Chapter 4: Introduction to Reaction Kinetics

Department of Chemistry

1 Overview

Reaction kinetics is the study of chemical reaction rates and the factors influencing them. It is essential for predicting product formation and optimizing reaction conditions.

2 Rate Laws

Rate Law Definition: Expresses reaction rate as a function of reactant concentration.
General Form:

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

where k is the rate constant, m, n are the orders with respect to reactants.

Example:

$$\text{H}_2 + 2\text{I} \rightarrow 2\text{HI}$$

$$\text{Rate} = k[\text{H}_2][\text{I}]^2$$

3 Order of Reactions

- Zero Order: Rate independent of [A]
- First Order: Rate proportional to [A]
- Second Order: Rate proportional to $[\text{A}]^2$ or [A][B]

Order	Differential Rate Law	Integrated Rate Law
0	$\text{Rate} = k$	$[\text{A}] = [\text{A}]_0 - kt$
1	$\text{Rate} = k[\text{A}]$	$[\text{A}] = [\text{A}]_0 e^{-kt}$
2	$\text{Rate} = k[\text{A}]^2$	$1/[\text{A}] = 1/[\text{A}]_0 + kt$

Table 1: Order of reaction and integrated rate laws

4 Experimental Determination of Rate Laws

- Method of Initial Rates: Measures rates at various concentrations.
- Graphical Analysis: Plots to determine the order.

5 Factors Affecting Rates

- Concentration: Higher molarity increases rate.
- Temperature: Each 10°C rise often doubles rate (Arrhenius equation).
- Catalysts: Lower activation energy.

6 Sample Problems

Problem 1:
A first-order reaction has $k = 0.25\,\text{min}^{-1}$. If $[\text{A}]_0 = 0.40\,\text{M}$, what is [A] after 10 min?
Solution:

$$[\text{A}] = 0.40 \times e^{-0.25\times 10} = 0.40 \times e^{-2.5} \approx 0.0328\,\text{M}$$

Problem 2:
For a zero-order reaction, what time is required for [A] to drop from 1.00 M to 0.25 M if $k = 0.10\,\text{mol}\,\text{L}^{-1}\text{min}^{-1}$?
Solution:

$$t = \frac{[\text{A}]_0 - [\text{A}]}{k} = \frac{1.00 - 0.25}{0.10} = 7.5\,\text{min}$$

7 Summary Points

- Kinetics links molecular structure, mechanism, and real-world process control.
- Rate, order, and mechanism are core exam concepts.

8 References

1. Atkins, P., Jones, L. *Chemical Principles*, 5th Ed.
2. Carey, F. *Organic Chemistry*, 9th Ed.