

Chapter 7: Electron Structure of the Atom

October 24, 2022

Chemistry Department, Cypress College

Class Announcements

Lab

- Experiment 16 - Electromagnetic Energy and Spectroscopy
- Review - Wavelength and Excitation of Electron
- Reminder - Need 70% of laborator points to pass the course

Lecture

- Review the Exam and proposal
- Ch 7+8 - Electronic Structure of Atom and Chemical Bonding
- Go over homework 8 (EC for students who present)
- Quiz and Homework assignment released Fri, Nov 4th at 3pm

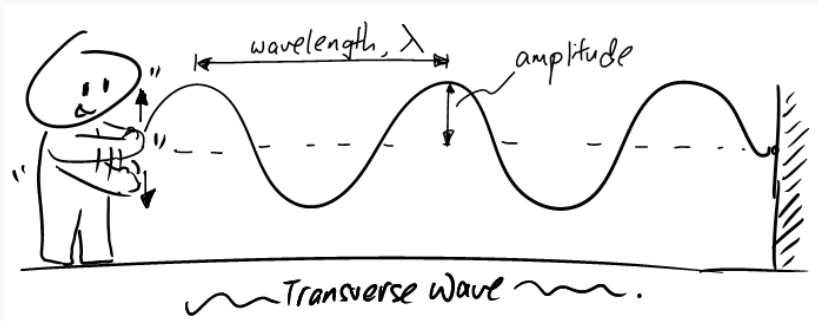
Review: Wavelength and Rydberg Formula

Periodicity of Electron Configurations

Valence electrons for Main-Group Elements

Periodic Properties of Atoms

The Wave



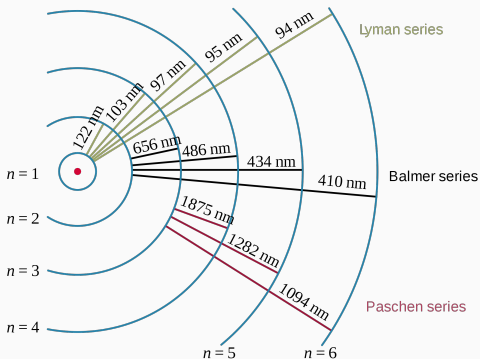
Practice: Determining the Wavelength

Suppose a 7.5m rope is shaken to yield 2.5 wavelength. Draw the wave for 7.5m rope. Determine the wavelength in m.

Rydberg Formula

$$\frac{1}{\lambda} = R \left(\frac{1}{n_f^2} - \frac{1}{n_i^2} \right) \quad (1)$$

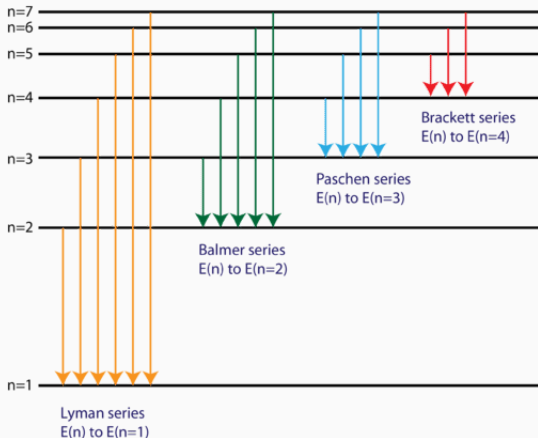
where n_f and n_i are the final and initial energy state, λ is the wavelength, and R is the Rydberg constant ($1.097 \times 10^7 \text{ m}^{-1}$)



H Atom Spectra

Q: What do notice about the transition energy for $n=1$ to $n=2$ and $n=2$ to $n=3$?

Electron transitions for the Hydrogen atom



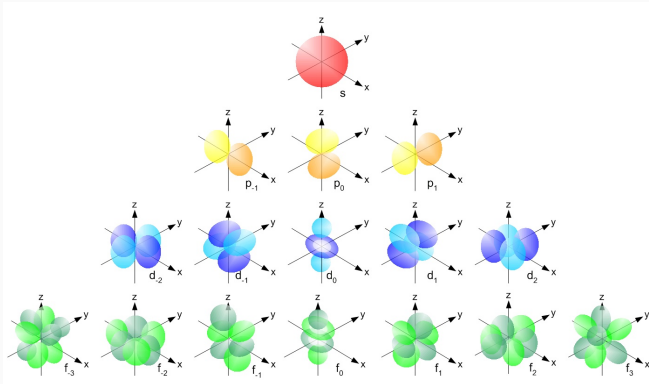
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Periodicity of Electron Configurations

Valence electrons for Main-Group Elements

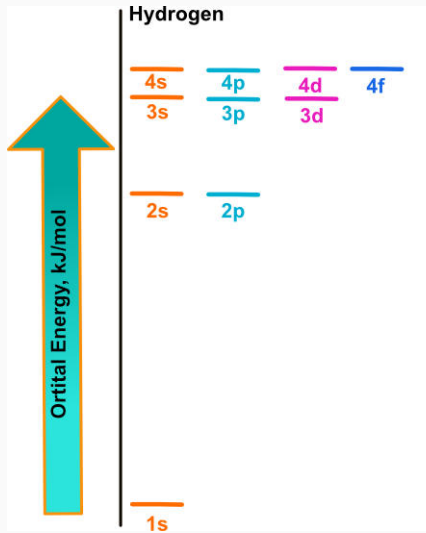
Periodic Properties of Atoms

Atomic Orbitals



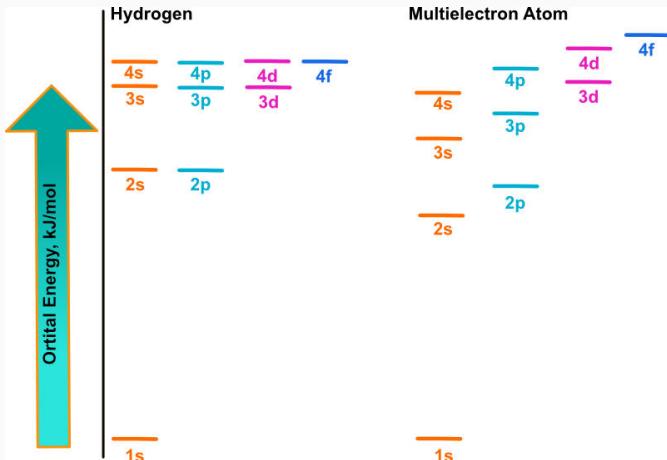
- Specific orbitals occupy certain **principal energy level** e.g. $n = 1, 2, 3, \dots$
- Basis in which atoms form bond; atomic orbitals combine to make molecular orbitals

Orbital Diagram - Hydrogen



Orbital Diagram - Multielectron Element

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



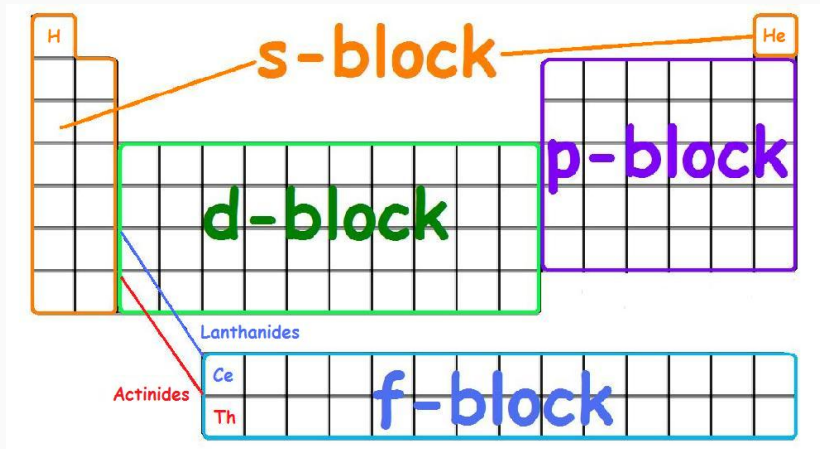
Principles for Filling Atomic Orbitals

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

H

He

Li

Na

Purpose of Electron Configurations

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

Practice: Writing Electron Configurations

F

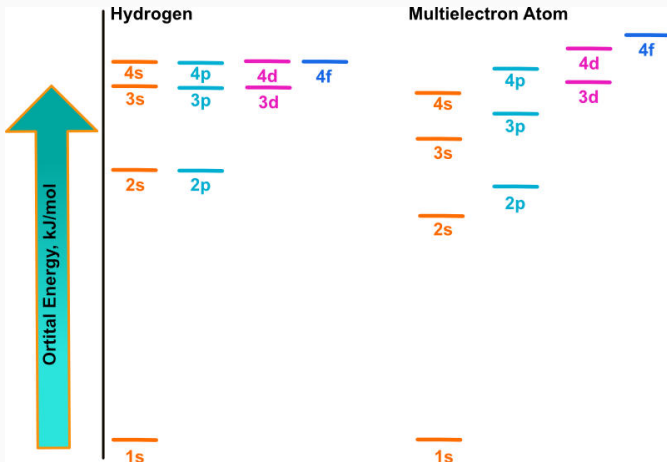
F⁻

Na⁺

Fe

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



Practice: Electron Configuration of Transition Metals

Cr

Mo

W

Cu

Ag

Au

Review: Wavelength and Rydberg Formula

Periodicity of Electron Configurations

Valence electrons for Main-Group Elements

Periodic Properties of Atoms

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: Determine number of valence electrons

Au

Na

Sb

Ag⁺

Cu³⁺

Ca²⁺

Review: Wavelength and Rydberg Formula

Periodicity of Electron Configurations

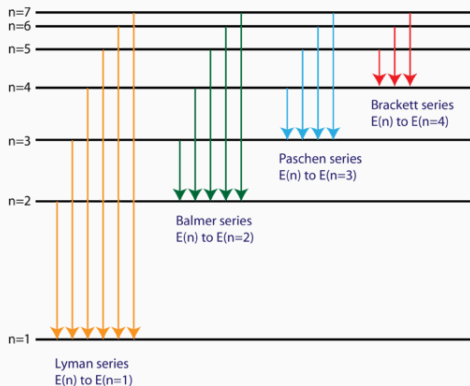
Valence electrons for Main-Group Elements

Periodic Properties of Atoms

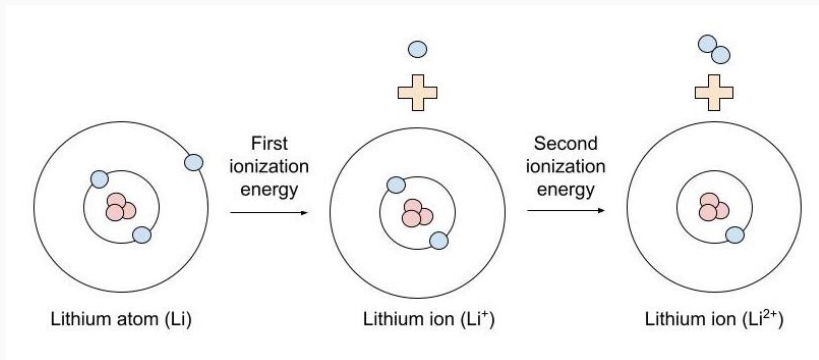
Ionization Energy

Ionization energy - Energy required to eject an electron

Electron transitions for the Hydrogen atom



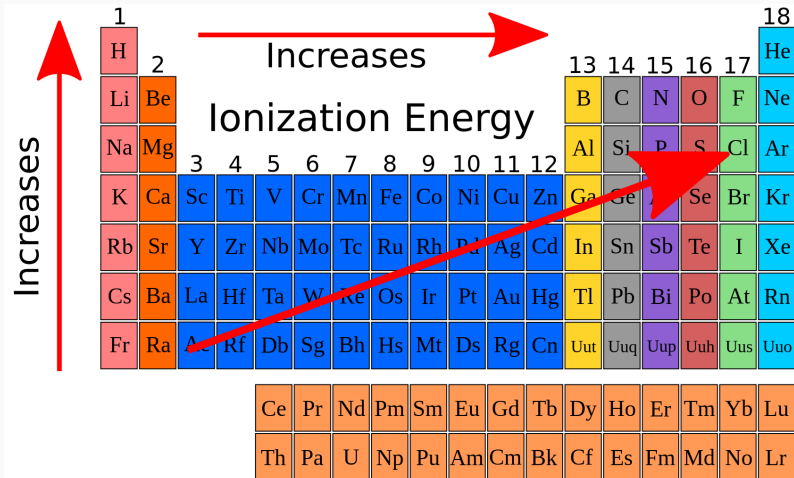
Meaning of Ionization



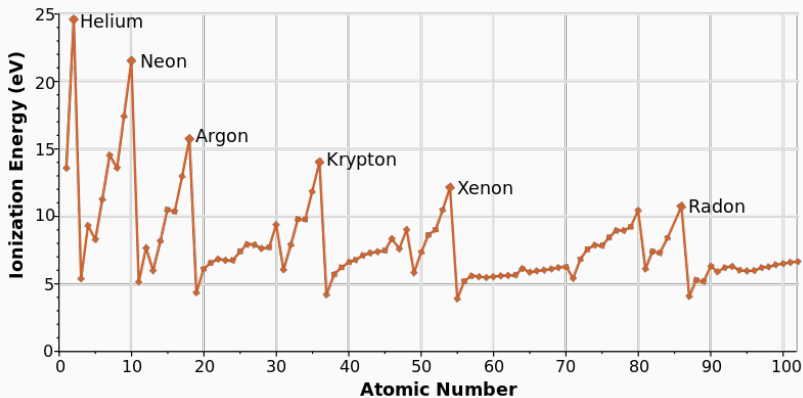
First ionization takes 520 kJ/mol and second ionization takes 7298 kJ/mol

Q: Why is the second ionization energy significantly higher?

First Ionization Energy Trends



First Ionization Energy Trends



Atomic Sizes of Neutral Atoms

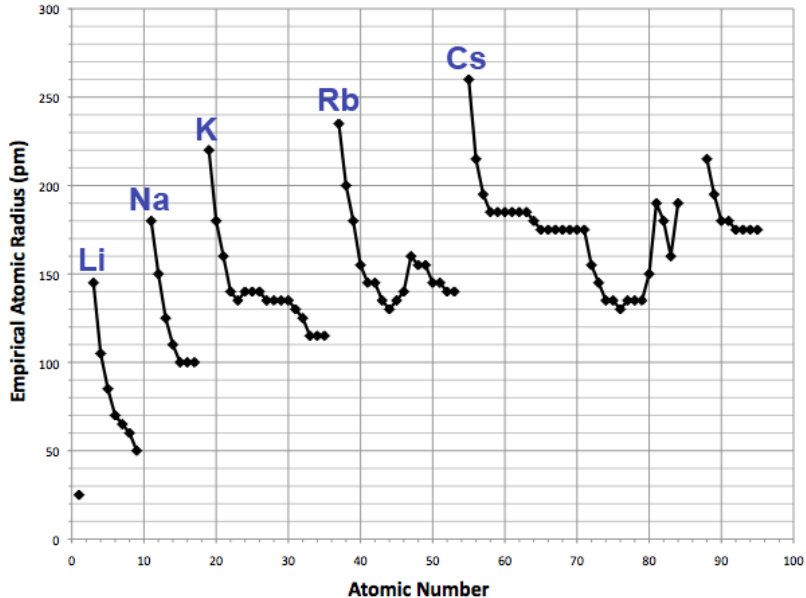
The diagram shows a periodic table with the following elements and their atomic numbers:

1 H																	18 He
2 Li	3 Be											13 B	14 C	15 N	16 O	17 F	18 Ne
11 Na	12 Mg											31 Al	32 Si	33 P	34 S	35 Cl	36 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	49 Ga	50 Ge	51 As	52 Se	53 Br	54 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	63 In	64 Sn	65 Sb	66 Te	67 I	68 Xe
55 Cs	56 Ba	57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu	
87 Fr	88 Ra	89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr	














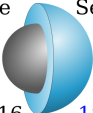
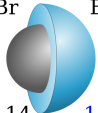



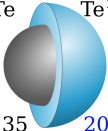
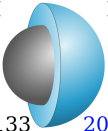
Below the main table, the lanthanide and actinide series are shown in two rows:

Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

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