Atomic Orbitals

Objectives

1. To learn about the shapes of the *s*, *p* and *d* orbitals
2. To review the energy levels and orbitals of the wave mechanical model of the atom
3. To learn about electron spin

Atomic Orbitals

A. Electron Location

- Energy Level
  - Called principal energy levels
  - Corresponds to row on periodic table
  - As n increases, E increases and the electron is farther away from the nucleus

Atomic Orbitals

A. Electron Location

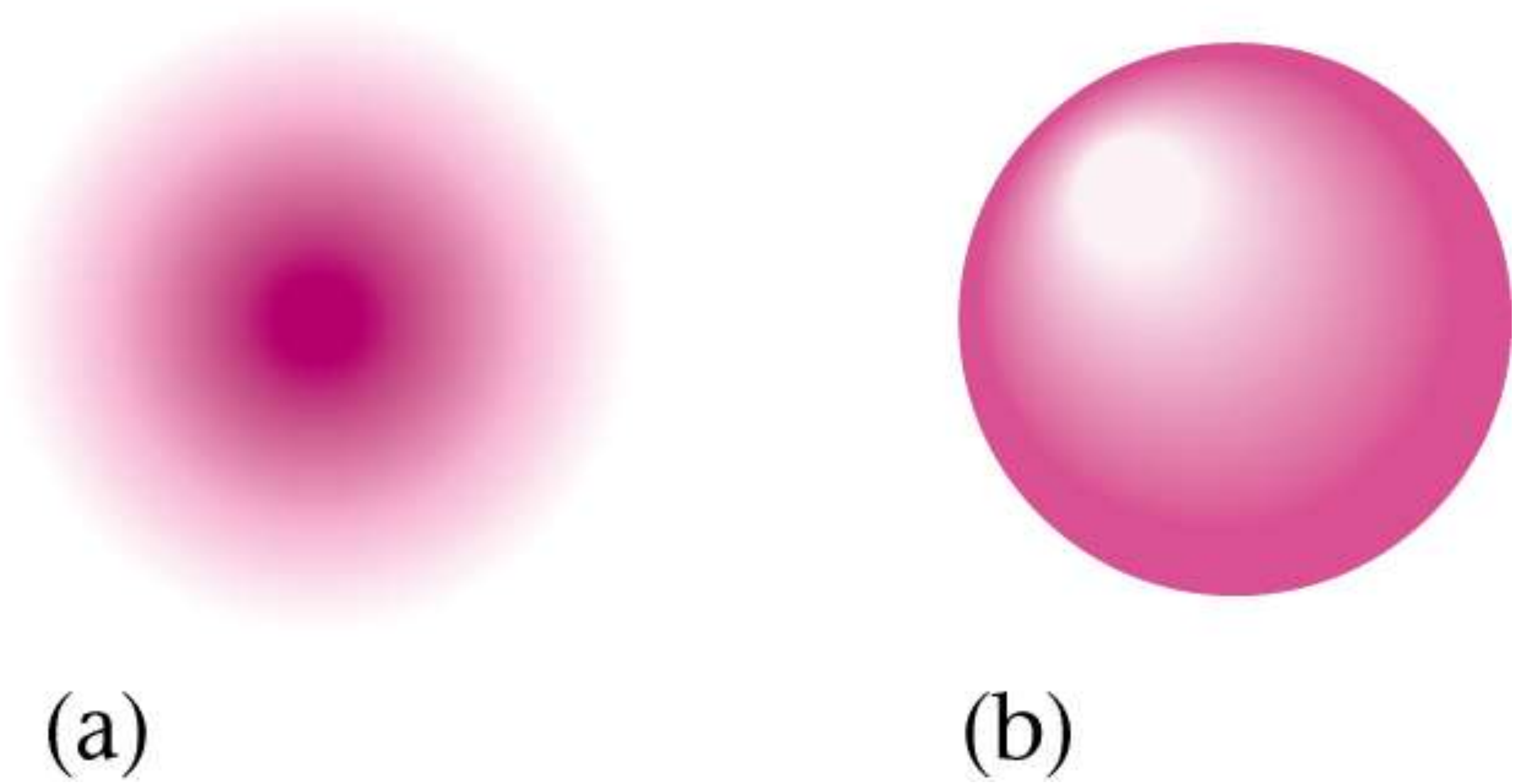
- Sublevel
  - Shape of electron cloud
    - s = spherical
    - p = dumbbell
    - d = too complex
    - f = too complex

    - 1st E level has 1 sublevel -- s
    - 2nd E level has 2 sublevels -- s and p
    - 3rd E level has 3 sublevels -- s, p, and d
    - 4th E level has 4 sublevels -- s, p, d and f

Atomic Orbitals

S Sublevel

- Orbitals do not have sharp boundaries.



Atomic Orbitals

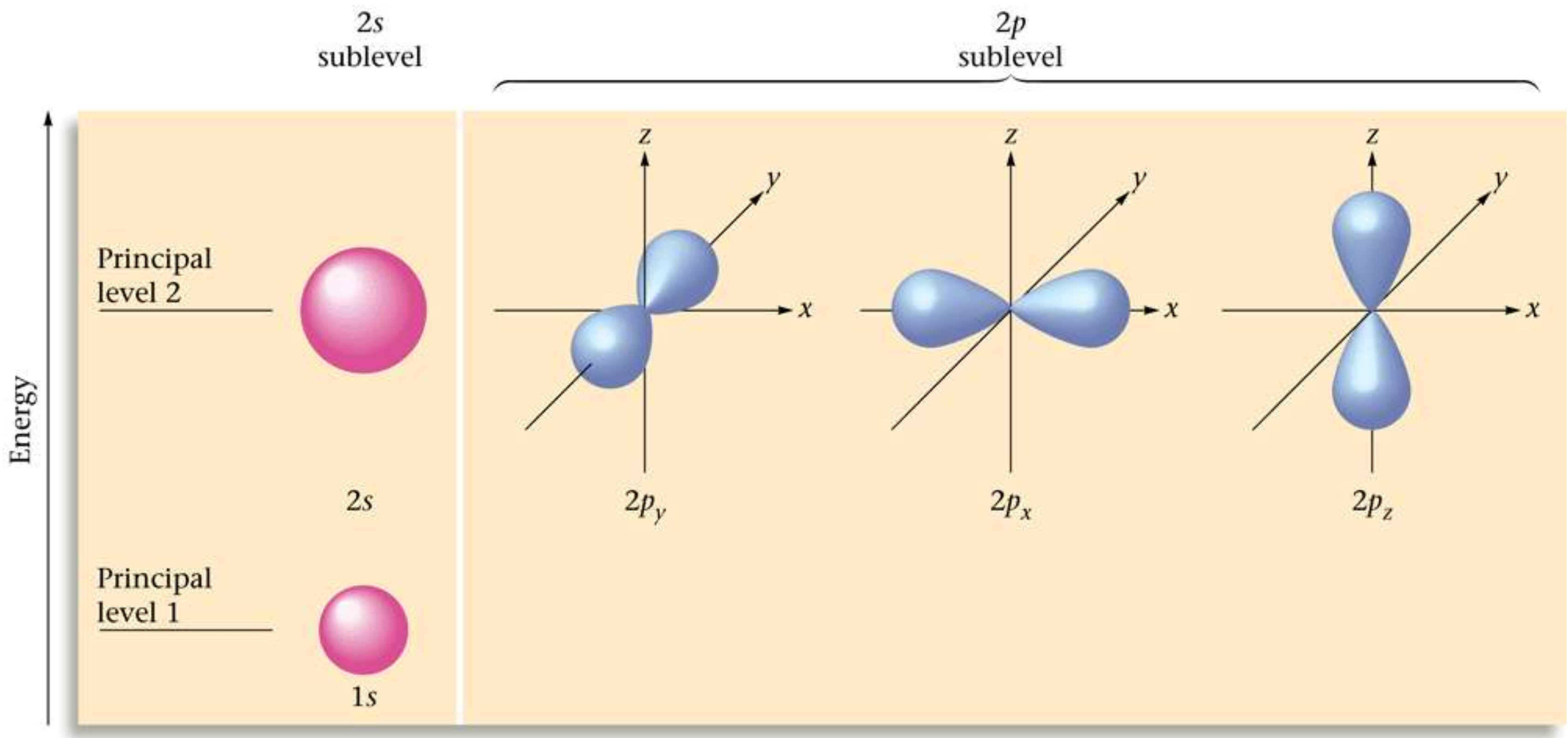
A. Electron Location

- Orbitals
  - Describes the orientation in space within a sublevel
    - s = 1 orbital
    - p = 3 orbitals
    - d = 5 orbitals
    - f = 7 orbitals

ONLY **2** electrons in any orbital!!!

Atomic Orbitals

- The *s* and *p* types of sublevel



Atomic Orbitals

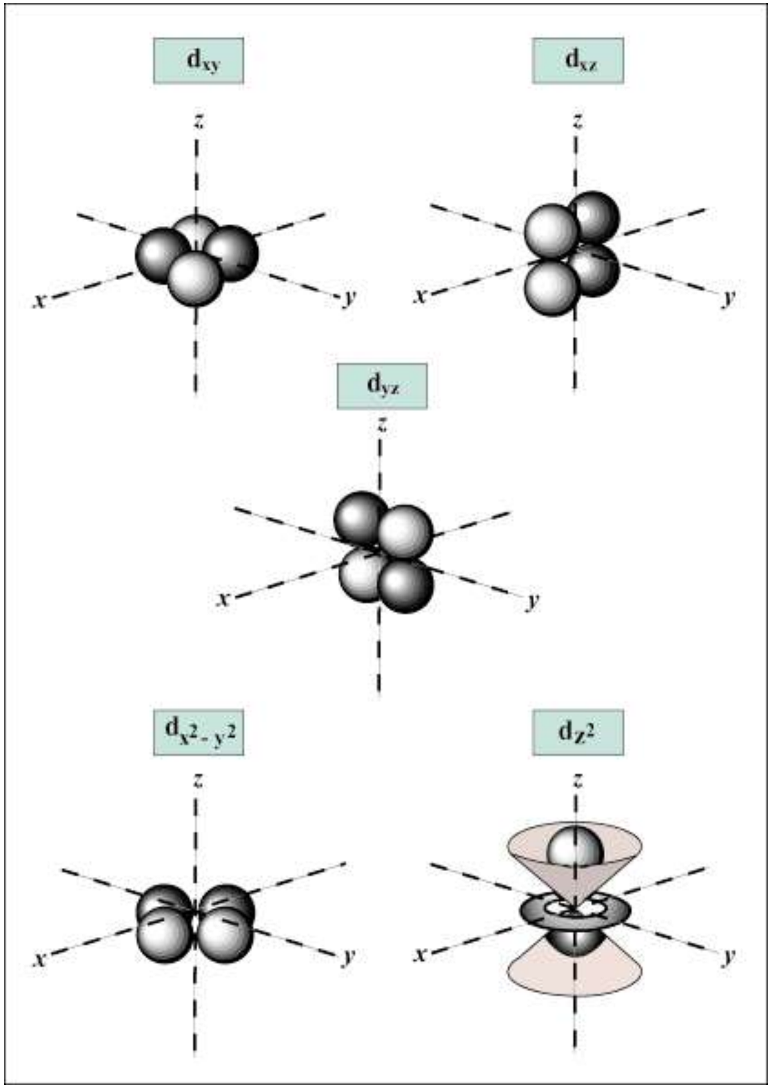
A. Electron Location

- Spin
  - Electrons in the same orbital must have opposite spins. One spins clockwise and the other spins counter-clockwise. (+1/2, or -1/2)

ONLY **2** electrons in any orbital!!!

Atomic Orbitals

d - orbitals



Atomic Orbitals

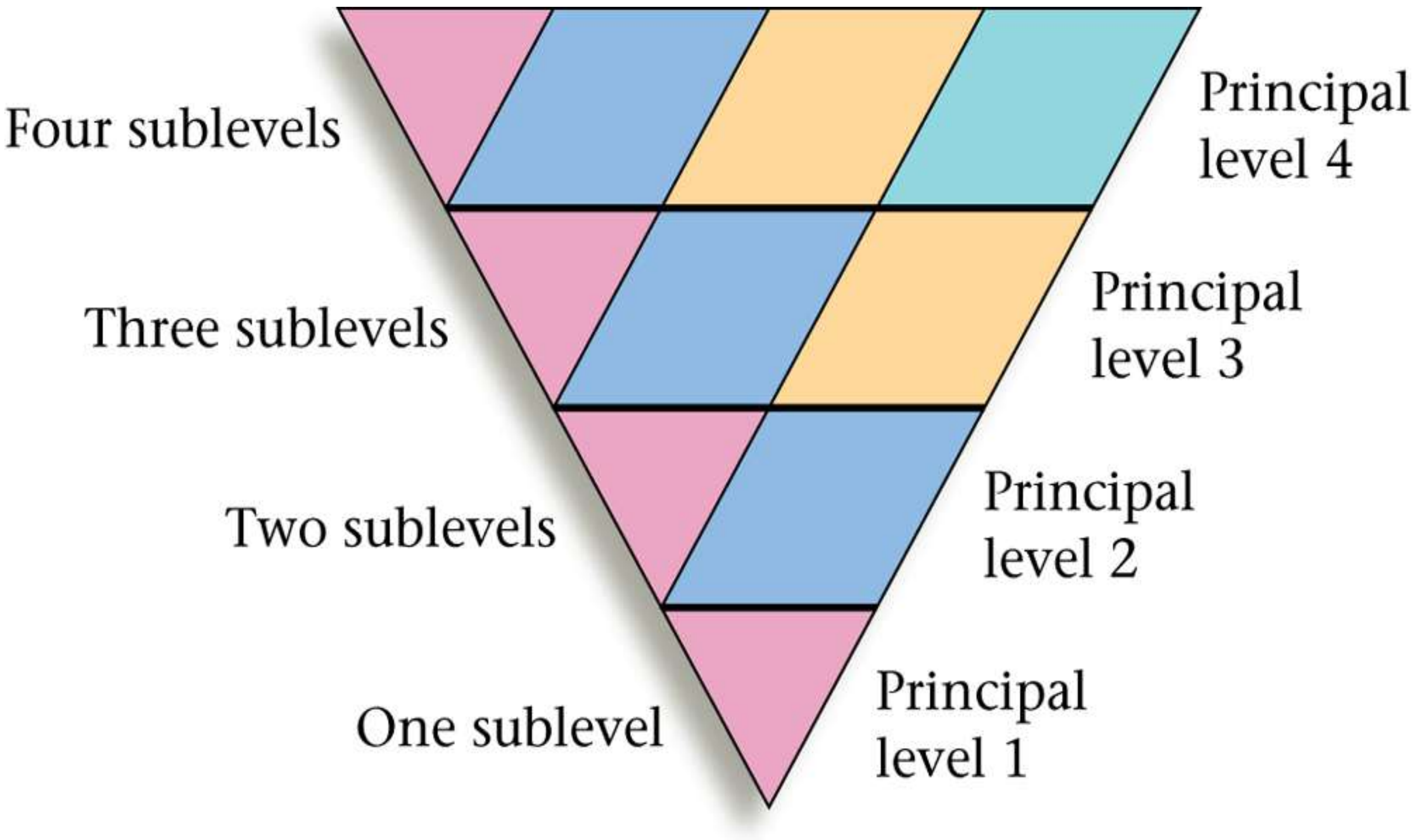
What is the maximum number of electrons found in each of the following?

- 2p orbital ______
- 2p sublevel ______
- 4p sublevel ______
- 3d orbital ________
- E level 1 ________
- E level 3 ________
- any f sublevel ________
- 4s orbital _________
- 2d orbital_________

Atomic Orbitals

Energy Level	# of Sublevels	Total # e / E Level

Atomic Orbitals



Electron Configuration

The way in which electrons are arranged around the nucleus according to energy specifications.

Electron Configuration

Three rules that dictate how electrons are arranged.

1. Aufbau Principle - electrons enter orbitals of lowest energy first. See diagonal chart or periodic table.

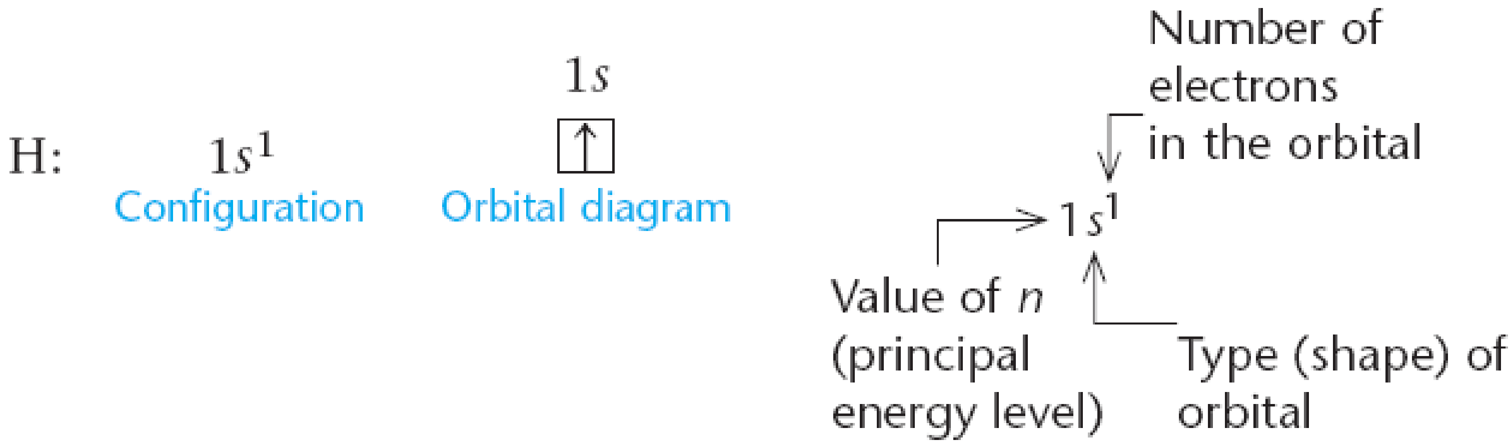
Electrons do not fill in orbitals in consecutive numerical order.

Electron Configuration

2. Pauli Exclusion Principle - an atomic orbital can hold a maximum of 2 electrons and those 2 electrons must have opposite spins

Electron Configuration

Orbital diagram – orbital is a box grouped by sublevel containing arrow(s) to represent electrons



Electron Configuration

3. Hund's Rule - When electrons occupy orbitals of equal energy (same sublevel), one electron enters each orbital with parallel spin before pairing oppositely.

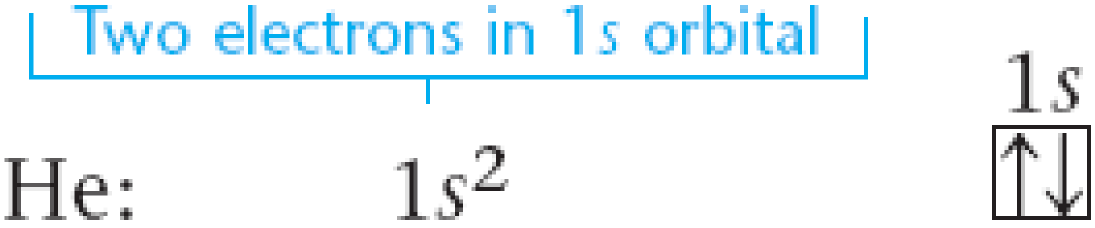
Example: a 2p sublevel with 3 electrons

a 3d sublevel with 8 electrons

Atomic Orbitals

He atom

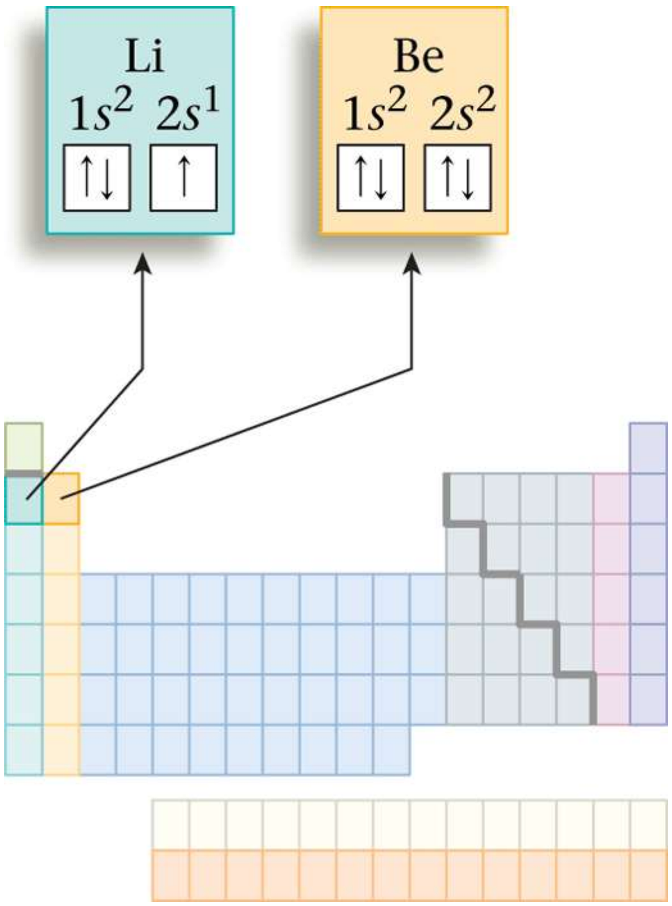
- Electron configuration– $1s^2$
- Orbital diagram



Atomic Orbitals

Li atom

- Electron configuration– $1s^2\ 2s^1$
- Orbital diagram



A. Electron Arrangements in the First 18 Atoms on the Periodic Table

H $1s^1$							He $1s^2$
Li $2s^1$	Be $2s^2$	B $2p^1$	C $2p^2$	N $2p^3$	O $2p^4$	F $2p^5$	Ne $2p^6$
Na $3s^1$	Mg $3s^2$	Al $3p^1$	Si $3p^2$	P $3p^3$	S $3p^4$	Cl $3p^5$	Ar $3p^6$

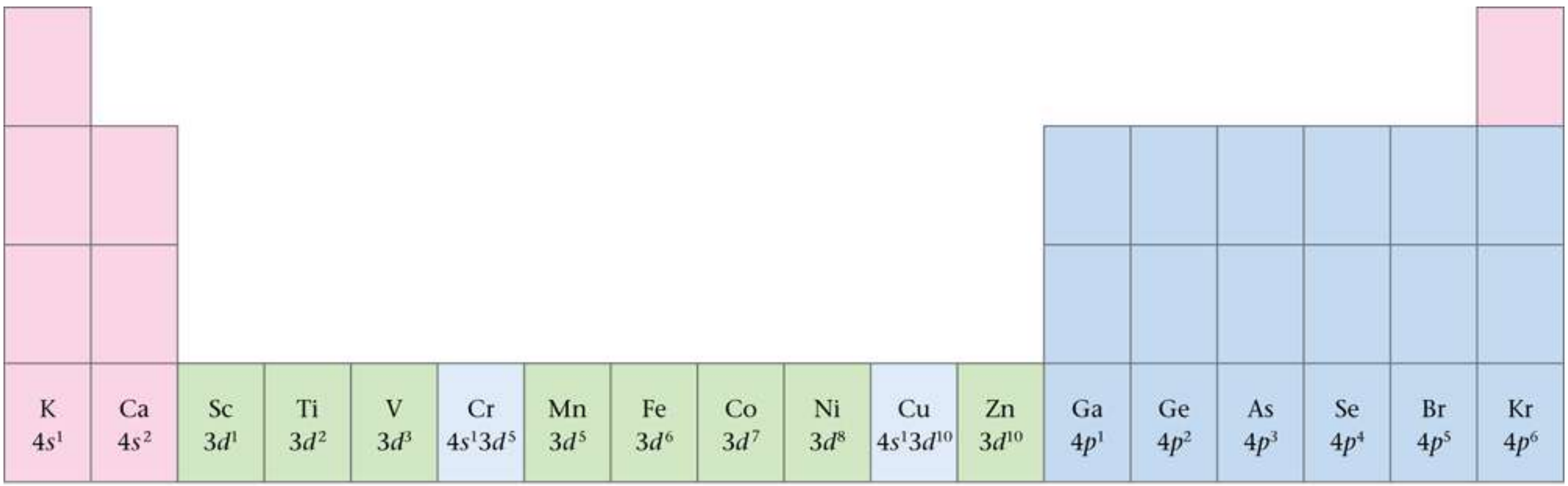
A. Electron Arrangements in the First 18 Atoms on the Periodic Table

Classifying Electrons

- Valence electrons – electrons in the outermost (highest) principal energy level of an atom
- Core electrons – inner electrons
- Elements with the same valence electron arrangement show very similar chemical behavior.

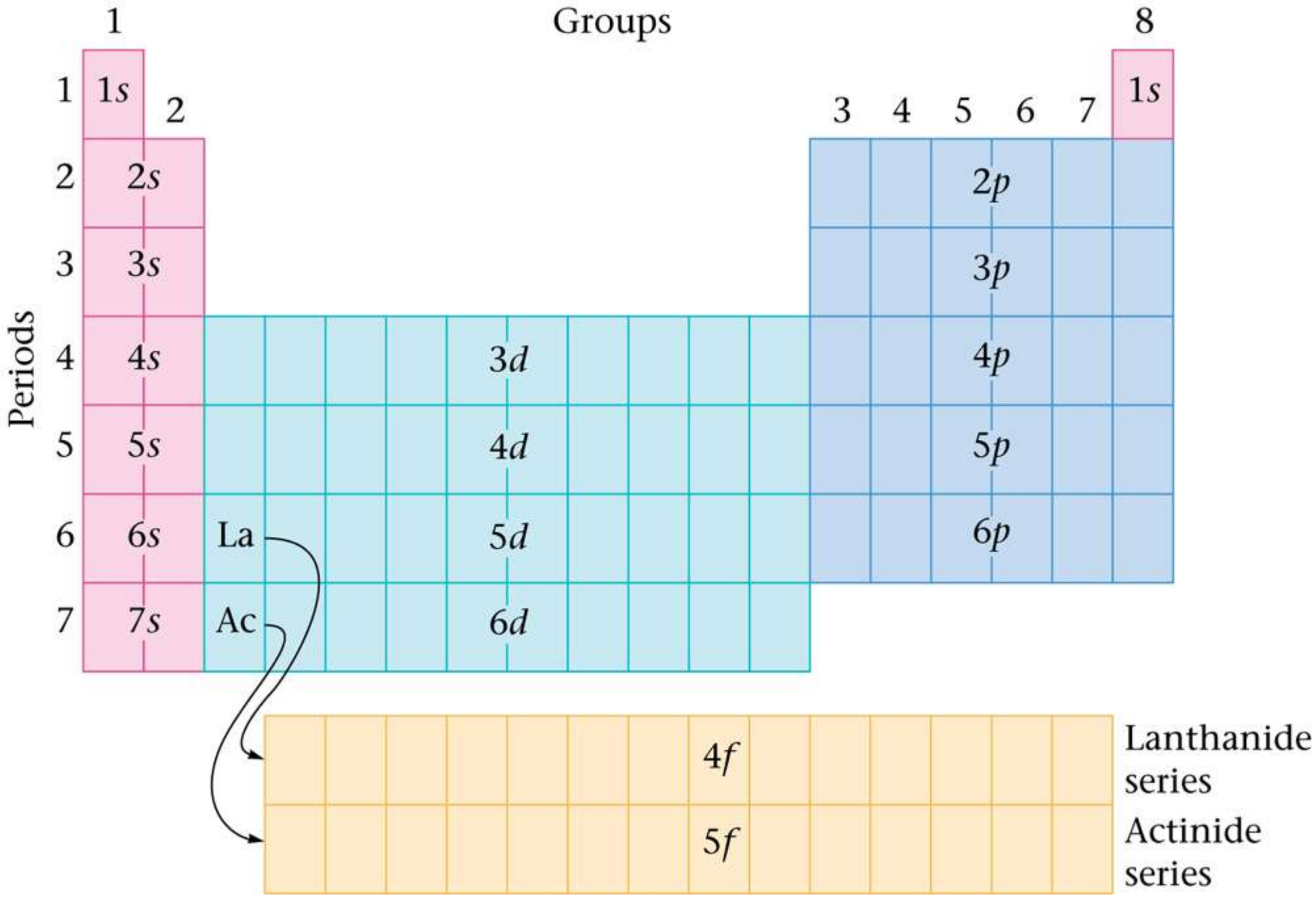
B. Electron Configurations and the Periodic Table

- Look at electron configurations for K through Kr



B. Electron Configurations and the Periodic Table

- Orbital filling and the periodic table



B. Electron Configurations and the Periodic Table

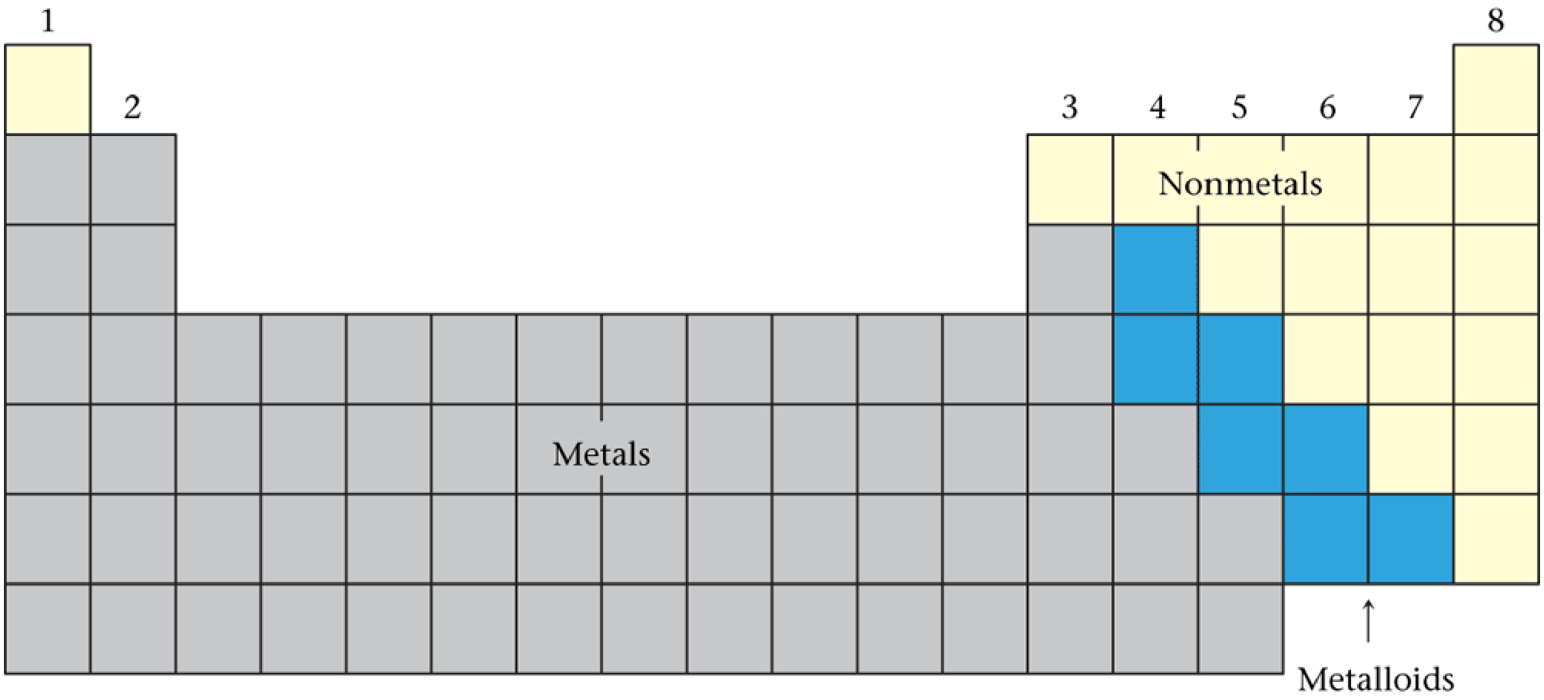
Periodic Table and Electron Configurations

1. The group labels for Groups 1, 2, 3, 4, 5, 6, 7, and 8 indicate the *total number* of valence electrons for the atoms in these groups. For example, all the elements in Group 5 have the configuration ns^2np^3. (Any *d* electrons present are always in the next lower principal energy level than the valence electrons and so are not counted as valence electrons.)
2. The elements in Groups 1, 2, 3, 4, 5, 6, 7, and 8 are often called the **main-group elements**, or **representative elements**. Remember that every member of a given group (except for helium) has the same valence-electron configuration, except that the electrons are in different principal energy levels.

C. Atomic Properties and the Periodic Table

Metals and Nonmetals

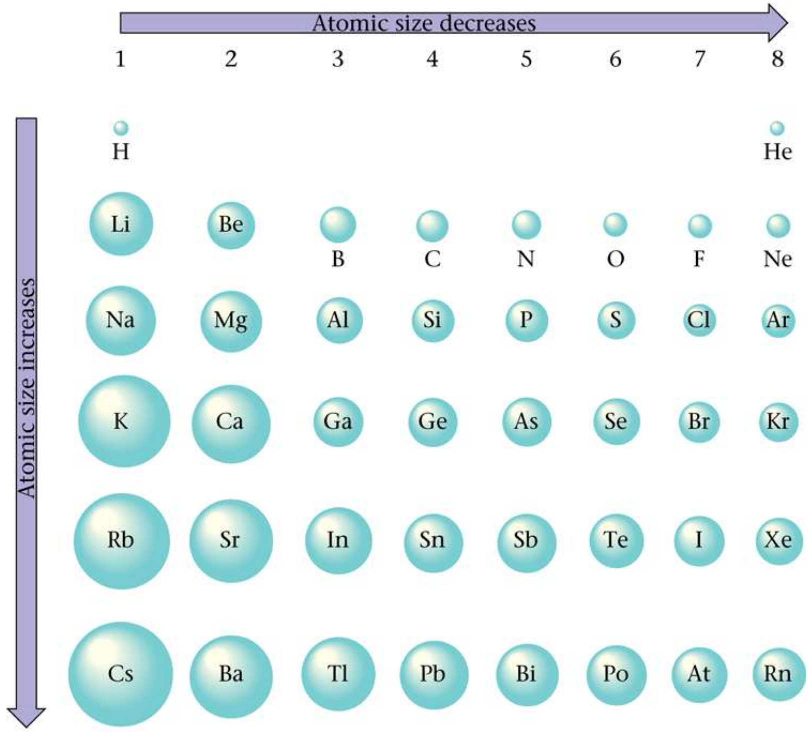
- Metals tend to lose electrons to form positive ions.
- Nonmetals tend to gain electrons to form negative ions.



C. Atomic Properties and the Periodic Table

Atomic Size

- Size tends to increase down a column. Why?
- Size tends to decrease across a row. Why?



C. Atomic Properties and the Periodic Table

Atomic size

Which is smaller?

C. Atomic Properties and the Periodic Table

Ion size

Cations – are smaller than their corresponding neutral atom

Ca or Ca^{+2}

Li^{+1} or Li

Anions – are larger than their corresponding neutral atom

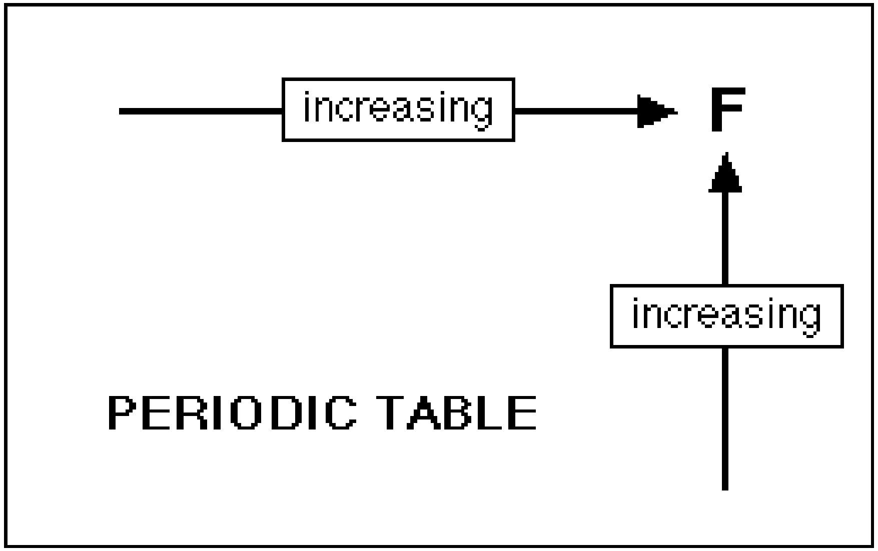
Br^{-1} or Br

S or S^{-2}

C. Atomic Properties and the Periodic Table

Ionization Energies

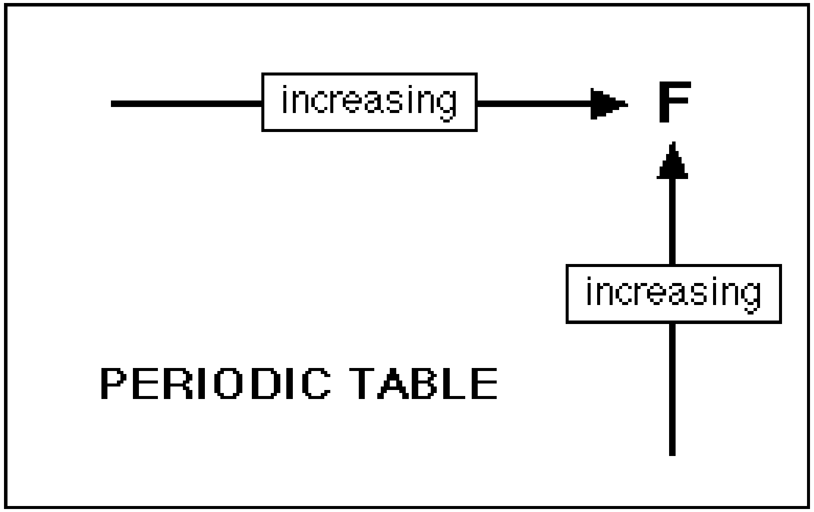
- Ionization Energy – energy required to remove an electron from an individual atom (gas)



  - Tends to decrease down a column
  - Tends to increase across a row

C. Atomic Properties and the Periodic Table

Electronegativity – tendency for an atom to attract electrons to itself when bonded to another element



- Tends to decrease down a column
- Tends to increase across a row

C. Atomic Properties and the Periodic Table

Lewis Dot Structure – shows the valence electrons for an element