

Breaking Down Water Into Hydrogen And Oxygen Using Electricity



Topic

Electrolysis

Introduction

In 1800, Italian inventor Alessandro Volta built the first device capable of producing an electric current. He called it the voltaic pile, and it was the forerunner of modern batteries. When news of Volta's experiments reached London, other scientists took up this line of research. Anthony Carlisle, a professor of anatomy, made his own version of the pile using silver half-crowns (old English coins), zinc disks, and pieces of cardboard soaked in brine. His friend William Nicholson copied the procedure and started his own investigations. In one of these he attached platinum wires to opposite ends of the pile. When he placed the other ends of the wires in a dish containing water and a few drops of sulfuric acid, he noticed bubbles of gas appearing at the ends of the wires. Nicholson collected these gases and tested them. The wire connected to the silver disk of the pile (positive) produced oxygen; the wire connected to the zinc disk (negative) produced hydrogen. Nicholson also found that twice as much hydrogen was produced as oxygen, suggesting that water was made up of two parts hydrogen to one part oxygen – something we now know to be true. This was the first time electricity – rather than heat – had been used to break down a substance. The process is called electrolysis.

Time required

1½ hours

Materials

clean, empty plastic food container
(a 16 oz empty cottage cheese pot is ideal)
2 pieces of graphite rod,
7–8 cm long, 3 mm diameter
Fun-tak®
DC power pack or 6V battery
50 cm length of insulated bell wire
2 crocodile clips
wire strippers
sharp scissors
distilled water

2M sulfuric acid
10 ml graduated cylinder
500 ml beaker
stirring rod (glass rod or chopstick)
ring stand with support ring
ignition tube (small test tube, about
6 cm long, 7 mm diameter)
matches
wood splinters
safety glasses
rubber gloves
partner to work with you

Safety note



Teacher supervision is required. Students must wear safety glasses and rubber gloves at all times, and take great care when pouring acid.

Procedure



1. Take the plastic food container and turn it upside down. Use the points of the scissors to make two small holes about 3 cm apart and large enough for the carbon electrodes to be pushed through.

2. Push the carbon electrodes through the holes so that just 1 cm projects from the bottom of the plastic pot.

3. Use small pieces of Fun-tak® to seal the holes around the carbon electrodes from both inside and outside the plastic container, as shown in the diagram below.

4. Support the plastic container on the support ring so that its base is approximately 5 cm above the table.



5. Take the wire and cut it in half using the scissors. Strip 3 cm of insulation from the ends of the wires using the wire strippers.

6. Connect one end of each wire to a crocodile clip. Connect the other end to one of the battery terminals.

7. Pour distilled water into the beaker until it is three-quarters full.



8. Put on safety glasses and keep them on until the end of the experiment.



9. Measure out 10 ml of sulfuric acid using the graduated cylinder, then carefully pour the acid into the beaker with the distilled water and stir the diluted sulfuric acid with the glass rod or chopstick.

10. Pour the diluted sulfuric acid from the beaker into the plastic container in the support ring. Leave enough diluted sulfuric acid in the beaker to fill the ignition tube four times.

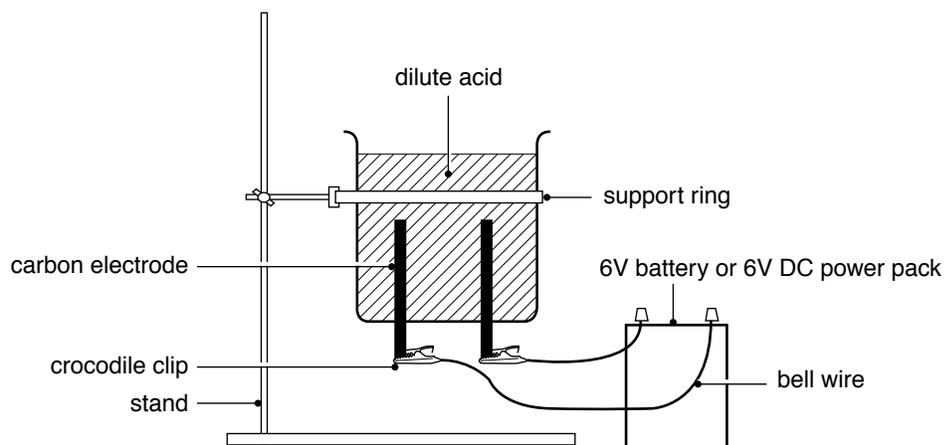
11. Connect the crocodile clips to the carbon electrodes below the plastic container. Make a note of which one is connected to the negative terminal of the power pack or battery and which one to the positive terminal. If you are using a power pack, set it to 6V and switch it on.



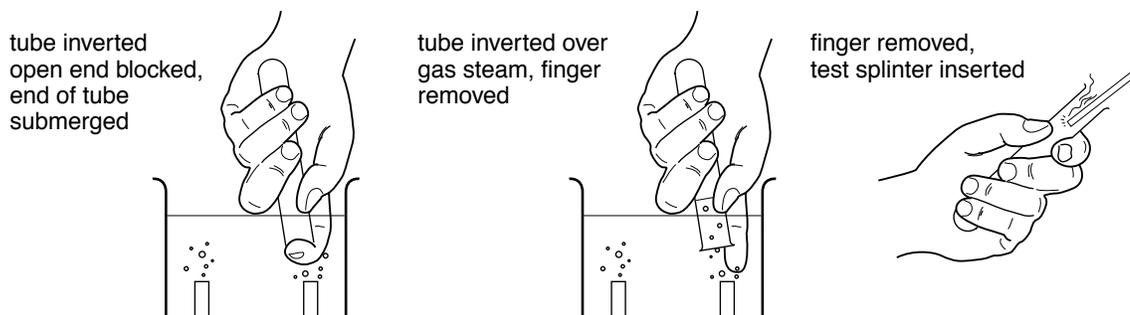
12. Watch what happens at the electrodes inside the container. Record your observations.



13. Put on rubber gloves and keep them on for the rest of the experiment.



14. Carefully fill one of the ignition tubes with dilute sulfuric acid from the beaker.
15. Put your finger over the end of the ignition tube so that air cannot get in. Transfer the tube to the plastic container, and invert it in the dilute acid solution so that the open end of the tube, blocked by your finger, is under the surface. Remove your finger from the end of the tube, move the open end of the tube directly over the positive electrode, and hold it there as shown in the diagram below.
16. When the tube has filled with gas, ask your partner to light one of the wood splinters. Put your finger over the opening of the tube and remove the tube from the plastic container. Keep the tube sealed with your finger. Tell your partner to blow out the flame to leave the splinter with a brightly glowing tip.
17. Tell your partner to plunge the glowing splinter into the ignition tube as soon as you remove your finger. Remove your finger and record your observations.
18. Repeat stages 14 to 17 over the same electrode, but this time ask your partner not to blow the flame out but instead to plunge the lighted splinter into the ignition tube as soon as you remove your finger. Remove your finger and record your observations.
19. Repeat stages 14 to 18, but this time collect the gas rising from the negative electrode. Record your observations.



Analysis

1. What happened when you connected the electrodes to the battery or power pack?
2. Describe what happened when you tested the gas produced at the positive electrode:
 - a. with a glowing splinter, and
 - b. with a lighted splinter.
3. Describe what happened when you tested the gas produced at the negative electrode:
 - a. with a glowing splinter and
 - b. with a lighted splinter.
4. Do some research on oxygen and hydrogen. Which is tested for with a glowing splinter, and which with a lighted splinter?
5. Did you notice any difference in collecting gas over the positive electrode and collecting gas over the negative electrode? If there was a difference, what did it tell you?

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1. Provided that the connections were made correctly, bubbles of gas are seen rising at both electrodes.
2. The glowing splinter immediately re-ignites in the gas collected from the positive electrode, while the flame on the burning splinter burns even brighter in this gas.
3. The glowing splinter does not re-light in the gas collected at the negative electrode, but when the lighted splinter is inserted, the gas ignites with a distinct “pop,” leaving water droplets on the inside of the ignition tube.
4. Oxygen re-lights a glowing splinter, so the gas collected at the positive electrode is oxygen. Hydrogen explodes with a characteristic “pop” when ignited, so the gas collected at the negative electrode is hydrogen. Hydrogen combines with oxygen in the air to form water, which explains why droplets of water appear on the inside of the ignition tube after the hydrogen has been ignited.
5. The ignition tube fills much more quickly over the negative electrode than it does over the positive electrode because twice as much hydrogen as oxygen is released during the electrolysis of water.

Practical note: Dilute sulfuric acid increases the ability of water to conduct electricity.

English chemist Michael Faraday (1791–1867) devised the technical terms we now use to describe the apparatus and processes demonstrated in this experiment:

the process of decomposition he called “electrolysis”

the substance being decomposed is the “electrolyte”

the wires through which electricity enters the electrolyte are called “electrodes”

the current enters the electrolyte through the “anode” (the positive electrode)

the current leaves the electrolyte through the “cathode” (the negative electrode).