

Experiment: Reaction of Hydrogen and Oxygen

Introduction

Hydrogen is a clear, colorless gas which is said to be "combustible," meaning that it can burn quite readily. Oxygen is also a clear, colorless gas that is said to "support combustion," meaning that it must be present for combustible materials to burn. In this lab, you will be generating, collecting, and testing hydrogen and oxygen gas.

Hydrochloric acid is reacted with zinc to generate hydrogen. In general, any strong acid and many different metals react to produce hydrogen gas. Hydrogen peroxide is added to manganese dioxide to generate the oxygen. Hydrogen peroxide decomposes by itself to produce water and oxygen gas at a slow, imperceptible rate; the manganese dioxide acts as a catalyst to speed up this reaction. By collecting and pop-testing (igniting) different hydrogen/oxygen mixtures, you will audibly compare them to determine the most reactive (loudest) mixture, which will be the optimal stoichiometric ratio for reaction.

Objectives

In this lab you will

- ✓ Write chemical equations to represent chemical reactions.
- ✓ Manipulate the ratio of reactants to investigate the stoichiometric relationship of a chemical reaction.
- ✓ Determine the limiting reactant in a chemical reaction.

Hazards

Since this lab is performed on the microscale level, the explosions, though potentially loud, are safe; however, sometimes the explosions can occur in the pipet bulb. This can be avoided by moving the bulb away from the flame immediately after squeezing the bulb without allowing gases back into the bulb.

The two solutions used in this lab, hydrochloric acid (HCl) and hydrogen peroxide (H₂O₂), can cause serious damage should they come in contact with your eyes. Use them with caution!

Procedure

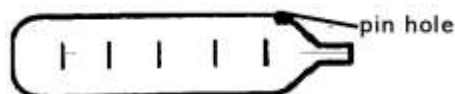
1. Fill a 250 mL beaker with tap water. This will act as a test tube holder, a temperature regulator, and a water reserve during the experiment.
2. Label two test tubes; one is a hydrogen generator, the other an oxygen generator.
 - To make the hydrogen generator: place approximately six pieces of zinc shot into the appropriately labeled test tube and add enough 3M HCl to fill the test tube to within 4 cm from the top. Top with a one-hole stopper.
 - To make the oxygen generator: place a small spatula full of MnO₂ into the appropriately labeled test tube. Add about 3 mL of 7.5% hydrogen peroxide. Top with a one-hole stopper. When oxygen production



slows down, add another 3 mL of 7.5% hydrogen peroxide. Repeat as needed; when tube gets to within 4 cm from the top, start a new tube.

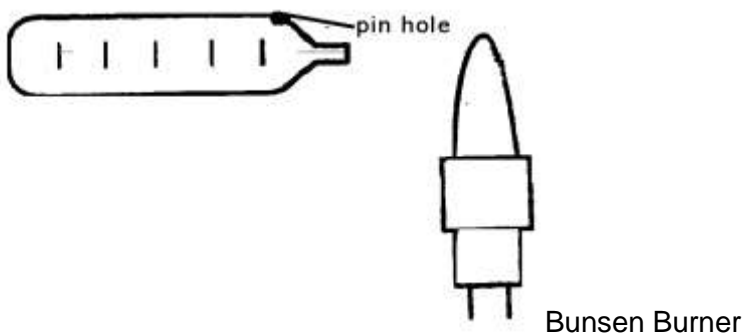
- Place both generators into the 250 mL beaker.

3. Cut off the long end of a polyethylene pipet leaving approximately a one-centimeter tip. Using a push pin, pierce the pipet near the end of the tip. (Alternately, this may be done for you ahead of time.) Mark the polyethylene pipet with a permanent marker to show approximately six equal-volume increments. This pipet will be referred to as the "collection bulb".



4. Fill the collection bulb with water. Do this by submerging it in water (open end up) and gently squeezing the bulb.

5. Insert the tip of the collection bulb into the one-hole stopper on the top of the hydrogen generator. Begin collecting hydrogen gas. You can sometimes speed up this collection process by using your finger to put slight pressure on the top of the bulb. This helps create a better seal between the bulb and the one hole stopper. (Do not squeeze the bulb too much, as this may introduce air into the bulb.) After you have collected a bulb of hydrogen gas, hold the bulb with the narrow end down to prevent losing hydrogen gas. (There may be a few drops of water, but this is ok. The water will act as a seal to prevent the gas from escaping into the room.) Keeping the bulb vertical, move it toward the flame. Quickly rotate it to a horizontal position with its mouth roughly 3-4 cm from the mid-section of the flame. Gently squeeze the contents of the bulb into the flame and observe. (If nothing happens, try squeezing the bulb again.) Avoid putting the bulb directly into the flame. It will melt and possibly burn. Should this happen, quench the tip in a beaker of water. Repeat this step until you obtain reproducible results.



6. Repeat the above, but this time collect oxygen gas. *****What seems different this time?*****

7. Repeat the above but this time collect and test all different possible ratios of hydrogen and oxygen gas in the same bulb. Do this by transferring the bulb from one generator to the other. During this transfer, hold the pipet with the open end "down".

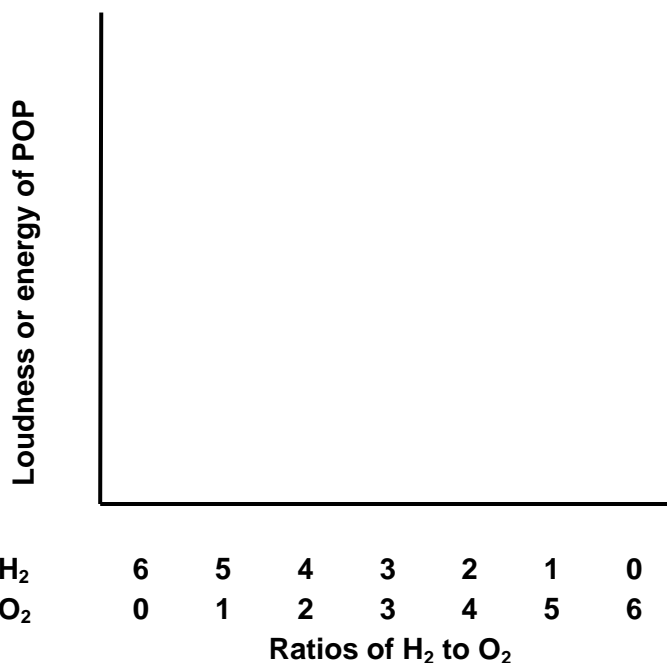
8. Put the liquid wastes into the proper waste container in the hood. Note that there are two separate waste containers so that the zinc and MnO_2 may be collected for reuse. The pipet bulbs may also be collected for reuse.

ReportHydrogen and Oxygen
CHEM& 121

Name _____ Section _____

Lab Partner _____

1. Use this template to create a bar graph showing the relative loudness of each of the samples that you tested (including the pure hydrogen and oxygen).



2. Write a balanced equation for the reaction taking place inside the hydrogen generator (the test tube containing Zn and HCl).

Solid zinc and aqueous hydrochloric acid react to generate hydrogen gas and aqueous zinc chloride.

3. Write a balanced equation for the reaction taking place inside the oxygen generator (the test tube containing H₂O₂). Hint: MnO₂ is a catalyst for this decomposition reaction. It is neither a reactant nor a product. You do NOT need to display it in the chemical equation.

Aqueous hydrogen peroxide decomposes to create liquid water and oxygen gas.

4. Based on your results, what ratio of hydrogen to oxygen ($H_2:O_2$) produced the most explosive mixture? ___ : ___

Compare your data with others. Give two possible reasons why the results may vary among different teams.

What ratio was the most explosive for the class overall? ___ : ___

5. Write a balanced equation for the reaction of hydrogen and oxygen to make water.

Based on the balanced equation, what should be the most explosive ratio of hydrogen to oxygen?

Explain. Note: The ratio of the reacting volumes of gases is equal to the mole ratios of the reacting gases.

6. Did you find any reaction bulbs that produced no explosion at all? Explain how that could happen?

7. Why don't the hydrogen and oxygen in the collection bulb react as soon as they mix? What role does the flame play?

8. For which ratios of $H_2:O_2$ was hydrogen the limiting reactant? _____
Show one calculation to support your answer.

For which ratios of $H_2:O_2$ was oxygen the limiting reactant? _____
Show one calculation to support your answer.

Prelab

Name _____ Section _____

Hydrogen and Oxygen
CHEM& 121

1. Write a balanced equation for the reaction of hydrogen gas and oxygen gas to form liquid water. Include physical states.

2. List all the ways you could classify the above reaction. (What type(s) of reaction?)

3. When collecting the hydrogen and oxygen gases, the collection bulb is initially filled with water. What happens to the water as the gas is collected? (Review the procedure.)

4. Challenge Question: If one mole of hydrogen gas is reacted with one mole of oxygen gas, which one is the limiting reactant (which one gets used up completely)? Explain.

HINT: It might help to think of this at the molecular level.