The conductivity of aqueous solutions of electrolytes

(Item No.: P1374900)

Curricular Relevance

Area of Expertise: Physik
Education Level: Klasse 7-10
Topic: Elektrizitätslehre
Subtopic: Der elektrische Strom und seine Wirkung
Experiment: Die Leitfähigkeit wässriger Lösungen von Elektrolyten

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

Additional Requirements:

- Table salt
- Tap water
- Cloth or absorbent paper

Experiment Variations:

Keywords:

Task and equipment

Information for teachers

Additional information

Salts, acids and bases are electrolytes. In pure form they do not (or hardly) conduct electric current, because in this condition they have no (or only extemely few) freely mobile electrons. In water, the dissolved electrolyte divides (dissociates) into positive and negative ions.
When voltage is applied to two electrodes which are dipped into an aqueous solution of an electrolyte, the ions migrate towards the electrode which has the opposite electric charge. Aqueous solutions of electrolytes are therefore capable of conducting electric current.
The students should find this out in this experiment, and also get to understand why an electrolyte which is not dissolved (or not melted) as well as distilled water are not conductive, or hardly so.

Safety measures

R: 34/ 36/ 38
S: 26-36/ 39-45
Diluted sulphuric acid and sodium hydroxid solutions are very corrosive to skin, eyes and mucous membranes. Vapour (aerosols) irritates the respiratory organs. Wear protective glasses and protective gloves.

Waste disposal

Dilute solutions with water, neutralise (pH 6-8) and rinse to drain.

Notes on setup and procedure

The diluted sulphuric acid (approx. 5 %) and diluted caustic soda (approx. 5 %) should be prepared for the students prior to the experiment.
It must be ensured that the students work very carefully and exactly follow the instructions given when carrying out experiments involving acids and bases. We recommend that the teacher himself distributes the diluted acids and bases, and also organises and superintends their central disposal.
We further recommend dividing the experimental work; i.e. each workgroup carries out the parts 1 to 3 of the experiment, but only one of the parts 4 to 6, and the results from the latter parts are subsequently combined. This saves time and also allows other examinations to be carried out which are not offered here, e.g. on aqueous solutions of sugar and food vinegar.

Remarks

The values for the current which are given in Table 1 are only approximate. The current intensity is not only dependent on the voltage applied, but also, for example, on the distance and the immersion area of the electrodes, as well as on the concentration of the solution. This can be easily qualitatively demonstrated in an extension of the experiment.
Common salt is highly hygroscopic. Salt which has not been stored in a tightly closed container can therefore possibly conduct electric current to some extent (current intensity of a few µA). This current, however, is not measurable in the 3 mA–measurement range.
The chemical processes which occur when current flows through an aqueous solution are in part very complicated. This experiment is therefore limited to the essentials: the conductivities of these liquids. As soon as the answering of question 2 is reached, the secondary reactions must be discussed, in order to completely represent the conduction process:
Na^+ ions migrate to the cathode and take up electrons there:

$2Na^+ + 2e^- \rightarrow 2Na$,
$2Na + 2H_2O \rightarrow 2NaOH + H_2\uparrow$,

i.e. atomic sodium splits water molecules to form sodium hydroxide (which again dissociates) and molecular hydrogen (which bubbles up out of the solution).
Cl^- ions migrate to the anode and donate an electron there:

$2Cl^- - 2e^- \rightarrow Cl_2\uparrow$,

i.e. chlorine gas is formed here, and this also bubbles up out of the solution.

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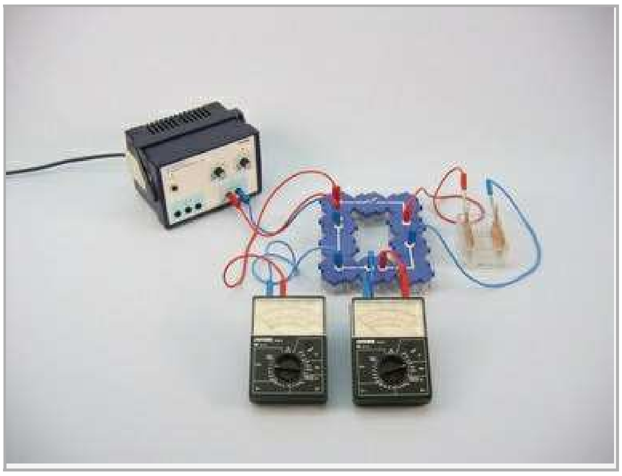
Task and equipment

Task

Do liquids also conduct electric current?

You will determine if water containing dissolved substances conducts electric current.



Equipment

Position No.	Material	Order No.	Quantity
1	Angled connector module, SB	05601-02	2
2	Straight connector module, SB	05601-01	1
3	Interrupted connector module, SB	05601-04	2
4	Junction module, SB	05601-10	2
5	Angled connector module with socket, SB	05601-12	2
6	On-off switch module, SB	05602-01	1
7	Trough, grooved, w/o lid	34568-01	1
8	Copper electrode, 76 mm x 40 mm	45212-00	2
9	Alligator clips, bare, 10 pcs	07274-03	1
10	Connecting cord, 32 A, 250 mm, red	07360-01	2
11	Connecting cord, 32 A, 250 mm, blue	07360-04	2
12	Connecting cord, 32 A, 500 mm, red	07361-01	2
13	Connecting cord, 32 A, 500 mm, blue	07361-04	2
14	PHYWE power supply DC: 0...12 V, 2 A / AC: 6 V, 12 V, 5 A	13506-93	1
15	Multi-range meter, analogue	07028-01	2
16	Sulphuric acid, 10%, tech.gr., 1000 ml	31828-70	1
17	Sodium hydroxide sol.,10%, 1000ml	31630-70	1
18	Water, distilled 5 l	31246-81	1
19	Emery paper, medium, 5 sheets	01605-02	1
20	Spoon,w.spatula end,18 cm,plastic	38833-00	1
Additional material			
	Table salt		
	Tap water		
	Cloth or absorbent paper		

Set-up and procedure

Set-up

Safety measures

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Set-up

Set up the experiment as shown in Fig. 1 and Fig. 2, with the switch open. The trough and the copper electrodes must be carefully cleaned before the electrodes are inserted in the outer grooves of the trough.
Fill the trough half way with distilled water; select the 3 V– and 3 mA– measurement ranges.

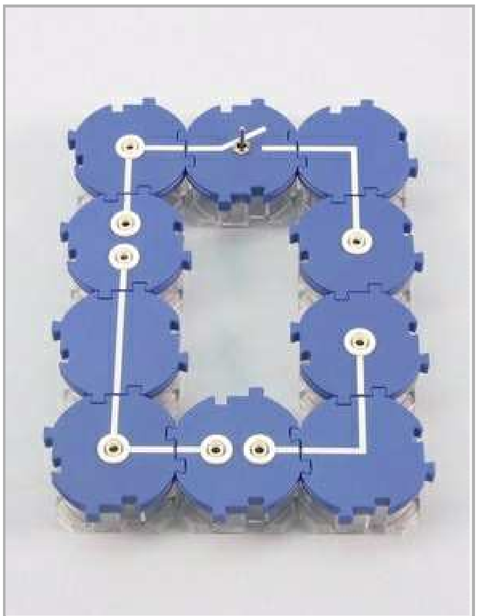

Fig. 1

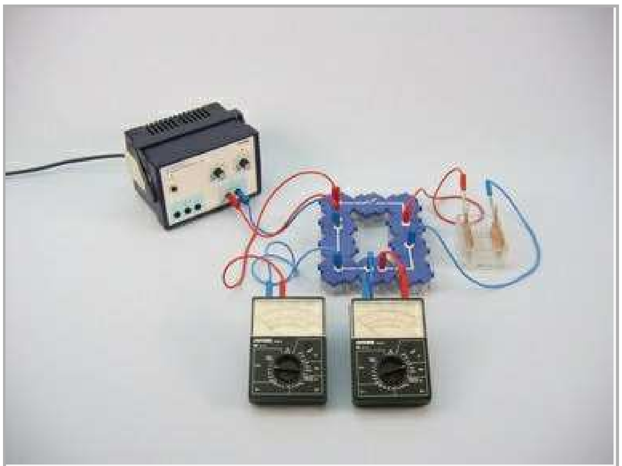

Fig. 2

Procedure

- Set the power supply to 0 V and switch it on.
- Close the switch, increase the power supply voltage until the voltmeter shows 2 V; measure the current I and note the measured value in Table 1 in the report.

- Open the switch, empty and dry the trough.
- Again position the electrodes in the trough, then fill the trough up to a height of about 2 cm with common salt.
- Close the switch, measure the current intensity at U = 2 V; note the measured value.

- Select the 30 mA– measurement range, then slowly pour distilled water onto the salt in the trough; while doing this, have a look at the ammeter and increase the measurement range when the current threatens to go above the 30 mA value.
- Use the spoon to stir the salt solution a little and measure the current intensity finally reached.
- Open the switch and note the measured value for I.

- Empty the trough. Thoroughly wash and dry the trough and the electrodes. Replace the electrodes in the trough.
- Select the 30 mA– measurement range and fill the trough half way with tap water.
- Close the switch and again measure the current intensity at U = 2 V; note the measured value.

- Open the switch and empty the trough.
- Select the 300 mA– measurement range, close the switch, then carefully pour diluted acid into the trough; measure the current and note the measured value.

- Open the switch, properly dispose of the aqueous solution, rinse the trough and the electrodes with water and dry them.
- Carry out the same procedure with diluted base.
- Set the power supply to 0 V and switch it off.
- Properly dispose of the aqueous solution, rinse the trough and the electrodes with water and dry them. Wash your hands with soap and water.

Report: The conductivity of aqueous solutions of electrolytes

Results – Table 1

Record the measured values in Table 1.

Exp. part no.	substance in the trough	current intensity *I* in mA
1	distilled water	1
2	salt	1
3	aqueous salt solution	1
4	tap water	1
5	acidic aqueous solution	1
6	basic aqueous solution	1

Evaluation – Question 1

Summarise the results obtained in the individual parts of the experiment in words.

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Evaluation – Question 2

Acids, bases and salts dissociate when they are dissolved in water, i.e. their molecules divide into positive and negative ions, either completely or partly, according to the concentration of the solution.

For common salt, for example: $NaCl \rightarrow Na^+ + Cl^-$.
Describe the conductive process in an aqueous solution of common salt.

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Evaluation – Question 3

Why does common salt, for example, not conduct electric current and distilled water also (almost) not, and why does normal tap water conduct current - even though not particularly well?

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Evaluation – Question 4

In electrotechnics, the earth is often used as a conductor. What is the explanation for this?

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