

## Solutions

# The Solubility of a Salt

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## OVERVIEW

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A key factor affecting the solubility of a substance – how much solute can be dissolved in a solvent – is temperature. For most substances increasing temperature will increase solubility - more solute will be able to dissolve in the same volume of solvent.

A solubility curve illustrates how the solubility of a substance varies with temperature. By determining the mass of solute that can be dissolved in a volume of solvent under a variety of temperatures we can easily construct a solubility curve.

In this lab exercise you will create a solubility curve for an ionic compound, potassium nitrate,  $\text{KNO}_3$ .

## PURPOSE

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- To calculate the solubility of a substance under a variety of temperatures.
- To construct a solubility curve based on experimental data.

## SAFETY

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- Use caution when using the hot water bath to avoid hot water and steam burns.

## EQUIPMENT AND MATERIALS

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- balance
- four test tubes per group

- hot water baths – 400 mL or 600 mL beaker, ring stand, test tube clamp, gas burner – or alternative
- four thermometers per group
- 10 mL graduated cylinder
- scoopula
- grease pencil
- test tube clamp
- test tube rack
- solid potassium nitrate
- distilled water

## PROCEDURE

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1. Prepare a water bath by filling a large beaker approximately 2/3 full with water. Place the beaker on a ring stand above a gas burner and begin heating the water to just below boiling. While this is heating continue with Step 2.
2. Using a grease pencil number your test tubes 1 through 4.
3. Accurately measure out the following masses of solid potassium nitrate, placing the salt in the appropriate test tube. It is not necessary that you measure out *exactly* the masses given below, but you must record the *precise* masses you actually use.

test tube 1: 2 grams  $\text{KNO}_3$

test tube 2: 4 g

test tube 3: 6 g

test tube 4: 8 g

4. Add exactly 5.0 mL of water to each of the test tubes.
5. Place each of the tubes into the water bath in order to dissolve the solid  $\text{KNO}_3$  in each test tube. You may find it necessary to use a stirring rod to help the

dissolving process, particularly for test tubes 3 and 4.

- Remove test tube 1 from the hot water bath once the  $\text{KNO}_3$  has fully dissolved and place a thermometer in the tube. Watch the solution carefully. Record the temperature as soon as you see crystals forming within the test tube (you will need to wait awhile for crystals to form in this first test tube).
- Repeat Step 6 for the other test tubes once the  $\text{KNO}_3$  dissolves.

Be prepared to act quickly for test tube 4 – crystallization may occur very soon after you remove the test tube from the hot water bath. It may be necessary to return the test tube to the water bath to redissolve the salt and allowing it to recrystallize again.

## RESULTS

- Copy the following table into your data book and fill it in with your own set of mass and volume data.

Convert the mass/volume ratio you used for each test tube into mass/100 mL ratio.

For example in test tube 1 you had 2.0 g  $\text{KNO}_3$  dissolved in 5.0 mL. This is equivalent to what mass of  $\text{KNO}_3$  per 100 mL of water?

- Also record the temperature at which recrystallization occurred. This is the solubility of the substance at that temperature - the maximum amount of solute that can be dissolved in 100.0 mL of water at that temperature.

Test Tube	Mass $\text{KNO}_3$ (g) used	Volume Water (mL)	Convert to g/100 mL	Saturation Temp ( $^{\circ}\text{C}$ )
1				
2				
3				
4				

- Using graph paper construct a solubility curve for  $\text{KNO}_3$  based on your data.

## CONCLUSIONS AND QUESTIONS

- The line on your graph represents the concentration of a saturated solution of  $\text{KNO}_3$  for various temperatures. Be sure to add values on both the X- and Y-axes.

Connect your data points by a smooth curve.

You may add this additional data to your curve:

Solubility at  $0^{\circ}\text{C}$ : 13 g/100 mL

Solubility at  $100^{\circ}\text{C}$ : 247 g/100 mL

- Based on your solubility curve, predict the solubility of  $\text{KNO}_3$  at the following temperatures:
  - $50^{\circ}\text{C}$
  - $70^{\circ}\text{C}$
- Based on your solubility curve, would you best describe the following solutions as unsaturated, saturated, or supersaturated?
  - 70 g / 100 mL  $\text{H}_2\text{O}$  at  $45^{\circ}\text{C}$
  - 80 g / 100 mL  $\text{H}_2\text{O}$  at  $70^{\circ}\text{C}$
  - 80 g / 100 mL  $\text{H}_2\text{O}$  at  $30^{\circ}\text{C}$

## The Solubility of Potassium Nitrate

