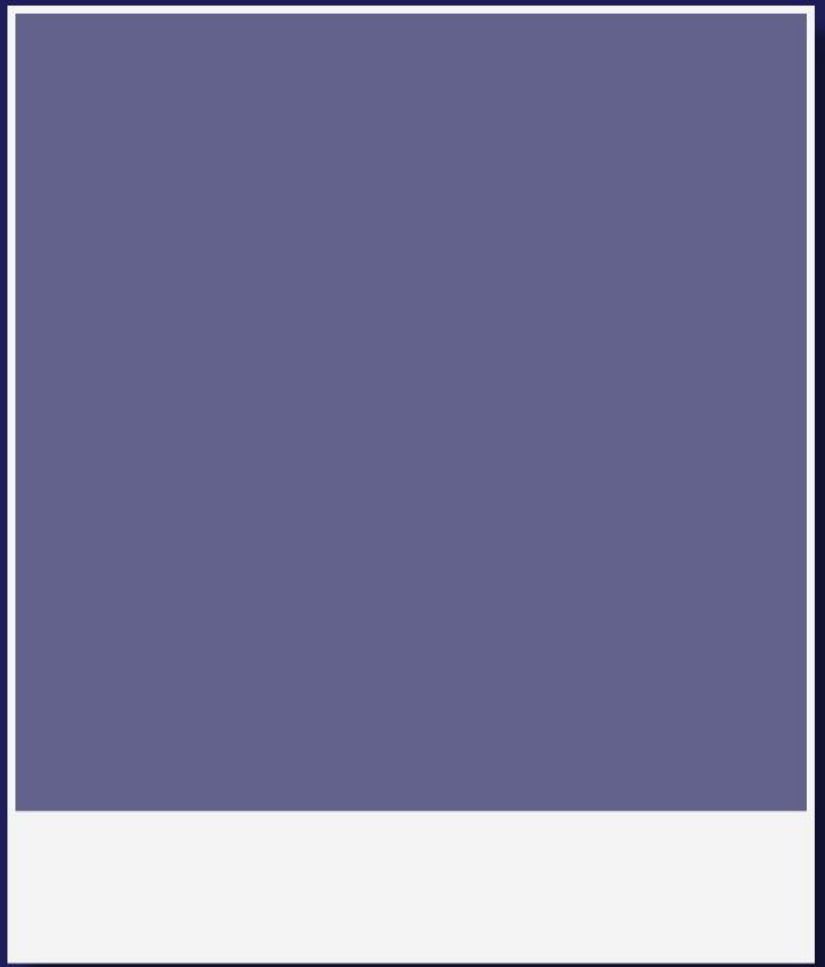
MOLE FRACTION AND MOLALITY

MISSION MBBS | NEET 2024

MOLE CONCEPT - L7

CHEMISTRY | CLASS 11

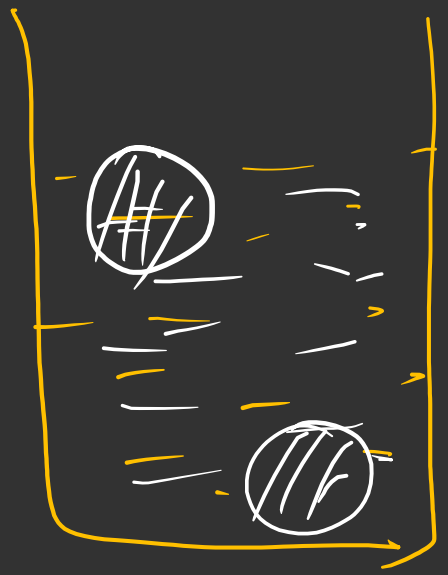


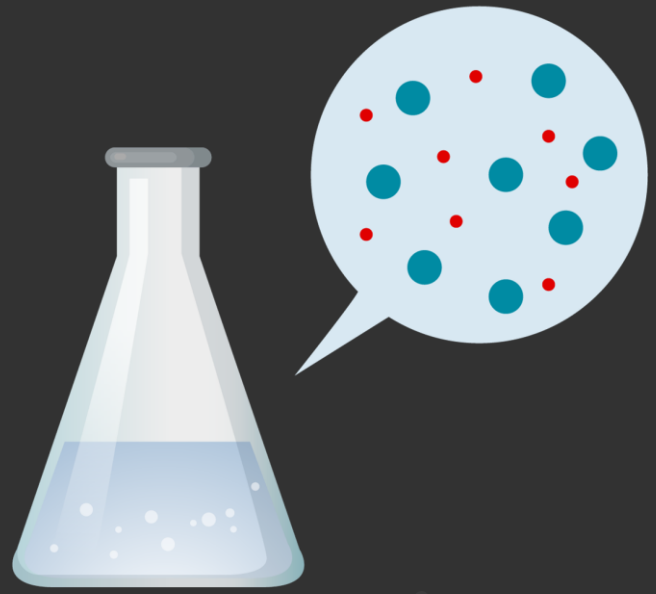
What is a solution?

Homogeneous mixture of **two or more substances**

What does being Homogeneous mean?

Having **uniform composition throughout**





Solution

Water (SOLVENT)

Salt (SOLUTE)

Salt Solution (SOLUTION)

Solvent + Solute

The **components** of a solution **cannot** be separated by **filtration**.

Concentration Terms

Somewhat analogous to '*taste*'

Mole fraction

Solution

$O_2 = n_1$

$N_2 = n_2$

$CO_2 = n_3$

Total moles $= n_1 + n_2 + n_3$

Ratio of the number of moles of a particular **component to the total number of moles** of the solution

χ (chi)

$$\chi_{O_2} = \frac{n_1}{n_1 + n_2 + n_3}$$

$$\chi_{N_2} = \frac{n_2}{n_1 + n_2 + n_3}$$

$$\chi_{CO_2} = \frac{n_3}{n_1 + n_2 + n_3}$$

Mole fraction

If substance '**A**' is dissolved in substance '**B**' and $\mathbf{n_A}$ and $\mathbf{n_B}$ are their respective moles, then

$$\textbf{Mole fraction of A} = \frac{\textbf{No. of moles of A}}{\textbf{No. of moles of solution}}$$

Mole fraction

$$X_A = \frac{n_A}{n_A + n_B}$$

$$X_B = \frac{n_B}{n_A + n_B}$$

Mole fraction

For a solution containing **i** number of components, we have

$$X_i = \frac{n_1}{n_1 + n_2 + ... + n_i} = \frac{n_1}{\Sigma n_i}$$

where, $X_1 + X_2 + ... + X_i = 1$

$$x_A + x_B = 1$$

$$x_A = 1 - x_B \quad \text{or} \quad x_B = 1 - x_A$$

Mole fraction

Mole fraction is a **pure number** and has **no units.**

No unit

unit less

NEET

JEE

Que :- 44 g CO_2, 28 g N_2 & 32 g O_2 present in a vessel of T temp. Find the $x_{O_2} = ?$

(a) $\frac{1}{2}$

(b) $\frac{1}{3}$

(c) $\frac{1}{4}$

(d) $\frac{2}{3}$

+4

$n_{CO_2} = \frac{44(g)}{44\ g\ mol^{-1}} = 1\ mol$

$n_{N_2} = \frac{28(g)}{28\ (g\ mol^{-1})} = 1\ mol$

$n_{O_2} = \frac{32(g)}{32\ (g\ mol^{-1})} = 1\ mol$

$n_T = 1 + 1 + 1 = 3$

$x_{O_2} = \frac{n_{O_2}}{Total\ n}$

$x_{O_2} = \frac{1}{3}$

Qno :- 2.24 L of O_2 mix with 4.4 g CO_2 & 1.2×10^{24} molecule of N_2 in a vessel find mole fraction of N_2 gas (STP)

Solution :-

$$n_{O_2} = \frac{2.24(L)}{22.4(L)} = .1 \text{ mol}$$

$$n_{CO_2} = \frac{4.4(g)}{44(g\,mol^{-1})} = .1 \text{ mol}$$

$$n_{N_2} = \frac{1.2 \times 10^{24}}{6 \times 10^{23}} = 2 \text{ mol}$$

$$x_{n_2} = \frac{n_{N_2}}{n_T}$$

$$x_{n_2} = \frac{2}{2+.1+.1} = \frac{2}{2.2}$$

$$x_{n_2} = \frac{1}{1.1} = .9$$

$$x_{N_2} = .9$$

What is the quantity of water (in g) that should be added to 16 g of methanol to make the mole fraction of methanol 0.25 ?

A. 12 g

B. 18 g

C. 27 g

D. 20 g

16 g CH_3OH + x g H_2O

$x_{CH_3OH} = 0.25$

What is the quantity of water (in g) that should be added to 16 g of methanol to make the mole fraction of methanol 0.25 ?

① CH_3OH (M.M)

$= 12 + 4 + 16$

$= 32 \text{ g mol}^{-1}$

② moles of $CH_3OH = \frac{16}{32} = .5$

③ $x_{CH_3OH} = \frac{n_{CH_3OH}}{n_{CH_3OH} + n_{H_2O}}$

$.25 = \frac{.5}{.5 + n_{H_2O}}$

$.25 \times .5 + .25\, n_{H_2O} = .5$

$.125 + .25\, n_{H_2O} = .5$

$n_{H_2O} = \frac{.5 - .125}{.25} = 1.5$

④ mass H_2O

$= n_{H_2O} \times 18 \text{ g mol}^{-1}$

$= 1.5 \times 18 = 27 \text{ g}$

Molality (moles Solute / mass Solvent)

n moles Solute

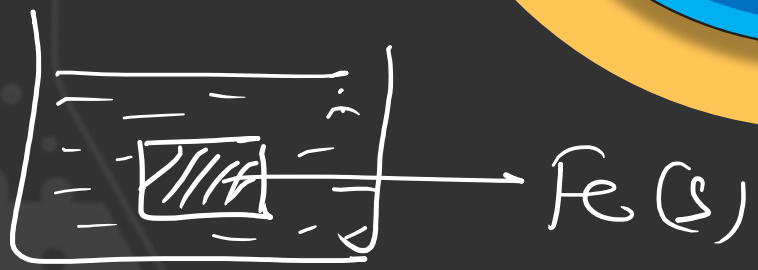
1 kg Solvent

Number of moles of solute present in **1 kg** of **solvent**

molality = 'm'

Ques 56 g of Fe (M.M$_{Fe}$=56 present in 1000 g of H_2O

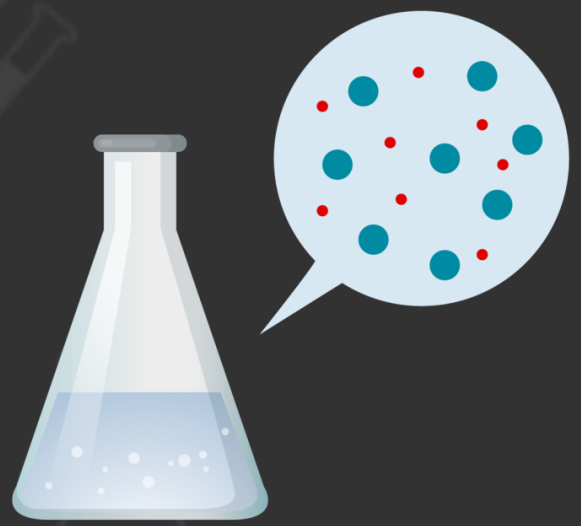
⇒ find the molality of solution



Molality

$$\text{Molality } (\mathbf{m}) = \frac{\text{No. of moles of solute}}{\text{Mass of solvent in kg}}$$

SI unit is **mol kg^{-1}** or **m(molal)**



1.0 Molal NaOH

$$m = \frac{n_{solute}}{W_1 (\text{mass of solvent in kg})} = \frac{n_{solute}}{\frac{W_1\,(g)}{1000}} =$$

$$m = n_2 \times \frac{1000}{W_1\,(g)}$$

if mass of solute in gram is given

$$m = \frac{n_2(g)}{M_2\,(g\,mol^{-1})} \times \frac{1000}{W_1\,(g)}$$

Que :- 49 g of H_2SO_4 dissolve in 250 g of water Find molality of solution

(a) 1

(b) 2

(c) $\frac{1}{3}$

(d) $\frac{1}{4}$

M.M of H_2SO_4 = $(1\times2)+32+(16\times4)=98$ g mol^{-1}

$$m = \frac{w_2}{M_2} \times \frac{1000}{w_1}$$

$$= \frac{49}{98} \times \frac{1000}{250} = 2 \text{ molal}$$

1 mole of glauber salt ($Na_2SO_4.10H_2O$) is dissolved in 320 g of water. Calculate the molality of solution?

A. 0.115 m

B. 2.225 m

C. 1.54 m

D. 3.125 m

$$m = \frac{n_{solute} \times 1000}{w_1 (g)}$$

$$m = \frac{1 \times 1000}{320} = 3.\ldots$$

1 mole of glauber salt ($Na_2SO_4.10H_2O$) is dissolved in 320 g of water. Calculate the molality of solution?

Calculate the molality of urea solution prepared by dissolving 6.0 g of urea to make 500 mL of the solution.
(Density of solution = 1.212 g/mL)

$$m = \frac{w_2}{M_2} \times \frac{1000}{w_1}$$

A. 0.167 m

B. 1.53 m

C. 1.98 m

D. 0.361 m

$w_2 = 6\ g$

$M_2 = 60\ g\ mol^{-1}$

$w_1 = ?$

$$d_{soln} = \frac{w_{soln}}{V_{soln}}$$

$w_{soln} = 1.212\ g\ ml^{-1} \times 500\ ml$

$= 606\ g$

Calculate the molality of urea solution prepared by dissolving 6.0 g of urea to make 500 mL of the solution.
(Density of solution = 1.212 g/mL)

$1\ ml = 1\ cm^3$

$W_{soln} = 606\ g$

$W_{soln} = W_2 + W_1$

$606 = 6 + W_1$

$W_1 = 600\ g$

Solvent

$m = \frac{W_2}{M_2} \times \frac{1000}{W_1}$

$m = \frac{6\ g}{60\ g\ mol^{-1}} \times \frac{1000}{600}$

$m = \frac{1}{6}$ molal

$= 0.166$

$\simeq 0.167$

Calculate the molality of a 1 L solution of 68% H_2SO_4 (w/v), if the density of the solution is given as 1.80 g mL^{-1}.

$$m = \frac{w_2}{m_2} \times \frac{1000}{w_1}$$

A. 6.8 m

B. 6.2 m

C. 6.94 m

D. 10.8 m

$d_{soln} = 1.80\ g\,ml^{-1}$

68% H_2SO_4 by mass/Vol

= 68 g H_2SO_4 in 100 ml soln

$w_{H_2SO_4} = 68\ g$

$w_{H_2O} = ?$

$m.m\ H_2SO_4 = 98\ g\,mol^{-1}$

Calculate the molality of a 1 L solution of 68% H_2SO_4 (w/v), if the density of the solution is given as 1.80 g mL^{-1}.

if 100 ml soln is there

$$d_{soln} = \frac{w_{soln}}{V_{soln}}$$

$$w_{soln} = 1.80 \times 100 = 180\ g$$

$$w_{H_2O} = 180 - 68 = 112\ g$$

$$m = \frac{68}{98} \times \frac{1000}{112}$$

$$m = 6.2\ \text{molal}$$

What is molality of 30% (w/w) H_2O_2 aqueous solution?

A. 8.82 m

B. 12.60 m

C. 15.60 m

D. 10.67 m

$M.M_{H_2O_2} = (1\times2) + (16\times2) = 34\ g\ mol^{-1}$

30 g H_2O_2 in 100 g solution

$w_{H_2O_2} = 30\ g$

$w_{H_2O} = 100 - 30 = 70\ g$

$$m = \frac{w_2}{M_2} \times \frac{1000}{w_1} = \frac{30}{34} \times \frac{1000}{70} = 12.6\ m$$

The mole fraction of the solute in 2.5 molal aqueous solution is:

Home work

A. 0.051

B. 0.43

C. 0.043

D. 0.156

“Stay Positive, Work Hard, Make It Happen“

THANK YOU