Oscillating Clock

Summary

Students will follow a set of directions that lead to the "oscillating clock" reaction. They will need to do careful molarity calculations and measurements for it to work correctly.

Main Core Tie

Science - Chemistry
Standard 6 Objective 1

Time Frame

1 class periods of 90 minutes each

Group Size

Pairs

Materials

- student sheet
  (attached)
  Malonic acid, $CH_2(COOH)_2$
  potassium iodate KIO_3
  manganese sulfate (available as the mono-hydrate ($MnSO_4 \cdot H_2O$).
  50.0 mL of 3.6 M hydrogen peroxide (H_2O_2)
  3% [w/v] starch in a dropper bottle.
  2.00 M solution sulfuric acid

Background for Teachers

The Oscillating Clock demonstration, based on the Briggs-Rauscher (BR) reaction, provides a visually impressive reaction in which a solution oscillates in color between amber-orange and blue-black. The solution will oscillate approximately 10-15 times, with the time between color changes increasing as the reaction proceeds. After about 15 minutes, the oscillations will stop and the solution will remain blue-black in color.

The BR reaction was developed as a hybrid of two other oscillating reactions, the Bray-Liebhafsky (BL) reaction and the Belousov-Zhabotinsky (BZ) reaction. In the BL reaction, H_2O_2 was used as both an oxidizing and reducing agent to cause oscillations between I_2 and IO_3^-. In the BZ oscillating reaction, organic compounds such as malonic acid were used along with electron transfer agents such as Mn(II) ions. The BR reaction utilized the H_2O_2 and IO_3^- from the BL reaction and the malonic acid and Mn(II) ions from the BZ reaction to develop a reaction that caused the oscillation of the evolution of oxygen and carbon dioxide gases and the concentration of iodine and iodide ions, which accounts for the observed color changes.

The mechanism for the BR reaction has been studied extensively, and the origin of the $[I_2]$ and $[I^-]$ oscillations has been explained. However, the proposed mechanism is unable to account for the production of CO_2 gas and does not identify the final organic products of the reaction. This reaction, therefore, is a prime example of the ongoing exploration by chemists of phenomena that we can visibly observe, but not yet explain.

Instructional Procedures

The lab can be performed as a demonstration or as a student lab. To prepare demonstration sized quantities, use the following calculations:

Solution A: 3.6 M H_2O_2

Pour 400 mL of distilled water into a 2 L beaker.

Wearing gloves, pour 410 mL of 30% H_2O_2 into the beaker of water. Dilute the solution to 1 L with distilled water. (This solution should be prepared fresh for each day of demonstrations.)

Solution B: 0.2 M KIO_3 and 0.08 M H_2SO_4

Place 43 g of KIO_3 and ~800 mL of distilled water in a 2 L beaker.

Add 4.3 mL concentrated H_2SO_4 to this mixture.

Warm and stir the mixture until the KIO_3 has dissolved. Dilute to 1 L with distilled water.

Solution C: .15 M$CH_2(COOH)_2$, .02 M $MnSo_4$-H_2O and Starch

Dissolve 16 g of malonic acid and 3.4 g of $MnSO_4$-H_2O in 500 mL of distilled water in a 2 L beaker.

In a 100 mL beaker, heat 50 mL of distilled water to a boil.

In a 50 mL beaker, mix 3g of soluble starch with 5 mL of distilled water and stir to form a slurry. Our the slurry into the boiling water and continue heating and stirring until the starch has dissolved.

Pour this start solution into the malonic acid/MnSO40H2O mixture.

Dilute the mixture to 1 L with distilled water

For a student lab, direct the students to the materials and read over the procedures on the student sheet below. You will need to prepare the starch and hydrogen peroxide solutions in advance.

Bibliography

Lesson Design by Jordan School District Teachers and Staff.

Authors

Utah LessonPlans