

# 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,  $\text{AlCl}_3$ , and calcium chloride,  $\text{CaCl}_2$ . 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.

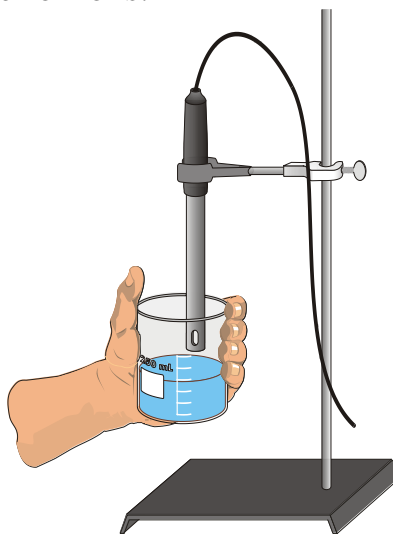


Figure 1

**MATERIALS**


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

distilled water  
100 mL beaker  
stirring rod  
tissue  
1.0 M  $\text{CaCl}_2$  solution  
1.0 M  $\text{AlCl}_3$  solution  
1.0 M  $\text{NaCl}$  solution  
1.0 M  $\text{C}_{12}\text{H}_{22}\text{O}_{11}$  sucrose solution

**PROCEDURE**

1. Obtain and wear goggles.
2. Your experiment setup should look like Figure 1. Before you start the Logger-Pro software, the Conductivity Probe is plugged into the interface device in channel 1. The square black box in the middle of the probe wire has a toggle switch. The switch 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 disposable pipet and fill the bulb with 1.0 M  $\text{NaCl}$  solution.
5. Before adding any drops of solution:
  - a. Click .
  - b. Carefully raise the beaker and its contents up around the Conductivity Probe (or lower the probe into the beaker) 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. ( This reading will be very low. If this reading is above 50, dump the water, rinse and dry the beaker, and start again.)
  - d. Click , (do not click “stop”)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. If you use your stirring rod, make sure it has been rinsed and dried before hand.
  - 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 by flushing them down the drain with running water. Rinse the probe tip with distilled water from a wash bottle. Carefully blot the probe dry with a tissue or some paper towel.
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, third, and fourth trials.
11. Repeat Steps 4-10, this time using 1.0 M CaCl<sub>2</sub> solution in place of 1.0 M NaCl solution.
12. Repeat Steps 4-10, this time using 1.0 M AlCl<sub>3</sub> solution.
13. Repeat Steps 4-9, this time using 1.0 M C<sub>12</sub>H<sub>22</sub>O<sub>11</sub> sucrose solution.

14. Click on the Linear Fit button, . Be sure all four data runs are highlighted, then click . A best-fit linear regression line will be shown for each of your four runs. In your data table, record the value of the slope,  $m$ , for each of the four solutions. (The linear regression statistics are displayed in a floating box for each of the data sets.)
15. You will need to print a graph for each person in your lab group (two or three copies depending how many are in your group). **BE SURE TO USE THE ROOM 108 LEXMARK T-630 as your printer.** To print a graph of concentration vs. volume showing all four data runs:
- Label all four curves by choosing Text Annotation from the Insert menu, and typing “sodium chloride” (or “calcium chloride” or “aluminum chloride”, or “Sucrose”) in the edit box. Then drag each box to a position near its respective curve.
  - USING THE PRINT COMMAND FOUND IN THE FILE MENU** - Print a copy of the graph, with all four sets of data points and the regression lines displayed. Enter your name(s) and the number of copies of the graph you want.

# REPORT SHEET

NAME \_\_\_\_\_ DATE \_\_\_\_\_

## DATA TABLE

Solution	Slope, $m$
1.0 M NaCl	
1.0 M AlCl <sub>3</sub>	
1.0 M CaCl <sub>2</sub>	
1.0 M C <sub>12</sub> H <sub>22</sub> O <sub>11</sub>	

## PROCESSING THE DATA

### ON YOUR OWN PAPER – NOT IN THE TINY SPACE BELOW

1. Describe the appearance of each of the four 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.
3. What kind of mathematical relationship does there appear to be between conductivity and concentration?
4. Write a balanced chemical equation for the dissociation (dissolving of salt) of NaCl, AlCl<sub>3</sub>, and CaCl<sub>2</sub> in water.
5. Write a balanced chemical equation for the dissolving of C<sub>12</sub>H<sub>22</sub>O<sub>11</sub> in water.
6. Which graph had the largest slope value among the salts?
7. Which graph had the smallest slope value among the salts?
8. How does the slope value for the sugar compare to the three salts?
9. Explain why the slope of the sugar is so low.
10. Since all solutions had the same original concentration (1.0 M), what accounts for the difference in the slope of the three salts? Explain.