Reactions in Aqueous Solutions

1.1 General Properties of Aqueous Solutions:

A ***solution*** is *a homogeneous mixture of two or more substances. The substance present in a smaller amount* is called the ***solute,*** whereas *the substance present in a larger amount* is called the ***solvent.*** A solution may be gaseous (such as air), solid (such as an alloy), or liquid (seawater, for example). In this section we will discuss only ***aqueous solutions,*** in which *the solute initially is a liquid or a solid and the solvent is water.*

Homogenous mixture: *means the mixture has the same composition everywhere. Like when sugar dissolves in water.*

Heterogeneous mixture: *a mixture that is not the same everywhere (such as orange juice, which has suspended solids)*

المحلول : هو خليط متجانس من مادتين او اكثر. **المذاب** : هو مادة متواجدة في الخليط المتجانس بكمية قليلة. **المذيب** :هو مادة متواجدة في الخليط المتجانس بكمية كبيرة.
يمكن ان يكون المحلول ذو طور غازي (مثل الهواء) او صلب (مثل السبائك) او سائل (مثل ماء البحر). سوف نهتم بدراسة المحاليل المائية و التي تكون مادة المذاب سائلة او صلبة و المذيب هو الماء.

الخليط المتجانس: هو الخليط الذي يمتلك نفس التركيب في كل مكان من الخليط. مثل خليط السكر الذائب في الماء. **الخليط الغير متجانس :** هو الخليط الذي لايمتلك نفس لتركيب في كل مان من الخليط مثل عصير البرتقال حيث يحتوي على عوالق صلبة.

1.1.1 Concentration of Solutions:

The ***concentration of a solution*** is *the amount of solute present in a given quantity of solution.* The concentration of solution can be expressed in many different ways. Here we will consider the most commonly used units in chemistry.

تركيز المحلول: هو كمية مادة المذاب الموجود في حجم معلوم من المحلول. يمكن التعبير عن تراكيز المحاليل بطرق عديدة. سنقوم بدراسة اهم هذه الطرق.

Avogadro's number (is the name given to the numerical value), denoted N_A, and equal to:

$$N_A = 6.022 \times 10^{23}$$

It has been selected in order that, if N_A carbon atoms (^{12}C) are put on a balance, then the balance will show a weight of 12 grams.

The **atomic weight** *of a chemical element is the weight of N_A atoms of it.* The atomic weights of the elements are included in the periodic table of the elements.

الوزن الذري : للعنصر هو وزن عدد افكادرو من ذرات العنصر

The **molecular weight** *of a molecule is the weight of N_A such molecules.* The molecular weight of a molecule is equal to the sum of the atomic weights of its constituting atoms. The molecular weight is calculated from the molecule's chemical formula and the atomic weights.

الوزن الجزيئي : هو وزن عدد افكادرو من جزيئات المركب.

For example M_w (NaCl) = 22.990 + 35.453 = 58.443 gram/mol.

Mole *referred to as (**mol.**) is a quantity of N_A atoms or molecules.* Therefore, the atomic weight is the weight of one mole of atoms, and the molecular weight is the weight of one mole of molecules.

المول: هو كمية عدد افكادرو من الذرات او الجزيئات. لذلك فان الوزن الذري هو وزن مول واحد من الذرات و الوزن الجزيئي هو وزن مول واحد من الجزيئات.

$$\boldsymbol{Number\ of\ moles\ (n) = \frac{Weight\ (W)}{Moleculer\ Wight\ (Mwt.)}}$$

The molecular weight M_w of a molecule, multiplied by the number of moles n, is equal to the total weight W of the molecules:

$$\boldsymbol{W = n * M.wt}$$

For example: to calculate the weight of 3.4 moles of sodium chloride

M.wt of NaCl = 58.443 gram, W = 3.4*58.443 = 198.7 gram.

1. ***Molarity (M),*** or ***molar concentration,*** which is *the number of moles of solute per liter of solution.* Molarity is defined as

$$\boldsymbol{Molarity\ (M)} = \frac{number\ of\ moles\ of\ solute}{volme\ of\ solution\ in\ liter}$$

المولارية او التركيز المولي: هو عدد مولات المذاب الوجودة في لتر واحد من المحلول.

Example**:** A 0.5 L solution containing 0.730 mole of C6H12O6. Calculate the concentration of solution in molarity.

$$M = \frac{0.730\ mol.}{0.5\ L} = 1.46\ M$$

We can also calculate the molarity using the equation

$$\boldsymbol{M} = \frac{Weight\ (wt.)}{Molculer\ Weight\ (M.wt)} * \frac{1000}{Volume\ (mL)}$$

Were the volume is in (mL) milliliters.

Q 1: what is the molarity of a solution containing (16 gram) of CH3OH in (200mL) of solution. Give that the atomic weight of C=12 g/mole and of H=1 g/mole.

Q 2: determine the weight of Na+ (22.99g/mole) in (25 g) of Na2CO3 (142 g/mole).

2. **Normality (N),** or **normal concentration,** which is *the number of gram-equivalents weights of solute per liter of solution.* Normality is defined as

$$\boldsymbol{Normality\ (N)} = \frac{number\ of\ gram-equivelat\ wight\ of\ solute}{volme\ of\ solution\ in\ liter}$$

النورمالية او التركيز النورمالي: هو عدد الوزن المكافئ من المذاب في لتر واحد من المحلول.

Or we can also use the equation where the volume is in mL

$$\boldsymbol{N} = \frac{Weight(wt.)}{Equivelent\ Wight(eq.wt.)} * \frac{1000}{Volume\ (mL)}$$

- **Calculations of equivalent weights**

A. For acids and bases, the number of reacting units is based on the number of protons (i.e., hydrogen ions) an acid will furnish or a base will react with.

$$\textbf{Equivalent weight of acid} = \frac{M\ wt.of\ acid}{No.of\ active\ H^{+}}$$

Example: Equivalent weight of H_2SO_4 = Mwt. H_2SO_4 / 2

Equivalent weight of H_3PO_4 = Mwt. H_3PO_4 / 3

$$\textbf{Equivalent weight of base} = \frac{M\ wt.of\ base}{No.of\ active\ OH^{-}}$$

Example: equivelant weight of NaOH = M.wt of NaOH/1

Q3: Calculate the Equivelant weight for the following HCl,Ba(OH)2.

B. For an ion

$$\textbf{Equivalent weight of an ion} = \frac{M\ wt.of\ ion}{Number\ of\ electronic\ charge}$$

Example: equivalent weight of carbonate ion in CO_3^{-2} = Mwt. $CO_3^{-2}/2$

=(12+3*16)/2 = 60/2=30

C. For oxidation–reduction reactions it is based on the number of electrons an oxidizing or reducing agent will take on or supply.

$$\textbf{Equivalent weight} = \frac{M\ wt.(gm/mole)}{No.of\ electrons\ gianed\ or\ lost}$$

3. **Percent Concentration:** There are three different ways of representing percent concentration:

A. Percent by mass (or mass–mass percent): is the mass of solute in a solution divided by the total mass of solution, multiplied by 100 (to put the value in terms of percentage).

$$\textbf{Percent by mass}\ (w/w) = \frac{mass\ of\ solute}{mass\ of\ solution} * 100$$

$$\textbf{Mass of solution} = mass\ of\ solute + mass\ of\ solvent$$

B. Percent by volume (or volume–volume percent): is the volume of solute in a solution divided by the total volume of solution, multiplied by 100.

$$\textbf{Percent by volume}(v/v) = \frac{volume\ of\ solute}{volume\ of\ solution} * 100$$

C. Mass–volume percent: is the mass of solute in a solution (in grams) divided by the total volume of solution (in milliliters), multiplied by 100.

$$\textbf{Mass} - \textbf{volume percent}(w/v) = \frac{\textbf{mass of solute}\ (g)}{\textbf{volume of solution}\ (mL)} * \mathbf{100}$$

4. **Parts per million (ppm):** is the gram of solute to one million grams of solution.

$$ppm = \frac{\textbf{grams of solute}}{\mathbf{10^6}\textbf{grams of solution}}$$

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1.2. Diluting Solutions: تخفيف المحاليل

Dilution: *is the process in which more solvent is added to a solution in order to lower its concentration.*

- التخفيف : هو عملية اضافة كمية اضافية من المذيب الى المحلول لغرض تقليل تركيزه

The purpose of dilution is to prepare a diluted solution from a concentrated solution. الهدف من التخفيف هو تحضير محلول مخفف من محلول ذو تركيز عالي.

For example to prepare 500 ml of 0.1 M solution from 0.25 M solution, more solvent must be added to 0.25 M solution to lower its concentration.

The mathematical expression for dilution:

1. **Using Molarity**: باستخدام المولارية

$$\underset{\text{Concentrated}}{\mathbf{M_1 * V_1}} = \underset{\text{Dilute}}{\mathbf{M_2 * V_2}}$$

Where
M_1: molarity of concentrated solution
V_1: volume of concentrated solution
M_2: molarity of diluted solution
V_2: volume of diluted solution

2. **Using Normality**: باستخدام النورمالية

$$\underset{\text{Concentrated}}{\mathbf{N_1 * V_1}} = \underset{\text{Dilute}}{\mathbf{N_2 * V_2}}$$

Where
N_1: normality of concentrated solution
V_1: volume of concentrated solution
N_2: normality of diluted solution
V_2: volume of diluted solution