Title: Water salinity research

Topics: Water salinity research	**Time**: 90 minutes (2 lessons)	**Age**: 14 – 15 years old pupils

Differentiation:

- Gifted pupils are asked, to write down the equation of current strength dependence on concentration level (from the graph) and to define physical meaning of linear direction coefficient.
- Students who complete the work quickly are asked to work on the extension tasks provided.

Guidelines, ICT support etc.:

- Students are presented with a consistent workflow and with a list of equipment needed for this activity.
- As the results of this work among students are not known in advance, the possibility of discussion in groups arises. Analysis of results and discussion effective when the work is done in pairs or in groups of 3-5 students.
- Experimental part of the lesson can be carried out with the other available appliances, for example, with the computerised teaching system *Nova5000* (Figure 2) or *Xplorer GLX*, using electrical conductivity sensor. Then, not the current strength of the electrolyte has to be measured, but its conductivity (mS).

Equipment needed for this activity:

- Dry salt,
- Distilled water,
- Scales,
- Voltage source (battery), 4,5 V,
- Milliampere meter,
- Wires,
- A lid with 2 metal electrodes,
- 100 ml measurement cylinder,
- A glass,
- A dish for wastewater,
- A stick,
- A spatula,
- Paper towel.

Required knowledge:

- Concepts of atom, ion, molecule, electrolyte, concentration of a solution, electrical current.
- Fractions, proportions, percent calculation.

Health and Safety:

Safe handling of experimental tools and materials.

Learning outcomes for this activity:

All

- Will know the main properties of electrolytes.
- Will be able to explain the processes, taking place in aqueous solutions.
- Will be able to arrange the appliances for work according to instruction.
- Will be able to make different concentration aqueous solutions.

Most

- Will be able to draw the graph of current strength in aqueous solution dependence on dissolved salt concentration.
- From the graph, will be able to determine current strength change, i.e. graph inclination angle tangent.

Some

- Will be able to write down the equation of current strength dependence on concentration.
- Will be able to evaluate electrical conductivity of electrolytes.

Lesson description

Starter Activity

Pupils enter the classroom put away coats and bags.
Pupils are asked to recall from mathematics: fractions, (proportions), percent calculation and linear equation.
There is a discussion about the impact of salinity on river water, soil, plants, and household and industrial water installations.
Pupils are asked to explain the main properties of electrolytes and the processes occurring in them.
For most able and talented a discussion about water and soil salinity influence on man and his surroundings.

Main Activity

Pupils begin work on **Water salinity research** worksheet.
An explanation of practical is given.

Aim: To investigate the dependence of electric current of salt solution from the salt concentration.

In order to draw graph of electrical current in salt solution dependence on salt concentration $I = f(c_{\%})$, it is necessary to make a few different percentage concentration of aqueous solutions (2 %, 4 %, 6 %, 8 %, 10 %) and measure electrical current in each of them.

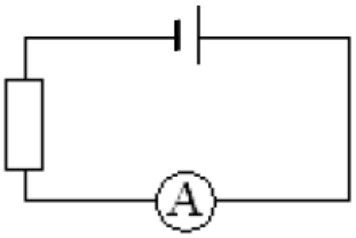


Figure 1. Electrical scheme

Percentage concentration [%] $c_{\%} = \frac{m_d}{m} \times 100\,\%$; where m_d – salt mass, g; m – the whole solution mass, g.

For measuring current strength in the solution, join the electrical circuit (Figure 1).
Carry out measurements and calculations. Record the data in the table.
Each time make $m = 100$ g different percentage concentration of salt water solution.

$$m = m_d + m_v.$$

The current strength of each solution measure exactly in the same amount of solution (in our case 100 ml solution), i.e., that the electrodes were equally submerged in the solution.

Extension

More able pupils at this point may be asked to consider any issues with the design of the experiment or they could be asked to suggest improvements.

Work sheet activity

Pupils are asked to complete the activity work sheets individually. Pupils are asked to record results, to fill in data table, decide which type of graph is most appropriate, then draw the graph, from the graph, calculate current strength change, having changed the concentration by 1% (in the graph inclination of an angle tangent is current strength change), define from the graph, what is 5 %, 7 % NaCl solution current strength.
More able pupils may be asked to write down the linear equation and to explain the linear direction coefficient.

Extension activity

Pupils who complete the work quickly are asked to work on the extension tasks provided (**Determining salt solution concentration)**.

Plenary

Pupils are asked about the procedure carried out; they are asked to consider the reason for any odd results.

Pupils are asked to make a conclusion about current strength relationship with NaCl concentration and about solution conductivity and mathematics dependence type of NaCl concentration.
With the more gifted pupils it is discussed whether this process is always linear and why deviations from the linear are possible when solution concentration is bigger.

Note

Experimental part of the lesson can be carried out with the other available appliances, for example, with the computerised teaching system ***Nova5000*** (Figure 2) or ***Xplorer GLX,*** using **electrical conductivity sensor**. Then, conductivity (ms) has to be measured not the strength of current,

Figure 2. Appliances and materials of the experiment with Nova5000

Water salinity research

Substances, dissolving in water or in another polar solvent, split, on their own, into positive charge ions - cations and negative charge ions – anions. Electrolytes are the substances, which, when dissolved or molten, conduct electric current. These properties are characteristic to acid, hydroxide and to almost all salt solutions.

It is known, that salt (NaCl) dissolving in water, molecules split into positive (Na^+) and negative (Cl^-) ions, i.e., electrolytic dissociation takes place.

$$NaCl\ (k) \rightarrow Na+\ (aq) + Cl-(aq).$$

When there is no external electric field, the molecules and the ions of the solution move chaotically. When the electric field occurs, a direct ion movement occurs as well: positive ions move towards a negative electrode, and negative ions – towards a positive one. Namely, these two opposite ion flows form the electric current in the electrolytes, and the current strength depends on solution concentration.

Conductivity is a property of a material to conduct electric current. The conductivity of a solution is defined according to the presence of dissolved inorganic salts, such as chloride, nitrate, sulphate and phosphate anions (negatively charged ions) or NaCl, magnesium, calcium, iron and aluminium cations (positively charged ions).

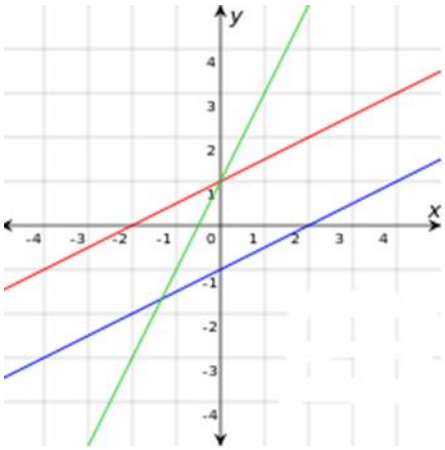
Aqueous solutions of organic combinations, such as: oil, phenol, alcohol, sugar conduct the electric current very weakly, therefore their electrical conductivity is small. As the conductivity depends on solution concentration, conductivity measurements is a good concentration indicator of the amount of dissolved solid bodies in the aqueous solution. Conductivity also depends on temperature: the conductivity of a warmer solution is bigger.

In a natural environment, the amount of salt can be relatively large both in the soil and in the water. For example, river waters are of very different salinity because of different types of soil, geological structures and saline underground water flows. The problems appear, when natural environment salinity balance changes.

Salinity is a big threat to the surface and underground water resources. Depending on the amount of salt in the soil, the growth of plants changes. Big salinity of rivers can limit the use of water in the irrigation systems, in agriculture, the supply of drinking water.

Salinity can also affect the flora of fresh water, flora, fauna and the shoreline vegetation. In the cities, water salinity decreases the exploitation time of household and industrial appliances, conditions a wider use of cleaning products and bigger expenses for surveillance.

In aqueous solutions the conductivity measurements that are usually used are *micro-Siemens for centimetre* (µS/cm) and milli-Siemens for centimetre (mS/cm).

Questions	Answers
1. What is electrical conductivity? 2. What determines the solution conductivity? 3. How is electrical conductivity of the solution measured? 4. After vaporizing saline water, 3% of salt is obtained. How much salt will be get after vaporizing 36 kg saline water? 5. Write down linear equations of the given graph. 	.

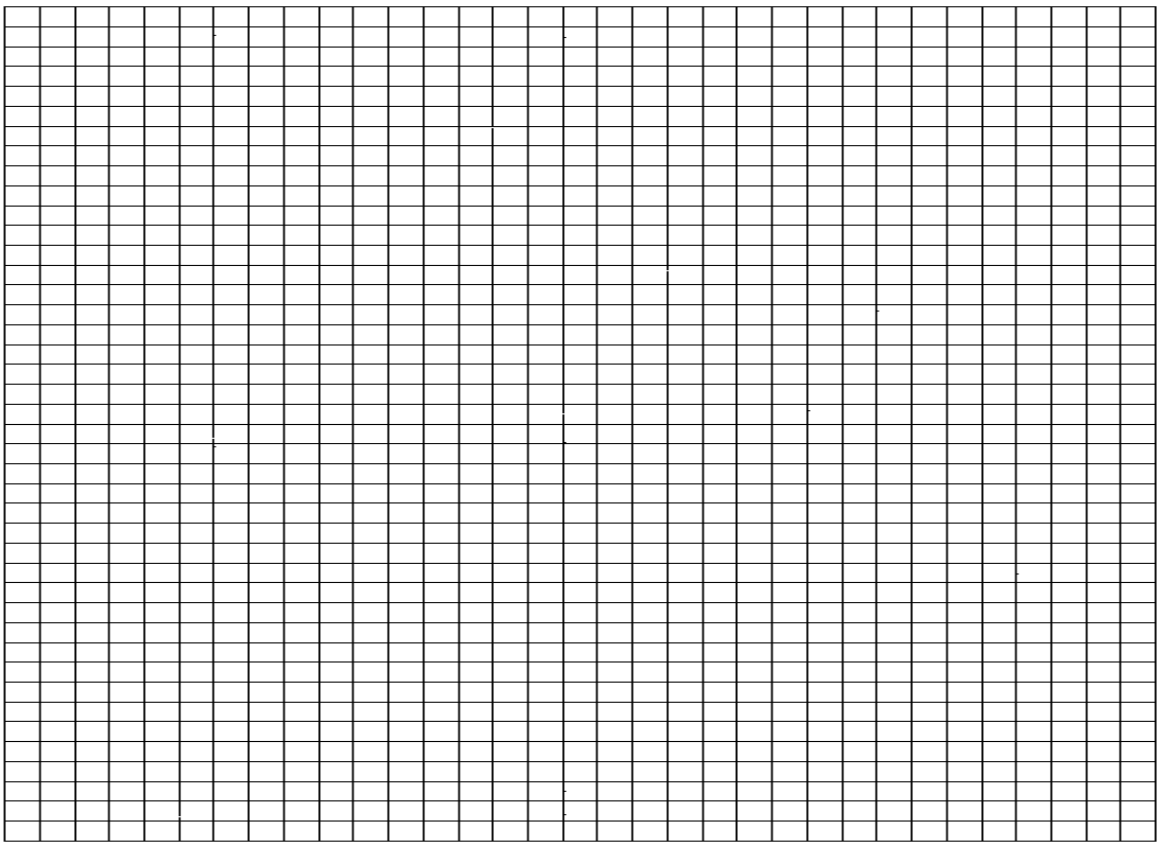
Water salinity research

Answer sheet

Enter data in the table.

Seq. No	Salt mass $m_{d,}$ g	Water mass m_v, g	Percentage concentration $c_{\%}$	Current strength I, mA
1				
2				
3				
4				
5				
6				

From the table data, draw the graph of electric current strength in the salt solution dependence on concentration $I = f(c_{\%})$.



From the graph, calculate electric current change after changing the concentration by one percent.

$\Delta I/\Delta c$ = ... mA/%.

From the graph calculate, what 5 % NaCl solution current strength is:

I (5 %) = ... mA,

From the graph define, what 7 % NaCl solution current strength is:

I (7 %) = ... mA,

In the graph, angle of inclination of a straight line tangent is the change in conductivity.

Additionally:

- From the graph, write down the equation of current strength dependence on concentration level.

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- Define physical meaning of linear direction coefficient.

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Conclusions:

- Draw a conclusion about current strength dependence on NaCl concentration:

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- Draw a conclusion about solution current strength and NaCl concentration mathematics dependency type.

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Salt solution concentration measurement

When pickling cucumbers for winter, it is necessary to prepare a salt solution. Tom and his mother, prepare 1.5 kg of salt solution, pours 3 spoons of salt into water. One spoon of salt weighs 20 g.

- What concentration salt solution does Tom‘s and his mother prepare?

Tom, trying to help his mother, prepared a bigger amount of salt solution, but during this he forgot how many spoons he had used. In the classroom, during the lesson, having measured 100 g of the produced solution, he got current strength $I_x = 150$ mA.

- From the graph of electric current strength in the salt solution dependence on concentration (draw during the lesson), define whether Tom made a suitable solution.