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كلية العلـــــوم
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المحاضرة الرابعة

Analytical Chemistry

المادة : كيمياء عامة
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Introduction to Analytical chemistry ,definition, scope and classification

Chemistry: is the study of matter, including its composition, structure, physical properties, and reactivity. It is divided into five fields: organic, inorganic, physical, biochemical, and analytical.

What is Analytical Chemistry?

Analytical chemistry is the branch of chemistry that deals with the analysis of different substances, and it involves the separation, identification, and the quantification of matter. by using of classical methods along with modern scientific instruments to achieve all these purposes.

The scope of analytical chemistry:

1. Identify and define the problem.
2. Design the experimental procedure.
3. Conduct an experiment, and gather data.
4. Analyze the experimental data.
5. Propose a solution to the problem.

Analytical chemistry consists of:

Qualitative Analysis: It deals with the identification of elements, ions or compounds present in the unknown sample.

Quantitative Analysis: It deals with the determination of the quantity of one

or more compounds of the sample.

• **What** chemical species are present in a sample ? (Qualitative Analysis)

• **How much** of each component is present ? (Quantitative Analysis).

This analysis can be divided into three types:

1. Volumetric Analysis(Titrimetric analysis) :

Base up on the measurement of the volume of the standard reagent to find the quantity of unknown substance.

2. Gravimetric Analysis:

Base up on the measurement of the weight of a precipitate to find the quantity of unknown substance.

3. Instrumental Analysis:

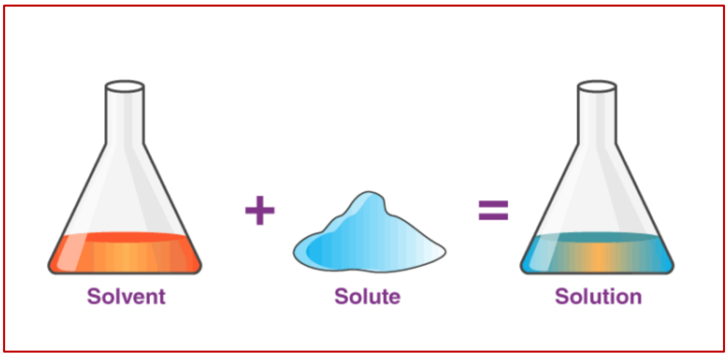
Is a field of analytical chemistry that investigates analyst using scientific instruments.

Well, we are speaking about the volumetric analysis, we shall consider, what the solutions are:

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 refered to as an **aqueous solution.**



Types of Solutions

It can be divided into two types:

1. Depend on the particle size of solute in solvent.

2. Depend on the concentration of solute in solvent.

- **Depend on the particle size of solute in solvent**

True solution.

Suspension solution: heterogeneous mixtures which settle on standing and its components can be separated by filtrating (Amoxicillin, Antibiotics), particle of solute visible to the naked eye.

Colloidal solution: homogeneous mixture which does not settle nor are their components filterable, solute particle visible with an electron microscope (milk).

We are now considered the standard solution which was defined as:

- **Depend on the concentration of solute in solvent**

Unsaturated solutions: if the amount of solute dissolved is less than the solubility limit, or if the amount of solute is less than the capacity of the solvent.

Saturated solutions: is one in which no more solute can dissolve in a given amount of solvent at a given temperature, or if the amount of solute equal to capacity of solvent.

Super saturated solutions: solution that contains a dissolved amount of solute that exceeds the normal solubility limit (saturated solution). Or a solution contains a larger amount of solute than the capacity of solvent at high temperature.

Methods of expressing concentration of solutions

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 .

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

Example1 :- Molar mass of glucose C_6H12O_6 :

$MC_6H_{12}O6 = \Sigma(6mole\ carbon + 12mole\ hydrogen + 6mole\ oxygen)atom$

$$MC_6H_{12}O_6 = 6\ x 12.0 + 12\ x\ 1.0 + 6\ x\ 16.0 = 180 \text{ g /mole}$$

Important Relations:-

M.wt = g /mole or mg /mmole

No. of moles = wt(g) / M. wt(g)

Wt (g) = No. of moles x M.wt

Mole =10^3mmole , mmole = 10^{-3}mole

Example2: 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:

$Na_2SO_4 \longrightarrow 2Na^+ + SO_4^{2-}$

1mole 2mole 1mole

moles of Na_2SO_4 (nNa_2SO_4) = $\frac{\text{Wt(g)Na2SO4}}{M.Wt(g)Na2SO4} = \frac{25}{142} = 0.176$

No. of moles of Na+(nNa+)= Number of moles Na_2SO_4 x 2

No. of moles of Na^+($n$$Na^+$)= 0.176 x 2 = 0.352 moles Na^+

Wt (g) = No. of moles x M.wt

Weight of Na^+(g) = moles Na+ x 22.99(g) Na+

Weight of Na^+(g) = 0.352 x 22.99 = 8.10 (g) Na^+

Hints

-No. of moles of Na+ (*n*Na+) in NaCl is = 1 x No. of moles of NaCl as

$NaCl \longrightarrow Na^+ + Cl^-$

1 mole 1 mole

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

$Na_3PO_4 \longrightarrow 3Na^+ + PO_4^{3-}$ (1 moleNa_3PO_4 3molesNa^+)

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 K_2SO_4 = ?

2. No. of moles of K+ (*n*k+) in KNO_3 = ?

3. No. of moles of Mg2+ (nMg^{2+}) in $MgSO_4$ = ?

4. No. of moles of Fe3+ (nFe^{3+}) in $FeCl_3$ = ?

5. No. of moles of Cl^- (nCl^-) in $FeCl_3$ = ?

1. Formality (F).
2. Molarity (M).
3. Normality (N).
4. Percent composition (%).
5. Parts per million (ppm) .
6. Molality (m).

1. Formality (F)

- Defined as the number of formula weight of substance dissolved per liter of the solution.
- Unit of formality is (F).

$$F = \mathbf{Wt/\ F.\ wt\ \times 1000/\ Vml}$$

2. Molarity (M)

- A concentration that is defined as the number of moles per Liter of solution (solvent).

- Unit of molarity is (M) or (mol / L).

$$\mathbf{M = Wt/\ M.\ wt \times 1000/\ Vml}$$

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:

$$\mathbf{M = Wt/\ M.\ wt \times 1000/\ Vml}$$

$$\mathbf{M = 2.02/\ 101 \times 1000/\ 2000 = \ 0.1\ \ M}$$

Example:

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

Solution:

$$\mathbf{M = Wt/\ M.\ wt \times 1000/\ Vml}$$

$$\mathbf{VmL = Wt \times 1000/M.wt. \times M}$$

$$\mathbf{=7.3 \times 1000/36.5 \times 12}$$

$$\mathbf{VmL = 16.7mL}$$

3. Normality (N)

- A concentration that is defined as number of equivalent per Liter of solution (solvent).

- Unit of normality is (N).

$$N = \mathbf{Wt / Eq.\ wt \times 1000 / Vml}$$

4. Percentage Compositions

There are three ways:

A. Weight / Weight W/W%

B. Volume / Volume V/V%

C. Weight / Volume W/V%

A. Weight / Weight W/W%

- Weight / Weight W/W% : grams of substances per 100 g of sample.

$$\frac{W}{W}\% = \frac{Wt\ of\ solute\ in\ g}{\text{wt of solution in g}} \times 100$$

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:

$$\frac{W}{W}\% = \frac{Wt\ of\ solute\ in\ g}{\text{wt of solution in g}} \times 100$$

$$10\% = \frac{Wt\ of\ solute\ in\ g}{25} \times 100$$

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

- Volume / Volume V/V% : ml of solute within100 ml of solvent for dilute solution.

$$\frac{V}{V}\% = \frac{V\ of\ solute\ in\ mL}{\text{Vof solution in mL}} \times 100$$

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:

$$\frac{V}{V}\% = \frac{V\ of\ solute\ in\ mL}{\text{Vof solution in mL}} \times 100$$

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

$$volume\ of\ acrtic\ acid = \frac{7.5 \times 500}{100} = 37.5\ mL$$

❖ Weight / Volume W/V% : gram of solute per 100 ml of solvent.

$$\frac{W}{V}\% = \frac{Wt\ of\ solute\ in\ g}{\text{V of solution in mL}} \times 100$$

Example: Calculate the $(\frac{W}{V})$ % 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:

$$\frac{W}{V}\% = \frac{Wt\ of\ solute\ in\ g}{\text{V of solution in mL}} \times 100$$

$$\frac{W}{V}\% = \frac{5gm}{\text{250 mL}} \times 100 = 2\%$$

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.

5. Part Per Million (ppm)

- When the amount of solute present in the solution in very less quantities, the concentration expressed as part per million (ppm).
- Defined as one part of solute in million parts of solution.

$$PPM = \frac{Wt\ of\ solute\ in\ mg}{\text{V of solution in L}} \times 100$$

6. Molality (m)

- **Number of moles of solute (n) per (Kg) of solvent this concentration is used for very specified preparation.**
- **Unit of molality is m = mol / Kg**

$$Molality = \frac{no.moles\ of\ solute}{\text{1000 gm of solvent}} \times 100$$

$$No.Moles = \frac{wt\ of\ matter}{m.wt\ of\ matter} \times 100$$