PRAYAS

JEE 2026

PHYSICAL CHEMISTRY

SOLUTIONS

Lecture –04

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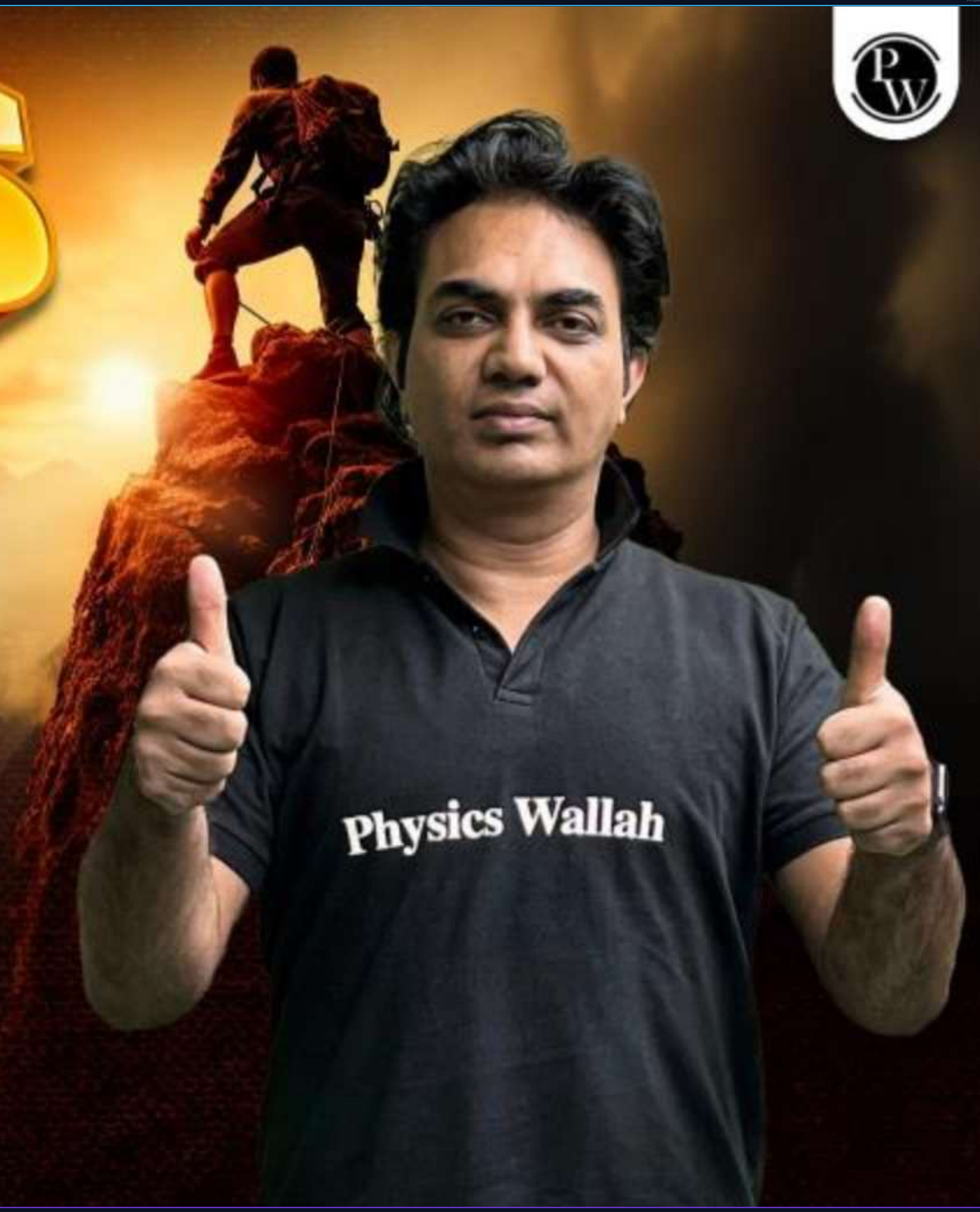


Topics to be covered

ATDB.uno

A Vapour Pressure of Solution

Recap :

Case - 1

Case - 2

Solute	Solvent	P_S
* Non volatile	Volatile	$p^0 x_{solvent}$
* Volatile	Volatile	$P_A^0 x_A + P_B^0 x_B$

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?

Soln 1 $\quad X_A = 0.25 ; P_T = 0.3$

$$0.3 = P_A^\circ (0.25) + P_B^\circ (1 - 0.25)$$

Soln 2 $\quad X_A = 0.50 ; P_T = 0.4$

$$0.4 = P_A^\circ (0.50) + P_B^\circ (1 - 0.50)$$

$$P_B^\circ = 0.2 \text{ bar}.$$

Ans : 0·2 bar

How to calculate the composition of vapour phase ?

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

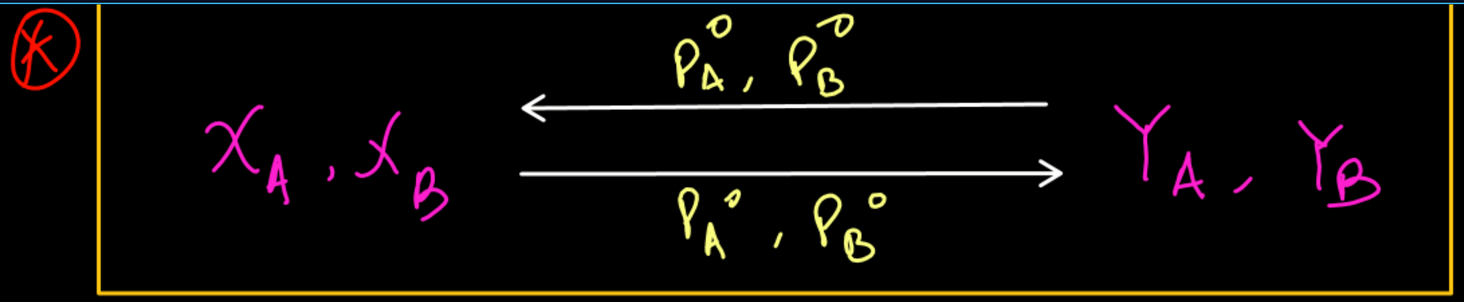
K.Be X_A, X_B are the mole fractions or composition of liquid phase.

Note : To calculate the composition of vapour phase we need to apply 'Dalton's Law'.

$$Y_A = \frac{P_A}{P_T} = \frac{P_A^0 X_A}{P_A^0 X_A + P_B^0 X_B} \quad - (1)$$

K.Be Y_A and Y_B are the mole fractions of A and B in vapour Phase.

$$Y_B = \frac{P_B}{P_T} = \frac{P_B^0 X_B}{P_A^0 X_A + P_B^0 X_B} \quad - (2)$$



$$\frac{Y_A}{Y_B} = \frac{\dfrac{P_A^\circ X_A}{P_A^\circ X_A + P_B^\circ X_B}}{\dfrac{P_B^\circ X_B}{P_A^\circ X_A + P_B^\circ X_B}} = \frac{P_A^\circ X_A}{P_B^\circ X_B}$$

K.B.O

$$\frac{Y_A}{1-Y_A} = \frac{P_A^\circ}{P_B^\circ}\left(\frac{X_A}{1-X_A}\right)$$

20 July, 2021 (Shift-II)

The vapour pressures of A and B at 25°C are 90 mm Hg and 15 mm Hg respectively. If A and B are mixed such that the mole fraction of A in the mixture is 0.6, then the mole fraction of B in the vapour phase is $x \times 10^{-1}$. The value of x is ____1____. (Nearest Integer)

P_A^0 → P_B^0

Y_B ← X_A

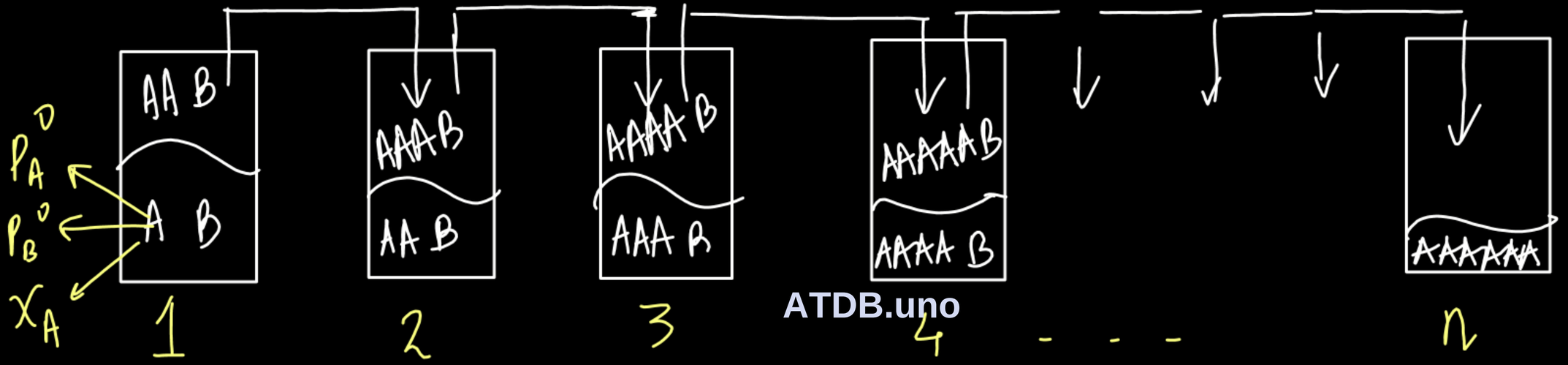
$$\frac{Y_A}{1-Y_A} = \frac{P_A^0}{P_B^0}\left(\frac{X_A}{1-X_A}\right) = \frac{90}{15}\left(\frac{0.6}{0.4}\right) = 9$$

$Y_A = 0.9$; $Y_B = 0.1$ → 1×10^{-1}

Aus : 1

Distillation

Suppose A is more volatile.



$$\frac{Y_{A,1}}{1-Y_{A,1}} = \left(\frac{P_A^0}{P_B^0}\right)^1 \left(\frac{X_{A,1}}{1-X_{A,1}}\right)$$

$$X_{A,2} = Y_{A,1}$$

$$1-X_{A,2} = 1-Y_{A,1}$$

$$\frac{Y_{A,2}}{1-Y_{A,2}} = \frac{P_A^0}{P_B^0}\left(\frac{X_{A,2}}{1-X_{A,2}}\right)$$

$$\frac{Y_{A,2}}{1-Y_{A,2}} = \frac{P_A^0}{P_B^0}\left[\frac{P_A^0}{P_B^0}\left(\frac{X_{A,1}}{1-X_{A,1}}\right)\right] = \left(\frac{P_A^0}{P_B^0}\right)^2\left(\frac{X_{A,1}}{1-X_{A,1}}\right)$$

$Y_{A,1}$ = mol. fract. of A in vap. phase of container 1.

$X_{A,1}$ = mol fract. of A in liq. phase of container 1.

K.B.O

$$\frac{Y_{A,n}}{1-Y_{A,n}} = \left(\frac{P^{\circ}_{A}}{P^{\circ}_{B}}\right)^{n} \left(\frac{x_{A,1}}{1-x_{A,1}}\right)$$

Question

A and B form an ideal solution. $P_A^\circ = 200$ torr

$P_B^\circ = 400$ torr

$X_{A,1} = 0.4$

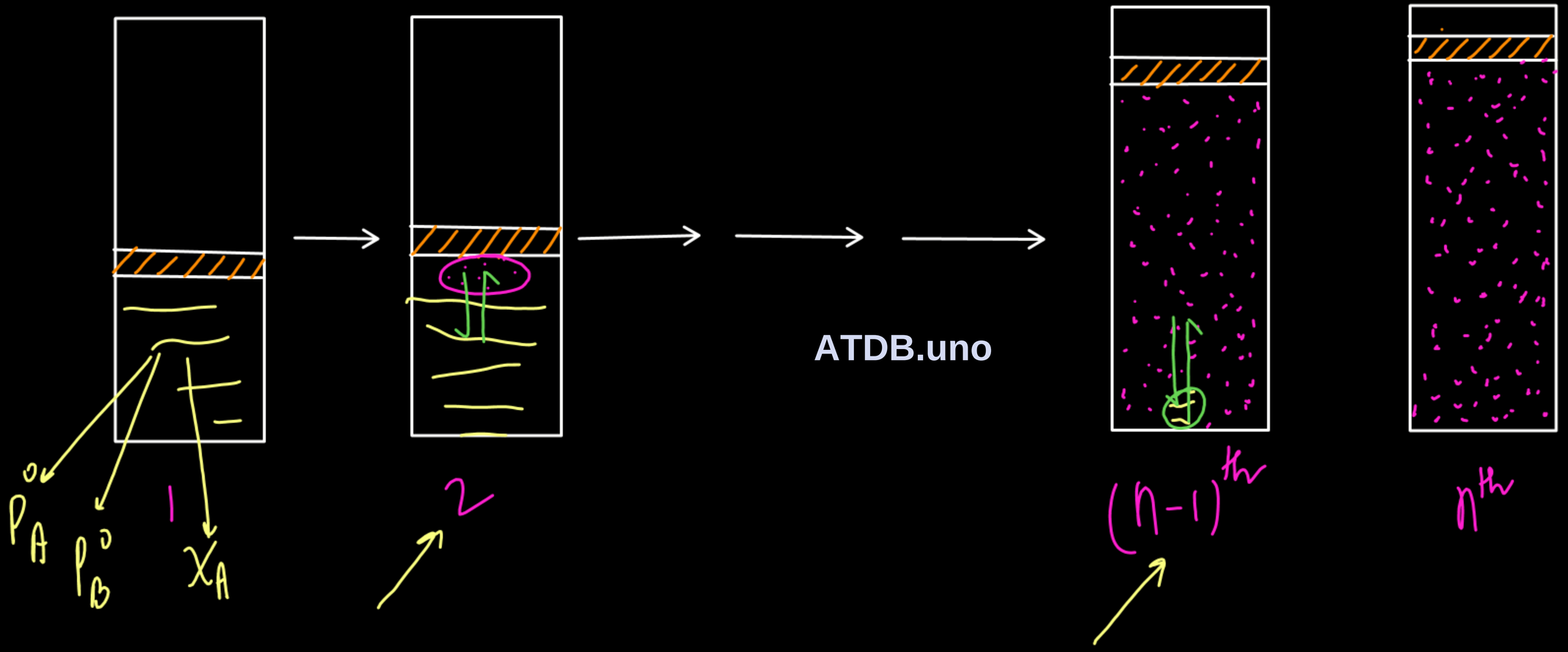
Find out $Y_{A,3}$?

$$\frac{Y_{A,3}}{1-Y_{A,3}} = \left(\frac{P_A^\circ}{P_B^\circ}\right)^3 \left(\frac{X_{A,1}}{1-X_{A,1}}\right) = \left(\frac{200}{400}\right)^3 \left(\frac{0.4}{0.6}\right)$$

$$= \frac{1}{8} \times \frac{4}{6} = \frac{1}{12}$$

$$\boxed{Y_{A,3} = \frac{1}{13}}$$

Case of Evaporation



Question 1

Find out the vapour pressure of solution when First drop of vapour formed.

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

X_A, X_B of container 1

$= X_A, X_B$ of container 2

(assumption)

Question 2

Find out the composition of first drop of vapour Formed.

$$\frac{Y_A}{1-Y_A} = \frac{P_A^0}{P_B^0}\left(\frac{X_A}{1-X_A}\right)$$

Question 3

Find out the composition of the last drop of liquid remained.

x_A of container 1 $\leftarrow$

$$\frac{Y_A}{1-Y_A} = \frac{P_A^0}{P_B^0}\left(\frac{x_A}{1-x_A}\right)$$

x_A of $(n-1)^{th}$ container can be calculated.

Question 4

Find out the total vapour pressure of the last drop of liquid remained.

$$P_T = P_A^{\circ} X_A + P_B^{\circ} X_B$$

24 Jan, 2023 (Shift-II)

1

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.

28 July, 2022 (Shift-II)

2

A gaseous mixture of two substances A and B, under a total pressure of 0.8 atm is in equilibrium with an ideal liquid solution. The mole fraction of substance A is 0.5 in the vapour phase and 0.2 in the liquid phase. The vapour pressure of pure liquid A is _____ atm. (Nearest Integer)

Ans: 2 atm

28 June, 2022 (Shift-II)

3

The vapour pressure of two volatile liquids A and B at 25°C are 50 Torr and 100 Torr, respectively. If the liquid mixture contains 0.3 mole fraction of A, then the mole fraction of liquid B in the vapour phase is $\frac{x}{17}$. The value of x is _____.

Ans: 14

24 Jan, 2023 (Shift-II)

4

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.

H.W

Question 5

A vessel labelled 1 contains 3 mol of A and 1 mol of liquid B forming an ideal solution. The solution is allowed to reach equilibrium with its vapours. The vapours are then quickly taken out and condensed in vessel labelled 2. Here again the solution is allowed to reach an equilibrium with its vapours. The vapours are again quickly taken out and condensed in vessel labelled 3. This process is continued several times. If $P_A^0 = 700$ mm Hg

$P_B^0 = 350$ mm Hg

i) composition of vapour in vessel 1.

ii) composition of vapour in vessel 2

iii) composition of vapour in vessel 100.

NCERT

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

NCERT

(7)

100 gm of liquid A (molar mass 140 g/mol) was dissolved in 1000 gm of liquid B (molar mass 180 g/mol). 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 the total vapour pressure of solution is 475 torr.

NCERT

(8)

Benzene and toluene form ideal solution over the entire range of composition. The vapour pressure of pure benzene and toluene at 300 K are 50.71 mm Hg and 32.06 mm Hg respectively. Calculate the mole fraction of benzene in vapour phase if 80 gm of benzene is mixed with 100 g of toluene.

NCERT

(9) Heptane and octane form an ideal solution. At 373 K, the vapour pressure of two liquid components are 105.2 kPa and 46.8 kPa respectively. What will be the vapour pressure of a mixture of 26.0 g of heptane and 35 g of octane?

Question

(19)

Equal moles of liq P and liq Q are mixed. What is the ratio of their moles in vapour phase? $P_P^\circ = 2P_Q^\circ$.

Question

11

The vapour pressure of two pure liquids, A and B, which form an ideal solution are 300 and 800 torr respectively, at temperature T. A liquid solution of A and B for which the mole fraction of A is 0.60 is contained in a cylinder closed by a piston on which the pressure can be varied. The solution is slowly vaporized at temperature T by decreasing the applied pressure, starting with a pressure of about 1atm. Calculate

A The pressure at which the first bubble of vapour is formed

B The composition of the vapour in this bubble

C The composition of the last droplet, and

D The pressure when only this last droplet of liquid remains.

Ans: i) 500 torr

ii) 0·36, 0·64

iii) 0·8, 0·2

iv) 400 torr

Question

12

The vapour pressure of hexane (C_6H_{14}) and heptane (C_7H_{16}) at 50°C are 408 torr and 141 torr respectively. The composition of vapour above the binary solution containing the mole-fraction of hexane = 0.300 is

[Y_6 = mole fraction of hexane and Y_7 = mole fraction of heptane]

A) $Y_6 = 0.8$, $Y_7 = 0.2$

B) $Y_6 = 0.554$, $Y_7 = 0.446$

C) $Y_6 = 0.300$, $Y_7 = 0.700$

D) $Y_6 = 0.871$; $Y_7 = 0.129$

Ans - (B)

Question

13

The vapour pressure of water at room temperature is 30 mm Hg. If the mole fraction of water in a solution is 0·9, the vapour pressure of solution will be –

Ans – (D)

A) 30 mm Hg

B) 24 mm Hg

C) 21 mm Hg

D) 27 mm Hg

Question

14

The vapour pressure in mm Hg of an ideal solution of A and B at 25°C is given by $P_{AB} = 33x + 94$, where as that of ideal solution of A and C at 25°C is given by $P_{AC} = 81x + 46$; 'x' being the mole fraction of A in the solution. The vapour pressure of solution containing 2 mole of A, 3 mole of B and 4 mole of C will be -

A) 80

B) 90

C) 100

D) none of these

Ans - (A)

Question

15

Vapour pressure of pure benzene at a certain temperature is 640 mm Hg. A non-volatile, non-electrolyte solute weighing 2.175 g. is added to 39 g benzene. The vapour pressure of solution is 600 mm Hg. What is the molecular weight of solute?

Ans — 65.25 g/mol

Question

16

The vapour pressure of pure benzene is 639·70 mm Hg and the vapour pressure of solution of a solute in benzene at the same temperature is 631·90 mm Hg. Calculate the molality of solution.

Ans – 0·158 molal

Question (Advanced level)

17. Two liquids A and B form ideal solution. At 300 K the vapour pressure of a solution containing 1 mol of A and 3 mol of B is 550 mm of Hg. At the same temperature one more mol of B is added to this solution, the vapour pressure of solution increases by 10 mm of Hg. Determine the vapour pressure of A and B in their pure state.

Ans- $P_A^0 = 400$ mm Hg

$P_B^0 = 600$ mm Hg