

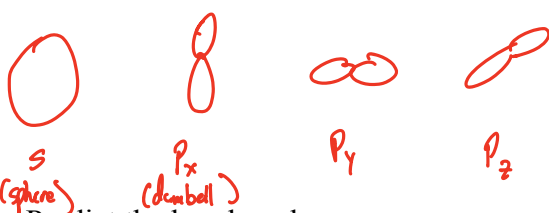
CHEM 223 (2024) SI Session # 2

Learning Objectives: By the end of this session, students should be able to:

- Describe the difference between hybrid and molecular orbitals
- Predict the type of molecular orbital produced by the overlap of two orbitals
- Use the hybridization of an atom to predict its bond angles
- Use line angle and lewis structures to predict the direction of bond dipoles

Section 1: Hybridization

1. Draw the 4 orbitals that a carbon atom can use to hybridize. How many of them are degenerate?



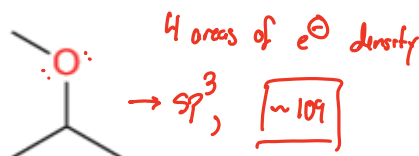
p orbitals are degenerate => all have the same energy.

2. Predict the bond angles

- a. Bond between O and CH₃

FQ: hybridization of the central carbon? → sp³

ether functional group



- b. (From 2023's Exam 1) Bond between N and CH₃

FQ: hybridization of the C=O carbon? → sp²
FQ: hybridization of the C=O oxygen? → sp²

amide functional group



N must be sp² to accommodate the resonance form. => [120°]

from last week: resonance limits the hybridization.

Section 2: Molecular Orbitals

3. What is a molecular orbital? How does a "bond" happen from an orbital perspective?

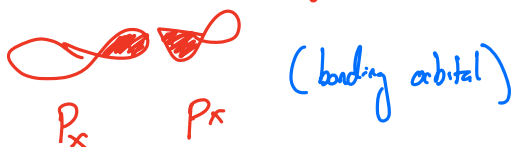
↳ orbitals that occur due to the interaction of 2 (or more) atoms.

↳ hybridization is within an atom.

↳ Bond = overlap of 2 orbitals. → σ vs π (below) & bonding vs antibonding (constructive vs destructive)

4. What is the difference between a sigma and pi bond, geometrically?

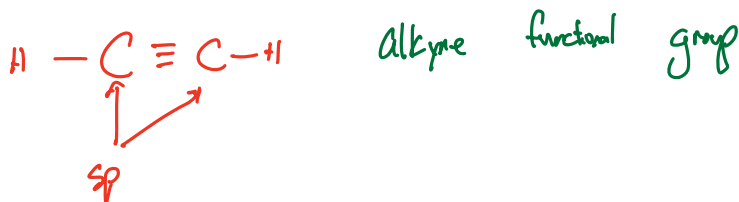
σ: head to head overlap:



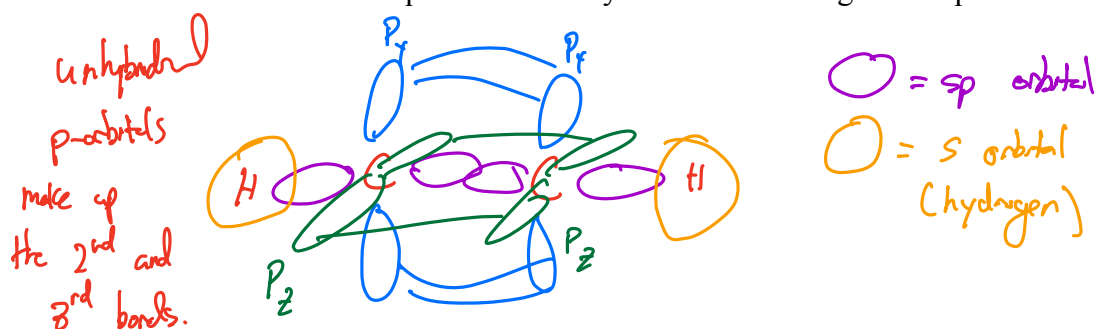
π: indirect, parallel overlap:



5. Using acetylene (the common name for C_2H_2 , or $HCCH$), answer the following questions
- Draw the lewis diagram of the molecule



- Draw the “orbital picture” of acetylene. Label the sigma and pi bonds.



6. (From 2023's Exam 1) Which of the following statements concerning pi molecular orbitals is/are correct?

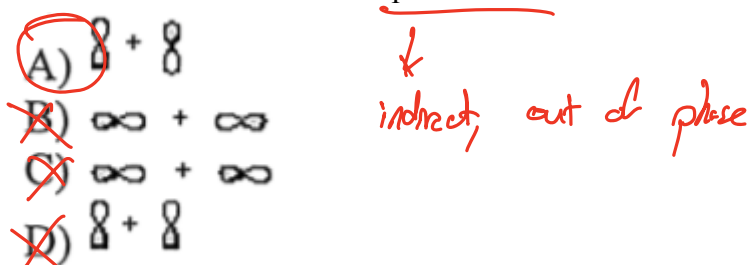
- ☒ Pi molecular orbitals are cylindrically symmetric σ MOs are.
- ☒ Most of the electron density in a pi molecular orbital is centered above and below the internuclear axis Symmetric along the cylinder
- ☒ When two atoms are connected by a double bond, both of these bonds are pi bonds.
- ☒ Both B and C
- ☒ All of the above

7. (From 2023's Exam 1) Which of the following orbital combinations will result in a sigma bond?

↓
 direct overlap,
 in-phase

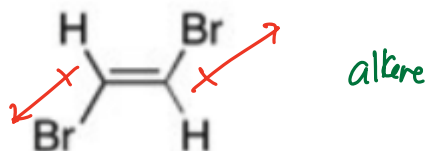
- ☒ $p + p$ π^* (out of phase)
- ☒ $\infty + \infty$ (in-phase, σ)
- ☒ $\infty + \infty$ σ^* (out of phase)
- ☒ $p + p$ π (in-phase, π)

8. Which of the following orbital combinations will result in a pi antibond?



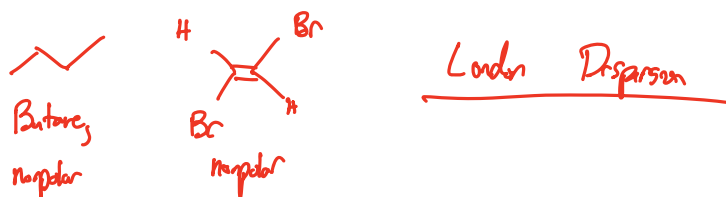
Section 3: Bond Dipoles & Intermolecular forces

9. (From 2021's Exam 1) Do you expect the following compound, 1,2 dibromoethene, to be polar? Explain by drawing the individual bond dipoles.



No; the C-Br bonds are trans, so the bond dipoles will cancel out.

10. The compound in (6) is put into a solution of butane. What is the strongest intermolecular force between the two?



11. Between diethyl ether (shown below) and ethanol, which compound has the higher boiling point? Explain your answer by drawing the interactions between the two.



ethanol; it can H-bond with itself:
 ether can hydrogen bond, but not with itself

