Chemical Kinetics

Clock Reaction Teaching Notes

GENERAL COMMENTS

There are several variations on the clock reaction, using different sets of reactants. The general results, however, will be the same – increasing the concentration of the reactants will increase reaction rate, and increasing temperature increases reaction rate.

The objectives of this lab are similar to the objective of the Rates of Reaction Lab. The clock reaction, however, allows the student to collect quantitative data on reaction rates, which may then be graphed.

The uncertainty can be very high in this experiment unless the students are careful in recording reaction times. Class averages should be used to make the results more meaningful.

If the reactions occur too rapidly, the solutions can be further diluted.

PURPOSE

- To measure the rate of a reaction
- To measure the effect of changing reactant concentration on reaction rate
- To measure the effect of changing temperature on reaction rate

SAFETY & CLEAN UP

- Avoid getting either solution on your skin or clothes. Wash any splashes with cold water.
- Wear safety goggles
- All solutions remaining after the reaction may be safely rinsed down the sink with plenty of water.

PREPARATION OF SOLUTIONS

These solutions should be prepared fresh, a day or so before the experiment.

potassium iodate, KIO_3

sodium bisulfite (sodium hydrogren sulfite), $NaHSO_3$

distilled water

soluble starch

1.0M sulfuric acid, H_2SO_4

Solution A

Dissolve 4.3 g KIO_3 per litre of solution

Solution B

2.0 g $NaHSO_3$
5 mL 1.0M H_2SO_4
4 g soluble starch

Begin by first creating a starch paste by dissolving 4 g soluble starch in approx 200 mL boiling distilled water. Allow this to cool, then add 2.0 g $NaHSO_3$ and 5 mL 1.0 M H_2SO_4 . Dilute to a total solution volume of 1.0 L.

To prepare 1.0 M H_2SO_4 solution:

add 55.6 mL concentration (18.0 M H_2SO_4) to water, diluting to 1.0 L

DISCUSSION

The reaction takes place in two stagess.

Stage 1:

$IO_3^-{}_{(aq)} + 3HSO_3^-{}_{(aq)} \rightarrow I^-{}_{(aq)} + 3SO_4^{2-}{}_{(aq)} + 3H^+{}_{(aq)}$

Stage 1 is the rate-determining step of the reaction mechanism. Decreasing the concentration of the IO_3^- ions by dilution will cause a decrease in the rate of the overall reaction (Part A).

Stage 2:

$5I^-{}_{(aq)} + 6H^+{}_{(aq)} + IO_3^-{}_{(aq)} \rightarrow 3I_{2(aq)} + 3\ H_2O_{(l)}$

Stage 2 is a very fast reaction. The molecular iodine, I_2, produced in Step 2 reacts with the starch (not shown in the equations), to produce the deep blue-black solution. The color change indicates that the first reaction is complete and the second one has begun to take place.

Increasing temperature (Part B) will increase the reaction rate.

SAMPLE RESULTS

Part A. Effect of Concentration

Trial	Volume KIO_3 (mL)	Distilled Water (mL)	Time to Completion (s)
1	10.0	0.0	16
2	9.0	1.0	20
3	8.0	2.0	22
4	7.0	3.0	24
5	6.0	4.0	26
6	5.0	5.0	29

Part B. Effect of Temperature

Trial	Solution Temperature (°C)	Time to Completion (s)
1	5°C	24
2	15°C	19
3	25°C	15
4	35°	11
5	45°C	9

Graphs of the sample data are shown on the following page.

See the document on Graphing Tips for Excel for some additional information about using a spreadsheet to create graphs.

ADDITIONAL WEB RESOURCES

Chemistry Comes Alive!
http://jchemed.chem.wisc.edu/JCESoft/CCA/CCA3/MAIN/CLOCKRX/PAGE1.HTM

Tom Stretton's Chemistry Pages
http://www.ucdsb.on.ca/tiss/stretton/chem2/ratelab1.htm

Indiana University, Department of Chemistry Demonstrations
http://chemlearn.chem.indiana.edu/demos/Hydrogen.htm

University of Regensburg
Video clip included
http://www.uni-regensburg.de/Fakultaeten/nat_Fak_IV/Organische_Chemie/Didaktik/Keusch/D-Landolt-e.htm

GRAPHS of SAMPLE RESULTS