Solubility

How is the quantity of solute in a saturated solution determined?

Why?

When we add salt to a pot of boiling water or sugar to a pitcher of iced tea, we expect that the added solute will completely dissolve. It requires a large quantity of these solutes to saturate a solution. On the other hand, water has flowed over rock riverbeds for centuries and only dissolved enough material in some cases to provide a trace of certain minerals in the water. Different solutes, such as salt, sugar, or minerals, dissolve to very different extents in water (and other solvents). In this activity you will learn how to quantify the amount of solute that is dissolved in a saturated solution.

Model 1 – Three Solutions

The following data refer to three experiments in which solute is added to water in a beaker at 20 °C. The mixtures are stirred and then allowed to sit for three hours before measuring the amount of solid that dissolves. Ten separate trials are conducted for each experiment. The same solute is used in all three experiments.

	Experiment 1 In 10.0 g water		**Experiment 2 In 20.0 g water**		**Experiment 3 In 50.0 g water**	
Trial	Mass of solute added (grams)	Mass of solute dissolved (grams)	Mass of solute added (grams)	Mass of solute dissolved (grams)	Mass of solute added (grams)	Mass of solute dissolved (grams)
1	1.0	1.0	1.0	1.0	3.0	3.0
2	2.0	2.0	2.0	2.0	6.0	6.0
3	3.0	3.0	3.0	3.0	9.0	9.0
4	4.0	3.6	4.0	4.0	12.0	12.0
5	5.0	3.6	5.0	5.0	15.0	15.0
6	6.0	3.6	6.0	6.0	18.0	18.0
7	7.0	3.6	7.0	7.0	21.0	18.0
8	8.0	3.6	8.0	7.2	24.0	18.0
9	9.0	3.6	9.0	7.2	27.0	18.0
10	10.0	3.6	10.0	7.2	30.0	18.0

1. Identify the variable(s) that were controlled among all three experiments in Model 1.

2. What variable(s) were changed purposefully among the three experiments in Model 1?

3. What experimental question can be answered by analyzing the data in the three experiments in Model 1? Use the words "solvent" and "solute" in your question.

4. In each of the three experiments in Model 1, determine the point in the experiment that the beakers became saturated. Draw a box around the entire section of data in each experiment that represents saturated solutions.
5. Consider the data in Model 1.
   a. Which experiment shows the largest mass of dissolved solute in the saturated solutions?

   b. Propose an explanation for why the mass of dissolved solute changed among the three experiments.

Read This!

Solubility is a measure of the maximum amount of solute that can dissolve in a given amount of solvent at a specific temperature. In other words, it is the ratio of solute to solvent in a saturated solution at a specific temperature. Solubility is typically reported as grams of solute per 100 g H_2O. For example, if a maximum of 20.4 g of table sugar (sucrose) will dissolve in 10.0 g of water at 20 °C, then the solubility of sucrose would be 204 g sucrose/100 g H_2O.

6. Would it be acceptable for a student to use Trial 2 from Experiment 1 to determine the solubility of the solute in Model 1? Explain your group's answer in a complete sentence.

7. In Model 1 none of the experiments used 100 g of water. Use complete sentences to explain how the ratio "grams of solute per 100 g H_2O" can be calculated from the data given in Model 1.

8. Use the data in Model 1 to calculate the solubility of the solute (at 20 °C) for all three experiments. Show your work.

   Experiment 1: Experiment 2: Experiment 3:

9. Circle the word or phrase that best completes each of the statements below.

   a. When the volume of solvent increases, the mass of solute that can dissolve in a saturated solution (increases/decreases/stays the same).

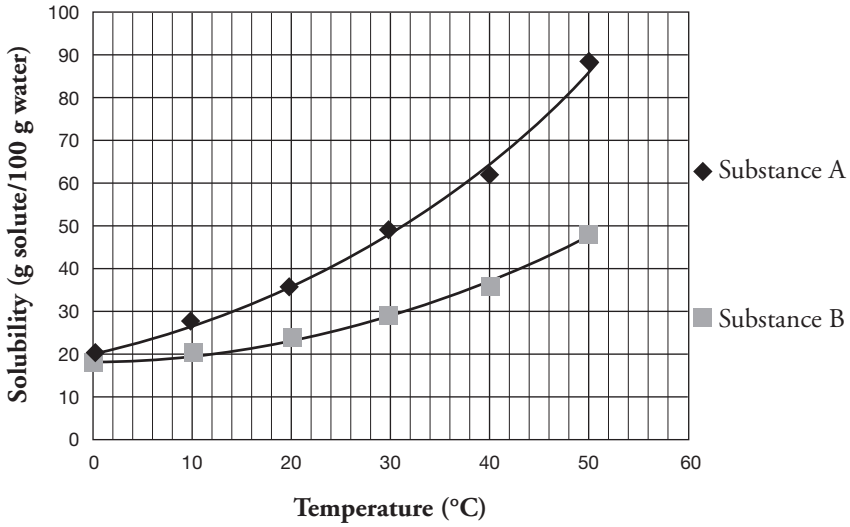
   b. When the volume of solvent increases, the solubility of a solute at a given temperature (increases/decreases/stays the same).

10. A student claims, "In Experiment 3, Trial 9, 18.0 grams of solute dissolves, whereas in Experiment 1, Trial 9, only 3.6 grams of solute dissolves. Obviously, the solubility is greater in Experiment 3." With your group, devise a well-constructed response.

11. Calculate the mass of the solute used in Model 1 that is needed to make a saturated solution in 140.0 g of water without leaving any solid solute at the bottom. Show your work.

Extension Questions

Model 2 – Solubility Curves



12. According to the graph in Model 2, what is the solubility of Substance A at 30 °C?

13. Describe the trend in solubility for Substances A and B in Model 2 as temperature increases.

14. If a saturated solution of Substance A in 100.0 g of water is cooled from 30 °C to 10 °C, what mass of solid solute would crystallize out? Show your work.

15. If a saturated solution of Substance B in 50.0 g of water at 30 °C is warmed to 50 °C, what mass of solute would need to be added to make the solution saturated again?