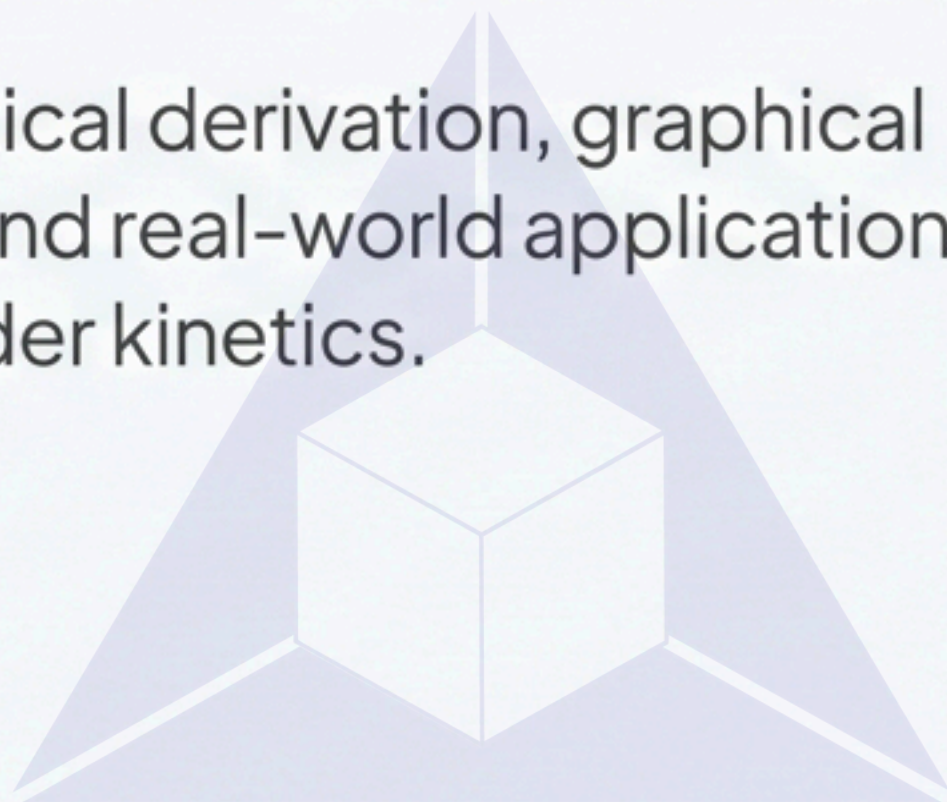


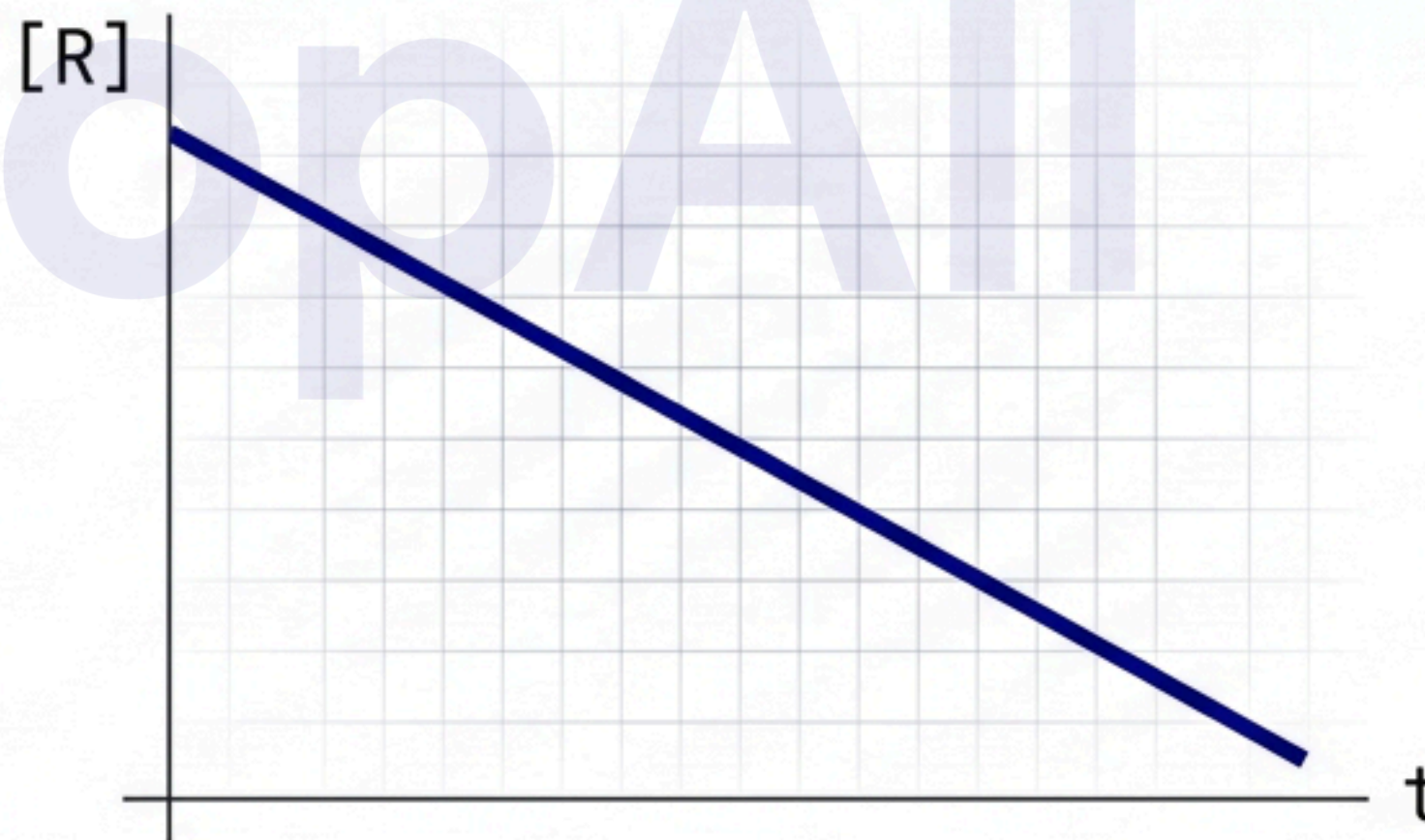
3.3.1 Zero Order Reactions

Mathematical derivation, graphical analysis, and real-world application of zero order kinetics.



 Exam Revision Deck

 Duration: 5 mins



CORE CONCEPT

Independence from Concentration

A zero order reaction means the rate of the reaction is entirely independent of the concentration of the reactants. The reaction proceeds at a constant speed until the reactant is completely depleted.

$$\text{Rate} \propto [R]^0$$

$$\text{Rate} = k[R]^0 = k$$



Mathematical Axiom: Any quantity raised to the power of zero is unity (1). Therefore, for these specific reactions, the reaction rate is exactly equal to the rate constant k .

The Differential Rate Equation

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

The negative sign indicates the decrease in reactant concentration over time.

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

Substitute the zero order condition (Rate = k) into the differential.

$$d[R] = -k dt$$

Isolate the variables to prepare for integration.



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INTEGRATION



Deriving the Integrated Rate Equation

$$\int d[R] = \int -k dt \rightarrow [R] = -kt + I$$

I is the constant of integration.

At time $t = 0$, concentration $[R] = [R]_0$

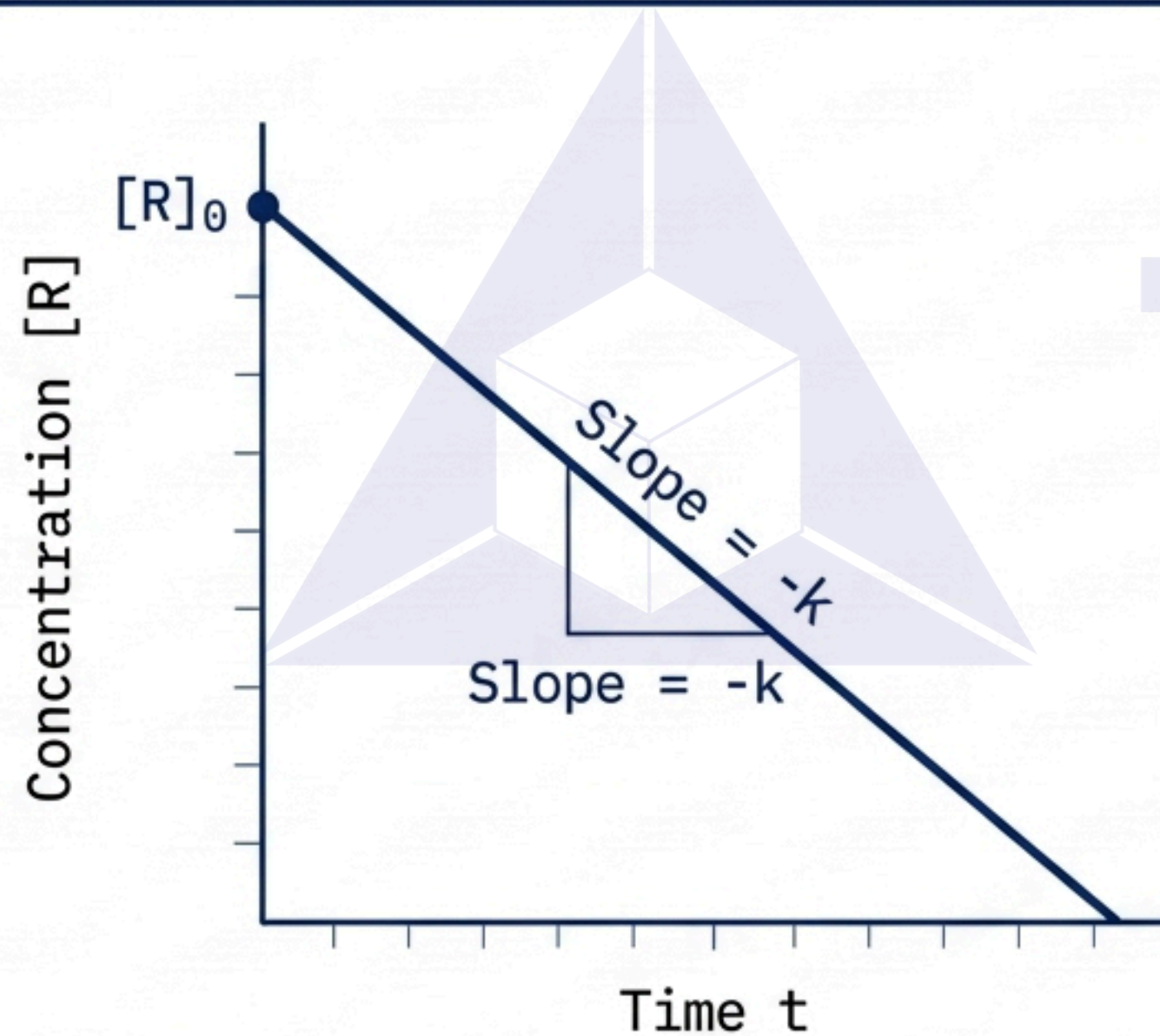
$$[R]_0 = -k(0) + I \rightarrow I = [R]_0$$

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

This integrated equation allows us to find the exact concentration of reactant [R] at any given time t.

GRAPHICAL REPRESENTATION

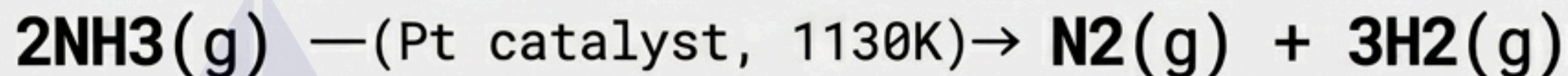
Visualizing the Linear Decrease



$$y = mx + c$$
$$[R] = -k t + [R]_0$$

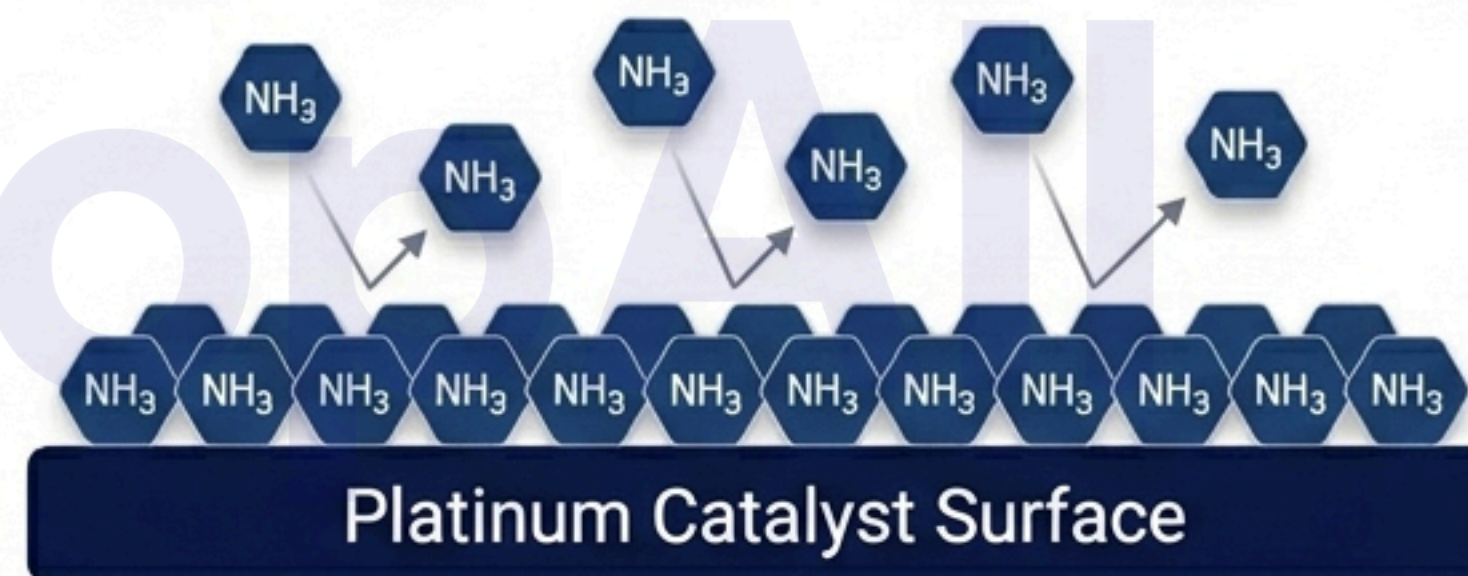
y-axis = $[R]$ x-axis = t Intercept = $[R]_0$ Slope = $-k$

Ammonia on a Hot Platinum Surface



At extremely high pressures, this reaction becomes zero order.

$$\text{Rate} = k[\text{NH}_3]^0 = k$$



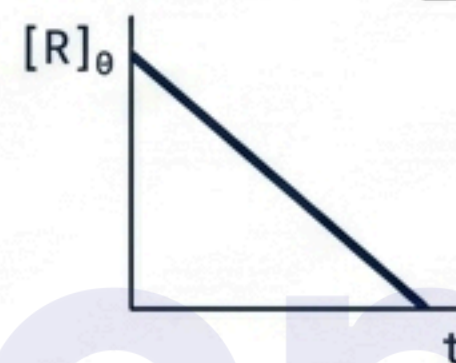
Surface Saturation: The platinum metal surface gets completely saturated with gas molecules. Once fully occupied, adding more NH₃ cannot speed up the reaction because there is no physical space left to react. The rate is strictly limited by the catalyst surface area.

Zero Order Summary

Constant Rate

The rate does not change as concentration drops. It is entirely independent of $[R]$.

Linear Decrease



Plotting $[R]$ vs t yields a perfectly straight downward line with slope $-k$.

Key Formulas

Diff: $\text{Rate} = k$

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

Rate Constant Units

$\text{mol L}^{-1} \text{s}^{-1}$

Matches the units of the overall reaction rate.

Exam Ready: Remember, true zero order reactions are rare and usually occur under special physical constraints, like saturated metal catalysts or specific enzyme reactions.



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