IODINE CLOCK

A Study of Reaction Rates.

In this lab you will be studying the Law of Mass Action. Please review that law in your text in the chapter on Chemical Kinetics. Basically, the law states that the rate of a chemical reaction is proportional to the concentration of the reactants raised to a power that corresponds to the coefficient in a balanced chemical reaction.

ORDER OF REACTION:

First Order: **A reaction is said to be First Order with respect to a particular reactant if the rate of the reaction is directly proportional to the concentration of that reactant (raised to the First Power).**

$$\text{Rate} \propto [\text{Reactant}]^1$$
$$\text{Rate} = k[\text{Reactant}]^1$$

Second Order **A reaction is said to be Second Order with respect to a particular reactant if the rate of the reaction is directly proportional to the concentration of that reactant squared (raised to the Second Power).**

$$\text{Rate} \propto [\text{Reactant}]^2$$
$$\text{Rate} = k[\text{Reactant}]^2$$

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INTRODUCTION

The reaction that we will be studying is an ionic reaction. We will be working with the persulfate ion ($S_2O_8^{-2}$) and the Iodide ion (I^-). The solution that will provide the persulfate ion will be an aqueous solution of Ammonium Persulfate ($(NH_4)_2S_2O_8$). The Iodide ion will be produced by an aqueous solution of Potassium Iodide (KI).

The primary reaction we are running and studying is:

$$S_2O_8^{-2} + 2\ I^- \rightarrow 2\ SO_4^{-2} + I_2$$

The rate of this reaction reaction is <u>First Order</u> with respect to the concentration of persulfate ion ($S_2O_8^{-2}$). That is:

$$\text{Rate} \propto [\ S_2O_8^{-2}\ ]$$

The rate is <u>Second Order</u> with respect to the concentration of Iodide ion (I^-). That is:

$$\text{Rate} \propto [\ I^-]^2$$

The rate statement for the reaction as a whole is:

$$\text{Rate} = k\ [\ S_2O_8^{-2}\ ] \cdot [\ I^-]^2$$

The purpose of the Sodium Thiosulfate ($Na_2S_2O_3$) solution is the same as the distance (perhaps 250 meters) in the story we discussed earlier. No Iodine (I_2) can exist in the presence of the Thiosulfate ion ($S_2O_3^{-2}$). The Thiosulfate will react with any available Iodine to produce Iodide ions according to the reaction:

$$I_2 + 2\ S_2O_3^{-2} \rightarrow 2\ I^- + S_4O_6^{-2}$$

This reaction will "eat up" the Iodine produced before it can react with the starch. Only after all of the Thiosulfate ion ($S_2O_3^{-2}$) is used up will free Iodine (I_2) be available to react.

The starch solution serves as the checkered flag. It tells you when the "race" is over. The starch reacts with any free Iodine (I_2) to produce a blue complex. The entire mixture will turn blue. When that happens you will stop the timing. The reaction is:

$$I_2 + \text{Starch} \rightarrow \text{Starch - Iodine Complex (Deep Blue)}$$

NOTE: **If you forget to put in the starch solution, the reaction mixture will slowly turn brown. If that happens you have just "blown" the run, and it must be done over.**

PROCEDURE

Obtain approximately 50 ml each of the solutions in labled beakers.

Set up four burets. Label each buret for the following chemicals

- **Ammonium Persulfate $(NH_4)_2S_2O_8$ 0.1 M**
- **Sodium Thiosulfate $Na_2S_2O_3$ 0.02 M**
- **Distilled Water H_2O**
- **Potassium Iodide KI 0.3 M**

Rinse the Burets several times with water.

Rinse the Burets twice with the appropriate chemical (2 - 3 ml). Discard the rinsings.

Add the appropriate amounts (Critical) of the first three chemicals to the reaction vessel (50 ml beaker). SEE table below for the amounts of each chemical. IN MILLILITERS!!

Add 4 or 5 drops of the starch solution (Not critical).

Measure the appropriate amount of Potassium Iodide (KI) into a SEPARATE container (Test Tube or Beaker).

SUDDENLY mix the Potassium Iodide (KI) into the reaction vessel. START the clock. AND stir the mixture constantly.

STOP the clock as soon as the mix turns BLUE.

Record the time on your data sheet.

Repeat the procedure for the next mixture.

MIXTURE AMOUNTS IN MILLILITERS					
	$(NH_4)_2S_2O_8$	$Na_2S_2O_3$	H_2O	KI	TOTAL VOLUME
1	12.0	1.0	0.0	12.0	25.0
2	9.0	1.0	3.0	12.0	25.0
3	6.0	1.0	6.0	12.0	25.0
4	3.0	1.0	9.0	12.0	25.0
5	12.0	1.0	3.0	9.0	25.0
6	12.0	1.0	6.0	6.0	25.0

7	12.0	1.0	9.0	3.0	25.0

DATA TABLES AND CALCULATIONS

$(NH_4)_2S_2O_8$		
RUN	ml	TIME (min:sec)
1.	12.0	
2.	9.0	
3.	6.0	
4.	3.0	

KI		
RUN	ml	TIME (min:sec)
1.	12.0	
5.	9.0	
6.	6.0	
7.	3.0	

For the following tables:

- **Convert time to Minutes only. (Divide the number of seconds by 60 to convert the seconds to decimal equivalent of a minute. Add that decimal to the number of minutes. Record the time in MINUTES on the table below.**

- **Find the concentration of $S_2O_8^{-2}$ ions in the reaction mix.**

(ml used) x (0.1 Molar) = (Total Volume of Reaction) x (Unknown Concentration)

Record the Concentrations on the table below.

- **Find the concentration of I^- ions in the reaction mix.**

(ml used) x (0.3 Molar) = (Total Volume of Reaction) x (Unknown Concentration)

Record the Concentrations on the table below.

- **To find the RATE of the reaction take the reciprocal of the time in MINUTES. (1.0 ÷ TIME IN MINUTES)**

Run	[$S_2O_8^{-2}$]	TIME (min)	RATE
1.			
2.			
3.			
4.			
	x axis		y axis

Run	[I^-]	TIME (min)	RATE
1.			
5.			
6.			
7.			
	x axis		y axis

Two graphs must be prepared for this lab.

1. **Rate of the reaction vs. Concentration of $S_2O_8^{-2}$.**

2. Rate of the reaction vs. Concentration of I^-.