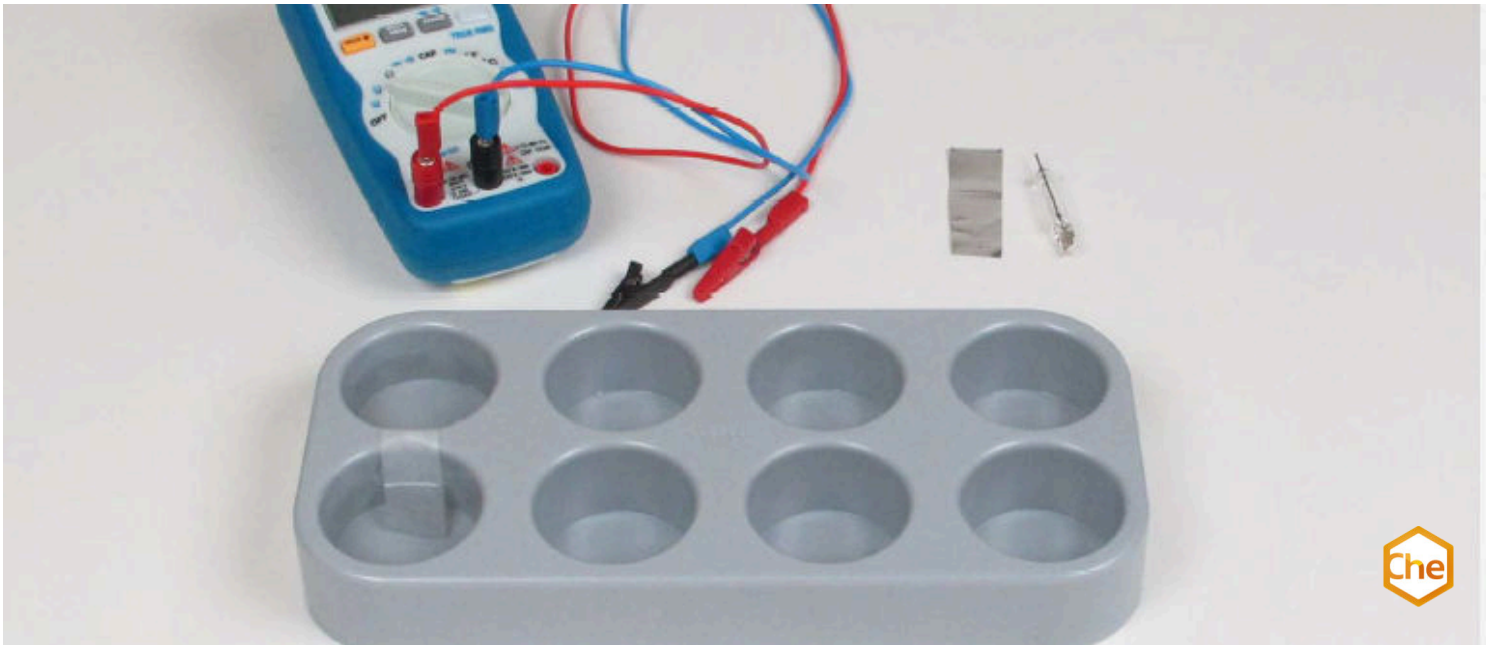
# The silver/silver chloride as reference electrode



In this experiment, the students learn another reference electrode, the silver/silver chloride electrode.

Chemistry > Physical chemistry > Electrochemistry > Electrochemical voltage series

| Difficulty level | Group size | Preparation time | Execution time |
|---|---|---|---|
| medium | 2 | 10 minutes | 20 minutes |

This content can also be found online at:

http://localhost:1337/c/63551a265e95bb0003701b1a

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# Teacher information

## Application

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Experimental setup

A precisely functioning normal hydrogen electrode is always somewhat complicated to manufacture and handle. For this reason, people have been looking for simpler electrodes with which it is also possible to carry out quite good potential measurements that can be reproduced at any time.

Two electrodes have proven to be very useful in the meantime. These are the silver/silver chloride electrode and the mercury/mercury chloride electrode (also called calomel electrode). If the exact potential difference between these two electrodes and the hydrogen electrode is known, standard potentials can easily be determined.



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## Other teacher information (1/5)

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**Prior knowledge**

The students should have worked with galvanic elements in theory and practice. They should also have already made a hydrogen electrode (experiment P7400900).

**Principle**

An accurately functioning normal hydrogen electrode is always somewhat awkward to make and handle. Alternatives are the silver/silver chloride electrode and the mercury/mercury chloride electrode.

## Other teacher information (2/5)

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**Learning objective**

In this experiment, the students learn another reference electrode, the silver/silver chloride electrode.

**Tasks**

The students should make a silver/silver chloride electrode and determine its potential compared to a normal hydrogen electrode.



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# Other teacher information (3/5)

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**Other information (1/3)**

A precisely functioning normal hydrogen electrode is always somewhat complicated to manufacture and handle. For this reason, one has looked for simpler electrodes with which one can also carry out quite good and always reproducible potential measurements. In the meantime, two electrodes have proved to be very useful. They are the silver/silver chloride electrode and the mercury/mercury chloride electrode (also called calomel electrode).
Short names of these electrodes are:

$$A_g/A_gCl \quad \text{and} \quad H_g/H_{g_2}Cl_2$$

If the exact potential difference between these two electrodes and the hydrogen electrode is known, standard potentials can be easily determined.

# Other teacher information (4/5)

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**Other information (2/3)**

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

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

This creates a simplified hydrogen electrode here. At the silver electrode, silver is converted into poorly soluble silver chloride by an oxidation process.

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

The silver chloride precipitates as a solid grey layer on the silver sheet, creating a silver/silver chloride electrode.



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# Other teacher information (5/5)

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**Other information (3/3)**

If you now connect the half-cells to form a galvanic cell using a voltmeter, a DC voltage of around 0.24 V can be measured when the chemical processes are reversed. (The measured values are usually slightly higher for the freshly manufactured electrode. They improve after the electrode has been stored in a 0.1 molar KCI solution for several days.) Since the hydrogen electrode forms the negative pole here, the measured potential has the sign +.

Under exact conditions, i.e. when using a platinised hydrogen electrode, at a temperature of 25°C and molarity 1 of the potassium chloride solution, the exact value of the standard potential of a silver/silver chloride electrode is +0.236 V. Once you have made such an electrode, you can use it at any time for potential measurements instead of a hydrogen electrode. Although one then obtains measured values that always deviate by a certain amount from the standard potentials, these can be easily calculated taking into account the intrinsic potential of the silver/silver chloride electrode.

# Safety instructions

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- Wear protective goggles and gloves.
- Sulphuric acid solutions of concentration c = 0.5 mol/l and potassium chloride solutions of concentration c = 1.0 mol/l have an irritant effect.
- For the H- and P-phrases please refer to the corresponding safety data sheets.
- The general instructions for safe experimentation in science lessons apply to this experiment.



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# Student information

## Motivation

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Experimental setup

In addition to the hydrogen electrode, there are other electrodes that have proven useful for making reproducible potential measurements:

The silver/silver chloride electrode and the mercury/mercury chloride electrode (also called calomel electrode). These electrodes are easier to manufacture.

In this experiment, you are to test whether they work accurately and whether they can also be used to determine standard potentials.



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# Tasks

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Make a silver/silver chloride electrode and determine its potential compared to a normal hydrogen electrode.



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# Equipment

| Position | Material | Item No. | Quantity |
|---|---|---|---|
| 1 | PHYWE Digital multimeter, 600V AC/DC, 10A AC/DC, 20 MΩ, 200 µF, 20 kHz, −20°C…760°C | 07122-00 | 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 | 2 |
| 5 | Alligator clip, insulated, 2 mm socket, 2 pcs. | 07275-00 | 1 |
| 6 | Set Strip electrode (Al, Fe, Pb, Zn, Cu) | 07856-00 | 1 |
| 7 | Emery paper, medium | 01605-00 | 1 |
| 8 | Block with 8 holes, d = 40 mm | 37682-00 | 1 |
| 9 | Coverage f.cell-meas.bloc,8 piec. | 37683-00 | 1 |
| 10 | Electrode platinum,short | 45207-00 | 1 |
| 11 | Silver foil, 150 x150 x 0.1 mm, 25 g | 31839-04 | 1 |
| 12 | Beaker, Borosilicate, tall form, 50 ml | 46025-00 | 2 |
| 13 | Bottle,wide neck,plastic,50ml | 33912-00 | 1 |
| 14 | Flat battery, 4.5 V | 07496-01 | 1 |



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# Preparation

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**Producing the required solutions**

- **Sulphuric acid (0.5 mol/l):** Pour 100 ml of distilled water into a beaker. Add 13.8 ml of 96 % sulphuric acid and fill up to 500 ml with distilled water.
- **Potassium chloride solution (1 mol/l):** Add 37.3 g potassium chloride to 250 ml distilled water. Mix well and fill up to 500 ml with distilled water.
- **Potassium nitrate solution (1 mol/l):** Add 55.5 g potassium nitrate to 250 ml distilled water. Mix well and fill up to 500 ml with distilled water.

# Set-up

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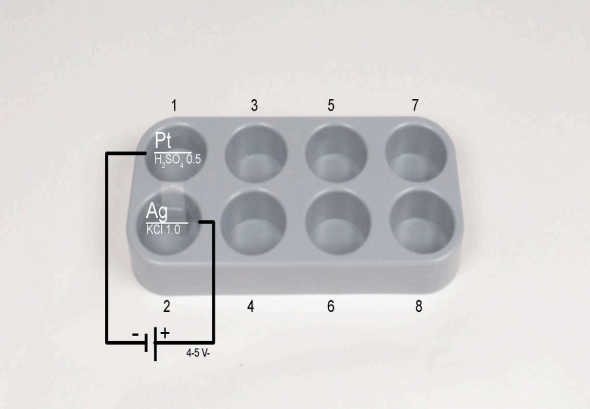
Fill measuring cell 1 with sulphuric acid (c = 0.5 mol/I), measuring cell 2 with potassium chloride solution (c = 1 mol/l) and connect both solutions with a current key made of a soaked filter paper strip (potassium nitrate solution) (fig. right).

Place lids on the cells and insert a platinum electrode into cell 1 and a silver electrode made from a strip of silver sheet (about 10 mm wide, 40 mm long) into cell 2.

Connect the electrodes to a DC voltage source (platinum electrode to the negative pole, silver electrode to the positive pole!) (Fig. right).




Fill the measuring cells



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# Procedure

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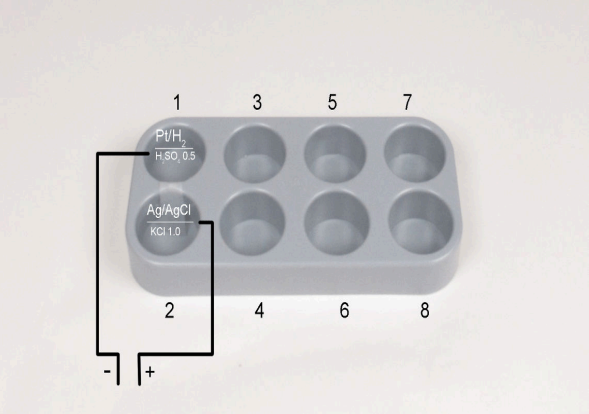
Electrolyse this cell arrangement for about 3 to 5 minutes at 4 to 5 V-. Then disconnect the connections at the voltage source and connect the measuring instrument (set measuring range 2 V-) (Fig. right).

The platinum electrode, or the hydrogen electrode that it has become, is connected to the earth socket (i.e. as the negative pole), the silver electrode to the volt socket (as the positive pole).

Measure the voltage between these two electrodes!




Measure the voltage between the two electrodes

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# Report



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## Task 1

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

- ○ The reaction equation is .
- ○ The reaction equation is .
- ○ The reaction equation is .

Check

## Task 2

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Why was an alternative to the hydrogen electrode sought?

- ○ A precisely functioning normal hydrogen electrode is always somewhat complicated to manufacture and handle. For this reason, people have been looking for simpler electrodes with which it is also possible to carry out quite good potential measurements that can be reproduced at any time.
- ○ Because it is very dangerous in its production.
- ○ Because it is very expensive to produce.
- ○ No alternative was sought.

Check



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# Task 3

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What happens at the silver electrode due to the oxidation process when the simplified hydrogen electrode is formed at the platinum electrode?

- ○ At the silver electrode, silver is converted into poorly soluble silver chloride by an oxidation process.
- ○ At the silver electrode, silver is converted into hydrogen by an oxidation process.
- ○ At the silver electrode, silver is converted into poorly soluble silver chloride by a reduction process.

Check

| Slide | Score / Total |
|---|---|
| Slide 17: Electrolysis | 0/1 |
| Slide 18: Reference electrode | 0/1 |
| Slide 19: Silver electrode | 0/1 |

**Total** 0 / 3

Solutions Repeat



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