Q. We know solution is a mixture of solute and solvent components. How we will decide which component is solvent?

Type of Solution

Type of Solution	Solvent	Solute
Solid solution	Solid	Gas
	Solid	Liquid
	Solid	Solid
Liquid Solution	Liquid	Gas
	Liquid	Liquid
	Liquid	Solid
Gaseous Solution	Gas	Gas
	Gas	Liquid
	Gas	Solid

Concentration of solution

1. Temperature independent:

- Mole Fraction
- Molality (m)
- % w/w
- Ppm

2. Temperature independent:

- % w/v
- % v/v
- Molarity (M)
- Normality (N)

Q. if 1.678 mg gold powder is dissolved in 1 lit of water (density of water = 1 g/ml). calculate % w/v.

Q. What are the final concentration of nitrate ion when following are mixed

$50\,ml\ of\ 0.12\,M\ Fe(NO_3)_3 + 100\,ml\ of\ 0.1\,M\ FeCl_3$
$+100\,ml\ of\ 0.26\,M\ Mg(NO_3)_2$

Ans. $[NO_3]^- = \dfrac{(50\times 0.12\times 3)+(100\times 0.26\times 2)}{250}$

= 70/250

= 0.28

Solubility

Factors affecting solubility:

- **Nature of component**
- **Temperature**
- **Pressure**

1. Solubility of a solid in a liquid:

Such a solution in which no more solute can be dissolved at the same temperature and pressure is called a saturated solution.

'Like dissolves like'.

Effect of temperature on solubility:

Case a- if dissolution process is endothermic ($\Delta_{sol}H > 0$) in nature then,

$$T\uparrow \longrightarrow Solubility\uparrow$$
$$T\downarrow \longrightarrow Solubility\downarrow$$

Case b- if dissolution process is exothermic ($\Delta_{sol}H < 0$) in nature then,

$T\uparrow \longrightarrow$ **Solubility** $\downarrow$

$T\downarrow \longrightarrow$ **Solubility** $\uparrow$

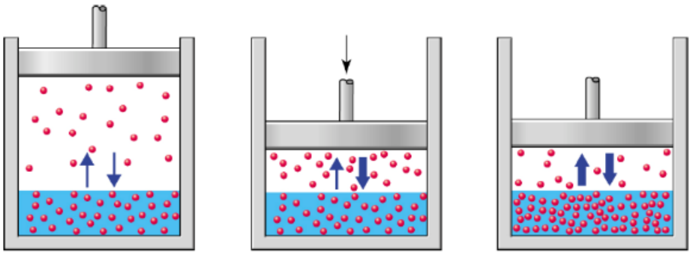
Effect of pressure on solubility:

Pressure does not have any significant effect on solubility of solids in liquids.

2. Solubility of a gas in a liquid:

1. Effect of pressure:

Generally on increment of pressure solubility of gas in a liquid is increases.



Henery Law:

The law states that at a constant temperature, the solubility of a gas in a liquid is directly proportional to the pressure of the gas.

a/c to Dalton experimental facts: mole fraction of gas in the solution is proportional to the partial pressure of the gas over the solution.

Henry's law states that "the partial pressure of the gas in vapour phase (p) is proportional to the mole fraction of the gas (x) in the solution"

Mathematically; $p = K_H x$,

Where, K_H **is Henry's law constant. (**K_H **depends on nature of gas)**

P = partial pressure of gas

x **= mole fraction**

For a particular gas, if value of K_H **is larger then, solubility is lesser.**

It was experimentally observed that for a particular gas, value of K_H increases on rise in temperature & hence, lesser the solubility.

Gas	Temperature	K_H(Kbar)
N_2	293	76.48
N_2	303	88.84
O_2	293	34.86
O_2	303	46.82
He	293	144.97

Q. If N_2 gas is bubbled through water at 293 K, how many millimoles of N_2 gas would dissolve in 1 litre of water. Assume that N2 exerts a partial pressure of 0.987 bar. Given that Henry's law constant for N2 at 293 K is 76.48 kbar.

Ans.

$$x_{N_2} = \frac{p_{N_2}}{K_H} = \frac{0.987 bar}{76480 bar} = 1.29 \times 10^{-5}$$

1 lit water contains 55.5 mole of water. So,

$$x_{N_2} = \frac{n_{N_2}}{n_{N_2} + n_{H_2O}} = \frac{n_{N_2}}{n_{N_2} + 55.5}$$

$$we\ can\ treat, n_{N_2} + 55.5 \approx 55.5,$$

$$\Rightarrow \frac{n_{N_2}}{55.5} = 1.29 \times 10^{-5}$$

$$\Rightarrow n_{N_2} = 7.16 \times 10^{-4}$$

Or milli-moles of N_2 gas is 0.716

Q. The Henry's law constant for the solubility of N2 gas in water at 298 K is 1.0×10^5 atm. The mole fraction of N_2 in air is 0.8. The number of moles of N_2 from air dissolved in 10 moles of water at 298 K and 5 atm pressure is

A. 4.0×10^{-4}

B. 4.0×10^{-5}

C. 5.0×10^{-4}

D. 4.0 X 10 $^{-6}$

Ans.

$$p = K_H x_{N_2}$$

$$\Rightarrow 0.8 \times 5 = 1 \times 10^5 \times x_{N_2}$$

$$\Rightarrow x_{N_2} = 4 \times 10^{-5}$$

$$\Rightarrow 4 \times 10^{-5} = \frac{n_{N_2}}{n_{N_2} + 10}$$

$$n_{N_2} = 4 \times 10^{-4}$$

Application of Henry's law

i. The Bends:

To avoid bends, as well as, the toxic effects of high concentrations of nitrogen in the blood, the tanks used by scuba divers are filled with air diluted with helium (11.7% helium, 56.2% nitrogen and 32.1% oxygen).

ii. Anoxia:

iii. To increase the solubility of CO2 in soft drinks and soda water, the bottle is sealed under high pressure.

2. Effect of temperature on solubility:

Solubility of gases in liquids decreases with rise in temperature.

if dissolution process is endothermic ($\Delta_{sol}H > 0$) in nature then,

$$T\uparrow \longrightarrow \text{Solubility}\uparrow$$
$$T\downarrow \longrightarrow \text{Solubility}\downarrow$$

Vapour Pressure of liquid solution:

Liquid solution means solvent is liquid, generally liquid is volatile but solute may or may not be volatile.

A. Vapour pressure liquid – liquid solution:

Assume a binary solution containing 2 volatile components A and B. at equilibrium between liquid and vapour phase,

$p_1 = partial\ vapour\ pressure\ of\ component\ 1$

$p_2 = partial\ vapour\ pressure\ of\ component\ 2$ **&**

$p_T = Total\ vapour\ pressure\ of\ solution$

$x_1 = mole\ fraction\ of\ component\ 1$

$x_2 = mole\ fraction\ of\ component\ 2$

Raoult's law:

for a solution of volatile liquids, the partial vapour pressure of each component in the solution is directly proportional to its mole fraction.

For component 1,

$\Rightarrow p_1\ \alpha\ x_1$

$\Rightarrow p_1 = p_1^0\ x_1$

Where, p_1^0 is vapour pressure of pure component 1

For component 2,

$\Rightarrow p_2\ \alpha\ x_2$

$\Rightarrow p_2 = p_2^0\, x_2$

Where, p_2^0 is vapour pressure of pure component 2.

According to Dalton's law of partial pressure,

$$p_T = p_1 + p_2$$

$$p_T = p_1^0 x_1 + p_2^0 x_2$$

We know, for a binary solution, $x_1 + x_2 = 1$

Let assume 2nd component is more volatile than 1st component. So, $p_1^0 < p_2^0$

$$p_T = p_1^0 x_1 + p_2^0 x_2$$

$$p_T = p_1^0 (1 - x_2) + p_2^0 x_2$$

$$p_T = p_1^0 + (p_2^0 - p_1^0) x_2$$

The composition of vapour phase, let y_1 and y_2 are the mole fraction of components 1 & 2 respectively.

$$y_1 = \frac{p_1}{p_T} = \frac{x_1 p_1^0}{x_1 p_1^0 + x_2 p_2^0}$$

$$y_1 = \frac{p_2}{p_T} = \frac{x_2 p_2^0}{x_1 p_1^0 + x_2 p_2^0}$$