Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME	

CENTRE NUMBER						CANDIDATE NUMBER					

* 6 2 8 7 6 4 0 9 9 4 *

CHEMISTRY **9701/34**

Paper 3 Advanced Practical Skills 2 **October/November 2021**

2 hours

You must answer on the question paper.

You will need: The materials and apparatus listed in the confidential instructions
Insert (enclosed)

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.
- The insert contains additional resources referred to in the questions.

For Examiner's Use	
1	
2	
3	
Total	

This document has **16** pages. Any 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 The thiosulfate ion, $S_2O_3^{2-}$, is unstable in the presence of acid. The following reaction occurs.

$$S_2O_3^{2-}(aq) + 2H^+(aq) \rightarrow S(s) + SO_2(aq) + H_2O(l)$$

The rate of this reaction can be measured by timing how long it takes for the solid sulfur that is formed to make the mixture too cloudy to see through.

You will investigate how the concentration of the thiosulfate ions affects the rate of this reaction.

Throughout these experiments care must be taken to avoid inhaling any SO_2 that is produced. It is very important that as soon as each experiment is complete, the contents of the beaker are emptied into the quenching bath and the beaker is rinsed thoroughly.

FB 1 is 0.100 mol dm^{-3} sodium thiosulfate, $Na_2S_2O_3$.
FB 2 is 2.00 mol dm^{-3} hydrochloric acid, HCl.
distilled water

(a) Method

Experiment 1

- Label one burette **FB 1** and fill it with **FB 1**.
- Run 45.00 cm^3 of **FB 1** from the burette into the 100 cm^3 beaker.
- Use the 25 cm^3 measuring cylinder to measure 10.0 cm^3 of **FB 2**.
- Add **FB 2** to **FB 1** and start timing **immediately**.
- Stir the mixture once and place the beaker on the printed insert.
- View the print on the insert from above the mixture.
- Stop timing when the print on the insert is no longer visible.
- Record this reaction time to the nearest second.
- Empty the contents of the beaker into the quenching bath.
- Rinse and dry the beaker so it is ready for use in **Experiment 2**.

Experiment 2

- Fill the second burette with distilled water.
- Refill the burette labelled **FB 1** with **FB 1**.
- Run 20.00 cm^3 of **FB 1** into the 100 cm^3 beaker.
- Run 25.00 cm^3 of distilled water into the same beaker.
- Use the 25 cm^3 measuring cylinder to measure 10.0 cm^3 of **FB 2**.
- Add **FB 2** to the beaker and start timing **immediately**.
- Stir the mixture once and place the beaker on the printed insert.
- View the print on the insert from above the mixture.
- Stop timing when the print on the insert is no longer visible.
- Record this reaction time to the nearest second.
- Empty the contents of the beaker into the quenching bath.
- Rinse and dry the beaker so it is ready for use in the next experiment.

Experiments 3–5

- Carry out three further experiments to investigate how the reaction time changes with different volumes of **FB 1**.

The combined volume of **FB 1** and distilled water must always be 45.00 cm^3.
Do not use a volume of **FB 1** that is less than 20.00 cm^3.

Record all your results in a table.
You should include the volume of **FB 1**, the volume of distilled water, the reaction time and the reaction rate for each of your five experiments.
Calculate the rate of reaction using the following formula.

$$\text{rate} = \frac{1000}{\text{reaction time}}$$

I	
II	
III	
IV	
V	
VI	
VII	
VIII	

[8]

(b) On the grid opposite, plot the rate on the *y*-axis against the volume of **FB 1** on the *x*-axis. Identify any anomalous points. Draw a line of best fit.

[4]

I	
II	
III	
IV	

[Turn over

(c) In these experiments, the volume of **FB 1** is related to the concentration of the thiosulfate ions.

Use your graph to suggest the relationship between the rate of reaction and the concentration of the thiosulfate ions.

....

.... [1]

(d) The quenching bath contains an aqueous mixture of sodium carbonate and universal indicator.

(i) How does the quenching bath prevent the further production of SO_2 from the reaction?

....

.... [1]

(ii) Suggest why the mixture contains universal indicator.

....

.... [1]

(e) **(i)** In each experiment the acid is in large excess.

Show, by calculation, that the acid is in large excess in **Experiment 1**.

[2]

(ii) Suggest a reason why the acid used should be in large excess.

....

.... [1]

[Total: 18]

2 In this experiment you will determine the concentration of a solution of copper(II) sulfate.
You will react an excess of zinc with copper(II) sulfate as shown.

$$Zn(s) + CuSO_4(aq) \rightarrow ZnSO_4(aq) + Cu(s)$$

FB 3 is zinc powder.
FB 4 is aqueous copper(II) sulfate, $CuSO_4$.

(a) Method

- Support the cup in the 250 cm^3 beaker.
- Using the 50 cm^3 measuring cylinder, transfer 40 cm^3 of **FB 4** into the cup.
- Measure and record the temperature of the solution in the cup.
- Add all of **FB 3** to the cup.
- Use the thermometer to stir the mixture gently.
- Measure and record the maximum temperature reached.
- Calculate and record the change in temperature.

[3]

(b) Calculations

(i) Use your results from **(a)** to calculate the heat energy produced 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 produced = ... J [1]

(ii) You can assume that under the conditions of your experiment the molar enthalpy change for the reaction is –218.7 kJ mol^{-1}.

Use this value to calculate the concentration, in mol dm^{-3}, of **FB 4**.

concentration of **FB 4** = ... mol dm^{-3}
[2]

(c) **(i)** Calculate the maximum percentage error in the temperature rise that you recorded in **(a)**.

Assume that the maximum error in a single thermometer reading is $\pm 0.5\,°C$.

maximum percentage error = ... % [1]

(ii) The maximum percentage error becomes smaller if the temperature rise is increased. A student suggests that using a greater volume of **FB 4** would increase the temperature rise as long as the zinc remains in excess.

Explain whether the student is correct.

....

....

....

.... [2]

[Total: 9]

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 5** is an aqueous solution containing three cations and a single anion.
Two of the cations are listed in the Qualitative Analysis Notes.
The anion is either the sulfate ion, SO_4^{2-}, or the sulfite ion, SO_3^{2-}.

(i) Carry out tests to identify the **three cations**.
Record your tests and observations.

I	
II	
III	
IV	
V	
VI	
VII	

The formulae for the cations present in **FB 5** are .... , ... and ....

[7]

(ii) Carry out tests to identify whether **FB 5** contains the sulfate ion, SO_4^{2-}, or the sulfite ion, SO_3^{2-}.
Record your observations.

The anion present in **FB 5** is ....

[2]

(b) **(i)** Carry out the following tests on **FB 6** and **FB 7** and record your observations.

test	*observations*
Test 1 Add a small spatula measure of **FB 6** to a hard-glass test-tube. Heat the sample gently at first and then more strongly.	
Test 2 Add a small spatula measure of **FB 7** to a hard-glass test-tube. Heat the sample strongly.	

[3]

(ii) State the type of reaction observed with **FB 6** in **(b)(i)**.

.... [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	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 –