Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME										
CENTRE NUMBER						CANDIDATE NUMBER				

3330954009

CHEMISTRY **9701/33**

Paper 3 Advanced Practical Skills 1 **October/November 2020**

2 hours

You must answer on the question paper.

You will need: The materials and apparatus listed in the confidential instructions

INSTRUCTIONS
- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working, use appropriate units and use an appropriate number of significant figures.
- Give details of the practical session and laboratory, where appropriate, in the boxes provided.

Session
Laboratory

INFORMATION
- The total mark for this paper is 40.
- The number of marks for each question or part question is shown in brackets [ ].
- The Periodic Table is printed in the question paper.
- Notes for use in qualitative analysis are provided in the question paper.

For Examiner's Use	
1	
2	
Total	

This document has **16** pages. Blank pages are indicated.

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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 on page 4.

Show your working and appropriate significant figures in the final answer to **each** step of your calculations.

1 In acidic solutions iron(III) ions are reduced by iodide ions to form iron(II) ions. The iodide ions are oxidised to iodine.

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

The rate of this reaction can be investigated by using starch indicator, which turns blue-black in the presence of iodine. Sodium thiosulfate is added to the reaction mixture to react with iodine as it is formed. The blue-black colour is seen when all the thiosulfate has reacted.

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

You will investigate how the rate of reaction is affected by changing the concentration of the iodide ions.

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

(a) Method

Prepare a table on page 4 for your results. You will need to include the volume of **FA 1**, volume of water, reaction time and rate of reaction for each of five experiments.

Experiment 1
- Fill the burette labelled **FA 1** with **FA 1**.
- Run 20.00 cm^3 of **FA 1** into the 100 cm^3 beaker.
- Use the 50 cm^3 measuring cylinder to add the following to the same 100 cm^3 beaker:
  - 20.0 cm^3 of **FA 3**
  - 10.0 cm^3 of **FA 4**.
- Use the 25 cm^3 measuring cylinder to measure 10.0 cm^3 of **FA 2**.
- Add this **FA 2** into the same 100 cm^3 beaker and start timing immediately.
- Stir once and place the beaker on the white tile.
- Stop timing as soon as the solution turns blue-black.
- Record this reaction time to the nearest second.
- Wash out the beaker and dry it with a paper towel.

Experiment 2
- Fill the second burette with distilled water.
- Run 10.00 cm^3 of **FA 1** into the 100 cm^3 beaker.
- Run 10.00 cm^3 of distilled water into the beaker containing **FA 1**.
- Use the 50 cm^3 measuring cylinder to add the following to the same 100 cm^3 beaker:
  - 20.0 cm^3 of **FA 3**
  - 10.0 cm^3 of **FA 4**.
- Use the 25 cm^3 measuring cylinder to measure 10.0 cm^3 of **FA 2**.
- Add the **FA 2** to the same 100 cm^3 beaker and start timing immediately.
- Stir once and place the beaker on the white tile.
- Stop timing as soon as the solution turns blue-black.
- Record this reaction time to the nearest second.
- Wash out the beaker and dry it with a paper towel.

Experiments 3–5

- Carry out three further experiments to investigate how the reaction time changes with different volumes of potassium iodide, **FA 1**.
  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.

Results

The rate of reaction can be calculated as shown:

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

I	
II	
III	
IV	
V	
VI	
VII	
VIII	
IX	
X	

[10]

(b) On the grid opposite, plot a graph of rate of reaction (*y*-axis) against volume of **FA 1** (*x*-axis). Include the origin, (0,0), in your scales. Circle any points you consider anomalous and draw a line of best fit. [3]

(c) **Use your graph** to calculate the time that the reaction would have taken if 5.00 cm^3 of **FA 1** had been used. **Show on the graph** how you obtained your answer.

time = ... s [2]

(d) (i) Using data from **Experiments 1** and **2**, show by calculation that the volume of aqueous potassium iodide, **FA 1**, used was directly proportional to the concentration of iodide ions.

[2]

(ii) Explain, by referring to your graph or your table of results, how the rate of reaction is affected by an increase in the concentration of aqueous potassium iodide, **FA 1**.

....

....

....

.... [2]

(e) Thiosulfate ions can reduce iron(III) ions and also react with acid to form sulfur, sulfur dioxide and water.

(i) Write an ionic equation for the reaction between thiosulfate ions and hydrogen ions in aqueous solution. Include state symbols.

.... [1]

(ii) A student carries out the same investigation as in **(a)** but the solutions are mixed in a different order. The student places **FA 1** and an appropriate volume of distilled water in one beaker and all the other reactants in a second beaker. The student then transfers the mixture from the second beaker to the first and starts timing.

Tick the box for the statement you consider correct. Explain your answer.

The student's method is better than that in **(a)**.	☐
The two methods are equally good.	☐
The student's method is not as good as that in **(a)**.	☐

reason ....

....

.... [1]

(f) Another student investigates the effect of iron(III) concentration on the rate of this reaction. The student carries out another experiment, **Experiment 6**, and the rate is compared to that of **Experiment 2**. In **Experiment 2**, the volumes used were:

reagent	volume / cm^3
FA 1	10.00
FA 2	10.0
FA 3	20.0
FA 4	10.0
distilled water	10.00

(i) Suggest the volumes the student could use for **Experiment 6**.

reagent	volume / cm^3
FA 1	
FA 2	
FA 3	
FA 4	
distilled water	

[2]

(ii) This student records a time of 178 s for **Experiment 2**.

The rate of reaction is directly proportional to the concentration of iron(III) ions.

Suggest how long it would take the reaction mixture proposed for **Experiment 6** in **(f)(i)** to turn blue-black. Assume that **Experiment 6** is carried out at the same temperature as **Experiment 2**.
Do not carry out Experiment 6.

time = ... s [1]

[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 5** is a salt consisting of two ions both of which are listed in the Qualitative Analysis Notes.

(i) Place a small spatula measure of **FA 5** into a hard-glass test-tube. Heat the tube gently at first and then more strongly. Record **all** your observations.

....

....

....

.... [3]

(ii) **FA 6** is a sample of the residue obtained from **FA 5** after strong heating.

Place a small spatula measure of **FA 6** in a test-tube and add a 1 cm depth of aqueous hydrogen peroxide. Record your observations.

....

.... [2]

(iii) Dissolve a spatula measure of **FA 5** in a 5 cm depth of distilled water in a boiling tube. Use separate 1 cm depths of this solution in test-tubes for the following tests. Record your observations.

Keep the remainder of FA 5(aq) for use in 2(b)(ii).

test	*observations*
Test 1 Add aqueous sodium hydroxide.	
Test 2 Add a 1 cm depth of aqueous hydrogen peroxide, then	
add aqueous sodium hydroxide.	

[2]

(b) (i) **FA 7** is a solution of a different salt. The cation present in **FA 7** is not listed in the Qualitative Analysis Notes.

FA 5(aq) and **FA 7** each contain either a halide ion or an anion containing sulfur. These anions are listed in the Qualitative Analysis Notes.

For both of these anions, select reagents that you would use in order to carry out tests that give positive results.

Record the reagents and the ions for which they would test.

[2]

(ii) Carry out both of your tests on **FA 5**(aq) and **FA 7** and record your results in the space below.

[3]

(iii) Use your observations in **(a)** and **(b)(ii)** to identify the ions present in **FA 5** and **FA 7**. Write the formula of each ion in the table. If the tests you carry out do not allow you to identify any of the ions, write 'unknown'.

	FA 5	**FA 7**
cation		
anion		

[2]

(iv) Suggest what you would observe if you added aqueous chlorine to separate portions of aqueous solutions of **FA 5** and **FA 7**.

Do not carry out this test.

aqueous chlorine and **FA 5**(aq) ....

aqueous chlorine and **FA 7**(aq) ....

[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 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

Group																	
1	2											13	14	15	16	17	18
				Key			1 H hydrogen 1.0										2 He helium 4.0
3 Li lithium 6.9	4 Be beryllium 9.0			atomic number atomic symbol name relative atomic mass								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 A*l* aluminium 27.0	14 Si silicon 28.1	15 P phosphorus 31.0	16 S sulfur 32.1	17 C*l* 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 T*l* 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 F*l* 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 –