ALMUSTAQBAL UNIVERSITY COLLEGE

Medical Labs Techniques Department

Stage : First year students

Subject :General chemistry 1 - Lecture 2

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Methods of expressing concentrations:

Concentration represents the amount of dissolved substance (solute) per unit amount of solution , It can be expressed by :

1) **Chemical units : equivalent weight - Molecular weight(mole).**
2) **Physical units : mass – volume**

1. Chemical Units:

The mole:

Is a unit for the amount of a chemical species , always associated with a chemical formula and represents Avogadro's number (6.022×10^{23}) of particles represented by that formula .

Molar Mass :Is the mass in grams of 1 mole of the substance ,it is calculated by summing the atomic masses of all the atoms appearing in a chemical formula .

Molar mass (M.wt) = $\sum \boldsymbol{atomic\ molar\ mass}$

Example :- The molar mass for formaldhyde CH_2O is :

$$M.wt_{CH_2O} = \sum(1mole\ carbon + 2mole\ hydrogen + 1mole\ oxygen)atom$$

$$M.wt_{CH_2O} = 1\ x\ 12gm + 2\ x\ 1.0gm + 1\ x\ 16.0gm$$

$= 30.0\ gm/mole\ of$ CH_2O

Example :- Molar mass of glucose $C_6H_{12}O_6$:

$$M.wt\ _{C_6H_{12}O_6} = \sum(6mole\ carbon + 12mole\ hydrogen + 6mole\ oxygen)$$

$$M.wt_{C_6H_{12}O_6} = 6\ x12.0 + 12\ x\ 1.0 + 6\ x\ 16.0 = 180\ \text{gm/mole}$$

<u>Important Relations:</u>

M.wt = g /mole or mg /mmole

$$\text{no. moles} = \frac{\text{wt}(_\text{g})}{\text{M. wt}(_\text{g}\ )}$$

Mole $=10^3$mmole , mmole $=\frac{1}{1000}$ mole $= 10^{-3}$mole

<u>Example:</u> How many grams of Na^+ (M.wt =22.99 g /mol) are contained in (25.0 gm) of Na_2SO_4 (M.wt = 142.0 g /mol)?

<u>Solution:</u>

$$\mathbf{Na_2SO_4 \longrightarrow 2Na^+ + SO_4^{2-}}$$

1mole 2mole 1mole

$$n_{Na_2SO_4} = \frac{\text{Wt}_{(\text{g})}Na_2SO_4}{\text{M.Wt}_{(\text{g})}Na_2SO_4} = \frac{25.0}{142.0} = 0.176\ \text{moles of}\ Na_2SO_4$$

$$n_{\text{Na}^+} = \text{number of moles}\ Na_2SO_4\ \text{x}\ \frac{2\text{moles}_{\text{Na}^+}}{1\text{moles}_{Na_2SO_4}} = \text{no. of moles of Na}^+$$

n_{Na^+} = 0.176 x 2 = 0.352 moles Na^+

Mass (g) = no. of moles x molar mass(g/mol)

mass Na^+(g) = moles Na^+ x 22.99(g) Na^+

mass Na^+ (g) = 0.352 x 22.99 = 8.10 (g) Na^+

$NaCl \longrightarrow Na^+ + Cl^-$ **or** **$Na_3PO_4 \rightarrow 3Na^+ + PO_4^{3-}$**

Molar concentration (M):

Molarity: Number of moles of solute per liter of solution Or number of mmoles of solute per milliter of solution.

$$\mathbf{M} = \frac{\text{number of moles of solute}}{\text{volume of solution(liter)}}$$

Or

$$\mathbf{M} = \frac{\text{number of mmole of solute}}{\text{volume of solution(mL)}}$$

Example:

What is (C_{NaCl}) the concentration of NaCl(58.5g/mol) in grams per milliliter(g/mL) for its 0.25 M aqueous solution?

Solution:

0.25 M =0.25 mol/L ≡ 0.25 mmol/mL = 0.25 x 10^{-3} mole / mL

C_{NaCl} in (g/mL) = 0.25 x 10^{-3} mole / mL x M.wt (g/ mol) = g / mL

C_{NaCl} in (g/mL) = 0.25 x 10^{-3} mole / mL × 58.5 g/mol = 0.0146 g/mL

Example :

Calculate(C_{K+}) the concentration of potassium ion (39.1 g/mol) in grams per liter for a 0.250 M aqueous solution of KCl (potassium chloride).

Solution:

KCl → K^+ + Cl^-

0.25 M KCl = 0.25 mol/ L K^+

Each mol of K^+ = 39.1 g = M.wt

Then C_{K+} in g/Liter = 0.25 mol/liter x 39.1 gm/mol = 9.77 g / liter

Molarity(M) Calculations:

$$\text{Molarity}(\mathbf{M}) = \frac{\text{no.of moles}}{\text{volume(L)}} = \frac{\frac{wt_{(g)}}{M.wt}}{V_L}$$

$$\text{Molarity}(\text{ M}) = \frac{wt_{(g)}}{M.wt \text{ x } V_L} \qquad \left(V_L = \frac{V_{mL}}{1000}\right)$$

$$\text{Molarity}(M) = \frac{wt_{(g)}}{M.wt \text{ x } \frac{VmL}{1000}}$$

$$\text{Molarity}(M) = \frac{wt_{(g)} \text{ x } 1000}{M.wt \text{ x } V_{mL}}$$

<u>Example:</u> Calculate the molar concentration of KNO_3 aqueous solution that contains (2.02 g) of KNO_3 (M.wt =101 g /mole) in (2.0 L) of solution.

<u>Solution:</u>

$$\text{Molarity}(\text{ M}) = \frac{wt_{(g)}}{M.wt \text{ x } V_L} = \frac{2.02_{(g)}}{101 \text{ x } 2.0 \text{ L}} = 0.10 \text{ M}$$

or

$$\text{Molarity}(M) = \frac{wt_{(g)} \text{ x } 1000}{M.wt \text{ x } V_{mL}} = \frac{2.02_{(g)} \text{ x } 1000}{101 \text{ x } 2000 \text{ mL}} = 0.10 \text{ M}$$

<u>Analytical Molarity</u>: The number of moles of solute in one liter of solution or number of mmole in one mililiter .

e.g: a sulfuric acid(98 g/mol) solution that has an analytical concentration of (1.0M) can be prepared by dissolving (1.0 mole) or (98 g) of H_2SO_4 in water and dilution to exactly (1.0 L). $\{ \text{Molarity(M)} = \frac{1\ mole}{1\ L} = 1\text{M} \}$

Example: **Describe the preparation of (2.00 liter) of (0.18 M) aqueous solution of $BaCl_2$ from solid $BaCl_2.2H_2O$ (244.3gm/mole) .**

Solution:

$$BaCl_2.2H_2O \rightarrow BaCl_2 + 2H_2O$$

1mole 1mole 2mole

Each (1mole $BaCl_2.2H_2O$) gives (1 mole $BaCl_2$).

As Molarity(M) = $\frac{\text{No.of moles}}{\text{volume(L)}}$

No. moles = molarity M x volume (L)

for 2 liter of 0.18 M $BaCl_2$ solution we have

No. moles $BaCl_2$ in Solution = $0.18 \text{ mole } \frac{BaCl_2}{L} \times 2.00 \text{ L} = 0.36 \text{mole } (BaCl_2)$

Then No .moles $BaCl_2.2H_2O$ needed = No. moles $BaCl_2$ = 0.36 moles

Mass (g) = No.of moles x molar mass

The mass of ($BaCl_2.2H_2O$) = 0.36mole x 244.3 gm/mol = 87.95 gm $BaCl_2.2H_2O$

The solution is prepared by dissolving 87.95gm of $BaCl_2.2H_2O$ in water and complete the volume to 2.00 L

Example:

Describe the preparation of 500 mL of 0.0740 M Cl^- solution from solid $BaCl_2.2H_2O$ (244.3 g/mol).

Solution:

$$BaCl_2.2H_2O \rightarrow Ba^{2+} + 2 Cl^- + 2 H_2O$$

1 mole 2 moles

No. of moles = Molarity (mol / liter) x Volume (Liters)

$$V_L = \frac{V_{mL}}{1000} = \frac{500}{1000} = 0.5 \text{ L}$$

moles Cl^- = 0.0740 mol Cl^- / L x 0.5L = 0.037 moles Cl^-

No .moles $BaCl_2.2H_2O$ needed = $\frac{1}{2}$ (No. of moles of Cl^-)

No .moles $BaCl_2.2H_2O$ needed = $\frac{0.037}{2}$ = 0.0185 mol

mass $BaCl_2.2H_2O$ = moles $BaCl_2.2H_2O$ x Mwt (244.3)

mass $BaCl_2.2H_2O$ = 0.0185 x 244.3 = 4.519 gm

Then the required solution is prepared by dissolving 4.519 g of $BaCl_2.2H_2O$ in water and dilute to 0.500 L (500 mL).

or

Weight $BaCl_2.2H_2O$ = $\frac{0.017\frac{\text{mol}}{\text{liter}}\text{Cl}^- \text{ x } 0.5 \text{ liter x } 244.3\text{g/mol}}{2}$ **= 4.519 gm**

Excercises:

1.Describe the preparation of 500 mL of 0.0740 M Cl^- aqueous solution from solid $CaCl_2.2H_2O$ (147 g/mol).

2.Calculate the weight in grams of solid NaCl (58.5 g/mol) required to prepare 250 mL of 0.04 M aqueous solution of Na^+ .

3. Describe the preparation of 700 mL of 0.0740 M Cl^- solution from solid $BaCl_2.2H_2O$ (244.3 g/mol).