

19. Electron Waves: Electron Configuration

In addition to “ n ” and “ l ” that describe the shape and structure of electron waves, there are two additional variables that describe electron wave configurations. The first of these, “ m_l ”, describes the possible number of orientations a given electron cloud can have in three-dimensional space. For example, an “s” orbital, ($l = 0$), can only have one configuration in three dimensions because it is a sphere. Therefore, there is only one value for m_l . For a “p” orbital ($l = 1$), however, there are multiple orientations. Each of these orientations results in a different possible electron cloud.

Go to the following applet: (*you will have to enable java for this applet*)

<http://www.bu.edu/dbin/quantumconcepts/Hybridization/explorers.html>

Select the “**Hydrogen Explorer**”, “**3D**”, “**Density**” and “**View All Orbitals**” radio buttons at the top left of the screen.

1) Using the applet, how many different orientations are there for 2p electron clouds? How are they labeled? What do these subscripts stand for?

You will notice that each of these orientations has is an individual orbital. That is because while they are each at the same energy value, and they have the same n and l values, each one is a separate orbital. The subscripts on each of these show the difference in orientation.

2) Using the applet, how many different orientations are there for 3d electron clouds?

The final quantum number, m_s , is called “spin”. This title can be very confusing, because the electron clouds are not actually spinning. What this term represents is an intrusive magnetic property of electrons. Based on this property, electron clouds can have two different orientations of “spin”: “spin up” and “spin down”. The “spin up” magnetic property has a slightly lower energy than “spin down”. This property results in the following rules of electron configuration in an atom:

- I. The two different spin orientations allow two electron clouds to exist in a single orbital (one “spin up” and one “spin down”) without cancelling each other out.
- II. While electron clouds may repel each other through the electromagnetic force, it is more energetically favorable for two electrons to occupy a single shell (n) before creating a new shell (because a higher n is a higher energy).
- III. Within a single energy level (same value of n or l , but different value of m_l), electrons will spread out within the orbitals before pairing up due to their repulsion.

Together, these form the “Aufbau Principle” for electron configuration. Answer the following questions based on these three rules.

3) How many total electrons can there be in the 1s orbital? 2p orbitals? 3d orbitals?

The boxes in the images below represent orbitals. The single boxes represent s orbitals (1s or 2s), while the p subshells have three boxes for the three p orbitals ($2p_x$, $2p_y$, $2p_z$). For the following questions, only one configuration can be correct. For the other configurations, explain the *different* reasons for why they are incorrect. The electrons are drawn as arrows to represent either “spin up” or “spin down”.

5)



6)

