

UNIT 8.2.1 • ORGANIC CHEMISTRY

The Shapes of Carbon Compounds

Mastering sp^3 , sp^2 , and sp hybridisation, molecular geometry, and the driving forces behind bond properties.

CORE PRINCIPLE

The Architecture of Carbon

Carbon's remarkable ability to form diverse structures stems from hybridisation—the mixing of atomic orbitals to form new, identical hybrid orbitals before bonding.

Why Hybridise?

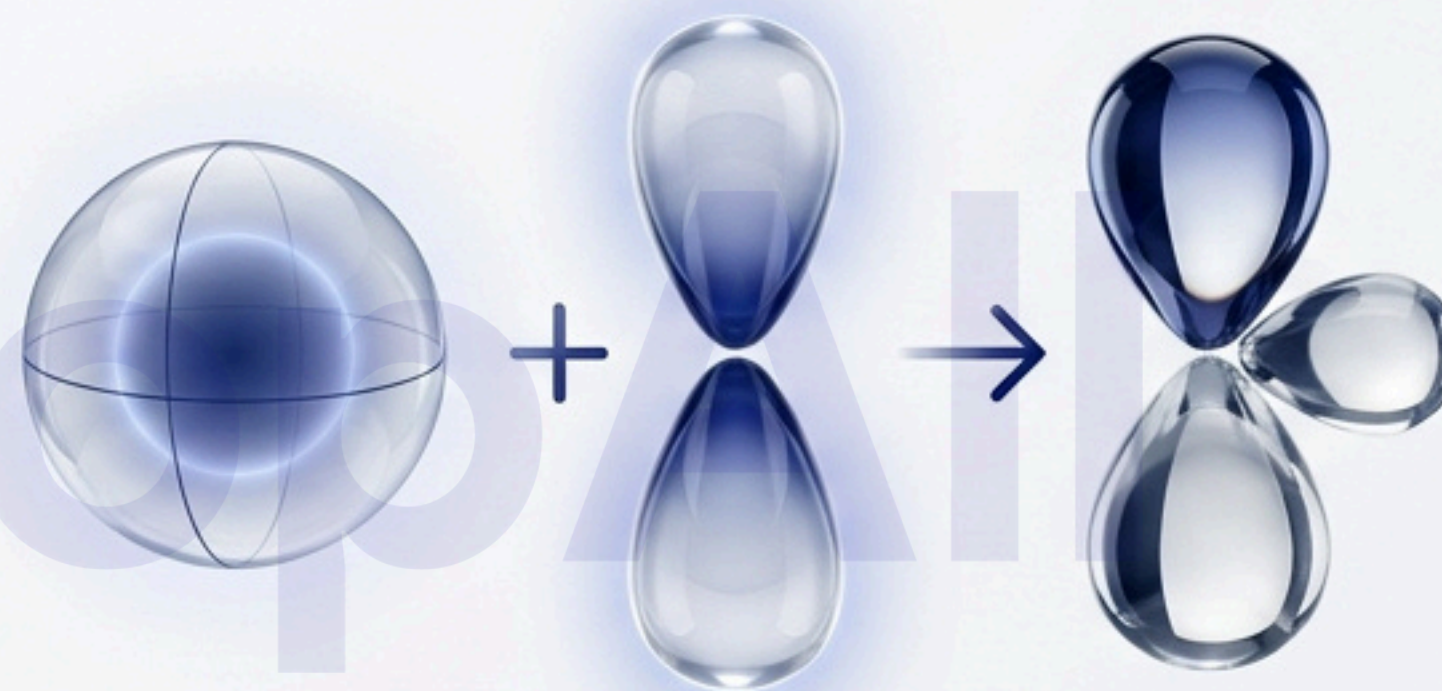
Native s and p orbitals have different energies and shapes. By mixing them, Carbon creates identical hybrid orbitals (sp^3 , sp^2 , or sp) that minimize electron repulsion and maximize bond stability.

The Three Blueprints

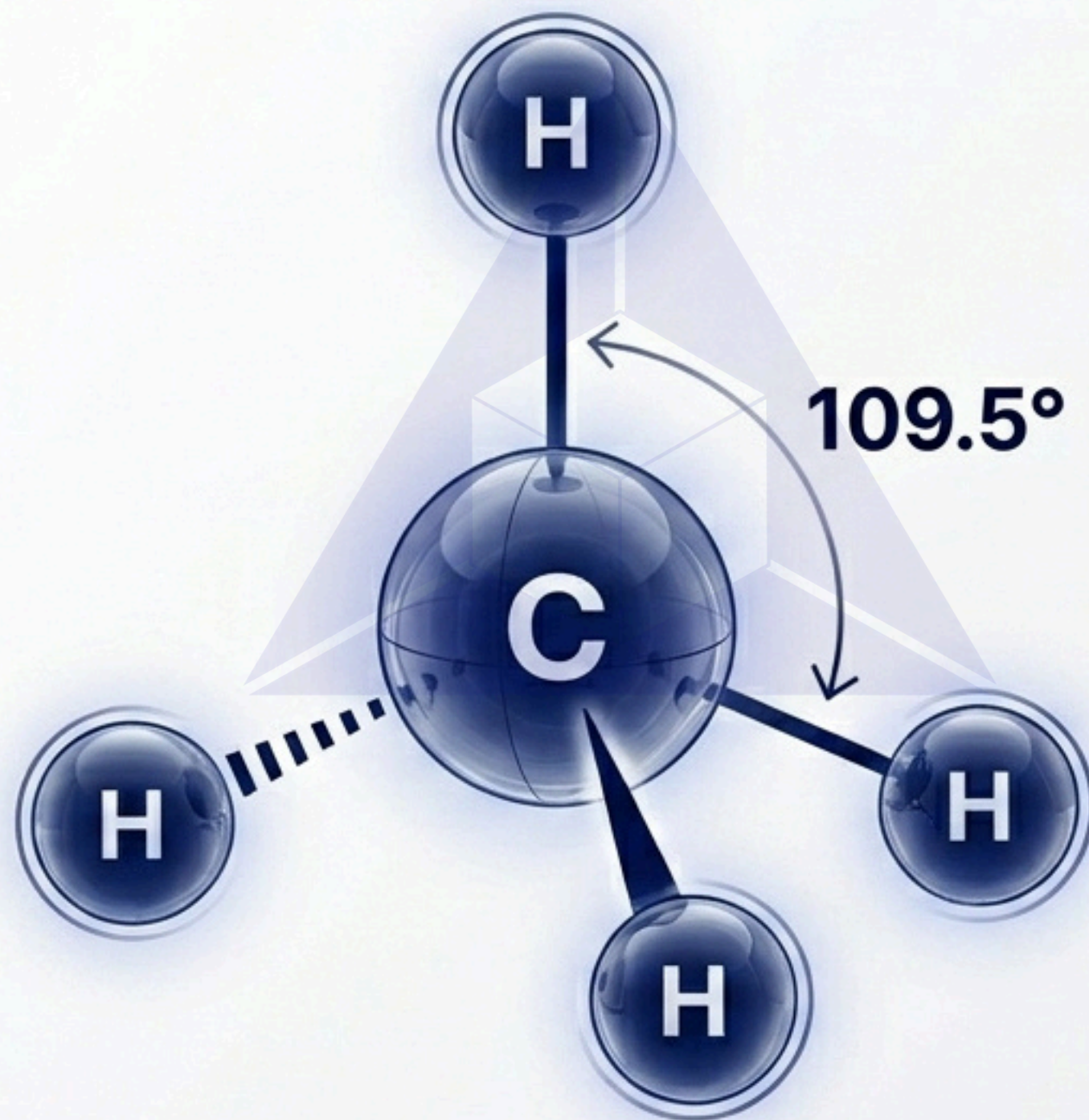
sp^3 (Single bonds)

sp^2 (Double bonds)

sp (Triple bonds)



Methane (CH₄)



Tetrahedral

4 hybrid orbitals point toward the corners of a regular tetrahedron to minimize repulsion.

- **Bond Angle:** 109.5°
- **Bonds:** 4 σ (Sigma) bonds

Orbital Mix

1 s orbital + 3 p orbitals.

- **s-character:** 25%



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$$E=mc^2$$



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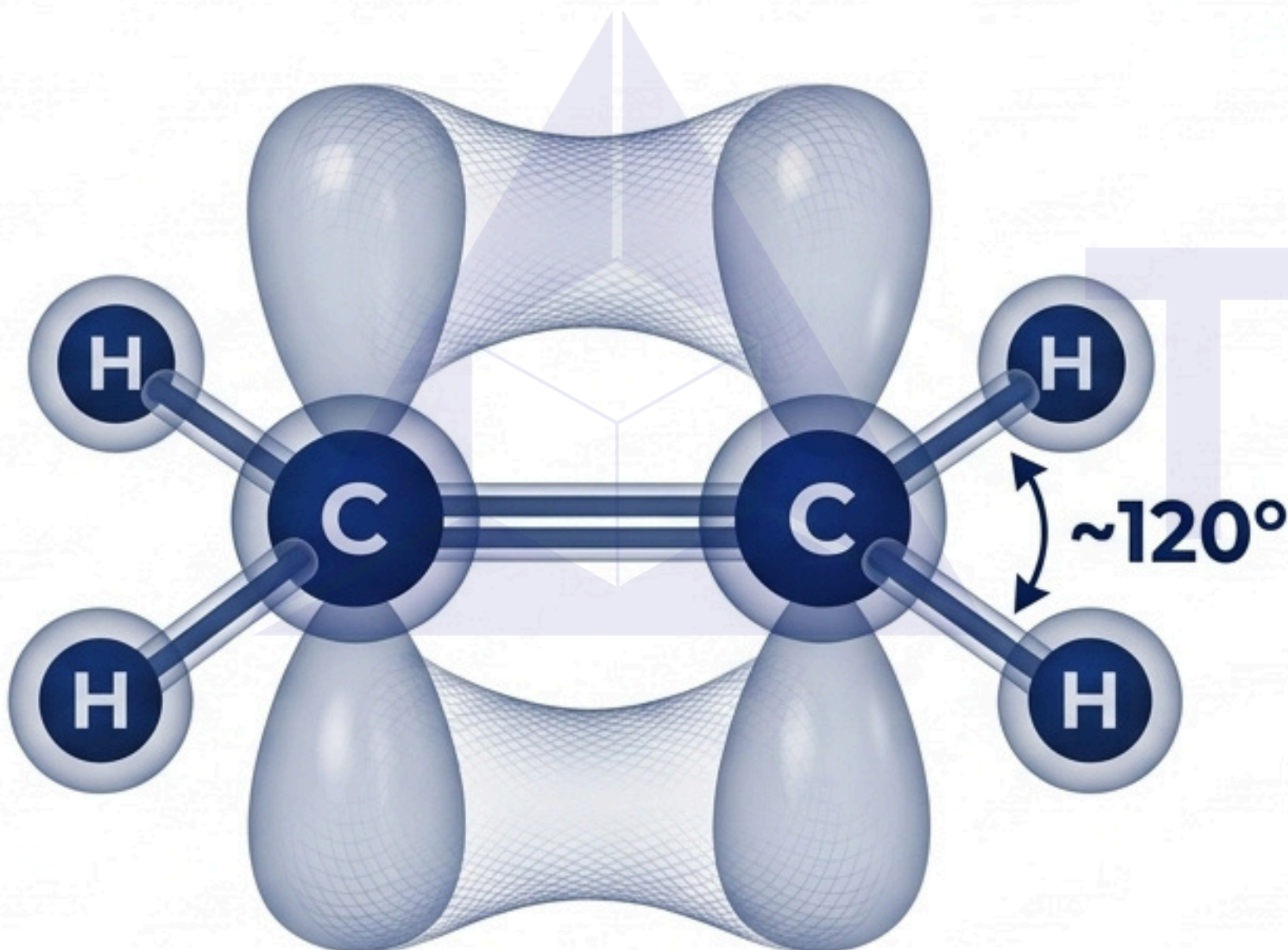
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Ethene (C₂H₄)



Trigonal Planar

The 3 hybrid orbitals lie flat in a single plane, while an unhybridised p-orbital sits perpendicular.

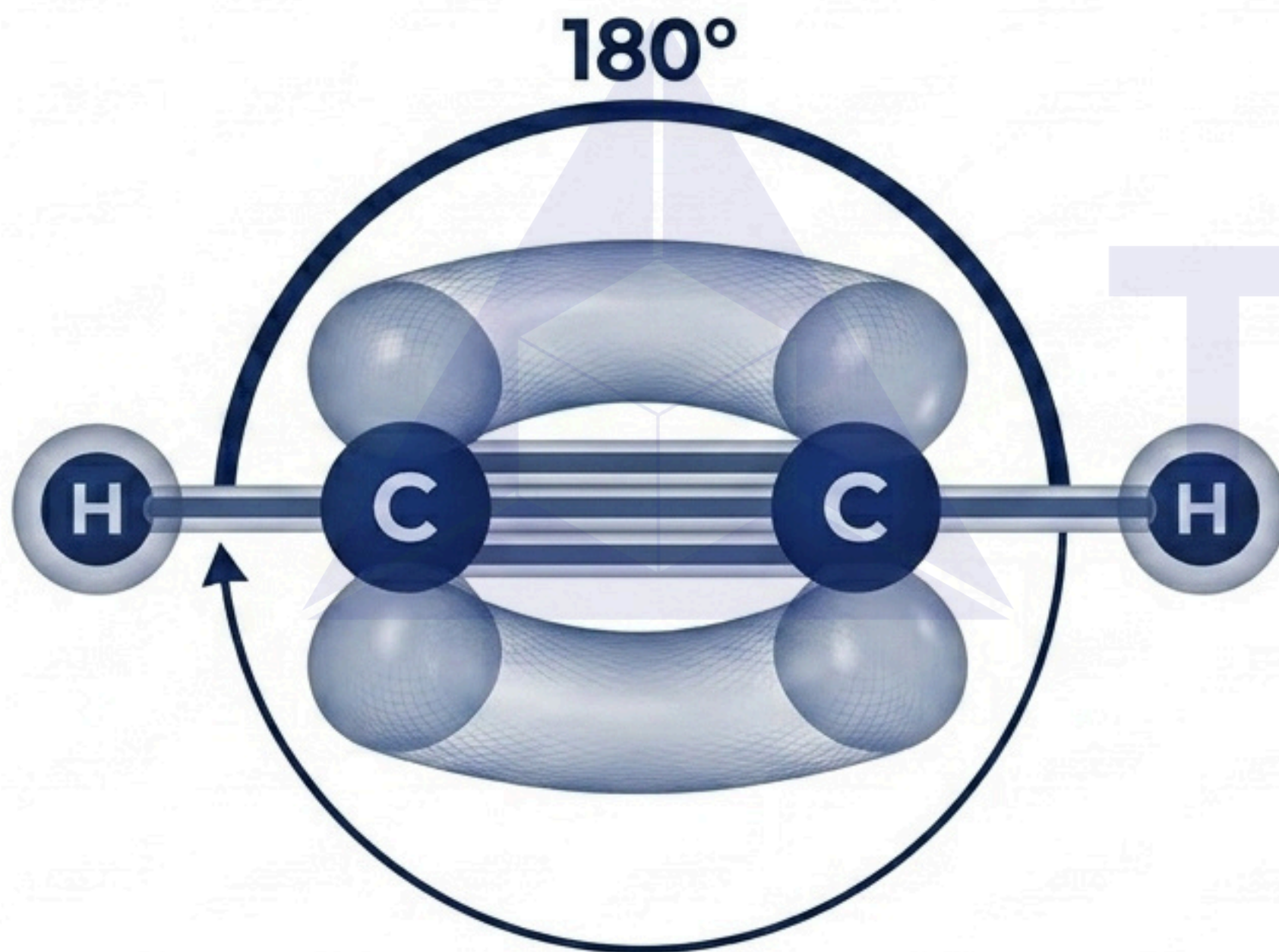
- **Bond Angle:** ~120°
- **Bonds:** 3 σ bonds, 1 π bond

Orbital Mix

1 s orbital + 2 p orbitals.

- **s-character:** 33.3%

Ethyne (C_2H_2)



Linear

The 2 hybrid orbitals form a straight line. Two unhybridised p-orbitals remain to form two separate pi bonds.

- **Bond Angle:** 180°
- **Bonds:** 2 σ bonds, 2 π bonds

Orbital Mix

1 s orbital + 1 p orbital.

- **s-character:** 50%

The Power of s-Character

Because s orbitals are closer to the nucleus than p orbitals, increasing the percentage of s-character dramatically alters the physical properties of the bond.

Hybridisation	% s-Character	Bond Length	Bond Strength	Electronegativity
sp^3 (Alkanes)	25%	Longest	Weakest	Lowest
sp^2 (Alkenes)	33.3%	Medium	Medium	Medium
sp (Alkynes)	50%	Shortest (↓)	Strongest (↑)	Highest (↑)

The "Why": A higher s-character means the bonding electrons are held closer to the carbon nucleus, pulling the bonded atoms tighter (shorter length, higher strength) and attracting shared electrons more aggressively (higher electronegativity).

High-Yield Takeaways

Review these core principles before your organic chemistry exam.

1. Match Shape to Hybrid

- sp^3 = Tetrahedral (109.5°)
- sp^2 = Trigonal Planar (120°)
- sp = Linear (180°)

2. Count the Pi Bonds

- 0 π bonds = sp^3
- 1 π bond = sp^2
- 2 π bonds = sp

(Unhybridised p-orbitals are required to form pi bonds!)

3. 50% Rule (sp)

As **s**-character increases (from 25% to 50%), the bond gets **shorter**, **stronger**, and the Carbon atom becomes **more electronegative**.



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