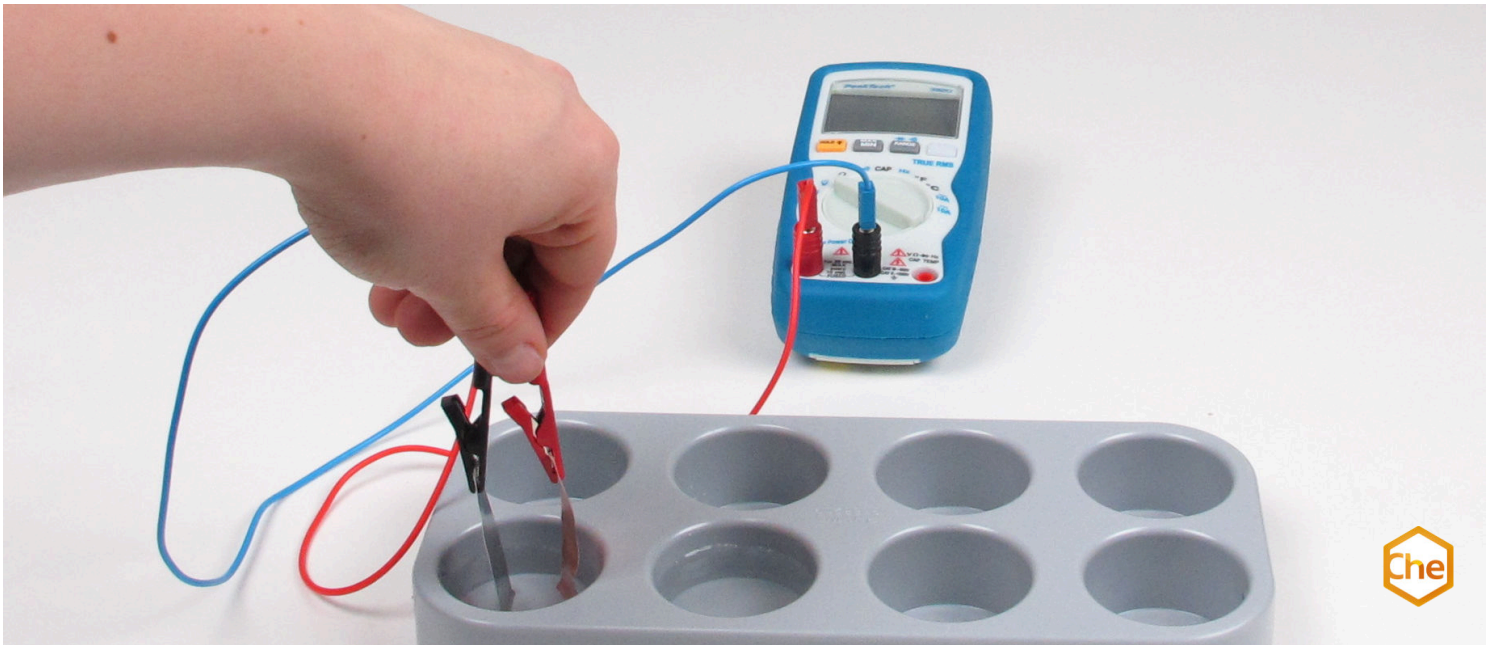
Solution pressure



The students learn electrochemical terms, especially the term "solution pressure". With the help of the solution pressure, the understanding of voltage is to be deepened.

Chemistry > Physical chemistry > Electrochemistry > Electrochemical measurement set

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

This content can also be found online at:

http://localhost:1337/c/63499d000379bd0003f78987

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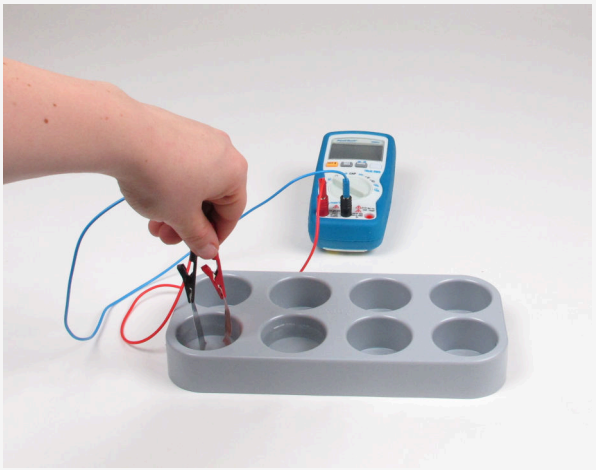
Teacher information

Application



Experimental setup

If you immerse two different metals, e.g. copper and zinc, in a suitable liquid, you can also detect an electrical voltage between these metals. This is based on the different solution pressure of different metals.

Solution pressure is the effort of metals to form ions in aqueous solution and thus fulfil the noble gas configuration. For example, if a metal is in water, the solution pressure causes metal ions to go into the solution and the metal becomes negatively charged.

Basically, the less noble a metal is, the greater its solution pressure. This explains, among other things, the different reactivity of noble and base metals with metal ions.

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Other teacher information (1/4)

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Prior knowledge

The students should have already learnt the theory of solution pressure. They should also have a basic understanding of electrical voltage.

Principle

The metals zinc and copper have a certain tendency to dissolve in water while releasing electrons. This tendency can be described as "solution pressure". During dissolution, metal atoms from the surfaces of the metal sheets pass into the ionic state.

Other teacher information (2/4)

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Learning objective

Students should learn more electrochemical terms, especially the term "solution pressure". Solution pressure will be used to deepen the understanding of voltage (and how it is generated).

Tasks

The students are to detect an electrical voltage in distilled water between a copper and a zinc sheet.

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Other teacher information (3/4)

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Other information (1/2)

The resulting ions diffuse into the water, the electrons remain on the plates and charge them negatively. Each metal has a characteristic solution pressure; the rule of thumb here is: the more noble a metal, the fewer ions go into solution and the lower the solution pressure. The development of an electrical voltage between the two electrodes now indicates that the less noble metal, in this case zinc, has a greater tendency to dissolve than the more noble copper. Consequently, more zinc ions dissolve and more electrons accumulate on the zinc sheet.

Only then does an electrical voltage develop, with the zinc representing the negative pole and the copper the positive pole. Due to the conditions of the experiment, no electron flow can take place because of the high internal resistance of the measuring instrument, so that the electrons remain on the electrodes. The greater the electron density on the plates, the more it counteracts the transition of the metal atoms into the ionic state, whereupon the dissolution process finally stops and equilibrium is reached.

Other teacher information (4/4)

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Other information (2/2)

Since the negatively charged electrode sheets exert an attractive force on the positively charged metal ions, they cannot diffuse into the water unhindered. Instead, these ions collect around the electrodes and form a positively charged ion layer there, which is called the Helmholtz layer. If the electrons of the zinc electrode were allowed to flow to the copper electrode, for example through a wire connection without significant resistance, the zinc would gradually dissolve completely (these processes are described in more detail in the experiments on corrosion).

During dissolution, metal atoms from the surfaces of the metal sheets pass into the ionic state.

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Safety instructions

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- During the experiment, all people in the room must wear protective goggles!
- The general instructions for safe experimentation in science lessons apply to this experiment.
- For the H and P phrases, please refer to the corresponding safety data sheets.
- **Copper sulphate solution (1 mol/l):** Add 15.9 g copper sulphate to 250 ml distilled water. Mix well and make up to 500 ml with distilled water.This experiment serves a qualitative proof, therefore the exact concentration is of no importance for the experiment (=> proof of deposition of copper on certain base metals).

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Student information

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Motivation

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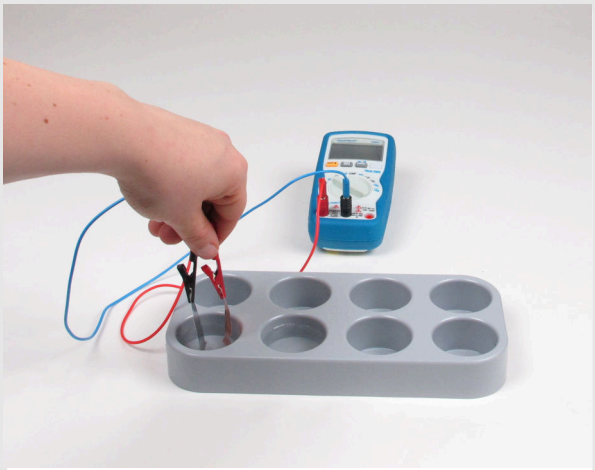

Experimental setup

If you immerse two different metals, e.g. copper and zinc, in a suitable liquid, you can also detect an electrical voltage between these metals.

The solution pressure is the effort of metals to form ions in aqueous solution and thus fulfil the noble gas configuration.

If one now holds different metals (e.g. iron or zinc) in a metal salt solution, the different reaction behaviour of base and noble metals becomes observable. If the metal is less noble than the metal ions (of the solution), elementary metal (from the solution) is deposited on the less noble metal.

Tasks

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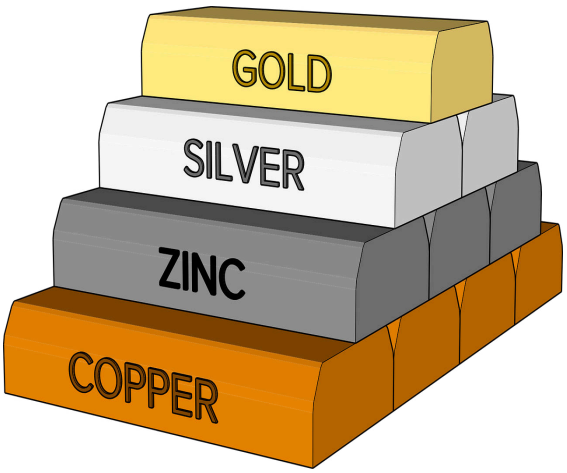

If you dip two electrodes made of different metals, e.g. copper and zinc, into pure, distilled water, you can also detect an electrical voltage between these metals.

Carry out such an experiment and answer the questions in the report.

Investigate holding different metals in a metal salt solution and answer the questions in the report.

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Equipment

Position	Material	Item No.	Quantity
1	Copper-II sulphate,cryst. 250 g	30126-25	1
2	PHYWE Digital multimeter, 600V AC/DC, 10A AC/DC, 20 MΩ, 200 µF, 20 kHz, −20°C…760°C	07122-00	1
3	Connecting cord, 2 mm-plug, 5A, 500 mm, red	07356-01	1
4	Connecting cord, 2 mm-plug, 5A, 500 mm, blue	07356-04	1
5	Reducing plug 4mm/2mm socket, 2	11620-27	1
6	Alligator clip, insulated, 2 mm socket, 2 pcs.	07275-00	1
7	Set Strip electrode (Al, Fe, Pb, Zn, Cu)	07856-00	2
8	Beaker, Borosilicate, tall form, 50 ml	46025-00	1
9	Block with 8 holes, d = 40 mm	37682-00	1

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Set-up

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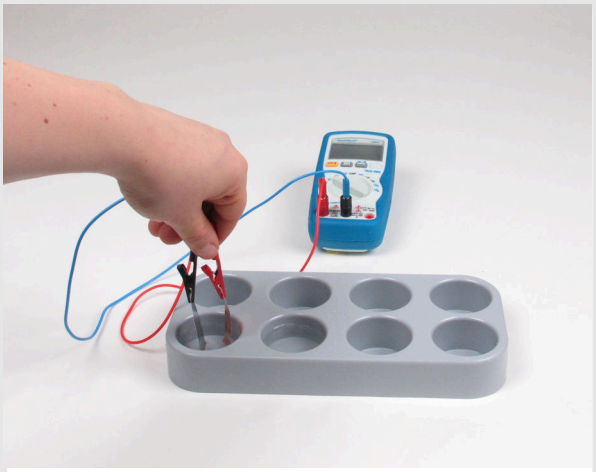


Experimental setup

Take a block of measuring cells and one zinc and one copper sheet each. Set up the experiment as shown on the left.

Fill one measuring cell of the measuring cell block with pure, distilled water.

Connect a zinc electrode (zinc sheet measuring 15 mm x 40 mm) to the ground socket and a copper electrode (measuring 15 mm x 40 mm) to the volt socket of the measuring instrument.

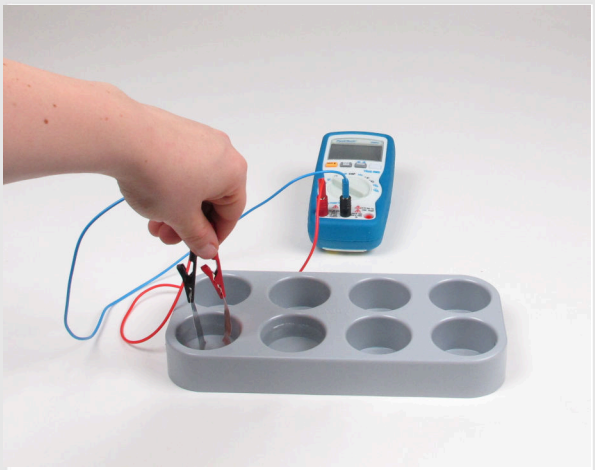
Procedure (1/2)

PHYWE

Set the measuring instrument to the measuring range 2 V DC and then insert both electrodes into the distilled water as shown in the illustration of the experimental setup on the "Motivation" slide.

The electrodes may **not** touch each other!

Do not touch the electrodes directly with your fingers during measurement, as contact with human skin can lead to measurement errors. The electrodes are therefore only held by means of the insulated alligator clips.



Experimentation

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Procedure (2/2)

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Now take the measuring cell block and a copper sulphate solution. Fill one cell block halfway with the copper sulphate solution.

Put the silver electrode in one cell block and a copper, zinc or iron electrode in the other measuring cell block.

The electrodes may **not** touch each other!

Observe the two electrodes and examine at which electrode copper is deposited.

Experimentation

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Report

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Task 1

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What is solution pressure?

- ○ The pressure that occurs when the metals zinc and copper are immersed in a sealed container of water.
- ○ Solution pressure refers to the pressure one feels when a solution to a particularly difficult problem is to be found.
- ○ The tendency of the metals zinc and copper to dissolve in water while releasing electrons.
- ○ None of the answers is correct.

Check

Task 2

PHYWE

Which metal has a higher solution pressure and what exactly does that mean?

- ☐ The "less noble" a metal is, the fewer ions go into solution and the lower the solution pressure.
- ☐ The more "noble" a metal is, the fewer ions go into solution and the lower the solution pressure.
- ☐ In this experiment, zinc is the "base" metal and is a higher metal and therefore has a higher solution pressure.
- ☐ In this experiment, zinc is the "nobler" metal and accordingly has a higher solution pressure.

Check

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Task 3

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How could one find out in a simple experiment which of the two metals is more noble?

- ○ This cannot be proven with a simple experiment.
- ○ You could see which of the two metals is more oxidised after some time in the water and has to be wiped off with an emery cloth. More ions collect here, so it is the "nobler" metal.
- ○ You could see which of the two metals is more oxidised after some time in the water and has to be wiped off with an emery cloth. More ions collect here, so it is the "less noble" metal.

Check

Task 4

PHYWE

What can be said about the reaction behaviour of the metals in the copper sulphate solution?

- ☐ Iron or zinc are more noble metals than copper. Therefore, they react with the copper salt solution to form elemental copper.
- ☐ Elemental copper is deposited in a copper salt solution on all metals that are less noble than copper.
- ☐ Silver is more noble than copper, so elemental copper does not deposit on metallic silver in a copper salt solution.

Check

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Slide	Score / Total
Slide 16: Solution pressure	0/1
Slide 17: Higher solution pressure	0/2
Slide 18: Attempt noble or ignoble	0/1
Slide 19: Reaction behaviour of noble metals	0/2

Total 0 / 6

Solutions Repeat

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