

## 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 ( $6.022 \times 10^{23}$ ) 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 .

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

**Example :-** The molar mass for formaldehyde  $\text{CH}_2\text{O}$  is :

$$M. wt_{\text{CH}_2\text{O}} = \sum (1 \text{ mole carbon} + 2 \text{ mole hydrogen} + 1 \text{ mole oxygen}) \text{ atom}$$

$$M. wt_{\text{CH}_2\text{O}} = 1 \times 12 \text{ gm} + 2 \times 1.0 \text{ gm} + 1 \times 16.0 \text{ gm}$$

$$= 30.0 \text{ gm/mole of } \text{CH}_2\text{O}$$

**Example :-** Molar mass of glucose  $\text{C}_6\text{H}_{12}\text{O}_6$  :

$$M. wt_{\text{C}_6\text{H}_{12}\text{O}_6} = \sum (6 \text{ mole carbon} + 12 \text{ mole hydrogen} + 6 \text{ mole oxygen})$$

$$M. wt_{\text{C}_6\text{H}_{12}\text{O}_6} = 6 \times 12.0 + 12 \times 1.0 + 6 \times 16.0 = 180 \text{ gm/mole}$$

**Important Relations:**

$$M. wt = \text{g /mole} \quad \text{or} \quad \text{mg /mmole}$$

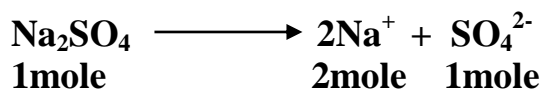
$$\text{no. moles} = \frac{\text{wt(g)}}{M. wt(\text{g})}$$

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

**Example:** How many grams of  $\text{Na}^+$  (M.wt =22.99 g /mol) are contained in

( 25.0 gm) of  $\text{Na}_2\text{SO}_4$  (M.wt = 142.0 g /mol)?

**Solution:**



$$n_{\text{Na}_2\text{SO}_4} = \frac{\text{Wt(g)}_{\text{Na}_2\text{SO}_4}}{M. \text{Wt(g)}_{\text{Na}_2\text{SO}_4}} = \frac{25.0}{142.0} = 0.176 \text{ moles of } \text{Na}_2\text{SO}_4$$

$$n_{\text{Na}^+} = \text{number of moles } \text{Na}_2\text{SO}_4 \times \frac{2 \text{ moles}_{\text{Na}^+}}{1 \text{ moles}_{\text{Na}_2\text{SO}_4}} = \text{no. of moles of } \text{Na}^+$$

$$n_{\text{Na}^+} = 0.176 \times 2 = 0.352 \text{ moles } \text{Na}^+$$

$$\text{Mass ( g)} = \text{no. of moles} \times \text{molar mass(g/mol)}$$

$$\text{mass } \text{Na}^+(\text{g}) = \text{moles } \text{Na}^+ \times 22.99(\text{g}) \text{Na}^+$$

$$\text{mass } \text{Na}^+(\text{g}) = 0.352 \times 22.99 = 8.10 \text{ (g) } \text{Na}^+$$



### Molar concentration (M):

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

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

Or

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

### **Example:**

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

### **Solution:**

$$0.25 \text{ M} = 0.25 \text{ mol/L} \equiv 0.25 \text{ mmol/mL} = 0.25 \times 10^{-3} \text{ mole / mL}$$

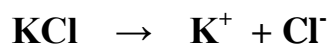
$$C_{\text{NaCl}} \text{ in (g/mL)} = 0.25 \times 10^{-3} \text{ mole / mL} \times \text{M.wt (g/ mol)} = \text{g / mL}$$

$$C_{\text{NaCl}} \text{ in (g/mL)} = 0.25 \times 10^{-3} \text{ mole / mL} \times 58.5 \text{ g/mol} = 0.0146 \text{ g/mL}$$

### **Example :**

Calculate( $C_{\text{K}^+}$ ) 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:**



$$0.25 \text{ M KCl} = 0.25 \text{ mol/ L K}^+$$

$$\text{Each mol of K}^+ = 39.1 \text{ g} = \text{M.wt}$$

$$\text{Then } C_{\text{K}^+} \text{ in g/Liter} = 0.25 \text{ mol/liter} \times 39.1 \text{ gm/mol} = 9.77 \text{ g / liter}$$

## Molarity(M) Calculations:

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

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

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

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

**Example:** Calculate the molar concentration of  $\text{KNO}_3$  aqueous solution that contains (2.02 g ) of  $\text{KNO}_3$  (M.wt =101 g /mole) in (2.0 L) of solution.

**Solution:**

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

or

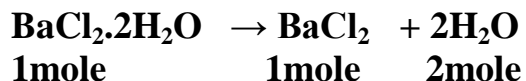
$$\text{Molarity(M)} = \frac{\text{wt(g)} \times 1000}{\text{M.wt} \times V_{\text{mL}}} = \frac{2.02(\text{g}) \times 1000}{101 \times 2000 \text{ mL}} = 0.10 \text{ M}$$

**Analytical Molarity:** The number of moles of solute in one liter of solution or number of mmole in one milliliter .

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  $\text{H}_2\text{SO}_4$  in water and dilution to exactly (1.0 L). { **Molarity(M) =  $\frac{1 \text{ mole}}{1 \text{ L}} = 1\text{M}$  }** }

**Example:** Describe the preparation of (2.00 liter) of (0.18 M) aqueous solution of BaCl<sub>2</sub> from solid BaCl<sub>2</sub>.2H<sub>2</sub>O (244.3gm/mole) .

**Solution:**



Each (1mole BaCl<sub>2</sub>.2H<sub>2</sub>O) gives ( 1 mole BaCl<sub>2</sub>).

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

No. moles = molarity M x volume (L)

for 2 liter of 0.18 M BaCl<sub>2</sub> solution we have

$$\text{No. moles BaCl}_2 \text{ in Solution} = 0.18 \text{ mole} \frac{\text{BaCl}_2}{\text{L}} \times 2.00 \text{ L} = 0.36 \text{mole (BaCl}_2)$$

Then No .moles BaCl<sub>2</sub>.2H<sub>2</sub>O needed = No. moles BaCl<sub>2</sub> = 0.36 moles

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

The mass of (BaCl<sub>2</sub>.2H<sub>2</sub>O) = 0.36mole x 244.3 gm/mol = 87.95 gm BaCl<sub>2</sub>.2H<sub>2</sub>O

The solution is prepared by dissolving 87.95gm of BaCl<sub>2</sub>.2H<sub>2</sub>O in water and complete the volume to 2.00 L

**Example:**

Describe the preparation of 500 mL of 0.0740 M Cl<sup>-</sup> solution from solid BaCl<sub>2</sub>.2H<sub>2</sub>O (244.3 g/mol).

**Solution:**



**1 mole**

**2 moles**

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

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

moles Cl<sup>-</sup> = 0.0740 mol Cl<sup>-</sup> / L x 0.5L = 0.037 moles Cl<sup>-</sup>

No .moles  $\text{BaCl}_2 \cdot 2\text{H}_2\text{O}$  needed =  $\frac{1}{2}$  ( No. of moles of  $\text{Cl}^-$  )

No .moles  $\text{BaCl}_2 \cdot 2\text{H}_2\text{O}$  needed =  $\frac{0.037}{2} = 0.0185 \text{ mol}$

mass  $\text{BaCl}_2 \cdot 2\text{H}_2\text{O}$  = moles  $\text{BaCl}_2 \cdot 2\text{H}_2\text{O}$  x Mwt (244.3)

mass  $\text{BaCl}_2 \cdot 2\text{H}_2\text{O}$  =  $0.0185 \times 244.3 = 4.519 \text{ gm}$

Then the required solution is prepared by dissolving 4.519 g of  $\text{BaCl}_2 \cdot 2\text{H}_2\text{O}$  in water and dilute to 0.500 L ( 500 mL).

or

$$\text{Weight } \text{BaCl}_2 \cdot 2\text{H}_2\text{O} = \frac{0.017 \frac{\text{mol}}{\text{liter}} \text{Cl}^- \times 0.5 \text{ liter} \times 244.3 \text{g/mol}}{2} = 4.519 \text{ gm}$$

**Excercises:**

**1. Describe the preparation of 500 mL of 0.0740 M  $\text{Cl}^-$  aqueous solution from solid  $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$  (147 g/mol).**

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

**3. Describe the preparation of 700 mL of 0.0740 M  $\text{Cl}^-$  solution from solid  $\text{BaCl}_2 \cdot 2\text{H}_2\text{O}$  (244.3 g/mol).**