

# N24 – Bonding

**Sigma and Pi Bonds**

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## Sigma and Pi Bonds

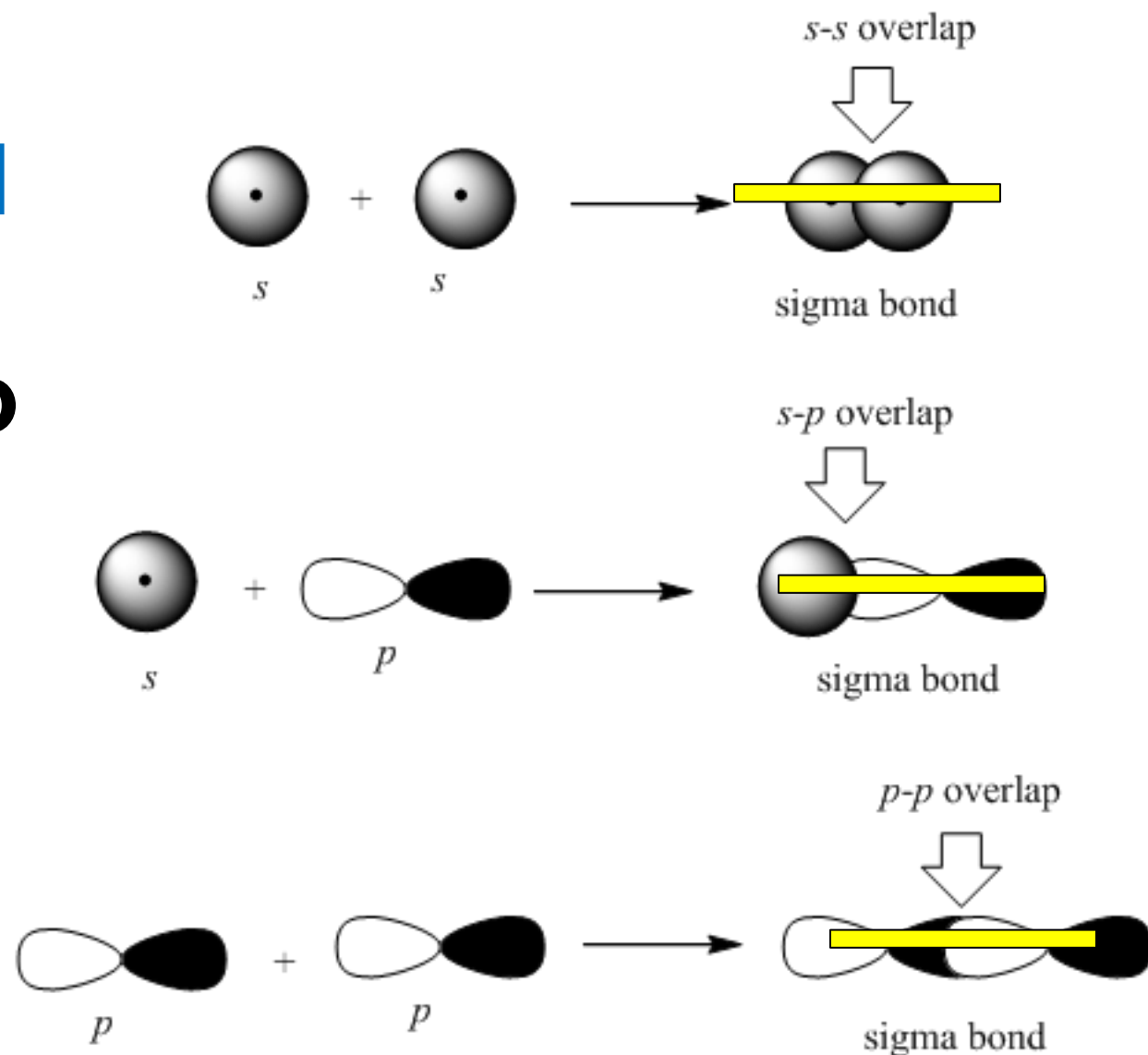
**Target:** I can describe and count sigma and pi bonds in a molecule, and how it explains resonance and bond strengths.

# Types of Bonds

- When we say “types of bonds” people often assume we mean ionic, covalent or metallic. Or they think we mean single, double, triple. Or polar, non-polar.
- BUT we can also be talking about how the bonds are formed in 3-dimensional space, describing how the orbitals overlap to form the bond.

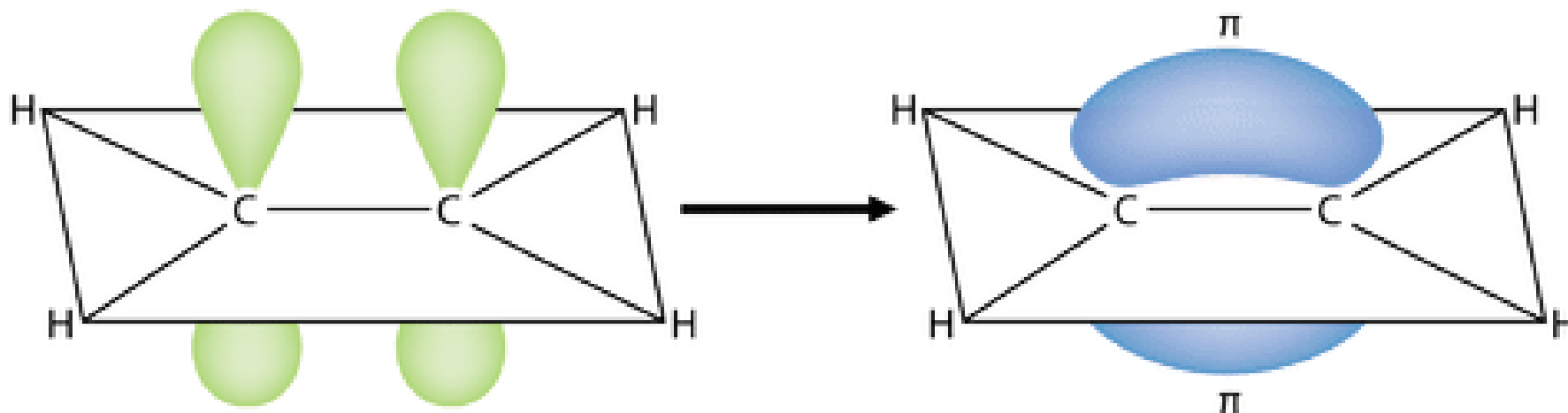
# Sigma Bond

- A **sigma (*s* or  $\sigma$ ) bond** forms when the atomic orbitals of two atoms line up along the axis directly between the nuclei.
  - Either standard atomic orbitals or hybrids
    - *s-s*, *p-p*, hybrid-hybrid, *s*-hybrid, etc.



# Pi Bond

- A **pi ( $p$  or  $\pi$ ) bond** forms when the atomic orbitals of two atoms line up above and below the plane where the nuclei are.
  - The unhybridized  $p$  orbitals from the two atoms that are parallel to each other.



# Strength of Bonds

- **$\sigma$  bonds are stronger than  $\pi$  bonds.**
  - Sigma orbitals directly overlap between the nuclei
  - Pi bonds are reaching up and over, they are further apart and less overlap than sigma bonds
    - That makes them weaker.

**But if pi bonds aren't as strong, why is a double/triple bond stronger than a single bond?**

Because there are MORE bonds present, a sigma plus a pi is still stronger than just a sigma!

# When Do You Have Each Kind?

## **Single Bond**

1 sigma bond

## **Double Bond**

1 sigma bond

1 pi bond

## **Triple Bond**

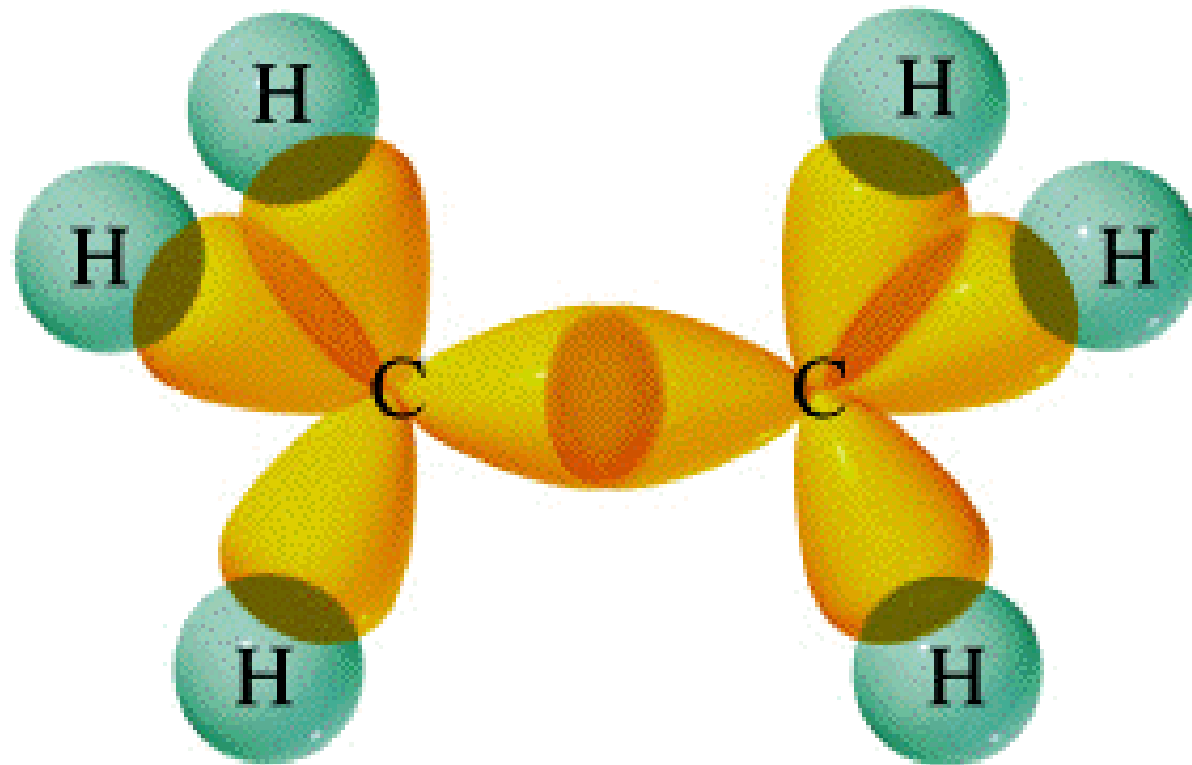
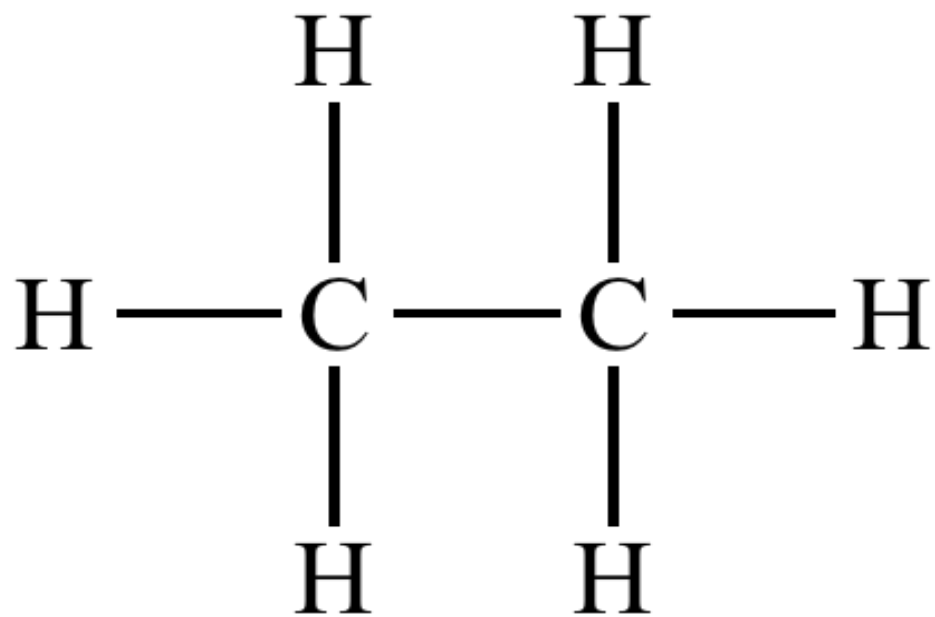
1 sigma bond

2 pi bonds

# Example: Ethane

7 single bonds

7  $\sigma$  bonds





# Example: Ethene

4 single bonds

4  $\sigma$  bonds

+

1 double bond

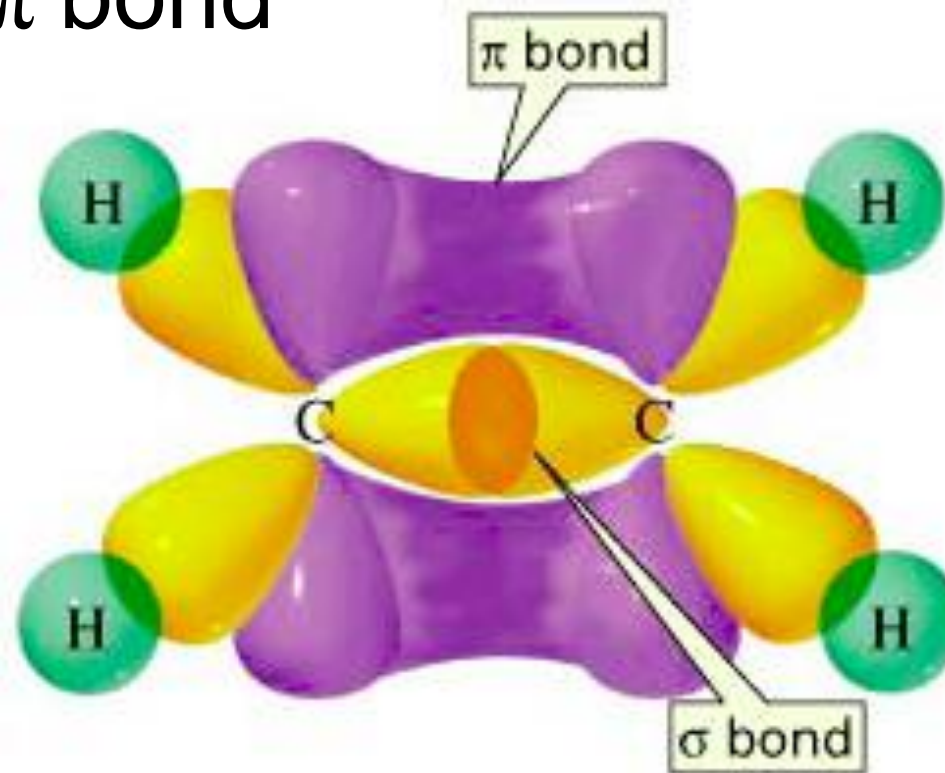
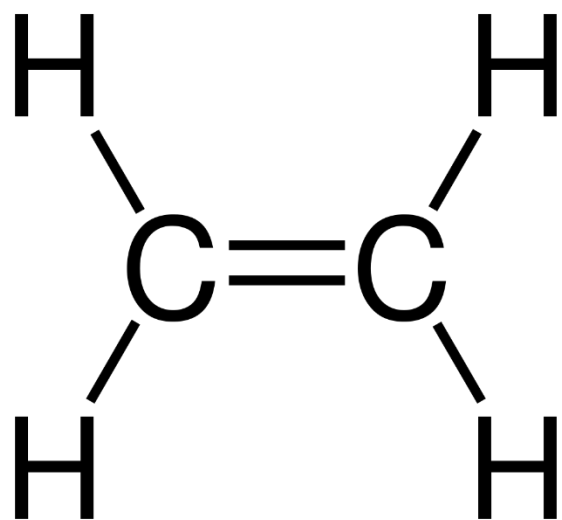
1  $\sigma$  bond

1  $\pi$  bond

=

5  $\sigma$  bonds

1  $\pi$  bond



# Example: Ethene

4 single bonds

4  $\sigma$  bonds

+

1 double bond

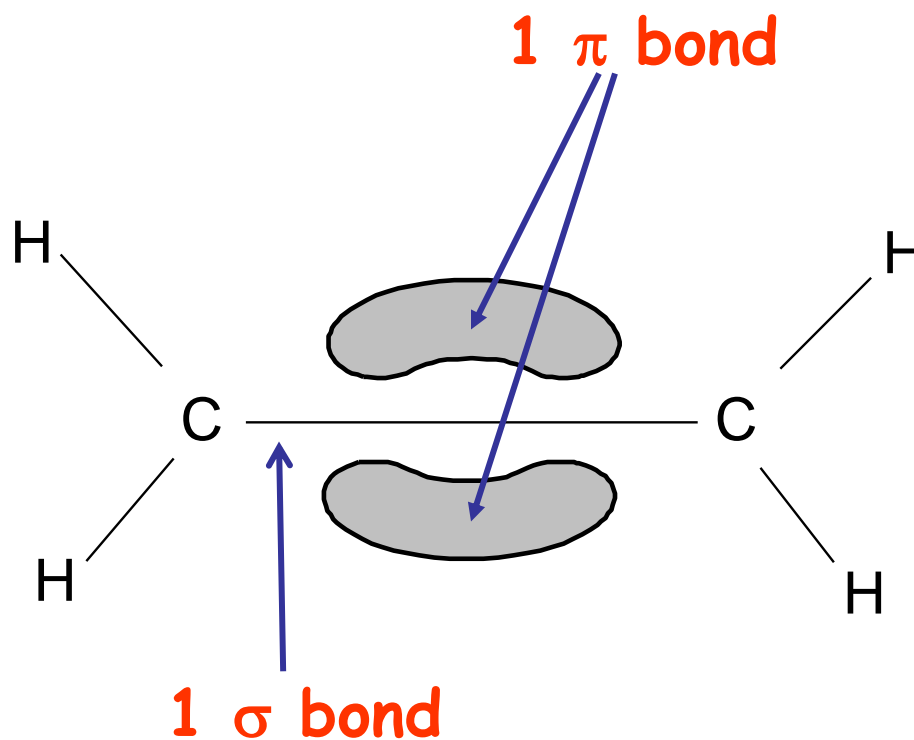
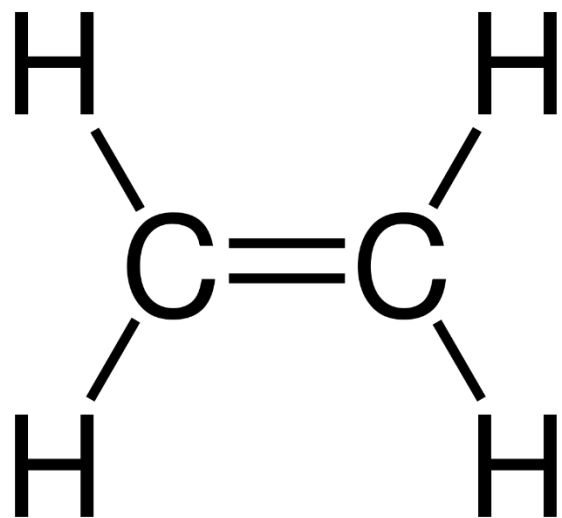
1  $\sigma$  bond

1  $\pi$  bond

=

5  $\sigma$  bonds

1  $\pi$  bond



\*\*\* The pi bond is on top and bottom – that is ONE pi bond not two.

# Example: Ethyne

2 single bonds

2  $\sigma$  bonds

+

1 triple bond

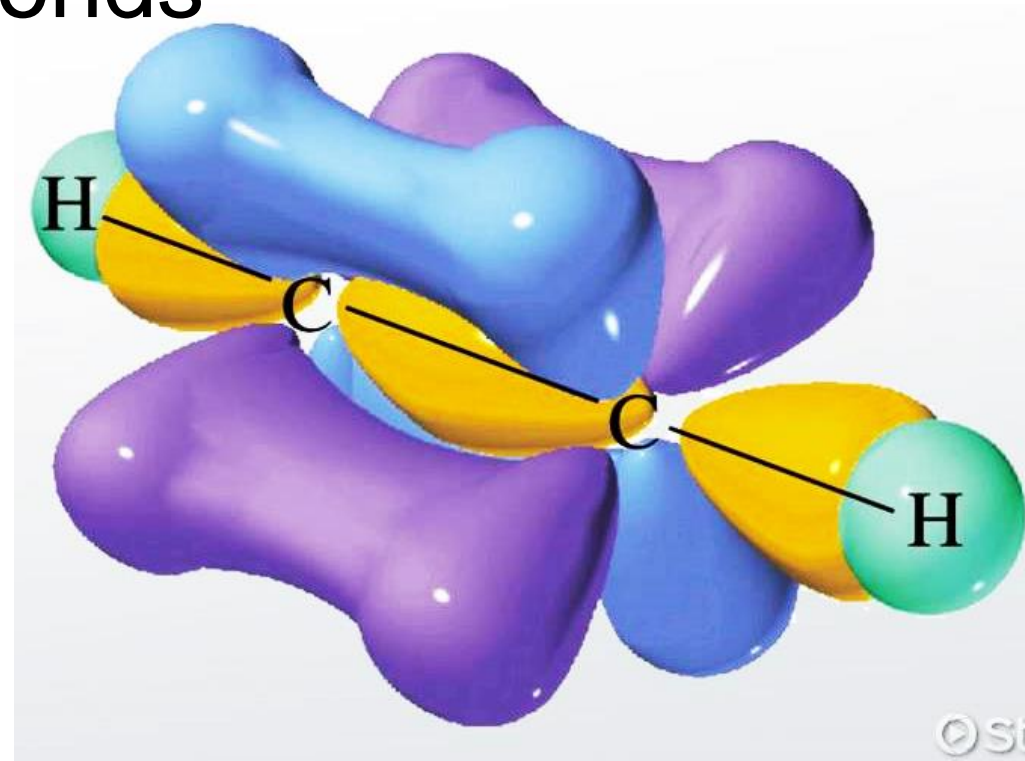
1  $\sigma$  bond

2  $\pi$  bonds

=

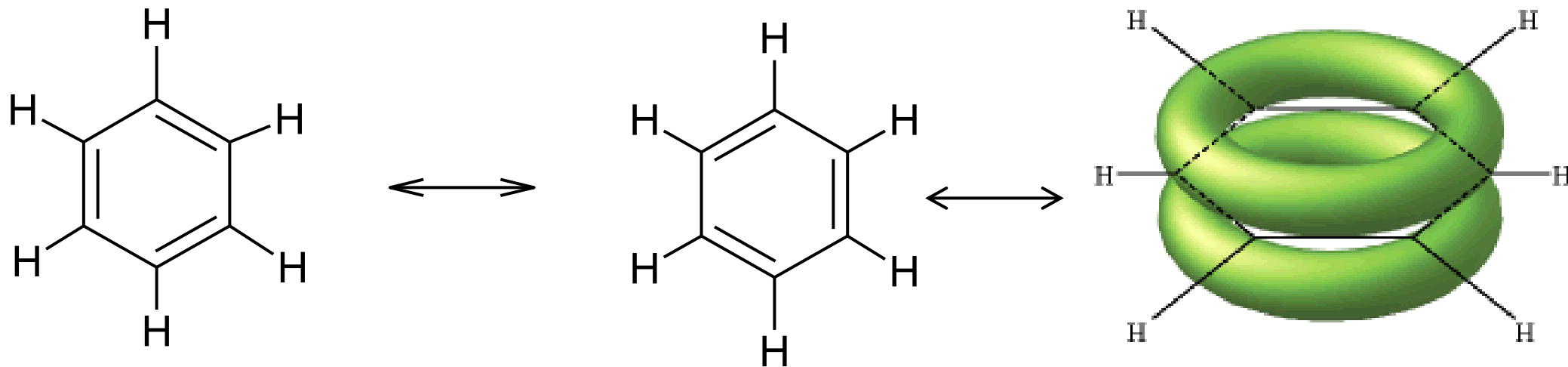
3  $\sigma$  bonds

2  $\pi$  bonds



# The De-Localized Electron Model

Pi bonds ( $\pi$ ) contribute to the **delocalized model** of electrons in bonding, and help explain resonance

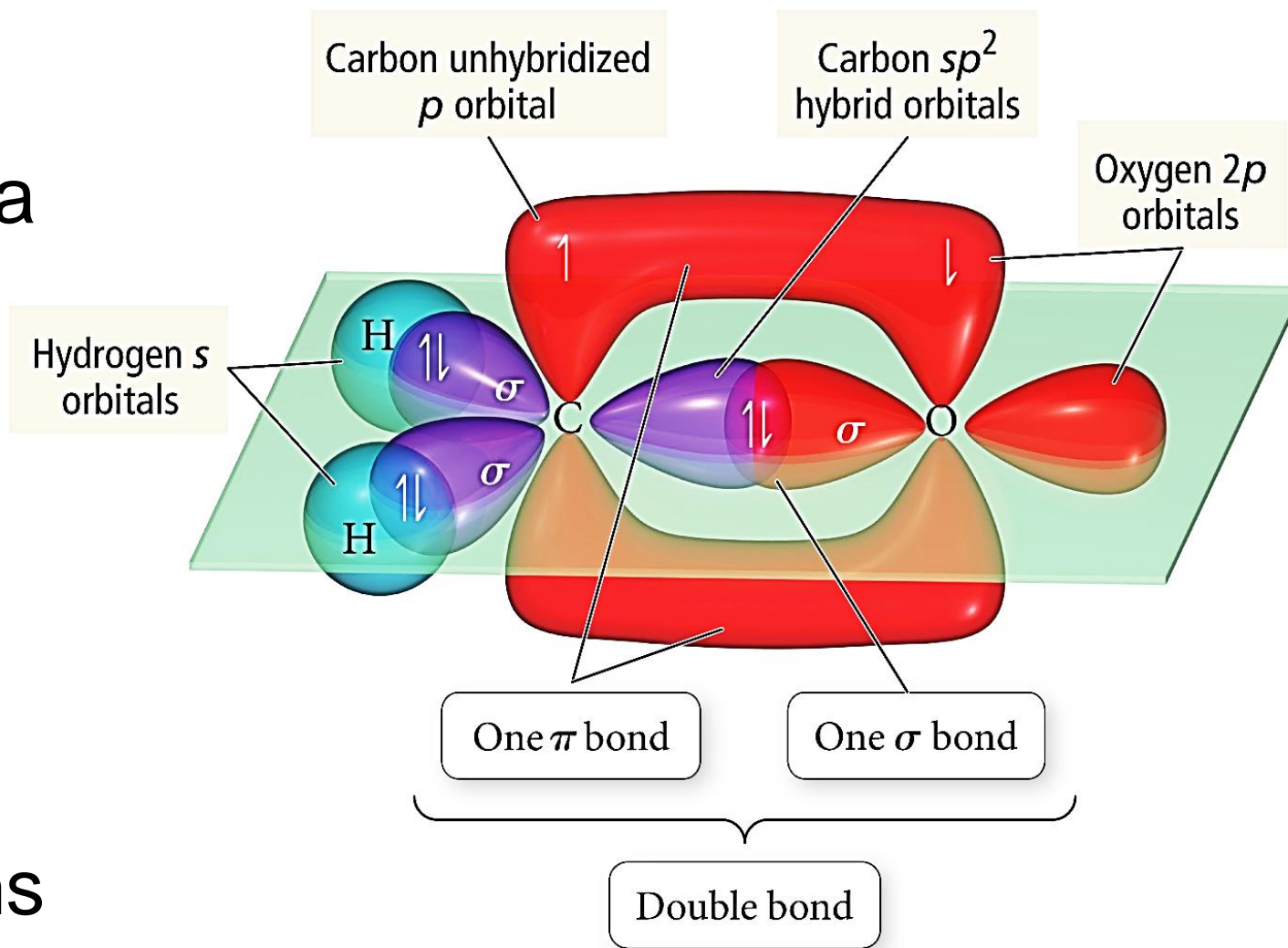


**Electron density from  $\pi$  bonds can be distributed symmetrically all around the ring, above and below the plane.**

# Looking at which orbitals are overlapping

**$\sigma$  Bond** - Overlap between a hybrid orbital on one atom and either a hybrid or nonhybridized orbital on another atom

**$\pi$  Bond** - Overlap between unhybridized  $p$  orbitals on bonded atoms



# Looking at which orbitals are overlapping



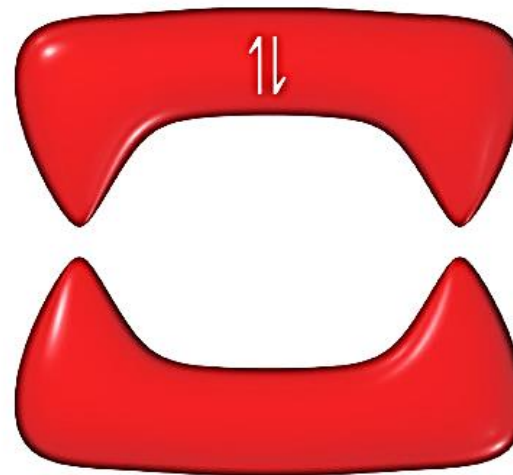
Half-filled  
 $p_y$  or  $p_z$  orbital

+

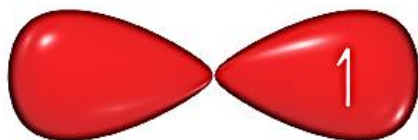


Half-filled  
 $p_y$  or  $p_z$  orbital

→

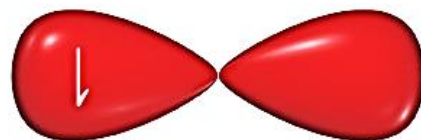


$\pi$  bond



Half-filled  
 $p_x$  orbital

+



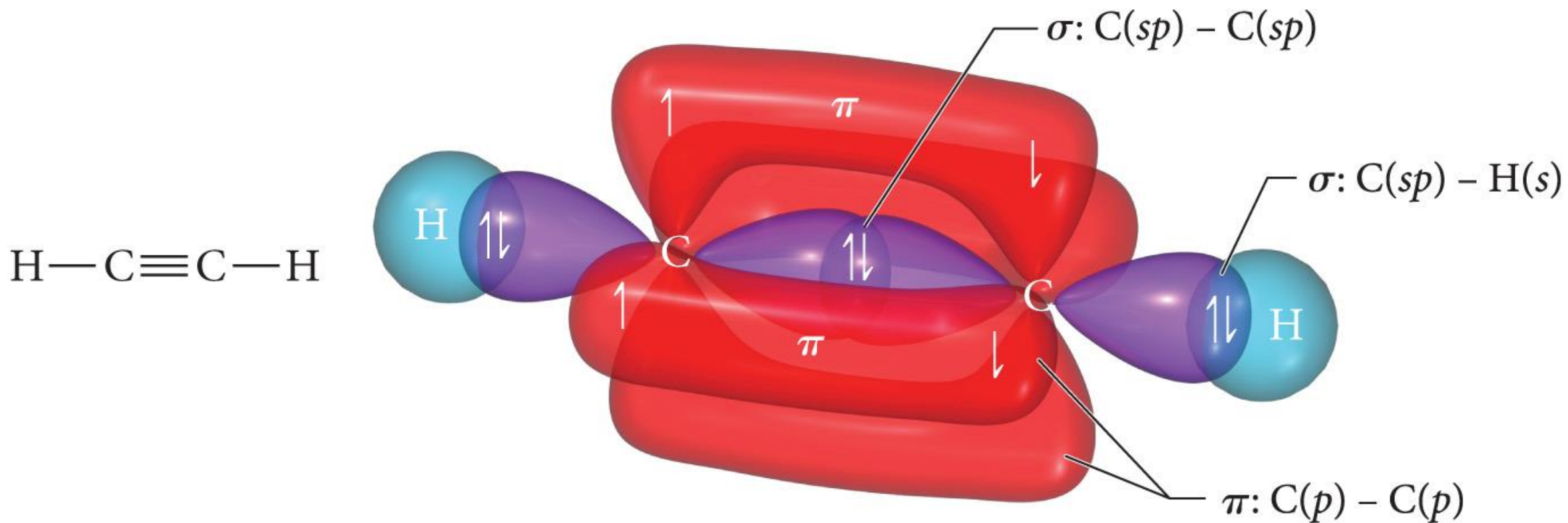
Half-filled  
 $p_x$  orbital

→



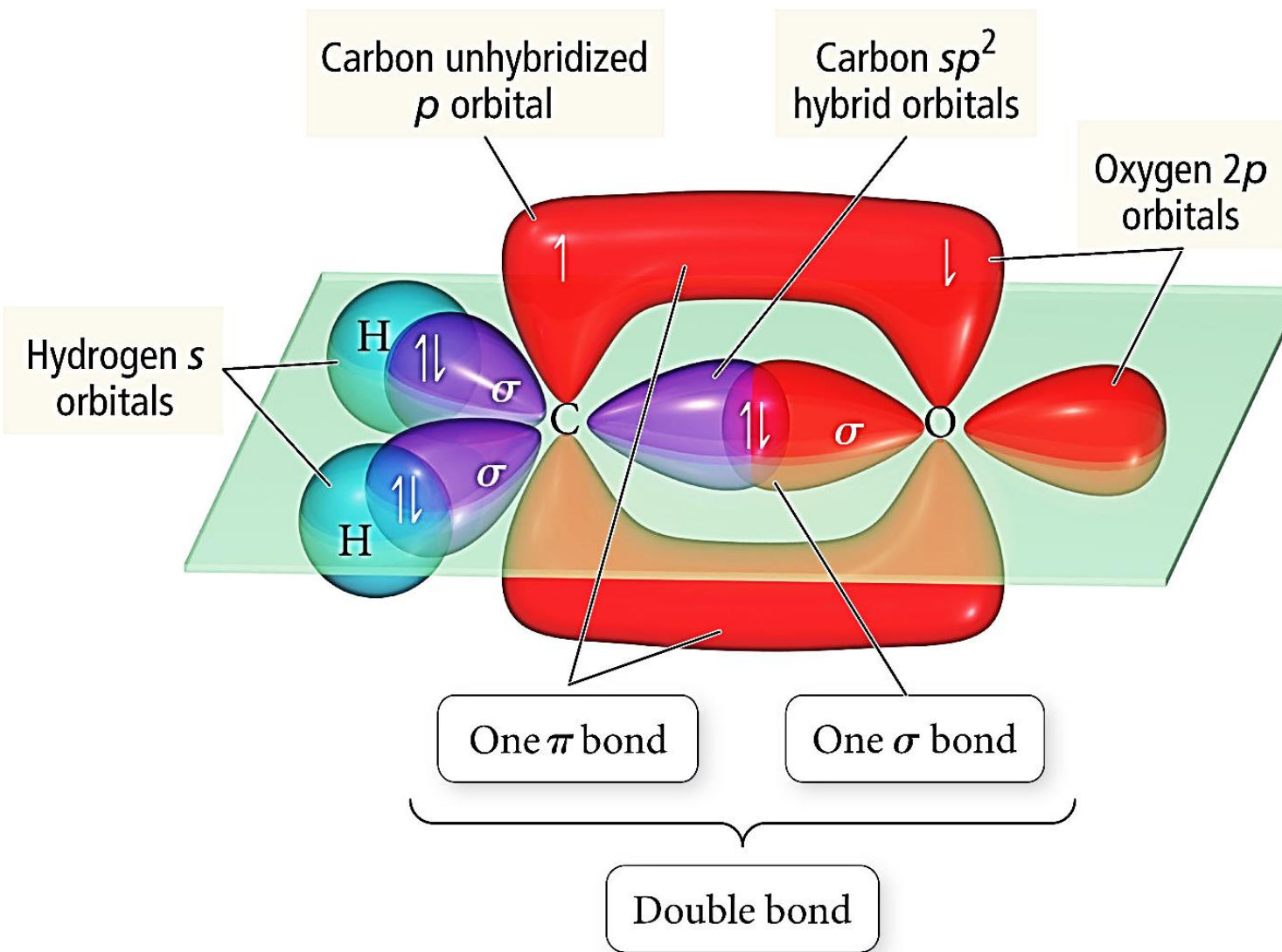
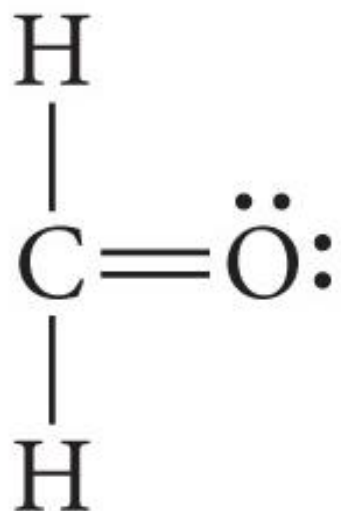
$\sigma$  bond

# Looking at which orbitals are overlapping





# Looking at which orbitals are overlapping





**YouTube Link to Presentation:**

**<https://youtu.be/iGzTW2S7Qf8>**