# Generation of hydrogen and oxygen using a PEM electrolyseur

## Task and equipment

## Information for teachers

## Additional information

The PEM electrolyser consists of a thin, proton-conducting polymer electrolyte membrane (PEM), the two sides of which are each coated with a catalysing material. These coatings form the anode and the cathode. The theoretical decomposition voltage of water is 1.23 V. This voltage is higher in practice, however, because of losses in the electrolyser. It is about 1.55 V in the electrolyser used here. When this voltage is exceeded, water molecules are decomposed and hydrogen and oxygen are generated.

## Notes on the Setup 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 electrolysers 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 amounts of gas and water in the gas storage can vary according to the filling accuracy. Such a variation can be neglected.
The amount of gas produced in the electrolyser can also vary, according to how moist or dry the electrolyser was at the beginning of the experiment.

**Caution:**
Use exclusively distilled water in experiments with the electrolyser as otherwise the electrolyser will be damaged beyond repair.


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## Task and equipment

### Task

### How can hydrogen be generated from water?

Observe what happens when a voltage is applied to the PEM electrolyser.

# Student's Sheet

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## Equipment


| Position No. | Material | Order No. | Quantity |
|---|---|---|---|
| 1 | Digital stop watch, 24 h, 1/100 s & 1 s | 24025-00 | 1 |
| 2 | Glass beaker DURAN®, short, 400 ml | 36014-00 | 1 |
| 3 | Connecting cord, 32 A, 500 mm, red | 07361-01 | 2 |
| 4 | Connecting cord, 32 A, 500 mm, blue | 07361-04 | 2 |
| 5 | Junction module, SB | 05601-10 | 2 |
| 6 | Gas storage, SB, incl. tubes and plugs | 05663-00 | 2 |
| 7 | PEM electrolyser, SB | 05662-00 | 1 |
| 8 | PHYWE power supply DC: 0...12 V, 2 A / AC: 6 V, 12 V, 5 A | 13506-93 | 1 |
| 9 | DMM with NiCr-Ni thermo couple | 07122-00 | 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 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 gas storage and, in each case, close it with a pinchcock (Fig. 2).

Fig. 2

Have about 150 ml of distilled water filled into your 400 ml glass beaker.
Use this water to fill each of the gas storages up to the upper mark from above (Fig. 3).
**Caution:**

Use only distilled water.

Fig. 3

Open the pinchcock while holding the free end of the tubing high up, so that water flows down into storage without spillage of water (Fig. 4).

Fig. 4

Close the pinchcocks again.
Connect the junction modules, with the shown polarity at the PEM electrolyser (Fig. 5), to the direct voltage output of the power supply that is in the switched-off condition.


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Fig. 5

Connect a voltmeter in parallel with the power supply (Fig. 6).

Fig. 6

## Procedure

First turn the adjusting knob of the power supply fully to the left, then to the right to set the current to 2 A.
Note under Result - Observations 1 how much gas there is in each of the gas storages to start with and about how much water is left above gas storage.
Switch the power supply on and set the measurement range of the voltmeter to 20 V-.
Set a voltage of 2 V on the power supply and start the stop watch (Fig. 7).

**Caution:**
Higher voltages could cause irreparable damage to the PEM electrolyser.


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Fig. 7

Observe what happens in the electrolyser and the two gas storages for 4 minutes and note the results of your observations under Result - Observations 2.
Note under Result - Observations 3 how much gas has come into the two gas storages within these 4 minutes.
Turn the adjusting knob of the power supply fully to the left again and switch the power supply off.
At the gas storage, hold up the free end of the tubing and open the hose clip so that the gas storage is again filled with water (Fig. 4).
When the two gas storages are again filled, note under Result - Observation 4 how much gas is present in the gas storages and how much water can still be seen in the space above gas storage. Compare the values you obtain with the values you noted at the start of the experiment to determine how much water has been consumed.

**Emptying gas storage:**
With the power supply switched off, remove the cable and the modules. Make sure that the hose clips are closed and 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 through one corner into the beaker (Fig. 8).

Fig. 8

Carry out the same procedure for the second gas storage.


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# Report: Generation of hydrogen and oxygen using a PEM electrolyseur

## Result - Observations 1

How much gas was there in the two gas storages at the start and about how much water was there still in the space above gas storage?

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## Result - Observations 2

What happens in the electrolyser and in the gas storages when a voltage of 2 V is applied?

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## Result - Observations 3

How much generated gas has come into the two gas storages in 4 minutes?

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## Result - Observations 4

How much gas was there still in the gas storages after you opened the tubings at the end of the experiment and how much water in the space above? Compare these values with their values at the start of the experiment and draw conclusions on how much water has been consumed.

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# Student's Sheet

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## Evaluation - Question 1

Which gases could have been generated from water?

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## Evaluation - Question 2

A large amount of gas has been collected in each of the two storages in the 4 minutes. What is their ratio to each other? How can you explain the difference?

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## Evaluation - Question 3

How can you explain a difference in the amounts of water in the experimental set-up before and after the experiment that has possibly been observed?

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## Evaluation - Supplementary problem 1

How does the decomposition of water occur in the PEM electrolyser?

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