Measuring and comparing the voltages of various halfcells leads to an "electrochemical series"

(Item No.: P7400600)

Curricular Relevance

Area of Expertise: Chemie

Education Level: Klasse 7-10

Topic: Physikalische Chemie

Subtopic: Grundlagen der Elektrochemie

Experiment: Messung und Vergleich der Spannungen zwischen verschiedenen Halbzellen führen zu einer »elektrochemischen Spannungsreihe«

Difficulty	Preparation Time	Execution Time	Recommended Group Size
Intermediate	10 Minutes	20 Minutes	2 Students

Additional Requirements:

- Filter paper strips

Experiment Variations:

Keywords:

half cell, electric current, electrochemical series

Information for teachers

Introduction

Principle

The combination of various half-cells to galvanic cells results in differing direct voltages. Consideration of these differences in voltages leads to the arrangement of the metals in a certain succession to an electrochemical (or electromotive) series.

The voltages measured give a certain succession of the 4 metals with respect to their tendency to dissolve or their potential. Zinc has the strongest tendency to go to the ionic state, silver the least tendency. Zinc therefore always performs as the negative pole against the other 3 metals, and silver always the positive pole.

Lead and copper, on the other hand, change their polarity according to the metal with which they are combined in the galvanic cell. Lead is positive against zinc, but negative against copper and silver. Lead is positive against zinc and lead, but negative against silver.

Knowledge of the succession of the metals according to their potentials, or the potential differences resulting from them, so allow the indirect determination of potential differences between metals, without directly measuring them. As shown by the diagram in Fig. 2, for example, the potential difference between zinc and silver is given both by the sum of the potential differences between silver and copper, copper and lead, lead and zinc (0.45 V + 0.47 V + 0.63 V = 1.55 V), as well as by the sum of those between silver and lead, lead and zinc (0.92 V + 0.63 V = 1.55 V), etc.

The arrangement of all metals in the succession of their potentials gives an "electrochemical series".

Educational objectives

During the experiment, the students will get to know the "electrochemical series" of metal.s

Preparation of solutions required in the experiment

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

Zinc sulphate solution (0.1 mol/l): Add 8.05 g of zinc sulphate to 250 ml distilled water. Stir well and fill up to 500 ml with distilled water.

Potassium nitrate solution (1 mol/l): Add 55.5 g of potassium nitrate to 250 ml distilled water. Stir well and fill up to 500 ml with distilled water.

Lead nitrate solution (0,1 mol/l): Add 16.6 g of lead nitrate to 250 ml distilled water. Stir well and fill up to 500 ml with distilled water.

Silver nitrate (0.1 mol/l): Add 8.49 g of silver nitrate to 250 ml distilled water. Stir well and fill up to 500 ml with distilled water.

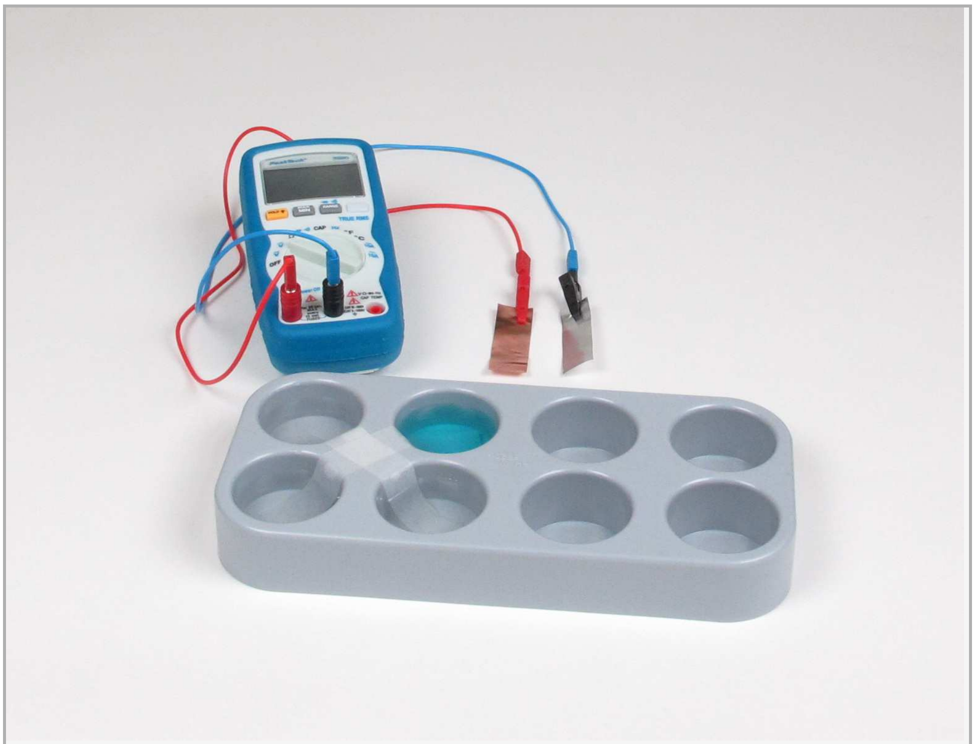

Fig. 1: Experimental set-up

Equipment

Position No.	Material	Order No.	Quantity
1	Digital multimeter 2005	07129-00	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	Copper foil, 0.1 mm, 100 g	30117-10	1
7	Zinc, sheet 250x125x0.5 mm, 200 g	30245-20	1
8	Emery cloth,158x224mm,2 pieces	01606-00	1
9	Silver foil, 150 x150 x 0.1 mm, 25 g	31839-04	1
10	Lead foil, f.analysis,0.4mm,250 g	31116-25	1
11	Glass beaker DURAN®, tall, 50 ml	36001-00	4
12	Dropping bottle,plastic,50ml	33920-00	1
13	Block with 8 holes, d = 40 mm	37682-00	1
14	Coverage f.cell-meas.bloc,8 piec.	37683-00	1
Additionally needed:			
	Copper sulphate solution, c = 0.1 mol/l		
	Lead nitrate solution, c = 0.1 mol/l		
	Zinc sulphate solution, c = 0.1 mol/l		
	Silver nitrate solution, c = 0.1 mol/l		
	Potassium nitrate solution (approx. 1 mol/l)		
	Filter paper strips		

Safety information

The general information for safe experimenting in natural science classes shall be applied in this experiment.

Lead and lead nitrate are poisonous by inhalation or if swallowed, whereby there is a danger of cumulative effects. They can also be taken in by the skin. Protect eyes and skin. Completely avoid contact of the chemicals with eyes and skin. Wear protective gloves and protective glasses!

Measuring and comparing the voltages of various halfcells leads to an “electrochemical series” (Item No.: P7400600)

Introduction

Application and task

Application

The discovery and further development of galvanic elements, better known as batteries, is of great importance for humankind. It has enables mobile power supply of various electrical devices, which is a big part of our today's living standard. The combination of various half-cells to galvanic cells results in differing direct voltages. Consideration of these differences in voltages leads to the arrangement of the metals in a certain succession to an electrochemical (or electromotive) series.

Task

4 Different half-cells (zinc/zinc sulphate solution, copper/copper sulphate solution, lead/lead nitrate solution and silver/silver nitrate solution) are to be prepared and paired in various combinations to galvanic cells. The direct voltages which are thereby measured are to be used to arrange the metals in a certain succession.

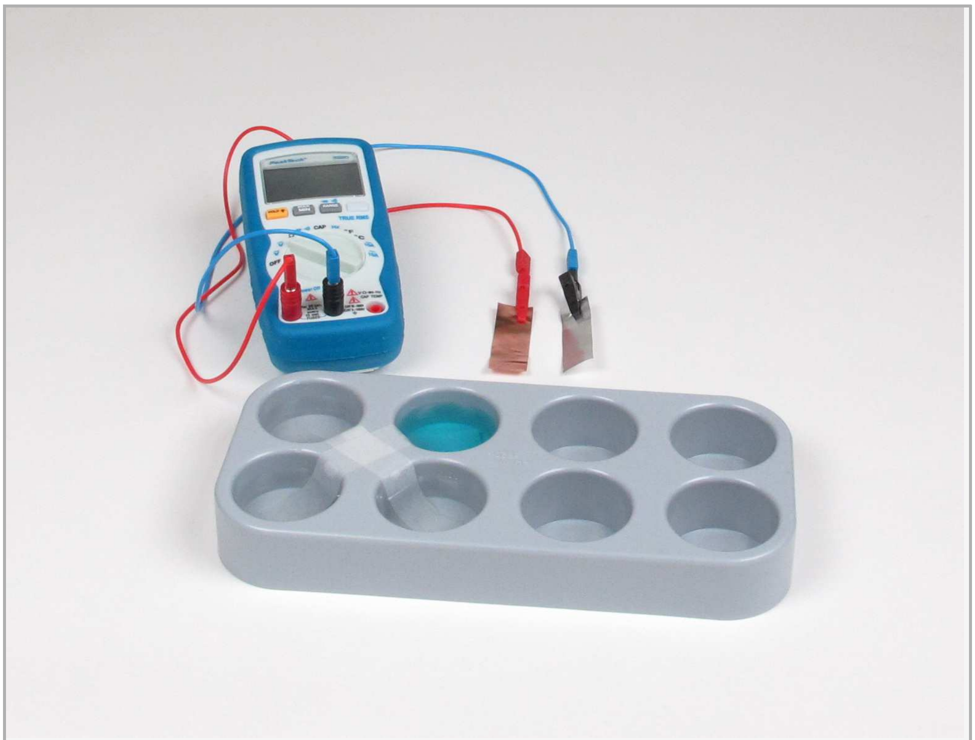

Fig. 1: Experimental set-up

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	Potassium nitrate solution (approx. 1 mol/l)		
	Filter paper strips		

Set-up and procedure

Fill measuring cells 1 to 4 with the 0.1 molar solutions as shown in Fig. 1 (use the positions shown to be sure to avoid mix-ups during measurements!). Conductively connect the 4 measuring cells with keys made up of filter paper strips wetted with 1 mol/l potassium nitrate solution, positioned crosswise as shown in Fig. 1. Put covers on the measuring cells and insert the appropriate (well cleaned) metal sheet electrodes. Set the measuring instrument to the measuring range 2 V.

Connect the earthed socket of the measuring instrument (negative pole) to the zinc electrode (half-cell 1), and the voltage socket (positive pole) successively with the lead, copper and silver electrodes (halfcells 2 to 4).

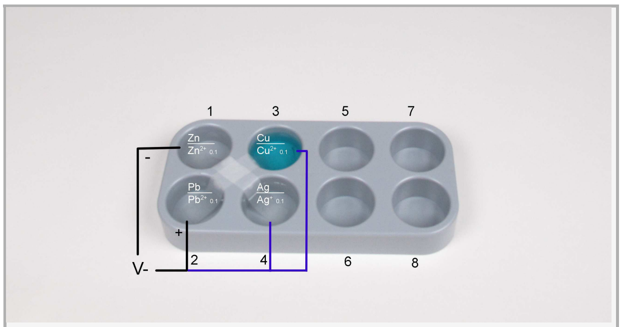

Fig. 2

Note in voltage displayed in each case. These voltages will be, with only little fluctuation, of the following orders of magnitude:

Electrode pairing	Voltage V-
Zn/Pb	0.63
Zn/Cu	1.10
Zn/Ag	1.55

After these measurements, connect the earthed socket of the measuring instrument to the lead electrode and measure the voltage against the copper and silver electrodes.

Electrode pairing	Voltage V-
Pb/Cu	0.47
Pb/Ag	0.92

Finally, connect the earthed socket of the measuring instrument to the copper electrode and measure the voltage against the silver electrode.

Electrode pairing	Voltage V-
Cu/Ag	0.45

Report: Measuring and comparing the voltages of various halfcells leads to an “electrochemical series”

Results - Question 1

Note down your observations.

Evaluation - Question 1

Display the measured voltages in a diagram.

Robert-Bosch-Breite 10
D - 37079 Göttingen

Tel: +49 551 604 - 0
Fax: +49 551 604 - 107

info@phywe.de
www.phywe.com

Evaluation - Question 2

Which of the four metals used in the experiment has the negative pole, which has the positive pole?

Evaluation - Question 3

Describe what happens with the two other metals that are neither the negative nor the positive pole.

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