

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 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 . A computer-interfaced Conductivity Probe will be used to measure conductivity of the solution. Conductivity is measured in microsiemens per centimeter ($\mu\text{S}/\text{cm}$).

OBJECTIVES

In this experiment, you will

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

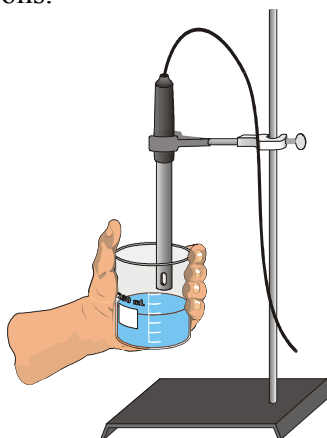


Figure 1

MATERIALS

computer
Vernier computer interface
LoggerPro
Vernier Conductivity Probe
ring stand
utility clamp
wash bottle

distilled water
100 mL beaker
1.0 M NaCl solution
1.0 M CaCl_2 solution
1.0 M AlCl_3 solution
stirring rod
tissue

PROCEDURE

1. Obtain and wear goggles.
2. Your experiment setup should look like Figure 1. The Conductivity Probe is already attached to the interface. It should be set on the 0–2000 $\mu\text{S}/\text{cm}$ position..
3. Prepare the computer for data collection by opening the file “14 Conductivity Solutions” from the *Chemistry with Vernier* folder.
4. Add 70 mL of distilled water to a clean 100 mL beaker. Obtain a dropper bottle that contains 1.0 M NaCl solution.
5. Before adding any drops of solution:
 - a. Click .
 - 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. Monitor the conductivity of the distilled water until the conductivity reading stabilizes.
 - d. Click , and then lower the beaker away from the probe. Type **0** in the edit box (for 0 drops added). Press the ENTER key to store this data pair. This gives the conductivity of the water before any salt solution is added.
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. Raise the beaker until the hole near the probe end is completely submerged in the solution. Swirl the solution briefly.
 - c. Monitor the conductivity of the solution until the reading stabilizes.
 - d. Click , and then lower the beaker away from the probe. Type **1** (the total drops added) in the edit box and press ENTER.
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 have been added.
9. Click when you have finished collecting data. Dispose of the beaker contents as directed by your teacher. Rinse the probe tip with distilled water from a wash bottle. Carefully blot the probe dry with a tissue.
10. Prepare the computer for data collection. From the Experiment menu, choose Store Latest Run. This stores the data so it can be used later, but it will be still be displayed while you do your second and third trials.
11. Repeat Steps 4–10, this time using 1.0 M AlCl_3 solution in place of 1.0 M NaCl solution.
12. Repeat Steps 4–9, this time using 1.0 M CaCl_2 solution.
13. Click on the Linear Fit button, . Be sure all three data runs are selected, then click . A best-fit linear regression line will be shown for each of your three runs. In your data table,

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record the value of the slope, m , for each of the three solutions. (The linear regression statistics are displayed in a floating box for each of the data sets.)

14. To print a graph of concentration vs. volume showing all three data runs:
 - a. Label all three curves by choosing Text Annotation from the Insert menu, and typing “sodium chloride” (or “aluminum chloride”, or “calcium chloride”) in the edit box. Then drag each box to a position near its respective curve.
 - b. Print a copy of the graph, with all three data sets and the regression lines displayed. Enter your name(s) and the number of copies of the graph you want.

DATA TABLE

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

PROCESSING THE DATA

1. Describe the appearance of each of the three curves on your graph.
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.