

To Understand the Complex Molecular Interactions in the Binary Systems

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Abstract

The study of molecular interactions in binary systems is essential for understanding the structural, thermodynamic, and physicochemical behaviour of mixtures containing two different components. Binary systems exhibit complex interactions arising from differences in molecular size, shape, polarity, hydrogen-bonding ability, and other intermolecular forces. This study focuses on understanding the nature and strength of molecular interactions in binary mixtures and their influence on measurable physical properties. Experimental investigations of parameters such as density, viscosity, refractive index, ultrasonic velocity, dielectric properties, and excess thermodynamic functions can provide valuable information about molecular association and structural changes within the mixtures. Deviations of these properties from ideal behaviour help identify the presence of specific interactions between unlike molecules. Depending on the chemical nature of the components, interactions may involve hydrogen bonding, dipole–dipole forces, dispersion forces, electrostatic interactions, or molecular association. The analysis of excess properties and derived interaction parameters can further reveal whether attractive or repulsive forces dominate the system. Such investigations are important for developing theoretical models and improving the understanding of liquid-phase behaviour. Knowledge of molecular interactions in binary systems has significant applications in chemical engineering, pharmaceutical formulation, separation processes, solvent selection, material science, and industrial process design. A systematic study combining experimental measurements with theoretical interpretation can therefore provide deeper insight into the microscopic mechanisms governing macroscopic properties. Understanding these interactions ultimately supports the design and optimization of mixtures with desired physical and chemical characteristics.

Keywords: Binary systems, molecular interactions, intermolecular forces, physicochemical properties, thermodynamics, molecular association, excess properties, hydrogen bonding, liquid mixtures, solution chemistry.