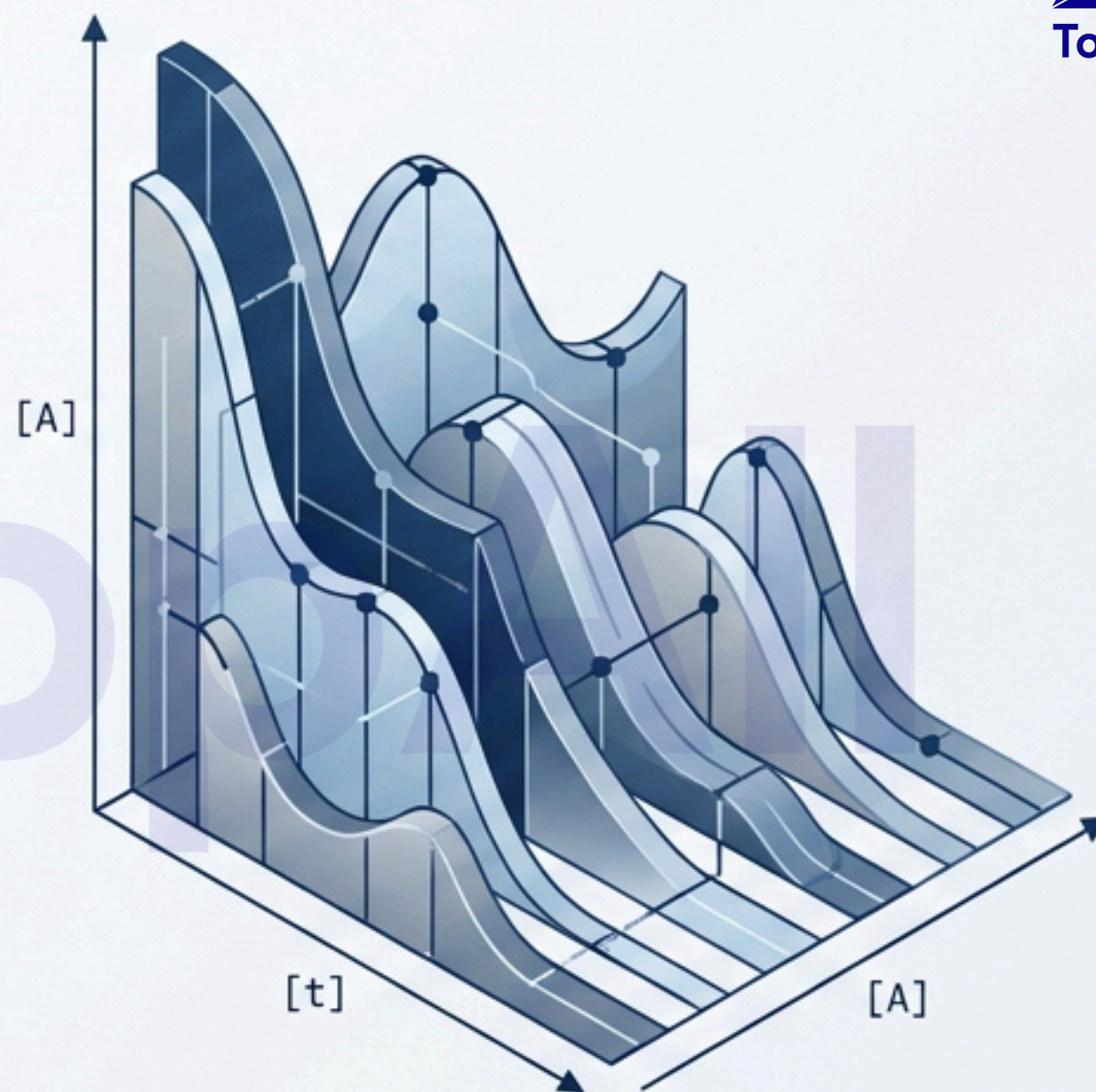


UNIT 3: CHEMICAL KINETICS

3.3.3 Half-Life of a Reaction

Understanding how reactant concentration dictates the speed of decay in zero and first-order reactions.



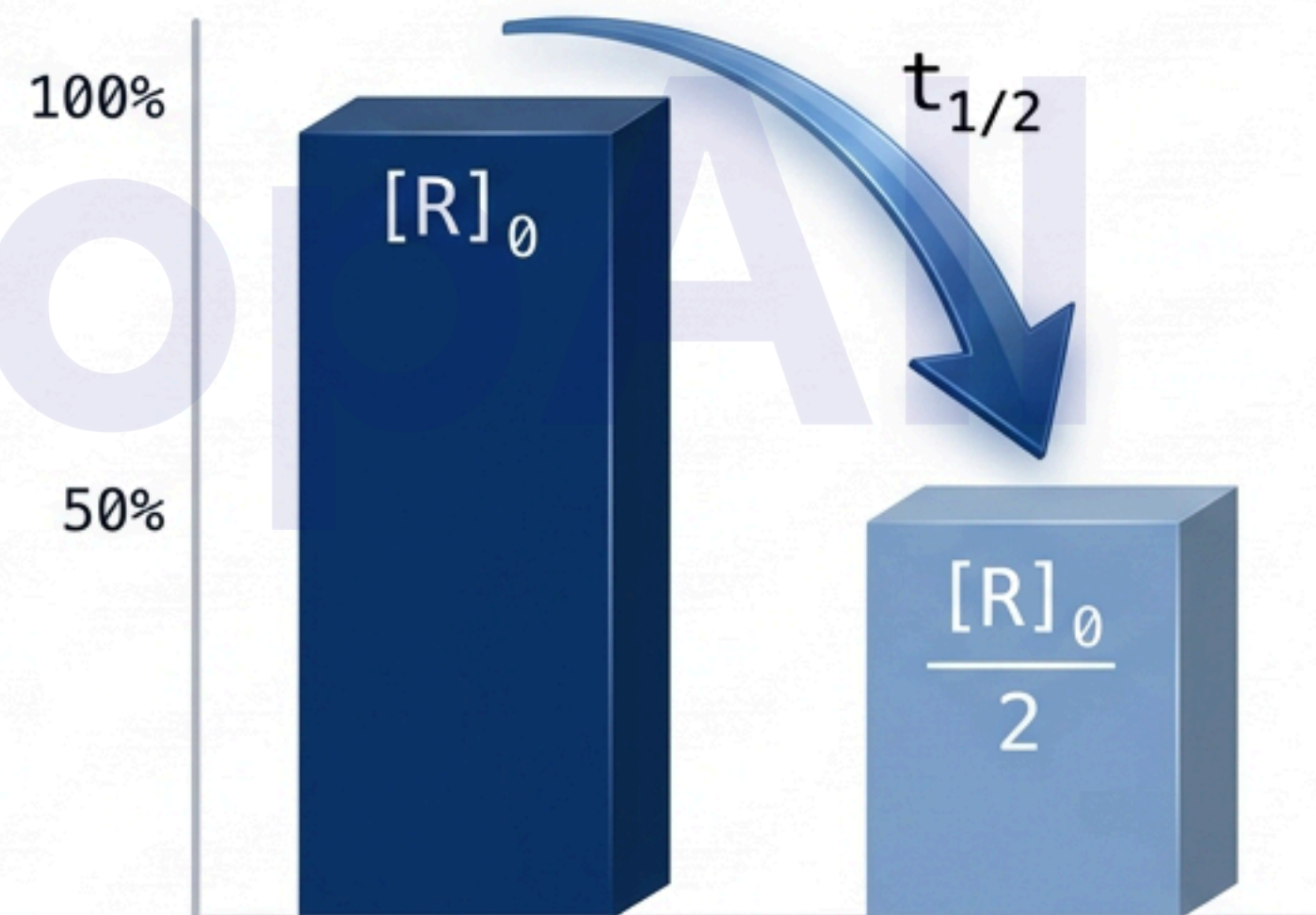
CORE CONCEPT

The Half-Life Benchmark

The time required for a reactant's concentration to drop to exactly 50% of its initial value.

Half-life ($t_{1/2}$) is the universal metric for reaction speed, marking the exact moment the reacting species is halved.

$$\text{At } t = t_{1/2}, [R] = \frac{[R]_0}{2}$$



Zero Order: Half-Life

In zero-order reactions, the half-life is directly proportional to the initial concentration.

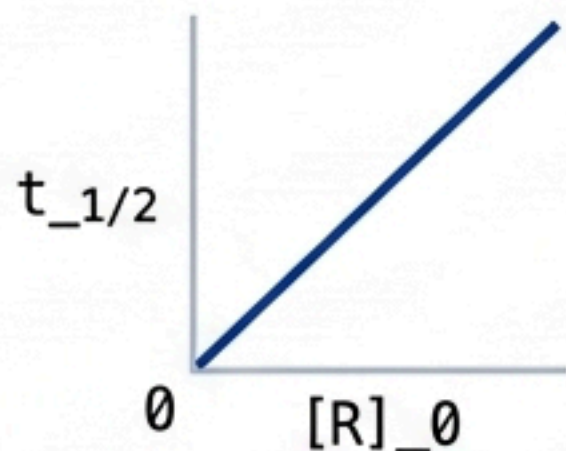
Derivation Strip

$$k = \frac{[R]_0 - [R]}{t}$$

$$\text{Insert } [R] = [R]_0 / 2$$

$$t_{1/2} = \frac{[R]_0}{2k}$$

Concept Card



Directly Proportional ($t_{1/2} \propto [R]_0$)



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First Order: Half-Life

In first-order reactions, the half-life is entirely independent of the initial concentration.

$$k = \frac{2.303}{t} * \log \frac{[R]_0}{[R]}$$

Base Equation Card

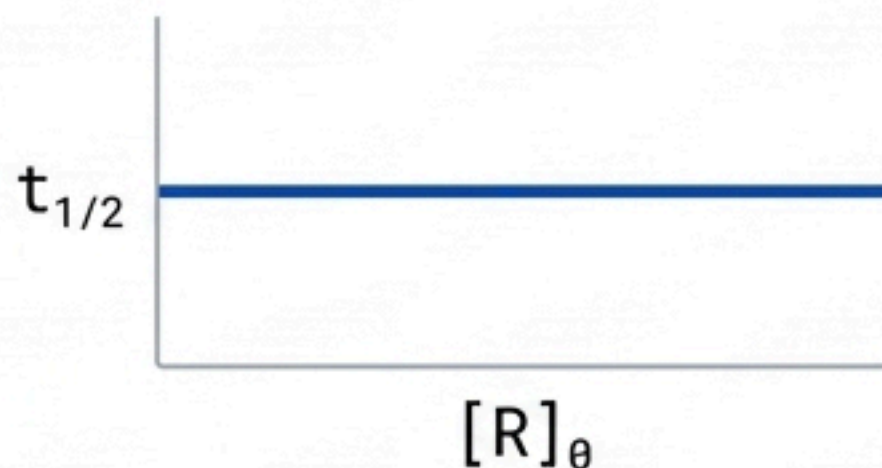
$$\text{Insert } [R] = \frac{[R]_0}{2}$$

Substitute Chip

$$t_{1/2} = \frac{0.693}{k}$$

(log 2 = 0.301)

Result Badge

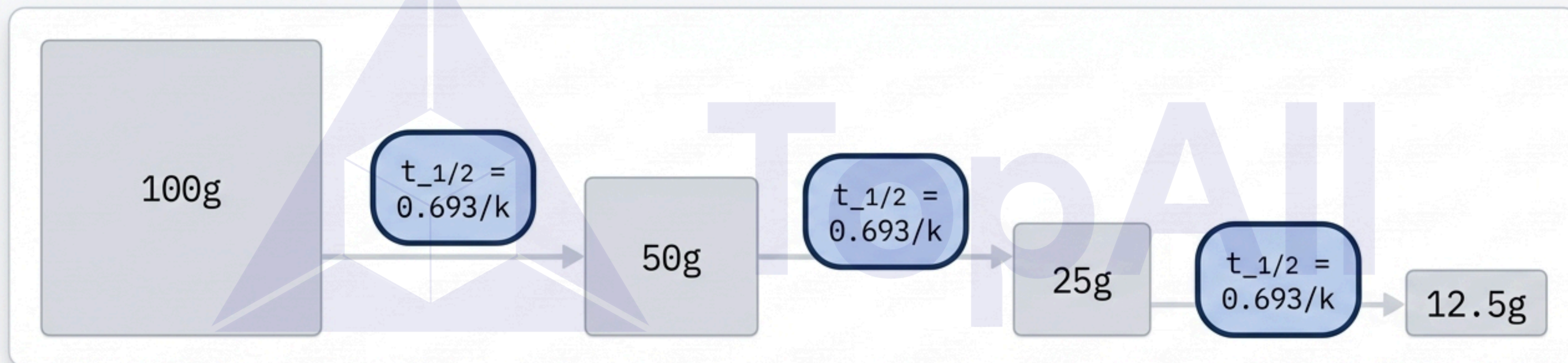


Independent ($t_{1/2}$ is constant)

Concept Card

The Memoryless Decay

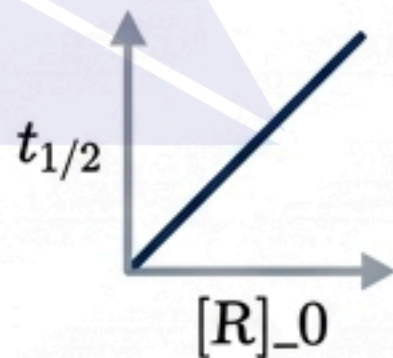
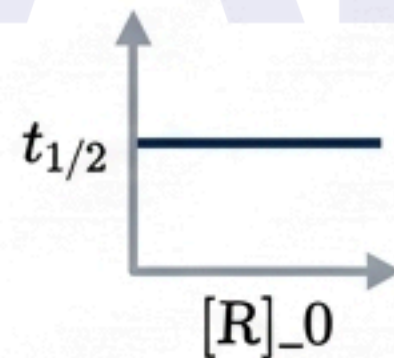
Why a first-order reaction takes the exact same amount of time to halve, regardless of how much you start with.



Because the reaction rate is directly tied to the current concentration, as the amount of reactant drops, the reaction slows down proportionally. This perfect synchronization results in a constant time to halve.

Zero Order vs. First Order

Zero order remembers initial concentration; first order does not.

	Zero Order	First Order
Formula	$t_{1/2} = \frac{[R]_0}{2k}$	$t_{1/2} = \frac{0.693}{k}$
Dependence	Proportional to $[R]_0$	Independent of $[R]_0$
Graph Shape		

CRUCIAL RULE: Zero order half-life scales with the starting amount. First order half-life is a universal constant.



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