Periodic Properties of the Elements (Chapter 8)

Electronic Configurations

1. The Aufbau Principle -- **Order of Filling Subshells**

atomic # = # protons = # electrons (in neutral atom)

add electrons to atomic orbitals, two per orbital, in the general order of increasing principle quantum number n, for example:

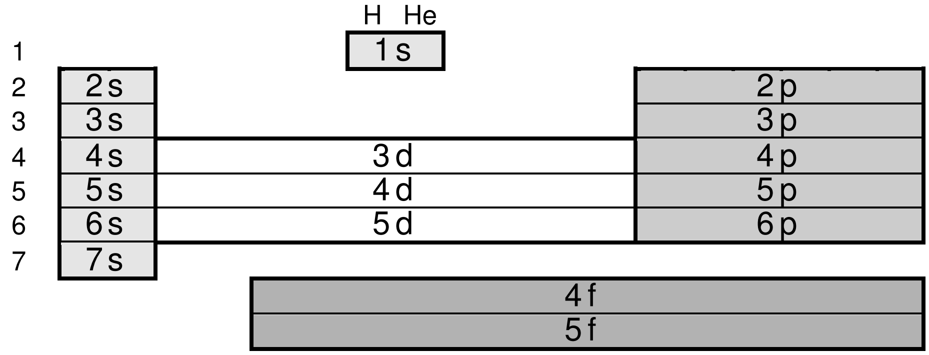
#	Atom	Configuration
1	H	$1s^1$
2	He	$1s^2$
3	Li	$1s^2\ 2s^1$
4	Be	$1s^2\ 2s^2$
5	B	$1s^2\ 2s^2\ 2p^1$
6	C	$1s^2\ 2s^2\ 2p^2$
7	N	$1s^2\ 2s^2\ 2p^3$
8	O	$1s^2\ 2s^2\ 2p^4$
9	F	$1s^2\ 2s^2\ 2p^5$
10	Ne	$1s^2\ 2s^2\ 2p^6$
11	Na	$1s^2\ 2s^2\ 2p^6\ 3s^1$

2. Hund's Rule (maximum # of unpaired electrons in orbitals of equal energy)

orbital diagrams:

	1s	2s	2p		
C	↑↓	↑↓	↑	↑	__
N	↑↓	↑↓	↑	↑	↑
O	↑↓	↑↓	↑↓	↑	↑

3. Relationship to Periodic Table



e.g., electronic configuration of Ge (# 32, group IV)

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

or, Ge $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^2$ (by values of n)

Short-hand notation -- show preceding inert gas config

Ge $[Ar]^{18}\ 4s^2\ 3d^{10}\ 4p^2$ where $[Ar]^{18} = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$

4. Valence Shell Configurations

valence shell -- **largest value of n (e.g., for Ge, n = 4)**
plus any *partially* filled subshells

Ge $4s^2\ 4p^2$ (valence shell electron configuration)

Ge ↑↓ (4s) ↑ ↑ __ (4p) (valence shell orbital diagram)

elements in same group have same valence shell e^- configurations

e.g., group V:

N	$2s^2\ 2p^3$
P	$3s^2\ 3p^3$
As	$4s^2\ 4p^3$
Sb	$5s^2\ 5p^3$
Bi	$6s^2\ 6p^3$

Variation of Atomic Properties

1. Atomic Size (atomic radius, expressed in pm - *pico*meters)

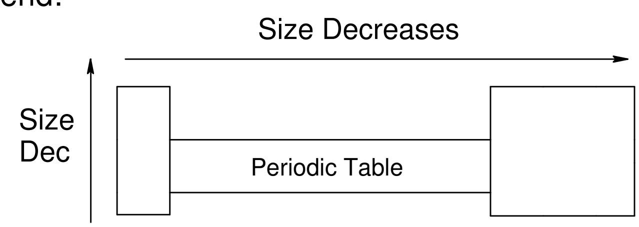
e.g., group I metals:

Atom	Radius in pm	Valence Shell
Li	152	$2s^1$
Na	186	$3s^1$
K	227	$4s^1$
Cs	248	$5s^1$

e.g., some elements in 2nd period:

atom	**B**	**C**	**N**	**O**	**F**
radius	88	77	70	66	64
e^- config	$2p^1$	$2p^2$	$2p^3$	$2p^4$	$2p^5$

General Trend:



Relative Sizes of Ions

cations are smaller than parent atoms

e.g.,	Na	186 pm	$2s^2\ 2p^6\ 3s^1$
	Na^+	95 pm	$2s^2\ 2p^6$

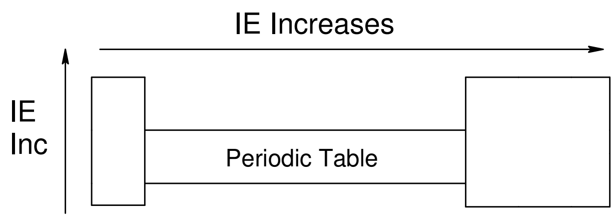
anions are larger than parent atoms

e.g.,	Cl	99 pm	$3s^2\ 3p^5$
	Cl^-	181 pm	$3s^2\ 3p^6$

2. Ionization Energy

IE = energy required to remove an electron from an atom or ion (always ***endothermic***, positive values)

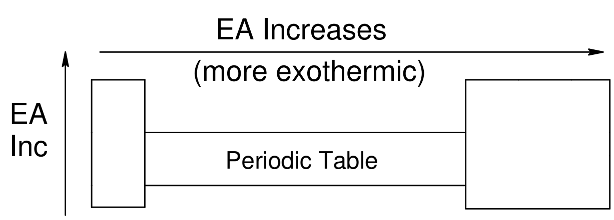
e.g., $Li_{(g)} \longrightarrow Li^{+}_{(g)} + e^{-}$ I.E. = 520 kJ/mole



3. Electron Affinity

EA = energy released when an electron is added to an atom or ion (usually ***exothermic***, negative EA values)

e.g., $Cl_{(g)} + e^{-} \longrightarrow Cl^{-}_{(g)}$ EA = -348 kJ/mole



The general trends in all of these properties indicate that there is a special stability associated with filled-shell configurations as in the inert gases.

Atoms tend to gain or lose an electron or two in order to achieve a stable "inert gas configuration" -- many important consequences of this in chemical bonding.