Conducting Solutions

In this experiment, you will study the electrical conductivity of water and various water solutions. A solution can contain molecules, ions, or both. Some substances, such as sucrose ($C_{12}H_{22}O_{11}$) and glucose ($C_6H_{12}O_6$), dissolve to give a solution containing mostly molecules. An equation representing the dissolving of sucrose (table sugar) in water is:

$$C_{12}H_{22}O_{11}(s) \longleftrightarrow C_{12}H_{22}O_{11}(aq)$$

where (s) refers to a solid substance and (aq) refers to a substance dissolved in water. Other substances, such as calcium chloride ($CaCl_2$), dissolve in water to produce a solution containing mostly ions. An equation is:

$$CaCl_2(s) \longleftrightarrow Ca^{2+}(aq) + 2\ Cl^{-}(aq)$$

Calcium ions are necessary for muscle contraction, mitochondrial activity, bone formation, and many other metabolic processes. Organisms may obtain minerals such as calcium from their water supply, since ions dissolve in water.

You will determine conductivity of the solutions using a Vernier Conductivity Probe. In this experiment microsiemens per centimeter, μS/cm, is the unit of conductivity.

OBJECTIVES

In this experiment, you will

- Write equations for the dissolving of substances in water.
- Use a Conductivity Probe to test the electrical conductivity of solutions.
- Determine whether molecules or ions are responsible for electrical conductivity of solutions.

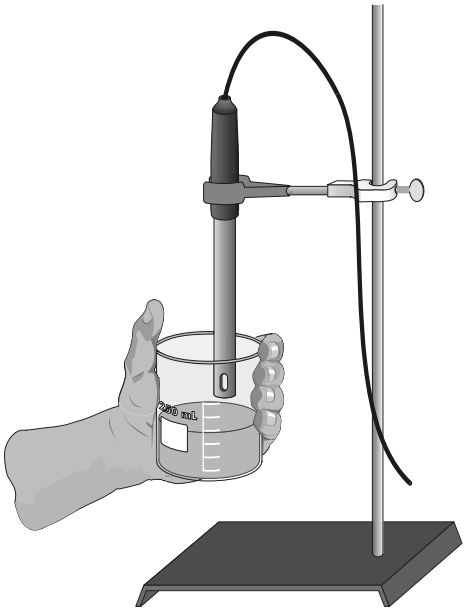

Figure 1

MATERIALS

TI-Nspire handheld **or**
computer and TI-Nspire software
data-collection interface
Vernier Conductivity Probe
sodium chloride, NaCl, solution
calcium chloride, $CaCl_2$, solution
aluminum chloride, $AlCl_3$, solution
ring stand
utility clamp
ethanol, C_2H_6O, solution
sucrose, $C_{12}H_{22}O_{11}$, solution
glucose, $C_6H_{12}O_6$, solution
stream or lake water
ocean water (optional)
various foods in solution
distilled water

PRE-LAB QUESTIONS

Many of the materials you will be using today are found in common household items. A list of common names or uses can be found below:

Sodium chloride, NaCl	Common household salt
Calcium chloride, $CaCl_2$	Used to pickle cucumbers, or to help concrete cure in cold weather
Acetic acid, CH_3COOH	Vinegar
Ethanol, C_2H_6O	Found in gasoline or in alcoholic beverages. Usually obtained from yeast fermentation
Fructose, $C_6H_{12}O_6$	Fruit sugar
Sucrose, $C_{12}H_{22}O_{11}$	Table sugar, beet or cane sugar
Glucose, $C_6H_{12}O_6$	Corn or blood sugar

1. An equation representing the dissolving of sucrose in water is:

$$C_{12}H_{22}O_{11}(s) \longleftrightarrow C_{12}H_{22}O_{11}(aq)$$

   Like solid sucrose, the substances glucose, $C_6H_{12}O_6(s)$, and ethanol, $C_2H_6O(l)$, dissolve in water to yield solutions containing mostly molecules. Write equations showing the dissolving of these two substances in water in Table 1.

2. An equation showing the dissolving of $CaCl_2$ in water is:

$$CaCl_2(s) \longleftrightarrow Ca^{2+}(aq) + 2\ Cl^{-}(aq)$$

   Like $CaCl_2$, the substances NaCl and $AlCl_3$ dissolve in water to give solutions containing mostly ions. Write equations in Table 2 showing these two substances dissolving in water.

PROCEDURE

1. Obtain and wear goggles. Secure the Conductivity Probe with the ring stand and utility clamp, as shown in Figure 1.

2. Set the selector switch on the side of the Conductivity Probe to the 0–20000 µS/cm range. Connect the Conductivity Probe to the data-collection interface. Connect the interface to the TI-Nspire handheld or computer.

3. Set up Events with Entry data collection.
   a. Choose New Experiment from the Experiment menu.
   b. Choose Collection Mode ► Events with Entry from the Experiment menu.
   c. Enter **Chemical** as the Name and leave the Units field blank.
   d. Select the Average over 10 s option. This will collect 10 seconds of data and report the average reading.
   e. Select OK.
4. Start data collection ().
5. Measure the conductivity of each solution listed in the data table. You can do the tests in any sequence.
   a. Place the Conductivity Probe into a small sample of the test solution. The hole near the probe end must be completely submerged in the solution.
   b. Once the conductivity reading has stabilized, click the Keep button (). A countdown dialog will show the 10 second data collection.
   c. Enter the name of the solution tested, and select OK.
   d. To avoid contaminating the solutions, rinse the probe with distilled water after each test. Blot the outside of the probe end dry with a tissue or paper towel. It is not necessary to dry the *inside* of the hole near the probe end.
6. Repeat Step 5 for all of your solutions.
7. Stop data collection ().
8. Click the Table View tab () to switch to Table View. Enter your results in Table 3

DATA

Table 1	
$C_6H_{12}O_6(s)$	$C_2H_6O(l)$

Table 2	
NaCl(s)	$AlCl_3(s)$

DATA (CONT.)

Table 3		
Solution	Material	Conductivity (µS/cm)
1	Distilled water	
2	Sodium chloride, NaCl	
3	Calcium chloride, $CaCl_2$	
4	Aluminum chloride, $AlCl_3$	
5	Ethanol, C_2H_6O	
6	Sucrose, $C_{12}H_{22}O_{11}$	
7	Glucose, $C_6H_{12}O_6$	
8	Tap water	
9	Stream water	
10	Ocean water	
11		
12		

QUESTIONS

1. Which solutions conduct electricity best, those containing mostly ions or those containing mostly molecules?

2. Does distilled water conduct electricity well? Explain.

3. Does tap water conduct electricity? Account for this observation.

4. Consider the conductivity readings for the NaCl, $CaCl_2$, and $AlCl_3$ solutions. What trend do you observe? Account for this trend.

5. How does the conductivity of ocean water compare to pond or stream water? How can you account for this?

6. Which foods in solution conducted electricity well? How can you account for this?

7. Suggest three other substances whose water solutions would conduct electricity well. Explain how you decided on your choices.

EXTENSION

1. Test your predictions for Question 7 above. Click the Store Latest Data Set button (🖹) before starting data collection.