



**Almustaqbal University College**

**Medical Laboratories Techniques Department**

**First year students**

**Subject : General chemistry 1 - Lecture 2A**

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## **Expressing concentrations By 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 and 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 .

$$\text{Molar mass} = \sum \text{atomic mass}$$

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

$$M_{C_6H_{12}O_6} = \sum (6\text{mole carbon} + 12\text{mole hydrogen} + 6\text{mole oxygen})\text{atom}$$

$$M_{C_6H_{12}O_6} = 6 \times 12.0 + 12 \times 1.0 + 6 \times 16.0 = 180 \text{ g /mole}$$

### **Important Relations:-**

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

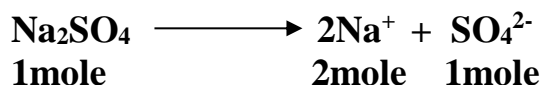
$$\text{No. of moles} = \frac{\text{wt(g)}}{\text{M. wt(g)}}$$

$$\text{Wt (g)} = \text{No. of moles} \times \text{M.wt}$$

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

**Example1:** How many grams of  $\text{Na}^+$  (M.wt = 22.99 g /mol) are contained in ( 25 gm) of  $\text{Na}_2\text{SO}_4$  (M.wt = 142.0 g /mol)?

**Solution:**



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

$$\text{No. of moles of } \text{Na}^+ (n_{\text{Na}^+}) = \text{Number of moles } \text{Na}_2\text{SO}_4 \times 2$$

$$\text{No. of moles of } \text{Na}^+ (n_{\text{Na}^+}) = 0.176 \times 2 = 0.352 \text{ moles } \text{Na}^+$$

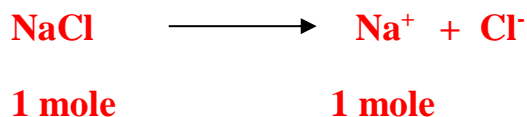
$$\text{Wt (g)} = \text{No. of moles} \times \text{M.wt}$$

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

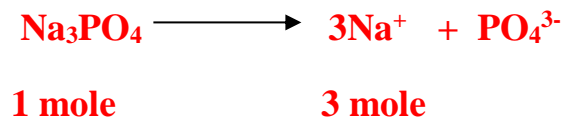
$$\text{Weight of } \text{Na}^+ (\text{g}) = 0.352 \times 22.99 = 8.10 (\text{g}) \text{Na}^+$$

**Hints**

-No. of moles of  $\text{Na}^+$  ( $n_{\text{Na}^+}$ ) in  $\text{NaCl}$  is = 1 x No. of moles of  $\text{NaCl}$  as



No. of moles of  $\text{Na}^+$  ( $n_{\text{Na}^+}$ ) in  $\text{Na}_3\text{PO}_4$  is = 3 x No. of moles of  $\text{Na}_3\text{PO}_4$  as



**Exercise:**

How many grams of  $\text{Na}^+$  ( 22.99 g /mol) are contained in 25 g of  $\text{Na}_3\text{PO}_4$  ( 164 g /mol)?

**Exercise :**

1. No. of moles of  $K^+$  ( $n_{K^+}$ ) in  **$K_2SO_4 = ?$**
2. No. of moles of  $K^+$  ( $n_{K^+}$ ) in  **$KNO_3 = ?$**
3. No. of moles of  $Mg^{2+}$  ( $n_{Mg^{2+}}$ ) in  **$MgSO_4 = ?$**
4. No. of moles of  $Fe^{3+}$  ( $n_{Fe^{3+}}$ ) in  **$FeCl_3 = ?$**
5. No. of moles of  $Cl^-$  ( $n_{Cl^-}$ ) in  **$FeCl_3 = ?$**

**Molar concentration (M):**

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

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

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

**Molarity calculations:**

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

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

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

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

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

**Solution:**

$$\text{Molarity (M)} = \frac{\text{wt(g)}}{\text{M.wt} \times V_L} = \frac{2.02(\text{g})}{101 \times 2.0 \text{ L}} = 0.1 \text{ M}$$

or

$$\text{Molarity (M)} = \frac{\text{wt(g)} \times 1000}{\text{M.wt} \times V_{\text{mL}}} = \frac{2.02(\text{g}) \times 1000}{101 \times 2000 \text{ mL}} = 0.1 \text{ M}$$

### Preparation of molar solutions

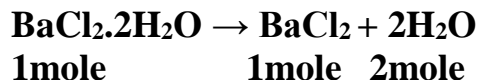
**Molarity** represents the number of moles of solute in one liter of solution or number of mmole in one milliliter .

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).

$$\{ \text{Molarity (M)} = \frac{\text{No. of moles}}{\text{Vol. (L)}} = \frac{1 \text{ mole}}{1 \text{ L}} = 1 \text{ M} \}$$

\* **Example:** Describe the preparation of (2.00 liter) of (0.18 M)  $\text{BaCl}_2$  from  $\text{BaCl}_2 \cdot 2\text{H}_2\text{O}$  (244.3 g/mole) .

Solution:



Each (1mole  $\text{BaCl}_2 \cdot 2\text{H}_2\text{O}$ ) gives ( 1 mole  $\text{BaCl}_2$ ).

for 2 liter solution we have

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

No. of moles = molarity M x volume (L)

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

Then No. of moles  $\text{BaCl}_2 \cdot 2\text{H}_2\text{O}$  needed = 0.36 moles

The mass of  $(\text{BaCl}_2 \cdot 2\text{H}_2\text{O}) = 0.36 \text{ mole} \times 244.3 \text{ g/mol} = 87.95 \text{ g BaCl}_2 \cdot 2\text{H}_2\text{O}$

The solution is prepared by dissolving 87.95gm  $\text{BaCl}_2 \cdot 2\text{H}_2\text{O}$  in water and complete the volume to 2.00 L

**Example:**

Describe the preparation of 500 mL of 0.0740 M  $\text{Cl}^-$  solution from solid  $\text{BaCl}_2$  (208 g/mol).

**Solution:**



1 mole                                      2 moles

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

moles  $\text{Cl}^- = 0.0740 \times 0.5 = 0.037$  moles  $\text{Cl}^-$

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

No .moles  $\text{BaCl}_2$  needed =  $\frac{0.037}{2} = 0.0185$  mole

weight of  $\text{BaCl}_2 = \text{No. of moles BaCl}_2 \times \text{M wt (208)}$

weight of  $\text{BaCl}_2 = 0.0185 \times 208 = 3.85$  grams

Then the required solution is prepared by dissolving 3.85 g of  $\text{BaCl}_2$  in water and dilute to 0.500 L ( 500 mL).

**Example:**

**Calculate the number of molecules (particles) of NaCl (58.5 g/mol) present in 1liter of 0.1 M solution.**

**Answer:**

**Each 1 mole contains Avogadro's number ( $6.022 \times 10^{23}$ ) of molecules then**

**No. of moles = Molarity(M) x V(liter) = 0.1 x 1= 0.1 mole**

**No. of moles =  $\frac{\text{No. of molecules}}{6.02 \times 10^{23}}$**

No. of molecules = No. of moles  $\times 6.02 \times 10^{23} = 0.1 \times 6.02 \times 10^{23}$   
No. of molecules =  $6.02 \times 10^{22}$  molecules

Excercise:

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).

### Conversion to molarity:

#### 1. Conversion of $\left(\frac{w}{v}\right)\%$ to Molarity(M)

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

#### 2. Conversion of Molarity(M) to mmol/L

$$\text{mmol/L} = \text{Molarity(M)} \times 1000$$

#### 3. Conversion of mmol/L to mg/dl

$$C_{\text{mg/dl}} = \frac{\text{mmol/dl} \times \text{Mwt}}{10}$$

#### Example:

Calculate the concentration of the solution that is 20(w/v)% of KCl (74.5 g/mol) in: a. Molarity(M)      b. mmol/L      c. mg/dl

#### solution:

a.

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

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

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

**b.  $C_{\text{mmol/L}} = \text{Molarity(M)} \times 1000$**

$$C_{\text{mmol/L}} = 2.68 \times 1000 = 2680 \text{ mmol/L}$$

**c.  $C_{\text{mg/dl}} = \frac{\text{mmol/dl} \times \text{Mwt}}{10} = \frac{2680 \times 74.5}{10} = 19966 \text{ mg/dl}$**

$$C_{\text{mg/dl}} = 19966 \text{ mg/dl}$$

**Exercises:**

**1. Which of the following contains the largest number of molecules :**

- a) 66g of CO<sub>2</sub> (44 g/mol)
- b) 80 g of NaOH (40 g/mol)
- c) 32 g of CH<sub>3</sub>OH (32 g/mol)

**2. Describe the preparation of 500 mL of 0.0740 M Cl<sup>-</sup> aqueous solution from solid CaCl<sub>2</sub>·2H<sub>2</sub>O (147 g/mol).**

**3. Calculate the weight in grams of solid K<sub>2</sub>SO<sub>4</sub> (174.26 g/mol) required to prepare 500 mL of 0.04 M aqueous solution of K<sup>+</sup> .**

**4. 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<sup>+</sup> .**

**5. Calculate the concentration of the solution that is 5(w/v)% of NaCl (58.5 g/mol) in:**      a. Molarity(M)              b. mmol/L              c. mg/dl