Cambridge International AS & A Level

Cambridge Assessment International Education
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME	

CENTRE NUMBER						

CANDIDATE NUMBER				

5982528859

CHEMISTRY **9701/33**

Paper 3 Advanced Practical Skills 1 **May/June 2019**

2 hours

Candidates answer on the Question Paper.

Additional Materials: As listed in the Confidential Instructions

READ THESE INSTRUCTIONS FIRST

Write your centre number, candidate number and name on all the work you hand in.
Give details of the practical session and laboratory where appropriate, in the boxes provided.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.
Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.
Use of a Data Booklet is unnecessary.

Qualitative Analysis Notes are printed on pages 14 and 15.
A copy of the Periodic Table is printed on page 16.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

Session
Laboratory

For Examiner's Use	
1	
2	
3	
Total	

This document consists of **12** printed pages, **4** blank pages and **1** Insert.

Cambridge Assessment International Education

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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, $S_2O_3^{2-}$, reacts in acidic conditions as shown.

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

You will investigate how the concentration of the thiosulfate ions affects the rate of this reaction. The rate can be measured by timing how long it takes for the solid sulfur that is formed to make the solution too cloudy to see through.

Small amounts of SO_2 gas may be produced during this reaction. Care must be taken to avoid inhaling this SO_2 gas.

It is very important that as soon as each experiment is complete the beaker containing the reaction mixture is emptied into the quenching bath.

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

(a) Method

Experiment 1

- Fill the burette labelled **FA 1** with **FA 1**.
- Run 45.00 cm^3 of **FA 1** from the burette into the 100 cm^3 beaker.
- Use the measuring cylinder to measure 10.0 cm^3 of **FA 2**.
- Add the **FA 2** to the **FA 1** in the beaker and start timing immediately.
- Stir the mixture once and place the beaker on the printed insert.
- Look down through the solution in the beaker at the print on the insert.
- Stop timing as soon as the precipitate of sulfur makes the print on the insert **just** invisible.
- Record this reaction time to the nearest second in your results table.
- Empty the contents of the beaker into the quenching bath.
- Wash out the beaker thoroughly.
- Shake the beaker to remove any excess water.

Experiment 2

- Fill a second burette with distilled water.
- Refill the burette labelled **FA 1** with **FA 1**.
- Run 20.00 cm^3 of **FA 1** into the 100 cm^3 beaker.
- Run 25.00 cm^3 of distilled water into the same beaker.
- Use the measuring cylinder to measure 10.0 cm^3 of **FA 2**.
- Add the **FA 2** to the **FA 1** in the beaker and start timing immediately.
- Stir the mixture once and place the beaker on the printed insert.
- Look down through the solution in the beaker at the print on the insert.
- Stop timing as soon as the precipitate of sulfur makes the print on the insert **just** invisible.
- Record this reaction time to the nearest second in your results table.
- Empty the contents of the beaker into the quenching bath.
- Wash out the beaker thoroughly.
- Shake the beaker to remove any excess water.

Experiments 3–5

Carry out three further experiments to investigate how the reaction time changes with different volumes of **FA 1**.
Note that the combined volume of **FA 1** and distilled water must always be 45.00 cm^3.
Do not use a volume of **FA 1** that is less than 20.00 cm^3.

Record all your results in a table. You should include the volume of **FA 1**, the volume of distilled water, the reaction time and the reaction rate for each of your five experiments. The rate of reaction can be calculated using the following expression.

$$\text{rate} = \frac{500}{\text{reaction time}}$$

I	
II	
III	
IV	
V	
VI	
VII	
VIII	
IX	

[9]

(b) On the grid, plot a graph of the rate (*y*-axis) against the volume of **FA 1** (*x*-axis). Label any anomalous points. Draw a line of best fit.

I	
II	
III	
IV	

[4]

(c) In these experiments, the volume of **FA 1** is related to the concentration of the thiosulfate ions. From your graph state the relationship between the rate of reaction and the concentration of the thiosulfate ions.

....

.... [1]

(d) Assume that the error in the time measured for each experiment was ± 2 s.

Calculate the minimum value for the reaction rate you observed in **Experiment 2**.
Show your working.

minimum rate for **Experiment 2** = ... [2]

(e) **(i)** A student suggested that, using a 250 cm^3 beaker, the time recorded for **Experiment 1** would be the same.

Discuss whether the student is correct.

....

.... [1]

(ii) A student carried out a further experiment using the same procedure as in **(a)**. The student used 5.00 cm^3 of **FA 1**, 40.00 cm^3 of distilled water and 10.0 cm^3 of **FA 2**.
The print on the insert never became invisible.

Explain why.

....

.... [1]

[Total: 18]

2 In this experiment you will determine the enthalpy change of solution for hydrated sodium thiosulfate.

FA 3 is hydrated sodium thiosulfate, $Na_2S_2O_3.5H_2O$.

(a) Method

- Support the plastic cup in the 250 cm^3 beaker.
- Rinse the measuring cylinder.
- Using the measuring cylinder, pour 25.0 cm^3 of distilled water into the plastic cup.
- Measure the temperature of the water in the cup.
- Weigh the container with **FA 3**.
- Add all the **FA 3** to the distilled water in the cup.
- Use the thermometer to stir the mixture gently until all the solid has dissolved.
- Measure the lowest temperature that is reached.
- Reweigh the container with any remaining **FA 3**.
- Record all your measurements.
- Calculate and record the mass of **FA 3** added and the change in temperature.

I	
II	
III	
IV	

[4]

(b) The enthalpy change of solution for **FA 3** is the enthalpy change when 1 mole of **FA 3** is dissolved in 1 dm^3 of solution.

(i) Calculate how many moles of **FA 3** were added to the water.

moles of **FA 3** = ... mol [1]

(ii) Calculate the energy change when the sample of **FA 3** was added to the distilled water.
[Assume that 4.2 J of heat energy changes the temperature of 1.0 cm^3 of solution by 1.0 °C.]

energy change = ... J [1]

(iii) Calculate the enthalpy change of solution of **FA 3**.

enthalpy change of solution = ...
sign *value* *units*
[1]

(c) One way to improve this experiment would be to use a balance that reads to more decimal places.

Suggest two other ways in which this experiment could be altered to give a more accurate value for the enthalpy change. Explain how each would improve the accuracy.

Suggestion 1

....

....

Suggestion 2

....

....
[2]

(d) A student carrying out the experiment in **Question 1** used all the **FA 1**. The student made up a fresh sample of **FA 1** of the correct concentration by dissolving some **FA 3** in water. This solution was then used immediately to repeat one of the experiments in **Question 1** but the time was then much greater than had been measured previously.

Explain why the time was greater.

....

....

.... [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)** **FA 4** is an aqueous solution containing a single cation and a single anion.
The anion is either the sulfate ion, SO_4^{2-}, or the sulfite ion, SO_3^{2-}.

(i) To an approximately 1 cm depth of **FA 4** in a test-tube, add aqueous sodium carbonate.
Record your observations.

....

....

.... [2]

(ii) Select reagents to identify the anion present in **FA 4**.
Carry out a test with these reagents and record your observations.

reagents ....

observations ....

....

....
[2]

(iii) Identify **FA 4**.

The formula of **FA 4** is .... [1]

(b) (i) **FA 5** contains one cation and two anions. Two of these ions are listed in the Qualitative Analysis Notes.
Carry out the following tests and record your observations.

test	*observations*
Add a small spatula measure of **FA 5** to a hard-glass test-tube. Heat the sample gently at first and then more strongly.	
Pour a 4 cm depth of dilute sulfuric acid into a boiling tube. Carefully add the remaining **FA 5**. Leave to stand until the reaction is complete. The solution produced is **FA 6**. Keep **FA 6** for use in the following tests.	
To a 1 cm depth of **FA 6** in a test-tube add aqueous sodium hydroxide.	
To a 1 cm depth of **FA 6** in a test-tube add aqueous ammonia.	

[5]

(ii) State the type of reaction observed when **FA 5** was heated.

.... [1]

(iii) Give the formula of the cation and one of the anions present in **FA 5**.

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

[Total: 12]

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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	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 –
