Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME			
CENTRE NUMBER		CANDIDATE NUMBER	

5884351244

CHEMISTRY **9701/36**

Paper 3 Advanced Practical Skills 2 **October/November 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 and **2** blank pages.

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 Iron(III) ions oxidise iodide ions, I^-, to iodine, I_2.

$$2Fe^{3+}(aq) + 2I^-(aq) \rightarrow 2Fe^{2+}(aq) + I_2(aq)$$

In this experiment you will investigate how the rate of this reaction is affected by the concentration of Fe^{3+} ions. To do this you will add thiosulfate ions, $S_2O_3^{2-}$, and starch indicator to a mixture of $Fe^{3+}(aq)$ and $I^-(aq)$. The iodine produced by the reaction reacts immediately with the thiosulfate ions and is reduced back to iodide.

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

When all the thiosulfate has reacted, the iodine remaining in solution turns the starch indicator blue-black. The rate of reaction can be determined by timing how long it takes for the reaction mixture to turn blue-black.

FB 1 is 0.0500 mol dm^{-3} acidified iron(III) chloride, $FeCl_3$.
FB 2 is 0.0500 mol dm^{-3} potassium iodide, KI.
FB 3 is 0.00500 mol dm^{-3} sodium thiosulfate, $Na_2S_2O_3$.
FB 4 is starch indicator.

(a) Method

Experiment 1

- Fill the burette labelled **FB 1** with **FB 1**.
- Run 20.00 cm^3 of **FB 1** into a 100 cm^3 beaker.
- Using the measuring cylinder add the following to the second 100 cm^3 beaker:
  - 10 cm^3 of **FB 2**
  - 20 cm^3 of **FB 3**
  - 10 cm^3 of **FB 4**
- Add the contents of the first beaker to the second beaker 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. Ignore any colour changes that occur before the intense blue-black colouration.
- Record this reaction time to the nearest second in the space provided on page 4.
- Rinse both beakers and shake dry. Rinse and dry the glass rod.

Experiment 2

- Fill a second burette with distilled water.
- Run 10.00 cm^3 of **FB 1** into a 100 cm^3 beaker.
- Run 10.00 cm^3 of distilled water into the same beaker containing **FB 1**.
- Using the measuring cylinder add the following to the second 100 cm^3 beaker:
  - 10 cm^3 of **FB 2**
  - 20 cm^3 of **FB 3**
  - 10 cm^3 of **FB 4**
- Add the contents of the first beaker to the second beaker 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. Ignore any colour changes that occur before the intense blue-black colouration.
- Record this reaction time to the nearest second in the space provided on page 4.
- Rinse both beakers and shake dry. Rinse and dry the glass rod.

Experiments 3–5

- Carry out three further experiments to investigate how the reaction time changes with different volumes of **FB 1**.
  Remember that the combined volume of **FB 1** and distilled water must always be $20.00\,cm^3$.
  Do **not** carry out an experiment using $15.00\,cm^3$ of **FB 1**.
  Do **not** use a volume of **FB 1** that is less than $5.00\,cm^3$.

Keep all FB labelled solutions for use in (e) and in Question 2.

Record all your results in a single table. You should include the volume of **FB 1**, the volume of distilled water and the reaction time.

The relative rate for the reaction is given by the following expression.

$$\text{relative rate} = \frac{1000}{\text{reaction time in seconds}}$$

Use this expression to calculate the relative rate for each of your experiments and record the values in your results table.

I	
II	
III	
IV	
V	
VI	
VII	
VIII	
IX	
X	

[10]

(b) On the grid opposite, plot the relative rate against the volume of **FB 1**. Include the origin in your plot. Label any points you consider anomalous. Draw a line of best fit.

I	
II	
III	
IV	

[4]

(c) From your graph, what conclusion can you make about the relationship between the relative rate for the reaction and the volume of **FB 1** used? Explain your answer.

....

....

.... [2]

(d) A student carried out the same experiment but used 15.00 cm^3 of **FB 1**. The student recorded a value for the reaction time of 28 s.

(i) Use your graph to calculate the time you would have expected to record if you had carried out an experiment using 15.00 cm^3 of **FB 1**.
Show the construction lines on your graph and show your working in the calculation.

reaction time = ... s [2]

(ii) Calculate the percentage difference between your value and that of the student.
Show your working.

percentage difference = ... % [1]

(e) You are to carry out a sixth experiment. The concentrations of iron(III) chloride, sodium thiosulfate and starch indicator should all be the same as in *Experiment 2* but the concentration of **iodide ions** should be **twice** the value that it is in *Experiment 2*.
State the volume of each solution used and record the reaction time to the nearest second.

[2]

(f) **(i)** 20.00 cm^3 of 0.0500 mol dm^{-3} $FeCl_3$, **FB 1**, were reacted with excess KI, **FB 2**.

Using the information on page 2, calculate the number of moles of I_2 produced.

moles I_2 = ... mol [2]

(ii) The iodine produced in **(i)** required 35.00 cm^3 of a different solution of sodium thiosulfate for complete reaction.

Calculate the concentration of the solution of sodium thiosulfate used.

concentration of $Na_2S_2O_3$ = ... mol dm^{-3} [1]

[Total: 24]

Qualitative Analysis

Where reagents are selected for use in a test, the **full 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)** **FB 1** is aqueous acidified iron(III) chloride, $FeCl_3$.
FB 5 is 0.150 mol dm^{-3} sodium thiosulfate, $Na_2S_2O_3$.

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

test	*observations*
To a 1 cm depth of **FB 1** in a test-tube add a 1 cm depth of **FB 5**. Leave to stand until there is no further change, then	
add aqueous sodium hydroxide.	
To a 1 cm depth of **FB 5** in a test-tube add a few drops of dilute hydrochloric acid. Leave to stand. Rinse the tube thoroughly.	

[3]

(ii) In **(i)** you should have observed a reaction between $Fe^{3+}(aq)$ and $S_2O_3^{2-}(aq)$.

Do you think that this reaction affected your results in **Question 1**? Refer to the equations on page 2. Explain your answer.

....

.... [1]

(b) **FB 6** is a solution containing a halide ion.

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

test	*observations*
To a 1 cm depth of **FB 6** in a test-tube add aqueous silver nitrate, then	
add aqueous ammonia.	
To a 1 cm depth of **FB 6** in a test-tube add aqueous silver nitrate, then	
add **FB 5**.	

[2]

(ii) The halide in **FB 6** is .... [1]

(c) **FB 7** is a solution of copper(II) sulfate, $CuSO_4$.

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

test	*observations*
To a 1 cm depth of **FB 7** in a test-tube add a 1 cm depth of **FB 2**, KI, then	
add **FB 4**, starch indicator.	
To a 1 cm depth of **FB 7** in a test-tube add a 1 cm depth of **FB 5**, then	
add a 1 cm depth of **FB 2** followed by **FB 4**, starch indicator.	

[3]

(ii) Give the formula of one of the products formed in the reaction of **FB 7** with **FB 2** in the first test.

.... [1]

(d) **FB 8** is a solution of a salt containing one cation and one anion from those listed in the Qualitative Analysis Notes.
The cation in **FB 8** is one of Mg^{2+}, Zn^{2+} or Al^{3+}.
The anion in **FB 8** is either SO_3^{2-} or SO_4^{2-}.

(i) Select reagents and carry out tests to identify which ions are present in **FB 8**.
Give details of your tests and observations.

[4]

(ii) The formula of **FB 8** is .... [1]

[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 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 –