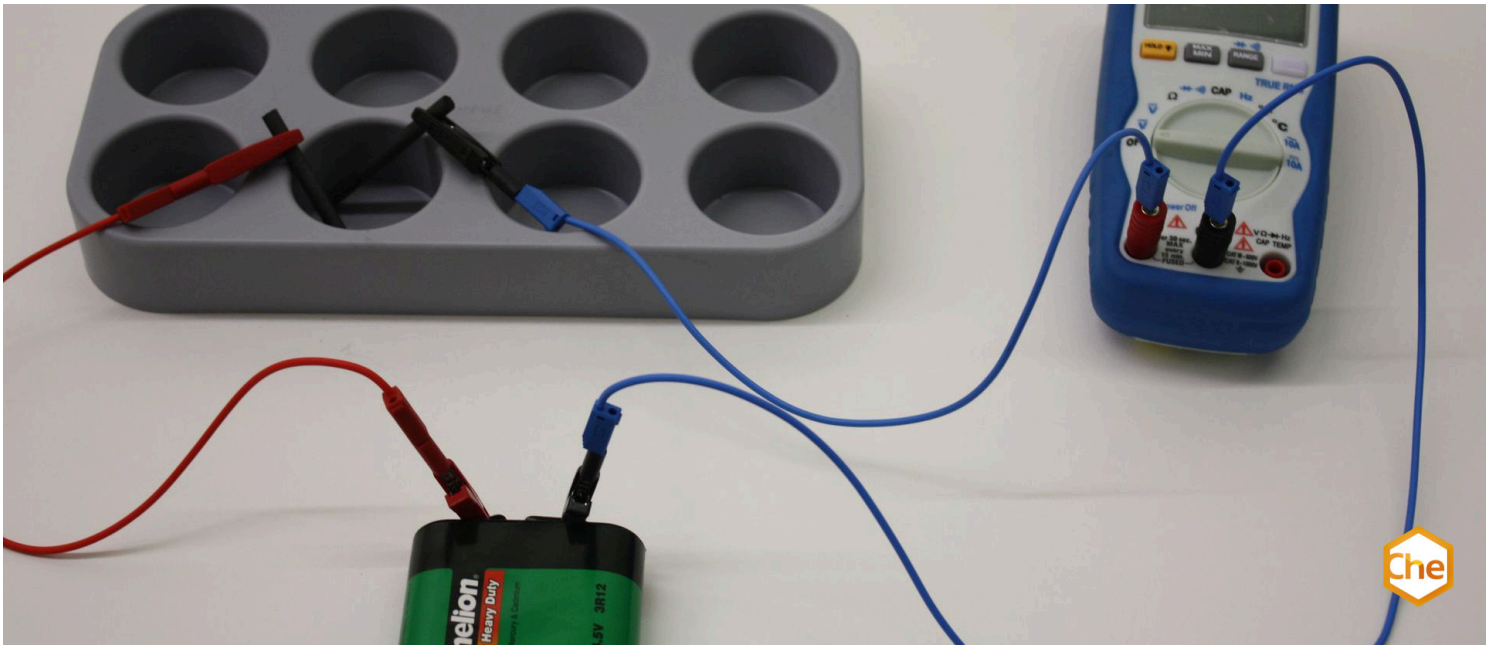
The zinc/oxygen cell



The students use this experiment to learn the functional principle of a battery with charging and discharging processes for storing electrical energy.

Chemistry > Physical chemistry > Electrochemistry > Galvanic elements, fuel cells

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

This content can also be found online at:

http://localhost:1337/c/636d3889f5a9600003a3590b

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Teacher information

Application

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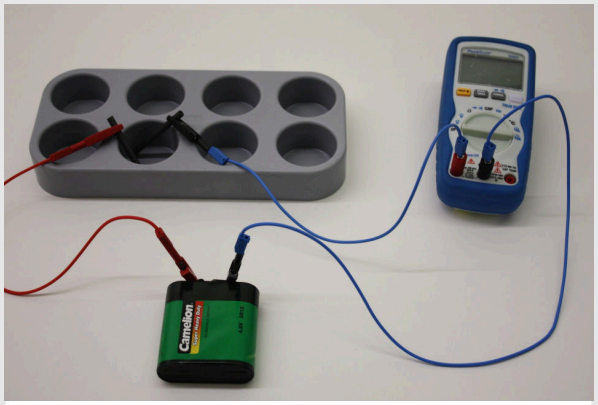

Experimental setup

Energy storage is essential in everyday life, a well-known example of which are batteries. Batteries store electrical energy based on redox reactions and are used in notebooks, cameras and many other devices. The zinc/oxygen cell, like the lead accumulator, is a rechargeable secondary battery. This means that it only becomes a galvanic element through a charging process, which can deliver current for a while and then has to be recharged. Every galvanic element has an electrolyte.

In this experiment, the electrolyte of this element is strongly alkaline, the oxidising agent during current output is oxygen. The zinc/oxygen cell is also used in engineering. The technical design allows the use of atmospheric oxygen as an oxidant.

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Other teacher information (1/2)

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Prior knowledge

Students should already know how batteries and accumulators work and how voltage is generated.

Principle

Applying a voltage leads to electron migration due to the potential difference. Dissolved zinc is reduced to elemental zinc at the cathode and hydroxide ions from the solution are oxidised to molecular oxygen and water at the anode.

If a consumer is connected into the circuit instead of a voltage source, the charged cell provides energy in the strength of the potential difference until the molecular oxygen and elemental zinc are consumed.

Other teacher information (2/2)

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Learning objective

The students learn the functional principle of a battery with charging and discharging processes for storing electrical energy by means of this experiment. The zinc/oxygen cell serves as a model of an energy storage device.

Tasks

In this experiment, a zinc/oxygen cell is set up as a model of an energy storage device. By applying a voltage, the charging process of the cell can be observed, and by connecting a consumer, the discharging process can be reproduced.

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Safety instructions

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- Wear protective goggles and gloves.
- Sodium zincate solution is highly corrosive!
- Sodium zincate mist irritates the respiratory organs, do not inhale mist.
- 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.

Disposal

Acids and bases are placed in the sink after neutralisation (pH 6 to 8), heavy metals and solutions containing heavy metals are disposed of in the canister for heavy metal waste.

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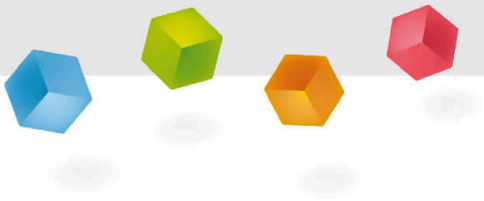

Student information

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Motivation

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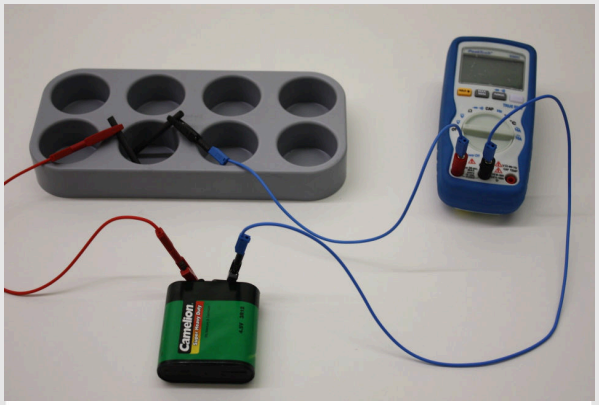

Experimental setup

Batteries are essential for everyday life. Many devices require batteries to operate and use their ability to store energy. The energy stored in a battery provides electrical power to the appliance. After a certain period of operation, the battery has discharged and the energy previously stored in the battery has been used to power the device.

The discharged battery can now be recharged by applying a voltage source, the recharged battery provides electrical energy again.

Tasks

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Build a zinc/oxygen cell as a model of an energy storage device.

By applying a voltage, the charging process of the cell can be observed; by connecting a consumer, the discharging process can be traced.

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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	2
4	Reducing plug 4mm/2mm socket, 2	11620-27	1
5	Alligator clip, insulated, 2 mm socket, 2 pcs.	07275-00	1
6	Block with 8 holes, d = 40 mm	37682-00	1
7	Graphite electrode,d=5,l=150,6pc	44510-00	1
8	Flat battery, 4.5 V	07496-01	1
9	Motor, 2 V DC	11031-00	1
10	Beaker, Borosilicate, tall form, 50 ml	46025-00	1
11	Set Strip electrode (Al, Fe, Pb, Zn, Cu)	07856-00	2
12	Sodium hydroxide, pellets, 500 g	30157-50	1
13	Zinc oxide 250 g	30248-25	1

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Set-up (1/2)

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Preparation of the sodium zincate solution

Add 7 g of zinc oxide to 250 ml of 10% sodium hydroxide solution and heat the solution to just below boiling point while stirring continuously (boiling distortion possible!).

Then let the solution cool down (excess zinc oxide will settle).

Then separate the clear solution from the residue by decanting or filtering and put it into a bottle.

Approximately 25 ml are needed per group of students.

Set-up (2/2)

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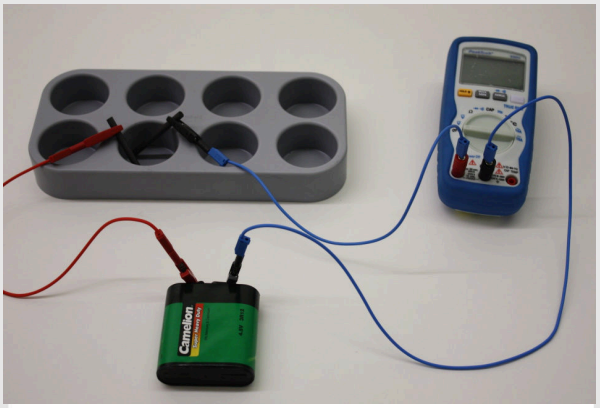
Fill a measuring cell with sodium zincate solution $Na_2[Zn(OH)_4]$.

Then set up the following circuit with electrodes, multimeter and voltage source (Fig. right).

Use 2 pieces of graphite about 40 mm long (d = 5 mm) as electrodes, which are placed in the measuring cell filled with sodium zincate solution. The electrodes should not touch each other.

The DC voltage source can be a flat battery 4.5 V. Set the measuring instrument for current measurement to the measuring range 10 A.



Set up the experiment exactly like this

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Procedure

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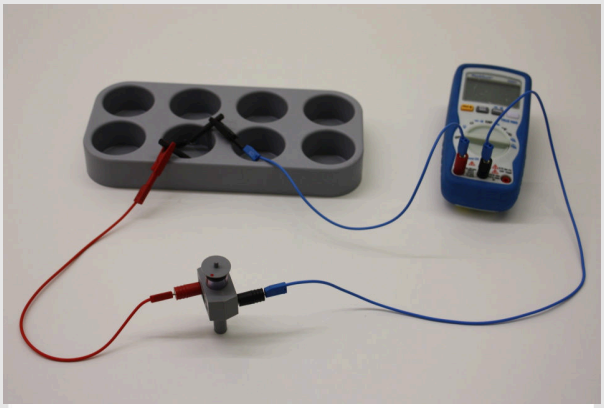
Loading the cell

As soon as the circuit is closed, the electrolysis of the sodium zincate solution between the graphite electrodes begins. First electrolyse for about 2 to 3 minutes.

Discharging the cell

After electrolysis, remove the current source from the circuit and install the small electric motor with the disc in its place (Fig. right). Observe and note down the measured current.



Install the motor in the circuit instead of the battery

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Report

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Task 1

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What happens when a voltage is applied to the zinc/oxygen cell?

- ○ Applying a voltage leads to electron migration due to the potential difference. Dissolved zinc is reduced to elemental zinc at the cathode and hydroxide ions from the solution are oxidised to molecular oxygen and water at the anode.
- ○ Applying a voltage has no effect.
- ○ The application of a voltage leads to electron fixation due to the potential difference.

Check

Task 2

PHYWE

What happens if a consumer is connected into the circuit instead of a voltage source?

- ○ The charged cell overheats and burns out.
- ○ The charged cell provides energy in the strength of the potential difference until the molecular oxygen and elemental zinc are consumed.
- ○ The charged cell provides energy in the strength of the potential difference. The amount of energy is almost unlimited.

Check

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Task 3

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Select the electrolyte from this experiment and the oxidising agent during the current delivery.

- [ ] The electrolyte in this experiment is distilled water.
- [ ] The oxidant during current delivery is oxygen.
- [ ] The electrolyte in this experiment is the prepared sodium zincate solution.
- [ ] The oxidising agent during power delivery is hydrogen.

Check

Slide	Score / Total
Slide 14: Voltage drink/oxygen cell	0/1
Slide 15: Consumer	0/1
Slide 16: Electrolyte and oxidant	0/2

Total 0 / 4

Solutions Repeat

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