

## Galvanisation of a metal

### Aims of the experiment

- To coat a metallic object with a more noble metal
- To perform metal coating by electrolysis
- To learn about the process of galvanisation

### Principles

Galvanisation is a method by which objects can be coated with a thin layer of metal by means of electrolysis. Objects can thus be copper-plated, chrome-plated or silver-plated, for example.

Galvanisation is named after the physicist Luigi Galvani, the discoverer of galvanic electricity. However, it is assumed that gold-plating of objects using galvanic techniques was already known in the antique.

In galvanisation, the metal layer of the more noble metal protects the less noble metal from oxidation and corrosion. Also, the object undergoes visual improvement with the more noble metal. Taps in the bathroom and the kitchen are chrome-plated so that they shine. Fashion accessories are silver-plated. This makes the accessory less expensive than if it were made completely of the noble metal. Stainless steel cutlery is frequently gold-plated, as gold has a totally neutral taste and also the cutlery cannot tarnish again.

But metallic objects are also often protected by applying a layer of a less noble metal (zinc). If the protective layer is damaged, the less noble metal will disintegrate first. In this way, corrosion of the more noble metal can be delayed. Food cans, for example, are made from sheet steel. Through electrolytic plating with tin (or chromium), the sheet steel becomes tinfoil and is thus protected against corrosion. As also steel and iron, for example, can be protected against rusting by galvanisation, this method has a very large range of applications and plays an important role.

So that the metal layer to be applied adheres well to the surface, the objects are usually polished and thoroughly degreased beforehand.

In this experiment, a metallic object (e.g. a key or a nail) will be coated with a thin layer of copper by galvanisation. Here, the object will be the cathode in the circuit and dipped into a solution of copper sulfate. A sheet of copper serves as the anode which is also immersed in the copper sulfate solution. The process is started by switching on a DC current supply.






Fig. 1: Set-up of the experiment.

## Risk assessment

Potassium hydroxide and sodium hydroxide are corrosive. Wherever possible, wear alkali-resistant protective clothing and work in a fume cupboard. Wear protective goggles and avoid skin contact.

Copper(II) sulfate 5-hydrate is toxic to aquatic organisms and must not be allowed to enter waters, waste water or the ground.

Potassium hydroxide, 1N (1 mol/l)	
 <b>Signal word:</b> <b>Hazard</b>	<p><b>Hazard statements</b></p> <p>H314 Causes severe skin burns and eye damage.</p> <p>H290 May be corrosive to metals.</p> <p><b>Precautionary statements</b></p> <p>P280 Wear protective gloves/protective clothing/eye protection/face protection.</p> <p>P303 + P361 + P353 IF ON SKIN (or hair): Remove/take off immediately all contaminated clothing. Rinse skin with water/shower.</p> <p>P305+P351+P338 IF IN EYES: Rinse continuously with water for several minutes. Remove contact lenses if present and easy to do. Continue rinsing.</p> <p>P309 + P310 IF exposed or you feel unwell: Immediately call a POISON CENTER or doctor/physician.</p> <p>P301+ P330 + P331 IF SWALLOWED: Rinse mouth. Do NOT induce vomiting.</p>
Copper (II) sulfate-5-hydrate	
 <b>Signal word:</b> <b>Caution</b>	<p><b>Hazard statements</b></p> <p>H302 Harmful if swallowed.</p> <p>H319 Causes serious eye irritation.</p> <p>H315 Causes skin irritation.</p> <p>H410 Very toxic to aquatic life with long-lasting effects.</p> <p><b>Safety statements</b></p> <p>P273 Avoid release to the environment.</p> <p>P302+P352 IF ON SKIN: Wash with soap and water.</p> <p>P305+P351+P338 IF IN EYES: Rinse continuously with water for several minutes. Remove contact lenses if present and easy to do. Continue rinsing.</p>

Sodium hydroxide pellets	
 <b>Signal word:</b> <b>Hazard</b>	<p><b>Hazard statements</b></p> <p>H314 Causes severe skin burns and eye damage.</p> <p>H290 May be corrosive to metals.</p> <p><b>Precautionary statements</b></p> <p>P280 Wear protective gloves/protective clothing/eye protection/face protection.</p> <p>P301+ P330 + P331 IF SWALLOWED: Rinse mouth. Do NOT induce vomiting.</p> <p>P309 + P310 IF exposed or you feel unwell: Immediately call a POISON CENTER or doctor/physician.</p> <p>P305+P351+P338 IF IN EYES: Rinse continuously with water for several minutes. Remove contact lenses if present and easy to do. Continue rinsing.</p>

## Equipment and chemicals

1 Electrochemistry demo equipment, CPS..664 4071
1 Stand bases, pair .....301 339
1 Beaker, Boro 3.3, 100 ml, tall .....664 137
1 Beaker, Boro 3.3, 250 ml, tall .....664 138
1 Plate electrode, copper, set of 10 .....664 382
1 Connecting leads 50 cm, red/blue .....501 45
1 Alligator clips, polished, 6 pcs. ....501 861
1 Hot plate .....666 767
1 Tweezers .....667 0344
1 Compact balance ..... OHCS-200E
3 Watch glass dish, 60 mm diam .....664 153
1 Potassium hydroxide 1N (1 mol/l), 1 L .....672 4460
1 Copper(II) sulfate pentahydrate, 100 g .....672 9600
1 Sodium potassium tartrate, 250 g .....672 6710
1 Sodium hydroxide, 100 g .....673 6800
1 Water, pure, 1L .....675 3400

Also required:  
Object to galvanise, e.g. a key, a nail (no objects made of iron, if possible).

## Set-up and preparation of the experiment

### Preparing the electrolyte solution:

For this, weigh out the following quantities onto separate watch glasses: 2 g of copper(II) sulfate pentahydrate, 20 g of sodium potassium tartrate and 2 g of sodium hydroxide. Then transfer the chemicals to a 250 ml glass beaker and dissolve them in 200 ml of distilled water.

### Preparation of the object:

The metal object to be copper-plated must be clean and grease-free. To do this, first clean it in potassium hydroxide solution. Fill the 100 ml beaker with potassium hydroxide solution and heat it on a hotplate. Place the metallic object into the hot potassium hydroxide solution using tweezers and leave it for a few minutes.

**Caution:** The solution is hot and dangerous! Potassium hydroxide solution is strongly corrosive.

Remove the object using the tweezers, rinse it under a running tap and allow it to dry.

Place the electrochemistry demonstration unit into both stand bases and connect it to the mains supply.

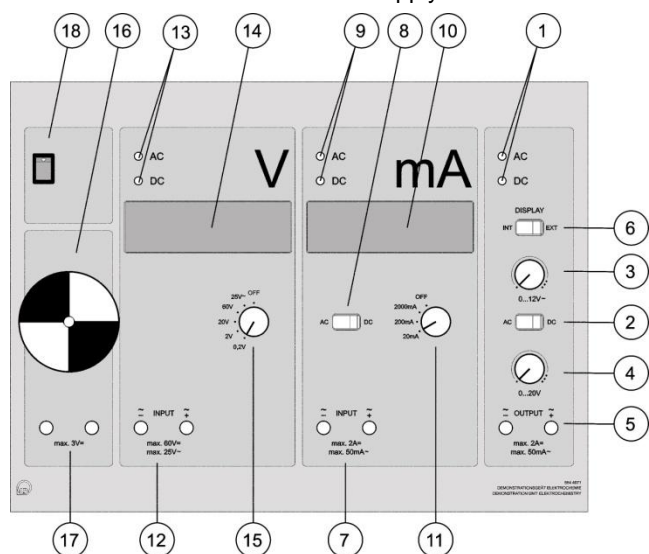


Fig. 2 Electrochemistry demonstration unit.

### Performing the experiment:

The 250 ml glass beaker containing the electrolyte solution serves as a galvanising bath. Connect the metallic object as the cathode (negative pole) and the copper electrode as the anode (positive pole) to the electrochemistry demonstration unit. For this, use alligator clips and blue and red connecting leads (see Fig. 1). Connect these to the power supply output (5) (see Fig. 2). Now immerse the cathode (the metallic object) and anode (copper electrode) prepared for the experiment into the solution ensuring that they do not touch each other. Also ensure that the electrochemistry demonstration unit is switched to direct current (DC) (2). Now switch the electrochemistry demonstration unit on at the switch (18).

When this is done, the rotary control (4) on the power supply can be set to a voltage of 3 V.

### Observation

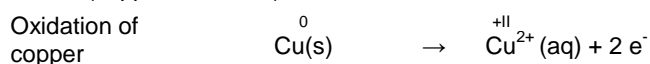
The solution begins to foam immediately after switching on. After about 5 minutes, the metallic object is coated with a thin layer of copper (red).

### Evaluation and result

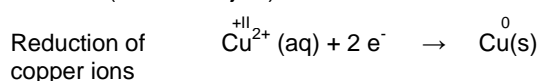
As soon as the voltage is switched on, the copper of the copper electrode goes into solution and migrates to the metallic object, where it is deposited. The initially silver-coloured key is now coated with a bright-red layer of copper.

The following reactions occur at the cathode and anode:

Anode (copper electrode):



Cathode (metallic object):



The copper (copper electrode) is oxidised at the anode and goes into solution. At the cathode, the copper ions are reduced to copper, which is deposited onto the metallic object.

So that the metal coating adheres firmly and evenly, only a small, and as far as possible constant amount of metal (here copper) may be deposited per unit of time. Complexing agents are added to the galvanising bath to prevent too many metal ions being in solution. The complexing agent used in our case is sodium potassium tartrate.

### Cleaning and disposal

Place the electrolyte solutions into the container for inorganic solutions.