Reflect

Imagine that you have a bowl of oranges, bananas, pineapples, berries, pears, and watermelon. How do you identify each piece of fruit? Most likely, you are familiar with the characteristics of each fruit such as color, size, and shape. For example, you know that a watermelon is large, green, and oval-shaped, while blueberries are small, round, and dark blue.

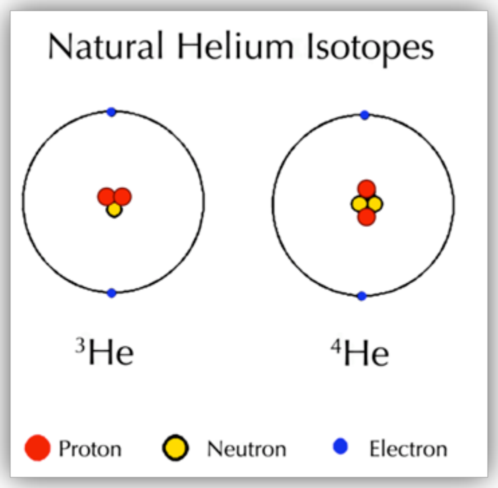
Like fruit that you are familiar with, elements (and the atoms from which they are made) have properties that help us identify them. What are these properties? Do they affect the way in which elements react with other elements?

Atomic Number

Remember that atoms contain three subatomic particles—protons, neutrons, and electrons. Protons are positively charged, neutrons do not have a charge, and electrons are negatively charged. Atoms of the same element always have the same number of protons. The number of protons in an atom is equal to the element's *atomic number.* An element can be distinguished from another element by its atomic number. For example, a carbon atom always has six protons. A neutral carbon atom has six protons and six neutrons in the nucleus. Since it is neutral, meaning it does not have an electrical charge, this carbon atom also has six electrons in the orbitals surrounding the nucleus. Each positive charge cancels out each negative charge.

Look Out!

Not all atoms of the same element have the same number of neutrons. *Isotopes* are atoms of the same element that have varying numbers of neutrons. The diagram on the right shows two isotopes of helium. One helium atom contains one neutron in its nucleus, while the other has two. Notice that the number of protons is the same in both forms of helium.

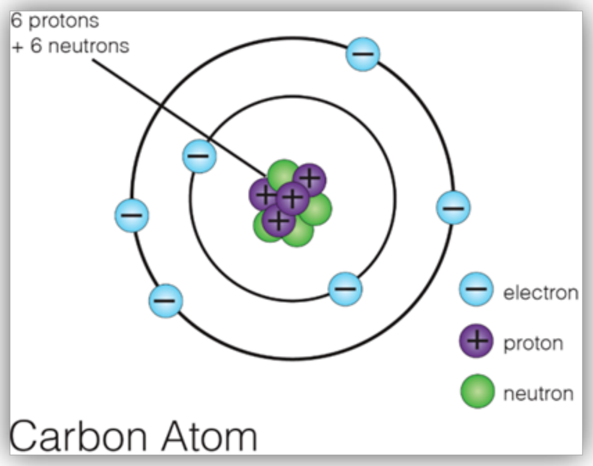


Energy Levels

In an atom, electrons are located outside of the nucleus in an electron cloud. An electron cloud is arranged in groups known as *energy levels.* Since an electron is always moving, it is located in one of the different energy levels, but never between energy levels.

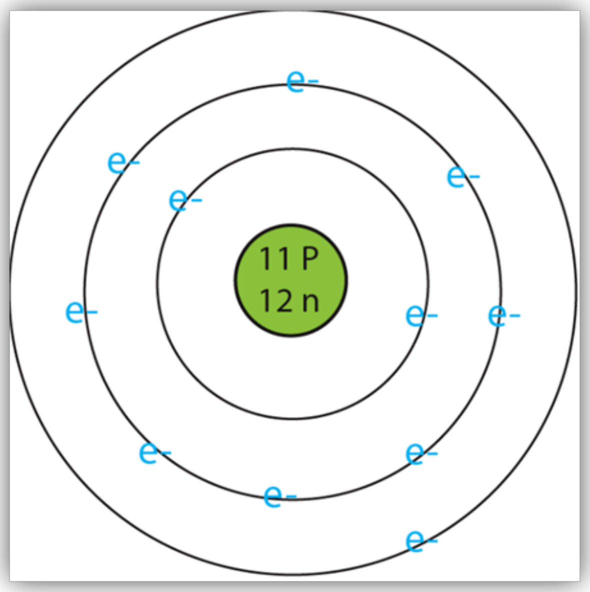
The energy levels are in groups that depend on their distance from the nucleus. Electrons in an energy level close to the nucleus are lower in energy than electrons in an energy level further from the nucleus. Each energy level can also contain a maximum number of electrons. For example, the first energy level that is closest to the nucleus can hold two electrons. The next energy level can hold eight electrons. Electrons in each lower level are filled before electrons fill the higher energy level. So, the two electrons in the first energy level are filled before electrons begin to fill the second energy level.

Let's look at an atom of carbon. The energy levels can be represented as circles surrounding the nucleus, as shown in the diagram to the right. Remember that carbon has an atomic number of six, so it contains six protons in its nucleus. Suppose that the carbon atom is neutral. It has six electrons. Two electrons fill the first energy level closest to the nucleus. Four electrons are in the second energy level further from the nucleus.



What Do You Think?

Look at the diagram of an atom below. The letter e- represents electrons, p represents protons, and n represents neutrons. What is the atom's atomic number? How many electrons are in the highest energy level?



Valence Electrons

The electrons found in the highest energy level are furthest from the nucleus, in the outermost level. These electrons are called *valence electrons*. They determine how an atom reacts with other atoms. Typically, atoms are stable when they have a full valence energy shell. This is referred to as the *octet rule*. Atoms with eight electrons in the valence shell are the most stable. This is true for most atoms except hydrogen and helium. These two elements have a full valence shell with two electrons because they only have one energy level. Atoms can satisfy the octet rule by either sharing or transferring valence electrons. So, valence electrons determine the chemical properties of an atom (whether an atom shares or transfers electrons) when new **molecules** are formed during a chemical change.

molecule: group of two or more atoms

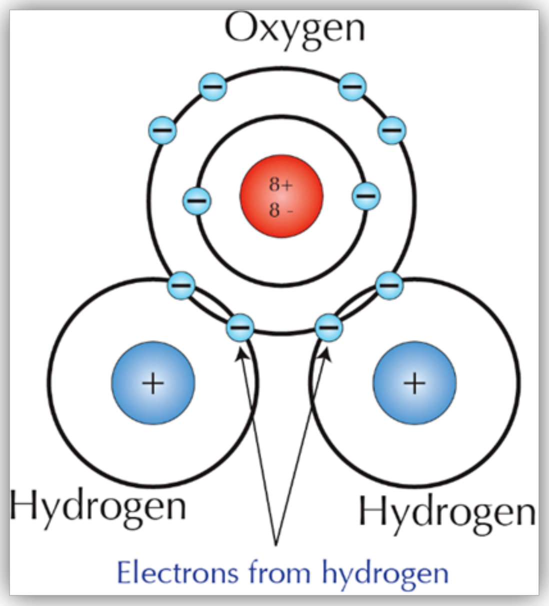
The *reactivity* of an atom is how easily and readily its valence electrons interact with the valence electrons of other atoms. Atoms of **metals** have a tendency to transfer electrons to **nonmetals** when they react. Atoms of nonmetals have a tendency to gain or share electrons when they react.

metals: group of elements, usually solid, with a shiny surface

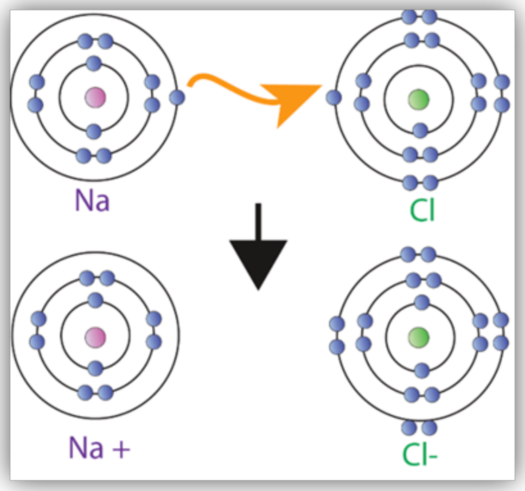
nonmetals: elements that lack the properties of metals

Let's look at the ways in which molecules share and transfer valence electrons.

- **Sharing electrons:** Some molecules share valence electrons between atoms. Commonly, when two or more nonmetals form a molecule, valence electrons are shared between atoms. For example, water is formed when two atoms of hydrogen and one atom of oxygen share electrons. Each hydrogen atom has one valence electron and needs one more electron to fill its outer energy level. The oxygen atom has six valence electrons and needs two electrons to fill its outer energy level. Each hydrogen atom shares one electron with the oxygen atom, and the oxygen atom shares one electron with each hydrogen atom. This fills all three atoms' outer energy levels.



- **Transferring electrons:** Sometimes electrons transfer between atoms when molecules form. When a metal reacts with a nonmetal, valence electrons transfer from the metal to the nonmetal atom. A common example of this is sodium chloride (NaCl), or table salt. An atom of sodium (Na) has one valence electron. An atom of chlorine (Cl) has seven valence electrons. The sodium atom donates, or transfers, its outer electron to the chlorine atom.



  Ions, or charged atoms, form when valence electrons transfer between atoms. In sodium chloride, sodium donates an electron to chlorine. Now, the sodium contains one more proton than electron, giving it a positive charge. The chlorine atom gains an electron. Thus, the chlorine atom has a negative charge.

Getting Technical: The Electron Microscope

Scientists have discovered that electrons can be used to reveal more of the details of small objects than a standard light microscope. In an electron microscope, electrons are focused into a beam, which travels through the object being observed. Some electrons scatter as they pass through the object, while other electrons do not. The electrons that do not scatter produce an image of the object. Because of this, an electron microscope may have a resolution almost 1,000 times greater than a light microscope.

An electron microscope allows scientists to see small details on organisms, such as this dust mite.

The electron microscope is used to view very fine details of different objects. Industries may use an electron microscope to study details of various materials to determine why they wear down or break over time. Biologists may use one to study tiny details of organisms or cells. These high-resolution images can provide details that cannot be seen with ordinary microscopes.

What Do You Know?

There are five atoms listed in the chart below. Use the information provided for each atom to fill in the missing information. Write your answers in the proper column of the chart. Remember that stable atoms have a full octet.

Atom	Number of Valence Electrons	Number of Protons	Atomic Number	Reactivity (Stable or Reactive)
Calcium (Ca)	2	20		
Lithium (Li)	1		3	
Argon (Ar)	8		18	
Helium (He)	2	2		
Potassium (K)	1	19		

Connecting With Your Child: Ion Models

To help your child learn more about ions, work together to build a model of electron transfer. You will need the following materials:

- Protons: 28 small round items of the same color, such as gumdrops or round cereal pieces
- Neutrons: 28 small round items of the same color, such as gumdrops or round cereal pieces. Use a different color than you used for protons.
- Electrons: 28 small round items of the same color, such as gumdrops or round cereal pieces. Use a different color than you used for protons and neutrons.
- A large sheet of paper

Have your child create two atoms by arranging the protons, neutrons, and electrons on the large sheet of paper based on the following information:
The atomic number of the first atom is 11. The atom is neutral.
The atomic number of the second atom is 17. The atom is neutral.

Next, ask your child to move the electron(s) from one atom to the other atom in order to model the transfer of electron(s). Your child should know that the first atom with 11 protons is reactive and should lose its electron to the other atom. If needed, guide your child by asking questions about the number of valence electrons in each atom.

Ask your child the following questions as you conduct the activity:

- How can you identify the elements represented by your models?
- Why did you move the electrons a particular way to model electron transfer?
- How did the charge of the atoms change once the electron was transferred?
- How could you make a similar model of atoms that share electrons?