Question 1 (cover during planning tutorial)

Procedure [5]

Key points to be included in the procedure:

- ✓ Apparatus used:
  - boiling tube
  - Bunsen burner
  - Analytical/weighing balance
- ✓ Duration of heating:
  - Gentle heating at first
  - Strong heating for 10 minutes
- ✓ Allow the boiling tube and its contents to cool before weighing
- ✓ Repeat heating-cooling-weighing process till constant mass
- ✓ Mass taken:
  - empty boiling tube
  - total mass of boiling tube and sample
  - total mass after each round of heat-cool-weigh process

Step 1: Using an analytical/weighing balance, weigh an empty, dry and clean boiling tube and record the mass.

Step 2: Transfer about 2.00 g of the mixture of $Mg(OH)_2$ and $Ba(OH)_2$ provided into the boiling tube. Weigh the boiling tube and the sample and record the total mass.

Step 3: Using a Bunsen burner, heat the boiling tube with its contents gently at first, and then strongly for 10 minutes. Ensure that the water droplets that condensed on the cooler parts of the boiling tube is driven off during heating.

Step 4: Allow the boiling tube and its contents to cool. Then weigh the cooled boiling tube and its contents and record the total mass.

Step 5: Repeat this heating-cooling-weighing process until constant mass is achieved.

Measurements and tabulation of experimental data

Mass of empty boiling tube / g	**A**
Mass of boiling tube and sample / g	**B**
Mass of boiling tube and contents after first heating / g after second heating / g after third heating / g	**C** **D** **D**

[1 for table]

Mass of sample (mixture of $Mg(OH)_2$ and $Ba(OH)_2$) used = (**B** – **A**) g
Mass of H_2O lost = (**B** – **D**) g **[1]**

Treatment of results

Amount of H_2O lost = (**B** – **D**)/18.0 mol

$Mg(OH)_2(s) \longrightarrow MgO(s) + H_2O(g)$

Amount of $Mg(OH)_2$ decomposed = Total amount of H_2O lost = (**B** – **D**)/18.0 mol

Hence, mass of $Mg(OH)_2$ in the mixture = (58.3)(**B** – **D**)/18.0 g **[1]**

Percentage by mass of $Mg(OH)_2$ in the mixture = [(58.3)(**B** – **D**)/18.0] ÷ (**B** – **A**) x 100% **[1]**

Question 2 (cover during planning tutorial)

(a)

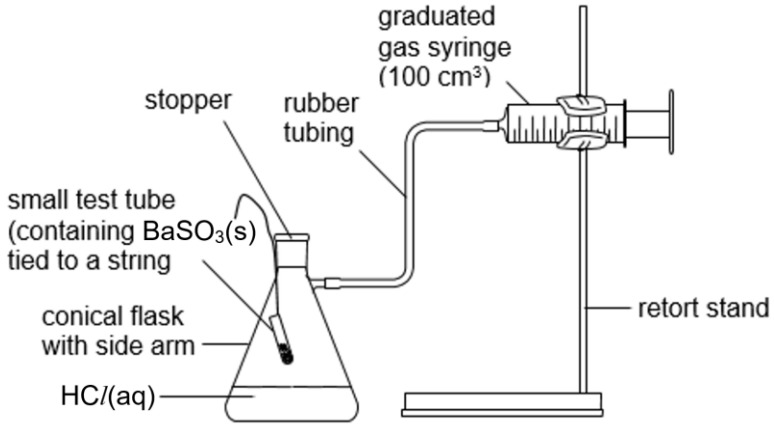


Diagram of the set-up [2]
✓ Labeling of apparatus used
✓ Appropriate choice of apparatus to collect gas (e.g. 100 cm^3 gas syringe).
✓ Reactants not mixed yet
✓ Air-tight and closed system by labeling the stopper to ensure no loss of gas

Pre-calculations

Mass of $BaSO_3$ to be used

Assume that 50.0 cm^3 of SO_2 gas is collected.

As 1 mole of gas occupies a volume of 24 dm^3 under laboratory conditions,

Amount of $SO_2 = \frac{50.0}{24000} = 2.08 \times 10^{-3}$ mol

$BaSO_3(s) + 2HCl(aq) \rightarrow BaCl_2(aq) + SO_2(g) + H_2O(l)$

Amount of $BaSO_3 = 2.08 \times 10^{-3}$ mol

Molar mass of $BaSO_3 = 137.3 + 32.1 + 3(16.0) = 217.4$ g mol^{-1}

Mass of $BaSO_3 = (2.08 \times 10^{-3})(217.4) = 0.4529 = 0.453$ g **[1]**

Volume of HCl(aq) to be used

Amount of HCl(aq) = $(2)(2.08 \times 10^{-3}) = 4.16 \times 10^{-3}$ mol

Volume of HCl to be used = $(4.16 \times 10^{-3}) / 0.200 \times 1000 = 20.8$ cm^3 **[1]**

Since HCl(aq) has to be in excess so that the $BaSO_3$ used is completely reacted, a suitable volume of HCl(aq) to be used is 25 cm^3. **[1]**

Procedure [5]

1. Using a burette, add 25.00 cm^3 of HCl(aq) into a clean and dry 250 cm^3 conical flask with a side arm.
2. Using an analytical balance, weigh accurately about 0.453 g of $BaSO_3$ in a small tube and tie it to a string.
3. Set up the apparatus as shown above.
4. Lower the filled tube into the conical flask, taking care that the reagents do not mix. Stopper the conical flask.
5. Check that the initial reading of the 100 cm^3 graduated gas syringe is set at the zero mark.
6. At a suitable time, loosen the stopper slightly to release the string to allow mixing of the reagents. Stopper the conical flask immediately.
7. Swirl the conical flask to ensure that the reagents are well mixed.
8. Allow the reaction to progress until it has ceased as indicated by a constant reading of the syringe.
9. Record the final reading on the graduated gas syringe.
10. Record temperature and pressure of the collected gas using a thermometer and a barometer respectively.
11. Repeat the experiment to get consistent results of volume of SO_2 gas collected.

Key Points:
- ✓ Appropriate apparatus used
  - o Analytical balance to weigh $BaSO_3$
  - o Burette/measuring cylinder to measure HC*l*(aq)
- ✓ Record initial and final reading of gas syringe
- ✓ Swirl and allow the reaction to complete (indicated by a constant reading of the syringe)
- ✓ Record temperature and pressure of the collected gas
- ✓ Repeat experiment to obtain consistent results

Calculations to obtain molar gas constant, R

Let the mass of solid $BaSO_3$ used be **m** g

Amount of $BaSO_3$ used = Amount of SO_2 formed = $\frac{m}{217.4}$ mol **[1]**

Let the average pressure, volume and temperature of the SO_2 collected be **P** Pa, **V** cm^3 and **T** K respectively.

$$R = \frac{PV}{nT} = \frac{P \times V \times 10^{-6}}{\frac{m}{217.4} \times T} = \frac{P \times V \times 10^{-6} \times 217.4}{m \times T} \text{ J K}^{-1} \text{ mol}^{-1}$$ **[1]**

(b) Dilute sulfuric acid should not be used because the <u>layer of insoluble $BaSO_4$</u> forming around $BaSO_3$(s) could <u>stop the reaction prematurely</u>. **[1]**

(c) The reaction of acid and metal will product H_2 gas. <u>H_2 deviates less from ideal gas behaviour</u> since the intermolecular forces of attraction between H_2 molecules are weaker than that between SO_2 molecules. **[1]**

Question 3 (covered on IVY during T2W10)

(a) Pre-calculations [2]

Let volume of $CuSO_4$ used be 25.0 cm^3

n($CuSO_4$) used = 25.0 / 1000 x 1.00 = 0.0250 mol

n(Zn) reacted = 0.0250 mol

Mass of Zn reacted = 0.0250 x 65.4 = 1.635 g

Since Zn is in excess, use 2.00 g of Zn.

Note:
- Set volume of $CuSO_4$(aq) to be between <u>25 cm^3 and 70 cm^3</u>.
  Volume of solution (assume capacity of Styrofoam cup is 200 cm^3)
  - o *should be sufficient to submerge the bulb of the thermometer*
  - o *should not exceed more than half the capacity of the Styrofoam cup (up to 100 cm^3)*
  - o *should allow for experiment to be repeated*
- Mass of Zn used must also allow for experiment to be repeated.

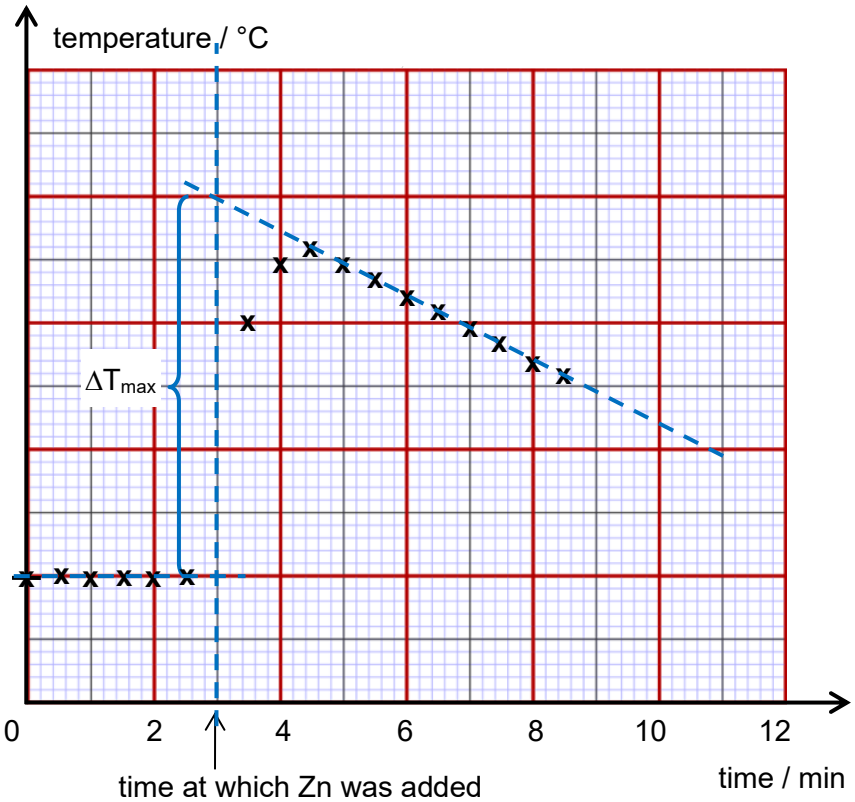
Procedure [5]

1 Place the styrofoam cup in the 250 cm^3 beaker.
2 Using a burette (or 25.0 cm^3 pipette), add 25.0 cm^3 of $CuSO_4$ into the styrofoam cup and put the lid on.
3 Using an analytical balance, weigh accurately about 2.00 g of Zn in a clean and dry weighing bottle. Record the total mass of Zn and weighing bottle.
4 Insert the thermometer through the lid and ensure that the bulb of the thermometer is in contact with the $CuSO_4$. Record the temperature at time = 0 min. Start timing using the stopwatch.
5 Record the temperature of the $CuSO_4$ every 0.5-minute interval until 2.5 minutes.
6 At exactly 3 minutes, open the lid of the cup and transfer the Zn carefully into the $CuSO_4$. Replace the lid quickly.
7 Using the thermometer, stir the mixture gently.
8 Record the temperature of the mixture at every 0.5-minute interval until there are 5 temperature readings after the highest temperature recorded.
9 Reweigh the weighing bottle with any residual Zn and record this mass reading.
10 Rinse out the styrofoam cup and the weighing bottle and dry them.

Repeat steps 1 to 9 to obtain another set of data to plot another graph. Obtain a second value of ΔT_{max} and enthalpy change of reaction and find the average value for the enthalpy change of reaction.

Key Points:
- ✓ use of appropriate apparatus (and its capacity) and instrument
- ✓ use of Styrofoam cup with lid
- ✓ appropriate mass of Zn to be used (Zn is in excess and allow for expt to be repeated)
- ✓ appropriate volume of $CuSO_4$ to be used (between 25 cm^3 and 70 cm^3)
- ✓ mass measurements (i.e. weighing by difference to determine the mass of Zn used)
- ✓ starting stopwatch and recording at least 3 temperature readings before addition of Zn
- ✓ recording at least 5 temperature readings after the highest temperature is reached
- ✓ repeat experiment to ensure reliability of results

(b)(i) & (b)(ii)



Extrapolate the two lines to t = 3 min (time of addition of Zn) and determine the maximum temperature change, ΔT_{max}, as shown above. **[3]**

Key Points:
✓ Two straight lines of best fit o one for the temperature of $CuSO_4$ before adding Zn (i.e. line showing constant initial temperature before addition of Zn) o one for the cooling of the solution once the reaction is complete (i.e. line showing a decrease in temperature after the highest temperature has been reached) ✓ Show constructions lines on graph and explain how to obtain ΔT_{max}

(b)(iii) Heat change, q = $mc\Delta T_{max}$ = (25 x c x ΔT_{max}) J **[1]**
(Note: m should not include the mass of Zn)

$n(CuSO_4)$ = 0.0250 mol

$$\Delta H_{reaction} = -\frac{q}{n(CuSO_4)} = -\frac{(25 \times c \times \Delta T_{max})}{0.0250} \text{ J mol}^{-1} \text{ or } -\frac{(25 \times c \times \Delta T_{max})}{0.0250} \times 10^{-3} \text{ kJ mol}^{-1}$$ **[1]**

(b)(iv) Heat loss to the surroundings is adequately accounted for via extrapolation of the graph to 3 min (time at which Zn was added). **[1]**

Question 4 (cover during planning tutorial)

(a) $NaHCO_3$ removes H^+ ions from the reaction mixture and thus stops the reaction of propanone and iodine. **[1]**

(b)

Preparation of standard solution of 1.00 mol dm^{-3} propanone
Using a 250 cm^3 volumetric flask,
amount of CH_3COCH_3 to prepare = 1.00 × 0.25 = 0.250 mol
mass of CH_3COCH_3(l) to weigh out = 0.250 × 58.0 = 14.5 g **[1]**

Procedure to prepare standard solution of propanone [1]

1. Weigh accurately 14.5 g of liquid propanone in a clean and dry 100 cm^3 beaker using an analytical balance.
2. Transfer the liquid quantitatively into a 250 cm^3 volumetric flask. Rinse the beaker with some deionised water and transfer the washings into the volumetric flask.
3. Top up to the mark with deionised water, stopper the volumetric flask and shake this solution to obtain a homogeneous solution.

Key Points:
✓ Use of appropriate apparatus o Volumetric flask, analytical balance, beaker (or other weighing bottle) ✓ Steps for preparing standard solution o Quantitative transfer o Stopper and shake

Pre-calculations for continuous method [1]

Amount of I_2 used = (50.0/1000)(0.040) = 2.00×10^{-3} mol

CH_3COCH_3 and H^+ are in large excess.
Amount of CH_3COCH_3 = (10)(Amount of I_2) = 2.00×10^{-2} mol
Minimum volume of CH_3COCH_3 = $(2.00 \times 10^{-2}) / 1.00 \times 1000 = 20.0$ cm^3

Amount of H^+ = (10)(Amount of I_2) = 2.00×10^{-2} mol
Amount of H_2SO_4 = (½)$(2.00 \times 10^{-2}) = 1.00 \times 10^{-2}$ mol
Minimum volume of H_2SO_4 to use = $(1.00 \times 10^{-2}) / 1.00 \times 1000 = 10.0$ cm^3

Assume that 25.0 cm^3 of CH_3COCH_3 and 25.0 cm^3 of H_2SO_4 are used.
Total volume of reaction mixture = 100.0 cm^3
Assume that 10.0 cm^3 of the mixture is sampled at suitable time intervals.
Amount of H_2SO_4 in 10.0 cm^3 of reaction mixture =(1/10)(25.0/1000)(1.0) = 2.5×10^{-3} mol
Amount of H^+ from H_2SO_4 = $(2.5 \times 10^{-3}) \times 2 = 5.0 \times 10^{-3}$ mol
Minimum amount of $NaHCO_3$ to add to react with H^+ = 5.0×10^{-3} mol
Minimum volume of $NaHCO_3$ needed = $(5.0 \times 10^{-3}) / 1 \times 1000 = 5.0$ cm^3

Procedure for continuous method and titration [5]

1. Using a burette, transfer 50.00 cm^3 of I_2(aq) into a 250 cm^3 beaker.
2. To the same beaker, add 25.0 cm^3 of H_2SO_4(aq) using a 50 cm^3 measuring cylinder.
3. Measure 25.0 cm^3 of CH_3COCH_3(aq) using another 50 cm^3 measuring cylinder.
4. Add the CH_3COCH_3(aq) into the same 250 cm^3 beaker in step 1. Start the stopwatch immediately. Stir the mixture using a glass rod to ensure even mixing.
5. Using a 10.0 cm^3 pipette, transfer 10.0 cm^3 of the reaction mixture into a 250 cm^3 conical flask.
6. At time **2 min**, add 10.0 cm^3 of $NaHCO_3$(aq) (measured using a 10 cm^3 measuring cylinder) into the 250 cm^3 conical flask.
7. Immediately titrate the iodine present in the conical flask against $Na_2S_2O_3$(aq) from a burette, until the solution turns pale yellow. Add 1 cm^3 starch from a dropper and continue the titration until the blue-black solution in the conical flask turns colourless.
8. Repeat steps 6-7 at 6, 10, 14, 18, 22, 26 minutes.
9. Record the titration results in a suitable table.

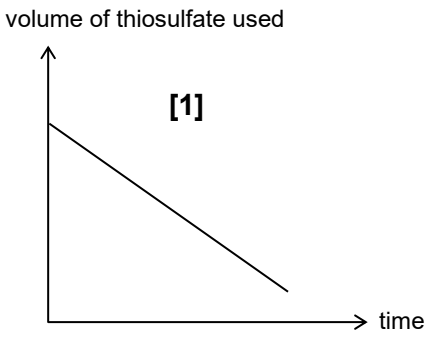
Key Points:
- Preparation of reaction mixture & starting of stop stopwatch
  (Note: I_2 or CH_3COCH_3 should be added LAST)
- Removal of aliquot (10 cm^3) & Quenching at (appropriate) time intervals with sufficient $NaHCO_3$
- Titration against $Na_2S_2O_3$(aq) & starch added & end-point colour change
- Repeat sampling, quenching and titration process such that at least 5 titre results are obtained (the total volume of the reaction mixture should be sufficient)
- Appropriate apparatus used for volume measurements.

Comments:
- **Preparation of propanone solution**
  - To prepare a standard solution of CH_3COCH_3(aq) from liquid CH_3COCH_3, a 100 cm^3 or 250 cm^3 volumetric flask should be used. Hence a pre-calculation should be done to determine the amount of CH_3COCH_3 required to prepare 100 cm^3 or 250 cm^3 of 1.00 mol dm^{-3} CH_3COCH_3(aq).
  - Since liquid CH_3COCH_3 and not aq. CH_3COCH_3 is provided, the density of $CH_3COCH_3(l)$ cannot be assumed to be 1.00 g cm^{-3}. Since the density of $CH_3COCH_3(l)$ is not known, the mass of $CH_3COCH_3(l)$ should be measured and not the volume.
- **Continuous method and titration**
  - The aim of this investigation is to determine the order of reaction with respect to I_2, in the reaction of I_2 with CH_3COCH_3(aq), catalysed by H_2SO_4. In order to determine the order

w.r.t. I_2, the concentration of CH_3COCH_3 and H_2SO_4 should be in large excess compared to I_2, as stated in the question.

- Using the continuous method, the concentration of I_2 (as a reactant) is monitored over time, by means of drawing samples of the reaction mixture at various time intervals, then quenching or stopping the reaction in the sample by adding $NaHCO_3$. The quenched sample is then titrated with $Na_2S_2O_3$ to determine the amount of I_2 present.
- In preparing the reaction mixture, the amounts of CH_3COCH_3 and H_2SO_4 used must be at least 10 times in excess compared to the amount of I_2 in 50.0 cm^3 0.040 mol dm^{-3} solution provided. CH_3COCH_3 or I_2 should be added LAST before starting the stopwatch (NOT H_2SO_4), as the reaction can still proceed (albeit slowly) with only I_2 and CH_3COCH_3 added. A measuring cylinder should be used for the LAST reagent added, just before the stopwatch is started.
- For the quenching step, the time of adding an aliquot sample to $NaHCO_3$ should be recorded (i.e. the actual time when the reaction in the sample is stopped), and NOT the time of withdrawing a sample from the reaction mixture. Sufficient $NaHCO_3$ should be added to the sample to remove all H_2SO_4 present.
- In the titration of the quenched sample with $Na_2S_2O_3$, starch should only be added when the I_2 in the sample has faded to a pale yellow colour. The end-point colour change from blue-back to colourless should be included in the plan.
- Since the concentration of I_2 in the reaction mixture has to be monitored over time, at least 5 samples need to be drawn in total at various times for quenching and titration. The time interval chosen should be adequate to realistically allow for time to pipette out an aliquot from the reaction mixture, and then to add in $NaHCO_3$. The total volume of the reaction mixture should also be sufficient to allow for the number of samples being drawn. For example, if the reaction mixture uses 50 cm^3 I_2 + 20 cm^3 CH_3COCH_3 + 20 cm^3 H_2SO_4, and 25 cm^3 aliquots are withdrawn from the reaction mixture, then only a maximum of 3 sample aliquots can be obtained.

(c)



[1]

The <u>volume of $Na_2S_2O_3$ used for titrating a sample of quenched aliquot at time t, is proportional to the concentration of I_2 present in the reaction mixture at time t</u>.

Since the <u>gradient of the graph is constant</u> with a negative value, the <u>rate of reaction is constant</u>. Hence, the order of reaction with respect to iodine is zero since the reaction rate is independent of the concentration of iodine. **[1]**

<u>Comments:</u>

- Volume of $Na_2S_2O_3$ used $\propto$ amount of $Na_2S_2O_3$ reacted $\propto$ amount of I_2 in quenched sample
  As volume of sample aliquots are kept constant at 10.0 cm^3,
  amount of I_2 present in conical flask $\propto$ $[I_2]$ present in reaction mixture
  Hence the graph of vol. of $Na_2S_2O_3$ used vs time is similar to the graph of $[I_2]$ vs time.
- The question required students to explain <u>how the graph can be used</u> to deduce the order of reaction w.r.t. iodine. Hence, the observation that the graph has a constant gradient and linking it to a constant reaction rate must be made.

Question 5 (covered on IVY during T2W10)

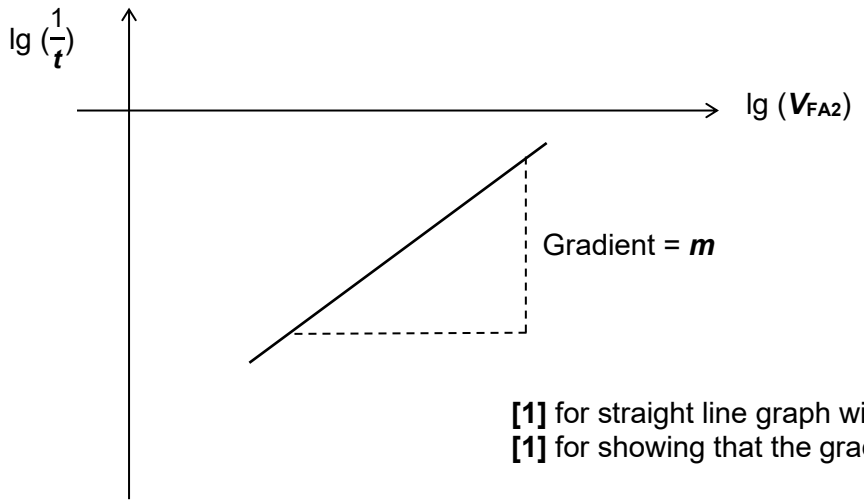
(a) Procedure [5]

1. Using a 50 cm^3 measuring cylinder, add 30.0 cm^3 of **FA 2** into a 100 cm^3 conical flask.
2. Using a 25 cm^3 measuring cylinder, measure 20.0 cm^3 of **FA 1**.
3. Pour **FA 1** rapidly into the conical flask. Start the stopwatch during the addition.
4. Mix the contents thoroughly by swirling the conical flask.
5. Place the conical flask on the printed material.

6. Stop the stopwatch when the words on the printed material become obscured.
7. Record the time taken, ***t***.
8. Discard the reaction mixture, wash the conical flask thoroughly with water. Stand it upside down on a paper towel to drain.
9. Repeat the experiment (steps 1-8) four times, adding 25.0, 20.0, 15.0 and 10.0 cm^3 respectively, of **FA 2** at step 1 into the conical flask.
10. In each experiment, keep total volume of the reaction mixture constant by using another 25 cm^3 measuring cylinder to add 5.0, 10.0, 15.0 and 20.0 cm^3 of deionised water respectively into the conical flask in step 1 (or before adding **FA 1** in step 3).
11. Record all volumes and time taken in a table. Calculate $1/t$, lg $(1/t)$ and lg $(V_{FA\,2})$ for each experiment.

Key points:
- ✓ Materials / Apparatus used and their capacities:
  - Measuring cylinders, 100 cm^3 (or 250 cm^3) conical flask, stopwatch, printed material
- ✓ Suitable volumes of **FA 2**, deionised water and **FA 1**
  - At least 5 volumes of **FA 2**, ranging from 5.00 to 30.00 cm^3
  - Corresponding volumes of deionised water so that the total volume is kept constant
  - Volume of **FA 1** kept constant at 20.0 cm^3
- ✓ Swirling of contents to ensure even mixing
- ✓ Measurement of ***t***
  - starting stopwatch on addition of **FA1** to conical flask
  - stopping stopwatch when words on printed material become obscured
- ✓ Recording of volumes and time taken and calculations of $(1/t)$, lg $(1/t)$ and lg $(V_{FA\,2})$
- ✓ Washing and draining of conical flask

(b)



[1] for straight line graph with positive gradient.
[1] for showing that the gradient is ***m***.

(c) Mass/amount of sulfur required to obscure the words on the printed material. **[1]**

(d) Sources of inaccuracy: **[1 mark each for any two points]**
- Temperature may not be kept constant.
- The perception of opacity and stopping of the stopwatch may not be the same for different experiments, i.e. the amount of sulfur formed in each experiment may not be exactly the same.
- When the conical flask is swirled once, the mixtures may not be mixed as evenly across different experiments.

(e) SO_2 produced is an irritant. **[1]**
Perform the experiment in the fume cupboard or a well-ventilated room. **[1]**

(f)(i) $8S_2O_3^{2-} \rightarrow S_8 + 8SO_3^{2-}$ **[1]**

(f)(ii) H^+ acts as a catalyst in the reaction as it participates in (step 1 of) the reaction and is regenerated in step 9 of the reaction. **[1]**

Question 6 (covered on IVY during T2W10)

(a) $H_2O_2(aq) + 2H^+(aq) + 2I^-(aq) \longrightarrow 2H_2O(l) + I_2(aq)$ **[1]**

(b) A mixture of ethanoic acid and sodium ethanoate forms an acidic buffer that provides a constant acidic pH that is required for the reaction to occur. **[1]**

(c) **Preparation of 3.0 mol dm^{-3} stock solution of H_2O_2 to be used [2]**

(At least one experiment has concentration of H_2O_2 higher than 1.5 mol dm^{-3} and will take significantly <20 s)

Let volume of 7.5 mol dm^{-3} H_2O_2 to be diluted be V cm^3.

$$\frac{V \times 10^{-3} \times 7.5}{250} \times 1000 = 3.0 \Rightarrow V = 100.00 \text{ cm}^3$$

1. Using a burette, add 100.00 cm^3 of 7.5 mol dm^{-3} H_2O_2 to a 250 cm^3 volumetric flask.
2. Top up to the mark with deionised water and stopper the flask and shake well to produce a homogeneous solution. Label this solution **C**. Solution **C** contains 3.0 mol dm^{-3} of H_2O_2.

(Note: During dilution of H_2O_2 or preparation of stock solution, apparatus such as volumetric flask, pipette and/or burette should be used. Use of less precise apparatus such as measuring cylinders, beakers or conical flasks is not acceptable.)

Experiments to determine order of reaction with respect to H_2O_2 [5]

3. Using a 50 cm^3 measuring cylinder/burette, add 25.0 cm^3 of solution **C** into a 250 cm^3 conical flask.
4. Using a 25 cm^3 measuring cylinder/burette, add 25.0 cm^3 of ethanoic acid to solution **C** in the conical flask.
5. Using another 50 cm^3 measuring cylinder, add 50.0 cm^3 of solution **A** to the mixture in the 250 cm^3 conical flask and start the stopwatch.
   (Note: A burette/pipette cannot be used for measurement of solution A as solution A must be added to the mixture 'at one go' and the stopwatch started. Time is required for solution to run down the burette/pipette and is hence not suitable for use here.)
6. Swirl the mixture and place it on a white tile. Stop the stopwatch when the colourless solution in the conical flask turns dark blue. Record the time taken to the nearest second.
7. Repeat steps 3 to 6 with the following volumes of solutions according to the table below. Use another 25 cm^3 measuring cylinder to measure the volume of deionised water required and add it to the conical flask in step 4.

Expt no.	Volume of **A** / cm^3	Volume of CH_3COOH / cm^3	Volume of H_2O_2, **C** / cm^3	Volume of H_2O / cm^3	Total volume / cm^3	t / s	$\frac{1}{t}$ / s^{-1}
1	50.0	25.0	25.0	0.0	100		
2	50.0	25.0	20.0	5.0	100		
3	50.0	25.0	15.0	10.0	100		
4	50.0	25.0	10.0	15.0	100		
5	50.0	25.0	5.0	20.0	100		

Use results to graphically determine order of reaction wrt H_2O_2 [2]

(Since total volume of all experiments is kept constant, volume of H_2O_2 used is directly proportional to $[H_2O_2]$. Also, since the same amount of sodium thiosulfate is used for all experiments, a fixed amount of I_2 must be produced when the colour change is observed. Hence, rate α 1/t.)

Calculate $\frac{1}{t}$ for each experiment. Plot a graph of $\frac{1}{t}$ against volume of **C** used.

- If a horizontal line is obtained, the reaction is zero order with respect to H_2O_2.
- If a straight line through the origin is obtained, the reaction is first order with respect to H_2O_2.

(d) Concentrated hydrogen peroxide is strongly oxidising and corrosive, hence gloves should be worn during the experiment to prevent the direct contact of hydrogen peroxide with the skin. **[1]**