# Reactions Organized by Compound Families

## Alkanes

1. Combustion
2. Halogenation

## Alkenes and Alkynes

1. Additions: hydrogenation, halogenation & halohydrin formation*, hydrohalogenation, hydration
2. Polymerization
3. Hydroboration*
4. Oxidation (KMnO4) and Ozonolysis (O3)*
5. Free radicals
6. Epoxide synthesis

## Aromatic Compounds

1. Substitutions: nitration, halogenation, sulfonation
2. Friedel Crafts Alkylation/Acylation *
3. Reduction w/ H2 Rh/C at 100°C*

## Alcohols

1. Elimination: dehydration
2. Oxidations
3. Ether synthesis: acid-catalyzed dehydration of ethanol*, Williamson Ether*, Alkoxymercuration-Demercuration*

## Aldehydes and Ketones

1. Addition: Acetal/hemiacetal formation by alcohol addition (Reverse reaction: Acetal hydrolysis with acid), imine* & enamine formation*
2. Michael addition*
3. Oxidation and Reduction for aldehydes (**Ketones* ***Ketones*** *go through reduction only*)
4. Wittig*
5. Grignard Reaction*

## Amines

1. Acid-Base reactions
2. (Hoffman elimination: from amine to alkene)*
3. Gabriel Synthesis: primary alkyl halide-> primary amine*

## Carboxylic Acids

1. Substitutions: esterification, amidation (Reverse reaction: ester hydrolysis with acid or base, amide hydrolysis with acid or base)
2. Acid-base reactions
3. Decarboxylation of ß keto acids*

## Epoxides

1. Nucleophilic ring-opening*
2. Acid-catalyzed ring-opening*

## Pericyclic Reactions

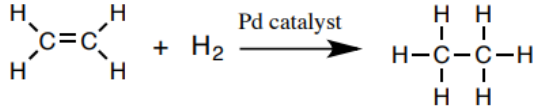
1. Cycloaddition*
2. Electrocyclic*
3. Sigmatropic*

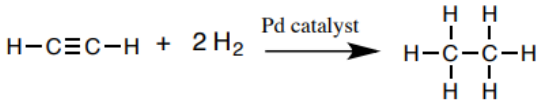
## Phosphoric acid and Phosphates

1. Phosphoric acid: Esterification with alcohol
2. Phosphates: Phosphorylation

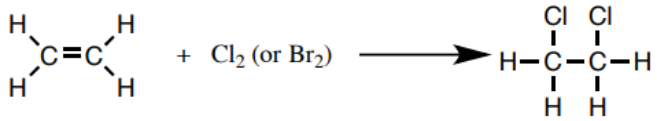
# Reactions Organized by Reaction Type

1. **ADDITION**
    a. Alkenes and alkynes
        - Hydrogenation

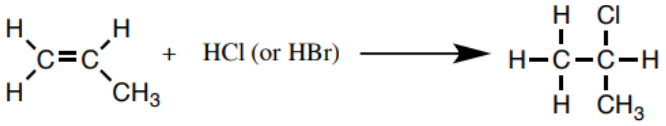



        - Halogenation

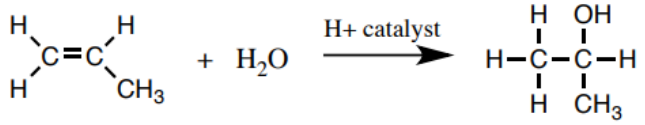


        - Hydrohalogenation



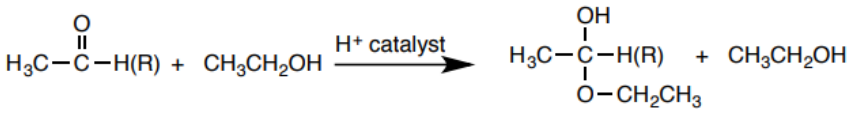
Markonikov's Rule applies: H adds to C with more Hs already.

        - Hydration

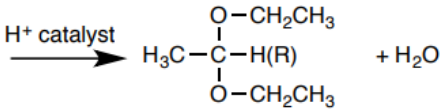


Markonikov's Rule applies.

    b. Aldehydes and ketones
        - Addition of alcohol to get hemiacetals or acetals




hemiacetal

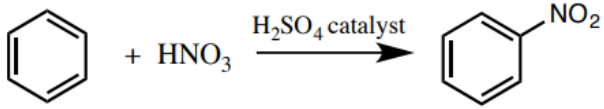



acetal

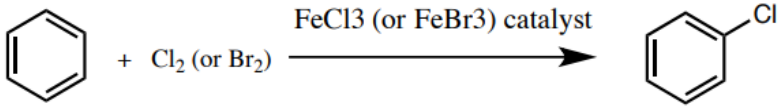
## 2. SUBSTITUTION

a. Aromatic compounds

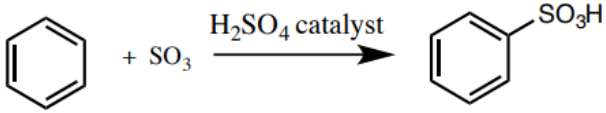
- Nitration




- Halogenation

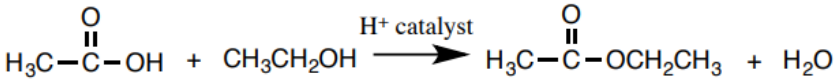



- Sulfonation

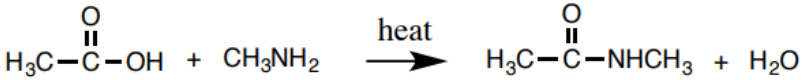



b. Carboxylic acids

- Esterification with alcohol

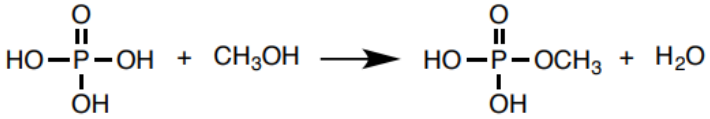



- Amidation with amine

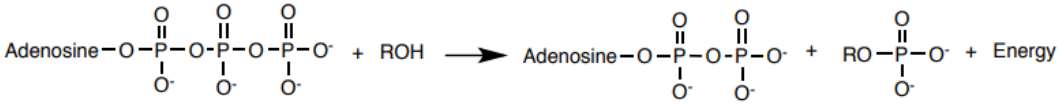



c. Phosphoric acid and phosphates

- Phosphoric acid: Esterification with alcohol



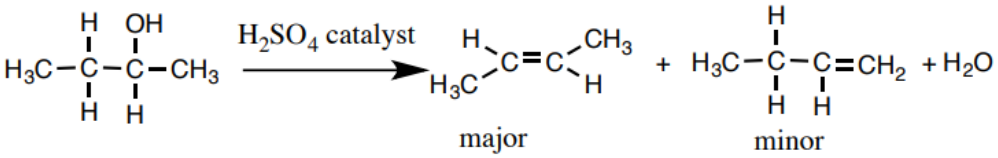
- Phosphates: Phosphorylation



**3. ELIMINATION**

a. Alcohols

- Dehydration

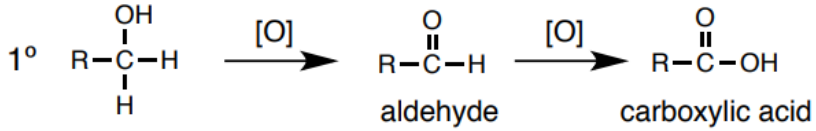


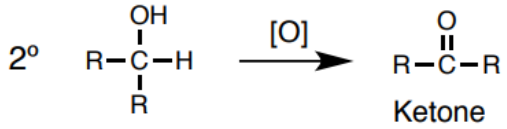

Zaitsev's Rule applies: More highly substituted alkene is major product.

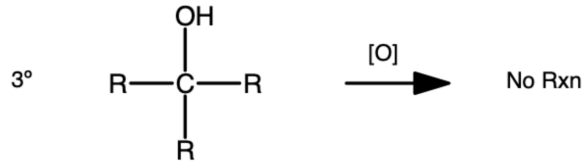
**4. OXIDATION/REDUCTION**

a. Alcohols

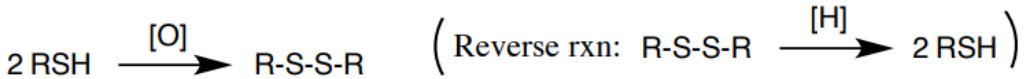
- Oxidation



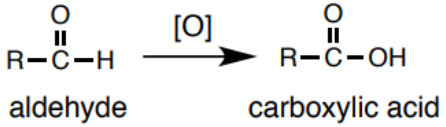





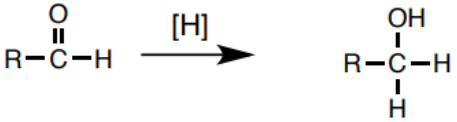

b. Thiols
   - Oxidation



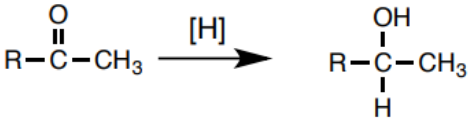

c. Aldehydes
   - Oxidation




   - Reduction (also addition)



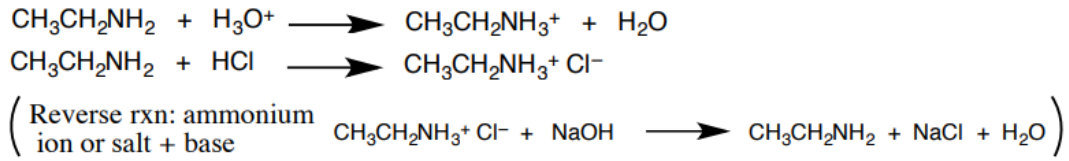

d. Ketones
   - Reduction (also addition)



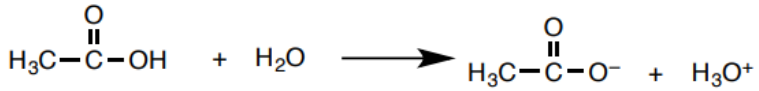

**5. ACID-BASE**

a. Amines (basic)
   - Reaction with water

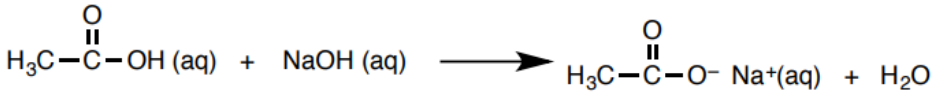

   - Neutralization with strong acid to get ammonium ion or salt



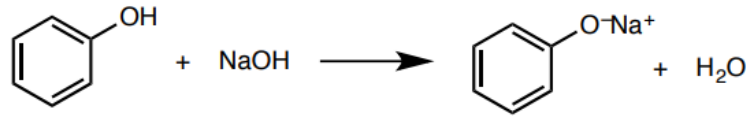

b. Carboxylic acids (acidic)
   - Rxn with water




   - Neutralization with a strong base to get carboxylic acid salt

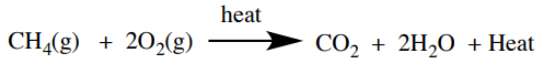



c. Phenols (<u>very</u> weakly acidic)
   - Neutralization with a strong base to get salt

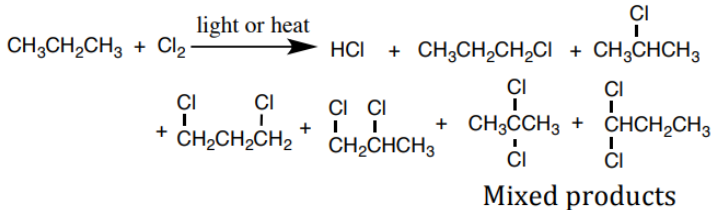



**6. RADICAL REACTIONS**

a. Alkanes
   - Combustion (also oxidation/reduction reaction)

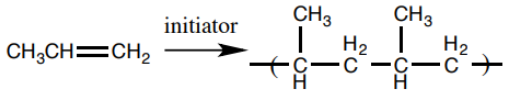



   - Halogenation




b. Alkenes

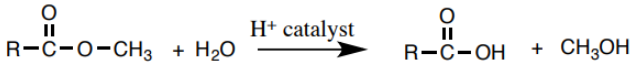
- Polymerization



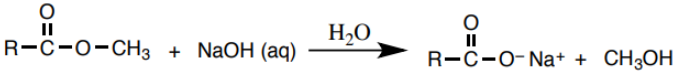

## 7. HYDROLYSIS

a. Esters (reverse reactions of carboxylic acid esterification)

- Acid hydrolysis to get carboxylic acid and alcohol

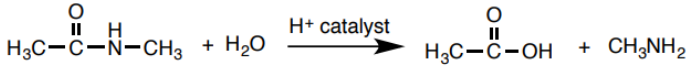



- Saponification: Base hydrolysis to get carboxylic acid salt and alcohol

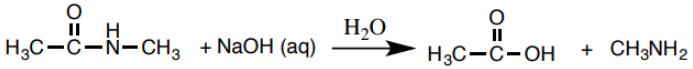



b. Amides (Reverse reactions of carboxylic acid amidation)

- Acid hydrolysis to get amine

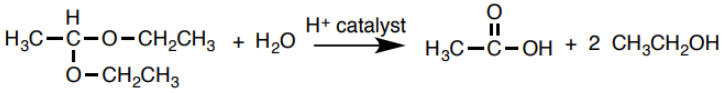



- Base hydrolysis to get amine




c. Acetals (Reverse reaction of acetal formation from aldehydes/ketones)

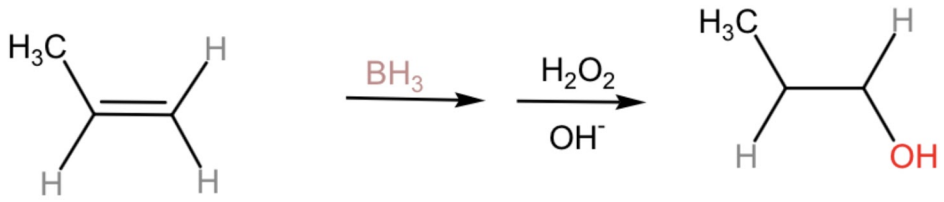
- Acid hydrolysis to get aldehydes of ketones (reverse of acetal formation)



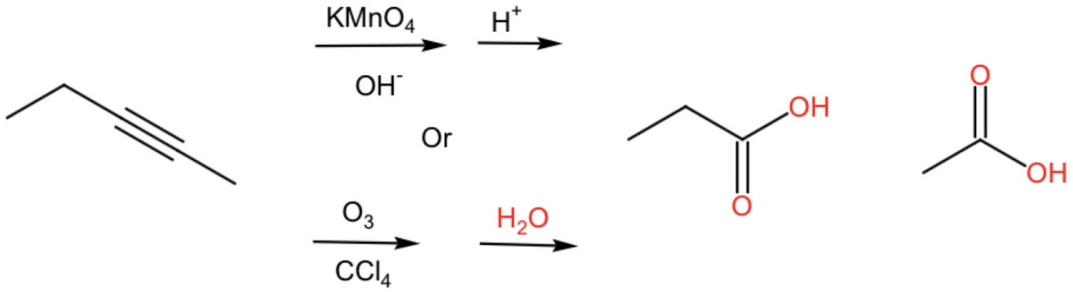
# Other Reaction Types

Additional Reactions for consideration

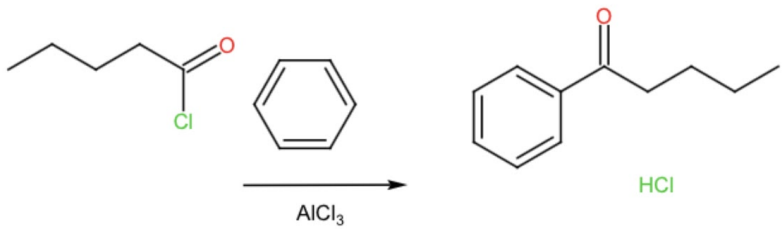
1. Hydroboration Reaction: <u>reduction</u> of an alkene (syn addition of OH)/alkyne (produces cis-alkene)



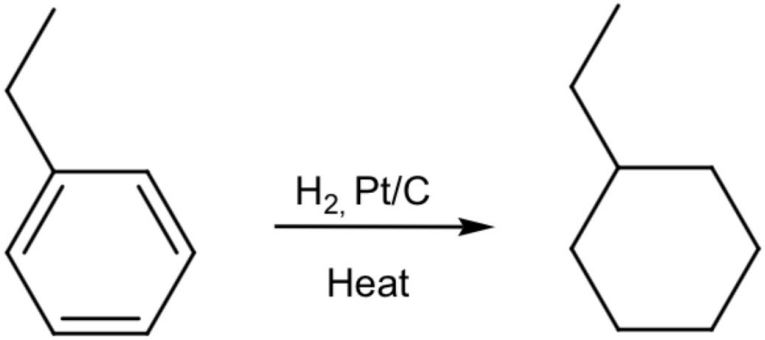

2. <u>Oxidation</u>/Ozonolysis of Alkene/Alkynes



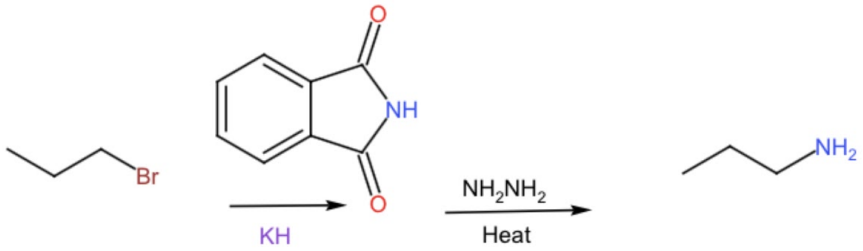

3. Friedel-Crafts Acylation (Part of Electrophilic <u>Additions</u> to Benzene)



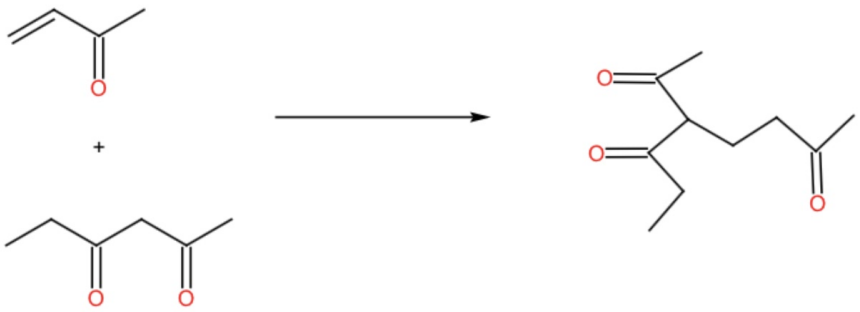
4. Reduction of Aromatic Compound via H2 and heat



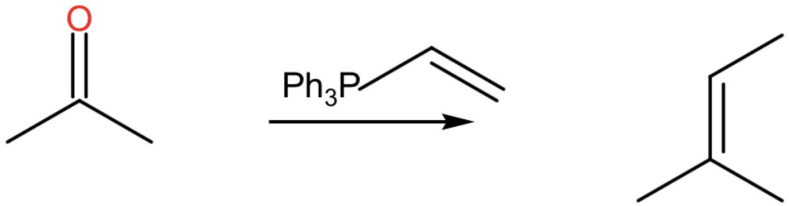

5. Gabriel Synthesis- the <u>substitution</u> of a primary acyl halide to a primary amine



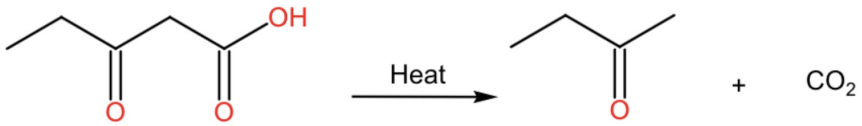

6. Michael <u>Addition</u>: addition to an enolate carbanion (formed with a strong base like LAH) of a carbonyl compound with a neighboring double bond



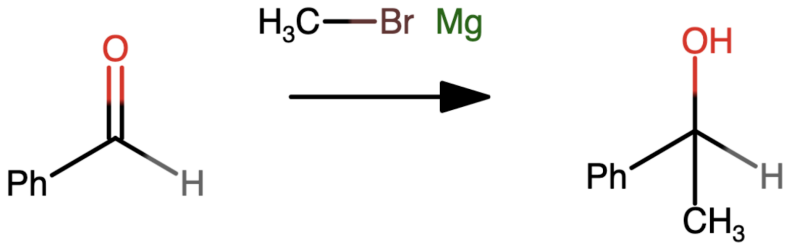
7. Wittig Reaction: substitution of C=O double bond with C=C



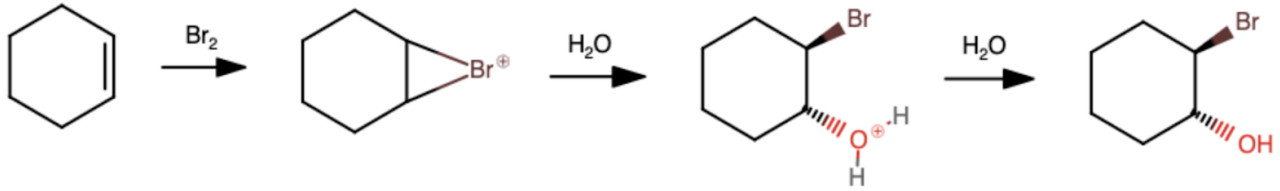

8. Decarboxylation of a beta keto acid: heat produces carbonyl compound + CO2



9. Grignard Reaction: nucleophilic attack of Grignard reagent (RXMg) on a δ+ carbonyl carbon to form an alcohol

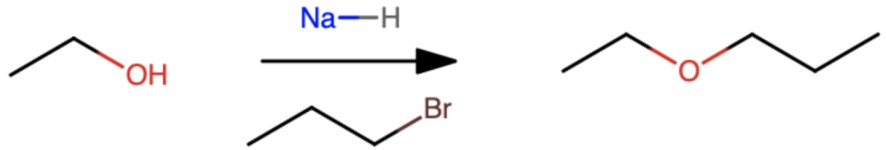


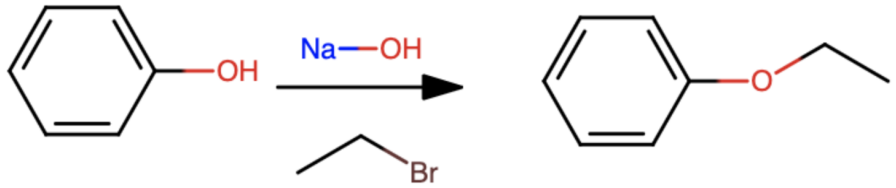

10. Halohydrin formation: halogenation reaction plus water, with anti-addition of an OH and halogen group to an alkene



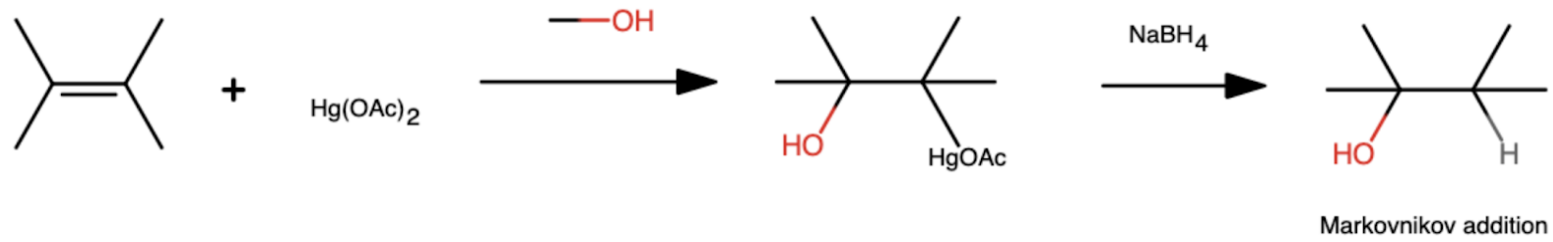

11. Ether synthesis: acid-catalyzed dehydration of EtOH, AKA solvolysis or ethanolysis


12. Williamson ether synthesis: formation of asymmetrical ethers using NaH or NaOH in acidic conditions and RX; does not apply to 3º alkyl halides

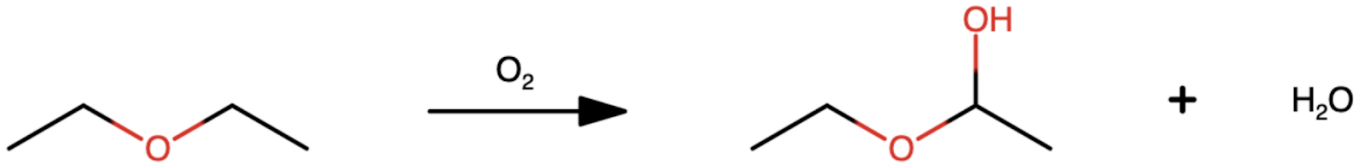


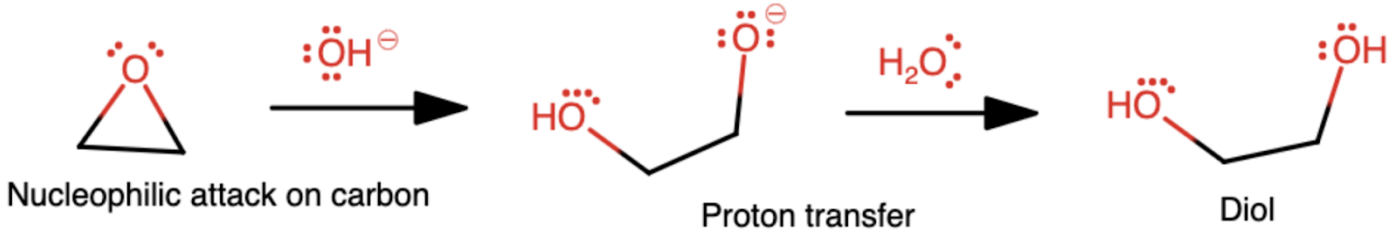
13. Alkoxymercuration-Demercuration: Markovnikov addition of an alcohol to an alkene, followed by NaBH4 reduction



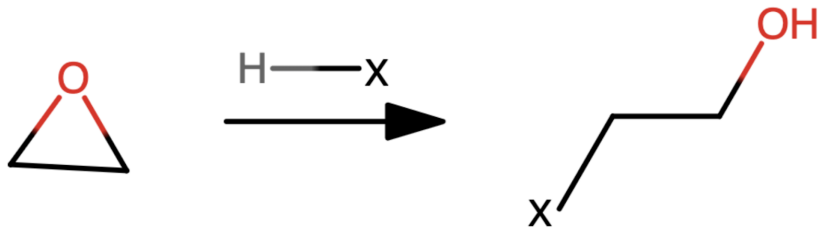

14. Free radical addition: ether reaction with O2, AKA autooxidation, causes explosive hydroperoxide to form




15. Epoxide ring openings:
    a. Nucleophilic

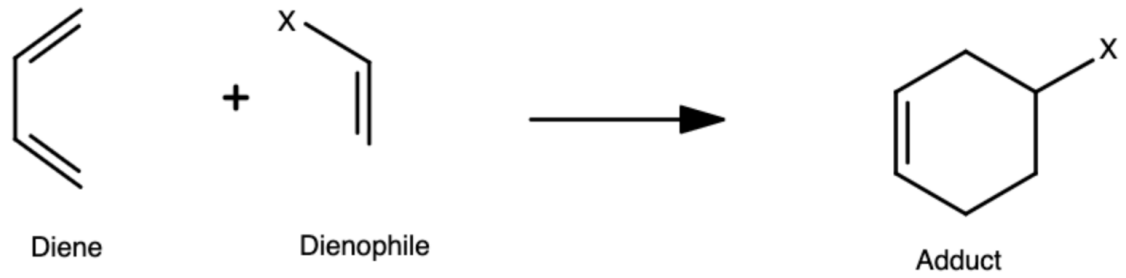



    b. Acid-catalyzed

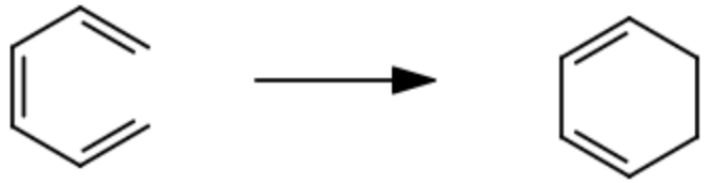



16. Pericyclic reactions

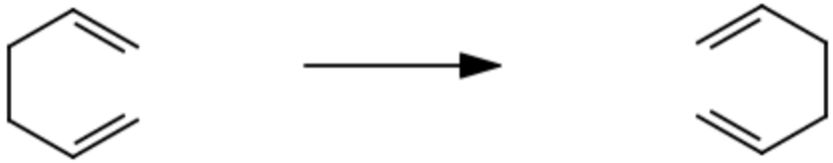
a. Cycloaddition, AKA Diels-Alder reaction: addition of a diene to a monosubstituted double bond, creating a cyclic compound with the same number of bonds




b. Electrocyclic addition: rearrangement of double bonds to create a cyclic compound



c. Sigmatropic rearrangement: migration of sigma bonds around a conjugated system



17. Imine/Enamine formation: aldehyde/ketone (R2CO) reaction with a primary or secondary amine under acidic conditions, resulting in a carbon-nitrogen double bond or rearranged carbon-carbon double bond, respectively