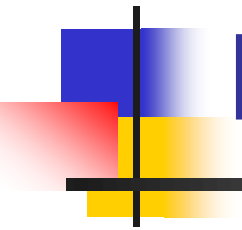
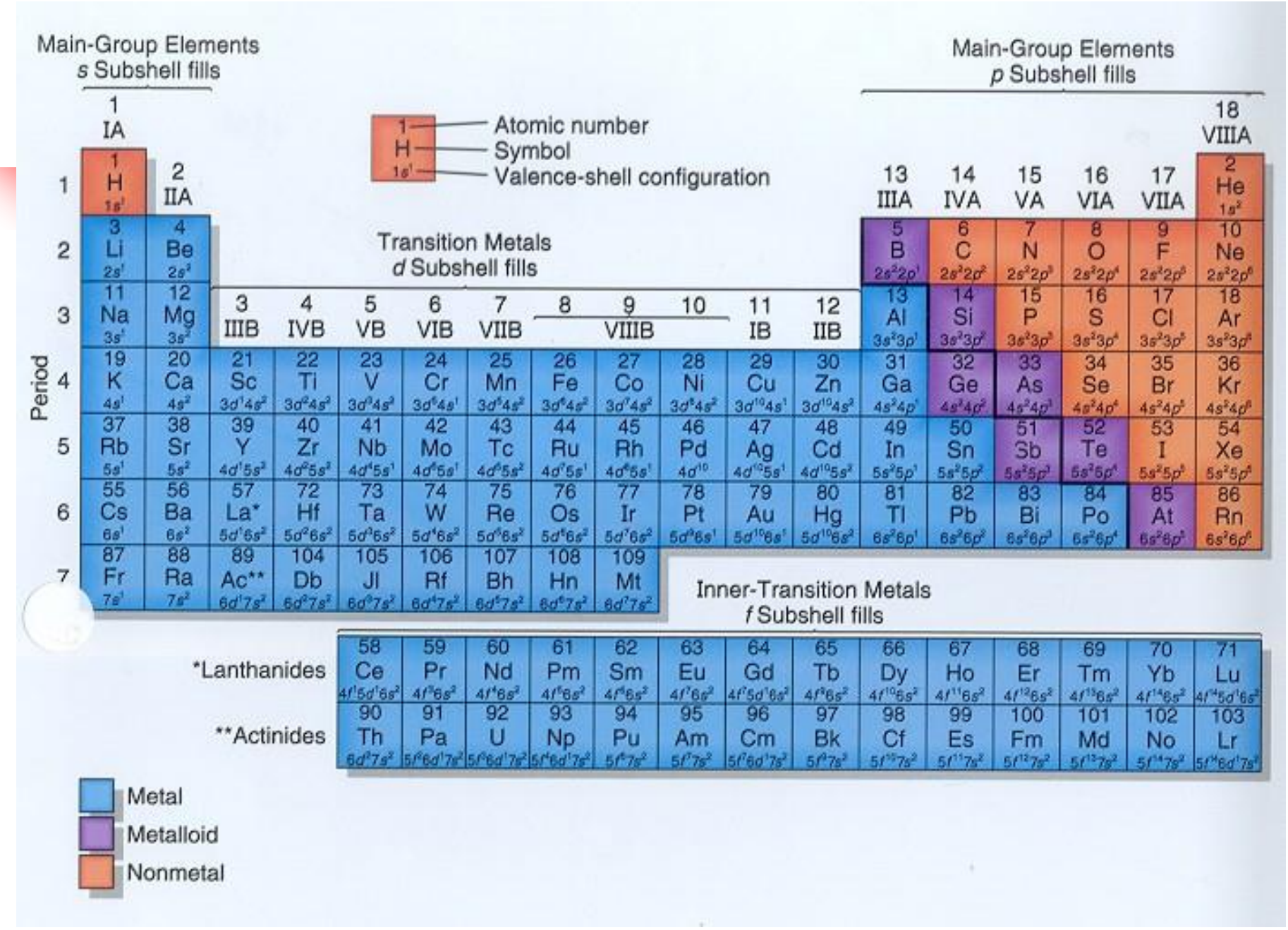
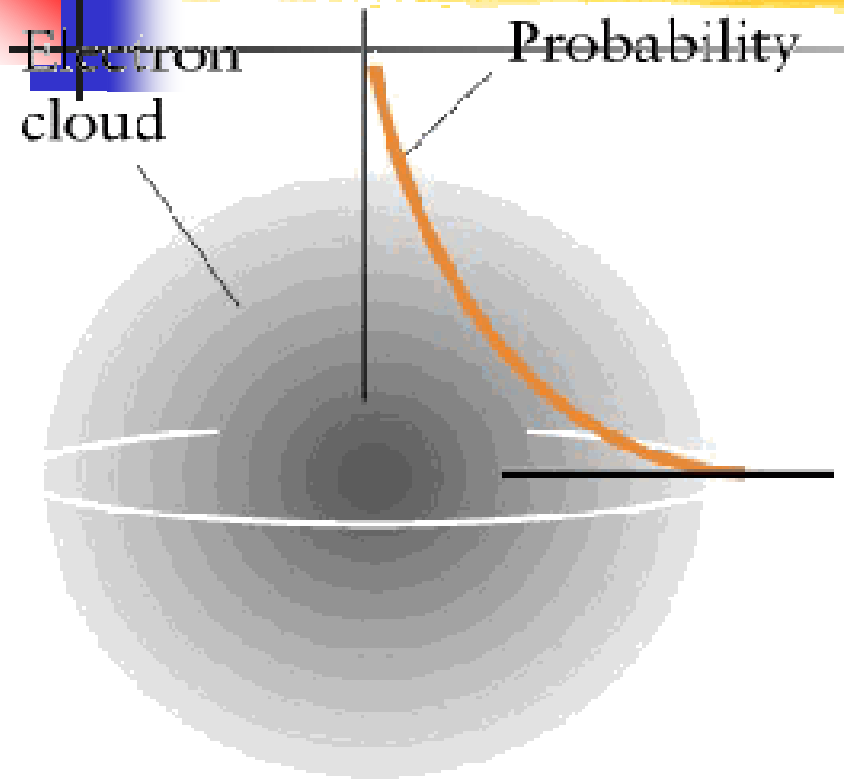


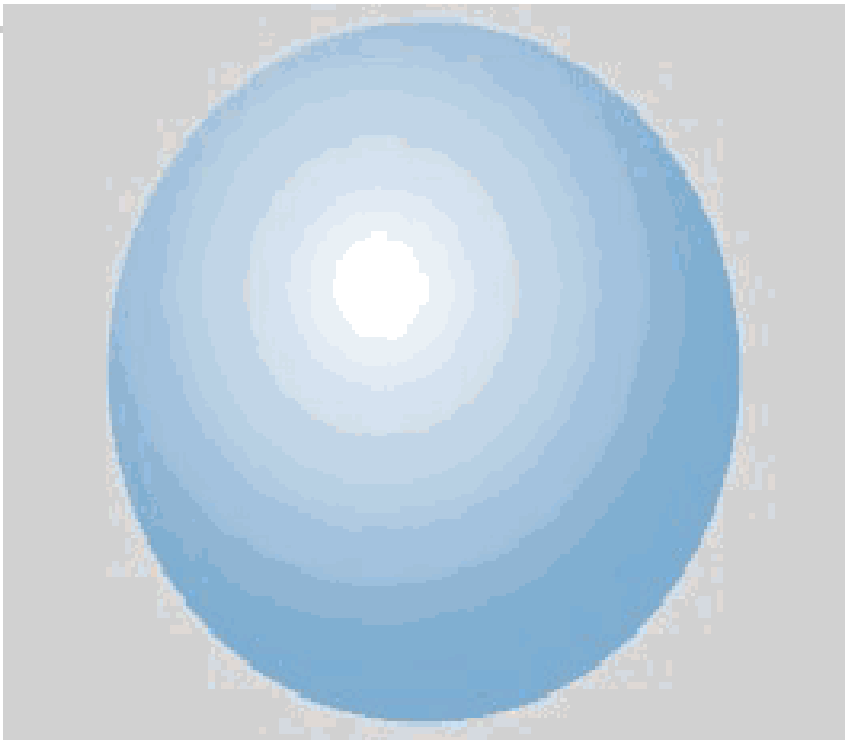
Periodický systém

Základní vlastnosti chemických prvků


Main-Group Elements
s Subshell fills
Main-Group Elements
p Subshell fills
1
IA
18
VIIIA
1
H
1s¹
2
IIA
Atomic number
Symbol
Valence-shell configuration
13
IIIA
14
IVA
15
VA
16
VIA
17
VIIA
2
He
1s²
Transition Metals
d Subshell fills
3
IIIB
4
IVB
5
VB
6
VIB
7
VIIB
8
9
10
VIIIB
11
IB
12
IIB
Period
1
2
3
4
5
6
7
3 Li 2s¹
4 Be 2s²
5 B 2s²2p¹
6 C 2s²2p²
7 N 2s²2p³
8 O 2s²2p⁴
9 F 2s²2p⁵
10 Ne 2s²2p⁶
11 Na 3s¹
12 Mg 3s²
13 Al 3s²3p¹
14 Si 3s²3p²
15 P 3s²3p³
16 S 3s²3p⁴
17 Cl 3s²3p⁵
18 Ar 3s²3p⁶
19 K 4s¹
20 Ca 4s²
21 Sc 3d¹4s²
22 Ti 3d²4s²
23 V 3d³4s²
24 Cr 3d⁵4s¹
25 Mn 3d⁵4s²
26 Fe 3d⁶4s²
27 Co 3d⁷4s²
28 Ni 3d⁸4s²
29 Cu 3d¹⁰4s¹
30 Zn 3d¹⁰4s²
31 Ga 4s²4p¹
32 Ge 4s²4p²
33 As 4s²4p³
34 Se 4s²4p⁴
35 Br 4s²4p⁵
36 Kr 4s²4p⁶
37 Rb 5s¹
38 Sr 5s²
39 Y 4d¹5s²
40 Zr 4d²5s²
41 Nb 4d⁴5s¹
42 Mo 4d⁵5s¹
43 Tc 4d⁵5s²
44 Ru 4d⁷5s¹
45 Rh 4d⁸5s¹
46 Pd 4d¹⁰
47 Ag 4d¹⁰5s¹
48 Cd 4d¹⁰5s²
49 In 5s²5p¹
50 Sn 5s²5p²
51 Sb 5s²5p³
52 Te 5s²5p⁴
53 I 5s²5p⁵
54 Xe 5s²5p⁶
55 Cs 6s¹
56 Ba 6s²
57 La* 5d¹6s²
72 Hf 5d²6s²
73 Ta 5d³6s²
74 W 5d⁴6s²
75 Re 5d⁵6s²
76 Os 5d⁶6s²
77 Ir 5d⁷6s²
78 Pt 5d⁹6s¹
79 Au 5d¹⁰6s¹
80 Hg 5d¹⁰6s²
81 Tl 6s²6p¹
82 Pb 6s²6p²
83 Bi 6s²6p³
84 Po 6s²6p⁴
85 At 6s²6p⁵
86 Rn 6s²6p⁶
87 Fr 7s¹
88 Ra 7s²
89 Ac** 6d¹7s²
104 Db 5d²7s²
105 Jl 6d³7s²
106 Rf 6d⁴7s²
107 Bh 6d⁵7s²
108 Hn 6d⁶7s²
109 Mt 6d⁷7s²
Inner-Transition Metals
f Subshell fills
*Lanthanides
58 Ce 4f¹5d¹6s²
59 Pr 4f³6s²
60 Nd 4f⁴6s²
61 Pm 4f⁵6s²
62 Sm 4f⁶6s²
63 Eu 4f⁷6s²
64 Gd 4f⁷5d¹6s²
65 Tb 4f⁹6s²
66 Dy 4f¹⁰6s²
67 Ho 4f¹¹6s²
68 Er 4f¹²6s²
69 Tm 4f¹³6s²
70 Yb 4f¹⁴6s²
71 Lu 4f¹⁴5d¹6s²
**Actinides
90 Th 6d²7s²
91 Pa 5f²6d¹7s²
92 U 5f³6d¹7s²
93 Np 5f⁴6d¹7s²
94 Pu 5f⁶7s²
95 Am 5f⁷7s²
96 Cm 5f⁷6d¹7s²
97 Bk 5f⁹7s²
98 Cf 5f¹⁰7s²
99 Es 5f¹¹7s²
100 Fm 5f¹²7s²
101 Md 5f¹³7s²
102 No 5f¹⁴7s²
103 Lr 5f¹⁴6d¹7s²
Metal
Metalloid
Nonmetal

s orbital

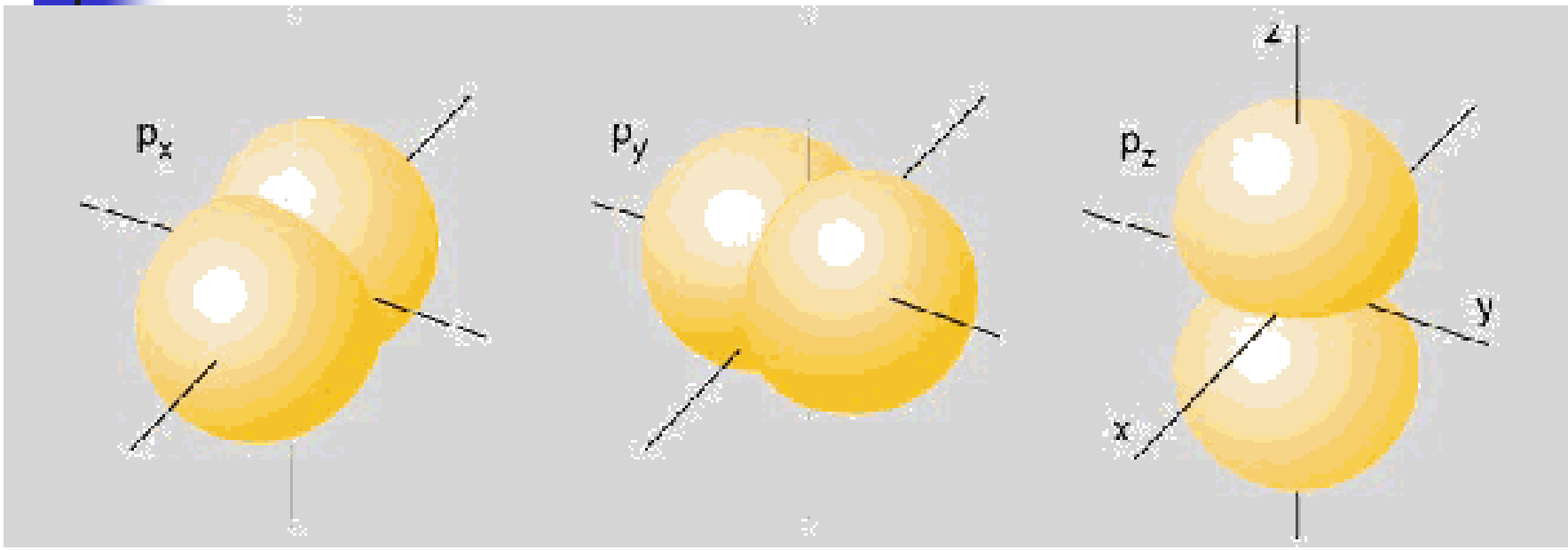




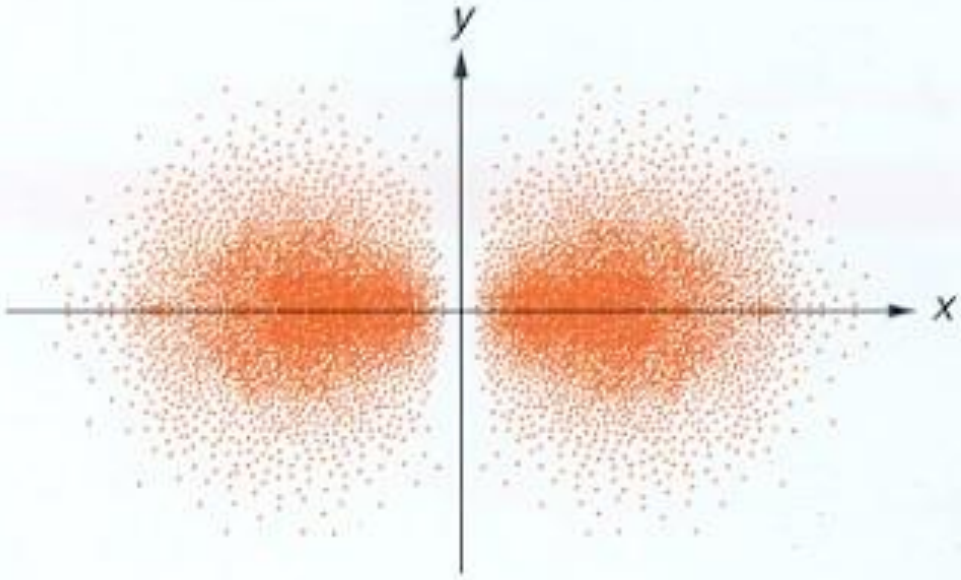
BOUNDARY SURFACE of s-orbital

- Spherical cloud
- Cloud becomes less dense as distance from nucleus increases
- Size of atoms very small - electron never found more than 100 pm away from nucleus
- Higher the energy of the s-orbital, bigger the diameter of the boundary surface

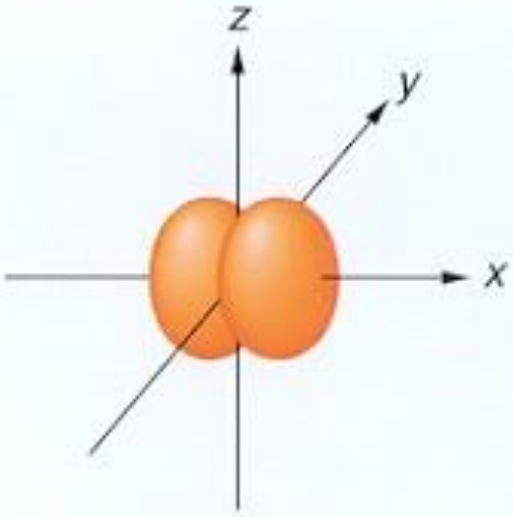
p orbitals



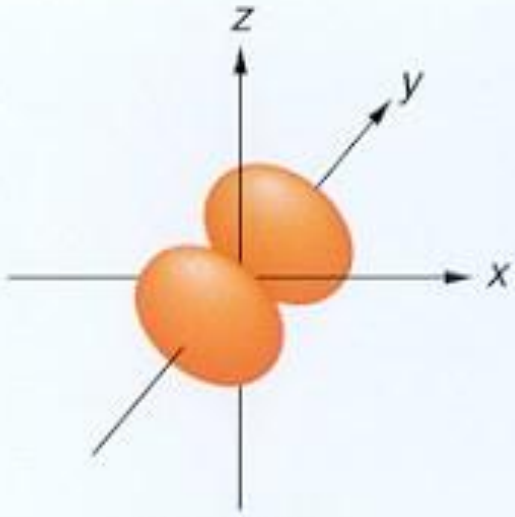
- Three p-orbitals for a given energy
- Cloud with two lobes on opposite sides of the nucleus
- Two lobes separated by a planar region - nodal plane
- Nodal plane cuts through the nucleus
- p-electron never found on nodal plane - therefore it is never found at the nucleus
- p-orbitals lie along three perpendicular axes



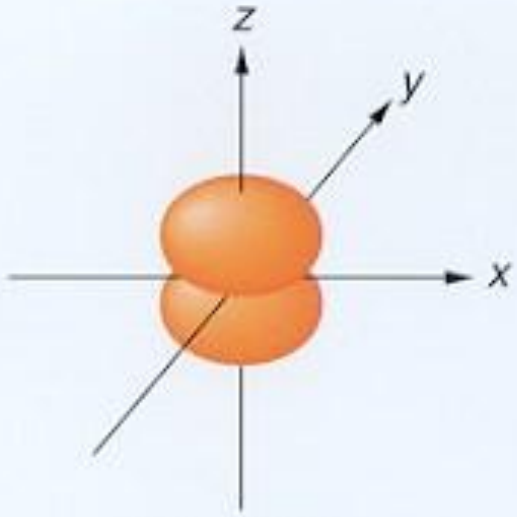
A



$2p_x$ orbital



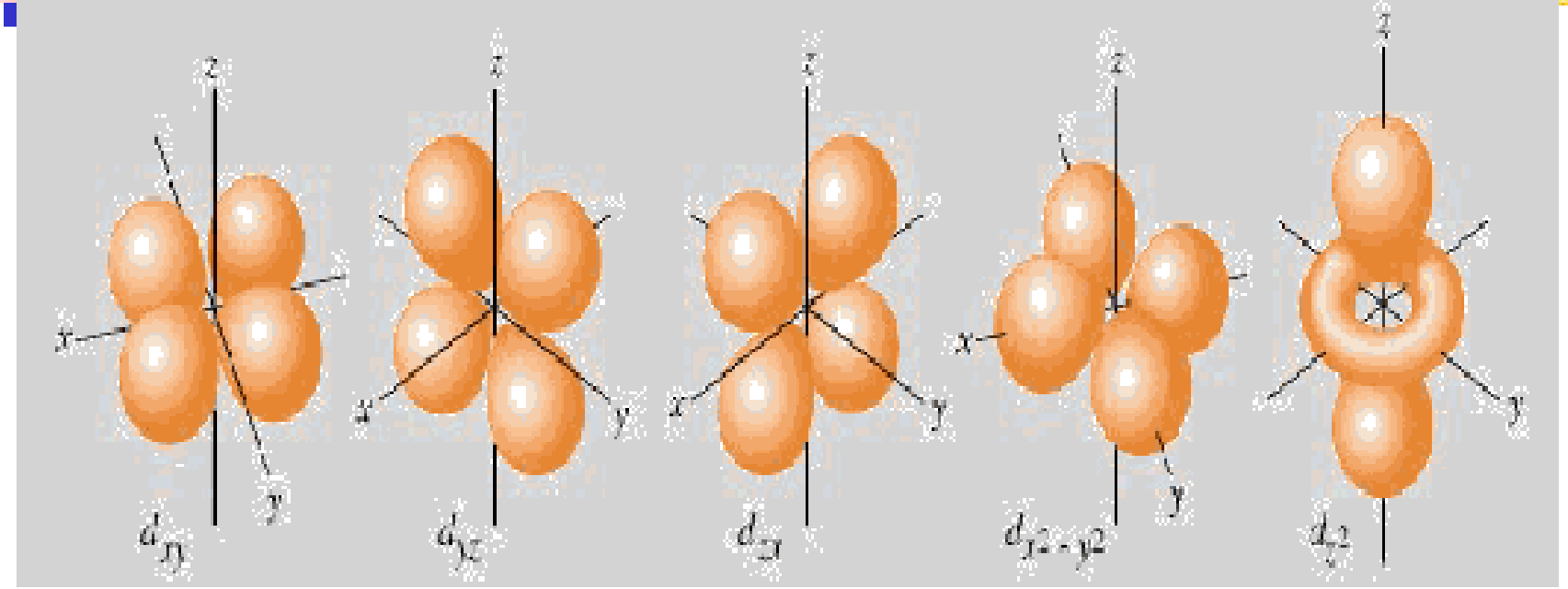
$2p_y$ orbital



$2p_z$ orbital

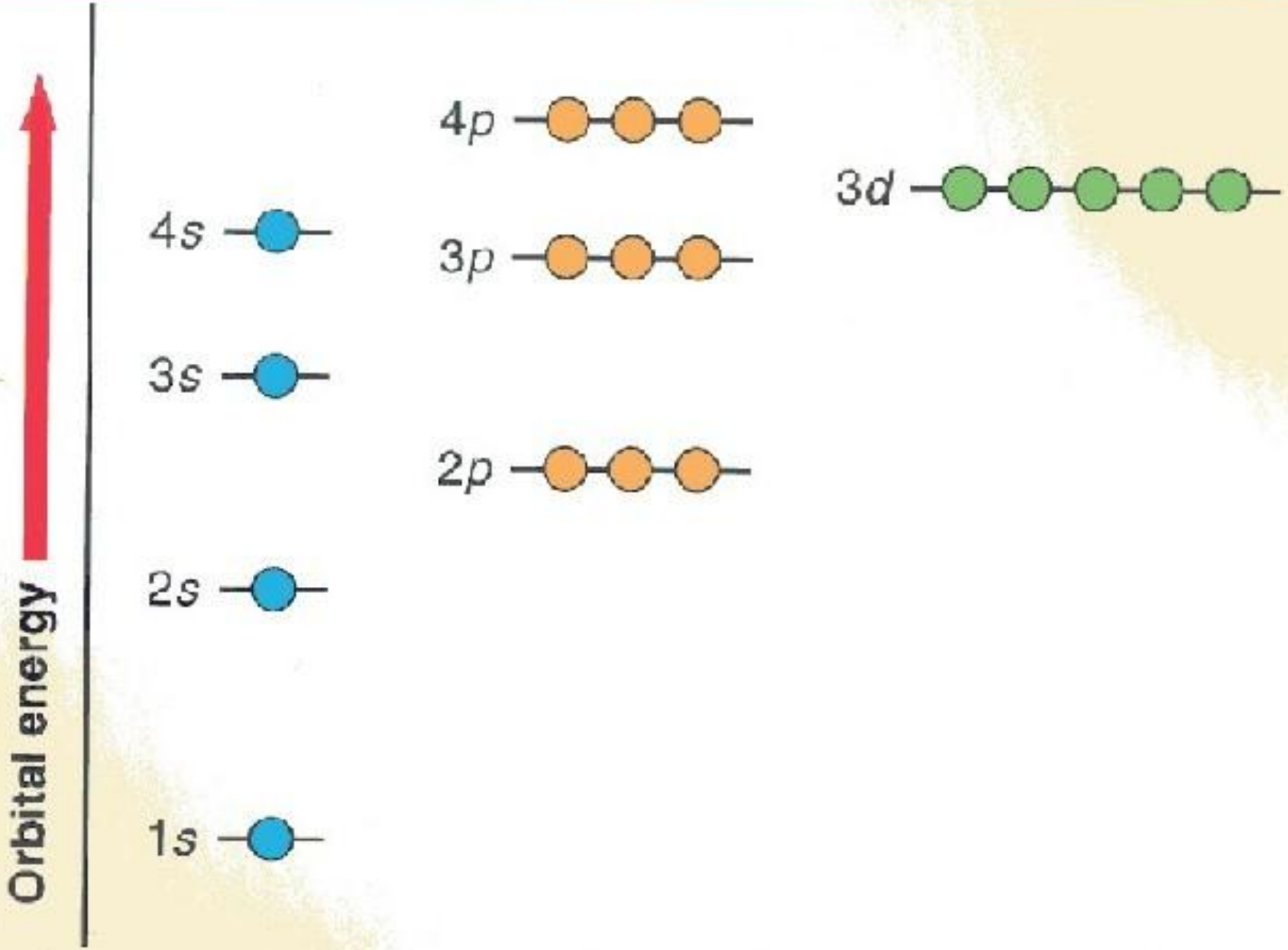
B

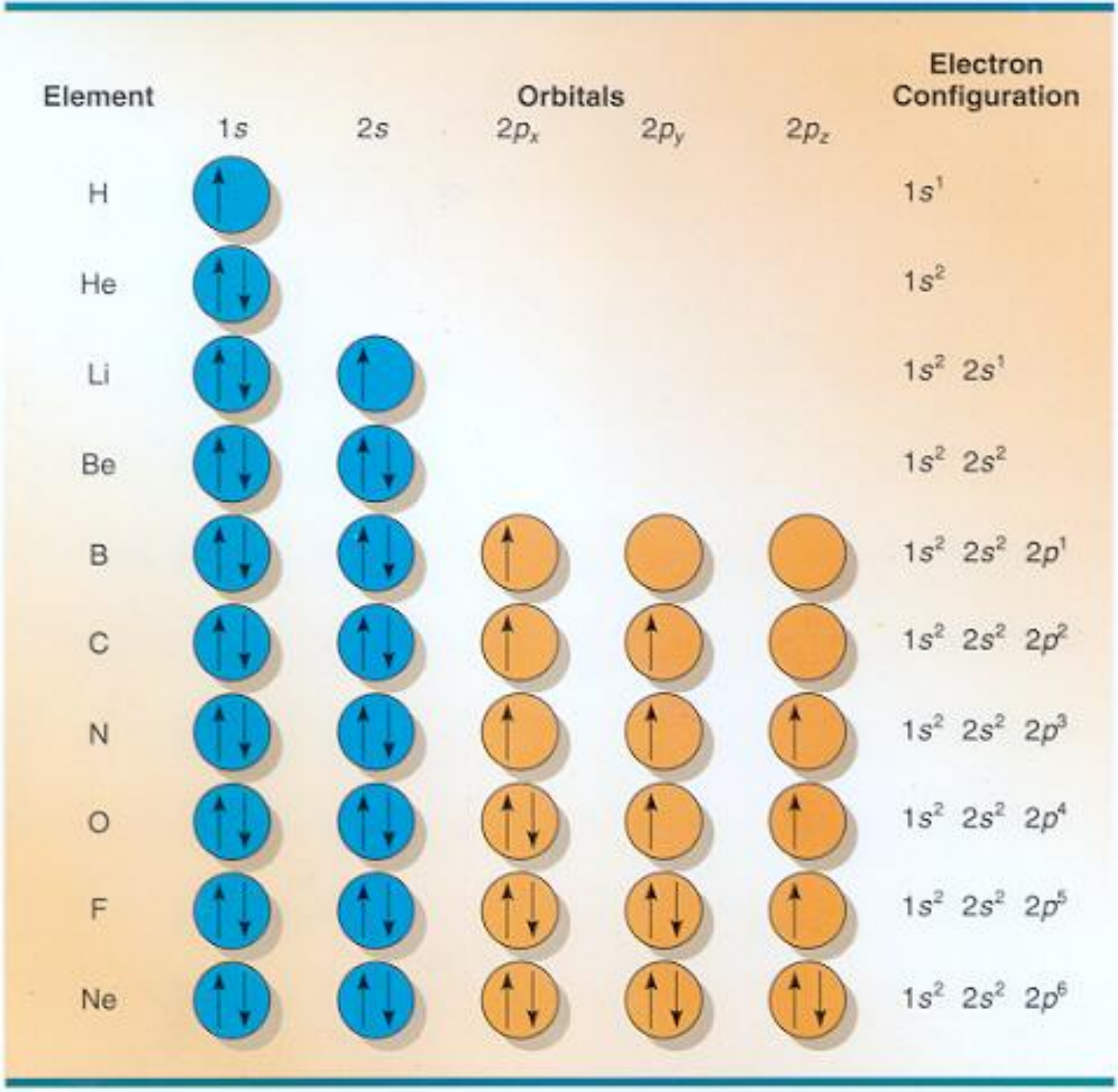
d orbitals

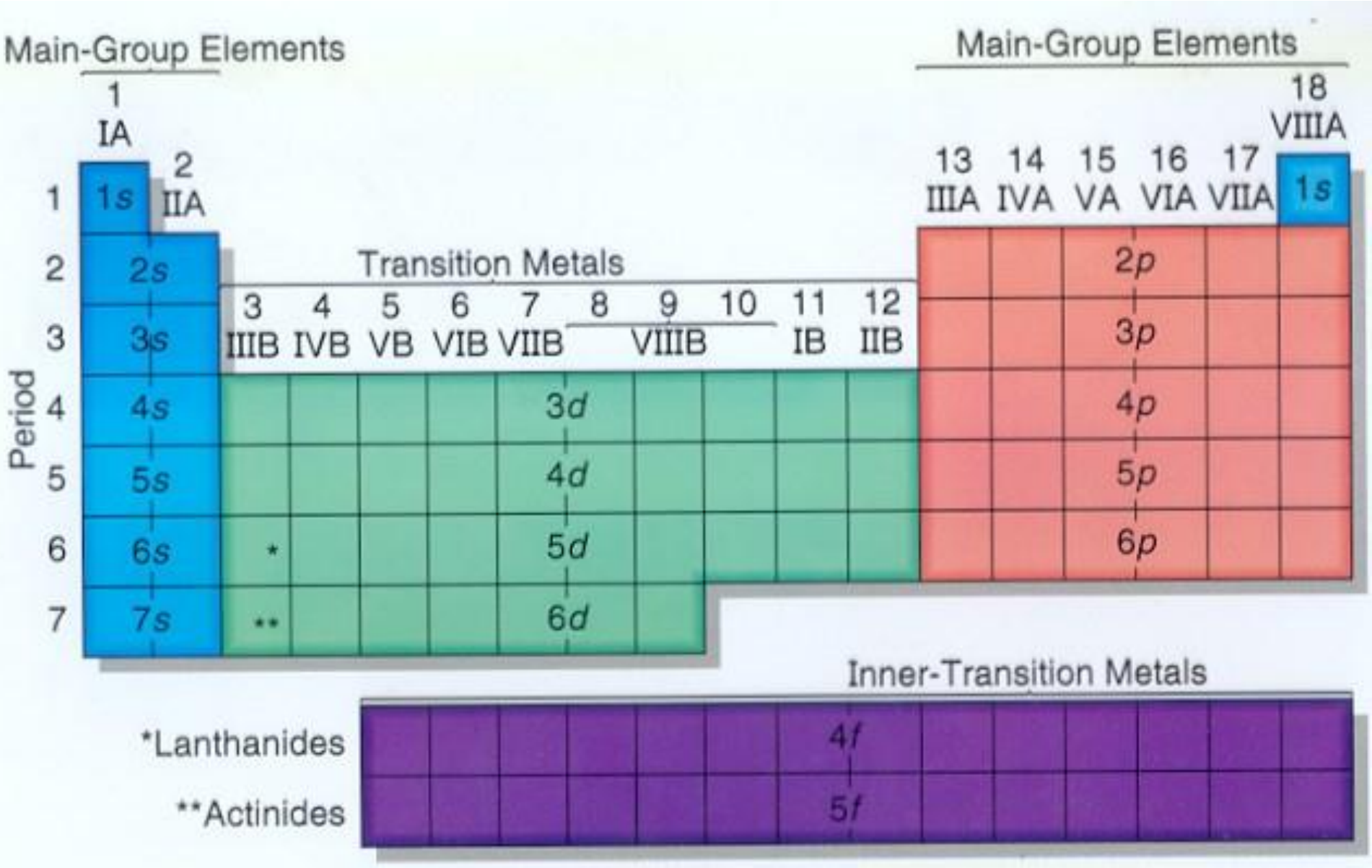


- More complicated than s or p orbital
- Five possible orientations for d orbitals
- Four of them have four lobes, fifth is different
- d-orbital electron will not be found at the nucleus

f orbital - does not explain chemical properties


Orbital energy
4p
3d
4s
3p
3s
2p
2s
1s


Element
Orbitals
1s
2s
2p_x
2p_y
2p_z
Electron Configuration
H
1s^1
He
1s^2
Li
1s^2 2s^1
Be
1s^2 2s^2
B
1s^2 2s^2 2p^1
C
1s^2 2s^2 2p^2
N
1s^2 2s^2 2p^3
O
1s^2 2s^2 2p^4
F
1s^2 2s^2 2p^5
Ne
1s^2 2s^2 2p^6


Main-Group Elements
1
IA
2
IIA
Main-Group Elements
18
VIIIA
13 14 15 16 17
IIIA IVA VA VIA VIIA
Transition Metals
3 4 5 6 7 8 9 10 11 12
IIIB IVB VB VIB VIIB VIIIB IB IIB
Period
1
2
3
4
5
6
7
1s
2s
3s
4s
5s
6s
7s
2p
3p
4p
5p
6p
3d
4d
5d
6d
*
**
Inner-Transition Metals
*Lanthanides
**Actinides
4f
5f

VFI Atomic Radii

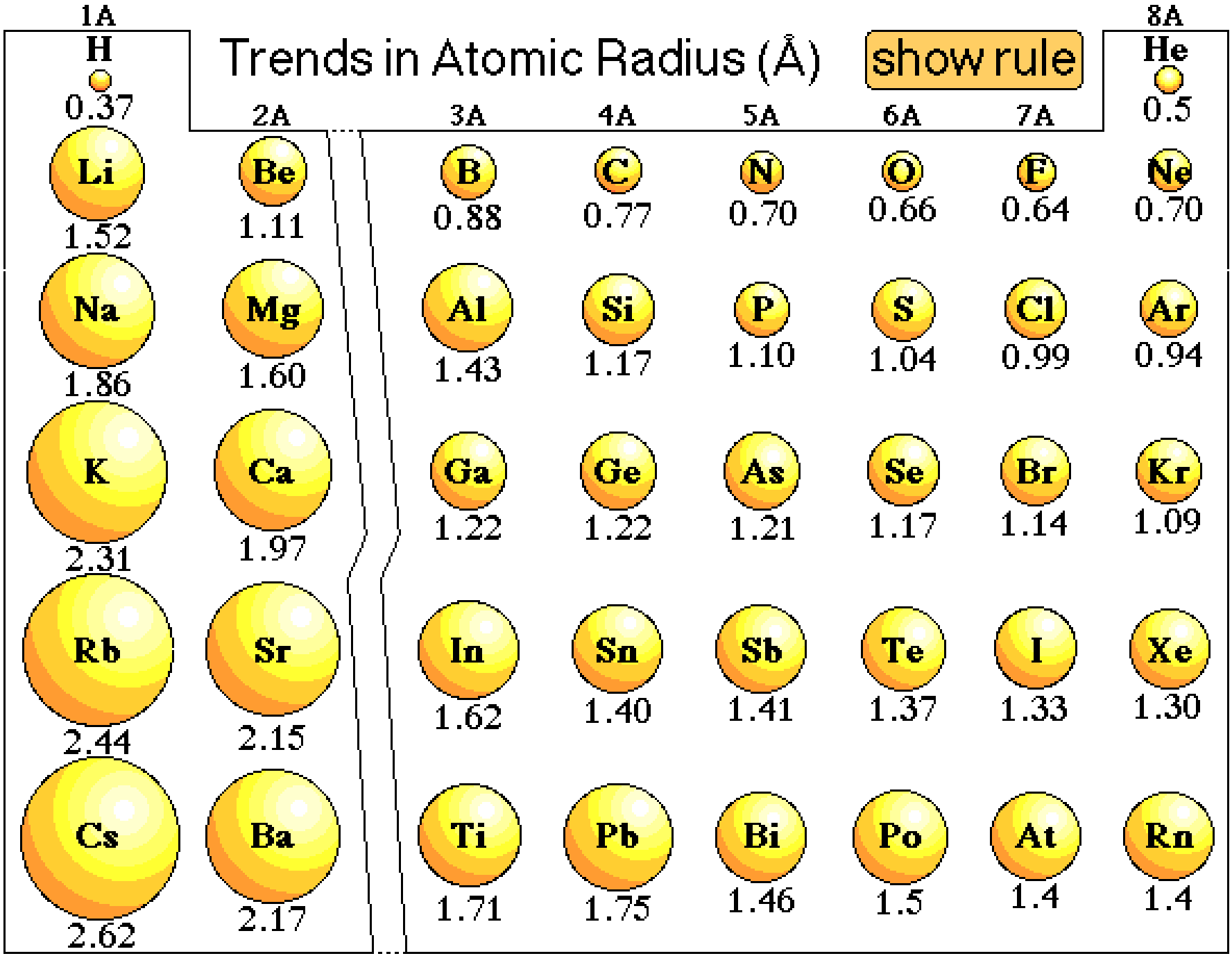
Image generated by CrystalMaker 6.3: interactive crystal & molecular structures visualization for Mac OS X

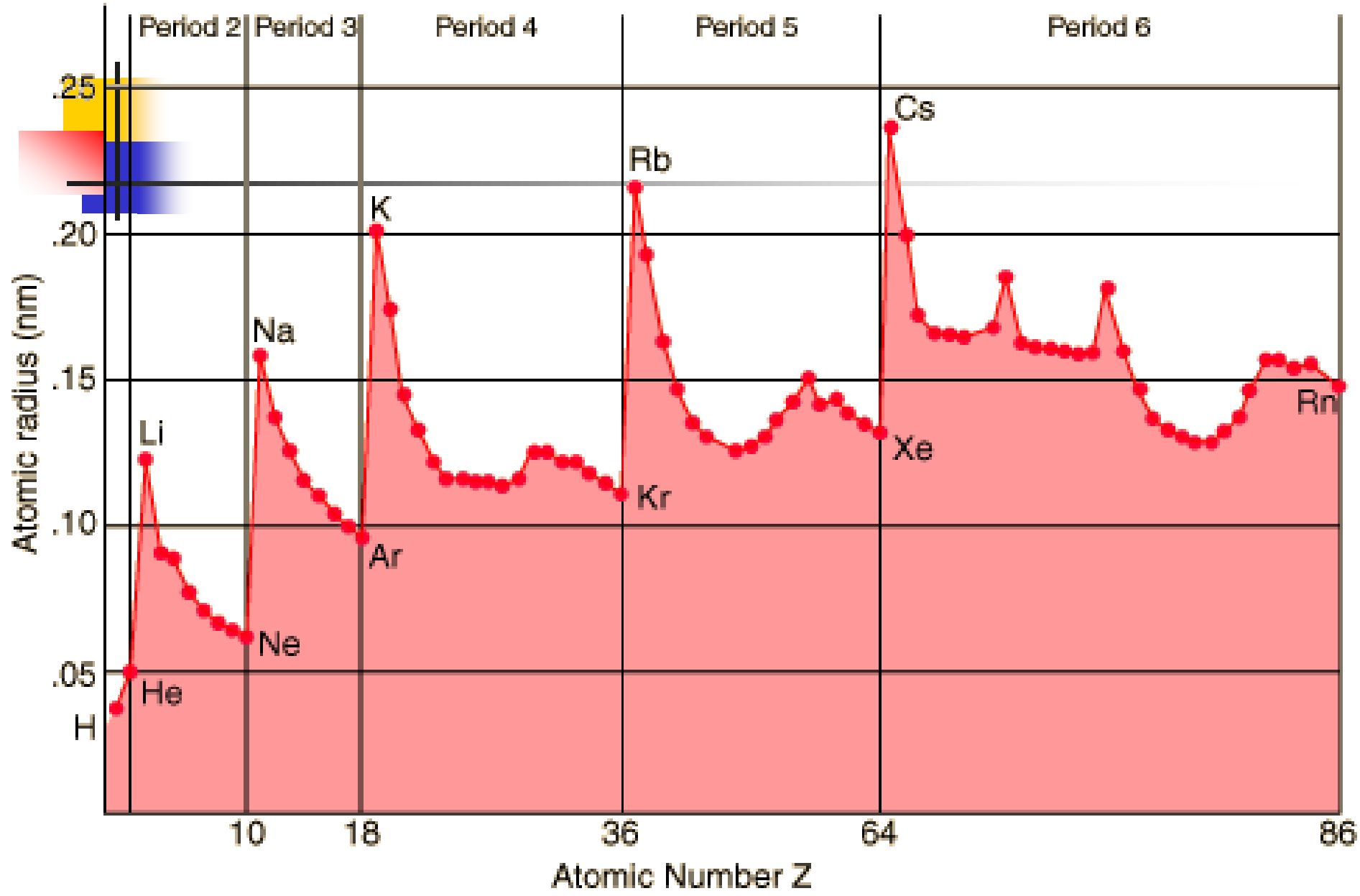
These data are based on interatomic distances in the structures of the elements. (Radii for metals correspond to coordination numbers of 12.) Where no radius value can be found for a particular element, its radius has been set to a default value of 1 Å and a circle is plotted instead of a rendered sphere. Data from Vainshtein et al., 1995; values for O, F, S, Cl, Br, I, At, Po, Pm, Rn have been taken from Clementi et al.1963.

References: Vainshtein BK, Fridkin VM, Indenbom VL (1995) Structure of Crystals, 3rd Edition. Springer Verlag, Berlin.

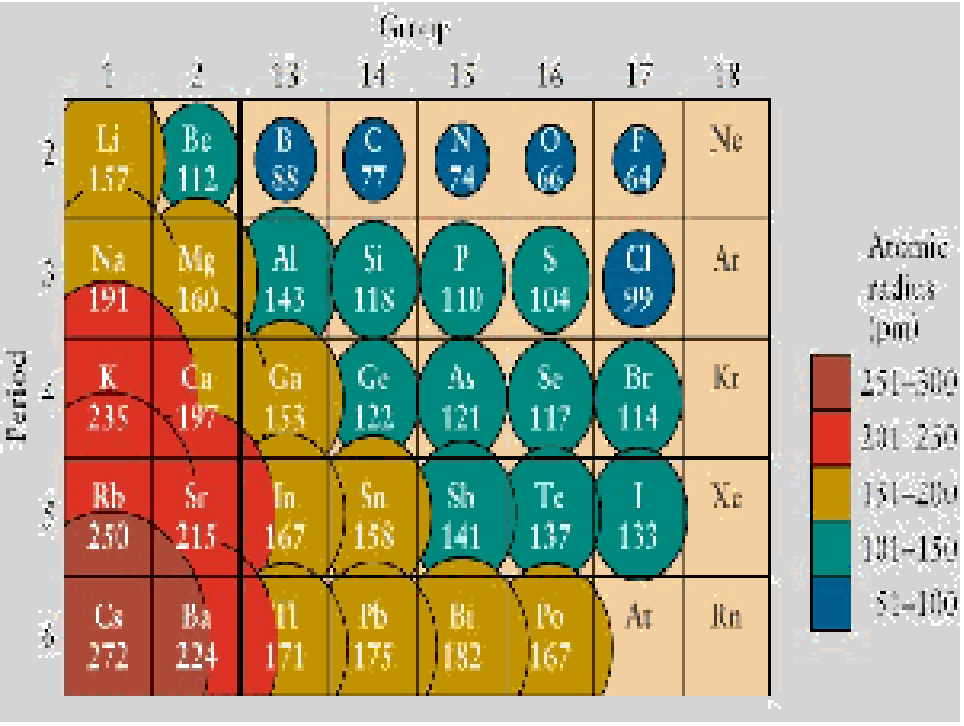
Clementi E, Raimondi DL, Reinhardt WP (1963) Journal of Chemical Physics 38:2686-

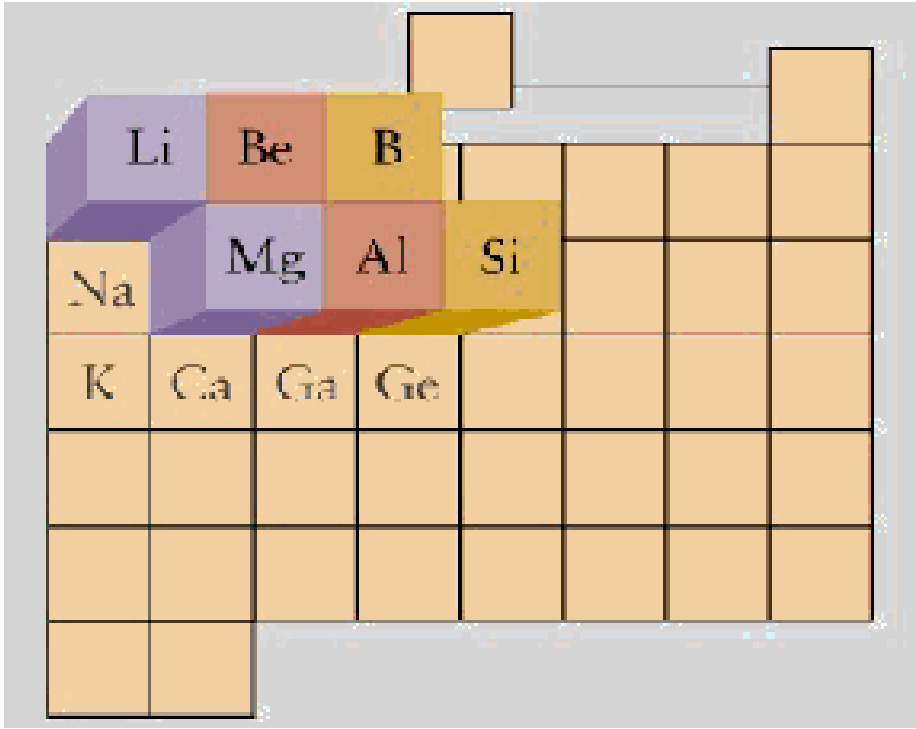
CrystalMaker SOFTWARE


Trends in Atomic Radius (Å)
show rule
1A
2A
3A
4A
5A
6A
7A
8A
H 0.37
He 0.5
Li 1.52
Be 1.11
B 0.88
C 0.77
N 0.70
O 0.66
F 0.64
Ne 0.70
Na 1.86
Mg 1.60
Al 1.43
Si 1.17
P 1.10
S 1.04
Cl 0.99
Ar 0.94
K 2.31
Ca 1.97
Ga 1.22
Ge 1.22
As 1.21
Se 1.17
Br 1.14
Kr 1.09
Rb 2.44
Sr 2.15
In 1.62
Sn 1.40
Sb 1.41
Te 1.37
I 1.33
Xe 1.30
Cs 2.62
Ba 2.17
Ti 1.71
Pb 1.75
Bi 1.46
Po 1.5
At 1.4
Rn 1.4

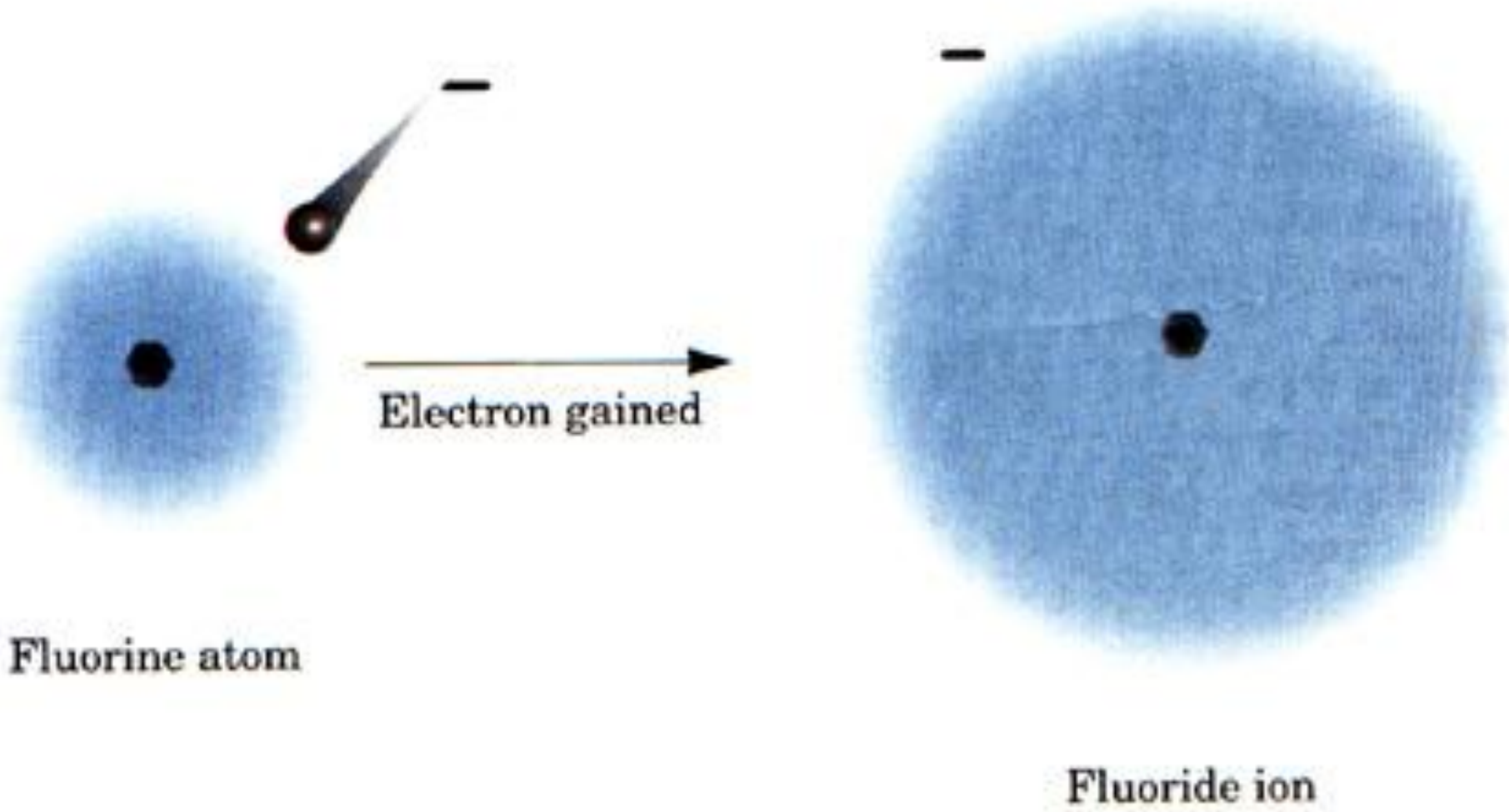

Period 2
Period 3
Period 4
Period 5
Period 6
.25
.20
.15
.10
.05
Atomic radius (nm)
H
He
Li
Ne
Na
Ar
K
Kr
Rb
Xe
Cs
Rn
10
18
36
64
86
Atomic Number Z

Diagonal Relationships



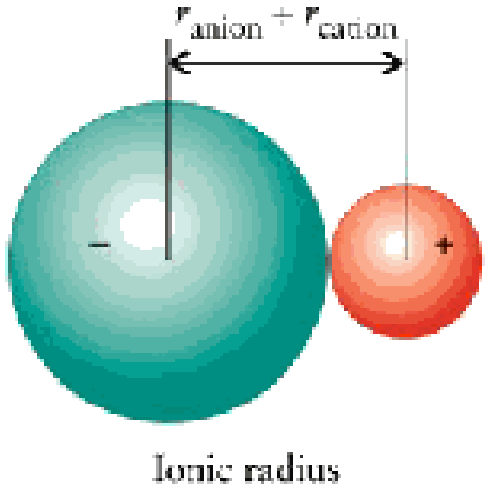


Diagonally related pairs of elements show similar chemical properties


Electron gained
Fluorine atom
Fluoride ion

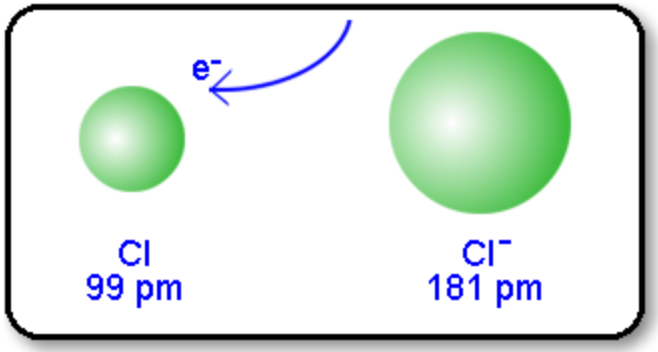
Ionic radius

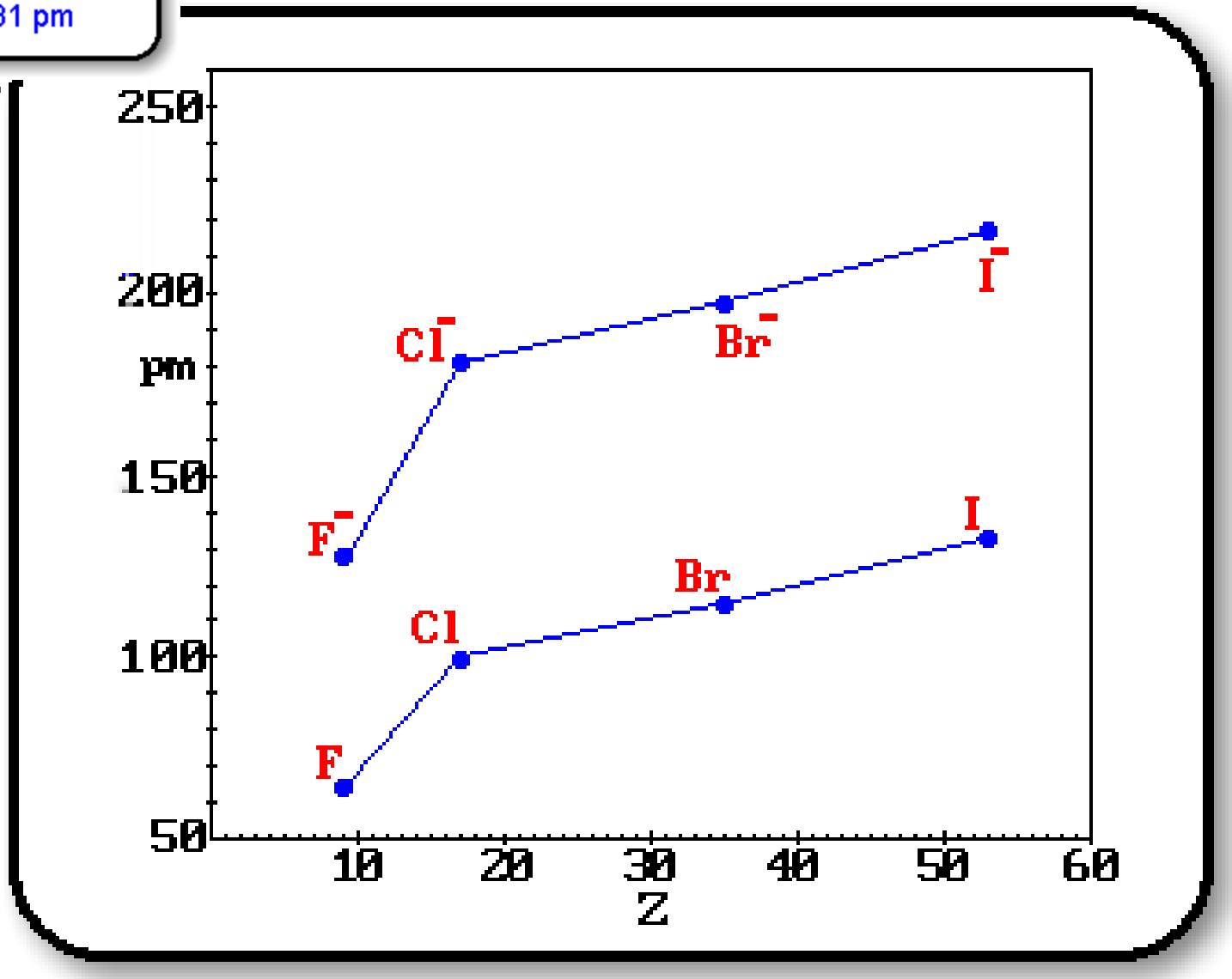
16

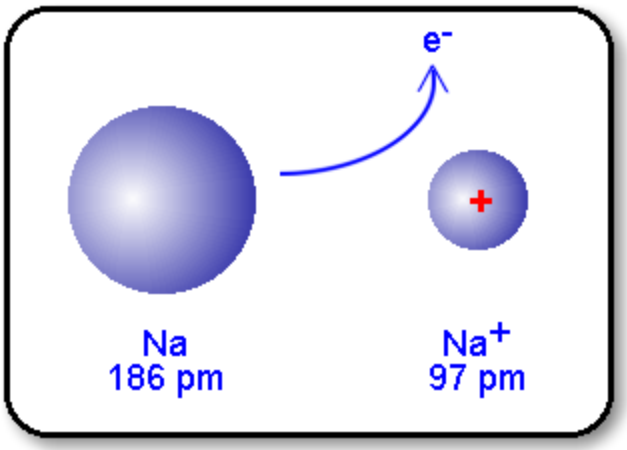


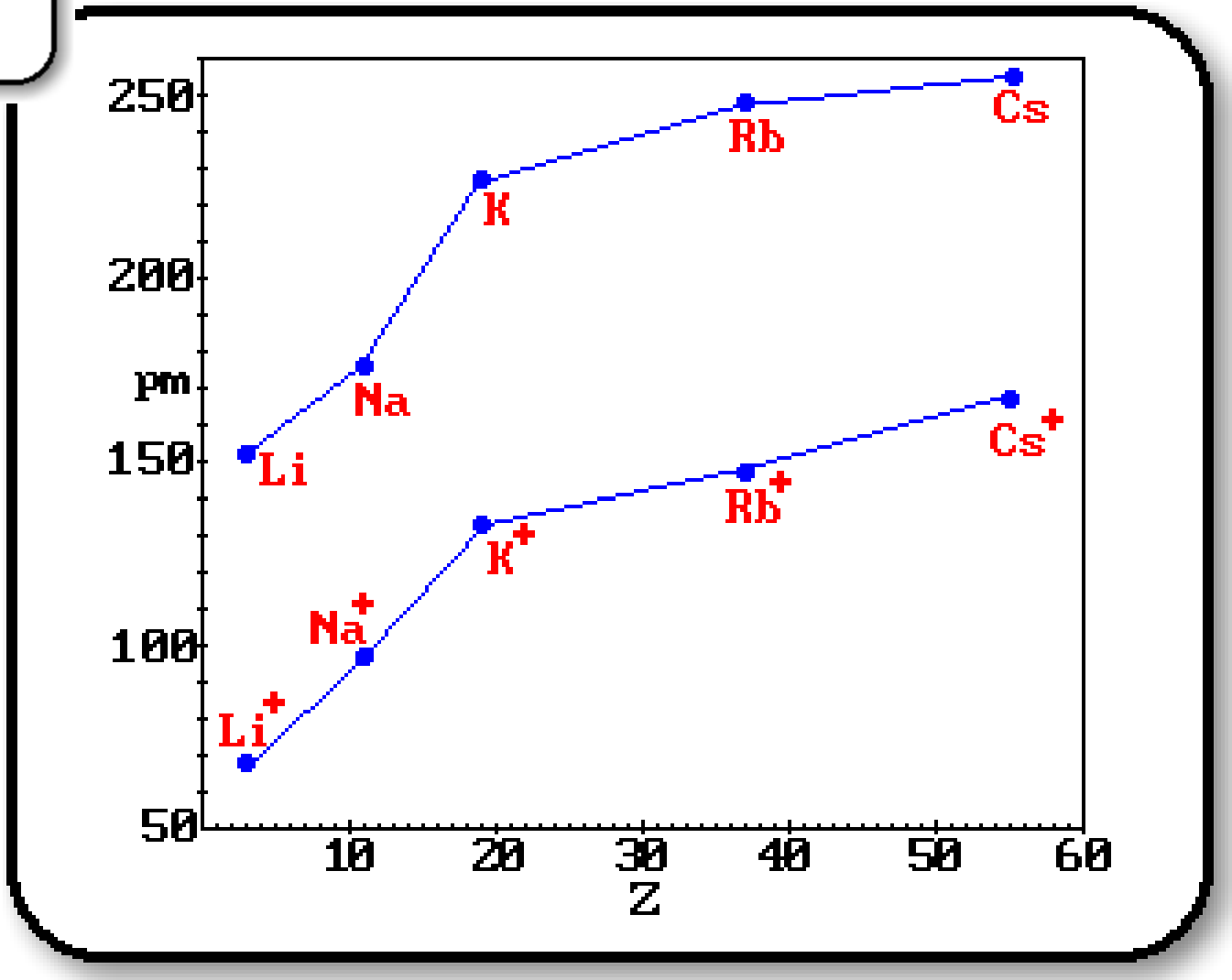
Ionic radius

- Share of distance between neighboring ions in an ionic solid
- Distance between the nuclei of a neighboring cation and anion = ionic radii (anion) + ionic radii (cation)

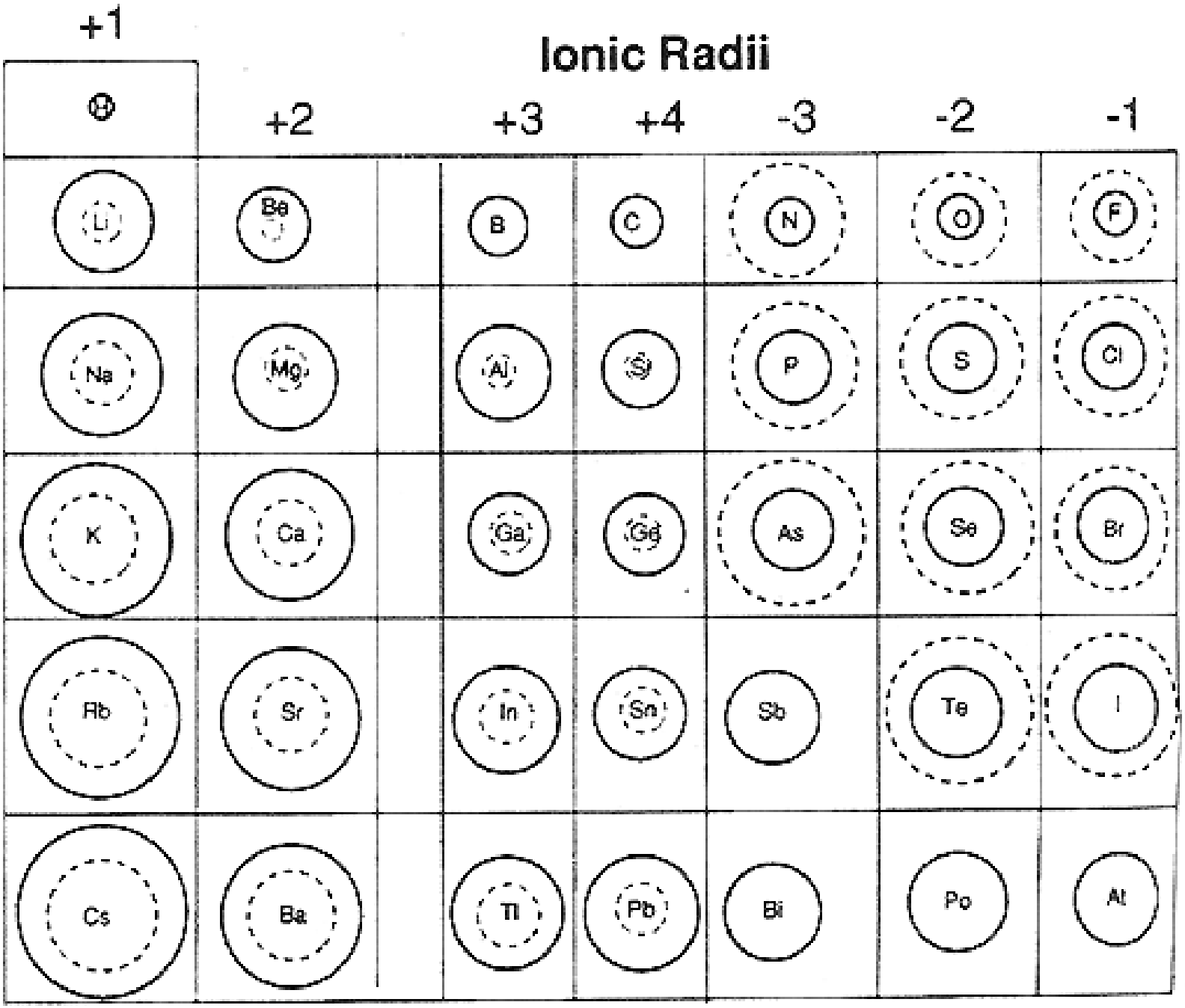

e-
Cl
99 pm
Cl-
181 pm


250
200
150
100
50
pm
Cl-
Br-
I-
F-
I
Br
Cl
F
10
20
30
40
50
60
Z

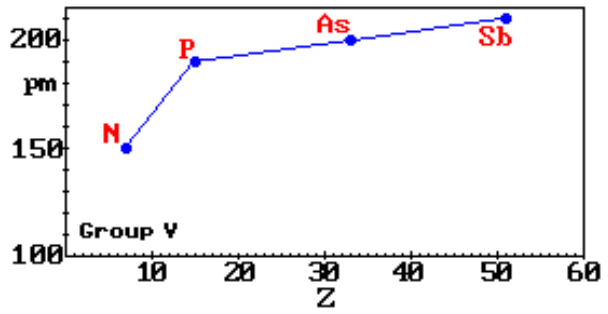

e-
Na
186 pm
Na+
97 pm

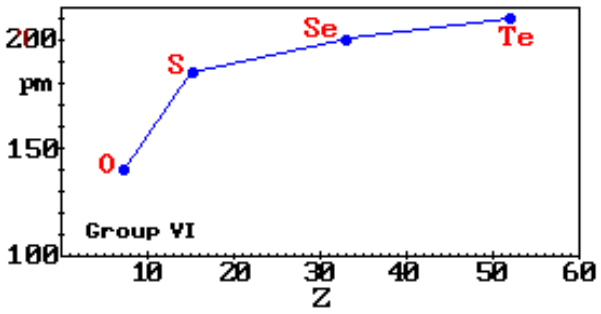

250
200
150
100
50
pm
Li
Na
K
Rb
Cs
Li+
Na+
K+
Rb+
Cs+
10
20
30
40
50
60
Z

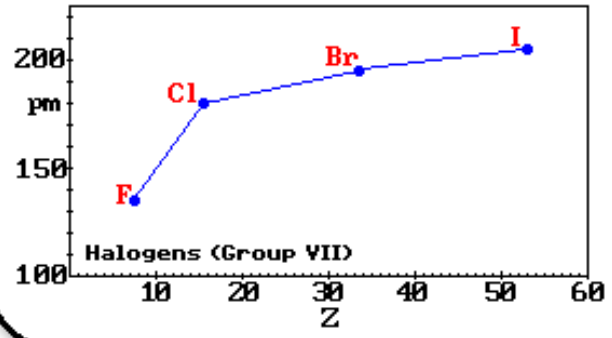
Ionic Radii

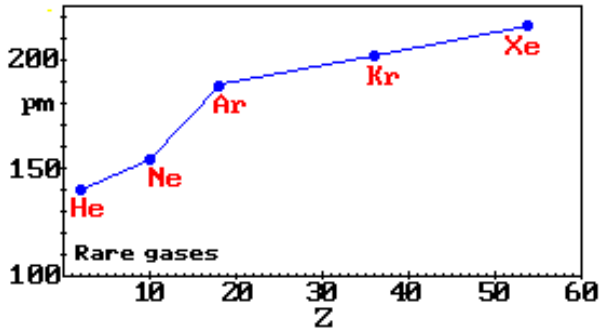

+1
+2
+3
+4
-3
-2
-1
Li
Be
B
C
N
O
F
Na
Mg
Al
Si
P
S
Cl
K
Ca
Ga
Ge
As
Se
Br
Rb
Sr
In
Sn
Sb
Te
I
Cs
Ba
Tl
Pb
Bi
Po
At

Van der Waals radii (1pm = 1×10^{-12})

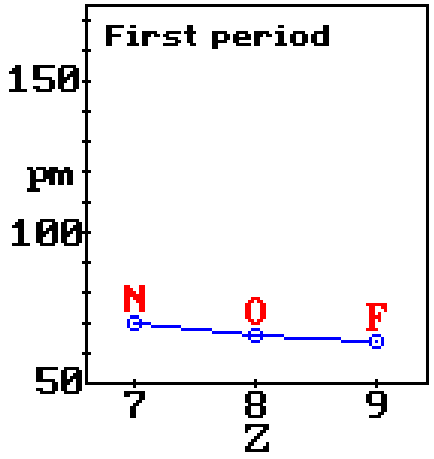


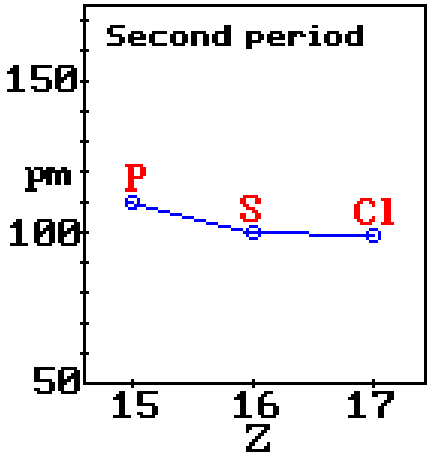


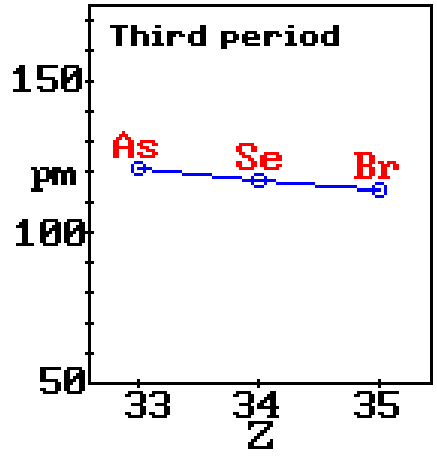


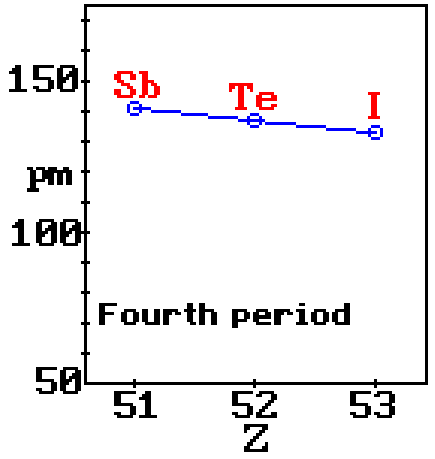


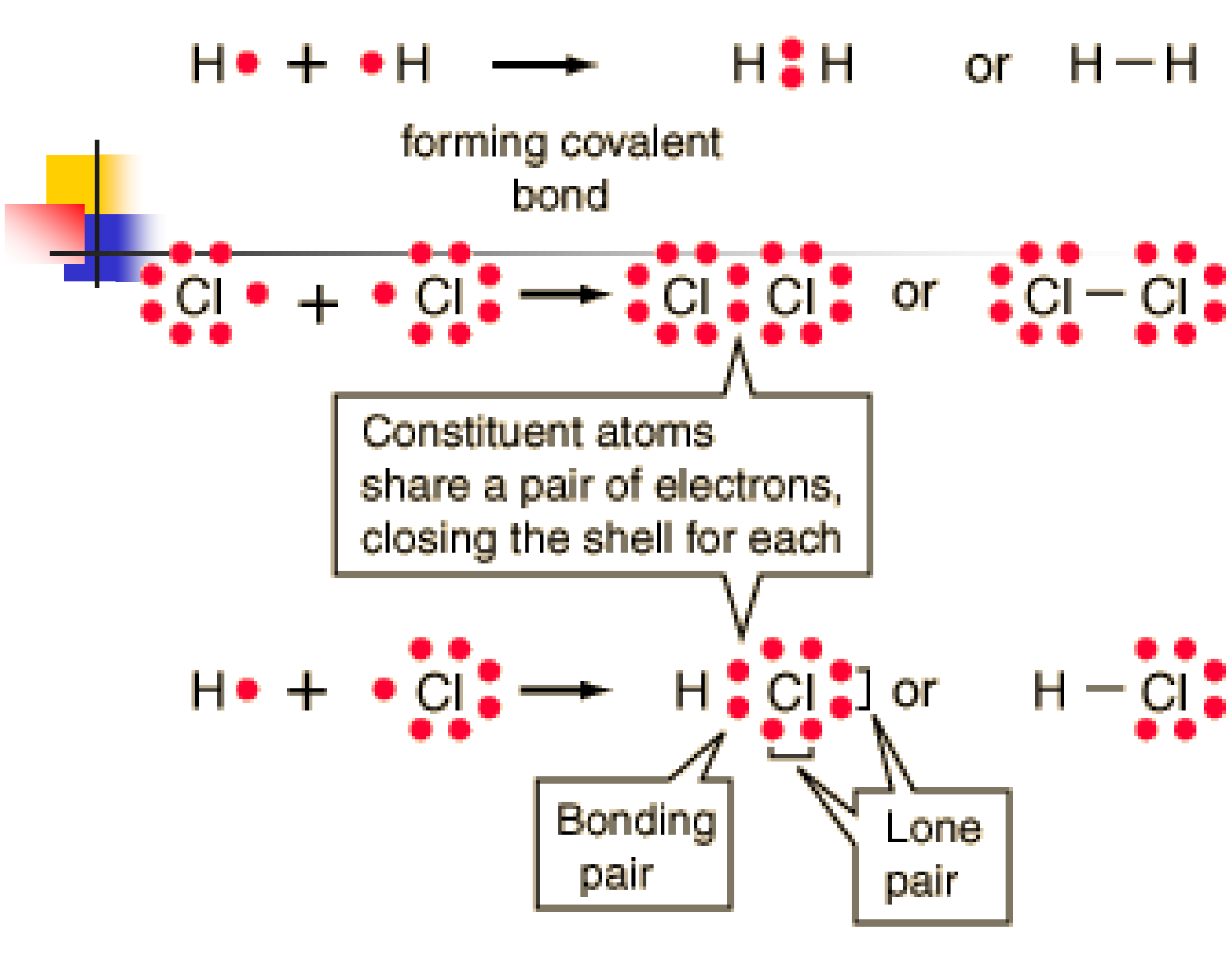
Covalent radii (1pm = 1×10^{-12})

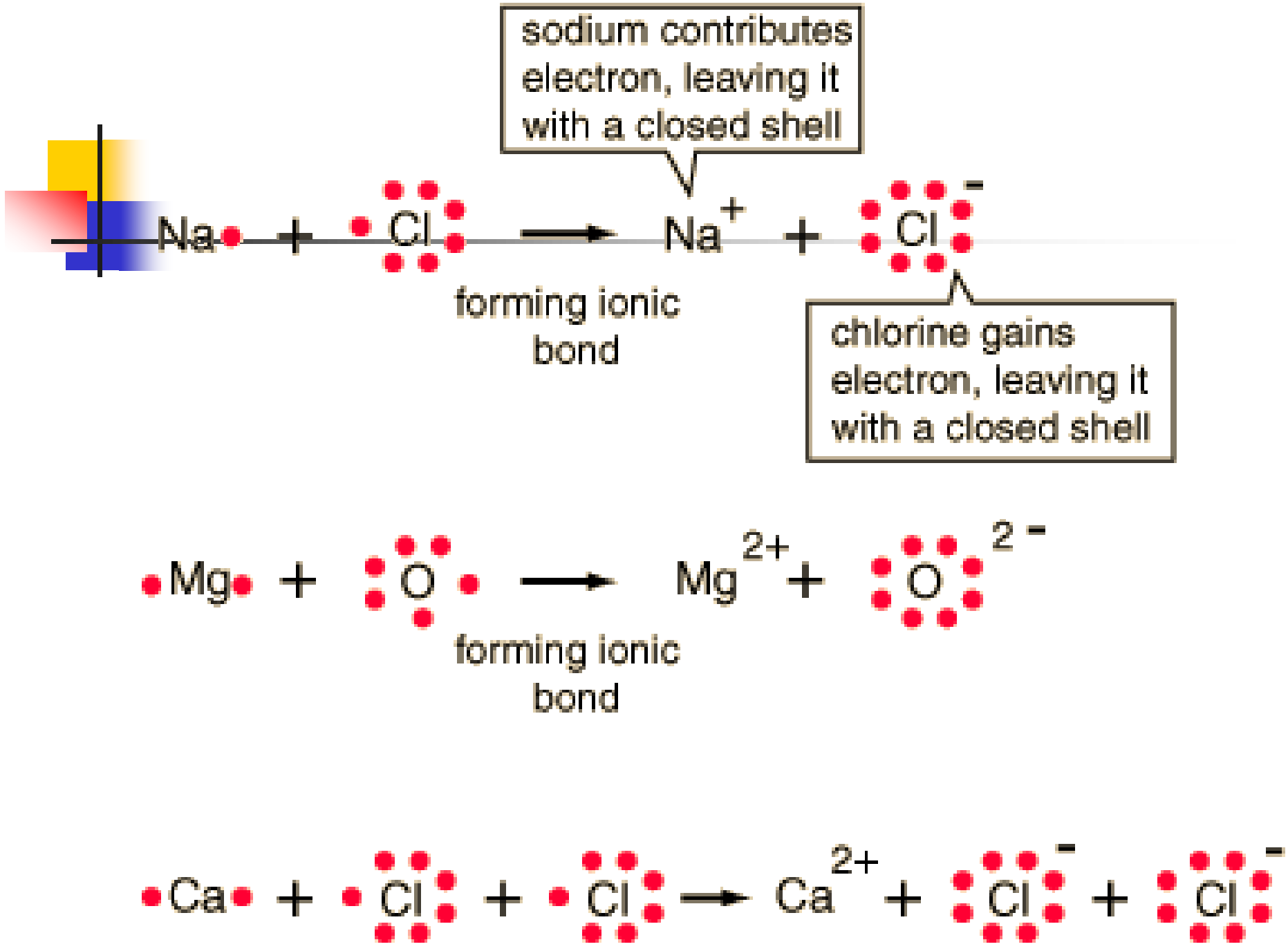


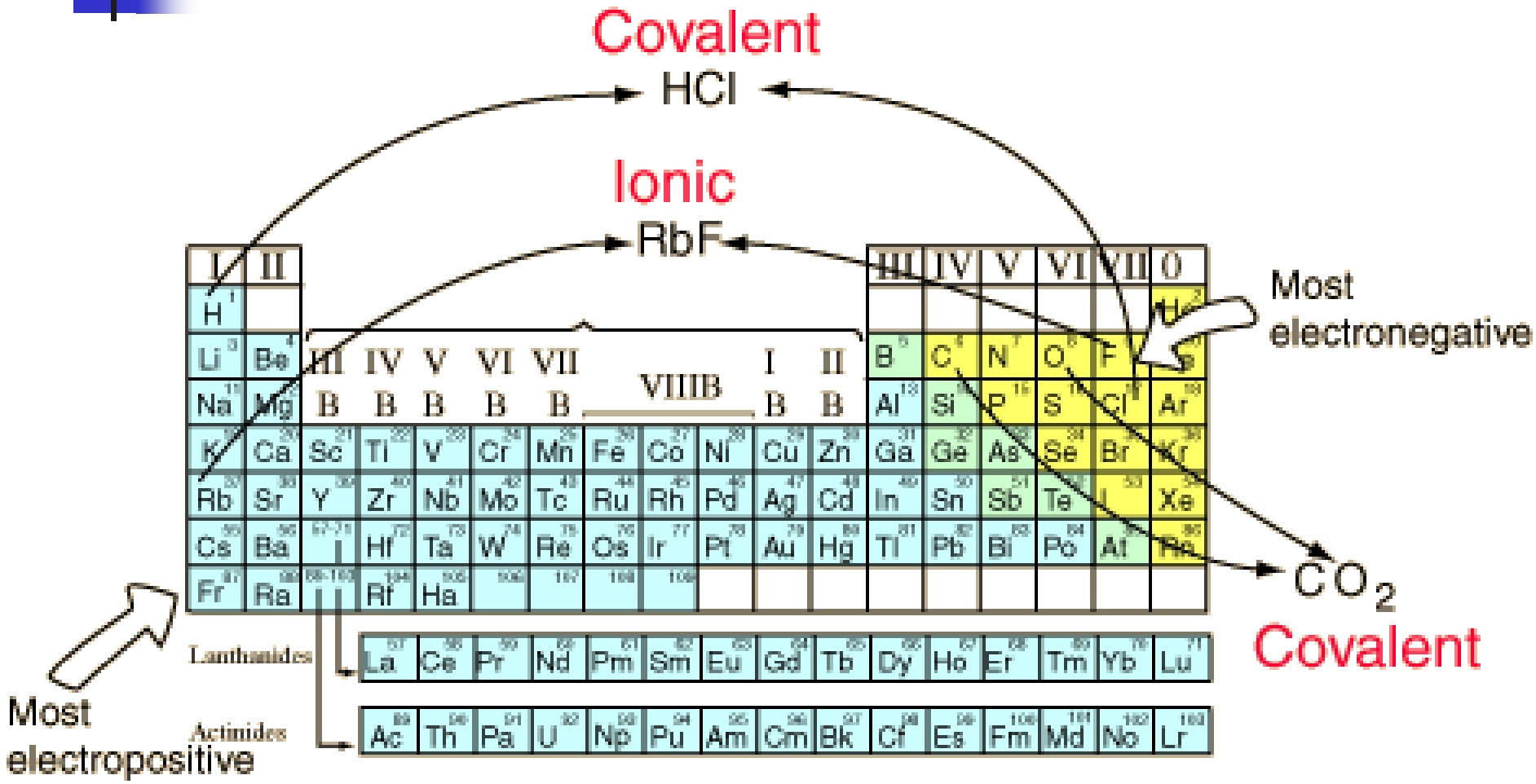


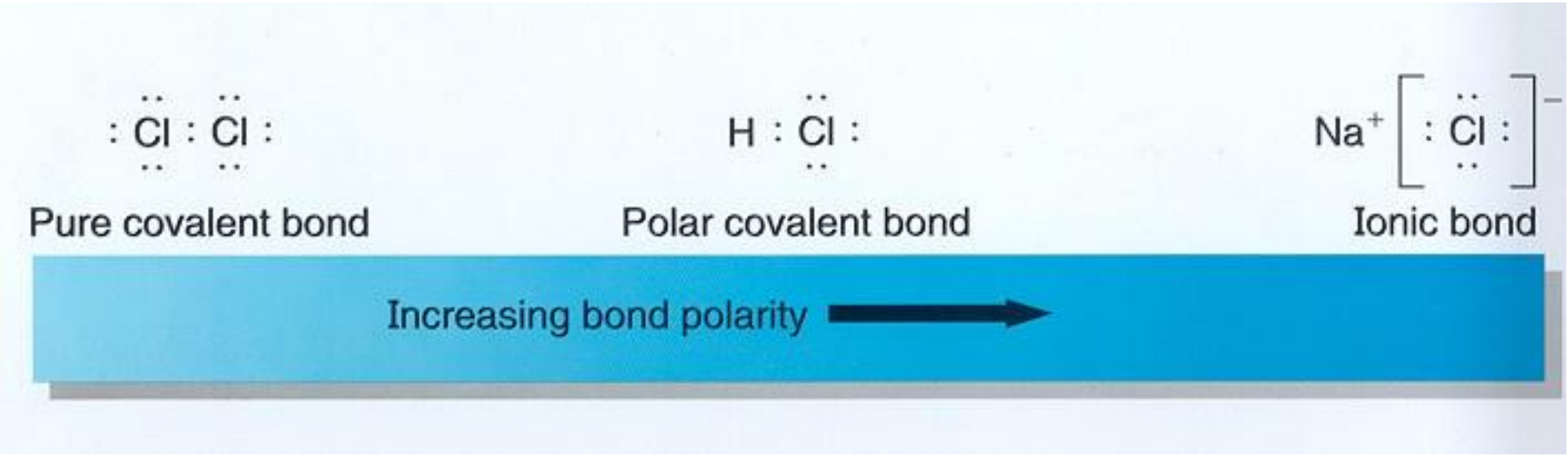


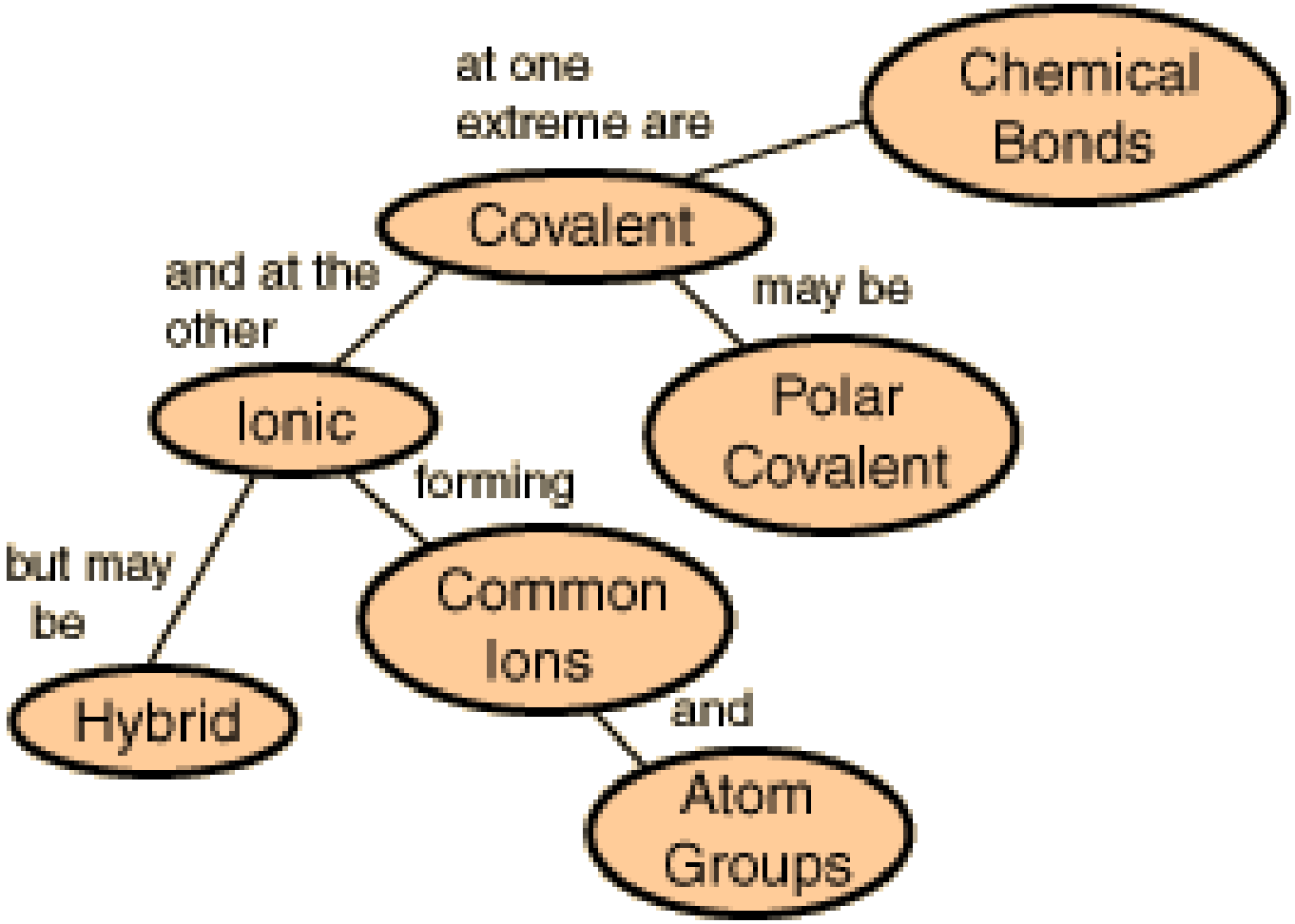


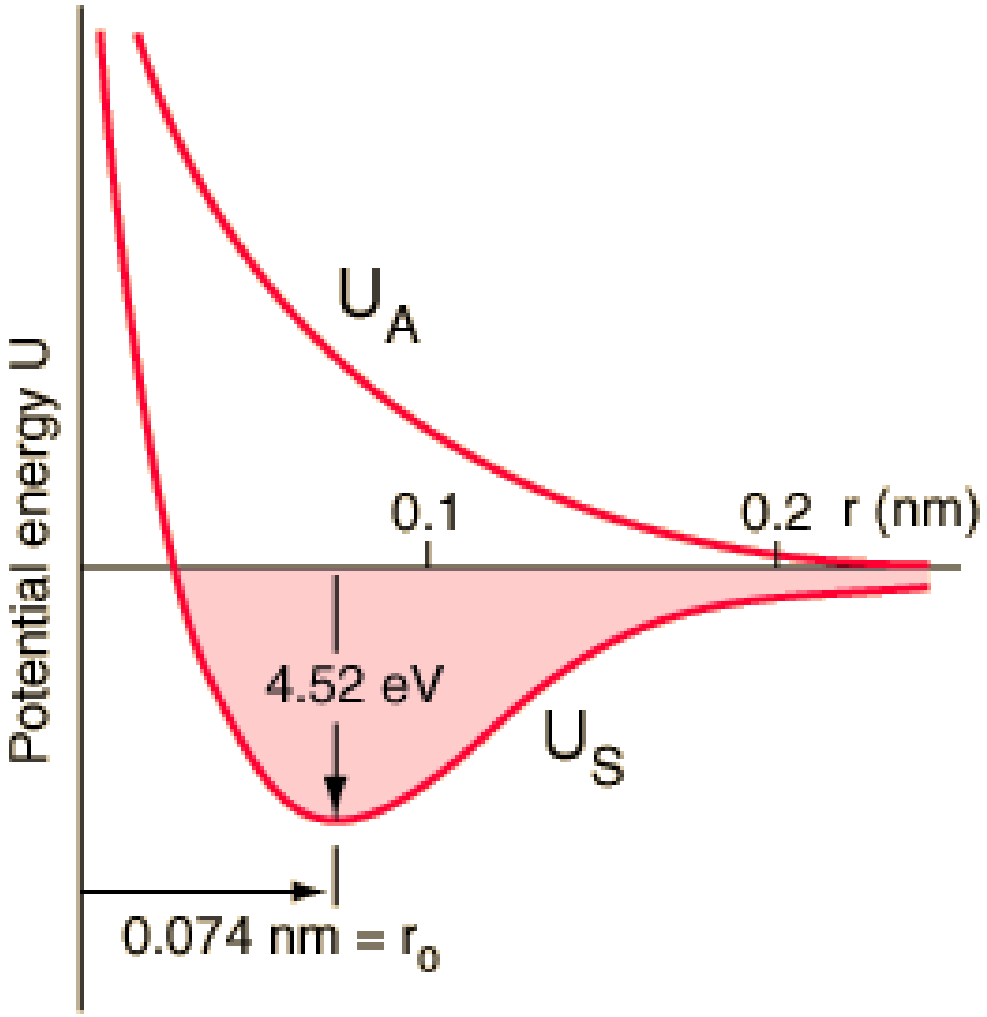

H + H → H H or H—H
forming covalent bond
Cl + Cl → Cl Cl or Cl—Cl
Constituent atoms share a pair of electrons, closing the shell for each
H + Cl → H Cl or H—Cl
Bonding pair
Lone pair

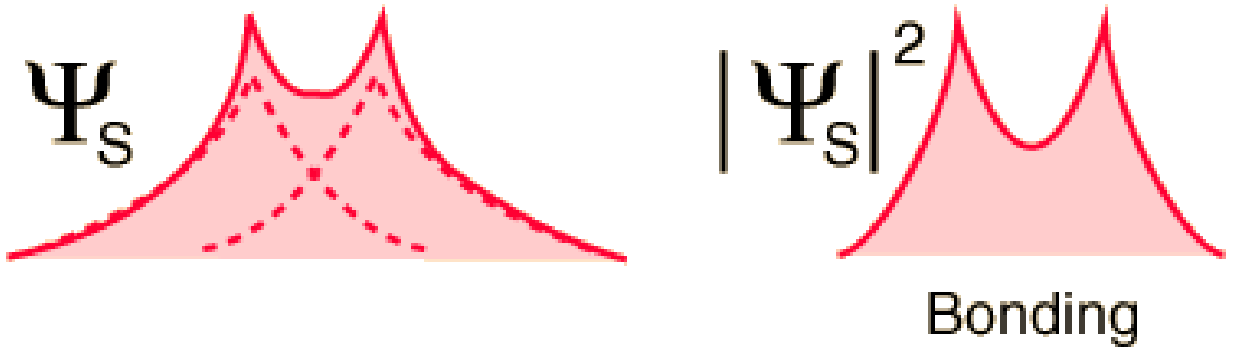

sodium contributes electron, leaving it with a closed shell
Na
Cl
Na+
Cl
forming ionic bond
chlorine gains electron, leaving it with a closed shell
Mg
O
Mg2+
O2-
forming ionic bond
Ca
Cl
Cl
Ca2+
Cl-
Cl-


Covalent
HCl
Ionic
RbF
Most electronegative
CO_2
Covalent
Most electropositive
Lanthanides
Actinides

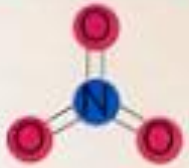
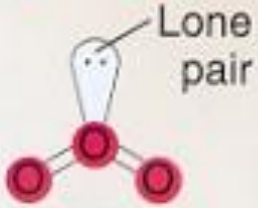
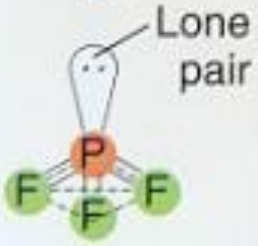
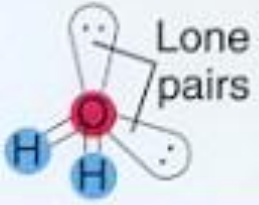

Cl : Cl
H : Cl :
Na+ [: Cl :]−
Pure covalent bond
Polar covalent bond
Ionic bond
Increasing bond polarity

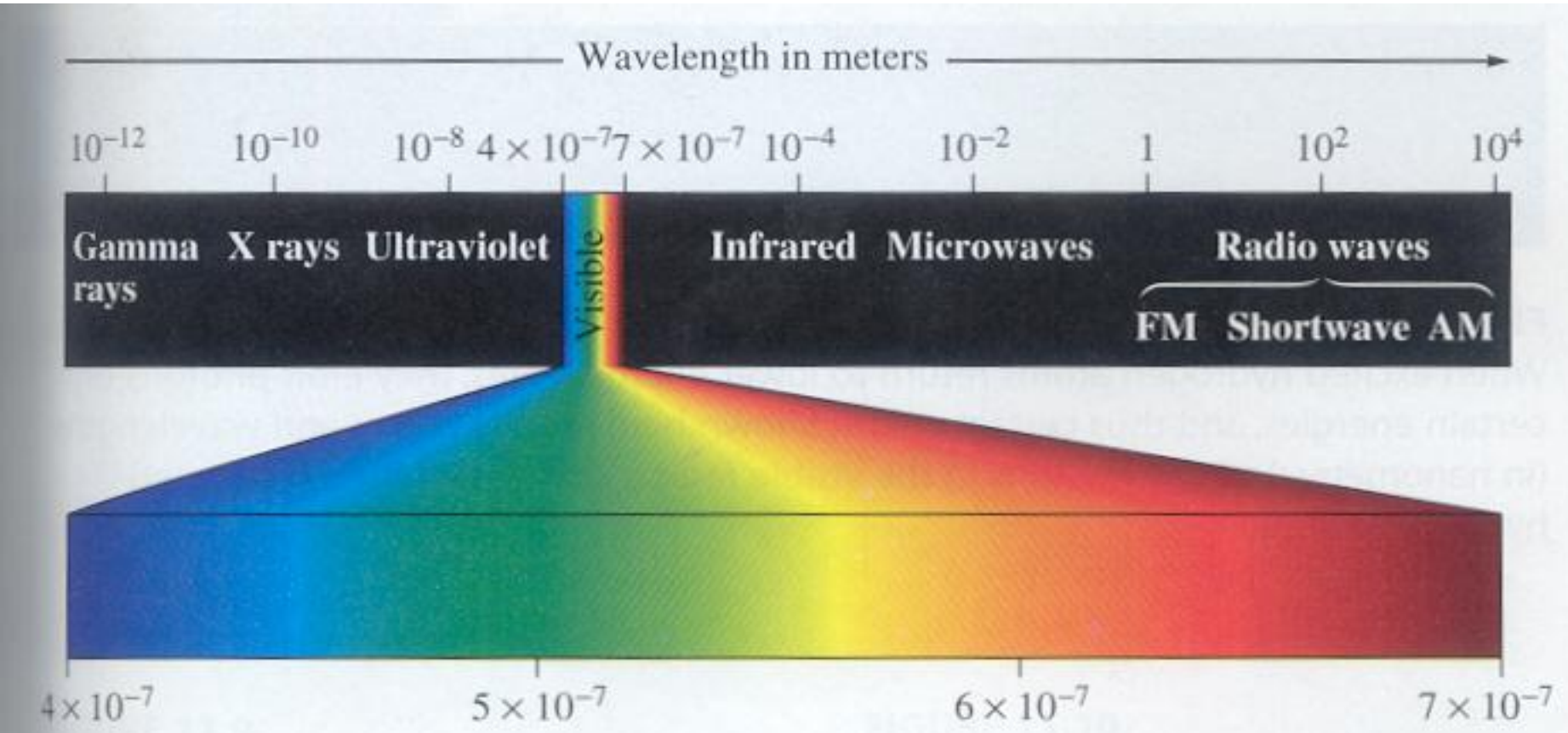

Chemical Bonds
at one extreme are
Covalent
and at the other
may be
Ionic
Polar Covalent
forming
but may be
Common Ions
Hybrid
and
Atom Groups

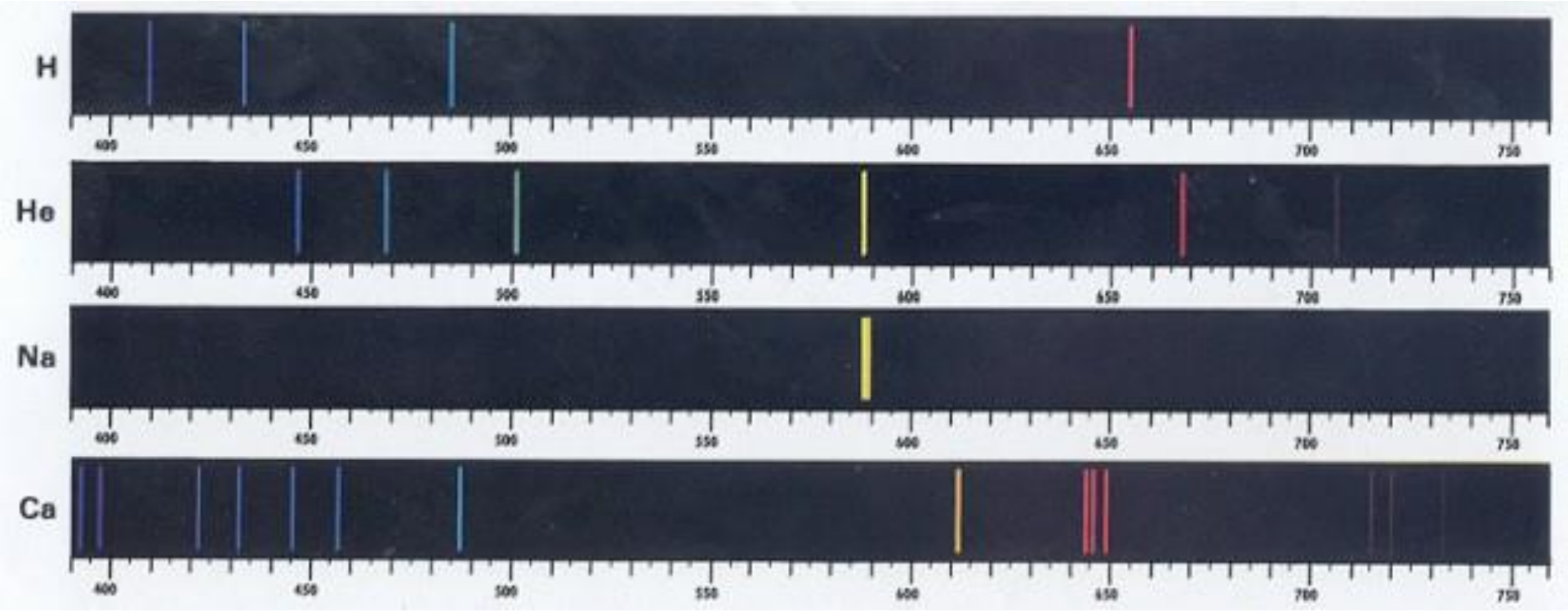

Potential energy U
U_A
0.1
0.2 r (nm)
4.52 eV
U_S
0.074 nm = r_0


Ψ_S
$|\Psi_S|^2$
Bonding


Ψ_A
$|\Psi_A|^2$
Anti-bonding

Electron Groups			Arrangement of Groups	Molecular Shape	Example
Total	Bonding	Lone			
2	2	0	Linear	Linear	CO_2 
3	3	0	Trigonal planar	Trigonal planar	NO_3^- 
	2	1		Bent (or angular)	O_3 
4	4	0	Tetrahedral	Tetrahedral	CH_4 
	3	1		Triangular pyramidal	PF_3 
	2	2		Bent (or angular)	H_2O 


Wavelength in meters
10^{-12}
10^{-10}
10^{-8}
4×10^{-7}
7×10^{-7}
10^{-4}
10^{-2}
1
10^{2}
10^{4}
Gamma rays
X rays
Ultraviolet
Visible
Infrared
Microwaves
Radio waves
FM
Shortwave
AM
4×10^{-7}
5×10^{-7}
6×10^{-7}
7×10^{-7}


H
He
Na
Ca
400
450
500
550
600
650
700
750