ORESOME RESOURCES
Minerals and Energy Education

Hydrogen Gas Production by Water Electrolysis

Background

Electrolysis is the process that uses electric current to induce non-spontaneous chemical reactions in electrolytic cells. An electrolytic cell consists of a power supply connected to two electrodes, a cathode and an anode that are separated by an ionically conducting electrolyte.

The electrolysis of water breaks the bonds of water molecules (H_2O) and produces hydrogen (H_2) and oxygen (O_2) molecules. Energy, as electric current, sent through the electrolytic cell flows in the form of electrons in the electrodes and as ions in the electrolyte.

In this experiment batteries can be used as the energy supply. The stored potential energy from the battery flows as the electricity when it is connected in a complete electrical circuit though the cell. As the current must flow through the electrolyte in the cell, the electrolyte needs to be a good conductor of electricity. Pure water itself is not a good conductor of electricity, so for this experiment it is an ionically conducting aqueous solution.

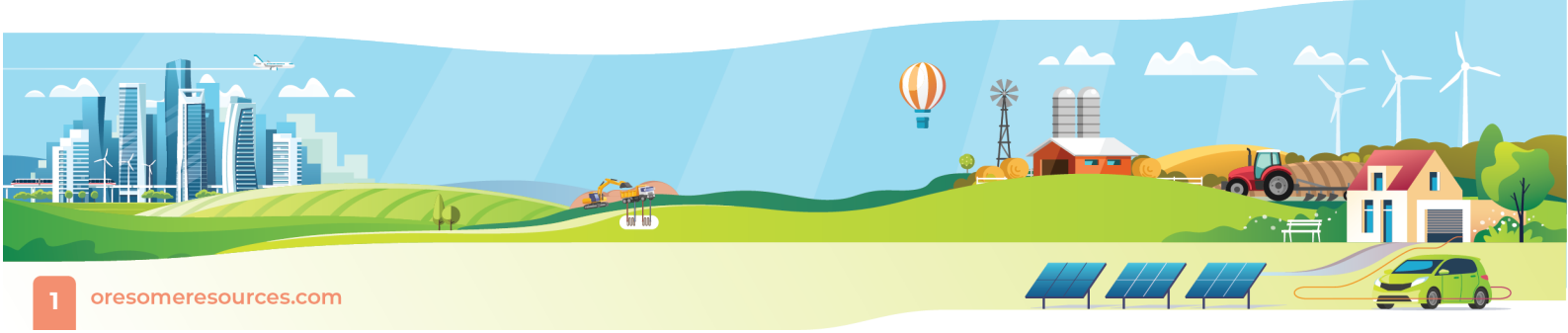
Hydrogen is needed to power most fuel cells to power fuel cell cars and trucks. To be able to produce the cleanest, most environmentally friendly hydrogen the power supply for the electrolyser needs to be considered and the electrolyser used needs to be the most efficient. The efficiency of electrolysers is determined by the different properties of the components used in them, eg electrolyte and electrode material.

Aim

This experiment allows for a study of the electrolysis of water without the use of the traditional Hoffman apparatus.

Safety

- Wear personal protection equipment to protect skin and eyes.
- Work in a well-ventilated area to protect airways.
- Ensure all apparatus is securely supported and stable.
- Wash hands with mild soap and water before eating or drinking.



Hydrogen Gas Production by Water Electrolysis

Materials

For splitting water

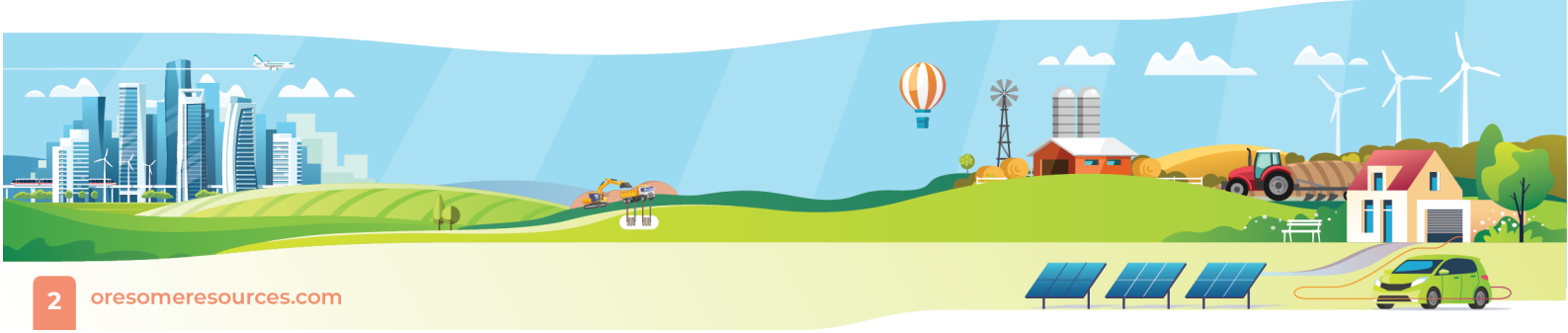
- large glass or plastic container
- 2 wide test tubes (boiling tubes)
- low voltage DC power supply, or 6 - 9V battery
- 2 wires with alligator clips at each end
- metal strips 1-2 cm wide and 6–10 cm long (platinum, stainless steel or aluminum)
- 2 retort stands with clamps.
- 2–4 small spatula measures solid sodium sulfate
- Bromothymol blue indicator
- Water
- Stirring rod
- Sticky tape
- Few drops of 0.1M sulfuric acid
- Few drops of 0.1M sodium hydroxide

Extras for testing the gases

- Splint
- Bunsen burner

Warnings

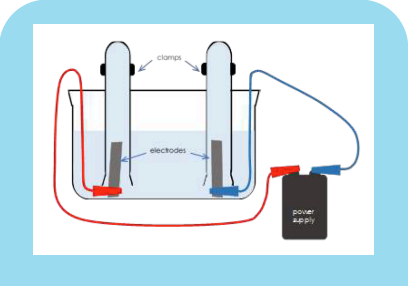
- 0.1M sulfuric acid could be a corrosive skin and airway hazard.
- Few drops of 0.1M sodium hydroxide could be a skin and airway irritant.



Hydrogen Gas Production by Water Electrolysis

Procedure

Splitting water



- Tape one alligator clip end from each of the wires to the inside bottom of the large container. Do not allow them to touch and leave enough space so that you can still open and close the clips.
- Attach an electrode strip to each of the alligator clips taped to the bottom of the container ensuring that each electrode is as vertical as possible.
- Pour water into the large container to about 2/3 full. Fill 2 test tubes up with water and invert each test tube and place in the container without allowing any air to enter the test tube.
- Use a clamp to hold the test tubes in place with the open end submerged in the water over an electrode each.
- Add indicator to the water to make a strong colour. The starting colour should be green. If the water is blue, add a few drops of sulfuric acid until the solution turns green. If the water is yellow, add a few drops of sodium hydroxide solution until the solution turns green.
- Clip one of the wires to the positive terminal of the power supply and the other wire to the negative terminal. A very small number of bubbles will form at the electrodes.
- Disconnect one of the wires from the power supply.
- Add two spatula measures of sodium sulfate to the water. Stir to dissolve.
- Reconnect the wire to the power pack. This time more bubbles should be produced. If there are still not many bubbles, disconnect the wire again and add two more spatula measures of sodium sulfate, stir to dissolve, and then reconnect the wire again.
- Watch bubbles collect at the anode and cathode and observe the relative volumes of the two gases produced.
- Disconnect the power supply.

Testing gases

To test the gas of smaller volume

- Release the clamp on the test tube with the smaller volume of gas and lift it vertically from the electrolyte. Keep the opening facing down, and quickly place a thumb over the opening of the tube as it comes out of the electrolyte.
- Use the Bunsen burner and light one end of the splint.
- Remove your thumb and as the gas flows out, hold the lit splint near the opening of the test tube and observe the effect.

To test the gas of larger volume

- Release the clamp on the test tube with the larger volume of gas and lift it vertically from the electrolyte. Keep the opening facing down, and quickly place a thumb over the opening of the tube as it comes out of the electrolyte.
- Use the Bunsen burner to light splint, blow out the flame to leave the splint glowing.
- Tilt the test tube opening upwards, remove your thumb and as the gas flows out, hold a glowing splint near the opening of the test tube and observe the effect.

Results

Record observations of the following:

- The amounts of gas produced at the electrodes connected to the positive and the negative power supply terminals.
- The colour produced as the electrolysis occurs.
- Results of the gas tests.

Further experimenting

This set up can also be used to produce hydrogen and oxygen gases by electrolysis of water to investigate answer to the following questions:

- What is the effect of voltage on the rate of electrolysis?
- What is the effect of using a solar cell instead of a battery have on the rate of electrolysis?
- What is the effect of the type of electrolyte solution on the rate of electrolysis?
- What is the effect of the electrode material on the rate of electrolysis?

Adapted from Royal Society of Chemistry - Experiment: Splitting water