

# **Colligative properties of Dilute Solutions**

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The properties which depend entirely upon the number of particles of the solute dissolved in a known volume of a given solvent and not at all upon the nature (i.e. chemical composition) of the solute. These properties mainly depend upon the nature of the solvent. The colligative properties can be defined as the properties of solvent in a given solution. The major colligative properties are as follows:

1. Lowering of vapor pressure
2. Osmotic Pressure
3. Elevation of Boiling point
4. Depression of Freezing Point

# Henry's Law

- Henry's law describes the relationship between the **solubility of a gas in a liquid** and the **pressure of that gas above the liquid** at constant temperature.

$$m \propto P \quad \text{or} \quad m = kP$$

$m$ = mass of gas dissolved per unit volume,  $P$ = pressure of gas in equilibrium with solution at constant temperature

- It states that **at constant temperature, the amount of a gas dissolved in a liquid is directly proportional to the partial pressure of that gas** in contact with the liquid.
- In simple words, **higher gas pressure → more gas dissolves in the liquid.**

## **Physical Meaning of Henry's Law**

When a gas is brought into contact with a liquid:

- Gas molecules strike the liquid surface.
- Some molecules enter the liquid phase.
- Some dissolved molecules escape back into the gas phase.

**At equilibrium, the rate of dissolution equals the rate of escape. Increasing gas pressure increases the number of molecules striking the surface, thus increasing solubility.**

Henry's law is obeyed under the following conditions:

- Temperature must remain constant.
- Gas should not chemically react with the solvent.
- Gas should not associate or dissociate in solution.
- Gas should be moderately soluble.
- Solution should be dilute.

## **Limitations of Henry's Law**

Henry's law fails when:

- Gas reacts chemically with solvent.
- Gas is highly soluble.
- High pressure or high concentration conditions exist.
- Electrolytes are present in large amounts.

# Factors Affecting Solubility of Gases

## (a) Pressure

- Increase in pressure increases gas solubility.

## (b) Temperature

- Increase in temperature generally **decreases** gas solubility because dissolution of gases is usually exothermic.

## (c) Nature of Gas and Solvent

- Polar gases dissolve better in polar solvents.

Non-polar gases dissolve better in non-polar solvents.

# Applications of Henry's Law

- Used in **carbonated beverages** where carbon dioxide is dissolved under high pressure.
- Important in **scuba diving**, explaining why gases dissolve in blood at high pressure.
- Used in **industrial gas absorption processes**.
- Helps estimate **solubility of atmospheric gases in water**.
- Useful in environmental chemistry for studying gas transfer between air and water.

# Raoult's Law

- Raoult's law describes the relationship between the **vapor pressure of a solution** and the **composition of the solution**. It explains how the presence of a volatile solute affects the vapor pressure of a solvent.
- It states that **the partial vapor pressure of each component in a solution is proportional to its mole fraction in the solution**.
- In simple words, the vapor pressure of a component decreases as its amount in the mixture decrease.

# Physical Meaning of Raoult's Law

- In a pure liquid, many molecules escape from the surface into the vapour phase.

When a non-volatile or less volatile solute is added:

- Fewer solvent molecules are present at the surface.
- Fewer molecules escape into the vapor phase.
- Vapor pressure of the solvent decreases.
- Thus, vapor pressure depends on how much of each component is present.

# Ideal Solutions

- Raoult's law is obeyed most accurately by **ideal solutions**.
- In ideal solutions:
  - a. Intermolecular forces between unlike molecules are similar to those between like molecules.
  - b. No heat is absorbed or released during mixing.
  - c. Volume does not change on mixing.
- Examples: benzene–toluene, hexane–heptane.

# Applications of Raoult's Law

- Explains **lowering of vapor pressure**.
- Used in determination of **molar mass** of solutes.
- Basis for studying **colligative properties**.
- Helps understand **vapor-liquid equilibrium** in solutions.
- Important in distillation and separation processes.

**Raoult's law states that the vapor pressure of a solution depends on the proportion of each component present and decreases as the amount of volatile solvent decreases.**