MiSP Solubility L3
Teacher Guide

Introduction

In this unit students will learn about solubility. Students should already be familiar with the basic chemistry concepts. They should know that some substances are soluble in water and others are not. The unit begins with a review of solubility and terms such as *solvent* and *solute* by way of a class experiment. The experiment demonstrates three ways to decrease the time it takes to dissolve sugar in water (stirring, increasing the temperature of the solvent, and increasing the volume of the solvent). Students will also compare how quickly sugar dissolves in different solvents. On day 2 they will use data that is provided to show how temperature affects the solubility of a salt, ammonium chloride. As part of this lesson, students will review graphing (L1, L2, and L3), unit rate of change / slope (L2 and L3), and linear equations (L3). On days 3 and 4 students will conduct an experiment in which they compare the rate at which sugar and salt can be dissolved in a given amount of water.

Standards

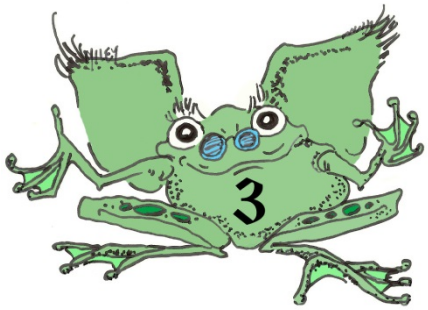
ILST Core Curriculum — Major Understandings:
Standard 4 Physical Setting 3.1a, 3.1b, 4.2e

Lesson Objectives: After completing this lesson, students will be able to:

- Define *solute*, *solvent*, *solution*, *soluble*, *insoluble*, and *solubility*
- Describe three ways to increase the rate of dissolving
- Collect data
- Create and interpret a graph depicting the change in the rate of dissolving of salt with changing temperature
- Describe how temperature changes affect dissolving rate
- Compare rate of dissolving for various solutes.

Day 1 — Observing Dissolving Rate

The lesson begins with a demonstration of factors that affect the rate at which a given substance will dissolve in a given volume of solute. In this case you should use sugar and water. Give the students Worksheet #1. Have four beakers and eight containers with 1 g of sugar available for the experiments. Add 200 ml of room temperature water to the first beaker, and ask the students to predict how long it will take to dissolve 1 g of sugar in the water. Write down the range of guesstimates. Add the sugar, start a timer, and show the students the crystals of sugar sitting at the bottom of the beaker.



Begin reviewing the concepts the students have already learned and given new, expanded definitions: *solute*, *solvent*, *solution*, *soluble*, *insoluble,* and *solubility*. Check the beaker occasionally. It will take more than 20 minutes for the sugar to dissolve.

After 10 minutes start the rest of the demonstration. Show the students that the sugar has not dissolved and ask them what you could do to speed up the rate of dissolving. They should be able to come up with the following answers: stir the water, increase the temperature, and increase the amount of water.

[Alternately, you may challenge the students to a contest. Give groups of students a large, pre-weighed (~10 g) amount of salt, sugar, or other solute of your choice and a container (all containers must be of equal size). The goal is to see which group can dissolve the most solute in a given amount of time (5–10 minutes). Have stirring rods available, as well as running hot and cold water. Let the students try to dissolve as much of the solute as possible in the specified time. At the end of the contest time have each group weigh their remaining solute. Penalties should be given for undissolved solute left in the container. The group that dissolves the most solute wins! Follow up by having the students discuss the methods they used to increase the rate of dissolving. Ask the students why this was not a scientific experiment. They should be able to recognize two problems with the experiment: 1) more than one variable was changed at the same time; and 2) final measurements were imprecise because undissolved solute already in the container could not be measured.]

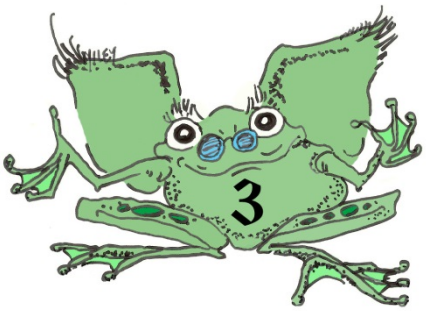
Conduct the following experiment. Divide the students into three groups: STIR, HEAT, and VOLUME. Give each group a container with 1 g sugar. The STIR group will get 200 ml room temperature water and a stirring rod. The HEAT group will get 200 ml hot tap water (measure this last). The VOLUME group will get 400 ml room temperature water. Students must wait to add sugar to their water on your signal.

(Continue to check the original sugar water beaker, and note the time when the sugar has completely dissolved.)

Have all groups add the sugar to their water and start the timer. The students must check their beaker periodically to see if the sugar crystals have dissolved. The STIR group must stop stirring every 30 seconds and let the solution settle completely to check for undissolved crystals. Students should signal to the instructor when their sugar has completely dissolved. The instructor will then check the beaker.

You should find that stirred sugar dissolves most quickly. Increasing volume will be the least effective way to speed up the dissolving rate. You can stop the experiment before the sugar in all containers is completely dissolved without loss of science content.

Have the students pour out their sugar water and rinse the beaker. Ask the question, can sugar dissolve equally well in all solvents?



Pour 200 ml of one of the following solvents into each group's beaker: water, alcohol, and mineral oil. Give each group 1 g of sugar and a stirring rod. Students should wait for your signal and then add the sugar to their solvent and begin stirring. Every 15 seconds stop all groups, let their solutions settle, and check the beaker for crystals. Note which solute dissolves first, second, and third, but you do not need to time.

Students should complete Worksheet #1 for homework.

Question of the Day:

What is the quickest way to dissolve sugar in water? Can sugar dissolve in all solvents?

Extension Question:
Explain in your own words what happens when sugar dissolves in water.

Day 2 — Solubility and Temperature

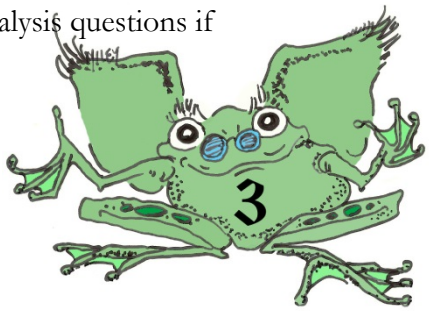
Today begin class with a quick demonstration of the effect of surface area on dissolving rate. Give half the class sugar cubes and the other half granulated sugar of equal mass. Have a race to see which group can dissolve the sugar first (in equal volumes of water with stirring).

Continue your discussion of solubility. Include a discussion of the properties of solutes and solvent that increase solubility (size of solute and solvent molecules, whether or not the molecules come apart [ionize], etc.). Also ask the students how a solute can be separated out of the solution. Show the class a beaker containing water from the beach. It should contain sand as well. This will provide the opportunity to compare soluble and insoluble materials. Ask students to brainstorm in small groups a way to separate the sand, the salt, and the water. Also ask what can be done to separate another mixture (e.g., salt, iron filings, and water).

Level 3

At level 3 students should not require guidance in the construction of the solubility curve. Questions that incorporate the idea of rate of change and slope have also been added at this level. Students are asked to calculate the rate of change between two data points. Note that the data that has been given will allow for a linear relationship to facilitate the calculation of slope. In the day 3 lab, the data will be nonlinear, allowing for a discussion of the difference between relationships. The formula for rate of change is given to the students as well, but now in terms of slope. Students will be expected to perform calculations, using data found on the data table and reading data from their constructed solubility curve. At level 3 students should use their calculations of slope to write the equation of the line they graphed. They will then use this information to extrapolate and predict the amount of solute at various temperatures. Students should also be directed to compare their extrapolations that were performed mathematically to their graph.

Students should be able to finish the graph for homework and complete the analysis questions if necessary.



Question of the Day:

Have students draw a diagram of the beaker containing sand and saltwater that was used earlier in the class. Given a word bank on the board, students will identify the solvent, the solute, and the solution. Which material is soluble? Which is insoluble?

Using the graph you finished in Worksheet #2, write an equation for the line. Depending on student ability, you may provide the formula for the class.

Days 3 and 4 — Solubility Lab

Overview:

In this lab the students will compare the dissolving rate of salt and sucrose in water at room temperature. They will do this comparison by collecting data on the time needed to dissolve each substance one gram at a time in the water. Solubility is the total amount of a certain substance that can dissolve in a specific amount of solvent at a given temperature. This is difficult to measure because determining the end amount before saturation is a difficult process. You should explain to the students that they are not measuring solubility.

Objective:

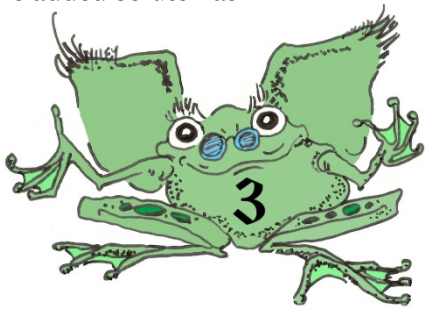
- To collect and record data
- To construct a dissolving rate curve
- To compare dissolving rate curves of two solutes

Materials (per group):

- 2 - 500 ml beakers
- Cup/container
- Sugar and kosher salt measured in 1 gram amounts (pill cups make good containers)
- Stirring rod
- Stopwatch

Procedure:

Students should work in groups of two to four. Have each group of students test both solutes. Students will follow the lab worksheet. They will add the solute, 1 gram at a time, to the water. Each gram must be totally dissolved before the next is added, and the students will keep a running log of total number of minutes needed to dissolve 1, 2, 3, and 4 grams of each solute in the 100 ml of water. They will dissolve by stirring for 15 seconds, after which they will stop and let the solution settle so they can check for undissolved solute in the bottom of the beaker. If the added solute has



not totally dissolved, they should continue stirring for additional 15-second intervals until all of the added solute is dissolved. Then they can add the next gram of solute. Salt should dissolve within 3 minutes and sugar will take about 5 minutes.

When all of the data are collected, the students should be directed to graph their results, plotting the grams of solute on the *x*-axis and the time on the *y*-axis. The amount of direction given will depend on the level; less direction should be needed because the students now have practice from Worksheet #2. In this experiment, solute is added in discrete amounts but will dissolve as a continuous series of amounts of solute. Therefore, it will be appropriate to draw a best-fit line through the data points for each solute. The students should add a key to distinguish the different solute lines on the graph. The students can then compare the line as a linear function.

Day 5

Administer the appropriate level assessment.