

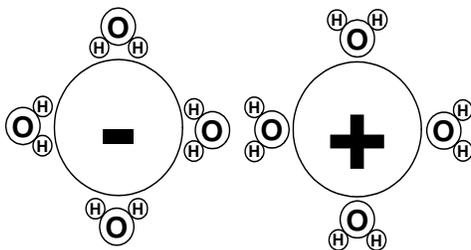
# SOLUTIONS: A Study of Solubility

## INTRODUCTION

In this experiment, four effects involving solubility will be examined. Three of these effects influence the speed with which the solvent dissolves the solute. These include circulation (shaking), the size of the particles, and the influence of temperature on the solvent. The fourth effect to be studied, the polarity differences between solvents and solutes, deals with the interactions of the polarity of the solvent with a potential solute.

Polarity in molecules is based on the electronegativity (relative attractions for electrons) of the atoms in the molecule. One way to think of electronegativity is to think of an atom with a high electronegativity liking to hold its electrons "tighter" than an atom with lower electronegativity. A useful analogy for polarity is to think of a simple magnet having a negative pole and a positive pole. Molecules composed of atoms with differing electronegativities are said to be **polar** because the atom with the higher electronegativity holds its electrons "tighter" and acts like the negative pole of a magnet while the atom with lower electronegativity acts like the positive pole. Molecules consisting of atoms with similar electronegativities are said to be **non-polar** because each atom holds its electrons equally tight so neither a negative or positive pole exists. An example of a polar solvent is water. The electronegativity of oxygen is 3.5 while the hydrogen has an electronegativity of 2.1. Therefore, the oxygen acts as the negative pole and the hydrogen acts as the positive pole. A molecule composed of carbon and hydrogen (commonly known as hydrocarbon solvents or hydrocarbons) are examples of non-polar solvents. Since the electronegativity of carbon (2.5) is similar to that of hydrogen (2.1), neither a positive pole or negative pole exists. As with any scientific investigation, a meaningful examination of each of these effects requires that only one parameter be varied at a time.

A solution results when two or more substances intermingle in a homogeneous fashion, i.e., sodium chloride ("salt") dissolves in water. The intermingling of substances occurs by various processes. Solids dissolve in liquids because the liquid molecules (the solvent molecules) attach themselves singly or in clusters to ions or molecules of the solid and carry the dissociated particle away from neighboring ions or molecules in the solid into the bulk of the solvent.



Solutions have at least two components: the solvent and one or more solutes. The solvent and solute may be solids, liquids or gases and any combination of these three. For example, alloys are solutions of solids; the atmosphere is a solution of gases; gasoline is a solution of liquid organic hydrocarbon compounds; soft drinks contain dissolved, gaseous carbon dioxide; etc. The solvent material is that component of the solution present in greatest molar quantity. In the atmosphere--78% nitrogen by volume--nitrogen serves as the solvent while all the other gases are considered to be solutes. When dissolved in tea, sugar is the solute.

The first three effects to be investigated in this experiment have an impact on the speed with which a solute dissolves into a solvent. The fourth effect regarding the polarity of the solvent on the potential solute will also be investigated. Solvents interact with solutes in several ways depending on the polarity of each. One general rule to remember is "like dissolves like". Polar solvents interact with polar solutes while non-polar solvents interact with non-polar solutes; polar won't interact with non-polar.

### SAFETY AND DISPOSAL

- Be sure to use a rubber stopper, not your finger or thumb, when shaking a solution in a test tube. Some of these solutions will stain your skin.
- Handle the iodine crystals like any other chemical, with a spatula and NOT your hands. Pure iodine crystals will not only stain your fingers, but will eat through your skin as well.
- Be careful around the hot plates! A hot plate looks the same whether it is hot or cold.
- DISPOSE OF ANY SOLUTION CONTAINING HEXANE IN THE WASTE CONTAINER PROVIDED. It will be located on the center bench and will be labeled as Waste--Hexane.

### EXPERIMENTAL PROCEDURE



will appear to remind you of potential dangers and hazards.

#### I. The Effect of Circulation

- Obtain two crystals of copper sulfate of about the same size.
- Fill two test tubes with 10 mL of water. Place a crystal of copper sulfate in each.
- Allow one test tube to stand in a holder while swirling and shaking the other. Using a stopper will facilitate vigorous shaking.
- Compare the speeds with which the crystals dissolve.

#### II. The Effect of the Size of the Particle

- Obtain two crystals of copper sulfate of about the same size.

- B. Crush one of the crystals using a mortar and pestle. Fill two test tubes with ten mL of water. Add the whole crystal to one tube and the powdered sample to the other.

- C. Stopper and shake both tubes simultaneously.
- D. Notice which tube's contents seem to be dissolving faster. Explain what you are observing.

### III. The Effect of Temperature

- A. Weigh out two samples of copper sulfate each having a mass of about 1.0 g.
- B. Fill two beakers with 50 mL of water. Add the copper sulfate to each beaker.
- C. Heat one beaker (no need to boil) and allow the other to stand.



Keep your skin, clothing, and belongings away from the hot plate even after you have turned it off! The hot plates take a while to cool off.

- D. Record your observations.

### IV. The Effect of Polarity of a Solvent

- A. Iodine
  - 1. Take two test tubes and put two or three crystals of iodine in each.



NOT handle iodine crystals with your hands!

- 2. Add 5 mL of water to one of them and 5 mL of ethanol (ethyl alcohol) to the other.
  - 3. Stopper and shake the test tubes simultaneously. Which solvent seems to be dissolving the iodine better?
  - 4. Save these solutions for part D.
- B. Vegetable oil
  - 1. Take two test tubes and put two or three drops of vegetable oil in each.
  - 2. To one tube add 5 mL of water, to the other add 5 mL of hexane.
  - 3. Stopper and shake each and observe. Which solvent dissolves the oil?
- C. Water/ Hexane ( $C_6H_{14}$ )
  - 1. Observe what happens when 5 mL of water and 5 mL of hexane are put into a test tube. (The order of addition does not matter.)
  - 2. Stopper and shake the test tube and allow it to stand for a while. What happens?
  - 3. Add a few flakes of copper sulfate to this solution and shake.
  - 4. Notice which layer contains the copper sulfate. Record your observations
- D. Hexane/ Iodine

1. To the solutions of part A add 5 mL of hexane, stopper and shake them well.
2. After allowing them to settle, describe what happens.
3. Obtain 5 mL of an iodine/water solution. Add 5 mL of hexane to this solution.
4. Stopper and shake a lot! Allow the solution to separate and make your observations.

V. Examples of the solution process (Instructor demo)

For each of the following reactions, record your observations and indicate if the reaction was exothermic or endothermic.

A. 15 mL of water is added to 25 g anhydrous  $\text{CuSO}_4$ . Record your observations.

B. 32 g of  $\text{Ba}(\text{OH})_2$  is added to 11 g of  $\text{NH}_4\text{Cl}$ . Record your observations.

**EXO-THERMIC**  
**"Outside - Heat"**

Reaction "gives off" heat

**ENDO-THERMIC**  
**"Inside - Heat"**

Reaction "absorbs" heat