Cambridge International AS & A Level

Cambridge Assessment International Education
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME			
CENTRE NUMBER		CANDIDATE NUMBER	

4629279920

CHEMISTRY **9701/32**

Paper 3 Advanced Practical Skills 2 **May/June 2019**

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 **12** printed pages.

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[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 Amidosulfonic acid is a monoprotic acid with the formula HSO_xNH_2. In this experiment you will determine the value of **x** in the formula by titration with an alkali.

FB 1 is amidosulfonic acid, HSO_xNH_2. You are supplied with approximately 3.0 g.
FB 2 is 0.110 mol dm^{-3} sodium hydroxide, NaOH.
thymolphthalein indicator

(a) Method

Preparing a solution of amidosulfonic acid

- Weigh the empty beaker. Record the mass.
- Add 2.50 – 2.70 g of **FB 1** to the beaker. Weigh the beaker and its contents. Record the mass.
- Calculate and record the mass of **FB 1** used.
- Add approximately 100 cm^3 of distilled water to the beaker and stir to dissolve **FB 1**.
- Transfer the solution to the 250 cm^3 volumetric flask.
- Rinse the beaker twice with approximately 20 cm^3 of distilled water each time and add to the volumetric flask.
- Add distilled water to the volumetric flask to make 250 cm^3 of solution.
- Shake the volumetric flask to mix the solution thoroughly and label it **FB 3**.

Titration of FB 3

- Fill the burette with **FB 2**.
- Pipette 25.0 cm^3 of **FB 3** into a conical flask.
- Add a few drops of thymolphthalein to the conical flask.
- Carry out a **rough** titration.
- Record your burette readings and the rough titre 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 **FB 2** added in each accurate titration.

I	
II	
III	
IV	
V	
VI	
VII	
VIII	

[8]

(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 3** required .... cm^3 of **FB 2**. [1]

(c) Calculations

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

(ii) Calculate the number of moles of sodium hydroxide, NaOH, in the volume of **FB 2** calculated in **(b)**.

moles of NaOH = ... mol [1]

(iii) One mole of sodium hydroxide neutralises one mole of amidosulfonic acid.

Complete the equation for the reaction of amidosulfonic acid with sodium hydroxide. Include state symbols.

......NaOH...... + ...HSO_xNH_2...... $\rightarrow$ .... + ...

State the number of moles of amidosulfonic acid that reacted with the number of moles of NaOH calculated in **(ii)**.

moles of HSO_xNH_2 = ... mol [1]

(iv) Use your results on page 2 and your answer to **(iii)** to calculate the relative formula mass, M_r, of amidosulfonic acid.

M_r of amidosulfonic acid = ... [1]

(v) Calculate the value of **x** in the formula of amidosulfonic acid, HSO_xNH_2.

x = ... [1]

(d) The salts produced from amidosulfonic acid are called amidosulfonates.

You are to carry out an experiment using **FB 1** to find out if barium amidosulfonate is soluble in water.

- Describe your experiment.
- Record your observation(s) **and** conclusion.

....

....

....

....

.... [2]

[Total: 16]

Question 2 starts on the next page.

2 When hydrated copper hydroxycarbonate, $CuCO_3.Cu(OH)_2.\mathbf{y}H_2O$ is heated, it decomposes as shown.

$$CuCO_3.Cu(OH)_2.\mathbf{y}H_2O(s) \rightarrow 2CuO(s) + CO_2(g) + (1 + \mathbf{y})H_2O(g)$$

In this experiment, you will heat hydrated copper hydroxycarbonate to decompose it. You will use your results to investigate the value of **y**.

FB 4 is hydrated copper hydroxycarbonate, $CuCO_3.Cu(OH)_2.\mathbf{y}H_2O$.

(a) Method

- Weigh the crucible with its lid and record the mass.
- Add all the **FB 4** from the container into the crucible.
- Weigh the crucible and lid with **FB 4** and record the mass.
- Place the crucible and contents on the pipe-clay triangle.
- Heat the crucible and contents gently for approximately two minutes with the lid on.
- Use tongs to remove the lid and heat strongly for approximately three minutes.
- Replace the lid and leave the crucible and residue to cool for several minutes.

While the crucible is cooling, you may wish to begin work on Question 3.

- When the crucible is cool, reweigh it with its lid and contents. Record the mass.
- Calculate and record the mass of **FB 4** and the mass of residue obtained.

Results

I	
II	
III	
IV	

State the observations made while the decomposition of **FB 4** was taking place.

....

....
[4]

(b) Calculations

(i) Calculate the number of moles of copper oxide, CuO, obtained as residue.

moles of CuO obtained = ... mol [1]

(ii) Use your results to calculate the relative formula mass, M_r, of hydrated copper hydroxycarbonate, $CuCO_3.Cu(OH)_2.\mathbf{y}H_2O$.

M_r of $CuCO_3.Cu(OH)_2.\mathbf{y}H_2O$ = ... [2]

(iii) Use the Periodic Table to calculate the relative formula mass of $CuCO_3.Cu(OH)_2$.

M_r of $CuCO_3.Cu(OH)_2$ = ...

Use your answer to **(ii)** and this M_r to comment on the value of **y** in the formula of hydrated copper hydroxycarbonate.

....

.... [2]

(c) State **one** way to improve the accuracy of the experiment, using the same mass of **FB 4**.

....

.... [1]

[Total: 10]

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)** **FB 5** contains one cation and one anion from those listed in the Qualitative Analysis Notes.

(i) Transfer a **small** spatula measure of **FB 5** into a hard-glass test-tube.
Heat gently at first and then heat strongly, until no further change occurs.

Record **all** your observations.

....

....

....

....

....

.... [3]

(ii) To a 1 cm depth of dilute hydrochloric acid in a test-tube, add a **small** spatula measure of **FB 5**.

Record your observations.

....

....

....

.... [2]

(iii) Deduce the formula of **FB 5**.

.... [1]

(b) **FB 6** is a solution of a compound containing one cation from those listed in the Qualitative Analysis Notes.

(i) Carry out the following tests using a 1 cm depth of **FB 6** in a test-tube for each test.

test	*observations*
Add two drops of Universal Indicator solution.	
Add an equal volume of aqueous manganese(II) chloride.	
Add an equal volume of dilute sulfuric acid.	
Add a few drops of aqueous silver nitrate, then	
add aqueous ammonia.	
Add a few drops of aqueous copper(II) sulfate, then	
add excess dilute hydrochloric acid.	

[4]

(ii) What can be determined about **FB 6** from its reaction with manganese(II) chloride?

.... [1]

(iii) Give the ionic equation for the reaction between **FB 6** and sulfuric acid.
Include state symbols.

.... [1]

(iv) When aqueous copper(II) sulfate was added to **FB 6**, **two** precipitates were formed.

Deduce the identity of the two precipitates.

.... and ....

Explain the observation you made when you added excess dilute hydrochloric acid in the final test of **(b)(i)**.

....

....

....
[2]

[Total: 14]

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 –