

ORGANIC CHEMISTRY II

CHM 2211

STUDY UNION

SPRING 2021

This mock exam covers all of the chapters that you will be tested on. Please do not rely on this document as your only study resource. There will be other review sessions so be sure to attend those for further help. The answers and recording will be posted on the Study Union website after the session on Saturday, April 24th 12:30-2:30pm.

Best of luck, Sofiana

Klein, David. *Organic Chemistry*. Third ed., Wiley, 2016.

- 1) What is the region called that contains all signals that arise from double, triple, and X-H bonds?
 - a. Diagnostic region
 - b. Fingerprint region

- 2) What is the region called that contains signals resulting from the vibrational excitation of most single bonds (stretching and bending)?
 - a. Diagnostic region
 - b. Fingerprint region

- 3) A conjugated C=O bond will produce a higher energy signal than an unconjugated C=O bond.
 - a. True
 - b. False

- 4) Fill in the blank: Useful information can be obtained by comparing the relative heights of the $(M+2)^{+}$ peak and the $(M)^{+}$ peak.
The structure likely contains a _____ atom if the latter peak is approximately one-third as tall as the former peak. The presence of a _____ atom is indicated when these two peaks are similar in height.

- 5) What does a signal at $M-15$ indicate the loss of?
 - a. Alcohol group
 - b. Ethyl group
 - c. Methyl group
 - d. Propyl group

- 6) What does a signal at $M-29$ indicate the loss of?
 - a. Alcohol group
 - b. Ethyl group
 - c. Methyl group
 - d. Propyl group

- 7) A compound possessing a π bond is unsaturated and represents one degree of unsaturation.
 - a. True
 - b. False

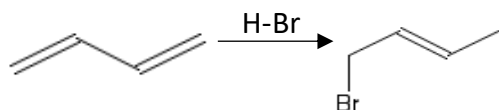
- 8) Calculate the HDI for a compound with the molecular formula $C_4H_8ClNO_2$ and identify the structural information provided by the HDI. _____

17) Select all that apply: what are the characteristics of the major product?

1,2-adduct

1,4-adduct

Kinetic product



Thermodynamic product

Low temperature

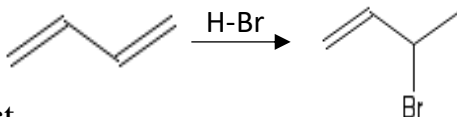
High temperature

18) Select all that apply: what are the characteristics of the major product?

1,2-adduct

1,4-adduct

Kinetic product



Thermodynamic product

Low temperature

High temperature

19) How can dienes be classified? (Most stable?)

a. Cumulated

b. Conjugated

c. Isolated

d. A, B, C

20) Why do conjugated dienes exhibit special properties and reactivity?

a. Contain one continuous system of overlapping *s* orbitals

b. Contain one continuous system of overlapping *p* orbitals

c. Contain one continuous system of overlapping *sp* orbitals

d. A, B

e. B, C

21) Conjugated dienes experience free rotation about the C2–C3 bond, giving rise to two important conformations: *s-cis* and *s-trans*. The *s-trans* conformation is higher in energy.

a. True

b. False

22) Which molecular orbital contains the π electrons most readily available to participate in a reaction?

a. HOMO

b. LUMO

23) What are the different classifications for pericyclic reactions?

a. Cycloaddition reactions

b. Electrocyclic reactions

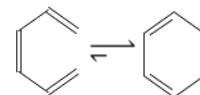
c. Sigmatropic rearrangements

d. All of the above

24) Select all that apply: what are the necessary conditions required for Diels-Alder [4+2] reactions to occur?

- Presence of diene and dienophile
- Electron-withdrawing substituent on dienophile
- S-cis* conformation on diene

25) Fill in the blank: an electrocyclic reaction is a pericyclic process in which a conjugated polyene undergoes cyclization. In the process, one ___ bond is converted into a ___ bond, while the remaining ___ bonds all change their locations.



26) What is the name for a [3,3] sigmatropic rearrangement when all six atoms of the cyclic transition state are carbon atoms?

- a. Claisen rearrangement
- b. Cope rearrangement

27) Compounds that possess a conjugated π system will absorb UV or visible light to promote an electronic excitation called which transition?

- a. $\sigma \rightarrow \sigma$ transition
- b. $\sigma \rightarrow \sigma^*$ transition
- c. $\pi \rightarrow \pi$ transition
- d. $\pi \rightarrow \pi^*$ transition

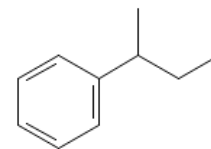
28) Compounds with a greater extent of conjugation will have a longer λ_{max} .

- a. True
- b. False

29) What is the oxidation progression of primary alcohols? Secondary alcohols? _____

30) Which reagent would you use to brominate at the benzylic position?

- a. Br_2/heat
- b. HBr/heat
- c. NBS/heat
- d. None of the above



31) Explain why benzene exhibits great stability. _____

- 32) Select all that apply: what are the requirements for a structure to be aromatic?
- Even number of electron pairs
 - Sp² hybridized atoms
 - Odd number of electron pairs
 - Sp³ hybridized atoms
- 33) Fill in the blank: the lone pair in _____ is localized and does not participate in resonance, while the lone pair in _____ is delocalized and participates in aromaticity.
- 34) What is the purpose of a Birch reduction? _____
- 35) How could you distinguish ¹H NMR signals of benzylic versus aromatic protons? _____
- 36) What step is involved in electrophilic aromatic substitution?
- a. Formation of an arenium ion
 - b. Protonation
 - c. Loss of a leaving group
 - d. All of the above
- 37) Fill in the blank: a Friedel–Crafts alkylation is only efficient in cases where _____ cannot occur. When choosing an alkyl halide, the carbon atom connected to the halogen must be ____ hybridized.
- 38) All activators are ortho-para directors.
- a. True
 - b. False
- 39) All deactivators are meta directors.
- a. True
 - b. False
- 40) What characterizes strong activators in electrophilic aromatic substitution?
- a. Presence of an EWG
 - b. Delocalized electrons outside of the ring
 - c. Lone pair adjacent to the ring
 - d. None of the above

- 41) What characterizes strong deactivators in electrophilic aromatic substitution?
- Powerful EWG
 - Conjugated π bond to an electronegative atom
 - Delocalized electrons outside of the ring
 - All of the above
- 42) Fill in the blank: when multiple substituents are present, the more powerful _____ dominates the directing effects. A _____ can be used to control the regiochemical outcome of an electrophilic aromatic substitution.
- 43) List the requirements needed for nucleophilic aromatic substitution. _____
- 44) What intermediate does an elimination-addition reaction occur via?
- Arynes
 - Benzynes
 - Alkynes
 - A, B
- 45) Fill in the blank: the suffix _____ indicates an aldehydic group, and the suffix _____ is used for ketones.
- 46) Aldehydes can be prepared via which reactions?
- Oxidation of primary alcohols
 - Ozonolysis of alkenes
 - Hydroboration-oxidation of terminal alkynes
 - All of the above
- 47) Ketones can be prepared via which reactions?
- Oxidation of secondary alcohols
 - Ozonolysis of alkenes
 - Acid-catalyzed hydration of terminal alkynes
 - Friedel-Crafts acylation
 - All of the above
 - A, B, C
- 48) Why are aldehydes more reactive than ketones? _____

- 49) What is the general mechanism for nucleophilic addition under basic conditions?
- Nucleophilic attack and protonation
 - Nucleophilic attack and deprotonation
 - Nucleophilic attack and proton transfer
- 50) Under acidic conditions, a mechanism will only be reasonable if it avoids the use or formation of strong acids.
- True
 - False
- 51) The reversibility of acetal formation enables acetals to function as what for ketones or aldehydes?
- Hydrates
 - Alcohol group
 - Strong base
 - Protecting group
- 52) Fill in the blank: in acidic conditions, an aldehyde or ketone will react with a _____ to form an imine and a _____ to form an enamine.
- 53) The reduction of a carbonyl group with LiAlH_4 or NaBH_4 is not a reversible process, because hydride does not function as a leaving group.
- True
 - False
- 54) Grignard reactions are reversible, because carbanions function as leaving groups.
- True
 - False
- 55) What is the Wittig reagent that accomplishes a ketone to an alkene transformation? _____
- 56) For a Wittig reagent generated from a simple alkyl halide, what alkene configuration is generally the major product?
- (E)
 - (Z)
- 57) For a stabilized Wittig reagent, what alkene configuration is generally the major product?
- (E)
 - (Z)

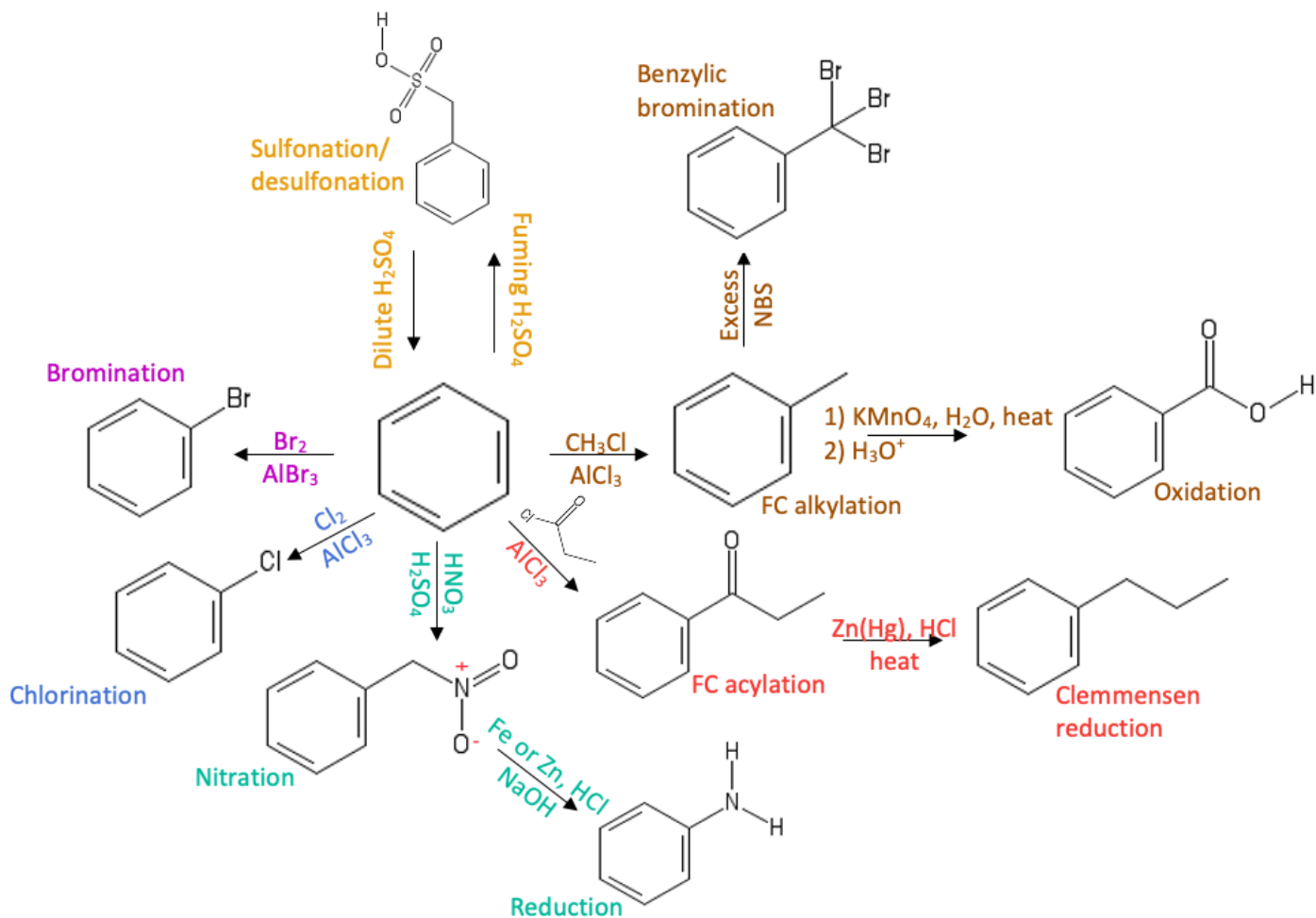
- 58) When an unsymmetrical ketone is treated with a peroxy acid, how will the product be formed? _____
- 59) List the C-C bond-forming and bond-breaking reactions discussed in this chapter. _____
- 60) What ^1H NMR signal is produced by an aldehydic proton?
- a. 6.5-8 ppm
 - b. 10-12 ppm
 - c. 9-10 ppm
 - d. 2-2.5 ppm
- 61) Fill in the blank: Compounds containing a carboxylic acid group are named with the suffix _____. Acid halides are named by replacing the suffix "ic acid" with _____. Acid anhydrides are named by replacing the suffix "ic acid" with _____. Esters are named by first indicating _____ atom, followed by the carboxylic acid, for which the suffix "ic acid" is replaced with _____. Amides are named by replacing the suffix "ic acid" or "oic acid" with _____. Nitriles are named by replacing the suffix "ic acid" with _____.
- 62) Treatment of a carboxylic acid with a strong base, such as sodium hydroxide, yields what product?
- a. Carboxylic acid
 - b. Ester
 - c. Acid chloride
 - d. Carboxylate salt
- 63) What is the pK_a of most carboxylic acids? _____
- 64) Determine the most acidic carboxylic acid structure.
- a. 2,2-dimethylbutanoic acid
 - b. 3-methoxybutanoic acid
 - c. 2,2-dinitrobutanoic acid
 - d. 2,2-dichlorobutanoic acid
- 65) What is the order of reactivity for carboxylic acid derivatives? _____

- 66) What is the general mechanism name for when a nucleophile attacks a carboxylic acid derivative?
- a. Nucleophilic acyl addition
 - b. Nucleophilic acyl substitution
 - c. Nucleophilic acyl elimination
 - d. None of the above
- 67) Fill in the blank: when a nucleophile attacks a carbonyl group to form a _____, always re-form the _____ group if possible but avoid expelling H^- or C^- .
- 68) What is the purpose for two equivalents of ammonia when treated with acid chlorides?

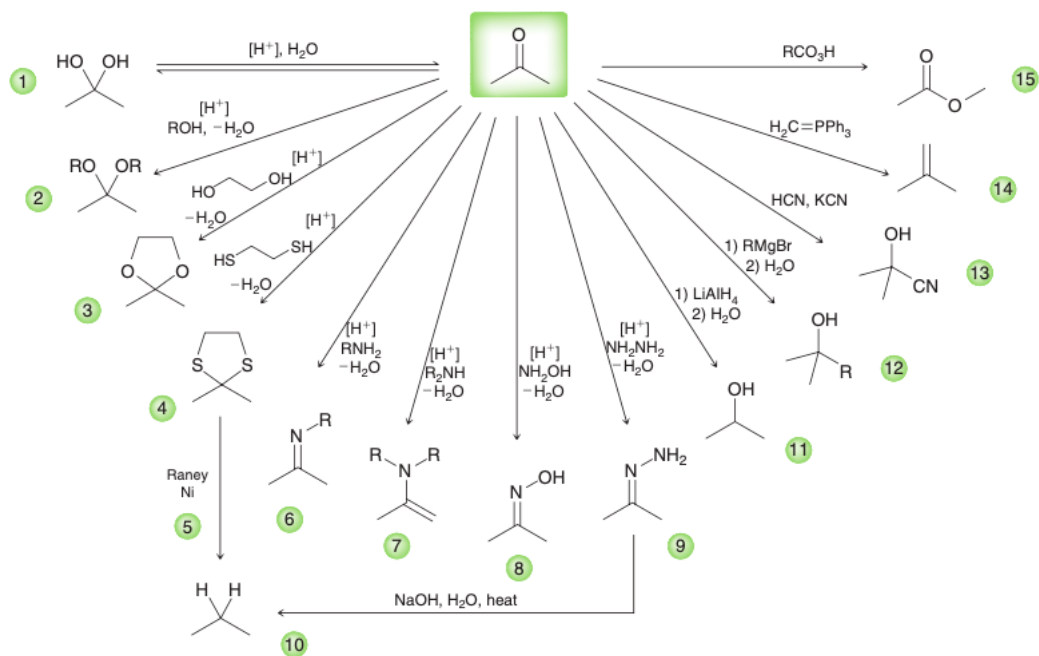
- 69) Name the process when carboxylic acids are converted into esters when treated with an alcohol in the presence of an acid catalyst and is reversible.
- a. Saponification
 - b. Fischer esterification
 - c. A, B
- 70) Fill in the blank: in the presence of catalytic acid or base, a ketone will exist in equilibrium with an _____. In general, the equilibrium will significantly favor the _____. The _____ position of an enol can function as a nucleophile.
- 71) Sodium hydride or LDA will reversibly and completely convert an aldehyde or ketone into an enolate.
- a. True
 - b. False
- 72) Elimination of water in an aldol condensation reaction occurs via what mechanism? _____
- 73) What is the name of the product formed in a Claisen condensation reaction? _____
- 74) Select all that apply: for unsymmetrical ketones, what features are specific to reactions with NaH?
- Low temperature
 - Room temperature
 - Kinetic enolate
 - Thermodynamic enolate
 - Less hindered position
 - More hindered position

- 75) Classify the products formed in malonic ester and acetoacetic ester synthesis.
- Carboxylic acid
 - Methyl ketone
 - A, B
- 76) What is the nucleophile in a Michael reaction? Electrophile? _____
- 77) Fill in the blank: regular enolates do not serve as Michael donors, but the desired Michael reaction can be achieved with a _____ .
- 78) What mechanisms are involved in a Robinson annulation?
- Aldol and Claisen
 - Intramolecular aldol and Michael addition
 - Intramolecular aldol and Dieckmann
- 79) What can the lone pair on the nitrogen atom of an amine function as?
- Acid
 - Base
 - Electrophile
 - Nucleophile
 - A, C
 - B, D
- 80) Fill in the blank: amines with fewer than five carbon atoms per functional group will typically be _____. The boiling point of an amine increases as a function of its capacity to form _____ bonds. Aryl amines are less basic than alkyl amines, because the lone pair is _____. _____ groups slightly increase the basicity of aryl amines, while _____ groups significantly decrease the basicity of aryl amines.
- 81) Between pyridine and pyrrole, which is the stronger base? Weakest base? _____

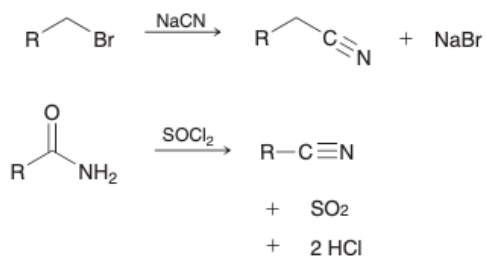
- 82) What is the desired product when an excess of alkyl halide is used and ammonia undergoes exhaustive alkylation?
- a. Tertiary amine
 - b. Quaternary ammonium salt
 - c. Primary amine
 - d. Ketone or aldehyde
- 83) What is the intermediate structure prepared via reductive amination in amines?
- a. Amide
 - b. Nitrile
 - c. Imine
 - d. Enamine
- 84) How is the alkene formed in the Hofmann elimination process? _____
- 85) Select all that apply: what reactions are useful to replace the diazo group in aryldiazonium salts?
- Sandmeyer
 - Schiemann
 - Aqueous treatment
 - Azo coupling
- 86) What compounds are considered strong bases and strong nucleophiles?
- a. R-Li
 - b. R-MgI
 - c. R₂CuLi
 - d. All of the above
 - e. A, B
- 87) What is a similarity between all of the coupling reactions (Stille, Suzuki, Negishi, Heck) mentioned in this chapter? _____
- 88) Fill in the blank: when a monosubstituted alkene is used in a Heck reaction, the process is observed to be highly regioselective, with the R group (of RX) being installed at the _____ substituted vinylic position of the alkene. When a monosubstituted alkene is used in a Heck reaction, the process is observed to be highly stereoselective with respect to the alkene, with the ___ isomer being formed, often exclusively.
- 89) How are simple sugars generally classified? _____



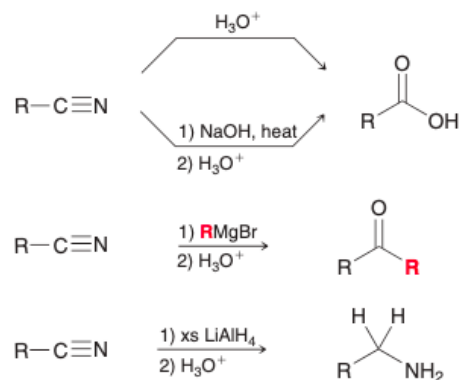
1. Hydrate Formation
2. Acetal Formation
3. Cyclic Acetal Formation
4. Cyclic Thioacetal Formation
5. Desulfurization
6. Imine Formation
7. Enamine Formation
8. Oxime Formation
9. Hydrazone Formation
10. Wolff-Kishner Reduction
11. Reduction of a Ketone
12. Grignard Reaction
13. Cyanohydrin Formation
14. Wittig Reaction
15. Baeyer-Villiger Oxidation



Preparation of Nitriles

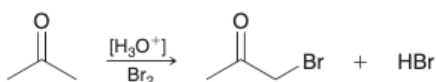


Reactions of Nitriles

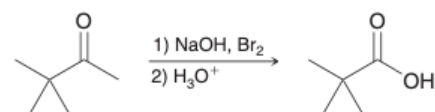


Alpha Halogenation

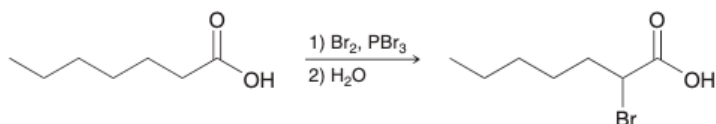
Of Ketones



Haloform Reaction

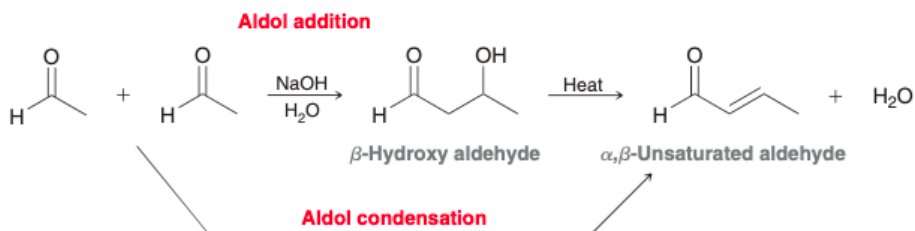


Of Carboxylic Acids (Hell-Volhard-Zelinsky Reaction)

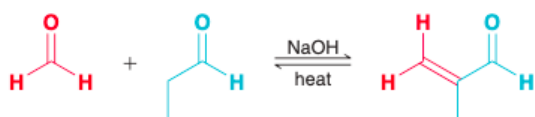


Aldol Reactions

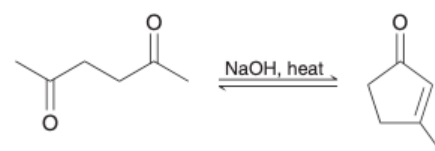
Aldol Addition and Condensation



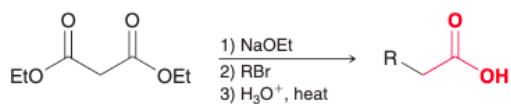
Crossed Aldol Condensation



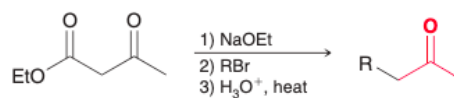
Intramolecular Aldol Condensation



The Malonic Ester Synthesis

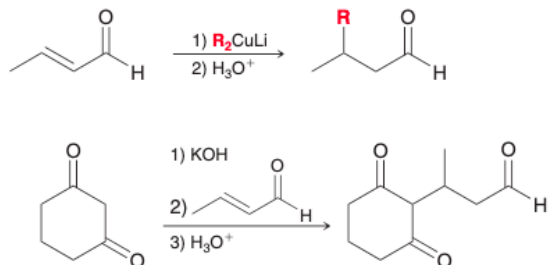


The Acetoacetic Ester Synthesis

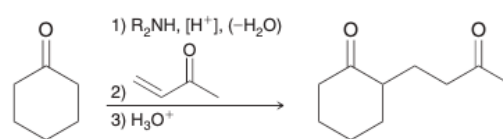


Michael Additions

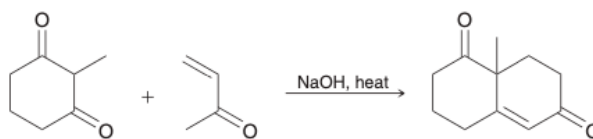
Stabilized Carbon Nucleophiles



The Stork Enamine Synthesis

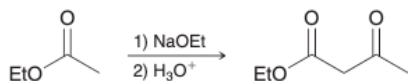


The Robinson Annulation

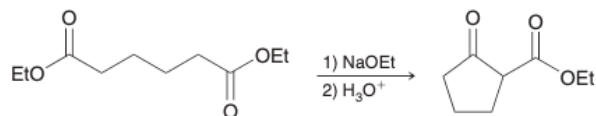


Claisen Condensation

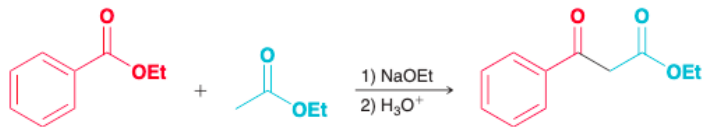
Claisen Condensation



Intramolecular Claisen Condensation (Dieckmann Cyclization)

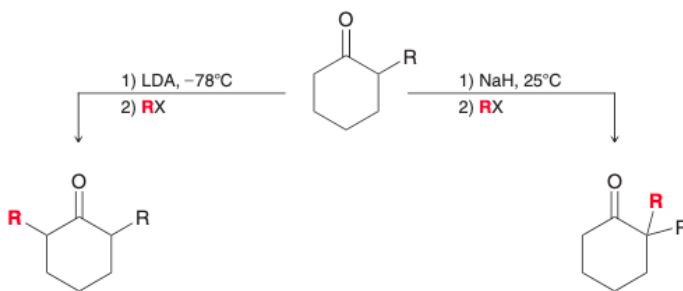


Crossed Claisen Condensations



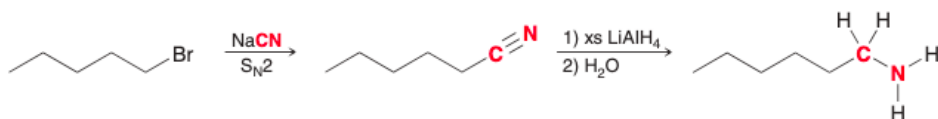
Alkylation

Via Enolate Ions

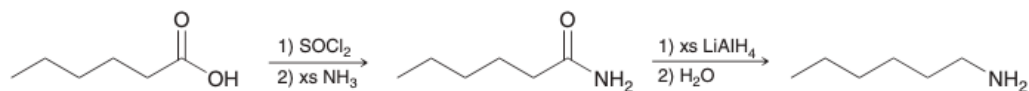


Preparation of Amines

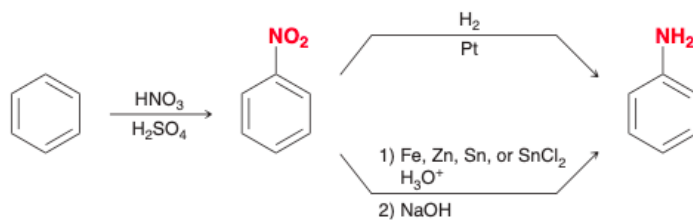
From Alkyl Halides



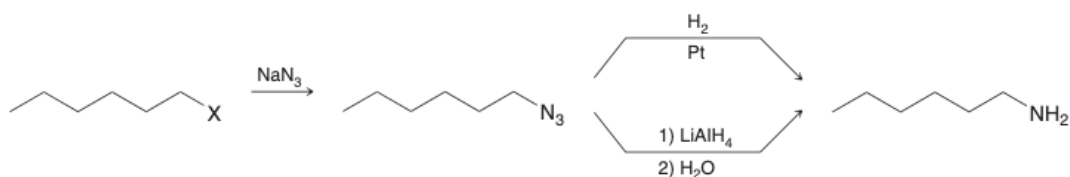
From Carboxylic Acids



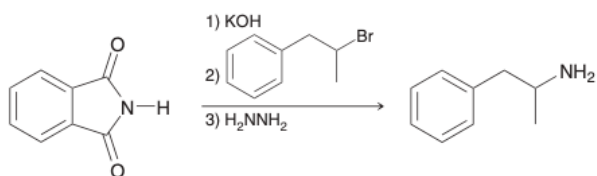
From Benzene



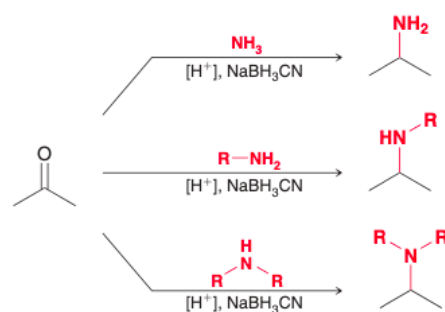
The Azide Synthesis



The Gabriel Synthesis

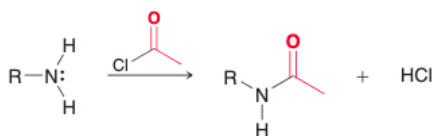


Via Reductive Amination

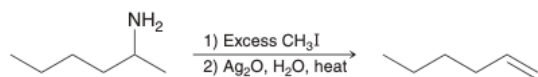


Reactions of Amines

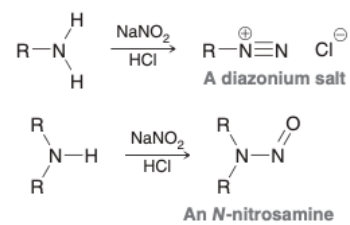
Acylation



Hofmann Elimination

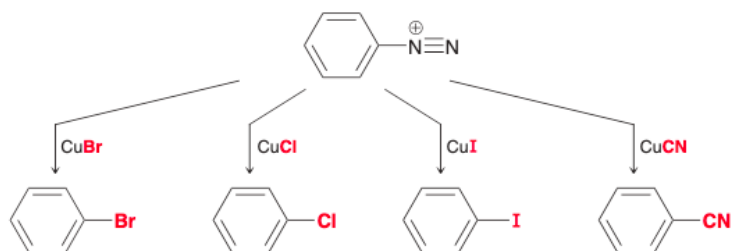


Reactions with Nitrous Acid

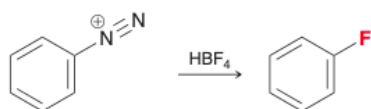


Reactions of Aryldiazonium Salts

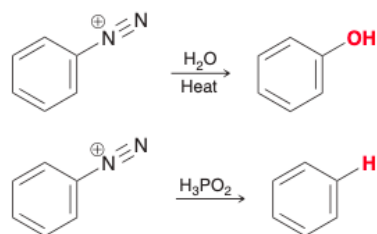
Sandmeyer Reactions



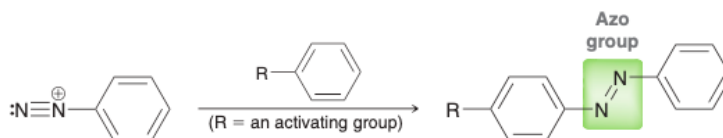
Fluorination (Schiemann Reaction)



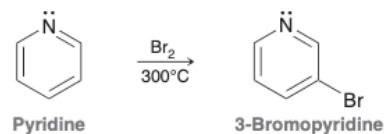
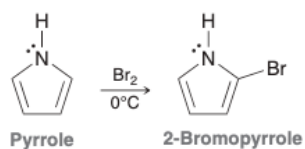
Other Reactions of Aryldiazonium Salts



Azo Coupling

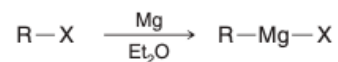
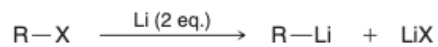


Reactions of Nitrogen Heterocycles



Organolithium and Organomagnesium Compounds

Preparation



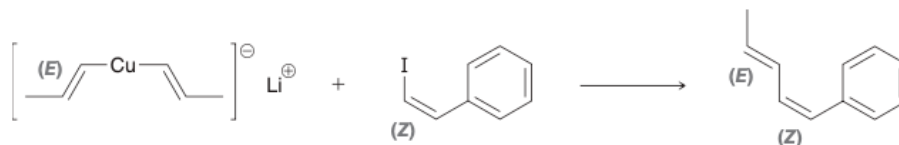
Organocuprates

Preparation of Gilman Reagents

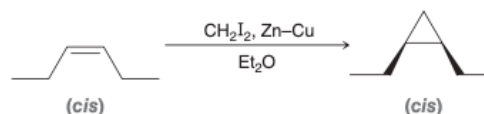
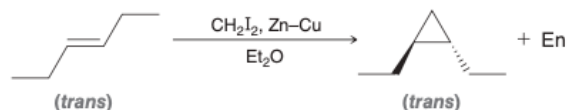
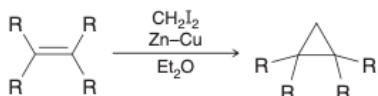


R = alkyl, aryl, or vinyl
X = I, Br, or Cl

Coupling Reaction of a Gilman Reagent with an Organoiodide

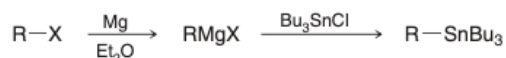


Simmons-Smith Reaction

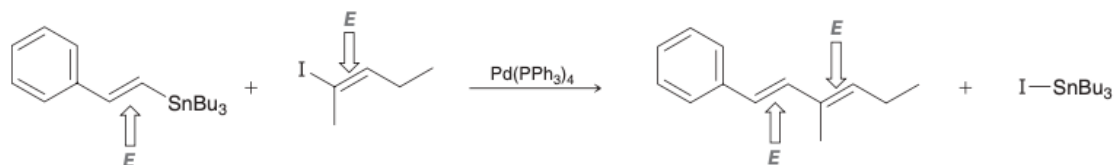
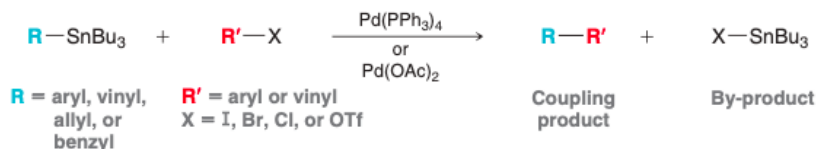


Stille Coupling

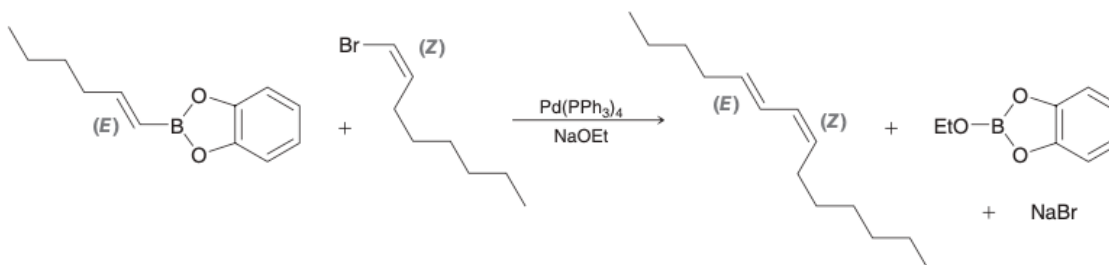
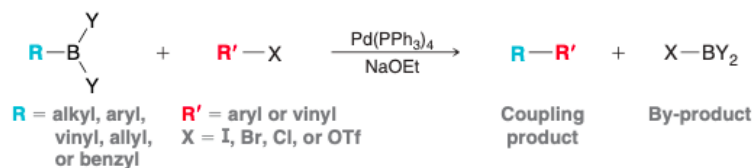
Preparation of Organostannanes



Coupling Reaction of an Organostannane with an Organoiodide

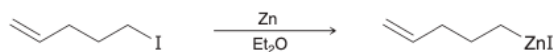
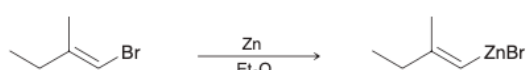
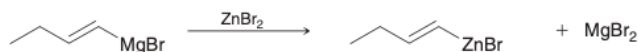
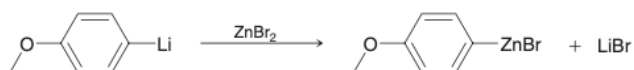


Coupling Reaction of an Organoboron Compound with an Organoiodide

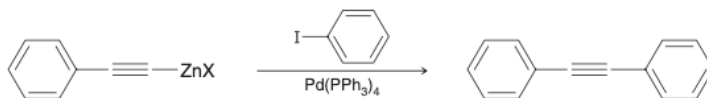
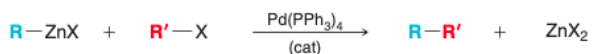


Negishi Coupling

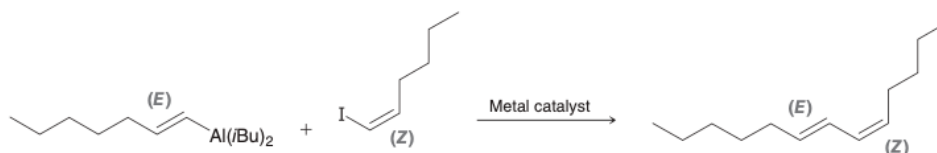
Preparation of Organozinc Compounds



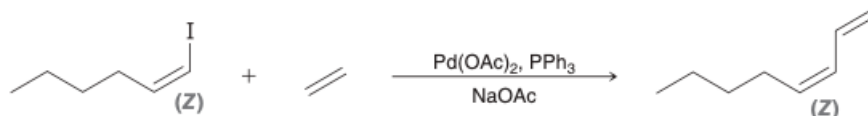
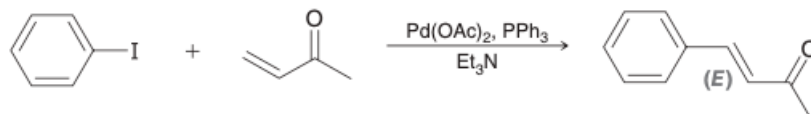
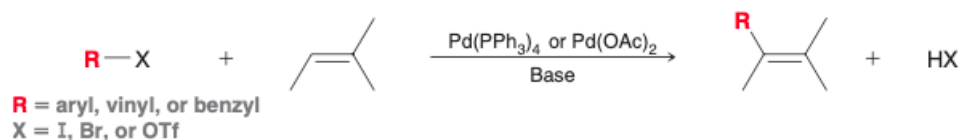
Coupling Reaction of an Organozinc Compound with an Organohalide



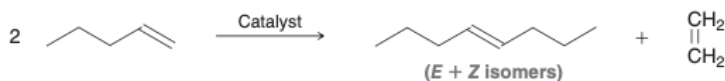
Coupling Reaction of an Organoaluminum Compound with an Organohalide



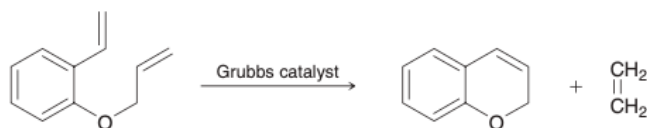
The Heck Reaction



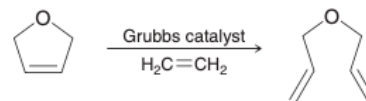
Alkene Metathesis

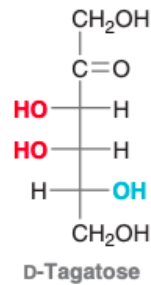
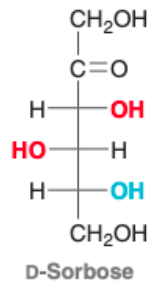
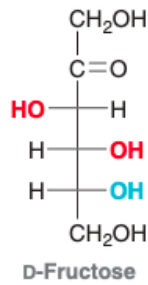
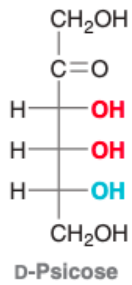
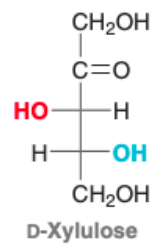
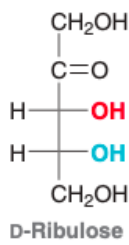
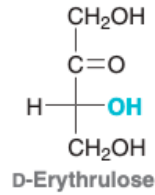
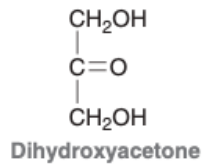


Ring-Closing Metathesis

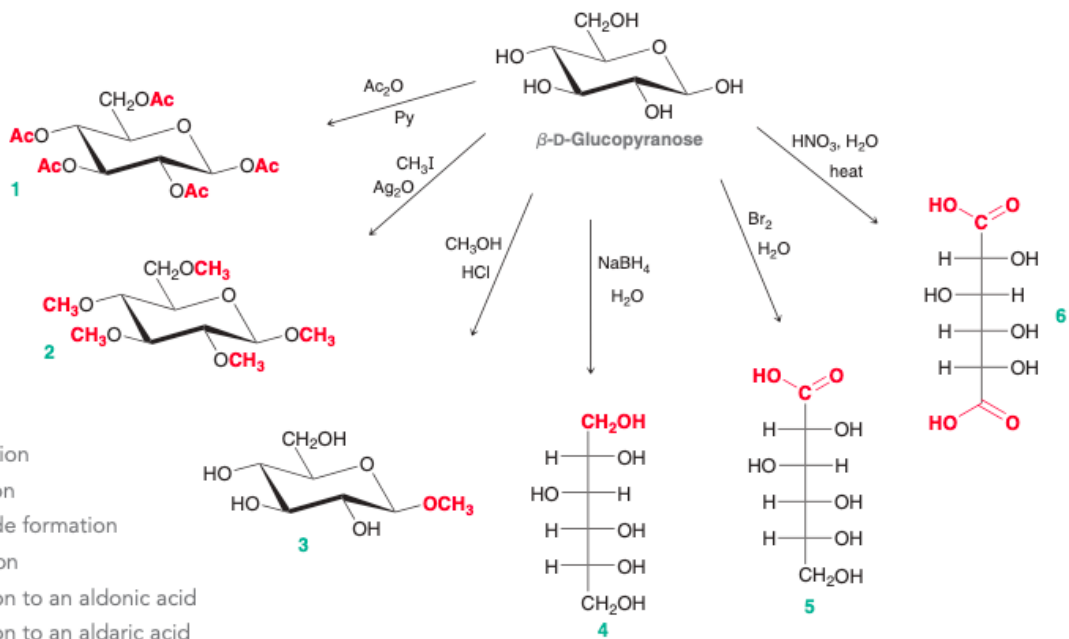


Ring-Opening Metathesis



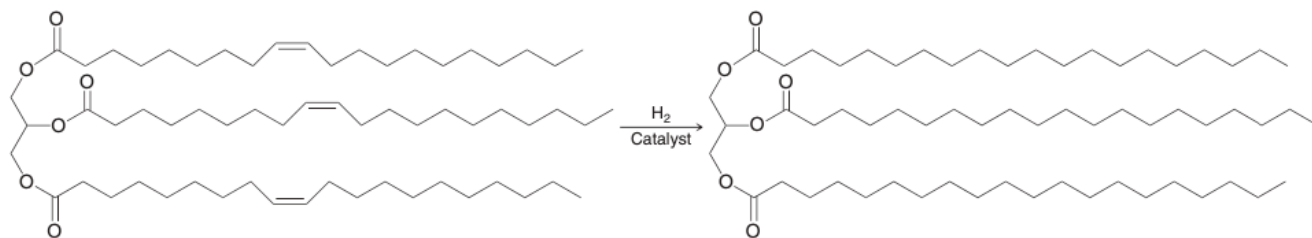


Reactions of Monosaccharides

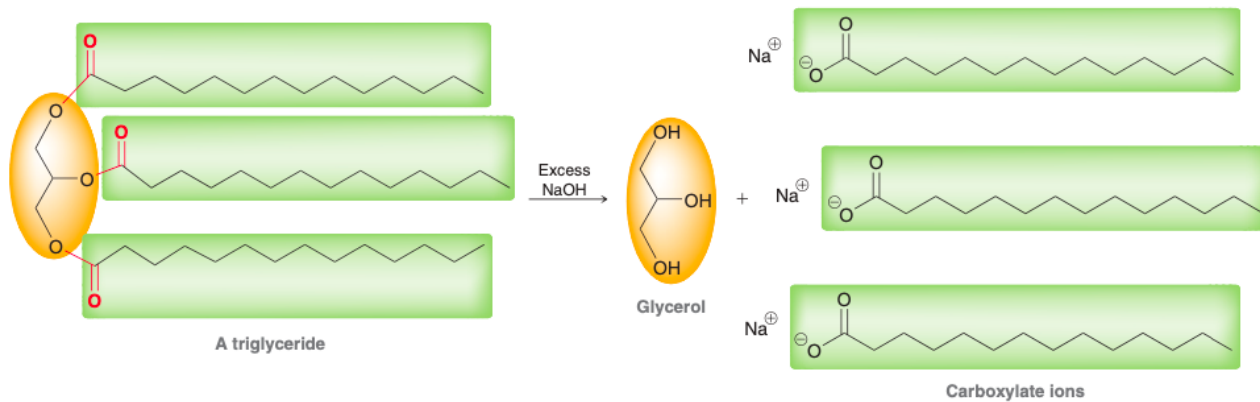


Reactions of Triglycerides

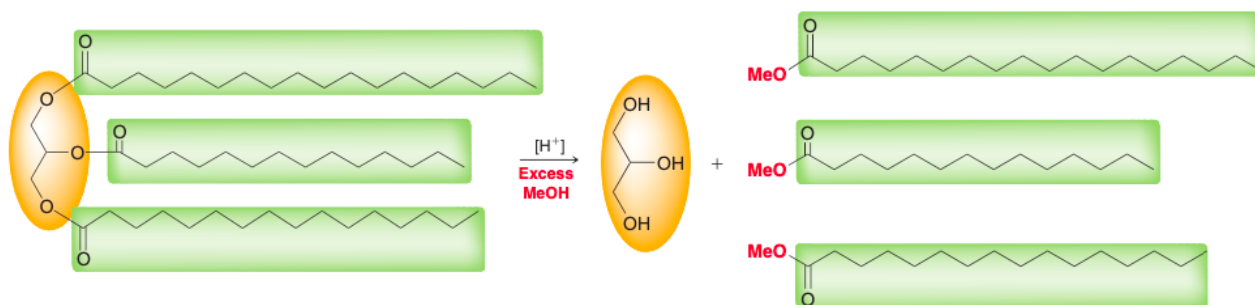
Hydrogenation (production of margarine)



Saponification (production of soap)



Transesterification (production of biodiesel)



Klein, David. *Organic Chemistry*. Third ed., Wiley, 2016.