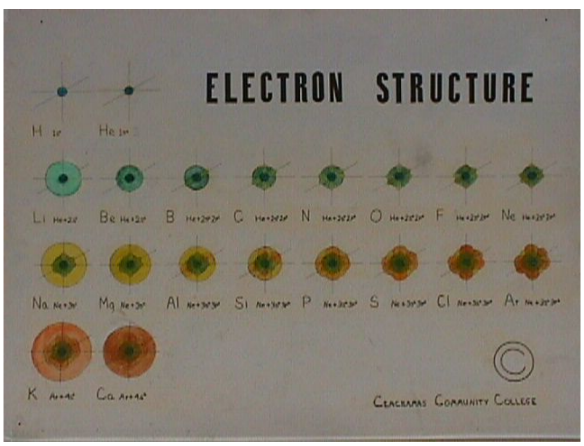
Electron Orbitals & Shells

The number of electrons in a neutral atom is the same as the number of protons. Let's see how those electrons are arranged by imagining the nucleus of a calcium atom (atomic number 20) sitting all by itself with no electrons. Then we'll drop in electrons one by one. They will arrange themselves as they stack up.

The first electron forms itself spherically with the nucleus at its center. The second electron joins it in this region of space, which chemists sometimes refer to as shell number 1.

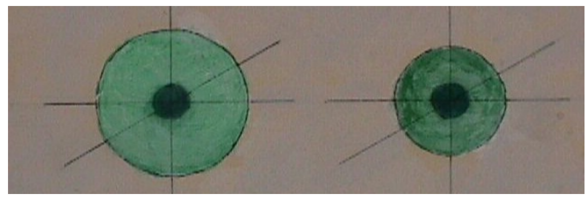
But the third electron that we drop onto our calcium nucleus occupies a larger spherical region that's also centered on the nucleus, a region called shell number 2. The next 7 electrons join the 3rd in this number 2 shell.



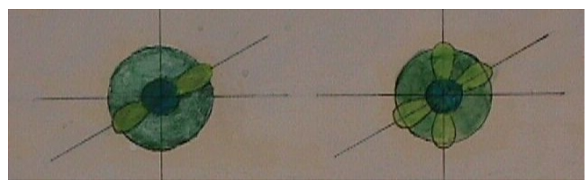
The figure above shows depictions of our atom as the electrons are added, one by one. The second row (blue) shows the atom as the 3rd through the 10th electrons are added on. You can see that shell 2 doesn't really get bigger as additional electrons are added. But the electrons are arranged in different configurations within this region.

The 11th through the 18th electrons occupy shell 3, which is a little bigger in size than shell 2. The final two electrons occupy shell 4.

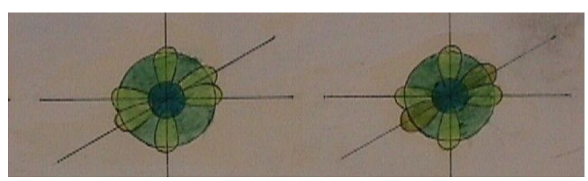
Let's look at the second row in a little more detail. The 3rd and 4th electrons arrange themselves into a spherical shape around the nucleus.



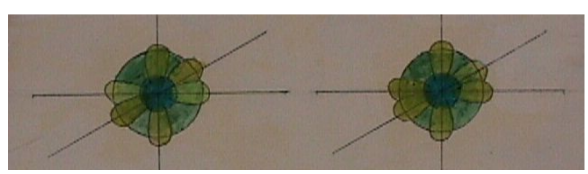
But the 5th and 6th take on hour-glass shapes that are perpendicular to each other.



The 7th electron makes a third hour-glass shape that's perpendicular to the other two. Then the 8th electron joins one of the other hour-glass shaped electrons in its hour-glass shape.



Finally, the 9th and 10th electrons each pair up with the other hour-glass shaped electrons.



As the 11th through 18th electrons join the atom (third row of the diagram), they arrange themselves in a way that is similar to that of the 3rd through 10th electrons, so shell 3 is similar to shell 2. The last two electrons to join the calcium atom occupy the beginnings of shell 4. Electrons occupying shell 4 form a greater variety of shapes than lower shells.

The strange shapes that the electrons take as they join the atom are called orbitals, and two electrons can fit into each of the shapes. The orbital occupied by the 1st and 2nd electrons make up shell one, and the 4 orbitals occupied by the 3rd through 10th electrons make up shell two.

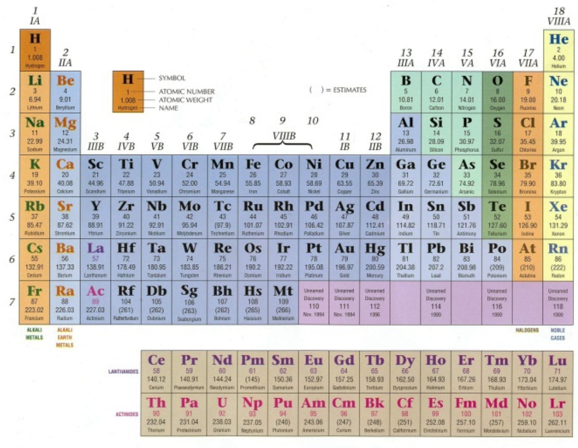
As we'll see, when atoms bond together into molecules, the orbitals change shape and in many cases the orbitals of multiple atoms merge.

Orbitals Are Electrons & Shells Groups of Them

The word shell is a bit misleading since it seems to imply that these are containers that exist prior to electrons being there. But the individual orbitals are themselves the electrons, and shells are simply collections of orbitals that happen to have similar size.

Relating This to the Elements

The arrangement of the periodic table now makes a little more sense. Shell 1 holds two electrons, and so hydrogen and helium occupy the top row because they have only enough electrons to occupy shell 1. Shells 1 and 2 are required for elements 3 through 10, and shell 3 is also necessary for elements 11 through 18. So the outer shell in row 1 elements is shell 1, the outer shell in row2 electrons is row 2, and so on.



An important term is **valence shell**. That's the outer shell of an atom. For H and He, that's shell 1. For Li through Ne, it's shell 2. For Na through Ar, shell 3. Electrons in the valence shell are called **valence electrons**. It's the valence electrons, the outer electrons, that cause an atom to bond to other atoms, and so it's the valence electrons that give an atom its chemical properties. Elements in the same column of the periodic table have the same number of valence electrons, which is why they have similar chemical properties.