



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

1 Identification of two cations and two anions

FA 1 and **FA 2** each contain one cation and one anion.
Neither of the anions contains sulfur.

You will carry out tests to identify the ions in **FA 1** and in **FA 2**.

Unless otherwise stated, the volumes given in Table 1.1 are approximate and should be estimated rather than measured.

Test any gases evolved during the tests.

If there is no observable change, write **no observable change**.

- (a)** Carry out the tests in Table 1.1 on both **FA 1** and **FA 2**.
Carefully record your observations in Table 1.1 on page 3.



Table 1.1

tests		observations with FA 1	observations with FA 2
1	Add 2 cm depth of the FA solution to a test-tube. Add aqueous sodium hydroxide until there is no further change. Keep the reaction mixture for test 2.	White ppt formed Soluble in excess NaOH(aq) to give a colourless solution	White ppt formed Soluble in excess NaOH(aq) to give a colourless solution
2	Pour the reaction mixture from test 1 into a boiling tube. Add 1 cm depth of aqueous sodium hydroxide to the reaction mixture. Add a piece of aluminium foil to the reaction mixture. Warm the mixture.	Effervescence observed Damp red litmus remains red	Effervescence observed Damp red litmus turns blue
3	Add 2 cm depth of the FA solution to a test-tube. Add aqueous ammonia until there is no further change.	White ppt formed Insoluble in excess NH ₃ (aq).	White ppt formed Soluble in excess NH ₃ (aq) to give a colourless solution
4	Add 2 cm depth of the FA solution to a test-tube. Add a 1 cm depth of dilute hydrochloric acid.	No effervescence observed Solution remains clear and colorless.	No effervescence observed Solution remains clear and colorless.
5	Add 2 cm depth of the FA solution to a test-tube. Add a 1 cm depth of aqueous silver nitrate.	White ppt	No ppt
	Add aqueous ammonia to the mixture, with shaking, until the aqueous ammonia is in excess.	White ppt partially dissolves to give colorless solution. When NH ₃ (aq) is in excess, white ppt remain insoluble.	White ppt soluble in excess NH ₃ (aq) to give a colourless solution

[8]

(b) Complete Table 1.2 to identify the ions present in FA 1 and in FA 2.

Table 1.2

	FA 1	FA 2
cation present		
anion present		

[4]



2 Investigating the kinetics of the reaction between iodate(V) ions and hydrogensulfite ions

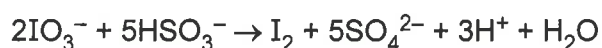
FA 3 is $0.100 \text{ mol dm}^{-3}$ potassium iodate(V), KIO_3 .

FA 4 is $0.0500 \text{ mol dm}^{-3}$ sodium hydrogensulfite, NaHSO_3 .

You are also provided with:

- **Solution S**, 1% starch solution
- deionised water
- a waste beaker containing sodium carbonate solution.

Iodate(V) ions react with hydrogensulfite ions according to the equation shown.



In this experiment, the rate of the reaction is studied by measuring the rate of formation of iodine using a 'clock' method. You will vary the concentration of iodate(V) ions and measure the time taken for a fixed amount of iodine to be produced. This will be indicated by the formation of a blue-black/purple colour in the presence of starch.

The reaction takes place in a series of steps. As a result, the blue-black/purple colour does not appear immediately.

You will perform a series of six experiments. For each experiment you will need to ensure that the same total volume of reaction mixture is used, by adding deionised water as required. For each experiment, you will measure the time, t , for the blue-black/purple colour to appear. You should avoid inhaling any gases produced.

(a) Prepare a table in the space provided on page 6 in which to record, to an appropriate degree of precision:

- the volumes of **FA 3** ($V_{\text{FA 3}}$), **FA 4** ($V_{\text{FA 4}}$) and deionised water (V_{water}) used
- all values of t
- calculated values of $\log(1/t)$
- calculated values of $\log(V_{\text{FA 3}})$.





Experiment 1

1. Use a teat pipette to add 10 drops of **Solution S** to a 100 cm³ conical flask.
2. Use a 10 cm³ measuring cylinder to measure 2.0 cm³ of **FA 3** into the conical flask.
3. Use a 25 cm³ measuring cylinder to measure 16.0 cm³ of deionised water into the same conical flask.
4. Use a second 10 cm³ measuring cylinder to measure 2.0 cm³ of **FA 4**.
5. Pour the **FA 4** into the same conical flask, starting the stopwatch during this addition.
6. Mix the contents thoroughly by swirling the flask several times. Then place the flask on a white tile.
7. Stop the stopwatch at the first appearance of a blue-black/purple colour.
8. Record the time taken, to the nearest second, in your table.
9. Discard the reaction mixture immediately into the waste beaker containing sodium carbonate solution.
10. Wash out the flask thoroughly with tap water and then with deionised water. Stand the flask upside down on a paper towel to drain.

Experiments 2 to 6

Repeat experiment 1 five times, adding 3.0 cm³, 4.0 cm³, 6.0 cm³, 8.0 cm³ and 10.0 cm³ of **FA 3** respectively in step 2.

In each experiment, you should adjust the volume of deionised water in step 3 to ensure the **same total volume** of reaction mixture is used.

You should alternate the use of the two 100 cm³ conical flasks. You should keep **FA 3** and **Solution S** for use in Question 3.

Record all volumes, the time taken and the calculated values of $\log(1/t)$ and $\log(V_{\text{FA 3}})$ in your table.

Results

expt	$V_{\text{water}} / \text{cm}^3$	$V_{\text{FA 3}} / \text{cm}^3$	$V_{\text{FA 4}} / \text{cm}^3$	t/s	$\log(1/t)$	$\log(V_{\text{FA 3}})$
1	16.0	2.0	2.0	39		
2	15.0	3.0	2.0	27		
3	14.0	4.0	2.0	24		
4	12.0	6.0	2.0	13		
5	10.0	8.0	2.0	11		
6	8.0	10.0	2.0	10		



- (b) (i) Plot a graph of $\log(1/t)$ on the y -axis against $\log(V_{FA3})$ on the x -axis on the grid in Fig. 2.1. Draw the best-fit straight line.

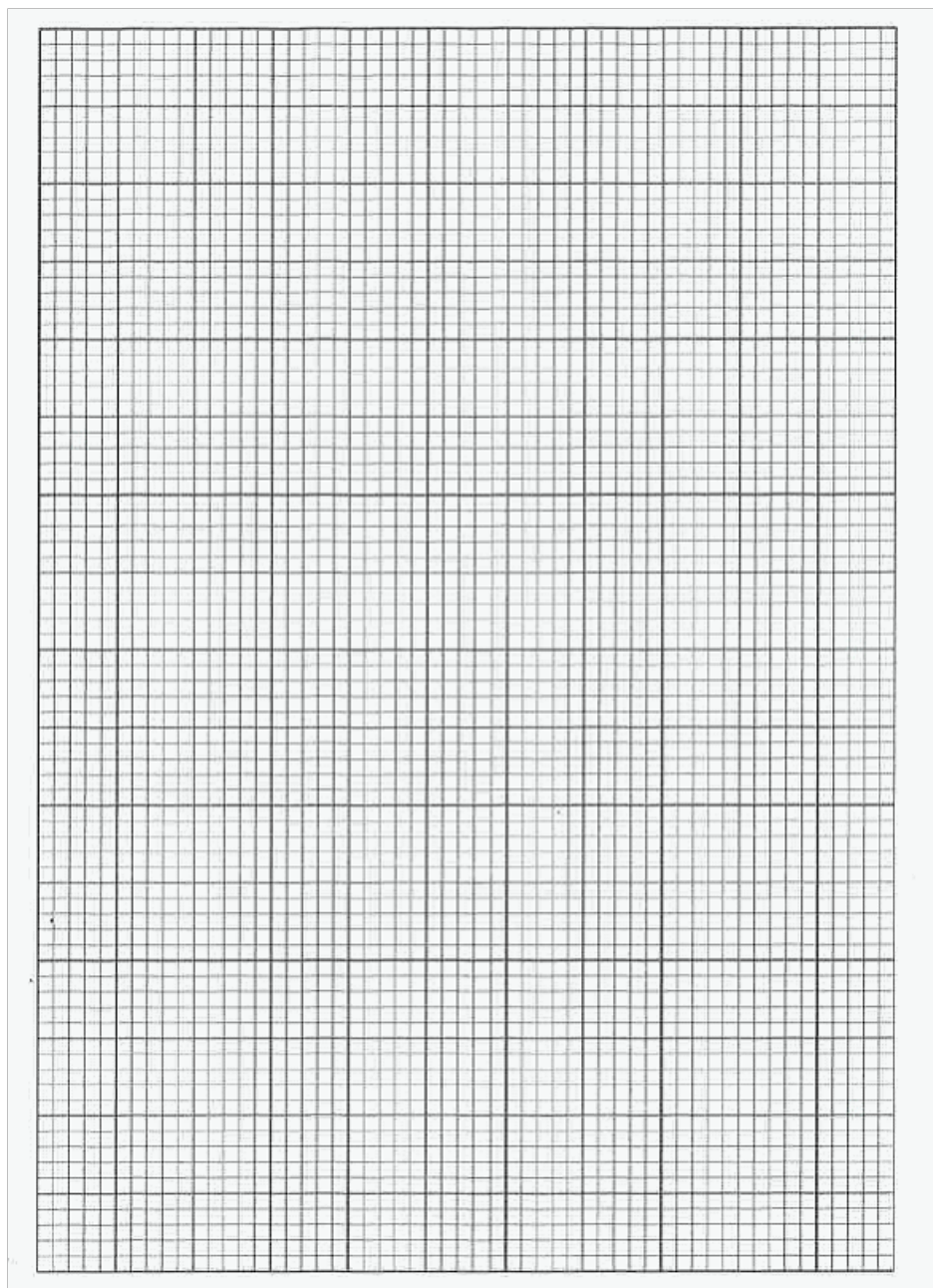


Fig. 2.1

[3]

- (ii) Calculate the gradient of the line to three significant figures, showing your working clearly.

gradient = [1]





- (iii) The gradient of the line gives the order of the reaction with respect to iodate(V) ions. The reaction is first order with respect to iodate(V) ions.
Calculate the percentage error in your value of the gradient.

percentage error = [1]

(c) Planning

It is suggested that the reaction between iodate(V) and hydrogensulfite ions may be catalysed by transition metal ions.

- (i) Suggest why the reaction between iodate(V) and hydrogensulfite ions is slower in the absence of a catalyst.

.....

.....

.....

..... [2]

- (ii) Plan an extension to the investigation in 2(a) to test how well two different transition metal cations, A^{2+} and B^{2+} , catalyse the reaction between iodate(V) and hydrogensulfite ions. You should **not** carry out your plan.

You may assume you are provided with solutions containing:

- $0.2 \text{ mol dm}^{-3} A^{2+}(\text{aq})$
- $0.1 \text{ mol dm}^{-3} B^{2+}(\text{aq})$.

Your plan should include:

- two further experiments
- a table of volumes of solutions used
- how you would know that the transition metal cations are both catalysts for this reaction
- how you would know which transition metal cation is the better catalyst.

You do **not** need to rewrite the method given.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....





..... [5]

[Total: 17]

DO NOT WRITE IN THIS MARGIN

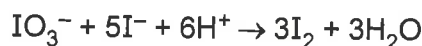




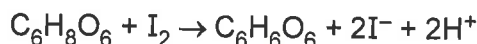
3 Analysis of vitamin C tablets

Vitamin C is ascorbic acid, $C_6H_8O_6$. Ascorbic acid can be titrated against potassium iodate(V) in the presence of excess acid and iodide ions.

The iodate(V) ion oxidises acidified iodide ions to iodine according to the equation shown.



If ascorbic acid is present, the iodine is removed from the solution according to the equation shown.



Once all of the ascorbic acid is used up, iodine remains in the solution and can be seen by the presence of a blue-black/purple colour in the presence of starch.

FA 5 is a solution prepared by dissolving four soluble vitamin C tablets in deionised water and making the solution up to 1 dm^3 .

FA 6 is 0.5 mol dm^{-3} potassium iodide.

You are also provided with **FA 3** and **Solution S**, which you used in Question 2, and dilute sulfuric acid.

(a) (i) Dilution of FA 3

FA 3 is 0.100 mol dm^{-3} potassium iodate(V), KIO_3 .

Use a pipette to transfer 10.0 cm^3 of **FA 3** into a 250 cm^3 volumetric flask.

Make the solution up to the mark with deionised water. Label this solution **FA 7**. This is a solution of potassium iodate(V) of a concentration suitable for the titration.

Titration of FA 5 against FA 7

1. Fill the burette with **FA 7**.
2. Use a pipette to transfer 25.0 cm^3 of **FA 5** into a 250 cm^3 conical flask.
3. Add to the conical flask:
 - approximately 5 cm^3 of **FA 6** using the 25 cm^3 measuring cylinder
 - approximately 5 cm^3 of dilute sulfuric acid using the same measuring cylinder
 - approximately 1 cm^3 of **Solution S** using a teat pipette.
4. Run **FA 7** from the burette into the conical flask. The end-point is reached when the first permanent blue-black/purple colour (lasting at least 15 seconds) is seen throughout the solution.
5. Record your titration results, to an appropriate level of precision, in the space provided on page 11.
6. Discard the reaction mixture via the sink.
7. Repeat steps 2 to 6 until consistent results are obtained.



Titration results

Final burette reading/ cm ³	28.80	26.90
Initial burette reading/ cm ³	8.00	6.00
Vol of FA 7 used / cm ³	20.80	20.90

[6]

- (ii) From your titrations, obtain a suitable volume of **FA 7** to be used in your calculations. Show clearly how you obtained this volume.

volume of **FA 7** = [1]

- (b) (i) Calculate the concentration of KIO_3 in **FA 7**.

concentration of KIO_3 in **FA 7** = [1]





- (ii) Calculate the mass of ascorbic acid in one vitamin C tablet.

Show all your working.

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

mass of ascorbic acid in one vitamin C tablet = [8]

- (iii) Suggest how the titration would be affected if potassium iodide solution was **not** added in excess.

..... [2]

[Total: 18]





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**

<i>anion</i>	<i>reaction</i>
carbonate, CO_3^{2-}	CO_2 liberated by dilute acids
chloride, $\text{Cl}^-(\text{aq})$	gives white ppt. with $\text{Ag}^+(\text{aq})$ (soluble in $\text{NH}_3(\text{aq})$)
bromide, $\text{Br}^-(\text{aq})$	gives pale cream ppt. with $\text{Ag}^+(\text{aq})$ (partially soluble in $\text{NH}_3(\text{aq})$)
iodide, $\text{I}^-(\text{aq})$	gives yellow ppt. with $\text{Ag}^+(\text{aq})$ (insoluble in $\text{NH}_3(\text{aq})$)
nitrate, $\text{NO}_3^-(\text{aq})$	NH_3 liberated on heating with $\text{OH}^-(\text{aq})$ and Al foil
nitrite, $\text{NO}_2^-(\text{aq})$	NH_3 liberated on heating with $\text{OH}^-(\text{aq})$ and Al foil; NO liberated by dilute acids (colourless NO $\rightarrow$ (pale) brown NO_2 in air)
sulfate, $\text{SO}_4^{2-}(\text{aq})$	gives white ppt. with $\text{Ba}^{2+}(\text{aq})$ (insoluble in excess dilute strong acids)
sulfite, $\text{SO}_3^{2-}(\text{aq})$	SO_2 liberated with dilute acids; gives white ppt. with $\text{Ba}^{2+}(\text{aq})$ (soluble in dilute strong acids)

(c) Tests for gases

<i>gas</i>	<i>test and test result</i>
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

<i>halogen</i>	<i>colour of element</i>	<i>colour in aqueous solution</i>	<i>colour in hexane</i>
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

Permission to reproduce items where third-party owned material protected by copyright is included has been sought and cleared where possible. Every reasonable effort has been made by the publisher (UCLES) to trace copyright holders, but if any items requiring clearance have unwittingly been included, the publisher will be pleased to make amends at the earliest possible opportunity.

Cambridge Assessment International Education is part of Cambridge Assessment. Cambridge Assessment is the brand name of the University of Cambridge Local Examinations Syndicate (UCLES), which is a department of the University of Cambridge.

