Aiden White

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

OBSERVATIONS/DESCRIPTION:
It is very Cloudy & thick / like syrup

Calculations

Molarity: (M)

$\frac{.58 \text{ moles}}{.225 \text{ L}} = 2.57 \text{ M}$

Molality (m)

$\frac{.58 \text{ moles}}{.1 \text{ Kg}} = 5.8 \text{ m}$

.58 Moles

SKETCH – UNSATURATED SOLUTION

OBSERVATIONS/DESCRIPTION:

lighter & clearer. Also it is now less thick.

Calculations:

Molarity (M):

$\frac{.7 \text{ moles}}{.250 \text{ L}} = \boxed{2.8\ M}$

.70 moles

Molality (m):

$\frac{.7 \text{ mol}}{.1 \text{ kg}} = \boxed{7 m}$

SKETCH – SATURATED SOLUTION

OBSERVATIONS/DESCRIPTION:

There was sugar in the bottom of the beaker + was thick, syrup-ey, and cloudy.

Calculations:

Amount of Precipitate Formed:

240g
− 225g (max sugar)
15g precipitate

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 , 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)
 Bright [illegible] mostly Clear	 Clear, not Cloudy.	 Not at all Clear. a rich Purple Color.

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)

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+}.	SO_4^{2-} are soluble except with Ca^{2+} Sr^{2+} Ba^{2+} Pb^{2+}
4. (Sulfates) SO_4^{2-} are soluble, ***except*** those of Ca^{2+}, Sr^{2+}, Ba^{2+}, Ag^+, and Pb^{2+}.	NO_3 ClO_3^- ClO_4^- + $C_2H_3O_2^-$ are soluble

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

The Concentration of a Solution (moles/Kg)

Molarity

Concentration of a Solution (Moles/L)

Solute

The thing that is dissolved into the solvent

Solvent

What the solute is dissolved into (typically a liquid)

Solution

When one substance is dissolved into another substance, creating a homogeneous mixture

Saturated Solution

It is the maximum amount of solvent

~~& an excess of when the maximum is undissolved in the solution~~

Supersaturated Solution

When it has too much & the excess solute is at the bottom in solid form

Unsaturated Solution

A solution where more of the solute can be dissolved

Solubility Curve

A graph that shows how the solubility goes up as the temperature goes up.

Soluble

This means that a substance can dissolve in a solvent

Insoluble

This means that a substance can not dissolve in a solvent

Precipitate

a solid that is formed in a chemical reaction. It floates in the solutions.