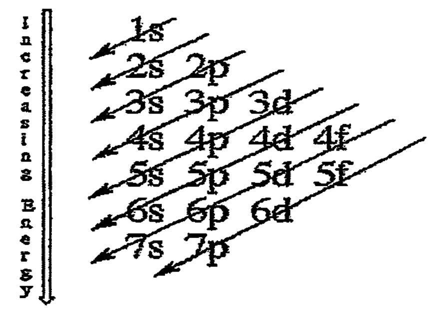
JHS Regents Chemistry Laboratory
ELECTRON ARRANGEMENTS

Introduction:

In 1911, Rutherford proposed our view of the nuclear atom. His model described the atom as having a very small nucleus containing most of the mass and all of the atom's positive charge. Bohr continued the research of the atom and proposed that the negatively charged electrons were distributed around the nucleus at great distances giving the atom a volume which was considered mostly empty space. A few years later, Schrodinger developed a theory describing the most likely location of electrons around the atom.

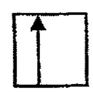
The electron configuration in the reference table denotes the placement of electrons in each energy level. For example, magnesium's (Mg) electron configuration is 2-8-2. In other words, in the first energy level (n=1) there are 2 electrons. When n=2, there are 8 electrons. Finally, in the outermost energy level also known as the **valence shell** there are 2 electrons.

A second method for illustrating the distribution of electrons is including the types of sublevels within each energy level. Whole numbers, 1, 2, 3, and so on are used to denote the main energy levels and s, p, d, and f denotes the energy sublevels. The sublevel describes the area and shape of the electron cloud. The subscripts above the sublevel letter indicate the number of electrons in that sublevel. For example, $2p^4$ indicates 4 electrons in the p sublevel of the second principle energy level. This electron configuration method follows the **Aufbau Principle** in which electrons enter orbitals of lowest energy first. See illustration at right

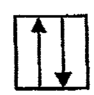


The third method for illustrating the distribution of electrons is the orbital filling diagram. According to the **Pauli Exclusion Principle**, an atomic orbital can describe at most two electrons. Atomic orbitals are represented using a box, circle or line

If an  orbital contains only one electron, it would be written like this:



In order for two electrons to fill the same orbital, they must have opposite spins. One electron spins clockwise and the other electron spins counter clockwise. An orbital with two electrons would look like this:

Hund's Rule: When electrons occupy orbitals of the same energy, electrons will enter empty  orbitals first.

The last method used to show electron arrangement is the electron dot diagram. This notation uses only those "s" and "p" electrons in the highest principle energy level. The s and p electrons are arranged around the symbol for the element.

The following represents all four methods of arrangement for the element oxygen

Element	Electron Configuration	Representative Electron Configuration	Orbital Diagram	Dot Diagram
Oxygen	2-8	$1s^22s^22p^4$	↑↓ ↑↓ ↑↓ ↑ ↑	

Objective: To practice each method of electron distribution of an atom.

Element	**Atomic Number**	**Symbol**	**Electron Configuration**	**Representative Electron Configuration**	**Orbital Diagram show only the outer energy level of the atom**	**Dot Diagram**
Nitrogen	7	N	2-5	$1s^2(2s^2 2p^3)$	$\underline{\uparrow\downarrow}_{2s^2}$ $\underline{\uparrow}\ \underline{\uparrow}\ \underline{\uparrow}_{2p^3}$	N
Fluorine	9	F	2-7	$1s^2(2s^2 2p^5)$	$\underline{\uparrow\downarrow}_{2s^2}$ $\underline{\uparrow\downarrow}\ \underline{\uparrow\downarrow}\ \underline{\uparrow}_{2p^5}$	F
Potassium	19	K	2-8-8-1	$1s^2 2s^2 2p^6 3s^2 3p^6 (4s^1)$	$\underline{\uparrow}_{4s^1}$	K
Calcium	20	Ca	2-8-8-2	$1s^2 2s^2 2p^6 3s^2 3p^6 (4s^2)$	$\underline{\uparrow\downarrow}_{4s^2}$	Ca
Argon	18	Ar	2-8-8	$1s^2 2s^2 2p^6 (3s^2 3p^6)$	$\underline{\uparrow\downarrow}_{3s^2}$ $\underline{\uparrow\downarrow}\ \underline{\uparrow\downarrow}\ \underline{\uparrow\downarrow}_{3p^6}$	Ar
Iron	26	Fe	2-8-14-2	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^6$	$\underline{\uparrow\downarrow}_{4s^2}$	Fe

Asl ext year!

Element	Atomic Number	Symbol	Electron Configuration	Representative Electron Configuration	Orbital Diagram show only the outer energy level of the atom	Dot Diagram
Neon	10	Ne	2-8	$1s^2(2s^2 2p^6)$	↑↓ ↑↓ ↑↓ ↑↓	Ne
Iodine	53	I	2-8-18-18-7	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 \boxed{5s^2 (4d^{10} 5p^5)}$	↑↓ (5s) ↑↓ ↑↓ ↑ (5p)	I
Silicon	14	Si	2-8-4	$1s^2 2s^2 2p^6 (3s^2 3p^2)$	↑↓ (3s) ↑ ↑ _ (3p)	Si
Zinc	30	Zn	2-8-18-2	$1s^2 2s^2 2p^6 3s^2 3p^6 (4s^2) 3d^{10}$	↑↓ (4s)	Zn
Copper	29	Cu	2-8-18-1	$1s^2 2s^2 2p^6 3s^2 3p^6 (4s^1) 3d^{10}$	↑ (4s)	Cu

Questions:

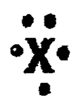
1) The orbital diagram has arrows pointing in opposite directions when two electrons occupy the same orbital. What do these arrows indicate? e- spin in opposite directions (repel each other)

valence e- only

2) How many electrons do the elements in Group 2 of the periodic table have in their electron dot diagrams? From which sublevel are the electrons found?

2 dots ⇒ from the "s" sublevel

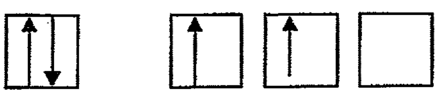
3) Element X has the following electron dot diagram. Name five elements from the periodic table that could represent X.



N, P, As, Sb, Bi (group 15)

4) Identify the element that has the following outer energy level orbital filling diagram.

Element: Sn



5s 5p

5) How many unpaired electrons are there in each of the following elements: ↑↓ ↑ ↑

a) Oxygen: 2 — 8e- $1s^2 2s^2 2p^4$

b) Potassium: 1 — 19e- $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$ ↑

c) Argon: 0 — 18e- $1s^2 2s^2 2p^6 3s^2 3p^6$

6) The electrons in the outermost energy levels are the only ones included in the electron dot diagrams.

Why do you think this is so? - furthest from nucleus and can easily be lost, gained or shared

7) Do the following for magnesium-24. Mg = 12e^-

a) Write the electron configuration for this atom based on the reference table.

2 - 8 - 2

b) Write the representative electron configuration in the ground state.

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

c) In the spaces provided below draw an orbital notation diagram for an atom of magnesium in the ground state.

1s	2s	2p			3s	3p		
↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	__	__	__

d) Using the spaces below, write the electron configuration for an atom of magnesium in an excited state.

e- jump to higher energy level.

1s	2s	2p			3s	3p		
↑↓	↑↓	↑↓	↑↓	↑↓	↑	↑	__	__