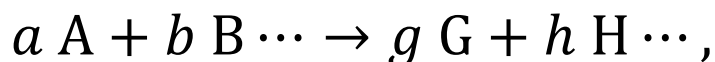


Chapter 12 Part 2

Dr. Turner

Rate Laws

- Describes the relationship between the rate of a reaction and the molar concentrations of the chemical reactants
- For the reaction



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

- $[A]$ and $[B]$ are the molar concentrations of the reactants
- k is the rate constant. The rate constant is specific only works for a particular reaction at a certain temperature and surface area.

Reaction Order

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

- The exponents m and n must be determined experimentally by observing how the rate of a reaction changes as the concentration of the reactants are changed
- The exponent of a particular reactant is the order of the reaction with respect to that reactant
- The sum of all of the exponents is the overall reaction order

Reaction Order

For a reaction with the rate law: $\text{rate} = k[\text{KOH}]^3[\text{H}_3\text{PO}_4]$, what is the order of the reaction with respect to KOH?

- A. 1
- B. 2
- C. 3
- D. 4

Reaction Order

For a reaction with the rate law: $\text{rate} = k[\text{KOH}]^3[\text{H}_3\text{PO}_4]$,
what is the overall order of the reaction?

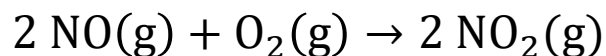
- A. 1
- B. 2
- C. 3
- D. 4

Determining the rate law from initial rates

$$\left(\frac{[A]_i}{[A]_j} \right)^m = \frac{\text{rate}_i}{\text{rate}_j}$$

- $[A]_i$ is the concentration of reactant A during experiment i .
- $[A]_j$ is the concentration of reactant A during experiment j .
- m is the order of the reaction with respect to A.
- rate_i is the rate of experiment i .
- rate_j is the rate of experiment j .

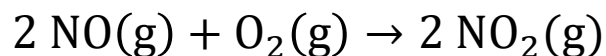
Method of Initial Rates



Experiment	Initial [NO]	Initial [O ₂]	Initial Rate of Formation of NO ₂ (M/s)
1	0.015	0.015	0.048
2	0.030	0.015	0.192
3	0.015	0.030	0.096
4	0.030	0.030	0.384

A. Determine the rate law (in terms of k)

Method of Initial Rates



Experiment	Initial [NO]	Initial [O ₂]	Initial Rate of Formation of NO ₂ (M/s)
1	0.015	0.015	0.048
2	0.030	0.015	0.192
3	0.015	0.030	0.096
4	0.030	0.030	0.384

B. Calculate the rate constant

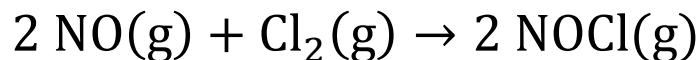
Method of Initial Rates

At 60 °C, acetone (CH_3COCH_3) decomposes to ketene ($\text{CH}_2=\text{C}=\text{O}$) and various hydrocarbons. Initial rate data are given in the table:

Experiment	Initial $[\text{CH}_3\text{COCH}_3]$	Initial Rate of Decomposition of CH_3COCH_3 (M/s)
1	6.0×10^{-3}	5.2×10^{-5}
2	9.0×10^{-3}	7.8×10^{-5}

- A. Determine the rate law (in terms of k)
- B. Calculate the rate constant.
- C. Calculate the rate of decomposition when the acetone concentration is 1.8×10^{-5} .

Method of Initial Rates



Experiment	[NO]	[Cl ₂]	Rate (M/s)
1	0.10	0.10	0.00300
2	0.10	0.15	0.00450
3	0.15	0.10	0.00675

- A. Determine the rate law (in terms of k)
- B. Calculate the rate constant
- C. Calculate the rate when the concentrations are $[\text{NO}] = 0.300 \text{ M}$ and $[\text{Cl}_2] = 0.400 \text{ M}$.

Rate Constants for Common Overall Reaction Orders

Reaction Order	Units of k
Zero	$\frac{\text{M}}{\text{s}}$
First	$\frac{1}{\text{s}}$
Second	$\frac{1}{\text{M s}}$
Third	$\frac{1}{\text{M}^2 \text{s}}$
$(m + n)$	$\frac{1}{\text{M}^{(m+n-1)} \text{s}}$