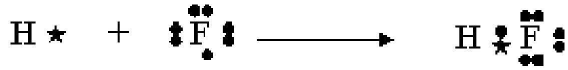
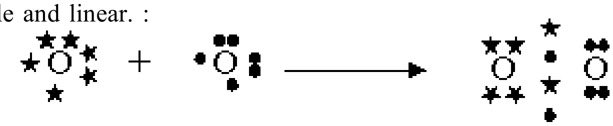
Covalent Bonding

When a non-metal reacts with another non-metal, both atoms attempt to gain electrons due to their high electron affinity; therefore, there will likely be no transfer of electrons and the atoms do not become ions. When non-metals react they compromise by sharing pairs of electrons and the bond formed is called a **covalent bond**. Through sharing electrons, both atoms achieve the electronic configuration of noble gas. Electrically neutral combination of atoms in fixed ratios are called **molecules.** Consider the bonding that takes place between hydrogen and fluorine

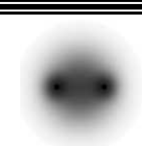
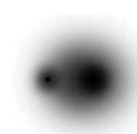
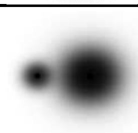


This results in eight outer electrons in fluorine (3 unshared pairs and 1 shared pair) and 2 outer electrons in hydrogen; thus, the atoms are stable. This is often represented by stick diagram H-F or HF, but to illustrate the bonding process, you need to show the sharing of electrons. Consider the interaction of two oxygen atoms to create a double bond and is represented as O=O or O_2. Just as with ionic bonding, you can use as many atoms as needed, but use the fewest possible and keep structures simple and linear. :

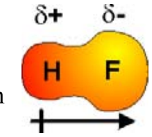


or simply

Different atoms pull on bonding electrons to differing degrees, and this difference is the pivotal property in determining whether a covalent or ionic bond is formed. When one atom has a much higher pull on bonding electrons than its partner, electron transfer occurs, and an ionic compound is formed. When both atoms have similar attractions for the bonding electrons, they'll share them more equitably and a covalent molecule is formed. Elements can be ranked by their relative attraction for bonding electrons. Linus Pauling and others considered several elemental properties to develop a consistent ranking scheme. Pauling used the element's ionization energy and electron affinity to predict how it will behave in a bond. These two energies were used to compute a numerical score called an **electronegativity**. Electronegativity ranks the element's tendency to attract electrons and acquire a more negative charge in a bonding situation. Electronegativities have been assigned to all atoms except noble gases (they typically don't bond) and since this is a relative number no units are used. Electronegativities increase as you move up a group and right across a period. Electronegativity values are written on the back of the periodic table. To determine the type of bond formed between two atoms, subtract the lower electronegativity from the higher electronegativity to obtain electronegativity difference:

Electronegativity Difference	Bond Type	Example	Diagram
0.0 - 0.4	covalent	F_2: F-F bond: 3.98 - 3.98 = 0.0 PH_3: P-H bond: 2.19 - 2.10 = 0.09	
>0.4 - 1.7	polar covalent	HCl: H-Cl bond: 3.16 - 2.20 = 0.96 H_2O: O-H bond: 3.44 - 2.10 = 1.34	
>1.7	ionic	NaCl: Na^+Cl^- bond: 3.16 - 0.93 = 2.23 HF: H-F bond: 3.98 - 2.10 = 1.88	

A covalent bond results from an equal sharing of electrons. Some authors site an electonegativity difference of 0.3 or 0.5 as the critical level when the bond switches to polar covalent. We will compromise and use 0.4. Under 0.4, there is not enough difference in sharing to really be detected as unequal sharing and the resulting bond shows no polar characteristics and would be described as nonpolar or pure covalent. When the electronegativity difference is above 0.4, electrons in a bond are not shared equally and are pulled closer to the more electronegative element. The resulting bond has polar characteristics and the atoms possess partial (perceived) charges. The atom with higher electronegativity is the one that has more power to pull shared pair of electrons closer and this atom becomes partial negative (δ^-) while the weaker atom becomes partial positive (δ^+). This results in the formation of a dipole with the polarity being in the direction of the more electronegative atom (shown as a vector arrow drawn in that direction). If the electronegativity difference is above 1.7 the sharing is so unequal, that the shared pair of electrons are mostly held by one atom resulting in one atom losing its valence electrons to the more electronegative atom. This is the harshest form of sharing, one in which one atom hogs the shared pair of electrons. The result is an ionic bond and the charges are no longer partial, but are instead real full +/– charges.



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