AL-Mustaqbal University

College of Health and Medical Technologies

Radiological Techniques Department

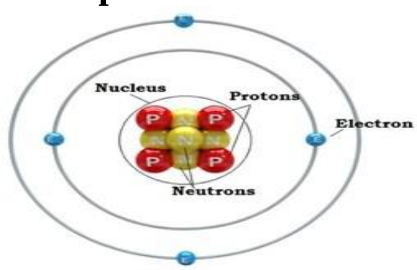
Subject:- General Chemistry (1)   (2024-2025)   lecture (1)

Assist.prof. Dr.Thamer A.A.M Alalwani

ATOMS

Atoms are made of small particles called protons, neutrons, and electrons. An atom is composed of two regions: the nucleus, which is in the center of the atom and contains protons and neutrons, and the outer region of the atom, which holds its electrons in orbit around the nucleus.

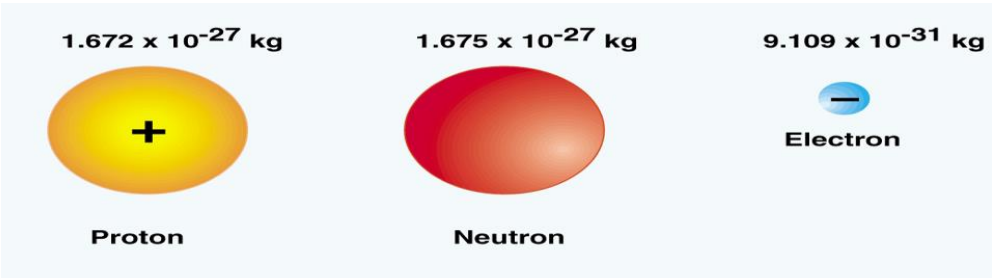
- **Proton is a positively charged particle in an atom**
- **Electron is a negatively charged particle in an atom**
- **Neutron is a neutral (neither negative nor positive) particle in an atom**
- **The Atomic Number is the number of protons in an atom**
- **The Atomic Mass Number is the number of protons and the number of neutrons in an atom**



The proton and neutron have roughly the same mass and have approximately one thousand times the mass of the electron. The proton and electron have equal, but opposite, electrical charges. A neutron does not have an electrical charge. In an atom, the protons and neutrons clump together in the center and are called the nucleus. Because the protons are positively charged, the nucleus has a positive electric charge. The electrons of the atom move rapidly around the nucleus. If we attempt to detect an electron in an atom, we might find evidence of it located almost anywhere around the nucleus.

The density of the cloud at any point is the probability of finding the electron at that point. The attractive electric force between the positively-charged protons in the nucleus and the negatively-charged electrons around the nucleus holds the atom together .

Atoms containing the same number of protons and electrons have no net charge.Atoms that have extra electrons or are missing electrons have a net electrical charge and are called ions. Ions can interact with other ions due to the electrical attraction between opposite charges.



Model of Proton, Neutron and Electron

The density of the cloud at any point is the probability of finding the electron at that point. The attractive electric force between the positively-charged protons in the nucleus and the negatively-charged electrons around the nucleus holds the atom together . Atoms containing the same number of protons and electrons have no net charge.Atoms that have extra electrons or are missing electrons have a net electrical charge and are called ions. Ions can interact with other ions due to the electrical attraction between opposite charges.

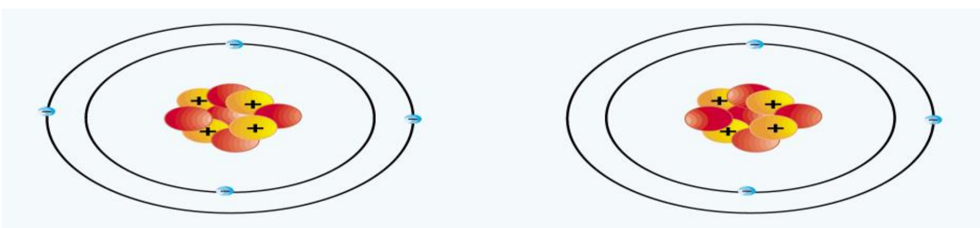


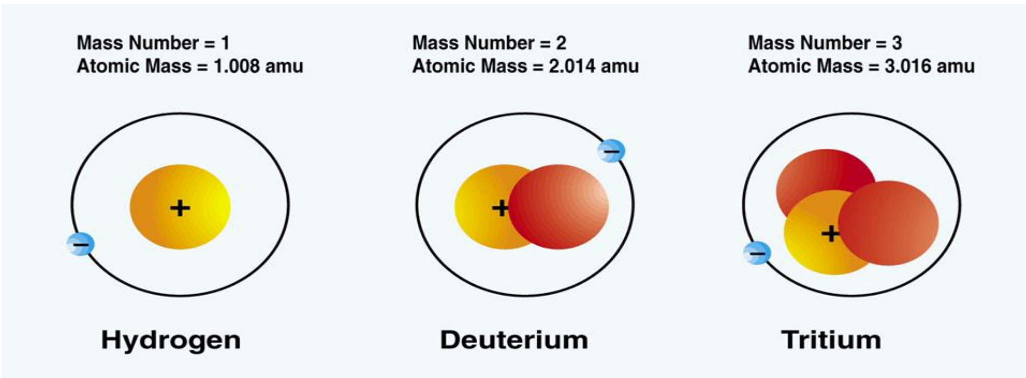
Diagram Comparing a Beryllium Atom and a Positively-Charged Beryllium Ion

Atoms interact with other atoms by sharing or transferring electrons that are farthest from the nucleus. These electrons are sometimes called valence electrons . These outer electrons determine the chemical properties of the element, such as how readily it interacts with other elements and the allowable ratios for its combinations with other substances.

ISOTOPES

When an element has atoms that differ in the number of neutrons in the nuclei, these atoms are called different isotopes of the element. All isotopes of one element have identical chemical properties. This means it is difficult to separate isotopes from each other by chemical processes. However, the physical properties of the isotopes, such as their masses, boiling points, and freezing points, are different. Isotopes can be most

easily separated from each other using physical processes. The sum of the number of protons and neutrons in the nucleus of an atom is called that element's mass number. This is not the same as the element's mass. Since different isotopes of an element contain different numbers of neutrons in the nuclei of their atoms, isotopes of the same element will have different atomic masses. This was shown above for the three isotopes of hydrogen. The symbol for an isotope is the symbol for the element followed by the mass number. Hydrogen is symbolized as H^1, while deuterium is symbolized as H^2.and tritium is H^3.



Mass Number and Atomic Mass of Hydrogen, Deuterium, and Tritium: -

The sum of the number of protons and neutrons in the nucleus of an atom is called that element's mass number. This is not the same as the element's mass. Since different isotopes of an element contain different numbers of neutrons in the nuclei of their atoms, isotopes of the same element will have different atomic masses. This was shown above for the three isotopes of hydrogen. The symbol for an isotope is the symbol for the element followed by the mass number. Hydrogen is symbolized as H^1, while deuterium is symbolized as H^2.and tritium is H^3.

Electron distribution: -

Electron distribution refers to the spatial arrangement of electrons within a compound, reflecting the system's topology and bonding characteristics.

The electron configuration of an element describes how electrons are distributed in its atomic orbitals. For example, the electron configuration of the neon atom is 1s2 2s2 2p6, meaning that the 1s, 2s, and 2p subshells are occupied by two, two, and six electrons, respectively but when 1s2 2s2 2p6 3s2 3p6 3d10 meaning that the 1s, 2s, and 2p subshells are occupied by two, two, and six electrons 3s3p3d10 subshells are occupied by two, six ,ten respectively.

It is important to note that there exist many exceptions to the Aufbau principle such as chromium and copper. These exceptions can sometimes be explained by the stability provided by half-filled or completely filled subshells.

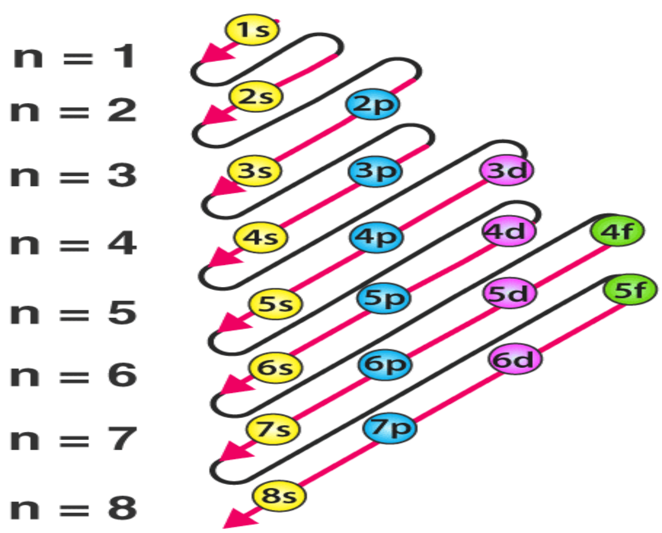
Pauli Exclusion Principle

- **The Pauli exclusion principle states that a maximum of two electrons, each having opposite spins, can fit in an orbital.**
- **This principle can also be stated as "no two electrons in the same atom have the same values for all four quantum numbers".**
- **Therefore, if the principal, azimuthal, and magnetic numbers are the same for two electrons, they must have opposite spins.**

Hund's Rule

- **This rule describes the order in which electrons are filled in all the orbitals belonging to a subshell.**
- **It states that every orbital in a given subshell is singly occupied by electrons before a second electron is filled in an orbital.**
- **In order to maximize the total spin, the electrons in the orbitals that only contain one electron all have the same spin (or the same values of the spin quantum number).**

For example, the electron configuration of sodium is $1s^2 2s^2 2p^6 3s^1$.

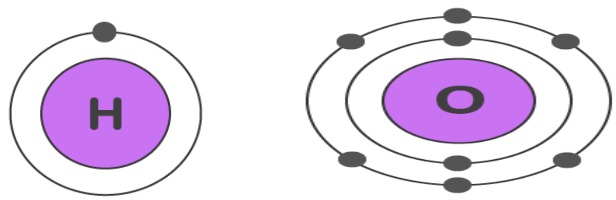


Representation of electronic Configuration of Atom

The electron configurations of a few elements are provided with illustrations in this subsection. Electron Configuration of Hydrogen The atomic number of hydrogen is 1. Therefore, a hydrogen atom contains 1 electron, which will be placed in the s subshell of the first shell/orbit. The electron configuration of hydrogen is $1s^1$,

Electron Configuration of Oxygen

The atomic number of oxygen is 8, implying that an oxygen atom holds 8 electrons. Its electrons are filled in the following order: K shell – 2 electrons , L shell – 6 electrons Therefore, the electron configuration of oxygen is 1s2 2s2 2p4.



Chlorine Electronic Configuration :-Chlorine has an atomic number of 17. Therefore, its 17 electrons are distributed in the following manner: K shell – 2 electrons L shell – 8 electronsM shell – 7 electrons

The electron configuration of chlorine is illustrated below. It can be written as $1s^2 2s^2 2p^6 3s^2 3p^5$ or as $[Ne]3s^2 3p^5$

Quantum numbers

Four quantum numbers can be used to completely describe all the attributes of a given electron belonging to an atom, these are:

- **Principal quantum number, denoted by n.**
- **Orbital angular momentum quantum number (or azimuthal quantum number), denoted by l.**
- **Magnetic quantum number, denoted by m_l.**
- **The electron spin quantum number, denoted by m_s.**

Number	Symbol	Possible Values
Principal Quantum Number	n	$1, 2, 3, 4, \ldots$
Angular Momentum Quantum Number	ℓ	$0, 1, 2, 3, \ldots, (n-1)$
Magnetic Quantum Number	m_l	$-\ell, \ldots, -1, 0, 1, \ldots, \ell$
Spin Quantum Number	m_s	$+1/2, -1/2$

Example:- How many electrons can fit in the orbital for which n=3 and l=1?

Answer 6 When n = 3 and l=1 orbital is 3p, so total number of electron that can be filled are 6 but in any orbital only 2 electrons can accumulate.

Example :-How many electrons can 3d hold? (10)There are 5 orbitals in d subshell and each orbital can accommodate 2 electrons. Hence maximum number of electrons that can be filled in 3d subshell is10

Quantum Numbers and Atomic Orbitals Each electron in an atom is described by four different quantum numbers (n, l, m l, & m s)					
l=	0	1	2	3	4
letter	s	p	d	f	g
if n =1		then l=0	s orbital	1s	
if n =2		then l=0	s orbital	2s	
if n =2		then l=1	p orbital	2p	
if n =3		then l=0	s orbital	3s	
		then l=1	p orbital	3p	
		then l=2	d orbital	3d	
Magnetic Quantum Number (m l):					
m l takes the values of - l, ..., 0, ..., + l.					
Spin Quantum Number (m s) Specifies the orientation of the spin axis of an electron. An electron can spin in only one of two directions: m s = +½ m s = -½					

Chemical Bonding

A chemical bond is an attraction between atoms This attraction may be seen as the result of different behaviors of the outermost or valence electrons of atoms. These behaviors merge into each other seamlessly in various circumstances, so that there is no clear line to be drawn between them.

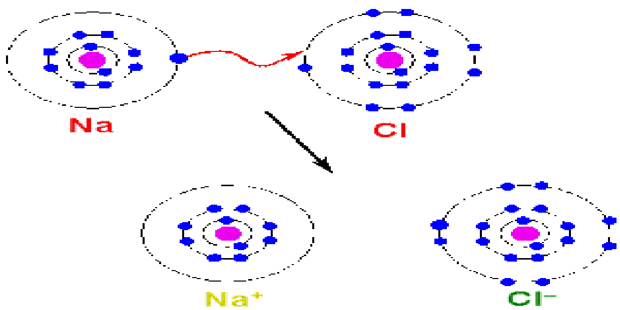
Major Types of Bonding in Chemistry and Their Properties

There are four major types of chemical bonds in chemistry, which includes;

a- Ionic bond

Ionic bonding is a type of chemical bonding that involves the electrostatic attraction between oppositely charged ions, or between two atoms with sharply different electro negativities, and is the primary interaction occurring in ionic compounds. The properties of Ionic Bonds

- **The ionic bond is the most reactive of all existing bonds in an appropriate medium since it possesses charge separation**
- **An ionic bond is the most powerful of all bonds**
- **The melting and boiling points of ionic bond compounds are pretty high**
- **Ionic-bonded molecules are strong conductors of electricity in their aqueous solutions or molten form. This is because ions, which function as charge carriers, are present**



b-Covalent bond

A covalent bond is formed when the electron pairs between atoms or constituents are shared. These electron pairs are said to be shared pairs or bonding pairs. The stable balance of attractive and repulsive forces between atoms or any constituents when they share electrons is known as covalent bonding.

Example: O_2 molecule CO_2

Covalent Bond Properties

The following are some of the characteristics of covalent bonds:

The production of additional electrons is not a result of the formation of covalent bonds.

There are powerful chemical bonds between atoms

The atoms that are bonded have definite orientations relative to one another. Therefore, covalent bonds are directional

Covalent bonds rarely break on their own after they have been formed

The enthalpies of vaporization and fusion are frequently lower in compounds containing covalent bonds.

Because of the absence of free electrons in covalently bonded compounds, they do not conduct electricity.

Water does not dissolve covalent compounds

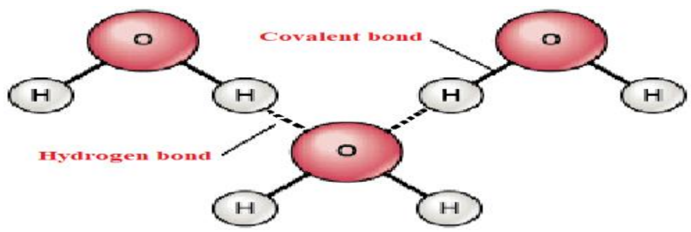
3. Hydrogen Bond

A hydrogen bond can be defined as the attractive force that binds one molecule's hydrogen atom with the electronegative atoms like fluorine, oxygen, and nitrogen of another molecule.

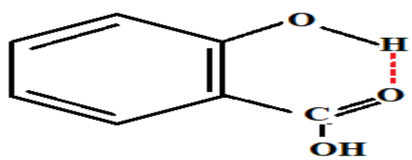
The magnitude of hydrogen bonding depends on the physical state of the compound, which is maximum in a solid state and minimum in a gaseous state. This allows the hydrogen bond to influence the structure and properties of the compounds strongly.

It is of two types Hydrogen Bond;

1-Intermolecular hydrogen bond: Bond formed between two different molecules.



2- Intramolecular hydrogen bond: Bond formed within a molecule



4. Metallic Bond

The collective sharing of a sea of valence electrons amongst many positively charged metal ions is referred to as a metallic bond.

Metallic bonding is a sort of chemical bonding that is responsible for various features of metals, including their lustrous luster, malleability, and heat and electricity conductivities.

Factors influencing the strength of a metallic bond. The total number of delocalized electrons.

The magnitude of the metal cation's positive charge. The cation's ionic radius

The properties attributed by the metallic bonding include: -

1. Electrical Conductivity. 2. Thermal Conductivity.

3. Malleability and Ductility. 4. Metallic Luster. 5. High Melting and Boiling Points: