Objective

In this experiment you will determine the solubility of potassium nitrate (KNO₃) in water at various temperatures. You will prepare a plot of solubility versus temperature and determine from the plot the solubility of KNO₃ in water at a particular temperature. You will also convert the solubility from a molality to a mole fraction.

Discussion

The solubility of any substance (solute) is the concentration of a saturated solution of that solute in a particular solvent, and the solubility of a substance generally depends on the temperature. The solubilities in water of many salts including KNO₃ increase with increasing temperature. When a solution contains the maximum possible amount of solute that can be dissolved in that solution at a given temperature, it is said to be saturated. You will be measuring the saturation (or crystallization) temperatures of five KNO₃ solutions; these temperatures will be measured using the MicroLab computer interface.

Using the Thermistor

Open the MicroLab program from the icon on the computer desktop and turn on the Microlab box by pressing the power button (if the box isn’t already on). You will see the initial menu below; highlight the “MicroLab Experiment” icon and press “okay” to begin. Acquire a thermistor from your instructor and then follow the instructions given below to set up a Temperature vs. Time experiment.

1. Plug the thermister into the left-most MicroLab box socket as shown here. You will next need to tell the computer what you want the box to do.

Peter Norris, YSU, January 2008
2. The computer window should now look like this with areas in which to add “sensors” (top left) and input data (like in Excel) at the bottom middle of the window. You will be able to create a graph in the top window.

Press the “add sensor” button

3. Drag down the list of probes and highlight “Temperature (thermistor)”

4. Click on the left-most input socket (highlighted), then click next.”
5. Click on “Read Calibration from a File” and then “Finish”

6. Select “Model 103 Thermistor” and then “Open”

7. Click on “Finish” in order to compete the thermistor setup

8. Press the “add sensor” button again
9. Drag down the list and then highlight “Time”

10. Click on Timer 1 and then press “next.”

11. Default settings are used so press “finish”

Drag the “Thermistor A” icon over to the Y axis of the graph and also below the header of Column A in the spreadsheet. Drag the “Time 1” icon to the X axis and then also to the header of column B. Your screen should look like the picture below, and then you are ready to begin collecting data.
Sample Preparation

Clean your large test tube and rinse it thoroughly with de-ionized water. Shake the tube thoroughly to get rid of the excess water or dry it with a paper towel. Obtain a 2-hole stopper and insert one of the metal stirring rods into one of the holes. Then carefully insert the thermocouple into the other hole such that the bottom will be situated about half an inch from the bottom of the test tube. Set up a water bath using your 400 mL beaker. Put about 300 mL of water into the beaker, place the beaker upon a wire gauze supported by a ring stand, and heat the water to boiling using a Bunsen burner. Maintain boiling throughout the experiment. While the water is heating up, weigh about 15 g of KNO₃ on weighing paper to the nearest 0.001 g and transfer all of the salt to the test tube. Pipet 10.00 mL of de-ionized water into the test tube. Clamp in an upright position in the water bath as shown below (Figures 1 and 2) and allow the salt to completely dissolve.

Before heating the KNO₃ only dissolves slightly  
Upon heating the solid will gradually dissolve

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Figure 1  
Figure 2
As the sample heats up the solid will begin to dissolve. Be patient with this and use the stirrer as needed but be careful not to be too aggressive as you might break the test tube. Once the entire solid is dissolved in the hot water you are ready to acquire solubility data.

**Data Acquisition**

Data acquisition for this experiment involves measuring the temperature at which KNO₃ crystals just begin to form as heated KNO₃ solutions (in which all of the KNO₃ is dissolved) are allowed to cool. This is the saturation (or crystallization) temperature for the solution. You will measure crystallization temperatures for a total of five KNO₃ solutions of known, but different, concentrations.

Follow these steps to obtain crystallization temperatures:

1. With your thermister about half an inch from the bottom of the test tube, and your test tube clamped in the boiling water (shown in Figure 2), click on the “Start” button in the MicroLab window to begin measuring the temperature of the sample against time. You will see data within Columns A and B and a graph will start to plot.

2. Stir the mixture gently as needed such that the entire solid dissolves. Keeping the test tube low in the water bath will help here but make sure that the bottom of the test tube does not touch the glass of the water bath. Once the entire solid has dissolved, raise the test tube out of the water bath to begin the cooling process.

3. As you continue to stir the solution, carefully watch the test tube and click on “Stop” in the MicroLab window the instant you notice KNO₃ crystals forming. Hover the cursor over the point on the graph that corresponds to the crystallization point and record the displayed temperature reading on your lab report. If you have noted the correct crystallization point, the amount of solid should increase quite quickly as the temperature continues to drop.

4. Remove the stopper and thermister from the test tube and pipet an additional 5.00 mL of de-ionized water into the mixture in the test tube. Replace the thermister into the tube and then clamp the tube in the boiling water bath. Begin measuring the temperature by clicking on “Start” and stir the sample gently until the entire solid has dissolved. Remove the tube from the bath and continue stirring and watching for the crystallization point as before. Record the crystallization temperature in your lab report.

5. Repeat the determination for THREE more additions of 5.00 mL of de-ionized water to the tube.

6. After the crystallization temperatures have all been measured and recorded, CAREFULLY remove the thermistor from the test tube and wash it with de-ionized water before returning it.

**Calculations and Data Analysis**

Calculate the concentration of each saturated solution as a molality (moles KNO₃/kg water; assume the density of water is 1.00 g/mL), and record the answers in the “Solubility, Molality” column on your report sheet. Then complete the graphing steps described on the “MicroLabgraph – 1516L Exp1” document in order to generate your plot of “Temperature vs. Solubility of KNO₃ (in molality units).”