

SOLUTION AND COLLIGATIVE PROPERTIES

Solution: Homogeneous mixture of two or more components.

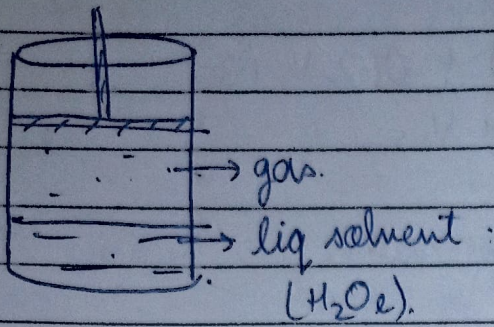
Homogeneous mixture → uniform composition throughout.
(single phase).
(region where composition is uniform)

→ Region of uniform composition of particles is known as phase.

Solⁿ → solute + solvent.
↓ ↓
lesser mols. excess of mols.

1 solute + 1 solvent → Binary solution

2 solute + 1 solvent → Ternary solⁿ.



$P_{\text{gas}} \propto$ solubility of gas in liq.

$P_{\text{gas}} \propto X_{\text{gas in liq}}$

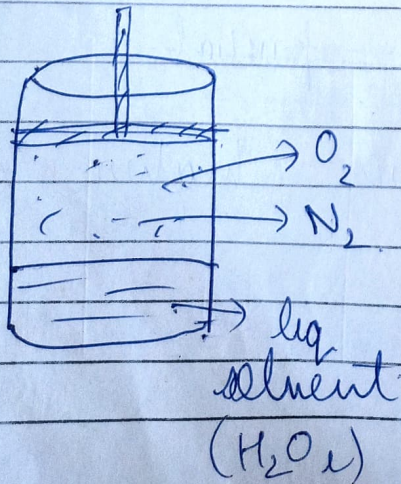
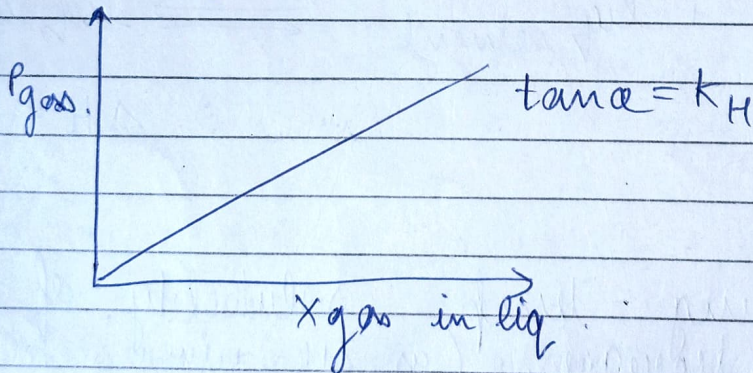
$$P_{\text{gas}} = K_H X_{\text{gas in liquid}}$$

Henry constant (atm)

$$P_{\text{gas}} = K_H M$$

atm mol^{-1}

On increasing temp, $K_H \uparrow$, solubility \downarrow



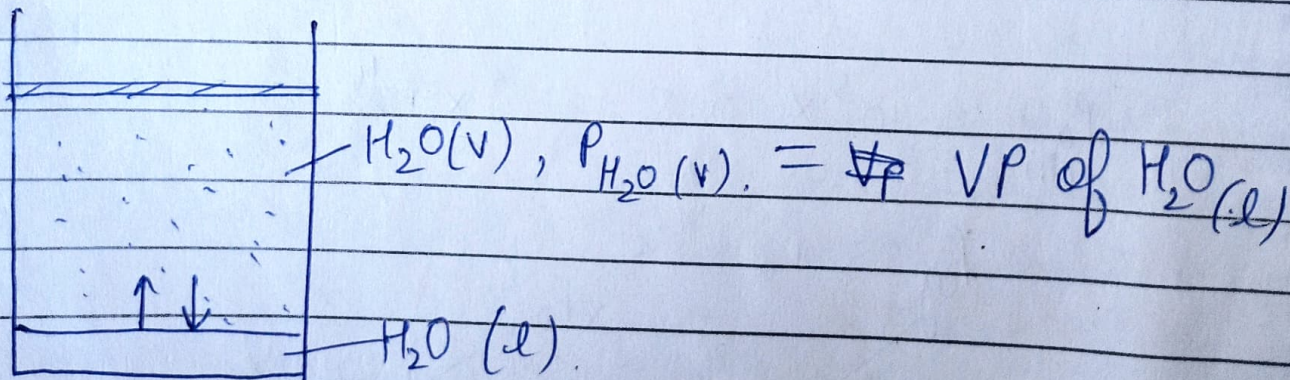
$$P_{N_2} = (K_H)_{N_2} X_{N_2 \text{ in } H_2O}$$

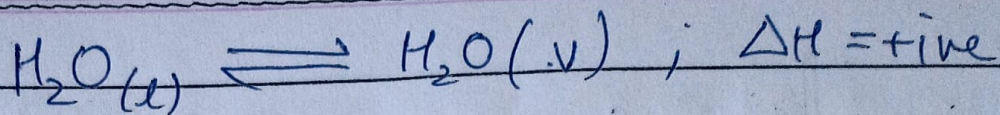
$$P_{O_2} = (K_H)_{O_2} X_{O_2 \text{ in } H_2O}$$

Note: Super saturated solution:

Solution which has more solute as compared to saturated solution is known as super saturated solution. This is achieved by heating or stirring the solⁿ.

Vapour pressure of Pure liquid, (P°)





$$K_c = [\text{H}_2\text{O}(v)]$$

$$K_p = P_{\text{H}_2\text{O}(v)} = VP$$

On increasing temp, $K_p \uparrow$, $\uparrow VP$.

$$\ln \frac{VP_2}{VP_1} = \frac{\Delta H_{\text{vap}}}{R} \left(\frac{1}{T_1} - \frac{1}{T_2} \right)$$

Definition

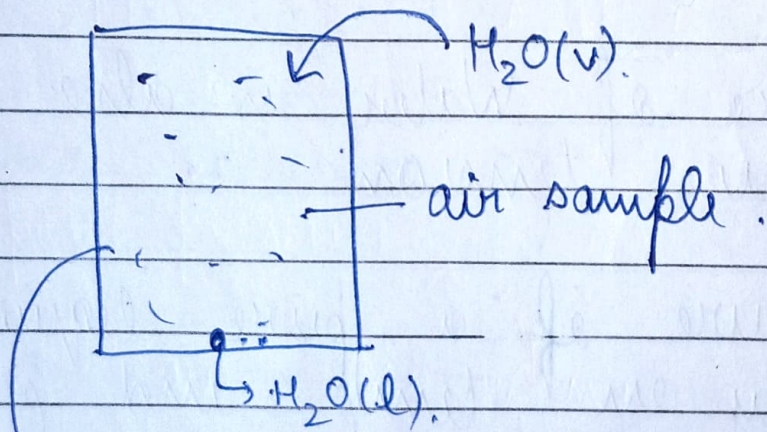
Vapour Pressure \rightarrow When a pure liquid & its vapour co exist in equilibrium then pressure applied by vapour is known as vapour pressure of that liquid.

VP: Petrol $>$ Water (H-bonding)
alcohol $<$ ether (GrMM = Same)
So Butane $>$ Butanol

★ Vapour pressure of water is also known as aqueous tension.

★ Vapour pressure of a pure liquid depends only on temp. and nature of liquid.

* Note :



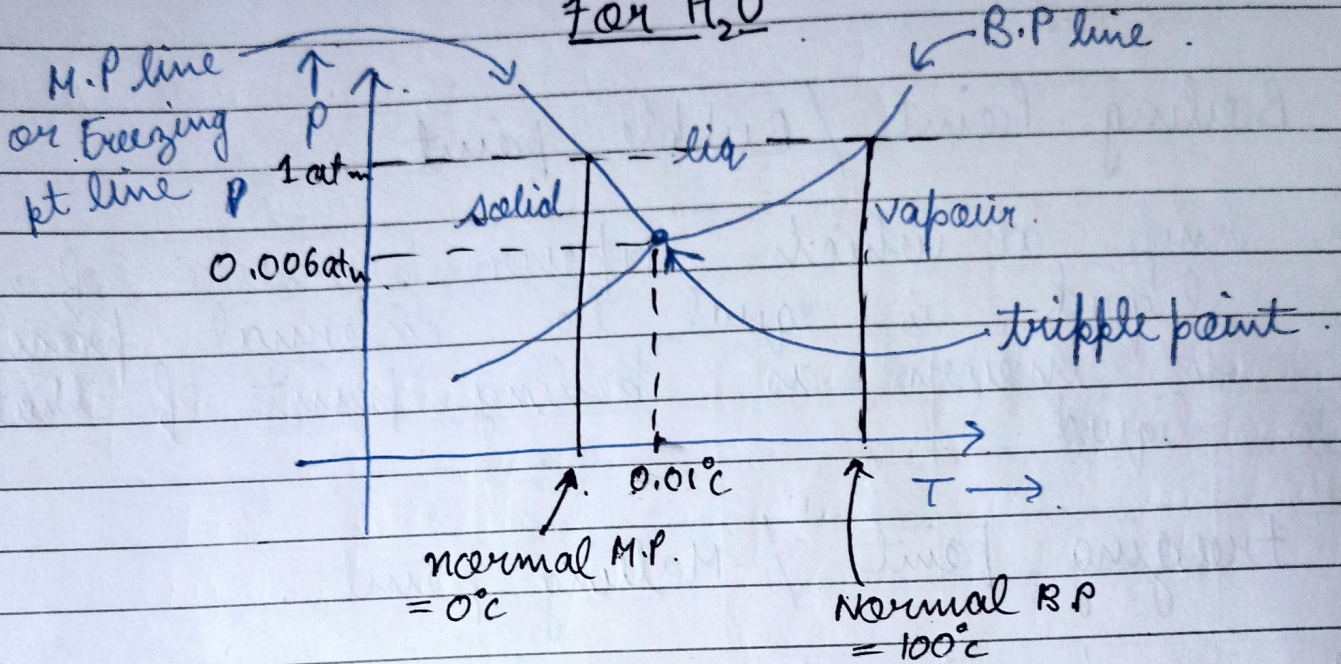
→ Total Pressure = $P_{air} + VP$ of $H_2O(l)$

↳ If air sample is saturated by $H_2O(v)$ then partial pressure of $H_2O(v)$ is equal to vapour pressure of H_2O .

Phase Diagram:

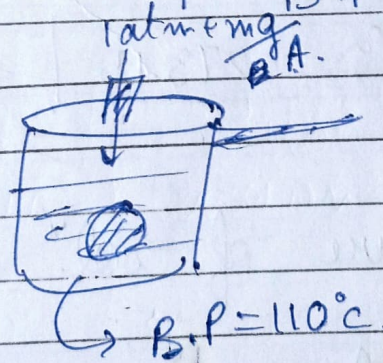
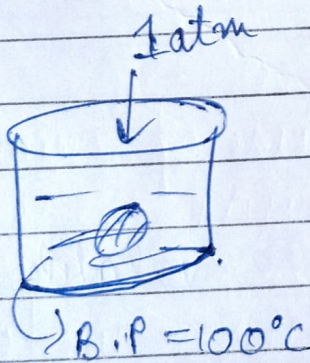
↳ Study of variation of physical state of a substance with pressure and temperature.

For H_2O



On increasing pressure \rightarrow M.P. of ice will \downarrow

\rightarrow B.P. of $H_2O(l)$ will \uparrow

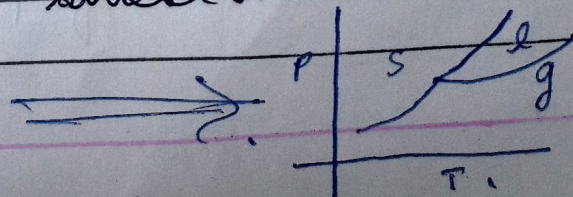


For $H_2O \Rightarrow d_{solid} < d_{liq}$

slope M.P. = -ive

↳ For most of the substances

$d_{solid} > d_{liq}$



- When external pressure is 1 atm then M.P. or ~~or~~ is known as normal M.P. & ~~Freezing pt~~ ^{Boiling} pt is known as normal ~~F.P.~~ B.P.

Boiling Point / Bubble point

↳ Temp. at which vapour pressure of a liquid is equal to external pressure is known as boiling point of that liquid.

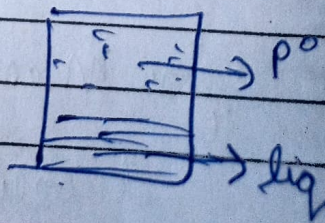
Freezing point / Melting point

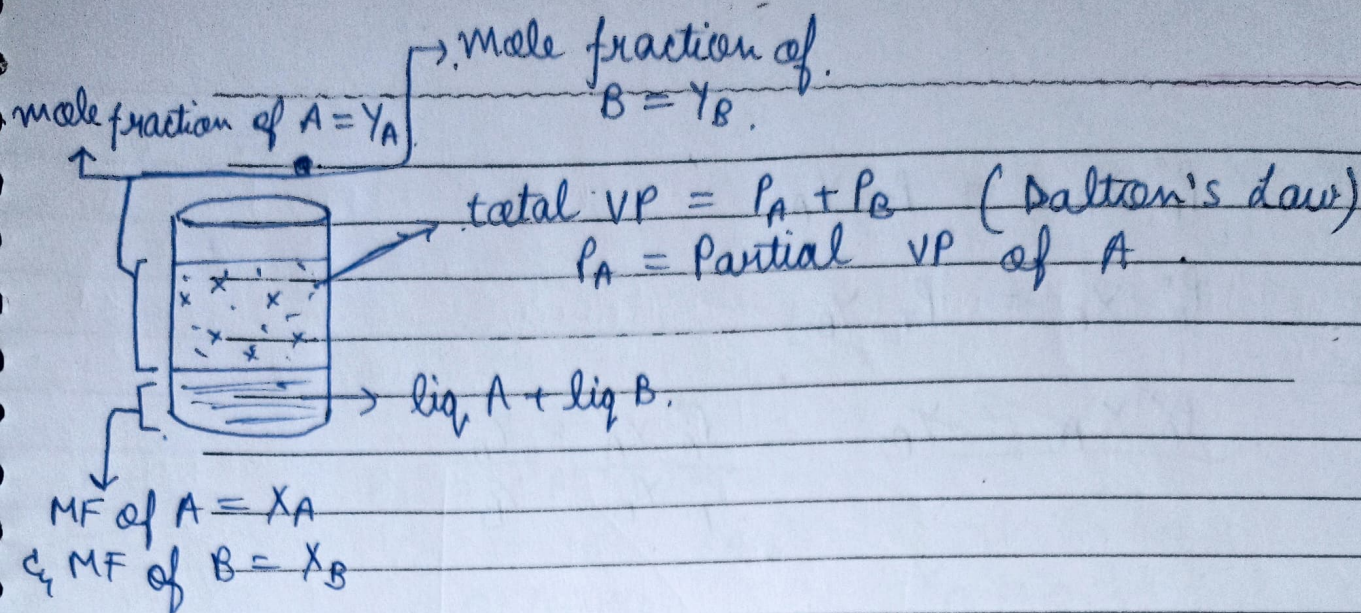
↳ Temp. at which solid & liquid phase of a substance can co-exist is known as F.P. or M.P.

$$K = ^\circ C + 273.15$$

Vapour pressure of solⁿ of 2 volatile liquid:

□ Rault law: According to this, partial vapour pressure of a liquid is equal to its ~~p.~~ P° and its mole fraction in solution.
where $P^\circ =$ V.P of pure liquid





Raoult Law

$$P_A \propto X_A \quad \left(\begin{array}{l} \text{ie} \\ \text{Partial VP of A} \propto \text{Mole fraction} \\ \text{of A in sol}^n \end{array} \right)$$

$$P_A = P_A^\circ X_A$$

$$P_B = P_B^\circ X_B$$

$$X_A + X_B = 1$$

$$Y_A + Y_B = 1$$

$$P_{\text{Total}} = P_A^\circ X_A + P_B^\circ X_B$$

$$P_A^\circ = \text{VP of pure liq. A}$$

$$P_B^\circ = \text{VP of pure liq. B}$$

$$P_A = P_T Y_A = P_A^\circ X_A$$

Dalton

Raoult

$$X_A = \frac{P_T Y_A}{P_A^\circ}$$

$$X_B = \frac{P_T Y_B}{P_B^\circ}$$

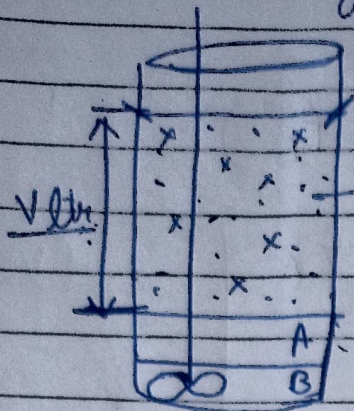
$$X_A + X_B = 1 = P_T \left[\frac{Y_A}{P_A^\circ} + \frac{Y_B}{P_B^\circ} \right]$$

$$\frac{1}{P_T} = \frac{Y_A}{P_A^\circ} + \frac{Y_B}{P_B^\circ}$$

Vapour pressure of Mixture of 2 insoluble liquids

eg $H_2O + \text{Oil}$; $H_2O + CS_2$; $H_2O + Hg$;
 $H_2O + C_6H_5NO_2$.

at BP; total VP = P_{ext}

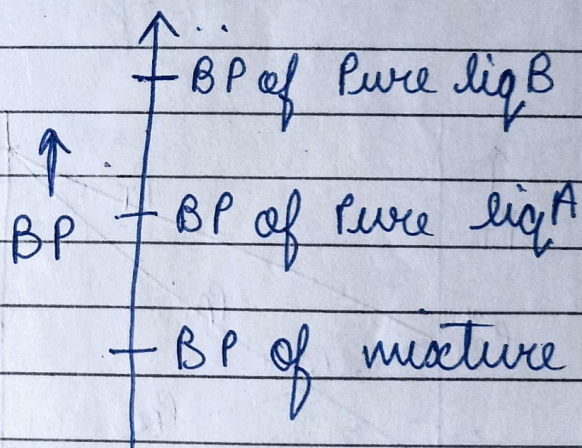
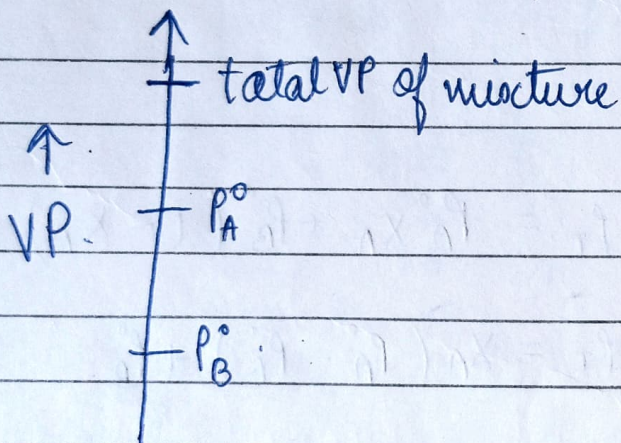


$$\begin{aligned} \text{total VP} &= ? && \rightarrow \frac{n_A RT}{V} \\ &= P_A^\circ + P_B^\circ && \rightarrow \frac{n_B RT}{V} \end{aligned}$$

$$\frac{P_A^\circ}{P_B^\circ} = \frac{n_A}{n_B} = \frac{W_A M_B}{M_A W_B}$$

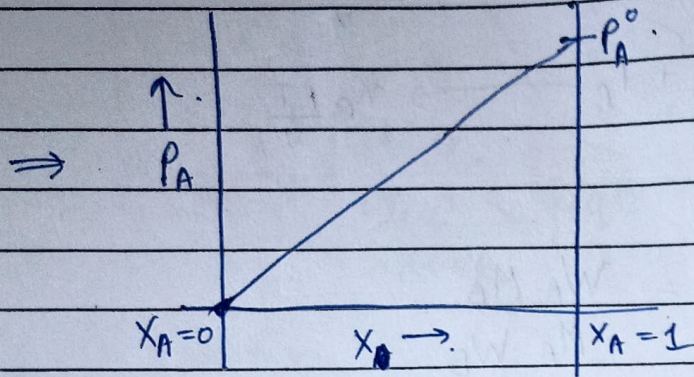
$$\boxed{\frac{W_A}{W_B} = \frac{P_A^\circ M_A}{P_B^\circ M_B}}$$

W_A = mass of A in gas phase
~~at~~ M_A = GMM of A.

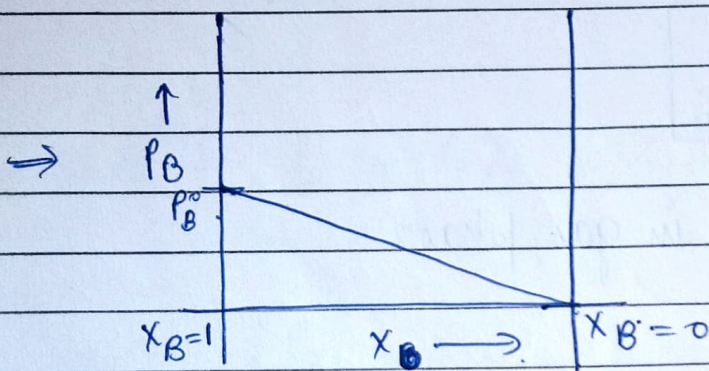


Some Graphs:

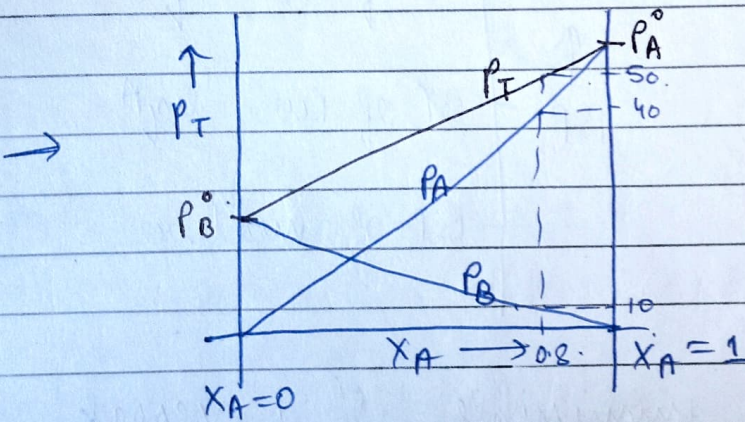
(Let $P_A^\circ > P_B^\circ$)



$$P_A = P_A^\circ X_A$$

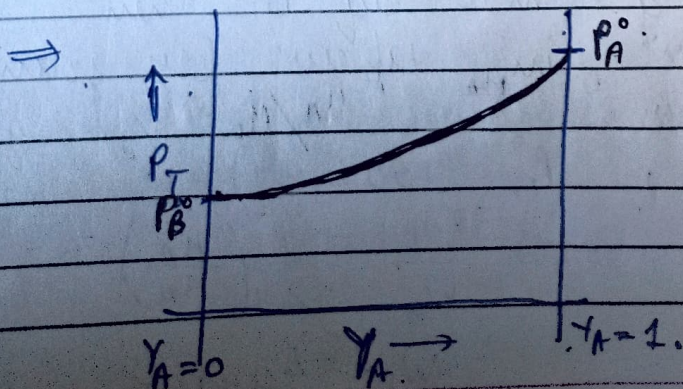


$$P_B = P_B^\circ X_B$$



$$P_T = P_A^\circ X_A + P_B^\circ (1 - X_A)$$

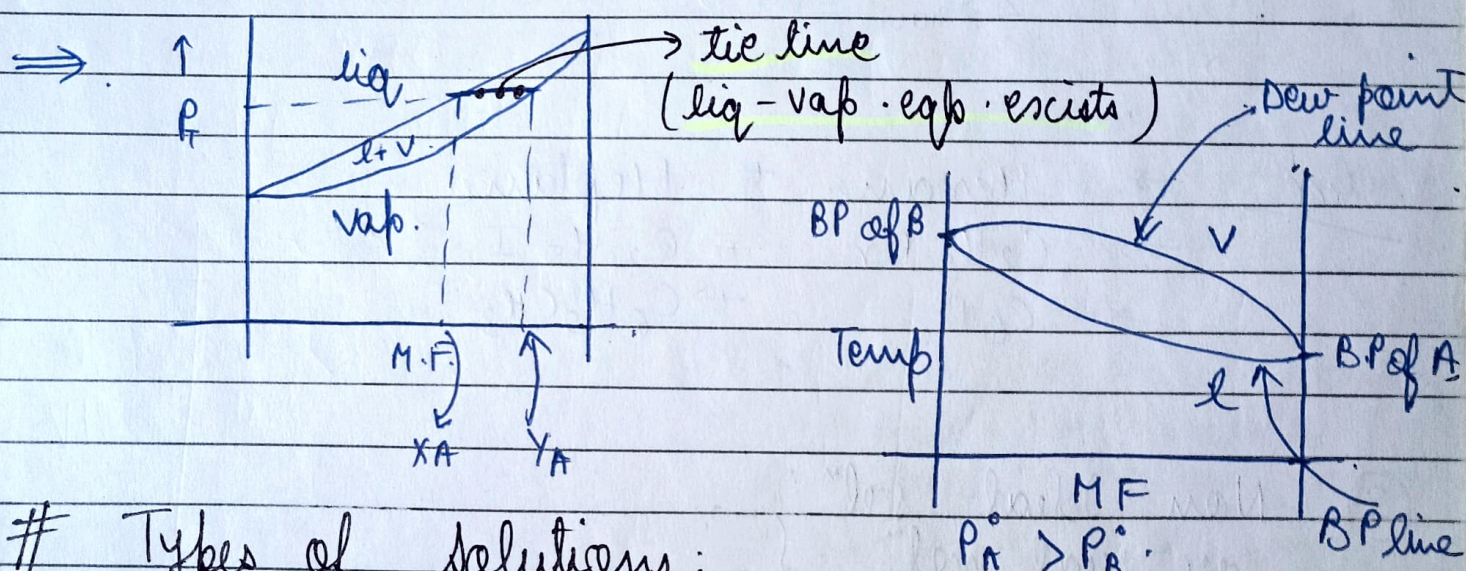
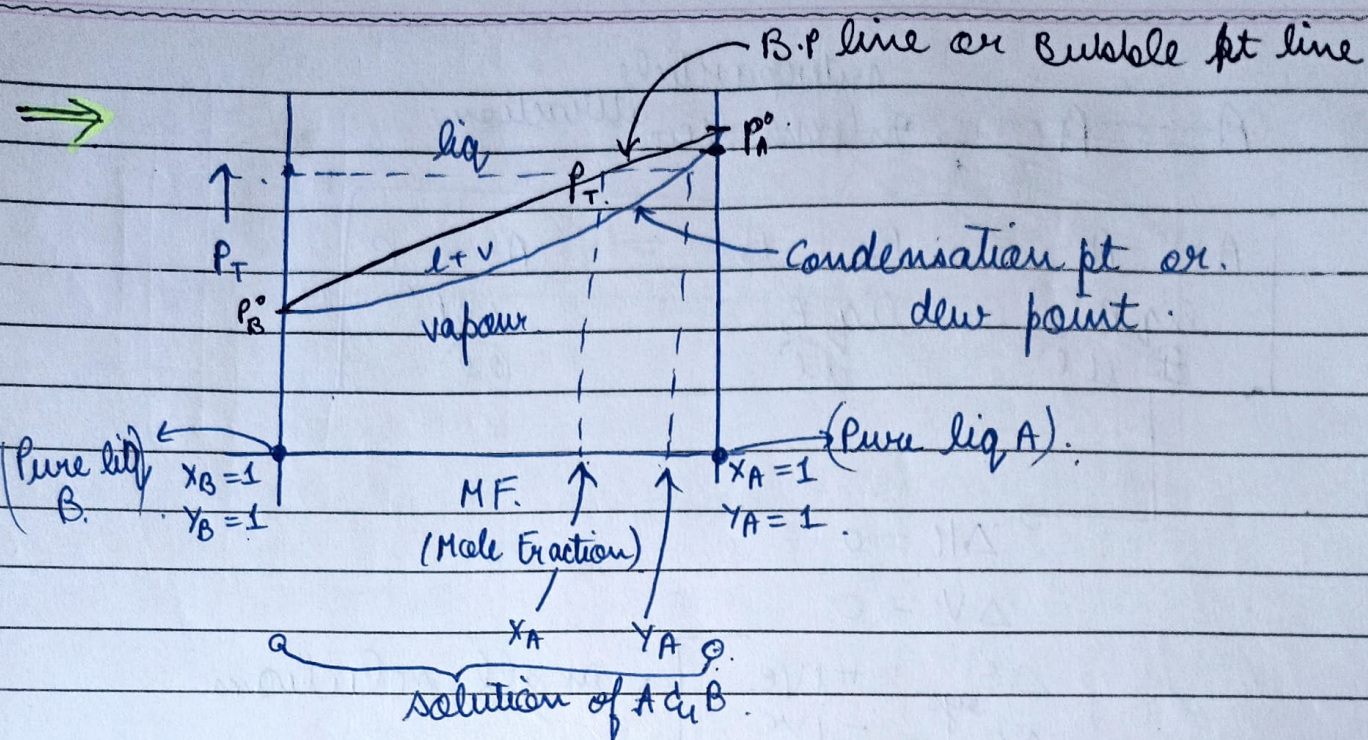
$$P_T = X_A (P_A^\circ - P_B^\circ) + P_B^\circ$$



$$P_T \Rightarrow \frac{1}{P_T} = \frac{Y_A}{P_A} + \frac{Y_B}{P_B}$$

$$\frac{1}{P_T} = \frac{Y_A}{P_A^\circ} + \frac{1 - Y_A}{P_B^\circ}$$

$$P_T = \frac{P_A^\circ P_B^\circ}{P_A^\circ + Y_A (P_B^\circ - P_A^\circ)}$$



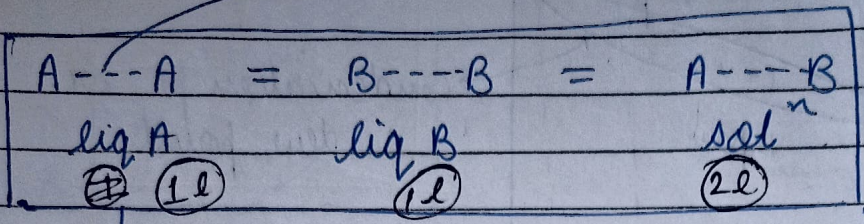
Types of solutions:

① Ideal solution →

↳ It follows Raoult law at all concentrations

$$\begin{aligned} \text{Total VP}_{\text{actual}} &= (\text{total VP})_{\text{Raoult}} \\ &= P_A^0 X_A + P_B^0 X_B \end{aligned}$$

Interparticle attraction
~~A --- A~~ → Intermolecular attraction



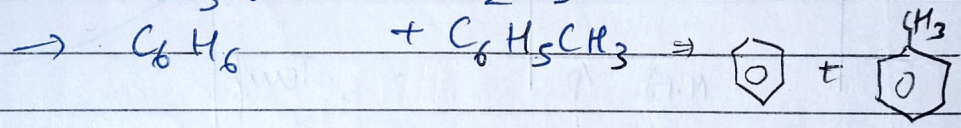
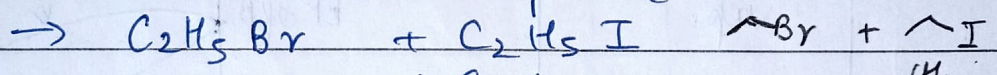
$\Delta H = 0$

$\Delta V = 0$

$\Delta S_{sys} = +ive$
 $\Delta G = -ive$ } → in all solutions

$\Delta S_{sur} = 0$

Ex → Hexane + Heptane



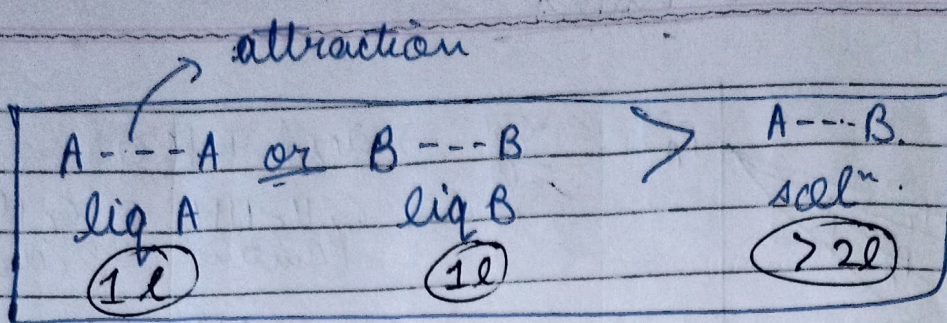
② Non-Ideal solⁿ }
 or real solⁿ } →

↳ Does not follow Raoult law at all concⁿ

$Total VP_{actual} \neq (Total VP)_{Raoult}$

(a) non ideal solⁿ having +ive deviation

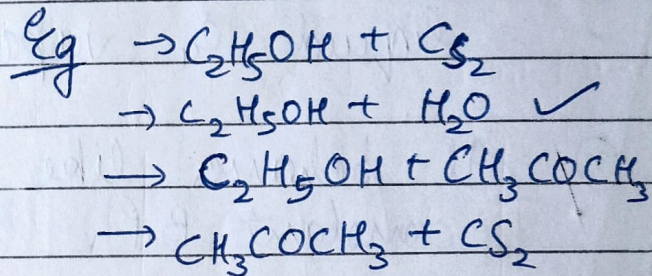
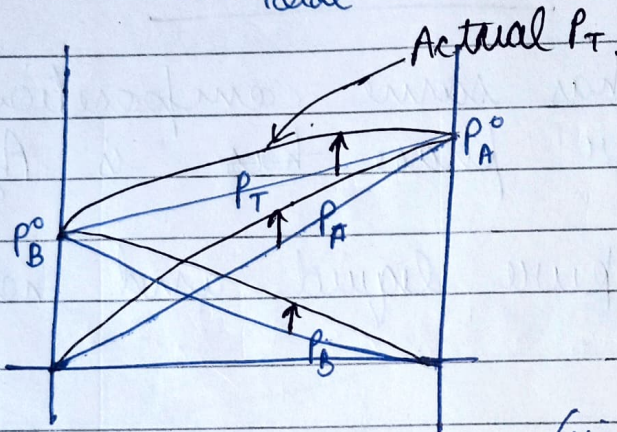
$total VP_{actual} > (Total VP)_{Raoult}$



$\Delta V = +ive$
 $\Delta H = +ive$
 $\Delta G = -ive$
 $\Delta S = +ive$

} always

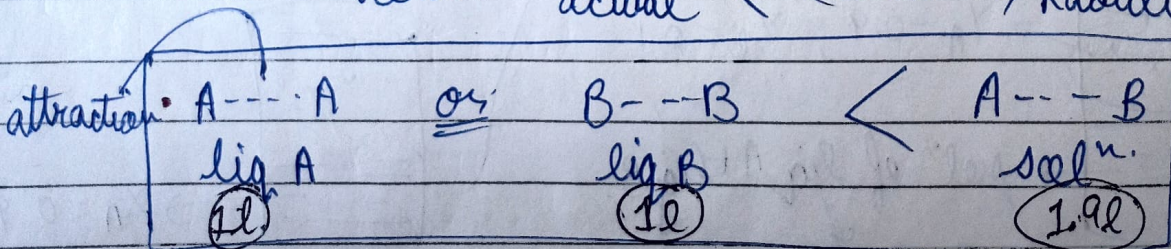
$\Delta S_{\text{sys}} = -ive$
 $\Delta S_{\text{total}} = +ive$



+ive deviation
 Hint: ① Polar & Non-Polar
 ② H-bond molecule & molecule which have not H-bonding

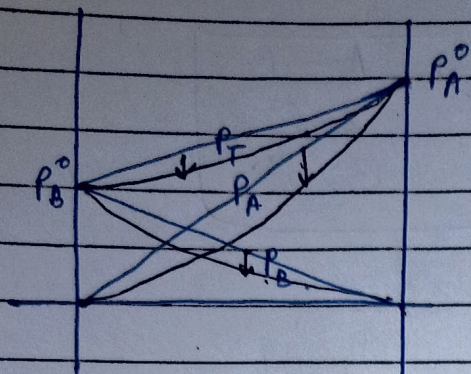
(b) Non ideal solⁿ ~~is~~ having -ive deviation.

total VP_{actual} < (total VP)_{raoult}

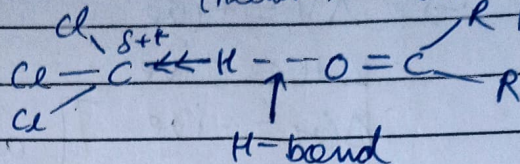
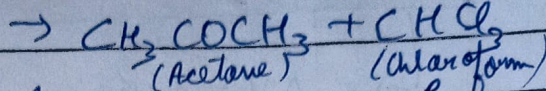
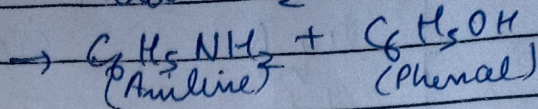


$\Delta V = -ive$
 $\Delta H = -ive$
 $\Delta G = -ive$
 $\Delta S_{\text{sys}} = +ive$

$\Delta S_{\text{sys}} = +ive$
 $\Delta S_{\text{total}} = +ive$

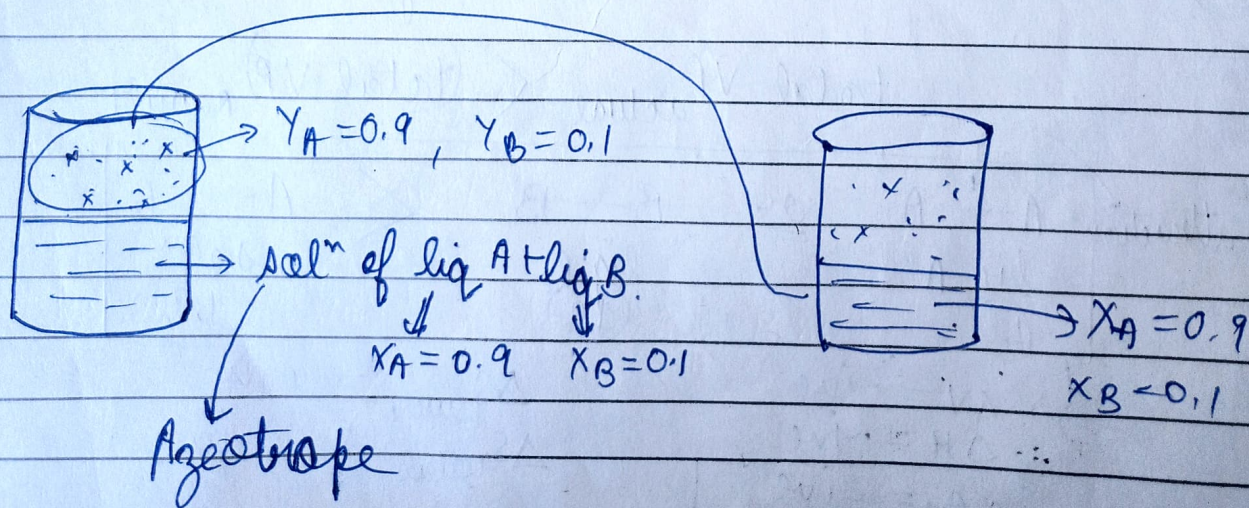


eg \rightarrow acid + H_2O

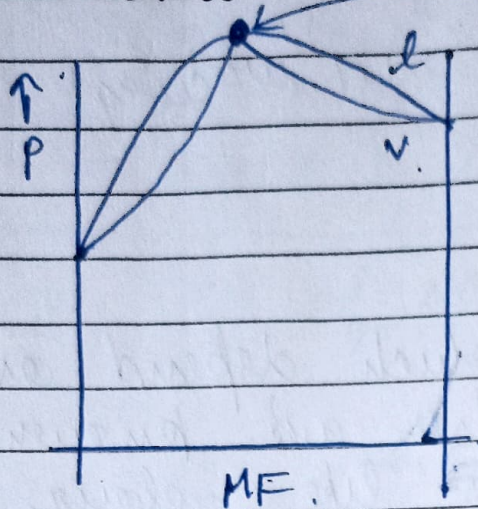


Azeotrope :

- ① solution which has same composition in liquid & vapour phase ~~has~~ is Azeotrope
- ② It behaves like pure liquid and has constant B.P.
- ③ It can not be further purified by fractional distillation
- ④ It is formed in real solⁿ.

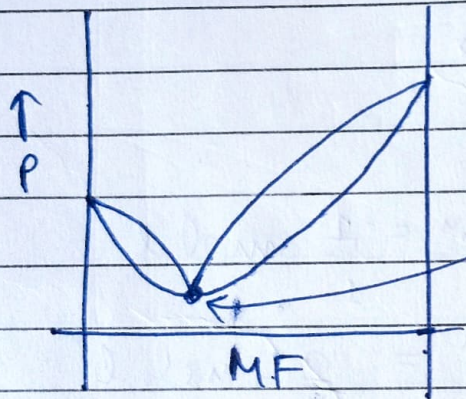


• +ive deviation



Azeotrope (max^m VP or min^m BP)

• -ive deviation



Azeotrope [min^m VP or max^m B.P]