pluck the guitar string

vibrating guitar string

node

upward displacement = the peak

downward displacement = the trough
1s atomic orbital

2s atomic orbital
node not shown

2s atomic orbital
node shown
\[
\begin{align*}
\text{H} & : \text{H} \\
\text{1s atomic orbital} & \quad \cdot \text{H} \\
\text{molecular orbital} \\
\end{align*}
\]
\[ \text{λ hydrogen atoms are close together} \]

\[ \text{λ hydrogen atoms are far apart} \]

Potential energy graph showing:
- Minimum potential energy at a bond length of 0.74 Å.
- Energy difference of -104 kcal/mol for bond dissociation.
**constructive combination**

waves reinforce each other, resulting in bonding

**destructive combination**

waves cancel each other, and no bond forms
\[ \text{\(\sigma\) bonding molecular orbital} \]

\[ \text{\(\sigma^*\) antibonding molecular orbital} \]

\[ \text{2p atomic orbital} \]

\[ \text{nodes} \]
The diagram illustrates the formation of a π bonding molecular orbital and a π* antibonding molecular orbital. The 2p atomic orbitals from two bonding atoms combine to form a bonding orbital (π bonding molecular orbital) and an antibonding orbital (π* antibonding molecular orbital). The nodal planes are indicated by dashed lines, showing the regions where the electron density is zero.
\[ \pi^* \text{ antibonding molecular orbital} \]

- \( p \) atomic orbital of carbon
- \( p \) atomic orbital of oxygen
- \( \pi \) bonding molecular orbital
Potential energy graph with the following labels:

- Promotion: 96 kcal/mol
- 420 kcal/mol
- 4 covalent bonds
The s orbital adds to the lobe of the p orbital.

The s orbital subtracts from the lobe of the p orbital.
perspective formula of methane

ball-and-stick model of methane

space-filling model of methane

electrostatic potential map for methane
$\sigma^*$ antibonding molecular orbital

$sp^3$ atomic orbital

$\sigma$ bonding molecular orbital

Energy
side view

top view

$p$

$sp^2$

$sp^2$

$sp^2$

$sp^2$
a. σ bond formed by \( sp^2-s \) overlap

b. \( \pi \) bond

b. σ bond

c. \( \pi \) bond

σ bond
A double bond consists of one σ bond and one π bond.
a. 180°

σ bond formed by $sp-s$ overlap

b.

σ bond formed by $sp-sp$ overlap

c.
A triple bond consists of one σ bond and two π bonds.