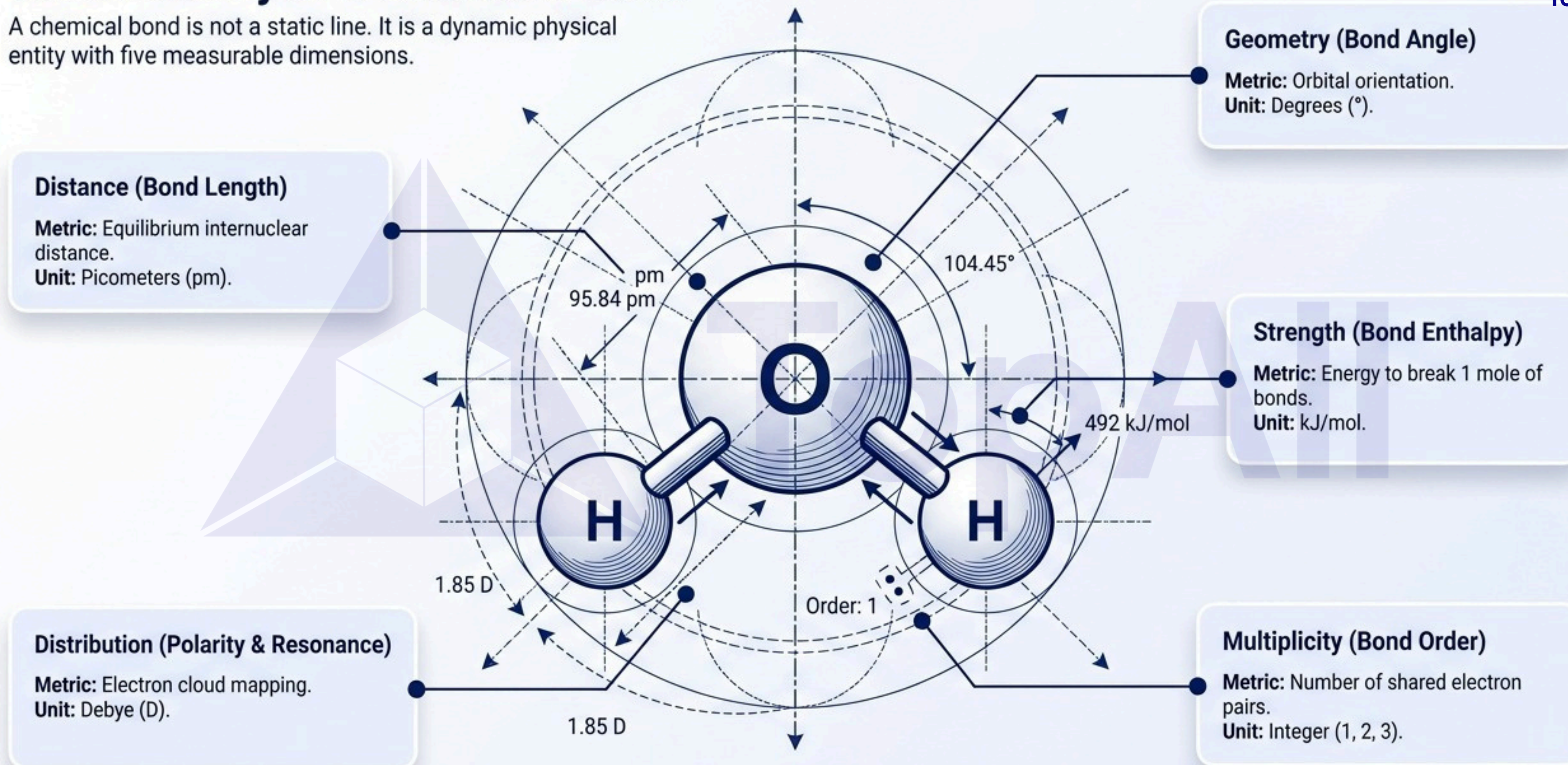


The Anatomy of a Chemical Bond

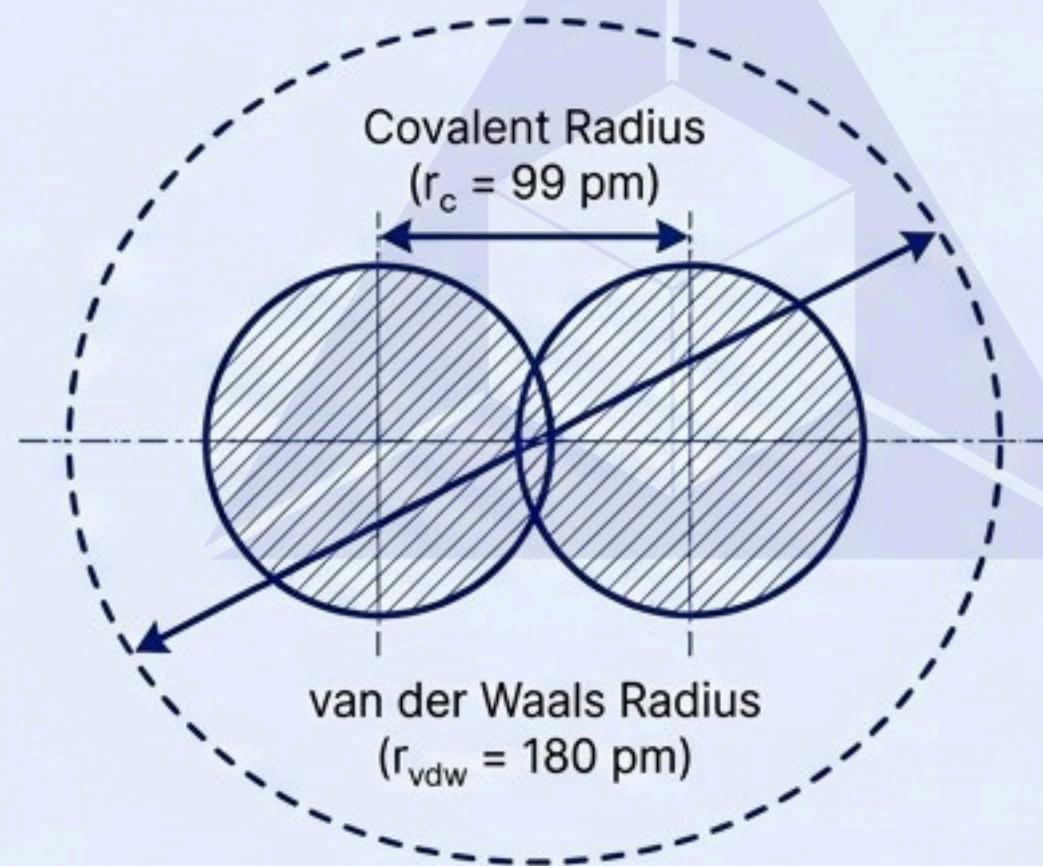
A chemical bond is not a static line. It is a dynamic physical entity with five measurable dimensions.



Spatial Geometry: Length & Angle

Bond Length (R)

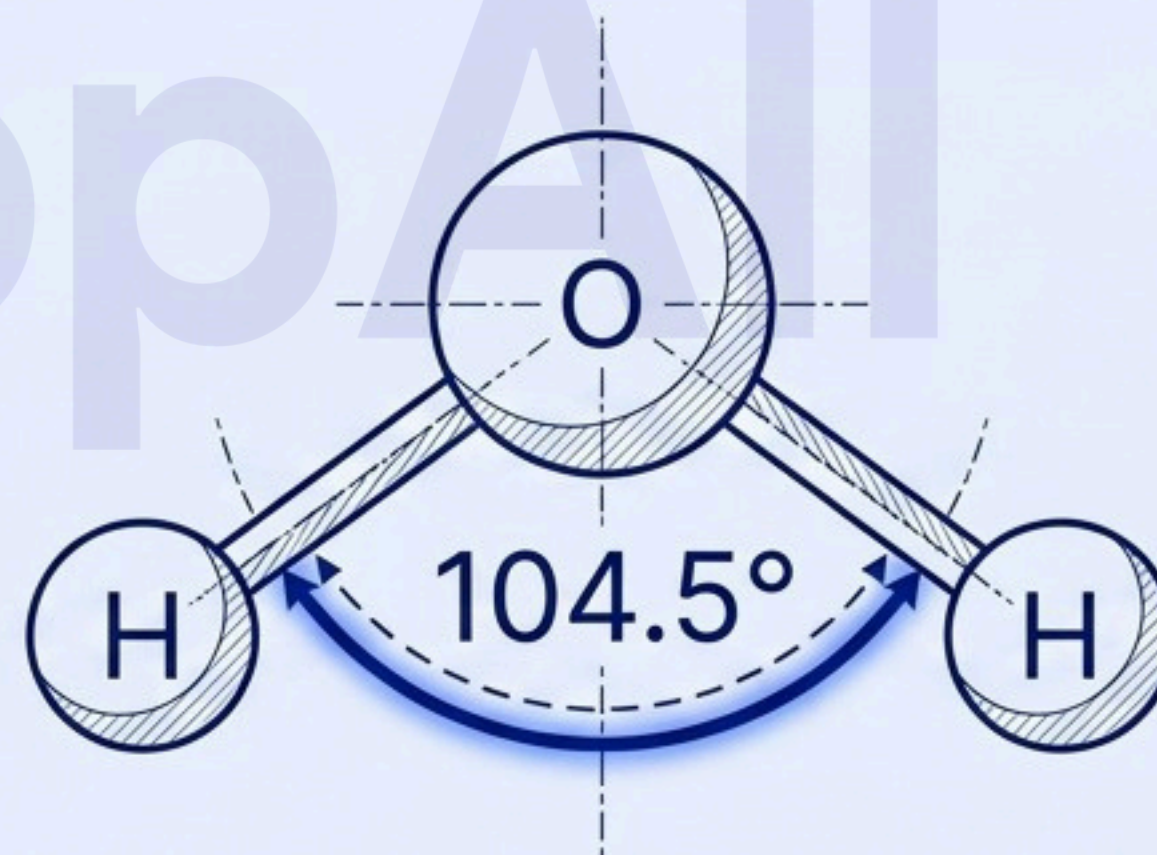
The equilibrium distance between the nuclei of two bonded atoms ($R = r_A + r_B$).



Note: vdW radius is always larger; it represents the collision boundary with other molecules in a solid.

Bond Angle

The angle between the orbitals containing bonding electron pairs around the central atom. It dictates the molecule's overall 3D shape.





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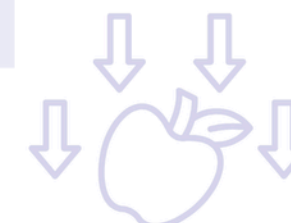
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Energetics: Strength & Multiplicity



Bond Order

The number of shared electron pairs.
Isoelectronic species (e.g., N_2 , CO , NO^+) have identical bond orders (Order = 3).

Bond Enthalpy

Energy required to break one mole of bonds in a gaseous state.

Note: Polyatomic molecules (like H_2O) use average bond enthalpy, as sequential bonds break at different energy thresholds.

Energetics Dashboard

Single Bond (C-C)

Order: 1

Length: 154 pm

Double Bond (C=C)

Order: 2

Length: 133 pm

Triple Bond (C $\equiv$ C)

Order: 3

Length: 120 pm

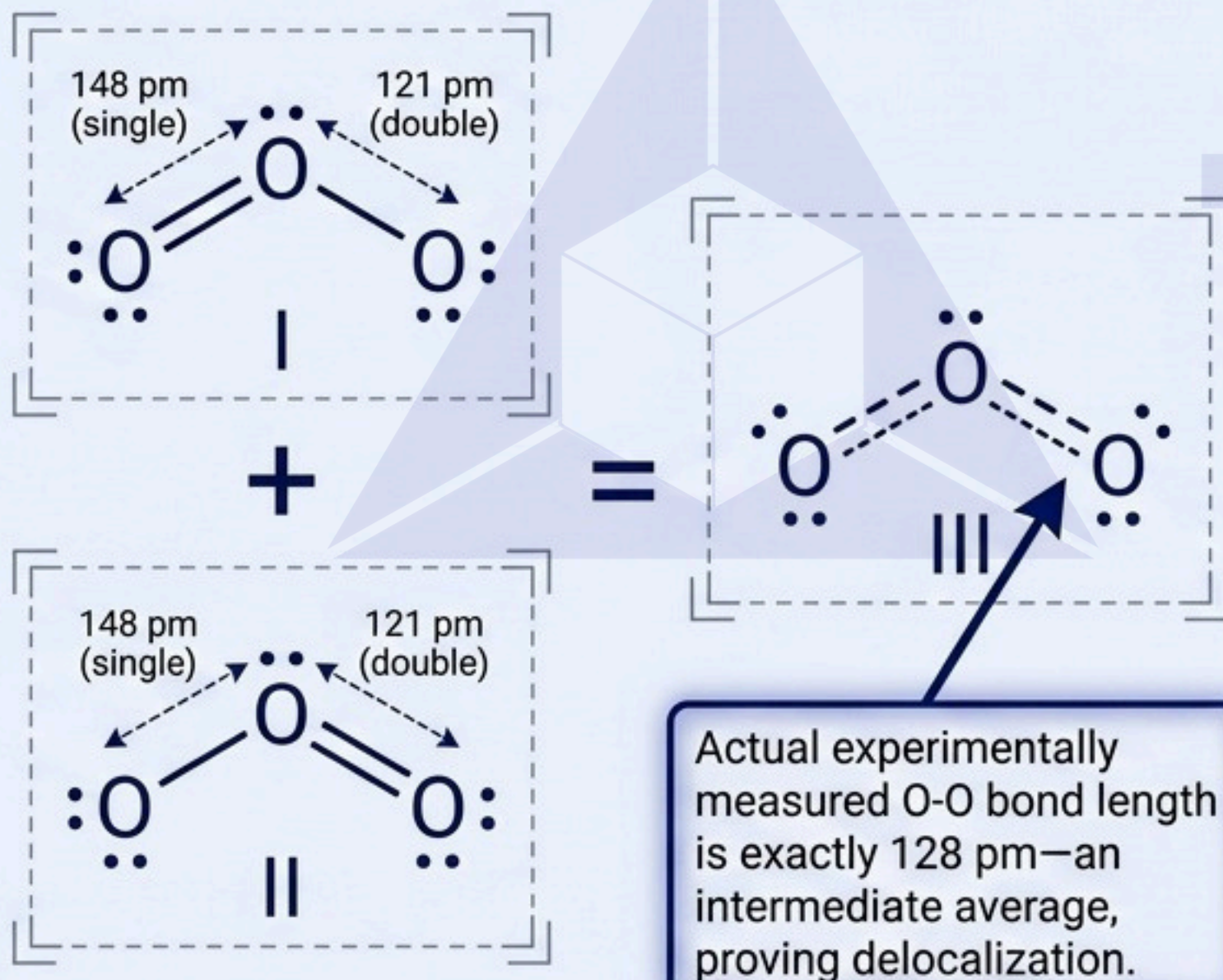
THE UNIVERSAL CORRELATION:

As Bond Order increases $\rightarrow$ Bond Enthalpy increases $\rightarrow$ Bond Length decreases.

Electron Distribution: Resonance & Polarity

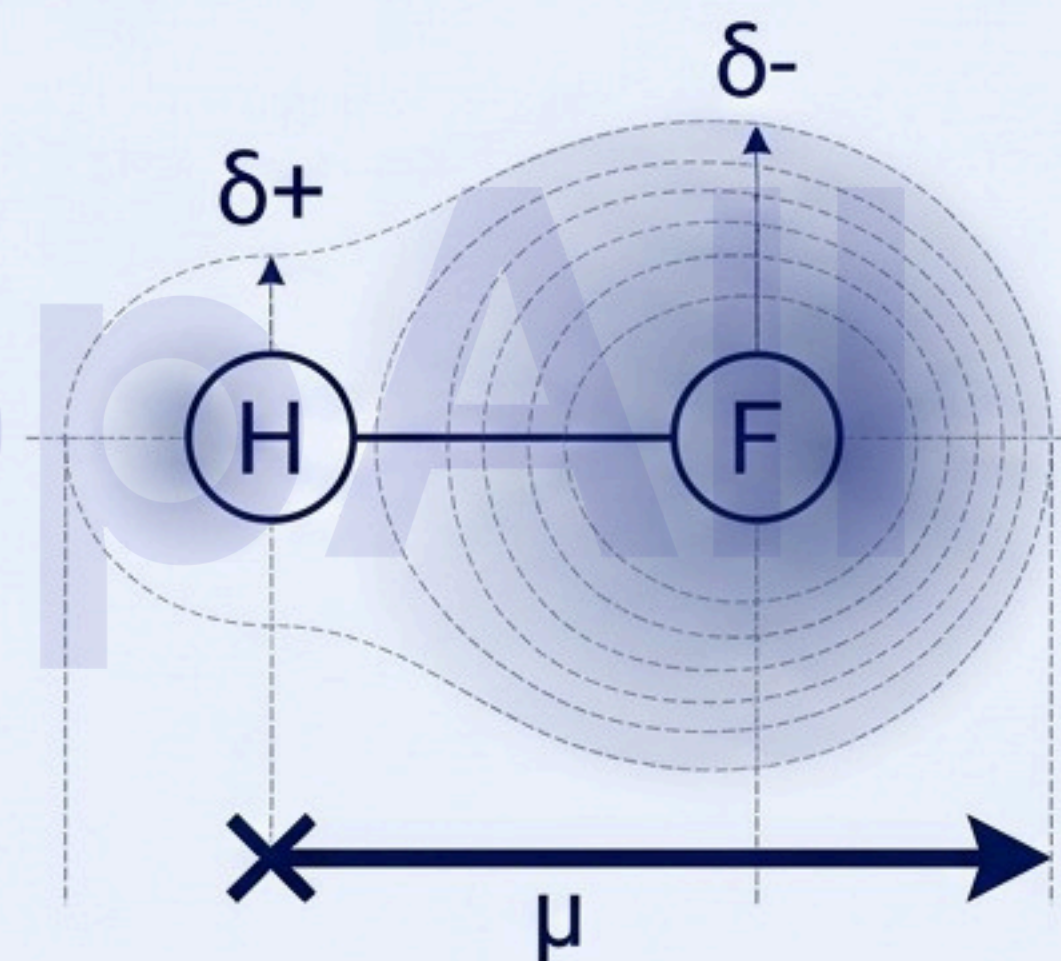
Resonance (The Ozone Example)

Concept: Single Lewis structures cannot describe some molecules. The actual structure is a hybrid.



Polarity (The HF Example)

Concept: Electrons are rarely shared equally. The more electronegative atom pulls the electron cloud.



Dipole Moment (μ) = Charge (Q) $\times$ Distance (r),
measured in Debye (D).

Revision Frame: Bond Parameters

	Distance (Bond Length)	Equilibrium internuclear distance (pm).	Covalent Radius (core contact) < van der Waals Radius (non-bonded collision size).
	Geometry (Bond Angle)	Orbital orientation around the central atom (°).	Dictates the ultimate 3D spatial shape of the molecule.
	Strength (Bond Enthalpy)	Energy to break 1 mole of bonds (kJ/mol).	Polyatomic molecules rely on average bond dissociation enthalpy.
	Multiplicity (Bond Order)	Number of shared electron pairs.	Isoelectronic species share orders. Drives the Golden Rule: ↑ Order = ↑ Enthalpy & ↓ Length.
	Electron Distribution	Actual quantum placement of electrons.	Measured via Dipole Moments (polarity) and mapped via Resonance Hybrids (delocalization).



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