HONORS CHEMISTRY
Unit G: ENERGY, KINETICS, and EQUILIBRIUM

CHAPTER SEVENTEEN: KINETICS
CHEMICAL REACTIONS proceed at a variety of RATES.

The SPEED of a reaction depends on the ENERGY PATHWAY and MOLECULAR CHANGES.

Reactions don’t usually occur in a single step (REACTANTS $\rightarrow$ PRODUCTS).

The REACTION MECHANISM is the step-by-step sequence of reactions in an overall reaction.
REACTION PROCESS

- COLLISION THEORY states that in order for a reaction to proceed the particles MUST COLLIDE.
- COLLISIONS must happen with sufficient ENERGY (FORCE) and PROPER ORIENTATION.
REACTION PROCESS

\[ \text{NO} + \text{O}_3 \rightarrow \text{Ineffective collision} \rightarrow \text{NO} + \text{O}_3 \]

\[ \text{NO} + \text{O}_3 \rightarrow \text{Effective collision} \rightarrow \text{NO}_2 + \text{O}_2 \]
ACTIVATION ENERGY

- ACTIVATION ENERGY is the energy required to transform the reactants to an activated complex.
- Energy input needed to make reaction happen.
- ACTIVATION ENERGY ($E_a$) is needed to overcome repulsive forces.
EXOTHERMIC reactions are self-sustaining after the $E_a$ is applied.

The $E_a$ (outside source) is often times HEAT energy.

ENDOTHERMIC reactions require a greater $E$ than the reverse (exothermic) reaction.

For a forward and reverse reaction the difference between the $E_a$ values is equal to the $\Delta E$ of reaction.
ACTIVATION ENERGY

Endothermic Reaction

- Activation energy
- Energy of reactants
- Energy absorbed
- Energy of products

Exothermic Reaction

- Activation energy
- Energy of reactants
- Energy released
- Energy of products
The ACTIVATED COMPLEX is a transitional state that occurs when collisions continue while old bonds are breaking (reactants) and new bonds are forming (products).
ACTIVATED COMPLEX

- KE of collisions converted to PE as bonds
- ACTIVATED COMPLEX occurs at the highest energy ($E_a$ peak)
- Is part reactant & part product
- Short-lived during the reaction process (unstable)
REACTION RATE

- REACTION RATE is equal to the $\Delta [\text{reactants}]$ per unit time
- REACTION RATES are calculated by experimental data collection
- REACTION RATE is influenced by at least 5 factors: REACTIVITY, SURFACE AREA, TEMPERATURE, CONCENTRATION, CATALYST
REACTION RATE

- **REACTIVITY** – more reactive substances react faster
- **SURFACE AREA** – solid substances with greater surface area (contact) react faster
- **TEMPERATURE** – higher substance temperature results in higher KE and collision frequency
- **CONCENTRATION** – for [aq] & (g) substances, higher [ ] results in higher collision frequency
REACTION RATE

- CATALYST is a substance that changes the reaction rate without being consumed.
- Provides an alternative energy pathway.
- Decreases $E_a$ required.
- Do not appear as a product or incorporated into a product.
The RATE LAW is an equation that relates the rate of reaction and the concentration of reactants:

\[ R = k[A]^n[B]^m \]

- The exponential values are “ORDERS” and not always stoichiometric.
- Usually zeroth, first, or second order with respect to reactants.
- Sum of reactant orders to give OVERALL ORDER.
RATE LAWS

rate = $k[A]^a[B]^b$

- rate in mol dm$^{-3}$s$^{-1}$
- rate constant
- concentrations in mol dm$^{-3}$

order of reaction with respect to A
order of reaction with respect to B
Writing a Rate Law

Part 3 - Determine the overall order for the reaction.

\[ R = k[NO]^2[Cl_2] \]

\[ 2 + 1 = 3 \]

\[ \therefore \text{The reaction is 3}^{\text{rd}} \text{ order} \]

Overall order is the sum of the exponents, or orders, of the reactants.
Sample Exercise 2:

- Use the kinetics data to write the rate law for the reaction. What overall reaction order is this? 
  \[ 2\text{NO} + \text{O}_2 \rightarrow 2\text{NO}_2 \]

<table>
<thead>
<tr>
<th>Exp #</th>
<th>[NO]</th>
<th>[O\textsubscript{2}]</th>
<th>Rate forming NO\textsubscript{2} (M/s)</th>
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