Cambridge International **AS & A Level** 

### Cambridge Assessment International Education

Cambridge International Advanced Subsidiary and Advanced Level

	CANDIDATE NAME		
	CENTRE CANDIE NUMBER NUMBE		
* 5 \$	CHEMISTRY		9701/33
8 2	Paper 3 Advanced Practical Skills 1	Ν	lay/June 2019
5 2			2 hours
° 8	Candidates answer on the Question Paper.		
5 9	Additional Materials: As listed in the Confidential Instructions		
*	READ THESE INSTRUCTIONS FIRST		
	<ul> <li>Write your centre number, candidate number and name on all the work you han Give details of the practical session and laboratory where appropriate, in the bo Write in dark blue or black pen.</li> <li>You may use an HB pencil for any diagrams or graphs.</li> <li>Do not use staples, paper clips, glue or correction fluid.</li> <li>DO NOT WRITE IN ANY BARCODES.</li> <li>Answer all questions.</li> <li>Electronic calculators may be used.</li> <li>You may lose marks if you do not show your working or if you do not use appropulse of a Data Booklet is unnecessary.</li> </ul>	xes provided.	
		Ses	sion
	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.	Labo	ratory
		For Exam	iner's Use
		1	
		2	
		3	

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

Total

### **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.

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

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<sup>-3</sup> sodium thiosulfate,  $Na_2S_2O_3$ . **FA 2** is 2.00 mol dm<sup>-3</sup> hydrochloric acid, HC*l*. distilled water

#### (a) Method

#### **Experiment 1**

- Fill the burette labelled **FA 1** with **FA 1**.
- Run 45.00 cm<sup>3</sup> of **FA 1** from the burette into the 100 cm<sup>3</sup> beaker.
- Use the measuring cylinder to measure 10.0 cm<sup>3</sup> 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<sup>3</sup> of **FA 1** into the 100 cm<sup>3</sup> beaker.
- Run 25.00 cm<sup>3</sup> of distilled water into the same beaker.
- Use the measuring cylinder to measure 10.0 cm<sup>3</sup> 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.

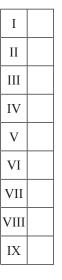
#### Experiments 3–5

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  $45.00 \text{ cm}^3$ . Do not use a volume of **FA 1** that is less than  $20.00 \text{ cm}^3$ .

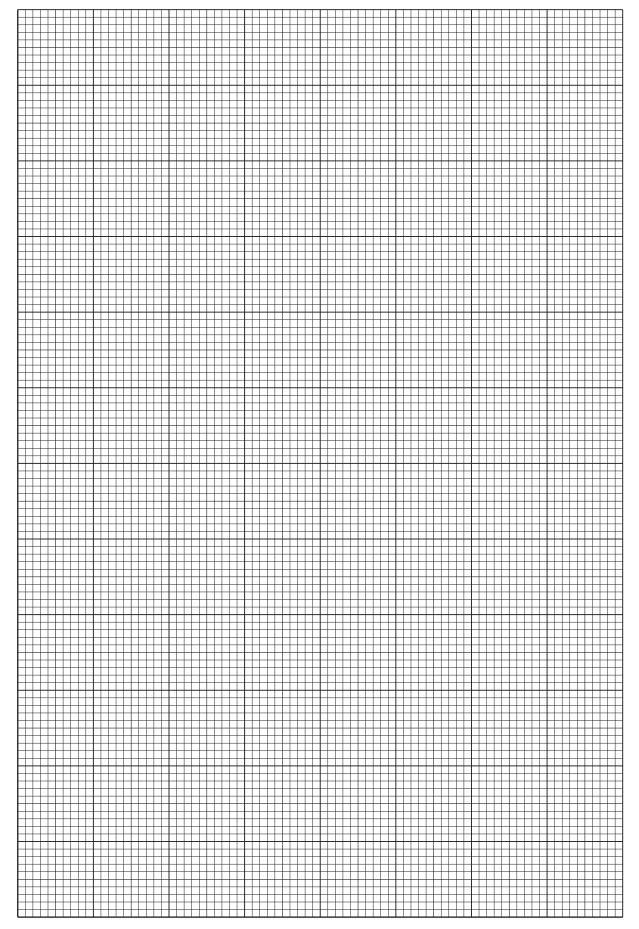
Record all your results in a table. You should include the volume of **FA 1**, the volume of distilled water, the reaction time and the reaction rate for each of your five experiments. The rate of reaction can be calculated using the following expression.

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

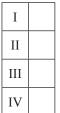


[9]

(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.



5



https://xtremepape.rs/

(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  $\pm 2s$ .

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

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

Discuss whether the student is correct.

(ii) A student carried out a further experiment using the same procedure as in (a). The student used 5.00 cm<sup>3</sup> of **FA 1**, 40.00 cm<sup>3</sup> of distilled water and 10.0 cm<sup>3</sup> 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<sup>3</sup> beaker.
- Rinse the measuring cylinder.
- Using the measuring cylinder, pour 25.0 cm<sup>3</sup> 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.

Ι	
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<sup>3</sup> 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 4.2J of heat energy changes the temperature of 1.0 cm<sup>3</sup> of solution by 1.0°C.]

	e	energy change =		J [	1]
(iii) Calculate the enthalpy ch	ange of solution of <b>FA</b>	3.			
	enthalpy change of s	olution =			
		sign	value		1]
One way to improve this exp places.	eriment would be to u	se a balance tha	t reads to n	nore decim	al
Suggest two other ways in w value for the enthalpy change	•		•	ore accura	te
Suggestion 1					

Suggestion		
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 <b>FA 4</b> . Carry out a test with these reagents and record your observations.	
	reagents	
	observations	
		[2]
(iii)	Identify <b>FA 4</b> .	
	The formula of <b>FA 4</b> 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 <b>FA 5</b> 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 <b>FA 5</b> . Leave to stand until the reaction is complete. The solution produced is <b>FA 6</b> .	
Keep <b>FA 6</b> for use in the following tests.	
To a 1 cm depth of <b>FA 6</b> in a test-tube add aqueous sodium hydroxide.	
To a 1 cm depth of <b>FA 6</b> 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 t	he anions present in <b>FA 5</b> .	
	cation:	anion:	[1]
		[Total:	12]

### 14

# Qualitative Analysis Notes

## 1 Reactions of aqueous cations

inn	react	tion with
ion	NaOH(aq)	NH <sub>3</sub> (aq)
aluminium, A <i>l</i> ³⁺(aq)	white ppt. soluble in excess	white ppt. insoluble in excess
ammonium, NH₄⁺(aq)	no ppt. ammonia produced on heating	_
barium, Ba²⁺(aq)	faint white ppt. is nearly always observed unless reagents are pure	no ppt.
calcium, Ca²⁺(aq)	white ppt. with high [Ca <sup>2+</sup> (aq)]	no ppt.
chromium(III), Cr³⁺(aq)	grey-green ppt. soluble in excess	grey-green ppt. insoluble in excess
copper(II), Cu²+(aq)	pale blue ppt. insoluble in excess	blue ppt. soluble in excess giving dark blue solution
iron(II), Fe²⁺(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), Fe³⁺(aq)	red-brown ppt. insoluble in excess	red-brown ppt. insoluble in excess
magnesium, Mg²⁺(aq)	white ppt. insoluble in excess	white ppt. insoluble in excess
manganese(II), Mn²⁺(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, Zn²⁺(aq)	white ppt. soluble in excess	white ppt. soluble in excess

### 2 Reactions of anions

ion	reaction
carbonate, CO <sub>3</sub> <sup>2–</sup>	CO <sub>2</sub> liberated by dilute acids
chloride, C <i>l</i> ⁻(aq)	gives white ppt. with Ag <sup>+</sup> (aq) (soluble in $NH_3(aq)$ )
bromide, Br⁻(aq)	gives cream ppt. with Ag <sup>+</sup> (aq) (partially soluble in $NH_3(aq)$ )
iodide, I⁻(aq)	gives yellow ppt. with Ag <sup>+</sup> (aq) (insoluble in $NH_3(aq)$ )
nitrate, NO <sub>3</sub> ⁻(aq)	NH₃ liberated on heating with OH⁻(aq) and A <i>t</i> foil
nitrite, NO₂⁻(aq)	$NH_3$ liberated on heating with $OH^-(aq)$ and $Al$ foil
sulfate, SO <sub>4</sub> ²-(aq)	gives white ppt. with Ba <sup>2+</sup> (aq) (insoluble in excess dilute strong acids)
sulfite, SO <sub>3</sub> <sup>2–</sup> (aq)	gives white ppt. with Ba <sup>2+</sup> (aq) (soluble in excess dilute strong acids)

# 3 Tests for gases

gas	test and test result
ammonia, NH <sub>3</sub>	turns damp red litmus paper blue
carbon dioxide, CO <sub>2</sub>	gives a white ppt. with limewater (ppt. dissolves with excess CO <sub>2</sub> )
chlorine, $Cl_2$	bleaches damp litmus paper
hydrogen, H <sub>2</sub>	'pops' with a lighted splint
oxygen, O <sub>2</sub>	relights a glowing splint

2         2           4         4         atomic number atomic number 9.0         fey           4         Be 9.0         Fey         Fey           9.0         beryllum 9.0         atomic number atomic number 9.0         fey           12         Mg         3         4         5         6           24.3         3         4         5         6         7           9.0         22.1         22         23         24         74           9.1         24.3         3         4         5         6           24.3         3         4         5         6         74           9.0         38         912         92.9         95.9         95.9           9.12         912         92.9         92.9         95.9         74           9.13         91.2         73         74         74         74           9.13         91.2         73         74         74         74           9.13         91.2         73         74         74         74           9.13         174.1         72         73         74         74           9.14         72         <								The Pe	riodic Ta	The Periodic Table of Elements	ements							
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56         57-71         72         73         74         75           Ba         Ianthanolds         Hf         Ta         W         Re           bantum         137.3         Instrinum         tantiaum         tantiaum         tantiaum         tantiaum           137.3         89-103         104         105         180.9         186.2           88         89-103         104         105         106         107           Radium         actinoids         Rf         Db         Sg         Bh           actinoids         La         Ce         Pr         Do         61           fs         140.1         praseodynium         seedynium         pontum         actinum           fs         90         91         92         93         91         A		strontium 87.6	yttrium 88.9	zirconium 91.2	niobium 92.9	molybdenum 95.9	technetium -	ruthenium 101.1	rhodium 102.9	palladium 106.4	silver 107.9	cadmium 112.4	indium 114.8	tin 118.7	antimony 121.8	tellurium 127.6	iodine 126.9	xenon 131.3
Ba         Ianthanoids         Hf         Ta         W         Re           bankum         137.3         Hafnium         tanalum         tanalum         tanalum         tanalum           137.3         88         89–103         104         105         180.9         186.2           88         89–103         104         105         105         186.2         186.2           Ra         actinoids         Rf         Db         Sg         Bh         107           actinoids         Rf         Db         Sg         Bh         107         106         107           actinoids         Rf         Db         Sg         60         61         Dr           actinoid         Ea         S         56         60         61         Dr           fstatum         certum         presedymium         reactum         presedymium         presedymium         presedymium           fantharum         140.1         140.3         144.4         -         M3	55	56	57-71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
batum 137:3         batum batum service         batum tantaum alterior         tantaum tantaum tantaum         tantaum tantaum         tantaum         tantau         tantau <thtantau< th="">         &lt;</thtantau<>	Cs	Ba	lanthanoids	Η	ā	≥	Re	Os	Ir	ł	Au	Hg	1T	Pb	Bi	Ро	At	Rn
88         89–103         104         105         106         107           Radium         actinoids         Rf         Db         Sg         Bh           addum         actinoids         Rf         Db         Sg         Bh	caesium 132.9	barium 137.3		hafnium 178.5	tan talum 180.9	tungsten 183.8	rhenium 186.2	osmium 190.2	iridium 192.2	platinum 195.1	gold 197.0	mercury 200.6	thallium 204.4	lead 207.2	bismuth 209.0	polonium -	astatine -	radon -
Ration     Ref     Db     Sg     Bh       addum     actinoids     Rf     Db     Sg     Bh	87	88	89-103	104	105	106	107	108	109	110	111	112		114		116		
radium         rutherfordium         dubnium         seaborgium         bohrium           -         -         -         -         -         -           -         -         -         -         -         -         -           -         -         -         -         -         -         -         -           -	Ъ,	Ra	actinoids	Ŗ	Db	Sg	Bh	Hs	Mt	Ds	Rg	ü		Fl		۲<		
57         58         59         60         61           La         Ce         Pr         Nd         Pm           Ianthanum         eanum         praseodymium         neodymium         promethum           138.9         90         91         92         93           Ac         Th         Da         144.4         -	francium -	radium -		rutherfordium -	dubnium I	seaborgium -	bohrium –	hassium -	meitnerium -	darmstadtium -	roentgenium -	copernicium -		flerovium -		livermorium -		
57         58         59         60         61           La         Ce         Pr         Nd         Pm           Ianthaum         cerium         praeedymium         neodymium         promethium           138.9         140.1         1400.9         144.4         -           AC         Th         Da         11         ND																		
ds         5/         38         39         60         61           La         Ce         Pr         Nd         Pm           lanthanum         eetum         praseodymium         proometrium         prometrium           138.9         140.1         140.9         144.4         -         -           AC         Th         Da         11         92         33         -		L	1		Ĩ	0		0	0				5	G	2	, T	;	
ds         La         Ce         Pr         Nd         Pm           Iantanum         eerium         praseodynium         neodynium         prometrium           138.9         140.1         140.9         144.4         -         -           89         90         91         92         93         -         -         -           Ar         Th         Da         11         ND         -         -         -			10		AC 1		0	70	03	45 (		00		00	80	0, 1,	₹.	
Ianthanum         cerum         praseodymium         promethum           138.9         140.1         140.9         144.4         -           89         90         91         92         93         93           Ar         Th         Da         1         No         No	nthanoid:	s	La		۲ ۲	Nd	Бд	Sn	п	в		D		Ъ	E	٩	Ľ	
89 90 91 92 93 AC Th P3 11 Nn			lanthanum 138.9		praseodymium 140.9	neodymium 144.4	promethium -	samarium 150.4	europium 152.0	gadolinium 157.3	terbium 158.9	dysprosium 162.5	holmium 164.9	erbium 167.3	thulium 168.9	ytterbium 173.1	175.0	
Ar Th Da II Nn			89		91	92	93	94	96	96		98		100	101	102	103	
	actinoids		Ac	Ч	Ра	⊃	ЧN	Pu	Am	СЗ	Ŗ	ç	Es	Е Н	Мd	No	Ļ	
actinium thorium protactinium uranium neptunium plutonium – 232.0 231.0 238.0 – –			actinium -	thorium 232.0	protactinium 231.0	uranium 238.0	neptunium -	plutonium -	americium -	curium	berkelium -	californium –	einsteinium –	fermium -	mendelevium -	nobelium -	lawrencium -	

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