

# SOLUTIONS

## Types

### Gaseous

Gas-Gas → Mixture of  $O_2$  and  $N_2$   
Liquid-Gas → Chloroform with  $N_2$   
Solid-Gas → Camphor in  $N_2$

### Liquid

Gas-Liquid →  $O_2$  dissolved in water  
Liquid-Liquid → Ethanol dissolved in water  
Solid-Liquid → Glucose dissolved in water

### Solid

Gas-Solid →  $O_2$  in Pd  
Liquid-Solid → Amalgam of Hg with Na  
Solid-Solid → Cu dissolved in gold

## Expressing Concentration of solutions

Mass by volume percentage (w/v)

$$\frac{\text{Mass of solute}}{\text{Volume of solution}} \times 100$$

Mass percentage (w/w)

$$\frac{\text{Mass of component in solution}}{\text{Total mass of solution}} \times 100$$

Parts per million : For trace quantities

$$\frac{\text{No. of parts of components} \times 10^6}{\text{Total no. parts of components of solution}}$$

Mole fraction

$$\frac{\text{No. of moles of component}}{\text{Total No. of moles of all components}}$$

Normality: Number of gram equivalents of the solute dissolved in one litre of solution

$$\frac{\text{No. of gram equivalent of solute} \times 100}{\text{Volume of solution (in L)}}$$

$$\text{Gram Equivalents of solute} = \frac{\text{Mass of solute}}{\text{Equivalent weight}}$$

$$\text{Equivalent weight} = \frac{\text{Molecular mass}}{\text{valency}}$$

Molality: Number of moles of solute per kilogram of the solvent

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

Molarity: Number of moles of solute in 1L solution

$$\frac{\text{No. of moles of solute} \times 100}{\text{Volume of solution (in L)}}$$

## Colligative properties

Osmotic pressure →  $\pi = i.C.RT$

$$\text{Depression in freezing point} \rightarrow \Delta T_f = \frac{i.K_f \times W_2 \times 1000}{M_2 \times W_1}$$

$$\text{Elevation of boiling point} \rightarrow \Delta T_b = \frac{i.K_b \times 1000 \times W_2}{M_2 \times W_1}$$

$$\text{Relative lowering of vapour pressure (for dilute solutions)} \rightarrow \frac{i.W_2 \times M_1}{M_2 \times W_1} = \frac{P^0 - P_s}{P^0}$$

## Van't Hoff factor

$$\text{Van't Hoff factor (i)} = \frac{\text{Number of particles after dissociation/association}}{\text{Number of particles before dissociation/association}}$$

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

Dissociation  
 $\alpha$  = Degree of Dissociation

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

Association  
 $\alpha$  = Degree of Association

## Abnormal molecular mass

Molecular mass is different from expected value

$$\text{Van't Hoff factor (i)} = \frac{\text{Normal molar mass}}{\text{Abnormal molar mass}}$$

## Obey Raoult's law

Ideal solution →  $\Delta H_{\text{mix}} = \Delta V_{\text{mix}} = 0$ ,  $\Delta S_{\text{mix}} > 0$ ,  $\Delta G_{\text{mix}} < 0$   
eg: n-hexane and n-heptane  
Ethyl bromide + Ethyl chloride,  
Chlorobenzene + Bromobenzene, etc.

## Do not Obey Raoult's law

Non-Ideal solution →  $\Delta H_{\text{mix}}$  or  $\Delta V_{\text{mix}} \neq 0$   
 $\Delta S_{\text{mix}} > 0$ ,  $\Delta G_{\text{mix}} < 0$

## Positive Deviation

$$\Delta H_{\text{mix}} > 0$$

$$\Delta V_{\text{mix}} > 0$$

eg: Acetone + Ethyl alcohol,  
Water + Ethyl alcohol,  
Carbon tetrachloride + Chloroform,  
Chloroform + Ethanol,  
Acetone + Carbon disulphide,  
Acetone + Benzene, etc.

## Negative Deviation

$$\Delta H_{\text{mix}} < 0$$

$$\Delta V_{\text{mix}} < 0$$

eg: Acetone + Aniline,  
 $HCl + H_2O$ ,  $HNO_3 + H_2O$ ,  
 $H_2SO_4 + H_2O$ ,  
Acetone + Chloroform (H-Bonding),  
 $HNO_3 + \text{Chloroform}$ ,  
Benzene + Chloroform,  
Pyridine + Glacial acetic acid, etc.

## Raoult's Law

For any solution, the partial vapour pressure of each volatile component is directly proportional to its mole fraction in solution phase

## Henry's Law

Partial pressure of gas in vapour phase is proportional to the mole fraction of gas in the solution.

$$p = K_H \cdot x$$

Q.  $K_H$  value for some gases at the same temperature 'T' are given:

Gas	$K_H$ /k bar
Ar	40.3
$CO_2$	1.67
HCHO	$1.83 \times 10^{-5}$
$CH_4$	0.413

where  $K_H$  is Henry's Law constant in water. The order of their solubility in water is : (NEET 2022)

- (1)  $HCHO < CH_4 < CO_2 < Ar$
- (2)  $Ar < CO_2 < CH_4 < HCHO$
- (3)  $Ar < CO_2 < CH_4 < HCHO$
- (4)  $HCHO < CO_2 < CH_4 < Ar$

## Azeotropes:

The mixtures of liquids which boil at constant temperature like a pure liquid and possess same composition of components in liquid as well as vapour phase are called constant boiling mixtures or azeotropic mixtures.

## Minimum boiling azeotropes:

They are formed by those liquid pairs which show positive deviations from ideal behaviour. eg: ethanol-water mixture.

## Maximum boiling azeotropes:

They are formed by those liquid pairs which show negative deviations from ideal behaviour e.g nitric acid-water mixture.

## Solid in liquid

### Effect of temperature

Endothermic  $\Delta_{\text{sol}} H > 0$ , Solubility Increases at high temp.

Exothermic  $\Delta_{\text{sol}} H < 0$ , Solubility decreases at high temp.

### Effect of Pressure

Not significant

## Solubility

### Effect of temperature

Increases with decrease in temperature

## Gas in liquid

### Effect of Pressure

Increases with increase in Pressure



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