Introductory Chemistry Lab: Solutions

Outcomes

As a result of today's laboratory, you will have:

- Observed a demonstration of supersaturation.
- Compared the solubility of two solutes in water at two temperatures.
- Used molarity to calculate the volume of a solution needed to obtain a given amount of solute.
- Reduced calculated volume to dryness to validate calculation.
- Calculated the % yield and % error in the amount of solute isolated.

Prelab

Prepare a Title (can use the lab handout for this), Purpose (a concise statement) and a Procedure (short "to do" list … see "Writing a Procedure" in the lab handouts folder), and Data Tables.

Purpose

To observe how the solubility of a solute varies with temperature and to isolate 1.000 g of NaCl by evaporating a calculated amount of solution.

Background Information

Solutions are homogeneous mixtures that result when one substance, the solvent, dissolves another substance called the solute. The amount of solute that can be dissolved in an amount of solvent depends on the nature of the solute, the nature of the solvent, and the temperature. A solution that contains the maximum amount of solute that can dissolve is said to be saturated. When additional solute is added to a saturated solution it will not dissolve, unless the temperature is changed. An unsaturated solution contains less than the maximum amount of solute. When more solute is added to an unsaturated solution, additional solute can dissolve until the saturated amount is reached. A solution that contains more than the maximum amount of solute at a given temperature is described as supersaturated. The amount of solute that can be dissolved in a specific amount of solvent, usually 100 grams, at a given temperature is called the solubility. When the solubility of a solute is plotted as a function of temperature the graph that results is called a solubility curve. Solubility curves for a number of solutes are shown at the end of this document.

The amounts of solute and solvent that are present in a solution are expressed in the concentration of the solution. There are a number of ways of indicating the concentration of a solution. Two of the most common concentration units are % by mass and molarity. The percentage by mass shows how many grams of solute are present per 100 grams of solution. A 7.0 % by mass solution of sucrose, table sugar, contains 7.0 grams of sucrose per 100 grams of solution. Note that the 100 grams of solution would contain 7.0 grams of sucrose and 93.0 grams of water since the solvent and the solute make up the solution.

$$\text{\% (by mass; often called weight)} = \frac{\text{Mass solute (g)}}{\text{Mass of solution (g)}} \times 100$$

Chemists prefer the concentration unit molarity, which gives the number of moles of solute per liter of solution. A 6.0 M solution of HCl contains 6.0 moles of HCl per 1 liter (1000 mL) of solution.

$$\text{Molarity (M)} = \frac{\text{Moles solute}}{\text{Liters of solution}}$$

The concentration of a solution can be used as a "per expression" relating the amount of solute and solution.

Procedure

Part I: Temperature and Solubility **Caution: Wear your safety goggles!**

1. Observe the super-saturation of sodium acetate demonstration.
2. Record your observations in Table 1.

Part II: Comparing Solubility at Two Temperatures **Work in groups of 2 (Each group does both salts)**

1. Put10 mL of water into a medium test tube and then add ~ 3.0 g of either NaCl or KNO_3. Stir with a stirring rod (with a circular motion, not an up and down motion; you do not want to break through the bottom of the test tube) to completely mix. Record your observations in Table 2.
2. Label the test tubes and put them into a 400-mL beaker of water. Leave the stirring rod in the test tube and occasionally stir the contents. Heat the beaker on a hot plate until the water in the beaker is boiling. Keep the test tube in the water for at least 5 min after the water starts to boil. Observe the solubility of the solids as the temperature increases and record in Table 2.
3. Put the test tubes into a beaker of cold water. Record any changes that occur in Table 2.

Part III. Isolate 1.00 g NaCl **Use the same balance for this entire procedure.**

1. Calculate how many milliliters of 2.000 M NaCl solution are needed to obtain 1.000 gram of NaCl.
2. Use a 10 mL graduated cylinder to measure out the calculated amount of 2.000 M NaCl solution. Record the volume (to 0.01 mL) in your journal in Table 3 as the Volume of NaCl Solution.
3. Measure the mass of a clean, dry evaporating dish and watch glass. Record the mass in Table 3.
4. Pour the sodium chloride solution into the evaporating dish and cover with a watch glass. Record the mass of the evaporating dish, watch glass and the solution in Table 3.
5. Use a Bunsen burner to carefully remove the water from the solution. Record the mass of the evaporating dish, watch glass and solid NaCl in Table 3.

Clean Up

1. The NaCl obtained is drain-disposable. Wash everything with tap water and then rinse with de-ionized water. Dry the evaporating dish and watch glass and put it back into the proper storage place.
2. Clean up all other glassware used and put away.
3. Return all equipment to proper places.

Data

I. Supersaturation Demonstration

Table 1: Temperature and Solubility Observations

Temperature	Appearance of test tube containing sodium acetate
Room Temperature	
~ 100°C	
After Cooling	
After Seeding	

II. Comparing Solubility at Two Different Temperatures
Indicate a small or large change in solubility of the solute with the temperature change.

Table 2: Solubility Comparison between NaCl and KNO_3

Solute	Temperature	Appearance of Solution
NaCl	Ambient	
NaCl	~100°C	
NaCl	After cooling	
KNO_3	Ambient	
KNO_3	~100°C	
KNO_3	After cooling	

III. Isolation of 1.00 g NaCl

Table 3: Isolation of 1.00 g NaCl

Volume of NaCl solution (mL)	
Mass of evaporating dish and watch glass	
Mass of evaporating dish , watch glass and NaCl Solution (g)	
Mass of evaporating dish , watch glass and Solid NaCl (g)	

Calculations ***Show all your work***

1. Calculate the volume of 2.000 M NaCl solution needed to obtain 1.000 gram of NaCl.
2. Calculate the mass of NaCl solution used.
3. Calculate the mass NaCl solid (actual NaCl) obtained.
4. Calculate the % yield of NaCl
5. Calculate the % error for the experiment given that the theoretical mass of NaCl = 1.000 g

Results

Table 4: Temperature and Solubility (From Table 1 Observations)

Temperature	Assumed State (unsaturated, saturated, supersaturated)
Room Temperature	
~ 100°C	
After Cooling	
After Seeding	

Table 5: Solubility Comparison between NaCl and KNO_3 from Table 2 Observations)
Decrease in visible material is an increase in solubility

<table>
<tr><th rowspan="3">Compound</th><th colspan="4">Solubility change with temperature</th></tr>
<tr><th colspan="2">Heating</th><th colspan="2">Cooling</th></tr>
<tr><th>Increase or decrease</th><th>Small or large</th><th>Increase or decrease</th><th>Small or large</th></tr>
<tr><td>NaCl</td><td></td><td></td><td></td><td></td></tr>
<tr><td>KNO_3</td><td></td><td></td><td></td><td></td></tr>
</table>

Table 6: Isolation of 1.00 g NaCl

Mass NaCl liquid (g)	
Mass NaCl solid (g)	
% Yield	
% Error	

Conclusion

1. Compare the solubility vs temperature changes for NaCl and KNO_3.
2. Compare the amount of NaCl isolated to the target value and give your percent yield and percent error.

Questions

1. What are 2 reasons why the actual amount of NaCl you collected is different from the theoretical yield?
2. Use Table 6 (NaCl solid and liquid mass) to calculate the % NaCl (by mass) of 2.00 M NaCl.

Use the data on the Solubility Curve below to answer the following questions. (Show work for 6 & 8)

3. Do the changes that you observed in the relative solubility of NaCl and KNO_3 agree with their Solubility Curves? Explain your answer.

4. When 30 grams of NH_4Cl are mixed with 100 grams of water at 50°C, will the solution that results be saturated, unsaturated, or supersaturated? Explain your answer.

5. List all of the solutes displayed that become less soluble in water as the temperature increases.

6. How many grams of potassium chlorate, $KClO_3$, can be dissolved in 300 grams of water at 30°C?

7. At 50°C, which solute is least soluble: KCl, $KClO_3$, NH_3 or NH_4Cl?

8. If 65 g of NH_4Cl are added to 100 g of water at 50 °C, how many grams of NH_4Cl will not dissolve?

Solubility Curves for Some Common Chemicals