General Chemistry Theoretical

First stage / Department of Physics

أستاذ المادة

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Analytical chemistry

It is a science that primarily focuses on determining the chemical composition of substances. In general, it identifies the quality and quantity of an unknown substance. It is the science that involves analyzing materials to determine their components quantitatively and qualitatively.

(Table showing System International units)

SI = System International

Unit Symbol رمز الوحدة	Unit الوحدة	Quantity Symbol رمز الكمية	Physical Quantity الكمية الفزيائية
M	Meter المتر	L	Length الطول
Kg	Kilogram الكيلوغرام	m	mass الكتلة
Hz	Hertz هيرتز	r	frequency التردد
N	Newton نيوتن	F	Force القوة
C	Coulomb كولوم	i	Current كمية التيار
J	Joule جول	E	Energy الطاقة
W	Watt واط	P	Power القدرة
K	Kelvinكلفن	T	Temperature الحرارة
H	Hour ساعة	t	time الزمن
Π	Ohm اوم	R	Resistance المقاومة
A°	Angstrom انكستروم	λ	Wave lengthالطول الموجي

(Experimental quantities)

Measurement القياس	Quantity الكمية
Kg , gm, mg , µ g , ng	Mass الكتلة
L, ml , µl	Volume الحجم
m , mm ,µm,	Length الطول
min , Sec.	Time الوقت
C° , F° , K (C° = F° -32/1.8)	Temperature الحرارة
Cal = 4.18 J	Energy الطاقة

(The Measurements in Chemistry)

1 milliliter (ml) = $\frac{1}{1000}$ Liter = 0.001 liter = 10^{-3}liter

1 microliter (µl) = $\frac{1}{1000,000}$ Liter = 10^{-6} liter

1mililiter (ml) = 1000µl

1 milligram (mg) = $\frac{1}{1000}$ gm = 0.001 gm = 10^{-3} gm

1 microgram (µg) = $\frac{1}{1000,000}$ gm= 10^{-6}gm

1 Kilogram (Kg) = 1000 gm

1 Kilometer = 1000 meter

1 millimeter (mm) = 10^{-3} meter

1 micrometer (µm) = 10^{-6} meter

(The Matter and their properties)

Matter- : is anything that has mass and occupies space. Any change in matter always involves a loss or gain of energy. Substances possess both physical and chemical properties, which are:

(Physical properties) :-

The properties that give substances their identity, apart from their chemical composition, include color, taste, smell, boiling point, melting point, and compressibility."

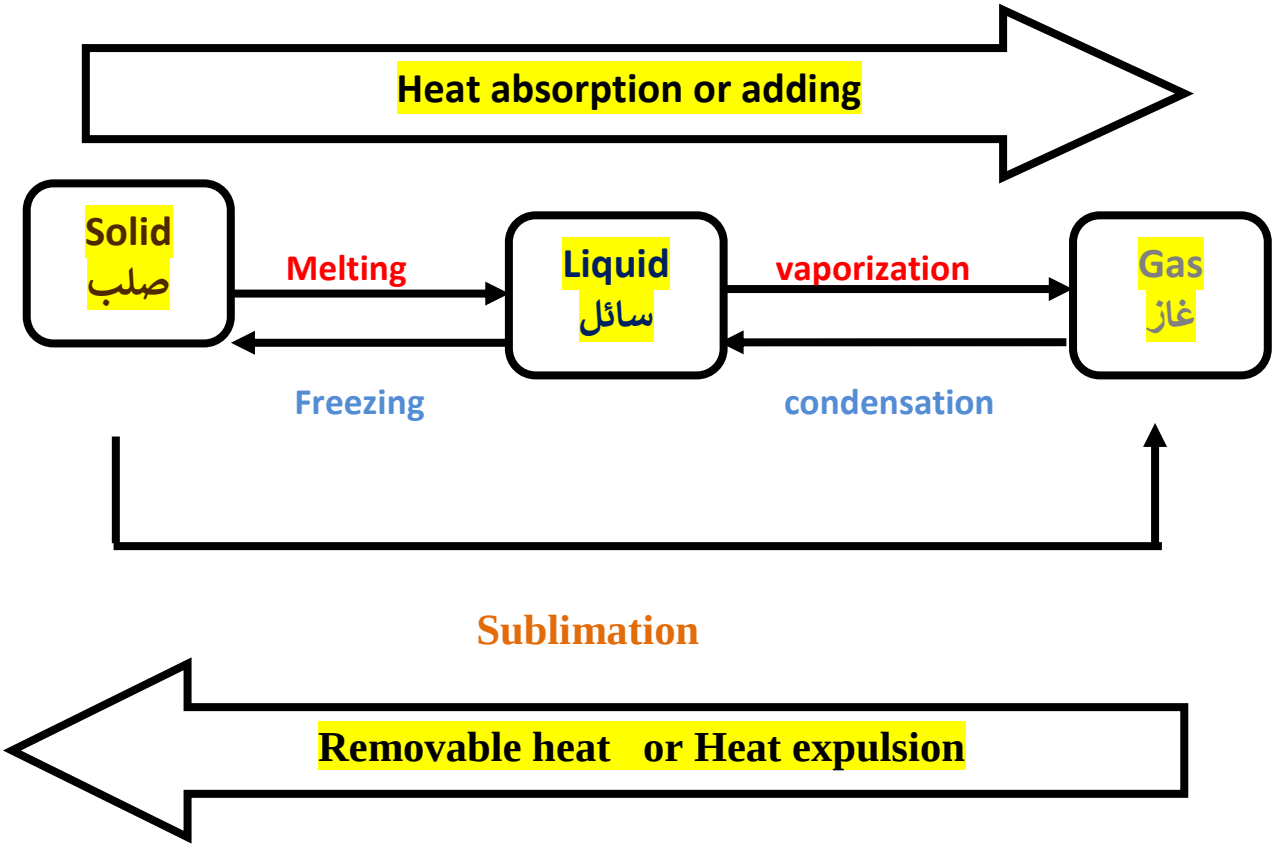
(Chemical properties) :-

The properties or changes that include a change in the composition of materials, and they are of two types: -

1- Intensive property: - does not depend on the amount of matter, such as density, for example, the density of a drop of water is the same as the density of a liter of water or specific weight.

2- Extensive property: - It depends on the amount of matter: mass and volume.

Physical states



(Types of Matters)

1- Pure materials: - **are materials that do not decompose in simple chemical reactions of two or more different materials, such as compounds and elements. An example of this is compounds and elements.**

2- Mixture: - **includes impure materials that contain many materials that overlap with each other and are of two types: -**

A- Homogeneous, whose parts cannot be distinguished,

B-Heterogeneous, whose parts can be distinguished.

(Types of analysis in chemistry)

1-Qualitative analysis

2-Quantitative analysis

3-Instrumental analysis

1. **Qualitative analysis: - is a group of processes aimed to identifying the materials or compounds that make up a specific substance is revealed or a mixture of materials, whether in the solid state or liquid in a specific solvent (i.e. what is the substance composed of).**

This analysis does not exposed to the quantities of these components at all.

2. **Quantitative analysis: - It seeks to quantify the amounts of components or elements present in a chemical compound or mixture (i.e., what is the quantity of each component present in the substance and what is its percentage?). Qualitative analysis precedes quantitative analysis when identifying an unknown substance. There are two types of quantitative analysis: organic quantitative analysis and inorganic quantitative analysis."**

Quantitative analysis methods

First// Gravimetric analysis, Gravimetric analysis methods

Quantitative analysis by weight is done by precipitating the material to be estimated as a single element (the cathode) or a specific derivative of known composition (adding a precipitating agent) that is separated from the solution by precipitation or centrifugation, then washing, drying and weighing it, where the weight of the material to be estimated is calculated from our knowledge of the weight

of the precipitate and its composition accurately or by using the cathode in the electrolytic cell, a specific weight of the metal will be deposited on it according to its passing electrical quantity that can be dried and weighed, so electrolytic precipitation analysis can be considered a type of quantitative gravimetric estimation. ميفصل

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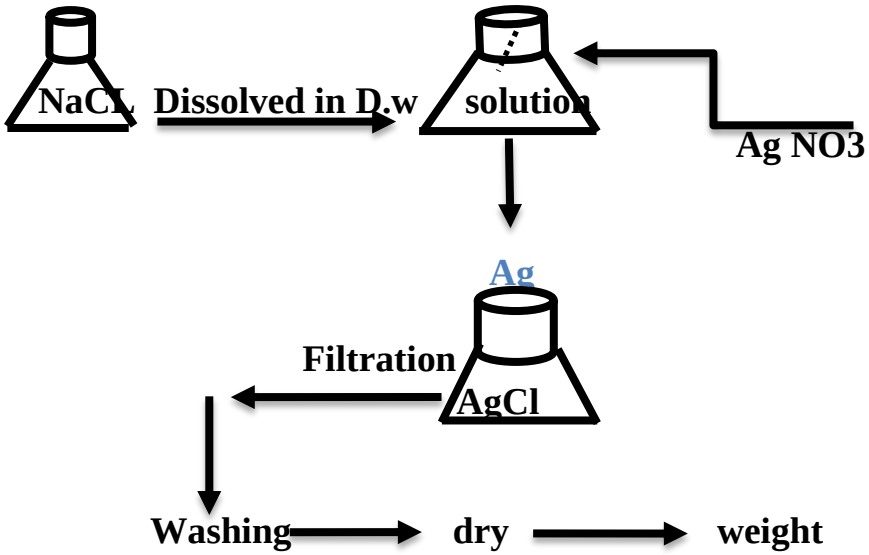
Example// How to determine the chlorine content in commercial table salt?



Gravimetric analysis methods include two methods in which the weights of materials or some of their components are estimated: -

A- Direct method: In which that determined the weight measurements of the products of the analytical process with a known composition.

B:-Indirect method: In which that determined the measurements of the lost weights or the loss in weight as a result of the sample's property of volatilization of species.

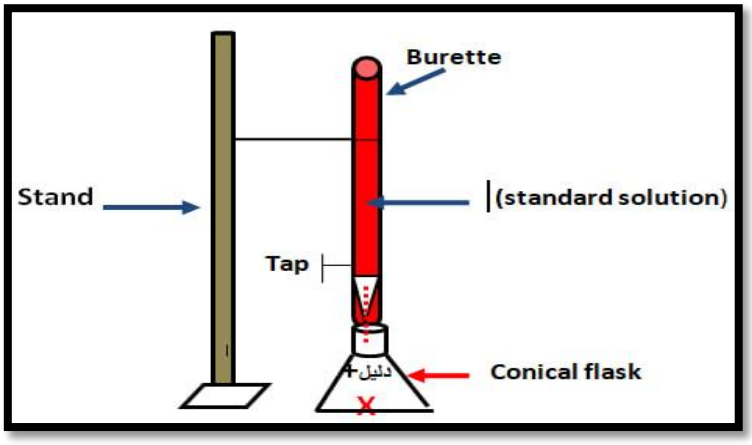
Second// Volumetric Analysis Methods or Volumetric Analysis:-

Indirect methods are used in this analysis to determine the weights of materials or some of their components. These methods include titration and gaseous analysis as follows:

A- Titration:-

It is one of the most important methods used in quantitative analysis. It is a quick process that includes the use of solutions with known concentrations (standard) known as the standard solution, It interacts quantitatively with the substance to be estimated (titrated) to the extent that it is revealed by the reactions of indicators that include a sharp change in the properties of the solution such as color or turbidity that is observed by the naked eye or measurement by physical chemical methods such as: - Measuring the potential difference or electrical conductivity. From knowing the volume of the standard solution (known volume and concentration), we calculate the weight of the substance to be estimated using chemical laws.

Endpoint: It is the point at which it appears that the reaction has taken place due to a physical change in the color of the solution or the appearance of a precipitate.



Equivalent point: - It is the point at which the amount of standard solution added from the burette is chemically equivalent to the amount of the analyst matter.

It is difficult to determine with extreme accuracy and its difference from the end point must be so small that it can be neglected.

How is the titration process done?

By adding one of the two solutions from a tube called a Burette to a small beaker containing a specific volume and accurately measured Pipette. This addition continues until the reaction between them is complete. After the titration is completed, we can use the pipette to calculate the weight from the laws of chemical equivalence and determine the volume of the standard solution used for the unknown substance or the weight ratios of the components in it, either directly or indirectly.

Conditions of the titration process:-

1- The process must represent a simple reaction that can be expressed by an equivalent chemical equation.

2- The reaction must occur and proceed very quickly.

3- The reaction must have a clear end point.

4- The reaction must be quantitative, with the equilibrium of the reaction pointing to the far right.

Indicators:-

They are weak organic acids or weak organic bases that change color or emit flash at a certain temperature (PH) by adding an acid or base. Most of these indicators have two or more contrasting colors, one of which appears in an acidic medium and the other appears in a basic medium. They are known as dichromatic indicators, such as bromophenol blue (yellow in an acidic medium and blue in a basic medium). While there are some monochromatic indicators, such as phenolphthalein (colorless in an acidic medium and purple in a basic medium).

Explanation of the work of indicators:

There are several theories to explain the change in the color of the indicator during titration, including the ionic theory, which defined indicators as weak organic acids or weak organic bases that ionize in solution such that the ion is characterized by a color that differs from the color of the unionized molecule, as in the following equation:

$$HInd \rightleftharpoons H^{+} + In$$

Types of reactions used in volumetric analysis:-

1- **Neutralization reactions:** These are reactions in which there is no change in the valence of the reactants.

2- **Precipitation reactions:** These are reactions in which the reaction depends on the complete precipitation of the substance.

3- **Oxidation and reduction reactions:** These reactions include the combination of the ions of the reactants accompanied by a change in their valences or the transfer of electrons.

Volumetric titration methods (types of titration):-

First:- **The volumetric analysis method by equilibration (acid-base titrations):- It depends on the formation of salt and water at the end of the reaction.**

Second:- **The volumetric analysis method by precipitation (precipitation titrations):- The end of the reaction depends on the complete precipitation of the substance and the precipitate may react after its formation with the precipitated substance forming complex ions.**

The volumetric analysis method by precipitation can be done in two ways, which are:

A-Direct methods: -

These are the titration processes whereby a silver nitrate solution is added to the unknown solution until the reaction end point is reached. The known methods include the following:

First // Mohr's method:-

It is a direct correction method that is widely used to correct the chloride and bromide ions with a standard solution of silver nitrate and uses potassium chromate as an indicator (the indicator changes color from yellow to reddish-brown) to determine the end point of the reaction by forming a red precipitate. It is preferable for the pH value of the solution to be between 7-10.

$$AgNO_3 + NaCl \longrightarrow AgCl\downarrow + NaNO_3$$

$$K_2CrO_4 + AgNO_3 \longrightarrow Ag_2CrO_4\downarrow + 2\,KNO_3$$

Red precipitate

Second//Fajan's Method

It is a direct titration method that depends on the adsorption of some organic compounds (adding adsorption indicators) on certain sediments, followed by a color change at the end point of the reaction due to the formation of new complexes of different colors (the organic dye is strongly adsorpted, forming a red complex). One of the indicators used in the Fayan method is fluorescein dye, where the color of the indicator changes from greenish yellow to pinkish red. The indicator is added to a neutral solution of chloride, bromide, or thiocyanate to titrate it with silver nitrate.

$$2NaCl + AgNO_3 \longrightarrow 2AgCl: Cl^- : Na^+$$

$$AgCl: Ag^+: NO^-_3$$

$$AgCl: Ag^+: Fl^-$$

Complex red color

B - Indirect methods:-

These methods rely on the formation of colored complexes. One such method is Volhard's method, which employs a standard solution of potassium or ammonium thiocyanate to titrate silver ions, using ferric salt as an indicator in a strongly acidic medium to prevent the decomposition of ferric complexes used as indicators in the titration process. Any excess thiocyanate forms a red complex with ferric ions. Ferric compounds (such as ferric sulfate or ferric nitrate), acidified with concentrated nitric acid, are used as indicators. The color of the solution changes from colorless to red upon the addition of AgNO3. The same thiocyanate can be used to titrate standard solutions of iodide, cyanide, and bromide, as shown in the following equations:

$$AgNO_3 + NH_4SCN \rightleftharpoons AgSCN + NH_4NO_3$$

$$6NH_4SCN + Fe_2(SO_4)_3 \rightleftharpoons 2\,Fe(SCN)_3 + 3(NH_4)_2SO_4$$

Complex red

B- Gas Analysis

In it, the substance is estimated by estimating the volume of gas that is consumed or produced. This method measures the quantity of gases produced. It is considered the resulting substance, and it may be the substance to be estimated or a product of the reaction of that substance with other substances, such that it produces a gas that can be estimated.

3-Methods of instrumental or physicochemical analysis:-

These methods depend on measuring some properties that are qualitatively related directly or indirectly to the concentration of the materials to be analyzed quantitatively, such as their physical or chemical properties such as density, color, refractive index, electrical conductivity, etc.

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