TEMASEK JUNIOR COLLEGE

2018 JC2 PRELIMINARY EXAMINATIONS

HIGHER 2

CANDIDATE NAME	
CIVICS GROUP	/
CENTRE NO. / INDEX NO.	/

CHEMISTRY **9729/04**

Paper 4 Practical **29 August 2018**

2 hours 30 minutes

Candidates answer on the Question Paper.

READ THESE INSTRUCTIONS FIRST

Write your Civics Group and name on all 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 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 on pages 20 and 21.
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.

Shift
Laboratory

For Examiner's Use	
1	/ 24
2	/ 14
3	/ 17
Total	/ 55

This document consists of 20 printed pages and 1 blank page.

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

1 Determination of the concentrations of sulfuric acid and potassium hydroxide

FA 1 is a dilute solution of sulfuric acid, H_2SO_4
FA 2 is a dilute solution of potassium hydroxide, KOH
FA 3 is 0.377 mol dm^{-3} aqueous sodium carbonate, Na_2CO_3

You are also provided with thymolphthalein solution.

Both potassium hydroxide and sodium carbonate are bases which will react with sulfuric acid to give a salt and water – a process known as neutralisation.

You will add different volumes of **FA 3** to identical samples of dilute sulfuric acid, **FA 1**. In each case, the volume of sodium carbonate solution you add will only neutralise part of the sulfuric acid. You will then complete the neutralisation of each mixture by titration with dilute potassium hydroxide, **FA 2**.

Analysis of your results using a graph will enable you to determine the concentrations of sulfuric acid and that of potassium hydroxide.

(a) (i) Preparation and titration of reaction mixtures

Prepare four different mixtures of **FA 1** and **FA 3** as described below.

Mixture 1

1. Pipette 25.0 cm^3 of **FA 1** into a conical flask. Label the flask **6.00 cm^3**.
2. Fill a burette with **FA 3.**
3. Add 6.00 cm^3 of **FA 3** into the same conical flask.
4. Thoroughly stir the mixture and set it aside for later use.

Mixture 2

Repeat the procedure used for **Mixture 1** but this time add 25.0 cm^3 of **FA 1** and 20.00 cm^3 of **FA 3** into a second conical flask. Label the flask **20.00 cm^3**.

Mixtures 3 and 4

Repeat the procedure used for **Mixture 1** but with **9.00 cm^3** and **16.00 cm^3** of **FA 3**. In each case, add 25.0 cm^3 of **FA 1** and the respective volume of **FA 3** into a 100 cm^3 beaker. Thoroughly stir the mixture.

Label each 100 cm^3 beaker with the volume of **FA 3** it contains.

Notes: You will perform each titration once only. Great care must be taken that you do not overshoot the end-point.

The end-point of the titration of **Mixture 1** should be at least 25 cm^3 of **FA 2**.

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

Titration

1. Fill the second burette with **FA 2**.
2. Add 3 to 4 drops of thymolphthalein solution to the flask labelled **6.00 cm^3**.
3. Titrate the mixture in the flask with **FA 2** until a blue colour, which lasts for at least 10 s is obtained.
4. Repeat points **1** to **3** above using your remaining mixtures. You should perform your titrations in order of **increasing** volume of **FA 3**.
5. Each of the mixtures stored in beakers should be transferred **completely** to a third conical flask prior to each titration. Rinse this conical flask thoroughly between each titration.

Results

Volume of **FA 3**	/ cm^3	6.00	9.00	16.00	20.00
Final burette reading	/ cm^3	26.35	47.40	34.85	45.75
Initial burette reading	/ cm^3	0.00	25.00	19.60	35.00
Volume of **FA 2**	/ cm^3	26.35	22.40	15.25	10.75

• correct headers and units + 4 sets of reading present and to nearest 0.05 cm^3
• correctly calculate all titre vol of FA2

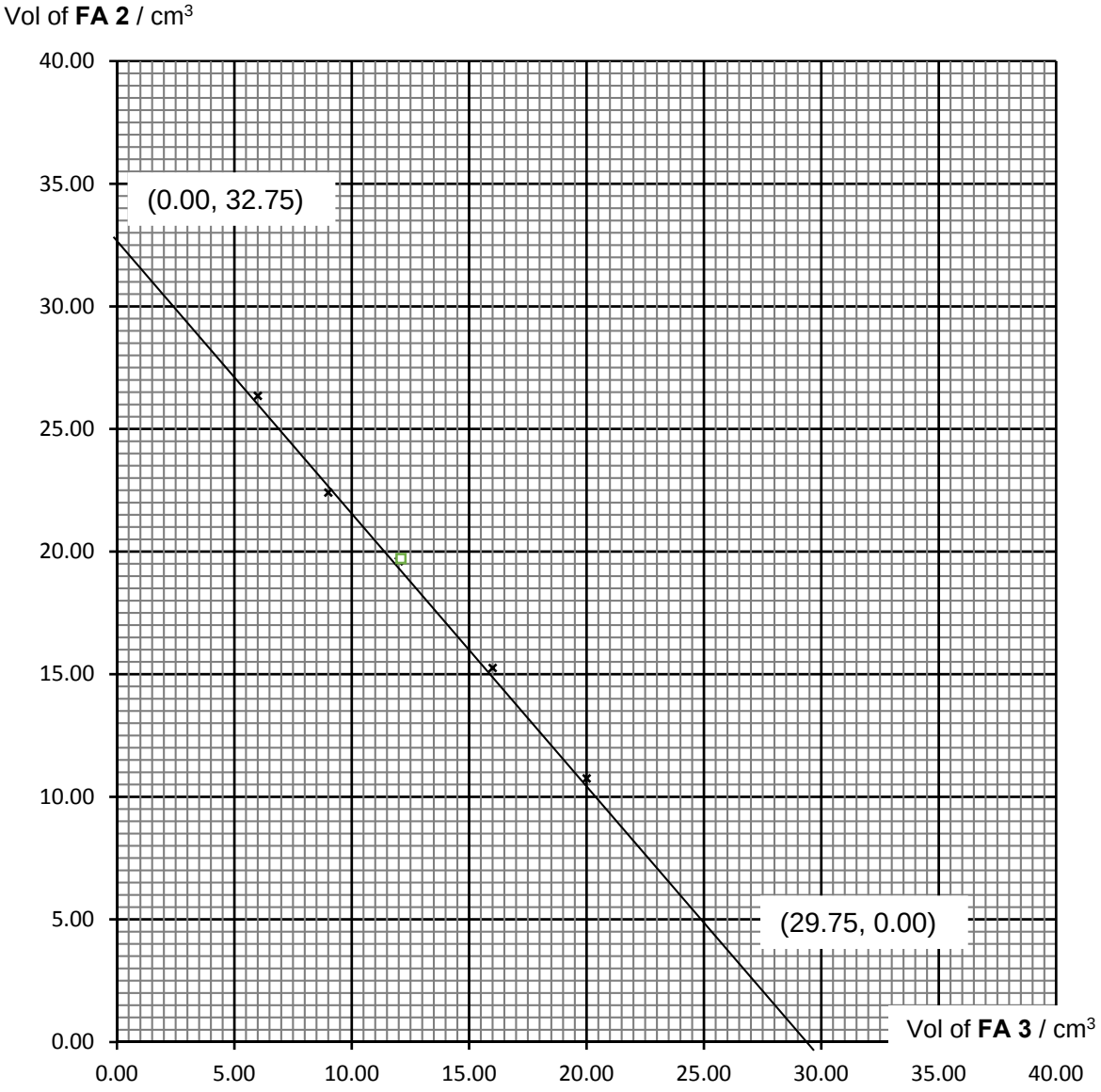
[2]

(ii) Plot on the grid below, your values for the **FA 2** titre (*y-axis*) against the volume of **FA 3** added (*x-axis*).

You should choose scales for the axes which will allow you to determine by extrapolation

- the volume of **FA 3** required, $\boldsymbol{V_{max}}$**(FA 3)**, to react completely with 25.0 cm^3 of **FA 1** if no **FA 2** is added
- the volume of **FA 2** required, $\boldsymbol{V_{max}}$**(FA 2)**, to react completely with 25.0 cm^3 of **FA 1** if no **FA 3** is added

Draw the line of best fit, taking into account all of your plotted points. Hence obtain values for $\boldsymbol{V_{max}}$**(FA 3)** and $\boldsymbol{V_{max}}$**(FA 2)**.



V_{max}(FA 3) = ……**29.75 cm^3**……. V_{max}(FA 2) = …….**32.75 cm^3**…….

Calculate the gradient of your graph line, showing clearly how you did this.

Gradient of the graph = $\frac{(32.75 - 0.00)}{(0.0 - 29.75)}$ = -1.10

gradient = ……**-1.10**……

[8]

- **axes correct way round + labels + units + scale**
- **all points plotted correctly based on student table**
- **best-fit straight line + correct extrapolation + no point further than 1 cm^3 away from line in either direction**
- **correctly read both intercept values as V_{max}(FA 3) and V_{max}(FA 2) based on drawn graph**
- **•• accuracy: each titre value within (inclusive) 1.0 cm^3 of supervisor**
- **clearly stated coordinates / or in working + at least 3 large squares in each direction**
- **correctly calculated gradient**

(b) **(i)** Explain the gradient obtained in **(a)(ii)** in terms of the chemistry involved.

When more Na_2CO_3 (FA 3) is added, more H_2SO_4 is neutralised by Na_2CO_3 and less KOH is required to neutralise the remaining/excess H_2SO_4. Hence, the gradient of the graph is negative.

[1]

(ii) Given that the concentration of aqueous sodium carbonate is 0.377 mol dm^{-3} and using the appropriate data from your graph, calculate the concentration of sulfuric acid in **FA 1.**

$Na_2CO_3 \equiv H_2SO_4$

No. of moles of $Na_2CO_3 = 0.377 \times \frac{29.75}{1000} = 0.0112$ mol

No. of moles of $H_2SO_4 = 0.0112$ mol

Concentration of $H_2SO_4 = 0.0112 \times \frac{1000}{25.0}$

$= 0.448$ mol dm^{-3}

concentration of sulfuric acid in **FA 1** = ……**0.448 mol dm^{-3}**……

[1]

(iii) Using your answer to **(b)(ii)** and appropriate data from your graph, calculate the concentration of potassium hydroxide in **FA 2.**

$2KOH \equiv H_2SO_4$

No. of moles of H_2SO_4 in 25.0 cm^3 of FA1 added = 0.0112 mol

No. of moles of KOH = 0.0112 x 2 = 0.0224 mol

Concentration of KOH $= 0.0224 \times \frac{1000}{32.75}$

$= 0.684$ mol dm^{-3}

concentration of potassium hydroxide in **FA 2** = ……**0.684 mol dm^{-3}**……

[2]

• **appropriate sf + units in Q1 aii, bii & biii**

(iv) The concentration of potassium hydroxide in **FA 2** can also be calculated using the expression below.

$$[KOH] = \frac{2[Na_2CO_3]}{|gradient|}$$

A student, Jack, performs this experiment and obtains the concentration of potassium hydroxide using the expression, but he calculated his gradient using two points which are close to each other. His classmate, Jill, used the results from Jack's experiment and calculated the concentration of potassium hydroxide using the method in **(b)(ii)** and **(b)(iii)**, and insists that her calculated value is more accurate.

Suggest whether Jill's claim is correct or wrong, and explain your answer.

Jill's claim is ..... correct. .....

because ..... if the two points for calculating gradient are close, any error in reading the coordinates will result in a larger percentage error in the gradient, while the value in (b)(iii) is calculated from intercept coordinates and has a smaller percentage error. .....

[1]

(c) The same experiment was carried out using **FA 3** that was prepared from a sample of solid anhydrous sodium carbonate containing a small amount of inert impurities.

(i) Suggest what effect this would have on the values of V_{max}**(FA 2)** and V_{max}**(FA 3)**. Explain your answer in each case.

effect on V_{max}**(FA 2)**..... V_{max}(FA 2) will be the same. .....

explanation..... At V_{max}(FA 2), no FA 3 is present and only KOH reacts with the H_2SO_4. (Since the concentration of H_2SO_4 and KOH remained unchanged, the same volume of KOH is needed to react with the H_2SO_4.) .....

effect on V_{max}**(FA 3)**..... V_{max}(FA 3) will be larger than the actual value. .....

explanation..... When the Na_2CO_3 with inert impurities is weighed out, the actual mass and, therefore, amount of Na_2CO_3 is smaller. The concentration of FA 3 is lower and a larger volume of FA 3 is needed to react with the HCl. .....

.....

[2]

(ii) Planning

You are required to write a plan for determining the exact percentage by mass of anhydrous sodium carbonate in the impure sample by collecting and measuring the volume of carbon dioxide gas evolved from its reaction with hydrochloric acid.

You may assume that you are provided with:

- impure solid anhydrous sodium carbonate,
- 0.10 mol dm^{-3} hydrochloric acid,
- the apparatus and chemicals normally found in a school or college laboratory.

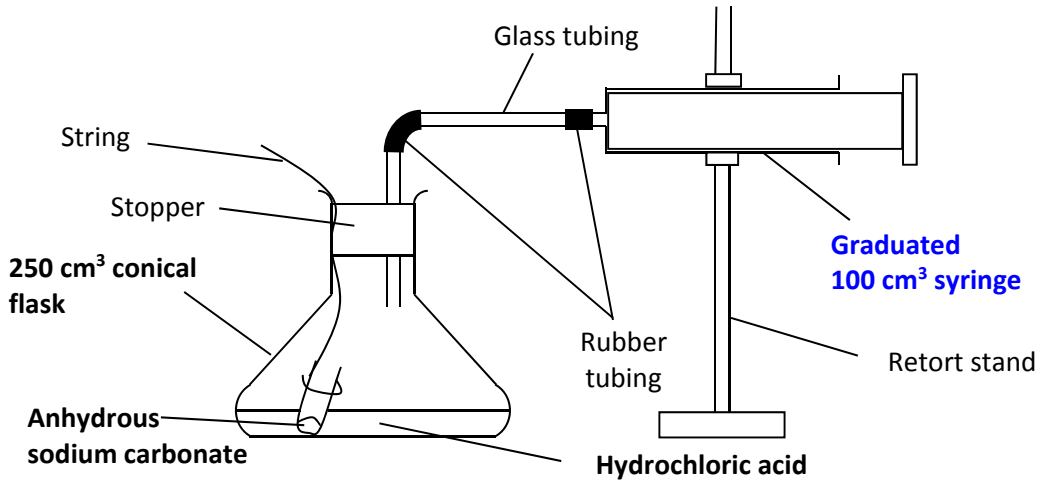
Your plan should include:

- practical details, including a well-labelled diagram of the set-up, of how you would carry out the gas collection when 0.30 g of carbonate was reacted with 80 cm^3 of hydrochloric acid;
- brief, but specific details of how the results would then be used to determine the exact percentage by mass of anhydrous sodium carbonate.

Set-up

• labeling of the capacity of gas syringe

• illustrating a method to add the acid to sodium carbonate or vice versa



Procedure

• measuring mass of sodium carbonate and vol of acid to be added

• recording the initial and final volume reading of the syringe (if thistle funnel is used, vol of gas collected = $V_{after} - V_{before} - V_{acid}$

• final reading taken approx. 20 min after reaction has completed and there is no movement of the plunger in the syringe.

1. Weigh 0.30 g of anhydrous sodium carbonate into a small test tube / container.

2. Measure 80.0 cm^3 of HC*l* using a 100 cm^3 measuring cylinder and transfer it to a 250 cm^3 conical flask.

3. Assemble the set-up as shown in the diagram.

4. **Record the initial volume reading of a 100 cm^3 gas syringe before removing the string to start the reaction.**
5. **Record the final volume reading of the gas syringe 20 minutes after the reaction has completed and there is no movement observed of the plunger in the syringe (to allow the temperature and pressure to equilibrate with the surroundings).**

Calculation

Let y cm^3 be the volume of carbon dioxide evolved.

No of moles of carbon dioxide = $\frac{y}{24000}$ mol

- **No of moles of Na_2CO_3 present = $\frac{y}{24000}$ mol**

Mass of anhydrous sodium carbonate present = $\frac{y\ x\ 106}{24000}$ = $\frac{53y}{12000}$ g

- **% by mass of anhydrous sodium carbonate = $\frac{53y\ x\ 100}{12000\ x\ 0.30}$ = $\frac{53y}{36}$ %**

[7]
[Total: 24]

2 To investigate the effect of concentration changes on the rate of reaction.

Potassium bromate(V) and potassium iodate(V) are powerful oxidising agents. When reacted with reducing agents such as sulfate(IV), SO_3^{2-}, the bromate(V) and iodate(V) ions will be reduced into the respective halogens.

The equation for the overall reaction is shown below:

$$2XO_3^- + 5SO_3^{2-} + 2H^+ \rightarrow X_2 + 5SO_4^{2-} + H_2O \qquad \text{(where X = Br or I)}$$

FA 4 is aqueous potassium iodate(V), KIO_3.
FA 5 is aqueous sodium sulfate(IV), Na_2SO_3.
FA 6 is 0.1 mol dm^{-3} sulfuric acid, H_2SO_4.

You are also provided with starch indicator and deionised water

In this experiment, you will be investigating the effect of the concentration of acid, **FA 6**, on the initial rate of the overall reaction between aqueous potassium iodate(V), KIO_3, **FA 4**, and aqueous sodium sulfate(IV), Na_2SO_3, **FA 5**.

(a) Potassium iodate(V) reacts with sodium sulfate(IV) in acidic solution to produce iodine in solution according to two stages.

In stage 1, iodate(V) and sulfate(IV) react to produce iodide and sulfate(VI) ions. In stage 2, the iodide ions formed react with iodate ions to give iodine.

Write equations for the 2 stages involved in the reaction of iodate(V) and sulfate(IV) ions.

Stage 1:
- **$IO_3^- + 3SO_3^{2-} \rightarrow I^- + 3SO_4^{2-}$**

Stage 2:
- **$5I^- + IO_3^- + 6H^+ \rightarrow 3I_2 + 3H_2O$**

[2]

The iodine formed reacts immediately with sulfate(IV) ions to give iodide ions. When sulfate(IV) ions are completely consumed, the liberated iodine would react with starch solution to give the dark blue colour of the starch-iodine complex. Time taken for the dark blue colour to appear depends on the rate of formation of iodine. The effect of the concentration of acid on the initial rate of the overall reaction can be determined by measuring the time taken for dark blue colour to appear.

You are to perform a series of four experiments, in which the concentration of acid, **FA 6**, is varied, and measure the time, ***t***, taken for the dark blue colour to appear.

For each experiment, you will require two solutions, **solution 1** and **solution 2**. **Solution 1** will be prepared using a fixed volume of **FA 4** and deionised water as described in **(b)(i)**. In each experiment, **solution 2** will contain the same volume of **FA 5** but varying volumes of **FA 6**. The total volume of **solution 2** is kept constant at 100 cm^3 by adding deionised water as required.

(b) (i) Experiment 1

Preparation of solution 1

Add 15 cm^3 of **FA 4** into the 100 cm^3 measuring cylinder labelled **solution 1**. Make up the volume to 100 cm^3 using deionised water.

Preparation of solution 2

Add 15 cm^3 of **FA 5** into the 100 cm^3 measuring cylinder labelled **solution 2**. Make up the volume to 100 cm^3 by adding 85 cm^3 of **FA 6**.

1. Place the 250 cm^3 beaker on the while tile.
2. Transfer **solution 1** into the 250 cm^3 beaker.
3. Using a 10 cm^3 measuring cylinder, measure and add 5 cm^3 of starch indicator into the 250 cm^3 beaker containing **solution 1**.
4. Transfer **solution 2** rapidly into the beaker containing **solution 1**, **starting a stopwatch as you do so.**
5. Stir the mixture gently using a glass rod, and measure the time, ***t***, for a dark blue colour to appear. Record your time, ***t***, to the nearest second.
6. Wash the beaker thoroughly with water and dry it.

(ii) Experiment 2

7. Prepare **solution 1** as described in **(b)(i)**.
8. Prepare **solution 2** by adding 15 cm^3 of **FA 5** and 25 cm^3 of **FA 6** into the 100 cm^3 measuring cylinder labelled **solution 2**. Make up the volume to 100 cm^3 by adding deionised water.
9. Repeat steps 1 to 6 in **(b)(i)** to determine the time taken for a dark blue colour to appear.

(iii) Experiments 3 – 4

10. Select **two** other suitable volumes of **FA 6**, between 25 cm^3 and 85 cm^3, for use in the remaining two experiments.
11. Prepare **solution 1** as described earlier.
12. Use your selected volume of **FA 6,** together with 15 cm^3 of **FA 5** and water, to prepare 100 cm^3 of **solution 2** for each experiment. Prepare a table in the space provided in **(c)** for recording purposes.
13. Repeat steps 1 to 6 in **(b)(i)** to determine the time taken in each case for a dark blue colour to appear.

(c) Prepare a table in the space provided below in which to record, for each experiment:

- all volumes used to prepare **solution 2**,
- all values of ***t***,
- calculated values of Vol of **FA 6** x t, (Vol of **FA 6**)^2 x t to 3 significant figures

Table of results

Expt No.	Solution 2			Time, t /s	V_{FA6} x t/ cm^3 s	$(V_{FA6})^2$ x t/ cm^6 s
	Volume of FA 5 /cm^3	Volume of FA 6 /cm^3	Volume of water /cm^3			
1	15	85	0	12	1020	86700
2	15	25	60	42	1050	26300
3	15	40	45	25	1000	40000
4	15	50	35	21	1050	52500

- **headers and units**
- **all volumes recorded to 1 cm^3, time to 1s, calculated values to 3 s.f.**
- **4 sets of data recorded, all values of t increase while volume of FA 6 decrease**
- **Correctly calculated values of V_{FA6} x t and $(V_{FA6})^2$ x t**

[4]

(d) (i) Explain clearly why the concentration of H^+ in the initial reaction mixture could be represented as the volume of **FA 6** used.

The total volume of the reaction mixture is constant in all experiments.
Concentration of H^+ = (Vol of FA 6 x conc of FA 6) / total volume
Since conc of FA 6 is also constant, hence conc of $H^+ \propto$ volume of FA 6

[1]

(ii) Calculate the concentration, in mol dm^{-3}, of hydrogen ions present in the reaction mixture for **experiment 1** at time t = 0 s.

Total volume of reaction mixture = 100 + 100 + 5
= 205 cm^3

Concentration of H^+ = $\dfrac{\frac{85}{1000}\times 0.1\times 2}{\frac{205}{1000}}$

= 0.0829 mol dm^{-3}

$[H^+]$ = **0.0829 mol dm^{-3}** [1]

(iii) Explain the significance of the values of (Vol. of **FA 6)** $\times$ time and (Vol. of **FA 6**)$^2 \times$ time.

Concentration of FA 6 is directly proportional to the volume of FA 6 (from (d)(i)).
- **The rate of reaction is directly proportional to the reciprocal of the time taken for a fixed amount of iodine to be formed.**

Rate $\propto$ [FA 6]^n where n is the order of reaction with respect to FA 6

- $\dfrac{1}{t} \propto$ **(Vol. of FA 6)^n**

(Vol. of FA 6)^n × t = constant

If (Vol. of FA 6) × t = constant, n = 1.

- **If (Vol. of FA 6)^2 × t = constant, n = 2.**

3 points = 2 marks
2 points = 1mark

[2]

(iv) With reference to your answers in **(d)(iii)**, deduce the order of reaction with respect to H^+ ions.

From the results obtained, the (Volume of FA 6) × t is approximately constant. Hence, it can be concluded that the order of reaction with respect to H^+ ions is 1.

[1]

(v) Explain the effect on the initial rate of reaction if the concentration of **FA 6** is increased from 0.1 mol dm^{-3} to 0.2 mol dm^{-3}. Assume all other conditions are kept constant.

Since the reaction is first order with respect to H^+, when the concentration of H^+ is increased by two times, the initial rate of reaction should increase by two times.

[1]

(e) Select, from **experiments 1** to **4**, the experiment which is likely to have the greatest error. Explain your choice.

In experiment 1, when time, t is the smallest value and so has the greatest % error.

Or In experiment 2, when the volume of H^+ is the smallest.

[1]

(f) Suggest how the collection of data can be improved so that the order of reaction with respect to acid for this experiment can be accurately determined.

Repeat each experiment and take average of the timings for the dark blue colour to appear.

OR

Plot the rate (1/time) against the volume of acid to more accurately how the rate (1/time) is dependent on the volume or conc. of acid, hence determine order.

[1]

[Total: 14]

3 Identification of ions

You are provided with **FA 7** solution, a mixture of two salts
You are to perform the tests below and record your observations in the spaces provided. Your answers should include

- details of colour changes and precipitates formed;
- the names of any gases evolved **and** details of the test used to identify each one.

The volumes given below are approximate and should be estimated rather than measured, unless otherwise stated.

You should indicate clearly at what stage in a test a change occurs.

If it appears that no reaction has taken place this should be clearly recorded.

Rinse and reuse test-tubes where possible.

No additional or confirmatory tests for ions present should be attempted.

Candidates are reminded that definite deductions may be made from tests where there appears to be no reaction.

FA 7 is a solution containing two cations.

		Test	*Observation*
(a)	Test the **FA 7** solution using Universal indicator paper.		• **pH 3-4**
(b)	**(i)**	Place about 2 cm^3 of **FA 7** into a test-tube. Carefully add sodium hydroxide, dropwise with shaking, until no further change are seen.	• **white ppt formed** • **then green ppt, insoluble in excess NaOH (turning brown in contact with air)**
		Swirl and filter the mixture, collecting the filtrate in a boiling tube labelled **FA 8**. The filtrate is **FA 8** which should be put to one side for use in **(c)(i).**	• **green residue turns brown in contact with air/ brown residue obtained** • **colourless/pale yellow filtrate**
		Wash the residue thoroughly with deionised water. Discard the washings. The residue is **FA 9**. Retain the residue for use in **(b)(ii)**	
	Note: When $KMnO_4$ is added in **(b)(ii) and (c)(ii)**, the end point is permanent pale pink colour. In each case, use the same dropping pipette and record the number of drops of $KMnO_4$ you added to reach the end point.		
	(ii)	Transfer a spatula load of **FA 9** into a clean test-tube.	
		Add hydrochloric acid, a few drops at a	• **Solid dissolves in acid to form orange to**

		time and shaking, until no further changes are seen. Add $KMnO_4$, dropwise with shaking, until the end point is reach	**form an orange/orange-brown/brown/ yellow solution** • **After > 3 drops (accept any number more than 3), it turns pink/end point is reached**
(c)	**(i)**	Place about 1 cm^3 of **FA 8** in a test-tube. Carefully add hydrochloric acid, dropwise with shaking, until no further change is seen. This solution is **FA 10**. Label this test tube **FA 10**.	• **White ppt forms** • **Ppt solube in excess HCl**
	(ii)	Place about 1 cm^3 of **FA 10** in test-tube. Add $KMnO_4$, dropwise with shaking, until the end point is reached.	• **Instant pink colour/ 1 drop of $KMnO_4$**
	(iii)	Place about 1 cm^3 of **FA 10** in a test-tube, add aqueous ammonia, dropwise with shaking, until no further change is seen.	• **White ppt forms,** • **Ppt insoluble in excess $NH_3(aq)$**

[These points are scaled to 5 MMO/PDO marks as follows.
12-10 = 5
8 - 9 = 4
6 - 7 = 3
5 - 4 = 2
2 – 3 = 1
0 - 1 = 0

[5]

(d) Conclusions

(i) Identify the **two** cations present in **FA 7.** [1]

- **Al^{3+} and Fe^{2+} [both must be correctly identified, reject Fe^{3+}]**

(ii) Identify the metal-containing complex present in **FA 8**.

Write equations to illustrate the formation of this complex.

- **$[Al(OH)_4]^-(aq)$**
  $Al(aq)^{3+} + 4OH^- \rightleftharpoons [Al(OH)_4]^-(aq)$
  OR
  $Al(OH)_3 + OH^- \rightleftharpoons [Al(OH)_4]^-$

[1]

(iii) Suggest an explanation for the observations in **(b)** and hence deduce the compositions of residue, **FA 9**.

- **Fe^{2+} reacts with OH^- to form green $Fe(OH)_2$ ppt, which is oxidised by oxygen in air to form brown $Fe(OH)_3$ ppt.**

- **Composition: $Fe(OH)_2$ and $Fe(OH)_3$**

[2]

(iv) Explain the difference, if any, in the number of drops of $KMnO_4$ required to reach the end point in **(b)(ii)** and **(c)(ii)**.

- **In (b)(ii), Fe^{2+} is present in the solution. Redox reaction takes place between Fe^{2+} & MnO_4^-/H^+ or Fe^{2+} is the reducing agent that reacts with MnO_4^-/H^+. Hence, more than 3 drops of MnO_4^-/H^+ requires before solution turns pink.**

- **In (c)(ii), Fe^{2+} is not found in the filtrate and no redox reaction takes place.**
  OR Al^{3+}/ other cation identified in the filtrate cannot be oxidised. The solution turns pink immediately with a drop of MnO_4^-/H^+ solution added.

[2]

(e) Planning

There are four solutions labelled **FB 1**, **FB 2**, **FB 3**, and **FB 4**. Each solution contains one of the following:

- dilute hydrochloric acid
- aqueous sodium carbonate
- aqueous barium nitrate
- aqueous aluminium chloride

The solution names and FB codes are not in order.

(i) Without any indicators and using these solutions alone, plan the steps which will enable you to identify these solutions. Write your plan in the space below, showing how you would record your observations in a table.

1. **•Add FB 1 separately to 1 cm^3 solutions of FB 2, FB 3 and FB 4 in a test–tube each.**
2. **Record your observations in the table below.**
3. **Repeat steps 1 to 2 using solutions FB 2, FB 3 and FB 4 separately, adding each solution in turn to all the other solutions.**

FB	1	2	3	4
1				
2				
3				
4				

•1 mark for the table

[2]

(ii) Describe, with reference to the reactions occurring, how you would use the observations to confirm the identities of **FB 1**, **FB 2**, **FB 3**, and **FB 4**.

	HCl	Na_2CO_3	$Ba(NO_3)_2$	$AlCl_3$
HCl		**CO_2 evolved**	**No reaction**	**No reaction**
Na_2CO_3			**White ppt**	**White ppt + CO_2 evolved**
$Ba(NO_3)_2$				**No reaction**
$AlCl_3$				

•The solution that forms a white ppt with one other solution is aqueous $Ba(NO_3)_2$, as Ba^{2+} will form a precipitate with carbonate.

•The solution that effervescence with one other solution is dilute HCl, as HCl will liberate CO_2 from Na_2CO_3.

•The solution that forms a white ppt with effervescence with one other solution is aqueous $AlCl_3$ as $AlCl_3$ will form a precipitate and liberate CO_2 from Na_2CO_3.

•The solution that forms only a white ppt with one solution, effervescence with another solution, and with the last solution, white ppt with effervescence is Na_2CO_3.

[4]

[Total: 17]

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 → (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) Colours 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