Kinetic Study of Thiosulfate in Acid

Theory: The acidification of thiosulfate solutions leads to the formation of colloidal sulfur. The rate of this reaction is studied by measuring the time required for the reaction mixture to become so turbid that is ceases to transmit light. The reaction is acid catalyzed and proceeds according to the following reaction:

$$S_2O_3^{2-} \rightarrow SO_3^{2-} + S$$

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Background

- A description of the sequence of steps by which a chemical reaction takes place is called a reaction mechanism. Many studies go into trying to determine possible mechanisms. The rates at which reactions take place provide important insights.
- The rate law for a chemical reaction is a quantitative expression involving constants related to the nature of the chemical reaction and the concentrations of reactants. In order for reactants to react, they must come in contact with one another (or at least come nearby). The probability of a collision is related to a function of the concentration. So, for the general rate law:

  rate = $k [A]^a[B]^b[C]^c$
- [A], [B], and [C] represent concentrations of reactants and or catalysts, and a, b, and c represent exponents that may or may not be related to the coefficients of the corresponding balanced chemical equation.
- The quantities in brackets are read as moles/liter and are raised to an appropriate power. Multiplied together with the constant (k), they give the rate of the reaction.

The numerical values of a, b, and c must be determined by experimentation. These numbers determine the order of the reaction. Added together they give the over-all order of the reaction. It is the purpose of this experiment to determine the order of $S_2O_3^{2-}$, a reactant.

Materials

two well strips
0.15 M $Na_2S_2O_3$
1.0 M HCl
distilled water
cotton swabs or pipe cleaners
watch/stop watch
pipets

Prelab:

1. What is a colloid? When do they form?
2. What does catalyzed production mean?
3. What is capillary action of liquids?
4. What is thiosulfate used for in everyday life?

Procedure

Practice mixing technique with water:
Select 2 well strips/plates. Place 3 drops of water in each of the wells in both strips. When one strip is inverted and stacked on the second strip, capillary action keeps the liquid in the upper wells. To mix the

chemicals, hold the stacked strips in an elevated position and quickly accelerate them in a downward direction. The water in the top strip should be in the bottom. When you are confident of the mixing technique (called "the shakedown technique"), completely empty the strips to use in the experiment.
Begin the experiment:
Prepare two well strips/plates according to the table below. Make sure that the pipet is held in a vertical position above each well. Let gravity pull each drop from the end of the pipet. **If using a well plate, place the A chemicals in the <u>top</u> row of plate 1 and the B chemicals in the <u>bottom</u> row of plate 2.**

	Strip A	Strip B	
	drops 0.15 M	drops 1 M	drops
	$Na_2S_2O_3$	HCl	water
Well 1	10	2	0
Well 2	9	2	1
Well 3	8	2	2
Well 4	7	2	3
Well 5	6	2	4
Well 6	5	2	5
Well 7	4	2	6
Well 8	3	2	7
Well 9	2	2	8
Well 10	1	2	9
Well 11	0	2	10
Well 12	0	2	10

When one strip is inverted and stacked on the second strip, capillary action keeps the liquid in the upper wells. Work with a partner. One partner mixes the chemicals with the shakedown technique. Your partner needs to begin timing now! Place the bottom strip over a line of text on this page. The other partner observes, notes, and records times. Mix the chemicals and note the time to the nearest second.
Note the time at which the words disappear (i.e., are no longer visible) through the top of the well.
Record the time for all wells.

Clean the strip **<u>immediately</u>** after the last well changes or the experiment is ended. Scrub the wells with a cotton swab or pipe cleaner.

Data: Observations:

Repeat three times and average the results:

	Trial 1	Trial 2	Trial 3	Average
	time(s)	time (s)	time (s)	time (s)
Well 1				
Well 2				
Well 3				
Well 4				
Well 5				
Well 6				
Well 7				
Well 8				
Well 9				
Well 10				

Well 11				
Well 12				

Discussion/Calculations

1. Prepare two graphs of your results. On one graph plot time on the y-axis and drops of thiosulfate on the x-axis. On the second graph plot the reciprocal of the time (1/time) on the y-axis and drops of thiosulfate on the x-axis. **Use graph paper!**

2. What is the order of this reaction with respect to the thiosulfate concentration: HINT: If the second graph has a slope of zero the reaction is zero order with respect to thiosulfate. If the second graph is a straight line with a non-zero slope the reaction is first order with respect to thiosulfate. If the second graph is parabolic the reaction is second order with respect to thiosulfate.

3. Write the rate law for this reaction.

Resources:

Error Analysis:

Conclusion: