Introduction

Chemistry is a subject about matter, its properties, and how it is transformed during a chemical change (such as when eggs, flour, oil and salt are mixed together and cooked to form a pancake or when an iron nail rusts). When a chemical change occurs, the atoms of one or more substances are rearranged to form new substances (pancakes are no longer eggs). The transformation occurs when the bonds that hold the atoms together in the substances break. Then what happens is new bonds are formed as the new substance or *product* is created. The **bonds**, which are the forces that are holding a substance together, are made by negatively charged electrons that are attracted to positively charged protons in the nuclei of atoms. When one bond is broken and a new bond is formed, the electrons which exist in one kind of **orbital** (a particular location in an atom) is moved to a different orbital, or a new location, perhaps in a different atom.

We are studying **atomic orbitals** and **electron configurations** because both of these topics describe the locations of electrons in atoms. If we understand the basic structure of where electrons are in atoms, we can better understand what happens when a chemical transformation occurs.

Orbitals are volumes of space in which an electron is most likely to be found. We say "most likely" because it is not currently possible to tell *exactly* where an electron is, and so we talk instead about the *probability* of where an electron is in an atom. This is similar to not being able to say *exactly* where a wave is at the beach. It is kind of spread out all along the coast so you cannot point to just one spot and say that all of the wave is there. We don't have to worry about this probability; the main thing is that when we discuss orbitals, they are similar to the coastline area, the wave is there, but it keeps moving and it occupies lots of locations at once so we cannot say exactly where the wave is. Similarly, because electrons are extremely small and move extremely fast, it is not possible to say *exactly* where the electron is.

Subshells are a way of grouping similar orbitals. **Subshells** are a group of orbitals that have similar shapes. All orbitals in a subshell have similar *features* in their shapes, even if the shapes themselves are not identical. There are four types of subshells and they are labeled s, p, d and f. The "s" type of orbital is spherical in shape. The "p" type of orbital looks like an 8. You should remember these two shapes. The d and f orbitals have more complex shapes and you do not have to remember what they are.

There is only one orbital in the s subshell.
There are three orbitals in the p subshell.
There are five orbitals in the d subshell, and
There are seven orbitals in the f subshell.

Shells are another way of grouping orbitals. This is a broader category than subshells so shells contain one or more subshells. These groups of orbitals have similar energy. The shells are labeled 1, 2, 3, 4, 5, etc... The lowest energy orbital is in Shell 1. The orbitals in shell 2 are higher in energy than those in shell 1, but lower in energy than those in shell 3. So as the shell number gets higher, the electrons in the orbitals, have more energy.

All atoms have electrons. An atom of hydrogen has only one electron, whereas an atom of calcium has 20 electrons. No matter what the atom is, the orbital structure is the same. In class we will learn how to use the periodic table to remember the orbital structure, and then write it using the shorthand notation of electron configurations.

Some things to remember:
- Each orbital can contain 0, 1, or 2 electrons (and no more!).
- Electrons always fill up the lowest energy orbital first. The lowest energy orbital is in shell 1 and subshell s. The subshells contained within a shell are ordered in this way:
- Lowest energy $s < p < d < f$ highest energy

An **Electron Configuration** is a shorthand notation that is used to describe the locations of all of the electrons in an atom. The electron configuration for a helium atom is:
He **$1s^2$**
- This means that there are 2 electrons in an s orbital. The s orbital is located in the first energy shell (energy shell **1**).

The electron configuration for a fluorine atom is: F $1s^2\ 2s^2\ 2p^5$
- An atom of fluorine has a total of 9 electrons, and so all of the superscripts in an electron configuration should add up to 9 (2+2+5 = 9).
- The $1s^2$ again means that the first 2 electrons in a fluorine atom go into the lowest energy shell (1) and into the s subshell, which contains the lowest energy orbital.
- The $2s^2$ means that the next 2 electrons go into the s orbital in the second energy level.
- The $2p^5$ means that the next 5 electrons go into the p orbitals in the second energy level or second shell. Remember that 5 electrons cannot fit into one orbital. The p subshell actually contains 3 orbitals, which all together, could hold up to 6 electrons.

You can use this sheet to write in our in-class work on these topics.
You will need to learn the electron configurations for all of the elements up through barium (Ba).

Element	Electron Configuration
H	
He	
Li	
Be	
B	

Chemistry 2A

Atomic Orbitals and Electron Configurations

Element	Electron Configuration	Noble gas Abbreviation
C		
N		
O		
F		
Ne		
Na		
Mg		
Al		
S		
Ar		
K		
Ca		
Mn		
Ni		
Zn		
As		
Br		
Sr		
Rh		
In		
Xe		
Ba		

Electron Configurations homework.

1. Write the full electron configuration for the elements C, Mo, and Sb.
2. Write the abbreviated electron configuration for C, Mo, and Sb.
3. How many valence electrons are there for C and Sb? (Omit transition metals for this type of question.)
4. What is the highest energy shell that electrons of antimony (Sb) occupy?
5. What are the lowest energy shell and subshell that electrons occupy?
6. Valence electrons are the outermost electrons, the electrons responsible for chemical reactivity. All of the other electrons are called core electrons. How many core electrons does an atom of carbon have?
7. What ion would the following atoms make if they became part of an ionic compound: Mg, K, P, S, I.
8. Write the electron configuration of the IONS in the question above.
9. How many orbitals are in the d subshell? How many electrons can the d subshell hold?
10. What does the "shell" number mean physically? What is the difference between orbitals in the second shell and orbitals in the third shell?
11. What does the subshell letter represent, physically?
12. How many valence electrons does an atom of argon have?

Answers:

1. C: $1s^2\ 2s^2\ 2p^2$; Mo: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ 5s^2\ 4d^4$
   Sb: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ 5s^2\ 4d^{10}\ 5p^3$
2. C: [He] $2s^2\ 2p^2$; Mo: [Kr] $5s^2\ 4d^4$; Sb: [Kr] $5s^2\ 4d^{10}\ 5p^3$
3. The valence electrons C: 4, Sb: 5
4. The highest shell is 5.
5. The lowest energy shell and subshell are 1 and s.
6. Carbon has 2 core electrons.
7. Mg^{2+} K^+ (the "one" is understood), P^{3-}, S^{2-} I^-(the "one" is understood).
8. Mg^{2+}: $1s^2\ 2s^2\ 2p^6$; K^+ $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$; P^{3-} $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$;
   S^{2-} $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$; I^- $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ 5s^2\ 4d^{10}\ 5p^6$
9. 5 orbitals in the d subshell; up to 10 electrons.
10. The shell represents energy. Orbitals in a shell have similar energies. Orbitals in the second shell have lower energy than orbitals in the third shell.
11. The subshell is a set of orbitals grouped by similarities in the shapes of the orbitals.
12. Argon is a noble gas. It has 8 valence electrons.