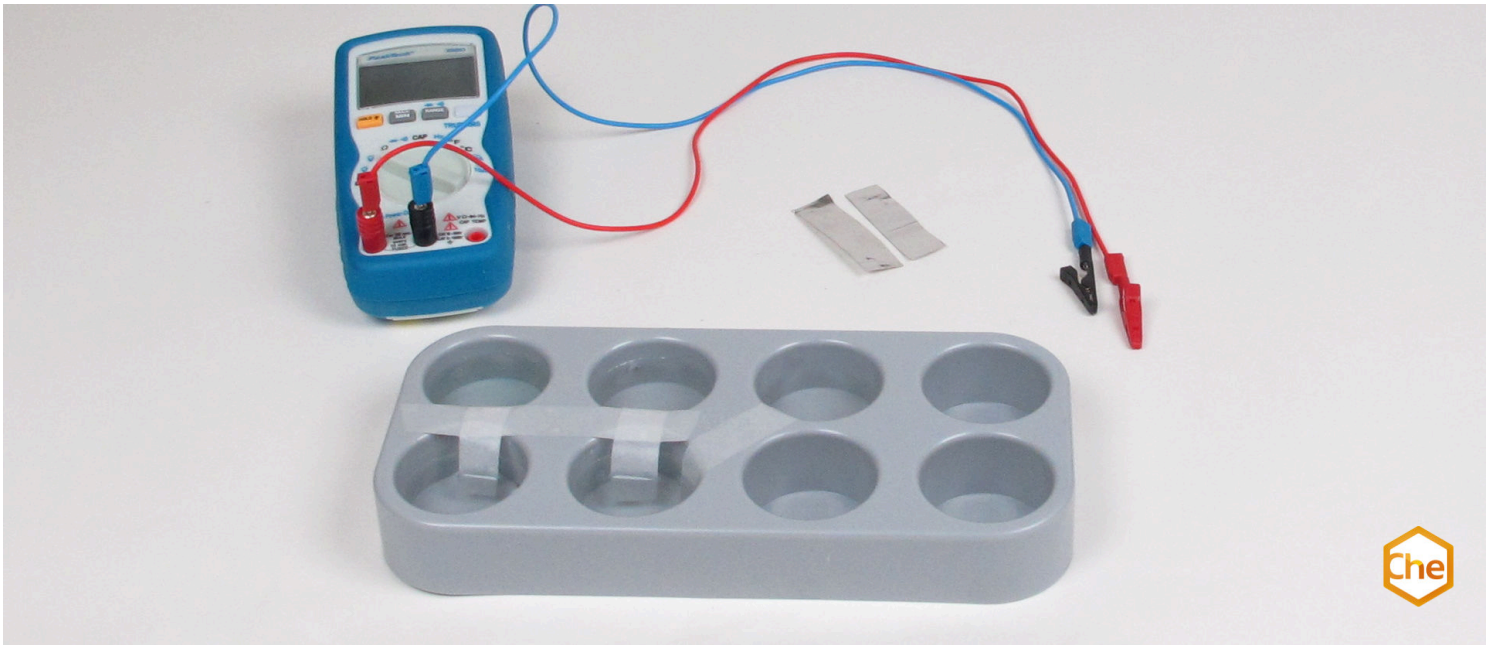
Setting up a concentration series with potassium chloride solutions and silver/silver chloride electrodes



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/637e186dc97a9800034c2f28

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Teacher information

Application

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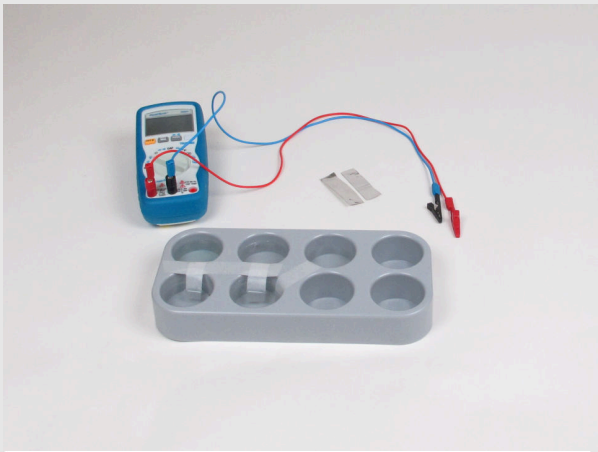

Experimental setup

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 voltage of such concentration chains is subject to a law that has found its mathematical expression in the so-called "Nernst equation".

Concentration chains from potassium chloride solutions and silver/silver chloride electrodes confirm the result of the previous experiment with silver nitrate solutions.

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Other teacher information (1/2)

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Prior knowledge

The students should already be able to determine standard potentials and make the required electrodes. They should also know what concentration chains are.

Principle

Concentration chains of potassium chloride solutions and silver/silver chloride electrodes confirm the result of the previous experiment (P7401300) with silver nitrate solutions. If silver nitrate is not available for a practical student exercise due to its high price, the Nernst equation can also be introduced using the experiment described here. Experience shows that the achievable measured values are not quite as reproducible as with concentration chains from silver nitrate solutions, but they are sufficient for school experiments.

Other teacher information (2/2)

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Learning objective

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

Concentration chains of potassium chloride solutions are to be constructed and their voltages measured. 2 silver/silver chloride electrodes are to be used as electrodes.

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Safety instructions

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- During the experiment, all persons in the room must wear protective goggles!
- Wear protective gloves.
- Potassium chloride solutions of concentration c = 1.0 mol/l have an irritant effect.
- 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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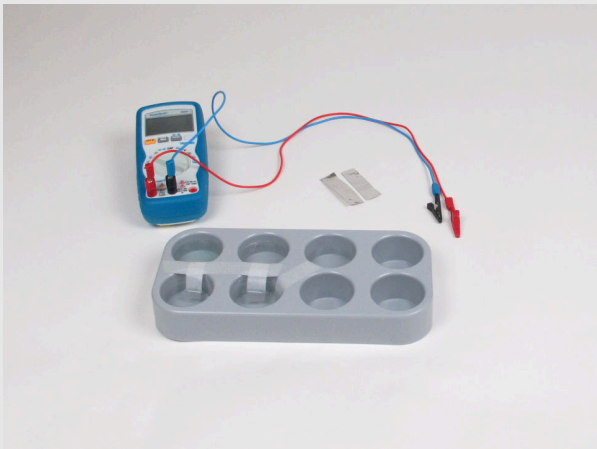

Experimental setup

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

In this experiment you will learn how to build a concentration chain. You make two half cells of the same type and measure the electrical voltage between them. The concentrations of the salt solutions differ.

Tasks

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You are to build up concentration chains from potassium chloride solutions and measure their voltage.

2 silver/silver chloride electrodes are to be used as electrodes.

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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	Silver foil, 150 x150 x 0.1 mm, 25 g	31839-04	1
8	Beaker, Borosilicate, tall form, 50 ml	46025-00	5
9	Bottle,wide neck,plastic,50ml	33912-00	1

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Preparation

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Producing the required solutions

- **Potassium chloride solution (1 mol/l):** Add 37.3 g potassium chloride to 250 ml distilled water. Mix well and make up to 500 ml with distilled water.
- **Potassium chloride solution (0.1 mol/l):** Add 50 ml of the potassium chloride solution (1 mol/l) to 450 ml of distilled water.
- **Potassium chloride solution (0.01 mol/l):** Add 50 ml of the potassium chloride solution (0.1 mol/l) to 450 ml of distilled water.
- **Potassium chloride solution (0.001 mol/l):** Add 50 ml of the potassium chloride solution (0.01 mol/l) to 450 ml of distilled water.

Set-up (1/2)

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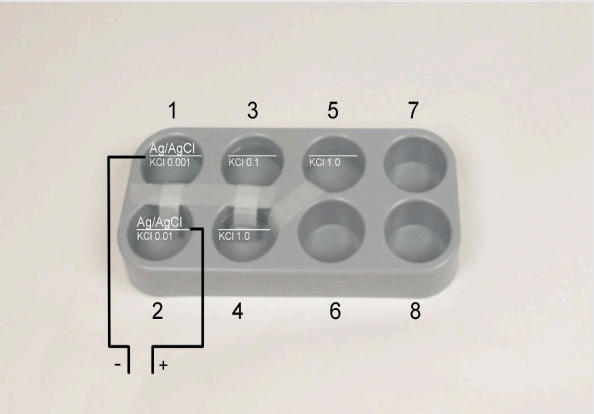
Distribute the potassium chloride solutions into the corresponding measuring cells (Fig. right).

Start with the strongest dilution (c = 0.001 mol/l) in measuring cell 1, and fill measuring cells 4 and 5 with 1 molar solution each.

All 5 filled measuring cells are conductively connected to each other with current keys according to the illustration.

However, the paper strips are not soaked with potassium nitrate solution.



Fill the measuring cells

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Set-up (2/2)

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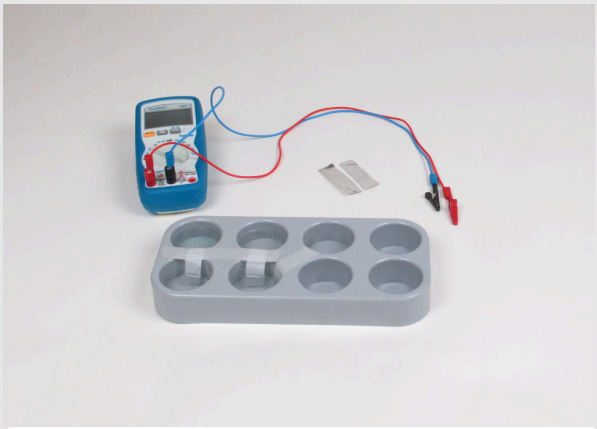
Instead, allow the solutions from the measuring cells to be drawn into the paper strips from the ends until they meet approximately in the middle.

You can also add a few drops of 1 molar potassium chloride solution to the longitudinal strip so that it is also completely saturated.

Then connect the ground socket of the measuring instrument with a blue connecting lead (via a reducing plug) and the volt socket with a red connecting lead (positive pole). Attach alligator clips to the free ends of the connecting leads and grasp one silver/silver chloride electrode each above the grey chloride coating.



Experimental setup

Procedure

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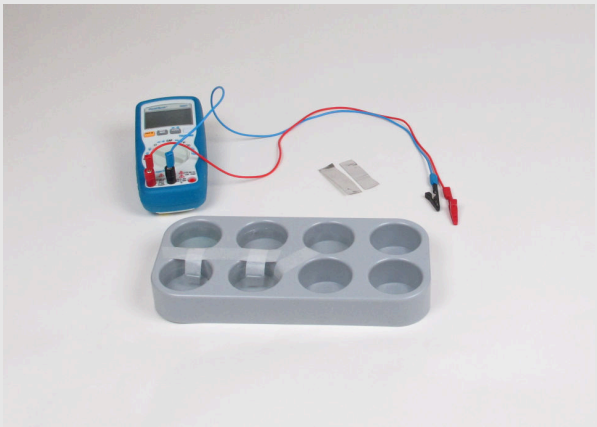
Now put the electrode connected to the ground socket (on the blue connecting lead) into the most diluted solution (measuring cell 1) and the electrode connected to the volt socket into the next lowest dilution (measuring cell 2) and measure the voltage.

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.

The silver/silver chloride electrodes give the best readings if they have been kept in 0.1 molar potassium chloride solution for a few days.



Experimentation

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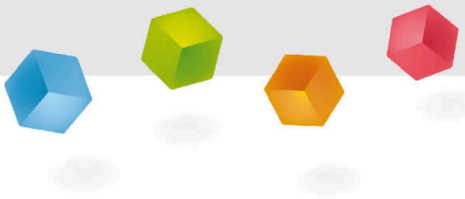

Report

Task 1

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Why is no voltage measured in cells 4 and 5?

- [ ] It was not measured correctly. Actually, a voltage should be measured.
- [ ] Because both solutions have the same concentration.
- [ ] None of the answers is correct.
- [ ] Because both contain potassium chloride solution.

Check

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Task 2

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When do silver/silver chloride electrodes give the best readings?

- ○ The silver/silver chloride electrodes give the best readings if they have been kept in 0.1 molar potassium chloride solution for a few days.
- ○ The silver/silver chloride electrodes give the best readings if they have already been in the fresh air for a few weeks.
- ○ The silver/silver chloride electrodes give the best readings when they are freshly made.

Check

Task 3

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Why is potassium chloride used instead of silver/silver chloride in this experiment and what effect does this have?

- ○ Because potassium nitrate gives much more accurate and reproducible values than silver nitrate. The values measured here are therefore very exact.
- ○ Silver nitrate is very expensive and is therefore replaced here by potassium chloride. As a result, the achievable measured values are not quite as reproducible as with concentration chains made from silver nitrate solutions.

Check

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Slide	Score / Total
Slide 15: No voltage	0/2
Slide 16: Best measured values	0/1
Slide 17: Potassium chloride	0/1

Total 0 / 4

Solutions Repeat

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