THE EFFECT OF TEMPERATURE ON SOLUBILITY

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INTRODUCTION

Students are given weighed samples of a soluble salt such as potassium nitrate. The sample is added to 20 mL of water and heated until all of the salt dissolves. The solution is cooled, and the temperature at which solid appears is noted. A solubility curve is prepared by pooling the data from all of the students.

Using the solubility curves of different solutes, it is possible to develop a simple method for separating substances. The solubility curves help to determine the temperature at which one salt could be recovered in a pure state from a mixture of salts. This process is called fractional crystallization. It is used extensively to purify salts which are contaminated by small amounts of other soluble species.

For all solids there is a limiting amount that will dissolve in a given amount of solvent. Some solids are very soluble in water, while others are nearly completely insoluble. About 200 grams of ordinary sugar will dissolve in 100 grams of water at 25°C, but only about 2×10^{-4}g AgCl will dissolve under those conditions.

The solubility of a solid in a given solvent depends on the temperature of the solution. Usually the solubility of a solid increases with increasing temperature, sometimes very markedly. A graph which plots the solubility as a function of temperature is called the solubility curve of the substance. Given such a graph, the solubility of the solid at any temperature may be determined.

PURPOSE
To study the effect of temperature on solubility.

SAFETY
Burns when handling hot objects are possible. The potassium nitrate and potassium chlorate are strong oxidizing agents.
Handle hot equipment and solutions cautiously.
These materials may be disposed of at the sink using large amounts of water.

MATERIALS
400-mL beaker	Single sided buret clamp
25 x 200 mm test tube	Labpro, calculator & Temp. probe
Ring stand	100 g KNO_3
Hot plate	100 mL distilled water
25 mL graduated cylinder	Balance and weighing paper

PROCEDURE

1. Set up a 400-mL beaker on a hot plate. Add about 300 mL of tap water.
2. Weigh out the amount of potassium nitrate, KNO_3, assigned by the instructor. The sample will range from 8.00 to 35.00 grams. Transfer the solid to a large test tube and add 20 mL (20 g) of distilled water.
3. Stir the mixture to dissolve as much potassium nitrate as possible. Carefully insert temperature probe.
4. Heat the water in the beaker with the hot plate. Clamp the test tube in water.
5. Stir the mixture gently until all of the potassium nitrate has dissolved. The temperature may vary from 25°c to 85°C depending on the amount of potassium nitrate in the sample
6. When all of the potassium nitrate has dissolved, loosed the clamp from the support stand and raise the tube out of the water bath. Turn off the hot plate. Reclamp the tube above and to one side of the beaker. Using the stirring rod, stir the solution gently and observe it as it cools. As soon as crystallization begins, note the temperature of the solution. It is easiest to see crystals by looking at the bottom of the test tube where they will collect as soon as they begin to form.
7. After the crystallization temperature has been recorded, put the test tube back into the water bath and warm the solution until all of the crystals have redissolved. Repeat the cooling procedure to check the crystallization temperature. The two readings should be within 1 degree of each other. If the two readings do not agree within 1 degree, rewarm the solution in the water bath, cool it, and continue until satisfactory agreement is obtained.
8. Your sample mass will be recorded on the blackboard; record the experimental temperature next to it.
9. When the data from all of the student samples are recorded at the board, copy them to draw a solubility curve for grams of potassium nitrate dissolved per 100 grams of water. You could use a computer or calculator to do this.

DATA TABLE

mass of KNO_3	saturation temp (°C)	mass/100g or water
8.00	26	
10.0	33	
15.0	44	
20.0	57	
25.0	65	
30.0	73	
35.0	83	

QUESTIONS

1. Your data furnish the amount of KNO_3 that will be dissolved in 20 g of water at each temperature. For each data point, calculate the amount of KNO_3 that would dissolve in 100 g of water. Your calculations will be the solubilities of KNO_3 in the water at each of the temperatures reported.
2. Construct the solubility curve for KNO_3 . Plot solubility in grams per 100 grams of water on the y-axis and temperature on the x-axis. Extrapolate the curve to include solubility from 10 °C to 100°C. State in words how the solubility of KNO_3 varies with temperature.
3. From your solubility curve predict:

   a. The solubility of KNO_3 at 100 °C.
   b. The solubility of KNO_3 at 10 °C.
   c. The solubility of KNO_3 at 25 °C in units of moles of solid/liter of solution (molarity). The density of the solution is about 1.17 g/mL.
   d. The mass percent of KNO_3 in its saturated solution at 50°C.
   e. The percentage of KNO_3 that will crystallize out when its saturated solution at 100 °C is cooled to 10 °C.