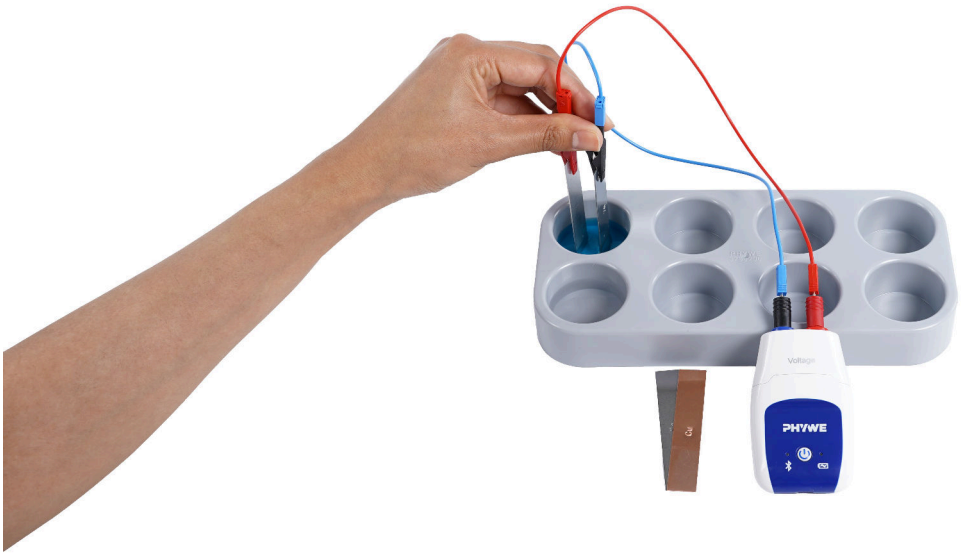
Solution pressure - reactivity of precious and base metals with Cobra SMARTsense



Pupils learn electrochemical terms, in particular the term "solution pressure". Solution pressure is used to deepen understanding of voltage.

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:

https://www.curriculab.de/c/68a8624a9513200002a5d96b

PHYWE
Robert-Bosch-Breite 10
37079 Göttingen
Tel.: 0551 604 - 0
Fax: 0551 604 - 107
info@phywe.de
www.phywe.de

PHYWE

Teacher information

Application

PHYWE

If two different metals, e.g. copper and zinc, are immersed in a suitable liquid, an electrical voltage can be detected between these metals. This is based on the different **Solution pressure** of the different metals.

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

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.

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Application

PHYWE

The different **Solution pressure** of different metals is used in batteries to convert chemical energy into electrical energy.

The concept also plays an important role in predicting chemical reactions using the electrochemical voltage series. One application is the **Corrosion protection:** In order to prevent rusting of a metal to be protected, a **Sacrificial anode** made of a base metal can be connected to it in an electrically conductive manner.

Other teacher information (1/6)

PHYWE

Prior knowledge

The students should have already dealt with solution pressure in theory. They should also have a basic understanding of electrical voltage.

Principle

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

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Other teacher information (2/6)

PHYWE

Learning objective

The students should learn further electrochemical terms, in particular the term "solution pressure". With its help, different metals can be categorised according to their reactivity (oxidisability). The solution pressure enables a better understanding of electrical voltage and its formation.

Tasks

Pupils are asked to detect an electrical voltage in distilled water and in copper sulphate solution between different metal sheets (copper, zinc, silver).

Other teacher information (3/6)

PHYWE

If two different metals are immersed in a conductive solution, **diffuse** metal ions into the water, while the electrons remain on the metal surfaces and these **negative** charge. As every metal has a **specific solution pressure** Depending on the nobility of the metal, there will be varying degrees of ion transfer (dissolution process). The rule of thumb is: the more noble a metal is, the fewer ions go into solution and the lower its solution pressure.

The measurable electrical voltage between the two electrodes shows that the less noble metal - in this case zinc - has a greater tendency to dissolve than the more noble copper. As a result, more zinc ions dissolve in the solution and correspondingly more electrons remain on the zinc sheet.

Zinc acts here as **Negative pole**, **Copper** as **Positive pole**. However, due to the lack of ions in distilled water, there is no current flow; the electrons remain on the plates. With increasing **Electron density** on the metals, the transfer of further metal atoms into solution is increasingly inhibited until a **Balance** and the dissolving process stops.

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Other teacher information (4/6)

PHYWE

In the copper sulphate solution, however, sufficient copper ions are present for a redox reaction to take place. Base metals such as zinc or iron give off electrons, copper ions absorb them and deposit as elemental copper on the more noble electrode (silver). This closes the circuit and enables a flow of electrons.

Other teacher information (5/6)

PHYWE

As the negatively charged electrode plates attract positively charged metal ions, these cannot diffuse unhindered into the solution. Instead, they collect on the electrode surface and form a so-called **Helmholtz layer** - a positively charged ion layer.

If the flow of electrons from the zinc electrode to the copper electrode were enabled, for example by a wire connection without significant resistance, the zinc sheet would gradually dissolve completely (these processes are described in more detail in the experiments on corrosion).

During dissolution, metal atoms from the surface go into solution by releasing electrons and passing into the liquid as positively charged ions:

$\mathrm{Zn} \rightarrow \mathrm{Zn}^{2+} + 2\mathrm{e}^{-}$ and $\mathrm{Cu}^{2+} + 2\mathrm{e}^{-} \rightarrow \mathrm{Cu}$

PHYWE
Robert-Bosch-Breite 10
37079 Göttingen
Tel.: 0551 604 - 0
Fax: 0551 604 - 107
info@phywe.de
www.phywe.de

Other teacher information (6/6)

PHYWE

The solution can be made for everyone to save chemicals!

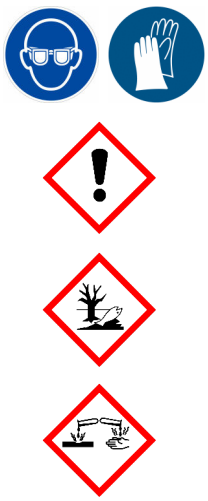
- **Copper sulphate solution** $(1\,\mathrm{mol/l})$: $124.9\,\mathrm{g}$ Copper sulphate to $250\,\mathrm{ml}$ of distilled water. Mix well and pour onto $500\,\mathrm{ml}$ fill up with distilled water.

This experiment is for qualitative detection, so the exact concentration is not important for the experiment. The aim is to find out which metal is more noble by observing whether copper is deposited or not.

When using this approach variable, a $600\,\mathrm{ml}$ beaker can be used. You can find this in the PHYWE webshop.

Safety instructions

PHYWE



- The general instructions for safe experimentation in science lessons apply to this experiment.
- All persons in the room must wear safety goggles during the experiment!
- Please refer to the corresponding safety data sheets for the H and P phrases.

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

PHYWE

Student information

Motivation

PHYWE

If two different metals, such as copper and zinc, are immersed in a conductive liquid, an electrical voltage is created between them. If the liquid does not contain any ions (it is non-conductive), no current can flow.

The basis for this is the so-called **Solution pressure** - the endeavour of metal atoms to release electrons and go into solution as positively charged ions in order to **Noble gas configuration** to fulfil. If a less noble metal such as zinc or iron is held in a solution with ions of a more noble metal, such as copper ions, elemental copper is deposited on the less noble metal.

This principle forms a central basis for electrochemical cells, batteries and corrosion protection.

PHYWE

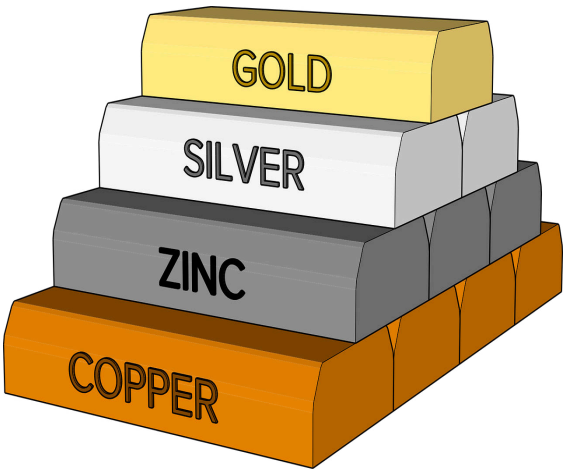
Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Tasks

PHYWE



1. Immerse two electrodes made of different metals, e.g. copper and zinc, in pure, distilled water and measure the resulting voltage.
2. Hold various metals in a copper sulphate solution and observe the reactions.
3. How can you recognise which metal is more precious and which is less precious?

PHYWE
Robert-Bosch-Breite 10
37079 Göttingen
Tel.: 0551 604 - 0
Fax: 0551 604 - 107
info@phywe.de
www.phywe.de

Equipment

Position	Material	Item No.	Quantity
1	Cobra SMARTsense Voltage - Sensor for measuring electrical voltage ± 30 V (Bluetooth + USB)	12901-01	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	1
7	Beaker, Borosilicate, tall form, 50 ml	46025-00	1
8	Block with 8 holes, d = 40 mm	37682-00	1
9	Copper-II sulphate,cryst. 250 g	30126-25	1
10	Water, demineralized, pure, 10000 ml	CHE-882041145	1
11	Silver foil, 150 x150 x 0.1 mm, 25g	31839-04	1
12	Protecting glasses, clear glass	39316-00	1

PHYWE
Robert-Bosch-Breite 10
37079 Göttingen
Tel.: 0551 604 - 0
Fax: 0551 604 - 107
info@phywe.de
www.phywe.de

Additional material

PHYWE

Position	Equipment	Article no.	Quantity
1	Tweezers	64610-01	1

Setup (1/4)

PHYWE

For measurement with the **Cobra SMARTsense sensors** the **PHYWE measureAPP** required. The app can be downloaded free of charge from the relevant app store (see below for QR codes). Before starting the app, please check whether your device (smartphone, tablet, desktop PC) is running **Bluetooth activated** is.

iOS

Android

Windows

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Setup (2/4)

PHYWE

The solution can be made for everyone to save chemicals!

- **Copper sulphate solution (1 mol/l):** Add $12.49\ \mathrm{g}$ of copper sulphate to $25\ \mathrm{ml}$ of distilled water. Mix well and fill up to $50\ \mathrm{ml}$ with distilled water. This experiment is for qualitative detection, so the exact concentration is not important for the experiment.

Setup (3/4)

PHYWE

Take a measuring cell block.

Fill one measuring cell of the measuring cell block with pure, distilled water and a second measuring cell with the copper sulphate solution.

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

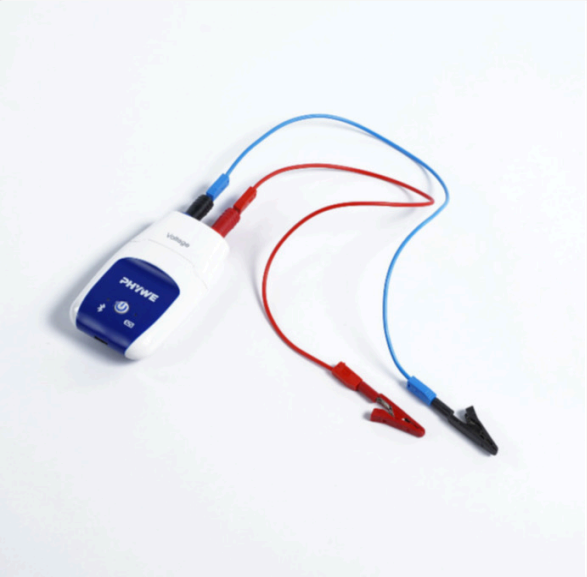
Structure (4/4)

PHYWE

Look at the two electrodes, copper (Cu) and zinc (Zn): If the metal has oxidised due to storage, use a piece of sandpaper to remove the oxide layer.

Note the colour of the connections below: blue (zinc, negative pole) always to blue (black) and red (copper, positive pole) always to red!

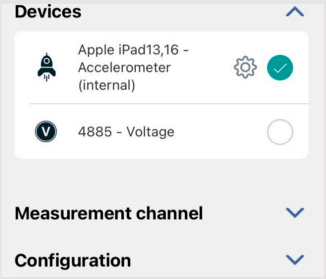
Connect the crocodile clips to the metal electrodes (copper and zinc sheet) and the leads to the Cobra SMARTsense Voltage Sensor using a reducing plug.

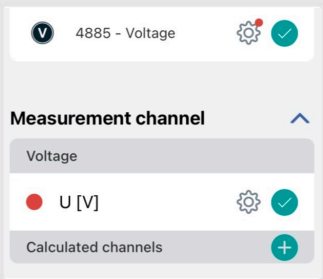


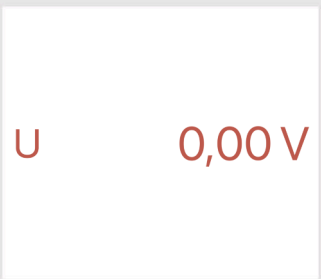
Procedure (1/3)

PHYWE

- Start the measureAPP on a mobile device.
- Press the start button on the sensor for approx. 3 seconds.
- Connect the sensor by tapping ◯ next to the description of the sensor in the measureAPP.
- Set the measured value display by tapping 0.0 above the diagram.







PHYWE
Robert-Bosch-Breite 10
37079 Göttingen
Tel.: 0551 604 - 0
Fax: 0551 604 - 107
info@phywe.de
www.phywe.de

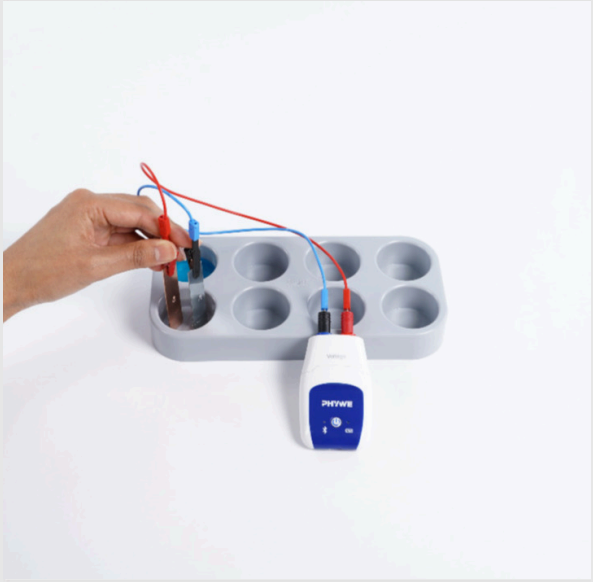
Procedure (2/3)

PHYWE

Place both electrodes in the measuring cell with distilled water (see illustration) and observe the voltage.

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

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



Procedure (3/3)

PHYWE

Remove the electrodes from the measuring cell with distilled water. Replace the copper electrode with the silver electrode and insert the electrodes into the measuring cell block with the copper sulphate solution.

The electrodes can also be used here **not** touch each other!

Observe the two electrodes and investigate on which electrode copper is deposited.

Then repeat the experiment by first replacing the zinc electrode with the copper electrode and then with the iron electrode.

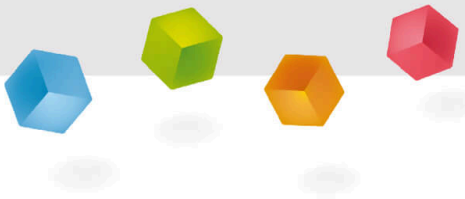
PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

PHYWE



Report

Task 1

PHYWE

What is the solution pressure?

- ○ None of the answers are correct.
- ○ Solution pressure refers to the pressure you feel when you need to find a solution to a particularly difficult problem.
- ○ The endeavour of the metals zinc and copper to dissolve in water by releasing electrons.
- ○ The pressure created when the metals zinc and copper are immersed in a sealed container of water.

Check

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Task 2

PHYWE

Which answers are correct?

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

Check

Task 3

PHYWE

In the experiment, a silver and a zinc electrode were immersed in a copper sulphate solution and it was observed that copper was deposited on one of the electrodes. Which statement is true?

- ○ The metal that is more oxidised does not need to be cleaned and is the nobler metal.
- ○ The metal that is more oxidised and whose surface needs to be cleaned is the less noble metal.
- ○ The metal on which copper is deposited is less noble, as it reduces copper ions.

Check

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Task 4

PHYWE

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

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

Check

Slide	Score / Total
Slide 24: Solution pressure	0/1
Slide 25: Higher solution pressure	0/2
Slide 26: Attempt noble or ignoble	0/1
Slide 27: Reaction behaviour of precious metals	0/2

Total amount 0 / 6

Solutions Repeat

PHYWE
Robert-Bosch-Breite 10
37079 Göttingen
Tel.: 0551 604 - 0
Fax: 0551 604 - 107
info@phywe.de
www.phywe.de