# Using Electricity to Slowly Make $H_2$ and $O_2$ from $H_2O$ and then Putting it Back Together in a Hurry

In this demonstration we see the following:

The slow conversion of chemical energy in a battery into an electrical current that makes water break up into hydrogen gas and oxygen gas.

$$2H_2O + \text{electrical energy} \rightarrow 2H_2 + O_2$$

The quick conversion of chemical energy of hydrogen and oxygen gas into water with the release of heat, light, and sound energy.

$$2H_2 + O_2 + \text{spark} \rightarrow 2H_2O + \text{heat} + \text{light} + \text{sound}$$

A hydrogen and oxygen atoms have lower energy when combined as water than when they form separate hydrogen and oxygen molecules, but a little extra energy is needed to start the conversion of the hydrogen and oxygen gases back to water. The spark starts a few molecules making the conversion and the heat released by those reactions triggers all the rest in rapid succession.

See Wikipedia for more about electrolysis: http://en.wikipedia.org/wiki/Electrolysis_of_water

Needed:

- 1.4 L (1.5 Qt.) meat loaf dish
- Two 0.4 m lengths of **stainless steel** rod (from welding supply shop), 2-3 mm diameter
- 12 V battery (or enough batteries in series to make 12 V)
- Clip leads to connect battery to stainless steel rods and later to copper wire igniter
- Two 0.5 m lengths of insulated copper "hook-up" wire, 0.5 to 1.0 mm diameter
- A few cm of very thin copper "magnet" wire, about 0.1 mm diameter
- **Epsom salt** ($MgSO_4$, magnesium sulfate) - **Do not use table salt**, NaCl.
- Quart Zip-Lock plastic bag, stapled at the midpoint of the zipper.
- Water - well water, rain water, or pure bottled water, but not chlorinated city water.

The dish is filled 3/4 full with water, $H_2O$, and two or three teaspoons of Epsom salt are dissolved in the water. The salt is to help the water conduct electricity better than pure water.

The open end of the flattened plastic bag is placed below the water surface in the dish. The two electrodes are bent at one end to form electrodes that can fit in the bag without touching each other, but still be located at the bottom of the dish below the water surface. You may want to use tape or plastic straws to insulate the free ends of the electrodes so they don't accidentally touch each other.

Connect the battery to the electrodes and observe small bubbles (hydrogen gas, $H_2$) coming up from the negative electrode and a smaller number of larger bubbles (oxygen gas, $O_2$) coming up from the positive electrodes. The bag will capture the bubbles and gradually billow out.

While the gas is collecting make the igniter. First remove 5 mm of insulation from each end of each insulated copper wire. Then, connect (ideally soldering) a short 1 cm length of the very thin magnet wire between the ends of the two insulated copper wires. This makes a fuse that will melt and spark when the 12 V is applied between the other ends of the wires. A new section of thin wire will need to be attached after each use.

After several hours the bag will have puffed out with the mixture of hydrogen and oxygen gas.

You now must be careful to not accidentally set off the explosion with a spark.

Disconnect the electrodes from the battery and set the battery aside.
**Do NOT yet connect the battery to the igniter.**

While keeping the open end of the bag below the surface of the water to prevent the escape of any of the

hydrogen and oxygen gas, remove the electrodes and insert the igniter with the thin wire section up in the gas at the top of the bag.

Put up a blast barrier or hide your face from the bag and dish of water. There must be plenty of space between the blast barrier and the bag so that the explosion will not break the blast barrier.

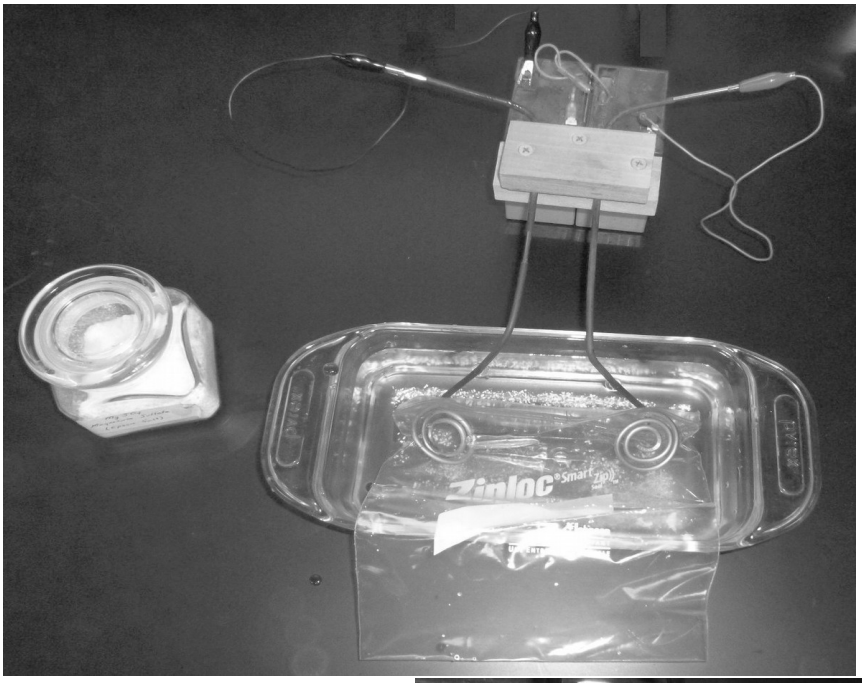
Attach one of the free ends of the igniter wires to one side of the battery. **Do not attach the other end until you are ready for the explosion.**

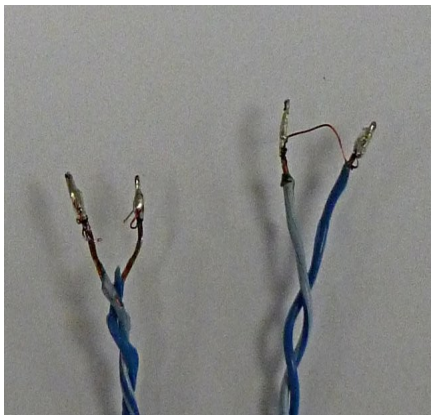
When ready, touch the other end to the other terminal of the battery. As the thin igniter wire melts, a spark will occur and the hydrogen and oxygen gas will very rapidly turn back into water (as steam) in an explosion.

The photograph on the right shows the layout at the very start of the electrolysis demo. The 12 V battery is actually two 6 V batteries connected in series. In this case the negative side of the battery is connected to the left stainless steel electrode where hydrogen will be produced. The positive side on the right is where oxygen will be produced.

The white granules of Epsom salt in the water have not yet dissolved into the water

The electrodes pass into the bag under the water. As the experiment progresses, the bag will fill with hydrogen and oxygen gas.



Two igniters, one used (blown open) and one ready for use are shown in the photo at the left.

The two electrodes are shown at the right after use. The one that produced oxygen on the right side is clean and polished. The one that produced hydrogen on the left has a crust of (I think) iron sulfate, iron from the stainless steel and sulfate from the $MgSO_4$.

Near the end of this course, we will learn about acids and bases and a quantity called the pH of a solution. We will steep some red cabbage to make a purple pH indicator solution. When this indicator is added to an acidic solution it will turn pink, but when added to a basic solution, it will turn green. In our electrolysis, hydrogen is removed from the negative electrode leaving the solution surrounding that electrode with fewer hydrogen ions and therefore a basic solution (green indication). At the positive electrode, hydroxide ions are removed leaving the solution around that electrode with an excess of hydrogen ions and therefore acidic (pink indication).