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Comprehensive Organic Chemistry Formula Sheet

Master Reactions, Functional Groups, Mechanisms, and Nomenclature at a Glance

1. General Nomenclature Priorities

Priority Order of Functional Groups:

1. Carboxylic acids ($-\text{COOH}$)
2. Esters ($-\text{COOR}$)
3. Amides ($-\text{CONH}_2$)
4. Nitriles ($-\text{CN}$)
5. Aldehydes ($-\text{CHO}$)
6. Ketones ($-\text{CO}-$)
7. Alcohols ($-\text{OH}$)
8. Amines ($-\text{NH}_2$)
9. Alkenes ($-\text{C}=\text{C}-$)
10. Alkynes ($-\text{C}\equiv\text{C}-$)

2. Electronic Effects

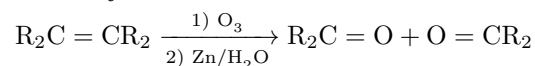
- **Inductive Effect (I):** Permanent displacement of σ -electrons along a carbon chain due to electronegativity difference.
 $-I$: $-\text{NO}_2 > -\text{F} > -\text{Cl} > -\text{Br} > -\text{OH} > -\text{C}_6\text{H}_5$
 $+I$: $-\text{O}^- > -\text{COO}^- > -\text{alkyl} (3^\circ > 2^\circ > 1^\circ)$
- **Resonance Effect (R / M):** Delocalization of π -electrons.
 $+R$: $-\text{O}^-$, $-\text{NH}_2$, $-\text{NHR}$, $-\text{OH}$, $-\text{OR}$, $-\text{Cl}$
 $-R$: $-\text{NO}_2$, $-\text{CHO}$, $-\text{COR}$, $-\text{COOH}$, $-\text{CN}$
- **Hyperconjugation:** σ -p or σ - π conjugation (No-bond resonance). Stability of alkenes and carbocations $\propto$ number of α -hydrogens.

3. Reaction Intermediates

- **Carbocations:** sp^2 hybridized, planar. Stability order: $3^\circ > 2^\circ > 1^\circ > \text{CH}_3^+$.
- **Carbanions:** sp^3 hybridized, pyramidal. Stability order: $\text{CH}_3^- > 1^\circ > 2^\circ > 3^\circ$.
- **Free Radicals:** sp^2 (quasi-planar). Stability order: $3^\circ > 2^\circ > 1^\circ > \text{CH}_3^\cdot$.

4. Alkanes, Alkenes, Alkynes

- **Hydrogenation:** Alkenes/Alkynes $+\text{H}_2$ over Pd/Pt/Ni $\rightarrow$ Alkanes (Syn addition).
- **Markovnikov's Rule:** In electrophilic addition to unsymmetrical alkenes, the electrophile adds to the carbon with more hydrogens (stable carbocation intermediate).
- **Anti-Markovnikov (Peroxide Effect):** Addition of HBr to alkenes in the presence of peroxides proceeds via free radical mechanism.
- **Ozonolysis:**



5. Aromatic Compounds (Benzene)

- **Electrophilic Aromatic Substitution (EAS):**
 $\text{C}_6\text{H}_6 + \text{E}^+ \xrightarrow{\text{Catalyst}} \text{C}_6\text{H}_5\text{E} + \text{H}^+$
- **Friedel-Crafts Alkylation:** $\text{R}-\text{Cl} + \text{AlCl}_3$.
- **Friedel-Crafts Acylation:** $\text{R}-\text{COCl} + \text{AlCl}_3$.

• Directing Groups:

Ortho/Para directing (Activating):
 $-\text{OH}$, $-\text{OR}$, $-\text{NH}_2$, $-\text{R}$

Meta directing (Deactivating): $-\text{NO}_2$, $-\text{CN}$, $-\text{CHO}$, $-\text{CO}$

6. Alkyl Halides (S_N1 vs S_N2)

Feature	S_N1	S_N2
Mechanism	Two-step via carbocation	Concerted, single step
Kinetics	Rate = $k[\text{RX}]$	Rate = $k[\text{RX}][\text{Nu}^-]$
Stereochem	Racemization	Inversion (Walden)
Substrate	$3^\circ > 2^\circ > 1^\circ$	$1^\circ > 2^\circ > 3^\circ$ (Sterics)
Solvent	Polar Protic	Polar Aprotic

7. Carbonyl Compounds

- **Nucleophilic Addition:** Aldehydes are more reactive than ketones due to steric and electronic factors.
- **Aldol Condensation:** Aldehydes/ketones with α -H react with dilute base to form β -hydroxy aldehydes.
- **Cannizzaro Reaction:** Aldehydes without α -H undergo disproportionation with concentrated alkali:
 $2\text{HCHO} \xrightarrow{\text{NaOH}} \text{CH}_3\text{OH} + \text{HCOONa}$
- **Clemmensen Reduction:** $\text{C}=\text{O} \xrightarrow[\text{HCl}]{\text{Zn-Hg}} \text{CH}_2$ (Acidic)
- **Wolff-Kishner Reduction:** $\text{C}=\text{O} \xrightarrow[\text{KOH}]{\text{NH}_2\text{NH}_2} \text{CH}_2$ (Basic)

8. Carboxylic Acids Derivatives

- **Acidity Order:** $-\text{NO}_2 > -\text{F} > -\text{Cl} > -\text{Br} > -\text{I} > -\text{CH}_3$.
- **Esterification (Fischer):** $\text{Acid} + \text{Alcohol} \rightleftharpoons \text{Ester} + \text{Water}$ (Acid catalyst).
- **Hofmann Bromamide Degradation:** $\text{Amide} + \text{Br}_2 + \text{NaOH} \rightarrow \text{Primary amine with one less carbon atom}$.

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