Name: _____	Class: _____	Date: _____

Earth Sciences | High School | 5 hours

Objective

Run experiments with an ethanol fuel cell learn about chemical reactions, electricity, and renewable energy.

Materials

- Horizon's Ethanol Fuel Cell Science Kit
- Ethanol solution
- Distilled water
- Stopwatch
- Horizon Renewable Energy Monitor (optional)

Background

Fig. 1: This car is powered by ethanol, not gasoline.

Biofuels are a promising solution to the problem of global climate change. They're made from plants which already exist as crops grown by the ton: sugar and corn. They're also carbon negative: growing the plants takes more carbon out of the atmosphere than burning them as biofuels puts back in.

One biofuel that's already widely used as an energy source is ethanol. Ethanol is a chemical that's a product of decomposing plants during a process called fermentation. Ethanol is being used to power cars (Figure 1) and as a heat source for homes. It can also be used by our fuel cell to produce electricity. You can learn more by reading Introduction to Ethanol.

With the right mixture of ethanol, our fuel cell will provide enough electricity to power a small motor on a fan. But it won't always produce the same amount of electricity. We can change how well the fuel cell works by changing things like how hot the fuel is or how much ethanol we mix with water.

What concentrations of ethanol are better for the fuel cell? At what temperature should it run? When scientists are building cars and machines that run on ethanol, they have to ask these kinds of questions to make sure they get the most energy out of their ethanol fuel. Now we'll use the ethanol fuel cell to explore these questions and more during this activity.

Method

We will be using the ethanol fuel cell to power a small fan. We will run experiments to understand more the most efficient way to make our ethanol fuel cell work.

Procedure

Procedure:

As you assemble your fuel cell and run your experiments, write down any interesting observations you have in the **Observations** section below.

1. Open the purging valve on the bottom of the fuel cell by pushing it towards the back, away from the fan.
2. Make sure the tubing connecting the fuel cell, purging valve, and fuel container is secure.
3. Open the fuel container and pour the ethanol solution in, then close the lid.
4. Wait 5-10 minutes for the fuel cell to begin the chemical reaction.
5. Attach the red and black alligator clips to the fuel cell and observe what happens.
6. When you're finished, disconnect the alligator clips.

Observations:
Write down anything interesting you observe while running the ethanol fuel cell.

Experimentation: Concentration of Ethanol

Will the fuel cell run better if the ethanol is more concentrated? Using the different concentrations of ethanol provided by your teacher, run the fuel cell as you did in the **Procedure** section.

Each time you run it with a different concentration, write down any observations below.

Concentration	***Observations***
5%	
7%	
10%	
12%	
15%	

What happened when you used different concentrations of ethanol in your fuel cell? *Construct an explanation* of what you observed.

Experimentation: Temperature

How does the fuel cell work with fuel at different temperatures? Using the heated fuel samples provided by your teacher, run the fuel cell as you did in the **Procedure** section. Record any observations below:

Temperature (ºC)	***Observations***

Did the temperature of the fuel affect how fast the fan was spinning? *Construct an explanation* of what you observed.

Analysis

Make a *scientific claim* about your ethanol fuel cell. What are the conditions that would generate the most electricity from this fuel cell? 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 air temperature on the fuel cell. Explain the steps of your experiment here:

Does it matter if the fuel cell is attached to something other than the fan? *Design an experiment* that would test what happens when other electric machines are powered by the ethanol fuel cell. Explain the steps of your experiment here:

Conclusion

1. What happens if you attach the wires to the fan backwards (red to black and black to red)? *Construct an explanation* of what you observe.

2. Could you use an ethanol fuel cell to provide power to your house? *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.

3. Do you think this ethanol fuel cell is better or worse than other kinds of renewable energy? *Develop an argument* to defend your opinion and discuss your answer with the rest of your group.

4. What would you do to improve the electricity production of your ethanol fuel cell? *Design a solution* that would increase the amount of electricity you would get from your fuel cell.

5. Ethanol puts carbon dioxide (CO_2) into the atmosphere, but it's still considered a source of "clean energy." Do you agree? *Develop an argument* to support your opinion and discuss your position within your group.

6. What factors would determine what places on Earth would be more likely to use ethanol as an energy source?

7. Using the factors you described in the last question, *develop an argument* that supports or opposes the use of ethanol in your area.

Measurement

How much electricity is running through our circuit? To find out, we'll need to use an ammeter like the Horizon Renewable Energy Monitor to measure the amount of electric current being produced by the generator. Read Measuring Current in a Circuit for more information on how to set this up.

When your ammeter is connected to your circuit, run the ethanol fuel cell to power the fan. Use a stopwatch and measure the amount of current in the circuit at different times. If you have the Horizon Renewable Energy Monitor, you can also measure the volts. Record your data below:

Time (min)	***Amps (A)***	***Volts (V)***
0		
2		
4		
6		
8		
10		

Does the amount of electricity produced by the fuel cell change? *Construct an explanation* of what you observed.