Galvanic cells from a series of concentrations, their potentials and how to calculate them

The students learn that electrical voltages can also be measured between two similar half-cells and how to use the Nernst equation.

Chemistry > Physical chemistry > Electrochemistry > Electrochemical voltage series

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/637e1c33a17d480003fce182

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Teacher information

Application

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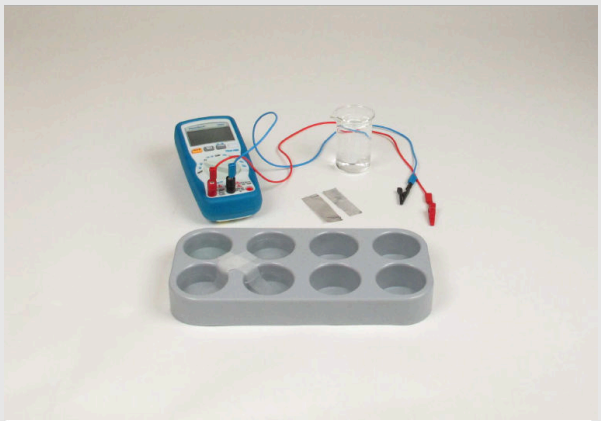

Experimental setup

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)

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Prior knowledge

Students should already be able to determine standard potentials and make the required electrodes.

Principle

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.

Other teacher information (2/5)

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Learning

Students learn that electrical voltages can also be measured between two similar half cells and how to use the Nernst equation. The term "concentration chain" is introduced.

Tasks

Silver/silver nitrate half-cells are to be produced whose silver ion concentrations differ from each other by a power of ten. The voltages between the possible combinations of these half cells are measured. Their evaluation leads to the derivation of the Nernst equation.

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Other teacher information (3/5)

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Other information (1/3)

processes at the electrodes:

Oxidation process (anode):

reduction process (cathode):

Other teacher information (4/5)

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Other information (2/3)

The table shows that the voltages or the potential differences of these concentration chains change proportionally to the logarithm of the quotient of c1 and c2, and not proportionally to the concentration.

Lösungskonzentration c (red)	Lösungskonzentration c (ox)	$\frac{c_1}{c_2}$	$\frac{log c_1}{c_2}$	gemessene Spannung V- (20 °C)
0,1	0,01	10	1	1 * 0,058
0,01	0,001	10	1	1 * 0,058
0,001	0,0001	10	1	1 * 0,058
0,1	0,001	100	2	2 * 0,058 = 0,116
0,01	0,0001	100	2	2 * 0,058 = 0,116
0,1	0,0001	1000	3	3 * 0,058 = 0,174

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Other teacher information (5/5)

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Other information (3/3)

With this, one can calculate the potential difference of concentration chains according to the equation

This relationship applies to monovalent ions, e.g. silver ions. For multivalent ions, the voltage decreases with the valence (n). It then applies

With the help of this "Nernst equation", one can calculate the potentials of concentration chains.

Safety instructions

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- 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

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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 voltages can also be measured between similar half-cells that differ only in the concentrations of their salt solutions.

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Tasks

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You are to produce silver/silver nitrate half cells whose silver ion concentrations differ from each other by a power of ten.

The voltages between the possible combinations of these half-cells are measured. Their evaluation leads to the derivation of the Nernst equation.

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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	Block with 8 holes, d = 40 mm	37682-00	1
7	Coverage f.cell-meas.bloc,8 piec.	37683-00	1
8	Silver foil, 150 x150 x 0.1 mm, 25 g	31839-04	1
9	Beaker, Borosilicate, tall form, 50 ml	46025-00	5

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Preparation

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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.
- **Silver nitrate solution (0.001 mol/l):** Add 50 ml of the prepared silver nitrate solution (0.01 mol/l) to 450 ml of distilled water.
- **Silver nitrate solution (0.0001 mol/l):** Add 50 ml of the prepared silver nitrate solution (0.001 mol/l) to 450 ml of distilled water.

Set-up (1/2)

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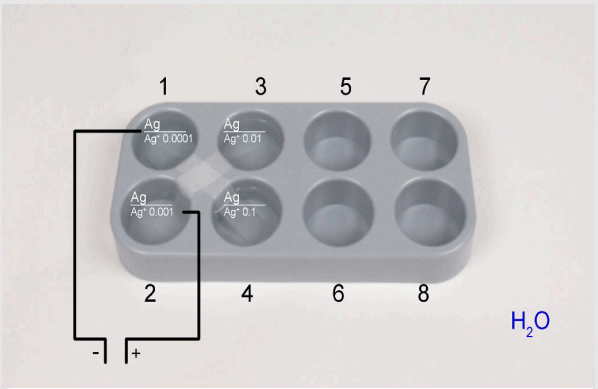
Fill the measuring cells 1 to 4 with the indicated silver nitrate solutions (fig. right).

Start with cell 1 with the concentration 0.0001 mol/l, in cell 2 place the 0.001 mol/l, in cell 3 the 0.01 mol/I and in cell 4 the 0.1 molar solution.

Then connect the 4 measuring cells with current spanners made of filter paper strips, but this time not soaked in potassium nitrate solution (fig. right).

Instead of the potassium nitrate solution, let the silver nitrate solutions from the respective measuring cells to be connected rise from the immersed paper ends into the strips until they meet in the middle.



Fill the measuring cells

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Set-up (2/2)

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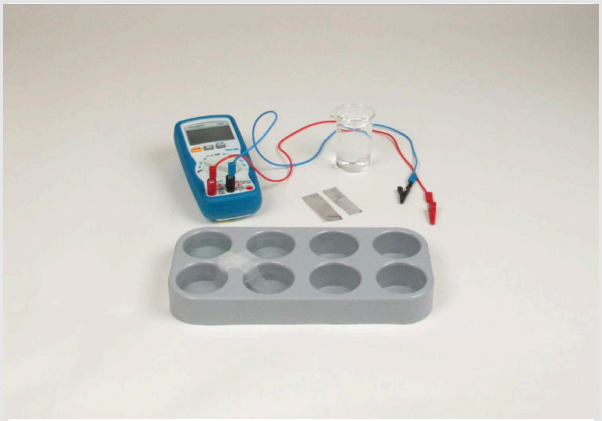
Make sure that the intersecting paper strips are close together to ensure a good current flow in all directions.

Lids do not need to be placed on the measuring cells. However, keep a beaker of pure water ready to rinse the silver electrodes in after each measurement.

Then connect a blue connecting lead to the ground socket (minus input) and a red connecting lead to the volt socket (plus input) of the measuring instrument. Fit the other ends of the connecting leads with alligator clips, which in turn hold the silver electrodes.



Experimental setup

Procedure

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Now first measure the voltages between the successive solution concentrations by dipping the electrode connected to the ground socket of the measuring instrument into the lower concentrated solution and the other electrode into the next higher concentration (it always forms the positive pole of such a concentration chain).

The voltages between the half cells 1 + 2, 2 + 3, 3 + 4 are therefore measured and noted. However, before you dip the electrodes into the next higher concentrated solutions, rinse them briefly in the beaker with pure (distilled) water (shake off the drops).

Experimentation

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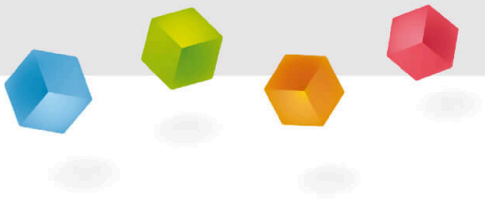

Report

Task 1

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What are the processes at the electrodes (anode, cathode)?

- ☐ (anode, oxidation)
- ☐ (cathode, reduction)
- ☐ (anode, oxidation)

Check

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Task 2

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What can be calculated with the Nernst equation?

- ○ The Nernst equation can be used to calculate current strengths of parallel circuits.
- ○ The Nernst equation can be used to calculate current strengths of series circuits.
- ○ The Nernst equation can be used to calculate potential differences of redox pairs.
- ○ The Nernst equation can be used to calculate potential differences of concentration chains.

Check

Task 3

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Select the Nernst equation.

- ○
- ○
- ○

Check

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Slide	Score / Total
Slide 18: Reaction equation anode	0/2
Slide 19: Nernst equation	0/1
Slide 20: Nernst equation 2	0/1

Total 0 / 4

Solutions Repeat

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