# Colligative Properties

*Colligative properties are those which depend only on the number of particles of the solute present in solution and not in any way on the nature of the solute.*

Note- Here, the solute is invariably taken as non-volatile

*Colligative properties can be regarded as the properties of the solvent in a given solution*

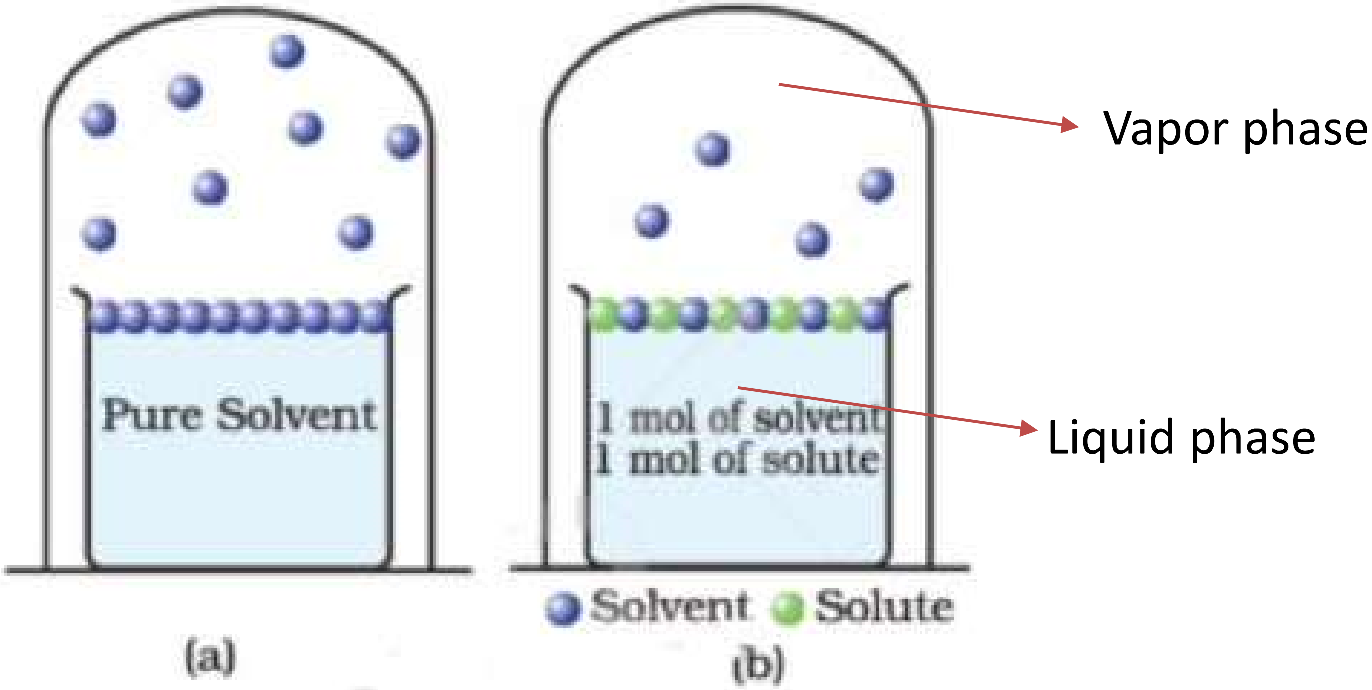
The various colligative properties are

- Lowering of vapour Pressure
- Osmotic Pressure
- Elevation of Boiling point
- Depression of Freezing Point

**Dilute Solution**- *When a solute (A) is dissolved in a given solvent (S), solute-solvent (A-S) interactions are set in, and if the solution is dilute, solute –solute interactions become minimal and hence negligible. So a solution may be called dilute till the concentration for which solute-solute interaction are negligible so that colligative property just depends upon number of solute particle*.

Note- We will consider only dilute solution, where there is no association and dissociation of solute particles.

# Lowering of Vapour Pressure of Solvent by a Non-Volatile Solute




*On the surface of pure solvent (a) there are more particles of solvent in surface than in solution (b). Therefore number of solvent molecules that escape from surface to vapour phase will be more in case of* (a) *than in* (b). *Thus vapour pressure of solution is lower than that of pure solvent.*

Note- Since the solute is non-volatile, it would have a negligible vapour pressure

**Raoult's Law**- *A law stating that the vapour pressure of an ideal solution is proportional to the mole fraction of the solvent.*

$$P_{solution} = \chi_{solvent} P^o_{solvent}$$

*where $P^o_{solvent}$ is the vapor pressure of the pure solvent and $\chi_{solvent}$ is the mole fraction of the solvent. Since this is a two-component system (solvent and solute), then*

$$\chi_{solvent} + \chi_{solute} = 1$$

*where $\chi_{solute}$ is the mole fraction of the solvent or solute. The change in vapor pressure ($\Delta P$) can be expressed*

*Lowering of vapour pressure,* $\Delta P = P^o_{solvent} - P_{solution} = P^o_{solvent} - \chi_{solvent} P^o_{solvent}$

$$= (1 - \chi_{solvent}) P^o_{solvent} = \chi_{solute} P^o_{solvent}$$

*Relative lowering of vapour pressure* $= \dfrac{\text{Lowering of vapour pressure}}{\text{Vapour pressure of pure solvent}}$

$$= \frac{\Delta P}{P^o_{solvent}}$$

$$= \frac{\chi_{solute} P^o_{solvent}}{P^o_{solvent}}$$

*Relative lowering of vapour pressure,* $\dfrac{P^o_{solvent} - P}{P^o_{solvent}} = \chi_{solute}$

The above expression may be stated as

*The relative lowering of vapour pressure of a solution is equal to the mole fraction of the non-volatile solute present in the solution*

**Problem**-Calculate the vapor pressure of a solution made by dissolving 50.0 g glucose in 500 g of water. The vapor pressure of pure water is 47.1 torr at 37 °C.

**Sol**-*we need to calculate the mole fraction of water (the solvent) in this sugar-water solution.*

$$\chi_{solvent} = \frac{\text{moles of water}}{\text{moles of solute} + \text{moles of solvent}}$$

$$\chi_{solvent} = \frac{n_{water}}{n_{glucose} + n_{water}}$$

The molar mass of glucose is 180.2 g/mol and of water is 18 g/mol. So

$$n_{water} = \frac{500\,g}{18\,g/mol} = 27.7\,mol$$

and

$$n_{glucose} = \frac{50\,g}{180.2\,g/mol} = 0.277\,mol$$

and

$$\chi_{solvent} = \frac{27.7\,mol}{0.277\,mol + 27.7\,mol} = 0.99$$

*The pressure of the solution is then calculated via Raoult's Law*

$$P_{solution} = 0.99 \times 47.1 = 46.63\,torr$$