

Effect of Temperature on Solubility of a Salt

In this experiment, you will study the effect of changing temperature on the amount of solute that will dissolve in a given amount of water. Water solubility is an important physical property in chemistry, and is often expressed as the mass of solute that dissolves in 100 g of water at a certain temperature. In this experiment, you will completely dissolve different quantities of potassium nitrate, KNO_3 , in the same volume of water at a high temperature. As each solution cools, you will monitor temperature using a computer-interfaced Temperature Probe and observe the precise instant that solid crystals start to form. At this moment, the solution is saturated and contains the maximum amount of solute at that temperature. Thus each data pair consists of a *solubility* value (g of solute per 100 g H_2O) and a corresponding *temperature*. A graph of the temperature-solubility data, known as a solubility curve, will be plotted using the computer.

OBJECTIVES

In this experiment, you will

- Study the effect of changing temperature on the amount of solute that will dissolve in a given amount of water.
- Plot a solubility curve.

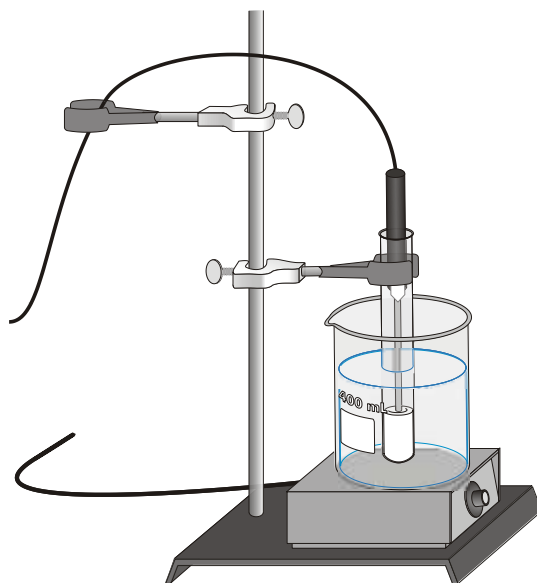


Figure 1

MATERIALS



computer
Vernier computer interface
LoggerPro
Temperature Probe
2 utility clamps
four 20 × 150 mm-test tubes
test tube rack
ring stand

hot plate
stirring rod
potassium nitrate, KNO₃
distilled water
400 mL beaker
10 mL graduated cylinder or pipet
250 mL beaker

PROCEDURE

1. Obtain and wear goggles.
2. Label four test tubes 1-4. Into each of these test tubes, measure out the amounts of solid shown in the second column below (amount per 5 mL). Note: The third column (amount per 100 g of H₂O) is *proportional* to your measured quantity, and is the amount you will enter for your graph in Step 7 below.

Test tube number	Amount of KNO ₃ used per 5 mL H ₂ O (weigh in Step 2)	Amount of KNO ₃ used per 100 g H ₂ O (use in Step 10)
1	2.0	40
2	4.0	80
3	6.0	120
4	8.0	160

3. Add exactly 5.0 mL of distilled water to each test tube (assume 1.0 g/mL for water).
4. Connect the probe to the computer interface. Prepare the computer for data collection by opening the file “12 Temp and Solubility” from the *Chemistry with Vernier* folder of LoggerPro.
5. Fill a 400 mL beaker three-fourths full of tap water. Place it on a hot plate situated on (or next to) the base of a ring stand. Heat the water bath to about 90°C and adjust the heat to maintain the water at this temperature. Place the Temperature Probe in the water bath to monitor the temperature and to warm the probe. **CAUTION:** *To keep from damaging the Temperature Probe wire, hang it over another utility clamp pointing away from the hot plate, as shown in Figure 1.*
6. Use a utility clamp to fasten one of the test tubes to the ring stand. Lower the test tube into the water as shown in Figure 1. **Note:** In order to dissolve all of the KNO₃, Test Tubes 3 and 4 need to be heated to a higher temperature than Test Tubes 1 and 2. Use your stirring rod to stir the mixture until the KNO₃ is *completely* dissolved. Do not leave the test tube in the water bath any longer than is necessary to dissolve the solid.
7. When the KNO₃ is completely dissolved, click . Remove the Temperature Probe from the water bath, wipe it dry, and place it into the solution in the test tube. Unfasten the utility clamp and test tube from the ring stand. Use the clamp to hold the test tube up to the light to look for the first sign of crystal formation. At the same time, stir the solution with a slight up and down motion of the Temperature Probe. At the moment crystallization starts to occur, click . Type the solubility value in the edit box (column 3 above, *g per 100 g H₂O*) and

press the ENTER key. Note: If you click too soon, you can press the ESC key to cancel the save. After you have saved the data pair, return the test tube to the test tube rack and place the Temperature Probe in the water bath for the next trial.

8. Repeat Steps 6 and 7 for each of the other three test tubes. Here are some suggestions to save time:
 - One lab partner can be stirring the next KNO_3 -water mixture until it dissolves while the other partner watches for crystallization and enters data pairs using the computer.
 - Test Tubes 1 and 2 may be cooled to lower temperatures using cool tap water in the 250 mL beaker. This drops the temperature much faster than air. If the crystals form too quickly, *briefly* warm the test tube in the hot-water bath and redissolve the solid. Then repeat the cooling and collect the data pair.
9. When you have finished collecting data, click . Record the temperature (in $^{\circ}\text{C}$) from the four trials in your data table, or, if directed by your instructor, print a copy of the table. Discard the four solutions as directed by your teacher.
10. Print a copy of the graph. Enter your name(s) and the number of copies you want to print.

PROCESSING THE DATA

1. Draw a best-fit curve for your data points on the printed graph.
2. According to your data, how is solubility of KNO_3 affected by an increase in temperature of the solvent?
3. Using your printed graph, tell if each of these solutions would be saturated or unsaturated:
 - a. 110 g of KNO_3 in 100 g of water at 40°C
 - b. 60 g of KNO_3 in 100 g of water at 70°C
 - c. 140 g of KNO_3 in 200 g of water at 60°C
4. According to your graph, will 50 g of KNO_3 completely dissolve in 100 g of water at 50°C ? Explain.
5. According to your graph, will 120 g of KNO_3 completely dissolve in 100 g of water at 40°C ? Explain.
6. According to your graph, about how many grams of KNO_3 will dissolve in 100 g of water at 30°C ?

DATA TABLE

Trial	Solubility (g / 100 g H ₂ O)	Temp (°C)
1	40.0	
2	80.0	
3	120.0	
4	160.0	