Bonding, Lewis Structures_____________ Z Ch 12.15, 13

"There are therefore Agents in Nature able to make the Particles of Bodies stick together by very strong Attractions. And it is the Business of Experimental Philosophy to find them out." **Isaac Newton, 1717**

"Two atoms may conform to the rule of eight, or the octet rule, not only by the transfer of electrons from one atom to another, but also by sharing one or more pairs of electrons. These electrons which are held in common by two atoms may be considered to belong to the outer shells of both atoms." **Gilbert Newton Lewis, 1916**

"We shall say that there is a chemical bond between two atoms or groups of atoms in case that the forces acting between them are such as to lead to the formation of an aggregate with sufficient stability to make it convenient for the chemist to consider it as an independent molecular species." **Linus Carl Pauling, 1939**

(Nobel Prize in Chemistry in 1954 "for his research into the nature of the chemical bond and its application to the elucidation of the structure of complex substances" and Nobel Peace Prize in 1962.)

13.1 – Types of Chemical Bonds
12.15 – Periodic Trends (13.2, 13.4)
13.9 - 13.10 – Lewis Structures
13.11 – Resonance
13.12 – Exceptions to Octet Rule
13.13 – VSEPR

grade estimate on FRIDAY

no quiz this week

OMIT Ch 13.5 – 13.8 in Zumdahl
no *s*, *p*, *d*, *f* electron configuration

Classical Description of Bonding

Chemical bond – forces that hold a group of atoms together causing them to function as a unit and lowering the energy of the system

Experimental evidence:

ionization energy – minimum energy to remove an electron in the gas phase

electron affinity – energy change when an electron is added to a gaseous atom

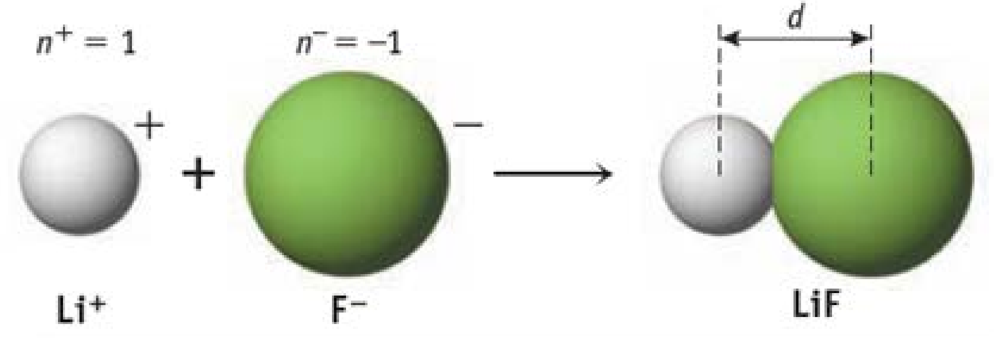
Classical Description of Bonding

1) **ionic bond –** e^- transferred

Coulomb's Law
(for force or energy):

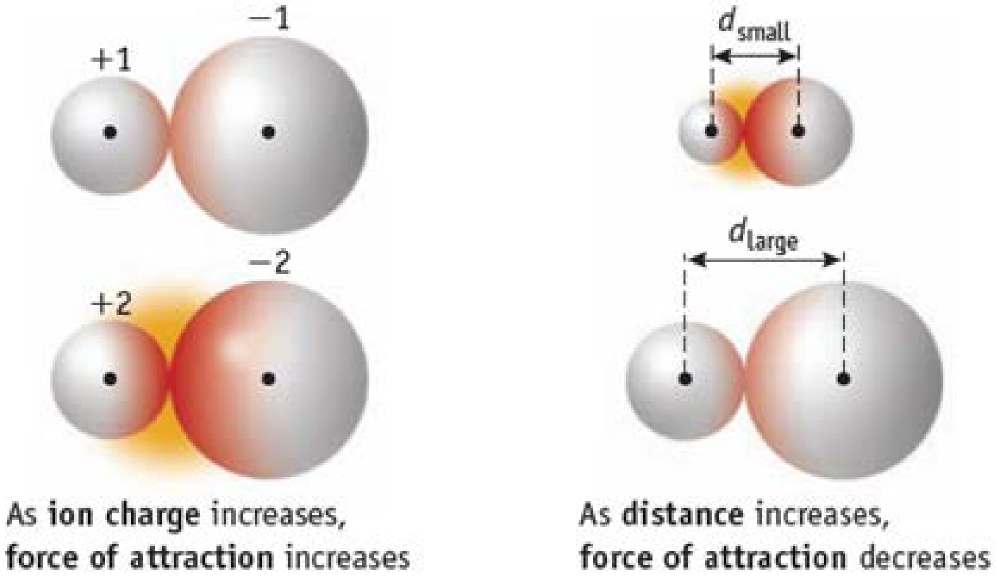
$F = k\frac{Q_1Q_2}{r^2}$ or $V = k\frac{Q_1Q_2}{r}$

$Q_1Q_2 < 0$ => attractive
$Q_1Q_2 > 0$ => repulsive



Ions such as Li^+ and F^- are held together by a coulombic force of attraction. Here a lithium ion is attracted to a fluoride ion, and the distance between the nuclei of the two ions is *d*.

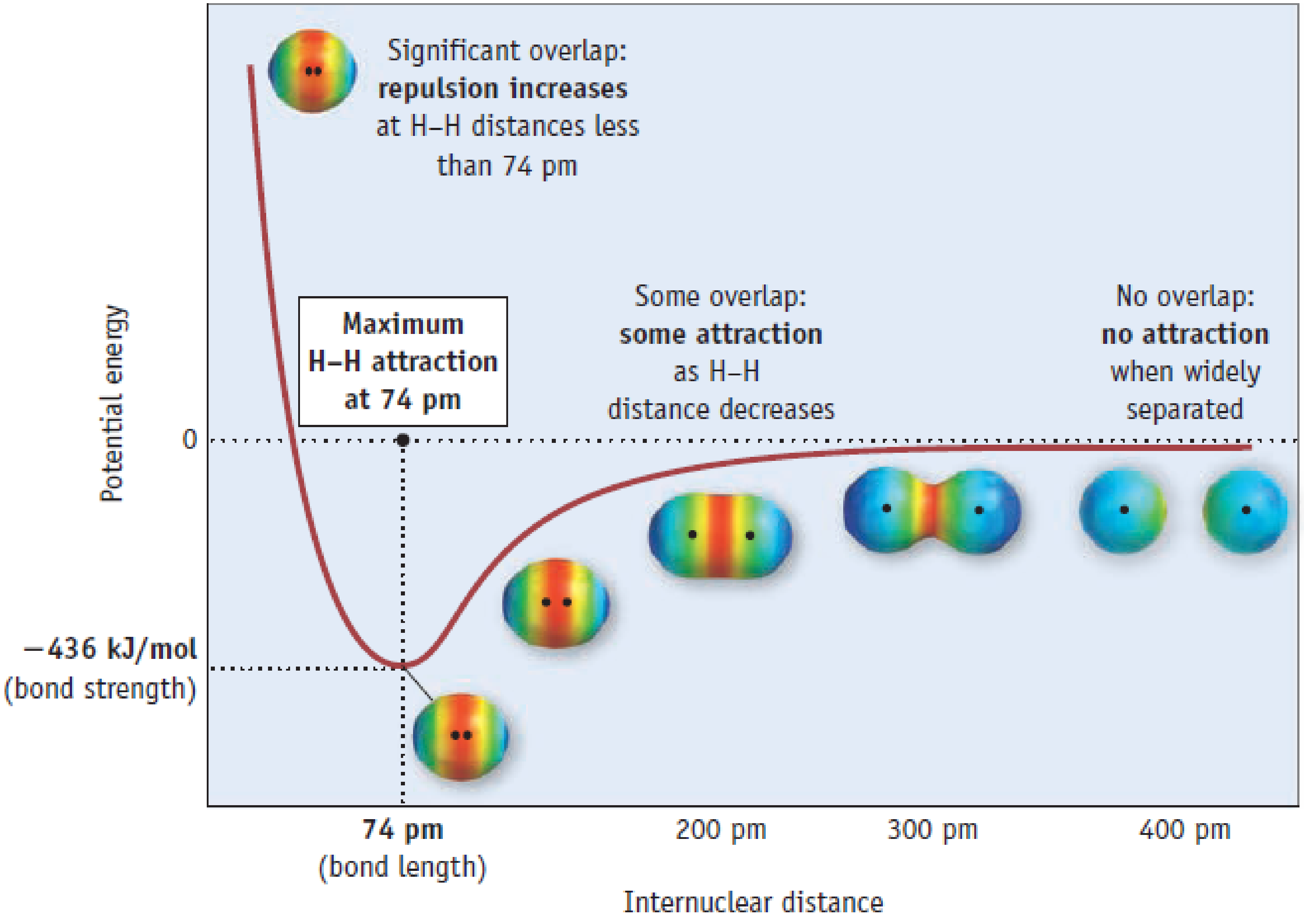
(a)



(b)

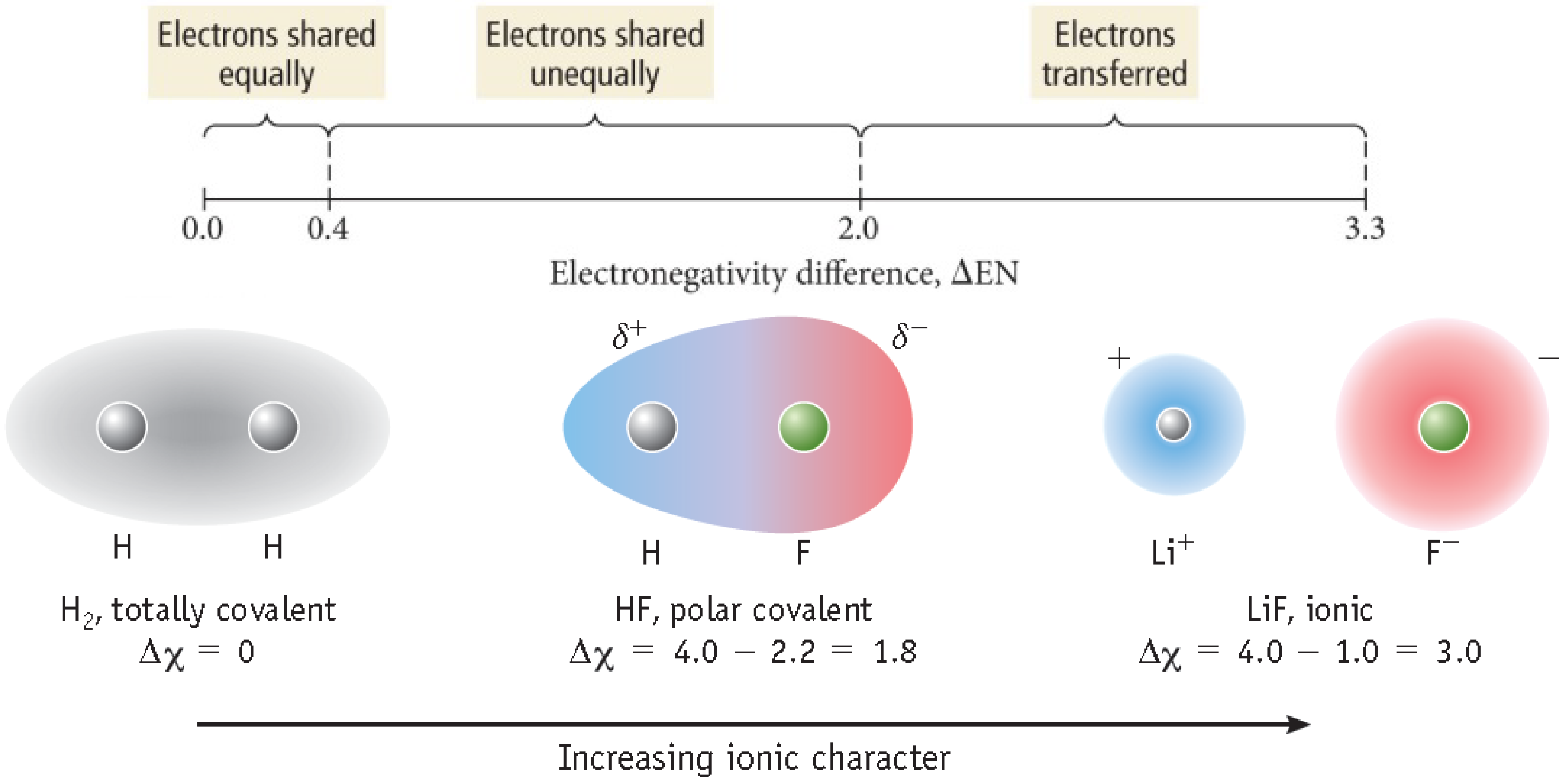
Classical Description of Bonding

2) **covalent bond –**
   e^- shared



Classical Description of Bonding

3) **polar covalent bond –** partial transfer



Periodic Trends: Ionization Energy

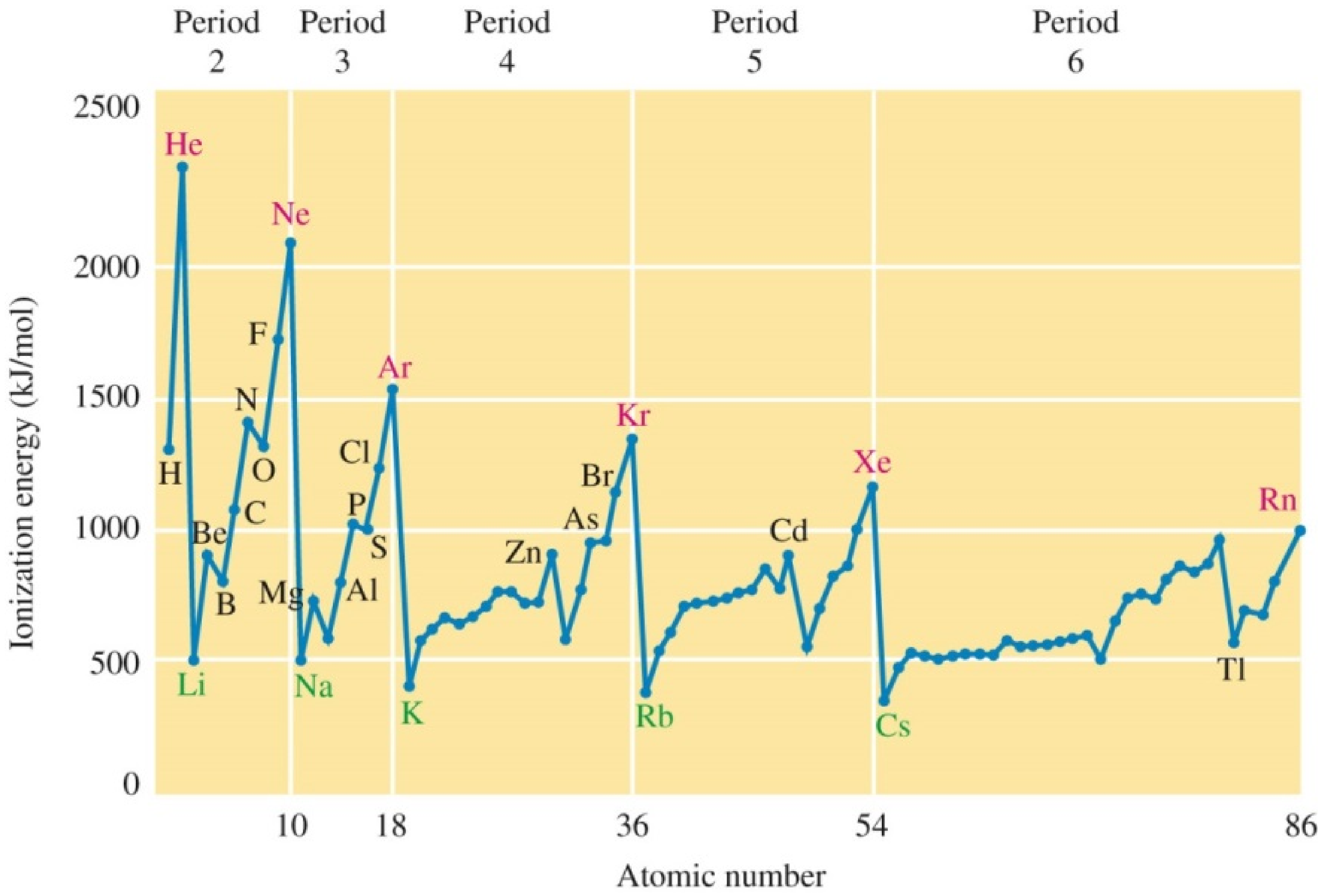


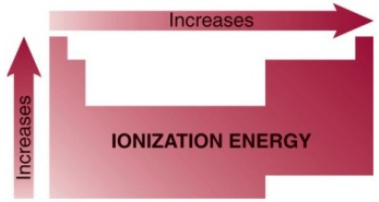
FIG I – First Ionization Energies (IE) of the Elements:

$X(g) \rightarrow X^+(g) + e^-$

shell structure

noble gas configuration

good metals



Periodic Trends: Size

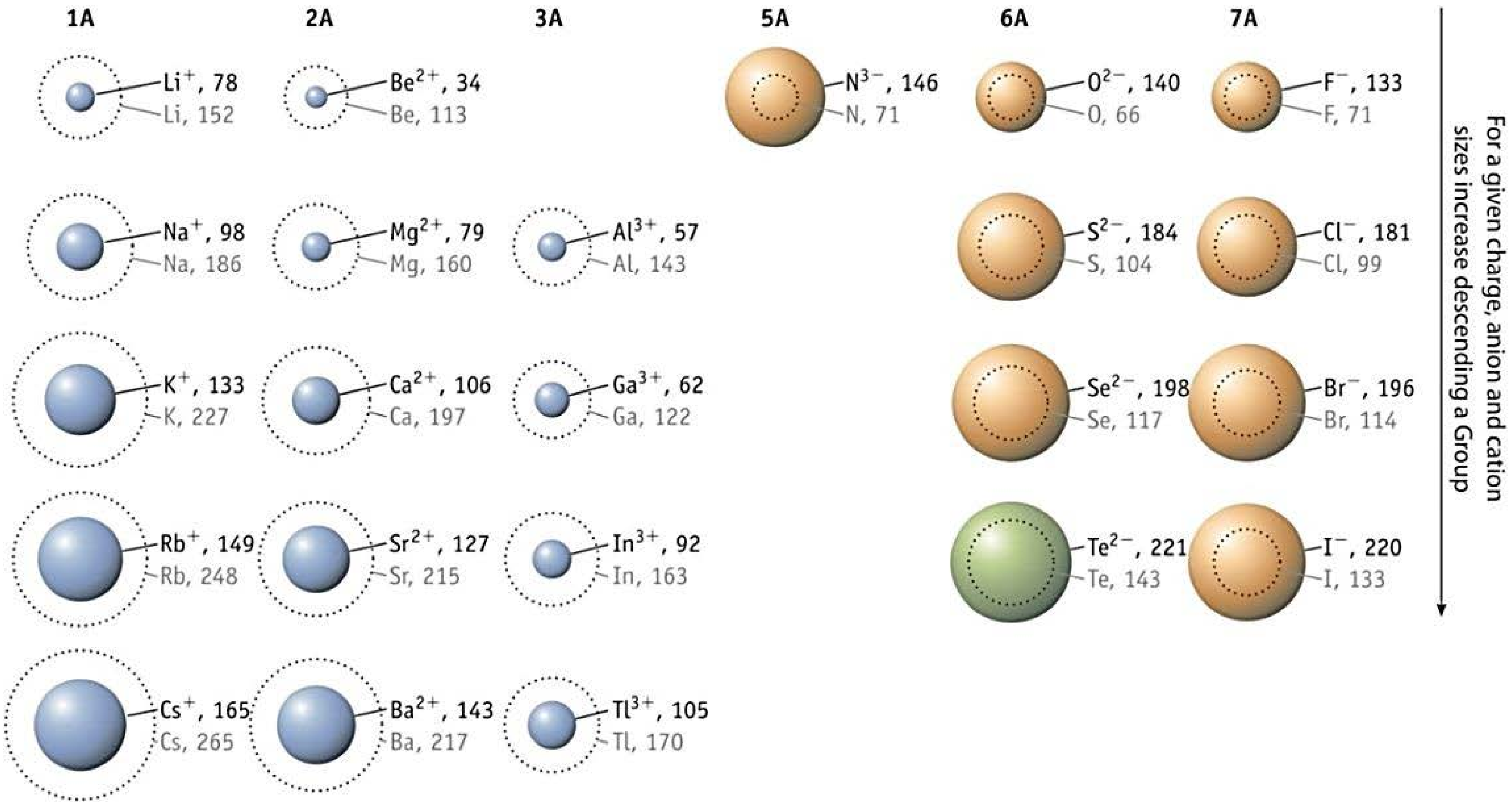
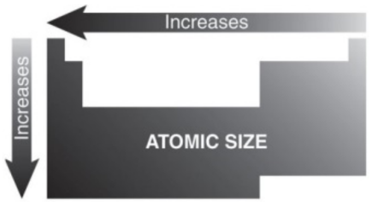


FIG II – Size of Atoms and Ions

reveals

shell structure



Periodic Trends: Electron Affinity

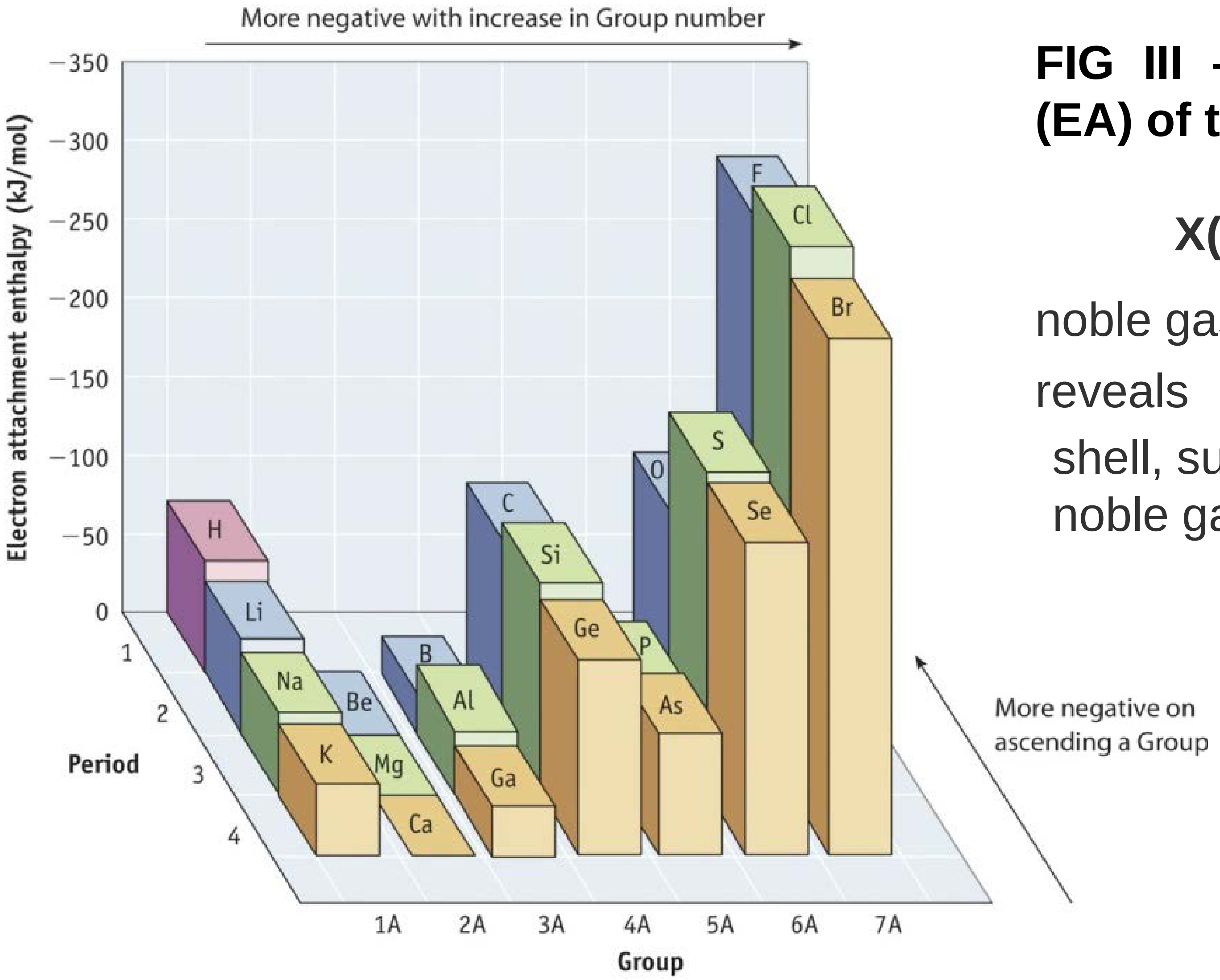


FIG III – Electron Affinities (EA) of the Elements

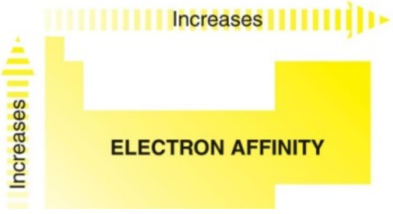
$$X(g) + e \rightarrow X^{-}(g)$$

noble gases have positive EAs

reveals

shell, subshell structure

noble gas configuration



Periodic Trends: Electronegativity

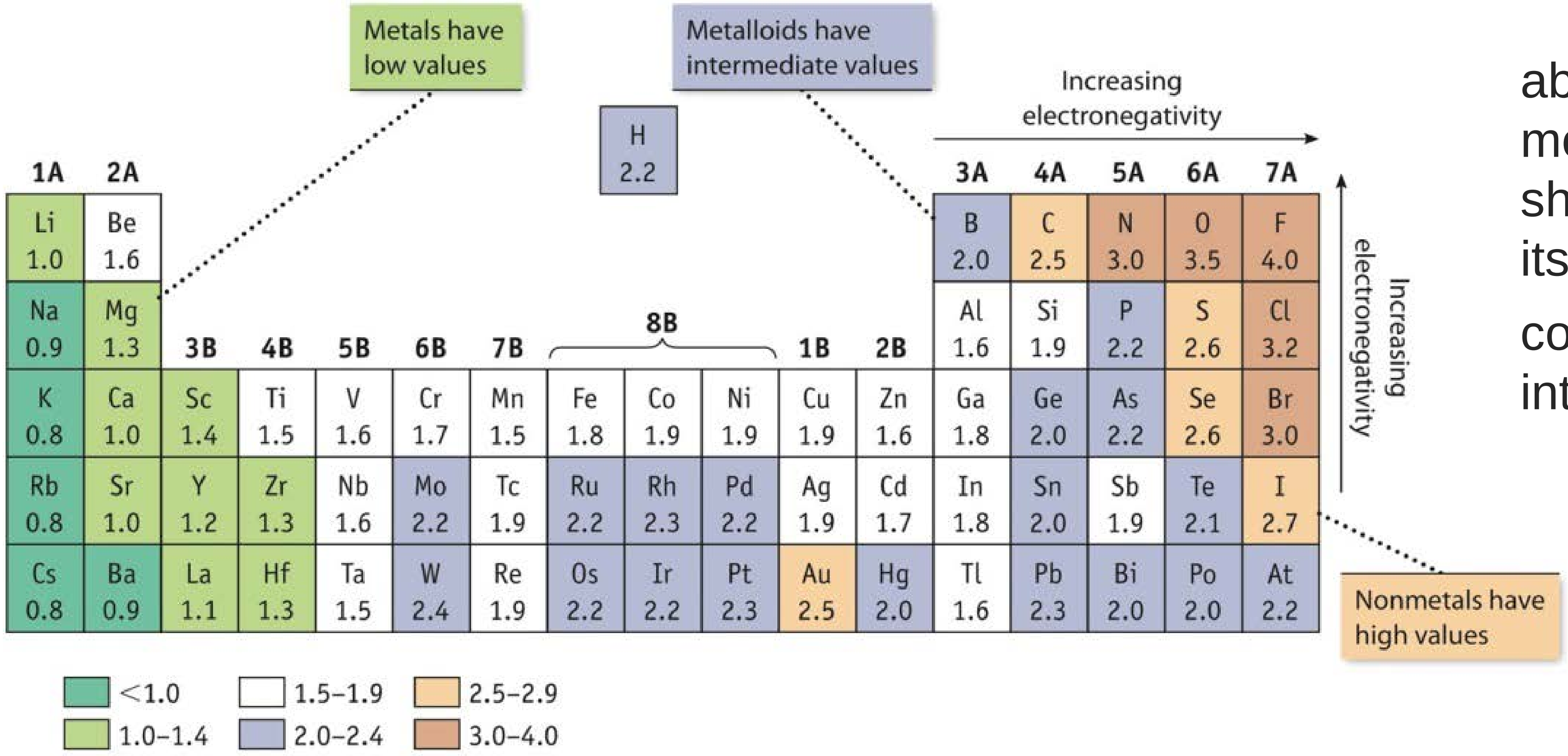


FIG IV – Electronegativities (EN) of the Elements

ability of an atom in a molecule to attract shared electrons to itself

combines IE and EA into one property

Seven SIMPLE BONDING CONCEPTS

1) Lewis structures – guidelines (13.10 – 13.12)

- determine total **number of valence electrons** from group numbers (GN); most atoms obey **octet rule** – exceptions to octet rule:

  2 – H, He
  4 – Be
  6 – B, Al
  species with odd number of electrons
  some species with an element beyond 2nd period

- draw structure with all bonding pairs and lone pairs using symmetry
- show all **resonance structures** (atoms do not move)
- determine **formal charge** (FC) on all atoms having any

  FC = GN – number of lone pair electrons – ½ number of bonding pair electrons

- **valence shell expand** (VSE) if atom is beyond 2nd period and 1) has a formal charge separation or 2) octet rule gives insufficient number of bonding electrons; VSE to minimize FC separation while maximizing number of resonance structures (VSE for Week 6)

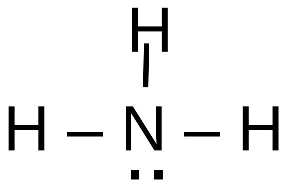
1A (1)																	8A (18)
1 **H** 1.008	2A (2)											3A (13)	4A (14)	5A (15)	6A (16)	7A (17)	2 **He** 4.0026
3 **Li** 6.94	4 **Be** 9.0122											5 **B** 10.81	6 **C** 12.011	7 **N** 14.007	8 **O** 15.999	9 **F** 18.998	10 **Ne** 20.180
11 **Na** 22.990	12 **Mg** 24.305	3B (3)	4B (4)	5B (5)	6B (6)	7B (7)	(8)	8B (9)	(10)	1B (11)	2B (12)	13 **Al** 26.982	14 **Si** 28.085	15 **P** 30.974	16 **S** 32.06	17 **Cl** 35.45	18 **Ar** 39.95
19 **K** 39.098	20 **Ca** 40.08	21 **Sc** 44.956	22 **Ti** 47.867	23 **V** 50.942	24 **Cr** 51.996	25 **Mn** 54.938	26 **Fe** 55.85	27 **Co** 58.933	28 **Ni** 58.693	29 **Cu** 63.55	30 **Zn** 65.4	31 **Ga** 69.723	32 **Ge** 72.63	33 **As** 74.922	34 **Se** 78.97	35 **Br** 79.904	36 **Kr** 83.80
37 **Rb** 85.468	38 **Sr** 87.62	39 **Y** 88.906	40 **Zr** 91.22	41 **Nb** 92.906	42 **Mo** 95.95	43 **Tc** (97/8)	44 **Ru** 101.1	45 **Rh** 102.91	46 **Pd** 106.42	47 **Ag** 107.87	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.71	51 **Sb** 121.76	52 **Te** 127.6	53 **I** 126.90	54 **Xe** 131.29
55 **Cs** 132.91	56 **Ba** 137.33	57 **La** 138.91	72 **Hf** 178.5	73 **Ta** 180.95	74 **W** 183.84	75 **Re** 186.21	76 **Os** 190.2	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 **Ac** (227)	104 **Rf** (267)	105 **Db** (268)	106 **Sg** (269)	107 **Bh** (271)	108 **Hs** (277)	109 **Mt** (276/7)	110 **Ds** (281)	111 **Rg** (282)	112 **Cn** (285)	113 **Nh** (286)	114 **Fl** (289)	115 **Mc** (290)	116 **Lv** (293)	117 **Ts** (294)	118 **Og** (294)

Lanthanides	58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** (145)	62 **Sm** 150.4	63 **Eu** 151.96	64 **Gd** 157.3	65 **Tb** 158.93	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.93	70 **Yb** 173.05	71 **Lu** 174.97
Actinides	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)	103 **Lr** (262)

1) Lewis Structures

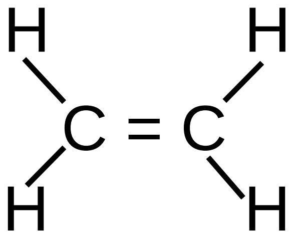
1. NH_3

VAL = 5 + 3 = 8 (/2 = **4** pairs)



2. C_2H_4

VAL = 2(4) + 4 = 12 (/2 = **6** pairs)

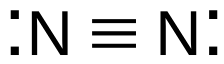


3. C_2H_2

VAL = 2(4) + 2 = 10 (/2 = **5** pairs)

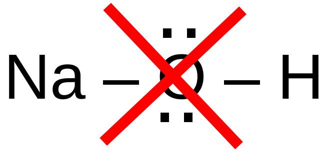
4. N_2

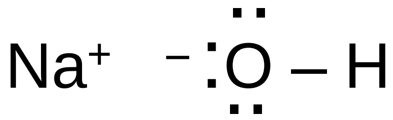
VAL = 2(5) = 10 (/2 = **5** pairs)



5. NaOH

VAL = 1 + 6 + 1 = 8 (/2 = **4** pairs)





6. S_2O