SOLUBILITY

Factors Influencing Solubility

To comprehend the impact of Temperature, Pressure, and the presence of other solutes on the solubility of solutes in solvents. Solubility is characterized as the maximum amount of solute that can be dissolved in a specific quantity of solvent at equilibrium. In this equilibrium state, Le Chatelier's principle can elucidate the primary factors influencing solubility. According to Le Châtelier's principle, the response of a system in chemical equilibrium to an applied stress can be anticipated, as the system tends to adjust in a manner that alleviates the stress.

Solute-Solvent Interactions Affect Solubility

The interaction between the solute and solvent plays a crucial role in determining solubility. Strong attractions between solute and solvent result in higher solubility, whereas weak interactions lead to lower solubility. Consequently, polar solutes exhibit enhanced dissolution in polar solvents, while non-polar solutes dissolve more readily in non-polar solvents. When dealing with a polar solute and non-polar solvent (or vice versa), solubility tends to be limited or only achievable to a minimal extent. A fundamental guideline to bear in mind is, "Like dissolves like."

Common-Ion Effect

The common-ion effect refers to the reduction in the solubility of an ionic compound when a salt containing an ion already present in the chemical equilibrium is introduced to the mixture. This phenomenon is best elucidated by Le Chatelier's principle. Consider the scenario where the moderately soluble ionic compound calcium sulfate ($CaSO_4$) is introduced to water. The net ionic equation for the resultant chemical equilibrium is as follows:

$$CaSO_{4(s)} \rightleftharpoons Ca^{2+}_{(aq)} + SO^{2-}_{4(aq)} \qquad (1)$$

Calcium sulfate exhibits slight solubility, with most of the calcium and sulfate existing in the solid form at equilibrium as calcium sulfate. Now, let's consider the introduction of the soluble ionic compound copper sulfate ($CuSO_4$) to the solution. Copper sulfate is soluble, and its primary impact on the net ionic equation is the introduction of more sulfate (SO_4^{2-}) ions.

$$CuSO_{4(s)} \rightleftharpoons Cu^{2+}_{(aq)} + SO^{2-}_{(aq)} \qquad (2)$$

The sulfate ions dissociated from copper sulfate are already present (common) in the mixture due to the slight dissociation of calcium sulfate. Consequently, the addition of sulfate ions imposes stress on the pre-existing equilibrium. Le Chatelier's principle dictates that the equilibrium shifts toward the reactants side to alleviate this new stress. As a result of this shift, the solubility of the slightly soluble calcium sulfate is further diminished.

Solubility of Solid in A Liquid

Like dissolves like: Polar solutes exhibit solubility in polar solvents, while non-polar solutes dissolve in non-polar solvents.

For instance, sodium chloride and sugar readily dissolve in water, whereas naphthalene and anthracene do not dissolve in water. Conversely, naphthalene and anthracene dissolve easily in benzene, while sodium chloride and sugar do not exhibit solubility in benzene.

Dissolution: when a solid solute is introduced into the solvent, resulting in the partial dissolution of the solute and an increase in its concentration within the solution.

Crystallisation: Crystallization involves certain solute particles within the solution colliding with solid solute particles and being separated from the solution.

This process is referred to as crystallization. At equilibrium, the rate of dissolution matches the rate of crystallization. During this phase, the concentration of the solute in the solution remains constant, given the specific conditions such as temperature and pressure. This type of solution is described as saturated with the specified solute.

$$\text{Solute} + \text{Solvent} \rightleftharpoons \text{Solution}$$

Effect of temperature on solubility of a solid in a liquid

Consider the equilibrium: Solute + Solvent ⇌ Solution. By Le Chatelier's Principle:

If above process is exothermic i.e., $\Delta H < 0$, then as T increases, solubility decreases.

If above process is endothermic i.e., $\Delta H > 0$, then as T increases, solubility increases.

Effect of pressure on solubility of a solid in a liquid (no effect)

Changes in pressure do not exert a noteworthy influence on the solubility of solids in liquids. This is primarily due to the fact that solids and liquids are highly incompressible, and as such, they tend to remain practically unaffected by alterations in pressure.

Types of Solutions Based on Solubility

Nearly every item we encounter in our daily routines comprises solutions, ranging from soda and deodorant to sugar and salt. A solution is a blend where two or more substances come together to form a unified mixture; it can be described as straightforward because the properties of the involved substances may or may not have changed.

Solution

As per the definition, a binary solution is a uniform blend of two constituents, namely the solute and the solvent. The solute is the substance that dissolves and is found in a smaller quantity, while the solvent is the liquid that dissolves the solute and is present in a substantially larger amount.

Type of Solutions

Various factors influence the nature of a solution, including the choice of solvent or solute. Let's briefly explore these factors in the section below:

Based on the Use of Water as a Solvent

There are two types of solutions depending on whether the solvent is water or not.

Aqueous solutions

These solutions involve water as the solvent. Examples include sugar in water, carbon dioxide in water, and similar solutions.

Non-Aqueous Solutions

These solutions do not utilize water as a solvent. The solvent could be ether, benzene, gasoline, carbon tetrachloride, or another substance. Examples include sulphur in carbon disulfide and naphthalene in benzene.