Class 12 Chemistry Chapter 1: Solution

Lecture 10

Solubility & Henry's Law.

Solubility of a substance is its maximum amount that can be dissolved in a specific amount of a solvent at a specified Temperature

Solubility depends upon :- a) Nature of Solute & Solvent
b) Temperature
c) Pressure.

Units of Solubility :-

(a) $\frac{g}{L}$ or (b) $\frac{mole}{L}$

a) Nature of Solute & Solvent

Like dissolves like :

i) Polar solvent like (H_2O) dissolves polar solutes like (Salts → NaCl)

ii) non polar solvent like (benzene) dissolves non-polar solutes like napthalene

Saturated Solution: In which no more solute can be dissolved at the same temperature and pressure

Unsaturated Solution: More solute can be dissolved at that temperature and Pressure.

"The concentration of a solute in a saturated solution is called Solubility"

b) Temperature :

	ΔH_{sol}	Solubility
Solid in Liquid (solute, solvent)	endothermic	Temp↑ Solubility↑
	exothermic	Temp↑ Solubility↓

c) Pressure

↳ effect of Pressure is observed in gases.

gaseous in Liquid
solute solvent

"Solubility of a gas in liquid is directly proportional to the partial pressure of the gas present above the surface of liquid or solution"

⇓

Henry's Law

Solubility of gas in liquid $\propto$ Partial pressure of gas above liquid surface

Mole fraction X_{gas} is used to measure solubility

(X_{gas} in liquid) ↑ ⇒ (solubility of gas) ↑

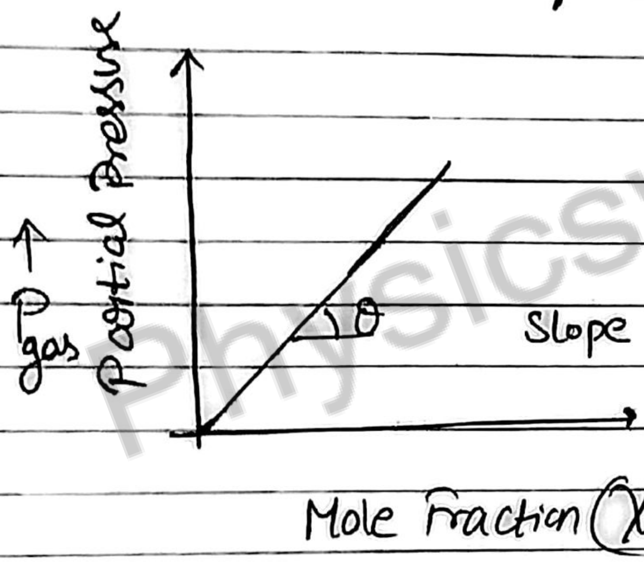
Henry's Law

Solubility $\propto$ P

$$P \propto X_{gas}$$

$$\boxed{P = K_H X_{gas}}$$

- P → Partial pressure of gas above liquid surface
- K_H → Henry's constant for a gas
- X_{gas} in liquid → Mole fraction of gas in liquid



Slope = $\tan\theta = K_H$

unit of K_H = same as unit of Pressure → atm

Different gases have different value of K_H in different Solvent

	K_H (in water)	
Helium	140	insoluble
Hydrogen	70	Soluble
Oxygen	35	Highly Soluble

(~~Here~~ K_H is in kbar) at 20°C

At a given Pressure

$$K_H = \frac{P}{X_{gas}}$$

$K_H \uparrow \Rightarrow X_{gas} \downarrow \Rightarrow$ Solubility $\downarrow$

$K_H \downarrow \Rightarrow X_{gas} \uparrow$ (in liquid) $\Rightarrow$ Solubility $\uparrow$

K_H for same gas is diff in diff solvents

K_H increases with increase in Temp

Temp ↑ K_H ↑ X_{gas} (in liquid) ↓ ⇒ Solubility ↓

Q) AQUATIC specie are more comfortable in cold waters why?

⇒ Cold water ⇒ Temp ↓ ⇒ solubility of O_2 ↑

Q) ~~SEE 2009~~

Q) Henry's Law Constant for CO_2 in water is 1.67×10^8 Pa at 298K. Calculate the quantity of CO_2 in 500ml of soda water when packed under 2.5 atm CO_2 pressure at 298K. (1atm = 1.01×10^5)

a) 2.6g
b) 3.2g
c) 0.8
d) 1.8g

$$P_{CO_2} = K_H X_{CO_2}$$

$$2.5 \times 1.01 \times 10^5 \text{ Pa} = 1.67 \times 10^8 \text{ Pa} \times X_{CO_2}$$

$$X_{CO_2} = \frac{2.5 \times 1.01 \times 10^5}{1.67 \times 10^8}$$

$$X_{CO_2} = 1.52 \times 10^{-3}$$

$$\frac{n_{CO_2}}{n_{CO_2} + n_{H_2O}} = 1.52 \times 10^{-3}$$

Let density of solution = 1 g/ml
mass of water = 500 g
(neglect soda)

$\because$ X_{CO_2} is very small

$\Rightarrow n_{CO_2} << n_{H_2O}$

So $X_{CO_2} \approx \frac{n_{CO_2}}{n_{H_2O}}$

$$1.5\times10^{-3} = \frac{\frac{x}{44}}{\frac{500}{18}}$$

$\boxed{x = 1.84g}$ mass of CO_2

Q2) JEE 2009

The K_H for N_2 gas in water at 298K 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 298K and 5 atm pressure is

a) 4.0×10^{-4} b) 4.0×10^{-5} c) 5.0×10^{-4} d) 4.0×10^{-6}

Solution: Find the partial pressure of N_2 in air.
Dalton's Law →
$P_{N_2} = P_{Total} \times X_{N_2}$
$= 5\text{atm} \times 0.8$
$= 4\text{atm}$

(rest must be O_2 in air = 1atm)

Now Calculate X_{N_2} dissolved in Solution (water)
Using Henry's law

$$P_{N_2} = K_H X_{N_2 \, dissolved}$$

$$4 \, atm = 1.0 \times 10^5 \, atm \times X_{N_2 \, dissolved}$$

$$X_{N_2 \, dissolved} = 4 \times 10^{-5}$$

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

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

as X_{N_2} is 4×10^{-5} (very small $n_{N_2} << n_{water}$)

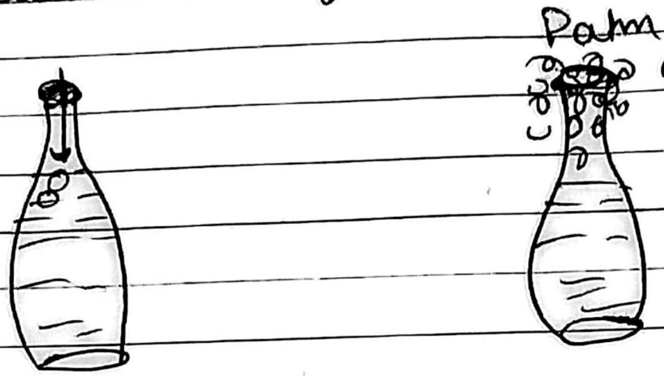
$$\frac{n_{N_2}}{n_{water}} = 4 \times 10^{-5}$$

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

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

Real life examples of Henry's law

i) Soda bottle fizzes when opened

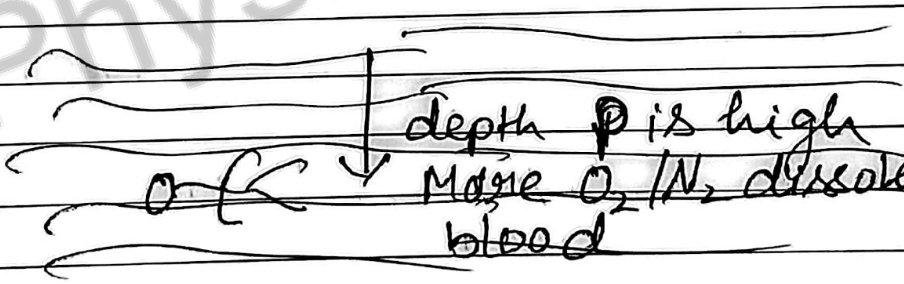


Pressure falls
⇓
Solubility of CO_2 decreases & CO_2 fizzes out

CO_2 dissolved at High Pressure

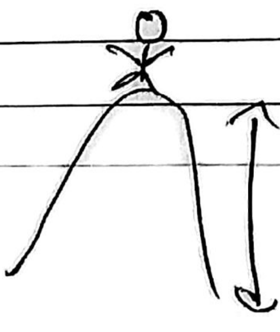
ii) Deep sea divers have their oxygen tanks diluted with He.

Reason:



when diver returns to surface, the dissolved O_2/N_2 bubbles out in cappalieries and cause serious health hazard known as bends

iii)



At mountains P fall
so lesser O_2 dissolve in blood
→ Causes mental disturbance → Anoxia