

Chapter 7: Electromagnetic Radiation (Light Energy)

November 10, 2022

Chemistry Department, Cypress College

Class Announcements

Lecture

- Review Chemical Equations and Limiting Reagent problems
- Work in groups and present the exam problems (If we finish, everyone receive 2 EC pt in lieu of HW presentations)
- Ch 7 - Electromagnetic Radiation
- Quiz and Homework assignment released Fri, Nov 4th at 3pm

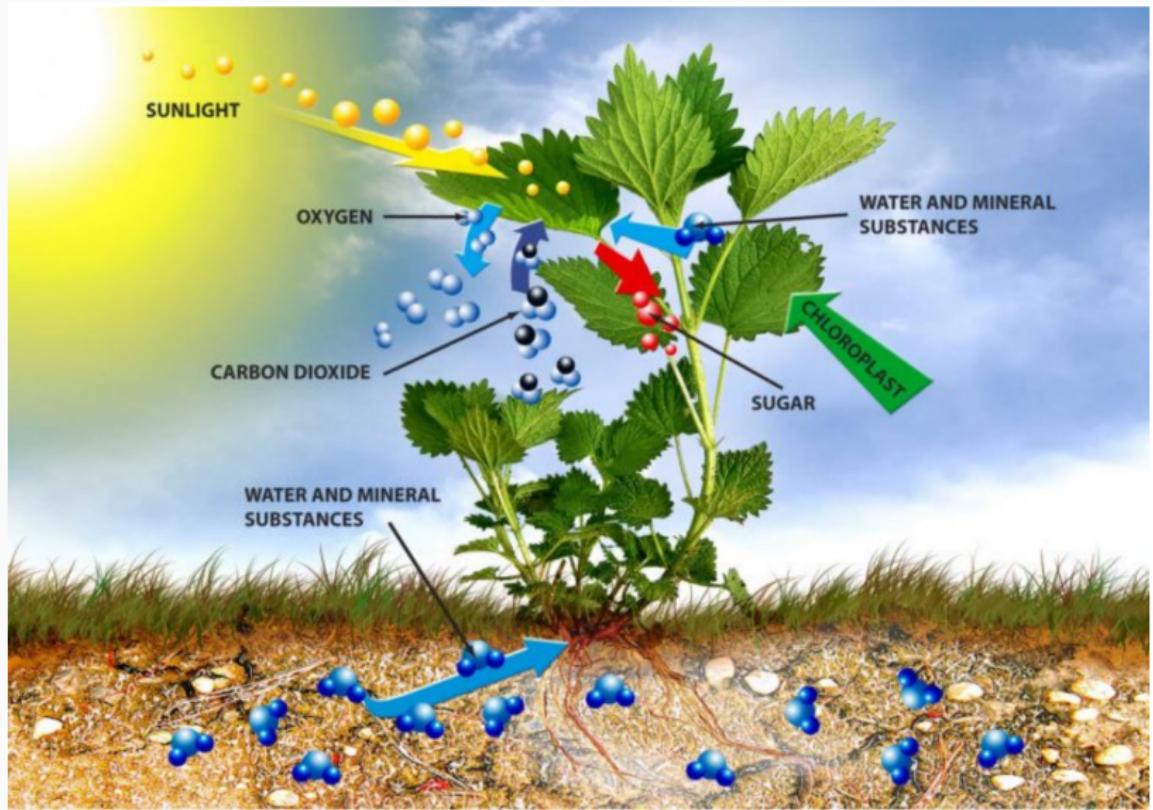
Outline

Light Energy

Periodicity of Electron Configurations

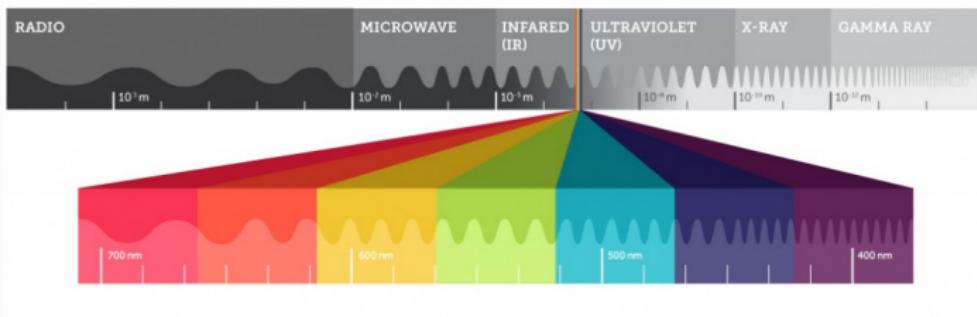
Periodic Properties of Atoms

Photosynthesis Harnesses Light

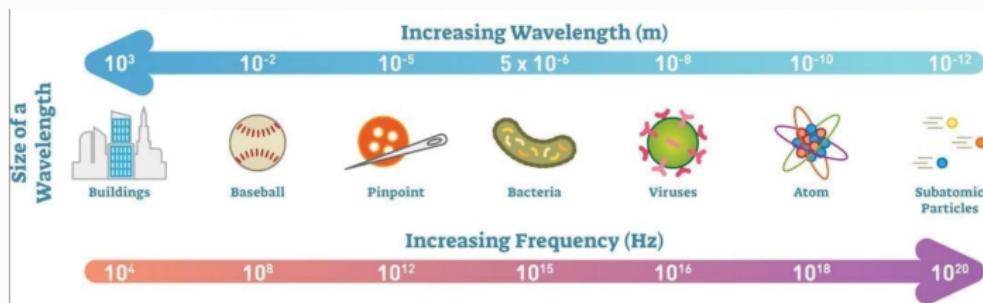


Electromagnetic Radiation

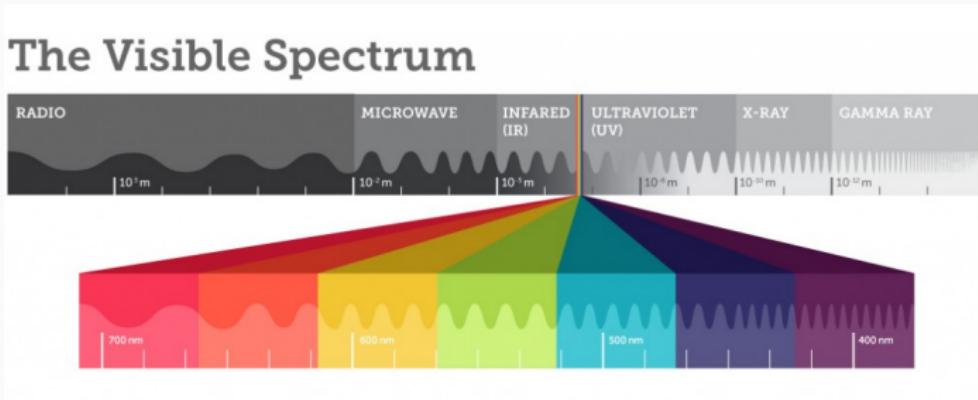
The Visible Spectrum



Visible light range from 700nm to 400nm; ROYGBV



Radiation Energy



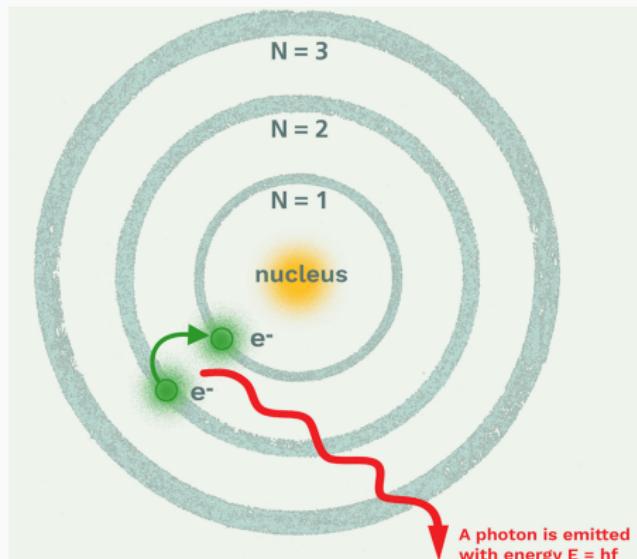
$$E = \frac{hc}{\lambda} \quad (1)$$

where λ is the wavelength (m), c is the speed of light (3.00×10^8 m/s), h is the Planck constant (6.626×10^{-34} J s) and E is energy (J)

Practice: Photosynthesis

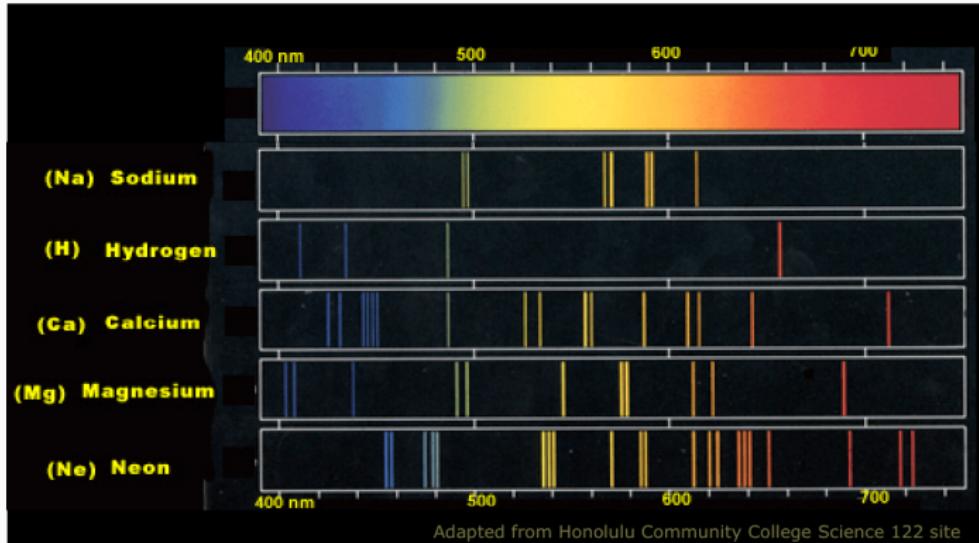
Chloroplast absorbs mostly violet (450 nm) and red (650 nm) light while reflecting green. What is the corresponding energies in J for these colors?

Where light energy comes from?



Youtube Link: What is Light?

Atomic Spectra



- Continuous spectra is given at the top and discrete lines are emitted by atoms
- **Q:** Why are there discrete lines for the atomic spectra?

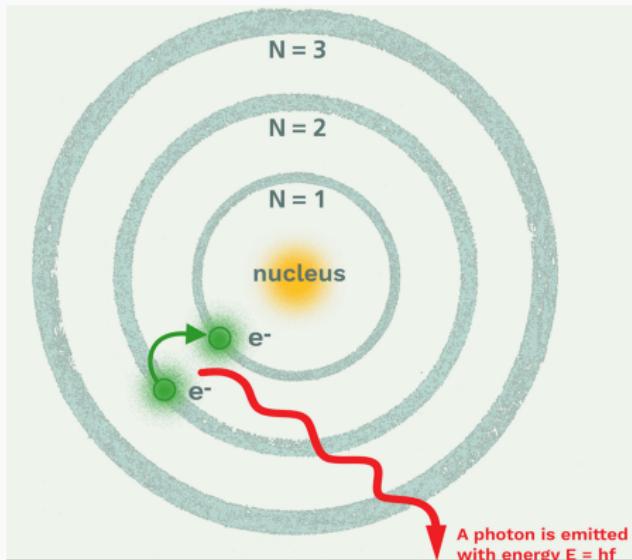
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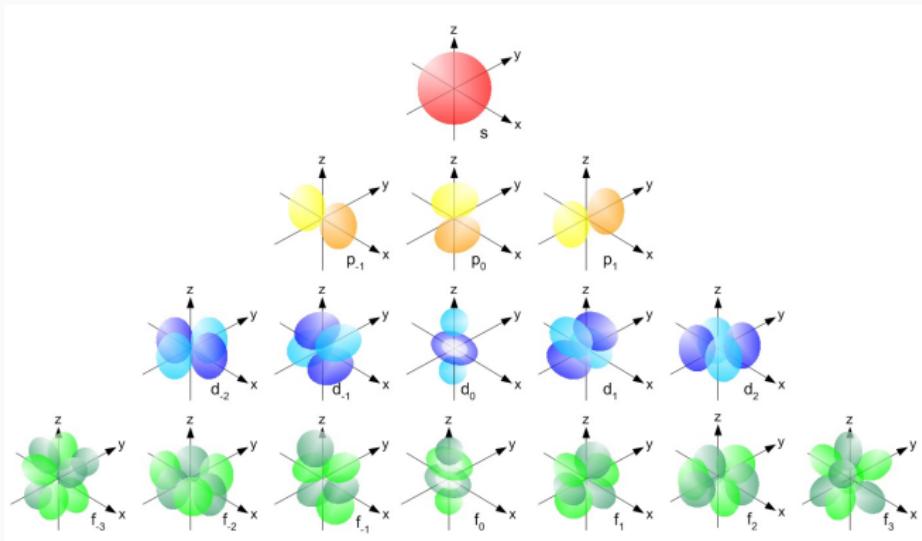
Periodic Properties of Atoms

Describing the Atom: Bohr Model



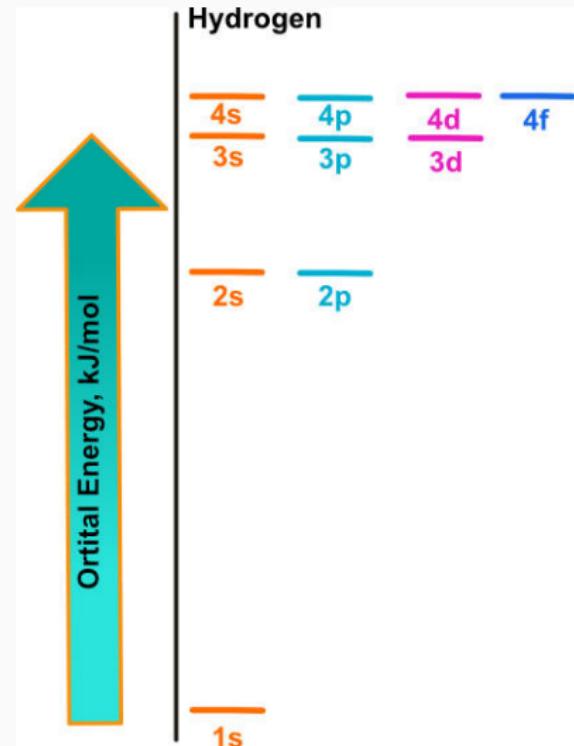
- Energy is quantized
- Electronic energy is proportional to the size of the orbit

Describing the Atom: Atomic Orbitals



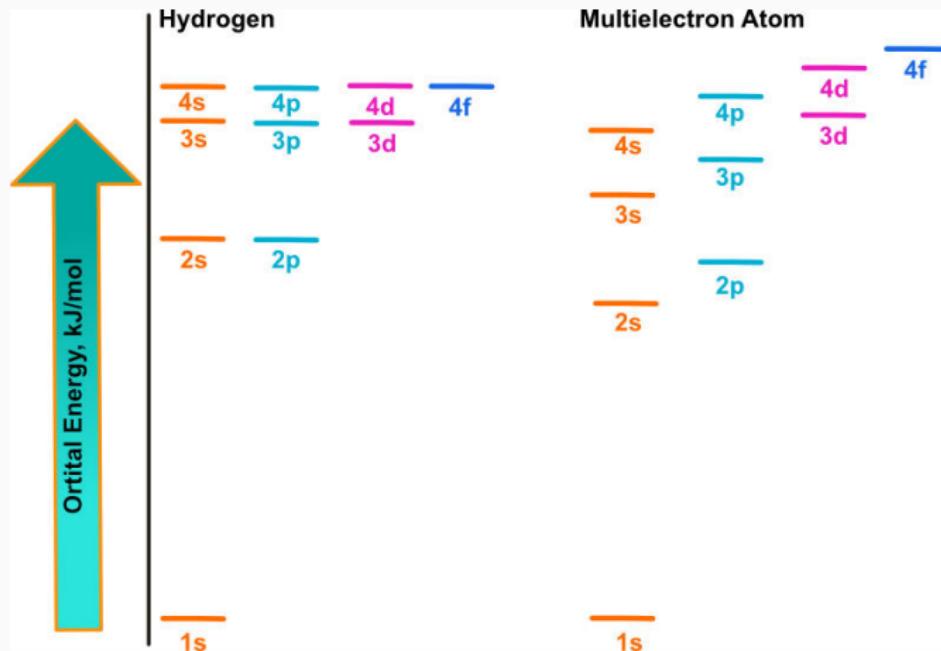
- Specific orbitals occupy certain **principal energy level** e.g.
 $n = 1, 2, 3, \dots$
- Basis in which atoms form bond e.g. atomic orbitals combine

Orbital Diagram - Hydrogen



Orbital Diagram - Multielectron Element

Q: What do you notice about the relative atomic orbital energies?



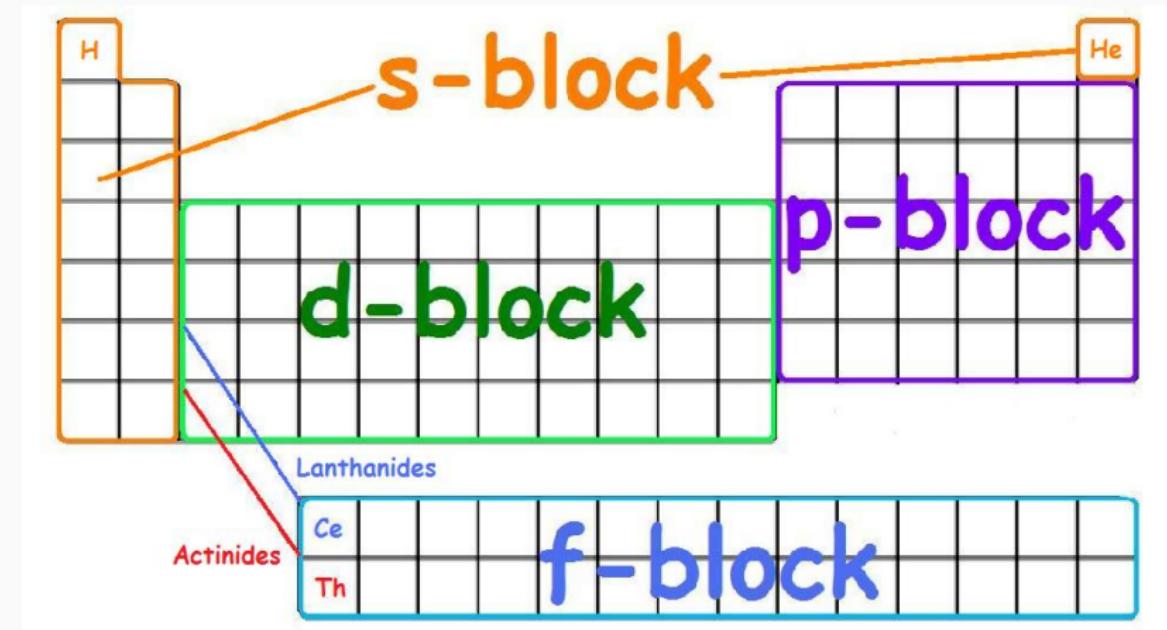
Principles for Filling Atomic Orbitals

Aufbau principle - electrons fill an orbital starting with the lowest energy level

Pauli exclusion principle - No two electrons with the same spin can occupy the same orbital

Hund's Rule - Maximize the number of unpaired electrons

Relating to Periodic Table



Examples: Write Electron Configurations

N

F

Ne

Na

Purpose of Electron Configurations

- Innermost shell is the core electrons
- Outermost shell is referred to as the valence electrons (**Q:** What is special about valence electrons?)

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- Innermost shell is the core electrons
- Outermost shell is referred to as the valence electrons (**Q:** What is special about valence electrons?)
- Predicts stability of the atom e.g. half-filled or fully filled orbitals are stable
- Make predictions how elements react forming new chemical compounds

Examples: Write Electron Configurations

Based on the electron configurations, which atom is the most stable?

N

F

Ne

Na

Core and Valence Electrons

Core Electrons - Energy level n below the valence electrons and these are completely filled orbitals

Valence Electrons - Outermost electrons above the energy level n of the core electrons

Example: Si - $1s^2 2s^2 2p^6 3s^2 3p^2$

Practice: Writing Electron Configurations

Determine the atomic orbitals that contain the core and valence electrons.

Br

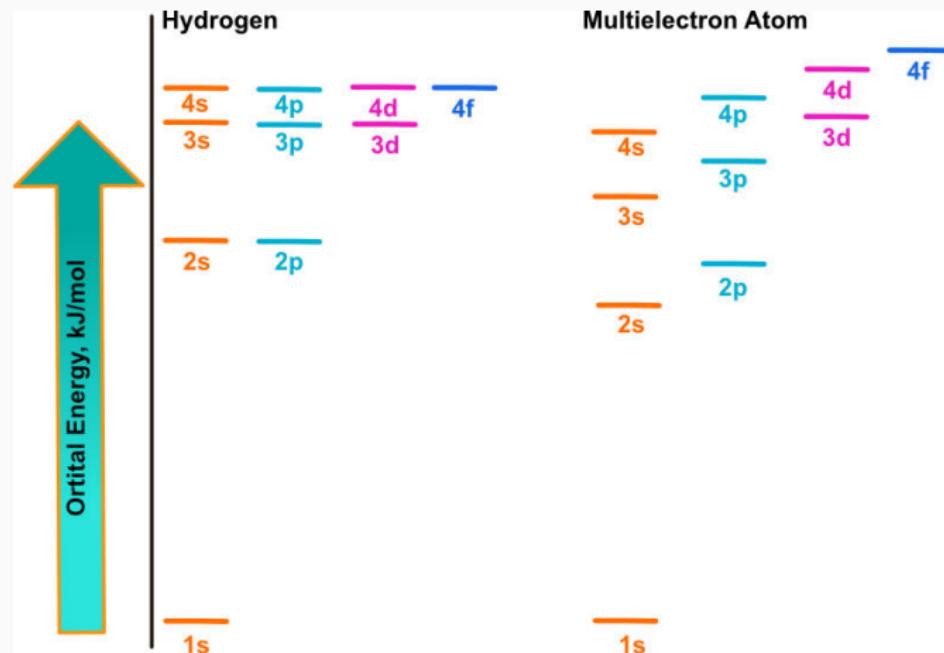
Mg

P

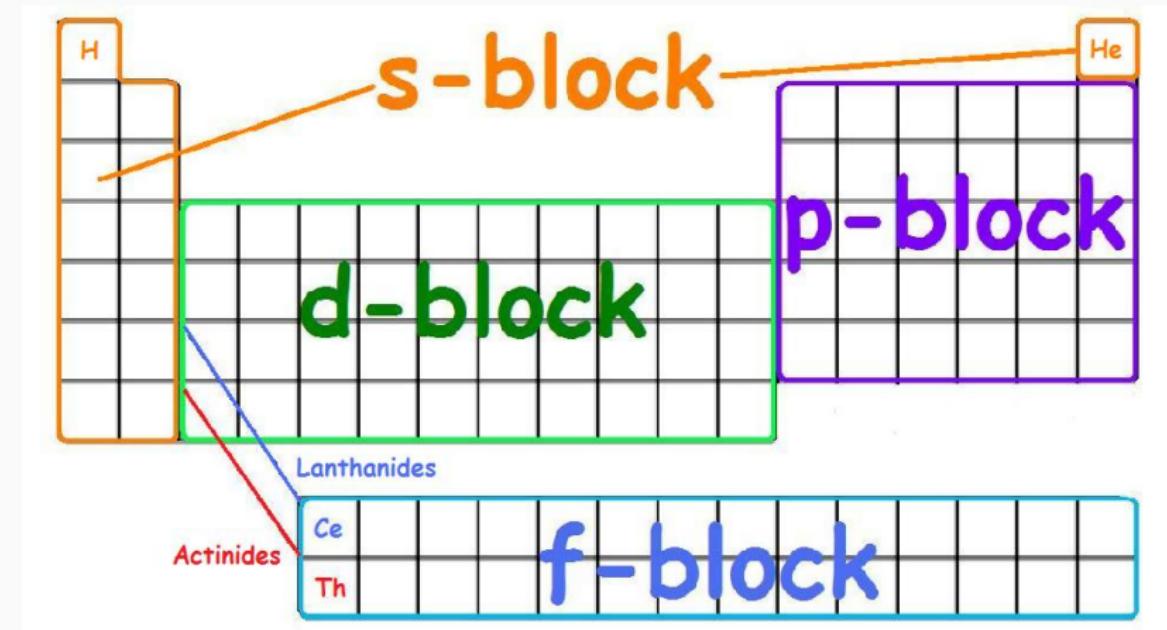
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Special Note about d-orbitals

Energy levels of 4s and 3d are close along with subsequent n levels
e.g. 5s and 4d, 6s and 5d



Relating to Periodic Table



Practice: Electron Configuration of Transition Metals

Cr

Mo

W

Cu

Ag

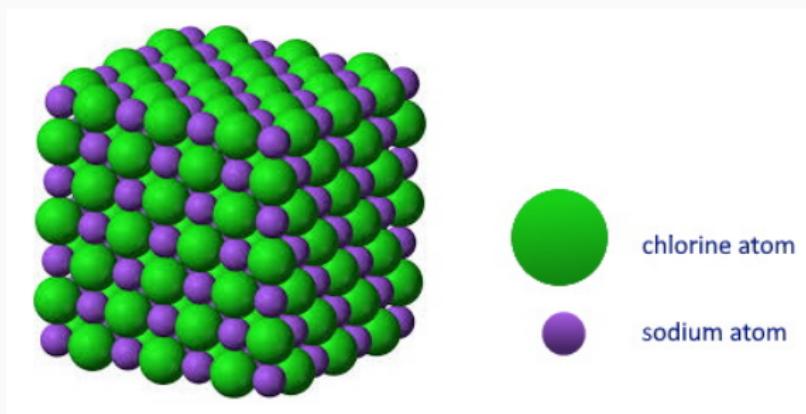
Au

Electron Configuration of Ions

Q: What is a cation? What is an anion?

Electron Configuration of Ions

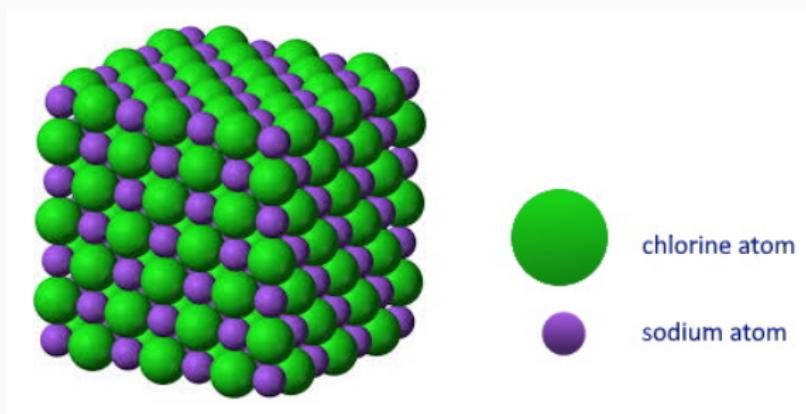
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Cation: Sodium ion (Na^+) **Anion:** Chloride ion (Cl^-)

Electron Configuration of Ions

Q: What is a cation? What is an anion?



Cation: Sodium ion (Na^+) **Anion:** Chloride ion (Cl^-)

Q: For electron configuration, how do we add/remove electrons from atomic orbitals for anion/cation?

Principles for Filling Atomic Orbitals

Aufbau principle - electrons fill an orbital starting with the lowest energy level

Pauli exclusion principle - No two electrons with the same spin can occupy the same orbital

Hund's Rule - Maximize the number of unpaired electrons

Practice: Writing Electron Configurations

F^-

Al^{3+}

Na^+

Fe^{3+}

S^{2-}

Outline

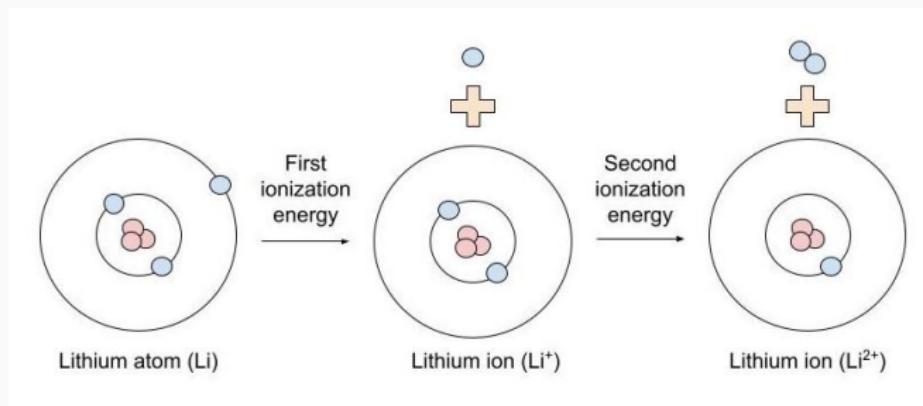
Light Energy

Periodicity of Electron Configurations

Periodic Properties of Atoms

Meaning of Ionization

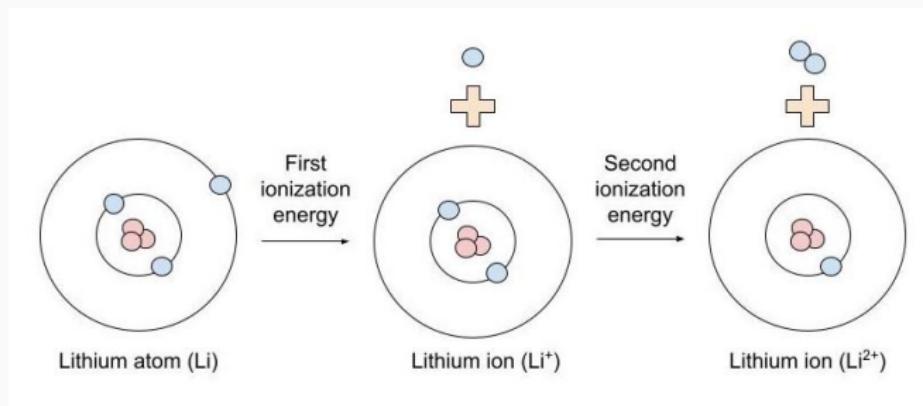
Ionization energy - Energy required to eject an electron



First ionization takes 520 kJ/mol and second ionization takes 7298 kJ/mol

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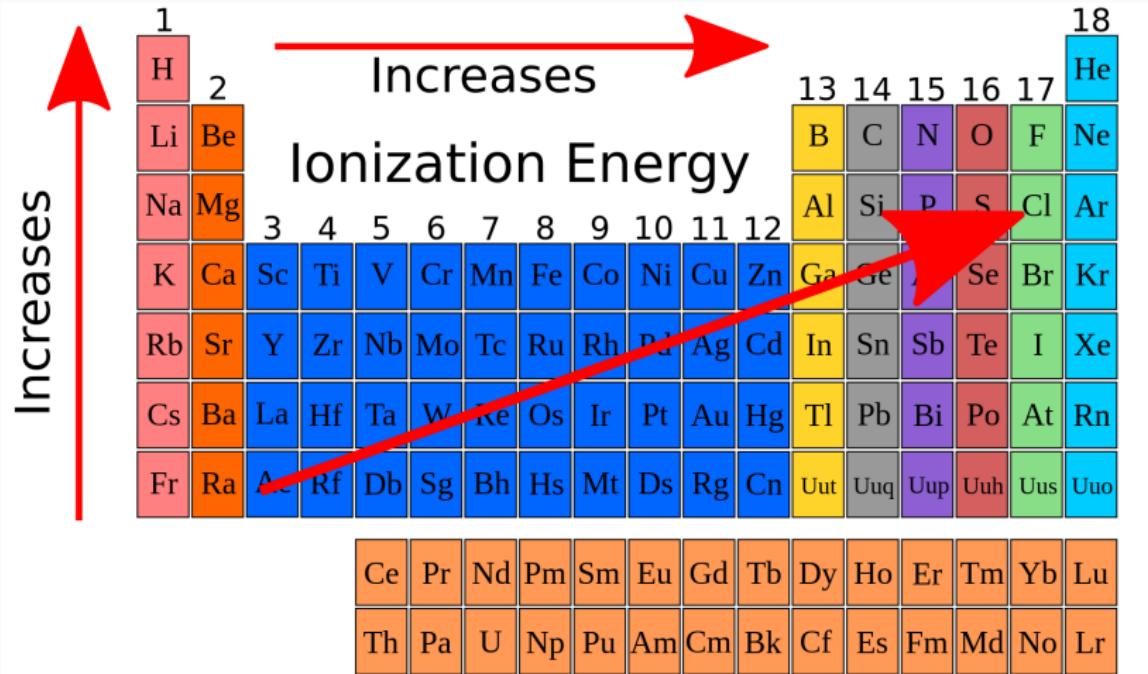
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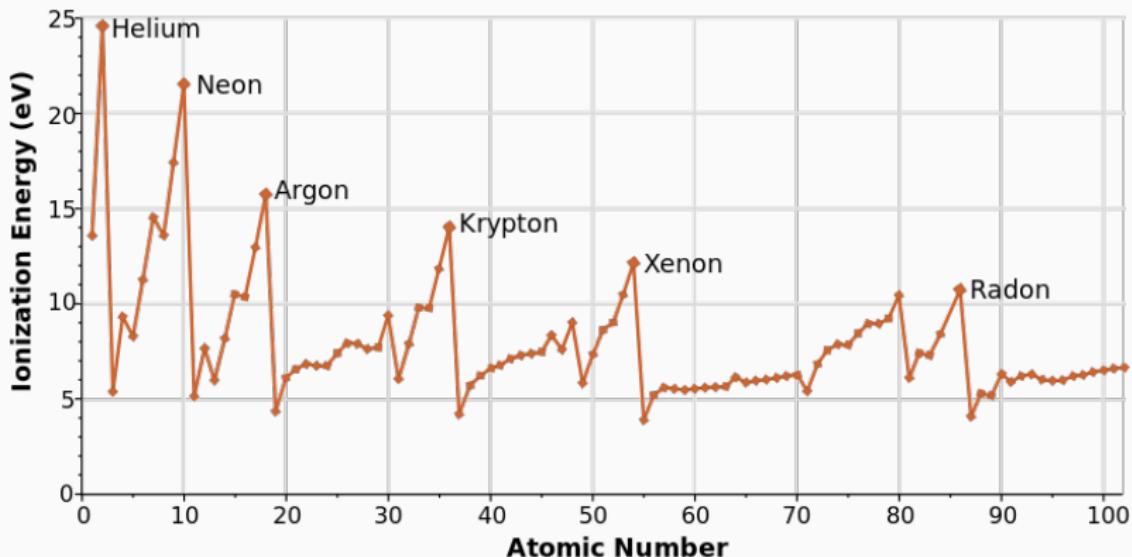
First ionization takes 520 kJ/mol and second ionization takes 7298 kJ/mol

Q: Why is the second ionization energy significantly higher?

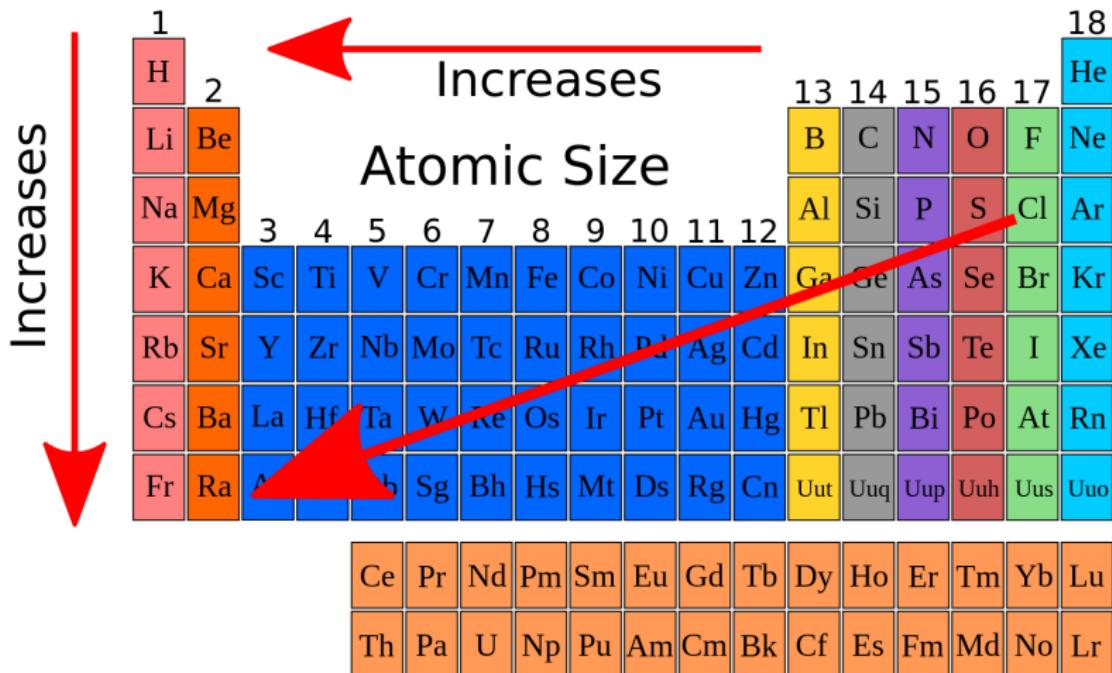
First Ionization Energy Trends



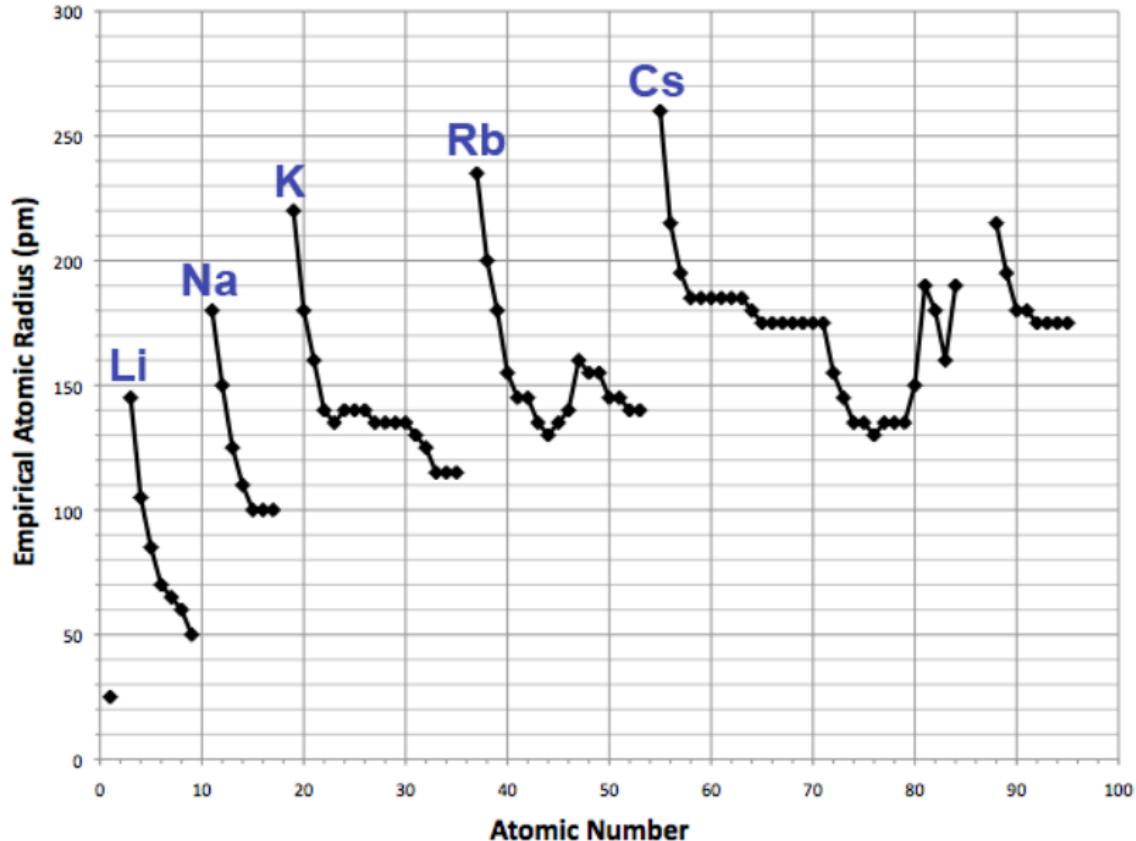
First Ionization Energy Trends



Atomic Sizes of Neutral Atoms

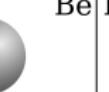
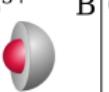
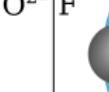
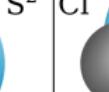
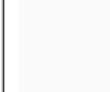
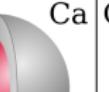
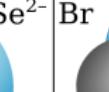
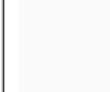
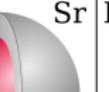
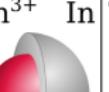
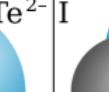
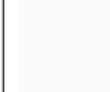


Atomic Sizes of Neutral Atoms



Atomic Sizes of Ions

Sizes of atoms and their ions in pm

Group 1	Group 2	Group 13	Group 16	Group 17
Li^+  90	Li  134	Be^{2+}  59	Be  90	B^{3+}  41
B  82	O  73	O^{2-}  126	F  71	F^-  119
Na^+  116	Na  154	Mg^{2+}  86	Mg  130	Al^{3+}  68
Al  118	S  102	S^{2-}  170	Cl  99	Cl^- 167
K^+  152	K  196	Ca^{2+}  114	Ca  174	Ga^{3+}  76
Ga  126	Se  116	Se^{2-}  184	Br  114	Br^- 182
Rb^+  166	Rb  211	Sr^{2+}  132	Sr  192	In^{3+}  94
In  144	Te  135	Te^{2-}  207	I  133	I^- 206