

Integrated Rate Equations

Bridging the gap between instantaneous rates and directly measurable concentration-time data.

$$\frac{-d[R]}{dt}$$



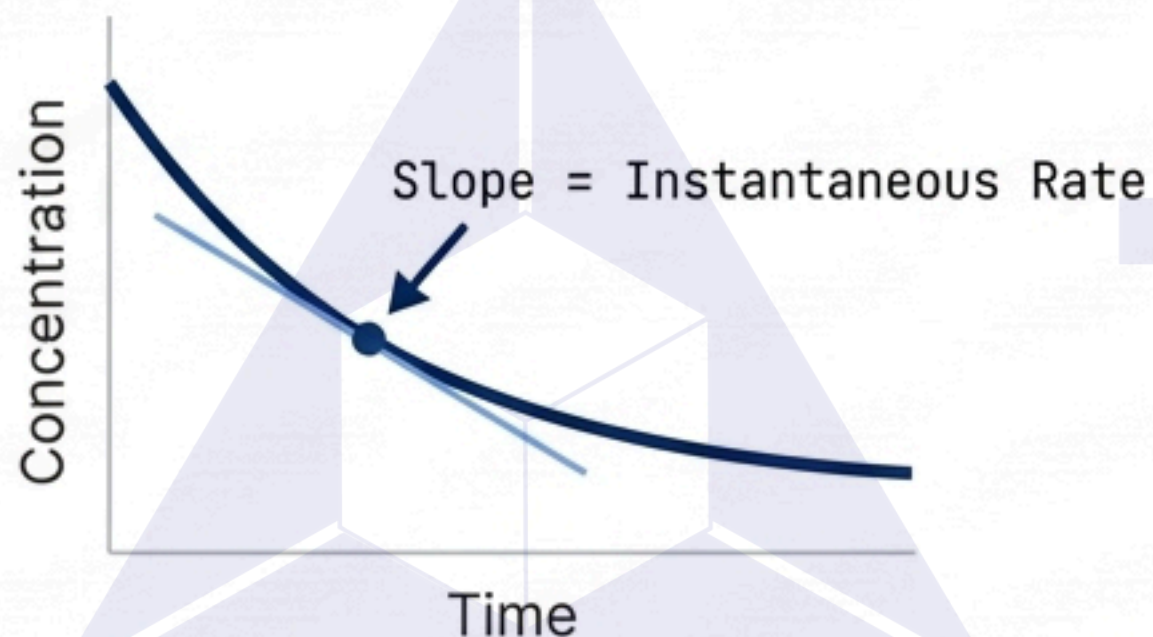
$$[R] = -kt + [R]_0$$

BRIDGE TO MEASUREMENT

Why the Differential Form Falls Short in the Lab

Impractical

The Tangent Problem



The Ideal Data

Directly Measurable

Time (t)	Concentration [R]
0	0.100
50	0.090
100	0.082

Differential Reality

Finding instantaneous rate requires drawing a tangent to a concentration-time curve. This is graphically tedious, prone to human error, and makes it difficult to accurately determine the rate law.

The Goal

We need a mathematical relationship that directly uses what we actually measure in the lab: concentrations at different intervals of time.



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$$E=mc^2$$



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Integration: The Tool for Measurable Kinetics

Differential Rate Law

$$\text{Rate} = \frac{-d[R]}{dt} = k[R]^n$$

Integration



Sums up the instantaneous changes over time.

Integrated Rate Law

$$f([R]) = kt$$

Integration eliminates the need to manually find the slope of a tangent. It converts the rate of change into a direct, testable formula linking Concentration [R] and Time t.

Why Focus on Zero and First Order?

Zero Order ($n=0$)

Focus:

Rate is completely independent of the reactant concentration.

Condition:

Rate = k

Real-World Examples:

Enzyme-catalyzed biological reactions; decomposition of gases on hot metal surfaces (e.g., NH_3 on Platinum at high pressure).

First Order ($n=1$)

Focus:

Rate depends linearly on the concentration of one single reactant.

Condition:

Rate = $k[R]$

Real-World Examples:

All natural radioactive decay (e.g., Radium-226 decaying to Helium and Radon); decomposition of N_2O_5 in the gas phase.

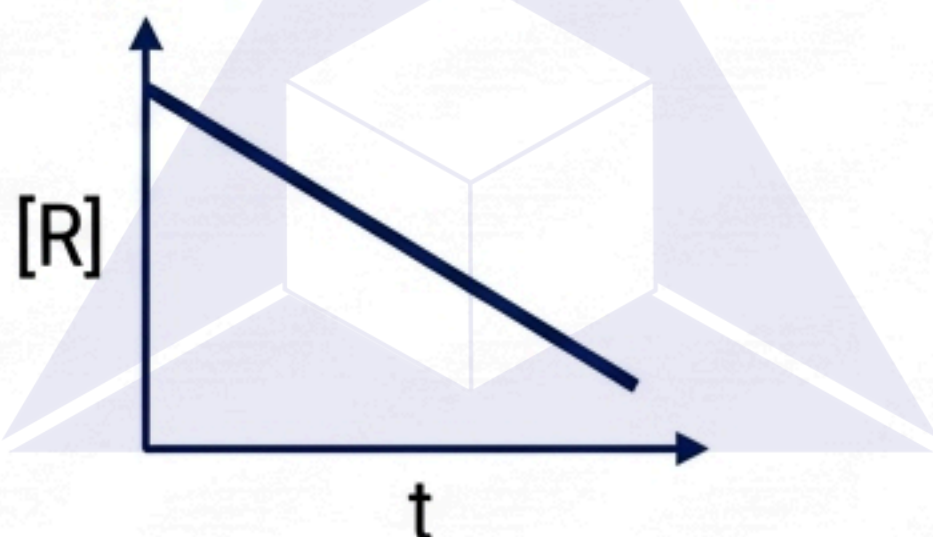
Higher-order reactions involve highly complex calculus and are incredibly rare in single-step mechanisms. Zero and first-order equations cover the vast majority of standard exam questions and practical laboratory applications.

The True Value of Integrated Equations

Differential = How rate behaves at a specific instant.

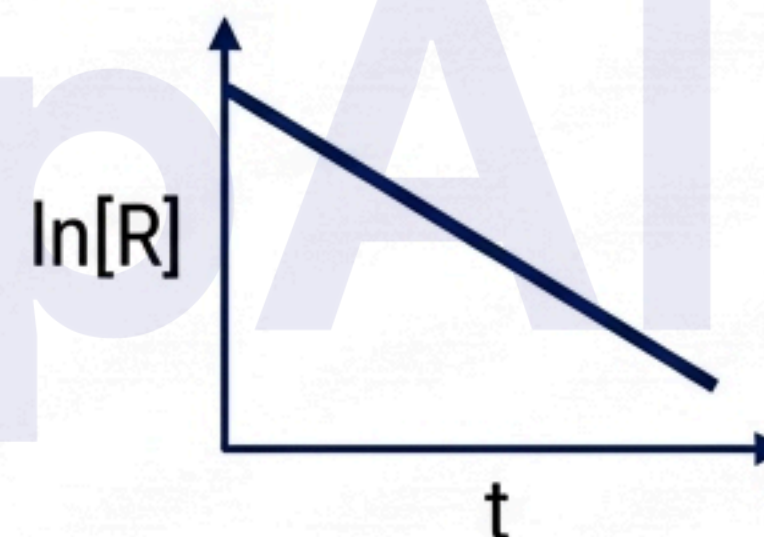
Integrated = How concentration changes over an interval.

Zero Order Preview



$$[R] = -kt + [R]_0$$

First Order Preview



$$\ln[R] = -kt + \ln[R]_0$$

By integrating the differential equations, chemists unlock the ability to determine reaction order and rate constants (k) using simple straight-line graphs and standard, easily measurable laboratory data.



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