Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME	
CENTRE NUMBER	
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CHEMISTRY **9701/34**

Paper 3 Advanced Practical Skills 2 **October/November 2020**

2 hours

You must answer on the question paper.

You will need: The materials and apparatus listed in the confidential instructions

INSTRUCTIONS
- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working, use appropriate units and use an appropriate number of significant figures.
- Give details of the practical session and laboratory, where appropriate, in the boxes provided.

Session
Laboratory

INFORMATION
- The total mark for this paper is 40.
- The number of marks for each question or part question is shown in brackets [ ].
- The Periodic Table is printed in the question paper.
- Notes for use in qualitative analysis are provided in the question paper.

For Examiner's Use	
1	
2	
3	
Total	

This document has **16** pages. Blank pages are indicated.

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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 Many hydrated salts lose water of crystallisation when heated.
You will identify the metal in a hydrated salt by heating the salt until it becomes anhydrous.

The equation for the dehydration of the hydrated salt, $X{\bullet}16H_2O$, is shown.

$$X{\bullet}16H_2O(s) \rightarrow X(s) + 16H_2O(g)$$

FB 1 is the hydrated salt, $X{\bullet}16H_2O$.

(a) Method

- Weigh a crucible with its lid and record the mass.
- Add between 1.8 g and 2.0 g of **FB 1** to the crucible.
- Weigh the crucible and lid with **FB 1** and record the mass.
- Place the crucible on the pipe-clay triangle. Gently heat the crucible and contents for approximately two minutes with the lid on.
- Remove the lid. Then heat the crucible and contents strongly for approximately four minutes.
- Replace the lid and leave the crucible and residue to cool for at least five minutes.

While the crucible is cooling, you may wish to begin work on Question 2 or 3.

- Reweigh the crucible and contents with the lid on. Record the mass.
- Remove the lid. Heat the crucible and contents strongly for a further two minutes.
- Replace the lid and leave the crucible and residue to cool for at least five minutes. Then reweigh the crucible and contents with the lid on. Record the mass.
- Calculate and record the mass of **FB 1** added to the crucible and the mass of residue obtained.

I	
II	
III	
IV	
V	

[5]

(b) Calculations

(i) Calculate the number of moles of water of crystallisation lost during heating of **FB 1**.

moles of H_2O lost = ... mol [1]

(ii) Use your answer to **(b)(i)** to calculate the number of moles of anhydrous residue, X, produced by the heating in **(a)**.

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

(iii) Calculate the relative formula mass of X.

M_r of X = ... [1]

(iv) X is the sulfate of a metal in Group 13 of the Periodic Table.

Calculate the relative atomic mass of the metal.
Show your working.

A_r of the metal = ... [1]

(v) Use your answer to **(b)(iv)** to identify the metal present in X.

The metal is .... [1]

(c) **(i)** Suggest why the crucible and contents were heated with the crucible lid on for the first two minutes of the experiment.

....

....

.... [1]

(ii) Suggest whether the experiment would be more accurate if you reheated the crucible and contents strongly for a **third** time.
Explain your answer.

....

....

.... [1]

[Total: 12]

2 In this experiment, you will determine the concentration of an alkali. You will mix different volumes of acid with a fixed volume of alkali and measure the temperature rise that occurs each time. You will then determine the enthalpy change for the neutralisation of the acid with the alkali.

FB 2 is aqueous sodium hydroxide, NaOH.
FB 3 is 1.95 mol dm^{-3} sulfuric acid, H_2SO_4.

(a) Method

- Use the thermometer to measure and record the initial temperature of **FB 2**.

initial temperature of **FB 2** = ... °C

- Support a plastic cup in the 250 cm^3 beaker.
- Fill one burette with **FB 3**. Label this burette **FB 3**.
- Fill the other burette with distilled water.

Experiment 1

- Use the 10 cm^3 pipette to transfer 10.0 cm^3 of **FB 2** into the plastic cup.
- Add 8.00 cm^3 of distilled water from the burette into the plastic cup.
- Add 2.00 cm^3 of **FB 3** from the burette into the plastic cup.
- Stir the mixture and measure the maximum temperature reached. (You may need to tilt the cup so that the bulb of the thermometer is completely immersed.) Record the maximum temperature.
- Empty, rinse and shake dry the plastic cup, ready for use in **Experiment 2**.

- Repeat this procedure to carry out experiments 2 to 5, using the volumes of **FB 2**, water and **FB 3** shown in the table. Record the maximum temperature reached in each experiment.

experiment	volume of **FB 2** / cm^3	volume of H_2O / cm^3	volume of **FB 3** / cm^3	maximum temperature / °C
1	10.0	8.00	2.00	
2	10.0	6.00	4.00	
3	10.0	4.00	6.00	
4	10.0	2.00	8.00	
5	10.0	0.00	10.00	
6	10.0			

I	
II	
III	
IV	
V	

Carry out **one** further experiment which will enable you to determine more precisely the minimum volume of **FB 3** that gives the highest maximum temperature. This is **Experiment 6**. Record the volumes of water and **FB 3** and the maximum temperature in the table above. [5]

(b) On the grid opposite, plot a graph of maximum temperature reached on the *y*-axis and volume of **FB 3** on the *x*-axis.
Select a scale on the *y*-axis which includes a temperature 3.0 °C above the maximum temperature reached.
Label any points you consider to be anomalous.

I	
II	
III	
IV	

Draw two **straight** lines of best fit on your graph. The first line is for increasing maximum temperature and the second after the maximum temperature was reached.

Extrapolate the two lines so that they intersect.

Use your graph to determine the volume of **FB 3** that reacts with 10.0 cm^3 of **FB 2**.

volume of **FB 3** = ... cm^3
[4]

(c) (i) Calculate the change in energy when the volume of **FB 3** in **(b)** is neutralised by **FB 2**, sodium hydroxide.
Assume that 4.2 J of energy changes the temperature of 1.0 cm^3 of solution by 1.0 °C.

energy change = ... J [1]

(ii) Calculate the number of moles of sulfuric acid in the volume of **FB 3** in **(b)**.
(If you were unable to answer **2(b)**, use 5.70 cm^3 as the volume of **FB 3**.)

moles of H_2SO_4 = ... mol [1]

(iii) Calculate the enthalpy change of neutralisation, in $kJ\,mol^{-1}$, for 1.00 mol of H_2SO_4 reacting with **FB 2**.

enthalpy change of neutralisation = ... $kJ\,mol^{-1}$ [1]
sign *value*

(iv) Write the equation for the neutralisation of **FB 3** with **FB 2**.
Include state symbols.

.... [1]

(v) Use your answer to **(c)(ii)** and the information on page 4 to calculate the concentration, in $mol\,dm^{-3}$, of NaOH in **FB 2**.

concentration of NaOH in **FB 2** = ... $mol\,dm^{-3}$ [1]

(d) Apart from using a more accurate thermometer, better insulation or taking more readings, suggest **one** modification to the **procedure** which would make the value for the enthalpy change of neutralisation calculated in **(c)(iii)** more accurate.

....

....

.... [1]

[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 The following information about the redox properties of some anions will be helpful.

anion	*property*
nitrite	easily oxidised
nitrate	cannot be oxidised
sulfite	easily oxidised
sulfate	cannot be oxidised

FB 4 and **FB 5** are solutions each containing one cation and one anion.
Both anions are listed in the Qualitative Analysis Notes.

(a) Carry out the tests and record your observations in the table.
Use a 1 cm depth of **FB 4** or **FB 5** in a test-tube for each test.

test	*observations*	
	FB 4	**FB 5**
Test 1 Add an equal volume of aqueous sodium carbonate.		
Test 2 Add aqueous ammonia.		
Test 3 Add a few drops of aqueous barium nitrate (or aqueous barium chloride).		
Test 4 Add an equal volume of dilute nitric acid. Allow to stand for one minute, then		
add a few drops of aqueous silver nitrate.		

[4]

(b) Carry out the following tests in boiling tubes and record your observations in the table.
Use a 1 cm depth of **FB 4** or **FB 5** for each test.

test	*observations*	
	FB 4	**FB 5**
Test 1 Add aqueous sodium hydroxide, then		
warm the mixture **gently and carefully**, then		
add one piece of aluminium foil to the mixture.		

[3]

(c) Using the information given at the start of the question, select **one** further test to enable you to identify the anions present in each of **FB 4** and **FB 5**.

- State the reagent(s) you will use for this test.
- Explain why this test will enable you to identify the anions in **FB 4** and **FB 5**.
- Carry out your test and record the observations.

reagent(s) ....

explanation ....

....

observations

[3]

(d) Write the formulae of the anions and cations present in **FB 4** and **FB 5**.
If the tests you carried out did not allow you to identify the ion, write 'unknown'.

FB 4: cation .... anion ....

FB 5: cation .... anion ....
[2]

(e) Give the ionic equation for **one** precipitation reaction you observed when using **FB 4**.
Include state symbols.

.... [1]

[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

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 –