

Chapter 7 : Periodic Properties of the Elements

Sizes of atoms and ions.

Ionization energy – How much energy is required to remove an e⁻

Electron affinity – How much an atom wants to gain an e⁻

H																	He																												
Li	Be											B	C	N	O	F	Ne																												
Na	Mg											Al	Si	P	S	Cl	Ar																												
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr																												
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe																												
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn																												
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt																																					
<table border="1"> <tr> <td>Ce</td> <td>Pr</td> <td>Nd</td> <td>Pm</td> <td>Sm</td> <td>Eu</td> <td>Gd</td> <td>Tb</td> <td>Dy</td> <td>Ho</td> <td>Er</td> <td>Tm</td> <td>Yb</td> <td>Lu</td> </tr> <tr> <td>Th</td> <td>Pa</td> <td>U</td> <td>Np</td> <td>Pu</td> <td>Am</td> <td>Cm</td> <td>Bk</td> <td>Cf</td> <td>Es</td> <td>Fm</td> <td>Md</td> <td>No</td> <td>Lr</td> </tr> </table>																		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
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																																
			Ancient Times			1735–1843			1894–1918																																				
			Middle Ages–1700			1843–1886			1923–1961			1965–																																	

Mendeleev's Predictions



http://en.wikipedia.org/wiki/Periodic_table

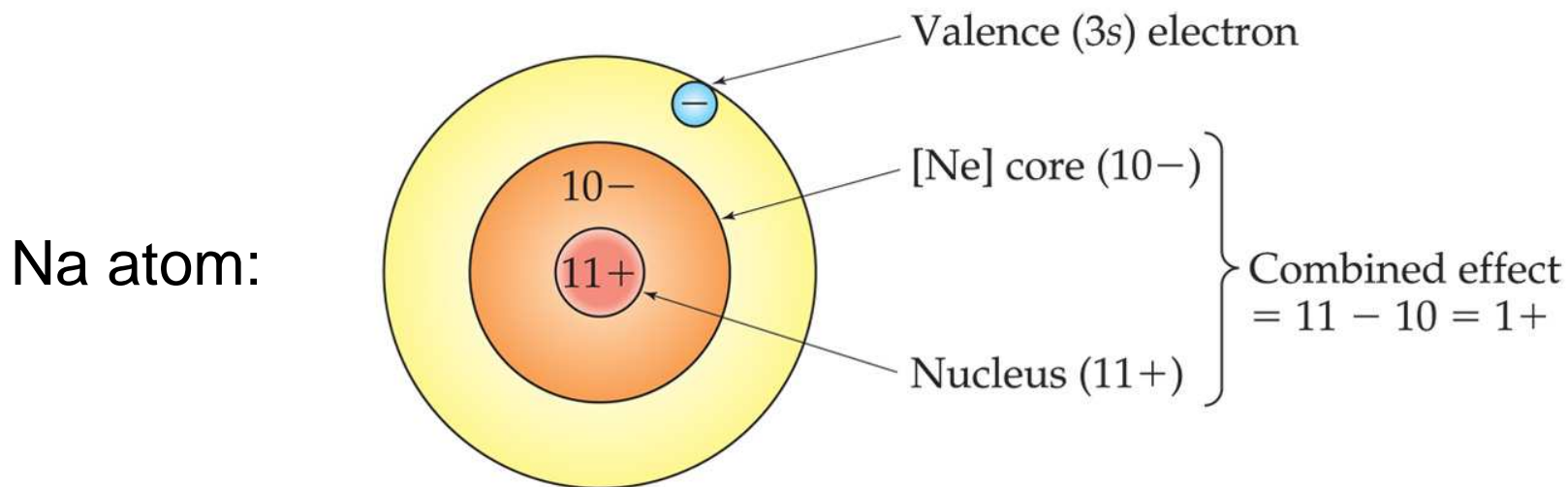
ОПЫТЪ СИСТЕМЫ ЭЛЕМЕНТОВЪ.
ОСНОВАННОЙ НА ИХЪ АТОМНОМЪ ВѢСѢ И ХИМИЧЕСКОМЪ СХОДСТВѢ.

	Ti = 50	Zr = 90	? = 180.
	V = 51	Nb = 94	Ta = 182.
	Cr = 52	Mo = 96	W = 186.
	Mn = 55	Rh = 104,4	Pt = 197,1.
	Fe = 56	Ru = 104,4	Ir = 198.
	Ni = Co = 59	Pd = 106,6	Os = 199.
H = 1	Cu = 63,4	Ag = 108	Hg = 200.
Be = 9,1	Mg = 24	Zn = 65,2	Cd = 112
B = 11	Al = 27,1	? = 68	Ur = 116 Au = 197?
C = 12	Si = 28	? = 70	Sn = 118
N = 14	P = 31	As = 75	Sb = 122 Bi = 210?
O = 16	S = 32	Se = 79,4	Te = 128?
F = 19	Cl = 35,5	Br = 80	I = 127
Li = 7	Na = 23	K = 39	Rb = 85,4 Cs = 133 Tl = 204.
		Ca = 40	Sr = 87,6 Ba = 137 Pb = 207.
		? = 45	Ce = 92
		?Er = 56	La = 94
		?Yt = 60	Di = 95
		?In = 75,6	Th = 118?

Д. Менделѣевъ

Property	Ekaaluminum	Gallium
atomic mass	68	69.72
density (g/cm ³)	6.0	5.904
melting point (°C)	Low	29.78
oxide's formula	Ea ₂ O ₃ (density - 5.5 g cm ⁻³) (soluble in both alkalis and acids)	Ga ₂ O ₃ (density - 5.88 g cm ⁻³) (soluble in both alkalis and acids)
chloride's formula	Ea ₂ Cl ₆ (volatile)	Ga ₂ Cl ₆ (volatile)

Effective Nuclear Charge



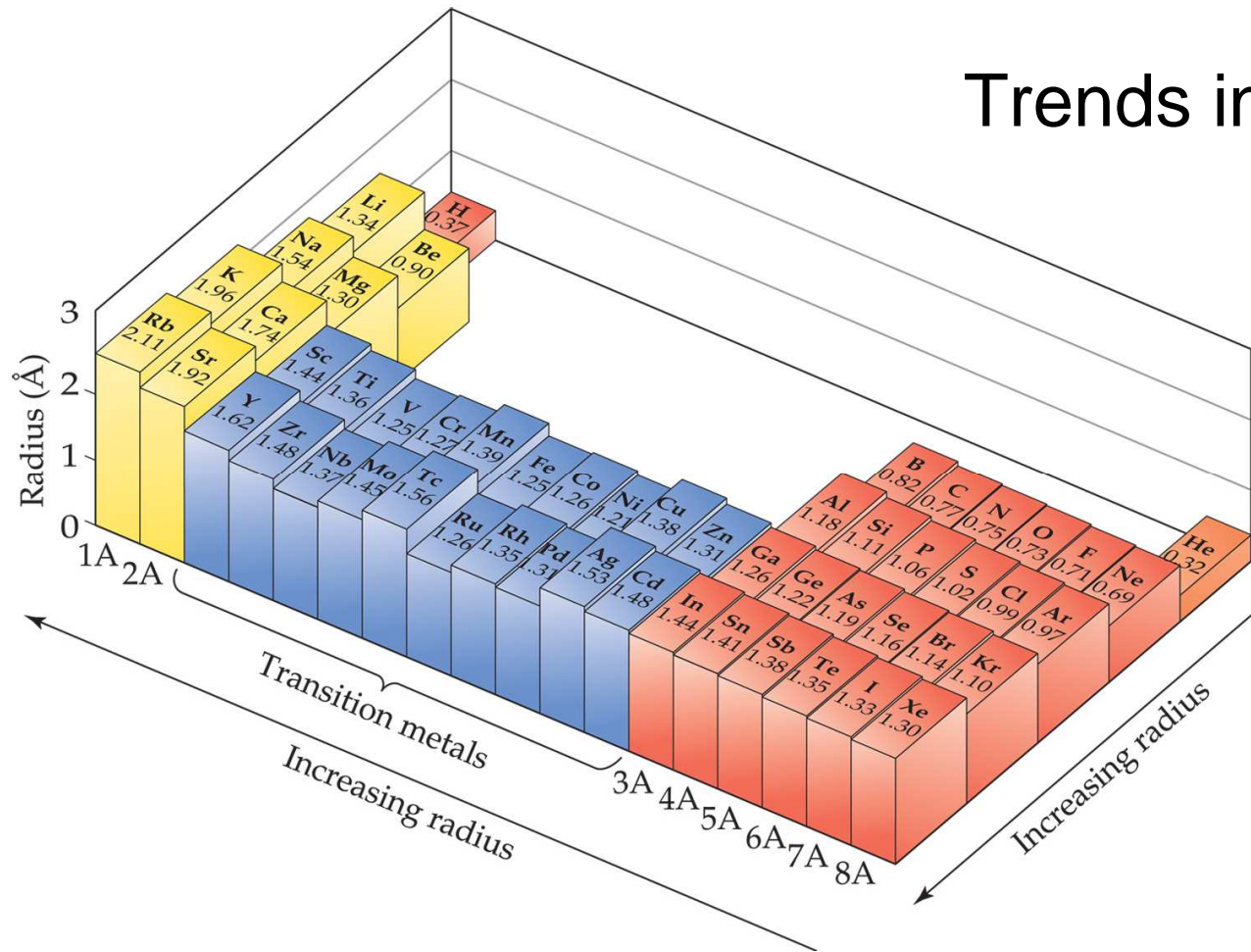
The attraction of valence electrons to the nucleus is weakened by core electrons, which they repel

The effective nuclear charge, Z_{eff} , is found this way:

$$Z_{\text{eff}} = Z - S$$

where Z is the atomic number and S is a screening constant, usually close to the number of inner electrons.

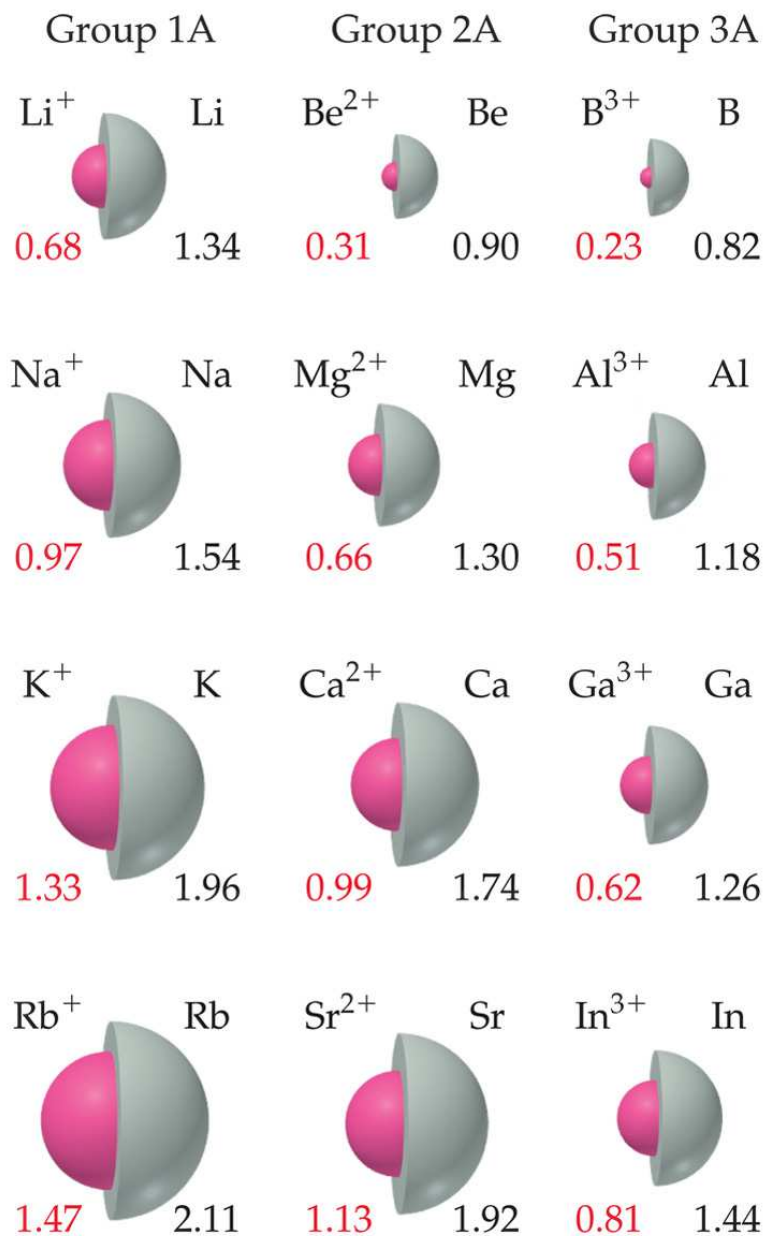
Trends in Atomic Radius



Atomic radius tends to decrease from left to right across a row due to increasing Z_{eff} .

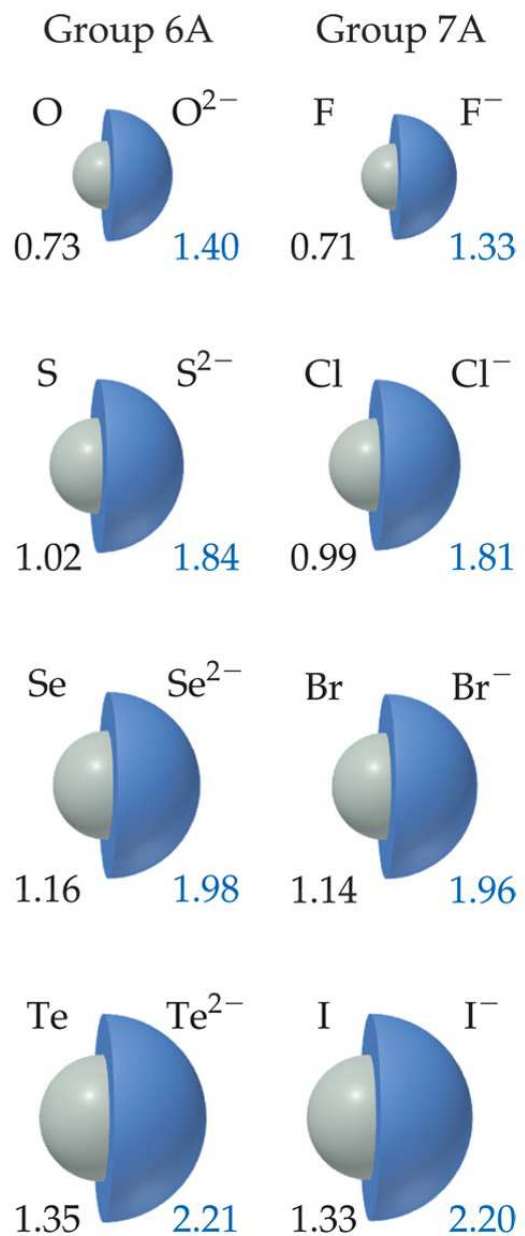
Atomic radius increases from the top to the bottom of a column due to increasing value of n

Cations are smaller than neutral atoms



The outermost electron is removed and electron repulsions are reduced.

Anions are larger than neutral atoms



Electrons are added
and repulsions are
increased.

Ionization Energy

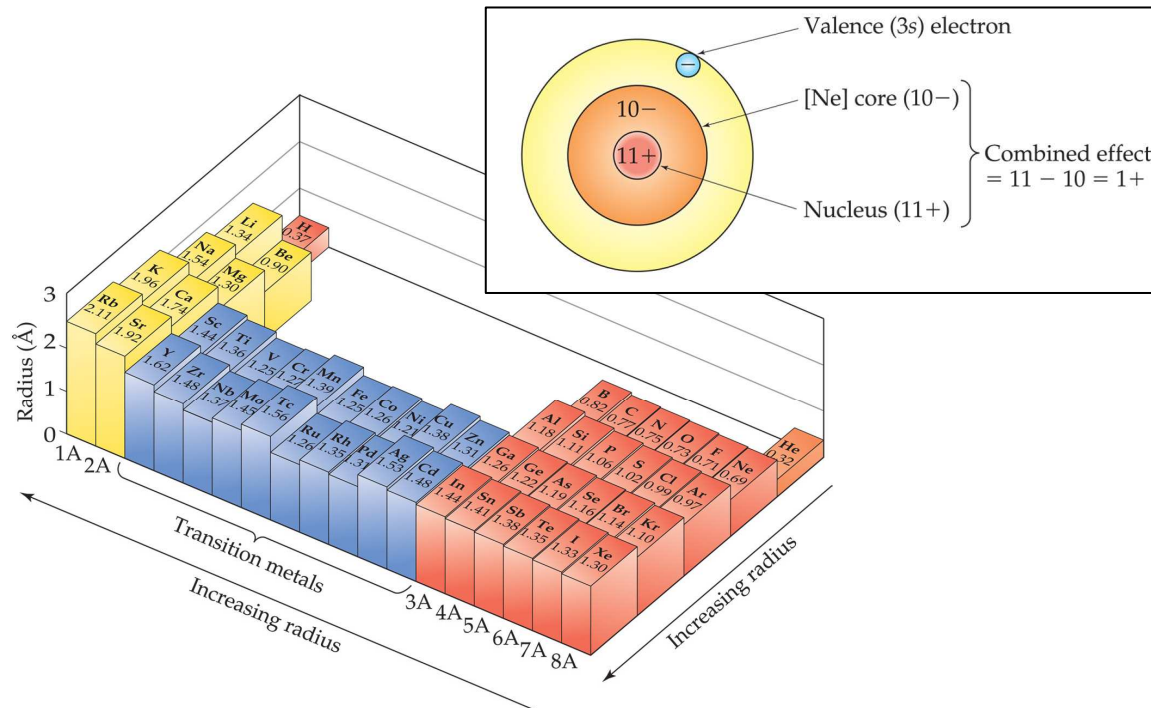


Energy required to remove an electron from an atom in the gas phase

1st ionization energy < 2nd ionization energy

What trend will ionization energy follow?

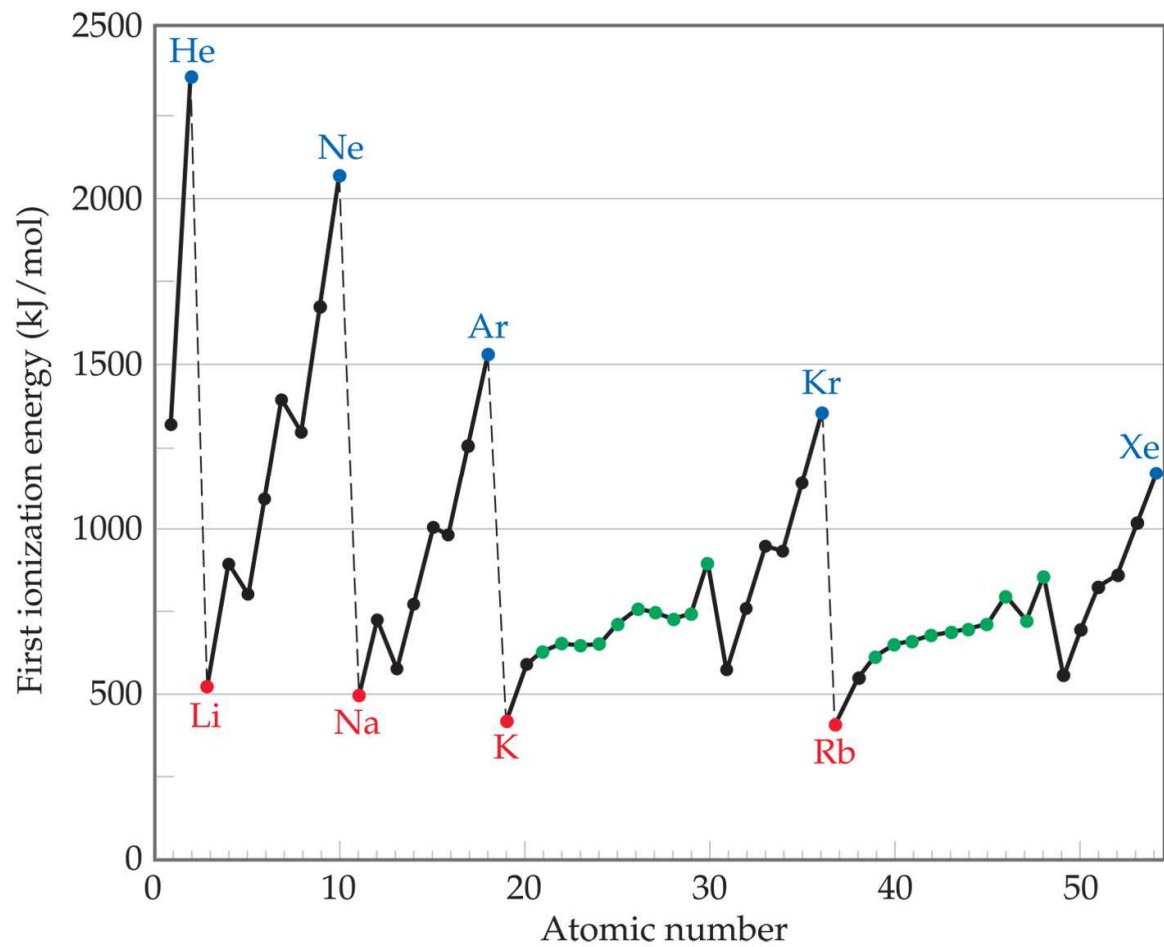
- A. Lower ionization energy with increasing atomic radius
- B. Lower ionization energy with larger cation radius
- C. Lower ionization energy with larger effective shielding
- D. All of the above**



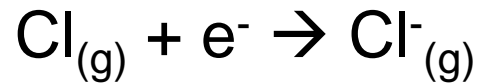
Group 1A		Group 2A		Group 3A	
Li ⁺	Li	Be ²⁺	Be	B ³⁺	B
0.68	1.34	0.31	0.90	0.23	0.82
Na ⁺	Na	Mg ²⁺	Mg	Al ³⁺	Al
0.97	1.54	0.66	1.30	0.51	1.18
K ⁺	K	Ca ²⁺	Ca	Ga ³⁺	Ga
1.33	1.96	0.99	1.74	0.62	1.26
Rb ⁺	Rb	Sr ²⁺	Sr	In ³⁺	In
1.47	2.11	1.13	1.92	0.81	1.44

Trend in Ionization Energy

1st ionization:



Electron Affinity



Measures the attraction or affinity of an atom for an electron

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
1A	2A	3A	4A	5A	6A	7A	8A

Generally electron affinity increases left to right
And decreases from the top down.

Fluorine has the highest electron affinity

Metals, Nonmetals, and Metalloids

- Metals tend to lose e^-

- Metals tend to be shiny, malleable, and ductile

- Metals are good conductors of heat and electricity

- Nonmetals tend to gain e^-

- Nonmetals usually are not shiny, and are brittle

- Nonmetals are poor conductors of heat and electricity



Au Bars

Metalloids have a mixture of all these traits



Silicon



C powder

Group Properties

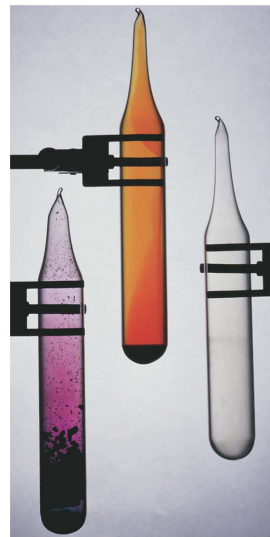
- Alkali and Alkali Earths easily ionize to form cations

- Alkali are very soft and light, Alkali Earth slightly harder and more dense



- Noble gases, because their orbitals are completely full, don't react with anything and exist as monoatomic gases

- Halogens exist as diatomic molecules
 $F_{2(g)}$, $Cl_{2(g)}$, $Br_{2(l)}$, $I_{2(s)}$



1A																		8A	
1																		18	
1	2											3A	4A	5A	6A	7A	2		
1	2											13	14	15	16	17	18		
3	4											5	6	7	8	9	10		
3	4	3B	4B	5B	6B	7B	8B			1B	2B	13	14	15	16	17	18		
3	4	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18		
4	5	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
4	5	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
5	6	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
5	6	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
6	7	55	56	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
6	7	Cs	Ba	Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
7		87	88	103	104	105	106	107	108	109	110	111	112	113	114	115	116		
7		Fr	Ra	Lr	Rf	Db	Sg	Bh	Hs	Mt									
		Metals																	
		Metalloids																	
		Nonmetals																	
		57	58	59	60	61	62	63	64	65	66	67	68	69	70				
		La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb				
		89	90	91	92	93	94	95	96	97	98	99	100	101	102				
		Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No				