Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME	

CENTRE NUMBER		CANDIDATE NUMBER	

8008546470

CHEMISTRY **9701/33**

Paper 3 Advanced Practical Skills 1 **February/March 2018**

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	
Total	

This document consists of **14** printed pages, **2** blank pages and **1** Insert.

CAMBRIDGE
International Examinations

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 You will investigate how increasing temperature affects the rate of a reaction.

Sodium thiosulfate reacts with acid to form a pale yellow precipitate of sulfur.
The ionic equation for the reaction is given.

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

You will measure the time it takes for the sulfur formed in the reaction to obscure the print on the Insert supplied.

Record your results in a table on page 4. Your table should include the rate of reaction for each experiment.

FA 1 is an 18.1 g dm^{-3} solution of hydrated sodium thiosulfate, $Na_2S_2O_3.5H_2O$.
FA 2 is a 0.050 mol dm^{-3} solution of a strong monoprotic acid, H**Z**.

(a) Method

- Approximately half fill the 250 cm^3 beaker with tap water and place it on the tripod and gauze over the Bunsen burner.
- Heat the water in the beaker to about 55 °C and then switch off the Bunsen burner. This will be your hot water bath.
- Use the 25 cm^3 measuring cylinder to transfer 10 cm^3 of **FA 1** into boiling tube **1**. Place boiling tube **1** into your hot water bath.
- Use the 50 cm^3 measuring cylinder to transfer 20 cm^3 of **FA 2** into boiling tube **2**. Place boiling tube **2** into your hot water bath.
- Leave boiling tubes **1** and **2** in the hot water bath to heat up for use in **Experiment 2**.
- Start **Experiment 1**.

Experiment 1

- Use the 50 cm^3 measuring cylinder to transfer 20 cm^3 of **FA 2** into the 100 cm^3 beaker.
- Measure and record the temperature of **FA 2**.
- Use the 25 cm^3 measuring cylinder to transfer 10 cm^3 of **FA 1** into the same beaker and start timing **immediately**.
- Swirl the beaker once to mix the solutions and place the beaker on the Insert.
- Look down through the beaker and contents onto the Insert.
- Stop timing as soon as the precipitate of sulfur obscures the print on the Insert.
- Record the 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

- Measure and record the temperature of **FA 2** in boiling tube **2**.
- Carefully transfer the hot contents of boiling tube **2** into the 100 cm^3 beaker.
- Carefully transfer the hot contents of boiling tube **1** into the same beaker and start timing **immediately**.
- Swirl the beaker once to mix the solutions and place the beaker on the Insert.
- Look down through the beaker and contents onto the Insert.
- Stop timing as soon as the precipitate of sulfur obscures the print on the Insert.
- Record the 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 3**.

Experiment 3

- Use the 25 cm^3 measuring cylinder to transfer 10 cm^3 of **FA 1** into boiling tube **1**. Place boiling tube **1** into your hot water bath.
- Use the 50 cm^3 measuring cylinder to transfer 20 cm^3 of **FA 2** into boiling tube **2**. Place boiling tube **2** into your hot water bath.
- Place the thermometer in boiling tube **2**. When the temperature of **FA 2** is about 8 °C lower than that for **Experiment 2** record the temperature. Remove the thermometer and transfer the contents of boiling tube **2** into the 100 cm^3 beaker.
- Transfer the contents of boiling tube **1** into the same beaker and start timing **immediately**.
- Swirl the beaker once to mix the solutions and place the beaker on the Insert.
- Look down through the beaker and contents onto the Insert.
- Stop timing as soon as the precipitate of sulfur obscures the print on the Insert.
- Record the 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 **Experiments 4 and 5**.

Experiments 4 and 5

- Repeat the method for **Experiment 3** but at **two** different temperatures.
- Keep the temperature of **FA 2** between room temperature and 55 °C. Do **not** exceed 55 °C.

Record all your results in your table on page 4.

Results

The rate of reaction can be calculated as shown.

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

Calculate the rate of reaction for each of your **five** experiments. Record these rates in your table.

I	
II	
III	
IV	
V	
VI	
VII	
VIII	

[8]

(b) On the grid plot a graph of rate of reaction on the *y*-axis, starting at zero, against temperature on the *x*-axis. Select a scale for the *x*-axis which includes a temperature of 15.0 °C. Label your axes and any points you consider anomalous.

Draw a line of best fit and extrapolate it to 15.0 °C.

I	
II	
III	
IV	

[4]

(c) **Use your graph** to calculate the **time** to the nearest second that the reaction would have taken if you had carried it out at 17.5 °C. Show **on the grid** how you obtained your answer.

time = ... s [2]

(d) Explain, by referring to your graph or your table of results, how the rate of reaction is affected by increasing temperature.

....

....

.... [2]

(e) **Calculations**

(i) Calculate the concentration of hydrated sodium thiosulfate, $Na_2S_2O_3.5H_2O$, in **FA 1** in mol dm^{-3}.

concentration of $Na_2S_2O_3.5H_2O$ in **FA 1** = ... mol dm^{-3} [1]

(ii) Calculate the concentration of the strong monoprotic acid, H**Z**, in the solution immediately **after FA 1** was added to **FA 2** in the beaker.

concentration of H**Z** = ... mol dm^{-3} [1]

(iii) Use the equation on page 2 to determine which reagent, **FA 1** or **FA 2**, was in excess.

The reagent in excess was .... [2]

(f) **(i)** Calculate the maximum percentage error in measuring the reaction time you recorded for **Experiment 2**. Assume that the maximum error of the timer is ±0.5 s.

maximum percentage error in the reaction time = ... % [1]

(ii) A student suggested that the error in measuring the reaction time in **Experiment 1** was greater than for **Experiment 2**.

Give **one** reason why the student could be correct.

....

.... [1]

(g) Suggest **two** ways to improve the accuracy of the results of these experiments.

1 ....

....

2 ....

....

[2]

[Total: 24]

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.

2 **(a)** **FA 3** is a more concentrated solution of the strong monoprotic acid, H**Z**, used for **Question 1**.

Select **two** sets of reagents and suitable apparatus to use in **two** separate tests, **Test 1** and **Test 2**, to investigate the identity of the anion, $\mathbf{Z}^-$, present in **FA 3**. The anion is one of those listed in the Qualitative Analysis Notes.

Complete the '*test*' boxes in the table **before** starting any practical work by circling whether you would use a test-tube or a boiling tube, and stating which reagents you would use.

Carry out your tests and record your observations. You must carry out both **Test 1** and **Test 2**.

test	*observations*
Test 1 To a 1 cm depth of **FA 3** in a *test-tube / boiling tube* add .... *(reagent(s))*	
Test 2 To a 1 cm depth of **FA 3** in a *test-tube / boiling tube* add .... *(reagent(s))*	

[4]

(b) Identify the anion present in H**Z** from your observations in **(a)**.

$\mathbf{Z}^-$ is .... [1]

(c) **FA 4** and **FA 5** both contain one cation and one anion. The ions present in **FA 4** are different from the ions present in **FA 5**. All four ions are listed in the Qualitative Analysis Notes. You are to identify the **four** different ions.

Carry out the following tests and record your observations.

test	*observations*
To a small spatula measure of **FA 4** in a boiling tube, add a 4 cm depth of **FA 3** and shake the tube well. Leave the tube to stand for at least five minutes. Label the solution formed **FA 6**.	
To a 1 cm depth of **FA 5** in a test-tube, add aqueous sodium carbonate.	
To a 1 cm depth of **FA 5** in a test-tube, add aqueous sodium hydroxide.	
To a 1 cm depth of **FA 5** in a test-tube, add aqueous ammonia.	
To a 1 cm depth of **FA 5** in a test-tube, add a few drops of aqueous silver nitrate.	
To a 1 cm depth of **FA 5** in a test-tube, add a few drops of aqueous barium chloride or aqueous barium nitrate, then	
add a 1 cm depth of a suitable acid.	
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.	
To a 1 cm depth of **FA 6** in a test-tube, add dilute sulfuric acid.	
To a 1 cm depth of **FA 6** in a test-tube, add a 1 cm depth of **FA 5**.	

[8]

(d) Give the formula of the acid you added to the mixture of **FA 5** and aqueous barium chloride or aqueous barium nitrate in **(c)**.

The acid added was .... [1]

(e) Identify the ions present in **FA 4** and **FA 5** from your observations in **(c)**.

	cation	anion
FA 4		
FA 5		

[2]

[Total: 16]

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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 A*l* foil
nitrite, NO_2^-(aq)	NH_3 liberated on heating with OH^-(aq) and A*l* 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 –

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