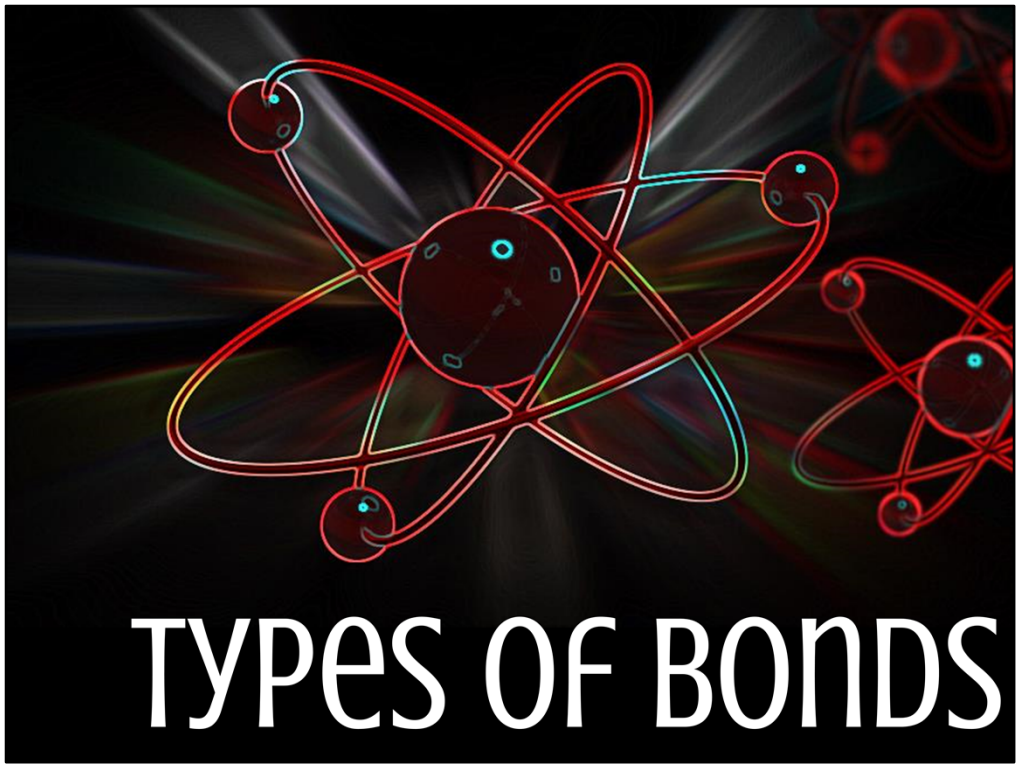
Module 4: Bonding, Formula Writing, and Nomenclature
Topic 1 Content: Types of Bonds Presentation Notes



Types of Bonds

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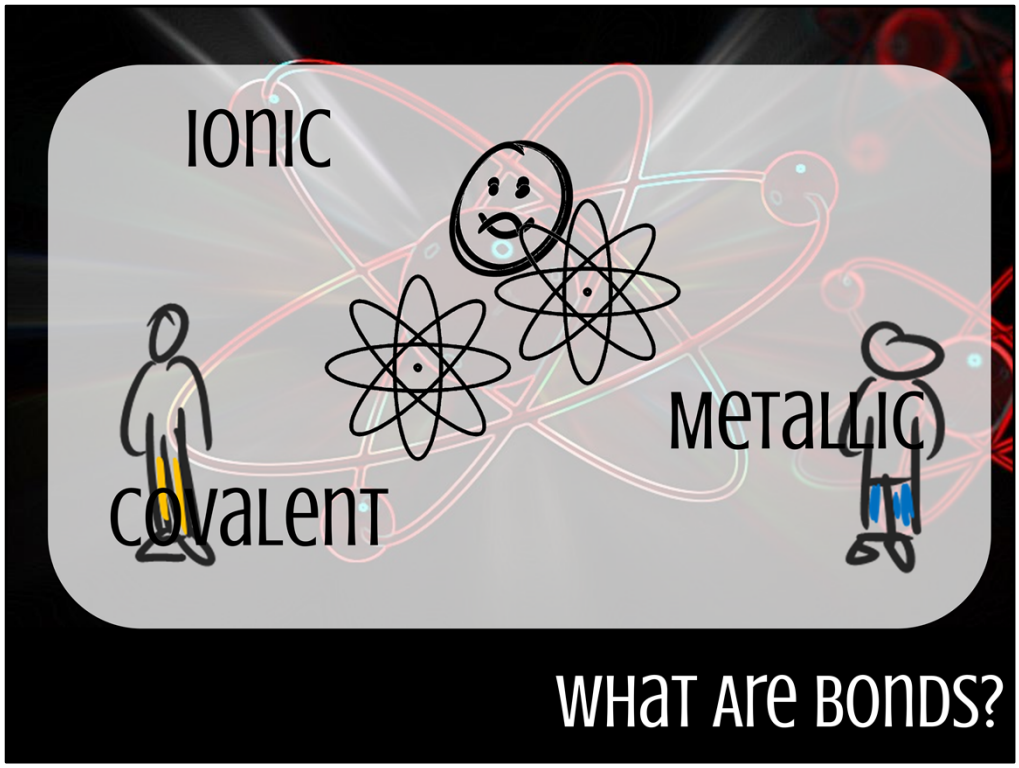

The interactions between atoms can be compared to the interactions between people. Just as two people come into contact with each other to meet, atoms must also come close together in order to react. Sometimes, people connect after meeting and become friends. Other times, people meet and repel each other. Similarly, when atoms come into contact with each other, their negatively charged electron clouds often repel each other; however, sometimes, the atoms bump into each other and stick together by sharing or transferring their outermost electrons. The amount of sharing or transferring between atoms is what determines the type of bonding between atoms and the properties of the compound. There are three main types of chemical bonds: ionic, covalent, and metallic.

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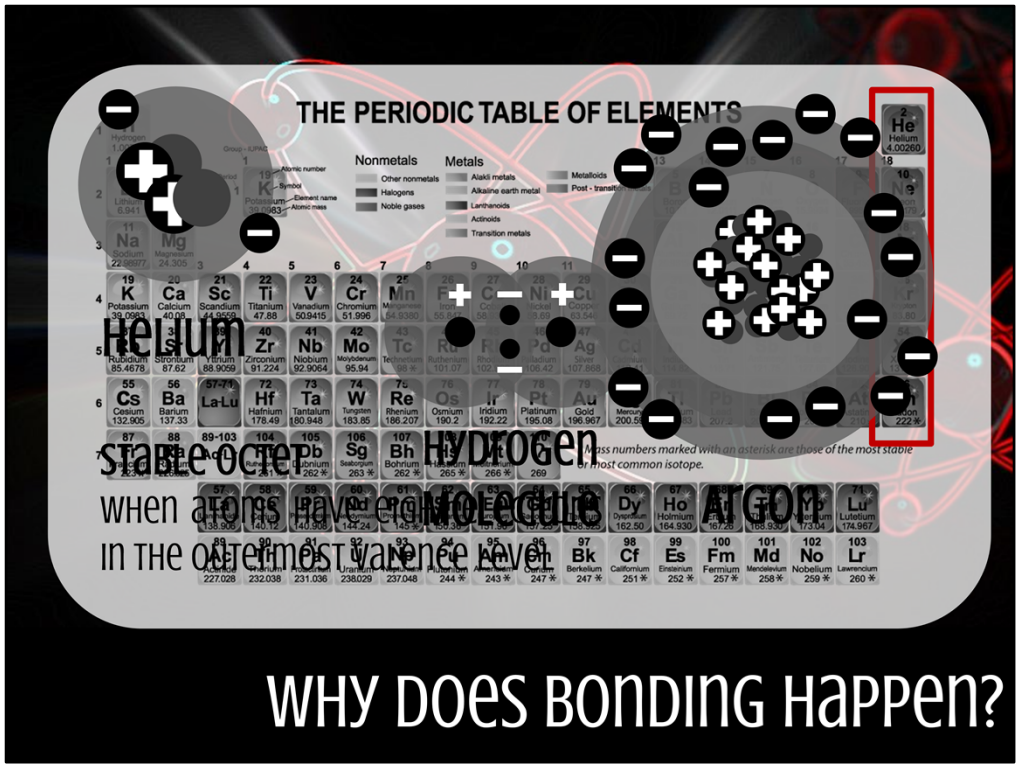

Bonding occurs when electrons are transferred or shared with another atom. It seems that atoms are always trying to achieve stability. Scientists have learned from experimental evidence that the Group Eighteen elements, the noble gases, are incredibly unreactive. This means that they are very stable and that there is something a bit special about their electron configuration. The Group Eighteen elements all contain completely filled valence energy levels. Helium is completely filled with two electrons. The rest of the noble gases are filled with eight valence electrons. Shown here is the noble gas argon with its eight filled valence electrons. When atoms have eight electrons in the outermost valence level, they are said to have a stable octet. Elements with their valence electrons in the first energy level only require two electrons and are said to have a stable duet.

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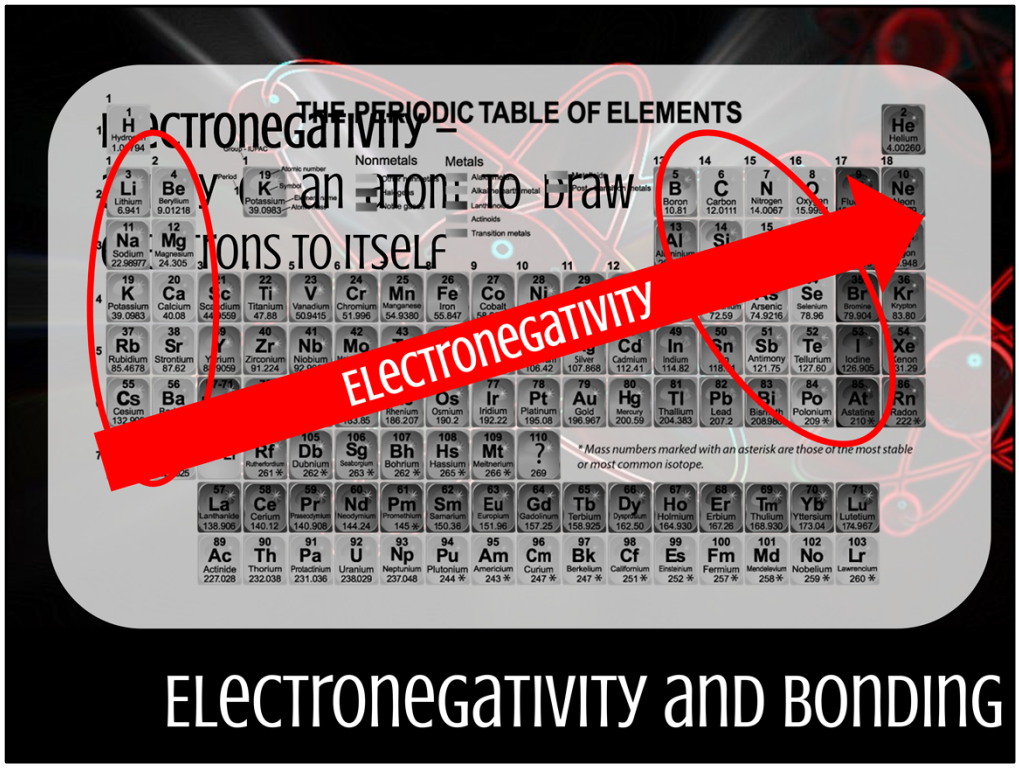

Electronegativity values are used to determine what type of bond will form. The ability of an atom to draw electrons to itself is called electronegativity. An atom that has a very high electronegativity value is most likely to take an electron, while an element with a low electronegativity value is most likely to give an electron. Where are the elements with the highest electronegativity located on the periodic table? They are on the upper right side. These elements are known as the nonmetals. Where are the elements with the lowest electronegativity located on the periodic table? They are on the left side. These elements are known as the metals. You could think of a bond as being somewhat of an electron "tug of war", in which electronegativity values are a measure of the electrons pulling power. As the electronegativity difference between two atoms increases, the electrons in the bond become unequally shared. The atom with the higher electronegativity will be winning the "tug of war" for the shared electrons. When the electronegativity difference between two atoms becomes quite different, the electron will not be shared any more, but completely transferred to one atom and an ionic bond results.

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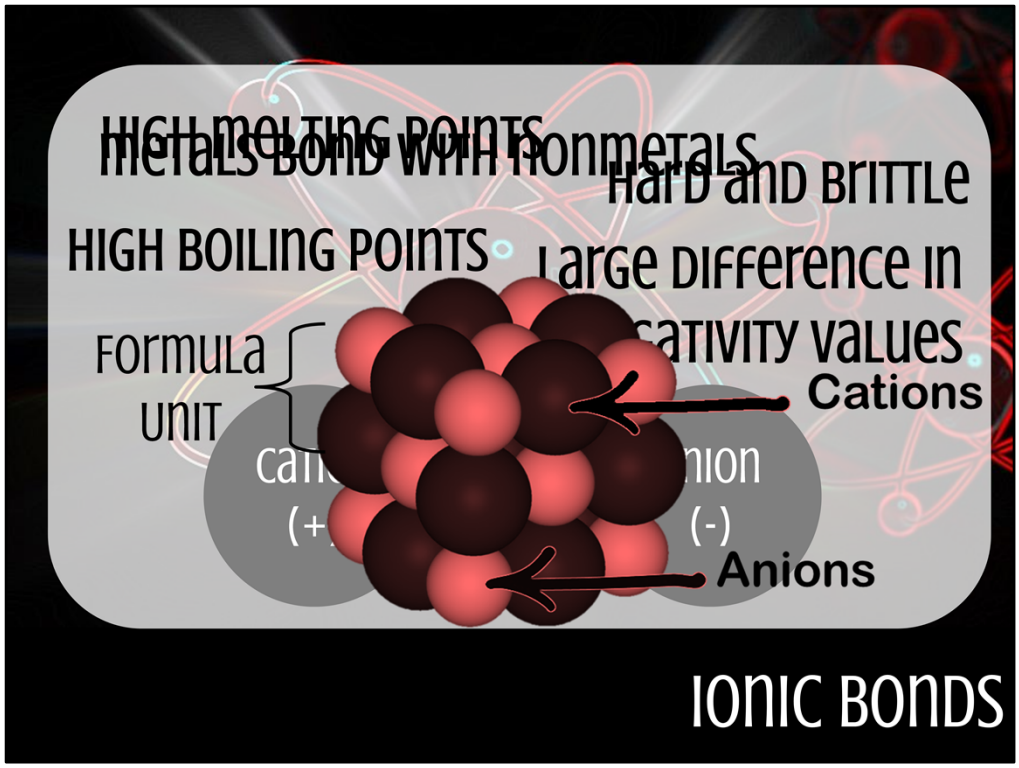
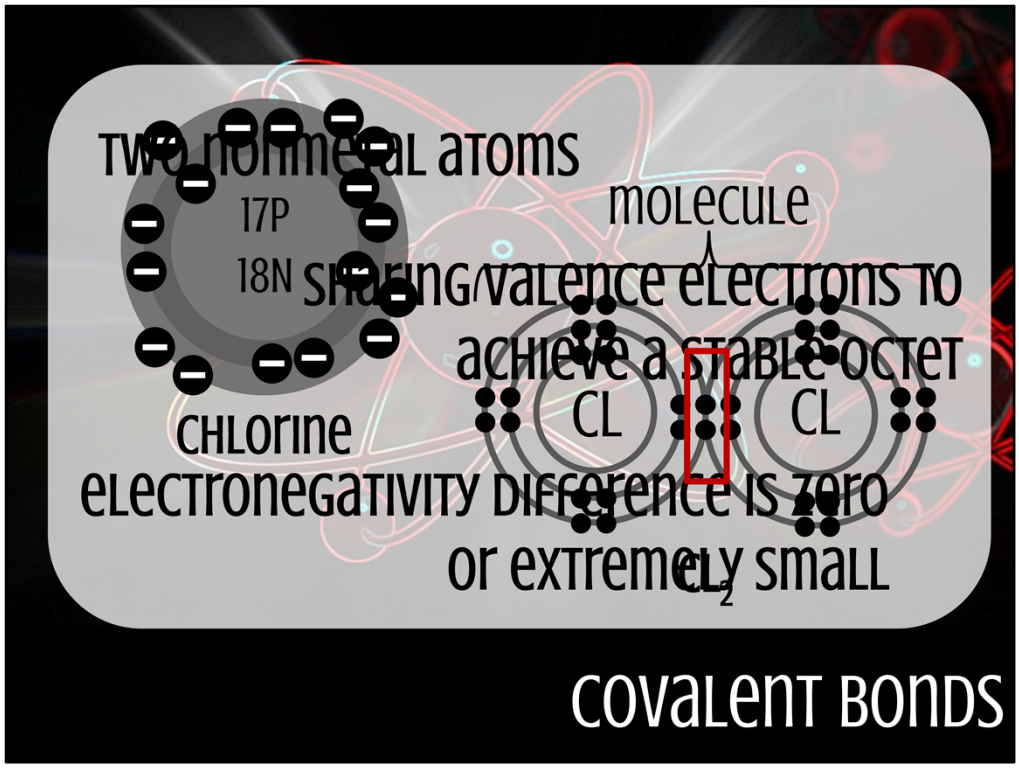


Some atoms achieve a stable octet by giving away or transferring their electrons to another atom. When metals bond with nonmetals, an ionic bond occurs because their electronegativity values are so different that one element will actually transfer an electron to the other. When an atom loses electrons, it ends up with a positive charge overall and it is called a cation. Atoms that gain electrons have a negative charge and are called anions. Elements that form cations are extremely different from elements that form anions. In fact, these elements are so different that they are on opposite sides of the periodic table. Cation are metals and are found on the left side.

Ionic substances create crystals in which each ion is surrounded by ions of an opposite charge. The ions are all equally attracted to all neighboring, oppositely-charged ions. This attraction between ions is quite strong and results in very high melting points and boiling points for ionic substances. Ionic compounds are hard, but very brittle. When a row of ions is shifted, the like charges are placed next to each other. These like charges repel each other and break apart. Inversely, it is fairly hard to move a row of ions when unlike forces are lined up because of the strong attractive forces. This gives ionic compounds the property of being hard.

In the solid phase, ions do not move, so electricity is not easily conducted. Most ionic compounds or “salts” dissolve very easily in water. This allows the charged ions to conduct electricity. Because each ion is not bonded in the true sense of the word to another particular ion, the term molecule is not really appropriate for ionic compounds. The smallest part of an ionic compound is referred to as a formula unit. A formula unit gives the lowest whole number ratio of cations to anions.



When two nonmetal atoms come together, each of their valence electrons are attracted to each other's nucleus. They are sharing their valence electrons in order for each to achieve a stable octet, which is something they could not do on their own. When the electronegativity difference between two atoms is zero or extremely small, the resulting bond is covalent. Shown here is the element chlorine and the covalent bond Cl_2. You can see from the image that each chlorine atom is sharing two electrons to form the covalent bond. From your studies, you may also remember that chlorine is a diatomic element. Diatomic elements form covalent bonds when they are bonded with themselves. Compounds with covalent bonding are called molecular compounds and the smallest particle is called a molecule. The forces of attraction between molecules are usually less than ionic substances, so their melting points and boiling points are generally much lower. Many molecular substances are gases or liquids at room temperature.

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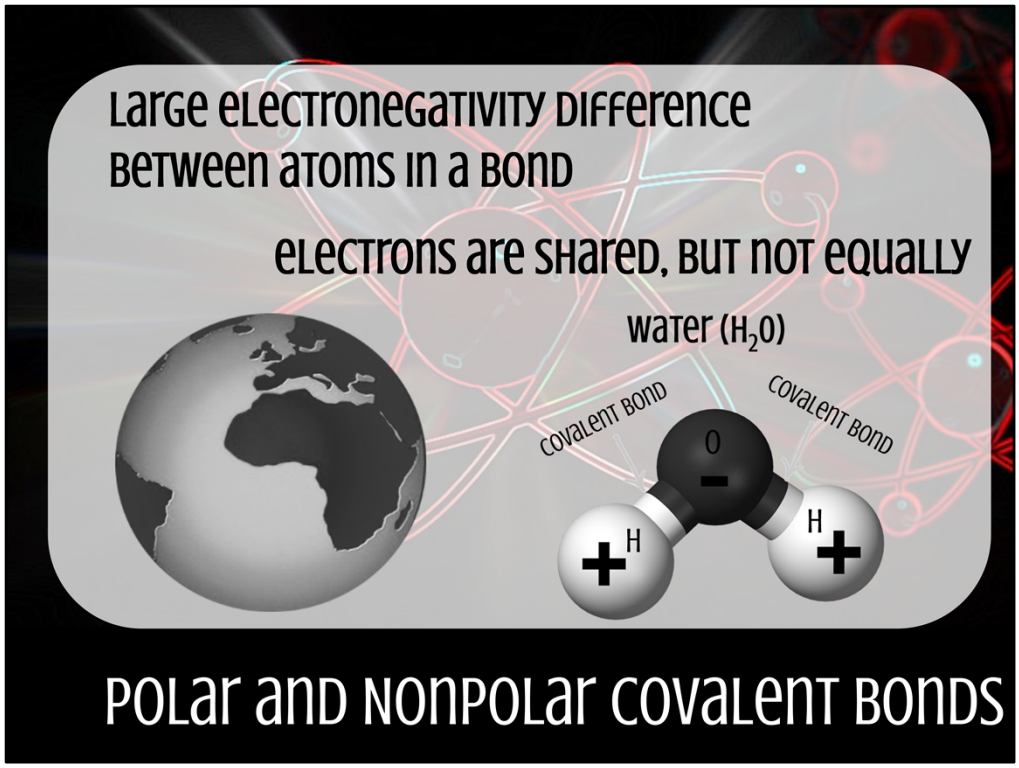
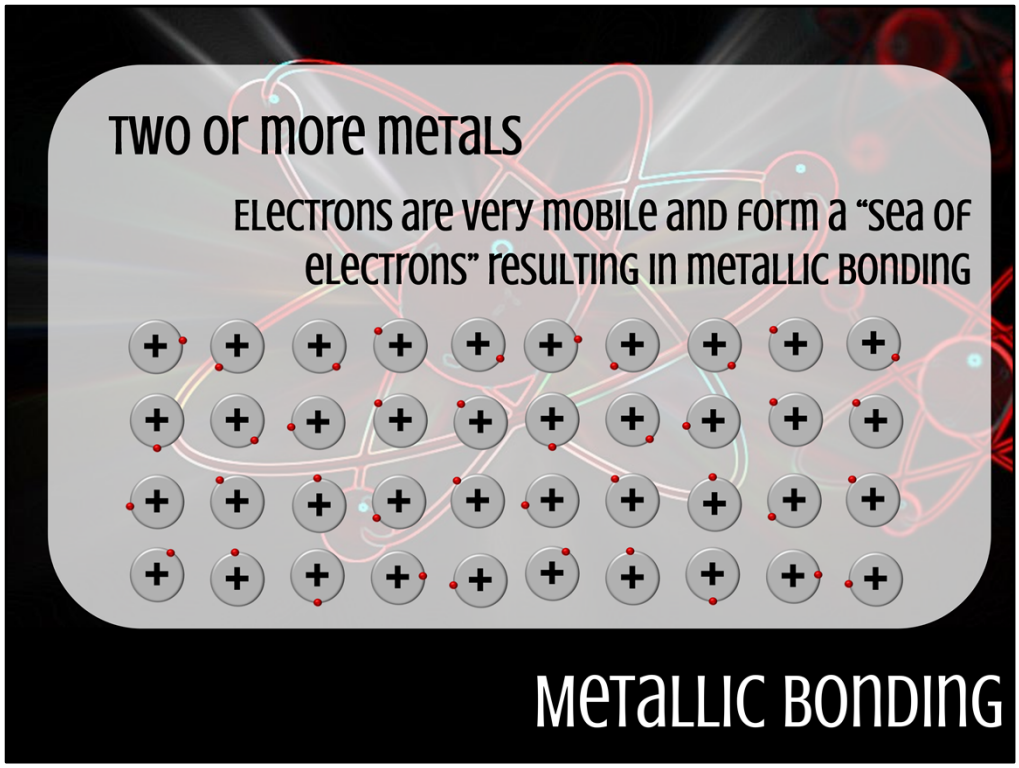


Polar covalent bonds result when there is large electronegativity difference between atoms in a bond. This means that the electrons are shared, but not equally. One of the most common substances on Earth is the result of a polar covalent bond. Water is a result of this type of bonding. Hydrogen and oxygen bond to form the water molecule.



Metallic bonds occur between two or more metals. Metals always have one, two, or three valence electrons in their highest energy level. That means that these valence electrons have lots of "vacant" orbitals to roam around. Scientists call these electrons "delocalized" because they do not belong to any one atom of the metal but are roaming freely around the entire metal. These electrons are very mobile and form a "sea of electrons" resulting in metallic bonding. These roaming or mobile electrons explain the special properties of metals. This is an image of what the metal sodium might look like. In this image, each sodium atom has one valence electron. There is plenty of empty space in the metal, which gives the metal special properties.