Bonding

What is Coulomb's Law?

Energy Profile:

Covalent Bonds

Electronegativity and Linus Pauling

2.1 H																
1.0 Li	1.5 Be											2.0 B	2.5 C	3.0 N	3.5 O	4.0 F
0.9 Na	1.2 Mg											1.5 Al	1.8 Si	2.1 P	2.5 S	3.0 Cl
0.8 K	1.0 Ca	1.3 Sc	1.5 Ti	1.6 V	1.6 Cr	1.5 Mn	1.8 Fe	1.8 Co	1.8 Ni	1.9 Cu	1.6 Zn	1.6 Ga	1.8 Ge	2.0 As	2.4 Se	2.8 Br
0.8 Rb	1.0 Sr	1.2 Y	1.4 Zr	1.6 Nb	1.8 Mo	1.9 Tc	2.2 Ru	2.2 Rh	2.2 Pd	1.9 Ag	1.7 Cd	1.7 In	1.8 Sn	1.9 Sb	2.1 Te	2.5 I
0.7 Cs	0.9 Ba		1.3 Hf	1.5 Ta	1.7 W	1.9 Re	2.2 Os	2.2 Ir	2.2 Pt	2.4 Au	1.9 Hg	1.8 Tl	1.8 Pb	1.9 Bi	2.0 Po	2.2 At
0.7 Fr	0.9 Ra															

Unequal Sharing

Polar Covalent Bond

Coordinate Covalent Bond

Ionic Bond

How can you theoretically determine what type of bond is forming?

F_2

H_2O

HCl

KCl

CH_4

NO_2

Lewis Structures
Valence electrons

Straight Forward Structures

H_2	Cl_2	H_2O
CH_4	I_2	NH_3
C_2H_6	CCl_4	PCl_3

Structures Containing Multiple Bonds

O_2 C_2H_4 CO_2

N_2 C_2H_2 CO

HCN C_2Cl_4 $COCl_2$

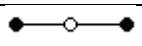
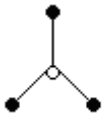
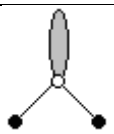
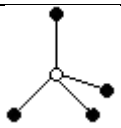
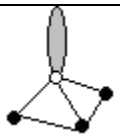
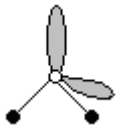
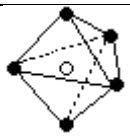
Complex Shapes/ Different Rules/ Ring Structures

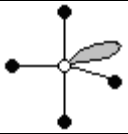
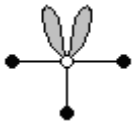
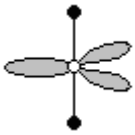
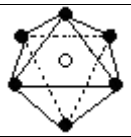
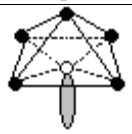
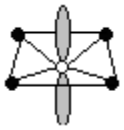
PCl_5 XeF_2 SF_4

I_3^- BeH_2 PBr_5

SF_6 BF_3 C_6H_6

VSEPR

Type	Picture	Shape	Example
A_2 and AB_2		Linear	H_2 / CO_2
AB_3		Triangular	BCl_3
AB_2E		Angular or Bent	PbI_2
AB_4		Tetrahedral	CH_4
AB_3E		Triangular pyramidal	NH_3
AB_2E_2		Angular or Bent	H_2O
AB_5		Triangular bipyramidal	PCl_5

Type	Picture	Shape	Example
AB_4E		Irregular tetrahedral (sea saw)	SF_4
AB_3E_2		T-shaped	ClF_3
AB_2E_3		Linear	XeF_2
AB_6		Octahedral	SF_6
AB_5E		Square pyramidal	ClF_5
AB_4E_2		Square planar	XeF_4
AB_7		Pentagonal bipyramidal	IF_7

Resonance

What is resonance?

NO_3^- NO_2^- XeO_3

Isomers

What is an isomer?

Draw the three Lewis Structures for $C_2H_2Cl_2$

What are cis and trans structures?

Free Radicals

Draw the Lewis Structure for NO_2 Why does it dimerize?

Lewis Acids and Bases

Formal Charge

How do you calculate formal charge?

Draw three Lewis Structures for the sulfate ion. Calculate the formal charge on sulfur for each.

Polarity

How can we distinguish between a polar bond and a polar molecule

Dipole moments

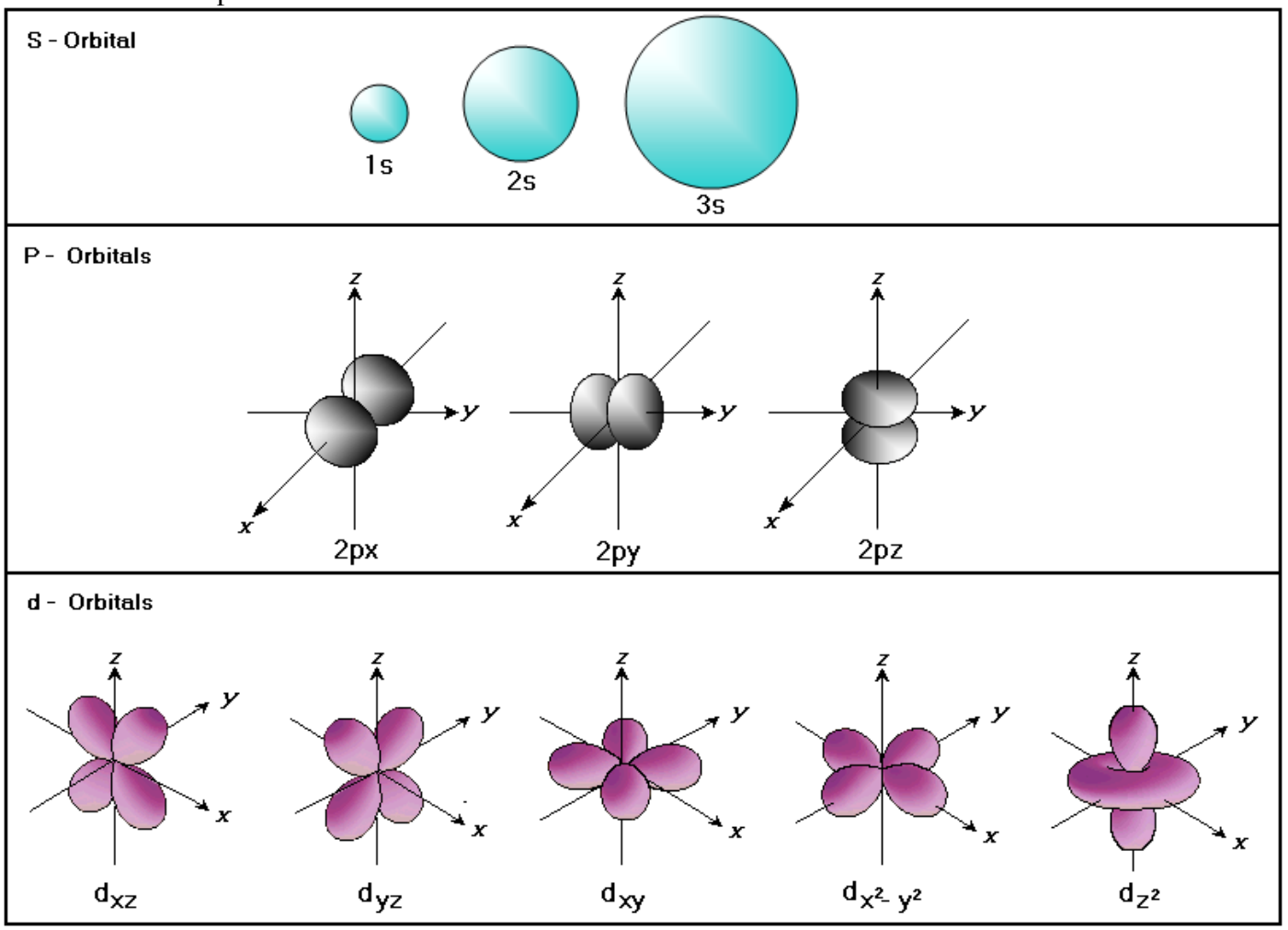
H_2 HCl

BCl_3 NH_3

How does symmetry effect a dipole moment?

Why Hybridize?

Remember the shapes of the orbitals:



sp^3 Hybridization

sp^2 Hybridization

sp Hybridization

dsp^3 Hybridization

d^2sp^3 Hybridization

How do we determine the Hybrid Orbital Number?

Number of things attached to the central atom	Hybrid Orbital Number	Geometry around the central atom	Hybridization

How does CH_4 bond together?

How does C_2H_4 bond together?

How does C_2H_2 bond together?

How does CO_2 bond together?

How does PCl_5 bond together?

How does N_2 bond together?

Molecular Orbitals

Why do we need another model?

What are M.O.'s?

What is the difference between a sigma and a pi bond?

What were the most important concepts for putting electrons into orbitals?

1)

2)

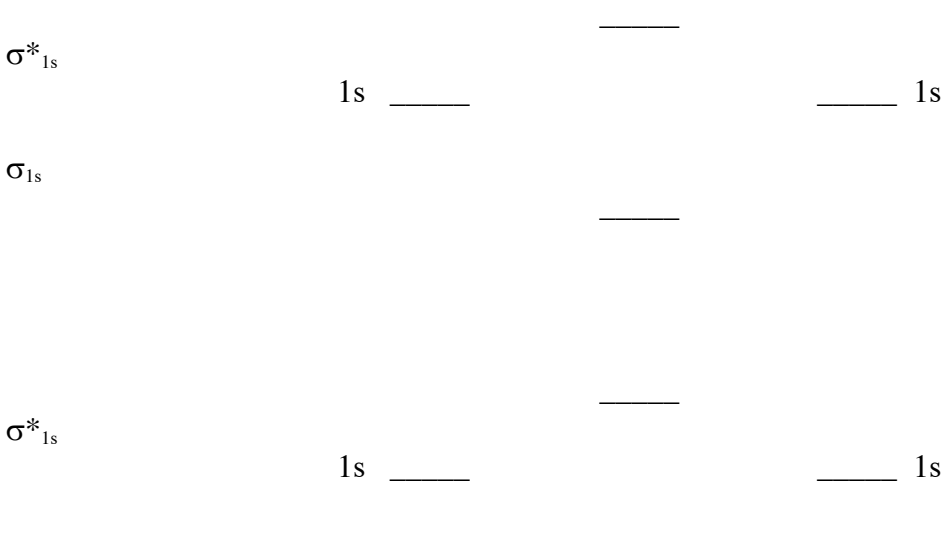
3)

Bond Order

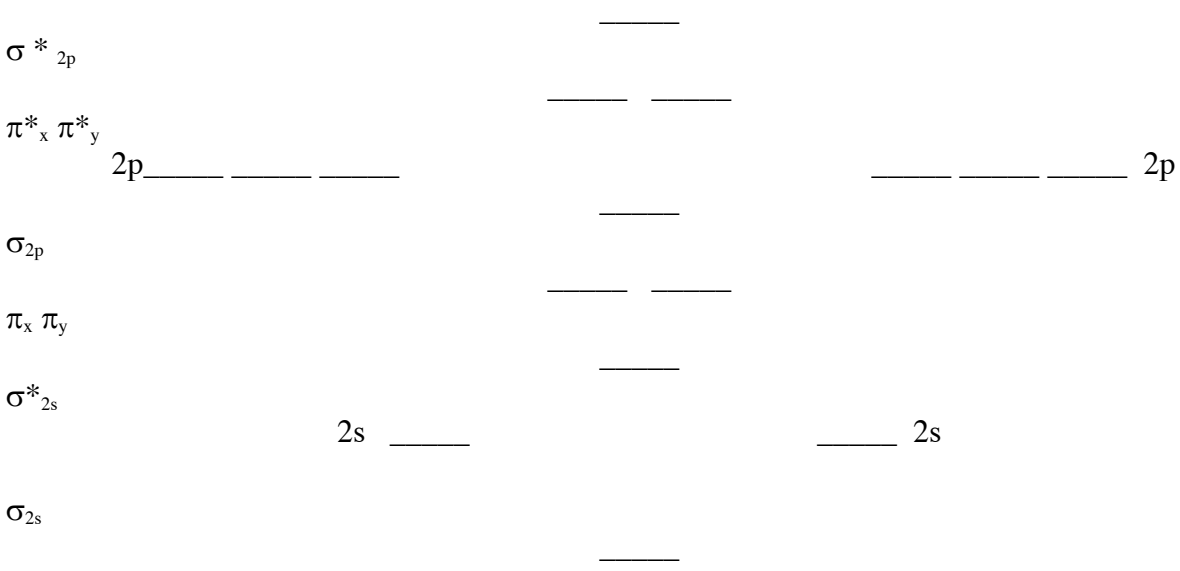
Paramagnetism versus Diamagnetism

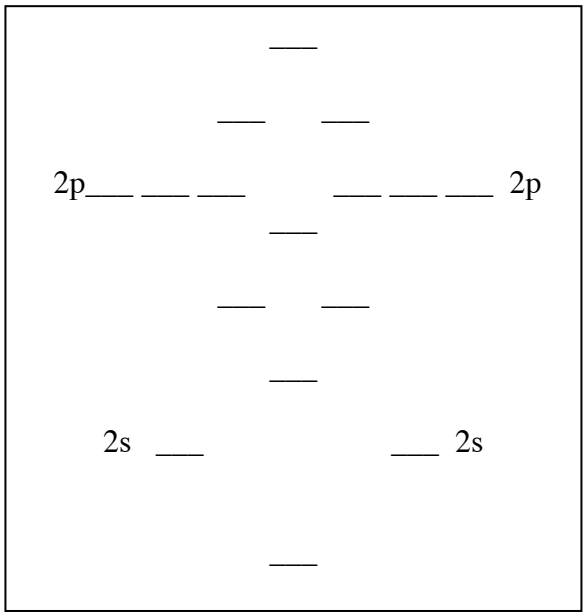
For Homonuclear Species

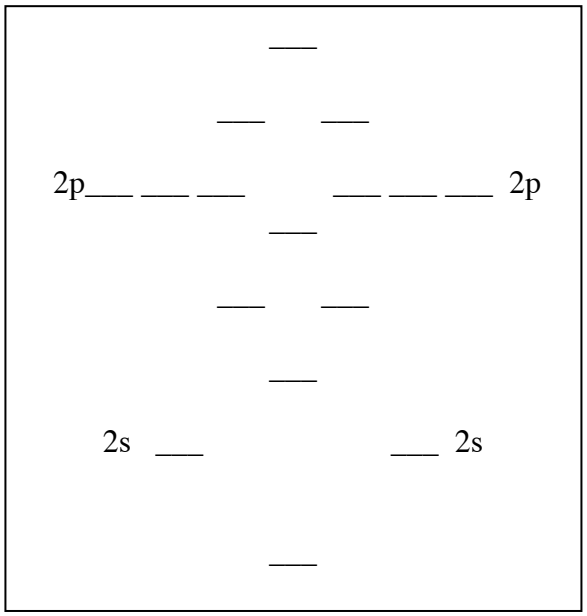
Diatomic Hydrogen and Helium

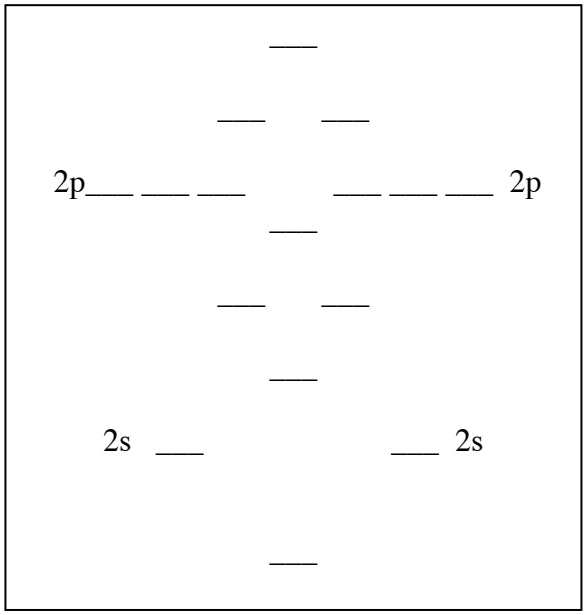


Higher Energy Orbital Filling Order




2p
2p
2s
2s


2p
2p
2s
2s


2p
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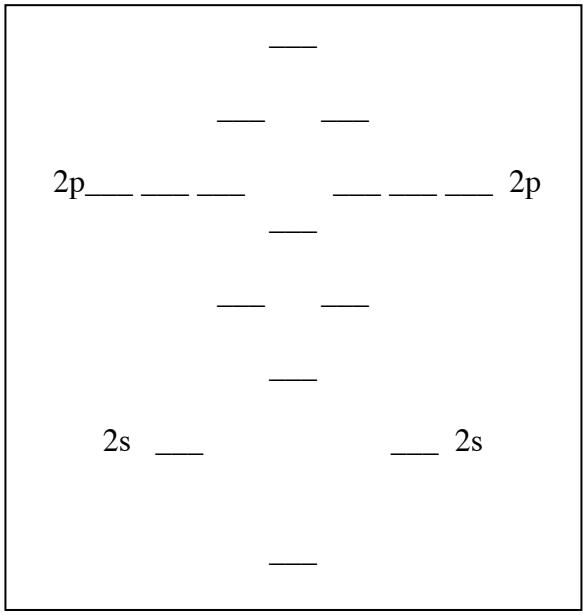
2p
2p
2s
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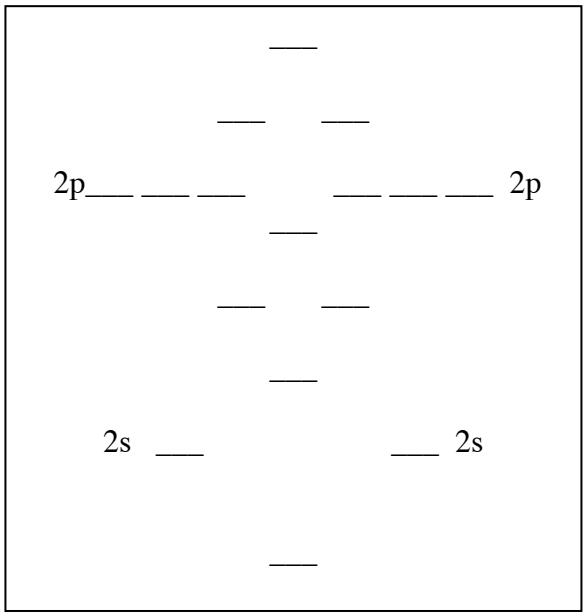
2p
2p
2s
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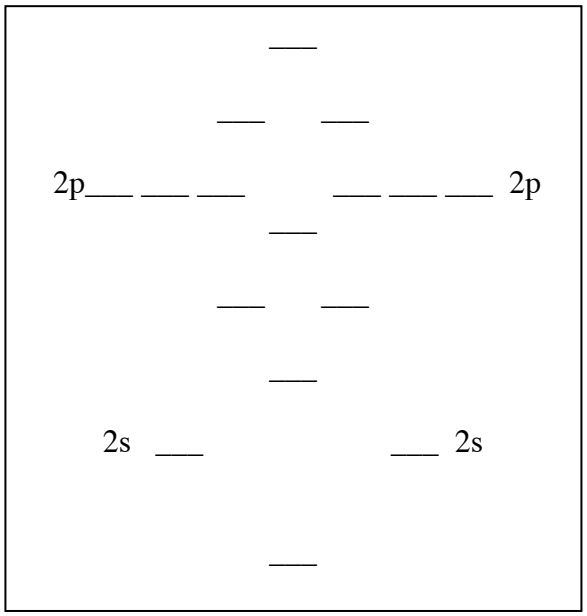

2p
2p
2s
2s

Molecule	B_2	C_2	N_2	O_2	F_2	Ne_2
Bond Order						
Magnetism						

Delocalized Electron Model

Benzene as predicted by Hybrid Orbital Model

Benzene as predicted by Molecular Orbital Model

Some Cool Molecules

1. For each of the following molecules or ions:
    a. Identify the central atom (or atoms)
    b. Draw the Lewis structure, and find from that the number of sigma bonds and the number of unshared pairs on the central atom.
    c. Identify the hybridization on the central atom.
    d. Determine the geometry of the atoms and lone pairs.
    e. Does the molecule have a dipole moment or other unusual features?

CH_4

ClF_3

H_2O

PI_5

SF_6

I_3^-

BH_3

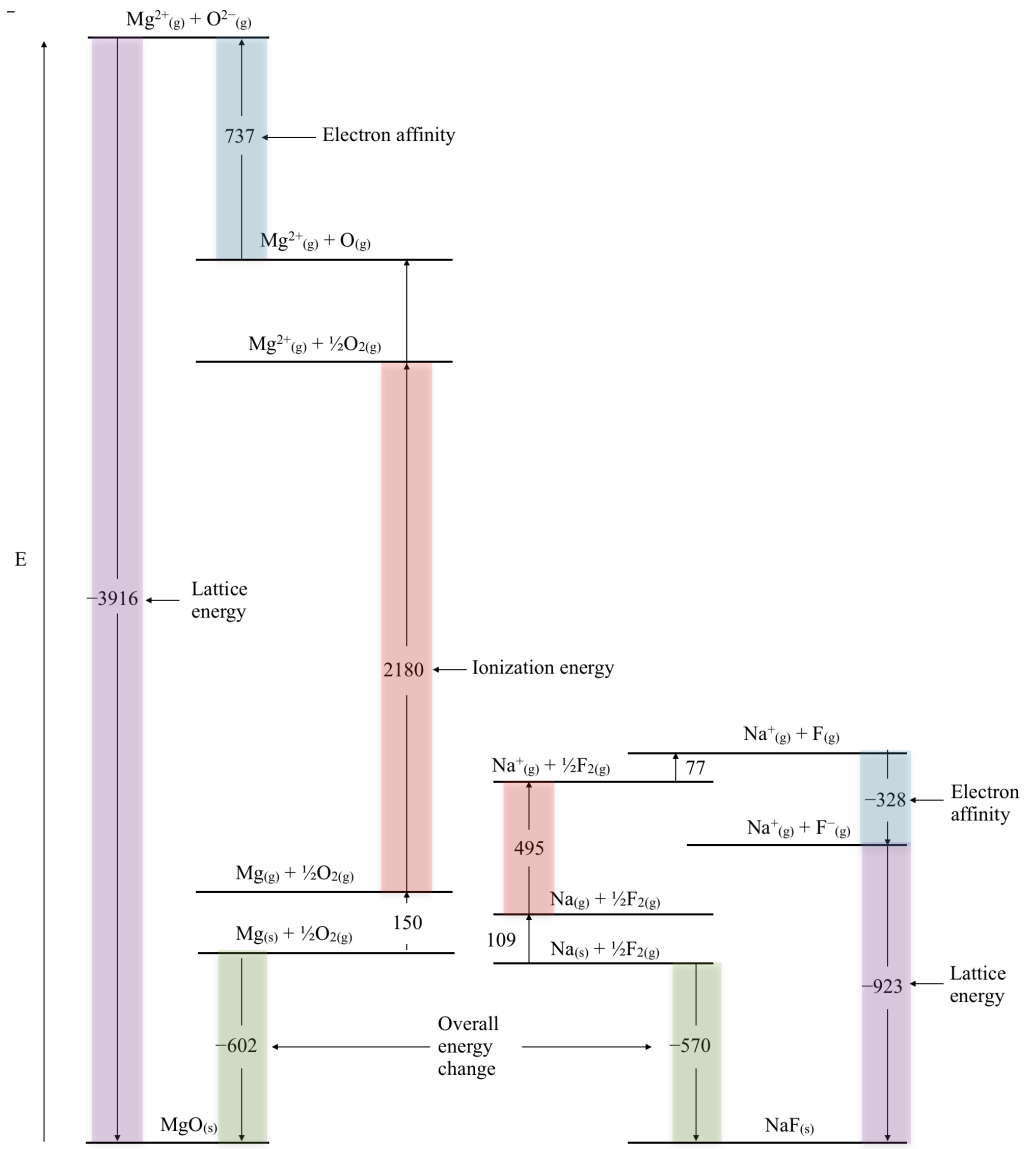
SF_4

NO_2^-

$BeCl_2$

Born-Haber Cycle

Lattice Energy



Coulombs Law helps account for this

1) Given the following equations:

$Mg(g) \leftrightarrows Mg^{2+}(g) + 2e^-$	$\Delta H^o = 2200.3$ kJ/mole
$Mg(s) \leftrightarrows Mg(g)$	$\Delta H^o = 150.2$ kJ/mole
$Cl_2(g) \leftrightarrows 2Cl(g)$	$\Delta H^o = 243.3$ kJ/mole
$Cl(g) + e^- \leftrightarrows Cl^-(g)$	$\Delta H^o = -367.8$ kJ/mole
$Mg^{2+}(g) + 2Cl^-(g) \leftrightarrows MgCl_2(s)$	$\Delta H^o = -2500$ kJ/mole

Find the Heat of Formation for $MgCl_2(s)$: $Mg(s) + Cl_2(g) \leftrightarrows MgCl_2(s)$ $\Delta H^o = ?$

2) Given the following equations:

$K(s) + \frac{1}{2} F_2(g) \leftrightarrows KF(s)$	$\Delta H^o = -562.6$ kJ/mole
$K(g) \leftrightarrows K^+(g) + e^-$	$\Delta H^o = 424.93$ kJ/mole
$F(g) + e^- \leftrightarrows F^-(g)$	$\Delta H^o = -349.7$ kJ/mole
$K(s) \leftrightarrows K(g)$	$\Delta H^o = 90.0$ kJ/mole
$F_2(g) \leftrightarrows 2F(g)$	$\Delta H^o = 157.99$ kJ/mole

Find the Lattice Energy for KF: $K^+(g) + F^-(g) \leftrightarrows KF(s)$ $\Delta H^o = ?$

3) Calculate the Lattice Energy for MgO from the following data:

Heat of formation for MgO(s)	–602 kJ/mole
Heat of sublimation for Mg(s)	150 kJ/mole
Ionization energy for Mg to Mg^{2+}	2188 kJ/mole
Bond energy for O_2	498 kJ/mole
Electron Affinity for O(g)	737 kJ/mole

4) Use the following data to estimate the Heat of Formation for KCl:

Lattice Energy	–690 kJ/mole
Ionization energy for K	419 kJ/mole
Electron Affinity of Cl	–349 kJ/mole
Bond energy of Cl_2	239 kJ/mole
Enthalpy of sublimation for K	64 kJ/mole