Unit 4: Properties of Solutions

# Solubility and Factors Affecting Solubility

This worksheet will explore the fundamental concept of solubility and rules guiding predictions of whether a compound will form a soluble solution or an insoluble precipitate. Factors influencing solubility, such as temperature, pressure (for gasses), and compound characteristics, will be covered. Understanding these factors is crucial for controlling dissolution and precipitation in various chemical processes and industrial applications.

1. What are the factors affecting solubility?

2. According to solubility rules, categorize each of the following compounds's solubility in water.
    a. Silver chloride ($AgCl$)
    b. Sodium sulfate ($Na_2SO_4$)
    c. Lead(II) carbonate ($PbCO_3$)
    d. Barium sulfate ($BaSO_4$)

3. Discuss the role of temperature in affecting the solubility of solid and gaseous substances. Provide examples for each case.

4. Explain the concept of a saturated solution and how it relates to solubility. Provide an example.

5. Imagine that you performed an experiment in which you dissolved different samples of sugar (sugar cubes, extra fine sugar and regular table sugar) into water samples to compare how long they took to dissolve. Compare, generally, the rates at which these samples would dissolve to each other.

6. Water contains dissolved oxygen that fish can breathe. Describe the factors that would affect the amount of oxygen that is dissolved in water.

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**ANSWER KEY:**

1. What are the factors affecting solubility?

Solubility, the capacity of a substance to dissolve in a solvent, is intricately influenced by several key factors. Firstly, temperature plays a significant role, with the general trend being that solubility increases with temperature for most solid solutes in liquid solvents. However, for gasses in liquids, solubility often decreases with rising temperature.

Pressure is another determinant, particularly affecting the solubility of gasses in liquids, where an increase in pressure generally leads to higher solubility. The nature of both the solvent and solute is crucial; the chemical compatibility and polarity of these substances affect their ability to dissolve in one another.

Additionally, the surface area of solid solutes can impact solubility, as increased exposure to the solvent, achieved through crushing or grinding, enhances dissolution. Stirring or agitation of a solution facilitates interaction between solute and solvent, promoting the dissolution process. The presence of other solutes in a solution can also influence solubility, with phenomena like the common ion effect impacting the solubility of certain substances. Ionic strength, representing the concentration of ions in a solution, particularly affects the solubility of electrolytes (common ion effect).

2. According to solubility rules, categorize each of the following compounds's solubility in water.
    a. Silver chloride (AgCl)
    b. Sodium sulfate ($Na_2SO_4$)
    c. Lead(II) carbonate ($PbCO_3$)
    d. Barium sulfate ($BaSO_4$)

    a. Silver chloride (AgCl) - according to the solubility rules, compounds containing Cl are soluble; however, the exceptions to that are halide salts that have $Ag^+$, $Pb2^+$, and $(Hg_2)^{2+}$. Therefore, AgCl is insoluble.
    b. Sodium sulfate ($Na_2SO_4$) - salts containing Group I elements are soluble. Additionally, salts that contain sulfates ($SO_4$) are also generally soluble. Therefore, sodium sulfate is soluble in water.
    c. Lead(II) carbonate ($PbCO_3$) -carbonates are generally insoluble. Given this, lead (II) carbonate is insoluble.
    d. Barium sulfate ($BaSO_4$) - although sulfates are generally soluble, barium sulfate is one of the exceptions to this rule and is actually insoluble.

3. Discuss the role of temperature in affecting the solubility of solid and gaseous substances. Provide examples for each case.

Temperature has different effects on the solubility of solids and gasses. Generally, increasing temperature increases the solubility of most solid substances. For example, sugar (sucrose) dissolves more readily in hot water compared to cold water. In contrast, the solubility of gasses in liquids typically decreases with increasing temperature. For instance, carbon dioxide ($CO_2$) is less soluble in warm soda than in cold soda, leading to the formation of bubbles when the soda warms up.

4. Explain the concept of a saturated solution and how it relates to solubility. Provide an example.

A saturated solution is a solution in which the maximum amount of solute has been dissolved in a solvent at a specific temperature and pressure, and no more solute can dissolve. Any additional solute added will not dissolve and will settle at the bottom. For example, if you keep adding sugar to a glass of iced tea and it eventually stops dissolving, you have reached a saturated solution of sugar in the tea at that temperature.

5. Imagine that you performed an experiment in which you dissolved different samples of sugar (sugar cubes, extra fine sugar and regular table sugar) into water samples to compare how long they took to dissolve. Compare, generally, the rates at which these samples would dissolve to each other.

The main point here is the effect of surface area in regards to solubility. The greater the surface area the faster a substance will dissolve. In this case, a sugar cube has the least amount of surface area, while the extra fine sugar has the greatest surface area (and regular table sugar is somewhere in between). So therefore, extra fine sugar would dissolve first (the quickest), then it would be regular table sugar and finally sugar cubes would dissolve last.

6. Water contains dissolved oxygen that fish can breathe. Describe the factors that would affect the amount of oxygen that is dissolved in water.

The amount of dissolved oxygen in water is influenced by various factors:

1. The solubility of oxygen decreases as water temperature increases. Warmer water holds less dissolved oxygen, while colder water can retain more.

2. Atmospheric pressure affects the dissolution of gasses in water. At higher altitudes, where atmospheric pressure is lower, oxygen dissolves less readily in water.

3. Saltwater has lower oxygen solubility compared to freshwater. As salinity (salt concentration) increases, the ability of water to hold dissolved oxygen decreases.

4. Oxygen dissolves more readily in water that is agitated or turbulent. Wave action, waterfalls, or stirring can increase the amount of dissolved oxygen..

5. The presence of other gasses, such as carbon dioxide, can influence the solubility of oxygen. High concentrations of certain gasses may compete with oxygen for space in the water.