**Chemical Kinetics**

# The Iodine Clock Reaction

## OVERVIEW

The Iodine Clock Reaction is a "classic" experiment demonstrating the effects of concentration and temperature on reaction rate.

In this experiment two solutions are mixed. The reaction takes place in two steps.

Step 1:

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

Step 2:

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

The iodine, $I_2$, produced in Step 2 will react with starch (not shown in the equations), producing a deep blue-black solution.

The rate of the entire reaction can be measured by timing how long it takes before the blue color appears once the two solutions are mixed.

By altering the concentration of one of the reactants (Part A) and by changing the reaction temperature (Part B), the effects of these factors on reaction rate can be determined.

## 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

- Avoid getting either solution on your skin or clothes. Wash any splashes with cold water.
- Wear safety goggles

## EQUIPMENT AND MATERIALS

- Solution A (contains $IO_3^-$ ions)
- Solution B (contains $HSO_3^-$ & starch)
- distilled water
- ice cubes
- beakers, 250 mL and 100 mL (2)
- graduated cylinders, 10 mL (2)
- LARGE test tubes (2)
- thermometer
- water baths
- timer (stop watch or clock with second hand)
- safety goggles
- lab apron recommended
- magnetic stirrer, optional

## PROCEDURE

### Part A. Effect of Concentration

1. For Trial 1 measure *exactly* 10.0 mL of solution A and pour into a 100 mL beaker

2. Use a different graduated cylinder to measure *exactly* 10.0 mL of solution B and pour it into a second 100 mL beaker

3. You will begin recording reaction time as soon as you first mix the two solutions. One person should record the time of reaction while the other partner mixes the solutions. Pour one of the solutions into the other, then pour the solutions back and forth several times to ensure thorough mixing. Then wait for the completion of the reaction.

4. Record the time at the instant the deep blue-black colour first appears.

5. You will repeat Steps 1 – 4 using different concentrations of solution A. Obtain the dilutions by adding distilled water to Solution A, according to the following table:

| Trial | Solution A (mL) | Distilled Water (mL) |
|---|---|---|
| 1 | 10.0 | 0.0 |
| 2 | 9.0 | 1.0 |
| 3 | 8.0 | 2.0 |
| 4 | 7.0 | 3.0 |
| 5 | 6.0 | 4.0 |
| 6 | 5.0 | 5.0 |
| 7 | 4.0 | 6.0 |
| 8 | 3.0 | 7.0 |

Rinse and dry the beakers and graduated cylinders between each trial to avoid contamination/early mixing of reactants.

If time is short, half the class may be assigned trials 2, 4, 6, 8 and the other half should do trials 3, 5, 7. All groups should do the 1st trial. At the end of the lab data should be shared between groups.

## Part B. Effect of Temperature

1. You will follow the same procedure as you used for Trial 1 of Part A, mixing 10.0 mL of Solution A with 10.0 mL of Solution B. The concentrations will be kept constant, but you will vary the temperature of the solutions before mixing.

   As with Part A, different groups of students may be assigned different temperatures.

2. Class data should be obtained for the following temperatures. Each group of students should do trials at four temperatures:

| | | | | |
|---|---|---|---|---|
| Set 1: | 5°C | 15°C | 25°C | 35°C |
| Set 2: | 10°C | 20°C | 30°C | 40°C |

3. Prepare water baths for your set of solutions. Fill a 250 mL beaker about two third full with water of the appropriate temperature. For water baths below room temperature, use ice to chill the water. For warmer baths use warm water from the tap or a kettle.

   There should be enough water in the beakers so that the solutions in the test tubes are well beneath the water level in the baths.

4. As before, measure out exactly 10.0 mL of Solution A and B, pouring each into their own test tube. Place the two test tubes in your water baths, allowing them to remain for about 10 minutes to allow the solution temperatures to reach the temperature of the water baths.

   Use the thermometer to monitor water bath temperatures. Try to keep the water bath temperature within 0.5°C of your assigned temperature. Add more ice or warm water as necessary. Record your water bath temperature just before mixing the solutions in the data table.

5. Once the solutions are at the desired temperatures, prepare to record time and mix the two solutions. Pour the mixture back and forth between the two test tubes several times to ensure mixing. Then place the test tube containing the mixed solutions back in the water bath.

   Record the time it takes from initial mixing until the deep blue-black colour appears.

   At the end of the lab, share temperature and reaction rate data between groups.

## RESULTS

Results may be recorded in the following data tables.

### Part A.  Effect of Concentration

| Trial | Volume $KIO_3$ (mL) | Distilled Water (mL) | Time to Completion (s) |
|---|---|---|---|
| 1 | 10.0 | 0.0 | |
| 2 | 9.0 | 1.0 | |
| 3 | 8.0 | 2.0 | |
| 4 | 7.0 | 3.0 | |
| 5 | 6.0 | 4.0 | |
| 6 | 5.0 | 5.0 | |
| 7 | 4.0 | 6.0 | |
| 8 | 3.0 | 7.0 | |

### Part B.  Effect of Temperature

| Trial | Solution Temperature (°C) | Time to Completion (s) |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |
| 5 | | |
| 6 | | |
| 7 | | |
| 8 | | |

## Conclusions and Questions

1. Plot your results for Part A and Part B on two graphs.

   Graph A – plot mL Solution A vs reaction time

   Graph B – plot Temperature vs reaction time

2. Based on your results what can you conclude regarding the effect of concentration on reaction rate? Use the collision theory to explain this effect.

3. Based on your results what conclusion can you make regarding the effect of temperature on reaction rate? Explain this in terms of the collision theory.