**Chemical Bonding**

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A chemical bond is an attraction between atoms that allows the formation of chemical substances that contain two or more atoms. The bond is caused by the electromagnetic force of attraction between opposite charges, either between electrons and nuclei, or as the result of a dipole attraction. The strength of chemical bonds varies considerably. There are strong bonds such as covalent or ionic bonds, and weak bonds such as dipole-dipole attraction and hydrogen bonding.

Chemical compounds are formed by joining two or more atoms. A stable compound occurs when the total energy of the combination has lower energy that the separated atoms.

## **Ionic Compounds**

* One or more electrons from one atom are removed and attached to the other
* Positive and Negative Ions attract each other
* Generally crystalline solids; made of ions; high melting point
* High melting and boiling points
* Metal + non-metal
* Naming – metal + non-metal (sodium chloride)
* Dissolves easily in water and polar solvents (likes dissolve)
* Easily conducts electricity in solution

Covalent Compounds

* One or more pairs of electrons are shared between two atoms
* Create noble gas configuration for each atom
* Low melting and boiling points
* Poor electric conductors
* Many soluble in non-polar liquids but not in water
* Electrons shared; not strongly attracted to each other

Metallic bonds are formed by metals. Positive ions lie in a sea of electrons, which can freely move in all direction in the metal. Metals have strong bonds, are malleable (atoms move) and can conduct heat and electricity through free electrons.

Hydrogen bonds occur between a hydrogen atom in one molecule, and a small atom of high electronegativity in another molecule. When atoms are covalently bonded with , or atoms, the partial positive charge on the atom is highly concentrated, this attracted the , or atom from other molecules. The attraction is called a dipole-diploe attraction.

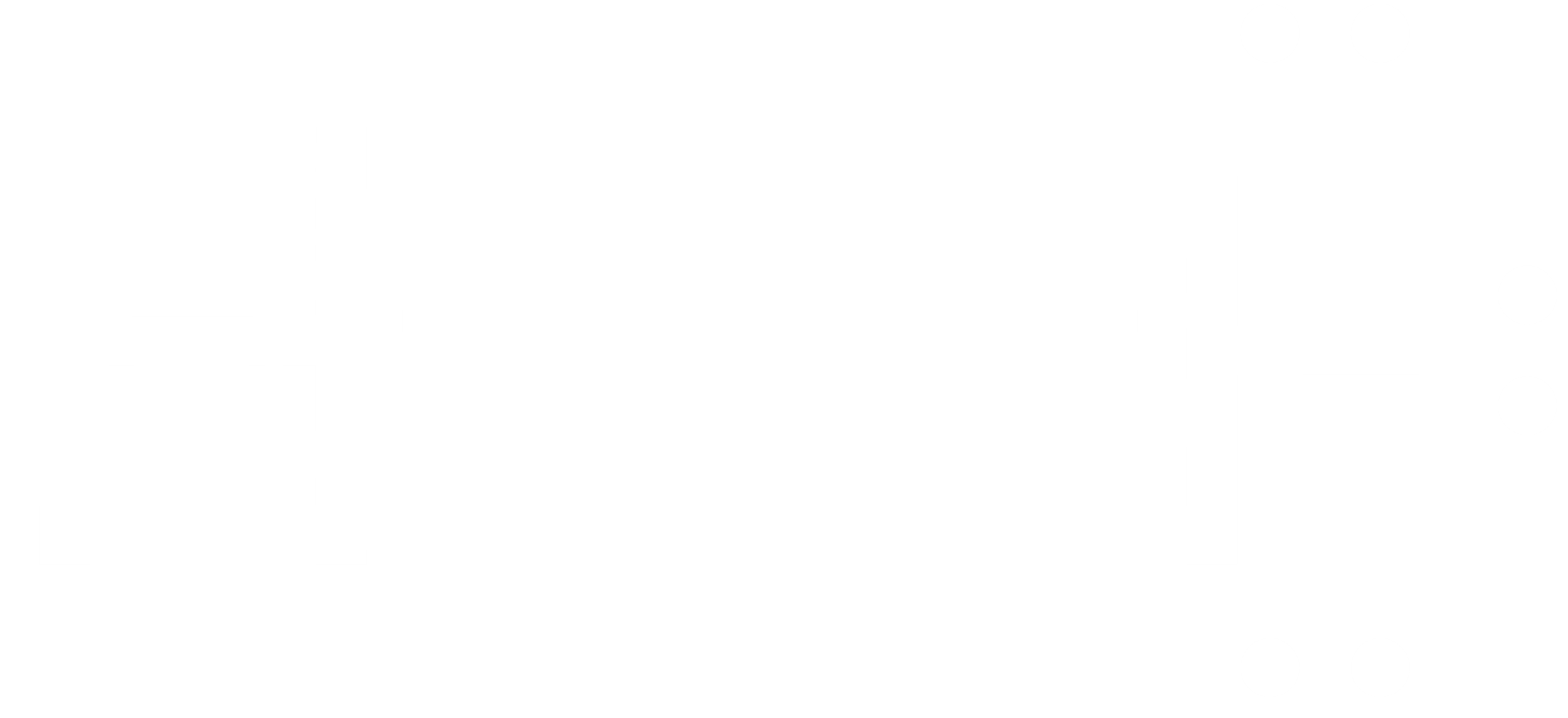
The chemical can refer to both or . These are called isomers. They have different boiling points, which would indicate that Van der Waal’s forces are not the only forces present.

Electronegativity is the ability of an atom to attract electrons. More electronegative atoms are smaller (thus less distance between the positive nucleus and an outside electron, and also fewer shells with electrons that repel the outside electron) and have a greater number of protons (thus more positive charge to attract the electron).

Partial Charges occur due to electronegativity. If electrons are shared between an atom that has a greater electronegativity and an atom that has less electronegativity, the electrons will be close to the atom that is more electronegative, thus causing a partial negative charge on that atom, while the less electronegative atom gets a partial positive charge. This causes dipole moment.

## Lewis Dot Structures

These are simplified representations of the valence shell electrons in a molecule. It is used to show how electrons are arranged around individual atoms in a molecule. Electrons are shown as dots, while bonds are shown as lines.



Lewis Dot Structure for

## Molecular Orbital Theory

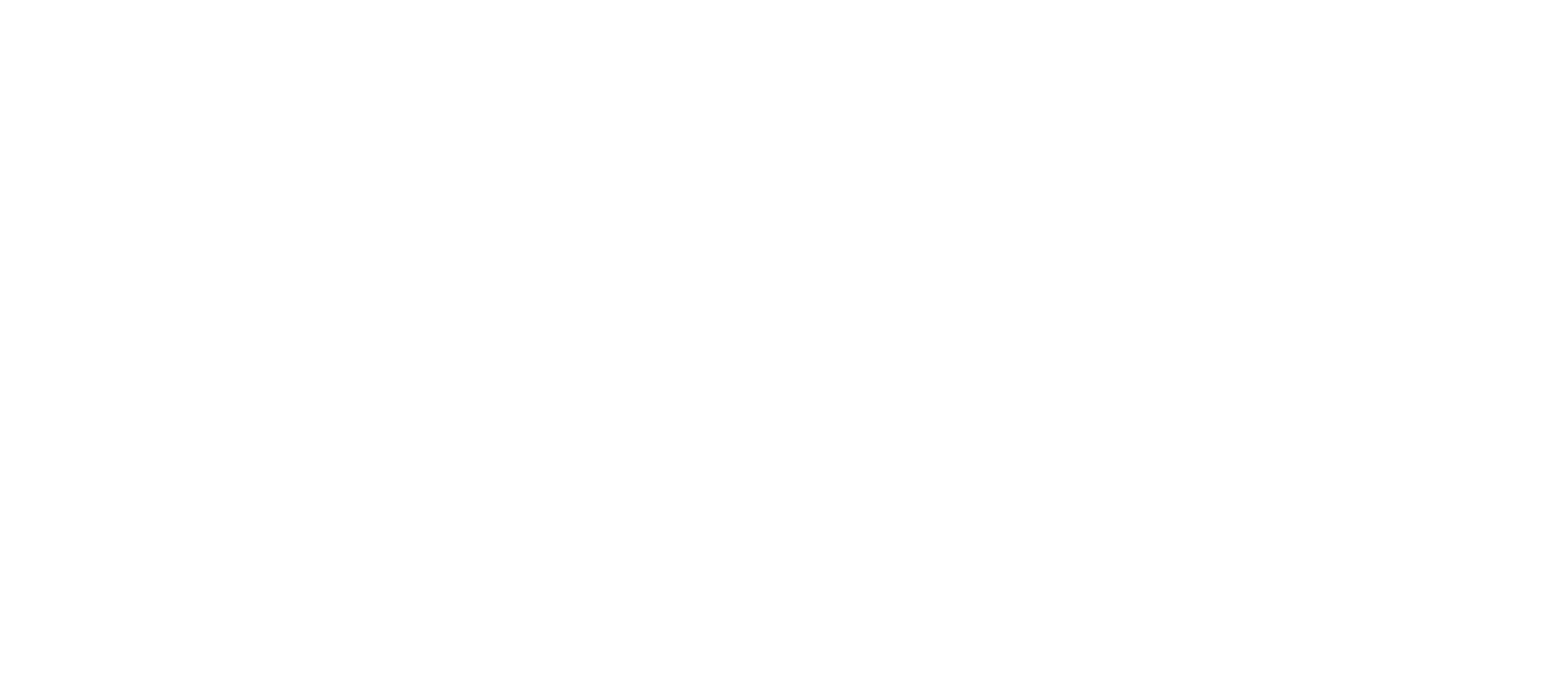
A molecular orbital is an orbital of a molecule’s electrons. Electrons around a molecule can be associated with more than one atom. Atomic orbitals within a molecule can interact, thus forming molecular orbitals. The number of molecular orbitals is equal to the number of atomic orbitals combined to form a molecule.

When two atomic orbitals are combined, the density of electrons in the overlapping region increases, meaning electrons spend more time in that region. They can thus hold the atoms together, forming a bond. This means they are often found in the regions between the nuclei. Molecular orbitals that are concentrated in regions between nuclei are called bonding orbitals.

Atomic orbitals may also be repulsed by each other. This means there is less chance of finding electrons in the region of overlap. Molecular orbitals that have zero values in the region between two nuclei (i.e. electrons are concentrated elsewhere) are called anti-bonding orbitals. These weaken the bond.

There is a third type of molecular orbital called the non-bonding orbital. These neither strengthen nor weaken the molecular bonding. Non-valence shell electrons are non-bonding electrons.

The electron configuration for a molecule may be shown in a diagram such as this:



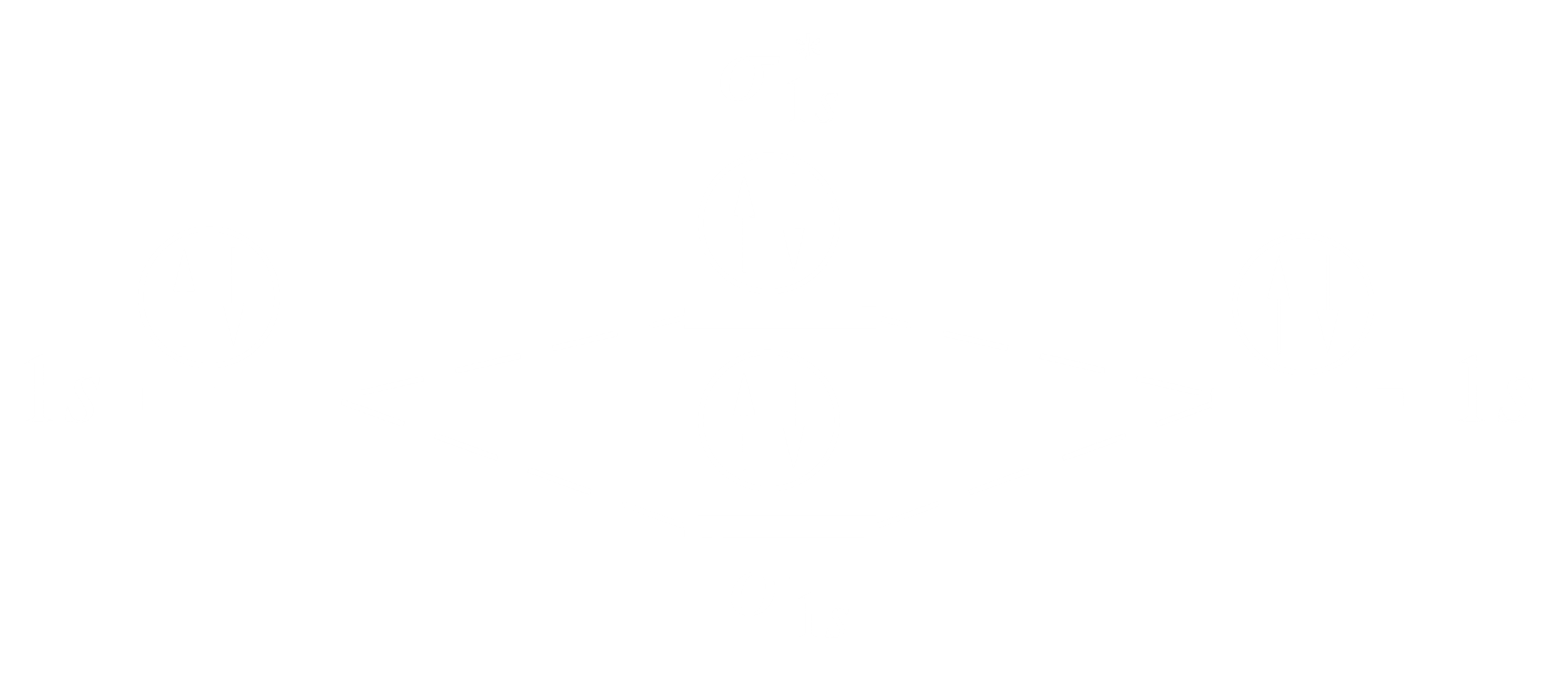
The diagram is for the molecule. Each atom contributes a single electron from the orbital, to form a single bonding orbital.

The bond order can be calculated from this. The Bond Order (B.O.) is the number of bonds formed by two atoms.

For ,

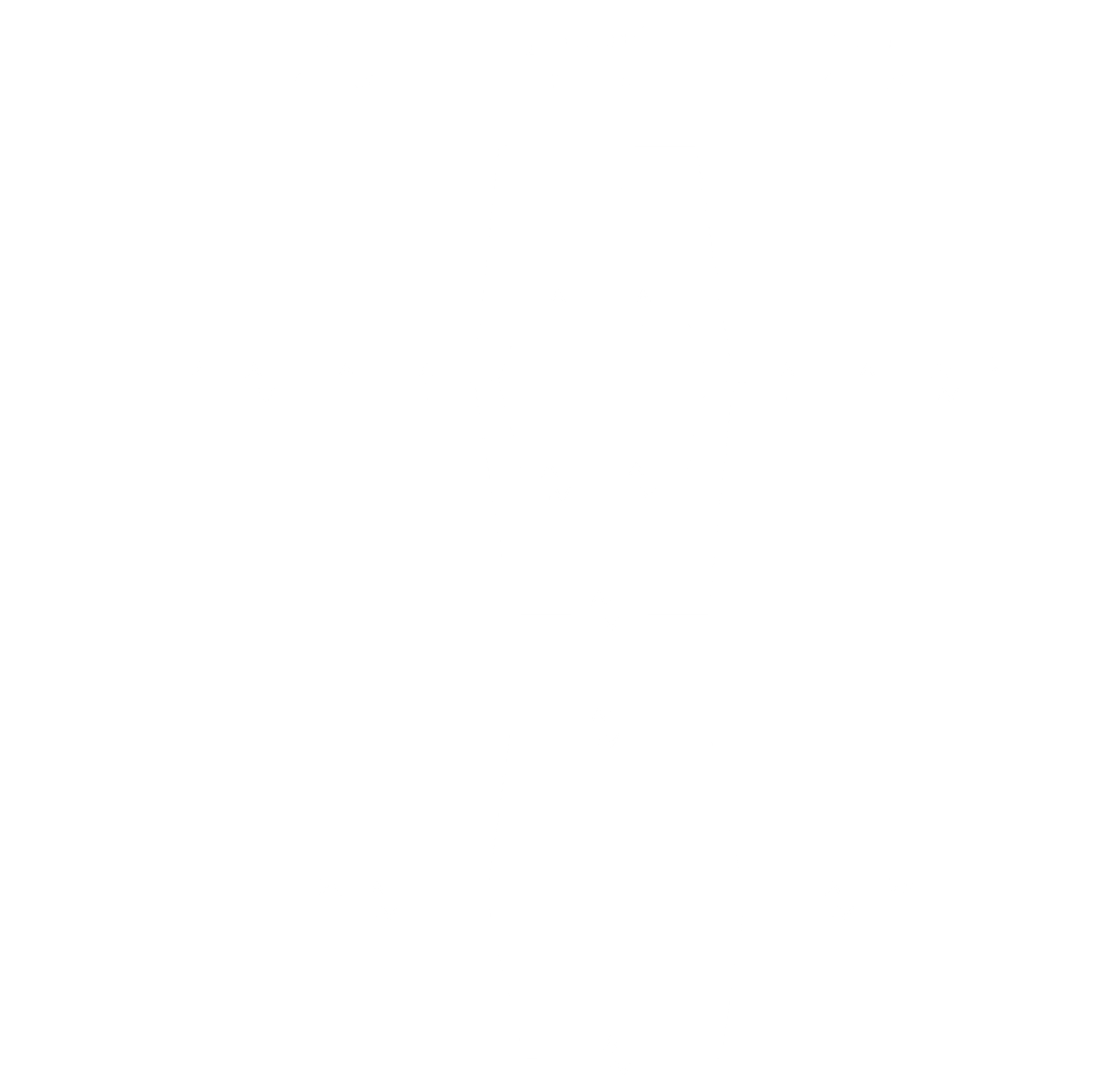
Thus, two atoms will form a single bond.

For , one electron from the orbital of each atom forms a bonding orbital, while the other forms an anti-bonding orbital.



Thus molecules do not form bonds. cannot exist.

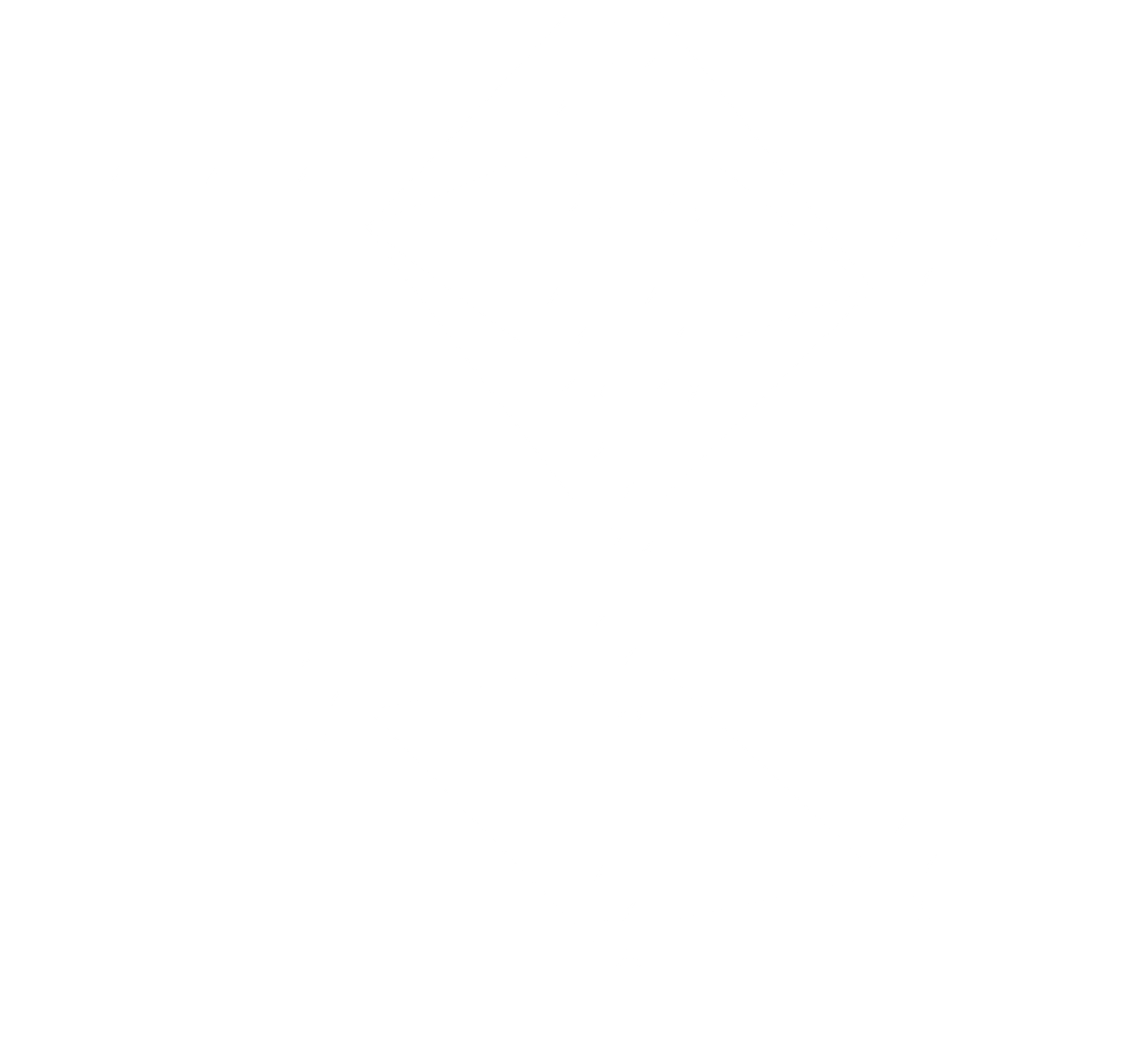
For



(double bond)

Here, note that the orbital is being disregarded. This is because it is a non-bonding molecular orbital in this case.

For ,



The B.O. for this molecule is a fraction. It is rounded up to . has bonds.

## Hund’s Rule

This states that every orbital on the same sublevel will be filled with one electron before a second electron is added to any of them, and that for orbitals with single electrons, the spin of the electrons will be the same, in order to maximize total spin.

For the , and orbitals, an electron each will be added to then and finally before a second electron is added to .

## Magnetism Basics

Paramagnets – Molecules that have subshells with unpaired electrons; these are weakly attracted by external magnetic fields

Diamagnets – molecules that do not have any subshells with unpaired electrons; these are repelled by external magnetic fields

## The Periodic Table

The Modern Periodic Law states that the physical and chemical properties of elements are the periodic function of the atomic numbers, meaning that various elements with similar properties repeat after certain regular intervals when arranged in order of increasing atomic number.

It was discovered by Dimitri Mendeleev.

The periodic table is important because it is organized to provide a large amount of information about elements and how they relate to one another in one, easy to use reference. It was used to predict the chemical and physical properties of then undiscovered elements, and is now used to obtain knowledge about things like what chemical reactions an element will take part in, whether it is hard or soft, if it conducts electricity and many other physical properties. It removes the need to have all of this information memorized and shows the atomic number of atomic weight of each element, along with the usually charge it has, indicated by the elements group.

The periodic table is divided into groups (columns) and periods (rows). Elements in the same group have the same number of valence electrons, and thus have similar properties, like the alkali metals in group 1 which all carry a charge of +1 in reactions, react vigorously with water and combine readily with non-metals. Elements in the same period have the same number of electron shells, and thus similar sizes.

### Trends in The Periodic Table

Ionic Radii: Increases down a group as shell numbers increases; decreases from left to right along a period for cations as the number of protons increases while the number of electrons stay constant, thus increasing attraction and decreasing size; increases from left to right for anions as the number of electrons exceeds the number of protons

Ionization Energy: Decreases down a group as the number of shells increases, making it easier to remove outer shell electrons; increases left to right across a period as the number of protons increases, decreasing size and increasing attraction, making it more difficult to remove outer shell electrons.

Metallic Character: Increases down a group since the number of shells increase, making it easier to lose an electron; decreases from left to right across a period since the number of protons increase, decreasing atomic size by increasing attraction, making it more difficult to lose electrons.

Electronegativity: Decreases down a group since the number of shells increases, putting more distance between an outside electron and the nucleus; increases left to right across a period as the number of protons increases, thus causing more attraction with outside electrons