Teaching Tips for Lesson 3: Electron Arrangement

Game Plan:

A. Review activities from previous meeting.

B. Introduce quantum mechanics as a means of predicting relative reactivity of various elements or families of elements.

C. Assign Practice page

D. Administer Lesson 3 test.

A. Review activities from previous meeting.

Before beginning this class period's activities, take time to review the concepts of atomic structure and atomic number presented during last week's class. If you assigned your students to create their "birthday atoms," have them present them to the class at this time. Consider creating a display of these models for others to appreciate.

B. Introduction of quantum mechanics

Begin class by asking why some elements (such as helium or neon) are very stable, non-reactive elements. Refer to the use of helium in childrens' balloons. Also, refer to the use of neon in store signs such as those often found at restaurants (like Pizza Hut). Contrast this relative non-reactivity to elements like hydrogen or sodium which are extremely reactive. Refer to examples like the Hindenburg airship, the hydrogen bomb or the fact that pure sodium metal reacts so violently with water vapor in the air that it must be stored in a petroleum-based solution. Another reactive element is oxygen. Ask if any class members have visited a hospital or nursing home where oxygen is in use. What precautions must be made when using pure oxygen?

Finally, ask your students if they have any ideas *why* some elements are so highly reactive while others appear to be very stable or non-reactive. Work towards an explanation based upon the **arrangement of electrons** found in atoms of those elements. Tell your students that by knowing the arrangement of electrons in atoms of particular elements, they could be able to predict the relative reactivity of elements.

Continue the discussion by introducing quantum mechanics. Tell your students that quantum mechanics is a systematic way to accurately describe the arrangement of electrons in an atom of a particular element. Continue by describing each of the four quantum numbers.

To illustrate the **principle** quantum number, use the layers found in an apple. Show the peel, white fruit tissue, the papery layer of the core and then the seeds. An alternative to the apple is an old baseball or golf ball that has been taken apart. Show the various layers and tell your students that the electrons are arranged in **layers** within the electron cloud.

To assist in visualizing the **orbital** quantum number, use balls to illustrate the s- (or spherical) shaped orbital and pears or light bulbs for the p- (or pear) shaped orbitals. Used Christmas bulbs (the larger kind often used outdoors) work well with a ball of clay or playdough to help visualize the **magnetic** quantum number. Position the bulbs into the clay in the x, y and z positions. If you have enough bulbs, have your students practice the three possible positions of the pear-shaped orbitals with their own ball of clay. To illustrate the **spin** quantum number, play the "Dizzy Electron Game."

The Dizzy Electron Game

Although not a competitive game, this activity quickly makes it clear how the electrons are traveling about the nucleus in pairs and are spinning in opposite directions. Ask your students to find a partner and to stand in a circle in an open playing area. Explain that they represent a pair of electrons traveling in a spherical-shaped orbital. Position yourself in the center of this "atom" to represent the nucleus of the atom. Ask your students what element they represent (the number of students present equals the number of electrons, hence the atomic number). Have them find this element on the periodic table.

Tell your students that they will travel through this imaginative spherical shaped path around the classroom. As they move through this orbital, one person will spin clockwise while the other spins counter-clockwise. On the signal of "go," have your students begin moving around the circle spinning as they go. The goal for each pair is to make it back to the spot where they started. Caution your students about the hazards of becoming too dizzy! Have them stop and sit down before they fall into a chair or other obstacle.

Once your students have made on "trip" through the "orbit," ask your students return to their seats for a thorough review of the four quantum numbers. Hold up your props (the apple, balls, pears, Christmas bulbs, etc.) as you review each quantum number. A thorough understanding of these concepts is vitally important at this point in their exploration of basic chemistry.

C. Assign practice page

Continue by assigning the practice page following the text.

D. Administer Lesson 3 Test.

After a quick review, give the Lesson 3 Test.

.

NAME______________________________________DATE___________________
FRIENDLY CHEMISTRY

Lesson 3 Test

Read each question below. Choose the one BEST answer to the question. Some answers may appear to be good answers. Choose the one best answer and write it in the left margin next to the question number.

1. It is important to learn about quantum mechanics because

A. This information allows us to understand why some chemicals are colorful and others are dull and muted.
B. This information tells us why certain elements may be very reactive while others may be relatively non-reactive.
C. This information tells us why certain elements are found as gases at room temperature.
D. This information tells us how atoms grow to become larger molecules.

2. The first quantum number is known as the _______________ quantum number and says that ____.

A. Orbital quantum number; electrons are found in layers around the nucleus of the atom.
B. Principle quantum number; electrons are found in four different shapes.
C. Principle quantum number, electrons are found in layers around the nucleus of the atom.
D. Spin quantum number, electrons spin in two directions while in travel.

3. How many layers of electrons might one encounter in an atom according to the theory of quantum mechanics?

A. 3
B. 8
C. 7
D. 12

4. The orbital quantum number says that…..

A. Electrons are found in layers around the nucleus of the atom.
B. Electrons are found in 5 different shaped pathways.
C. Electrons spin as they move along their pathways.
D. Electrons travel in pathways having four different shapes.

5. When thinking about the different shaped paths on which electrons travel, which shape below is NOT one of the shapes that we discussed?

A. Rectilinear
B. Spherical
C. Pear-shaped
D. Dumb-bell shaped

6. The magnetic quantum number says……….

A. That the s-shaped orbits can be found in three different orientations in space.
B. That the p-shaped electrons move in three different shaped pathways.
C. That the p-shaped orbits are found in three different orientations in space (a, b and c).
D. That the p-shaped orbits are found in three different orientations in space (x, y and z).

7. The spin quantum number says…..

A. That the electrons travel in pairs with one electron spinning clockwise and the second spinning counterclockwise.
B. That the electrons travel in pairs with one electron spinning clockwise and the second electron sitting in a stationery position.
C. That the electrons are arranged in p-shaped orbits aligned along three axes in space.
D. That the nucleus of the atom rotates along the x-axis while the electrons, traveling in pairs, each spins accordingly.

8. Choose the element symbol pair which is correctly matched.

A. Carbon Ca
B. Calcium C
C. Chlorine Ch
D. Cobalt Co

9. The atomic number of an element tells the

A. Address of the element
B. Number of protons, neutrons and croutons the element enjoys on its salad!
C. Number of protons, neutrons and electrons found in an atom of that element.
D. The number of electrons found spinning clockwise around one atom of that element.

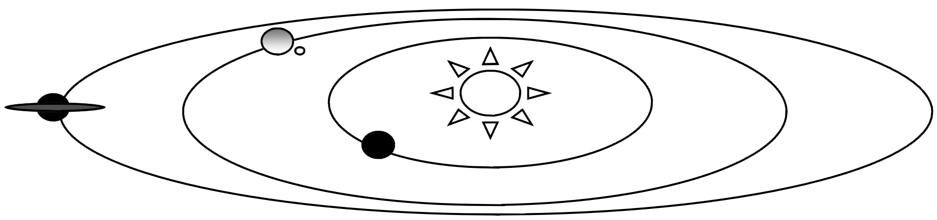
10. Of the three subatomic particles, electrons have the greatest mass.
A. True
B. False

Lesson 3: The Arrangement of Electrons in Atoms

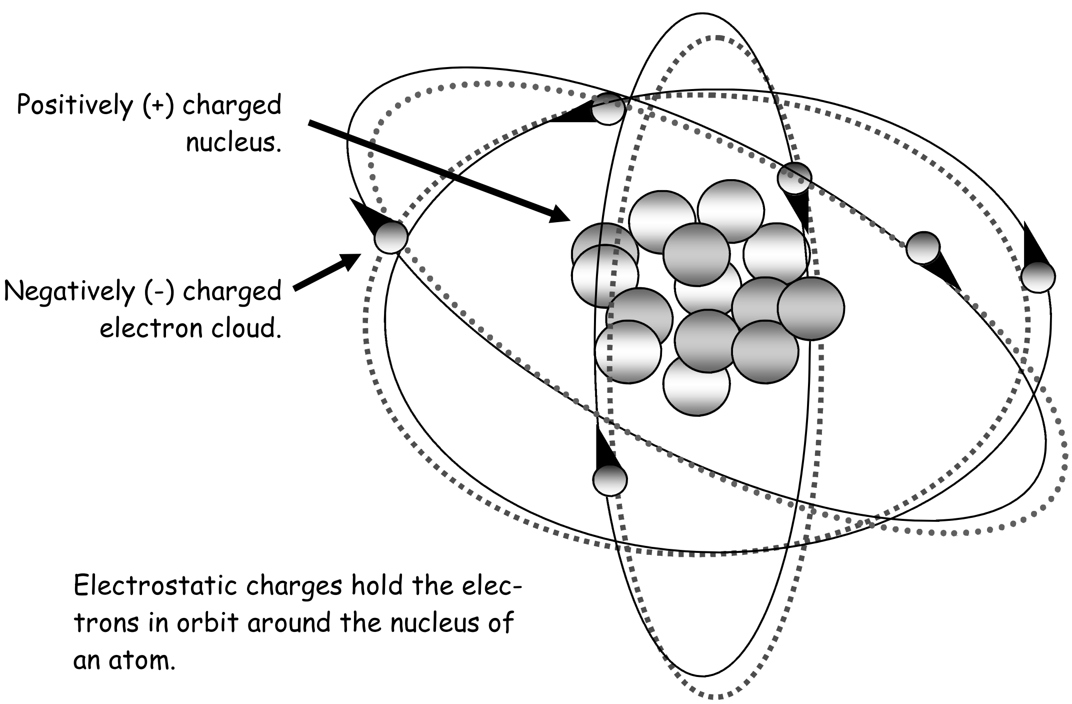
In Lesson 2 we discussed the names and locations of the subatomic particles found in atoms. We stated that the atomic number for any element found on the periodic table tells the number of protons or electrons and "generally" the number of neutrons found in each atom of that element. Let's continue now and learn how the electrons are arranged in atoms.

First, let's examine the protons and electrons a bit more closely. Based upon experiments done by some famous chemists, it is accepted that electrons and protons carry an electrostatic charge. You might think of an electrostatic charge as being like the tiny spark you can elicit after you shuffle your feet across a carpet and then touch a doorknob. In this example, the spark you see (and can even feel) is negatively charged electrons moving from you through the air to the doorknob. On the atomic level, **electrons carry a negative electrostatic charge**.

On the other hand, **protons carry a positive electrostatic charge**. Neutrons carry a neutral (or no) charge. With this in mind, we can see that the nucleus, since it is composed of protons and neutrons, in effect, carries an overall **positive** charge while the electron cloud carries a **negative** charge. It is theorized that these opposite charges (positive nucleus and negative electron cloud) attract each other like the north and south poles of magnets attract each other. We can make an analogy in which the electrons are held in an orbit around the nucleus similar to the way the planets (or any other satellites) are held in orbit around the sun due to gravitational forces. See the diagrams below. The electrons, like the planets, have energy of motion that keeps them moving in an orbit around the nucleus. If you would like to learn more details about the experiments mentioned above, please consult the chemistry section of your local library.



Planets are held in orbit by gravitational forces from the sun.



Electrostatic charges hold the electrons in orbit around the nucleus of an atom.

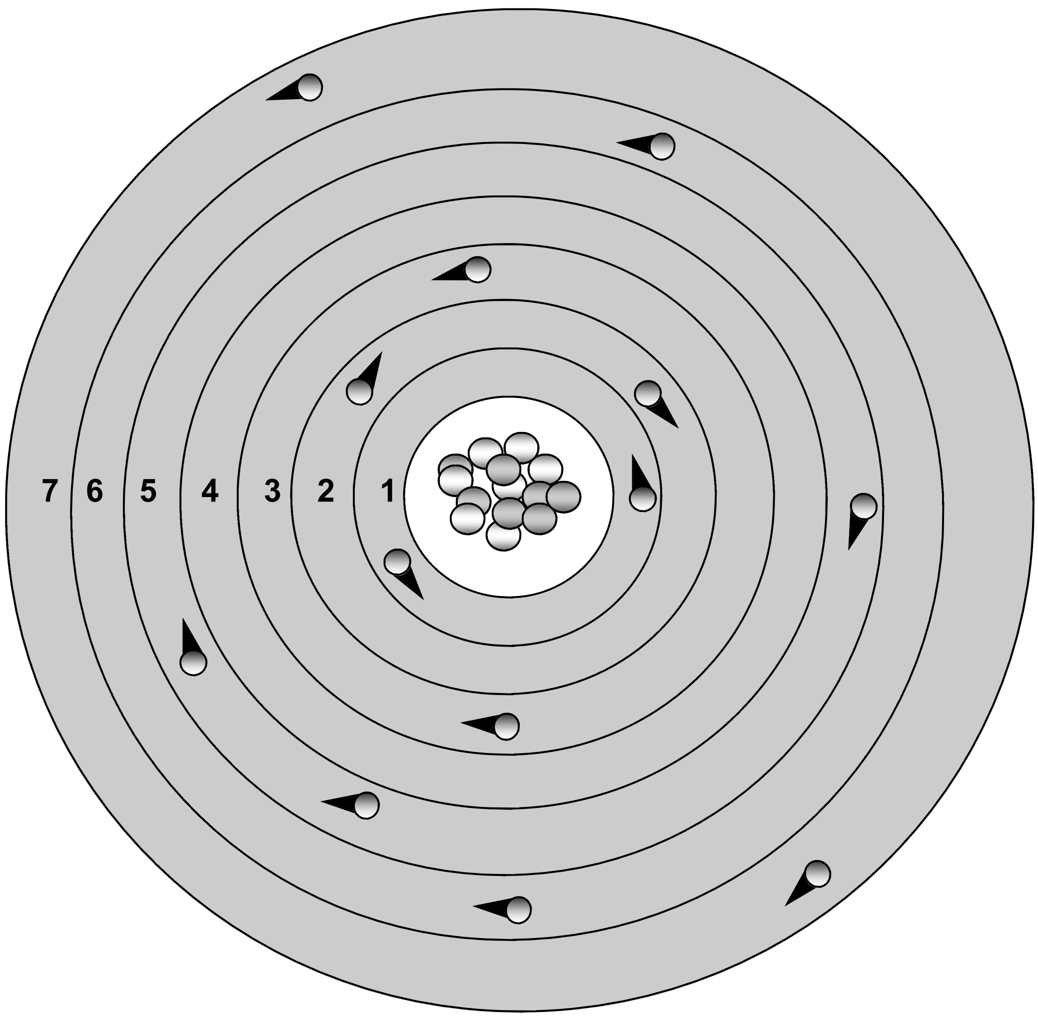
While the neutrons and protons are clustered together in the nucleus, the electrons are thought to be in various arrangements circling the nucleus. It is this variation in arrangement of the electrons that is responsible for the way each element interacts with other elements. In other words**, the arrangement of electrons around each nucleus of an element's atoms determines the reactivity of that element.** As you might suspect, some elements are highly reactive while some appear to not react at all with others. Consider the fate of the Hindenbergh. The hydrogen-filled derigible of the early 1900's crashed, which resulted in the hydrogen reacting with oxygen. The resulting raging fire consumed the entire airship. Compare the Hindenbergh's hydrogen with helium which is used today in blimps and party balloons. Helium is very non-reactive compared to hydrogen or even pure oxygen, for that matter!

Sodium, as another example, is so reactive with water that is must be stored within a solution of diesel to keep the explosive metal from coming into contact with water vapor droplets in the air! The arrangement of those tiny electrons makes an enormous (and sometimes explosive) difference in how elements react with other elements.

Let's move on and learn more about how these electrons are arranged and how the arrangements affect an atom's reactivity. There is an area of scientific knowledge used to describe the arrangement of electrons about an atom's nucleus. This is known as **quantum mechanics**. Quantum mechanics is just a means for describing where the electrons are, kind of like a code which can help you understand more about the atoms that make up elements.

The code of quantum mechanics is based upon four quantum numbers (although, only the first quantum number is actually a number while the other three are letters or symbols). You might think of these four quantum numbers as being like the letters in our alphabet: a set of symbols which, together, make up words which have meaning. The four quantum numbers, when used together, create a meaningful description of the arrangement of an atom's electrons.

The first quantum number is known as the **principle quantum number**. As its name implies, the principle quantum number serves as a basis upon which the other three quantum numbers are built. The principle quantum number, as we stated above, is actually a number, and the principle quantum number is a whole number. The lowest principle quantum number is 1 and the highest is 7. Each principle quantum number corresponds to the position the electrons occupy as they travel around the nucleus of the atom. In other words, not all of the electrons in an atom travel in the same path at the same distance from the nucleus. They are arranged in concentric orbits or energy levels around the nucleus just like the planets in our solar system revolve around the sun at various distances. The first orbit (or energy level) from the nucleus is given the principle quantum number of 1. The second orbit (or energy level) moving outward from the nucleus is given the principle quantum number of 2. The third orbit or (energy level) is given the principle quantum number of 3 and so on up until you reach the seventh level which is given-yes, you've got it-the principle quantum number of 7. You might think

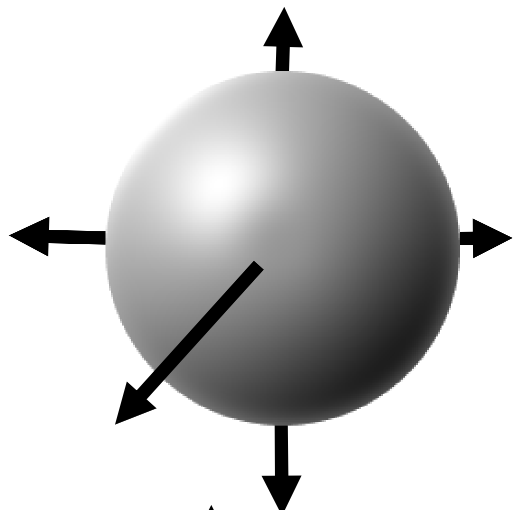


The principle quantum number indicates the relative distance an orbit or energy level is from the nucleus of an atom. Note the orbits numbered 1-7 with 1 being the closest to the nucleus and 7 being the farthest from the nucleus.

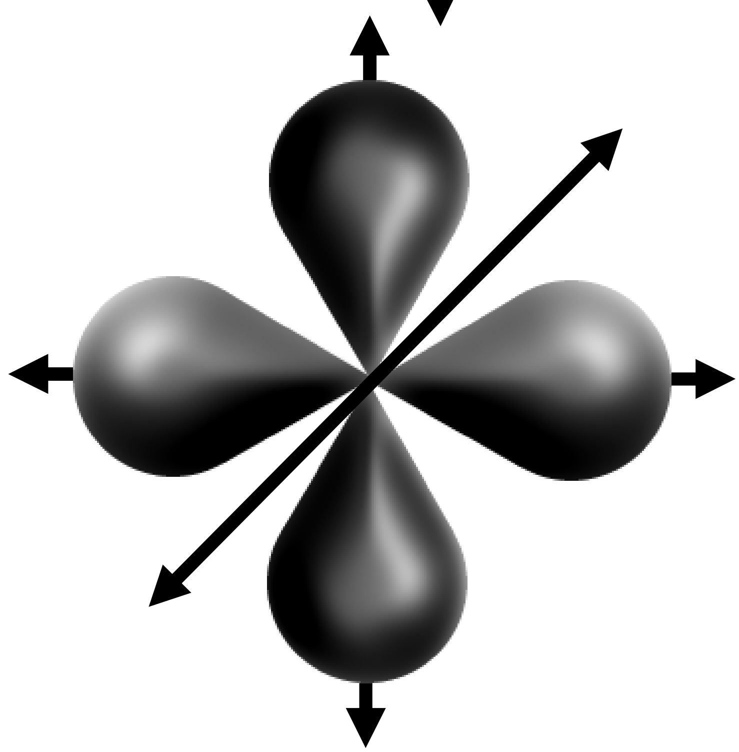
of these orbits (or energy levels) as being like the layers of rubber bands you find inside a golf ball. However, not all of these orbits are spherical or ball-shaped.

The second quantum number, known as the **orbital quantum number**, allows us to indicate the **shape** of the orbit or path that the electrons follow. There are four possible path shapes that the electrons may follow. However, only two of those shapes are readily described: spherical and pear-shaped. We indicate these shapes by using a lower-case “s” to indicate spherical and a “p” to indicate pear-shaped. The two remaining shapes, although not described by chemists, are given the letters “d” and “f.” Some chemists feel the d-shaped orbit is shaped like a dumbbell. To review, the second quan-

Spherical or s-shaped orbit.



Pear or p-shaped orbit.

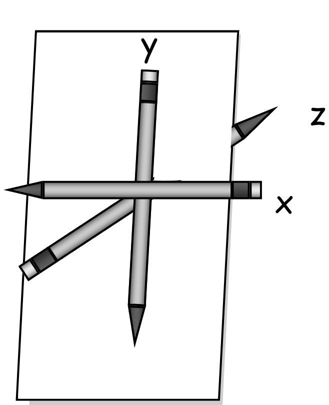


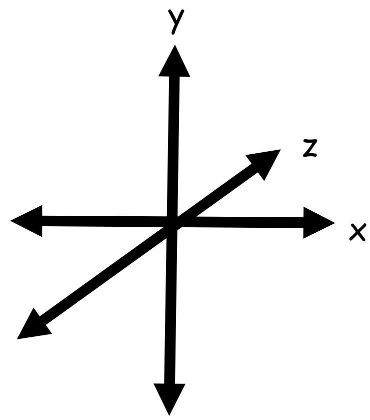
tum number (the orbital quantum number) is a letter (s, p, d or f) which tells the shape of the orbit that the electrons follow.

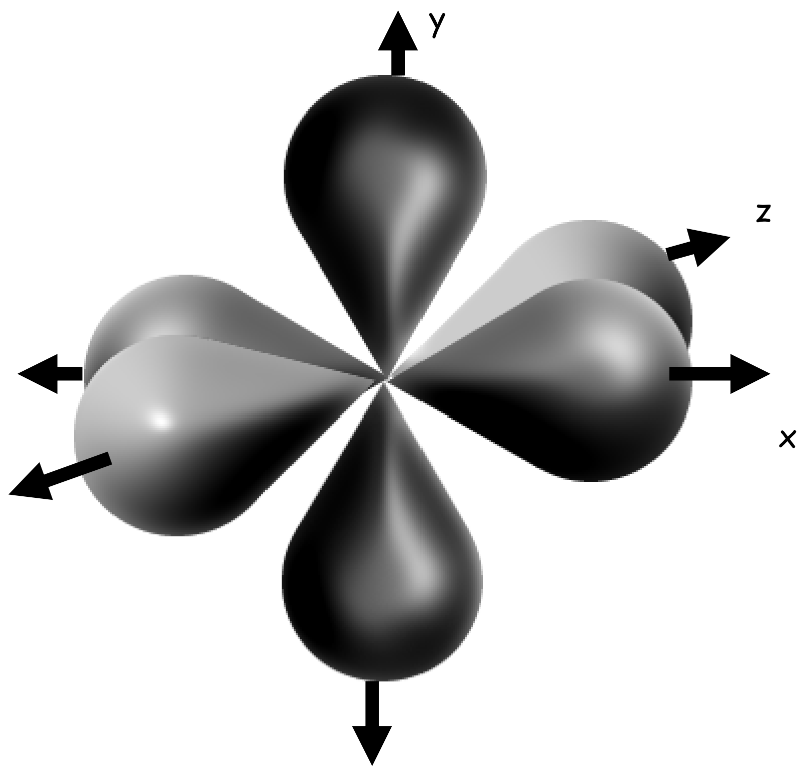
There can be more than one shape of orbit within each orbit or energy level. In other words, you might have a combination of shapes within each orbit or energy level. It just so happens that the principle quantum number equals the variety of shapes within each energy level. For example, the first energy level, principle quantum number of 1, has only 1 shape of orbit (which is spherical). The second energy level, principle quantum number of 2, has two shapes within the level: spherical and pear-shaped. Can you guess how many shapes are found within the third energy level? You're correct if you said 3! Those shapes would be spherical, pear-shaped and the shape indicated by the letter d. The sequence of shapes is spherical (s), then pear-shaped (p), then the d shape and, finally, in the fourth energy level, the f shape. We will primarily be using the elements whose electrons fill the s-, p- and d-shaped orbitals.

Well, we're half-way through this discussion of how electrons are arranged in each atom and how the arrangement of electrons around the nucleus of any atom determines the reactivity of that atom. Let's pause and review what we talked about so far. We've discussed the principle quantum number which tells the position or distance an orbit (or energy level) is away from the nucleus (whole numbers, 1-7, 1 being the closest and 7 being the farthest from the nucleus). Next, we discussed the orbital quantum number which indicates the shape of the orbit (letters s, p, d or f; s being spherical, p being pear-shaped). If you feel at all confused at this point, consider re-reading the chapter up to this point. As with most things, as you apply the concepts outlined above, you will undoubtedly feel more comfortable with them.

The third quantum number, **the magnetic quantum number**, tells the direction or orientation in space that each orbit has. The magnetic quantum number tells how the orbit is positioned along imaginary lines or axes which go right through the center of the nucleus of the atom. These axes are given the notations of x, y and z. The x axis runs right and left, the y axis runs up and down, and the z axis runs *into* and *out of* the page. If you laid a pencil across this page, it would be aligned with the x axis. If you laid a pencil going up-and-down on this page, it would be aligned with the y axis. If you *inserted* a pencil *through* this page, it would be aligned with the z axis. The magnetic





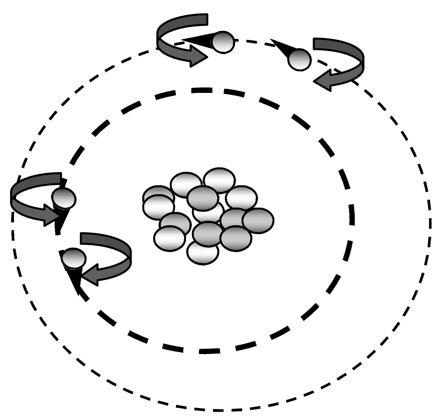


The magnetic quantum number states that the p-shaped orbits may be aligned along three imaginary axes: x, y and z.

quantum number utilizes these three orientations about the center of an atom: x, y and z. It is only the p or pear-shaped orbits that we are concerned with regarding the x, y and z orientations. Look at the diagrams on the preceding page to see these three orientations of the pear-shaped orbits.

The fourth quantum number is the simplest of all to visualize. This quantum number, known as the **spin quantum number**, tells the direction the electrons are rotating, hence the name spin quantum number. Not only are the electrons traveling in an orbit around the nucleus in an atom, they are also spinning much like the earth rotates on its axis as it revolves around the sun. The direction of spin can either be clockwise or counter-clockwise. It is theorized that two electrons can be found in each shaped orbit, i.e. 2 electrons in each s-shaped orbital, 2 in each p-shaped orbit and so on. One of these electrons is thought to be spinning clockwise while the other spins counter-clockwise.

The spin quantum number says that the electrons travel in pairs with one electron spinning clockwise and the other spinning counter-clockwise. Elements with an odd number of electrons will have one lone electron in its outermost orbit.



Quantum Number	And what that Quantum Number Means
Principle Quantum Number	Tells the position or **layer** (energy level) that the electrons are traveling in. Whole numbers: 1-7. 1 is closest to the nucleus.
Orbital Quantum Number	Tells the **shape** of the path in which the electrons are traveling (s, p, d and f).
Magnetic Quantum Number	Tells the **orientation** in space of the p-shaped orbits along the x, y and z axes.
Spin Quantum Number	Tells that within each **pair** of electrons, one electron **spins** clockwise and the other spins counter-clockwise.

Name________________________________Date__________________
Friendly Chemistry

Quantum Mechanics Review

Fill in the blanks with the appropriate words. Refer to your text if you need help!

In our discussion of quantum mechanics, we said there were _________ quantum numbers. The first quantum number is known as the __________________ and it said that _________ are arranged in _______________. It said that there can be up to _____________ layers. The layer closest to the nucleus is the ___________ layer. The second quantum number is known as the _______________________. It says that electrons are found in different ____________ paths as they move around the nucleus of an atom. There are __________ different shapes of paths: __________________, ___________________, ____________________ and ____________________. The letter abbreviations for these shapes are: _____, ________, ________ and __________.

The third quantum is called the _____________________________. It says that the ___________-shaped orbits can be found in ________________ different orientations in space. These three orientations are labeled as _______, ________ and _______.

The fourth quantum number is called the ________________________. It says that _________________ travel in ________________ about the nucleus of the atom. One electron will __________ ________________________ while the other electron will _________ _____________________________________.

It is important to know about quantum mechanics because quantum mechanics will _________________ why some elements are very __________________ while others are very _________________________________. By knowing how the electrons are arranged in various atoms helps one __________________________________
____.

Notes