Fuel Cell Football

Limiting and Excess Reactants

Introduction

This inexpensive demonstration can be used to illustrate many different scientific principles. When properly filled with a mixture of hydrogen and oxygen, a jumbo-sized plastic pipet bulb can be projected 20–30 feet across a classroom. The goal of this activity is to make a "chemical field goal" by sending the pipet bulb through the goal post on the opposite side of the classroom.

Concepts

- Balancing equations
- Stoichiometry of gases
- Conservation of momentum

Materials

Hydrochloric acid, HCl, 2 M, 30 mL
Hydrogen peroxide, H_2O_2, 3%, 30 mL
Yeast
Zinc, mossy
Assembled launch pads and goal post
Gas generating vials
Plastic plate

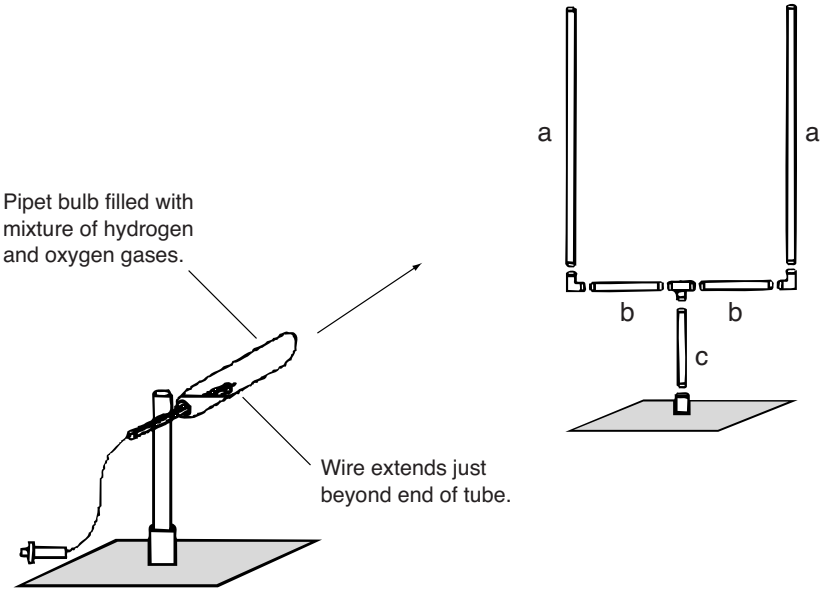

Figure 1. The basic layout of the football field.

Safety Precautions

Hydrochloric acid and hydrogen peroxide are corrosive to body tissue; avoid all body tissue contact. While the quantities of hydrogen gas used in this reaction are fairly small, proper care must be taken to insure that no open flames are present in the classroom. Wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron. 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

Before beginning this activity, review the Fuel Cell Football: Construction Notes at the end of this ChemFax for instructions on how to build the piezoelectric igniter, launch pad, and goal post assembly.

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Procedure

1. Pour 30 mL of 2 M HCl into one vial and add 2–3 small pieces of mossy zinc.
2. Snap the lid onto the vial and set aside. This will serve as the hydrogen gas generator and should be labeled H_2 (see Figure 2).
3. Pour 30 mL of 3% H_2O_2 into a second vial.
4. Add about 10 grains of yeast to the bottle containing hydrogen peroxide and then replace the cap to the vial. This vial will serve as the oxygen generator and should be labeled O_2 (see Figure 2).

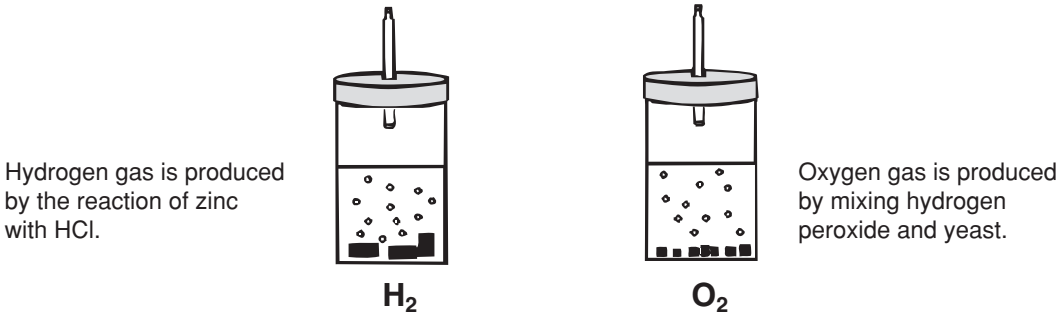

Figure 2. Diagram showing the two gas generating vials.

5. Place the labeled vials on a plastic plate.
6. Fill the jumbo pipet bulb with water. Hold the water-filled pipet bulb so that the opening is pointed downward. The water will remain inside the pipet bulb.
7. Collect the hydrogen and oxygen gases by water displacement as shown below in Figure 3. If this is done over the plastic plate, the water from the pipet bulb will be contained.

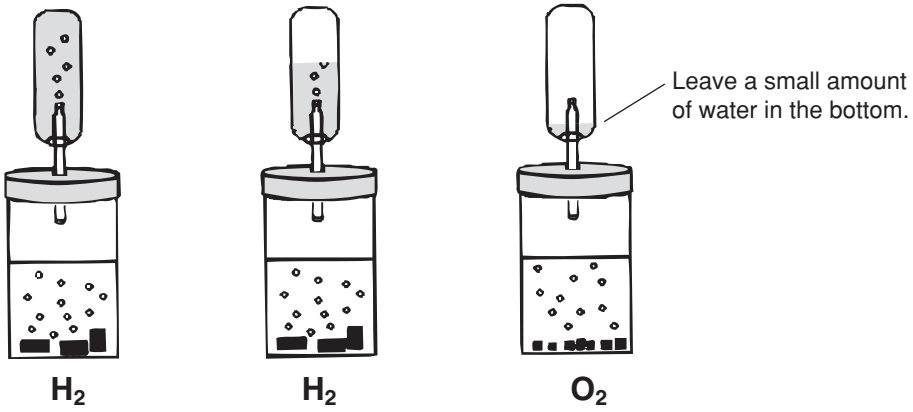

Figure 3. Collection of gases by water displacement.

8. When almost all of the water has been displaced, remove the bulb from the gas generator and carry the bulb (with the opening pointed downward) to the launch pad. Slide the pipet bulb over the brass tube.
9. Stand back and press the Piezoelectric igniter to initiate the chemical reaction.

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 materials in the hydrogen gas generating bottles may be poured into a large beaker inside a fume hood. Any excess acid may be neutralized with baking soda before being rinsed down the drain with plenty of water according to Flinn Suggested Disposal Method #24b. The materials used in the oxygen generating bottles may be rinsed directly down the drain with water according to Flinn Suggested Disposal Method #26b.

Discussion

The chemical reaction between hydrogen and oxygen is exothermic. Fuel cells often utilize this chemical reaction to produce energy. This experiment will take advantage of this release of energy to propel a jumbo-sized plastic pipet bulb across the classroom.

Once the hydrogen and oxygen gases are inside the pipet bulb, an electrical spark is needed to initiate the reaction. The Piezoelectric igniter provides this spark after the pipet is placed on the launch pad.

The following chemical reaction is used to produce the hydrogen gas.

$$Zn(s) + 2HCl(aq) \rightarrow H_2(g) + ZnCl_2(aq)$$

The oxygen gas is prepared from the following reaction.

$$2H_2O_2(aq) + \text{yeast} \rightarrow O_2(g) + 2H_2O(l)$$

Inside the bulb of the rocket, the following reaction occurs.

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$$

The volume of water that remains inside the rocket is an important variable because it provides the forward force for the rocket when the chemical reaction is initiated.

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
Content Standards: Grades 5–8
Content Standard B: Physical Science, properties and changes of properties in matter
Content Standard F: Science in Personal and Social Perspectives, science and technology in society
Content Standards: Grades 9–12
Content Standard B: Physical Science, chemical reactions
Content Standard F: Science in Personal and Social Perspectives, science and technology in local, national, and global challenges

References

Brouwer, H. *J. Chem. Educ.* **1993**, *70*, 329.

Clift, P. A. *The Science Teacher*, October, 1992, p. 23–25.

Rohr, W. Flinn Scientific's Morning of Chemistry, NSTA Convention, New Orleans, 1997.

Goalpost dimensions can be found at http://www.optonline.com/comptons/ceo/01709_A.html

Flinn Scientific—Teaching Chemistry™ eLearning Video Series

A video of the *Fuel Cell Football* activity, presented by Jeff Bracken, is available in *Limiting and Excess Reactants* as well as *Hydrogen and Oxygen Explosions*, part of the Flinn Scientific—Teaching Chemistry eLearning Video Series.

Materials for *Fuel Cell Football* are available from Flinn Scientific, Inc.

Materials required to perform this activity are available in the *Micro Mole Rockets—Student Laboratory Kit* available from Flinn Scientific. Materials may also be purchased separately.

Catalog No.	Description
AP6374	Micro Mole Rockets—Student Laboratory Kit
H0034	Hydrochloric Acid Solution, 3 M, 500 mL
H0009	Hydrogen Peroxide, 3%, 473 mL
Z0003	Zinc, Mossy, 500 g
AP6286	Piezoelectric Igniter

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

Fuel Cell Football: Construction Notes

Piezoelectric Igniter Assembly

Materials

Copper wire, insulated, 22 cm

Piezoelectric igniter

Tape, electrical

Tape, transparent

Figure 1.

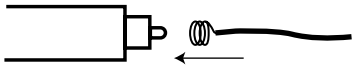

Figure 2.

Procedure

1. Cut two pieces of insulated copper wire, about 10 cm and 12 cm, respectively. Strip about 1.5 cm of insulation off the end of the shorter wire and about 1 cm off the end of the longer wire (Figure 1).
2. Curl the 1.5 cm end of bare wire around a pencil to make a small, tight coil. Insert the coil around the metal post in the center of the piezoelectric igniter (Figure 2).
3. Line up the bare wire end of the second piece of insulated wire directly on top of the bare copper wire that runs down the side of the piezoelectric igniter (Figure 3). Using transparent tape, tape the stripped wire to the copper wire on the piezoelectric igniter as shown.
4. Line up the two pieces of insulated wire and tape them together just above the metal post (Figure 4).
5. Cut the insulated ends of the two pieces of wire so they are the same length. Tape the insulated ends together so there is only a small "spark gap" between the wires (Figure 5). This is the sparking portion of the modified igniter.
6. Wrap the body of the igniter with electrical tape for safety.

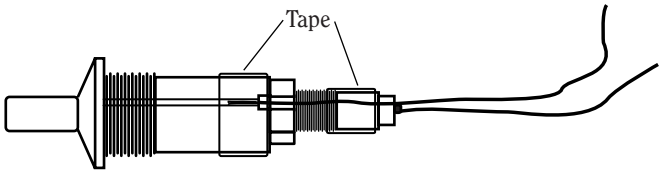

Figure 3.

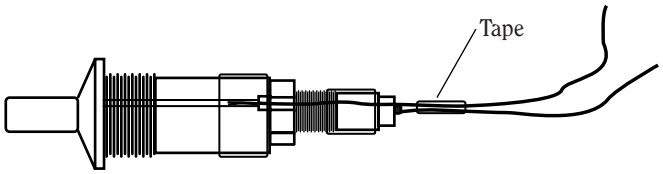

Figure 4.

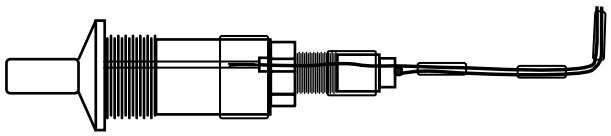

Figure 5.
(Wrap with electrical tape when done.)

Launch Pad Assembly

Materials

Brass tubing, 12 cm, 5/32″ diameter

Drill

PVC cement

PVC coupling, ¾″, 2

PVC pipe, ¾″ diameter

Procedure

1. Use PVC cement to attach a ¾″ PVC coupling to 20 cm × 20 cm Plexiglas square.
2. Insert a 30 cm length of PVC pipe into the coupling. Drill a small hole into the PVC pipe.
3. On the opposite side of the PVC pipe, drill a second hole. The location of this hole depends on the height of your classroom ceilings. Slide the brass tubing through the two holes. The tubing should be held tight by the PVC pipe. You will need to determine the best angle for the brass tubing so that the pipet bulbs can be shot across the classroom without hitting the ceiling.
4. Slide the end of the speaker wire through the tube so that it just extends beyond the upper end of the brass tubing. Test the Piezoelectric igniter to insure that an electrical spark occurs at the end of the wire.

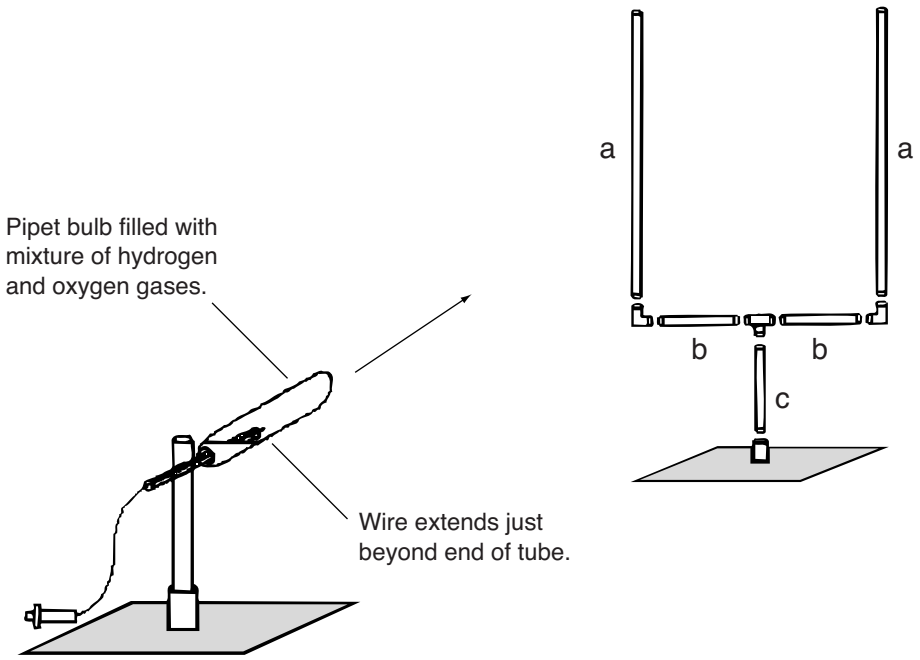

Figure 1. The basic layout of the football field.

Goalpost Assembly

Materials

Plexiglas square, 20 cm × 20 cm
PVC cement
PVC coupling, ¾″
PVC Pipe (¾″ diameter)
Yellow spray paint

Procedure

1. Cut the PVC pipe to the dimensions as shown in the figure where a = 130.6 cm, b = 40.2 cm, and c = 43.5 cm. These dimensions are one-seventh the scale of a National Football League goalpost.
2. Use PVC cement to attach the PVC coupling to 20 cm × 20 cm Plexiglas square.
3. Connect the PVC pipes as shown in the diagram. The entire goalpost can be painted yellow to resemble an NFL goalpost.

Preparation of the Jumbo Pipets

Flatten the base of the pipet bulb and then cut the narrow stem from the jumbo pipet. If done properly, the resulting hole should be an ellipse shape that is slightly larger than the brass tubing. The hole should allow the bulb to easily slide over the brass tube on the launch pad.