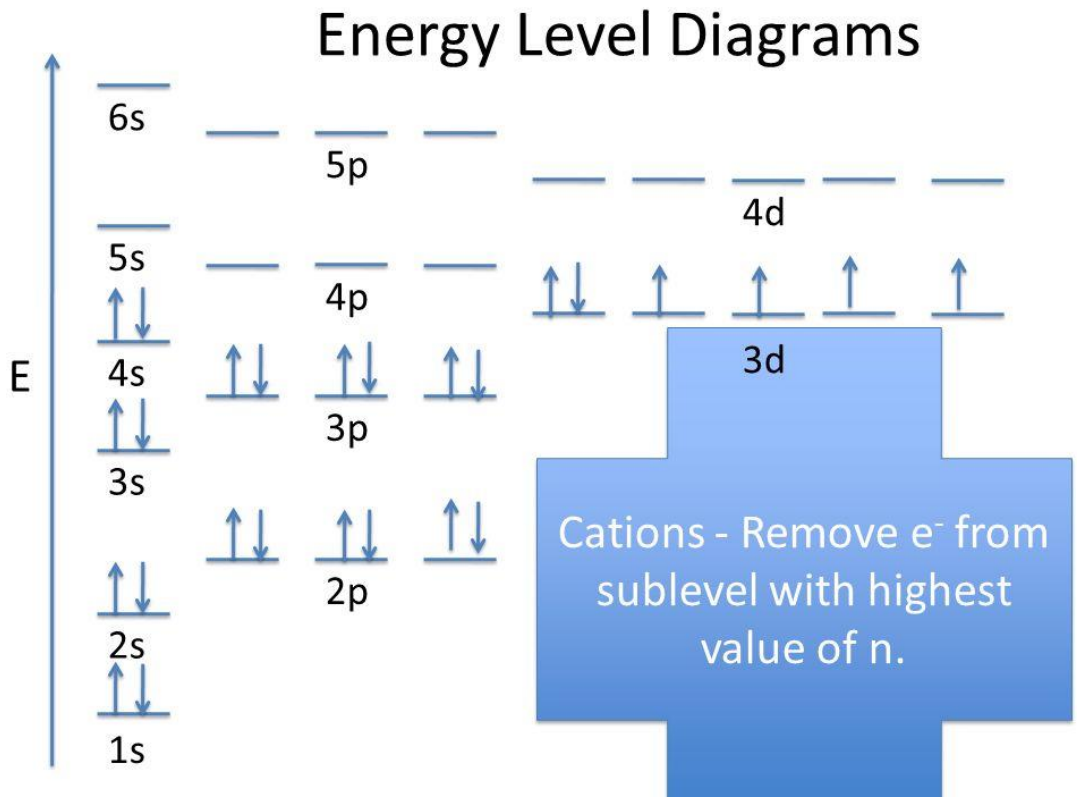
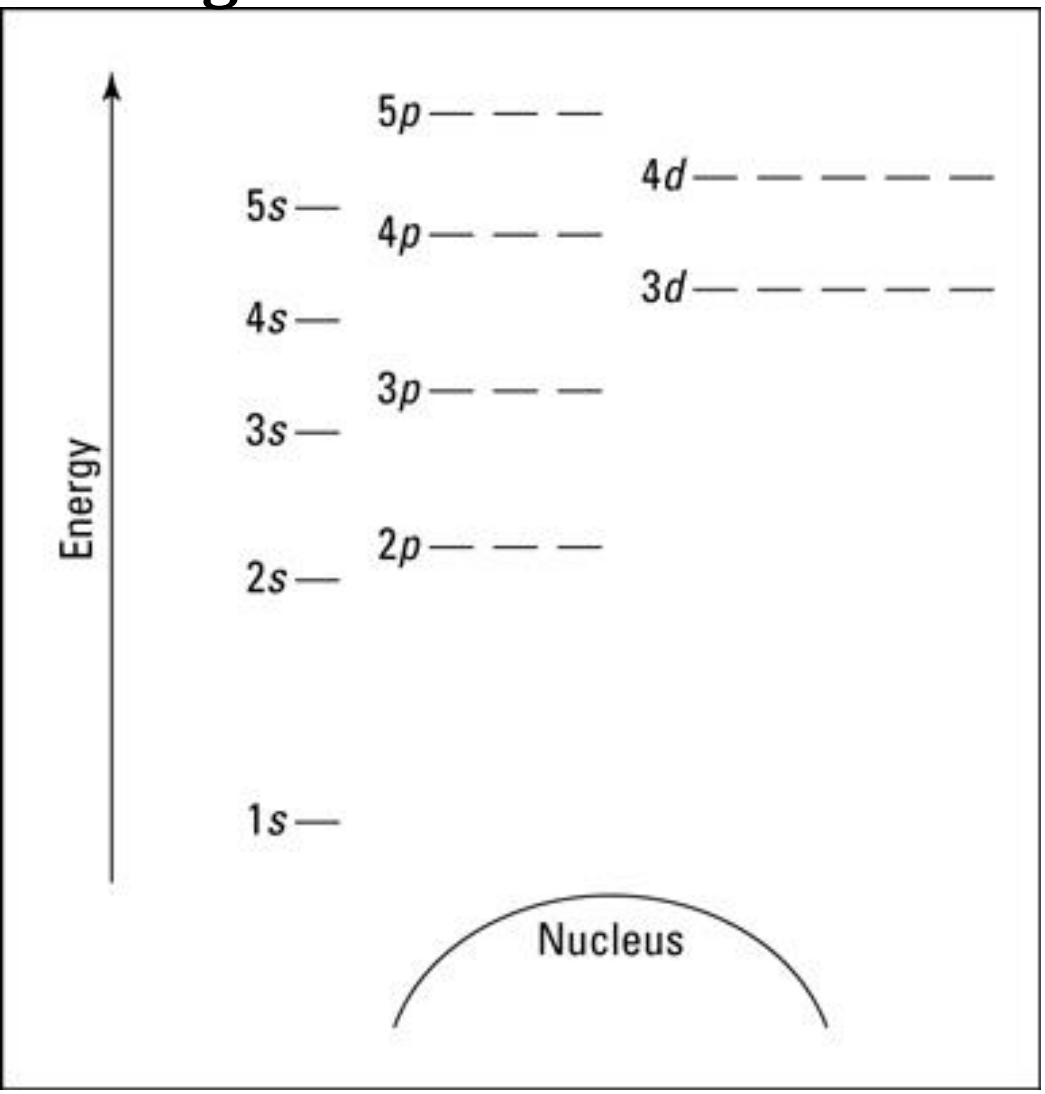
[3.3] Energy Level Diagrams and Configurations

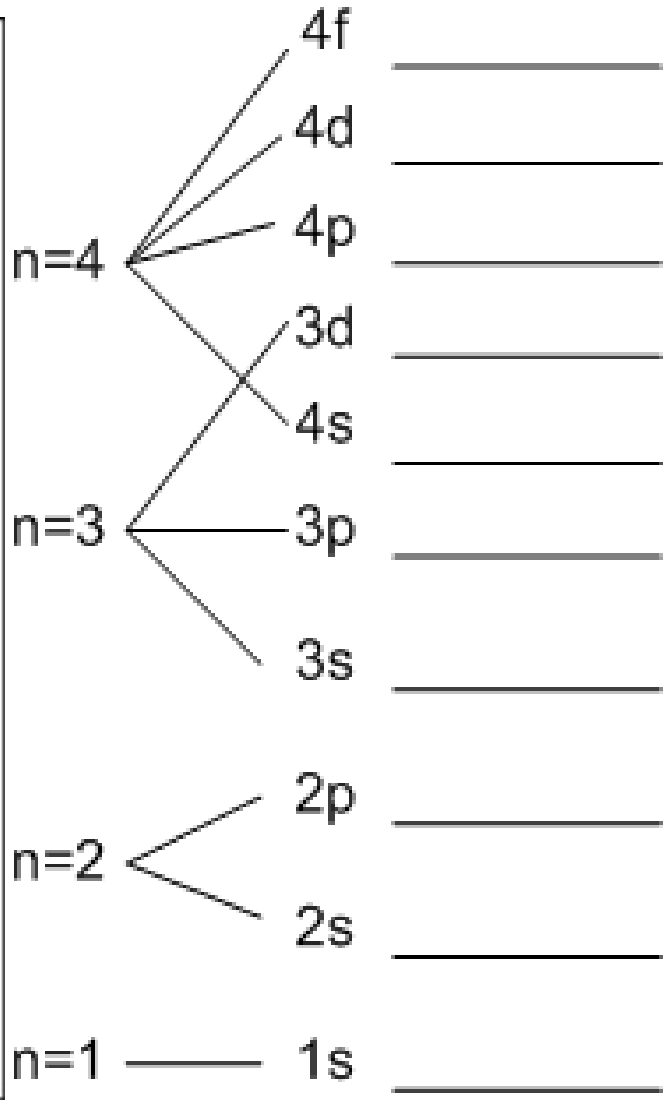
1A	2A	3A	4A	5A	6A	7A
1 **H** $1s^1$						
3 **Li** $1s^2$ $2s^1$	4 **Be** $1s^2$ $2s^2$	5 **B** $1s^2$ $2s^2 2p^1$	6 **C** $1s^2$ $2s^2 2p^2$	7 **N** $1s^2$ $2s^2 2p^3$	8 **O** $1s^2$ $2s^2 2p^4$	9 **F** $1s^2$ $2s^2 2p^5$
11 **Na** [Ne] $3s^1$	12 **Mg** [Ne] $3s^2$	13 **Al** [Ne] $3s^2 3p^1$	14 **Si** [Ne] $3s^2 3p^2$	15 **P** [Ne] $3s^2 3p^3$	16 **S** [Ne] $3s^2 3p^4$	17 **Cl** [Ne] $3s^2 3p^5$

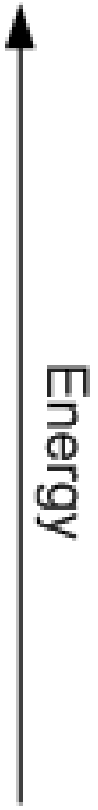


Energy Level Diagrams

Energy level diagrams are used to represent the **electron arrangement** in an atom

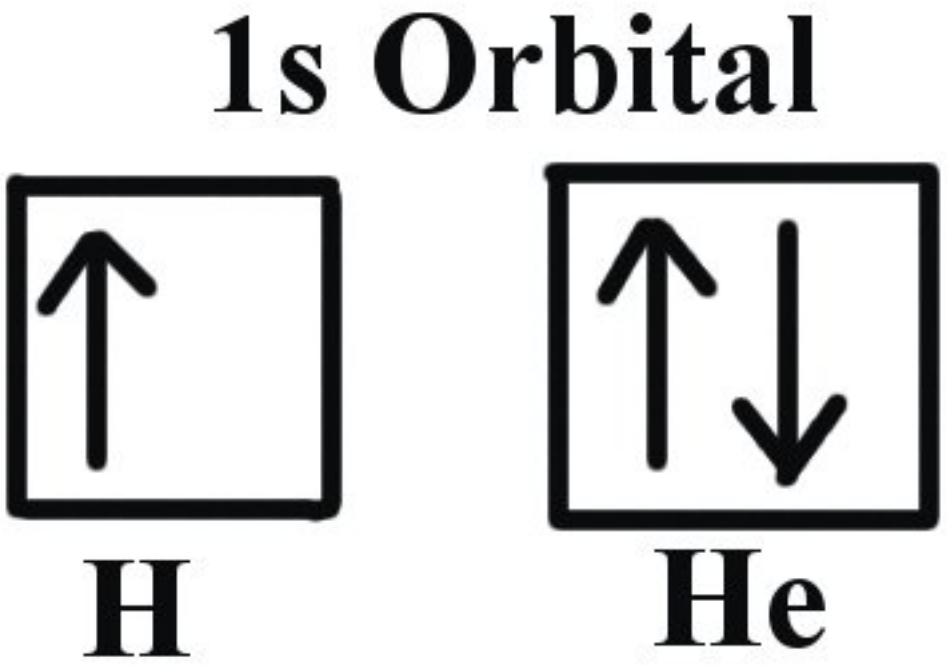






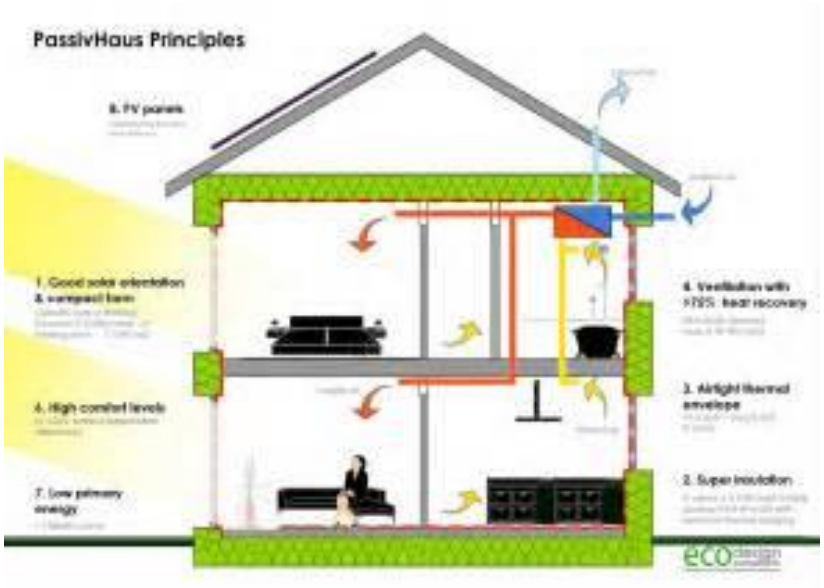
Pauli's Exclusion Principle

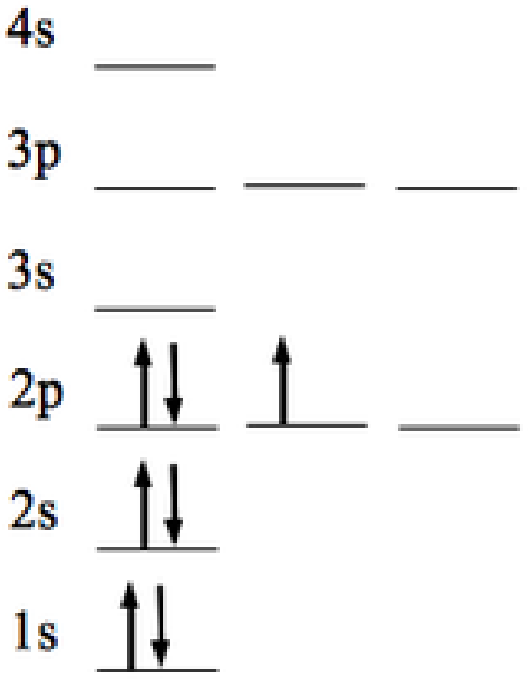
- No two electrons have the same 4 quantum numbers
- One electron will **spin up**, the other will **spin down**
- We write the electron that spins up first.



Aufbau Principle

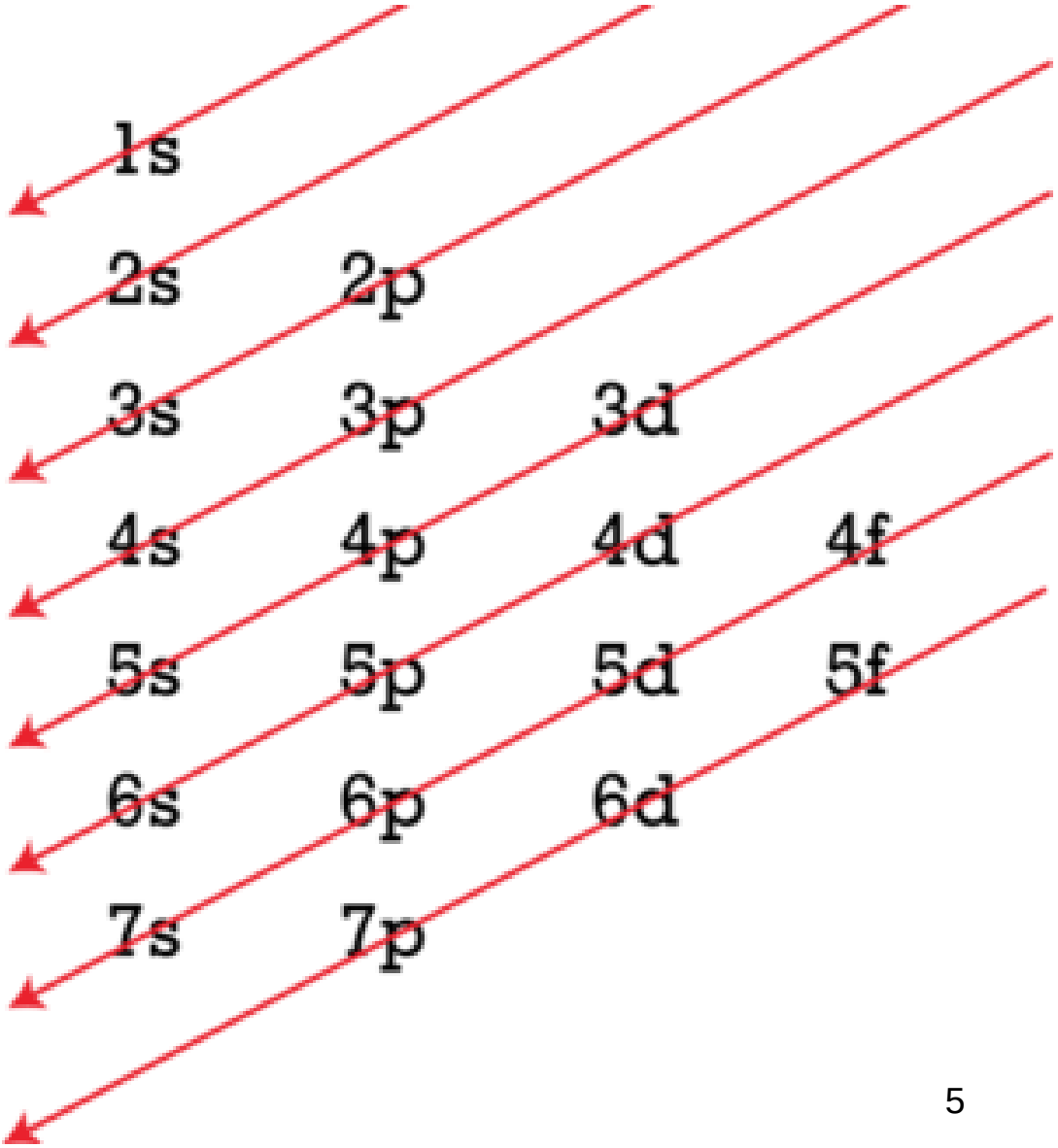
- The number of electrons in an atom is equal to the atomic number
- Each added electron will enter the orbitals in the order of **increasing energy**
- **Orbitals of lowest energy are filled first**
- An orbital cannot take more than 2 electrons



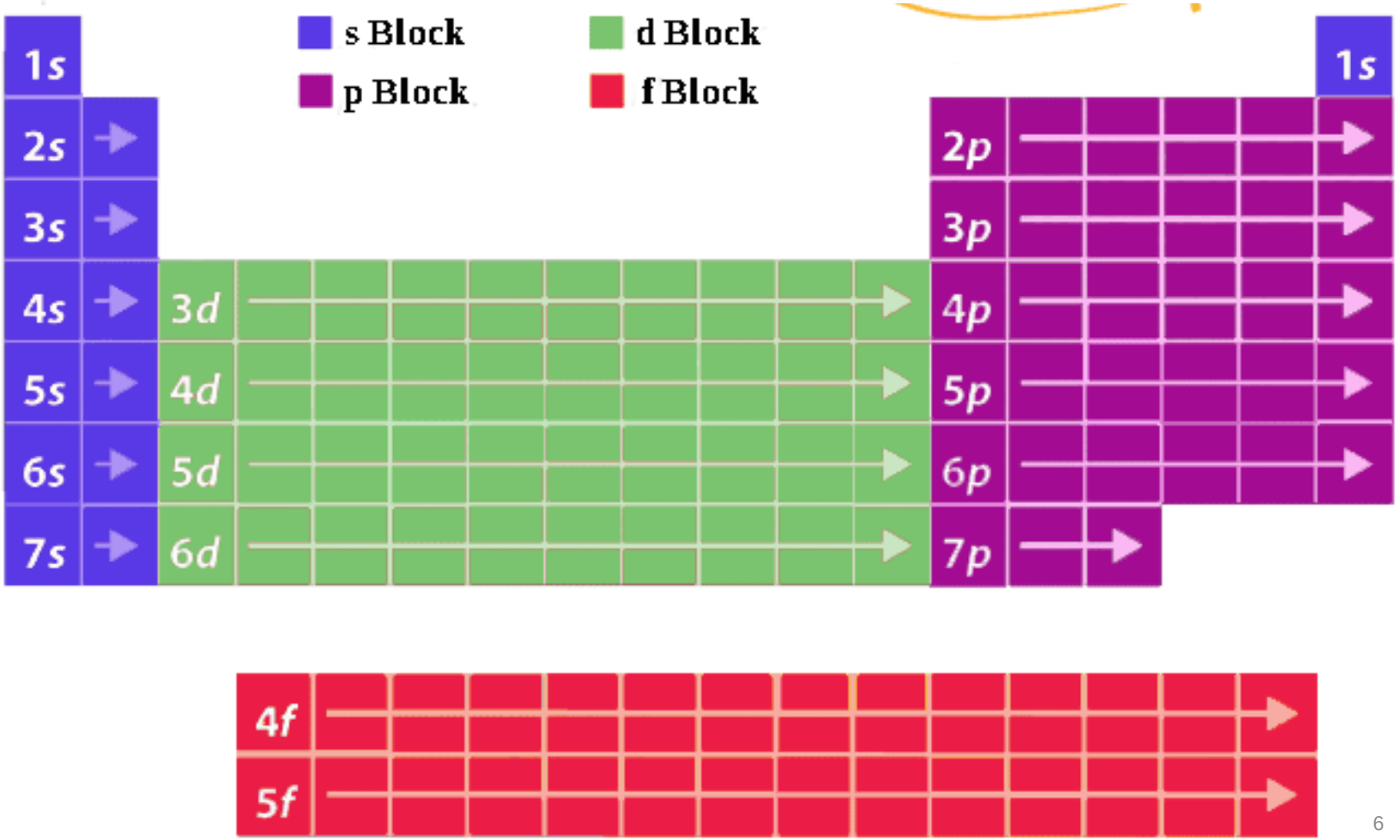


Aufbau Principle

The diagonal rule for electron filling order.

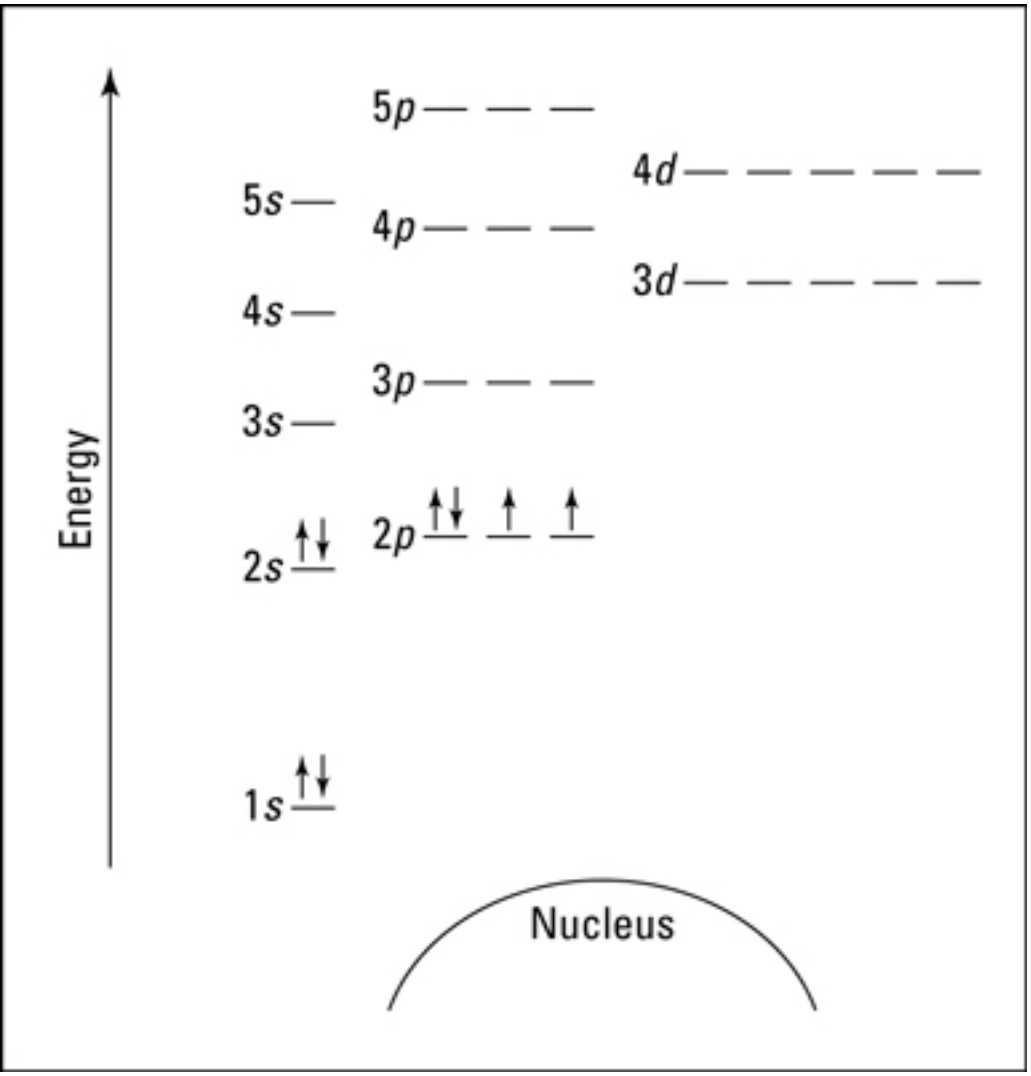


Shells and Subshells

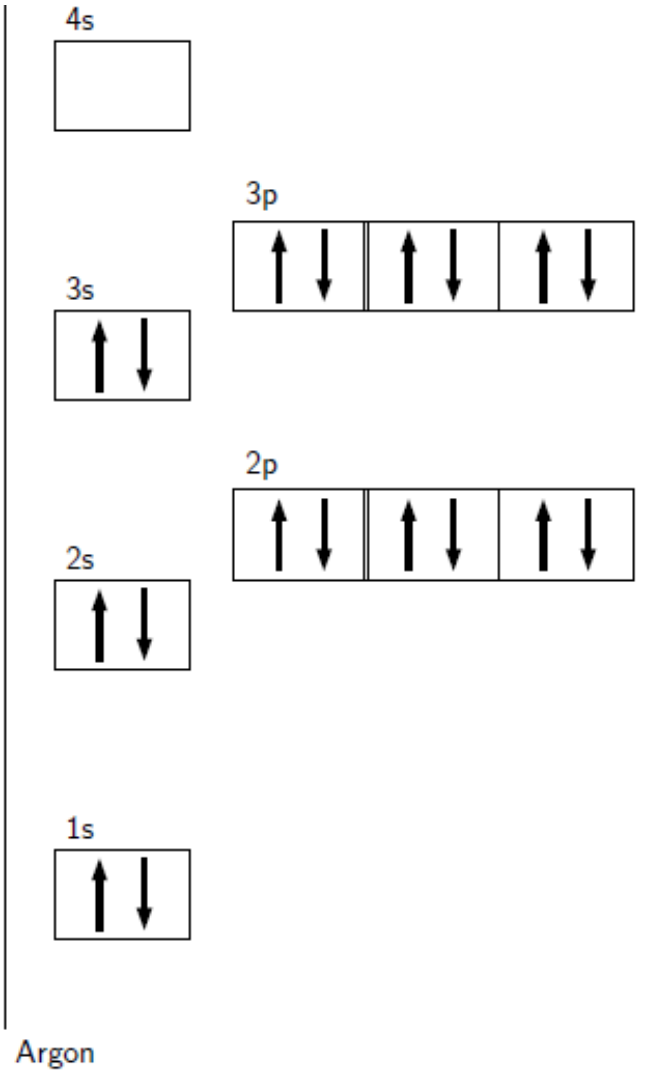


Energy Level Diagrams

Energy Level Diagram for Oxygen

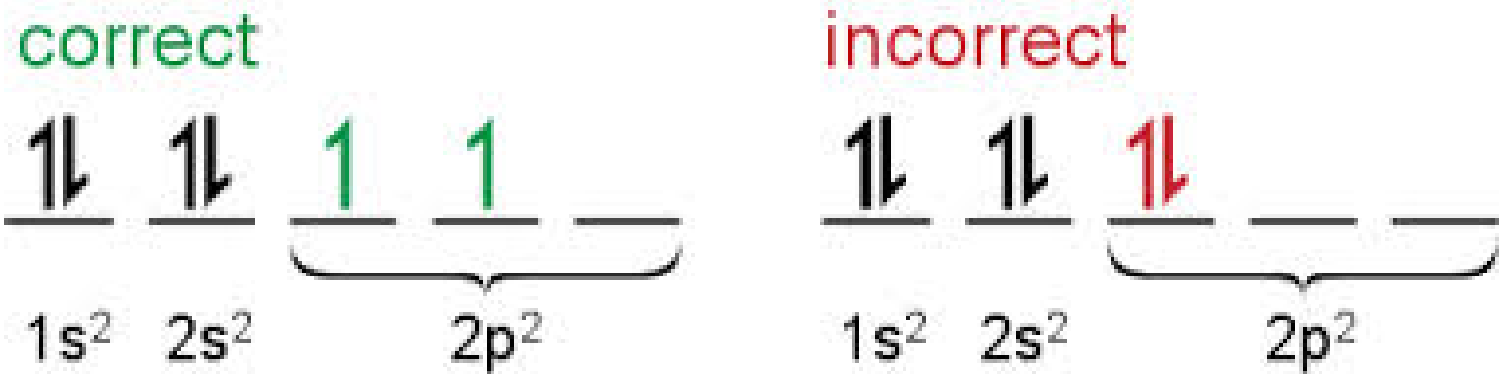


Energy Level Diagram for Argon



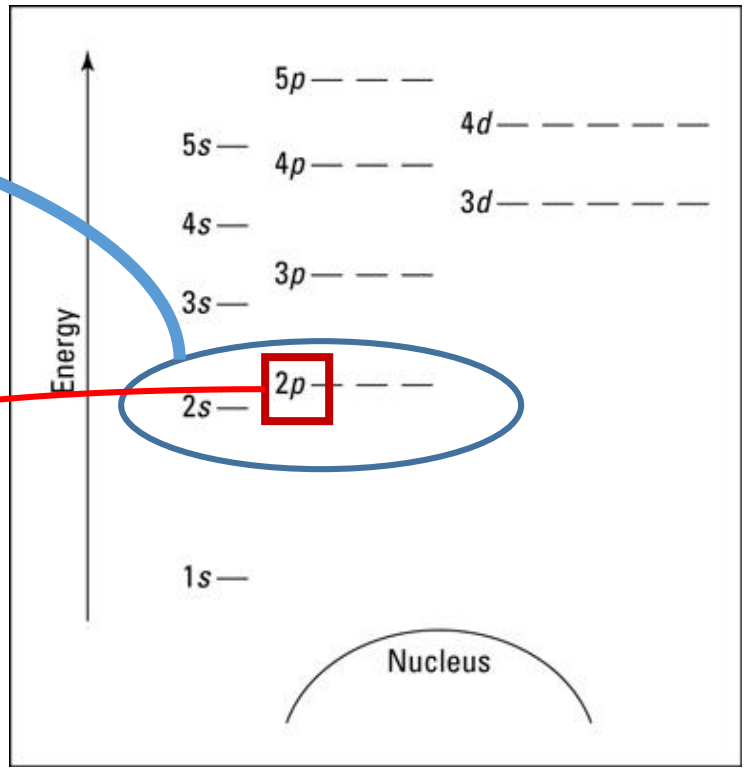
Hund's Rule

- Every orbital in a subshell is singly occupied with **one electron** before any one orbital is doubly occupied
- All electrons in singly occupied orbitals have the same spin.
- **Analogy:** When boarding the bus, you would take an empty seat rather than sit beside someone.

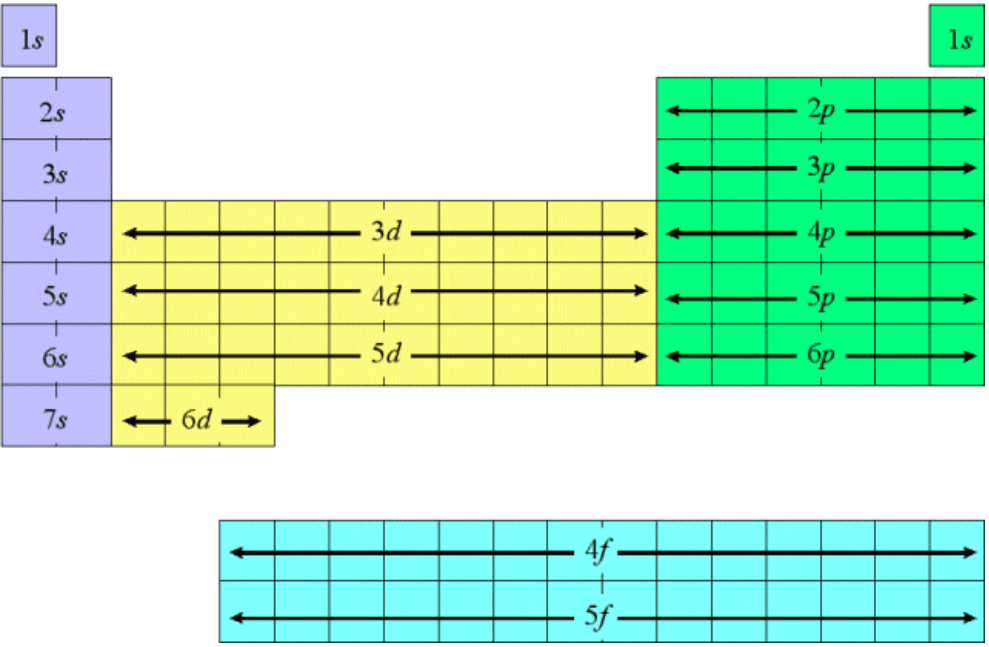


Vocabulary

- **Shell**: A set of orbitals having the same n-value
- **Subshell**: A set of orbitals of the same type

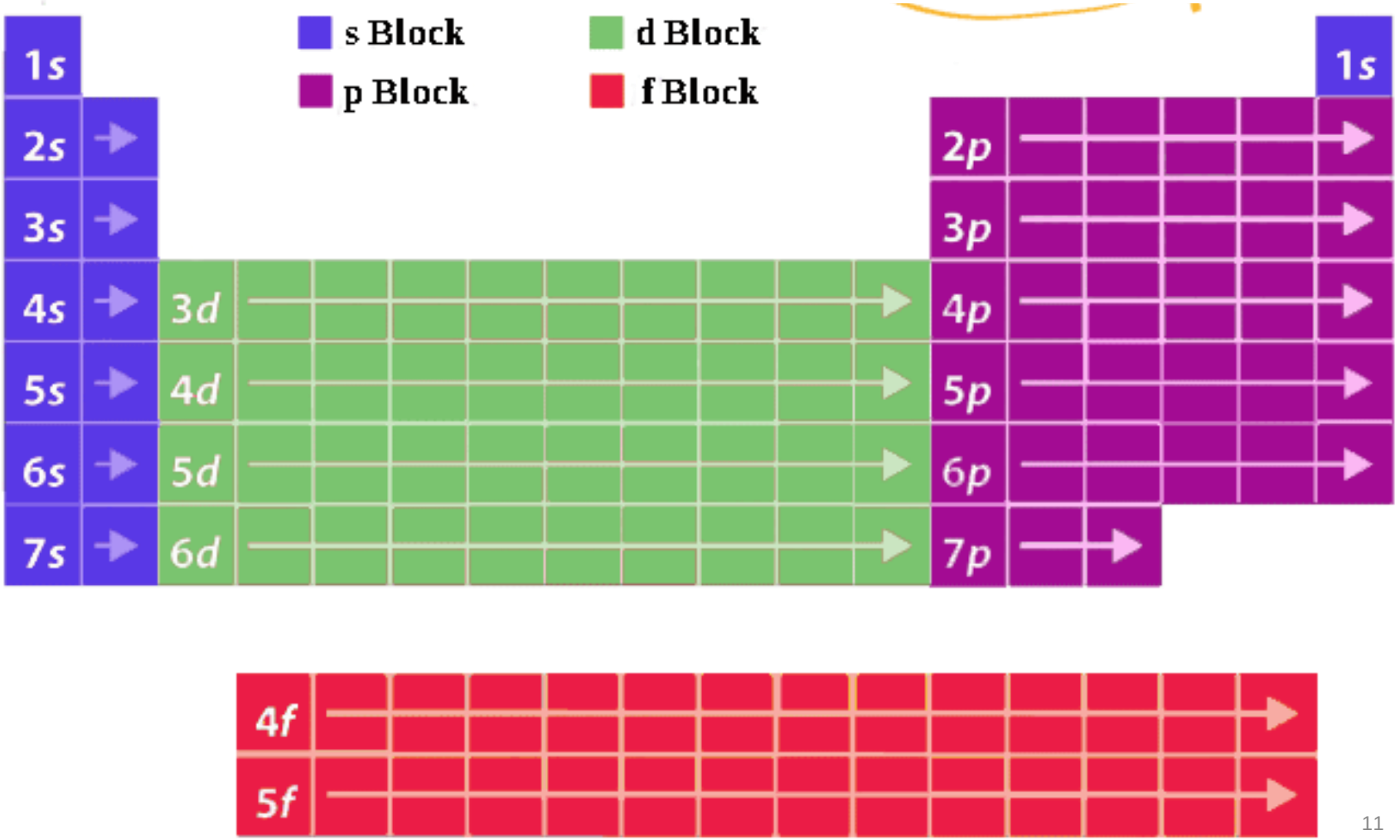


Shells and Subshells



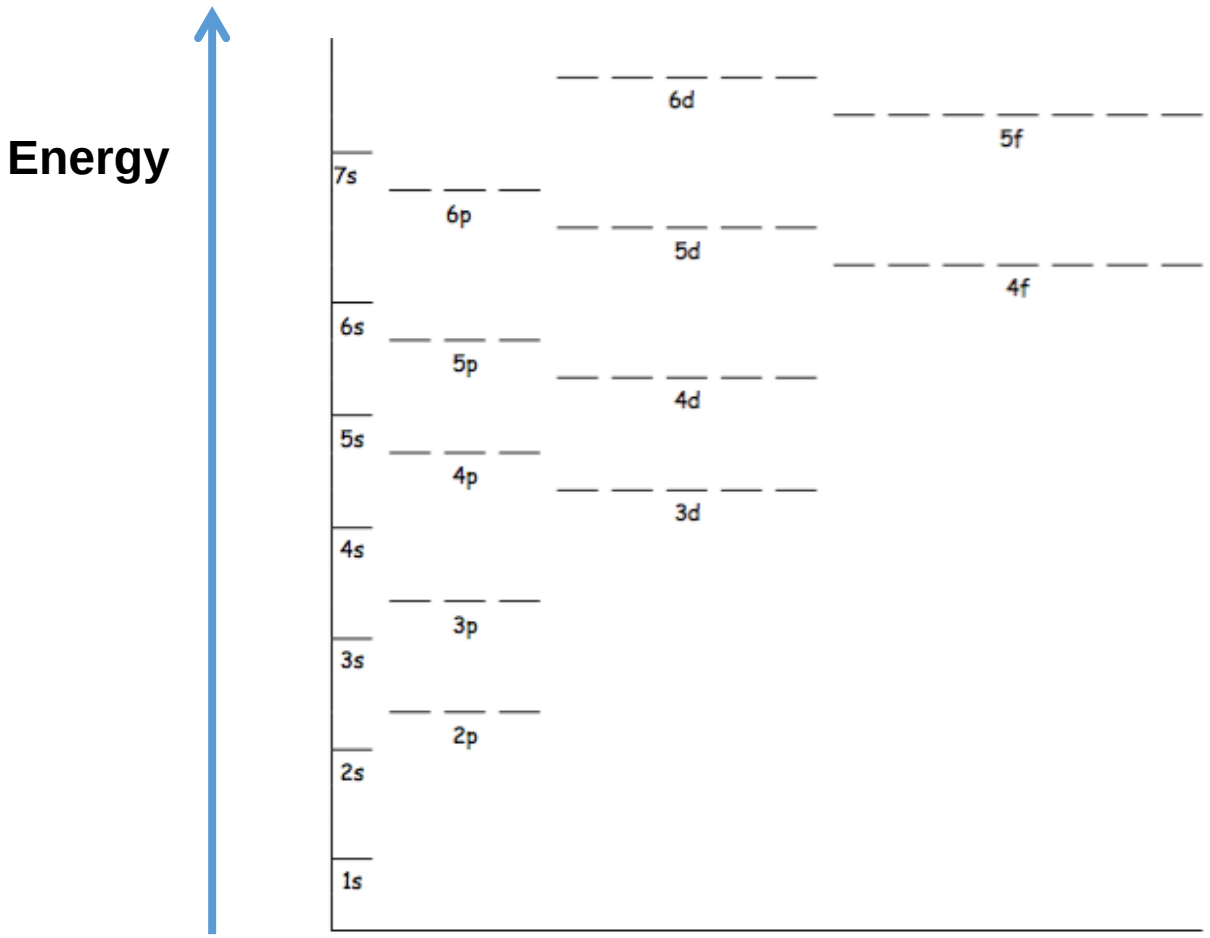
- S orbital = 1 s-orbitals
- P orbital = 3 p-orbitals
- D orbital = 5 d-orbitals
- F orbital = 7 f-orbitals

Shells and Subshells



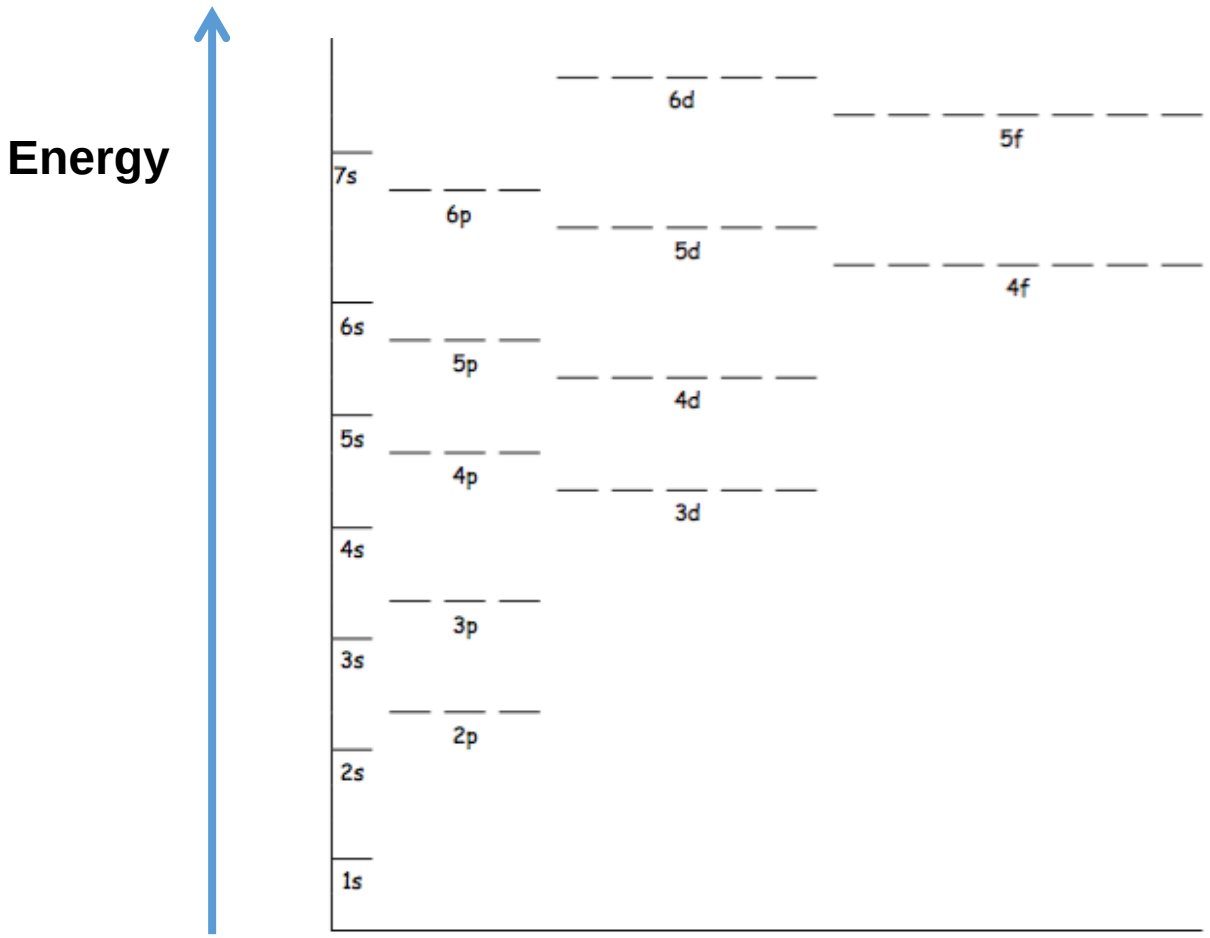
Practice Problem #1

Draw the electron energy diagram for Lithium



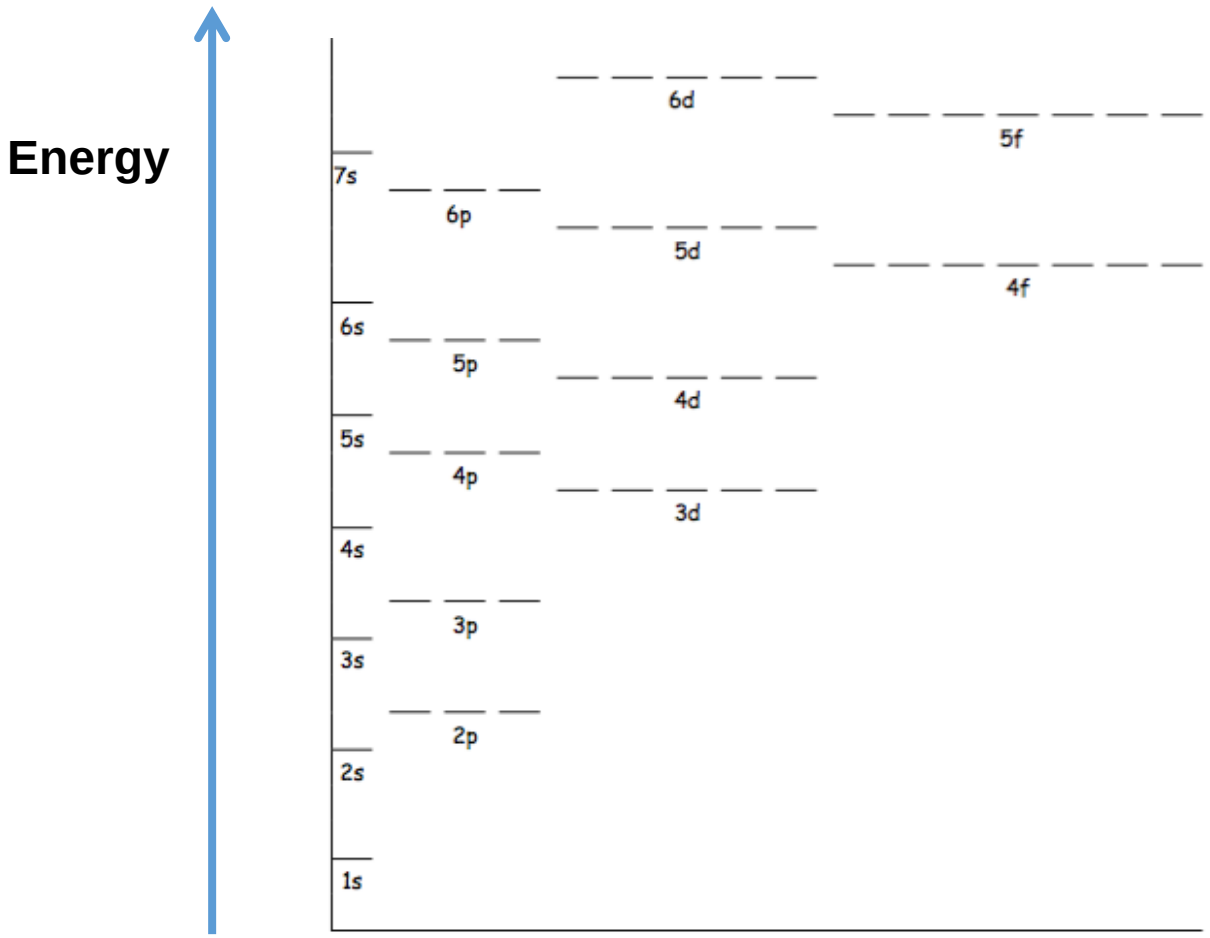
Practice Problem #2

Draw the electron energy diagram for Nitrogen



Practice Problem #3

Draw the electron energy diagram for Calcium



Complete Electron Configuration

The thing we are finding the electron configuration for

# of electrons in the orbital

$$He\ 1s^2$$

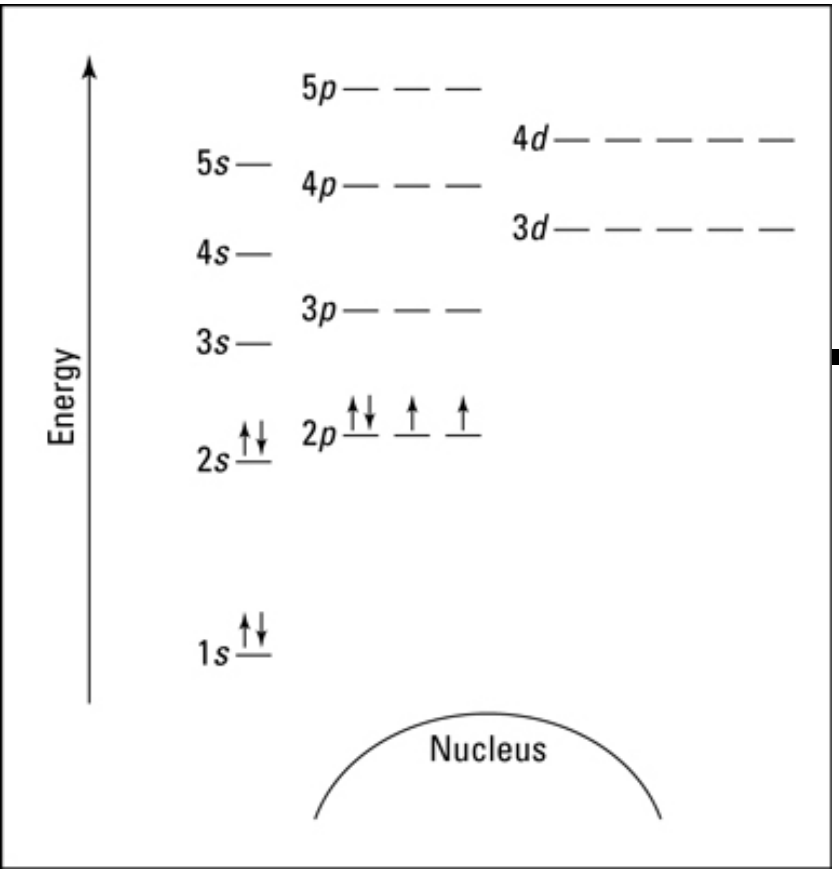
Principal quantum number "*n*"

Secondary quantum number "*l*"

Complete Electron Configuration

You can transfer the information from your energy level diagrams to complete electron configurations to indicate the arrangement of electrons

Energy Level Diagram for Oxygen



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

Practice Problem #5

Write the complete electron configuration for Sodium

Write the complete electron configuration for Neon

Write the complete electron configuration for Iron

Practice Problem #5

Write the complete electron configuration for Sodium

Na: 1s2, 2s2, 2p6, 3s1

Write the complete electron configuration for Neon

Write the complete electron configuration for Iron

Practice Problem #5

Write the complete electron configuration for Sodium

Na: 1s2, 2s2, 2p6, 3s1

Write the complete electron configuration for Neon

Ne: 1s2, 2s2, 2p6

Write the complete electron configuration for Iron

Practice Problem #5

Write the complete electron configuration for Sodium

Na: 1s2, 2s2, 2p6, 3s1

Write the complete electron configuration for Neon

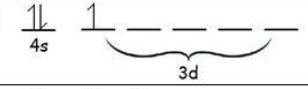
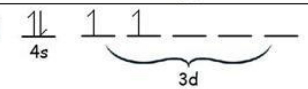
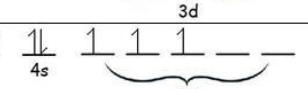
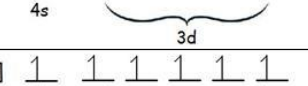
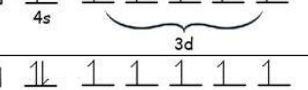
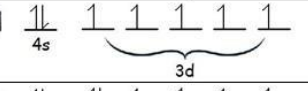
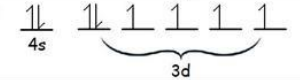
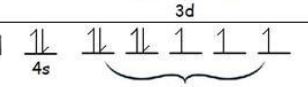
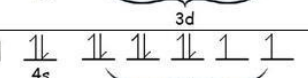
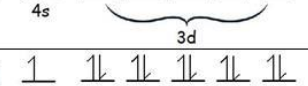
Ne: 1s2, 2s2, 2p6

Write the complete electron configuration for Iron

Fe: 1s2, 2s2, 2p6, 3s2, 3p6, 4s2, 3d6

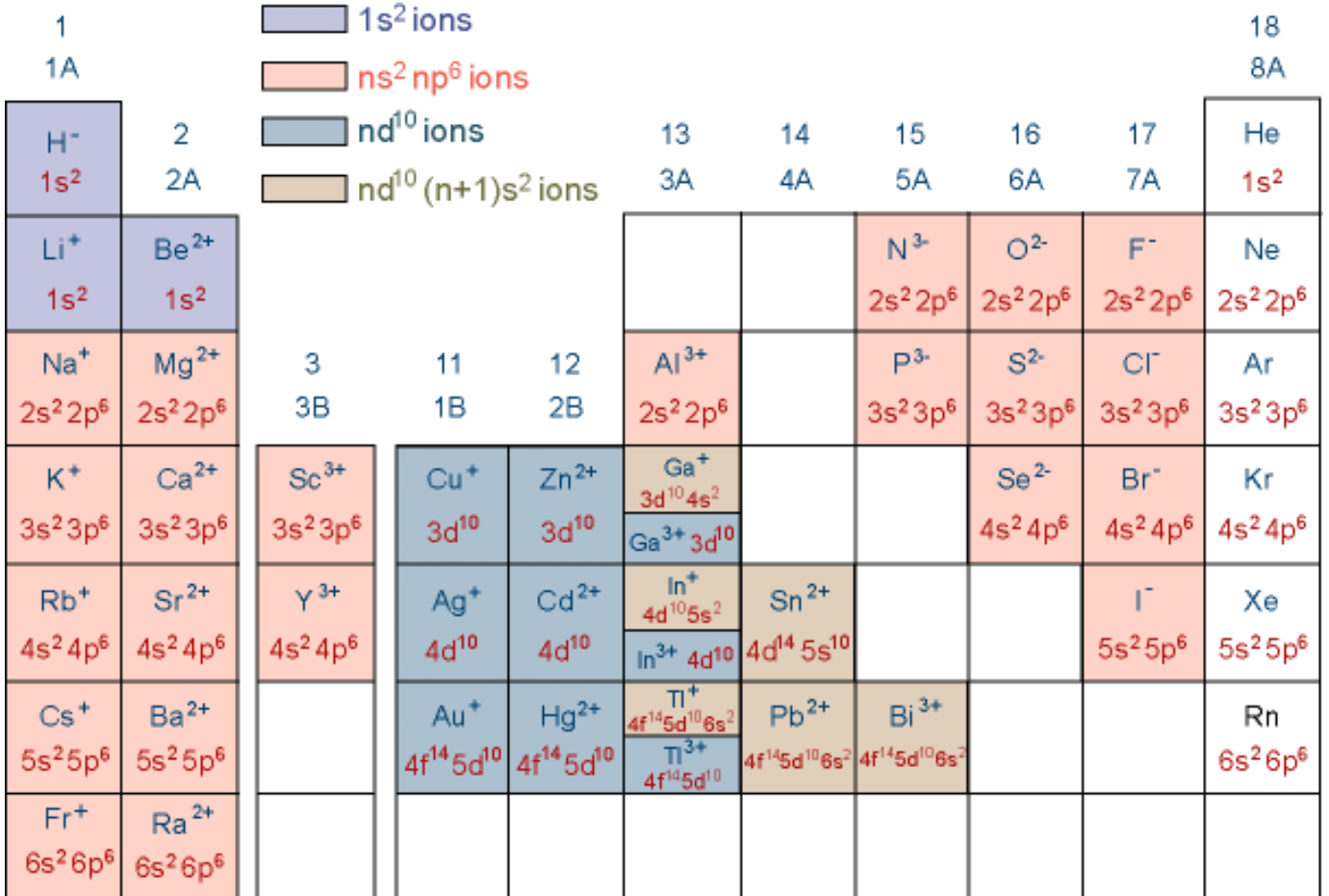
Exceptions to Complete Electron Configuration

Chromium & Copper are the two exceptions to the electron configuration (They do not follow the general pattern). They are more stable with this electron arrangement

Element Name and Symbol	Atomic Number	Common Oxidation States	Electron Configuration	
Scandium (Sc)	21	+3	Sc: [Ar] $4s^2 3d^1$	Sc: [Ar] 
Titanium (Ti)	22	+4	Ti: [Ar] $4s^2 3d^2$	Ti: [Ar] 
Vanadium (V)	23	+2, +3, +4, +5	V: [Ar] $4s^2 3d^3$	V: [Ar] 
Chromium (Cr)	24	+2, +3, +6	Cr: [Ar] $4s^1 3d^5$	Cr: [Ar] 
Manganese (Mn)	25	+2, +3, +4, +6, +7	Mn: [Ar] $4s^2 3d^5$	Mn: [Ar] 
Iron (Fe)	26	+2, +3	Fe: [Ar] $4s^2 3d^6$	Fe: [Ar] 
Cobalt (Co)	27	+2, +3	Co: [Ar] $4s^2 3d^7$	Co: [Ar] 
Nickel (Ni)	28	+2	Ni: [Ar] $4s^2 3d^8$	Ni: [Ar] 
Copper (Cu)	29	+1, +2	Cu: [Ar] $4s^1 3d^{10}$	Cu: [Ar] 
Zinc (Zn)	30	+2	Zn: [Ar] $4s^2 3d^{10}$	Zn: [Ar] 

Electron Configuration for Ions

- For **anions**: **add extra electrons**
- For **cations**: draw the neutral atom, then **subtract** the required number of electrons from the orbital with the highest principal quantum number "n"



Practice Problem #6

Write the complete electron configuration for Mg^{2+}

Write the complete electron configuration for S^{2-}

Write the complete electron configuration for Cl^{-}

Practice Problem #6

Write the complete electron configuration for Mg^{2+}

Mg^{2+}: 1s2, 2s2, 2p6,

Write the complete electron configuration for S^{2-}

Write the complete electron configuration for Cl^{-}

Practice Problem #6

Write the complete electron configuration for Mg^{2+}

Mg^{2+} : 1s2, 2s2, 2p6

Write the complete electron configuration for S^{2-}

S^{2-} : 1s2, 2s2, 2p6, 3s2, 3p6

Write the complete electron configuration for Cl^{-}

Practice Problem #6

Write the complete electron configuration for Mg^{2+}

Mg^{2+} : 1s2, 2s2, 2p6

Write the complete electron configuration for S^{2-}

S^{2-} : 1s2, 2s2, 2p6, 3s2, 3p6

Write the complete electron configuration for Cl^{-}

Cl^{-} : 1s2, 2s2, 2p6, 3s2, 3p6

Core Notation

- The core notation is used to condense the complete electron configuration.

To complete a core notation:

1. **Find the noble gas that comes before the element and write the noble gas in square brackets**
2. **Show the remaining extra electrons of the element as you would on a regular electron configuration**

Complete electron configuration of Oxygen

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

Core notation of Oxygen

$[He]2s^2 2p^4$

Practice Problem #7

Write the core notation for Chlorine

Write the core notation for Iron

Write the core notation for Zinc

Practice Problem #7

Write the core notation for Chlorine

Cl: [Ne] 3s2, 3p5

Write the core notation for Iron

Write the core notation for Zinc

Practice Problem #7

Write the core notation for Chlorine

Cl: [Ne] 3s2, 3p5

Write the core notation for Iron

Fe: [Ar] 4s2, 3d6

Write the core notation for Zinc

Practice Problem #7

Write the core notation for Chlorine

Cl: [Ne] 3s2, 3p5

Write the core notation for Iron

Fe: [Ar] 4s2, 3d6

Write the core notation for Zinc

Zn: [Ar] 4s2, 3d10