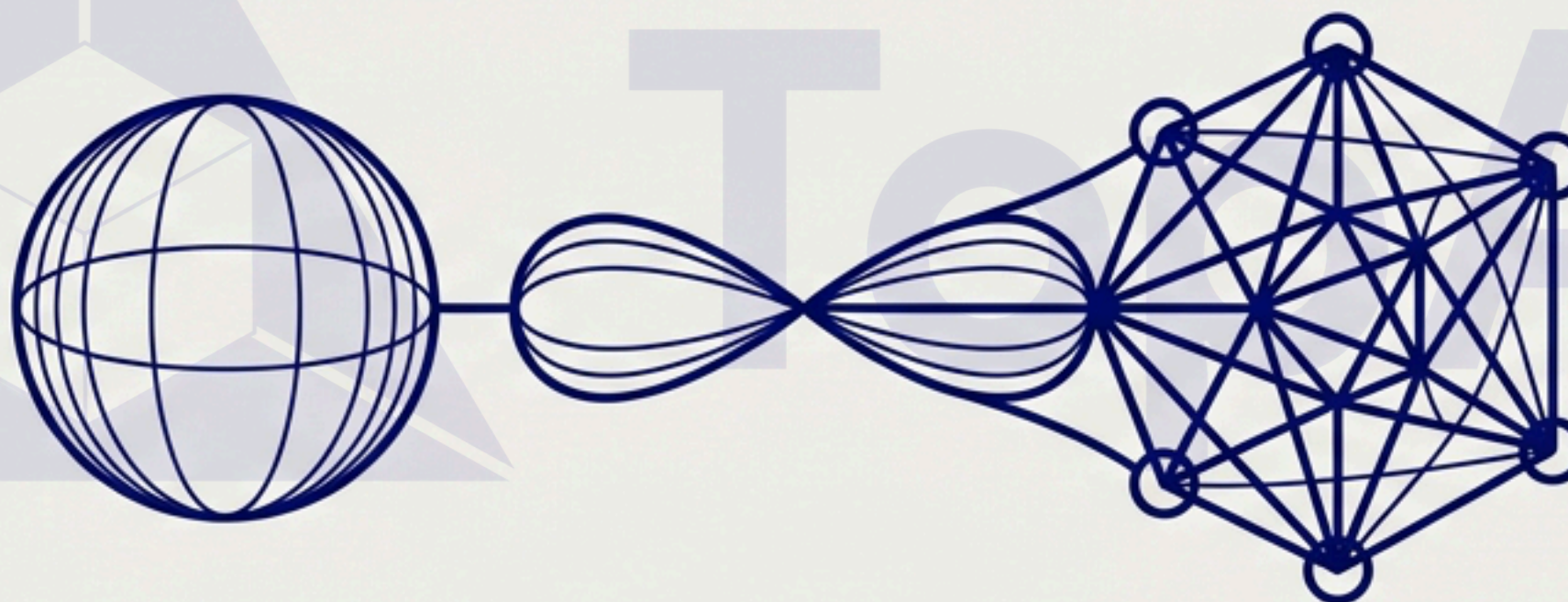


UNIT 4 • CHEMICAL BONDING & MOLECULAR STRUCTURE

4.6.1 Types Of Hybridisation

The process of intermixing atomic orbitals to form a new set of equivalent hybrid orbitals.



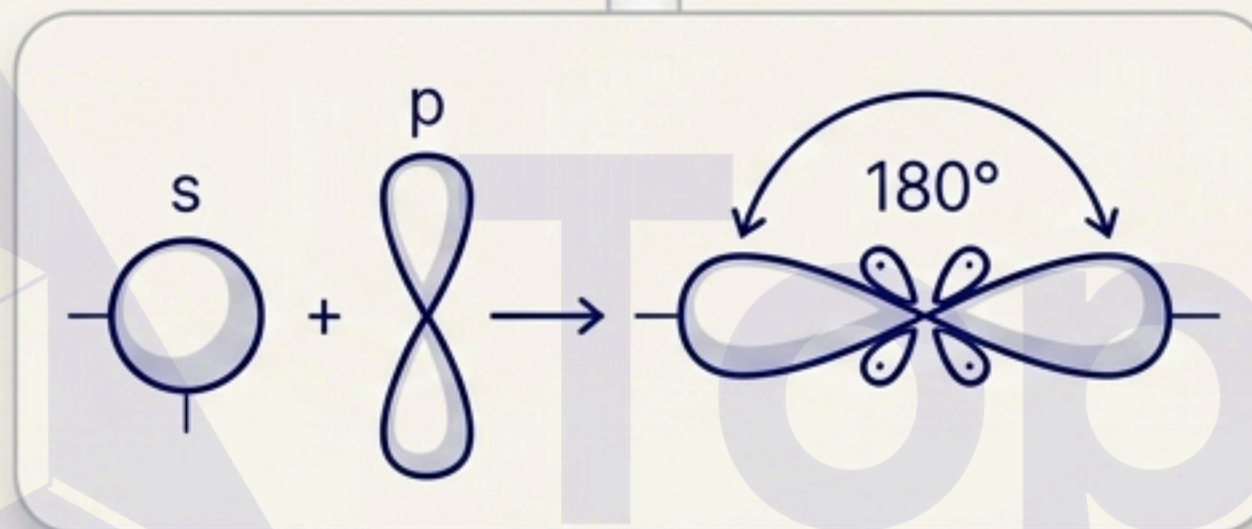
Concept

The type of hybridisation dictates the final geometric shape of the covalent molecule.

sp Hybridisation

The Orbital Mix

- **Inputs:** $1s + 1p$ (specifically p_z if aligned on z-axis)
- **Outputs:** Two equivalent sp hybrid orbitals.
- **Alignment:** The two hybrids point in opposite directions along the z-axis (positive lobes projecting outwards, very small negative lobes).



The Geometric Reality

- **Shape:** Linear (Diagonal Hybridisation)
- **Angle:** 180°
- **Traits:**

50% s-character

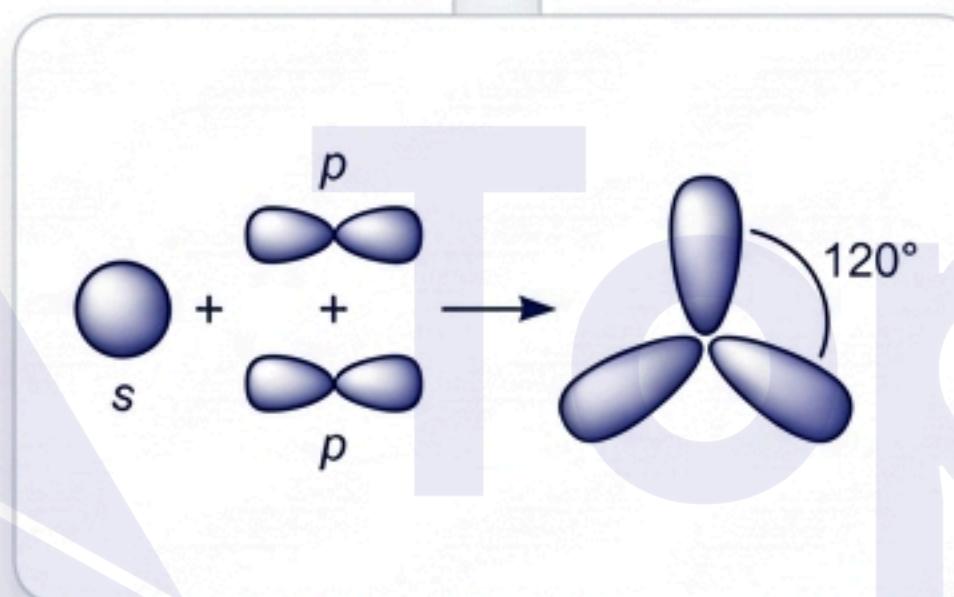
50% p-character

$1s \text{ orbital} + 1p \text{ orbital} \rightarrow 2sp \text{ hybrid orbitals} \rightarrow \textbf{Linear Geometry}$

sp^2 Hybridisation

The Orbital Mix

- **Inputs:** 1s + 2p orbitals
- **Outputs:** Three equivalent sp^2 hybrid orbitals.
- **Alignment:** Directed toward the corners of an equilateral triangle, ensuring minimum repulsion between electron pairs.



The Geometric Reality

- **Shape:** Trigonal Planar
- **Angle:** 120°
- **Traits:**

~33% s-character

~67% p-character

1s orbital + 2p orbitals $\rightarrow$ $3sp^2$ hybrid orbitals $\rightarrow$ **Trigonal Planar Geometry**



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Key Highlights

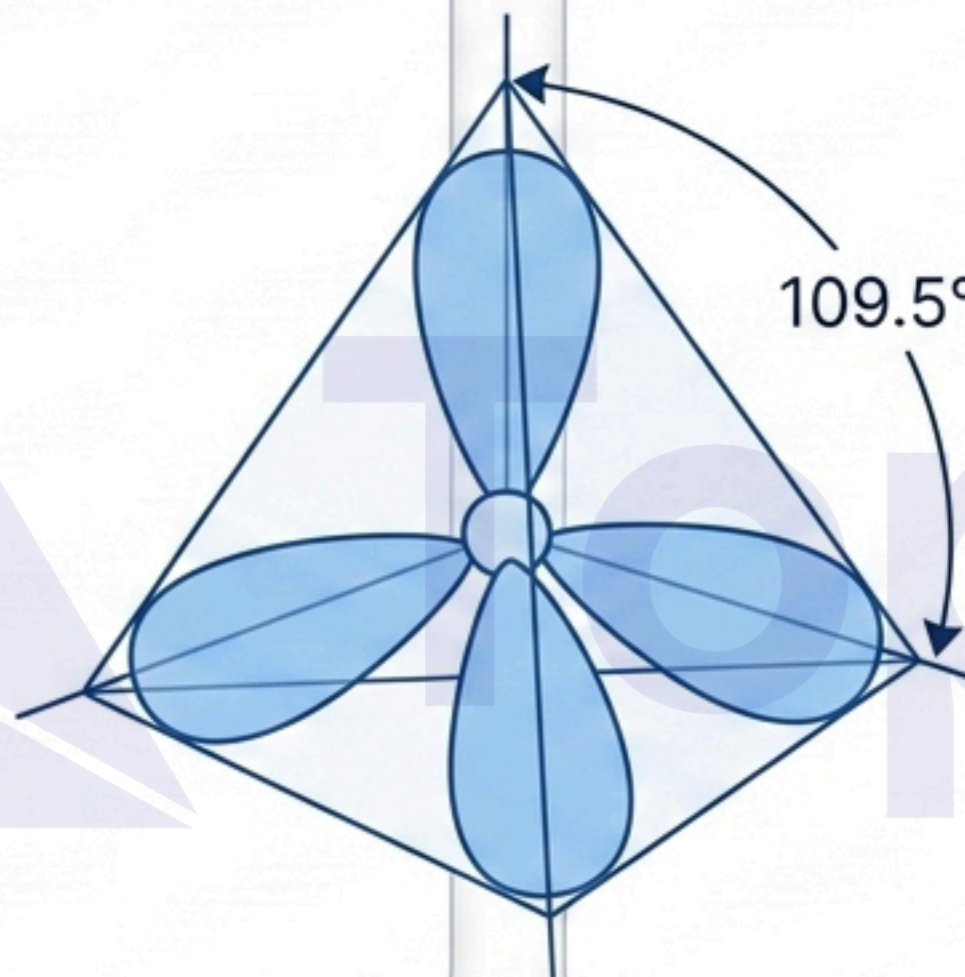
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sp^3 Hybridisation

The Orbital Mix

- **Inputs:** $1s$ + $3p$ orbitals (p_x, p_y, p_z)
- **Outputs:** Four equivalent sp^3 hybrid orbitals.
- **Alignment:** Directed toward the four corners of a regular tetrahedron in 3D space.



The Geometric Reality

- **Shape:** Tetrahedral
- **Angle:** 109.5°
- **Traits:**
 - 25% s-character
 - 75% p-character

$1s$ orbital + $3p$ orbitals $\rightarrow$ $4sp^3$ hybrid orbitals $\rightarrow$ **Tetrahedral Geometry**

The Formation Of BeCl_2

Step 1: Excitation

Beryllium (Be) Ground State:
 $1s^2 2s^2$

Be Excited State:
 $1s^2 2s^1 2p^1$

Action: One 2s electron is promoted to a vacant 2p orbital to account for bivalency.

Step 2: Hybridisation

The Mix: The 2s and 2p orbitals hybridise.

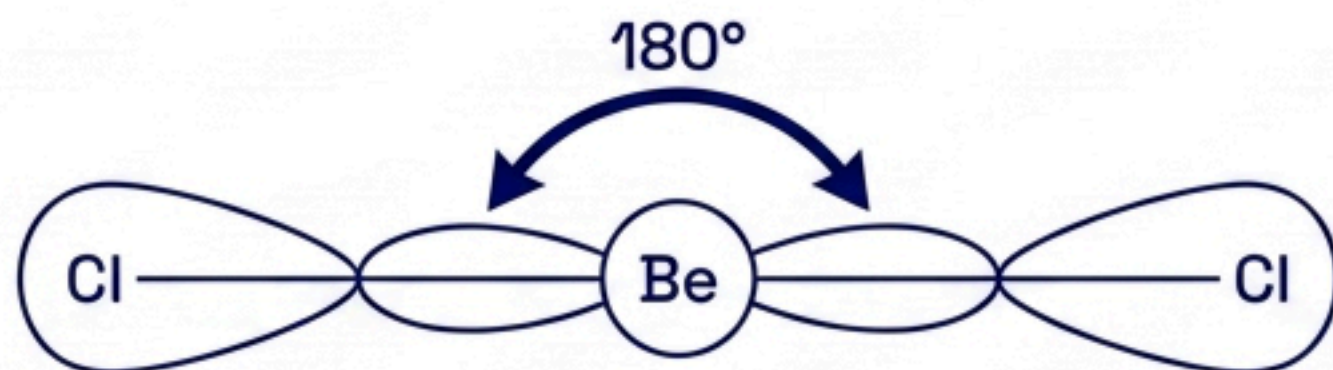
Result: Two sp hybrid orbitals are formed.

Action: They orient in opposite directions to minimize repulsion.

Step 3: Orbital Overlap

The Bond: Each sp hybrid orbital of Beryllium overlaps axially with the 2p orbital of a Chlorine atom.

Result: Two Be-Cl sigma (σ) bonds.



Geometry: Linear

The Formation Of BCl_3

Step 1: Excitation

Boron (B) Ground State:

$1s^2 2s^2 2p^1$

B Excited State:

$1s^2 2s^1 2p^2$

- **Action:** One 2s electron is promoted to a vacant 2p orbital, yielding 3 unpaired electrons.

Step 2: Hybridisation

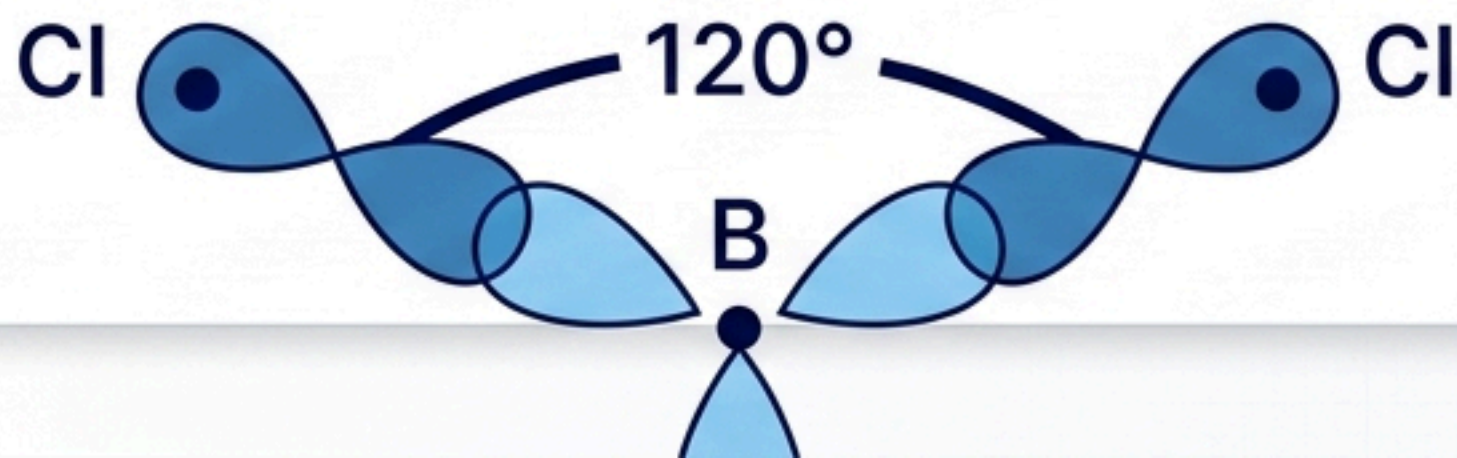
The Mix: One 2s and two 2p orbitals hybridise.

- **Result:** Three sp^2 hybrid orbitals are formed.
- **Action:** They orient in a flat triangle to minimize repulsion.

Step 3: Orbital Overlap

The Bond: Each sp^2 hybrid orbital of Boron overlaps with the 2p orbital of a Chlorine atom.

- **Result:** Three B-Cl sigma (σ) bonds.



Geometry: Trigonal Planar

Hybridisation Code → Geometry

Hybridisation Code	Orbitals Mixed	Resulting Geometry	Bond Angle	s-Character	Classic Example
sp	$s + p$	Linear	180°	50%	BeCl_2
sp^2	$s + p + p$	Trigonal Planar	120°	~33%	BCl_3
sp^3	$s + p + p + p$	Tetrahedral	109.5°	25%	CH_4

The Core Principle: Hybridisation redistributes the energy of differing atomic orbitals to form a **new set of equivalent orbitals**. These new orbitals arrange themselves in space to **minimize** electron pair repulsion, which directly defines the molecule's physical shape.



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