THE RATE LAW -- relationship between rate of reaction & concentrations of reactants

CHEMICAL EQUATION   aA + bB ⟶ products

coefficients NOT important for rate law
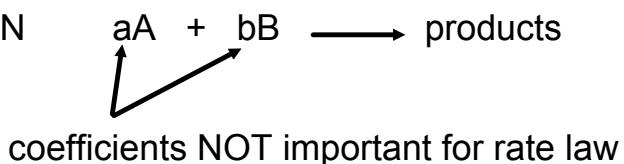
RATE OF REACTION based on ***INITIAL RATE METHOD***:

- Rate proportion statement: **rate α $[A]^m[B]^n$**

    where m & n are calculated by experiment.

- **RATE LAW EQUATION:**   **rate = $k[A]^m[B]^n$**

Eg.   Given rate = $k[A]^1[B]^2$

    -- **ORDER OF REACTION** -- based on exponents

        -- 1st order with respect to **A**
        -- 2nd order with respect to **B**
        -- 3rd order **overall** (m + n = 1 + 2)

The RATE CONSTANT --   **k**

    -- **k** shows speed of reaction

    -- if **k** is small, reaction is slow; if **k** is large, reaction is fast

    -- as reaction proceeds, rate slows down, but **k** stays constant

    -- **k** only different if ***temperature changes***; therefore, must always state **T** with **k**.

HOW TO DETERMINE EXPONENT VALUES & CONSTANT

-- based on experiment

-- Initial Rates Method

    -- compare initial rates of various reactant concentrations

$$3\,A \longrightarrow B + 2\,C \qquad \text{Therefore, rate} = k[A]^m$$

Given Table:

experiment	initial [A] (mol/L)	initial rate (mol/Ls)
1	0.3	15
2	0.6	30
3	0.9	45

TO FIND m:

Use 2 of the trials: $\dfrac{rate_2}{rate_1} = \dfrac{k[0.6]^m}{k[0.3]^m} = \dfrac{30}{15}$

$$(2)^m = 2$$

Therefore, $m = 1$ -- first order

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

TO FIND k:

Use any of the given trials from the table, substitute the rate and [ ]:

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

$$15\ \text{mol/Ls} = k\,(0.3\ \text{mol/L})$$

$$k = \frac{15\,mol/Ls}{0.3\,mol/L}$$

$$k = 50\ s^{-1}$$

$$\text{rate} = 50 s^{-1}[A]^1$$

Eg.

experiment	initial [A] (mol/L)	initial rate (mol/Ls)
1	0.3	15
2	0.6	60
3	0.9	135

Consider the reaction: 2 A +   4 B ———→ 5 C +   3 D

experiment	initial [A] (mol/L)	initial [B] (mol/L)	initial rate (mol/Ls)
1	0.3	0.2	0.6
2	0.3	0.4	4.8
3	0.6	0.4	4.8

rate = k [A]^m[B]^n

[B] -- keep [A] same --

[A] -- keep [B] same --

Eg. $2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(g)}$
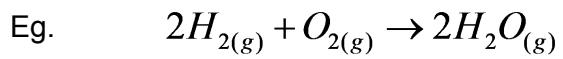
trial	[H₂] (mol/L)	[O₂] (mol/L)	initial rate of H₂O produced (mol/L min)
1	0.020	0.020	0.0036
2	0.040	0.020	0.0144
3	0.020	0.040	0.0073

rate =