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The Pink Catalyst

Introduction

Add a pink cobalt chloride solution to a colorless solution containing potassium sodium tartrate and hydrogen peroxide and watch as a very obvious green-colored complex forms. As the reaction ends, the solution will return to its original pink color—indicating that the cobalt chloride catalyst is not used up in the reaction.

Concepts

- Catalysts
- Kinetics

Materials

Cobalt chloride solution, $CoCl_2$, 0.1 M, 15 mL
Hydrogen peroxide solution, 6%, H_2O_2, 40 mL
Potassium sodium tartrate solution, 0.2 M, 100 mL
Water, distilled, approximately 100 mL
Beaker, 150-mL
Beaker, 500-mL or 1-L
Graduated cylinder, 100-mL
Hot plate
Spatula or scoop
Stirring rod or magnetic stirrer
Thermometer

Safety Precautions

Cobalt chloride solution is moderately toxic by ingestion; the solid is a possible carcinogen as a fume or dust. Hydrogen peroxide is a strong oxidizer and a skin and eye irritant. Avoid contact of all chemicals with eyes and skin. 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

Prepare 0.2 M potassium sodium tartrate solution by dissolving 6 g of $KNaC_4H_4O_6 \cdot 4H_2O$ in 100 mL of distilled water.

Procedure

1. Using a graduated cylinder, measure out 100 mL of 0.2 M potassium sodium tartrate solution and pour it into a 500-mL or 1-L beaker.
2. Place the beaker on a hot plate at a medium setting and slowly warm the solution to 70 °C.
3. When the temperature of the potassium sodium tartrate solution reaches 70 °C, carefully add 40 mL of 6% hydrogen peroxide. No reaction is observed.
4. Note the initial pink color of the cobalt chloride solution, and then add the solution to the 500-mL beaker and stir.
5. Observe the rate and progress of the resulting chemical reaction. *(The solution turns bright green and vigorous bubbling ensues within one minute. The mixture begins to froth and foam, then just as suddenly subsides. When the rate of bubbling diminishes, the green color disappears and the pink color of the cobalt chloride solution returns.)*

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 final cobalt-containing solution may be treated according to Flinn Suggested Disposal Method #27d.

Tips

- The use of a large beaker is important so that the reaction does not froth over.
- To measure the reaction rate, begin timing the reaction upon addition of the pink catalyst solution. Complete the timing after the original pink color of the cobalt chloride solution has returned. Using a hot plate–magnetic stirrer combination is strongly recommended to measure reaction times. The reaction rates may be measured at different temperatures (50. 60, and 70 °C)

Discussion

The reaction of tartrate ions with hydrogen peroxide is an example of an oxidation–reduction reaction. Hydrogen peroxide is a strong oxidizing agent, resulting in the complete oxidation of tartrate ions to give carbon dioxide and water (Equation 1).

$$C_4H_4O_6^{2-} + 5H_2O_2 \rightarrow 4CO_2 + 6H_2O + 2OH^- \qquad \textit{Equation 1}$$

In the absence of a catalyst, the decomposition reaction, although thermodynamically favorable, is kinetically very slow. Thus, even at 70 °C, the reaction occurs at a barely noticeable rate.

To speed up the reaction, a catalyst must be used. Cobalt ions are known to catalyze the decomposition of hydrogen peroxide. The action of the cobalt catalyst can be followed by observing the color changes of the solution. The solution starts out pink, the color of the cobalt(II) aquo complex [$Co(H_2O)_6^{2+}$]. The mixture then quickly turns green, indicating the formation of a cobalt(III) complex. The rapid production of gas bubbles due to oxidation of the tartrate ions occurs almost immediately after the green color has been observed. As the tartrate ions are consumed and the amount of gas production subsides, the color of the solution returns to the original pink color of the cobalt(II) catalyst.

The first step is the formation of a Co(II)-tartrate coordination compound. This is followed by oxidation to a green Co(III) complex which is thought to be the actual catalyst in the reaction. In the course of oxidation of the tartrate ions, the Co(III) complex is reduced back to Co(II). When all the tartrate has been consumed, the color of the solution reverts back to pink, indicating that only Co(II) ions are present.

Cobalt chloride is a catalyst because it is not consumed during the course of the reaction and it greatly speeds up the reaction.

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 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 of atoms, structure and properties of matter, chemical reactions

Acknowledgment

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References

Cesa, I. *Flinn ChemTopic™ Labs,* Vol. 14, *Kinetics.* Batavia, IL: Flinn Scientific, 2002.

Materials for *The Pink Catalyst* are available from Flinn Scientific, Inc.

Catalog No.	Description
AP2084	Pink Catalyst—Chemical Demonstration Kit
C0242	Cobalt Chloride Solution, 0.1 M, 500 mL
P0084	Potassium Sodium Tartrate, 100 g
H0028	Hydrogen Peroxide, 6%, 500 mL

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