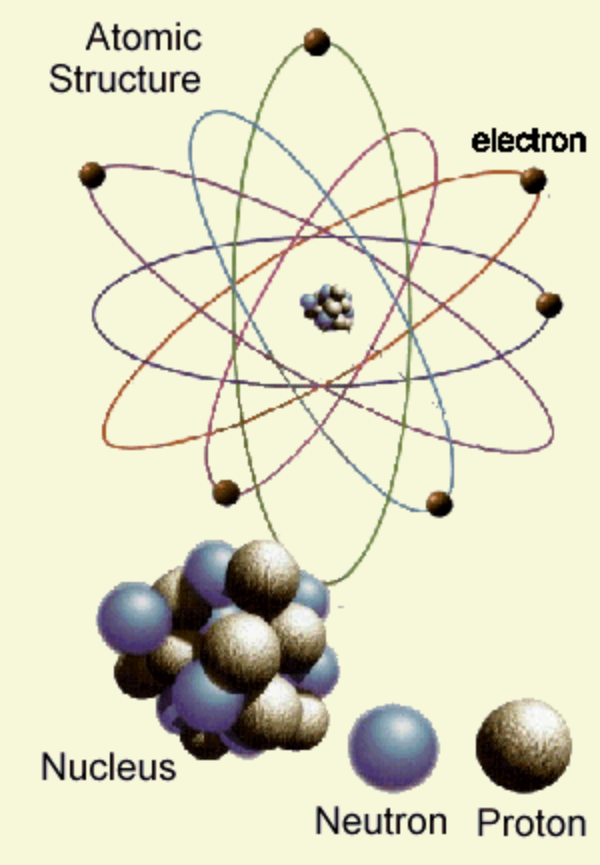
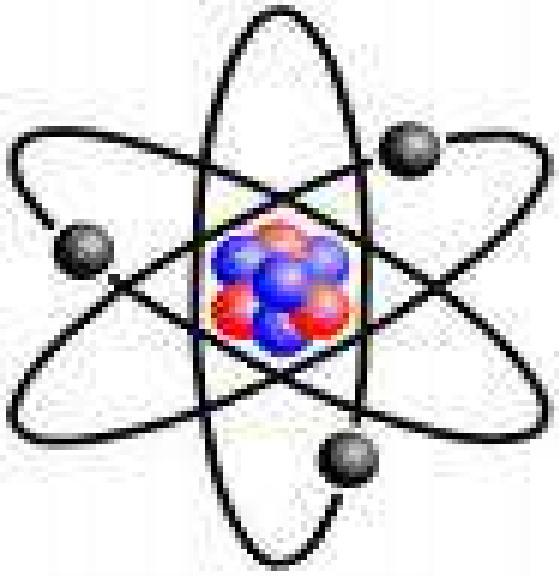
Chapter 5: Electrons in Atoms



Models of the Atom

- Rutherford used existing ideas about the atom and proposed an atomic model in which the electrons move around the nucleus, like the planets move around the sun.



- Rutherford's atomic model could not explain the chemical properties of elements.

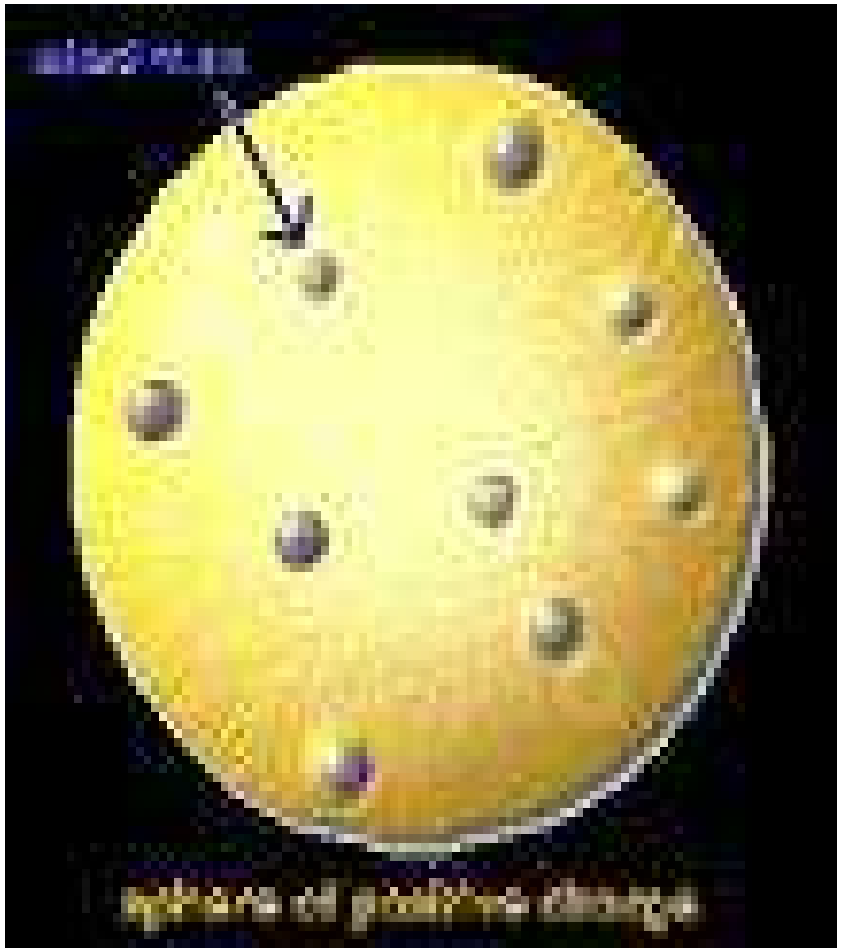
  - Rutherford's model fails to explain why objects change color when heated.

Models of The Atom

1863- John Dalton pictures atoms as tiny, indestructible particles, with no internal structure.

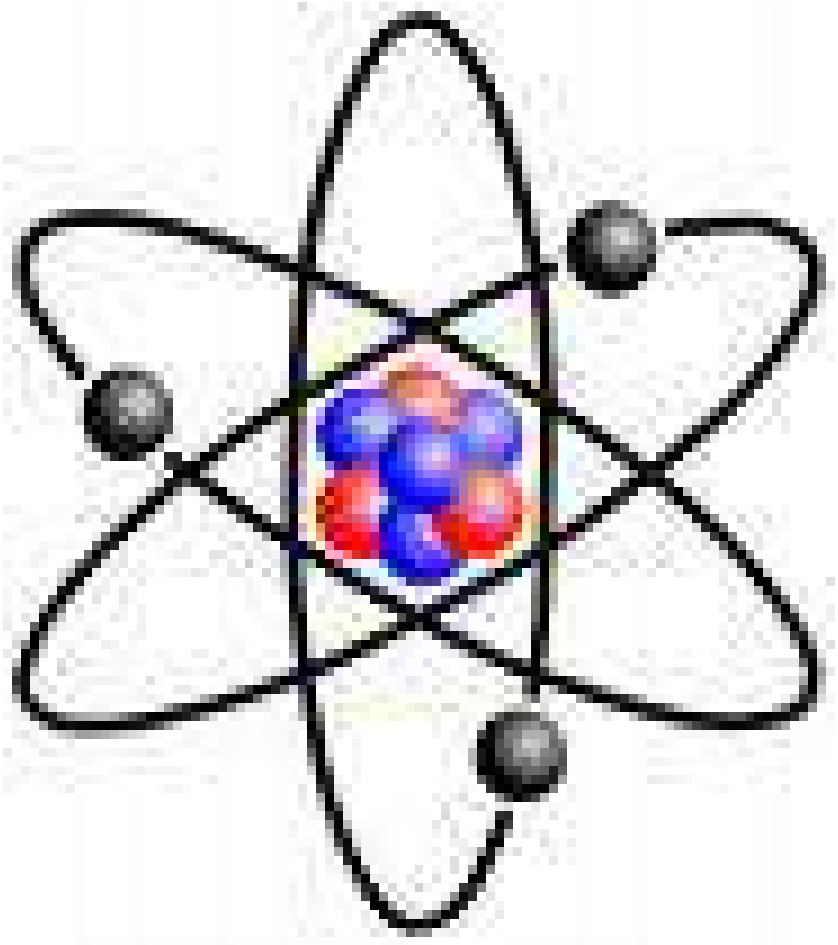
Models of the Atom

- 1897- J.J. Thomson, a British scientist, discovers the electron. The later leads to his "Plum Pudding" model. He pictures electrons embedded in a sphere of positive electrical charge.



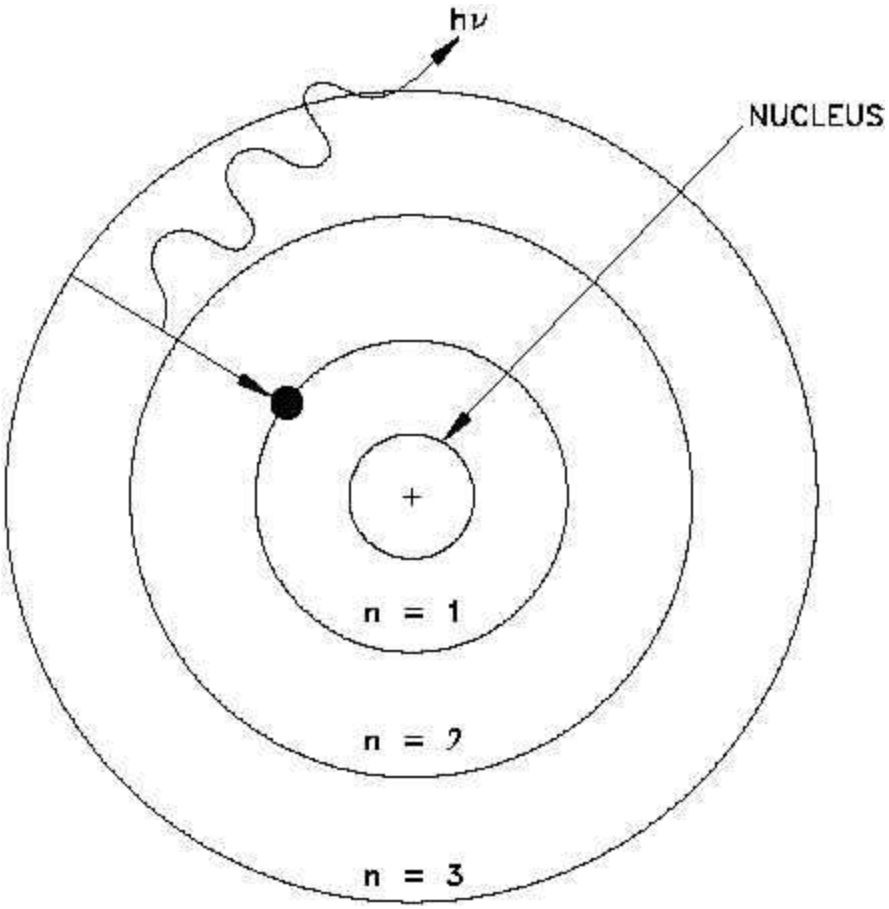
Models Of the Atom

- 1911- Ernest Rutherford finds that an atom has a small, dense, positively charged nucleus. Electrons move around the nucleus.



Models of the Atom

- 1913- Neils Bohr's model, the electron moves in a circular orbit at fixed distances from the nucleus.

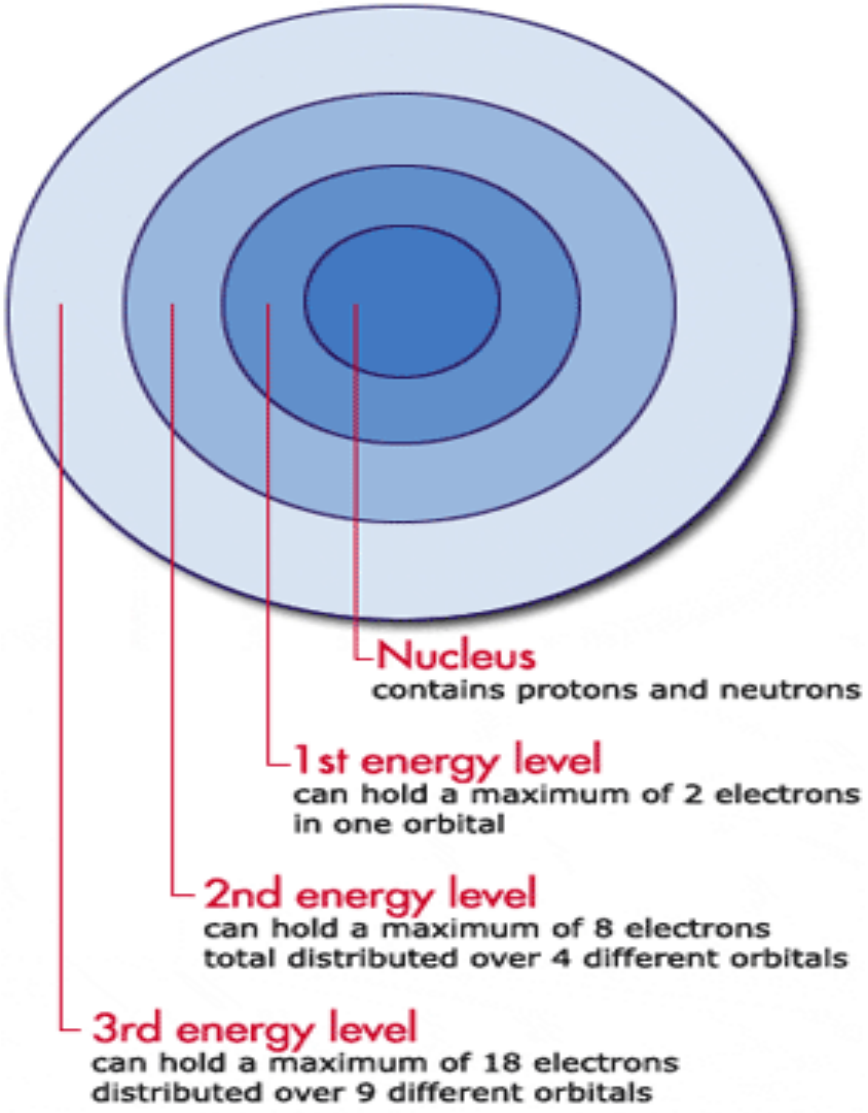


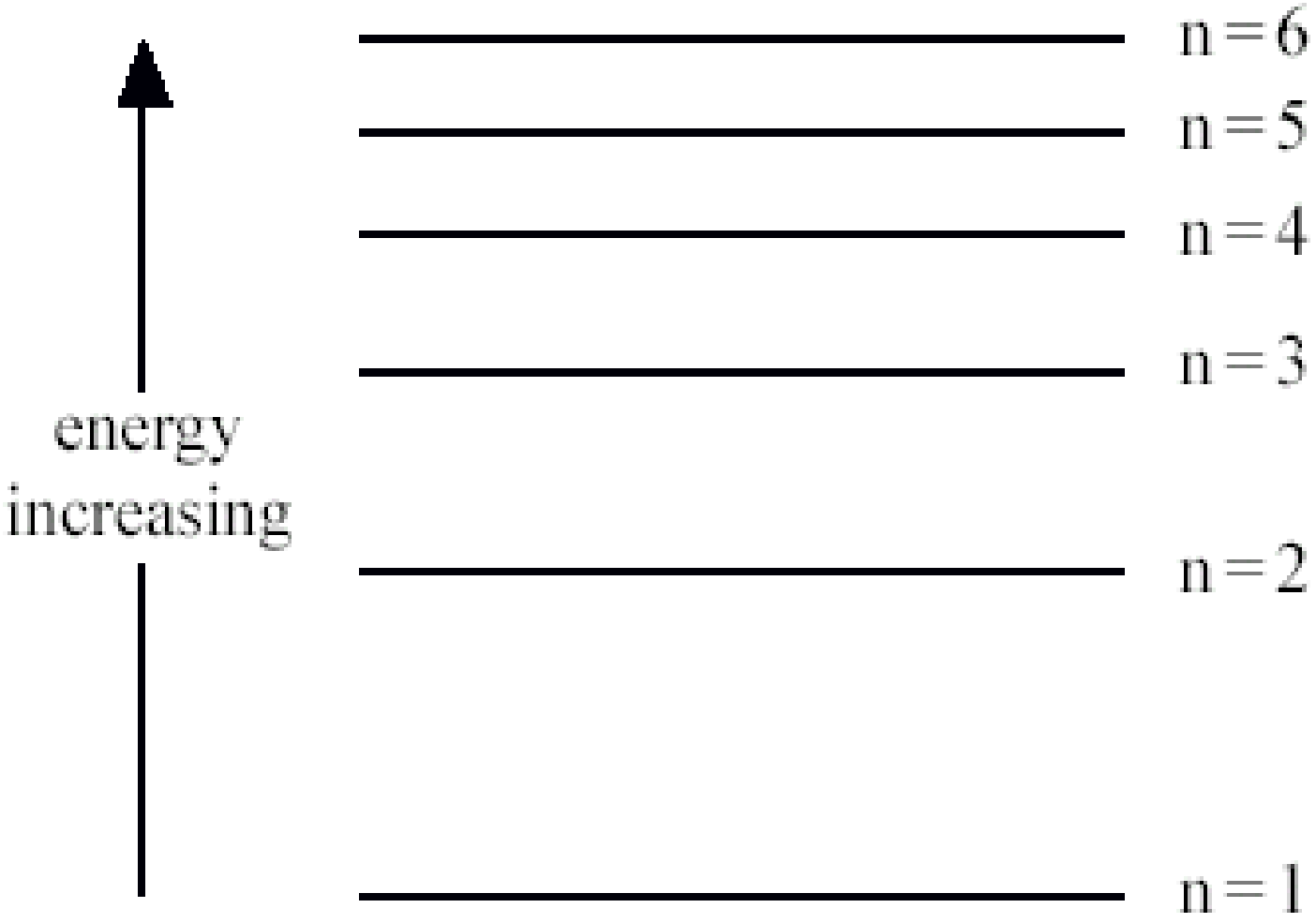
The Bohr Model

- **Bohr proposed that an electron is found only in specific circular paths, or orbits, around the nucleus.**
- **Each orbit has a fixed energy. These fixed energies an electron can have are called energy levels.**

- These ladder steps are somewhat like energy levels.
- The higher an electron is on the energy ladder, the farther it is from the nucleus.
- quantum of energy is the amount of energy required to move an electron from one energy level to another energy level.

- To move from one energy level to another an electron must gain or lose just the right amount of energy.
- The higher an electron is on the energy ladder, the farther from the nucleus.





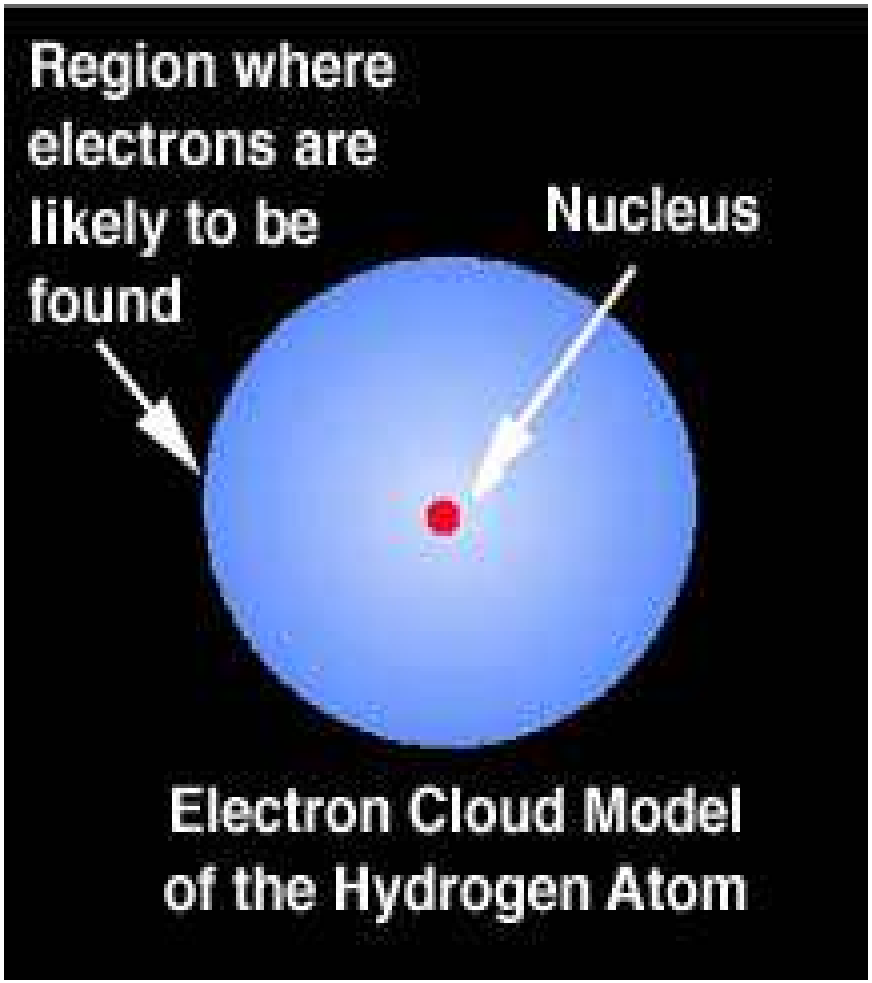
Nucleus

The Bohr Model

- The Bohr model establishes the concept of definite electron energy levels within atoms. But Bohr's model was rather simplistic and as scientists made more discoveries about more complex atoms, Bohr's model was modified and eventually was replaced by more sophisticated models.

Models Of the Atom

- 1926- Erwin Schrodinger develops mathematical equations to describe the motion of electrons in atoms. His work leads to the electron cloud model.



The Quantum Mechanical Model

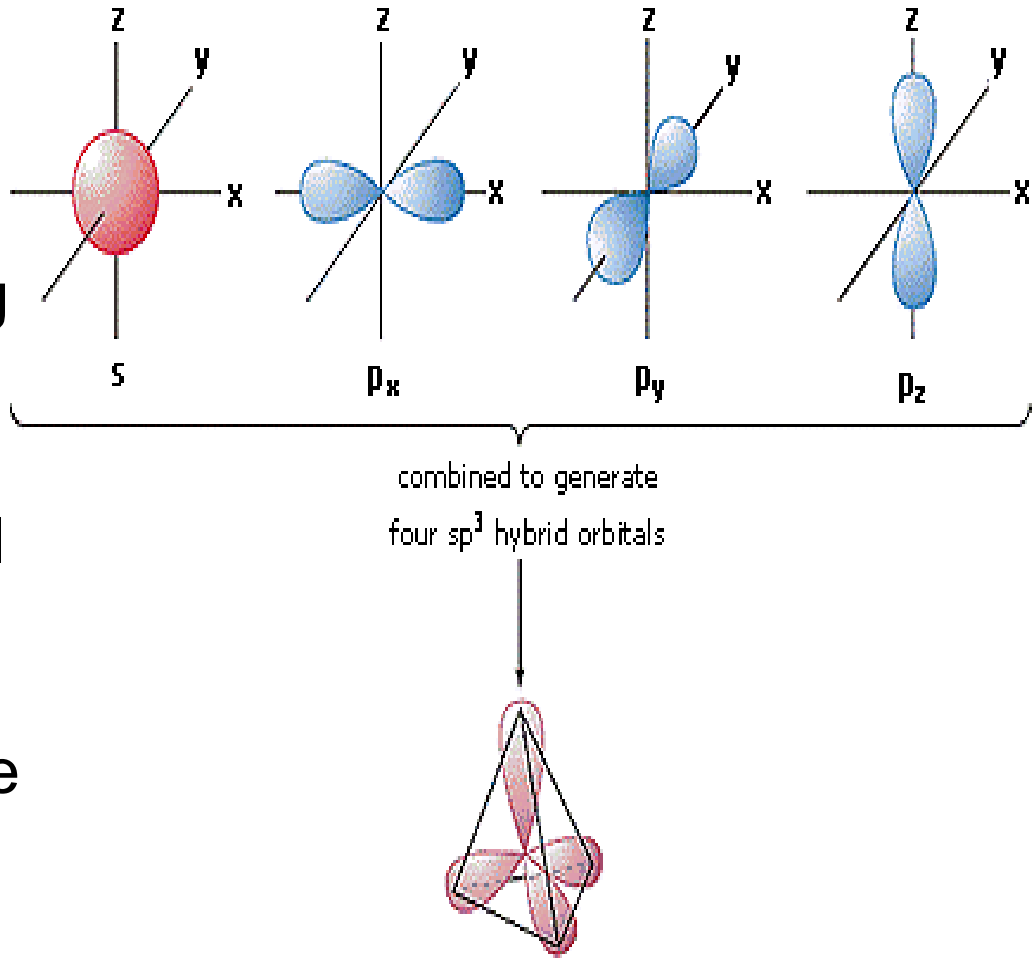
- The modern description of the electrons in atoms, the Quantum Mechanical Model, comes from the mathematical solutions to the Schrodinger equation.
- Like the Bohr model, the quantum mechanical model of the atom restricts the energy of electrons to certain values.
- Unlike the Bohr model, however, the QMM does not involve an exact path the electron takes around the nucleus.

Key Concept!!!

- The Quantum Mechanical model determines the allowed energies an electron can have and how likely it is to find the electron in various locations around the nucleus.

Atomic Orbitals

- An atomic orbital is often thought of as a region of space in which there is a high probability of finding an electron.
- Each energy level corresponds to an orbital of a different shape, which describes where the electron is likely to be found.



Atomic Orbitals Cont…

- The numbers and kinds of atomic orbitals depend on the energy sublevel.
- The lowest principal energy level (n=1) has only one sublevel, called 1s.
- The second level (n=2) has two sublevels, 2s and 2p. Thus, the second energy level has four orbitals: 2s, $2p_x$,$2p_y$,$2p_z$.
- The third level (n=3) has three sublevels, 3s,3p and 3d. Thus the third energy level has nine orbitals: one 3s, three 3p, and five 3d.
- The fourth level (n=4) has four sublevels, 4s,4p,4d, and 4f. Thus the fourth energy level has 16 orbitals: one 4s, three 4p, five 4d, and seven 4f orbitals.

Maximum # of Electrons

- Energy level nMax. # of electrons
- 12
- 28
- 318
- 432

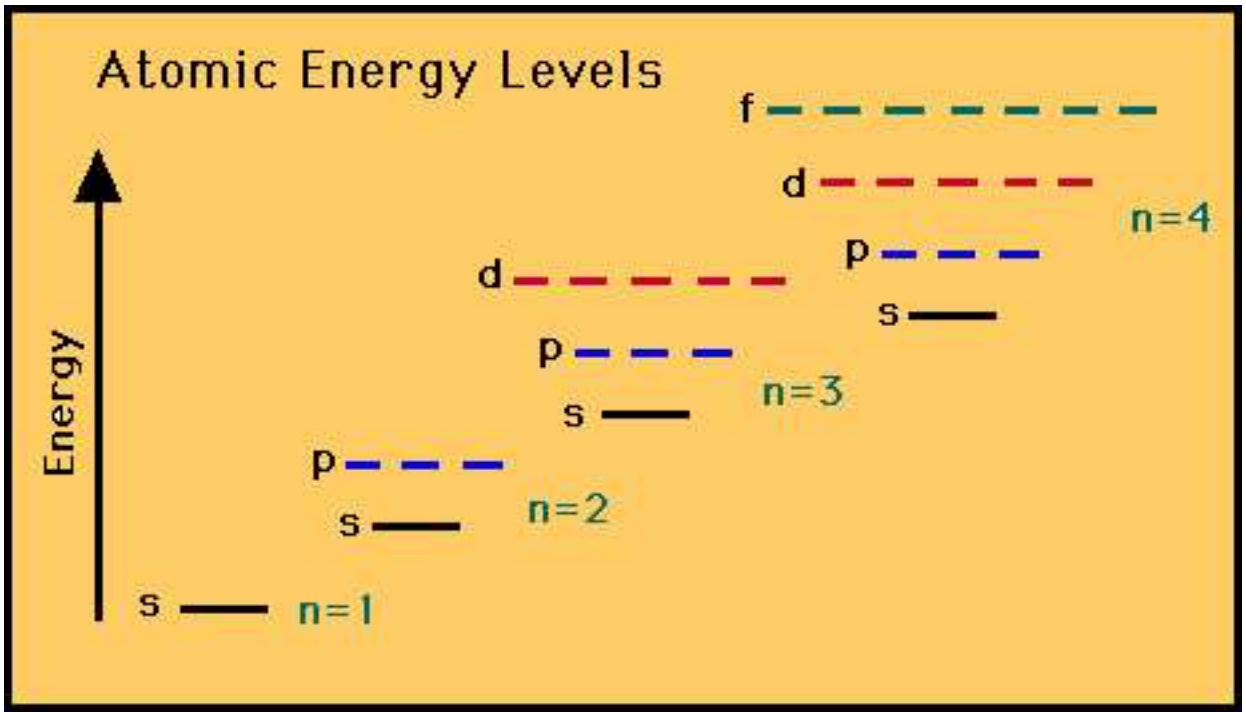
5.2 Electron Arrangement in Atoms

- The ways in which electrons are arranged in various orbitals around the nuclei of atoms are called electron configurations.

- Three Rules- the Aufbau Principle, the Pauli exclusion principle, and Hund's rule- tell you how to find the electron configurations of atoms.

Aufbau Principle

- Electrons occupy the orbitals of lowest energy first.



Pauli Exclusion Principle

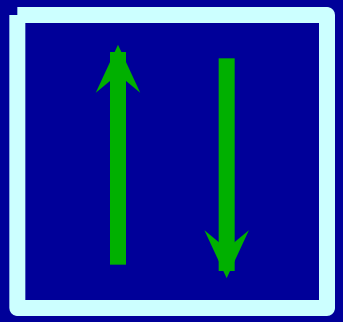
- An atomic orbital may describe at most two electrons.
  - For example, either one or two electrons can occupy an s or p orbital. To occupy the same orbital, two electrons must have opposite spins; that is, the electron spins must be paired.

The Helium 1s orbital

The Hydrogen 1s orbital

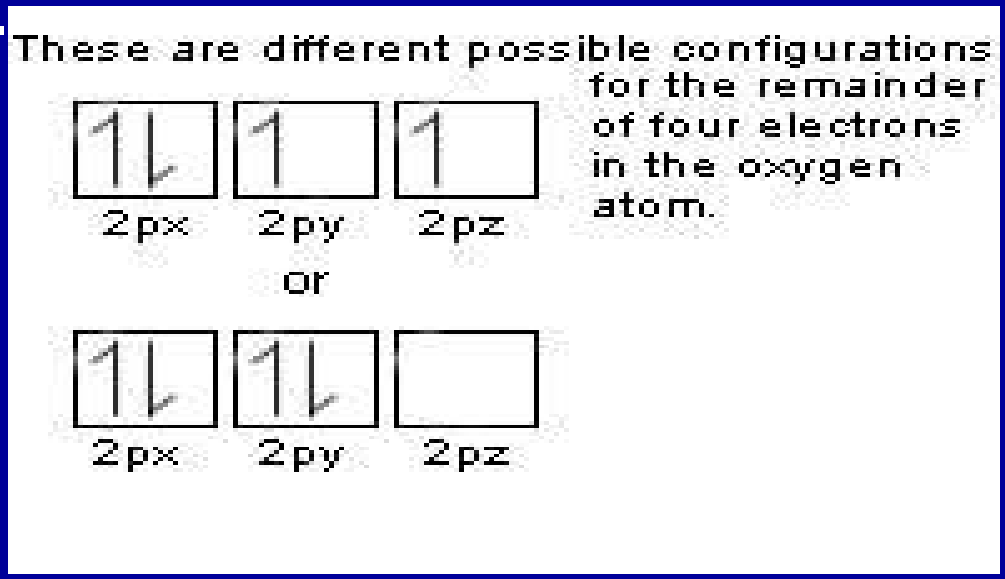
A. General Rules

- **Pauli Exclusion Principle**
  - Each orbital can hold TWO electrons with opposite spins.



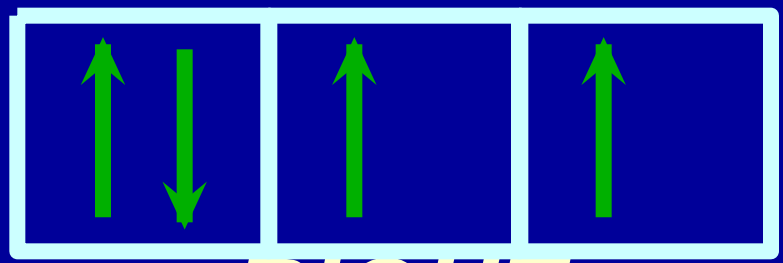
Hund's Rule

- Electrons occupy orbitals of the same energy in a way that makes the number of electrons with the same spin direction as large as possible.



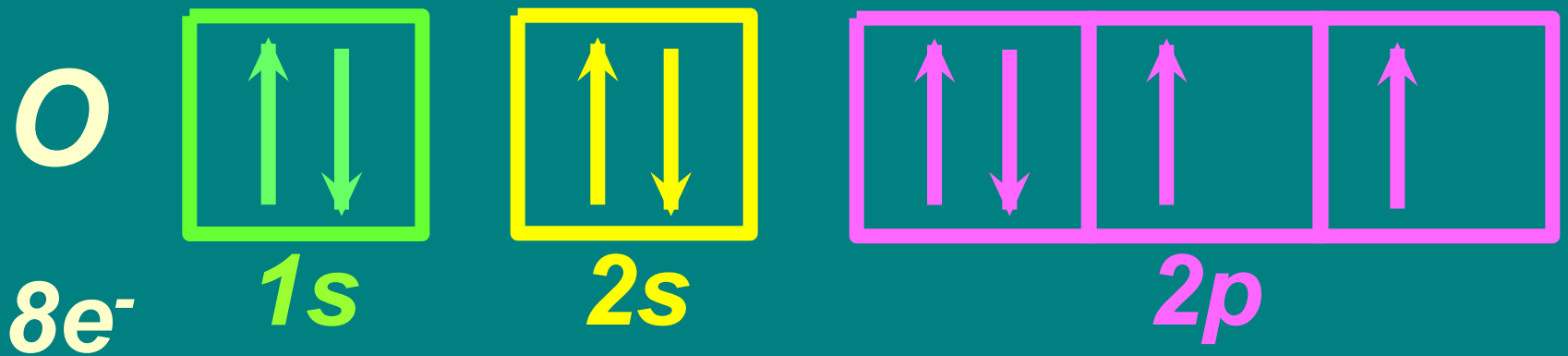
A. General Rules

- **Hund's Rule**
  - Within a sublevel, place one e^- per orbital before pairing them.
  - "Empty Bus Seat Rule"



B. Notation

- **Orbital Diagram**



- ***Electron Configuration***

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

B. Notation

- **Longhand Configuration**

$S\ 16e^-\ 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4$

Core Electrons — Valence Electrons

- ***Shorthand Configuration***

$S16e^-[Ne]\ 3s^2\ 3p^4$

C. Periodic Patterns

- **Example -** Hydrogen

$1s^1$ ← 1st column of s-block

1st Period

s-block

Practice, Practice, Practice!!!

- Write the electron configurations for each atom.
- **Carbon**
- **Argon**
- **Nickel**