It's Elementary

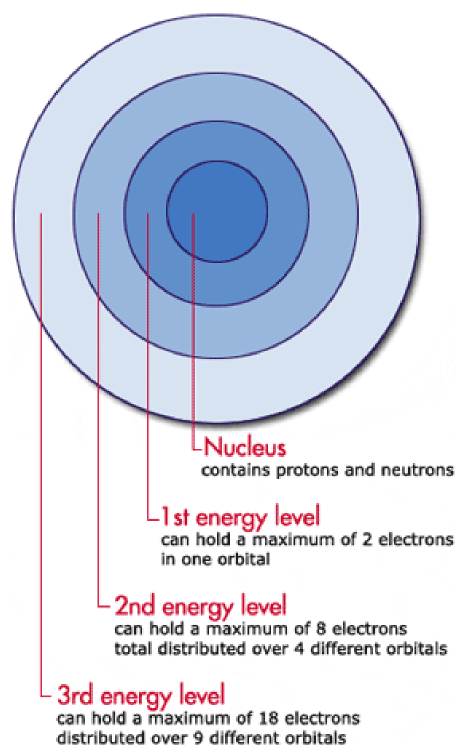
At the end of the last chapter, we discussed what changing the number of protons in an atom does to the element. Surprise, you have a different element altogether! Now we are going to look at changing the number of electrons to match the number of protons in the atom. After all, there has to be the same number of negative charges as positive charges or the atom will not be neutral.

Before we get into electrons, look at your Periodic Table of the Elements.

The table has the elements organized into columns and rows. The seven horizontal rows correspond to the energy levels found outside an atom's nucleus. The row any element is located in tells you what the highest energy level is that will be accepting electrons. For example, calcium, Ca, is located in the fourth row from the top of the table, so the highest energy level that contains electrons in calcium is the fourth energy level.

But how do energy levels relate to the Periodic Table?

When you look at the Periodic Table of the Elements, the energy levels of the atoms correspond to the rows of the table. The two elements in the top row, hydrogen and helium, are filling their first energy level with their final electrons. The eight elements of the second row are filling their second energy level. It is the outermost electrons that determine the chemical properties of the element.



In looking at a diagram of an atom, note that the nucleus is fairly centrally located. The energy levels are built up from the level closest to the nucleus outward. This process of filling in the electrons from the first, lowest energy level to the second, slightly higher energy level to the third, even higher energy level is called filling the electrons in by the **Aufbau Principle**.

The **Aufbau principle**, very simply stated, is: start at the lowest energy level and build up to the higher energy levels only after the lowest are filled.

But what does it mean to "fill an energy level"? It turns out that electrons exist at energy levels in defined areas known as "orbitals."

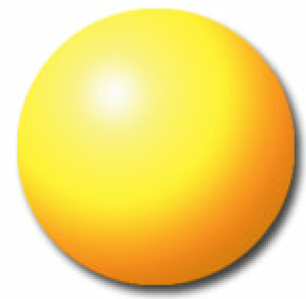
http://www.learner.org/interactives/periodic/elementary.html

Orbitals and Electrons

An orbital is a region of probability in which the electron can be found. These regions have very specific shapes, based on the energy of the electrons that will be occupying them. Try to think of an orbital as a loveseat. An orbital, like a loveseat, can hold up to two occupants, in this case electrons. The loveseats can be different "styles" based on the energy of the electrons that will occupy them and the energy level they are found in. The lowest-energy "style" orbital is the **s orbital**. It is sphere-shaped and is always the first orbital filled in any energy level. The first energy level has only one orbital, so it must be an s orbital. All of the elements in the first two columns on the left side of the Periodic Table are filling the s orbital of their highest energy level with their final (highest energy) electron. This makes the first two columns of the table the s block of elements.

The S Orbital

The sphere shaped s orbital is the first place an electron can be located in any atom. Most of any atom is really empty space! Now let's try filling in the electrons in a couple of atoms. Starting with hydrogen, with one proton it will have one electron. That electron has to go into the first energy level, in the 1s orbital. Helium, with two protons, will have two electrons. These are placed one at a time into the 1s orbital. This makes helium a very contented atom. It has a complete energy level and does not want to gain or lose any electrons. The helium atom is not reactive. In fact, helium is the first of a group of elements often referred to as the inert or **noble gases**.

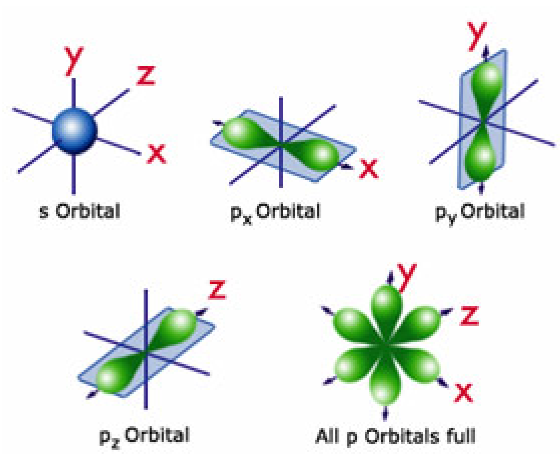


The shape of **s** orbitals is a sphere. Electrons can move anywhere within the sphere.

The P Orbital

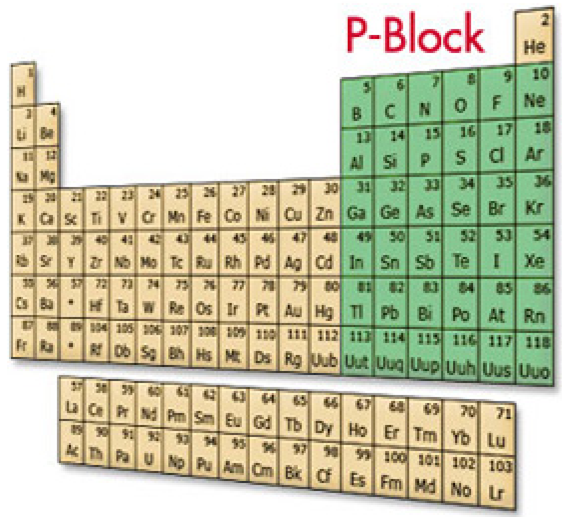
Once the s orbital has been filled for any energy level, electrons start filling in the next higher orbital "style" -- the **p orbital**. The p orbitals are shaped like propeller blades, with one set lined up along the x axis of the atom (horizontally). A second p orbital is lined up along the y axis of the atom (vertically). The third and final p orbital is lined up along the z axis (from front to back through the atom).

This makes a total of three p orbitals to be filled in any given energy level from the second up. Each of these three p orbitals needs to be filled with electrons in the second and higher energy levels. But there is another rule to follow in placing the electrons in the p orbitals. This is **Hund's Rule**.



Hund's rule states that each p orbital must receive one electron before any p orbital can receive a second filling electron. You could think of this as the good mother rule. Everybody gets one before anybody gets seconds.

Filling the Orbitals



Let's try a sample filling of electrons in p orbitals. To do this we will have to go all the way over to element number five, boron. This means there are five protons and five electrons in the atom. Remember, the first orbital of any energy level is an s orbital. This means that the elements lithium and beryllium, while they need to put electrons in the second energy level, must fill their 2s orbital with their highest energy electrons. In boron, the first two electrons are placed into the 1s orbital. The first energy level cannot hold any more electrons, and there are still three to place in the atom. These electrons will have to be placed in the next higher energy level. The first orbital to be filled in the second energy level is the 2s orbital. This still leaves one electron to be placed. The last electron has to go into a p orbital. Boron is the first element of a section of the periodic table that could be called the "p block." It is made up of the elements that are filling p orbitals with their final electrons. In the table, there is a rectangular segment located to the right of the drop-down central portion. There are six columns of elements in this rectangle. These are the elements with filled p orbitals -- the p block. (Helium is an exception, as the first energy level does not have any p orbitals.)

The D Orbital

There are two other "styles" of orbitals that are too complex to go into detail about here. They are the **d orbitals**, of which there are five, and the f orbitals, of which there are seven. The Periodic Table provides a section for each of these groups of orbitals. The 10 electrons of the five d orbitals are filled by the elements found in the dropped central section of the table. This section is referred to as the d block elements, or the transition metals. The two rows found separated at the bottom of the table are the elements of the **f block**. These elements fill the highest energy levels of the f orbitals when they place their last and highest-energy electrons at the ground state.

With so many orbitals, you may be wondering how to write the description of an element with all its orbitals. It's time to talk notation styles.

Style One

Chemists commonly use two systems of notation to show the electron placement in an atom. The electron configuration of boron is

$$\mathbf{1s^2\ 2s^2\ 2p^1}$$

The 1 on the left tells you that the first energy level is being used. The type of orbital in the first energy level is an s orbital. It contains two electrons. The next energy level being filled is the second energy level, shown by the 2 in the notation. The first orbital to receive any electrons in this level is an s orbital. The 2s orbital contains two electrons (its maximum). The last electron to be placed in an atom of boron is also in the second energy level. This electron is placed in the first p orbital. All the elements can have their electron arrangements listed in this way. The total of the superscripts will always be equal to the atomic number of the element when the notation is properly written.

http://www.learner.org/interactives/periodic/elementary.html

Style Two

The second system of notation is called orbital notation. The electrons are drawn in on blanks representing the orbitals. Each electron is represented as either an up-facing arrow or a down-facing arrow. The order of the orbitals being filled can be determined by looking at the orbital chart below. The orbital notation for boron is shown.

Note that the first arrow of each orbital is up-facing. Remember, according to Hund's Rule, each of the 2p orbitals will receive one electron (up-facing arrow) before any will get a second electron (down-facing arrow). The total number of arrows in the notation will equal the atomic number.

Periodic Table of the Elements

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 H																	2 He
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba	*	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra	**	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Uub	113 Uut	114 Uuq	115 Uup	116 Uuh	117 Uus	118 Uuo

*	57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
**	89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

http://www.learner.org/interactives/periodic/elementary.html