

ALMUSTAQBAL UNIVERSITY

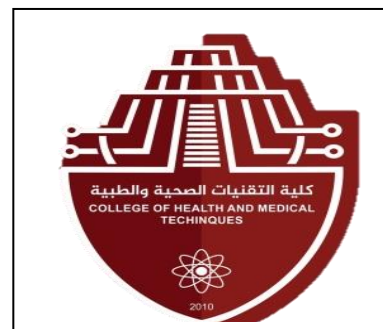
College of Health and Medical Techniques

Medical Laboratories Techniques Department

Stage : 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.

5. ANALYTICAL CHEMISTRY

Involves the analysis of substance to determine its **composition and the quantity** of its components . It is concerned with answering the questions:

- **What** chemical species are present in a sample ? (Qualitative Analysis)
- **How much** of each component is present ? (Quantitative Analysis).

It is done through volumetric , gravimetric or instrumental methods .

There is a huge overlap between Chemistry and Engineering, Biology, Medicine, Physics, Geology, and other fields. Chemistry really is a **CENTRAL SCIENCE**.

Properties of Solutions

A **solution** is a homogeneous mixture of two or more substances. It is composed of one or more **solutes**, dissolved in a **solvent**.

For example, when sugar (the solute) is added to water (the solvent), the sugar dissolves in the water to produce a solution.

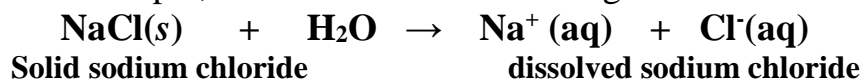
For the cases where the solvent is water, the homogeneous mixture is referred to as an **aqueous solution**.

Electrolytic solutions:

Are solutions formed from solutes that are soluble **ionic** compounds (electrolytes). They dissociate in solution to produce ions that behave as charge carriers.

Solutions of electrolytes are good conductors of electricity.

For example, sodium chloride dissolving in water:



Nonelectrolytic Solutions:

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

For example, dissolving Glucose sugar in water:



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 HNO_3 for each (100 g) of solution.

Example:

Intravenous dextrose injections are given to restore sugar levels in patients. What is the mass of sugar dissolved in 25 g of a 10 % dextrose solution?

Solution:

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

$$10 \% = \frac{\text{weight of solute}}{25} \times 100 \%$$

$$\text{Weight of solute(dextrose sugar)} = \frac{10 \times 25}{100} = 2.5 \text{ g}$$

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.

Example:

What is the volume of acetic acid needed for the preparation of 500 mL of vinegar, aqueous solution of 7.5% (v/v) of acetic acid ?

Solution:

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

$$7.5\% = \frac{\text{volume of acetic acid}}{500 \text{ mL}} \times 100\%$$

$$\text{Volume of acetic acid} = \frac{7.5 \times 500}{100} = 37.5 \text{ mL}$$

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 g) of KNO_3 in sufficient amount of water to give (100 mL) of solution .

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 :

- a. Calculate the (w/v)% of 0.2 L of solution containing 15 g KCl.
- b. Calculate the mass (in g) of sodium hydroxide required to make 2 L of a 1 % (w/v)% solution
- c. 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 (6.022×10^{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:-

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

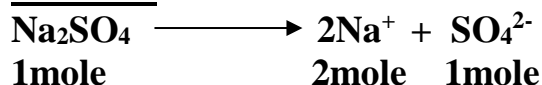
$$\text{No. of moles} = \frac{\text{wt(g)}}{\text{M. wt(g)}}$$

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

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

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

Solution:



$$\text{moles of } \text{Na}_2\text{SO}_4 (n_{\text{Na}_2\text{SO}_4}) = \frac{\text{Wt}_{(g)}\text{Na}_2\text{SO}_4}{\text{M. Wt}_{(g)}\text{Na}_2\text{SO}_4} = \frac{25}{142} = 0.176$$

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

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

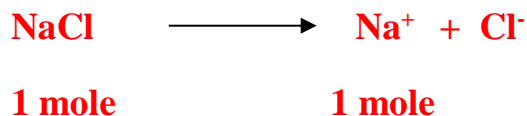
$$\text{Wt (g)} = \text{No. of moles} \times \text{M.wt}$$

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

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

Hints

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



No. of moles of Na^+ (n_{Na^+}) in Na_3PO_4 is = 3 x No. of moles of Na_3PO_4 as



Exercise:

How many grams of Na⁺ (22.99 g /mole) are contained in 25 g of Na₃PO₄ (164 g /mole)?

Exercise :

1. No. of moles of K⁺ (n_{K^+}) in **K₂SO₄ = ?**
2. No. of moles of K⁺ (n_{K^+}) in **KNO₃ = ?**
3. No. of moles of Mg²⁺ ($n_{Mg^{2+}}$) in **MgSO₄ = ?**
4. No. of moles of Fe³⁺ ($n_{Fe^{3+}}$) in **FeCl₃ = ?**
5. No. of moles of Cl⁻ (n_{Cl^-}) in **FeCl₃ = ?**

Molar concentration (M):

Molarity: Number of moles of solute per liter of solution

Or number of m moles 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:

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

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

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

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

Example: calculate the molar concentration of KNO_3 aqueous solution that contains (2.02 g) of KNO_3 (101 g /mole) in (2 L) of solution?

Solution:

$$\text{Molarity (M)} = \frac{\text{wt(g)}}{\text{M.wt} \times V_L} = \frac{2.02(\text{g})}{101 \times 2 \text{ L}} = 0.1 \text{ M}$$

or

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

Example:

How many milliliters of 12 M hydrochloric acid contain 7.30 g of HCl solute (36.5 g/mole)?

Solution:

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

$$V(\text{mL}) = \frac{\text{wt(g)} \times 1000}{\text{M.wt} \times \text{Molarity (M)}} = \frac{7.3 \times 1000}{36.5 \times 12} = 16.7 \text{ mL}$$

Preparation of molar solutions

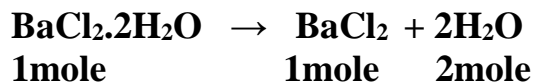
Molarity represents the number of moles of solute in one liter of solution or number of mmole in one milliliter .

e.g: a sulfuric acid(98 g/mole) solution that has an analytical concentration of (1 M) can be prepared by dissolving (1 mole) or (98 g) of H_2SO_4 in water and dilution to exactly (1 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 liter) of (0.18 M) BaCl_2 from $\text{BaCl}_2 \cdot 2\text{H}_2\text{O}$ (244.3 g/mole) .

Solution:



Each (1mole BaCl₂.2H₂O) gives (1 mole BaCl₂).

for 2 liter solution we have

$$\text{No. of moles} = \frac{\text{weight (g)}}{M.wt} \dots\dots\dots(1)$$

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

$$\text{No. of moles} = \text{molarity M} \times \text{volume (L)} \dots\dots\dots(2)$$

$$\frac{\text{weight (g)}}{M.wt} = \text{molarity M} \times \text{volume(L)}$$

$$\text{Weight (g)} = \text{molarity M} \times \text{volume(L)} \times \text{M.wt}$$

$$\text{Weight of BaCl}_2 \cdot 2\text{H}_2\text{O(g)} = 0.18 \times 2 \times 244.3 = 87.95 \text{ g BaCl}_2 \cdot 2\text{H}_2\text{O}$$

The solution is prepared by dissolving 87.95gm BaCl₂.2H₂O in water and complete the volume to 2 L

Example:

Describe the preparation of 500 mL of 0.0740 M Cl⁻ solution from solid BaCl₂ (208 g/mole).

Solution:



1 mole 2 moles

$$\text{No of moles} = \text{Molarity (mole / liter)} \times \text{Volume (Liters)}$$

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

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

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

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

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

Then the required solution is prepared by dissolving 3.85 g of BaCl_2 in water and dilute to 0.5 L (500 mL).

Example:

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

solution:

Each 1 mole contains Avogadro's number (6.022×10^{23}) of molecules then

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

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

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

No. of molecules = 6.02×10^{22} molecules

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 /mole) ?

solution:

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

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

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

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

Conversions:

1. Molarity to m mole/ L

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

2. Molarity to mg/dL

$$\text{mg/dL} = \text{m mol/L} \times \left(\frac{M.\text{wt}}{10}\right)$$

$$\text{Then } C(\text{mg/dL}) = \frac{\text{Molarity}(M) \times 1000 \times M.\text{wt}}{10}$$

$$C(\text{mg/dL}) = \text{Molarity}(M) \times M.\text{wt} \times 100$$

3. $\left(\frac{w}{v}\right)\%$ to mg/dL

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

$$\text{Then } C(\text{mg/dL}) = \frac{\left(\frac{w}{v}\right)\% \times 10}{M.\text{wt}} \times M.\text{wt} \times 100$$

$$C(\text{mg/dL}) = \left(\frac{w}{v}\right)\% \times 1000$$

Example

A solution of heparin sodium, an anticoagulant for blood, contains 1.8 g of heparin sodium dissolved to make a final volume of 15 mL of solution. What is the concentration of this solution in $(\frac{w}{V})\%$ and in mg/dL ?

SOLUTION

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

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

$$\left(\frac{w}{V}\right)\% = \frac{1.8(g)}{15(mL)} \times 100\% = 12\%$$

$$\left(\frac{w}{V}\right)\% \times 1000 = \text{mg /dL}$$

$$12 \times 1000 = 12000 \text{ mg / dL}$$

Exercises:

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

- a) 66g of CO₂ (44 g/mole)
- b) 80 g of NaOH (40 g/mole)
- c) 32 g of CH₃OH (32 g/mole)

2. Describe the preparation of 500 mL of 0.0740 M Cl⁻ aqueous solution from solid CaCl₂·2H₂O (147 g/mole).

3. Calculate the weight in grams of solid K₂SO₄ (174.26 g/mole) required to prepare 500 mL of 0.04 M aqueous solution of K⁺.