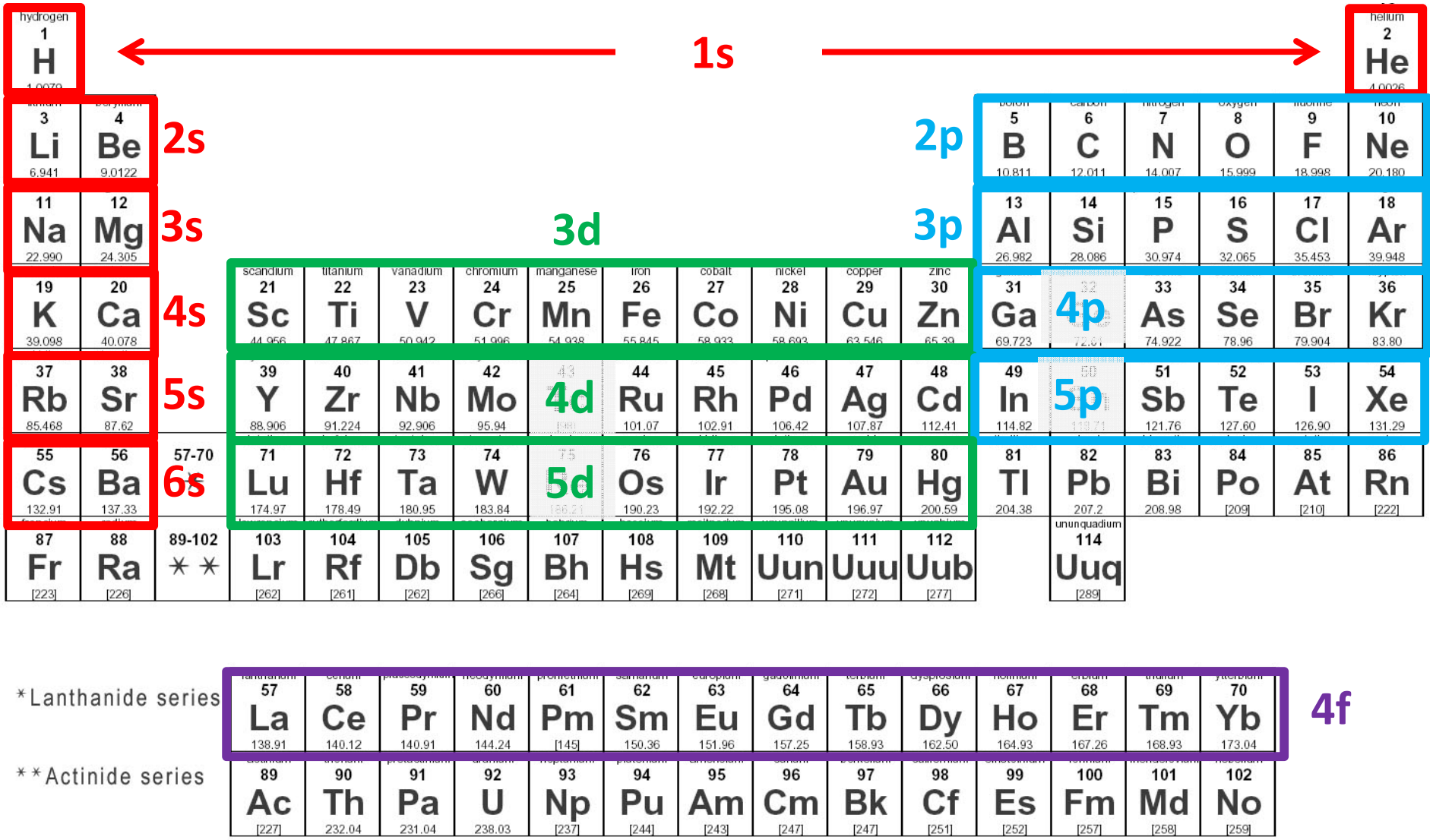
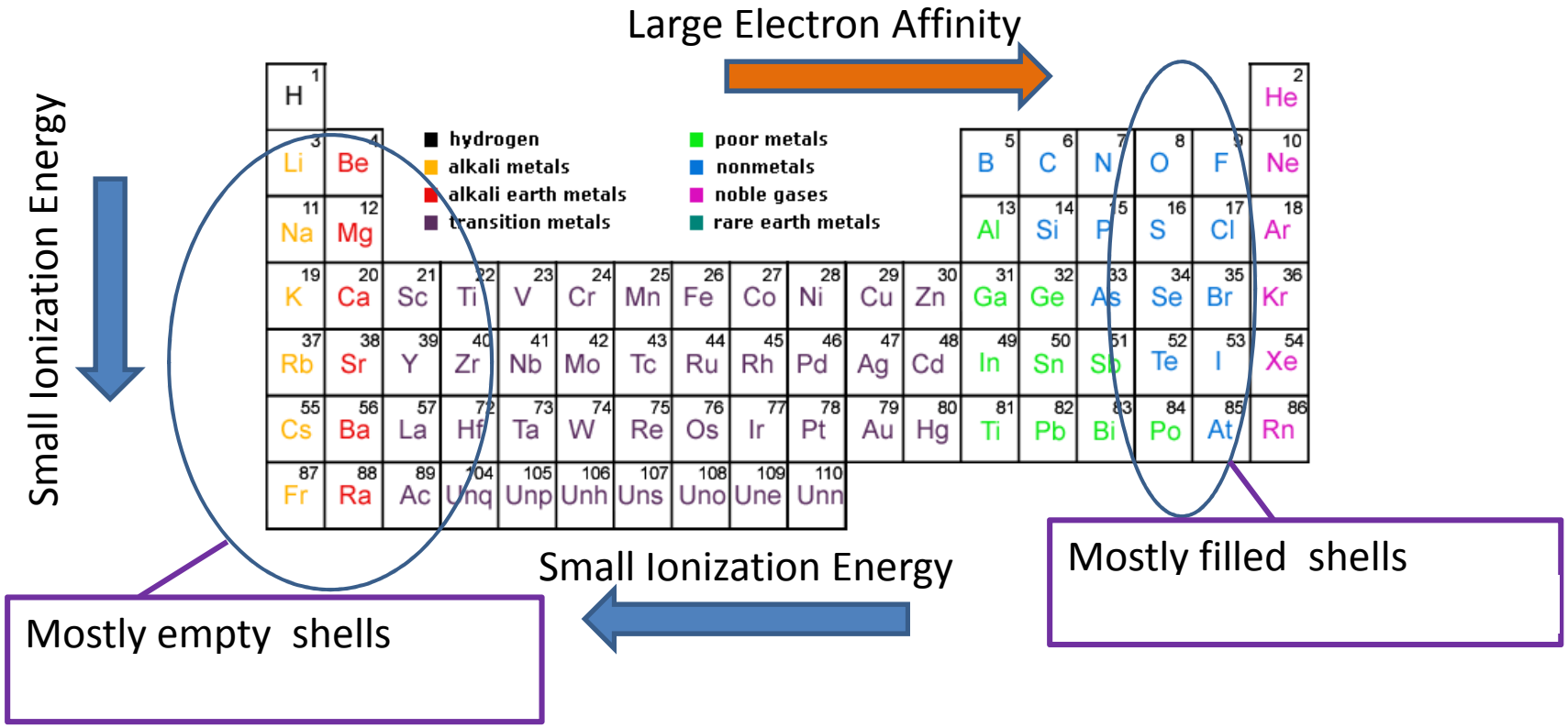
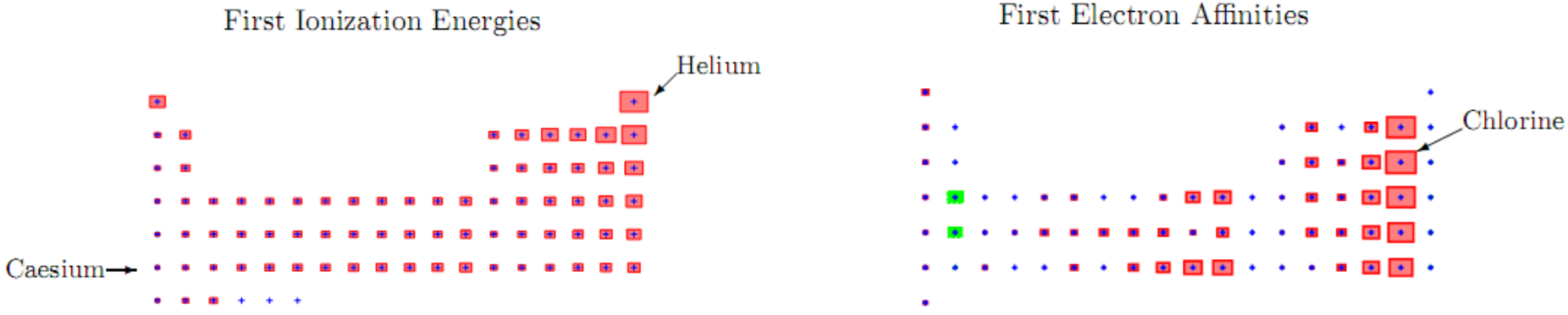
Slides
Condensed Matter Physics
Lecture 5


1s
2s
3s
4s
5s
6s
2p
3p
3d
4p
4d
5p
5d
4f
1 H hydrogen
2 He helium
3 Li 6.941
4 Be
5 B 10.811
6 C 12.011
7 N 14.007
8 O 15.999
9 F 18.998
10 Ne 20.180
11 Na 22.990
12 Mg 24.305
13 Al 26.982
14 Si 28.086
15 P 30.974
16 S 32.065
17 Cl 35.453
18 Ar 39.948
19 K 39.098
20 Ca 40.078
21 Sc scandium 44.956
22 Ti titanium 47.867
23 V vanadium 50.942
24 Cr chromium 51.996
25 Mn manganese 54.938
26 Fe iron 55.845
27 Co cobalt 58.933
28 Ni nickel 58.693
29 Cu copper 63.546
30 Zn zinc 65.39
31 Ga 69.723
33 As 74.922
34 Se 78.96
35 Br 79.904
36 Kr 83.80
37 Rb 85.468
38 Sr 87.62
39 Y 88.906
40 Zr 91.224
41 Nb 92.906
42 Mo 95.94
44 Ru 101.07
45 Rh 102.91
46 Pd 106.42
47 Ag 107.87
48 Cd 112.41
49 In 114.82
51 Sb 121.76
52 Te 127.60
53 I 126.90
54 Xe 131.29
55 Cs 132.91
56 Ba 137.33
57-70 *
71 Lu 174.97
72 Hf 178.49
73 Ta 180.95
74 W 183.84
76 Os 190.23
77 Ir 192.22
78 Pt 195.08
79 Au 196.97
80 Hg 200.59
81 Tl 204.38
82 Pb 207.2
83 Bi 208.98
84 Po [209]
85 At [210]
86 Rn [222]
87 Fr [223]
88 Ra [226]
89-102 **
103 Lr [262]
104 Rf [261]
105 Db [262]
106 Sg [266]
107 Bh [264]
108 Hs [269]
109 Mt [268]
110 Uun [271]
111 Uuu [272]
112 Uub [277]
ununquadium
114 Uuq [289]
*Lanthanide series
57 La 138.91
58 Ce 140.12
59 Pr 140.91
60 Nd 144.24
61 Pm [145]
62 Sm 150.36
63 Eu 151.96
64 Gd 157.25
65 Tb 158.93
66 Dy 162.50
67 Ho 164.93
68 Er 167.26
69 Tm 168.93
70 Yb 173.04
**Actinide series
89 Ac [227]
90 Th 232.04
91 Pa 231.04
92 U 238.03
93 Np [237]
94 Pu [244]
95 Am [243]
96 Cm [247]
97 Bk [247]
98 Cf [251]
99 Es [252]
100 Fm [257]
101 Md [258]
102 No [259]

Type of Bonding	Description	Typical of which compounds	Typical Properties
Ionic	Electron is transferred from one atom to another, and the resulting ions attract each other	Binary compounds made of constituents with very different electronegativity: Ex, group 1-7 such as NaCl or group 2-7 compounds.	• Hard, Very Brittle • High Melting Temperature • Electrical Insulator • Water Soluble
Covalent	Electron is shared equally between two atoms forming a bond. Energy lowered by delocalization of wavefunction	Compounds made of constituents with similar electronegativities (ex, 3-5 compounds such as GaAs), or solids made of one element only such as Diamond (C)	• Very Hard (Brittle) • High Melting Temperature • Electrical Insulators or Semiconductors
Metallic Bonds	Electrons delocalized throughout the solid forming a glue between positive ions.	Metals. Left and Middle of Periodic Table.	• Ductile, Maleable (due to non-directional nature of bond. Can be hardened by preventing dislocation motion with impurities) • Lower Melting Temperature • Good electrical and thermal conductors.
Molecular (van der Waals or Fluctuating Dipole)	No transfer of electrons. Dipole moments on constituents align to cause attraction. Bonding strength increases with size of molecule or polarity of constituent.	Nobel Gas Solids, Solids made of Non-Polar (or slightly polar) Molecules Binding to Each Other (Wax)	• Soft, Weak • Low Melting Temperature • Electrical Insulators
Hydrogen	Involves Hydrogen ion bound to one atom but still attracted to another. Special case because H is so small.	Important in organic and biological materials	• Weak Bond (stronger than VdW though) • Important for maintaining shape of DNA and proteins

Table 4.1: Types of Bonds in Solids. This table should be thought of as providing rough rules. Many materials show characteristics intermediate between two (or more!) classes.


Large Electron Affinity
Small Ionization Energy
hydrogen
alkali metals
alkali earth metals
transition metals
poor metals
nonmetals
noble gases
rare earth metals
Small Ionization Energy
Mostly filled shells
Mostly empty shells


First Ionization Energies
Helium
Caesium
First Electron Affinities
Chlorine