Experiment 9
It's A Gas!

OUTCOMES

After completing this experiment, the student should be able to:

- generate small amounts of carbon dioxide, oxygen, and hydrogen.
- prove experimentally that gases comprise one of the states of matter.
- test various properties of a gas to aid in its identification.

DISCUSSION

Gases tend to be a rather abstract concept for many introductory science students. This is due to the fact that **<u>most</u>** (but **not all**) of the gases we regularly encounter are colorless, odorless, and tasteless. We have constant exposure to air. Dry air is composed of 78% by volume nitrogen and 21% by volume oxygen, yet we generally give little thought to these gases being present. However, almost all of us know that oxygen is vital for sustaining life on Earth.

Gases comprise one of the states of matter. Matter, by definition, is anything that has mass and occupies space. How could we *prove* that gases occupy space, other than just saying they are all around us? More challenging still, how could we *prove* that gases have mass? In other words, is it possible to *prove* that gases are, in fact, a state of matter? Rather than giving you an answer, see if you can determine how the results of this experiment confirm that gases may be defined as a state of matter.

In Part 1 of this experiment, three different gases will be generated and collected — oxygen, carbon dioxide, and hydrogen. Various properties of these gases will be tested. In Part 2, a portion of an Alka-Seltzer tablet will be dropped into water, generating a gas. The gas will be the same as one of the gases tested in Part 1. Properties of the gas will be examined to aid in its identification. The density of the gas will also be determined.

PROCEDURE

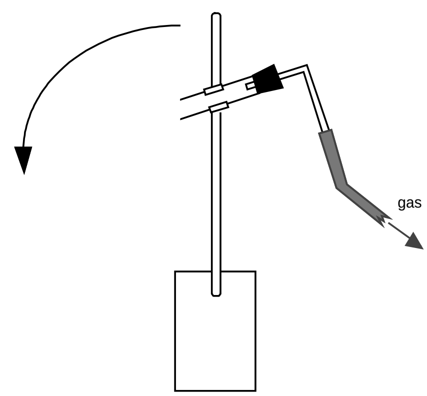
⚠ ***Wear large chemical splash goggles at all times for this experiment.*** *If the rubber hose should become inadvertently become pinched or plugged, the stopper may fly out, chemicals may spray, or the test tube may shatter causing serious injury to the eye.*

⚠ ***Wear gloves while working with the chemicals in this experiment.***

Part 1

1. Collect together the following materials: a ring stand with a clamp, a 25 × 200 mm test tube, a one-hole #4 rubber stopper fitted with a glass bend and a rubber hose, several clean 16 × 150 mm test tubes, several #0 solid rubber stoppers, and a bucket or pan of tap water about 2/3 full.

2. Set up the apparatus shown to the right, clamping the large test tube to the ring stand. Inspect the system to check for leaks. Be sure that the hose is long enough to comfortably reach the pan of water. Place the smaller test tubes into the pan of water and allow them to fill with water.



3. Instructions for generating hydrogen, oxygen, and carbon dioxide are on the next page. You may generate the gases in any order. **Please read the instructions below for step 4 first** so you're ready to collect the gas immediately once the reaction begins.

⚠ ***Make sure the rubber hose does not get pinched or plugged.***

4. To prepare for gas collection, invert the small test tubes in the pan of water. Keep the mouth of the test tubes under the surface of the water to prevent the water from draining out. Once gas production begins, you will place the end of the rubber hose under the mouth of the test tube and capture the bubbles in the test tube. Water will be displaced and the test tube will fill with the gas. **Discard the first one or two test tubes collected** by simply refilling them with water, as they will contain some of the air originally in the larger test tube. Stopper the tubes underwater to contain the gas, at which point they can be stored in the rack while you are performing your tests.

   If the bubbles stop before you have filled enough test tubes with gas, you may remove the stopper to the large test tube, quickly add more of one of the reactants, and quickly replace the stopper.

Use the following instructions to generate each of the gases. They may be generated in any order. Be sure you've read step 4 on the previous page before you begin producing any gas.

- **Hydrogen.** Using a graduated cylinder, measure 20 mL of 1 *M* acetic acid ($HC_2H_3O_2$) into the large test tube. Clamp the test tube to the ring stand at the approximate angle shown in the diagram above. Obtain 10-15 cm of magnesium ribbon (it should be precut), squeeze it into a ball, and place it in the test tube. Stopper as shown in the diagram. Tilt the ring stand so the magnesium slides into the acid. Collect 4-5 full test tubes of hydrogen gas (not counting the tubes you discard initially) as described in step 4 on the previous page, then perform the three chemical tests as described in step 5 on the next page, saving 1-2 test tubes of hydrogen for the additional tests in the following paragraph.

  With the remaining test tubes of hydrogen, experiment with how the flaming splint test can be affected by changes in position and time before testing. For instance, what happens when you perform the flaming splint test 5-10 seconds after removing the stopper? What happens if you hold the test tube straight up as you're performing the test? Is it any different when a test tube is held upside down as it is unstoppered and tested? What happens if you wait for 20-30 seconds before igniting?

- **Oxygen.** Using a graduated cylinder, measure 10 mL of 7.5% hydrogen peroxide (H_2O_2) into the large test tube and clamp the test tube to the ring stand. Add a portion of potassium iodide (KI) equivalent to the amount of about 2 peas. Stopper as shown above and, if necessary, tilt the ring stand so the crystal slides into the liquid. Collect 3-4 full test tubes of oxygen gas (not counting the tubes you discard initially) as described in step 4 on the previous page, then perform the three chemical tests as described in step 5 on the next page.

⚠ ***Use care when working with 6 M hydrochloric acid (HCl) – it causes serious chemical burns.*** *In the event of skin contact, immediately* ***rinse with cold water*** *and report it to your instructor.*

- **Carbon Dioxide.** Using a graduated cylinder, measure 5 mL of 6 *M* hydrochloric acid (HCl) in the large test tube and clamp it to the ring stand. Add several chips of calcium carbonate (also $CaCO_3$ or marble) equivalent to the amount of about 3 peas. Stopper as shown above and, if necessary, tilt the ring stand so the chips slide into the liquid. Collect 3-4 full test tubes of carbon dioxide gas (not counting the tubes you discard initially) as described in step 4 on the previous page, then perform the three chemical tests as described in step 5 on the next page.

5. After producing several test tubes of a gas, you will perform the following three tests on the gas, using a different test tube for each test. If you have extra test tubes of the gas remaining, repeat any tests that gave ambiguous results.

   - **Bromthymol blue test.** Add 5 drops of bromthymol blue indicator solution to one of the test tubes of gas. Stopper the test tube and gently shake. Record the color of the indicator.

⚠ ***Use the burner carefully. Never leave a burner unattended.***

   - **Flaming splint test.** Light a wood splint and gently insert the flaming end into a different test tube of the same gas, while holding the test tube sideways. Record what happens to the flame.

   - **Glowing splint test.** Light a wood splint and allow it to burn for several seconds. Blow out the flame to obtain glowing embers. Gently insert the splint about half of the way into a different test tube of the same gas while holding the test tube sideways. Record what happens to the splint.

⚠ ***Dispose of all chemicals in the proper waste container.***

6. When you are finished generating a gas, empty the contents of the large test tube into the waste container, and rinse the large test tube with deionized water between each of the gases you collect. Rinse the smaller test tubes with tap water and place them back into the pan of water to collect the remaining gases.

Part 2

1. Use the same apparatus set-up that you did in Part 1, except replace the smaller test tubes in the pan with a gas collection bottle. Also obtain one large and one small rubber band and half of a tablet of Alka-Seltzer (or a similar product). Do not allow the tablet to become moist (use dry fingers!) or it will begin to react. Wrap the tablet with the small rubber band.

2. Add 10 mL of water to the large test tube. Dry the inside of the upper 1/4 of the test tube. Do not allow the water to splash up the walls of the test tube. Set the test tube inside a 250 mL Erlenmeyer flask. Place the wrapped tablet and the Erlenmeyer flask holding the test tube onto a balance and record the combined mass.

3. Fill the gas collection bottle with tap water and place the large rubber band around the bottle. Cover the top of the bottle with a watch glass ensuring no air bubbles are trapped in the bottle. Invert the bottle and lower it into the pan, again ensuring no air bubbles are trapped inside the bottle.

4. Clamp the test tube into position on the ring stand as before. Using dry fingers, place the wrapped tablet in the upper portion of the test tube. Do NOT allow it to slide into the

water. Stopper the test tube and insert the rubber hose about halfway up inside of the gas collection bottle. Be sure that there is sufficient slack in the rubber hose. Set the bottle in a corner of the pan so it is slightly tilted and is not pinching the hose. Do not allow the bottle to tip over for the remainder of the experiment or else you will need to start over. Inspect the system for any leaks and check the gas collection bottle for air bubbles.

5. Tilt the ring stand as before causing the tablet to drop into the water. Do NOT allow the rubber hose to be pulled from inside the bottle. Right the ring stand and allow the reaction to proceed. Hold the bottle so it does not tip over. Continue collecting the gas until there is no more than one bubble every 30 seconds. Slide the large rubber band either up or down so it is at the same level as the water inside the bottle. The rubber band marks the volume of gas that was collected in the bottle.

6. Cover the mouth of the bottle with your fingers or a bottle cap, remove the bottle from the pan, and turn the bottle upright. Keep the top of the bottle covered with a watch glass or bottle cap. Lower a flaming splint into the gas. What happens to the flame? Add 10 drops of bromthymol blue indicator to the water in the bottle. Gently swirl the water and note its color. If the color is too faint, add additional drops of bromthymol blue until the color is evident. It may be helpful to compare this color with that of a small beaker of deionized water to which you have added 10 drops of the indicator. Compare these results with your results from Part 1. Which gas was generated by the Alka-Seltzer tablet?

7. In order to calculate the density of the gas, we must measure the mass and volume of the gas generated. Remove the test tube from the clamp, put it into the same 250 mL Erlenmeyer flask as before, and weigh it on the same balance. Record the combined mass. How do you find the mass of the gas that was generated?

8. Recall that the large rubber band marked the volume of gas in the bottle. The gas filled the space from the bottom of the bottle up to the rubber band. How can we measure this volume? Simply fill the bottle with water up to the line marked by the rubber band. Pour the water from the gas collection bottle into a graduated cylinder and measure the volume of the water. The volume of water in the bottle is equal to the volume of gas produced.

Name____ Lab Section________________

PRELAB QUESTIONS

1. What are some general characteristics of ***<u>ALL</u>*** gases? (Not just some) You may need to consult your textbook or the internet.

2. Name two gases NOT mentioned in this experiment.

3. What is contained in a clean, dry test tube? (Is it really empty?)

4. If a chemical reaction produces a gas, how can that gas be captured in a test tube?

5. List all safety precautions that must be observed during this experiment.

Name____ Lab Section______________

Partner's Name__________________________________

DATA

Part 1

Gas	Bromthymol Blue Test	Flaming Splint Test	Glowing Splint Test
hydrogen			
oxygen			
carbon dioxide			

Part 2

Read your directions carefully **before** collecting data in this Part!

Make sure each measurement has correct units.

Mass of the flask, test tube, water, and tablet BEFORE the reaction	
Mass of the flask, test tube, and contents AFTER the reaction	
Mass of gas generated	
Volume of gas generated	
Color of the bromthymol blue indicator AFTER the reaction	
Flaming splint test	
Identity of the gas collected in Part 2	

Name____ Lab Section________________

Partner's Name_____________________________________

POSTLAB QUESTIONS

1. Bromthymol blue indicator is blue in basic solution, bluish-green at a neutral pH of 7.0, and greenish-yellow or yellow in an acidic solution. Did any of the gases cause the bromthymol blue to change color – *i.e.*, were any of the gases acidic? If so, which one(s)?

2. Which gas produced in this experiment…

   a. is flammable (the gas itself burns)?

   b. ***only*** extinguishes a flame?

   c. supports combustion (the gas allows something else to burn)?

3. What mass of gas was collected in Part 2? What volume of gas was collected? Convert the volume of gas collected to liters. Show your work.

4. The densities of gases are usually reported in units of gram per liter, since the densities are quite small in units of grams per milliliter. What was the density of the gas collected in Part 2 in g/L? Show your work.

5. What were the differences in the flaming splint tests with the hydrogen gas when changing the position of the test tube or the amount of time the test tube is left open? Speculate as to the reason for these differences.

6. How does this experiment prove that gases are a form of matter?