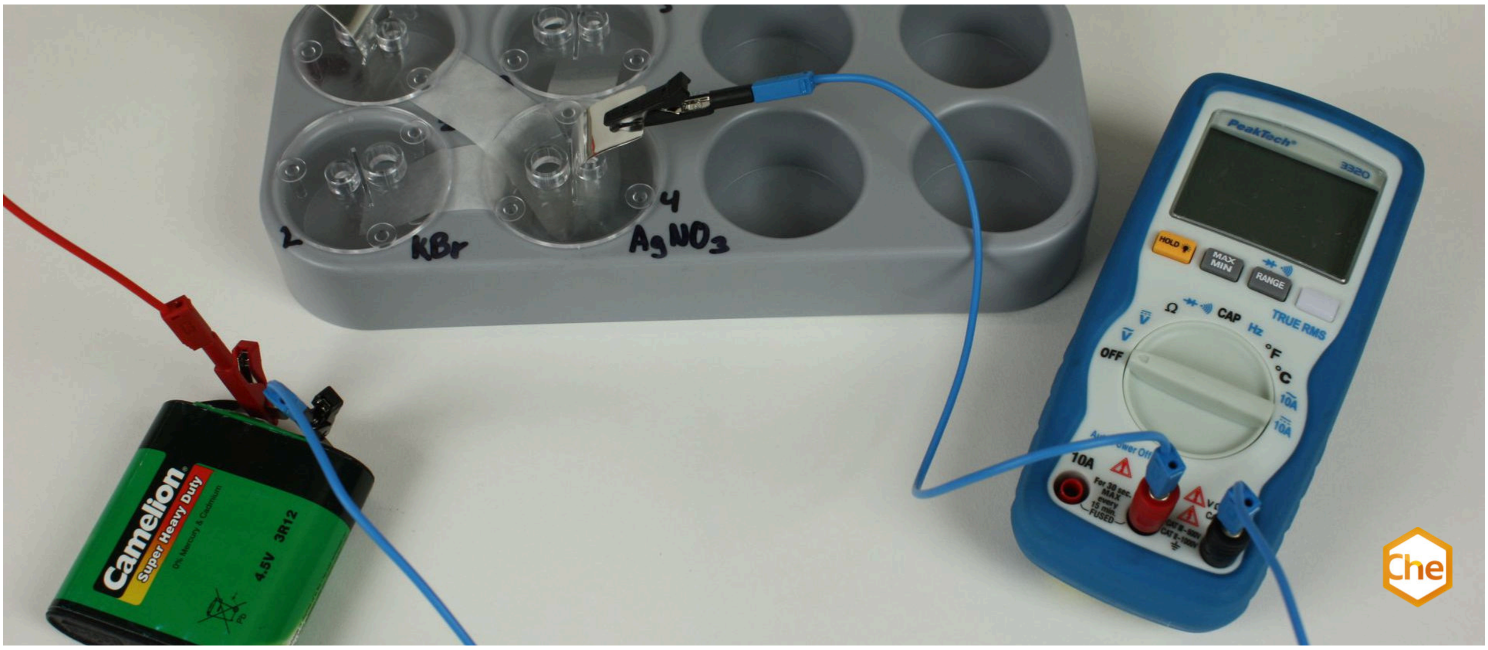
The solubility products of silver halides



Students should learn how to calculate the solubility products of the corresponding silver halides.

Chemistry > Physical chemistry > Electrochemistry > Electrochemical voltage series

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

This content can also be found online at:

http://localhost:1337/c/6378d6796f21a7000309741d

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Teacher information

Application

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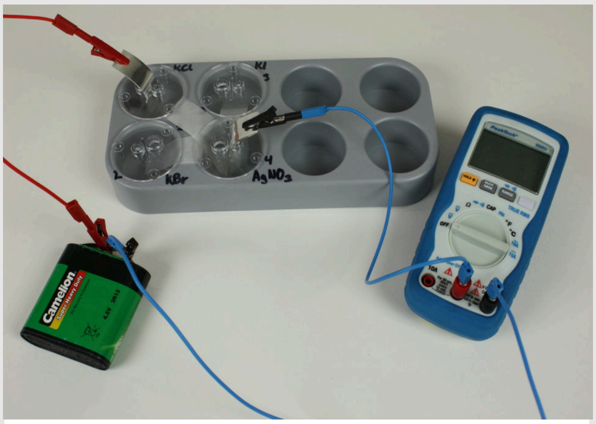

Experimental setup

If a few drops of a strongly diluted silver nitrate solution (c = 0.01 mol/l) are added to a 1 molar potassium halide solution (= KCl, KBr, KI), the corresponding silver halide (AgCl, AgBr, AgI) precipitates immediately because the solubility products of these poorly soluble salts are already exceeded by these small amounts of added silver ions. Only as many free silver ions remain in these silver halide solutions as the solubility product KL allows.

Since the relationship between concentration difference and voltage in a concentration chain follows the Nernst equation, one can calculate the solubility product or the silver ion concentration of the respective silver halide solution from the measured voltage.

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Other teacher information (1/4)

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Prior knowledge

Students should already know what concentration chains are, how their tensions are measured and how to calculate the solubility products of the precipitated silver halides.

Principle

Since the relationship between concentration difference and voltage in a concentration chain follows the Nernst equation, the solubility product or the silver ion concentration of the respective silver halide solution can be calculated from the measured voltage.

Other teacher information (2/4)

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Learning objective

The students build concentration chains from a silver half-cell with 0.01 molar silver nitrate solution (as a reference cell) and half-cells with 1 molar KCl, KBr and KI solutions in which a small amount of the respective silver halide has been precipitated by adding a few drops of silver solution. The voltages of these concentration chains are measured and the solubility products of the corresponding silver halides are calculated.

Tasks

Concentration chains are to be constructed from a silver half-cell with 0.01 molar silver nitrate solution (as a reference cell) and half-cells with 1 molar KCl, KBr and KI solutions, in which a small amount of the respective silver halide was precipitated by adding a few drops of silver solution. The voltages of these concentration chains are to be measured and the solubility products of the corresponding silver halides calculated.

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Other teacher information (3/4)

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Other information (1/2)

Since only a negligible amount of this ion type is bound compared to the initial concentration of the halide ions (c = 1 mol/l), its concentration remains practically constant despite precipitation of the silver halides; c (Hal) therefore remains = 1 mol/l.

Other teacher information (4/4)

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Other information (2/2)

This means that the solubility product is equal to the concentration of the free silver ions. If one now places a silver electrode in such a potassium halide solution saturated with silver ions, a silver half-cell with a very strongly diluted silver ion concentration can be obtained. If this half cell is then connected to another silver half cell with a known silver ion concentration (reference cell) to form a concentration chain, a voltage ΔE corresponding to the silver ion concentration difference of this chain can be measured.

Since the relationship between concentration difference and voltage in a concentration chain follows the Nernst equation, one can calculate the solubility product or the silver ion concentration of the respective silver halide solution from the measured voltage.

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Safety instructions

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- Wear protective goggles and gloves.
- Potassium bromide and potassium chloride solutions of concentration c = 1.0 mol/l have an irritant effect.
- Potassium iodide solutions of concentration c = 1.0 mol/l are harmful if swallowed, sensitisation by skin contact being possible.
- 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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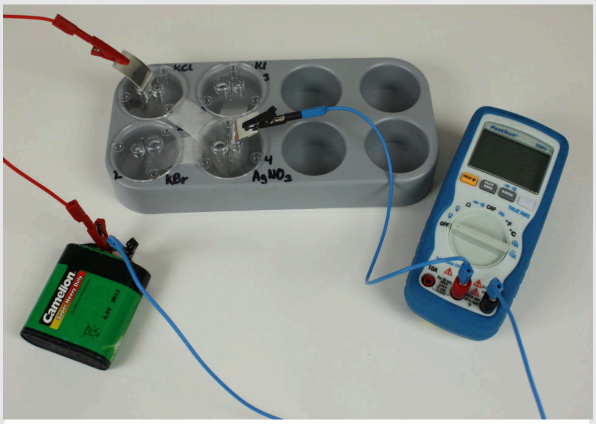

Experimental setup

In this experiment, you build a concentration chain from a silver half-cell and compare it with other half-cells to which you add silver solution and thus precipitate silver halides.

Since the relationship between concentration difference and voltage in a concentration chain follows the Nernst equation, one can calculate the solubility product or the silver ion concentration of the respective silver halide solution from the measured voltage.

Tasks

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Build concentration chains from a silver half-cell with 0.01 molar silver nitrate solution (as a reference cell) and half-cells with 1 molar KCl, KBr and KI solutions in which a small amount of the respective silver halide was precipitated by adding a few drops of silver solution.

The tensions of these concentration chains are measured and the solubility products of the corresponding silver halides are calculated.

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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	Beaker, Borosilicate, tall form, 50 ml	46025-00	4
9	Dropping bottle,plastic,50ml	33920-00	1
10	Pipette with rubber bulb	64701-00	1
11	Silver foil, 150 x150 x 0.1 mm, 25 g	31839-04	1
12	Emery paper, medium	01605-00	1
13	Set Strip electrode (Al, Fe, Pb, Zn, Cu)	07856-00	2
14	Silver nitrate sol. 0,1M 250 ml	30223-25	1
15	Potassium chloride 250 g	30098-25	1
16	Potassium bromide, 100 g	30258-10	1
17	Potassium iodide 50 g	30104-05	1
18	Potassium nitrate 250 g	30106-25	1
19	Water, distilled 5 l	31246-81	1
20	Filter paper,580x580 mm,10 sheets	32976-03	1

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Preparation

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Producing the required solutions

- **Silver nitrate solution 0.01 M:** Pour 25 ml 0.1 M silver nitrate solution into a beaker and fill it with distilled water to 250 ml.
- **Potassium chloride solution 1 M:** Put 18.64 g potassium chloride into a beaker and fill it up to 250 ml with distilled water. This will dissolve the solid in it.
- **Potassium bromide solution 1 M:** Put 29.75 g potassium bromide into a beaker and fill it up to 250 ml with distilled water. This will dissolve the solid in it.
- **Potassium iodide solution 1 M:** Put 41.5 g potassium iodide into a beaker and fill it up to 250 ml with distilled water. This will dissolve the solid in it.
- **Potassium nitrate solution 1 M:** Put 25.28 g potassium nitrate into a beaker and fill it up to 250 ml with distilled water. This will dissolve the solid in it.

Set-up (1/2)

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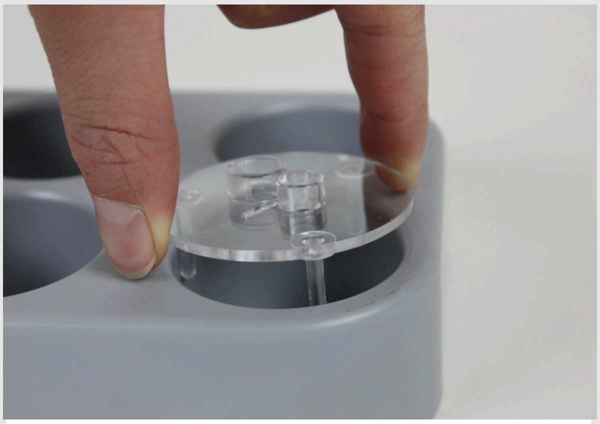
Fill cell 1 with potassium chloride solution (c = 1 mol/l), cell 2 with potassium bromide solution and cell 3 with potassium iodide solution of the same concentration.

Fill cell 4 with 0.01 molar silver nitrate solution.

Place a lid on the measuring cell 1. Measuring cell 2, on the other hand, remains open.

Add 3 to 4 drops of the 0.01 molar silver nitrate solution to each of the three halide solutions using a dropper pipette and then connect these measuring cells to measuring cell 4 using current keys (filter paper strips soaked in potassium nitrate solution).



Place the lids on the four measuring cells

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Set-up (2/2)

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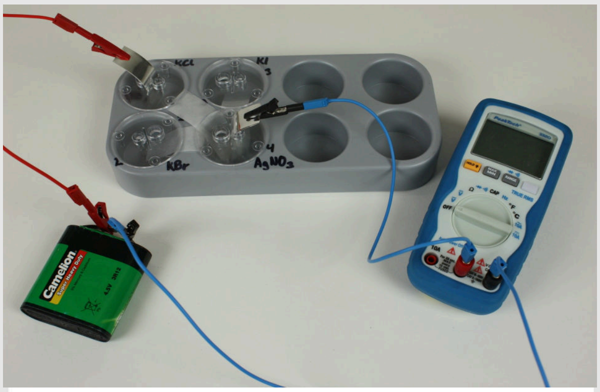
Place lids on the 4 measuring cells.

Then connect a perfectly clean silver electrode to the volt socket (= positive pole connection) of the measuring instrument and insert it into the measuring cell 4 (silver nitrate solution).

Connect a second completely clean silver electrode to the ground socket of the measuring instrument (= negative pole connection). Then insert this electrode first into measuring cell 1 (potassium chloride solution with silver chloride precipitate) and measure the voltage between half cells 1 and 4.



Measure the voltage between half cells 1 and 4.

Procedure

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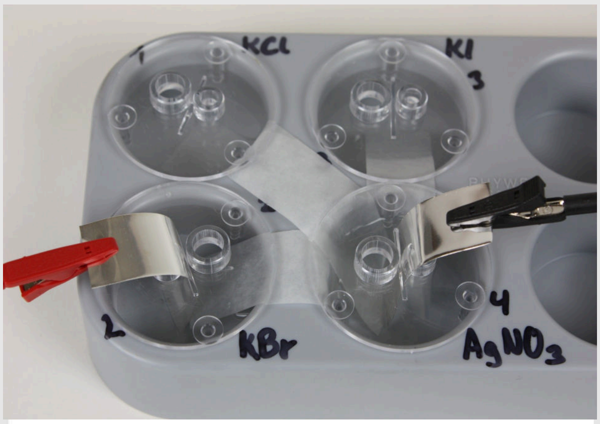
Take the silver electrode out of measuring cell 1 again, clean it carefully and then insert it into measuring cell 2 (potassium bromide solution with silver bromide precipitate) (fig. right).

Measure the voltage between half cells 2 and 4. Then proceed in the same way with half cell 3 (potassium iodide solution with silver iodide precipitate).



Measure the voltage between half-cells 2 and 4.

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Report

Task 1

What happens if you add a few drops of a very dilute silver nitrate solution (0.01 mol/l) to a 1 molar potassium halide solution?

- ○ The solution turns red due to the chemical reaction of the potassium halide solution and the silver nitrate.
- ○ The corresponding silver halide (AgCl, AgBr, Agl) precipitates immediately.
- ○ Nothing happens because potassium halide solution and silver nitrate solution do not react with each other in any way.

Check

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Task 2

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Select the equation for the solubility product.

- ○ The equation for the solubility product is .
- ○ The equation for the solubility product is .
- ○ The equation for the solubility product is .

Check

Task 3

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What happens when you place a silver electrode in a potassium halide solution saturated with silver ions?

- ○ You get a silver half-cell with a very highly concentrated silver ion concentration.
- ○ The silver electrode oxidises within a short time and can no longer be used.
- ○ None of the answers is correct.
- ○ You get a silver half-cell with a very diluted silver ion concentration.

Check

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Slide	Score / Total
Slide 17: Precipitation	0/1
Slide 18: Solubility product	0/1
Slide 19: Silver electrode	0/1

Total 0 / 3

Solutions Repeat

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