Wave Mechanics or Quantum Mechanics (Schroedinger Wave Equation)

Erwin Schroedinger devised a wave equation based on a vibrating string that describes the motion of waves. This important equation was also used to describe the probability of finding an electron in a given region. It also describes in a general way the probable manner in which electrons will move in space as the energy of the electrons changed. The Schroedinger equation is a differential equation which is capable of giving a large number of possible solutions. In one of the solutions an equation was arrived at which expressed the energy of an electron in terms of four numbers known as quantum numbers. You can use four quantum numbers to accurately describe the energy and most probable location of an electron in an atom.

1. Principal Quantum Number (n): This number refers to the average distance of the orbital from the nucleus. 1 is closest to the nucleus and has the least energy. The numbers correspond to the orbits in the Bohr model. They are numbered 1 to 7 and correspond to the seven different horizontal rows of the periodic table. They are called energy levels.
2. Orbital Quantum Number (l): l= n-1.....0 This number is sometimes referred to as the azimuthal or angular momentum quantum number. It indicates the shape of the electron cloud. (orbital) . When l=0 it means there is an "s" sublevel, l=1 is the "p" sublevel, l=2 is the "d" sublevel and l=3is the "f" sublevel. In any permissible jump of an electron between energy levels, the l value must change by only +1 or -!. This means that a jump between an electron from an "s" orbital to a "p" orbital or vice versa is possible, while a jump between an "s" orbital and a "d" orbital is not permissible.
3. Magnetic Quantum Number (m): m=-l....0....+l This number indicates how an orbital is oriented in space. The electron cloud can be oriented in a few discrete positions. When a magnetic field is imposed on electrons, certain orientations of the electron cloud are detected. Therefore, the values of m, when an external magnetic field is applied are 0, +-1, +-2, +-3. "S" sublevels have 1 space –oriented orbital, "p" sublevel has 3 space-oriented

orbitals, "d" has 5 space –oriented orbitals and "f" has 7 space-oriented orbitals.

4. Spin Quantum Number (s): This number indicates how an electron spins on its axis while in motion. The spin can only be in two directions, clockwise or counterclockwise. The number s has only two values +1/2 and -1/2. Each orbital can be filled by only two electrons with opposite spins. (also represented by two arrows one pointing upward and the other downward)

Important Rules to follow:

a. Aufbau Principle: An electron occupies the lowest energy orbitals first. Follow the n+l rule. For example the 4s (4 + 0) is filled before the 3d.(3 + 2)
b. Hund's Rule of Maximum Multiplicity: Each orbital gets one electron before pairing occurs.
c. Pauli Exclusion Principle: No two electrons in an atom can have the same four quantum numbers. Therefore within any given orbital the electrons must have opposite spins.

Examples:

Atomic Number	Element	Electron Configuration	Orbital Notation	Electron dot	Quantum Numbers of last entering electron N l m s	
1	Hydrogen	$1s^1$			1 0 0 +	
2	Helium	$1s^2$			1 0 0 -	
3	Lithium	$1s^2 2s^1$			2 0 0 +	

ELECTRON QUANTUM NUMBERS

Using Quantum numbers to describe electrons in atoms:

DESIGNATION	NAME	ELECTRON CHARACTERISTIC
n	Principal Quantum Number (n)	Principal Energy level
ℓ	Orbital Quantum Number l=(n-1)	Shape of the orbital (or energy sublevel)
m	Magnetic Quantum Number m=(-l to +l)	Magnetic characteristics
s	Spin Quantum Number s= +1/2,-1/2	Direction of spin

Principal Quantum Number (n)	Orbital Quantum Number (l) n-1....0	Orbital Shape designation	Magnetic Quantum – Number (m) -l...0...+1	Number of Orbitals (n^2)	Spin Quantum number (s) +1/2,-1/2 / Total number of electrons ($2n^2$)
1					
2					
3					
4					

Orbital Model Name:____________________

Part A: Answer the following questions on the space provided.

______1. What is the maximum number of electrons that can be in the third energy level?
______2. What is the maximum number of electrons that can be held in a 4f ~~Orbital?~~ sublevel?
______3. How many orbitals are in a 3d sublevel?
______4. What is the number of electrons that can be in the 5p sublevel?
______5. How many sublevels are in the third principal energy level?
______6. What is the maximum number of electrons in the 3s orbital?
______7. How many orbitals are in the 2nd principal energy level?
______8. What is the maximum number of electrons in ANY orbital?
______9. What is the atomic number of an atom having the following electronic configuration $1s^22s^22p^63s^23p^64s^23d^5$?
______10. How many valence electrons are in question 9 above?

Part B: Answer the following questions for the atom of Silicon (atomic number 14).

1. Write the electronic configuration.

2. Write the orbital notation.

3. Write the electron dot.

4. How many completely filled orbitals?

5. How many half filled orbitals?

6. How many valence electrons?

7. How many completely filled sublevels?

Part C: Answer the following questions. Show work.

1. How many completely filled principal energy levels are there in a chorine atom in the ground state? (atomic number 17)

2. How many completely filled orbitals are there in a fluorine atom in the ground state? (atomic number 9)

3. How many completely filled orbitals are there in an O^{-2} ion? (atomic number 8)_

4, How many completely filled energy levels are there for a K^{+1} ion? (atomic number 19)

5. What are the four quantum numbers for the last electron in an atom of nitrogen?