Types of Bonds: Covalent, Ionic, Hydrogen, and van der Waals

Kimberly Hatch Harrison

Chemical bonds allow atoms to be more stable by filling their valence shell of electrons. This can happen by an atom either sharing electrons with another atom (covalent bonds), or by completely transferring electrons to another atom (ionic bonds). Weak electrostatic attractions (hydrogen bonds and van der Waals interactions) also stabilize structures, reversibly holding biochemical molecules together.

THERE ARE FOUR TYPES OF CHEMICAL BONDS ESSENTIAL FOR LIFE TO EXIST. Covalent bonds, ionic bonds, hydrogen bonds, and van der Waals interactions all play important roles in biochemical structures and reactions.

These bonds have varying strengths, and that is the fundamental reason why we need these various kinds of bonds. Sometimes you need a very strong bond, like when you're building permanent structures. Other times, you want a weak, reversible interaction, like when you have a hormone binding a receptor, and you need it to fall off so it doesn't keep sending the signal forever.

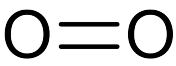
It's a good idea to learn an example of each of these kinds of bonds. If you have an example molecule in mind, that can help keep the more abstract concepts clear.

4 Types of Chemical Bonds in Biology

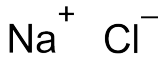
1. Covalent Bonds

A bond formed through the sharing of electrons between two atoms.

Covalent bonds are either polar or nonpolar. The nature of the bond is determined by the electronegativities of the atoms in the bond. If their electronegativities are equal, the electrons are equally shared. This is a nonpolar covalent bond (e.g. molecular oxygen, O_2). If one of the atoms is significantly more electronegative than the other, the electrons will be shared unequally. This is a polar covalent bond (e.g. nitric oxide, NO).

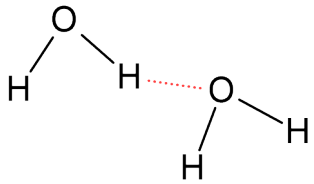


2. Ionic Bonds
A bond formed by the electrostatic attraction of two oppositely charged ions.



Interestingly, in chemistry, this is often thought of as a very strong bond. Think how hard it is to break apart table salt, NaCl (requires very high temperature). But in the context of biochemistry, where everything is in a watery environment, ionic bonds readily separate into their component ions. These oppositely charged ions are still attracted to each other, through electrostatic attraction.

3. Hydrogen Bonds
A hydrogen atom is weakly shared between two electronegative atoms.



Hydrogen bonds are an example of a readily reversible electrostatic interaction. Hydrogen with a weak positive charge is attracted to another atom that is weakly negatively charged, usually fluorine, oxygen, or nitrogen. The most commonly cited example is water. Hydrogen bonds are the attraction that holds different water molecules associated together, leading to a number of water's unusual properties, such as its highly cohesive nature and high specific heat.

4. van der Waals Interactions
The weakest interaction due to the motion of electrons.

Electrons are constantly in motion, which leads to temporary patches of negative charge (electrons clustered together) or positive charge (the absence of electrons) on the surface of biological molecules. In the next instant, the patches disappear and reappear somewhere else. Occasionally, there will be a complementary patch on another molecule, that allows two molecules to be briefly attracted to each other. Individual attractions of this sort are too weak to be significant, but can be substantial when distributed over two surfaces, such as the adhesive feet of tree frogs gripping onto smooth tree branches.

Additional Resources

4 Types of Chemical Bonds in Biology (Video)