Measurement of the standard potential of the redox couple Fe3+/Fe2+

The students learn to deal with standard potentials. Furthermore, the term "redox couple" is examined in more detail.

Chemistry > Physical chemistry > Electrochemistry > pH & potential measurement

Difficulty level	Group size	Preparation time	Execution time
medium	2	10 minutes	10 minutes

This content can also be found online at:

http://localhost:1337/c/635520525e95bb0003701b35

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Teacher information

Application

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Experimental setup

It is known that iron(III) ions can be reduced to iron(II) ions by suitable reducing agents. The driving force of such an ionic recharge can also be measured as the standard potential of an appropriately constructed galvanic cell.

In addition to a reference electrode (e.g. standard hydrogen electrode or silver/silver chloride electrode), an electrode is needed that does not participate in the reaction between the iron ions but only serves to supply electrons, a so-called inert electrode. A platinum electrode or, as shown here in the experiment, a carbon electrode can be used as such.

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Other teacher information (1/4)

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Prior knowledge

Students should have already made a hydrogen electrode and a silver/silver chloride electrode to determine a standard potential.

Principle

With suitable reducing agents, iron(III) ions can be reduced to iron(II) ions.

Other teacher information (2/4)

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Learning objective

The students learn to deal with standard potentials. Furthermore, the term "redox couple" is examined in more detail.

Tasks

The students are to construct galvanic cells, each consisting of a reference electrode and a half cell in which a carbon electrode is immersed in a solution mixture with Fe(3+) and Fe(2+) ions. A hydrogen electrode (simplified) and a silver/silver chloride electrode are to be used as reference electrodes. The potentials of these cells are to be measured.

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Other teacher information (3/4)

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Other information (1/3)

It is known that iron(III) ions can be reduced to iron(II) ions by suitable reducing agents. The driving force of such an ionic transmutation can also be measured as the standard potential of an appropriately constructed galvanic cell. In addition to a reference electrode (e.g. standard hydrogen electrode or silver/silver chloride electrode), an electrode is needed that does not participate in the reaction between the iron ions, but only serves to supply electrons, a so-called inert electrode. A platinum electrode or, as shown here in the experiment, a carbon electrode can be used as such.

At the negative pole (hydrogen electrode or silver/silver chloride electrode), hydrogen is oxidised into hydronium ions in the presence of water, or silver is converted into silver chloride.

Other teacher information (4/4)

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Other information (2/2)

At the positive pole (carbon electrode) Fe^{3+} ions are reduced to Fe^{2+} ions.

The literature value of the standard potential of this ionic recharge is +0.771 V with respect to hydrogen and +0.535 V with respect to a silver/silver chloride electrode.

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Safety instructions

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- Wear protective goggles and gloves.
- Potassium chloride and zinc sulphate 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

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Motivation

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Experimental setup

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

One of them is the silver/silver chloride electrode, which you will work with in this experiment. You will also learn about the concept of the "redox couple".

Tasks

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Build galvanic cells, each consisting of a reference electrode and a half cell in which a carbon electrode is immersed in a solution mixture containing Fe(3+) and Fe(2+) ions.

A hydrogen electrode (simplified) and a silver/silver chloride electrode are to be used as reference electrodes. The potentials of these cells are to be measured.

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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	1
5	Alligator clip, insulated, 2 mm socket, 2 pcs.	07275-00	1
6	Block with 8 holes, d = 40 mm	37682-00	1
7	Coverage f.cell-meas.bloc,8 piec.	37683-00	1
8	Graphite electrode,d=5,l=150,6pc	44510-00	1
9	Electrode platinum,short	45207-00	1
10	Beaker, Borosilicate, tall form, 50 ml	46025-00	3
11	Dropping bottle,plastic,50ml	33920-00	1
12	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.
- **Iron(II) sulphate solution (c = 0.2 mol/l):** Add 15.2 g iron(II) sulphate to 250 ml distilled water. Mix well and fill up to 500 ml with distilled water.
- **Iron(III) chloride solution (c = 0.2 mol/l):** Add 16.2 g iron(III) chloride to 250 ml distilled water. Mix well and fill up to 500 ml with distilled water.

Set-up

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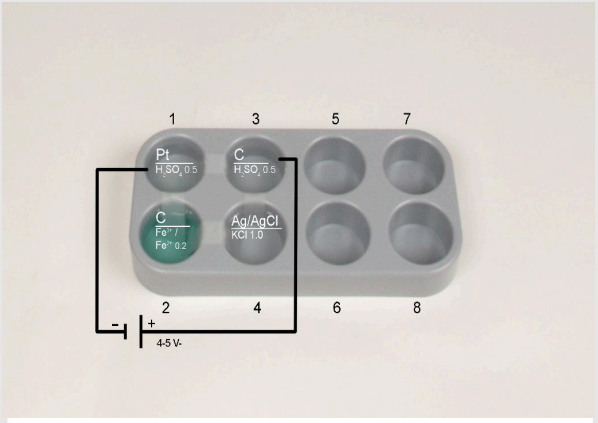
Fill measuring cells 1 and 3 of the measuring cell block with sulphuric acid (c = 0.5 mol/I), measuring cell 2 with a mixture of equal parts of an iron(II) sulphate solution (c = 0.2 mol/I) and an iron(III) chloride solution (c = 0.2 mol/l), and measuring cell 4 with potassium chloride solution (c = 1 mol/I) (fig. right).

Connect the cells with current keys made of soaked filter paper strips (potassium nitrate solution), put on lids and insert a platinum electrode into cell 1, a carbon electrode into each of cells 2 and 3 and a silver/silver chloride electrode into cell 4 (fig. right).



Fill the measuring cells

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Procedure

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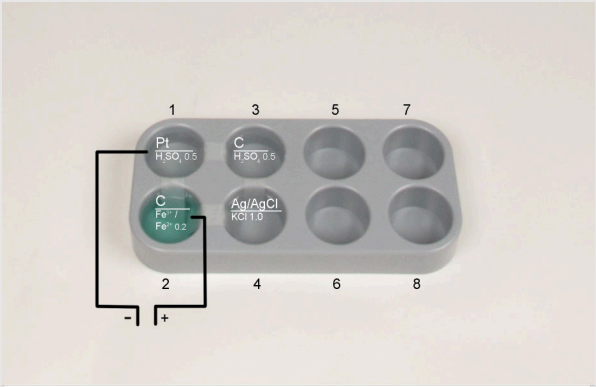
Now connect the platinum electrode to the negative pole and the carbon electrode of half cell 3 to the positive pole of a DC voltage source (flat battery 4.5 V or transformer with rectifier) and electrolyse for 3 to 5 minutes at a voltage of about 4 to 5 volts. This electrolysis is used to make a simplified hydrogen electrode in half cell 1.

Then connect the platinum electrode to the ground socket of the measuring instrument and the carbon electrode from half-cell 2 to the volt socket and read the voltage displayed on the measuring instrument. Then disconnect the connection on the platinum electrode and connect the silver/silver chloride electrode in half cell 4 instead (fig. right).



Connect the platinum electrode to the earth socket.

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Report

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Task 1

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At the negative pole (hydrogen electrode or silver/silver chloride electrode), hydrogen is oxidised into hydronium ions in the presence of water, or silver is converted into silver chloride.

What is the recation equation of the anode?

- ○
- ○
- ○

Check

Task 2

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What is reduced at the positive pole?

- ○ At the positive pole (carbon electrode), Fe3+ ions are oxidised to Fe2+ ions.
- ○ At the positive pole (carbon electrode) Fe3+ ions are reduced to Fe2+ ions.
- ○ At the positive pole (carbon electrode) Ag3+ ions are reduced to Ag2+ ions.
- ○ At the positive pole (carbon electrode), Fe2+ ions are reduced to Fe3+ ions.
- ○ At the positive pole (carbon electrode), Fe2+ ions are reduced to Fe3+ ions.

Check

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Task 3

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What is a redox couple?

- ○ A redox couple is two substances that react with each other in a redox reaction. One of the substances is oxidised and one is reduced.
- ○ A redox couple is two substances that react with each other in a redox reaction. In the process, both substances are reduced and give up electrons.
- ○ A redox couple is two substances that react with each other in a redox reaction. In the process, both substances are reduced and take up electrons.

Check

Slide	Score / Total
Slide 16: Reaction equation anode	0/1
Slide 17: Positive pole	0/1
Slide 18: Redox couple	0/1

Total 0 / 3

Solutions Repeat

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