Chemistry: is the study of matter, including its composition, structure, physical properties, and reactivity. There are many approaches to studying chemistry, but, for convenience, we traditionally divide it into five fields: ***organic, inorganic, physical, biochemical, and analytical.*** Although this division is historical and arbitrary, as witnessed by the current interest in interdisciplinary areas such as bioanalytical and organometallic chemistry, these five fields remain the simplest division spanning the discipline of chemistry.

1:1. Matter

It is everything that take up space and has mass .

Matter consists of small units are the basic for the construction of the materials , which are called **atoms**, and defined by Dalton as the atom *(smallest part of the matter involved in the chemical reaction).*

Also can be defined a *(atom is smallest particle of an element that still has all the chemical properties of the element).*

The Italien Avogadro was considered that a smallest part of the matter can be found in private , may consist of more than one atom and holds properties , that called **molecule** also can be defined as (molecule is the smallest unit of a chemical compound that still has the same chemical properties of that compound **)**. Also can be defined (the smallest unit of a substance that keeps all of the physical and chemical properties of that substance; it can consist of one atom or two or more atoms bonded together).

1:2. States of matter

There are three states of matter is :

1-The gaseous state (has a variable size and shape of variable) .

2-The liquid state (has a fixed size and shape of variable).

3- The solid state (has a fixed size and shape of a fixed).

1:3. Type of matter

1-Pure substances: a sample of matter, either a single element or a single compound, that has definite chemical and physical properties. Every pure substance has characteristic properties that can be used to identify it .Characteristic properties can be physical or chemical properties.

For example, copper always melts at 1083°C, which is a physical property that is characteristic of copper. There are two types of pure substances: elements and compounds.

a) Element: a substance that cannot be separated or broken down into simpler substances by chemical means; all atoms of an element have the same atomic number it is substance made of only one type of atom like H_2 , N_2 ,etc .

b) Compound: it is substance made of two or more element held together by chemical bonds like H_2O ,NaCl , etc .

2-Non pure substance: a sample of matter that contains two or more pure substances is a mixture Most kinds of food are mixtures, sugar and salt being rare exceptions. Air is a mixture, mostly of nitrogen and oxygen.

1:4. Atomic structure

Several key discoveries in the late 19th and early 20th centuries led to our understanding of the structure of atoms many scientists have contributed in the description of atomic structure round them .Dalton, Thomson, Rutherford and Bohr provides (Modern Theory) in the description of atomic structure on the following :

1- Atom is composed of small nucleus size occupies most of the mass of the atom is found in the center of the atom and contains protons and neutrons .

2- Electrons revolve around a nucleus at distance far from it in the levels of energy ,expressed by the main quantum number symbolized by the symbol (**n**) .

<u>Principle shell consist of a number of sub shell :</u>

Number of sub shell = **n**

K → n=1 → 1s

L → n=2 → 2s , 2p

M → n=3 → 3s , 3p , 3d

N → n=4 → 4s , 4p , 4d , 4f

O → n=5 → 5s , 5p , 5d , 5f , 5g

1:5. Electron Configurations

In atomic physics and quantum chemistry the electron configuration is the distribution of electrons of an atom or molecule (or other physical structure) in atomic or molecular orbitals.For example, the electron configuration of the neon atom is $1s^2\ 2s^2 2p^6$.Electronic configurations describe electrons as each moving independently in an orbital, in an average field created by all other orbitals. Mathematically, configurations are described by Slater determinants or configuration state functions. There are a number of "rules" that determine the way in which the electrons of an atom may be distributed, that is, that determine the electronic configuration of an atom .

The Aufbau principle (from the German Aufbau meaning “building up, construction”: also Aufbau rule or building-up principle) is used to determine the electron configuration of an atom , molecule or ion .

Rule of Aufbau: *lower energy orbitals fill before higher energy orbitals*

1s→2s→2p→3s→3p→4s→3d→4p→5s→4d→5p→6s→4f →5d→6p→7s→5f→6d→7p

Figure (1) shows how distribution of electrons in the energy levels .

Hund's Rule:
(If two or more orbitals with the same energy are available one electron goes in each until all are half full . The electrons the half filled orbitals all have same value of their spin quantum number)

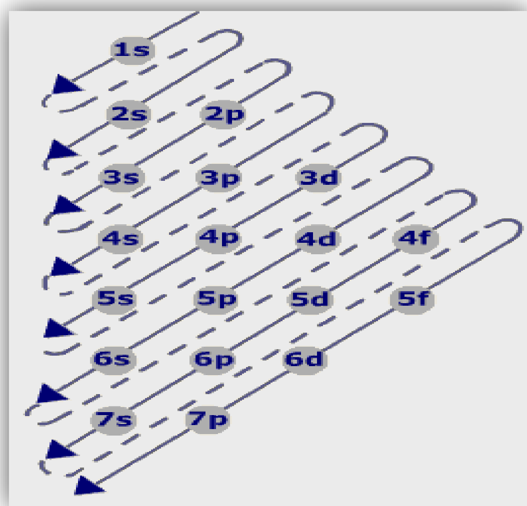


Figure (1)

Example 1.

Give the electron configuration of Arsenic , Z=33 ? .

<u>*Sol:*</u>

$_{33}$As 1s 2s 2p 3s 3p 4s 3d 4p

Example 2.

Give the electron configuration for ($_1$H , $_2$He , $_7$N)? .

Sol:

$_{1}H$ $1s^{1}$, $_{2}He$ $1s^{2}$, $_{7}N$ $1s^{2}$ $2s^{2}$ $2p^{3}$

H.W

Give the electron configuration for ($_{8}O^{2-}$, $_{15}P^{3+}$, $_{1}H^{+1}$)? .

1:6. Quantum number

1-The principle quantum numbers (**n**) .

It's appositive integer (n=1,2,3,4,5…..) an which the size and energy level of the orbital primarily depend .

2- The angular momentum quantam numbers (**L**) .

Defines the three dimensional shape of the orbital (L =n-1) .

If n=1→ then L=0 → s
If n=2→ then L=1 → s , p
If n=3→ then L=2 → s , p , d
If n=4→ then L=3 → s , p , d , f
If n=5→ then L=4 → s , p , d , f , g

L	0	1	2	3	4
Sub shell	s	p	d	f	g

3-The magnetic quantum numbers (**M_L**) .

Define the spatial probation of the orbital with respect to a standard set of coordinate axes .

M_L	0	+1 0 -1	+2 +1 0 -1 -2	+3 +2 +1 0 -1 -2 -3
	S	P	d	f

4-Electron spin quantum numbers (**M_S**) .

Can have one of two values + ½ and – ½ it adopted the phenomenon.

M_S + ½ ↑↓ - ½

Pauli Exclusion Principle:

In a given atom no two electrons can have the of four quantum numbers (n ,L , M_S, M_L) . The Pauli exclusion principle is one rule to help you write an electron configuration for an atom.

Example 3.

Principle quantum level n=5 ,determine the number of allowed subshells(different values of L) and give the designation of each ?.

Sol

n=5 →(L=0→n-1)→L=(0,1,2,3,4)

→5s ,5p ,5d ,5f ,5g

Example 4.

Appointed the values of four quantum numbers for the last electron of chlorine atoms (Z=17) ? .

Sol.

^{17}Cl $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^5$

n=3 , L=1 , $M_L=0$, $M_S = -1/2$

+1	0	-1
↑↓	↑↓	↑

3p

1:7. Periodic Table

The peridic table is a chart that includes all of natural and artificial elements know in the universe, it′s also aguide and tool to understanding all chemical reaction and the materials involved in building the earth and universe. The first chemist to recognize patterns was Johann Dobereiner who found several group of three element that have similar properties.The next notable attempt was made by the English chemist John Newlands ,who in 1864 suggested that elements should be arranged in octaves .The present from of the periodic table was conceived in dependently by two chemists Meyer and Mendeleev where the elements are arranged according to atomic mass . Matter periodic table consist from seven period and eighteen groups .By meansure atomic number in periods and groups.

Period: one of seven horizotal rows in the periodic table .

Group: one of eighteen vertical columns in the periodic table elements in the same groups usually ,but not alaways have similar properties.

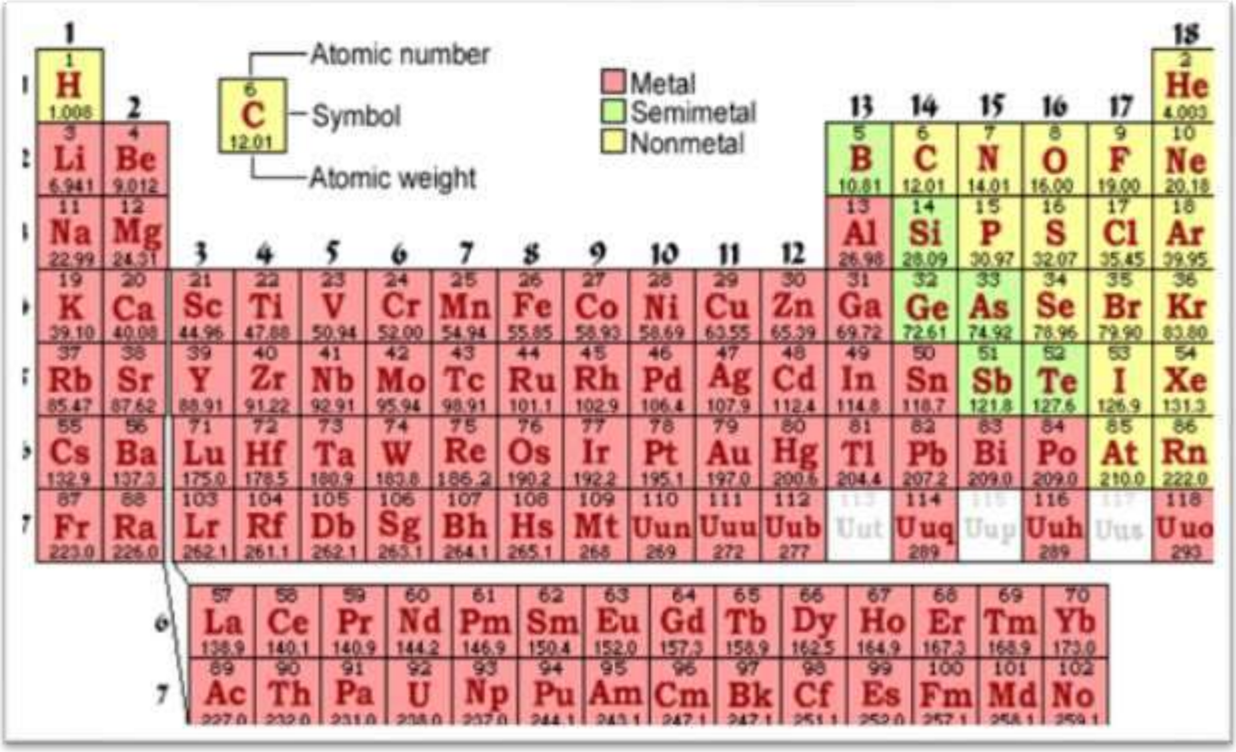
Figure(2) illustrates the periodic table is divided into periods and groups.Divided the elements in the periodic table into two group. ***Group (A)***:The include the block S (group 1 and 2) and block P (group 3,4,5,6,7 and 8) .

Group (B):The include the block d (transition elements)and block f (internal transition elements) . Figure(3) illustrates the periodic table is divided into group A and group B.

Main-group elements an element in the s-block or p-block of the periodic table .Elements in groups 1, 2, and 13–18 are known as the main-group elements .

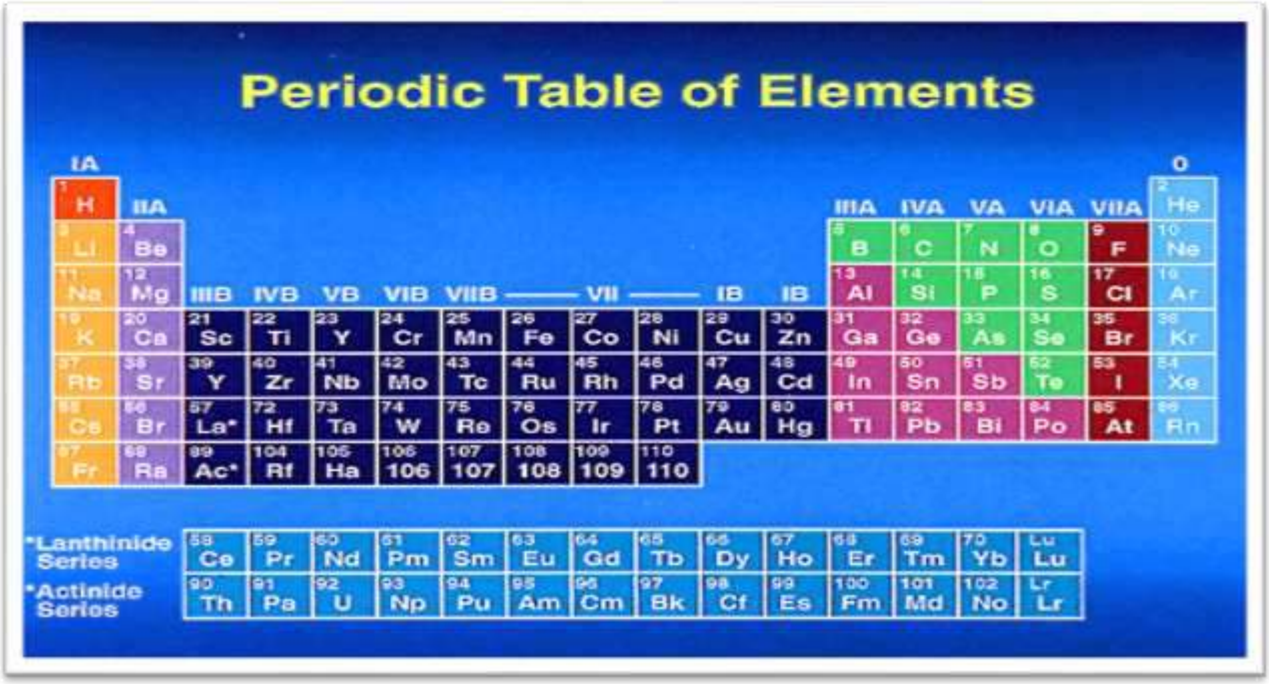
Alkali metal one of the elements of Group 1 of the periodic table (lithium, sodium, potassium, rubidium, cesium, and francium). Alkali metals are so named because they are metals that react with water to make alkaline solutions .

Alkaline-earth metal one of the elements of Group 2 of the periodic table (beryllium, magnesium, calcium, strontium, barium, and radium) Like the alkali metals, the alkaline-earth metals are highly reactive, so they are usually found as compounds rather than as pure elements .



Figure(2)

As elements classified in the periodic table to metals and nonmetals and semimetal.



Figure(3)

<u>Halogen</u> one of the elements of Group 17 of the periodic table (fluorine, chlorine, bromine, iodine, and astatine); halogens combine with most metals to form salts . The halogens are the most reactive group of nonmetal elements because of their electron configuration .
<u>Noble gas</u> an unreactive element of Group 18 of the periodic table (helium, neon, argon, krypton, xenon, and radon) that has eight electrons in its outer level (except for helium, which has two electrons).The noble gas atoms have a full set of electrons in their outermost energy level.
<u>Transition metal</u> one of the metals that can use the inner shell before using the outer shell to bond .
The constitute Groups 3 through 12 and are sometimes called the d-block elements because of their position in the periodic table, Unlike the main-group elements, the transition metals in each group do not have identical outer electron configurations. For example, nickel, Ni, palladium, Pd, and platinum, Pt, are Group 10 metals. However, Ni has the electron configuration $3d^8 4s^2$, Pd has the configuration $4d^{10}$, and Pt has the configuration $4f^{14} 5d^9 6s^1$. Notice, however, that in each case the sum of the outer d and s electrons is equal to the group number, 10.
<u>Lanthanides</u> a member of the rare-earth series of elements, whose atomic numbers range from 58 (cerium) to 71 (lutetium) .
<u>Actinides</u> any of the elements of the actinide series, which have atomic numbers from 89 (actinium, Ac) through 103 (lawrencium, Lr)

Periodic trends in atomic properties

1-Ionization energy: it′s the energy required to removed an electron from as atom or ion

$$x_{(g)} \rightarrow x_{(g)} + e^-$$

2-Electron affinity: it′s the energy change associated with the addition of an electrons to gaseous atoms

$$x_{(g)} + e^- \rightarrow x^-_{(g)}$$

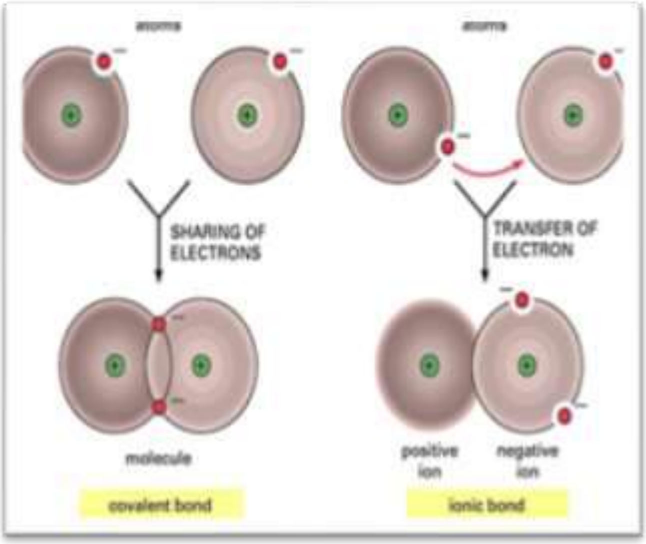
3-Atomic radius:these values can be obtained by measuring the distance between atomic in chemical compounds .
4-Electron negativity: it′s the ability of an atom in a molecule to attract shared electrons to itself .

1:8. Bond

The first graet advance in qualitative understanding of chemical bounding was N. Lewis′s suggestion in 1916 that atomis in stable molecules or ions tend attian the configuration of neareast noble gas .

Ionic bond:

It′s formed between two atoms when the atoms involved undergo a transfer of on (or more) electrons to produce two changed species ,a positive ion (cation) and a negative ion (anion) Figure(4) illustrates ionic bond and covalent bond.

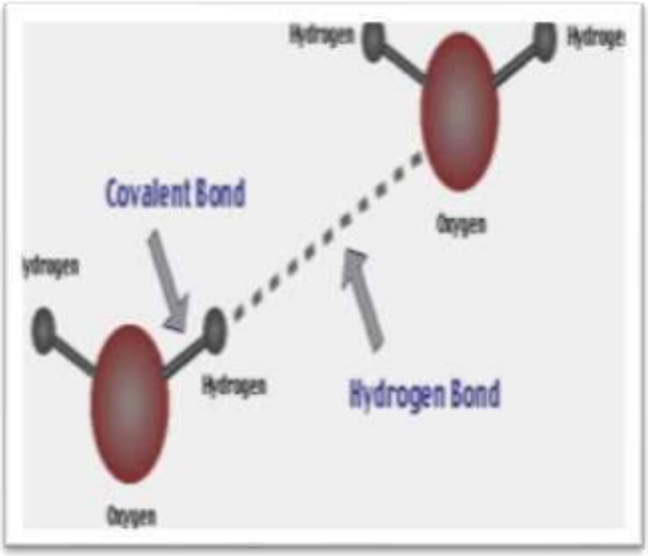


Figure(4)

Covalent bond:

It′s formed ,the atoms share an electron pair ,often obeying the octet rule by sharing electron pairs .Other types of bonds include **metallic bonds** and **hydrogen** bonding.

The attractive forces molecules in a liquid can be characterized as van der Waals bonds .



Figure(5)

Hydrogen bonding:

A hydrogen bond is a type of attractive (dipole-dipole) interaction between an electronegative atom and a hydrogen atom bonded to another electronegative atom. This bond always involves a hydrogen atom. Hydrogen bonds can occur between molecules or within parts of a single molecule.

A hydrogen bond tends to be

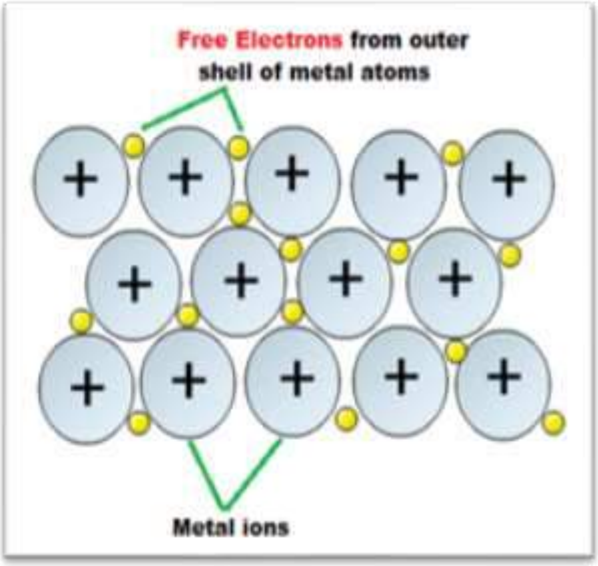
stronger than van der Waals forces, but weaker than covalent bonds or ionic bonds. Figure(5) illustrates hydrogen bond .

Van der Waals:

Forces are the weak forces which contribute to intermolecular bonding.

Metallic bond :

The chemical bonding that holds the atoms of a metal together. Metallic bonds are formed from the attraction between mobile electrons and fixed, positively charged metallic atoms. Whereas most chemical bonds are localized between specific neighboring atoms, metallic bonds extend over the entire molecular structure. Figure(6) illustrates metallic bond. .



Figure(6)

1:9. DEFINITION OF SOLUTION, SOLVENT AND SOLUTE

When a small amount of sugar (solute) is mixed with water, sugar uniformally dissolves in water and a sugar solution is obtained. In this solution, sugar molecules are uniformly dispersed in molecules of water. Similarly, a common salt (NaCl) when dissolve in water, if uniformly disperse in water and salt solutions is obtained so a solution of salt in water consist of ions of salt (Na^+, Cl^-) dispersed in water.

Solutions are homogenous mixtures in which one substance is said to have been dissolved in the other. The dissolved substance may be present as individual molecules or ions through out the other substance. Since both the components of a solution are present in the molecular or ionic state, it constitutes a perfectly uniform and transparent system.

1:10.Components of Solution

In the study of solution, it is customary to designate the components in solution. The components are:

Solvent

The component present in larger proportion is known as solvent.

Solute

The component present in smaller proportion is known as solute.

Solution = Solvent + Solute

Ex. Sugar solution = Sugar (solute) + Water (solvent)

Common salt solution = Salt (solute) + Water (solvent)

1:11. TYPES OF SOLUTION

Homogenous Solution

A solution in which two substances are mixed has uniform composition and the components cannot be identified separately.

Ex.

Sugar solutions → Two substances → Sugar (solute)
→ Water (solvent)

Heterogenous Solution

A solution in which two or more substances are mixed has non-uniform composition and the components can be identified separately

Ex.

Naphthalene solution → Two substances → Naphthalene (solute)
→ Water (solvent)

In naphthalene solution, both water and naphthalene can be identified and separated from one another and non-uniform in their properties like density, concentration and viscosity etc.

Aqueous Solution

Solution containing water as solvent is called aqueous solution.

Ammoniacal Solution

Solution containing ammonia as solvent is called ammoniacal solution.

Non-aqueous Solution

Solution containing solvent other than water is called non-aqueous solution.

1:12.Classification of Solutions

Based on the physical state of components, the solutions are classified into gaseous solutions, liquid solutions and solid solutions.

1. Gaseous solutions: In these solutions, gas is solvent and the solute may be solid or liquid
or gas.

(*a*) Gas in Gas

Ex. H_2 and O_2 mixture, air

(*b*) Liquid in Gas

Ex. Water in air

(*c*) Solid in Gas

Ex. Camphor in air

2. Liquid solutions: In these solutions, liquid is the solvent and the solute may be solid or
liquid or gas.

(*a*) Gas in Liquid

Ex. Soda water (CO_2 in water)

(*b*) Liquid in Liquid

Ex. Alcohol in water

(*c*) Solid in Liquid

Ex. Salt in water

3. Solid solutions: In these solutions, solid is the solvent and the solute may be solid or liquid or gas.

(*a*) Gas in Solid

Ex. H_2 palladium

(*b*) Liquid in Solid

Ex. Hg in Zn

(*c*) Solid in Solid

Ex. Alloys (Zn in Cu)