The Hydrogen Peroxide Rainbow

Chemical Demonstration

Introduction

Produce a rainbow of colors by demonstrating how hydrogen peroxide can both oxidize and reduce. Hydrogen peroxide, a colorless solution, will cause another colorless solution to turn yellow, then red-orange. It also has the ability to make a purple solution go through a color change with the end solution being colorless.

Concepts

- Oxidation–reduction
- Oxidizing agent
- Reducing agent

Materials

Hydrogen peroxide solution, 6%, H_2O_2, 5 mL
Potassium iodide solution, KI, 0.12 M, 50 mL
Potassium permanganate solution, $KMnO_4$, 0.004 M, 50 mL
Sulfuric acid solution, H_2SO_4, 1 M, 18 drops
Beakers, 250-mL, 2
Graduated cylinders, 50-mL or 100-mL, 2
Overhead projector (optional)
Stirring rod or magnetic stirrer

Safety Precautions

Sulfuric acid is severely corrosive to skin, eyes, and other tissue. Hydrogen peroxide solution is an oxidizer and corrosive to skin, eyes, and other tissue. Potassium permanganate solution is an oxidizing agent and strong skin irritant; common cause of eye accidents. 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.

Preparation

1. Prepare 0.12 M potassium iodide by dissolving 4 g of potassium iodide in 200 mL of distilled water.
2. Prepare 0.004 M potassium permanganate solution by dissolving 0.13 g potassium permanganate in 200 mL of distilled water.

Procedure

Part A

1. Using a graduated cylinder, measure 50 mL of potassium iodide solution and transfer it to a 250-mL beaker.
2. Add 18 drops of sulfuric acid solution to the beaker. Stir the contents using a stirring rod.
3. Add the hydrogen peroxide solution dropwise to the beaker, stirring after each drop, until the solution turns red-orange. Note the color changes from colorless to yellow to red-orange. Approximately 40 drops of hydrogen peroxide solution will be needed to produce the color changes.

Part B

1. Using a graduated cylinder, measure 50 mL of potassium permanganate solution and transfer it to a clean, 250-mL beaker.
2. Add 18 drops of sulfuric acid solution to the beaker and stir to mix the contents.
3. Add the hydrogen peroxide solution dropwise to the beaker, stirring after each drop, until the solution becomes colorless. Note the color changes from purple to brown to colorless. Approximately 10 drops of hydrogen peroxide solution will be needed to produce the color changes.

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 solution from Part A may be reduced according to Flinn Suggested Disposal Method #12a. The solution from Part B may be neutralized according to Flinn Suggested Disposal Method #24b.

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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

Tips

- Adding the hydrogen peroxide drop by drop, and stirring after the addition of each drop, helps students better observe t he color changes that occur in both parts.
- Make sure that the students can see all of the color changes, especially in Part B where the brown is a precipitate and the purple becomes lighter. Doing the demonstration in the vicinity of the students or on the overhead projector will make the demonstration more dramatic. Stir after the addition of each drop.
- The KI solution may have an initial pale yellow tinge. This merely indicates the presence of trace I_2.

Discussion

The reactions that take place in Parts A and B are oxidation–reduction (redox) reactions. Hydrogen peroxide can act as both a strong oxidizing agent and a weak reducing agent. A reducing agent is oxidized in a redox reaction. This means it loses electrons, causing its oxidation number to increase. An oxidizing agent is reduced in a redox reaction, thereby gaining electrons and causing its oxidation number to decrease.

Hydrogen peroxide acts as an oxidizing agent in Part A. Hydrogen peroxide is reduced to water and the iodide ion is oxidized to iodine. The solution changes from colorless to yellow, indicating the presence of free iodine (I_2) in solution. The iodine combines with iodide ions (I^-) to form red-orange I_3^- ions.

Part A Reactions

$$\underset{\text{colorless}}{H_2O_2(aq) + 2H^+(aq) + 2I^-(aq)} \rightarrow \underset{\text{yellow}}{2H_2O(l) + I_2(aq)}$$

$$\underset{\text{yellow}}{I^-(aq) + I_2(aq)} \rightarrow \underset{\text{red-orange}}{I_3^-(aq)}$$

In Part B, hydrogen peroxide, in the presence of strong oxidizer permanganate, MnO_4^-, now acts as a reducing agent, reducing $Mn^{(7+)}$ to Mn^{2+}. Mn^{2+} is not initially produced. $Mn^{(7+)}$ is first reduced to $Mn^{(4+)}$ producing a brown precipitate in solution. $Mn^{(4+)}$ is then reduced to Mn^{2+}, giving a clear solution.

Part B Reactions

Step 1 $\underset{\text{purple}}{2MnO_4^-(aq)} + 3H_2O_2(aq) + 2H^+(aq) \rightarrow \underset{\text{brown}}{2MnO_2(s)} + 3O_2(g) + 4H_2O(l)$

Step 2 $\underset{\text{brown}}{2MnO_2(s)} + 2H_2O_2(aq) + 4H^+(aq) \rightarrow \underset{\text{clear}}{2Mn^{2+}} + 2O_2(g) + 4H_2O(l)$

Overall $\underset{\text{purple}}{5H_2O_2(aq) + 2MnO_4^-(aq)} + 6H^+(aq) \rightarrow 8H_2O(l) + 5O_2(g) + \underset{\text{colorless}}{2Mn^{2+}(aq)}$

Acknowledgment

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Materials for *The Hydrogen Peroxide Rainbow—Chemical Demonstration* are available from Flinn Scientific, Inc.

Catalog No.	Description
AP8659	The Hydrogen Peroxide Rainbow—Chemical Demonstration Kit
S0202	Sulfuric Acid, 1 M, 500 mL
H0028	Hydrogen Peroxide, 6%, 500 mL
P0077	Potassium Permanganate, Reagent, 100 g

Consult the Flinn Scientific website for current prices.