



# Hydrogen Energy

Hydrogen— a colorless and odorless gas— is the most abundant element in the universe. However, because it combines easily with other elements, it's rarely found by itself in nature. Hydrogen usually combines with other elements, forming organic compounds called *hydrocarbons*. Hydrocarbons include plant material and fossil fuels such as petroleum, natural gas, and coal. Water is produced during the burning of any hydrocarbon.

Hydrogen can be separated from hydrocarbons through the application of heat— a process known as *reforming*. Currently, most hydrogen is made this way from natural gas. An electrical current can also be used to separate water into its components of oxygen and hydrogen. This process is known as *electrolysis*.

Currently, hydrogen has great potential as a power source for fuel cells. Hydrogen fuel cells can provide heat for homes and buildings, generate electricity, and power vehicles. Hydrogen can also join electricity as an important *energy carrier*. An energy carrier moves and delivers energy in a usable form to consumers.

## Hydrogen Fuel Cells

Hydrogen offers tremendous energy potential, but hydrogen has a low energy density meaning it requires a large storage container to make it practical for use in a motor vehicle. Several car manufacturers including GM and Toyota have developed hydrogen vehicles. Hydrogen can be used in internal combustion engines replacing gasoline or in fuel cells to generate electric to power the vehicle. However, there are some limitations to the current technology that may limit the economic viability hydrogen powered vehicles in the near term. But there are no detrimental emissions with hydrogen as apposed to hydrocarbon fuels thus providing tremendous benefits as vehicle efficiency improves.

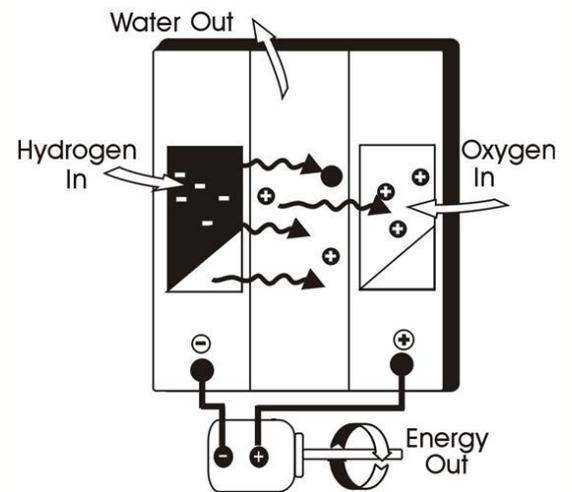
**1** Hydrogen fuel is channeled through field flow plates to the anode on one side of the fuel cell, while oxygen from the air is channeled to the cathode on the other side of the cell.

**2** At the anode, a platinum catalyst causes the hydrogen to split into positive hydrogen ions (protons) and negatively charged electrons.

**3** The Polymer Electrolyte Membrane (PEM) allows only the positively charged ions to pass through it to the cathode. The negatively charged electrons must travel along an external circuit to the cathode, creating an electrical current.

**4** At the cathode, the electrons and positively charged hydrogen ions combine with oxygen to form water, which flows out of the cell.

## Hydrogen Fuel Cell





Electrolysis is the process of using an electric current to separate water molecules into hydrogen and oxygen gases. Every molecule of water has two hydrogen atoms and 1 oxygen atom.

### HYDROGEN PRODUCTION —Grades 6-8

#### Procedure:

Mix salt in water until salt dissolves.  
Bend each paperclip as shown in diagram.  
Connect one alligator clip to each battery terminal.  
Connect the other ends of the alligator clips to the ends of the paper clips.  
Place the two paper clips in the salt water so that they do not touch.  
Observe the paper clips.

#### Results:

Bubbles will form at both of the paper clips. More will form at one end than the other because two molecules of hydrogen gas are produced for every 1 molecule of oxygen gas.

#### Evaluation:

Which battery terminal (+ or -) produces oxygen?  
Which battery terminal (+ or -) produces hydrogen?

#### Extension:

If 20 molecules of water are split, how many molecules of hydrogen and how many molecules of oxygen will be produced?



#### Materials:

- 100 mL warm water
- 2 cubic centimeters salt (helps electric current travel through water)
- 6 volt battery (DO NOT substitute for another size)
- 2 sets alligator clips with wires
- 2 large metal paper clips
- 1 small flat plastic dish
- Safety glasses

Visit <http://205.254.135.24/kids/resources/teachers/pdfs/HydrogenElectrolysisElementary.pdf> for more information or a picture diagram.



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