How Does a Clock Reaction Work?

Rate Laws

FLINN SCIENTIFIC CHEM FAX!

Introduction

Use this demonstration as a helpful, supplementary tool for explaining a clock reaction. Your whole class will be moving and engaged in this "kinetic" model!

Concepts

- Kinetics
- Clock reactions

Materials

Bags, opaque, 2–3

Paper plates, white on one side, blue on the other, 4–5

Poster board sheets, white on one side, blue on the other, 4–5

Safety Precautions

Although this activity is considered nonhazardous, please observe all normal classroom or laboratory safety guidelines.

Background

A clock reaction typically involves a mixture of chemicals that, after a short period of time, shows a sudden color change. Many versions of the iodine clock reaction have been adapted for use in kinetics experiments. Some well known examples include $I^-/S_2O_8^{2-}$, I^-/HSO_3^{2-}, I^-/H_2O_2, and I^-/BrO_3^-. In all of these reactions, iodide ions are oxidized to iodine and starch, which forms a characteristic dark blue color with iodine, is added as an indicator to signal when a specified amount of iodine has been formed. The time needed for the reaction to occur, from the time of mixing to the time when the blue color suddenly appears, is measured and used to calculate the rate of reaction. In most cases, the reactions use a limiting quantity of sodium thiosulfate or sodium bisulfite to determine when a threshold concentration of iodine has been produced. The experiments are usually designed so that the concentration of the limiting reactant is about 1/10th of the initial iodide concentration. In general, the iodine is formed in a slow or rate-determining step, but the reaction of iodine with sodium thiosulfate is extremely fast. As a result, the iodine is consumed as fast as it is formed. As soon as all of the thiosulfate ions have reacted, however, iodine begins to accumulate. The presence of iodine is then detected by the sudden appearance of the dark blue color of the starch–iodine complex.

Although iodine clock reactions are extremely useful for kinetics experiments, the rationale for the use of thiosulfate or bisulfite ions usually confuses students. Adding the details of this second reaction involving a limiting reactant may be frustrating for students, who are struggling to understand the kinetics concepts, only to find themselves "thrown off the trail" by this second reaction. The purpose of this simulation or model activity is to present a physical analogy for the formation of a colored complex and the use of a scavenger molecule that traps the colored compound so that it is not visible. The color, therefore, is not observed until all the scavenger molecules have reacted. In this simulation, the two distinctively shaped paper objects represent two different molecules that combine to form a colored product, such as iodine and starch. The brown paper bags represent the thiosulfate scavenger ions that trap the iodine and mask the color change. The bags are the limiting reactant, however, so as soon as the number of colored products exceeds the number of bags, the color will suddenly appear.

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Procedure

1. Obtain paper plates and poster board sheets.

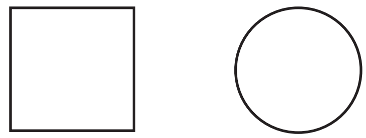


Figure 1.

2. When these “reactants” combine or react, the product is colored. Turn the cards over to indicate the color change.

Figure 2.

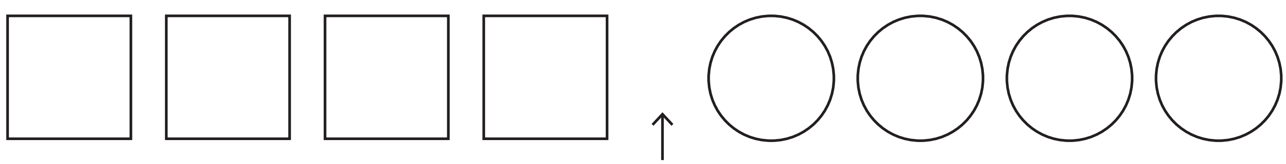
3. Obtain the brown paper bags. As soon as two reactants come together, quickly cover them with the bag, hiding the color. This represents the reaction of the limiting reactant with thiosulfate or bisulfite scavenger ions.
4. Continue “bagging” the colored compounds until the limiting quantity of paper bags has been fully used up or “consumed” in the reaction.
5. At this point, any additional colored compounds that are formed will be visible. The color change should be very sudden.

Disposal

None required.

Tips

- This activity is best performed with student (class) participation. Have students come up and hold the cards.



Teacher stands in the middle with 3 bags.

Figure 3.

- Bring the “reactants” together, turn them over to the colored side, immediately bag the colored product, and repeat two more times. Finally, when the last molecules come together, you are out of bags, and the solution stays colored.
- As with all simulations or models, there are simplifying assumptions in this activity that make the model imperfect and may lead to unintended misconceptions. The main assumption is that the blue color is trapped or hidden by the bags. In an iodine clock reaction, the blue color is due to the starch–iodine complex, but the compound that is “trapped” by thio sulfate ions is iodine itself, which is reduced back to colorless iodide ions.

Connecting to the National Standards

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

Unifying Concepts and Processes: Grades K–12
Evidence, models, and explanation
Constancy, change, and measurement
Content Standards: Grades 9–12
Content Standard A: Science as Inquiry
Content Standard B: Physical Science, structure and properties of matter, chemical reactions

Flinn Scientific—Teaching Chemistry™ eLearning Video Series

A video of the *How Does a Clock Reaction Work?* activity, presented by Jamie Benigna, is available in *Rate Laws*, part of the Flinn Scientific—Teaching Chemistry eLearning Video Series. Additionally, examples of iodine clock reaction demonstrations can be found in *Rate Laws* and *Reaction Pathways.*

Materials for *How Does a Clock Reaction Work?* are available from Flinn Scientific, Inc.

Catalog No.	Description
AP4601	Iodine Clock Reaction: Effect of Concentration, Temperature, and a Catalyst on Reaction Rate
AP2086	Cinnamon Clock Reaction
AP2089	The Overhead Oscillating Clock

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