This week: NO QUIZ / Lab → MAS 439!

11/18/2019

e^- config of ions.

largest n

cations: remove valence e^-s

anions: add valence e^-s

ex: $_3Li$ $1s^2 2s^1$ // O $1s^2 2s^2 2p^4$

Li^+ $1s^2$ // O^{2-} $1s^2 2s^2 2p^6$

or [He] or [Ne]

~~transmiti~~ transition metal ions... "tricky"

valence e^-s

ex: V : $[Ar]\ 4s^2 3d^3$

V^{2+} : $[Ar]\ 3d^3$

valence! (n=4!)

Zn $[Ar]\ 4s^2 3d^{10}$

Zn^{2+} $[Ar]\ 3d^{10}$

why not: Zn^{2+} $[Ar]\ 4s^2 3d^8$?

orbital diagrams: $[Ar]4s^2 3d^8$ vs $[Ar]4s^0 3d^{10}$

Zn^{2+}

[Ar] [↑↓] [↑↓|↑↓|↑↓|↑|↑] vs. [Ar] [ ] [↑↓|↑↓|↑↓|↑↓|↑↓]

4s 3d 4s 3d

some (2) unpaired (↑↑) e^-s | all paired (↑↓) e^-s

when we have unpaired e^-s: attracted INTO a magnetic field.

- PARAMAGNETIC

paired e^-s... slightly repelled by a magnetic field.

- DIAMAGNETIC

Zn^{2+}

Ionic radii

Cations... loss e^-s, e^- cloud shrinks, radius $\downarrow$

$$Li \xrightarrow{-1e^-} Li^+$$

$r = 152pm$ $\quad$ $r = 60pm$

$$B \xrightarrow{-3e^-} B^{3+}$$

$r = 85pm$ $\quad$ $r = 23pm$

Anions... gain e^-s, e^- cloud expands, radius $\uparrow$

$$O \xrightarrow{+2e^-} O^{2-}$$

$r = 73pm$ $\quad$ $r = 140pm$

consider an isoelectronic series of ions

Ca^{2+}	K^+	Cl^-	S^{2-}
$20p^+$	$19p^+$	$17p^+$	$16p^+$
$18e^-$	$18e^-$	$18e^-$	$18e^-$
99pm	133pm	181pm	184pm

$\longrightarrow$ larger radius

$\longleftarrow$ smaller radius

Ionization Energy, IE

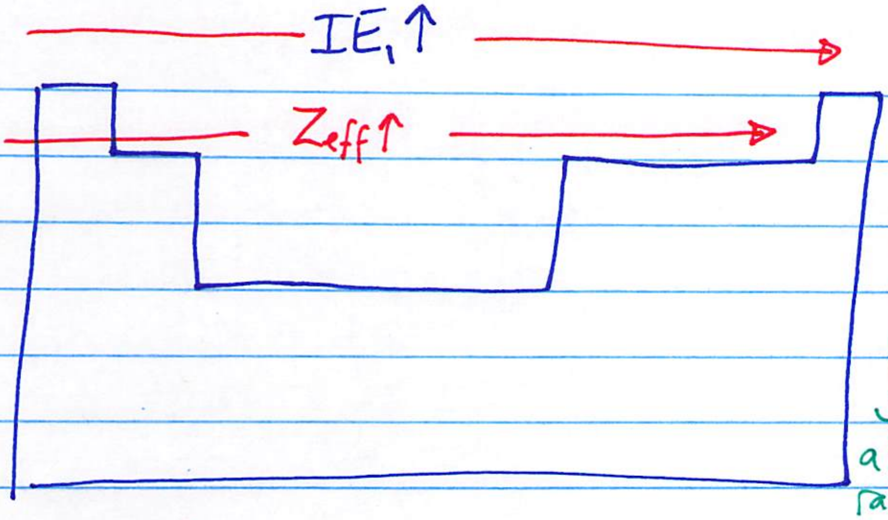
E to remove 1 mol e^-'s from 1 mol gas atoms

ex: IE for ${}_3Li$:

$$Li(g) \longrightarrow Li^+(g) + e^-$$
$$IE_1 = +520\ kJ/mol.$$

$$Li^+(g) \longrightarrow Li^{2+}(g) + e^-$$
$$IE_2 = +7298\ kJ/mol$$

$$Li^{2+}(g) \longrightarrow Li^{3+}(g) + e^-$$
$$IE_3 = +11{,}815\ kJ/mol$$



atomic radius increases (more shells)

$IE_1 \downarrow$

removing e's further away from nucleus. EASIER.

$$f \propto \frac{q_1 q_2}{r^2}$$

Li: $IE_1 = +520$ kJ/mol

$IE_2 = +7{,}298$ kJ/mol

$IE_3 = +11{,}815$ kJ/mol

giant (1000%) increase

Li: $1s^2 2s^1$ $\boxed{\uparrow\downarrow}$ $\boxed{\uparrow}$

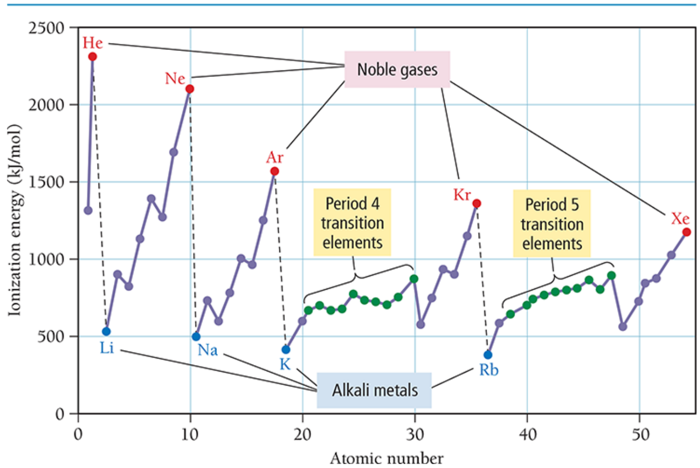
IE_2 IE_1 IE_3

1s 2s

$\underbrace{\text{CORE}}_{\text{close to nucleus!}}$ VALENCE

First Ionization Energy versus Atomic Number for the Elements through

First Ionization Energies



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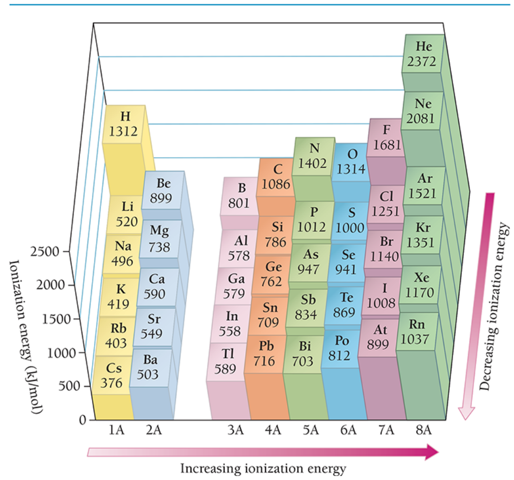
Trends in Ionization Energy

Trends in First Ionization Energy



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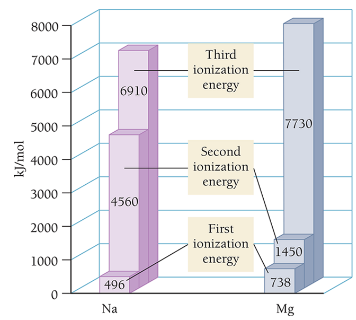
Trends in Successive Ionization Energies

- Removal of each successive electron costs more energy.
  - Shrinkage in size due to having more protons than electrons
  - Outer electrons closer to the nucleus; therefore harder to remove
- There's a regular increase in energy for each successive valence electron.
- There's a large increase in energy when core electrons are removed.



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Trends in Second and Successive Ionization Energies

Element	IE_1	IE_2	IE_3	IE_4	IE_5	IE_6	IE_7
Na	496	4560					
Mg	738	1450	7730		Core electrons		
Al	578	1820	2750	11,600			
Si	786	1580	3230	4360	16,100		
P	1012	1900	2910	4960	6270	22,200	
S	1000	2250	3360	4560	7010	8500	27,100
Cl	1251	2300	3820	5160	6540	9460	11,000
Ar	1521	2670	3930	5770	7240	8780	12,000

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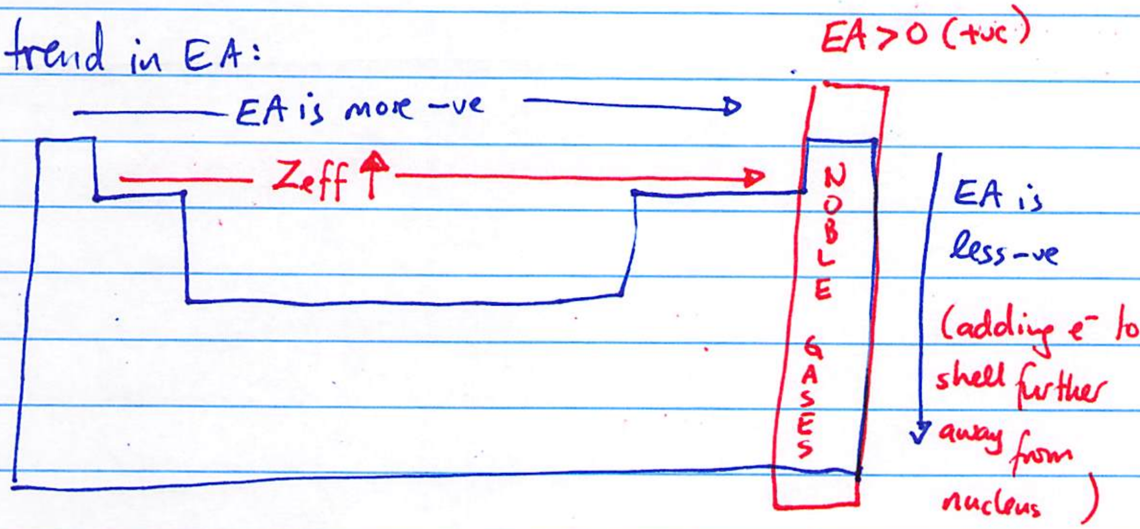
Electron Affinity, EA

$\dot{E}$ when we add 1 mol e^- to 1 mol of gaseous atoms.

ex: EA for Cl: $1e^- + Cl(g) \longrightarrow Cl^-(g)$; $EA = -349 \frac{kJ}{mol}$

trend in EA:



Electron Affinities of Selected Main-Group Elements

Electron Affinities (kJ/mol)

1A	2A	3A	4A	5A	6A	7A	8A
H −73							He >0
Li −60	Be >0	B −27	C −122	N >0	O −141	F −328	Ne >0
Na −53	Mg >0	Al −43	Si −134	P −72	S −200	Cl −349	Ar >0
K −48	Ca −2	Ga −30	Ge −119	As −78	Se −195	Br −325	Kr >0
Rb −47	Sr −5	In −30	Sn −107	Sb −103	Te −190	I −295	Xe >0

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Periodic Trends Summary

Blank	Trend Moving Down a Column	Reason for Trend Moving Down	Trend Moving Across a Row	Reason for Trend Moving Across
Property	Blank	Blank	Blank	Blank
Atomic Radii	Increasing	Size of outermost occupied orbital increases	Decreasing	Effective nuclear charge increases
First Ionization Energy	Decreasing	Outermost electrons further away from nucleus (and therefore easier to remove)	Increasing	Effective nuclear charge increases
Electron Affinity	No definite trend	Blank	Decreasing (more negative)	Effective nuclear charge increases
Metallic Character	Increasing	Ionization energy decreases	Decreasing	Ionization energy increases

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