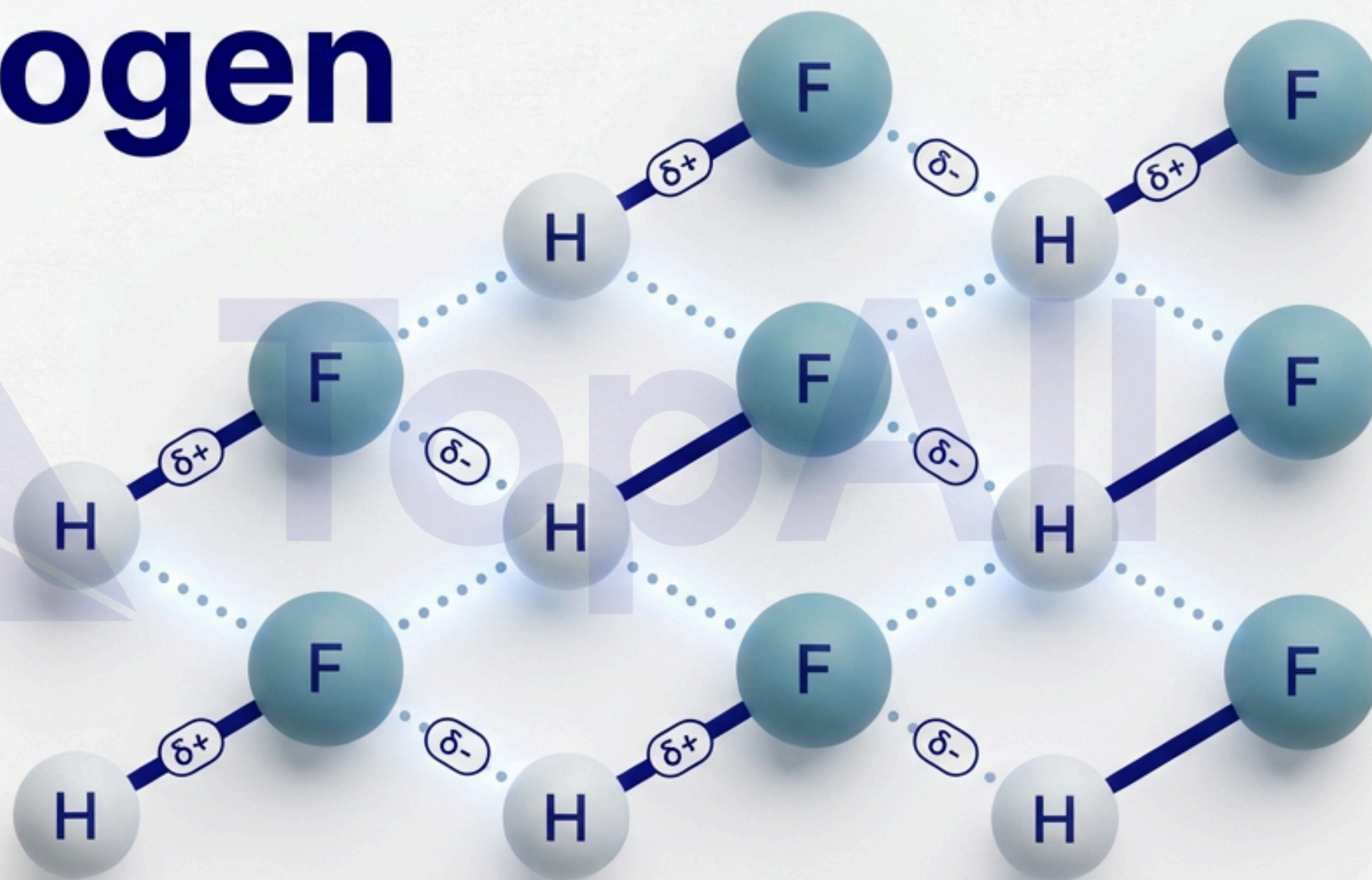


4.9 Hydrogen Bonding



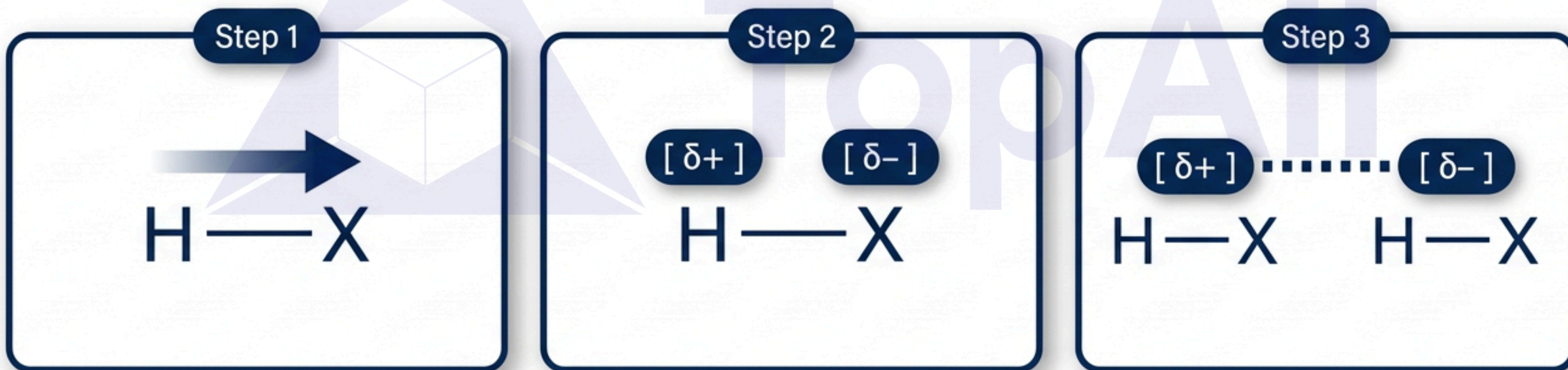
CONCEPT DEFINITION



The Electrostatic Bridge

The attractive force that binds a hydrogen atom—already covalently attached to a highly electronegative atom—to another electronegative atom on a different molecule.

Mechanism Diagram



It acts as a bridge: one side held by a true covalent bond, the other by a strong electrostatic attraction.



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$$E=mc^2$$



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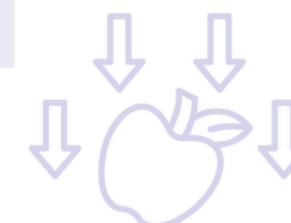
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The Electronegativity Factor

[N] Nitrogen

[O] Oxygen

[F] Fluorine

1. Extreme Electronegativity



These elements pull shared electrons far away from the hydrogen atom, creating an intense, highly polarized dipole (δ^+ / δ^-).

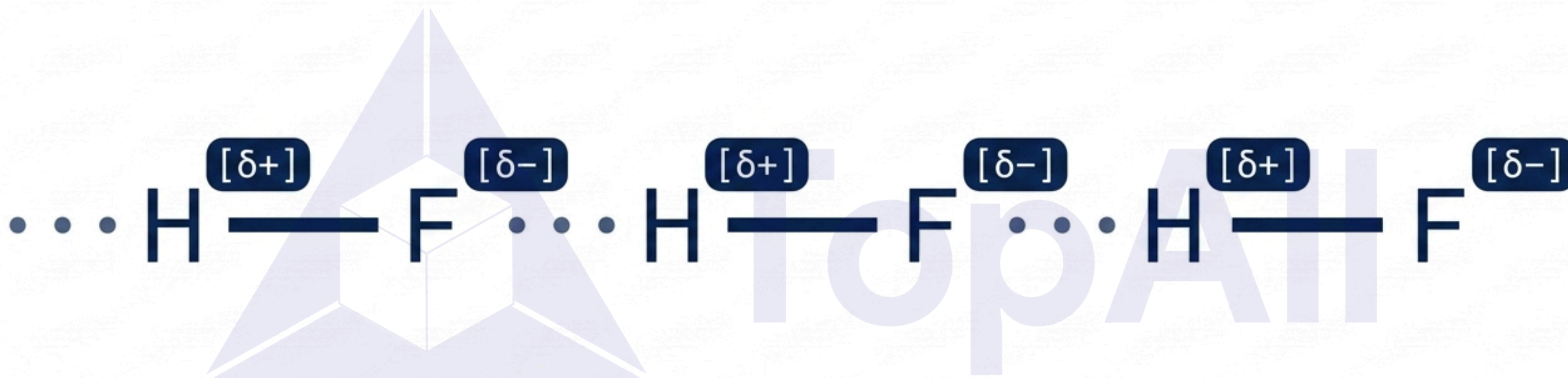
2. Small Atomic Size



Their exceptionally small radii concentrate the negative charge, making their electrostatic pull on neighboring positive hydrogens incredibly strong.

Exam Tip: Cl (Chlorine) has high electronegativity too, but its larger size diffuses the charge—weakening the effect and preventing true hydrogen bonding.

The Hydrogen Fluoride Chain



Visual Legend

- [—] Solid Line = Covalent Bond (Intramolecular)
- [...] Dotted Line = Hydrogen Bond (Intermolecular)

Notice the bridge: The H atom is trapped between two highly electronegative F atoms—bridging the gap between distinct HF molecules.

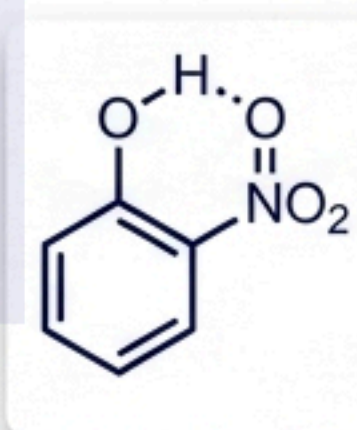
Intermolecular vs. Intramolecular Forces

Covalent Bond

Nature:	Sharing of electron pairs.
Location:	Strictly Intramolecular (within the same molecule).
Strength:	Extremely strong (determines chemical identity).
Representation:	Solid line (—)

Hydrogen Bond

Nature:	Electrostatic dipole attraction.
Location:	Usually Intermolecular (between molecules, e.g., HF). Can be Intramolecular (within molecules, e.g., o-nitrophenol).
Strength:	Weaker than covalent, but the strongest of the dipole forces.
Representation:	Dotted line (· · ·)



Weak Individually, Powerful in Effect

A single hydrogen bond is much weaker than a covalent bond. However, when multiplied across millions of molecules, they dramatically alter the physical world.

1. Physical State

Explains the anomaly of water: why H_2O is a liquid at room temperature while heavier H_2S is a gas.

2. Solid State Maximization

H-bonds are maximized and most rigid in solid crystal lattices, explaining why ice structures expand and float.

3. Structural Integrity

They dictate the 3D shapes and fundamental properties of vital biological molecules (like DNA) and synthetic polymers.

Remember: Covalent bonds build the molecule. Hydrogen bonds organize the crowd.



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