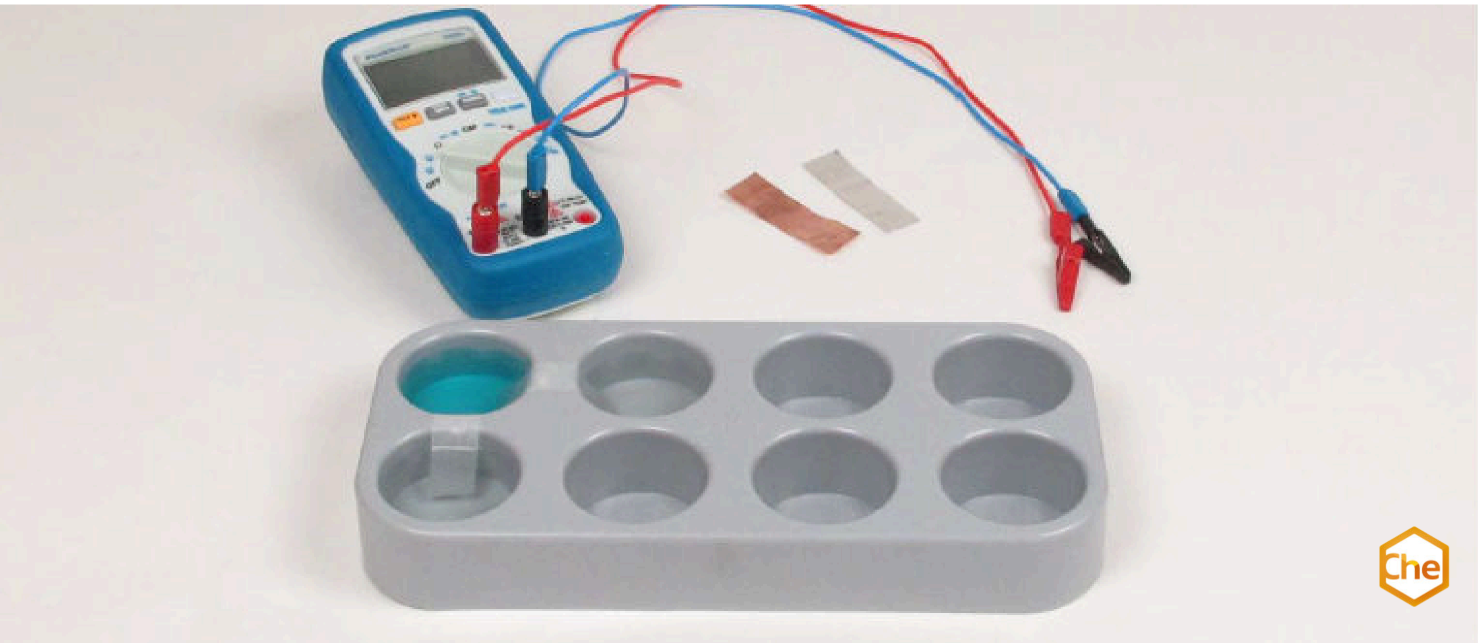
Galvanic cells with different redox couples/concentrations and the calculation oftheir potentials



Students learn how the Nernst equation can also be used to calculate galvanic cells composed of different redox pairs with different solution concentrations.

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

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

This content can also be found online at:

http://localhost:1337/c/637e16cfa17d480003fce17c

Teacher information

Application

Experimental setup

Electrical voltages can be measured not only between half-cells made of different metals in their salt solutions, but also between half-cells of the same type that differ only in the concentrations of their salt solutions.

Such pairings of identical half-cells with different salt concentrations are called "concentration chains". The measurable tension of such concentration chains is subject to a law that has found its mathematical expression in the so-called "Nernst equation".

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Other teacher information (1/5)

Prior knowledge

Students should already be able to determine standard potentials and make the required electrodes. They should also already know the Nernst equation.

Principle

The Nernst equation can also be used to calculate galvanic cells composed of different redox pairs with different solution concentrations.

Other teacher information (2/5)

Learning objective

Students learn how the Nernst equation can also be used to calculate galvanic cells composed of different redox pairs with different solution concentrations.

Tasks

Students check theoretical calculations of the Nernst equation with different redox pairs of different solution concentrations in practice.

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Other teacher information (3/5)

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Other information (1/3)

If, for example, a galvanic cell consists of a copper half-cell with a 1 molar copper sulphate solution (standard copper cell) and a silver half-cell with a 0.1 molar silver nitrate solution, the voltage results from the following relationship:

E is the potential of the silver half-cell, which forms the cathode (reduction process) in this system. E0 (Cu/Cu2+) is the standard potential of the copper half cell, i.e. +0.34 V-. The potential of the silver electrode with a solution concentration of 0.1 mol/l results from the difference of the standard potential E0 (A/Ag+) of a silver half cell and the potential of a concentration chain of silver half cells with the concentrations c1 = 1 mol/l and c2 = 0.1 mol/l according to the Nern equation.

Other teacher information (4/5)

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Other information (2/3)

Substituting this expression into the above equation gives the voltage of the galvanic cell described:

Since silver ions are monovalent, n = 1; and the logarithm of the quotient of c1 and c2 is also equal to 1 in our example.

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Other teacher information (5/5)

Other information (3/3)

Then the voltage of the described element is

If the silver ion concentration of the silver half cell were not 0.1 molar but 0.01 molar, the voltage of this element would be

Safety instructions

- Wear protective goggles.
- 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

Motivation

Experimental setup

You have already learned that we can no longer do without batteries in today's world. You can also already make different electrodes.

Up to now, the electrical voltages of two metals have been measured in the same salt concentration. However, it also works the other way round:

In this experiment you will learn that electrical voltage can also be measured between two redox pairs with different solution concentrations.

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Tasks

Check the calculations of the Nernst equation, which you will find in the preparation section.

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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	1
6	Set Strip electrode (Al, Fe, Pb, Zn, Cu)	07856-00	2
7	Beaker, Borosilicate, tall form, 50 ml	46025-00	3
8	Block with 8 holes, d = 40 mm	37682-00	1
9	Coverage f.cell-meas.bloc,8 piec.	37683-00	1
10	Silver foil, 150 x150 x 0.1 mm, 25 g	31839-04	1

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Preparation (1/4)

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Producing the required solutions

- **Silver nitrate solution (0.1 mol/l):** Add 8.49 g silver nitrate to 250 ml distilled water. Mix well and make up to 500 ml with distilled water.
- **Silver nitrate solution (0.01 mol/l):** Add 50 ml of the prepared silver nitrate solution (0.1 mol/l) to 450 ml of distilled water.
- **Copper sulphate solution (1 mol/l):** Add 79.5 g copper sulphate to 250 ml distilled water. Mix well and make up to 500 ml with distilled water.

Preparation (2/4)

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Calculations (1/3)

If, for example, a galvanic cell consists of a copper half-cell with a 1 molar copper sulphate solution (standard copper cell) and a silver half-cell with a 0.1 molar silver nitrate solution, the voltage results from the following relationship:

E is the potential of the silver half-cell, which forms the cathode (reduction process) in this system. E0 (Cu/Cu2+) is the standard potential of the copper half cell, i.e. +0.34 V-. The potential of the silver electrode with a solution concentration of 0.1 mol/l results from the difference of the standard potential E0 (A/Ag+) of a silver half cell and the potential of a concentration chain of silver half cells with the concentrations c1 = 1 mol/l and c2 = 0.1 mol/l according to the Nern equation.

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Preparation (3/4)

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Calculations (2/3)

Substituting this expression into the above equation gives the voltage of the galvanic cell described:

Since silver ions are monovalent, n = 1; and the logarithm of the quotient of c1 and c2 is also equal to 1 in our example.

Preparation (4/4)

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Calculations (3/3)

Then the voltage of the described element is

If the silver ion concentration of the silver half cell were not 0.1 molar but 0.01 molar, the voltage of this element would be

These calculations are to be verified in an experiment.

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Set-up

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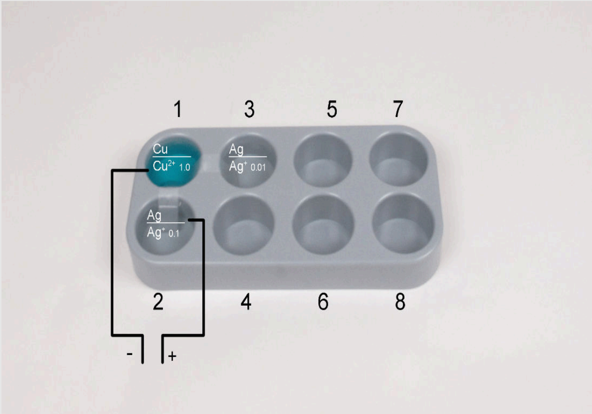
Fill measuring cell 1 with the copper sulphate solution (c = 1 mol/l), measuring cell 2 with the silver nitrate solution c = 0.1 mol/l and measuring cell 3 with the silver nitrate solution c = 0.01 mol/l. (Fig. right).

Then connect measuring cell 1 conductively to measuring cells 2 and 3 using current keys made of filter paper strips.

The current keys are not soaked with potassium nitrate solution.

Instead, let the solutions from the two measuring cells to be connected rise from the ends of the paper until they meet in the middle of the strips.



Fill the measuring cells

Procedure

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Cover the measuring cells and insert a copper electrode into the copper sulphate solution of measuring cell 1 and a silver electrode into measuring cell 2.

Connect the copper electrode as negative pole to the ground socket of the measuring instrument, the silver electrode as positive pole to the volt socket.

Measure the voltage of this galvanic cell. Then insert the silver electrode (after any drops of solution have dried up) into the measuring cell 3 with the solution concentration c = 0.01 mol/l and measure the voltage here too.

Now put the electrode connected to the ground socket (on the blue connecting lead) into the most diluted solution (measuring cell 1) and the electrode connected to the volt socket into the next lowest dilution (measuring cell 2) and measure the voltage.

Then measure the voltages between the measuring cells 2 and 3, 3 and 4, 4 and 5 in the same way. Note the measured values. Then measure the voltages between cells 1 + 3, 1 + 4 and 2 + 4.

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Report

Task 1

Can electrical voltages only be measured between two half-cells made of different metals in their salt solutions?

- [ ] No, among other things also between similar half-cells that only differ from each other in the concentrations of their salt solutions.
- [ ] Yes, this is not possible in other half-cells.
- [ ] No, but in other half cells the voltage is always exactly 1V.
- [ ] None of the answers is correct.

Check

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Task 2

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What do you call pairings of the same half-cells with different salt concentrations?

- Pairings of the same half-cells with different salt concentrations are called "concentration stresses".
- Pairings of the same half-cells with different salt concentrations are called "concentration chains".
- Pairings of the same half-cells with different salt concentrations are called "concentration pyramids".

Check

Task 3

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Select the equation that represents the silver ion concentration of the silver half cell as 0.01 molar rather than 0.1 molar.

-
- None of the equations corresponded to the question.
-

Check

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Slide	Score / Total
Slide 20: Half cell voltage	**0/2**
Slide 21: Designation	**0/1**
Slide 22: Equation	**0/1**

Total 0 / 4

Solutions Repeat

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