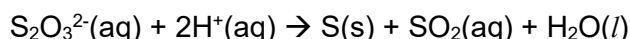


## Investigating the kinetics of the reaction between thiosulfate ions and acid

**FA 1** is  $0.100 \text{ mol dm}^{-3}$  sodium thiosulfate,  $\text{Na}_2\text{S}_2\text{O}_3$ .

**FA 2** is  $1.00 \text{ mol dm}^{-3}$  sulfuric acid,  $\text{H}_2\text{SO}_4$

The thiosulfate ion,  $\text{S}_2\text{O}_3^{2-}$ , decomposes when an acid is added according to the equation shown.



In this experiment, the rate of the reaction is studied by measuring the rate of formation of sulfur using a 'clock' method. You will vary the concentration of thiosulfate ions and measure the time taken for a fixed amount of sulfur to be produced. This will be indicated by how long it takes for the solid sulfur forming to obscure the print on the insert.

You will perform a series of five experiments. For each experiment you will need to ensure that the same total volume of reaction mixture is used, by adding deionised water as require. For each experiment, you will measure the time,  $t$ , for the sulfur to obscure the print on the insert.

**Note: A small amount of sulfur dioxide gas may be formed in the experiment. It is very important that you avoid inhaling any fumes. As soon as each experiment is complete, add the reaction mixture to the waste beaker and rinse the beaker thoroughly.**

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

- the volumes of **FA 1** ( $V_{\text{FA 1}}$ ) and deionised water used
- all values of  $t$
- rate

### Experiment 1

- 1) Use the  $50 \text{ cm}^3$  measuring cylinder to measure  $40.0 \text{ cm}^3$  of **FA 1** into the  $100 \text{ cm}^3$  beaker.
- 2) Use the  $25 \text{ cm}^3$  measuring cylinder to measure  $10.0 \text{ cm}^3$  of **FA 2**.
- 3) Pour the **FA 2** into the same beaker, starting the stopwatch during this addition.
- 4) Stir the mixture once and place the beaker on the printed insert.
- 5) Stop the stopwatch when the print on the insert becomes obscured.
- 6) Record the time taken, to the nearest second, in your table.
- 7) Discard the reaction mixture immediately into the waste beaker.
- 8) Wash out the beaker thoroughly with tap water and then with deionised water. Stand the beaker upside down on a paper tower to drain.

### Experiment 2

- 1) Use the 50 cm<sup>3</sup> measuring cylinder to measure 20.0 cm<sup>3</sup> of **FA 1** into the 100 cm<sup>3</sup> beaker.
- 2) Use the same 50 cm<sup>3</sup> measuring cylinder to measure 20.0 cm<sup>3</sup> of deionised water into the same beaker.
- 3) Use the 25 cm<sup>3</sup> measuring cylinder to measure 10.0 cm<sup>3</sup> of **FA 2**.
- 4) Pour the **FA 2** into the same beaker, starting the stopwatch during this addition.
- 5) Stir the mixture once and place the beaker on the printed insert.
- 6) Stop the stopwatch when the print on the insert becomes obscured.
- 7) Record the time taken, to the nearest second, in your table.
- 8) Discard the reaction mixture immediately into the waste beaker containing sodium carbonate solution.
- 9) Wash out the beaker thoroughly with tap water and then with deionised water. Stand the beaker upside down on a paper tower to drain.

### Experiments 3 - 5

Carry out three further experiments to investigate how using different volumes of **FA 1** affects the reaction time.

Do not use a volume of **FA 1** that is less than 15.00 cm<sup>3</sup>.

In each experiment, you should adjust the volume of deionised water in step 12 to ensure the **same total volume** of reaction mixture is used.

You should alternate the use of the two 100 cm<sup>3</sup> beaker. You should keep **FA 1** and **FA 2** for use in Question 2.

Record all your results in a table. You should include all volumes, the reaction time and the reaction rate for each of your five experiments in your table.

The rate of reaction can be calculated using the following formula.

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

[5]

| Expt | V <sub>FA 1</sub> / cm <sup>3</sup> | Volume of water / cm <sup>3</sup> | t / s | rate / s <sup>-1</sup> |
|------|-------------------------------------|-----------------------------------|-------|------------------------|
| 1    | 40.0                                | 0.0                               | 26    | 38.5                   |
| 2    | 20.0                                | 20.0                              | 54    | 18.5                   |
| 3    | 30.0                                | 10.0                              | 35    | 28.6                   |
| 4    | 25.0                                | 15.0                              | 44    | 22.7                   |
| 5    | 15.0                                | 25.0                              | 75    | 13.3                   |

**PDO Layout [M1]**

- Tabulates  $V_{\text{FA1}}$ , volume of **FA 1**, volume of water, time and rate
- Table contain correct headers and units

**PDO Record [M2]** Records all:

- time to nearest s
- volumes of **FA 1** and water to 1 dp.

**PDO Manipul [M3]** correctly calculates rate for Experiment 1 and 2 and 3 other experiments of varying amount of **FA1** and shown to 3 sf.

**MMO Collect [M4]**

- 5 experiments done
- 3 additional experiments with volume **FA 1**  $\geq 15.00 \text{ cm}^3$ ,  $< 40.00 \text{ cm}^3$  and no volume closer than  $5.00 \text{ cm}^3$  to another volume
- Volumes of water chosen so that total volume =  $40.00 \text{ cm}^3$  for additional experiments.

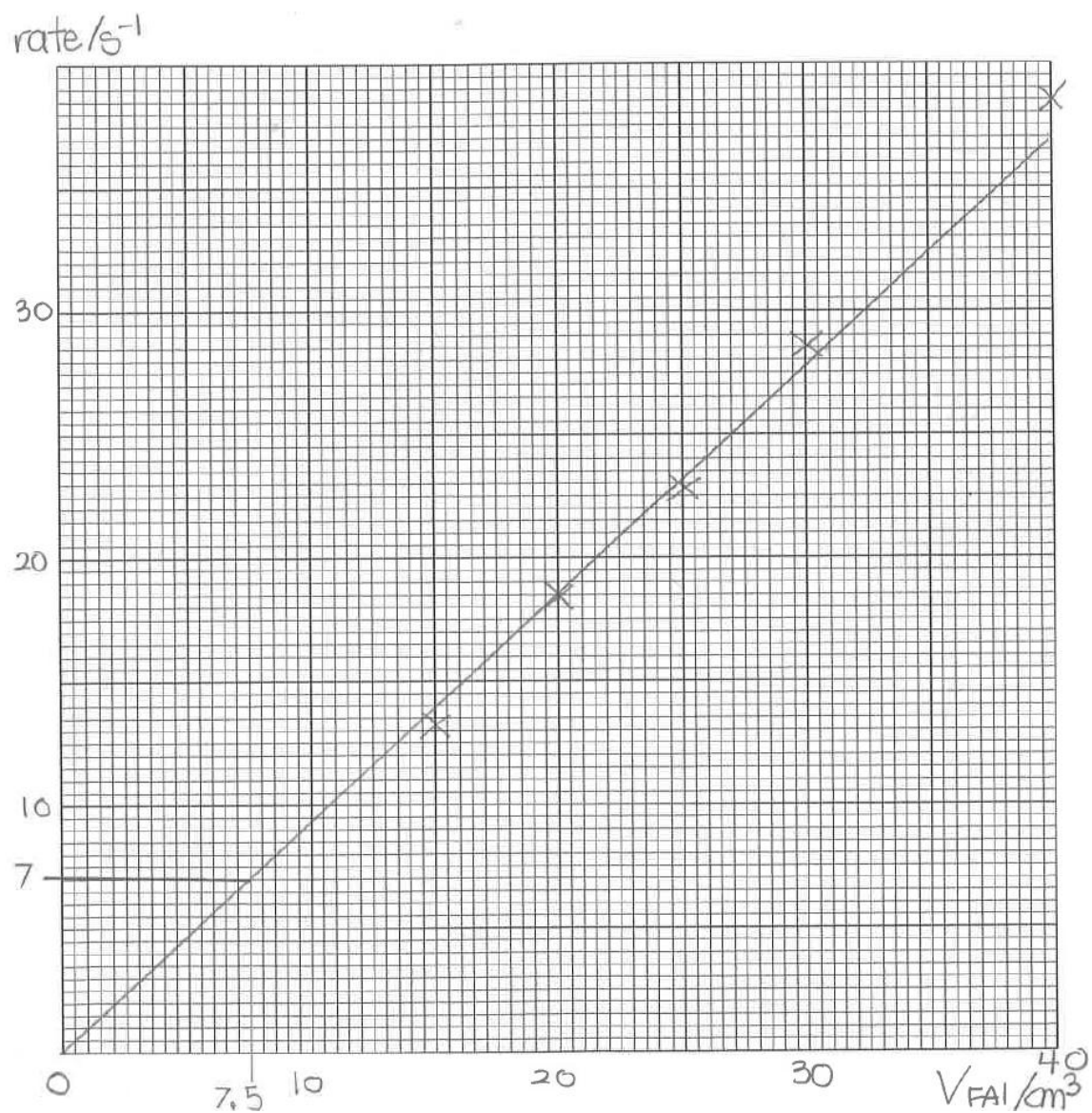
**MMO Quality [M5]** Award when all times recorded increase with decreasing volume of **FA 1**.

- (b) (i) Plot a graph of rate on the y-axis against the volume of **FA 1** on the x-axis on the grid in Fig. 1.1.

Start each axis at the origin (0,0).

Draw the best-fit line.

[3]



**Fig. 1.1**

**PDO Layout [M1]**

- Axes correct way round + correct unambiguous labels + units + scale.
- Scales chosen so that plotted points occupy at least half graph grid in x axes
- The scale must start at zero on both the x and y-axis.

**PDO Layout [M2]** All points correctly plotted within  $\pm \frac{1}{2}$  small square.

**PDO Manipul [M3]** Line of best fit drawn takes into account only the 5 points, not, straight line or smooth curve, that ignores anomalous results.

- (ii) From your graph, what conclusion can you make about the relationship between the relative rate for the reaction and the volume of **FA 1** used?

Explain your answer.

[2]

If straight line: rate is directly proportional to volume of FA 1 [1] because it shows a straight line passing through the origin or shows a  $y = mx$  graph [1].

If curve: rate is directly proportional to square of the volume of FA 1 [1] because it shows a curve passing through the origin or shows a  $y = mx^2$  graph [1].

- (iii) From your graph, determine the time it would take for the print to be obscured if 7.50 cm<sup>3</sup> of **FA 1**, 32.5 cm<sup>3</sup> of water and 10.0 cm<sup>3</sup> of **FA 2** had been used.

Show clearly on the graph how you worked out your answer.

time for printing to be obscured = ..... s [2]

$$7 = 1000 / t$$

$$t = 143 \text{ s}$$

#### **PDO Manipul [M1]**

- Correct line(s) drawn
- rate correctly read within half a small square.

#### **ACE interpret [1]**

- $1000/\text{rate}$ , ecf from point read
- correctly calculates answer to 3 sf.

- (c) (i) A student found that the reaction was first order with respect to  $[H^+]$ .

Predict and explain how the value of  $t$  in Experiment 1 would be affected if hydrochloric acid of the same concentration had been used instead of **FA 2**.

[1]

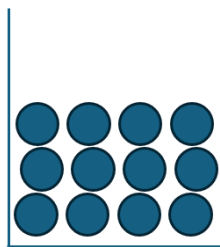
$t$  will be doubled. HC/ is monoprotic, while  $H_2SO_4$  is diprotic. When HC/ is used,  $[H^+]$  is halved and rate of reaction is halved.

#### **ACE interpret**

- (ii) Predict and explain how the value of  $t$  in Experiment 1 would be affected if a 250 cm<sup>3</sup> beaker with larger base area was used instead of the 100 cm<sup>3</sup> beaker.

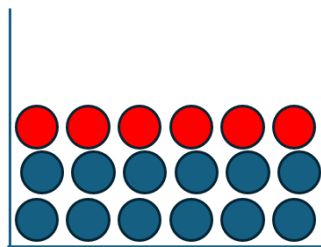
[1]

t will be larger. A larger amount of solid sulfur (wef) would need to be produced for the solution to become opaque due to the larger base area.



100 cm<sup>3</sup> beaker

12 particles produced in t to form 3 layers to obscure insert



250 cm<sup>3</sup> beaker

12 particles produced in t, but need more particles to form 3 layers to obscure insert

**ACE interpret**

[Total: 14]

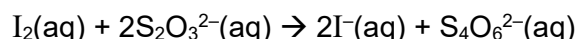
## 2

**Determination of the x of a iodate ion,  $\text{IO}_x^-$** 

Iodate ions contain iodine and oxygen. They have the formula  $\text{IO}_x^-$  where x is an integer.

- (a) In this experiment you will determine the value of x in an iodate. You will first react  $\text{IO}_x^-$  with an excess of iodide ions,  $\text{I}^-$ , to form iodine,  $\text{I}_2$ .

The amount of iodine produced is then determined by titration with thiosulfate ions,  $\text{S}_2\text{O}_3^{2-}$ .



**FA 1** is  $0.100 \text{ mol dm}^{-3}$  sodium thiosulfate,  $\text{Na}_2\text{S}_2\text{O}_3$ .

**FA 2** is dilute sulfuric acid,  $\text{H}_2\text{SO}_4$ .

**FA 3** is a solution containing  $0.0140 \text{ mol dm}^{-3}$   $\text{IO}_x^-$  ions.

**FA 4** is  $0.500 \text{ mol dm}^{-3}$  potassium iodide, KI.

**FA 5** is starch indicator.

(i) **Titration**

- 1) Fill the burette with **FA 1**.
- 2) Use the pipette to transfer  $25.0 \text{ cm}^3$  of **FA 3** into a  $250 \text{ cm}^3$  conical flask.
- 3) Use the  $25 \text{ cm}^3$  measuring cylinder to transfer  $10.0 \text{ cm}^3$  of **FA 2** to the same conical flask.
- 4) Use the same measuring cylinder to transfer  $10.0 \text{ cm}^3$  of **FA 4** to the same conical flask.
- 5) Run **FA 1** from the burette into this flask until the solution turns yellow.
- 6) Add 10–15 drops of **FA 5** to the solution in the conical flask.
- 7) Continue to add more **FA 1** from the burette until the blue-black colour just disappears.
- 8) Record your titration results in Table 2.1 on page ?. Make certain that your recorded results show the precision of your working.
- 9) Repeat steps 1 to 8 as necessary until consistent results are obtained.

You should keep **FA 3** for use in Question 3.

**Results**

**Table 2.1**

|                                         |       |       |  |  |  |
|-----------------------------------------|-------|-------|--|--|--|
| final burette reading / $\text{cm}^3$   | 22.20 | 22.10 |  |  |  |
| initial burette reading / $\text{cm}^3$ | 0.00  | 0.00  |  |  |  |
| volume of FA 1 added / $\text{cm}^3$    | 22.20 | 22.10 |  |  |  |

[4]

**PDO Record [M1]** All accurate burette readings are recorded to the nearest 0.05 cm<sup>3</sup>.

Penalise here when initial burette reading > final burette

**MMO Quality [M2]** Has at least two uncorrected titres for end-point within 0.10 cm<sup>3</sup>

**MMO Quality, MMO Accuracy**

**[M3]** when 21.90 – 22.50 cm<sup>3</sup> → based on (ii)

**[M4]** when 22.00 – 22.40 cm<sup>3</sup> → based on (ii)

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

Volume of **FA 1** = ..... cm<sup>3</sup> [1]

Vol of FA 1 = (22.20 + 22.10) / 2 = 22.15 cm<sup>3</sup> (2 dp)

**MMO Decision [1]** Student obtains appropriate 'average', to 2 dp.

- (b) (i) Calculate the amount of iodine formed when 25.0 cm<sup>3</sup> of **FA 3** reacts with 10 cm<sup>3</sup> of **FA 2**.

amount of iodine formed = ..... mol [1]

Amt of I<sub>2</sub> = ½ x (a)(ii)/1000 x 0.1 = 1.11 x 10<sup>-3</sup> mol (3sf)

**ACE Interpret**

**3 sf mark in (b)(iv)**

- (ii) Calculate the amount of IO<sub>x</sub><sup>-</sup> ions in 25.0 cm<sup>3</sup> of **FA 3**.

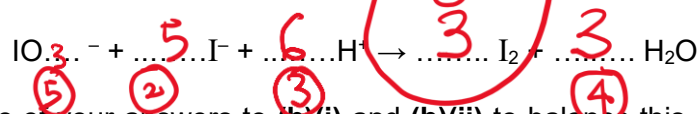
amount of IO<sub>x</sub><sup>-</sup> ions in 25.0 cm<sup>3</sup> of **FA 3** = ..... mol [1]

Amt of IO<sub>x</sub><sup>-</sup> = 0.025 x 0.014 = 3.50 x 10<sup>-4</sup> mol (3sf)

**ACE Interpret**

**3 sf mark in (b)(iv)**

- (iii) An unbalanced equation for the reaction of  $\text{IO}_x^-$  ions with iodide ions,  $\text{I}^-$ , and hydrogen ions,  $\text{H}^+$ , is shown.

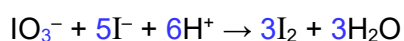


Use the ratio of your answers to (b)(i) and (b)(ii) to balance this equation and determine the value of  $x$ .

Show your working.

[2]

$$(b)(i)/(b)(ii) = 3.17 \text{ (ignore sf)}$$



$$x = 3$$

**ACE Interpret [M1]** Display of (b)(i) / (b)(ii) ratio, ecf ratio

**ACE Interpret [M2]** Equation balanced for value of  $x$ , do not award when  $x$  is more than 5 (iodine only has 7 valence electrons)



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

[2]

Less iodine is produced and volume of FA 1 will be smaller.

**ACE Interpret [M1]** Less iodine is produced + volume of FA 1 will be smaller.

**[M2]** sf for (b)(i)(ii)

- (c) A student performed the experiment in 2(a)(i) using a sample of another iodate salt. The student obtained a mean titre value of  $22.20 \text{ cm}^3$ .

The teacher calculated that the mean titre volume of **FA 1** required should have been  $22.40 \text{ cm}^3$ . The teacher told the student that the total percentage error from the burette in the experiment was 0.4%.

Calculate the percentage error in the student's result, based on these data. State and explain whether or not the student's result is accurate.

[2]

$$\% \text{ error} = (22.40 - 22.20) / 22.40 \times 100\% = \underline{0.893\%} > 0.4\%$$

Student's experiment is not accurate.

**ACE Interpret [M1]** overall experimental error = 0.0893%

**ACE Conclusion [M2]** not accurate AND justifies this in terms of experimental error being > apparatus error

- (d) The reaction between iodate and iodide in acidic solution is highly exothermic. Other than the direct titration method in **2(a)**, it is possible to determine the equivalence point and subsequently the concentration of iodate through thermometric titration.

A solution of  $8.00 \text{ g dm}^{-3}$  iodate was prepared from solid  $\text{KIO}_x$ .  $2.00 \text{ cm}^3$  of iodate solution is progressively added to  $25.0 \text{ cm}^3$  of acidified iodide solution until equivalence point is reached and passed. The temperature is monitored throughout the experiment.

The data obtained is plotted and two best-fit graph lines are drawn. One line is drawn using data before equivalence-point and the second line using the remaining data. These lines are then extrapolated (extended) until they cross.

You may assume you are provided with

- 10 g of  $\text{KIO}_x$  solid
  - $100 \text{ cm}^3$  of  $0.500 \text{ mol dm}^{-3}$  acidified potassium iodide, KI
  - the equipment normally found in a school or college laboratory.
- (i) Describe how you would make  $250.0 \text{ cm}^3$  of  $8.00 \text{ g dm}^{-3}$   $\text{KIO}_x$  solution for your experiment.

[3]

- 1) Using a mass balance, weigh  $2.00 \text{ g}$  of  $\text{KIO}_x$  solid in a weighing bottle.
- 2) Transfer  $\text{KIO}_x$  into a  $100 \text{ cm}^3$  beaker containing  $50 \text{ cm}^3$  of deionised water.
- 3) Stir with a glass rod to dissolve  $\text{KIO}_x$ .
- 4) Transfer the solution in the beaker and washing into a  $250 \text{ cm}^3$  volumetric flask.
- 5) Top up to the mark with deionised water.
- 6) Stopper and shake/invert the flask.
- 7) Reweigh the weighing bottle.

|                                                                                            |                                                 |    |
|--------------------------------------------------------------------------------------------|-------------------------------------------------|----|
| Using a mass balance, weigh $2.00 \text{ g}$ of $\text{KIO}_x$ solid in a weighing bottle. | Mass balance                                    | A1 |
|                                                                                            | Weigh $2.00 \text{ g}$ (2 dp must be specified) | Q  |

|                                                                             |                                            |    |
|-----------------------------------------------------------------------------|--------------------------------------------|----|
| Dissolve $\text{KIO}_x$ in a beaker of $50.0 \text{ cm}^3$ deionised water. | Dissolve $\text{KIO}_x$ in deionised water | P1 |
| Transfer solution and washing into a $250 \text{ cm}^3$ volumetric flask.   | Transfer solution and washing              | P2 |
|                                                                             | $250 \text{ cm}^3$ volumetric flask        | A2 |
| Top up to the mark with deionised water.                                    |                                            | P3 |
| Stopper and shake/invert the flask                                          |                                            | P4 |

[3]: 6-7 pts      [2]: 4 – 5 pts      [1]: 2 – 3 pts

- (ii) Plan a thermometric titration in which iodate solution prepared in (d)(i) is added to acidified iodide solution. You should assume the equivalence volume is between  $10.00 \text{ cm}^3$  to  $40.00 \text{ cm}^3$ .

In your plan, you should include brief details of:

- the apparatus you would use
- the procedure you would follow
- the measurements you would make.

You may assume that the experiment is carried out at room temperature.

[4]

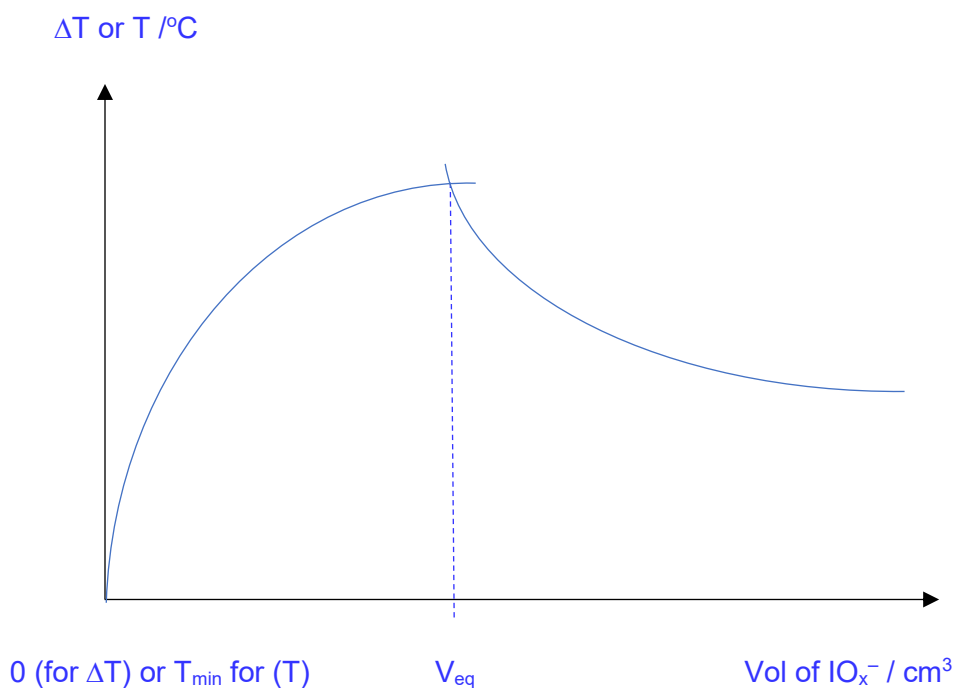
- 1) Transfer the iodate solution into a  $50.00 \text{ cm}^3$  burette [A]
- 2) Place a polystyrene cup [A] into another cup and place it in a  $250 \text{ cm}^3$  beaker.
- 3) Using a pipette [A], transfer  $25.0 \text{ cm}^3$  of acidified KI into the polystyrene cup.
- 4) Using a  $0.2^\circ\text{C}$  thermometer [A], stir the solution in the cup and measure the initial temperature.[P]
- 5) From the burette, add  $2.00 \text{ cm}^3$  of iodate [M] solution. Stir [P] the solution and measure the temperature. Record the maximum temperature [P] and the total volume of iodate solution added.
- 6) Repeat step 5 until there are 4 points for decrease in temperature [M] or until  $48.00 \text{ cm}^3$  of iodate solution is added

|                                                                   |                                                                |    |
|-------------------------------------------------------------------|----------------------------------------------------------------|----|
| Transfer the iodate solution into a $50.00 \text{ cm}^3$ burette. | Burette for iodate solution.<br>Precision can be infer from M1 | A1 |
|-------------------------------------------------------------------|----------------------------------------------------------------|----|

|                                                                                                                                                              |                                                                               |    |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------|----|
| Using a 25.0 cm <sup>3</sup> pipette, transfer 25.0 cm <sup>3</sup> of acidified KI into the polystyrene cup.                                                | 25 cm <sup>3</sup> pipette, .0 specified at pipette or volume of acidified KI | A2 |
|                                                                                                                                                              | <i>Accept burette</i><br>polystyrene cup                                      | A3 |
| Using a 0.2°C thermometer, stir the solution in the cup and measure the initial temperature.                                                                 | 0.2°C thermometer or specify temperature record to nearest 0.1°C.             | A4 |
|                                                                                                                                                              | Stir the solution                                                             | P1 |
|                                                                                                                                                              | measure temperature                                                           | P2 |
| From the burette, add 2.00 cm <sup>3</sup> of iodate solution. Record the maximum temperature and the total volume of iodate solution added.                 | measure maximum temperature                                                   | P3 |
|                                                                                                                                                              | Increments of 2.00 cm <sup>3</sup> of KIO <sub>3</sub>                        | M1 |
| Repeat step 5 until there are at least 3 points for decrease in temperature or until at least 46.00 cm <sup>3</sup> of IO <sub>x</sub> <sup>-</sup> is added | Repeat till 48.00 cm <sup>3</sup> or 50.00 cm <sup>3</sup><br>OR              | M2 |
|                                                                                                                                                              | Repeat till at least 3 points after a decrease in temp                        |    |

[4]: 9 pts      [3]: 6 - 8 pts      [2]: 4 – 5 pt      [1]: 2 - 3 pts

- (ii) In the axis below, label the axis and sketch the graph you would obtain. Indicate the equivalence volume,  $V_{eq}$ , on the graph.



[2]

**ACE [M1]**

- axis label (ignore units)
- 2 lines that intersect
- If y-axis is  $\Delta T$ , start from 0  
If y-axis is T graph must start from y-axis

Allow:  or 

**ACE [M2]**  $V_{eq}$  labelled

(iii) Hence, explain the shape of the graph after  $V_{eq}$ .

[1]

The reaction is complete and no more heat is released. The additional FA 4 is of a lower temperature and cools the reaction mixture. Hence, temperature drops.

[Total: 10]

3

**Investigation of an inorganic compound and an organic compound.**

**FA 5** contains two cations and one anion.

Compound **Y** is an organic compound with two functional groups.

- (a) (i) You will carry out tests to identify the ions present in **FA 5**.

You are provided with **FA 5** and other necessary bench reagents. You will also need access to the **FA 3** solution you used in **Questions 2 and 3**.

Carry out the tests described in Table 3.1.

Carefully record your observations **at each stage** of the tests in Table 3.1.

The volumes given in Table 3.1 are approximate and should be estimated rather than measured.

Test and identify any gases evolved.

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



**Table 3.1**

FA 5

| Tests |                                                                                                                                                                                                   | observations                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|-------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1     | <p>Add 1 cm depth of <b>FA 5</b> to a clean boiling tube.</p> <p>Add aqueous sodium hydroxide slowly, with shaking, until the aqueous sodium hydroxide is in excess.</p> <p>Warm the mixture.</p> | <p><u>Green ppt ✓ formed insoluble ✓ in excess NaOH (aq).</u></p> <p><u>Green ppt turns brown ✓ on contact with air.</u></p> <p><u>Gas evolved turns moist red litmus paper blue. ✓ Gas is NH<sub>3</sub>. ✓</u></p> <div style="display: flex; justify-content: space-around;"> <div style="text-align: center;"> <br/>           NaOH(aq)         </div> <div style="text-align: center;"> <br/>           excess NaOH(aq)         </div> </div> <div style="display: flex; justify-content: space-around;"> <div style="text-align: center;"> <br/>           during warming         </div> <div style="text-align: center;"> <br/>           after warming         </div> </div> |

[5]

|   |                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                   |
|---|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2 | <p>Add 1 cm depth of <b>FA 5</b> to a clean boiling tube.</p> <p>Add 2 cm depth of <b>FA 3</b>.</p> <p>Warm the mixture.</p> <p>Keep the reaction mixture for test 3.</p>                                                                                                                                           |  <p><u>Solution turns orange/brown</u> ✓ upon heating.</p>                                                                                                      |
| 3 | <p>To the reaction mixture from test 2, add aqueous sodium hydroxide slowly, with shaking, until the aqueous sodium hydroxide is in excess.</p>                                                                                                                                                                     | <p><u>Reddish-brown/brown ppt</u> ✓ formed <u>insoluble</u> ✓ in excess NaOH (aq).</p> <p><i>Penalise one ✓ for reddish-brown/brown solution formed instead of "ppt"</i></p>                                                                      |
|   | <div style="display: flex; justify-content: space-around;">   </div> <p style="text-align: center;">NaOH(aq)                  excess NaOH(aq)</p> |                                                                                                                                                                                                                                                   |
| 4 | <p>Add 1 cm depth of <b>FA 5</b> to a clean test-tube.</p> <p>Add 1 cm depth of aqueous barium nitrate.</p> <p>Add dilute nitric acid until the nitric acid is in excess.</p>                                                                                                                                       | <p><u>White ppt</u> ✓ formed <u>insoluble</u> ✓ in excess HNO<sub>3</sub> (aq).</p> <p><i>Penalise one ✓ for white solution formed instead of "ppt"</i></p>  |

[5] - 10 ✓      [4] – 8/9 ✓      [3] – 6/7 ✓      [2] – 4/5 ✓      [1] – 2/3 ✓

- (ii) Use your observations in Table 3.1 to identify the cations and the anion in **FA 5**.

cations ..... and .....

anion .....

[2]

cations: NH<sub>4</sub><sup>+</sup> and Fe<sup>2+</sup> [1]

anion: SO<sub>4</sub><sup>2-</sup> [1]

- (iii) Explain the reaction between **FA 3** and **FA 5** in test 2.

[1]

Redox reaction. Fe<sup>2+</sup> in FA 5 is oxidised to Fe<sup>3+</sup>, while IO<sub>x</sub><sup>-</sup> in FA 3 is reduced to I<sub>2</sub>.

(b) In this question, you will deduce the two functional groups in **Y**.

Consider the observations recorded in Table 3.2.

**You do not perform the following tests. Observations have been recorded for you.**

**Table 3.2**

| tests |                                                                                                                                                                                                                                                             | observations                                                                          |
|-------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
| 5     | Add 1 cm depth of <b>Y</b> into a test-tube.<br><br>To this test-tube, add 8 drops of sodium hydroxide solution followed by iodine solution, dropwise, until a permanent orange colour is present.<br><br>Warm the mixture in a water bath for two minutes. | yellow precipitate formed                                                             |
| 6     | Add 1 cm depth of <b>Y</b> into a clean test-tube.<br><br>Add a small amount of phosphorus pentachloride solid.                                                                                                                                             | no white fumes evolved                                                                |
| 7     | Add 1 cm depth of <b>Y</b> into a clean test-tube.<br><br>Add a small piece of sodium.                                                                                                                                                                      | effervescence observed and gas evolved extinguishes lighted splint with a 'pop' sound |

- (i) Use the information and observations recorded in Table 3.2 to complete Table 3.3 and identify the two functional groups in Y.

For each functional group, give evidence to support your conclusion.

**Table 3.3**

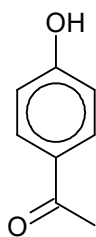
| functional group                     | Evidence                                                                                                                                                                                                           |
|--------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| methyl<br>carbonyl/ketone<br><br>[1] | <u>Test 5/yellow ppt suggests it's a methyl carbonyl/CH<sub>3</sub>CO ✓ or CH<sub>3</sub>CH(OH)-. ✓</u><br><br><u>Test 6 suggests that it is not an alcohol since there is no reaction with PCl<sub>5</sub>. ✓</u> |
| Phenol [1]                           | <u>Test 6 suggests that it is not an alcohol or carboxylic acid. ✓</u><br><br><u>Test 7 suggests there is -OH or phenol ✓</u>                                                                                      |

[2]: 4-5 ✓ [1]: 2-3 ✓

[4]

- (ii) Suggest the structure of a compound with 8 carbons that contain the functional groups identified in Table 3.3.

[1]



the 2 FGs can be at 1,2 1,3 or 1,4 positions wrt to each other

[Total: 13]