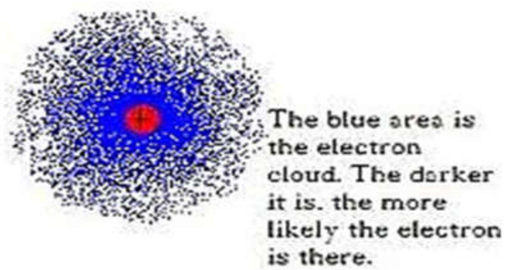
Honors Chemistry

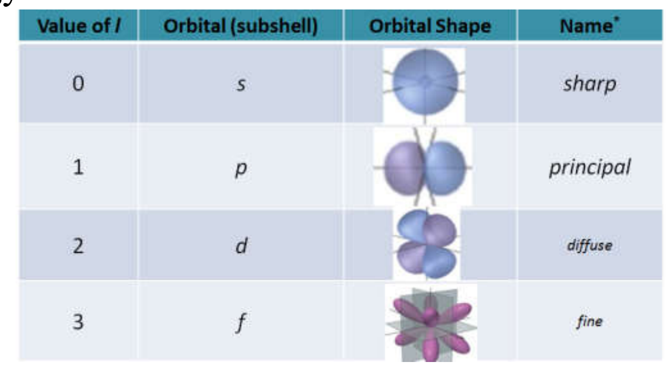
Name ______________________________
Date ____________________Block _____

An Electron's Address

<u>Information:</u> Energy Levels and Sublevels

As you know, in his solar system model Bohr proposed that electrons are located in energy levels. The current model of the atom isn't as simple as that, however. Recall that the modern model of the atom (quantum model) pictures electrons moving around in regions called **orbitals**. Let's take a closer look at how energy levels and orbitals are related.





Value of *l*	Orbital (subshell)	Orbital Shape	Name*
0	*s*		*sharp*
1	*p*		*principal*
2	*d*		*diffuse*
3	*f*		*fine*

<u>Sublevels</u> are located inside energy levels just like subdivisions are located inside cities. Each sublevel is given a name. Note the following table:

TABLE 1

<u>Energy Level</u>	**<u>Names of sublevels that exist in the energy level</u>**
1st energy level	s
2nd energy level	s and p
3rd energy level	s, p, and d
4th energy level	s, p, d, and f

Note that there is no such thing as a "d sublevel" inside of the 2nd energy level because there are only s and p sublevels inside of the 2nd energy level.

<u>Questions:</u> Use the information above to answer the following questions

1. How many/which sublevels exist in the 1st energy level?

2. How many/which sublevels exist in the 2nd energy level?

3. How many/which sublevels exist in the 3rd energy level?

4. Does the 3f sublevel exist? (Note: the "3" stands for the 3rd energy level.)

<u>Information</u>: Orbitals

So far we have learned that inside energy levels there are different sublevels. Now we will look at orbitals. **<u>Orbitals</u>** are located inside sublevels just like streets are located inside subdivisions. Different sublevels have different numbers of orbitals.

TABLE 2

Sublevel	**# of Orbitals Possible**
s	1
p	3
d	5
f	7

Here's an important fact: **<u>only two electrons</u>** can fit in **<u>each orbital</u>**. So, in an s orbital you can have a maximum of 2 electrons; in a d orbital you can have a maximum of 2 electrons**; in any <u>orbital</u> there can only be <u>two electrons</u>.**

Since a d <u>sublevel</u> has 5 <u>orbitals</u> (and each orbital can contain up to two electrons) then a d <u>sublevel</u> can contain 10 electrons (= 5 x 2). <u>Pay attention to the difference between "sublevel" and "orbital".</u>

5. Use the information from table 1 and table 2 to determine the total number electrons that can fit in each energy level. The 2nd energy level has been done for you as an example.

Energy Level	**Types of Sublevels**	**# orbitals x # electrons in each orbital**	**Total # of Electrons in this Energy Level**
1st energy level			
2nd energy level	s and p	s: 1 x 2 = 2 p: 3 x 2 = 6	8
3rd energy level			
4th energy level			

<u>Information</u>: Representing the Most Probable Location of an Electron

The following is an "address" for an electron—a sort of shorthand notation. The diagram below represents an electron located in an orbital inside of the p sublevel in the 3rd energy level.

EXAMPLE #1: **3p** ↑ ___ ___ ___

Some important facts about the above diagram:

- The **arrow represents an electron**.
- The upward direction means that the electron is spinning <u>clockwise</u>.
- "3p" means that the electron is in the p sublevel of the 3rd energy level.
- **Each blank represents an orbital**. Since there are three orbitals in a p sublevel, there are also three blanks written beside the p.
- In the diagram, the electron is in the first of the three p orbitals.

Here's another example:

EXAMPLE #2: **4d** ↓ ___ ___ ___ ___ ___

<u>Questions:</u> Use the information above to answer the following questions

6. In example #2, why are there 5 lines drawn next to the d?

7. In example #2, what does it mean to have the arrow pointing down?

8. Write the notation for an electron in a 2s orbital spinning clockwise.

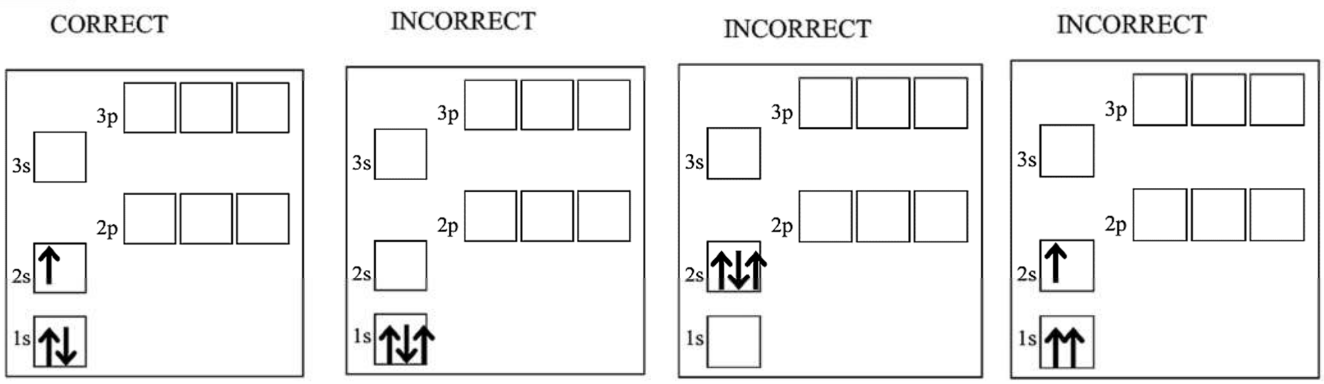
9. Write the notation for an electron in the first energy level spinning clockwise.

Now let's look at how to represent the location of all the electrons of an atom of a specific element.

Orbital Diagrams

In the following examples, you will look at how electrons are filled in the various orbitals. Some drawings show correct electron configurations and some show incorrect electron configurations. You will use these drawings to figure out the rules for electron configuration

PART I: What is the rule for the number of electrons and the direction of the arrow in <u>ONE</u> orbital?



Note: an arrow represents one electron. Each small box represents one orbital

1. What does each arrow represent in the orbital diagrams above?

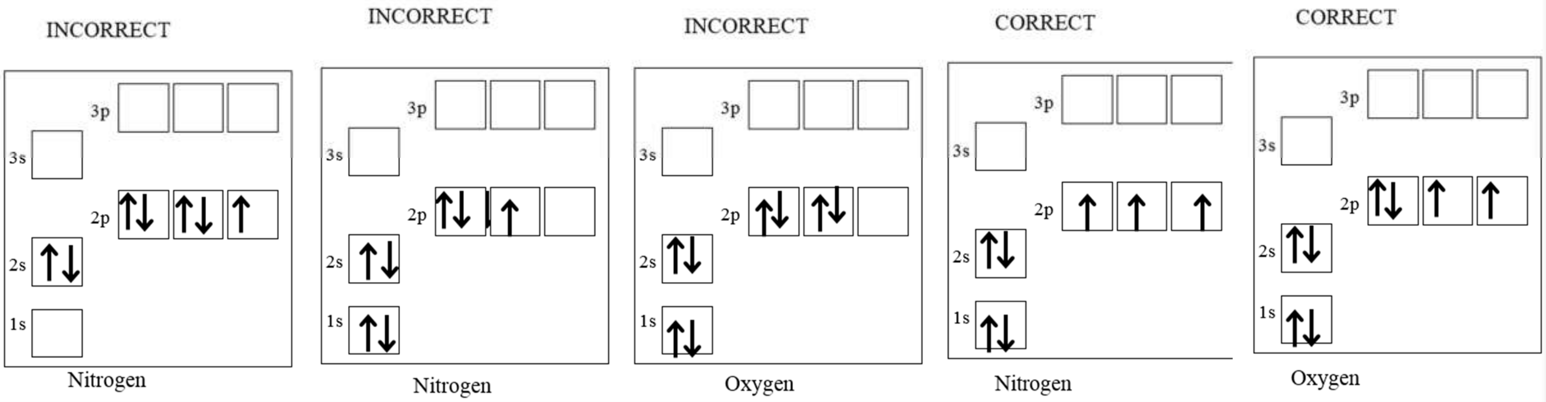
2. What do the 3 boxes next to the 2p sublevel represent?

3. **Pauli Exclusion Principle (1):** What is the maximum number of electrons allowed in each orbital? How is this represented in the **correct** orbital diagram?

4. **Pauli Exclusion Principle (2): "If two electrons occupy the same orbital, they must have ____________________."** Circle the correct answer.
   a. the same spin
   b. opposite spins

5. What element do you think the **correct** orbital diagram pictured is representing (assume the atom is neutral)? How do you know?

PART II: What is the rule for how electrons fill multiple orbitals?



Aufbau Principle: Examine the order of how electrons fill up the orbitals. Circle the correct responses to the questions below.

1. **Based on where a single electron is placed, the lowest energy electron in an atom is found in the ________ sublevel.**
   a. 1s b. 2s c. 3s

2. **Electrons will occupy a p-orbital *only* after ____________**
   a. the previous s-orbital is completely full
   b. the previous s-orbital is empty

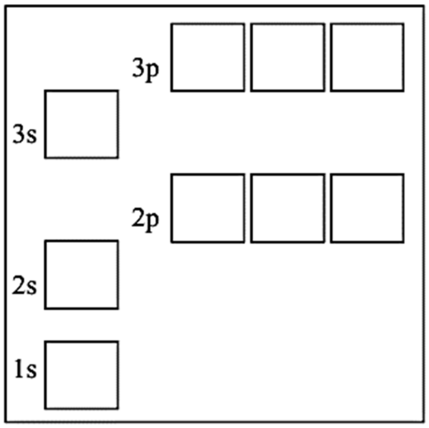
3. **Electrons can begin to occupy energy levels with the next highest integer designation (e.g. 2 vs. 1, 3 vs. 2) *only* after __________________ on the energy levels below it are completely occupied.**
   a. at least one of the orbitals
   b. all of the orbitals

Hund's Rule: Compare the correct and incorrect electron configurations for **nitrogen** and **oxygen** and focus on the ***2p orbitals***. Circle the correct responses to the questions below.

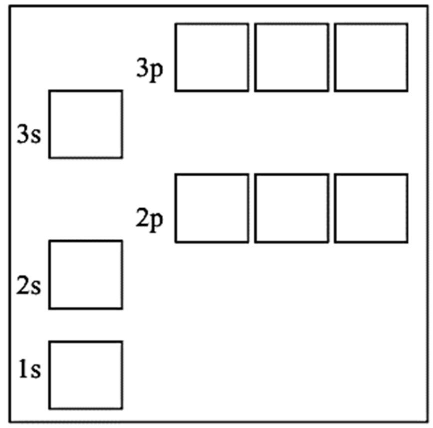
1. **Electrons will pair up in an orbital only when __________________**
   a. there is an even number of electrons in the sublevel
   b. all orbitals in the same sublevel already have one electron

2. **When single electrons occupy different orbitals of the same sublevel,** ____________.
   a. they all have the same spin
   b. they all have different spins

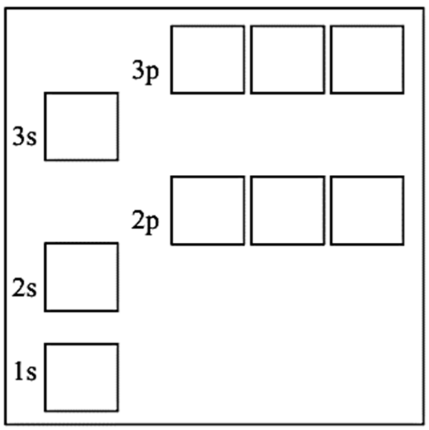
Practice: Based on the rules you looked at, complete the ground state orbital diagrams **and** write the corresponding electron configurations for the following elements:



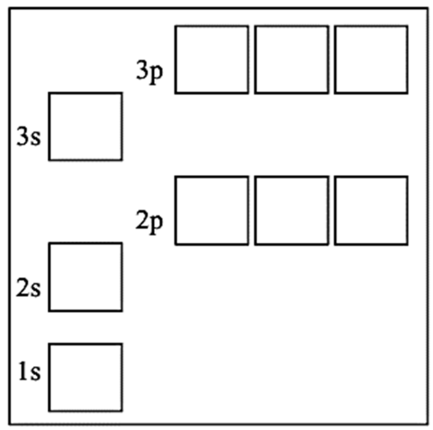
Beryllium



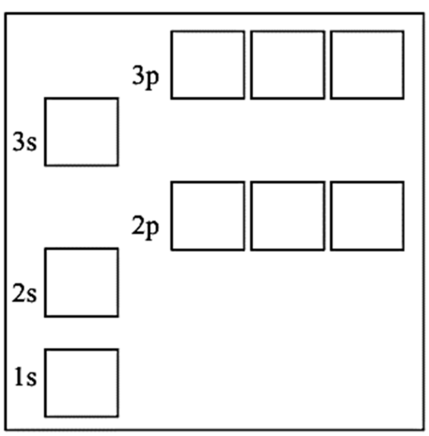
Sodium



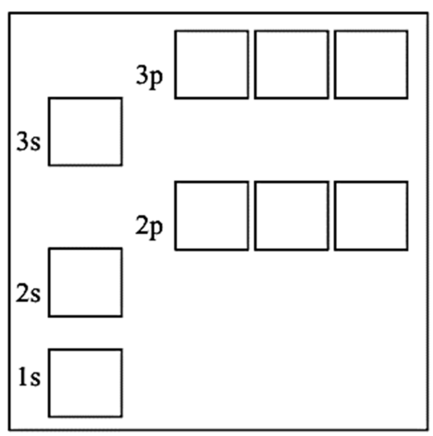
Carbon



Boron



Phosphorus



Chlorine