LAKSHYA JEE

LAKSHYA KO HAR HAAL ME PAANA HAI

SOLUTION

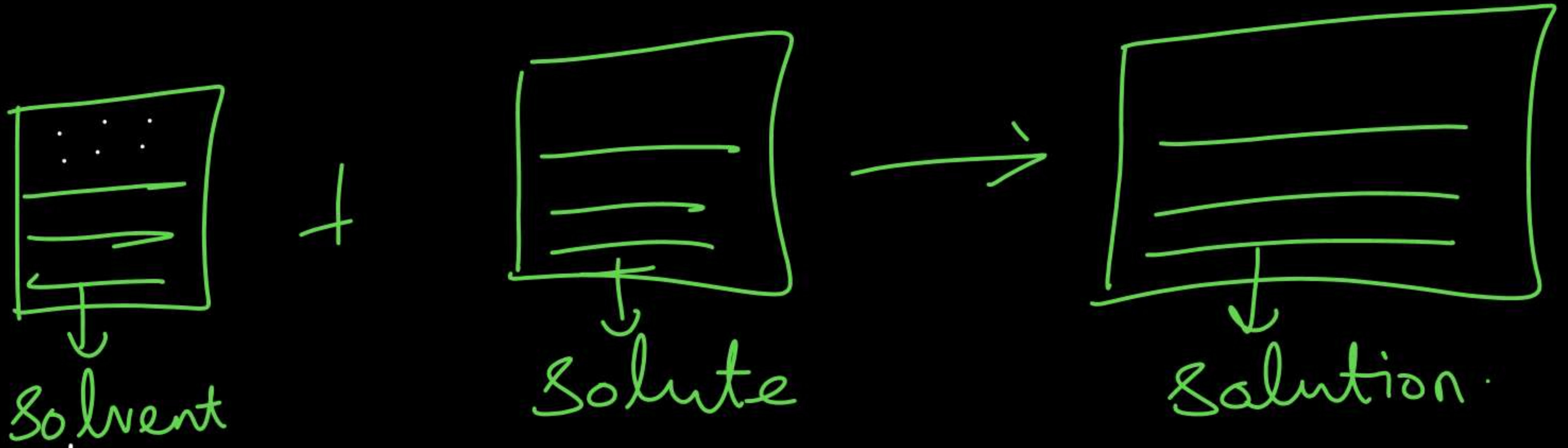
By

Amit Mahajan Sir

- RAOULT'S LAW
- IDEAL SOLUTION

Raoult's law :

p_A^0 = V. P. of solvent in pure form.



volatile

$P^{o}_{A} \neq 0$

P_A = V.P. of solvent in solution

$$P_A = P^{o}_{A}\, x_A$$

Raoult's law :-

V.P. of any Component in solution is equal to product V.P. of Component in pure form & it's mole-fraction in Solution

$$P_A = P_A^\circ x_A$$

P_A = V.P. of A in solution.

$$P_B = P^\circ_B x_B$$

P_B → V.P. of solute in solution.

P°_B = V.P. of solute in Pure form

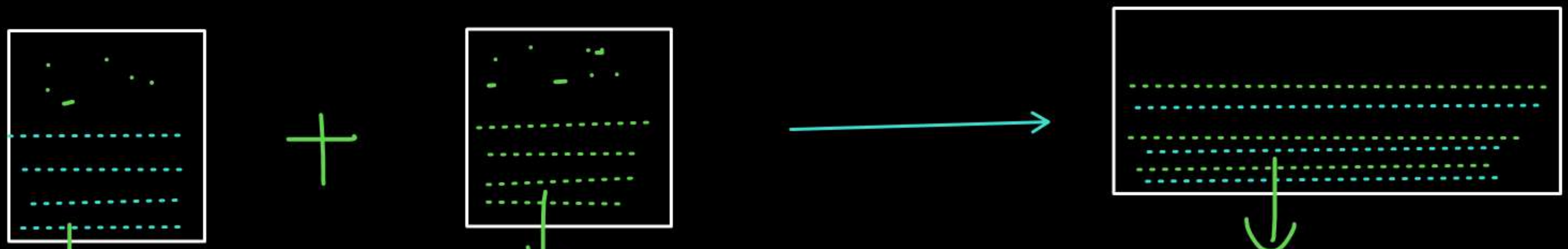
x_B = mole-fraction of B in solution.

$$x_A + x_B = 1 \Rightarrow x_B = 1 - x_A$$

$$\frac{n_A}{n_A + n_B} + \frac{n_B}{n_A + n_B} = 1$$

$$\frac{n_A + n_B}{n_A + n_B} = 1$$

(a) Raoult's law for Volatile Solute



Solvent → Volatile → $P^0_A \neq 0$

Solute → Volatile → $P^0_B \neq 0$

Solution

P_S = V. P. of solution

$$P_S = P_A + P_B$$

$$P_A = P_A^{o} x_A$$

$$P_B = P_B^{o} x_B$$

$$P_S = P_A^{o} x_A + P_B^{o} x_B$$

$$P_S = P_A^{o}(1 - x_B) + P_B^{o} x_B$$

$$P_S = P_A^{o} - P_A^{o} x_B + P_B^{o} x_B$$

$$P_S = (P_B^{o} - P_A^{o})\, x_B + P_A^{o}$$

$$P_S = P_A^{o} + (P_B^{o} - P_A^{o})\, x_B$$

(b) Raoult's law for non-volatile solute:

Volatile Solvent → $p^{\circ}_A \neq 0$

Non-volatile Solute → $p^{\circ}_B = 0$

Solution V.P. = P_S

$$P_S = p^{\circ}_A x_A + p^{\circ}_B x_B$$

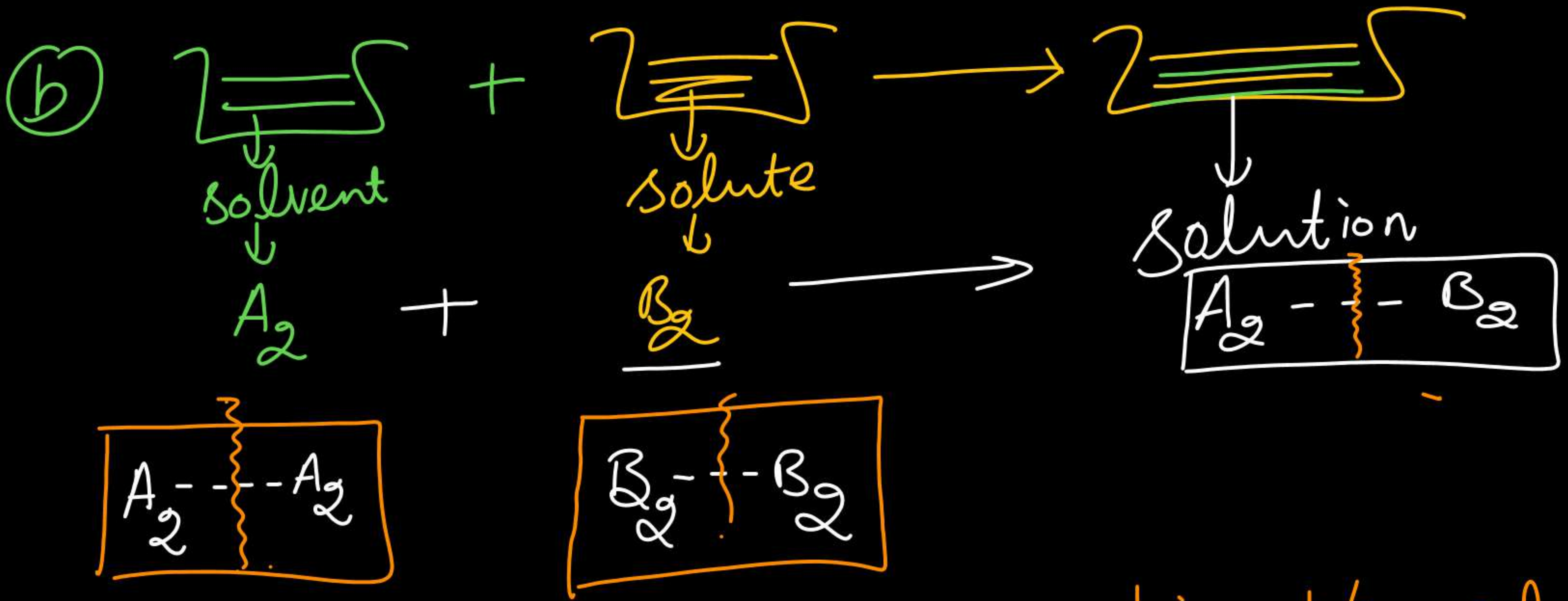
as $p^{\circ}_B = 0$

$$P_S = P_A^{o} x_A$$

Ideal solution :

(a) Solutions which obey Raoult's law at all temperature & Pressure.

$$P_S = P^{\circ}_A \chi_A + P^{\circ}_B \chi_B$$



When Forces of interaction b/w solvent-solvent or solute-solute are similar as that of solution.

Properties of Ideal solution

(a) $P_S = P^o_A x_A + P^o_B x_B$

(b) $\Delta H_{mixing} = 0$ (c) $\Delta V_{mixing} = 0$

(d) $\Delta G_{mixing} = (-)ve$ (e) $\Delta S_{mixing} = (+)ve$.

(f) $\Delta U_{mixing} = 0$

$$\Delta H_{mix} = \Delta U_{mix} + P \Delta V_{mix}$$

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

↓

Ideal solution

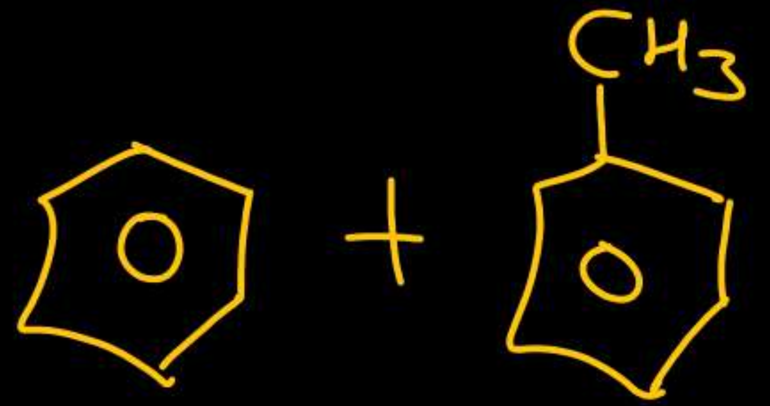
for ex:- same homologous series
↓
Ideal solution

(a) n-Octane + n-nonane

(b) $C_2H_5Br + C_2H_5I$

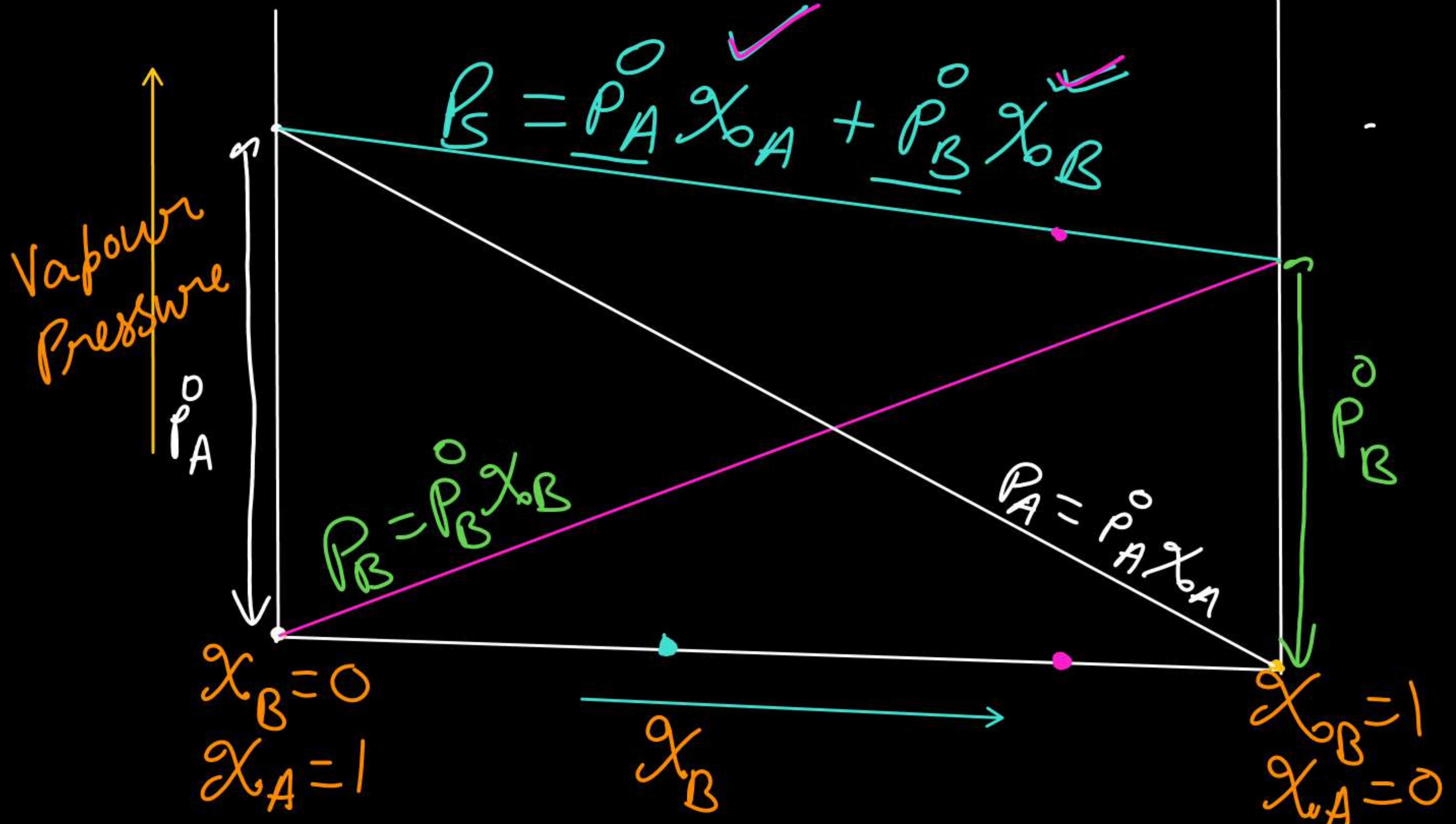
(c) $C_2H_5Br + C_3H_7Br$

(d) n-Heptane + n-octane

(e) 

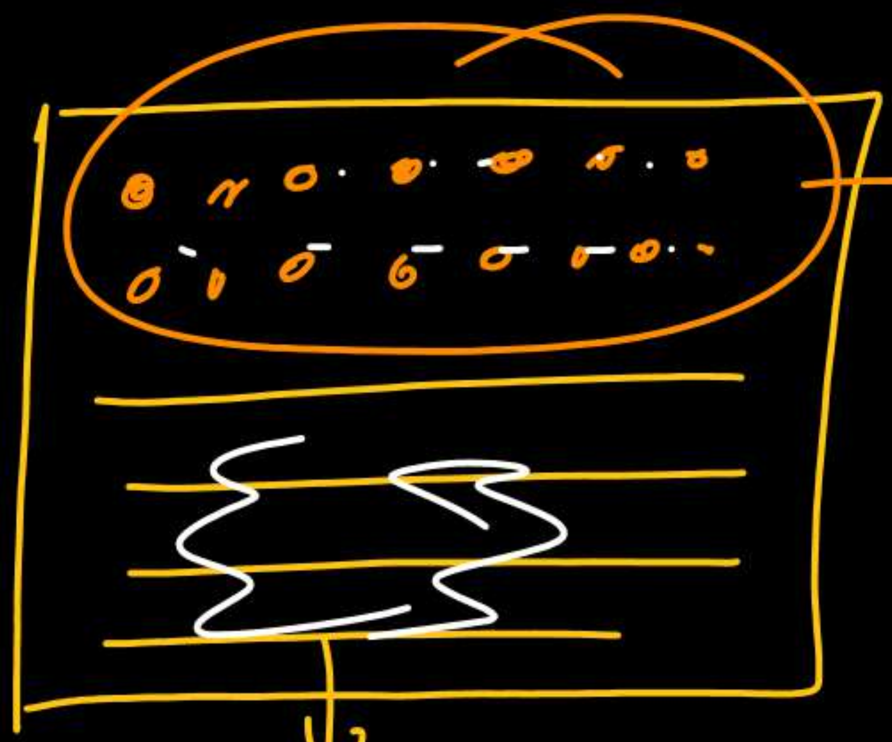
Benzene Toluene

$P_A^o > P_B^o$ → A is more Valatile than B



$P_B = P_B^o x_B$

$P_A = P_A^o x_A$



→ Vapours of A & B

↓

Mole fraction of A & B in Vapor phase is denoted by Y_A & Y_B

A + B → x_A & x_B

↓

Solution

$$x_A = \frac{n_A}{n_A + n_B}$$

$$x_B = \frac{n_B}{n_A + n_B}$$

Dalton's law of Partial Pressure.

$$P_A = Y_A P_S$$

$$Y_A = \frac{P_A}{P_S} = \frac{P_A^o x_A}{P_A^o x_A + P_B^o x_B}$$

$$Y_B = \frac{P_B}{P_S} = \frac{P^o_B x_B}{P^o_A x_A + P^o_B x_B}$$

$$\boxed{x_A + x_B = 1}$$

||larly $\boxed{Y_A + Y_B = 1}$

$$\frac{P^o_A x_A}{P_S} + \frac{P^o_B x_B}{P_S} = 1$$

$$\frac{\overset{\circ}{P}_A x_A + \overset{\circ}{P}_B x_B}{P_S} = 1$$

$$\frac{P_S}{P_S} = 1$$

$$Y_A + Y_B = 1$$

$$Y_B = 1 - Y_A$$

Benzene and toluene form a ideal solution and V.P. of pure benzene and toluene are 160 mm of Hg and 60 mm of Hg. Calculate partial pressure of benzene and toluene and total pressure also

(a) Containing equal mass of both benzene and toluene

(b) Containing equal molecules of both benzene and toluene

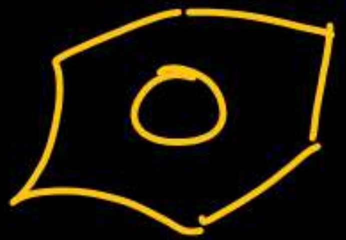
(c) Containing 1 mole of benzene and 4 moles of toluene

(d) Also calculate mole fraction of Benzene and toluene in vapour phase if equal moles of benzene and toluene mixed

$P^0_B = 160$ mm of Hg | $P_A = ?$ | $P_S = ?$

$P^0_A = 60$ mm of Hg | $P_B = ?$

(a) Containing equal mass of Benzene & toluene

B = Benzene  C_6H_6 ⇒ Molar mass of B = 78g

A = Toluene  C_7H_8 ⇒ Molar mass of A = 92g ✓

$$W_A = W_B = 7176$$

$$M_A = 92, \quad M_B = 78g$$

$$P_A = P_A^0 x_A$$

$$x_A = \frac{n_A}{n_A + n_B} =$$

$$n_A = \frac{w_A}{M_A} = \frac{7176}{92} = 78$$

$$n_B = \frac{w_B}{M_B} = \frac{7176}{78} = 92$$

$$x_A = \frac{n_A}{n_A + n_B} = \frac{78}{92+78} = \frac{78}{170} = 0.46$$

$$x_B = 1 - x_A$$

$$x_B = 0.54$$

$$P_S = P_A^0 x_A + P_B^0 x_B$$

$$P_S = (60 \times 0.46 + 160 \times 0.54) \text{ mm of Hg}$$

(b) Same molecules ∴ same no. of moles

$n_A = n_B = x$

$\chi_A = \frac{x}{x+x} = \frac{x}{2x} = \frac{1}{2} = 0.5$

$\chi_B = 1 - \chi_A = 0.5$

$P_A = P_A^\circ \chi_A = 60 \times 0.5 = 30$ mm of Hg

$P_B = P_B^\circ \chi_B = 160 \times 0.5 = 80$ mm of Hg

$P_S = P_A^\circ \chi_A + P_B^\circ \chi_B = 30 + 80 = 110$ mm of Hg

(C) $n_A = 4$, $n_B = 1$

$$\chi_A = \frac{4}{5} = 0.8$$

$$\chi_B = 1 - \chi_A = 0.2$$

$$P_A = P_A^0 \chi_A = 60 \times 0.8 = 48 \text{ mm of Hg}$$

$$P_B = P_B^0 \chi_B = 160 \times 0.2 = 32 \text{ mm of Hg}$$

$$P_S = 48 + 32$$

$$\boxed{P_S = 80 \text{ mm of Hg}}$$

(d) $n_A = n_B$

$x_A = \frac{1}{2}$

$x_B = \frac{1}{2}$

$P_S = 110$ mm of Hg

$P_A = 30$ mm of Hg

$P_B = 80$ mm of Hg

$Y_A = \frac{P_A}{P_S} = \frac{30}{110}$ mm of Hg

$Y_B = 1 - Y_A = 1 - \frac{3}{11}$

$Y_B = \frac{8}{11}$ mm of Hg

At a given temperature, the vapour pressure in mm of Hg of a solution of two volatile liquids A and B is given by equation $P = 120 - 80\,\chi_B$

Calculate V.P. of pure A and B at same temperature

$$P_S = 120 - 80\,\chi_B$$

$$P_A^0 = ?\ ,\ P_B^0 = ?$$

$$P_S = P_A^0 + (P_B^0 - P_A^0)\,\chi_B$$

$$P_A^0 = 120 \text{ mm of Hg}$$

$$P_B^0 - P_A^0 = -80$$

$$P_B^0 - 120 = -80$$

$$P_B^0 = 40 \text{ mm of Hg}$$

Two liquids A and B form an Ideal solution at 300 K the V.P. of solution having 1 mole of A and 3 mole of B is 550 mm of Hg. At same temperature if 1 more mole of B is added to solution, V.P. of solution increases by 10 mm of Hg. Determine V.P. of A and B in pure state. **[IIT]**

Ans

$n_A = 1$, $n_B = 3$

$P_S = 550$ mm of Hg

$x_A = \frac{1}{4} = 0.25$

$x_B = 0.75$

$n_A = 1$

$n_B = 4$

$P_S' = 560$ mm of Hg

$x_A' = 0.2$

$x_B' = 0.8$

Let $P^0_A = a$

$P^0_B = b$

L.H.S.

$P_S = P^0_A \chi_A + P^0_B \chi_B$

$550 = 0.25a + 0.75b$

$P_S' = P^0_A \chi_A' + P^0_B \chi_B'$

$560 = 0.2a + 0.8b$

$550 = 0.25a + 0.75b$

For an ideal solution, the correct option is

(a) $\Delta_{mix} S = 0$ at constant T and P

(b) $\Delta_{mix} V \neq 0$ at constant T and P

(c) $\Delta_{mix} H = 0$ at constant T and P

(d) $\Delta_{mix} G = 0$ at constant T and P

Which one is not equal to zero for an ideal solution?

(a) $\Delta P = P_{observed} - P_{Raoult}$

(b) ΔH_{mix}

(c) ΔS_{mix}

(d) ΔV_{mix}

$$\Delta P = P_{observed} - P_{Raoult's\ law} = 0$$

Thank You Lakshyians