



**Title:** Create Hydrogen Energy Written by GEF Staff

**Grades:** Middle School

**Subjects:** Science, Social Studies

**Time:** 60 minutes

**Standards:** Students will...

Science Standard 8: Understand the property and structure of matter.

- Benchmark #1: Know that matter is made up of tiny particles called atoms, and different arrangements of atoms into groups compose all substances.
- Benchmark # 4: Know that substances containing only one kind of atom are elements and do not break down by normal laboratory reactions (e.g., heating, exposure to electric current, reaction with acids); over 100 elements exist.

Science Standard 12: Understand the nature of scientific inquiry.

- Benchmark # 1: Know that there is no fixed procedure called the “scientific method”, but that investigations involve systematic observations, carefully collected, relevant evidence, logical reasoning, and some imagination in developing hypotheses and explanations.
- Benchmark # 3: Design and conduct a scientific investigation (e.g., formulate hypotheses, design and execute investigations, interpret data, synthesize evidence into explanations).
- Benchmark # 6: Use tools and techniques to gather, analyze and interpret scientific data.

Technology Standard 6: Understand the nature and uses of different forms of technology.

- Benchmark # 3: Know that most technological systems require an input of energy, which is an important consideration both in designing an object or a system and in conserving energy (e.g., so many things require energy that alternative sources to fossil fuels should be used when possible).

Geography Standard 14: Understand how human actions modify the physical environment.

- Benchmark # 3: Understand the ways in which technology influences the human capacity to modify the physical environment (e.g., the effects of the introduction of electricity, combustion engine vehicles, chemicals and fertilizers).
- Benchmark # 4: Understand the environmental consequences of both the unintended and intended outcome of major technological changes in human history (e.g., the effects of automobiles using fossil fuels, nuclear power plants creating the problem of nuclear-waste storage, the expansion of the amount of land brought into agriculture).

Geography Standard 18: Understand global development and environmental issues.

- Benchmark # 1: Understand how the interaction between physical systems and human systems affects the current conditions on Earth (e.g., relationships involved in economic, political, social, and environmental changes; geographic impact of using non-renewable and renewable energy sources).

**Objectives:** Students will be able to...

- Describe the effects human actions have had on the environment over time and explain the resulting consequences as they relate to economic, political, social and environmental change.
- Identify the need for alternative energy sources and explain how hydrogen energy might be used to address that need.
- Describe how to use the process of electrolysis to generate hydrogen.
- Form and test a hypothesis, observe and record the results, analyze the data collected and draw logical conclusions.

**Materials:**

- Nine volt battery (one per group)
- Aluminum foil

- Electric wire with alligator clips
- Beaker or small bowl (one per group)
- Water - Spoon (one per group)
- Graduated cylinder (a few can be shared by the class)
- Worksheet included
- Pencil

**Overview:** When electricity is applied to water, bubbles of oxygen gas form at the anode (the positive electrode) and bubbles of hydrogen gas form at the cathode (the negative electrode). The bubbles are easily seen. This process is called electrolysis. To conduct electrolysis, have electricity pass through some water between two electrodes placed in that water. Salt is added to the water to ionize the water and assist the flow of electricity.

Like electricity, hydrogen is a secondary source of energy. It stores and carries energy that is produced from other resources, such as fossil fuels, water and biomass. Today, it is not widely used, but it has potential as a future energy carrier. Steam reforming and electrolysis (water splitting) are the two most common methods of producing hydrogen. Steam reforming, the most commonly used process for hydrogen production, results in greenhouse gas emissions linked to global warming. Electrolysis, which splits water into hydrogen and oxygen, has no emissions but is a costly process. However, new technologies are currently being developed for use in years to come.

**Kid's Speak:** Electrolysis splits water into hydrogen and oxygen. This process has potential for future energy use. When electricity is applied to water, bubbles of oxygen gas form at the anode (the positive electrode) and bubbles of hydrogen gas form at the cathode (the negative electrode). The bubbles are easily seen. Salt is added to the water to ionize the water and assist the flow of electricity.

**Eco-Fact:** About 9 million metric tons of hydrogen are produced in the United States annually, enough to power 20-30 million cars or 5-8 million homes. Most of this hydrogen is produced in three states: California, Louisiana and Texas.

#### Procedures:

##### Before Conducting the Experiment:

- Discuss the need for clean, environmentally friendly, alternative energy sources. Review with students the effects and consequences non-renewable energy sources have had on the environment. Provide students with background information on hydrogen energy and discuss its potential as an alternative energy source.
- Explain to students that electrolysis is a technique used to separate a compound or molecule into its component parts. For example, water can be separated into hydrogen and oxygen by adding electricity and providing a path for particles to flow. Explain to students that the experiment they are about to conduct shows how adding a flow of electricity to salt water will breakdown the water into its two parts: oxygen and hydrogen.
- Divide the class into groups of three or four and explain the experiment's steps. Have students write their own experiment objectives and hypothesis on included worksheet. Tell students to make careful observations on the worksheet throughout the experiment.

##### Conducting the Experiment:

- Hold the piece of aluminum the long way and fold it like an accordion. When completely folded, each piece should be about 1cm by 6cm in size.
- Dissolve salt into water at the ratio of one teaspoon salt to 50ml of water. Stir to dissolve salt.
- Hang pieces of foil – soon to be electrodes – onto the side of the bowl so they dip into the water. The foil pieces should be separated a few inches. Don't let them touch.
- With two wires, attach one wire end to the foil and the other end to a battery; note which wire is attached to the negative end of the battery and which is attached to the positive end. 5. Record the results.



**After Conducting the Experiment:** - Students will write about their experiment. Students should include their experiment objective, hypothesis, observations and conclusions.

**Adaptations:** Have younger students observe the experiment as a demonstration and create a diagram to show observations.

**Extensions:** Have students research fuel cells and new fuel cell technology.