Activity: Solubility Curves



Background: Read This!

Solubility is a measure of the amount of solute that will dissolve in a given amount of solvent - usually water. A solubility curve shows how much solute dissolves in a given volume of a solvent at a given temperature. How much sugar dissolves in a cup of hot coffee? How much salt can dissolve in cold water? What if warmer water were used? Chemists use this type of information when preparing solutions. Solutions are combinations of two or more substances that exist together in a homogeneous mixture.

Learning Objectives:

- Determine solubilities based on information presented in table format.
- Distinguish solubility trends between solids and gases with changes in temperature.

Vocabulary:

Solute
Solvent
Solution
Solubility
Saturated
Unsaturated
Supersaturated

Thinking Questions:

1.) Which vocabulary term in the list above applies to a sponge that is dry?

2.) Which vocabulary term in the list above applies to a sponge that is soaked?

3.) Can you add more water to a sponge that is already soaked?

MODEL 1: Solubility Data

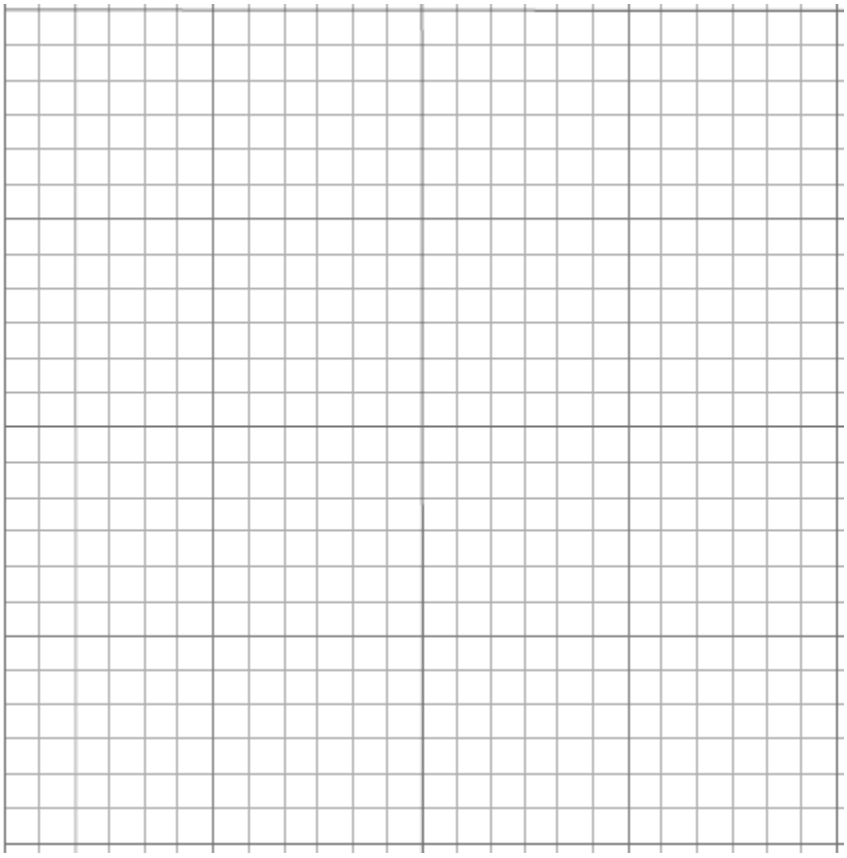
Table 1. Solubility Data

Temperature (^{o}C)	Solute (g) per 100 g of H_2O (l)
10	33
30	42
50	52
70	62
90	73

Task:

Complete a graph on the next page by doing the following:

- Using the grid on the next page, make a graph of the solubility data in Table 1. **USE A PENCIL!!**
- Plot Solute (g) per 100 g of H2O (l) (y-axis) vs. temperature ^{o}C (x- axis).
- Create appropriate scales for each axis



Model 1 Questions:

1. What information is provided by the data in Table 1?

2. What is the relationship between temperature and solubility for this solute?

3. What will happen to this solute when 12 g is added to 100 g of water at 20oC?

4. A(n) _____ *(unsaturated, saturated, or supersaturated)* solution is obtained when 12 g of this solute is added to 100 g of water at 20^{o}C.

5. At 20^{o}C, what is the maximum amount of this solute that can be dissolved in 100 g of water?_____ g

6. A(n) _____ *(unsaturated, saturated, or supersaturated)* solution is obtained when the maximum amount of a solute is dissolved in water.

7. At 20^{o}C, 50 g of this solute is added to 100 g of water. What will happen to the extra solute?

8. A(n) _____ *(unsaturated, saturated, or supersaturated)* solution is obtained under the conditions given in Question #7.

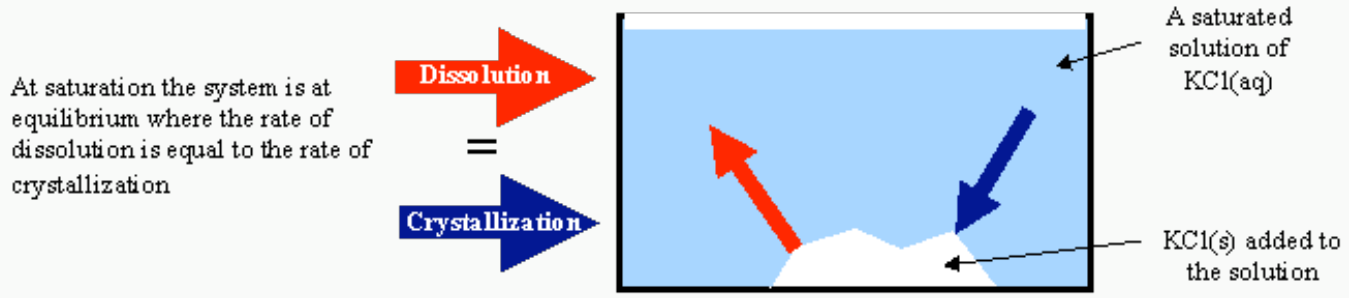
MODEL 2: Saturated Solutions & Equilibrium

In a **saturated solution** of KCl(aq), **at constant temperature**, with **excess KCl(s)**, the following occur:

Forward reaction (dissolving or "dissolution"): $KCl(s) \rightarrow K^+(aq) + Cl^-(aq)$

Reverse reaction (precipitating or "crystallization"): $K^+(aq) + Cl^-(aq) \rightarrow KCl(s)$

At equilibrium: $KCl(s) \leftrightarrow K^+(aq) + Cl^-(aq)$



If a solution is saturated with solute, then there is an equilibrium between dissolved and un-dissolved solid. To maintain this condition, the temperature must be held constant.

Model 2 Questions:

1. A saturated solution that contains some of the solid solute at the bottom of the container is called a solution equilibrium system. An example of solution equilibrium with table sugar (sucrose) is shown by the equation below.

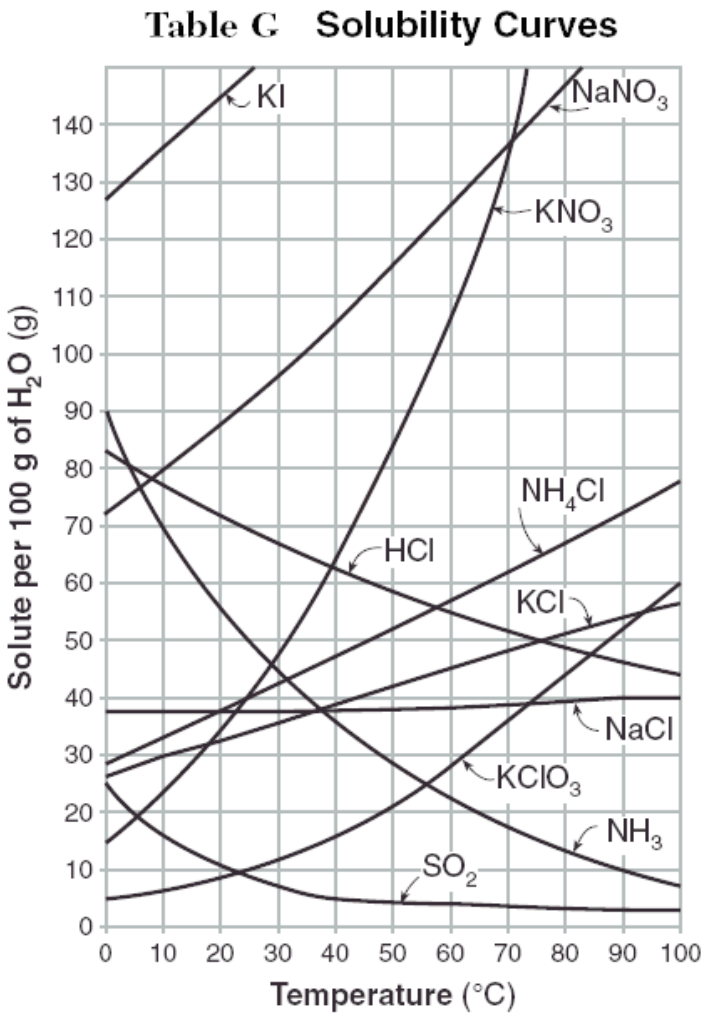
$$C_{12}H_{22}O_{11}(s) \xleftrightarrow{water} C_{12}H_{22}O_{11}(aq)$$

What do you see in this equation that indicates this is a dynamic equilibrium system?

2. When we report the "solubility" of a substance at a certain temperature, we are telling how much solute is needed to "saturate" the solvent at that temperature. What is the amount of the solute from Model 1 (p. 2) needed to have "solution equilibrium" in 100 grams of 60oC water?

g

MODEL 3: Reference Table G



Model 3 Questions:

1. Compare the graph you made in Model 1 to the curves on Reference Table G. Which of the solutes on Table G is the solute from your graph?

2. Identify the most soluble substance shown on Table G, at a temperature of 60°C.

3. Identify the least soluble substance shown on Table G, at a temperature of 10°C.

4. What is the difference between the solubility curve for NH_3 and the one for NH_4Cl? (Note that NH_3 is a gas at room temperature and NH_4Cl is a solid.)

5. What are the other two gas solutes shown on Table G?

6. Claudette mixes 35 grams of KNO_3 in 100 grams of 40°C water. Is the solution saturated, unsaturated, supersaturated? How do you know?

7. Bob mixes 65 grams of KI in 50 grams of 10°C water. Is the solution saturated, unsaturated, supersaturated? How do you know?

8. 60 grams of NH_4Cl are dissolved in 100 grams of 90°C water to make an unsaturated solution. How much more NH_4Cl will need to be dissolved to make the solution saturated?

9. Use Table G to determine how many grams of $NaNO_3$ will precipitate from a saturated solution of $NaNO_3$ when it is cooled from 80°C to 10°C?

10. Every day Jenn walks in to Dunkin' Donuts and orders either a medium iced coffee with four sugars, or a medium hot coffee with four sugars. She notices that the iced coffee is never as sweet as the hot coffee, even though both have four sugars in them. Why do you think this happens, in terms of solubility?

11. Ryan would like to make rock candy. The recipe calls for 200 grams of sugar dissolved into 100 grams of water. After mixing these ingredients together, Ryan notices a small pile of sugar still on the bottom of the pan. Based on your knowledge of solubility, what should Ryan do to get all of the sugar dissolved?