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 $COCl_2$

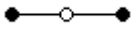
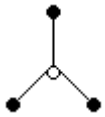
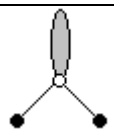
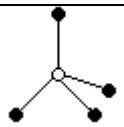
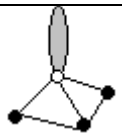
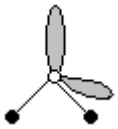
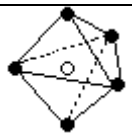
Complex Shapes/ Different Rules/ Ring Structures

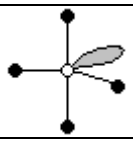
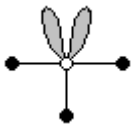
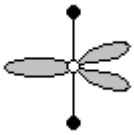
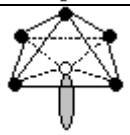
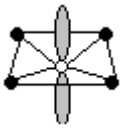
PCl_5 XeF_2 SF_4

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

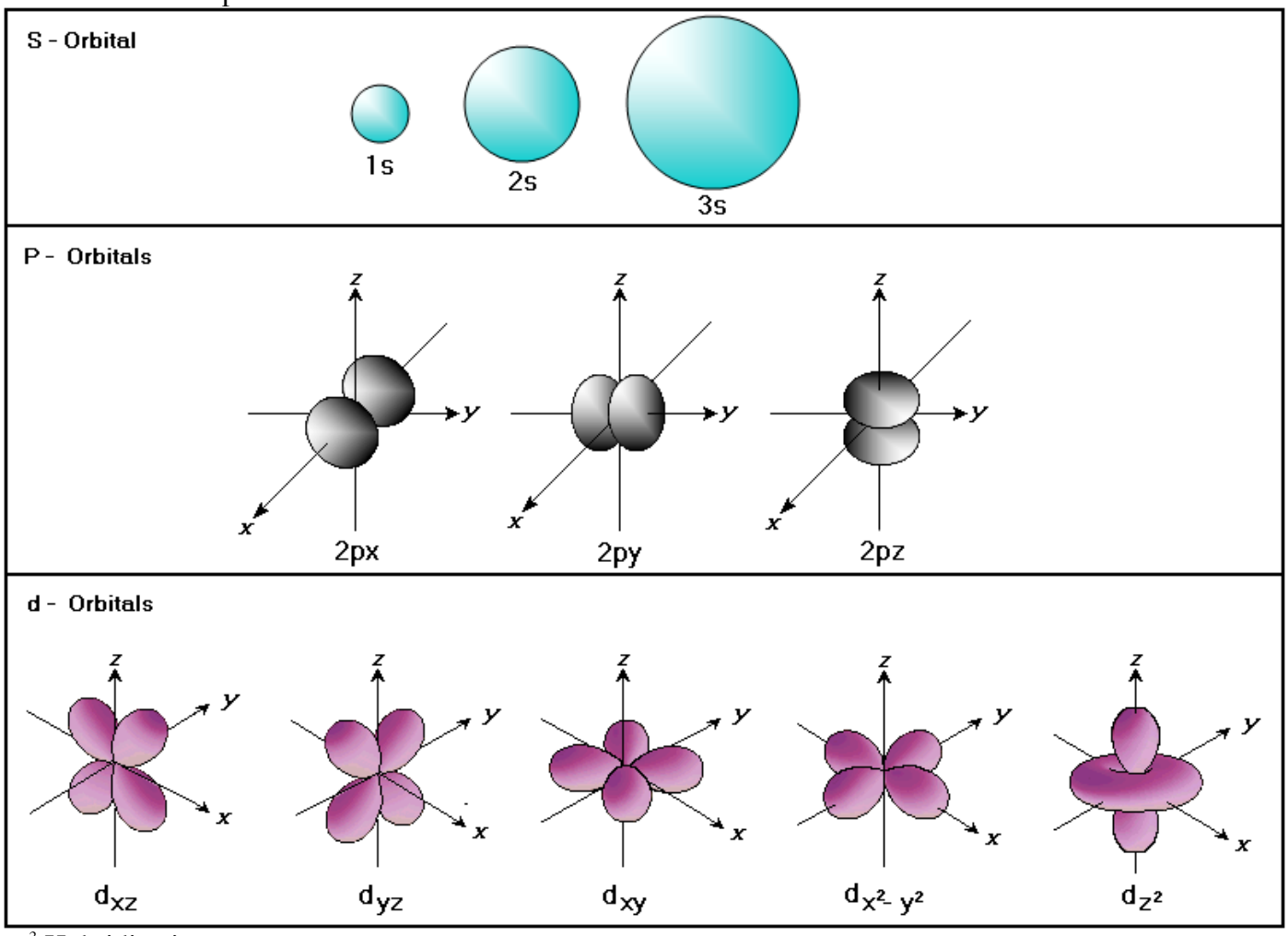
H_2 HCl

BCl_3 NH_3

How does symmetry effect a dipole moment?

Why Hybridize?

Remember the shapes of the orbitals:



sp^3 Hybridization

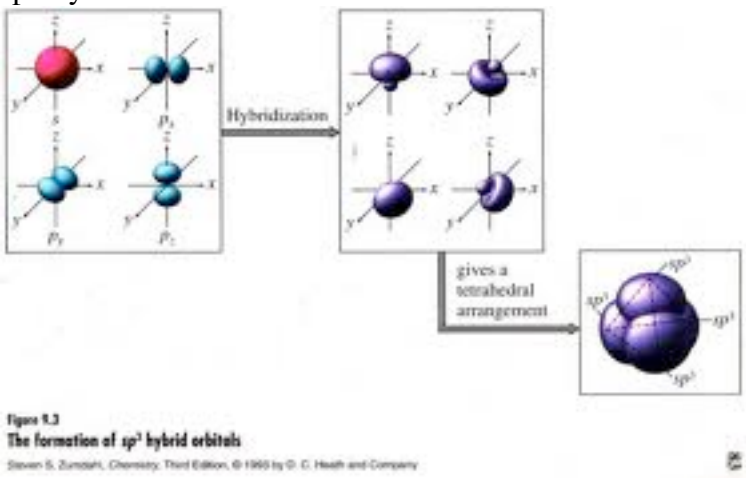


Figure 9.3
The formation of sp^3 hybrid orbitals

sp^2 Hybridization

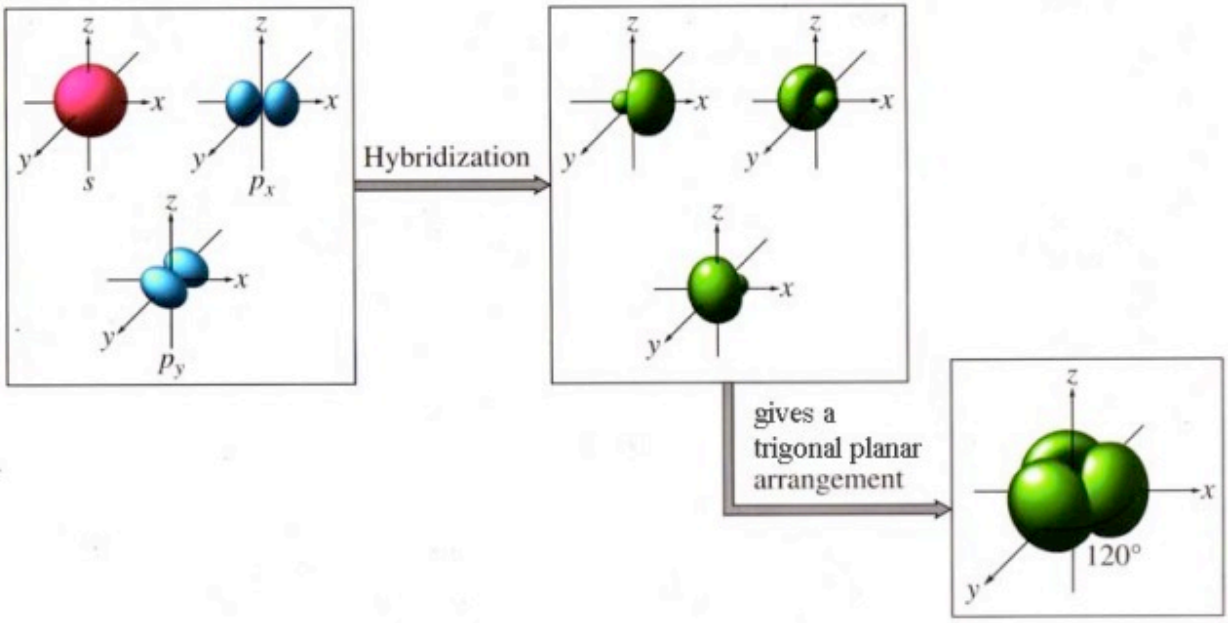


Figure 9.8
The formation of sp^2 hybrid orbitals

Steven S. Zumdahl, *Chemistry*, Third Edition, © 1993 by D. C. Heath and Company

98

sp Hybridization

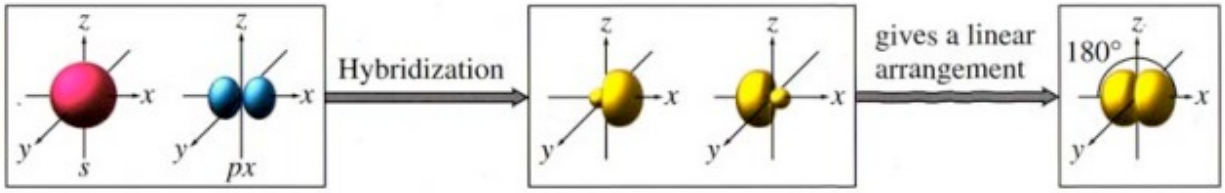
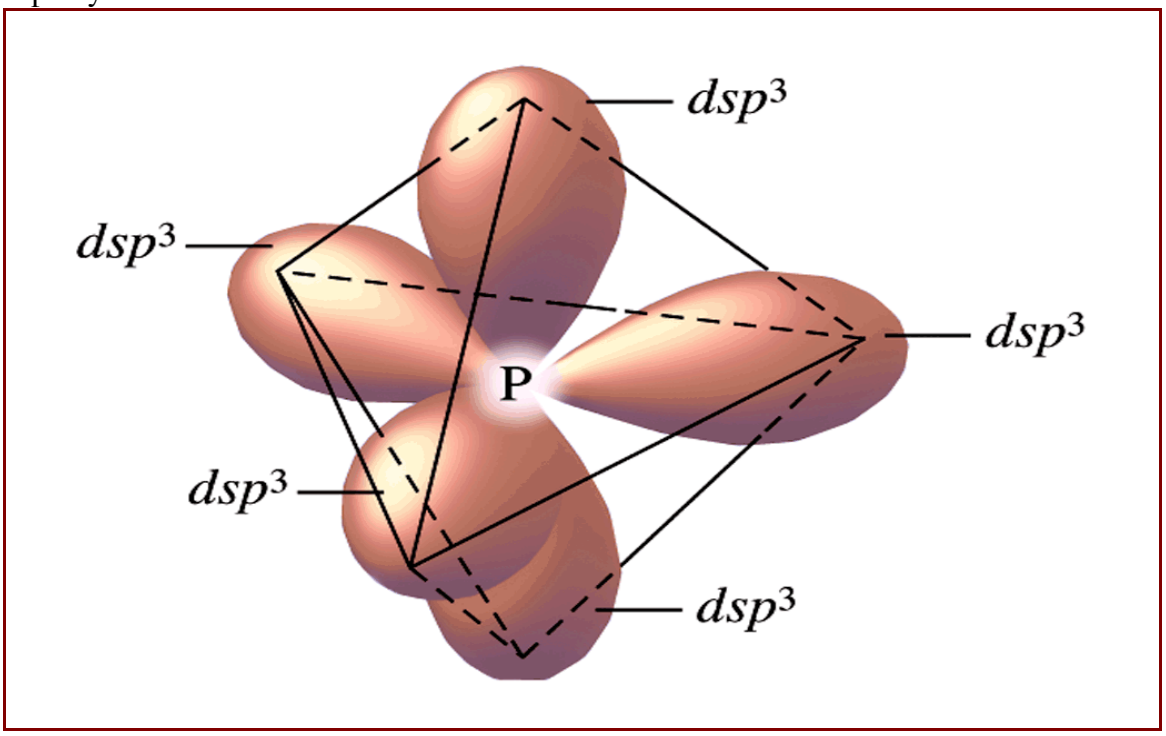


Figure 9.14
The formation of *sp* hybrid orbitals

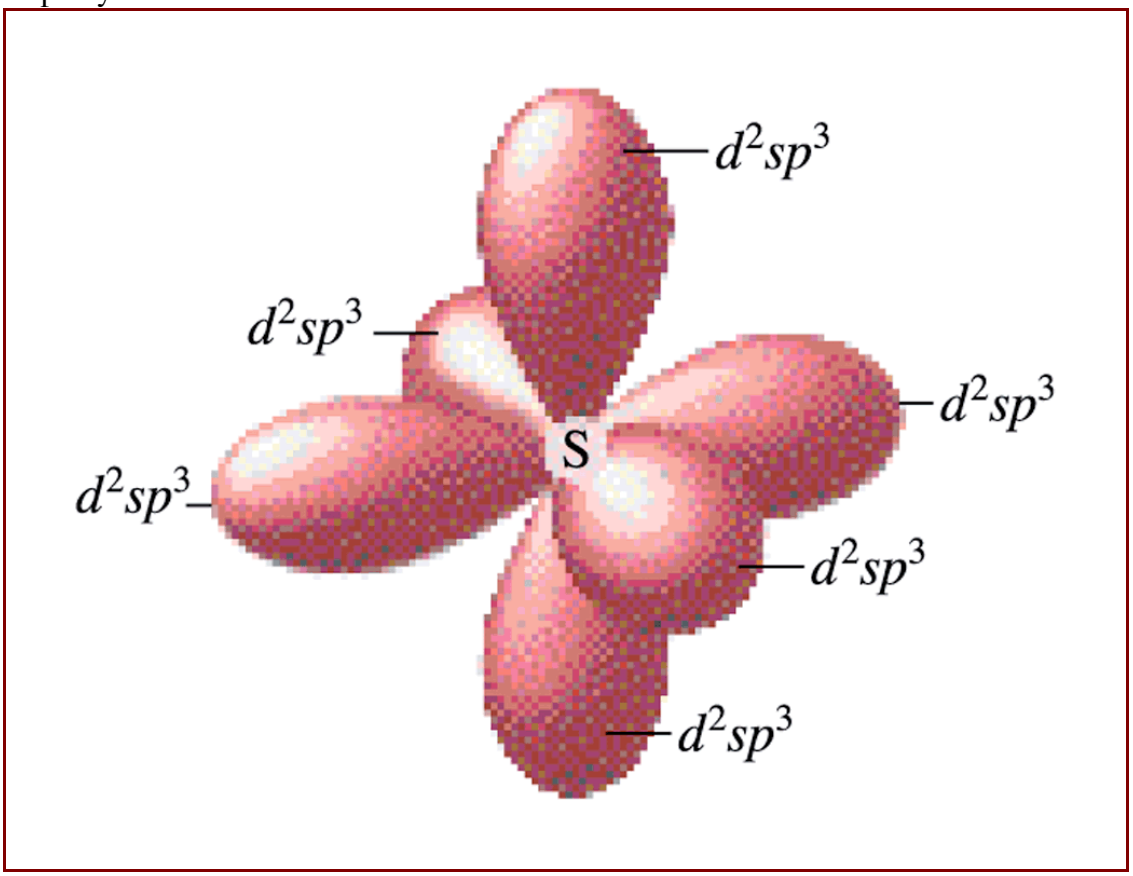
Steven S. Zumdahl, *Chemistry*, Third Edition, © 1993 by D. C. Heath and Company

16

dsp^3 Hybridization



d^{2}sp^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

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^-

$BeCl_2$

1999

Answer the following questions using principles of chemical bonding and molecular structure.

(a) Consider the carbon dioxide molecule, CO_2, and the carbonate ion, CO_3^{2-}.

(i) Draw the complete Lewis electron-dot structure for each species.

(ii) Account for the fact that the carbon-oxygen bond length in CO_3^{2-} is greater than the carbon-oxygen bond length in CO_2.

(b) Consider the molecules CF_4 and SF_4.

(i) Draw the complete Lewis electron-dot structure for each molecule.

(ii) In terms of molecular geometry, account for the fact that the CF_4 molecule is nonpolar, whereas the SF_4 molecule is polar.

1989

CF_4 XeF_4 ClF_3

(a) Draw a Lewis electron–dot structure for each of the molecules above and identify the shape of each.

(b) Use the valence shell electron–pair repulsion (VSEPR) model to explain the geometry of each of these molecules.