Types of Chemical Bonds

Key Ideas:

- How are chemical bonds formed?
- What are the differences between ionic bonds and covalent bonds?

Old Words

Compound: a pure substance with two or more elements that are chemically combined
Proton: subatomic particle with a charge of +1 and a mass of 1, found in the nucleus
Electron: subatomic particle with a charge of -1 and a mass of almost 0, found orbiting the nucleus
Valence Electron: electrons in last energy level, involved in bonding
Energy Level or shell: region where electrons orbit the nucleus

New Words

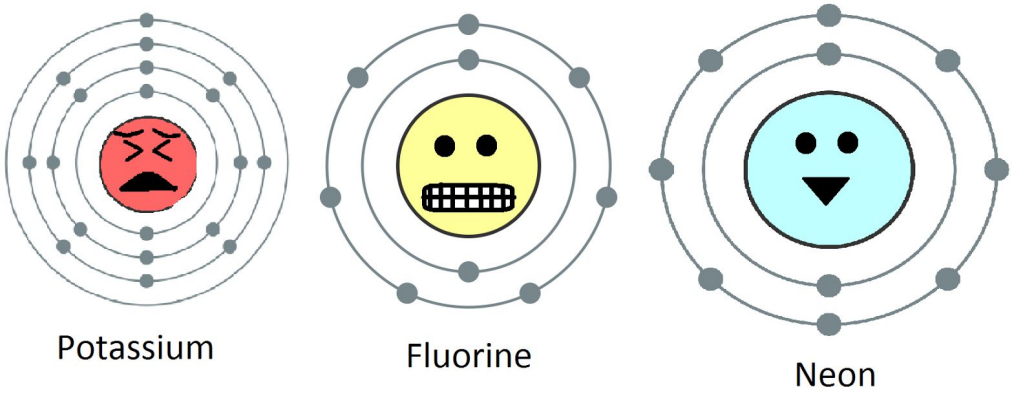
Chemical bond: when two or more atoms share or transfer electrons to form a unique substance with unique properties
Ionic bond: bond where valence electrons are transferred from one atom to another
Ion: charged particle
Cations: atoms with a positive charge
Anions: atomics with a negative charge
Covalent bonds: bonds where valence electrons are shared between atoms
Molecule: group of atoms covalently bonded

As you remember from the previous lesson, the atom is made of three types of subatomic particles: protons, neutrons and electrons. The number of protons and electrons are specific to each element: all nitrogen electrons have 7 proton and 7 electrons, all iron atoms have 26 protons and 26 electrons, and so on and so forth according to the atomic number. However, most atoms are usually not found with equal numbers of protons and electrons. They have exchanged their electrons with other atoms to create compounds with unique properties. This exchange and sharing of electrons create **chemical bonds.**

Love and Happiness: The Octet Rule

From our previous lesson, you know that electrons are not distributed evenly around the nucleus. You know that each energy level has a different number of electrons it can hold, the first level can hold 2, the second 8, the third 18. You also know that any electron in the outer energy level is known as a valence electron and that these electrons are involved in bonding.

Consider the following: How many valence electrons does potassium have? What about fluorine and neon?



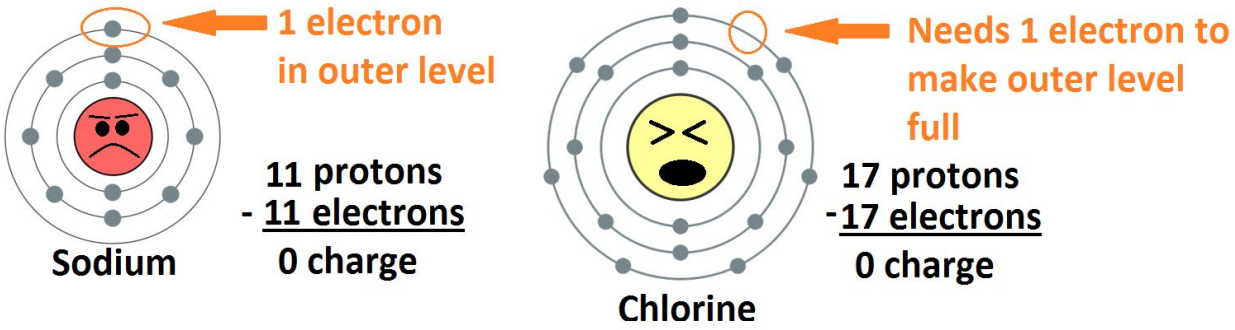
So why are valence electrons so important? It all has to do with the outer ring. Elements that have their last energy level full of electrons are chemically very stable. Notice that neon has 8 electrons in it's outer level, making it full. Neon is a very stable atom. However, fluorine has 7 electrons in it's outer level. It only needs one more electron to complete its outer shell. It *really* wants another electron and will react with almost anything to get it. Potassium on the other hand, has 1 valence electron. It wants to give that electron away so bad that it will bond with anything that will take it.

This pattern of gaining or losing electrons in order to have 8 electrons in their outer shell is called the **octet rule.** This rule helps predict how elements will create chemical bonds. However with any rule, there are some exceptions. Hydrogen, helium, lithium, beryllium and boron not follow the octet rule. This is because the first energy level can only fit 2 electrons. Each of these elements only have a few electrons. It is much easier for them to form a bond by filling the first energy level rather than gaining 8 electrons to fill the second.

Octet Rule: atoms will bond with other atoms until their outer energy level has 8 electrons because it is more stable. Exceptions: H, He, Li, Be, B

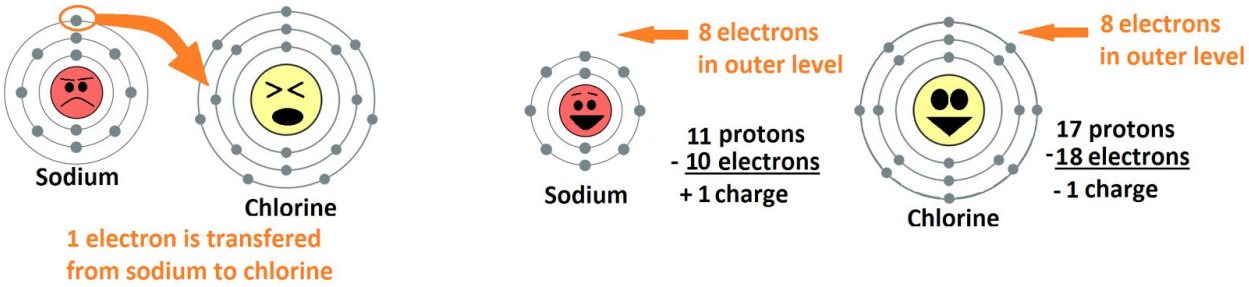
Isn't it Ionic: Ionic Bonds

Ionic bonds are formed by the transfer of valence electrons between two or more atoms. Remember that neutral atoms have equal numbers of protons and electrons. However because of the octet rule, most elements want to get lose or gain or lose valence electrons. You can see in the figure below that sodium has 1 valence electron in its outer level that it would like to lose. Chlorine has 7 valence electrons in its outer level and needs to gain in order to complete its octet.



Below we can see how an ionic bond works by sodium giving its valence electron to chlorine. This results in both sodium and chlorine with 8 electrons in their outer shells, fulfilling the octet rule. It also results in each atom having an uneven number of protons and electrons. This causes each atom to become an **ion,** or charged particle. Since the sodium atom now has one less electron than proton, it has a net charge of +1. The chlorine atom has one more electron than proton giving it a net charge of -1. We call ions with a positive

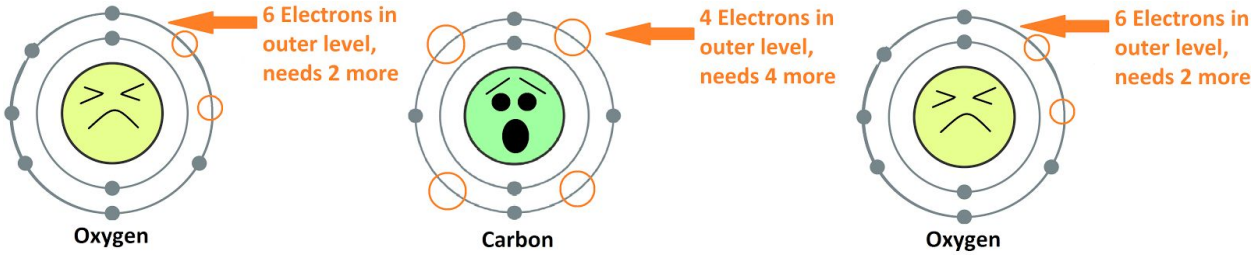
charge **cations** and ions with a negative charge, anions. We call the resulting compound sodium chloride, which you might recognize as table salt.



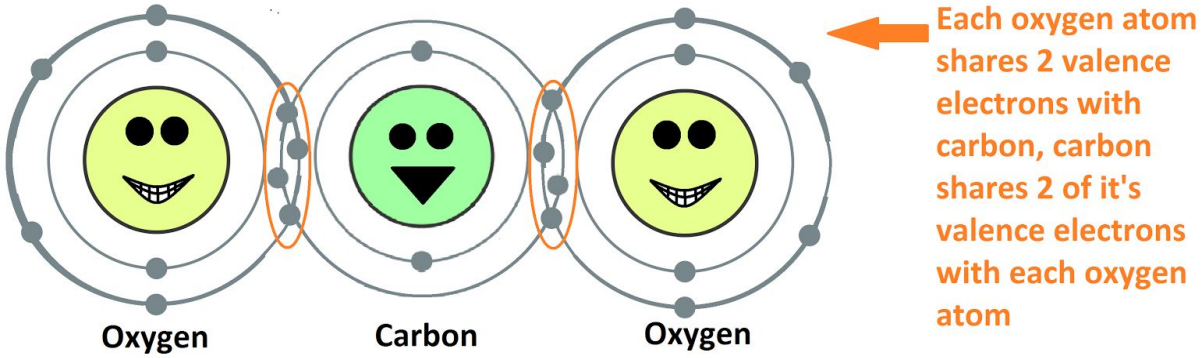
Once electrons are transferred and each atom is in its ion form, there is a strong attraction between sodium and chlorine. This creates a regular arrangement of sodium and chlorine ions (more detail will be discussed in later chapters). Other examples of ionic bonds are iron oxide (Fe_2O_3 - rust) and magnesium oxide (MgO).

Sharing is Caring: Covalent Bonds

In a **covalent bond**, valence electrons are shared between two or more atoms. Take a look at the figure below. Both oxygen and carbon need to gain electrons to complete their outer energy level. Neither one really wants to give any of their valence electrons up; oxygen only needs 2 more to complete its octet and carbon needs 4.



Instead of one atom giving away its electrons and another gaining them, carbon shares two valence electrons with each oxygen atom and each oxygen atom share two valence electrons with carbon. Notice in the picture below that through sharing electrons, each atom ends up with a full octet. When atoms combine to create covalent bonds, the resulting collection of atoms is called a **molecule**. A molecule is the simplest unit of a covalent compound that retains the unique properties of that substance. Examples of covalent compounds include carbon dioxide (CO_2) which is shown below, water (H_2O, glucose (sugar - $C_6H_{12}O_6$).



Conclusion

Chemical bonds are caused by atoms wanting to have 8 electrons in their outer shells (octet rule). When atoms form compounds, they create chemical bonds by either transferring or sharing electrons. There are two types of bonds: ionic and covalent. Ionic bonds take place when one atom transfers an electron to another, creating a cation (atom with a positive charge) and an anion (atom with a negative charge). The attraction between the two oppositely charged atoms is what makes the bond. Covalent bonds are created when two or more atoms share valence electrons.

Ionic Bonds	**Covalent Bonds**
Electrons are transferred	Electrons are shared
Examples: sodium chloride (NaCl), iron oxide (Fe_2O_3), magnesium oxide (MgO)	Examples: carbon dioxide (CO_2), water (H_2O), glucose ($C_6H_{12}O_6$)
Tend to be good conductors of heat and electricity	Tend to be good insulators of heat and electricity

Go Beyond: Why do you think ionic bonds would be good conductors of electricity?

Text Citations

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