PRAYAS

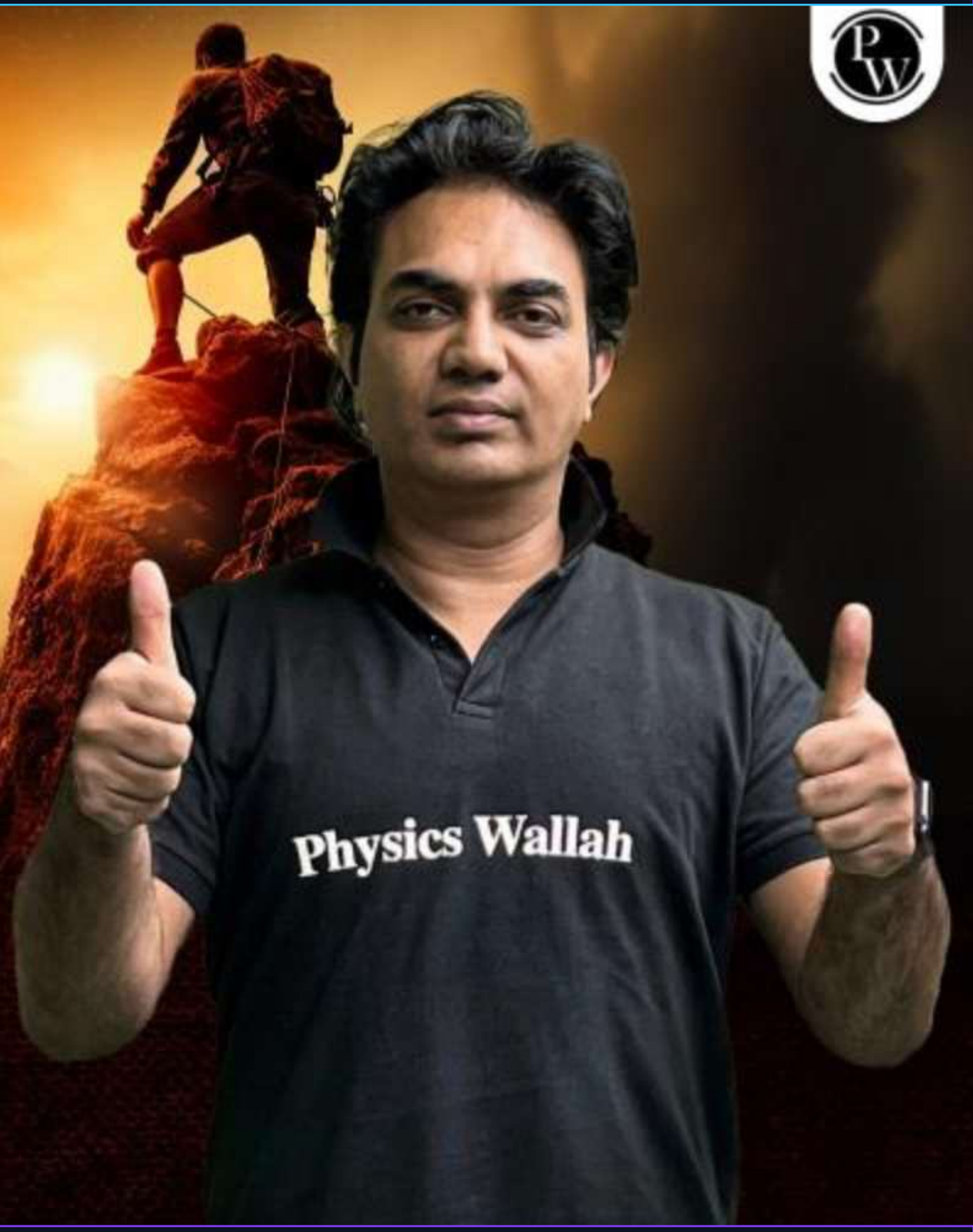
JEE 2026

PHYSICAL CHEMISTRY

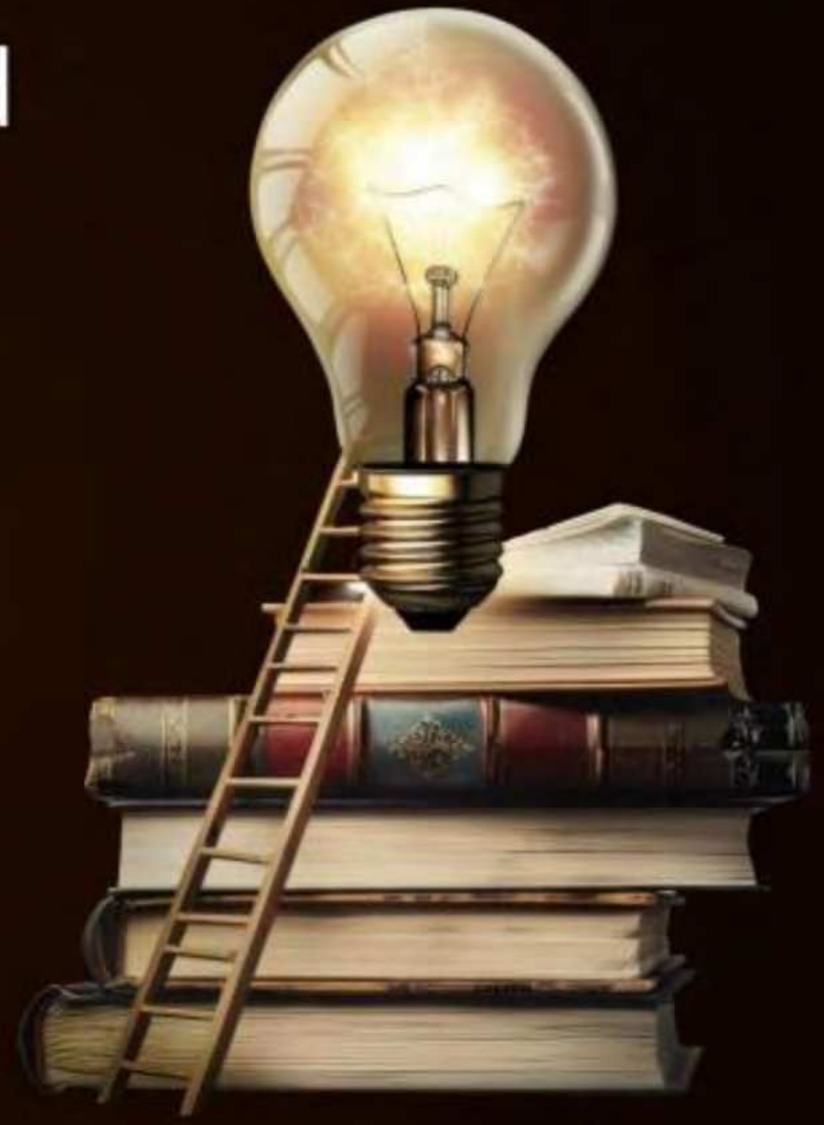
SOLUTIONS

Lecture – 3

FAISAL RAZAQ



Topics to be covered



A **Vapour Pressure of Solution**

Question Vapour Pressure of liquid nickel at 1606°c is 0·100 torr, whereas at 1805°c it V·P is 1·000 torr. At what temperature does the liquid have V·P 2·500 torr?

$T_1 = 1606^\circ C \rightarrow K$

$T_2 = 1805^\circ C \rightarrow K$

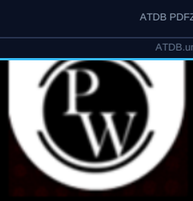
$$\log \frac{1}{0.1} = \frac{\Delta H}{2.303R}\left[\frac{1}{T_1} - \frac{1}{T_2}\right]$$

$\Delta H = ?$

$$\log \frac{2.5}{1.0} = \frac{\Delta H}{2.303R}\left[\frac{1}{T_1} - \frac{1}{T_2}\right]$$

T_1 → $1805^\circ \rightarrow K$

Ans: 2169 K

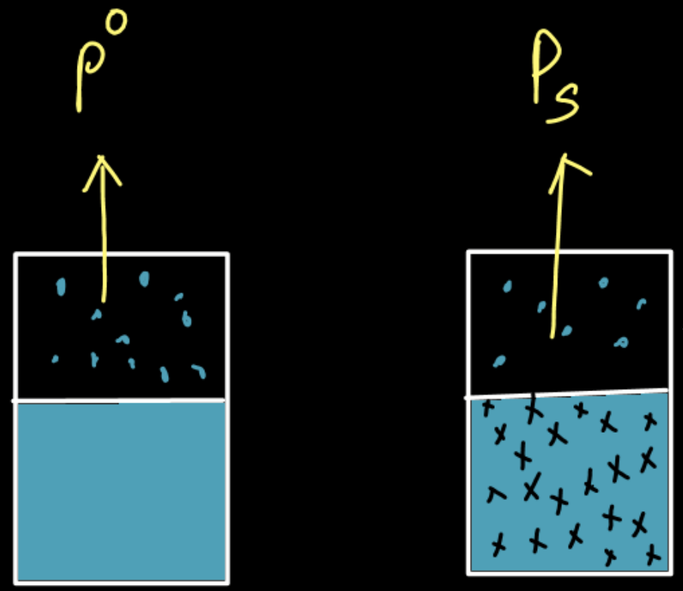


Vapour Pressure for Solutions

volatile = जो उड़ता है |
non volatile = जो नहीं उड़ता है |

1. Solution of a non-volatile solute in volatile solvent

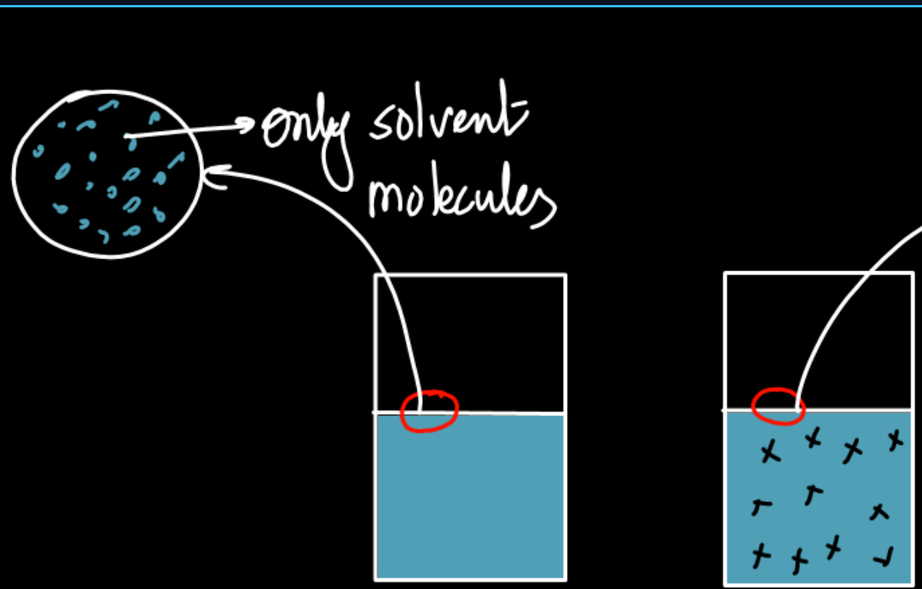
Note :
* They both are different equilibria.
* They have different 'K' values.

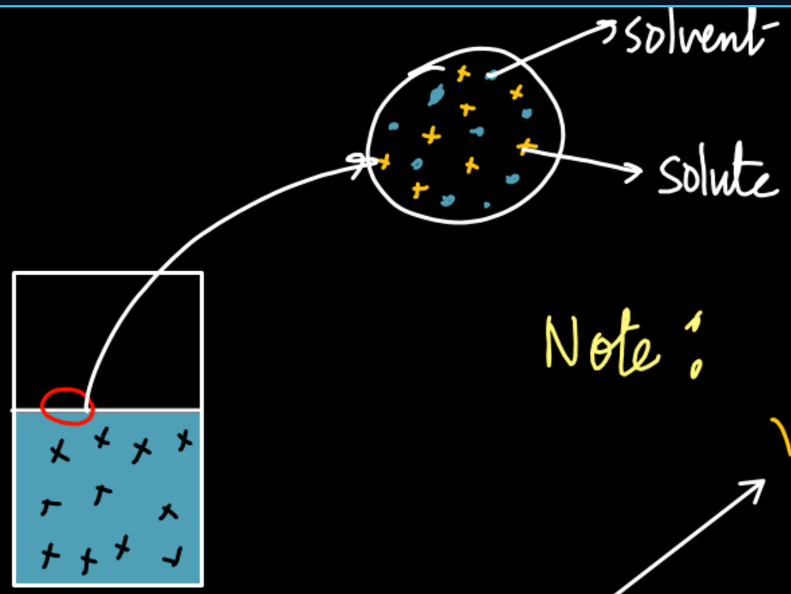


(pure liquid) (solution)

Solvent $\rightleftharpoons$ vap Solution $\rightleftharpoons$ vap

$$P^\circ \neq P_s$$ at temperature T.





$P_s < P_o$

Note :

* Per unit surface area there exist some solute Particles with solvent solvent, so solvent are relatively less.

Due to solute - solvent interaction V.P decreases.

$\text{Wng}\,(V.P)_{\text{solution}} < (V.P)_{\text{solvent}}$ at T (Mathematically)

Raoult's Law:

$$(\text{rate})_{\text{evap}} \propto X_{\text{solvent}}$$

$$(\text{rate})_{\text{evap}} = k_1 X_{\text{solvent}} \quad \text{— (i)}$$

$$(\text{rate})_{\text{cond}} \propto P_s$$

$$(\text{rate})_{\text{cond}} = k_2 P_s \quad \text{— (ii)}$$

at Eq^{bm} $(rate)_{evap} = (rate)_{cond.}$

$$k_1 X_{solvent} = k_2 P_s$$

$$P_s = \frac{k_1}{k_2} X_{solvent}$$

$$P_s = P^0 X_{solvent}$$

$\because X_{solvent} < 1$

$\therefore P_s < P^0$

{ if $X_{solvent} = 1$ i.e. $P_s = P^0$

$$P^0 = \frac{k_1}{k_2}(1)$$ }

* $P_s = P^0 X_{solvent} = P^0 \left(\frac{n_{solvent}}{n_{solvent} + n_{solute}} \right)$

* $P_s = P^0 X_{solvent} = P^0 \left(\frac{W_{solvent}/M_{solvent}}{W_{solvent}/M_{solvent} + W_{solute}/M_{solute}} \right)$

* $P_s = P^0 (1 - X_{solute}) \Rightarrow \frac{P^0 - P_s}{P^0} = X_{solute} = \left(\frac{n_{solute}}{n_{solute} + n_{solvent}} \right)$

* $\frac{P^0 - P_s}{P^0} = X_{solute} = \left(\frac{W_{solute}/M_{solute}}{W_{solute}/M_{solute} + W_{solvent}/M_{solvent}} \right)$

*** if $n_{solute} << n_{solvent}$

$$\frac{p^0 - p_s}{p^0} = x_{solute} = \frac{n_{solute}}{n_{solute} + n_{solvent}} \simeq \frac{n_{solute}}{n_{solvent}} = \frac{W_{solute}/M_{solute}}{W_{solvent}/M_{solvent}}$$

Question The vapour pressure of a solvent is 20 torr, while that of its dilute solution is 17 torr, the mole fraction of solvent is

(P^0) (P_s)

A) 0·60

B) 0·85

C) 0·50

D) 0·70

$$P_s = P^0 X_{solvent}$$

$$17 = 20\, X_{solvent}$$

$$X_{solvent} = \frac{17}{20} = 0.85$$

Ans: (B)

Question Two solutions 'A' and 'B' of cane sugar in water are prepared. In solution 'A' mole fraction of cane sugar is 0·1. Solution 'B' is 1 molal. Which solution has higher vapour pressure?

Imp

$(P_s)_A = P^\circ X_{solvent}$

$(P_s)_B = P^\circ X'_{solvent}$

Jahan par $X_{solvent}$ ↑ P_s ↑

Solution A	solution B
$X_{solute} = 0.1$	1 molal
$X_{solvent} = 0.9$	1 mole cane sugar in 1000 g water

$$X_{solvent} = \left(\frac{1000/18}{1000/18 + 1}\right) = \frac{55.55}{56.55}$$

$$\left(\chi_{solvent}\right)_B > \left(\chi_{solvent}\right)_A$$

$$\boxed{\left(P_s\right)_B > \left(P_s\right)_A}$$

Ans: solution 'b'

Question When a certain amount of solid 'A' is dissolved in 100 g of water at 25°C to make a solution, the vapour pressure of the solution is reduced to one-half of that of pure water. The vapour pressure of pure water is 23.76 mm Hg. The number of moles of solute 'A' added is ____ (nearest integer).

$\frac{100}{18}$

$P_s = P^0/2$

$$\frac{P^0 - P_s}{P^0} = \chi_{solute} = \frac{n_{solute}}{n_{solute} + n_{solvent}}$$

[JEE-Mains 2022]

$$\frac{\rho^{\circ} - \frac{\rho^{\circ}}{2}}{\rho^{\circ}} = \frac{n}{n + \frac{100}{18}}$$

On solving this equation we get the value of 'n'.

$$\frac{1}{2} = \frac{n}{n + 5.55}$$

$$n + 5.55 = 2n$$

$$\boxed{n = 5.55}$$

K.B.O

$$\frac{p^0 - p_s}{p^0} = \frac{n_{solute}}{n_{solute} + n_{solvent}}$$

$$\frac{p^0 - p_s}{p_s} = \frac{n_{solute}}{n_{solvent}}$$

$$\frac{p^0}{p^0 - p_s} = \frac{n_{solute} + n_{solvent}}{n_{solute}}$$

$$= 1 + \frac{n_{solvent}}{n_{solute}}$$

$$\frac{p^0}{p^0 - p_s} - 1 = \frac{n_{solvent}}{n_{solute}}$$

$$\frac{p_s}{p^0 - p_s} = \frac{n_{solvent}}{n_{solute}}$$

$$\frac{p^0 - p_s}{p_s} = \frac{n_{solute}}{n_{solvent}}$$

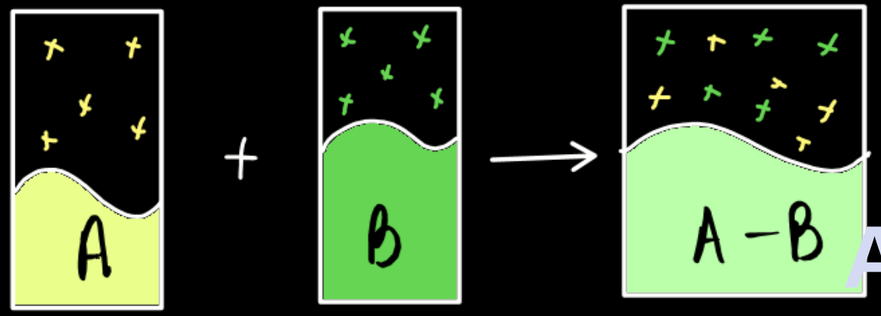
$$\frac{P^0 - \frac{P_0}{2}}{\frac{P^0}{2}} = \frac{n}{\frac{100}{18}} = \frac{n}{5.55}$$

$$n = 5.55$$

Ans : 6

2. Solution of a volatile solute in volatile solvent where both are miscible मिल जाते हैं।

A-A & B-B interaction = A-B interaction



P_A^0 P_B^0 P_T

$$P_T = P_A + P_B$$

$$P_T = P_A^0 X_A + P_B^0 X_B$$

Khoobsurat Law
Raoult's Law

$$P_T = P_A X_A + P_B^0 (1 - X_A)$$

$$P_T = P_B^0 + X_A (P_A^0 - P_B^0)$$

$$P_T = P_A^0 + X_B (P_B^0 - P_A^0)$$

Question

If the total vapour pressure of the liquid mixture A and B is given by the equation : $P = 180\ X_A + 90$ then the ratio of the vapour pressure of the pure liquids A and B is given by :

A. 3 : 2
B. 4 : 1
C. 3 : 1
D. 6 : 2

$$P_T = P_A^0 X_A + P_B^0 X_B$$

$$P_T = P_B^0 + X_A(P_A^0 - P_B^0) = 90 + X_A(180)$$

$$P_B^0 = 90$$

$$P_A^0 - P_B^0 = 180 \Rightarrow P_A^0 = 270$$

$$\frac{P_A^0}{P_B^0} = \frac{270}{90} = 3:1$$

Ans : (2)

Question

The vapour pressure of ethyl alcohol and methyl alcohol are 45mm and 90mm. An ideal solution is formed at the same temperature by mixing 60g of C_2H_5OH with 40g of CH_3OH. Total vapour pressure of the solution is approximately

(A) 70 mm

(B) 35 mm

(C) 105 mm

(D) 140 mm

JEE Adv.2020

Liquids A and B form ideal solution for all compositions of A and B at 25°C. Two such solutions with 0.25 and 0.50 mole fractions of A have the total vapor pressures of 0.3 and 0.4 bar, respectively. What is the vapor pressure of pure liquid B in bar?

Ans : 0·2 bar

24 Jan, 2023 (Shift-II)

The Total pressure observed by mixing two liquid A and B is 350 mm Hg when their mole fractions are 0.7 and 0.3 respectively.

The total pressure becomes 410 mm Hg if the mole fractions are changed to 0.2 and 0.8 respectively for A and B. The vapour pressure of pure A is mm Hg. (Nearest Integer)

Consider the liquid and solution behave ideally.

Ans : 434 mm Hg

Question

Two liquids, A and B have the same molecular weights and form an ideal solution. The solution of composition x_A has the vapour pressure **700 mm Hg** at **80°C**. The above solution is distilled without reflux till **3/4** of the solution is collected as condensate. The composition of the condensate is $x_A' = 0.75$ and that of residue is $x_A = 0.3$. If the vapour pressure of the residue at **80°C** is **600 mm Hg**, calculate x_A, P_A^0 and P_B^0.

Ans: 0·636 , 809 torr , 510 torr

Question

Vapour pressure of water at 293 K is 17.535 mm Hg. Calculate vapour pressure of water at 293 K when 25 gm glucose is dissolved in 450 gm of water.

Ans: 17·438 mm Hg