

Liquid Solution

Solution :-

Homogeneous mix of two or more components.

Solution → Solute (one or more than one)

→ Solvent (only one)

(a) Component having same physical state as that of solution

(b) If there are more than one components having same physical state as that of soln, then the one which is present in excess amount (by mole) is solvent.

Liquid Solution :-

- ① Solution of liquid in liquid
- ② Solution of Solid in liquid
- ③ Solution of gas in liquid

Volatile and Non-Volatile substance :-

- Substance having tendency to form vapour and have some vapour pressure are volatile substance.

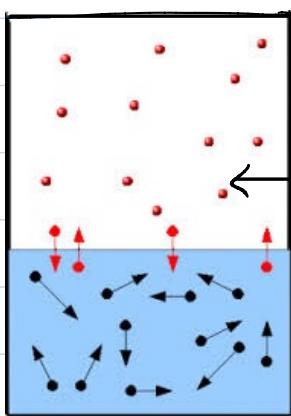
e.g.: liquids are generally volatile.

Water, alcohols, Benzene, Toluene, Acetone etc

- Substance having no tendency to form vapour are non volatile.

eg: Solids are generally non volatile
All salts and sugars, Hg etc

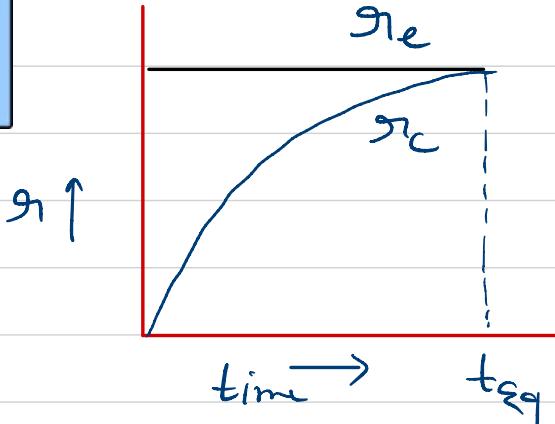
Vapour Pressure (V.P) :-



$$t=0 \quad \pi_e > \pi_c$$

$$t_{eq} \quad \pi_e = \pi_c$$

$$\text{Eq pressure} = V.P.$$



Pressure developed by vapours of volatile substance at eq. is called as Vapour Pressure



$$k_p = P_{A_{(g)}} = V.P.$$

$$\ln\left(\frac{k_{p_2}}{k_{p_1}}\right) = -\frac{\Delta H_{\text{vap}}}{R} \left[\frac{1}{T_2} - \frac{1}{T_1} \right]$$

$$= \ln\left(\frac{P_2}{P_1}\right)$$

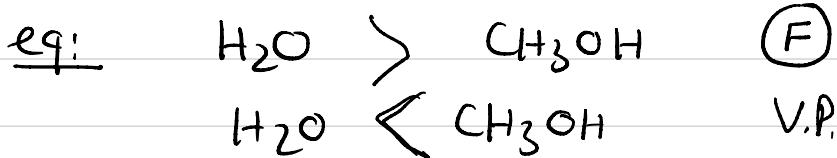
factors affecting V.P. :-

① Temp (T)

$$T \uparrow \Rightarrow V.P. \uparrow$$

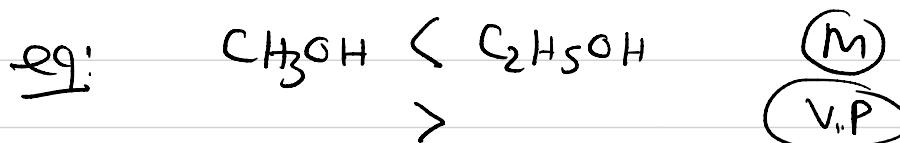
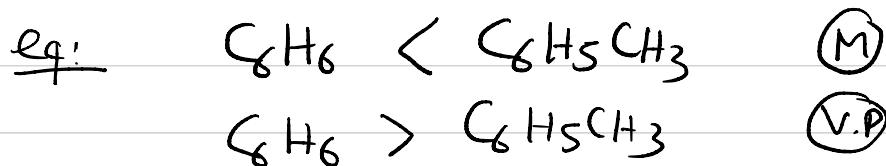
② Intermolecular forces (F) :-

$$F \uparrow \Rightarrow V.P. \downarrow$$

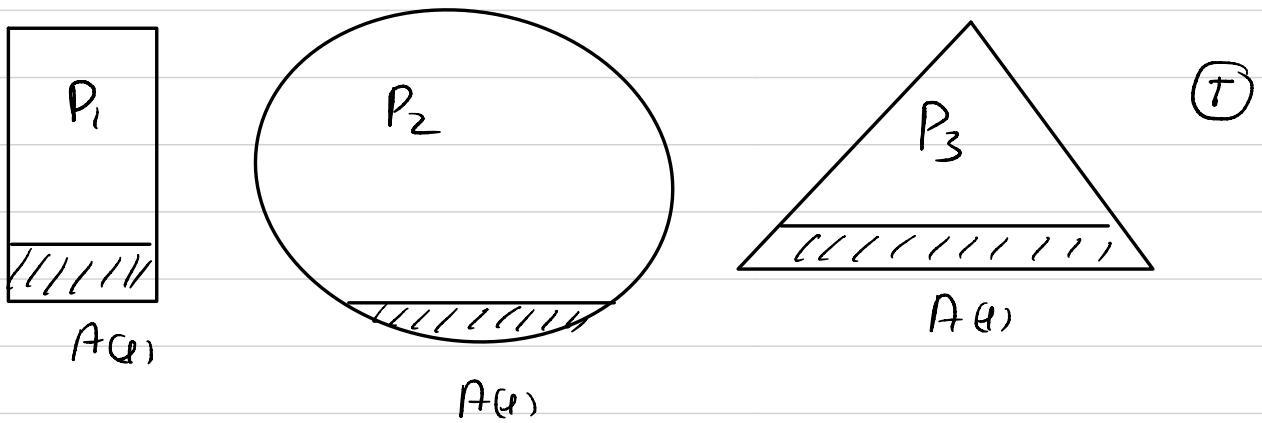


③ Molecular mass (M) :-

$$M \uparrow \Rightarrow V.P \downarrow$$



e.g.



$$P_1 = P_2 = P_3$$

Raoult's Law :- Raoult's Law is valid for ideal solution.

According to this law, V.P. of volatile substance in liquid not depend on its mole fraction and is directly proportional to it.

① Solution of liquid in liquid :-

A + B		Pure		V.P. in soln
y_A	y_B	x_{liquid}	x_{vap}	
P_A	P_B	x_A	y_A	P_A
$T \uparrow \uparrow$		x_B	y_B	P_B
A + B		$x_A \quad x_B$		# Acc to Raoult's Law

$$P_A \propto x_A$$

$$P_A = P_A^\circ x_A$$

$$P_B = P_B^\circ x_B$$

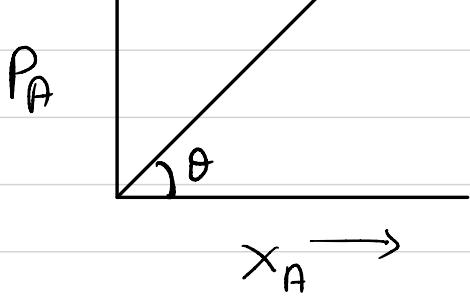
Using Dalton's Law

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

$$y_A \times P_T = P_A$$

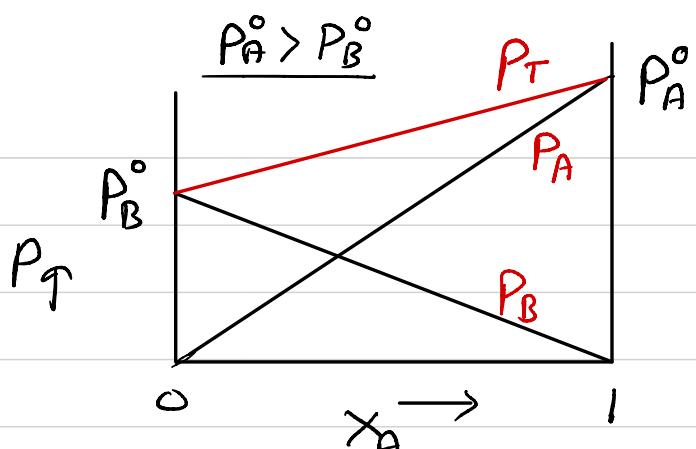
$$y_A = \left(\frac{P_A}{P_T} \right) = \frac{P_A^\circ x_A}{P_A^\circ x_A + P_B^\circ x_B}$$

$$x_B = 1 - y_A$$



$$P_A = P_A^\circ \times_A$$

$$\tan \theta = P_A^\circ$$

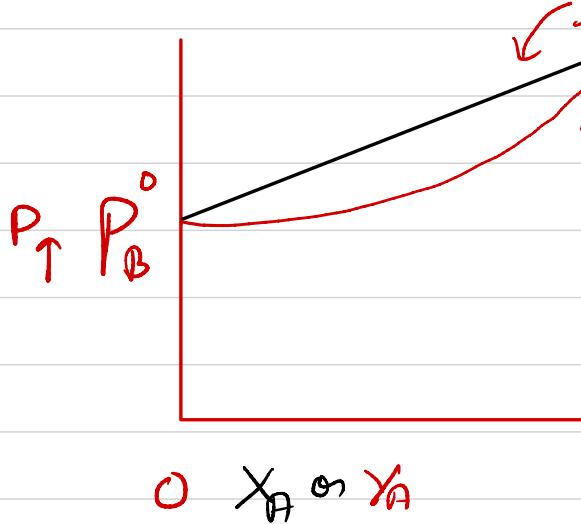


$$P_T = P_A^\circ \times_A + P_B^\circ \times_B$$

$$P_T = P_A^\circ \times_A + P_B^\circ (1 - x_A)$$

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

$$\Rightarrow x_A = \frac{P_T - P_B^\circ}{(P_A^\circ - P_B^\circ)}$$



$$Y_A \times P_T = P_A^\circ \times_A$$

$$= P_A^\circ \left[\frac{P_T - P_B^\circ}{P_A^\circ - P_B^\circ} \right]$$

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

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

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

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

$$\text{If } Y_A = 0 \Rightarrow P_T = P_B^\circ$$

$$X_A = 1 \Rightarrow P_T = P_A^\circ$$

② Solution of Solid in liquid:

Sol^m = Non volatile solid + Volatile liquid

Component	Pure V.P.	Mole fraction in liquid	V.P.	
A (Non volatile)	—	x_A	—	$\frac{P_B}{A+B} \uparrow \uparrow T$
B (volatile)	P_B°	x_B	P_B	$x_A \quad x_B$

Decrease in V.P. = $P_B^\circ - P_B$
 $= P_B^\circ (1-x_B)$
 $= P_B^\circ \approx x_A$

Relative decrease in V.P. = $\frac{(P_B^\circ - P_B)}{P_B^\circ} = x_A$

(RLVP)

RLVP will increase with increase in mole fraction of non-volatile solid.

Note:

① For very dilute solution

Solvent >> Solute $\Rightarrow n_B \gg n_A$

$$n_A + n_B \approx n_B$$

$$\frac{P_B^\circ - P_B}{P_B^\circ} = x_A \approx \frac{n_A}{n_B}$$

$$\text{② } \frac{P_B^\circ - P_B}{P_B} = \frac{P_B^\circ x_A}{P_B^\circ x_B} = \left(\frac{n_A}{n_B} \right)$$

Benzene and toluene forms an ideal solution. Vapour pressure of pure benzene is 100 torr while that of pure toluene is 50 torr. If mole fraction of benzene in liquid phase is $\frac{1}{3}$. Then calculate the mole fraction of benzene in vapour phase :

- (a) $\frac{2}{3}$
- (b) $\frac{1}{2}$
- (c) $\frac{2}{5}$
- (d) $\frac{1}{3}$

$$P_T = 100 \times \frac{1}{3} + 50 \times \frac{2}{3}$$

$$= \frac{200}{3} \text{ torr}$$

$$Y_B \times P_T = P_B^\circ \times X_B$$

$$Y_B \times \frac{200}{3} = 100 \times \frac{1}{3}$$

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

An ideal mixture of liquids A and B with 2 moles of A and 2 moles of B has a total vapour pressure of 1 atm at a certain temperature. Another mixture with 1 mole of A and 3 moles of B has a vapour pressure greater than 1 atm. But if 4 moles of C are added to second mixture, the vapour pressure comes down to 1 atm. Vapour pressure of C, $P_C^\circ = 0.8$ atm. Calculate the vapour pressure of pure A and B :

- (a) $P_A^\circ = 1.4$ atm, $P_B^\circ = 0.7$ atm
- (b) $P_A^\circ = 1.2$ atm, $P_B^\circ = 0.6$ atm
- (c) $P_A^\circ = 1.4$ atm, $P_B^\circ = 0.6$ atm
- (d) $P_A^\circ = 0.6$ atm, $P_B^\circ = 1.4$ atm

$$1 = P_A^\circ \times \frac{1}{2} + P_B^\circ \times \frac{1}{2}$$

$$P_A^\circ + P_B^\circ = 2 \quad \text{---(1)}$$

$$1 = P_A^\circ \times \frac{1}{8} + P_B^\circ \times \frac{3}{8} + 0.8 \times \frac{1}{2}$$

$$P_A^\circ + 3P_B^\circ = 4.8 \quad \text{---(2)}$$

$$2P_B^\circ = 2.8 \Rightarrow P_B^\circ = 1.4$$

$$\underline{P_A^\circ = 0.6 \text{ atm}}$$

Two liquids X and Y form an ideal solution. At 300 K, vapour pressure of the solution containing 1 mol of X and 3 mol of Y is 550 mmHg. At the same temperature, if 1 mol of Y is further added to this solution, vapour pressure of the solution increases by 10 mmHg. Vapour pressure (in mmHg) of X and Y in their pure states will be, respectively :

- (a) 300 and 400
- (b) 400 and 600
- (c) 500 and 600
- (d) 200 and 300

$$550 = P_X^\circ \times \frac{1}{4} + P_Y^\circ \times \frac{3}{4}$$

$$P_X^\circ + 3P_Y^\circ = 2200 \quad \text{---(1)}$$

$$560 = P_X^\circ \times \frac{1}{5} + P_Y^\circ \times \frac{4}{5}$$

$$P_X^\circ + 4P_Y^\circ = 2800 \quad \text{---(2)}$$

$$\Rightarrow P_Y^\circ = 600 \quad \left\{ \begin{array}{l} \\ \end{array} \right.$$

$$P_X^\circ = 400 \quad \left\{ \begin{array}{l} \\ \end{array} \right.$$

$$\frac{P^{\circ} - 0.95P^{\circ}}{0.95P^{\circ}} = \frac{n_{\text{solute}}}{n_{\text{solvent}}}$$

$$\frac{0.05}{0.95} = \frac{m_{\text{solute}} / M_{\text{solute}}}{m_{\text{solvent}} / M_{\text{solvent}}}$$

$$\frac{\Sigma}{M} = \frac{m_{\text{solute}} \times 0.3}{m_{\text{solvent}}}$$

$$\frac{m_{\text{solvent}}}{m_{\text{solute}}} = \frac{95 \times 0.3}{5} = 5.7$$

$$\frac{10 - 9}{9} = \frac{1/M}{20/200}$$

$$\frac{1}{9} = \frac{10}{M} \Rightarrow M = 90$$

The vapour pressure of a solution of a non-volatile solute B in a solvent A is 95% of the vapour pressure of the solvent at the same temperature. If the molecular weight of the solvent is 0.3 times the molecular weight of the solute, what is the ratio of weight of solvent to solute?

- (a) 0.15
- (b) 5.7
- (c) 0.2
- (d) None of these

The vapour pressure of pure liquid A is 10 torr and at the same temperature, when 1 g of B (non-volatile solid) is dissolved in 20 g of A , its vapour pressure is reduced to 9.0 torr. If the molecular mass of A is 200 amu, then the molecular mass of B is :

- (a) 100 amu
- (b) 90 amu
- (c) 75 amu
- (d) 120 amu