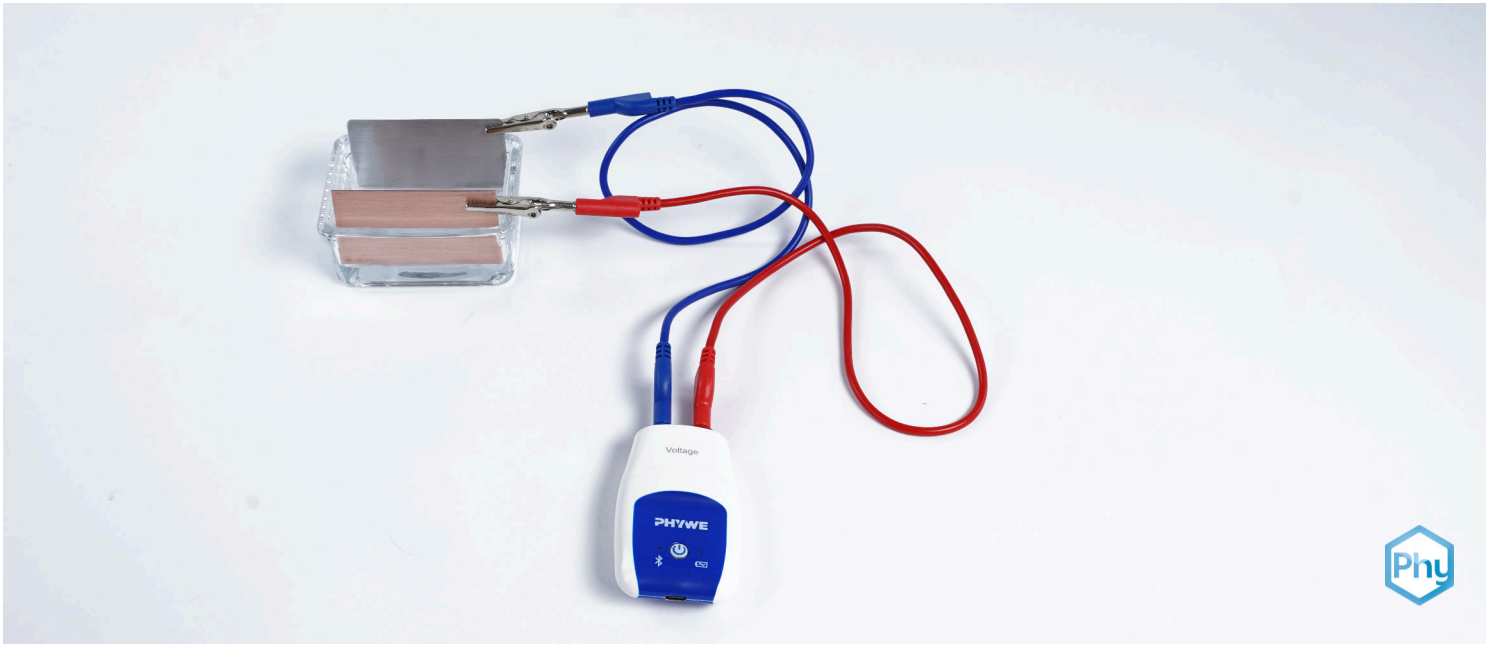
Galvanic cells with Cobra SMARTsense



With this experiment, the students expand their knowledge of electrochemistry and learn about another galvanic element, the Volta element.

Physics > Electricity & Magnetism > Electric current & its effects

Difficulty level	Group size	Preparation time	Execution time
easy	2	10 minutes	10 minutes

This content can also be found online at:

https://www.curriculab.de/c/685be0a5f4e84c0002b28d9e

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Teacher information

Application

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Setup

The functional principle of a commercially available battery is that of a galvanic cell. A galvanic cell consists of two different metals (electrodes) connected by an electrolyte. A voltage is generated between the electrodes when positive metal ions leave the surface of the electrodes and enter the electrolyte, while freely moving electrons remain on the electrodes.

In this experiment, the voltaic element is considered a special case of the galvanic cell. In the Voltaic element, both electrodes are placed in the same container.

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Other teacher information (1/5)

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Prior knowledge

The students should know what a reduction and an oxidation is.

Principle

In the Voltaic element, zinc and copper react in sulphuric acid: zinc releases electrons (oxidation), while protons gain electrons at the copper electrode and are reduced to hydrogen gas (reduction). As a result, electrons flow through an external conductor from zinc to copper — generating an electric current. The sulphuric acid allows ions to move within the solution, maintaining charge balance.

Other teacher information (2/5)

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Learning objective

The students learn how electric current can be generated with the help of a galvanic cell and thus gain an introduction to electrochemistry.

Tasks

The students should set up a galvanic cell and measure the resulting voltage. When short-circuiting the electrodes, they observe the special features of hydrogen deposition.

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Other teacher information (3/5)

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The following section explains how the Volta cell works.

Zinc reacts with dilute sulphuric acid according to the following reaction equation:

$$\mathrm{Zn} + \mathrm{H_2SO_4} \rightarrow \mathrm{Zn^{2+}} + \mathrm{SO_4^{2-}} + \mathrm{H_2} \uparrow$$

The zinc switches to the ionic state (oxidation) and simultaneously reduces hydrogen ions to molecular hydrogen. Copper, on the other hand, does not react with the diluted sulphuric acid under these conditions.

Other teacher information (4/5)

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If a zinc electrode is connected to a copper electrode via a wire and both are placed in diluted sulphuric acid, zinc dissolves at the surface of the zinc electrode according to the reaction equation described above. The electrons released in this process flow (at least partially) through the wire to the copper electrode, where they reduce hydrogen ions to molecular hydrogen.

If, instead, a high-resistance voltmeter is connected between the two metals, only a very small number of electrons flow. As a result, the reduction of hydrogen ions takes place primarily at the zinc electrode, while at the copper electrode it occurs only to a minor extent — barely visible to the naked eye.

Since the resulting hydrogen forms a thin film on the copper electrode, it blocks further access of hydrogen ions and causes the voltage to drop below the theoretical potential difference of $1.1\ \mathrm{V}$. Under idealised conditions, the potential may fall to around $0.76\ \mathrm{V}$.

The experiment “Production of a Simplified Hydrogen Electrode” provides a more detailed explanation.

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Other teacher information (5/5)

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The solution can be made for everyone to save chemicals!

Sulphuric acid (0.5 mol/l): Pour $270\ \mathrm{ml}$ of distilled water into a $600\ \mathrm{ml}$ beaker. Add $230\ \mathrm{ml}$ of 10 % sulphuric acid.

You can find the $600\ \mathrm{ml}$ beaker in the PHYWE webshop

Safety instructions

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- The general instructions for safe experimentation in science lessons apply to this experiment.
- During the test, all persons in the room must wear safety goggles and protective gloves.
- Sulphuric acid solutions of the concentration $c = 0.5\ \mathrm{mol/l}$ have an irritant effect.
- Avoid any contact of the chemicals with the eyes and skin.
- For H- and P-phrases please refer to the safety data sheet of the respective chemical.

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Student information

Motivation

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Experimental setup

The functional principle of a commercially available battery is that of a galvanic cell. It produces electrical energy through chemical reactions. The first functioning galvanic cell was the Voltaic cell and was developed by Alessandro Volta in 1799.

In today's experiment, you will investigate how this cell works and how chemical reactions generate electrical energy. You will build voltaic ash cells and measure the resulting voltage.

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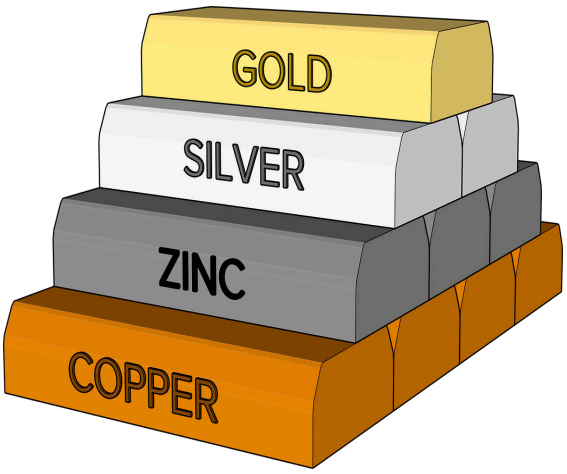
Tasks



1. Build a Volta element.
2. Measure the voltage at the cell.
3. Create a short circuit between the electrodes and observe the hydrogen deposition.

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Equipment

Position	Material	Item No.	Quantity
1	Cobra SMARTsense Voltage - Sensor for measuring electrical voltage ± 30 V (Bluetooth + USB)	12901-02	1
2	Trough, grooved, w/o lid	34568-01	1
3	Copper electrode, 76 mm x 40 mm	45212-00	2
4	Zinc electrode, 76 mm x 40 mm	45214-00	1
5	Alligator clips, bare, 10 pcs	07274-03	1
6	Connecting cord, 32 A, 500 mm, red	07361-01	1
7	Connecting cord, 32 A, 500 mm, blue	07361-04	1
8	Emery paper, medium	01605-00	1
9	Water, distilled 5 l	31246-00	1
10	Sulphuric acid, 10%, tech.gr., 1000 ml	31828-70	1
11	measureAPP - the free measurement software for all devices and operating systems	14581-61	1

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Setup (1/3)

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To measure with the **Cobra SMARTsense sensors**, the **PHYWE measureAPP** is required. The app can be downloaded free of charge from the respective app store (QR codes below). Please check that **Bluetooth is enabled** on your device (smartphone, tablet, desktop PC) before starting the app.

iOS

Android

Windows

Setup (2/3)

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The solution can be made for everyone to save chemicals!

Sulphuric acid (0.5 mol/l): Pour $270\ \mathrm{ml}$ of distilled water into a beaker. Add in $230\ \mathrm{ml}$ of 10 % sulphuric acid.

When using this preparation size, a $600\ \mathrm{ml}$ beaker can be used. You can find this in the PHYWE webshop

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Setup (3/3)

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- Look at the two electrodes, copper (Cu) and zinc (Zn): If the metal has oxidised due to storage, use a piece of sandpaper to remove the oxide layer.
- *Note the colour of the connections: blue (zinc, negative pole) always to blue and red (copper, positive pole) always to red!*
- Connect the crocodile clips to the metal electrodes (copper and zinc sheet) and the leads to the Cobra SMARTsense Voltage Sensor.

Procedure (1/3)

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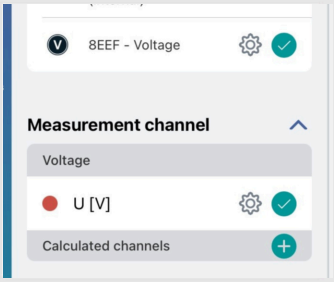
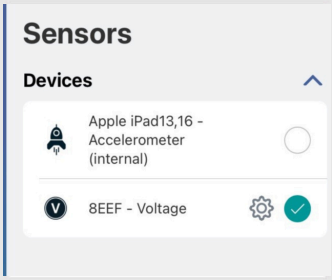
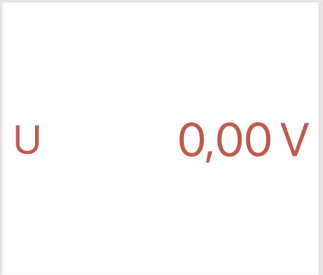
- Start the measureAPP on a mobile device.
- Press the start button on the sensor for approx. 3 seconds.
- Connect the sensor by tapping ◯ next to the description of the sensor in the measureAPP.
- Set the measured value display by tapping 0.0 above the diagram.







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Procedure (2/3)

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- Immerse both electrodes in the sulphuric acid at the same time (see illustration). The electrodes must **not** touch each other!
- Note the measured voltage!

Procedure (3/3)

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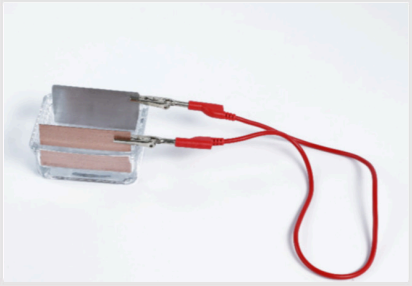
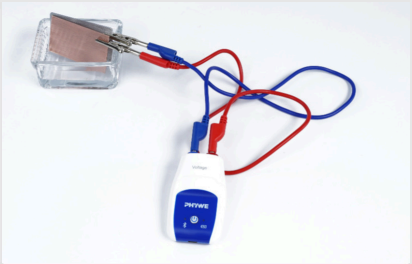
- Create a short circuit in a cell by:
  1. connect the copper and zinc electrodes directly with a wire (fig. above),

     or

  2. both electrodes touch each other directly (Fig. below).
- Observe the gas development at the electrodes, especially at the copper electrode.





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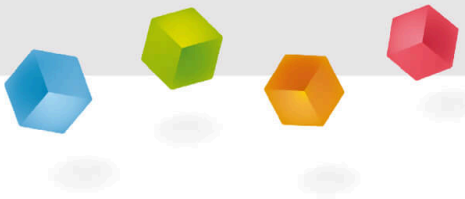

Report

Task 1

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Tick the correct statements.

- [ ] A galvanic cell is a device that converts thermal energy into electrical energy
- [ ] A galvanic cell is a device that converts chemical energy into electrical energy
- [ ] A galvanic cell consists of two electrodes and an electrolyte

Check

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Task 2

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What is a Volta element?

- ○ A galvanic element in which both metal electrodes are placed together in an electrolyte solution of dilute sulphuric acid.
- ○ A galvanic element in which both metal electrodes are placed together in an electrolyte solution of diluted caustic soda.

Check

Task 3

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What describes the reaction of zinc and copper with sulphuric acid?

- ☐ Zinc does not react with diluted sulphuric acid.
- ☐ The copper changes to the ionic state (oxidation) and thereby reduces hydrogen ions to molecular hydrogen.
- ☐ Copper does not react with diluted sulphuric acid.
- ☐ The zinc changes to the ionic state (oxidation) and thereby reduces hydrogen ions to molecular hydrogen.

Check

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Slide	Score / Total
Slide 20: Galvanic cell - General	0/2
Slide 21: Volta element	0/1
Slide 22: Z/K in sulphuric acid	0/2

Total amount 0 / 5

Solutions Repeat

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