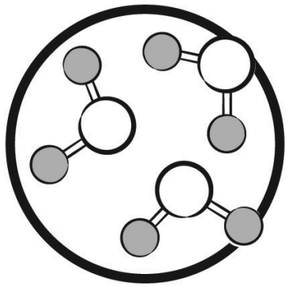
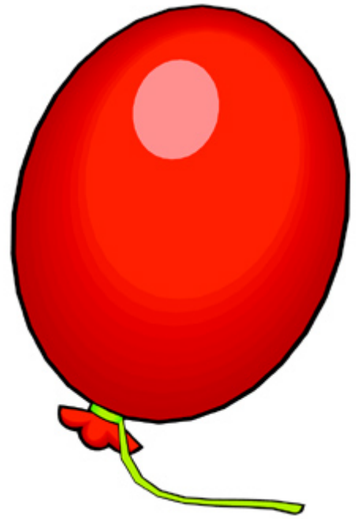


It's a Gas!

1. Always wear safety goggles.
2. Remove the stoppers. Rinse the large flask.
   Do not rinse the small flask or beaker.
   Keep the blue water.
3. Add all of the blue water to the small flask.
4. Assemble the flasks, beaker and tubing as pictured.
   Make sure the end of the loose tube is in the beaker.
5. Add one spoonful of baking soda to the large flask.
6. Use the graduated cylinder to measure 50 mL water.
   Add to the large flask. Swirl to mix the contents.
7. **READ CAREFULLY:** Add one spoonful of citric acid to the large flask. Quickly replace the stopper.
   Hold both stoppers tightly.
   - What is happening in the large flask?
   - Why does the blue water move?
8. Save the blue water (in the beaker).
   Remove the stoppers. Rinse the large flask in the sink.

What makes the blue water move?



A Closer Look

In a gas, molecules or atoms move constantly and spread far apart. If a gas cannot escape its container, it applies pressure on the container. For example, gas pressure inflates a balloon. Gas can also escape as fizz from open soft drink cans. In those cases, the fizz is carbon dioxide gas, the same gas you create in this experiment.

In this experiment, the chemical reaction between citric acid ($C_6H_8O_7$) and baking soda ($NaHCO_3$) in water (H_2O) produces carbon dioxide gas (CO_2). The gas fills the large flask and travels through the tubing to the small flask, where it applies enough pressure to force the blue water up the tube and into the beaker.

Talking Points: It's a Gas

Extensions

Try these experiments:

1) Light a match. Take the stopper off the large flask and dip the match into the carbon dioxide.
   Explain that even though there appears to be air in the flask, you can prove it has no air because the match burns in air, but not in the carbon dioxide.
2) Light the candle. Show that you can put the flame out by pouring the carbon dioxide on it. (Be careful not to pour the liquid). If it doesn't work, add more acid to the flask and try again.
   You are demonstrating that carbon dioxide is denser than air, and when poured flows downward to smother the flame.

Applications

In this experiment, they are creating a **chemical reaction** that creates a gas (as seen by the bubbles). This gas (carbon dioxide) can do work (move the blue water from one flask to the other).

Carbon dioxide is used in fire extinguishers (like the one that hangs on the wall of the Chemistry Lab near the Storeroom). If there is a fire, you can use the fire extinguisher to put carbon dioxide on the fire and smother it.

Point out that there are three requirements to have a fire: a fuel (such as wood or paper), oxygen, and heat. If you prevent oxygen from reaching the fire, it will immediately stop.

In-Depth Information

Baking soda will react with any acid (most often vinegar, acetic acid, is used) to form carbon dioxide:

$$NaHCO_3 + H^+ \longrightarrow Na^+ + H_2O + CO_2$$

The carbon dioxide, a gas, expands and quickly pushes the blue water from the central flask into the beaker. (If the visitor comments that the water has been sucked into the beaker, correct this misconception). Because carbon dioxide is heavier than air, it remains in the large flask even when the stopper is removed, until you tip the flask to pour it out.

For many centuries the experts did not know that air was a mixture of gases (78% nitrogen, 21% oxygen, 1 percent argon, and smaller amounts of carbon dioxide and other gases). It was only in the late 1700's that researchers began to identify individual gases and realized that air was not an element.

Good CO_2, Bad CO_2

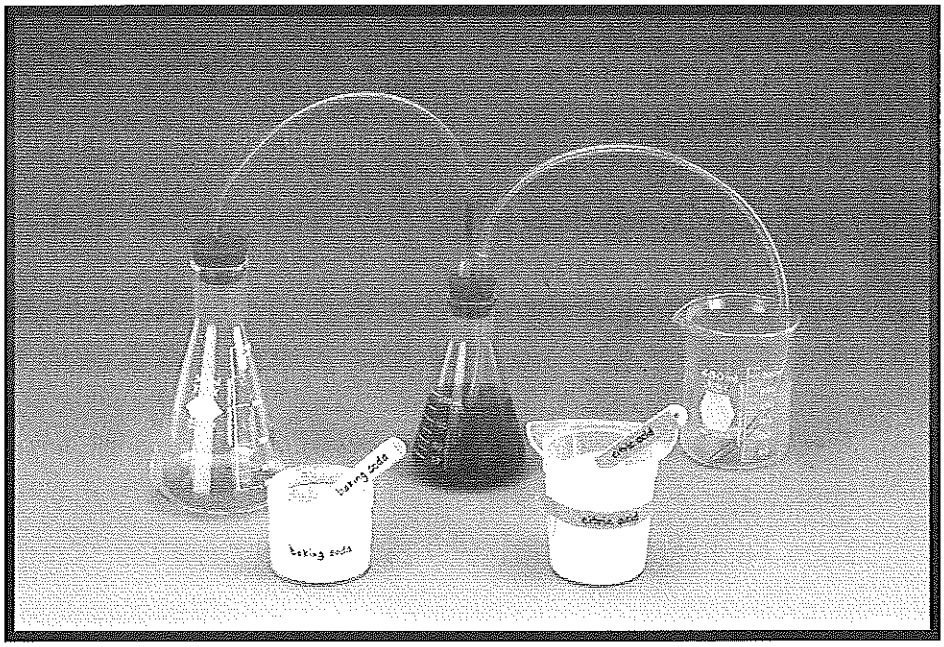
Carbon dioxide is a great boon when we use it to extinguish a fire, or in its frozen form (dry ice) as a refrigerant. But it is the most common **greenhouse gas**. Carbon dioxide along with methane, sulfur oxides, and nitrogen oxides are greenhouse gases that contribute to the increasing temperature of the atmosphere. Scientists agree that this increase of temperature will have strong effects on weather patterns, and could result in dire consequences for life on Earth.

One of the most important challenges of our time will be to change our sources of energy to reduce the amount of carbon dioxide released into the atmosphere.

EXPERIMENT

It's a Gas!

Visitors mix water and sodium bicarbonate (baking soda) in a large flask. They then add citric acid to the mixture and stopper the flask. The resulting reaction creates carbon dioxide gas. The gas passes through the tubing into a small flask filled with blue water and displaces the water into a beaker.



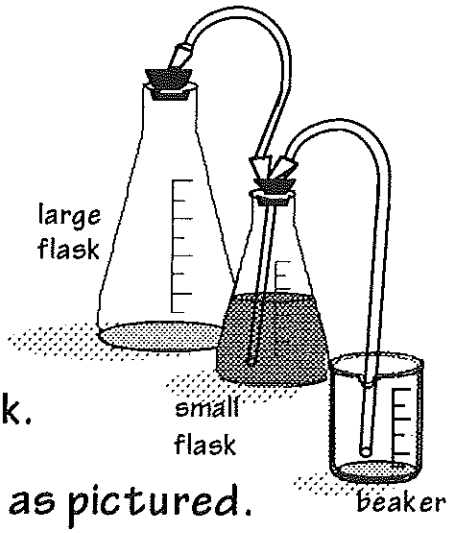
OBJECTIVES:

Visitors observe a chemical reaction with a gas as a product. They infer that a gas takes up space and can exert pressure, whether or not it is visible.

SCIENCE TOPICS	PROCESS SKILLS	VOCABULARY
Properties of Gases	Observing	Atom
Pressure of a Gas	Measuring	Gas
Products of Chemical Reactions	Inferring	Molecule

It's a Gas!

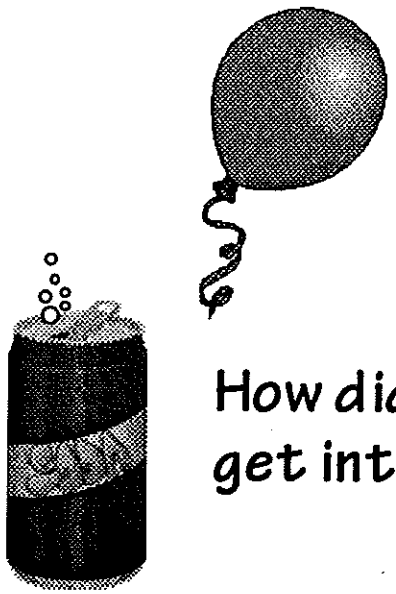
Procedure:



1. Always wear safety goggles.
2. Remove the stopper and rinse the large flask.
3. Add 200 ml blue water to the small flask.
4. Assemble the flasks, beaker, and tubing as pictured. Make sure the end of the loose tube is in the beaker.
5. Add one teaspoon of baking soda to the large flask. Use the graduated cylinder to measure and add 50 ml water (H_2O) to the large flask. Swirl to mix the contents.

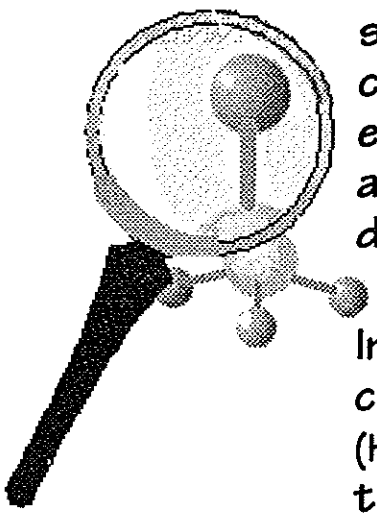
********** READ STEP 6 CAREFULLY **********

6. Add one teaspoon of citric acid to the large flask and <u>quickly</u> replace the stopper. Tightly hold the stoppers on both flasks.
7. Notice the bubbling gas produced in the large flask.
   Where is the gas going?
8. Try adding more citric acid to the large flask.
   Does the reaction continue ?
9. Save the blue liquid (in the beaker) for the next person. Remove the stoppers. Rinse the large flask in the sink.



How did the blue water get into the beaker?

A Closer Look



In a gas, molecules or atoms move constantly and spread far apart. If a gas cannot escape its container, it applies pressure on the container. For example, gas pressure inflates a balloon or escapes as fizz, carbon dioxide gas, when you open a soft drink.

In this experiment, the chemical reaction between citric acid ($C_6H_8O_7$), baking soda ($NaHCO_3$), and water (H_2O) produces carbon dioxide gas (CO_2). The gas fills the large flask and travels through the tubing to the small flask, where it applies enough pressure to force the blue water up the tube and into the beaker.

MATERIALS

(with amounts to have on hand)

- One 500-ml Erlenmeyer flask (narrow mouth) with a tightly fitting rubber stopper with one hole
- One 250-ml Erlenmeyer flask with a tightly fitting rubber stopper with two holes
- Stopper/tubing apparatus to connect the flasks
- Three pieces of glass tubing (each 1½-in. long), to fit tightly through the three holes in the rubber stoppers
- 3 ft of plastic tubing (A) the same diameter as the glass tubing
- 5 in. of plastic tubing (B) to use as joints connecting the glass and the long plastic tubing
- One 400-ml beaker
- One 100-ml graduated cylinder
- One 250-ml squeeze bottle
- One 500-ml bottle
- Blue food coloring
- Two small jars with lids (about 200-cc size)
- Two ½-tsp measures
- Baking soda (two 4-lb boxes)
- Citric acid (crystalline)–enough for about 1000 g per day during peak times
- One 100-ml beaker (optional)
- One votive candle, matches (optional)

Setup/Takedown Procedures

ORIGINAL SETUP

- ❑ Label the 250-ml squeeze bottle "Water (H_2O)."
- ❑ Label the 500-ml bottle "Blue Water."
- ❑ Color-code and label two small jars "Baking Soda" and "Citric Acid."
- ❑ Label two ½-tsp measures "Baking Soda" and "Citric Acid." Color-code the labels to match the respective jars.

View the picture on the visitor copy to visualize and set up the apparatus as follows:

- ❑ Gently insert a piece of snugly fitting 1½-in.-long glass tubing through each of the three holes in the two rubber stoppers. Take care not to break the glass and cut your fingers.

- ❑ Cut the long piece of plastic tubing (A) into three pieces of the following lengths: 18 in., 12 in., and 4½ in.
- ❑ Cut four 1¼-in. pieces of larger plastic tubing (B).
- ❑ With the 12-in. piece of plastic tubing (A), connect the rubber stopper from the larger flask to the rubber stopper from the smaller flask (use 1¼-in. pieces of plastic tubing (B) as joints between the plastic tubing (A) and the glass tubing in the rubber stoppers).
- ❑ Attach the 18-in. piece of plastic tubing (A) to the remaining hole on the top of the rubber stopper of the smaller flask. Attach the 4½-in. piece of plastic tubing (A) to the bottom side of this rubber stopper hole (so that the short tube will hang into the flask, almost reaching the bottom).

WEEKLY SETUP

- ❑ Get a large box (4-lb size) of baking soda from stock and place it in the experiment tub.
- ❑ Fill the 500-ml bottle with water. Add two drops of blue food coloring.

DAILY SETUP

- ❑ Set out the visitors' instructions in a Plexiglas stand.
- ❑ On a plastic tray with a white mat, set out the following:
  - One 500-ml Erlenmeyer flask
  - One 250-ml Erlenmeyer flask
  - Two small jars labeled "Citric Acid" and "Baking Soda"
  - One teaspoon labeled "Baking Soda" (placed next to the jar of baking soda)
  - One teaspoon labeled "Citric Acid" (placed next to the jar of citric acid)
  - Stopper/tubing apparatus: the apparatus should fit the glassware openings; check for large leaks
  - One 100-ml graduated cylinder
  - One 250-ml squeeze bottle labeled "Water (H_2O)"
  - One 400-ml beaker
- ❑ Fill the baking soda and citric acid jars.
- ❑ Fill the water bottle.
- ❑ Check the supply of citric acid and baking soda in the cabinet under the bench. Refill containers from stock if necessary.
- ❑ Pour 200 ml of blue water into the beaker.
- ❑ Check to see that there is at least 200 ml of blue water remaining in the storage bottle. If not, fill the bottle with water and add two drops of blue food coloring.

DAILY TAKEDOWN

- ❑ Empty the water from the squeeze bottle.
- ❑ Clean all glassware and inspect for damage.
- ❑ Pour the blue water back into the storage bottle.
- ❑ Tightly cap all bottles and store them in an upright position under the counter.
- ❑ Return countertop supplies to the tub under the counter.
- ❑ Close the citric acid jar or return its contents to the storage jar under the cabinet.

WEEKLY TAKEDOWN

- ❑ Return the large box (4-lb size) of baking soda to the household storage cabinet.
- ❑ Empty the jar of blue water.
- ❑ Rinse all glassware and sponge out the tub.
- ❑ Return the white mat to general lab storage.

RUNNING SUGGESTIONS

- ◊ Expect stoppers or tubing to pop out of the flasks due to the gas pressure.
- ◊ Check the stopper/tubing apparatus for correct connections.
- ◊ Watch to see that visitors place the loose end of the tube in the beaker.
- ◊ Make sure protective eyewear is on all visitors near this experiment.

EXTENSIONS

Show visitors that the gas produced is CO_2 (carbon dioxide) by "pouring" the gas over a lighted candle to extinguish the flame.

Note the pH changes by adding bromthymol blue indicator to the reaction flask. (Do not use water with food coloring.)

SAFETY & DISPOSAL

No special precautions are needed; follow standard lab safety procedures.