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LAB REPORT ON THE RATE LAW FOR IODINE CLOCK

References. See footnotes and embedded documents section at end of document.

Abstract

The intent of this report is to detail the lab conducted to determine the rate law of a reaction using an iodine clock method.

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1. Introduction and Background

Determining a rate law for a reaction is a key part of Kinetic Chemistry. The most common method to determine rate law is through the running of a series of experiments to time the length of a reaction. Determining when a reaction has started or finished can often be tricky and for this reason an indicator is often used. One common method used is an Iodine clock. [1]

An iodine clock is a basic method to measure the time of reaction. It works by combining two chemicals together with an reactant and indicator, in this example the base chemicals are Potassium Iodide (KI) and Ascorbic Acid ($C_6H_8O_6$) and the reactant is Hydrogen Peroxide (H_2O_2) all mixed with a starch indicator.

When mixed initially the ascorbic acid will react with the Hydrogen Peroxide, once this is consumed the Potassium Iodide will begin to react and turn the mixture Blue and then Black. From the time of initial mixture to the moment there is a colour change is the reaction time (t).

In the world of OME chemical kinetics are vital for predicting sensitivity, performance and stability overtime. These predictions are always supported by performance testing and analysis as predictions can vary. [2]

2. Experiment Purpose

The purpose of the conducted experiment is to define the rate law for the given example by running a series of experiments to determine the Rate Constant K and orders of reaction M and N .

3. Observations and Data

The process for this experiment was provided by the lecturer and is detailed in Annex 1. The raw results for this experiment recorded are available at Annex 2.

The below table details the Summarised results for both sets of experiments

Trial	Reactant	A: KI 0.20 M/ml (ml)	A: Vit C 0.010M/ml (ml)	A: Starch 1% (ml)	B: H2O2 3% Ml	Time t (m:s)	Time t (s)
1A	H2O2	3	1.5	1	1	00:02:33	153
1B	H2O2	3	1.5	1	2	00:01:10	70
1C	H2O2	3	1.5	1	3	00:00:37	37
1D	H2O2	3	1.5	1	4	00:00:32	32
2A	KI	1	1.5	1	3	00:02:47	167
2B	KI	2	1.5	1	3	00:01:40	100
2C	KI	3	1.5	1	3	00:01:11	71
2D	KI	4	1.5	1	3	00:00:55	55

Table 1 - Summarised Results

4. Calculations and Processing [3]

Before the can be used to define the rate law for these reactions some processing is required.

The general rate law equation for this reaction is defined as:

$$\text{Equation 1 : Rate} = k((H_2O_2)^m(I^-)^n)$$

Where:

k = Rate Constant

n = I^- Reaction Order

m = H_2O_2 Reaction Order

t = Time of reaction / Colour change

H_2O_2 = Initial concentration in reaction

I^- = Initial concentration in reaction

As the Rate is proportional to $\frac{1}{t}$ Equation 1 can be expressed as:

$$\text{Equation 2 : } \frac{1}{t} = k^1((H_2O_2)^m(I^-)^n)$$

Where:

k^1 = Proportional Rate Constant for a fixed amount of iodine at set temperatures and pressures.

By taking Log of both sides Equation 2 can be represented as

$$\text{Equation 3 : } \log \frac{1}{t} = \log(k^1) + \log(H_2O_2)^m + \log(I^-)^n$$

As the two experiments only vary one reactant at a time the non-changing reactant becomes a constant and can be assumed a part of the constant k^1 . Therefore Equation 3 can be split in two, one for each experiment. Note k^1 has changed into k^H and k^I respectively for the relevant reactant

$$\text{Equation 4 : } \log \frac{1}{t} = m \log(H_2O_2) + \log(k^H)$$

$$\text{Equation 5 : } \log \frac{1}{t} = n \log(I^-) + \log(k^I)$$

These Equations now represent the $y = mx + c$ format of a straight-line graph. To plot these graphs the data must be transformed. This is detailed in Table 2

		X Axis		Y Axis
Trial	Time t (s)	Log(1/t) (S ⁻¹)	Reactant	Log [Log [KI] [H2O2]]
1A	153	-2.185	H2O2	-1.452
1B	70	-1.845	H2O2	-1.151
1C	37	-1.568	H2O2	-0.975
1D	32	-1.505	H2O2	-0.850
2A	167	-2.223	KI	0.903
2B	100	-2.000	KI	1.204
2C	71	-1.851	KI	1.380
2D	55	-1.740	KI	1.505

Table 2 - Transformed Results

Plotting these results yields the graph in Figure 1. Associated trend lines can be used for each series, and the trend line equations can be mapped to Equation 4 and Equation 5

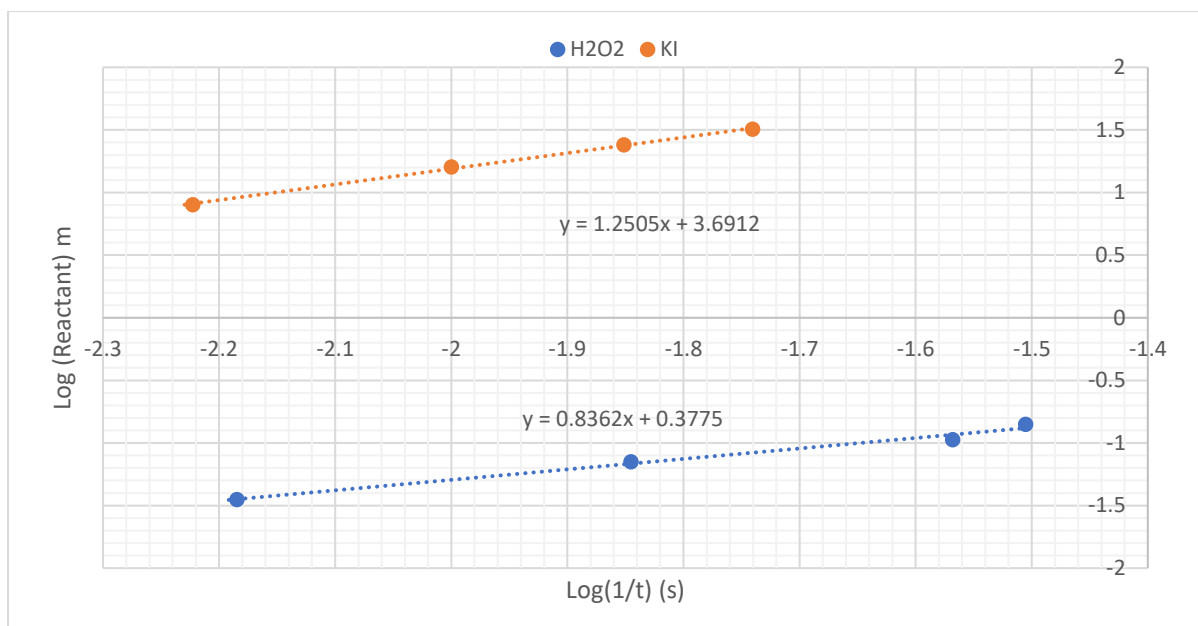


Figure 1 - Results

From these equations the below can be determined.

$$m = 0.836, \log(k^H) = 0.3775 \text{ therefore } k^H = 2.385$$

And

$$n = 1.250, \log(k^I) = 3.691 \text{ therefore } k^I = 4909.079$$

Substituting these back into Equation 2 allowing the calculation of K for each point.

$$\frac{1}{t} = k((H_2O_2)^{0.836}(I^-)^{1.250})$$

Rearrange for k

$$k = \frac{1}{t} \div ((H_2O_2)^{0.836}(I^-)^{1.250})$$

Calculating K for each result

Trial	Time t (s)	1/t (S ⁻¹)	[H ₂ O ₂]	[KI]	k
1A	153	0.007	0.035	24.00	5.697
1B	70	0.014	0.070	24.00	6.976
1C	37	0.027	0.106	24.00	9.403
1D	32	0.031	0.141	24.00	8.548
2A	167	0.006	0.106	8.00	0.528
2B	100	0.010	0.106	16.00	2.096
2C	71	0.014	0.106	24.00	4.900
2D	55	0.018	0.106	32.00	9.063

Table 3 - K Results

The results for k show a general increase at each stage, what would be expected here is a more static value with slight variation. Instead, there seems to be an external factor that is greatly impacting the trial.

5. Results & Conclusions

The full results and calculations can be seen at Annex 3. The final results demonstrate reaction orders for m and n that are in the region of what is expected for this experiment. Unfortunately, the result for k shows large variation indicating an unknown unaccounted variable.

Error in any experiment is a critical factor that must be recorded at each stage and form part of the result. There are many types of error that include but are not limited to; Accuracy, Sampling, Method, Measurement and Personal. To of the main errors that have affected this experiment are Method and Personal errors. [4]

Reflecting on the experiment and perusing the instructions the samples were mistakenly continuously 'swirled' until they changed colour. This was supposed to only last a second or two to ensure even mixture of the reactants. Instead, this continued mixing will have incorporated additional energy to the mixture, shortening the reaction time. This is a form of Method Error. Consequently, the reduced reaction time will increase the measurement error as the proportion of measurement error in timing (Stopping the stop watch) will be greater in a shorter timeframe trial. Though this error was noticed during the initial trials it was kept the same to ensure an even application of error that could be considered across all results.

The second major form of error is personal error of when the person timing notices the change in colour. This error can be standardised by ensuring the same person makes the judgment each time to reduce this error or enable the person to make an easier judgement the sample can be places on a bright white background with good lighting. This would provide the best conditions to observe any change in colour.

The final achieved rate equation for this set of experiments is detailed below but K has been left unknown due to the variability of the results.

$$\text{Equation 6 : Rate} = k((\text{H}_2\text{O}_2)^{0.836}(\text{I}^-)^{1.250})$$

Overall the experiment was not a resounding success and should likely be re done to better reflect the true rate law of this reaction.

6. References

- [1] LibreTexts Chemistry, "1 - The Iodine Clock Reaction," LibreTexts, [Online]. Available: https://chem.libretexts.org/Ancillary_Materials/Laboratory_Experiments/Wet_Lab_Experiments/MIT_Labs/Lab_3%3A_Chemical_Kinetics/1_-_The_Iodine_Clock_Reaction. [Accessed 06 11 2025].
- [2] M. J. C. K. D. S. D. G. T. J. W. R. M. A. R. T. J. D. M. M. C. C. a. T. D. A. Virginia W. Manner, "An Integrated Experimental and Modeling Approach for Assessing High-Temperature Decomposition Kinetics of Explosives," *JACS*, vol. 146, no. 38, pp. 26286 - 26296, 2024.
- [3] E. Kazimerska, "Correct Calculations of M, N and K," 10 2025. [Online]. [Accessed 06 11 2025].
- [4] D. Harvey, "Characterizing Experimental Errors," Libre Textx, [Online]. Available: https://chem.libretexts.org/Courses/Providence_College/CHM_331_Advanced_Analytical_Chemistry_1/03%3A_Evaluating_Analytical_Data/3.02%3A_Characterizing_Experimental_Errors. [Accessed 06 11 2025].
- [5] E. Kazimerska, "Exp 2 Rate of reaction lab report Adv Chem 2526," UWTSD, Swansea, 2025.

7. Annex 1 – Procedure [5]**PROCEDURE**

Put on the lab coat, safety goggles, and gloves. Make sure that long hair is tied.

IMPORTANT: Record all your observation sin the data sheets at the end o f this script.

Lab tools and supplies:

- 50 mL conical flasks x4
- Glass pipettes x2 (*pipette 1 used for KI and ascorbic acid; pipette 2 – H₂O₂*) and pipette filler
- Graduated cylinder or small beaker and test tube
- Stopwatch
- Glass stirring rod

Chemicals:

Solution A (in conical flask):

- 0.20 M KI solution
- 0.010 – 0.025 M ascorbic acid (Vitamin C) solution
- 1 % starch indicator
- Distilled water

Solution B (in test tube):

- 3% H₂O₂ solution

Procedure:**I. Order of the reaction in [H₂O₂]**

1. In four conical flasks prepare solution A according to the table. Use one glass pipette to measure the required volumes of KI and Vit C solutions. Add ~1 mL of starch solution.
2. With the second glass pipette measure the required volume of H₂O₂ (solution B) and transfer it in the test tube.
3. Pour quickly solution B from the test tube to solution A in the conical flask, stir and start the timer as soon as the solutions are mixed.
4. Record the time until the first permanent blue colour appears.

Trial	A: KI 0.20 M (mL)	A: Vit C 0.010 M (mL)	A: Starch 1% (mL)	A: Water (mL)	B: H ₂ O ₂ 3% (mL)
I.1	3.0	1.5	1.0	18.5	1.0
I.2	3.0	1.5	1.0	17.5	2.0
I.3	3.0	1.5	1.0	16.5	3.0
I.4	3.0	1.5	1.0	15.5	4.0

Figure 2 - Procedure Page 1 [5]

II. Order of the reaction in [I⁻]

5. In four conical flasks prepare solution A according to the table. Use one glass pipette to measure the required volumes of KI and Vit C solutions. Add ~1 mL of starch solution.
6. With the second glass pipette measure the required volume of H₂O₂ (solution B) and transfer it in the test tube.
7. Pour quickly solution B from the test tube to solution A in conical flask, stir and start the timer as soon as the solutions are mixed.
8. Record the time until the first permanent blue colour appears.

Trial	A: KI 0.20 M (mL)	A: Vit C 0.010 M (mL)	A: Starch 1% (mL)	A: Water (mL)	B: H ₂ O ₂ 3% (mL)
II.1	1.0	1.5	1.0	18.5	3.0
II.2	2.0	1.5	1.0	17.5	3.0
II.3	3.0	1.5	1.0	16.5	3.0
II.4	4.0	1.5	1.0	15.5	3.0

Figure 3 - Procedure Page 2 [5]

8. Annex 2 – Raw Results

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PROCEDURE

Put on the lab coat, safety goggles, and gloves. Make sure that long hair is tied.

IMPORTANT: Record all your observation sin the data sheets at the end o f this script.

Lab tools and supplies:

- 50 mL conical flasks x4
- Glass pipettes x2 (pipette 1 used for KI and ascorbic acid; pipette 2 – H_2O_2) and pipette filler
- Graduated cylinder or small beaker and test tube
- Stopwatch
- Glass stirring rod

Chemicals:

Solution A (in conical flask):

potassium Iodide

- 0.20 M KI solution
- 0.010 – 0.025 M ascorbic acid (Vitamin C) solution
- 1 % starch indicator
- Distilled water

Solution B (in test tube):

- 3% H_2O_2 solution

Procedure:

I. Order of the reaction in $[\text{H}_2\text{O}_2]$

1. In four conical flasks prepare solution A according to the table. Use one glass pipette to measure the required volumes of KI and Vit C solutions. Add ~1 mL of starch solution.
2. With the second glass pipette measure the required volume of H_2O_2 (solution B) and transfer it in the test tube.
3. Pour quickly solution B from the test tube to solution A in the conical flask, stir and start the timer as soon as the solutions are mixed.
4. Record the time until the first permanent blue colour appears.

Trial	A: KI 0.20 M (mL)	A: Vit C 0.010 M (mL)	A: Starch 1% (mL)	A: Water (mL)	B: H_2O_2 3% (mL)	
I.1 <i>A</i>	3.0	1.5	1.0	18.5	1.0	<i>Restart time 2:33 1:10 0:37 0:32</i>
I.2 <i>B</i>	3.0	1.5	1.0	17.5	2.0	
I.3 <i>C</i>	3.0	1.5	1.0	16.5	3.0	
I.4 <i>D</i>	3.0	1.5	1.0	15.5	4.0	

Figure 4 - Raw Results P1

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II. Order of the reaction in $[I^-]$

5. In four conical flasks prepare solution A according to the table. Use one glass pipette to measure the required volumes of KI and Vit C solutions. Add ~1 mL of starch solution.
6. With the second glass pipette measure the required volume of H_2O_2 (solution B) and transfer it in the test tube.
7. Pour quickly solution B from the test tube to solution A in conical flask, stir and start the timer as soon as the solutions are mixed.
8. Record the time until the first permanent blue colour appears.

✓ Restart ✓ ✓

Trial	A: KI 0.20 M (mL)	A: Vit C 0.010 M (mL)	A: Starch 1% (mL)	A: Water (mL)	B: H_2O_2 3% (mL)
2 II.1 A	1.0	1.5	1.0	18.5	3.0
II.2 B	2.0	1.5	1.0	17.5	3.0
II.3 C	3.0	1.5	1.0	16.5	3.0
II.4 D	4.0	1.5	1.0	15.5	3.0

table

Time

2.47

1:40

1:11

0:55

$$M(nL) = \text{moles per mL}$$

convert to moles per L

Figure 5 - Raw Results P2

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DATA SHEET to RECORD OBSERVATIONS, CALCULATIONS and RESULTS

STUDENT'S NAME: Charles Hadley 2207149

PARTNERS' NAMES: _____

REPORT IS DUE OCTOBER 31ST 2025 (DD. OCTOBER 7TH) @3.00pm submitted via Moodle

Record the times before blue colour of I₂-starch complex appear.

Calculate [H₂O₂]₀ (Part 1), [I⁻]₀ (Part 2), log[Reactant]₀ and 1/t.

Trial	[Reactant] ₀ (M)	Clock Time t (s)	1/t (s ⁻¹)	log[Reactant]	log(1/t)
1 A		2:33			
1 B		1:10			
1 C		0:37			
1 D		0:32			
2 A		2:47			
2 B		1:40			
2 C		1:11			
2 D		0:55			

Plot $\log(1/t)$ vs $\log[\text{H}_2\text{O}_2]_0$ (and $\log[\text{I}^-]_0$) to determine reaction order from the slope of these lines.

The intercept gives $\log k$.

The reciprocal of the time lag is proportional to the rate, so the y-axis is a measure of the reaction rate.

You can do it in Excel or on graph paper.

Derive the rate law.

If relevant to this experiment, calculate half-life, $t_{1/2}$.

What experiment would you advise to determine activation energy, E_a , and collision factor, A ?

Figure 6 - Raw Results P3

9. Annex 3 – Full Data and Calculations

																	Initial Concentration		Initial [KI] Concentration			
	Time t (ms)	Time t (s)	A: KI 0.20		A: Vit C 0.010M/ml		A: Starch 1%		B:H2O2 Concentration		B:H2O2 3%					Water (ml)	Total Volume	[H2O2] (M/L)	Log [H2O2]	Concentration (M/L)	Log[KI]	k
Trial			M/ml	KI (M)	(ml)	A: Vit C (M)	(ml)	B: H2O2 3% M	on M/L	L2	H2O2 Moles	1/t (S^-1)	Log(1/t)	Reactant								
1A	00:02:33	153	3	0.6	1.5	0.015	1	1	0.001	0.880	0.00088	0.007	-2.185	H2O2	18.5	0.025	0.035	-1.453	24.00	1.380	5.697	
1B	00:01:10	70	3	0.6	1.5	0.015	1	2	0.002	0.880	0.00176	0.014	-1.845	H2O2	17.5	0.025	0.070	-1.152	24.00	1.380	6.976	
1C	00:00:37	37	3	0.6	1.5	0.015	1	3	0.003	0.880	0.00264	0.027	-1.568	H2O2	16.5	0.025	0.106	-0.976	24.00	1.380	9.403	
1D	00:00:32	32	3	0.6	1.5	0.015	1	4	0.004	0.880	0.00352	0.031	-1.505	H2O2	15.5	0.025	0.141	-0.851	24.00	1.380	8.548	
2A	00:02:47	167	1	0.2	1.5	0.015	1	3	0.003	0.880	0.00264	0.006	-2.223	KI	18.5	0.025	0.106	-0.976	8.00	0.903	0.528	
2B	00:01:40	100	2	0.4	1.5	0.015	1	3	0.003	0.880	0.00264	0.010	-2.000	KI	17.5	0.025	0.106	-0.976	16.00	1.204	2.096	
2C	00:01:11	71	3	0.6	1.5	0.015	1	3	0.003	0.880	0.00264	0.014	-1.851	KI	16.5	0.025	0.106	-0.976	24.00	1.380	4.900	
2D	00:00:55	55	4	0.8	1.5	0.015	1	3	0.003	0.880	0.00264	0.018	-1.740	KI	15.5	0.025	0.106	-0.976	32.00	1.505	9.063	

Figure 7 - Full Calculations

Trial	Time t (m:s)	Time t (s)	A: KI 0.20		A: Vit C 0.010M/ml		A: Starch 1%		B: H ₂ O ₂ Concentration		B: H ₂ O ₂ 3%		1/t (S ⁻¹)	Log(1/t)	Reactant	Water (ml)	Total Volum	Initial Concentra tion [H ₂ O ₂]		Initial [KI] Concentrati		k
			M/ml	KI (M)	(ml)	A: Vit C (M)	(ml)	B: H ₂ O ₂ 3% M	L2	H ₂ O ₂ Moles		(M/L)						Log [H ₂ O ₂]	on (M/L)	Log[KI]		
1A	0.00176692	153	3	0.6	1.5	0.015	1	1	0.001	0.880	0.00088	0.007	-2.185	H ₂ O ₂	18.5	0.025	0.035	-1.453	24.00	1.380	5.697	
1B	0.00083333	70	3	0.6	1.5	0.015	1	2	0.002	0.880	0.00176	0.014	-1.845	H ₂ O ₂	17.5	0.025	0.070	-1.152	24.00	1.380	6.976	
1C	0.00041667	37	3	0.6	1.5	0.015	1	3	0.003	0.880	0.00264	0.027	-1.568	H ₂ O ₂	16.5	0.025	0.106	-0.976	24.00	1.380	9.403	
1D	0.00038462	32	3	0.6	1.5	0.015	1	4	0.004	0.880	0.00352	0.031	-1.505	H ₂ O ₂	15.5	0.025	0.141	-0.851	24.00	1.380	8.548	
2A	0.00192308	167	1	0.2	1.5	0.015	1	3	0.003	0.880	0.00264	0.006	-2.223	KI	18.5	0.025	0.106	-0.976	8.00	0.903	0.528	
2B	0.00142857	100	2	0.4	1.5	0.015	1	3	0.003	0.880	0.00264	0.010	-2.000	KI	17.5	0.025	0.106	-0.976	16.00	1.204	2.096	
2C	0.00144761	71	3	0.6	1.5	0.015	1	3	0.003	0.880	0.00264	0.014	-1.851	KI	16.5	0.025	0.106	-0.976	24.00	1.380	4.900	
2D	0.00090909	55	4	0.8	1.5	0.015	1	3	0.003	0.880	0.00264	0.018	-1.740	KI	15.5	0.025	0.106	-0.976	32.00	1.505	9.063	

Figure 8 - Full Calculations Formula