# How can electric current be generated from chemical processes?

EEP 4.5 | S

**Task**

To examine if voltages are generated between two electrodes of different materials held in an aqueous solution of an electrolyte.

**Equipment**

| | | |
|---|---|---|
| Trough, grooved | 34568.01 | 1 |
| Copper electrode, 76 x 40 mm | 45212.00 | 2 |
| Zinc electrode, 76 x 40 mm | 45214.00 | 2 |
| Lead electrode, 76 x 40 mm | 45215.00 | 2 |
| Iron electrode, 76 x 40 mm | 45216.00 | 2 |
| Connecting cable, 25 cm, red | 07313.01 | 2 |
| Connecting cable, 25 cm, blue | 07313.04 | 2 |
| Crocodile clips, bare, 2 from 10 | 07274.03 | (1) |
| Multi-range meter | 07028.01 | 1 |
| Sulphuric acid, 10%, tech. gr., 1000 ml | 31828.70 | 1 |
| Water, distilled, 5 l | 31246.81 | 1 |
| Emery paper, medium, 1 sheet from 5 | 01605.02 | (1) |
| Cloth or absorbent paper | | |

**Danger!**

Sulphuric acid is corrosive. Wear protective glasses!
Lead is harmful to health. Carry out the cleaning of the lead electrodes in a fume cupboard whenever possible!
Wear protective gloves! Wash your hands thoroughly after the experiment!

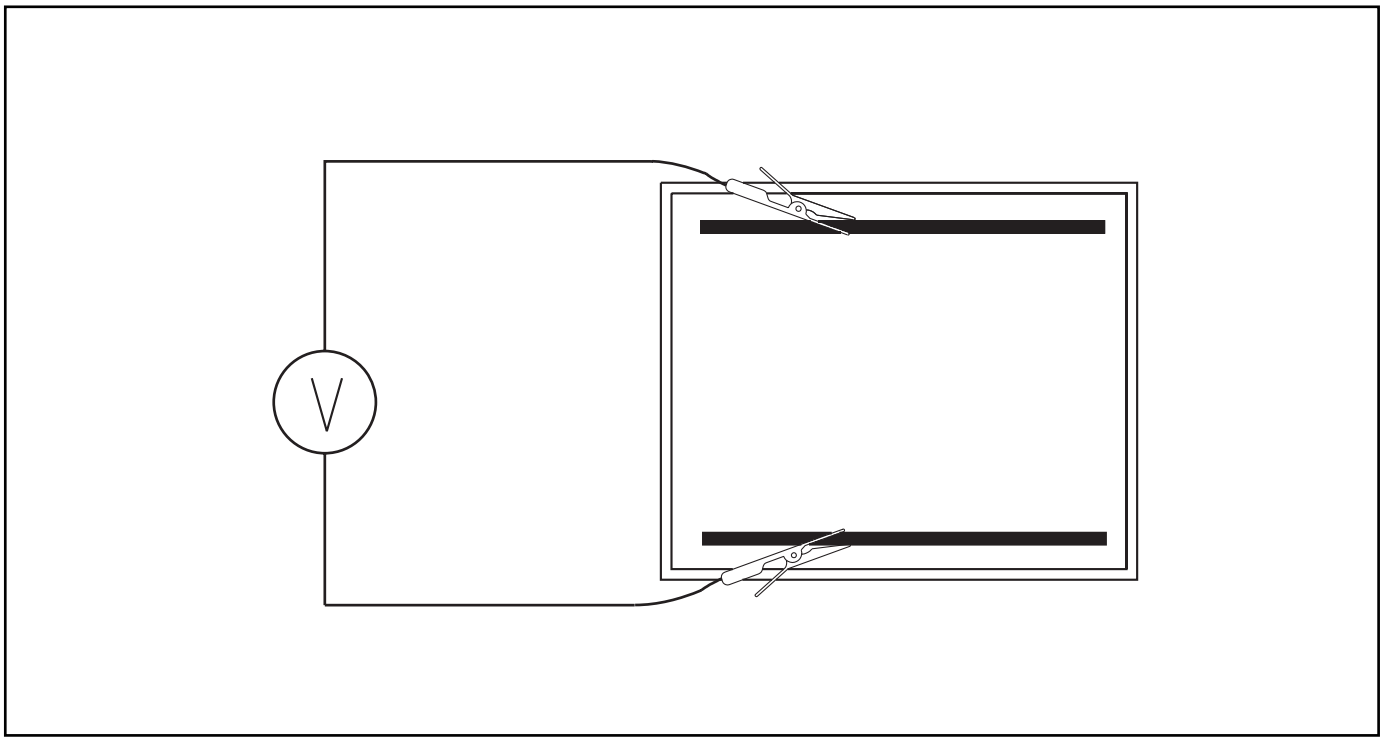
**Set-Up and Procedure**

— Clean the trough and all electrodes. Fill the trough with dilute sulphuric acid (approx. 5%).
— Set up the experiment as shown in Fig.1, first fixing the copper and zinc electrodes in the trough.
— Select the 1 V- measurement range and connect the (+) input of the voltmeter to the copper electrode, read off the voltage and enter this value in Table 1.
— Successively replace one of the electrodes by another and - when necessary - reverse the polarity of the voltmeter; in each case, measure the voltage and enter the value measured and the polarities of the electrodes used in Table 1.
— Finally again measure the voltage between the copper and zinc electrodes.
— Reduce the areas of the electrodes by lifting them up and thereby observe the voltmeter. Note your observation under (1).
— Reduce the distance between the electrodes and thereby observe the voltmeter. Note your observation under (2).
— Dry the electrodes, properly dispose of the aqueous solution; clean the trough and wash your hands with soap and water.

**Waste disposal**

Pour the contents of the trough into the container for acid and alkaline wastes.
Clean the lead electrode with paper and rub it down with emery.
Put lead waste into the container for heavy metal wastes.

Fig. 1



**Observations and Measurement Results**

Table 1

| Electrode at the front | | Electrode at the back | | Voltage |
|---|---|---|---|---|
| Material | Polarity | Material | Polarity | U/V |
| Cu | + | Zn | – | |
| Cu | | Pb | | |
| Cu | | Fe | | |
| Cu | | Cu | | |
| Fe | | Pb | | |
| Fe | | Zn | | |
| Zn | | Pb | | |

(1)

(2)

**Evaluation**

1. With which electrode combination (apart from Cu-Cu) is the voltage found the highest or lowest?

2. Attempt to arrange the metals of the electrodes in a series, so that each metal is positive against the one following it:

3. Which conclusions can be drawn from the observations noted under (1) and (2)?

(How can electric current be generated from chemical processes?)

In principle, a galvanic cell consists of two different metallic electrodes which dip into an aqueous solution of an electrolyte. A voltage is generated between the electrodes, the origin of which can be explained, in a simplified way, by the passage of positive metal ions from the surface of the electrodes into solution, as a result of which freely mobile electrons are left behind on the electrodes.
Because this process occurs to different extents with different metals, the strengths of their negative charges are different. This difference in charge is the source of the voltage.
In this experiment, the students should become acquainted with the construction and mode of action of single cells which are frequently used in practice, but are more complicated.

**Notes on Set-Up and Procedure**
Dilute sulphuric acid (approx. 5%) should be prepared in advance of the experiment..
It is important that the students follow all appropriate safety precautions when handling the aqueous solution and the electrodes (lead is poisonous!).
The proper waste disposal of the aqueous solutions should be carried out centrally under supervision of the teacher.

**Danger!**
Sulphuric acid is corrosive. Wear protective glasses!
Lead is harmful to health. Carry out the cleaning of the lead electrodes in a fume cupboard whenever possible!
Wear protective gloves! Wash your hands thoroughly after the experiment!

**Waste disposal**
Put all lead waste resulting from cleaning lead electrodes before and after the experiment into the container for heavy metal wastes.
Poue all remainders of sulphuric acid into the container for acid and alakaline wastes.

**Observations and Measurement Results**
Refer to Table 1.
(1) The voltage does not change.
(2) The voltage does not change.

**Evaluation**
1. The voltage is highest with the combination Cu-Zn, and lowest with the combination Fe-Pb.
2. Cu – Pb – Fe – Zn.
3. The voltage between the electrodes is not dependent on the distance between them or their effective areas.

**Remarks**
The measured values given in Table 1 are only to be considered as examples, because the voltages which can be obtained are dependent on the state of the surfaces of the electrodes. For this reason, the lead electrodes in particular should be carefully cleaned prior to their use in the experiment. The suggestion for the succession of the electrode combinations listed in Table 1 has been so chosen, so that the students must reverse the polarity of the voltmeter several times and become orientated towards the “voltage series” (see point 2 of the Evaluation). Should you wish to avoid reversal of polarity, change over the positions of the electrodes given in lines 5 and 7 of Table 1.

Table 1

| Electrode at the front | | Electrode at the back | | Voltage |
|---|---|---|---|---|
| Material | Polarity | Material | Polarity | U/V |
| Cu | + | Zn | – | 0.96 |
| Cu | + | Pb | – | 0.43 |
| Cu | + | Fe | – | 0.51 |
| Cu | 0 | Cu | 0 | 0.00 |
| Fe | – | Pb | + | 0.17 |
| Fe | + | Zn | – | 0.50 |
| Zn | – | Pb | + | 0.58 |

(How can electric current be generated from chemical processes?)

Room for notes