

Lesson 8: Quantum Mechanical Model of the Atom

Orally: *In the Bohr model, electrons are said to orbit around the nucleus. Unfortunately the Bohr model is not sophisticated enough to describe what appears to actually be happening. The quantum model expresses electron movement around the nucleus as orbitals, or regions of space where one is very likely to find an electron. Let's compare the Bohr model to the quantum model.*

Similarities between Bohr and the Quantum model:

1. An energy shell that shows the basic energy level of the electron is used.
2. Electrons fill from the lowest to highest energy state (i.e., **Aufbau Principle**).
3. The higher the energy level, the further the electron may be from the nucleus.

Difference:

1. Bohr model uses orbits while quantum model uses orbitals. (i.e., electrons in orbitals occupy volumetric regions in space often referred to as an electron cloud).
2. Bohr model uses rings and dots to show the electronic configuration (i.e., the energy and location of all the electrons in the atom), while the quantum model uses a form of exponential notation.

Q: What do orbitals look like?

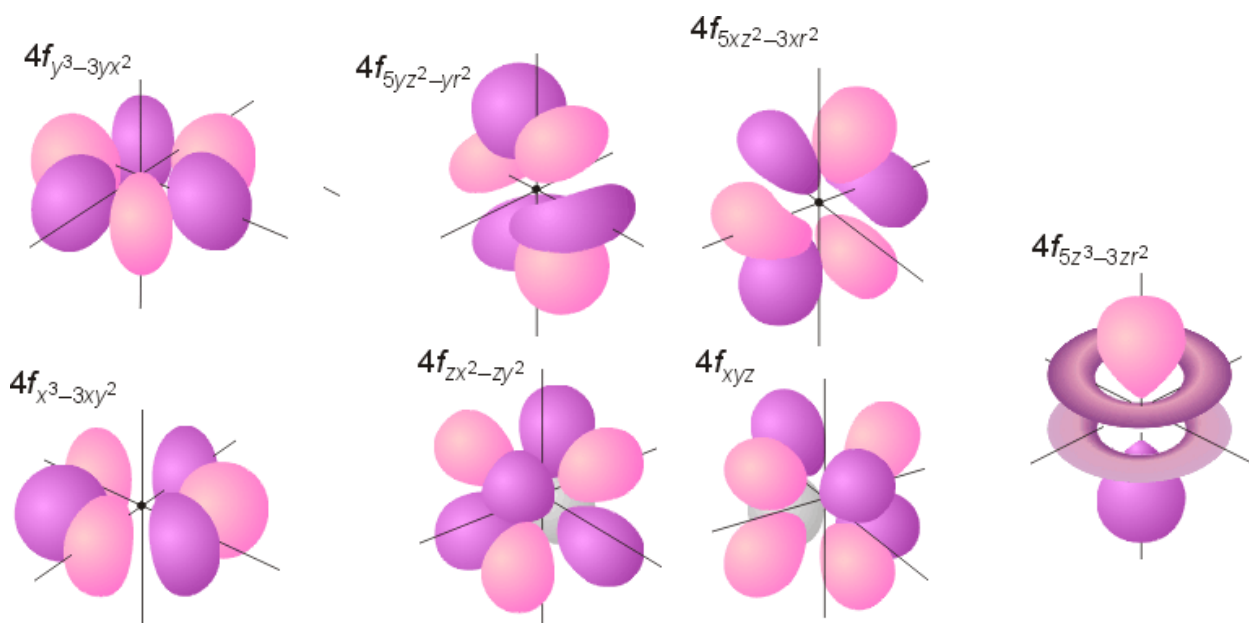
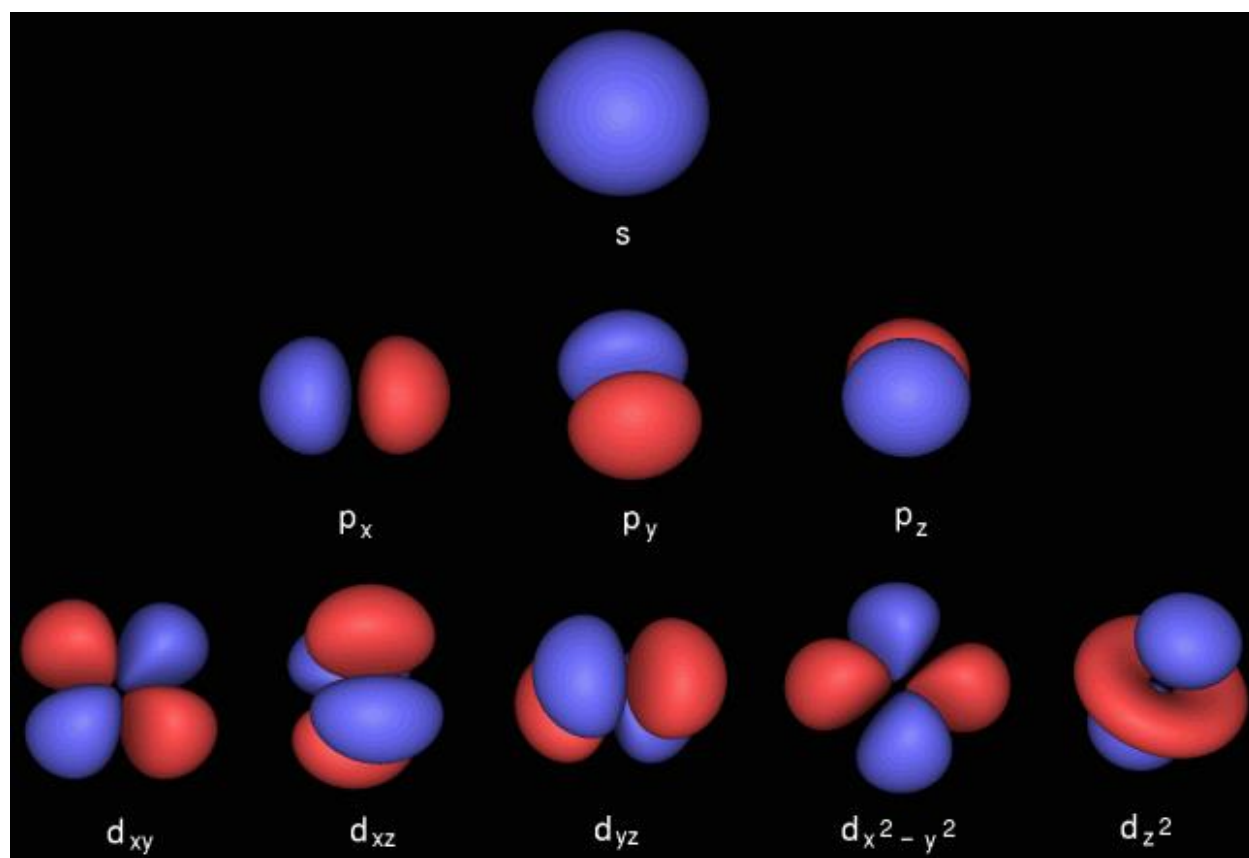
A: You will be responsible for the first two types of orbitals.

(Have students draw the s and p orbitals. Diagram on the next page.)

1. s orbital: Spherical in shape.
2. p orbital: Hour-glass shape. The p_x , p_y , and p_z each hold $2e^-$ for a total of $6e^-$

Orally: *The letters that represent the orbitals are derived from line spectra resulting from electron excitation. The line groups were called sharp (s), principal (p), diffuse (d), and fundamental (f). There are even higher energy orbitals that will not be discussed here.*

Don't make the mistake of thinking that the electrons are trapped in a sphere, rather the electron movement defines the volume(s) that we "see".



<http://www.falstad.com/qmatom/>

(Atom viewer shows the different types of orbitals)

Energy shell represented by the principal quantum number (n)	Orbital or Subshell represented by the angular momentum quantum number (l)	Max. number of electrons
1	1s $l=0$	2
2	2s and 2p $l=1$	2 and 6 for a total of 8
3	3s, 3p and 3d $l=2$	2, 6 and 10 for total = 18
4	4s, 4p, 4d, and 4f $l=3$	2, 6, 10 and 14 for total = 32

Orally: In the chart above, notice that the energy level and the total number of electrons is consistent with what we know about the Bohr model.

The angular momentum (i.e., Azimuthal) quantum number represents the number of nodes that one would expect to find with the associated orbital. For example, an s orbital has no nodal plane while each p orbital has 1 and so on.

Orally: Question: Where are the orbitals relative to each other?

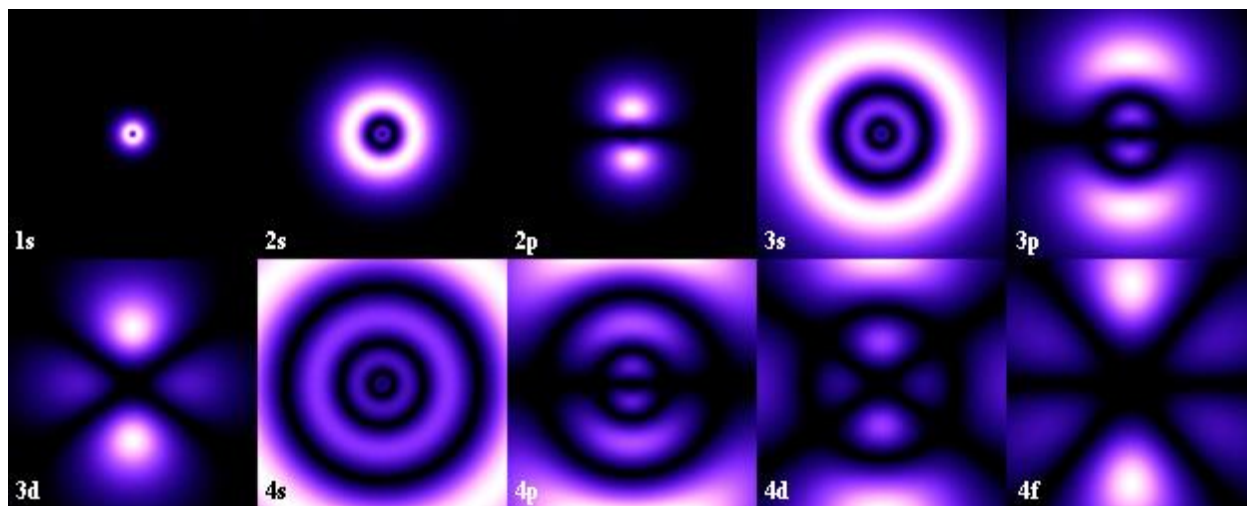
Answer: The interactions of the orbitals are more complicated than we will deal with in this course, but you can think of them as being nested. The smallest orbitals are on the inside and the larger ones “swallow” the smaller ones. For example have you ever seen Russian nesting dolls? (see diagram below)



The smallest doll can be thought of as the 1s orbital which is placed inside the next doll which would be the 2s and so on.

Let's have a look at how the orbitals nest.

http://www.uwosh.edu/faculty_staff/gutow/Orbitals/Cl/Cl_AOs.shtml



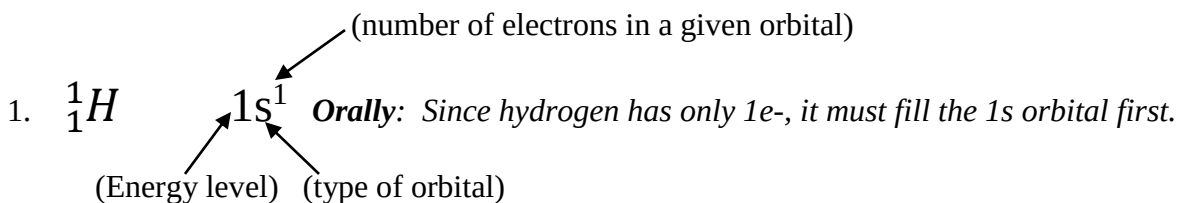
Question: How do I write the electronic configuration of an atom using the quantum model?

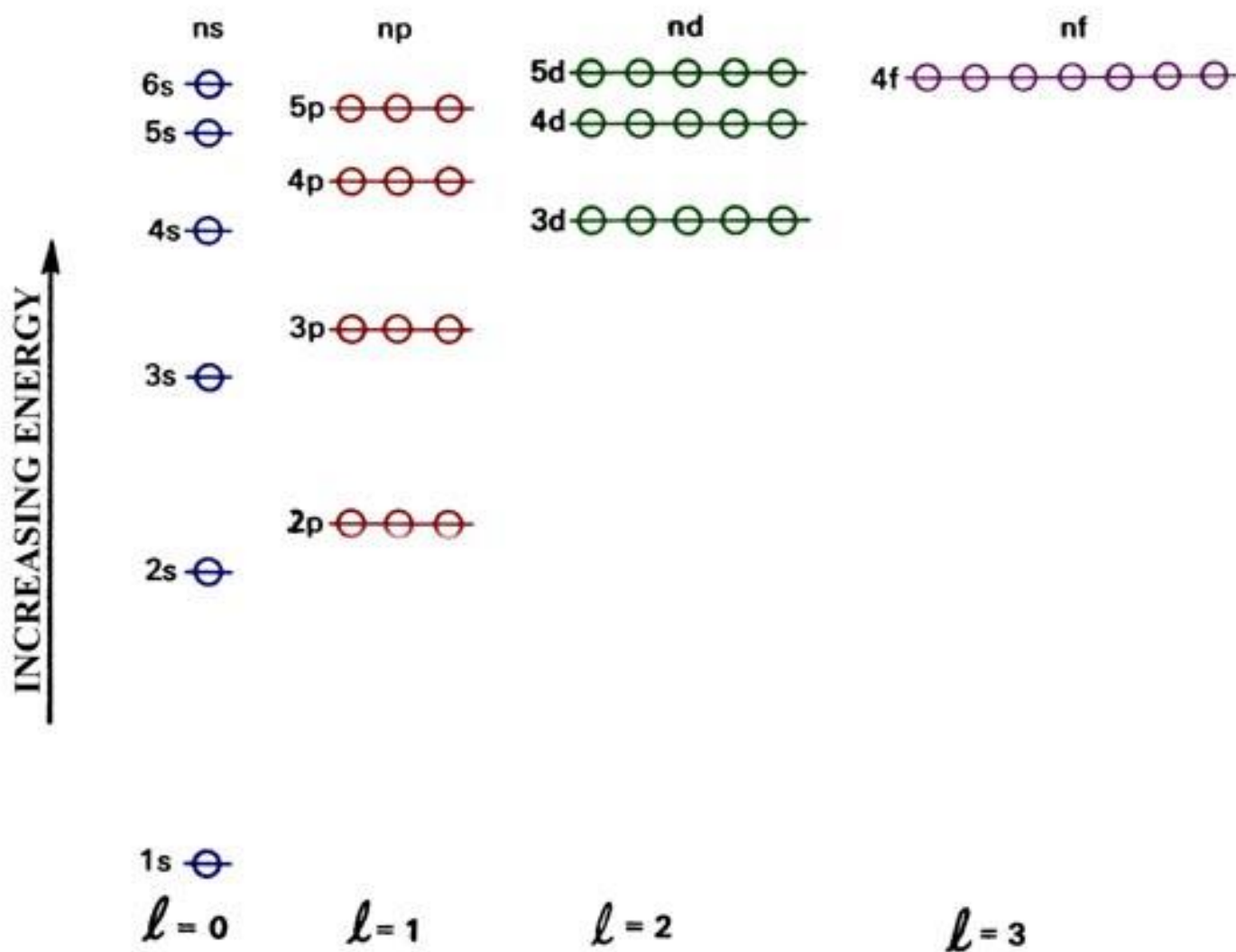
Orally: The order that electrons fill is given by the following chart. (Also refer students to the orbital filling chart in their periodic table booklets and the chart on the wall) The circles in the chart represent the same thing as the dashes you have on your chart; they simply represent the number of each kind of orbital that you have at each energy level.

Answer:

1. Write the energy level followed by the orbital letter.
2. The number of electrons is expressed as an exponent above the orbital letter.
3. Fill the lowest energy level with electrons first. Surplus electrons spill over into the next lowest energy level.

Exercises: Write the electronic configuration for the following atoms using the quantum model.





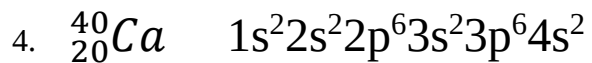
2. ${}^7_3\text{Li}$ $1s^2 2s^1$ we read this as, "1s two, 2s one."

Orally: Since the 1s orbital cannot hold 3 electrons, the surplus electrons spill over to the 2s orbital.

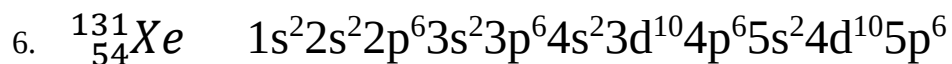
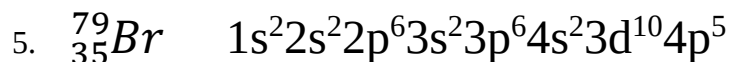
3. ${}^{14}_7\text{N}$ $1s^2 2s^2 2p^3$

The specific orientation of the p orbitals is not necessary here.

Have students try the following electronic configurations on their own.



Orally: Did it seem odd to you that the 4s fills before the 3d? This is not a mistake; we will discuss this in more detail next day.



Assignment: Hebden pg. 155 #26