FUEL CELL EXPERIMENTATION

Grade Level: 6-8

Group/Team Size: 2

Time Required: 120 minutes

Summary: This activity will guide students through four experiments with a hydrogen fuel cell to learn how to fill the unit, decompose water through electrolysis, measure the amount of gas produced, and test the gases generated.

Engineering Connection: At many levels, Engineers and Scientists have been and are currently involved in the discovery, creation, optimization and infrastructure development for many types of fuel cells in many different industries. Governments around the world employ engineers to investigate, adapt, and optimize fuel cells to generate power for industry and consumer use. Automobile manufacturers are building cars with fuel cells and working to make it a more affordable, and viable, choice for consumers.

Learning Objectives: Students will

▪ Learn how to assemble and fill the fuel cell.
▪ Understand how a fuel cell operates.
▪ Appreciate the efficiency of fuel cells.

Materials: Each group will need:

▪ 1 – Fuel Cell Car Kit (refer to the last page for content listing and picture)
▪ 1 – 400 mL Beaker
▪ 2 – Pair of Safety Glasses
▪ 2 – Connecting Wires with Alligator Clips on both ends
▪ 1 – 9V Battery
▪ Masking Tape
▪ 1 – Wooden Splinter
▪ 2 – Matches
▪ 1 – Test Tube
▪ 1 – Wash Bottle filled with Distilled Water

Safety: Students should wear safety glasses at all times during these experiments. As you will be using batteries and electrical components, use care when making connections between components. The fuel cell operates ONLY on Distilled Water and is a very sensitive piece of equipment. Please use great care in handling the cell. Filling the fuel cell with liquid other than Distilled Water will result in damage.
EXPERIMENT #1: Assembling & Filling the Fuel Cell

Procedure:

2. Locate the Fuel Cell (Item #1), clear tubing, and plugs (Item #16) pictured in Figure 1 within the Fuel Cell Car Kit. Assemble per Figure 1, noting that the red side of the cell is the Hydrogen side and the blue side is the Oxygen side.

3. Fill the both the Wash Bottle and the 400 mL beaker halfway with Distilled Water.
4. Place the Car Chassis (Item #4) on the table. The motor drive is at the front of the car and the tank storage bin is at the rear. Slide the Fuel Cell with assembled tubing into the center slot in the Chassis. Note: the red side of the Fuel Cell should be pointing to the right with the vehicle looking forward.
5. Locate the Syringe (Item #10), small piece of tubing, and the syringe tip. Assemble per Figure 2.

Figure 1: Preparing the Fuel Cell for filling
6. Place the 400 mL beaker behind the Chassis. Place the two long tubes ends with clear plugs from the Fuel Cell into the beaker, making sure that the ends remain under water. Use masking tape as necessary to secure the tubes.

7. Per Figure 3, attach the Syringe Assembly to one side of the Fuel Cell by removing the red plug from the short piece of tube and connecting the needle of the syringe to it.
8. Now you will remove all air from the tubing and the Fuel Cell by replacing it with Distilled Water. The Fuel Cell will not operate properly if air bubbles remain inside. So, check that all tubing connections are secure and slowly pull the plunger on the syringe. The Fuel Cell system will be full once the syringe begins to fill with water. Note: you may need to add additional Distilled Water to the beaker during this process. Remember, the ends of the tubes in the beaker must remain under water at all times or you will introduce additional air into the fuel cell system.

9. Pinch the tube above the connection to the syringe to create a vacuum, and remove the syringe tip. Quickly replace the red plug in the end of the short tube.

10. Repeat the filling process on the other side of the Fuel Cell.
EXPERIMENT #2: Water Electrolysis – Splitting of Water Using the Fuel Cell

Procedure:
1. Locate the 120 mm long connection wires (one red and one black) from the Fuel Cell Car Kit. Plug the red wire into the connection port at the top of the red side of the fuel cell and the black wire into the port on the blue side of the fuel cell. Connect an alligator clip to the free end of each wire. Refer to Figure 4.

![Figure 4: Electrical Connections for Powering the Fuel Cell](image)

2. Check that both ends of the tubes are submerged in the distilled water.
3. Attach the free ends of the Connector Wires with Alligator clips to the 9V battery.
4. The fuel cell should begin to separate the water into Hydrogen and Oxygen gas immediately and you should see the gas begin to evacuate the tubes and bubble into the beaker.
5. When you are finished splitting the water, disconnect the battery from the connecting wires.
EXPERIMENT #3: Measurement of Gas Generation – Collecting gas in the tank and measuring the rate of generation.

Procedure:

1. Locate the Gas Collector (Item #5) in the Fuel Cell Car Kit.
2. Carefully pull the ends of the long tubes off of the stubs on either side of the fuel cell. Insert these tubes into the upper tank openings from the inside until the ends with the clear nozzles have been tightly secured. Carefully place the entire unit into the water container at the rear of the vehicle, making sure that the larger Hydrogen tank is on the right side of the car (red side of the Fuel Cell).

![Figure 5: Attaching the gas collection tank to the Fuel Cell tubing.](image)

3. Using the beaker, carefully fill the storage tank up to the rim with distilled water without spilling.
4. Per the procedure in Experiment #1, use the syringe to fill both sides of the Fuel Cell and the entire system of tubes and tank with distilled water. Note: You may need to replenish the storage tank with additional distilled water during this process.
5. Now you will measure the rate of gas generation in both tanks by recording the amount of gas produced every 15 seconds and recording it in Figure 6.
6. Reconnect the alligator clips to the battery and begin the gas generation. Begin timing once the first gas bubbles reach the top entry of the respective tanks and disconnect the battery once all data points have been recorded.
7. Using the values recorded in Figure 6, label and plot the data points in Figure 7 for both hydrogen and oxygen. Make a best fit line for each gas.
**Test Time (s)** | **Gas Volume Generated (mL)**  
---|---
| **Oxygen** | **Hydrogen** |
| 0 |  |
| 15 |  |
| 30 |  |
| 45 |  |
| 60 |  |
| 75 |  |
| 90 |  |
| 105 |  |
| 120 |  |

*Figure 6: Gas Volumes Generated by the Fuel Cell*

*Figure 7: Label and Plot Values from Gas Generation for Both Gases*

Procedure:
1. Remove the gas collector from the water tank in the back of the Chassis.
2. Fill the beaker with distilled water until the test tube can be fully submerged and evacuated of air.
3. Submerge the gas tank upside down in distilled water in the beaker. Place the opening of the test tube over the opening in one of the tanks similar to the set up in Figure 8.

Figure 8: Filling the test tube with gas generated by the Fuel Cell

4. Connect the alligator clips once again to the battery and begin gas generation.
5. Watch as the gas generated begins to fill up the test tube and push out the water. While the test tube is filling with gas, light a match and use it to bring the tip of the wooden splinter to a glow (no active flame, just red and glowing). Once the test tube has been completely filled, pull it up from the water while keeping the opening facing downward. Put the glowing wooden splinter into the test tube. What happens?
6. Repeat the procedure with the other side of the gas collection tank. Record your observations in the discussion section.
FUEL CELL EXPERIMENTATION

Data & Calculations: Use the following section to record any data and calculations.

Observations & Discussion:

1. What is the difference between distilled water and tap water? Fuel cells only use distilled water. Which type should humans drink?

2. How does the electrolysis of water by the fuel cell compare to the same procedure using the graphite pencils during Day Camp 1?

3. How long do you think that the gas generated would stay in the tanks if left for some time? Why?

4. Why is it important to measure the rate of gas generation?

5. Using your plot in Figure 7, determine the rates of gas generation for both hydrogen and oxygen.

Contributors: Adapted from Thames and Kosmos Fuel Cell Car and Experiment Kit Lab Manual
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6. What happened when you performed the glow test on the test tube filled with Hydrogen gas? What about the Oxygen gas? Why is there a difference?
# Fuel Cell Car Kit Contents

<table>
<thead>
<tr>
<th>Part</th>
<th>Description</th>
<th>Item Number</th>
<th>Part</th>
<th>Description</th>
<th>Item Number</th>
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<tbody>
<tr>
<td>1</td>
<td>Fuel cell, complete</td>
<td>287 160</td>
<td>15</td>
<td>Stick-on label</td>
<td>287 147</td>
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<tr>
<td>2</td>
<td>Wiring assembly for fuel cell</td>
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<td>16</td>
<td>Bag with small parts for fuel cell</td>
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<td>Connection wire, red, 120 mm</td>
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<td></td>
<td>3. Hose clamps</td>
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<td></td>
<td>2. Plugs</td>
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<td>3. Miniature banana plugs, black</td>
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<tr>
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<td>Syringe</td>
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<td>4 Wheels with tires each</td>
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<td>14</td>
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