

## Renewable Energy Dep.

### THE first lecture

#### Introduction :

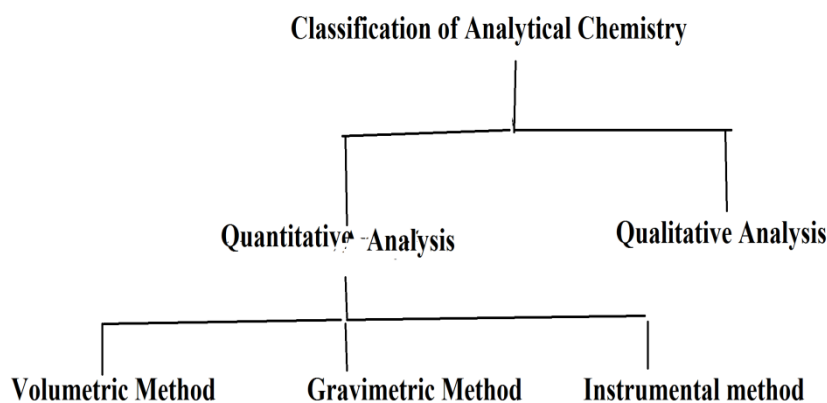
**Chemistry** is the science that deals with the nature of compounds (composition , structure , properties ) and the changes in the composition of matter .

#### **Branches of Chemistry**

The field of chemistry is divided into branches such as :

- . **General chemistry** is the study of the properties , composition and reaction of matter .
- . **Organic chemistry** is the study of compounds that contain the element carbon .
- . **Inorganic chemistry** is the study of all other substances except those that contain the element carbon .
  
- . **Analytical chemistry** the branch of chemistry that is concerned with
  - \_ The identification of substances present in sample .
  - \_ The amount of each that is present .

## Classification of analytical chemistry



**A- Qualitative Analysis** : Determination of chemical identity of the species in the sample .

**B- Quantitative Analysis** : Determination of **amount of** species or analysis , in numerical terms .

In order to perform quantitative analysis , complete qualitative analysis is needed .

### Classification of quantitative method of analysis

**A – Volumetric Method** : Volume is measured or used to determined amount of sample via concentration .

**B—Gravimetric method** : Mass is measured .

**C- Instrumental Method** : Use an Instrumental technique to assay the amount of sample , such as visible

Spectrophotometer based upon light absorption.

Today , chemistry is often combined with other sciences such as geology , biology and physics to form geochemistry , biochemistry and physical chemistry .

. **Geochemistry** : The study of the chemical composition of ores , soils and minerals of the surface of earth and other

. **Biochemistry** : The study of the chemical reactions that place in biological systems .

. **Physical chemistry** : The study of the physical nature of chemical system including energy changes .

## **Matter**

Matter is anything that has mass and occupies space example car and your body are all composed of matter.

**Mass** : Is defined as the amount of matter in an object .

## **Physical states of matter :**

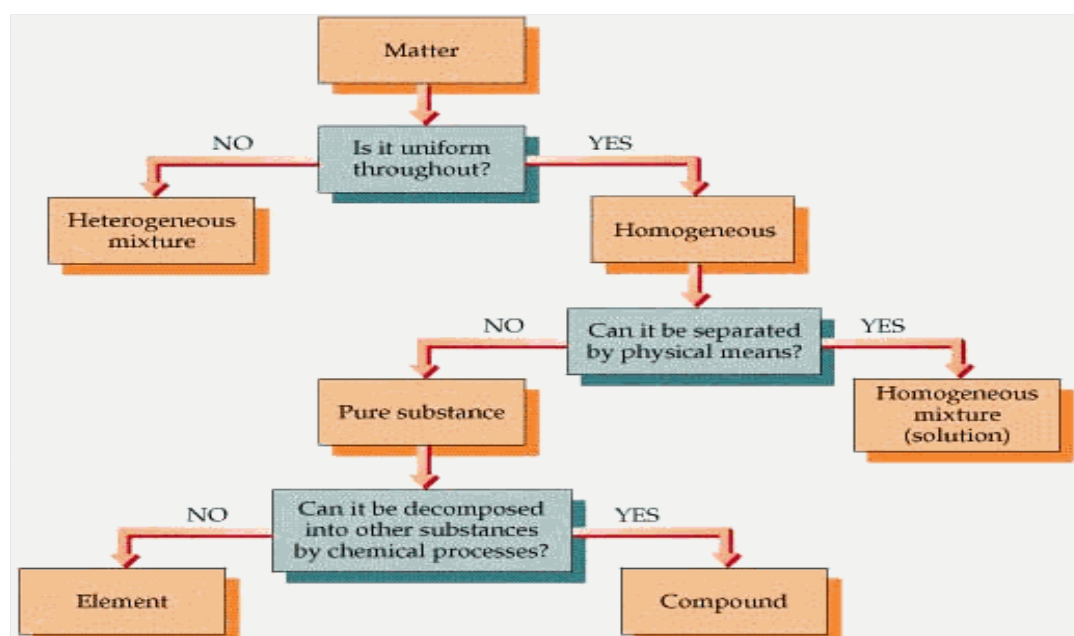
In general , We can group all matter into three groups called states of matter :

1- **Solid** is the physical state characterized by a definite shape and a definite volume, examples of solids are rocks and sand .

2- **Liquid** is the physical state characterized by a definite shape and a definite volume . That is , they take the shape of their container, examples of liquid are water & oil

3- **Gas** is the physical state characterized by a indefinite shape and an indefinite volume . They assume not only the shape of their container , but also the volume of their container. Gasses may be expanded or compressed to fit the container in which they are being placed .

By asking these questions scientists can classify matter into : Mixtures & Elements & Compounds



**H.W**

**Q1: What are the methods of classification of quantitative analysis.**

**Q2 : Define the homogeneous matter . And explaining the homogeneous matter that cannot it be separated by physical method .**

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### THE second lecture

**Mixtures** : Two or more substances that are not chemically combined with each other and can be separated by physical means . The substances in a mixture retain their individual properties .

**Heterogeneous mixtures** : Made of multiple substances, are not uniform throughout the sample, whose presence can be seen. Portions of a sample have different composition and properties .

**Homogeneous mixtures** : Made of multiple substances, are uniform throughout the sample, but appears to be one substance . Air is a gaseous mixture of ( primarily ) oxygen and nitrogen .

**Solution** : a special kind of mixture where one substance dissolves in another, the most common type of solution is described by a solid ( solute ) dissolved in a liquid(solvent) or have an invariable composition and are composed of either elements or compounds .

**Elements** : Simplest form of pure substance . They cannot be broken into anything else by physical or chemical means .

- In 1813, a system of representing elements with symbols was introduced.
  - Each symbol consists of one or two letters (one capital letter plus two small letter ).
  - Two letters are needed for a chemical symbol when the first letter of that element's name has already been used.

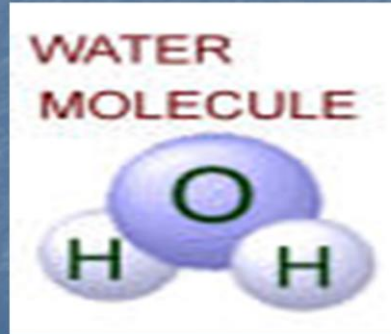
### Common Elements

Aluminum	Al
Bromine	Br
Calcium	Ca
Carbon	C
Gold	Au
Helium	He
Hydrogen	H
Nitrogen	N

**Compound** : Pure substances that are the unions of two or more elements . They can be broken into simpler substances by chemical means.

# Compounds

- Compounds are also pure substances.
- But compounds are made from more than one element.
- Water is a compound.
- Water can be broken down into simpler substances – hydrogen and oxygen.



## Properties of the matter

Properties can also be classified as either physical and chemical, depending on whether the property involves a change in the chemical makeup of substance.

- **physical Properties** are the characteristics of matter that do not involve a change in sample composition
- **Chemical Properties** are the characteristics that determine how the composition of matter changes as a result of the influence of energy.



Same example of physical and chemical propertiesphysical properties

Temperature  
Color  
Solubility  
Thermal conductivity  
Electrical conductivity  
Malleability

chemical properties

Combustion  
Acidity  
Basicity  
Explosive  
Oxidizing  
Reducing

**Units of Measurement**

Chemistry is an experimental science . But if our experiments are to be reproducible , we must be able to describe fully the substances we are working with their amounts, volumes, temperatures and so forth . Thus, one of the most important requirements in chemistry is that we have a way to measure things . Under an international agreement concluded in 1960 , scientists throughout the world now use the **International System of Units** for measurement , abbreviated **SI** for the French System International Units . Based on the metric system ,

which is used in all industrialized countries of the world except the United States , the SI system has seven ( 7) fundamental units .

### The Seven Fundamental SI Units of Measure

<u>Physical Quantity</u>	<u>Name of Unit</u>	<u>Abbreviation</u>
Mass	Kilogram	Kg
Length	Meter	M
Temperature	Kelven	K
Time	Second	S
Amount of Substance	Mole	Mol
Electric Current	Ampere	A
Luminous Intensity	Candela	Cd

**The Mole** : The mole is the SI unit for the amount of a chemical species , it is always associated with a chemical formula and represents Avogadro's number  $6.022 \times 10^{23}$  of particles represented by that formula .

**The molar mass** of a substance is the mass in grams of 1 mole that substance , molar masses are calculated by summing the atomic masses of all the atoms appearing in a chemical formula

## Atomic Mass Units and the Mole

The masses for the elements listed in the table inside the back cover of this text are relative masses in terms of **atomic mass units ( amu ) or Daltons**. The molar mass of any other element is the mass in grams of  $6.022 \times 10^{23}$  atoms of that element and is numerically equal to the atomic mass of the element in **amu** units . Thus , the atomic mass of naturally occurring oxygen is 15.9994 gm .

### Atoms :

Atoms meaning indivisible the ultimate building blocks of matter , the final division of matter such as results as graphite results in atoms of the element carbon .

### **What are atoms comprised ?**

- \* Neutron : Electrically neutral , found in nucleus , have mass .
- \* Protons : Positively charged , found in nucleus , have mass .
- \* Electrons : Negatively charged , encircle the nucleus , do not have mass .

### **How do we describe atoms ?**

We define different atoms based upon the number of each of their three component Neutrons , Protons , Electrons .

\* Atoms are usually neutral . The number of electrons equals the number of protons .

\* The atomic mass describes the sum of protons and neutrons .

### Atomic Number

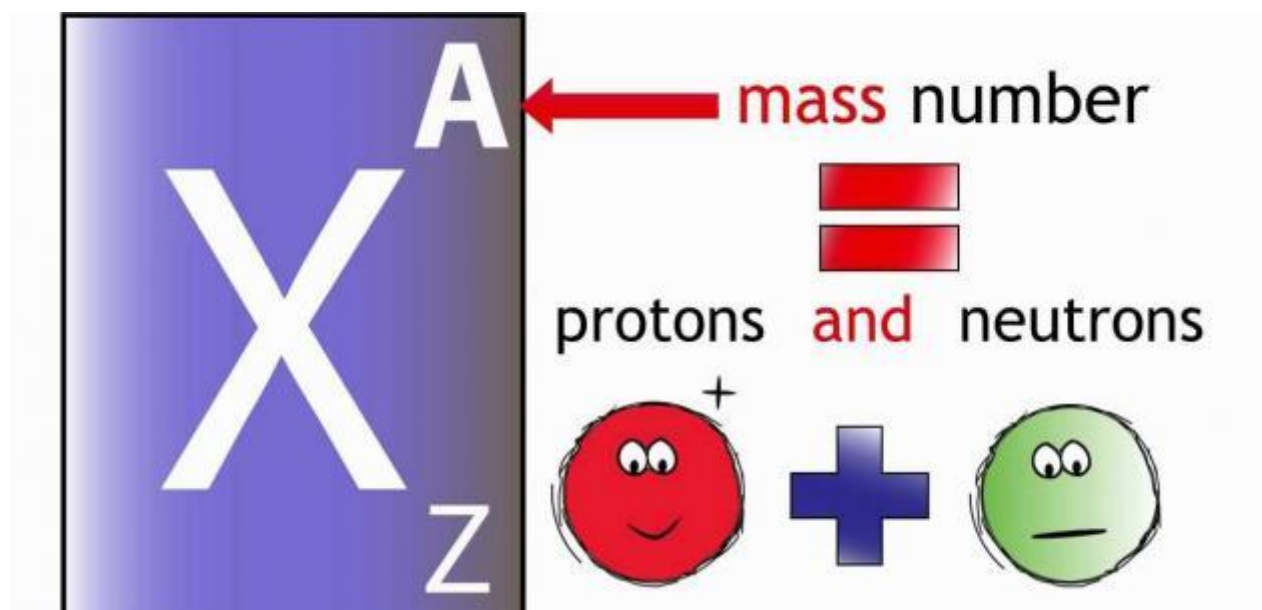
Elements differ from one another according to the number of the protons in their atoms, a value called the elements atomic number.

The atomic number of an atom is equal to the number of protons in the nucleus of the atom . For example , a carbon atom has six protons in its nucleus, therefore , the atomic number of carbon is six .

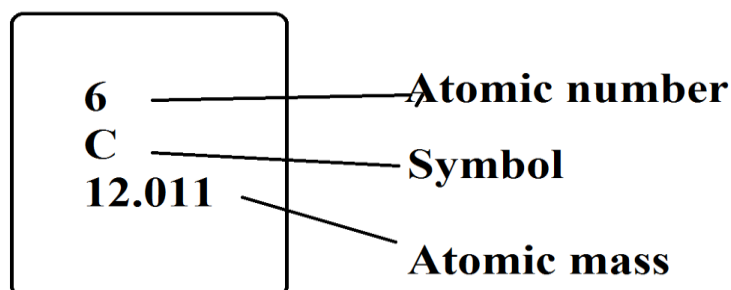
### Mass Number or Atomic Weight or Atomic Mass

The total number of neutrons and protons present in the nucleus of an atom of an element.

Mass No. = No. of protons + No. of neutrons



The atomic weight of an atom is equal to the number of protons in the nucleus of the atom plus the number neutrons in the nucleus of the atom . Therefore , a carbon atom with six protons and six neutrons has an atomic weight of **12** .



**Question :** The atomic number of an element is 17 and the number of neutrons in its atom is 18. Find the mass number of the element?

**Solution:**

Atomic number or number of protons = 17

Number of neutrons = 18

Mass number= Number of protons + Number of neutrons

Mass number= 17 + 18

Mass number= 35

H.W :

Q1: The atomic number of an element is 17 and the number of neutrons in its atom is 18 .

1 – Find the atomic mass and mass number of the element .

2 – Explain the relationship between atomic mass and mass number .

## Renewable Energy Dep.

### THE third lecture

#### Isotopes

Isotopes are atoms of an element that have the same number of protons and the same number of electrons but different number of neutrons .

**Different Isotopes** always have the same atomic number and different mass number .

For example , three isotopes of hydrogen exist :  $^1\text{H}$  ,  $^2\text{H}$  ,  $^3\text{H}$

$^1\text{H}$  , have single proton and no neutron in its nucleus,  
hydrogen -1 is by far the most abundant isotope ( 99.985 %)

$^2\text{H}$  , have single neutron and addition single proton in its nucleus,

hydrogen – 2 , has abundance of ( 0.015 % )

$^3\text{H}$  , have two neutron and addition single proton in its nucleus,

#### **Characterized isotopes**

- Isotopes of an element have the same chemical properties
- Their , physical properties are often slightly different
- All isotopes of an element have the same number of protons

- **Isotopes of an element have different numbers of neutrons**
- Isotopes are identified by three mass number

### **Name of the three isotopes of hydrogen**

**a- Protium   b- Deuterium   c- Tritium**

a- **Protium** : have one proton and no neutrons, therefore mass number = 1

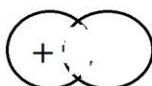
b- **Deuterium** : have one proton and one neutrons, therefore mass number = 2

c- **Tritium** : : have one proton and two neutrons, therefore mass number = 3

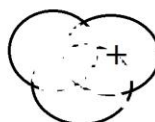
a- : have one proton and one neutrons, therefore mass number = 2



**Protium**



**Deuterium**



**Tritium**



## The Periodic Table

The periodic table is organized into groups and periods. The legend identifies the following categories:

- Other nonmetals (Light green)
- Alkali metals (Orange)
- Alkaline earth metals (Yellow)
- Noble gases (Light blue)
- Metalloids (Teal)
- Halogens (Cyan)
- Transition metals (Red)
- Post-transition metals (Grey)
- Lanthanoids (Light red)
- Actinoids (Purple)

For elements with no stable isotopes, the mass number of the isotope with the longest half-life is in parentheses.

57	58	59	60	61	62	63	64	65	66	67	68	69	70	71
La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
89	90	91	92	93	94	95	96	97	98	99	100	101	102	103
Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

***Elements Listed by Chemical Name***

[Actinium](#)      [Ac](#) [89](#)

[Aluminum](#)    [Al](#) [13](#)

[Americium](#)    [Am](#) [95](#)

[Antimony](#)     [Sb](#) [51](#)

[Argon](#)         [Ar](#) [18](#)

[Arsenic](#)        [As](#) [33](#)

[Astatine](#)      [At](#) [85](#)

[Barium](#)         [Ba](#) [56](#)

[Berkelium](#)     [Bk](#) [97](#)

[Beryllium](#)     [Be](#) [4](#)

[Bismuth](#)       [Bi](#) [83](#)

[Bohrium](#)       [Bh](#) [107](#)

[Boron](#)          [B](#) [5](#)

[Bromine](#)        [Br](#) [35](#)

[Cadmium](#)       [Cd](#) [48](#)

[Calcium](#)        [Ca](#) [20](#)

[Californium](#)   [Cf](#) [98](#)

[Carbon](#)         [C](#) [6](#)

[Cerium](#)         [Ce](#) [58](#)

[Cesium](#)        [Cs](#) [55](#)

[Chlorine](#)      [Cl](#) [17](#)



<a href="#">Indium</a>	<a href="#">In</a> <a href="#">49</a>
<a href="#">Iodine</a>	<a href="#">I</a> <a href="#">53</a>
<a href="#">Iridium</a>	<a href="#">Ir</a> <a href="#">77</a>
<a href="#">Iron</a>	<a href="#">Fe</a> <a href="#">26</a>
<a href="#">Krypton</a>	<a href="#">Kr</a> <a href="#">36</a>
<a href="#">Lanthanum</a>	<a href="#">La</a> <a href="#">57</a>
<a href="#">Lawrencium</a>	<a href="#">Lr</a> <a href="#">103</a>
<a href="#">Lead</a>	<a href="#">Pb</a> <a href="#">82</a>
<a href="#">Lithium</a>	<a href="#">Li</a> <a href="#">3</a>
<a href="#">Livermorium</a>	<a href="#">Lv</a> <a href="#">116</a>
<a href="#">Lutetium</a>	<a href="#">Lu</a> <a href="#">71</a>
<a href="#">Magnesium</a>	<a href="#">Mg</a> <a href="#">12</a>
<a href="#">Manganese</a>	<a href="#">Mn</a> <a href="#">25</a>
<a href="#">Meitnerium</a>	<a href="#">Mt</a> <a href="#">109</a>
<a href="#">Mendelevium</a>	<a href="#">Md</a> <a href="#">101</a>
<a href="#">Mercury</a>	<a href="#">Hg</a> <a href="#">80</a>
<a href="#">Molybdenum</a>	<a href="#">Mo</a> <a href="#">42</a>
<a href="#">Moscovium</a>	<a href="#">Mc</a> <a href="#">115</a>
<a href="#">Neodymium</a>	<a href="#">Nd</a> <a href="#">60</a>
<a href="#">Neon</a>	<a href="#">Ne</a> <a href="#">10</a>
<a href="#">Neptunium</a>	<a href="#">Np</a> <a href="#">93</a>
<a href="#">Nickel</a>	<a href="#">Ni</a> <a href="#">28</a>
<a href="#">Nihonium</a>	<a href="#">Nh</a> <a href="#">113</a>
<a href="#">Niobium</a>	<a href="#">Nb</a> <a href="#">41</a>
<a href="#">Nitrogen</a>	<a href="#">N</a> <a href="#">7</a>
<a href="#">Nobelium</a>	<a href="#">No</a> <a href="#">102</a>
<a href="#">Oganesson</a>	<a href="#">Og</a> <a href="#">118</a>
<a href="#">Osmium</a>	<a href="#">Os</a> <a href="#">76</a>
<a href="#">Oxygen</a>	<a href="#">O</a> <a href="#">8</a>
<a href="#">Palladium</a>	<a href="#">Pd</a> <a href="#">46</a>
<a href="#">Phosphorus</a>	<a href="#">P</a> <a href="#">15</a>
<a href="#">Platinum</a>	<a href="#">Pt</a> <a href="#">78</a>
<a href="#">Plutonium</a>	<a href="#">Pu</a> <a href="#">94</a>
<a href="#">Polonium</a>	<a href="#">Po</a> <a href="#">84</a>
<a href="#">Potassium</a>	<a href="#">K</a> <a href="#">19</a>
<a href="#">Praseodymium</a>	<a href="#">Pr</a> <a href="#">59</a>
<a href="#">Promethium</a>	<a href="#">Pm</a> <a href="#">61</a>

<a href="#">Protactinium</a>	<a href="#">Pa</a> <a href="#">91</a>
<a href="#">Radium</a>	<a href="#">Ra</a> <a href="#">88</a>
<a href="#">Radon</a>	<a href="#">Rn</a> <a href="#">86</a>
<a href="#">Rhenium</a>	<a href="#">Re</a> <a href="#">75</a>
<a href="#">Rhodium</a>	<a href="#">Rh</a> <a href="#">45</a>
<a href="#">Roentgenium</a>	<a href="#">Rg</a> <a href="#">111</a>
<a href="#">Rubidium</a>	<a href="#">Rb</a> <a href="#">37</a>
<a href="#">Ruthenium</a>	<a href="#">Ru</a> <a href="#">44</a>
<a href="#">Rutherfordium</a>	<a href="#">Rf</a> <a href="#">104</a>
<a href="#">Samarium</a>	<a href="#">Sm</a> <a href="#">62</a>
<a href="#">Scandium</a>	<a href="#">Sc</a> <a href="#">21</a>
<a href="#">Seaborgium</a>	<a href="#">Sg</a> <a href="#">106</a>
<a href="#">Selenium</a>	<a href="#">Se</a> <a href="#">34</a>
<a href="#">Silicon</a>	<a href="#">Si</a> <a href="#">14</a>
<a href="#">Silver</a>	<a href="#">Ag</a> <a href="#">47</a>
<a href="#">Sodium</a>	<a href="#">Na</a> <a href="#">11</a>
<a href="#">Strontium</a>	<a href="#">Sr</a> <a href="#">38</a>
<a href="#">Sulfur</a>	<a href="#">S</a> <a href="#">16</a>
<a href="#">Tantalum</a>	<a href="#">Ta</a> <a href="#">73</a>
<a href="#">Technetium</a>	<a href="#">Tc</a> <a href="#">43</a>
<a href="#">Tellurium</a>	<a href="#">Te</a> <a href="#">52</a>
<a href="#">Tennessine</a>	<a href="#">Ts</a> <a href="#">117</a>
<a href="#">Terbium</a>	<a href="#">Tb</a> <a href="#">65</a>
<a href="#">Thallium</a>	<a href="#">Tl</a> <a href="#">81</a>
<a href="#">Thorium</a>	<a href="#">Th</a> <a href="#">90</a>
<a href="#">Thulium</a>	<a href="#">Tm</a> <a href="#">69</a>
<a href="#">Tin</a>	<a href="#">Sn</a> <a href="#">50</a>
<a href="#">Titanium</a>	<a href="#">Ti</a> <a href="#">22</a>
<a href="#">Tungsten</a>	<a href="#">W</a> <a href="#">74</a>
<a href="#">Uranium</a>	<a href="#">U</a> <a href="#">92</a>
<a href="#">Vanadium</a>	<a href="#">V</a> <a href="#">23</a>
<a href="#">Xenon</a>	<a href="#">Xe</a> <a href="#">54</a>
<a href="#">Ytterbium</a>	<a href="#">Yb</a> <a href="#">70</a>
<a href="#">Yttrium</a>	<a href="#">Y</a> <a href="#">39</a>
<a href="#">Zinc</a>	<a href="#">Zn</a> <a href="#">30</a>
<a href="#">Zirconium</a>	<a href="#">Zr</a>

(Spectrophotometer, an apparatus for measuring the intensity of light in a part of the spectrum, especially as transmitted or emitted by particular substances). A detector ideal for comparison with spectrophotometers should exhibit intensity readings dependent on the cosine of the incident angle.

$$= x = aA = b^k$$

### The Periodic Table

A chart in which display of the chemical elements , elements are listed in order of increasing atomic number .

. **A group** is a vertical column in the periodic table .

\_ Designated by a number and letter at top .

\_ In some groups the elements have very similar properties .

. **A period** is a horizontal row in the periodic table .

\_ Each period shows the pattern of properties repeated in the next period .

Look at the following group , for instance , to see some examples of this behavior :

( Group 1)- Alkali metals

Lithium (Li) , Sodium (Na) , Potassium (K) , Rubidium (Rb) and Cesium (Cs) . This group are shiny and soft metals .

#### (Group 2)- Alkaline earth metals

Beryllium (Be) , Magnesium (Mg) , Calcium (Ca) , Strontium (Sr) , Barium (Ba) and Radium (Ra). This group are also lustrous , silvery metals , but are less reactive than neighbors in (Group 1) alkali metals .

#### (Group 7)- Halogens

Fluorine (F) , Chlorine (Cl) , Bromine ( Br) and Iodine ( I) . This group are colorful, corrosive nonmetals .

#### (Group 8)- Noble gases

Helium (He) , Neon (Ne) , Argon (Ar) , Krypton (Kr) ,Xenon (Xe) and Radon (Ra) . This group are gases of very low reactivity .

The periodic table is often divided into three major classes of elements : **metals** , **nonmetals** and **semimetals**

#### Periodic trends of groups

Elements in the same group show patterns in their atomic radius , ionization energy and electronegativity .

From **top** to **bottom** in a group :

a - The atomic radii of the elements increase .

b – Each successive element has low ionization energy .

c - Decrease in electronegativity due to an increasing distance between valence electrons and the nucleus .

### **Periodic trends of periods**

Moving from **left** to **right** across a period .

a – Atomic radius usually decreases .

b – The ionization energy increases .

c - Electronegativity increases in the same manner as ionization energy .

d – Electron affinity , metals ( left side of a period ) generally have a lower electron affinity than nonmetals ( right side of a period ) with the exception of the noble gases .



## Renewable Energy Dep.

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### Chemical Bond

A chemical bond results from strong electrostatic interaction between two atoms . The nature of the atoms determines the

Kind of bond .

Ionic bonding :

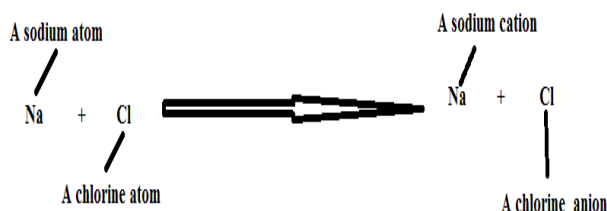
The formation of an ionic bond is the result of the transfer of one or more electron from a metal onto a non metal .

... One or more electrons from one atom are removed and attached to another atom , resulting in positive ( cation ) and negative ( anion ) ions which attract each other .

... An ionic bond is typically formed between a metal and a non metal.

... Metal have low electronegativity while non metal have high electronegativity .

This results in the metal becoming a cation , and the non-metal becoming an anion .



## Covalent Bonding :

Bonding between non metals consists of two electrons shared between two atoms . In covalent bonding the two electrons shared by the atoms are attracted to the nucleus of both atoms . Neither atom completely loses or gains electrons as in ionic bonding .

There are two types of covalent bonding :

- 1 - Non – polar bonding with an equal sharing of electrons between identical non- metals ( exception carbon – hydrogen )
- 2 – Polar bonding results when two different non – metals unequally share electrons between them . One well known exception to the identical atom rule is the combination of carbon and hydrogen in all organic compounds . Hydrogen Chloride forms a polar covalent molecule .

Electronegativity ( EN ) : The ability of an atom in a molecule to attract the shared electrons in a covalent bond .

Ionization energy ( $E_i$ ) : The amount of energy necessary to remove a valence electron from an isolated neutral atom .

Electron affinity ( $E_{ea}$ ) : The amount of energy released or absorbed when an electron adds to an isolated neutral atom .

First Class

**Chemistry I**

Dr. Fayq H. Jabbar

**Renewable Energy Dep.**

**THE six lecture**

**Instrumental Method :**

such as visible Spectrophotometer based upon light absorption.

**Spectrophotometer**, an apparatus for measuring the intensity of light in a part of the spectrum, especially as transmitted or emitted by particular substances). A detector ideal for comparison with spectrophotometers should exhibit intensity readings dependent on the cosine of the incident angle.

### **Major Techniques of Instrumental Method :**

First Class

**Chemistry I**

Dr. Fayq H. Jabbar

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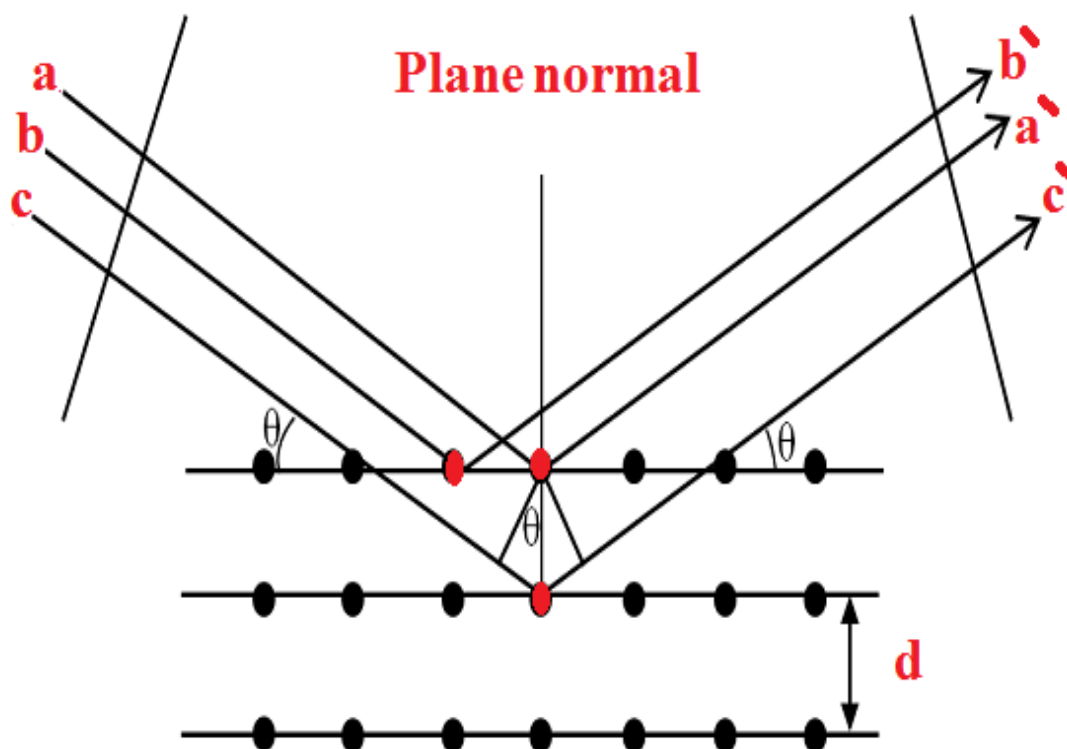
#### **X-Ray diffraction (XRD) analysis**

X-Ray diffraction study was carried out, this method is very common techniques to analyze the composition of the materials. X-rays are the electromagnetic radiation, according to quantum theory, which have wave-particle duality. The diffractogram was scanned in the ranges from  $2$  to  $10^\circ$  at a scan rate of  $1^\circ/\text{min}$ . and their energy ranges from  $100 \text{ eV}$  to  $10 \text{ MeV}$ . X-rays were discovered by German physicist Wilhelm Conrad Rontgen in 1895. Afterwards, the idea that a crystal can be the

diffraction grating was proposed by Paul Peter Ewald and Max von Laue. Since the order of magnitude of wavelength is larger than the spacing in crystals, visible light as the diffraction source cannot reflect from crystal. On the contrary, Laue successfully used X-Ray for the diffraction which has the same order of magnitude of wavelength with spacing in crystals. In 1912, William Lawrence Bragg and his father William Henry Bragg formulated

**Bragg's law  $n\lambda=2d\sin\theta$**

which is the significant equation to build the relation of diffraction. When the wavelength of radiation is close to the spacing between the atoms, the atoms can be considered as the diffraction grating and have the constructive and destructive interference of the scattering which is shown in Figure .



**Figure** Clearly measured incident angle by X-ray diffraction from a layered structure

X-ray diffraction technique was used to measure the interlayer distance of the silicate layers of the clay and modified silicate layers with alkyl- amidiumion cation. It was also used to

measure the silicate layers interlayer distance of natural silicate layers or clay (Na-MMT) and modified. The inter silicate layers layer distance of Na-MMT was expanded from 1.21nm to about 2.65nm for FAs-MMT obtained from XRD analysis, shown in Table.

**Table** :XRD analysis of silicate layers or natural clay (Na-MMT) and modified silicate layers or clay (FAs-MMT)

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Type of clay	Exchange cation	2 $\theta$ (degree)	d-spacing (nm)
Na-MMT	Na <sup>+</sup>	7.28	1.21
FAs-MMT	RCO-NH <sub>3</sub> <sup>+</sup>	3.47	2.65

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**THE Seven lecture**

The summary of the intercalated silicate layer in NR/unmodified MMT and NR/modified MMT (FAs-MMT) used in this study, obtained from the XRD analysis is given in table .

**Table :** XRD analysis of NR/unmodified clay (Na-MMT) and NR/modified clay(FAs-MMT)

NR/Type of clay	d-Spacing (nm)				
	1 phr	2 phr	3 phr	4 phr	5 phr
NR/Na-MMT	1.37	1.38	1.33	1.31	1.30
NR/FAs-MMT	2.05	2.78	3.14	2.15	1.90



The incident beam a and b have the same incident angle and travel distance which causes the constructive interference. The incident beam c moves in phase with a and b if the extra travel distance  $2d\sin\theta$  is equal to the integral number of wavelength, or it results in destructive interference when out of phase.

The constituents of an X-Ray diffractometer are the source, sample, mono-chromater, detector and output device. In the hot cathode tube, the electrons are emitted from tungsten filament when heated, and travel through the electron field to impinge anode. There are two phenomena that happen when the impingement occurs. One is the inelastic collision when the partial kinetic energy of electron transfers into the continuous spectrum which is also called white radiation. Another is the characteristic spectrum which is caused by the excitation of the inner-shell electron with collision and meanwhile, the outer-

shell electron fills the inner-shell and releases energy between the energy levels in X-Ray form. The source of the X-Ray diffractometer has a characteristic radiation, usually using Cu  $K\alpha$  and filtered by nickel as the mono-chromater, the wavelength of which is ( $\lambda = 0.15406$  nm).

The sample is mounted for the measurement and held in the x-ray beam passage and rotated. The detector is working as the film or charge-coupled device to record the pattern of spots or reflection. Afterwards, the output device assesses the collected data.

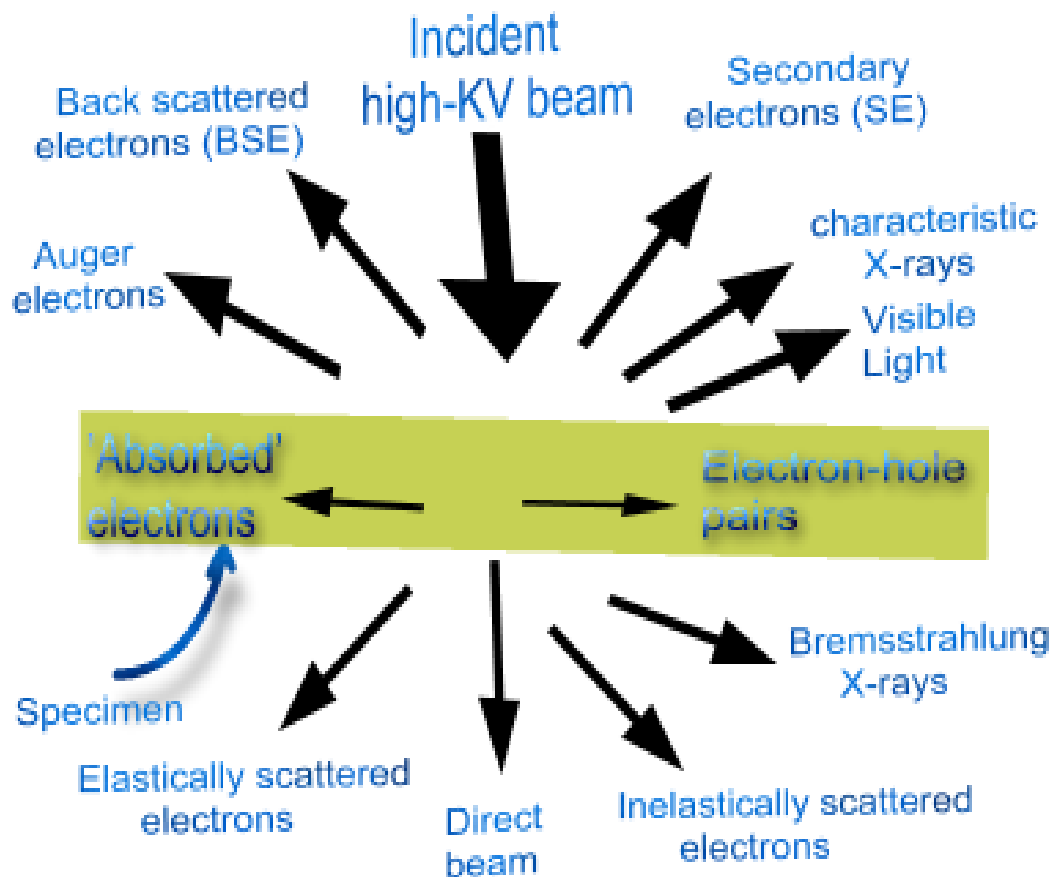
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**THE Eight lecture****Transmission electron microscopy (TEM)**

The transmission electron microscopy (TEM) is an essential instrument to diagnose materials. The historical development of TEM is from the discovery of the electron by J. J. Thomson in 1897 and the fact that electron beams could be deflected and concentrated through electrostatic and magnetic fields. In 1924, Louis de Broglie revealed the hypothesis that the electrons travel in a waveform pattern and derived the formula ( $\lambda=h/mv$ ) where  $h$  is Planck's constant,  $m$  is the mass of a particle and  $v$  is the velocity of a particle. Afterwards, Ernst E. Ruska developed the magnetic lens and built the first TEM in 1931.

The TEM can provide information on several properties of the material studied including morphology, structure, lattice imaging and chemical composition [66]. The TEM can be divided into three components: the illumination system, the objective lens/specimen stage, and the imaging system. The illumination system, consisting of the gun and the condenser lenses, emit the electrons from the heated filament. They are a<sub>c</sub>celerated

by a potential difference and passed through a set of condenser lenses to limit the desired diameter. The illumination system can be operated in two principal modes: parallel beam and convergent beam. The objective lens and the sample stage system is the heart of the TEM where the electron beams penetrate the ultra thin specimen and cause all the interactions shown in Figure.



The lenses of the imaging system magnify the electron intensity distribution and focus on a fluorescent screen. The image can be recorded by direct exposure of a photographic emulsion or an image plate inside the vacuum or digitally via a fluorescent screen coupled by a fiber-optic to a charge-coupled device (CCD).

The dispersion of clay was studied by using Energy Filtering Transmission Electron Microscopy (EFTEM). TEM pictures were taken in a LEO 912 AB Energy Filtering Transmission Electron Microscope with an acceleration voltage of 120 Ke V. The specimens were prepared using a Ultracut E (Reichert and Jung) cryomicro tome. Thin sections of about 100nm were cut with a diamond knife at -120 °C.



**THE Nine lecture**

**Atomic force microscope (AFM)**

The atomic force microscope gives an image of the outer surface of the sample show in the below Fig. represents the shape ,size and homogeneity of the preparad nanoparticles, showing the spherical shape with good sorting without any clumping and homogeneous in size distribution . It is also noticed from the figure that the nanoparticles of sample ( clay ) appear in different forms, but they are still grouped in the nanoscale . And the picture was taken with a scale 100 nm.

AFM assays support TEM and XRD assays when we obtain nanomodel for natural polymer

The difference between a TEM and AFM notices that TEM gives a picture of the internal of a sample and AFM gives an image of the external surface of the sample.

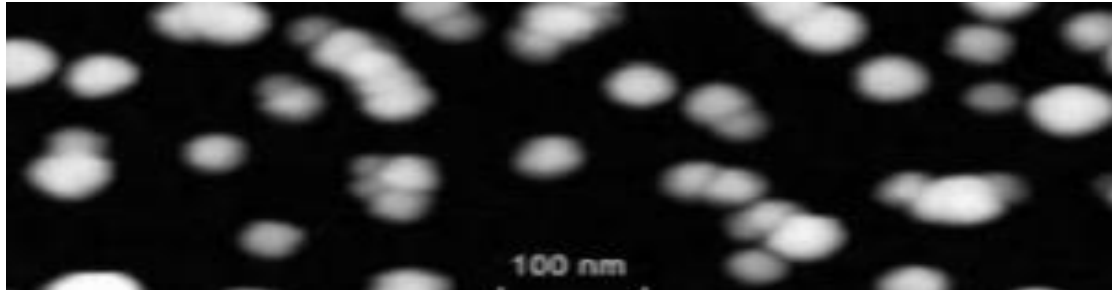


Fig. Image of atomic force microscopy to NR/ FAc –MMT nanocomposite

**THE Ten lecture**

**Types of composite of structure by TEM**

Three main types of composites may be obtained when a layered clay is associated with a polymer. These primarily depend on the method of preparation and the nature of components used (layered silicates, organic cation and polymer matrix)

TEM is therefore used to determine This conventional composite and nanocomposite morphology. In addition to these two defined structures, both intercalation and partial exfoliation result in a broadening of the diffraction peak.



Polymer or Monomer



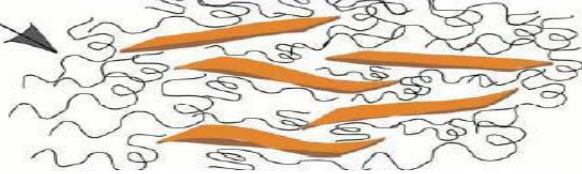
Clay layers



a: conventional composite



b: intercalated nanocomposite



c: exfoliated nanocomposite

**THE Eleven lecture**

**Thermogravimetric analysis (TGA)**

Observation of the response of the materials when heated is dated back to ancient times. However, the serious measurement is based on the invention of thermocouple at the end of 19th century. The development of thermal analysis applied to geosciences is from the experiment of La Chatelier in 1887 when he classified the different samples of clay by their dehydration point. In the 1930s, it became a simple and inexpensive technology in the field of mineralogy, compared to X-ray diffraction (XRD) which was expensive during that time [59]. Thermogravimetric analysis (TGA) is a common thermal analysis technique involving measuring the sample weight as a function of temperature or time while the sample is loaded on a precise thermobalance and subjected to a heating program in a controlled atmosphere, the thermal stability of the samples was studied by using Perkin Elmer model TGA thermogravimetry analyzer.

The samples are heated from 35 to 800 °C with the heating rate of 10 °C /min under nitrogen atmosphere with a nitrogen flow rate of 20

ml/min[60]. The components of the instrument are microbalance, furnace, programmer controller and a computer shown in below Figure

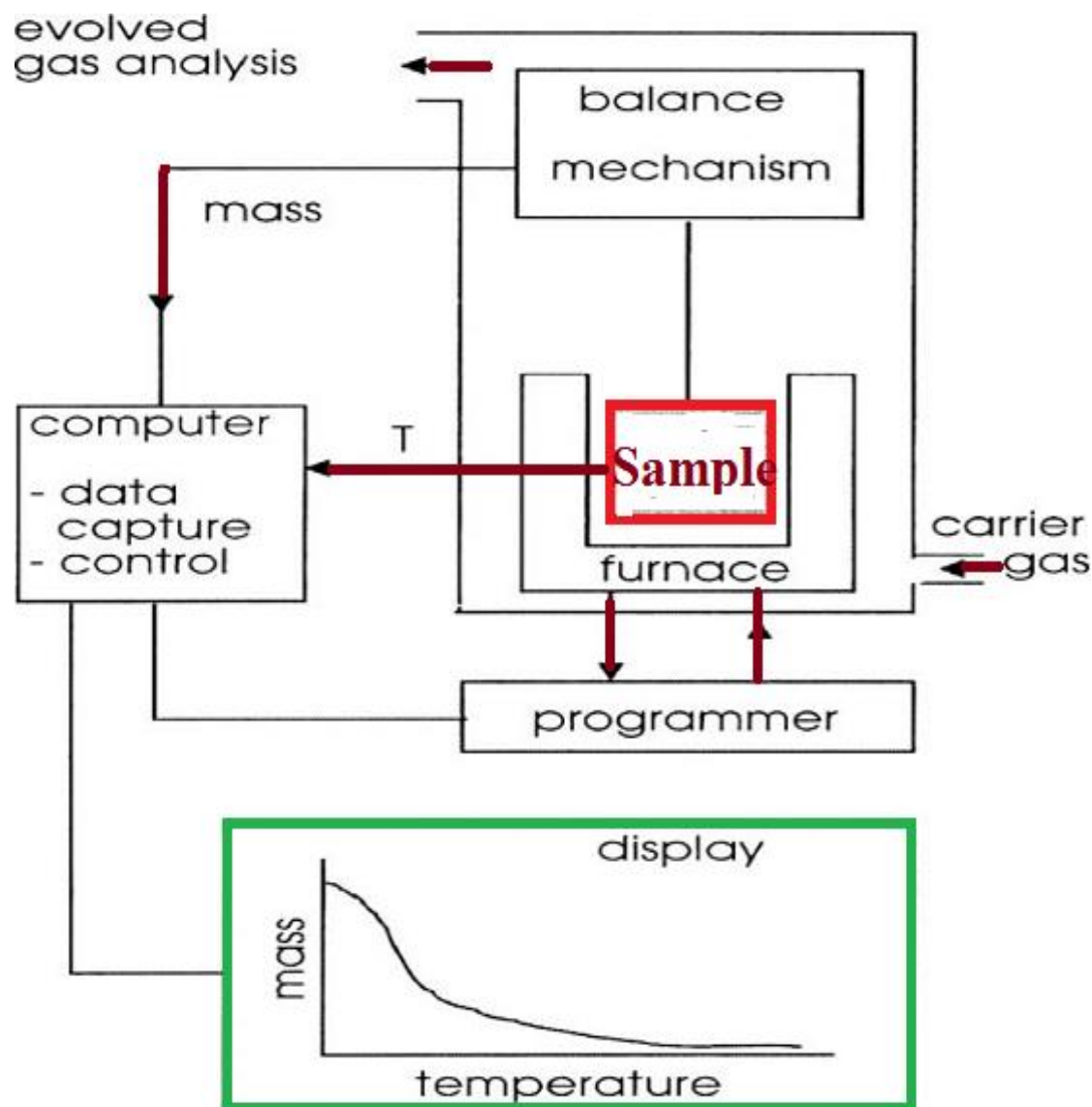
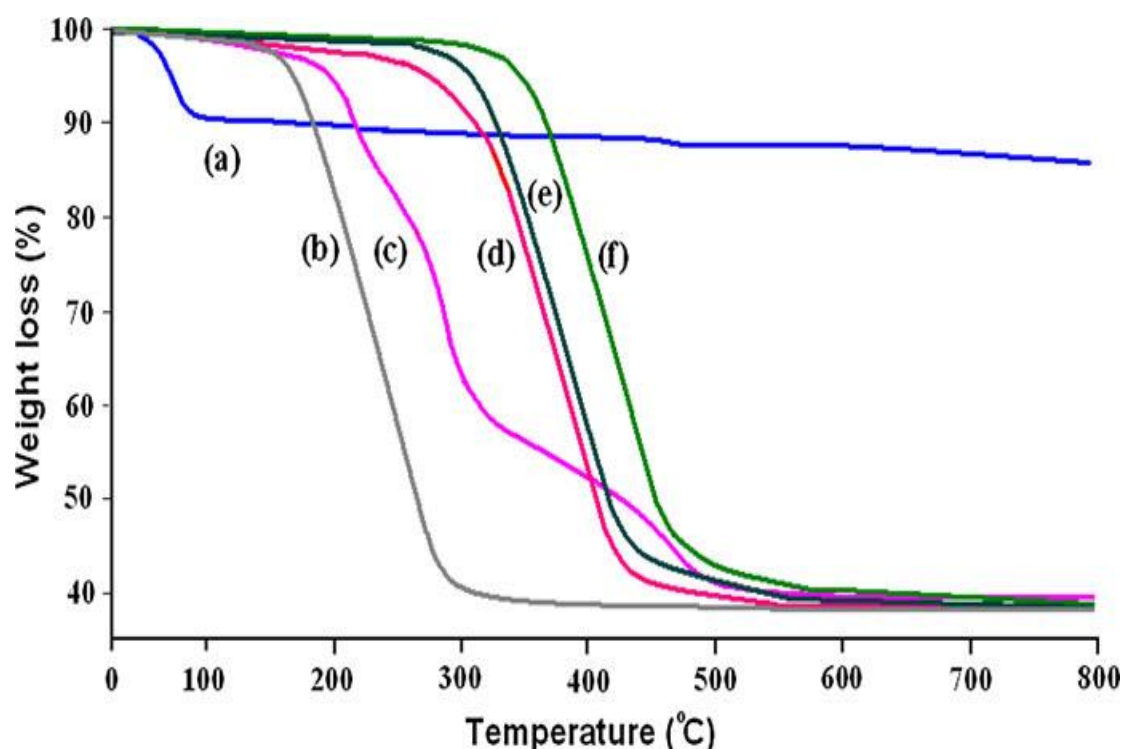


Figure: The scheme of TGA instrument

The balance should be in a suitably enclosed system so that the nature and pressure of the atmosphere surrounding the sample can be controlled

Thermogravimetric curves are plotted with the weight change on the vertical axis and temperature on the horizontal axis. However, this curve is difficult to interpret. Therefore, the first derivative of the weight loss curves are plotted to assist in the interpretation and reveal the inflection points. Generally, TGA can provide information on physical and chemical properties. The physical properties include melting, evaporation, sublimation and adsorption while the chemical properties include dehydration, dissociation, oxidation and reduction. Specifically, TGA characterizes the decomposition and thermal stability of materials under various conditions including the specific temperature ranges and heating rates and to examine the kinetics of the physicochemical processes occurring in the sample. For polymer nanocomposites, TGA is beneficial in quantifying the amount of the organic matter exchanged on the surface of the filler particles, thus generating an idea of the success or

extent of the ion exchange process. For clay minerals, the endothermic reactions occur with adsorption of surface  $H_2O$ , dehydration of interlayer  $H_2O$  at low temperature ( $<100\text{ }^\circ\text{C}$ ), dehydroxylation at high temperature and melting. Exothermic reactions are related to recrystallization which are concurrent or after dehydroxylation and melting. Example explaining of analysis by TGA



**Figure** :TGA thermograms of a- Na-MMT, b- FAs, c- FAs-MMT,  
d- NR, e- NR/2phr Na-MMT microcomposite & f- NR/3phr  
FAs- MMT nanocomposite