Hydrocar Chem. Lab

Name: _____	Class: _____	Date: _____

Chemistry | High School | 6 hours

Objective

Perform experiments with a hydrogen fuel cell car to explore the reaction of electrolysis.

Materials

- Horizon's Hydrocar Science Kit
- Distilled water
- Stopwatch

Background

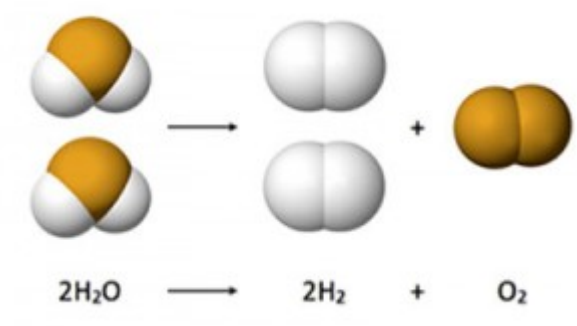

Fig. 1 Splitting water molecules into hydrogen and oxygen

Electrolyzers use electrical energy to break water 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 produce pure hydrogen. Our electrolyzer 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 fuel cell, the membrane allows the hydrogen ion to transfer from the anode side of the membrane to the cathode side, and separates the hydrogen and oxygen gases. The 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.

First we need to produce hydrogen to use in our fuel cell, then use that hydrogen to power the car. Our fuel cell works in two directions. When it's filled with water and you connect it to a power source, it splits the water to create hydrogen and oxygen gas (Fig. 1). When it's filled with hydrogen and oxygen gas and you connect it to a motor, it recombines the hydrogen and oxygen to produce water and electrical energy.

These reactions: electrolysis of water and the synthesis of hydrogen and oxygen to produce water, are the main focus of this activity.

Method

We will be using the electrolyzer of the fuel cell car to split water molecules and make calculations about the reaction.

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 change the reactions in the fuel cell 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 the reactions you observed: the electrolysis and the recombining of H_2 and O_2. How could you change the rate of those reactions? What factors are contributing to how those reactions happen? For example: does the recombination reaction continue for a longer time if the car can turn its wheels with less resistance?
7. Decide on one factor to change and repeat the steps to run the electrolysis and recombination reactions again. Record your data in the **Data 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 during the electrolysis an recombination reactions.

Data Table:

Trial	***Time (sec)***	***How Car Was Changed***	***Effect on Reaction***
1			
2			
3			
4			
5			
6			

Analysis

Make a *scientific claim* about your car: what factor is most important in the electrolysis and recombination reactions? 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

In the 1780s, Antoine Lavoisier and Henry Cavendish discovered that water wasn't an element as had been assumed for hundreds of years, but was a chemical combination of "inflammable air" (hydrogen) and "dephlogisticated air" (oxygen). Using your knowledge of the characteristics of hydrogen and oxygen, *design an experiment* that you could run to show conclusively that H_2 and O_2 are the gases that combine to form water. Explain the steps of your experiment here:

Use your knowledge of the properties of hydrogen and oxygen to *design an experiment* that tests the effect of water temperature on the electrolysis reaction. 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.

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.

Think about one of the issues with hydrogen fuel you just listed and *design a solution* that could be used to overcome it. Describe and/or sketch your idea below.

Measurement

Is there a way we can tell more precisely how much energy your car is producing? Quantitative measurements can be used to see how much hydrogen gas was produced and how much was converted to electrical energy.

Before you produce hydrogen by attaching the battery pack or the solar cell, note the level of water in the H_2 and O_2 cylinders. Each line is one milliliter, so as you produce gases, the change in the water level will correspond to the amount of hydrogen and oxygen produced. Start the electrolzyer and note how the levels change. Stop the electrolyzer once bubbles start escaping the cylinder. Subtract the original water level from the water level after you finish producing the gases and you'll know how much you produced.

Hydrogen gas produced: _____ mL Oxygen gas produced: _____mL

We can now use the Ideal Gas Law to calculate how many moles of hydrogen are present. You can assume standard temperature and pressure for this calculation. For help with this calculation, read The Ideal Gas Law.

Did the oxygen cylinder fill at the same rate as the hydrogen cylinder? *Construct an explanation* of what you observe.

When you run the electrolyzer in reverse to recombine H_2 and O_2, does the water level return to its original level? *Construct an explanation* of what you observe.