

Conductivity of Solutions: The Effect of Concentration

If an ionic compound is dissolved in water, it dissociates into ions and the resulting solution will conduct electricity. Dissolving solid sodium chloride in water releases ions according to the equation:



In this experiment, you will study the effect of increasing the concentration of an ionic compound on conductivity. Conductivity will be measured as concentration of the solution is gradually increased by the addition of concentrated NaCl drops. The same procedure will be used to investigate the effect of adding other solutions with the same concentration (1.0 M), but different numbers of ions in their formulas: aluminum chloride, AlCl_3 , and calcium chloride, CaCl_2 . The Conductivity Probe will be used to measure conductivity of the solution. Conductivity is measured in microsiemens per centimeter ($\mu\text{S/cm}$).

OBJECTIVES

In this experiment, you will

- Use a Conductivity Probe to measure the conductivity of solutions.
- Investigate the relationship between the conductivity and concentrations of a solution.
- Investigate the conductivity of solutions resulting from compounds that dissociate to produce different number of ions.

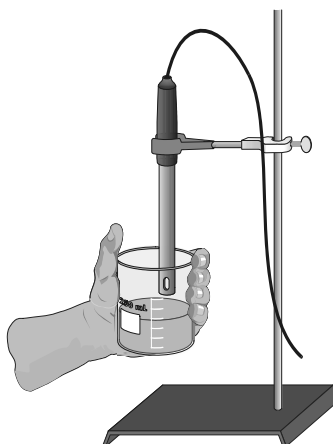








Figure 1




MATERIALS

TI-Nspire handheld or
computer and TI-Nspire software
data-collection interface
Vernier Conductivity Probe
ring stand
utility clamp
stirring rod

100 mL beaker
distilled water
wash bottle
1.0 M NaCl
1.0 M AlCl_3
1.0 M CaCl_2

PROCEDURE

1. Obtain and wear goggles.
2. Add 70 mL of distilled water to a clean 100 mL beaker. Obtain a dropper bottle that contains 1.0 M NaCl solution.
3. Set the switch on the side of the Conductivity Probe to the 0–2000 $\mu\text{S}/\text{cm}$ range. Connect the Conductivity Probe to the data-collection interface. Connect the interface to the TI-Nspire handheld or computer.
4. Choose New Experiment from the  Experiment menu. Choose Collection Mode ► Events with Entry from the  Experiment menu. Enter **Volume** as the Name and **drops** as the Units. Select OK.
5. Before adding any drops of solution:
 - a. Start data collection ().
 - b. Carefully raise the beaker and its contents up around the Conductivity Probe until the hole near the probe end is completely submerged in the solution being tested. **Important:** Since the two electrodes are positioned on either side of the hole, this part of the probe must be completely submerged.
 - c. Before you have added any drops of NaCl solution, click the Keep button (). Enter **0**, the volume (in drops) and then select OK to save this data pair for this experiment.
 - d. Lower the beaker away from the probe.
6. You are now ready to begin adding salt solution.
 - a. Add 1 drop of NaCl solution to the distilled water. Stir to ensure thorough mixing.
 - b. Carefully raise the beaker and its contents up around the Conductivity Probe until the hole near the probe end is completely submerged in the solution being tested.
 - c. Briefly swirl the beaker contents. Monitor the conductivity of the solution for about 5 seconds.
 - d. When the conductivity readings stabilize, click the Keep button (). Enter **1** as the volume in drops and then select OK. The conductivity and volume values have now been saved for the second trial.
 - e. Lower the beaker away from the probe.
7. Repeat the Step 6 procedure, entering **2** this time.
8. Continue this procedure, adding 1-drop portions of NaCl solution, measuring conductivity, and entering the total number of drops added, until a total of 8 drops has been added.
9. Stop data collection (.

10. To analyze the relationship between conductivity and volume plot the linear regression curve on your graph.
 - a. Choose Curve Fit ► Linear from the  Analyze menu. **Note:** Since increasing the volume (drops) of NaCl increases the concentration of NaCl in the solution, the graph actually represents the relationship between *conductivity* and *concentration*. The linear-regression statistics for these two lists are displayed for the equation in the form
$$y = mx + b$$
where y is conductivity, x is volume, m is the slope, and b is the y-intercept.
 - b. Record the value for the slope, m , in your data table.
11. Click the Store Latest Data Set button () to save the first run. Repeat Steps 5–10, this time using 1.0 M AlCl₃ solution in place of 1.0 M NaCl solution.
12. Click the Store Latest Data Set button () to save the second run. Repeat Steps 5–10, this time using 1.0 M CaCl₂ solution.
13. To view a graph of concentration *vs.* volume showing all three data runs, click **run3** and select All. All three runs will now be displayed on the same graph axes.
14. (optional) Print a copy of the graph displayed in Step 13. Label each run as “1.0 M NaCl,” “1.0 M AlCl₃,” or “1.0 M CaCl₂.”

DATA

Solution	Slope, m
1.0 M NaCl	
1.0 M AlCl ₃	
1.0 M CaCl ₂	

QUESTIONS

1. Describe the appearance of each of the three curves on your graph in Step 13.
2. 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?
3. Write a chemical equation for the dissociation of NaCl, AlCl₃, and CaCl₂ in water.
4. Which graph had the largest slope value? The smallest? Since all solutions had the same original concentration (1.0 M), what accounts for the difference in the slope of the three plots? Explain.