Magic Genie

Decomposition Reactions

Introduction

When manganese dioxide is dropped into a flask or bottle containing 30% hydrogen peroxide, a "magical" genie appears in the form of water droplets trapped in steam and oxygen gas.

Chemical Concepts

- Exothermic reaction
- Catalysts
- Decomposition reactions

Materials (for each demonstration)

Hydrogen peroxide, H_2O_2, 30%, 50 mL
Manganese dioxide, MnO_2, 5 g
Filter paper or tissue
Graduated cylinder, 50-mL or 100-mL
Volumetric flask, Pyrex®, 1000-mL

Safety Precautions

Hydrogen peroxide, 30%, will act as an oxidizing agent with practically any substance. It decomposes to produce oxygen gas and thus requires special handling and storage procedures. The substance is severely corrosive to the skin, eyes and respiratory tract; a very strong oxidant; and a dangerous fire and explosion risk. Do not heat 30% hydrogen peroxide. Manganese dioxide may produce manganese metal, which is irritating as a dust or fume. The reaction flask will get extremely hot; use only a Pyrex or borosilicate glass flask and hold with a towel around it to prevent burns. Do not point the mouth of the flask towards yourself or anyone else. Never tightly close a vessel containing hydrogen peroxide—it may explode. Wear chemical splash goggles, chemical-resistant gloves and chemical-resistant apron. Please review current Safety Data Sheets for additional safety, handling, and disposal information.

Procedure

1. Wrap 4–5 g of manganese dioxide in a small piece of filter paper or tissue. Staple the filter paper so that no solid leaks out.
2. Add 50 mL of the 30% hydrogen peroxide solution to a 1000-mL Pyrex volumetric flask. *Caution:* Wear rubber gloves when handling 30% H_2O_2. Contact with skin may cause burns.
3. Set the flask on a counter and hold the flask with a thick cloth towel. Drop in the manganese dioxide packet. Make sure the flask is upright and that all students are a safe distance away. A "magic genie" (water droplets and oxygen gas) will emerge from the flask. The flask will get extremely hot. The towel will hide the flask contents as well as protect your hand from the heat produced.

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. Filter the mixture to retrieve the spent catalyst, which may be packaged for landfill disposal according to Flinn Suggested Disposal Method #26a. The remaining liquid may be flushed down the drain with excess water according to Flinn Suggested Disposal Method #26b.

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Tips

- It is very important that this demonstration be done in a borosilicate glass (e.g., Pyrex) flask. A flask that is not borosilicate glass will crack from the evolution of heat.
- In the video, this demonstration is performed in a pop bottle that is clamped to a support stand. It is important if using a plastic bottle, it must be clamped to a support stand. It must be clamped because of its light weight. It may tip during the demonstration resulting in a steam accident.
- A large flask (1000-mL) is necessary because a dark brown or black liquid may spurt out at the end of the reaction. A large flask will help prevent this from happening.
- A thick cloth towel will prevent your students from seeing what is happening in the flask, as well as protect you from the heat evolved in the reaction. Another option is to wrap the flask in aluminum foil and decorate it like a "genie bottle." A more colorful option is to add food coloring to the flask.
- Sodium iodide can be substituted for manganese dioxide in this demonstration. Both chemicals catalyze the reaction and will cause the release of oxygen from hydrogen peroxide. Other substances that catalyze the decomposition of hydrogen peroxide include manganese metal and other transition metals and their ions such as Fe^{3+}.
- The catalyst packet can also be attached to a piece of thread and hung inside the flask. Attach the thread to the outside of the flask with tape or a stopper. *Warning:* Do not use a solid stopper or cap. If the reaction starts prematurely, the pressure buildup may explode the flask. Use a one- or two-holed stopper and place it loosely on the flask.

Discussion

The Magic Genie demonstrates the decomposition of hydrogen peroxide into oxygen gas and water vapor (Equation 1). The decomposition is catalyzed by manganese dioxide (MnO_2), which is not changed during the reaction. It is an exothermic reaction and will evolve a lot of heat. The special effects in this demonstration are due to a "fog" produced by the condensation of water droplets in the steam and oxygen gas mixture.

$$2H_2O_2(aq) \xrightarrow{MnO_2(s)} 2H_2O(l) + O_2(g) + \text{Heat Energy} \qquad \textit{Equation 1}$$

The mechanism of decomposition of hydrogen peroxide by MnO_2 is believed to involve the production of Mn(II) and Mn(III) intermediates, as well as hydroperoxide ions (HOO^-) and superoxide anion radicals (O_2^-). Mn(II) ions are then rapidly reoxidized to MnO_2, resulting in regeneration of the catalyst (Equations 2–4).

$$2H^+ + MnO_2 + H_2O_2 \rightarrow Mn^{2+} + 2H_2O + O_2 \qquad \textit{Equation 2}$$

$$Mn^{2+} + 2H_2O_2 \rightarrow Mn(OH)_2 + 2H^+ \qquad \textit{Equation 3}$$

$$Mn(OH)_2 + H_2O_2 \rightarrow MnO_2 + 2H_2O \qquad \textit{Equation 4}$$

The overall result of Equations 2–4 is the decomposition to oxygen and water shown in Equation 1.

NGSS Alignment

This laboratory activity relates to the following Next Generation Science Standards (2013):

Disciplinary Core Ideas: Middle School
- MS-PS1 Matter and Its Interactions
  - PS1.A: Structure and Properties of Matter
  - PS1.B: Chemical Reactions
- MS-PS3 Energy
  - PS3.A: Definitions of Energy
  - PS3.B: Conservation of Energy and Energy Transfer

Disciplinary Core Ideas: High School
- HS-PS1 Matter and Its Interactions
  - PS1.A: Structure and Properties of Matter
  - PS1.B: Chemical Reactions

Science and Engineering Practices
- Developing and using models
- Constructing explanations and designing solutions

Crosscutting Concepts
- Cause and effect
- Energy and matter
- Structure and function
- Stability and change

Answers to Worksheet Questions

1. Describe what happened in this demonstration.

   A hydrogen peroxide solution was poured into a volumetric flask. Manganese dioxide, enclosed in filter paper, was dropped into the flask, and a great deal of steam and water vapor (fog) was produced.

2. Write the chemical equation for the decomposition of hydrogen peroxide. Include heat in the equation to indicate whether the reaction was endothermic or exothermic.

   $2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g) + Heat$

3. What is a catalyst? Name the catalyst in this demonstration. Should it be included as a reactant in the chemical equation?

   A catalyst is a substance that increases the reaction rate but is not consumed in the course of the reaction. The catalyst in this demonstration was manganese dioxide. It would not be included as a reactant, because it was all recovered after the experiment, therefore it is a catalyst.

Flinn Scientific—Teaching Chemistry™ eLearning Video Series

A video of the *Magic Genie* activity, presented by Lee Marek, is available in *Decomposition Reactions* and in *Catalysis*, part of the Flinn Scientific—Teaching Chemistry eLearning Video Series.

Materials for *Magic Genie* are available from Flinn Scientific, Inc.

Catalog No.	Description
AP2092	Magic Genie Demonstration Kit
H0037	Hydrogen Peroxide, 30%, 100 mL
H0008	Hydrogen Peroxide, 30%, 500 mL
M0205	Manganese Dioxide, 100 g
GP4045	Pyrex Volumetric Flask, 1000-mL

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

Magic Genie Worksheet

Discussion Questions

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