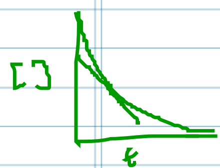
Relative Rate

$$2A + B \longrightarrow 3C + 2D$$

If the rate of appearance of D is 0.01 mol/s, then...



A is disappearing at a rate of −0.01 mol/s
B 0.005 mol/s
C 0.015 mol/s

Rate Law → an equation that describes how a change in concentration affects the reaction rate

A+B → products

$$\text{rate} = k[A]^m[B]^n$$

k = rate constant
T dependent

m = "order of reaction" for A
n = "order of reaction" for B
m+n = "overall order"

Example: For the reaction $2NO + O_2 \rightarrow 2NO_2$ it is known that at 25°C,

$$\text{rate} = k[NO]^2[O_2]$$

and that $k = 7.1 \times 10^9\ M^{-2}s^{-1}$

What is the rate when the initial concentrations are [NO] = 0.00350 mol/L and $[O_2]$ = 0.00500 mol/L?

$$\text{rate} = (7.1\times10^9\ M^{-2}s^{-1})(0.00350)^2(0.00500)$$
$$= 435\ Ms^{-1}$$

435 M/s 435 mol/L·s

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435 M/s   435 mol/L·s

Determining the orders of the reaction from experimental Data

For the reaction A + B + C ⟶ products
the following data is collected

$[A]^1$	$[B]^2$	$[C]^0$	initial rate (M/s)
0.010	0.010	0.010	0.200
0.020 (×2)	0.010	0.010	0.400 (×2 = $×2^{1}$ ①)
0.030	0.010	0.010	0.600
0.030	0.020 (×2)	0.010	2.40 (×4 = $×2^{2}$ ②)
0.030	0.030	0.010	5.40
0.030	0.030	0.020 (×2)	5.40 (×1 = 2^{0})
0.030	0.030	0.030	5.40

What is the rate law? $rate = k[A][B]^2[C]^0$

What is the reaction rate when [A] = 0.00050 M, [B] = 0.0025 M, and [C] = 0.100 M ?

$$k = \frac{rate}{[A][B]^2} = \frac{0.200\ M/s}{(0.010M)(0.010M)^2} = 2\times10^5\ M^{-2}s^{-1}$$

Determine the rate law for the following reaction from the data given

$$NH_4^+{}_{(aq)} + NO_2^-{}_{(aq)} \longrightarrow N_{2\,(g)} + 2\,H_2O_{(l)}$$

$[NO_2^-]^1$	$[NH_4^+]^1$	rate (M/s)
0.0100	0.2000	5.4×10^{-7}
0.0200 (↓ ×2)	0.2000	10.8×10^{-7} (↓ $\times 2^1$)
0.0400	0.2000	21.5×10^{-7}
0.2000	0.0202	10.8×10^{-7}
0.2000	0.0404 (↓ ×2)	21.6×10^{-7} (↓ $\times 2^1$)

$$\text{rate} = k\,[NO_2^-]^1\,[NH_4^+]^1$$

$$k = \frac{\text{rate}}{[NO_2^-][NH_4^+]} = 2.7 \times 10^{-4}\ M^{-1}s^{-1}$$