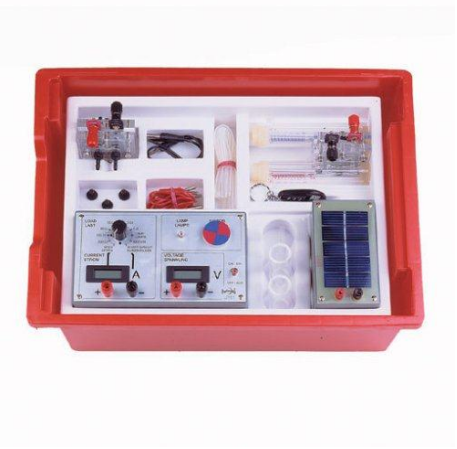
Mr. Ross McCurdy
Ponaganset High School
Solar Hydrogen Fuel Cell Science Lab

Solar Hydrogen Fuel Cell Science Lab

Introduction:

Fuel cells produce electricity from hydrogen using a chemical reaction that produces zero pollution with a very high efficiency. Large fuel cells are currently being used for stationary power and in cars, buses, and other vehicles and small fuel cells will soon be used to power laptop computers and other portable electronics. With a relatively inexpensive fuel cell science kit, students can produce hydrogen from water using solar power and make electricity with a fuel cell in the classroom.



The Helocentris Solar Hydrogen Fuel Cell Science Kit. This includes the solar panel, electrolyzer, fuel cell, connecting wires and tubing, and a load box to measure volts and amps along with a motorized wheel and light bulb to use the fuel cell electricity.

Note to teachers:

This lab requires a Heliocentris Solar Fuel Cell Science Kit, which is available at www.fuelcellstore.com SKU 80042 and costs $410.40.

These fuel cell kits are easy, fun to use, very dependable, and have been successfully used at Ponaganset High School for over five years. A single one of these fuel cell kits led to exciting fuel cell projects, sizeable grants, and an entire Fuel Cell Systems course! This lab is designed for students to get a general understanding of fuel cells, renewable energy, and the scientific principles involved. The answers to the teacher version of the worksheet are written in red and a student version of the worksheet is also included. Feel free to modify and develop this for your own classes. Good luck with your fuel cell lessons!

Grade Level: 9-12

With some modifications or as a class demonstration these fuel cell kits have been successfully used with elementary and middle school students.

Duration: 45 – 90 minutes

This unit can also be broken down into shorter lessons.

Mr. Ross McCurdy
Ponaganset High School
Solar Hydrogen Fuel Cell Science Lab

Overview and Purpose:

Students will use solar energy to electrolyze water to produce hydrogen and oxygen gases. The hydrogen and oxygen gases will then be recombined in a fuel cell to produce electricity and small quantities of water as a byproduct. Students will use the electricity to power a small light bulb and motor and will measure the volts, amps, and volts.

Educational Standards Addressed: Rhode Island Grade Span Expectations:

PS1: All living and nonliving things are composed of matter having characteristic properties that distinguish one substance from another (independent of size or amount of substance).
PS2: Energy is necessary for change to occur in matter. Energy can be stored, transferred, and transformed, but not destroyed.
PS2 6a: Writing simple balanced chemical equations to represent chemical reactions and illustrate the conservation of matter.

Objectives:

Students will be able to electrolyze water using solar electricity, set up and operate a small fuel cell, measure the electricity produced, and use the electricity to do work.

Materials: Heliocentris Solar Hydrogen Fuel Cell Science Kit
(available from www.fuelcellstore.com Item Number: 533708 cost: $311.00
150 Watt incandescent lamp (or direct sunlight)
Distilled water

Procedures: ***Detailed setup instructions are also included with the fuel cell science kits***

1. fill the electrolyzer with distilled water
2. Connect two wires between the solar panel and the electrolyzer
3. connect two tubes from the electrolyzer to the fuel cell
4. connect two wires from the fuel cell to the amp inputs of the load box
5. switch load box to motor setting
6. shine incandescent lamp onto solar panel from a distance of about 25 cm (~10 inches)
7. observe bubbles forming in electrolyzer and watch for power at the load box

Extensions beyond the classroom:

Fuel Cells are a commercially emerging technology that is very relevant in today's current affairs. Fuel cells are now in prototype cars, buses, and used in stationary power. Internet, magazine, and newspaper articles can be used to connect the lesson to current affairs. If within the vicinity, a field trip to a fuel cell organization can be arranged and guest speakers in the fuel cell field can also be invited to meet and talk with students.

Mr. Ross McCurdy
Ponaganset High School
Solar Hydrogen Fuel Cell Science Lab

Solar Hydrogen Fuel Cell Science Kit:
Save the World Funsheet (not a worksheet)

Teacher Version with answers in red

1. Describe the purpose of the 150-Watt incandescent lamp. Would this be needed outside on a sunny day? Explain.

The purpose of the incandescent lamp is to provide light energy (photons) for the photovoltaic solar panel. The lamp would not be needed since sunlight will power the solar panel. Direct sunlight actually provides more power for the solar panel than the lamp.

2. Describe the function of the solar panel.

The photovoltaic solar panel converts the light energy to electricity. The solar electricity can be used to power the electrolyzer or the motor and light directly.

3. Explain the purpose of the electrolyzer. Write the balanced equation for the chemical reaction that it performs.

The electrolyzer used electricity to break the chemical bonds holding the water molecules together. The water molecules are broken down into their constituent atoms, hydrogen and oxygen, which then form diatomic hydrogen and oxygen molecules, H_2 and O_2.
The balanced chemical equation that takes place at the electrolyzer is:

$$2H_2O \rightarrow 2H_2 + O_2$$

4. Explain the purpose of the fuel cell. Write the balanced equation for the chemical reaction that it performs.

The fuel cell chemically combines hydrogen and oxygen gases to produce electricity and water. This chemical reaction is the reverse of what takes place at the electrolyzer.

$$2H_2 + O_2 \rightarrow 2H_2O$$

5. According the electrical load and measurement box, how many amps did the fuel cell produce during operation? _____amps

The student answers will vary, but will probably be somewhere around 0.018 amps

6. According the electrical load and measurement box, how many volts did the fuel cell produce during operation? _____volts

The student answers will vary, but will probably be somewhere around 0.200 volts

7. Watts is a measure of power and can be calculated by multiplying amps x volts. How many watts is your fuel cell producing? _____ watts

8. Would you expect the wheel on the load measurement box to spin if no light was provided to the solar panel but the electrolyzer and fuel cell were connected? Explain your answer.

As long as there is hydrogen and oxygen stored in the electrolyzer tubes then the wheel on the motor will continue to spin, even though no power is being produced by the solar panel. Hydrogen is a means of storing energy and can be used to supplement solar energy, which does not work at night or during cloudy weather. A good demonstration is to plug the solar panel directly into the motor and with the motor turning block the light to the solar panel with your hand. The motor will abruptly stop since the solar panel cannot produce power without light.

9. Describe in detail what you observed during the observation of the fuel cell lab kit.

Student answers will vary. A general description includes: light from the bulb shined onto the solar panel which produced electricity. The electricity went into the electrolyzer and broke the water molecules into hydrogen and oxygen gases. The hydrogen and oxygen gases went into the fuel cell where they recombined to produce electricity and water. The electricity from the fuel cell powered the motor and the small light bulb.

10. Why is it critical that the electrolyzer be filled only with **distilled water**?

Tap water may have dissolved impurities which can damage the membrane in the electrolyzer.

11. What two gases were produced by the electrolyzer?

Hydrogen and oxygen were produced by the electrolyzer.

12. In what ratio would you expect the two gases to be produced?

2:1 The electrolyzer will produce twice as much hydrogen as oxygen since water is H_2O and contains twice as may hydrogen atoms as oxygen atoms. It is fun to ask students why there is more hydrogen in the electrolyzer and see them work towards the answer.

13. What was produced by the fuel cell?

The fuel cell produced electricity and water. The quantities of water are very small and may not be readily visible.

14. How could the use of fuel cells benefit society?

The benefits of fuel cells include:
Zero pollution when fueled with hydrogen and very low pollution when using other fuels. This will result in less air pollution, acid rain, and global warming gases.
Fuel Cells are more efficient than internal combustion engines. In a fuel cell car this would mean more miles per “gallon” or equivalent unit of fuel.
Fuel cells can be powered by renewably produced hydrogen rather than fossil fuels such as gasoline or oil, which are limited resources.

Mr. Ross McCurdy
Ponaganset High School
Solar Hydrogen Fuel Cell Science Lab

Name: Date: Period:

Solar Hydrogen Fuel Cell Science Lab:
Save the World Funsheet (not a worksheet)

1. Describe the purpose of the 150-Watt incandescent lamp. Would this be needed outside on a sunny day? Explain.

2. Describe the function of the solar panel.

3. Explain the purpose of the electrolyzer. Write the balanced equation for the chemical reaction that it performs.

4. Explain the purpose of the fuel cell. Write the balanced equation for the chemical reaction that it performs.

5. According the electrical load and measurement box, how many amps did the fuel cell produce during operation? _____amps

6. According the electrical load and measurement box, how many volts did the fuel cell produce during operation? _____volts

7. Watts is a measure of power and can be calculated by multiplying amps x volts. How many watts is your fuel cell producing? _____ watts

8. Would you expect the wheel on the load measurement box to spin if no light was provided to the solar panel but the electrolyzer and fuel cell were connected? Explain your answer.

9. Describe in detail what you observed during the observation of the fuel cell lab kit.

10. Why is it critical that the electrolyzer be filled only with **distilled water**?

11. What two gases were produced by the electrolyzer?

12. In what ratio would you expect the two gases to be produced?

13. What was produced by the fuel cell?

14. How could the use of fuel cells benefit society?