General Chemistry

Chemical Bonding

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Chapter Description

- Expected Outcome:
- At the end of the lecture, the students should be able to understand and solve the problems regarding Lewis Structure, Molecular Shape & Polarity Orbital.

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- Reference:

1) Martin S. Silberberg. Principles of General Chemistry. McGraw-Hill.

2) Raymond Chang. General Chemistry: The essential concepts. McGraw-Hill.

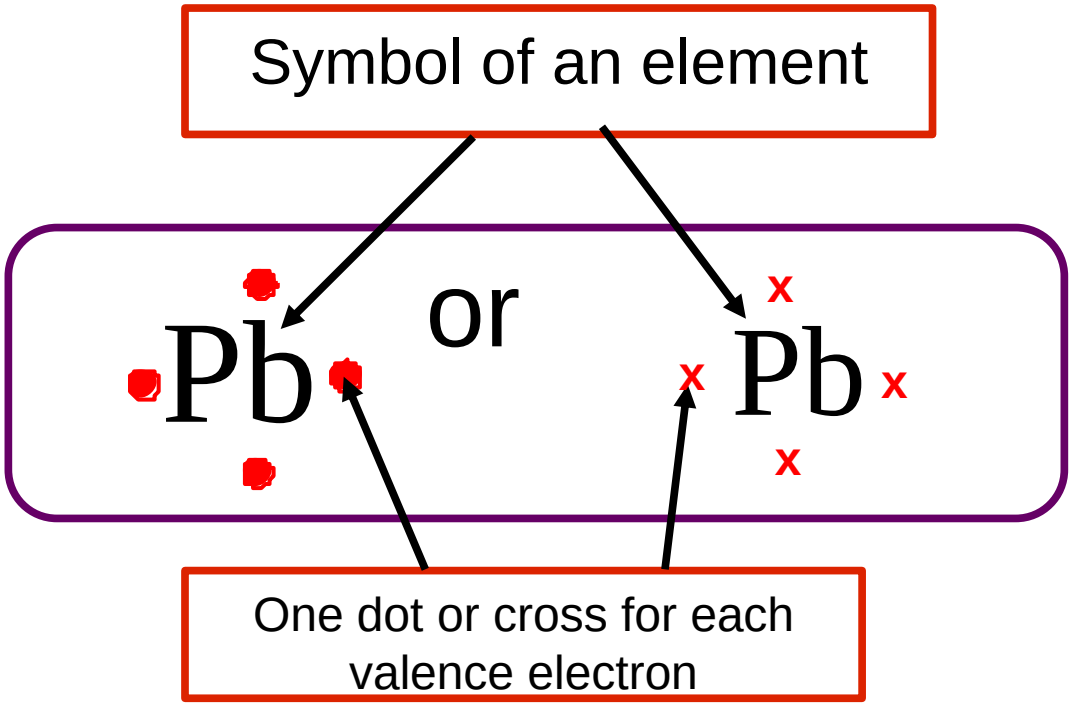
Contents

- Lewis Structure
- Molecular Shape
- Polarity Orbital

CHEMICAL BONDS

- The forces of attraction that holds the atoms together in new species
- 3 types of bonds : ionic, covalent and metallic

LEWIS SYMBOLS



Lewis structure- THE OCTET RULE

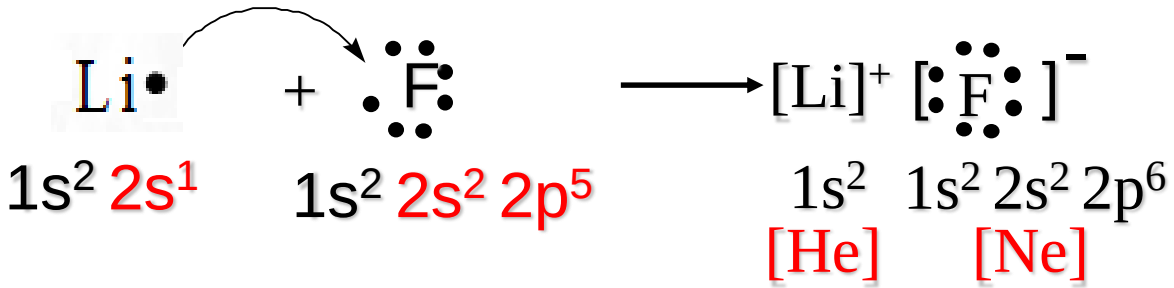
- The tendency of molecules and polyatomic ions to have structures in which 8 electrons surround each atom

- Hydrogen atom achieve electronic configuration of 2 electrons (duplet)

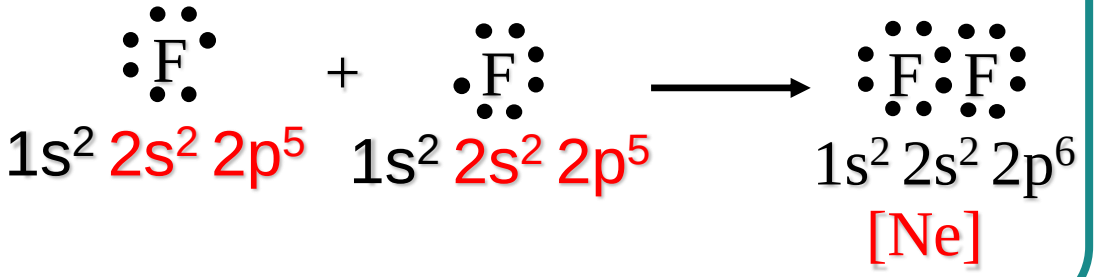
THE OCTET RULE

Atoms achieve noble gas configuration by:

Transfer (lose/gain) of electron

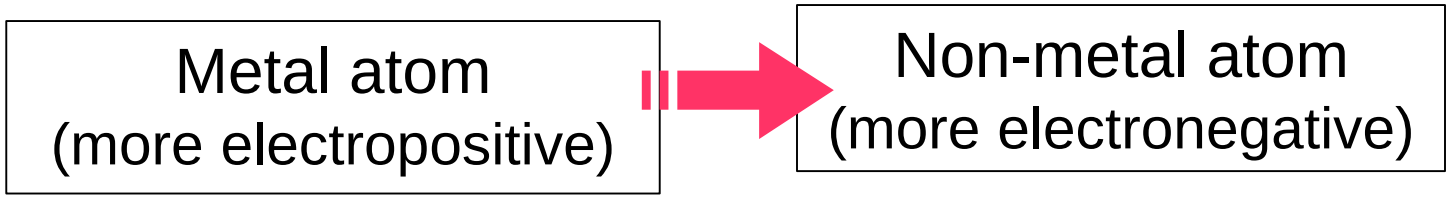


Sharing of electron

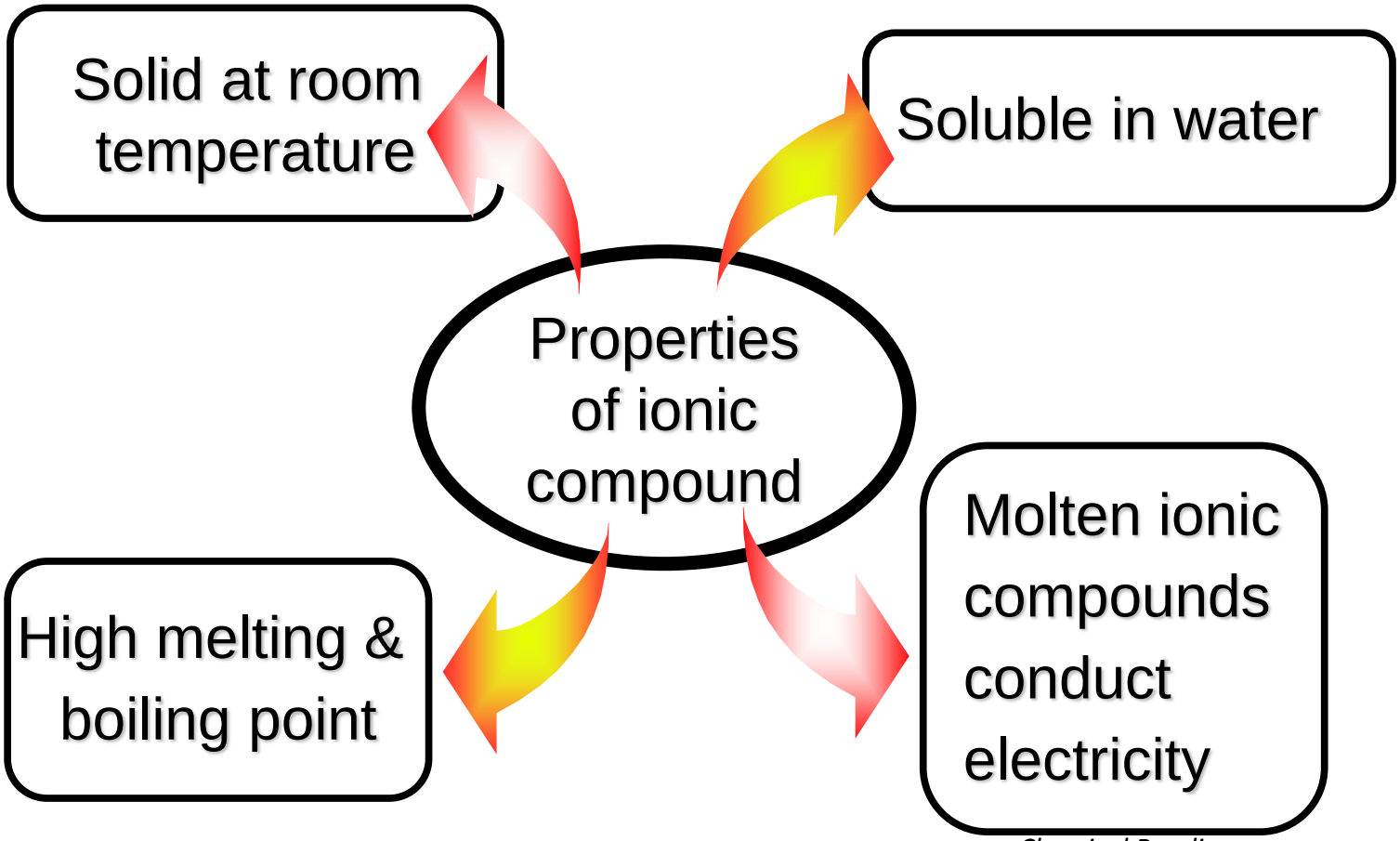


Lewis structure- FORMATION OF IONIC BOND

- The electrostatic forces between the positive ions and negative ions
- Involved the transfer of electrons from:

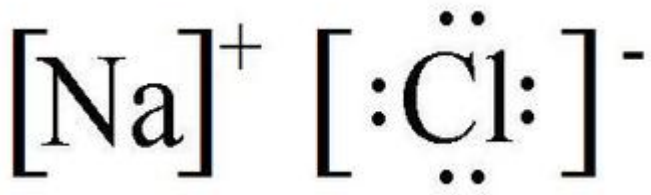


PROPERTIES OF IONIC BOND

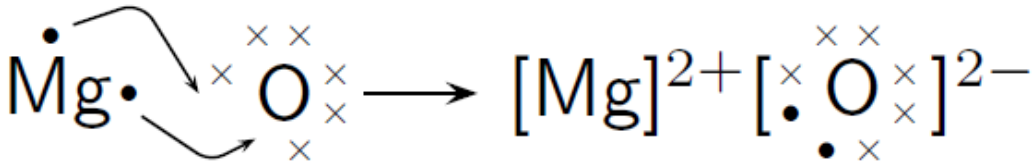


LEWIS STRUCTURE OF IONIC BOND

Formation of NaCl



Formation of MgO



Lewis structure- FORMATION OF COVALENT BOND

Formed by sharing of one or more pairs of valence electrons between the bonded atoms

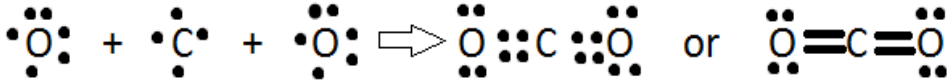
LEWIS STRUCTURE OF COVALENT BOND

Single bond

two atoms share one pairs of electrons

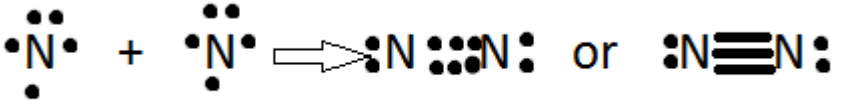
Double Bond

two atoms share two pairs of electrons



Triple Bond

two atoms share three pairs of electrons



BOND LENGTHS and strength

Bond Strength → Single bond < Double Bond < Triple Bond

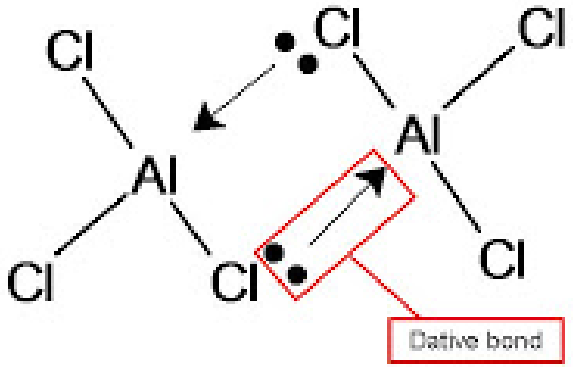
Bond length → Triple bond < Double Bond < Single Bond

FORMATION OF DATIVE BOND

Formed when one atom provides two electrons which are then shared with another atom.

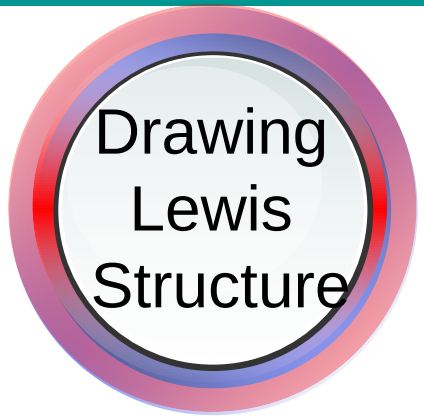
Donor atom have a lone pair electrons

Acceptor atom have an empty orbital to fill the two electrons.



Picture source:
http://1.bp.blogspot.com/_OdZZiyNKEoU/SeH3Ma_Ul3I/AAAAAAAAAP0/qMIGqHkvrxc/s320/Slide3.jpg

STEPS IN DRAWING LEWIS STRUCTURE

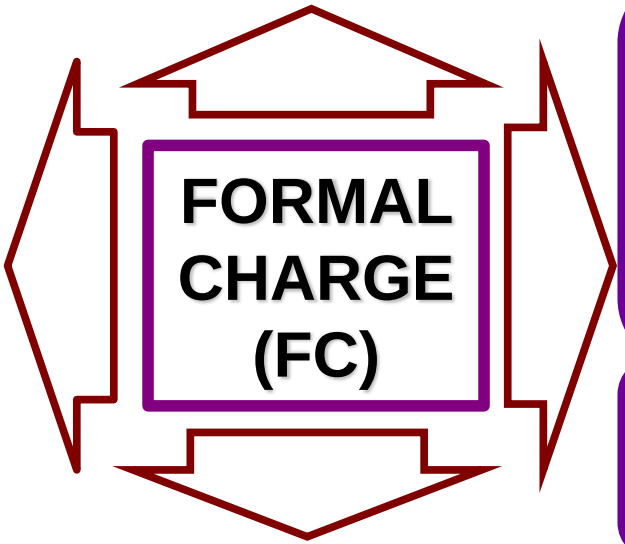


1. Determine central atom & count valence e^-
2. Draw single bond and calculate the non-bonding e^-
3. Complete the octet of the terminal atom
4. Place any remaining e^- at the central atom
5. Form double or triple bond if octet rule is not satisfied

FORMAL CHARGE

Negative FC -- on more electronegative atom

Positive FC -- on more electropositive atom



The sum of the FC of the atoms must equal the charge on the molecule or ion

FC should be as small as possible

Is used to find the most stable Lewis structure

CONCEPT OF RESONANCE

Two or more Lewis structures for a single molecule that cannot be represented accurately by only one Lewis structure

Are shown by using double headed arrow (↔)

Have same bond length and bond energy

Involved the sharing of the same no. of electron pairs

Resonance hybrid

Two or more plausible Lewis structure can be written for certain molecule but cannot neither one could accurately represent the molecules

Are shown by using dotted line to show the delocalised of electron over the entire molecule

Also known as equivalent resonance structure

Molecular geometry

The 3D arrangement of atoms in a molecule

Affects physical and chemical properties

Is predicted by using Valence Shell Electron Pair Repulsion (VSEPR) model

VSEPR Theory

Electron pairs around the central atom will repel one another and arrange themselves as far apart as possible from each other. This is to minimise the electron pair-electron pair repulsion around the central atom

Two type of electron pair around the central atom:

1) bonding pairs
2) lone pairs

To predict the molecular shape from the Lewis structure

Represent the lowest energy configuration of molecule or polyatomic ion

ELECTRON PAIR REPULSIVE FORCE

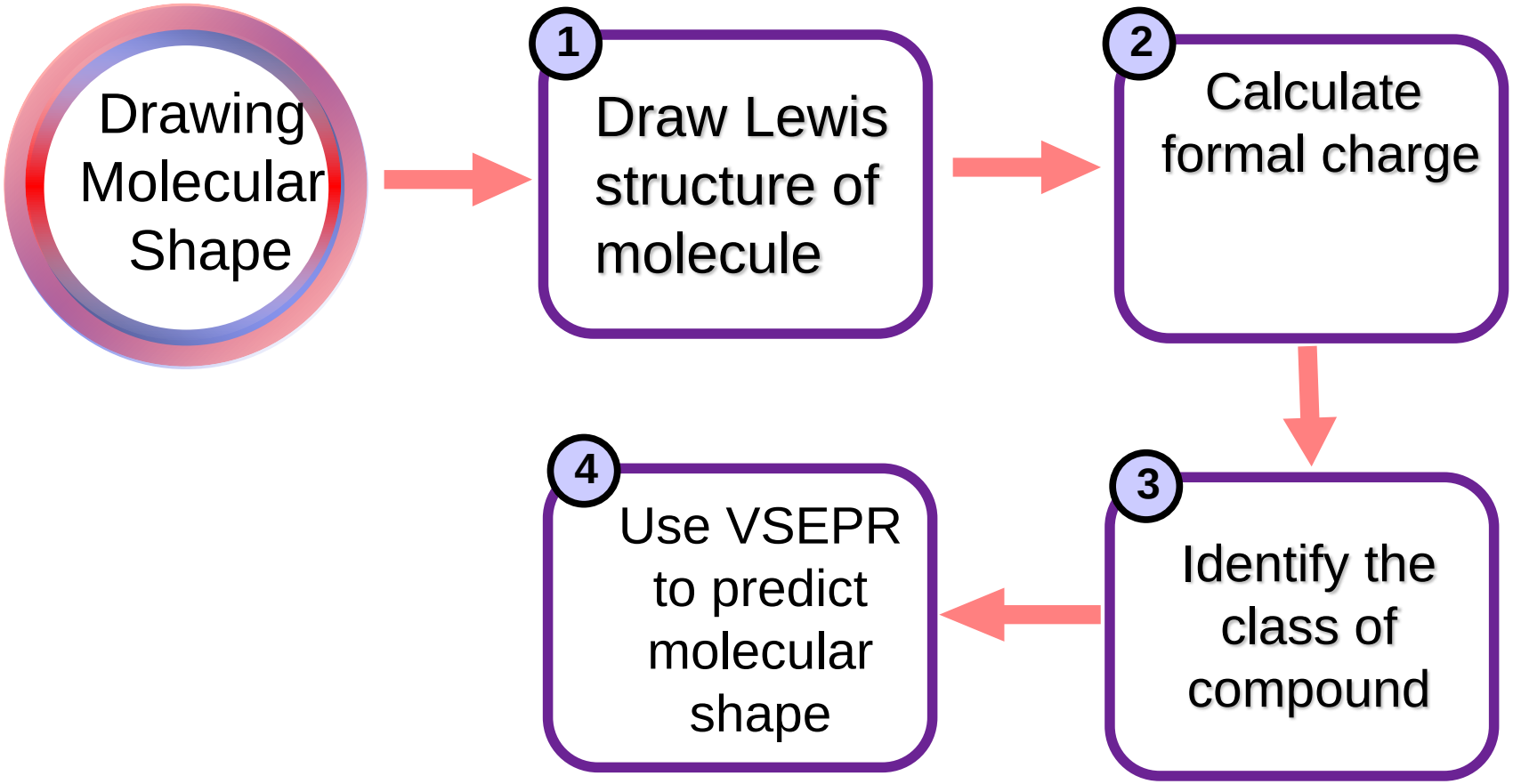
3 types of repulsive force

- Bonding Pair – Bonding Pair (BP-BP)
- Lone Pair – Bonding Pair (LP-BP)
- Lone Pair – Lone Pair (LP-LP)

The order of strength of electron pair repulsive force

LP-LP > LP-BP >BP-BP

DRAWING MOLECULAR SHAPE



EFFECTS OF LONE PAIRS ON MOLECULAR GEOMETRY

Lone pair of electrons are closer to the nucleus compared to bonding electron

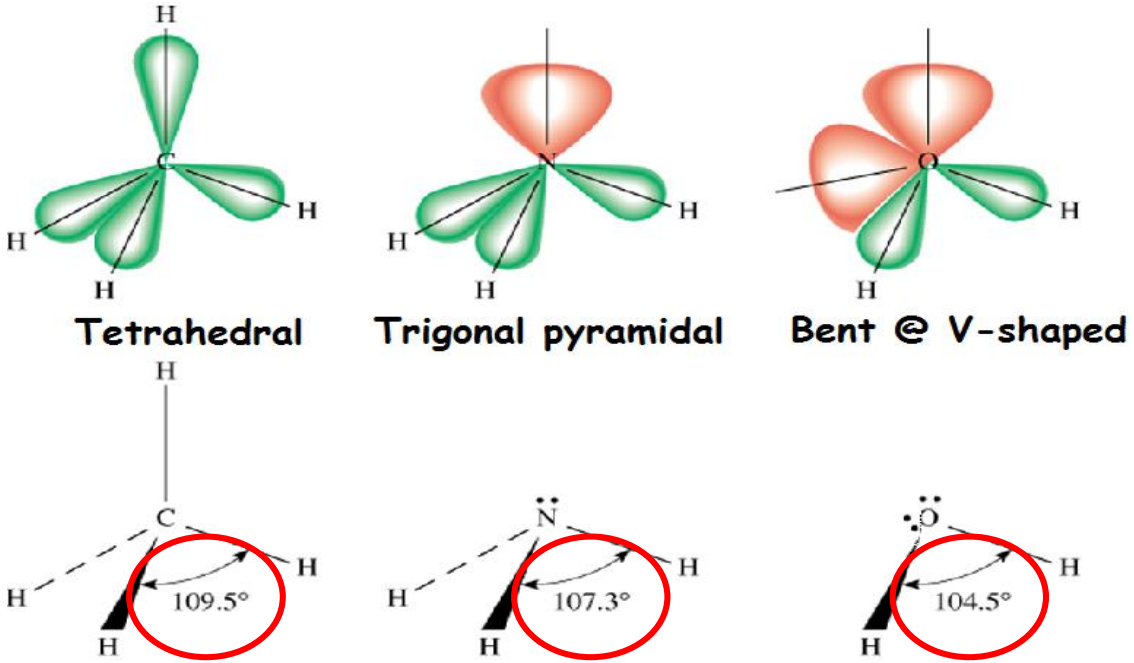
Lone pair of electrons exert stronger repulsion on one another

Strength of electron repulsive force:

LP-LP > LP-BP >BP-BP

EFFECT OF LONE PAIRS ON MOLECULAR GEOMETRY

Central atoms in CH_4, NH_3 and H_2O are surrounded by four electrons pairs. However, their bond angles are different.



EFFECTS OF LONE PAIRS ON MOLECULAR GEOMETRY

CH_4	NH_3	H_2O
Four electron pairs at C (4 bonding pairs)	Four electron pairs at N (3 bonding pairs, 1 lone pair electron)	Four electron pairs at O (2 bonding pairs, 2 lone pair electron)
The type of repulsion is bonding pair-bonding pair repulsion	Lone pair-bonding pair repulsion is stronger than bonding pair-bonding pair repulsion.	Lone pair-lone pair repulsion is stronger than lone pair-bonding pair and bonding pair-bonding pair repulsion.

BOND POLARITY AND DIPOLE MOMENT

Polar Bond

A bond between atoms of different electronegativities in which the distribution of the density of the bonding electron pair is asymmetrical.

Polar Molecule

A dipole molecule in which the positive and negative pole can be distinguished (because of the separation of the charge).

BOND POLARITY AND DIPOLE MOMENT

Non – Polar Bond

A bond between atoms of same / similar electronegativities in which the bonding electron pairs are shared equally between them.

Non – Polar Molecule

A molecule that consist of two identical atom with equal distribution of electrons among its atoms.

DIPOLE MOMENT (μ)

The product of the magnitude of the charge ($\delta+$) and the distance (d) that separates the centre of the positive and negative charge

$$\mu = q \times r$$

q = charge (coulomb)
r = the distance between charges (m)

Measured in Debyes (D)
1 D = 3.36×10^{-30} C m

POLARITY OF MOLECULES

Diatomic molecules with two identical atom: Non - polar molecules

Diatomic molecules with two different atom: Polar molecules

Polarity of covalent bond

Molecules with symmetrical shapes: Non – polar molecules

Molecules with asymmetrical shapes: Polar or non-polar molecules

Author Information

Aini Hidayah Mohamed is a lecturer from Faculty of Industrial Sciences & Technology Industry, Universiti Malaysia Pahang, Malaysia. She is also a chemist who is expert in general chemistry, industrial chemistry and natural product.