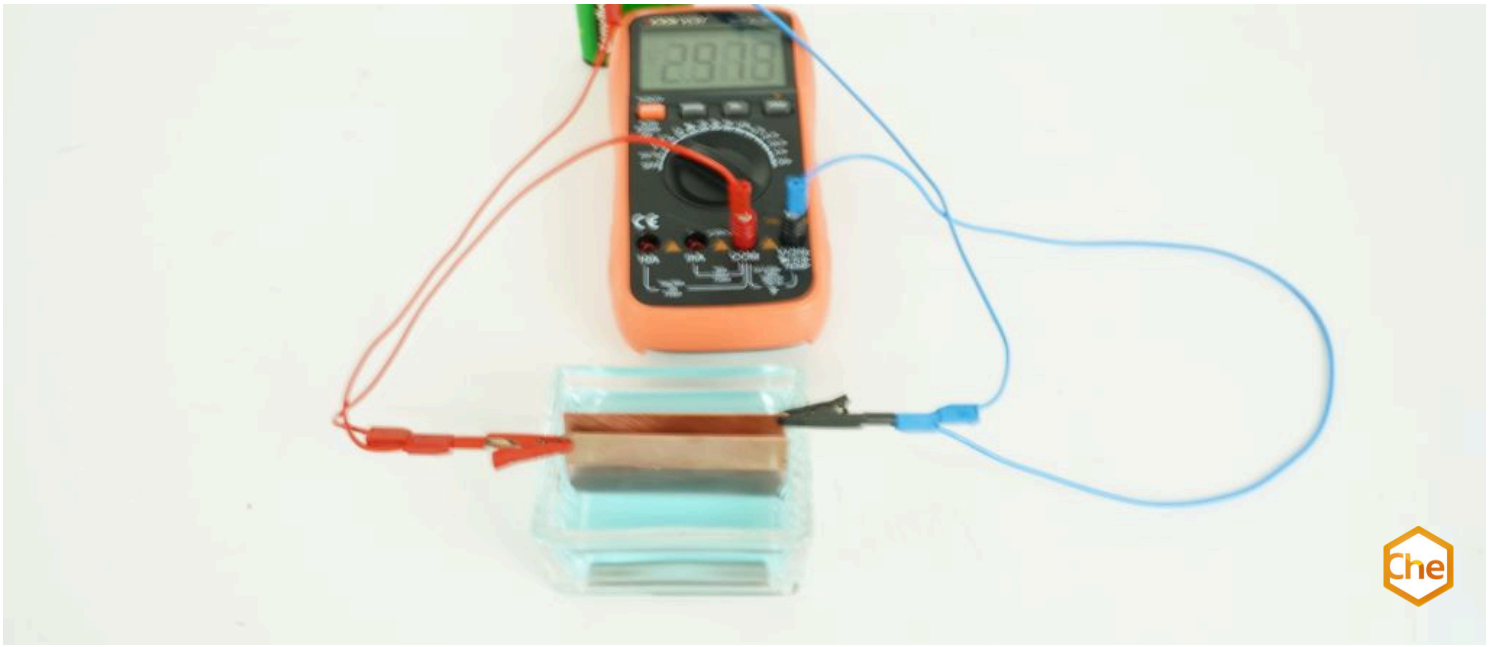
First law of Faraday



The first Faraday law describes the relationship between the quantity of material deposited and the electrical energy supplied and is investigated experimentally in this experiment.

Chemistry > Physical chemistry > Electrochemistry > Electrolysis

Difficulty level	Group size	Preparation time	Execution time
easy	1	10 minutes	10 minutes

This content can also be found online at:

http://localhost:1337/c/61a8e0f022e1e50003a26e88

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Teacher information

Application

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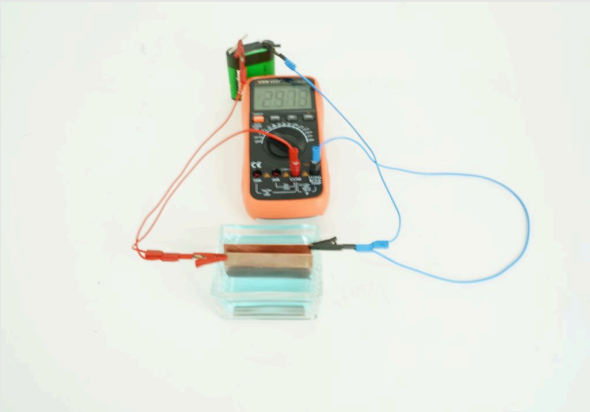

Experiment setup

Faraday's laws are also called the basic laws of electrolysis and describe the process in this.

In this experiment, students learn about the principle of Faraday's 1st Law, which states that the amount of material deposited on an electrode is proportional to the electric charge sent through the electrolyte, by using an electrolysis experiment.

(Source: Michael Faraday: Experimental Researches in Electricity. Seventh Series. In: Philosophical Transactions of the Royal Society of London. Ribbon 124, January 1834, S. 77-122)

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Other teacher information (1/2)

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Previous 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. In addition, they should already have a basic theoretical knowledge of Faraday's laws.

Scientific Principle

The first Faraday's law, published by Michael Faraday in 1834, states that the amount of material deposited on an electrode is proportional to the electric charge sent through the electrolyte. (Source: Michael Faraday: Experimental Researches in Electricity. Seventh Series. In: Philosophical Transactions of the Royal Society of London. Ribbon 124, January 1834, S. 77-122)

Other teacher information (2/2)

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Learning objective

Students learn about Faraday's first law experimentally and demonstrate its correctness. They recognise that the amount of material deposited during electrolysis is proportional to the product of current and time.

Tasks

Students perform electrolysis and demonstrate Faraday's first law by weighing the electrodes. In this experiment, copper sulfate solution is electrolyzed for three different periods of time (5, 10, and 15 minutes) and the amount of copper deposited on the electrode is weighed.

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Safety instructions

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- Wear protective goggles and gloves.
- 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.

Theory

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- During electrolysis, bubbles can be seen forming on the positive electrode (anode), while copper forms on the negative electrode (cathode).
- Elemental oxygen is formed from the water at the anode and elemental copper from the copper ions at the cathode.
- If the voltage source (battery) is switched off during electrolysis, the finely distributed deposited copper easily falls off the electrode. Therefore, the electrode must be weighed carefully after electrolysis.
- Electrolysis is performed for three different reaction durations (5, 10 & 15 minutes). To save time, it is recommended to use new copper electrodes each time (cleaning the electrodes takes some time).

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Student Information

Motivation

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Aluminium beverage can

Faraday's laws were discovered and described by Michael Faraday in 1834. They form the basis for the electrolysis we know today.

Electrolysis is mainly used for the extraction of metals, but also for the purification of metals. Especially metals like aluminium or copper can be extracted electrochemically.

The first Farady's law states that the amount of charge supplied is proportional to the amount of material discharged (at the electrodes). This important basic principle of electrochemistry is investigated in this experiment.

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Tasks

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1. Set up an electrolysis apparatus as shown in the experimental setup figure and start the electrolysis.
2. Measure the inserted copper electrodes before and after (precision balance!) and note down your observations.
3. Perform the electrolyses with three different reaction durations (5, 10 and 15 minutes).
4. Prove that (at constant current): m ~ I t (mass is proportional to the product of current and time).

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Equipment

Position	Material	Item No.	Quantity
1	Protecting glasses, clear glass	39316-00	1
2	Digital multimeter, 750V AC/DC, 10A AC/DC, 40MΩ, 100mF, 30 MHz, -20...1000°C, Auto range	07123-12	1
3	Connecting cord, 2 mm-plug, 5A, 250 mm, 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	Copper-II sulphate,cryst. 250 g	30126-25	1

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Preparation (1/2) - Preparation of the electrolyte

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- Clean the two copper electrodes. If necessary, use steel wool or emery paper and scrub them clean.
- If necessary, prepare a copper sulphate solution (picture top right). The copper sulphate solution serves as an electrolyte in the electrolysis process.
  - Add about 0.8 g of copper (II) sulphate pentahydrate ($CuSO_4 \times 5 H_2O$) to 100 ml of demineralised water.
  - Stir until the powder has dissolved.
  - The water should have taken on a slightly bluish colour (picture below right).

Copper sulfate solution

bluish water

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Preparation (2/2) - Measuring the voltage

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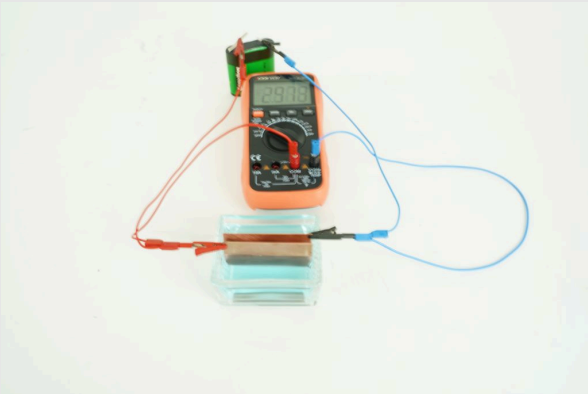

Experimental setup with multimeter connected in parallel to measure the voltage.

- First mix your electrolyte. To do this, add approx. 85 ml copper sulphate solution and 15 ml diluted sulphuric acid to the grooved trough.
- Now set up the electrolysis apparatus as shown in the figure on the right. The multimeter is connected in parallel in the circuit.
- The electrodes and also the alligator clips on the electrodes must not touch each other, but should be close together.
- Now clamp the battery into the current circuit and read the voltage on the multimeter. For a successful electrolysis you need at least 2 volts voltage.

Procedure (1/2)

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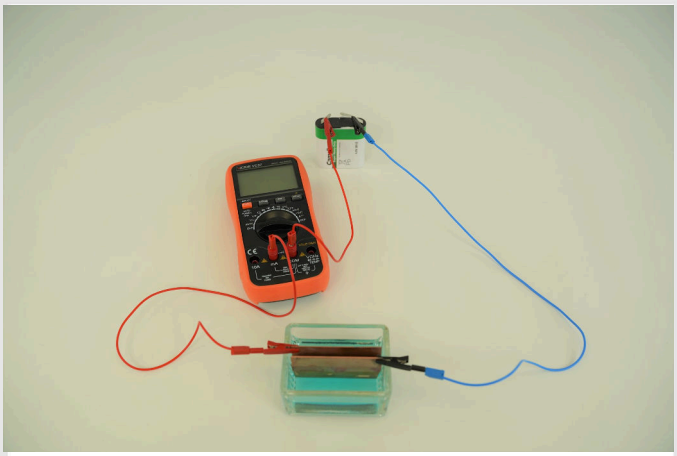
- Now set up the circuit as shown on the right. The multimeter is now connected in series to measure the current.
- Make sure that you note which electrode, i.e. which copper sheet, is connected to the positive terminal and which to the negative terminal of the battery. If vapours rise, do not inhale them!
- Turn on the multimeter and set it to amperage. Now connect the battery.
- Let the electrolysis run for 5 minutes and note the value the multimeter reads.



Experimental setup with multimeter connected in series to measure the current.

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Procedure (2/2)

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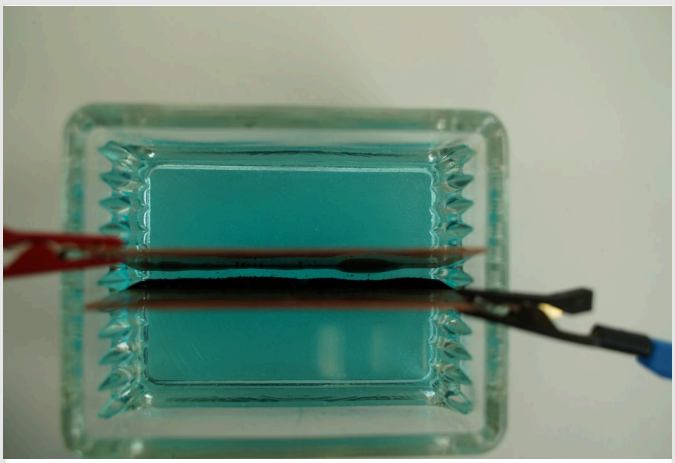
- Stop the electrolysis: Disconnect the battery and wait until the water has cooled down.
- Wash, dry and weigh the two electrodes. Calculate the changes in weight.
- Now clean the copper electrodes, weigh them again and carry out the electrolysis with a reaction time of 10 or 15 minutes.
- Now plot the weight change and the respective time duration in a diagram.



If you look closely, you can see gas forming between the electrodes.

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Report

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Task 1

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What does Faraday's first law say?

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

Check

Task 2

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

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

Check

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Task 3

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Mark the correct answers.

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

Check

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