GENERAL CHEMISTRY
THEORETICAL

First Stage Students
Department of Physics

أستاذة المادة

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Analytical chemistry

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Solutions

A solution is a homogeneous mixture of two or more substances, one of which is called a solute and the other a solvent, such as sugar and water. This mixture is called an aqueous solution because the solvent is water.

There is a solution of gases as well as solids. A general characteristic of liquid solutions is that they are clear and do not contain any suspended substances that have no smell.

Types of solutions

First // (in relation to the size of the atoms or molecules of the solute):-

1- True solutions

They are solutions that in which the solid solute particles are distributed homogeneously throughout the liquid and the solid solute cannot be separated by filtration or by concentration due to gravity, such as table salt or sugar in water.

2- Suspended solutions

They are solutions that can be seen with the naked eye or with a microscope, and the liquid can be separated from them by filtration or concentration, such as a clay suspension.

3- Colloidal solutions

They are solutions that consist of molecular groups charged with an identical electrical charge, spread in the solvent liquid, with diameters ranging between (1-200) milli microns. They cannot be seen with a super-microscope and do not separate by concentration unless chemical materials are added to them that cause them to precipitate, and they often pass, at least partially, through the filter paper.

Secondly // (Regarding the concentration of the solute in the solution):-

1- Saturated solutions

These solutions are in which the solute dissolves in the solution equal to what precipitates from it, meaning that the solute is in dynamic equilibrium with the solution, and the amount of solute remaining in the volume of the fixed solution at a certain temperature remains constant.

2-Un saturated solutions

These are solutions in which the solvent has the ability to dissolve another amount of the dissolved substance at that temperature because the concentration of the solution is less than the concentration of the saturated solution of the same substance, and therefore there is no kinetic equilibrium between the solute and the solvent.

3- Supper saturated solutions

These are solutions that contain a higher concentration than the saturated solution of the same dissolved substance. This happens as a result of the solvent being able to dissolve another amount of solute after raising its temperature. Such a solution is not in a stable state, and therefore it tends to precipitate the excess amount of solute over the saturation limit until it reaches the state of kinetic equilibrium, reaching the saturated solution.

Homogeneous solutions

It is a homogeneous molecular mixture of two or more substances that do not react with each other chemically. Its features include the regular distribution of molecules or ions of the solute in the solvent and the ease of recovering the solvent or solute from the solution and separating them from each other in simple ways. Solutions are not only produced by dissolving a solid substance in a liquid solvent, but solutions can be obtained from gaseous, liquid or solid substances.

Standard solution

These are solutions in which the specified volume contains a known weight of the dissolved substance. These solutions have a known and precisely defined concentration. Standard solutions with a fixed concentration are prepared by dissolving a precisely defined weight of a substance characterized by being of a high degree of purity and stability, called the primary standard substance, in a specific volume to give the exact necessary concentration. However, when the substance is not of a high degree of purity, then solutions of it with approximate concentrations are prepared, then their concentration is determined exactly with standard solutions of previously known concentrations, and these solutions are called secondary standard solutions.

Conditions of the standard substance

1- It has a known composition and is easy to obtain with a high degree of purity.

2-It is non-hydroscopic.

3-Its equivalent weight is large so that errors in the weight become negligible.

4-It is easily soluble in water.

5-The reaction with it must be one of the reactions that appear completely at the equivalence point.

6-The solution of the standard substance must not be colored.

7-It must not be affected by light, temperature, dust, and organic materials.

Examples of some primary standard materials

Acids and bases: oxalic acid, sodium carbonate, etc.

Precipitation: Ag NO3, KCl, NaCl, etc.

Oxidation and reduction: K2Cr2O7, KBrO4, etc.

Examples of some secondary standard materials

Ammonium hydroxide, nitric acid, phosphoric acid, sulfuric acid, glacial acetic acid.

The Buffer solutions

It is a solution consisting of a mixture of a weak acid and its salt, or a solution of a weak base and one of its salts. One of the properties of these solutions is that they resist changes in pH if a small amount of a strong acid or a strong base is added to the solution.

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Buffer capacity

It is the ability of a buffer solution to withstand quantities of strong acid or strong base without changing its pH except slightly. It depends on two factors:-

1- The ratio between the molecular concentration of salt and acid. The capacity reaches its maximum when the salt concentration equals the acid concentration.
2- The concentration of both salt and acid, as the capacity increases as the concentration increases.

Practical applications of buffer solutions

1- It is useful in the chemical reactions that take place in the body of a living organism (plant or animal), as human blood is a buffer solution (pH (7.4-6.8), and amino acids also work as a buffer solution.

2- Buffer solutions enter into many processes, including sedimentation processes, enzymatic reactions, and colorimetric determination. Elements are separated by extraction and ion exchange methods.

3- Proteins contain groups (COOH-) and (-NH_2) and other acidic and basic groups, and their salts represent systems that regulate pH.

Methods expressing of matter quantity

1- (Gram-Atomic weight) (At.wt)

It is the atomic weight of the element measured in grams.

2- (Gram Molecular weight) (mole)

It is the weight of the molecular formula of the compound or the molecular weight of the element, measured in grams. Calculated on the basis of the sum of the atomic weights of the elements that make it up, measured in grams.

Example:- What is the molecular weight of acetic acid if you know that the atomic weight of carbon and hydrogen and oxygen? It is 1, 12, 16 respectively.

Molecular weight (M. wt.) = Sum of Atomic weights

M. Wt. (CH_3COOH) =2 C + 4H + 2O

=2x12 + 4x1 +2x16 = 60 gm/mol.

Example:- What is the molecular weight of sulfuric acid?
If you know that the atomic weight of sulfur is 32

3-(Gram equivalent weight)

It is the equivalent weight of the element or compound, measured in grams. It is calculated as follows:

A // Equivalent weight of element (Eq.wt)

The atomic weight of an element is related to its equivalent weight and valency by the mathematical relationship:

Atomic weight = Equivalent weight (Eq.wt) x Valance

$$\text{Eq.wt of element} = \frac{\text{At.wt}}{\text{Valance}}$$

Example: What is the equivalent weight of calcium, **if you know that the atomic weight of calcium is 40?**

$$\text{Eq.wt of element} = \frac{\text{At.wt}}{\text{Valance}} = \frac{40}{2} = \textbf{20 gm/Eq.}$$

Example: What is the equivalent weight of sodium, **if you know that the atomic weight of sodium is 23?**

B//Equivalent weight of acid(Eq.wt)

It is the weight of the acid in grams that contains an equivalent weight of replaceable or ionizable hydrogen. There are three types of acids:

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Monobasic: $HClO_3$, CH_3COOH , HNO3, HCl

Dibasic H_2SO_4, H_2SO_3 , H_2S

Tribasic : H_3PO_4

Example: What is the equivalent weight of sulfuric acid, **if you know that the atomic weight of sulfur is 32?**

$$\text{Eq.wt of acid} = \frac{\text{Wt of molecular Formula}}{\text{No. of } H^+}$$

M.wt (H_2SO_4) = **Sum. Of At.wt**
= **2x1 + 32x1 + 4x16 = 98 g/mol**

$$\text{Eq.wt of } H_2SO_4 = \frac{98}{2} = 49 \text{ gm/Eq.}$$

Example: What is the equivalent weight of phosphoric acid, **if you know that the atomic weight of phosphorus is 31?**

C// Equivalent weight of Base

It is the weight in grams of the base that contains one equivalent weight of the replaceable hydroxyl.

$$\text{Eq.wt of base} = \frac{\text{Wt. of Molecular formula}}{\text{No. of } OH^-}$$

Example: What is the equivalent weight of calcium hydroxide?
If you know that the atomic weight of calcium is 40.

M.wt of $Ca(OH)_2$ = **Sum. Of At.wt**
= **40 x1 + 2x16 + 2x1 = 74 gm/mol**

$$\text{Eq.wt of base} = \frac{\text{Wt. of Molecular formula}}{\text{No. of } OH^-}$$

$$\text{Eq.wt } Ca(OH)_2 = \frac{74}{2} = 37 \text{ gm/Eq.}$$

Example: What is the equivalent weight of zinc hydroxide, given that the atomic weight of zinc is **25.38**?

D// Equivalent weight of Salts

The equivalent weight of salts is calculated in reactions in which there is no change in valences (acidity, base and precipitation reactions). The equivalent weight of a salt is its weight in grams that contains a weight of metal that can combine or replace an equivalent weight of hydrogen or its equivalent of non-hydrogen. An example of this is:-

1. Salts whose equivalent weights are equal to the weights of their molecular formula, such as:

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$AgCl$, $NaCl$,$AgNO_3$,$NaNO_3$

2 . A salts whose equivalent weights are equal to half the weights of their molecular formula, such as:

Na_2SO_4 , $CaCO_3$,$BaSO_4$

Example: Calculate the equivalent weight of sodium sulfate?

M.wt (Na_2SO_4) = Sum. Of At.wt

= 2x23 + 1x32 +4x16 = 142 gm/mol

$$\text{Eq.wt } (Na_2SO_4) = \frac{\text{M.wt}}{2} = \frac{142}{2} = 71 \text{ gm/Eq.}$$

Example: Calculate the equivalent weight of barium sulfate?
If you know that the atomic weight of barium is 137.33?