Gaseous Diffusion and Effusion

Diffusion of Gases

Introduction

Show Graham's Law to students using this visual demonstration of the effusion of hydrogen through a porous cup.

Concepts

- Diffusion
- Effusion
- Graham's law

Materials

Food coloring, green
Hydrogen, lecture bottle
Water, tap
Beakers, borosilicate glass, Berzelius, 1-L
Cardboard, 6-inch square
Clamp, double buret
Glass tubing, 6-mm, 4-inch, 2
Lecture bottle regulator
Lecture bottle support
Porous cup
Ring support, 2-inch
Ring support, 4-inch
Stoppers, rubber, one-hole, 2
Support stands, 2
Tubing, latex, amber, 1/8-inch, 2-feet
Tubing, plastic, 1/8-inch, 1-foot
Tubing, plastic, 1/2-inch, 2-feet

Safety Precautions

Handle pressurized gas sources with caution. Hydrogen gas is flammable. Avoid contact of hydrogen with any ignition sources. Always wear chemical splash goggles whenever working with chemicals, glassware, or heat. Wash hands thoroughly with soap and water before leaving the laboratory. Follow all laboratory safety guidelines. Please review current Material Safety Data Sheets for additional safety, handling, and disposal information.

Preparation

Build the manometer and effusion apparatus

1. Clamp the two ring supports onto one support stand with the smaller ring support on the bottom.
2. Clamp the double buret clamp onto the second support stand.
3. Clamp the ½-inch plastic tubing into the double buret clamp to form a U shape (see Figure 1).
4. Insert each 4-inch piece of glass tubing into the two one-hole rubber stoppers.
5. Cut a hole in the center of the 6-inch cardboard square to accommodate the glass tubing.
6. Place the cardboard square on the small ring support.
7. Place the glass tubing in the size 7 stopper through the hold in the cardboard. Ensure the large side of the stopper is toward the cardboard (see Figure 2)
8. Attach one end of the latex tubing to the glass tubing that extends below the cardboard square.
9. Place the porous cup on top of the size 7 rubber stopper.
10. Place the 1-L Berzelius (tall form) beaker through the large ring support, onto the porous cup.

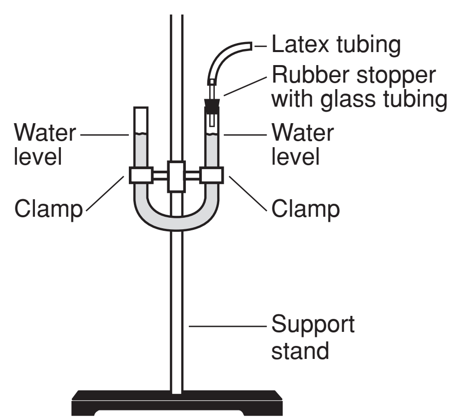

Figure 1.

11. Insert the second rubber stopper into one end of the ½-inch plastic tubing.
12. Attach the free end of the latex tubing onto the top side of the second rubber stopper-glass tubing setup.
13. Fill the ½-inch plastic tubing about ¾ full with green colored water.

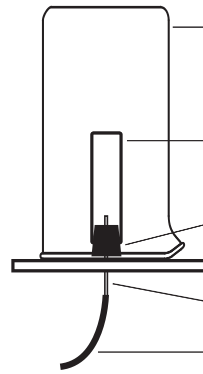

Figure 2.

Procedure

1. Remove the 1-L Berzelius (tall form) beaker from the ring support. Ensure the open end of the beaker is facing down and fill the beaker with hydrogen gas.
2. Carefully place the 1-L Berzelius (tall form) beaker back through the ring support so that it rests over the porous cup.
3. Immediately observe the water level in the manometer (U-shaped tubing).
4. After discussing the observations, remove the 1-L Berzelius (tall form) beaker from the porous cup and observe the water level a second time.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures, and review all federal, state and local regulations that may apply, before proceeding. The green water may be rinsed down the drain according to Flinn Suggested Disposal Method #26b.

Tips

- Other gases may be used instead of hydrogen; however, hydrogen will show the greatest change on the manometer.
- Gases heavier than air will also work but the apparatus must be adjusted so that the heavier gas is captured in the beaker and porous cup.
- The manometer built in this demonstration may be used to study Boyle's Law as well.

Discussion

Gas diffusion refers to the mixing of different gases throughout an enclosed space due to the random molecular motion of the gas particles. The rate of diffusion is controlled by the root mean square of the speed of the gas molecules. If two different gas molecules have the same average kinetic energy but have different masses, then the lighter molecules will move faster.

The kinetic-molecular theory (KMT) assumes that the particles in a gas are in constant motion and therefore predicts that the gas will eventually fill its container. The KMT also predicts that if two gases are added to a container, they will quickly mix and form a homogenous solution. The mixing of gases is called *diffusion*.

Effusion is similar to diffusion except that the gases must move through the pores of a container. Like diffusion, lighter gases such as hydrogen will move, and therefore effuse, faster than heavier gases such as nitrogen. *Graham's law of effusion* states that the rates of effusion for two gases are inversely proportional to the square roots of their molar masses if the two gases are at the same temperature and pressure.

Ensure that students understand that the hydrogen gas in the inverted beaker and the atmospheric nitrogen contained within the porous cup are under the same conditions of temperature and pressure before placing the hydrogen filled beaker over the porous cup. The lighter hydrogen gas diffuses inward through the pores in the porous cup, thereby increasing the pressure inside the cup. The increased pressure inside the porous cup causes the water level to be pushed down on the cup side of the manometer. This pushing causes the water level to rise on the opposite side of the manometer. Since both the hydrogen and nitrogen molecules are at the same temperature, the change in pressure is due to the hydrogen gas molecules traveling faster and colliding more frequently with the cup. More collisions means more instances in which hydrogen molecules pass through a pore in the cup creating a pressure increase inside the cup. The manometer level adjusts to reflect the increased pressure of the gases against the water inside the tubing of the manometer.

When the 1-L Berzelius (tall form) beaker is removed from the porous cup, the rapidly moving hydrogen molecules pass through the pores of the cup, decreasing the pressure inside the cup causing the manometer level to shift backward.

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
Constancy, change, and measurement
Evolution and equilibrium
Content Standards: Grades 5–8
Content Standard B: Physical Science, motions and forces
Content Standards: Grades 9–12
Content Standard B: Physical Science, motions and forces

Flinn Scientific—Teaching Chemistry™ eLearning Video Series

A video of the *Gaseous Diffusion and Effusion* activity, presented by Mike Roadruck, is available in *Diffusion of Gases*, part of the Flinn Scientific—Teaching Chemistry eLearning Video Series.

Materials for *Gaseous Diffusion and Effusion* are available from Flinn Scientific, Inc.

Catalog No.	Description
AP1065	Ring Support, 2-inch
AP1067	Ring Support, 4-inch
AP1312	Porous Cup
AP2076	Tubing, Latex, Amber, 1/8-inch, 10-feet
AP2261	Clamp, Double Buret
AP2307	Stopper, Rubber, One-Hole, Size 7
AP8226	Support Stands, 2
AP8373	Tubing, Plastic, 1/8-inch, 10-feet
AP8378	Tubing, Plastic, 1/2-inch, 10-feet
GP1061	Beakers, Borosilicate Glass, Berzelius, 1-L
GP9010	Glass Tubing, 7-mm, 24-inches
LB1015	Hydrogen, Lecture Bottle
LB1045	Lecture Bottle Support
LB1050	Lecture Bottle Regulator

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