Chapter 5—Electrons in Atoms

- Who is Niels Bohr?
- Niels Bohr studied the behavior of electrons
  - –He proposed the Bohr model
  - –In his model all of the electrons circled the nucleus in set paths, much like the planets orbit the sun.
  - –An analogy of his model is like the rungs/steps on a ladder. You cannot be in between rungs/steps since you can't stand in the middle.
  - –In Bohr's atomic model, electrons could not occupy space between orbitals.

Bohr Model and Electrons

– Where can electrons be found?

–All electrons can be found in energy levels

–These are also called shells

–The energy levels are numbered starting with number 1

–The main energy level is also referred to as the principal quantum number

–Each energy level is a different distance from the nucleus

–Electrons with the greatest energy are found farthest from the nucleus

Bohr Model and Electrons

- Lower number energy levels indicate lower energy electrons—higher numbers indicate more energy in the electrons
- What is the capacity of each energy level?
    - Energy Level 1---2 electrons
    - Energy Level 2---8 electrons
    - Energy Level 3---18 electrons
    - Energy Level 4---32 electrons
- Electrons fill the orbitals from the lowest energy level to the highest energy level
- This means they start at the center and work their way farther and farther out

Bohr Model and Electrons

– Electrons fill up energy levels starting with Level 1

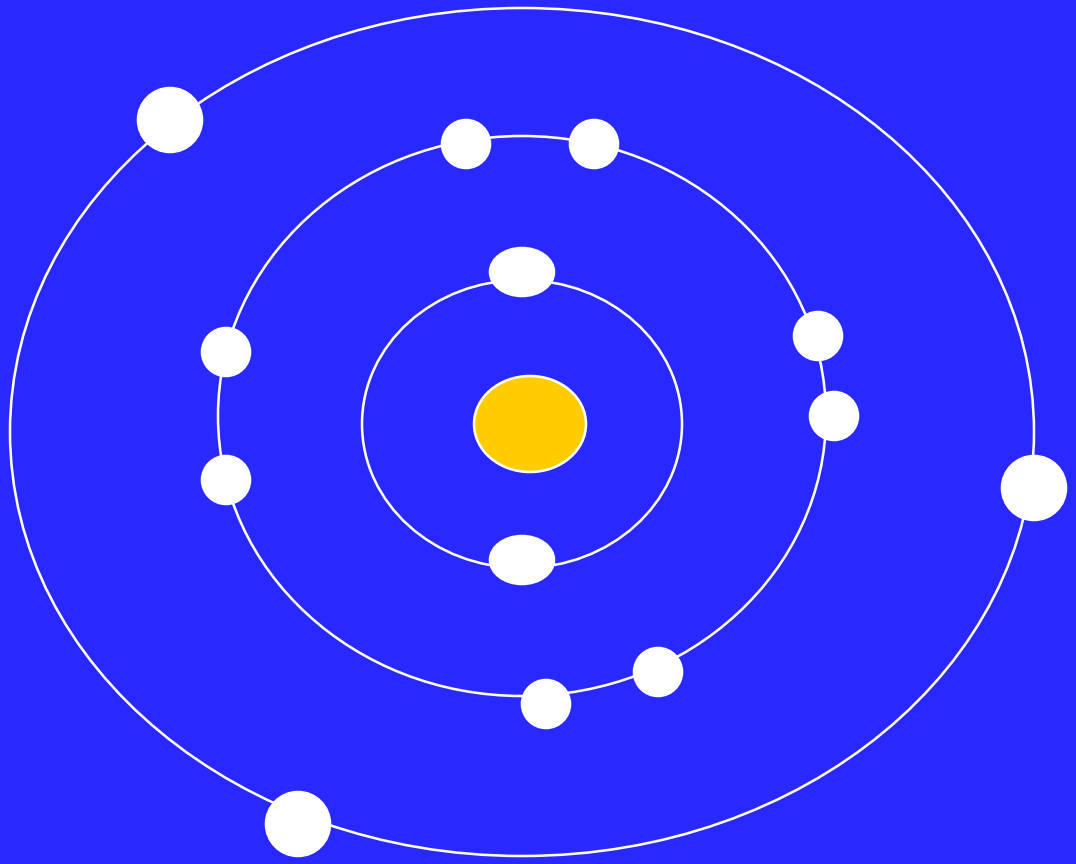
–Level 1 has the lowest energy

–The farther out you go the higher the energy in that level

–Does energy level 2 or 3 have the most energy?

three

Bohr Model



Can you identify which element is represented?

Electrons in an atom—**valence electrons**

- What are Valence Electrons?
  - –The outermost energy level has a special name called the valence
- How can you use the PT to determine the number of valence electrons?
  - –You can easily determine how many valence electrons an atom has by using the group number on the PT
  - –Ex: All elements in group 1A have 1 valence electron, Group 2A have 2 valence electrons, Group 3A have 3 valence electrons, Group 4A have 4 valence electrons, etc.

Valence electrons

- Mini quiz
  - –How many valence electrons do the elements in Group 5A have?
    - 5
  - –How many valence electrons do the elements in group 8A have?
    - 8
  - –How many valence electrons do the elements in Group 6A have?
    - 6

How are electrons arranged in an atom?

- Can electrons change energy levels?
  - –Electrons can "jump" to higher energy levels if they gain energy

  What is one way that atoms gain energy?
    - Heating
  - –Electrons can move to lower energy levels by losing energy
  - –Atoms lose energy by cooling
  - –The smallest amount of energy an atom can gain or lose is called a quantum.
  - –A photon is a tiny piece of electromagnetic radiation that carries a quantum of energy.

Valence Electrons

- What else should I know about Valence Electrons?
  - 8 is a magic number for atoms
  - When atoms have 8 electrons in their last energy level we say that the atom has an "octet"
  - We can also say that the level is "full" and that the atom is "stable"
  - All atoms are stable if there is an octet in the last energy level, even if that level is not at capacity
  - So for an atom's condition:

    stable= has octet = "full" energy level

Valence Electrons

- How do atoms use their valence electrons?
  - –Atoms WANT to be stable
  - –So they have come up with a system to "adjust" themselves to reach the "magic number 8"
  - –Atoms in groups 1A-3A will give up their valence electrons
  - –Atoms in groups 6A and 7A will add-on electrons to reach the magic 8
  - –Atoms in groups 4A and 5A will try to share electrons with another atom to get 8

Lewis Dot Diagrams

- What is a Lewis Dot Diagram?
  - –A scientist named Lewis came up with a shortened way to draw an element and its valence electrons
  - –The chemical symbol is written and one "dot" is used to represent each valence electron
    - Ex: Hydrogen is shown

H•

Carbon is shown

Electron Configuration

- It was discovered that INSIDE the main energy levels that Bohr proposed there were SUBLEVELS
- What are the 4 commonly used sublevels?
- Each sublevel is identified by a letter: *s, p, d, f*
- Each sublevel contains a different number of orbitals
- What is an orbital?
- Orbital = three dimensional region around the nucleus that indicates the probable location of an electron
- Orbitals hold only 2 electrons

Electron Configuration

- *s* sublevel
  - –It has 1 orbital that can hold 2 electrons
  - –It has a shape like a sphere or ball
- *p* sublevel
  - –There are 3 orbitals in a p sublevel
  - --Each holds 2 electrons
  - –Orbitals in a p sublevel are dumbbell shaped (kind of like a free weight)

Electron Configuration

- *d* sublevel
  - –Has 5 orbitals
  - –Each orbital holds 2 electrons
  - –Sometimes called "double dumbbell" shape and one is shaped like a dumbbell with a doughnut
- *f* sublevel
  - –Has 7 orbitals
  - –Each orbital holds 2 electrons
  - –Each orbital is shaped differently

Electron Configuration

- What does the main energy level number tell you?
- Principal quantum number for an electron AND how many sublevels it has

Ex.

- Energy level 1= 1 sublevel
- Sublevel = s
- Holds a total of 2 electrons
- Total number of electrons for energy level 1 is equal to 2

Electron Configuration

- Energy level 2 = 2 sublevels
- Sublevels = *s, p*
  - –s sublevel has 1 orbital (spherical) that holds 2 electrons
  - –p sublevel has 3 "dumbbell" shaped orbitals each with 2 electrons
  - – Total of 6 electrons in a full p sublevel
  - –Total number of electrons in energy level 2 = 2(s sublevel) + 6 (p sublevel) = 8 electrons

Electron Configuration

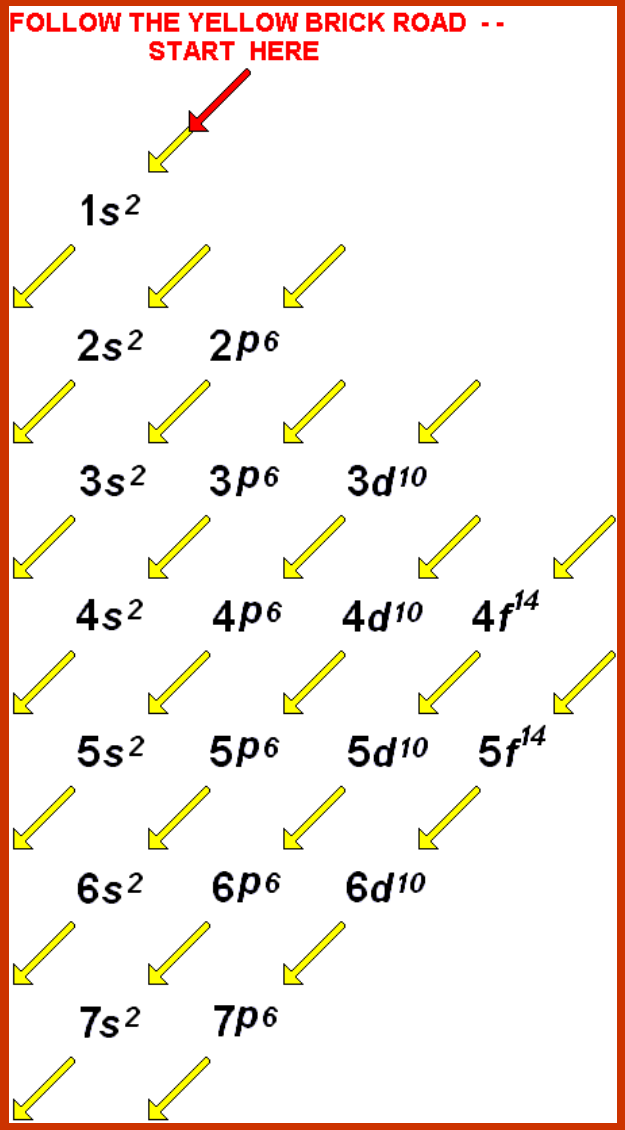
- Energy level 3 = 3 sublevels
- Sublevels = *s, p, d*
  - –s sublevel has 1 orbital (spherical) that holds 2 electrons
  - –p sublevel has 3 "dumbbell" shaped orbitals each with 2 electrons (total 6)
  - –d sublevel has 5 orbitals that hold 2 electrons
  - –Total of 10 electrons in d sublevel
- Total electrons in energy level 3 = 2 (s sublevel) + 6 (p sublevel) + 10 (d sublevel) = 18 electrons

Electron Configuration

- Energy level 4 = 4 sublevels
- Sublevels = *s, p, d, f*
  - –s sublevel has 1 orbital (spherical) that holds 2 electrons
  - –p sublevel has 3 "dumbbell" shaped orbitals each with 2 electrons (total 6)
  - –d sublevel has 5 orbitals (total 10)
  - –f sublevel with 7 different orbitals that hold 2 electrons each is 14 electrons
- Total electrons in energy level 4 = 2 (s sublevel) + 6 (p sublevel) + 10 (d sublevel) + 14 (f sublevel) = 32 electrons

Electron Configuration

- Notice that each main energy level contains the number of electrons that Bohr predicted
- The main energy levels have sublevels
- Sublevels contain specific numbers of orbitals
- Electrons fill these orbitals from the lowest energy slots out to the highest energy slots
- Notice that the order is not perfectly predictable



Electron Configuration

- Three rules or principles define how electrons can be arranged in an atom's orbitals
- Aufbau Principle—states that electrons occupy the lowest energy orbital available
  - In each main energy level the order from lowest to highest energy sublevel is *s, p, d, f*
- Sometimes main energy levels overlap—notice how the 4s sublevel is filled before the 3 d sublevel
- Hund's Rule-- states that all orbitals of the same sublevel get one electron each BEFORE electrons can go back an pair up (remember each orbital can hold 2e-)

Electron Configuration

- –Example: total strangers getting on a bus will choose to sit alone until there are no more empty rows—then they have to pair up

- Pauli Exclusion Principle—states that in each orbital one electron spins in one direction and the other electron spins in the opposite direction
  - –Example: one will spin clockwise and the other spins counterclockwise
- Electron configurations represent the most likely location for electrons in the ground state
- The ground state is the lowest energized state

Electron Configuration

- While doing his atomic research, Werner Heisenberg made his own discovery.
- He found that it was impossible to SIMULTANEOUSLY predict the position and speed of an electron
- They call this the Heisenberg Uncertainty Principle

Noble Gas Configuration

- What are two ways that can be used to write an electron configuration?
- You can write an electron configuration using numbers and orbital letters—OR–
- You can use ***Noble Gas Notation***.
- In Noble Gas Notation, you use the symbol for the noble gas that comes before the element, and only write the numbers and orbital letters for the electrons that are left. IT IS A SHORTCUT!
- Ex. Mg = $1s^2 2s^2 2p^6 3s^2$ OR

  = [Ne] $3s^2$