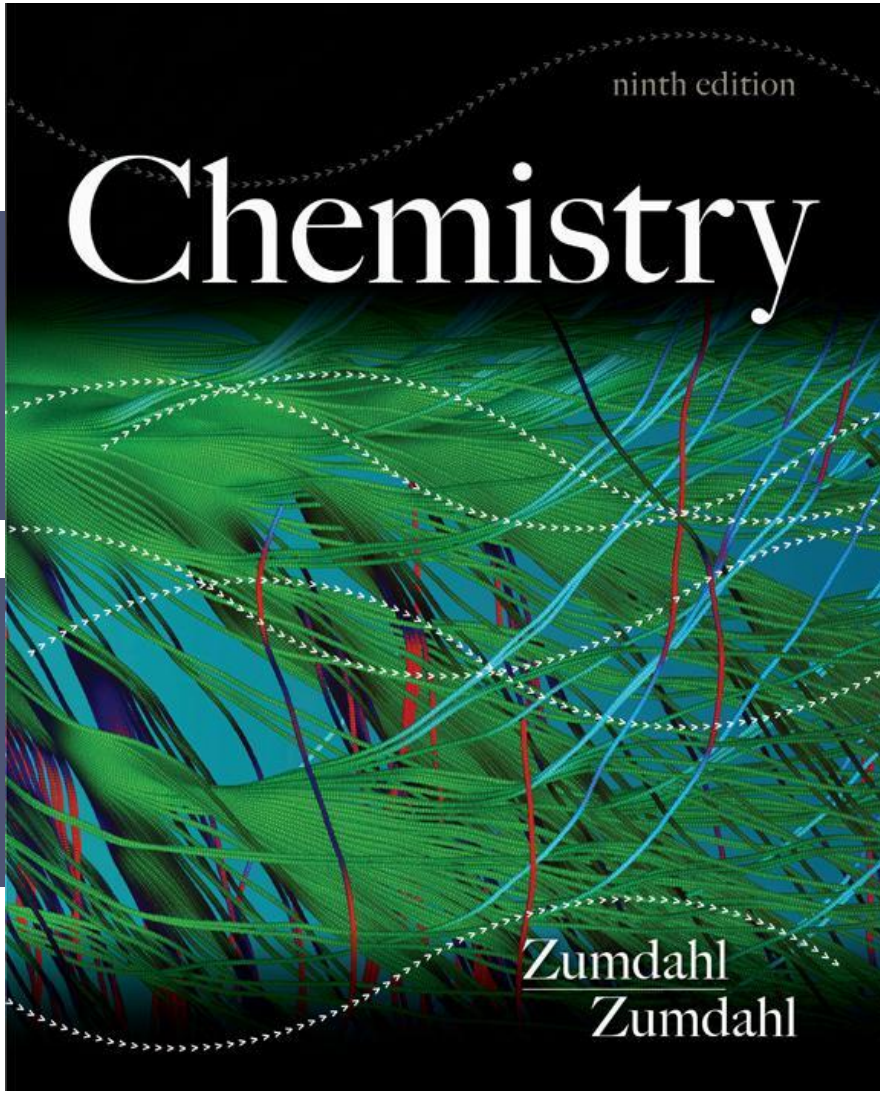
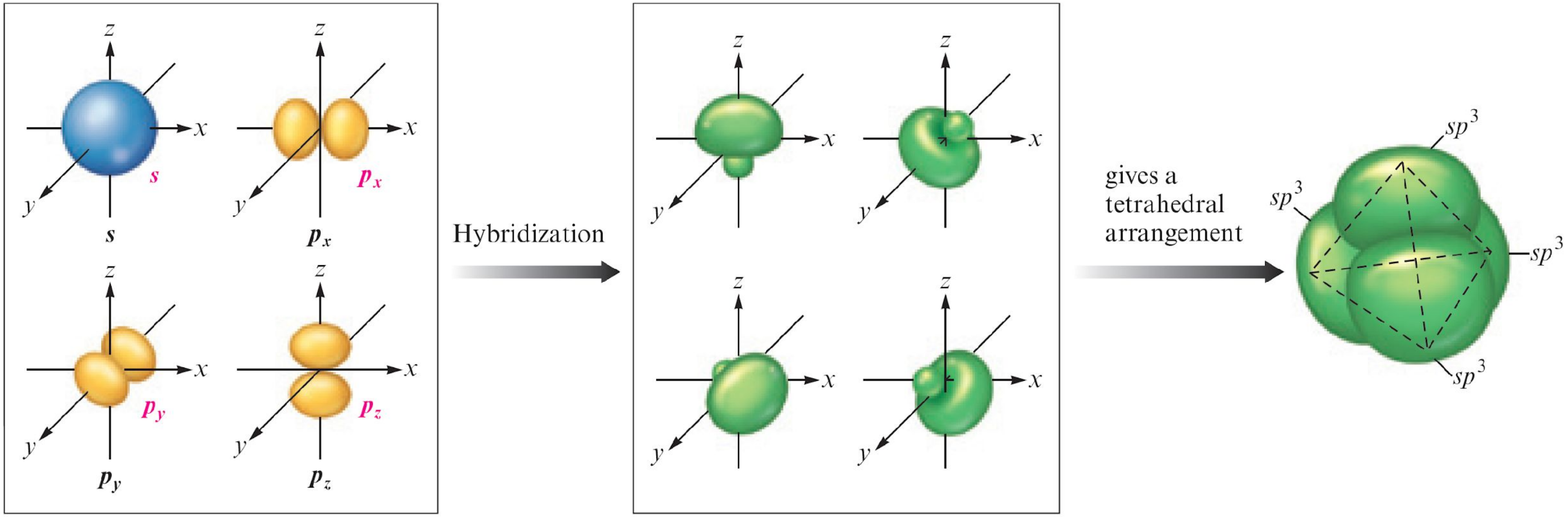


Chapter 9

Covalent Bonding: Orbitals

Figure 9.3 - sp^3 Hybridization of a Carbon Atom



Orbital Energy-Level Diagram

- Example - Hybridization of the carbon 2*s* and 2*p* orbitals in methane

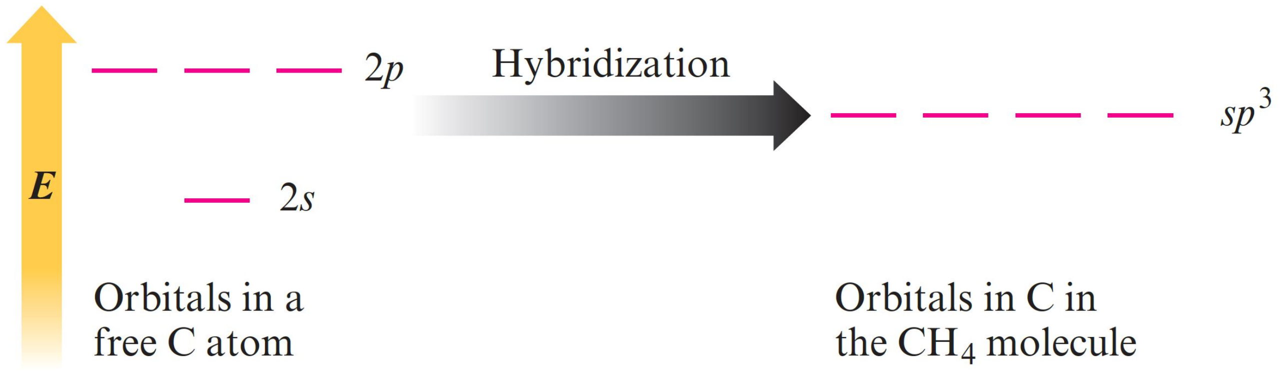
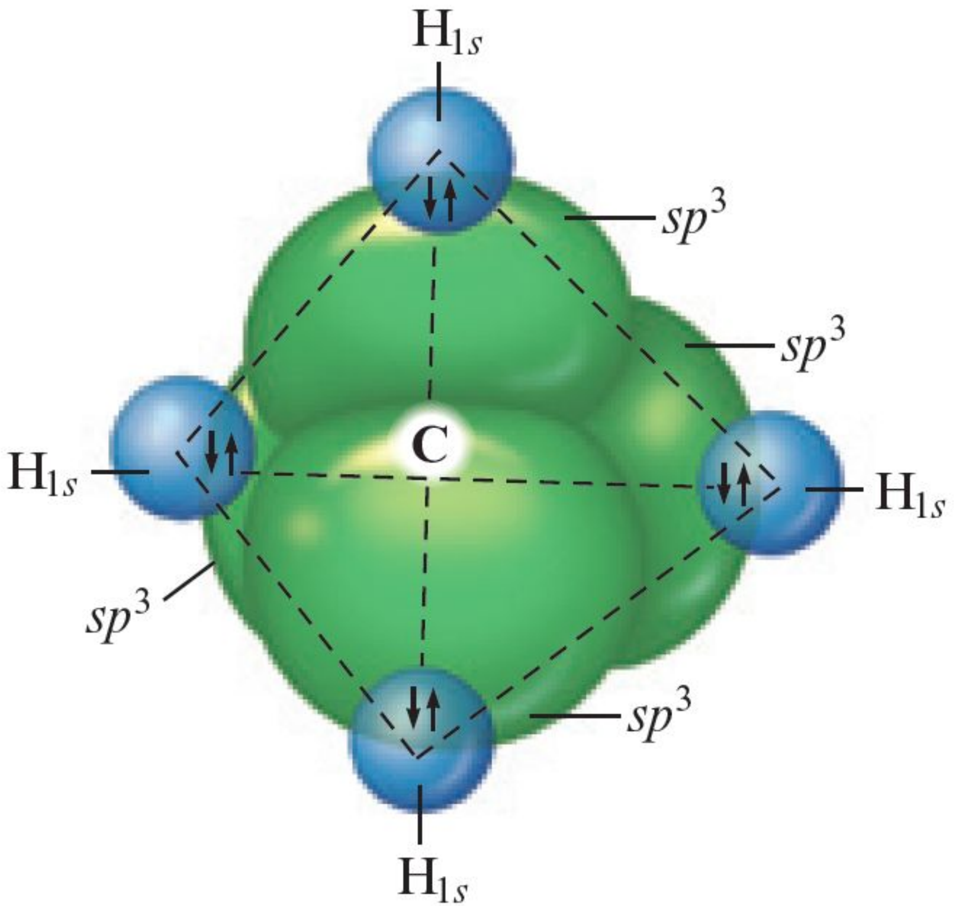


Figure 9.6 - Tetrahedral Set of Four sp^3 Orbitals



Answer in your notes, compare with a partner

- Describe the bonding in the ammonia molecule using the localized electron model

Example 9.1 - Solution

- Write the Lewis structure
- Determine arrangement of e- pairs using VSEPR
- Determine the hybrid orbitals needed

Example 9.1 - Solution (Continued 2)

- In the NH_3 molecule, three sp^3 orbitals are used to form bonds to three hydrogen atoms, and the fourth sp^3 orbital holds the lone

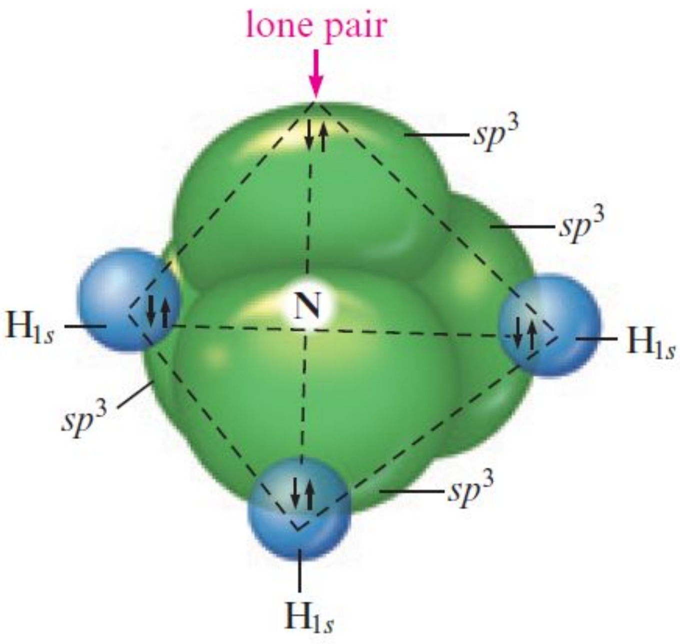


Figure 9.8 - Formation of sp^2 Orbitals

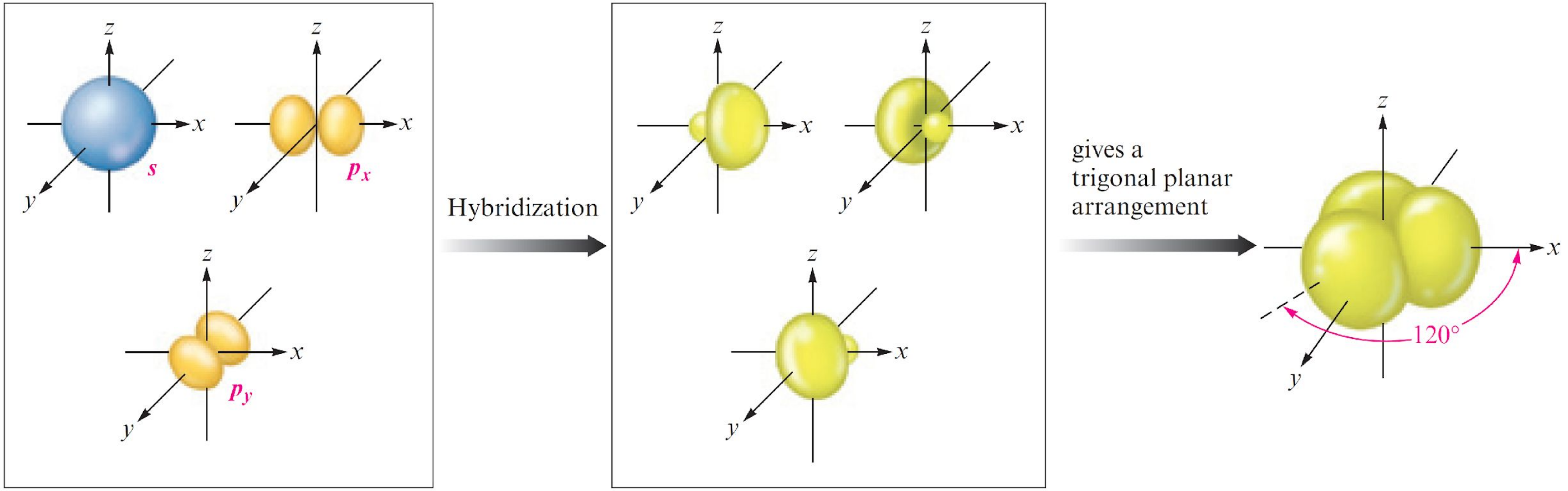


Figure 9.9 - Orbital Energy-Level Diagram for the Formation of *sp*² Orbitals in Ethylene

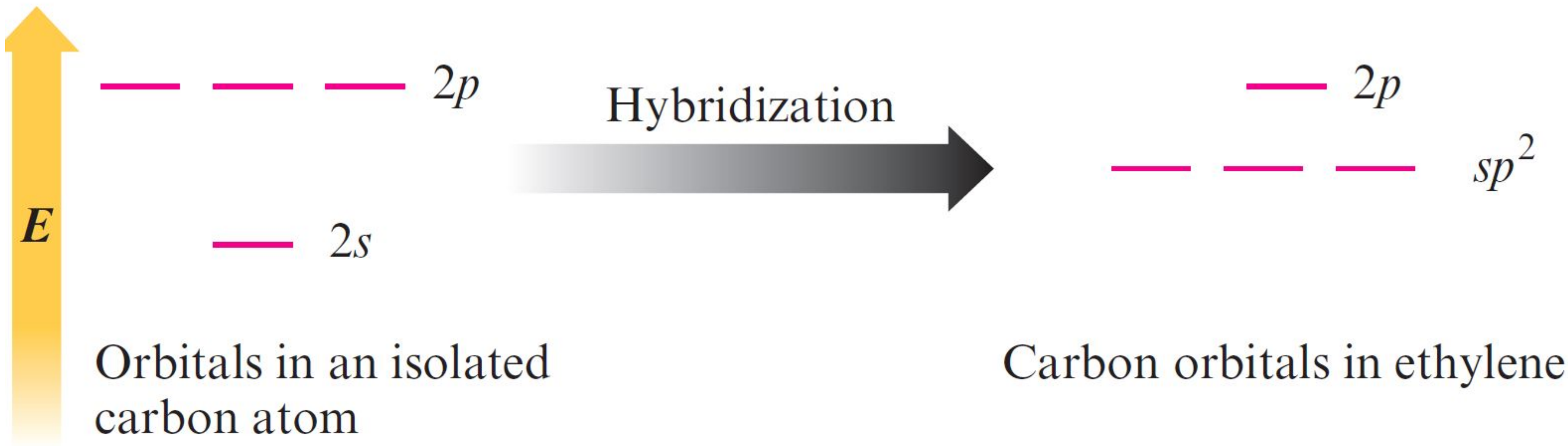
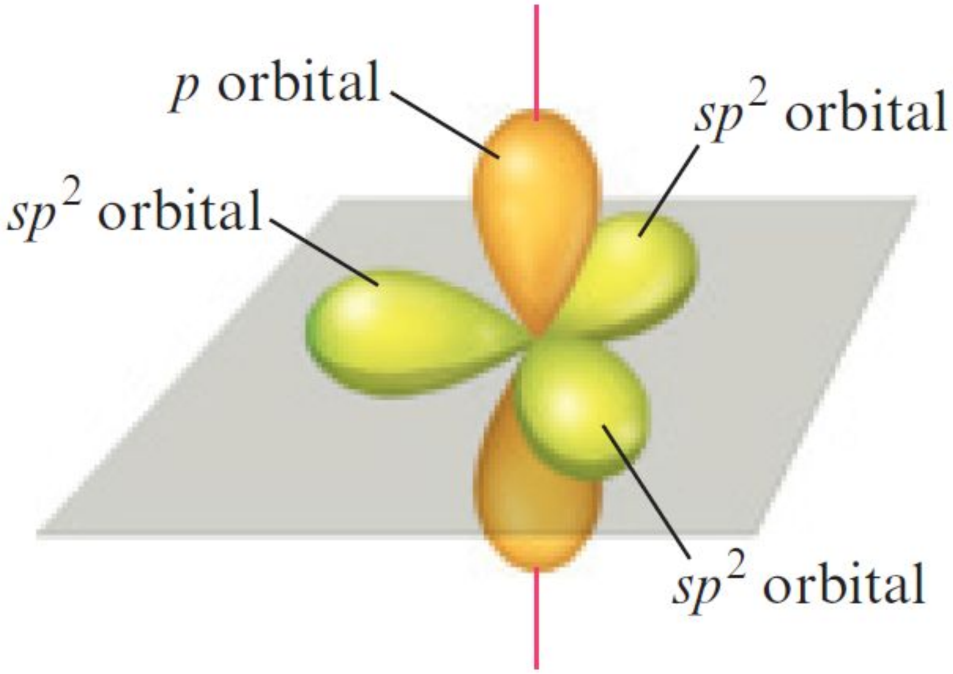


Figure 9.10 - *sp*^{2} Hybridization



Key Principle in *sp*^{2} Hybridization

- If an atom is surrounded by three effective pairs, a set of *sp*^{2} hybrid orbitals is required

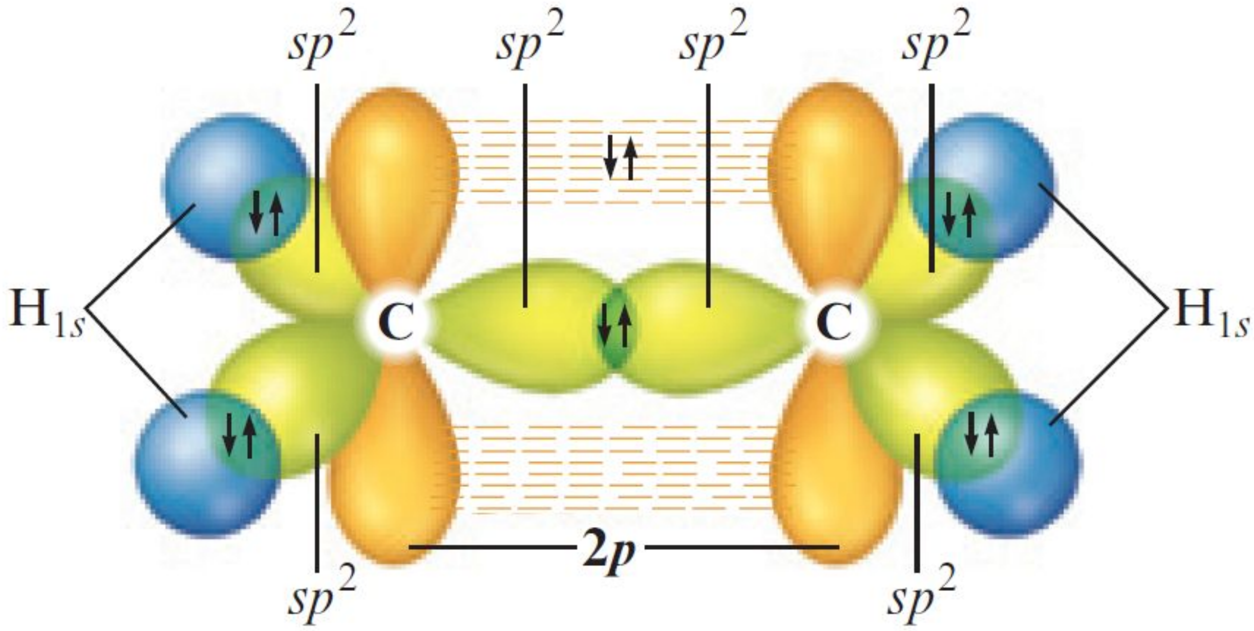


Figure 9.14 - Formation of *sp* Orbitals

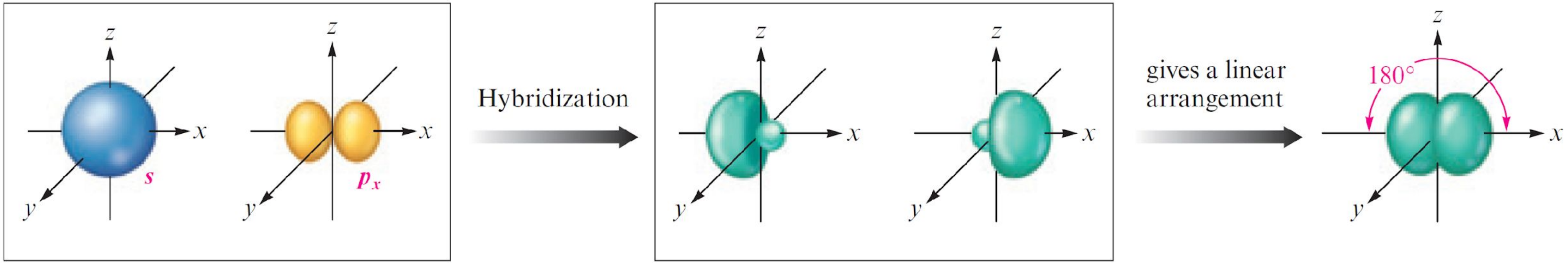


Figure 9.15 - Hybrid Orbitals in the CO_2 Molecule

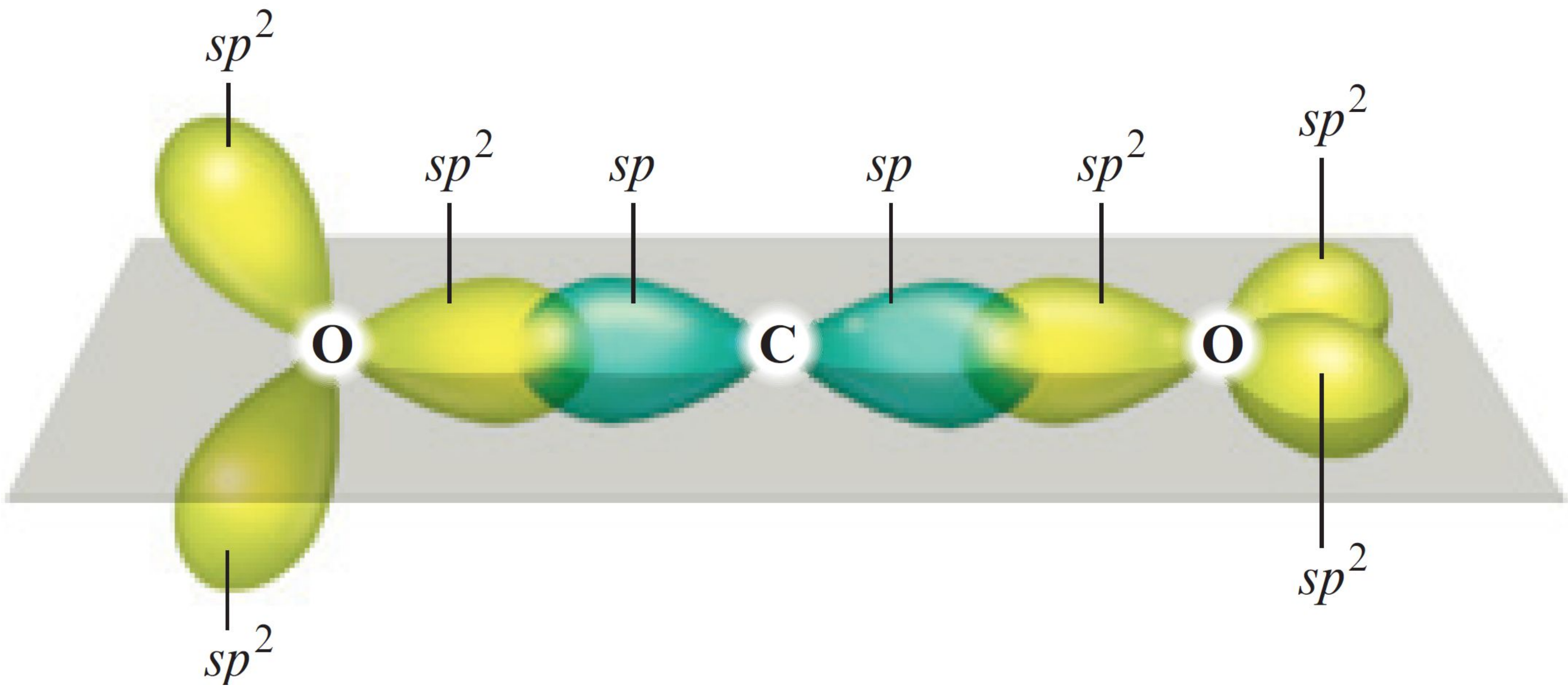


Figure 9.16 - Orbital Energy-Level Diagram for the Formation of *sp* Hybrid Orbitals on Carbon

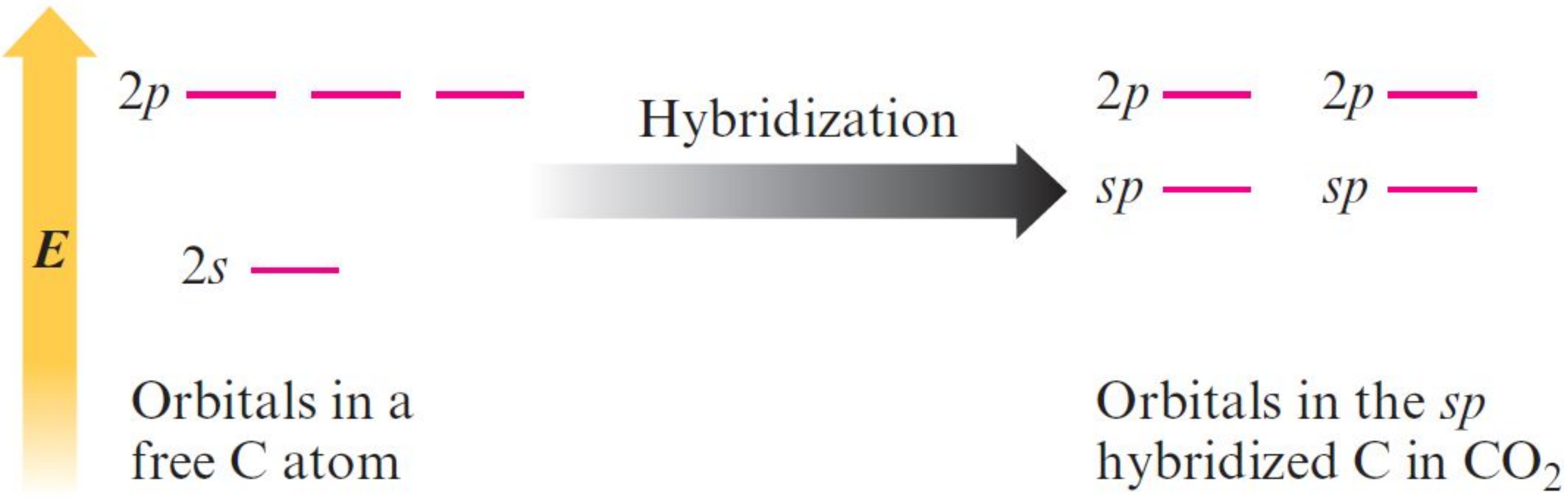


Figure 9.17 - An *sp* Hybridized Carbon Atom

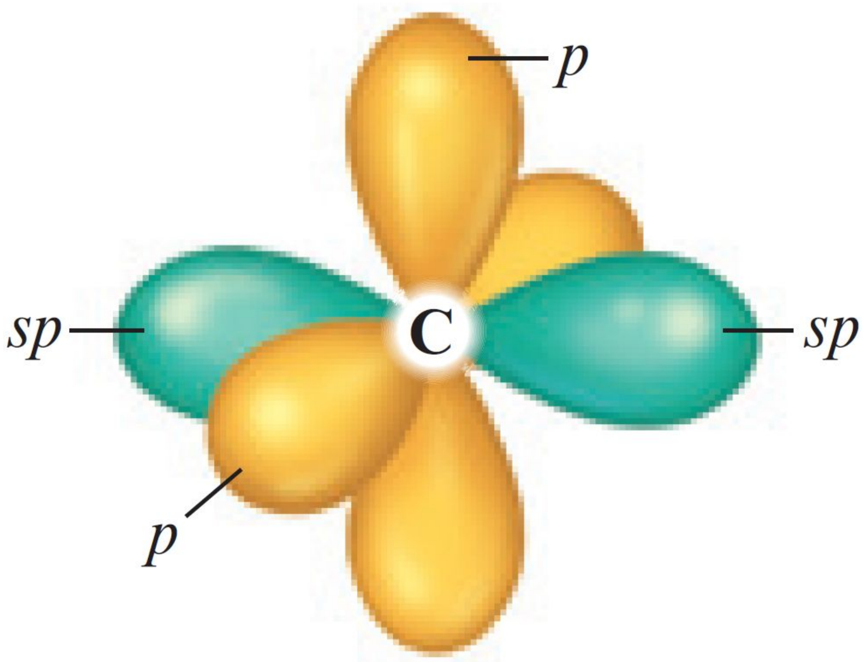
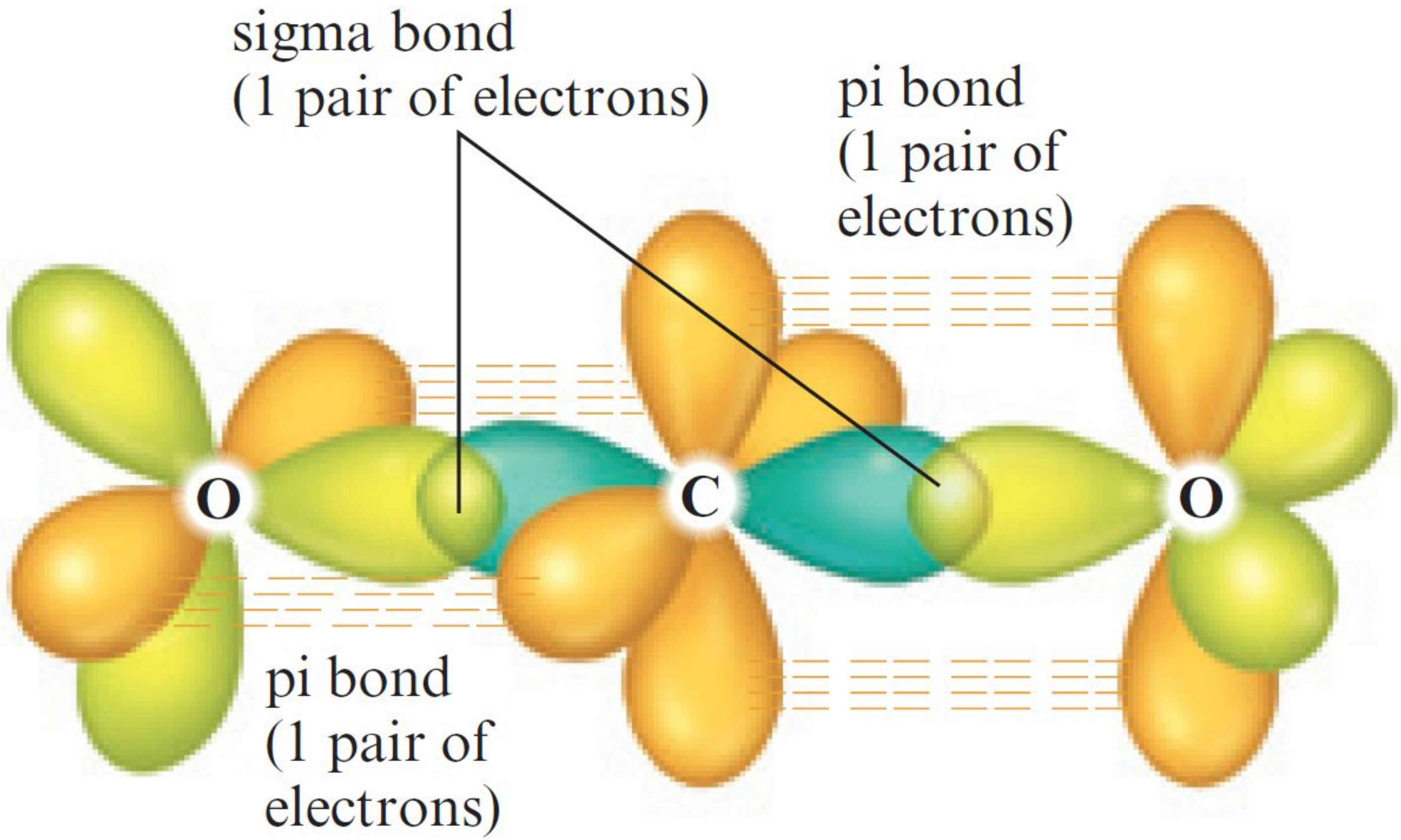


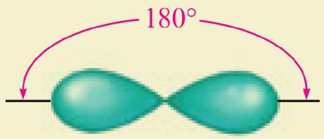
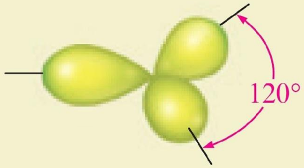
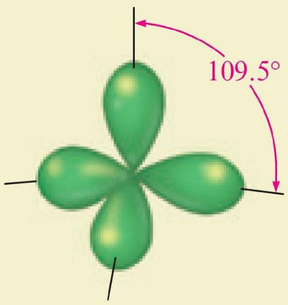
Figure 9.19 (a) - Orbitals Forming Bonds in Carbon Dioxide



Answer in your notes, compare with a partner

- Describe the bonding in the N_2 molecule

Figure 9.24 - Relationship between the Number of Effective Pairs, Spatial Arrangement, and Hybrid Orbitals

Number of Effective Pairs	Arrangement of Pairs	Hybridization Required
2	Linear	*sp* 
3	 Trigonal planar	sp^2 
4	 Tetrahedral	sp^3 

Answer in your notes, compare with a partner

- For each of the following molecules or ions, predict the hybridization of each atom, and describe the molecular structure

a. CO

b. BF_4^-

c. XeF_2

Figure 9.25 - Formation of Molecular Orbitals

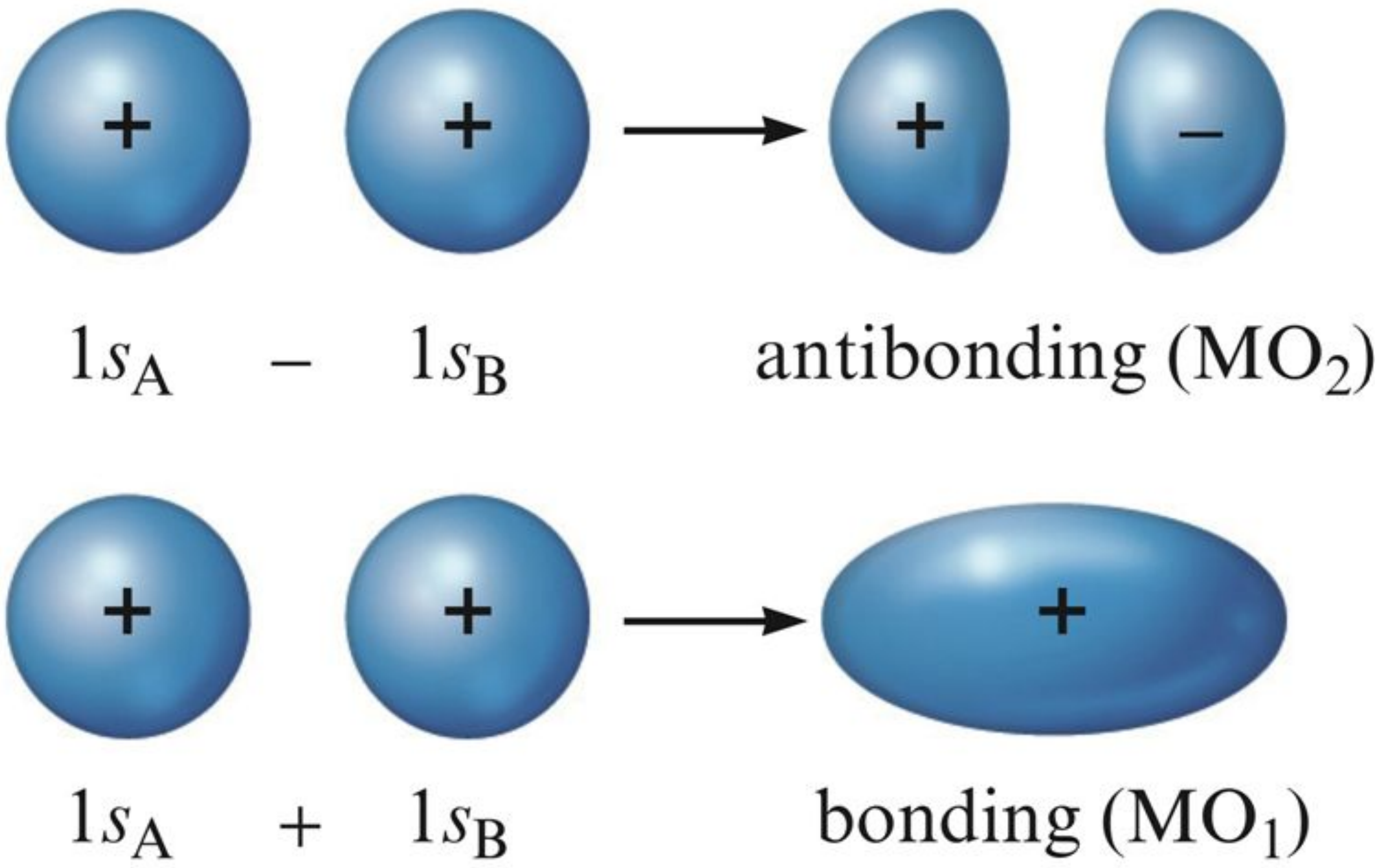
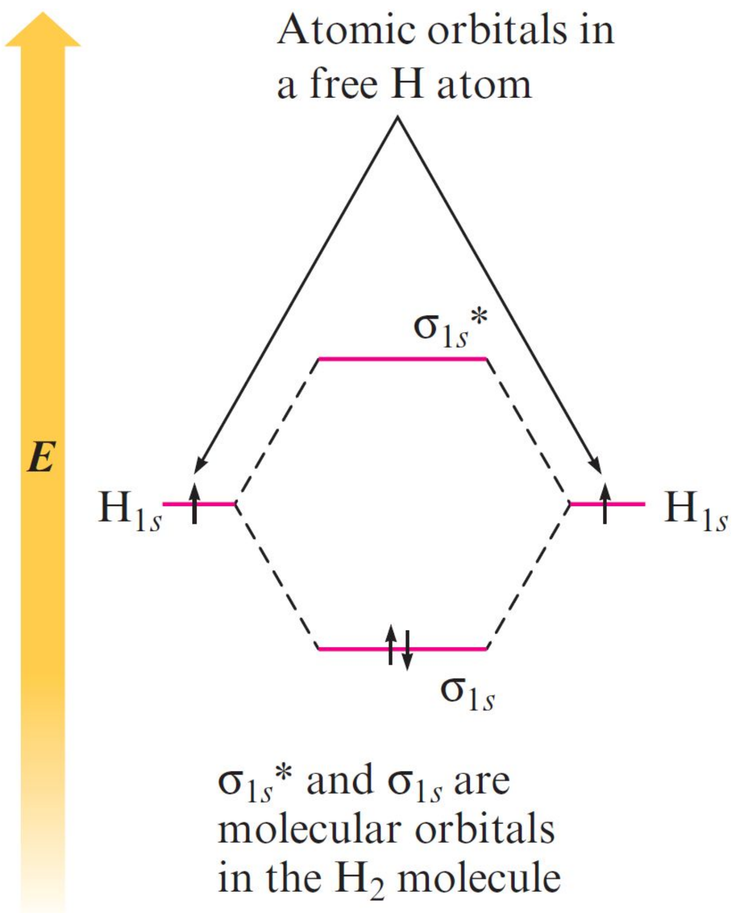


Figure 9.28 - Molecular Energy-Level Diagram for the H_2 Molecule



Bond Order

- Used to indicate bond strength

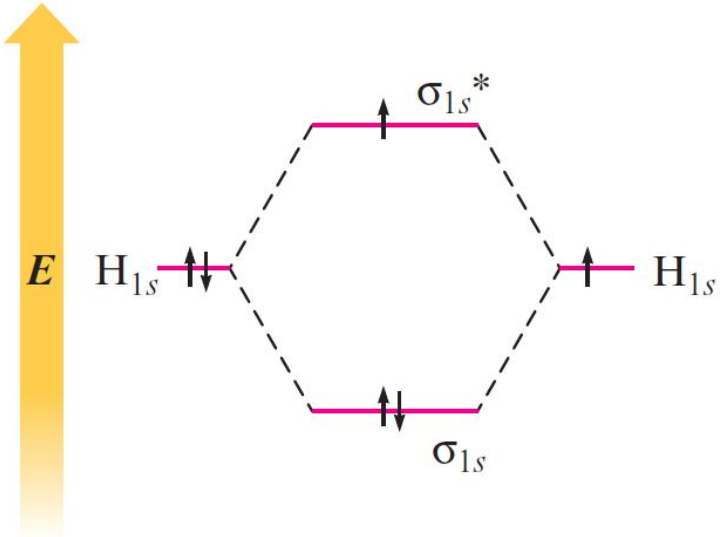
$$\text{Bond order} = \frac{\text{number of bonding electrons} - \text{number of antibonding electrons}}{2}$$

  - Bonds are perceived in terms of pairs of electrons
- Larger the bond, greater the bond strength

Bond Order (Continued)

- Consider the H_2^- ion
  - Contains two bonding electrons and one antibonding electron

$$\text{Bond order} = \frac{2-1}{2} = \frac{1}{2}$$



Types of Magnetism in the Presence of a Magnetic Field

- **Paramagnetism**: attracted into inducing magnetic field
  - Associated with unpaired electrons
  - Substance that has both paired and unpaired e-
- **Diamagnetism**: repelled from inducing magnetic field
  - Associated with paired electrons

Heteronuclear Diatomic Molecules

- **Heteronuclear**: Different atoms
- A special case involves molecules containing atoms adjacent to each other in the periodic table
  - MO diagram can be used for homonuclear molecules as atoms involved in such molecules are similar

Answer in your notes, compare with a partner

- Use the molecular orbital model to predict the magnetism and bond order of the NO^+ and CN^- ions

Interactive Example 9.8 - Solution

- The NO^{+} ion has 10 valance electrons (5 + 6 – 1)
- The CN^{-} ion also has 10 valance electrons (4 + 5 + 1)
- Both ions are diamagnetic

$$\text{Bond order} = \frac{8-2}{2} = 3$$