Class	Adm No

Candidate Name: ____________________

Shift
Laboratory

H

millennia institute

2021 Preliminary Examinations
Pre-University 3

H2 CHEMISTRY **9729/04**

Paper 4 Practical **1 Sept 2021**

2 hours 30 min

Candidates answer on the Question paper.

READ THESE INSTRUCTIONS FIRST

Do not turn over this question paper until you are told to do so

Write your name, class and admission number on all the work you hand in.
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.

Answer **all** questions in the spaces provided on the Question Paper.
The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.
Qualitative Analysis Notes are printed at the back of the Question Paper.

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.

Question	**1**	**2**	**3**	**4**	Total
Marks	**13**	**20**	**10**	**12**	**55**

1 Determine the formula of the ion IO_x^- by titration

In this experiment you will determine the formula of the ion, IO_x^-.
Iodine, I_2, is formed when IO_x^- ions reacts with an excess of iodide ions.
The equation for this reaction is:

$$IO_x^- + \boldsymbol{y}\, I^- + \boldsymbol{z}\, H^+ \rightarrow \left(\frac{\boldsymbol{y+1}}{2}\right) I_2 + \frac{\boldsymbol{z}}{2} H_2O$$

where ***x***, ***y*** and ***z*** are all integers.
The amount of iodine produced will then be determined by titration with thiosulfate ions, $S_2O_3^{2-}$.

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

FA 1 is a solution containing 0.0150 mol dm^{-3} IO_x^- ions.
FA 2 is dilute sulfuric acid, H_2SO_4.
FA 3 is 0.500 mol dm^{-3} potassium iodide, KI.
FA 4 is 0.100 mol dm^{-3} sodium thiosulfate, $Na_2S_2O_3$.
starch indicator

(a) Method

- Pipette 25.0 cm^3 of **FA 1** into a conical flask.
- Using a measuring cylinder, add 20.0 cm^3 of **FA 2** to the conical flask.
- Using a measuring cylinder, add 10.0 cm^3 of **FA 3** to the conical flask. The solution will turn brown as iodine is produced.
- Fill the burette with **FA 4**.
- Add **FA 4** from the burette until the solution in the conical flask turns yellow.
- Add 1 cm^3 of starch indicator to the conical flask. The solution will turn blue-black.
- Continue to add more **FA 4** dropwise from the burette until the blue-black colour just disappears.
  This is the end-point of the titration.
- Carry out as many accurate titrations as you think necessary to obtain consistent results.
- Record the burette readings and the volume of **FA 4** added in each accurate titration in the space below.

Results

M1

M2

M3

M4

M5

(b) From your titration results, obtain a value for the volume of **FA 4** to be used in your calculations. Show clearly how you obtained this value.

25.0 cm^3 of **FA 1** required .... cm^3 of **FA 4**. **M6**

(c) Calculations

(i) Use your answer to **(b)** to calculate the amount of iodine that was formed.

Amount of I_2 = ……………………….. **M7**

(ii) Calculate the amount of IO_x^- ions in 25.0 cm^3 of **FA 1**.

amount of IO_x^- ions=………………………………….. **M8**

(iii) Using your answers in **(c)(i)** and **(c)(ii)**, calculate the value of ***y*.**

$$IO_x^- + \boldsymbol{y}\, I^- + \boldsymbol{z}\, H^+ \rightarrow \left(\frac{y+1}{2}\right) I_2 + \frac{z}{2} H_2O$$

M9

y = ………………………… M10

(iv) Hence, determine the value of ***x*** in IO_x^- ion.

x = …………………….. M11

(d) **(i)** The maximum error in the volume measured using the pipette is ±0.05 cm^3.

Calculate the maximum percentage error in the volume of **FA 1** used.

Maximum percentage error:……………….. M12

(ii) A student suggested that a more accurate value of ***x*** could be obtained if a burette is used to measure **FA 3** instead of a measuring cylinder.
Do you agree with the student? Explain your answer.

....

....

....

.... **M13**

[Total: 13]

2 Determination of the enthalpy change of the decomposition of $NaHCO_3$

You are required to determine the enthalpy change of the decomposition of $NaHCO_3$.

$$NaHCO_3 \rightarrow ½Na_2CO_3 + ½H_2O + ½CO_2$$

FA 5 is anhydrous sodium hydrogencarbonate.
FA 6 is anhydrous sodium carbonate.
FA 7 is 1.0 mol dm^{-3} hydrochloric acid.

You will determine the enthalpy change of reaction for each of **FA 5** and **FA 6** with the excess addition of **FA 7**. You will then use these values to calculate the enthalpy change of the decomposition of sodium hydrogencarbonate.

(a) Determining the enthalpy change of reaction between FA 5 and FA 7

$$NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2$$

Method

- Weigh an empty weighing boat.
- Weigh about 4.0 g of **FA 5** in a weighing boat.
- Using a 50 cm^3 measuring cylinder, transfer 50.0 cm^3 of **FA 7** into a 250 cm^3 **beaker**.
- Stir the solution and record the initial temperature.
- Start timing and do not stop the stopwatch until the whole experiment has been carried out for 7 minutes.
- Record the temperature of the solution mixture every minute for 2 minutes.
- At exactly 3 minutes, carefully add **FA 5** into the beaker and stir the mixture. You do not need to measure the temperature of the solution at the 3^{rd} minute. Break up any clumps while stirring.
- Record the temperature at t = 3.5 min.
- Repeat the measurement every 0.5 min until t = 7min.
- Reweigh the weighing boat containing residual sodium hydrogencarbonate.
- In an appropriate format in the space provided below, prepare tables in which to record results for your experiment in **(a)**:
    - all weighings to an appropriate level of precision,
    - all values of temperature, *T*, to an appropriate level of precision,
    - all values of time, *t*, recorded to the nearest 0.5 min.

Results

M14
M15

(b) Plot a graph of temperature, T, on the y-axis, against time, t, on the x-axis on the grid in Fig. 2.1.

Draw a best-fit straight line taking into account all of the points before t = 3.0 min.

Draw another best-fit straight line taking into account all of the points after the temperature of the mixture has started to rise steadily.

Extrapolate both lines to t = 3.0 min and determine the theoretical fall in temperature.

M16

M17

M18

Fig. 2.1

theoretical fall in temperature = ... **M19**

(c) Calculations

(i) Using the answer from **(b)**, calculate the heat energy taken in during the reaction of **FA 5** with **FA 7.**

[4.2 J is required to raise the temperature of 1 cm^3 of solution by 1 °C]

Heat energy taken in = …………………………………… **M20**

(ii) Calculate the amount of **FA 5**, $NaHCO_3$, used in the experiment.

[A_r: C, 12.0; H, 1.0; O, 16.0; Na, 23.0]

Amount of **FA 5**, $NaHCO_3$ used = ……………………………… **M21**

(iii) Hence, determine the enthalpy change of reaction, ΔH_1 for the following reaction.

$$NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2 \text{ ---- } \Delta H_1$$

ΔH_1 = …………………………… **M22**

(d) Determine the enthalpy change of reaction between FA 6 and FA 7

Method

- Weigh an empty weighing boat.
- Place about 2.4 g of **FA 6** in the weighing boat.
- Place a dry Styrofoam cup inside a 250 cm^3 beaker.
- Using a measuring cylinder, place 50 cm^3 of **FA 7** into the Styrofoam cup.
- Place the lid onto the cup through the thermometer from the top. Stir the liquid in the cup with the thermometer and measure its temperature. Record this temperature in your table.
- Tip cautiously the contents of the weighing boat into the acid in the Styrofoam cup, stir gently with the thermometer and record the highest temperature obtained in your table.
- Calculate the change in temperature.
- Reweigh the empty weighing boat.
- In an appropriate format in the space provided below, record all measurements of mass and temperature. Include the mass of **FA 6** used in your recording.

Results

M23
M24
M25
M26
M27

(e) **(i)** Given that 4.2 J is required to raise the temperature of 1 cm^3 of solution by 1 ^oC, calculate the heat energy given out in the reaction between **FA 6** and **FA 7**.

Heat energy given out = ……………………….……… **M28**

(ii) Calculate the amount of **FA 6**, Na_2CO_3 added to the cup.
[A_r: C, 12.0; O, 16.0; Na, 23.0]

Amount of **FA 6**, Na_2CO_3 = ………………………….. **M29**

(f) Calculate the enthalpy change ΔH_2 for the following reaction.

$$Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2 \text{ ---- } \Delta H_2$$

M30

ΔH_2 = ……………………………………… **M31**

(g) Using your answers in **(c)(iii)** and **(f)**, calculate the enthalpy change of decomposition of $NaHCO_3$, ΔH_3.

$$NaHCO_3 \rightarrow \tfrac{1}{2}Na_2CO_3 + \tfrac{1}{2}H_2O + \tfrac{1}{2}CO_2 \text{ ---- } \Delta H_3$$

ΔH_3 =…………………………………. **M32**

(h) A student repeats the experiment with 2.0 mol dm^{-3} HCl instead of the given concentration of 1.0 mol dm^{-3}, with the same total volume.

State and explain the effect of this change on the value of ΔH_3 that she has calculated.

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……

……

…… **M33**

[Total: 20]

3 **Qualitative Analysis**

You are provided with three solutions, **FA 8**, **FA 9** and **FA 10**.

Perform the test-tube experiments described below and record your observations in the table.

Use fresh samples of each solution in the tests (a)(i), (a)(iii) and (a)(iv).

		observations with **FA 8**	observations with **FA 9**	observations with **FA 10**	
(a)(i)	Place about 1 cm^3 of **FA 8** in a test-tube. Add sodium hydroxide, dropwise with shaking, until in excess. **Repeat using FA 9 and FA 10. Retain the mixtures for use in (a)(ii).**				
(ii)	Add hot water to a 500 cm^3 beaker provided until it is approximately half-filled. Place the test-tubes from **(a)(i)** in the beaker for 5 minutes. **While you are waiting, begin the tests below.**				
(iii)	Place about 1 cm^3 of **FA 8** in a test-tube. Add about 1 cm^3 of Fehling's solution and shake the mixture. Place the test-tube in the beaker with hot water for around 5 minutes. **While you are waiting, begin test (a)(iv).**				
(iv)	Place about 1 cm^3 of **FA 8** in a test-tube. Add two drops of acidified potassium manganate(VII) and shake the mixture. Place the test-tube in the beaker with hot water for around 5 minutes. **Repeat using FA 9 and FA 10.**				**M34** **M35** **M36** **M37**

(b) From your observations, state and quote evidence for:

- one conclusion you can draw about **FA 8**

conclusion about **FA 8** ....

evidence ....

....

- the identity of the cation in **FA 9**

cation in **FA 9** ....

evidence **M38**

.... **M39**

(c) Perform the experiment described below and record your observations in the table.

		observations
	Place about 2 cm^3 of **FA 10** in a test-tube. Add 2 pieces of magnesium ribbon. Place the test-tube in the beaker with hot water for around 5 minutes.	

M40

(d) Deduce the cation present in **FA 10**. Hence, suggest a balanced equation for one of the reactions that occurred in **(c)**.

....

.... **M41**

(e) **FA 10** contains an anion which is either an iodide ion or sulfate ion.
Devise and perform a simple test, based on the Qualitative Analysis Notes to identify the anion present in **FA 10**. Record your observations and hence deduce the identity of the anion in **FA 10**.

....

....

.... **M42**

M43

[Total: 10]

4 Planning

Lead can form oxides of varied formulae, including Pb_2O and PbO. Lead(II) carbonate, $PbCO_3$, decomposes on heating to form either one of these oxides.

The two possible decomposition equations are:

1. $PbCO_3(s) \rightarrow PbO(s) + CO_2(g)$

2. $2PbCO_3(s) \rightarrow Pb_2O(s) + 2CO_2(g) + \frac{1}{2}O_2(g)$

You are to plan an experiment to investigate the decomposition of lead(II) carbonate on heating and hence determine the actual decomposition product using gas collection method.

(a) You may assume that you are provided with a sample of lead(II) carbonate and the apparatus commonly found in a college laboratory.

Your plan should include:

- a sketch of the experimental set-up
- calculation of the mass of lead(II) carbonate to be used
- details of how you would carry out the experiment
- a table to show the data you would measure and record during the experiment. Include in your table any other data you would calculate from the experimental results. Insert in your table the letters **A**, **B**, **C**, etc. to represent each data.
- brief, but specific, details of how the results would then be used to reach a conclusion.

[A_r : C, 12.0; O, 16.0; Pb, 207.2]

M44
M45

M46
M47
M48
M49
M50
M51

(b) State one assumption made in the calculations to determine the actual decomposition product.

……………………………………………………………………………………………..…………

……..…………………………………………………………………………………………...…… **M52**

(c) Suggest another method to collect the gas evolved from the reaction and state its limitation.

Method: ……………………………………………………………………………………….

Limitation: …………..………………………………………………………………………… **M53**

…………..…………………………………………………………………………………… **M54**

(d) Other than the gas collection method, suggest another method to determine the decomposition product.

..…………..………………………………………………………………………………...…

………...…………..……………………………………………………………………………… **M55**

[Total: 12]

END OF PAPER

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Qualitative Analysis Notes

[ppt. = precipitate]

(a) Reactions of aqueous cations

cation	*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)	ammonia produced on heating	–
barium, Ba^{2+}(aq)	no ppt. (if 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 giving dark green solution	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. insoluble in excess	green ppt. 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. insoluble in excess	off-white ppt. insoluble in excess
zinc, Zn^{2+}(aq)	white ppt. soluble in excess	white ppt. soluble in excess

(b) Reactions of anions

ions	*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 pale 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, $SO_3^{2-}(aq)$	SO_2 liberated with dilute acids; gives white ppt. with $Ba^{2+}(aq)$ (soluble in dilute strong acids)

(c) Test for gases

ions	*reaction*
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
sulfur dioxide, SO_2	turns aqueous acidified potassium manganate(VII) from purple to colourless

(d) Colour of halogens

halogen	*colour of element*	*colour in aqueous solution*	*colour in hexane*
chlorine, Cl_2	greenish yellow gas	pale yellow	pale yellow
bromine, Br_2	reddish brown gas / liquid	orange	orange-red
iodine, I_2	black solid / purple gas	brown	purple