Solar-hydrogen system

Task and equipment

Information for teachers

Additional information

Whereas coal, natural gas and crude oil sources will be exhausted in the not too distant future, the sun is expected to continue to exist in the form known to us for about 5 billion years. Solar energy can be utilised, but is not always available when it is needed. It must therefore be stored for utilisation of it around the clock. Hydrogen could be the future solution for the storage problem. The excess energy of the sun can be used to separate water into hydrogen and oxygen, which enables the energy to be stored in pressure tanks, cryogenic tanks or metal hydrides. When this energy is required, at night, for example, a fuel cell can be used to convert the hydrogen back to electric energy and water. This process functions without any hazardous waste products that would pollute the environment. Solar cells are mostly used to make solar energy utilisable in the first place. They usually consist of doped silicon. A voltage is induced in them by the photoelectric effect, so that a great light intensity results in a high performance to the electrolyser. This leads in turn to a greater gas production.

Notes on set-up and procedure

The electrolyser and the fuel cell are differentiated by colour marking. The electrolyser is blue.
The maximum permissible values for the electrolyser are 2 V for the voltage and 2 A for the amperage.
Take care that the two openings on each side of the electrolyser are connected with tubing again at the end of the experiment, so that the membrane does not dry out. Refer here to Fig. 1 in Set-up.
The values determined in this experiment could vary according to the working accuracy and the dryness or moistness of the equipment, but a meaningful evaluation should always be possible.

Take into consideration also that, prior to the experimental procedure, the gas storages are each filled with approx. 5 cm^3 of air and that, following it, electrolysis causes gaseous mixtures of hydrogen with air and of oxygen with air to be produced in them. The running time of the motor is therefore not directly dependent on the amount of gas produced, i.e. on the light intensity, but far more on the mixture of gases.

Caution:
Never apply voltage to the fuel cell, as this would then be destroyed.
Use exclusively distilled water in experiments with the electrolyser and fuel cell as otherwise they will be damaged beyond repair.

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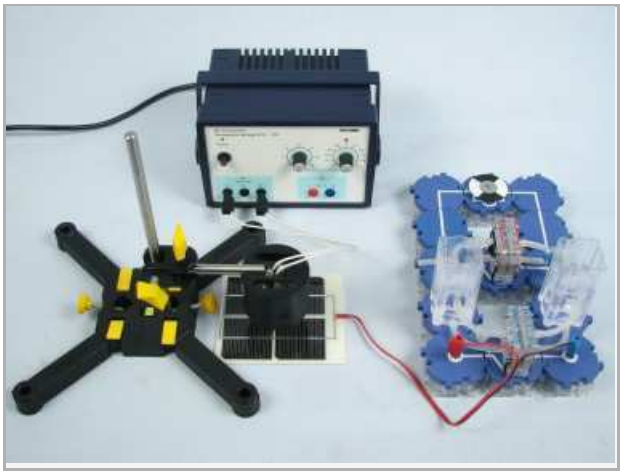
Solar-hydrogen system

Task and equipment

Task

Can the hydrogen system also be operated by light?

A halogen lamp is used to irradiate a solar battery to determine if this energy is sufficient to drive the hydrogen system and so also the motor.



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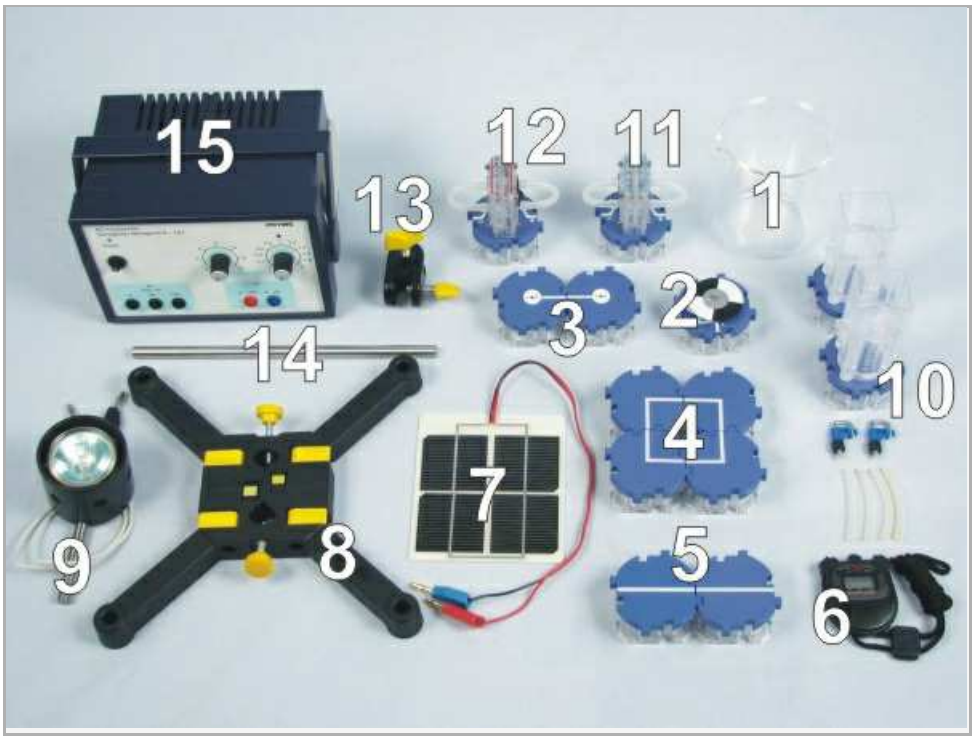
Equipment



Position No.	Material	Order No.	Quantity
1	Glass beaker DURAN®, short, 400 ml	36014-00	1
2	Motor with indicating disc, SB	05660-00	1
3	Junction module, SB	05601-10	2
4	Angled connector module, SB	05601-02	4
5	Straight connector module, SB	05601-01	2
6	Digital stop watch, 24 h, 1/100 s & 1 s	24025-00	1
7	Solar battery, 4 cells, with cable and connectors	06752-20	1
8	Support base, variable	02001-00	1
9	Halogen lamp with reflector, 12V / 20W	05780-00	1
9	Mount for halogen lamp with reflector	05781-00	1
10	Gas storage, SB, incl. tubes and plugs	05663-00	2
11	PEM electrolyser, SB	05662-00	1
12	PEM fuel cell for hydrogen/ oxygen operation and	05661-00	1
13	Boss head	02043-00	1
14	Support rod, stainless steel, l = 250 mm, d = 10 mm	02031-00	1
15	PHYWE power supply DC: 0...12 V, 2 A / AC: 6 V, 12 V, 5 A	13506-93	1
Additional material			
	Distilled water		
	Protective glasses		

Set-up and procedure

Set-up



H: 220 / 270
P: 210 / 220

- Oxygen is a colourless, odourless and tasteless fire-promoting gas. It is a fire hazard on contact with combustible materials.
- Hydrogen is a colourless, odourless and tasteless combustible gas which easily forms explosive mixtures with air. All sources of ignition must therefore be removed prior to starting experiments which involve hydrogen.
- Wear protective glasses.

Setup

Plug the two junction modules, the two gas storages and the blue-marked PEM electrolyser together as shown in Fig. 1.

Fig. 1

Connect both gas storages to the PEM electrolyser, each with two pieces of tubing.
Additionally connect a piece of tubing to the free end of each of the gas storages and, in each case, close it with a pinchcock (Fig. 2).

Fig. 2

Construct a circuit that contains the fuel cell, motor and connecting modules as shown in Fig. 3.
Pay attention to polarity. Connect the positive side of the motor to the positive side of the fuel cell.

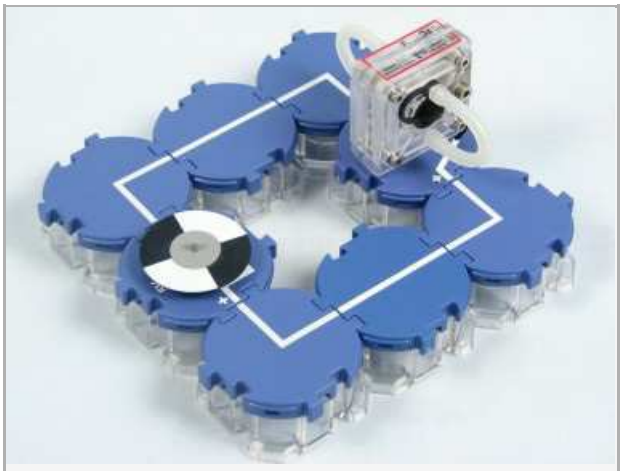


Fig. 3

Connect both components as shown in Fig. 4.
Check the polarity and, if necessary, reverse the motor and fuel cell. The fuel cell, electrolyser and motor must have the same polarity on the left side, and the same polarity on the right side.

Fig. 4

Have about 250 ml of distilled water filled into your 400 ml glass beaker.
Use this water to fill each of the gas storages up to the lower mark from above (Fig. 5).

Caution:
Use only distilled water.

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Fig. 5

Open the pinchcocks while holding the free end of the tubing high up, so that water flows down into storage without spillage of water (Fig. 6).

Fig. 6

Close the pinchcocks again and connect the free ends of it to the fuel cell (Fig. 7).
The two additional pieces of tubing are intended to prevent any water that emerges water from reaching the contacts.

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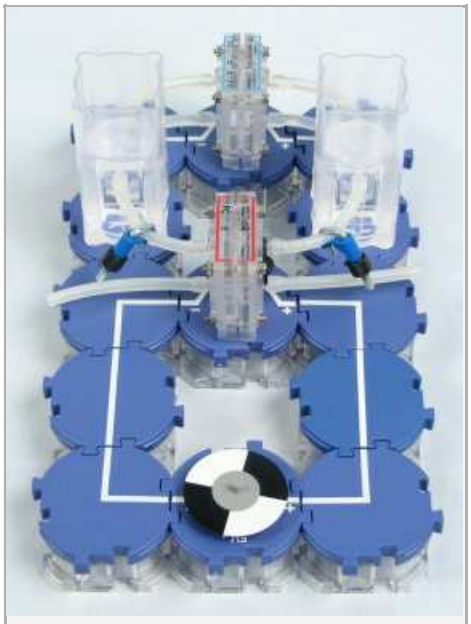

Fig. 7

Fit the support rod vertically in the stand base and the boss head to the top end of the support rod (Fig. 8).

Fig. 8

As shown in Fig. 8, fix the halogen lamp to the boss head and connect it to the 12 V output of the switched-off power supply (Fig. 9).

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Fig. 9

Connect the solar cell to the junction module, taking care of correct polarity with regard to the electrolyser. The red plug connector is the positive pole, the blue plug connector is accordingly the negative pole (Fig. 10).

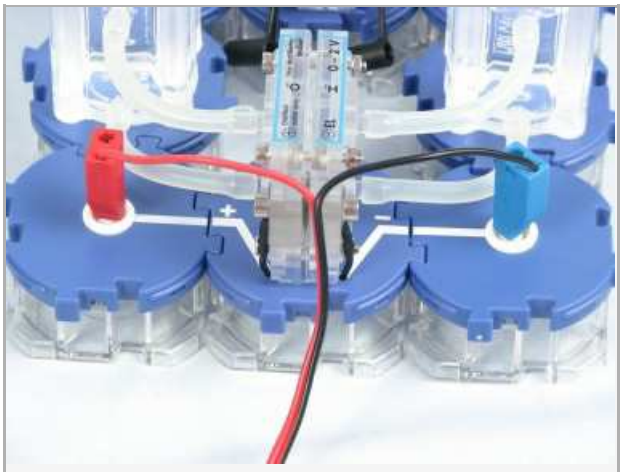

Fig. 10

Lay the solar cell directly under the halogen lamp (Fig. 11).

Fig. 11

Procedure

Experiment 1

First note the actual filling level in each gas storage under Result - Observations 1.
Switch the power supply on and start the stop watch (Fig. 12).

Fig. 12

After 5 minutes, switch the power supply off and again note the filling levels in the two gas storages under Result - Observations 2.
Open the pinchcock on the oxygen side of the fuel cell (observe the marking of the fuel cell and the electrolyser).

Open the pinchcock on the hydrogen side and time how long the motor runs.
Note your observations under Result - Observations 3.

Experiment 2

- Empty the two gas storages as described below, then fill them again in the same way as above.
- Slide the boss head complete with halogen lamp to about one third of the height of the support rod (Fig. 13).

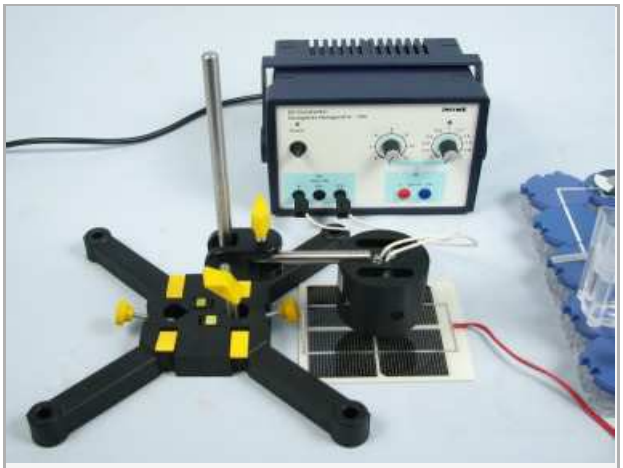

Fig. 13

Repeat experiment 1 and note your observations under Result - Observations 4, 5 and 6 analogously to Result - Observations 1, 2 and 3.

Emptying gas storage:
With the power supply switched off, remove the cable, connecting modules and fuel cell with motor. first ensure that the pinchcocks are closed, then grip the two gas storages, one in each hand. Do not remove the electrolyser. Lift up one gas storage above the beaker and tip the contents out over one corner into the beaker (Fig. 14).

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Fig. 14

Proceed in exactly the same way with the second gas storage.

Report: Solar-hydrogen system

Result - Observations 1

How much gas was in each gas storage to start with?

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Result - Observations 2

How much gas was in each of the gas storages after 5 minutes?

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Result - Observations 3

How long did the motor run after you opened the pinchcock on the hydrogen side of the fuel cell?

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Result - Observations 4

How much gas was there in each gas storage to start with?

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Result - Observations 5

How much gas was there in each gas storage after 5 minutes this time?

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Result - Observations 6

How long did the motor run this time after you opened the pinchcock on the hydrogen side of the fuel cell?

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Evaluation - Question 1

How much of each gas was produced in each of the two experiments?

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Evaluation - Question 2

Why are different amounts of the gases produced when the distance between the halogen lamp and the solar battery is changed?

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Evaluation - Question 3

When the pinchcock is opened, there is an immediate flow of gas and the water level in each gas storage is again the same as at the start of the experiment.

Why is there nevertheless a great difference in the running times of the motor?

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Evaluation - Question 4

Why must both gas storages be emptied and refilled between the two experiments?

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Evaluation - Question 5

The halogen lamp serves as substitute for the sun in this experiment.

Which advantages and disadvantages does the sun have as a source of energy?

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Evaluation - Supplementary problem 1

Why not use a rechargeable battery instead of going the long way round via gas production and a fuel cell?

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