Shree H.N.Shukla College of Science Rajkot

F.Y.B.Sc. Sem-I

BC-101: PHYSICAL AND CHEMICAL ASPECTS OF BIOCHEMISTRY

Prepared By :- Jinesh Kaneriya

UNIT-1 CHEMICAL BONDS

Concept of atoms and molecules.

The atom is the fundamental unit of matter and matter is any substance of universe that has mass and occupies space.

Living organisms are composed of matter. Matter can be changed form one form to another in a chemical reaction process in which different forms of matter combine or break apart.

Atom

An atom is composed of hundreds of smaller subatomic particles OR an atom is the smallest portion of an element.

Elements

An element is a substance composed exclusively of one kind of atom.

Properties of atoms.

Atoms are composed of two regions The nucleus The surrounding electron orbits The nucleus of an atom consist of two sub atomic particles Protons and Neutrons A third type of particle , electrons are found in orbitals,in motion surrounding the nucleus of atom.

Protons.

It is sub atomic particle carry positive charge in a nucleus of an atom.

Neutrons.

It is sub atomic particle carrying neutral charges, present in nucleus of atom

Electrons.

Subatomic particles carry negative charges, moving on outer orbits of an atom.

Structure of atom

An atom is a sphere (Round)like strcture in which particulary in the center of an atom (sphere) a nucleus is located.

Nucleus is abo spherical strcture carring protons & neutrons in it but it occupies a very little space in an atom.

Electrons are mouing surrounding an atom in an outer most orbits.

Atomic number- it is define as the total number of protons present in the nucleus of an atom.

Atomic mass – it is define as the sum of the total number of protons & neutrons present in the nucleus of an atom.

Isotopes—they are the atoms which have same atomic number but different atomic mass .

e.g. $_{1}H^{1}$ & $_{1}H^{2}$

(protium) (Deuterium).

Isobars—they are the atoms which have the same mass number but different atomic number.

e.g. $_{20}ca^{40}$, $_{18}Ar^{40}$

Properties of electrons

- Negatively changed, Very small mass
- The no. of electrons in a pure atom is the same as the no. of protons.
- Electrons are always in motion found in orbitals located it fixed distance outside of the nucleus called "electron-shells" The orbital of an e^- is the most probable location where the e^- might be found.

Electrons and energy levels:

An e^- moving on an orbit has a characteristic energy. Each e^- orbital's has a different energy so that e^- in different orbitals have different amount of energy.

These orbitals or shells are represented by the letters K,L,M,N..... or the numbers=1,2,3,4,.... The maximum no. of e^-present in a shell is given by the formula $2n^2$ where n is the orbit no.1,2,3,4. The maximum no. of e^- that can be fit into the outermost orbit is 8. The orbits are filled up by e^- in a stepwise manner.

Valency:

The number of electron's ability of an outermost orbit to gain,loose or share and complete it's outer orbit is called the valency.

Chemical bond

The nucleus of an atom tends to provide stability while e^- shells permit interactions between atoms called bond. Bond form when e^- from one atom are gained, lost or shared its another atoms. such interaction are called chemical bonds.

A chemicals bond is an attractive force that holds atom together and give strength to the atom.

Types of Bonds:

Primary binds are strong such as covalent bonds, which almost never break at physiological temperature.

Secondary bonds are weak bonds which include ionic bonds,vanderwaal's bonds and hydrogen bonds are easily broken.

Main three types of chemicals bonds

Covalent bind, Ionic bond,Coordinate bond OR dative bond

COVALENT BONDS:-

The major elements found in living organism like carbon, hydrogen, oxygen and nitrogen tend to form covalent bonds.

COVALENT BOND'S CHARACTERISTICS:-

A covalent bond is formed when different atoms share one or more of their electrons with each-other.

Depending on the total number of electrons an atom has to share, an atom may covalently bond with one or with several other atoms.

Single covalent bond: - The two atoms are sharing 1 electron pair. E.g. H_2

Double covalent bond: - The two atoms are sharing 2 electron pair.

Triple covalent bond: - The two atoms are sharing 3 electron pair.

The number of electrons contributed by an atom for sharing, to form a covalent bond is called covalency.

E.g. Covalency of hydrogen is 1, while covalency of oxygen, nitrogen & carbon are 2, 3 & 4 respectively.

SIGNIFICANCE OF COVALENT BOND:-

- ♣ The primary structure of any biomolecules is determined by covalent bonds. (Whether small molecules such as water a simple salts, acids & bases or large molecules such as DNA & proteins.)
- ♣ The **(-s-s-)** disulfide bond formation in protein structure.

- A number of metal ions such as mercury, lead & copper react with sulphydral groups in enzymes & coenzymes by covalent bond formation.

Types of Covalent bonds

Polar covalent bond:- A molecule formed by unequal sharing of electrons between the two atoms, in which one end of an atom acquire slightly negatively charge, while the other end of atom possess slightly positively charge & ultimately it results into a polar covalent bond.

Non-polar covalent bond: - A molecule found between the two atoms by equal sharing of electrons.

HYDROGEN BOND:-

Attraction between adjacent polar molecules. It is defined as the bond between hydrogen of one molecule & the electronegative atom of the other molecule.

Electronegative atom: - A tendency of an atom to attract more electrons towards itself. E.g. F, O, S, N.

The sharing of proton between two electronegative atoms is called a hydrogen bond & commonly represented by a broken line. E.g. **(X-H-----Y)**

The presence of strong H-O-H bonding in liquid H_2O accounts for its higher boiling point as compared to NH_3 or H_2S.

SIGNIFICANCE OF H-BONDING:- (use of H-bond)

- Hydrogen bond formation is of great importance in biological system. Life would have been impossible without liquid water, which is the result of intermolecular hydrogen bonding. (H-bonding formed between two different elements of the different atoms.)
- H-bonding increases rigidity & strength of wood fibers & thus useful for furniture & other needs.
- The bond energy of H-bond is low (2-7 kcal/mol) but the additional effects of such bonds can stabilize an interaction between atoms significantly.
- The ordered structure of nucleic acids & proteins are because of multiple H-bond formation.
- The ability of ---C-NH residue to form intermolecular & molecular H-bonds (C=O---N-H) is responsible for the helical & pleated structure of proteins respectively.
- The four nitrogen bases E.g. cytosine(C), thymine(T), adenine(A), guanine(G) present in DNA can associate with each-other through hydrogen bonding & additive effect of these H–bond is responsible for stabilization of the double helical structure of DNA.
- H-bond plays an important role in the process of replication.
- H-bonds are also responsible for synthesis of proteins.

IONIC BOND:-

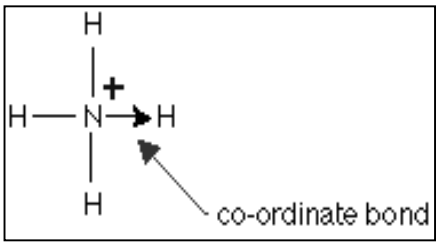
- A chemical bond formed between two atoms either by completely loosing or completely gaining the electrons fro an outermost orbit.
- So, an atom which losses its e^- becomes (+) positively charged ion, while an atom which gains an e^- becomes (-) negatively charged ion.
- E.g. **sodium chloride (salt)**

Na	+	Cl	→	$[Na^+]$	$[Cl^-]$	or	$Na^+ Cl^-$
Sodium atom		chlorine atom		sodium ion	chlorine ions		
[2, 8, 1]		[2, 8, 7]		[2, 8]	[2, 8, 8]		

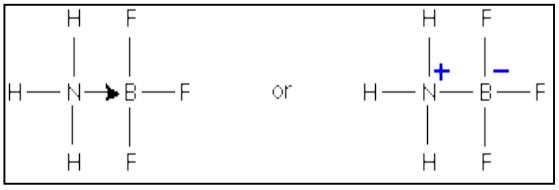
It is a strong bond.

CO-ORDINATE COVALENT BOND:-

- In which, only one of the contribution atoms donates a pair of electrons is usually referred to as co-ordinate covalent bond. This type of bonding therefore leaves a fractional positive charge on the donor atom and an equivalent negative charge on the acceptor atom.
- E.g.
- Here, the lone pair of nitrogen atom of ammonia serves to form a co-ordinate covalent bond with a proton to give ammonium cat ion (NH^{4+})



- Compounds formed by co-ordinate bond are called co-ordination compounds.
- The co-ordinate bond is shown by (→) sign. Head of arrow is towards the acceptor atom while the tail is towards the donor atom. i.e. A→B
- The co-ordinate or dative bond is a directional bond.
- The second diagram shows another way that you might find co-ordinate bonds drawn. The nitrogen end of the bond has become positive because the electron pair has moved away from the nitrogen towards the boron - which has therefore become negative.



VANDER WAAL'S BOND:-

- The intermolecular attractive forces between all molecules (polar as well as non-polar) are close to one another are called Vander Waal's force.
- This type of bonding operates at very short distance [their energy depends heavily upon the distance between interacting groups.
- Vander Waal's forces are much stronger in the solid state & liquid state than in gaseous state.
- Vander Waal's forces are in antigen-antibody reaction, drug receptor & enzyme substrate association.
- It includes two types of forces-
- **Attractive force**: - A natural attraction between the nucleus of one molecule & the electron could of other molecule.
- **Repulsive force:** - Repulsion between the two nuclei & also repulsion between the two negative charges of electron clouds.

Electrophiles (e^- acceptor):-

An electrophiles is an agent attracted to electrons that participates in a chemical reaction by accepting an electron pair in order to bond to a nucleophile [lone pair of e^-]

Nucieophiles (e^- donor): -

Reagent forms a chemical bond to its reaction partner the electrophile by donating both bonding electrons. [Pair of e^-]

Dipole:-

The valance electron in water molecules spend more time around the oxygen atom. Than the oxygen ends of the molecules develops a partial negative charge and for the same reason the hydrogen end of the molecules develops a partial positive charge.

In this case, the ions are not formed but a molecule develops a partial electrical charge across it is called dipole