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

1 (a)

Initial burette reading/ cm^3	0.00	0.00
Final burette reading/ cm^3	22.00	21.90
Volume of **FA 1** used/ cm^3	22.00	21.90

[4]

(b) volume of **FA 1** used = ½ (22.00 + 21.90)

- = **<u>21.95 cm^3</u>**

(c) (i) No. of moles of $KMnO_4$ = 21.95/1000 x 0.0300

- = **<u>6.59 x 10^{-4} mol</u>**

(ii) No. of moles of H_2O_2 = 5/2 x 6.59 x 10^{-4}

- = **<u>1.65 x 10^{-3} mol</u>**

Concentration of H_2O_2 in **FA 4** = 1.65 x 10^{-3} / 0.025

- = **<u>0.0659 mol dm^{-3}</u>**

(iii) Concentration of H_2O_2 in **FA 2** = 0.0659 x $\frac{250}{25}$

- = **<u>0.659 mol dm^{-3}</u>**

(iv) Volume of O_2 = 0.659 x ½ x 24 = 7.90

- Volume strength = **<u>7.90</u>**

OR

- Volume strength = 1.02 x ½ x 24 = **<u>12.2</u>**

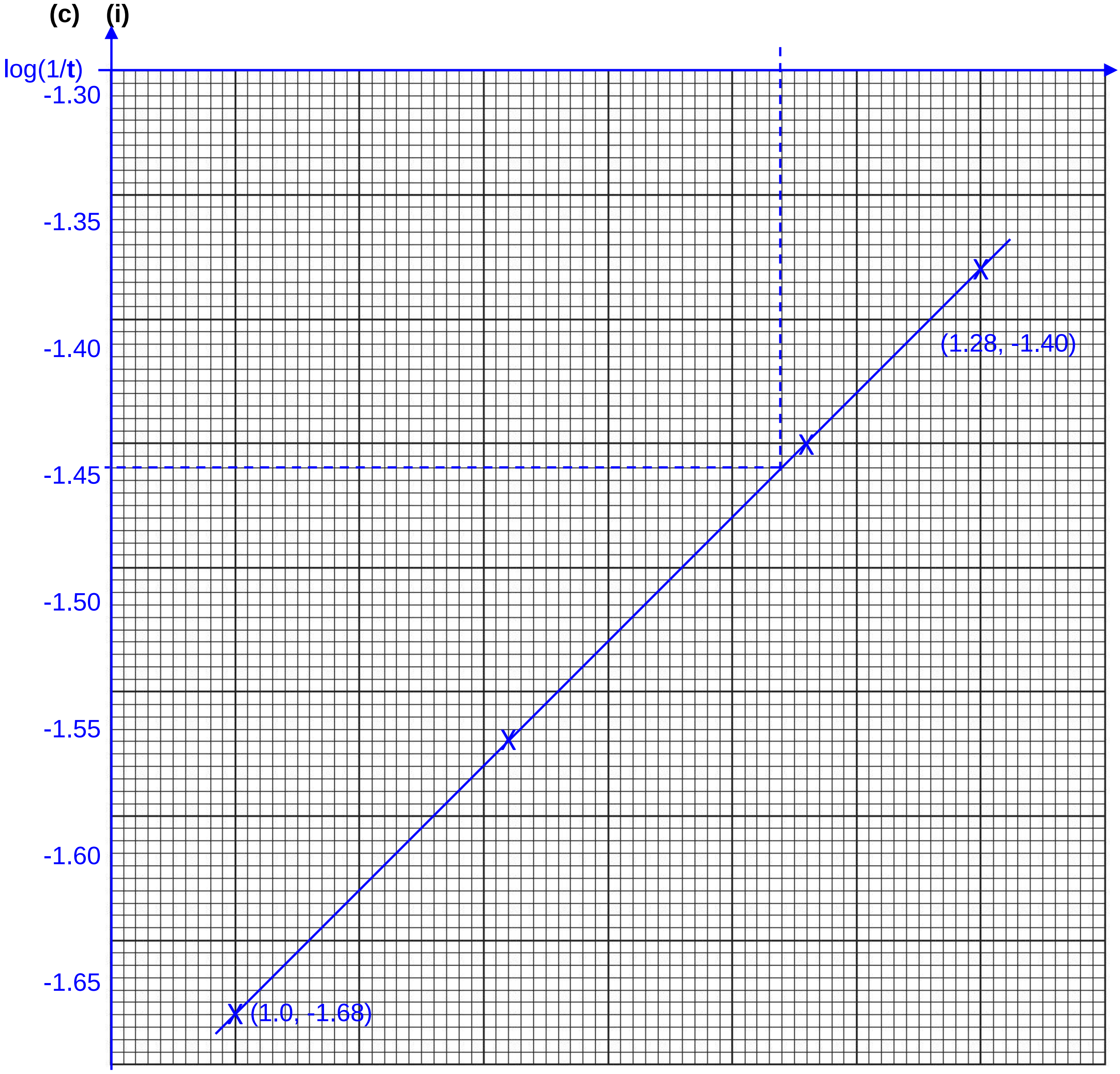
[Total: 10]

2 (b) Table of results

Expt	$V_{FA\ 4}$/ cm^3	Volume of water/ cm^3	**t**/ s	1/t /s^{-1}	log(1/**t**)	log($V_{FA\ 4}$)
1	20.0	0.0	23.8	0.0420	-1.38	1.30
2	10.0	10.0	48.0	0.0208	-1.68	1.00
3	13.0	7.0	37.0	0.0270	-1.57	1.11
4	17.0	3.0	27.9	0.0358	-1.45	1.23

[4]

(c) (i)



[3]

(ii) Gradient = $\frac{-1.40+1.68}{1.28-1.0}$ = 1.00

(iii) log $V_{FA\,4}$ = log 16.50 = 1.22
From graph, log (1/t) = -1.46
t = 28.8 s

[1]

(d) Number of moles of $S_2O_3^{2-}$ used = 0.025 x 10.0/1000 = 2.50 x 10^{-5} mol
Total volume of reacting mixture = 51.0 cm^3
$[S_2O_3^{2-}]_{initial}$ = (2.50 x 10^{-5}) / (51.0 x 10^{-3}) = 4.90 x 10^{-3} mol dm^{-3}
$[S_2O_3^{2-}]_{final}$ = 0
Rate of change of $[S_2O_3^{2-}]$ = (4.90 x 10^{-3} – 0)/ 23.8
= 2.10 x10^{-4} mol dm^{-3} s^{-1}

[3]

(e) **(i)** Higher conc. of thiosulfate means greater reaction time (allow reaction will be slower) and so a smaller percentage error.

[1]

(ii) Reason: change of temperature
Use thermostatically-controlled water bath to maintain constant temperature
Reason: decomposition of hydrogen peroxide
Store H_2O_2(aq) at low temperature, make up fresh H_2O_2(aq), keep H_2O_2(aq) in dark/dim light

[2]

(f)
- Increase number of experiments carried out and hence data points plotted. **OR**
- Have a greater spread of data points, e.g. V_{FA4} less than 10cm^3

[1]

(g) For Experiment 1 and 2, same amount of H_2O_2 will be reacted with as the same fixed amount of $S_2O_3^{2-}$ is added into each reacting mixture.
Since experiment 2 has the lower initial amount or conc of H_2O_2 added, it will have the larger percentage drop/ decrease in concentration of H_2O_2.
Hence, experiment 2 shows a greater difference than experiment 1. [1]

[Total: 18]

3 **(a)**

	Test	*Observation*
(i)	To a 1 cm depth of **FA 7** in a test-tube, add aqueous sodium hydroxide until it is in excess. Warm the tube, gently and carefully. Then, add a 1 cm depth of **FA 2**.	• green ppt, • insoluble in excess, ppt turns brown on standing • on warming, NH_3 gas evolves, turns moist red litmus blue • Brown ppt. Effervescence. Gas evolved relights glowing splint.

(ii)	Place about 2 cm^3 of **FA 7** in a test-tube. Add 3-4 pieces of magnesium ribbon. Leave it on test tube rack for 5 minutes.	• Effervescence • Gas evolved causes lighted splint to 'pop' • Green ppt formed • Brown/black deposit on Mg ribbon OR brown/black ppt

[3]

(b) **(i)** **FA 7**: cations are are **NH_4^+** and **Fe^{2+}**

(ii) **Green ppt is $Fe(OH)_2$ which darkens/ turns brown as it is oxidised to $Fe(OH)_3$.**
OH^- is produced from the reaction between Mg and H_2O.
Mg is more reactive than Fe, so Fe is coated on Mg
$Mg + 2H_2O \rightarrow Mg(OH)_2 + H_2$
$Fe^{2+} + 2OH^- \rightarrow Fe(OH)_2$
$2Fe(OH)_2 + [O] + H_2O \rightarrow 2Fe(OH)_3$
$Fe^{2+} + Mg \rightarrow Fe + Mg^{2+}$

[5]

(c)

	Test	*Observation*
(i)	To a 1 cm depth of **FA 8** in a test-tube, add a 1 cm depth of **FA 5** and leave it on test tube rack for 1-2 minutes, then add **FA 6**.	Solution turns brown/yellow brown or black ppt Solution turns blue
(ii)	Transfer about 5 cm^3 of **FA 8** into a boiling tube. Add **all** the sample of zinc powder provided to the solution. Stir the mixture. Record **all** the observations. When no further changes are seen, filter the reaction mixture into a test tube. This is solution **FA 9**.	Effervescence, gas evolved pops with lighted splint Solution turns yellow → green → **blue** → green → **violet** Violet filtrate (can award mark for the 3rd colour here if violet is not mentioned above)
(iii)	To a 1 cm depth of **FA 9** in a test-tube, add 2 cm of H_2SO_4 followed by **FA 1** dropwise until in excess. Record **all** the observations. When **FA 1** is in excess, the solution will be pink.	Solution turns violet/final colour given in **(a)(ii)** →green →blue→ green →yellow(orange) → pink/purple
(iv)	To a 1 cm depth of **FA 9** in a test-tube, add a 1 cm depth of **FA 8**.	Solution turns blue/green

[4]

(d) **FA 9** undergoes oxidation.
MnO_4^- is an oxidising agent/is reduced/changes from purple to colourless

[1]

[Total:14]

4 **(a)** Add an excess of aqueous Na_2CO_3 to precipitate $MnCO_3$. Filter the mixture to separate the precipitate from the solution using a pre-weighed filter paper.

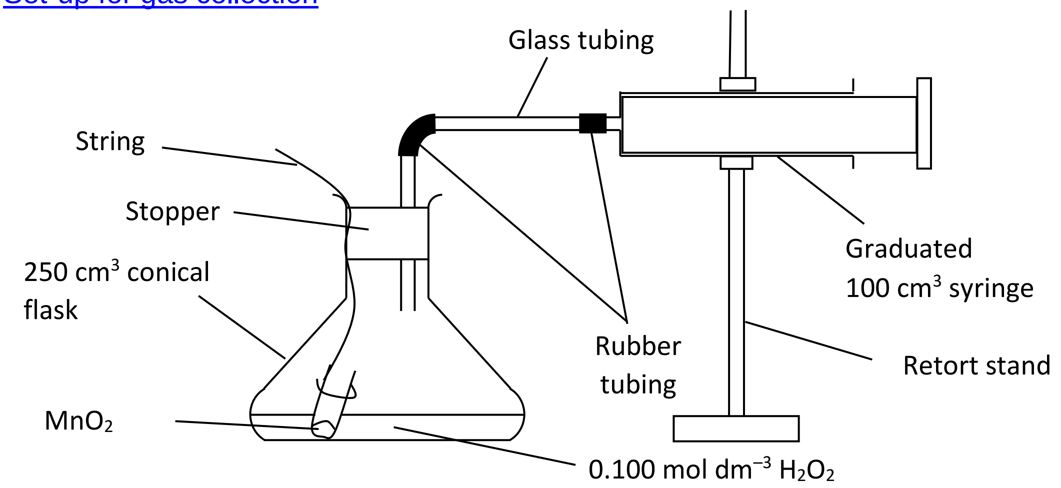
Wash the precipitate to remove any impurities. Dry the precipitate together with the filter paper by heating in an oven to remove the water.

[2]

(b) **(i)** Pre-calculations

Assume O_2 gas collected in a 100 cm^3 gas syringe to be 80 cm^3.
No of moles of O_2 gas in 80 cm^3 = 80 / 24000 = 3.33 x 10^{-3} mol
No of moles of H_2O_2 required = 2(3.33 x 10^{-3}) = 6.67 x 10^{-3} mol
• Vol of H_2O_2 required = 6.67 x 10^{-3} / 0.1 = 66.7 cm^3

Set-up for gas collection

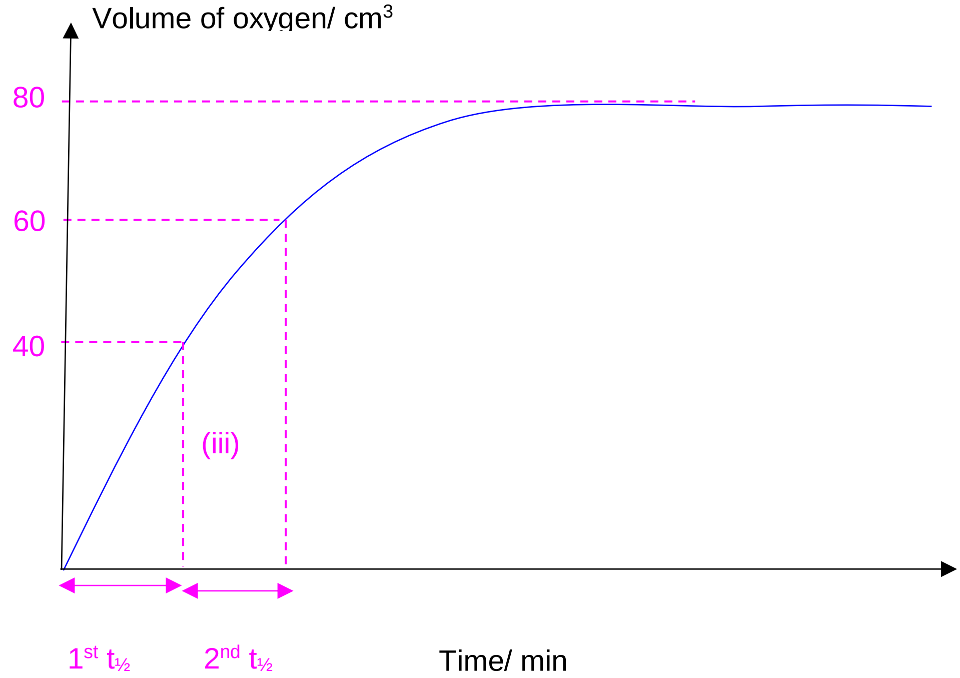


Experimental Procedure

1. Using a 50 cm^3 measuring cylinder, measure approximately 70 cm^3 (or any other vol in excess) of H_2O_2 and transfer it to a conical flask.
2. Assemble the set-up as shown in the diagram.
3. Note the initial volume reading of a 100 cm^3 gas syringe before removing the string to start the reaction. Start stopwatch immediately.
4. Record volume of gas produced at 30-second interval (or any logical time intervals)
5. Record the final volume reading of the gas syringe approx 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).

[6]

(ii)



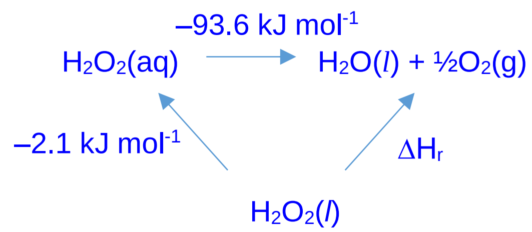
[1]

(iii) Determine two t ½ values from the graph.

• If both t ½ is a constant, order of reaction wrt $[H_2O_2]$ is 1st order.

[2]

(c)



•Energy cycle

By Hess' Law,

• ΔH_r = -2.1 + (-93.6) = <u>-95.7 kJ mol^{-1}</u>

[2]

[Total: 13]