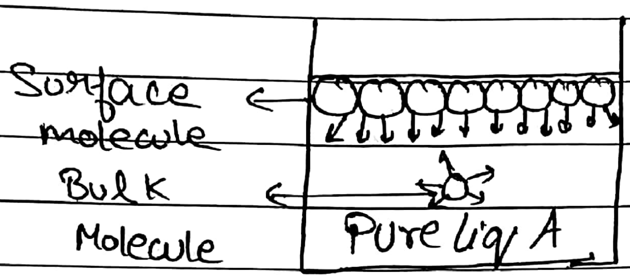
Class 12 Chapter 01: Solutions - Lecture 02

Vapour Pressure

Solubility of Gases - Henry's Law
(Towards the end)

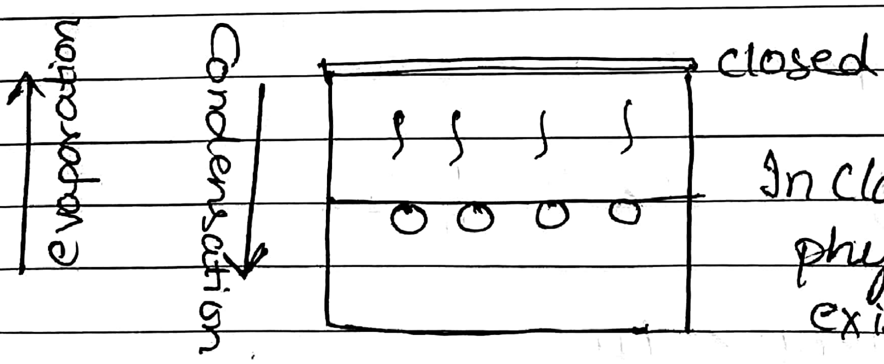
Evaporation:



if we take some liq in an OPEN container, after some time weight of liquid decreases → why?

→ Surface Molecule have more kinetic Energy & experience lesser force
→ These molecules can escape ⇒ evaporate

If we take same liquid in a closed vessel then weight will not change



In Closed container physical equilibrium exists

liq $\rightleftharpoons$ vapour equilibrium

These vapour exert pressure on liquid surface called Vapour Pressure.

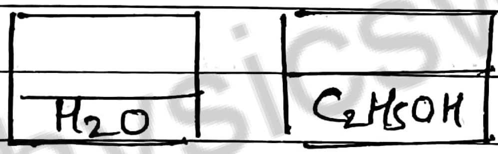
Vapour Pressure (VP) Ka Concept Sirf Closed Container ke lie Defined है.

[equilibrium closed container में Hota है]

→ Vapour Pressure does not depend on shape/size of container

Factors Affecting Vapour Pressure (V.P.)

① Nature of liquid



$H_2O - H_2O$ $\quad$ $C_2H_5OH - C_2H_5OH$

↓ $\quad$ ↓

H-bond $\quad$ H-bond

(1 molecule 4 H Bond banata hai)

H_2O ko evaporate करना Mushkil है

So, VP of $C_2H_5OH >$ VP of H_2O

$P^0_{C_2H_5OH} > P^0_{H_2O}$

P^0
↓
VP of Pure liquids

a) C_2H_5OH (less H bond)

b) CH_2-OH
$|$
CH_2-OH

c) CH_2-OH
$|$
$CH-OH$
$|$
CH_2-OH (More H bond)

$$P^\circ_a > P^\circ_b > P^\circ_c$$

$$V.P. \propto \frac{1}{\text{Force of Attraction between Molecules}}$$

Classification of Substances on bases of V.P.

a) Volatile Substances: $P^\circ \neq 0$

H_2O, CH_3OH, C_2H_5OH, C_6H_6

b) non volatile Substances

Substances having No Tendency for Vapourisation.

$P^\circ = 0$

Solids → { urea NH_2CONH_2 Molar Mass = 60
glucose $C_6H_{12}O_6$ " " = 180
sucrose $C_{12}H_{22}O_{11}$ " " = 340 }

← in most questions

② Temperature:

On increasing Temp ⇒ K.E ↑ ⇒ More evaporation ⇒ More V.P.

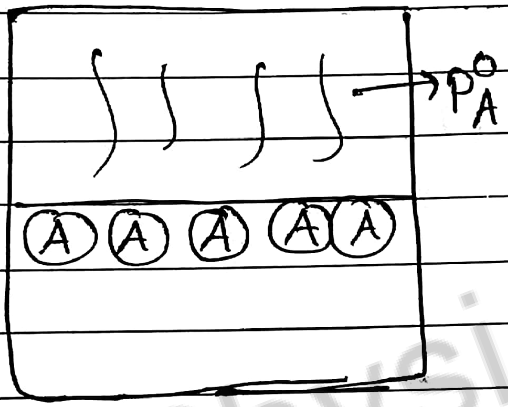
$$V.P. \propto \text{Temp}$$

Vapour Pressure of Solutions

Solute volatile ⇓ Liquid

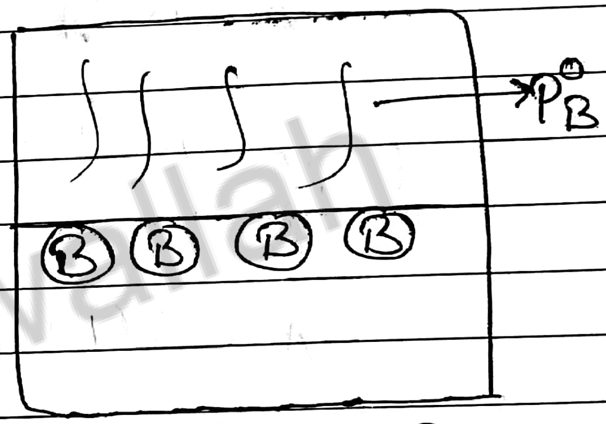
Solvent volatile ⇓ Liquid

binary solution of 2 liquids (volatile)



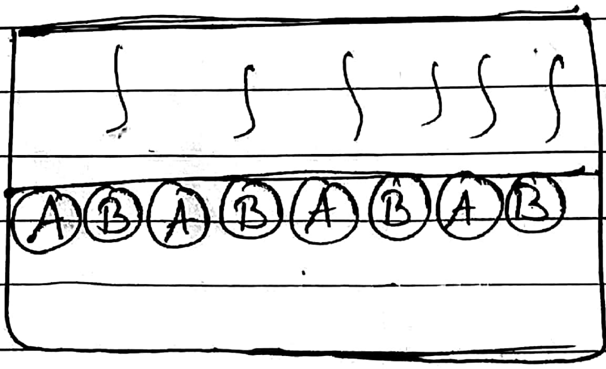
Pure liquid A

$P_A^o \rightarrow$ VP of Pure A



Pure Liquid B

$P_B^o \rightarrow$ VP of pure B



$P_A \propto X_A$ → RAULT'S LAW ← $P_B \propto X_B$

P_A → partial pressure of A

X_A → Mole fraction of A

$$\chi_A = \frac{n_A}{n_A + n_B} \qquad \chi_B = \frac{n_B}{n_A + n_B} \qquad \boxed{\chi_A + \chi_B = 1}$$

$n_A, n_B \rightarrow$ no of moles of A & B

RAULT'S LAW: for solution containing 2 volatile liquids

"The partial pressure of each component is directly proportional to the vapour Pressure of that Component in Solution."

$$P_A \propto \chi_A$$

$$P_A = K\chi_A$$

if $\chi_A = 1$ (Pure liquid A)

$$P_A = P^o_A$$

$$\Rightarrow P^o_A = K(1)$$

$$\Rightarrow \boxed{P_A = P^o_A \chi_A}$$

Similarly $\boxed{P_B = P^o_B \chi_B}$

$\boxed{P_T = P_A + P_B}$ Dalton's Law

Total pressure of 2 non reacting gas $= P_A + P_B$

$$\boxed{P_T = P^o_A \chi_A + P^o_B \chi_B}$$

P_T = Total VP of Solution

P^o_A, P^o_B = VP of pure Liq A & B resp.

χ_A, χ_B = Mole fraction of A & B resp.

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Q1) Solution of 0.78g Benzene and 0.92g of Toulene.
VP of Pure benzene = 400mmHg
VP of Pure Toluene = 200mm Hg
Molar Mass of Benzene = 78g
Molar Mass of Toluene = 92g

Find Total VP of solution.

Solution

$$n_b = \frac{\text{mass benzene}}{\text{Molar Mass benzene}} = \frac{0.78}{78} = 0.01$$

$$n_t = \frac{0.92}{92} = 0.01$$

$$\chi_b = \frac{n_b}{n_b + n_t} = \frac{0.01}{0.01 + 0.01} = 0.5$$

$$\chi_t = \frac{n_t}{n_b + n_t} = 0.5$$

$$P_T = P_b^o \chi_b + P_t^o \chi_t$$

$$= 400 \times 0.5 + 200 \times 0.5$$
$$= 200 + 100$$
$$= 300 \text{ mm Hg}$$

(3 moles) (1 mole)

Q2) ethanol & methanol Find Total VP.

$P_e^0 = 55$ mm Hg $P_m^0 = 50$ mm Hg

$$\chi_e = \frac{n_e}{n_e + n_m} = \frac{3}{3+1} = \frac{3}{4}$$

$$\chi_m = \frac{n_m}{n_m + n_e} = \frac{1}{1+3} = \frac{1}{4}$$

$$P_T = P_e^0 \chi_e + P_m^0 \chi_m$$

$$= 55 \times \frac{3}{4} + 50 \times \frac{1}{4}$$

$$= 41.25 + 12.5 = 53.75 \text{ mm Hg}$$

Q3) Two volatile Liquids X & Y are mixed as 2 moles of X and 3 moles of Y, the total pressure is 500 mm Hg. When the moles are interchanged, the total VP is 400 mm Hg. Find VP of pure X & Y.

$$P_T = P_X^0 \chi_X + P_Y^0 \chi_Y$$

$$500 = P_X^0 \frac{2}{5} + P_Y^0 \frac{3}{5} \quad \text{—(i)}$$

$$400 = P_X^0 \frac{3}{5} + P_Y^0 \frac{2}{5} \quad \text{—(ii)}$$

Solve (i) & (ii) Ans $P_X^0 = 200$ $P_Y^0 = 700$

Q4) 0.92 g ethanol and 0.32 g methanol ($P^o_e = 55mm$, $P^o_m = 50mm$) are mixed. Assuming Ideal solution, Calculate
i) P_e & P_m
ii) P_{Total}
iii) mole fraction of each component in Vapour Phase.

Solution

$$n_e = \frac{0.92g}{46g} = 0.02$$

$$n_m = \frac{0.32}{32} = 0.01$$

$$X_e = \frac{0.02}{0.02+0.01} = \frac{2}{3}$$

$$X_m = \frac{1}{3}$$

$$P_e = P^o_e X_e = 55 \times \frac{2}{3}$$

$$P_e = \frac{110}{3} = 36.66$$

$$P_m = P^o_m X_m = 16.67$$

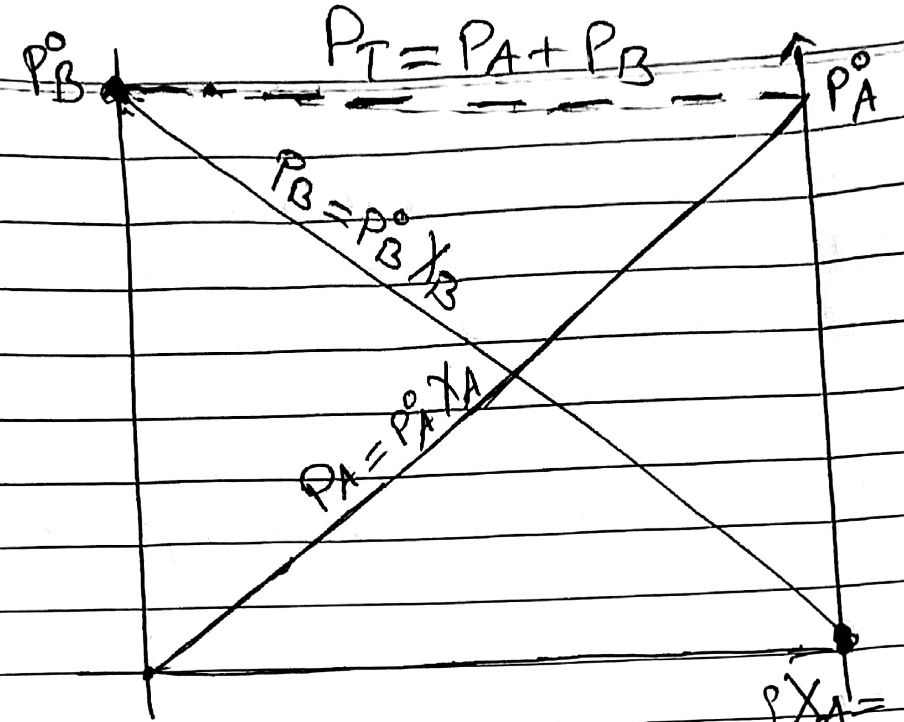
$$P_T = \underbrace{P^o_e X_e}_{P_e} + \underbrace{P^o_m X_m}_{P_m}$$

$$P_T = 55 \times \frac{2}{3} + 50 \times \frac{1}{3} = \frac{160}{3} = 53.3 \text{ mmHg}$$

mole fraction of e in VP $y_e = \frac{P_e}{P_T} = \frac{36.66}{53.33} = 0.68$

" " " m in VP

$$y_m = \frac{P_m}{P_T} = \frac{16.67}{53.33} = 0.312$$



$X_A = 0$, $X_B = 1$ ⟹ $P_A = 0$, $P_B = P_B^\circ$

$X_A = 1$, $X_B = 0$ ⟹ $P_A = P_A^\circ$, $P_B = 0$

<u>Note:</u> $P_T = P_A^\circ X_A + P_B^\circ X_B$

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

$$\boxed{P_T = P_A^\circ + X_B(P_B^\circ - P_A^\circ)}$$ <u>imp</u>

<u>Q)</u> Find VP of pure benzene in a solution of benzene and toluene with total VP

$P_T = 100 + 60\,X_B^\circ$

X_B° = mole fraction of benzene in liq state

<u>Solution:</u> Compare with above equation

$P_t^\circ = 100 \qquad P_b^\circ - P_t^\circ = 60$

$P_b^\circ = 160$