic acids contain one H^+ that can be donated per molecule. Diprotic acids contain two H^+ that can be donated per molecule.

You will determine by a titration method whether acid **Z** is monoprotic or diprotic.

FA 1 is a solution containing 6.10 g dm^{-3} of acid **Z**.
FA 2 is 0.105 mol dm^{-3} aqueous sodium hydroxide, NaOH.
bromophenol blue indicator

(a) Method

- Pipette 25.0 cm^3 of **FA 1** into a conical flask.
- Fill a burette with **FA 2**.
- Add several drops of bromophenol 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 for the volume of **FA 2** 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

Then deduce the number of moles of H^+ present in 25.0 cm^3 of **FA 1**.

moles of H^+ in 25.0 cm^3 of **FA 1** = ... mol
[1]

(ii) Calculate the number of moles of H^+ present in 1 dm^3 of **FA 1**.

moles of H^+ in 1 dm^3 of **FA 1** = ... mol [1]

(iii) **FA 1** contains 6.10 g dm^{-3} of acid **Z**. The relative molecular mass of **Z** is 126.

Calculate the number of moles of **Z** in 1 dm^3 of **FA 1**.

moles of **Z** in 1 dm^3 of **FA 1** = ... mol [1]

(iv) Use your answers to **(ii)** and **(iii)** to determine whether **Z** is a monoprotic or a diprotic acid. Explain your answer.

....

.... [1]

[Total: 12]

2 When an acid reacts with an alkali the neutralisation reaction is always exothermic.

$$H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$$

You will determine the enthalpy change of neutralisation, Δ*H*, for a monoprotic acid **X**.

FA 3 is aqueous sodium hydroxide, NaOH.
FA 4 is a 2.00 mol dm^{-3} solution of monoprotic acid **X**.

(a) Method

- Support the plastic cup in the 250 cm^3 beaker.
- Fill the second burette with **FA 3**.
- Use the measuring cylinder to transfer 25.0 cm^3 of **FA 4** into the plastic cup.
- Measure and record the temperature of **FA 4** in the plastic cup.
- Add 5.00 cm^3 of **FA 3** from the burette into the plastic cup. Stir the contents of the cup. Read and record the maximum temperature of the solution.
- Add a further 5.00 cm^3 of **FA 3** from the burette into the cup. Stir the contents of the cup. Read and record the maximum temperature of the solution.
- Repeat the addition of **FA 3**, in 5.00 cm^3 portions, until 50.00 cm^3 have been added. Read and record the maximum temperature of the solution after each addition.

I	
II	
III	
IV	

[4]

(b) On the grid plot a graph of temperature, (*y*-axis), against volume of **FA 3** added, (*x*-axis). Your scale should allow a temperature of 2 °C above the maximum measured to be plotted.

On your graph draw two lines of best fit. One line should be for when the temperature was rising and the other for after the maximum temperature had been reached. You should indicate clearly any points you consider to be anomalous.

Extrapolate the lines so that they intersect. [4]

(c) From your graph, determine the maximum temperature reached in the experiment and the volume of **FA 3** added to produce this maximum temperature.

maximum temperature reached = ... °C

volume of **FA 3** added to reach maximum temperature = ... cm^3

[1]

(d) **(i)** Calculate the energy released during this experiment.

[Assume that 4.2 J of heat 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 acid **X** in 25.0 cm^3 of **FA 4**.

moles of **X** = ... mol [1]

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

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

(e) Without changing the apparatus or solutions used, suggest **one** way in which the experiment could be modified to make the values obtained in **(c)** more accurate.

....

.... [1]

(f) The enthalpy change of neutralisation of hydrochloric acid with aqueous sodium hydroxide is more exothermic than the enthalpy change of neutralisation of acid **X**.

Explain what this tells you about acid **X**.

....

....

....

.... [2]

[Total: 15]

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 **(a)** **FA 5**, **FA 6** and **FA 7** are 1.0 $mol\,dm^{-3}$ sulfuric acid, 0.1 $mol\,dm^{-3}$ sulfuric acid and 1.0 $mol\,dm^{-3}$ hydrochloric acid but not necessarily in that order.

You are to plan and carry out tests to determine the identities of **FA 5**, **FA 6** and **FA 7**. You should record, in a suitable form in the space below, your tests and observations. You should show clearly the observations for each of **FA 5**, **FA 6** and **FA 7** with all test reagents.

FA 5 is ....

FA 6 is ....

FA 7 is ....

[4]

(b) **FA 8** and **FA 9** each contain one anion and one cation.

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

For each test you should use a **small** spatula measure of **FA 8** or **FA 9**.

test	*observations*	
	FA 8	**FA 9**
Add a small spatula measure to a 1 cm depth of distilled water in a test-tube and shake. Add a few drops of universal indicator. Record the pH of the mixture.		
Heat a small spatula measure in a hard-glass test-tube.		
Dissolve a small spatula measure in a 2 cm depth of dilute hydrochloric acid in a boiling tube (heat gently if necessary). Place a 1 cm depth of this solution into two test-tubes.		
To one test-tube, add aqueous sodium hydroxide.		
To the second test-tube, add aqueous ammonia.		

[6]

(ii) Mix a spatula measure of **FA 8** with a spatula measure of **FA 9**. Heat the mixture in a hard-glass test-tube. Record your observations.

....

....

.... [1]

(iii) From your observations in **(b)(i)** and **(b)(ii)** identify the ions present in **FA 8** and **FA 9**.
If you are unable to identify an ion, write 'unknown'.

FA 8 cation .... anion ....

FA 9 cation .... anion ....

[2]

[Total: 13]

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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

Group																	
1	2											13	14	15	16	17	18
				Key			1 H hydrogen 1.0										2 He helium 4.0
3 Li lithium 6.9	4 Be beryllium 9.0			atomic number atomic symbol name relative atomic mass								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 A*l* aluminium 27.0	14 Si silicon 28.1	15 P phosphorus 31.0	16 S sulfur 32.1	17 C*l* 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 T*l* 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 F*l* 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 –