THE CHEMICAL CONTEXT OF LIFE

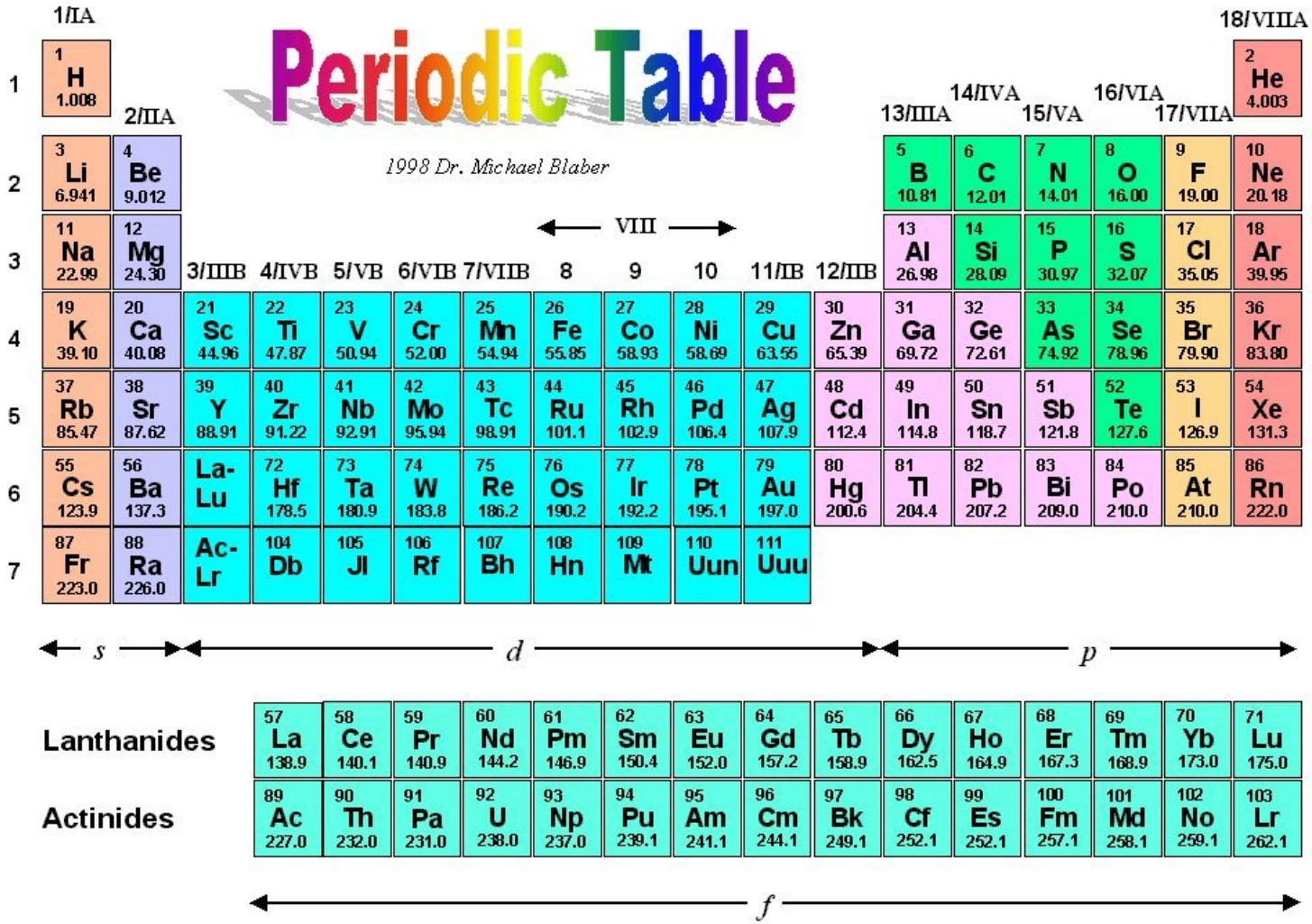
Chapter 2

Objectives

- Be familiar with the chemical vocabulary discussed in class
- Know the basic parts of an Atom and its properties
- Understand the relationship between energy level and electron orbit
- Be familiar with the kinds of chemical bonds formed between **atoms**. Understand what causes their formation.
- Be familiar with the kinds of chemical bonds formed between **molecules**. Understand what causes their formation.

Chemical Elements and Compounds

- Matter: anything that takes up space and has mass
- Element: substance that cannot be broken down to other substances by chemical reactions
  - CHNOPS, Ca, K, Na, Cl, Mg
  - Trace elements: Fe, I
- Compound: substance made of 2 or more elements

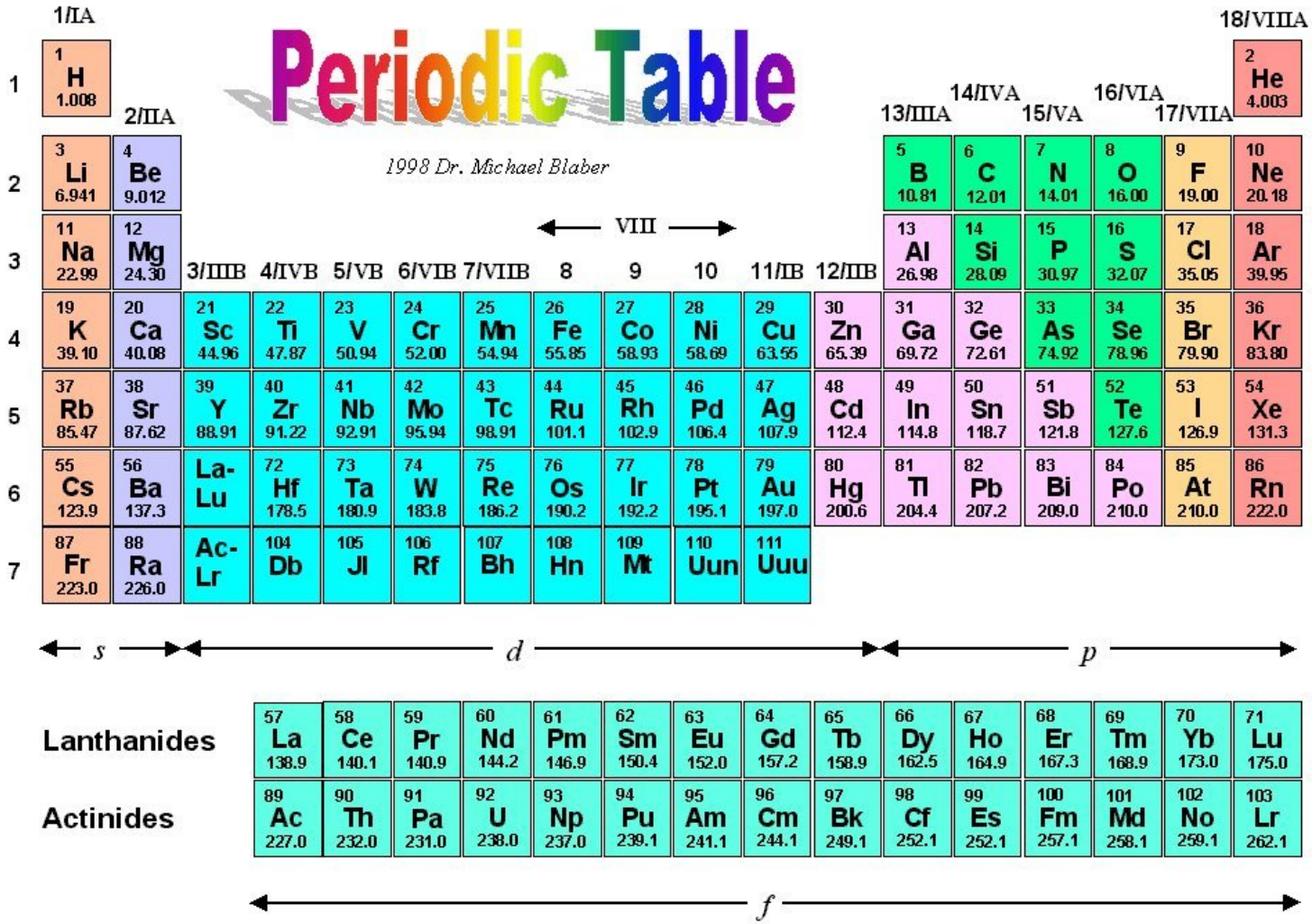

Periodic Table
1998 Dr. Michael Blaber
1/IA
2/IIA
3/IIIB
4/IVB
5/VB
6/VIB
7/VIIB
VIII
8
9
10
11/IB
12/IIB
13/IIIA
14/IVA
15/VA
16/VIA
17/VIIA
18/VIIIA
1 H 1.008
2 He 4.003
3 Li 6.941
4 Be 9.012
5 B 10.81
6 C 12.01
7 N 14.01
8 O 16.00
9 F 19.00
10 Ne 20.18
11 Na 22.99
12 Mg 24.30
13 Al 26.98
14 Si 28.09
15 P 30.97
16 S 32.07
17 Cl 35.05
18 Ar 39.95
19 K 39.10
20 Ca 40.08
21 Sc 44.96
22 Ti 47.87
23 V 50.94
24 Cr 52.00
25 Mn 54.94
26 Fe 55.85
27 Co 58.93
28 Ni 58.69
29 Cu 63.55
30 Zn 65.39
31 Ga 69.72
32 Ge 72.61
33 As 74.92
34 Se 78.96
35 Br 79.90
36 Kr 83.80
37 Rb 85.47
38 Sr 87.62
39 Y 88.91
40 Zr 91.22
41 Nb 92.91
42 Mo 95.94
43 Tc 98.91
44 Ru 101.1
45 Rh 102.9
46 Pd 106.4
47 Ag 107.9
48 Cd 112.4
49 In 114.8
50 Sn 118.7
51 Sb 121.8
52 Te 127.6
53 I 126.9
54 Xe 131.3
55 Cs 123.9
56 Ba 137.3
La-Lu
72 Hf 178.5
73 Ta 180.9
74 W 183.8
75 Re 186.2
76 Os 190.2
77 Ir 192.2
78 Pt 195.1
79 Au 197.0
80 Hg 200.6
81 Tl 204.4
82 Pb 207.2
83 Bi 209.0
84 Po 210.0
85 At 210.0
86 Rn 222.0
87 Fr 223.0
88 Ra 226.0
Ac-Lr
104 Db
105 Jl
106 Rf
107 Bh
108 Hn
109 Mt
110 Uun
111 Uuu
s
d
p
Lanthanides
57 La 138.9
58 Ce 140.1
59 Pr 140.9
60 Nd 144.2
61 Pm 146.9
62 Sm 150.4
63 Eu 152.0
64 Gd 157.2
65 Tb 158.9
66 Dy 162.5
67 Ho 164.9
68 Er 167.3
69 Tm 168.9
70 Yb 173.0
71 Lu 175.0
Actinides
89 Ac 227.0
90 Th 232.0
91 Pa 231.0
92 U 238.0
93 Np 237.0
94 Pu 239.1
95 Am 241.1
96 Cm 244.1
97 Bk 249.1
98 Cf 252.1
99 Es 252.1
100 Fm 257.1
101 Md 258.1
102 No 259.1
103 Lr 262.1
f

ATOMS AND MOLECULES.

- Atom: smallest chemical unit
- Atomic structure determines the behavior of an element
- Atoms usually consist of 3 subatomic particles
  - Proton
  - Neutron
  - Electron

ATOMS AND MOLECULES

- Atomic number
  - equivalent to the # of Protons
  - electrically neutral so equal to # of electrons
- Atomic Mass
  - measured in Daltons; proton and neutron = 1 Dalton, electrons = 0 Daltons
  - calculated as sum of protons, neutrons, and electrons
- Molecule: substance composed of two or more Atoms:


Periodic Table
1998 Dr. Michael Blaber
1/IA
2/IIA
3/IIIB
4/IVB
5/VB
6/VIB
7/VIIB
VIII
8
9
10
11/IB
12/IIB
13/IIIA
14/IVA
15/VA
16/VIA
17/VIIA
18/VIIIA
1 H 1.008
2 He 4.003
3 Li 6.941
4 Be 9.012
5 B 10.81
6 C 12.01
7 N 14.01
8 O 16.00
9 F 19.00
10 Ne 20.18
11 Na 22.99
12 Mg 24.30
13 Al 26.98
14 Si 28.09
15 P 30.97
16 S 32.07
17 Cl 35.05
18 Ar 39.95
19 K 39.10
20 Ca 40.08
21 Sc 44.96
22 Ti 47.87
23 V 50.94
24 Cr 52.00
25 Mn 54.94
26 Fe 55.85
27 Co 58.93
28 Ni 58.69
29 Cu 63.55
30 Zn 65.39
31 Ga 69.72
32 Ge 72.61
33 As 74.92
34 Se 78.96
35 Br 79.90
36 Kr 83.80
37 Rb 85.47
38 Sr 87.62
39 Y 88.91
40 Zr 91.22
41 Nb 92.91
42 Mo 95.94
43 Tc 98.91
44 Ru 101.1
45 Rh 102.9
46 Pd 106.4
47 Ag 107.9
48 Cd 112.4
49 In 114.8
50 Sn 118.7
51 Sb 121.8
52 Te 127.6
53 I 126.9
54 Xe 131.3
55 Cs 123.9
56 Ba 137.3
La-Lu
72 Hf 178.5
73 Ta 180.9
74 W 183.8
75 Re 186.2
76 Os 190.2
77 Ir 192.2
78 Pt 195.1
79 Au 197.0
80 Hg 200.6
81 Tl 204.4
82 Pb 207.2
83 Bi 209.0
84 Po 210.0
85 At 210.0
86 Rn 222.0
87 Fr 223.0
88 Ra 226.0
Ac-Lr
104 Db
105 Jl
106 Rf
107 Bh
108 Hn
109 Mt
110 Uun
111 Uuu
s
d
p
Lanthanides
57 La 138.9
58 Ce 140.1
59 Pr 140.9
60 Nd 144.2
61 Pm 146.9
62 Sm 150.4
63 Eu 152.0
64 Gd 157.2
65 Tb 158.9
66 Dy 162.5
67 Ho 164.9
68 Er 167.3
69 Tm 168.9
70 Yb 173.0
71 Lu 175.0
Actinides
89 Ac 227.0
90 Th 232.0
91 Pa 231.0
92 U 238.0
93 Np 237.0
94 Pu 239.1
95 Am 241.1
96 Cm 244.1
97 Bk 249.1
98 Cf 252.1
99 Es 252.1
100 Fm 257.1
101 Md 258.1
102 No 259.1
103 Lr 262.1
f

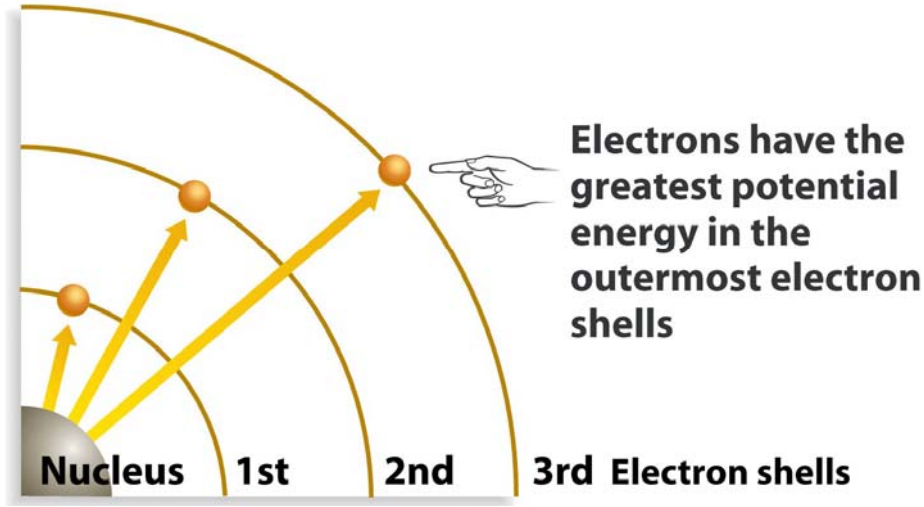
ISOTOPES

- Isotope: an atom with a greater number of neutrons than other atoms of the same element
- Radioactive Isotopes: Atomic nuclei that are unstable may lose a proton (decay) and energy (radiation).
- Applications of radioactive isotope: dating of objects, diagnosing disease

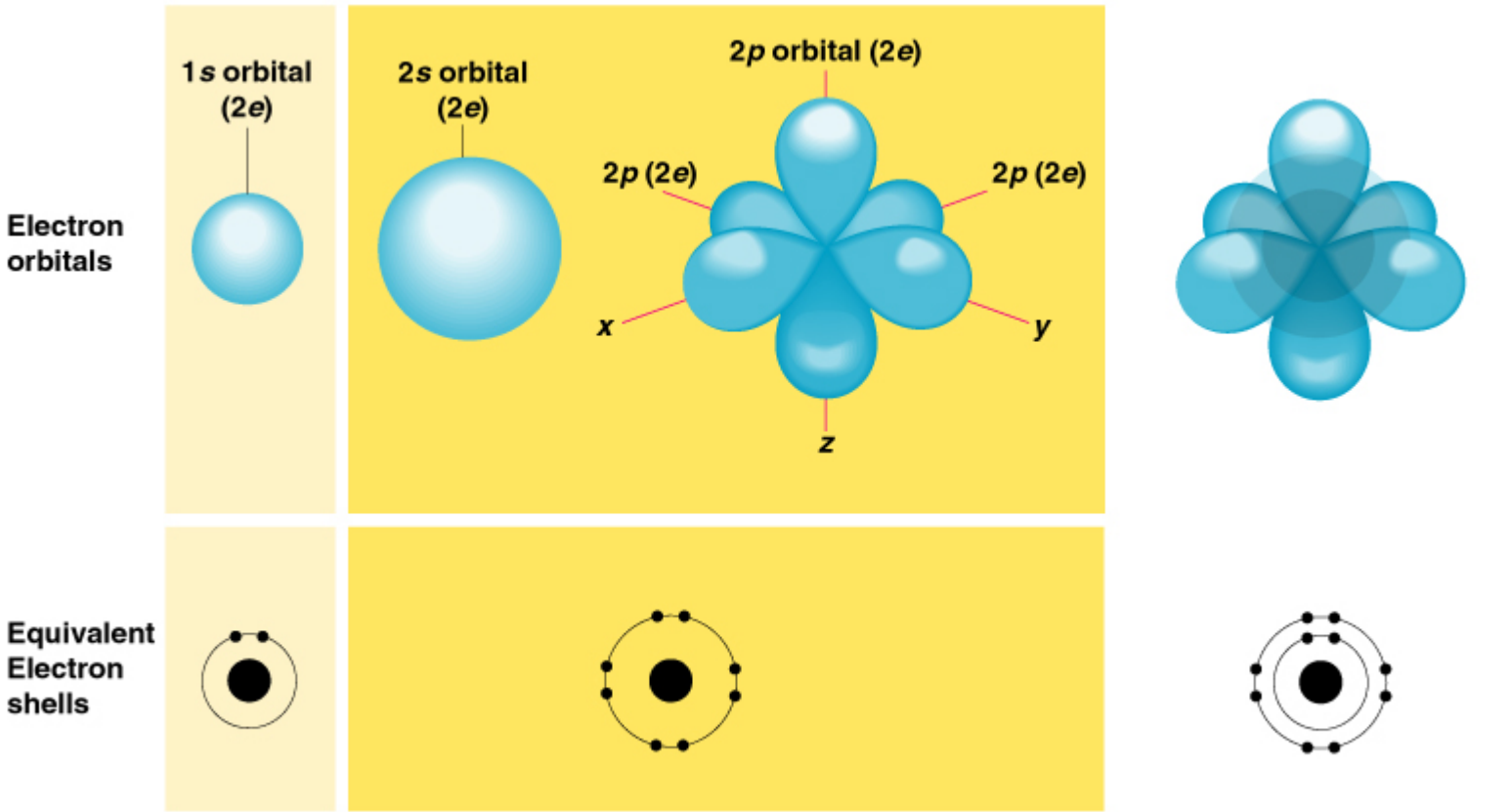
THE ENERGY LEVELS OF ELECTRONS

- Electrons are the only particles involved in chemical reactions
- An atom's electrons vary in their energy level
  - Energy: ability to do work
- **Potential energy**: amount of energy stored as a result of position or location

Electron Orbitals



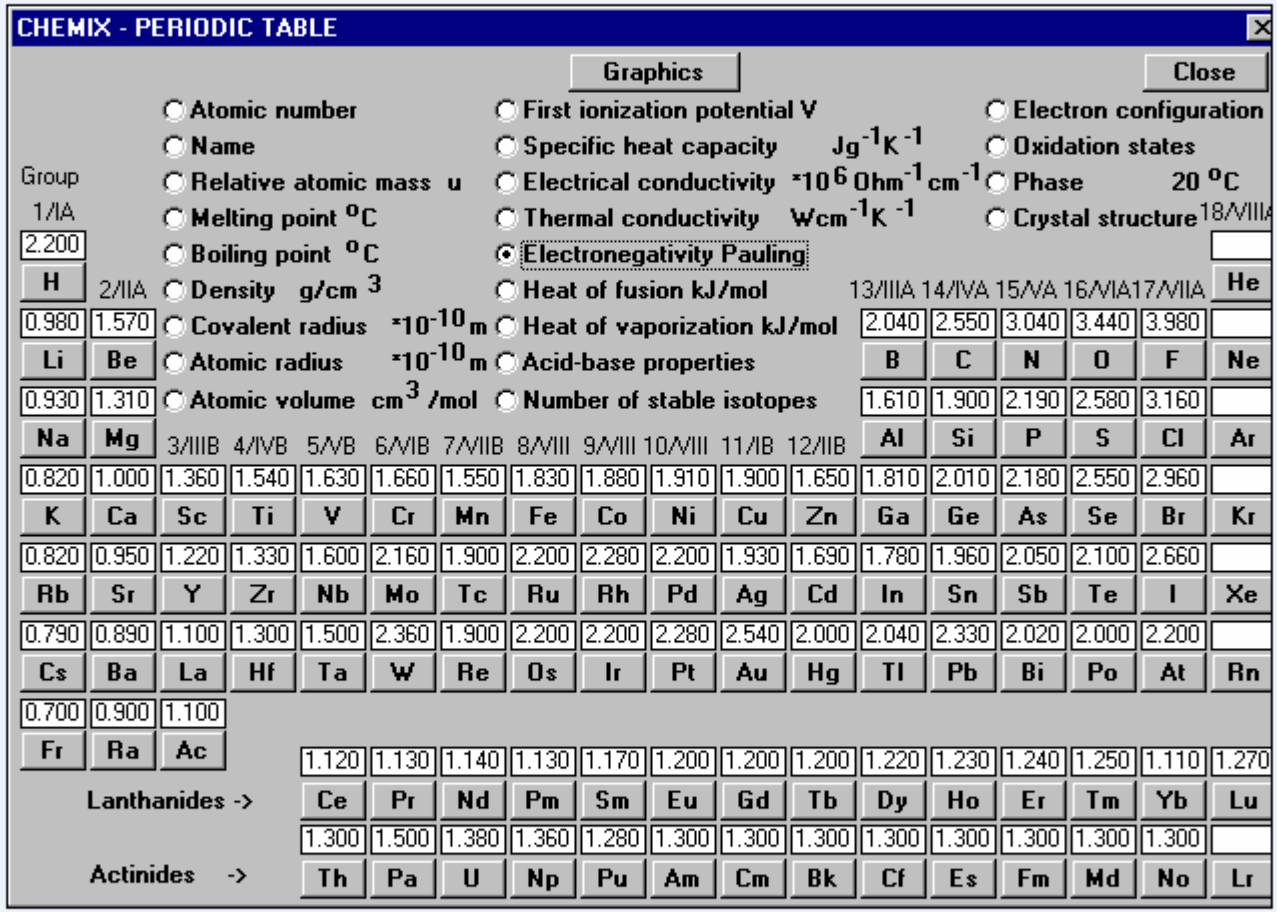
- Potential energy of an atom ↑ as electrons move farther from the atomic nucleus
- Electrons reside in orbitals (3D space) around the atomic nucleus within energy shells
  - orbital can be spherical (s) or dumbbell shaped (p)
- The number of electrons in the outermost shell of an atom determine its reactivity in chemical reactions

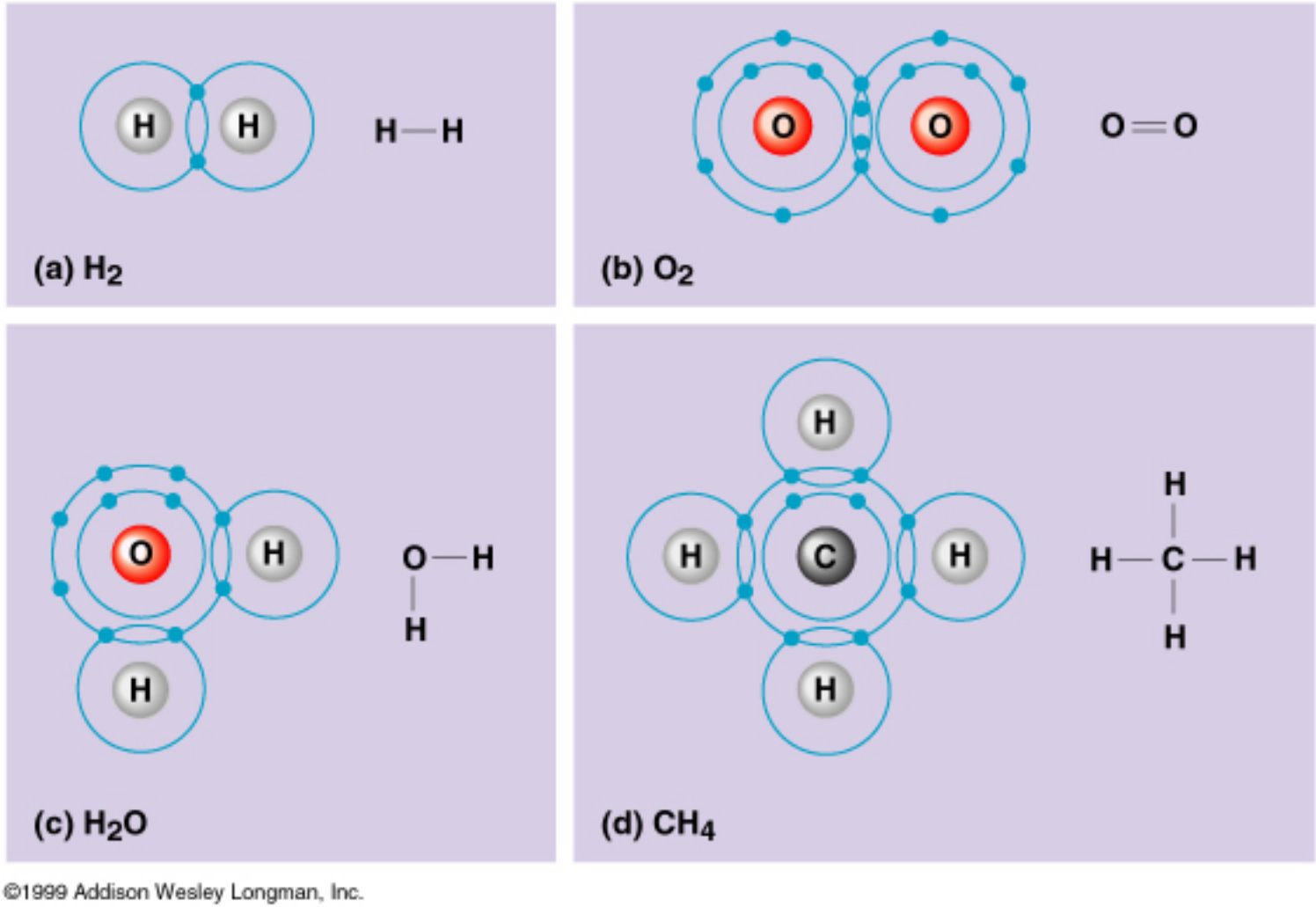


(a) 1*s* orbital (b) 2*s* and 2*p* orbitals (c) Neon ($_{10}$Ne): 1*s*, 2*s* and 2*p*

ATOMS COMBINE BY CHEMICAL BONDING TO FORM MOLECULES.

- Chemical bond: attraction between atoms as a result of interactions of electrons. Two types: **Covalent** and **Ionic**
- **Covalent bonds**: result from the sharing of valence electrons, influenced by the pulling power of an atom (**electronegativity**)
  - Nonpolar covalent bonds
  - Polar covalent bonds





If O>>N>C ≈ H

CHEMICAL BONDS Continued

- **Ionic bonds**: result from the transfer of electrons between atoms owing to a large difference in electronegativity; may be strong or weak depending on the chemical environment
- **Ion**: is a positively or negatively charged atom or molecule
  - **Cation**: +
  - **Anion**: -

Chemical Bonds Between Molecules

- Hydrogen Bonds: weak attraction of a slightly positive region of one molecule (hydrogen atom) for the slightly negative region of another molecule (more electronegative atom)
  - Important in DNA and protein structure
- van der Waals interactions: changing “hot spots” of positive and negative charges due to the random non-symmetrical distribution of electrons in molecules