

## The Edison accumulator

Time required: 30 min

### Aims of the experiment

- To build an Edison accumulator.
- To understand the fundamentals of accumulators.
- To understand the differences between primary and secondary cells.
- Charging and discharging processes are based on redox reactions.

### Principles

In 1908, the American inventor and entrepreneur *Thomas Edison* patented the first steel accumulator of its kind. Later, the *Edison* accumulator (nickel-iron battery) was further developed by *Waldemar Junger* from Sweden, resulting in the nickel-cadmium accumulator. Accumulator batteries belong to the class of secondary cells. The reverse reaction of a current-producing reaction is possible, and the cell can be re-charged. In contrast, common batteries belong to the class of primary cells, i.e. they cannot undergo a reverse reaction and are therefore not re-chargeable.

FeNi accumulators have found wide application. They were used in miner's lamps and in various automobiles (for example Detroit Electric). They also found applications in the field of uninterruptible power supplies. They are very insensitive and have a long lifespan. In the 1970s, they were met with competitive products such as Li-ion accumulators. Today, they are still useful in many areas.

Researchers in the USA have revolutionised and improved the *Edison* accumulator by chance. The research group developed an electrode made of nickel hydroxide on graphene. It was found that the correct counter-electrode is iron. Thus, the *Edison* has become an alternative in the meantime.

But what happens during charging and discharging in the cell?

By potassium hydroxide solution as the electrolyte, nickel and iron hydroxide emerge. During the charging cycle, nickel hydroxide reacts with hydroxide ions in an oxidation reaction. Secondly, iron hydroxide is reduced. The reverse reaction occurs during discharging. The redox reactions during charging are as follows.

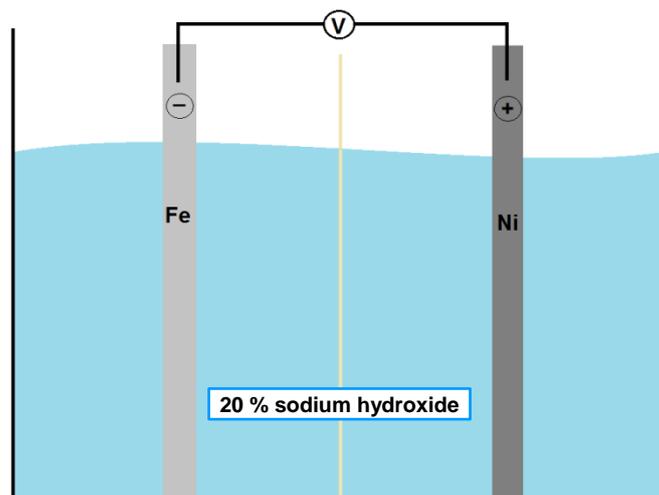
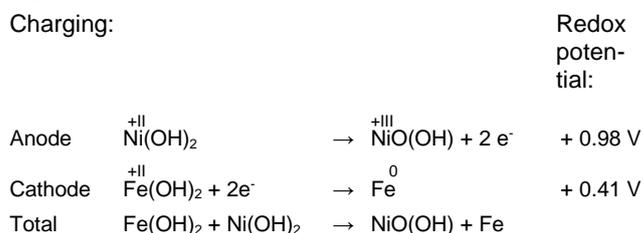


Fig. 2: Sketch of the equipment set-up, during discharging.



Fig. 1: Set-up and materials for the experiment.

## Risk assessment

Potassium hydroxide and potassium hydroxide solution are corrosive. Avoid skin contact. Wear a laboratory coat and goggles.

Potassium hydroxide	
 	<p><b>Hazard warnings:</b></p> <p>H314 Causes severe skin burns and eye damage.</p> <p>H302 Harmful if swallowed.</p> <p>H290 May be corrosive to metals.</p>
	<p><b>Safety information:</b></p> <p>P280 Wear protective gloves and goggles/face protection.</p> <p>P301 + P330 + P331 IF SWALLOWED: Rinse mouth. Do NOT induce vomiting.</p> <p>P303+P361+P353 IF ON SKIN (or hair): Remove/take off all contaminated clothing immediately. Rinse skin with water/shower.</p> <p>P305+P351+P338 IF IN EYES: For several minutes rinse continuously with water. Remove contact lenses if present and if possible to do so. Continue rinsing.</p> <p>P309+P310 IF exposed or you feel unwell: Immediately call a POISON CENTER or doctor/physician.</p>
<p><b>Signal word:</b></p> <p><b>Hazard</b></p>	

## Equipment and chemicals

1	Electrochemistry demonstration unit, CPS.....	664 4071
1	Panel frame C50, two-level, for CPS .....	666 425
1	Electrochemistry table, CPS .....	666 472
1	Electrochemistry accessories set.....	664 401
1	Electrolysis cell .....	from 664 041
1	Drip pan .....	from 664 401
2	Paper diaphragm .....	from 664 401
2	Crocodile clips.....	from 664 401
1	Grindstone .....	from 664 401
4	Connecting leads .....	from 664 401
1	Iron electrode.....	from 664 401
1	Nickel electrode .....	from 664 401
1	Beaker, 150 ml.....	602 023
1	Beaker, 250 ml.....	664 130
1	Mini magnetic stirrer.....	607 105
1	Stirring magnet.....	666 851
1	Scales .....	ADACB501
1	Measuring cylinder, 100 ml .....	665 754
1	Spoon-ended spatula, 120 mm .....	666 963
1	Watch glass dish, 125 mm .....	664 157
1	Potassium hydroxide, 250 g.....	672 6400
1	Water, pure, 1 l .....	675 3400

## Set-up and preparation of the experiment

### Set-up of the experiment

Place the demonstration unit and the electrochemistry table in the panel frame. Place the drip pan in the centre on the electrochemistry table. Fix the two half cells of the electrolysis cell with the screws so that a gap about 0.5 cm wide remains. In this gap, place two paper diaphragms one atop the other and screw the two half-cells tight. The electrolysis cell is now sealed. Now place an iron and a nickel electrode into the third

groove (see Fig. 2). If rust is visible at the iron electrode, remove it using the grindstone beforehand. Place the electrolysis cell and the drip pan in the centre of the electrochemistry table.

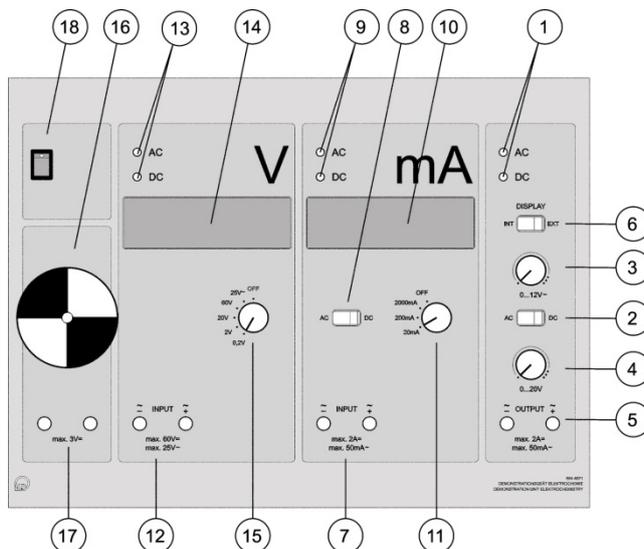


Fig. 3: Sketch of the demonstration unit.

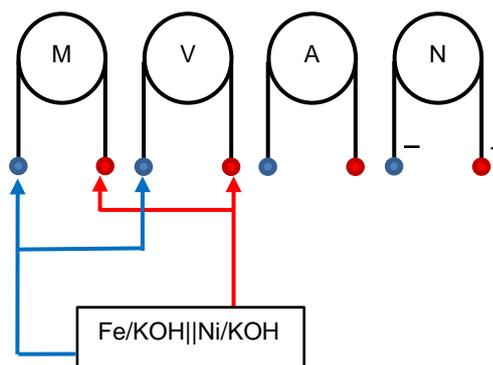


Fig. 4: Discharging circuit.

### Preparing the 20% potassium hydroxide solution

Place 120 ml of distilled water in a beaker (250 ml) with a stirring magnet (use a measuring cylinder). Weigh out 30 g of potassium hydroxide onto a watch glass dish using the scales. Place the beaker in the centre on the magnetic stirrer. Turn on the magnetic stirrer and adjust the stirrer to medium speed. Now, add the potassium hydroxide in portions using the spatula.

**CAUTION:** Do not add the flakes too quickly since potassium hydroxide dissolved in water generates a lot of heat.

Now, divide the 20% potassium hydroxide solution into two equal portions (about 70-75 ml). First, measure 70 ml in the measuring cylinder and transfer to a beaker (150 ml). Then measure another 70 ml in the measuring cylinder.

Connect the outlet jacks of the power supply (5) (see Fig. 3) to the electrodes using the connecting leads. Nickel is connected to the positive outlet and iron is connected to the negative outlet. Set the selector switch (6) to internal power source. Set the changeover switch (2) to direct current (DC) on the power supply. Also set the changeover switch (8) and rotary controller (15) to direct current (DC). Turn on the measurement display using the changeover switch (8).

## Performing the experiment

### Charging the Edison accumulator

Place the potassium hydroxide solution into the prepared electrolysis cell into both half cells. Raise the electrodes a bit in the process. Set a direct current voltage of 2V at the power supply using rotary controller (4). After 10 min the charging can be ended by turning off the demonstration unit.

### Discharging the Edison accumulator

Connect the electrodes to the output sockets of the voltmeter (12). Now set the selector switch (6) to the external power supply. Turn on the demonstration unit using the switch (18). Set a range between 2V - 20V using the rotary controller (15). First measure the voltage in the unloaded state (electromotive force) and record.

In the next step, connect the motor. Thus, connect each electrode to an outlet of the electric motor (17) (see Fig. 4). Now stop the time when the motor comes to a stop and the accumulator is discharged.

Repeat the test. During charging, apply a voltage of 3.5 V for 10 min.

### Observation

During charging, gas generation can be seen at both electrodes. During discharging, there is no gas generation. The motor turns quickly at first and slows down over time until it comes to a stop.

### Evaluation

The charging time is 10 min. The clamping voltage (EMF) is 1.3 V. The following table contains further measurement results.

Tab. 1: Measurement results of the Edison accumulator.

No.	Charging voltage	Charging time	EMF V	Discharging time
1	2 V	10 min	1.3 V	14 s
2	3.5 V	10 min	1.3 V	21 s

## Results

The *Edison* accumulator is a simple and relatively environmentally safe accumulator. The capacity of the *Edison* accumulator shown here in simplified fashion is very low in this experiment, however. After 10 min of charging, the electric motor was only able to run for 14 seconds and 21 seconds, respectively. However, modern *Edison* accumulators have shorter charging times and longer discharging times. Manufacturers do not use just one electrode each, but multiple electrodes in a very narrow space, the electrodes being shielded from one another through separators. This accumulator is well suited for the application.

## Cleaning and disposal

Potassium hydroxide solution can be disposed of in the laboratory drain with plenty of water. Dilute potassium hydroxide solution significantly with tap water first.