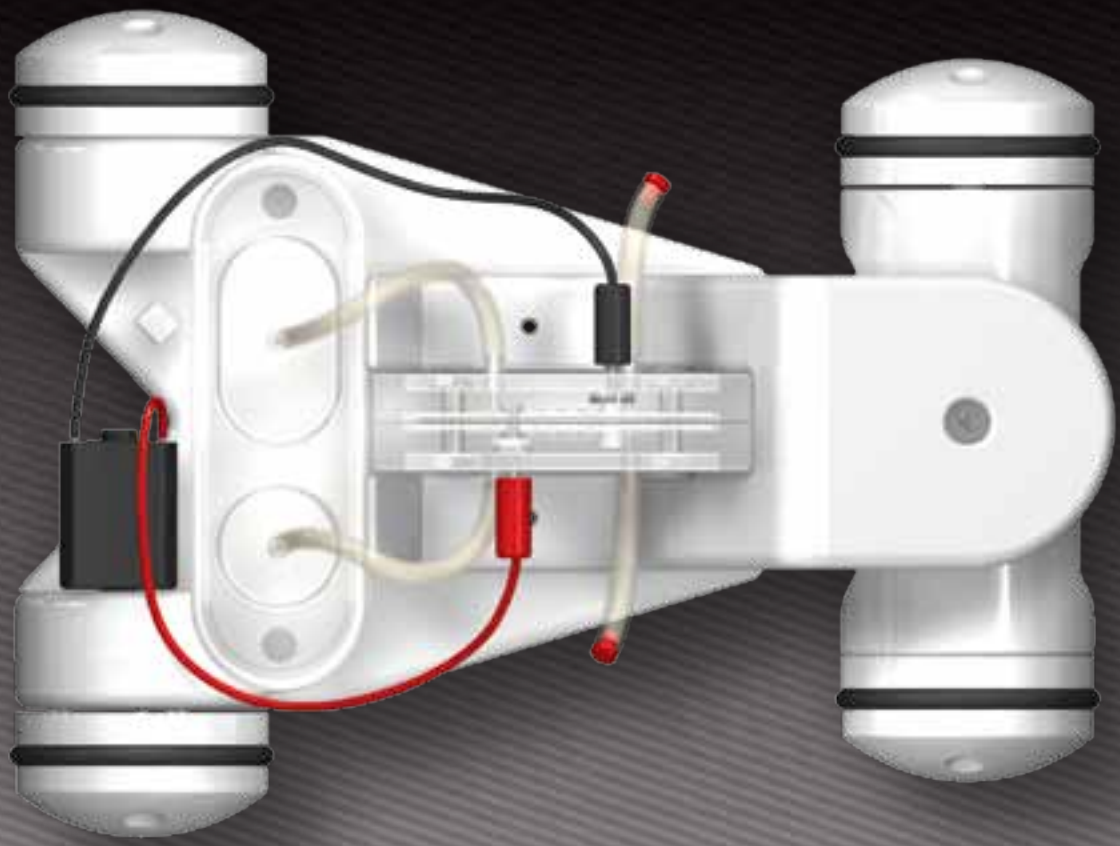
fuel cell

car and experiment kit



SCIENCE EDUCATION SET

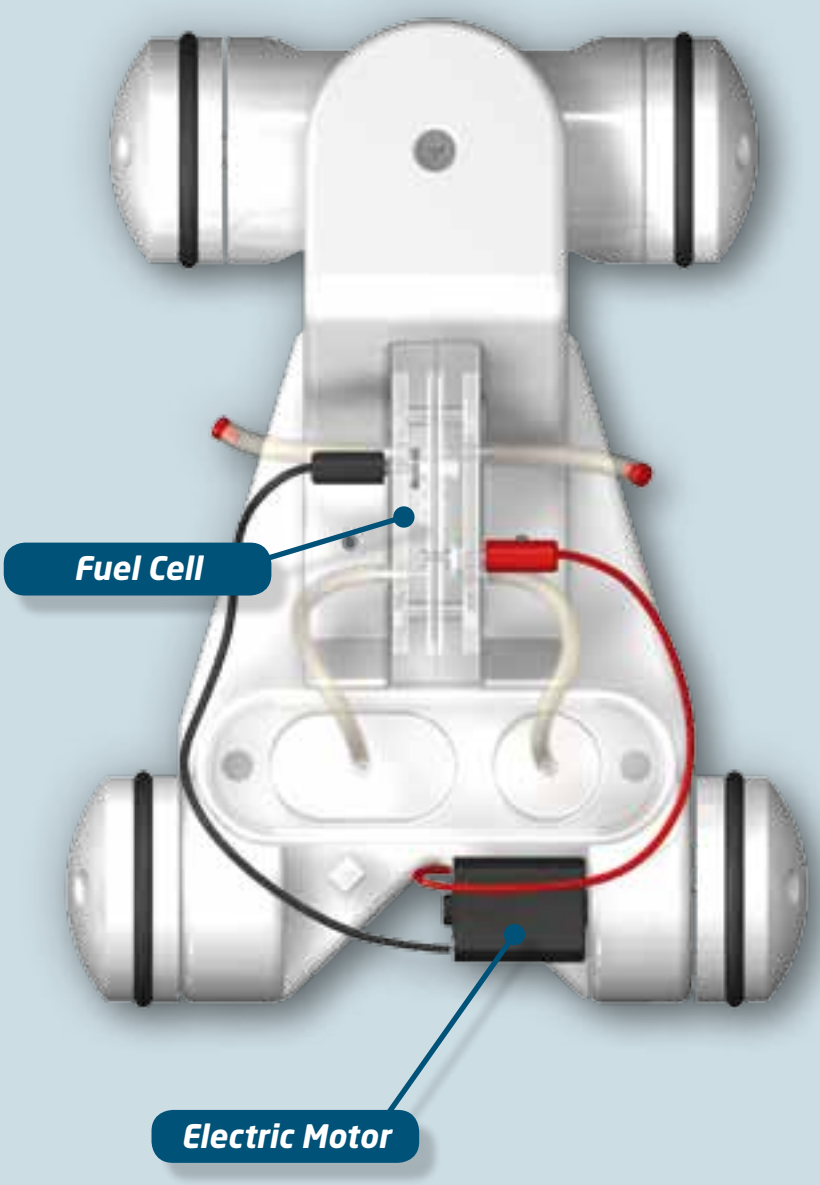
WARNING — This set contains chemicals that may be harmful if misused. Read cautions on individual containers carefully. Not to be used by children except under adult supervision.

Experiment Manual

Thames & Kosmos

Concept Fuel Cell Car

This fuel cell car works in a two-step process. First, the fuel cell splits water into hydrogen and oxygen and those gases are stored in tanks. When the electric motor is connected to the fuel cell, the fuel cell combines those two gases into water, which produces electricity to run the motor. We can also use our car to investigate other alternative electric car concepts.



Fuel cell technology in the model

Process

To power the fuel cell, we will start with the sun, because the fuel for the fuel cell car is generated using solar power.

1. The solar panel generates electricity from sunlight.

2. The electricity from the solar panel is used for electrolysis of water.

3. The hydrogen gas produced during electrolysis is the fuel for the fuel cell.

4. The fuel cell uses hydrogen and oxygen to generate electricity to power the car's electric motor.

Fuel Cell 10

Overview of Components

If you are missing a part, please contact Thames & Kosmos Technical Support.

Production of Fuel with Battery Current

When the sun is not shining, you can also produce fuel with battery power.

- Connect the red battery terminal to the red oxygen (O_2) socket of the fuel cell.
- Connect the black battery terminal to the black hydrogen (H_2) socket.

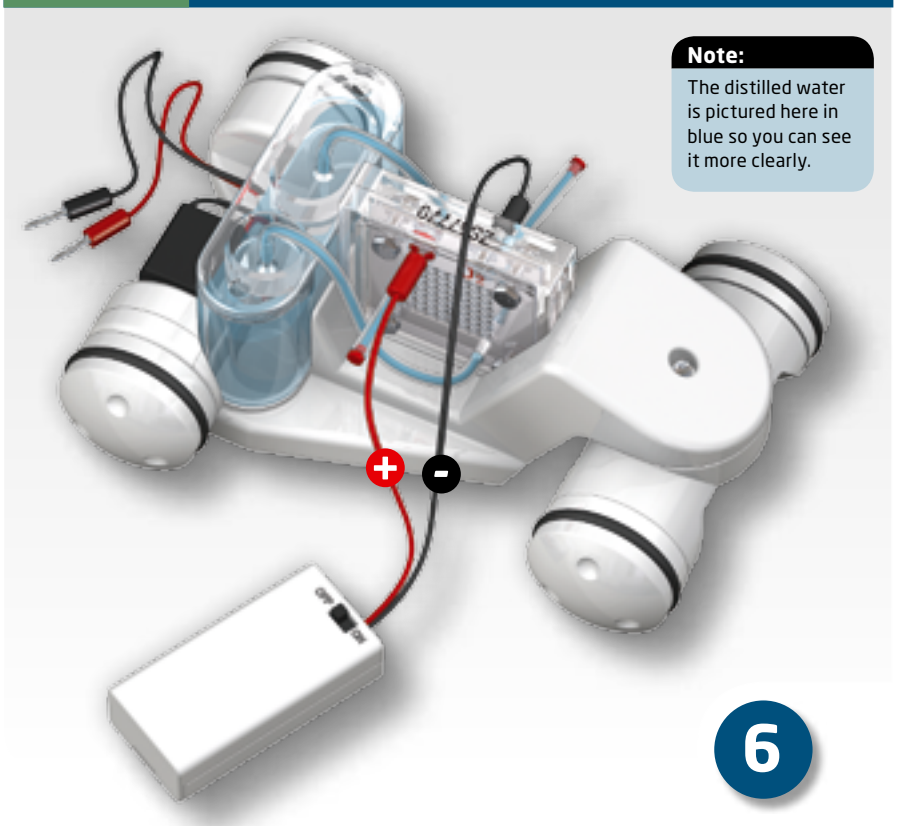
Checking the Gas Production

Now electrolysis begins in the fuel cell, which is the splitting of water into its elements, hydrogen and oxygen. The water that remains in the tubes is pushed from the cell through the long hoses to the gas tanks and the water tank by the gas that is produced. The larger tank fills with hydrogen gas, the smaller one with oxygen. After just a few minutes, you will be able to see how the gases push the water down in their storage tanks and the water level in the water tank starts to rise.

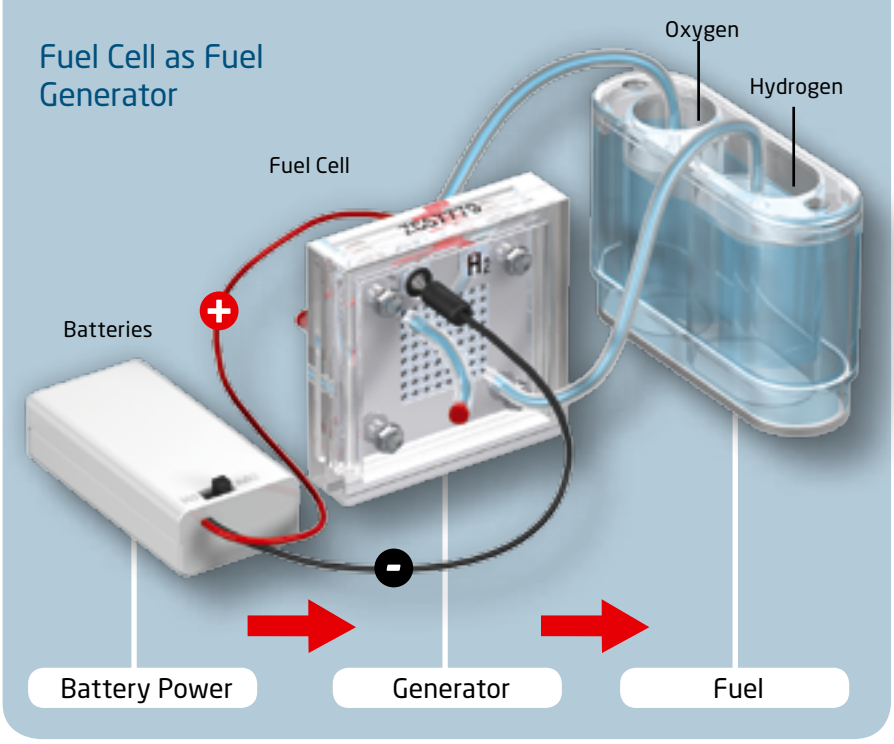
When the first bubbles rise out of the gas tanks to the water's surface, the tanks are full.

Remove the cables between the fuel cell and solar panel.

Do It! Produce Fuel with Battery Power



Concept The Fuel Cell Generates Fuel

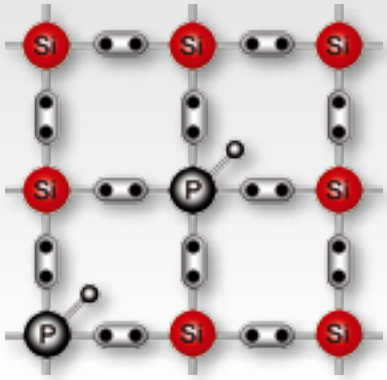


Structure and Function of a Solar Cell

Doping the Silicon

To create solar cells from the highly pure silicon wafers, they have to be somewhat "impurified" again. This process is known as doping. It involves vapor-deposition of tiny doses of pure elemental phosphorus on one surface of the wafer, and boron on the other surface. The proportion of these doping elements to the silicon is about equivalent to one drop of water in a swimming pool.

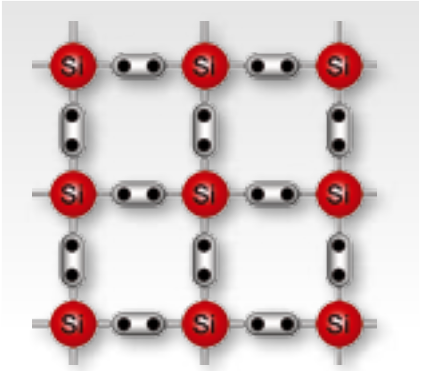
Silicon Crystal Lattice Doped with Phosphorus



In the upper layer, a silicon atom will be replaced by a phosphorus atom in a few spots (above). In its outer shell, phosphorus has five electrons. There is one electron left over, since it can only

Silicon Atom

Silicon Crystal Lattice

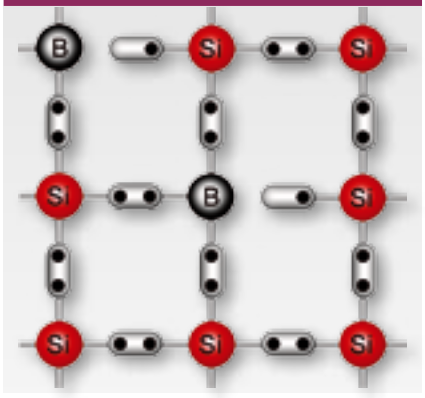


enter into a covalent bond with four silicon atoms in the crystal lattice. That is because silicon is usually tetravalent, meaning it has four "bonding arms."

So the phosphorus atom's fifth electron cannot find a bonding partner, and it is therefore very loosely attached to the phosphorus atom. Even at room temperature, the bond will be easily broken. So silicon doped in this manner has free electrons (negative charges) and is therefore called an n-doped layer.

The solar cell's lower layer is doped with boron in a similar manner (below). Boron has three electrons in its outer shell, each of which enters into a bond with the neighboring silicon atom.

Silicon Crystal Lattice Doped with Boron



There is an electron missing for a fourth bond, however. This kind of defect or gap is known as an "electron hole."

Even at room temperature, an electron from a neighboring Si atom can "jump over" into this hole, making the hole seem to move. The conductivity of the silicon doped in this manner, in other words, depends on the mobility of the "holes" (positive charges). This zone is known as a p-doped layer.

Both the p-doped and the n-doped layers conduct well, and are neutral on their own. So there is no voltage.

This is how the silicon is manipulated to make it photoelectrically sensitive. A look into the solar cell's crystal lattice will show us how it works.

Creating the Voltage Potential

In the area where the p- and n-doped layers touch, a boundary layer known as a p-n junction forms, where a few electrons from the n-doped layer wander over into the p-doped layer. There, they replace electrons that are missing for covalent bonding. The movement of the electrons from the n-doped layer

Tests

Measuring the Solar Panel and Fuel Cell Output

Solar Panel Voltage

To determine the power of the solar panel, we will measure the short circuit voltage on the V= side of the multimeter in measurement range 20 (Figure 2). The voltage will vary depending on the strength of the light hitting it, but it should be about 2.8 volts.

Solar Panel Current

We will measure its short circuit current on the A= side in the 200m range (Figure 3). The current will also vary depending on the amount of light, but an average current reading is about 250 mA.

Multiply 0.25 A x 2.8 V to calculate a power of 0.7 watts.

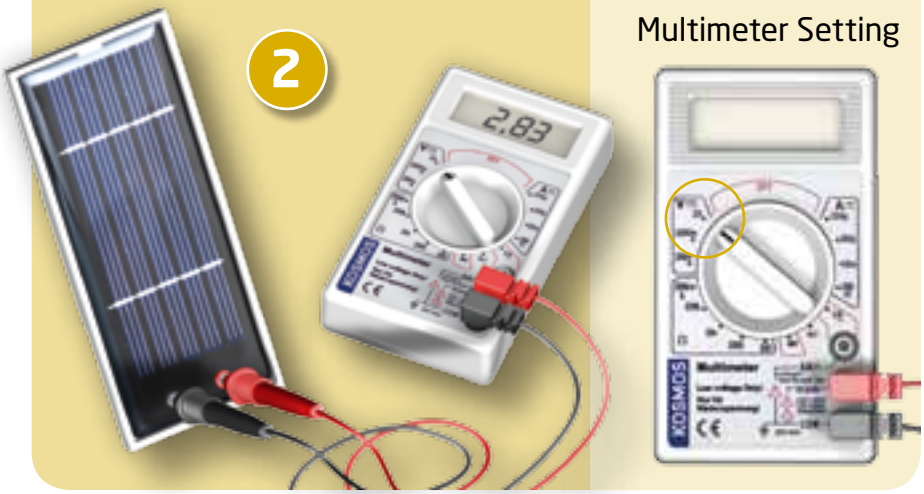
Fuel Cell Power

To measure the power of the fuel cell, first fill the tanks with hydrogen and oxygen. Instead of connecting the motor, insert the meter probes into the cell's ⊕ and ⊖ sockets and take a reading (Figure 4). Thus, we can calculate the fuel cell:

Power = Voltage x Current

With 1.4 volts and 16 mA (0.16 A), the power output would be 0.22 watts. The values drop by half as soon as we hook up a load (the electric motor) to the circuit instead of just the multimeter. Then, the value readings are called operating voltage or operating current, instead of no-load values.

Measure *Solar Panel Voltage*



Measure *Solar Panel Current*

Measure *Fuel Cell Voltage*