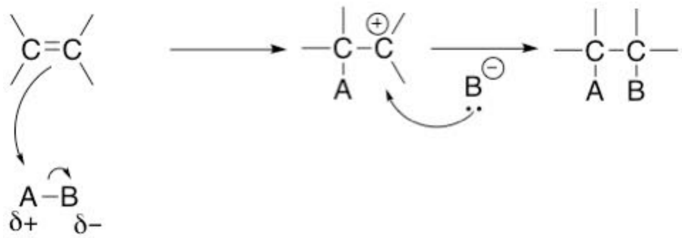
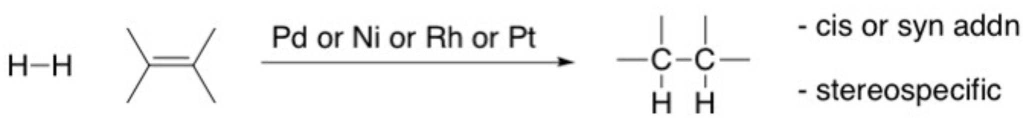
RECALL:

Addition Reactions

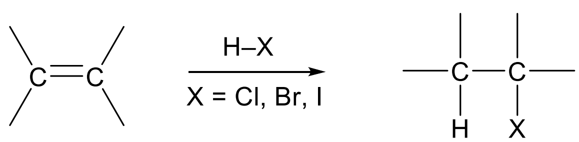
- Occurs on double bonds and triple bonds



Hydrogenation Addition of H_2



Hydrogen Halide (HX) Addition



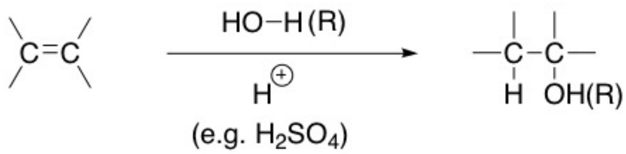
Reaction generally leads to syn/cis addition

Markovnikov's Rule: In an addition reaction, the positive end of an A–B system (e.g. I–Cl) adds to the least substituted end of the double bond to make the more stable carbocation.

Addition of H_2O and ROH (Hydration and Ether Formation)

HO−H or RO−H

Addition R = Alkyl

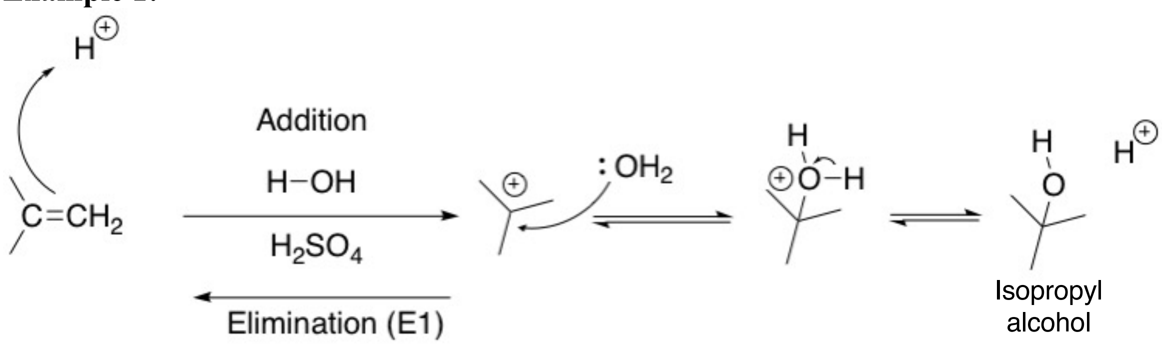


Not Stereospecific

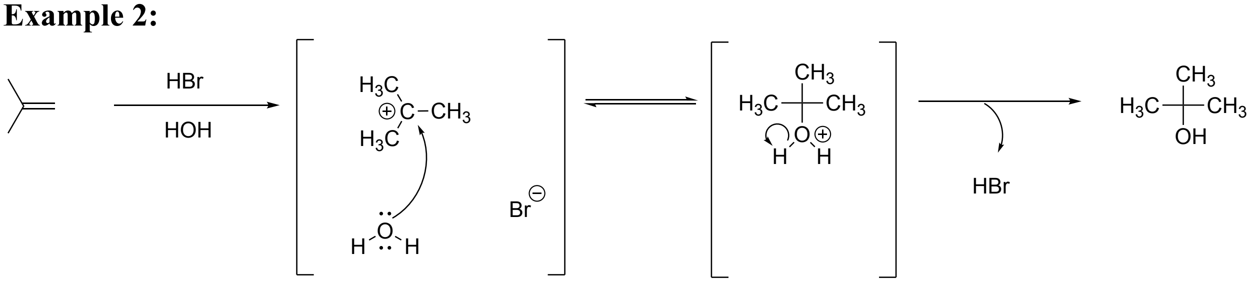
Hydration formation

- H_2O or ROH by itself cannot add to the double bond. Need an acid (H^+) to pull the electrons from the double bond.
- H_2SO_4 (H^+) is a catalyst, meaning that it is not transformed or used up in the reaction but is present to lower the activation energy.
- Follows Markovnikov rules

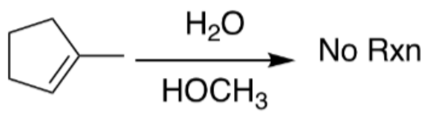
Example 1:



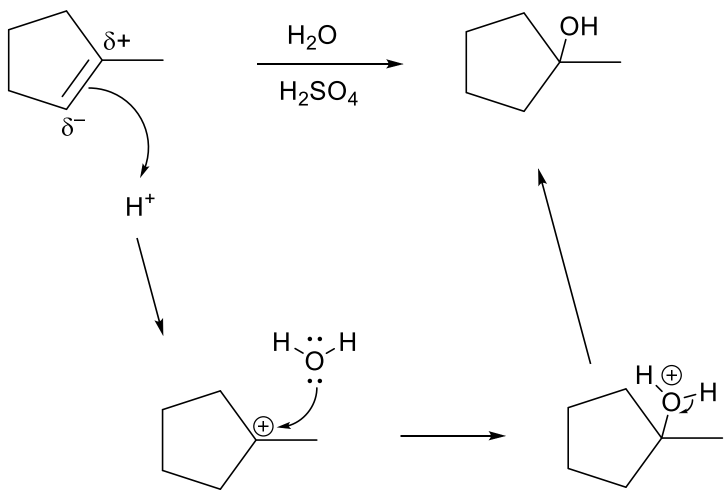
Example 2:



Example 3:

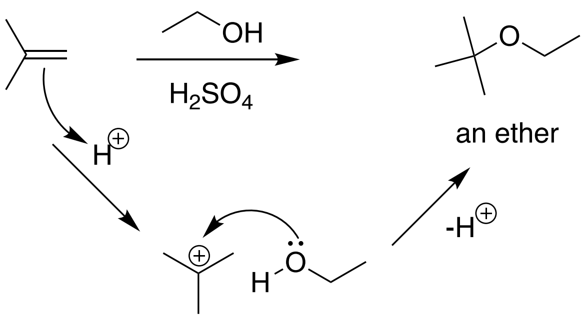


Example 4:

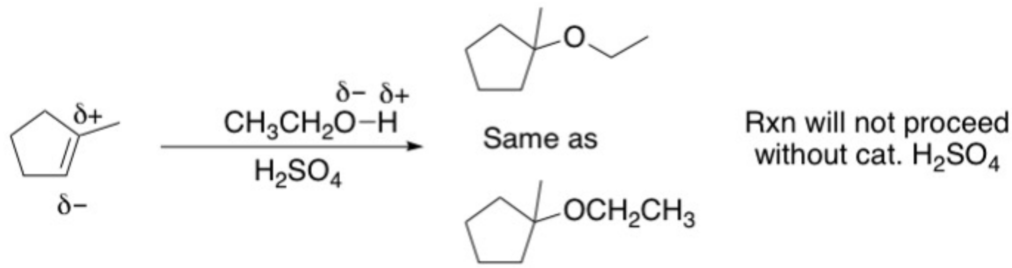


Ether formation

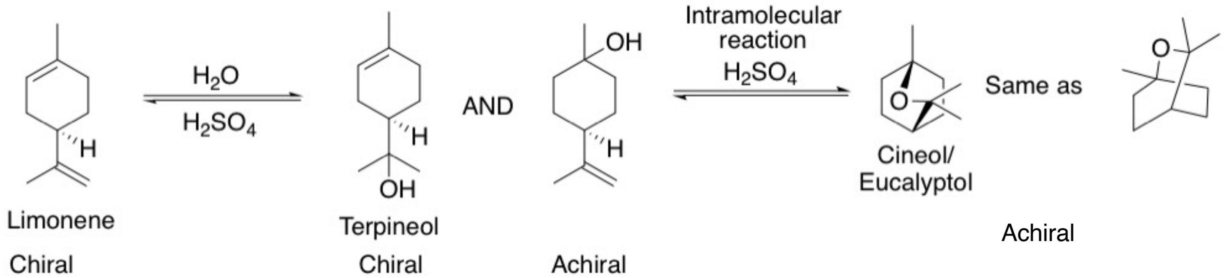
Example 1:



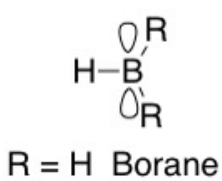
Example 2:



Example 3 (Limonene):

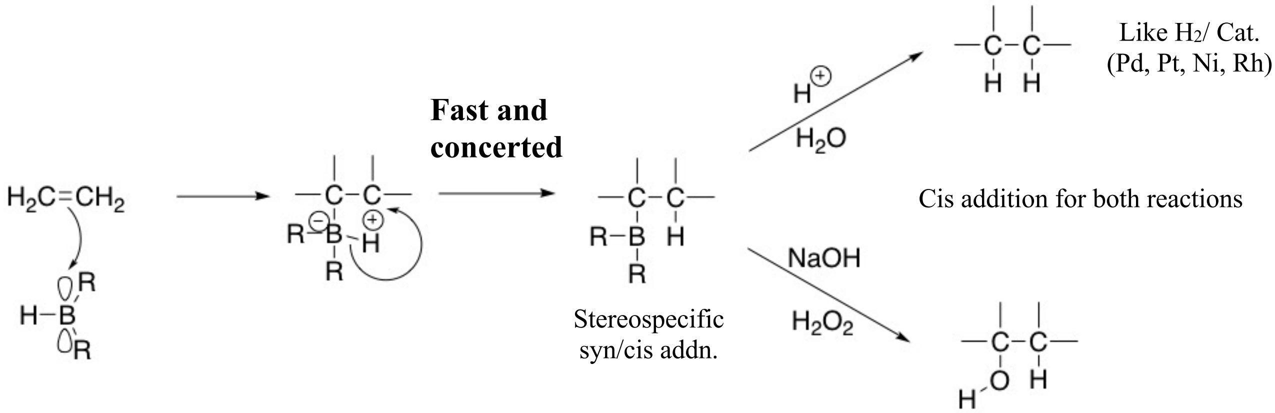


Hydroboration



Lewis acid Empty orbitals allow it to accept a pair of e⁻

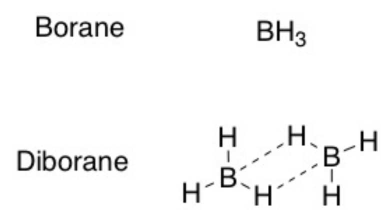
- B when stable and uncharged has 3 bonds and no lone pairs
- Borane forms partial bonds with another borane molecule to form B_2H_6 (diborane)
- Borane is a hydride (H^-) donor



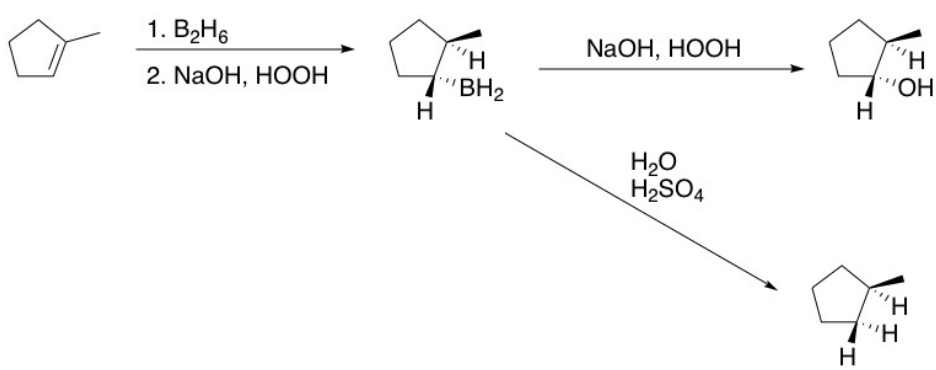
Concerted reaction: bond breaking and bond formation happens in a single step
Anti-Markovnikov: the hydrogen ends up on the more substituted C in a double bond. It is SYN.

Structure of borane

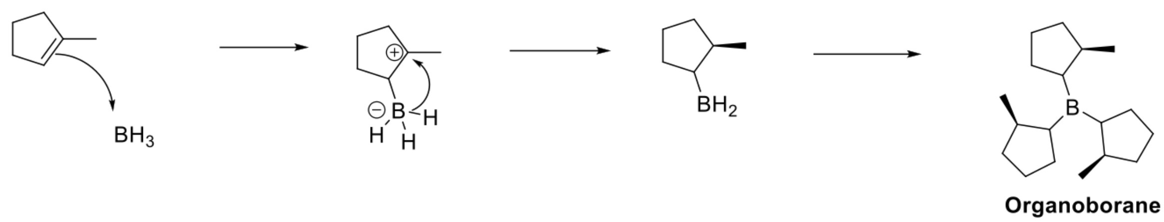
Exists as Diborane (B_2H_6), but behaves like BH_3

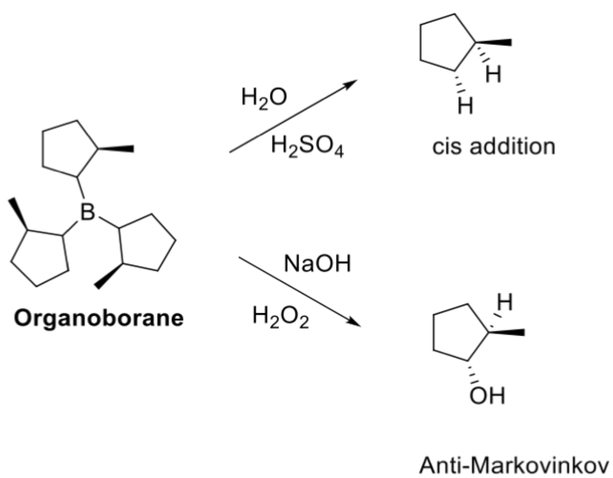


Example



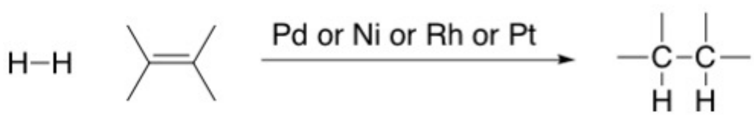
Syn addition, but anti-Markovnikov addition of OH





Oxidation and Reduction
Oxidation- removal of electron
Reduction- Addition of electron

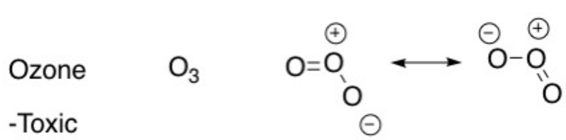
Example of Reduction (Hydrogenation)



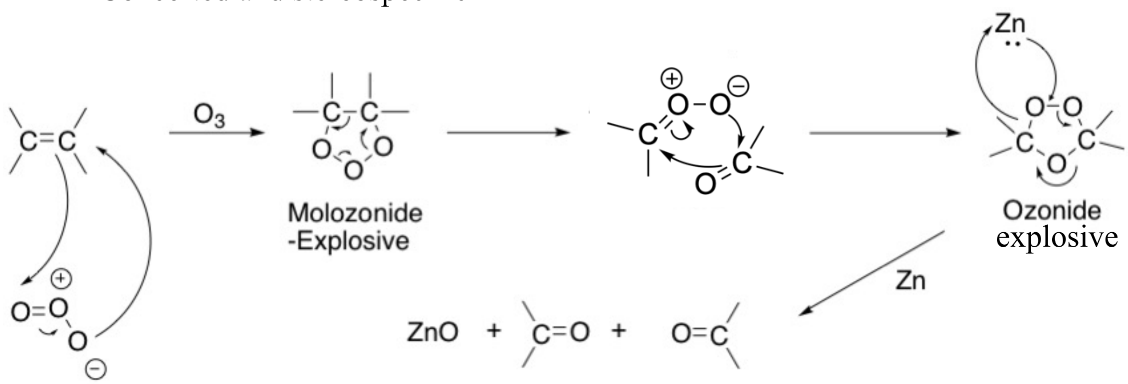
There are 12 electrons in the reagent side and 14 electrons in the product side. There is an addition of two electrons, therefore classified as **reduction**.

<u>**Oxidation Reactions**</u>

Ozonolysis (lysis = cleavage) – cleavage by ozone (O_3)

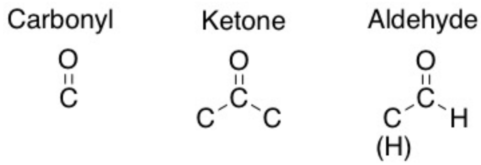


- Use double-headed arrow to indicate resonance (↔)
- Highly reactive (always looking for negative charge such as the negative charge in a double bond)
- Concerted and stereospecific

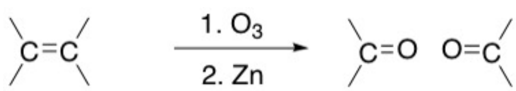


- Reaction is irreversible

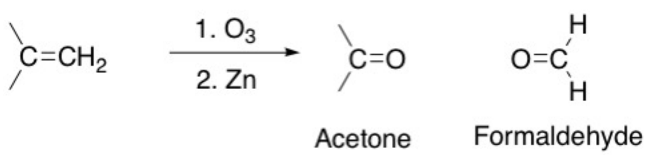
Examples of carbonyl groups

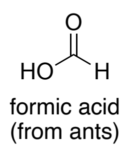


Reaction scheme of ozone

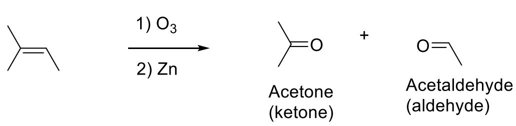


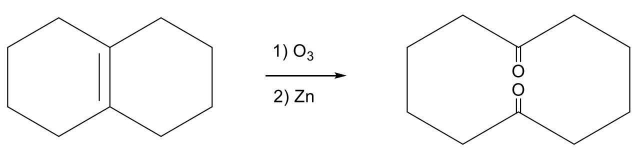
Example

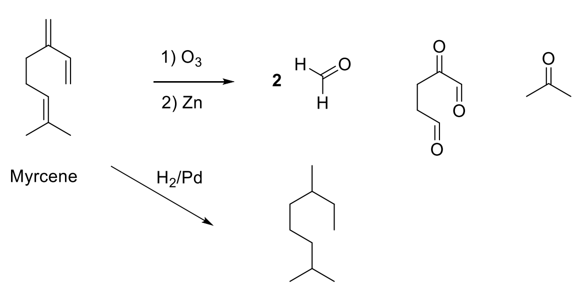




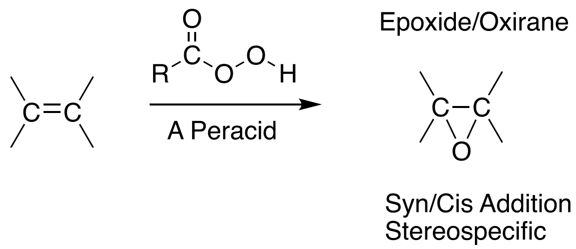
More examples



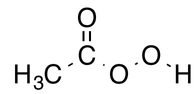




Epoxidation:

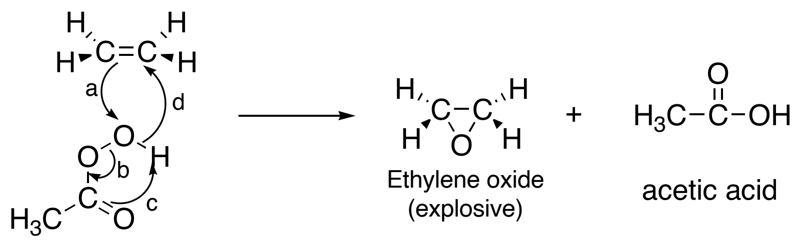


Example of a peracid

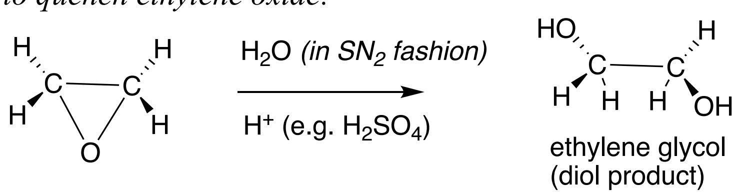


Concerted (bonds break and form at the same time)

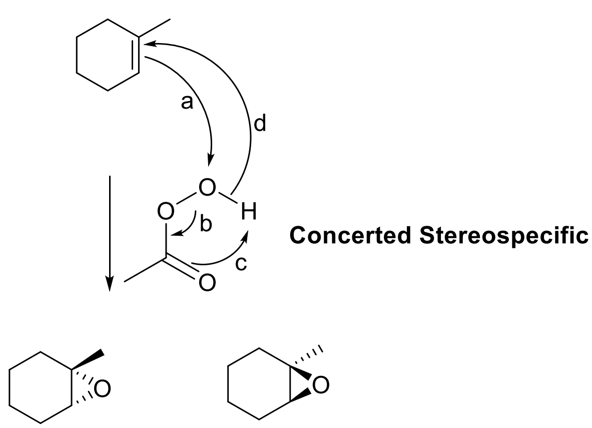
Mechanism:



to quench ethylene oxide:



Example: 1-methyl-1-cyclohexene



Racemic mixture (1:1)
cis/syn addition