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Comprehensive Organic Chemistry Formula Sheet

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

1. General Nomenclature Priorites

Priority Order of Functional Groups:

1. Carboxylic acids ($-COOH$)
2. Esters ($-COOR$)
3. Amides ($-CONH_2$)
4. Nitriles ($-CN$)
5. Aldehydes ($-CHO$)
6. Ketones ($-CO-$)
7. Alcohols ($-OH$)
8. Amines ($-NH_2$)
9. Alkenes ($-C=C-$)
10. Alkynes ($-C\equiv C-$)

2. Electronic Effects

- **Inductive Effect (I):** Permanent displacement of σ-electrons along a carbon chain due to electronegativity difference.

  $-I$: $-NO_2 > -F > -Cl > -Br > -OH > -C_6H_5$

  $+I$: $-O^- > -COO^- > -$alkyl ($3^>2^>1^>$)
- **Resonance Effect (R / M):** Delocalization of π-electrons.

  $+R$: $-O^-, -NH_2, -NHR, -OH, -OR, -Cl$

  $-R$: $-NO_2, -CHO, -COR, -COOH, -CN$
- **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: $3^>2^>1^> > CH_3^+$.
- **Carbanions:** sp^3 hybridized, pyramidal. Stability order: $CH_3^- > 1^>2^>3^>$.
- **Free Radicals:** sp^2 (quasi-planar). Stability order: $3^>2^>1^> > CH_3^\bullet$.

4. Alkanes, Alkenes, Alkynes

- **Hydrogenation:** Alkenes/Alkynes $+H_2$ 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:**

  $$R_2C=CR_2 \xrightarrow[2)\ Zn/H_2O]{1)\ O_3} R_2C=O + O=CR_2$$

5. Aromatic Compounds (Benzene)

- **Electrophilic Aromatic Substitution (EAS):**

  $$C_6H_6 + E^+ \xrightarrow{\text{Catalyst}} C_6H_5E + H^+$$
- **Friedel-Crafts Alkylation:** $R-Cl + AlCl_3$.
- **Friedel-Crafts Acylation:** $R-COCl + AlCl_3$.
- **Directing Groups:**

  Ortho/Para directing (Activating): $-OH, -OR, -NH_2, -R$

  Meta directing (Deactivating): $-NO_2, -CN, -CHO, -CO$

6. Alkyl Halides (S_N1 vs S_N2)

Feature	S_N1	S_N2
Mechanism	Two-step via carbocation	Concerted, single step
Kinetics	Rate $= k[RX]$	Rate $= k[RX][Nu^-]$
Stereochem	Racemization	Inversion (Walden)
Substrate	$3^>2^>1$	$1^>2^>3$ (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:

  $$2HCHO \xrightarrow{NaOH} CH_3OH + HCOONa$$
- **Clemmensen Reduction:** $C=O \xrightarrow{\text{Zn-Hg / HCl}} CH_2$ (Acidic)
- **Wolff-Kishner Reduction:** $C=O \xrightarrow{NH_2NH_2/\ KOH} CH_2$ (Basic)

8. Carboxylic Acids Derivatives

- **Acidity Order:** $-NO_2 > -F > -Cl > -Br > -I > -CH_3$.
- **Esterification (Fischer):** Acid + Alcohol $\rightleftharpoons$ Ester + Water (Acid catalyst).
- **Hofmann Bromamide Degradation:** Amide $+Br_2 + NaOH \rightarrow$ Primary amine with one less carbon atom.