solution

→ A Homogeneous mixture of two or more chemically non-reacting substances whose composition can be varied within certain limits.

→ when solution is composed of only two components it is called Binary solution.

In Binary solution, there are two components.

① solute
↓
component of solution which is Present in small amount.

② solvent.
↓
which is present in large amount

Types of solutions

① solid solution

Solid in solid → Ex. Alloys, brass, bronze ↑ $(Cu + Tn)$ ↑ Making weapons

Liquid in solid → Hydrated salts, (sugar sol.) + (salt sol.

Gas in solid → Dissolved gases in minerals
or H_2 in Pd (Palladium

② Liquid solutions

solid in Liquid → salt or glucose. or sugar or urea

Liquid in Liquid → Methanol & ethanol in
Alcohol in water water

Gas in Liquid → Aerated drinks., O_2 in water
gas-liquid mixture (coke)

③ Gaseous solutions. Sublimation

solid in gas → Iodine vapours in air
Camphor in N_2 gas

Liquid in gas → Humidity in air, Moist air
chloroform mixed with N_2 gas

Gas in gas → Air (O_2 + N_2)

☆ Saturated solution → A solution that can not dissolve any more of the solute at a given temperature is called saturated.

☆ Unsaturated solution → A sol. in which more of the solute can be dissolve at a given temp. is called unsaturated solution.

concentration term

Perenctage → w/w

w/V

V/V

① w/w% → $$\frac{\text{weight of solute}}{\text{weight of solution(g)}} \times 100$$

② w/V% → $$\frac{\text{weight of solute}}{\text{~~weight~~ volume of solution(g)}} \times 100$$

③ V/V% → $$\frac{\text{vol. of solute (ml)}}{\text{vol of solution}} \times 100$$

Strength → It is defined as amount of solute (g) dissolved in 1L of solution.

$$= \frac{\text{Amount of solute}}{\text{volume of solution (L)}}$$

$\boxed{\text{Unit } g/L}$

Molarity → It is defined as the no. of moles of
(M) solute dissolved in 1 L or 1000 ml of Solution

$$M = \frac{\text{no. of moles of solute}}{\text{Vol. of solution in (L)}}$$

Unit → molar (M) or $mol\,L^{-1}$

Molality (m) → It is defined as the no. of moles of solute dissolved in 1 kg or 1000 g solvent

$$m = \frac{\text{no. of moles of solute}}{\text{Mass of solvent (in g)}} \times 1000$$

or

$$\frac{\text{no of moles of solute}}{\text{mass of solvent (in kg)}}$$

PPM (Parts Per million)

$$PPM = \frac{\text{mass of solute}}{\text{mass of soln}} \times 10^6$$

~~PPB~~

~~PPB~~ 2

Solubility → It is defined as maximum amount of solute that can be dissolved in a specified amount of solvent (like 100g solvent) to prepare its saturated solution.

→ Solubility is affected by many factors like nature of solute and solvent, temp. press. etc.

☆ Solubility of solids in liquids →

Solubility of a solid in a liquid is mainly affected by two solubility factors.

① Nature of solute & solvent

→ Like dissolve like

Eg → NaCl + water

② Temperature → Inc in temp. can have both +ve & -ve effect on solubility depending upon dissolution, process and Le-chatlie'r Principal.

→ for Endothermic process →

$$\text{Solute} + \text{solvent} + \text{Heat} \rightleftharpoons \text{solution}$$

Acc. to Le-chatlier's principal when temp is increased solubility also increase for Endothermic process.

→ For Exothermic process →

$$\text{Solute} + \text{solvent} \rightleftharpoons \text{Solution} + \text{Heat}$$

Acc. to Le-chatlier principal when temp. is increased process shifts to bacward dir^n and solubility decrease.

☆ Pressure does not affects the solubility of solids in liquid because Solids are higly incompressible.

ⓑ Solubility of gases in liquid →

① Temp → Solubility of gases in liquid $\propto \frac{1}{\text{Temp.}}$

② **Pressure** → solubility of a gas in liquid is directly proportional to the partial pressure of that gas on the surface of liquid.

Point to be Remember

$K_H \uparrow$ tem $\updownarrow$ sol

① Higher the value of K_H the lower is solubility

Que K_H value for Ar → 40.39,

CO_2 → 1.67

HCHO → 1.83×10^{-5}

CH_4 → 0.413

$\frac{1{,}83}{10000000}$

$\frac{413}{1000}$

Soln Ar < CO_2 < CH_4 < HCHO

② Value of Henry's const. (K_H) increase with inc in temp. but solubility decrease

Que

More the value of van't Hoff factor (i) more is the boiling point.

Ex. $NaOH \rightarrow Na^+ + OH^- = i = 2$

$Na_2SO_4 \rightarrow 2Na^+ + SO_4^{2-} \quad i = 3$

$NH_4NO_3 \rightarrow NH_4^+ + NO_3^- \quad i = 2$

$KNO_3 \rightarrow K^+ + NO_3^- \quad i = 2$

i is max for Na_2SO_4 it has a max. boiling point.

$$\left(\begin{array}{l} i > 1 \\ i < 1 \end{array} \right.$$

$$\left(i = 2 \right.$$

Henry's Law. → solubility of a gas in a liquid

The partial pressure (p) of the gas in vapour phase is proportional to the mole fraction (x) of the gas in the solution.

$$p \propto x \qquad \boxed{p = K_H x}$$

Law

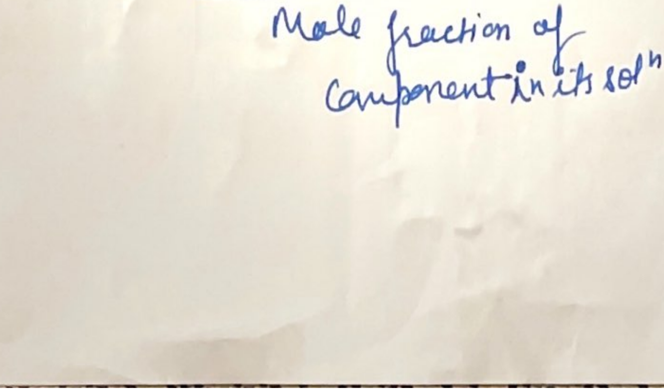
Henry const.

Higher the value of K_H at given pressure, the lower is the solubility of the gas in the liquid.

The value of K_H decrease with increase in the temp. **Thus** aquatic species are more comfortable in cold water rather than warm water.

Reason.

if Temp decs than oxygen more dissolve in water.



Applications →

→ In manufacture of soft drinks and soda water, CO_2 is passed at high pressure to increase its solubility.

→ To minimise the painful effects (bends) the decompression of deep sea divers, O_2 diluted with less soluble He gas and N_2 gas is used as breathing gas.

→ At High Altitude, the partial pressure of O_2 is less than that at the ground level. This leads to low concentration of O_2 in the blood of climbers. which cause anoxia

~~mol L^{-1}~~

~~Unit of k → atm^{-1} or bar^{-1}~~

Unit of Henry's Law Const → mol L^{-1} bar^{-1}

76 p

Vapour pressure of liquid solutions and Raoult's Law

Pressure formed by the vapour of the liquid over the surface of the liquid.

Vapour pressure is the pressure caussed by the evaporation of liquid.

Factor affecting →

① Nature of the liquid → weaker are the intermolecular forces, greater the amount of vapour because more molecules can leaves the liquid. and Come into the vapour phase.

② Temperature → Higher the temp., greater the vapour pressure. Becaus inc. In temp

$$\boxed{\text{Vapour pressure} \propto \text{Temp}}$$

concentration of solute → The presence of solute in the liquid will decrease the vapour pressure

Raoult's Law for volatile solutes.

Mole fraction of the solute component in a solution is directly proportional to its partial pressure:

$p \propto x$ $\qquad$ $\cancel{p_A \propto x_A}$

$$\boxed{\cancel{p_A = p_A^{\circ} x_A}}$$

Let us consider a mixture of two completely volatile liquid A & B. Having mole fraction x_A & x_B

$P_A = x_A P_A^{\circ}$ $\qquad$ and $\qquad$ $P_B = x_B P_B^{\circ}$

If P is total pressure of the system at the same temp., then by Dalton's law of partial pressure-

$$P_{Total} = P_A + P_B$$

$$P_{Total} = x_A P_A^{\circ} + x_B P_B^{\circ}$$

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

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

$$P_{Total} = (1 - x_B) P_A^{\circ} + x_B P_B^{\circ}$$

$$P_{Total} = P_A^{\circ} - P_A x_B + x_B P_B^{\circ}$$

$$\boxed{P_{Total} = (P_B^\circ - P_A^\circ)x_B + P_A^\circ}$$

X not

~~Rauto~~ Raoult's Law for Non volatile solutes

The decrease in vapour pressure of solvent depends on the quantity of non-volatile solute present in the solution irrespective of its nature.

vapour pressure of the solution. $\boxed{P_s = x_1 \times P^\circ}$ $\boxed{P_s \propto x_1}$

$$\boxed{\frac{P_s}{P^o} = x_1}$$

Mole fraction of the solvent in solution

$$x_1 = \frac{n_1}{n_1 + n_2}$$

Put $x_1 = \frac{P_s}{P_o}$

$$\boxed{\frac{P_s}{P_o} = \frac{n_1}{n_1 + n_2}}$$

Sub. 1 each side

$$1 - \frac{P_s}{P_o} = 1 - \frac{n_1}{n_1 + n_2}$$

$$\boxed{\frac{p^0 - p_s}{p^0} = \frac{n_2}{n_1 + n_2}}$$

$p^0 - p_s$ = lowering of vapour pressure

$\frac{p^0 - p_s}{p^0}$ = called relative lowering of vapour pressure.

☆ The relative lowering of vapour pressure of a solution containing a non-volatile solute is equal to the mole fraction of the solute in the solution.

Expressing solubility in terms of mole fraction of the gas in the solution.

So Henery's Law can be written as →

$m \propto p$

$$\boxed{m = kp}$$

or

$p \propto x$

$$\boxed{p = K_H x} \quad — ①$$

$$x_A = k' p_A \quad — ②$$

from eq - ②

$$\boxed{P_A = \frac{1}{k'} x_A}$$

$$\boxed{P_A = K_H x_A}$$

$$\boxed{K_H = \frac{1}{k'}}$$ is called Henry's Const.

Formulas used for Numericals

$$\boxed{P_A = K_H x_A}$$

Significance of K_H

$$x \propto \frac{1}{K_H}$$

Higher is the value of Henry's constant lower is the solubility of gas in liquid.

Ideal solution	Non-Ideal solution
① solutions which obey raoult's law under all conditions of temp. and concentration.	① Solutions which do not obey the raoult's law under all conditions are non-ideal solution
② $P_S = (p_A^0 * x_A) + (p_B^0 * x_B)$	② $P_S \neq (p_A^0 \times x_A) + (p_B^0 \times x_B)$
③ The interaction b/w the components are similar to those in the pure components. A-A, B-B	③ The interaction b/w the components are different to those of the pure components. Ex A-B,
④ $\Delta H_{mixing} = 0$ ΔH → Enthalpy $\Delta V_{mix} = 0$ ΔV = volume	④ $\Delta H_{mix} \neq 0$ $\Delta V_{mix} \neq 0$
⑤ They do not form Azeotropes. ↓ This is a type of liquid mixture having a definate composition and boil like a pure liquid. Eg → H_2O (↓ 100°c) and Ethyl alcohol (↓ 78·3°c)	⑤ They form Azeotropes define Enthalpy → means total heat present ↓ The measurment of energy in a thermodynamic system. $\boxed{\Delta H = \underset{\text{internal Energy}}{\Delta E} + P\Delta V}$

Azeotropes is of two types

① minimum boiling Azeotropes →

The azeotropes mixture which have boiling point lesser than the boiling Point of either of the pure components.

Eg → Ethanol (B.P → 351.3k) and water Containing 95.4%. Ethanol form an Azeotropic with boiling point 351.3

② Maximum Boiling Azeotropes →

The azeotropes mixture which have boiling point higher than the boiling point Either of the pure components.

☆ If it is exhibit Higher.B.P→ ~~negative~~ Positive deviation

☆ If it is Exhibit Lower B.P → Negative deviation

Non-ideal solutions are of two types →

Solutions showing +ve deviation	solutions showing -ve deviation.
① The interaction b/w the components are lesser than the interaction in pure components.	① The interaction b/w the components are stronger than the interactions in pure components.
$A-A, B-B > A-B$	$A-A, B-B < A-B$
② $p_s > x_A p_A^0 + x_B p_B^0$	② $p_s < x_A p_A^0 + x_B p_B^0$
③ $\Delta H_{mixing} = +ve$ $\Delta V_{mixing} = +ve$	③ $\Delta H_{mixing} = -ve$, $\Delta V_{mixing} \to -ve$.
④ They form minimum boiling azeotropes.	④ They form maximum boiling Azeotropes.

Colligative Properties :-

Properties of solutions which depends upon amount of solute or no. of solute particles

① Relative lowering in vapour pressure -

for solutions have non-volatile solute :-

Acc. to Raoult's Law

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

$\boxed{P_S = P_A}$ $\boxed{P_S = P_A + P_B}$

[Because solute is non volate
($P_B \doteqdot 0$)

$\boxed{x_A + x_B = 1}$

$$P_S = x_A P_A^\circ + P_B \Rightarrow 0$$

$$P_S = (1 - x_B) P_A^\circ$$

$$\frac{P_S}{P_A^\circ} = 1 - x_B \qquad = \frac{P_S}{P_A^\circ} - 1 = -x_B$$

$$\boxed{1 - \frac{P_S}{P_A^\circ} = x_B} \rightarrow \text{Mole fraction of solute}$$

↓

Relative lowering in vapour pressure

$$\boxed{\frac{p_A^\circ - P_s}{p_A^\circ} = \frac{n_B}{n_A + n_B}}$$

If $n_A >>> n_B$, we can neglect n_B in ~~deno~~ denominator.

$$\boxed{\frac{p_A^\circ - p_s}{p_A^\circ} = \frac{n_B}{n_A}}$$

$$\frac{p_A^\circ - p_s}{p_A^\circ} = \frac{w_B / m_B}{w_A / m_A} = \frac{w_B \cancel{+} m_A}{w_A \cancel{+ m} B} \quad \frac{w_B}{m_B} \times \frac{m_A}{w_A}$$

Numerical

The vapour pressure of pure benzene at a certain temp is 0.850 bar (p_A°) a non-volatile solute weighing 0.5g is added to 39 gm of benzene (m.m. 78 g) The vapour pressure of solⁿ then is 0.845 bar. (P_s) what is Molar mass of solid solute.

Solⁿ

$$\frac{p_A^\circ - P_s}{p_A^\circ} = \frac{w_B}{m_B} \times \frac{m_A}{w_A}$$

$$\frac{0.850 - 0.845}{0.850} = \frac{0.5}{m_B} \times \frac{78}{39}$$

$$\frac{0.005}{0.850} = \frac{0.5 \times 2}{m_B}$$

$$m_B = \frac{850}{5} = 170g.$$

Osmosis → spontaneous flow of solvent particle from the lower concentration sol^n to the higher concentration sol^n through a semi perimable membrane is called osmosis.

Diffusion → The spontaneous mixing of particles of the solute and the solvent to form a Homogenous mixture is called Diffusion.

or

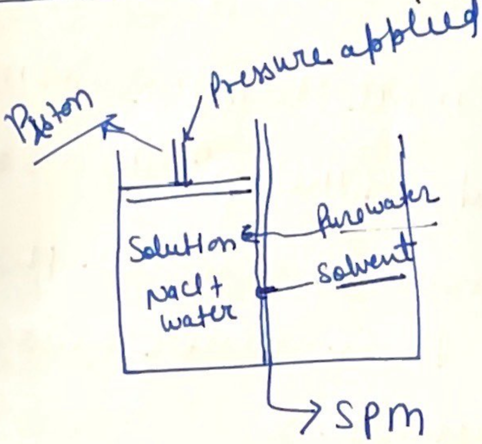
Spontaneous flow of particle from their higher concentration to their lower conc. is called diffusion.

If Diffusion ~~Pass~~ occurs through SPM Semi Permiable menbrane then it is called osmosis.

Semi-permiable membrane

A membrane which allows only the solvent molecules to pass through but not solute ~~mo~~ particles.

Osmatic Pressure (π) K Π



The minimum excess pressure that has to be applied on the solution just to stop the entry or movement of solvent in it through a semi permeable membrane is called osmatic pressure

* Osmatic Pressure is directly proportional to the molar concentration and its temp.

$\pi \propto C$

$\pi \propto T$

$\pi \propto C \times T$

$\boxed{\pi = RCT}$

$$\boxed{\pi = CRT} \rightarrow \text{Temp.}$$

Concentration of sol^n.

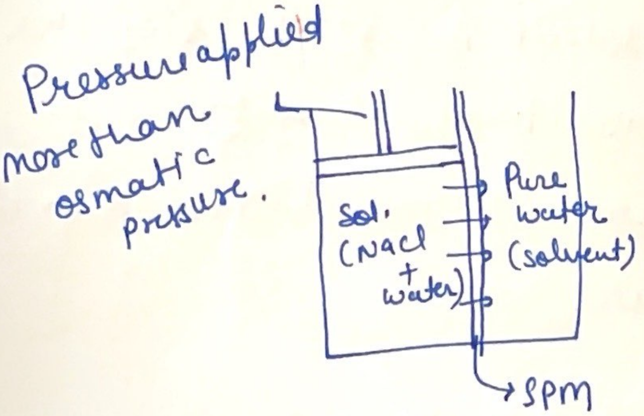
universal gas const.

$C = \frac{n}{V}$ $n = \frac{w}{m}$

$$\boxed{\pi = \frac{w}{m} \times \frac{RT}{V}}$$

Reverse osmosis

If the pressure more than the osmotic pressure is applied on the sol^n. then solvent particles show reverse osmosis. that is They move from their lesser amount to the higher amount.



- → R.O is used in purification of water, desalination of water

Remove salt from sea water

- → S.P.M used in R.O is cellulose acetate

↓ one of the lowest protein binding filters available.