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Applied Sciences

Liquid Conductivity

Measuring conductivity in saline water solutions

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USA Standards Correlation

FRAMEWORK FOR K-12 SCIENCE EDUCATION © 2012

The Dimension I practices listed below are called out as **bold** words throughout the activity.

Dimension 1 Science and Engineering Practices	✓	Asking questions (for science) and defining problems (for engineering)	✓	Use mathematics and computational thinking
	✓	Developing and using models	✓	Constructing explanations (for science) and designing solutions (for engineering)
	✓	Planning and carrying out investigations	✓	Engaging in argument from evidence
	✓	Analyzing and interpreting data	✓	Obtaining, evaluating, and communicating information

Dimension 2 Cross Cutting Concepts	✓	Patterns	✓	Energy and matter: Flows, cycles, and conservation
	✓	Cause and effect: Mechanism and explanation	✓	Structure and function
	✓	Scale, proportion, and quantity	✓	Stability and change
	✓	Systems and system models		

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Dimension 3 Core Concepts	Discipline	Core Idea Focus
	Physical Science	PS1: Matter and Its Interactions
		PS1.A: Structure and Properties of Matter
		PS3: Energy
		PS3.D: Energy in Chemical Processes and Everyday Life

NGSS Standards	Middle School Standards Covered	High School Standards Covered
	MS.PS-SFIP: Structure, Function and Information Processing	HS.PS-SFIP: Structure, Function and Information Processing
	MS.PS-E: Energy	HS.PS-E: Energy

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Content Standards (K-12)			
✓	Systems, order, and organization		Evolution and equilibrium
✓	Evidence, models, and explanation	✓	Form and Function
✓	Constancy, change, and measurement		

Physical Science Standards Middle School		Physical Science Standards High School	
✓	Properties and Changes of Properties in Matter		Structure of Atoms
	Motions and Forces	✓	Structure and Properties of Matter
✓	Transfer of Energy		Chemical Reactions
			Motions and Forces
		✓	Conservation of Energy and Increase in Disorder
		✓	Interactions of Energy and Matter

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LEARNING OBJECTIVES

Core Objectives (National Standards):

- Develop the ability to refine ill-defined questions and direct to phenomena that can be described, explained, or predicted through scientific means.
- Develop the ability to observe, measure accurately, identify and control variables.
- Decide what evidence can be used to support or refute a hypothesis.
- Gather, store, retrieve, and analyze data.
- Become confident at communicating methods, instructions, observations and results with others.

Activity Objectives:

The purpose of this activity is to study the relationship between dissolved ions and the conductivity of a saline water solution, determine and interpret the molar conductivity, create a hypothesis and proceed to test it using the Globisens Labdisc conductivity sensor.

Time Requirement:

60 – 90 minutes

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Objective

The purpose of this activity is to study the relationship between dissolved ions and the conductivity of a saline water solution, determine and interpret the molar conductivity, create a hypothesis and proceed to test it using the Labdisc conductivity sensor.

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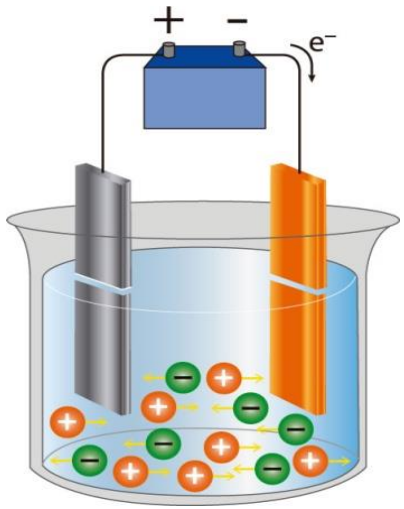
Measuring conductivity in saline water solutions

Introduction and theory

An aqueous medium is necessary from both an organic and inorganic viewpoint. We approach this aspect of nature through the study of solutions which have different characteristics in terms of their components. In particular, the electrolytic solutions have moving dissolved ions which are capable of conducting electric current in the presence of electric potential.



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Introduction and theory

Do you know some examples of conductive solutions?

Could you suggest some advantages and disadvantages of this kind of solution?

Carry out the experiment activity with your class so that at the end you'll be able to answer the following question:

What directly determines the conductivity of a solution?

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Introduction and theory

Theoretical

In ionic solutions it is important to know how easily the electric current passes i.e. conductivity. The conductivity depends on the solute's features, and on the concentration of dissolved ions which are responsible for the electric flux. Strong electrolytes are solutes that completely dissociate in a solution (HCl, NaCl, KOH) and show the general relation for electrolytes:

$$c \Lambda = k$$

Λ: Molar conductivity [mS cm^{-1} M^{-1}]
k: Conductivity [mS cm^{-1}]
c: Concentration [mol/L or M]

The molar conductivity is the proportion between the solution conductivity and its concentration.

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Introduction and theory

Now students are encouraged to raise a hypothesis which must be tested with an experiment.

How are the solution concentration and conductivity related?

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Activity description

Students measure the conductivity of a solution of distilled water with varying amounts of NaCl and will use GlobiLab software to visualize their results and carry out a preliminary analysis. They will also calculate molar conductivity of this solution and then construct a scatter plot using the EXCEL tools.

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Resources and materials

1. Labdisc Biochem
2. Beaker (500 ml)
3. Conductivity electrode
4. Stirrer bar
5. Distilled water
6. Salt

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Using the Labdisc

Labdisc configuration

To collect measurements with the Labdisc and conductivity electrode, the Labdisc must be configured according to the following steps:

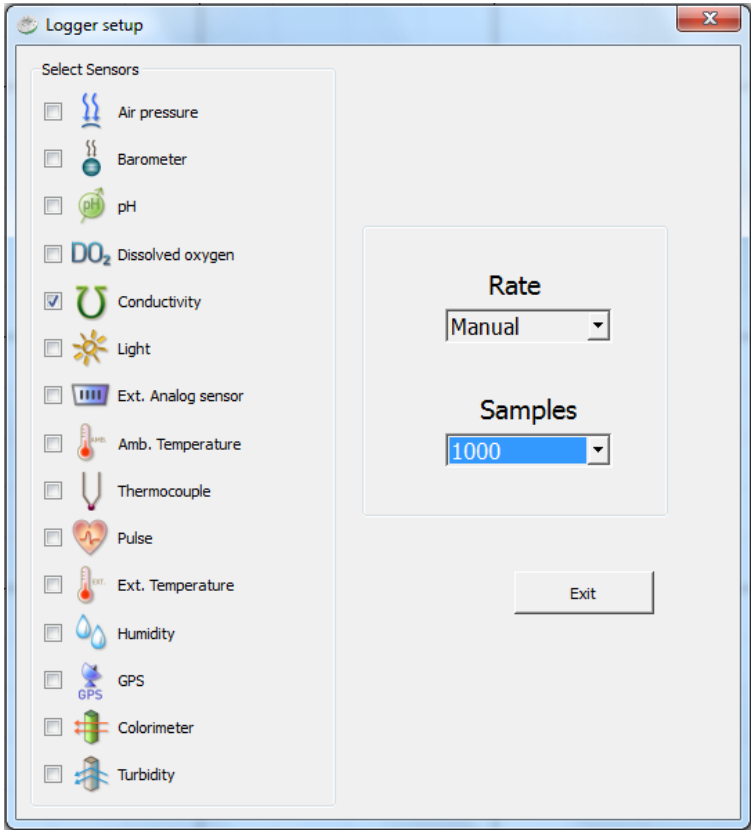
1. Open the GlobiLab software and turn on the Labdisc

2. Click on the Bluetooth icon in the bottom right corner of the GlobiLab screen. Select the Labdisc you are currently using. Once the Labdisc has been recognized by the software, the icon will change from a grey to blue color 

. If you prefer a USB connection follow the previous instruction clicking on the USB icon. You will see the same color change when the Labdisc is recognized 

.

3 Click on  to configure the Labdisc. Select pH in the “Logger Setup” window. Enter “Manual” for Rate.



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Using the Labdisc

4. Set the Labdisc display to show Bar Graph 
5. Once you have finished the sensor configuration start measuring by clicking 
6. Once you have finished measuring stop the Labdisc by clicking 

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Experiment

1. Turn on the Labdisc
2. Fill 500 ml of distilled water in the beaker and measure its conductivity (Sample 1) click on 
3. Mix 0.1 g of NaCl (Sample 2) until it dissolves completely using the stirrer bar and measure the conductivity

4 Repeat the previous step measuring saline water adding 0.05 g of salt each time. The five samples are showed in the following table:

Sample	NaCl [g]	Concentration [M]
1	0.00	0.0000
2	0.05	0.0017
3	0.10	0.0034
4	0.15	0.0052
5	0.20	0.0069

Note: the molar concentration is equivalent to [mol/L]

5 Once you have finished, stop the Labdisc

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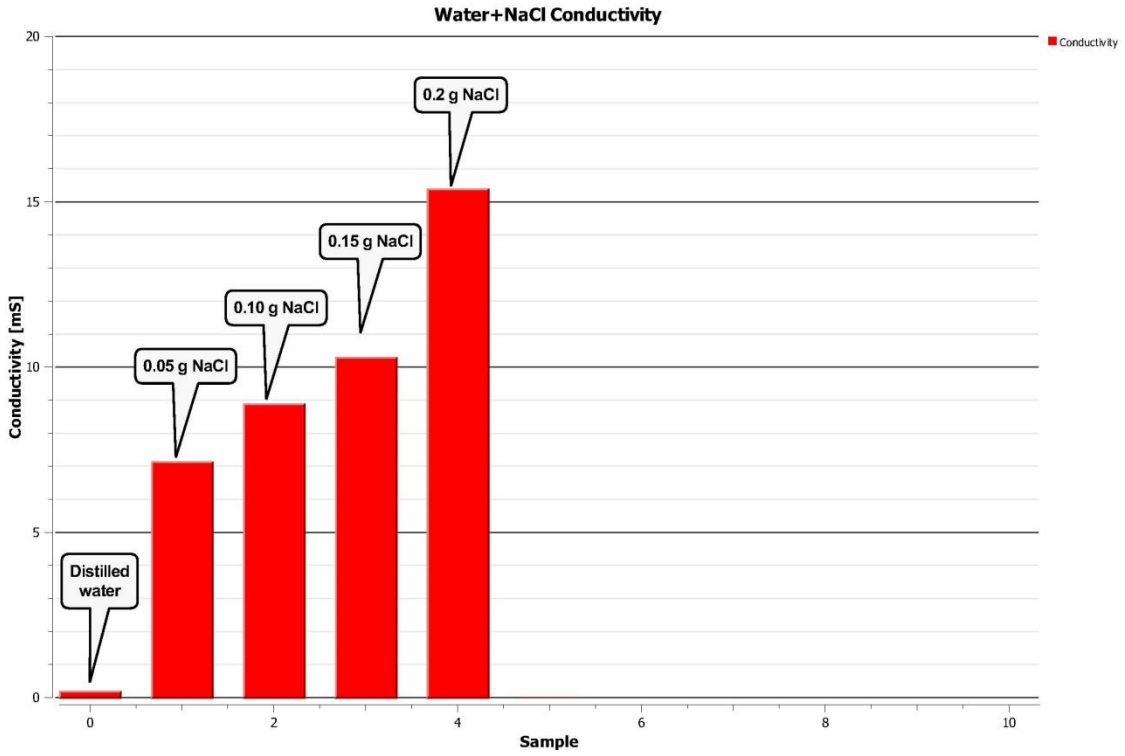
Experiment

The graph below should be similar to the one the students came up with



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1. Use the Annotation  function to annotate the Bar Graph as shown above

2. Export the data to Excel clicking on  . Save the data on your computer

3. Paste the concentration values from the previous table. Organize the data from the second sample to the last and calculate the molar concentration values in each case. Data should be organized as showed in the following table:

Sample	Conductivity [mS/cm]	Concentration [M]	Molar conductivity

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Results and analysis

4. Calculate the average molar conductivity from the four obtained values and interpret its meaning based on the units.

5. Create a line graph of conductivity as a function of concentration. To do this, first create a scatter plot and add a regressing line to the graph by right-clicking on the points and selecting “Add Trendline”. Select the linear regression type.

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Results and analysis

- Was the hypothesis proved?
- How did conductivity change with increasing salt concentration in the solution?
- What was the conductivity value of pure distilled water? Did you expect that value?
- What are the Λ units of measurement?

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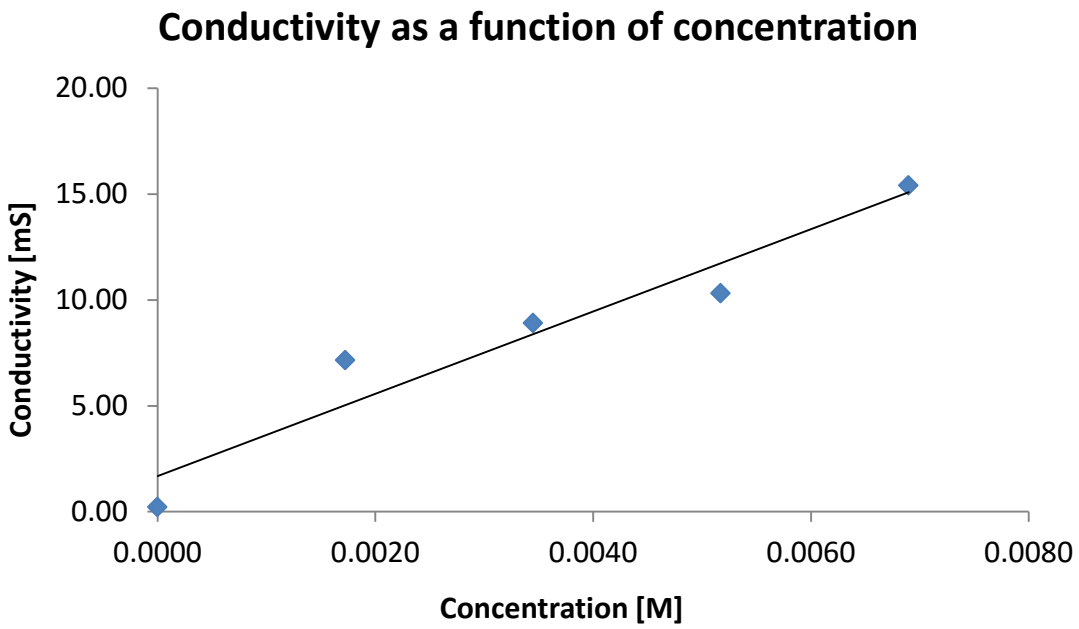
Results and analysis

The graph below should be similar to the one the students came up with:



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Conclusion

Why is saline solution conductive?

Students should point out that the salt dissociates into its Na^+ and Cl^- ions when it dissolves in water allowing the transportation of charges in the presence of an electrical potential.

Why is conductivity made higher by increasing the amount of NaCl in the solution?

Students should indicate based on the theoretical framework that increasing sodium chloride in the solution produces an increment of dissolved charge carriers that facilitate the flow of electric current.

Conclusion

How would you interpret molar conductivity?

Students should suggest that according to the units of measurement from this value, they are proportionaly constant, indicating the increased rate of the conductivity per unit of concentration in the solution.

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Activities for further application

If you wanted to monitor the purity of water, would you use conductivity as an indicator? Explain.

Students might point out that the purity of water is given by the concentration of different types of dissolved solutes. Many of them are separated into ions, such as sodium chloride, so that the conductivity reports give us an approximate value of the concentration of dissolved solutes.

If you stir a volume of distilled water with your fingers, will the conductivity vary?

Students should suggest that the excretion of salts through the skin produces a little conductivity change in distilled water.

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