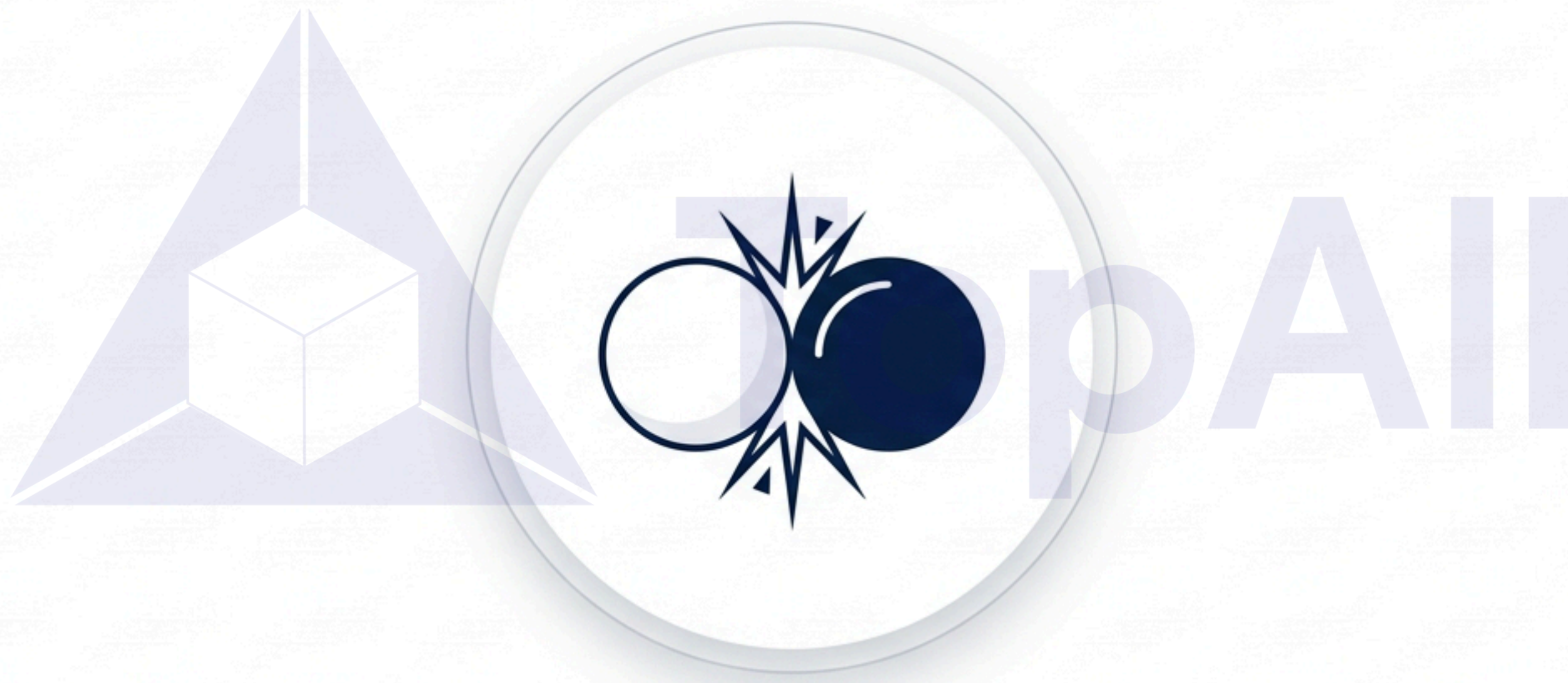


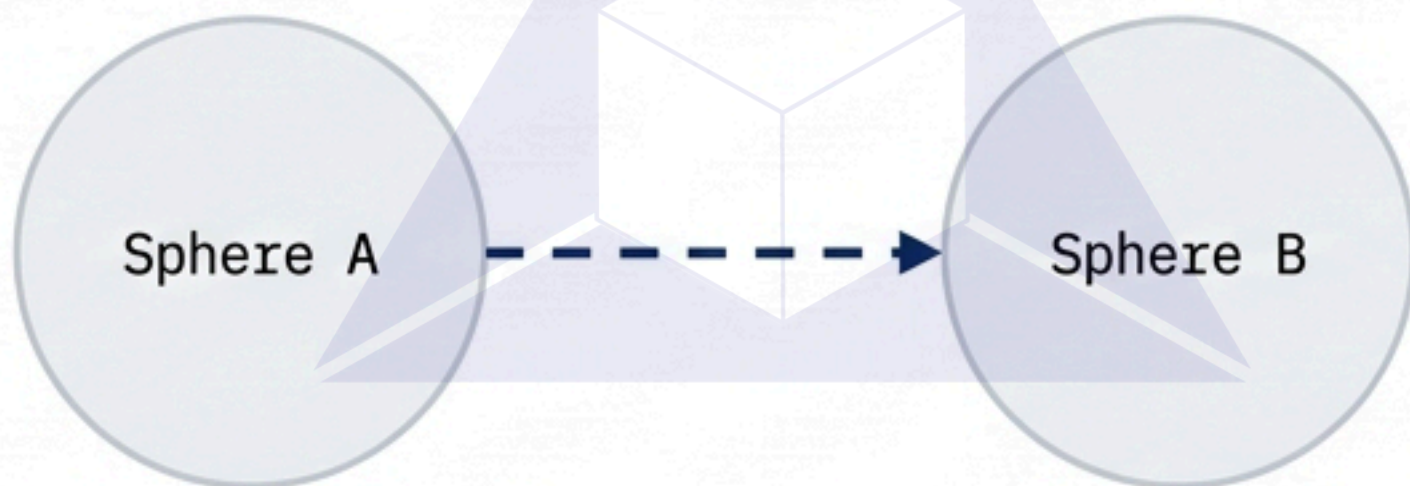
3.5 Collision Theory of Chemical Reactions



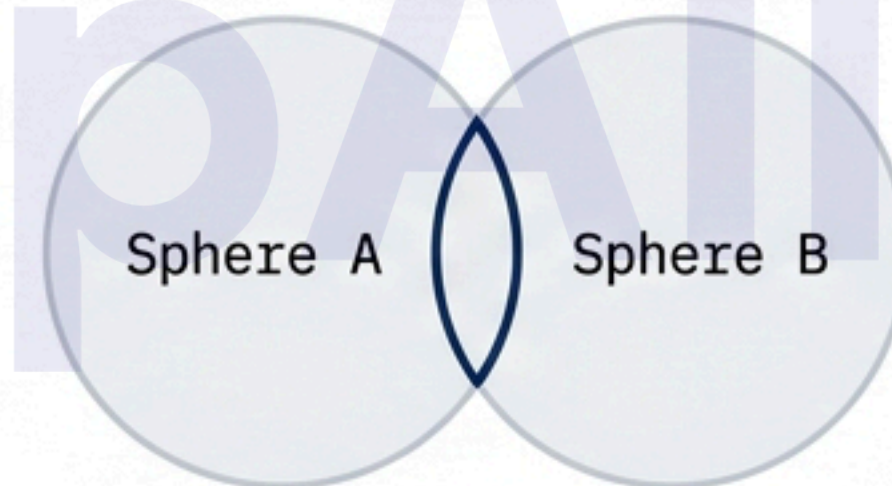
Unit Synthesis Deck

Why Collisions Matter

The 'Hard Sphere' Postulate: In collision theory, reacting atoms and molecules are mathematically modeled as rigid, hard spheres. A chemical reaction is postulated to occur only when these spheres physically collide.



✗ No Collision = No Reaction



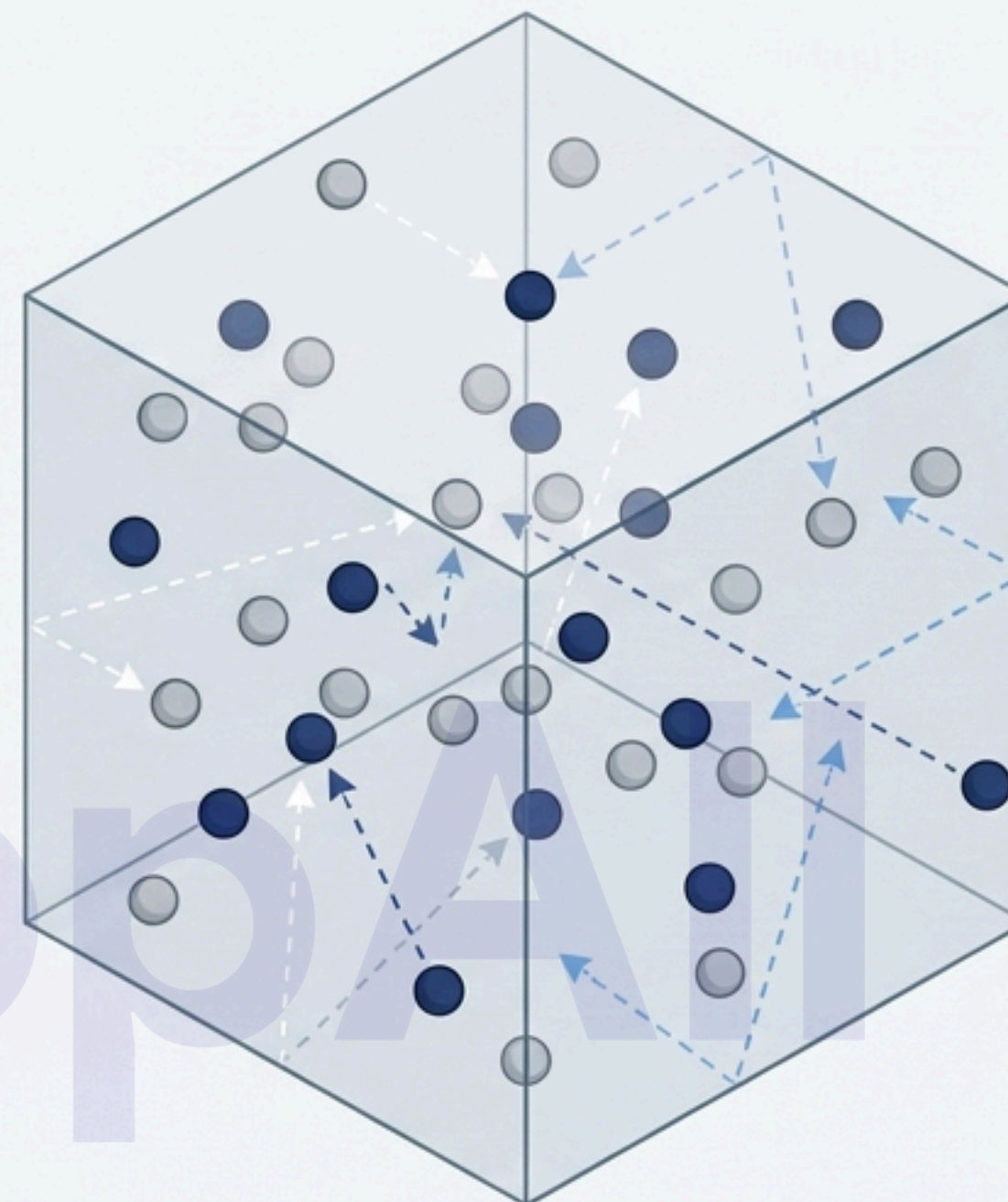
✓ Collision = Potential Reaction

Hitting each other is the absolute prerequisite. But is hitting each other enough?

Collision Frequency (Z)

Molecules in a gas or liquid are in constant, chaotic motion, colliding millions of times per second.

We measure this baseline activity using Collision Frequency (Z).



Z_{AB} = Number of collisions per second per unit volume of the reaction mixture.

Observation: If collision frequency is so incredibly high, why are some reactions slow?
Answer: Because most collisions are ineffective.



You've Learned the Theory. Let's Test Them Now.

$$E=mc^2$$



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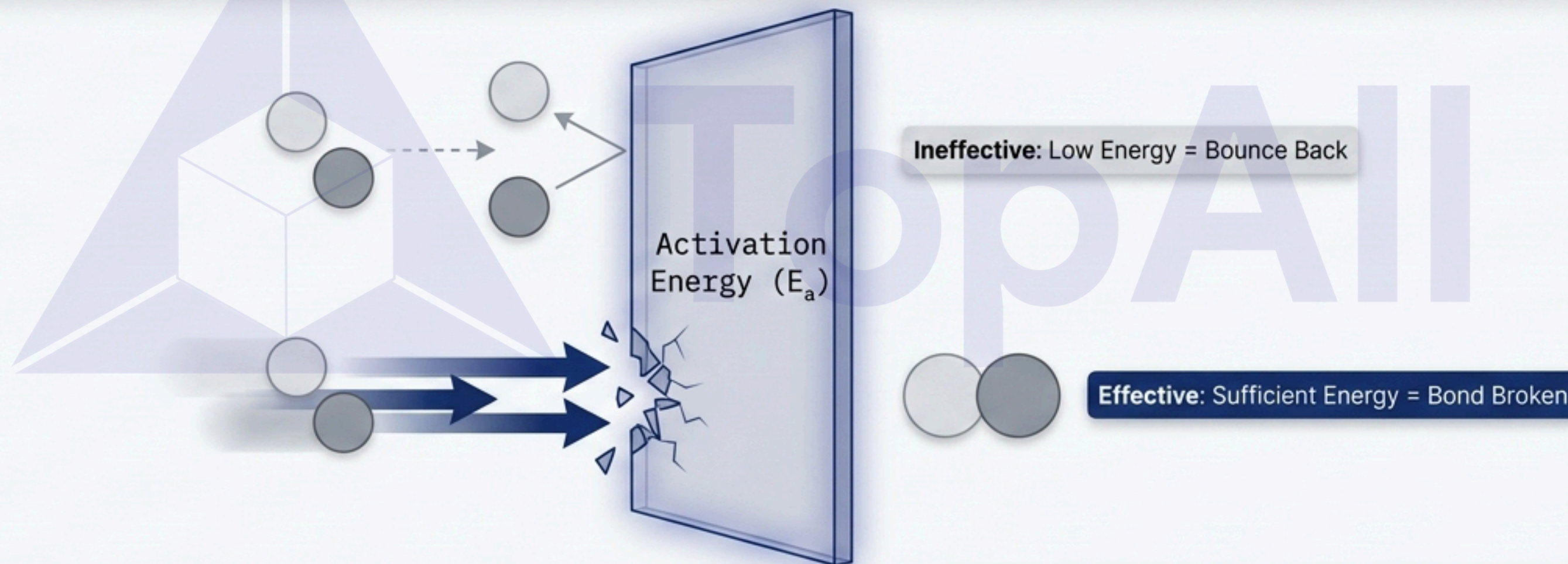
Key Highlights

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Effective Collisions & Threshold Energy

Not all collisions lead to a reaction. To be an effective collision, molecules must strike each other with sufficient kinetic energy to break existing chemical bonds and form new ones.



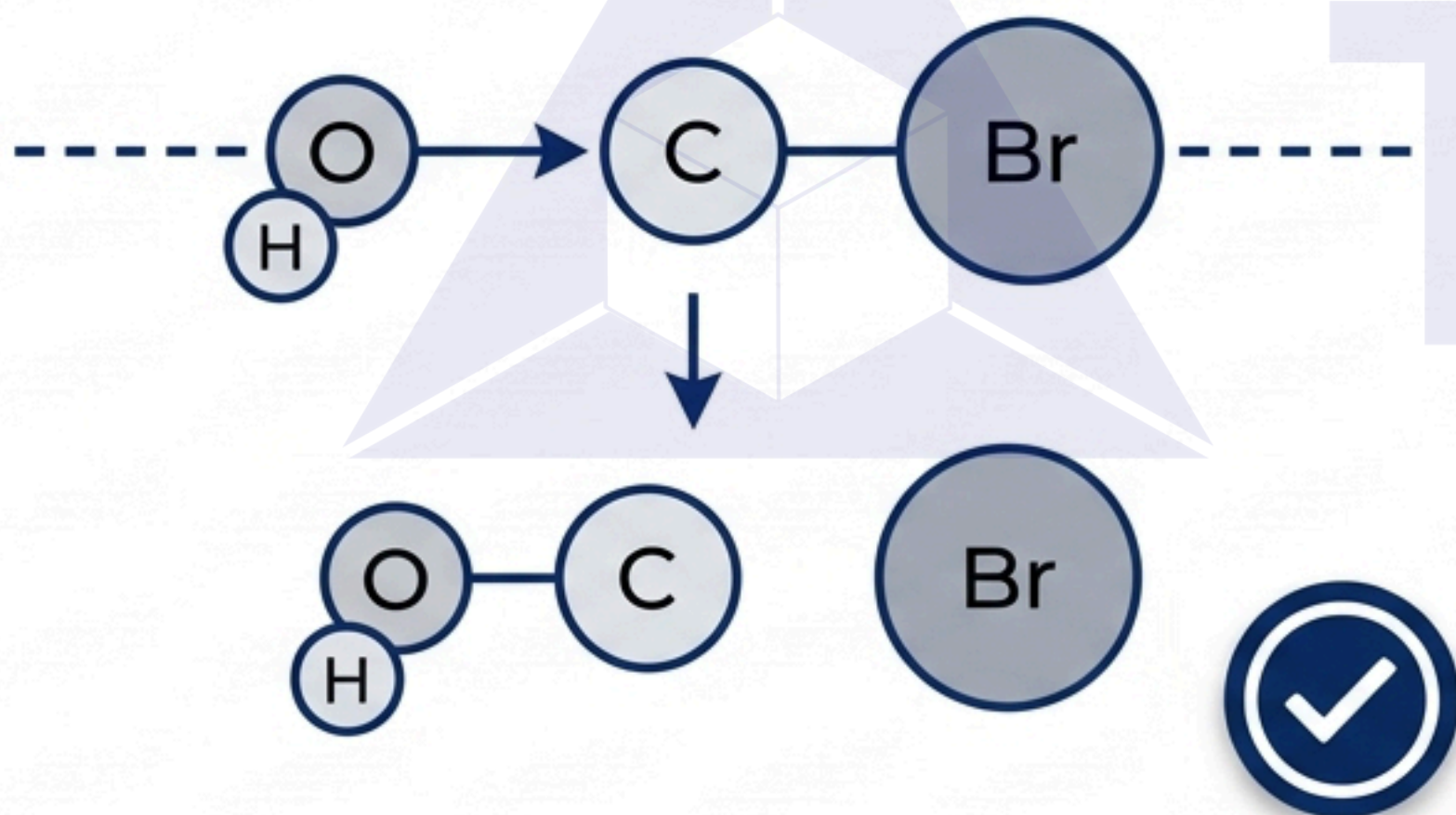
Fraction of molecules with enough energy = $e^{(-E_a/RT)}$

$$\text{Threshold Energy} = \text{Reactant Energy} + \text{Activation Energy } (E_a)$$

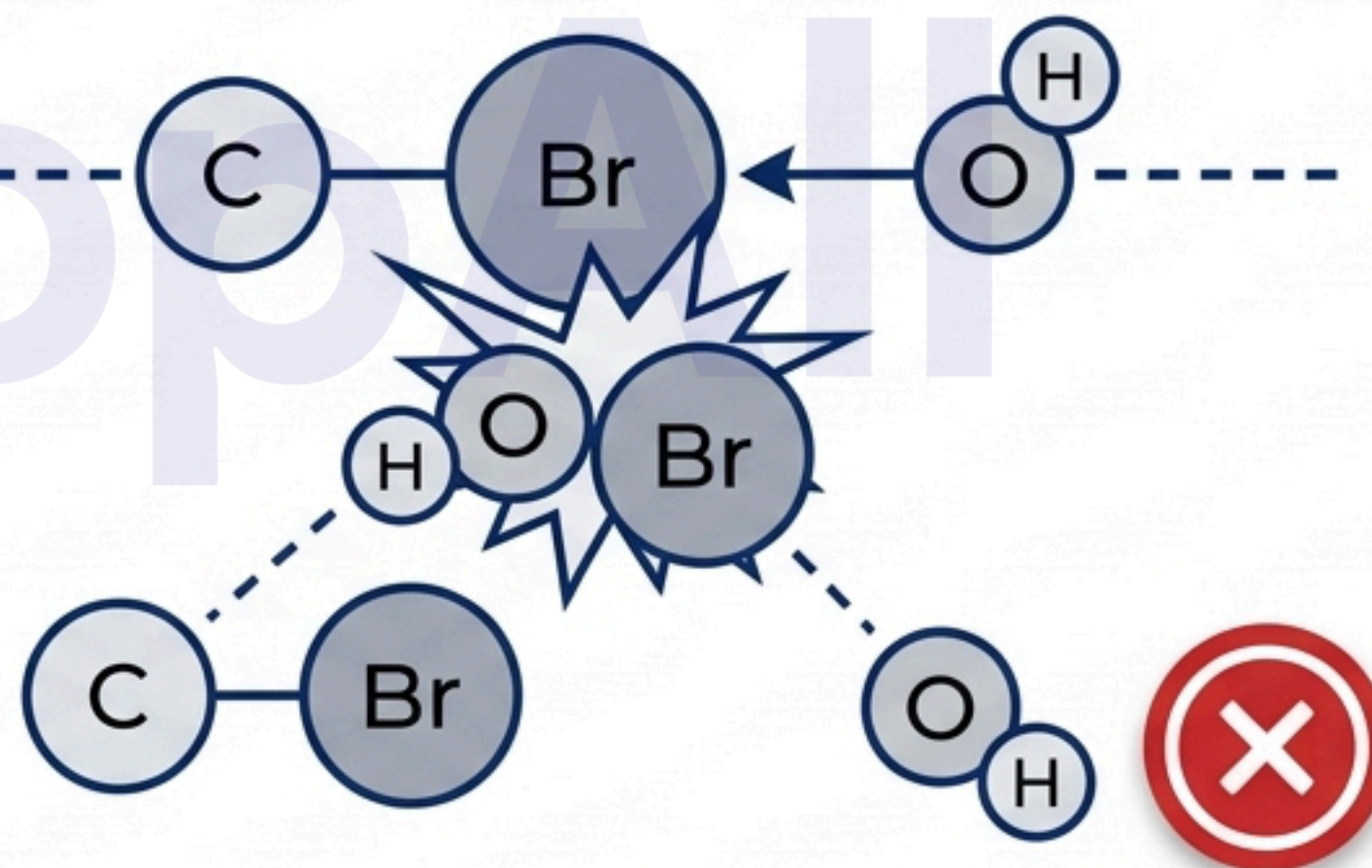
Proper vs. Improper Orientation

Even if molecules collide with sufficient threshold energy, they will fail to react if their alignment is wrong. They require a precise “lock and key” geometric alignment.

Proper Orientation



Improper Orientation



To account for this strict spatial requirement, we introduce a new variable: **The Steric Factor (P)**.

The Complete Rate Equation

Comparison Panel

Arrhenius Equation:
 $k = A e^{(-E_a/RT)}$

Collision Theory:
 $\text{Rate} = (P \cdot Z_{AB}) e^{(-E_a/RT)}$

The generic Arrhenius factor 'A' is physically explained by P and Z_{AB} .

$$\text{Rate} = P \cdot Z_{AB} \cdot e^{(-E_a/RT)}$$

P (Steric Factor)

Probability that molecules have the Proper Orientation.

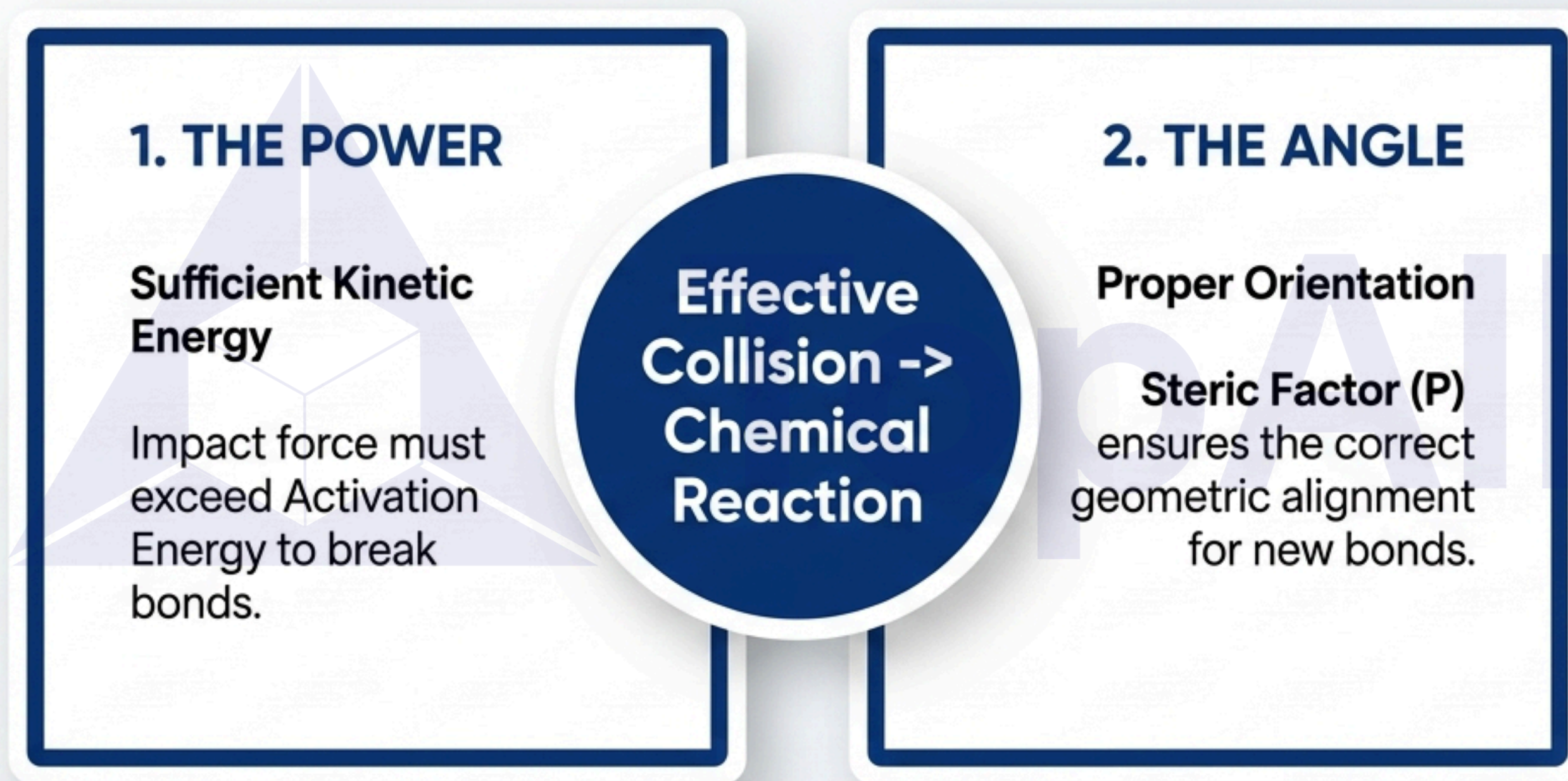
Z_{AB} (Collision Frequency)

Total number of hits per second per unit volume.

$e^{(-E_a/RT)}$ (Energy Fraction)

Fraction of hits with Sufficient Kinetic Energy.

The Anatomy of a Successful Collision



Key-Takeaway Box: Critical Flaw of the Theory: While powerful, Collision Theory fundamentally treats complex, flexible molecules as rigid 'hard spheres,' ignoring their internal structural complexity.



You've Learned the Theory.

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