Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Period \_\_\_\_\_\_\_ Date \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Solubility Curves Lab**

**LAB**

**15**

*How does temperature affect how much of a substance will dissolve?*

**PRE-LAB**: Today we will be working with one of the three main ingredients of gunpowder, potassium nitrate.

1. Write the formula for potassium nitrate: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. Calculate the gram-formula mass (molar mass) of potassium nitrate: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
3. Record the definitions for the following three terms:
4. Solute: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
5. Solvent: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
6. Solution: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Read the following information carefully. Answer the 2 short questions that follow.

**OVERVIEW**

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

 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 liquid 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, KNO3.

**PURPOSE**

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

**SAFETY**

* Use caution when using the hot water bath to avoid hot water and steam burns.
1. What is a key factor affecting the solubility of a solid substance? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. What will you be doing during lab today? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**BEGIN LAB**: Obtain the materials you need to complete the lab procedure. Answer the analysis questions that follow.

**EQUIPMENT AND MATERIALS**

* balance
* three test tubes per group
* hot water baths – 400/600 mL beaker, Bunsen burner
* thermometer
* 10 mL graduated cylinder
* scoopula
* test tube rack
* solid potassium nitrate, KNO3 (s)
* water
* glass stirring rod

**PROCEDURE**

1. Prepare a water bath by placing a large beaker approximately 1/2 full with water over a Bunsen burner with a LOW flame. While this water is heating, continue with Step 2.

2. Number your test tubes 1 through 3.

3. Accurately measure out the following masses of solid potassium nitrate. Use an empty beaker or weigh boat to weigh the solid; **Make sure you “zero” out the container on the scale**! Place the salt in the appropriate test tube.

 test tube 1: 3 grams KNO3

 test tube 2: 5 g

 test tube 3: 7 g

4. Add *exactly* 5.0 mL of water to each of the test tubes. Use a graduated cylinder to accurately measure volumes of liquid.

5. Place each of the tubes into the hot water bath in order to dissolve the solid KNO3 in each test tube. You may find it necessary to use a glass stirring rod to help the dissolving process. Stir well, but BE CAREFUL NOT TO BREAK TEST TUBES. THEY ARE FRAGILE!

6. Read this whole step before doing it… Remove the test tubes from the hot water bath once the KNO3 has fully dissolved (you see a clear, homogeneous solution) and put them in the test tube rack. Place a thermometer in test tube 3. Watch the solution carefully. Record the temperature (°C) as soon as you see crystals forming at the base of the test tube. THIS MAY HAPPEN QUICKLY FOR TEST TUBE 3. PAY ATTENTION!

7. Once you have recorded the crystallization temperature of test tube 3, move the thermometer to test tube 2. Record the temperature at which crystals begin to form, then repeat one final time for test tube 1.

**RESULTS**

1. Record the temperature at which recrystallization occurred in the last column.
2. Convert the mass/volume ratio you used (mass/5 mL) for each test tube into mass/100 mL ratio by **multiplying the mass in column 1 by 20**. 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.

**Table 1**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Test Tube | MassKNO3 (g) used | VolumeWater (mL) | **Convert to g/100 mL** | **SaturationTemp (°C)** |
| 1 | 3 g | 5 mL |  |  |
| 2 | 5 g | 5 mL |  |  |
| 3 | 7 g | 5 mL |  |  |

**SUMMARY AND APPLICATION QUESTIONS**

1. Using the graph paper on the last page, construct a solubility curve for KNO3 based on your data. The line on your graph represents the concentration of a saturated solution of KNO3 for various temperatures. Be sure to label both the X- and Y-axes.
2. Add this additional data to your curve:

 Solubility at 0°C: 13 g/100 mL

 Solubility at 73°C: 150 g/100 mL

1. Connect the points on the curve with a smooth line

2. Based on your solubility curve, predict the solubility of KNO3 at the following temperatures:

1. 50°C b. 10°C
2. Turn to Table G of your Reference Table. Find the solubility curve for KNO3. Is the curve on your graph a good match with theirs? Draw a smiley face below if they match up fairly well.
3. Read the following definitions carefully:
* **Unsaturated solution**: less than the maximum amount of solute has been dissolved (more solute can be added and dissolved easily)—points BELOW the solubility curve line
* **Saturated solution**: the maximum amount of solute has been dissolved—points ON the solubility curve line
* **Supersaturated solution**: too much solute exists in the solution, so solids will begin to form—points ABOVE the solubility curve line

Based on your solubility curve, would you best describe the following solutions as unsaturated, saturated, or supersaturated?

 a. 70 g / 100 mL H2O at 45°C \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

 b. 80 g / 100 mL H2O at 70°C \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

 c. 80 g / 100 mL H2O at 30°C \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Use **Table G** to respond to the following questions.
2. What is the maximum number of grams of KCl(s) that will dissolve in 200. grams of water at 50⁰C to produce a saturated solution?
3. 38 g
4. 42 g
5. 58 g
6. 84 g
7. Which substance forms an unsaturated solution when 80. grams of the substance are added in 100. grams of H2O at 10⁰C?
8. KI
9. KNO3
10. NaNO3
11. NaCl
12. HCl, NH3, and SO2 are the three gases whose solubilities are graphed on Table G. What do you notice about their curves compared to the other solid substances?

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1. At STP (look up what temperature this means in Table A!), which of these substances is most soluble in H2O?
2. NH3
3. KCl
4. HCl
5. NaNO3

4. Use your data, analysis questions, and Table G to answer this conclusion question: How does temperature affect how much of a substance will dissolve?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**The Solubility of Potassium Nitrate**



180

160

140

120

100

60

80

20

40

0

Solubility g KNO3 / 100 mL H2O

 0 10 20 30 40 50 60 70 80 90

Temperature (°C)