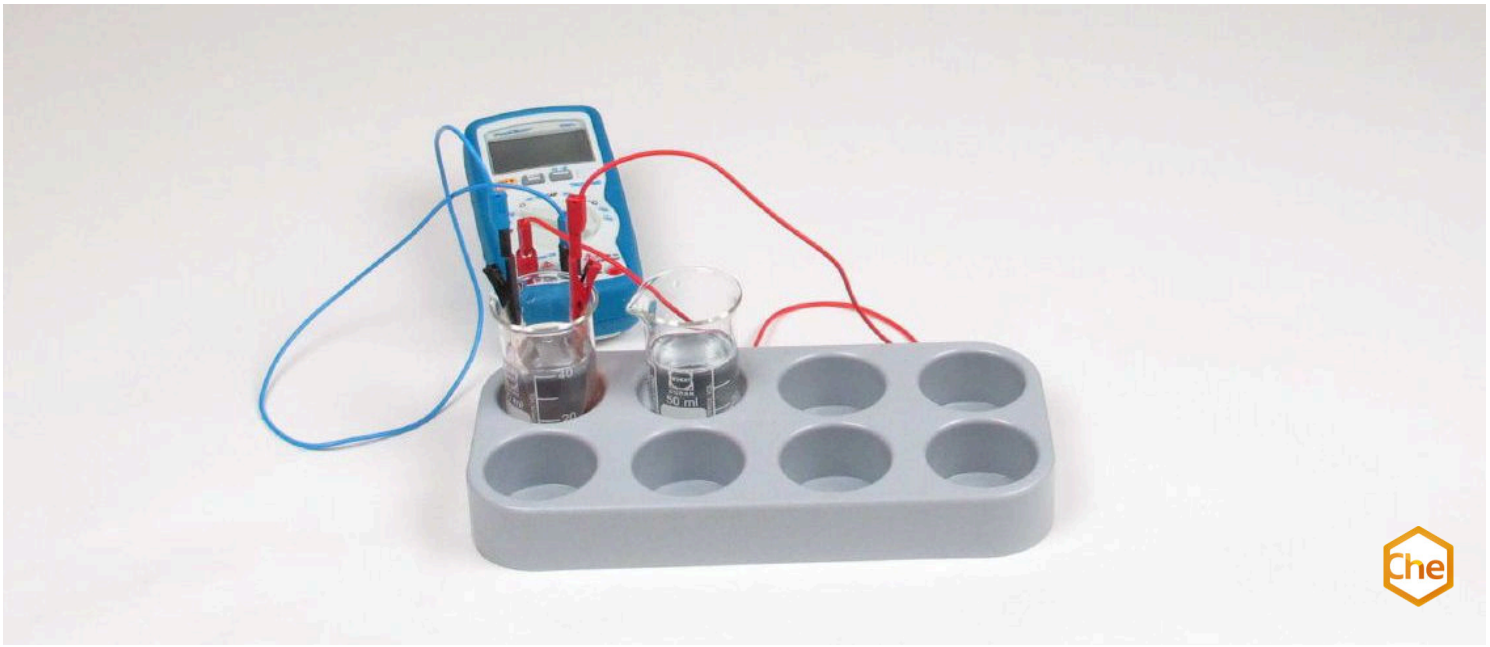
The voltaic cell



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

Chemistry > Physical chemistry > Electrochemistry > Electrochemical voltage series

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

This content can also be found online at:

http://localhost:1337/c/6353cf6b30e03500032bda0e

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Teacher information

Application

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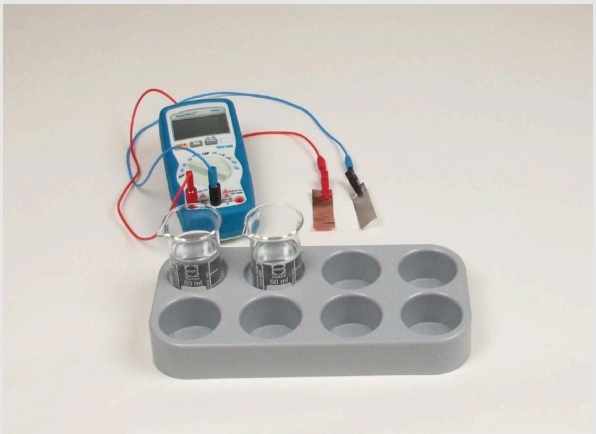

Experimental setup

The first galvanic element was described in 1799 by the Italian physicist Alessandro Count Volta. This "Volta element" or "Volta cell" is also a copper/zinc element, but unlike the Daniell element developed later, here both metal electrodes are together in an electrolyte solution of diluted sulphuric acid.

This relatively simple construction made it possible to combine many such elements in a very compact design in series. These batteries of voltaic elements, which became known as "voltaic columns", were used to generate high voltages.

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Other teacher information (1/4)

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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 the "Volta cell" is also a copper/zinc element, but unlike the Daniell element developed later, here both metal electrodes are together in an electrolyte solution of diluted sulphuric acid.

Other teacher information (2/4)

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Learning

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

Tasks

The students are to set up 2 Volta elements. They measure the voltage of a single cell and the voltage after series connection. When the electrodes are short-circuited, they observe the peculiarities of hydrogen separation.

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Other teacher information (3/4)

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Other information (1/2)

This relatively simple construction made it possible to combine many such elements in a very compact design in series. These batteries of voltaic elements, which became known as "voltaic columns", were used to generate high voltages.

Zinc reacts with sulphuric acid according to the following equation:

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

Other teacher information (4/4)

PHYWE

Other information (2/2)

If a zinc electrode is connected to a copper electrode via a wire and both are then placed in diluted sulphuric acid, zinc dissolves on the surface of the zinc electrode according to equation I. The electrons released flow (at least partially) via the wire to the copper and reduce hydrogen ions to molecular hydrogen on its surface according to equation II. The electrons released in the process flow (at least in part) via the wire to the copper and reduce hydrogen ions to molecular hydrogen on its surface according to equation II.
If a high-impedance measuring device (voltmeter) is connected between the two metal electrodes, only very few electrons can flow from the zinc to the copper. Therefore, in this case, the reduction of the hydrogen ions to hydrogen takes place almost exclusively at the zinc electrode (equation III), although it also takes place very weakly at the copper electrode, although this is not visible to the eye.
As the molecular hydrogen that forms slowly coats the copper electrode in a thin layer, shielding it from the entry of further hydrogen ions, the electrical voltage drops somewhat below the actual potential difference of 1.1 V- between zinc and copper. In extreme cases and using the purest chemicals and metals, the voltage of this voltaic element can drop to about 0.76 V-. The explanation for this is given in experiment 2.1, "Production of a simplified hydrogen electrode".

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Safety instructions

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- Wear protective goggles and gloves.
- Sulphuric acid solutions of concentration c = 0.5 mol/l have an irritant effect.
- Avoid any contact of the chemicals with the eyes and skin.
- For the H- and P-phrases please refer to the corresponding safety data sheets.
- The general instructions for safe experimentation in science lessons apply to this experiment.

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Student information

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Motivation

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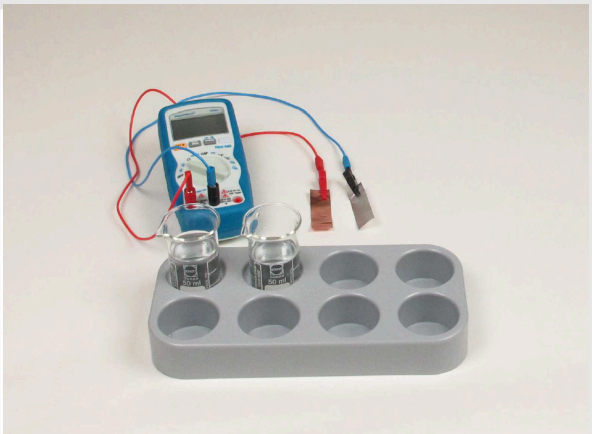

Experimental setup

If we want to generate a high voltage, we need a construction with a relatively large number of "voltaic cells". The relatively simple construction allows us to combine many of these cells in a very compact design in series connection.

These batteries have become known as "voltaic columns" and were used to generate high voltages.

Tasks

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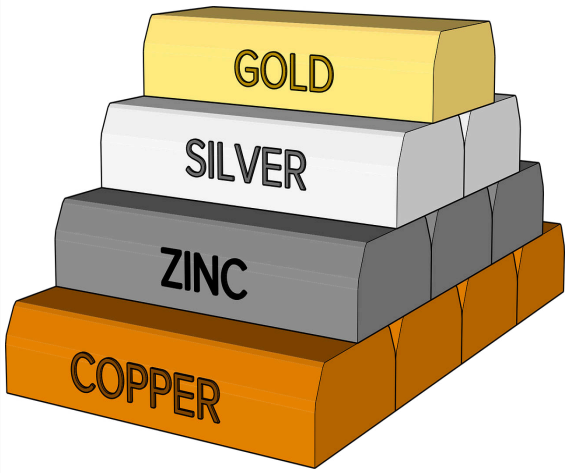

Set up 2 Volta elements. Measure the voltage of a single cell and the voltage after series connection.

With a short-circuit connection of the electrodes, peculiarities of the hydrogen separation are to be observed.

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Equipment

Position	Material	Item No.	Quantity
1	PHYWE Digital multimeter, 600V AC/DC, 10A AC/DC, 20 MΩ, 200 µF, 20 kHz, −20°C…760°C	07122-00	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	Set Strip electrode (Al, Fe, Pb, Zn, Cu)	07856-00	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

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Set-up

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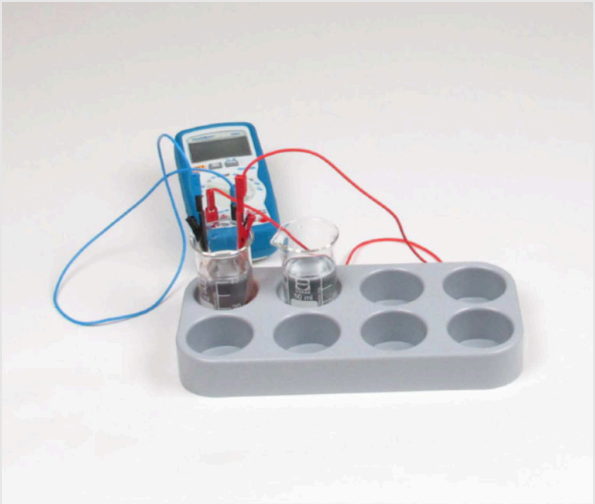
Producing the required solutions

Sulphuric acid (0.5 mol/l) Pour 100 ml of distilled water into a beaker. Add 13.8 ml of 96 % sulphuric acid and fill up to 500 ml with distilled water.

Set-up:

Place 2 beakers (50 ml) in the measuring cell block and add about 25 ml of diluted, about 2 to 3% sulphuric acid to each (fig. right).

Connect a zinc electrode to the ground socket (negative pole) and a copper electrode to the volt socket (positive pole) of the measuring instrument.



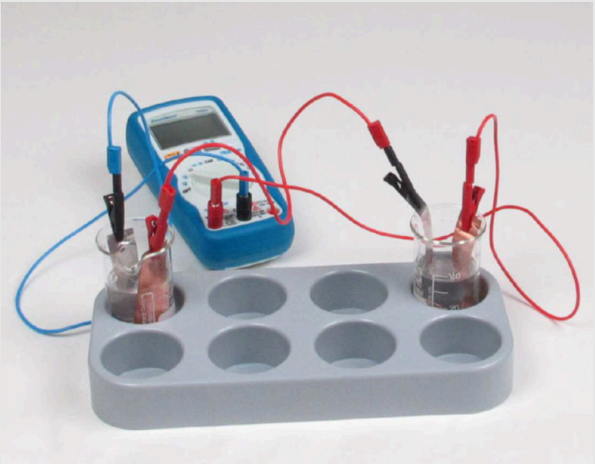
Place 2 beakers in the measuring cell block.

Procedure (1/2)

PHYWE

Set the measuring instrument to the measuring range 2 V- and then briefly dip both electrodes into the sulphuric acid at the same time. The electrodes must not touch each other!

Now place a zinc and a copper electrode in the acid of the second beaker and then connect the two voltaic cells in series (Fig. 3). Measure the voltage of this combination.



Connect the two Voltaschen cells in series

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Procedure (2/2)

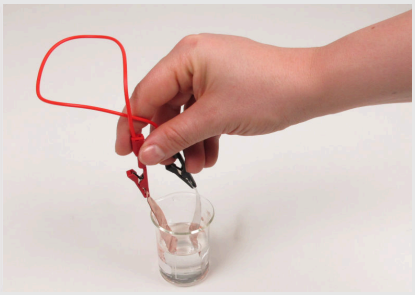
However, if one short-circuits a copper electrode and a zinc electrode in a cell by

- connects them directly via a line (Fig. top right),

or

- can simply be touched to each other (Fig. bottom right),

you can also clearly see gas bubbles rising at the copper electrode.



Report

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Task 1

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What is a Volta Element?

- ○ The Volta element is also a copper/zinc element, but unlike the Daniell element developed later, here both metal electrodes are together in an electrolyte solution of diluted sulphuric acid.
- ○ The Volta element is also a copper/zinc element, but unlike the Daniell element developed later, here both metal electrodes are together in an electrolyte solution of diluted sodium hydroxide solution.

Check

Task 2

PHYWE

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

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

Check

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Task 3

PHYWE

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

- ○ The relatively simple construction makes it possible to generate voltages of up to 90 volts.
- ○ The relatively simple design allows many such elements to be combined in a very compact way in parallel connection.
- ○ The relatively simple design allows many such elements to be combined in a very compact manner in series connection.
- ○ None of the answers is correct.

Check

Slide	Score / Total
Slide 16: Volta element	0/1
Slide 17: Z/K in sulphuric acid	0/2
Slide 18: Positive negative	0/1

Total 0 / 4

Solutions Repeat

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