Lab: Forming Precipitates via Chemical and Physical Changes

Research Questions:

How does the identity of the solute and solvent effect the solubility of a substance? How does temperature affect the solubility of a solid solute?

Introduction:

When one substance dissolves into another substance, a solution is formed. A solution consists of the solute and the solvent. The solvent is usually present in larger amounts than the solute. Often, but not always, water is the solvent because it is closest of all to a universal solvent. When water is the solvent, the solution is called an aqueous solution, denoted by *(aq)* in a chemical equation. The solubility of the solute not only depends on the identities of the solute and solvent but also on certain conditions under which the solution is produced.

Part A – How does temperature affect the solubility of a solid solute?

Procedures:

100 mL of room temperature water (20°-22°C) is measured in a graduated cylinder and poured into a beaker. Using the scale, 200 grams of sugar is measured and then added to the water. The water and solution are mixed using a stirring. This forms a saturated solution, and this solution's molality and molarity is calculated, and a sketch of this solution is made. The solution is then heated on a hot plate to form and unsaturated solution. Then 40 more grams of sugar is measured on the scale, added to this heated solution, and stirred. A sketch is made of this unsaturated solution, and the molality and molarity for this solution is calculated. The unsaturated solution is placed into the freezer and allowed to cool for 3-4 minutes forming a supersaturated solution. Sketch this supersaturated solution. With a thermometer, take the temperature of this solution and use the attached solubility graph for sugar to calculate the amount of precipitate the cooled solution can hold at its saturation point.

Data/Observations:

SKETCH – SATURATED SOLUTION

Cloudy
Thick, and creamy, syrupy.

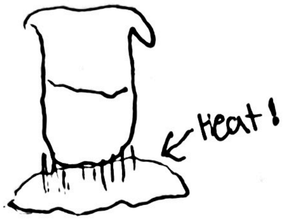
OBSERVATIONS/DESCRIPTION:
The water was syrupy and thick from the sugar cloudy.

Calculations

Molarity: (M) $\frac{0.58 \text{ moles}}{.225L}$ $\boxed{2.57m}$ Molality (m) $\frac{0.58 \text{ moles}}{.1kg}$ $\boxed{5.8m}$

$\frac{200.0g\ C_{12}H_{22}O_{11}}{1} \cdot \frac{1 \text{ mole}}{342} \cdot 0.58 \text{ moles}$

SKETCH – UNSATURATED SOLUTION



OBSERVATIONS/DESCRIPTION:
the water is still cloudy but it flows better and is not as thick from the heat.

Calculations:

Molarity (M): $\frac{0.70 \text{ moles}}{.250 L} = \boxed{2.8 M}$

Molality (m): $\frac{0.70 \text{ Moles}}{.1 kg}$ $\boxed{7m}$

$\frac{240.0 g\ C_{12}H_{22}O_{11}}{1} = \frac{1 \text{ mole}}{342 g}$ 0.70

SKETCH – SUPERSATURATED SOLUTION

too much solute so it settles on the bottom. percepetent.

OBSERVATIONS/DESCRIPTION:
The water was cooled making it have even less room.

Calculations:

Amount of Precipitate Formed:

240
$- 225 g\ C_{12}H_{22}O_{11}$ (max)

15 g precipatate

Conclusion:

When the water was heated it was able to absorb the additional 40 grams of sugar. At this increased temperature, the solution was not saturated, making it clearer and easier to stir. The increase in temperature raised the solution's saturation point and allowed more solid solute to be dissolved, but when the solution's temperature was decreased to 25°C, its saturation point was lowered. Therefore, the extra sugar fell out of solution (or precipitated) and settled to the bottom of the solution as a solid.

Temperature has a direct effect on the amount of sugar that can be dissolved in a specified amount of water. Increases or decreases in temperature can affect the solubility of a solid solute. The following rule for solubility is demonstrated by this experiment: For solid solutes, solubility usually increases with increasing temperature.

We chose sucrose (table sugar) for our experiment because it has a noticeable curve, whereas sodium chloride's (salt) curve is almost constant, having little variation with temperature. This small amount of variation would be difficult for us to analyze had we used sodium chloride.

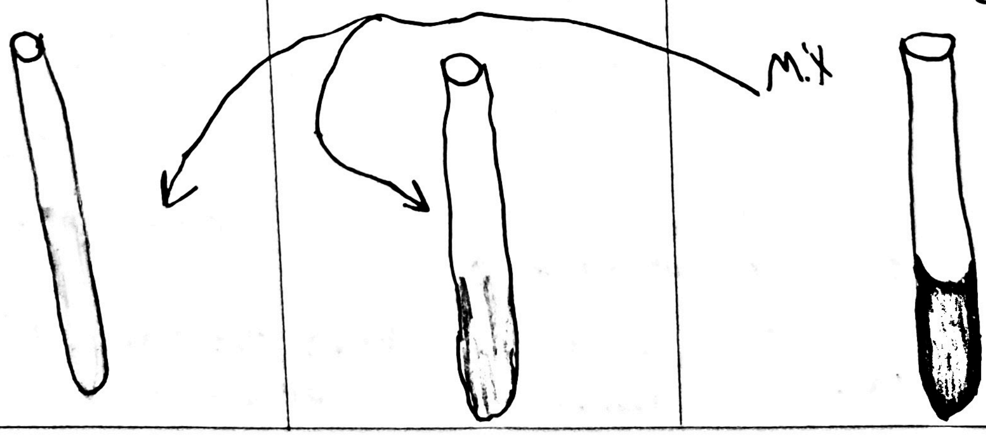
Part B - How does the identity of the solute and solvent effect the solubility of a substance?

Procedures:

Fill two test tubes ½ full of distilled water and then place ½ teaspoon of cobalt chloride in one test tube and ½ teaspoon of sodium carbonate in the other test tube, shaking each one vigorously while holding gloved thumb over each test tube's opening. When thoroughly mixed, place test tubes in holder, sketch, and then record observations of each one. Pour the sodium carbonate-water solution into the cobalt-chloride water solution and note the result.

Data/Observations:

Test Tube- $CoCl_2$	Test Tube – Na_2CO_3	Test Tube (Mixed) $CoCO_3$



Balanced Chemical Equation for this reaction is:

$CoCl_2 \bullet 6H_2O\,(aq) + Na_2CO_3\,(aq) \longrightarrow CoCO_3\,(s) + 2NaCl\,(aq) + 6H_2O\,(l)$

PRECIPATANT

Conclusion:

In water, this combination will result in formation of highly insoluble cobalt carbonate, which can then be collected by filtration and dried. This process has been used to manufacture cobalt carbonate.

This experiment demonstrates that a precipitate can be formed through a chemical reaction in which, although initial reactants may be soluble, a product that is insoluble can be formed when they are combined, producing a precipitate. Rules of solubility govern what compounds are soluble. The table below shows these rules of solubility:

SOLUBLE IONIC COMPOUNDS	INSOLUBLE IONIC COMPOUNDS
1. **Group 1A ions (Li^+, Na^+, K^+, etc.) and ammonium ion (NH_4^+)** are soluble.	1. **(Hydroxides) OH^- and (Sulfides) S^{2-}**, are insoluble ***except*** when with Group 1A ions (Li^+, Na^+, K^+, etc.), ammonium ion (NH_4^+) and Ca^{2+}, Sr^{2+}, Ba^{2+}.
2. **(Nitrates) NO_3^-, (acetates) CH_3COO^- or $C_2H_3O_2^-$**, and most **perchlorates (ClO_4^-)** are soluble.	2. **(Carbonates) CO_3^{2-}** and **(Phosphates) PO_4^{3-}** are insoluble ***except*** when with Group 1A ions (Li^+, Na^+, K^+, etc.), ammonium ion (NH_4^+).
3. **Cl^-, Br^-, and I^-** are soluble, ***except*** when paired with Ag^+, Pb^{2+}, Cu^+ and Hg_2^{2+}.	
4. **(Sulfates) SO_4^{2-}** are soluble, ***except*** those of Ca^{2+}, Sr^{2+}, Ba^{2+}, Ag^+, and Pb^{2+}.	

Under Rule #2, $CoCO_3$ (one of the products formed in our experiment), is insoluble, while our other product, NaCl, by rule #1 & #4, is soluble. Therefore, the identity of the two solutes when mixed matters because they can form products that are insoluble.

Vocabulary:

Molality Concentration unit in chemistry that measures the number of moles of solute per liter of solution.

Molarity Concentration unit defined to be the number of moles of solute divided by the number of liters of solution.

Solute a substance that is dissolved in another substance, known as a solvent.

Solvent where the Solute is mixed, Present in more quantity

Solution Homogeneous mixture of two or more Substances. A solution may exist in any Phase.

Saturated Solution Chemical Solution that containing the maximum amount of Solute.

Supersaturated Solution
contains more than the maximum amount of Solute

Unsaturated Solution
Solute is completly dissolved

Solubility Curve
is a graph of solubility

Soluble
Capable of being dissolved

Insoluble
not capable of being dissolved

Precipitate
insoluble solid that forms in a Solution during a chemical reaction or by diffusion.