AP CHEMISTRY CHEAT SHEET

Unit 5 : KINETICS

Quick Overview

- **Focus:** reaction rates, rate laws, integrated rate laws, activation energy, and reaction mechanisms.
- **Exam Lens:** connect experimental data → rate law → mechanism → energy profile.

Reaction Rate Basics

- Reaction rate = change in concentration per unit time.
- Rate is always positive.
- **Units of rate:** $mol \cdot L^{-1} \cdot s^{-1}$ (M/s).
- Rate depends on temperature, concentration, surface area, catalysts, and nature of reactants.

Rate Laws

General rate law:
rate = $k[A]^m[B]^n$

- m, n = reaction orders (determined experimentally, not from coefficients).
- Overall order = m + n.
- Zero order → rate independent of concentration.
- First order → rate $\propto$ [A].
- Second order → rate $\propto$ $[A]^2$ or [A][B].

Key rule: Doubling concentration increases rate by 2^m.

Determining Rate Laws (Method of Initial Rates)

- Compare trials where only one reactant changes.
- Ignore coefficients in balanced equation.
- Rate ratio = $(\text{concentration ratio})^m$.

Mnemonic: “Change one thing, watch the rate.”

Integrated Rate Laws

Used to determine concentration at time t.

Zero Order:

- $[A] = -kt + [A]_0$
- Straight line: [A] vs t

First Order:

- $\ln[A] = -kt + \ln[A]_0$
- Straight line: ln[A] vs t

Second Order:

- $1/[A] = kt + 1/[A]_0$
- Straight line: 1/[A] vs t

Half-Life

Time for concentration to drop to half its initial value.

- **First order only:**
  $t_{1/2} = 0.693 / k$
- Independent of initial concentration.
- Zero and second order half-lives change over time.

Mnemonic: “Only first is constant.”

Rate Constant (k)

- Larger k → faster reaction.
- Units depend on overall order:
  - -Zero: M/s
  - -First: s^{-1}
  - -Second: $M^{-1} \cdot s^{-1}$

k increases with temperature.

Collision Theory

For a reaction to occur:

1. Particles must collide.
2. Collision must have enough energy (≥ Ea).
3. Correct orientation required.

Catalysts lower activation energy, not ΔH or ΔG.

Activation Energy & Arrhenius Equation

Arrhenius equation:
$k = A \cdot e^{(-Ea / RT)}$

Linearized form:
$\ln k = -(Ea / R)(1/T) + \ln A$

- Ea = activation energy
- $R = 8.314\ J \cdot mol^{-1} \cdot K^{-1}$
- Slope of ln k vs 1/T = -Ea / R

Reaction Energy Diagrams

- Reactants → peak → products.
- Peak height = activation energy.
- **Exothermic:** products lower than reactants.
- **Endothermic:** products higher than reactants.
- Catalyst lowers Ea for both forward and reverse reactions.

Reaction Mechanisms

- Series of elementary steps.
- Slow step = rate-determining step.
- Rate law comes from slow step only.
- Overall reaction = sum of elementary steps.

Key rule:
Intermediates appear in mechanism but not overall equation.

Catalysts

- Provide alternative pathway with lower Ea.
- Not consumed.
- Do not affect equilibrium position.
- Increase forward and reverse rates equally.