ALMUSTAQBAL UNIVERSITY COLLEGE

Biomedical Engineering Department

Stage : Second year students

Subject : Chemistry 1 - Lecture 7

Lecturer: Assistant professor Dr. SADIQ . J. BAQIR

Expressing concentrations By Physical units :

A. Percent concentration (parts per hundred):

It can be expressed in several ways such as :

① Weight percent (w/w) %

Weight percent $(\frac{w}{w})\% = \frac{weight\ of\ solute}{weight\ of\ solution} \times 100\ \%$

e.g : Nitric acid (70%) solution, means that it contains (70 g) of HNO_3 for each (100 g) of solution.

② volume percent (V/V)%

Volume percent $(\frac{V}{V})\% = \frac{volume\ of\ solute}{volume\ of\ solution} \times 100\%$

It is commonly used to specify the concentration of a solution prepared by diluting a pure liquid with another liquid.(e.g : perfumes)

e.g: 5% aqueous solution of a perfume usually describe a solution prepared by diluting 5 mL of perfume with enough water to give 100 mL.

③weight/volume percent (w/V)%

weight/volume percent ($\frac{w}{V}$)% = $\frac{weight\ of\ solute(gm)}{volume\ of\ solution(\ mL)}$ x 100%

It is often employed to indicate the composition of dilute aqueous solution of solid dissolved in water. **e.g** : 5% aqueous potassium nitrate refers to a solution prepared by dissolving (5.0 g) of KNO_3 in sufficient amount of water to give (100 mL) of solution .

<u>Example:</u>

Describe the preparation of one liter of (10%) NaCl solution ($\frac{w}{v}$)%.

<u>Solution:</u>

weight/volume percent ($\frac{w}{V}$)% = $\frac{weight\ of\ solute(g)}{volume\ of\ solution(mL)}$ x 100%

10% = $\frac{weight\ of\ solute(g)}{1000\ mL}$ x 100%

Weight of solute (g) =$\frac{10\ x\ 1000}{100}$ = 100 g

Then (100 g) of NaCl is to be dissolved in a sufficient volume of water and the volume is to be completed to (1) liter to get $10\%\ solution\ of\ NaCl$.

<u>Example</u>

Prepare a 20 mL of 5% KCl solution ($\frac{w}{v}$)% from pure solid KCl .

<u>Solution</u>

weight/volume percent ($\frac{w}{V}$)% = $\frac{weight\ of\ solute(g)}{volume\ of\ solution(mL)}$ x 100%

5% = $\frac{weight\ of\ solute(g)}{20mL}$ x 100%

Weight of solute, KCl (g) =$\frac{5\ x\ 20}{100}$ = 1 g

Then 1 g of KCl is to be dissolved in water and the volume is to be completed to 20 mL.

Example:

Calculate the $\left(\frac{w}{v}\right)$% concentration of the aqueous solution of sodium chloride prepared by dissolving 5 g of NaCl in water and completing the volume to 250 mL .

Answer:

$$\left(\frac{w}{v}\right)\% = \frac{weight\ of\ solute(g)}{volume\ of\ solution(mL)} \text{ x } 100\%$$

$$\left(\frac{w}{v}\right)\% = \frac{5\ gm}{250\ mL} \text{ x } 100\% = 2\ \%$$

ملاحظه:

نلاحظ ان هذا النوع من التراكيز ليس له علاقه بالكتله المولية للماده المطلوب تحضير محلول منها والشرط المهم هنا ان تكون الماده المذابه(solute) تامة الذوبان في المحلول المحضر فيمكن ان ياتي في السؤال اي نوع ماده (مثلا KNO_3 , Na_2SO_4 ,NaCl, KCl , $NaNO_3$) ويكون الحل للسؤال بنفس الطريقه لكل المواد اي لايؤثر اسم الماده في الحل .

Conversion to molarity:

$$\textbf{Molarity (M)} = \frac{\left(\frac{w}{V}\right)\% \times 10}{M.wt}$$

Example:

Calculate the Molarity of the solution that is 20(w/v)% of KCl (74.5 g /mol) ?

solution:

$$\text{Molarity(M)} = \frac{\left(\frac{W}{V}\right)\% \times 10}{M.wt}$$

$$\textbf{Molarity(M)} = \frac{20 \times 10}{74.5} = 2.68\ M$$

طريقه ثانيه للحل

Checking by using $\textbf{Molarity(M)} = \frac{wt_{(g)} \times 1000}{M.wt \times V_{mL}}$

$$\textbf{Molarity(M)} = \frac{20_{(g)} \times 1000}{74.5 \times 100_{mL}} = 2.68\ M$$

B. Part per million (ppm) and part per billion (ppb):

It is a convenient way to express the concentration of the very dilute solution (by ppm or ppb).

(1 **ppm** = 1 **mg / liter**) or (1 **ppm** = 1 **µg /mL**)

ppm: is a mass ratio of grams of solute to one million grams of sample or solution.

$$C_{ppm} = \frac{mass\ of\ solute(g)}{mass\ of\ solution\ (g)} \times 10^6$$

ppb: is a mass ratio of grams of solute to one billion grams of sample or solution .

$C_{ppb} = \frac{mass\ of\ solute(g)}{mass\ of\ solution\ (g)}$ x 10^9

also

$$\mathbf{Cppm} = \frac{mass\ of\ solute(mg)}{volume\ of\ solution(liter)}$$

$$\mathbf{Cppm} = \frac{wt(mg)}{V\ (liter)} = \frac{\frac{wt(\mu g)}{1000}}{\frac{VmL}{1000}}$$

$$\mathbf{Cppm} = \frac{wt(\mu g)}{VmL} \quad (\mu g / mL)$$

1 g =1000 mg , 1mg = 1000 µg

1 g = 10^6µg , 1 g = 10^9 ng

$$\mathbf{Cppm} = \frac{wt(\ g\ )}{VmL}\ x\ 10^6$$

<u>Example:</u> Prepare (500mL) of (1000 ppm) KCl aqueous solution .

<u>solution :</u>

$$\mathbf{Cppm} = \frac{wt(\ g\ )}{VmL}\ x\ 10^6$$

$$wt_{\ g} = \frac{C_{ppm}\ x\ V_{mL}}{10^6}$$

$$wt\ (\ g\ ) = \frac{1000\ x\ 500}{10^6} = 0.5\ g$$

Then 0.5 g of KCl is to be dissolved in water and the volume is completed to 500 mL in a volumetric flask to get(1000 ppm) solution.

Relationship of ppm with Molarity(M) and Normality (N)

ppm = M x M.Wt x 1000

ppm = N x Eq.Wt x 1000

Molarity(M) $= \frac{PPm}{Mwt\, x1000}$

يستخدم هذا القانون لتحويل التركيز من PPm الى المولاريه(M)

Or $Normality(N) = \frac{PPm}{Eq.wt\, x1000}$

يستخدم هذا القانون لتحويل التركيز من PPm الى التركيز النورمالي (N)

Example: Calculate the molarity of K^+ (39.1 g/ mol) for the $K_3Fe(CN)_6$ aqueous solution of (63.3 ppm) concentration?

Solution **:**

$$\underset{1mole}{K_3Fe(CN)_6} \longrightarrow \underset{3mole}{3K^+} + Fe(CN)_6^{3-}$$

63.3ppm $k_3Fe(CN)_6$ $\rightarrow$ 3x 63.3ppm K^+ = 189.9 ppm K+

Molarity(M) $= \frac{PPm}{Mwt\, x1000} = \frac{189.9PPm}{39.1\, x1000}$ = 4.86 x 10^{-3} M (molarity of K^+)

Molarity of K^+ (M_{k+}) = 4.86 x 10^{-3} M

Example:

The maximum allowed concentration of chloride in drinking water supply is (2.50×10^2 ppm) . express this concentration in terms of mole/liter (M) ?

Solution:

ppm = mg/L

$$Molarity(M) = \frac{PPm}{Mwt\ x 1000}$$

$$Molarity(M) = \frac{PPm}{Mwt\ x 1000} = \frac{2.5\ x\ 10^2}{35.5\ x\ 1000} = 7.05 \times 10^{-3}\ M$$

Second method:

$$2.5\ x 10^2 \text{ppm} = \frac{2.5\ x 10^2 \text{mg}}{\text{liter}}$$

$$\text{Molarity (M)} = \frac{\text{wt}_{\text{ g}}}{\text{M. wt}\ x\ \text{V}_\text{L}}$$

$$\text{Molarity(M)} = \frac{(2.5\ x\ 10^2 x\ 10^{-3})\ \text{g}}{35.5\ x\ 1}$$

Molarity (M) = 7.05×10^{-3} M

P- fuctions:

pX = - log [X]

Examples:

$pH = -\log[H_3O^+]$

$[H_3O^+] = 10^{-pH}$

$pOH = -\log[OH^-]$

$[OH^-] = 10^{-pOH}$

$pNa = -\log[Na^+]$

$pCl = -\log[Cl^-]$

Example:

Calculate the P-value of each ion in 1.76×10^{-3} M aqueous solution of Na_3PO_4 .

Solution:

Na_3PO_4	$\longrightarrow$ **$3Na^+$**	+	**PO_4^{3-}**
1 mole	**3 mole**		**1 mole**
1.76×10^{-3}	**$3\,(1.76 \times 10^{-3})$**		**1.76×10^{-3}**

$[Na^+] = 3 \times 1.76 \times 10^{-3} = 5.28 \times 10^{-3}$ M

pNa^+ $= -\log\,[5.28 \times 10^{-3}] = 2.277$

$p(PO_4^{3-})$ $= -\log[1.76 \times 10^{-3}] = 2.754$

Note :

in case of $Na_2CO_3 \rightarrow 2Na^+ + CO_3^{2-}$ or $K_2CO_3 \rightarrow 2K^+ + CO_3^{2-}$

$NaCl \rightarrow Na^+ + Cl^-$ or $KCl \rightarrow K^+ + Cl^-$

Example:

Calculate the P-value of each ion in 1740 ppm aqueous solution of K_2SO_4 (174 g / mol).

Solution:

$$\text{Molarity}(M) = \frac{PPm}{Mwt\ x1000}$$

$$\text{Molarity}(M)\text{of } K2SO4 \text{ solution} = \frac{1740}{174\ x1000} = 0.01\ M$$

K_2SO_4	$\rightarrow$	$2K^+$	$+ SO_4^{2-}$
1 mole		2 mole	1 mole
0.01		2(0.01)	0.01

$[K^+] = 0.02$ M

$pK^+ = -\log(0.02) = 1.69$

$[SO_4^{2-}] = 0.01$ M

$pSO_4^{2-} = -\log(0.01) = 2$