CHEM FAX!

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Seeing the Invisible

Chemical Demonstration Kit

Introduction

Carbon dioxide is an odorless, colorless gas. Place lit candles on a ramp; create some invisible CO_2 gas in a beaker, then "pour" the CO_2 down the ramp. The gas becomes dramatically visible to the students as successive candles are extinguished.

Science Concepts

- Buoyancy
- Gas density

Materials (for each demonstration)

Baking soda, $NaHCO_3$, 10 g*
Balance, 0.1-g precision
Beaker, 600-mL
Buret clamp
Clay, modeling*
Graduated cylinder, 100-mL
Matches
Ramp, clear plastic, 30 inches*
Ring stand
Tea candles, 5*
Vinegar, CH_3CO_2H, 100-mL*
Weighing dish

**Materials included in kit.*

Safety Precautions

While this demonstration is considered non-hazardous, wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron. Please consult current Material Safety Data Sheets for additional safety, handling, and disposal information.

A student worksheet is included as an optional assessment tool for the instructor.

Procedure

1. Attach a buret clamp to the ring stand. Place the clamp about seven inches above the base. Rotate the clamp so that it faces away from the ring stand base. See Figure 1.
2. Equally space and attach the five tea candles to the ramp with modeling clay, so that the candles are angled up from the surface of the ramp.
3. Place the top of the ramp on the buret clamp and the bottom of the ramp on the bench top. Secure the bottom in place with a piece of modeling clay. See Figure 2.
4. Adjust the position of the tea candles so that they are parallel to the bench top.
5. Mass 10 grams of baking soda and transfer the baking soda to the 600-mL beaker.
6. Measure out 100 mL of vinegar in a graduated cylinder.

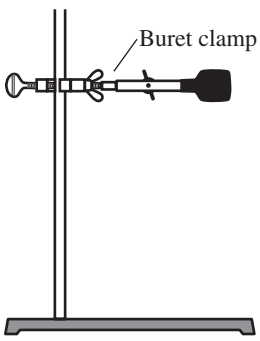

Figure 1.

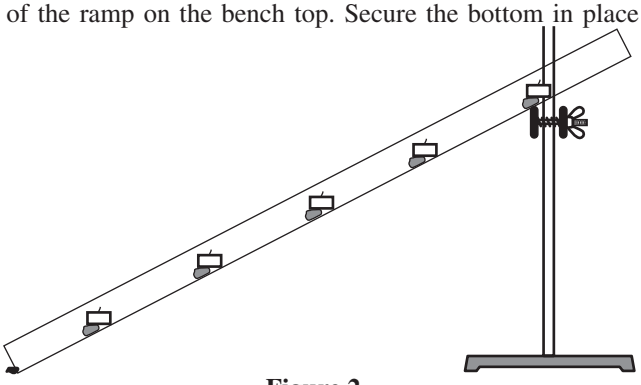

Figure 2.

7. Light the five tea candles.
8. Bring the 600-mL beaker up to the edge of the ramp, tilt the beaker 45 degrees, and then slowly add the vinegar to the beaker. Make sure the foam does not pour over the edge of the beaker and down the ramp.
9. Watch the candle flames go out one by one as the carbon dioxide "pours" down the ramp!

Disposal

The reaction solution may be disposed of according to Flinn Suggested Disposal Method #26b. Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory wastes.

Tips

- This kit contains enough materials to perform the demonstration at least seven times: 100 grams of baking soda, 750-mL of vinegar, one 30-inch ramp, ten tea candles, and one stick of modeling clay.
- Practice the demonstration until you are comfortable producing the correct amount of carbon dioxide when adding the vinegar to the beaker.
- Pick a demonstration area that is free from drafts and air currents. This is key.
- A variation of the demonstration uses an aquarium tank. Use blocks to place the candles at different heights. Place the beaker with baking soda in the bottom of the aquarium. Slowly add the vinegar to the beaker. The CO_2 will displace the air, extinguishing the candles from the bottom to the top. Experiment with the amounts of baking soda and vinegar to produce enough CO_2 to extinguish all the candles.

Discussion

When a dense solution of sugar is gently poured through water, little mixing occurs even though the sugar solution and the water are quite soluble. The water layer sits on top of the sugar solution.

Soluble gases act in the same way. Carbon dioxide has density of 1.80 kg/m^3 at STP, while that of air is 1.29 kg/m^3. When vinegar is added to the baking soda, carbon dioxide gas is generated.

$$\underset{\textit{Vinegar}}{CH_3CO_2H(aq)} + \underset{\textit{Baking soda}}{NaHCO_3(s)} \rightarrow \underset{\textit{Carbon dioxide}}{CO_2(g)} + \underset{\textit{Sodium acetate}}{NaCH_3CO_2(aq)} + \underset{\textit{Water}}{H_2O(l)} \qquad \textit{Equation 1}$$

As the amount of CO_2 increases, it flows over the lip of the beaker and down the ramp. The candles are extinguished one by one as the column of CO_2 flows over them.

Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

Unifying Concepts and Processes: Grades K–12
Evidence, models, and explanation
Content Standards: Grades 5–8
Content Standard A: Science as Inquiry
Content Standard B: Physical Science, properties and changes of properties in matter
Content Standards: Grades 9–12
Content Standard A: Science as Inquiry
Content Standard B: Physical Science, structure and properties of matter

Answers to Seeing the Invisible Worksheet *(Student answers will vary.)*

The reaction taking place in the beaker is;

$$\underset{\textit{Vinegar}}{CH_3CO_2H(aq)} + \underset{\textit{Baking Soda}}{NaHCO_3(s)} \rightarrow \underset{\textit{Carbon dioxide}}{CO_2(g)} + \underset{\textit{Acetate}}{CH_3CO_2^-(aq)} + \underset{\textit{Water}}{H_2O(l)}$$

1. What do the candles need to remain lit?

   The candles need a source of oxygen.

2. In what order were the candles extinguished?

   The candles were extinguished from top to bottom.

3. Why were the candles extinguished?

   As the carbon dioxide flowed down the ramp, the carbon dioxide displaced the air above each candle.

4. Carbon dioxide is soluble in air. Did the carbon dioxide from the reaction mix with the air? Why or why not?

   Because they candles were extinguished, the column of gases did not have any significant amount of oxygen, which it would if the carbon dioxide had mixed with the air.

5. Based on your observations, how does the density of the carbon dioxide compare to that of air?

   Because the carbon dioxide flowed down the ramp, it must be more dense that the air it displaced.

Acknowledgment

Special thanks to Jesse Bernstein, Hawken School, Gates Mills, OH and Randolph Femmer, New Smyrna Beach, FL, for sharing this demonstration with Flinn Scientific.

The *Seeing the Invisible—Chemical Demonstration Kit* is available from Flinn Scientific, Inc.

Catalog No.	Description
AP7046	Seeing the Invisible—Chemical Demonstration Kit

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

Name: _____

Seeing the Invisible Worksheet

The reaction taking place in the beaker is:

$$CH_3CO_2H(aq) + NaHCO_3(s) \rightarrow CO_2(g) + NaCH_3CO_2(aq) + H_2O(l)$$

Vinegar *Baking Soda* *Carbon dioxide* *Sodium acetate* *Water*

1. What do the candles need to remain lit?

2. In what order were the candles extinguished?

3. Why were the candles extinguished?

4. Carbon dioxide is soluble in air. Did the carbon dioxide from the reaction mix with the air? Why or why not?

5. Based on your observations, how does the density of the carbon dioxide compare to that of air?