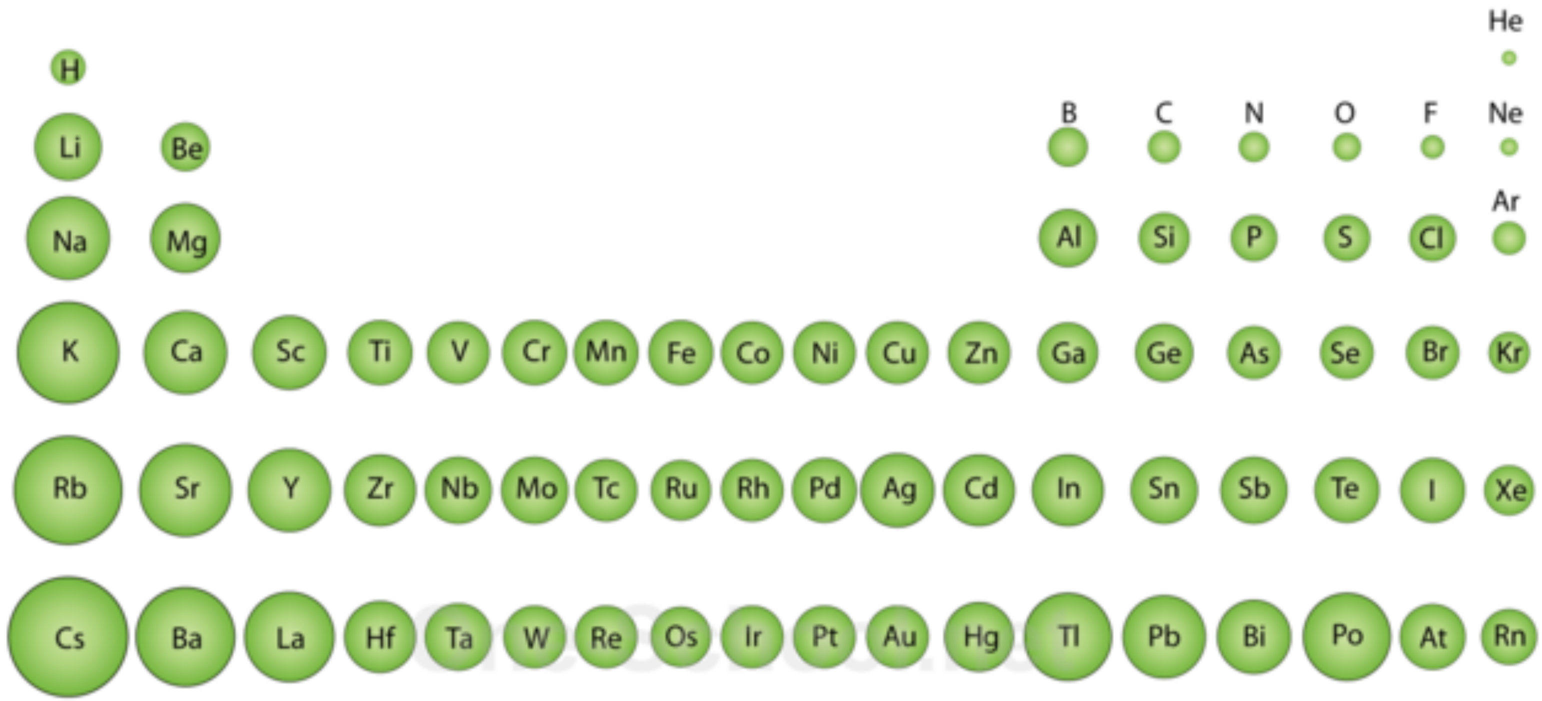
The Periodic Table: Chapter 8

	1 1A	2 2A	3 3B	4 4B	5 5B	6 6B	7 7B	8	9 8B	10	11 1B	12 2B	13 3A	14 4A	15 5A	16 6A	17 7A	18 8A
1	1 **H** $1s^1$																	2 **He** $1s^2$
2	3 **Li** $2s^1$	4 **Be** $2s^2$											5 **B** $2s^22p^1$	6 **C** $2s^22p^2$	7 **N** $2s^22p^3$	8 **O** $2s^22p^4$	9 **F** $2s^22p^5$	10 **Ne** $2s^22p^6$
3	11 **Na** $3s^1$	12 **Mg** $3s^2$											13 **Al** $3s^23p^1$	14 **Si** $3s^23p^2$	15 **P** $3s^23p^3$	16 **S** $3s^23p^4$	17 **Cl** $3s^23p^5$	18 **Ar** $3s^23p^6$
4	19 **K** $4s^1$	20 **Ca** $4s^2$	21 **Sc** $4s^23d^1$	22 **Ti** $4s^23d^2$	23 **V** $4s^23d^3$	24 **Cr** $4s^13d^5$	25 **Mn** $4s^23d^5$	26 **Fe** $4s^23d^6$	27 **Co** $4s^23d^7$	28 **Ni** $4s^23d^8$	29 **Cu** $4s^13d^{10}$	30 **Zn** $4s^23d^{10}$	31 **Ga** $4s^24p^1$	32 **Ge** $4s^24p^2$	33 **As** $4s^24p^3$	34 **Se** $4s^24p^4$	35 **Br** $4s^24p^5$	36 **Kr** $4s^24p^6$
5	37 **Rb** $5s^1$	38 **Sr** $5s^2$	39 **Y** $5s^24d^1$	40 **Zr** $5s^24d^2$	41 **Nb** $5s^14d^4$	42 **Mo** $5s^14d^5$	43 **Tc** $5s^24d^5$	44 **Ru** $5s^14d^7$	45 **Rh** $5s^14d^8$	46 **Pd** $4d^{10}$	47 **Ag** $5s^14d^{10}$	48 **Cd** $5s^24d^{10}$	49 **In** $5s^25p^1$	50 **Sn** $5s^25p^2$	51 **Sb** $5s^25p^3$	52 **Te** $5s^25p^4$	53 **I** $5s^25p^5$	54 **Xe** $5s^25p^6$
6	55 **Cs** $6s^1$	56 **Ba** $6s^2$	57 **La** $6s^25d^1$	72 **Hf** $6s^25d^2$	73 **Ta** $6s^25d^3$	74 **W** $6s^25d^4$	75 **Re** $6s^25d^5$	76 **Os** $6s^25d^6$	77 **Ir** $6s^25d^7$	78 **Pt** $6s^15d^9$	79 **Au** $6s^15d^{10}$	80 **Hg** $6s^25d^{10}$	81 **Tl** $6s^26p^1$	82 **Pb** $6s^26p^2$	83 **Bi** $6s^26p^3$	84 **Po** $6s^26p^4$	85 **At** $6s^26p^5$	86 **Rn** $6s^26p^6$
7	87 **Fr** $7s^1$	88 **Ra** $7s^2$	89 **Ac** $7s^26d^1$	104 **Rf** $7s^26d^2$	105 **Db** $7s^26d^3$	106 **Sg** $7s^26d^4$	107 **Bh** $7s^26d^5$	108 **Hs** $7s^26d^6$	109 **Mt** $7s^26d^7$	110 **Ds** $7s^26d^8$	111 **Rg** $7s^26d^9$	112 **Cn** $7s^26d^{10}$	113 $7s^27p^1$	114 $7s^27p^2$	115 $7s^27p^3$	116 $7s^27p^4$	117 $7s^27p^5$	118 $7s^27p^6$

58 **Ce** $6s^24f^15d^1$	59 **Pr** $6s^24f^3$	60 **Nd** $6s^24f^4$	61 **Pm** $6s^24f^5$	62 **Sm** $6s^24f^6$	63 **Eu** $6s^24f^7$	64 **Gd** $6s^24f^75d^1$	65 **Tb** $6s^24f^9$	66 **Dy** $6s^24f^{10}$	67 **Ho** $6s^24f^{11}$	68 **Er** $6s^24f^{12}$	69 **Tm** $6s^24f^{13}$	70 **Yb** $6s^24f^{14}$	71 **Lu** $6s^24f^{14}5d^1$
90 **Th** $7s^26d^2$	91 **Pa** $7s^25f^26d^1$	92 **U** $7s^25f^36d^1$	93 **Np** $7s^25f^46d^1$	94 **Pu** $7s^25f^6$	95 **Am** $7s^25f^7$	96 **Cm** $7s^25f^76d^1$	97 **Bk** $7s^25f^9$	98 **Cf** $7s^25f^{10}$	99 **Es** $7s^25f^{11}$	100 **Fm** $7s^25f^{12}$	101 **Md** $7s^25f^{13}$	102 **No** $7s^25f^{14}$	103 **Lr** $7s^25f^{14}6d^1$

What Influences Atomic Size?

What factors determine the size of an atom?

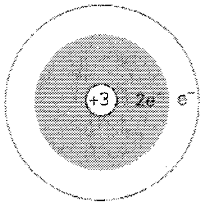


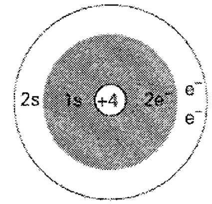
Effective Nuclear Charge

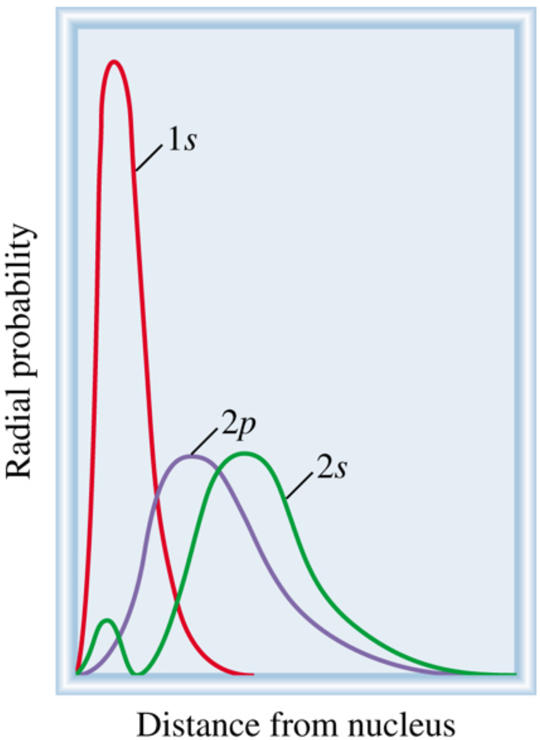
What factors determine how much positive charge or 'pull' an electron experiences?

Define a term called *effective nuclear charge*, Z_{eff}, which in any given atom is the amount of nuclear charge or "pull" the outermost electron experiences.

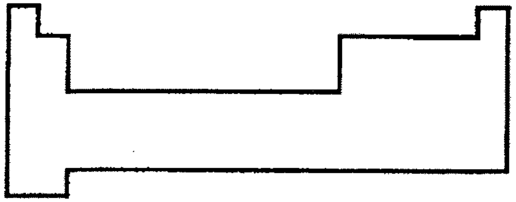
Effective Nuclear Charge: $Z_{eff} = Z - S$



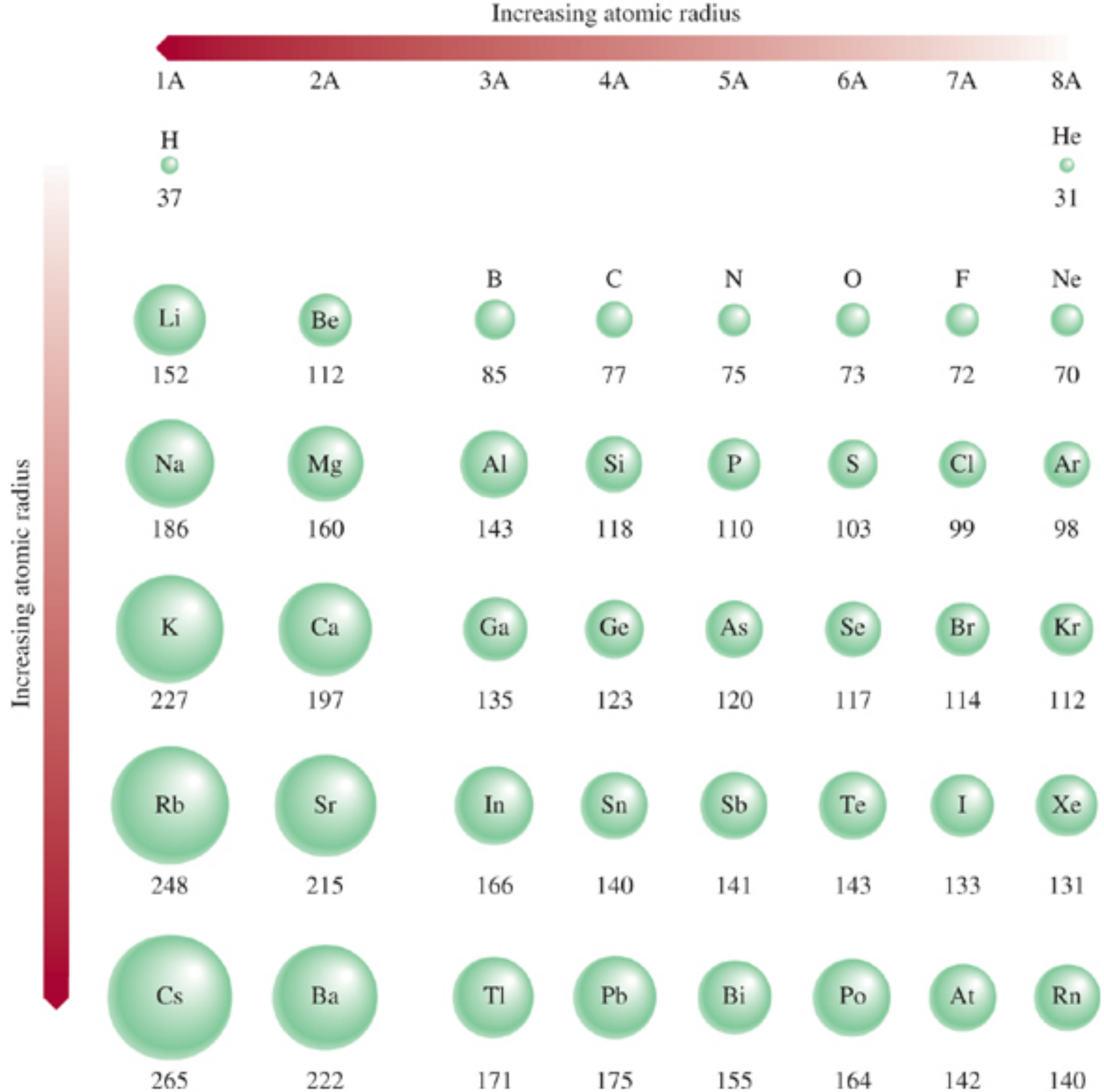




Periodic Trend:



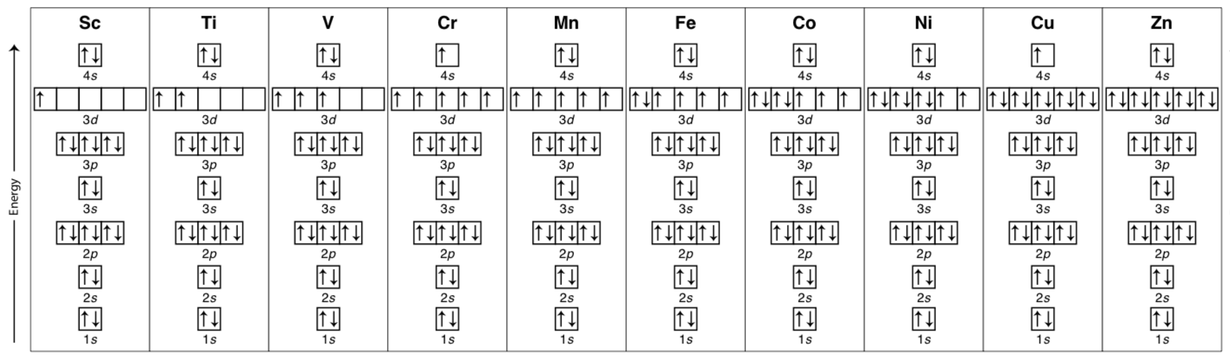
Explaining the Periodic Trends in Atomic Size

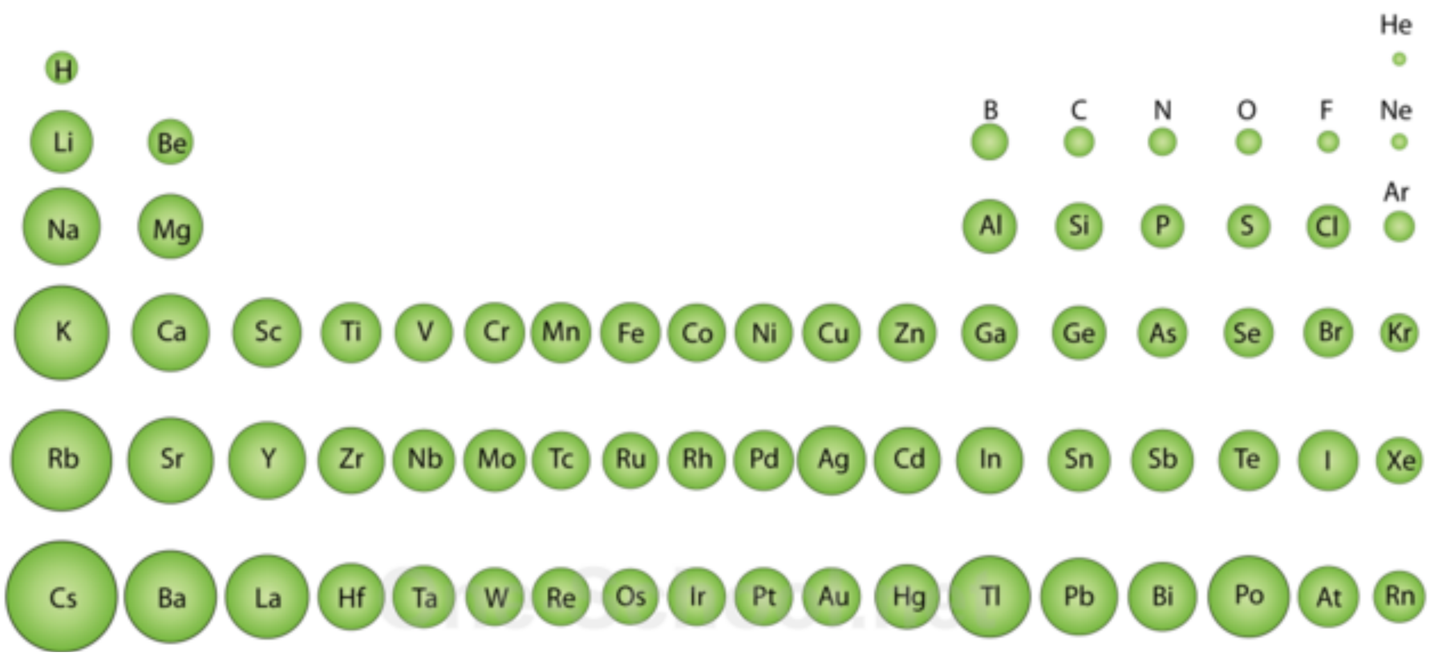


What Influences Atomic Size?

What factors determine the size of an atom?

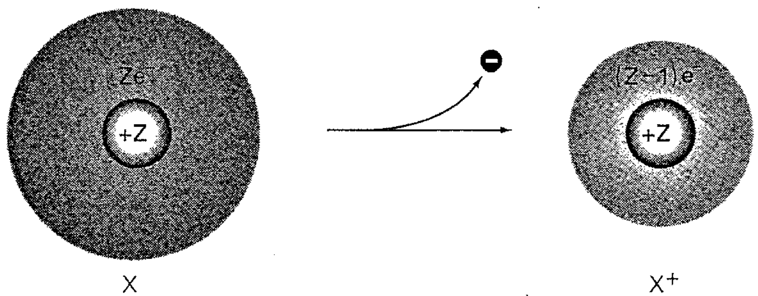
The size of an atom is the distance of the outermost electron to the nucleus. The location of that outermost electrons is determined by the net positive attractive forces of the nucleus, Zeff, and the principal quantum number of the outermost electron, n.



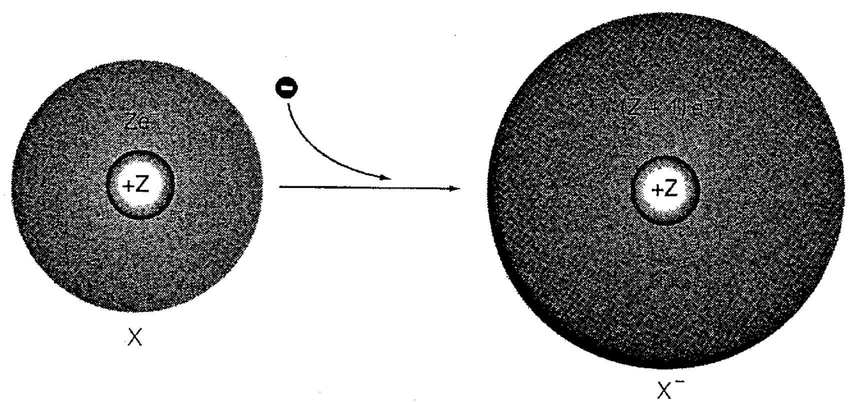


Sizes of Ions

Cations:



Anions:



Rank the following according to increasing size Li^+, Li^- and Li

Writing the Electron configuration of Ions

- We will use the electron configuration of the neutral atoms to write the electron configuration of the ions

Rules for writing electron configurations of ions:

Always begin by writing the electron configuration of the neutral atom.

For cations (positively charged ions)

- **When removing an electron** from an element always remove the electron from the orbital that has the highest n (principle quantum number)

- If there are two orbitals with the same highest principle quantum number then remove the electron from the orbital that is highest in energy. (lower energy) s<p<d<f (higher energy)

Fro anions (negatively charged ions)

- **When adding electrons** to an element always add the electrons to the available orbital that has the lowest n (principle quantum number).

- If there are two available vacant orbitals with the same lowest principle quantum number then add the electron to the orbital that is lowest in energy. (lower energy) s<p<d<f (higher energy)

Write the abbreviated electron configurations for:

Rh:

Rh^{2+}:

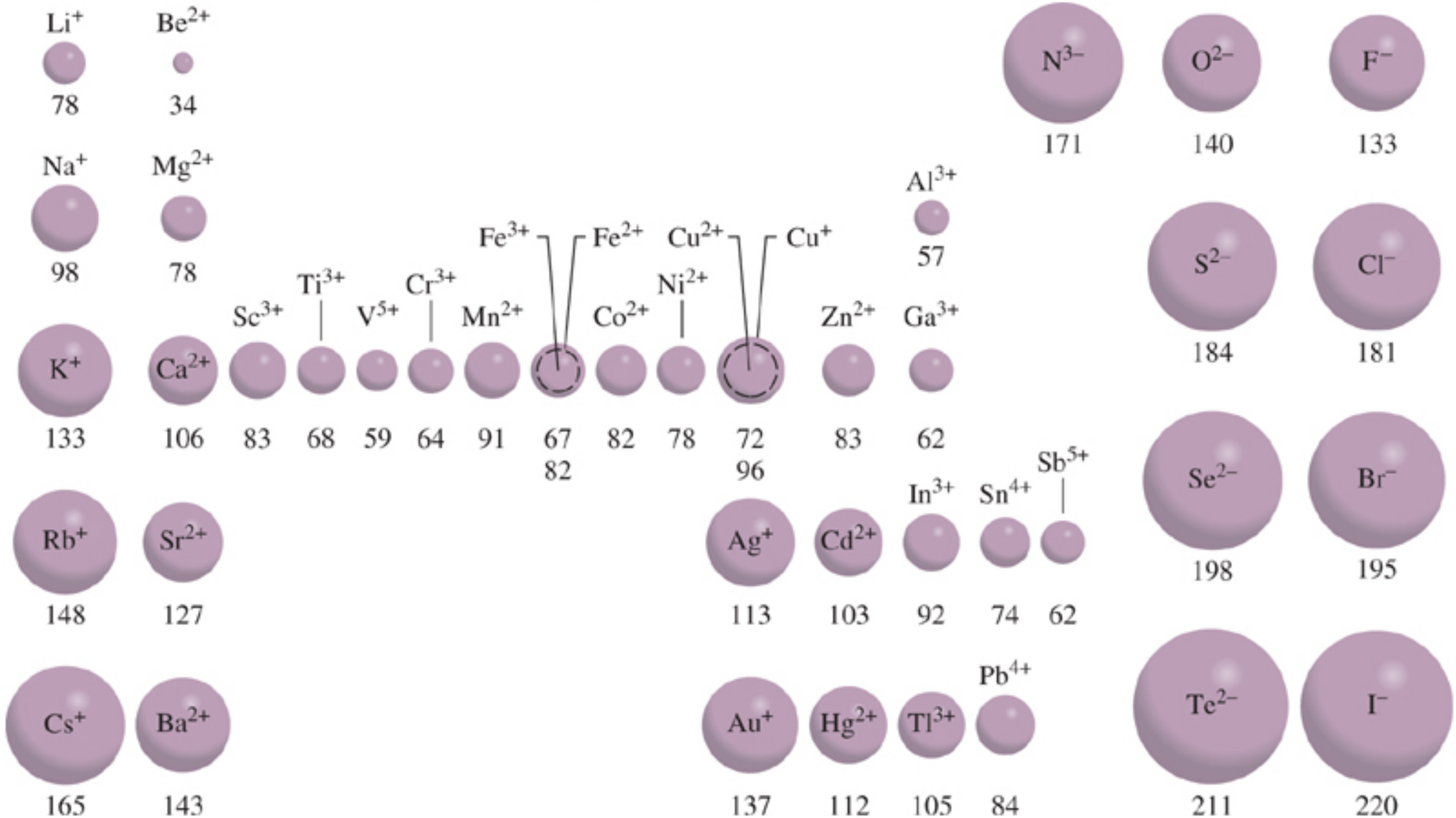
P:

P^{3-}:

Know how to write the electron configuration for any element and how to write the electron configuration for any ion.

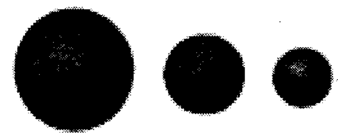
Fig. 8.8

Periodicity of Ionic Size



Questions

Consider the following spheres: Which represents Ca, Ca^{2+}, Mg^{2+}?



Arrange the following in order of increasing size Ca, Ti^{4+}, Sc^{3+}

Provide and explain the following

Cl^{-} is larger than Cl

S^{2-} is larger than O^{2-}

Alkali Metal Reactions Revisited

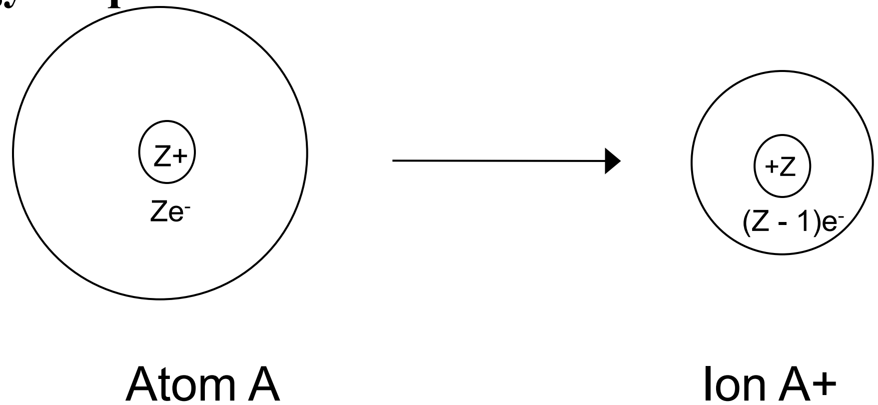
Reaction	How violent?
$2Li + 2H_2O \text{ ---> } 2LiOH + H_2$	
$2Na + 2H_2O \text{ ---> } 2NaOH + H_2$	
$2K + 2H_2O \text{ ---> } 2KOH + H_2$	
$Ca + 2H_2O \text{ ---> } Ca(OH)_2 + H_2$	

What is oxidation state of Li, Na, K and Rb in products and reactants?

Taking e- out and putting them in is very important
to understand reactivity.

Ionization Energy:

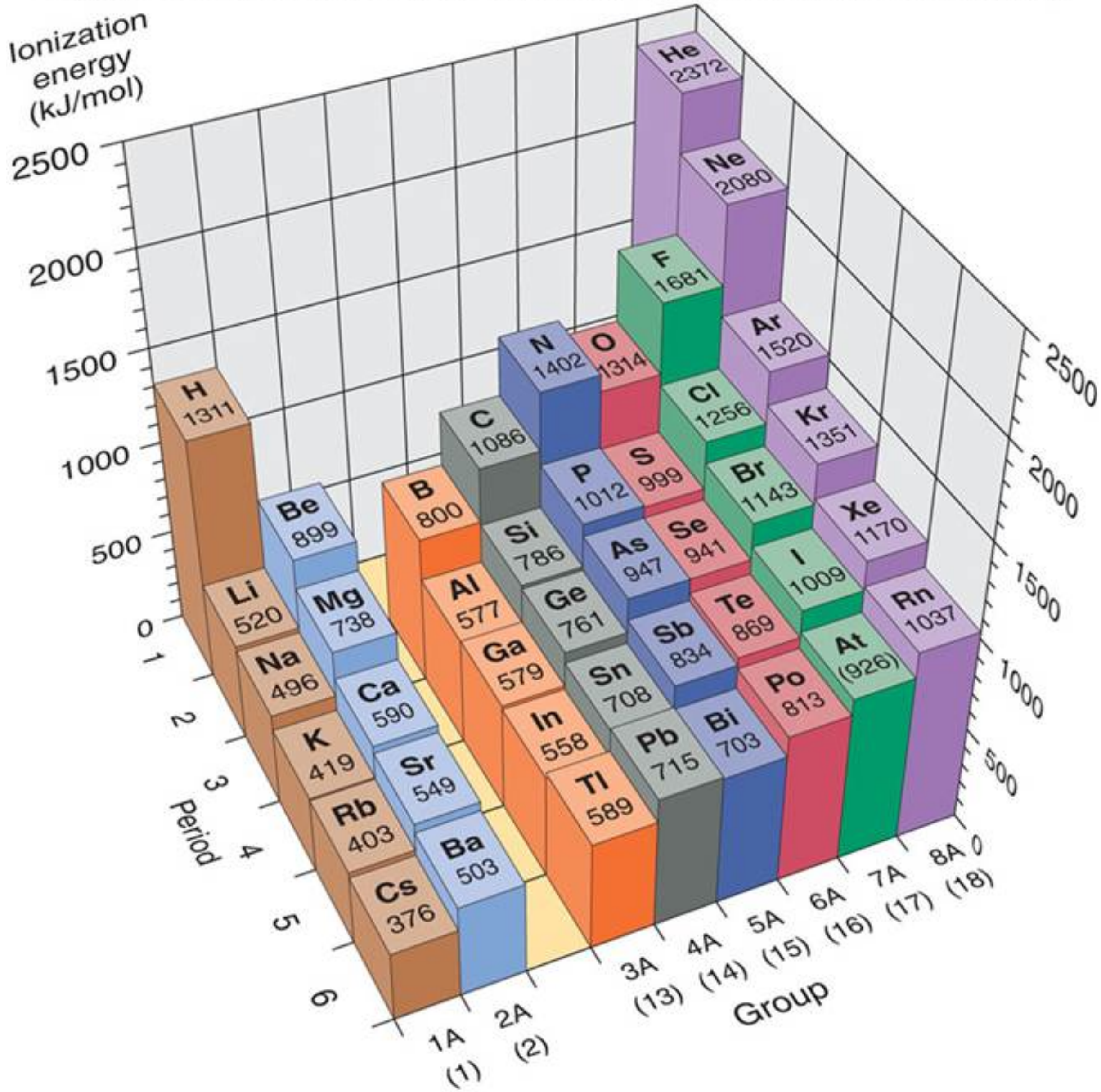
Energy Required to Remove an Electron from an Atom or Ion



First Ionization Energy: Is the energy required to remove the outermost electron from a neutral atom or molecule that is in the gas phase

Second Ionization Energy: Is the energy required to remove another electron from the singly positive ion that is in the gas phase

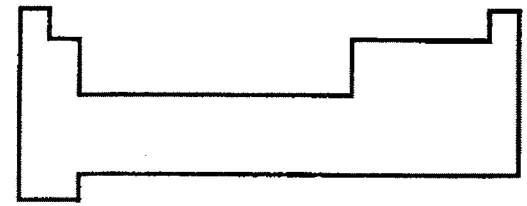
Ionization Energies



http://www.uwec.edu/boulteje/Boulter103Notes/21October.htm

Ionization Energy

What is the trend?



Trends in Second Ionization Energies

TABLE 8.2 The Ionization Energies (kJ/mol) of the First 20 Elements

Z	Element	First	Second	Third	Fourth	Fifth	Sixth
1	H	1,312					
2	He	2,373	5,251				
3	Li	520	7,300	11,815			
4	Be	899	1,757	14,850	21,005		
5	B	801	2,430	3,660	25,000	32,820	
6	C	1,086	2,350	4,620	6,220	38,000	47,261
7	N	1,400	2,860	4,580	7,500	9,400	53,000
8	O	1,314	3,390	5,300	7,470	11,000	13,000
9	F	1,680	3,370	6,050	8,400	11,000	15,200
10	Ne	2,080	3,950	6,120	9,370	12,200	15,000
11	Na	495.9	4,560	6,900	9,540	13,400	16,600
12	Mg	738.1	1,450	7,730	10,500	13,600	18,000
13	Al	577.9	1,820	2,750	11,600	14,800	18,400
14	Si	786.3	1,580	3,230	4,360	16,000	20,000
15	P	1,012	1,904	2,910	4,960	6,240	21,000
16	S	999.5	2,250	3,360	4,660	6,990	8,500
17	Cl	1,251	2,297	3,820	5,160	6,540	9,300
18	Ar	1,521	2,666	3,900	5,770	7,240	8,800
19	K	418.7	3,052	4,410	5,900	8,000	9,600
20	Ca	589.5	1,145	4,900	6,500	8,100	11,000

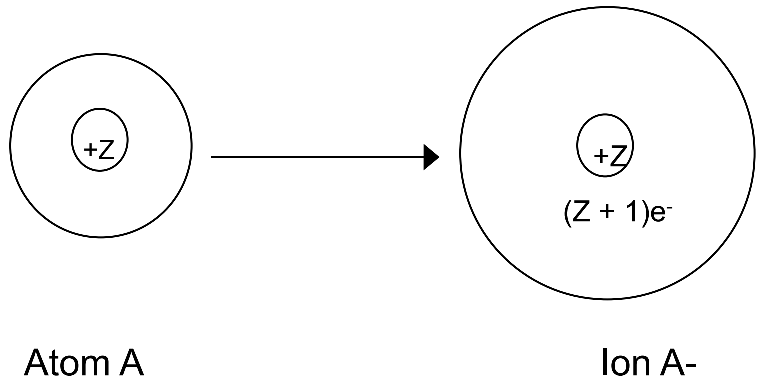
Ionization Energy: Periodic Trends and Exceptions

1. In general: Increases across row and up a group.

2. But there are exceptions: Consider Be (IE=899 KJ/mol) vs B (IE=801 KJ/mol), why are these the reverse of what we expect?

Electron Affinity:

Energy Released or Required to Add an Electron to an Atom, Ion or Molecule



Electron Affinity: is the energy changed when a gaseous atom or molecule gains an electron to form an gaseous ion

Electron Affinity Used in Chemistry E-1a

1A (1)	2A (2)	3A (13)	4A (14)	5A (15)	6A (16)	7A (17)	8A (18)
H −72.8							**He** (0.0)
Li −59.6	**Be** ≤0	**B** −26.7	**C** −122	**N** +7	**O** −141	**F** −328	**Ne** (+29)
Na −52.9	**Mg** ≤0	**Al** −42.5	**Si** −134	**P** −72.0	**S** −200	**Cl** −349	**Ar** (+35)
K −48.4	**Ca** −2.37	**Ga** −28.9	**Ge** −119	**As** −78.2	**Se** −195	**Br** −325	**Kr** (+39)
Rb −46.9	**Sr** −5.03	**In** −28.9	**Sn** −107	**Sb** −103	**Te** −190	**I** −295	**Xe** (+41)
Cs −45.5	**Ba** −13.95	**Tl** −19.3	**Pb** −35.1	**Bi** −91.3	**Po** −183	**At** −270	**Rn** (+41)

http://www.uwec.edu/boulteje/Boulter103Notes/21October.htm

Electron Affinity in Textbook: opposite sign!

TABLE 8.3 Electron Affinities (kJ/mol) of Some Representative Elements and the Noble Gases*

1A	2A	3A	4A	5A	6A	7A	8A
H							He
73							< 0
Li	Be	B	C	N	O	F	Ne
60	≤ 0	27	122	0	141	328	< 0
Na	Mg	Al	Si	P	S	Cl	Ar
53	≤ 0	44	134	72	200	349	< 0
K	Ca	Ga	Ge	As	Se	Br	Kr
48	2.4	29	118	77	195	325	< 0
Rb	Sr	In	Sn	Sb	Te	I	Xe
47	4.7	29	121	101	190	295	< 0
Cs	Ba	Tl	Pb	Bi	Po	At	Rn
45	14	30	110	110	?	?	< 0

*The electron affinities of the noble gases, Be, and Mg have not been determined experimentally, but are believed to be close to zero or negative.

Special Stability Situations

Case I:

Be ([He] $2s^2$) ----> Be^+[He] $2s^1$ + e^- $\Delta E = +899$ kJ/mol
B ([He]$2s^22p^1$)----> B^+[He]$2s^2$ + e^- $\Delta E = +801$ kJ/mol

Case II:

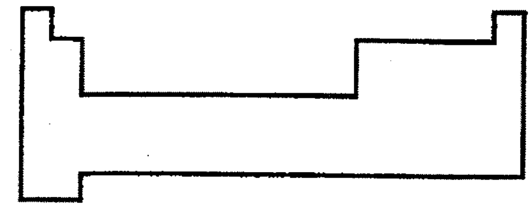
N ([He]$2s^22p^3$)----> N^+[He]$2s^22p^2$+ e^- $\Delta E = +1402$ kJ/mol
O ([He]$2s^22p^4$)----> O^+[He]$2s^22p^3$ + e^- $\Delta E = +1314$ kJ/mol

Case III:

Cl([Ne]$3s^23p^5$) + e- ----> Cl^- ([Ne]$3s^23p^6$) $\Delta E = -349$ kJ/mol
Ar ([Ne]$3s^23p^6$) + e- ----> Ar^- ([Ne]$3s^23p^64s^1$) $\Delta E = +$ VBN kJ/mol

Metals, Nonmetals, and Metalloids

What kinds of elements are metals?



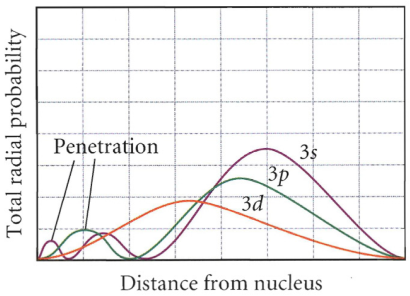
- Metal character refers to the properties of metals

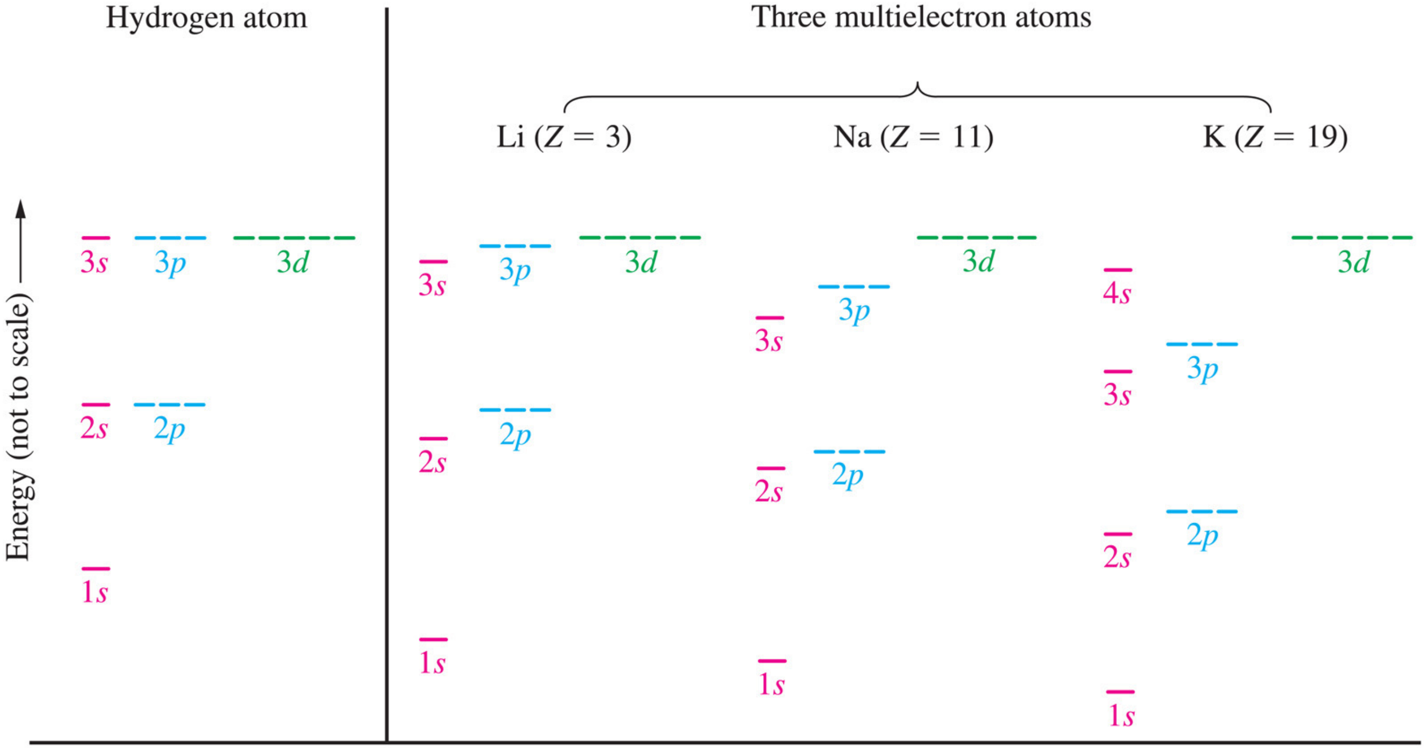
- Metal character increases down a group, metal character decreases across a period.

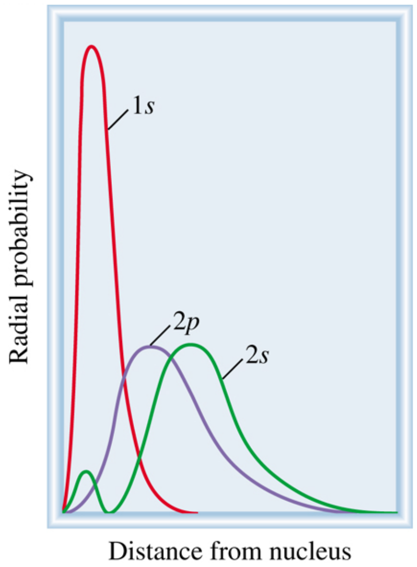
- What is a non-metal and a metalloid?

Multi-electron Atoms

- In multi-electron atoms, orbitals with same *n* but different *l* have ***different*** energy.







Ionization Energy for Many Electron Atoms

We learned that we can use the Rydberg equation to calculate the energies of electrons in hydrogen atoms. We can use a modification of this equation for atoms with more than 1 electron. This equation is:

$$\Delta E = 2.18 \text{ X } 10^{-18} \text{J } Z_{eff}^2 \,(1/n_i^2 - 1/n_f^2)$$

Where ΔE is the first ionization energy of an electron in an atom. Use this equation to calculate the Z_{eff} for Li.

Different World Periodic Table

You land on a distant planet in another universe and find that the n=1 level can hold a Maximum of 4 electrons, the n=2 level can hold a maximum of 5 electrons, and the n = 3 level can hold a maximum of 3 electrons. Like our universe, protons have a charge of +1, and electrons have a charge of -1, and opposite charges attract. Also, a filled shell results in greater stability of an atom, so the atom tends to gain or lose electrons to give a filled shell. Predict the formula of a compound that results from the reaction of a neutral metal atom Z, which has 7 electrons, and a neutral atom Y, which has three electrons.