Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME	

CENTRE NUMBER						CANDIDATE NUMBER					

3406760508

CHEMISTRY **9701/32**

Paper 3 Advanced Practical Skills 2 **May/June 2021**

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.

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 Washing soda consists of hydrated sodium carbonate, $Na_2CO_3•10H_2O$. When it is stored it loses some of its water of crystallisation to leave $Na_2CO_3•xH_2O$. Since water has been lost x is no longer an integer.

You will carry out a titration to determine the value of x. You will titrate a solution of the sodium carbonate with hydrochloric acid.

The equation for the reaction is shown.

$$Na_2CO_3•xH_2O(aq) + 2HCl(aq) \rightarrow 2NaCl(aq) + CO_2(aq) + (x+1)H_2O(l)$$

FB 1 is an aqueous solution containing 11.30 g dm^{-3} of $Na_2CO_3•xH_2O$.
FB 2 is 0.100 mol dm^{-3} hydrochloric acid, HCl.
bromophenol blue indicator

(a) Method

- Fill the burette with **FB 2**.
- Pipette 25.0 cm^3 of **FB 1** into a conical flask.
- Add a few drops of bromophenol blue indicator.
- 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 your recorded results show the precision of your practical work.
- Record in a suitable form, in the space below, all of your burette readings and the volume of **FB 2** added in each accurate titration.

I	
II	
III	
IV	
V	
VI	
VII	

[7]

(b) From your accurate titration results, obtain a 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 1** required .... cm^3 of **FB 2**. [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 hydrochloric acid present in the volume of **FB 2** you calculated in **(b)**.

moles of HC*l* = ... mol [1]

(iii) Use the equation on page 2, and your answer to **(c)(ii)**, to calculate the concentration, in $mol\,dm^{-3}$, of $Na_2CO_3{\bullet}xH_2O$ present in **FB 1**.

concentration of $Na_2CO_3{\bullet}xH_2O$ = ... $mol\,dm^{-3}$ [1]

(iv) Calculate the value of x in this sample of $Na_2CO_3{\bullet}xH_2O$.

Show your working.

x = ... [3]

[Total: 14]

2 When anhydrous sodium carbonate dissolves in water the following reaction occurs.

$$Na_2CO_3(s) + aq \rightarrow 2Na^+(aq) + CO_3^{2-}(aq)$$

The enthalpy change for this reaction is the enthalpy change of solution of anhydrous sodium carbonate. Its value is –28.1 kJ mol^{-1}.

You will use this information to find the percentage purity of an impure sample of anhydrous sodium carbonate.

FB 3 is a sample of impure anhydrous sodium carbonate.

(a) Method

Experiment 1

- Weigh the cup and record the mass.
- Place between 1.9 g and 2.1 g of **FB 3** in the cup. Record the mass of the cup + **FB 3**.
- Calculate and record the mass of **FB 3** used.
- Support the cup in the beaker.
- Place 25.0 cm^3 of distilled water into the measuring cylinder. Measure and record the temperature of the water.
- Place the water in the cup and stir until all the solid dissolves.
- Place the thermometer in the solution and record the highest temperature reached. Tilt the cup if necessary so that the bulb of the thermometer is fully covered.
- Rinse the cup and shake dry ready to carry out **Experiment 2**.

Experiment 2

- Repeat the experiment using between 3.9 g and 4.1 g of **FB 3** and 25.0 cm^3 of water.
- Record your results in the same way as in **Experiment 1**.

Results

I	
II	
III	
IV	
V	

[5]

(b) Calculations

(i) Use your results from **Experiment 1** to calculate the heat energy, in J, released when the **FB 3** dissolves.
(Assume 4.2 J of heat energy changes the temperature of 1.0 cm^3 of solution by 1.0 °C.)

heat energy = ... J [1]

(ii) Use the information on page 4 to calculate the number of moles of anhydrous sodium carbonate needed to release the amount of energy in your answer to **(b)(i)**.

moles of Na_2CO_3 = ... mol [1]

(iii) Calculate the mass of anhydrous sodium carbonate present in the number of moles in your answer to **(b)(ii)**.

mass of Na_2CO_3 = ... g [1]

(iv) Use your answer to **(b)(iii)** to calculate the percentage purity of anhydrous sodium carbonate in **FB 3**.

percentage purity = ... [1]

(c) In **(b)(iv)** you calculated the percentage purity of anhydrous sodium carbonate in **FB 3**.

What did you assume about the impurity present?

....

.... [1]

(d) You carried out two experiments to measure the temperature change when anhydrous sodium carbonate was dissolved in water.

Complete the sentence below to explain which of these experiments was more accurate.

Your answer should not make reference to the fact that different masses of sodium carbonate were used.

Experiment .... was more accurate because ....

....

.... [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 (a) **FB 4** and **FB 5** each contain one cation and one anion from those listed in the Qualitative Analysis Notes.

Carry out the following tests and record your observations.

test	*observations*	
	FB 4	**FB 5**
Test 1 Heat a spatula measure of solid in a hard-glass test-tube gently at first and then more strongly, then		
leave the tube to cool.		
Test 2 To a small spatula measure of solid in a boiling tube add a 2 cm depth of dilute sulfuric acid.		

[5]

(b) **FB 6** is a solution prepared by reacting **FB 4** with dilute sulfuric acid.
FB 7 is a solution prepared by reacting **FB 5** with dilute sulfuric acid.
In each test use a 1 cm depth of **FB 6** or **FB 7** in a test-tube. Carry out the tests and record your observations.

test	*observations*	
	FB 6	**FB 7**
Test 1 Add a 1 cm depth of aqueous edta.		
Test 2 Add aqueous sodium hydroxide until no further reaction occurs.		
Test 3 Add aqueous ammonia until no further reaction occurs.		
Test 4 Add a 1 cm length of magnesium ribbon and leave to stand for a few minutes.		
Test 5 Add a 2 cm depth of aqueous potassium iodide, then		
add a few drops of starch indicator.		
Test 6 Add concentrated hydrochloric acid (CARE) drop by drop until no further change is seen. Wash the test-tube thoroughly with plenty of water once your observations are complete.		

[7]

(c) Complete the table with the formula of each cation and each anion in **FB 4** and **FB 5**. If you are unable to identify an ion write 'unknown'.

	FB 4	**FB 5**
cation		
anion		

[2]

(d) Write the ionic equation for the reaction between **FB 6** and magnesium. Include state symbols.

.... [1]

[Total: 15]

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	pale 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 –