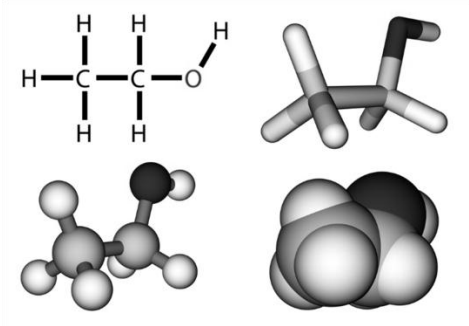
Chapter 4

Chemical Bonding

Day - 1

INTRODUCTION

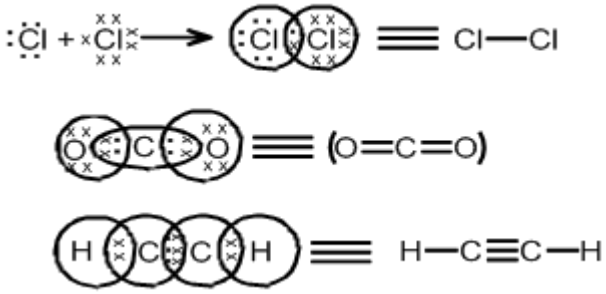
The attractive force which holds together the constituent particles (atoms, ions or molecules) in chemical species is known as chemical bond.



1. **Kössel-Lewis Approach to Chemical Bonding**

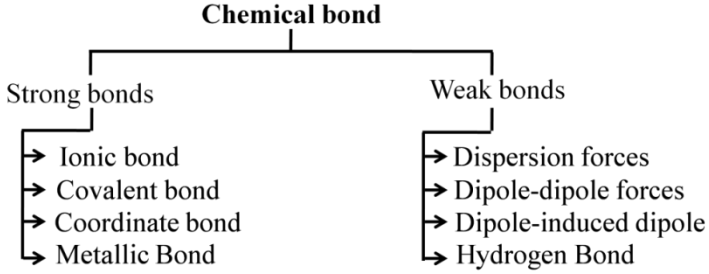
They assumed that atom have positive kernel surrounded by electrons occupying the corners of a cube. If they have all the eight electrons in their outer shell they will be stable (octet rule). Otherwise they achieve stability (octet) through chemical bonding.

LEWIS STRUCTURE



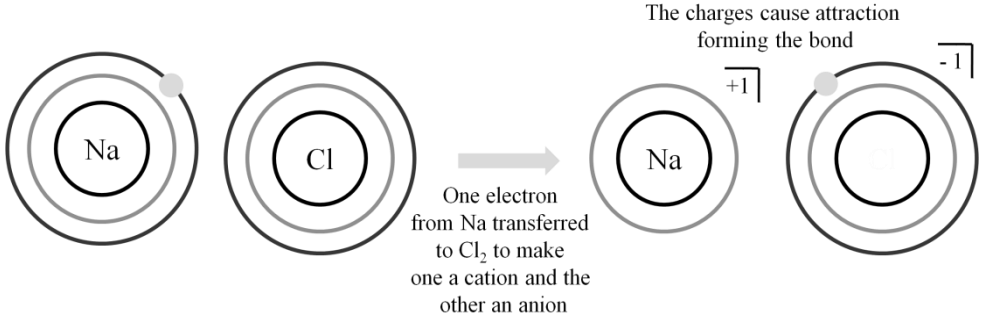
Why chemical bonds are formed.

If the resultant molecule has lower Gibb's energy then the reacting species, then chemical bonds are formed.



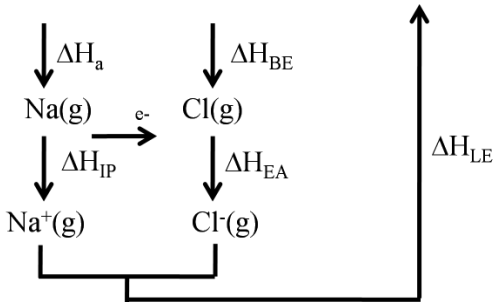
IONIC BOND

Ionic bonds are strong electrostatic forces between cation & anion which are formed when an atom looses an electron or gains an electron.



BORN HABER CYCLE FOR SODIUM CHLORIDE

$$Na(s) + \frac{1}{2}Cl(g) \xrightarrow{\Delta Hg} NaCl(s)$$

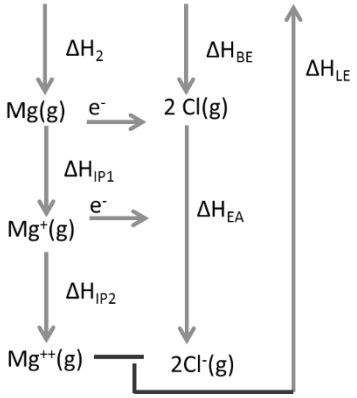


$$\Delta H_R = \Delta H_a + \frac{1}{2}\Delta H_{BE} + \Delta H_{IP} + \Delta H_{EA} + \Delta H_{LE}$$

$Na(s) \rightarrow Na(g)$	ΔH_a = 108.4 kj/mole
$Na(g) \rightarrow Na^+(g) + e^-$	ΔH_{IP} = 496 kj/mole
$\frac{1}{2} Cl_2(g) \rightarrow Cl(g)$	ΔH_{BE} = 121 kj/mole
$Cl(g) + e^- \rightarrow Cl^-(g)$	ΔH_{EA} = - 348.6 kj/mole
$Na^+(g) + Cl^-(g) \rightarrow Nacl(s)$	ΔH_{LE} = - 788 kj/mole
$Na(s) + \frac{1}{2} Cl_2(g) \rightarrow Nacl(s)$	ΔH_R = - 411.2 kj/mole

Ex.1: Draw Born Haber cycle for formation of Magnesium chloride

$$Mg(s) + Cl_2(g) \xrightarrow{\Delta Hg} Mgcl_2(s)$$



$$\Delta H_R = \Delta H_a + \Delta H_{IP_1} + \Delta H_{IP_2} + \Delta H_{BE} + 2\Delta H_{EA} + \Delta H_{LE}$$

PROPERTIES OF IONIC COMPOUNDS

1. They are crystalline in nature
2. They have high Melting and Boiling point
3. Hard and Brittle
4. Soluble in polar solvents
5. Conduct electricity in molten state and aqueous state but not in solid state.
6. Do not show Isomerism.

VARIABLE ELECTROVALENCY

Fe (26) $\rightarrow 3s^2\ 3p^6\ 3d^6\ 4s^2$
Fe^{+2} (24) $\rightarrow 3s^2\ 3p^6\ 3d^6$ (less stable)
Fe^{+3} (23) $\rightarrow 3s^2\ 3p^6\ 3d^5$ (more stable)

Solubility of ionic compounds in water. There are two things happen on dissolving ionic compounds in water.
1. Breaking of ionic lattice
2. Mixing of ions in water
For the first process, lattice energy to be provided to the solution and for second process hydration energy will be released by the system
If $\Delta H_{hyd} > \Delta H_{L.E.}$ Compound is soluble in water

(a) Lattice Energy

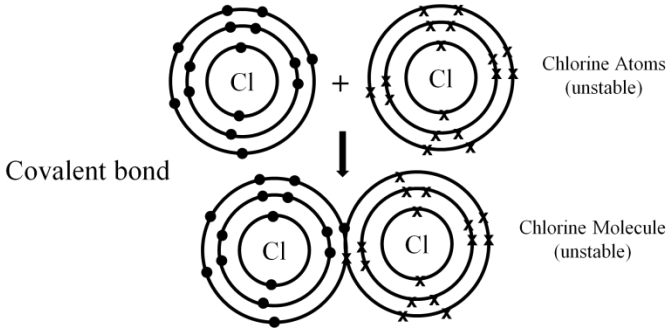
1. If depends on size of cation and anion.
Smaller the size greater is the Lattice Energy.
Ex. $\rightarrow$ LiCl > NaCl > KCl
$\rightarrow$ NaCl > NaBr > NaI
2. If depends on Charge of cation and anion.
Bigger the charge, lesser is it Lattice energy.
Ex. $MgCl_2$ > NaCl
3. In case anions are extremely large, then the rule one charges smaller the cation lesser is Lattice Energy.
Ex. $MgSO_4 < CaSO_4 < SrSO_3 < BaSO_4$

(b) Hydrogen energy

Smaller the cation, greater is the hydration enthalpy.
Ex. Compare Solubility $BaSO_4$ and $CaSO_4$
L.E. $\Rightarrow$ $BaSO_4 > CaSO_4$
Hyd. Energy $\Rightarrow$ $CaSO_4 > BaSO_4$
So $CaSO_4$ is more soluble.
Ex. Compare solubility of NaCl and $BaCl_2$
L.E. $\Rightarrow$ $BaCl_2$ > NaCl
Hyd. Energy $\Rightarrow$ NaCl > $BaCl_2$
So NaCl is more soluble.

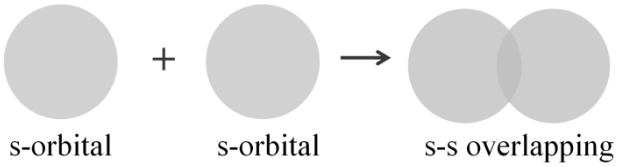
COVALENT BOND

Combining of unpaired electrons of atoms to achieve a stable configuration and formation of molecules is called covalent bond.

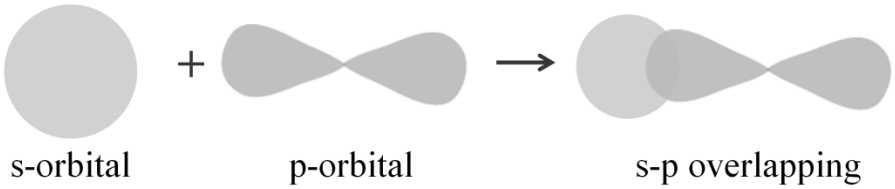


SIGMA (σ) BOND: THIS TYPE OF COVALENT BOND is formed by the end to end (head-on) overlap of bonding orbitals along the inter-nuclear axis. This is called as head on overlap or axial overlap

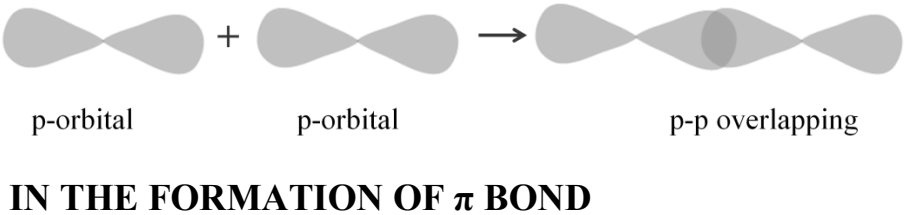
s - s overlapping: In this case, there is overlap of two half killed s-orbitals along the inter-nuclear axis as shown below:



s-p overlapping: This type of overlap occurs between half filled s-orbitals of one atom and half filled p-orbitals of another atom:

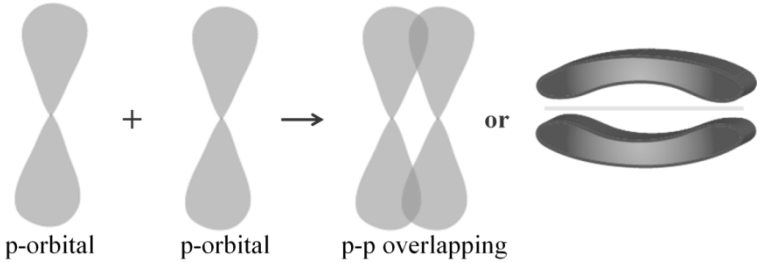


p-p overlapping: This type of overlap takes place between half filled p-orbitals of the two approaching atoms:



Pi (π) BOND: IN THE FORMATION OF π BOND

The atomic orbitals overlap in such a way that their axes remain parallel to each other and perpendicular to the inter-nuclear axis.



Characteristic of Convent compounds

1. Physical state → gases, liquids of law b.p. & soft solids

2. Melting Point/Boiling point → with exception of network solids, they have low M.P. and B.P.
3. Electrical conductance → generally bad conductors
4. Solubility → soluble in non-polar solvents
5. Isomerism → yes Physical state → gases, liquids of law b.p. & soft solids
6. Melting Point/Boiling point → with exception of network solids, they have low MP/B.
7. Electrical conduce → generally bed conductors
8. Solubility → soluble in non-polar solvents
9. Isomerises → yes

COMPARISON BETWEEN IONIC AND COVALENT BONDS

Ionic Bond	Covalent Bond
l. Formed by the transference of electron or electrons from electro- positive (metal) to electronegative (non-metal) atoms. Such a bond is possible between dissimilar atoms.	Formed by sharing of electrons between two non-metal atoms when the electrons are equally contributed by both the atoms. Such a bond is possible between similar and dissimilar atoms.
2. Consists of electrostatic force between atoms.	Consists of shared pair or pairs of electrons which are attracted by both the nuclei.
3. Non-rigid and non-directional, does not cause Isomerism.	Rigid and directional, causes isomerism.
4. It is a weak bond, since the electrostatic force between the ions can be broken easily.	It is strong bond, since the paired electrons cannot be separated easily.
5. It is polar in nature.	It is non-polar if the electronegativity difference is zero or small

COMPARISON BETWEEN IONIC AND COVALENT COMPOUNDS

Ionic compounds	Covalent compounds
l. Crystalline solids at room temperature.	Gases, liquids or soft solids under ordinary conditions.
2. High melting and boiling points.	Low melting and boiling points with the exception of giant molecules.
3. Hard and brittle.	Soft and waxy with the exception of giant molecules.
4. Freely soluble in water and in polar solvents. Insoluble in non- polar solvents.	Usually insoluble in water and in polar solvents. Soluble in non- polar solvents
5. In solid state bad conductors of electricity. Good conductors in in molten state and in solutions.	Bad conductors of electricity with few exceptions having layer lattice structure.
6. Undergo ionic reactions Rates of rections are very high and reaction are fast and instantaneous	Undergo molecular reactions Rates of reactions are low Reactions are slow,