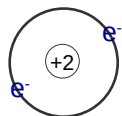
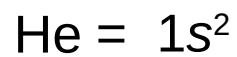
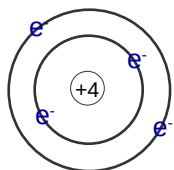
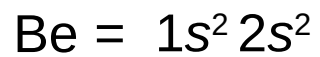


1s



1s

Coulombic attraction holds valence electrons to atom.



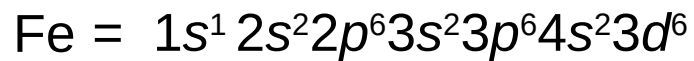
1s



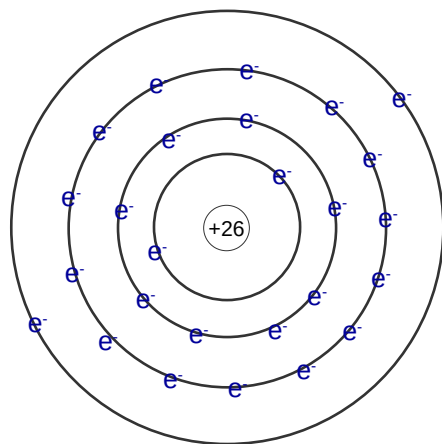
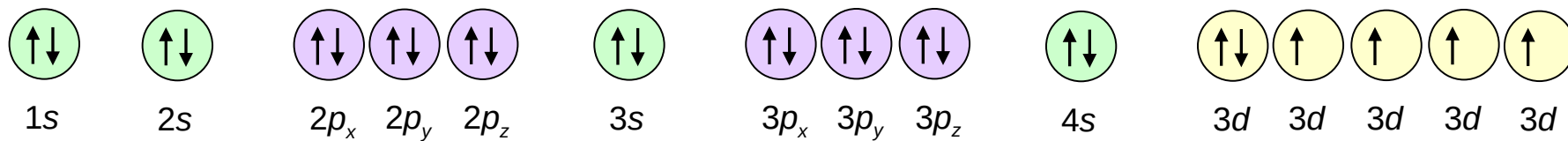
2s

Coulombic attraction holds valence electrons to atom.

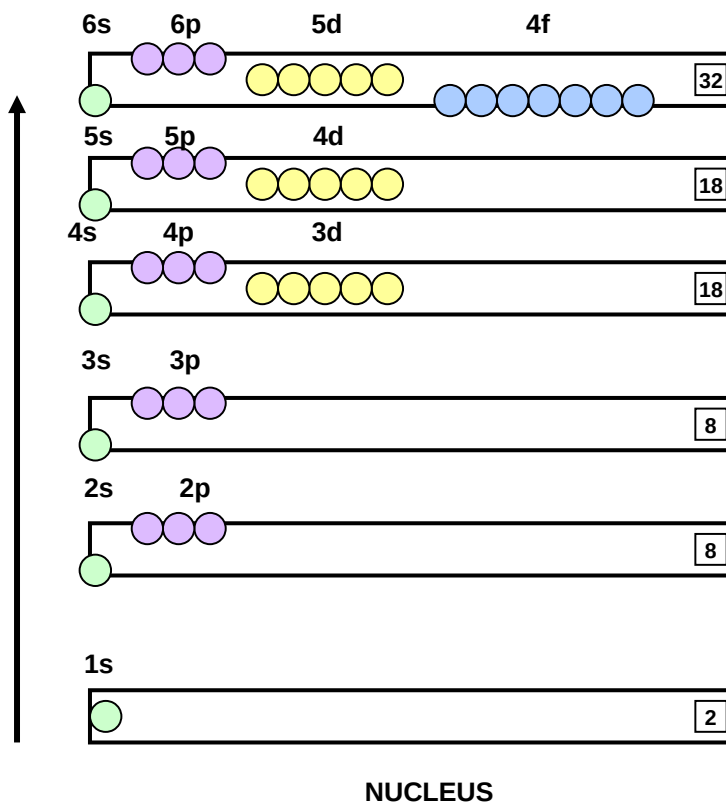
Valence electrons are shielded by the kernel electrons.
Therefore the valence electrons are not held as tightly in Be than in He.



Iron has 26 electrons.



**Arbitrary
Energy Scale**



Electron Configurations

Orbital Filling							Electron Configuration
Element	1s	2s	2p _x	2p _y	2p _z	3s	
H	↑						1s ¹
He	↑↓						1s ²
Li	↑↓	↑					1s ² 2s ¹
C	↑↓	↑↓	↑	↑			1s ² 2s ² 2p ²
N	↑↓	↑↓	↑	↑	↑		1s ² 2s ² 2p ³
O	↑↓	↑↓	↑↓	↑	↑		1s ² 2s ² 2p ⁴
F	↑↓	↑↓	↑↓	↑↓	↑		1s ² 2s ² 2p ⁵
Ne	↑↓	↑↓	↑↓	↑↓	↑↓		1s ² 2s ² 2p ⁶
Na	↑↓	↑↓	↑↓	↑↓	↑↓	↑	1s ² 2s ² 2p ⁶ 3s ¹

NOT CORRECT
Violates Hund's
Rule



Electron Configurations

Element	Orbital Filling					Electron Configuration	
	1s	2s	2p _x	2p _y	2p _z		3s
H	↑						1s ¹
He	↑↓						1s ²
Li	↑↓	↑					1s ² 2s ¹
C	↑↓	↑↓	↑	↑			1s ² 2s ² 2p ²
N	↑↓	↑↓	↑	↑	↑		1s ² 2s ² 2p ³
O	↑↓	↑↓	↑↓	↑	↑		1s ² 2s ² 2p ⁴
F	↑↓	↑↓	↑↓	↑↓	↑		1s ² 2s ² 2p ⁵
Ne	↑↓	↑↓	↑↓	↑↓	↑↓		1s ² 2s ² 2p ⁶
Na	↑↓	↑↓	↑↓	↑↓	↑↓	↑	1s ² 2s ² 2p ⁶ 3s ¹



Filling Rules for Electron Orbitals

Aufbau Principle: Electrons are added one at a time to the lowest energy orbitals available until all the electrons of the atom have been accounted for.

Pauli Exclusion Principle: An orbital can hold a maximum of two electrons. To occupy the same orbital, two electrons must spin in opposite directions.

Hund's Rule: Electrons occupy equal-energy orbitals so that a maximum number of unpaired electrons results.



**Aufbau* is German for “building up”

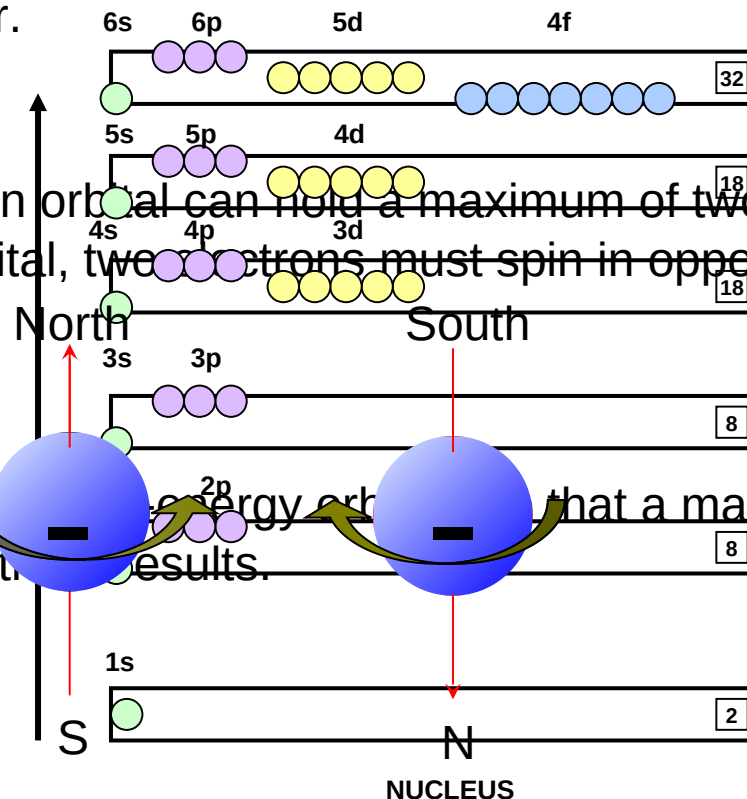
Filling Rules for Electron Orbitals

Aufbau Principle: Electrons are added one at a time to the lowest energy orbitals available until all the electrons of the atom have been accounted for.

Pauli Exclusion Principle: An orbital can hold a maximum of two electrons. To occupy the same orbital, two electrons must spin in opposite directions.

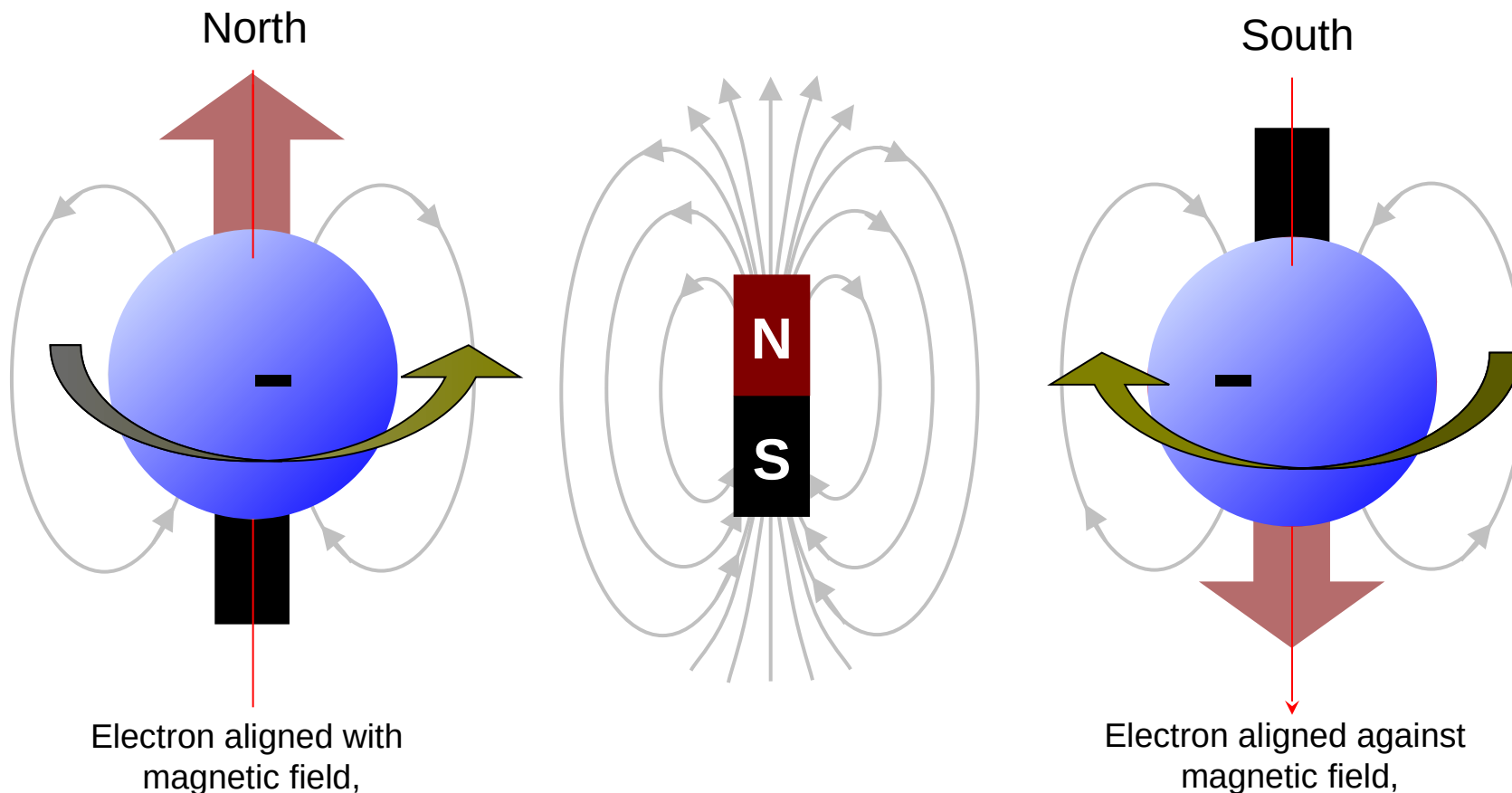
Hund's Rule: Electrons occupy energy orbitals that a maximum number of unpaired electrons results.

Arbitrary
Energy Scale



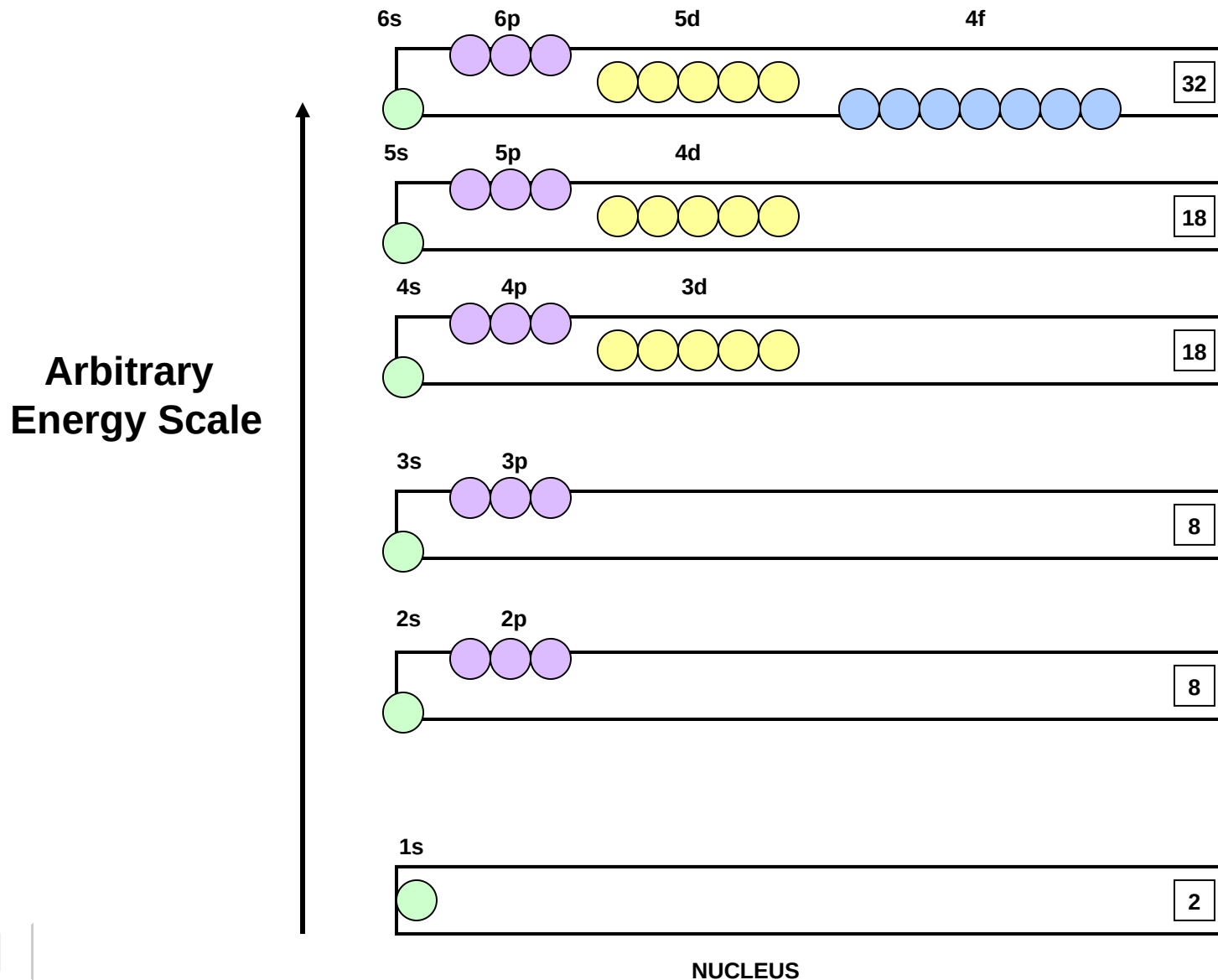
*Aufbau is German for "building up"

Spin Quantum Number, m_s



The electron behaves as if it were spinning about an axis through its center. This electron spin generates a magnetic field, the direction of which depends on the direction of the spin.

Energy Level Diagram of a Many-Electron Atom



Maximum Number of Electrons In Each Sublevel

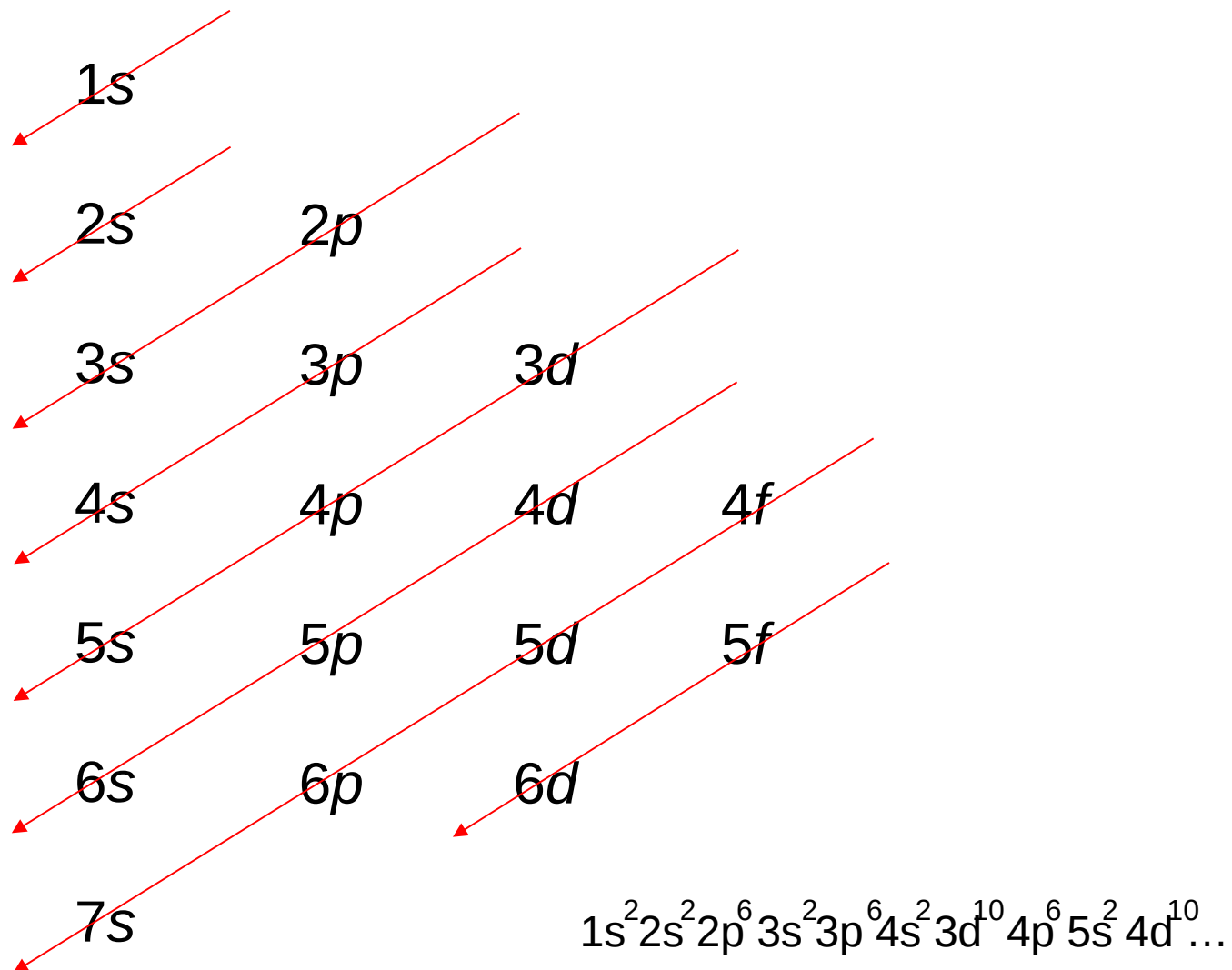
Sublevel	Number of Orbitals	Maximum Number of Electrons
<i>s</i>	1	2
<i>p</i>	3	6
<i>d</i>	5	10
<i>f</i>	7	14



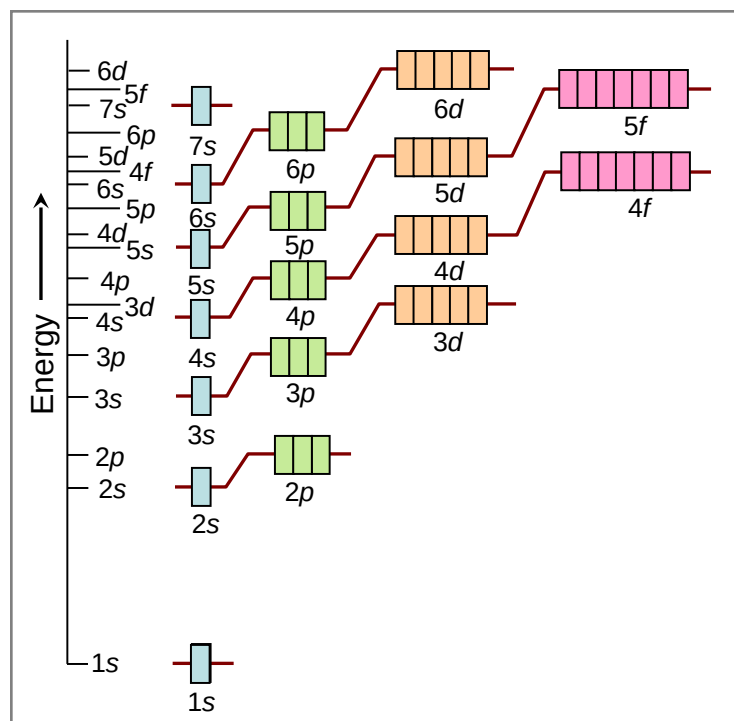
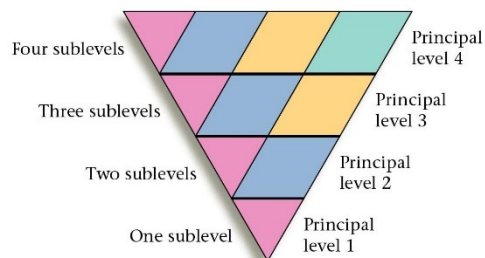
Quantum Numbers

n	→ shell	1, 2, 3, 4, ...
l	→ subshell	0, 1, 2, ... $n - 1$
m_l	→ orbital	- / ... 0 ... +/
m_s	→ electron spin	$+1/2$ and $-1/2$

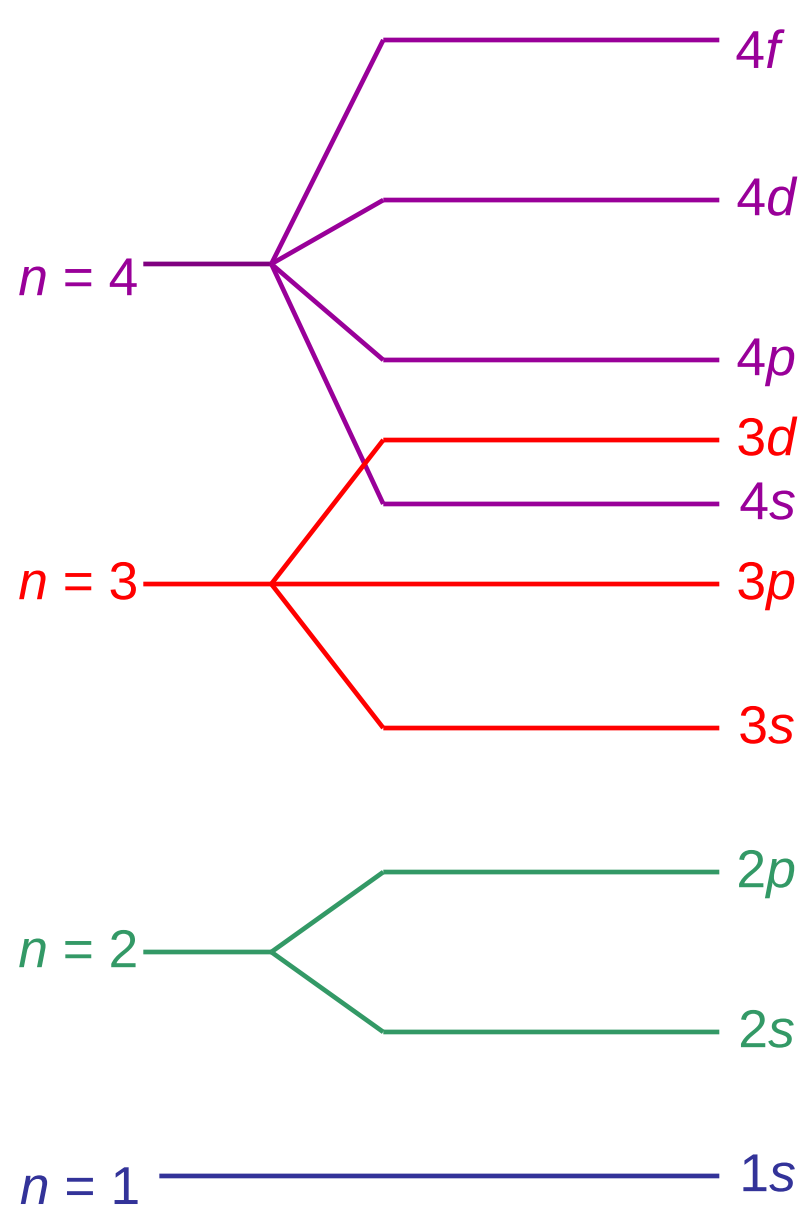
Order in which subshells are filled with electrons



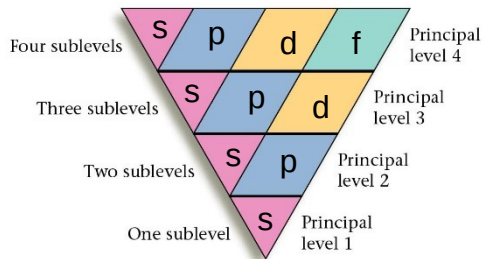
Sublevels



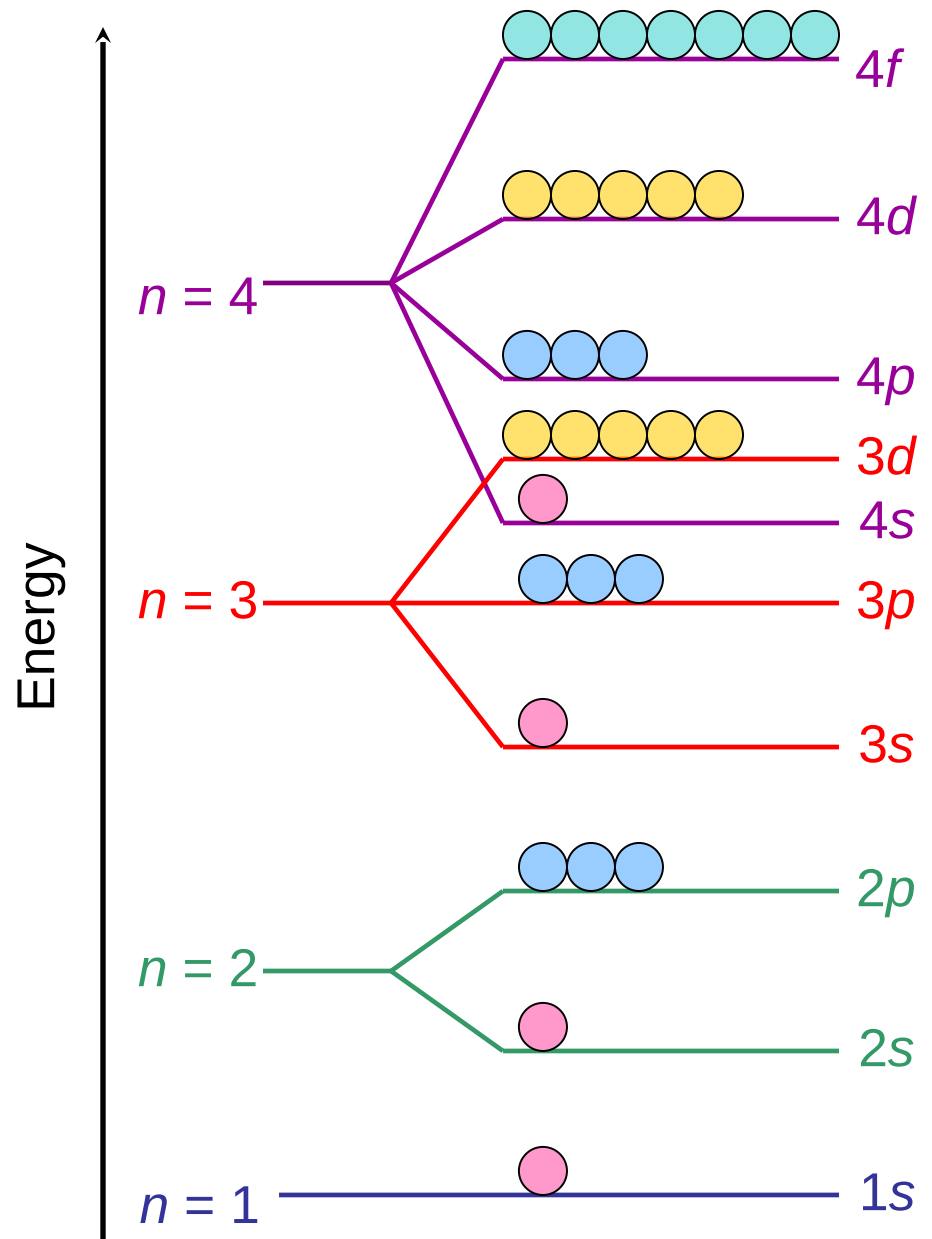
Energy



Sublevels



$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} \dots$



Filling Rules for Electron Orbitals

Aufbau Principle: Electrons are added one at a time to the lowest energy orbitals available until all the electrons of the atom have been accounted for.

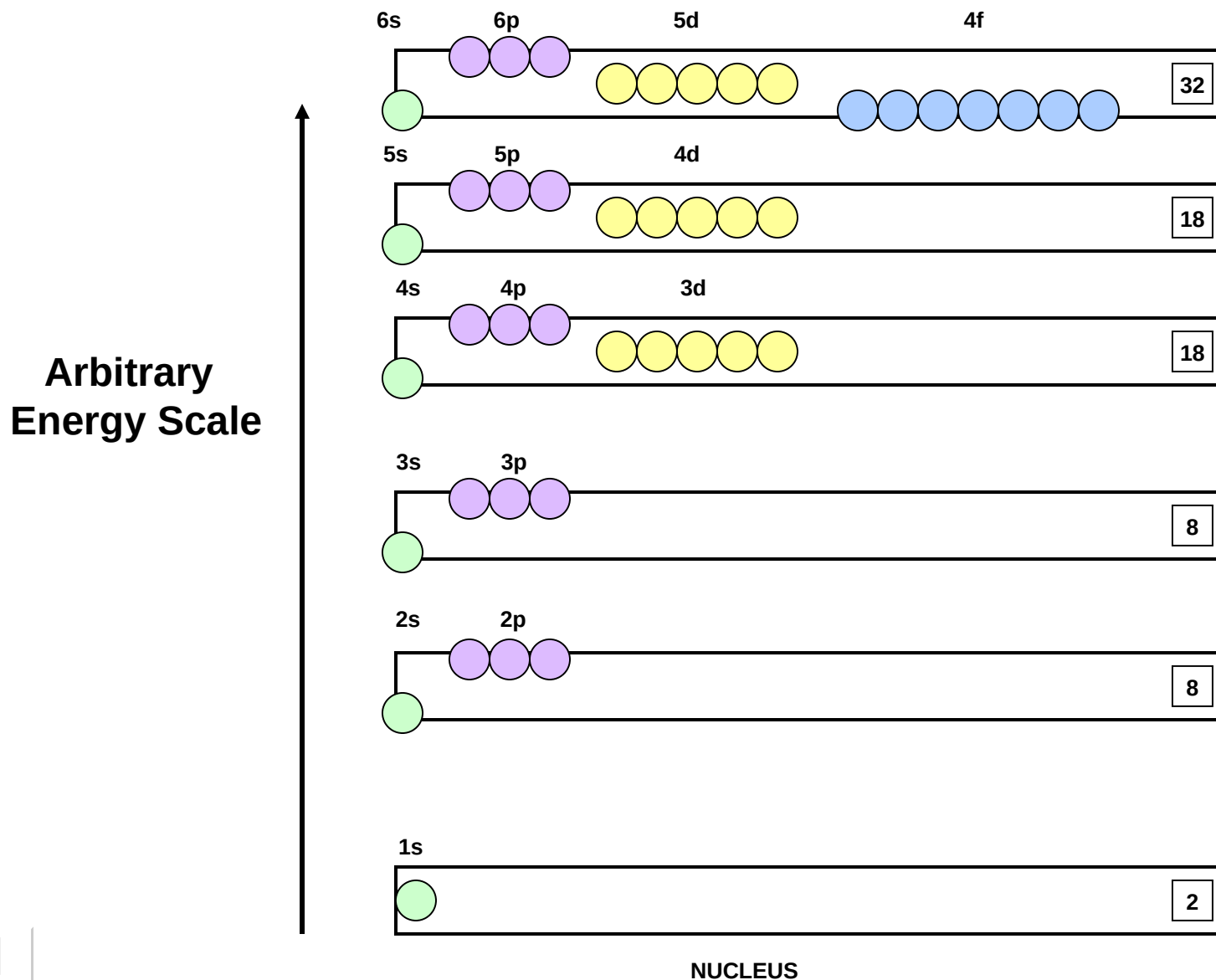
Pauli Exclusion Principle: An orbital can hold a maximum of two electrons. To occupy the same orbital, two electrons must spin in opposite directions.

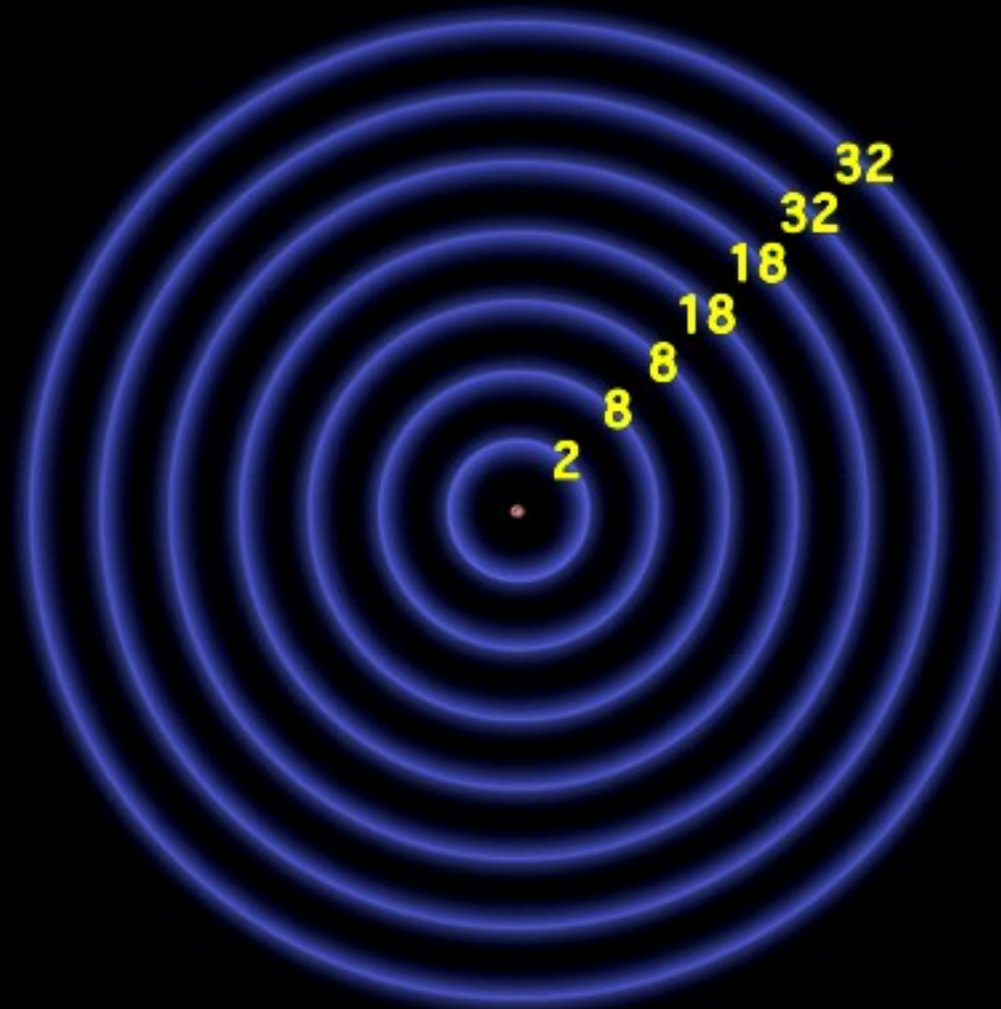
Hund's Rule: Electrons occupy equal-energy orbitals so that a maximum number of unpaired electrons results.



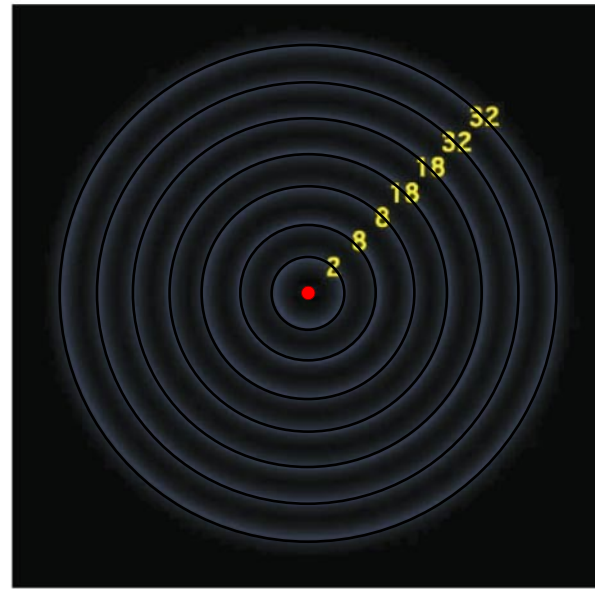
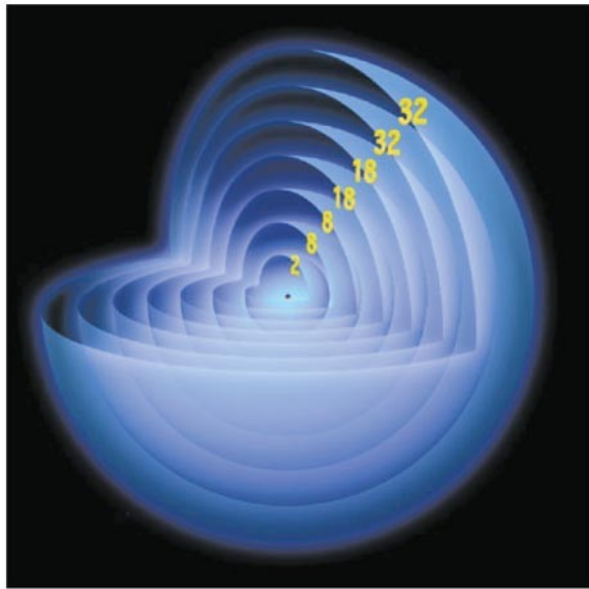
**Aufbau* is German for “building up”

Energy Level Diagram of a Many-Electron Atom



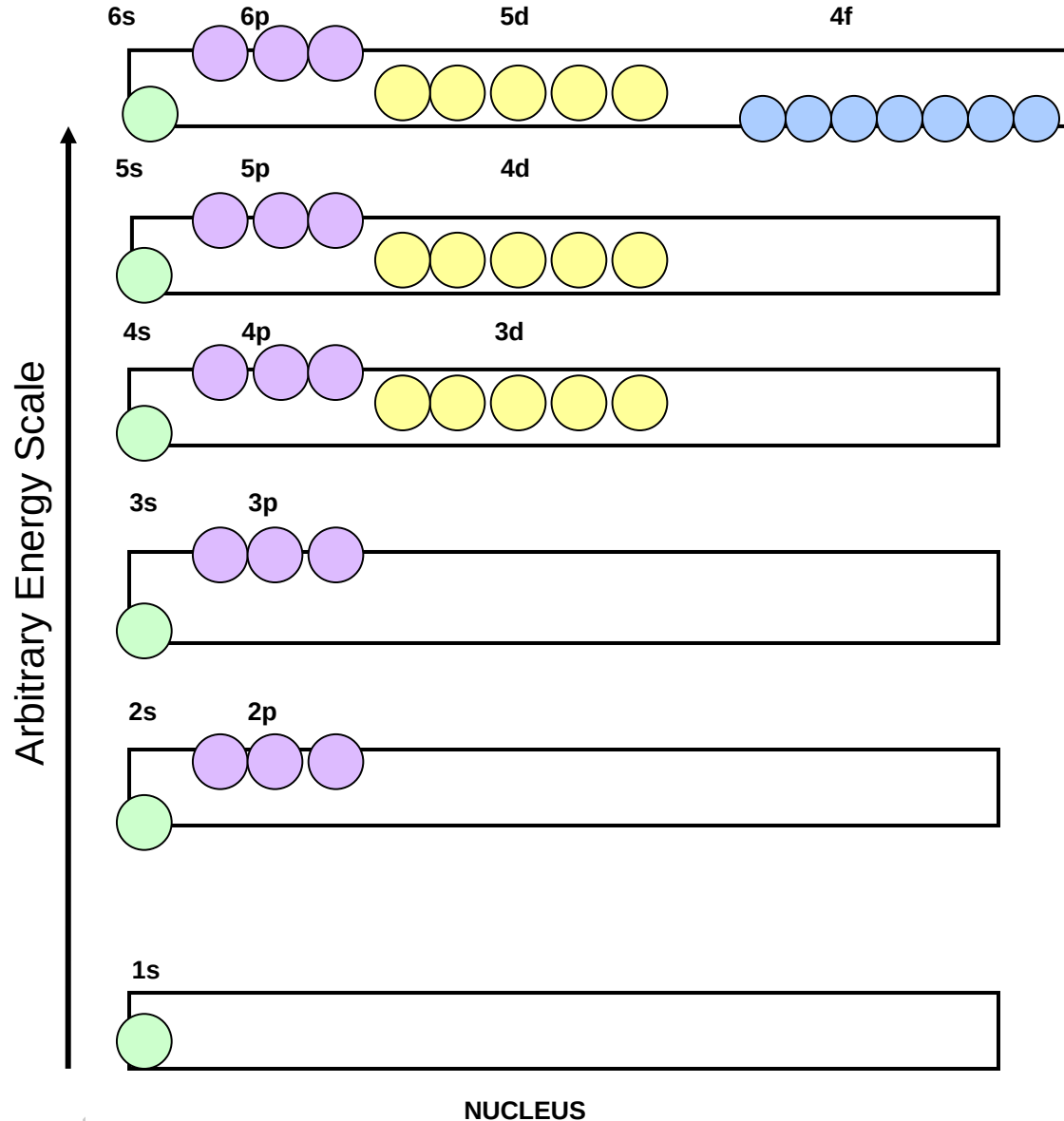


Electron
capacities

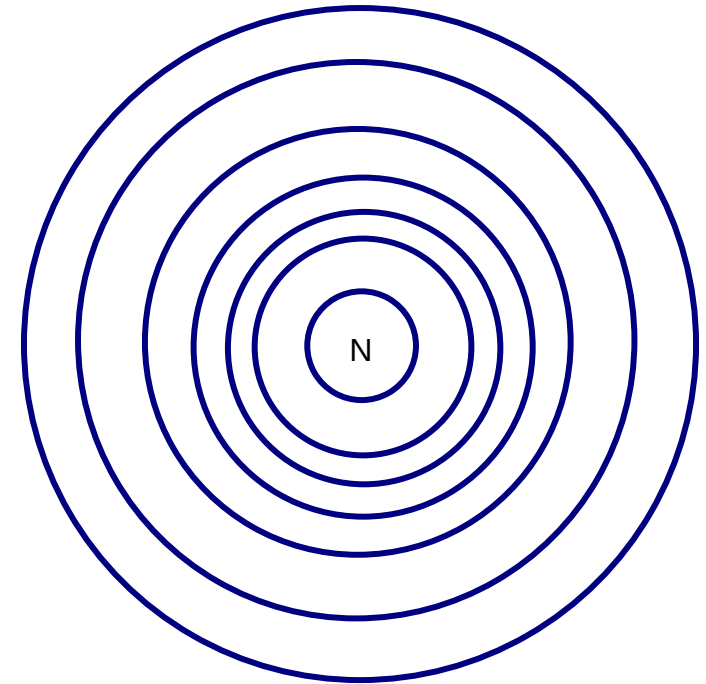


2 8 18 32 32

Energy Level Diagram



Bohr Model

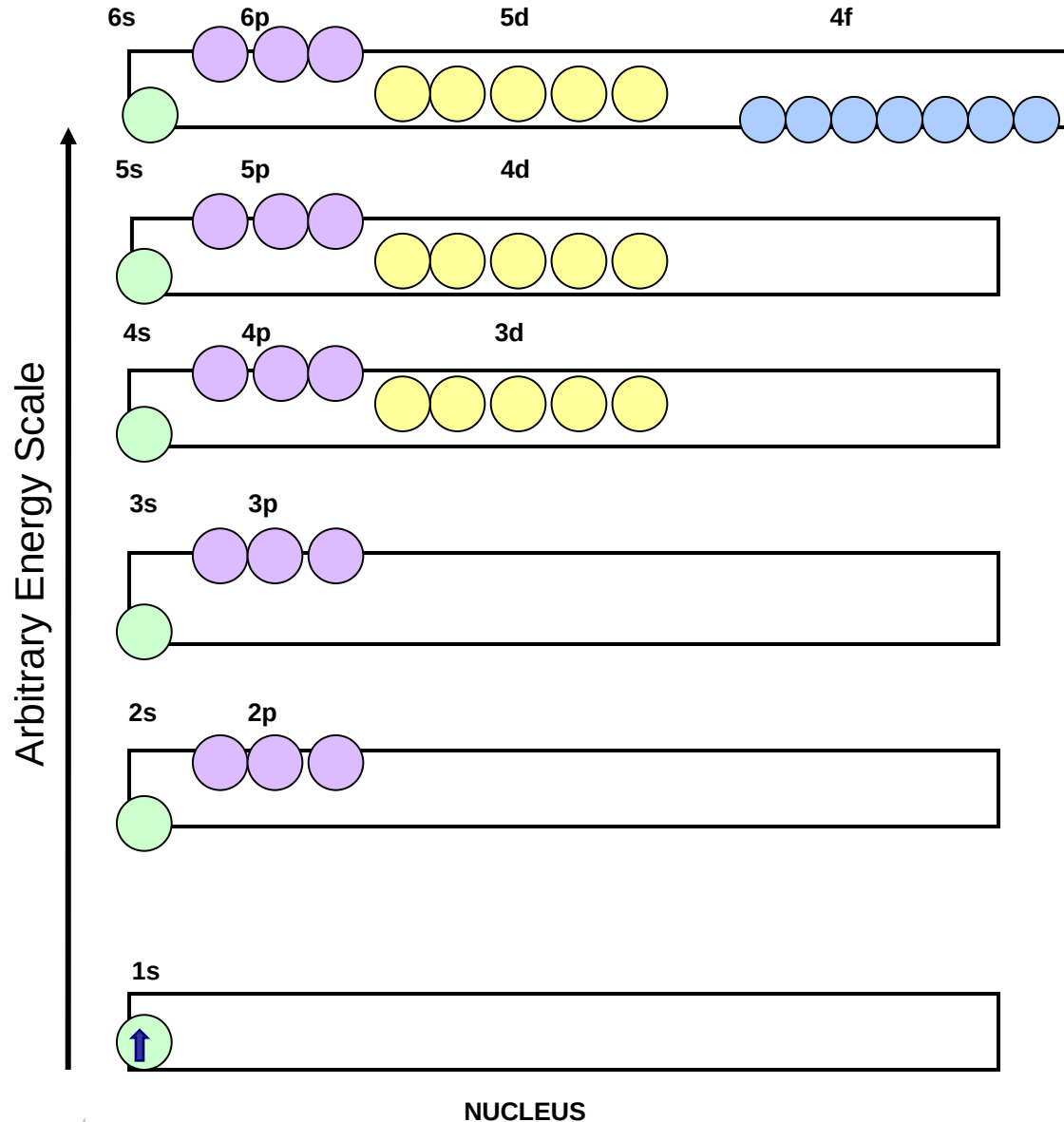


Electron Configuration

[H](#) [He](#) [Li](#) [C](#) [N](#) [Al](#) [Ar](#) [F](#) [Fe](#) [La](#)

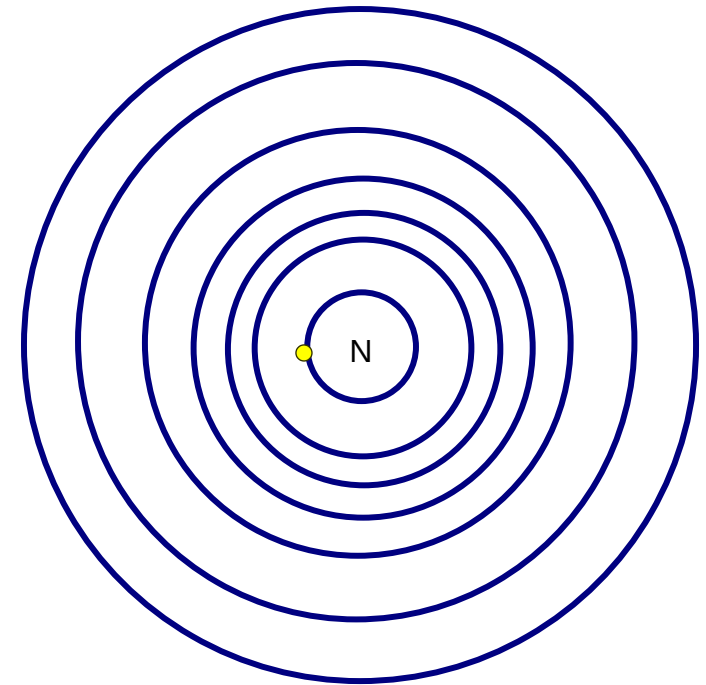
CLICK ON ELEMENT TO FILL IN CHARTS

Energy Level Diagram



Hydrogen

Bohr Model



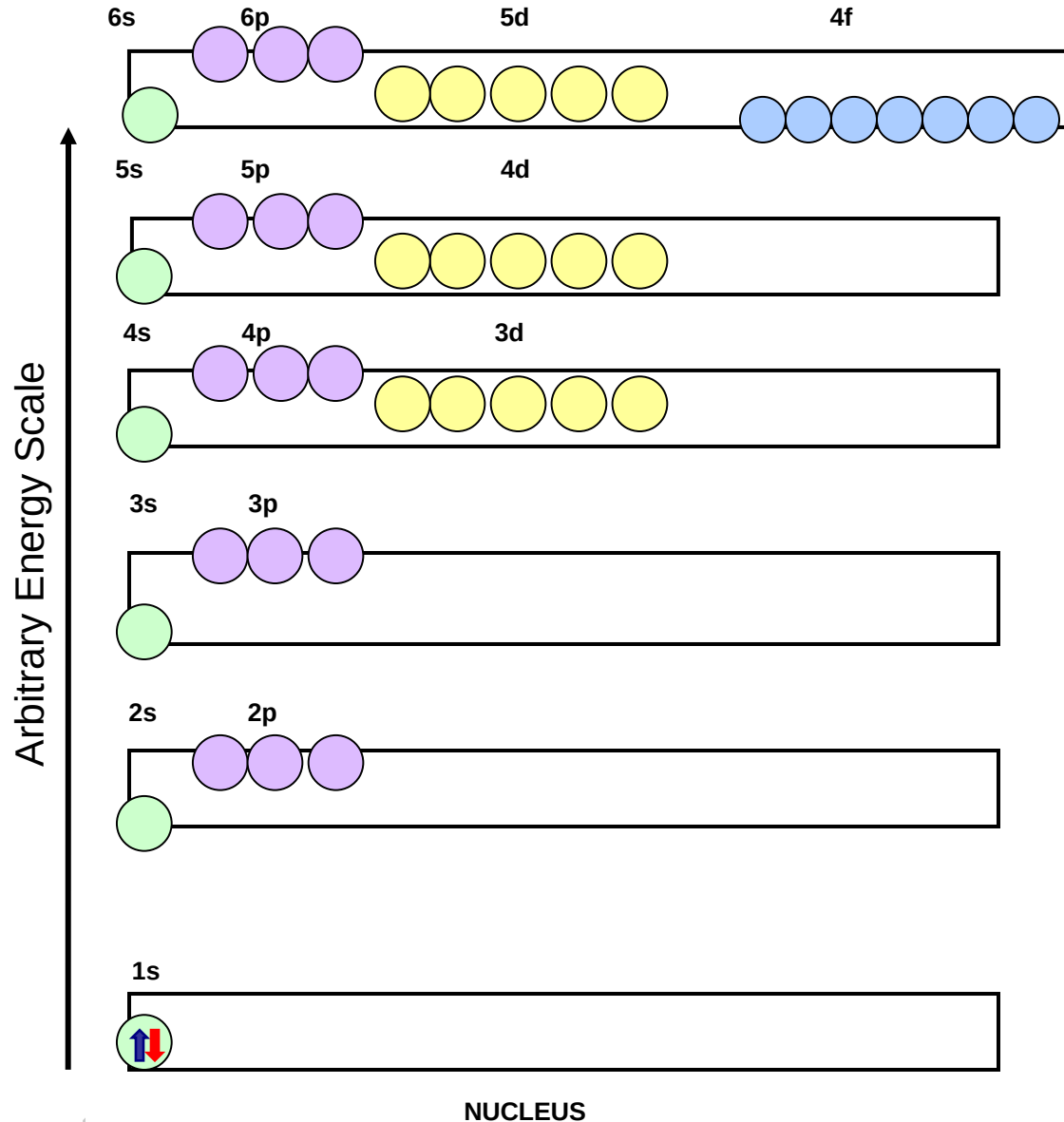
Electron Configuration

$H = 1s^1$

[H](#) [He](#) [Li](#) [C](#) [N](#) [Al](#) [Ar](#) [F](#) [Fe](#) [La](#)

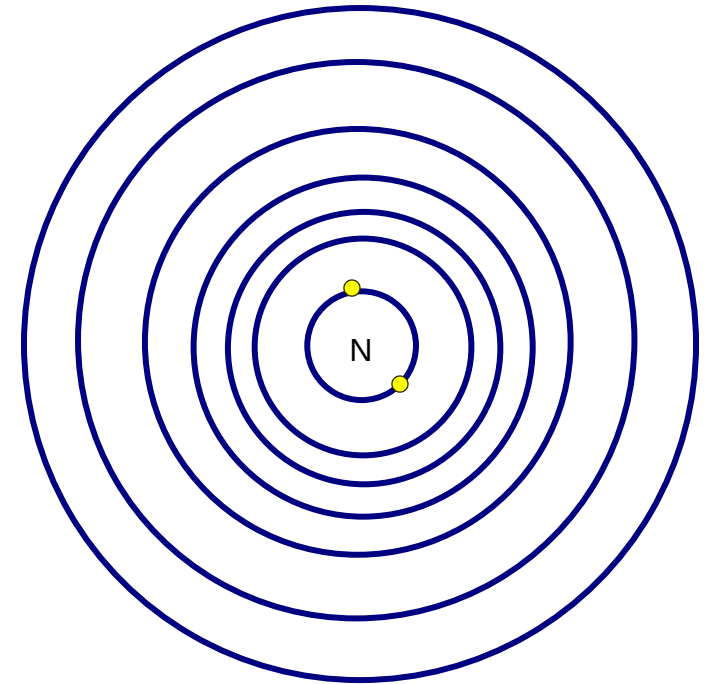
CLICK ON ELEMENT TO FILL IN CHARTS

Energy Level Diagram



Helium

Bohr Model



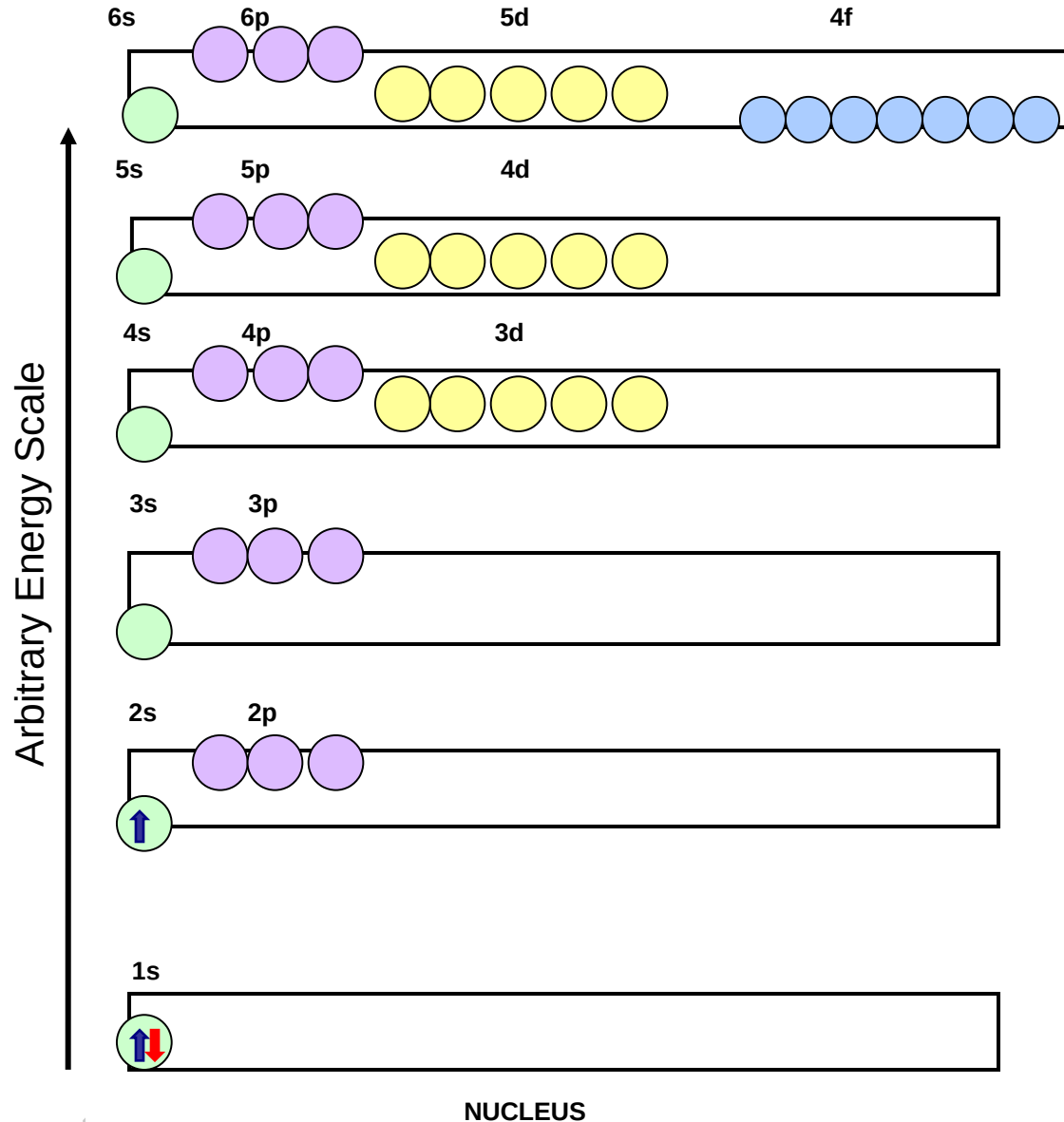
Electron Configuration



[H](#) [He](#) [Li](#) [C](#) [N](#) [Al](#) [Ar](#) [F](#) [Fe](#) [La](#)

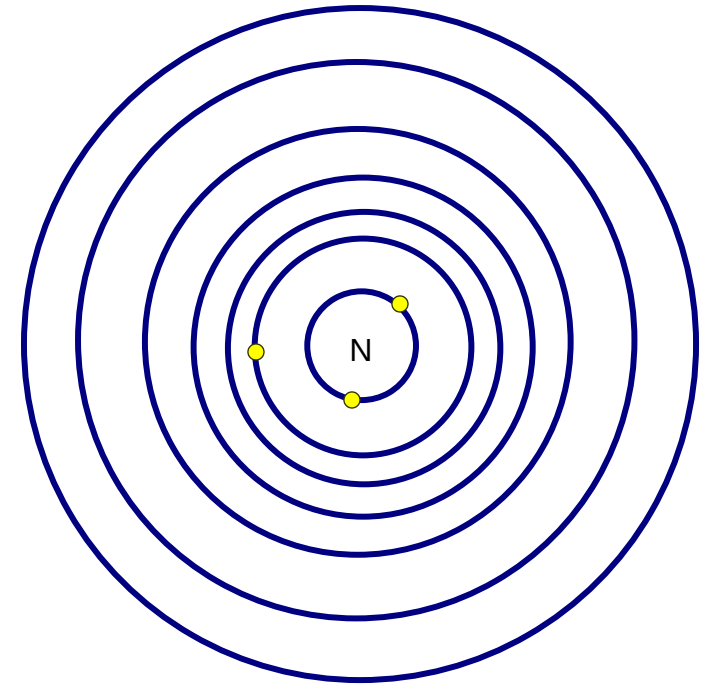
CLICK ON ELEMENT TO FILL IN CHARTS

Energy Level Diagram



Lithium

Bohr Model



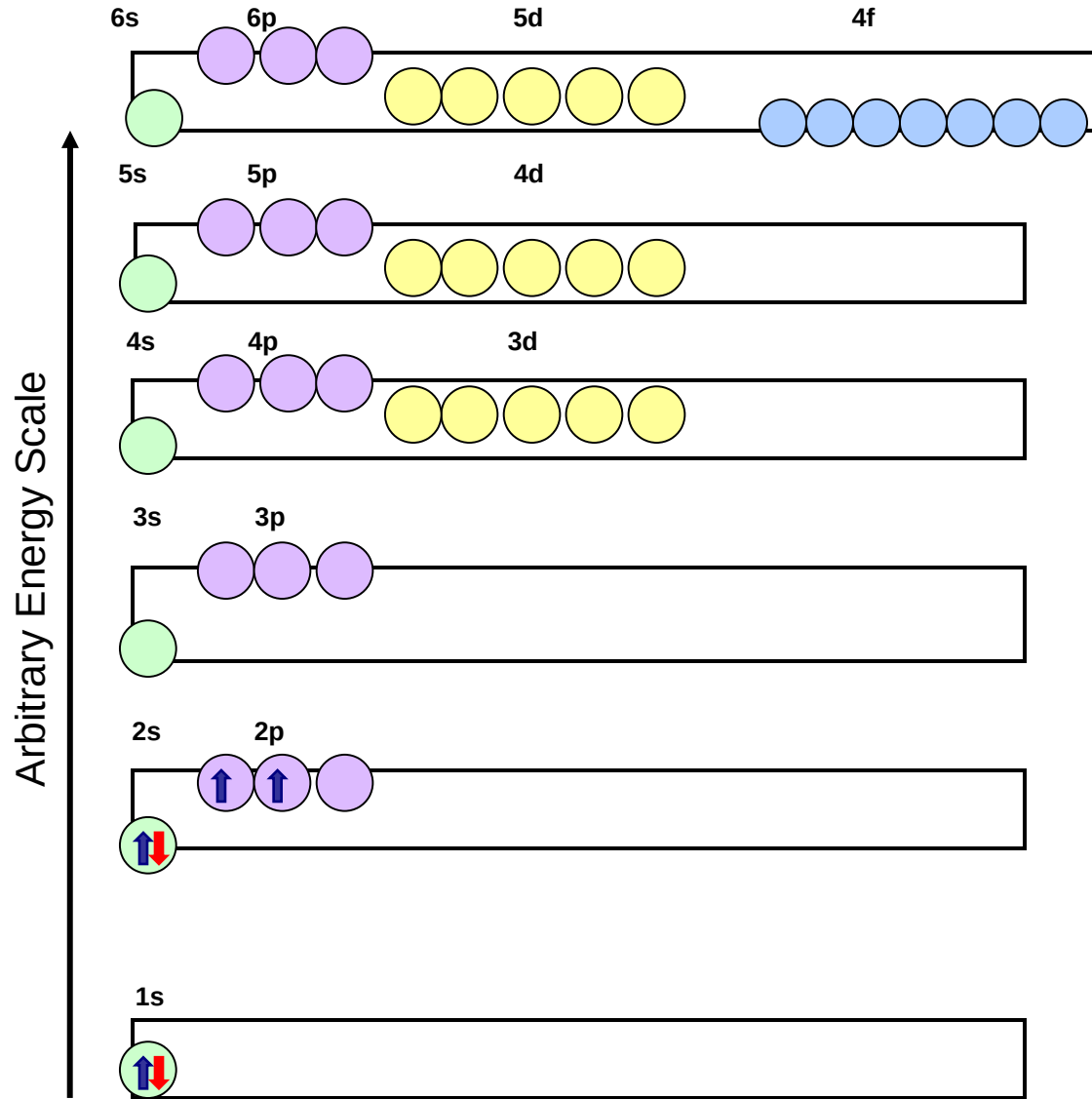
Electron Configuration



[H](#) [He](#) [Li](#) [C](#) [N](#) [Al](#) [Ar](#) [F](#) [Fe](#) [La](#)

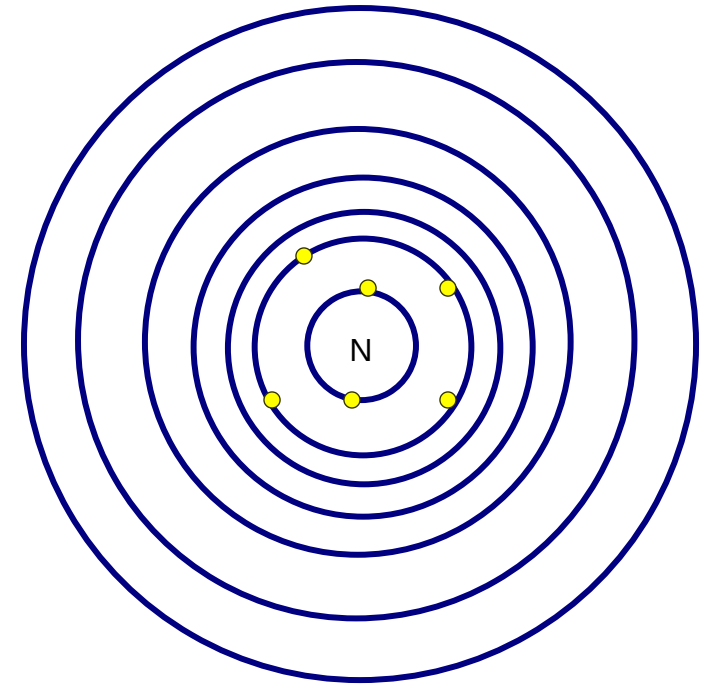
CLICK ON ELEMENT TO FILL IN CHARTS

Energy Level Diagram



Carbon

Bohr Model



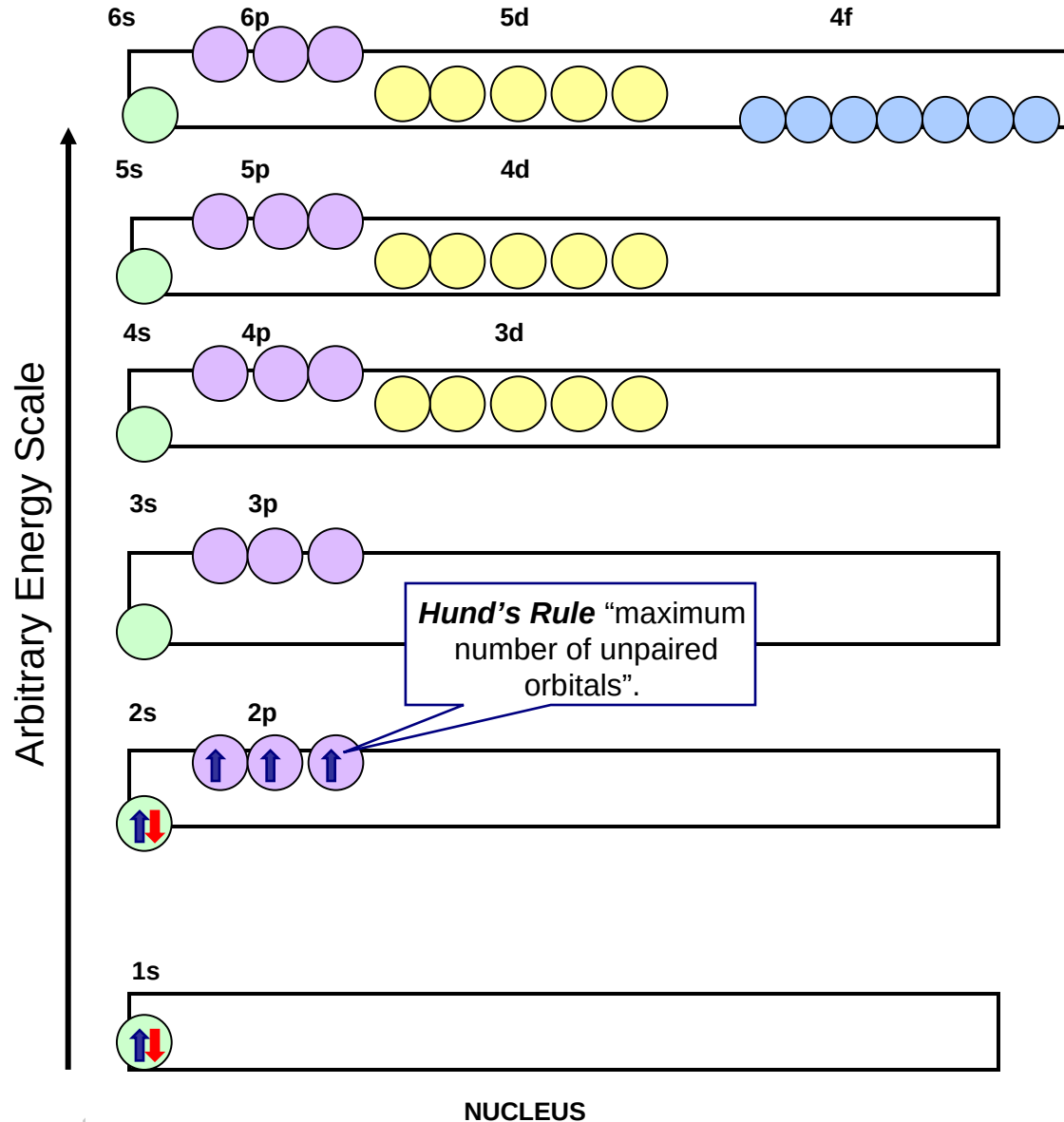
Electron Configuration



[H](#) [He](#) [Li](#) [C](#) [N](#) [Al](#) [Ar](#) [F](#) [Fe](#) [La](#)

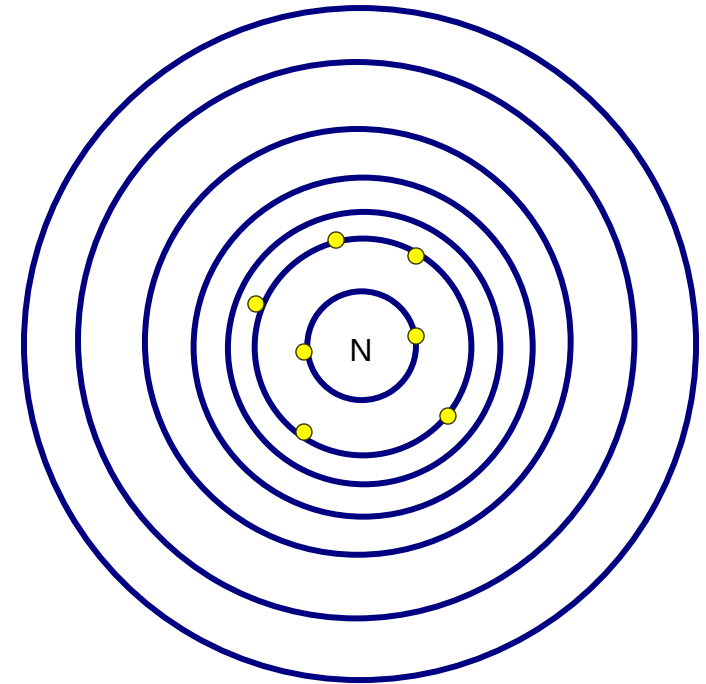
CLICK ON ELEMENT TO FILL IN CHARTS

Energy Level Diagram



Nitrogen

Bohr Model



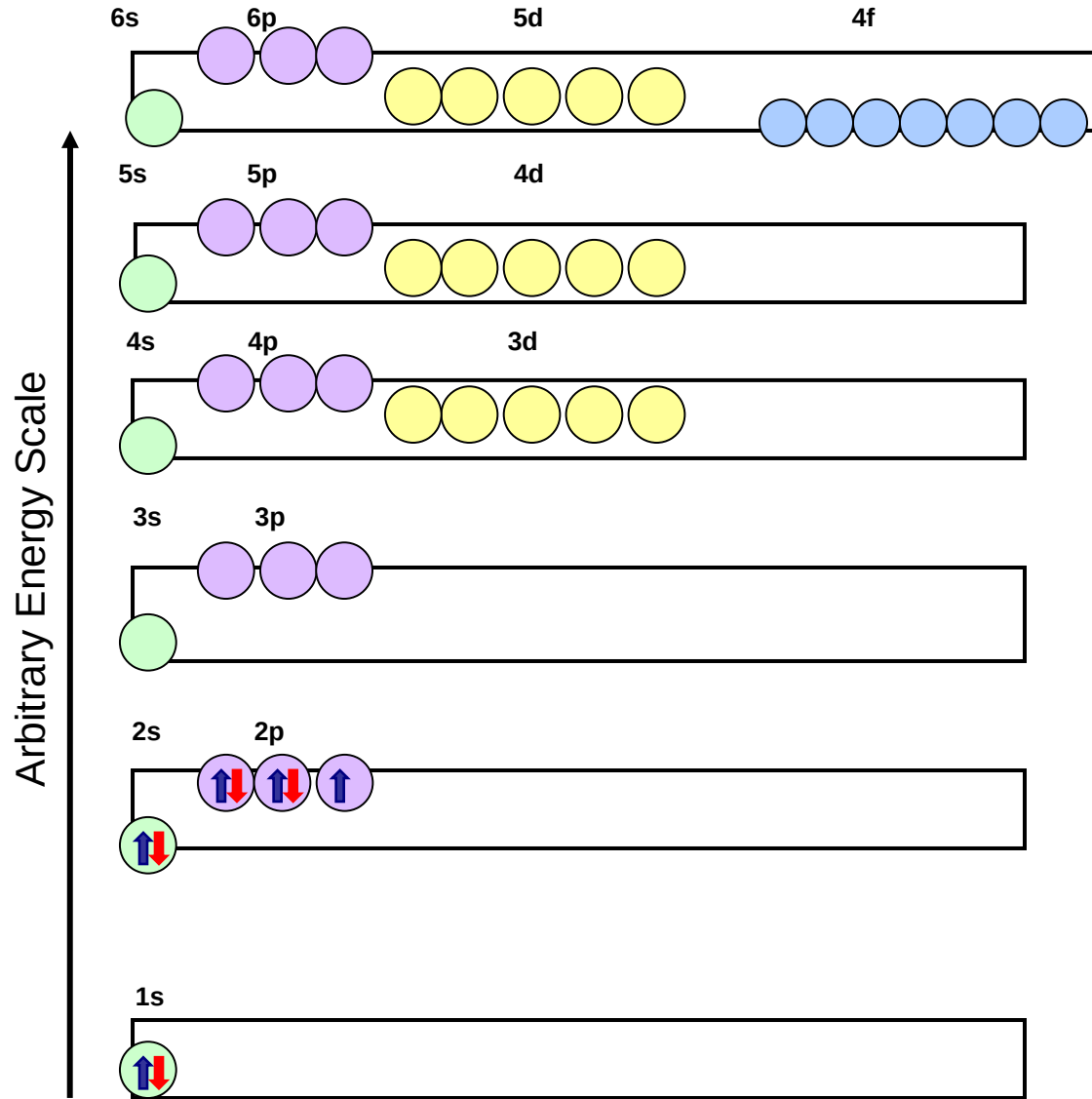
Electron Configuration



[H](#) [He](#) [Li](#) [C](#) [N](#) [Al](#) [Ar](#) [F](#) [Fe](#) [La](#)

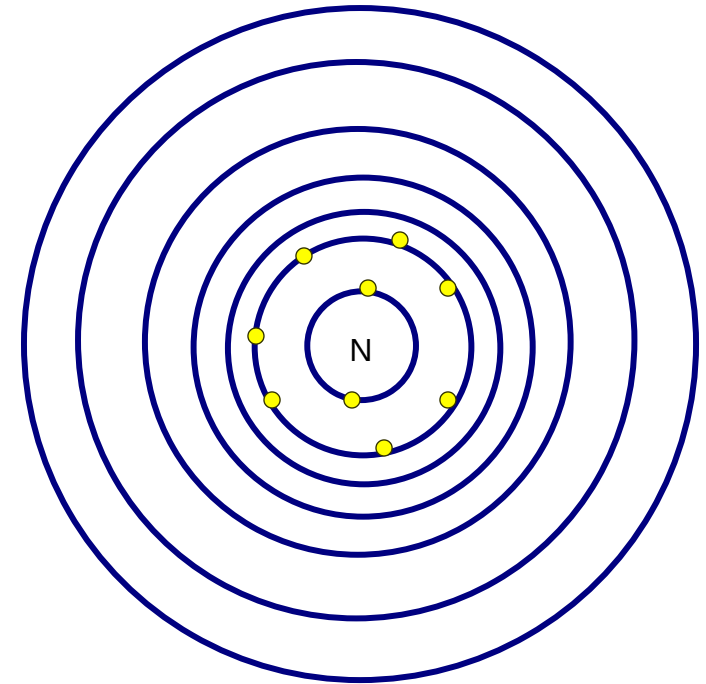
CLICK ON ELEMENT TO FILL IN CHARTS

Energy Level Diagram



Fluorine

Bohr Model



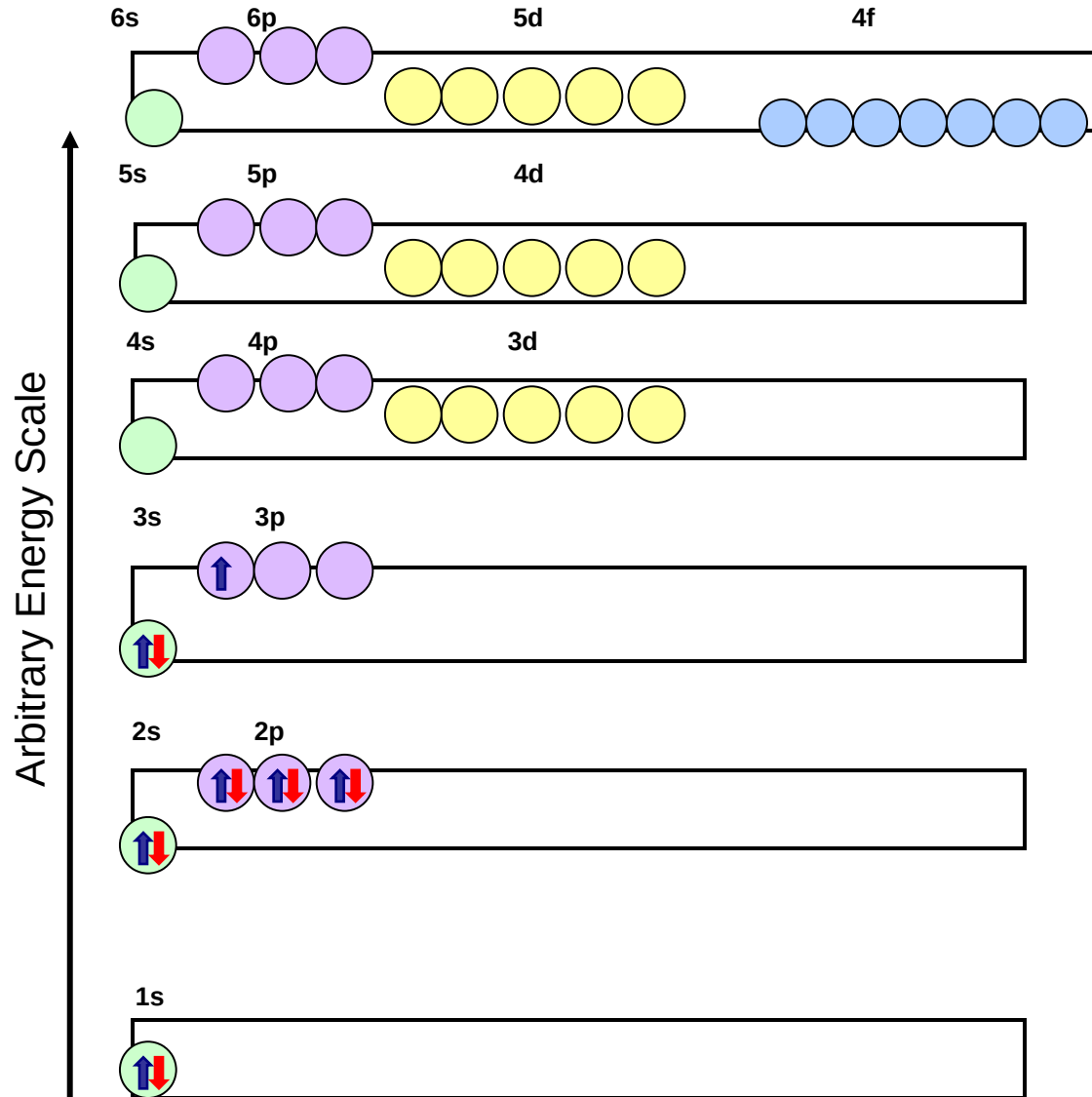
Electron Configuration



[H](#) [He](#) [Li](#) [C](#) [N](#) [Al](#) [Ar](#) [F](#) [Fe](#) [La](#)

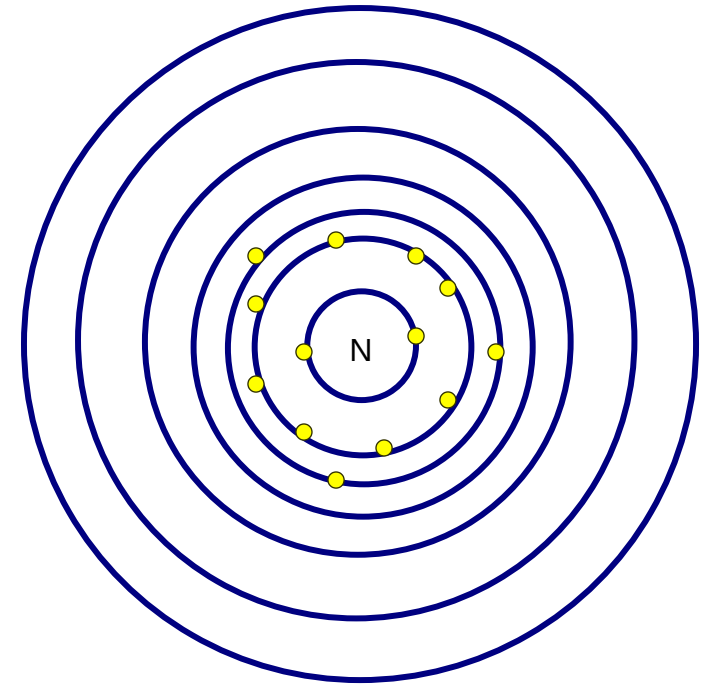
CLICK ON ELEMENT TO FILL IN CHARTS

Energy Level Diagram



Aluminum

Bohr Model



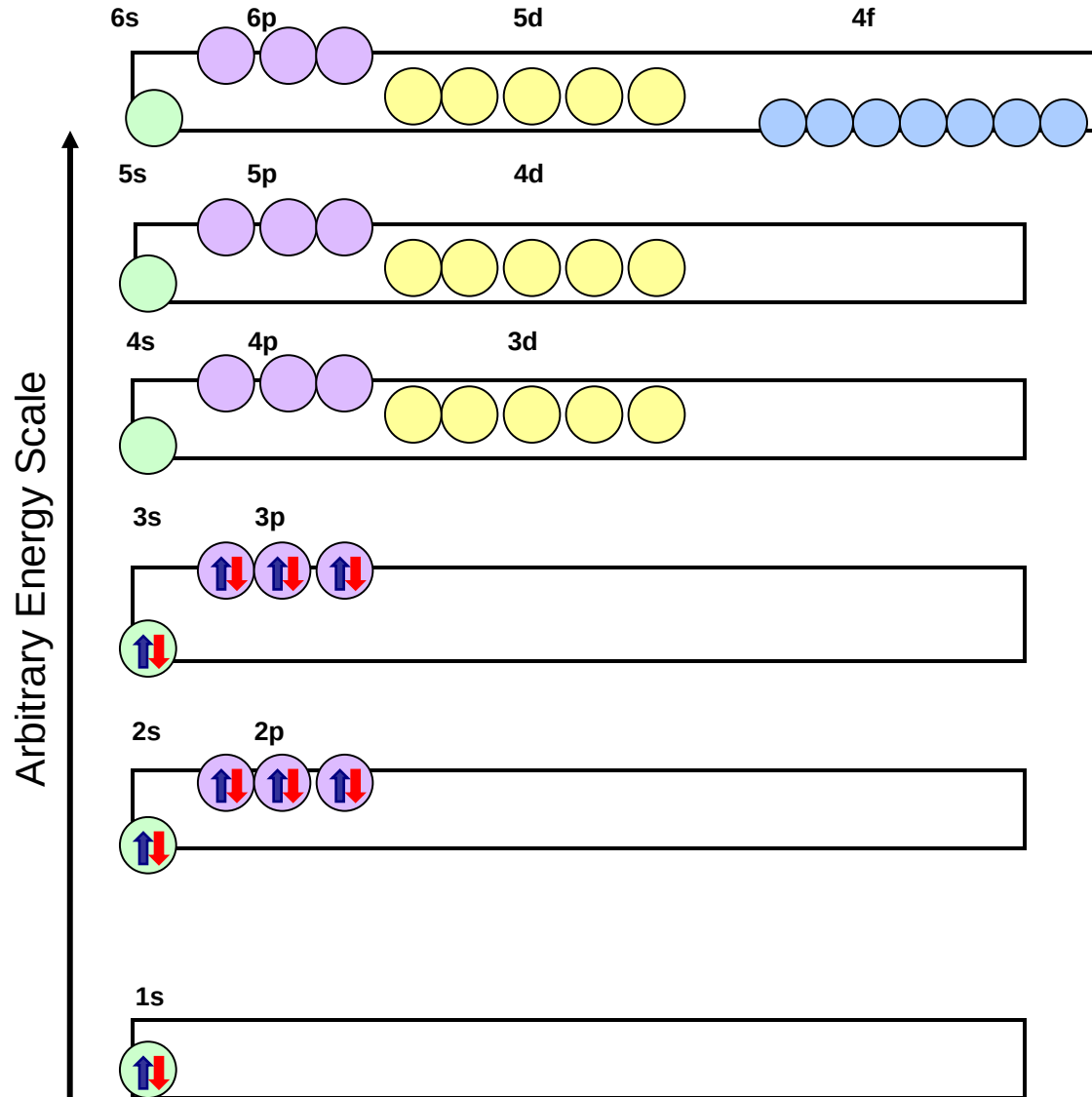
Electron Configuration



H He Li C N **Al** Ar F Fe La

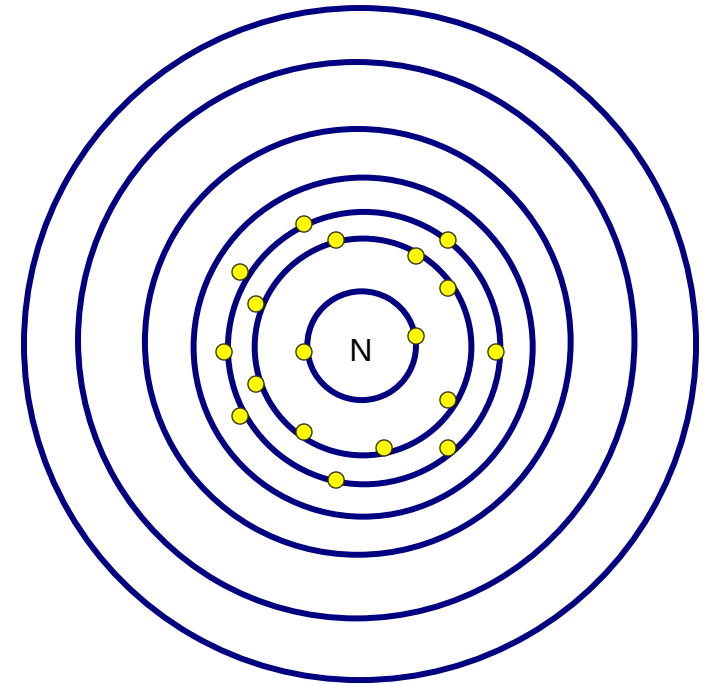
CLICK ON ELEMENT TO FILL IN CHARTS

Energy Level Diagram



Argon

Bohr Model



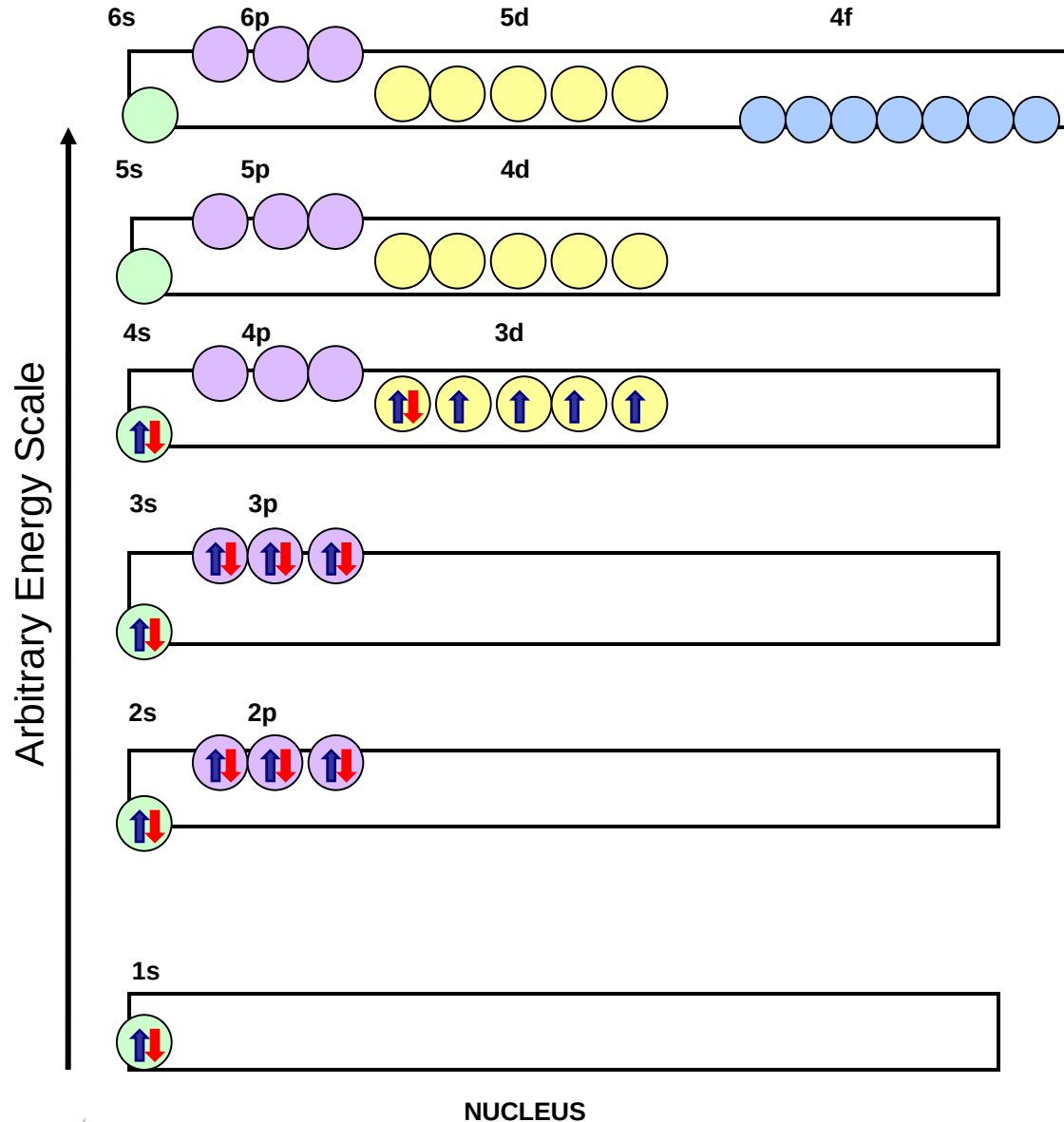
Electron Configuration



H He Li C N Al Ar F Fe La

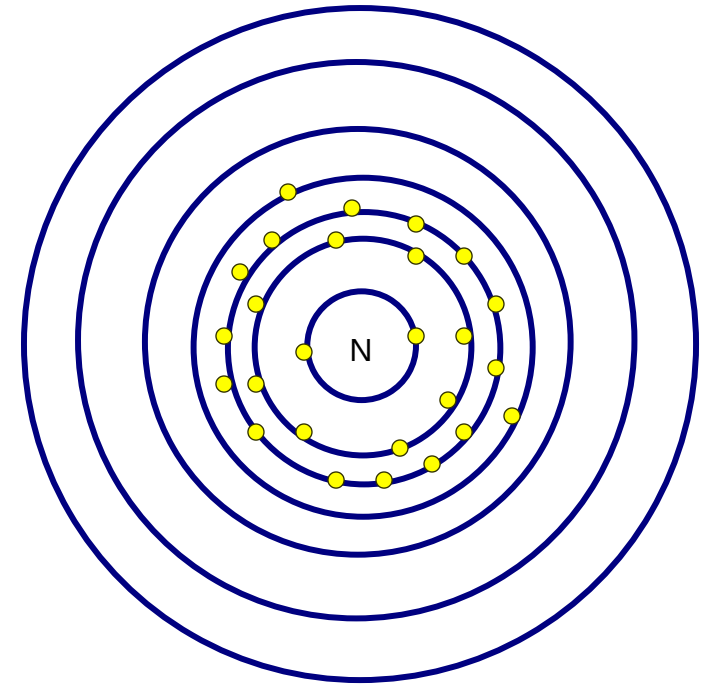
CLICK ON ELEMENT TO FILL IN CHARTS

Energy Level Diagram



Iron

Bohr Model



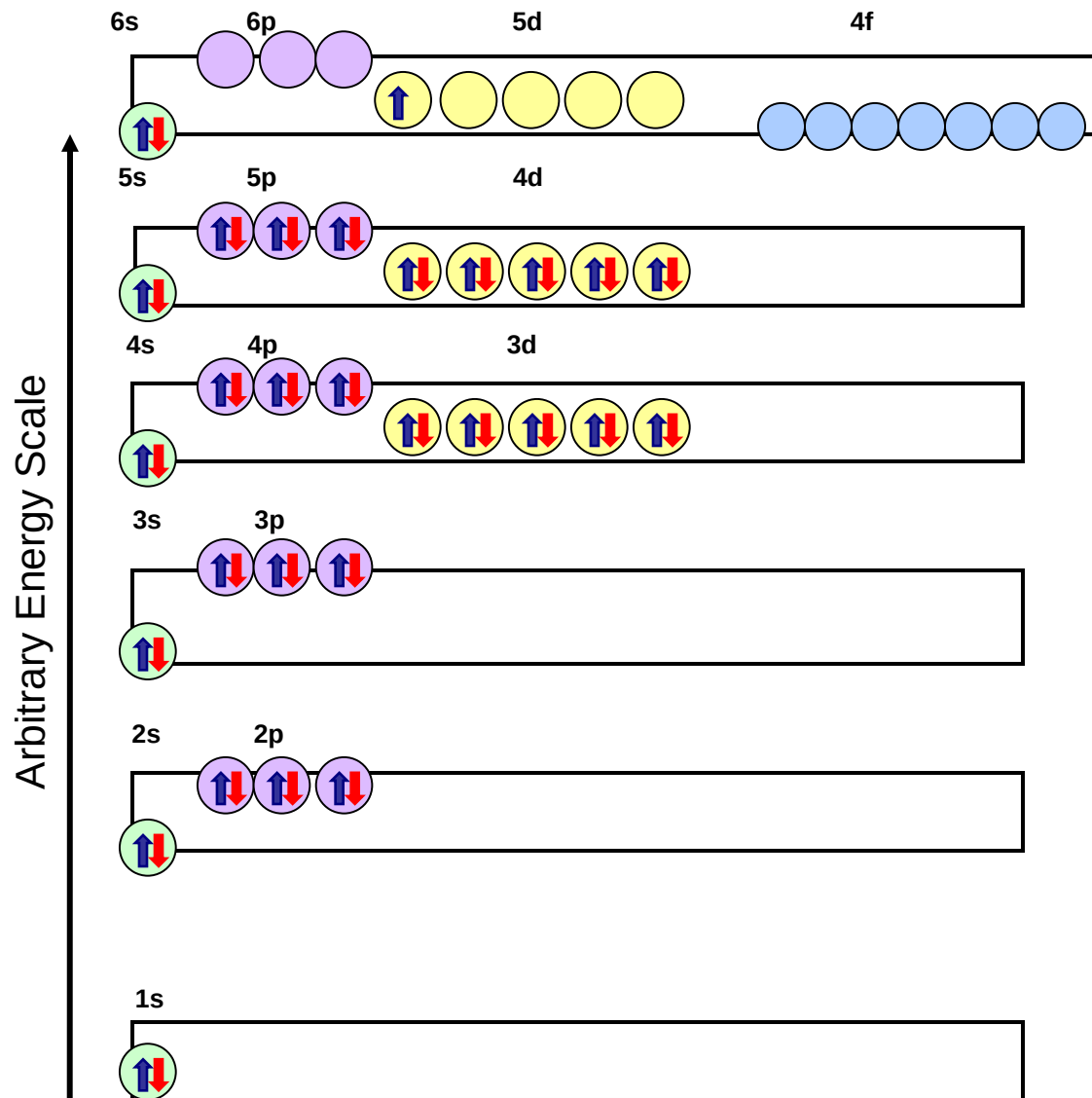
Electron Configuration



H He Li C N Al Ar E **Fe** La

CLICK ON ELEMENT TO FILL IN CHARTS

Energy Level Diagram



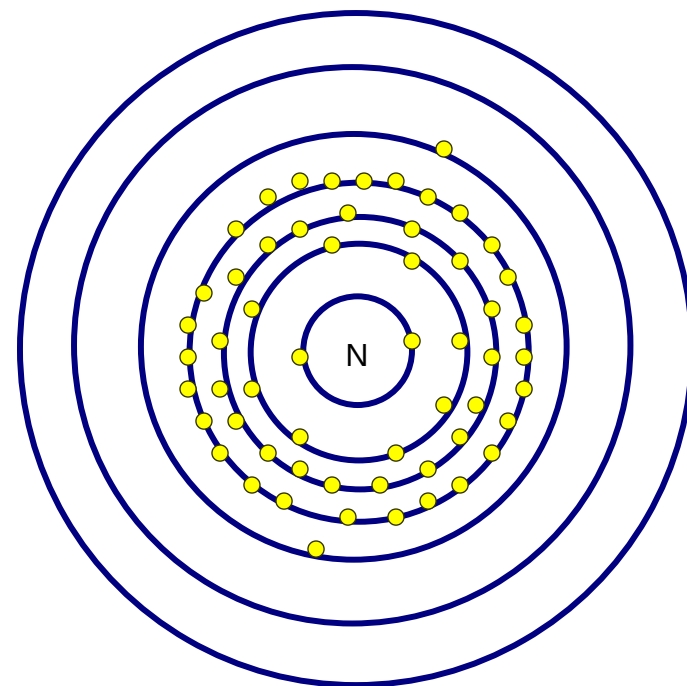
NUCLEUS

[H](#) [He](#) [Li](#) [C](#) [N](#) [Al](#) [Ar](#) [Fe](#) [La](#)

CLICK ON ELEMENT TO FILL IN CHARTS

Lanthanum

Bohr Model

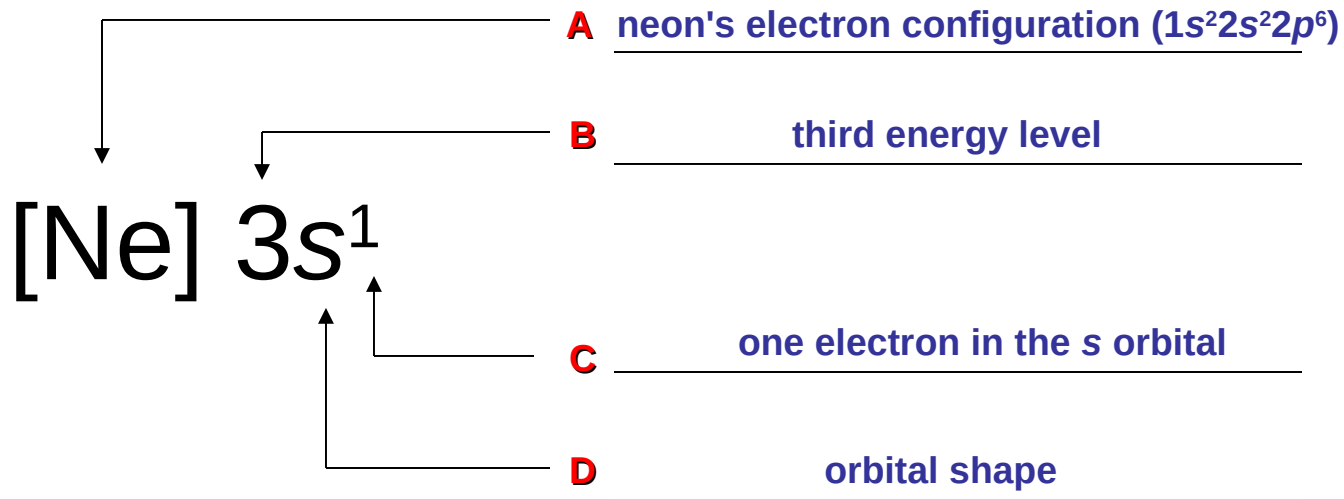


Electron Configuration

$\text{La} = 1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10}$

$\text{La} 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^6 6s^2 5d^1$

Shorthand Configuration



Shorthand Configuration

Element symbol

Electron configuration

Ca

[Ar] 4s²

V

[Ar] 4s² 3d³

F

[He] 2s² 2p⁵

Ag

[Kr] 5s² 4d⁹

I

[Kr] 5s² 4d¹⁰ 5p⁵

Xe

[Kr] 5s² 4d¹⁰ 5p⁶

Fe

[Ar] 4s² 3d⁶

Sg

[Rn] 7s² 5f¹⁴ 6d⁴

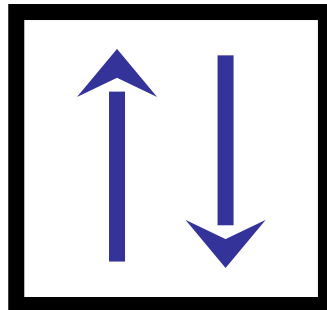


General Rules



Wolfgang Pauli

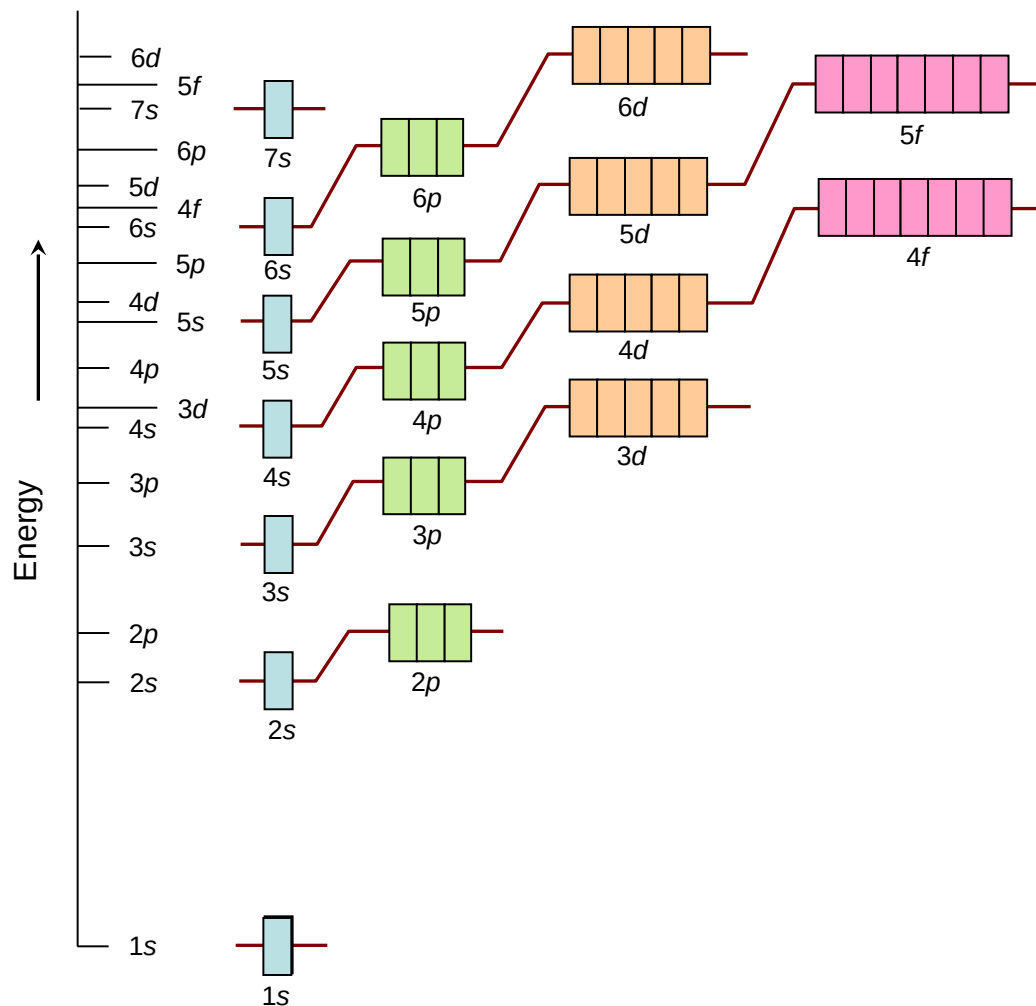
- **Pauli Exclusion Principle**
 - Each orbital can hold TWO electrons with opposite spins.



General Rules

Aufbau Principle

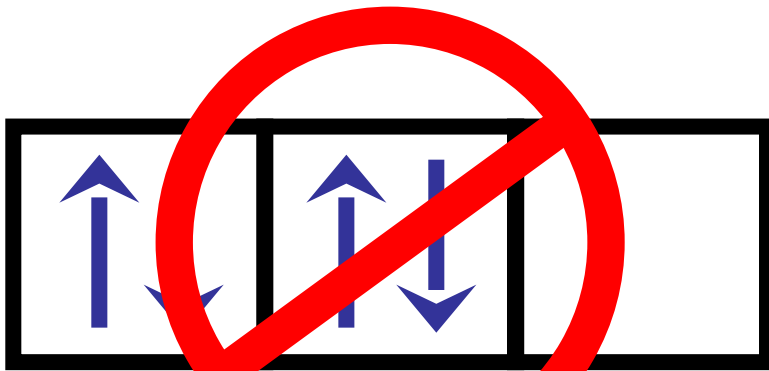
- Electrons fill the lowest energy orbitals first.
- “Lazy Tenant Rule”



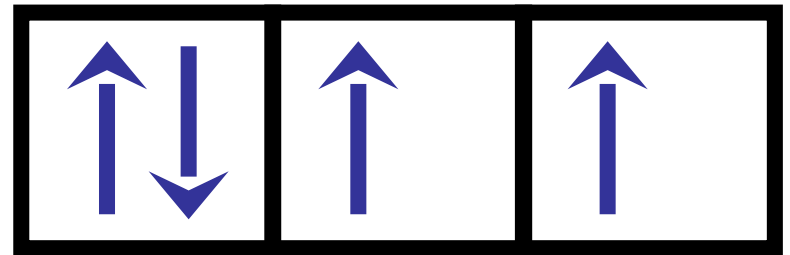
General Rules

- **Hund's Rule**

- Within a sublevel, place one electron per orbital before pairing them.
- “Empty Bus Seat Rule”

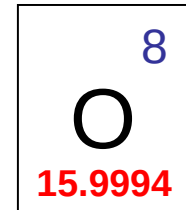


WRONG

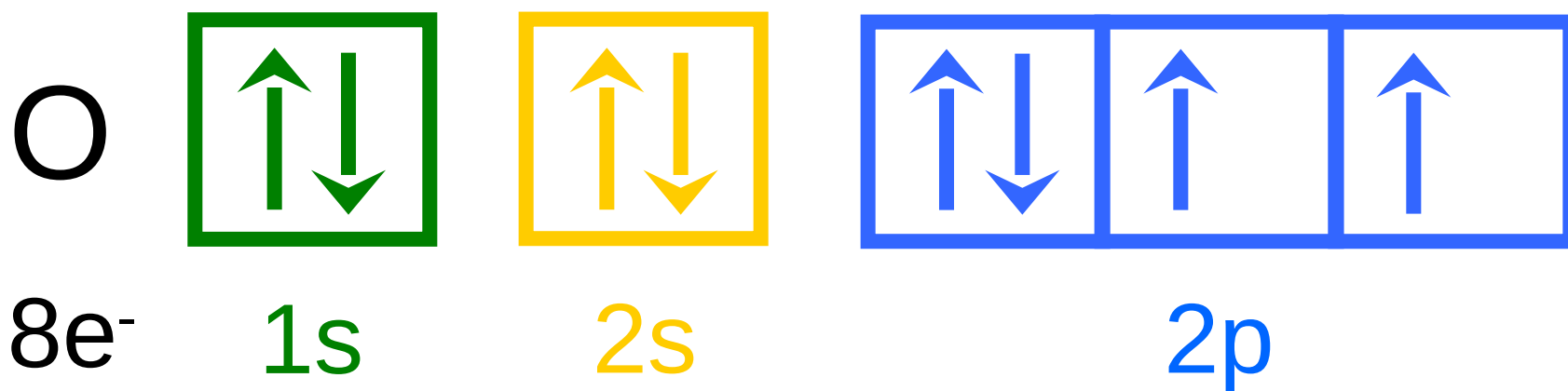


RIGHT

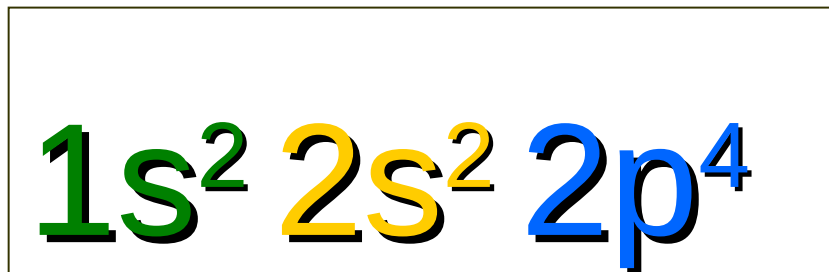
Notation



- Orbital Diagram



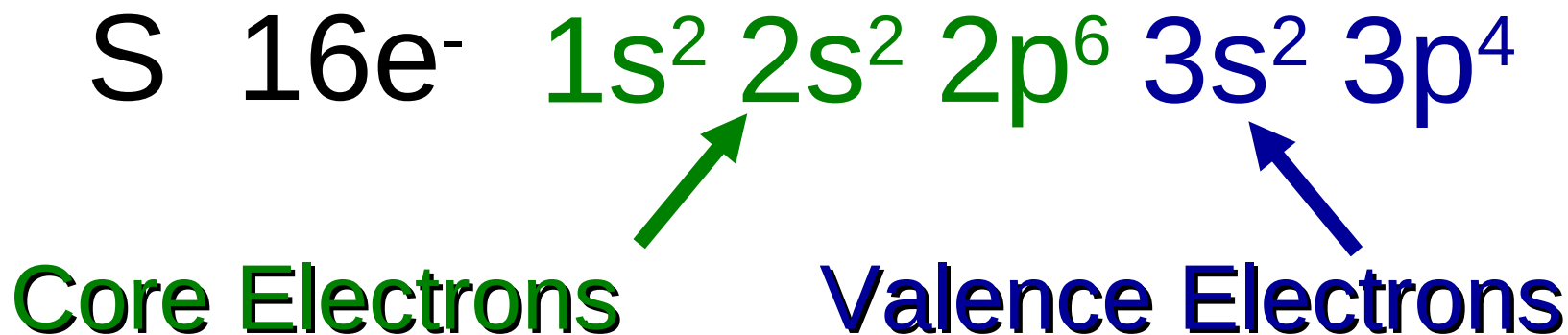
- Electron Configuration



16
S
32.066

Notation

- Longhand Configuration



- Shorthand Configuration



Periodic Patterns

The diagram illustrates the periodic table with the following orbital filling patterns:

- s-orbitals:** Yellow cells, labeled $1s, 2s, 3s, 4s, 5s, 6s, 7s$ on the left. A large s is at the top left.
- p-orbitals:** Orange cells, labeled $2p, 3p, 4p, 5p, 6p, 7p$ on the right. A large p is at the top right.
- d-orbitals:** Green cells, labeled $3d, 4d, 5d, 6d$ in the center. A large $d (n-1)$ is in the center.
- f-orbitals:** Light blue cells at the bottom, labeled $4f, 5f$ in the center. A large $f (n-2)$ is at the bottom left.

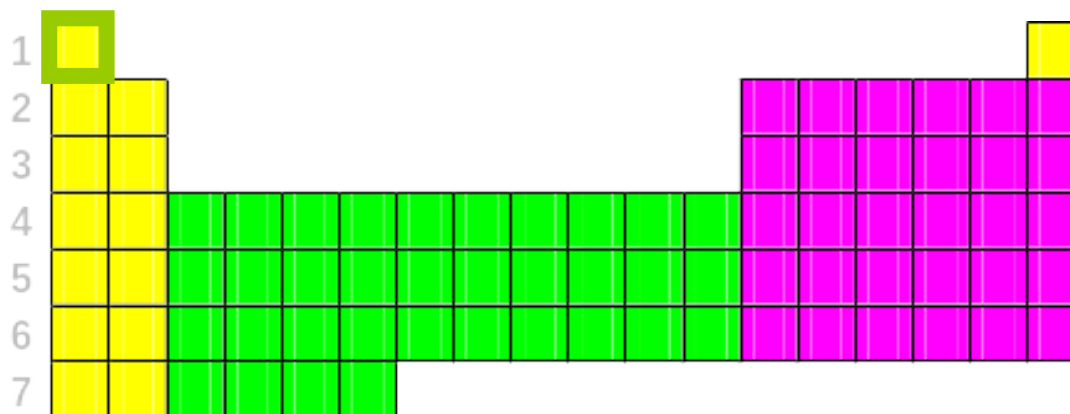
Principal quantum numbers $1, 2, 3, 4, 5, 6, 7$ are listed on the far left, corresponding to the rows of the periodic table.

Periodic Patterns

- **Period #**
 - energy level (subtract for d & f)
- **A/B Group #**
 - total # of valence e-
- **Column within sublevel block**
 - # of e- in sublevel

Periodic Patterns

- **Example - Hydrogen**



1s¹

**1st column
of s-block**

1st Period

s-block

Periodic Patterns

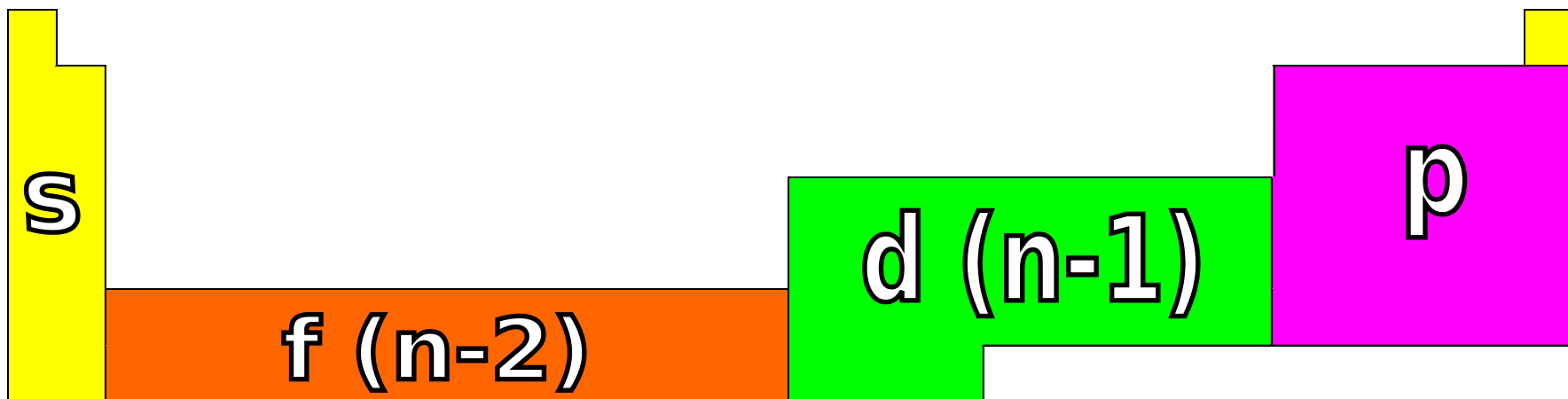
- **Shorthand Configuration**

- **Core electrons:**

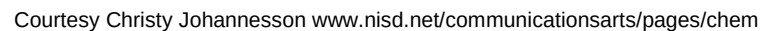
- Go up one row and over to the Noble Gas.

- **Valence electrons:**

- On the next row, fill in the # of e⁻ in each sublevel.

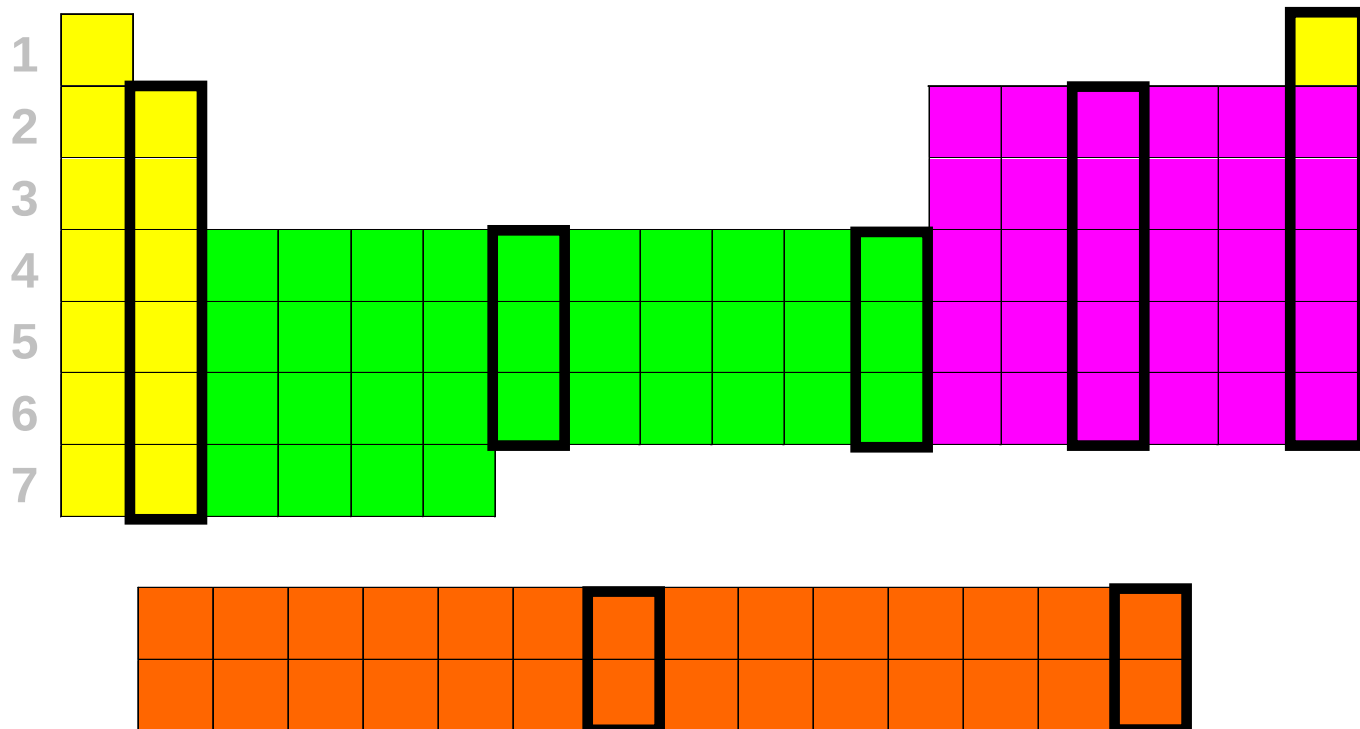


-
- A 7x15 grid representing a game board. The grid is divided into three colored regions: yellow (top-left, 1x3, 2x2, 3x2), green (middle, 4x12), and pink (bottom-right, 3x12). A black arrow points from a black square at (4, 13) to a blue square at (3, 15).



Stability

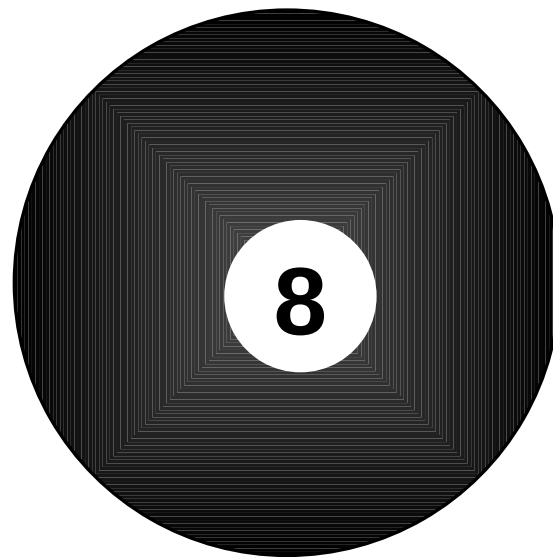
- Full energy level
- Full sublevel (s, p, d, f)
- Half-full sublevel



The Octet Rule

Atoms tend to gain, lose, or share electrons until they have eight valence electrons.

This fills the valence shell and tends to give the atom the stability of the inert gasses.



ONLY **s**- and **p**-orbitals are valence electrons.

Stability

- Electron Configuration Exceptions

- Copper

EXPECT: $[\text{Ar}] 4s^2 3d^9$

ACTUALLY: $[\text{Ar}] 4s^1 3d^{10}$

- Copper gains *stability* with a full d-sublevel.

Stability

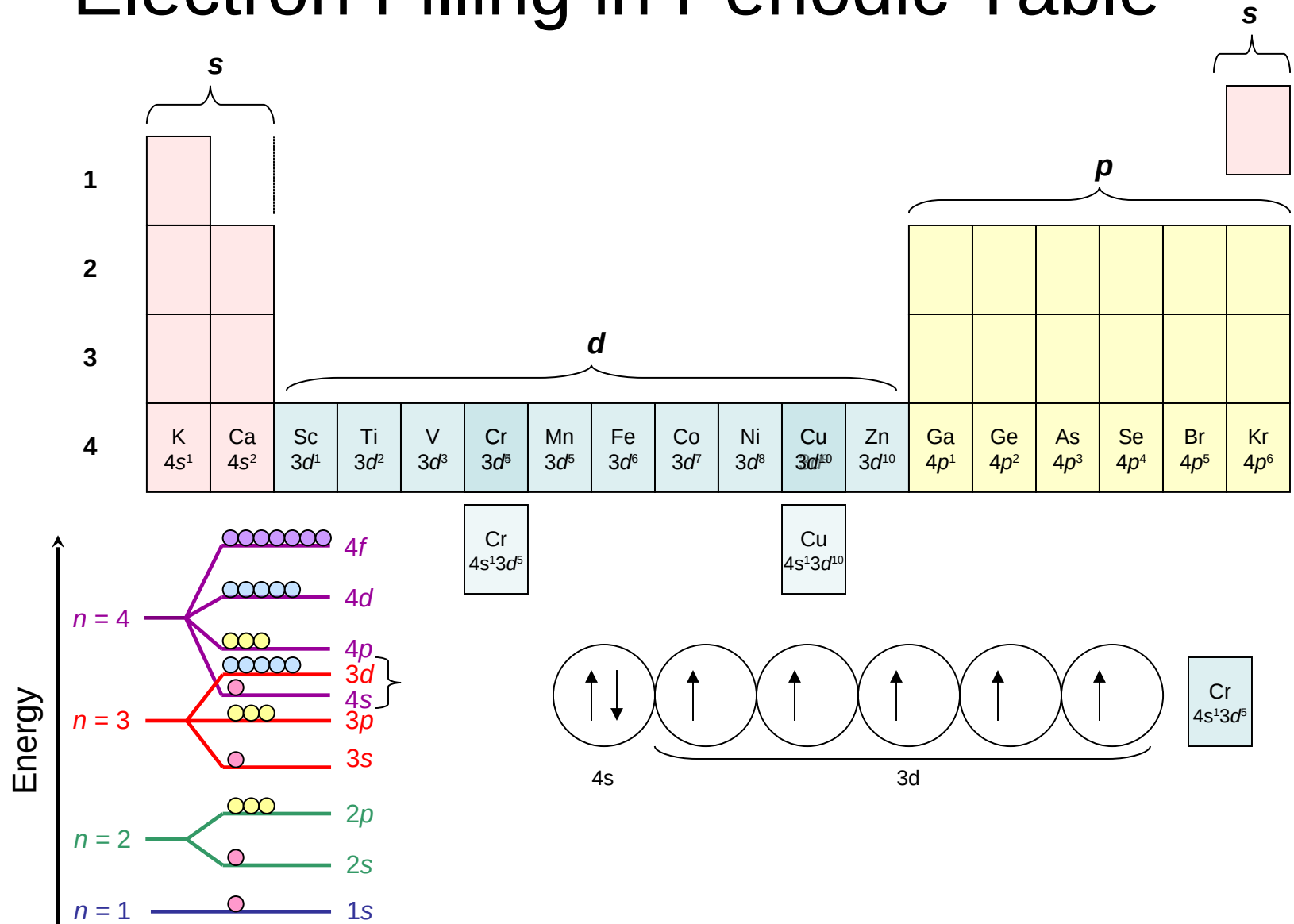
- Electron Configuration Exceptions
 - Chromium

EXPECT: $[\text{Ar}] 4s^2 3d^4$

ACTUALLY: $[\text{Ar}] 4s^1 3d^5$

- Chromium gains *stability* with a half-full d-sublevel.

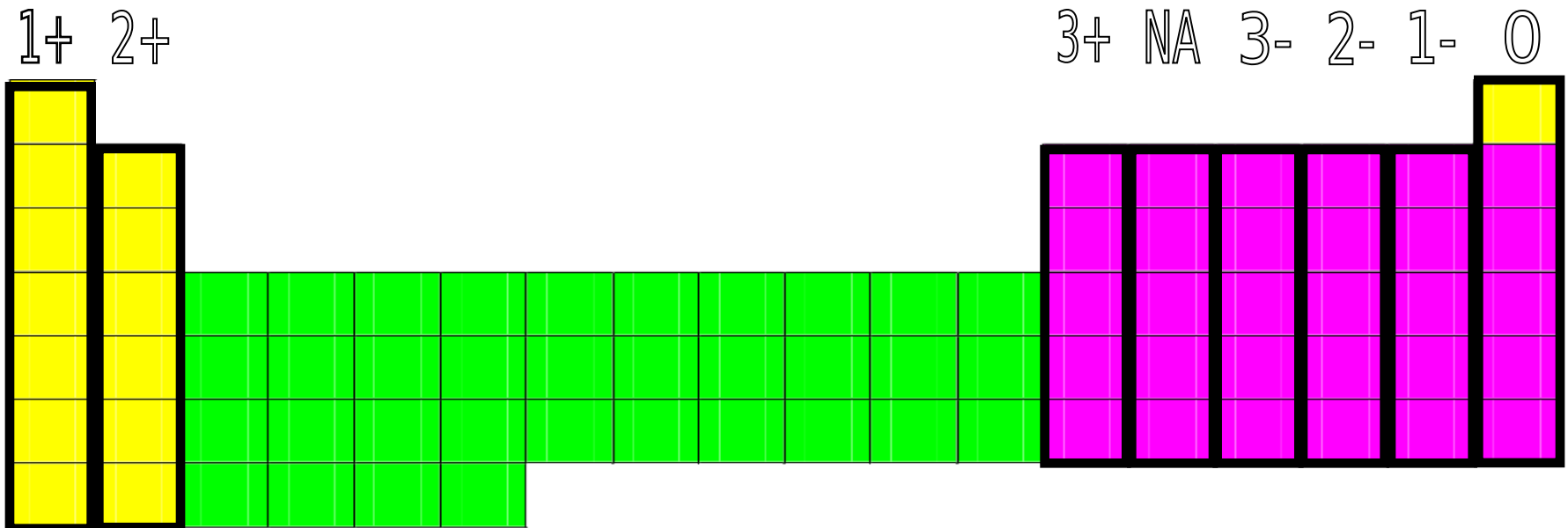
Electron Filling in Periodic Table



Stability

- **Ion Formation**

- Atoms gain or lose electrons to become more stable.
- Isoelectronic with the Noble Gases.



Stability

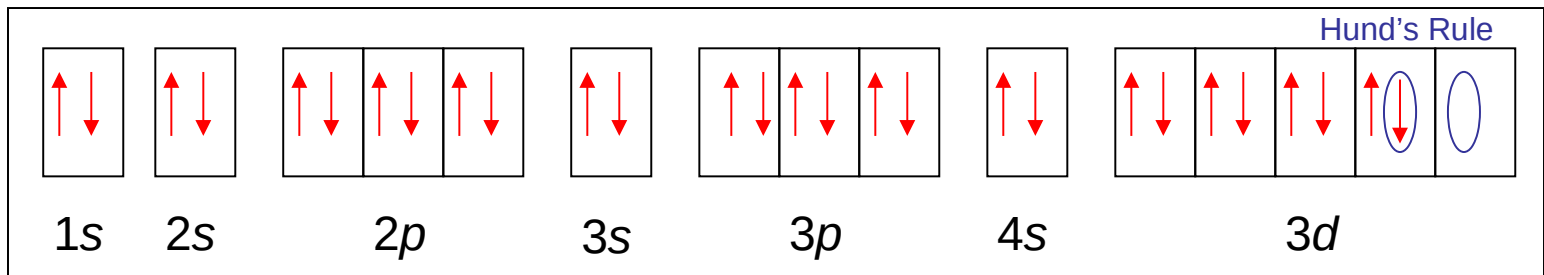
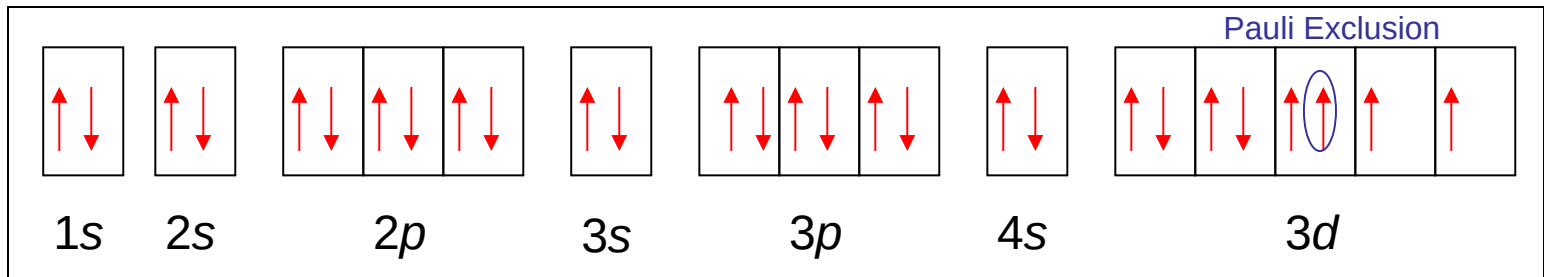
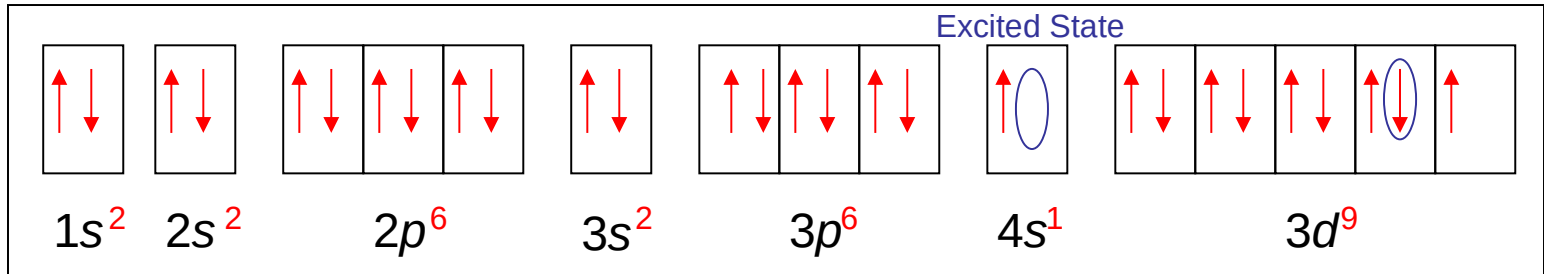
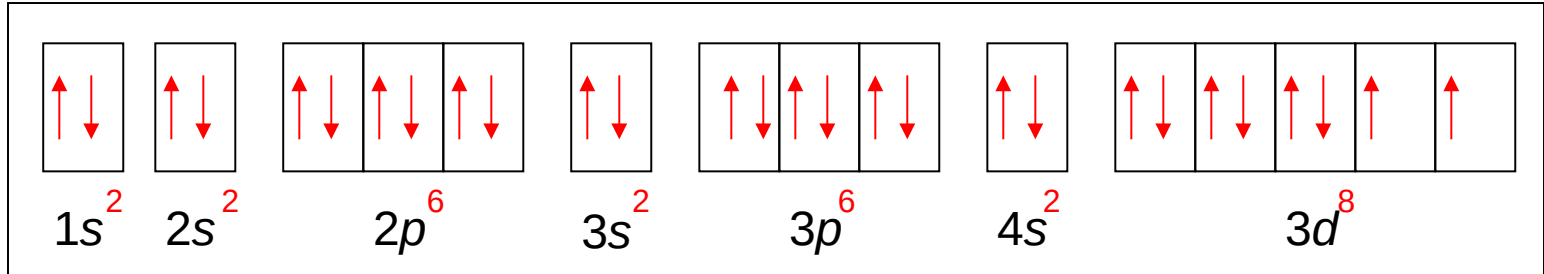
- **Ion Electron Configuration**

- Write the e- configuration for the closest Noble Gas

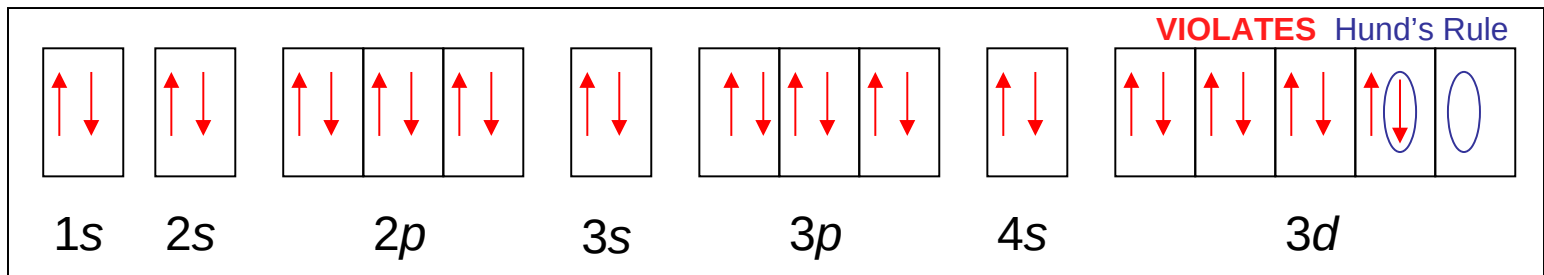
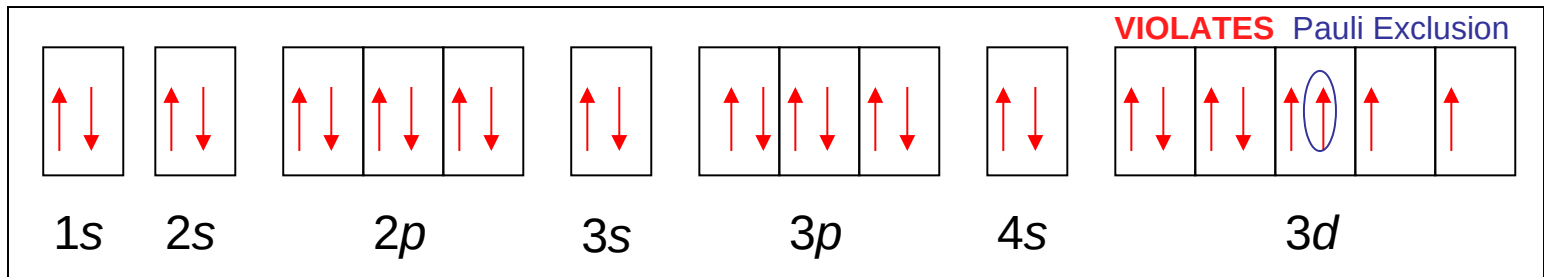
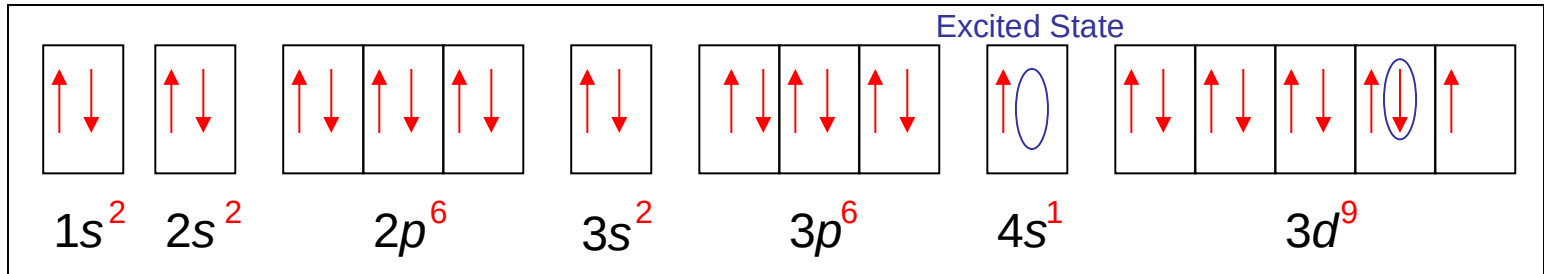
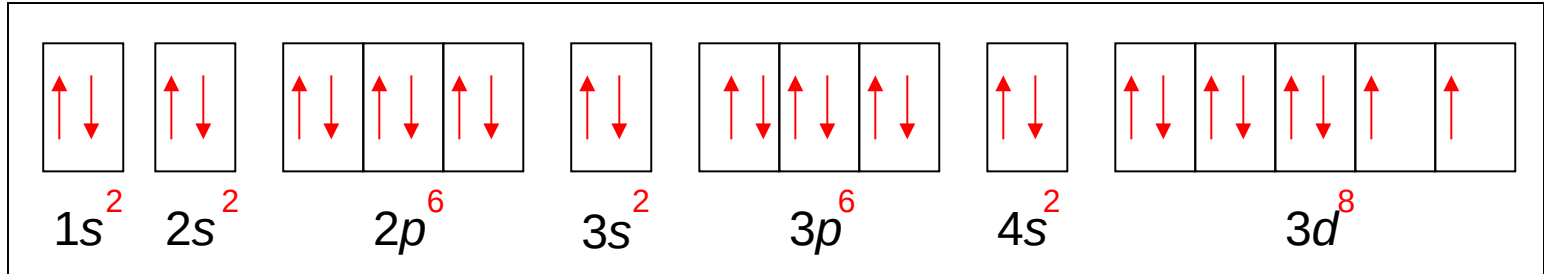
- EX: Oxygen ion $\rightarrow \text{O}^{2-} \equiv \text{Ne}$



Orbital Diagrams for Nickel



Orbital Diagrams for Nickel



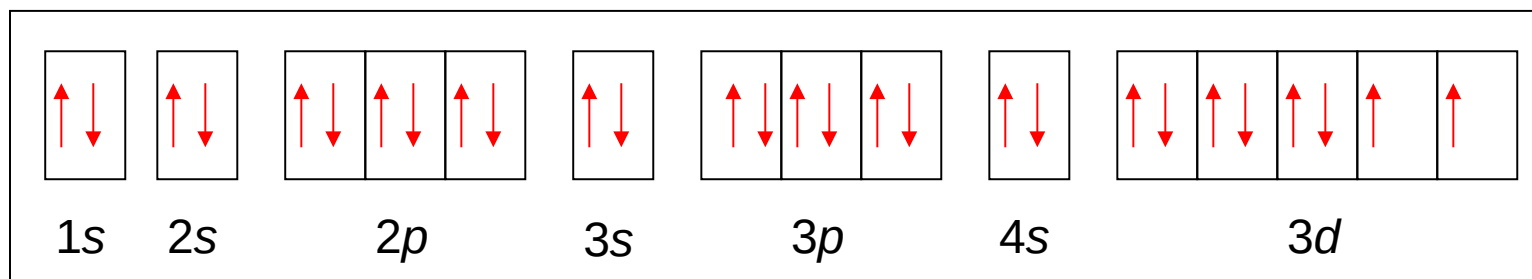
Write out the complete electron configuration for the following:

1) An atom of nitrogen **$1s^2 2s^2 2p^3$**

2) An atom of silver **$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^9$**

3) An atom of uranium (shorthand) **$[Rn] 7s^2 6d^1 5f^3$**

Fill in the orbital boxes for an atom of nickel (Ni)



Which rule states no two electrons can spin the same direction in a single orbital?

Pauli exclusion principle

Extra credit: Draw a Bohr model of a Ti^{4+} cation.

Ti^{4+} is *isoelectronic* to Argon.

