

## Crash Course for NEET 2020

### KEY NOTES ON Solutions

Biomentors Classes Online, Mumbai

NCERT Based - Very Important Points

### Different types of solutions and their examples

Type of Solution	Solute	Solvent	Common Examples
Gaseous Solutions	Gas	Gas	Mixture of oxygen and nitrogen gases
	Liquid	Gas	Chloroform mixed with nitrogen gas
	Solid	Gas	Camphor in nitrogen gas
Liquid Solutions	Gas	Liquid	Oxygen dissolved in water
	Liquid	Liquid	Ethanol dissolved in water
	Solid	Liquid	Glucose dissolved in water
Solid Solutions	Gas	Solid	Solution of hydrogen in palladium
	Liquid	Solid	Amalgam of mercury with sodium
	Solid	Solid	Copper dissolved in gold

### Henry's law

The effect of a pressure on the solubility of of gas in a liquid is directly proportional to the pressure of the gas over the solution at a definite temperature

If  $m$  is the mass of the gas dissolved per unit volume of the solvent and  $P$  is the pressure of the gas in equilibrium with the solution, then

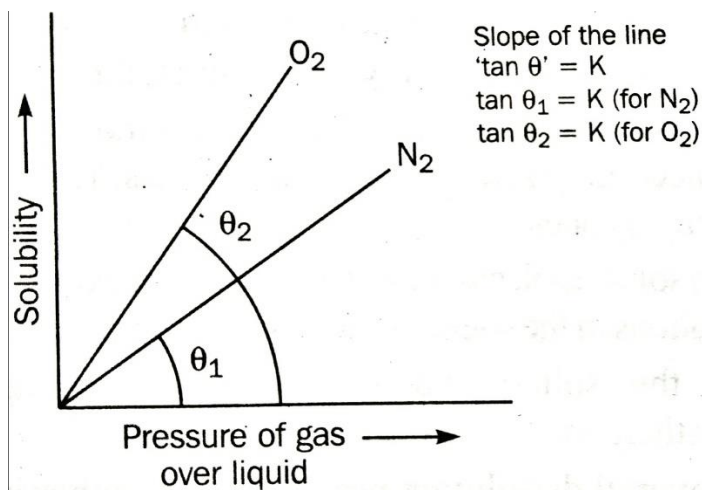
$$m \propto P$$

Or

$$m = K_H P \quad \dots \dots \dots (i)$$

Where,  $K_H$  =Proportionality constant which is called Henry's constant  $K_H$  depends on the nature of the gas, nature of the solvent, temperature and unit of pressure

Equation (i) represents equation of a straight line( $y = mx$ ) passing through the origin.



The straight line shows the validity of a Henry's law.

If the solubility of the gas is known at one particular pressure, then it can be calculated at other pressure using the following relationship

$$\frac{m_1}{m_2} = \frac{P_1}{P_2}$$

For a mixture of gases in equilibrium with a liquid, the solubility of any gas, expressed in term of mole fraction ( $X_A$ ) in the solution is directly proportional to its partial pressure i.e,  $p_A = K_H X_A$

The plot of  $p_A$  vs  $X_A$  is a straight line passing through the origin

### Raoult's law

When a non-volatile substance is dissolved in a liquid, the vapour pressure of the liquid (solvent) is lowered.

Raoult's law states that at a given temperature, the partial vapour pressure of any component of the solution is equal to the product of the vapour pressure of the pure component and its mole fraction in the solution

$$p_A = p_A^\circ X_A \text{ and } p_B = p_B^\circ X_B$$

The total vapour pressure  $P$  of such solution containing two compounds A and B is

$$\begin{aligned} P &= p_A + p_B \\ &= p_A^\circ X_A + p_B^\circ X_B \end{aligned}$$

$$\text{But } X_A + X_B = 1$$

$$X_A = (1 - X_B)$$

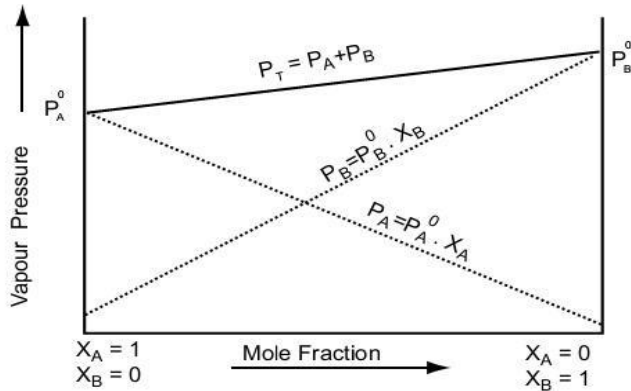
$$\text{Hence } P = (1 - X_B)p_A^\circ + p_B^\circ X_B$$

$$P = (p_B^\circ - p_A^\circ)X_B + p_A^\circ$$

## Ideal solution

In ideal solutions solute-solute and solvent-solvent interaction are almost similar to solute - solvent interactions.

$$\Delta H_{mix} = 0 \quad \text{and} \quad \Delta V_{mix}$$



Vapour Pressure Diagram for Ideal Solution

## Non-ideal or Real solution

These are the solution in which solute-solvent interactions are different from solute-solute and solvent-solvent interactions. These solution do not obey Raoult's law for all concentration and temperature

$$\Delta H_{(mix)} \neq 0$$

$$\Delta V_{(mix)} \neq 0$$

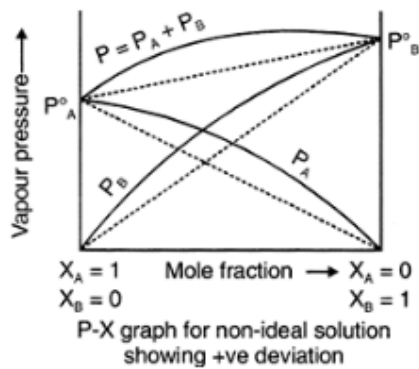
### Solution showing positive deviations

When  $\Delta H_{(mix)} > 0$  and  $\Delta V_{(mix)} > 0$  and in such cases, the observed vapour pressure of each component and total vapour pressure are greater than predicted by Raoult's law *i. e.*  $p_A > p_A^0 X_A$   
 $p_B > p_B^0 X_B \quad P > p_B + p_A$

This is because the new interaction are weaker than those in pure component

### Example

- Acetone and Carbon disulphide
- Acetone and Benzene
- Carbon Tetrachloride and Chloroform
- Acetone and Ethanol
- Ethanol and Water
- Chloroform and ethanol



### Solution showing negative deviations

When  $\Delta H_{(mix)} < 0$  and  $\Delta V_{(mix)} < 0$  and in such cases the observed vapour pressure of each component and total vapour pressure are less than predicted by Raoult's law i. e;  $p_A < p_A^\circ X_A$

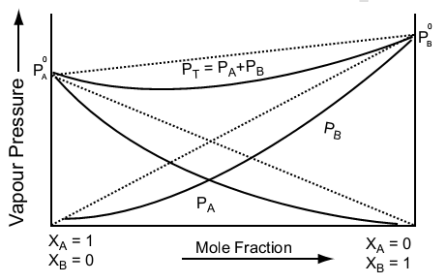
$$p_B < p_B^\circ X_B$$

$$P < p_A + p_B$$

This is because the new interactions are stronger than those in pure components

Examples

1. Acetone + aniline
2. HCl + H<sub>2</sub>O
3. H<sub>2</sub>SO<sub>4</sub> + H<sub>2</sub>O
4. Acetone + Chloroform
5. Pyridine + glacial acetic acid



### Azeotropic mixture

The mixtures of liquids which boil at constant temperature like a pure liquid and possess same composition of the components in liquid as well as vapour phases are called constant boiling mixture or azeotropic mixture.

**Relative lowering of vapour pressure** is defined as the ratio of lowering of vapour pressure to the vapour pressure of the pure solvent. It is determined by Ostwald-Walker method.

Thus according to Raoult's law,

$$\frac{p^0 - p}{p^0} = \frac{n}{n + N} = \frac{\frac{w}{m}}{\frac{w}{m} + \frac{W}{M}}$$

where,  $p$  = Vapour pressure of the solution

$p^0$  = Vapour pressure of the pure solvent

$n$  = Number of moles of the solute

$N$  = Number of moles of the solvent

$w$  and  $m$  = weight and mol. wt. of solute

$W$  and  $M$  = weight and mol. wt. of the solvent.

### Elevation of Boiling Point

For dilute solutions the elevation of boiling point ( $\Delta T_b$ ) is directly proportional to the molal concentration of the solute in a solution. Thus

$$\Delta T_b \propto m$$

$$\Delta T_b = K_b m$$

$T_b^\circ$  be the boiling point of pure solvent and  $T_b$  be the boiling point of solution. The increase in the boiling point  $\Delta T_b = T_b - T_b^\circ$  is known as elevation of boiling point.  $K_b$  is called Boiling Point Elevation Constant or Molal Elevation Constant (Ebullioscopic Constant)

**Depression in freezing point** is directly proportional to the lowering of vapour pressure.

$$\Delta T_f \propto p^\circ - p$$

$$\Delta T_f = K_f \times m$$

where  $K_f$  = molal depression constant or cryoscopic constant;  $m$  = Molality of the solution (i.e., no. of moles of solute per 1000 g of the solvent);  $\Delta T_f$  = Depression in freezing point

$$\Delta T_f = \frac{1000 \times K_f \times w}{m \times W} \quad \text{or} \quad m = \frac{1000 \times K_f \times w}{\Delta T_f \times W}$$

### Osmotic pressure of the solution: -

Osmotic pressure may be defined as the excess pressure which must be applied to a solution in order to prevent flow of solvent into the solution through the semi-permeable membrane.

According to Boyle Van't Hoff law (at conc. temp.)

$$\pi \propto C$$

According to Gaylussac Van't Hoff law (at conc. temp.)

$$\pi \propto T$$

From equation (i) and (ii)

$\pi \propto CT$ ,  $\pi = CRT$  (Van't Hoff equation)

$$\pi = \frac{n}{V}RT \quad \left( \because C = \frac{n}{V} \right); \quad \pi = \frac{w}{m} \frac{RT}{V} \quad \left( \because n = \frac{w}{m} \right)$$

Here,  $C$  = concentration of solution in *moles per litre*

$R$  = gas constant ;  $T$  = temperature

$n$  = number of *moles* of solute ;  $V$  = volume of solution  $m$  = molecular weight of solute ;  $w$  = weight of solute

**Van't Hoff's factor ( $i$ ) :**

$$i = \frac{\text{Observed value of colligative property}}{\text{Calculated value of colligative property assuming no association or dissociation}}$$

$$i = \frac{\text{No. of particles after association or dissociation}}{\text{No. of particles before association or dissociation}}$$

Introduction of the Van't Hoff factor modifies the equations for the colligative properties as follows,

$$\text{Relative lowering of vapour pressure} = \frac{P_A^{\circ} - P_A}{P_A^{\circ}} = iX_B$$

Elevation of boiling point,  $\Delta T_b = ik_b m$

Depression in freezing point,  $\Delta T_f = ik_f m$

Osmotic pressure,  $\pi = \frac{inRT}{V}$ ;  $\pi = iCRT$

From the value of ' $i$ ', it is possible to calculate degree of dissociation or degree of association of substance.

**Degree of dissociation ( $\alpha$ ) :** It is defined as the fraction of total molecules which dissociate into simpler molecules or ions.

$$\alpha = \frac{i-1}{m-1}; \quad m = \text{number of particles in solution}$$

**Degree of association ( $\alpha$ ) :** It is defined as the fraction of the total number of molecules which associate or combine together resulting in the formation of a bigger molecules.

$$\alpha = \frac{i-1}{1/m-1}; \quad m = \text{number of particles in solution.}$$