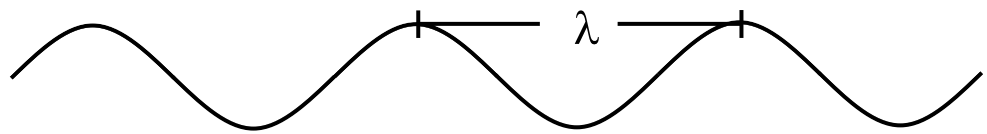
Outline

- Modern Atomic Theory
- Electron Configurations
- Periodic Trends

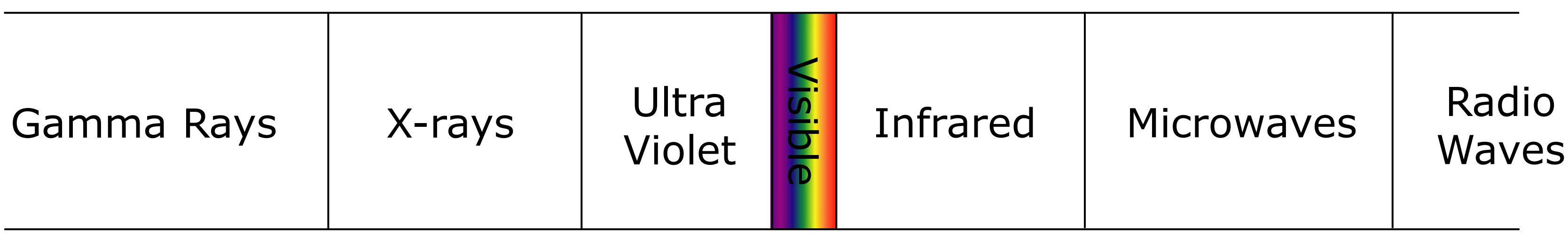
Modern Atomic Theory

Electromagnetic radiation (EMR) is energy traveling as waves at the speed of light



EMR behaves like stream of energy packets: <u>photons</u>

Different types of EMR differ in their wavelengths (energy)



1910

Two questions:

1. What keeps electrons from falling into nucleus?
2. What is the origin of line spectra?

1913

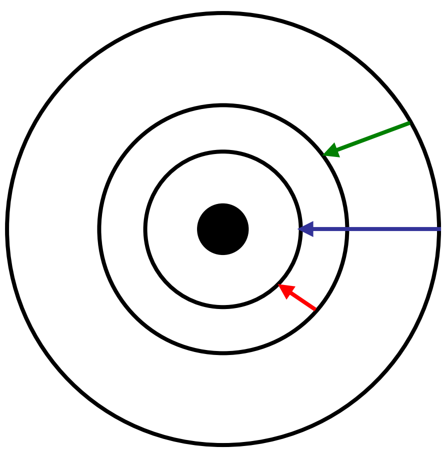
Niels Bohr answered these two questions:

1. The electron cannot fall into nucleus
2. Line spectra results from movement of electrons

Bohr's Quantum Model of the Atom

electrons…

1. orbit in specific circular orbits called Bohr orbits
2. are quantized – only have specific values of energy
3. emit or absorb energy only when changing orbits



1924

de Broglie proposed that all matter possesses wave properties

1926

Schrödinger wrote a wave equation for an electron

The wave equation…

predicts discrete principal energy levels within atoms

describes how the electrons are distributed in space

The space occupied by electrons are called orbitals

The principal energy level…

indicates the energy, or average distance of an electron from the nucleus

$n = 1, 2, 3, \ldots$

is divided into “n” different <u>sublevels</u>

Each sublevel contains a group of <u>orbitals</u> with the same shape

s sublevel	1 “spherical” s-orbital
p sublevel	3 “peanut” p-orbitals
d sublevel	5 “clover-shaped” d-orbitals
f sublevel	7 “flower-shaped” f-orbitals

Energy Level	Sublevels	Number of Orbitals	
1	1 (s)	1	
2	2 (s, p)	4	(1 + 3)
3	3 (s, p, d)	9	(1 + 3 + 5)
4	4 (s, p, d, f)	16	(1 + 3 + 5 + 7)

Orbitals are identified by naming their energy level and sublevel

Orbitals are represented as dashes in <u>orbital diagrams</u>

1s	2s		2p	
____	____	____	____	____

Electron Configurations

Electrons populate orbitals from the “ground” up (Aufbau principle)

	1s
H	↑

$1s^1$

Each orbital is capable of holding two electrons; electrons in same orbital must have opposed spins (Pauli Exclusion Principle)

	1s
He	↑↓

$1s^2$

	1s	2s
Li	↑↓	↑

$1s^2 2s^1$

	1s	2s
Be	↑↓	↑↓

$1s^2 2s^2$

<u>Valence electrons</u> are found in highest energy level

Orbitals of identical energy will be occupied by only 1 e$^-$ until all orbitals contain 1 e$^-$ (Hund's Rule)

	1s	2s	2p			
B	↑↓	↑↓	↑	—	—	$1s^2 2s^2 2p^1$
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	$1s^22s^22p^63s^1$	or	[Ne] $3s^1$	(Abbreviated Configuration)
Mg	$1s^22s^22p^63s^2$	or	[Ne] $3s^2$	

Al	[Ne]$3s^23p^1$
Si	[Ne]$3s^23p^2$
P	[Ne]$3s^23p^3$
S	[Ne]$3s^23p^4$
Cl	[Ne]$3s^23p^5$
Ar	[Ne]$3s^23p^6$

The next e^- goes in a 4s orbital instead of a 3d orbital

K	$1s^22s^22p^63s^23p^64s^1$	or	[Ar]$4s^1$

The position of each element on the periodic table gives the sublevel of its final electron

Na	$[Ne]3s^1$
K	$[Ar]4s^1$
Rb	$[Kr]5s^1$
Cs	$[Xe]6s^1$
Fr	$[Rn]7s^1$

The valence electron configuration is same for elements in same column

Similar chemical behavior for same number of valence electrons

Write the electron configuration for…

Vanadium (23)

$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^3$ or $[Ar]4s^2 3d^3$

Arsenic (33)

$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^3$ or $[Ar]4s^2 3d^{10} 4p^3$

Iodine (53)

$[Kr]5s^2 4d^{10} 5p^5$

Platinum (78)

$[Xe]6s^2 4f^{14} 5d^8$

Periodic Trends

These trends depend on...

Coulomb's law

attractive force increases with increasing charge

attractive force decreases with increasing distance

The number of protons

The more protons an atom has, the greater its nuclear charge

The number of energy levels

The more energy levels an atom has, the greater the distance of electrons from the nuclear charge

1. Atomic Radii

The “size” of an atom

Group

Radii increase going down… due to increased number of energy levels

Period

Radii decrease moving right… due to the increasing nuclear charge

Largest Atom? Francium

Smallest Atom? Helium

2. Ionization Energy (IE)

The energy required to remove one electron from a gaseous atom

Group

IE decreases going down… due to increased number of energy levels

Period

IE increases moving right… due to the increasing nuclear charge

Atom with the highest IE? Helium

Atom with the lowest IE? Francium

3. Metallic Character (MC)

ease of ionization

Group

MC increases going down… due to decreasing IE

Period

MC decreases moving right… due to increasing IE

Most metallic element? Francium
Lease metallic element? “Helium”