

Rate Expression & Rate Constant

Decoding the mathematical language of chemical kinetics.



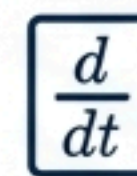
Rate Law

The mathematical expression linking a reaction's rate to its reactant molar concentrations.



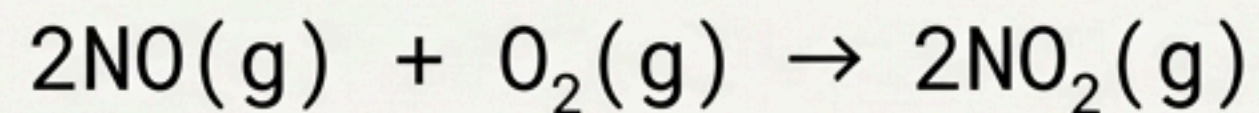
Rate Constant (k)

The proportionality constant specific to a given reaction at a specific temperature.



Differential Rate Equation

The rate expressed as a derivative of concentration over time (e.g., $-d[R]/dt$).



Experiment	Initial [NO] / mol L ⁻¹	Initial [O ₂] / mol L ⁻¹	Initial Rate / mol L ⁻¹ s ⁻¹
1	0.30	0.30	0.096
2	0.60	0.30	0.384
3	0.30	0.60	0.192

**[NO] doubles,
Rate × 4.**
(Rate depends
on [NO]²)

**[O₂] doubles,
Rate × 2.**
(Rate depends
on [O₂]¹)



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$$E=mc^2$$



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Step 1: The General Form

$$\text{Rate} = k[A]^x[B]^y$$

Rate Constant k Exponents indicating sensitivity to concentration changes

Step 2: The Derived Form (from experimental data)

$$\text{Rate} = k[\text{NO}]^2[\text{O}_2]^1$$

Exponents 2 and 1 are derived directly from the doubling logic, representing the reaction order.

Step 3: The Differential Form

The exact same relationship, expressed as the rate of disappearance of reactants.

$$-d[R]/dt = k[\text{NO}]^2[\text{O}_2]$$

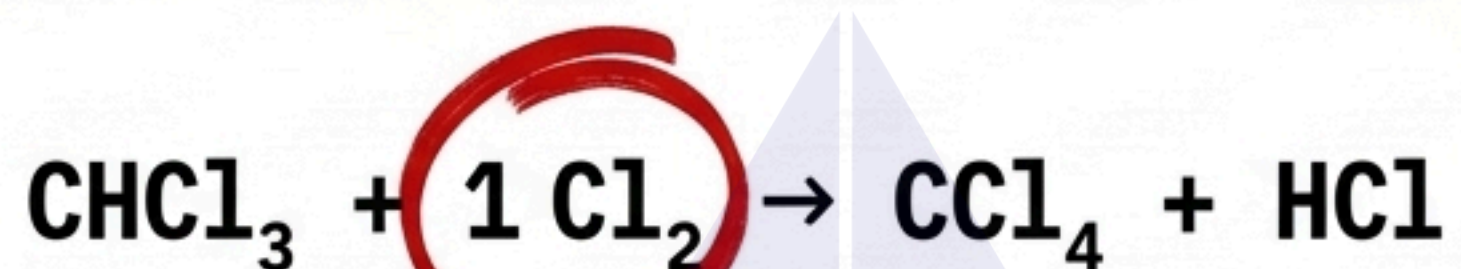


THE STOICHIOMETRY ILLUSION

Never assume the stoichiometric coefficients (**a**, **b**) from the balanced chemical equation can be copied into the rate law as exponents (**x**, **y**).

Key Axiom: The balanced equation tells you **WHAT** happens. It does **NOT** tell you **HOW FAST** it happens. Exponents must **ALWAYS** be determined experimentally.

Chloroform Reaction



$\neq$

$$\text{Rate} = k[\text{CHCl}_3][\text{Cl}_2]^{1/2}$$

Ester Hydrolysis



$\neq$

$$\text{Rate} = k[\text{CH}_3\text{COOC}_2\text{H}_5]^1[\text{H}_2\text{O}]^0$$

Practice Check — Identify the Exponents

Reaction: $A + B \rightarrow \text{Products}$

Experiment	[A]	[B]	Initial Rate
1	0.1	0.1	R
2	0.2	0.1	4R
3	0.1	0.2	R

Based entirely on the experimental data above, what is the correct rate law?

A $\text{Rate} = k[A]^1[B]^1$

B $\text{Rate} = k[A]^2[B]^1$

C $\text{Rate} = k[A]^2[B]^0$ ✓

D $\text{Rate} = k[A]^4[B]^0$

Core Axioms of the Rate Law



The rate law is strictly an empirical construct—it is always determined experimentally, never theoretically assumed.



Exponents (x , y) represent reaction order. They may or may not match the stoichiometric coefficients (a , b) of the balanced equation.



The rate constant (k) is the crucial bridge, translating theoretical concentration inputs into the actual physical speed of the reaction.



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