



Energetic Electrolysis:

The Potentials of Hydrogen Power

Activity Guide

Description: This activity uses electrolysis to introduce the science behind hydrogen power. Visitors will use an electrical current to separate water into hydrogen and oxygen gas. The audience will then observe a demonstration showing the explosive properties of hydrogen gas.

Audience: Hands-on activity for families and kids ages 7 and up

Length: Approximately 25 minutes

Learning Objectives

- The components of water can be separated into oxygen and hydrogen using an electrical current, a process is called electrolysis
- If hydrogen gas is generated using a renewable energy source such as wind or solar, it has a lot of potential as a “clean” energy source
- Once hydrogen gas has been captured and stored it can be used to power cars, homes, or computers
- Hydrogen power is one example of how technological innovations can be used to address energy and environmental concerns

Climate Connection

Electrolysis is the process of using an electrical current to separate water into hydrogen and oxygen gas. The electrical charge that is applied to water will break the chemical bond between the hydrogen and oxygen atoms and produce charged particles called ions. For the purposes of this experiment the charged hydrogen and oxygen gas is produced at aluminum foil electrodes. Once captured and stored, hydrogen gas can be run through a fuel cell to power cars, homes, even computers.

Hydrogen gas produced through electrolysis can be used for power when run through a fuel cell. A fuel cell combines separated hydrogen and oxygen to make electricity. In the past several years we have seen great advances in fuel cell technology and an accompanying increase in excitement around the potentials for hydrogen power to replace fossil fuel energy sources.

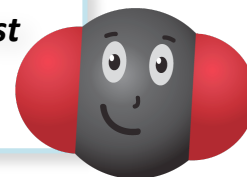
There are several obstacles to overcome if we are to use hydrogen as an energy source. Hydrogen gas is very flammable, and there are safety issues surrounding its storage and transport. The explosive property of hydrogen is demonstrated in this

activity and serves as a good launching point for discussing storage issues. Currently scientists are working on developing safe transport and storage systems for hydrogen gas.

The production of hydrogen gas is not always “clean and green.” In fact most hydrogen gas produced in the United States today is made using non-renewable resources such as electricity produced from coal fired power plants that produce the electricity necessary for electrolysis.

Hydrogen does have the potential to be a clean energy carrier if the electrical current necessary for electrolysis is produced from a renewable energy source such as solar or wind power. Images of off-shore hydrogen power plants powered by solar panels have increased the excitement around hydrogen power. In addition to having plentiful sunlight, the salty ocean water helps to conduct electricity that allows for electrolysis to occur. Using hydrogen power and fuel cells to store renewable energy can reduce our use of pollution-producing energy sources such as fossil fuels, therefore reducing pollution and helping to slow the rate of climate change.

The technology to use hydrogen as a power source was first developed for use on the space station.



Materials

For the presenter

- One set of the materials for each pair of visitors
- Matches
- 2 large test tubes

For each pair of visitors

- One 6 volt lantern battery
- 2 small strips of aluminum foil
- Small plastic container (with a center divider)
- 2 alligator clips
- Tap water
- Sodium sulfate or sodium chloride (table salt)

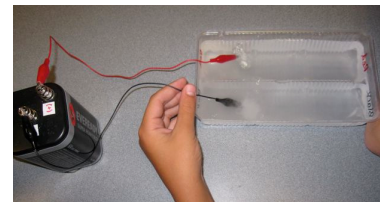
Note: Practice the demonstration before conducting the demonstration! This is highly recommended as the explosion part of the demo can be a little tricky!

Set Up

Set up takes approximately 10 minutes

Step 1: Prepare the salt water solution adding one heaping spoonful of sodium chloride or sodium sulfate per cup of water.

Step 2: Prepare the materials in groups so that each group of visitors will have access to a battery, two alligator clips, two pieces of aluminum foil, and the plastic container with salt water.



Step 3: Practice the demonstration.

- Create a basic electrolysis set up using the lantern battery, 2 alligator clips, aluminum foil electrodes and sodium sulfate (or salt) water solution.
Note: Don't let the electrodes touch; this will short out the battery.
- Completely submerge the test tube into the water and slide the electrode into the test tube. (It helps to fill the test tube with salty water, then submerge it to prevent air from entering the tube.) Once the electrolysis has begun the hydrogen and oxygen gas will displace the water in the test tube.
- After half of the water in the test tube has been displaced by hydrogen gas, unclip the alligator clips and stop the electrolysis.
- Slowly pull the test tube with hydrogen gas out of the water solution, being careful to keep the test tube pointed down so the gas doesn't escape. Pull the test tube up slowly and avoid having water flow up the test tube.
- Holding the lit match under the test tube slowly tilt the test tube. The hydrogen gas will encounter the flame and a quick explosion will occur.



Program Delivery

[Connect the alligator clips on the demonstration set up and begin the electrolysis.]

[Welcome visitors. Explain that each pair of participants should sit in front of a battery. Explain to parents that this is a family activity, and they should work with their children if needed.]

Today's program is all about energy. Where does energy come from? [the sun, wind, water, coal, oil, wood, etc. Try writing answers down and grouping them into two categories, renewable and non-renewables.]

We are going to talk about an exciting way to store energy that is produced from the sun, wind, coal, or any of the other energy sources you suggested. This is the formation of hydrogen gas.

Who knows anything about using hydrogen for power? [Participants may comment on combustibility, hydrogen power, hydrocars, etc.]

Hydrogen is a gas that, if stored and harnessed correctly, can help us power cars, homes, or even computers in a clean, green way. The technology to use hydrogen as a power source was first developed for use on the space station. In order to get hydrogen gas we need to separate water molecules.

Who know the two parts of water? [Hydrogen and Oxygen, H₂O]

The chemical formula for water is H₂O [Write this symbol down if appropriate.] Every water molecule includes two atoms of hydrogen and one atom of oxygen. We use a process called **electrolysis** to break apart water molecules into hydrogen and oxygen. Electrolysis uses an electrical current to split the molecule apart.

In this activity we are going to split water molecules into hydrogen and oxygen gases using electrolysis.

In order for electrolysis to work you need to use the materials that you have in front of you. [Show visitors the materials.] Because we are working with electricity, it is very important that you listen to instructions carefully.

The battery provides the electrical current that we need to separate the water molecule into hydrogen and oxygen. The power that went into manufacturing or producing this battery probably came from a nonrenewable resource. If the power for electrolysis comes from a renewable resource, then hydrogen power is a very clean energy source because it does not result in the production of carbon dioxide, the main greenhouse gas responsible for climate change.

The plastic container will hold the water that we will separate. Salt (or sodium sulfate) has been added to the water because it conducts electricity.

Can you think of a place on Earth where we have lots of salty water? [the ocean] Many people are excited about hydrogen power because we can use the hydrogen separated from ocean water.

Next we need to make electrodes using pieces of aluminum foil. In order to attract these two parts of the water molecules we must attach electrodes on the end of our power source, in our case the battery.

The electrodes carry the electrical current from the battery to the water and hydrogen gas is produced at one electrode and oxygen gas is produced at the other. [Note that oxygen gas is only produced if you are using sodium sulfate in your water solution]

[Demonstrate the following procedure] Let's all make two electrodes. Because we want an electrode with a lot of surface area, we are going to take a thin strip of foil and fold it back and forth accordion style. First push down your electrode so that it is flat.

The alligator clips will carry the electricity from the battery into the electrodes. Clip one electrode on the end of each of your alligator clips.

Next we can fully submerge our electrodes into the salt water. Before we connect to the battery please make sure that your electrodes are not touching each other. If the electrodes touch each other while they are connected to the battery, the battery will be damaged. [Stress the importance of this: if the electrodes touch, it will ruin the battery.]

Now clip each free end of your alligator clips onto the springs of your battery. What do you see? (Gas bubbles will be produced on each electrode. There should be more gas bubbles on the electrode that is attached to the negative, cathode side where the hydrogen gas is produced)

Do you notice more gas being produced at one of the electrodes? [There will be more gas produced at the cathode, negative side, where the hydrogen gas is produced.]

Why do you think there is more gas produced there? [The electrolysis is splitting water or H_2O . For each water molecule we see twice as much hydrogen gas than oxygen gas.] [Note: This is only accurate if you are using a sodium sulfate solution.]

Great, what you are seeing is the production of hydrogen and oxygen gas!

Why do you think there are more gas bubbles on one electrode than the other? [For every water molecule that separates, there is twice as much hydrogen (H_2O).]

How do we know that we are actually trapping hydrogen gas? [Run a test, use our observation skills, etc.]

One property of hydrogen gas is that it is very flammable. In fact hydrogen gas is so flammable that scientists are concerned about ways to safely store large amounts of hydrogen gas.

[Show visitors the demonstration you have set up to capture hydrogen gas.] Slowly pull the test tube with hydrogen gas out of the water solution, being careful to keep the test tube pointed down so the gas doesn't escape and to avoid having water flow up the test tube.

[Holding the lit match under the test tube, slowly tilt the test tube. The hydrogen gas will encounter the flame and a quick explosion will occur.]

Frequently Asked Questions

- **What do I do if only a few bubbles are being produced during electrolysis?**
Try adding more sodium sulfate or salt to the water solution, or try bringing the electrodes closer to each other (remembering not to let them touch!).
- **Isn't hydrogen gas dangerous? I've heard it is very combustible.**
Although in large amounts hydrogen gas is very explosive, the amount we are producing today does not risk explosion. The question of combustibility, however, is a concern in the use of hydrogen power as a source of large-scale energy.
- **Can I use a different sized battery?**
For safety concerns we recommend that only a 6 volt battery be used. These batteries can be found at any general hardware store.
- **Will electrolysis work without added salt in the water?**
Sometimes. If you live in a place with high amounts of iron in your tap water, the iron may act as a good enough conductor to produce gas.
- **What is the difference between using sodium chloride (table salt) and sodium sulfate?**
Both salt and sodium sulfate serve as a conductor of electricity, which increases the amount of hydrogen gas produced by the electrolysis. When salt is used, it produces chlorine gas, instead of oxygen on the anode side of the current. Using a sodium sulfate and water solution will cause oxygen gas to form.
(*Note: The amount of chlorine gas that is produced when using a salt solution is very small and is not a concern.)
- **What is the difference between a fuel cell and a battery?**
Fuel cells consume power from an external source that needs to be replenished, while batteries store electrical energy chemically. In the case of a hydrogen fuel cell, the external source is hydrogen as fuel, and oxygen is an oxidant during combustion.

Credits

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