Pipette Rocket Lab

Objective:

Determine the optimal ratios of hydrogen and oxygen needed to launch pipette "rockets."

Your teacher will prepare gas generators using the following materials:

Hydrogen Gas Generator:

- 15 mL 1 M hydrochloric acid, HCl
- (5) 50 g zinc, Zn (mossy)

Oxygen Gas Generator:

- 15 mL 1% hydrogen peroxide, H_2O_2 (diluted from 3% stock solution)
- 5 mL 2% yeast suspension

Materials:

- (2) 20 oz plastic bottles with caps
- (2) Petri dishes
- 250 mL beaker with water
- 10 mL graduated cylinder
- paper towels
- piezo sparker with speaker wire attached for igniter
- (4) Beral-type pipettes
- permanent marker

Students should follow all safety protocols. Chemical splash goggles must be worn throughout this activity. Additionally, students should wear chemical-resistant gloves and a chemical-resistant apron. Hydrochloric acid is corrosive to skin and eyes and is toxic if ingested or inhaled. Hydrogen peroxide is a skin and eye irritant. Avoid chemical contact with skin and eyes, and notify your teacher immediately in the case of a spill. Upon completion of the activity, all materials should be disposed of properly and students should wash their hands thoroughly with soap and water.

Procedure:

Build Gas Generators

These will be prepared in advance by your teacher.

Mark the Gas Collection Bulbs

1. Pour tap water into a 250 mL beaker until it is half full.
2. Put one of the cut-off pipette bulbs under water. Fill the bulb completely with water and remove it from the beaker. You will likely need to turn it upside down and squeeze out the air, then dip it into the water again to completely fill it.
3. Squeeze the water out of the pipette bulb into an empty graduated cylinder to measure the total volume (V) of water in the bulb.
4. Use the marker to divide the contents of the pipette bulbs into six, equal-volume increments. Refill the pipette bulb, 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. 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. (Pipette calibration may be done by the teacher in advance.)
5. Once the first pipette bulb has been calibrated, the rest of the pipette bulbs can be copied to save time. Simply rest a wooden 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.

Collect and Test Hydrogen and Oxygen Gases Independently

1. Add 50 mL 3 M hydrochloric acid to the mossy zinc in the hydrogen gas generators. Cap the bottle. Wait approximately one minute before proceeding to the next step. This will allow time for the air to be released through the hole in the cap of the bottle.
2. Completely fill a marked pipette bulb with water and place the bulb over the gas delivery tube to collect hydrogen gas. The hydrogen gas will gradually replace the water, which will flow out of the bulb and down the sides.
3. As soon as the bulb is filled with hydrogen, remove it from the gas delivery tube and immediately place your finger over the mouth of the bulb to keep the hydrogen inside.
4. You can make a piezoelectric igniter by using hot glue to attach a three-inch speaker wire next to the sparker of an empty (without fuel) gas grill lighter. Hold the gas bulb so the opening is pointed upward and have a classmate ignite the gas in the pipette by placing the pipette onto the igniter wire and pulling the trigger. If you do not have an igniter, you may use a safety match. Listen for the sound made by the combustion, if any. Rate the sound on a scale of loudness, with 0 being no sound and 10 being a very loud sound. Record the results of the hydrogen pop test in the data table.

5. Add 100 mL 3% hydrogen peroxide to the yeast suspension in one of the oxygen gas generators. Cap the bottle. Wait approximately one minute before proceeding to the next step. This will allow time for the air to be released from the hole in the cap of the bottle.
6. Repeat the steps above to collect oxygen. Record the results of the oxygen pop-test in a data table.

Collect and Test the Oxygen and Hydrogen Gas Mixtures

1. Fill a marked pipette bulb completely with water as described above, and place it over the hole in the cap of the oxygen gas generator to collect oxygen.
2. When the bulb is one-sixth full of oxygen, quickly remove it from the oxygen generator bottle and place it over the hydrogen gas generator.
3. Collect hydrogen until the bulb is filled with gas. This bulb will contain a 1:5 ratio of oxygen and hydrogen.
4. Remove the bulb, placing your finger over the opening to keep the gas inside. Conduct the pop-test to determine its relative loudness as described above for hydrogen and oxygen. Create a scale to record how loud this mixture is compared to pure hydrogen and pure oxygen. Record the results in your data table.
5. Repeat the steps above to collect and test additional volume ratios (2:4, 3:3, 4:2, 5:1) of oxygen and hydrogen according to your data table. Always collect oxygen first, followed by hydrogen. Record all results in your data table.
6. Rank the gas mixtures according to your loudness scale from the pop-test. This ratio will help you to confirm the correct balanced equation for the combustion reaction.

Be sure to collect various gas mixtures as many times as needed to determine the optimum ratio of oxygen and hydrogen for combustion.

NOTE: The pop-test is obviously subjective, but by repeating it several times with each possible mixture, it should be possible to determine the most explosive (loudest) gas mixture.

Rocket Launches

With your teacher's permission, use the optimal mix of hydrogen and oxygen to launch pipette rockets at the cardboard target as demonstrated by our students. You may wish to try several different launch methods. For example, leave a small amount of water in the pipette before igniting the gas mixture. The water will act as a heavy propellant which will probably push the rocket much farther. Try measuring the distance travelled by the rocket using various combinations of hydrogen, oxygen, and water.

More information supporting this activity can be found here:
https://www.flinnsci.com/media/621403/91612.pdf