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# Organic Chemistry Reactions (Quick Study Academic)

**Quick Study ACADEMIC**

## ORGANIC CHEMISTRY REACTIONS

**Features of an Organic Reaction**

- Mechanism:** Describes the overall reaction using a series of single steps.
- Stoichiometry:** Calculate reactant and product masses using the balanced equation and molar masses.
- Kinetics:** Study of the reaction rate and mechanism.
- Theoretical Yield:** Mass of product given by a complete reaction, % yield =  $\frac{\text{actual yield}}{\text{theoretical yield}} \times 100\%$ .
- Equilibrium:** Reaction does not proceed to completion, instead, it reaches a balanced state of forward and reverse reactions.

**Major Reaction Types**

- Acid
- Base
- Oxidation-reduction
- Coordination
- Substitution ( $S_N1, S_N2$ )
- Radical reaction
- Ionic reaction
- Elimination (E1, E2)
- Cyclization
- Hydrolysis
- Addition

**Important Named Reactions**

- Diels-Alder:** Forms cyclic alkenes
- Friedel-Crafts:** Add acyl or alkyl group
- Grignard:** Add alkyl or aryl group
- Wittig Reaction, Clemmensen:** Reduce ketones to alkanes

**Wittig:** Convert aldehyde/ketone to alkene

**Kinetics & Reaction Mechanism**

**Transition State (TS):** Maximum on the reaction coordinate curve, the least stable intermediate.

**Activation Energy ( $E_a$ ):** Energy of the TS relative to the reactants. The change in enthalpy ( $\Delta H$ ) is  $-E_a$  for exothermic reactions and  $+E_a$  for endothermic reactions.

**Hammond-Lefler Postulate:** The TS is more like the reactant or product that is closer in energy. The endothermic TS is like the product and the exothermic TS is like the reactant.

**Kinetic vs. Thermodynamic Control:**  $k_f$  and  $k_r$  describe thermodynamic stability. If  $k_f$  is large and negative ( $\Delta G$ ), the product formation is likely controlled by "thermodynamics." A large  $k_{eq}$  corresponds to a large amount of product relative to reactant. A large  $E_a$  may give rise to "kinetic" control, the energy of the TS controls the reaction, instead of the product-reactant thermodynamicity.

**Solvent Effects:** A solvent may stabilize an intermediate, decreasing the  $E_a$  and increasing the rate of the reaction. Charged complexes are stabilized by polar solvents.

**Organic Acid & Base**

**Acid**

- Electron-pair acceptor (Lewis acid)
- Proton donor (Brønsted-Lowry acid)
- EX: Carboxylic acid

**Base**

- Electron-pair donor (Lewis base)
- Proton acceptor (Brønsted-Lowry base)
- EX: Amine

**Factors Enhancing Acid Strength (HA)**

- Weaker H-A bond
- Greater electronegativity of "A"
- Inductive effect of substituent on "A" (electron-withdrawing enhances transfer)
- More "s" character in hybrid orbital (s-orbital is lower in energy than p-orbital)
- Resonance-stabilized conjugate base (A')

**Factors Enhancing Base Strength**

- Reverse of acid strength guidelines
- A base is a nucleophilic, electronic effect which shifts electron density to the atom with the lone pair increases base strength

**Alkane**

**Properties**

- Hydrocarbon
- Weak intermolecular forces
- Non-Cyclic: General formula  $C_nH_{2n+2}$
- Tetrahydro: C-C-C (109°)

**Nomenclature**

- Add "ane" to prefix
- Locate substituent by position #
- Halobutane: Substrate halide for-H

**Cycloalkane ( $C_nH_{2n}$ )**

- Bicyclic: Two fused or bridged rings
- Cyclopropane:  $n = 3$  (highly strained)
- Cyclobutane:  $n = 4$  (some flexibility)
- Cyclopentane:  $n = 5$  (slight puckering)
- Cyclohexane:  $n = 6$  (no strain)

**Chair Conformation:** Stable conformation

- Boat Conformation:** Less stable
- Axial Position:** Perpendicular to ring
- Equatorial Position:** In ring plane
- See H<sub>a</sub> and H<sub>e</sub> in chair diagram below

**Cis:** Two substituents in the up position

**Trans:** One substituent up and one down

**Substituents**

- Hydrogenate alkene or alkyne (H<sub>2</sub>, Pt catalyst)
- Free-radical reaction of alkene
- Enthalp halohalide (Zn, H<sup>+</sup>)
- Friedel-Crafts alkylation

**Reactions**

- Combustion:** Alkane + O<sub>2</sub> → CO<sub>2</sub> + H<sub>2</sub>O
- Halogenation to haloalkane (Cl<sub>2</sub>/Br<sub>2</sub>, light or heat)

**Alkene -C=C-**

**Properties**

- Similar to alkanes, non-polar, flammable

**Nomenclature**

- Add "ene" to prefix, use # to denote C-C position
- Isotactic: C-C-C-C-C-C
- Cumulative: C=C=C
- Polymersaturated Fatty Acid: 7 or more C-C
- Alkene: Adjacent C=C
- Vinyl Group: H<sub>2</sub>C=CH-
- Methylene Group: H<sub>2</sub>C
- Allyl Group: H<sub>2</sub>C=CH-CH<sub>2</sub>-
- Vinyl Halide: Halide replaces-H on >C=C<
- Conjugated: Alternate C=C and C-C (monomers)
- Alkadiene: 2 conjugated C=C (e.g., butadiene), cis and trans isomers about C=C bond
- Alkatriene: 3 conjugated C=C
- Aromatic: Conjugated monocyclic compound
- EX: (H) aniline = benzene
- Aromatic Cyclic base: Cyclohexadiene anion, cyclopentadienyl anion (6 electrons)

**Isomers**

- No free rotation of C=C
- E:Z isomers groups by atomic weight
- Z: Higher priority groups on the same side

**Nomenclature:** Cis is less stable (steric hindrance)

- Cis: Cis is more stable
- Markovnikov Addition:** H adds to C with more alk
- Zaitsev Elimination:** Favors alkene with more substitution

**Substituents**

- Dehydro: alcohol (H<sub>2</sub> loss) (elimination)
- Dehydrohalogenate: haloalkane (lose, heat)
- Dehydrogenate: vic. dihalide (lose, water, heat)
- Hydrogenate: alkene
- Anti, Z/E: isomer (H<sub>2</sub>, Pt catalyst)
- Anti, E/trans isomer (H<sub>2</sub>, NH<sub>2</sub>, -78°C)
- Wittig: Aldehyde/ketone + phosphorus ylide

**Reaction**

- Combustion (EX)
- Hydrate to 2°/3° alcohol (H<sub>2</sub>O, H<sup>+</sup> from alkene, anti-Markovnikov)
- Hydrate to alcohol, hydrohalogenation (HBr, H<sub>2</sub>O, H<sup>+</sup>, OH<sup>-</sup>, anti-Markovnikov)
- Oxidation: vic-dihalide to alcohol
- Hydrohalogenation (HX) (Markovnikov)
- Halogenation (Br<sub>2</sub>, Cl<sub>2</sub>), vic. dihalide (X<sub>2</sub>, CCl<sub>4</sub>, anti-addition)
- Hydrolysis (X<sub>2</sub>, H<sub>2</sub>O, anti-addition)
- Hydrochloride or form a 1,2-diol (KMnO<sub>4</sub>, cold OH<sup>-</sup>, syn-addition)
- Oxidize to carboxylic acid (KMnO<sub>4</sub>, hot OH<sup>-</sup>)
- Oxidation to ketone (O<sub>3</sub>, Zn, H<sub>2</sub>O)
- Hydrogenate to alkane (H<sub>2</sub>, Pt, syn-addition)
- Free radical polymerization
- Alkylation reaction
- Allylic halogenation (Cl<sub>2</sub>, heat)
- Diels-Alder: Cyclohexene from diene + alkene/alkyne



## Synopsis

Quick Reference for the core essentials of a subject and class that is challenging at best and that many students struggle with. In 6 laminated pages our experienced chemistry author and professor gathered key elements organized and designed to use along with your text and lectures, as a review before testing, or as a memory companion that keeps key answers always at your fingertips. As many students have said "it's a must have" • study tool. Suggested uses: o Quick Reference " instead of digging into the textbook to find a core answer you need while studying, use the guide to reinforce quickly and repeatedly o Memory " refreshing your memory repeatedly is a foundation of studying, have the core answers handy so you can focus on understanding the concepts o Test Prep " no student should be cramming, but if you are, there is no better tool for that final review

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