EUNOIA JUNIOR COLLEGE
JC2 Preliminary Examination 2018
General Certificate of Education Advanced Level
Higher 2

CANDIDATE NAME							
CIVICS GROUP	1	7	–			INDEX NUMBER	

CHEMISTRY

9729/04

Paper 4 Practical

28 August 2018

2 hours 30 minutes

Candidates answer on the Question Paper.

Additional Materials: As listed in the Confidental Instructions

READ THESE INSTRUCTIONS FIRST

Write your name, civics group and registration number on the work you hand in.
Give details of the practical shift 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 paper clips, highlighters, 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 on pages 19 and 20.

Shift
Laboratory

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.

For Examiner's Use	
1	
2	
3	
4	
Total	

This document consists of **19** printed pages and **1** blank page.

Answer **all** the questions in the spaces provided.

For Examiner's Use

1 Analysis of a solution containing both sodium hydroxide and sodium carbonate by Warder titration (double indicator method)

Aqueous sodium hydroxide easily reacts with atmospheric carbon dioxide. This results in the sodium hydroxide being contaminated with sodium carbonate Na_2CO_3.

The Warder titration (double indicator method) can be used to analyse a mixture containing both sodium hydroxide and sodium carbonate.

FA 1 is 0.125 mol dm^{-3} hydrochloric acid, HC*l*.
FA 2 is an aqueous solution containing sodium hydroxide, NaOH, and sodium carbonate, Na_2CO_3.

(a) Titration of FA 2 against FA 1 using methyl orange or screened methyl orange indicator

In this titration, **FA 1** is run from the burette into the conical flask containing **FA 2** with methyl orange or screened methyl orange indicator.

The end-point is reached when the yellow colour changes to orange for methyl orange, or the green colour changes to grey for screened methyl orange.

(i) 1. Fill the burette with **FA 1**.

2. Using a pipette, transfer 25.0 cm^3 of **FA 2** into a conical flask.

3. Add a few drops of methyl orange or screened methyl orange indicator.

4. Run **FA 1** from the burette into the conical flask until the colour of the solution changes.

5. Record your titration results in the space provided below. Make certain that your recorded results show the precision of your working.

6. Repeat points **1** to **5** as necessary until consistent results are obtained.

Results

Titration number	1	2
Final burette reading / cm^3	33.70	35.80
Initial burette reading / cm^3	0.00	2.00
Volume of **FA 1** used / cm^3	33.70	33.80
	✓	✓

[1] table with correct headings *('burette' must be stated)* and units.
(Do not award if any final and initial burette readings are inverted/ if 50 is used as initial burette reading/ burette reading is >50)
[1] All burette readings recorded to the nearest 0.05 cm^3 + correct computation of titres
[1] Has two uncorrected titres for end-point within 0.10 cm^3 + place ✓ under two selected titres within 0.10 cm^3. *(Do not award if additional titration is performed after consistent titres are obtained.)*
[2] Accuracy (Teacher's reading ±0.20 cm^3: 2m; ±0.40 cm^3: 1m)

[5]

For Examiner's Use

(ii) From your titrations, obtain a suitable volume of **FA 1** to be used in your calculations. Show clearly how you obtained this volume.

Average volume of **FA 1** $= \frac{33.70 + 33.80}{2}$

$= 33.75 \text{ cm}^3$

- **state correct term "Average volume"**
- **quote the selected titres in the average working**
- **give correct final value to 2 d.p.**

Volume of **FA 1** = ... **33.75 cm³** ..... [1]

(b) Titration of FA 2 against FA 1 using thymolphthalein indicator

When the titration in **(a)** was repeated using thymolphthalein as the indicator, 25.0 cm^3 of **FA 2** required 23.35 cm^3 of **FA 1**.

The following explains why different results were obtained using two different indicators.

- When **thymolphthalein** is used as the indicator, the following reactions would have taken place at the end-point of the titration.

  1. $NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$
  2. $Na_2CO_3(aq) + HCl(aq) \rightarrow NaCl(aq) + NaHCO_3(aq)$

- When **methyl orange** is used as the indicator in **(a)**, the following reactions would have taken place at the end-point of the titration.

  1. $NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$
  2. $Na_2CO_3(aq) + HCl(aq) \rightarrow NaCl(aq) + NaHCO_3(aq)$
  3. $NaHCO_3(aq) + HCl(aq) \rightarrow NaCl(aq) + CO_2(g) + H_2O(l)$

(i) Calculate the amount of hydrochloric acid present in the volume of **FA 1** calculated in **(a)(ii)**.

Amount of HCl in 33.75 cm^3 of **FA 1** $= 0.125 \times \frac{33.75}{1000} =$ **0.00422** mol

amount of HCl in volume in **(a)(ii)** = ... **0.00422 mol** ..... [1]

(ii) Calculate the amount of hydrochloric acid in 23.35 cm^3 of **FA 1**.

Amount of HCl in 23.35 cm^3 of **FA 1** $= 0.125 \times \frac{23.35}{1000} =$ **0.00292** mol

amount of HCl in 23.35 cm^3 of **FA 1** = ... **0.00292 mol** ..... [1]

For Examiner's Use

(iii) Using your answer to **(b)(i)** and **(b)(ii)**, calculate the amount of hydrochloric acid that reacts with the Na_2CO_3 in the titration using thymolphthalein indicator.

Amount of HC*l* that react with Na_2CO_3 = 0.00422 – 0.00292 = **0.00130** mol

amount of HC*l* that react with Na_2CO_3 = ... **0.00130 mol** ..... [1]

(iv) Hence, calculate the mass of sodium carbonate present in 25.0 cm^3 of **FA 2**.

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

Mass of Na_2CO_3 in 25.0 cm^3 of **FA 2** = 0.00130 × 106.0 = **0.138** g

mass of Na_2CO_3 in 25.0 cm^3 of **FA 2** = ... **0.138 g** ..... [1]

(v) The **overall** equation for the reaction of Na_2CO_3 with HC*l* when methyl orange is used as indicator is given below.

$$Na_2CO_3(aq) + 2HCl(aq) \rightarrow 2NaCl(aq) + CO_2(g) + H_2O(l)$$

Calculate the amount of HC*l* that reacted with the Na_2CO_3 in the above equation in 25.0 cm^3 of **FA 2**.

Amount of HC*l* that react with Na_2CO_3 = 2 × 0.00130 = **0.00260** mol

amount of HC*l* = ... **0.00260 mol** ..... [1]

(vi) Use your answers to **(b)(i)** and **(b)(v)** to calculate the mass of sodium hydroxide in 25.0 cm^3 of **FA 2**.

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

Mass of NaOH in 25.0 cm^3 of **FA 2** = (0.00422 – 0.00260) × 40.0 = **0.0648** g

mass of NaOH = ... **0.0648 g** ..... [1]

For Examiner's Use

(vii) Calculate the percentage by mass of sodium carbonate in the mixture of sodium hydroxide and sodium carbonate in **FA 2**.

$$\% \text{ by mass of } Na_2CO_3 \text{ in } \mathbf{FA\ 2} = \frac{0.138}{0.138 + 0.0648} \times 100 = \mathbf{68.0\%}$$

percentage by mass of Na_2CO_3 in **FA 2** = **68.0%** [1]

(c) The error (uncertainty) associated with **each reading** is given as follows:

50.00 cm^3 burette: ±0.05 cm^3

25.0 cm^3 pipette: ±0.04 cm^3

Using the above data, calculate the percentage error (uncertainty) when a

(I) 50.00 cm^3 burette

(II) 25.0 cm^3 pipette

is used to measure 25 cm^3 of **FA 2** into the conical flask.

Hence state whether a 50.00 cm^3 burette or 25.0 cm^3 pipette will be more suitable to measure 25.0 cm^3 of **FA 2** accurately.

Error when burette is used = $2 \times \pm 0.05 = \pm 0.10\ cm^3$
Note: This is because when using the burette, 2 readings are made- initial and final; hence the error has to be added up.
% error when using burette = $0.10/25 \times 100\% =$ **0.4%**
Error when 25 cm^3 pipette is used = $\pm 0.04\ cm^3$
% error when using 25 cm^3 pipette = $0.04/25 \times 100\% =$ **0.16%**
[1]

The use of a burette to measure 25 cm^3 of **FA 2** will result in greater % error.
Hence a **25.0 cm^3 pipette is more suitable** to measure 25 cm^3 of **FA 2**. **[1]**
(from correct % calculations, allow ecf from % error)

[2]

[Total: 15]

For Examiner's Use

2 To determine the percentage by mass of sodium hydrogencarbonate in the unknown sample based on gravimetric method

Sodium hydrogencarbonate decomposes on heating to give sodium carbonate, carbon dioxide and water vapour.

$$2NaHCO_3(s) \xrightarrow{\Delta} Na_2CO_3(s) + CO_2(g) + H_2O(g)$$

Sodium chloride on the other hand is unaffected by heat.

FA 3 is a mixture of anhydrous sodium hydrogencarbonate, $NaHCO_3$, and sodium chloride, NaC*l*.

In this question, you will heat to decompose the sodium hydrogencarbonate in **FA 3** and determine the mass of carbon dioxide and water lost. The data will be used to determine

- the mass of $NaHCO_3$ in **FA 3**,
- the percentage composition by mass of $NaHCO_3$ in **FA 3**.

(a) Thermal decomposition of $NaHCO_3$

In this experiment, solid **FA 3** is heated strongly in a boiling tube, over a non-luminous Bunsen flame, until there is no further change in the mass.

1. Weigh accurately about 4.5 g of **FA 3** in the boiling tube provided. Record your weighings in the space provided below.

2. Heat the tube gently first, then strongly.

3. Place the boiling tube into a **dry** 250 cm^3 beaker to cool.

> You may wish to proceed with other experiments while waiting for the boiling tube to cool.

4. Weigh and record the mass of the cooled boiling tube containing the residue.

5. Repeat points **2** to **4** as necessary until a constant mass is obtained.

6. **Turn off your Bunsen burner**.

(i) In an appropriate format in the space below, record all weighing measurements.

Mass of empty boiling tube / g	29.410
Mass of boiling tube and **FA 3** / g	33.891
Mass of **FA 3** used / g	4.481
Mass of boiling tube and residue after first heating /g	33.218
Mass of boiling tube and residue after second heating /g	33.065
Mass of boiling tube and residue after third heating /g	33.065

[1] Record "total mass of boiling tube + FA 3" + "mass of boiling tube + residue after 1st heating" + "mass of boiling tube + residue after 2nd heating"
[1] Record <u>two constant masses</u> (within 0.01g) of boiling tube + residue after heating
[1] All mass readings are recorded to 3 d.p. and mass of FA 3 used is within ±0.05 g, with appropriate units stated [3]

For Examiner's Use

(ii) Using your results, calculate the mass of carbon dioxide and water vapour evolved.

Mass of CO_2 and H_2O evolved = 4.481 g – 3.655 g = 0.826 g

mass of CO_2 and H_2O evolved = **0.826 g** [1]

(iii) Using your answer to **(a)(ii)**, calculate the amount of carbon dioxide evolved.

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

Let the amount of carbon dioxide evolved by x mol.

$n_{CO_2} = n_{H_2O} = x$ mol

$$x(44.0) + x(18.0) = 0.826$$

$$x = \frac{0.826}{44.0 + 18.0} = 0.01332$$

amount of CO_2 evolved = **0.0133 mol** [1]

(iv) Calculate the mass of sodium hydrogencarbonate in the sample of **FA 3**.

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

$$n_{NaHCO_3} = 2n_{CO_2} = 2 \times 0.01332 = 0.02665 \text{ mol}$$

$$\text{Mass of } NaHCO_3 = 0.02665 \times (23.0 + 1.0 + 12.0 + 3 \times 16.0)$$

$$= 0.02665 \times 84.0$$

$$= 2.238 \text{ g} \approx 2.24 \text{ g}$$

mass of $NaHCO_3$ in sample of **FA 3** = **2.24 g** [1]

(v) Determine the percentage by mass of sodium hydrogencarbonate in **FA 3**.

$$\% \text{ by mass of } NaHCO_3 \text{ in FA1} = \frac{2.238}{4.481} \times 100\% = 49.9\%$$

percentage by mass of $NaHCO_3$ in **FA 3** = **49.9%** [1]

For Examiner's Use

(b) Suggest one possible source of error in this experiment. How would this error affect the calculated results in **(a)(iii)**?

Incomplete decomposition **[1]** may occur and therefore the mass lost recorded or mass of CO_2 and H_2O evolved is lower than actual. The calculated mass of $NaHCO_3$ is lower than actual. **[1]**

[2]

(c) Planning

Plan an experiment to determine the percentage by mass of sodium hydrogencarbonate in the unknown sample based on volumetric analysis method.

In this experiment, you will titrate a **solution of FA 3** against **FA 1**, using a suitable indicator.

You can assume you are provided with the following reagent:

FA 4 is a solution containing 30.00 g dm^{-3} of **FA 3**.

In your plan, you should include details of

- the amount of reagents you would use,
- the apparatus you would use and the procedure you would follow,
- the measurements you would take,
- appropriate calculations to show how the percentage by mass of sodium hydrogencarbonate in **FA 3** can be determined, assuming the average titre is ***y*** cm^3.

Procedure

Step 1: Pipette 25.0 cm^3 of **FA 4** into a 250 cm^3 conical flask and add 1–2 drops of methyl orange indicator.

Step 2: Fill a burette with **FA 1**.

Step 3: Titrate the contents of the conical flask with **FA 4** from the burette until the solution changes from yellow to orange at the end point.

Step 4: Tabulate your titration values in the table below.

Titration number	Accurate		
	1	2	
Final burette reading / cm^3			
Initial burette reading / cm^3			
Volume of **FA 1** used / cm^3			

Step 5: Obtain from your titration results a suitable average titre. Show clearly the titres you used in calculating this average.

- Suitable volume of reagents used, apparatus used **[1]**
- Suitable indicator and colour change at the end point **[1]**
- Logical flow of procedure and Data collection **[1]**

For Examiner's Use

Calculations

Average titre = y cm^3

Calculate the mass of $NaHCO_3$ per dm^3 of **FA 4**

$HCO_3^- + H^+ \longrightarrow CO_2 + H_2O$

n_{HCl} used in titration = $\frac{y \times 0.200}{1000} = 2y \times 10^{-4}$ mol = n_{NaHCO_3} in 25.0 cm^3 of **FA 4** [1]

n_{NaHCO_3} per dm^3 = $\frac{2y \times 10^{-4} \times 1000}{25} = 8y \times 10^{-3}$ mol

mass of $NaHCO_3$ per dm^3 = $8y \times 10^{-3} \times 84.0 = 0.672y$ g [1]

% mass of $NaHCO_3$ in **FA 3** = $\frac{0.672y}{30.0} \times 100\% = 2.24y$ % [1]

[6]

[Total : 15]

For Examiner's Use

3 Investigation of the kinetics of the reaction between calcium carbonate and hydrochloric acid

Calcium carbonate that reacts with hydrochloric acid in an acid-carbonate reaction as shown below.

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

FA 5 is powdered $CaCO_3$.

In this question, you will measure the volume of CO_2 gas produced at timed intervals until the reaction is complete, using an excess of dilute hydrochloric acid.

You will need access to **FA 1** solution you used earlier.

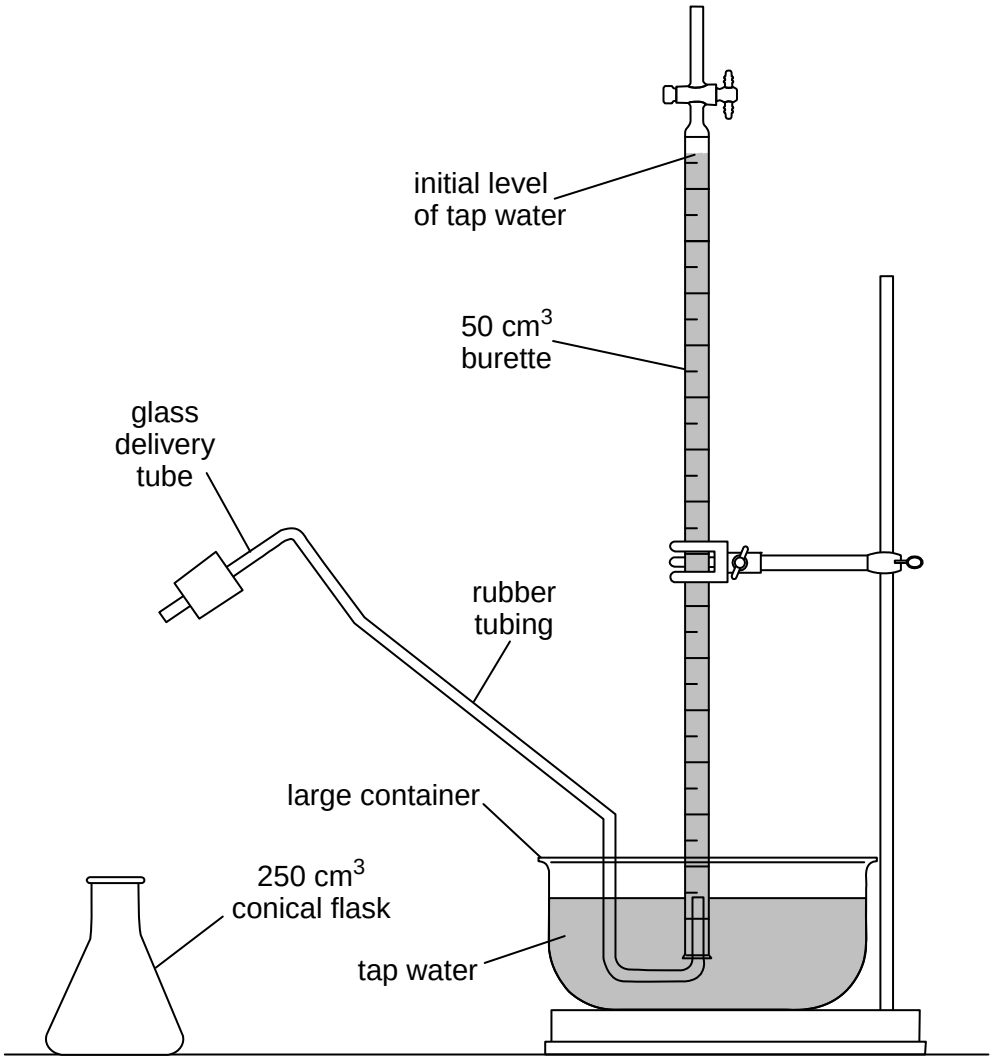

Fig 3.1

You will measure the level of water in the burette at timed intervals.

In an appropriate format in the space provided on page **11**, prepare a table in which you may record each burette reading and the time it was taken. The time taken should be recorded to one decimal place.

In addition, your table will need to show the volume of CO_2 collected up to that time, recorded to one decimal place.

For Examiner's Use

1. Set up the apparatus as shown in the Fig. 3.1. You should insert the plastic/rubber tubing to a sufficient depth in the burette so that it will not subsequently shake loose.

2. Adjust the water level in the burette until it is between 48.0 cm^3 and 50.0 cm^3. You may find it helpful to use an empty dropping pipette to introduce small amounts of air from the bottom of the burette tube.

3. Transfer all the solid **FA 5** provided in the weighing bottle into a dry and clean 250 cm^3 conical flask.

4. Use an appropriate measuring cylinder, measure 40 cm^3 of **FA 1**.

5. Transfer the **FA 1** into the conical flask containing **FA 5** and insert the bung into the conical flask.

6. Allow any bubbles created in the burette when the bung was inserted in the conical flask to rise to the top. Start the stopwatch, read and record the initial water level in the burette.

   Note: Once you have started the stopwatch, allow it to continue running for the duration of the experiment. You **must not stop** the stopwatch until the reaction is complete.

7. Check that the plastic/rubber tubing is securely positioned in the burette.

8. Hold the flask by its neck and **gently swirl** it continuously.

9. At *t* = 0.5 min, read and record the water level in the burette, to 1 decimal place, together with the time it was measured, in your table.

10. Continue to gently swirl the flask. Read and record the water level in the burette every half minute, until the reaction is complete.

(a) (i) Experimental Results

Time / min	Burette Reading / cm^3	Volume of CO_2 / cm^3
0.0	48.0	0.0
0.5		
1.0		

[1] Tabulates burette readings at t = 0 until the end of the experiment, time/min and volume of CO_2/cm^3.
Tables have correct headers and units.
Tabulation may be vertical or horizontal; lines are not essential but there should be no absence of headers. Where units have not been included in the header, there should be the appropriate unit for each entry in the table
[1] All burette readings and CO_2 volumes to 0.1 cm^3, and times to 0.5 min.
[1] Full set of results with final readings that have at least 3 values that are the same

[3]

For Examiner's Use

(ii) Plot on the grid below, a graph of the volume of CO_2 on the *y*-axis, against time, *t*, on the x-axis.

Draw the most appropriate best-fit curve, taking into account all of your points.

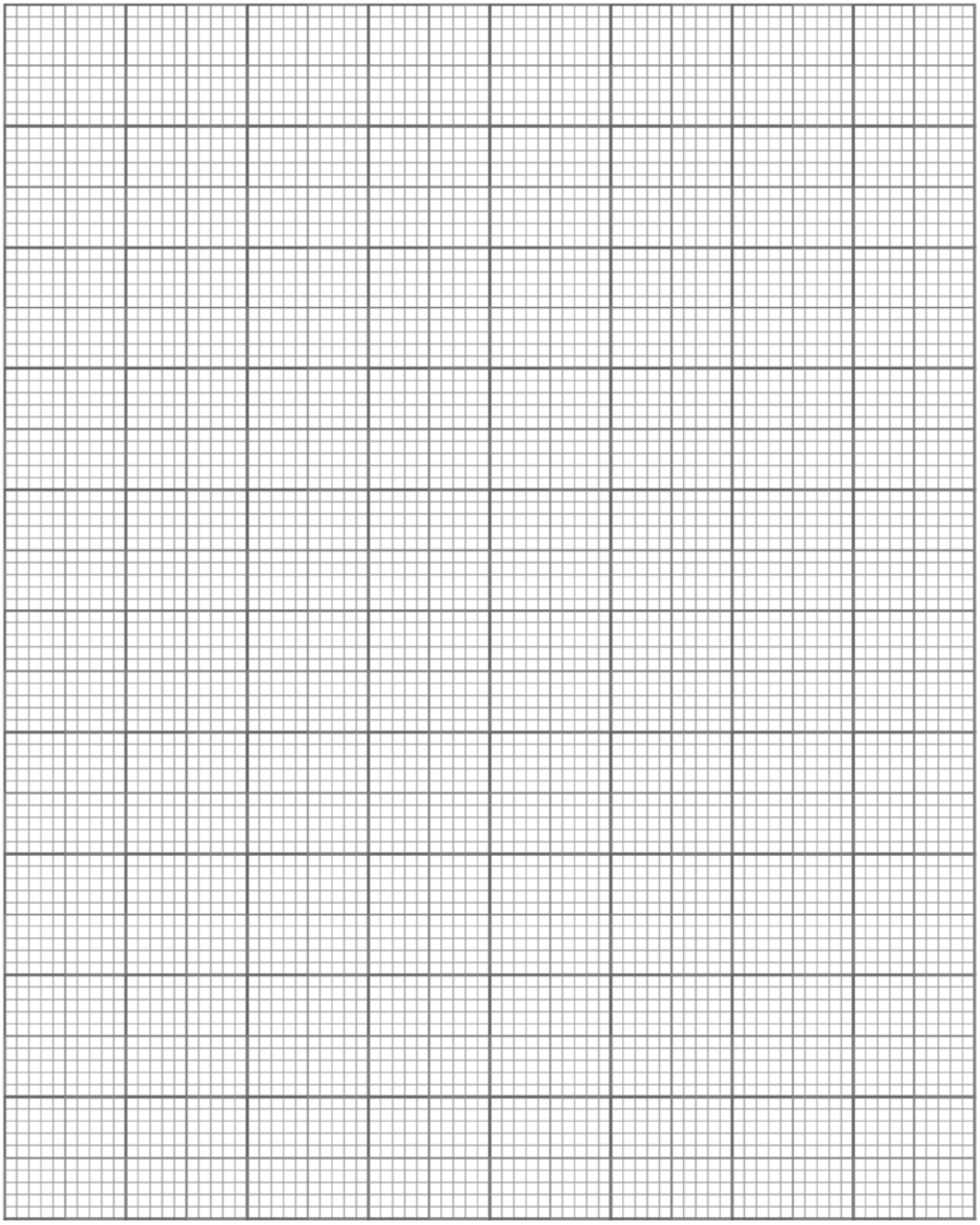

Fig. 3.2 [3]

[1] Axes correct way round + correct labels + units + scale
Sensible linear scale must be chosen so that plotted points occupy at least half the graph grid in both x and y directions

[1] All points correctly plotted to within ±½ small square. Check all points and put ticks if correct

[1] Graph line must be best-fit line (*Do not allow mark if clearly anomalous points are included*)

For Examiner's Use

(iii) It has been claimed that the reaction between calcium carbonate and hydrochloric acid is pseudo-first order with respect to calcium carbonate.

State whether you agree or disagree with this claim. Use evidence from your graph in Fig. 3.2 to support your answer.

[1] Determine at least 2 half-lives .....

[1] Conclude correctly on claim based on half-lives obtained .....

.....

.....

.....

..... [2]

(b) Planning

Besides using the continuous measurement method in **3(a)** to determine the order of reaction of a reactant, the initial rates method can also be used.

Plan an investigation, which **does not** involve graph plotting, to determine the order of reaction with respect to hydrochloric acid, HC*l*, using the initial rates method.

You are provided the following chemicals and apparatus:

- same apparatus used in the experimental setup in **3(a)**,
- 2.00 mol dm^{-3} HC*l* solution
- **FA 5** powdered $CaCO_3$
- stopwatch

In your plan, you should include details of:

- the different concentrations of the reactants used and the conditions of the experiment,
- the procedure you would follow, including the end-point of the experiment
- the measurements you would take,
- an outline of how you would use your results to determine the order of reaction with respect to HC*l*.

You may use the space below to draw a table indicating the headers of the measurements and calculations you would be performing.

For Examiner's Use

[1] Controls concentrations, volumes and total volume to be used for the experiment. States that temperature should be done at constant T (room temperature)

[2] Describe a suitable "stop-time"; *i.e.* the time required to produce at most 10% of the expected total volume of CO_2

[3] Propose to use the same procedure as 3(a) but modified to include the collection of CO_2 for two different concentrations of HC*l* that can be used to determine order of reaction.

[4] Describe the appropriate measurements needed to be taken and describing the calculations of 1/*t*

[5] Describe the use of 1/*t* as the initial rate of the experiment.

[6] Using inspection method or mathematically, describe how the deduction of the order of reaction of HC*l* can be done.

..... [6]

[Total: 14]

For Examiner's Use

4 Carry out the following experiments with **FA 6**.

In all tests the reagents should be added gradually until no further change is observed unless you are instructed otherwise.

Observations should include:

(i) descriptions of colour changes and precipitates;

(ii) names of gases evolved and details of the test used to identify each one.

You should indicate clearly at which stage in a test a change occurs, writing any deductions that you make alongside the observations upon which they are based.

Marks will be given *only* for the prescribed tests and will *not* be given for chemical equations.

TEST	OBSERVATION	CONCLUSION
Tests of FA 6 **(a)** Heat **FA 6** in a test-tube until no further change is observed. **Allow the residue to cool** and retain it for **(b)**. You may wish to proceed with the tests in **4(c)** while waiting for the residue to cool.	• Violet gas evolved which bleaches litmus. **[1] with identity of gas** • Colourless gas evolved which relights glowing splint. **[1] with identity of gas** • White residue, same colour as original	• Gas is I_2 • Gas is O_2 • IO_3^- present • K^+, Na^+, Ca^{2+}, Ba^{2+} or Mg^{2+} may be present
(b) Dissolve the residue from test **(a)** in deionised water and use separate portions of the solution for tests **(i)** to **(iii)**	• Colourless solution	
(i) Add aqueous silver nitrate to a portion of the solution.	• Yellow ppt	
Then add aqueous ammonia.	• Ppt insoluble in aqueous ammonia **[1] for both**	• I^- present in residue **[1]**

TEST	OBSERVATION	CONCLUSION
(ii) Add a few drops of aqueous potassium manganate(VII) followed by dilute sulfuric acid.	• Brown solution / black ppt **[1]** • Purple $KMnO_4$ decolourised	• I_2 produced **[1]** • I^- present in residue • Reducing agent present **[1]**
(iii) Add a few crystals of **FA 6**, shake to dissolve and then add dilute sulfuric acid.	• Brown solution obtained **[1]** **with identification of I_2**	• I_2 produced • **FA 6** is an oxidising agent **[1]** • I^- present in residue
(c) Dissolve **FA 6** in water and use separate portions of the solution for tests **(i)** and **(ii)**.	• Colourless solution	
(i) Add a few drops of aqueous potassium manganate(VII) followed by dilute sulfuric acid.	• Purple colour of $KMnO_4$ remains **[1]**	• Reducing agent absent **[1]**
(ii) Add aqueous potassium bromide followed by dilute sulfuric acid. Add hexane and shake the mixture.	• Orange solution formed • Dark red top organic layer and yellow/orange bottom aqueous layer	**[1] either** • Br_2 produced **[1]** • Oxidising agent present **[1]**

You are *not* required to identify **FA 6**. **[14 max 7]** [7]

For Examiner's Use

For Examiner's Use

(d) (i) **FA 6** and the residue from **(a)** contains element **X** in two different oxidation states. Using your observations from the tests in **(b)** and **(c)**, explain which compound, **FA 6** or the residue, contains **X** in the higher oxidation state.

FA 6 [1, with correct reasoning] contains **X** in the higher oxidation state. From test **(c)(i)**, **FA 6** does not react with the strong oxidising agent, $KMnO_4$, whereas in test **(b)(ii)**, the residue decolourises $KMnO_4$. **[1]** Hence, **FA 6** cannot be oxidised, while the residue can be oxidised, meaning that **FA 6** must have contained **X** in the higher oxidation state

..... [2]

(ii) The reaction in test **(b)(iii)** is said to be a **comproportionation** reaction. In light of your observations to test **(b)(i)** and **(b)(iii)**, together with your answer to **(d)(i)**, suggest what the term comproportionation may refer to.

Test **(b)(i)** confirms the presence of I^- in the residue, which is oxidised to I_2 by **FA 6**, which contains I (**X**) in a higher oxidation state, in test **(b)(iii)**. **[1]**

Comproportionation refers to a reaction in which **two reactants**, each containing the **same element** but with a **different oxidation state**, form **a product** in which the element involved has the **same intermediate oxidation state**. **[1]**

.....

..... [2]

[Total: 11]

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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., 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

(b) Reactions of anions

anion	***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) 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
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