07 November 2020 11:29

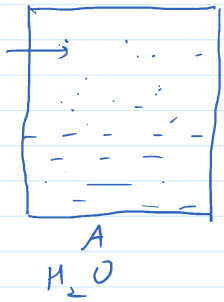
Raoult's law (Mixing volatile component in volatile liquid)

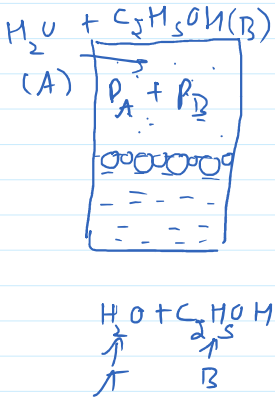
P_A (Vapour pressure of A) in solution P_A°

$= P_A^\circ x_A$

P_B (vapour pressure of B in solution)

$= P_B^\circ x_B$





By Dalton's law of partial pressure

$P_T = P_A + P_B$

$$P = P_A^\circ x_A + P_B^\circ x_B$$

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

$= P_A^\circ - P_A^\circ x_B + P_B^\circ x_B$

$$P = P_A^\circ + (P_B^\circ - P_A^\circ) x_B$$

Question

Heptane and octane form an ideal solution. At 373k, the vapour pressure of the two liquid components are 105.2 kPa and 46.8 kPa respectively. What will be vapour pressure of 26 g heptane and 35 g octane mixture.

Answer

$C_7H_{16} \rightarrow A$, $C_8H_{18} \rightarrow B$

$M_A = 100$ $M_B = 114$

$P_A^\circ = 105.2\ kPa$ $P_B^\circ = 46.8\ kPa$

$n_A = \frac{W_A}{M_A} = \frac{26}{100} = 0.26\ mol$ $n_B = \frac{W_B}{M_B} = \frac{35}{114} = 0.31\ mol$

$x_A = \frac{n_A}{n_A + n_B} = \frac{0.26}{0.26 + 0.31} = 0.456$ $x_B = 1 - x_A = 1 - 0.456 = 0.544$

$P = P_A^\circ x_A + P_B^\circ x_B$

$= 105.2 \times 0.456 + 46.8 \times 0.544$

$= 73.43$ kPa

Question

100 gm of liquid A (molar mass 140 $g\,mol^{-1}$) was dissolved in 1000 g of liquid B (molar mass 180 $g\,mol^{-1}$). the vapour pressure of pure liquid B was found to be 500 torr. Calculate the vapour pressure of pure liquid A and its vapour pressure in the solution. If total vapour pressure of the solution is 475 torr.

Answer:

$$n_A = \frac{w_A}{M_A} = \frac{100}{140} = 0.714 \text{ moles}$$

$$n_B = \frac{w_B}{M_B} = \frac{1000}{180} = 5.556 \text{ moles}$$

$P_B^\circ = 500$ torr

$P_A^\circ = ?$, $P_A = ?$

$P = 475$ torr

$$x_A = \frac{n_A}{n_A + n_B} = \frac{0.714}{0.714 + 5.556} = 0.114$$

$$x_B = 1 - x_A = 1 - 0.114 = 0.886$$

Raoult's law

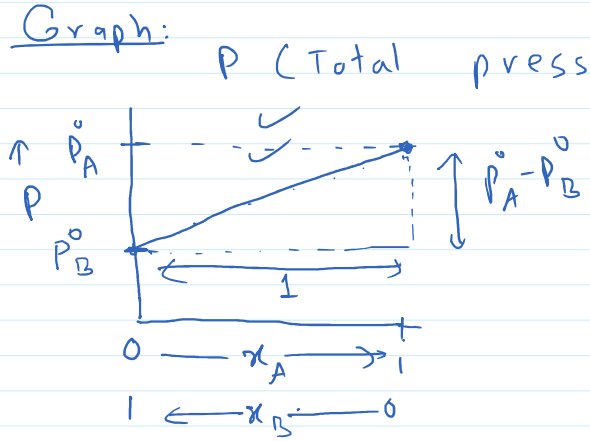
$$P = P_A^\circ x_A + P_B^\circ x_B$$

$$475 = P_A^\circ \times 0.114 + 500 \times 0.886$$

$$P_A^\circ = 280.7 \text{ torr}$$

$$P_A = P_A^\circ x_A = 280.7 \times 0.114 = 32 \text{ torr.}$$

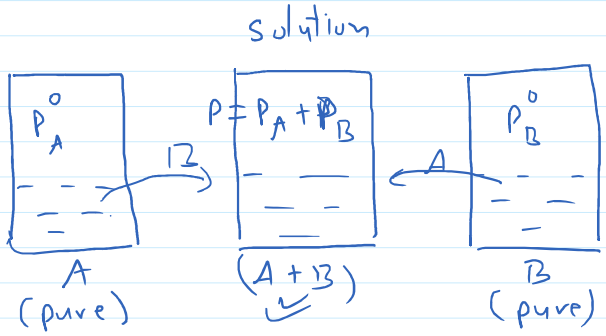
Graph:

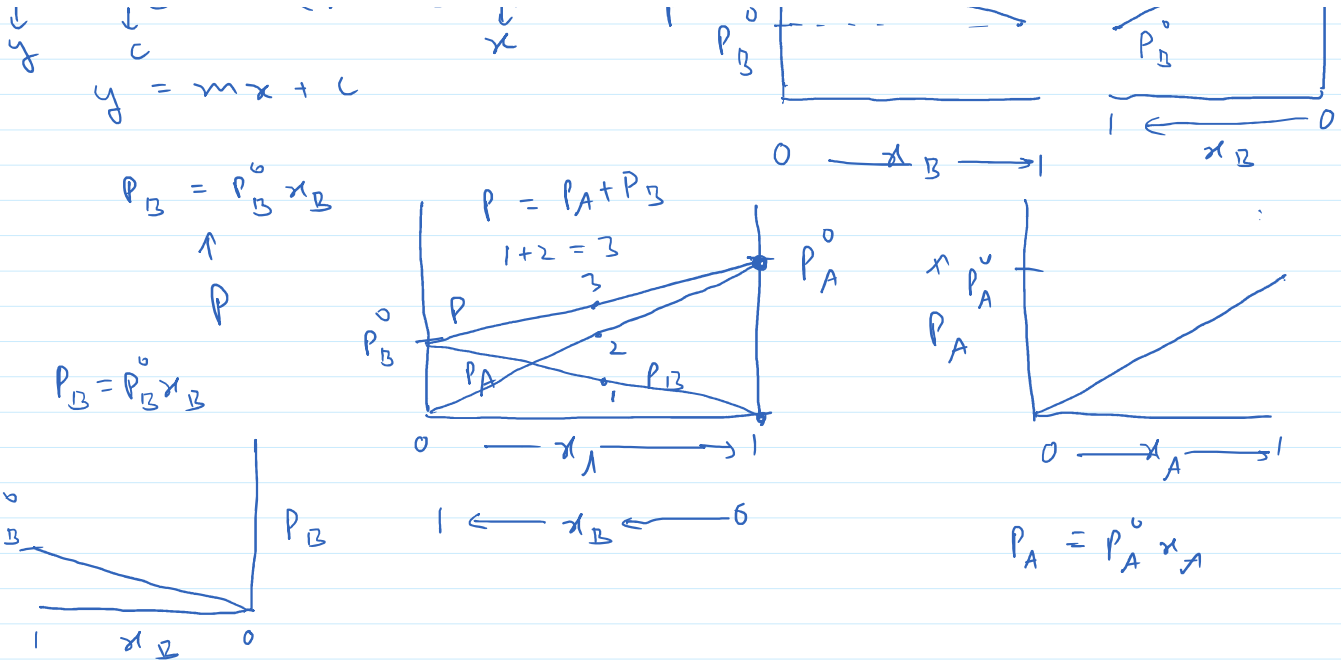


$$P = P_B^\circ + (P_A^\circ - P_B^\circ) x_A$$

$y = c \quad x$

$y = mx + c$




y = mx + c
$P_B = P_B^0 x_B$
P
$P_B = P_B^0 x_B$
$P = P_A + P_B$
1+2 = 3
P_B^0
P_A^0
P
P_A
P_B
1
2
3
0 → x_1 → 1
1 ← x_B ← 0
P_B^0
P_B
1 x_B 0
0 → x_B → 1
P_B^0
1 ← x_B 0
x_A P_A^0
P_A
0 → x_A → 1
$P_A = P_A^0 x_A$