IJIMM, Volume 4, Issue 02, 2026 ISSN: 2995-5319
http://medicaljournals.eu/index.php/IJIMM/issue/view/3 International Journal of Integrative and Modern Medicine

Solutions and Their Physicochemical Properties

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ABSTRACT

This article examines solutions and their physicochemical properties from a scientific perspective. The concept of a solution, its composition, classification, and formation mechanism are analyzed based on theoretical principles. Particular attention is given to solubility, different methods of expressing concentration, electrolyte and nonelectrolyte solutions, colligative properties, and osmotic pressure.

The practical importance of solutions in industry, medicine, agriculture, and everyday life is discussed. Environmental aspects related to solution processes are also considered. The paper is intended for students studying chemistry and aims to strengthen theoretical knowledge and develop a deeper understanding of solution chemistry.

Keywords: *solution, solvent, solute, concentration, solubility, electrolyte, osmosis, colligative properties.*

Introduction

Solution chemistry represents one of the fundamental branches of general chemistry. A significant number of natural and industrial processes occur in the form of solutions. Biochemical reactions in living organisms, the action of pharmaceutical preparations, dissolution of fertilizers in soil, and corrosion of metals are all directly related to solution processes.

Therefore, the study of solutions has both theoretical importance and practical relevance. This paper discusses the concept of solutions, their classification, mechanisms of formation, concentration expressions, physicochemical properties, and practical applications.

1. Concept and General Characteristics of Solutions

A solution is defined as a homogeneous system composed of two or more substances uniformly distributed at the molecular, atomic, or ionic level. The component present in a larger amount is called the solvent, while the substance dissolved in it is referred to as the solute.

The solvent usually determines the physical state of the solution. For example, when sugar dissolves in water, water acts as the solvent and sugar as the solute.

Solutions differ from mechanical mixtures. In mechanical mixtures, components can often be separated by simple physical methods such as filtration. In contrast, the particles in a solution are dispersed at the molecular level and cannot be separated by ordinary mechanical techniques.

2. Classification of Solutions

2.1 According to Physical State

Solutions may exist in different aggregate states:

• Liquid solutions, such as salt dissolved in water;
• Solid solutions, including metallic alloys like bronze;
• Gaseous solutions, such as air, which is a mixture of gases.

2.2 According to Concentration

Solutions can also be classified based on concentration:

• Dilute solutions
• Concentrated solutions
• Saturated solutions

• Supersaturated solutions
A saturated solution contains the maximum amount of solute that can dissolve at a given temperature. Changes in temperature may result in precipitation of the excess solute.

3. Mechanism of Solution Formation

The formation of a solution involves physicochemical processes occurring in several stages:

1. Partial disruption of interactions between solvent molecules;
2. Separation of solute particles;
3. Formation of new interactions between solvent and solute particles.

When ionic compounds dissolve in water, they dissociate into ions that become surrounded by water molecules. This process is known as hydration.

Dissolution may be accompanied by heat absorption (endothermic process) or heat release (exothermic process), depending on the nature of intermolecular interactions.

4. Solubility and Influencing Factors

Solubility is defined as the amount of a substance that can dissolve in 100 grams of solvent at a specific temperature.

4.1 Effect of Temperature

For most solid substances, solubility increases with rising temperature. In contrast, the solubility of gases in liquids generally decreases as temperature increases.

4.2 Effect of Pressure

Pressure significantly affects the solubility of gases. An increase in pressure leads to greater gas solubility in liquids.

4.3 Nature of Substances

The principle "like dissolves like" explains that polar substances dissolve better in polar solvents, while nonpolar substances dissolve in nonpolar solvents.

5. Concentration of Solutions

Concentration expresses the quantity of solute present in a given amount of solution.

5.1 Mass Percent

Mass percent concentration is calculated as:

$C\% = (\text{mass of solute} / \text{mass of solution}) \times 100\%$

5.2 Molarity

Molar concentration (molarity) is defined as:

$C = n / V$

where

n — amount of substance (in moles),
V — volume of solution (in liters).

5.3 Molality

Molality represents the number of moles of solute dissolved in one kilogram of solvent.

6. Electrolyte and Nonelectrolyte Solutions

Substances that dissociate into ions in aqueous solutions and conduct electricity are called electrolytes. These include acids, bases, and salts.

Substances that do not form ions in solution are called nonelectrolytes, such as sugar solutions.

Electrolytes may be classified as strong or weak depending on the degree of ionization.

7. Colligative Properties of Solutions

Colligative properties depend on the number of dissolved particles rather than their chemical nature.

7.1 Boiling Point Elevation

Solutions generally boil at higher temperatures than pure solvents.

7.2 Freezing Point Depression

Solutions freeze at lower temperatures compared to pure solvents.

7.3 Osmotic Pressure

Osmotic pressure arises when solvent molecules pass through a semipermeable membrane from a region of lower solute concentration to higher solute concentration. This phenomenon plays a vital role in biological systems.

8. Practical Applications of Solutions

Solutions are widely used in medicine, agriculture, industry, and daily life. Pharmaceutical preparations are often administered as solutions. Fertilizers are applied in dissolved form. Industrial processes such as electroplating and chemical manufacturing rely heavily on solution chemistry. Household cleaning products and beverages are also examples of solutions used in everyday life.

9. Environmental Aspects of Solutions

Environmental pollution frequently involves harmful substances entering water bodies in dissolved form. Therefore, water purification and waste treatment technologies are essential for minimizing ecological damage.

Conclusion

Solutions represent a fundamental concept in chemistry with broad theoretical and practical significance. Their physicochemical properties play an essential role in biological processes, industrial production, and environmental systems.

A deeper understanding of solution chemistry contributes to scientific advancement, industrial efficiency, and environmental protection.

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