

Genie in a Bottle

Kitchen Table Demonstration

The Rundown

Time: 10 - 15 minutes

Content: decomposition reactions, catalysis

Safety Concerns: Minimal

Materials Availability: Manganese dioxide is a necessary chemical for this demo. All other materials are common.

We often talk about the three states of matter: solids, liquids, and gases. Solids and liquids are easy for us to see with our bare eyes. But how do we know that gases exist when they are colorless and invisible to the human eye? We have to rely on our indirect observations of the effects of gas production, and the behavior of substances around the gas.



Content Application

- Decomposition
- Kinetics
- Catalysis
- Activation Energy



Enduring Understandings

- Decomposition reactions occur when a complex substance breaks down into two or more simpler substances.
- Catalysis is the process of speeding up a reaction by lowering the energy barrier presented by the uncatalyzed reaction.



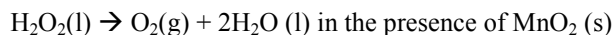
Chemistry

There are two different chemistry concepts that can be used to explain this demonstration.

Decomposition reactions are those which occur when a complex substance breaks down into two or more simpler substances.

In this demonstration, the overall reaction involves hydrogen peroxide (H_2O_2) decomposing to produce

oxygen gas and water in the presence of manganese dioxide by the following exothermic reaction:



Because the reaction is so exothermic, as water is produced, much of it is quickly converted into a vapor, which is what results in the “Genie in a Bottle” effect.

Kinetics is the study of reaction rates. It is an area of chemistry that investigates how different experimental conditions influence the speed of a chemical reaction. One variable which determines the rate of a reaction is its activation energy. **Activation energy** is the energy barrier that must be overcome in order for a chemical reaction to move forward. This activation barrier can be lowered if a catalyst is present in the reaction. As such, the reaction seems to speed up, when in actuality, it is simply the result of the activation energy being lowered.

In this demonstration, the manganese dioxide acts as the catalyst which is responsible for speeding up the decomposition of hydrogen peroxide, which normally occurs over a longer period of time. MnO_2 does this by lowering the activation energy of the reaction.



Materials

1. Soda bottle, 2L
2. Hydrogen Peroxide, 30%
3. Tea bag or tissue paper
4. Thread
5. MnO_2 (1g) or KI (2g)
6. 1 hole rubber stopper



Safety

- Goggles and apron – bubbling and fizzing will occur.
- Hydrogen peroxide is severely corrosive to the skin, eyes, and respiratory tract; a very strong oxidant; and a dangerous fire and explosion risk.
- Manganese dioxide is a strong oxidant is moderately toxic.
- The reaction vessel will get very hot.



Procedure

1. Place 30-40mL of 30% hydrogen peroxide carefully into the bottle using a long stem funnel. Be certain the bottle is secured from tipping over.
2. Prepare a “sachet” of about one gram of manganese dioxide (like a tea bag) using tissue or toilet paper making sure none of the catalyst comes through the paper. Tie the bag with string, thread or a fine wire.
3. Hang the bag in the top of the neck of the bottle and hold it in place with a 1-hole rubber stopper. The stopper must have a hole in it – allowing the steam to escape in case a reaction occurs inadvertently.
4. Initiate the reaction by removing the stopper and permitting the bag to fall into the peroxide. The reaction may take a few seconds, be patient.



Disposal

- The solution may be rinsed down the drain with excess water.



Student Participation and Follow-Up

Questions to ask:

1. Predict the products of this reaction. (If not discussed prior to the demonstration).
2. What evidence did you observe that indicated that a chemical change was taking place? What does this imply about the products formed?
3. Was a gas formed? How do you know? Could you see the gas?
4. Demonstrate the uncatalyzed version of the decomposition of hydrogen peroxide. Have the students make observations. Ask the students to compare and contrast the uncatalyzed reaction with the catalyzed version.

Follow-Up:

1. Perform another catalyzed reaction of the same decomposition of hydrogen peroxide, but using a different catalyst, such as iodine (see the next demonstration in the manual to make Elephant Toothpaste by catalytic decomposition of H_2O_2).