

Leah4Sci
presents:

CHEAT SHEET COLLECTION

(c) Leah4sci.com

These cheat sheets may be shared with friends/classmates but may not be edited in any way

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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FUNCTIONAL GROUPS

Learn how to name each group: Leah4sci.com/Naming

'R' Group ← not a real group

'R' represents the 'Rest' of the molecule

Alkane



ex



hexane

Alkene



ex

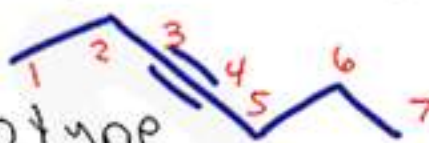


cis-3-octene

Alkyne

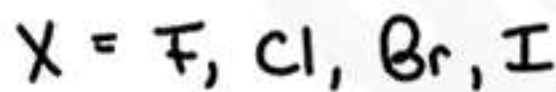


ex



3-heptyne

Alkyl Halide



ex



1-chlorobutane

Alcohol

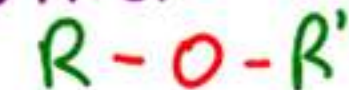


ex



2-methyl-2-butanol

Ether

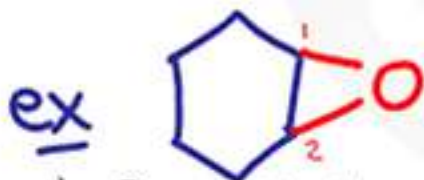
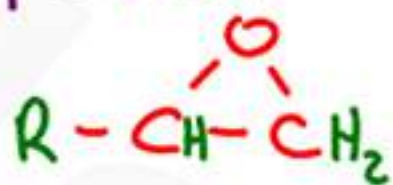


ex



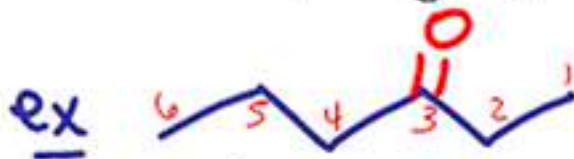
1-ethoxy-2-methylpropane

Epoxide



1,2-epoxycyclohexane

Ketone



3-hexanone

Aldehyde



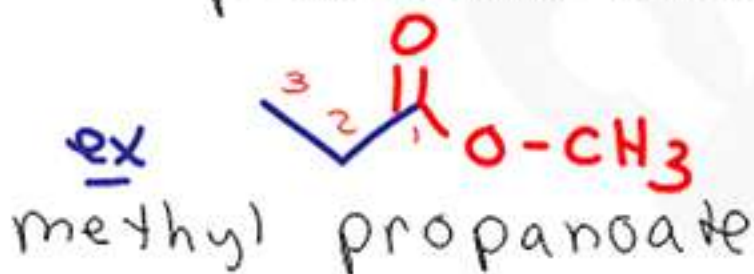
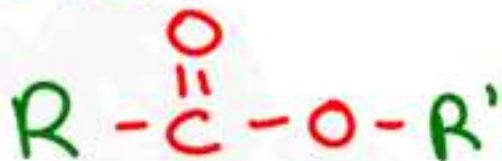
butanal

Carboxylic Acid

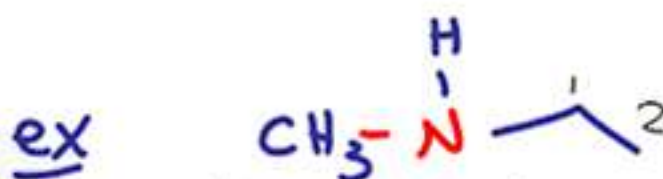


pentanoic acid

Ester



Amine

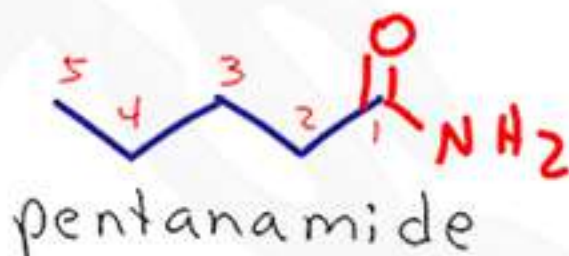


N-methylethylamine

Amide



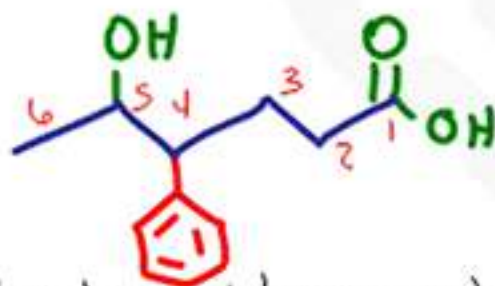
ex



Phenyl



ex



visit: Leah4sci.com/Naming for the complete
21 video series on naming organic compounds
Questions or Comments: Leah4sci.com/Contact

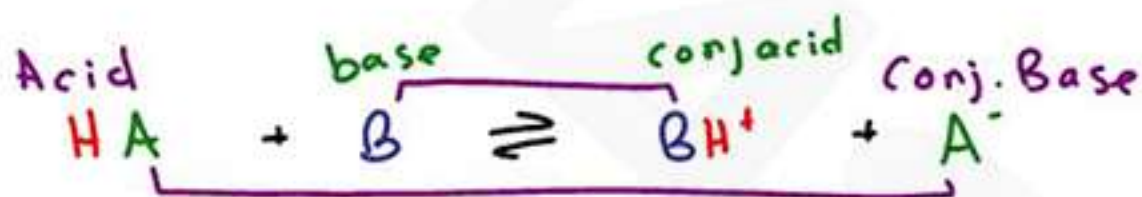
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ACIDS & BASES

Video series + Quiz - Leah4sci.com/acidbase

Arrhenius	Acid = Litmus Red H^+ in H_2O ex. HCl	Base Litmus Blue 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

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

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

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

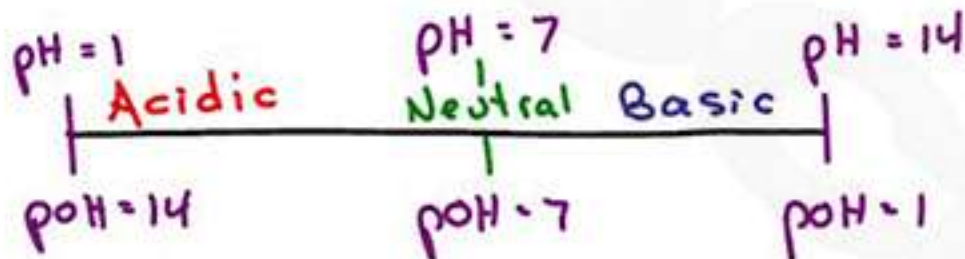
$$pH = -\log [H^+]$$

$$pOH = -\log [OH^-]$$

$$pH + pOH = 14$$

$$pK_a + pK_b = pK_w = 14$$

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

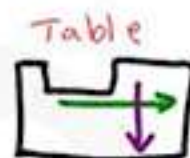
O = orbital / hybridization

See videos for full explanation + examples

LEAH4SCI.COM/acidbase

Charge: $+ / \delta+$ more acidic } when compare
 $- / \delta-$ more basic } species

Atom: In same period \uparrow eneg \uparrow acidity
In same group \uparrow size \uparrow acidity



Resonance: \uparrow Res \uparrow charge distribution
 \uparrow acidity (Aromaticity = \uparrow stable)

Inductive Effect: \uparrow e⁻ neg nearby atom
 \uparrow acidity

Orbital/hybridization \uparrow % s \uparrow acidity
 $sp = 50\% > sp^2 = 33\% > sp^3 = 25\%$

Acid base video series + practice problems:

Leah4sci.com/acidbase

Questions or Comments - Leah4sci.com/contact

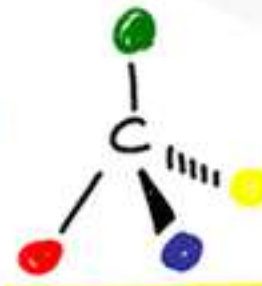
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CHIRALITY/STEREOCHEMISTRY

Complete Chirality video series and Practice Quiz:
Leah4sci.com/Chirality

Chiral C

- 4 unique substituents
- sp^3 hybrid
- tetrahedral geometry



Follow with your own model kit
LEAH4SCI.COM/KIT

Ranking:
Cahn - Ingold - Prelog
high to low atomic #

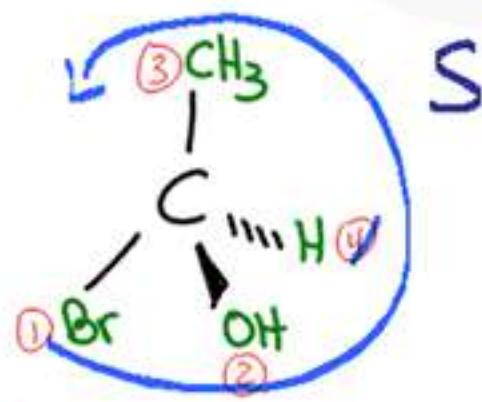
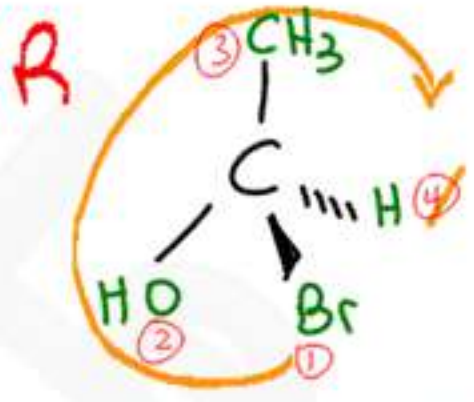
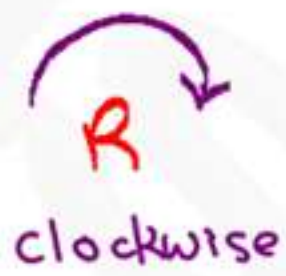
* Memorize 10 most common orgo atoms

D = deuterium H-2 isotope

H D *	lowest priority		
C	N	O	F
	P	S	Cl
			Br
			I ← highest priority

Absolute Configuration

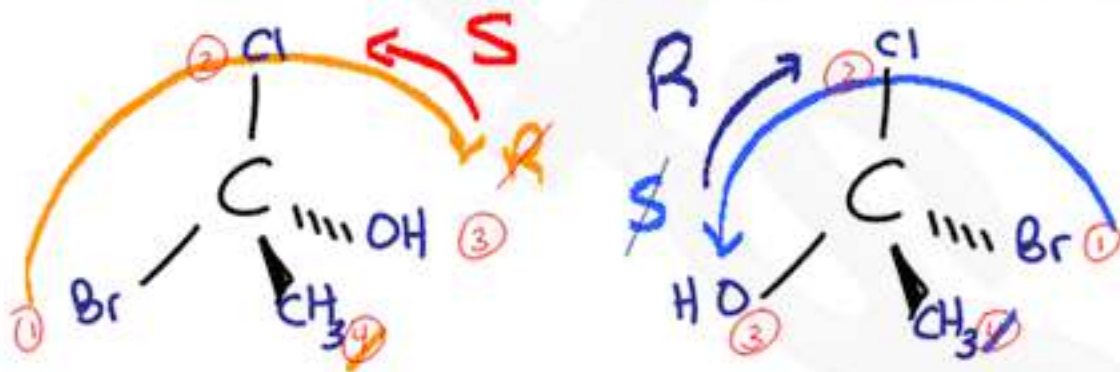
- 1- assign ranking priority
- 2- ensure priority #4 back
- 3- cross out #4
- 4- trace arc 1 → 2 → 3



wedge out of page
dashes into page (dashes down)

1 = highest, # 4 = lowest priority

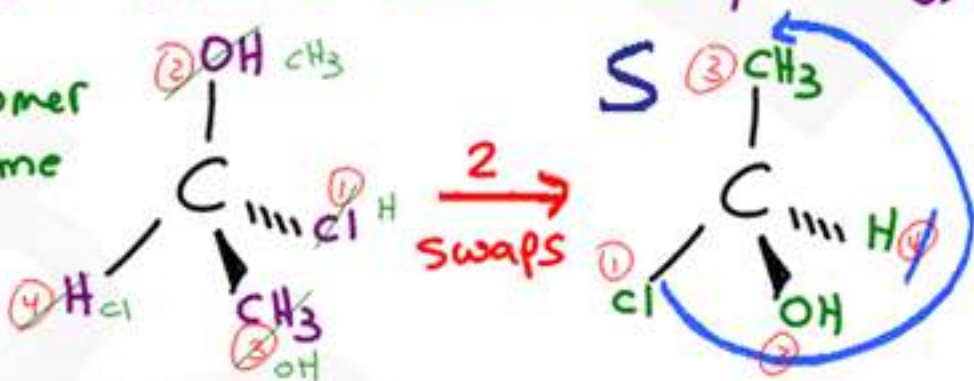
When group #4 is forward
 $R \rightarrow S$ $S \rightarrow R$ (see backwards)



Swap Method (see tutorial Leah4sci.com/chirality)

odd # swaps = Enantiomer
 even # swaps = Same

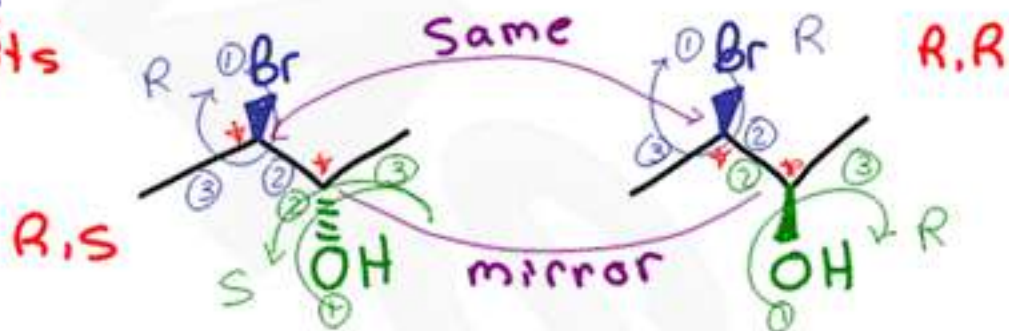
goal = #4 back



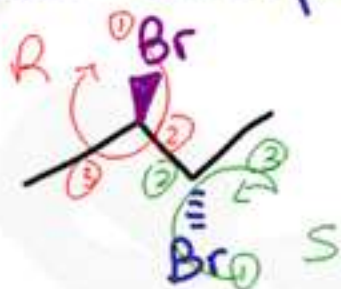
Vocabulary

- Chiral = has optical activity, 4 unique subs
- Enantiomers / mirror images - pair of chiral isomers that are non-superimposable ($R + S$)
- Superimposable = 2 same molecules. $R + R$, $S + S$ or... achiral with its achiral twin
- Diastereomers = 2 (or more) chiral atoms where at least 1 = same, 1 = mirror image
- Meso Compound = has (at least) 2 chiral atoms w/ same substituents + internal symmetry
- 2^n = max potential stereoisomers n = # chiral centers

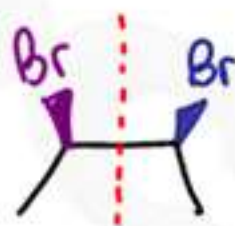
Diastereomers 2 chiral units



Meso Compounds



Confused?
rotate center
180°



Internal
Symmetry

Meso R,S or S,R

Tutorial videos, cheat sheets and more:

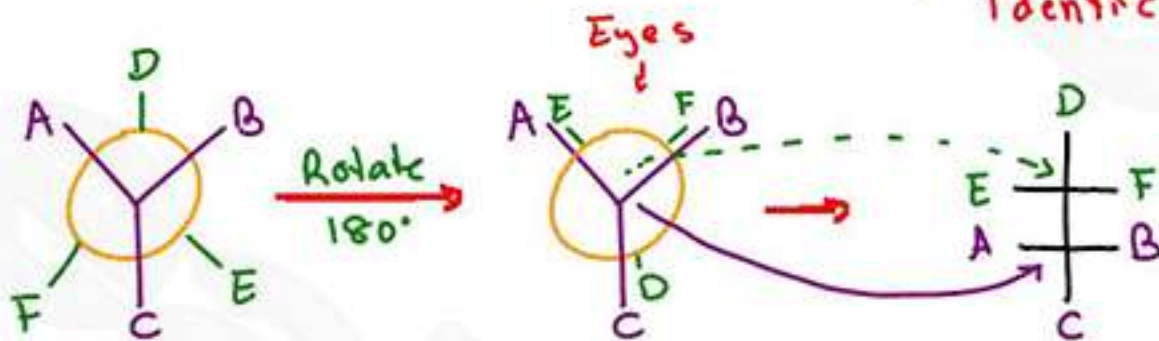
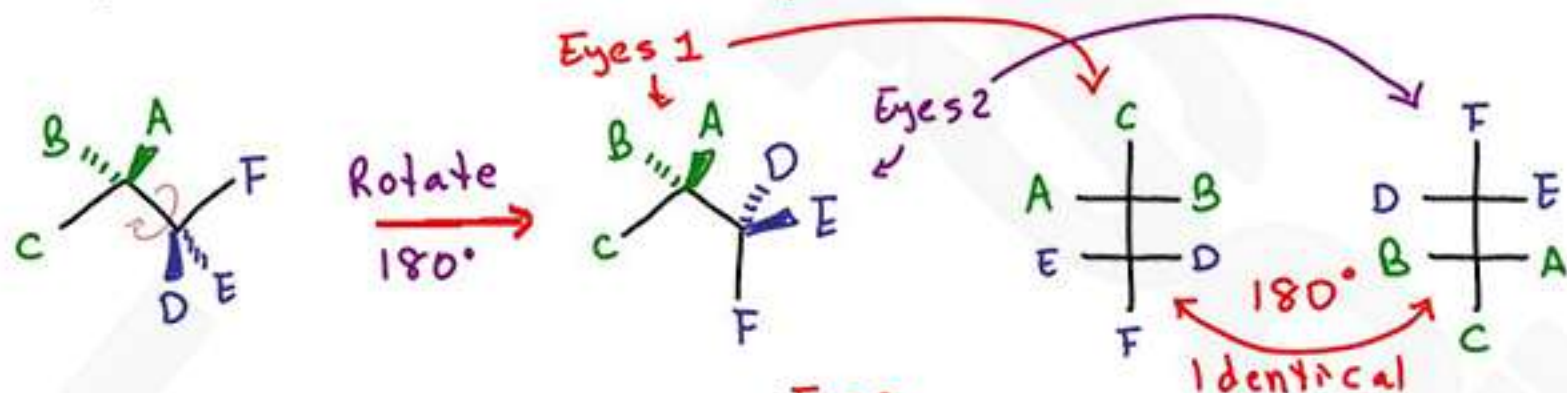
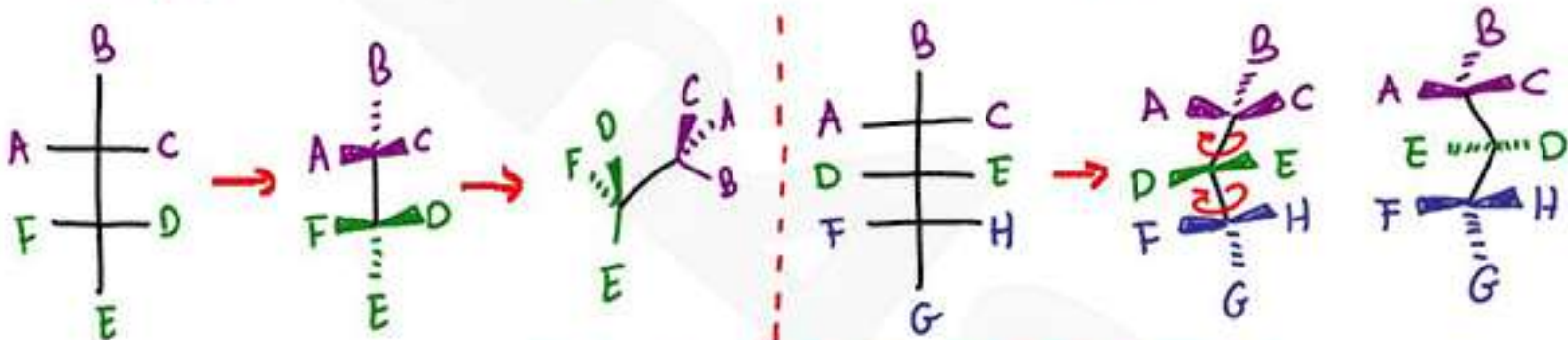
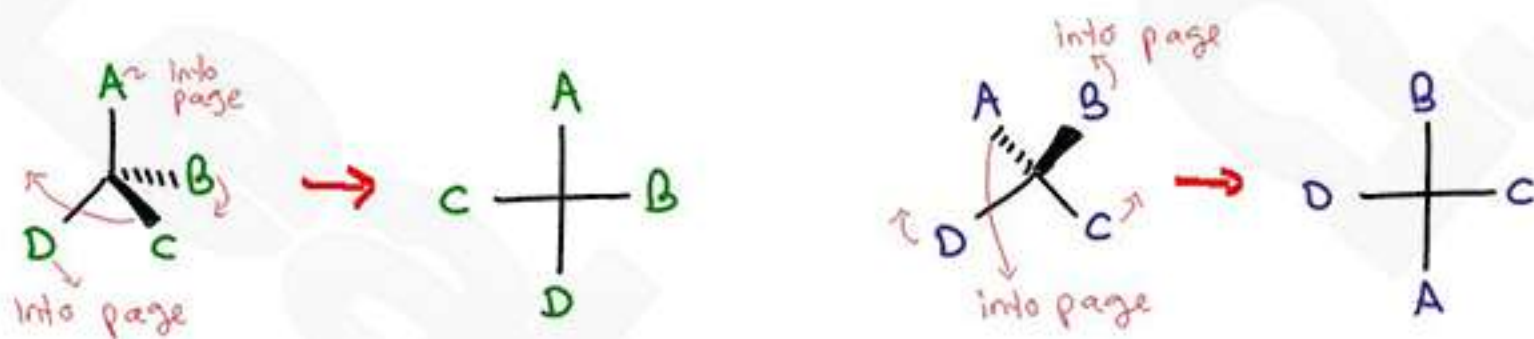
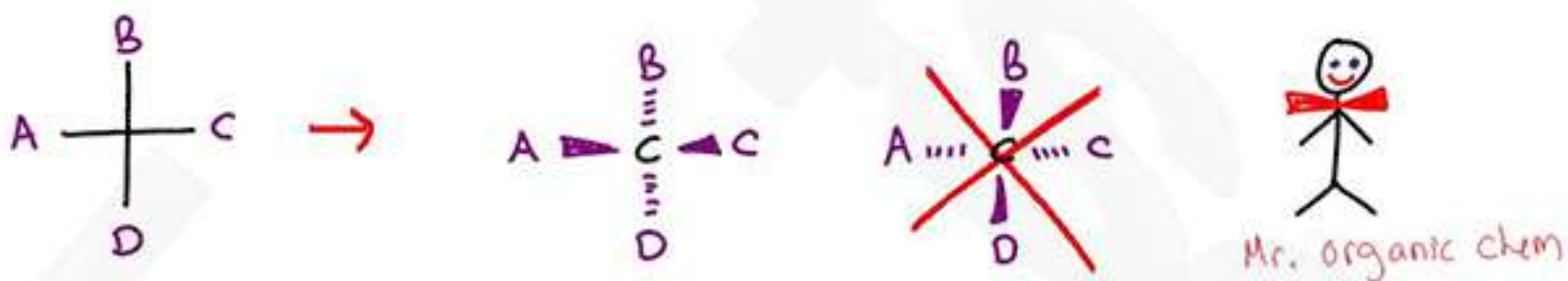
Leah4sci.com

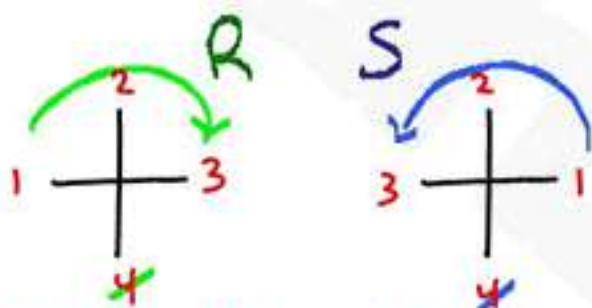
Questions or Comments - Leah4sci.com/contact

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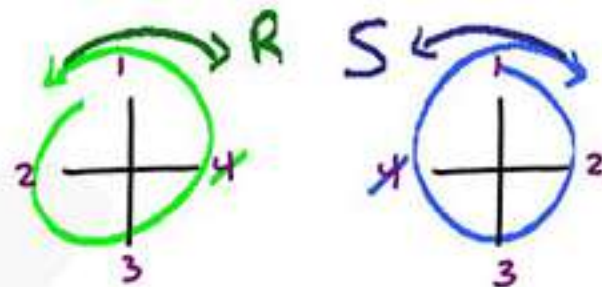
FISCHER PROJECTIONS

Complete Video series and Practice Quiz: Leah4sci.com/Fischer

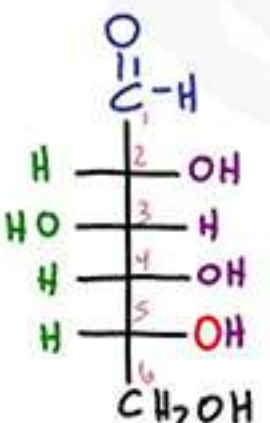
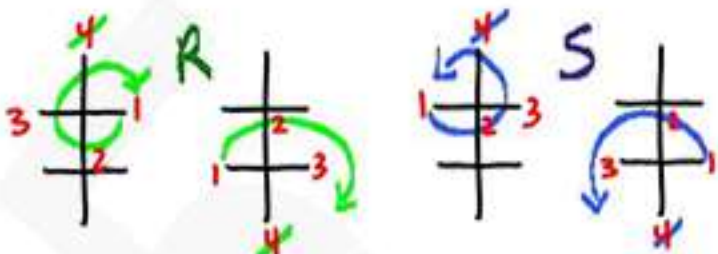




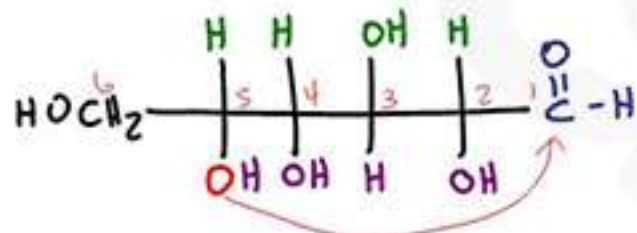
4 back = Ideal



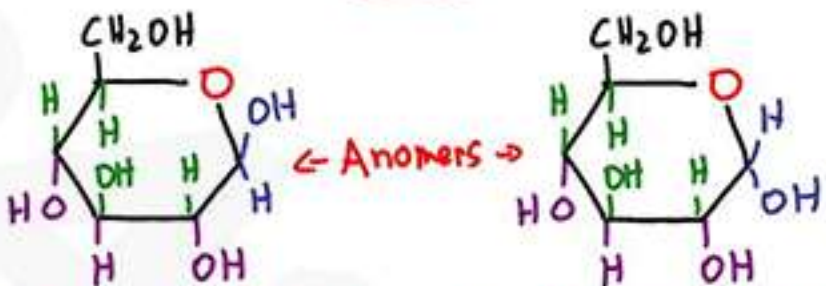
4 forward = reverse R+S



drop it
Right Down
other side
is
Left up

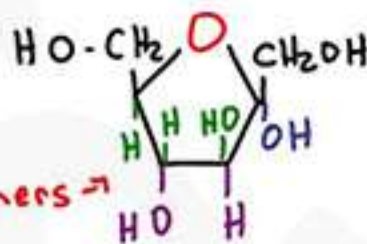
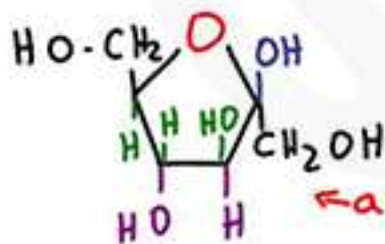
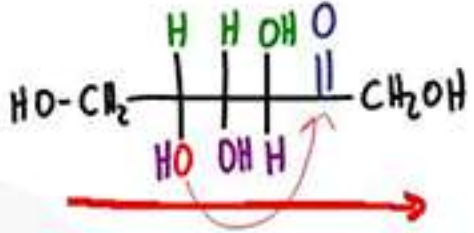
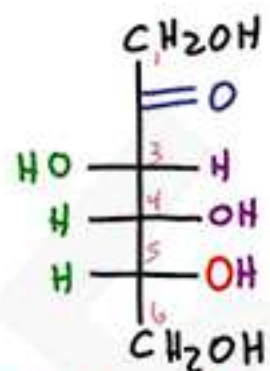


D-glucose



β-D-glucopyranose

α-D-glucopyranose



D-fructose

β-D-fructofuranose

α-D-fructofuranose

MCAT tutorial videos, cheat sheets and more:

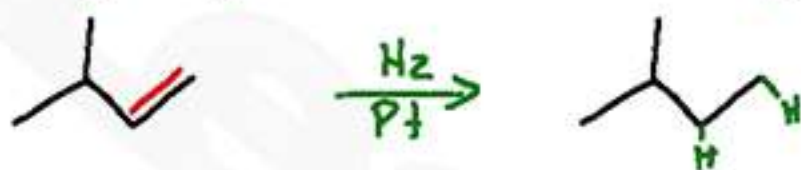
Leah4sci.com/mcat

Questions or Comments: Leah4sci.com/contact

ALKENE REACTIONS

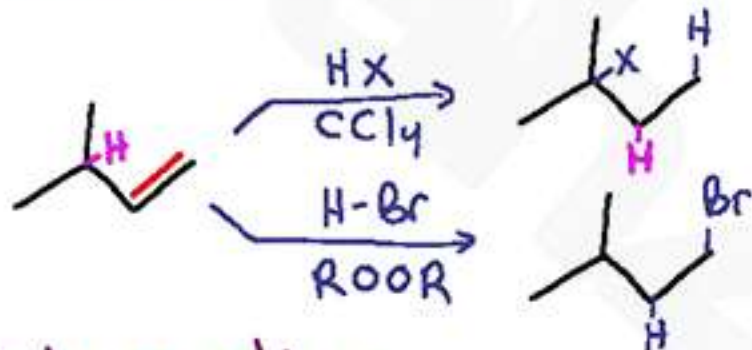
entire video series - Leah4sci.com/alkene-reactions

Hydrogenation - Catalytic Reduction



Syn Addition

Hydrohalogenation



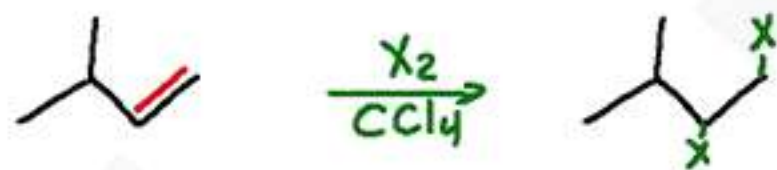
Mark, H-shift, C+

X = Cl, Br, I

ROOR = peroxides

Anti-Mark

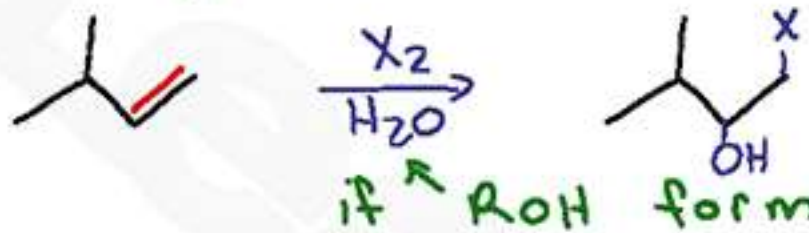
Halogenation



Anti-addition

X = Cl, Br

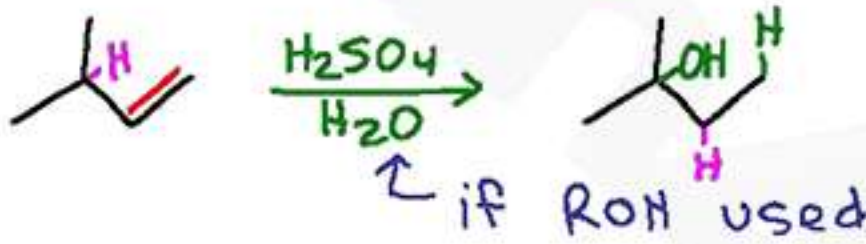
Halohydrin Formation



Anti, OH = Mark

No C+ X = Cl, Br

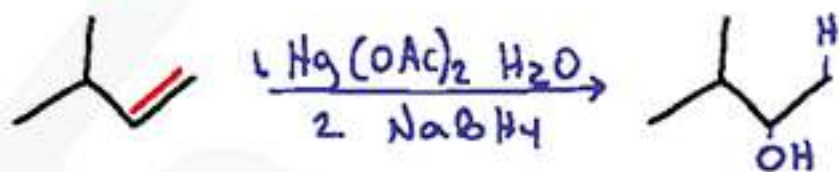
Acid Catalyzed Hydration



Mark, H-shift, C+

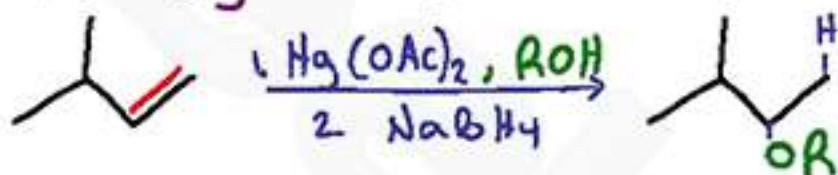
also see H⁺/H₂O or H₃O⁺

Oxymercuration - Reduction



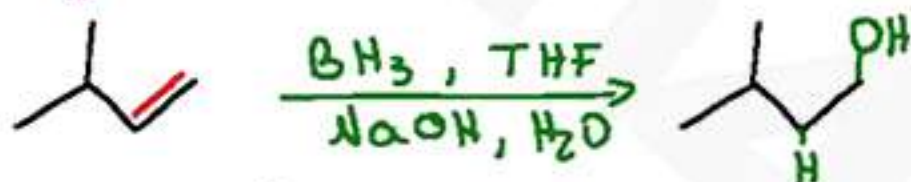
Mark, no H-shift
Anti

Alkoxymercuration-Reduction



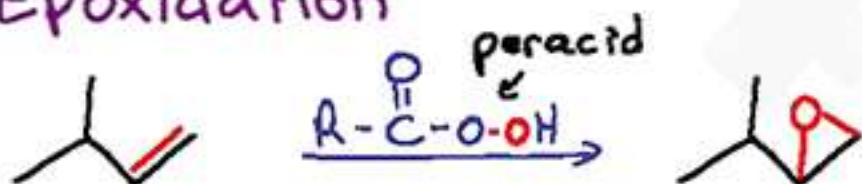
Mark, no H-shift
Anti

Hydroboration - Oxidation



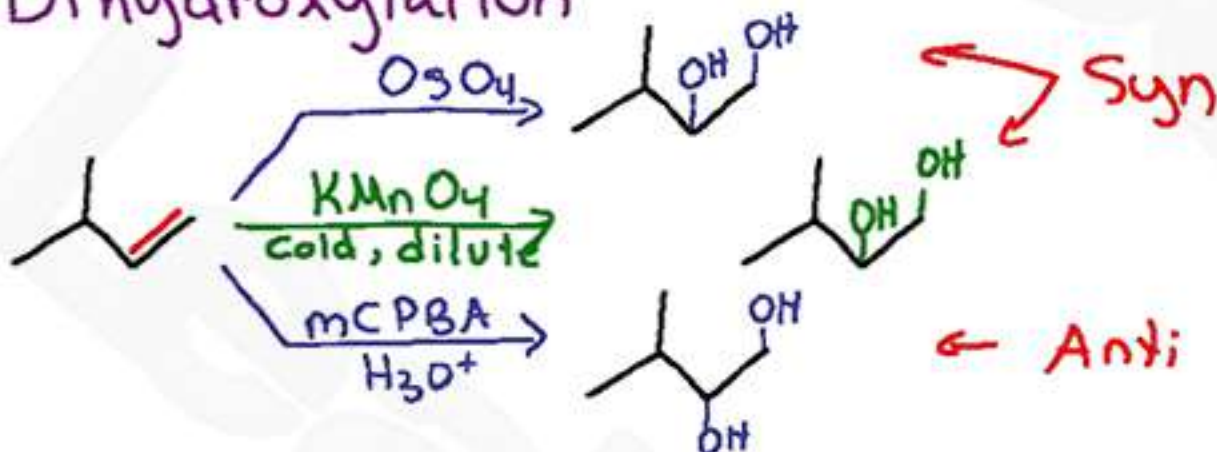
Anti-Mark

Epoxidation

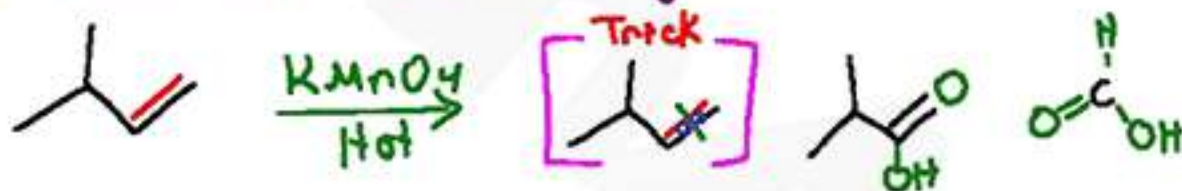


Syn
mCPBA often used

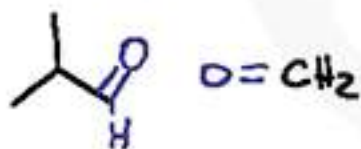
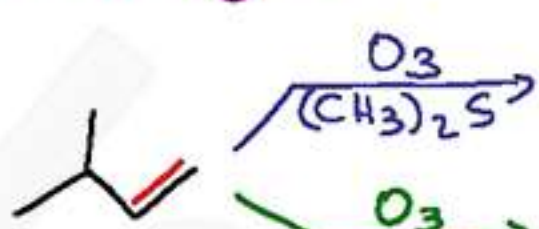
Dihydroxylation



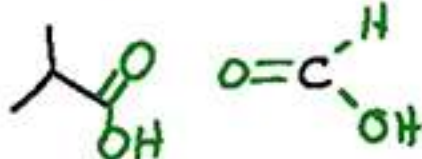
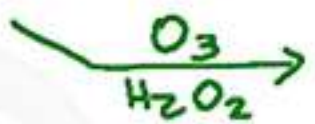
Oxidative Cleavage



Ozonolysis

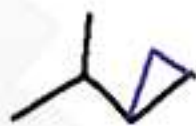


$1^\circ C \rightarrow$ aldehyde

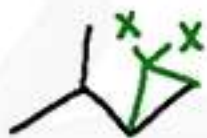
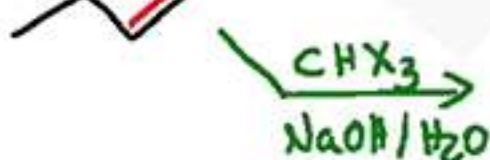


$1^\circ C \rightarrow$ carboxylic acid

Cyclopropanation



\leftarrow 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

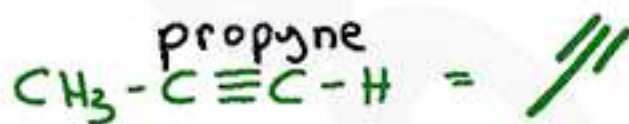
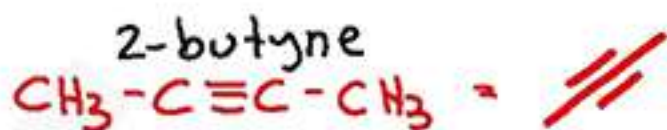
Find the entire video series at:

Leah4sci.com/alkene-reactions

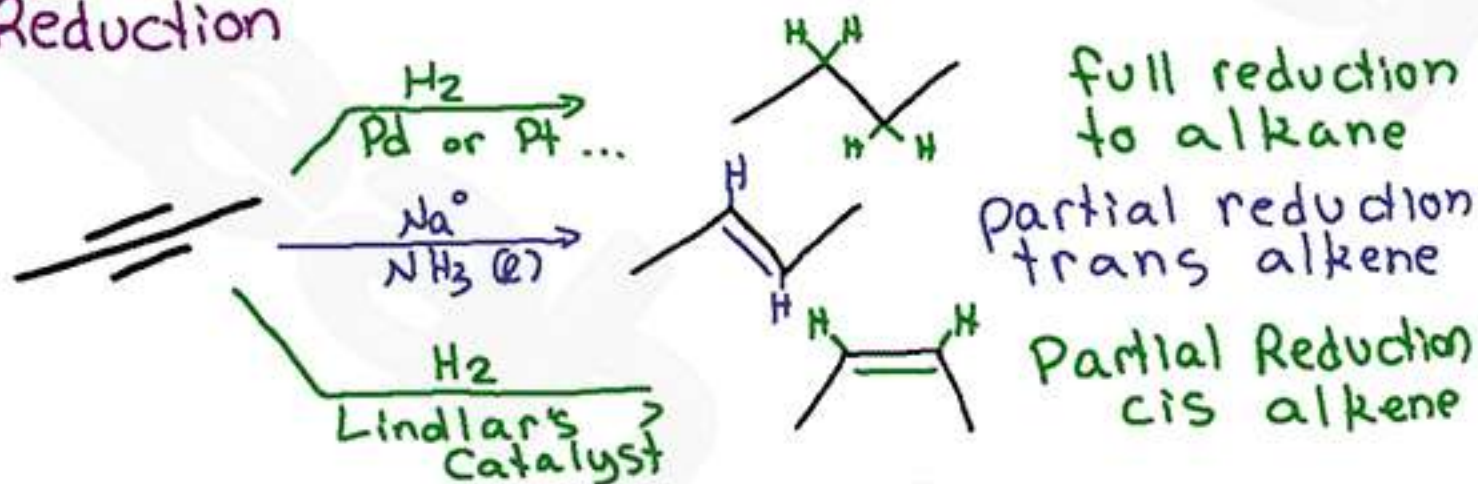
Questions or Comments - Leah4sci.com/contact

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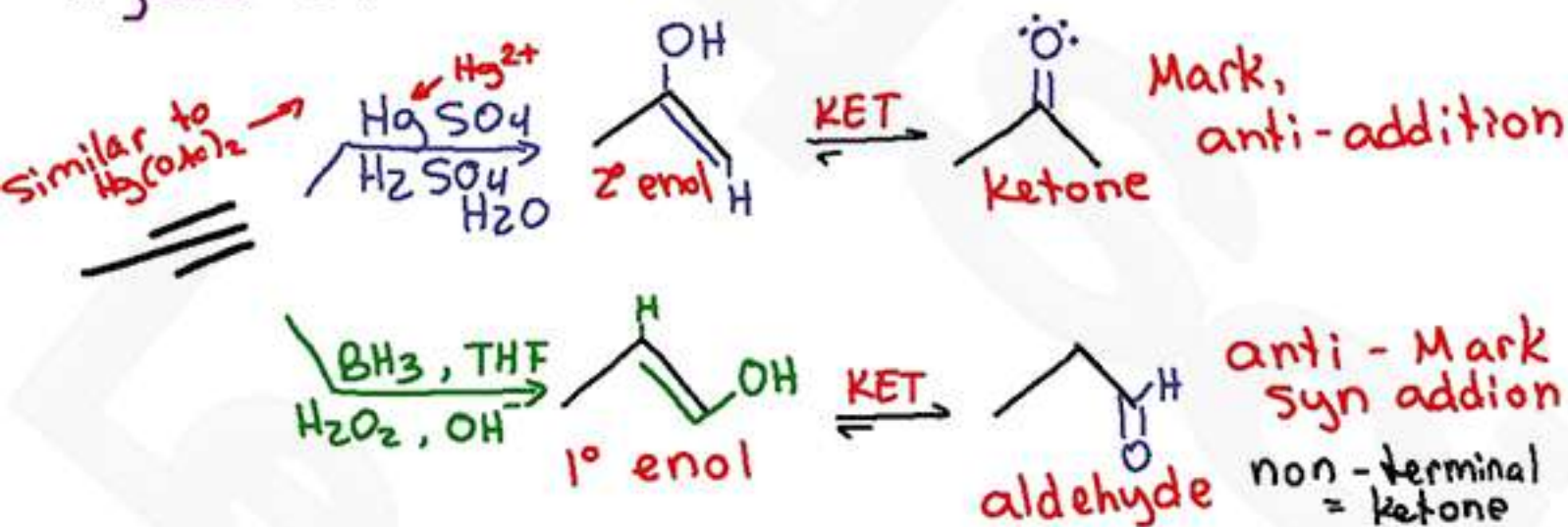
ALKYNE REACTIONS



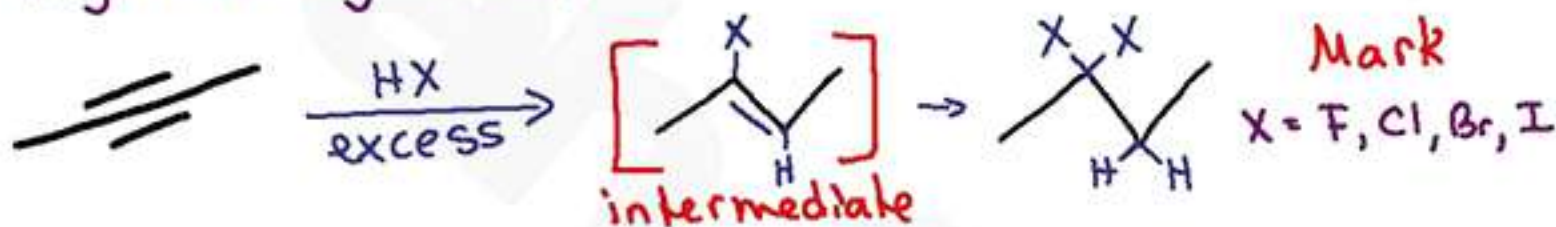
Reduction



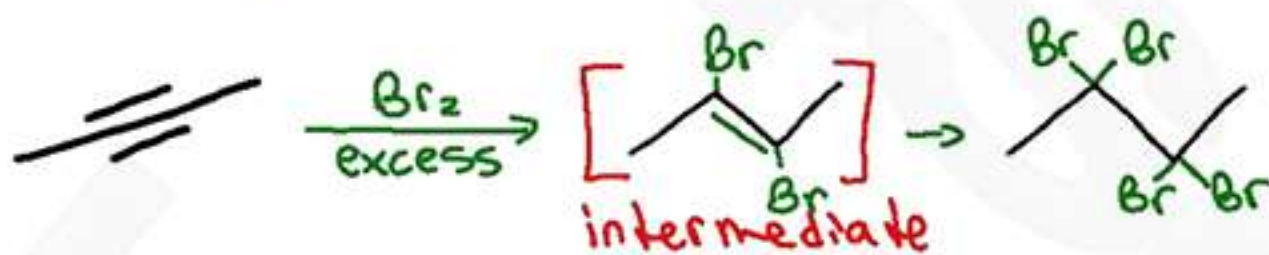
Hydration



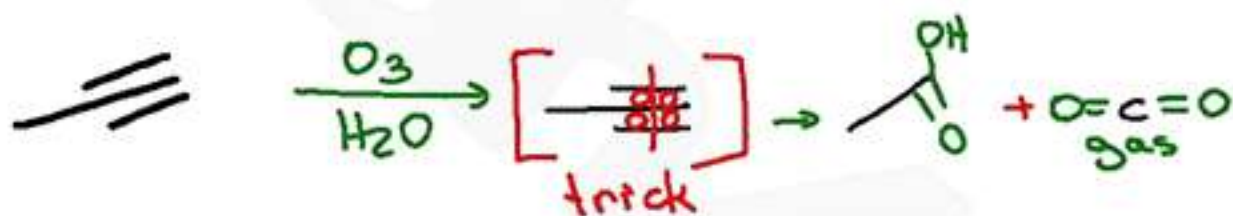
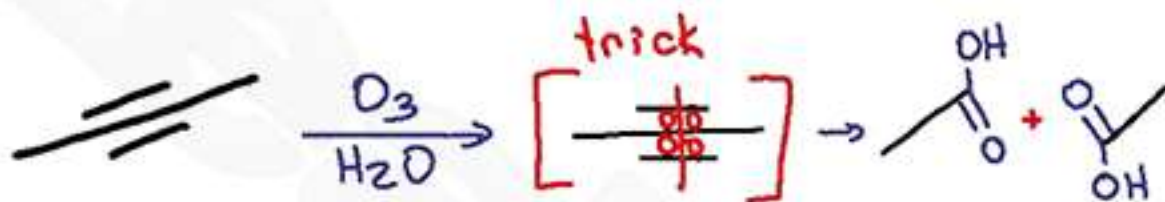
Hydrohalogenation



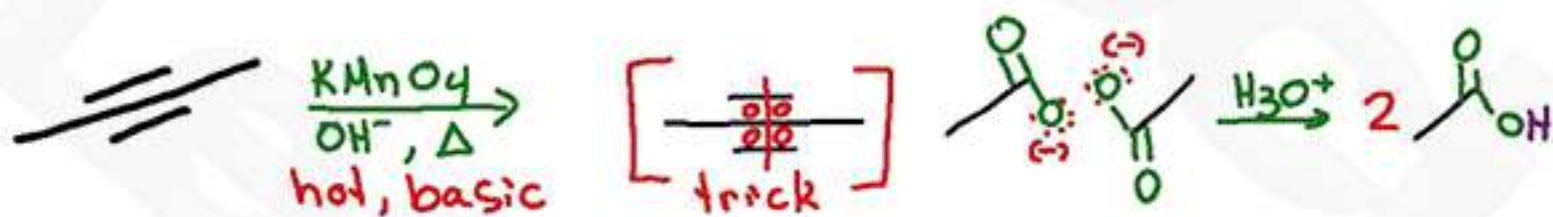
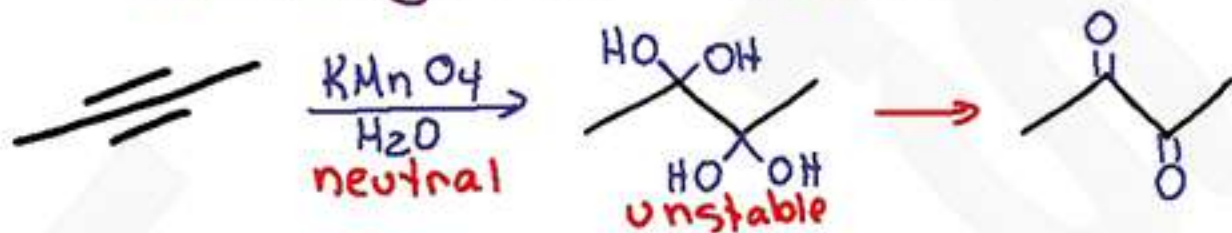
Halogenation



Ozonolysis



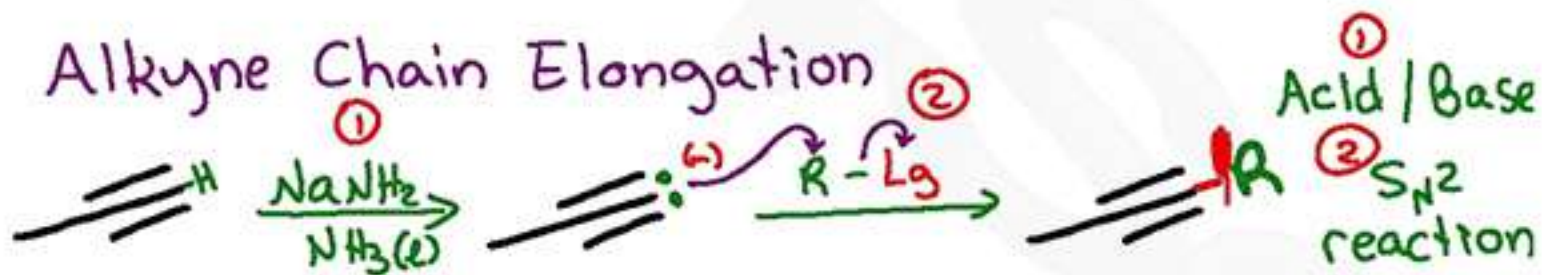
Permanganate Oxidation



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

Questions or Comments - Leah4sci.com/contact

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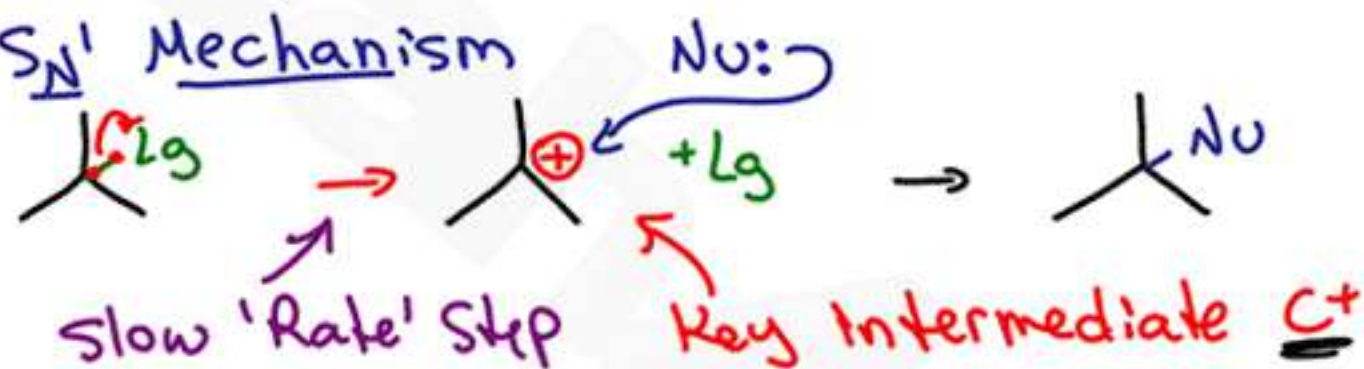
SN1 SN2 E1 E2

Complete orgo Substitution Elimination video series
Leah4Sci.com/Substitution-Elimination

S_N1 = Nucleophilic Substitution Unimolecular

$$\text{Rate}_{S_N1} = k [\text{alkyl}] \quad \text{1st order Rxn}$$

S_N1 Mechanism



S_N2 = Nucleophilic Substitution Bimolecular

$$\text{Rate}_{S_N2} = k [\text{alkyl}] [\text{Nu}] \quad \text{2nd order Rxn}$$

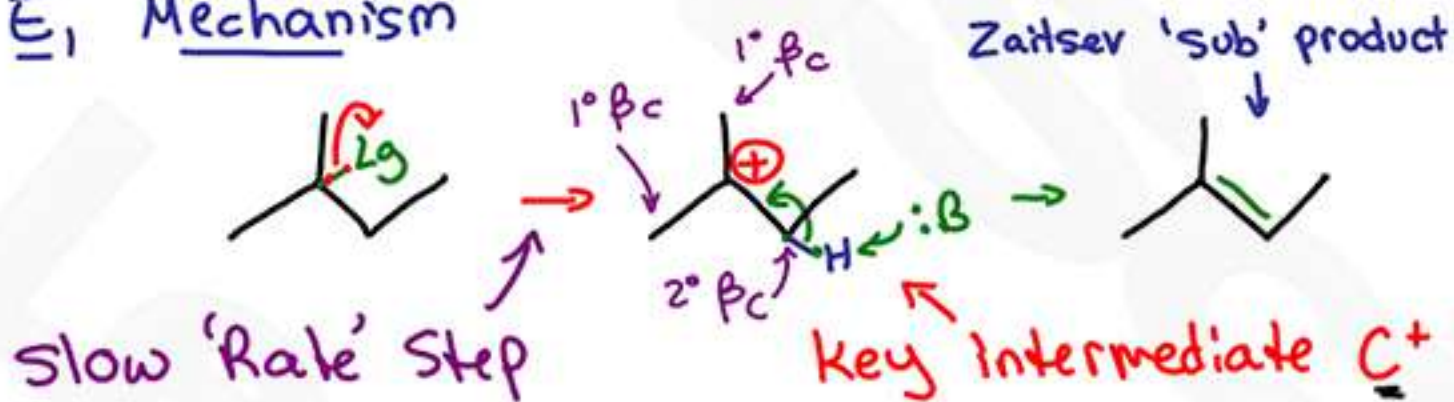
S_N2 Mechanism



$E_1 = \beta$ -Elimination Unimolecular

Rate _{E_1} = k [alkyl] $\xrightarrow{1^{st}$ order Rxn

E_1 Mechanism



$E_2 = \beta$ -Elimination Bimolecular

Rate _{E_2} = k [alkyl][B] $\xrightarrow{2^{nd}$ order Rxn

E_2 Mechanism



4-Part Checklist

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

Carbocation Stability



Alkyl Chain Analysis ← Position of Leaving Group

Methyl = only S_N2 ~~S_N1~~ ~~$E1$~~ unstable C^+ ~~$E2$~~ No β -H

Primary = S_N2 > $E2$ ~~S_N1~~ ~~$E1$~~ unstable C^+ (neutral)

Secondary = S_N1 S_N2 $E1$ $E2$ $E1$ S_N1 = if weak Nu/B

if strong Nu/B $E2$ > S_N2 protic, S_N2 > $E2$ aprotic

Tertiary = S_N1 $E1$ $E2$ ~~S_N2~~ steric hindrance

S_N1 $E1$ if weak Nu/B $E2$ if strong B

Strength of attacking Nucleophile or Base

Negative = 'stronger'

ex CH_3O^- , OH^- , NH_2^- , X^-

Neutral = 'weaker'

ex CH_3OH , H_2O , NH_3 , $X-H$

Leaving Group Ability = Stability of anion

$Lg = X^-$ $I^- > Br^- > Cl^- > F^-$ $Lg \neq X$ $H_2O > CH_3-C(=O)-O^- > OH^- > OR^- > NH_2^-$

Solvent Type

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

ex. H_2O , CH_3OH , NH_3

Polar Aprotic = No H for H-bonding favors S_N2

ex. DMSO, DMF, Acetone, Acetonitrile

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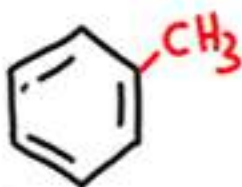
REACTION MAP

COMMON AROMATIC COMPOUNDS

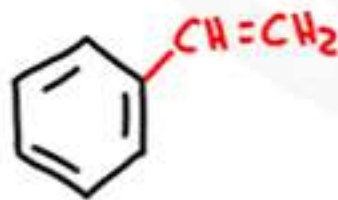
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benzene



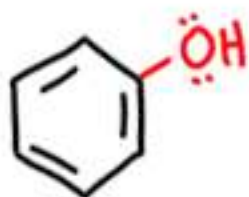
toluene



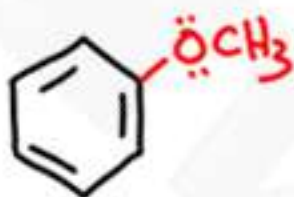
styrene



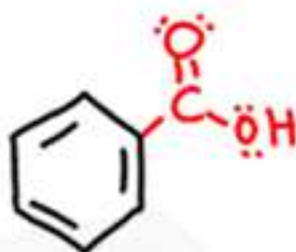
phenylacetylene



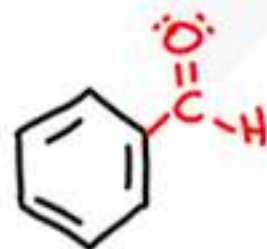
phenol



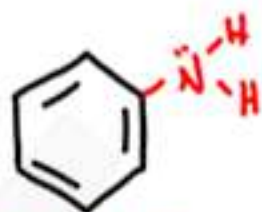
anisole



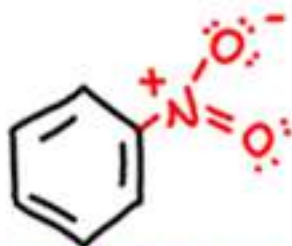
benzoic acid



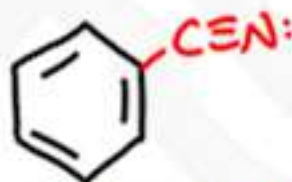
benzaldehyde



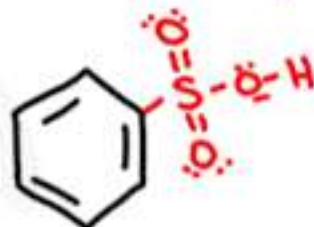
aniline



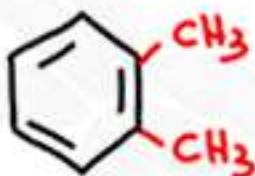
nitrobenzene



benzonitrile



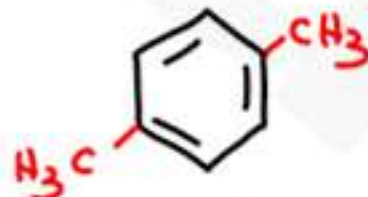
benzenesulfonic acid



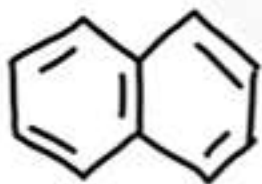
o-xylene
ortho xylene



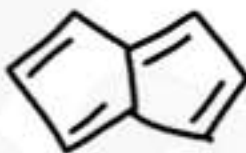
m-xylene
meta xylene



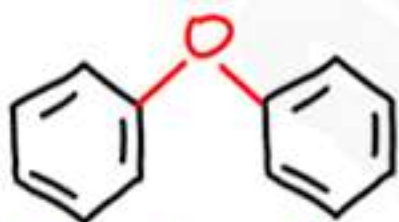
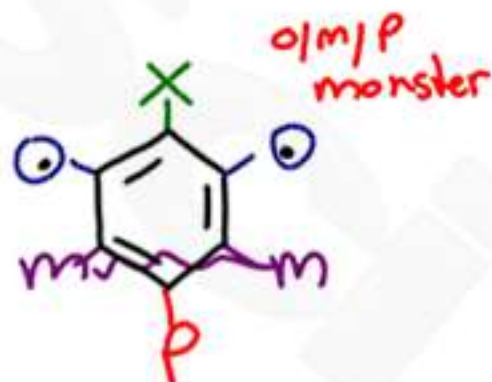
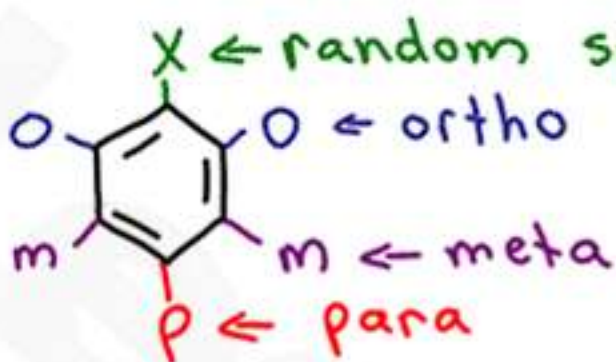
p-xylene
paraxylene



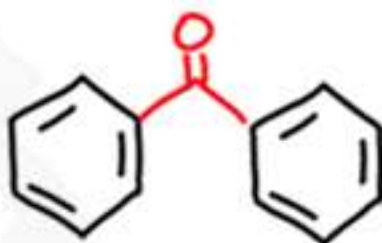
naphthalene



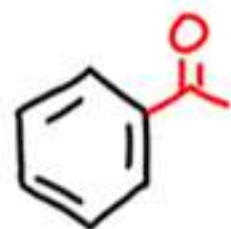
pentalene



diphenyl ether



benzophenone



acetophenone



pyrrole



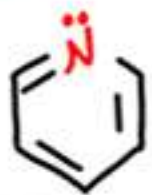
furan



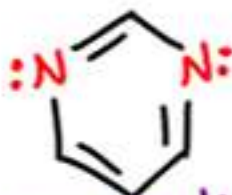
thiophene



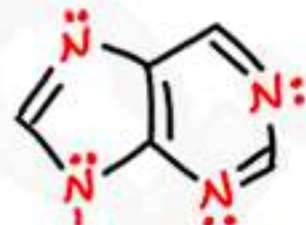
imidazole



pyridine



pyrimidine



purine

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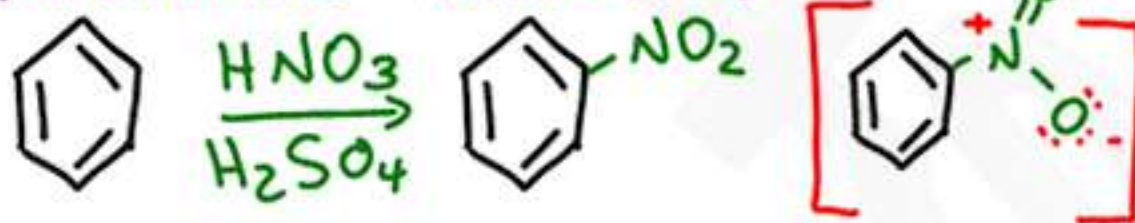
Aromatic Halogenation



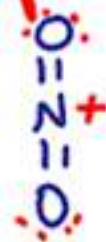
Super E⁺



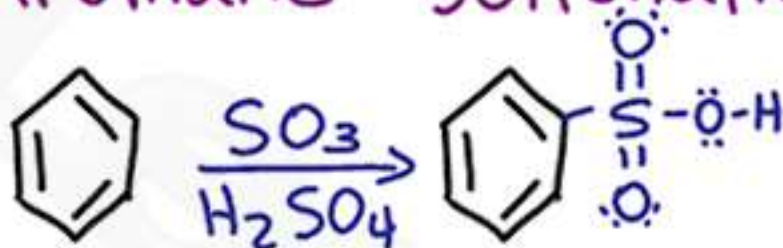
Aromatic Nitration



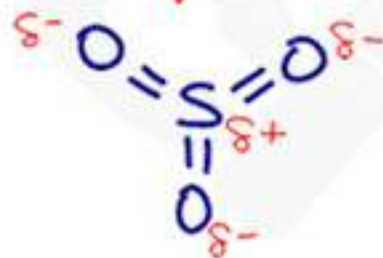
Super E⁺



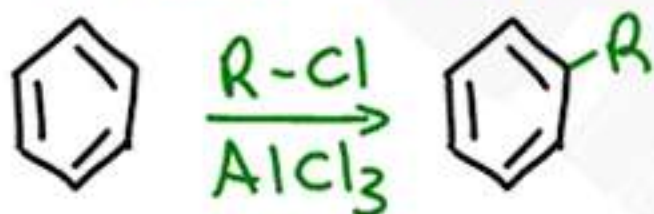
Aromatic Sulfonation



Super E⁺



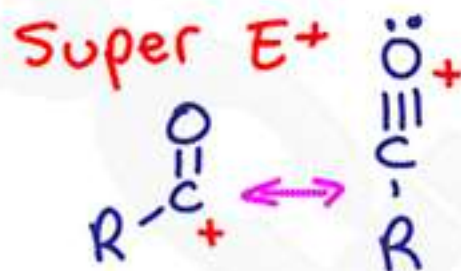
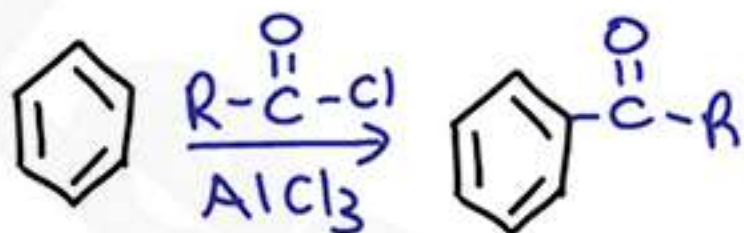
Friedel-Crafts Alkylation



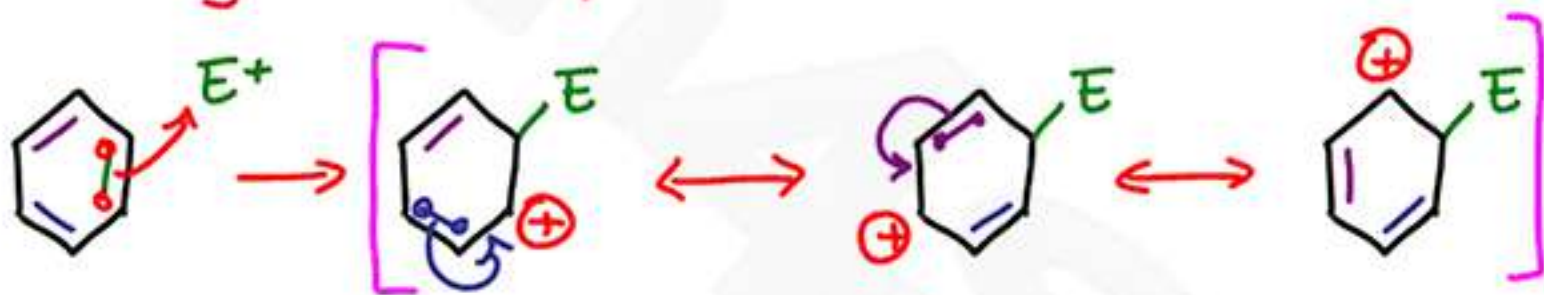
Super E⁺



Friedel-Crafts Acylation

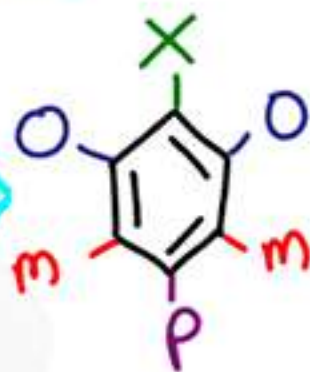
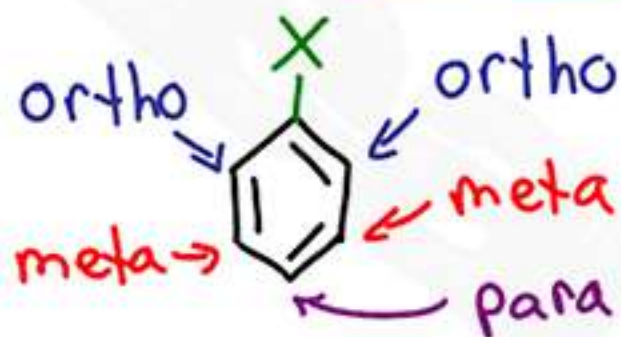


Sigma Complex Resonance



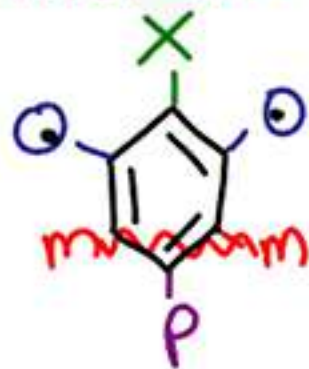
Substituted Benzene

X = substituent



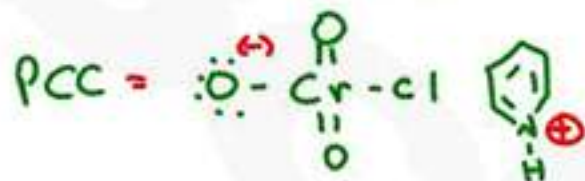
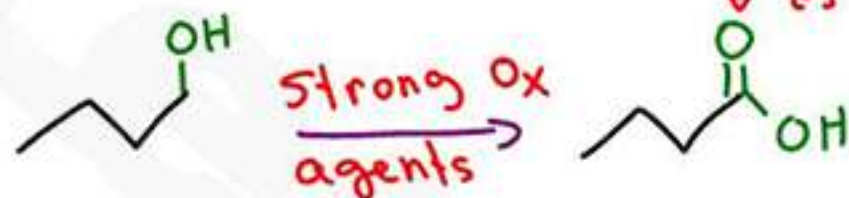
add
- eyes
- mouth
- tongue

O/M/P
monster

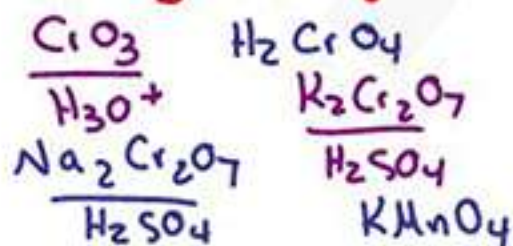


OXIDATION & REDUCTION

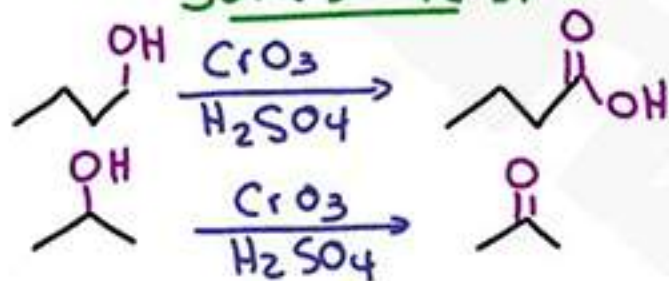
Oxidation = Gain O bonds, Lose H bonds



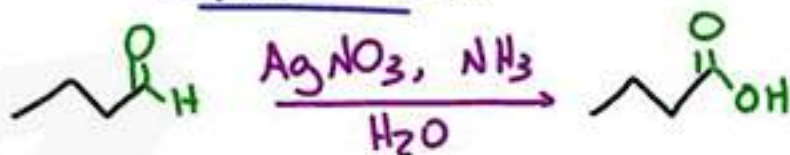
Strong ox agents



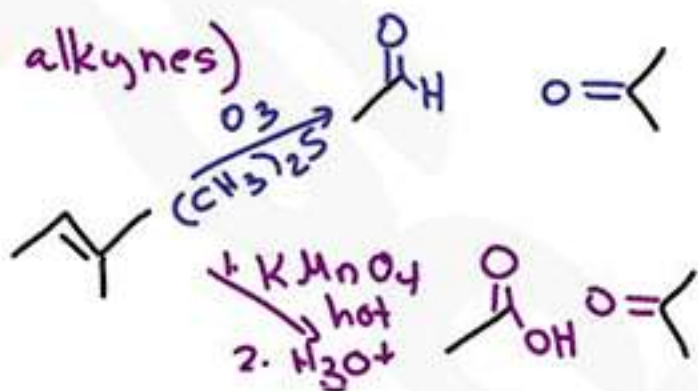
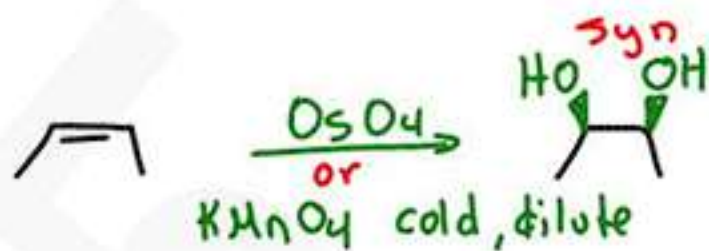
Jones Test



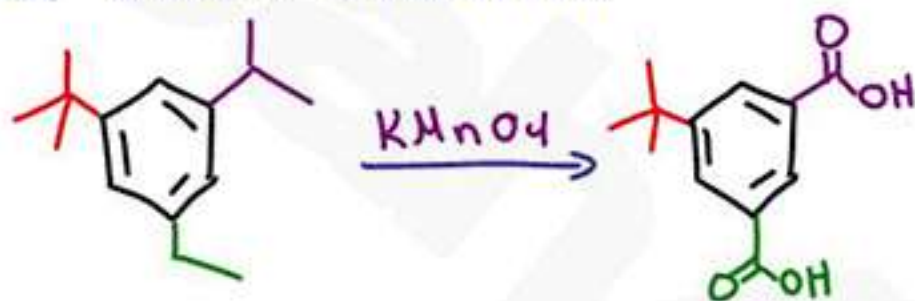
Tollens Test



Alkene Oxidation (also alkynes)



Side chain Oxidation

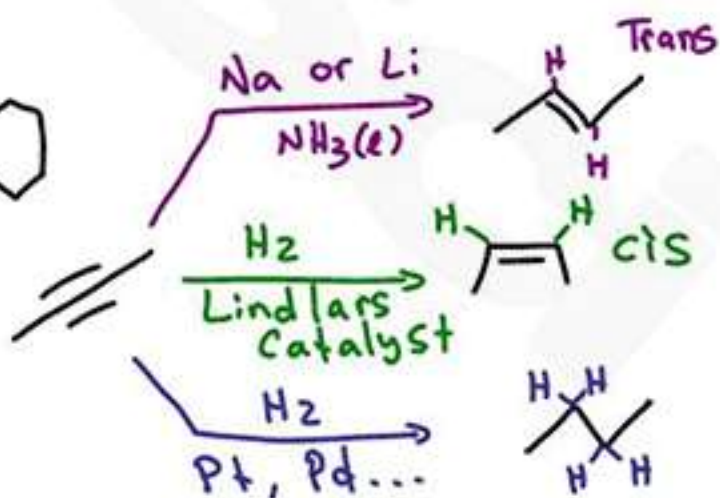
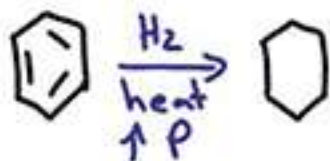
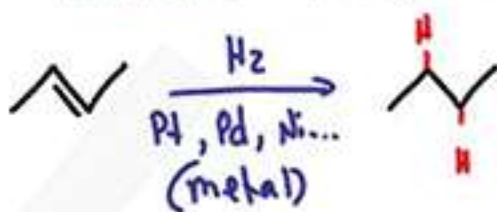


only 1° & 2°
get oxidized
3° = N/R

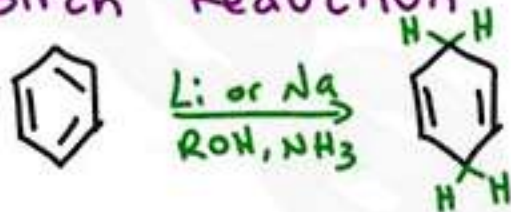
Reduction = Gain H bonds, Lose O bonds

Alkene Reduction

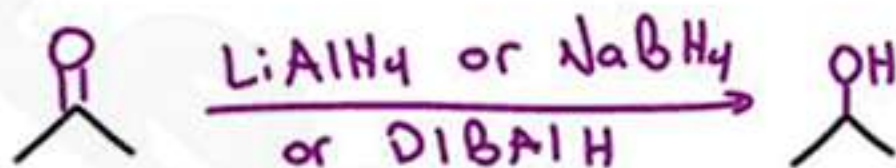
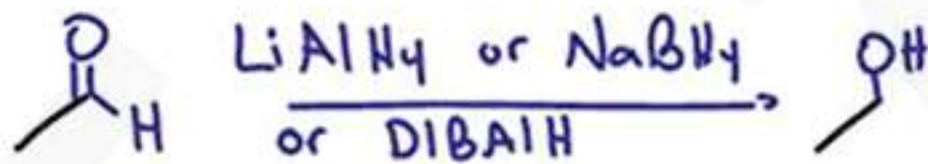
Alkyne Reduction



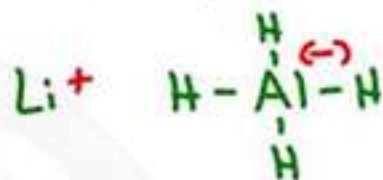
Birch Reduction



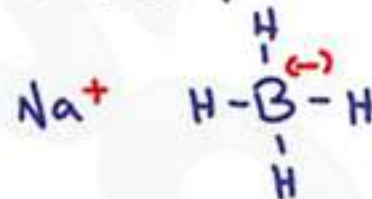
Reduction with Metal Hydrides



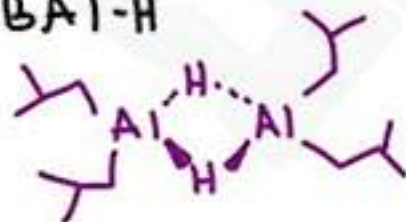
LiAlH₄ = strong



NaBH₄ = weak

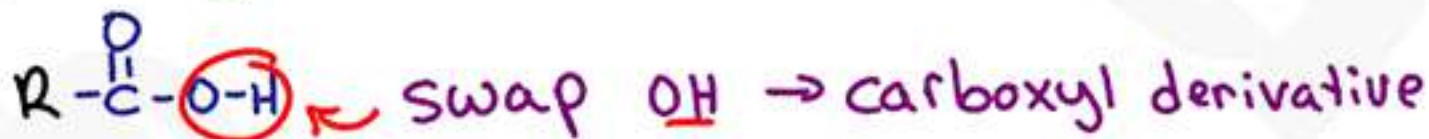


DIBAL-H

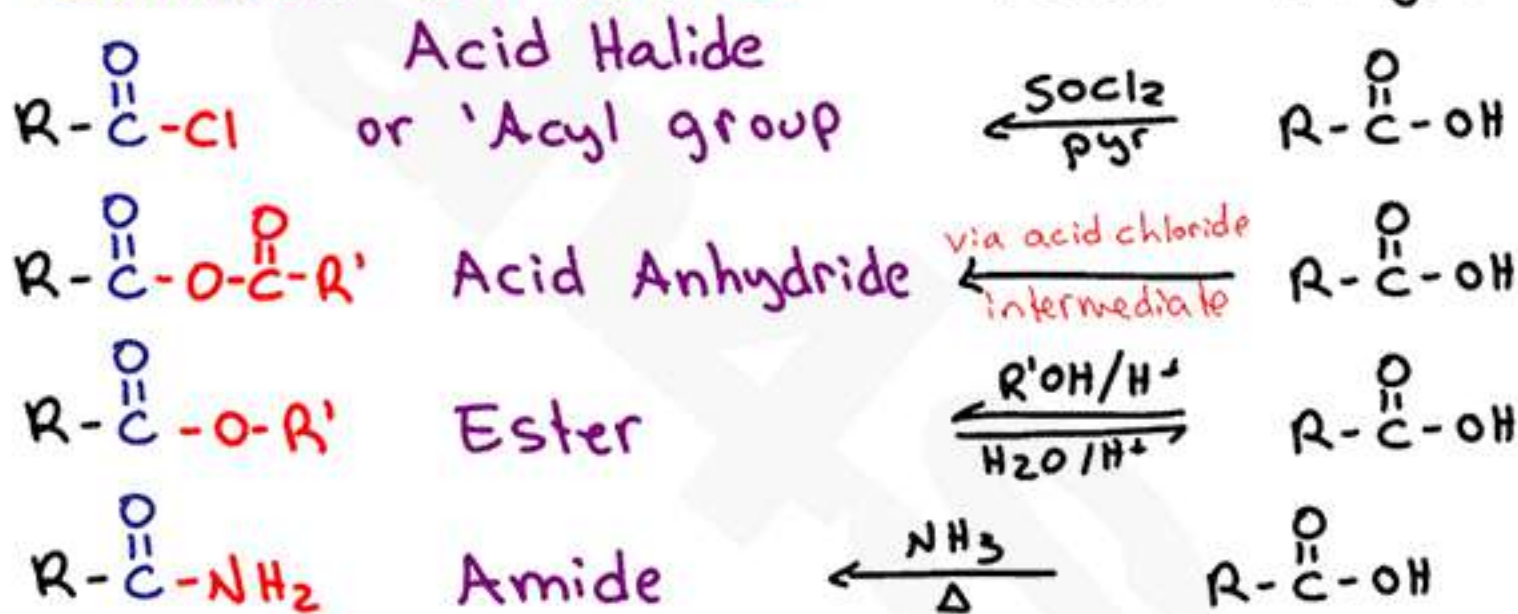


CARBOXYLIC ACID DERIVATIVES

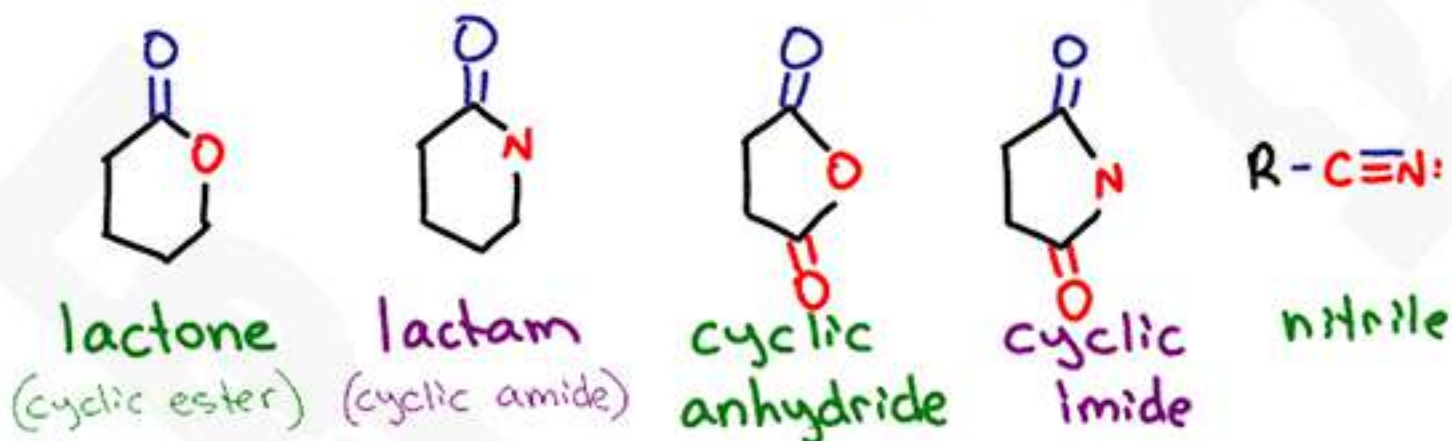
Carboxylic Acid



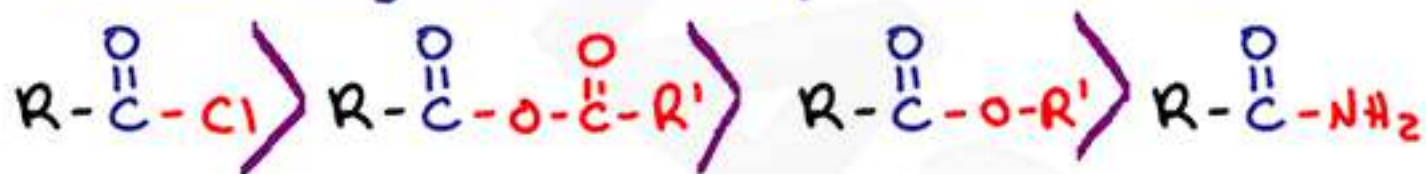
Common Derivatives



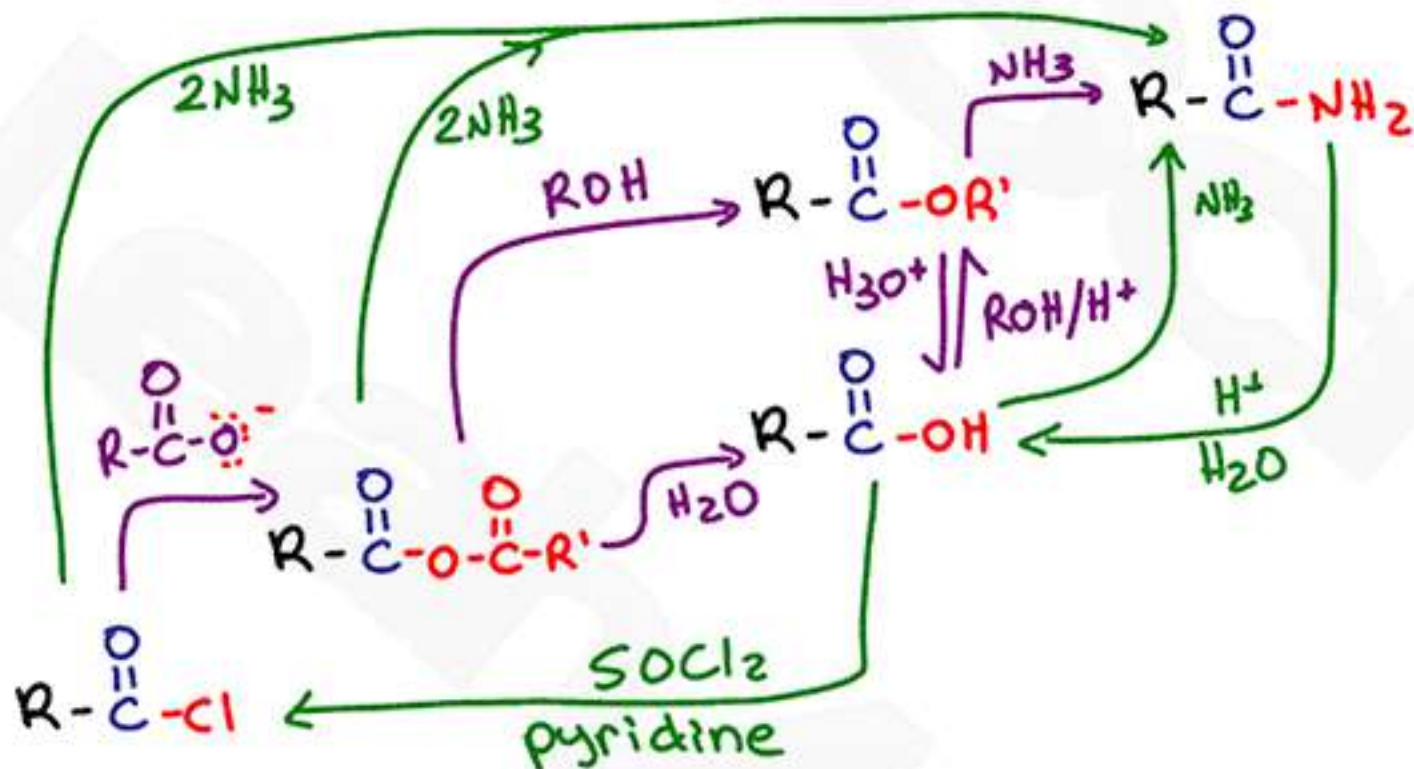
Less Common Carboxyl Derivatives



Reactivity of Carboxyl Derivatives



Interconversion Between Derivatives



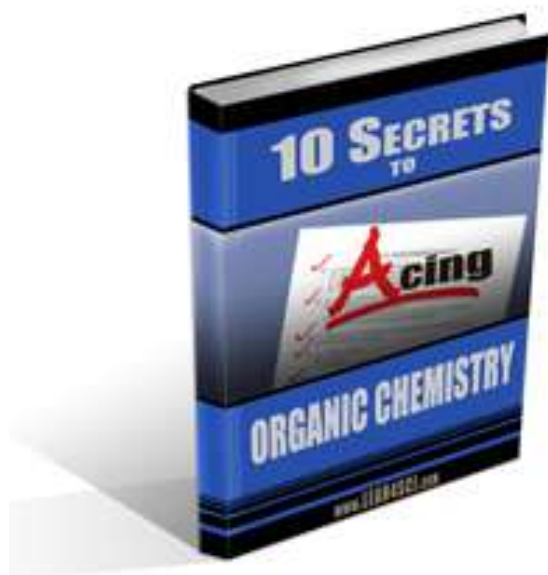
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