Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME			
CENTRE NUMBER		CANDIDATE NUMBER	

8148906248

CHEMISTRY **9701/35**

Paper 3 Advanced Practical Skills 1 **May/June 2017**

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 10 and 11.
A copy of the Periodic Table is printed on page 12.

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 **11** printed pages and **1** blank page.

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CAMBRIDGE International Examinations

[Turn over

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1 Sulfur forms the peroxodisulfate anion, $S_2O_8^{2-}$. This ion can oxidise iodide ions, I^-, to iodine, I_2, as shown in the equation.

$$2I^-(aq) + S_2O_8^{2-}(aq) \rightarrow I_2(aq) + 2SO_4^{2-}(aq)$$

You will carry out a series of experiments to investigate how the rate of this reaction is affected by changing the concentration of the solutions.

The rate can be measured by adding thiosulfate ions, $S_2O_3^{2-}$, and starch indicator. As the reaction between $S_2O_8^{2-}$ and I^- occurs iodine is produced, but it reacts immediately with the thiosulfate.

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

When all the thiosulfate has reacted, the iodine will remain in the mixture and cause the starch indicator to turn blue-black. The rate of reaction may be determined by timing how long it takes the reaction mixture to turn blue-black.

FA 1 is 0.0200 mol dm^{-3} potassium peroxodisulfate, $K_2S_2O_8$.
FA 2 is 1.00 mol dm^{-3} potassium iodide, KI.
FA 3 is 0.00500 mol dm^{-3} sodium thiosulfate, $Na_2S_2O_3$.
starch indicator

Read through the instructions carefully and prepare a table for your results on page 4 before starting any practical work.

(a) Method

Experiment 1

- Fill the burette labelled **FA 1** with **FA 1**.
- Use the pen to label one of the 100 cm^3 beakers '**A**' and the other 100 cm^3 beaker '**B**'.
- Run 20.00 cm^3 of **FA 1** from the burette into beaker **A**.
- Use the measuring cylinder to add 20.0 cm^3 of **FA 2** into beaker **B**.
- Use the measuring cylinder to add 10.0 cm^3 of **FA 3** to beaker **B**.
- Add 10 drops of starch indicator to beaker **B**.
- Add the contents of beaker **A** to beaker **B** and start timing **immediately**.
- Stir the mixture once and place the beaker on a white tile.
- Stop timing as soon as the solution turns blue-black.
- Record this reaction time to the nearest second in your results table.
- Wash out both beakers and shake to remove excess water.

Experiment 2

- Fill a second burette with distilled water.
- Run 10.00 cm^3 of **FA 1** into beaker **A**.
- Run 10.00 cm^3 of distilled water into beaker **A**.
- Use the measuring cylinder to add 20.0 cm^3 of **FA 2** into beaker **B**.
- Use the measuring cylinder to add 10.0 cm^3 of **FA 3** to beaker **B**.
- Add 10 drops of starch indicator to beaker **B**.
- Add the contents of beaker **A** to beaker **B** and start timing **immediately**.
- Stir the mixture once and place the beaker on a white tile.
- Stop timing as soon as the solution turns blue-black.
- Record this reaction time to the nearest second in your results table.
- Wash out both beakers and shake to remove excess water.

Experiments 3-5

- Carry out three further experiments to investigate how the reaction time changes with different volumes of potassium peroxodisulfate, **FA 1**.
  Note that the combined volume of **FA 1** and distilled water must always be 20.00 cm^3.
  Do not use a volume of **FA 1** that is less than 6.00 cm^3.

Keep FA 1, FA 2, FA 3 and the starch indicator for use in (e).

Calculating the rate of the reaction

The rate of the reaction can be represented by the formula shown.

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

Use this formula to calculate the rate for each of your five experiments.

Record all your results in a single 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.

I	
II	
III	
IV	
V	
VI	
VII	
VIII	
IX	
X	

[10]

(b) On the grid on page 5, plot the rate (y-axis) against the volume of **FA 1** (x-axis). Include the origin in your plot. Draw a straight line of best fit and circle any clearly anomalous points.

I	
II	
III	
IV	

[4]

(c) The volume of **FA 1** is directly related to the concentration of potassium peroxodisulfate.

From your results, what can be stated about the relationship between the rate of reaction and the concentration of potassium peroxodisulfate?

....

.... [1]

(d) (i) **Use your graph** to calculate the reaction **time** you would expect to measure if you carried out an experiment using 5.00 cm^3 of **FA 1**.
Show your working.

reaction time = ... s

(ii) Assume that the error in the time measured for each reaction was ± 0.5 s in total.
Calculate the maximum percentage error in the reaction time you measured in **Experiment 1**.
Show your working.

maximum percentage error = ... %

(iii) A student suggested that this error could be reduced if 0.0100 $mol\,dm^{-3}$ sodium thiosulfate were used in place of **FA 3**.

Do you agree with this student? Explain your answer.

....

....

....

(iv) A student repeated **Experiment 1** but used 0.100 $mol\,dm^{-3}$ sodium thiosulfate in place of **FA 3**. The student found that the reaction mixture never turned blue-black.

Explain why.

....

....

....
[5]

(e) **(i)** Using the same method as in **(a)**, carry out an additional experiment to record the reaction time to the nearest second when the following solutions are mixed together.

- 10.00 cm^3 of **FA 1**
- 20.0 cm^3 of **FA 2**
- 5.0 cm^3 of **FA 3**
- 15.00 cm^3 of distilled water
- 10 drops of starch indicator

reaction time = ...

(ii) Use your answer to **(i)** to **estimate** the reaction time that would be measured if the following solutions were mixed together.

DO NOT CARRY OUT THIS EXPERIMENT

- 10.00 cm^3 of **FA 1**
- 20.0 cm^3 of **FA 2**
- 20.0 cm^3 of **FA 3**
- 10 drops of starch indicator

Explain your answer.

estimated reaction time = ...

....

....

....

[4]

[Total: 24]

2 Qualitative Analysis

At each stage of any test you are to record details of the following.

- colour changes seen
- the formation of any precipitate
- the solubility of such precipitates in an excess of the reagent added

Where reagents are selected for use in a test, the **name** or **correct formula** of the element or compound must be given.

Where gases are released they should be identified by a test, **described in the appropriate place in your observations**.

You should indicate clearly at what stage in a test a change occurs.
No additional tests for ions present should be attempted.

If any solution is warmed, a boiling tube MUST be used.
Rinse and reuse test-tubes and boiling tubes where possible.

(a) **FA 4** and **FA 5** are aqueous solutions. Each solution contains two different cations and the sulfate anion.

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

test	*observations*	
	FA 4	**FA 5**
To a 1 cm depth of solution in a boiling tube, add aqueous sodium hydroxide, then		
warm the tube carefully.		
To a 1 cm depth of solution in a test-tube, add aqueous ammonia.		

(ii) Identify as many as possible of the cations in **FA 4** and **FA 5**.

FA 4 contains the cation(s) ....

FA 5 contains the cation(s) ....

[7]

(b) **FA 6** is a salt containing either the sulfate anion or sulfite anion. You will first make a solution of **FA 6**.

- Rinse one of the 100 cm^3 beakers with distilled water.
- Place all the sample of **FA 6** into the beaker and add approximately 40 cm^3 of distilled water.
- Stir the mixture until the solid has dissolved.

Select reagent(s) and carry out tests to identify the anion in **FA 6**. Record your results in the space below.

The formula of the anion in **FA 6** is .... [3]

(c) **FA 7** is a solution containing one cation and the **sulfate** anion.
FA 8 is a solution containing the **sodium** cation and one of the anions from those listed in the Qualitative Analysis Notes.

(i) Carry out the following tests to determine the formulae of **FA 7** and **FA 8**.

test	*observations*
To a 2 cm depth of **FA 7** in a test-tube, add a 2 cm strip of magnesium.	
To a 1 cm depth of **FA 7** in a test-tube add a 1 cm depth of **FA 8** and shake the tube.	

(ii) The formula of **FA 7** is ....

The formula of **FA 8** is ....

(iii) Give the ionic equation for the reaction that takes place when magnesium is added to **FA 7**. Include state symbols.

....

[6]

[Total: 16]

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; NO liberated by dilute acids (colourless NO $\rightarrow$ (pale) brown NO_2 in air)
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											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	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 –