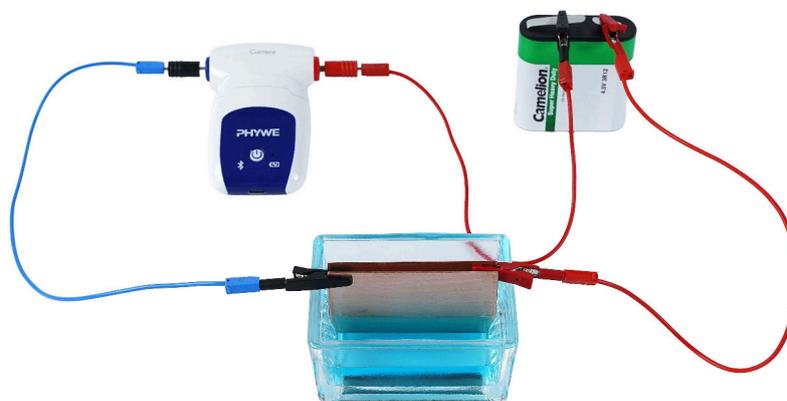


First law of Faraday with Cobra SMARTsense



Faraday's first law describes the relationship between the amount of substance deposited and the electrical energy supplied and is investigated experimentally in this experiment

Chemistry

Physical chemistry

Electrochemistry

Electrolysis



Difficulty level

easy



Group size

1



Preparation time

10 minutes



Execution time

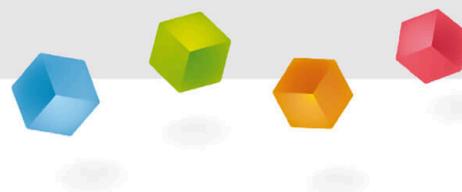
10 minutes

This content can also be found online at:



<https://www.curriculab.de/c/68f5fc712d93de00022ccd03>

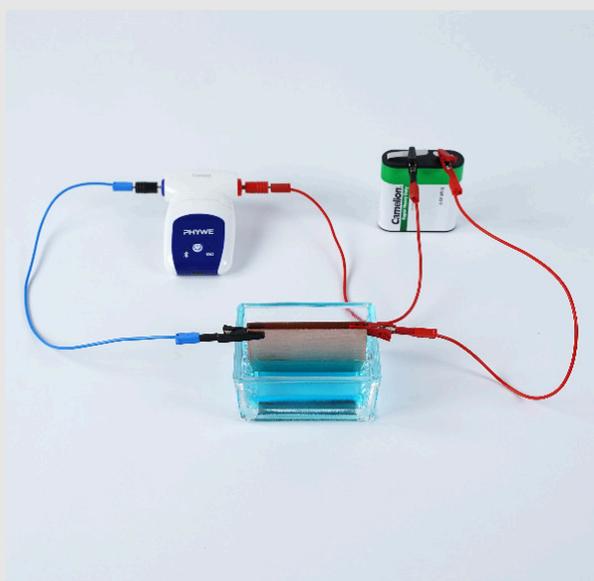
PHYWE



Teacher information

Application

PHYWE



The **Faraday's laws** are regarded as the basic laws of electrolysis and describe how electrical energy drives chemical reactions in electrolytes.

In this experiment, students learn the principle of **1. Faraday's law** know: It states that the amount of a substance deposited on an electrode is directly proportional to the electrical charge flowing through the electrolyte.

The law makes it possible to accurately predict the amount of substance deposited if the current strength and time are known. It therefore forms the basis for the calculation of electrolysis processes in the laboratory and industry.

Other teacher information (1/4)

PHYWE

Prior knowledge



The students should already be familiar with the principle of electrolysis. They should also already be familiar with charge transport, current strength and conductivity. They should also already have a basic theoretical knowledge of Faraday's laws.

Principle



The **1. Faraday's law** which was formulated by Michael Faraday in 1834, states that the amount of substance deposited on an electrode is directly proportional to the electrical charge flowing through the electrolyte.

Other teacher information (2/4)

PHYWE

Learning objective



The students familiarise themselves with Faraday's 1st law experimentally and prove that it is correct. They recognise that the amount of substance deposited during electrolysis is proportional to the product of current and time.

Tasks



The students carry out an electrolysis and prove Faraday's 1st law by weighing the electrodes. In this experiment, copper sulphate solution is electrolysed for three different periods of time (5, 10 and 15 minutes) and the amount of copper deposited on the electrode is weighed.

Other teacher information (3/4)

PHYWE

During electrolysis, the **positive electrode (anode)** a blister formation is visible, while on the **negative electrode (cathode)** metallic copper is deposited.

Copper atoms are oxidised to copper ions at the anode: $\text{Cu} \rightarrow \text{Cu}^{2+} + 2\text{e}^-$. At the cathode, the copper ions are reduced back to elemental copper: $\text{Cu}^{2+} + 2\text{e}^- \rightarrow \text{Cu}$. If the voltage source (e.g. a battery) is switched off, the finely dispersed copper easily detaches from the electrode. The cathode must therefore be carefully weighed after electrolysis.

Electrolysis is carried out for three different reaction times: **5, 10 and 15 minutes**. To save time, it makes sense to use new copper electrodes for each measurement, as cleaning used electrodes is time-consuming.

Other teacher information (4/4)

PHYWE

The solutions can be produced for everyone to save chemicals!

- **Copper sulfate solution (0,05 mol/l):** Add 6,2 g Copper sulfate to 250 ml distilled water. Mix well and fill up to 500 ml with distilled water.

When using this approach variable, a 600 ml beaker can be used. You can find this in the PHYWE webshop.

Safety instructions

PHYWE



- The general instructions for safe experimentation in science lessons apply to this experiment.
- All persons in the room must wear safety goggles during the experiment!
- For H and P phrases, please refer to the safety data sheet of the respective chemical.

PHYWE



Student information

Motivation

PHYWE



The **Faraday's laws** were discovered by Michael Faraday in 1834 and form the basis for electrolysis as we know it today.

Electrolysis is used to **extract** or to **purify** metals. For example, aluminium or copper can be **electrochemical** produced.

Faraday's first law states that the amount of a substance deposited on the electrode depends directly on the **electric charge** flowing through the solution. This important basic principle of electrochemistry is investigated in this experiment.

Tasks

PHYWE



1. Set up an electrolysis apparatus and start the electrolysis.
2. Weigh the copper electrodes before and after use (*Analysing scales!*) and note down your observations.
3. Carry out the electrolysis with three different reaction times (5, 10 and 15 minutes).
4. Prove that the following applies (at constant current):
 $m \propto I \cdot t \rightarrow$ Mass is proportional to the product of current and time

Equipment

Position	Material	Item No.	Quantity
1	Cobra SMARTsense Voltage - Sensor for measuring electrical voltage ± 30 V (Bluetooth + USB)	12901-01	1
2	Cobra SMARTsense Current - Sensor for measuring electrical current ± 1 A (Bluetooth + USB)	12902-01	1
3	Connecting cord, 2 mm-plug, 5A, 25 cm, red	07355-01	1
4	Connecting cord, 2 mm-plug, 5A, 250 mm, blue	07355-04	1
5	Connecting cord, 2 mm-plug, 5A, 500 mm, red	07356-01	1
6	Connecting cord, 2 mm-plug, 5A, 500 mm, blue	07356-04	1
7	Flat battery, 4.5 V	07496-01	1
8	Trough, grooved, w/o lid	34568-01	1
9	Copper electrode, 76 mm x 40 mm	45212-00	2
10	Reducing plug 4mm/2mm socket, 2	11620-27	1
11	Alligator clip, insulated, 2 mm socket, 2 pcs.	07275-00	2
12	Protecting glasses, clear glass	39316-00	1
13	Copper-II sulphate,cryst. 250 g	30126-25	1
14	Water, demineralized, pure, 10000 ml	CHE-882041145	1
15	Sulphuric acid,0.5M 1000 ml	48462-70	1

Setup (1/5)

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) is running **Bluetooth activated** is.



iOS



Android



Windows

Setup (2/5)

PHYWE

The solutions can be produced for everyone to save chemicals!

- **Copper sulfate solution** ($\approx 0,05 \text{ mol/l}$): Add 1 g Copper sulfate to 50 ml distilled water. Mix well and fill up to 100 ml with distilled water.

Setup (3/5)

PHYWE

1. Take a look at the two copper electrodes: If the metal has oxidised due to storage, use a piece of sandpaper to remove the oxide layer.
2. Weight the two electrodes and note down the initial weight.
3. Mix your electrolyte: Add approx. 85 ml Copper sulfate solution and then 15 ml Sulphuric acid (0,5 mol/L) into the grooved trough.
4. Place the copper electrodes in the trough without them touching each other (see picture).

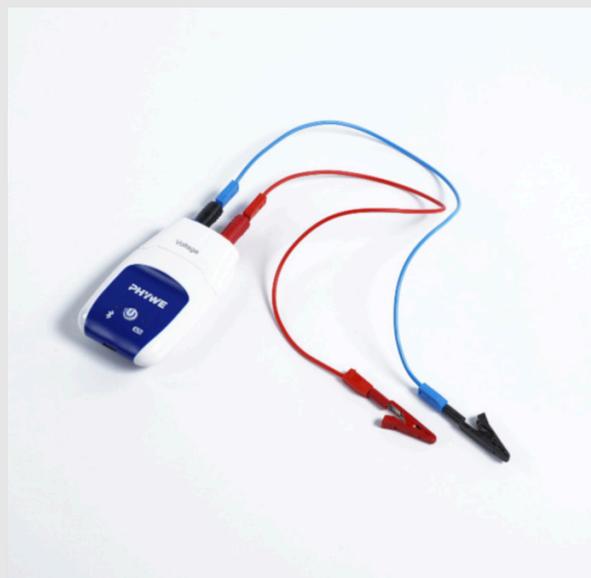


Setup (4/5)

PHYWE

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

Connect the cables to the Cobra SMARTsense Voltage Sensor using a reducing plug.



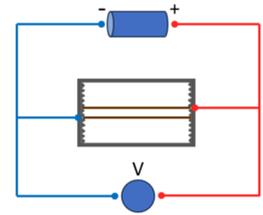
Setup (5/5)

PHYWE

Now set up the electrolysis apparatus as shown in the illustration on the right.

1. Connect the Cobra SMARTsense Voltage Sensor to the copper electrodes using the crocodile clips.
2. Attach another connecting cable to the crocodile clips on the electrodes and also attach a crocodile clip to the free end of the cable.

Do **not** connect the crocodile clips with the battery yet.



Procedure (1/5)

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 measureAPP.
- Set the measured value display by tapping 0.0 above the diagram.



Devices

- Apple iPad13,16 - Accelerometer (internal)
- 4885 - Voltage

Measurement channel

Configuration

4885 - Voltage

Measurement channel

Voltage

U [V]

Calculated channels

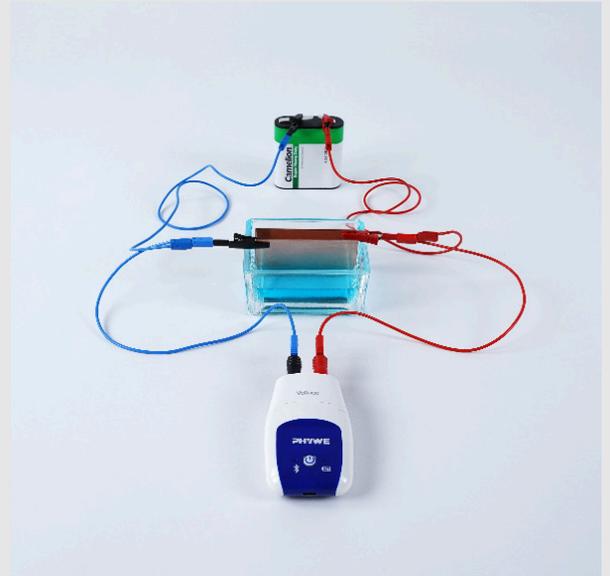
U 0,00 V

Procedure (2/5)

PHYWE

Voltage measurement

1. Now connect the crocodile clips to the battery. *Blue (negative pole) always to blue (black) and red (positive pole) always to red!*
2. Make sure that you note which electrode, i.e. which copper plate, is connected to the positive terminal and which to the negative terminal of the battery. *If vapours rise, do not inhale them!*
3. Let the electrolysis run for one minute and note the voltage value.



Procedure (3/5)

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 measureAPP.
- Set the measured value display by tapping 0.0 above the diagram.

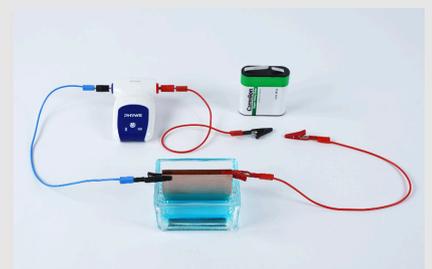
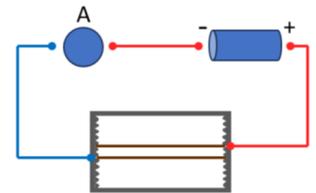
The screenshot displays the PHYWE measureAPP interface. At the top left, there is a 'Current' sensor icon. To the right, the 'Sensors' section lists 'Apple iPad13,16 - Accelerometer (internal)' and '7EDE - Current', with the latter selected. Below this, the 'Measurement channel' is set to 'Current', and the unit is 'I [mA]'. The main display area shows a large '0 mA' reading.

Procedure (4/5)

PHYWE

Preparation for current measurement

1. Clean the copper electrodes and dry them thoroughly.
2. Weigh the electrodes and note the weights in the table on slide *Measurement results as m* at time 0.
3. To measure the current, replace the voltage sensor with the current sensor and connect the current circuit in series. Now set up the circuit as shown on the right. Do **not** connect the crocodile clips with the battery yet!

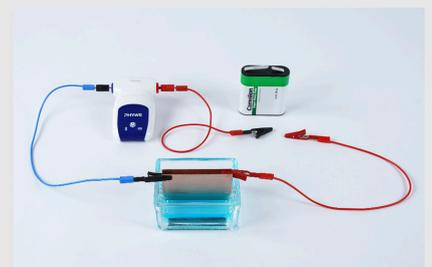
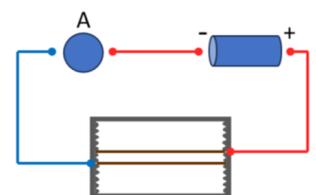


Procedure (5/6)

PHYWE

Current measurement

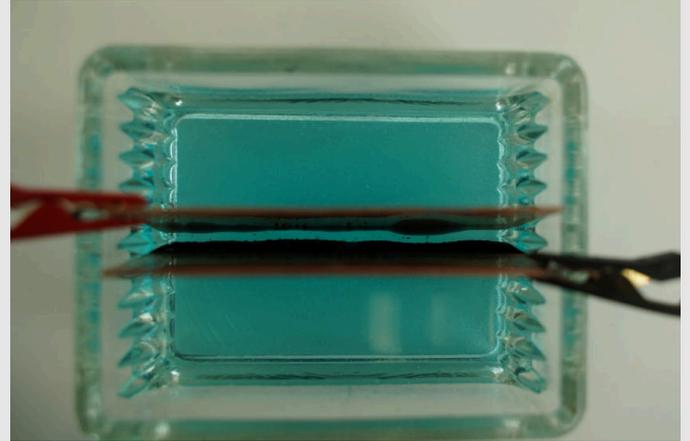
1. Again, make sure that you note which electrode is connected to the positive terminal and which to the negative terminal of the battery. If vapours rise, do not inhale them!
2. Now connect the battery.
3. Let the electrolysis run for 5 minutes and note the value of the current.



Procedure (6/6)

PHYWE

1. Stop the electrolysis: Remove the battery terminals and wait until the water has cooled down.
2. Carefully wash the two electrodes, dry them, and weigh them. Record the weights in the table on the slide *Measurement Results*.
3. Continue the electrolysis for another 5 minutes and then repeat steps 1 and 2.
4. Repeat the electrolysis a third and final time for 5 minutes and then repeat steps 1 and 2 again.



If you look closely, you should see the first gas bubbles between the electrodes.

Measurement Results

PHYWE

Note the masses of the electrodes here.

Time t / min	0	5	10	15
Mass anode m / g	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Mass cathode m / g	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

Then calculate the corresponding differences and plot them against the respective electrolysis duration in a diagram.

$$\Delta m_1 = m_{t=5} - m_{t=0}$$

$$\Delta m_2 = m_{t=10} - m_{t=0}$$

$$\Delta m_3 = m_{t=15} - m_{t=0}$$

Report

Task 1

PHYWE

What does Faraday's first law say?

- Faraday's first law states that the amount of substance deposited on an electrode is proportional to the electrical charge sent through the electrolyte.
- Faraday's second law states that the mass of an element deposited by a certain amount of charge is proportional to the atomic mass of the deposited element and inversely proportional to its valence.
- None of the answers describe Farady's first law.

✓ Check

Task 2

PHYWE

What can you determine after comparing the weights of the two copper electrodes before and after electrolysis?

- The weight of the electrodes has not changed.
- The copper sheet, which serves as the cathode, has become heavier by exactly the same amount as the metal, which serves as the anode, has become lighter.
- The copper sheet, which serves as the anode, has become heavier by exactly the same amount as the metal, which serves as the cathode, has become lighter.

 Check

Task 3

PHYWE

Mark the correct answers.

- The liquid in which the electrodes are placed is called electrolyte.
- The electrode connected to the positive terminal of the battery is called the anode, the electrode connected to the negative terminal is called the cathode.
- Electrons move from the anode to the cathode.
- The electrode connected to the positive terminal of the battery is called the cathode, the electrode connected to the negative terminal is called the anode.

 Check

Slide	Score / Total
Slide 25: 1st Faraday's law	0/1
Slide 26: Weight shift	0/1
Slide 27: The electrode	0/3

Total amount  0/5

 Solutions

 Repeat

 Export text