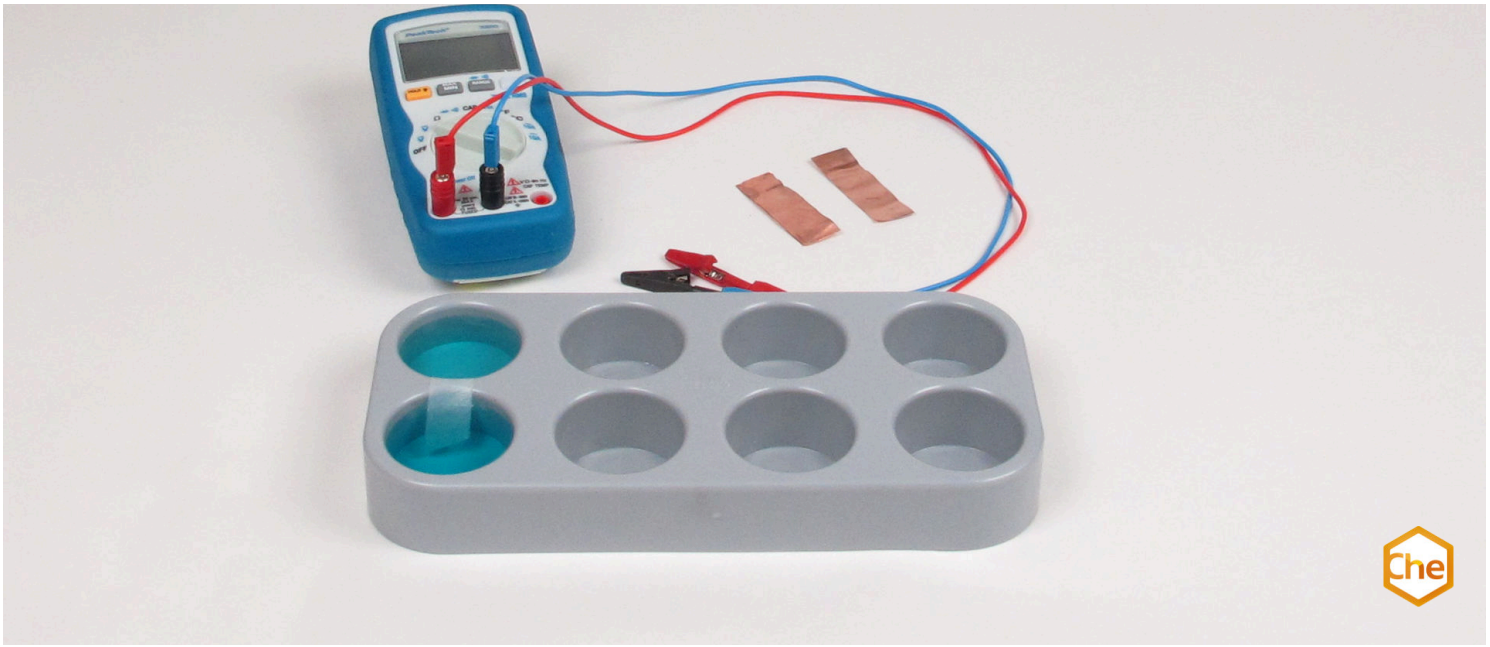
Changes in the voltage of a concentration seriesdue to precipitation or binding



The students should learn what the consequences are of changing the tension of a concentration chain by e.g. precipitation.

Chemistry > Physical chemistry > Electrochemistry > Electrochemical voltage series

Chemistry > Analytical Chemistry > Simple qualitative verifications

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/637e148fa17d480003fce171

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Teacher information

Application

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Experimental setup

In concentration chains, the voltage is higher the more the concentrations of the solutions in the half cells differ from each other. No voltage can be measured on a concentration chain consisting of two absolutely identical half cells, e.g. copper electrodes in 0.1 molar copper sulphate solution.

However, if ions are added to the solution of one of the half-cells that form a poorly soluble compound with the effective metal ion of the solution (e.g. Cu2+) (e.g. iodide ions, which sometimes react to form poorly soluble copper(I) iodide), some of the metal ions precipitate. The result is the formation of a more or less large difference in concentration between the two solutions of the half-cells, which increases the voltage of the concentration chain.

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Other teacher information (1/4)

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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 the term "concentration chain".

Principle

In concentration chains, the voltage is higher the further the concentrations of the solutions in the half cells deviate from each other.

Other teacher information (2/4)

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Learning objective

The students should learn what the consequences are of changing the voltage of a concentration chain by e.g. precipitation.

Tasks

A galvanic cell is to be constructed from identical copper half-cells. After connecting a volt-meter, concentrated ammonia solution is to be dripped into the copper solution of one of the half-cells until the measurable voltage has reached a certain maximum value.

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Other teacher information (3/4)

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Other information (1/3)

In concentration chains, the voltage is higher the more the concentrations of the solutions in the half cells differ from each other. No voltage can be measured on a concentration chain consisting of two absolutely identical half cells, e.g. copper electrodes in 0.1 molar copper sulphate solution. However, if ions are added to the solution of one of the half-cells that form a poorly soluble compound with the effective metal ion of the solution (e.g. Cu2+) (e.g. iodide ions that react with Cu2+ to form poorly soluble copper(I) iodide), some of the metal ions precipitate.

The result is the formation of a more or less large concentration difference between the two solutions of the half cells, which increases the voltage of the concentration chain. Even if a complexing agent is added to one of the solutions of a concentration chain (e.g. NH3 to Cu2+), the effective ion concentration is reduced as a result of the complex formation. This also has the effect of increasing the voltage.

By adding ammonia to the copper sulphate solution, the deep blue copper tetramine complex is formed according to the equation;

Other teacher information (4/4)

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Other information (2/2)

in which the active copper ion is bound. This causes the copper ions to drop out to form a potential, which is equivalent to a reduction in concentration. As the copper ions decrease, the voltage increases. At a little more than 400 mV, a state of equilibrium of complex formation is reached, so that the copper ion concentration can no longer be reduced despite further addition of ammonia. The voltage change in concentration chains per power of ten is known to have a value of (0.058/n) V (20 °C).

0.420 : 0.029 = 14048 since the copper ion concentration was reduced by about 14 powers of ten in the experiment.

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Safety instructions

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- Wear protective goggles and gloves.
- Concentrated ammonia solution has a corrosive effect, pungent smelling vapours rise from the solution.
- 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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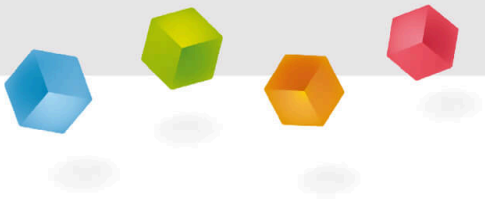

Student information

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Motivation

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Experimental setup

By now you know what happens when you make concentration chains with metals where the concentrations of the solutions are different. But what about when the concentrations of the solutions differ further?

In concentration chains, the voltage is higher the more the concentrations of the solutions in the half cells differ from each other. No voltage can be measured on a concentration chain consisting of two absolutely identical half cells, e.g. copper electrodes in 0.1 molar copper sulphate solution.

Tasks

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Build a galvanic cell from identical copper half-cells.

After connecting a volt-meter, concentrated ammonia solution is to be dripped to the copper solution of one of the half-cells until the measurable voltage has reached a certain maximum value.

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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	Block with 8 holes, d = 40 mm	37682-00	1
8	Coverage f.cell-meas.bloc,8 piec.	37683-00	1
9	Beaker, Borosilicate, tall form, 50 ml	46025-00	2
10	Pipette with rubber bulb	64701-00	1

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Set-up

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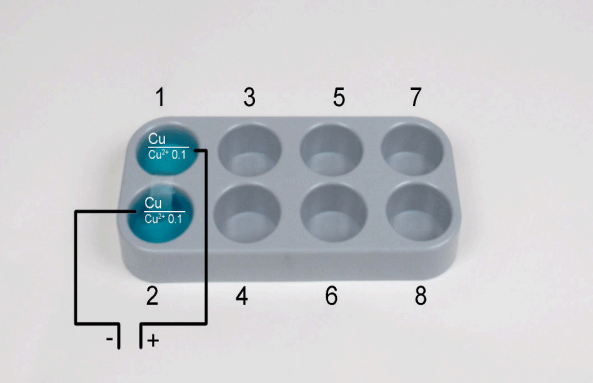
Copper sulphate solution (0.1 mol/l): Add 7.95 g copper sulphate to 250 ml distilled water. Mix well and make up to 500 ml with distilled water.

Fill the measuring cells 1 and 2 with 0.1 molar copper sulphate solution (fig. right).

Then connect both measuring cells conductively with a current key made of a filter paper strip that is also soaked with 0.1 molar copper sulphate solution (simply let the solutions rise from the ends of the paper until they meet in the middle of the paper strip).

Place a lid on the measuring cell 1. Measuring cell 2, on the other hand, remains open.



Fill the measuring cells

Procedure

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Now connect two copper electrodes to the measuring instrument (set the measuring range to 2 V-) and insert the electrode connected to the volt socket (= positive pole connection) into measuring cell 1, the other electrode into measuring cell 2 (fig. "Experiment set-up" on slide "Motivation").

Measure the voltage.

Now slowly drop concentrated ammonia solution (25%) into the copper sulphate solution in cell 2 using a dropping pipette and stir a little with the electrode.

Add ammonia until the voltage no longer changes. The deep blue copper tetramine complex forms immediately in the copper sulphate solution.

The voltage continues to rise after each drop of ammonia. Finally, it reaches its highest value at just over 400 mV, which is practically unchanged by further addition of ammonia.

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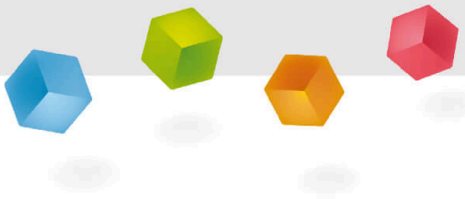

Report

Task 1

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What happens when ammonia is added to the copper sulphate solution?

- ○ As a result of the complex formation, the ion concentration is increased, which increases the voltage. The colour changes to a deep blue.
- ○ As a result of the complex formation, the ion concentration is reduced, which increases the voltage. The colour changes to a deep blue.
- ○ As a result of the complex formation, the ion concentration is reduced, which lowers the voltage. The colour changes to a deep blue.

Check

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Task 2

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Select the equation for copper tetramine complexation.

- ○
- ○
- ○

Check

Task 3

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What voltage could be measured before the addition of ammonia solution?

- ○ An increased voltage can be measured on a concentration chain consisting of two absolutely identical half cells. Thus, a high voltage of 12V was measured before the addition of ammonia solution.
- ○ The same voltage can be measured on a concentration chain of two absolutely identical half cells as after the addition of ammonia solution.
- ○ No voltage can be measured on a concentration chain consisting of two absolutely identical half cells. Thus, no voltage was measured before the addition of ammonia solution.

Check

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Slide	Score / Total
Slide 15: Ammonia to copper	0/1
Slide 16: Copper tetramine	0/1
Slide 17: Ammonia solution	0/1

Total 0 / 3

Solutions Repeat

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