Solution :- A solution is homogeneous mixture composed of two or more substance/component..
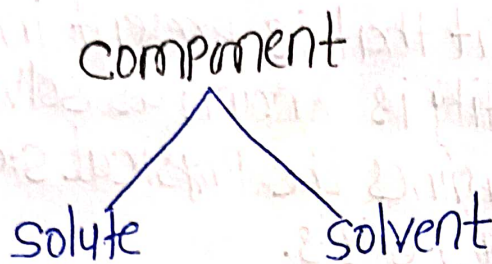
E.g- Seawater, Lemonade, Fe+Mg

component
  /   \
solute   solvent

Solution = Solute + solvent

Types of solutn	Solute	Solvent	Common example
Gaseous soln	Gas	Gas	mixture of oxygen and nitrogen gases
	Liquid	Gas	chloroform mixed with nitrogen gas
	Solid	Gas	Camphor in nitrogen gas
Liquid soln	Gas	Liquid	oxygen dissolved in water
	Liquid	Liquid	ethanol dissolved in water
	Solid	Liquid	Glucose dissolved in water
Solid soln	Gas	Solid	solution of hydrogen in Palladium
	Liquid	Solid	Amalgam of mercury with sodium
	Solid	Solid	copper dissolved in gold

Classification

↳ Solution which contain two components in it are called Binary solution

⇒ Substance which are used to prepare a solution are called as components.

⇒ The component that is present in the largest quantity is known as solvent. solvent determines the physical state in which solution exists.

⇒ The other component present in lesser quantity in the solution is termed as solute.

Aqueous solution

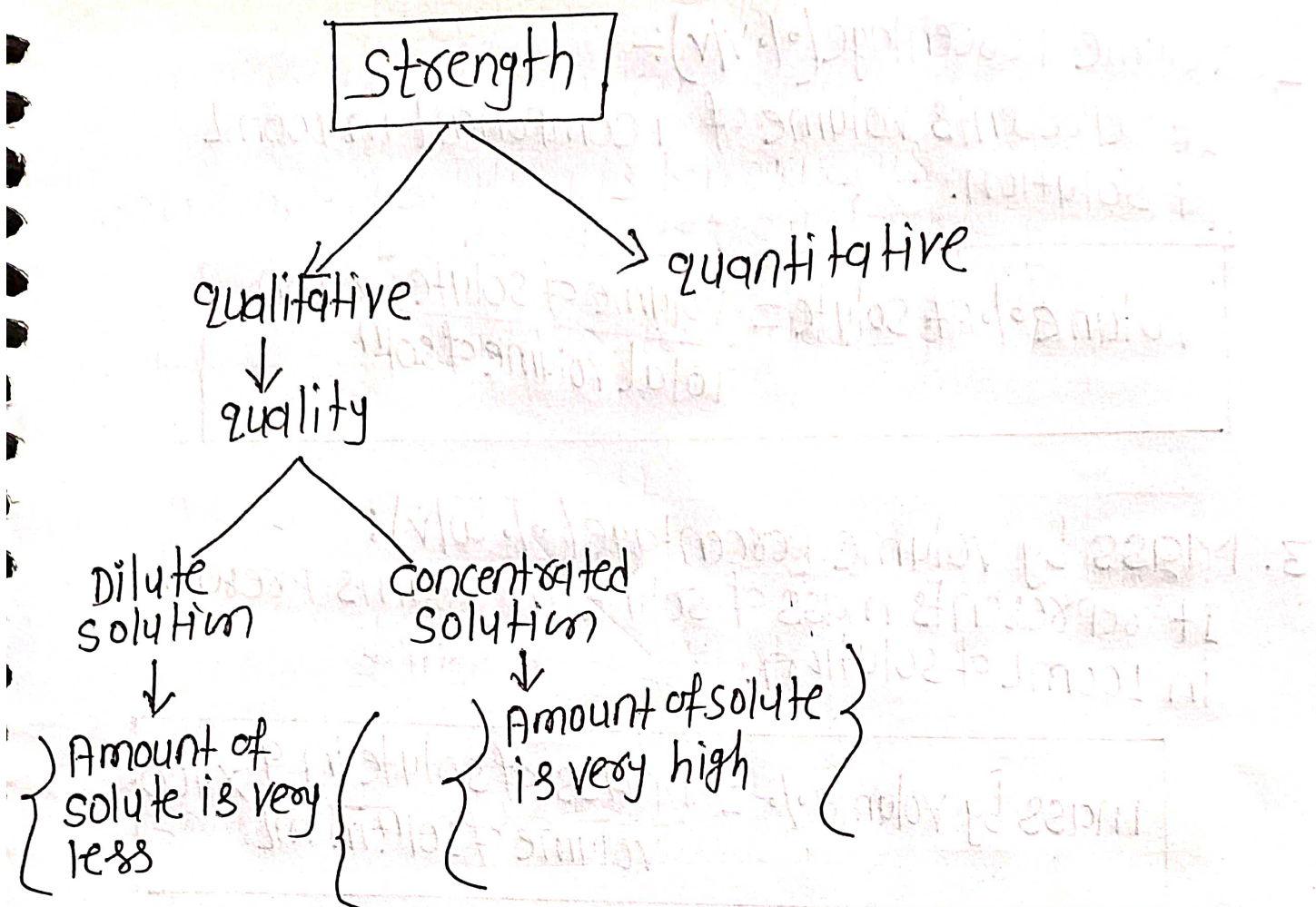If solvent of a solution is water then solution is known as Aqueous solution.

Non-Aqueous solution

If solvent is other than water then solution is known as the non-aqueous solution

methods of expressing strength of solution

strength or concentration

It is the amount of solute dissolved in per unit solvent is called strength of solution

$$\boxed{\text{Strength}}$$

Strength → qualitative

Strength → quantitative

qualitative ↓ quality

quality → Dilute solution

quality → concentrated solution

Dilute solution ↓ { Amount of solute is very less

concentrated solution ↓ { Amount of solute is very high

⇒ There are various methods of measuring strength of a solution. :

1. Mass Percentage (mass/mass % or m/m % or w/w %):

It may be defined as the number of parts of mass of solute per hundred parts by mass of solution

$$\text{mass \% of solute} = \frac{\text{mass of solute}}{\text{Total mass of soln.}} \times 100$$

$$\text{\% by mass } \frac{w}{w} = \frac{\text{wt. of solute}}{\text{wt. of solution}} \times 100$$

[x % by mass means 100 gm solution contains x gm solute and $(100-x)$ gm solvent]

2. volume percentage (% v/v):-

It represents volume of a component in 100mL of solution.

$$\text{volume \% of solute} = \frac{\text{volume of solute}}{\text{Total volume of soln}} \times 100$$

3. Mass by volume percentage (% w/v):

It represents mass of solute in grams present in 100mL of solution.

$$\text{mass by volume \%} = \frac{\text{Mass of solute in } g}{\text{volume of soln in } mL} \times 100$$

4. Parts per million (PPM):-

The amt. or mass of solute present in millionth part in the mass of soln.

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

5. Mole per kg concentration (molality, m):-

It is the number of moles of solute per kilogram of solvent.

$$\text{molality (m)} = \frac{\text{moles of solute}}{\text{mass of solvent in } kg}$$

unit of molality = mol/kg or molal

6. Molarity (M):-

It represents moles of solute present in 1L of solution
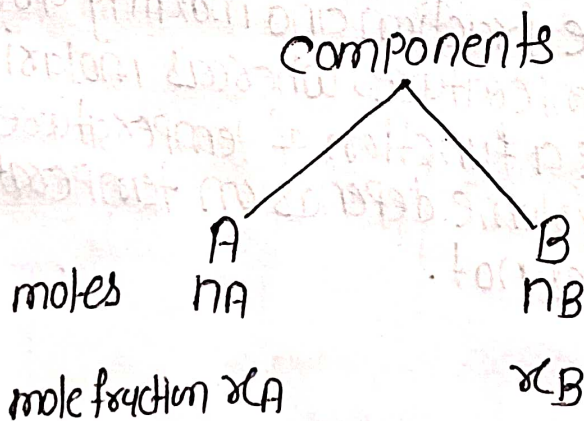
$$\text{Molarity (M)} = \frac{\text{Moles of solute}}{\text{Volume of soln. in L}}$$

7. mole fraction (x):-

mole fraction may be defined as the ratio of number of moles of one component to the total number of moles of all the components present in solution.

$$\text{Mole fraction (x)} = \frac{\text{moles of solute}}{\text{Total moles of soln.}}$$

$\Rightarrow$ The sum of all mole fraction in a solution always equal one.

$$\text{Components}$$

$$\overset{A}{\underset{\substack{\text{moles} \quad n_A}}{}} \qquad \overset{B}{\underset{n_B}{}}$$

mole fraction x_A $\qquad\qquad x_B$

$$\text{mole fraction } x_A = \frac{n_A}{n_A + n_B}$$

$$x_B = \frac{n_B}{n_A + n_B} \qquad\qquad x_A + x_B = 1$$

8. Normality (N)

It represents no. of equivalents of solute present in 1L of solution.

$$\text{Normality (N)} = \frac{\text{No. of equivalents of solute}}{\text{volume of solution in L}}$$

$$\text{Equivalents moles} = \frac{\text{given mass}}{\text{equivalent mass}}$$

$$\text{Equivalent mass} = \frac{\text{molar mass}}{n\text{-factor}}$$

Some important

$$\text{Normality} = z \times \text{molarity}$$

mass %, ppm, mole fraction and molality are independent of temperature, whereas molarity and normality are a function of temperature. This is because volume depends on temperature and the mass does not.
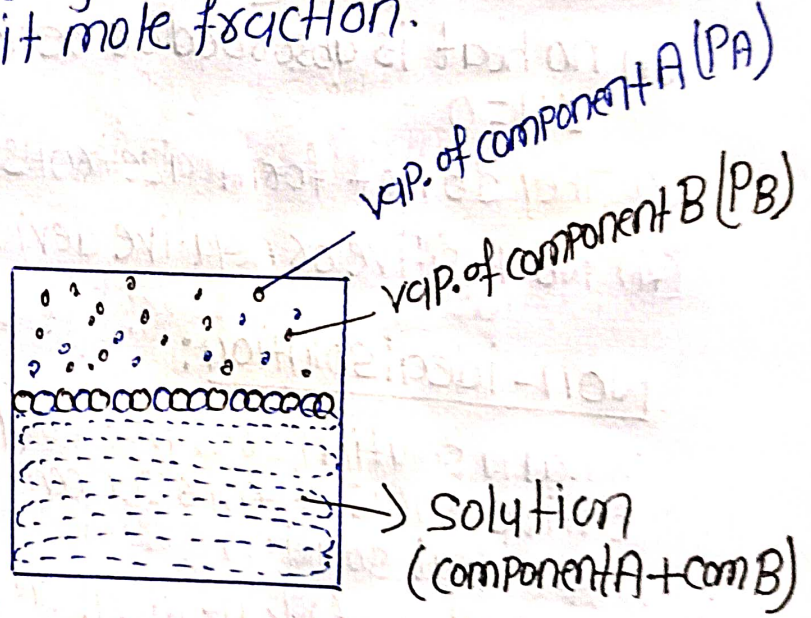
Vapour pressure

When we boil water it produces vapour. These vapour exert the pressure which is called the vapour pressure.

vapour

H_2O $T = 100°C - B.P.$
$P = 1 atm$
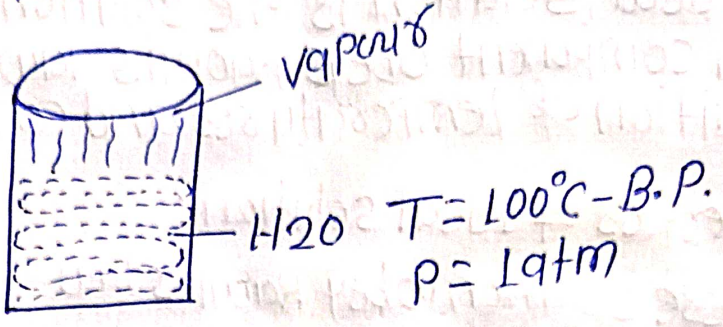
Raoult's law

The pressure applied by solute or solvent in a sol^n will be α to it mole fraction.

$$P \alpha x$$

vap. of component A (P_A)

vap. of component B (P_B)

→ Solution
(component A + com B)

→ mole fraction solute

Solute: $P_A = P_A° x_A$

Partial vap. pressure of solute

$P_A° = $ vap. pressure of pure solute

Solvent: $P_B = P_B° x_B$

$P_{solution} = P_A + P_B$

Total vap. pressure of solution.

Ideal and Non-ideal Solutions

Ideal solutions:

An ideal solution is the solution in which each component obeys Raoult's law under all condition of temperatures and concentration.

properties of Ideal solution:

(i) These solution obey Raoult's law

(ii) $\Delta H_{mixing} = 0$ { enthalpy change in mixing }

(iii) $\Delta V_{mixing} = 0$ { no change in volume upon mixing solute & solvent }

(iv) no heat is absorbed or realeased during dissolution
$\Delta H = 0$

(v) They do not form azetrops

(vi) No. positive or negative deviation are seen.

Non-ideal solution:

When a solution does not obey Raoult's law over the entire range of ceats concentration, then it is called non-ideal solution

properties of Non-ideal solution

(i) These solution do not follow Raoult's law

(ii) $\Delta H_{mixing} \neq 0$

(iii) $\Delta V_{mixing} \neq 0$

(iv) Heat is absorbed or released during dissolution
$\Delta H \neq 0$

(v) They form azeotropes

(vi) positive or negative deviation are seen.

Solubility

Solubility of a solid in liquid

Solubility of a substance is its maximum amount that can be dissolved in a specified amount of solvent.

Factors affecting the solubility of a solid in liquid:

1. Nature of solute and solvent:
   Like dissolves like. For example, while sodium chloride and sugar dissolve readily in water, naphthalene and anthracene do not. On the other hand, naphthalene and anthracene dissolve readily in benzene but sodium chloride and sugar do not.

2. Temperature:
   In a nearly saturated solution
   If ($\Delta_{sol} H > 0$), the solubility increase with rise in temperature and

   If ($\Delta_{sol} H < 0$) the solubility decrease with rise in temperature.

Effect of pressure
   Does not have any significant effect as solids and liquids are highly incompressible.

Henry's law

The mass of a gas dissolved per unit volume of solvent is proportional to the pressure of the gas at constant temperature.

$$m \propto P$$

$$m = K \cdot P$$

or moles $\propto P$

mole fraction $\propto P$

$$x \propto P$$

$$x = KP$$

$$P = \frac{1}{K} \cdot x \quad \text{or} \quad \boxed{P = K_H x}$$

↑ Henry's constant

$P = K_H \cdot x$ where K_H is Henry's constant.

Application of Henry's law

1. In the production of carbonated beverages.

2. In the deep sea diving.

3. People at high altitudes

Colligative properties

Colligative properties are those properties which depends upon the no. of particles or no. of moles of solute. irrespectively.

There are four colligative properties:

1. Relative Lowering of vapour pressure
2. Elevation in Boiling Point
3. Depression in freezing point
4. Osmotic pressure

1. Relative Lowering of vapour pressure

After adding the solute, the vapour pressure of the solution is found to be lower than that of the pure liquid at a given temperature. It is called Relative lowering of vapour pressure.

According to Raoult's law

$$P_{sol} = P_A^° \cdot x_A + P_B^° \cdot x_B$$

Here solute(B) → Non-volatile
$$P_B^° = 0$$

$$P_{sol} = P_A^° \cdot x_A + P_B^° \cdot x_B$$

$$P_{sol} = P_A^° \cdot x_A + 0 \cdot x_B$$

$$P_{sol} = P_A^° \cdot x_A$$

Vapour pressure of solution is totally dependent on vapour pressure of solvent.

$$P_{sol} = P_A^0 \cdot x_A$$

$$\frac{P_{sol}}{P_A^0} = x_A$$

Substract 1 from both side

$$1 - \frac{P_{sol}}{P_A^0} = 1 - x_A$$

$$\boxed{\frac{P_A^0 - P_{sol}}{P_A^0} = x_B}$$

[where P_A^0 is pure vapour pressure of solvent, and P_{sol} is Total vapour pressure of solution, x_B is mole fraction of solute.]

$$\frac{P_A^0 - P_{sol}}{P_A^0} = x_B \quad \text{--- (i)}$$

$$x_B = \frac{W_B}{m_B} \times \frac{M_A}{W_A} \quad \text{--- (ii)}$$

equate (i) & (ii)

$$\frac{P_A^0 - P_{sol}}{P_A^0} = \frac{W_B}{m_B} \times \frac{M_A}{W_A}$$

$$\boxed{M_B = \frac{W_B \times M_A}{\frac{P_A^0 - P_{sol}}{P_A^0} \times W_A}}$$

Here
W_B = given wt of solute
m_B = molar mass of solute
m_A = molar mass of solvent
W_A = given wt of solvent.

2. Elevation in Boiling Point

The increase in the boiling point of a solvent upon the addition of a solute.

or

When a non-volatile solute is added to a solvent, the resulting solution has a higher boiling point than that of the pure solvent.

Elevation in Boiling point $(\Delta T_b) = T_b - T_b^0$

[Here T_b is Boiling point of solute, T_b^0 is Boiling point of solvent]

$$\boxed{\Delta T_b \propto \text{molality of solution (m)}}$$

$\Delta T_b = K_b \cdot m$ Here k_b is molal elevation constant or ebullioscopic constant

$\Delta T_b = k_b \cdot m$

Here $m = \dfrac{\text{no. of moles of solute}}{\text{mass of solvent}} \times 100$

$$\boxed{\Delta T_b = \dfrac{k_b \times W_B \times 1000}{M_B \times W_A}}$$

$$\boxed{m = \dfrac{W_B \times 1000}{M_B \times W_A}}$$

3. Depression of Freezing Point

Freezing point depression is the decrease of the Freezing point of a solvent on addition of a non-volatile solute.

$$\Delta T_f = T_f^\circ - T_f$$

Here ΔT_f is D.F.P. and T_f° is F.P. of pure solvent, T_f is F.P. of solution.

$$\Delta T_f \propto \text{molality}$$

$$\Delta T_f = k_f \cdot m$$ [Here k_f is molal depression constant or cryoscopic constant.]

$$\Delta T_f = k_f \cdot m$$

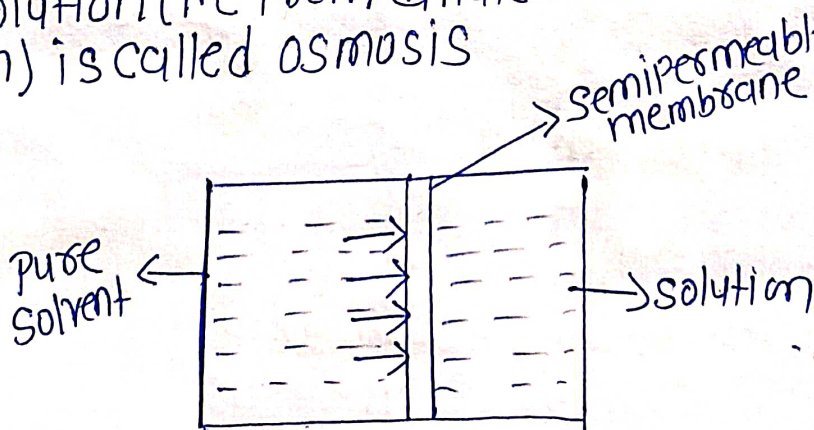$$\Delta T_f = \frac{k_f \cdot W_B \times 1000}{M_B \times W_A}$$

Here W_B = Given wt of solute

M_B = molar mass of solute

W_A = given wt of solvent

4. Osmosis

The spontaneous flow of the solvent through a semipermeable membrane (SPM) from pure solvent to a solution (i.e from dillute solution to concentrated solution) is called osmosis

is called osmotic pressure(π).

or

The excess pressure which must be exerted on solution side in order to prevent the flow of solvent molecules towards the solution side when both are separated semipermeable membrane is called osmotic pressure.

osmotic pressure

- osmotic pressure is denoted by π
- mathematically

$$\pi = CRT$$

π = osmotic pressure

C = concentration of solution

R = gas constant

T = Temperature

osmotic pressure(π) - Depend upon two factor

(i) $\pi \propto$ concentration(molarity)

(ii) $\pi \propto$ Temperature

$T \uparrow$ solvent molecule $K.E \uparrow$ motion $\uparrow$ osmosis $\uparrow$ osmotic pressure $\uparrow$

$\pi \propto C$ ---(i)

$\pi \propto T$ ---(ii)

can write both together

$\pi \propto CT$

$\pi = RCT$ Here R= gas constant

$$\text{Concentration} = \frac{\text{no. of moles of solute}}{\text{volume}}$$

$$C = \frac{n_B}{V}$$

$$\Pi = CRT$$

$$\Pi = \frac{n_B}{V} RT$$
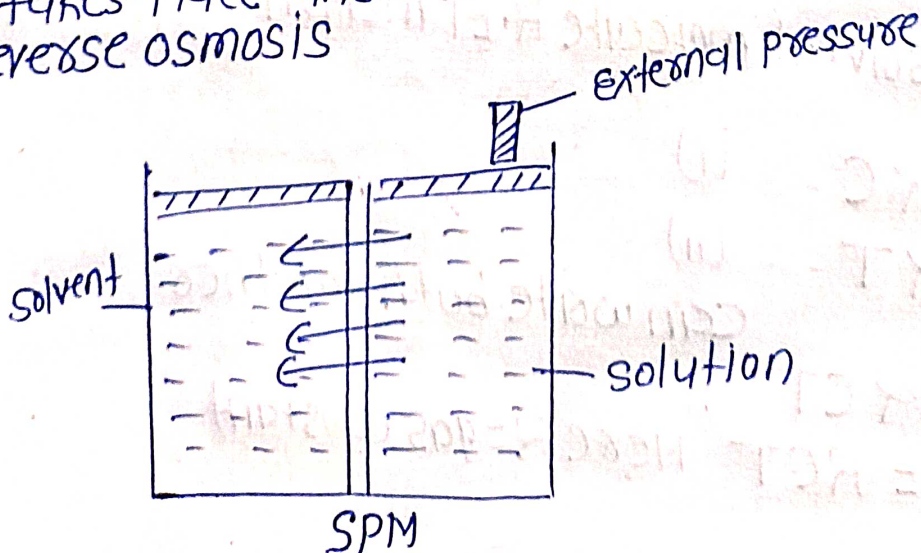
$$\boxed{\Pi V = n_B RT}$$

$$\Pi V = n_B RT$$

We known that

$$n_B = \frac{W_B}{M_B}$$

$$\Pi V = \frac{W_B}{M_B} RT$$

$$\boxed{M_B = \frac{W_B \times R \times T}{\Pi V}}$$

Reverse osmosis

When external pressure exceeds the osmotic pressure flow of solvent from solution side to the pure solvent side takes place and this Phenomenon is known as Reverse osmosis

van't Hoff Factor

To calculate extent of association or dissociation van't Hoff introduced a factor i, known as the van't Hoff factor.

$$i = \frac{\text{Normal molar mass}}{\text{Abnormal molar mass}}$$

$$i = \frac{\text{observed colligative property}}{\text{calculated colligative property}}$$