Solutions Class 12 (chemistry)

covered all the topics widely

What is Solution?

→ Solutions are homogenous mixtures of two or more than two components.

→ Homogenous mixture - composition & properties are uniform throughout the mixture.

→ Solute and Solvent

1) Solvent → component that is present in the largest quantity.

2) Solvent determines the physical state in which solution exists.

3) Solute → One or more components prsnt in the solⁿ other than solvent are called solute.

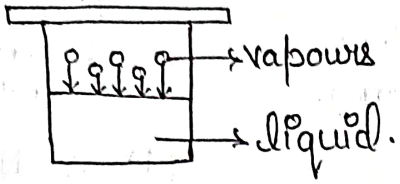
{ 1 solute + 1 solvent = Binary Solⁿ. }

→ Types of Solutions

Types of Solutions	Solute	Solvent	Common ex.
Gaseous solⁿ.	G	G	→ Mixture of Oxygen & Nitrogen gas
	L	G	→ Chloroform mixed with nitrogen gas
	S	G	→ Camphor in Nitrogen gas
Liquid Solⁿ	G	L	→ Oxygen dissolved in H_2O.
	L	L	→ Ethanol dissolved in H_2O
	S	L	→ Glucose dissolved in H_2O
Solid Solⁿ	G	S	→ Solⁿ of Hydrogen in Palladium.
	L	S	→ Amalgam of Mercury with Sodium. (Na-Hg)
	S	S	→ Cu dissolved in Au.

Vapour Pressure

The Pressure exerted by the vapours over the surface of liq. when vap. & liq are in eqm.



$$H_2O_{(l)} \underset{\text{condensation}}{\overset{\text{evaporation}}{\rightleftharpoons}} H_2O_{(v)}$$

(rate of eva = rate of condensation)

$\Rightarrow$ $\boxed{\text{When Vap. pressure = atmospheric pressure, Temperature} \rightarrow \text{Boiling point.}}$

Factors affecting VP.

1). Temperature. T ↑, Kinetic Energy of liq ↑, escaping tendency of liq ↑, Vapours ↑

Hence, VP ↑. $\boxed{VP \propto Temp}$

$$\boxed{\log \frac{P_2}{P_1} = \frac{\Delta H_{vap}}{2.3R}\left[\frac{1}{T_1} - \frac{1}{T_2}\right]}$$ ← Clausius clapeyron eqn.

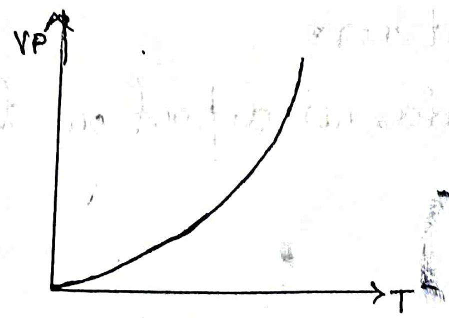
$$\boxed{P = Ae^{-\frac{\Delta H_{vap}}{RT}}}$$

P_1 = Vp at temp T_1 (K)

P_2 = VP at temp T_2 (K)

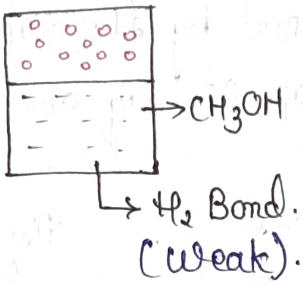
ΔH_{vap} = heat of vap. (J/mol)

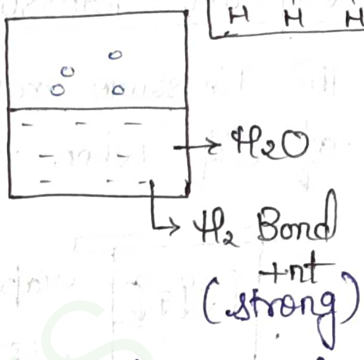
$R = \frac{25}{3}$ J/mol-K.

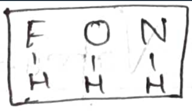


2) Intermolecular forces b/w liquids.

IMF ↓, escaping tendency ↑, Vapours ↑, VP ↑.







$$\boxed{VP \propto \frac{1}{IMF}}$$

(C–O–H) (H–O–H)

forces: Hydrogen Bond (H_2O) > DP-DP (HCl---HCl) > DP-IDP (HCl---Cl-Cl) > IDP-IDP (Cl-Cl---Cl-Cl).

$\mu \neq 0$ $\mu \neq 0$ | $\mu \neq 0$ $\mu = 0$ | $\mu = 0$ $\mu = 0$

F–H, O–H, N–H

1 liq (Hydrogen Bond > DP > IDP)

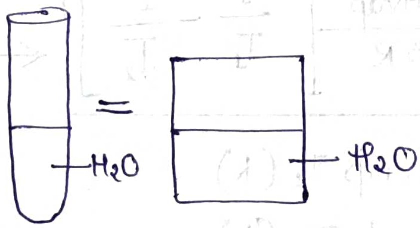
low EN	High EN
H–	Cl

H–Cl: $\mu \neq 0$

Cl – Cl: $\mu = 0$

Factors do not affect VP.

1) Surface Area.



(Same VP in both case)

2) It does not depend on Volume of liq in the container.

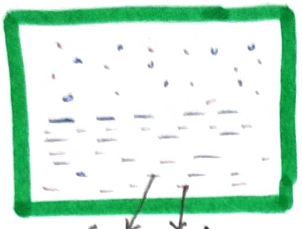
3) It does not depend on the vol. of VPhase.

Volatile and Non-Volatile Substances.

Volatile → Jiski vapours banti ho.

Non-Volatile → Jiski vapours nhi banti ho.

Binary sol^n.

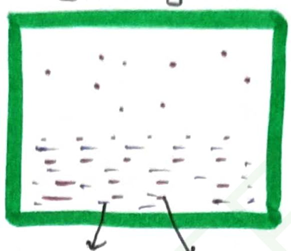


(A+B)

A → Volatile

B → Volatile.

Binary sol^n.



(A+B)

A (Non-volatile)

B (Volatile)

Raoult's Law

Case-1 For two volatile liq. — The Vap.p of component is directly proportional to the mole fraction of component in solution.

A + B

A → solvent, B → solute

① $P_A \propto x_A$

$$\boxed{P_A = P_A^\circ x_A}$$

P_A = VP of A in Sol^n

P_A° = VP of pure A

x_A = mole fraction of A in sol^n.

② $P_B \propto X_B$

$$\boxed{P_B = P_B^\circ X_B}$$

P_B = VP of B in sol^n

P_B° = VP of pure B

X_B = Mole fraction of B in sol^n.

③ $P_T = P_A + P_B$

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

$$\# \left\{ \begin{array}{l} P_A^\circ > P_A \\ P_B^\circ > P_B \end{array} \right\} \#$$

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Q (pyq). The correct option for the value of VP of a sol^n at 45°C with benzene to octane in a molar ratio 3:2 is –

(At 45°C VP of Benzene = 280 mm of Hg , Assume Ideal gas) .
VP of octane = 420 mm Hg

Sol

$$P_S = P_B + P_O$$

$$P_S = P_B^{\circ} X_B + P_O^{\circ} X_O$$

$$P_S = 280 \times \frac{3}{5} + 420 \times \frac{2}{5}$$

$$P_S = 168 + 168$$

$$\boxed{P_S = 336 \text{ mmHg}}$$

$$X_B = \frac{3}{3+2} = \frac{3}{5}$$

$$X_O = \frac{2}{3+2} = \frac{2}{5}$$

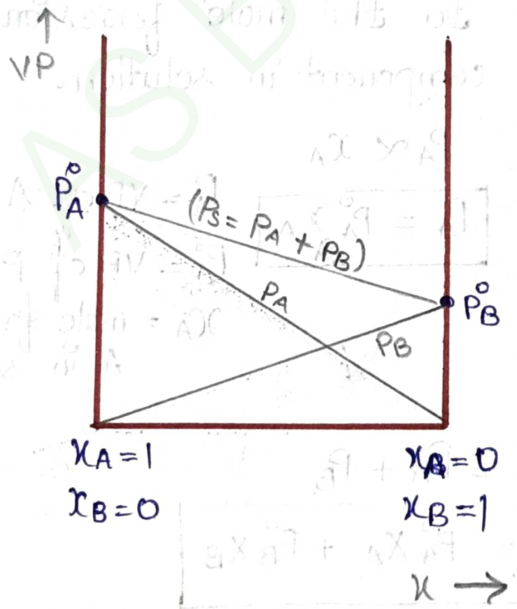
Value b/w

$$\boxed{P_B^{\circ} < P_S < P_O^{\circ}}$$

280 —— 420

a) 336 ✓ b) 350 c) 160 ✗ d) 168 ✗

Graph. A is more volatile than B ($P_A^{\circ} > P_B^{\circ}$)



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

→ $x_A = 1$ $x_B = 0$

$P_S = P_A^{\circ}$

→ $x_A = 0$ $x_B = 1$

$P_S = P_B^{\circ}$

Why straight line ?

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

$$P_S = P_A^{\circ} x_A + P_B^{\circ}(1 - x_A)$$

$$P_S = P_A^{\circ} x_A + P_B^{\circ} - P_B^{\circ} x_A$$

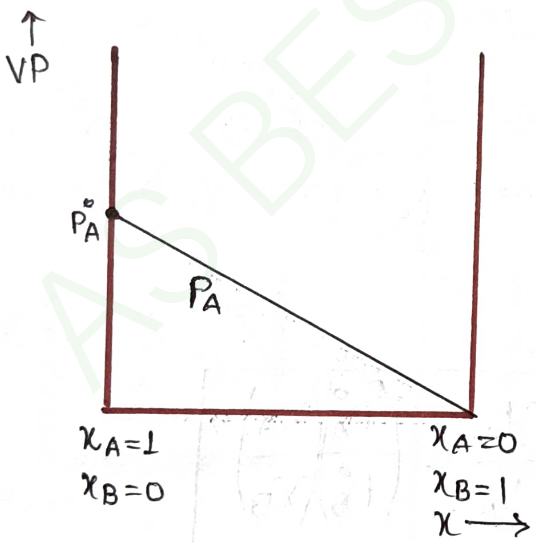
$$P_S = (P_A^{\circ} - P_B^{\circ}) x_A + P_B^{\circ}$$

st line ← $y = mx + c$

$$P_S = P_A^\circ x_A + P_B^\circ x_B$$
$$P_S = P_A^\circ (1 - x_B) + P_B^\circ x_B$$
$$P_S = P_A^\circ - P_A^\circ x_B + P_B^\circ x_B$$
$$P_S = P_A^\circ + (P_B^\circ - P_A^\circ) x_B .$$
$$P_S = (P_B^\circ - P_A^\circ) x_B + P_A^\circ$$
$$y = m x + c \longrightarrow \text{st line.}$$

Case. 2 For non-volatile solute (B) – Volatile solvent (A).

$$P_B = 0 \qquad\qquad P_A = P_A^\circ x_A$$
$$P_T = P_S = P_A + \cancel{P_B}^{\,0}$$
$$\Rightarrow \boxed{P_T = P_S = P_A^\circ x_A} \longrightarrow P_S = P_A^\circ (1 - x_B)$$
$$P_S = P_A^\circ - P_A^\circ x_B$$
$$P_A^\circ x_B = P_A^\circ - P_S$$
$$\boxed{\frac{P_A^\circ - P_S}{P_A^\circ} = x_B}$$



$P_A^\circ - P_S$ = Lowering in VP

$\dfrac{P_A^\circ - P_S}{P_A^\circ}$ = Relative Lowering in VP (RLVP).

" RLVP is equal to mole fraction of solute in solution ".

Q pyq One mole of non-volatile sugar is dissolved in three moles of volatile water at 298 K. The relative lowering of VP is ——

Sol
$$\frac{P_A^\circ - P_S}{P_A^\circ} = x_B = \frac{1}{1+3} = \frac{1}{4} = 0.25$$

Mole fraction in Vapour Phase.

$$\boxed{P_{gas} = X_{gas} P_T}$$

$x \rightarrow$ mole fraction in liq. phase.

Dalton's law:

$$\boxed{P_{gas} = Y_{gas} P_T}$$

y = mole fraction in Vapour phase.

$P_A = y_A P_T$

$P_B = y_B P_T$

$$\boxed{y_A = \frac{P_A}{P_T}}$$

$$\boxed{y_B = \frac{P_B}{P_T}}$$

$$\boxed{y_A + y_B = 1}$$

$P_A = P_A^\circ X_A$

$P_B = P_B^\circ X_B$

$P_T = P_A + P_B = P_S$

$P_T = P_A^\circ X_A + P_B^\circ X_B = P_S$.

Op point :- $\frac{y_A}{y_B} = \frac{P_A}{P_B} \Rightarrow$

$$\boxed{\frac{y_A}{y_B} = \frac{(P_A^\circ)(X_A)}{(P_B^\circ)(X_B)}}$$

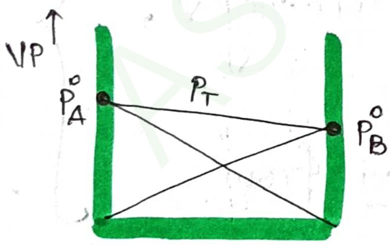
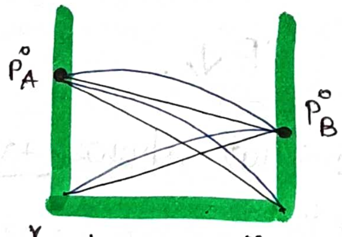
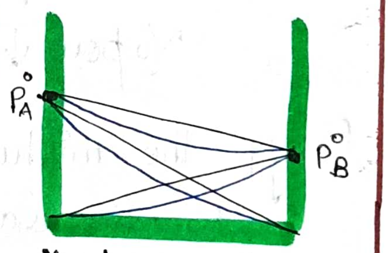
mole f° in V Phase

mole f° in L Phase

* IMF forces weak, escaping tendency ↑, Vapour ↑, VP ↑
* IMF forces strong, escaping tendency ↓, Vap ↓, VP ↓

Types of Solution.

- **Ideal Soln** — obey Raoult's law.
- **Non-Ideal Soln.** — does not obey Raoult's law.
  - Positive deviation
  - negative deviation.

(Ideal Soln)	(Non-Ideal Solution)	
	jyda VP (+ve Devi.)	km VP. (−ve Devi.)
→ The intermolecular forces b/w A−A & B-B, are nearly equal to A−B.	→ The inter. f b/w A-A & B-B is stronger than A-B weak IMF	→ The IMF b/w A−A & B−B are weaker than A-B strong IMF
→ $(P_T)_{cal} = (P_T)_{obser.}$	→ $(P_T)_{cal} < (P_T)_{obs.}$	→ $(P_T)_{cal} > (P_T)_{obs}$ observed km kyuki vapour km ho rae
→ $\Delta H_{mix} = 0$ $\Delta V_{mix} = 0$ $\Delta S_{mix} > 0$ $\Delta G_{mix} < 0$ at const T & P	→ $\Delta H_{mix} > 0$ $\Delta V_{mix} > 0$ $\Delta S_{mix} > 0$ $\Delta G_{mix} < 0$	→ $\Delta H_{mix} < 0$ $\Delta V_{mix} < 0$ $\Delta S_{mix} > 0$ $\Delta G_{mix} < 0$ at const T & P.
 $x_A = 1$ $x_B = 0$ $x_A = 0$ $x_B = 1$ x ⟶	 $x_A = 1$ $x_B = 0$ $x_A = 0$ $x_B = 1$	 $x_A = 1$ $x_B = 0$ $x_A = 0$ $x_B = 1$
→ $C_2H_5Br + C_2H_5Cl$ Benzene + Toluene hexane + heptane (Same family)	(Bond Break krta) → Acetone + Ethanol. → CCl_4 + Benzene $CCl_4 + CH_3OH$ $CCl_4 + C_2H_5OH$ $C_2H_5OH + H_2O$. (Minimum Boiling azeo.)	→ $HNO_3 + H_2O$ Acetone + $CHCl_3$ $HCl + H_2O$ $CHCl_3 + CH_3COOH$ (Maxm Boiling Azeo)

eq. ② $BaCl_2$ — $Ca(OH)_2$ — CP — same / different

$Ba^{+2} + 2Cl^- = ③$ — $Ca^{+2} + 2\bar{O}H \Rightarrow n = ③$

③ $Ba(OH)_2$ — H_2SO_4 — CP — same / different

$Ba^{+2} + 2OH^- \Rightarrow n = ③$ — $2H^+ + SO_4^{2-} \Rightarrow n = ③$

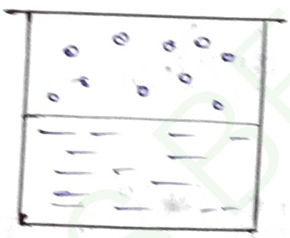
④ $CaCl_2$ — $HClO_4$ — CP — same / diff.

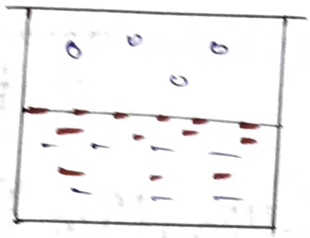
$Ca^{+2} + 2Cl^-$ — $H^+ + ClO_4^-$

$n = ③$ — $n = ②$

1. RLVP (Relative lowering in VP).

Statement :→ When non-volatile solute is added to volatile solvent, its VP decreases.





P_A° (Pure solvent A) > P_S (Solution)

⇓

(Volatile solvent + non-volatile solute.)

$P_S = P_A + \cancel{P_B}^{\,0}$

B → non-volatile solute

A → volatile solvent

$P_S = P_A^\circ \chi_A$

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

$P_S = P_A^\circ - P_A^\circ \chi_B$

$P_A^\circ \chi_B = P_A^\circ - P_S$

$\boxed{\chi_B = \dfrac{P_A^\circ - P_S}{P_A^\circ}}$]→ Lowering in VP]→ RLVP

$P_A^\circ - P_S > 0$ (as mole fraction −ve ni ho skte)

$\boxed{P_A^\circ > P_S}$

Maximum & Minimum boiling Azeotropes.

→ (Constant boiling mixture)

just a example → A + B
80°C   100°C

(Aisa solution jo ek single liquid ki tarah kaam kre (Do jism ek Jaan))

← Minim boiling azeo.
VP max
+ve devi.
(eg. of +ve devi)

→ Max^m. boiling azeo.
VP min
−ve devi.
(eg. of −ve devi.)

[VP ∝ T
VP ∝ 1/BP.]

① The mixture that forms max^m boiling azeo. —

a) Heptane + Octane (ideal)

b) Water + Nitric Acid (−ve devi)- Max^m azeo.

c) Ethanol + Water (+ve devi)

d) Acetone + Carbon ~~dioxide.~~ disulphide. (+ve devi).
(CS_2).

∞(*) Colligative Properties(*)∞ (most imp.)

⇒ The property which depends on no. of solute particles irrespective of its nature is called CP.

eg., ① HCl (Acid)   ② NaCl (Salt)   ③ NaOH (Base).

$H^+ + Cl^-$ $Na^+ Cl^-$ $Na^+ + {}^-OH$

no. of particle = 2   2   2.

⇒ Colligative prop. of ①, ②, ③ are same as it depends on number of particle but does not depends on Nature.

Op point

① Ideal sol^n = same family wale.

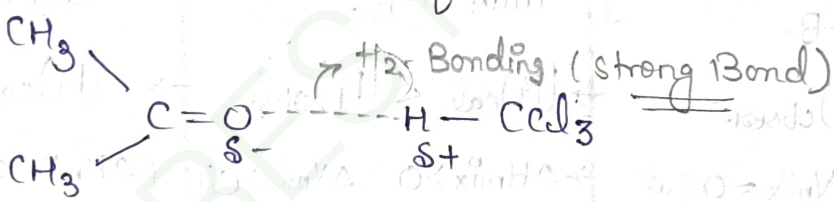
② +ve devi = CCl_4 (nonpolar), CS_2 (nonpolar) → Bond weak kr deta

③ −ve devi = Acid → (polar) HCl, HNO_3, CH_3COOH → Bond strong kr deta.

- CCl_4 + ---- +ve
- $CHCl_3$ + --- −ve
- C_6H_6 + --- +ve
- Acid + --- −ve.

Ideal sol^n can be separated in pure components by fractional distillation. (100% separation hoga). (Non-Ideal me 100% nhi hota sep.)

Q Why acetone & $CHCl_3$ form −ve devi?



⇒ force of attraction ↑, escaping tendency ↓, Vapour ↓, VP ↓.

Q pyq The mixture that shows +ve devi from Raoult's law?

a) Benzene + Toluene (Ideal Sol^n)

b) Chloroethane + Bromethane (Ideal Sol^n)

c) Acetone + chloroform (−ve devi)

d) Ethanol + Acetone (+ve devi) ✓

For numerical :→ Elevation in BP is directly proportional to molality of soln.

$\Delta T_b \propto m$ ΔT_b = ELBP

$\boxed{\Delta T_b = K_b m}$

K_b = molal elevation constant (depends on solvent)
or
ebullioscopic constant.

$(K_b)_{H_2O} = 0.52\ K\text{-}Kg/mol$ or $°C\text{-}Kg/m$.

$$\boxed{K_b = \frac{R\,T_b^{o\,2}}{1000\,L_v}}$$

→ R = Gas const = 25/3
T_b^o = standard BP.
L_v = Latent heat of Vaporisation
$L_v = \frac{\Delta H_v}{M_W}$ (ΔH_v = Heat of Vap.).

Q If 1 mol of non-volatile solute is added to 4 mol of volatile solvent (H_2O). find BP of Soln? ($K_b = 0.52\ k\,kg/mol$)

⇒ $n_B = 1\,mol$; $n_A = 4\,mol$

$m = \frac{n_B}{W_A(Kg)} = \frac{10^3}{72}$.

$W_A = 4 \times 18 = 72 \times 10^{-3}\,kg$
$T_b^o = 100°C$

$\Delta T_b = K_b\, m.$

$T_b - T_b^o = 0.52 \times \frac{1}{72}$

$T_b = \frac{10^3 \times 0.52}{72} + 100$

$T_b = \frac{520}{72} + 100.$

$T_b = 107°C$

Q If 8 g of a non-electrolyte solute is dissolved in 114g of n-octane to reduce its VP to 80%, the molar mass (in g/mol) of the solute is ——
(MM of n-octane is 114g/mol).

⇒

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

Non-electrolyte solute → n-octane solvent

$$P_S = \frac{80}{100} P_A^\circ$$

$$\frac{P_A^\circ - \frac{80 P_A^\circ}{100}}{P_A^\circ} = \frac{n_B}{n_A + \cancel{n_B}^{0}}$$

$$0.2 = \frac{8}{M_B} \times \frac{\cancel{114}}{\cancel{114}}$$

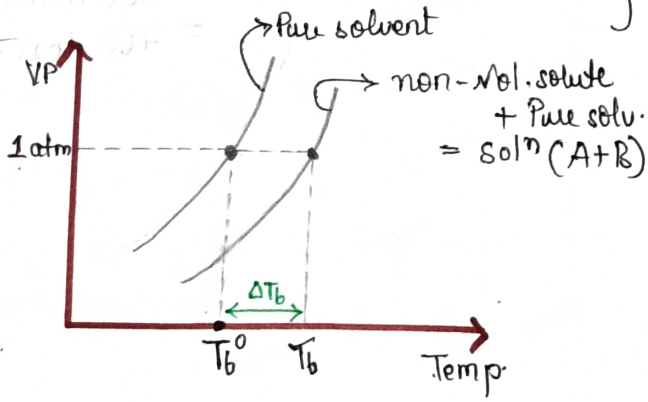
$$\left(M_B = 40 \ g/mol \right)$$

2. Elevation in Boiling Point (EBP)

Statement :→ When non-volatile solute is added to volatile solvent, its VP ↓es, thus BP ↑es.

$$\left\{ VP \propto \frac{1}{BP} \Rightarrow VP\downarrow, BP\uparrow \right\}$$

$\boxed{T_b^\circ = 100^\circ C \text{ (pure water)}}$



- Pure A → volatile solvent

(A+B) sol^n B → non-V solute

T_b° = BP of pure solvent

T_b = BP of sol^n.

$\boxed{\Delta T_b = T_b - T_b^\circ}$ ⇒ Elevation in BP.

⇒* ① Lowering in VP is not a CP but RLVP is a CP.

mole fraction = mole = no. of particle.

$$\left(\frac{P_A^\circ - P_s}{P_A^\circ}\right) = x_B \leftarrow \text{colligative particle.}$$

$$(P_A^\circ - P_s) = x_B \boxed{P_A^\circ}$$ → Pure VP of solvent.

② For numericals.

$$\frac{P_A^\circ - P_s}{P_A^\circ} = x_B.$$

$$\frac{P_A^\circ - P_s}{P_A^\circ} = \frac{n_B}{n_A + n_B}.$$

for dilute solution, $n_A >>> n_B$. $(n_A + \cancel{n_B} \nearrow 0)$.

$$\boxed{\frac{P_A^\circ - P_s}{P_A^\circ} = \frac{n_B}{n_A}}$$ → it gives approx answer

③

$$\boxed{\frac{P_A^\circ - P_s}{P_s} = \frac{n_B}{n_A}}$$ → it gives exact answer

④ If solvent is H_2O or aq. solution, $\left\{ \begin{array}{l} P_A^\circ = 1 \text{ atm} \\ = 76 \text{ cm of Hg} \\ = 760 \text{ mmHg} \\ = 760 \text{ torr.} \end{array} \right\}$

Q. The amount of ice that will separate out on cooling a solution containing 50 g of ethylene glycol (non-volatile) in 200 g water to $-9.3°C$ is –

$\left(K_f = 1.86 \text{ K kg/mol}\right)$

$$\Delta T_f = T_f^{\circ} - T_f = 0 - (-9.3) = 9.3$$

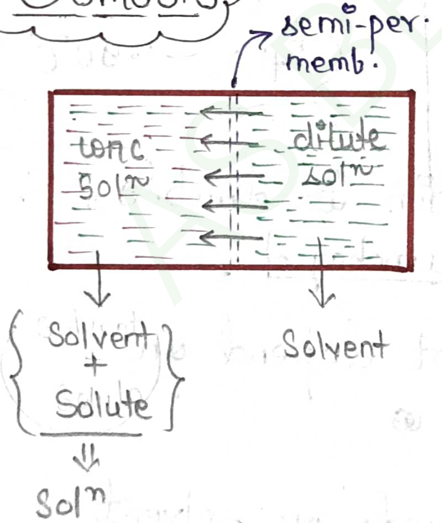
$$\Delta T_f = K_f m$$

$$9.3 = 1.86 \times \frac{50 \times 1000}{62 \times W_A}$$

$$W_A = 161 \text{ gm}$$

$$\text{ice separate out} = 200 - 161 = 39 \text{ gm}$$

Osmosis



The flow of solvent molecules from lower solute conc. to higher solute conc. (w.r.t solute)

(or)

The flow of solvent molecules from solvent side (right side) to ~~solute~~ ~~sol~~ s. soln side (left side).

(or)

The flow of solvent molecules from higher solvent conc. to lower solvent conc.

eg. ① Raw mangoes shrivel when pickled in brine (salt water).
② Wilted flowers revive when placed in fresh water.
③ Blood cells collapse when suspended in saline water.

Q The molal freezing point constant for water is 1.86°C kg/mol. If 342 gm of cane sugar is dissolved in 1000 g. of water, the solⁿ will freeze at —

$\Delta T_f = K_f m$

$m = \frac{n_B}{W_A(kg)} = \frac{342}{342} \times \frac{10^3}{10^3} = 1$

$T_f^\circ - T_f = K_f m.$

$0 - T_f = 1.86 \times 1$

$T_f = -1.86\ ^\circ C$

Q An aqueous solⁿ of a non-electrolyte solute boils at 100.52°C. The freezing point of the solⁿ will be —

$T_b = 100.52^\circ C$

$T_b^\circ = 100\ ^\circ C$

$\Delta T_b = T_b - T_b^\circ$

$= 0.52^\circ C$

$\Delta T_b = 0.52^\circ C$

$\frac{\Delta T_b}{\Delta T_f} = \frac{K_b \times \cancel{m}}{K_f \times \cancel{m}}$

$\frac{\cancel{0.52}}{\Delta T_f} = \frac{\cancel{0.52}}{1.86}$

$\Delta T_f = 1.86$

$T_f^\circ - T_f = 1.86$

$0 - T_f = 1.86$

$T_f = -1.86^\circ C$

Q If molality of the dilute solution is double, the value of K_f will be — unchanged.

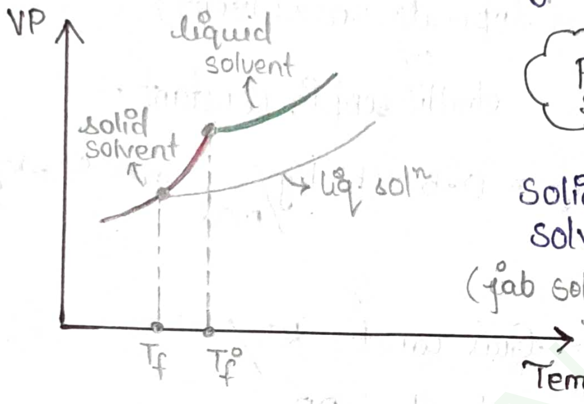
$K_f = \frac{R T_f^{\circ 2}}{1000 L_f}$ ⇒ K_f does not depend on molality

only depends on solvent.

Thus, unchanged

3. Depression in Freezing point (DFP)

When non-volatile solute is added to volatile solvent, its VP ↓es, thus Freezing point ↓es.



pure solvent

non-volatile solute

Solid solvent $\rightleftharpoons$ liq. solvent (T_f°)

(jab solid component liq comp ke sth eqm pr hoga, us time pr jo temp - Freez. point)

$$\boxed{\Delta T_f = T_f^\circ - T_f}$$

solid solvent $\rightleftharpoons$ liq soln (T_f)

ΔT_f = Depressing in FP

T_f° = Freezing point of pure solvent

T_f = Freezing point of solⁿ.

The depression in FP is directly proportional to the modality.

$$\Delta T_f \propto m$$

$$\boxed{\Delta T_f = k_f m.}$$

$$\boxed{\Delta T_f = T_f^\circ - T_f}$$

k_f = molal dep. constant (cryoscopic constant)

for H_2O, $k_f = 1.86\ ^\circ C\ Kg/mol.$

$$\boxed{k_f = \frac{R\,T_f^{\circ 2}}{1000\,L_f}.}$$

$R = 25/3$

T_f° = standard FP

L_f = Latent heat of Fusion

$= \frac{\Delta H_f}{MW.}$ → enthalpy (or heat) of fusion.

4. Osmotic Pressure.

⇒ The minimum pressure which must be apply to solution side to prevent osmosis.

$\pi \propto C$ — $\pi \rightarrow$ osmotic pressure

$\pi \propto T$ — $C \rightarrow$ concentration (mol/L)

$\pi \propto CT$ — $R \rightarrow$ gas constant $= 0.082 = \frac{1}{12} \frac{L\cdot atm}{mol\text{-}K}$.

$\boxed{\pi = CRT}$ — $T \rightarrow$ Temp. (K).

* 1 atm = 760 mm of Hg
= 76 cm of Hg
= 760 torr. *

* ⟶ Soln 1. π_1 — Soln 2. π_2.

\# Case (1) $\pi_1 = \pi_2 \longrightarrow$ Isotonic solution.

\# Case (2) $\pi_1 > \pi_2 \longrightarrow$ 1 Hypertonic soln
or
2 Hypotonic soln.

\# Case (3) $\pi_1 < \pi_2 \longrightarrow$ 1 Hypotonic soln
or
2 Hypertonic soln.

Q. The passing of solvent particles through semi-p. membrane is called ______ Osmosis.

Q. Two soln have diff. osmo. pr. The soln of higher π is ___ Hypertonic Soln

Q The os.p of 0.2 M solⁿ of urea at 300 K —
($R = \frac{1}{12}$ L-atm/mol K) —

sol.

$$\pi = CRT$$
$$= 0.2 \times \frac{1}{12} \times 300$$
$$= 5 \text{ atm.}$$

Q The osmotic pressure of 10 % (W/V) aq. solⁿ of urea (π_1) is related to that of 10 % (W/V) aq. solⁿ of glucose (π_2) as —

1) $\pi_1 = \pi_2$ ~~2)~~ $\pi_1 > \pi_2$ 3) $\pi_1 < \pi_2$ 4) $\pi_1 = 1 - \pi_2$ . .

sol.

Urea ① ($M_w = 60$) Glucose ② ($M_w = 180$)

$$\pi = CRT$$
$$\pi = \frac{n}{V} RT$$
$$\pi = \frac{W}{M_w} \times \frac{RT}{V}$$

$\pi_1 > \pi_2$

$\pi \propto \frac{1}{M_w}$

$M_w \uparrow$, $\pi \downarrow$

Q A 5% solⁿ of cane sugar is isotonic with 0.877 % of X . The molecular weight of substance X is —

sol:-

$$\pi_1 = \pi_2$$

5 gm of cane sugar +nt in 100 ml solⁿ.

$$\frac{n_1}{\cancel{100}} \cancel{RT} = \frac{n_2}{\cancel{100}} \cancel{RT}$$

0.877 gm of X +nt in 100 ml of solⁿ.

$$\frac{W_1}{M_1} = \frac{W_2}{M_2}$$
$$\frac{5}{342} = \frac{0.877}{M_2}$$

$$M_2 = \frac{0.877 \times 342}{5}$$
$$= 59.98$$
$$\approx 60 \text{ g/mol}$$

Q The following solⁿ were prepared by dissolving 10 g of glucose in 250 ml of water (P_1), 10 g of urea (CH_4N_2O) in 250 ml of water (P_2) and 10 g of sucrose in 250 ml of water (P_3). The right option for the decreasing order of op of these solⁿ—

a) $P_2 > P_3 > P_1$ ×
b) $P_3 > P_1 > P_2$ ×
c) $P_2 > P_1 > P_3$ ✓
d) $P_1 > P_2 > P_3$.

$op \propto \frac{1}{Mw}$ as weight, volume, R, T same -

P_1 = Glucose ($M_1 = 180$)
P_2 = urea ($M_2 = 60$)
P_3 = Sucrose ($M_3 = 342$).

$M_2 < M_1 < M_3$
$P_2 > P_1 > P_3$

Reverse Osmosis.

→ If $P > \pi$, then solvent molecules will flow from conc. solⁿ to dilute solution.

Van't Hoff factor (i).

Glucose	$(C_6H_{12}O_6)$	non-electrolytes → do not dissociate into ions.
Urea	(NH_2CONH_2)	
Sucrose (cane-sugar).	$(C_{12}H_{22}O_{11})$	

$$\boxed{i = 1 + \left(\frac{1}{n} - 1\right)\alpha} \quad (i<1)$$

Non- electrolyte , $\alpha = 0$, $i = 1$

Dissociation

a) Strong electrolyte , $\alpha = 1$, $i = n$

b) weak electrolyte , $\alpha < 1$ $\boxed{i = 1 + (n-1)\alpha}$

$(i > 1)$

Association

a) $\boxed{i = 1 + \left(\frac{1}{n} - 1\right)\alpha}$ $(i<1)$.

Q The van't Hoff factor for 0.1 M $Ba(NO_3)_2$ soln is 2.74. The degree of dissociation is—

$$Ba(NO_3)_2 \longrightarrow Ba^{+2} + 2NO_3^- \quad (n=3)$$

$$i = 1 + (n-1)\alpha$$

$$2.74 = 1 + 2\alpha$$

$$1.74 = 2\alpha$$

$$\alpha = \frac{1.72}{2}$$

$$\boxed{\alpha = 0.86}$$

$$\%\alpha = \frac{1.72}{2} \times 100$$

$$= 86\%$$

$$i = \frac{\text{total no. of moles after dissociation/asso}}{\text{initial moles taken.}}$$

Calculation of i

Case ① for Dissociation.

$t=0$

$$\underset{1-\alpha}{\overset{1}{A_n}} \rightleftharpoons \underset{n\alpha}{\overset{0}{nA}}$$

$DOD = \frac{x}{1}$

$(n = \text{no. of ions})$.

moles before diss $= 1+0 = 1$

moles after disso $= 1 - x + n\alpha$
$= 1 + (n-1)\alpha$

$$i = \frac{1+(n-1)\alpha}{1}$$

$$\boxed{i = 1 + (n-1)\alpha}$$

e.g., (i) $KCl \longrightarrow K^+ + Cl^-$

$\alpha = 1$

$i = 1 + (2-1)1$

$i = 1 + 2 - 1$

$\boxed{i = 2}$

strong electrolyte, $i = n$.
as $(\alpha = 1)$

(ii) $CH_3COOH \rightleftharpoons CH_3COO^- + H^+$

$i = 1 + (n-1)\alpha$

$i = 1 + (2-1)\alpha$

$\boxed{i = 1+\alpha}$

weak electrolyte.
$\boxed{\alpha < 1}$
$i = 1 + (n-1)\alpha$
$\boxed{i > 1}$

Case ② for association.

$$nA \rightleftharpoons A_n.$$

$DOA = \alpha$

$$\underset{1-\alpha}{\overset{1}{A}} \rightleftharpoons \underset{\frac{\alpha}{n}}{\overset{0}{\frac{1}{n}A_n}}$$

Dissociation.

$KCl \rightsquigarrow K^+ + Cl^-$

1   1   1

$n=1$ $n=2$

CP $\rightsquigarrow$ double.

(colli. prop)

Association

$2CH_3COOH \xrightarrow{\text{Benzene}} (CH_3COOH)_2$

Molecules

Do not dissociate

Glucose

Sucrose

Urea.

Dissociate (In H_2O)

$KCl \rightarrow K^+ + Cl^-$ $n=2$

$NaCl \rightarrow Na^+ + Cl^-$ $n=2$

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

$K_2SO_4 \rightarrow 2K^+ + SO_4^{2-}$ $n=3$

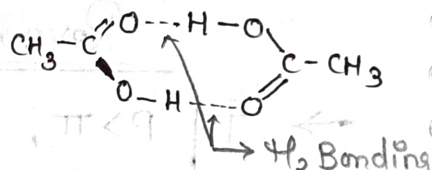
$K_4[Fe(CN)_6] \rightarrow 4K^+ \; [Fe(CN)_6]^{4-}$ $n=5$

$Ca_3(PO_4)_2 \rightarrow 3Ca^{+2} + PO_4^{-3}$ $n=4$

$CH_3COOH \rightarrow CH_3COO^- + H^+$ $n=2$

Associate. (due to intermolecular H-Bond)

$2(CH_3COOH) \xrightarrow{\text{B}} (CH_3COOH)_2$



Dimer (two molecules)

$$i = \frac{\text{observed colligative property}}{\text{cal. colligative property.}}$$

$$i = \frac{\text{Normal Molecular weight}}{\text{abnormal Mw}}$$

$$i = \frac{\text{abnormal Cp}}{\text{normal cp.}}$$

cal → normal

obs → abnormal

Solutions Class 12 (chemistry)

covered all the topics widely

Q Of the following 0.10 m aq. soln, which one will exhibit the largest Bp elevation?

ΔT_b

(a) KCl (b) $C_6H_{12}O_6$ ~~(c)~~ $Al_2(SO_4)_3$ (4) K_2SO_4

$\Delta T_b \uparrow$ $\Delta T_b = i k_b m$

$\Delta T_b \uparrow = i \uparrow$

Q largest bp? 0.10 m aq soln.

(a) KCl (b) $C_6H_{12}O_6$ ~~(c)~~ $Al_2(SO_4)_3$ (d) K_2SO_4

$\uparrow \Delta T_b = \uparrow T_b - T_b^{\circ}$ $\boxed{\Delta T_b \propto i \propto T_b}$

$\Delta T_b \uparrow = \uparrow T_b = i \uparrow$

Q of the following 0.10 M aq. soln, which one will exhibit the largest Osmotic Pressure?

Sol (a) KCl ~~(b)~~ $Al_2(SO_4)_3$ (c) $C_6H_{12}O_6$ (d) K_2SO_4

$\pi = iCRT$ $\pi \propto i$

Q

$$\text{RLVP} \propto i \propto \frac{1}{VP}$$

$$\Delta T_b \propto i \propto T_b$$

$$\Delta T_f \propto i \propto \frac{1}{T_f}$$

$$\pi \propto i$$

Q The freezing point of 1 molal NaCl solⁿ assuming NaCl to be 100% dissociated in water —

m = 1 molal

$NaCl \longrightarrow Na^+ + Cl^-$

$n = 2$

$\alpha = 1$

$(i = 2)$

$T_f^\circ - T_f = i K_f \times m$

$0 - T_f = 1.86 \times 1 \times 2$

$T_f = -3.72°C$

Q Of the following 0.10 m aq. solⁿs, which one will exhibit the largest freezing point depression?

Sol

$\Delta T_f \uparrow$

$\Delta T_f = i K_f m$

(a) KCl $n = 2$

(b) $C_6H_{12}O_6$ $n = 0$

(c) $Al_2(SO_4)_3$ $n = 5$

(d) K_2SO_4 $n = 3$

agar DOD, kuch na di ho toh 100% lena hai –
$\alpha = 1$, $i = n$.

$i \uparrow$, $\Delta T_f \uparrow$

Q Of the following 0.10 m aq. solⁿ, which one will exhibit the largest freezing point?

$\boxed{\Delta T_f \propto i \propto \frac{1}{T_f}}$

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

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

$T_f \uparrow$ $\Delta T_f \downarrow$ $i \downarrow$

(a) KCl

(b) $C_6H_{12}O_6$ $n = 0$

(c) $Al_2(SO_4)_3$

(d) K_2SO_4

Solutions Class 12 (chemistry)

covered all the topics widely

Q The values of observed and calculated molecular weights of calci nitrate are respectively 65.6 and 164. The degree of disso. nitrate will be —

$\hookrightarrow i > 0$

$Ca(NO_3)_2 \longrightarrow Ca^{+2} + 2NO_3^-$

$(n=3)$

$\Rightarrow$

$i = \frac{164}{65.6}$ bda / chota

$i = 2.5$.

$i = 1 + (n-1)\alpha$

$2.5 = 1 + 2\alpha$

$\frac{1.5}{2} = \alpha$

$\alpha = 0.75$

$\% \alpha = 75\%$

Now colligative prop :-

(for disso, asso)

$\boxed{RLVP} \Rightarrow \frac{P_A^\circ - P_S}{P_A^\circ} = i \frac{n_B}{n_A}$

$\boxed{EBP} \Rightarrow \Delta T_b = i k_b m$.

$\boxed{DFP} \Rightarrow \Delta T_f = i k_f m$.

$\boxed{OP} \Rightarrow \pi = iCRT$

Q The molal elevation constant of water = 0.52 K/molality. The boiling point of 1.0 molal aqueous KCl solⁿ (assuming complete disso. of KCl), should be —

Sol $K_b = 0.52\ K/mole$.

$m = 1.0$ molal.

$KCl \longrightarrow K^+ + Cl^-$

$(n=2)$ $\alpha = 1$

strong Electrolyte

$(i=n)$

$i = 1 + (n-1)\alpha$

$i = 1 + 1$

$i = 2$.

$\Delta T_b = 2 \times 1 \times 0.52$

$T_b - T_b^\circ = 2 \times 1 \times 0.52$

$T_b = 1.04 + 100$

~~$T_b = 101.04°C$~~

$T_b = 101.04°C$

Pyq (2015) $(\Delta T_b)_x > (\Delta T_b)_y$

$\Delta T_b = i k_b m$

$T_b \propto \Delta T_b \propto i$

(X is undergoing disso in water)

Q A 0.2 molal aq. soln of a weak acid (HX) is 20% ionised? The freezing point of this soln —
($k_f = 1.86$ K/m for water) —

$HX \rightarrow H^+ + X^-$

Sol

$\alpha = \frac{20}{100} = \frac{1}{5}$.

$\Delta T_f = i k_f m.$

$T_f^\circ - T_f = i k_f m.$

$0 - T_f = 1.2 \times 1.86 \times 0.2$

$\boxed{T_f = -0.45^\circ C}$

$i = 1 + (n-1)\alpha$

$i = 1 + (2-1)\, 0.2$

$i = 1 + 0.2$

$i = 1.2$

Q 72.5 g of phenol is dissolved in 1 kg of a solvent ($k_f = 14$) which leads to dimerization of phenol & freezing point is lowered by 7 Kelvin. What % of total phenol is prnt in dimeric form? association

$\alpha = ?$

Sol.

$m = \frac{72.5}{94} = 0.77$

$k_f = 14$

$\Delta T_f = 7$

$\Delta T_f = i k_f m$

$i = \frac{7}{14 \times 0.77}$

$i = 0.65$

$i = 1 + \left(\frac{1}{n} - 1\right) x$

$$i = 1 + \left(\frac{1}{n} - 1\right)\alpha$$

$$0.65 = 1 + \left(\frac{1}{2} - 1\right)\alpha$$

$$0.65 - 1 = -\frac{1}{2}\alpha$$

$$\cancel{-}0.35 = \cancel{-}\frac{1}{2}\alpha$$

$$\alpha = 0.7$$

$$\alpha\% = 70\%$$

Q The freezing point depression constant for water is $1.86°C\ m^{-1}$. If 5.00 g Na_2SO_4 is dissolved in 45.0 g H_2O, the freezing point is changed by $-3.72°C$. Calculate the van't Hoff factor for Na_2SO_4.

Sol

$K_f = 1.86°C$ $\quad\quad \Delta T_f = -3.72°C.$

$$m = \frac{5}{142} \times \frac{1000}{45}$$

$$m = 0.78 \text{ molal.}$$

$$\Delta T_f = i\, k_f\, m.$$

$$i = \frac{3.72}{1.86 \times 0.78} \approx 2.56.$$

Q 20 gm of a binary ($n=2$) electrolyte (mol. mass = 100 g/mole) is dissolved in 500 g of water. The freezing point of the solⁿ is $-0.74°C$ if $K_f(H_2O) = 1.86$ K/molality. Then degree of ionisation of the electrolyte —

Sol

$$m = \frac{20}{100} \times \frac{1000}{500} = 2/5 \text{ —}$$

$T_f = -0.74°C$

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

$\Delta T_f = 0.74$

$\Delta T_f = i k_f m$

$0.74 = i \times 1.86 \times 2/5$

$i = \frac{0.74 \times 5}{1.86 \times 2}$

$i = 1$

$\alpha = 0 \rightarrow 0\%$

Q The molecular weight of benzoic acid in benzene as determined by depressing in freezing point method corresponds to —

dimer

bnata h.

⇒ Demerization of benzoic Acid.

Solubility (Amount of solute dissolved.)

→ solubility → gm/ml , gm/l , mol/L.

→ solubility → mole fraction (gas in liq.)

Factors —

1. Nature of solute
2. Nature of solvent

like dissolve like → polar in polar; → Non polar in Non polar.

3. Pressure → No effect
4. Temperature.

Exo ← Case ① solid solute + liq. solvent ⇌ sol^n + Heat (rxn back) T↑, solu

Endo ← Case ② solid solute + liq solvent + Heat ⇌ sol^n (Rxn forward) T↑ Solub.↑.

Examples of Henry's law $T\downarrow, S\uparrow$ → O_2 dissolved more in cold water

→ Aquatic species are more comfortable in cold water.

→ Carbonated drinks are prepared at low temp.

→ At high altitude, low atm pressure, low conc of O_2

→ Scuba ~~drivers d~~ divers - painful effect hota h. to low solubility ke liye the milate h.

Q Henry's law constant for CO_2 in water is 1.67×10^8 Pa at 298 K. Calculate the quantity of CO_2 in 500 ml of soda water. when packed under 2.5 atm CO_2 pressure at 298 K.

Sol

$K_H = 1.67 \times 10^8$ Pa

1 atm = 10^5 Pa.

$P = K_H \, x_{gas}$

$d = 1$ gm/ml

$x_{gas} = \frac{2.5}{1.67} \times 10^{-3}$

$V = 500$ ml

$W_{H_2O} = 500$ gm

$\frac{n_{gas}}{\cancel{n_{gas}}^{\,0} + n_{H_2O}} = \frac{2.5}{1.67} \times 10^{-3}$

$n_{H_2O} = \frac{500}{18}$

$n_{gas} = \frac{2.5}{1.67} \times \frac{500}{18} \times 10^{-3}$

$n_{H_2O} >>> n_{gas}$!

$n_{gas} = 41.58 \times 10^{-3}$

$= 0.042$

$W_{CO_2} = 0.042 \times 44$

$= 1.848$ gm

Factor affecting solubility of gas in liquid

1. Nature of solute $T_c \uparrow$, Solu $\uparrow$
2. Nature of solvent
3. Temperature – always exothermic
4. Pressure.

$$\boxed{T_c = \frac{8a}{27Rb}}$$

a = intermolecular forces
b = excluded volume.

Gas + liq $\rightleftharpoons$ sol^n + Heat
(T$\uparrow$, sol$\downarrow$.)

Pressure → Henry's law
(P$\uparrow$,Solu$\uparrow$).

Henry's law (Solub. in terms of mole fraction) Solub. of gas in liq $\propto$ Pressure.

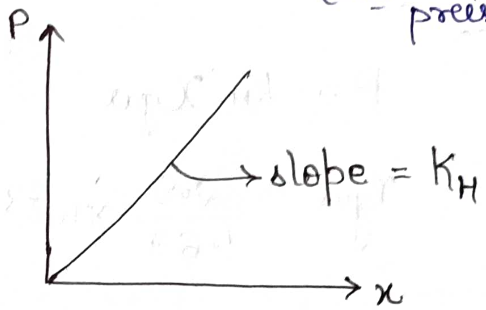
$$\boxed{P \propto X_{gas} \text{ in liq.}}$$

$$\boxed{P = K_H X}$$

K_H → Henry's law constant (unit same as pressure).

at P = constant

$$\boxed{K_H X = \text{constant}}$$



Limitations

1. The pressure of gas is not too high.
2. The temp. is not too low.
3. The gas should not undergo any chemical reaction with solvent eq. NH_3(gas) + H_2O(solvent) = NH_4OH
4. The gas should not undergo disso in sol^n.
eq. $HCl + H_2O \rightarrow H^+_{(aq)} + Cl^-_{(aq)}$.