

## 14: Chemical Bonding Theories

### Key Chemistry Terms

- **Ionic Bond:** Bond formed from electrostatic attraction between ions (charged atoms)—formed from metals with nonmetals
- **Covalent Bond:** Bond formed between two nonmetals that involves shared electrons
- **Polar covalent bond:** Bond formed between two nonmetals—uneven sharing of electrons
- **Metallic bond:** Formed between metal atoms—electrons are pooled between the network of atoms.
- **Polar bond:** Bond between two atoms with a great difference in electronegativities—uneven sharing of electrons resulting in a slightly positive region and a slightly negative region of the bond.
- **Electronegativity:** An atoms “pull” on electrons shared with another atom.
- **Polar molecule:** Molecule where the polar bonds do not cancel each other out in 3D orientation
- **Isomers:** Molecules with the same chemical formula, but different bonding structure.
- **Resonance:** Two compounds with multiple bonds in different locations
- **Valence Bond Theory:** Overlap of atomic orbitals form bond
- **Sigma ( $\sigma$ ) bond:** First bond between two atoms formed from head on overlap of orbitals
- **Pi ( $\pi$ ) bond:** 2<sup>nd</sup> r 2<sup>rd</sup> bond between two atoms formed from overlap of parallel p orbitals
- **Hybridization:** Atomic orbitals hybridize into orbitals of the same energy for all sigma bonds of the atom.
- **Molecular Orbital Theory:** Molecules form new orbitals when bonding, rather than using the overlap of atomic orbitals
- **Bonding Orbital:** Molecular orbital that pulls the nuclei together
- **Antibonding Orbital (\*):** Molecular orbital that pushes the nuclei apart.
- **Bond Order:** determines the type of bond (none, single, double, triple) based on bonding and antibonding electrons

$$\text{Bond Order} = \frac{\text{bonding} - \text{antibonding}}{2}$$

- **Paramagnetic:** Compound with unpaired electrons in the molecular orbital structure. Does display magnetic properties.
- **Diamagnetic:** Compound with only paired electrons in the molecular structures. Does not display magnetic properties

### Characteristics of bond types

Bond type	Happens between	Electrons are
Ionic	Metal & non-metal	Transferred
Covalent	Non-metals	Shared
Polar Covalent	Non-metals	Shared unevenly
Metallic	Metals	pooled

#### Common characteristics:

- **Ionic:** High melting points, most dissolve in water, conduct electricity when dissolved in water, brittle
- **Covalent:** Low melting points, most do not dissolve in water, do not conduct electricity when dissolved in water
- **Polar covalent:** Medium melting points, some dissolve in water, do not conduct electricity when dissolved in water
- **Metallic:** Soft, conduct heat and electricity, do not dissolve in water

### Bond Polarity

When nonmetals bond covalently with a large difference in electronegativity

- Absolute value of differences:
  - 0 – 0.4 = covalent
  - 0.5 – 1.4 = polar covalent
  - 1.5 – 4 = ionic

Symbolized with an arrow pointing towards the more electronegative element and a crossed tail by the less electronegative element

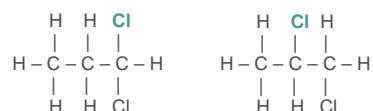
#### Example:

C – N    Electronegativity difference of 0.5 = polar bond

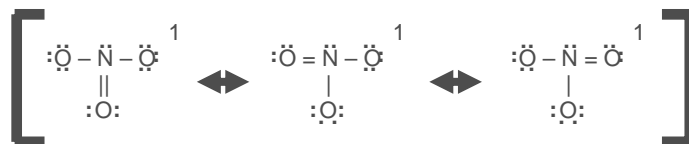


### Isomers and Resonance

#### Isomer examples:

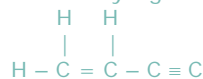


#### Resonance examples:



### Sigma and Pi bonds

How many sigma and pi bonds are in the following?



6 sigma bonds & 3 pi bonds

### Hybridization

# of sigma bonds	Hybridization	Formed from
2	sp	1 s and 1 p
3	sp <sup>2</sup>	1 s and 2 p
4	sp <sup>3</sup>	1 s and 3 p

### Molecular Orbital Theory

#### Order of filling molecular orbitals:

1 $\sigma$  1 $\sigma^*$  2 $\sigma$  2 $\sigma^*$  1 $\pi_a$  1 $\pi_b$  3 $\sigma$  1 $\pi_a^*$  1 $\pi_b^*$  3 $\sigma^*$

#### Example:

Give the molecular orbital structure, bond order and magnetism for O<sub>2</sub>

O<sub>2</sub> has 16 electrons (8+8):

#### Molecular orbital structure:

1 $\sigma^2$  1 $\sigma^{*2}$  2 $\sigma^2$  2 $\sigma^{*2}$  1 $\pi_a^2$  1 $\pi_b^2$  3 $\sigma^2$  1 $\pi_a^{*1}$  1 $\pi_b^{*1}$

Bond Order: (10-6)/2 = 2 (double bond)

There are 2 unpaired electrons (1 $\pi_a^{*1}$  1 $\pi_b^{*1}$ ) = **paramagnetic**

How to Use This Cheat Sheet: These are the keys related this topic. Try to read through it carefully twice then recite it out on a blank sheet of paper. Review it again before the exams.