The Volta element with Cobra SMARTsense

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

Chemistry	Physical chemistry	Electrochemistry	Electrochemical measurement set
Chemistry	Physical chemistry	Electrochemistry	Galvanic elements, fuel cells

Difficulty level	Group size	Preparation time	Execution time
medium	2	10 minutes	20 minutes

This content can also be found online at:

https://www.curriculab.de/c/68a86212a65c99000273a96b

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Teacher information

Application

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The first galvanic element was described in 1799 by the Italian physicist Alessandro Count Volta. This so-called **Volta element** or the voltaic ash cell is also a copper-zinc element. However, unlike the Daniell element, which was developed later, both metal electrodes in the Voltaic cell are placed together in an electrolyte solution of dilute sulphuric acid.

Thanks to their comparatively simple design, many of these elements could be connected in series to save space. These as **Voltasche columns** known batteries consisting of several Volta elements were used to generate high voltages.

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Other teacher information (1/5)

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Prior knowledge

The students should have worked with galvanic elements (Daniell element) in theory and practice. They should also already know what a series circuit is.

Principle

The "Volta element" or "Voltaic cell" is also a copper/zinc element, but unlike the Daniell element, which was developed later, both metal electrodes are located together in an electrolyte solution of dilute sulphuric acid.

Other teacher information (2/5)

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Learning objective

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

Tasks

The students should set up two Volta elements. They measure the voltage of a single cell and the voltage after series connection. 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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Zinc reacts with dilute sulphuric acid according to the following reaction equation:

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

The zinc changes to the ionic state (oxidation). If the zinc electrode is connected to the copper electrode via a wire and both are placed in diluted sulphuric acid, zinc dissolves on the surface of the zinc electrode according to the reaction equation described above. The electrons released in the process flow (at least partially) via the wire to the copper electrode, where they reduce 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 high-resistance voltmeter is connected between the two metals instead, only very few electrons flow. The reduction of the hydrogen ions then takes place predominantly at the zinc electrode, while at the copper electrode it only takes place to a small extent that cannot be seen with the naked eye.

As the resulting hydrogen is deposited as a thin layer on the copper electrode and shields it from further hydrogen ions, the voltage falls below the theoretical potential difference of $1.1\ \mathrm{V}$. The voltage can be reduced to approx. $0.76\ \mathrm{V}$ fall off.

The experiment "Production of a simplified hydrogen electrode" (P7400869) 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!

Optional sulphuric acid $(0.5\ \mathrm{mol/l})$ Pour into a beaker $100\ \mathrm{ml}$ distilled water. With a pipette, add $14\ \mathrm{ml}$ of 96% sulphuric acid and fill up to $500\ \mathrm{ml}$ with distilled water.

When using this approach variable, a $600\ \mathrm{ml}$ beaker can be used. You can find this 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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The voltaic cell was the first functioning galvanic element and was developed by Alessandro Volta back in 1799. Its simple design made it possible to connect several cells in series and thus generate a higher electrical voltage. This arrangement became known as the "voltaic column" and represented an important step in the development of electrical energy sources.

In today's experiment, you will investigate how chemical reactions generate electrical energy. You will set up voltaic cells, measure the voltage of a single cell and observe how the voltage changes when connected in series. In this way, you will investigate a basic principle of modern batteries.

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Tasks

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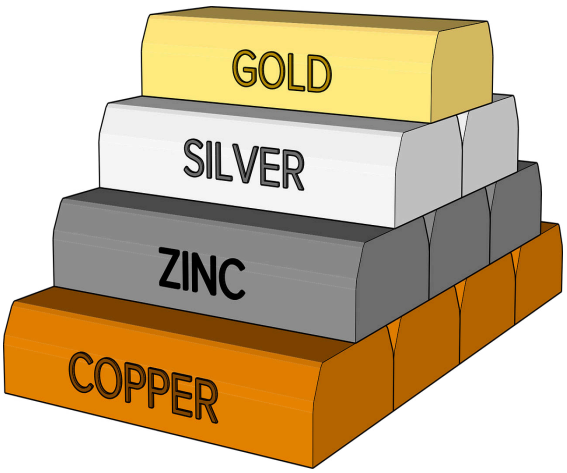

1. Build two Volta elements.
2. Measure the voltage of a single cell.
3. Connect the two cells in series and measure the total voltage.
4. Create a short circuit between the electrodes and observe the gas development.

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Equipment

Position	Material	Item No.	Quantity
1	Cobra SMARTsense Voltage - Sensor for measuring electrical voltage ± 30 V (Bluetooth + USB)	12901-01	1
2	Connecting cord, 2 mm-plug, 5A, 500 mm, red	07356-01	1
3	Connecting cord, 2 mm-plug, 5A, 500 mm, blue	07356-04	1
4	Reducing plug 4mm/2mm socket, 2	11620-27	1
5	Alligator clip, insulated, 2 mm socket, 2 pcs.	07275-00	2
6	Copper strip electrode for student electrochemistry experiments Length: 75 mm, width 15 mm	07856-10	2
7	Connecting cord, 2 mm-plug, 5A, 250 mm, blue	07355-04	1
8	Block with 8 holes, d = 40 mm	37682-00	1
9	Beaker, Borosilicate, tall form, 50 ml	46025-00	2
10	Sulphuric acid,0.5M 1000 ml	48462-70	1
11	Water, demineralized, pure, 10000 ml	CHE-882041145	1
12	Zinc strip electrode for student electrochemistry experiments Length: 75 mm, width 15 mm	07856-20	2
13	Protecting glasses, clear glass	39316-00	1

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Setup (1/3)

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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 (2/3)

PHYWE

The solution can be made for everyone to save chemicals!

Optional sulphuric acid $(0.5\ \mathrm{mol/l})$ Pour into a beaker $10\ \mathrm{ml}$ distilled water. With a pipette, add $1,4\ \mathrm{ml}\ 96\%$ sulphuric acid and fill up to $50\ \mathrm{ml}$ with distilled water.

Place 2 beakers $(50\ \mathrm{ml})$ into the measuring cell block and pour into each approximately $25\ \mathrm{ml}$ the $0.5\ \mathrm{molaren}$ Sulphuric acid (Fig. right).

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Setup (3/3)

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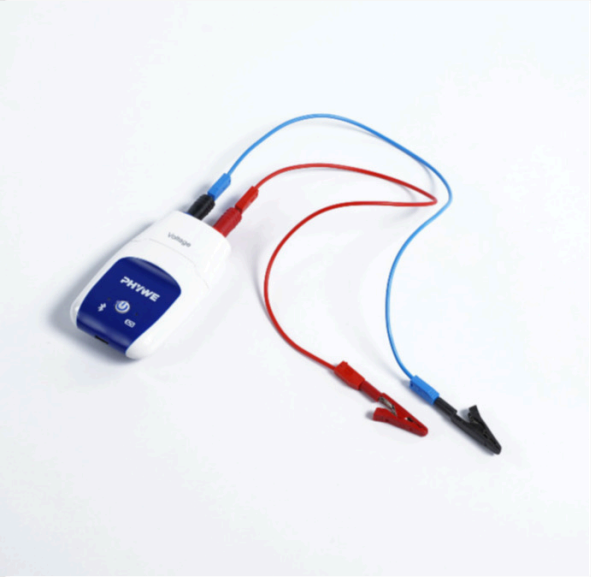
Look at the two electrodes, copper (Cu) and zinc (Zn): If the metal has oxidised due to storage, use a piece of sandpaper to remove the oxide layer.

Note the colour of the connections below: blue (zinc, negative pole) always to blue (black) 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 using a reducing plug.



Realisation (1/4)

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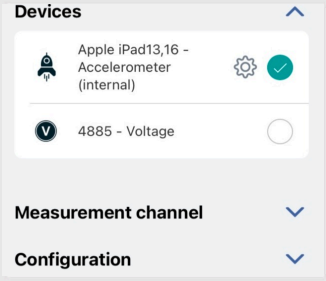
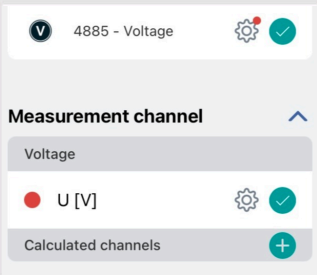
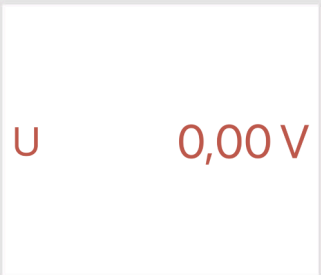
- Start the measureAPP on a mobile device.
- Press the start button on the sensor for approx. 3 seconds.
- Connect the sensor by tapping ○ next to the description of the sensor in the measureAPP.
- Set the measured value display by tapping 0.0 above the diagram.







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Realisation (2/4)

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

Note the measured voltage!

Realisation (3/4)

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Now also insert a zinc and a copper electrode into the second beaker and then connect the two voltaic cells in series (see illustration).

Measure the voltage of this combination.

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Procedure (4/4)

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Create a short-circuit circuit in a cell by:

a) connect the copper and zinc electrodes directly with a wire (Fig. above), or

b) both electrodes touch each other directly (Fig. below).

Observe the gas development at the electrodes, especially at the copper electrode. What gas is produced here?

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Report

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Task 1

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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 2

PHYWE

What describes the reaction of zinc and copper with sulphuric acid? Tick all the correct statements.

- ☐ Zinc does not react with diluted sulphuric acid.
- ☐ The zinc changes to the ionic state (oxidation).
- ☐ The copper changes to the ionic state (oxidation).
- ☐ Copper does not react with diluted sulphuric acid.

Check

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Task 3

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How does the redox reaction work? Which gases are produced?

- ☐ $\mathrm{Zn} + \mathrm{H_2SO_4} \rightarrow \mathrm{Zn^{2+}} + \mathrm{SO_2} + \mathrm{H_2} \uparrow + \mathrm{O_2} \uparrow$
- ☐ Oxygen and hydrogen are produced $(\mathrm{O_2})$ and $(\mathrm{H_2})$.
- ☐ Hydrogen is produced $(\mathrm{H_2})$.
- ☐ $\mathrm{Zn} + 2\mathrm{H^+} + \mathrm{SO_4^-} \rightarrow \mathrm{Zn^{2+}} + \mathrm{SO_4^{2-}} + 2\mathrm{e^-} + 2\mathrm{H^+} \rightarrow \mathrm{Zn^{2+}} + \mathrm{SO_4^{2-}} + \mathrm{H_2} \uparrow$

Check

Task 4

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What does the relatively simple structure of the Volta elements make possible?

- ○ Voltages up to $90\ \mathrm{V}$ to generate
- ○ The elements can be combined in series in a very compact design.
- ○ None of the answers is correct.
- ○ The elements can be combined in a very compact parallel circuit.

Check

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Slide	Score / Total
Slide 21: Volta element	0/1
Slide 22: Z/K in sulphuric acid	0/2
Slide 23: Z/K in sulphuric acid	0/2
Slide 24: Positive negative	0/1

Total amount 0 / 6

Solutions Repeat

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