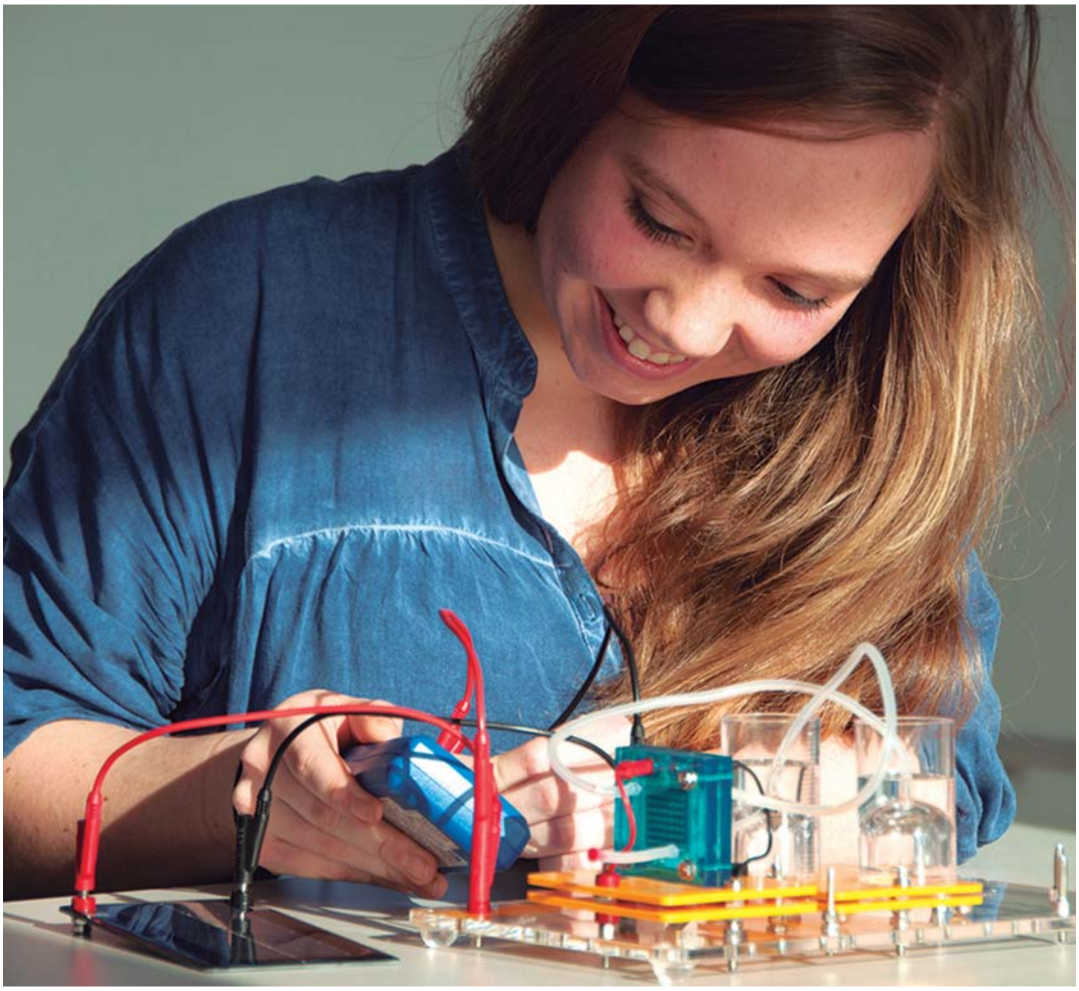
leXsolar-H_2 Large



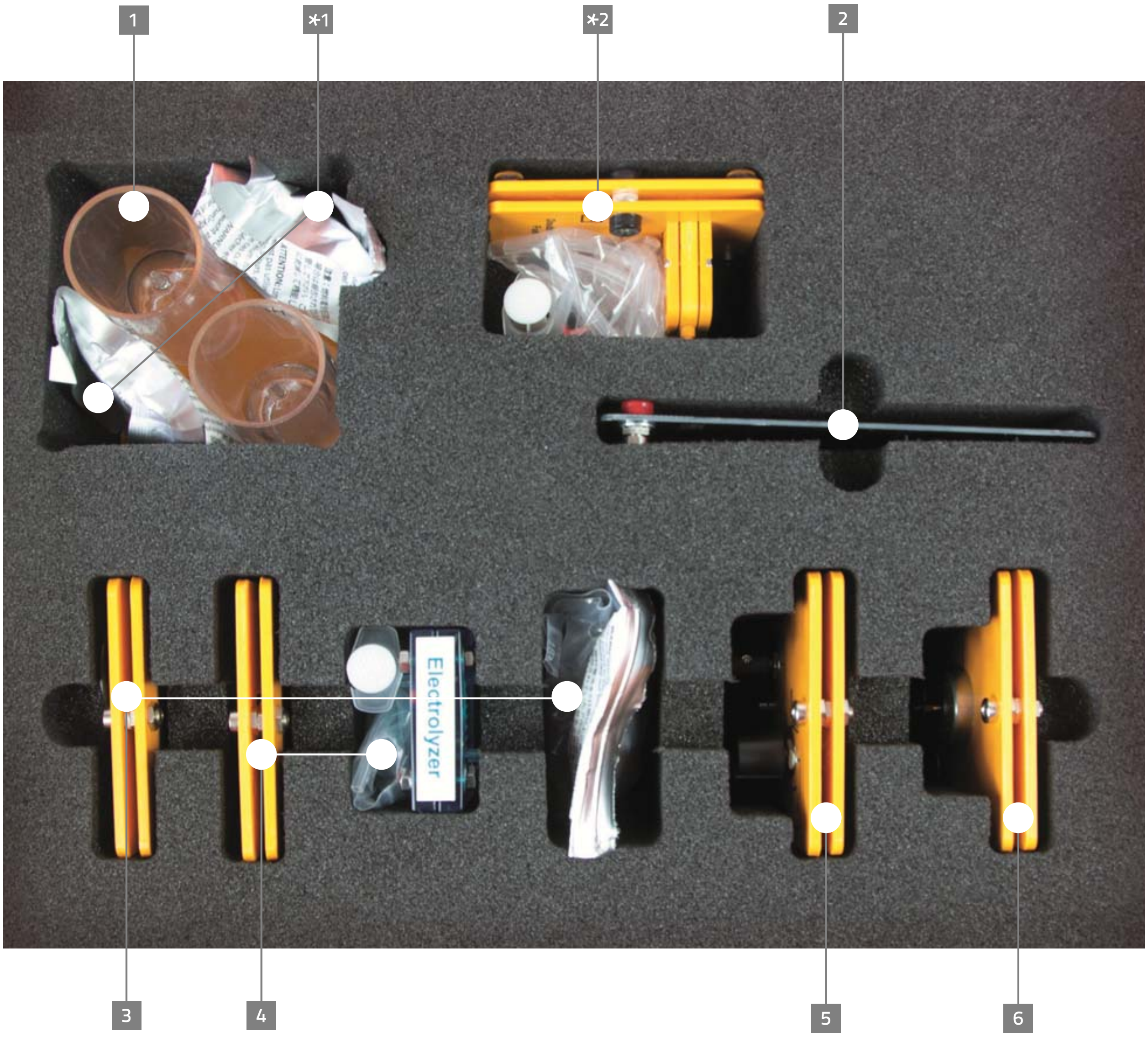
Teacher's Manual

Layout diagram leXsolar-H_2 Large 2.0

Item-No.1218

Bestückungsplan leXsolar-H_2 Large 2.0

Art.-Nr.1218



1	1213-01 Gas storage module 1213-01 Gasspeichermodul
2	1100-31 Solar panel 2.5 V, 420 mA 1100-31 Solarmodul 2.5 V, 420 mA
3	1218-02 PEM-Fuel cell module 1218-02 PEM-Brennstoffzellenmodul
4	1218-03 Electrolyzer module 2.0 1218-03 Elektrolyseurmodul 2.0
5	1100-23 Potentiometer module 1100-23 Potentiometermodul
6	1100-27 Motor module with L2-02-017 Yellow propeller 1100-27 Motormodul ohne Getriebe mit L2-02-017 Luftschraube (Propeller) gelb

Optional expansions
Optionale Erweiterungen

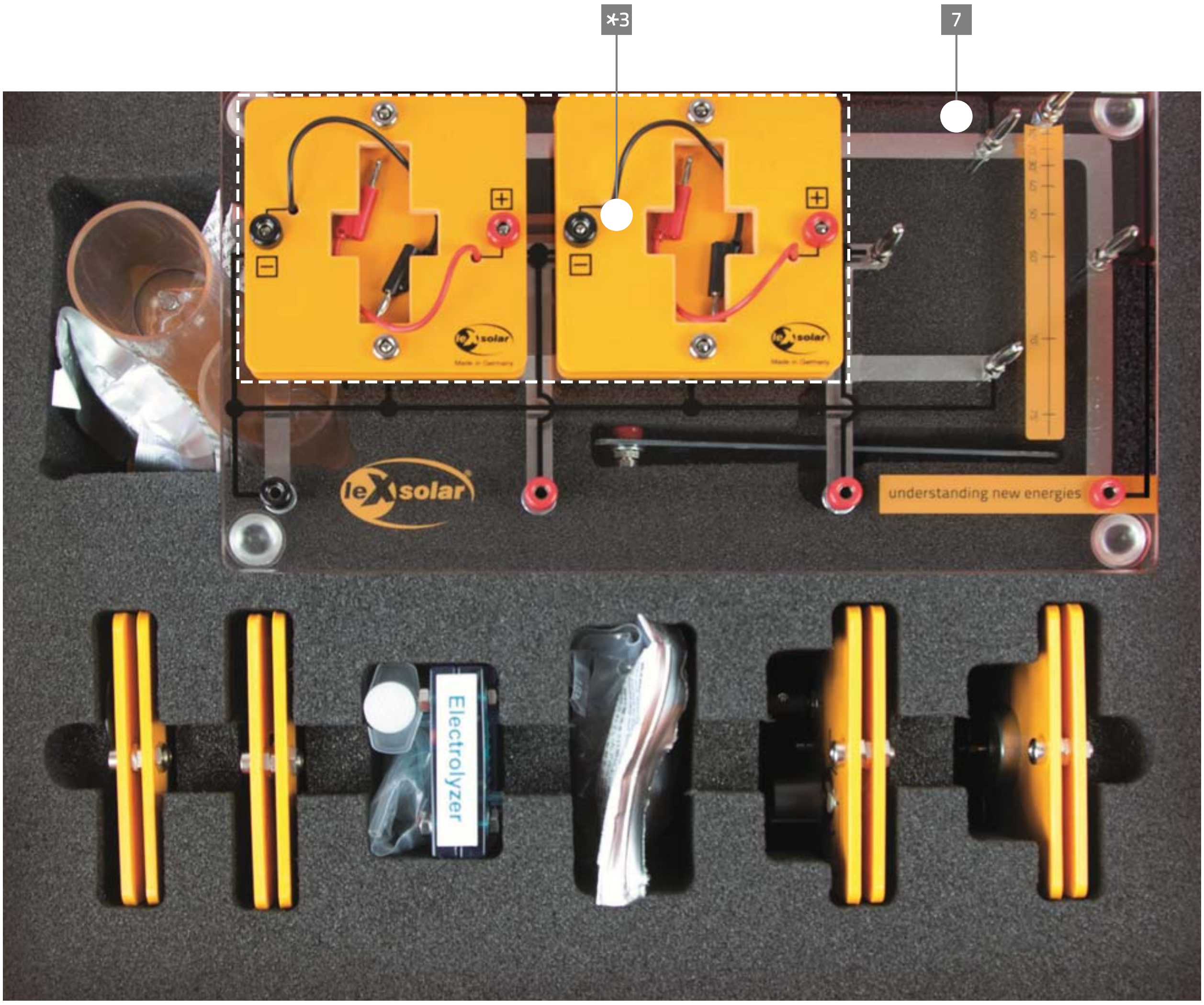
*1	2x1218-02 PEM-Fuel cell module with *3 2x1218-02 PEM-Brennstoffzellenmodul mit *3
*2	1700-01 Ethanol fuel cell module 1700-01 Ethanol-Brennstoffzellenmodul

Version number
Versionsnummer

L3-03-164_16.03.2017

CE RoHS2

Layout diagram leXsolar-H_2 Large 2.0
Item-No.1218
Bestückungsplan leXsolar-H_2 Large 2.0
Art.-Nr.1218



7 1100-19 Base unit large
1100-19 Grundeinheit groß

Optional expansions
Optionale Erweiterungen

*3 2x1218-02 PEM-Fuel cell module with *1
2x1218-02 PEM-Brennstoffzellenmodul mit *1

CE RoHS2

leXsolar-H_2 Large

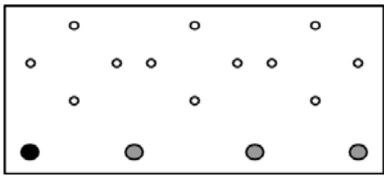
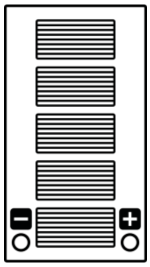
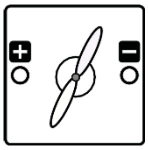
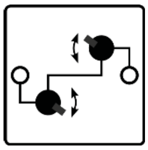
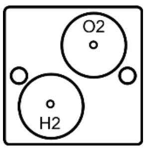
Teacher's manual

I Introduction

II Experiments

** This experiment is only possible with 2 x expansion "1218-02 PEM fuel cell"*
*** This experiment is only possible with 1 x expansion "1700-01 Ethanol fuel cell"*

1 Designation of components

Standard equipment of leXsolar-H_2 Large		
Designation	**Component**	**Symbol in the Experimental Setup**
	leXsolar main board	
	Solar module (2.5V, 420mA)	
 	Motor module without gear	
	Potentiometer module	
	Gas storage module	

2 Handling suggestions

When conducting experiments with the leXsolar-H_2 Large, some advice concerning the handling of the components and devices should be considered.

2.1 Operation of the electrolyzer

Specifications:

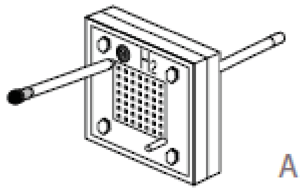
- Input voltage: 1.8 V ~ 3 V (D.C.)
- Input current: 0.7 A
- Hydrogen production rate: 7 ml per minute at 1 A
- Oxygen production rate: 3,5 ml per minute at 1 A

Important handling guidelines:

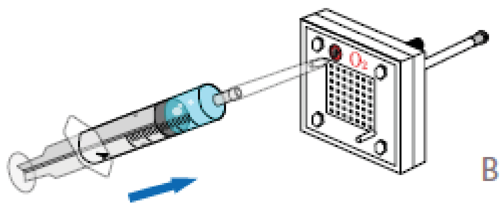
- Whenever not in use, the electrolyzer should be stored in an air-tight plastic bag, to keep it from drying out.
- Positive and negative pin of the electrolyzer must always be connected to correctly to the voltage source, to avoid damages to the electrolyzer.
- The electrolyzer must only be used with moistened membranes. The distilled water must be filled in on the O_2-side and should be allowed to soak for about 3 minutes. Connecting the dry electrolyzer to the voltage source can lead to irreparable damages.

User instructions:

1. The electrolyzer should be placed on a flat surface. The short piece of tube must be connected to the upper port on the H_2-side (black port) and be sealed with the black pin (see A).

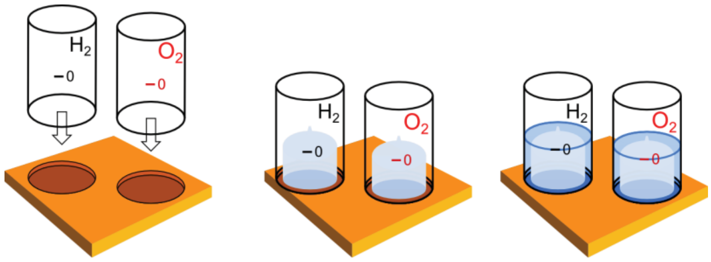


2. The syringe must be filled with distilled water and another short piece of tube should be fitted to it. The other end of the tube must be connected to the upper port on the O_2-side (red port) (see B).



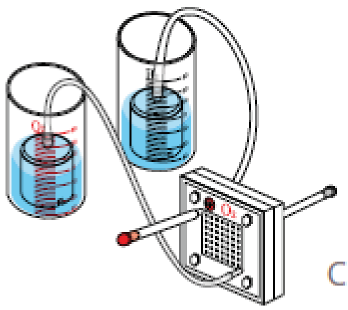
Now, using the syringe, the water should slowly be pumped into the electrolyzer until it leaks out of the lower port. The syringe can now be pulled off the tube, which can be sealed with the red pin. At this point the electrolyzer should sit for 3 minutes.

3. Now, the water barrels should be filled with distilled water up to their respective markings.



4. Each gas storage tank should be pinned onto the ring mount at the bottom of each water barrel, so that the grooves on the bottom of the gas tanks are aligned with the grooves of the ring mounts. Excess water can be removed using the syringe.

5. At this point, the gas storage tanks can be connected to the lower ports of the electrolyzer using the long pieces of tube. The black port of the H_2-side must be connected to the H_2- storage tank and the same goes for the red O_2-side and the O_2 tank (see C).



6. The electrolyzer can now be placed onto the module plate and be connected to it using the respective cables (red for O_2, black for H_2).

7. Now, the unit can be connected to the solar module or an external voltage source to start the electrolytic process.

<u>NOTE</u>: If the hydrogen gas shall later be used for a fuel cell experiment, it is recommended to put a clamp on the tube connecting the H_2-side of the electrolyzer with the H_2 tank. It can be closed after the gas production, so that the hydrogen can be stored in its tank for later experiments.

2.2 Operation of the PEM fuel cell

Specifications:

- Output power: 270 mW
- Output voltage: 0,6 V (DC)
- Output current: 0,45 A

Important handling guidelines:

- Whenever not in use, the fuel cell should be stored in an air-tight plastic bag, to keep it from drying out.

User instructions:

1. To operate the fuel cell, hydrogen gas is needed. This can be obtained from the H_2-Storage or from the H_2 tank from a previous experiment.

2. If the hydrogen is taken from the gas tank, the tube must be clamped to avoid hydrogen gas to leak.

3. The tube of the H_2 tank must be connected to the lower port of the fuel cell. The O_2 supply for this model is ensured by the ambient air.

4. The upper port of the fuel cell must be sealed, using a short piece of tube and a pin.

5. The fuel cell can now be placed onto the module plate and be connected to it using the respective cables (red for O_2, black for H_2).

6. Now, the unit can be connected to an electrical load. (Mind the polarity!).

7. By opening the tube clamp the experiment can be started.

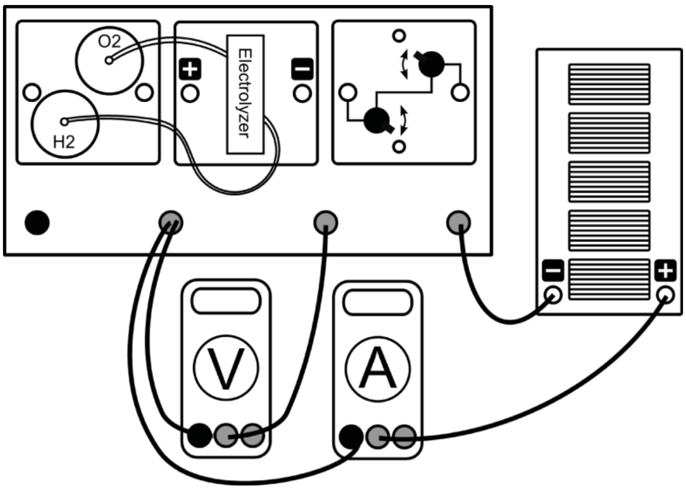
NOTE: For quantitative experiments like taking a characteristic curve, we recommend flushing the fuel cell with hydrogen gas by initiation the gas supply (opening the tube clamp on the tank or opening the valve on the H_2 storage) and removing the pin on the short tube for only 1-2 seconds.

2.4 Derivation of FARADAY's first law

Goals

Deduce FARADAY's first law using the electrolyzer.

Setup



Equipment needed

- leXsolar main board
- Electrolyzer module
- Solar module
- Potentiometer module
- Voltmeter
- Ammeter
- Tubes
- Gas storage module
- Cables
- Stop watch
- Distilled water
- Lamp

Procedure

1. Set up the experiment in accordance with the drawing. Place the lamp in front of the solar module (distance ca. 30 cm).
   You can find notes on how to set up and use the electrolyzer in chapter "Operation of the electrolyzer" on page 7.
2. Set the potentiometer to the lowest resistance.
3. Switch on the lamp and measure the corresponding current. Enter that value into the table.
4. Every 150 s, measure both the produced H_2 volume and the current and enter your measurements into the table
5. Switch off the lamp. Remove the tube from the gas storage to drain the H_2 and put it back on.
6. Switch the lamp back on and adjust the potentiometer to set different current values. Measure the H_2-volume and the current every 300 s and enter your values into the table.

Measurements

1. Measurement:

t in s	0	150	300	450	600
I in mA	51	51	51	51	51
V in ml	0	1	2	3	4

Measurements

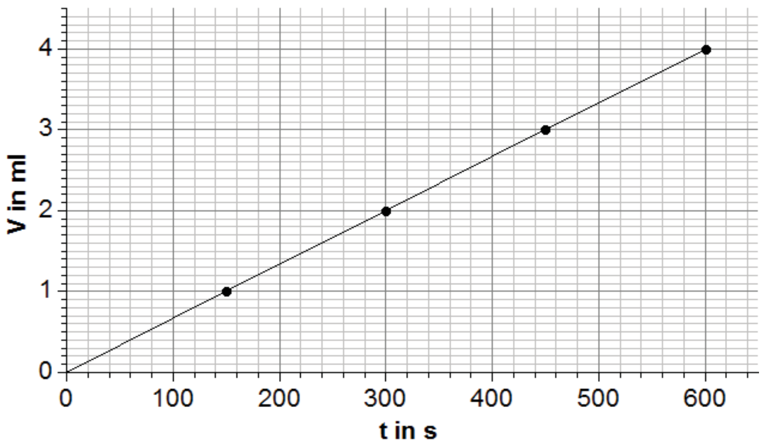
2. Measurement:

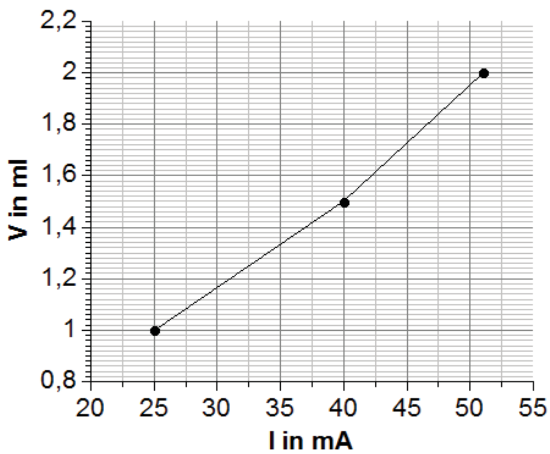
t in s	300	300	300
I in mA	51	40	25
V in ml	2	1.5	1

Evaluation

1. Note your measured values in the provided diagram.
2. What correlation can be deduced between the produced hydrogen volume and the applied charge (FARADAY's first law)?
3. Calculate the deposited charge Q and the molar charge Q_m.

Diagrams





Evaluation

1.

V~t and V~I

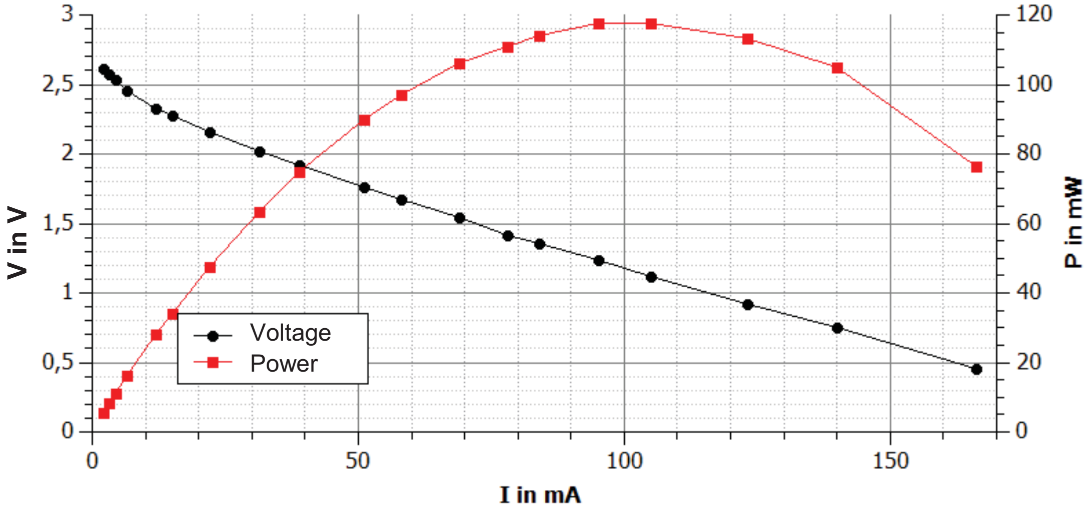
If V~t and V~I, then V~I*t =Q holds true

Thus: V~Q and V=n*V_m, therefore n~Q (n= amount of substance, V_m= molar volume)

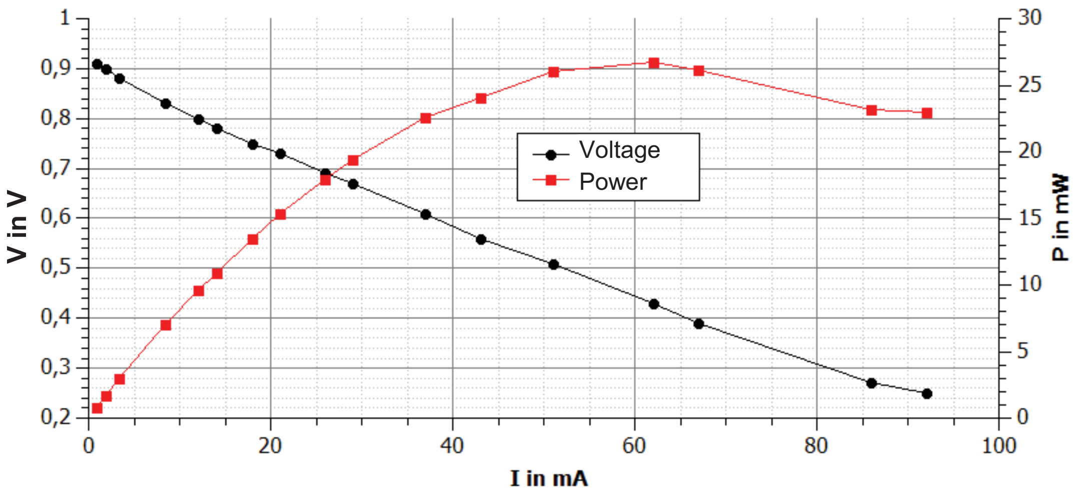
The amount of substance n, which is electrolytically produced, is proportional to the time t and the current I and therefore to the applied charge Q

Diagrams

a) Series circuit



b) Parallel circuit



Evaluation

3.

The first part of the I-V-curve strongly decreases, especially for the series circuit. After that the curve progresses more shallowly. The highest possible voltage of this PEM fuel cell amounts to 0.9 V in parallel and to 2.6 V in series connection. The power of the fuel cell increases with current and reaches a maximum. For the parallel circuit this is situated at around 60 mA and for the series circuit at around 100 mA.

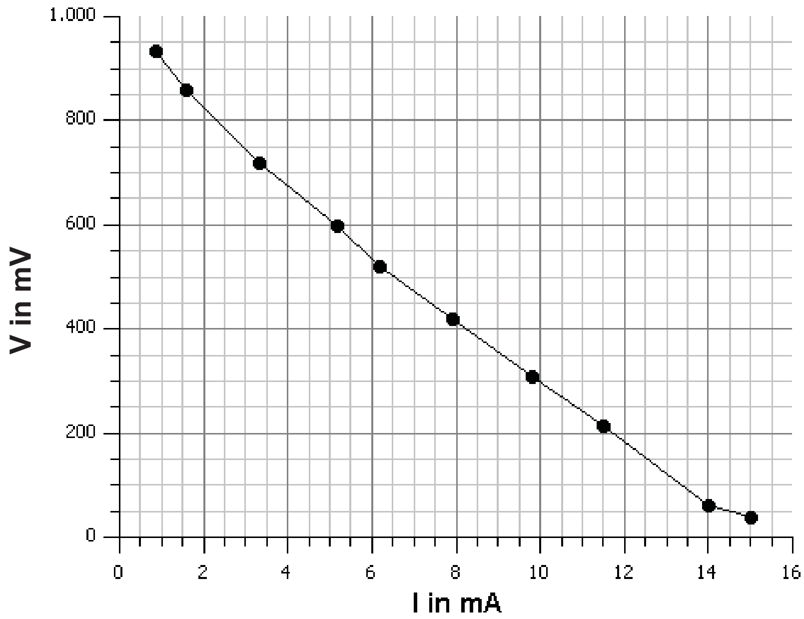
In general, both the achievable voltage and power of the fuel cell are higher for the series circuit.

4.2 Characteristic curve of an ethanol fuel cell

Evaluation

1. Plot your measured values in the respective diagram.
2. What causes the fluctuations in your measurements?

Diagram



Evaluation

2.

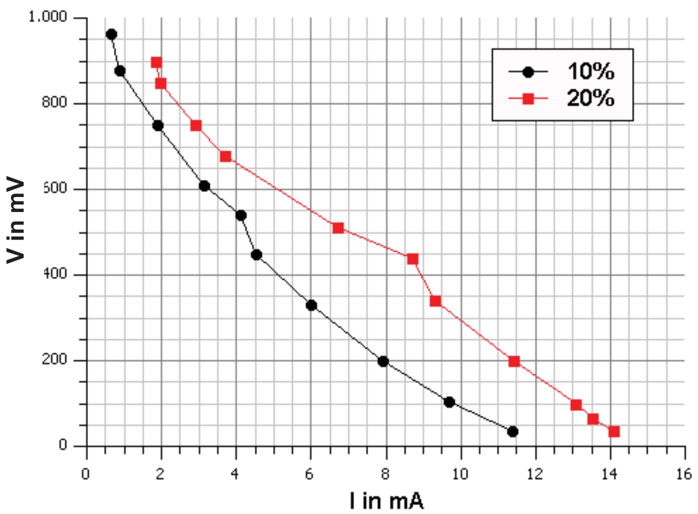
The measured values never remain constant for a given amount of time, because the chemical reaction never completely seizes, but rather takes place, perpetually. Therefore, the measured values fluctuate slightly, which should, however, not impair the overall measurement.

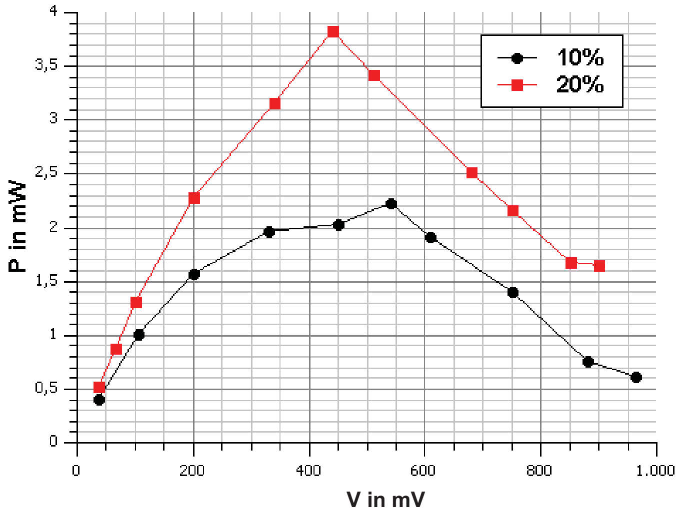
4.4 Concentration dependence of an ethanol fuel cell

Evaluation

1. Calculate the cell's power output for each value and enter your results into the table.
2. Plot your measurements as well as the results of your calculations in the diagrams.
3. How can the curves be interpreted?

Diagrams





Evaluation

3.

It is obvious, that the power increases with a higher ethanol concentration. This is due to the fact that at a higher concentration more ethanol molecules are present, which enables a higher electron flow.

The position of the power maximum, however, does not seem to shift (ca. 450 V). This is important for the technical application of the fuel cell.

Looking at the same voltage value, the 20% solution shows a higher current than the 10% solution. This is due to the fact, that the current is defined as number of charge carriers per area unit per unit of time. For a higher ethanol concentration, there are more electrons available, therefore the current increases.

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