

Kinetics Lab

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1 Background

Chemical kinetics is the study of the rates of chemical reactions. This involves examining how different experimental conditions such as temperature, pressure, or solvent affect the rate of reaction. Central to chemical kinetics is the idea of collision theory, which is that molecules must physically collide with each other for reactions to occur. As a result, we can increase reaction speed by increasing the frequency at which these molecules collide. This can be done in a number of ways, such as increasing the speed of molecules, increasing the concentration of molecules or providing a catalyst to increase the probability that the molecules will collide in a way that a reaction would occur. Enzyme catalysts such as DNA polymerase, DNA helicase or sucrose play a vital role in our body.

Mathematics also plays a role in determining rates of reaction. We can use rate laws, mathematical expressions that allow us to calculate rate of reactions using the concentration of the reactants. The most common types of rate laws are zero-order reactions, first-order reactions, and second-order reactions. In each of these rate laws, the rate of reaction depend on different attributes of the chemical reactions. In a zero-order reaction, the rate of reaction is not affected by the concentration of the reactants. In a first-order reaction, the rate of reaction is affected only by the concentration of one reactant and in a second-order reaction, the rate is affected by the concentration of two reactants or the square of one reactant.

2 Purpose

The purpose of this lab is to determine the reaction rate of several mixtures of reactants and compare them in order to understand the significance of chemical kinetics.

3 Materials

Spectrophotometer
Beral pipets
Graduated cylinder
Cuvets
Parafilm
Timer

18 mL Potassium Iodide (KI)
18 mL Iron Nitrate (FeNO_3)
12 mL Distilled water

4 Procedure

1. Prepare three mixtures of each group inside cuvetts, according to the recipes below. Mix the KI and the H_2O together. Do not add the FeNO_3 yet.
Group 1: 2 mL KI, 1 mL H_2O , 1 mL FeNO_3
Group 2: 1 mL KI, 1 mL H_2O , 2 mL FeNO_3
Group 3: 1 mL KI, 2 mL H_2O , 1 mL FeNO_3
Group 4: 2 mL KI, 0 mL H_2O , 2 mL FeNO_3
2. Prepare the spectrophotometer by inserting a cuvet filled with water only.
3. Add the FeNO_3 , cover the cuvet with parafilm and flip it twice to mix the contents. Begin the timer immediately.
4. Insert the cuvet into the spectrophotometer at 450 nm and record the %T every 15 seconds for 2 minutes.
5. Repeat 2-4 for the rest of the mixtures.

5 Data

Mixture 1

Time (s)	Absorbance	Average %T	%T1	%T2	%T3
15	0.247	56.6	58.7	58.2	53.1
30	0.382	41.5	43.2	44.2	37.2
45	0.484	32.8	34.1	35.5	28.8
60	0.566	27.1	28.3	29.8	23.3
75	0.639	23.0	23.9	25.7	19.3
90	0.703	19.8	20.6	22.5	16.4
105	0.758	17.5	18.2	20.1	14.1
120	0.808	15.6	18.2	18.1	12.4

Mixture 2

Time (s)	Absorbance	Average %T	%T1	%T2	%T3
15	0.117	76.3	92.8	72.5	63.6
30	0.177	66.5	80.9	65.4	53.4
45	0.228	59.2	70.8	60.2	46.6
60	0.276	52.9	61.9	55.8	41.2
75	0.317	48.2	55.5	52.1	37.0
90	0.354	44.2	50.2	48.9	33.6
105	0.387	41.0	46.3	46.0	30.7
120	0.417	38.2	42.8	43.6	28.4

Mixture 3

Time (s)	Absorbance	Average %T	%T1	%T2	%T3
15	0.103	78.9	79.3	78.8	78.8
30	0.147	71.2	72.6	70.6	70.6
45	0.186	65.1	67.0	64.2	64.3
60	0.219	60.3	62.0	59.6	59.5
75	0.248	56.5	58.4	55.8	55.4
90	0.274	53.1	55.4	52.2	51.9
105	0.299	50.2	52.6	49.2	48.8
120	0.322	47.6	50.1	46.5	46.2

Mixture 4

Time (s)	Absorbance	Average %T	%T1	%T2	%T3
15	0.437	36.5	38.0	33.0	38.6
30	0.645	22.6	26.0	21.3	20.6
45	0.868	13.6	13.3	14.3	13.1
60	1.0	9.7	9.6	10.3	9.3
75	1.1	7.4	7.3	7.9	7.1
90	1.2	5.9	5.8	6.3	5.6
105	1.3	4.8	4.7	5.1	4.5
120	1.4	4.0	3.9	4.3	3.7

6 Analysis

Group	Proportion of KI	Proportion of FeNO ₃	Initial Rate $\frac{(A_{30} - A_{15})}{(30 - 15)}$
1	2 mL	1 mL	0.00900
2	1 mL	2 mL	0.00395
3	1 mL	1 mL	0.00297
4	2 mL	2 mL	0.0138

The order of reaction with respect to each reactant can be determined by comparing the proportion that the initial rate of reaction changes against the proportion of each reactant. We can use the method of initial rates to calculate the order of reaction for KI and FeNO₃.

KI reaction order

Here we compare the ratios of the initial rates of Group 3 and Group 1 to determine the order of reaction of KI.

$$\frac{\text{Initial Rate}_1}{\text{Initial Rate}_3} = \frac{.00900}{.00297} = 3.03 = 2^m = \frac{k[\text{KI}]_1^m [\text{FeNO}_3]_1^n}{k[\text{KI}]_3^m [\text{FeNO}_3]_3^n}$$

$$m = 1.60$$

Therefore the reaction is approximately one and a half order with regards to KI.

FeNO₃ reaction order

We can compare the ratios of the initial rates of Group 3 and Group 2 to determine the order of reaction of FeNO₃.

$$\frac{\text{Initial Rate}_2}{\text{Initial Rate}_3} = \frac{.00395}{.00297} = 1.33 = 2^n = \frac{k[\text{KI}]_2^m [\text{FeNO}_3]_2^n}{k[\text{KI}]_3^m [\text{FeNO}_3]_3^n}$$

$$n = 0.411$$

Therefore the reaction is approximately a half order with regards to FeNO₃.

7 Conclusion