

**Almustaqbal University College**

**Medical Laboratories Techniques Department**

**First year students**

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

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## **Chemistry**

Chemistry is the science that study matter, its chemical and physical properties, the chemical and physical changes it undergoes, and the energy changes that accompany those processes.

### **Major Areas of Chemistry**

#### **1. ORGANIC CHEMISTRY**

Involves the study of the structure, properties, and preparation of chemical compounds of diverse substances such as plastics, drugs, solvents, industrial chemicals that consist primarily of **Carbon and Hydrogen**.

#### **2. Inorganic chemistry**

Involves the study of the properties and behavior of inorganic compounds. It covers all chemical compounds other than organic compounds. It studies minerals, metals, catalysts, and most elements in the Periodic Table.

#### **3. PHYSICAL CHEMISTRY**

Deals with the study of the effect of chemical structure on the physical properties of a substance. , the rate of a chemical reaction, the interaction of molecules with radiation, and the calculation of structures and properties.

#### **4. BIOCHEMISTRY**

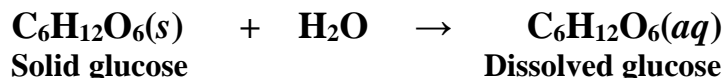
Is related to the study of chemical reactions that take place in living beings (animals, plants and micro organisms). It tries to explain them in chemical terms.



### Nonelectrolytic Solutions:

Are solutions formed from non dissociating *molecular* solutes (non electrolytes), and these solutions are nonconducting.

For example, dissolving Glucose sugar in water:



### A true solution

is a homogeneous mixture with uniform properties throughout.

, the solute cannot be isolated from the solution by filtration through the filter paper. Furthermore, solute particles will not “settle out” after a time.

### Degree of Solubility

The rule “*like dissolves like*” was described as the fundamental condition for solubility. Polar solutes are soluble in polar solvents, and nonpolar solutes are soluble in nonpolar solvents.

The *degree of solubility*, indicates how much solute can dissolve in a given volume of solvent, which is a quantitative measure of solubility.

## Methods of expressing concentrations-

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

- 1) physical units : mass-volume
- 2) chemical units : equivalent weight- Molecular weight(mole).

### Expressing concentrations By Physical units :

#### A. Percent concentration %

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  $\text{HNO}_3$  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  $\text{KNO}_3$  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:

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:

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

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

Practice exercises :

- Calculate the (w/v)% of 0.2 L of solution containing 15 g KCl.
- Calculate the mass (in g) of sodium hydroxide required to make 2.00 L of a 1 % (w/v)% solution
- Calculate the volume (in mL) of a 25 % (w/v)% solution containing 10 g NaCl.

## 2.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 .

$\text{Molar mass} = \sum \text{atomic mass}$
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**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:-**

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

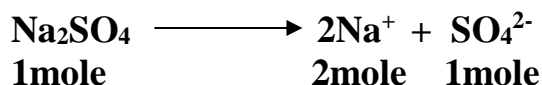
$$\text{No. of moles} = \frac{\text{wt(g)}}{\text{M. wt(g)}}$$

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

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

**Example1:** How many grams of  $Na^+$  (M.wt = 22.99 g /mol) are contained in ( 25 g) of  $Na_2SO_4$  (M.wt = 142 g /mole)?

**Solution:**



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

$$\text{No. of moles of } Na^+ (n_{Na^+}) = \text{Number of moles } Na_2SO_4 \times 2$$

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

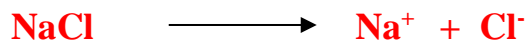
$$\text{Wt (g)} = \text{No. of moles} \times \text{M.wt}$$

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

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

## Hints

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



**1 mole**                      **1 mole**

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



**1 mole**                      **3 mole**

**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  $\text{K}^+$  ( $n_{\text{K}^+}$ ) in  $\text{K}_2\text{SO}_4 = ?$
2. No. of moles of  $\text{K}^+$  ( $n_{\text{K}^+}$ ) in  $\text{KNO}_3 = ?$
3. No. of moles of  $\text{Mg}^{2+}$  ( $n_{\text{Mg}^{2+}}$ ) in  $\text{MgSO}_4 = ?$
4. No. of moles of  $\text{Fe}^{3+}$  ( $n_{\text{Fe}^{3+}}$ ) in  $\text{FeCl}_3 = ?$
5. No. of moles of  $\text{Cl}^-$  ( $n_{\text{Cl}^-}$ ) in  $\text{FeCl}_3 = ?$

## Molar concentration (M):

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

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

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

## Molarity calculations:

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

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

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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  $\text{KNO}_3$  (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 .

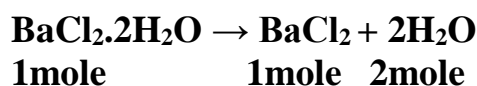


e.g: a sulfuric acid(98 g/mol) solution that has an analytical concentration of (1.0M) can be prepared by dissolving (1.0 mole) or (98 g ) of H<sub>2</sub>SO<sub>4</sub> in water and dilution to exactly (1.0 L).

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

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

Solution:



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

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)

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

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

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

The solution is prepared by dissolving 87.95 g 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> (208 g/mol).

Solution:



1 mole    2 moles

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

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

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

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

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

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

Then the required solution is prepared by dissolving 3.85 g of BaCl<sub>2</sub> 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 1 liter of 0.1 M solution.**

**Answer:**

**Each 1 mole contains Avogadro's number (6.022 x 10<sup>23</sup>) of molecules then**

$$\text{No. of moles} = \text{Molarity(M)} \times \text{V(liter)} = 0.1 \times 1 = 0.1 \text{ mole}$$

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

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

$$\text{No. of molecules} = 6.02 \times 10^{22} \text{ molecules}$$

Excercise:

Describe the preparation of 700 mL of 0.0740 M Cl<sup>-</sup> solution from solid BaCl<sub>2</sub>.2H<sub>2</sub>O (244.3 g/mole).

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

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

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

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

**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**