

ALMUSTAQBAL UNIVERSITY COLLEGE

Biomedical Engineering Department

Stage : Second year students

Subject : Chemistry 1 - Lecture 7

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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) %

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

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)%

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

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.

③ weight/volume percent (w/V)%

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

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 .

Example:

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

Solution:

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

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

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

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.

Example

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

Solution

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

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

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

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:

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

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

ملاحظه:

نلاحظ ان هذا النوع من التراكيز ليس له علاقه بالكتله الموليه للماده المطلوب تحضير محلول منها والشرط المهم هنا ان تكون الماده المذابه (solute) تامه 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:

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

Example:

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

solution:

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

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

طريقه ثانيه للحل

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

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

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).

$$(1 \text{ ppm} = 1 \text{ mg / liter}) \quad \text{or} \quad (1 \text{ ppm} = 1 \text{ } \mu\text{g /mL})$$

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

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

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

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

also

$$C_{\text{ppm}} = \frac{\text{mass of solute}(mg)}{\text{volume of solution}(liter)}$$

$$C_{\text{ppm}} = \frac{\text{wt}(mg)}{V(\text{liter})} = \frac{\frac{\text{wt}(\mu g)}{1000}}{\frac{VmL}{1000}}$$

$$C_{\text{ppm}} = \frac{\text{wt}(\mu g)}{VmL} \quad (\mu g / mL)$$

$$1 \text{ g} = 1000 \text{ mg} \quad , \quad 1 \text{ mg} = 1000 \mu g$$

$$1 \text{ g} = 10^6 \mu g \quad , \quad 1 \text{ g} = 10^9 \text{ ng}$$

$$C_{\text{ppm}} = \frac{\text{wt}(g)}{VmL} \times 10^6$$

Example: Prepare (500mL) of (1000 ppm) KCl aqueous solution .

solution :

$$C_{\text{ppm}} = \frac{\text{wt}(g)}{VmL} \times 10^6$$

$$\text{wt}_g = \frac{C_{\text{ppm}} \times V_{\text{mL}}}{10^6}$$

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

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)

$$\text{ppm} = M \times M.Wt \times 1000$$

$$\text{ppm} = N \times Eq.Wt \times 1000$$

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

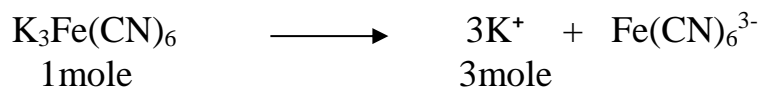
يستخدم هذا القانون لتحويل التركيز من PPm الى المولاليه (M)

$$\text{Or Normality}(N) = \frac{PPm}{Eq.wt \times 1000}$$

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 :



$$63.3\text{ppm } K_3Fe(CN)_6 \rightarrow 3 \times 63.3\text{ppm } K^+ = 189.9 \text{ ppm } K^+$$

$$\text{Molarity}(M) = \frac{PPm}{Mwt \times 1000} = \frac{189.9PPm}{39.1 \times 1000} = 4.86 \times 10^{-3} M \text{ (molarity of } K^+)$$

$$\text{Molarity of } K^+ (M_{k^+}) = 4.86 \times 10^{-3} M$$

Example:

The maximum allowed concentration of chloride in drinking water supply is (2.50 x 10² ppm) . express this concentration in terms of mole/liter (M) ?

Solution:

ppm = mg/L

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

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

Second method:

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

$$\text{Molarity}(M) = \frac{\text{wt}_g}{M. \text{wt} \times V_L}$$

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

$$\text{Molarity}(M) = 7.05 \times 10^{-3} M$$

P- functions:

$$pX = -\log [X]$$

Examples:

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

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

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

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

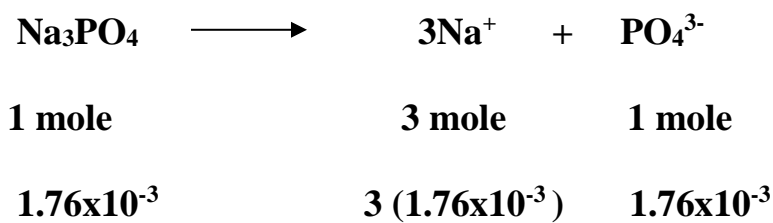
$$pNa = -\log[Na^+]$$

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

Example:

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

Solution:



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

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

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

Note :



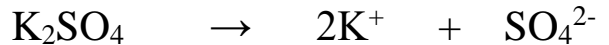
Example:

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

Solution:

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

$$\text{Molarity}(M) \text{ of } \text{K}_2\text{SO}_4 \text{ solution} = \frac{1740}{174 \times 1000} = 0.01 \text{ M}$$



1 mole 2 mole 1 mole

0.01 2(0.01) 0.01

$$[\text{K}^+] = 0.02 \text{ M}$$

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

$$[\text{SO}_4^{2-}] = 0.01 \text{ M}$$

$$\text{pSO}_4^{2-} = -\log(0.01) = 2$$