Priestly and Soda Pop
Student Activity

Introduction and Historical Context

In the 1770s, a time in history when science thought there was only one "air" (as in the Greek idea of the elements—earth, air, fire, and water), Priestley investigated many gases. In addition to his work with carbon dioxide, or "fixed air," Priestley was also the first to isolate oxygen, and he helped describe seven other gases—nitrogen dioxide (NO_2), nitrous oxide (N_2O), hydrogen chloride (HCl), carbon monoxide (CO), ammonia (NH_3), sulfur dioxide (SO_2), and silicon tetrafluoride (SiF_4). He also developed many of the devices first used to prepare and collect gases in the laboratory.

Today we can trace our affection for "soda" like Coke and Pepsi to Priestley's method of carbonating water, the topic of this activity. Priestley's method was designed for the laboratory and not for commercial production. In the late 1700s and early 1800s there were a few small manufacturers of soda, or seltzer, water. In 1830 Joseph Matthews, an Englishman, arrived in New York City and set up carbonating machines. The machines produced CO_2 by reacting marble powder (calcium carbonate) with sulfuric acid in lead vessels. The late 1800s saw flavoring added to the carbonated water and the invention of both Coca-Cola and Pepsi. By the turn of the century, glass bottles were being mass-produced, and a major beverage industry was on its way.

Purpose

Joseph Priestley was the first to artificially dissolve carbon dioxide gas in water, duplicating the natural "soda water" he found near his home in Leeds, England. The gas dissolved in today's sodas is carbon dioxide. You should first predict the volume of carbon dioxide that can be dissolved in a 1 .0-L bottle of soda and then measure the actual volume of gas that escapes from the solution.

Safety

If you are allergic to latex, notify your teacher and do not touch the balloons.

Materials and Apparatus

- 1 .0-L bottle of club soda or seltzer water (chilled, unopened) 2.0-L soda bottle, empty
- Balloon, 9-inch size
- Beaker (a large plastic container may be substituted) Plastic container
- Warm water
- Rubber tubing
- Graduated cylinder
- Felt-tip marker

Pre-Lab Questions

1. Record your observations during the teacher demonstration.
2. How do you know that a gas is produced in the demonstration?
3. How do you know that the gas is carbon dioxide?
4. Write the equation for the reaction you observed.
5. Is it possible to determine from the demonstration whether CO_2 is soluble in water?
6. What factors affect the solubility of gases in water?
7. You already know that CO_2 is soluble in water. Predict the volume of CO_2 that is dissolved in 1 liter of a carbonated beverage. Record your prediction in writing.

Procedure

1. Obtain a 1 .0-L bottle of chilled soda from your teacher.
2. Carefully remove the cap and observe any changes that take place.
3. Quickly place a rubber balloon over the opening of the bottle. Observe.

4. After several minutes place the bottle and balloon assembly into a beaker, and add warm water to the beaker so that the water level is about one-third of the way up the soda bottle. Observe.
5. GENTLY shake the soda bottle occasionally. You can remove it from the beaker of warm water as you shake it. Replace the soda bottle in the beaker.
6. When bubbles stop rising in the soda bottle, place about two inches of water in a plastic container. Fill the 2.0-L soda bottle completely with water. Place your hand over the opening and invert the 2.0-L bottle in the plastic container. When the mouth of the bottle is underwater, remove your hand.
7. Carefully pinch the neck of the balloon to prevent any gas from escaping. Remove the balloon from the top of the soda bottle.
8. Insert the rubber tubing into the neck of the balloon and use your fingers to seal the balloon around the tubing so no gas escapes. Thread the other end of the tubing into the mouth of the inverted 2.0-L bottle.
9. Be sure to keep the balloon sealed against the tubing and SLOWLY allow gas to escape from the balloon by reducing the pinching pressure you exert on the balloon neck. Continue until all the gas has escaped into the larger bottle.
10. Hold the inverted 2.0-L bottle so that the surface of the water inside is level, and mark the water level with a felt marker.
11. Empty all the water out of the bottle. Now refill the bottle up to the mark you made on the bottle.
12. Measure the volume of water by pouring it into a graduated cylinder.
13. Clean up. Be sure to recycle the plastic soda bottles according to your teacher's instructions.

Post-Lab Questions

1. Compare your prediction of the volume of CO_2 gas that is dissolved in 1 liter of a carbonated beverage to the volume you measured in this activity.
2. Look at your answer to pre-lab question 6, and show where each factor is used in this activity.
3. Given what you have learned about the solubility of CO_2 in water, what are some possible sources of error in your measured volume of CO_2 in this activity?

Extension Questions

1. Why is carbon dioxide so important in our environment? Think about photosynthesis, the burning of fossil fuels, and global warming. What processes release CO_2 into the atmosphere? What processes remove it?
2. Priestley lived at the time of both the French and American revolutions. How was the work of Priestley (and Boyle and Lavoisier) part of a scientific revolution?