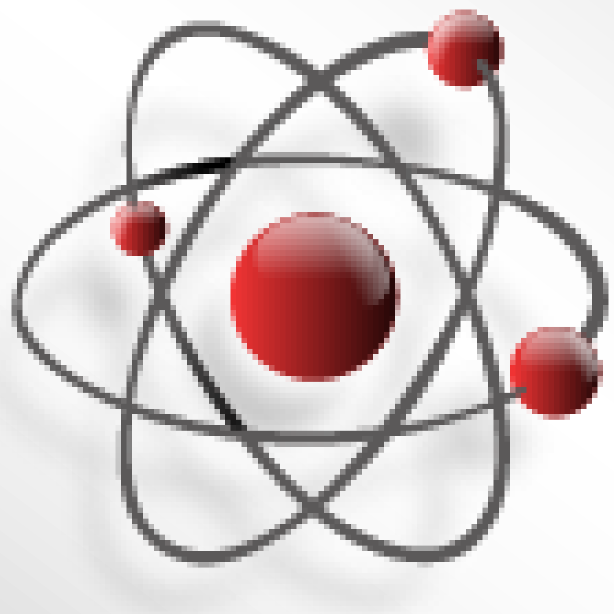
Electron Configuration



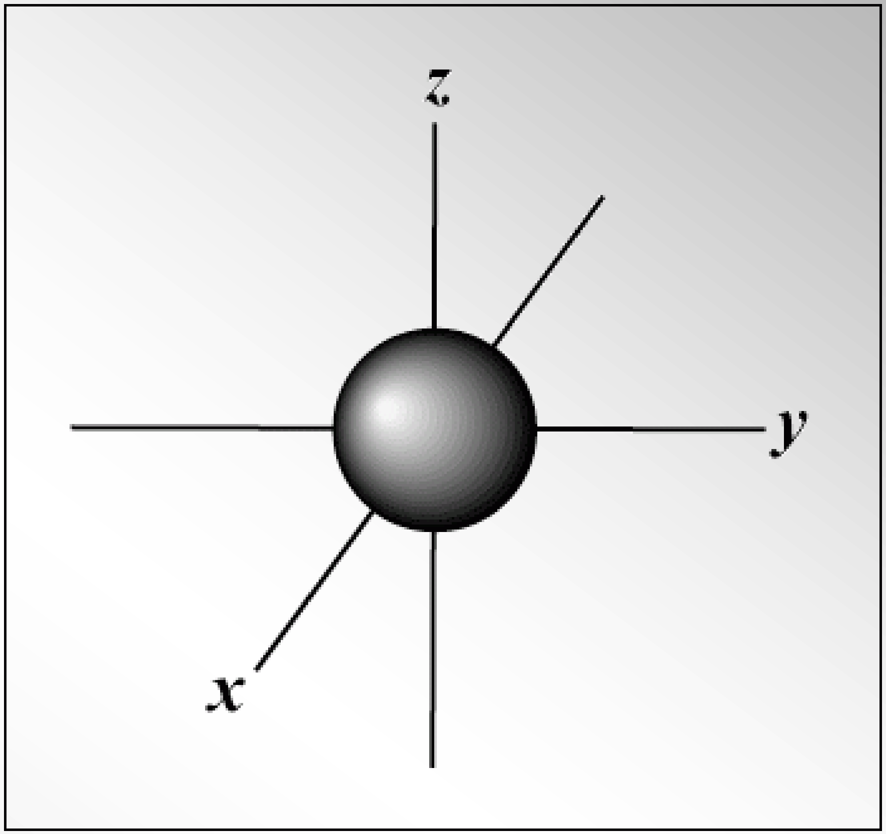
Orbitals

- Remember that orbitals simply represent an area where the electron is most likely to be found.
- Formally, orbitals are defined using four quantum numbers
- Orbitals have particular shapes, and not all of them are “spherical”.
  - In chemistry, there are four common orbital shapes known respectively as s, p, d, and f orbitals.
  - Each shape within an orbital can **<u>hold at most two electrons</u>**

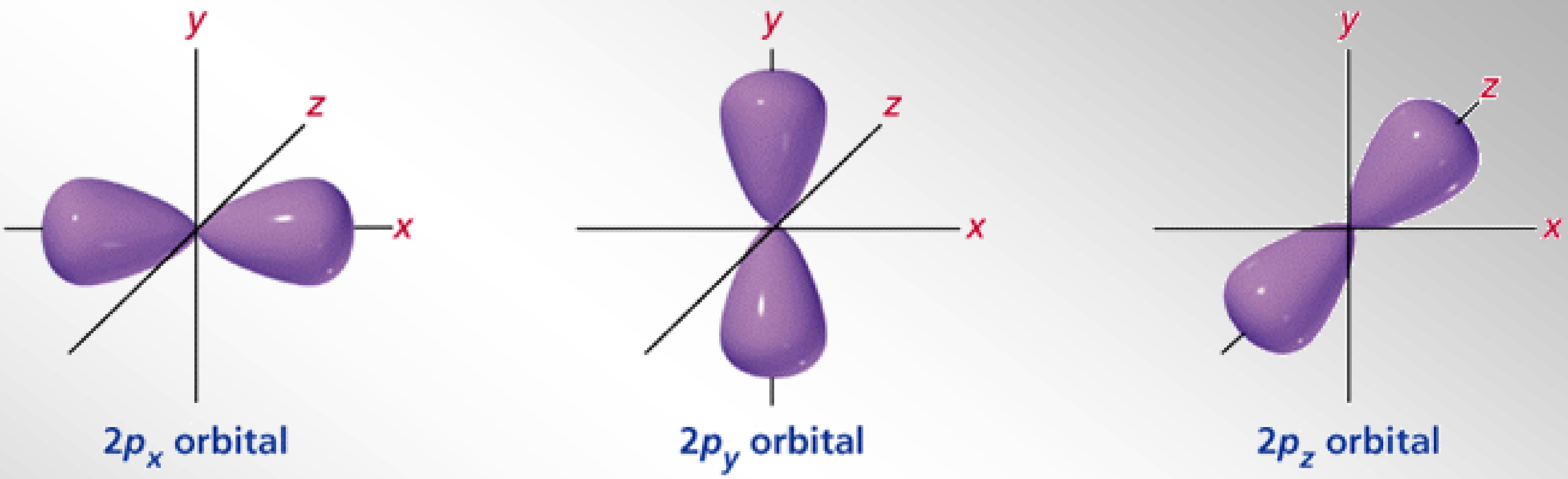
S-Orbitals

The *s* orbital has a spherical shape centered around the origin of the three axes in space.

Because there is only one subshell shape, s-orbitals can only hold two electrons

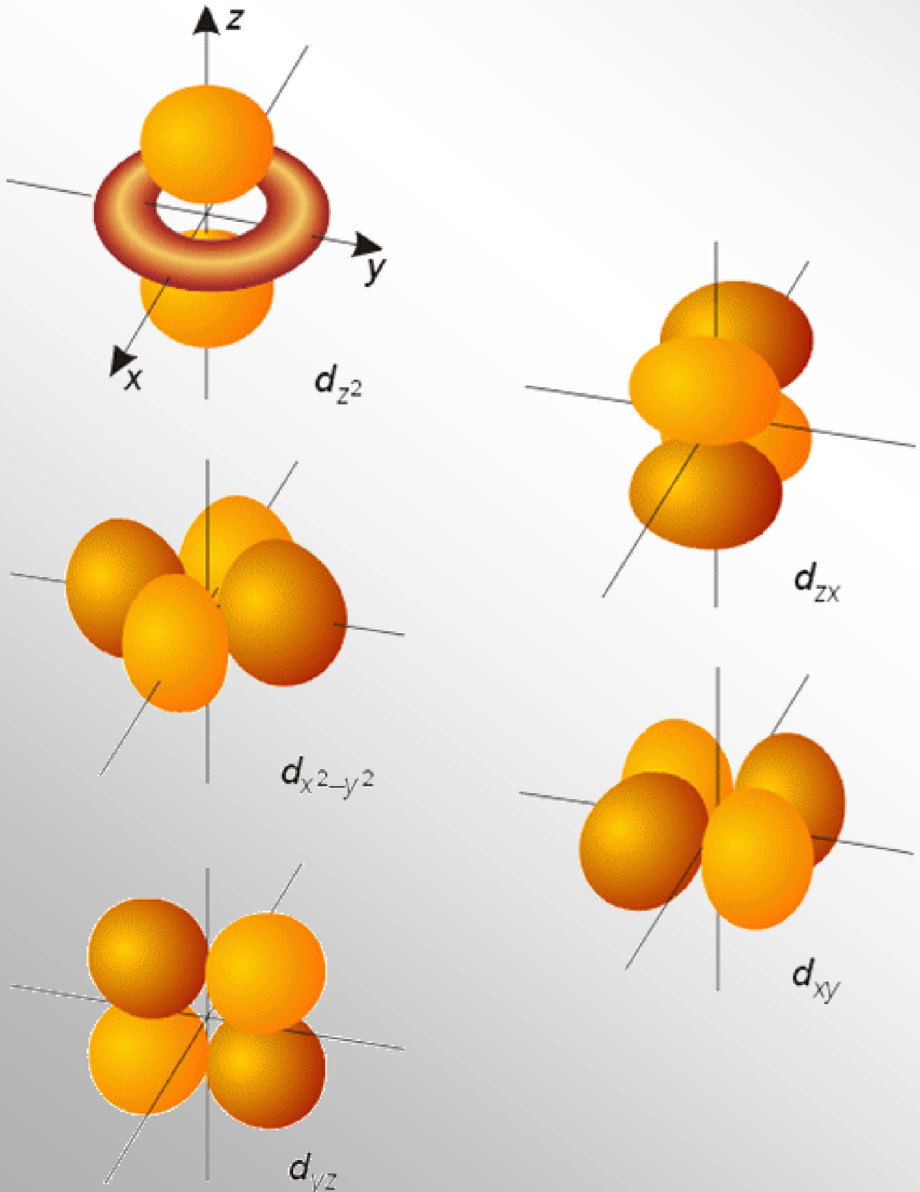


P-Orbitals



There exist three p-orbitals subshell shapes. Each p-orbital falls along the x, y, and z-axis respectively. With three subshell shapes, p-orbitals can hold 6 electrons

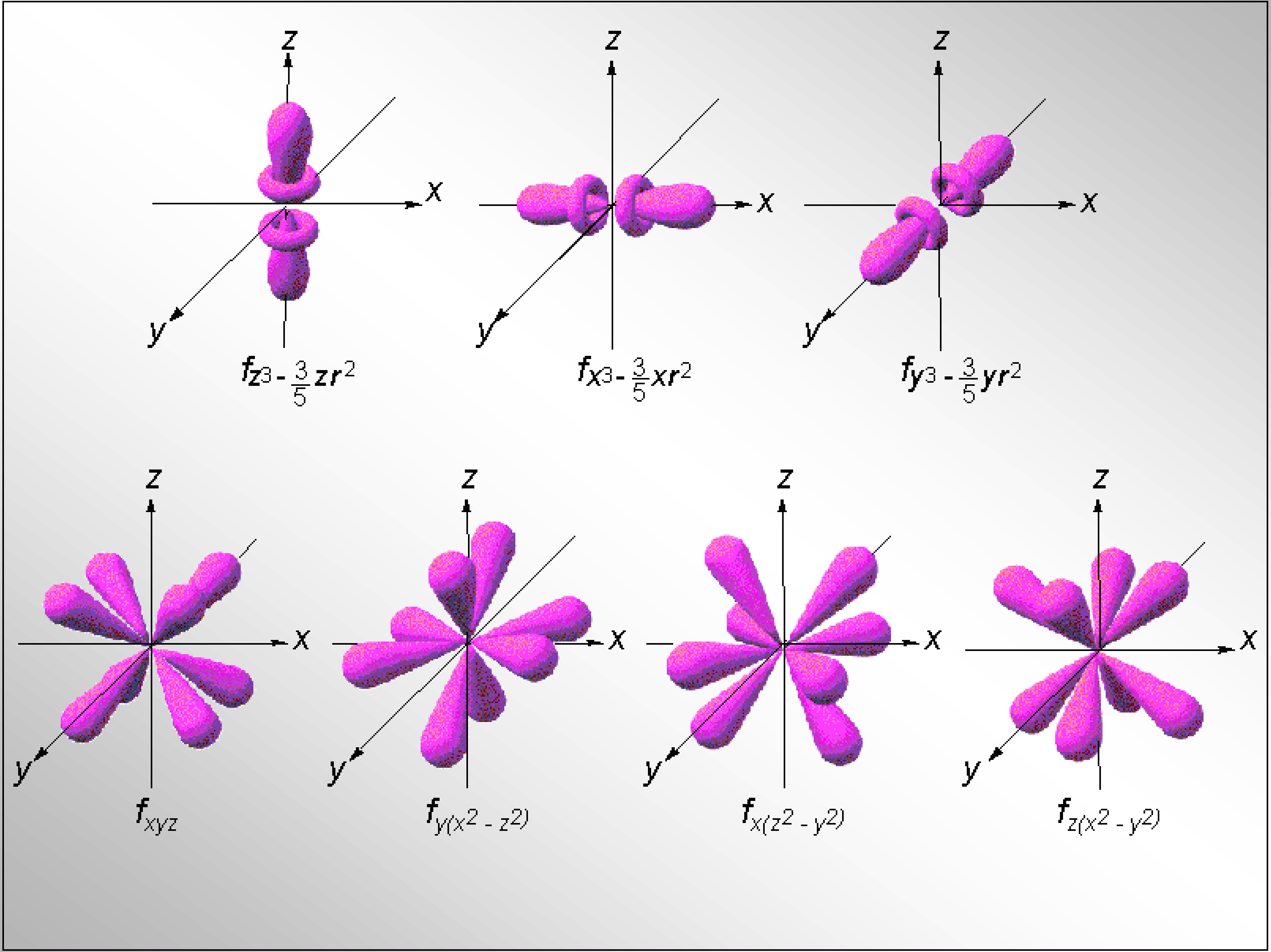
D-orbitals



There exist 5 subshell shapes for d-orbitals, which are shown to the left. Four look like “double dumbells” while a fifth has a “doughnut”

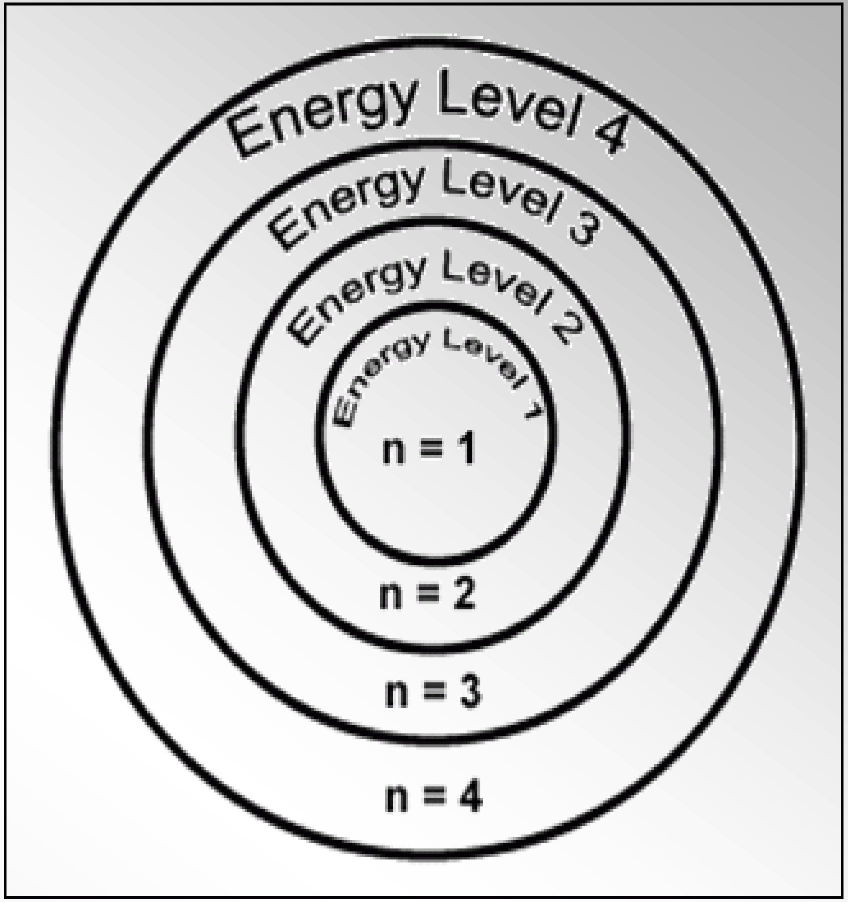
With 5 shapes, d-orbitals can hold 10 electrons

The Seven F-Orbitals (14 e^-)



Electron Energy Levels (Shells)

Generally symbolized by “n”, it denotes the probable distance of the electron from the nucleus. “n” is also known as the **Principal Quantum Number**



Number of electrons that can fit in a shell:

$2n^2$

Electron Configuration

- Electron configuration is a way to indicate where the electrons are located in an atom
- As each element has a distinct and unique number of protons, each neutral atom (and thus element) has a unique electron configuration.
- You can think of electron configuration as an “address” or “mailbox number” for any given element on the periodic table

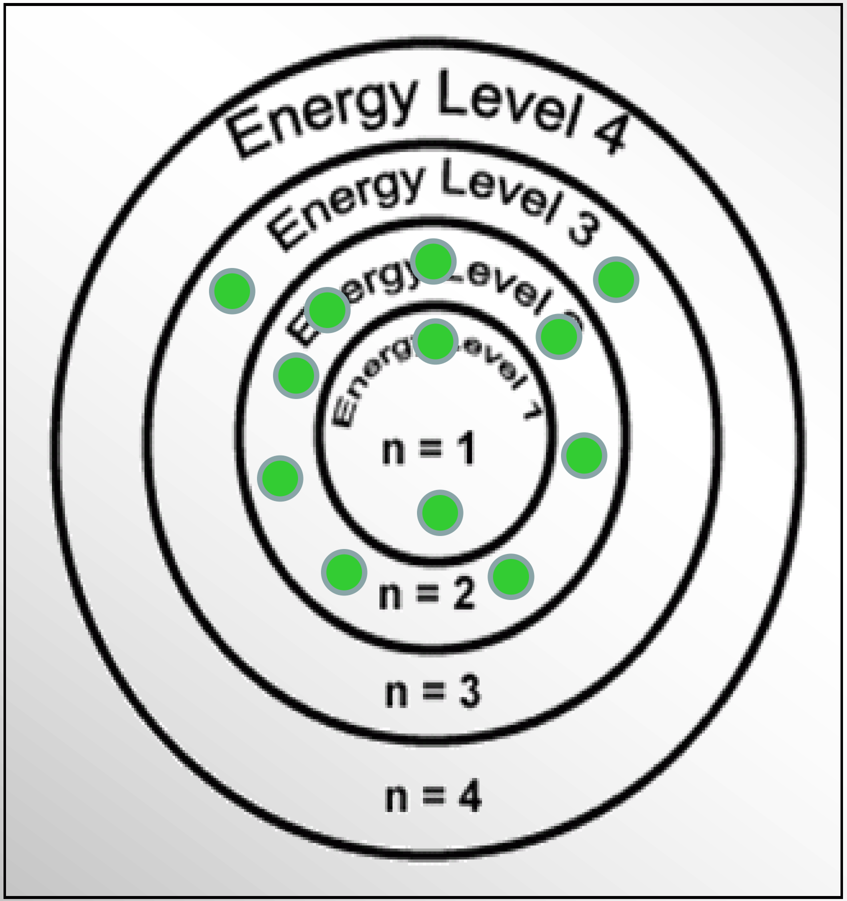
Electron Configuration

- Electrons fill an atom according to four principles
  - The Pauli Exclusion Principle
    - States that each electron orbital can only hold two electrons
  - The Aufbau Principle
  - Hund’s Rule
  - The Electron Spin Rule

Aufbau Principle

- States electrons fill orbitals from the lowest to the highest energy level

Suppose I had 12 electrons. How will they fill the shells?

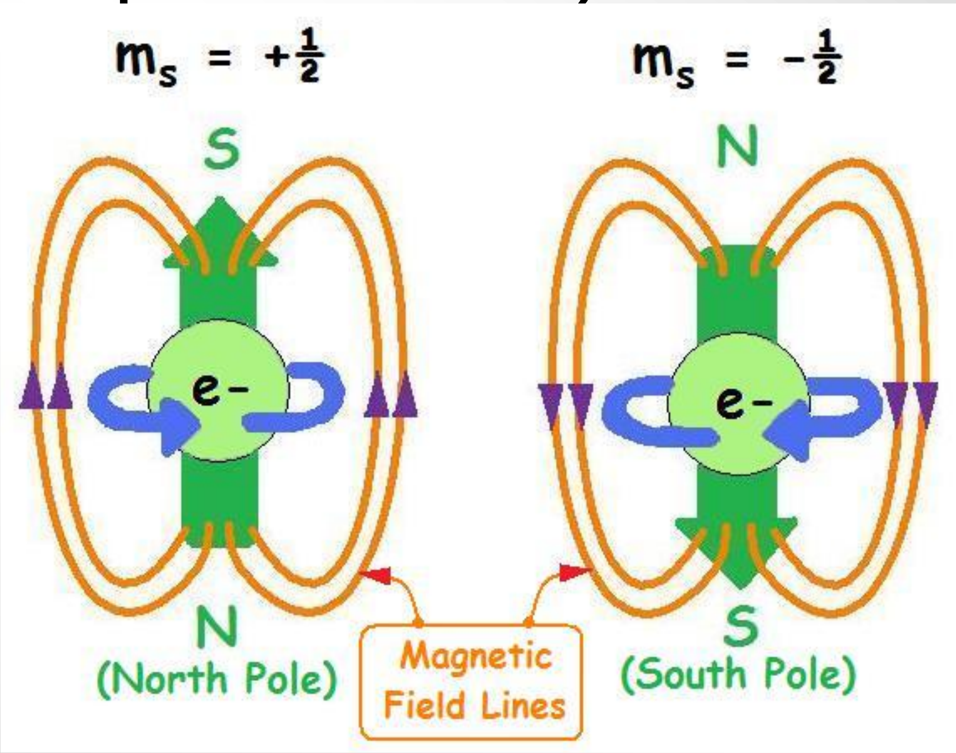


First shell can only hold 2 electrons ($2n^2 = 2$) [n=1]

Second shell can hold 8 electrons ($2n^2 = 8$) [n=2]

Electron Spin

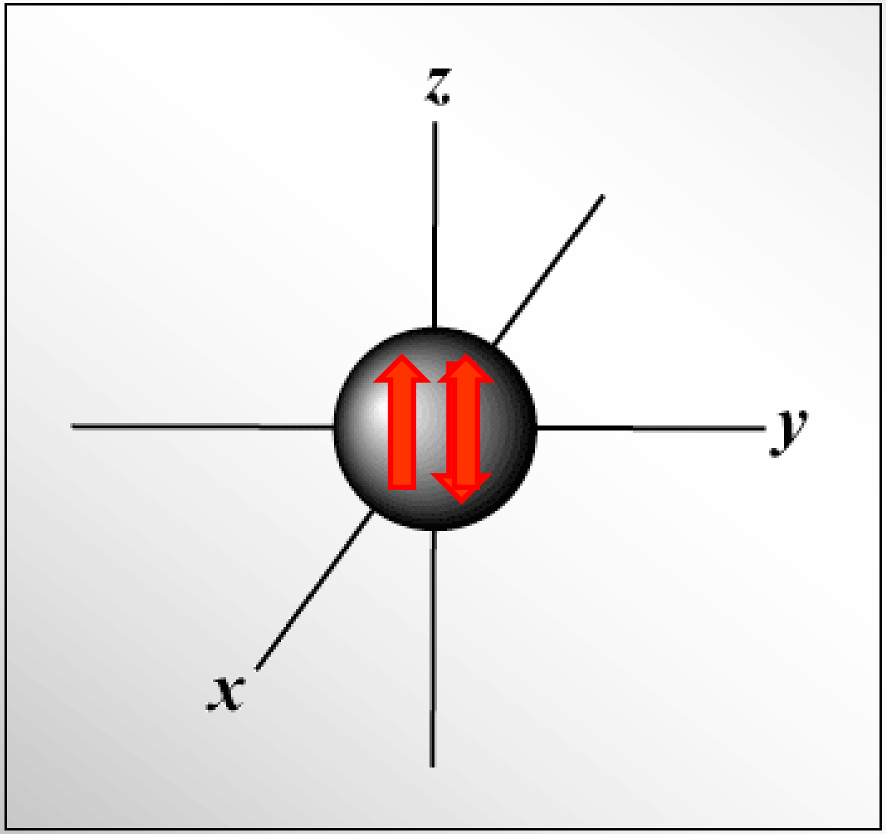
- Refers to the angular momentum (in other words, the spin direction) of an electron



In chemistry, this is written as…

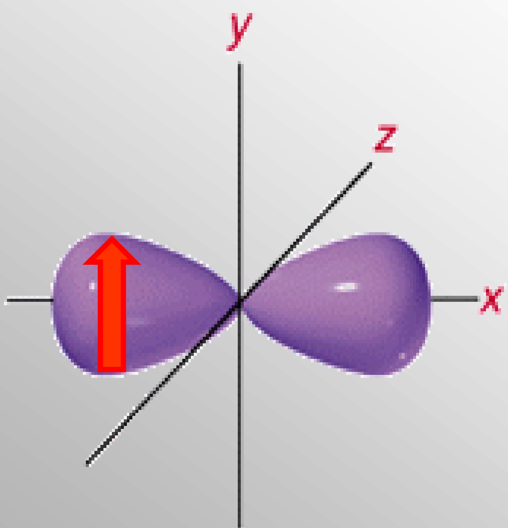
Electron Spin Rule

- States that no two electrons of the same spin can occupy the same orbital

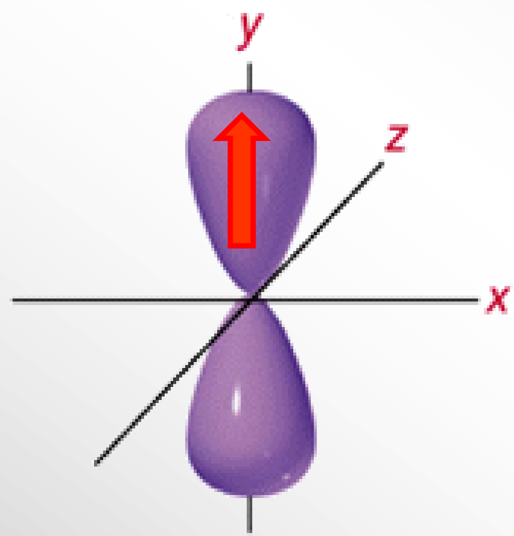


Hund's Rule

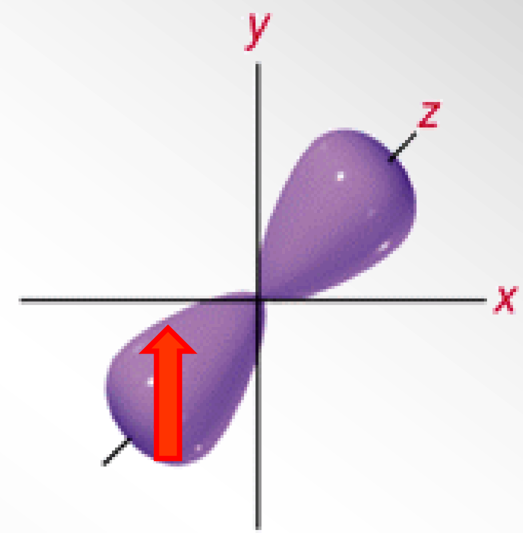
- States that electrons of the same spin must occupy all suborbitals first.
- In other words, before orbitals can "fill up" with two electrons, all suborbitals must have one.



$2p_x$ orbital



$2p_y$ orbital



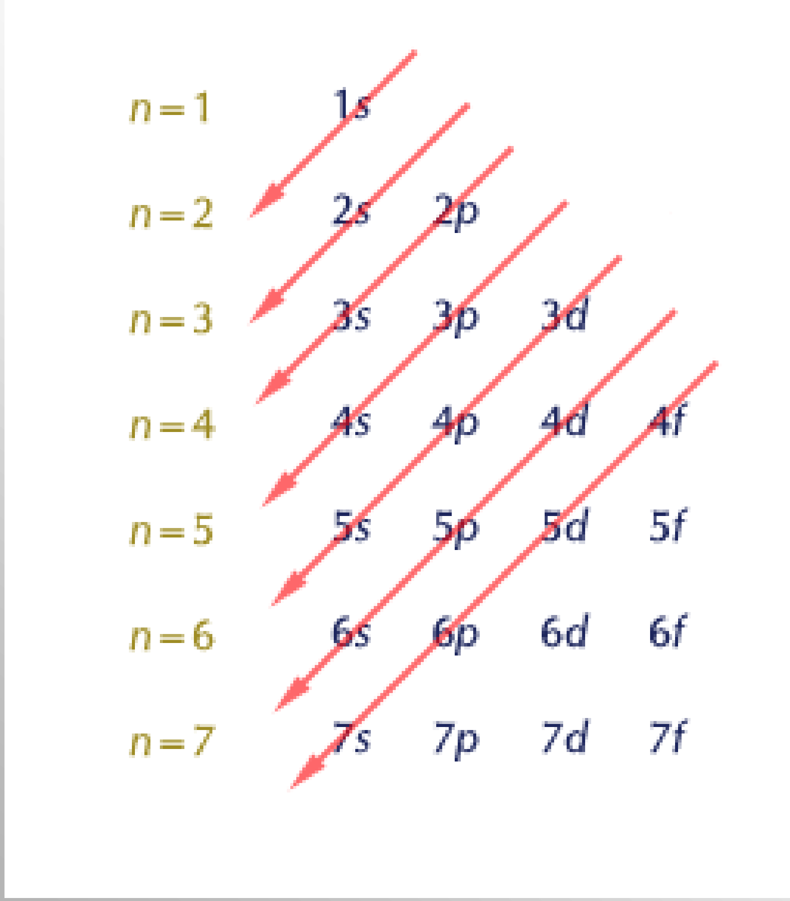
$2p_z$ orbital

Electron Configurations

- There are several steps to finding the electron configuration of an element.
- Suppose we wanted to know the electron configuration of Sodium.
- Step #1: Determine how many electrons are in the element
  - With Sodium, there are 11 electrons

Electron Configurations (Sodium)

- Step #2: Determine how the electrons fill the available electron orbitals



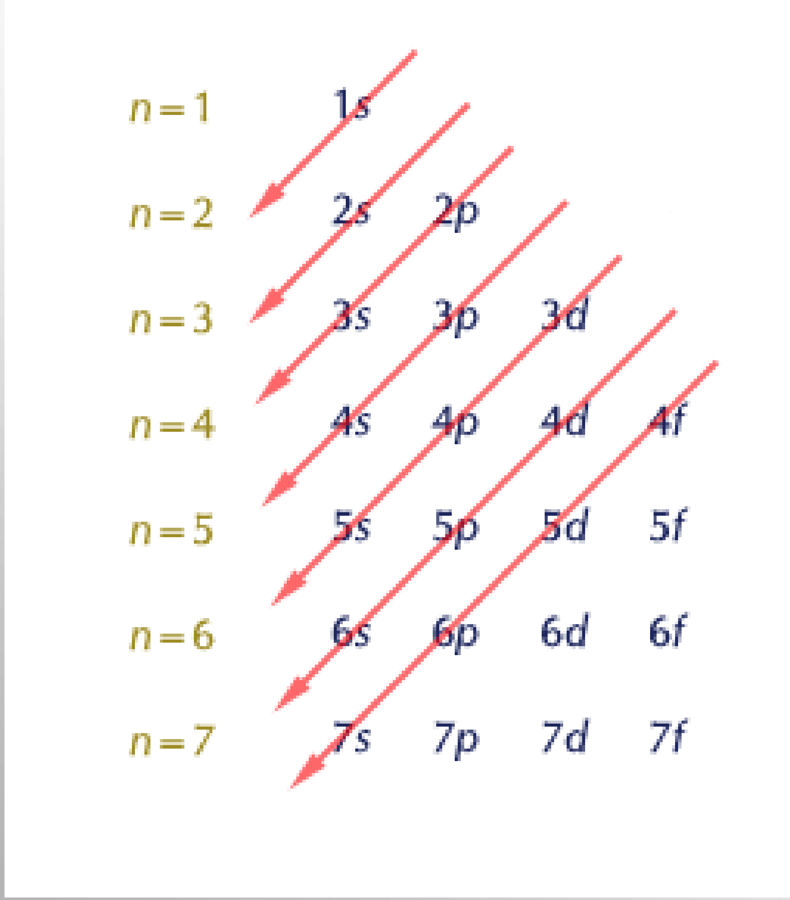
This chart is known as the diagonal method.

Electrons start filling in the 1s orbital, then the 2s orbital, then the 2p, 3s, 3p, 4s, etc.

Remember, each s orbital can hold 2 electrons, p orbitals can hold 6, d orbitals can hold 10, and f orbitals can hold 14

Electron Configurations (Sodium)

- Step #2: Determine how the electrons fill the available electron orbitals



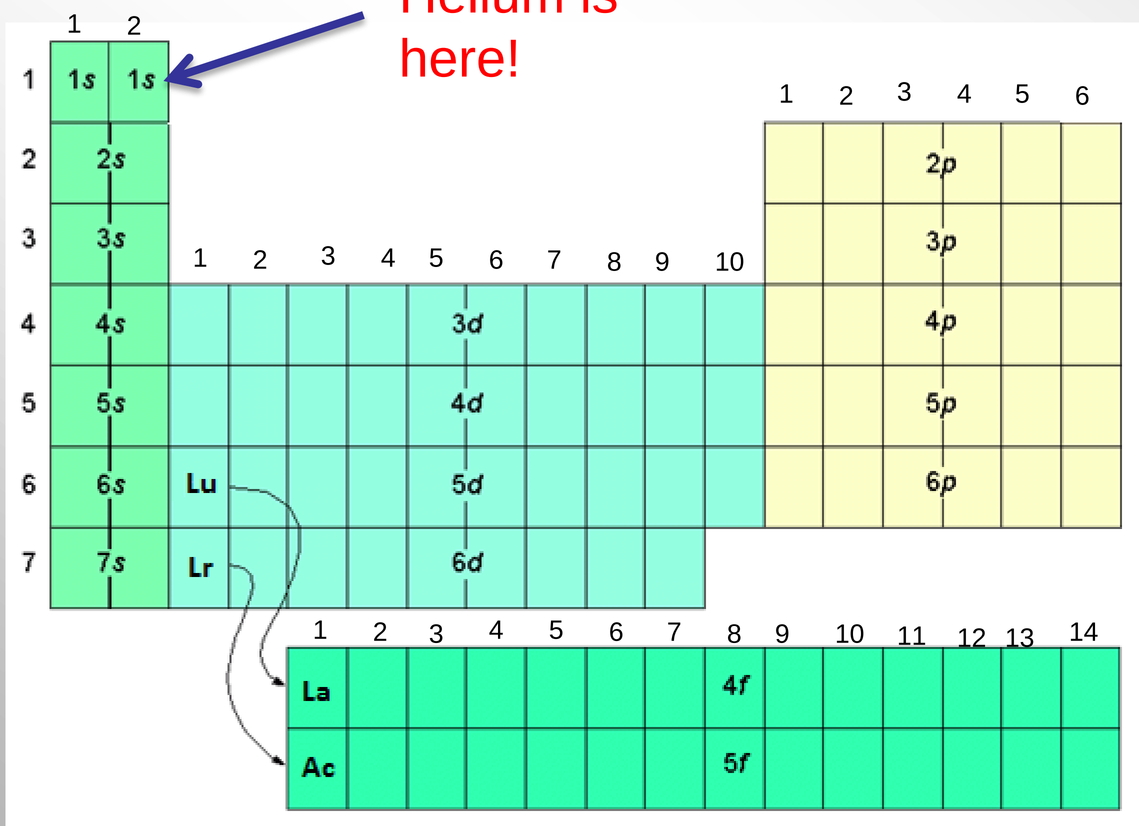
- As Sodium has 11 electrons…
  - The 1s orbital is completely filled (2 electrons)
  - The 2s orbital is filled (2 electrons)
  - The 2p orbital is filled (6 electrons)
  - There is one electron in the 3s orbtial

Thus Sodium's electron configuration is: $1s^2 2s^2 2p^6 3s^1$

Electron Configurations (Sodium)

- Step #2: Determine how the electrons fill the available electron orbitals

Helium is here!

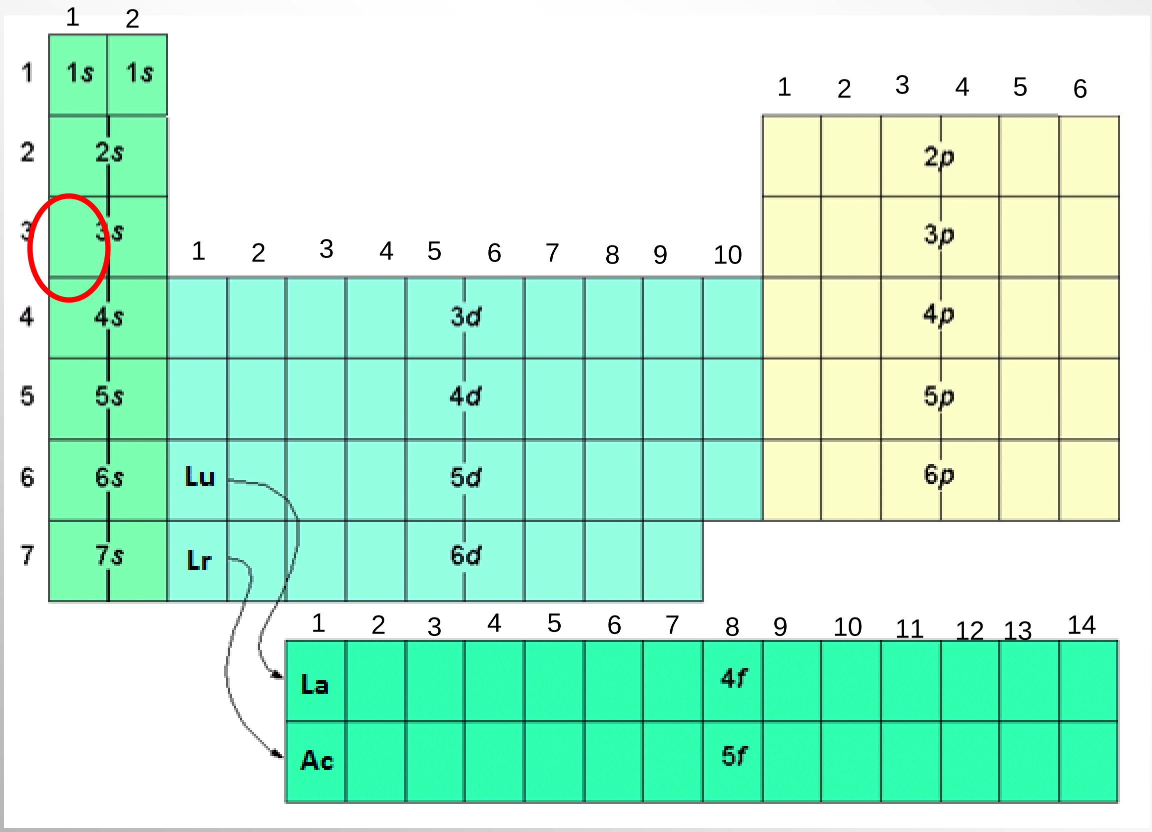


Or…you can use the periodic table to easily figure out electron configurations.

First, familiarize yourself with the modified table to the left.

Electron Configurations (Sodium)

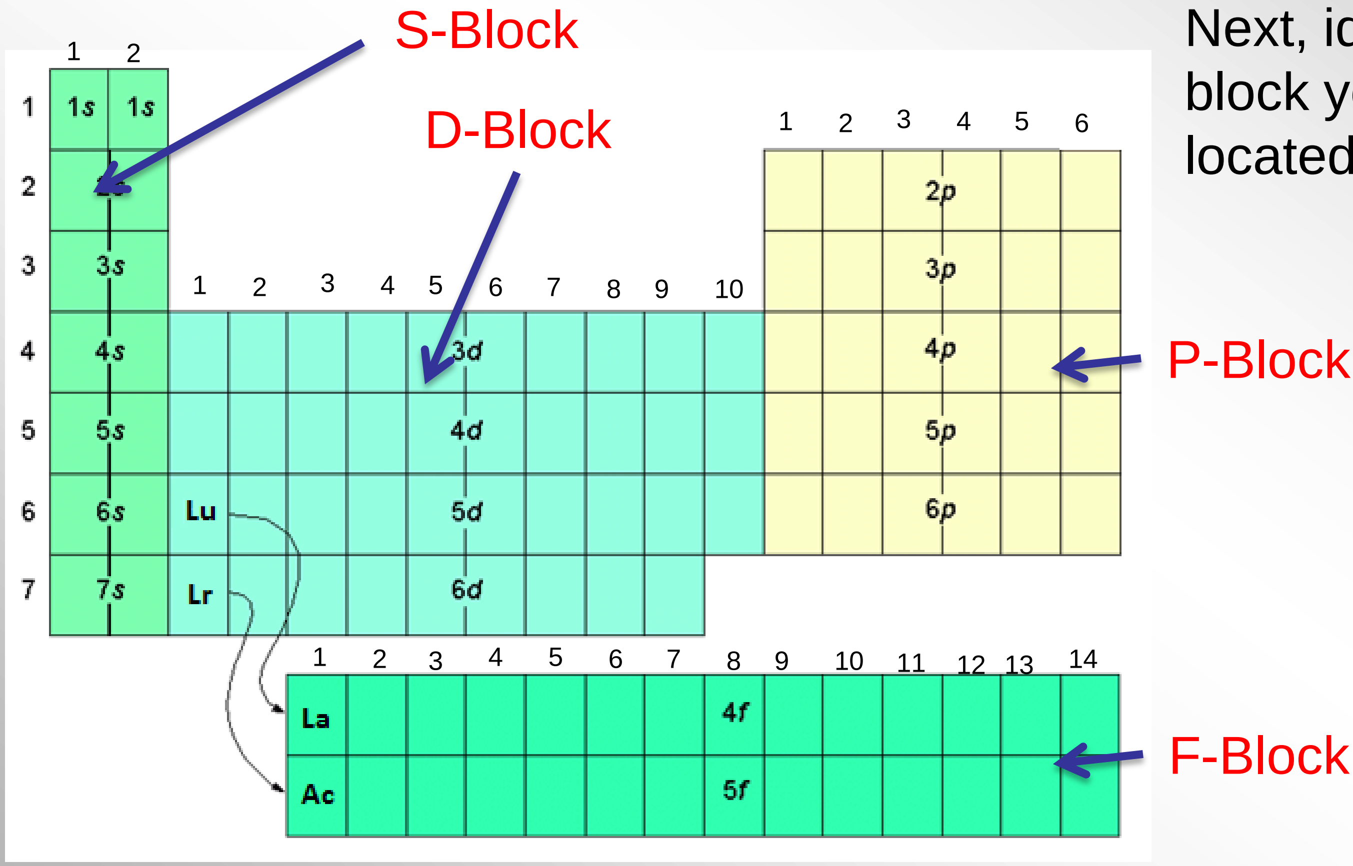
- Step #2: Determine how the electrons fill the available electron orbitals



Now, identify where on this table your element is.

Electron Configurations (Sodium)

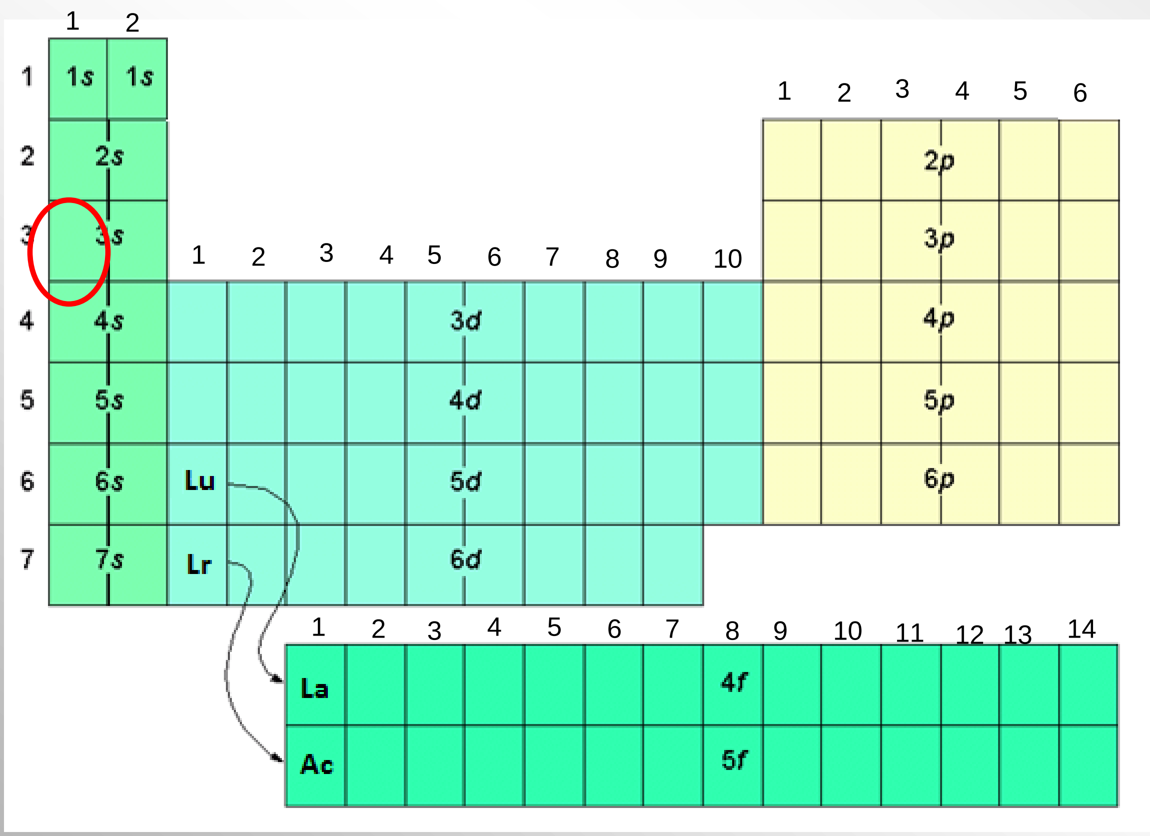
- Step #2: Determine how the electrons fill the available electron orbitals



Next, identify the block your element is located in.

Electron Configurations (Sodium)

- Step #2: Determine how the electrons fill the available electron orbitals



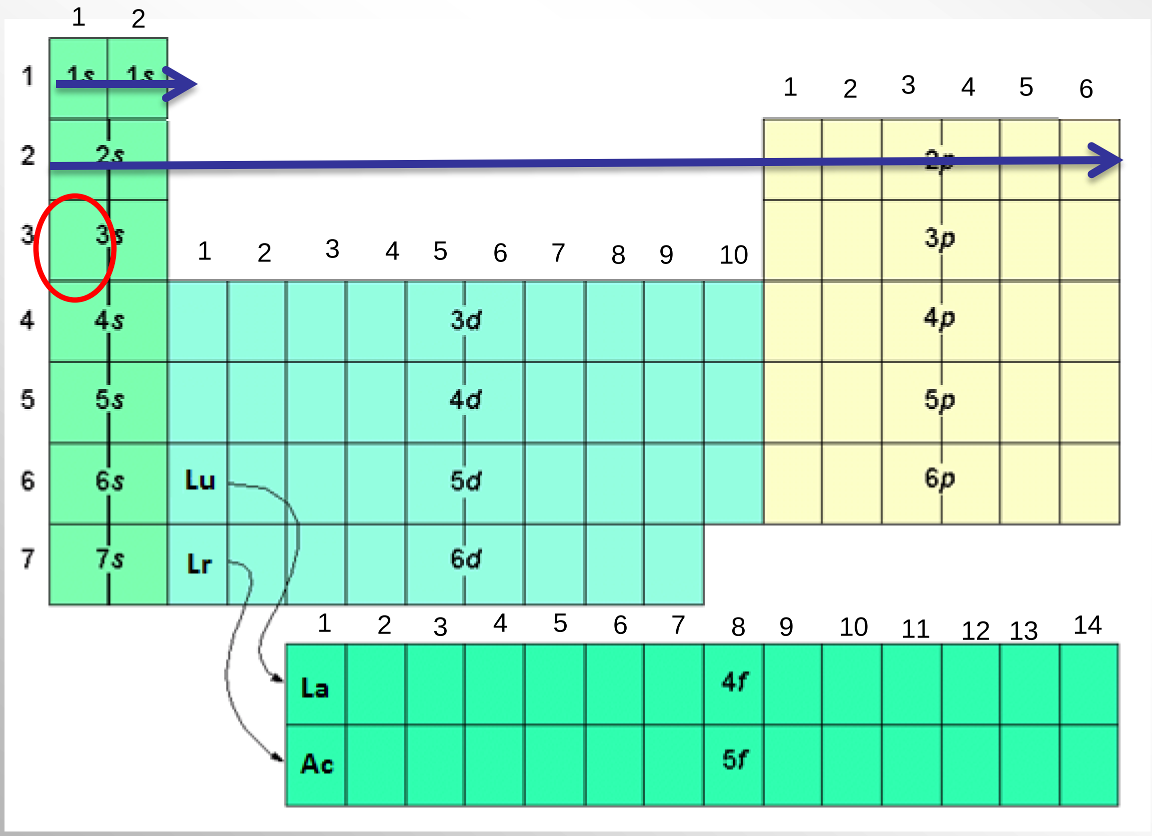
Write out the “grid coordinates” that your element is located in.

The format for the grid is the period number, followed by the block, and finally the number across the top as a subscript

With Sodium, this “grid coordinate” would be $3s^1$

Electron Configurations (Sodium)

- Step #2: Determine how the electrons fill the available electron orbitals



Next, write out from left to right, top to bottom, all the orbitals that exist before element's grid coordinate

So with Sodium, we go through the 1s, 2s, and 2p orbitals

Electron Configurations (Sodium)

- Next, write out your two "halves" next to each other.

1s 2s 2p $3s^1$

All the orbitals before the "grid coordinate"

From the "grid coordinate"

Electron Configurations (Sodium)

- Then with the orbitals before the grid coordinate, add the number of electrons that can go into each orbital (s=2, p=6, d=10, f=14)

$1s^2 2s^2 2p^6$ $3s^1$

These orbitals are all filled!

From the "grid coordinate"

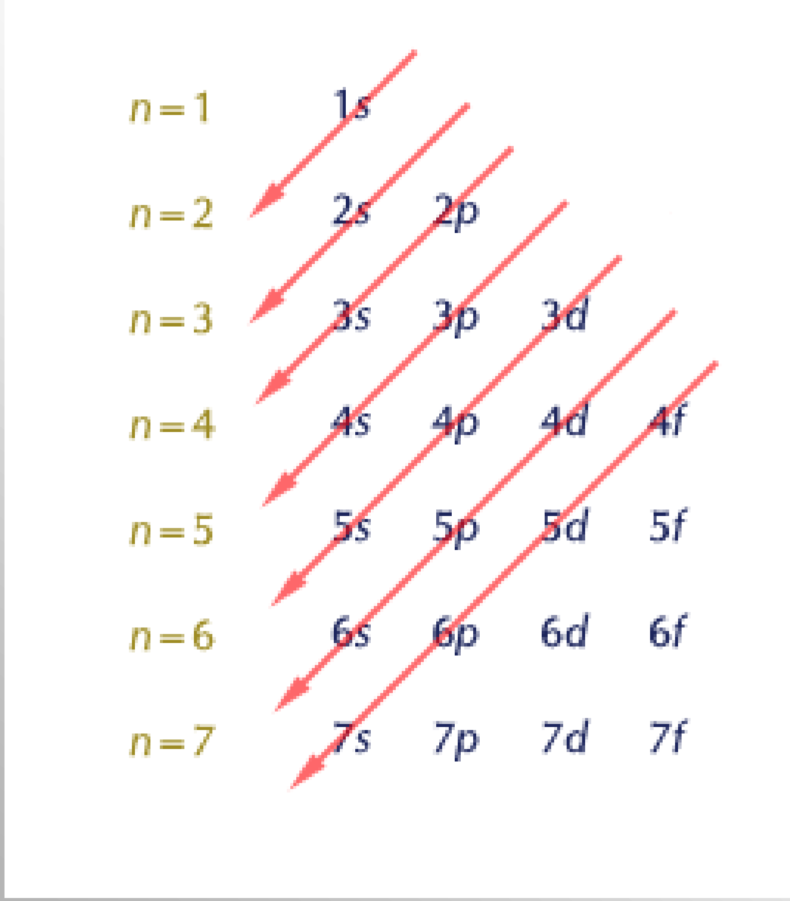
Electron Configurations (Sodium)

- Finally, put both sides together to get the final electron configuration

$1s^2 2s^2 2p^6\ 3s^1$

Electron Configurations (Sulfur)

- Sulfur has 16 electrons. So what would be its electron configuration?



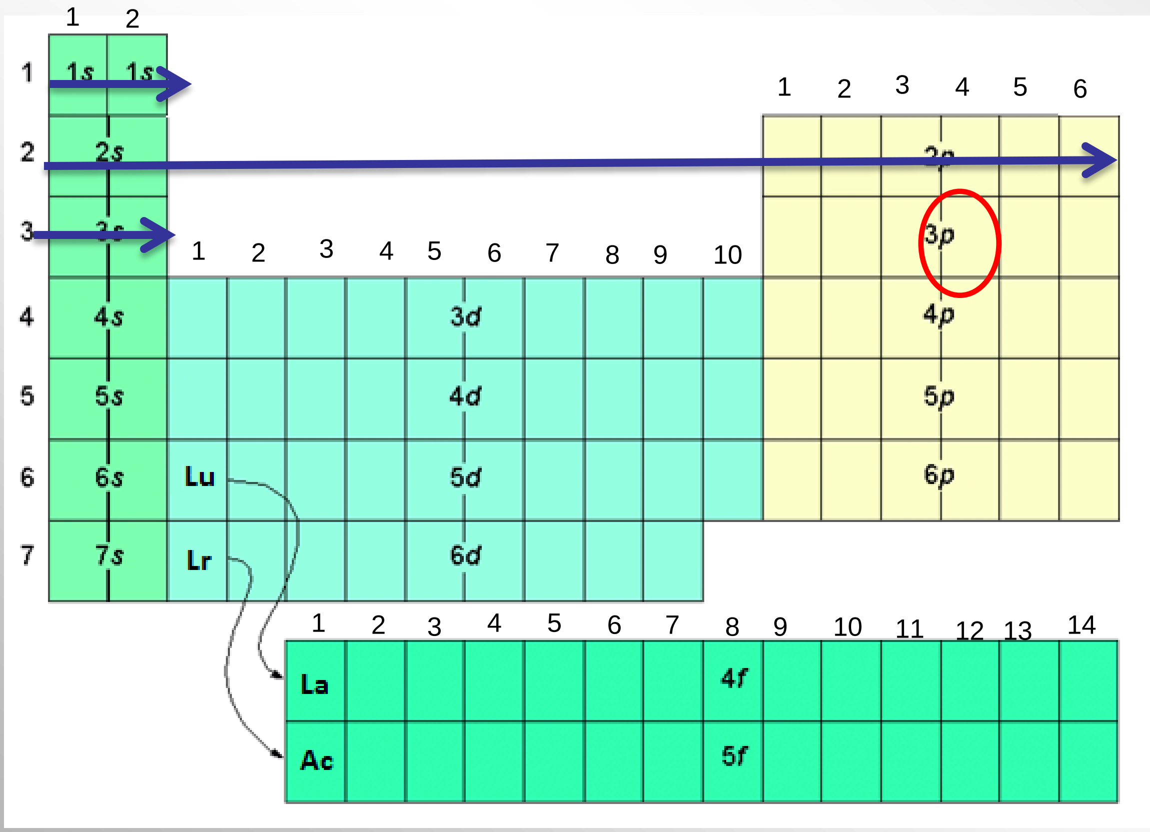
With 16 electrons, the 1s, 2s, 2p, and 3s orbitals are completely filled (2, 2, 6, 2 respectively)

The 3p orbital would have four electrons

Therefore, Sulfur's electron configuration would be $1s^2 2s^2 2p^6 3s^2 3p^4$

Electron Configurations (Sulfur)

- Step #2: Determine how the electrons fill the available electron orbitals



Sulfur ends with a $3p^4$

The orbitals in front of Sulfur are 1s, 2s, 2p, and 3s.

Electron Configurations (Sulfur)

- Place the two sides together,

1s 2s 2p 3s $3p^4$

These orbitals are all filled!

From the "grid coordinate"

Electron Configurations (Sulfur)

- Place the two sides together,

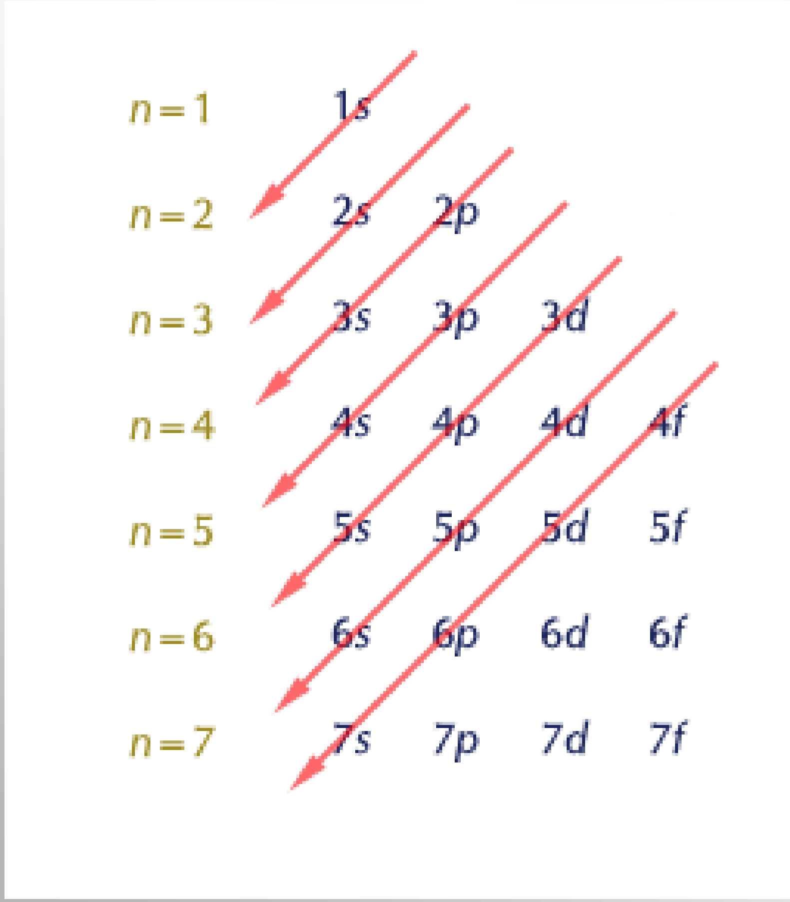
$1s^2 2s^2 2p^6 3s^2 3p^4$

These orbitals are all filled!

From the "grid coordinate"

Electron Configurations (Copper)

- Copper has 29 electrons. So what would be its electron configuration?



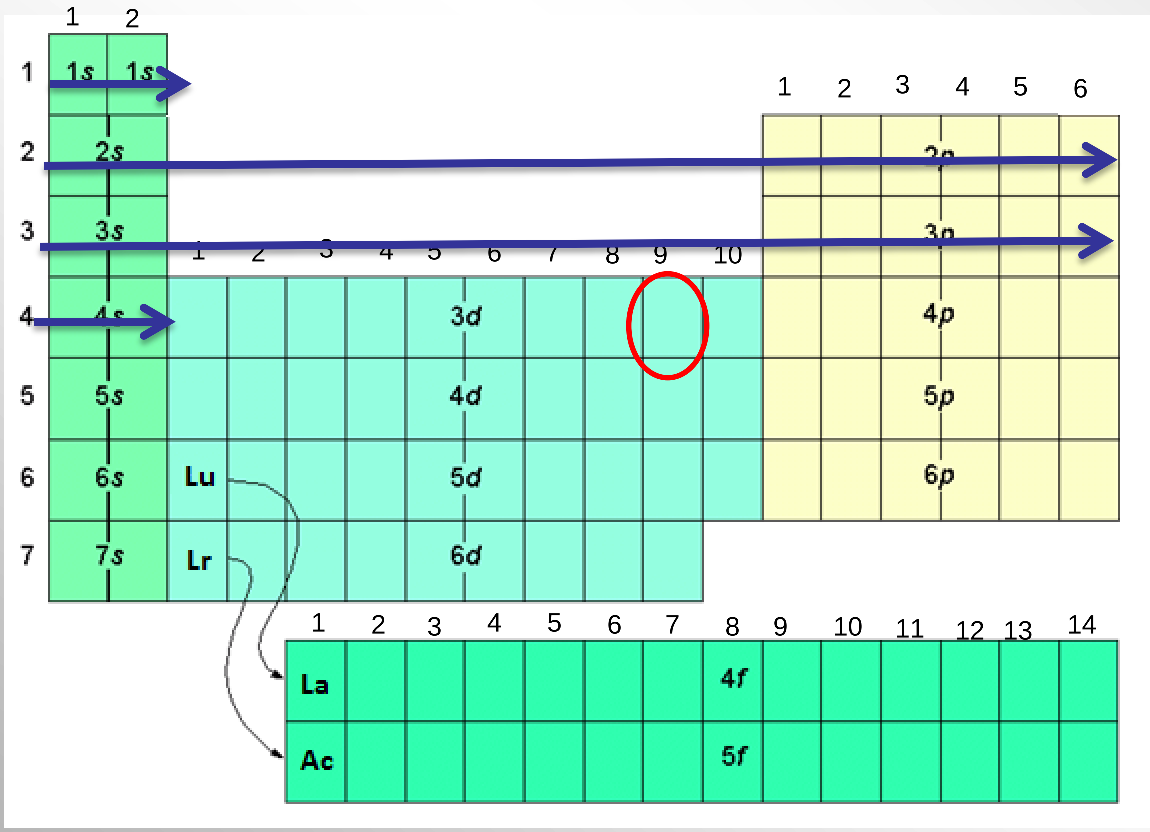
With 29 electrons, the 1s, 2s, 2p, 3s, 3p, and 4s orbitals are completely filled (2, 2, 6, 2, 6, and 2 respectively)

The 3d orbital would have 9 electrons

Therefore, Copper's electron configuration would be $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^9$

Electron Configurations (Copper)

- Step #2: Determine how the electrons fill the available electron orbitals



Copper ends with a $3d^9$

The orbitals in front of Copper are 1s, 2s, 2p, 3s, 3p, and 4s

Electron Configurations (Copper)

- Place the two sides together,

1s 2s 2p 3s 3p 4s $3d^9$

These orbitals are all filled!

From the “grid coordinate”

Electron Configurations (Copper)

- Place the two sides together,

$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2\ 3d^9$