Objectives for Chapter 11 – Alkenes I

I. Introduction to Alkenes

Bond structure

1. Give the hybridization and geometry of the carbons in a C=C, and recognize when they are incorrectly drawn.

2. Explain the molecular orbitals involved in forming a C=C, and why the pi bond is higher in energy.

Classifying compounds with C=C's

1. Explain the difference between alkenes, aromatic compounds, and unsaturated compounds.

2. Classify molecules containing C=C's as alkenes, aromatic compounds, and/or unsaturated compounds.

3. Classify molecules containing more than one C=C as isolated, conjugated, or cumulated alkenes, and describe their relative energies.

Physical Properties

1. Describe the physical properties of alkenes, including polarity, water solubility, density, and flammability.

2. Explain what effect molecular weight and branching have on the boiling points of alkenes, and predict which of two alkenes will have a higher boiling point.

Reactivity

1. Explain why alkenes are more reactive than alkanes.

2. Show how alkenes can react with electrophiles, acids, and radicals.

Occurrence and uses of alkenes

1. State whether alkenes are common in nature, and recognize exceptions.

2. State where alkenes come from, and the most commonly used alkene in industry.

Spectroscopy

1. Give the two important bands that characterize the IR spectrum of an alkene.

2. Give the chemical shift range for H's on C=C's in proton NMR spectra of alkenes.

3. Explain why alkenes often have complex splitting.

Stability of Alkenes

1. Explain how degree of substitution and stereochemistry affect the stability of alkenes, and predict which of two alkenes is more stable.

2. Explain why cyclic alkenes become less stable as ring size gets smaller than 6 carbons.

3. Explain why rings smaller than 8 carbons must be cis, but rings with 8 or more carbons can be cis or trans.

II. Unsaturation Number

1. Explain what unsaturation number is, and why it can be determined by looking at the molecular formula for a compound.

2. Give the formula for determining the unsaturation number of a hydrocarbon, and of a compound with halogens and/or nitrogen atoms.

3. For a given formula, give the unsaturation number, and draw a possible structure for that formula.

III. Nomenclature of Alkenes

1. List the priorities for choosing the principle chain in an alkene.

2. List the priorities for numbering an alkene.

3. Explain how to construct an alkene name with one or more C=C's.

4. Name substituents containing alkenes.

Stereochemistry in nomenclature

1. Determine if it is necessary to include stereochemistry in the name of an alkene.

2. Explain when cis and trans are acceptable, and when E and Z are required.

3. Explain how to assign priority to the two substituents on each side of a C=C, and use them to assign E and Z to a compound.

4. Explain when a number is needed with the E or Z to specify where it is in the compound.

5. Write the correct name if given the structure of an alkene, or draw the correct alkene if given the name, including stereochemistry if needed.

IV. Introduction to C=C reactions

1. Explain the difference between substitution, elimination, and addition reactions.

V. Addition of HX to alkenes

Carbocation mechanism

1. Write the mechanism for the addition of HX to an alkene.

2. Explain why the halogen ends up on the more substituted side of the alkene, and what will happen with equally substituted alkenes.

3. Predict the product(s) of the reaction of a given alkene with a hydrogen halide, including products which are the result of a rearrangement.

4. Analyze an alkyl halide to determine what alkenes could possibly be used as starting materials, and determine whether the reaction of each of these alkenes with a hydrogen halide would be effective to synthesize the given alkyl halide.

Radical mechanism

1. Write the mechanism for the addition of HBr to an alkene in the presence of an organic peroxide.

2. Explain why the halogen ends up on the less substituted side of the alkene, and give the structure of the radical intermediate.

3. Explain why rearrangements do not occur with this reaction.

4. Explain why the organic peroxide is catalytic.

5. Predict the product(s) of the reaction of a given alkene with HBr in the presence of an organic peroxide.

6. Analyze an alkyl halide to determine what alkenes could possibly be used as starting materials, and determine whether the reaction of each of these alkenes with HBr in the presence of an organic peroxide would be effective to synthesize the given alkyl halide.

VI. Hydration of alkenes

Acid-catalyzed hydration

1. Give the mechanism of the addition of water to an alkene in the presence of sulfuric acid to form an alcohol.

2. Explain why this reaction follows a different pathway and gives a different product from the reaction of an alkene with HX.

3. Explain why the acid is catalytic.

4. Explain why the OH ends up on the more substituted side of the alkene, and what happens if the alkene is equally substituted.

5. Predict the product(s) of the reaction of a given alkene with water in the presence of sulfuric acid.

6. Analyze an alcohol to determine what alkenes could possibly be used as starting materials, and determine whether the reaction of each of these alkenes with water in the presence of sulfuric acid would be effective to synthesize the given alcohol.

Oxymercuration-reduction

1. Give the reagents necessary for performing an oxymercuration-reduction, and show how both steps can be written with a single arrow.

2. State the regioselectivity for this reaction, and whether or not rearranged products are observed.

3. Explain what advantage oxymercuration-reduction has over acid-catalyzed hydration of an alkene.

4. Give the product(s) of an oxymercuration-reduction of an alkene.

5. Analyze an alcohol to determine what alkenes could possibly be used as starting materials, and determine whether oxymercuration-reduction of each of these alkenes would be effective to synthesize the given alcohol.

Hydroboration-oxidation

1. Give the reagents necessary for performing a hydroboration-oxidation reaction, and show how both steps can be written with a single arrow; recognize alternative ways in which borane may be written.

2. State the regioselectivity for this reaction, and whether or not rearranged products are observed.

3. Write the mechanism for the reaction of an alkene with borane, and explain how this affects the regioselectivity of the reaction.

4. Give the product(s) of a hydroboration-oxidation reaction of an alkene.

5. Analyze an alcohol to determine what alkenes could possibly be used as starting materials, and determine whether hydroboration-oxidation of each of these alkenes would be effective to synthesize the given alcohol.

6. Compare and contrast the three hydration reactions of alkenes.