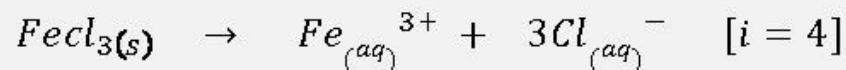
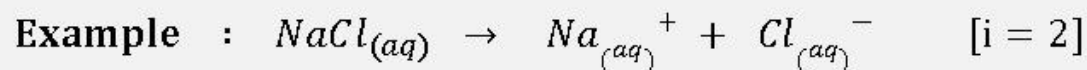


## Van't Hoff Factor (i) for Electrolytes

For strong electrolytes, number of ions produced in solution is equal to  $i$



Strong acid and bases come in category of strong <sup>4</sup>electrolytes <sup>1</sup>  
 (5)



Note that it depends on formula mass of the electrolyte

Note that for non electrolytes (like urea, sucrose etc),  $i$  is essentially 1

## Ideal Binary Solution of Miscible Liquids

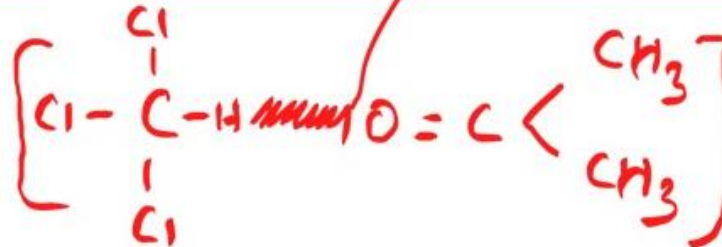
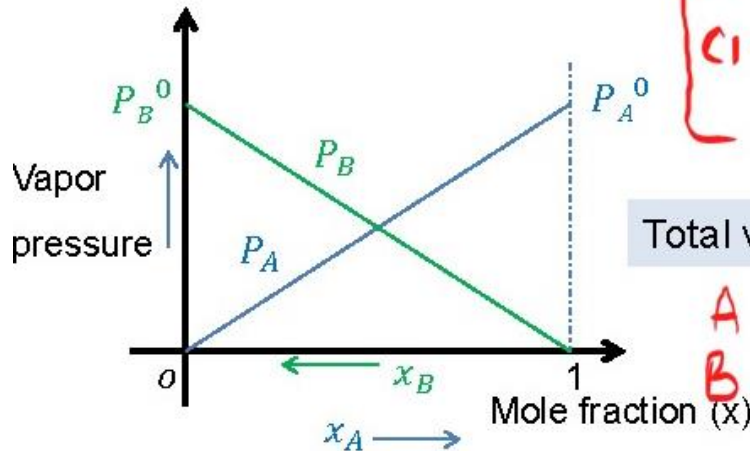
Following conditions must be true for an ideal binary solution

$$\Delta H_{mix} = 0$$

$$\Delta V_{mix} = 0$$

No chemical reaction between A & B

IMFOAT VP↓



$$\text{Total vapor pressure of solution (P)} = x_A P_A^0 + x_B P_B^0$$

$$\begin{array}{l} \text{A} \rightarrow P_A = P_A^0 x_A \\ \text{B} \rightarrow P_B = P_B^0 x_B \end{array} \left. \begin{array}{l} \\ \\ \end{array} \right\} \begin{array}{l} P_T = P_A + P_B \\ = P_A^0 x_A + P_B^0 x_B \end{array}$$

Note that ideal solution obey Raoult's law at every range of concentration

## Vapor Pressure Lowering : Raoult's Law

Vapor pressure of liquid is the pressure exerted by a vapor in equilibrium with its liquid ( $P^0$ )

$$(P^0 - P) \propto \frac{n_1}{n_1 + n_2}$$

Note that addition of solute particles lowers the vapor pressure of the solvent; say, lowering is  $(P^0 - P)$

$$P^0 - P = P^0 \frac{n_1}{n_1 + n_2}$$

$$\frac{P^0 - P}{P^0} = \frac{n_1}{n_1 + n_2}$$

*n* solute  
*n* solvent

dilute solution

Note that if  $n_1 \ll n_2$  then the mole fraction of solute  $\approx \frac{n_1}{n_2}$

$\frac{P^0 - P}{P^0}$  is known as relative lowering of Vapour Pressure

$$\frac{\frac{w}{M}}{\frac{W}{M}} = \frac{wM}{Wm}$$

## Colligative Properties



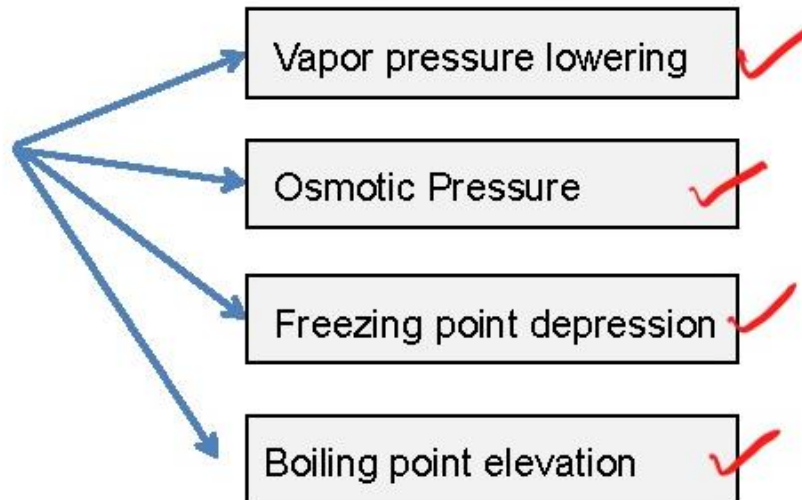
CP  $\propto$  NO of moles of non volatile

Those properties of dilute solutions which do not depend upon the nature of solute present

But, only on the number of solute particles

no of moles  $\uparrow$  CP  $\uparrow$     LOVP  $\uparrow$     EIBP  $\uparrow$     DIFP  $\uparrow$     OP  $\uparrow$   
 VP  $\downarrow$     BP  $\uparrow$     FP  $\downarrow$     DP  $\uparrow$

Example



## Non Ideal Solution: Negative Deviation

$$\Delta H_{mix} < 0,$$

$$\Delta V_{mix} < 0$$

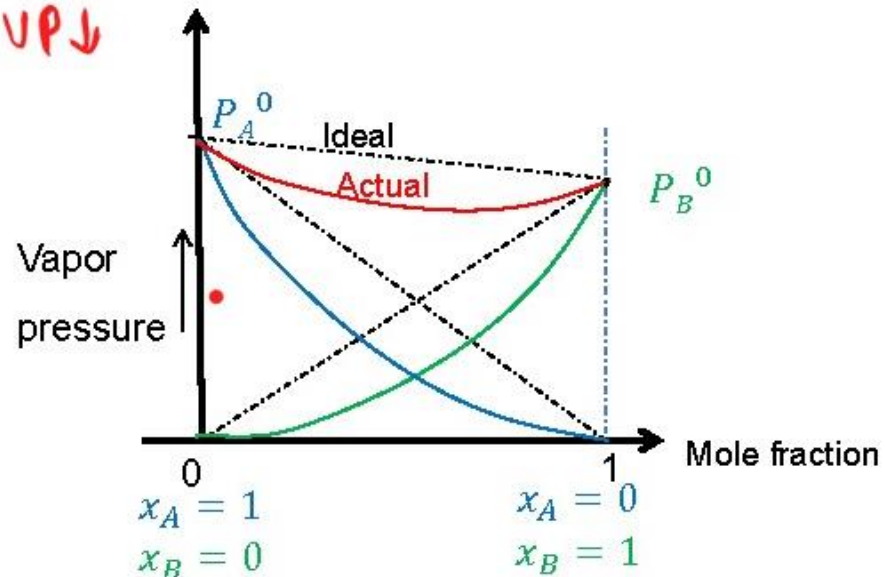
AND

$$P_A < x_A P_A^0,$$

$$P_B < x_B P_B^0$$

$$N_{bp} < O_{bp}$$

IMPORANT UP↓  
BPT



$$P_A + P_B < x_A P_A^0 + x_B P_B^0 \rightarrow \text{(do not obey Raoult's law)}$$

Note that such solution boil at higher temperature than either of components

## Non Ideal Solution: Positive Deviation

Cyclohexane +  $C_2H_5OH$   
40ml 10ml

$$\Delta H_{mix} > 0, \checkmark$$

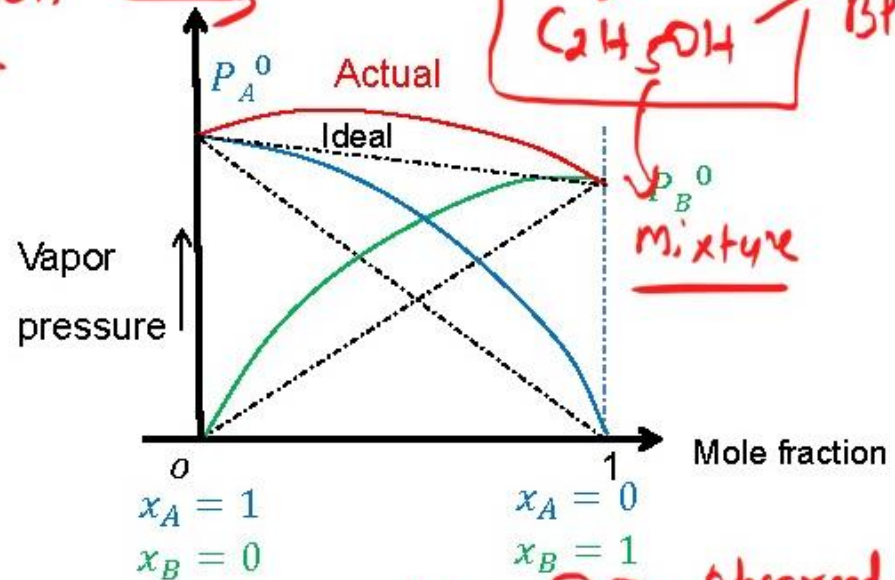
$$\Delta V_{mix} > 0, \checkmark$$

AND

$$P_A > x_A P_A^0, \checkmark$$

$$P_B > x_B P_B^0, \checkmark$$

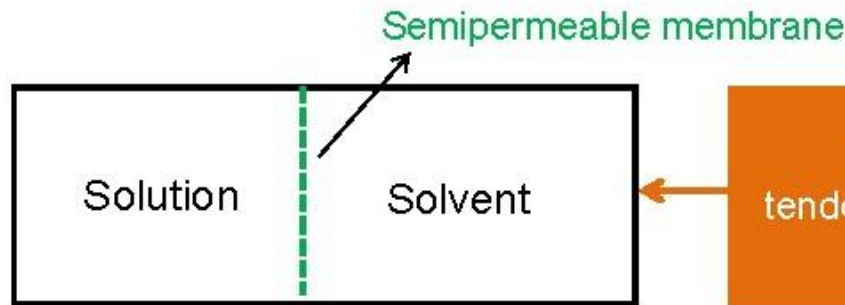
$NBP > DBP$



$$P_A + P_B > x_A P_A^0 + x_B P_B^0 \rightarrow (\text{do not obey Raoult's law})$$

Note that such solution boil at lower temperature then either of the components

# Osmotic Pressure



Note that Osmosis is process where a fluid has tendency to pass through semipermeable membrane to equalize the concentration on both sides

$PV = nRT$      $\pi V = nRT$  ,     $\pi = \frac{n}{V}RT$   
 $\pi$      $\pi = CRT$

Excess pressure applied to solution to just stop osmosis is osmotic pressure of solution ( $P_{os}$ )

$\propto$  molar concentration of solute at temperature  $T(^{\circ}C)$

$$P_{os} = \frac{n}{V}RT = CRT$$

n is number of moles of solute  
V is volume of solution in litres

Isotonic  $\pi_1 = \pi_2$   
hypertonic

hypotonic

## Depression in Freezing Point (F. P.)

Depression in F.P.  $\propto$  molal concentration of solute ( $m$ )

$$\Delta T_f \propto m$$

$$K_f = \frac{\Delta T_f}{m} \quad \text{for } H_2O \text{ (1.86)}$$

$$K_f = \frac{R(T_f^0)^2}{1000 L_f}$$

$$\Delta T_f = K_f m$$

$K_f$  is molar depression constant of solvent

$$m = \frac{\omega}{M'} \times \frac{10^3}{W}$$

$$m = \frac{n}{\omega} \times 1000$$

$n$  is the number of moles of solute

$\omega$  is weight in grams of solvent



## Van't Hoff Factor ( $i$ )

In case the solute undergoes dissociation / association number of solute particles change  $CP \propto \frac{1}{\text{Molal}}$



Abnormal results obtained for colligative properties

Experimental (Abnormal)

$$i = \frac{\text{observed value of colligative property}}{\text{normal value of colligative property}}$$

Note however that molecular weight and colligative properties are inversely related

$$i = \frac{\text{normal molecular weight}}{\text{observed molecular weight}}$$

## Van't Hoff Factor (i) for Weak Electrolytes

Weak electrolytes do not ionize completely

$$\alpha = 1$$

$$i = k$$



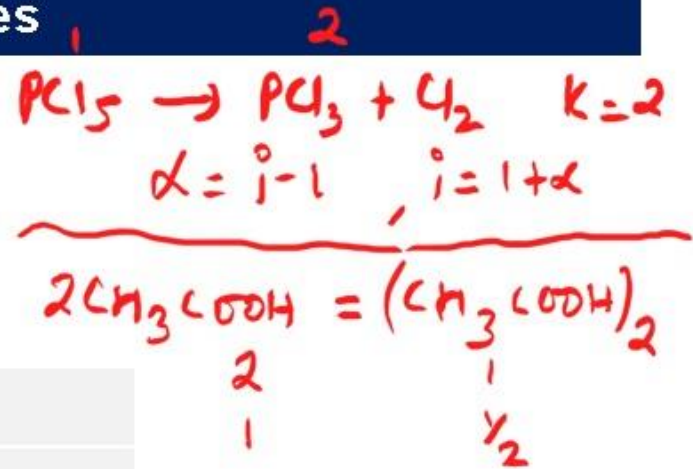
$$\alpha = \frac{i-1}{k-1}$$



Initially	1 mole	0	0
At equilibrium	$(1-\alpha)$ mole	$p\alpha$ mole	$q\alpha$ mole

$$\begin{aligned} \text{Total moles} &= 1 - \alpha + p\alpha + q\alpha \\ &= 1 + \alpha(q + p - 1) \end{aligned}$$

$$i = 1 + \alpha(q + p - 1)$$



$\alpha$  is the degree of dissociation per mole of weak electrolyte

$$\alpha = \frac{i-1}{\frac{1}{2}-1}$$

$$\left( i = 1 - \frac{\alpha}{2} \right)$$

## Van't Hoff Factor (i) for Weak Electrolytes

Weak electrolytes do not ionize completely



$$\frac{p^0 - p}{p^0} = i \times \text{solute}$$

$$\Delta T_b = i K_b m$$

$$\Delta T_f = i K_f m$$

$$\Pi = i CRT$$



Initially	1 mole	0	0
At equilibrium	$(1-\alpha)$ mole	$p\alpha$ mole	$q\alpha$ mole

$\alpha$  is the degree of dissociation per mole of weak electrolyte

$$\begin{aligned} \text{Total moles} &= 1 - \alpha + p\alpha + q\alpha \\ &= 1 + \alpha(q + p - 1) \end{aligned}$$

$$i = 1 + \alpha(q + p - 1)$$