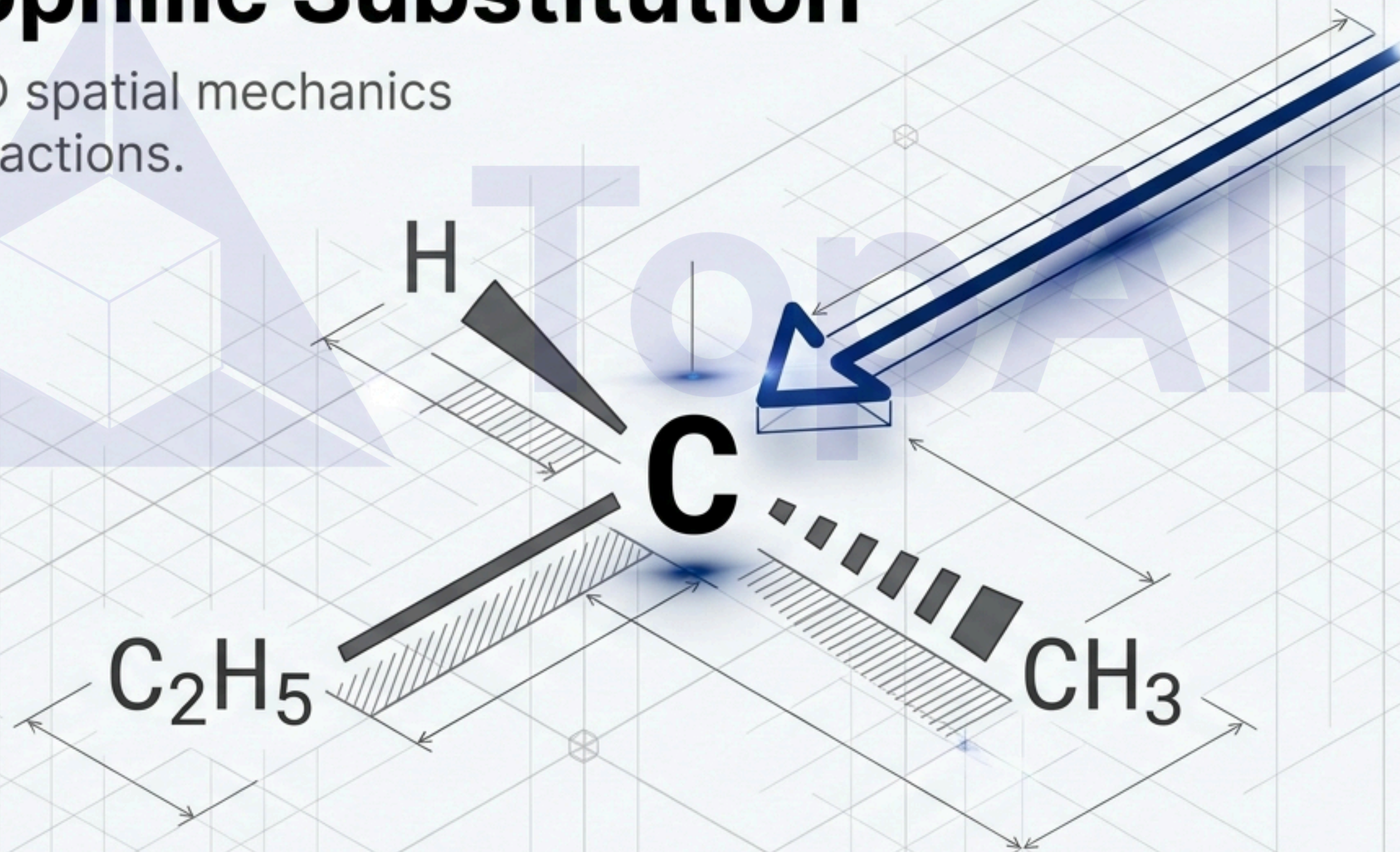


Stereochemical Aspects of Nucleophilic Substitution

Visualizing the 3D spatial mechanics of S_N1 and S_N2 reactions.



The Spatial Vocabulary

The Source

A molecule is **chiral** if it lacks symmetry. This usually requires an **asymmetric carbon** (stereocentre)—a carbon bonded to four entirely different groups.

The Pairs

Enantiomers are stereoisomers that exist as non-superimposable mirror images of each other. They have identical physical properties but behave differently in 3D space.

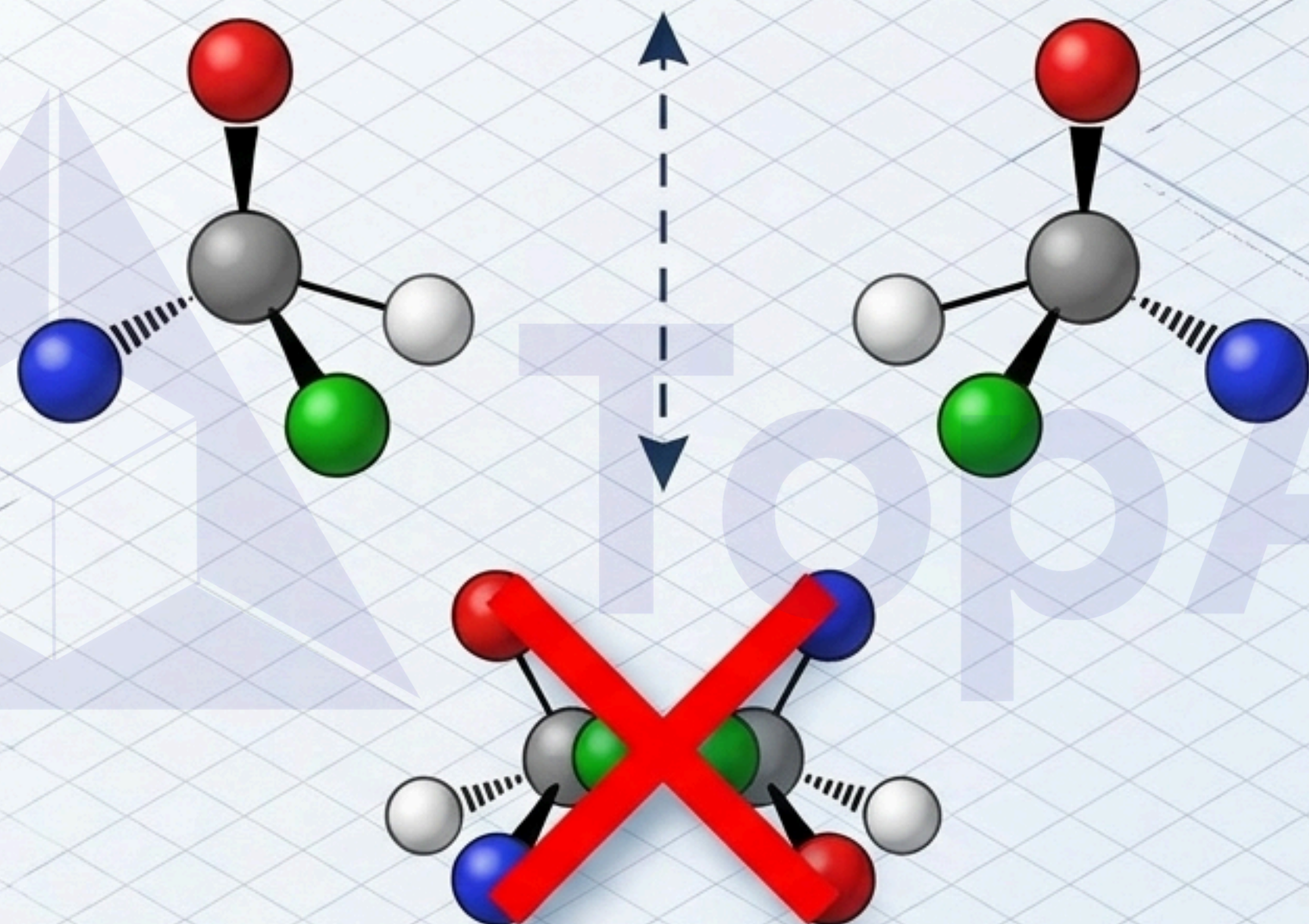
The Measurement

Optical Activity is the ability of chiral molecules to rotate plane-polarised light. Measured as dextrorotatory (+) or laevorotatory (-).

The Outcomes

Retention: 3D shape is kept.
Inversion: 3D shape is flipped.
Racemisation: 50:50 mix of both, cancelling out any optical activity.

The Chirality Test: Superimposability



If the mirror image cannot perfectly overlap the original, the molecule is **chiral**.
These two distinct molecules are **enantiomers**.



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$$E=mc^2$$



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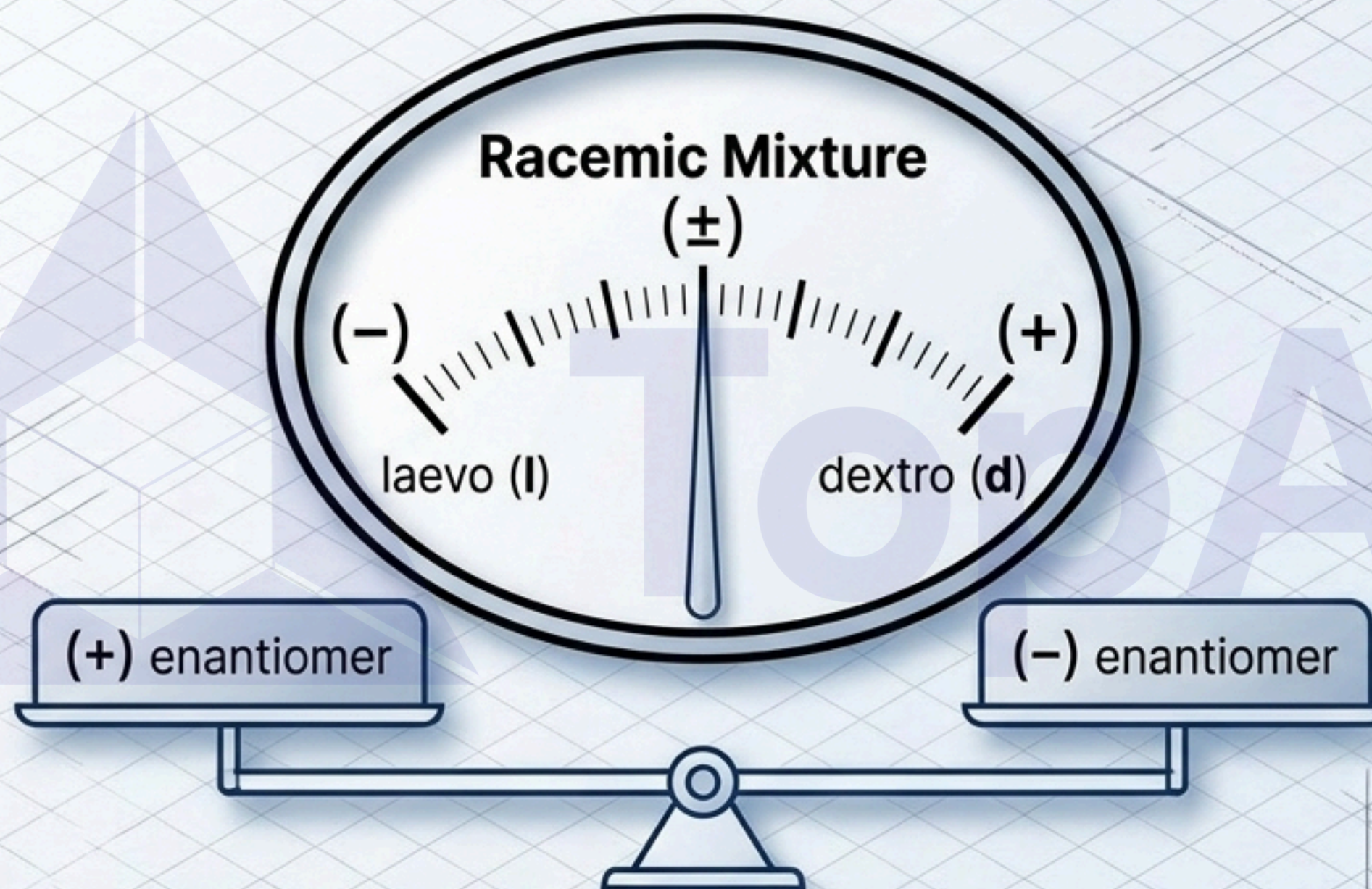
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Measuring Space: The Polarimeter Dial

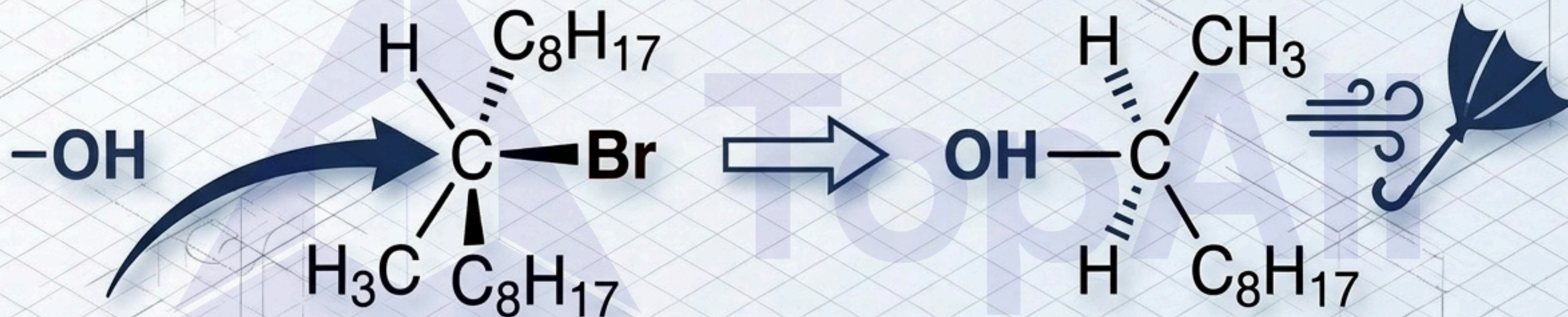


A **racemic mixture** contains equal parts of both enantiomers. The optical rotation of one cancels the other, resulting in zero net rotation.

S_N2 Mechanics: Complete Inversion

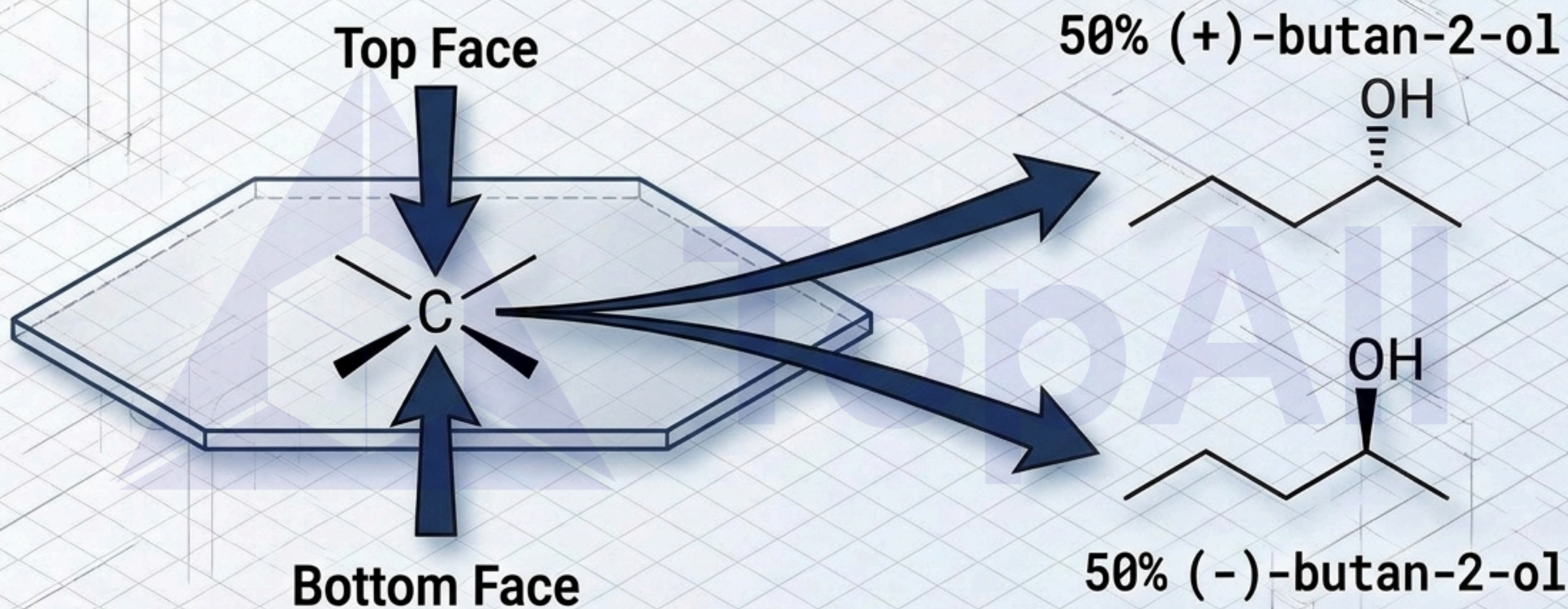
(-)-2-bromooctane

(+)-octan-2-ol



Because the nucleophile forces its way in from the back, the molecule's spatial arrangement undergoes a clean, 100% flip. S_N2 always results in **inversion of configuration**.

S_N1 Mechanics: The Planar Attack



The intermediate carbocation is completely flat (achiral). The nucleophile has an equal 50/50 chance of attacking from either face.

Result: Racemisation. A 1:1 racemic mixture with zero net optical rotation.

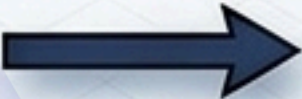
Spatial Blueprint: S_N2 vs. S_N1

S_N2 Mechanism

S_N1 Mechanism

Intermediate: None (1-step transition state)

Intermediate: Flat sp^2 Carbocation

Attack Path: Backside only 

Attack Path: Both faces equally 

Outcome: 100% Inversion



Outcome: Racemisation
50:50 mixture, zero rotation

Watch For This Common Trap



The Trap: Assuming an S_N1 reaction simply swaps the leaving group for the nucleophile while keeping the same 3D shape.

The Reality: Because the S_N1 intermediate becomes a **flat plane**, spatial memory **is lost**. The nucleophile will attack both sides equally. You do not get a single product; you get a **racemic mixture**.

Key Takeaways

- **S_N2 = Complete Inversion.** The nucleophile performs a backside attack, flipping the molecule's spatial configuration like an umbrella in the wind.
- **S_N1 = Racemisation.** The reaction creates a flat sp^2 carbocation intermediate. Nucleophilic attack occurs equally from both faces, resulting in a 50:50 racemic mixture with zero net optical rotation.

Mastering these spatial blueprints is the key to predicting stereochemical products accurately.



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