Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER | CANDIDATE NUMBER

2030103863

CHEMISTRY **9701/32**

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.

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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 In this experiment you will determine the formula of the ion, IO_x^-. To do this you will first react IO_x^- ions with an excess of iodide ions, I^- , to form iodine, I_2.

The equation for this reaction is:

$$IO_x^- + yI^- + zH^+ \rightarrow \left(\frac{1+y}{2}\right)I_2 + \frac{z}{2}H_2O$$

where x, y and z are all integers.

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

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

FB 1 is a solution containing 0.0150 mol dm^{-3} IO_x^- ions.
FB 2 is dilute sulfuric acid, H_2SO_4.
FB 3 is 0.500 mol dm^{-3} potassium iodide, KI.
FB 4 is 0.100 mol dm^{-3} sodium thiosulfate, $Na_2S_2O_3$.
starch indicator

(a) Method

- Pipette 25.0 cm^3 of **FB 1** into a conical flask.
- Use the measuring cylinder to add 25 cm^3 of **FB 2** to the conical flask.
- Use the measuring cylinder to add 10 cm^3 of **FB 3** to the conical flask. The solution will turn brown as iodine is produced.
- Fill the burette with **FB 4**.
- Add **FB 4** from the burette until the solution in the conical flask turns yellow.
- Add 10–15 drops of starch indicator to the conical flask. The solution will turn blue-black.
- Continue to add more **FB 4** 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 below.

The rough titre is .... cm^3.

- 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 of your burette readings and the volume of **FB 4** added in each accurate titration.

Keep FB 3 and FB 4 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 **FB 4** 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 4**. [1]

(c) Calculations

(i) Give your answers to **(c)(ii)**, **(c)(iii)** and **(c)(iv)** 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 form when 25.0 cm^3 of **FB 1** react with 10 cm^3 of **FB 3**.

moles of I_2 = ... mol [1]

(iii) Calculate the number of moles of IO_x^- ions in 25.0 cm^3 of **FB 1**.

moles of IO_x^- ions = ... mol [1]

(iv) Use the ratio of your answers to **(c)(ii)** and **(c)(iii)** along with the relevant equation given on page 2 to calculate the value of y. (Note that y is an odd integer such as 1, 3, 5, 7 etc.) Show your working.

y = ... [2]

(v) Use your value of y to determine the formula of the IO_x^- ion.

formula = ... [1]

(d) **(i)** The maximum error in the volume dispensed by the pipette is ±0.06 cm^3.

Calculate the maximum percentage error in the volume of **FB 1** used.

maximum percentage error = ...% [1]

(ii) A student suggested that a more accurate value of x could be obtained if a 10 cm^3 pipette is used to measure **FB 3** rather than the measuring cylinder.

State whether you agree with the student. Explain your answer.

....

....

.... [1]

[Total: 16]

2 In this experiment you will determine the enthalpy change of solution, ΔH_{sol}, for hydrated sodium thiosulfate, $Na_2S_2O_3 \cdot 5H_2O$. To do this you will measure the temperature change when a known mass of hydrated sodium thiosulfate is dissolved in a known volume of water.

FB 5 is hydrated sodium thiosulfate, $Na_2S_2O_3 \cdot 5H_2O$.

(a) Method

- Support the cup in the 250 cm^3 beaker.
- Use the 25 cm^3 measuring cylinder to transfer 20.0 cm^3 of distilled water into the cup.
- Weigh the stoppered container of **FB 5** and record the mass.
- Measure and record the initial temperature of the water in the cup.
- Add all the **FB 5** to the water in the cup.
- Stir the mixture and record the minimum temperature that is reached.
- Reweigh the stoppered container. Record the mass.
- Calculate and record the mass of **FB 5** added to the water and the change in temperature.

I	
II	
III	
IV	

[4]

(b) Calculations

(i) Calculate the energy change of the reaction.
(Assume that 4.2 J of heat energy changes the temperature of 1.0 cm^3 of solution by 1.0 °C.)
Show your working.

energy change = ... J [1]

(ii) Calculate the enthalpy change of solution, ΔH_{sol}, for hydrated sodium thiosulfate.

ΔH_{sol} for $Na_2S_2O_3 \cdot 5H_2O$ = ... $kJ\,mol^{-1}$
sign *value* [2]

(iii) Assume that under the same conditions, the enthalpy change of solution, ΔH_{sol}, for anhydrous sodium thiosulfate, $Na_2S_2O_3$, is –7.7 kJ mol^{-1}.
Construct a Hess's cycle and determine the enthalpy change for the following reaction.
(If you were unable to calculate an answer to **(b)(ii)**, assume a value of +32.2 kJ mol^{-1}. Note this is not the correct value.)

$$Na_2S_2O_3(s) + 5H_2O(l) \rightarrow Na_2S_2O_3{\bullet}5H_2O(s)$$

ΔH = ... kJ mol^{-1}
sign *value* [2]

(c) How would your temperature change in **(a)** be affected if your sample of **FB 5** contained a small amount of anhydrous sodium thiosulfate?
Explain your answer.

....

....

.... [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 6** is an aqueous solution containing one cation and one anion, both of which are listed in the Qualitative Analysis Notes.

(i) Carry out tests to identify the cation in **FB 6**.
Record your tests and observations in the space below.

[2]

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

test	*observations*
Test 1 To a 2 cm depth of **FB 6** in a test-tube, add a few drops of nitric acid, followed by a few drops of aqueous silver nitrate.	
Pour approximately half the contents of the test-tube into a clean test-tube.	
Test 2 To one of the test-tubes add aqueous ammonia.	
Test 3 To the other test-tube add **FB 4**, $Na_2S_2O_3(aq)$.	

[2]

(iii) Deduce the formula of **FB 6**.

.... [1]

(b) **FB 7** is acidified aqueous iron(III) chloride, $FeCl_3$.

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

test	*observations*
Test 1 To a 1 cm depth of **FB 7** in a test-tube, add a 1 cm depth of **FB 3**, KI(aq), then	
add starch indicator.	

[1]

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

test	*observations*
Test 1 To a 1 cm depth of **FB 7** in a test-tube, add a 1 cm depth of **FB 4**, $Na_2S_2O_3$(aq). Leave to stand until there is no further change, then	
add aqueous sodium hydroxide.	

[2]

(iii) Explain your observation in **(b)(ii)** when aqueous sodium hydroxide is added.

....

....

.... [2]

(c) **FB 8** is acidified aqueous iron(II) sulfate, $FeSO_4$.

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

test	*observations*	*conclusions*
Test 1 To a 1 cm depth of **FB 8** in a **boiling tube**, add a 1 cm depth of hydrogen peroxide, then		
add aqueous sodium hydroxide.		

[3]

(ii) Write an ionic equation for the reaction that occurs on addition of sodium hydroxide in **(c)(i)**.

.... [1]

[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

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		**Key** atomic number atomic symbol name relative atomic mass									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 –