Conductivity of Solutions: The Effect of Concentration – ID: 16152

By Texas Instruments

TEACHER GUIDE

Time required
45 minutes

Topic: Solutions

- *Describe the effects of ion concentration on solution conductivity.*

Activity Overview

In this activity, students dissolve different amounts of various ionic compounds in water. They measure the conductivity of the solutions as a function of ion concentration. Studnets use this data to determine the relationship between concentration and conductivity for three different salts.

Materials

To complete this activity, each student will require the following:

- *TI-Nspire™ technology*
- *Vernier Conductivity Probe*
- *Vernier EasyLink™or Go!® Link interface*
- *stirring rod*
- *ring stand*
- *electrode support*
- *safety goggles*
- *100-mL beaker*
- *distilled water in a wash bottle*
- *1.0 M NaCl solution in a dropper bottle*
- *1.0 M $AlCl_3$ solution in a dropper bottle*
- *1.0 M $CaCl_3$ solution in a dropper bottle*
- *copy of student worksheet*
- *pen or pencil*

TI-Nspire Applications

Data & Statistics, Lists & Spreadsheet, Notes

Teacher Preparation

Students should be familiar with how ionic compounds dissolve in water and what conductivity measures.

- *The screenshots on pages 2–3 demonstrate expected student results.*
- ***To download the .tns file, go to education.ti.com/exchange and enter "16152" in the search box.***

Classroom Management

- *This activity is designed to be **student-centered**, with the teacher acting as a facilitator while students work cooperatively. The student worksheet guides students through the main steps of the activity and includes questions to guide their exploration. Students may record their answers to the questions on blank paper or answer in the .tns file using the Notes application.*
- *The ideas contained in the following pages are intended to provide a framework as to how the activity will progress. Suggestions are also provided to help ensure that the objectives for this activity are met.*
- *In some cases, these instructions are specific to those students using TI-Nspire handheld devices, but the activity can easily be done using TI-Nspire computer software.*

The following questions will guide student exploration during this activity:

- How is the concentration of ions in a solution related to the conductivity of the solution?
- How does the identity of an ionic compound affect the relationship between concentration and conductivity?

Problem 1 – Preliminary Questions

Step 1: Students should open the file **07_Conductivity.tns** and read the first page. Then, they should answer questions 1–4.

Q1. When solid NaCl is dissolved in water, _____ are formed.

A. *Na^+ and Cl^- ions*

Q2. When one formula unit of $CaCl_2$ dissolves in water, how many total ions form?

A. *3*

Q3. When solid NaCl, $CaCl_2$, or $AlCl_3$ is dissolved in water, the resulting solution conducts electricity because of the presence of_____.

A. *ions*

Q4. As the concentration of an ionic compound in solution increases, the conductivity of the solution will_____.

A. *increase*

Problem 2 – Data Collection and Analysis

Step 1: Students should wear safety goggles throughout the experiment.

Step 2: Students should thoroughly clean and dry a 100-mL beaker and then add 70 mL of distilled water to it.

Step 3: Students should connect the conductivity probe to the EasyLink or Go!Link interface and then connect the interface to their handheld devices or computers. They should use an electrode support to suspend the conductivity probe from the ring stand. Students should make sure that the probe is high enough for the beaker to fit under the probe.

Step 4: Next, students move to the *Data & Statistics* application on page 2.1. A data collection console should have opened automatically when they connected the probe. Students should set the data collection to **Events with Entry** mode.

Step 5: Next, students should begin the data collection and raise the beaker so that the water completely covers the end of the conductivity probe.

Step 6: Students should record their first data point, and then lower the beaker away from the probe. Make sure students use caution when moving the beaker so that they do not jostle the probe.

Step 7: Students should add one drop of NaCl solution to the beaker and then stir it with a stirring rod to ensure that it is thoroughly mixed in.

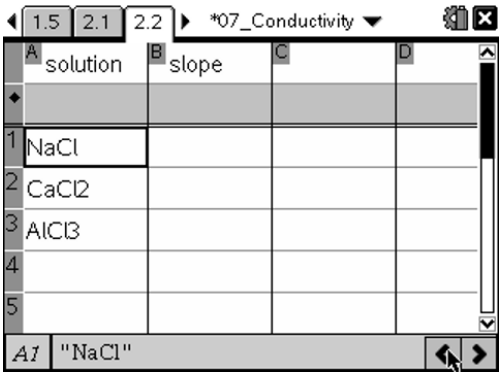
Step 8: Next, students should record another conductivity reading.

Step 9: Students should repeat the data collection until they have added 8 total drops of NaCl to the beaker.

Step 10: Once all data points have been entered, students can stop the data collection. They should keep the probe connected to the handheld.

Step 11: Next, students should analyze the data they collected. They should determine the best-fit line for their data using the **Linear Regression** tool. Then, they should record the value of the slope in the *Lists & Spreadsheet* application on page 2.2.

Step 12: Students should then move back to page 2.1 and re-start the data collection. They should be sure to store the previous run.



Step 13: Next, students should empty the beaker, wash it, dry it, and add more distilled water to it.

Step 14: Students should repeat the data collection procedure using $AlCl_3$ solution instead of NaCl solution.

Step 15: Next, students should repeat the data collection using $CaCl_2$ solution instead of NaCl solution. Make sure they wash and dry the beaker between trials. Remind students to collect the same number of data points in all three trials.

Step 16: When all data have been collected, students can compare the data sets by plotting all three sets on the graph on page 2.1.

TI-Nspire Navigator Opportunity: *Quick Poll*

Quick Poll can be used here to have students describe the plots on page 2.1. Ask students to describe the three plots in terms of their shape, and then list each plot in order of slope, from steepest to shallowest. If students have incorrectly ordered the plots, have them check to be sure that they obtained appropriate data sets.

Step 17: Students should disconnect the probe and then answer questions 5–8.

Q5. Compare the shapes and slopes of the three different curves.

A. *All three graphs should be straight lines with positive slopes. The slope of the curve for $AlCl_3$ should be the steepest; the slope for NaCl should be the shallowest.*

Q6. Describe the change in conductivity as the concentration of the NaCl solution was increased by the addition of NaCl drops. What kind of mathematical relationship does there appear to be between conductivity and concentration?

A. *It is a linear direct relationship.*

Q7. Write chemical equations for the dissociation of NaCl, $AlCl_3$, and $CaCl_2$ in water.

A. $NaCl \rightarrow Na^+(aq) + Cl^-(aq)$
$AlCl_3 \rightarrow Al^{3+}(aq) + 3Cl^-(aq)$
$CaCl_2 \rightarrow Ca^{2+}(aq) + 2Cl^-(aq)$

Q8. Which graph had the largest slope value? Which graph had the smallest slope value? Given that all solutions had the same original concentration (1.0 M), how can you explain the differences between the slopes of the three plots?

A. *$AlCl_3$ has the largest slope value, and NaCl has the smallest. The differences in slope result from the different amounts of ions produced by each formula unit of each compound. NaCl produces two ions per formula unit, so a 1.0 M solution has an ion concentration of 2.0 M. In contrast, $AlCl_3$ produces four ions per formula unit, so a 1.0 M solution has an ion concentration of 4.0 M. The higher the concentration of ions in solution, the greater the conductivity of the solution.*