Chapter 3 (AS-Level)

Chemical bonding and structure

A. Covalent bonding

Simple molecular

- Liquids and gases
- Low melting solids
- H_2O, NH_2, C_2H_5OH, Sucrose

Properties:

A. ***Low boiling point and melting point***
B. ***Nonconductors of electricity***
C. ***May be insoluble in H_2O, may dissolve in organic solvents***

Giant molecular

- Solids of high melting point and boiling point
- Quartz

Properties:

A. ***High boiling point and melting point***
B. ***Nonconductors***
C. ***Insoluble in H_2O and other solvents***

In covalent bonds, electron pairs are shared between atoms. The electron – pairs lying between the two nuclei are attracted by both nuclei, thus bonding them and thus overcoming the repulsion between them.

In covalent compounds, the shared electron pairs are in molecular orbitals rather than atomic orbitals

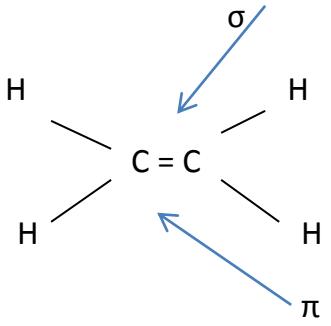
Molecular Orbitals arise from the overlap of atomic orbitals.

Atomic Orbitals

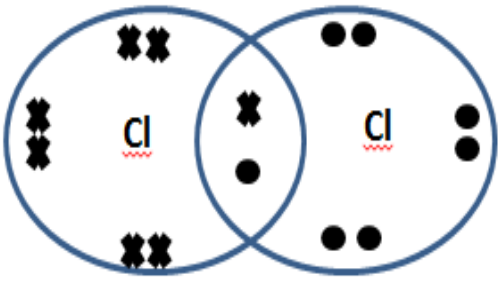
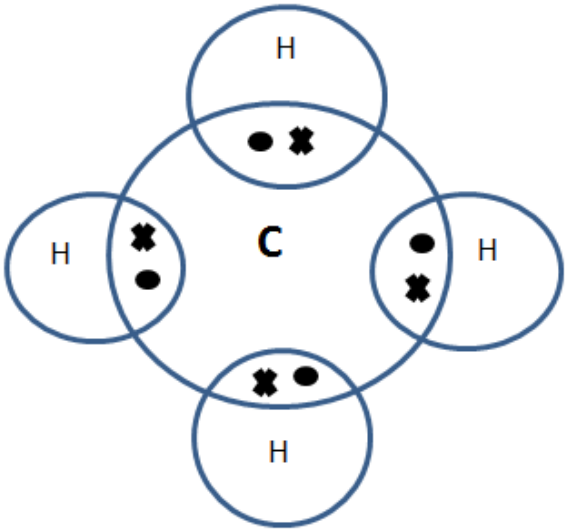
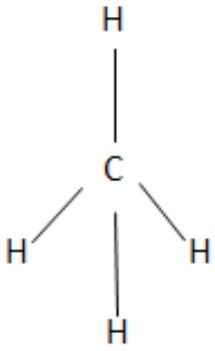
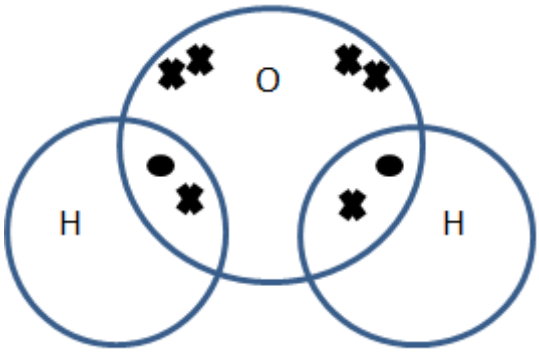
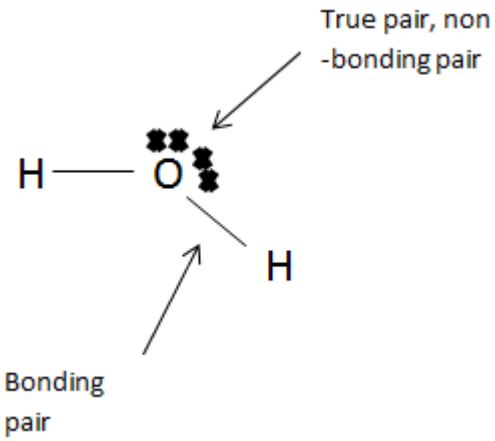
s, p, d

Molecular Orbitals

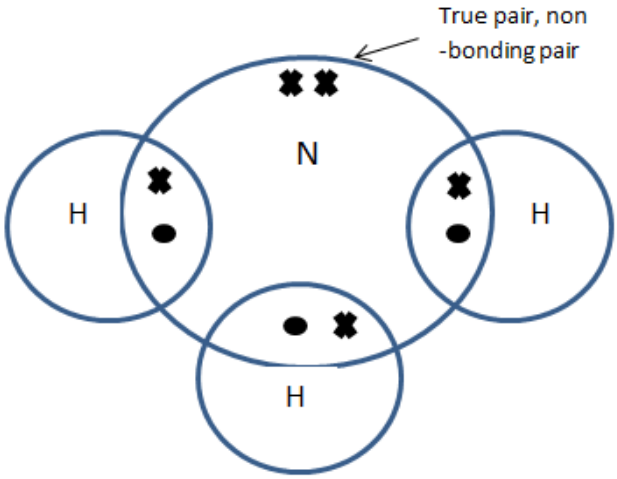
σ, π, δ

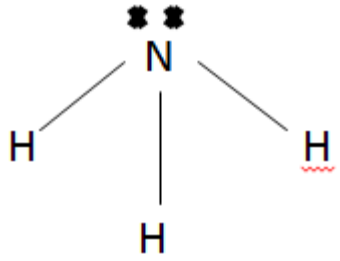


Examples of simple covalent molecules:

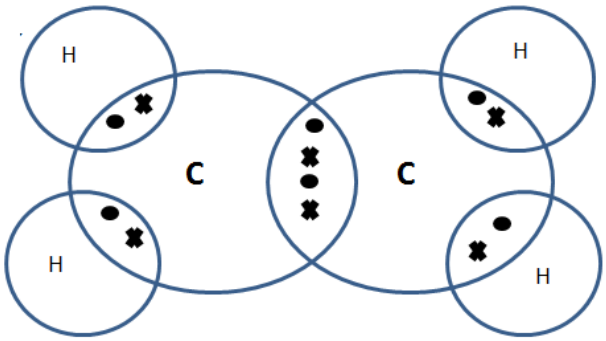
Molecular formula	Structure	Bonds
Cl_2		Cl-Cl
CH_4		
H_2O		

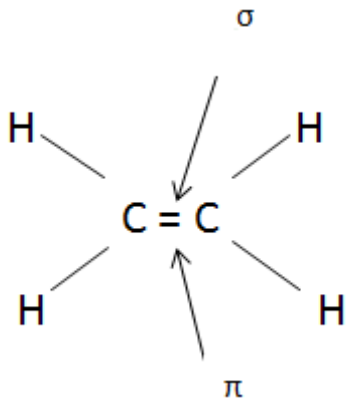
NH_3



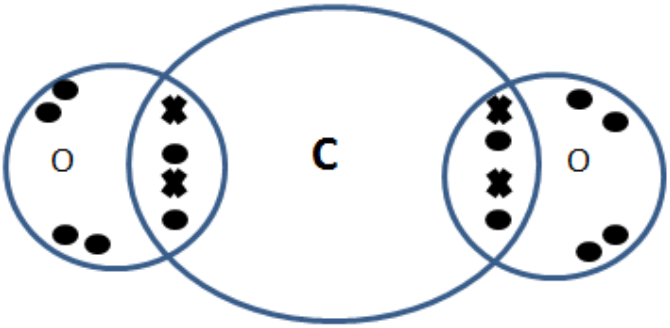


C_2H_4





CO_2



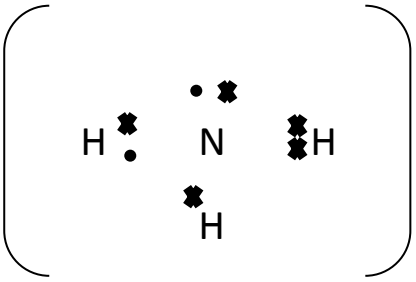
O = C = O

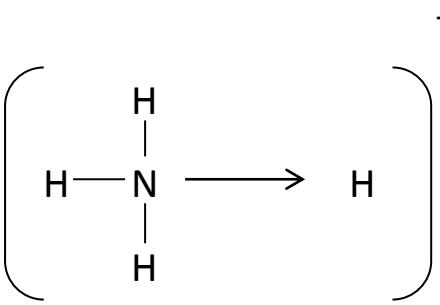
Dative covalent (coordinate) bond:

A lone pair from one atom overlaps with an empty orbital in another atom.

Ex:

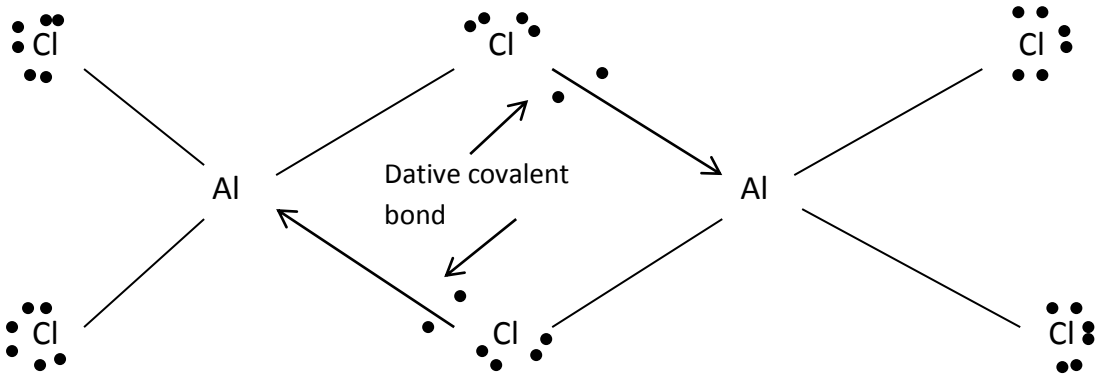
$NH_3 + [H]^+ \rightarrow H$





Ex:

Al_2Cl_6



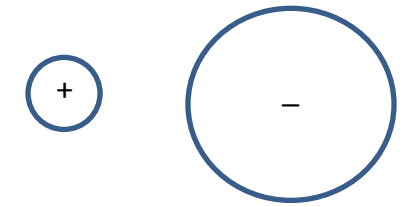
B. Bonds of intermediate (in between covalent & ionic) character

Ionic, of covalent character:

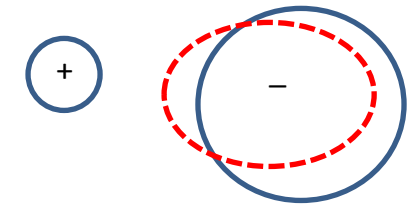
Polarization of Ions:

These are ionic compounds that show some properties which are more characteristic of covalent compounds. These ionic compounds contain anions which have become polarized.

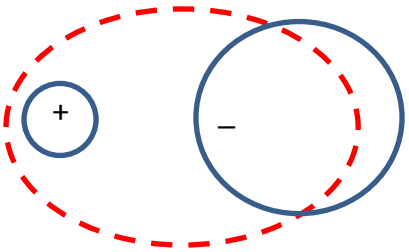
1) Polarization of anion is the distortion of electronic cloud by the cation.
2) Polarization brings more electron charge between the two ionic nuclei producing a certain degree of covalent bonding.
3) Distortion:



purely ionic



partial ionization



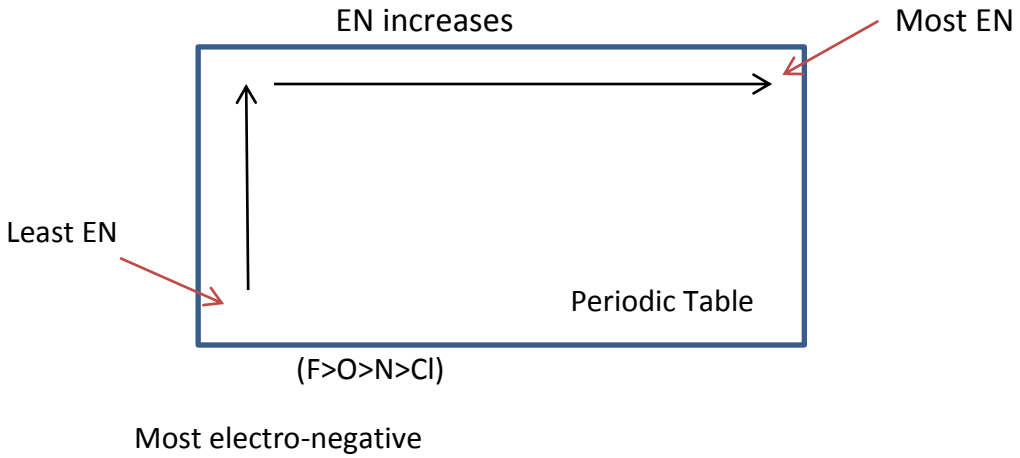
extensive → Ionic Molecule of Covalent Character

4) Cations with smaller radius and greater charge (i.e. greater charge density) have greater polarization on anions.
5) Anions with larger radius and greater charge are more easily polarized by cations.

Covalent, of ionic character

Polarity of Covalent Bond

1) Covalent bonds in molecules become polar if there is difference in electronegativity between the elements. EN is the ability to attract the shared e-pairs.

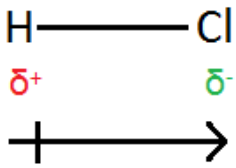


2) The more electronegative atom attracts the shared pair(s) more to itself leading to formation of a dipole. (i.e. ionic character).

3) In polyatomic molecules, the shape of the molecule must be taken into account.

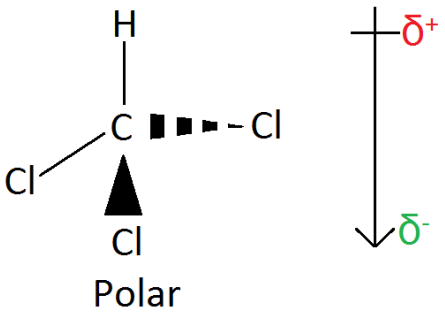
Diatomic and polyatomic molecules

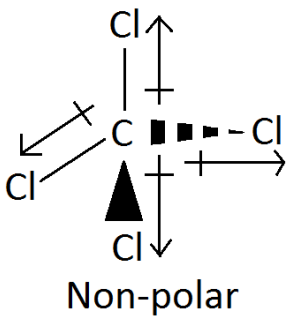
Diatomic



To predict the polarity in a molecule, the molecular shape should be known

Polyatomic





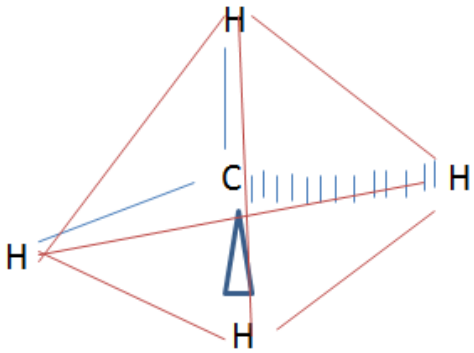
Non-polar, the 4 polar bonds cancel each other out.

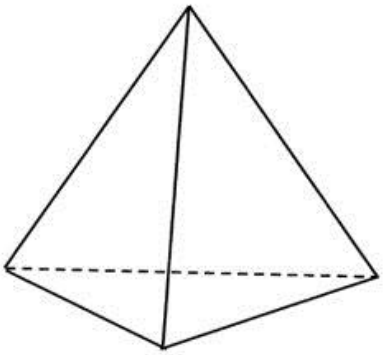
Shapes of simple molecules:

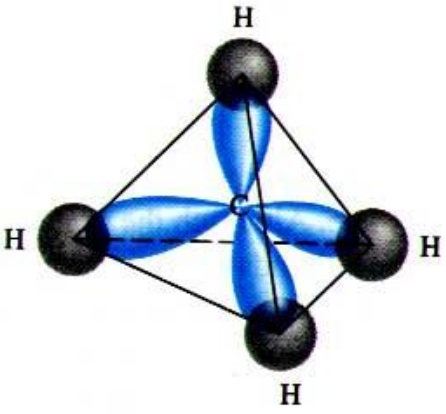
We apply VSEPR (Valency Shell Electron-Pair Repulsion Theory).

Bonding and non-bonding e-pairs repel each other. The repulsion causes these pairs to move as far apart as possible. The orientation in space of these pairs determines the shape of the molecule.

CH_4 (tetrahedron)

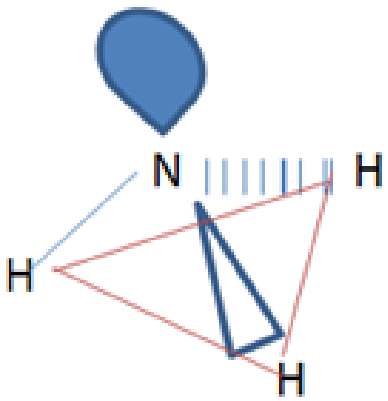


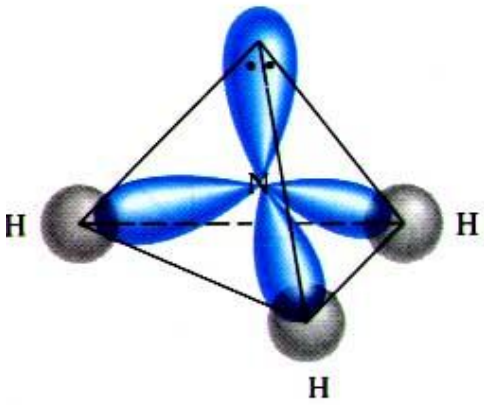




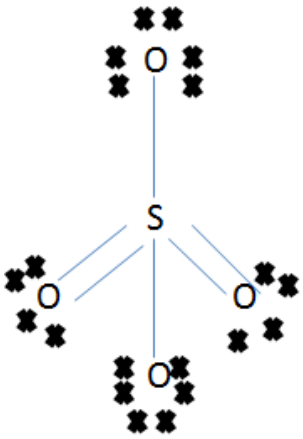
NH_3 (trigonal pyramidal)

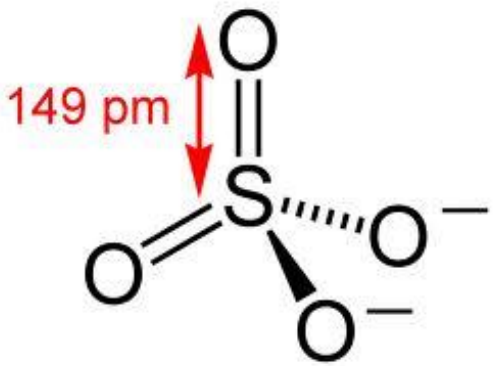
Lone pair



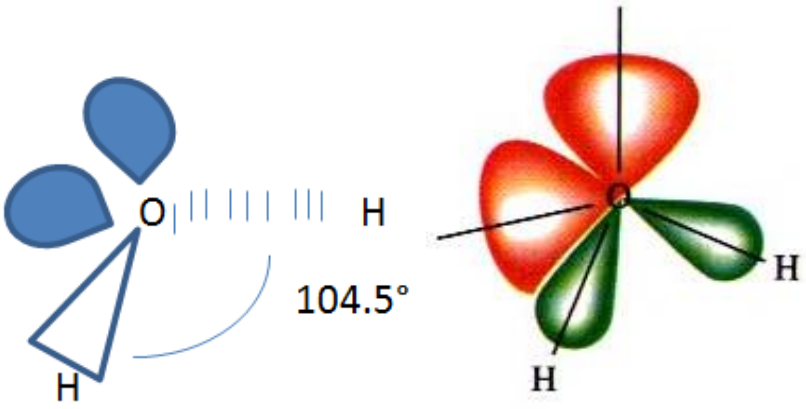


SO_4^{2-} ion

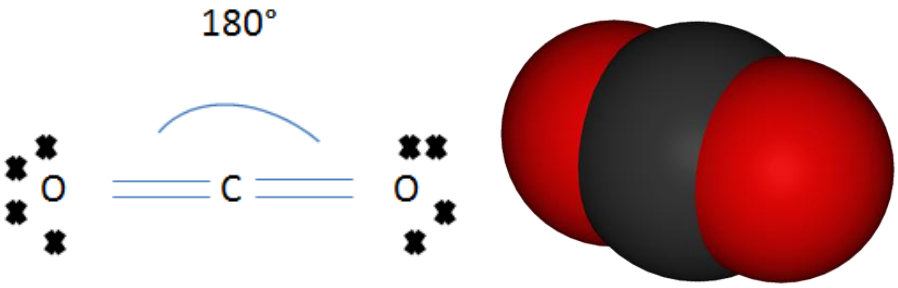




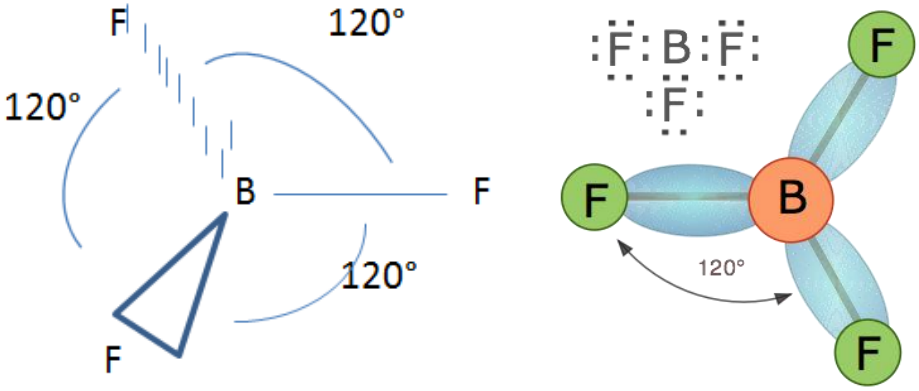
H_2O (V-shaped)



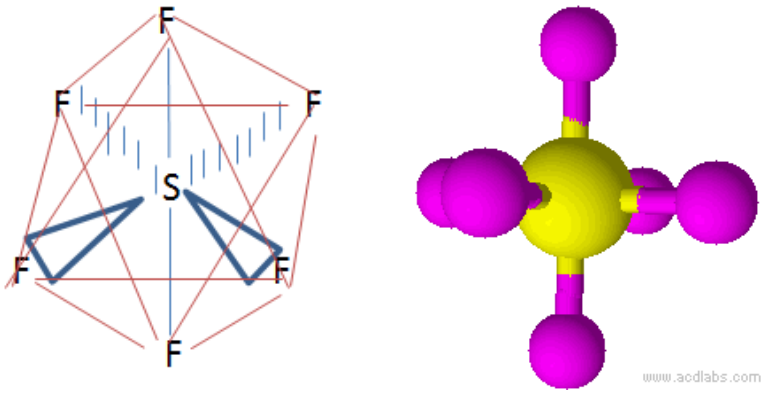
CO_2 (linear)



BF_3 (trigonal planar)



SF_6 (octahedral)



Summary:

1) Simple Molecules, central atom has no LP's

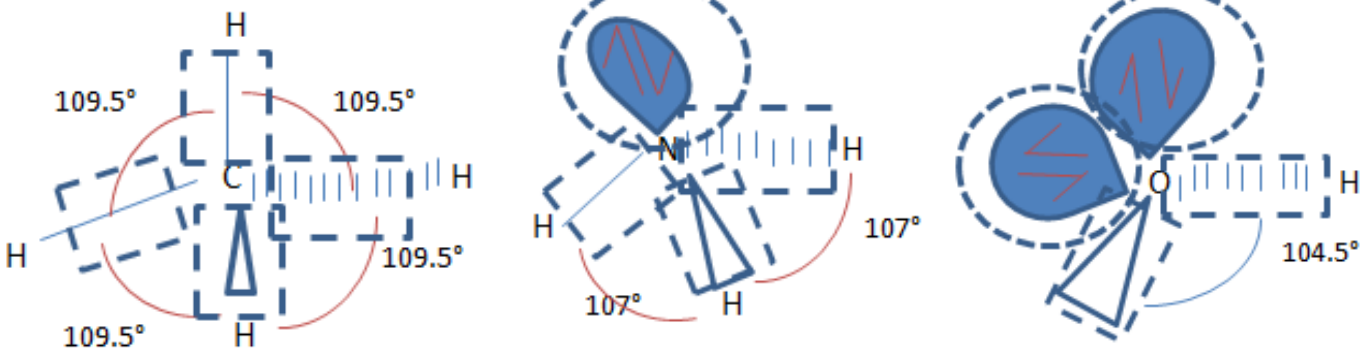
Formula	Shape
AB_2	linear
AB_3	trigonal planar
AB_4	tetrahedral
AB_5	trigonal bipyramidal
AB_6	octahedral

2) Simple Molecules, central atom has LP's

Formula	# of LP's	Shape
AB_2	1	V-shaped
AB_2	2	V-shaped
AB_3	1	trigonal pyramidal

Lone pairs, bonding-pairs and bond angles:

Lone-pairs , Bonding-pairs , Bond Angles



LP's occupy bigger space than BP's

LP-LP > LP-BP > BP-BP

Bond length and bond enthalpy:

Single Bond Length > Double Bond Length > Triple Bond Length

Bond Enthalpy: energy required to break 1 mol of given bond in 1 mol of gaseous molecules.

Single Bond Enthalpy < Double Bond Enthalpy < Triple Bond Enthalpy

C. Metallic bonding

Properties of Metals:

- *Shiny*
- *Good conductor of electricity & heat in solid state*
- *Sonorous*
- *Ductile*
- *Malleable*

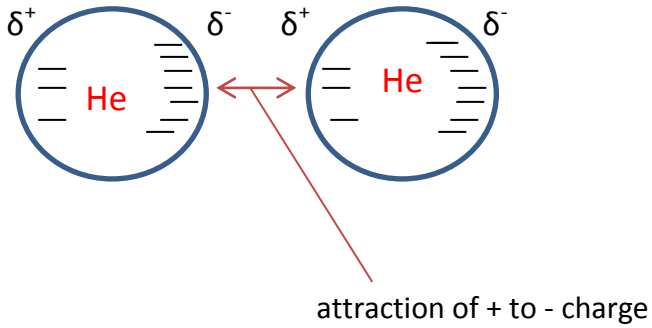
Bonding: In metallic bonding (lattice), the atoms lose their electrons (outer-shell), which extend throughout the lattice, thus forming a sea of electrons surrounding a lattice of positive ions.

Metallic bonding explains the properties of metals.

Intermolecular forces:

Instantaneous – dipole, induced dipole (van der waals forces)

Present in atoms and non-polar molecules.



Ex: noble gases, alkanes, polymers like LDPE & HDPE….., graphite

Gases: Cl_2 Liquids: Br_2 Solids: I_2

Permanent dipole, dipole

Present in polar molecules.

Ex: H_2O, NH_3, HCl, $CHCl_3$

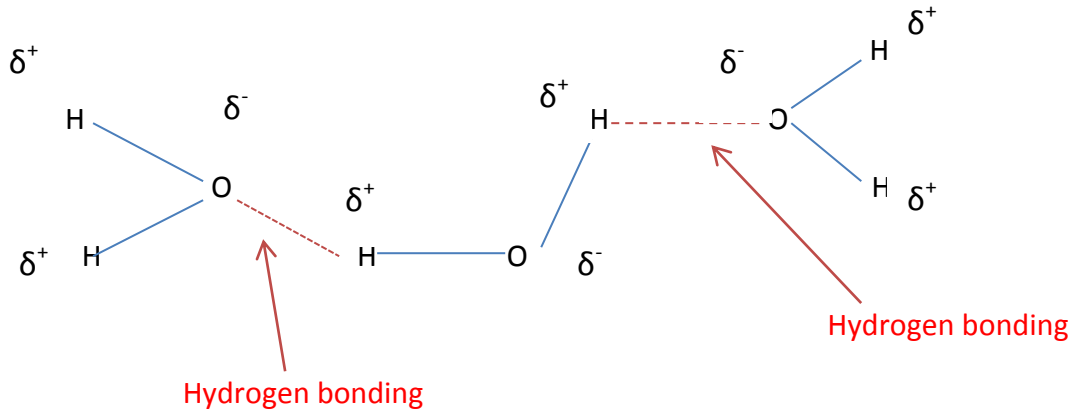
Hydrogen bonding (H-bonding)

H-bonding is present in molecules with possibility of H-bonding. This is by far the strongest type of intermolecular force.

i.e. with: **F-H, O-H, N-H** bonds

Hydrogen bonding is responsible for the liquid state of water, and water is responsible for the presence of life….

Ex: H_2O, NH_3, proteins, C_2H_5OH (carboxylic acids)



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