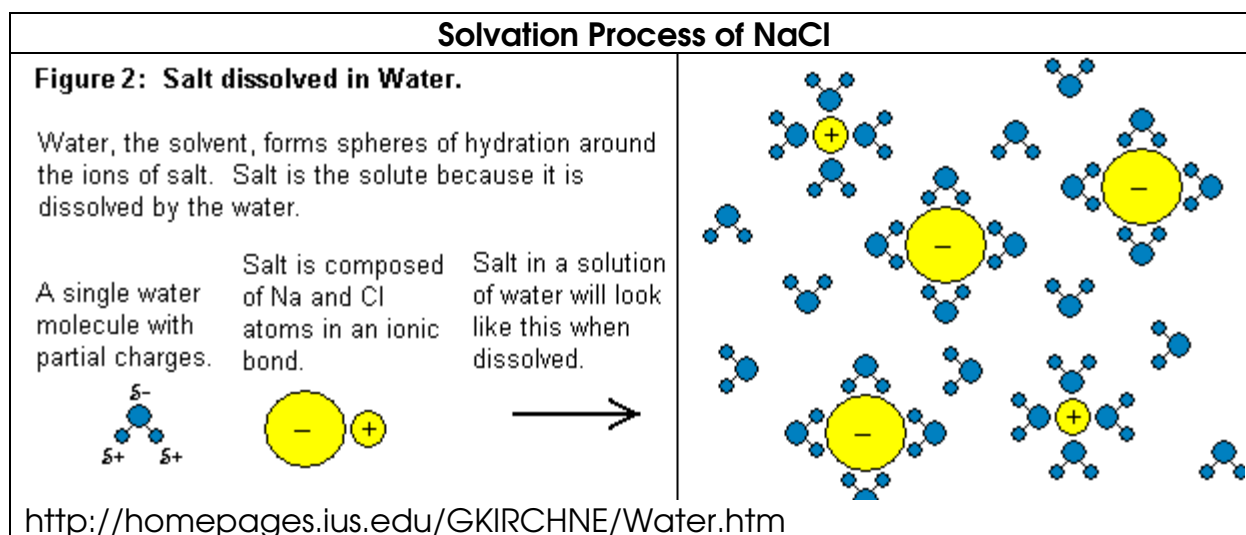


Title: Solubility Curve of Potassium Nitrate in Water

Background:

Solutions are homogeneous mixtures of **solvents** (the larger volume of the mixture) and **solutes** (the smaller volume of the mixture). For example, a hot chocolate is a solution, in which the solute (the chocolate powder) is dissolved in the solvent (the milk or water). The solute and solvent can be either a solid, liquid or a gas. A solution forms when the attractive forces between the solute and the solvent are similar. For example, the ionic or polar solute, NaCl, dissolves in water, a polar solvent. The phrase "like dissolves like" has often been used to explain this.

As the water molecules collide with the ionic compound (NaCl), the charged ends of the water molecule become attracted to the positive sodium ions and negative chloride ions. The water molecules surround the ions and the ions move into solution. This process of attraction between the water molecules (the solvent) and the ionic compound (NaCl, the solute) is called **solvation**. Solvation continues until the entire crystal has dissolved and all ions are distributed throughout the solvent.



Some solutions form quickly and others form slowly. The rate depends upon several factors, such as, the size of solute, stirring, or heating. When making hot chocolate, we stir chocolate powder into hot milk or water. When a solution holds a maximum amount of solute at a certain temperature, it is said to be **saturated**. If we add too much chocolate powder to the hot milk, the excess solute will settle on the bottom of the container. Generally, the chocolate powder dissolves better in hot milk than cold milk. Thus, heating the solution can increase the amount of solute that dissolves. Most solids are more soluble in water (solvents) at higher temperatures.

Solubility is the quantity of solute that dissolves in a given amount of solvent. The solubility of a solute depends on the nature of the solute and solvent, the amount of solute, the temperature and pressure (for a gas) of the solvent. **Solubility** is expressed as the quantity of solute per 100 g of solvent at a specific temperature.

Target:

In this experiment, you will be measuring the solubility of different quantities of KNO_3 at various temperatures of crystallization. The start of **crystallization** indicates that the

solution has become saturated at this temperature. You will construct a solubility curve for KNO_3 in water and be able to identify and understand the key terms: solubility, solute, solvent, solvation, saturated, unsaturated and supersaturated solutions. Student will use the solubility curve graph to solve various problems and determine trends in the curve.

Materials:

Balance	Test Tubes	Potassium Nitrate (KNO_3)
HotPlate	Test tube rack	Distilled water
Spatula	400mL Beaker	Thermometer
10 mL graduated cylinder	stirring rod	

Pre-Lab Questions:

1. Why does an oil and vinegar salad dressing have two separate layers?
2. When making hot chocolate, how does stirring affect the rate of solvation? Describe at a molecular level.
3. How is the solubility of sugar in water affected by increasing the temperature? Talk about what happens at the molecular level.
4. What does the phrase "like dissolves like" mean?
5. How is solubility expressed?
6. What is the difference between a saturated and an unsaturated solution?

Procedures:

1. Divide the lab up so that one lab partner completes steps 2-3, while the other partner begins on step 4.
2. Number four test tubes and place them into a test tube rack.
3. Using a balance to measure the KNO_3 , prepare the test tubes as indicated below:

Test tube #	grams of KNO_3	ml of distilled H_2O
1	2.0	5
2	4.0	5
3	6.0	5
4	8.0	5

4. Fill a 400 ml beaker about $\frac{3}{4}$ full of tap water. This will be used as a hot water bath. Place the water bath and test tube # 1 on the hot plate. Heat the water to 90°C and adjust the flame to maintain this temperature.
5. Stir the KNO_3 -water mixture with a glass stirring rod until the KNO_3 is completely dissolved. Remove the tube.
6. One lab partner repeats step 5 for test tube # 2. The other lab partner holds a warm thermometer into the solution in the test tube # 1. Hold the test tube up to the light and water for the first signs of **crystallization** in the solution. Record the temperature immediately as crystallization begins in the data table.
7. Repeat steps 5 and 6 for all four test tubes. One partner should do step 5 and the other step 6. Record all temperatures in the data table.

Data Table:

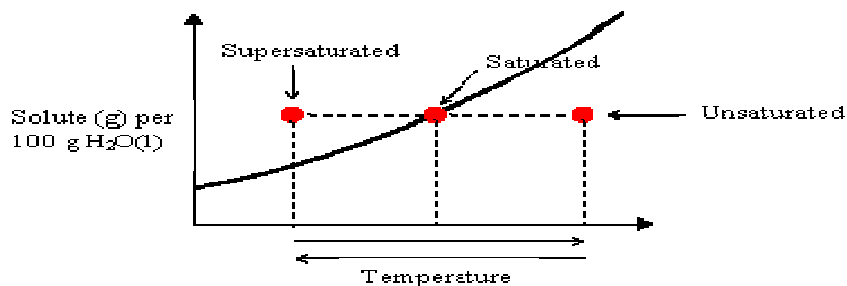
Test tube #	grams of KNO ₃ + ml of H ₂ O	Crystallization temp. (°C)
1	2g/5ml	
2	4g/5ml	
3	6g/5ml	
4	8g/5ml	

Calculations:

1. Convert mass/**5.0 ml** ratios to mass/**100 ml** ratios.
2. Plot your data. Note: Plot the mass of solute per 100 ml of water on the y-axis and the temperature of crystallization on the x-axis.
3. Construct a solubility curve by connecting the plotted points on your graph.

Questions:

1. According to your graph, how does the solubility of KNO₃ change as the temperature rises?
2. Explain at the molecular level why this relationship exists between temperature and solubility.
3. Using your graph, how many grams of KNO₃ can be dissolved in 100 ml of water at the following temperatures?
4. On your solubility curve, what is the change in solubility from 30°C to 60°C?
5. Using your graph, how much KNO₃ must be added to make a saturated solution at 55 °C.
6. Define the terms saturated, unsaturated and supersaturated. Use the diagram below to explain the terms.

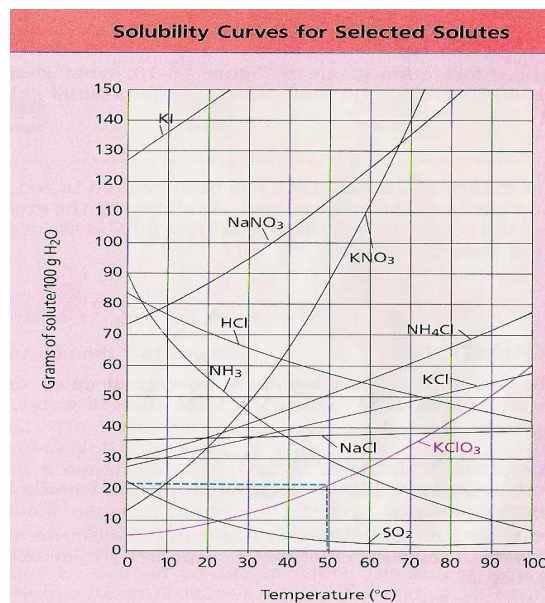


Use the solubility curve provided on the right to determine the answers to the following questions:

7. How many grams of solute are required to saturate 100 g of water in each of the following solutions?
 - a) KCL at 80°C
 - b) KClO₃ at 90°C
 - c) NaNO₃ at 10°C
 - d) SO₂ at 20 °C
 - e) NH₄Cl at 70°C

8. What is each of the solutions below: saturated, unsaturated or supersaturated? All of the solutes are mixed with 100 g of water.
- 40 g of NaCl at 50°C
 - 30 g of NH₃ at 30°C
 - 70 g of HCl at 20°C
 - 80 g of KNO₃ at 60°C
 - 80 g of NH₄Cl at 80°C

9. How many grams of KNO₃ per 100 g of water would be crystallized from a saturated solution as the temperature drops from:
- 80°C to 20°C
 - 60°C to 40°C
 - 50°C to 30°C
 - 80°C to 0°C
 - 50°C to 10°C



10. How many additional grams of NaNO₃ are required to keep each of the following NaNO₃ solutions saturated during the temperature changes indicated?
- 100 g of water with a temp change of 10°C to 30°C
 - 200 g of water with a temp change of 10°C to 30°C
 - 100 g of water with a temp change of 40°C to 90°C
 - 1000g of water with a temp change of 40°C to 90°C
 - 100 ml of water with a temp change of 10°C to 60°C
 - 1 L of water with a temp change of 10°C to 60°C
11. At what temperature are the following solutes equally soluble in 100 g of water?
- NaNO₃ and KNO₃
 - NH₄Cl and HCl
 - NH₃ and KNO₃
 - KClO₃ and NaCl
 - SO₂ and KClO₃
12. Which solute is least affected by the temperature changes?
13. Which three solutes show a decrease in solubility with increasing temperature?
14. How does the solubility of all "ionic solids" change with an increase in temperature? Explain.
15. How does the solubility of all "gases" (NH₃, SO₂ and HCl) change with increased temperatures? Explain at the particle level the cause of the change in solubility.