Task

To determine if water containing dissolved substances conducts electric current.

Equipment

Plug-in board	06033.00	1
On/off switch	39139.00	1
Trough, grooved	34568.01	1
Copper electrode, 76 x 40 mm	45212.00	2
Connecting cable, 25 cm, red	07313.01	2
Connecting cable, 25 cm, blue	07313.04	2
Connecting cable, 50 cm, red	07314.01	2
Connecting cable, 50 cm, blue	07314.04	2
Crocodile clips, bare, 2 from 10	07274.03	(1)
Multi-range meter	07028.01	2
Power supply, 0...12 V-,6 V~, 12 V~	13505.93	1
Spoon with spatula end (e.g. 38833.00)		
Sulphuric acid, 10%, tech. gr., 1000 ml	31828.70	1
Sodium hydroxide solution, 10%, 1000 ml	31630.70	1
Water, distilled, 5 l	31246.81	1
Emery paper, medium, 1 sheet from 5	01605.02	(1)
Common salt		
Tap water		
Cloth or absorbent paper		

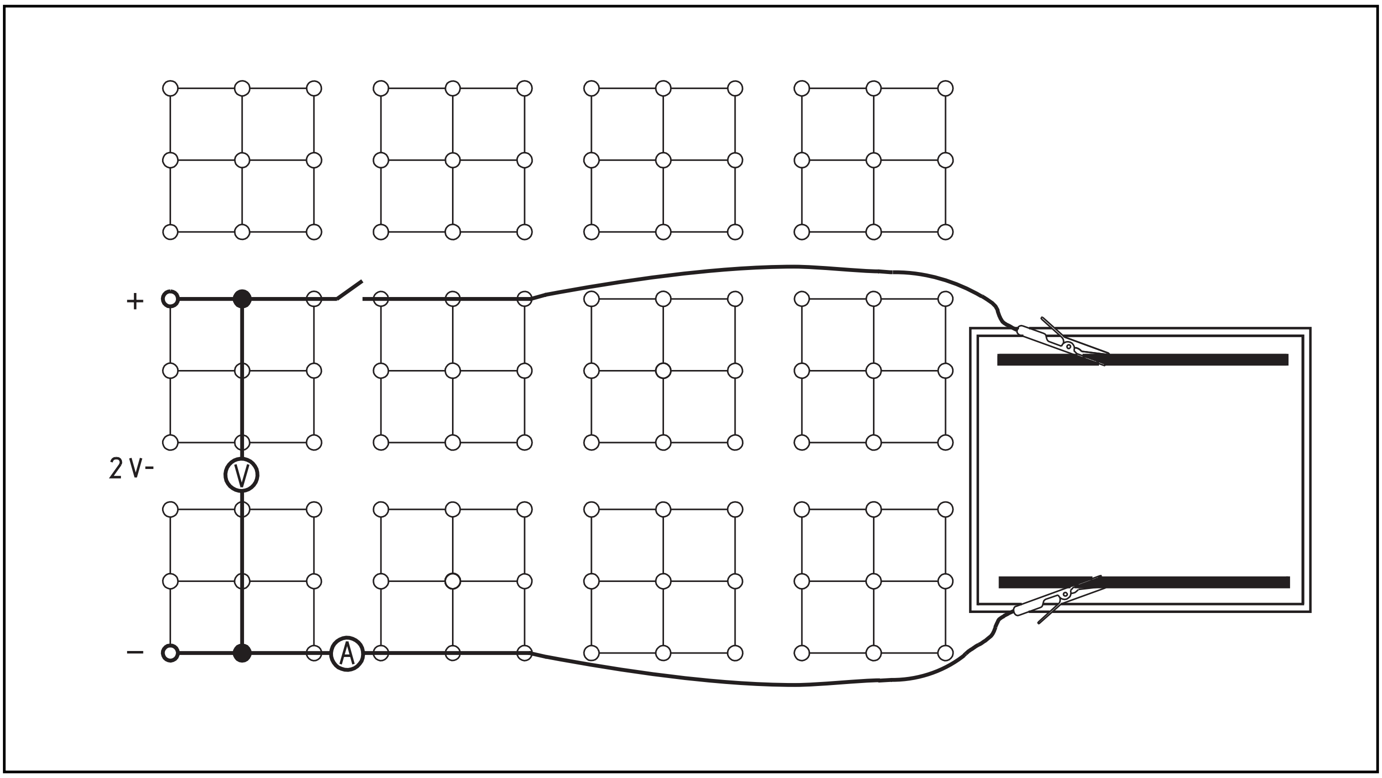
Danger!

Sulphuric acid and sodium hydroxide are corrosive. Wear protective glasses!

Set-Up and Procedure

— Set up the experiment as shown in Fig.1, 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.
— Half-fill the trough with distilled water; select the 3 V- and 3 mA- measurement ranges.
— 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.
— 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 commmon salt.
— Close the switch, measure the strength of the current 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, keep a watch on 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 strength of the current 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 half-fill the trough with tap water.

Fig. 1



- Close the switch and again measure the strength of the current at U = 2 V; note the measured value.
- Open the switch and empty and dry the trough.
- Select the 300 mA- measurement range, close the switch, then carefully pour dilute 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 dilute alkali.
- 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.

Waste disposal
Pour sulphuric acid and sodium hydroxide into the container for acids and bases.

Measurement Results
Table 1

Exp. part no.	Substance in the trough	Current strength I /mA
1	Distilled water	
2	Salt	
3	Aqueous solution of a salt	
4	Tap water	
5	Aqueous solution of an acid	
6	Aqueous solution of a base	

Evaluation

1. Summarize the results obtained in the individual parts of the experiment in words.

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 how concentrated the solution is.
   With common salt, for example: $NaCl \longrightarrow Na^+ + Cl^-$.
   Describe the conductive process in an aqueous solution of common salt.

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

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

The conductivity of aqueous solutions of electrolytes

(Do liquids also conduct electric current?)

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 electricity.
The students should find this out in this experiment, and also get to understand why an electrolyte which is not dissolved (or not melted), and also distilled water, are not conductive, or hardly so.


Danger!
Sulphuric acid and sodium hydroxide are corrosive. Wear protective glasses!

Notes on Set-Up and Procedure
The dilute sulphuric acid (approx. 5%) and dilute 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 dilute acids and bases, and also organizes and superintends their central disposal.
We further recommend that the experimental work be divided up; 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 ice cream.

Waste disposal
The dilute acids and alkalies can be collected for re-use in further similar experiments. If this is not done, pour them into the waste container for acids and bases.

Measurement Results
See Table 1

Evaluation
1. Salt does not conduct electric current, distilled water only very poorly. Tap water is also not a good conductor. Aqueous solutions of salts, acids and bases are good conductors of electric current.

Table 1

Exp. part no.	Substance in the trough	Current strength I /mA
1	Distilled water	0.1
2	Salt	0
3	Aqueous solution of a salt	200
4	Tap water	8
5	Aqueous solution of an acid	210
6	Aqueous solution of a base	205

2. When voltage is applied to the electrodes dipping into the aqueous salt solution, the Na^+ ions migrate towards the cathode, where they take up an electron. The Cl^- ions migrate towards the anode and donate an electron there. A closed circuit is so formed.
3. Common salt clearly has no freely mobile electrons (carriers of a charge): Distilled water contains only very few freely mobile electrons. Normal tap water contains traces of electrolytes which it has dissolved on its way from the cloud to the consumer, particularly from earth. In comparison with distilled water it therefore contains a relatively large number of freely mobile electrons.
4. The earth is moist. The water in it contains dissolved electrolytes which make the earth conductive.

Remarks
The values for the current which are given in Table 1 are only approximate. The strength of the current is not only dependent on the voltage applied, but also, for example, on the distance apart of the electrodes and their immersed area, 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 strength of a few μA). This current is not measurable in the 3 mA- measurement range, however.
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:

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

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:

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

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