SOLUTIONS

Solution : Homogenous mixture of two or more substances whose composition may be altered within certain limits.

Pre-requisite knowledge

- Basic concentration terms like Molarity, Molality, Mass percentage etc from Some basic concepts of chemistry

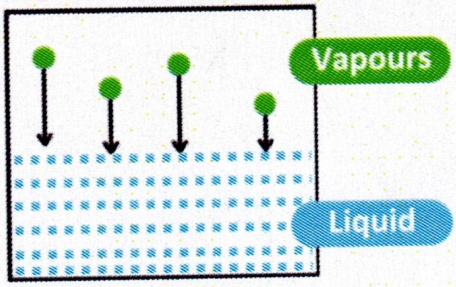
Solubility

$$\text{Solubility} = \frac{\text{Amount of solute dissolved}}{\text{Amount of solvent}} \times 100$$

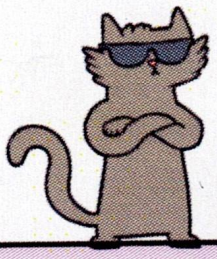
Types of Liquids

- **Volatile** - Which converts into vapours fast.
- **Non Volatile** - which doesn't convert into vapours.

Vapour Pressure



- In closed containers only.
  Liquid ⇌ Vapours
- Pressure exerted by the vapours



VP ∝ Temperature

VP ∝ 1/Intermolecular forces

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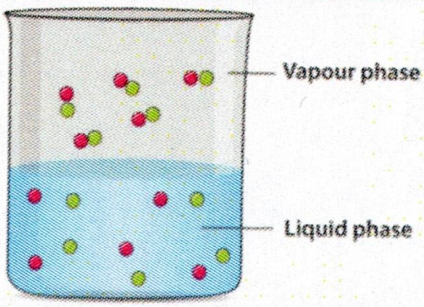
Clausius Clapeyron Equation

Relation between VP of liquid and temperature	$\ln\left(\frac{P_2}{P_1}\right) = \frac{\Delta H_{vap}}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$

Boiling Point : Temperature at which vapour pressure of a volatile liquid becomes equal to the external pressure.
Vapour Pressure is inversely proportional to B.P.

Raoult's Law for two volatile liquids

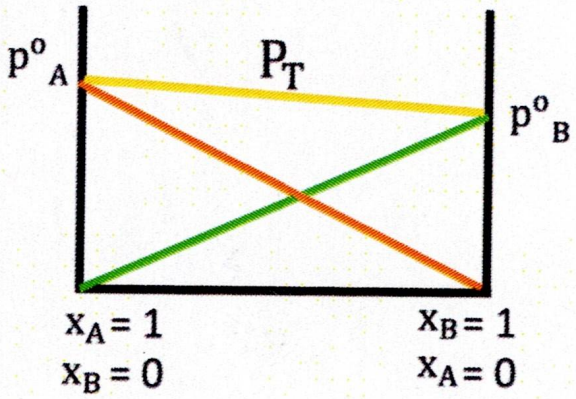


$p_A = p^o_A \cdot x_A$ & $p_B = p^o_B \cdot x_B$

Total Pressure = $P_T = p_A + p_B$

$= p^o_A \cdot x_A + p^o_B \cdot x_B$

p^o_A & p^o_B : Partial vapour pressure of pure A & B
x_A & x_B : Mole fractions in liquid phase
p_A & p_B : Vapour Pressure of A & B in solution



This case is valid when A is more volatile than B
x, here is mole fractions in liquid phase

Dalton's Law

if y is mole fractions in gas phase

$p_A = p^o_A \cdot y_A$ & $p_B = p^o_B \cdot y_B$

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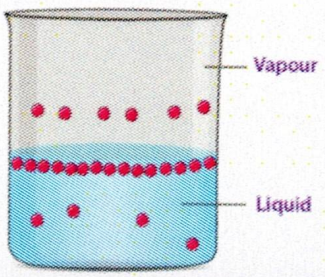
Raoult's Law for non volatile solute

If A is solvent and B is solute, then B doesn't vapourise Thus, $p_B = 0$

$$P_T = p_A + 0 = p^o{}_A \cdot x_A$$
$$= p^o{}_{solvent} \cdot x_{solvent}$$



Ideal Solutions	Ideal and Non-Ideal Solutions	
Obeys Raoult's	Doesn't obey Raoult's Law	
	Positive Deviation	**Negative Deviation**
IMF b/w **A-A and B-B = A-B**	IMF b/w **A-A & B-B > A-B**	IMF b/w **A-A & B-B < A-B**
$p_A = p^o{}_A \cdot x_A$ $p_B = p^o{}_B \cdot x_B$	$p_A > p^o{}_A \cdot x_A$ $p_B > p^o{}_B \cdot x_B$	$p_A < p^o{}_A \cdot x_A$ $p_B < p^o{}_B \cdot x_B$
$\Delta H_{mix} = 0$ $\Delta V_{mix} = 0$ $\Delta S_{mix} > 0$ $\Delta G_{mix} < 0$	$\Delta H_{mix} > 0$ $\Delta V_{mix} > 0$ $\Delta S_{mix} > 0$ $\Delta G_{mix} < 0$	$\Delta H_{mix} < 0$ $\Delta V_{mix} < 0$ $\Delta S_{mix} > 0$ $\Delta G_{mix} < 0$
• Bromoethane + chloroethane • Benzene + Toluene	• $CCl_4 + C_6H_6$ • $CCl_4 + CH_3OH$ • $CCl_4 + C_2H_5OH$ • Ethanol + water	• $HNO_3 + H_2O$ • Acetone + Chloroform • Chloroform + Acetic acid

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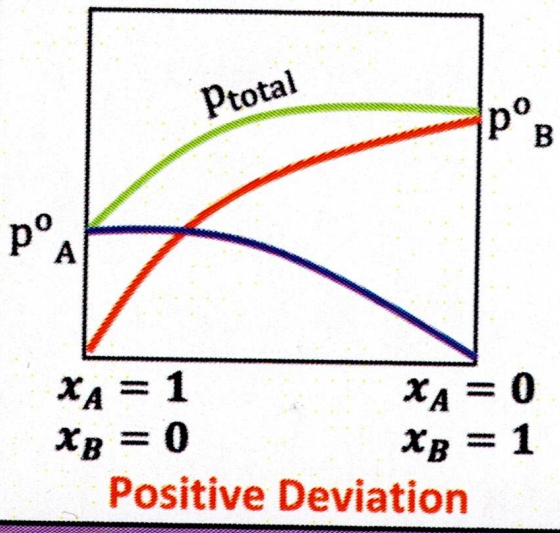
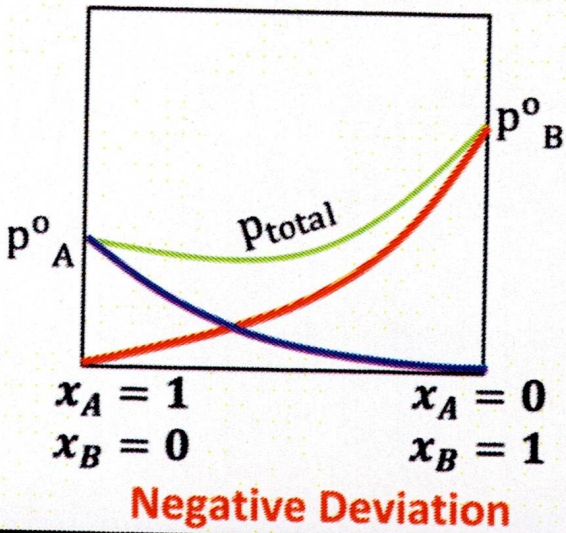


Positive Deviation



Negative Deviation

Azeotropic mixture

A liquid mixture with a **constant boiling point** and **vapour composition the same as liquid composition.** The components **cannot be separated by distillation.**

Minimum Boiling Azeotrope	Maximum Boiling Azeotrope
• B.P. of Azeotrope less than individual Comp.	• B.P. of Azeotrope more than individual Comp.
• Solutions swith Positive deviation from R.L.	• Solutions with Negative deviation from R.L.

Colligative Properties (Defined on page)

Properties of dilute solution containing non volatile solute which depends upon number of solute particles.

These properties do not depend upon nature of solute but may depend upon the nature of solvent.

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Vant Hoff Factor (*i*)

- Non Electrolytes do not undergo dissociation.
- Electrolytes (Strong or weak) undergo dissociation or association when dissolved in solvent.
- Thus, Actual solute particles differ from theoretical.

For Dissociation	$i > 1$	**For Association**	$i < 1$

$$i = \frac{\text{Actual no. of moles of solute present}}{\text{Theoritical no. moles of solute mixed}}$$

Formula to calculate vant hoff factor when D.O.D (α) is involved	$i = 1 + (n-1)\alpha$

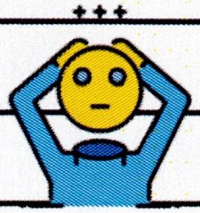
Value of n in different mechanisms

Case of Dissociation

n = 2	$NaCl \rightarrow Na^{+} + Cl^{-}$	Two ions Dissociate
n = 3	$BaCl_2 \rightarrow Ba^{+2} + 2Cl^{-}$	Three ions Dissociate

Case of Association

n = 1/2	$2CH_3COOH \rightleftharpoons (CH_3COOH)_2$



- For Dimerisation, i = 1/2 ; For Trimerisation i = 1/3
- In case of Non-Electrolytes like Glucose,Urea, sucrose, n = 1 resulting in i = 1.
- *i* is included in all the colligative formulas.
- Degree of dissociation is 1 for strong electrolytes

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Relative Lowering in Vapour Pressure

On adding non volatile solute to a volatile solvent, the vapour pressure of the solvent **decreases**

P_A^o = partial vapour pressure of Pure solvent
P_s = Partial vapour pressure of solvent in solution

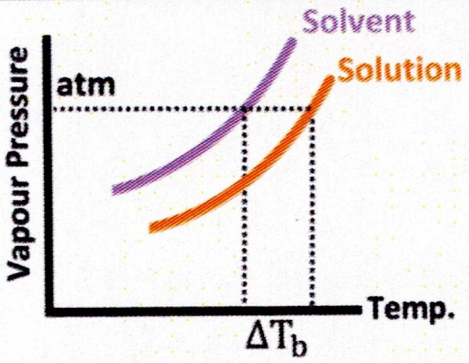
$$\frac{P_A^o - P_s}{P_A^o} = i\,x_B \simeq i\,\frac{n_B}{n_A}$$

Elevation in Boiling Point

When non volatile solute is dissolved in volatile solvent its V.P decreases. Thus, Boiling point increases

$$\Delta T_b = T_b - T^o_b$$
$$\Delta T_b = iK_b m$$

T_b = Boiling pt. of Solution
T^o_b = Boiling pt. of pure solvent
m = molality of solution
K_b = Ebullioscopic Constant



Ebullioscopic constant

K_b(water) = 0.52 K kg/mol

$$K_b = \frac{RT_b^{o2}}{1000\,L_v}$$

T_b^o = Standard B. P.
L_v = Latent Heat of vap.
$= \frac{\Delta H}{M.W.}$

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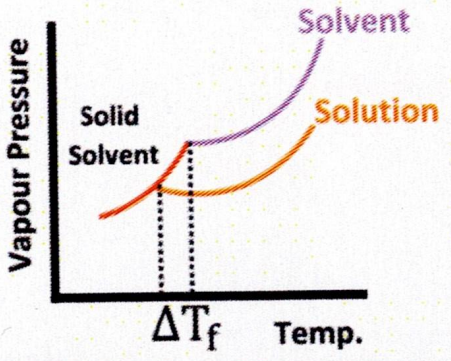
Depression in Freezing Point

When non volatile solute is dissolve in volatile solvent its V.P decreases. Thus, freezing point decreases.

$$\Delta T_f = T^o_f - T_f$$
$$\Delta T_f = iK_f m$$

T_f = Freezing pt. of Solution
T^o_f = Freezing pt. of pure solvent
m = molality of solution
K_f = Cryoscopic Constant



Cryoscopic constant

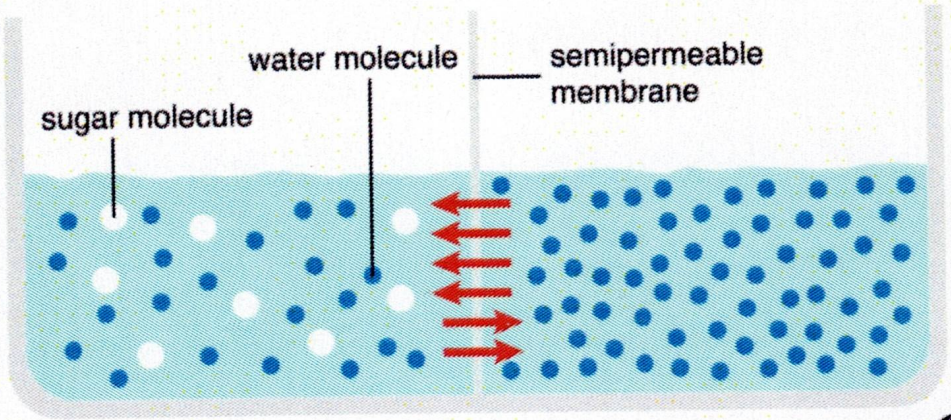
$K_f(\text{water}) = 1.86\ \text{K kg/mol}$

$$K_f = \frac{RT_f^{o2}}{1000\ L_f}$$

T_f^o = Standard F. P.
L_v = Latent Heat of fus.
$= \frac{\Delta H}{M.W.}$

Osmosis

Flow of solvent from Lower conc. to Higher conc.



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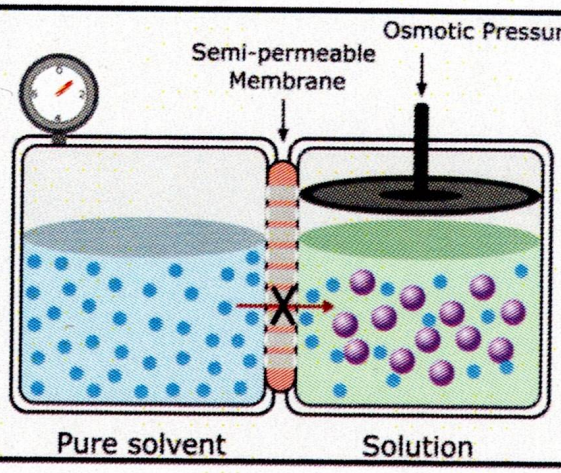
Osmotic Pressure

The minimum pressure which must be applied on solution side to prevent osmosis



Osmosis only takes place in solutions with different conc.

$$\pi = i\,CRT$$

C = concentration
R = gas constant
T = Absolute Temperature

if two solutions
a. have same (Isotonic solution)
b. have $\pi_1 > \pi_2$
Then π_1 = Hypertonic ; π_2 = Hypotonic

Henry's Law

The solubility of a gas in a liquid is proportional to pressure of the gas

$$p = K_H . x$$

- x is mole fraction of gas in liquid, K_H is Henry's const.
- Temp $\propto$ 1/Solubility
- Pressure $\propto$ Solubility
- $K_H \propto$ Temperature

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