Determination of standard potential using the silver/silver chloride as reference electrode

(Item No.: P7401100)

Curricular Relevance

Area of Expertise: Chemie

Education Level: Klasse 10-13

Topic: Physikalische Chemie

Subtopic: Elektrochemie - Potenziale, Leitfähigkeit, Elektrolyse

Experiment: Bestimmung von Standardpotenzialen mit einer Silber/Silberchloridelektrode als Bezugselektrode

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

Additional Requirements:

- Filter paper strips

Experiment Variations:

Keywords:

silver chloride electrode, reference electrode

Information for teachers

Introduction

Principle

During electrolysis, hydrogen ions, or hydronium ions, are reduced at the platinum electrode to hydrogen.

$$2\ H_3O^+ + 2\ e^- \rightarrow 2\ H_2O + H_2$$

This causes a simplified hydrogen electrode to form here. At the silver electrode, silver is subjected to an oxidative process and is converted to sparely soluble silver chloride.

$$Ag + Cl^- \rightarrow AgCl + e^-$$

The silver chloride thereby precipitates on the silver electrode as a solid gray layer, so that a silver/silver chloride electrode forms here.

When the half-cells are connected together via a voltmeter, the chemical processes are reversed and a direct voltage of about 0.24 V is measurable (this measured value is mostly a little higher with freshly made electrodes. It improves after storing the electrodes for several days in 0.1 molar KCl solution). As the hydrogen electrode forms the negative pole here, the + sign is to be given to the potential measured.

$$E^0(Zn/Zn^{2+}) = -1.0 + 0.236 = \mathbf{-0.764\ V}$$
$$E^0(Cu/Cu^{2+}) = +0.1 + 0.236 = \mathbf{+0.366\ V}$$

Note

This experiment requires the availability of a silver/silver chloride electrode which was prepared as in Experiment 2.3 and subsequently stored in 0.1 molar potassium chloride solution for some days.

The silver/silver chloride electrode made in this experiment should be stored in 0.1 molar potassium chloride solution in a small wide-necked flask, and is then ready for use at any time.

Under exact conditions, i.e. the using a platinized hydrogen electrode at a temperature of 25°C and with a potassium chloride solution of molarity 1, the accurate value of the standard potential of a silver/silver chloride electrode is +0.236 V.

When one has once made such an electrode, then it can be used at any time for potential measurements in place of a hydrogen electrode. The measured values which are then obtained always deviate by a certain amount from the standard potentials, but the latter can be easily calculated by taking the self-potential of the silver/silver chloride electrode into consideration.

Educational objectives

The students will deepen their knowledge about standard potentials as well as practice the usage of reference electrodes such as the silver/silver chlorid electrode.

Preparation of the required solutions

Copper sulphate solution (1 mol/l): Add 79.5 g of copper sulphate to 250 ml distilled water. Stir well and fill up to 500 ml with distilled water.

Potassium chloride solution (1 mol/l): Add 37.3 g of potassium chloride 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.

Zinc sulphate solution (1 mol/l): Add 80.5 g of zinc sulphate 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	Block with 8 holes, d = 40 mm	37682-00	1
10	Coverage f.cell-meas.bloc,8 piec.	37683-00	1
11	Silver foil, 150 x150 x 0.1 mm, 25 g	31839-04	1
12	Glass beaker DURAN®, tall, 50 ml	36001-00	3
13	Dropping bottle,plastic,50ml	33920-00	1
14	Bottle,wide neck,plastic,50ml	33912-00	1
Additionally needed:			
	Potassium chloride solution, c = 1 mol/l		
	Zinc sulphate solution, c = 1 mol/l		
	Copper sulphate, c = 1 mol/l		
	Potassium nitrate solution, c = 1 mol/l		
	Filter paper strips		

Safety information

Potassium chloride and zinc sulphate solutions of concentration c = 1.0 mol/l act as irritants. Protect eyes and skin. Avoid contact of the chemicals with eyes and skin. Wear protective gloves and protective glasses!

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Introduction

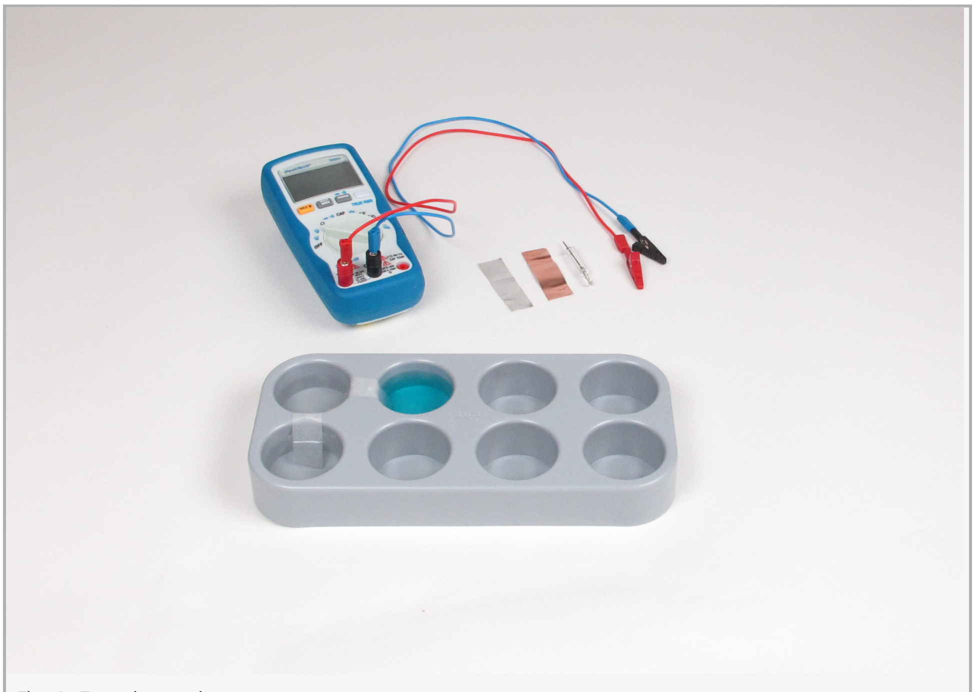
Application and task

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. Differently high voltages are generated between the various metals when they are combined in galvanic cells. These voltages are the quantitative expression of the potential differences between the two half-cells connected together. As it is not possible to measure the tendency to go into solution, i.e. the potential of a metal, alone in one half- cell, it cannot be given a definite order of magnitude. The differences between the potentials of various metals are measurable when they are connected in galvanic cells. This opens up the possibility of giving each metal (and other redox couples also) a relative potential value by coupling it in a galvanic cell with a reference electrode which is always the same.

Task

To determine the standard potentials of zinc and copper half-cells, using a silver/silver chloride electrode as reference electrode.



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	Copper sulphate, c = 1 mol/l		
	Potassium nitrate solution, c = 1 mol/l		
	Filter paper strips		

Set-up and procedure

Fill the cells 1 to 3 in the measuring cell block with the 1 molar solutions as shown in Fig. 2. Connect cell 1 with both cell 2 and cell 3, using keys made from filter paper strips wetted with potassium nitrate solution (see Fig. 2).

Place covers on the measuring cells and insert the corresponding electrodes in the cells (the silver/silver chloride electrode in the potassium chloride solution, zinc in the solution). Place covers on the measuring cells and insert a platinum electrode in cell 1 and a silver electrode made from a strip of silver foil of roughly 10 mm width and 40 mm length in cell 2.

Connect the electrodes to a source of direct voltage as shown in Fig. 2 (platinum electrode to the negative pole, silver electrode to the positive pole). Electrolyze this arangement for about 3 to 5 minutes at 4 to 5 V-.

At the end of this time, break connection to the source of voltage and connect the measuring instrument (set at 2 V-), as shown in Fig. 2. Connect the platinum electrode, or rather, the hydrogen electrode it has now become, to the earthed socket (also the negative pole) and the silver electrode to the voltage socket (as positive pole).

Measure the voltage between the two electrodes!

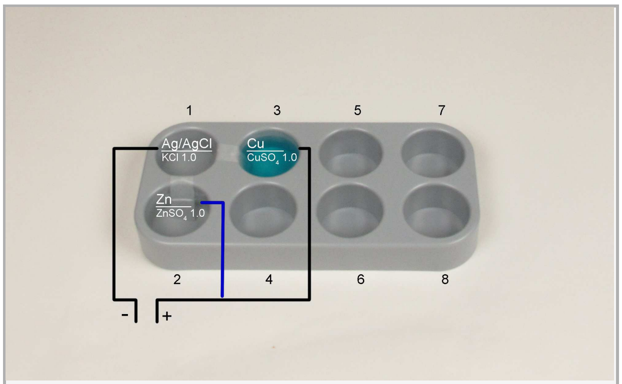

Fig. 2

Report: Determination of standard potential using the silver/silver chloride as reference electrode

Results - Question 1

Note down the measured voltage between the two electrodes.

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Evaluation - Question 1

Which of the two electrodes forms the negative pole?

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Evaluation - Question 2

During electrolysis, hydrogen ions, or hydronium ions, are reduced at the platinum electrode to ... ?

- [ ] hyydrogen
- [ ] hyrdoxide ions
- [ ] just water

Evaluation - Question 3

A measurement of the potential of the redox system
$Zn \leftrightarrow Zn^{2+} + 2e^-$

with a silver/silver chloride electrode gave a value of -0.996 V. The standard potential of zinc is given by adding the measured value to the potential of the silver/silver chloride electrode, taking the signs into consideration.

Calculate the standard potential of zinc.

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