

WARNING!

For use by children over the age of 10 only. To be used only under the close supervision of adults, who have taken the necessary precautions described in the experiments kit. Read the instructions before use, follow them and keep them ready to hand.

They contain instructions for parents and these must be followed. Keep the packaging and instructions, as they contain important information. Hydrogen is produced during the experiment. Hydrogen can form an explosive mixture with atmospheric oxygen. Therefore, all ignition sources must be removed before carrying out the experiment.

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Fuel Cell kit

How does a fuel cell work? How can you produce hydrogen with it? The Fuel Cell kit imparts knowledge on all aspects of this exciting topic. With the fuel cell and the additional solar module, interesting additional models can be built in conjunction with the Profi Oeco Energy kit. The didactic activity booklet in the Profi Oeco Energy kit provides help. All of your questions are answered.

Important instructions on use of the Fuel Cell kit

The Fuel Cell Kit is an extension kit. You will also need the Profi Oeco Energy kit (Item # 520400) to operate the fuel cell and to perform the experiments described in this instruction manual. Alternatively, you can also use the Profi Oeco Tech kit (Item # 505284).

Advice for supervising adults

- This experiments kit is only intended for use by children over the age of 10 years.
- The instructions should enable adults to assess the experiment's suitability for the child concerned.

Safety rules

- Read these instructions before starting the experiment, follow them and keep them ready to hand.
- Keep the experiments kit out of reach of small children.
- Do not put wires into the electrical outlet.
- Warning: Do not remove the protective diode between the connections of the fuel cell! It prevents irreparable damage to the fuel cell if a short circuit occurs between the positive pole (red) and the negative pole (black) or if cables get too hot.
- Do not short circuit the fuel cell (explosion hazard)!
- Warning: (Connection) errors or unauthorized changes can cause temperature increases on exposed surfaces that can exceed the allowable limits!
- The fuel cell may only be operated with a direct voltage up to 3V. Never connect any other power supplies, e.g. 9V fischertechnik.
- Do not short circuit the contact points of the fuel cell.
- Too high voltage or a short circuit can destroy the fuel cell membrane.

- Do not produce electricity or hydrogen for any purposes other than those given in the instruction manual.
- Do not produce or store more hydrogen than fits in the storage cylinder of the fuel cell (around 20 ml).
- Avoid continuous charging of the fuel cell.

Proper use

The Fuel Cell kit's fuel cell may only be used to operate fischertechnik models.

How the fuel cell works

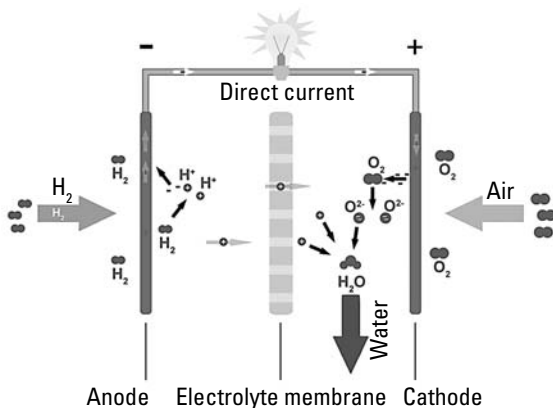
■ A fuel cell converts the chemical energy of a fuel (e.g. hydrogen) into electric current (electricity). A fuel cell is therefore not an energy store but an energy converter. Fuels cells are used, for example, to drive vehicles and to supply homes with heat and electricity.

A fuel cell consists of two electrodes (anode and cathode), which are separated from each other by an electrolyte membrane.

The electrodes are made of metal or carbon. They are coated with a catalyst, for example, platinum or palladium.

Inside the fuel cell, hydrogen and oxygen react to form water. This reaction produces an electric voltage between the two electrodes which can be used, for example, to drive an electric motor.

■ The fuel cell included in the Fuel Cell Kit is a so-called reversible fuel cell. This means that the fuel cell has the following two functions:

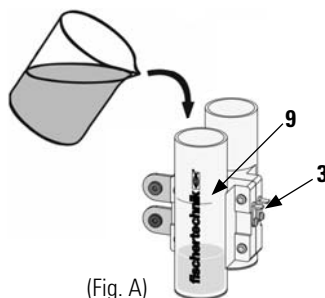


- On the one hand, the reversible fuel cell can be used as a so-called electrolyzer, for producing hydrogen and oxygen from distilled water. This process is called electrolysis. The hydrogen and oxygen are stored in storage cylinders.
- On the other hand, the reversible fuel cell can be used to produce electrical energy by reacting the stored hydrogen with the stored oxygen.

Operating the fuel cell

Description of the fuel cell (see Fig. 1 on page 3).

- 1 Overflow chamber, hydrogen side
- 2 Hydrogen storage cylinder
- 3 Plugs for air vents
- 4 Oxygen storage cylinder
- 5 Negative jack (black)
- 6 Protective diode
- 7 Positive jack (red)
- 8 Overflow chamber, oxygen side
- 9 Level mark



(Fig. A)

Filling the fuel cell with distilled water

Place the fuel cell on a flat plate.

Then remove the two plugs (3) from the ventilation ducts. Fill the two storage cylinders with distilled water up to the level mark (9).

(See Fig. A)



Caution! Material damage possible:

Tap water and other liquids permanently damage the fuel cell membrane.

When the water is added the air in the fuel cell escapes through the air vents. Gently bang the fuel cell on the table to let the water flow more easily around the membrane and the current collecting metal plates.

Add a little bit more water, only enough to make water escape through the air vents and at the same time for the water in the overflow chambers to reach up to the level mark.

You can now use the plugs to re-close the air vents. Ensure that no air is trapped in the storage cylinder. A small air bubble does not cause any problems and can be ignored.

If the fuel cell has not been used for a long time, wait for around 10 minutes to allow the membrane to become sufficiently impregnated.

Producing hydrogen and oxygen (electrolysis)

The fuel cell must be supplied with a direct voltage between 1.8 and 3 volt.



Caution! Material damage possible:

If the voltage is too high, it can destroy the fuel cell membrane. The fuel cell must never be connected to a 9V fischertechnik power supply.

The solar module included in the Fuel Cell kit consists of two solar cells, which are connected in series. Without load, the solar module supplies a maximum voltage of 1.0 V. As this voltage is not enough for the electrolysis, you will need another solar module from the Profi Oeco Energy kit.

Connect the two solar modules (Item # 146142) in series and connect them to the fuel cell (see Fig. 2 on page 3). Depending on the light intensity, the two solar modules now supply a voltage of 1.6 – 2 volt.

Tip: Have you got the "Profi Oeco Tech" kit? Then you can use its solar module and the solar module of the Fuel Cell kit. Connect them in series and connect everything to the fuel cell (1 x solar module Item # 136239, 1x solar module Item # 146142).

Hydrogen and oxygen production begins as soon as the solar modules are illuminated with sufficient sunlight or a suitable light source. The gases are stored in the corresponding storage cylinders. The water is pressed into the overflow chambers above the cylinders.

The fuel cell is completely "charged" when all the water from the hydrogen storage cylinder (2) has been pressed into the overflow chamber above it (1). This process lasts around 15 – 60 minutes, depending on the light intensity.

You can now disconnect the fuel cell from the solar modules. This stops the production of hydrogen and oxygen.

Tip: If you want to achieve the optimum output of the fuel cell, flush all the air out of the fuel cell. To do this, continue producing hydrogen until the last of the water has been pressed out of the oxygen storage cylinder and into the overflow chamber above it.

Experiment 1:

Measure how much hydrogen is produced in a certain period of time during the production of hydrogen and oxygen. Measure the time needed for the hydrogen storage cylinder to become completely filled with hydrogen (20ml hydrogen). Observe the effect that the light intensity has on the time required.

If the light intensity is high, more hydrogen is produced during the same time. If the light intensity is too low, no hydrogen is produced at all.

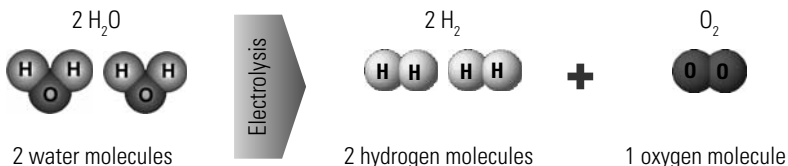
If you use a 100W light bulb as a light source at a distance of 30cm from the solar modules, it takes around 15min for the hydrogen storage cylinder to completely fill with gas.

Experiment 2:

Observe the quantity of water displaced in the two overflow chambers while hydrogen and oxygen are being produced. What can you observe?

Twice as much hydrogen is produced as oxygen. Why?

Water (H_2O) consists of compounds of hydrogen (H_2) and water (O_2). These compounds are called water molecules. A water molecule consists of two hydrogen atoms and one oxygen atom. When the molecule is split during electrolysis, twice as many hydrogen molecules are produced as oxygen molecules.



Producing electric energy

As soon as there is hydrogen and oxygen in the storage cylinders, they react with each other and an electric voltage of 0.5 to 0.9 V is produced at the jacks. The fuel cell supplies a 600 mA current and has a nominal power of 300 mW.

Experiment:

Connect the motor in the Profi Oeco Energy kit (alternatively: Profi Oeco Tech) (Item # 69205) to the jacks of the fuel cell (see Fig. 3, on page 3).

What do you see?

The motor is rotating. It is driven by the electrical energy generated by the fuel cell.

Shutting down/storing the fuel cell

The fuel cell should not be stored filled with water.

Therefore, after you have finished your experiments, remove the plugs from the fuel cell and pour out the water. Shake the fuel cell to empty it completely. Then leave it to dry.

Notes on environmental protection:

Do not put the electrical and electronic components of this construction set such as motors, lamps and sensors in the household waste. At the end of their service life, hand them in to a collection point for the recycling of electrical and electronic devices.

The symbol on the product, packaging or the instructions indicates this.

Liability

Liability on the part of fischertechnik GmbH for damages, which resulted from the fact that the kit was not used in accordance with instructions, is excluded.

Experiments using the Fuel Cell kit & Profi Oeco Energy

The activity booklet of the Profi Oeco Energy kit contains many other exciting experiments that you can perform with the Fuel Cell kit.

The corresponding models are described in the Profi Oeco Energy assembly instructions.

Experiments using the Fuel Cell kit & Profi Oeco Tech

Experiments and models are shown in the Profi Oeco Tech kit which require the Hydro Cell kit.

You can also perform these experiments with the Fuel Cell kit. However, you will have to improve a bit when installing the fuel cell and the solar module, as these have different dimensions and mounting options to the components in the Hydro Cell kit. Further notes on this are given on page 77.

Fuel cell technical data

General		Operation as electrolyzer	
Operating temperature	10–40 °C	Operating voltage	2–3 V
Storage temperature	5–40 °C	Operating current	400–1500 mA
Hydrogen storage capacity	20 ml	Maximum hydrogen production rate	8 ml / min

Operation as fuel cell	
Operating voltage	0.5–0.9 V
Operating current	600 mA
Nominal power	300 mW

Troubleshooting

Fault	Possible cause	Remedy
Unusually high voltage, if a load is connected to the fuel cell	Coat on the surface of the catalyst	The coat on the surface of the catalyst, which increases the initial output voltage of the fuel cell, disappears after a few seconds
No or very slow hydrogen production	Incorrect connection between solar modules and fuel cell	Check connections and if necessary correct
	Light intensity too low	Increase the light intensity
	Fuel cell membrane is too dry	Leave the fuel cell filled with distilled water to stand for 30 minutes
Low fuel cell output	Fuel cell membrane is too wet	Pour water out of the fuel cell and leave the fuel cell to stand open for a day