

Solutions Lab #1: Effect of Temperature on Solubility of a Salt; SC7a



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 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 LabQuest. The purpose of this lab is study the effects of changing temperatures on solubility and to also plot a solubility curve.



MATERIALS

LabQuest
LabQuest App
Temperature Probe
ring stand
four 20 X 150 mm test tubes
test tube rack
hot plate

400 mL beaker
10 mL graduated cylinder
250 mL beaker
ring stand
2 utility clamps
stirring rod
potassium nitrate, KNO_3

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 H_2O) is *proportional* to your measured quantity, and is the amount you will enter for your graph in Step 8.

| Test tube number | Amount of KNO_3 used per 5 mL H_2O (weigh in Step 2) | Amount of KNO_3 used per 100 g H_2O (use in Step 10) |
|------------------|-------------------------------------------------------------------------------|-------------------------------------------------------------------------------|
| 1 | 2.0 | 40 |
| 2 | 4.0 | 80 |
| 3 | 6.0 | 120 |
| 4 | 8.0 | 160 |

3. Add precisely 5.0 mL of distilled water to each test tube (assume 1.0 g/mL for water). Have your partner start step 6 now to start heating the water.
4. Connect the Temperature Probe to LabQuest and choose New from the File menu. If you have an older sensor that does not auto-ID, manually set up the sensor.
5. Set up the data-collection mode, which is under the “experiment” tab.
 - a. On the Meter screen, tap Mode. Change the mode to Events with Entry.
 - b. Enter the Name (Solubility) and Units (g/100g). Select OK.
6. Fill a 400 mL beaker about 200mL 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.*

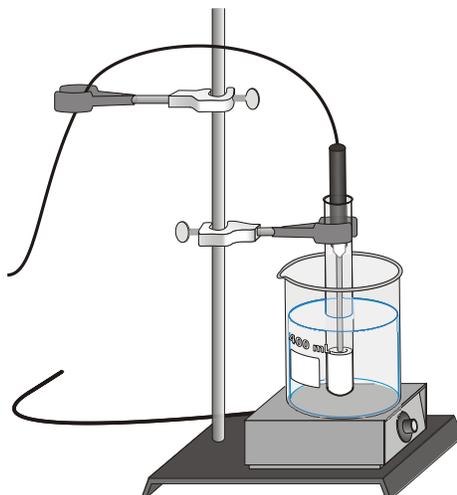


Figure 1

7. 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 KNO_3 , 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 KNO_3 is *completely* dissolved. Do not leave the test tube in the water bath any longer than is necessary to dissolve the solid.
8. You are now ready to collect temperature-solubility data.
 - a. To start data collection click “collect”
 - b. When the KNO_3 is completely dissolved, remove the Temperature Probe from the water bath, wipe it dry, and place it into the solution in the test tube.
 - c. 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.
 - d. At the moment crystallization starts to occur, tap Keep. When the pop-up option appears enter the mass in grams (mass (g) is the solubility value in **column 3 of Step 2**, *g per 100 g H_2O*). For example, enter “40” for the first trial. Select OK to store the temperature-mass data pair. Always click **APPEND DATA** if an additional pop-up window appears.
 - e. After you have saved the temperature-mass data pair, return the test tube to the test tube rack and place the Temperature Probe in the water bath for the next trial.
9. Repeat Steps 7 and 8 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.
 - 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.

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- When you have collected the fourth and last data pair, stop data collection. Discard the four solutions as directed by your instructor.
- Examine the data points along the curve on the displayed graph and record the temperature values in your data table.
- Prepare a graph of solubility vs. temperature. Before you print the "option" graph, set up the graph style and the scaling of the axes:
 - Tap the y-axis label and choose Solubility.
 - Tap the x-axis label and choose Temperature.
 - Choose Graph Option from the Graph menu.
 - Enter **100** as the X-Axis Right value.
 - Enter **0** as the X-Axis Left value.
 - Enter **200** as the Y-Axis Top value.
 - Enter **0** as the Y-Axis Bottom value.
 - Select OK.

PROCESSING THE DATA

- Under f(x), draw a best-fit curve for the data points on your printed graph. Label both axes and show correct units. Label tick marks with the numerical values they represent. **Note:** If you did not print a graph, manually plot a graph of solubility of KNO_3 vs. temperature using your data.
- According to your data, how is solubility of KNO_3 affected by an increase in temperature of the solvent?
- Using your printed graph, tell if each of these solutions would be saturated or unsaturated:
 - 110 g of KNO_3 in 100 g of water at 40°C
 - 60 g of KNO_3 in 100 g of water at 70°C
 - 140 g of KNO_3 in 200 g of water at 60°C
- According to your graph, will 50 g of KNO_3 completely dissolve in 100 g of water at 50°C ? Explain.
- According to your graph, will 120 g of KNO_3 completely dissolve in 100 g of water at 40°C ? Explain.
- According to your graph, about how many grams of KNO_3 will dissolve in 100 g of water at 30°C ?

| Trial | Solubility (g/100 g H_2O) | Temp ($^\circ\text{C}$) |
|-------|-----------------------------------------------|------------------------------|
| 1 | 40.0 | |
| 2 | 80.0 | |
| 3 | 120.0 | |
| 4 | 160.0 | |