Elephant Toothpaste

Kitchen Table Demonstration

The Rundown

Time: 10 - 15 minutes
Content: decomposition reactions, catalysis
Safety Concerns: Minimal
Materials Availability: Potassium iodide 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

(The same explanation as that for the "Genie in a Bottle" Demonstration, but with a different catalyst).

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 by the following reaction:

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

However, this reaction is catalyzed by the iodide ion by the following mechanism:

$$H_2O_2(aq) + I^-(aq) \text{ --> } OI^-(aq) + H_2O(l)$$
$$H_2O_2(aq) + OI^-(aq) \text{ --> } I^-(aq) + H_2O(l) + O_2(g)$$

Because of the presence of the dish soap, the detergent captures the oxygen produced and forms bubbles. This results in the effect demonstrated by the reaction contents growing.

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 iodide ion acts as the catalyst which is responsible for speeding up the decomposition of hydrogen peroxide, which normally occurs over a longer period of time. I^- does this by lowering the activation energy of the reaction.

Materials

1. Graduated Cylinder, 250mL
2. Potassium Iodide, KI, 10g
3. Liquid Dishwashing Detergent, 5mL
4. Dishpan
5. Wooden Splint
6. Water
7. Hydrogen PeroxideH_2O_2, 30% solution, 50mL

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.
- Do not stand over the reaction; steam and oxygen are produced quickly.

Procedure

1. Prepare a dishwashing detergent/potassium iodide solution by dissolving 10g of Potassium Iodide in 5mL of water,
2. Add this solution to 25ml of liquid dishwashing detergent.
3. Place a 250mL graduated cylinder in a large shallow pan. Add the soap mixture to the cylinder.
4. Quickly pour 50mL hydrogen peroxide into the graduated cylinder. USE CAUTION!!! A foam-like snake should quickly push out of the graduate and spill into the dishpan. This is an exothermic reaction and a tremendous amount of steam may be produced.

Disposal

- The foam left in the cylinder 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. If this is a follow-up to the "Genie in a Bottle" demonstration, have the students compare and contrast the two catalytic, exothermic reactions.