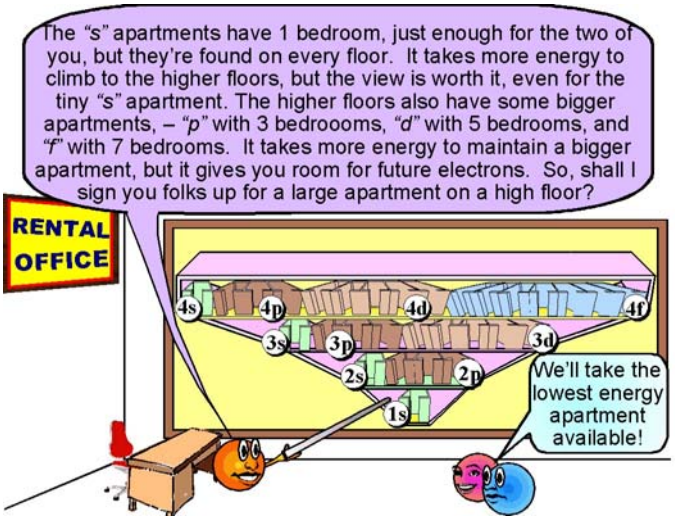
Location of Electrons

Electrons are in regions of the atom known as orbitals. Roughly speaking, they are located in principal energy levels similar to the shells or energy levels of the Bohr model. Each of the energy levels is designated by a quantum number, *n*, from 1 to 7. None of the known elements has atoms with more than 7 principal energy levels. The principal energy level with the lowest energy is 1. The highest is 7. Principal energy levels can be thought of as being subdivided into energy sublevels. The maximum number of sublevels in a principal energy level is *n*, but none of the existing elements use more than 4 sublevels even in principal energy levels 5–7. Sublevels are designated by the letters s, p, d, and f, in increasing order of energy The orbitals are regions within a sublevel where electrons of a given energy are likely to be found. There are a maximum of 2 electrons in an orbital. A useful analogy to help you visualize this is an apartment building. Each floor represents a different principal energy level. Each apartment represents a sublevel. Each bedroom represents an orbital. The electrons are the tenants in the bedrooms. Electrons are most likely to be found in the lowest energy locations available. Knowing this, it is possible to figure out how the electrons are arranged in an atom.



The most common difficulty renting to electrons

The number of orbitals within a sublevel varies in a predictable pattern. The number of orbitals within a sublevel and the maximum number of electrons is as follows:

Sublevel	s	p	d	f
Number of orbitals	1	3	5	7
Maximum Number of Electrons	2	6	10	14

The first energy level has only one sublevel, s; the second energy level has two sublevels, s and p; the third energy level has three sublevels, s, p, and, d; and so on. This results in the pattern shown below.

Summary

Principal Quantum Number (n)	Number of Orbitals (n^2)	Orbitals per Sublevel				Maximum Number of Electrons ($2n^2$)
		s	p	d	f	
1	1	1	-	-	-	2
2	4	1	3	-	-	8
3	9	1	3	5	-	18
4	16	1	3	5	7	32

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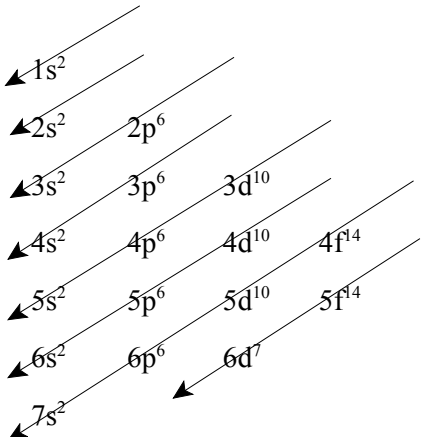
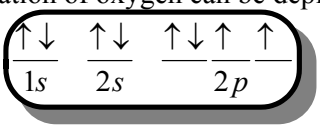
The electrons are arranged according to the following rules:

1. the number of electrons equals the number of protons (atomic number)
2. electrons occupy orbitals in sequence beginning with those of the lowest energy (see diagram to the right)
3. in a given sublevel, a second electron is not added to an orbital until each orbital in the sublevel contains one electron



This results in the order of filling for elements 1 to 109 pictured to the right. Follow each arrow from beginning to end. Then go to the beginning of the next arrow down. When you follow this pattern, you will note that no more than four orbitals are occupied in the outermost principal energy level. This is because, once the p sublevel is filled, the next energy sublevel is always the s in the next principal energy level. Oxygen has 8 protons and 8 electrons. Its electron configuration in sublevel notation is as follows: $1s^2 2s^2 2p^4$. This means there are 2 electrons in the first level and 6 in the second (add the superscripts). As a result the electron arrangement can also be written as follows: 2–6. This is known as Bohr notation.

Remember, electrons never pair in an orbital until every orbital in a sublevel has an electron. When they do pair, they spin in opposite directions. This reduces the repulsion between them. The opposite spins of the electrons are represented by up arrows and down arrows. The electron configuration of oxygen can be depicted as follows:



Each horizontal line represents an orbital in a sublevel. Each arrow represents an electron in an orbital. This is called orbital notation.

For each of the elements below, write the sublevel notation, the Bohr notation, and the orbital notation.

Element	Atomic Number	Electron Configuration		
		Sublevel Notation	Bohr Notation	Orbital Notation
H	1			
N	7			
Ca	20			
Al	13			
Cu	29			
C	6			
Ar	18			
Na	11			
S	16			
Ne	10			
P	15			