E z1	**Characteristic Curve of the Fuel Cell**	heliocentris

Materials required:

Dismantable fuel cell with 0.3 mg/cm^2 Pt membrane, hydrogen and oxygen end plates, mounted according to assembly instructions

Components from the Solar Hydrogen Technology Science Kit:
Solar module
Electrolyser

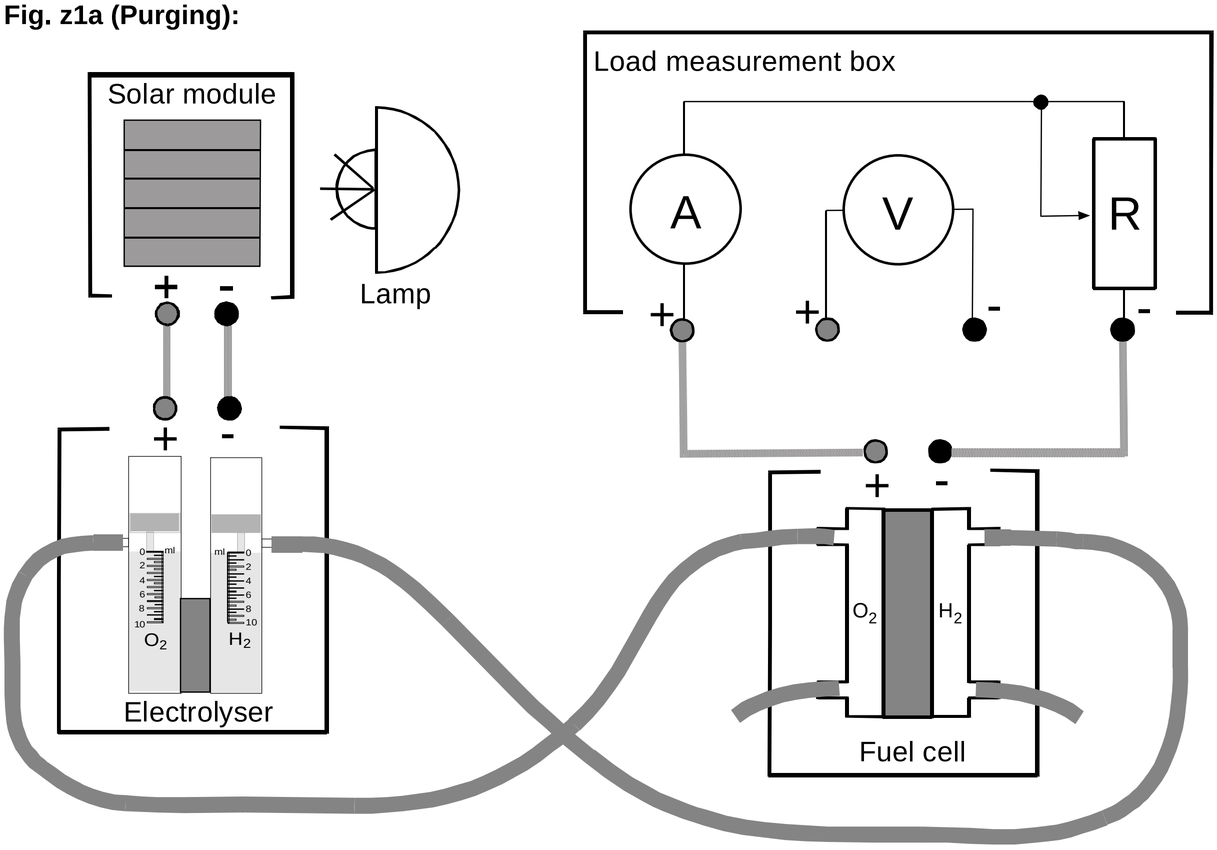
Load measurement box
4 hook-up cables
2 long tubes
2 short tubes
2 tubing stoppers

Additional components:
Lamp 100-150 Watt
Distilled water

Instructions:

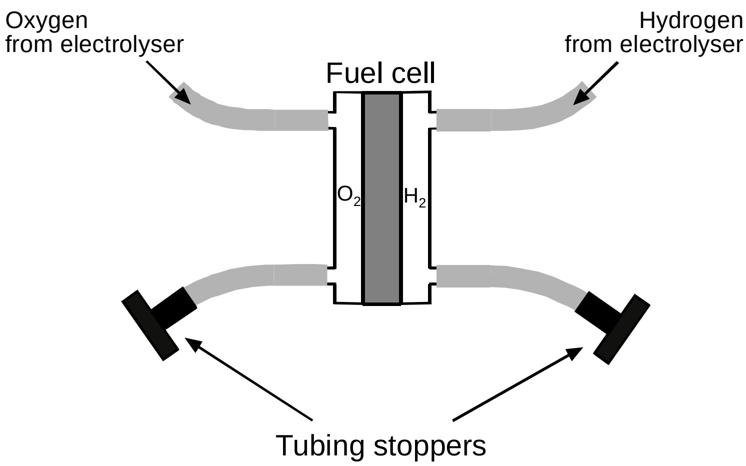
Please follow the operating instructions!
Wear protective goggles and keep ignition sources at a distance when experimenting!!!!

Fig. z1a (Purging):



1. Set up the apparatus as shown in Fig. z1a. **Check the polarity of the electrolyser!**
2. Check that the gas tubes between the electrolyser and the fuel cell are correctly connected. Adjust the rotary switch on the load measurement box to “OPEN”.
3. Make sure both of the gas storage cylinders of the electrolyser are filled with distilled water up to the 0 ml mark. Using the illuminated solar module, set a constant current to the electrolyser of between 200 and 300 mA. The solar module must be positioned towards the light source in such a way that gas production can be clearly observed.
4. Purge the complete system (consisting of the electrolyser, fuel cell and tubes) for 5 minutes with the gases produced. Then set the rotary switch on the load measurement box to 3 • for 3 minutes. The ammeter of the load measurement box should now already show a current. Purge the system again with the rotary switch in the “OPEN” position for 3 minutes.

Fig. z1b (Storing)



5. Stop the power supply to the electrolyser for a short time and use the stoppers to close the two short tubes at the gas outlets of the fuel cell (see Fig. z1b).
6. Reconnect the solar module to the electrolyser and store the gases in the gas storage cylinders of the electrolyser. Interrupt the power supply when the hydrogen side of the electrolyser has reached the 10 ml mark.
7. Remove the cables between the solar module and the electrolyser and use them to connect the voltmeter of the load measurement box to the fuel cell (see Fig. z1c).
8. Record the characteristic curve of the fuel cell by varying the measurement resistance (rotary switch of the load measurement box). Start at position “OPEN” (off-load voltage), then decrease the resistance step by step by turning the rotary switch to the right. Record the voltage and current for each resistance. Wait for 30 seconds each time before taking the measurements. Enter the figures in the table of measurements. Finally measure the figures for the lamp and the electric motor.
9. After recording the characteristic curve, reset the rotary switch of the load measurement box to “OPEN” and remove the fuel cell stoppers.

Fig. z1c (Recording the characteristic curve):

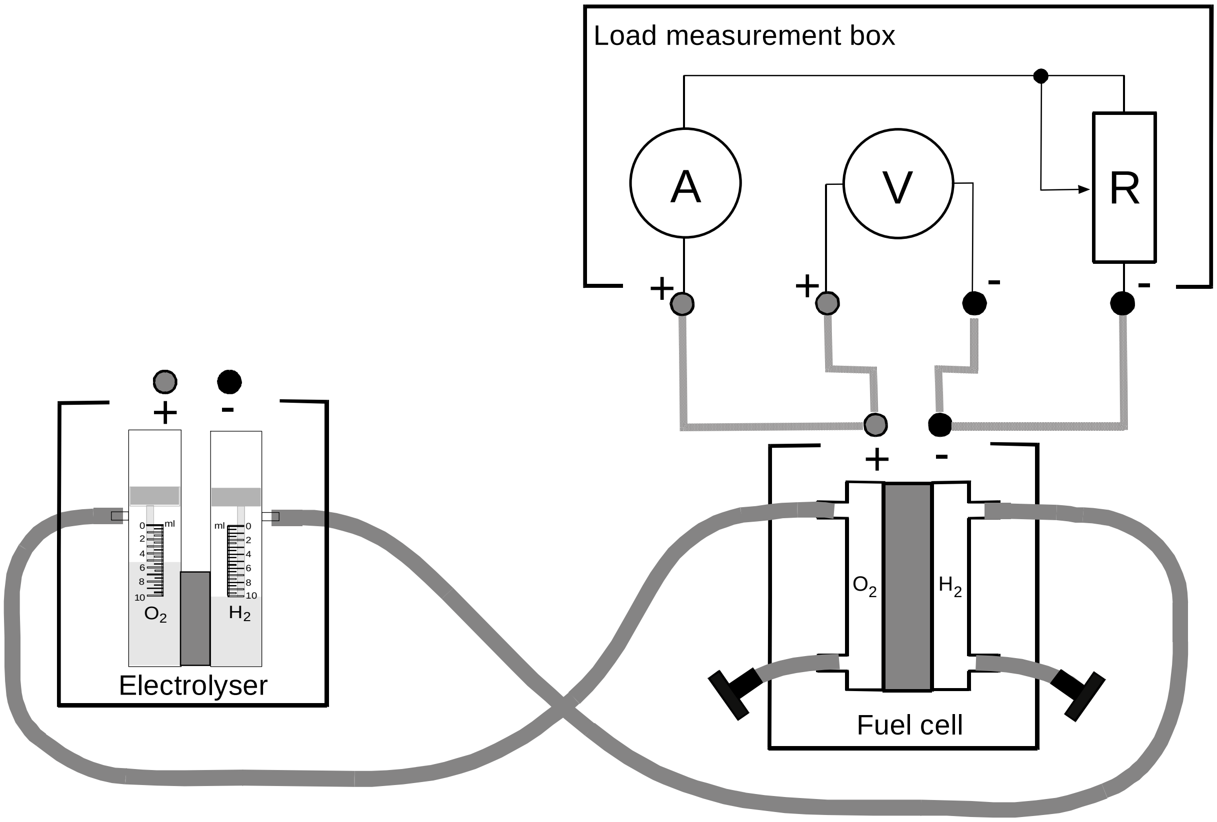


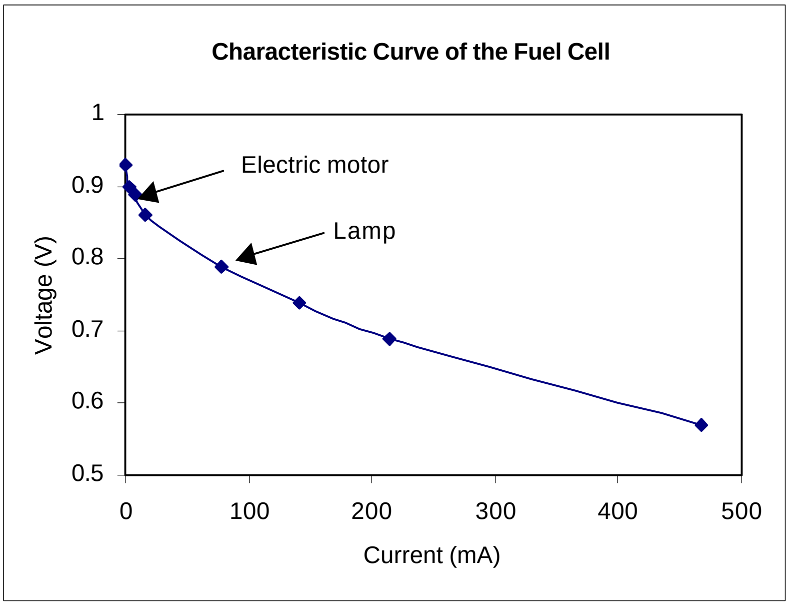
Table of Measurements:

Resistance (Ω)	Voltage (V)	Current (mA)

Evaluation:

1. Draw the VI characteristic curve of the fuel cell.
2. Interpret the characteristic curve.
3. Enter the motor's and the lamp's operating voltages and currents in the VI characteristic curve.
4. Draw a PI diagram.
5. Calculate the motor's and the lamp's power consumption and enter the values into the P I diagram.

Interpretation/Notes:



In order to understand the characteristic curve of a fuel cell, recall the characteristic curve of the electrolyser (see experiment e1 for the hydro-Genius™ Solar Hydrogen Technology Science Kit). The processes in the fuel cell are the reverse of those that take place in electrolysis. In the electrolysis of water, at least 1.23 volts must be applied before the water begins to split; as a rule the voltage is higher (overpotential).

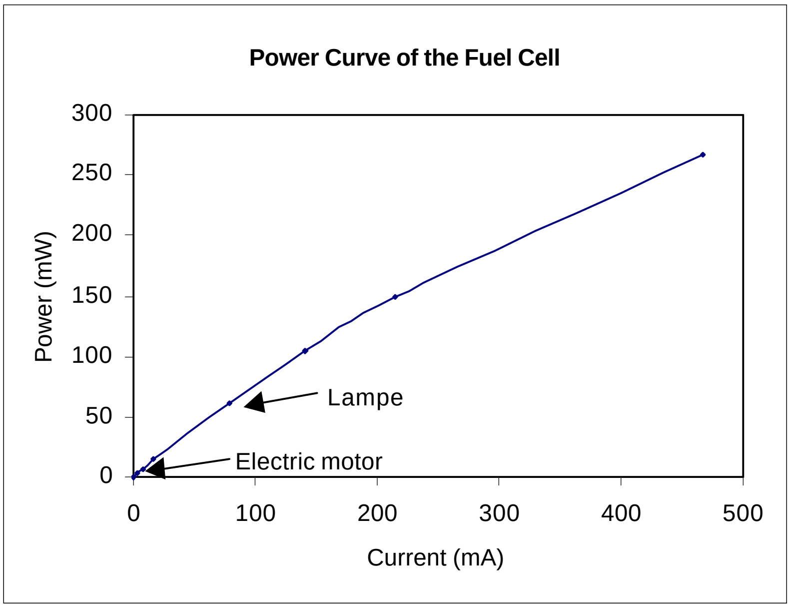
In the case of a fuel cell (a galvanic cell), less voltage is generated for the same reasons. Here, too, the characteristic curve is affected by the materials used for the electrodes (catalysis), the internal resistance, the temperature and the volume of hydrogen and oxygen being supplied.

At very small or zero current drain, the voltage across the fuel cell amounts to approx. 0.9 volts. This voltage is called off-load voltage (by analogy to a battery). In the case of the fuel cell, it is very dependent on the volume and purity of the input gases. The more current is drawn from the fuel cell, the smaller the voltage becomes. Accordingly, there is an exponential increase in the current as the voltage declines.

If the operating point of the electric motor is entered in the P I diagram, it can be seen that the motor does not run at the optimum point, i.e. hydrogen is being lost. More power can therefore be drawn from the fuel cell.

In practice, efforts are made to draw as much current as possible from the fuel cell (i.e. to operate it at maximum output). However, the efficiency of the fuel cell declines at high current values (see experiment z2), so that the task here is to find an optimum operating point (high efficiency, high output).

For a more precise explanation of characteristic curves of a fuel cell, please consult experiment instructions z6.


Power Curve of the Fuel Cell
Power (mW)
300
250
200
150
100
50
0
Lampe
Electric motor
0
100
200
300
400
500
Current (mA)