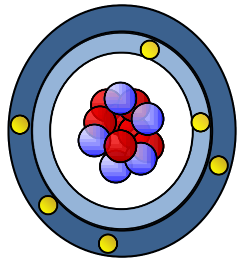


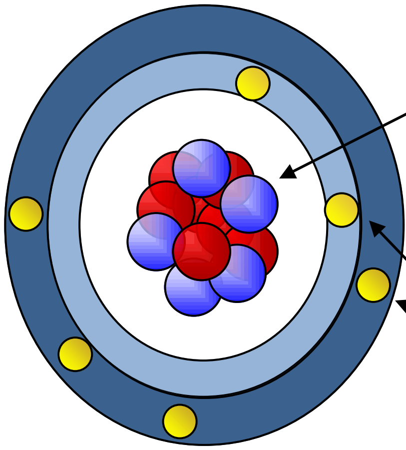
Lesson 2: A Little Bit of Chemistry

In Lesson 1, we discussed five characteristics that living things possess in order for them to be considered alive. We said that living things move, reproduce, require a source of energy, grow and develop and respond to their environment. In order for all of these things to happen, certain events must take place at the very small, microscopic and even sub-microscopic, or, atomic, level. To understand this, in this lesson, we'll take time to review some basic chemistry concepts regarding atoms, elements and the compounds they form.

The first idea to consider is that all things, whether living or not, are made up of tiny bits of matter known as atoms. Atoms are so tiny that, alone, they cannot be seen with the naked eye or even powerful microscopes. Much of what we know about atoms is based upon theories which have been thought and studied about for many, many years. These theories say that everything in this world as we know it is made up of atoms.

Everything is made of small bits of matter known as atoms.

The theory says that atoms are designed similarly to the way our solar system is designed. There is a central portion, much like the sun in our solar system, known as the nucleus of the atom. The nucleus of the atom is made up of even smaller bits of matter known as subatomic particles. There are two kinds of subatomic particles found in the nucleus of an atom: neutrons and protons. Circling around the nucleus of an atom is a third type of subatomic particle known as electrons.



Compared to the neutrons and protons within the nucleus, electrons are very light. Most of the mass of an atom is in its neutrons and protons. However, the electrons tell us a lot about the **behavior** of particular atoms. In other words, it is the way the electrons are arranged in atoms which predicts how the atom behaves around various other atoms.

Before we explore the electrons more deeply, we need to discuss the number of each subatomic particle (neutrons, protons and electrons) found in particular atoms. Chemists say that each element on the periodic table has its own number of protons, neutrons and electrons. The number found for each element is called the atomic number. Look at the periodic table on the next page.

Note that the atomic number is the whole number found in the upper left-hand corner of each square. Hydrogen (upper left side) with the symbol H, has an atomic number of 1. This means that atoms of hydrogen have one proton, one neutron and one electron (for the most part, as hydrogen is a sort of renegade when it comes to the number of electrons and may have up to three!).

Atomic Number → 1

Element Symbol → H

Element → Hydrogen

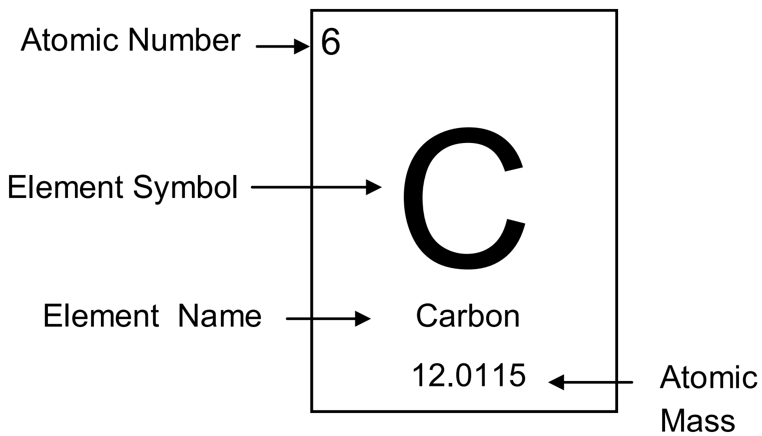
1.0080 ← Atomic Mass

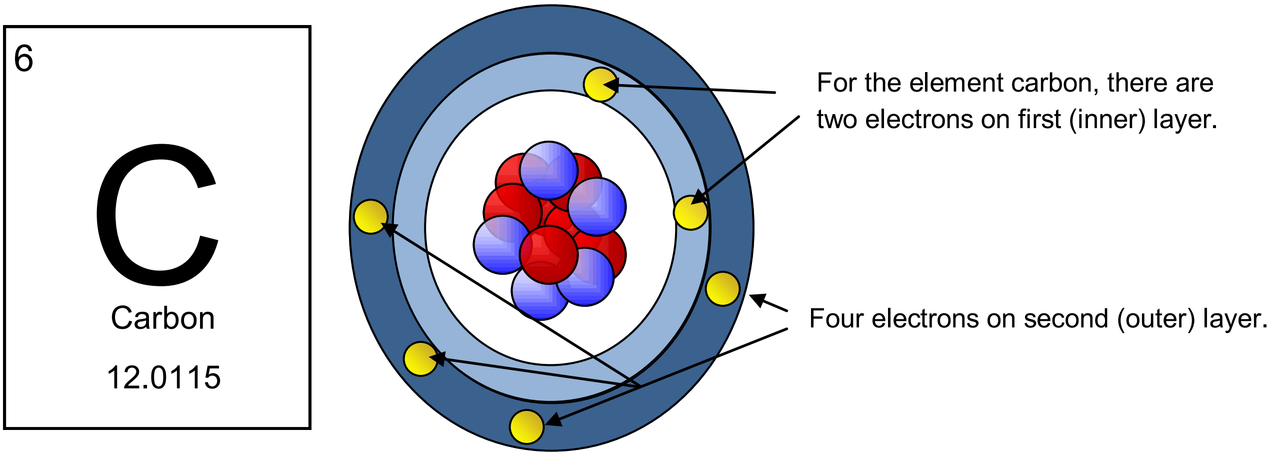
1 H Hydrogen 1.0080																	2 He Helium 4.0026
3 Li Lithium 6.94	4 Be Beryllium 9.012											5 B Boron 10.811	6 C Carbon 12.0115	7 N Nitrogen 14.0067	8 O Oxygen 15.994	9 F Fluorine 18.994	10 Ne Neon 20.18
11 Na Sodium 22.9898	12 Mg Magnesium 24.31											13 Al Aluminum 26.9815	14 Si Silicon 28.086	15 P Phosphorus 30.974	16 S Sulfur 32.06	17 Cl Chlorine 35.453	18 Ar Argon 39.948
19 K Potassium 39.102	20 Ca Calcium 40.08	21 Sc Scandium 44.96	22 Ti Titanium 47.9	23 V Vanadium 50.94	24 Cr Chromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.847	27 Co Cobalt 58.933	28 Ni Nickel 58.71	29 Cu Copper 63.546	30 Zn Zinc 65.37	31 Ga Gallium 69.72	32 Ge Germanium 72.59	33 As Arsenic 74.9216	34 Se Selenium 78.96	35 Br Bromine 79.909	36 Kr Krypton 83.80
37 Rb Rubidium 85.47	38 Sr Strontium 87.62	39 Y Yttrium 88.91	40 Zr Zirconium 91.22	41 Nb Niobium 92.91	42 Mo Molybdenum 95.94	43 Tc Technetium (99)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.91	46 Pd Palladium 106.4	47 Ag Silver 107.868	48 Cd Cadmium 112.40	49 In Indium 114.82	50 Sn Tin 118.69	51 Sb Antimony 121.75	52 Te Tellurium 127.60	53 I Iodine 126.904	54 Xe Xenon 131.30
55 Cs Cesium 132.91	56 Ba Barium 137.34	71 Lu Lutetium 174.97	72 Hf Hafnium 178.49	73 Ta Tantalum 180.95	74 W Tungsten 183.85	75 Re Rhenium 186.2	76 Os Osmium 190.2	77 Ir Iridium 192.22	78 Pt Platinum 195.09	79 Au Gold 196.97	80 Hg Mercury 200.59	81 Tl Thallium 204.37	82 Pb Lead 207.2	83 Bi Bismuth 208.98	84 Po Polonium (210)	85 At Astatine (210)	86 Rn Radon (222)
87 Fr Francium (223)	88 Ra Radium (226)	103 Lr Lawrencium (256)	104 Unq	105 Unp	106 Unh	107 Uns	108 Uno	109 Une									

However, the remaining elements each have the number of protons, neutrons and electrons equal to their atomic numbers. Helium has two of each particle, lithium has three, beryllium four, etc. To complete the "story," we need to mention that in some cases, the number of neutrons found in atoms may fluctuate up or down slightly. So, for the most part, the atomic number of an element tells us the number of protons, neutrons and electrons atoms of that element will have.

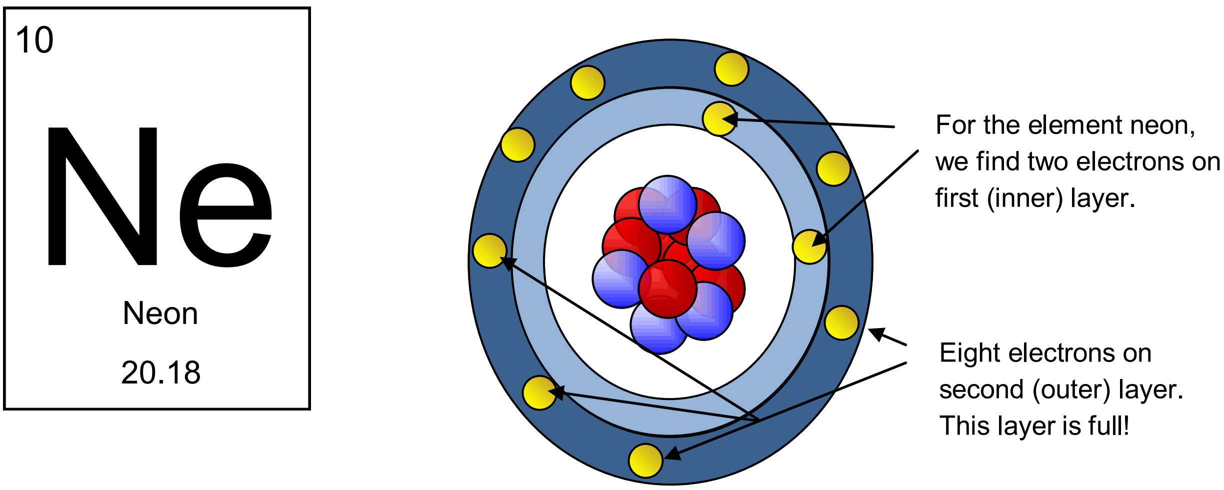
Let's return to our discussion of how the arrangement of electrons determines the behavior of atoms. Theories say that the electrons of atoms are arranged in layers or shells around the nucleus of the atom. On the first layer, nearest the nucleus of the atom, there are a maximum two electrons. After the first layer, there are up to eight electrons on each layer. The theories say that eight electrons is the maximum number of electrons that you'll ever find on a layer. The electrons fill up the layers nearest the nucleus first and then fill the next layer in an outward direction.

Let's look at an example of the element carbon. Look for carbon on the periodic table. The element symbol for carbon is C and can be found towards the right side of the table. Note that the atomic number for carbon is 6. From our discussion in the previous paragraph, this means an atom of carbon has six electrons circling about the nucleus. Two of these electrons will fill the first layer and then the remaining four will take their place in the second layer out.

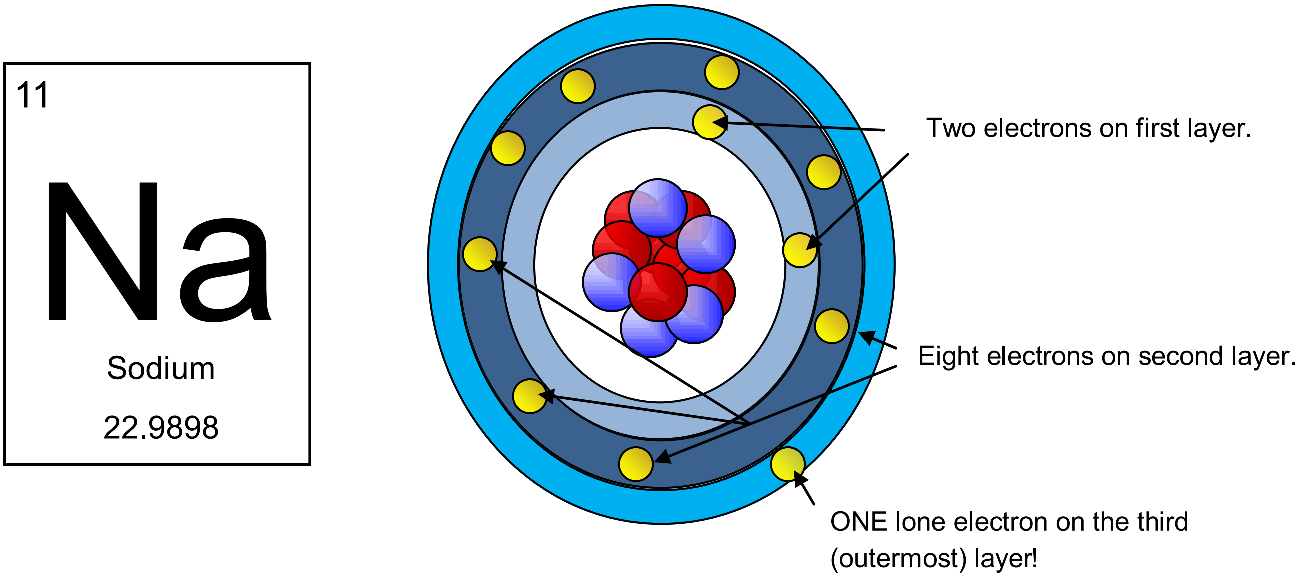




Let's look at another example. Find the element neon on the periodic table. The symbol for neon is Ne and can be found on the far right side of the table. Note that the atomic number for neon is 10, which means atoms of neon each have ten electrons. Once again, there will be two atoms on the first layer and the remaining eight will take their positions on the second layer. As we stated earlier, eight electrons is the maximum number of electrons that can be found on one layer, so the element neon has its outermost layer completely filled.



If we look at the next element on the table, sodium (Na, number 11), we find that it has two electrons on the first layer, eight on the second (total of 10, so far) and then we move to the third layer where there would be the one final electron.



Now, what does this arrangement of electrons have to do with the behavior of atoms? Atoms that have their outermost orbit or shell completely filled with electrons are atoms that are the most non -reactive or stable. These atoms do not want to react with any other atoms of any other elements. The family of elements that is the epitomy of stability is the noble gas family found on the far right-hand side of the periodic table of elements (helium, neon, argon, krypton, xenon and radon). Each of the elements in this family have their outermost orbit completely filled. Another name for this family of elements is the inert gas family. Inert means no action or movement. These elements do not react very much whatsoever with any other elements. They are extremely stable elements. We might say they are "happy" the way they are.

The remaining elements on the periodic table, which do not have their outermost orbits or shells filled (this includes all the other elements but the noble gas family members), are not "happy" the way they are. Some are extremely "unhappy" and are, consequently, extremely reactive. To reduce this irritability, these elements often reorganize their electrons in such a way that it appears that their outermost orbits are now filled. Some of these irritable elements "borrow" electrons from other elements in an effort to make their outer layers of electrons appear full.

						2 He Helium
	5 B Boron	6 C Carbon	7 N Nitrogen	8 O Oxygen	9 F Fluorine	10 Ne Neon
	13 Al Aluminum	14 Si Silicon	15 P Phosphorus	16 S Sulfur	17 Cl Chlorine	18 Ar Argon
30 Zn Zinc	31 Ga Gallium	32 Ge Germanium	33 As Arsenic	34 Se Selenium	35 Br Bromine	36 Kr Krypton
48 Cd Cadmium	49 In Indium	50 Sn Tin	51 Sb Antimony	52 Te Tellurium	53 I Iodine	54 Xe Xenon
80 Hg Mercury	81 Tl Thallium	82 Pb Lead	83 Bi Bismuth	84 Po Polonium	85 At Astatine	86 Rn Radon

Noble gas family. All members have their outer layer filled with electrons. Another name for this family is the inert gas family. Inert means non-reactive.

Other elements find that if they can move one or two of the electrons found in their outermost layer, they, too, can appear to look like a member of the stable noble gas family. So, by gaining a few electrons or losing a few, atoms of these "irritable" elements can gain the stability of the noble gas family members. In many cases, atoms of elements that would like to get *rid* of electrons find they can easily do so when mixed with atoms of elements who desire to *gain* a few electrons. By allowing these atoms to come into contact with one another, the electrons can be moved accordingly and stability attained.

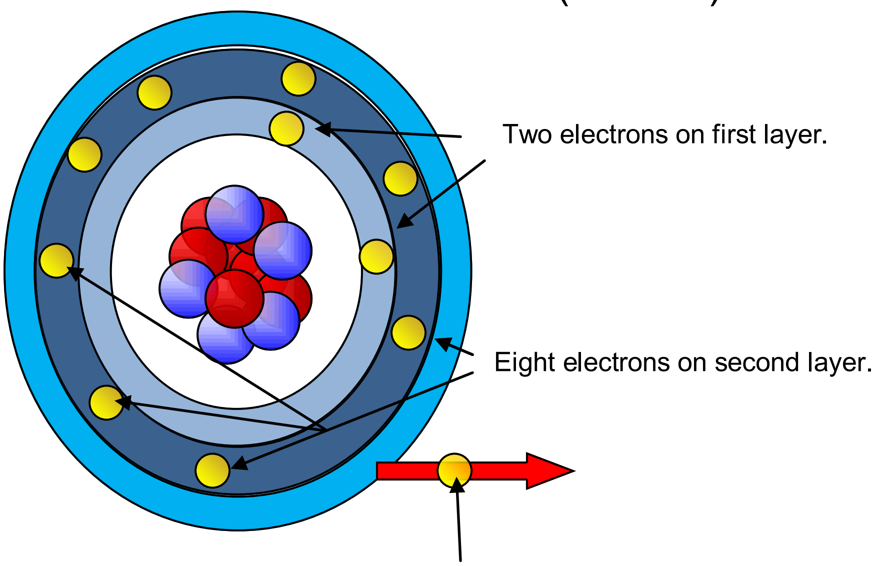
Noble gas family members are very stable. All other elements are "green" with envy and gain, lose or share electrons with other atoms to gain the appearance and stability of a noble gas family member.

1 H Hydrogen 1.0080																	2 He Helium 4.0026
3 Li Lithium 6.94	4 Be Beryllium 9.012											5 B Boron 10.811	6 C Carbon 12.0115	7 N Nitrogen 14.0067	8 O Oxygen 15.994	9 F Fluorine 18.994	10 Ne Neon 20.18
11 Na Sodium 22.9898	12 Mg Magnesium 24.31											13 Al Aluminum 26.9815	14 Si Silicon 28.086	15 P Phosphorus 30.974	16 S Sulfur 32.06	17 Cl Chlorine 35.453	18 Ar Argon 39.948
19 K Potassium 39.102	20 Ca Calcium 40.08	21 Sc Scandium 44.96	22 Ti Titanium 47.9	23 V Vanadium 50.94	24 Cr Chromium 51.996	25 Mn Manga-nese 54.938	26 Fe Iron 55.847	27 Co Cobalt 58.933	28 Ni Nickel 58.71	29 Cu Copper 63.546	30 Zn Zinc 65.37	31 Ga Gallium 69.72	32 Ge Germani-um 72.59	33 As Arsenic 74.9216	34 Se Selenium 78.96	35 Br Bromine 79.909	36 Kr Krypton 83.80
37 Rb Rubidium 85.47	38 Sr Strontium 87.62	39 Y Yttrium 88.91	40 Zr Zirconium 91.22	41 Nb Niobium 92.91	42 Mo Molyb-denum 95.94	43 Tc Techneti-um (99)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.91	46 Pd Palladium 106.4	47 Ag Silver 107.868	48 Cd Cadmium 112.40	49 In Indium 114.82	50 Sn Tin 118.69	51 Sb Antimony 121.75	52 Te Tellurium 127.60	53 I Iodine 126.904	54 Xe Xenon 131.30
55 Cs Cesium 132.91	56 Ba Barium 137.34	71 Lu Lutetium 174.97	72 Hf Hafnium 178.49	73 Ta Tantalum 180.95	74 W Tungsten 183.85	75 Re Rhenium 186.2	76 Os Osmium 190.2	77 Ir Iridium 192.22	78 Pt Platinum 195.09	79 Au Gold 196.97	80 Hg Mercury 200.59	81 Tl Thallium 204.37	82 Pb Lead 207.2	83 Bi Bismuth 208.98	84 Po Polonium (210)	85 At Astatine (210)	86 Rn Radon (222)
87 Fr Francium (223)	88 Ra Radium (226)	103 Lr Lawrencium (256)	104 Unq	105 Unp	106 Unh	107 Uns	108 Uno	109 Une									

This process of gaining or losing electrons is known as **ionization** and results in atoms forming "relationships" with other atoms to gain the stability "enjoyed" by the noble gas family members. These "relationships" are scientifically known as bonds which are links between various atoms. When electrons get transferred from one atom to another in the attempt to gain stability, the bonds that result are called **ionic bonds**.

A great example of this is the combination of sodium and chlorine atoms. Find the element sodium on the periodic table. Look for it on the left side, about half-way down with the symbol Na. Note that sodium has eleven total electrons. If we look at how these electrons are arranged, we find two on the first layer, eight on the second and then one on the third layer (for a total of eleven electrons). If the sodium atoms could lose the one electron on the third layer, they would "look like" neon, a noble gas family member. Note that these sodium atoms don't actually become neon, instead they just take on the stability of neon. Look now at the chlorine atoms.

Na (sodium)

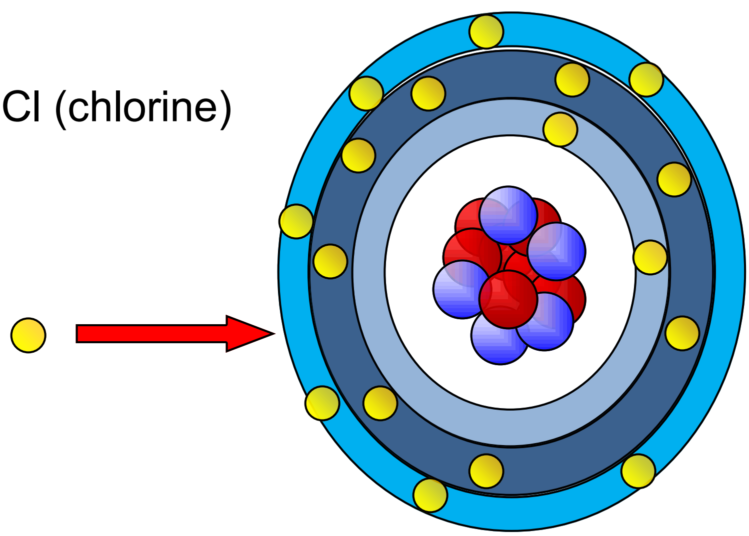


ONE lone electron on the third (outermost) layer. If this electron could be given to another atom willing to receive it, this sodium atom could take-on the appearance of the element neon (with 10 electrons.) In doing so, it could attain the stability of neon and be "happy."

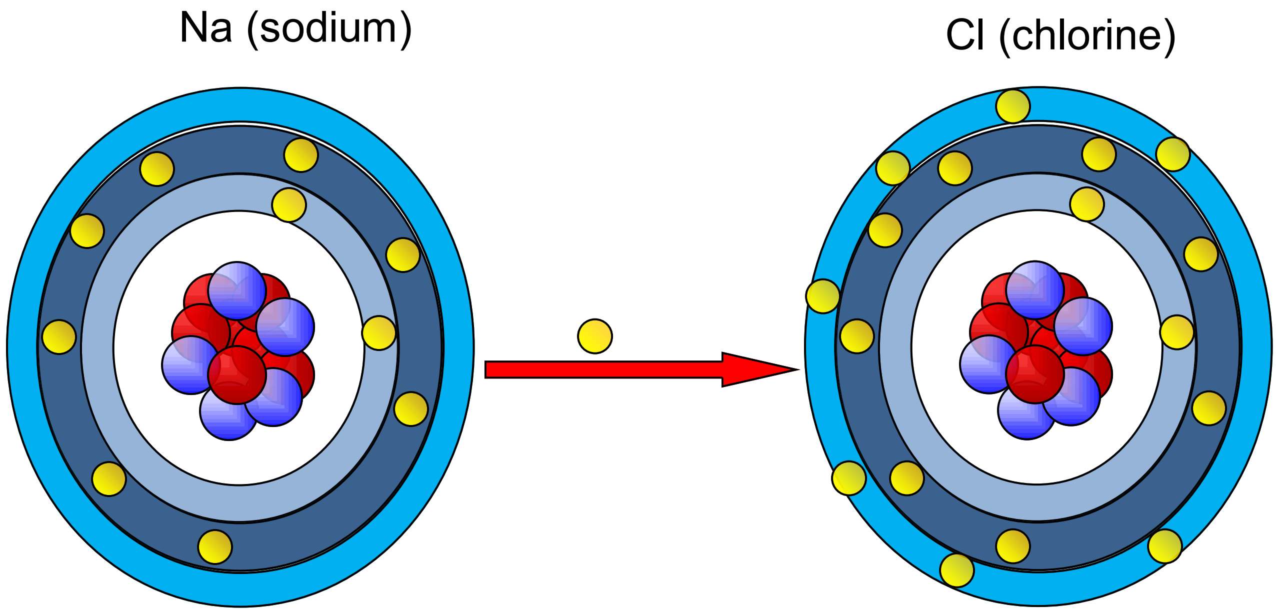
Find the element chlorine on the periodic table. It can be found over on the right-hand side in the family just next to the noble gas family. The element symbol for chlorine is Cl. The atomic number for chlorine is 17 meaning chlorine atoms have 17 electrons. If we look at how these electrons are arranged, we find there are two electrons on the first layer, eight on the second layer and then seven on the third layer. If chlorine atoms could each gain one electron from some other source, they could take-on the stability of argon (atomic number 18) and be very "happy."

Cl (chlorine)

Chlorine has seven electrons in its outermost layer. It will very willingly accept one more electron to have its outer layer filled with eight electrons. When it accepts one electron it will now have 18 total electrons and will attain the appearance and stability of argon and be very "happy."



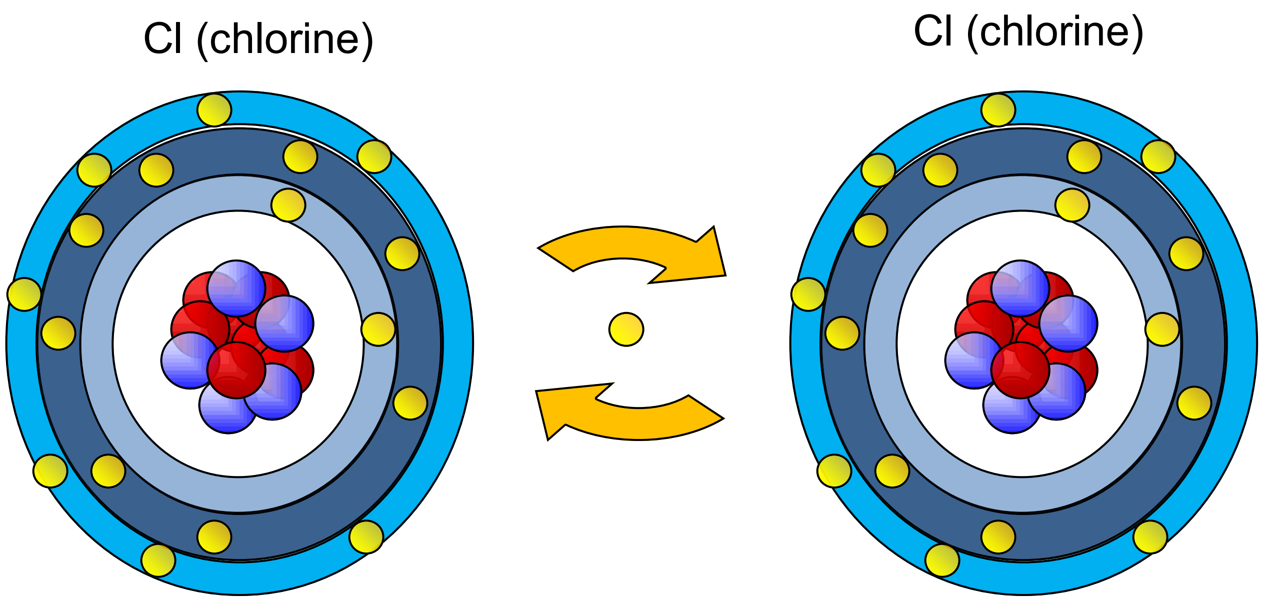
As you probably assume, if the sodium atoms get "mixed" with the chlorine atoms, the sodium atoms will readily "donate" their one extra electron to the willing chlorine atoms who are very happy to accept their donations. When this happens, ionic bonds are formed. The resulting combination of elements sodium and chlorine will produce the very stable compound sodium chloride, known more commonly as table salt! So, we see that elements from all across the periodic table can "work things out" by transferring electrons to form very stable compounds.



The sodium atom donates its outermost electron to the chlorine atom. In doing so, both atoms gain the appearance and stability of its nearest noble gas neighbor. The sodium atoms "looks" like neon and the chlorine atom, because it has gained one electron, "looks" like argon. This transfer of an electron results in the formation of an ionic bond between the two atoms.

In some cases, however, some elements find that sharing, rather than transferring electrons, is how they prefer to form bonds and, consequently, compounds. These elements are still attempting to fill their outermost layer of electrons and do so by allowing electrons to "be" at one atom for a short time and then moved back to another atom. We can liken this situation to the sharing of a toy. You have a ball (electron) which allows you to have a full toy box (outer layer of electrons). Your neighbor next door also likes the ball since it will fill up his toy box when it is at his house. Between the two of you, as long as you share the ball (electron) back and forth, each can have the stability the filled outer layer brings. This type of bonding which results from the sharing of electrons, rather than the transfer, is called **covalent bonding**. The name covalent comes from co– meaning with or among and –valent which refers to the valence electrons, those electrons found in the outermost layers. Covalent bonds are formed when electrons are shared between atoms.

Some elements form covalent bonds by sharing one electron and these bonds are called single covalent bonds. An example of this is chlorine gas. Chlorine gas consists of two atoms of chlorine each which share one electron. For part of the time, one of the atoms has a full outer layer and then the shared electron returns to the other atom allowing it to attain stability.



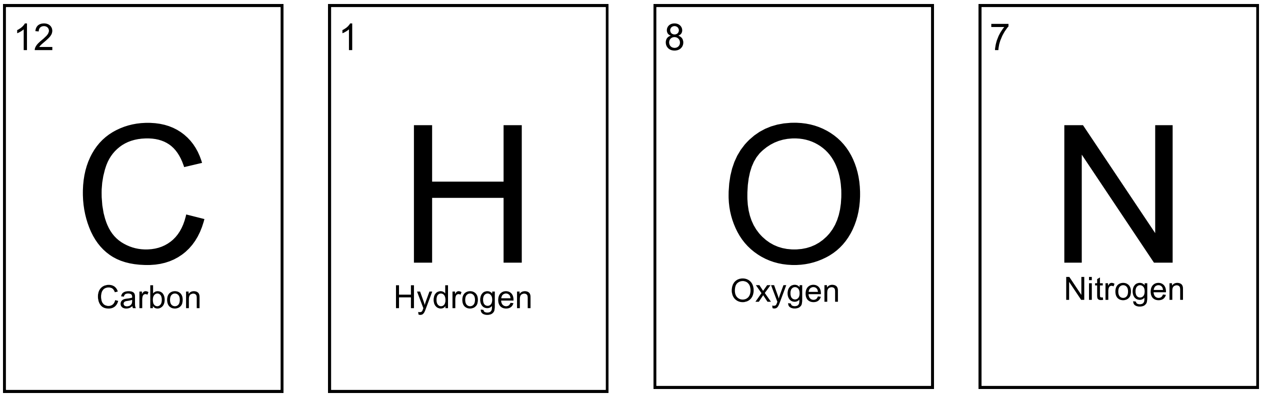
Some atoms like to share electrons, rather than transfer them. This sharing of electrons results in what is known as covalent bonds.

Other elements share two electrons and these bonds are called double covalent bonds. Oxygen gas is an example of a compound formed between two atoms of oxygen each sharing two electrons back and forth between them. Still other elements—nitrogen, for example—form stable compounds by sharing three electrons. These bonds that are formed when three electrons are shared are called triple covalent bonds.

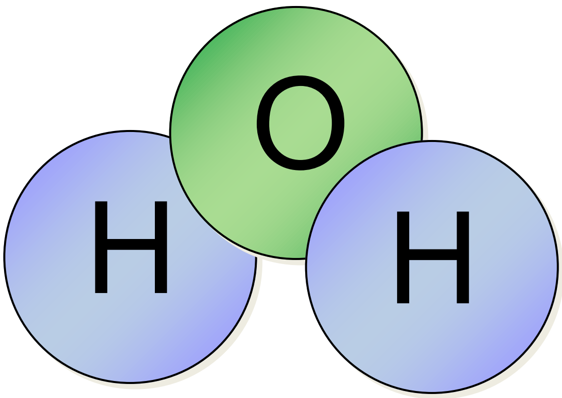
Ionic bonds form when atoms transfer electrons from one to another.

Covalent bonds form when atoms share electrons.

If you look at the periodic table of elements, you can see that there are over 100 known elements and, obviously, many, many ways that the atoms of elements could combine to form compounds. However, as we study living things, we will concentrate on only a few very important elements which are vital to life. **Those important elements include carbon (C), hydrogen (H), oxygen (O) and nitrogen (N).** Note that there are many more elements that are required for living things to survive, such as sodium, potassium, calcium and magnesium, for example. We will discuss those elements later in this course. At this time, we will concentrate on carbon, hydrogen, oxygen and nitrogen.



The compounds that these four elements form are necessary for life. Think about hydrogen and oxygen, for example. Can you think of any compound made from hydrogen and oxygen that is so important that we must consume some every day and that makes up over 70% of our bodies? Water! Yes, water is vitally important to the survival of all living things, albeit some to a lesser degree than others. The combination of hydrogen and oxygen atoms to form the compound water is extremely important!



Water is formed from two hydrogen atoms and one oxygen atom: H_2O.

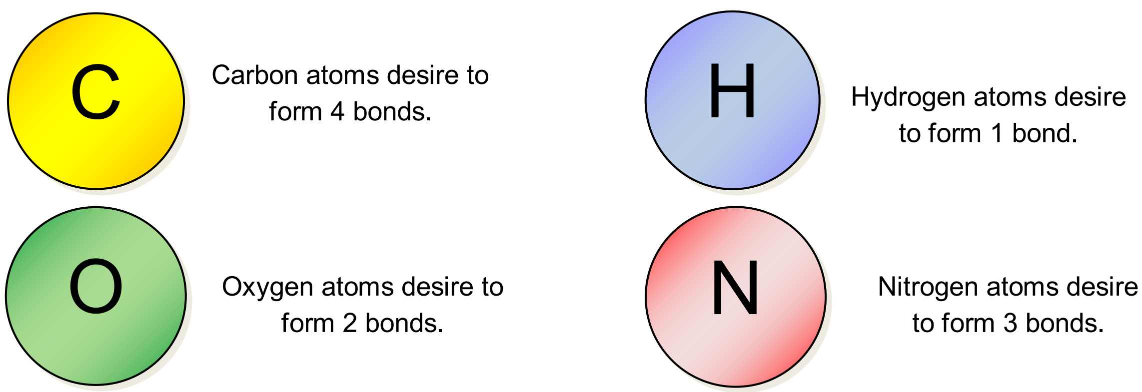
Before we end our discussion on basic chemistry, let's take a slightly closer look at the atomic structure of each of these elements. Recall that we said an atom of carbon has a total of six electrons (carbon is atomic number six.) This meant that in an atom of carbon, we'd find two electrons on the inner layer of electrons and then four on its outer layer. Because carbon would rather have some combination of electrons to make eight electrons on its out layer, we find that carbon has the desire to gain four electrons from neighboring elements. In other words, carbon atoms generally desire to form four bonds with other elements.

If we were to look at oxygen atoms, we'd find of the total of eight electrons, there are, again, two on the inner layer of electrons and six on the outer layer. Because oxygen would like to have eight on its outer layer, it has the desire to form two bonds with neighboring elements. So far we've said that carbon atoms desire to form four bonds and oxygen atoms desire to form two bonds.

Let's look at hydrogen atoms now. If we find hydrogen on the periodic table, we see that it is atomic number one indicating, for the most part, hydrogen atoms have one electron. Chemists have found that hydrogen atoms readily donate this lone electron to neighboring elements to gain their desired stability. Therefore, hydrogen atoms desire to form one bond with neighboring elements.

Finally, let's look at nitrogen. The nitrogen atom has a total of seven electrons. Two of these seven will be found on the inner layer of electrons while the remaining five will be on the outer layer. Knowing that all atoms desire to have eight on their outer layer, how many bonds do you guess nitrogen atoms like to form? If you said three, you're exactly right. Nitrogen atoms desire to form three bonds with neighboring elements.

Knowing these bonding arrangements of these four important elements will be very helpful in the upcoming lessons where we examine how these elements are used by living organisms.



Lets pause and review now. In this lesson we've learned that:

- Everything in our world, living or non-living, is composed of matter. Theories tell us that matter is composed of very tiny bits known as atoms.
- Atoms consist of a central nucleus containing neutrons and protons. Circling around the nucleus are electrons.
- It is the arrangement of electrons in atoms that allows us to understand why some elements can be very reactive while others are very stable.
- Atoms that have their outermost layer of electrons totally filled are the most stable. The noble gas family members enjoy this stability.
- All other elements adjust the number of electrons in their outer layers by either transferring electrons from one to another and forming ionic bonds or by sharing electrons back-and-forth resulting in the formation of covalent bonds.
- As atoms join together in various ways to gain stability, compounds form.
- The elements carbon, hydrogen, oxygen and nitrogen are of vital importance to living organisms.
- Based upon their atomic structure, carbon atoms desire to form four bonds, oxygen atoms desire to form two bonds, hydrogen atoms desire to form one bond and nitrogen atoms desire to form three bonds with other elements.

Name ____Date_____________________

Lesson 2 Practice Page 1

Instructions: Fill in the blank with the appropriate word. Refer back to the text portion of the lesson for help.

1. All things, whether living or non-living consist of tiny bits of matter known as _________.

2. The central portion of an atom is known as the ________________ and it contains subatomic particles known as the _____________________ and the _________________.

3. Circling around the nucleus of the atom are a third type of subatomic particle which are the _______________________.

4. Theories say it is the _______________________ of the electrons which determines the behavior of various elements on the periodic table.

5. To determine the number of protons or electrons an atom of a particular atom has, one looks for the _________________________ of that element on a periodic table.

6. The electrons are thought to exist in _________________ around the nucleus of an atom and that there can be no more than _______________ on one of these layers.

7. Elements which have their outermost layer of electrons filled are the elements which are very _______________________ in their behavior.

8. Elements which have their outermost layers incompletely filled are elements which are very ________________________ in their behavior.

9. Elements which are very reactive seek to gain stability by moving or sharing ____________________ with neighboring atoms of elements.

10. The family of elements whose atoms have their outer layers of electrons completely filled making their very, very stable is the __________________ family.

11. Atomic bonds which form between atoms who have transferred electrons from one to another are known as _____________ bonds.

12. Atomic bonds which form between atoms who are sharing electrons between themselves are known as _________________ bonds.

13. Of the many elements known to man, there are four that are common to all living things and deserve our special attention. Those four elements are: _________________, _________________, _________________ and _________________. Write their element symbols next to their names, too!

14. Of the elements listed below, choose the one that would most likely be the least reactive.

A. Hydrogen

B. Carbon

C. Sodium

D. Neon

15. Of the elements listed below, choose the one that would most likely be the most reactive.

A. Neon

B. Sodium

C. Argon

D. Helium

16. Which subatomic particle is thought to be responsible for an atom's behavior?

A. Proton

B. Neutron

C. Electron

D. Crouton

17. Suppose Atom A desires to get rid of one electron and Atom B is willing to accept that one electron. Together, by moving this electron, they can become a compound which is stable. This type of bond formation where electrons are moved is called a

A. Proton bond

B. Single covalent bond

C. Double covalent bond

D. Ionic bond

E. James bond

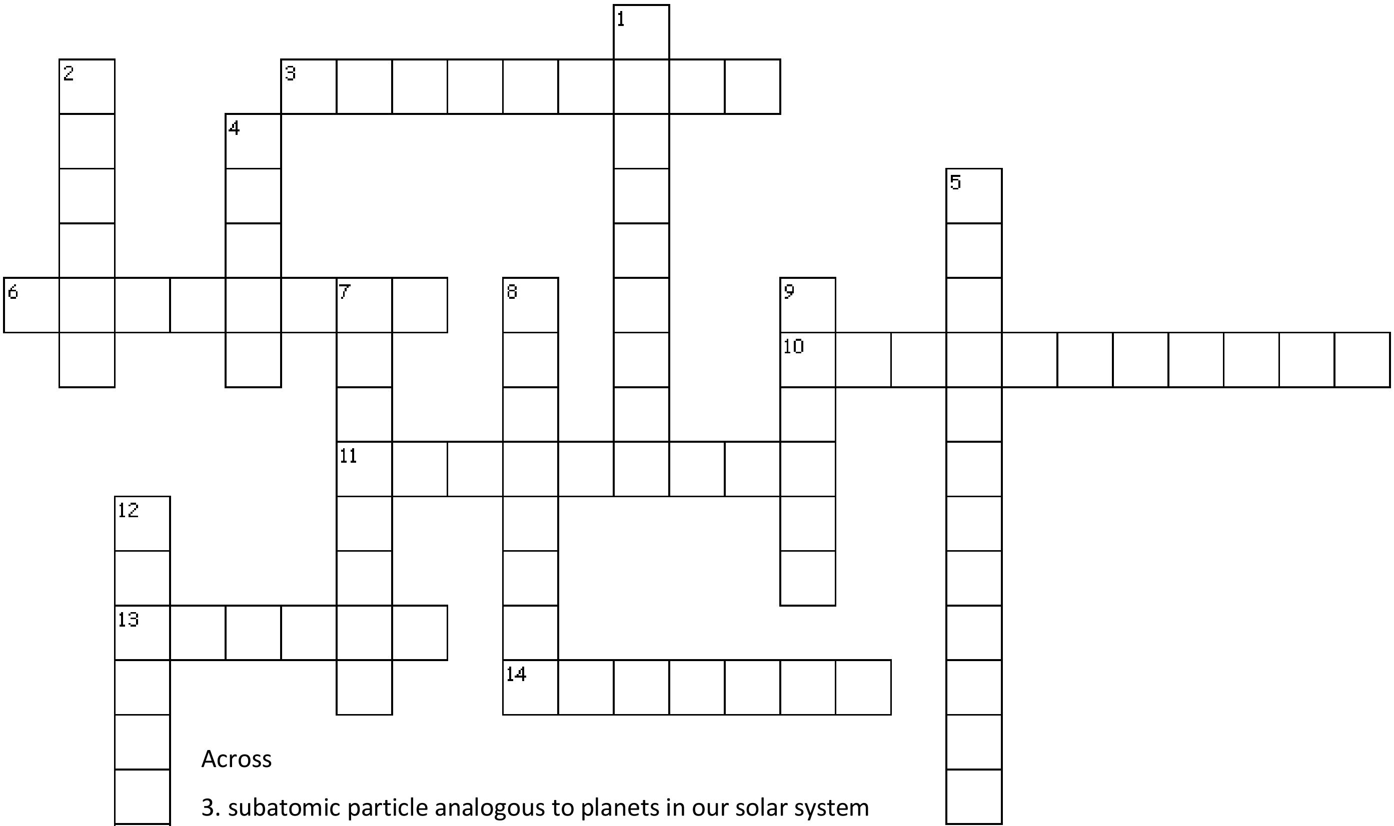
18. There are many elements required by living things in order to maintain life. There are four that we will study next. Circle these four important elements found in this list of element symbols:

H He C Ca Li Be Ar Ox O Br Ni N Zn As Pb Cu

Name ____Date_____________________

Lesson 2 Practice Page 2

Instructions: Below you will find clues to solve this crossword puzzle. Refer back to the text portion of the lesson for help.



Across

3. subatomic particle analogous to planets in our solar system
6. defined as a change in position or location, a feature of living creatures
10. It is the _______ of electrons which determines reactivity of an element.
11. a feature of living things where more living things just like the parents are created
13. an important element found in living organisms, a component of our air
14. the central part of an atom

Down

1. the type of bond formed when electrons get transferred from one atom to another
2. an important element of living organisms which has the atomic number six
4. tiny bits of matter from which all things are thought to be made
5. the type of bond formed when atoms share electrons between themselves to gain stability
7. an important element of living organisms which has the symbol N
8. an important element in living organisms, also found in water
9. electrons are arranged in ______ around the nucleus of an atom
12. subatomic particles found in the nucleus of atoms

Lesson 1 Lab Activity: In Quest of Carbon: The Marshmallow Inferno!

IMPORTANT: READ ALL OF THESE INSTRUCTIONS FIRST BEFORE BEGINNING!

The purpose of this lab activity is to allow you to isolate a sample of carbon from a marshmallow. Recall that the symbol for carbon is C and the atomic number for carbon is six. To isolate a sample of carbon, you will take a "raw" (uncooked marshmallow) and incinerate it over an open flame. Please read all of the instructions below before beginning this lab activity. To prepare for the marshmallow "roasting," you will need to collect the following supplies:

- an old, metal spoon
- candle in candlestick or holder
- tray or newspaper "placemat" in which to catch spills
- matches
- marshmallows - regular size, at least 4-5 in order to make observations

Safety considerations: If you are conducting this lab in a public facility or have a smoke-detector in your home, check to see if the smoke that you create will set it off or activate a smoke alarm system. If so, you may wish to re-locate to an outdoor table to complete this activity. Just as a precaution, you may want to locate the nearest fire extinguisher. Plan to have a bowl of water nearby should you need to extinguish any accidental fires or cool a burned finger. Note that a metal spoon will conduct heat and you may experience this phenomenon during the heating of the marshmallow. A kitchen mitt or pot holder may be used to protect your hand.

Procedure:

1. Begin the activity by taking out a "raw" marshmallow and make as many observations as you can from it. Don't forget to "dissect" the marshmallow to examine the inner parts of the marshmallow. Include observations made on sight, smell, touch, sound and of course, taste!

Write your observations here:

2. Next, think about from what ingredients are marshmallows made. Write what you think they are made from here and then check the ingredients label on the bag.

3. Continue the activity by placing a "raw" marshmallow on the metal spoon and heating it over the open candle flame. Allow the marshmallow to catch fire and allow it to cook until all that remains is a black, crunchy shell. This may take quite awhile to accomplish. The marshmallow may smoke for a while and then seem to quit and then begin to smoke again later with a different color smoke. Keep cooking until all smoking ceases. Write your observations here:

4. Allow the blackened marshmallow to cool and then make a new set of observations both inside and outside the marshmallow. Again, make observations of color, texture, smell and even taste! Know that the spoon and inside portions of the marshmallow may still be hot. Record these new observations and compare them with the initial set made of the "raw" marshmallows. Get another "raw" marshmallow, if necessary, to allow direct comparisons! Write your new observations here:

5. Finally, think about what remains of the marshmallow. Does it smell like ashes or charcoal? What is left now is a piece of carbon. The sugar, gelatin and starch compounds that make up marshmallows all contain carbon along with water and some other elements. The water that was originally found in these compounds has been cooked away. What is left is the carbon.

As an interesting side note, did you find that the underneath surface of the spoon you used to hold the candle turned black? What do you suppose this is? You may know that soot from a fire can turn things black like in a fireplace or inside a chimney. This soot, again, is another deposit of carbon.

In the case of the wax candle, depending upon which kind of candle you used, it could be made from a petroleum product or if you used a beeswax candle, from the product of bees. In either case, in the process of burning, not all of the wax gets burned and some carbon is actually found in the smoke. This carbon gets deposited on the underneath side of the spoon as soot.

In the next lessons in this course, we will examine in much greater detail how carbon along with water and other elements are vitally important to living creatures. Carbon is an essential ingredient!

To finish your lab, first make sure your candle has been extinguished and allowed to cool before moving to avoid being burned with the melted wax. Your spoon can be cleaned by allowing it to soak in soapy water overnight and then washed the next day. Clean up your work area and then make plans to use your remaining marshmallows for your next dessert or campout.

Finally, in the space below, write some things you learned in this lab.

I learned that...