Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

9533612219

CHEMISTRY **9701/33**

Paper 3 Advanced Practical Skills 1 **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. 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 Bleach is made by reacting chlorine with a cold solution of sodium hydroxide. This reaction produces sodium chlorate(I), NaC*l*O.

$$Cl_2(aq) + 2NaOH(aq) \rightarrow NaClO(aq) + NaCl(aq) + H_2O(l)$$

In this experiment you will determine the concentration of sodium chlorate(I) in a sample of bleach, **FA 1**.
To do this, you will react an acidified dilute solution of the bleach with iodide ions, I^-. This reaction produces iodine, I_2.

$$ClO^-(aq) + 2I^-(aq) + 2H^+(aq) \rightarrow I_2(aq) + Cl^-(aq) + H_2O(l)$$

The amount of iodine produced will then be determined by titration with thiosulfate ions, $S_2O_3^{2-}$.

$$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$$

FA 1 is a solution of bleach.
FA 3 is dilute sulfuric acid, H_2SO_4.
FA 4 is 0.500 mol dm^{-3} potassium iodide, KI.
FA 5 is 0.100 mol dm^{-3} sodium thiosulfate, $Na_2S_2O_3$.
starch indicator

(a) Method

Dilution

- Pipette 25.0 cm^3 of **FA 1** into the 250 cm^3 volumetric flask.
- Add distilled water to make 250 cm^3 of solution and shake the flask thoroughly.
- Label this flask **FA 2**.

Titration

- Fill a burette with **FA 5**.
- Rinse the pipette thoroughly with distilled water and then with a little **FA 2**.
- Pipette 25.0 cm^3 of **FA 2** into a conical flask.
- Use the measuring cylinder to add 20 cm^3 of **FA 3** to the conical flask.
- Use the measuring cylinder to add 15 cm^3 of **FA 4** to the conical flask. The solution will turn brown as iodine is produced.
- Add **FA 5** from the burette until the solution has turned yellow.
- Add 10 drops of starch indicator to the conical flask. The solution will turn blue-black.
- Continue to add more **FA 5** from the burette until the blue-black colour just disappears. This is the end-point of the titration.
- Carry out a rough titration and record your burette readings in the space provided.

The rough titre = ... cm^3.

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- Carry out as many accurate titrations as you think necessary to obtain consistent results.
- Make sure that your recorded results show the precision of your practical work.
- Record in a suitable form in the space below all your burette readings and the volume of **FA 5** added in each accurate titration.

Keep FA 4 and FA 5 for use in Question 3.

I	
II	
III	
IV	
V	
VI	
VII	

[7]

(b) From your accurate titration results, obtain a value for the volume of **FA 5** to be used in your calculations. Show clearly how you obtained this value.

25.0 cm^3 of **FA 2** required ..... cm^3 of **FA 5**.
[1]

(c) Calculations

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

(ii) Use your answer to **(b)** and the relevant equation on page 2 to calculate the number of moles of iodine that formed when 25.0 cm^3 of **FA 2** reacted with **FA 4**.

moles of I_2 = ... mol
[1]

(iii) Calculate the concentration of sodium chlorate(I) in **FA 1**.
Show your working.

concentration of NaC*l*O = ... mol dm^{-3}
[2]

(d) (i) In this method an excess of potassium iodide must be added to 25.0 cm^3 of **FA 2**.

Use your answer to **(c)(ii)** to show by calculation that the potassium iodide is in excess.

[1]

(ii) A student carries out the same method but the concentration of the potassium iodide solution is not stated.

What change to the practical procedure could the student make to check that the potassium iodide is in excess?
Explain your answer.

.....

.....

..... [2]

[Total: 15]

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2 In this experiment you will determine the value of *x* in the formula for hydrated sodium thiosulfate, $Na_2S_2O_3 \cdot xH_2O$. In this formula *x* is an integer.

FA 6 is hydrated sodium thiosulfate, $Na_2S_2O_3 \cdot xH_2O$.

(a) Method

- Support the cup in the 250 cm^3 beaker.
- Rinse the measuring cylinder thoroughly with distilled water.
- Use the measuring cylinder to transfer 20.0 cm^3 of distilled water into the cup.
- Measure and record the initial temperature of the water in the cup. Tilt the cup if necessary so that the bulb of the thermometer is fully covered.
- Weigh the stoppered container of **FA 6** and record the mass.
- Carefully add all the sample of **FA 6** to the water in the cup.
- Stir the mixture and record the minimum temperature.
- Reweigh the stoppered container and any residual **FA 6**. Record the mass.
- Calculate and record the mass of **FA 6** added to the water and the change in temperature.

I	
II	
III	
IV	

[4]

(b) Calculations

(i) Calculate the heat energy change in the reaction.
(Assume that 4.2 J are required to change the temperature of 1.0 cm^3 of solution by 1.0 °C.)

heat energy change = ... J
[1]

(ii) Use your answer to **(b)(i)** to calculate the relative formula mass, M_r, of hydrated sodium thiosulfate.

You should assume that the enthalpy change of hydration, ΔH_{hyd}, for $Na_2S_2O_3 \cdot xH_2O$ is +47.4 kJ mol^{-1} under the conditions of your experiment.
Show your working.

M_r of $Na_2S_2O_3 \cdot xH_2O$ = ...
[2]

(iii) Use your answer to **(b)(ii)** to calculate the value of x in the formula $Na_2S_2O_3 \cdot xH_2O$.

x = ...
[1]

(c) A student repeats the experiment but adds 25.0 cm^3 of distilled water into the cup instead of 20.0 cm^3. The student carries out the calculations based on adding 20.0 cm^3.

What effect would this have on the student's answer to **(b)(ii)**?
Explain your answer.

.....

.....

..... [2]

[Total: 10]

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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 7** is a salt containing one cation and one anion, both of which are listed in the Qualitative Analysis Notes.

(i) Transfer a small spatula measure of **FA 7** to a hard-glass test-tube and heat, gently at first and then more strongly.
Record all your observations.

.....

.....

..... [2]

(ii) Place the remaining **FA 7** in the 100 cm^3 beaker and dissolve in approximately 50 cm^3 of distilled water.
Use a sample of this solution to test for the cation present in **FA 7**.
Record your tests and observations in the space below.

Keep the solution for use in (a)(iii).

[3]

(iii) To a 1 cm depth of solution **FA 7** in a test-tube, add a few drops of aqueous silver nitrate. Record your observations.

..... [1]

(iv) Suggest the ions present in **FA 7**.

cation ..... anion .....
[1]

(b) **FA 8** is acidified aqueous iron(III) chloride, $FeCl_3$.

Carry out the following tests and record your observations.

test	*observations*
Test 1 To a 1 cm depth of **FA 8** in a test-tube, add a 1 cm depth of **FA 4**, then	
add starch indicator.	
Test 2 To a 1 cm depth of **FA 8** in a test-tube, add a 1 cm depth of **FA 5**. Allow to stand until there is no further change, then	
add a 1 cm depth of **FA 4**, then	
add starch indicator.	

[3]

(c) Half fill the 250 cm^3 beaker with water. Place the beaker on a gauze supported on the tripod and heat the water to approximately 70 °C. Switch off the Bunsen burner. This will be used as a water-bath.

FA 9, **FA 10** and **FA 11** are each one of the following.

- 1.0 mol dm^{-3} hydrochloric acid, HC*l*
- 1.0 mol dm^{-3} methanoic acid, HCOOH
- 1.0 mol dm^{-3} sodium sulfite, Na_2SO_3

(i) Carry out the following tests and record your observations. For each test use a 1 cm depth in a test-tube.

test	*observations*		
	FA 9	**FA 10**	**FA 11**
Test 1 Add a 1 cm strip of magnesium.			
Test 2 Add a few drops of aqueous acidified potassium manganate(VII). Place the test-tube in the hot water-bath.			

[3]

(ii) Identify each of the solutions.

FA 9 is ..... .

FA 10 is ..... .

FA 11 is ..... .

[2]

[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

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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

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The Periodic Table of Elements

Group																		
1	2											13	14	15	16	17	18
																	2 He helium 4.0
												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
3 Li lithium 6.9	4 Be beryllium 9.0											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
11 Na sodium 23.0	12 Mg magnesium 24.3											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
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	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
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	81 Tl thallium 204.4	82 Pb lead 207.2	83 Bi bismuth 209.0	84 Po polonium –	85 At astatine –	86 Rn radon –
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		114 Fl flerovium –		116 Lv livermorium –		
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 –						

Key

atomic number
atomic symbol
name
relative atomic mass

1 H hydrogen 1.0

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 –

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