Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME	

CENTRE NUMBER		CANDIDATE NUMBER	

* 0 7 4 4 5 9 0 1 3 9 *

CHEMISTRY **9701/34**

Paper 3 Advanced Practical Skills 2 **May/June 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 **12** pages. Blank pages are indicated.

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 **FB 1** is a solution of hydrated sodium carbonate, $Na_2CO_3{\bullet}xH_2O$, where x is an integer. You will determine the value of x in this compound by a titration method.

You will add **FB 1** to a known volume and concentration of hydrochloric acid, **FB 2**. The hydrochloric acid is in excess. You will then titrate the remaining acid with aqueous sodium hydroxide, **FB 3**.

FB 1 is a solution containing 37.5 g dm^{-3} hydrated sodium carbonate, $Na_2CO_3{\bullet}xH_2O$.
FB 2 is 0.200 mol dm^{-3} hydrochloric acid, HCl.
FB 3 is 0.100 mol dm^{-3} sodium hydroxide, NaOH.
bromophenol blue indicator

(a) Method

- Fill the burette with **FB 3**.
- For each titration:
  Use the **25 cm^3** pipette to place 25.0 cm^3 of **FB 2** into a conical flask.
  Use the **10 cm^3** pipette to place 10.0 cm^3 of **FB 1** into the same conical flask.
- Add a few drops of bromophenol blue indicator.
- Titrate the contents of the conical flask with **FB 3** from the burette.
- 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 3** added in each accurate titration.

I	
II	
III	
IV	
V	
VI	
VII	

[7]

(b) From your titration results, obtain a suitable value to be used in your calculations. Show clearly how you obtained this value.

volume of **FB 3** used in titration = ... cm^3 [1]

(c) Calculations

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

(ii) Calculate the number of moles of sodium hydroxide present in the volume of **FB 3** calculated in **(b)**.

moles of NaOH = ... mol

This number of moles of sodium hydroxide neutralises the remaining hydrochloric acid. Deduce the number of moles of remaining hydrochloric acid.

moles of remaining HCl = ... mol [1]

(iii) Calculate the initial number of moles of hydrochloric acid in each 25.0 cm^3 sample of **FB 2** pipetted into the conical flask.

initial moles of HCl in each sample of **FB 2** = ... mol

You have calculated
- the number of moles of remaining HCl
- the initial number of moles of HCl in each sample of **FB 2**.

Calculate the number of moles of hydrochloric acid neutralised by the $Na_2CO_3{\bullet}xH_2O$ in **FB 1** in each titration.

number of moles of HCl neutralised by the $Na_2CO_3{\bullet}xH_2O$ = ... mol [1]

(iv) Complete the equation. Include state symbols.

...... Na_2CO_3(aq) + ...HCl..... → .... + ... + ...

Deduce the number of moles of Na_2CO_3•xH_2O present in each 10.0 cm^3 sample of **FB 1**.

number of moles of Na_2CO_3•xH_2O present = ... mol [1]

(v) **FB 1** contains 37.5 g dm^{-3} Na_2CO_3•xH_2O.

Use your answer to **(c)(iv)** to calculate the relative formula mass, M_r, of Na_2CO_3•xH_2O.
Show your working.

relative formula mass of Na_2CO_3•xH_2O = ... [2]

(vi) Determine the value of x in the formula Na_2CO_3•xH_2O.

x = ... [1]

(d) A student suggested a different method.

- To 250 cm^3 of **FB 2**, add 100 cm^3 of **FB 1**.
- Pipette 25.0 cm^3 of this mixture of solutions into a conical flask.
- Titrate this mixture of solutions with **FB 3**.
- Repeat titrations until concordant results are achieved.

Comment on one disadvantage **or** one advantage of using this method rather than the method you used in **(a)**.

....

....

.... [1]

[Total: 16]

2 You will now investigate a different hydrated salt with the formula **M**SO_4•$7H_2O$, where **M** is a Group 2 metal. By heating a sample of **M**SO_4•$7H_2O$ to produce anhydrous **M**SO_4 you will determine its relative formula mass and hence identify **M**.

FB 4 is the hydrated salt **M**SO_4•$7H_2O$.

(a) Method

- Weigh the crucible with its lid. Record the mass.
- Place between 1.80 g and 2.20 g of **FB 4** in the crucible.
- Reweigh the crucible, its lid and contents and record the mass.
- Without the lid, place the crucible on the pipe-clay triangle and heat gently for approximately 1 minute and then strongly for approximately 4 minutes.
- Place the lid on the crucible and leave it to cool.
- You may wish to start **Question 3** while you are waiting for the crucible to cool.
- Reweigh the crucible, its lid and contents and record the mass.
- Calculate, and record, the mass of **FB 4**, the mass of residue after heating and the mass of water lost.

[4]

(b) Calculations

(i) Calculate the number of moles of water lost when your sample of **M**SO_4•$7H_2O$ was heated.

moles of water = ... mol [1]

(ii) Write the equation for the reaction that occurs when **M**SO_4•$7H_2O$ is heated. Include state symbols.

....

Deduce the number of moles of anhydrous salt, **M**SO_4, left after the heating.

moles of **M**SO_4 = ... mol
[1]

(iii) Calculate the relative formula mass, M_r, of **M**$SO_4•7H_2O$.

M_r of **M**$SO_4•7H_2O$ = ... [1]

(iv) Determine the relative atomic mass, A_r, of **M** and hence identify **M**.
Show your working.

A_r = ...

M is ....
[2]

(c) **(i)** In the method used above, the lid was placed on the crucible when the crucible was left to cool.

Explain why the lid was placed on the crucible.

....

.... [1]

(ii) Suggest and explain the effect on the calculated value of the relative atomic mass of **M** if the lid had not been placed on the crucible during cooling.

....

.... [1]

[Total: 11]

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 In this question you may need Tollens' reagent. To prepare this, place a 2–3 cm depth of aqueous silver nitrate in a test-tube, add aqueous sodium hydroxide drop by drop until a small amount of brown precipitate is formed and then add aqueous ammonia drop by drop with shaking until the precipitate just dissolves. This is Tollens' reagent. If Tollens' reagent is used, ensure that all test-tubes are thoroughly rinsed immediately after use.

Half fill the 250 cm^3 beaker with water and heat to boiling. Then turn off the Bunsen burner. This will be used as a hot water bath.

(a) **(i)** You are to investigate some reactions of solid **FB 5**.

To a 2 cm depth of aqueous ammonium vanadate(V) in a test-tube add a small spatula measure of **FB 5**. Leave for approximately 4 minutes with occasional shaking.

Record all the changes that you observe.

Keep the test-tube and its contents for use in the next test.

....

....

....

.... [2]

(ii) Transfer a 1 cm depth of the **solution** from **(a)(i)** into a test-tube and add acidified potassium manganate(VII) a few drops at a time until no further reaction occurs. At this stage the solution is pink because unreacted $KMnO_4$ is present.

Record all the changes that you observe.

....

....

.... [1]

(iii) State the type of reaction occurring in the test in **(a)(ii)**.

.... [1]

(iv) To a 1 cm depth of dilute sulfuric acid in a test-tube add a small spatula measure of **FB 5**. Record your observations. Place the test-tube in the hot water bath if necessary to start the reaction.

....

.... [2]

(b) **FB 6** is an aqueous solution that has been made by reacting solid **FB 5** with dilute sulfuric acid.

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

test	*observations*
Test 1 To a 1 cm depth of **FB 6** in a test-tube add aqueous sodium hydroxide.	
Test 2 To a 1 cm depth of **FB 6** in a test-tube add aqueous ammonia.	

[2]

(ii) Identify **FB 5**.

FB 5 is .... [1]

(iii) Give the equation for the reaction of **FB 5** with sulfuric acid to make **FB 6**. Include state symbols.

.... [1]

(c) **FB 7** is either ethanal, CH_3CHO, or propanone, CH_3COCH_3.

(i) Describe a test that would enable you to identify which of these compounds is present in **FB 7**. You should state the observation expected for ethanal and propanone.

test ....

....

expected observations

ethanal ....

propanone ....
[2]

(ii) Carry out this test on **FB 7**. Record the result of the test and hence identify **FB 7**.

result ....

FB 7 is ....

[1]

[Total: 13]

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 –