



Name: _____

Class: _____

Date: _____



Earth Sciences

Middle School

5 hours

Objective

Build and modify a hydrogen fuel cell car to explore the concepts of renewable energy and human effects on global climate.

Materials

- Horizon's Hydrocar Science Kit
- Distilled water
- Stopwatch
- Horizon Renewable Energy Monitor (optional)

Background



The FCV, one of the first hydrogen fuel cell cars

The car on your desk might not look like the car in this picture, but they have a lot in common. They're both powered by a high-tech device called a hydrogen fuel cell.

Hydrogen fuel cells use hydrogen and oxygen to produce an electric current that can be used to power an engine like the one in a car. You can read [Introduction to Electrodes and Fuel Cells](#) to find out more about how the hydrogen fuel cell works.

All sources of fuel have different levels of efficiency in the engines they run. For instance, a gasoline engine in a full-sized car has an efficiency of around 20-40%. Fuel cells like the one in our little car can produce energy at up to 60% efficiency. An engine's efficiency can be thought of as the difference between how much energy was put into the engine and how much was converted to kinetic energy to make the engine move. But a higher efficiency isn't the only benefit of a hydrogen fuel cell. Unlike a gasoline-powered engine, a hydrogen-powered

engine produces no carbon emissions.

Carbon dioxide (CO₂) is a greenhouse gas that affects the Earth's atmosphere and is produced by all cars, power plants, and any other energy sources that burn fossil fuels like coal and oil. This hydrogen car only produces water (H₂O). How does it produce power without making any pollution? How could a full-sized car be powered by hydrogen?

Method

We will split water into hydrogen and oxygen gas, then use the hydrogen to power our car. We will examine how the car works and compare hydrogen to other fuel sources.

Assembly

If car is already assembled, go to the Procedure section

These discussion questions will help you assemble your car. Read each of them carefully and discuss your responses with your group, then use your answers to put your car together. As you assemble your car, write down any interesting observations you have in the **Observations** section below.

1. The body of your car has places where other pieces can attach to it. Discuss with your group where you think individual pieces should go.
2. How would you attach the H₂ and O₂ cylinders to the body of the car? Does it matter where they go?
3. Look at the fuel cell. It has two short tubes attached to it. Are there any other places on the fuel cell where you could attach the longer pieces of tubing?
4. When turned on with electric current, the fuel cell will produce hydrogen and oxygen gas from the water inside it. How will you trap the gas so that it doesn't float away?
5. What source of electricity will be better at separating the hydrogen and oxygen in the water: the solar cell or the battery pack? How should the electricity source be connected?
6. How do you know when the fuel cell is generating hydrogen? How can the hydrogen be used to power the car?

Procedure

As you try out different experiments to increase the efficiency of your car, write down any interesting observations you have in the **Observations** section below.

1. To generate hydrogen, you must attach an electric current to your fuel cell. Use the solar cell or the battery pack to power the fuel cell by connecting the red and black wires to the appropriate sockets on the fuel cell.
2. Observe the car as it's creating hydrogen. How do you know that it's working? What do you *observe* as the fuel cell splits the water inside it?
3. When the cylinders can't hold any more gas, you'll see bubbles start to come up from the bottom. Once this happens, you can disconnect the power source. Your car is now ready to run.

4. Have one group member ready with the stopwatch before you plug in the car's motor. The car will run as soon as you plug it in.
5. Measure the amount of time the car runs and record it in the data table below.
6. Repeat steps 8-12 three or more times to get an average running time for your car.

Observations:

Write down anything interesting you observe while building or running the car.

Data Table:

<i>Trial</i>	<i>Time (sec)</i>
1	
2	
3	
4	
5	

Analysis

Make a *scientific claim* about your car: what affected how far or how fast it could go? To help you write a claim statement, see [Stating a Scientific Claim](#).

Claim

What evidence can you use from your observations of the car to back up your claim? State the reasoning you used to make your claim.

Evidence

State the reasoning you used to make your claim.

Reasoning

Now that you've seen the hydrogen fuel cell car working, *design an experiment* that could determine the best surface for the car to run on. Explain the steps of your experiment here:

Use your knowledge of global climate change, *design an experiment* that would compare the environmental impact of a hydrogen fuel cell car to that of a gasoline-powered car. Explain the steps of your experiment here:

Conclusion

1. What would be the advantages and disadvantages of using hydrogen fuel cells in a full-sized car? *Develop an argument* for or against hydrogen fuel cell cars using evidence you observed during this activity and defend your argument if there are different points of view in your group.

2. What other renewable energy sources could be used to power cars of the future? Compare hydrogen fuel cells to other energy sources and *develop an argument* supporting the fuel source you think is the best.

3. Was energy created or used up during this experiment? *Construct an explanation* of where energy was moving during this activity and how you know if it was created or used up.

Measurement

Is the amount of time the car runs related to the amount of electric current it produces? To find out, we'll need to use an ammeter to measure the amount of current being produced by the fuel cell. Read [Measuring Current in a Circuit](#) for more information on how to set this up.

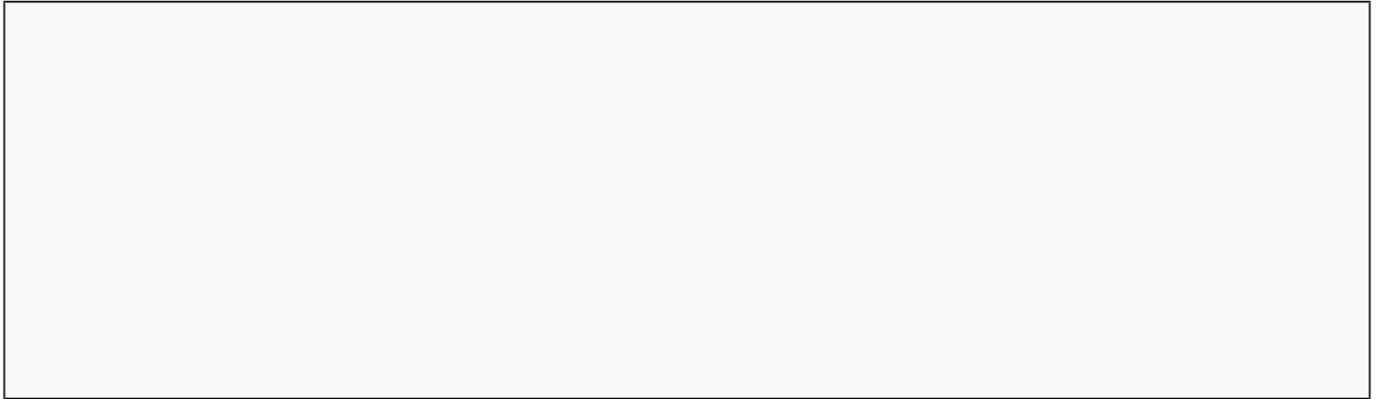
With an ammeter connected to the car, connect the circuit to the fuel cell and start the car. What is the amperage produced?

Car running produces _____ amps.

Using some of the ways you modified the car in the previous section of this activity, try to make the car run for as long and as short as possible. What happens to the amount of electricity produced?

Longer run time produces _____ amps. Shorter run time produces _____ amps.

Make a *scientific claim* about the cause of the differences you observe. What evidence can back up your claim? What is your reasoning?



What if your car didn't carry water to produce hydrogen and instead just carried hydrogen gas. How would that car be different? In the space below, sketch what that car might look like and write an explanation of how it would work.

