Type of Chemical Bonds

- Covalent bond
- Polar Covalent bond
- Ionic bond
- Hydrogen bond
- Metallic bond
- Van der Waals bonds
Covalent Bonds

Covalent bond: bond in which one or more pairs of electrons are shared by two atoms.

Covalent bonding occurs when two (or more) elements share electrons. This most commonly occurs when two nonmetals bond together.

Because both of the nonmetals will want to gain electrons, the elements involved will share electrons in an effort to fill their valence shells.
Such bonds lead to **stable molecules** if they share electrons in such a way as to create a noble gas configuration for each atom.

Diamond is strong because it involves a vast network of covalent bonds between the **carbon atoms in the diamond**.
Diamond

- Carbon has **four electrons** in its valence shell (outershell).

- Since this energy shell can hold eight electrons, **each carbon atom can share electrons** with up to four different atoms.
Carbon alone forms the familiar substances **graphite and diamond**.

**Both are made only** of carbon atoms.

Graphite is very soft and slippery.

Diamond is the hardest substance known to man.
Carbon atoms in diamond are **covalently bonded** and are arranged in a three-dimensional tetrahedral structure.

In this rigid network, **none of the carbon atoms can move**.

This accounts for the fact that **diamonds are so hard** and have such a high melting point.
Diamond is the purest form of natural carbon. It occurs as small crystals embedded in rocks. These are supposed to have been formed by the crystallization of carbon under extreme pressure and temperature in the interior of the earth.
Nowadays, synthetic industrial diamonds are being manufactured by subjecting graphite to very high temperatures and pressures.

Carbon atoms in diamond have tetrahedral structure. Each atom of carbon is surrounded by four other atoms that together forms the tetrahedral structure.
1. Diamond is chemically very inert.

2. It does not react with any substance at ordinary temperatures.

3. When heated in oxygen to about 800° C, it completely burns to form carbon dioxide.

4. This shows that diamond is pure form of carbon.
A good example of a **covalent bond** is that which occurs **between two hydrogen atoms**.

**Atoms** of hydrogen (H) have one **valence electron** in their first electron shell.

Since the capacity of this shell is two electrons, each hydrogen **atom** will "want" to pick up a second **electron**.
In an effort to pick up a second *electron*, hydrogen *atoms* will react with nearby hydrogen (H) *atoms* to form the *compound* $\text{H}_2$.

In this way, both *atoms* share the stability of a full *valence shell*. 
Because the hydrogen compound is a combination of equally matched atoms, the atoms will share each other's single electron, forming one covalent bond.
2 hydrogen atoms + 2 fluorine atoms → hydrogen molecule

2 oxygen atoms + carbon atom → carbon dioxide molecule

4 fluorine atoms + carbon atom → a molecule of carbon tetrafluoride
Covalent bond
There are, in fact, two subtypes of covalent bonds.

- Polar and
- Nonpolar Covalent Bonding
The H₂ molecule is a good example of the first type of covalent bond, the nonpolar bond.

Because both atoms in the H₂ molecule have an equal attraction (or affinity) for electrons, the bonding electrons are equally shared by the two atoms, and a nonpolar covalent bond is formed.
Polar covalent bond

A polar bond is formed when **electrons are unequally shared** between two **atoms**.

Polar covalent bonding occurs because one **atom** has a stronger affinity for **electrons** than the other (yet not enough to pull the **electrons** away completely and form an **ion**).
In a polar covalent bond, the bonding electrons will spend a greater amount of time around the atom that has the stronger affinity for electrons.

A good example of a polar covalent bond is the hydrogen-oxygen bond in the water molecule.

Oxygen is much more electronegative than hydrogen, and so the electrons involved in bonding the water molecule spend more time there.
The primary difference between the H-O bond in water and the H-H bond is the degree of electron sharing.

- The large oxygen atom has a stronger affinity for electrons than the small hydrogen atoms.

- Because oxygen has a stronger pull on the bonding electrons, it preoccupies their time, and this leads to unequal sharing and the formation of a polar covalent bond.
Polar covalent bonding simulated in water
Ionic Bond

- **Ionic bond**: bond in which one or more electrons from one atom are removed and attached to another atom, resulting in positive and negative ions which attract each other.

- If one or more atoms lose electrons and other atoms gain them in order to produce a noble gas electron configuration, the bond is called an ionic bond.
Atoms share electrons to form a covalent bond.

Atoms transfer an electron to form an ionic bond.
Chlorine is in a group of elements having seven electrons in their outer shells. Members of this group tend to gain one electron, acquiring a charge of -1.

Sodium is in another group with elements having one electron in their outer shells.

Members of this group tend to lose that outer electron, acquiring a charge of +1.

Oppositely charged ions are attracted to each other, thus chlorine Cl- and sodium Na+ form an ionic bond, becoming the molecule sodium chloride.
Ionic bonds generally form between elements in:

**Group I** (having one electron in their outer shell) and

**Group VIIa** (having seven electrons in their outer shell).

Such bonds are relatively weak, and tend to disassociate in water, producing solutions that have both Na and Cl ions.
Formation of a crystal of sodium chloride. Each positively charged sodium ion is surrounded by seven negatively charged chloride ions; likewise each negatively charged chloride ion is surrounded by seven positively charged sodium ions. The overall effect is electrical neutrality.
Hydrogen Bond.

The fact that the oxygen end of a water molecule is negatively charged and the hydrogen end positively charged means that the hydrogens of one water molecule attract the oxygen of its neighbor and vice versa.

This is because unlike charges attract each other.
This largely electrostatic attraction is called a hydrogen bond and is important in determining many important properties of water that make it such an important liquid for living things.

Water can also form this type of bond with other polar molecules or ions such as hydrogen or sodium ions.
Hydrogen Bonds

Polar molecules, such as water molecules, have a weak, partial negative charge at one region of the molecule (the oxygen atom in water) and a partial positive charge elsewhere (the hydrogen atoms in water).

Thus when water molecules are close together, their positive and negative regions are attracted to the oppositely-charged regions of nearby molecules.

The force of attraction, shown here as a dotted line, is called a hydrogen bond. Each water molecule is hydrogen bonded to four others.
This picture represents a small group of water molecules.

Hydrogen bonds between unlike charges are shown as lines without arrows on the ends.

The double arrowed lines represent the fact that like charges repel each other.

Both hydrogen bonds and the repelling forces balance each other and are both are important in determining the properties of water.
Hydrogen Bonding

- Hydrogen bonding differs from other uses of the word "bond" since it is a force of attraction between a hydrogen atom in one molecule and a small atom of high electronegativity in another molecule.

- That is, it is an intermolecular force, not an intramolecular force as in the common use of the word bond.

- Hydrogen bonding has a very important effect on the properties of water and ice.
The hydrogen bonds that form between water molecules account for some of the essential and unique properties of water:

- The attraction created by hydrogen bonds keeps water liquid over a wider range of temperature than is found for any other molecule.

- The energy required to break multiple hydrogen bonds causes water to have a high heat of vaporization; that is, a large amount of energy is needed to convert liquid water, to water vapor.
Metallic Bonds

- The properties of metals suggest that their atoms possess strong bonds, yet the ease of conduction of heat and electricity suggest that electrons can move freely in all directions in a metal.

- Not important in soils.
Van der Waals bonds

The **attractive forces** between molecules in a liquid can be characterized as **van der Waals bonds**.

Van der Waals bonding is important in minerals such as:

- graphite and
- clay minerals (Van der Waals bonds may be a major source of cohesion in fine grained soils).
the van der Waals force, named after Dutch scientist Johannes Diderik van der Waals is the attractive or repulsive force between molecules (or between parts of the same molecule) other than those due to covalent bonds or to the electrostatic interaction of ions with one another or with neutral molecules.
Van der Waals bonds

- Neutral molecules may be held together by a weak electric force known as the van der Waals bond.

- It results from the distortion of a molecule so that a small positive charge develops on one end and a corresponding negative charge develops on the other.
A similar effect is induced in neighbouring molecules, and this dipole effect propagates throughout the entire structure.

An attractive force is then formed between oppositely charged ends of the dipoles.

Van der Waals bonding is common in gases and organic liquids and solids.
ideal ionic structure

covalent bonding in diamond

tetrahedron

metallic structure

Possible electron (e⁻) paths around the nuclei of the metal atoms (represented as spheres with a positive charge) are shown.

instantaneous dipole on A induces a dipole on B

weak dipole attraction of van der Waals bond
van der Waals bonds