CHEMISTRY **ELECTRON CONFIGURATIONS**

Electron Energy Levels and Notations

PRINCIPAL ENERGY LEVELS

The electrons in an atom are located at specified distances from the nucleus and are found to have different amounts of energy. Only seven (7) main --principal energy levels, or electron shells are necessary to account for the electrons of the known elements. The main or principal energy levels (n) are numbered, starting with n = 1 as the energy level nearest to the nucleus and going to n = 7 . The energy levels are also identified by the letters K, L, M, N, O, P, and Q, with K equivalent to the first energy level, L equal to the second level etc.

Energy Level	n	Letter
First	1	K
Second	2	L
Third	3	M
Fourth	4	N
Fifth	5	O
Sixth	6	P
Seventh	7	Q

The maximum number of electrons that can occupy a specific energy level can be calculated by using the formula $\mathbf{2n^2}$, where **n** is the number of the principal energy level. Thus, the third energy level (3) can hold 18 electrons. [$2(3)^2 = 18$]

ENERGY SUBLEVELS

In each principal energy level the electrons are seen to differ in how they carve out space around the nucleus. The four different patterns are called sublevels. These sublevels contain the orbitals in which the electrons are located. These four sublevels are identified by the letters *s, p, d, and f*. Thus there are *s* orbitals, *p* orbitals, *d* orbitals, and *f* orbitals. Each orbital type has a particular spatial arrangement or shape. An electron spins on its own axis in one of only two directions---clockwise or counterclockwise. As a result, only two electrons can occupy the same orbital, one spinning clockwise and the other spinning counterclockwise. When an orbital contains a pair of electrons, the electrons are said to be paired.

Sublevel Chart

Sublevel	Electrons Possible	Orbitals Possible
s	2	1
p	6	3
d	10	5
f	14	7

Not all principal energy levels contain each and every type of sublevel. To determine what type of sublevels occur in an energy level, we need to know the maximum number of electrons possible in that principal energy level, and we need to use two rules:

1. No more than two electrons can occupy one orbital.
2. An electron will occupy the lowest sublevel possible.

ELECTRON CONFIGURATION NOTATION (ECN)

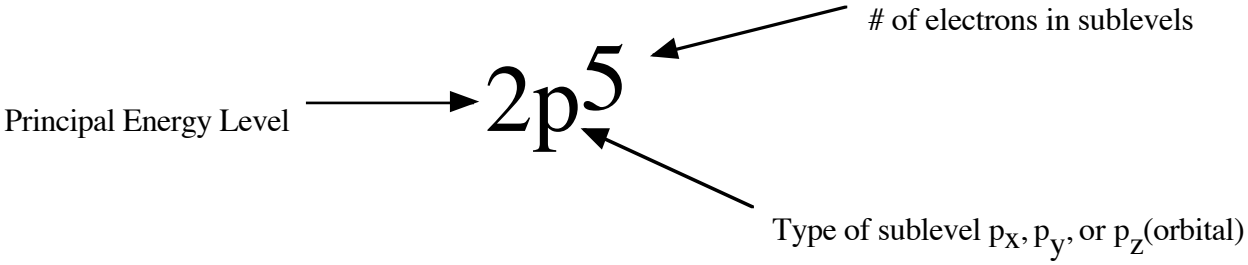
In order to understand the chemical properties of an element, you must be able to place its electrons in the proper principal energy levels and sublevels. Our next task is to determine the order in which electrons occupy the various principal energy levels and sublevels. This arrangement of electrons in the principal energy levels and sublevels is called "electron configuration notation" **ECN**. The chart below will help us to determine the proper order for filling.

1s			
2s	**2p**		
3s	**3p**	**3d**	
4s	**4p**	**4d**	**4f**
5s	**5p**	**5d**	**5f**
6s	**6p**	**6d**	**6f**
7s	**7p**	**7d**	**7f**

This chart will guide you through the correct filling order of electrons in writing the electron configuration notation for any atom on the periodic table.

Diagonal Rule / Aufbau Principle

The following notation illustrates how to read ECN:



Write the ECN for Oxygen, Z = 8

$1s^2 2s^2 2p^4$

Notice the sum of the superscripts totals (8) and is equal to the atomic number of the atom. You must have as many electrons as protons.

Write the ECN for Chlorine, Z = 17

$1s^2 2s^2 2p^6 3s^2 3p^5$

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Orbital Notation (ON)

Orbital filling diagrams called orbital notation (ON) illustrate the distribution of electrons. Only those electrons in the outermost principal energy level need to be shown unless a "d" or "f" sublevel is partially filled, then that sublevel must be shown. All orbital diagrams are shown for the elements "ground state", the lowest energy possible. The symbol  represents an orbital containing a pair of electrons spinning in opposite directions--one clockwise and one counterclockwise. In order to write correct orbital notation you must use the elements electron configuration notation (ECN). Listed below are the electron configuration notations **ECN** and orbital notations **ON** for the first seven elements:

ECN: $_1H$ $1s^1$

ON: 

ECN: $_2He$ $1s^2$

ON: 

ECN: $_3Li$ $1s^2$ $2s^1$

ON: 

notice that only those electrons in the outermost principal energy level are shown in the orbital notation the 1s orbital electrons are not shown

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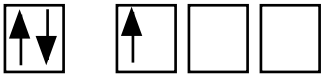
ECN: $_4Be$ $1s^2$ $2s^2$

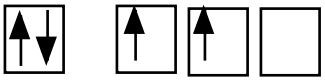
ON: 

ECN: $_5B$ $1s^2$ $2s^2$ $2p^1$

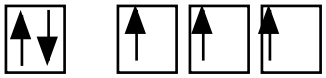
ON: 

ECN: $_6C$ $1s^2$ $2s^2$ $2p^2$

notice the second 2p electron enters the next empty 2p orbital--it does not pair with the first 2p electron

ON: 

ECN: $_7N$ $1s^2$ $2s^2$ $2p^3$

ON: 

CHEMISTRY **ELECTRON CONFIGURATIONS**

Hund's Rule: states that when electrons fill orbitals within a sublevel, each orbital is occupied by a single electron before any orbital has two electrons, and all electrons in singly occupied orbitals have the same direction of spin.

Electron Dot Notation or Electron Dot Symbol (EDN)

A third method used to show electron arrangement is the electron dot notation. This notation uses only those electrons in the outermost principle energy level. The "s" and "p" orbitals are arranged around the symbol for the element. To write the correct electron dot notation (symbol) for an element you can use the orbital notation to determine how many paired and unpaired electrons exist in the outermost level.
Examples:

ECN: **$_{1}$H** $1s^1$

ON: 

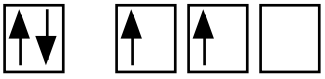
EDN: **H•** (one unpaired electron)

ECN: **$_{2}$He** $1s^2$

ON: 

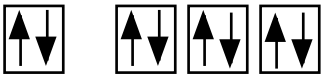
EDN: **He:** (one pair of electrons)

ECN: **$_{6}$C** $1s^2$ $2s^2$ $2p^2$

ON: 

EDN: **·C:** (one pair and two unpaired electrons)

ECN: **$_{10}$Ne** $1s^2$ $2s^2$ $2p^6$

ON: 

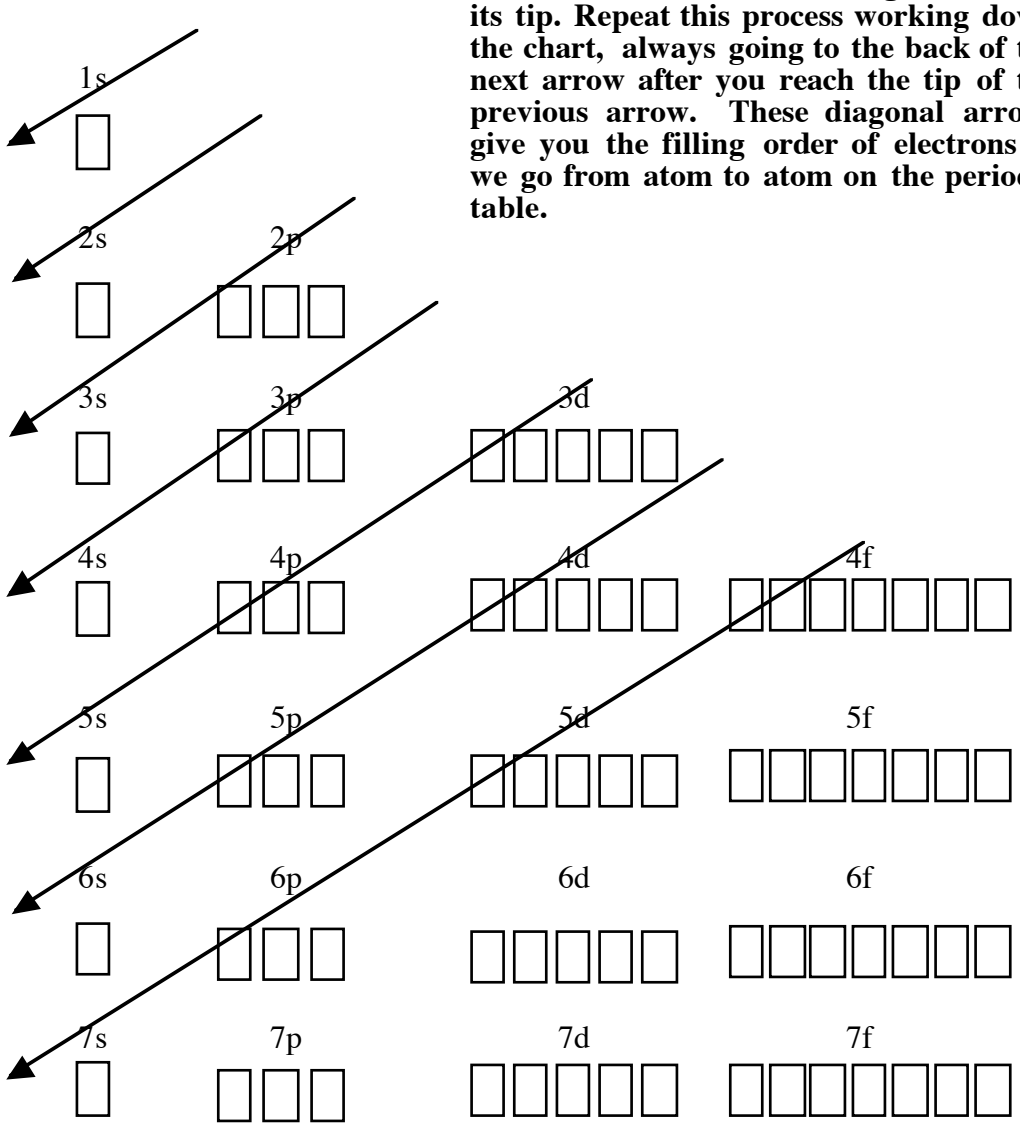
EDN: **:Ne:** (four pairs of electrons)

There will never be any more than eight electrons (4 pairs) in the electron dot symbol

CHEMISTRY **ELECTRON CONFIGURATIONS**

ORBITAL FILLING CHART

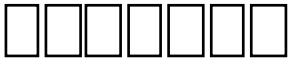
Start at the back of the top arrow and follow the diagonal line. When you get to the tip of the arrow go to the back of the next arrow and follow the diagonal line to its tip. Repeat this process working down the chart, always going to the back of the next arrow after you reach the tip of the previous arrow. These diagonal arrows give you the filling order of electrons as we go from atom to atom on the periodic table.



CHEMISTRY **ELECTRON CONFIGURATIONS**

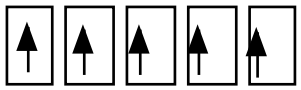
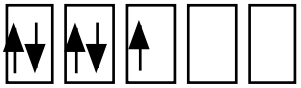
Summary:

PRINCIPAL LEVELS: The 1st principal energy level, or K shell, is the level closest to the nucleus of the atom. As you move out from the nucleus the levels get larger numbers 2, 3, 4, etc.

ORBITALS:  An orbital is a region in space where there is a high probability of finding an electron. We have represented an orbital with a block. Each block represents a single orbital. A single orbital can hold 0, 1, or 2 electrons. Each principal level has one single "s" type orbital. Each principal level except the 1st has three "p" type orbitals.  Each principal level except the first two have a set of five "d" type orbitals.  After the third principal level, each principal level has a set of seven "f" type orbitals. 

ORDER OF FILLING: Under normal conditions the "1s" orbital is filled first. After it becomes full (with 2 electrons) you follow the second diagonal line down and see that the "2s" orbital is filled next, followed by the "3s" orbital. You will then go to the next diagonal line and see that next the "3p" orbitals are filled, followed by the "4s" orbital. You then follow the next diagonal line to see that the "3d" orbitals are filled followed by "4p", followed by the "5s" orbital. Continue this following of the diagonal lines as far as you need. It is important to see that as atoms add more and more electrons, they don't fill them level by level-----the filling pattern is staggered as shown by the orbital filling diagram. This staggered process is called the Aufbau Process.

FILLING ORBITALS WITHIN A SET: Within a set of orbitals, such as within the "3d" set, the first electron can go in any orbital. The next electron should go into a vacant orbital within the set rather than into an orbital that already has an electron, and so on. Once all of the orbitals within a set are filled with one electron then you can go back and begin to double up electrons in the orbitals.

This  not this  if you were adding 5 electrons to "d" orbitals.

Two electrons within the same orbital are said to have opposite spins. We represent this by showing one upward pointing arrow and one downward pointing arrow. 

EXAMPLE:

Using the Orbital Filling Diagram write the Electron Configuration Notation (ECN), The Orbital Notation (ON), and the Electron Dot Notation(EDN) for an atom of Bromine.

SOLUTION:

Bromine, from the Periodic Table, is Atomic Number 35, meaning it has 35 protons in its nucleus. Therefore we must have a total of 35 electrons located outside the nucleus for the atom to be electrically neutral.

ECN: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^5$ *sum of superscripts = 35*

The highest occupied principal energy level is level 4. Therefore we must base our Orbital Notation on the electrons and how they are arranged in the orbitals "4s" and "4p"orbitals from our ECN.

ON:

The orbital notation tells us that we have three pairs of electrons and one unpaired electron. In other words three pair of dots and one unpaired dot surrounding the symbol for chlorine will be our electron dot notation.

EDN:

Student Practice

On a separate piece of paper, write all three notations for the first 36 elements on the Periodic Table.