Electrical voltage from a salt solution with Cobra SMARTsense

Pupils deepen their understanding of basic electrochemical processes. This experiment explains how to generate a DC voltage in a salt solution using two electrodes. The Cobra SMARTsense voltage sensor is used here in conjunction with the PHYWE measureAPP for simple data acquisition.

Difficulty level	Group size	Preparation time	Execution time
easy	-	10 minutes	10 minutes

PHYWE
Robert-Bosch-Breite 10
37079 Göttingen
Tel.: 0551 604 - 0
Fax: 0551 604 - 107
info@phywe.de
www.phywe.de

PHYWE

Teacher information

Application

PHYWE

The experimental setup

Two electrodes in a salt solution represent the simplest form of a battery, i.e. an electrical source through which voltage is generated.

The discovery and further development of the so-called *galvanic elements* (batteries) is particularly important for people: among other things, it makes the mobile power supply of various electrical devices possible, which significantly characterises our standard of living today.

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Other teacher information (1/3)

PHYWE

Prior knowledge

The students should already know what an electrolyte solution is and what electrodes are used for. They should also be familiar with the basics of "voltage", such as the units and measurement methods.

Principle

If sheets of two different metals, e.g. zinc and copper, are placed in an electrolyte or salt solution, an electrical voltage can be detected between these two metals using a measuring instrument.

Other teacher information (2/3)

PHYWE

Learning objective

Students should deepen their understanding of basic electrochemical processes. To visualise this, this experiment explains how a DC voltage can be generated in a salt solution using two electrodes. The term "voltage" is also explained in more detail.

Tasks

The students should measure a DC voltage in a salt solution between a copper and a zinc electrode.

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Other teacher information (3/3)

PHYWE

In the salt solution, the less noble metal (here: zinc) gives off electrons to the more noble metal (here: copper). The metal wires used act as *Electrodes* and the salt solution as *Electrolyte*. Zinc releases electrons to the wire and slowly dissolves in the process. Zinc ions are released and enter the solution.

The electrons emitted flow through the wire into the copper electrode, where they provide a negative excess charge. At the copper electrode, the reaction of electrons with water produces hydroxide ions and hydrogen, which can rise out of the solution as a gas. The electrodes are connected with a wire and electrons or current flow from the negative pole (zinc) to the positive pole (copper).

This causes the poles to discharge, whereby the endeavour to balance the charge is expressed as an electrical voltage. *U* is defined. The unit of electrical voltage is volt (V). Physically speaking, *U* is the difference in potential electrical energy between two points (here: between the electrodes).

Safety instructions

PHYWE

- Potassium chloride solutions $c = 1,0\,\mathrm{mol/l}$ have an irritant effect. Protect eyes and skin. Avoid contact of the chemical with the eyes and skin.
- Wear protective gloves and safety goggles.
- Please refer to the relevant safety data sheets for the H and P (hazard and precaution) phrases.
- The general instructions for safe experimentation in science lessons apply to this experiment.

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

PHYWE

Student information

Motivation

PHYWE

The battery of an electrical car is charged

Can you imagine being able to recreate a battery in its simplest form with just a salt solution and some copper and zinc sheeting?

The discovery and further development of so-called galvanic elements, better known as batteries, is of particular importance to mankind. Among other things, batteries make the mobile power supply of various electrical devices possible, which has a significant impact on our standard of living today.

The electrical voltage between the electrodes of the battery can be used to recharge the battery of an electric vehicle, for example.

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Tasks

PHYWE

The experimental setup

If you immerse a copper and a zinc sheet in a salt solution, you can measure a DC voltage. Check this statement using two different salt solutions.

Then answer the questions in the protocol section.

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Equipment

Position	Equipment	Item no.	Quantity
1	Cobra SMARTsense Voltage - Sensor for measuring electrical voltage ± 30 V (Bluetooth + USB)	12901-01	1
2	Connection cable, 2 mm plug, 5 A, 50 cm, red	07356-01	1
3	Connection cable, 2 mm plug, 5 A, 50 cm, blue	07356-04	1
4	Reducing plug 4/2 mm socket, 1 pair	11620-27	1
5	Crocodile clip, insulated, red & black, 2 mm, 2 pieces	07275-00	1
6	Strip electrode set for student experiments in electrochemistry Length: 75 mm, width 15 mm	07856-00	2
7	Sandpaper, medium grit	01605-00	1
8	Beaker, boro, tall shape, 50 ml	46025-00	2
9	Measuring cell block with 8 holes, d = 40 mm for setting up galvanic cells	37682-00	1

PHYWE
Robert-Bosch-Breite 10
37079 Göttingen
Tel.: 0551 604 - 0
Fax: 0551 604 - 107
info@phywe.de
www.phywe.de

Setup (1/4)

PHYWE

For measurement with the **Cobra SMARTsense sensors** the **PHYWE measureAPP** required. The app can be downloaded free of charge from the relevant app store (see below for QR codes). Before starting the app, please check whether your device (smartphone, tablet, desktop PC) has **Bluetooth activated**.

iOS

Android

Windows

Setup (2/4)

PHYWE

Preparation of salt solutions:

Two salt solutions are used, each is created with a concentration of $1\ \mathrm{mol/l} (1\ \mathrm{M})$. The batch can also be reduced in size as required to save chemicals.

1. **1 M potassium nitrate solution** Add : Add $50,5\ \mathrm{g}$ Potassium nitrate to $250\ \mathrm{ml}$ distilled water. Mix well and fill up with distilled water to $500\ \mathrm{ml}$
2. **1 M potassium chloride solution** Add : Add $37\ \mathrm{g}$ Potassium chloride to $250\ \mathrm{ml}$ distilled water. Mix well and fill up with distilled water to $500\ \mathrm{ml}$

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Setup (3/4)

PHYWE

The experimental setup

Cut a 15 mm x 40 mm electrode from each of the copper and zinc sheets. If the copper has oxidised due to storage, use a piece of emery cloth to clean it.

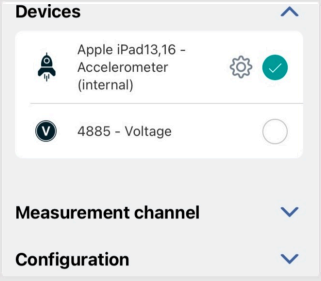
Note the colour of the connections below: blue (zinc, negative pole) always to blue (black) and red (copper, positive pole) always to red!

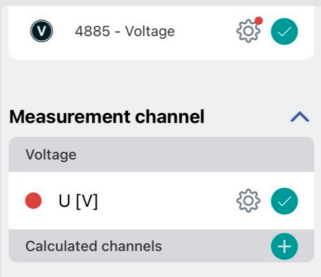
Connect the crocodile clips to the connecting cables and the cables to the Cobra SMARTsense Voltage Sensor using a rerouting plug.

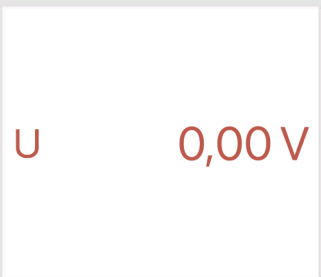
Setup (4/4)

PHYWE

- Start the *measureAPP* on a mobile device.
- Press the start button on the sensor for approx. 3 seconds.
- Connect the sensor by tapping next to the description of the sensor in the *measur* ◯ *P*.
- Set the measured value display by tapping above the diagram. 0.0







PHYWE
Robert-Bosch-Breite 10
37079 Göttingen
Tel.: 0551 604 - 0
Fax: 0551 604 - 107
info@phywe.de
www.phywe.de

Procedure

PHYWE

Make sure that the electrodes do not touch each other during the measurement!

Fill one well of the measuring cell block with each of the salt solutions. The wells are called "measuring cells". Then dip the two electrode plates into the KCl salt solution.

Observe the voltage displayed in the *measureAPP*and note it down as soon as it shows a constant value.

Then rinse the electrodes with tap water and clean the surface of at least the copper electrode with emery cloth. Carry out the same measurement in the second salt solution.

The experimental setup

PHYWE

Report

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

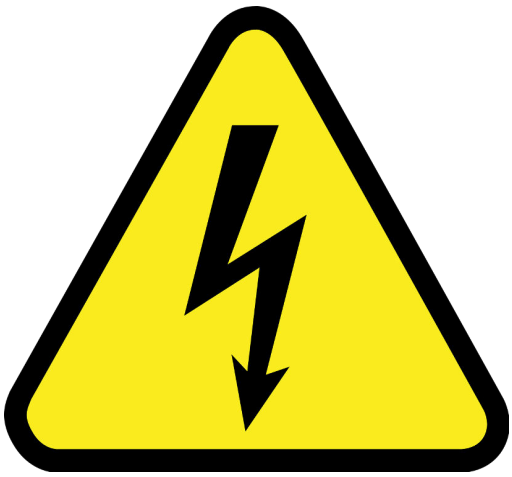
Task 1

PHYWE

What is the general unit for electrical voltage?

- ○ The electrical voltage is generally specified in volts (V).
- ○ The electrical voltage is generally specified in watts (W).
- ○ The electrical voltage is generally specified in amperes (A).

Check



Task 2

PHYWE

Where does the energy come from that is expressed here in the development of an electrical voltage? Does it come from the salt solution? Does it come from the metals?

- ○ The energy comes from the flow of electrons. The "less noble" metal gives electrons to the "more noble" metal. The salt solution acts as an electrolyte and conducts the current.
- ○ The energy comes from the flow of electrons. The "more noble" metal gives electrons to the "less noble" metal. The salt solution acts as an electrolyte and conducts the current.
- ○ The energy comes from the salt solution. A force pushes salt molecules from one electrode to the other. The resulting kinetic energy is the source of the energy measured here.

Check

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Task 3

PHYWE

Select the definition for the electrical voltage.

- ○ The electrical voltage U is defined as the difference in potential electrical energy between two points.
- ○ The electrical voltage U is defined as the brightness reached by a standard light bulb after 2 hours of burning.
- ○ None of the answers are correct.
- ○ The electrical voltage U is defined as the number of electrons per unit of time in seconds.

Check

Slide	Score / Total
Slide 17: Voltage unit	0/1
Slide 18: Energy origin	0/1
Slide 19: Electrical voltage	0/1

Total amount 0 / 3

Solutions Repeat

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de