Micro Mole Rockets

Hydrogen and Oxygen Mole Ratio

As adapted from Flinn ChemTopic- Labs - Molar Relationships & Stoichiometry

Introduction

The combustion reaction of hydrogen and oxygen is used to produce the explosive energy needed to power the space shuttle. The reaction is also being engineered to serve as a source of continuous energy for fuel cells in electric vehicles. What factors determine the explosiveness of the reaction of hydrogen with oxygen? In this lab, we will generate microscale quantities of hydrogen and oxygen and test their explosive nature.

Concepts

• Mole ratio, Stoichiometry, Combustion, Limiting reactants

Background

Hydrogen, the most abundant element in the universe, is a colorless, odorless gas. It is combustible, which means that it burns quite readily. Hydrogen gas is conveniently generated in the lab by the reaction of zinc metal with hydrochloric acid.

Oxygen, the most abundant element on Earth, is also a colorless, odorless gas. Oxygen gas supports combustion, that is, it must be present for combustible materials to burn. Small scale quantities of oxygen gas are conveniently generated in the lab by the decomposition of hydrogen peroxide. The decomposition reaction of hydrogen peroxide requires a catalyst to initiate the reaction. A variety of different catalysts, including manganese, manganese dioxide, potassium iodide, and even yeast, have been used in this reaction. In this lab, yeast will be used to catalyze the decomposition of hydrogen peroxide and generate oxygen gas.

Experiment Overview

The ultimate goal of this lab is to determine the composition of the most "powerful" gas mixture of oxygen and hydrogen by using it to launch a rocket across the room! In order to do this, you will need to first determine the best ratio of hydrogen to oxygen fuel. Use the data table below to start your data collection for this lab. Each time a launch is done, data should be recorded and your data from the lab will be **TURNED IN WITH THE LAB WRITE-UP!** **Note:** Your data table should change as you change the focus of your tests.

Hydrogen	Oxygen	Trial 1 Distance	Trial 2 Distance	Notes
5	1			
4	2			
3	3			
2	4			
1	5			

- The group in each class obtaining the greatest horizontal launch distance will receive 5 bonus points.
- The group achieving the greatest launch distance across all chemistry classes will receive an additional 5 bonus points.
- For a launch distance to count, the INSTRUCTOR MUST OBSERVE THE LAUNCH AND THE SUBSEQUENT MEASUREMENT! Groups thinking they have optimized their ratios must let their instructor know before the launch.

Materials

Hydrochloric acid, HCI, 3 M, 15 mL
Hydrogen peroxide, H_20_2, 3%, 15 ml
Yeast suspension, 2%, 5 ml
Zinc, mossy, Zn, about 5 g
Graduated cylinder, 10-ml
Marker (permanent pen)
One-hole rubber stoppers, to fit test tubes, 2
Test tube rack
Test tubes, small, 2
Pipets, Beral-type, graduated, 1
Scoopula

Safety Precautions

Hydrochloric acid is toxic by ingestion and inhalation and is corrosive to skin and eyes. Hydrogen peroxide is a skin and eye irritant. Avoid contact of all chemicals with skin and eyes and notify your teacher immediately in the case of a spill. Wear chemical splash goggles and chemical-resistant gloves and apron. Wash hands thoroughly with soap and water before leaving the laboratory.

Construct Gas Generators

1. The gas generators consist of a small test tube, a rubber stopper, a gas delivery tube, and a gas collection bulb. See Figure 1.
2. Cut four Beral-type pipets as shown in Figure 1b to obtain four gas-collecting bulbs and four gas-delivery tubes. Discard the middle part of the pipet stem. It is important that the pipet bulbs have similar lengths. Trim the lengths so they are equal.
3. Place the gas delivery tube ends into the tops of rubber stoppers as shown in Figure 1.

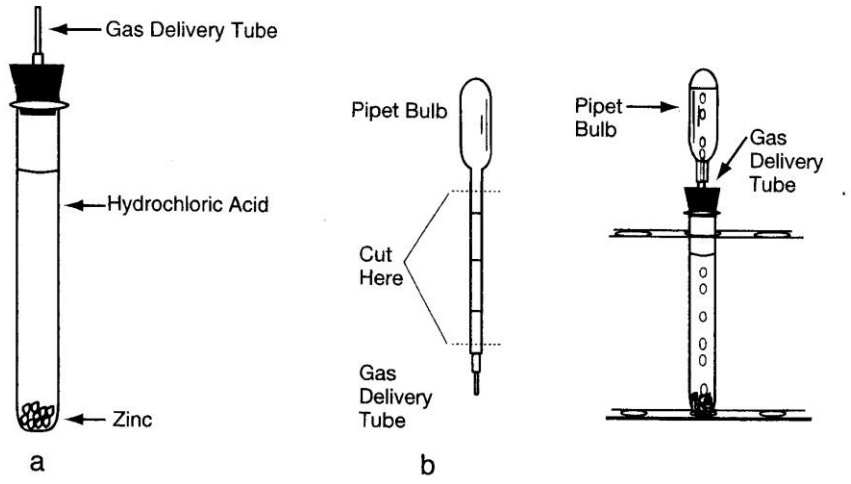

Figure 1. Constructing a Gas Generator

4. Prepare a hydrogen gas generator by placing about four pieces of mossy zinc into the bottom of a small test tube marked "HCl".
5. Prepare an oxygen gas generator by placing about 2 mL of yeast suspension into the bottom of the other small test tube marked "H_2O_2".
6. Set the test tubes in a test tube rack.

Calibrate Gas Collection Bulbs

7. Fill a 250-ml, beaker about one-half full with tap water. (You can also fill up the rocket using running water in the sink.
8. Immerse one of the cut-off pipet bulbs under water. Fill the bulb completely with water and remove it from the beaker.
9. Squeeze the water out of the pipet bulb into an empty graduated cylinder to measure the total volume (V) of water in the bulb.
10. Divide the pipet bulb into six, equal-volume increments by following steps 11-12.
11, Refill the pipet bulb, and then squeeze out one-sixth of the total volume (V/6) into an empty graduated cylinder. Release the squeeze and use a permanent pen to mark the water-level on the side of the bulb.
12. Squeeze out a second V/6 volume, mark the level again, and repeat for the remainder of the water. This should serve to divide the bulb into six, equal-volume increments.
13. Once the first pipet bulb has been calibrated, the rest can be copied to save time. Simply rest a wood splint across the bulb, with the end of the splint flush with the end of the bulb, and mark off the splint at the same places that the bulb is marked. Then use the splint as a template to mark the rest of the bulbs.

Generating and Collecting the Gases

14. To generate hydrogen gas, add 3 M hydrochloric acid to the mossy zinc in one of the hydrogen gas generators until the liquid level is about 1 cm below the mouth of the test tube. Cap the tube with the gas delivery stopper. *Note:* Wait about one minute before collecting gas within your bulb (i.e. rocket). This will allow time for the air to be purged from the test tube.
15. Add 3% hydrogen peroxide to the yeast suspension in one of the oxygen gas generators until the liquid level is about 1 cm below the mouth of the test tube. Cap the tube with the gas delivery stopper. *Note:* Wait about one minute before collecting gas within your rocket.
16. To collect a quantity of gas, fill your bulb (rocket) completely with water. Invert the opened end of the bulb over the tip of the pipet located in the stopper of your oxygen or hydrogen gas generator. Fill your bulb with the amount of gas desired. Important: always leave a little bit of water within your bulb to serve as a water seal. When your rocket is full of gas (oxygen and/or hydrogen), you are ready to launch!

YOUR WRITE-UP

1. Provide your final distance and the ratio of the volume of oxygen gas to the volume of hydrogen gas you used on your best trial.
2. Provide all stoichiometric calculations (including balanced chemical equations) that are necessary to determine the stoichiometric (ideal) ratio of gas volumes.
3. Compare your optimum ratio determined in this project experimentally to the stoichiometric ratio of oxygen and hydrogen gas. Comment and offer an explanation to any discrepancy you observed.

- Your score for this project depends upon the accuracy, completeness, and quality of your responses to these three items.