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# Iodine Clock Reaction

## A Study of the Effects of Concentration, Temperature, and a Catalyst on Reaction Rate

### Introduction

Mix two colorless solutions and watch as, after a few seconds, they suddenly change from colorless to a dramatic deep-blue color! Captivate your students' attention with this popular starch-iodine clock reaction while studying the effects of concentration, temperature, and a catalyst on the rate of reaction.

### Concepts

- Clock Reactions
- Kinetics/Rates of Reaction
- Catalysts
- Indicators

### Materials

|   |                            |
|---|----------------------------|
| Potassium iodate solution, $\text{KIO}_3$ , 0.20 M, 325 mL      | Graduated cylinder, 10-mL  |
| Starch solution, 2%, 180 mL                                     | Graduated cylinder, 50-mL  |
| Sodium metabisulfite, $\text{Na}_2\text{S}_2\text{O}_5$ , 3.8 g | Graduated cylinder, 100-mL |
| Sulfuric acid solution, $\text{H}_2\text{SO}_4$ , 0.1 M, 10 mL  | Hot plate                  |
| Water, distilled or deionized                                   | Ice bath                   |
| Balance   | Thermometer                |
| Beakers, 250-mL, 6  | Timer or stopwatch         |
| Beakers, 400-mL, 6  | Stirring rod               |

### Safety Precautions

*Potassium iodate is an oxidizer. It is moderately toxic by ingestion and a body tissue irritant. Sodium metabisulfite is a skin and tissue irritant. Sulfuric acid solution is corrosive to eyes, skin, and other tissues. Wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron. Please review current Material Safety Data Sheets for additional safety, handling, and disposal information. Wash hands thoroughly with soap and water before leaving the laboratory.*

### Preparation

1. Prepare 100 mL of a 0.20 M sodium metabisulfite solution by dissolving 3.8 g of sodium metabisulfite in enough distilled or deionized water to make 100 mL of solution. This solution has a poor shelf life (about 1–2 months) and should be prepared fresh for the demonstration.
2. Prepare a 2% starch solution by first making a smooth paste with 20 g of soluble (potato) starch and 100 mL of distilled or deionized water. Pour the starch paste into 1 L of boiling water while stirring. Stir until dissolved and the solution is clear. Allow the solution to cool to room temperature before use. Starch solutions have a poor shelf life and will form mold if kept too long. Fresh solutions work best. Use within one or two months.

3. Prepare a series of solutions called Solution A according to the following chart. Use 400-mL beakers.

|  | Beaker 1A | Beaker 2A | Beaker 3A | Beaker 4A | Beaker 5A | Beaker 6A |
|--|-----------|-----------|-----------|-----------|-----------|-----------|
| <b>Potassium Iodate Solution, 0.20 M</b> | 50 mL     | 100 mL    | 25 mL     | 50 mL     | 50 mL     | 50 mL     |
| <b>Distilled or Deionized Water</b>      | 150 mL    | 100 mL    | 175 mL    | 150 mL    | 150 mL    | 140 mL    |
| <b>Sulfuric Acid Solution, 0.1 M</b>     | 0 mL      | 0 mL      | 0 mL      | 0 mL      | 0 mL      | 10 mL     |
| <b>Temperature of Solution A</b>         | Room Temp | Room Temp | Room Temp | 45 °C     | 10 °C     | Room Temp |

4. Prepare a series of six identical solutions called Solution B (1B–6B) by mixing 10 mL of 0.20 M sodium metabisulfite solution, 30 mL of starch solution, and 40 mL of distilled or deionized water in 250-mL beakers. Keep each of the solutions at room temperature.

## Procedure

- Control Reaction.** Pour Solution 1B into Solution 1A. Stir. Carefully time the reaction with a stopwatch or timer. Record the time from when the two solutions are mixed until the appearance of the blue color.
- The Effect of Concentration upon Reaction Rate.** Pour Solution 2B into Solution 2A. Record the time from when the two solutions are mixed until the appearance of the blue color. Repeat with Solutions 3B and 3A.
- The Effect of Temperature upon Reaction Rate.** Pour Solution 4B into Solution 4A. Record the time from when the two solutions are mixed until the appearance of the blue color. Repeat with Solutions 5B and 5A.
- The Effect of a Catalyst on the Reaction Rate.** Pour Solution 6B into Solution 6A. Record the time from when the two solutions are mixed until the appearance of the blue color. *Note:* Sulfuric acid is a catalyst for this reaction.

## Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures, and review all federal, state and local regulations that may apply, before proceeding. The resulting solutions may be flushed down the drain with excess water according to Flinn Suggested Disposal Method #26b.

## Results and Discussion

|                                  | 1         | 2         | 3         | 4      | 5      | 6         |
|----------------------------------|-----------|-----------|-----------|--------|--------|-----------|
| <b>[KIO<sub>3</sub>]</b>         | 0.04 M    | 0.07 M    | 0.02 M    | 0.04 M | 0.04 M | 0.04 M    |
| <b>Temperature</b>               | Room Temp | Room Temp | Room Temp | Warm   | Cool   | Room Temp |
| <b>Catalyst Added?</b>           | No        | No        | No        | No     | No     | Yes       |
| <b>Time Until the Blue Color</b> | 6 sec     | 3 sec     | 12 sec    | 4 sec  | 8 sec  | 2 sec     |

In this reaction, potassium iodate and sodium metabisulfite react to form iodine. The starch solution serves as an indicator of the end of the reaction by forming a deep-blue colored starch–iodine complex. The reaction time can thus be measured by noting the time until the appearance of the blue color for each trial. Three general statements can be made by looking at the results from this experiment. (1) The reaction rate increases as concentration increases and decreases as the concentration decreases. (2) The reaction rate increases with increasing temperature and decreases with decreasing temperature. (3) The reaction rate increases in the presence of a catalyst.

## Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

### *Unifying Concepts and Processes: Grades K–12*

Constancy, change, and measurement

### *Content Standards: Grades 5–8*

Content Standard B: Physical Science, properties and changes of properties in matter

### *Content Standards: Grades 9–12*

Content Standard B: Physical Science, structure and properties of matter, chemical reactions

## Materials for the Iodine Clock Reaction are available from Flinn Scientific, Inc.

| Catalog No. | Description                              |
|-------------|--|
| P0168       | Potassium Iodate Solution, 0.2 M, 500 mL |
| S0151       | Starch Solution, 500 mL                  |
| S0317       | Sodium Metabisulfite, 100 g              |

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.