

*Chemistry 51*  
**Experiment 7**  
Properties of Solutions

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**INTRODUCTION**

When a crystal of sugar dissolves in water the crystal is broken down by the water to individual molecules. These molecules are so small they cannot be detected by the eye or even with the most powerful microscope. Because they are so small they are held in suspension by water for indefinite periods of time, and also cannot be removed by filtration. Because of the molecular motion of the water and the sugar, the sugar solution remains mixed indefinitely and has the same properties throughout. A mixture of substances like this is said to be homogeneous (one kind).

The amount of sugar dissolved in a given quantity of water may be a little or a lot; sugar-water mixtures may therefore have variable compositions. Any such mixture which is homogeneous and whose composition is variable is called a solution. Sometimes the particles of a mixture are not small enough to be invisible nor small enough to be held in suspension. When the particles can be observed optically, or are large enough to settle out, the mixture is said to be heterogeneous (two or more kinds of matter), and it is not called a solution but simply a heterogeneous mixture. Sand and water or oil and water are examples of this. Occasionally mixtures are prepared in which the particles are big enough to observe optically, by making the mixture appear cloudy, but not big enough to settle out or to filter out. This intermediate type of mixture is called a colloidal "solution" or a colloidal suspension. Sometimes it is just called a suspension.

True solutions can be prepared from all possible combinations of physical states. That is, solids dissolved in liquids, liquids in liquids, gases in liquids, gases in gases, solids in solids (alloys), etc. The chemist is most often concerned, however, with solutions of solids, liquids and gases dissolved in liquids. We will restrict our study in this experiment to these types.

In this experiment you will prepare solutions under several different sets of conditions to see what factors affect the rate of dissolving, the degree of solubility of various substances and finally the properties of solutions as contrasted to heterogeneous mixtures.

**PROCEDURE**

**Part I. Factors Involved in the Preparation of Solutions from solids**

- A. Obtain 2 small (about the volume of a pea) crystals of rock salt. Grind one portion to a powder. Place this ground portion in a medium test tube and place the unground portion in another. Fill each test tube about 1/3 full with water. Stopper and shake each test tube until the salt has dissolved. Note the rates of dissolving. Save the solutions for use in Part IV.

- B. Select two crystals of rock salt of about equal size. Place each crystal in a separate large test tube and then add water to each until the test tube is about 1/2 full. Leave one test tube undisturbed, but stopper and shake the other until the crystal has dissolved.
- C. Place about 1/4 teaspoon of granular (or crushed) sugar in each of two test tubes. Fill one tube 1/2 full of cold water and the other 1/2 full of hot water. Stopper and shake both tubes.

### **Part II. Factors Involved in the Preparation of Solutions from liquids**

- A. Place a few mL of water in one test tube and a few mL of cyclohexane in a second test tube. Add about 10 drops of cottonseed oil to each test tube. Stopper, shake both tubes, and observe. Repeat this experiment using rubbing alcohol instead of the oil and then repeat again using vinegar.
- B. Using your recently acquired knowledge about the solubility of the following liquids, pour about 1 mL of each liquid into a clean test tube in such a manner as to obtain three distinctly separate layers. Before adding the three liquids into the test tube consider carefully the order in which you will add them.

Vinegar      Rubbing alcohol      Cottonseed oil

Present the test tube with the layers to the instructor along with a sketch of your observations. Label your sketch clearly. If the test tube was corked and shaken, predict which layer(s) would result and which layer would remain on the bottom (that is: which substance is more dense). Shake the test tube to verify your prediction.

### **Part III. Differences Between Solutions and Suspensions**

- A. Examine the salt solutions saved from Part I-A. Hold one of the stoppered test tubes of salt solution sideways over this experiment page and attempt to read print through it. Gravity filter (using a funnel and folded filter paper) one of the tubes of solution and pour the filtrate (the liquid which flowed through the filter paper) into a clean test tube.
- B. Place about 1/4 teaspoon of corn starch in a large test tube and fill 1/2 full with water. Stopper the test tube, shake vigorously for about a minute and then observe the result. Set the test tube aside until near the end of the period and again observe the results.
- C. Add a small amount of starch to another test tube and fill the tube about 1/2 full with water. Stopper the mixture and shake. Gravity filter the mixture and collect the filtrate in a clean test tube.

### **Part IV. Properties of solutions: Conductivity**

Solutions composed of ions are conductors of electricity. A solution with a large concentration of ions is called a strong electrolyte, if the solution has a small amount of ions and is composed of mostly molecular substances it is considered a weak electrolyte, and a solution without ions does not conduct electricity and is called a nonelectrolyte. Strong acids, strong bases, and salts are all strong electrolytes. In the following experiment, you will use a battery-operated conductivity tester to test for conductance. A bright flashing light indicates a strong electrolyte, a weak light means a weak electrolyte, and the light does not glow for a nonelectrolyte. In a spot plate, place about 10 drops of each solution (or substance) into the individual cavities. Test each substance for conductance.

1. deionized water
2. tap water
3. solid NaCl (no water)
4. 1.0 M NaCl
5. glacial acetic acid
6. 1.0 M acetic acid
7. 1.0 M HCl
8. 1.0 M NaOH
9. solid sucrose (no water)
10. 1.0 M sucrose
11. BaSO<sub>4</sub> in DI water
12. Equal volumes of 1.0 M BaCl<sub>2</sub> & 1.0 M Na<sub>2</sub>SO<sub>4</sub>

**Part V. Properties of solutions: Freezing point depression**

Salt water looks like pure water. Tasting the solution is one way to determine if the water is a pure substance or a mixture. Another way to test if a liquid is a pure substance or a mixture is to study an intrinsic property of the liquid. A pure substance will undergo a phase transition (boil or freeze) at a distinct, single temperature. A solution is composed of two or more components (or substances); the component in greater quantity is called the solvent and the minor component is called the solute. The boiling or freezing point for a solution will vary depending on the amount of solute dissolved in the solvent and the phase transition will happen over a range of degrees instead of at a single temperature. In this experiment you will study how the addition of salt (the solute) changes the property of the pure liquid (water, the solvent). Questions you will answer in this experiment include the following. What effect does the addition of salt have on the temperature of ice water? Does it matter how much salt is added to the ice water?

1. Fill a 250-mL beaker two-thirds full of crushed ice. Add water until it fills the beaker two-thirds full. Stir well. Measure and record the temperature on your report sheet.
2. Add 5.0 g salt (NaCl, sodium chloride) to the ice water mixture and stir well using a glass stirring rod to dissolve the salt. (DO NOT STIR WITH THE THERMOMETER!!!). Measure and record the temperature after 5 minutes.
3. Add 5.0 g more of salt. (Total salt is now 10.0 g.) Stir to completely dissolve. Measure and record the temperature after about 5 minutes.
4. Predict the temperature that will result when a third 5 g of salt is added. \_\_\_\_\_. To verify your prediction, add 5.0 g more salt. (Total salt is now 1.0 g.) Stir to dissolve. Measure and record the temperature after about 5 minutes.
5. On graph paper, plot grams of salt (mass) vs. temperature. Make the graph large, possibly using the entire page. Record the points collected in this experiment then draw the best-fit straight line between all of the points. Next extrapolate the temperature of the mixture if 20.0 g of salt was added: \_\_\_\_\_. Extrapolation is a process where you extend the line drawn above to the next mass value. Now verify your extrapolation by adding 5.0 more grams of salt to your solution, allow it to completely dissolve then measure and record the temperature. Attach your graph to the report sheet.

Preparation and Properties of Solutions

**Part I.** Factors Involved in the Preparation of Solutions from solids

Which sample of salt dissolved most rapidly, crushed or rock? \_\_\_\_\_

Which sample had the greater total surface exposed to the water? \_\_\_\_\_

Was the rock salt that was left undisturbed completely dissolved by the time the other one was dissolved? \_\_\_\_\_

How does agitation affect the rate of solution? \_\_\_\_\_

What effect does an increase in temperature have on the rate of solution? \_\_\_\_\_

As a summary, list three ways of increasing the rate of solution of salt in water \_\_\_\_\_

**Part II.** Factors Involved in the Preparation of Solutions from liquids

In which solvent is the oil most soluble? \_\_\_\_\_

In which solvent is the rubbing alcohol most soluble? \_\_\_\_\_

In which solvent is the vinegar most soluble? \_\_\_\_\_

Is water a polar or nonpolar molecule? \_\_\_\_\_

The general rule for the solubility of solutions is "like dissolves like". List the polar liquids in this experiment. \_\_\_\_\_

Is cyclohexane a polar or nonpolar molecule? \_\_\_\_\_

How does the structure of the solvent and/or solute influence the degree of solubility? \_\_\_\_\_

List the order of the three liquids in the test tube in section II.

Sketch the test tube containing the three liquids to the right. (Label clearly)

Top: \_\_\_\_\_  
middle: \_\_\_\_\_  
bottom: \_\_\_\_\_

Could you add the three liquids in a different order and obtain the same column with three distinct layers? \_\_\_\_\_

What did you observe after mixing the liquids and then allowing them to settle undisturbed for about 5 minutes? \_\_\_\_\_

Which of the three liquids is most dense? \_\_\_\_\_

**Part III.** Differences Between Solutions and Suspensions

Is the color and consistency of the salt solution uniform throughout the tube? \_\_\_\_\_

Has any of the salt solute settled out of solution? \_\_\_\_\_

Is the solution clear or cloudy? \_\_\_\_\_

Was any of the salt removed from the solution by filtration? \_\_\_\_\_

Is the starch-water mixture clear or cloudy immediately after shaking? \_\_\_\_\_

After standing, did any of the starch settle out of the water? \_\_\_\_\_

How do you suppose the particle size of this starch suspension varies from that of the salt solution? \_\_\_\_\_

What would you call the mixture remaining in the test tube if it had remained slightly cloudy but would not settle out? \_\_\_\_\_

Was any of the starch removed by the filtration? \_\_\_\_\_

Is any of the starch visible in the filtrate? \_\_\_\_\_

As a summary, state three physical differences between solutions and heterogeneous mixtures.

1. \_\_\_\_\_

2. \_\_\_\_\_

3. \_\_\_\_\_

**Part IV.** Properties of solutions: Conductivity

Substance	Results of Tester	Type of electrolyte (S, W, Non)
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deionized water	_____	_____
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tap water	_____	_____
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solid NaCl	_____	_____
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1.0 M NaCl	_____	_____
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glacial acetic acid	_____	_____
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1.0 M acetic acid	_____	_____
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1.0 M HCl	_____	_____
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1.0 M NaOH \_\_\_\_\_

solid sucrose \_\_\_\_\_

1.0 M sucrose \_\_\_\_\_

BaSO<sub>4</sub> in DI water \_\_\_\_\_

1.0 M BaCl<sub>2</sub> & 1.0 M Na<sub>2</sub>SO<sub>4</sub> \_\_\_\_\_

Explain the difference between the conductivities of de-ionized water and tap water. \_\_\_\_\_

What two criteria are required for the conductance of electricity? \_\_\_\_\_ & \_\_\_\_\_

What evidence was there that a chemical reaction occurred in the last cavity? \_\_\_\_\_

What type of substances are strong electrolytes? \_\_\_\_\_