Hydrocar Physics Lab

Name: _____	Class: _____	Date: _____

Physics	High School	6 hours

Objective

Build and test a hydrogen fuel cell car to explore the concepts of electrolysis and renewable energy.

Materials

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

Background

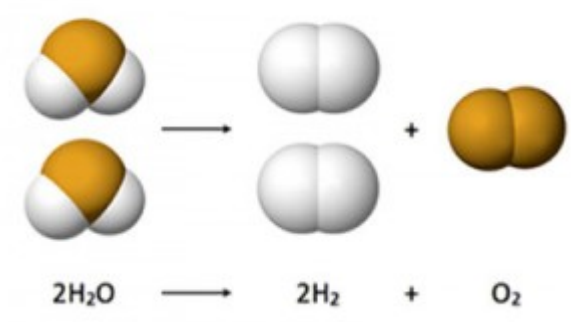

Fig. 1 Splitting water molecules into hydrogen and oxygen

Hydrogen is the most abundant element in the universe, however, very little pure hydrogen exists naturally on Earth, so electrolyzers are very useful because they split water molecules to produce pure hydrogen. (Fig. 1) The electrolyzer in the hydrogen fuel cell car you'll be using for this activity is a proton exchange membrane (PEM) electrolyzer, which is also the reversible fuel cell for our car. The details of how the PEM fuel cell works are explained in The PEM Electrolyzer/Fuel Cell.

In the PEM electrolyzer, hydrogen is produced at the anode, and oxygen is produced at the cathode. What are anodes and cathodes? Read Introduction to Electrodes and Fuel Cells to find out.

As with any conversion of energy, there are factors that will contribute to its efficiency. We will examine some of these factors as we assemble the car.

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 calculated by comparing the amount of energy put into the system to the amount of useful energy put out by the system.

Mathematically, we'd say:

$$Efficiency\ \% = \frac{Usesful\ Energy}{Energy\ Input} * 100\%$$

A more efficient engine means you get more kinetic energy out of the same amount of fuel, so we can get an idea of how efficient our engine is by measuring how many seconds our car moves before it runs out of fuel.

If the energy we put into the car isn't being converted into motion to make the car run, where is it going? What kinds of things do you think will affect how long your car will run?

Method

We will test different ways to make the car more energy efficient and try to make it drive for a longer period of time when fully charged with hydrogen fuel. Each trial will only change one variable so we can be certain of the cause of any difference in driving time.

Assembly

If your car is already assembled, you can skip 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 H_2 and O_2 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 how much time the car runs and record it in the data table below.
6. Talk within your group about how you want to change the car to make it run for longer. Do you want to change the weight of the car? How about the surface it runs on? What else could you change?
7. Change one characteristic and repeat the steps to produce more hydrogen and run the car again. Record your data in the table below.
8. Repeat this process for as many different characteristics as you can think of. If you can think of more things to change, record your data on a separate sheet of paper.

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

Once your car is assembled, see how long it will run on its hydrogen fuel. Try making more hydrogen and running the car again. How long can you get the car to run? Try at least four times and write your results in the **Data Table**.

Try and make some changes to the car to make it run faster. Could you increase its fuel capacity? Can you decrease friction in some way? Does it matter what kind of surface it runs on? Discuss some possible changes you could make to your car and run your experiment to see if your changes result in a longer run time. Put your results in the second **Data Table**.

Data Table:

Trial	*Time (sec)*		*How Car Was Changed*	*Time (sec)*
1				
2				
3				
4				
5				

Average time:_____

Analysis

Make a *scientific claim* about your car: what change that you made was most effective in getting it to run longer? 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

Use the data you collected to *design an experiment* that you could run to test the effect of high-pressure fuel on the efficiency of the car. Explain the steps of your experiment here:

Conclusion

What are the advantages and disadvantages of using hydrogen as a fuel source for a full-sized car? *Develop an argument* to support or oppose the adoption of hydrogen powered cars. Support your position using evidence you observed during this activity and defend your argument if there are different points of view in your group.

What data from your experiments would be most useful when designing and building a full-sized hydrogen fuel cell car? *Develop an argument* to support your position using evidence you observed during this activity and defend your argument if there are different points of view in your group.

Create a diagram showing all the ways that energy was transformed from one form to another during this experiment. Be sure to include any ways that energy was "lost" through transformation into less usable forms such as friction.

What additional experiments could you perform to increase the car's efficiency? What if you had all the money and materials you needed? *Plan an investigation* that you could carry out to test variables you were unable to change in this activity.

Measurement

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 the renewable energy monitor, you can also measure the voltage in volts and the power produced by the car, measured in watts. What is the power output of the hydrogen fuel cell?

Voltage: _____ volts Power output: _____ watts

We know that power in watts is the current in amps multiplied by the voltage in volts, or $P_{(W)} = I_{(A)}V_{(V)}$. Is this true based on the data you gathered? *Construct an explanation* of the possible sources of error in your measurements.

We know that one amp is the same as one coulomb (1C) of charge per second. 1C is equal to the charge of approximately 6.241×10^{18} electrons. Knowing the amperage you measured and the run time of your car, calculate how many electrons moved through your car's circuit during a typical run.