Chemical Structure and Atomic Bonding

Atomic structure and chemical bonding are fundamental concepts in chemistry, explaining how atoms combine to form molecules and compounds. Understanding atomic structure is crucial because it dictates the types of chemical bonds an atom will form.

What Is Chemical Bonding?

Chemical bonding refers to the formation of a chemical bond between two or more atoms, molecules or ions to give rise to a chemical compound. These chemical bonds are what keep the atoms together in the resulting compound.

The attractive force which holds various constituents (atoms, ions, etc.) together and stabilises them by the overall loss of energy is known as chemical bonding. Therefore, it can be understood that chemical compounds are reliant on the strength of the chemical bonds between their constituents; the stronger the bonding between the constituents, the more stable the resulting
compound will be.

The opposite also holds true; if the chemical bonding between the constituents is weak, the resulting compound would lack stability and would easily undergo another reaction to give a more stable chemical compound (containing stronger bonds). To find stability, the atoms try to lose their energy.

Whenever matter interacts with another form of matter, a force is exerted on one by the other. When the forces are attractive in nature, energy decreases. When the forces are repulsive in nature, energy increases. The attractive force that binds two atoms together is known as a chemical bond.

Important Theories on Chemical Bonding

Albrecht Kossel and Gilbert Lewis were the first to explain the formation of chemical bonds successfully in the year 1916. They explained chemical bonding on the basis of the inertness of noble gases

Lewis Theoryof Chemical Bonding

- An atom can be viewed as a the positively charged ‘Kernel’ (the nucleus plus inner electrons and the outer shell. The outer shell can accommodate a maximum of eight electrons only.
- The eight electrons present in the outer shell occupy the corners of a cube which surround the ‘Kernel’. The atoms have an octet configuration, i.e., 8 electrons in the outermost shell, thus symbolizing a stable configuration.
- Atoms can achieve this stable configuration by forming chemical bonds with other atoms. This chemical bond can be formed either by gaining or losing an electron(s)(NaCl, MgCl2) or, in some cases, due to the sharing of an electron (F2).
- Only the electrons present in the outer shell, also known as the valence electrons, take part in the formation of chemical bonds. Gilbert Lewis used specific notations, better known as Lewis symbols, to represent these valence electrons.
- Generally, the valency of an element is either equal to the number of dots in the corresponding Lewis symbol or 8 minus the number of dots (or valence electrons).

Lewis symbols for lithium (1 electron), oxygen (6 electrons) and neon (8 electrons) are given below.

Here, the number of dots that surround the respective symbol represents the number of valence electrons in that atom.

Kossel's Theory of Chemical Bonding

- Noble gases separate the highly electronegative halogens and the highly electropositive alkali metals. Halogens can form negatively charged ions by gaining an electron. Whereas alkali metals can form positively charged ions by losing an electron.
- These negatively charged ions and positively charged ions have a noble gas configuration, that is, 8 electrons in the outermost shell. The general electronic configuration of noble gases (except helium) is given by ns2np6.
- As unlike charges attract each other, these unlike charged particles are held together by a strong force of electrostatic attraction existing between them.
- For example, MgCl2 – magnesium ions and chlorine ions – are held together by the force of electrostatic attraction. This kind of chemical bonding existing between two, unlike charged particles, is known as an electrovalent bond.

Types of Chemical Bonds

When substances participate in chemical bonding and yield compounds, the stability of the resulting compound can be gauged by the type of chemical bonds it contains.

- The type of chemical bonds formed varies in strength and properties.

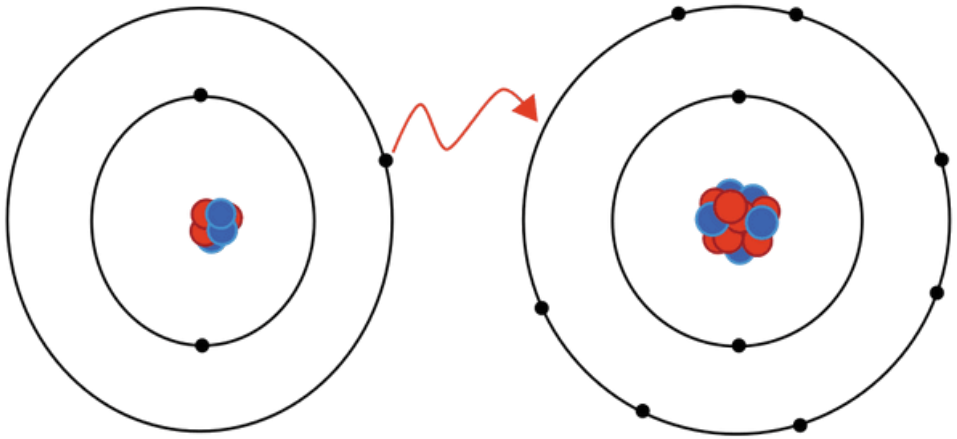
There are 4 primary types of chemical bonds which are formed by molecules to yield compounds. These types of chemical bonds include

- Ionic Bonds
- Covalent Bonds
- Hydrogen Bonds
- Polar Bonds

These types of bonds in chemical bonding are formed from the loss, gain or sharing of electrons between two atoms/molecules.

Ionic Bonding

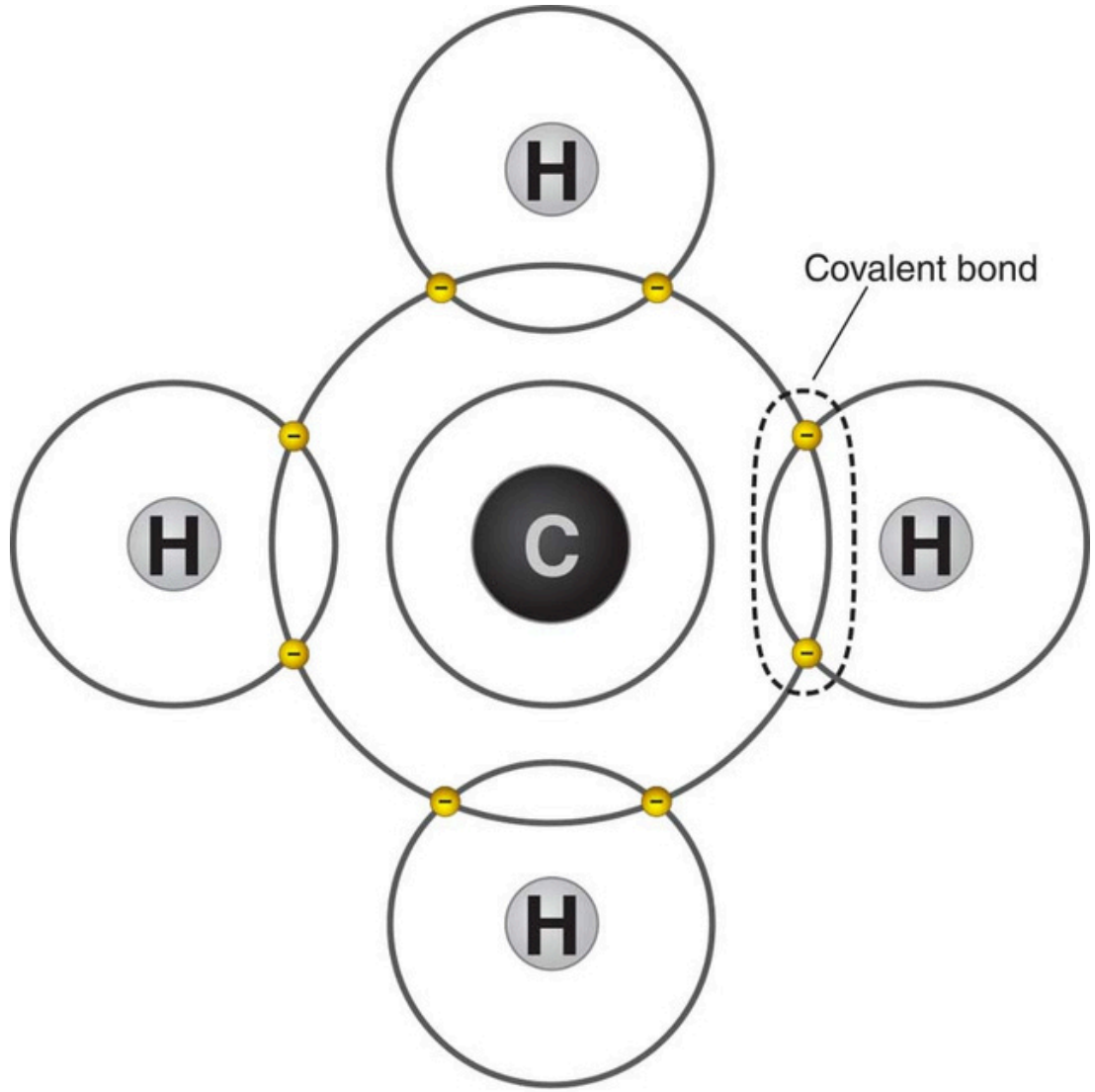
Ionic bonding is a type of chemical bonding which involves a transfer of electrons from one atom or molecule to another. Here, an atom loses an electron, which is, in turn, gained by another atom. When such an electron transfer takes place, one of the atoms develops a negative charge and is now called the anion.



The other atom develops a positive charge and is called the cation. The ionic bond gains strength from the difference in charge between the two atoms, i.e., the greater the charge disparity between the cation and the anion, the stronger the ionic bond.

Covalent Bonding

A covalent bond indicates the sharing of electrons between atoms. Compounds that contain carbon (also called organic compounds) commonly exhibit this type of chemical bonding. The pair of electrons which are shared by the two atoms now extend around the nuclei of atoms, leading to the creation of a molecule.


H
Covalent bond
H
C
H
H

Polar Covalent Bonding

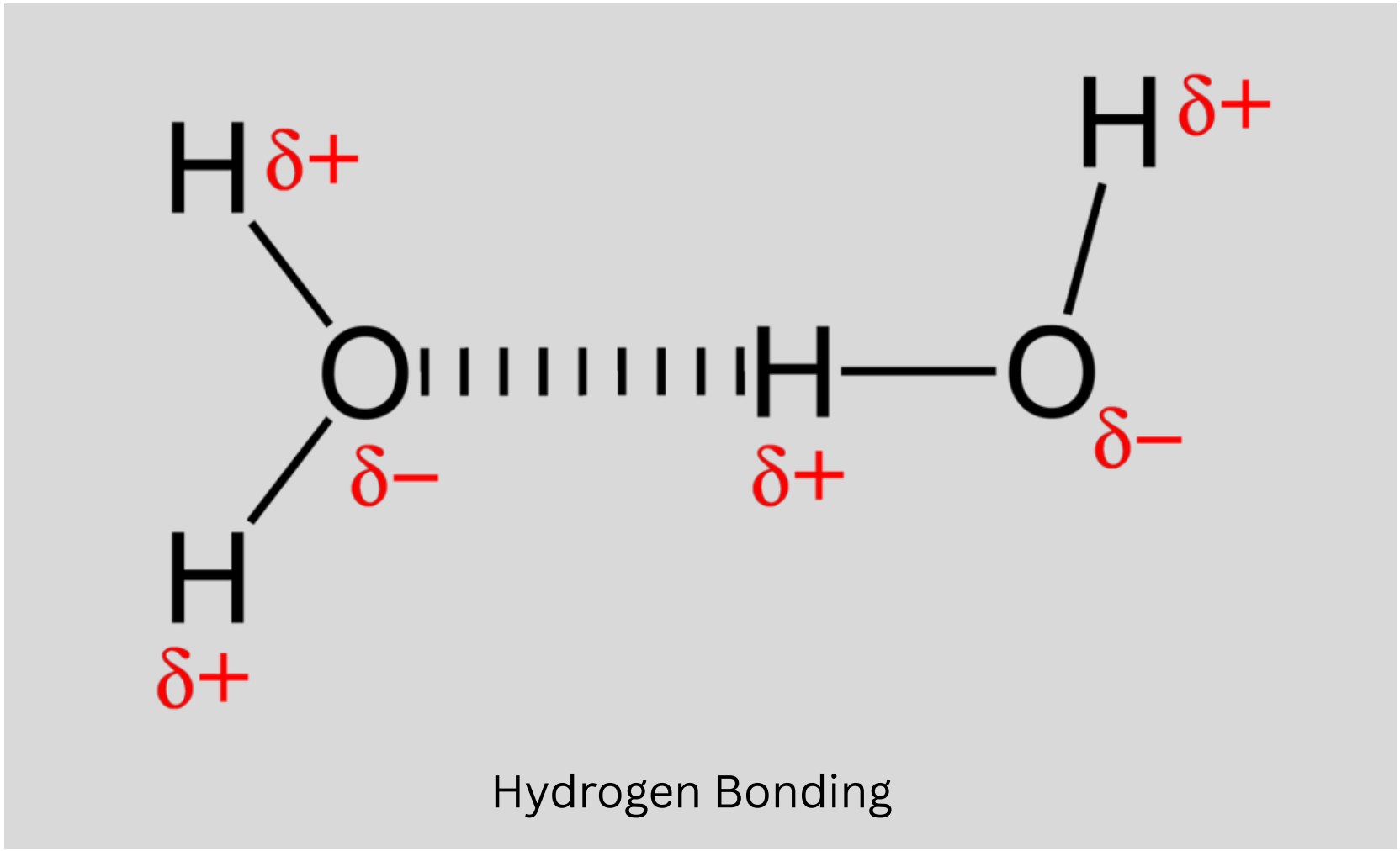
Covalent bonds can be either polar or non-polar in nature. In polar covalent chemical bonding, electrons are shared unequally since the more electronegative atom pulls the electron pair closer to itself and away from the less electronegative atom. Water is an example of such a polar molecule.

A difference in charge arises in different areas of the atom due to the uneven spacing of the electrons between the atoms. One end of the molecule tends to be partially positively charged, and the other end tends to be partially negatively charged.

Hydrogen Bonding

Compared to ionic and covalent bonding, Hydrogen bonding is a weaker form of chemical bonding. It is a type of polar covalent bonding between oxygen and hydrogen, wherein the hydrogen develops a partial positive charge. This implies that the electrons are pulled closer to the more electronegative oxygen atom.

This creates a tendency for the hydrogen to be attracted towards the negative charges of any neighboring atom. This type of chemical bonding is called a hydrogen bond and is responsible for many of the properties exhibited by water.



Hydrogen Bonding

What Is Ionic Bond?

The bond formed as a result of strong electrostatic forces of attraction between a positively and negatively charged species is called an electrovalent or ionic bond. The positively and negatively charged ions are aggregated in an ordered arrangement called the crystal lattice, which is stabilised by the energy called the Lattice enthalpy.

Conditions for the Formation of an Ionic Bond

- The low ionisation energy of the atom forming the cation.
- High electron gain enthalpy of the atom forming the anion.
- High electron gain enthalpy of the atom forming the anion.

Generally, the ionic bond is formed between a metal cation and a non-metal anion.

Thank You

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