Leah4Sci presents:

Cheat Sheet Collection

I create 1-3 cheat sheets per semester, here is a copy of all orgo cheat sheets to date.

You can find 100+ detailed tutorial videos and more by visiting my website: Leah4sci.com/

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OXIDATION REDUCTION

CARBOXYLIC ACID DERIVATIVES

Common ORGANIC CHEMISTRY FUNCTIONAL GROUPS

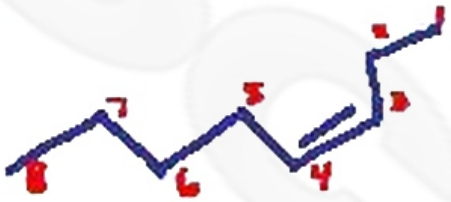
Learn how to name each group type at http://Leah4sci.com/naming

'R' Group ← not a real group
'R' represents the 'Rest' of the molecule

Alkane
R-CH_2-CH_2-R

ex 
hexane

Alkene
R-CH=CH-R

ex 
cis-3-octene

Alkyne
R-C≡C-R

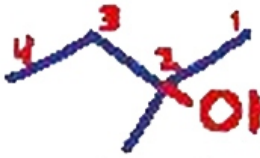
ex 
3-heptyne

Alkyl Halide
R-X

X = F, Cl, Br, I

ex 
1-chlorobutane

Alcohol
R-OH

ex 
2-methyl-2-butanol

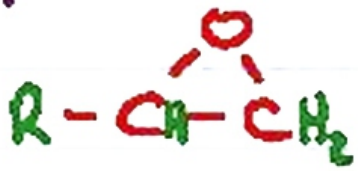
Ether

R-O-R'

ex 

1-ethoxy-2-methylpropane

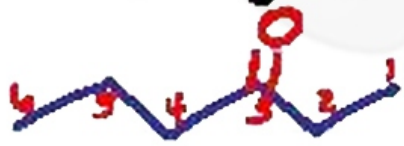
Epoxide



ex 

1,2-epoxycyclohexane

Ketone

ex 

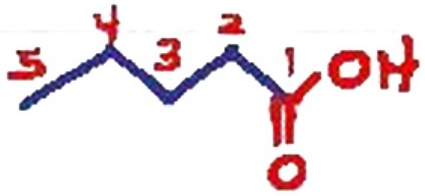
3-hexanone

Aldehyde

ex 

butanal

Carboxylic Acid

ex 

pentanoic acid

Ester

ex 

methyl propanoate

Amine

R-NH$_2$

ex 

N-methylethylamine

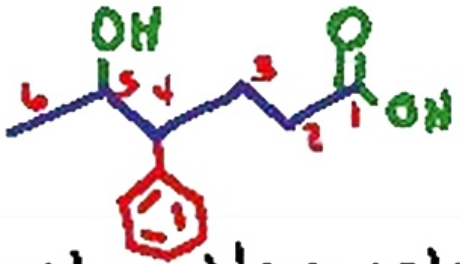
Amide

ex

pentanamide

Phenyl

ex



5-hydroxy-4-phenylhexanoic acid

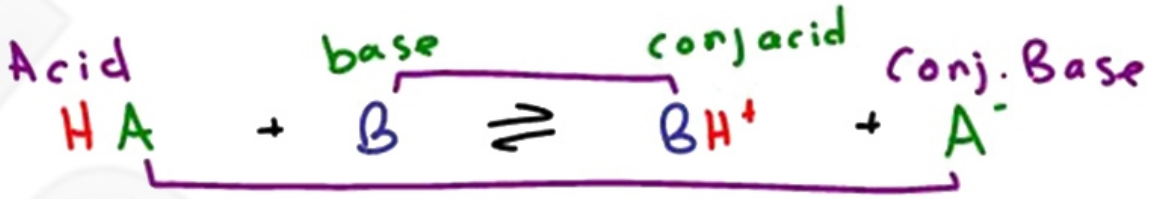
Visit Leah4sci.com/naming for my complete 21-video series on Naming Organic Compounds

ORGO ACIDS & BASES
CHEAT SHEET

VIDEO SERIES + QUIZ - LEAH4SCI.COM/ACIDBASE

	Acid: Litmus Red	Base Litmus Blue
Arrhenius	H^+ in H_2O ex. HCl	OH^- in H_2O ex NaOH
Bronsted-Lowry	H^+ donor ex NH_4Cl	Accepts H^+ NH_3
Lewis (electrons)	Accepts e^- pair ex $AlCl_3$	e^- pair donor ex. Cl^-

Acid - Base Reaction



Equations to recognize

$$K_a = \frac{[H^+][A^-]}{[HA]} \qquad pK_a = -\log(K_a) \Rightarrow K_a \propto [H^+] \propto \frac{1}{pK_a}$$

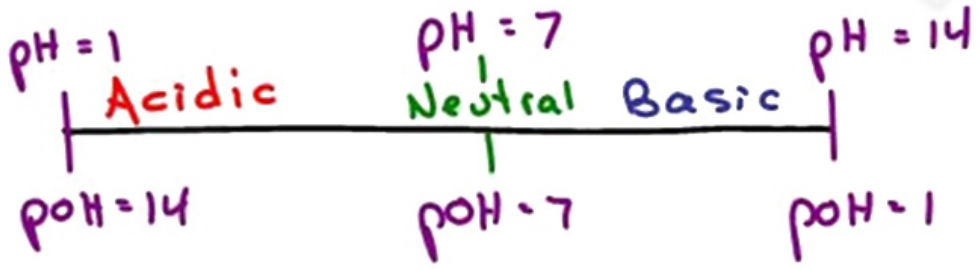
Strong Acid $\uparrow [H^+]$ $\uparrow K_a$ $\downarrow pK_a$

Weak Acid ↓ $[H^+]$ ↓ K_a ↑ pK_a

$pH = -\log [H^+]$
$pOH = -\log [OH^-]$

$pH + pOH = 14$
$pK_a + pK_b = pK_w = 14$

pH scale
pH → ← pOH



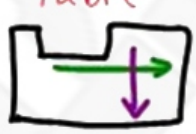
STRONG ACIDS FORM STABLE CONJUGATE BASES

CARIO
C = charge of acid or conj. base
A = Atom holding charge
R = Resonance
I = Inductive effect
O = orbital / hybridization

See videos for full explanation + examples LEAH4SCI.COM/acidbase

Charge: + / δ+ more acidic } when compare species
− / δ− more basic }

Atom: In same period ↑ eneg ↑ acidity
In same group ↑ size ↑ acidity



Resonance: ↑ Res ↑ charge distribution
↑ acidity (Aromaticity = ↑ stable)

Inductive Effect: ↑ e⁻neg nearby atom
↑ acidity

Orbital / hybridization ↑ % S ↑ acidity
sp = 50% > sp^2 = 33% > sp^3 = 25%

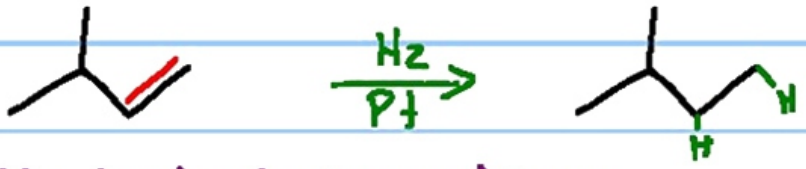
ACID BASE VIDEO SERIES + PRACTICE PROBLEMS
LEAH4SCI.COM/ACIDBASE

QUESTIONS OR COMMENTS - LEAH4SCI.COM/CONTACT

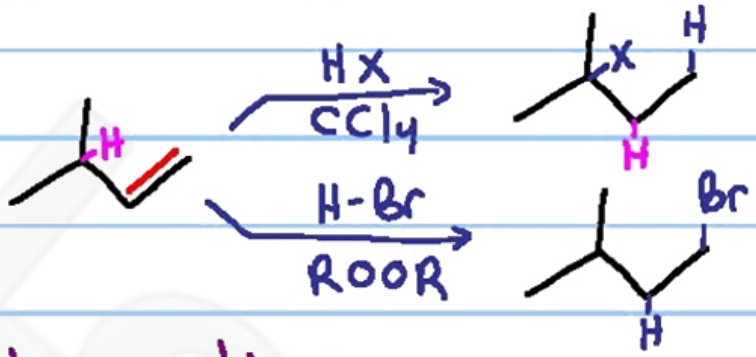
ALKENE REACTIONS

Hydrogenation - Catalytic Reduction

Syn Addition



Hydrohalogenation



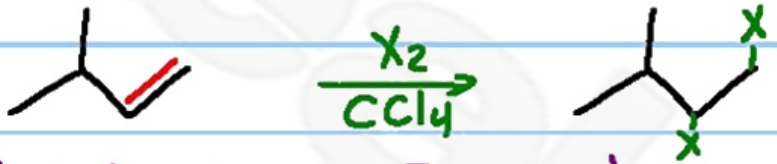
Mark, H-shift, C+

X = Cl, Br, I

ROOR = peroxides

Anti-Mark

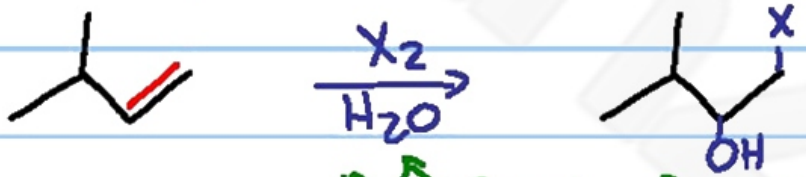
Halogenation



Anti-addition

X = Cl, Br

Halohydrin Formation

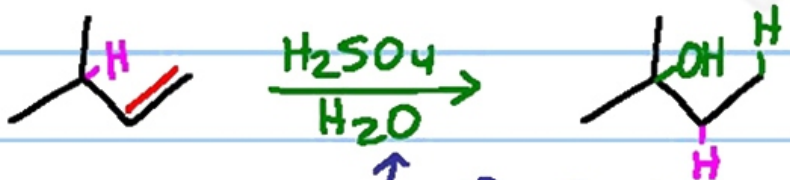


Anti, OH = Mark

No C+ X = Cl, Br

if ROH form ether

Acid Catalyzed Hydration

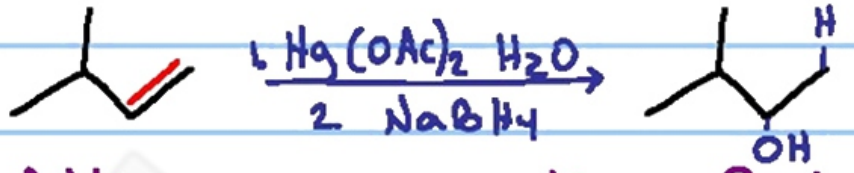


Mark, H-shift, C+

also see H^+/H_2O or H_3O^+

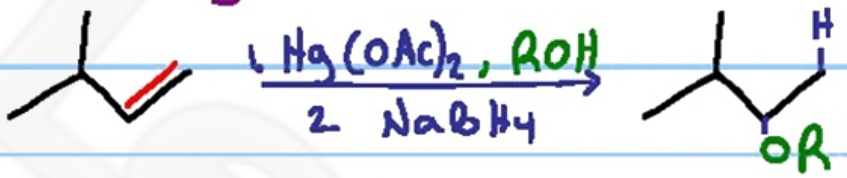
if ROH used form ether

Oxymercuration - Reduction



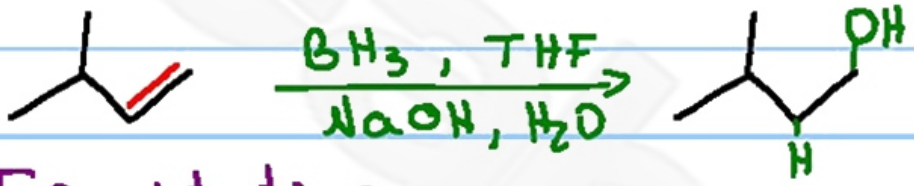
Mark, no H-shift
Anti

Alkoxymercuration- Reduction



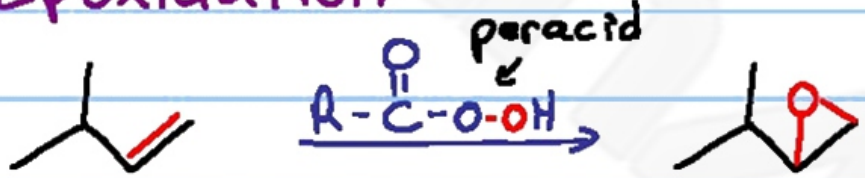
Mark, no H-shift
Anti

Hydroboration – Oxidation



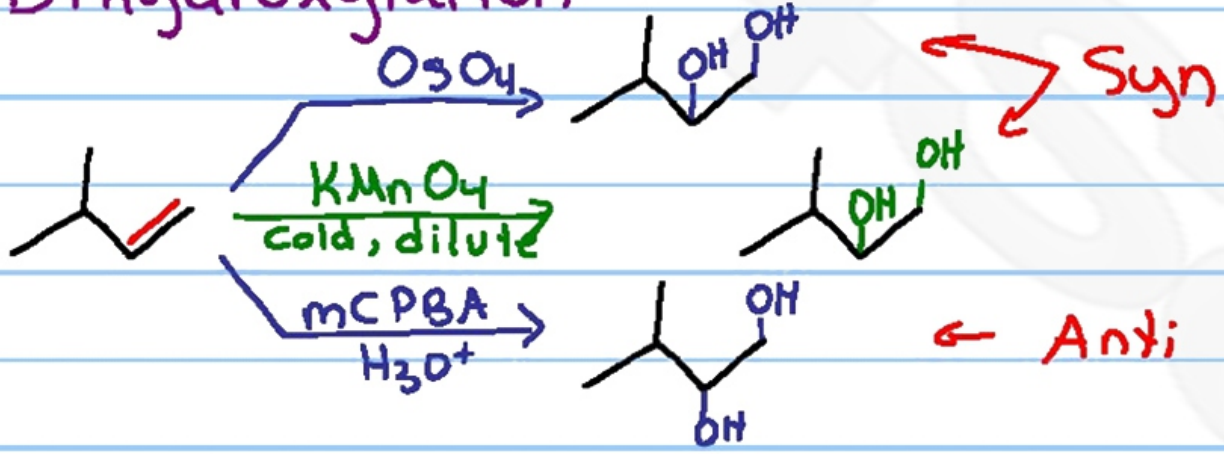
Anti-Mark

Epoxidation



Syn
mCPBA often used

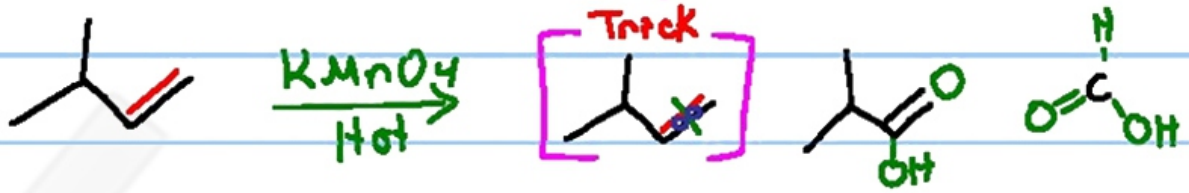
Dihydroxylation



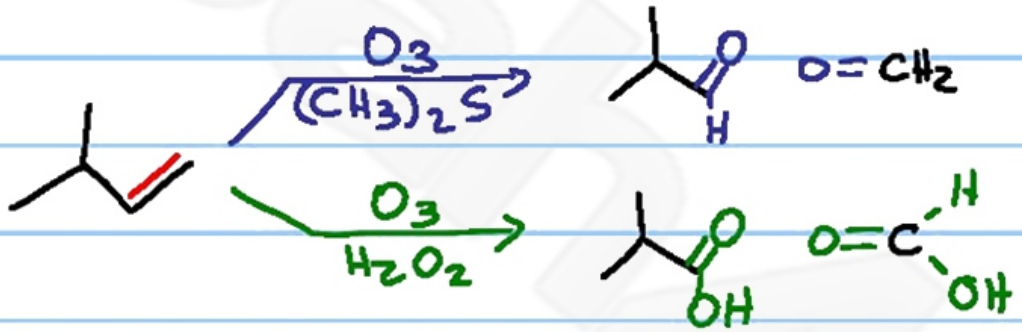
Syn

Anti

Oxidative Cleavage



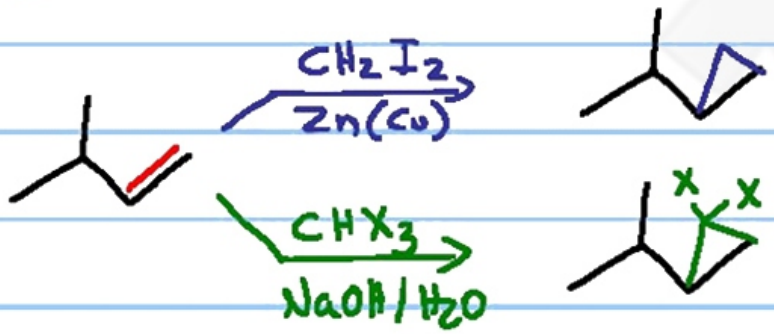
Ozonolysis



1° C → aldehyde

1° C → carboxylic acid

Cyclopropanation



← Simmons-Smith Rxn

Notes Key

Syn = Syn addition Anti = Anti-addition

Mark = Markovnikov Anti-Mark = anti-Markovnikov

C+ = carbocation Intermediate

H-shift = Hydride shift, C+ rearrangement

Questions? Email: ORGO@Leah4sci.com

ALKYNE REACTIONS

2-butyne $CH_3-C\equiv C-CH_3$ =

propyne $CH_3-C\equiv C-H$ =

Reduction

H_2, Pd or Pt ... → full reduction to alkane

Na°, NH_3 (l) → partial reduction trans alkene

H_2, Lindlar's Catalyst → Partial Reduction cis alkene

Hydration

Similar to $Hg(OAc)_2$

$HgSO_4$ (Hg^{2+}), H_2SO_4, H_2O → 2° enol → KET → ketone

Mark, anti-addition

BH_3, THF; H_2O_2, OH^- → 1° enol → KET → aldehyde

anti - Mark
syn addion

non-terminal = ketone

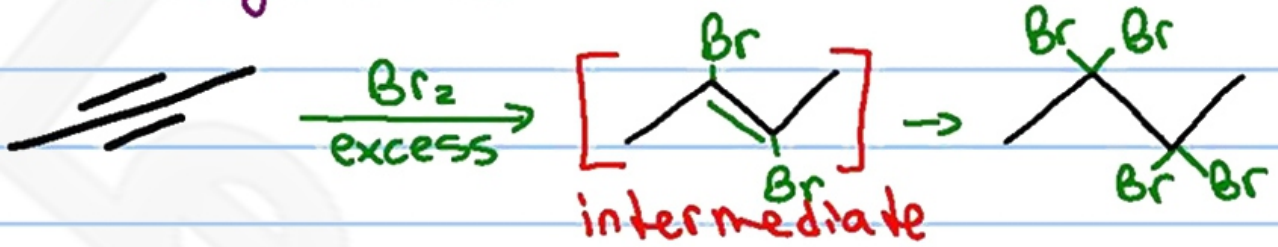
Hydrohalogenation

HX excess → intermediate → product

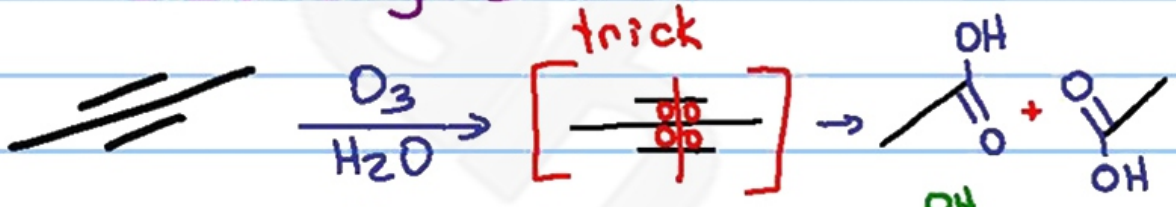
Mark

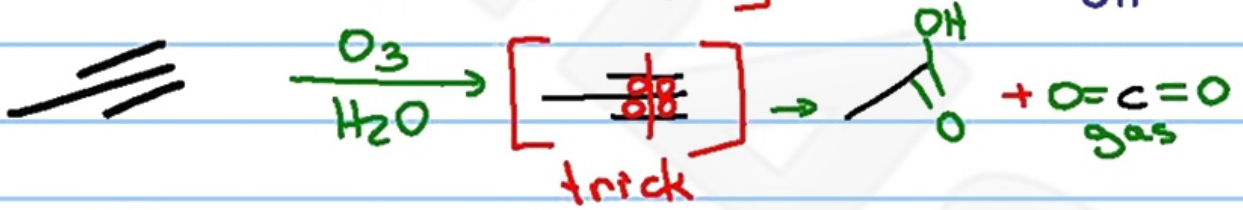
X = F, Cl, Br, I

Halogenation

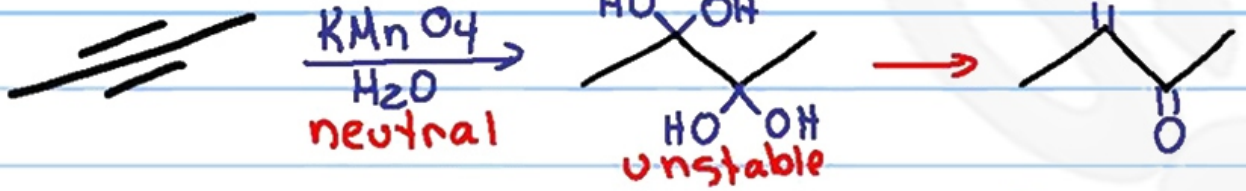


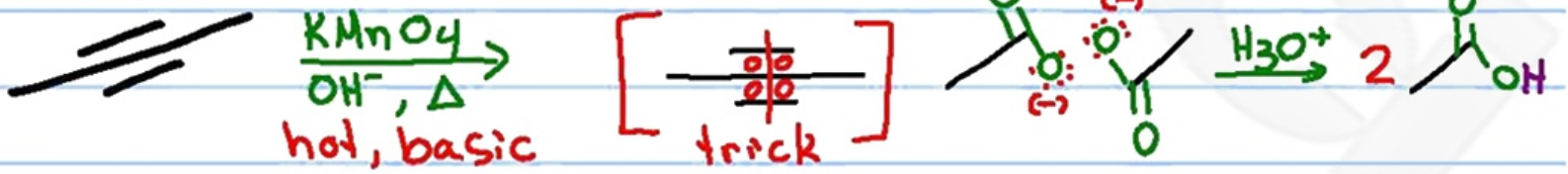
Ozonolysis



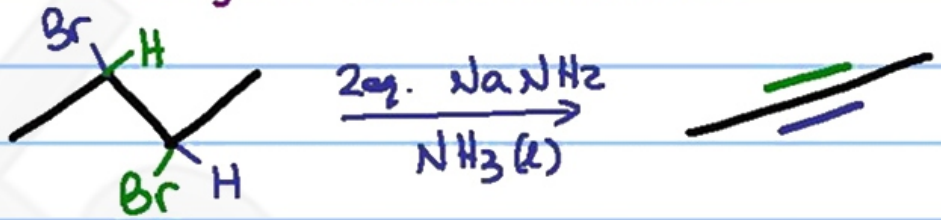


Permanganate Oxidation





Alkyne Formation



Alkyne Chain Elongation

Notes Key:

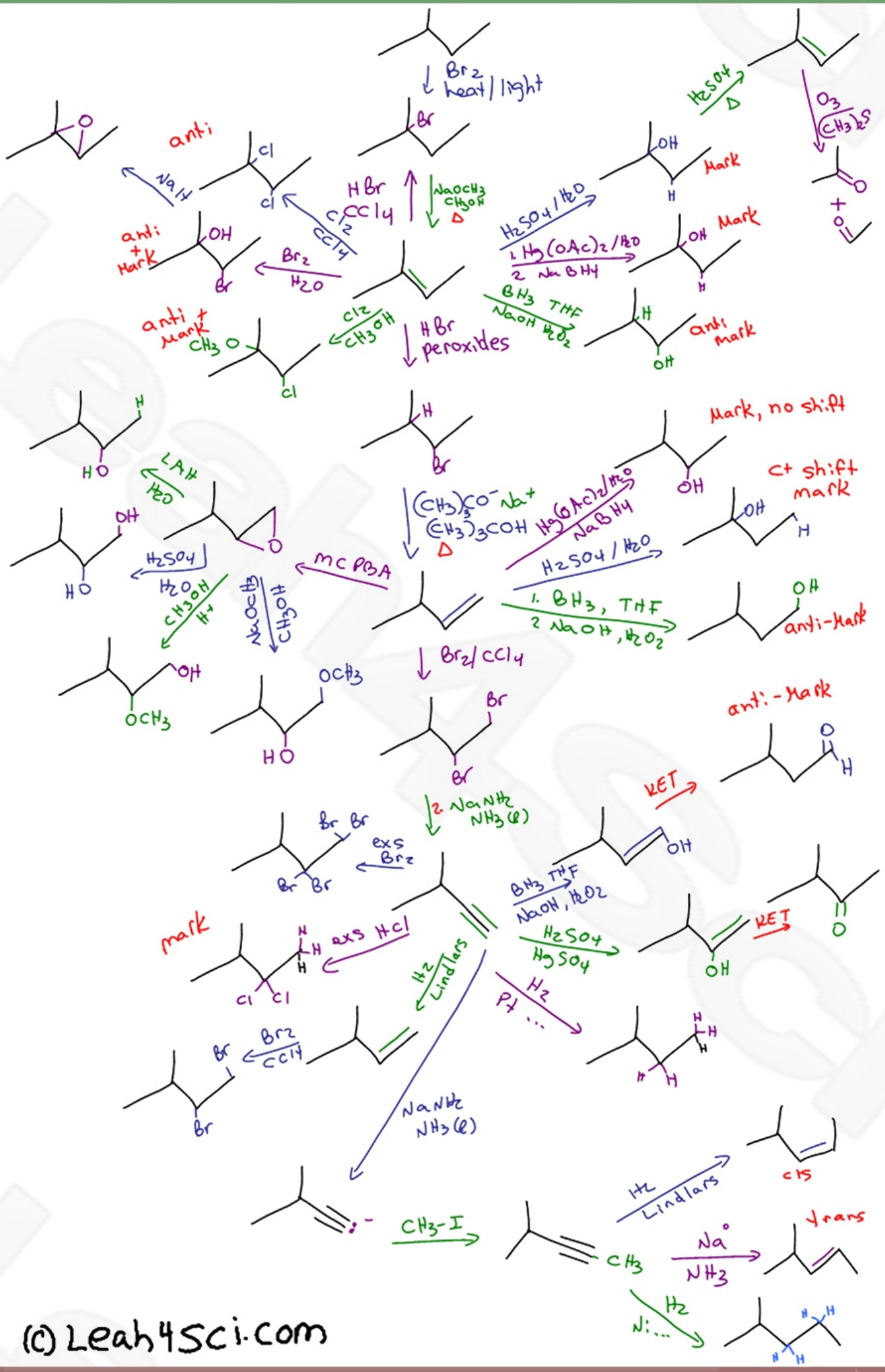
Mark = Markovnikov Anti-Mark = Anti-Markovnikov

Syn = Syn addition Anti = anti addition

Lg = Leaving group (S_N2) ex. Cl, Br, I

KET = Keto Enol Tautomerization

errors? questions? email: Leah@Leah4sci.com



S_N1 S_N2 E_1 E_2

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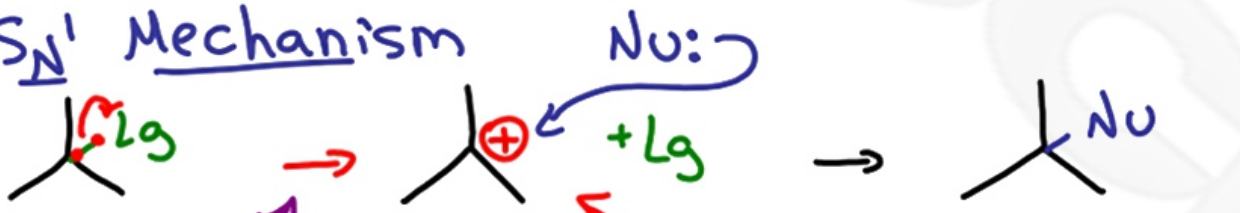
Complete Tutorial video series LEAH4SCI.COM/substitution-elimination

S_N1 = Nucleophilic Substitution Unimolecular

$Rate_{S_N1} = k[alkyl]$ ← 1st order Rxn

S_N1 Mechanism



Slow 'Rate' Step — Key Intermediate C^+

S_N2 = Nucleophilic Substitution Bimolecular

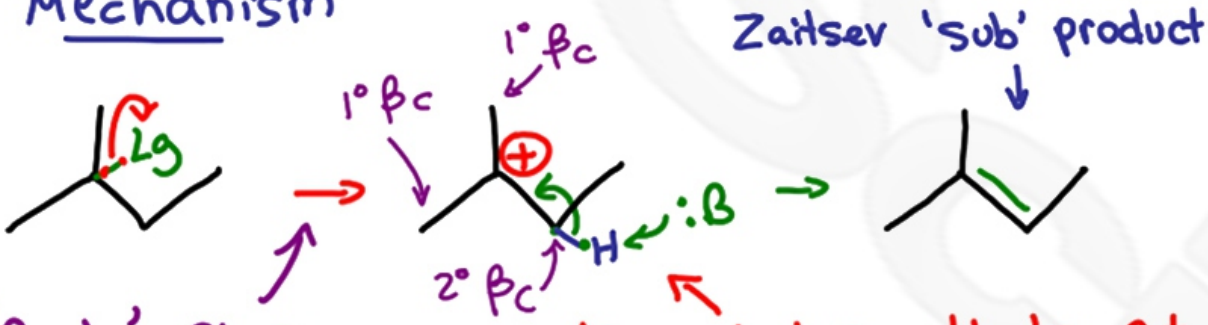
$Rate_{S_N2} = k[alkyl][Nu]$ ← 2nd order Rxn

S_N2 Mechanism

E_1 = β-Elimination Unimolecular

$Rate_{E_1} = k[alkyl]$ ← 1st order Rxn

E_1 Mechanism



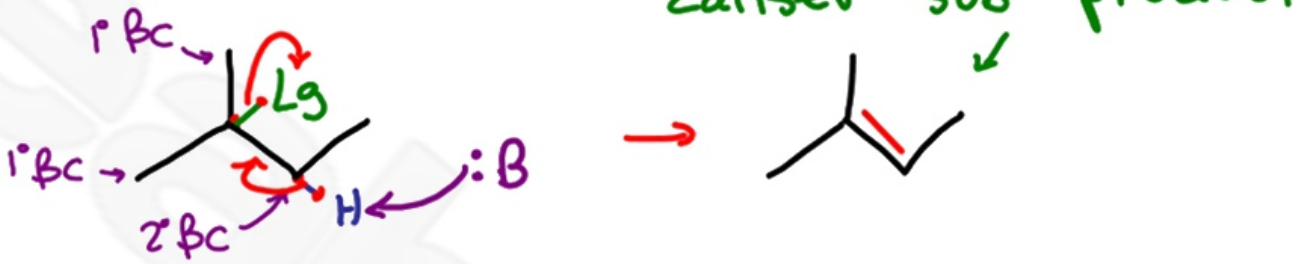
Slow 'Rate' Step

Key Intermediate C^+

E_2 = β- Elimination Bimolecular

$Rate_{E_2} = k[alkyl][B]$ 2nd order Rxn

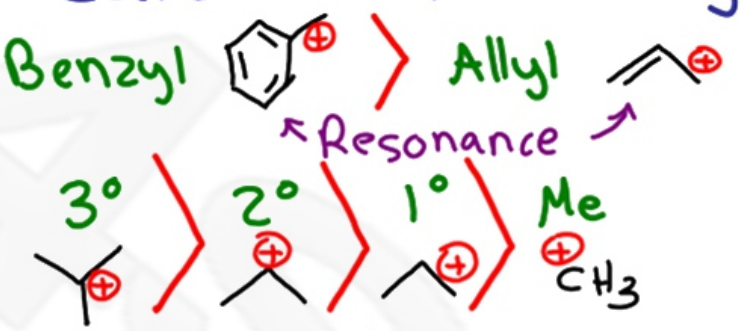
E_2 Mechanism



4-Part Checklist

- Alkyl chain
- Atacking Nu / B
- Leaving Group
- Solvent

Carbocation Stability



Alkyl Chain Analysis ← Position of Leaving Group

Methyl = only S_N2 ~~S_N1~~ ~~E_1~~ unstable C^+ ~~E_2~~ No β-H

Primary = S_N2 > E_2 ~~S_N1~~ ~~E_1~~ unstable C^+

Secondary = S_N1 S_N2 E_1 E_2 E_1 S_N1 = if weak (neutral) Nu/B

if strong negative Nu/B $E_2 > S_N2$ protic, $S_N2 > E_2$ aprotic

Tertiary = S_N1 E_1, E_2 ~~S_N2~~ steric hindrance

S_N1 E_1 if weak Nu/B E_2 if strong B

Strength of attacking Nucleophile or Base

Negative = 'stronger' Neutral = 'Weaker'

ex CH_3O^-, OH^-, NH_2^-,  ex CH_3OH, H_2O, NH_3, 

Leaving Group Ability = Stability of anion

Lg = X^- $I^- > Br^- > Cl^- > F^-$ Lg ≠ X $H_2O > CH_3\text{-}\overset{\overset{O}{\|}}{C}\text{-}O^- > OH^- > OR^- > NH_2^-$

Solvent Type

Polar Protic = H-bonding (H on N, O, F)

ex. H_2O, CH_3OH, NH_3 favors S_N2

Polar Aprotic = No H for H-bonding

ex. DMSO, DMF, Acetone, Acetonitrile

Complete Sub-Elim Tutorial Video Series

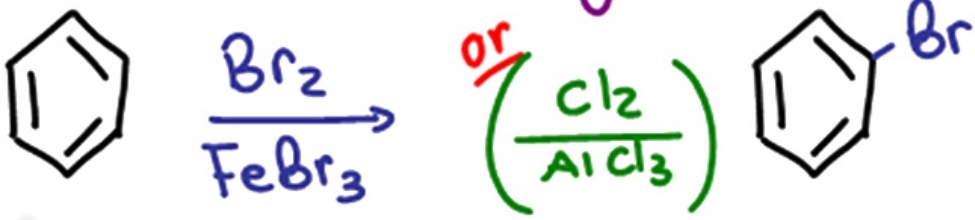
LEAH4SCI.COM/Substitution-elimination

Electrophilic Aromatic Substitution

by Leah4sci.com

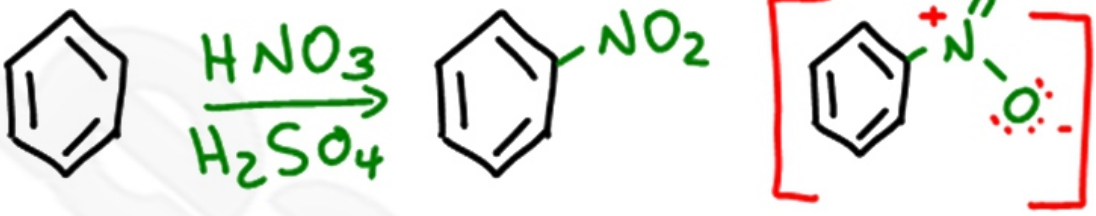
Complete EAS tutorial video series Leah4sci.com/EAS

Aromatic Halogenation



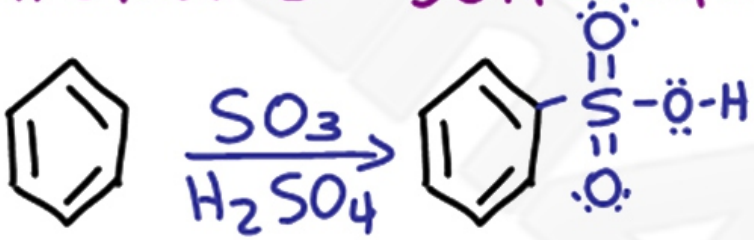
Super E+

Aromatic Nitration

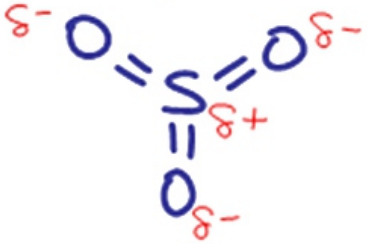


Super E+

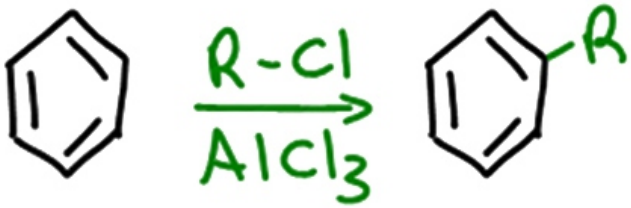
Aromatic Sulfonation



Super E+



Friedel-Crafts Alkylation

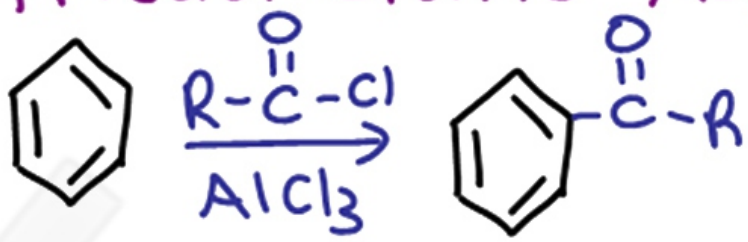


Super E+

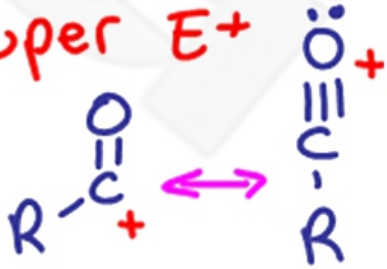
R+

carbocation

Friedel-Crafts Acylation



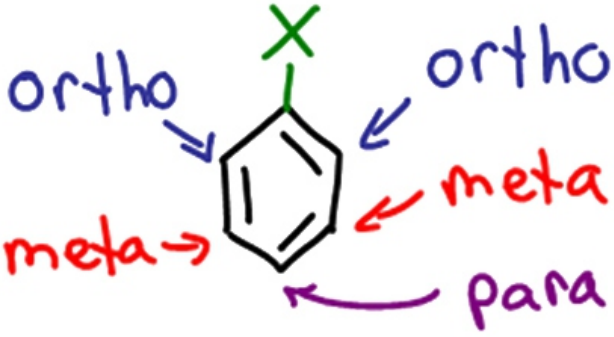
Super E+

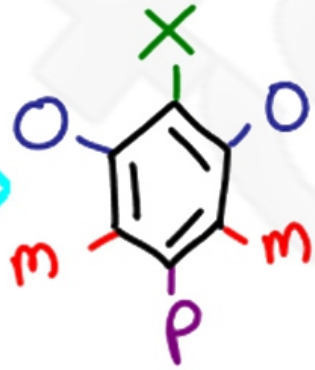


Sigma Complex Resonance

Substituted Benzene

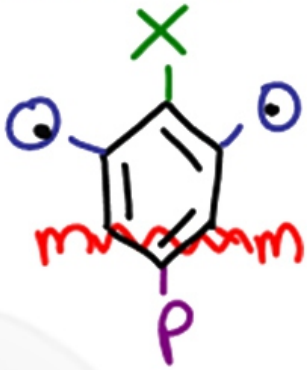
X = substituent





add
- eyes
- mouth
- tongue

O/M/P monster



Directing Effects

ortho / para = activating

- $-NH_2$
- $-NHR$
- $-NR_2$
- $-OH$
- $-OR$
- $-NH-C(=O)-R$
- $-R$
- $-O-C(=O)-R$

exception

- $-F$
- $-Cl$
- $-Br$
- $-I$

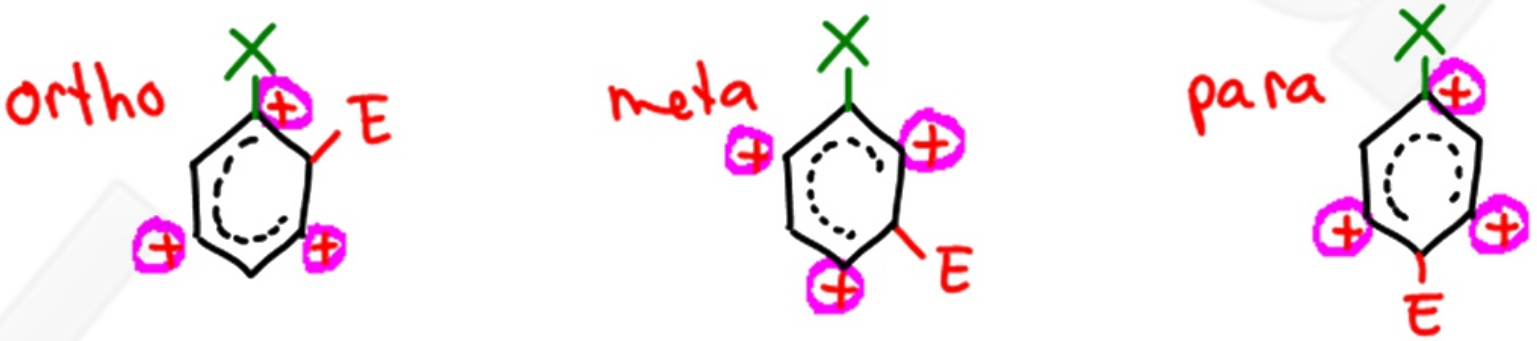
ortho, para deactivating

meta = deactivating

- $-C(=O)-H$
- $-C(=O)-R$
- $-C(=O)-OH$
- $-C(=O)-N$
- $-NO_2$
- $-S(=O)(=O)-OH$
- $-\overset{+}{N}H_3$
- $-CF_3$
- $-C\equiv N$
- $-CCl_3$

Strength ← → Strength

Carbocation Resonance Trick



Complete EAS tutorial video series

Leah4sci.com/EAS

EAS cheat sheet (C) Leah4sci.com

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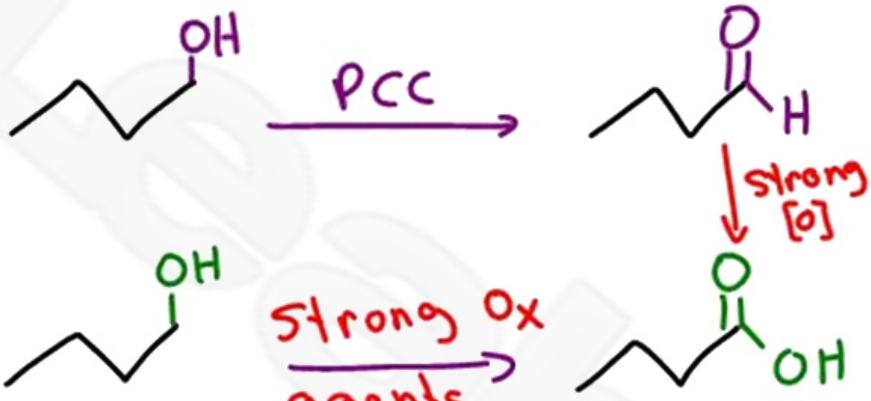
ORGO OXIDATION + REDUCTION

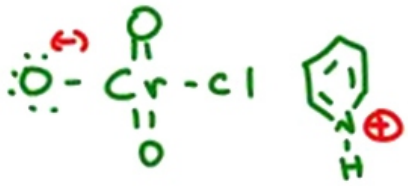
By: LEAH4SCI.COM

Organic Chemistry tutorial videos, cheat sheets...

Oxidation = Gain O bonds, Lose H bonds



PCC =



Strong ox agents

CrO_3, H_3O^+

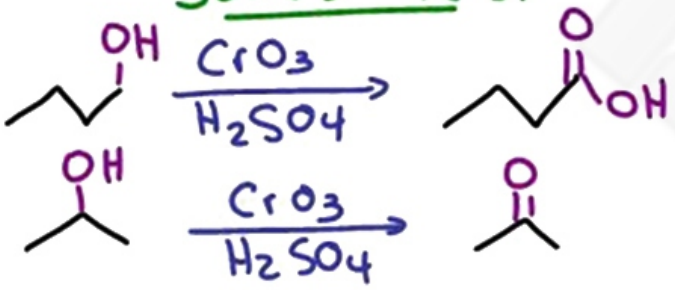
$Na_2Cr_2O_7$, H_2SO_4

H_2CrO_4

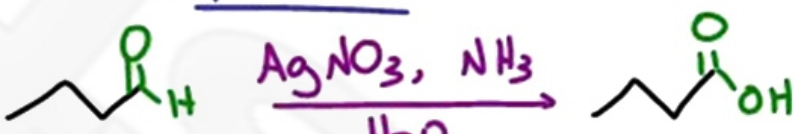
$K_2Cr_2O_7$, H_2SO_4

$KMnO_4$

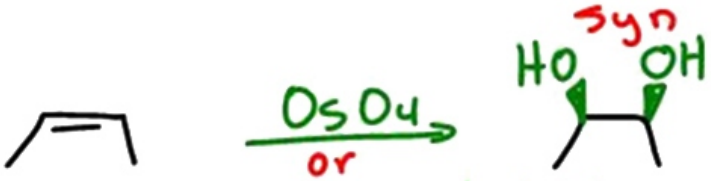
Jones Test

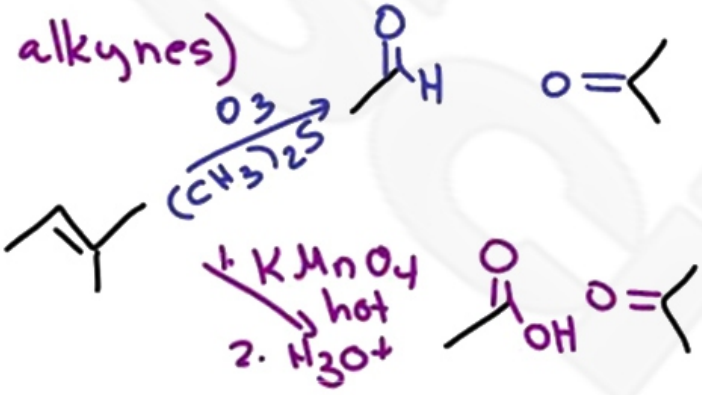


Tollens Test

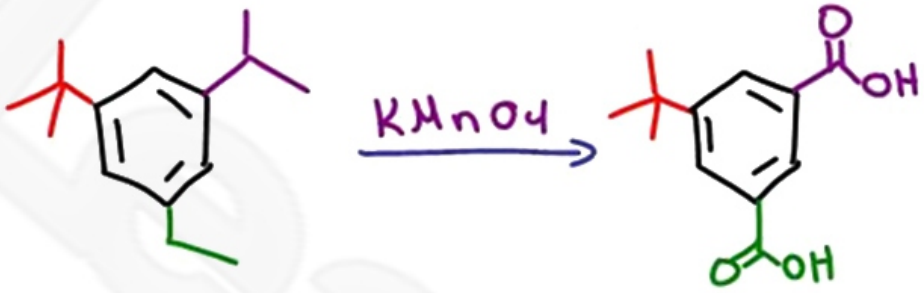


Alkene Oxidation (also alkynes)





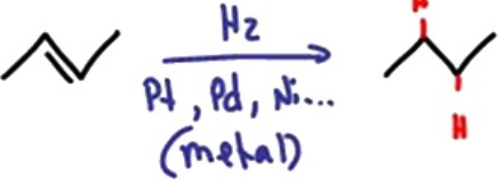
Side Chain Oxidation



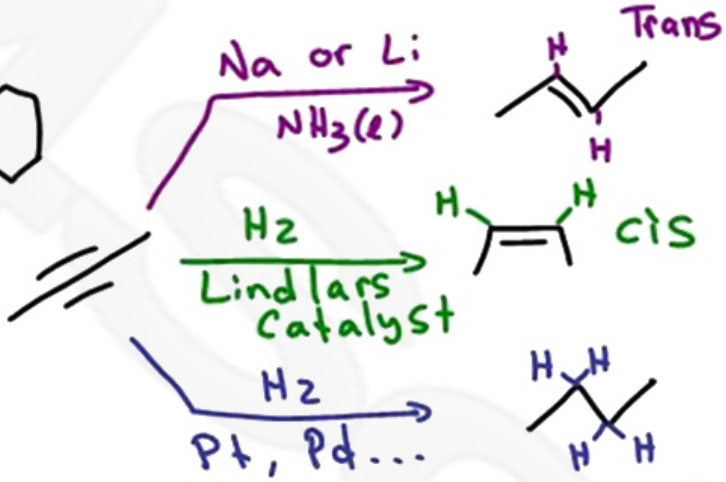
only 1° & 2° get oxidized
3° = N/R

Reduction = Gain H bonds, Lose O bonds

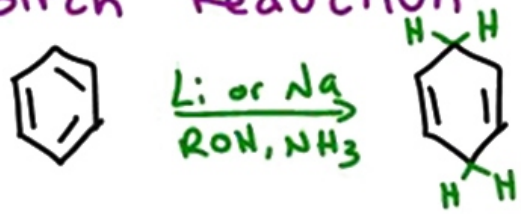
Alkene Reduction



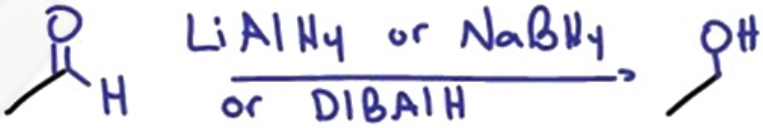
Alkyne Reduction

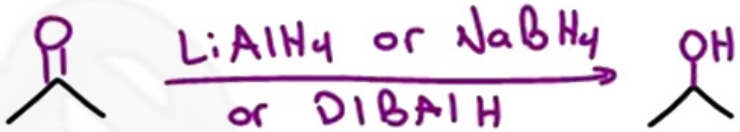


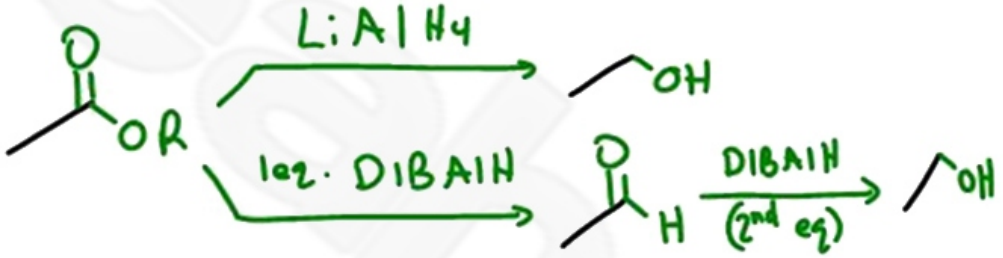
Birch Reduction



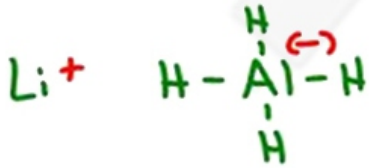
Reduction With Metal Hydrides



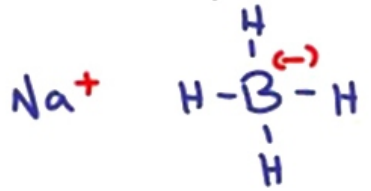




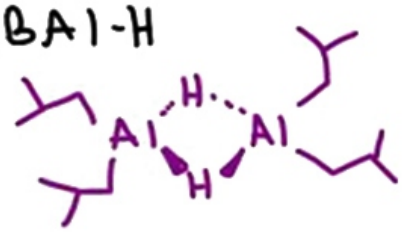
LiAlH4 = strong

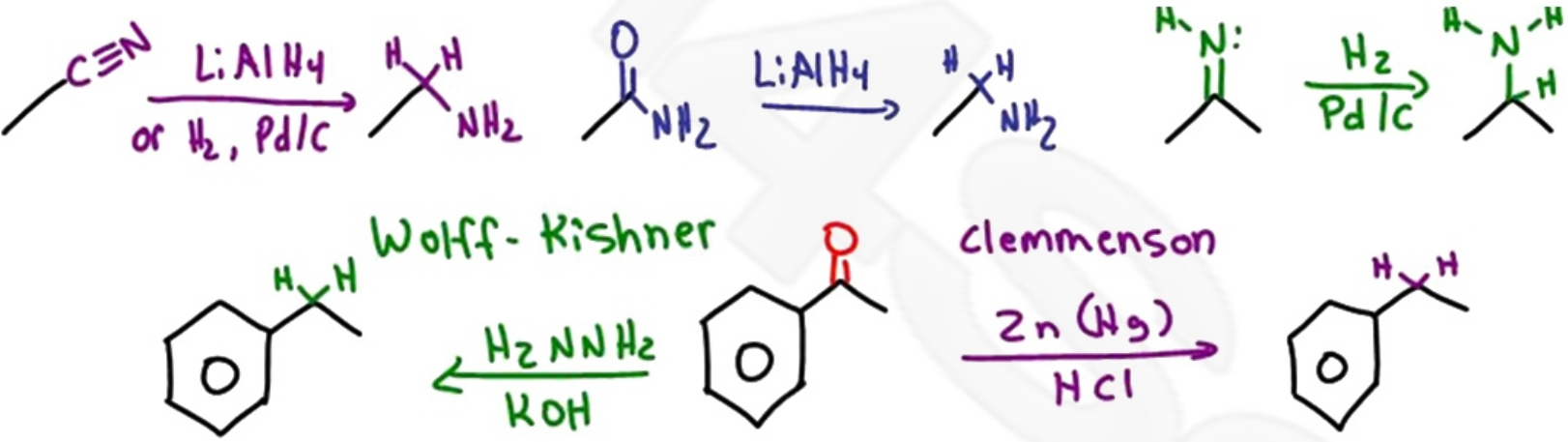


NaBH4 = weak



DIBAl-H





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CARBOXYLIC ACID DERIVATIVES

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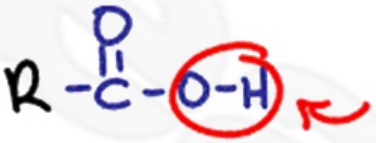
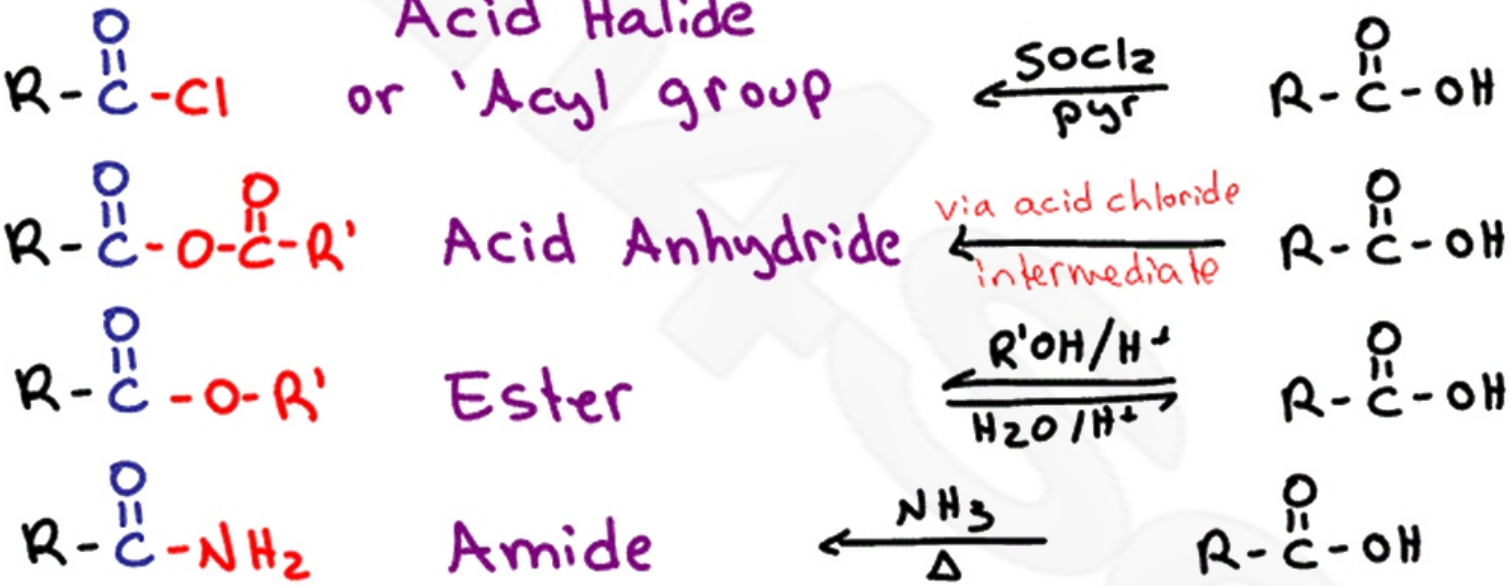
Carboxylic Acid

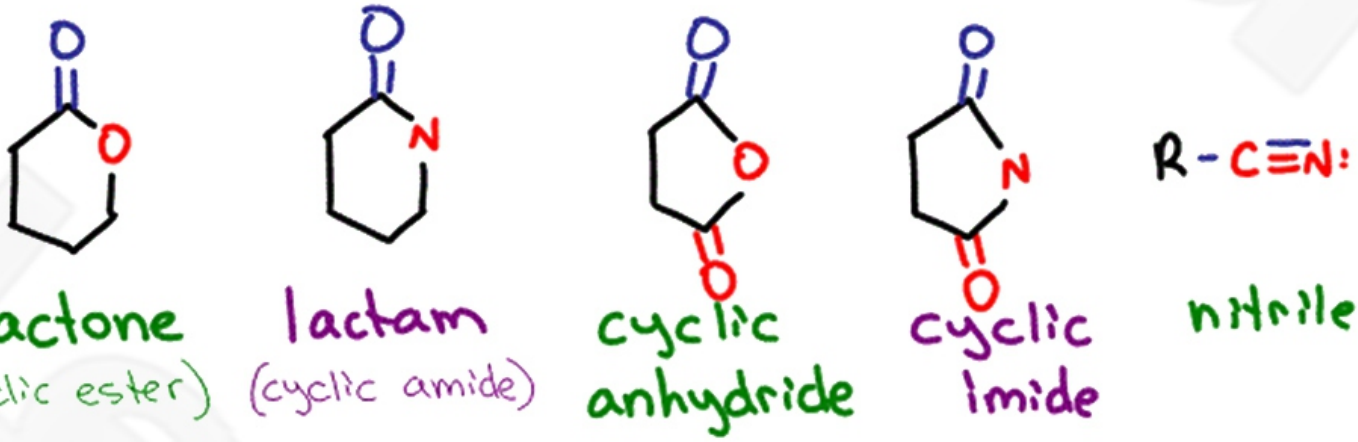


Common Derivatives

Reaction Reagents

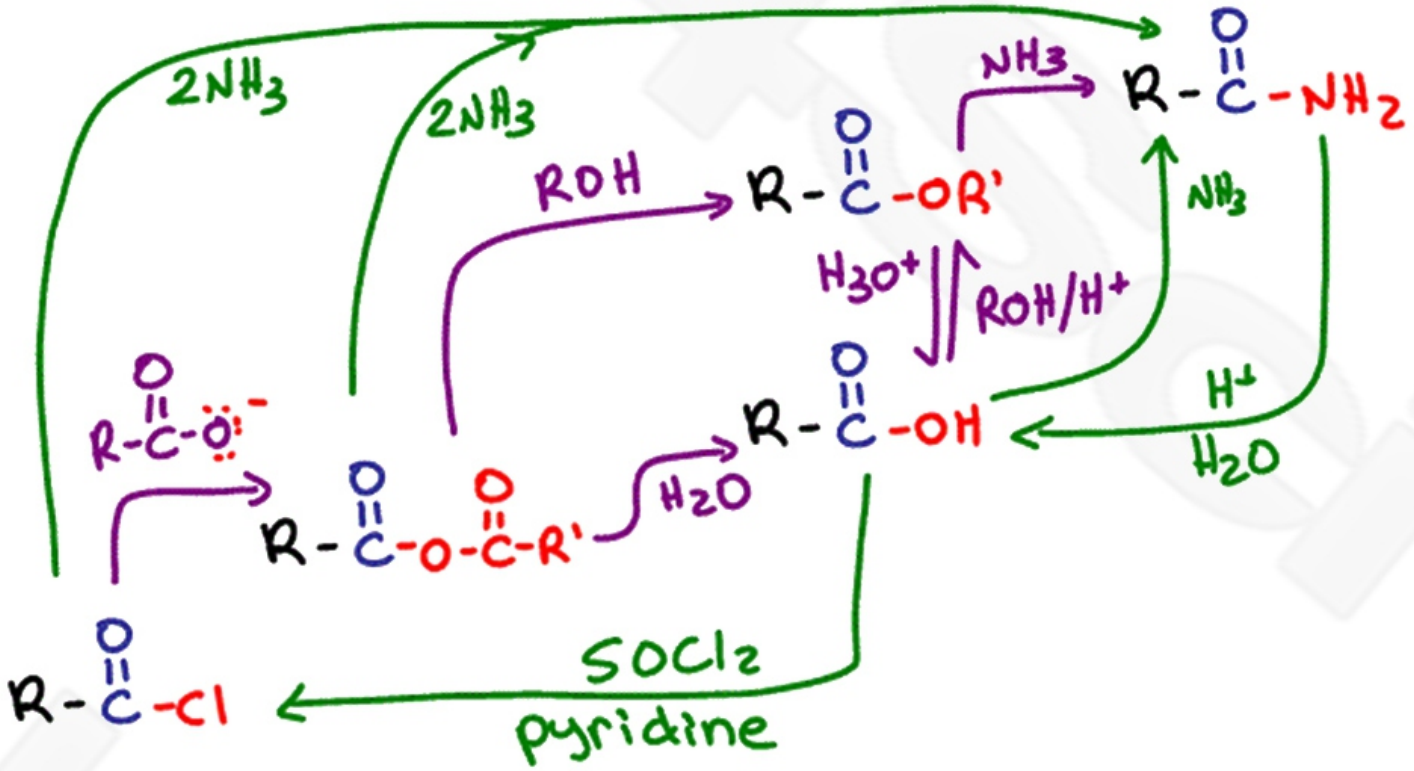


Less Common Carboxyl Derivatives



Reactivity of Carboxyl Derivatives

Interconversion Between Derivatives



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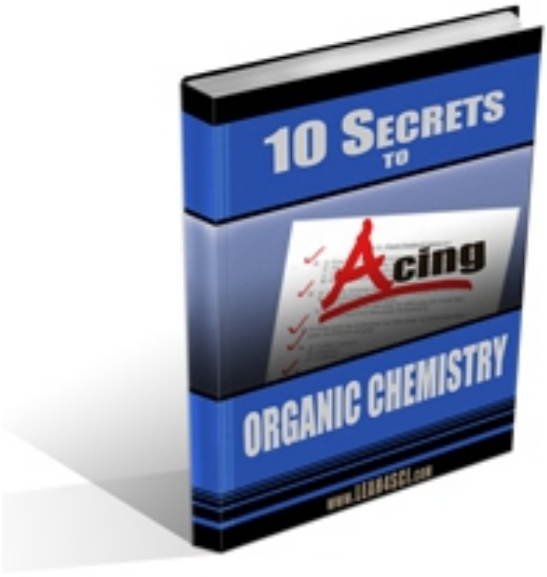

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