Types of Solutions: Saturated, Supersaturated, or Unsaturated

Resource ID: **CM5L3** Grade Range: **9–12**

SECTIONS

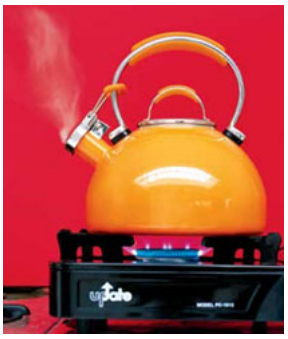
Unsaturated, Saturated, and Supersaturated Examples

The next time you add sugar to unsweetened tea, take notice of the changes to the solution in the following scenarios.

Source: Iced Tea, Renee Cornet, Wikimedia Commons

1. You add the first packet of sugar, and stir until it all dissolves with no sugar settled on the bottom.
2. You add a second packet of sugar and it takes a little more time for the sugar to dissolve. After stirring for a minute, you realize that there are still some sugar crystals at the bottom of the glass.
3. After tasting your tea, you decide it is still not sweet enough and add more sugar. However, it all settles at the bottom, and regardless of how much you stir, the crystals stay at the bottom of the cup.

What can you do to help the sugar crystals dissolve?



Source: Kang Kim, Real Simple

Did you think about heating up the tea? You are right! Heating up the tea (or most any solution) will help the sugar dissolve more. However, it is Texas, and most of us like to drink cold tea in the summer, not hot. Add ice to make your now sweetened tea cold again. Will the sugar stay dissolved? Yes!

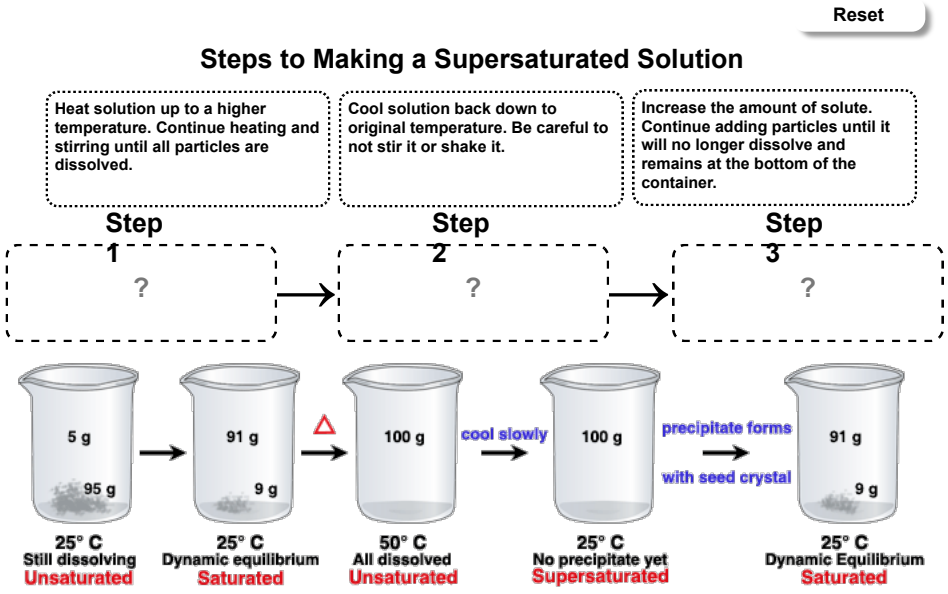
In each of the three steps above, you created one of the following types of solutions: saturated, unsaturated, and supersaturated.

Interactive Exercise Identify which type of solution was created in each step.

Steps for Sweetening Iced Tea	Type of Solution
1. Add one packet of sugar. All of the sugar crystals dissolved with none settled on the bottom.	Feedback:
2. Add second packet of sugar. Not all of the sugar crystals dissolved and a few settled on the bottom.	Feedback:
3. Add third packet of sugar. None of the sugar crystals dissolved and all settled on the bottom. To dissolve the sugar, you do the following: a. Heat up the tea to dissolve the sugar. b. Cool it back down so you can drink it.	Feedback:

A supersaturated solution is one that has more solute than it can hold at a certain temperature. Typically when the temperature of a solution is increased, more particles can be dissolved, thus increasing the amount of solute. A supersaturated solution goes through all of the steps listed above for the iced tea.

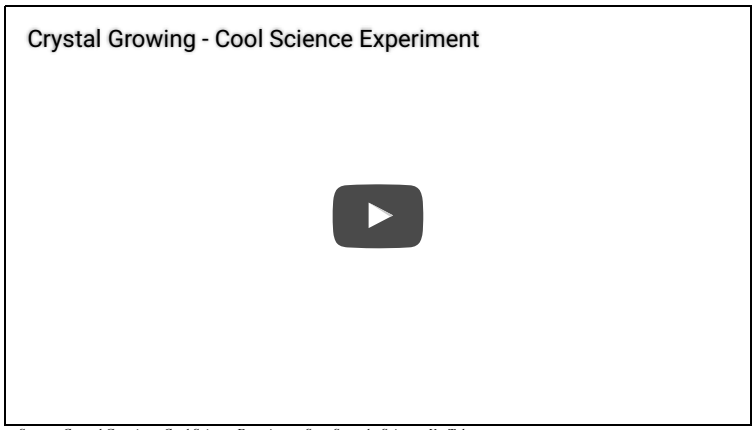
Interactive Exercise Drag and drop the steps below to create a supersaturated solution (use the picture below to help guide you).



Remember, a supersaturated solution will look just like an unsaturated solution with no solute settled at the bottom. However, there is more solute than the solvent can actually hold. Any slight change to the solution will cause all of the solute to come out.

Now you know how to make a supersaturated solution, but why, outside of chemistry class or making really sweet iced tea, would you want to do this?

Video Segment Watch the video below and use your notes to answer the following questions.



Source: Crystal Growing - Cool Science Experiment, SteveSpanglerScience, YouTube

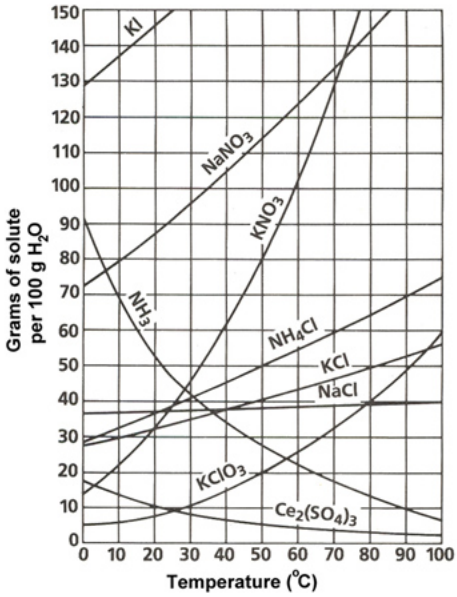
1. What two commercial applications of supersaturated solutions are sold at stores like Wal-Mart?
   Check Your Answer

2. The liquid inside reusable hand warmers will crystalize over time. However, they can be reheated in the microwave and go back to the liquid form. Explain why the crystals form and why reheating the hand warmers "removes" the crystals.
   Check Your Answer

It is important to know that the terms saturated, unsaturated, and supersaturated are relative terms. As the temperature of the solution changes, so does the amount of particles that can be dissolved in the solvent. Solubility curves show how changing the temperature changes the solubility of particles in a solvent.

How to Read a Solubility Graph

Solubility curves or solubility graphs typically look like the one shown below. This shows the solubility of many different ionic compounds.



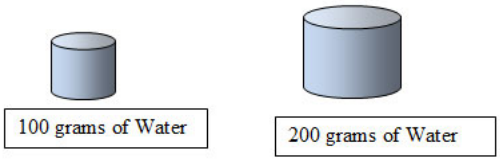
Source: Solubility Chart, Sasketchewan Schools

This solubility graph has a lot of information on it. Let's walk through this graph to understand it better. Use your notes to answer the following questions:

1. What is the label of the x-axis?
   Check Your Answer

2. What is the label of the y-axis?
   Check Your Answer

3. If the graph displayed the amount of H_2O per 200 grams instead of 100 grams, how would the amount of solute to be dissolved change? (See hint below.)

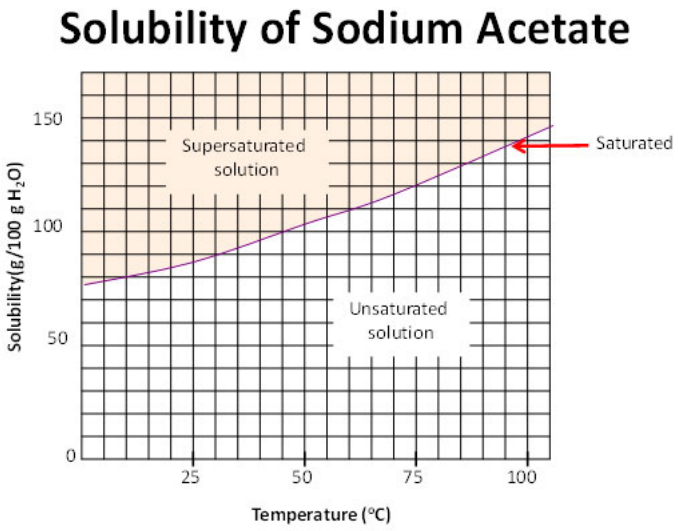


   Check Your Answer

4. Describe the general trend in solubility of the salts shown on this graph.
   Check Your Answer

5. NH_3 is the exception to this trend. NH_3 is gaseous ammonia. Why do you think it has the opposite trend of the other compounds?
   Check Your Answer

Now let's take a closer look at how to read a solubility curve.



Source: Solubility curve, Pennsylvania Dept of Education

Trace the solubility of a substance with increasing temperature.

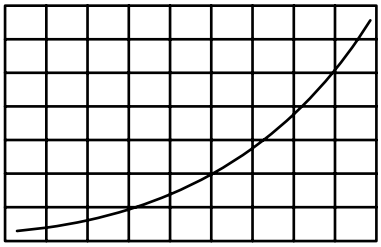
- The curved line represents **saturation**.
- **Below** the curve, the solution is **un**saturated.
- **Above** the curve the solution is supersaturated. This means there is more solute than the solution can hold.

The solution can be classified as the following:

- Saturated if crystals remain at the bottom of the container
- **Super**saturated if no crystals remain at the bottom of the container

Practice Reading a Solubility Graph—Part 1

Solubility of Potassium Chlorate, $KClO_3$

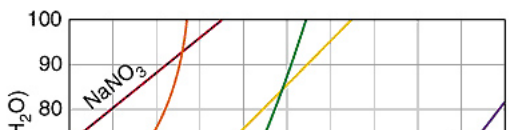


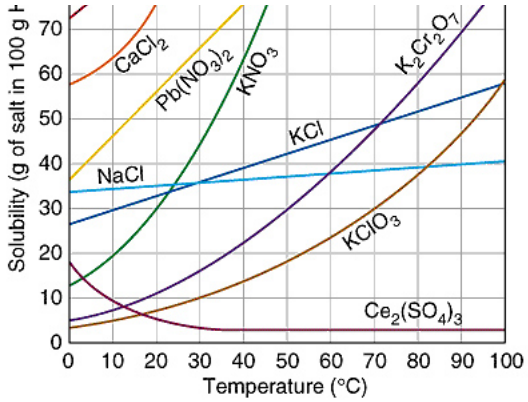
Need a Hint?

Check Your Answer

Practice Reading a Solubility Graph—Part 2

Use the same skills to read a solubility graph with multiple compounds shown.





Source: National Archives and Record Administration

Sample Reading of the Solubility Table

At 20°C, 34 grams of KCl will just saturate 100 grams of H_2O. The solubility of KCl at 20°C is 34 grams NaCl per 100 grams H_2O.

1. A solution of potassium chlorate, $KClO_3$, has 20 grams of the salt dissolved in 100 grams of water at 70 °C. Approximately how many more grams of the salt can be added to the solution before reaching the saturation point?
   A. 60 grams
   B. 30 grams
   C. 10 grams
   D. 80 grams

2. At approximately what temperature does the solubility of sodium chloride, NaCl, match the solubility of potassium dichromate, $K_2Cr_2O_7$?
   A. 60 °C
   B. 30 °C
   C. 83 °C
   D. 50 °C

3. Which salt is LEAST soluble at 50 °C?
   A. KNO_3
   B. $K_2Cr_2O_7$
   C. $KClO_3$
   D. $Ce_2(SO_4)_3$

4. Which of these salts **decreases** in solubility as the temperature **increases**?
   A. $K_2Cr_2O_7$
   B. $Ce_2(SO_4)_3$
   C. $KClO_3$
   D. KNO_3

5. A beaker containing 80 grams of lead(II) nitrate, $Pb(NO_3)_2$, in 100 grams of water has a temperature of 30 °C. Approximately how many grams of the salt are undissolved on the bottom of the beaker?
   A. 66 grams
   B. 80 grams
   C. 14 grams
   D. 20 grams