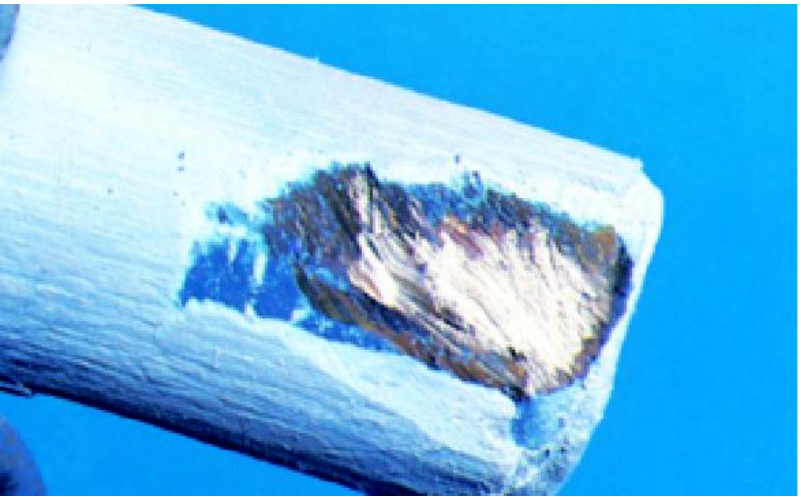
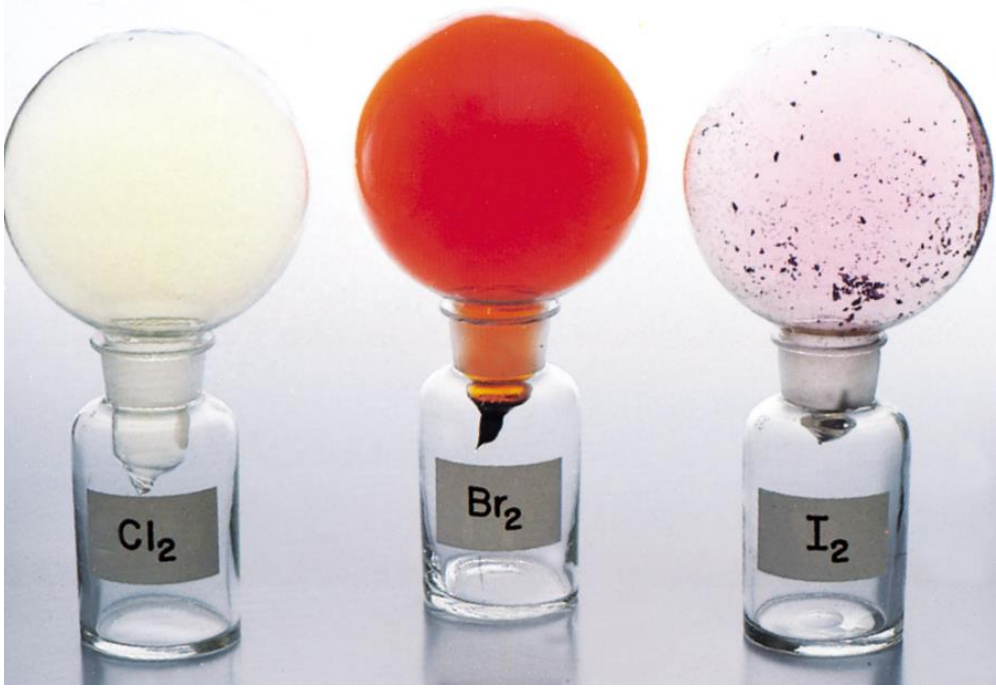
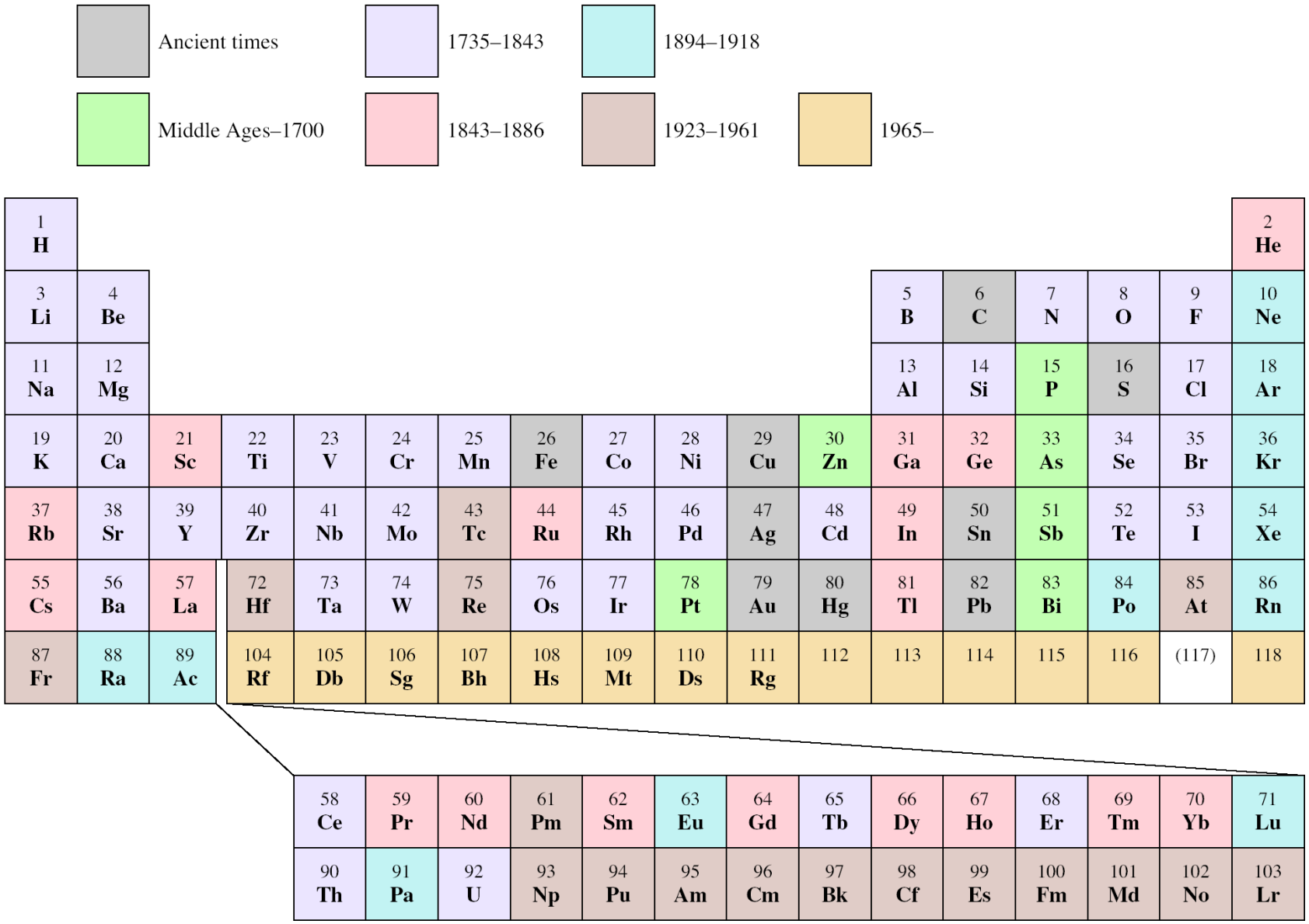


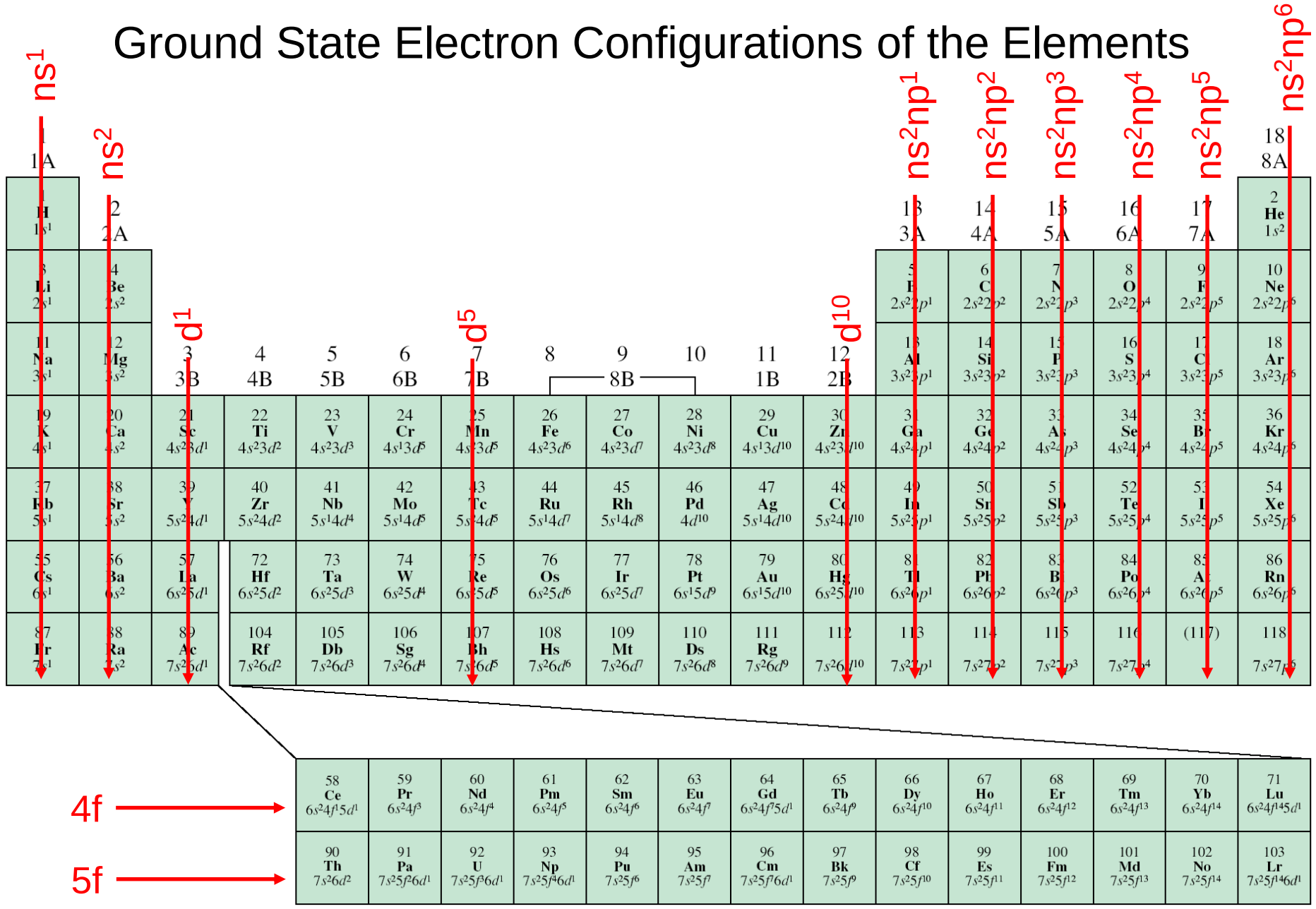


Periodic Relationships Among the Elements

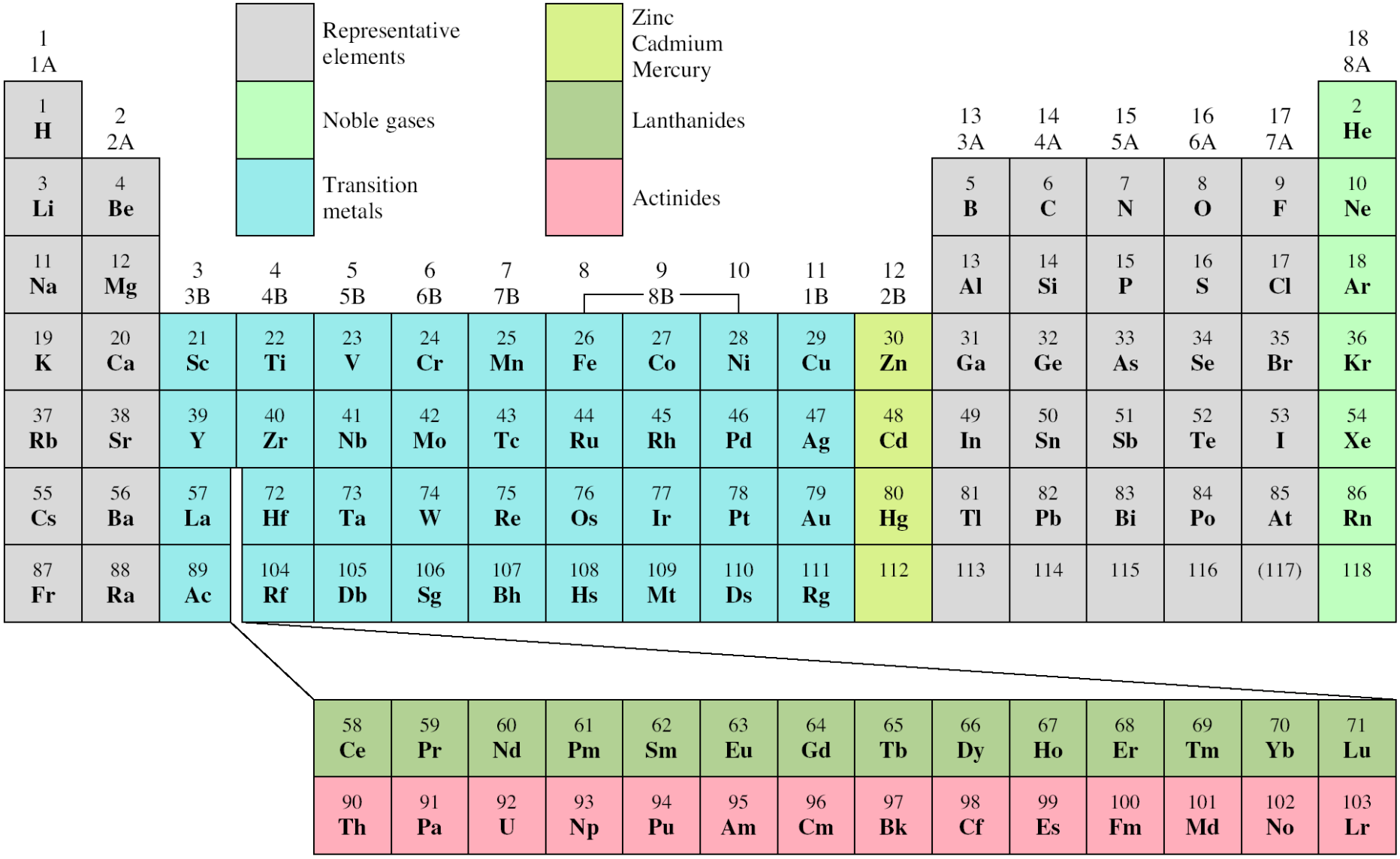
When the Elements Were Discovered



Ground State Electron Configurations of the Elements



Classification of the Elements



Electron Configurations of Cations and Anions Of Representative Elements

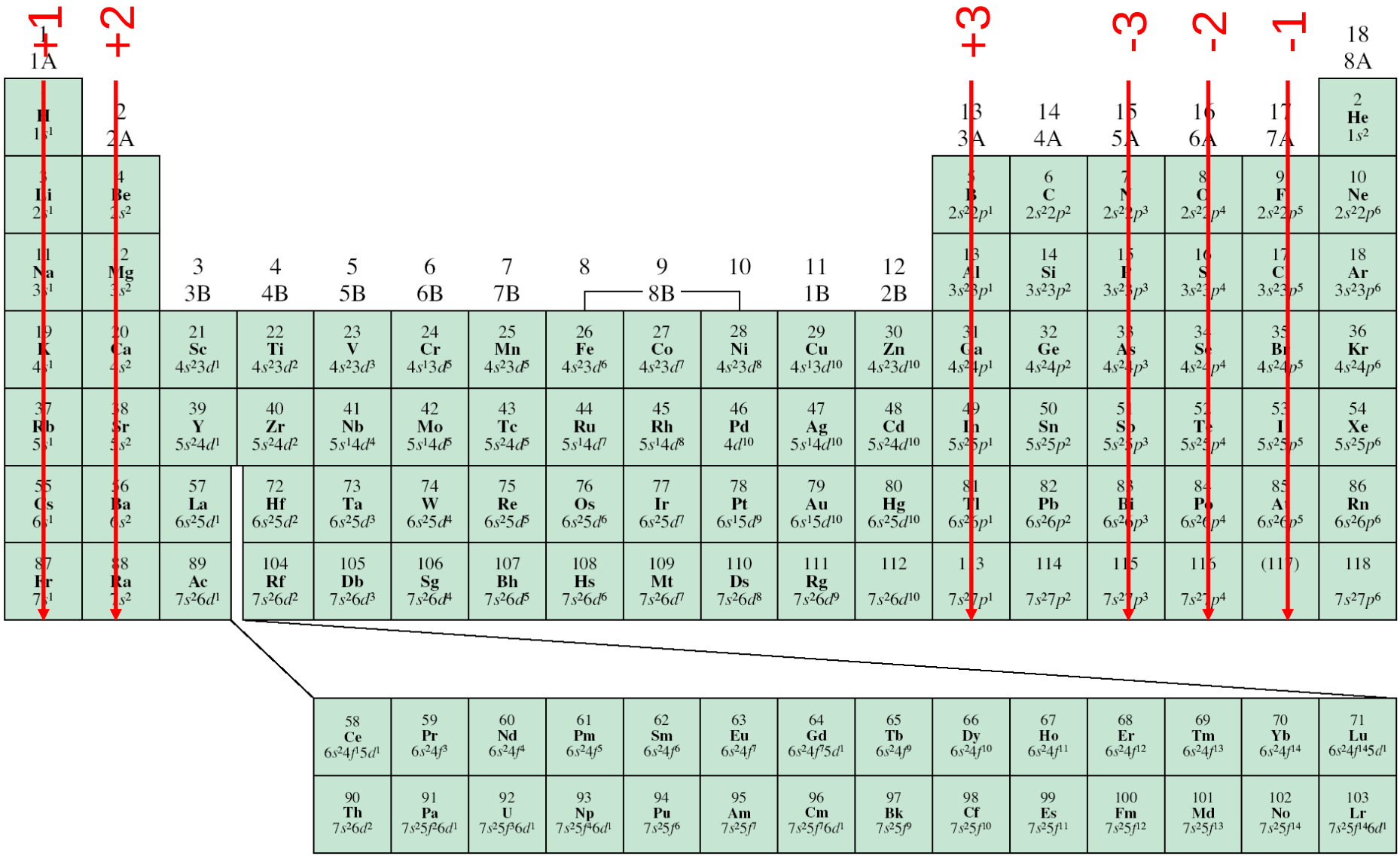
Na	$[Ne]3s^1$	Na^+	[Ne]
Ca	$[Ar]4s^2$	Ca^{2+}	[Ar]
Al	$[Ne]3s^23p^1$	Al^{3+}	[Ne]

Atoms lose electrons so that cation has a noble-gas outer electron configuration.

Atoms gain electrons so that anion has a noble-gas outer electron configuration.

H	$1s^1$	H^-	$1s^2$ or [He]
F	$1s^22s^22p^5$	F^-	$1s^22s^22p^6$ or [Ne]
O	$1s^22s^22p^4$	O^{2-}	$1s^22s^22p^6$ or [Ne]
N	$1s^22s^22p^3$	N^{3-}	$1s^22s^22p^6$ or [Ne]

Cations and Anions Of Representative Elements



Isoelectronic: have the same number of electrons, and hence the same ground-state electron configuration

Na^+: [Ne] Al^{3+}: [Ne] F^-: $1s^2 2s^2 2p^6$ or [Ne]

O^{2-}: $1s^2 2s^2 2p^6$ or [Ne] N^{3-}: $1s^2 2s^2 2p^6$ or [Ne]

Na^+, Al^{3+}, F^-, O^{2-}, and N^{3-} are all ***isoelectronic*** with Ne

What neutral atom is isoelectronic with H^- ?

H^-: $1s^2$ same electron configuration as He

Electron Configurations of Cations of Transition Metals

When a cation is formed from an atom of a transition metal, electrons are always removed first from the *ns* orbital and then from the (*n* – 1)*d* orbitals.

Fe: $[Ar]4s^2 3d^6$

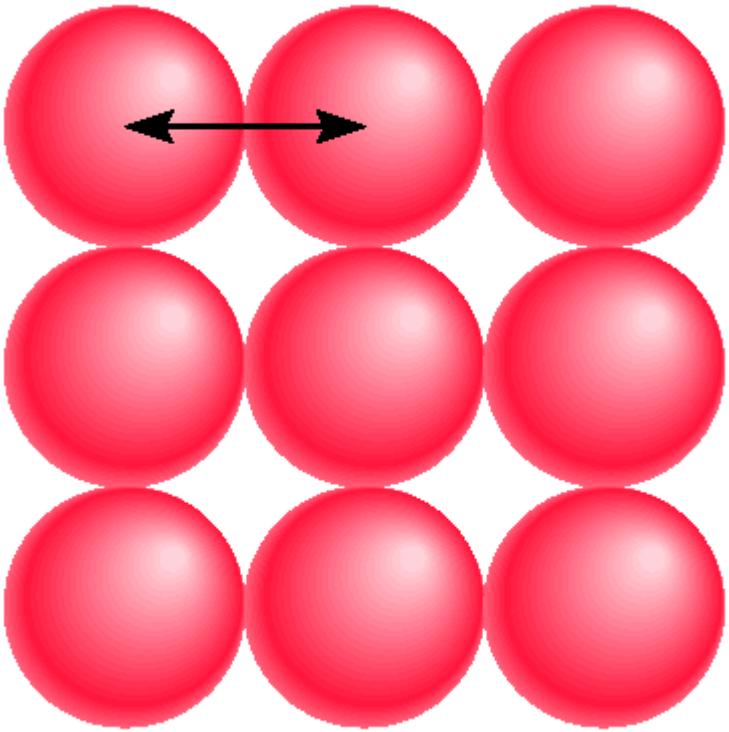
Fe^{2+}: $[Ar]4s^0 3d^6$ or $[Ar]3d^6$

Fe^{3+}: $[Ar]4s^0 3d^5$ or $[Ar]3d^5$

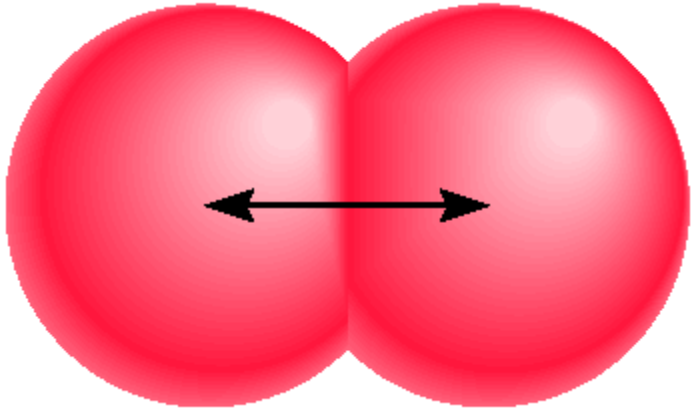
Mn: $[Ar]4s^2 3d^5$

Mn^{2+}: $[Ar]4s^0 3d^5$ or $[Ar]3d^5$

Atomic Radii



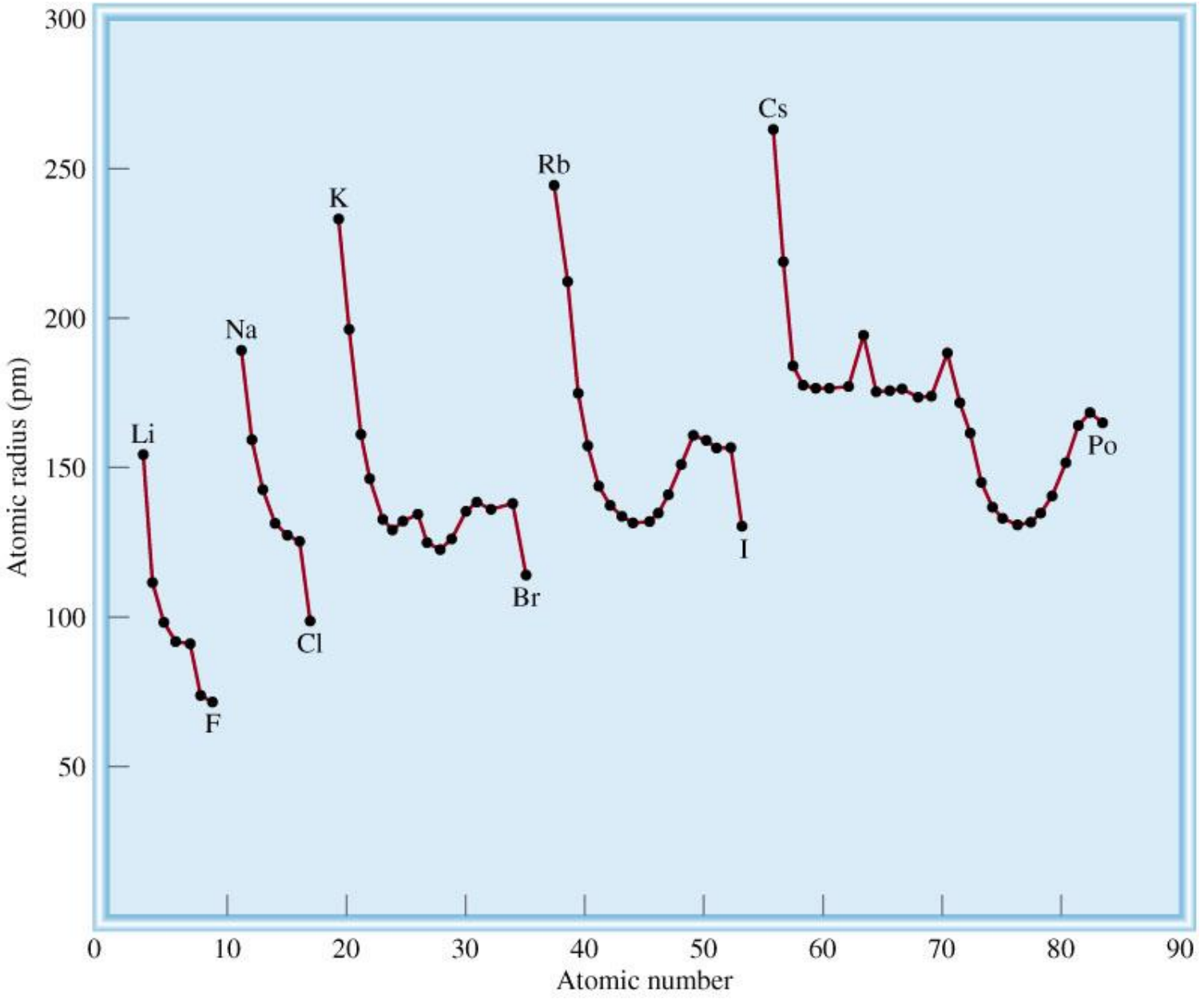
metallic radius



covalent radius


Increasing atomic radius
Increasing atomic radius
1A
2A
3A
4A
5A
6A
7A
8A
H
37
He
31
B
C
N
O
F
Ne
Li
Be
152
112
85
77
75
73
72
70
Na
Mg
Al
Si
P
S
Cl
Ar
186
160
143
118
110
103
99
98
K
Ca
Ga
Ge
As
Se
Br
Kr
227
197
135
123
120
117
114
112
Rb
Sr
In
Sn
Sb
Te
I
Xe
248
215
166
140
141
143
133
131
Cs
Ba
Tl
Pb
Bi
Po
At
Rn
265
222
171
175
155
164
142
140

Trends in Atomic Radii



Ionization energy is the minimum energy (kJ/mol) required to remove an electron from a gaseous atom in its ground state.

$I_1 + X_{(g)} \longrightarrow X^+_{(g)} + e^-$ I_1 first ionization energy

$I_2 + X^+_{(g)} \longrightarrow X^{2+}_{(g)} + e^-$ I_2 second ionization energy

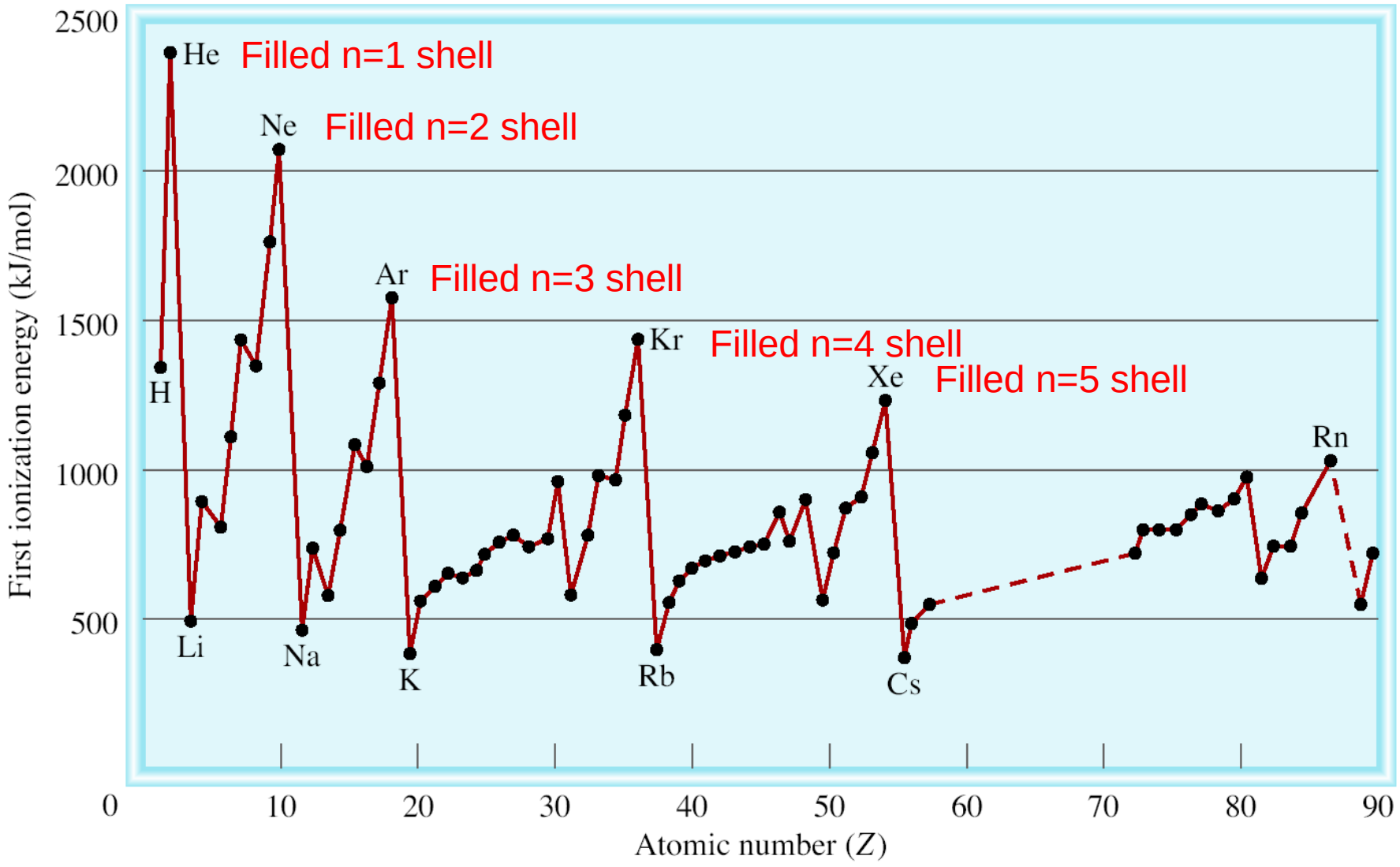
$I_3 + X^{2+}_{(g)} \longrightarrow X^{3+}_{(g)} + e^-$ I_3 third ionization energy

$$I_1 < I_2 < I_3$$

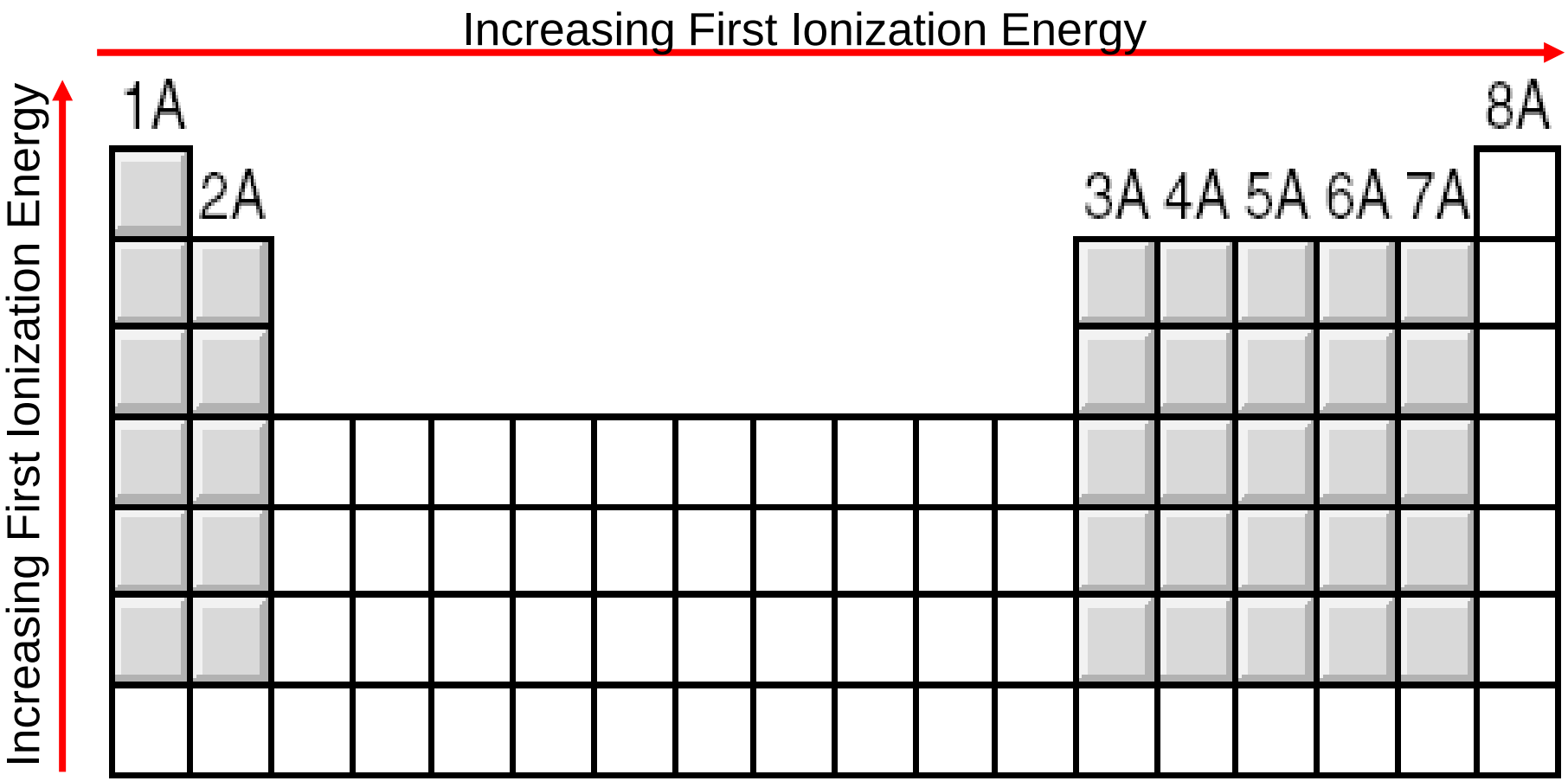
TABLE 8.2 The Ionization Energies (kJ/mol) of the First 20 Elements

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

Variation of the First Ionization Energy with Atomic Number



General Trends in First Ionization Energies



Electron affinity is the negative of the energy change that occurs when an electron is accepted by an atom in the gaseous state to form an anion.

$$X_{(g)} + e^- \longrightarrow X^-_{(g)}$$

$F_{(g)} + e^- \longrightarrow X^-_{(g)}$ $\Delta H = -328$ kJ/mol EA = +328 kJ/mol

$O_{(g)} + e^- \longrightarrow O^-_{(g)}$ $\Delta H = -141$ kJ/mol EA = +141 kJ/mol

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.

Variation of Electron Affinity With Atomic Number (H – Ba)