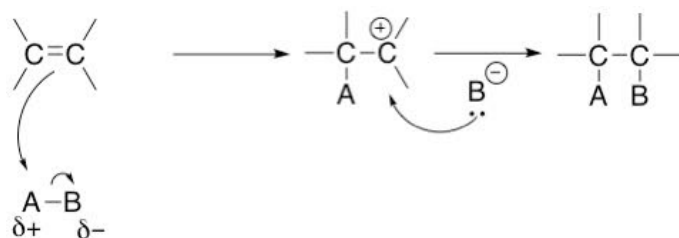
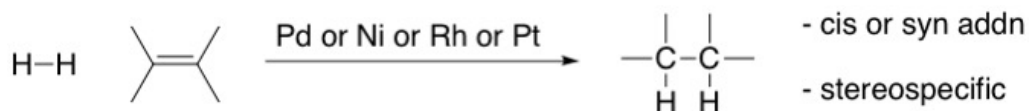
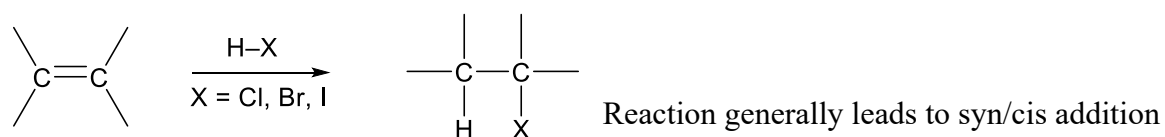
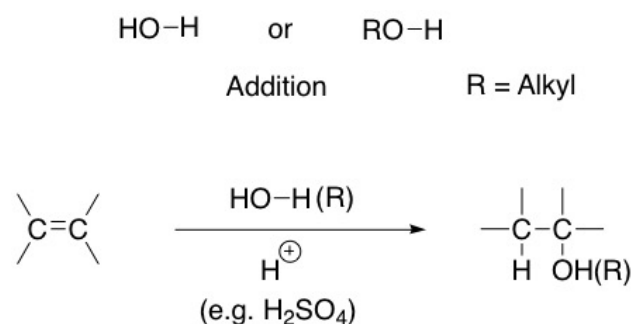


**RECALL:****Addition Reactions**

- Occurs on double bonds and triple bonds

**Hydrogenation Addition of H<sub>2</sub>****Hydrogen Halide (HX) Addition**

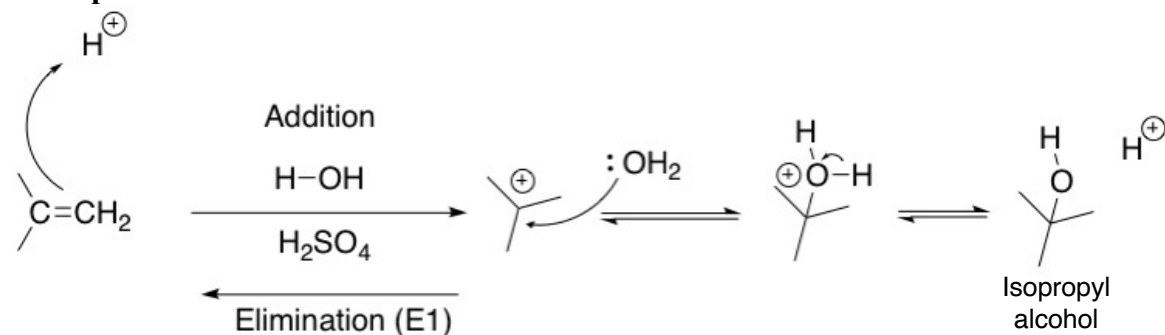
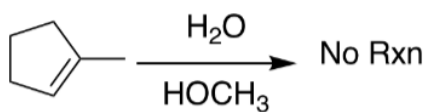
**Markovnikov's Rule:** In an addition reaction, the positive end of an A-B system (e.g. I-Cl) adds to the least substituted end of the double bond to make the more stable carbocation.

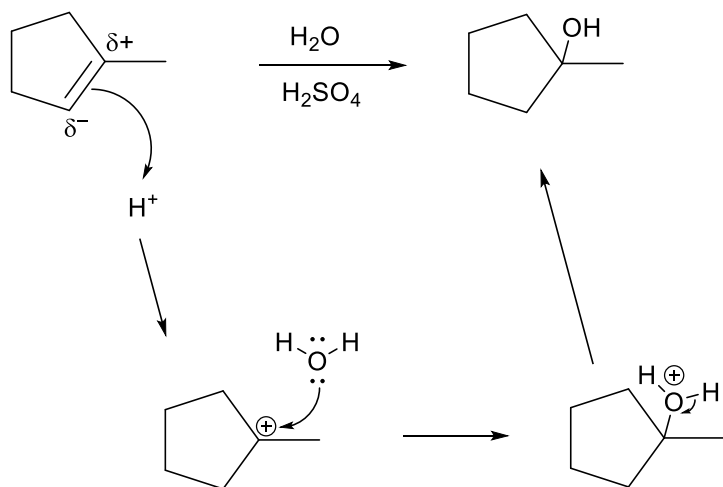
**Addition of H<sub>2</sub>O and ROH (Hydration and Ether Formation)**

Not Stereospecific

**Hydration formation**

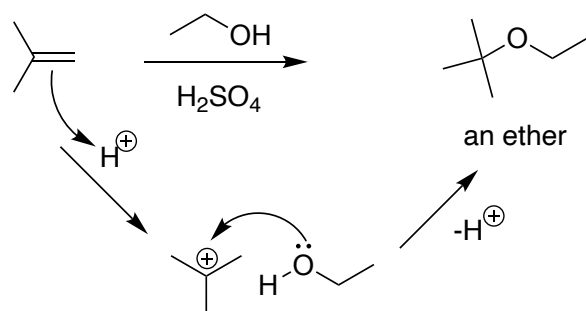
- H<sub>2</sub>O or ROH by itself cannot add to the double bond. Need an acid (H<sup>+</sup>) to pull the electrons from the double bond.
- H<sub>2</sub>SO<sub>4</sub> (H<sup>+</sup>) is a catalyst, meaning that it is not transformed or used up in the reaction but is present to lower the activation energy.
- Follows Markovnikov rules

**Example 1:****Example 2:**

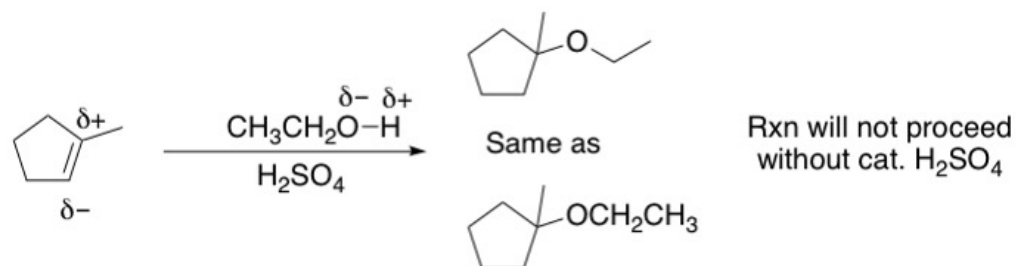


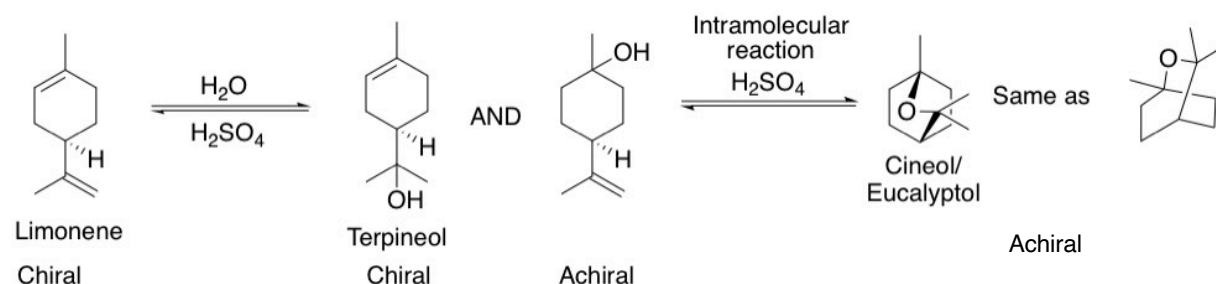
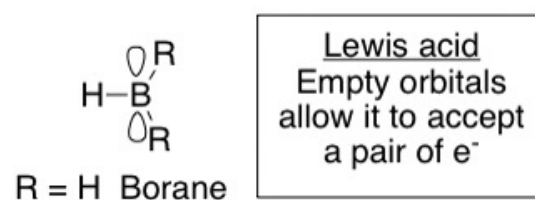
### Ether formation

#### Example 1:

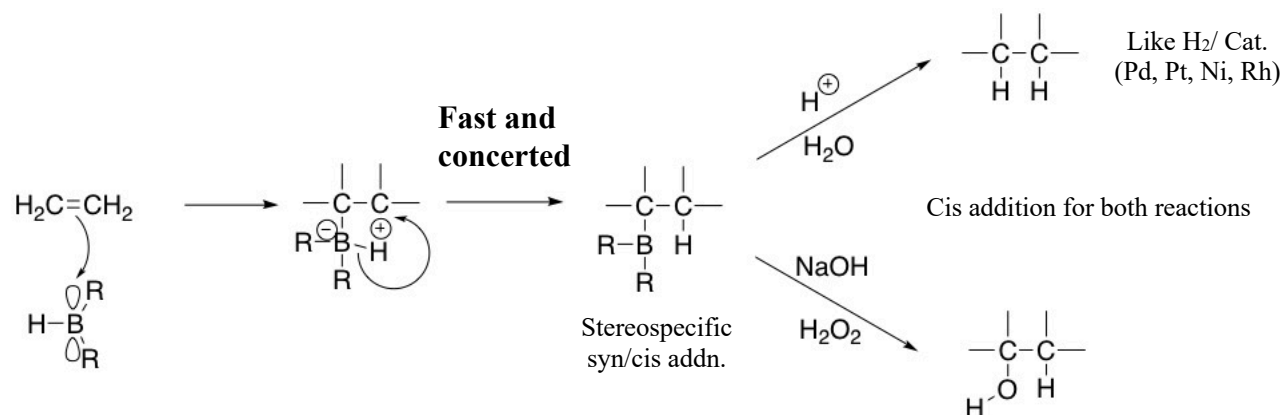


#### Example 2:



**Example 3:****Hydroboration**

- B when stable and uncharged has 3 bonds and no lone pairs
- Borane forms partial bonds with another borane molecule to form  $\text{B}_2\text{H}_6$  (diborane)
- Borane is a hydride ( $\text{H}^-$ ) donor



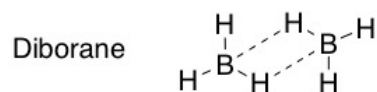
**Concerted reaction:** bond breaking and bond formation happens in a single step

**Anti-Markovnikov:** the hydrogen ends up on the more substituted C in a double bond. It is SYN.

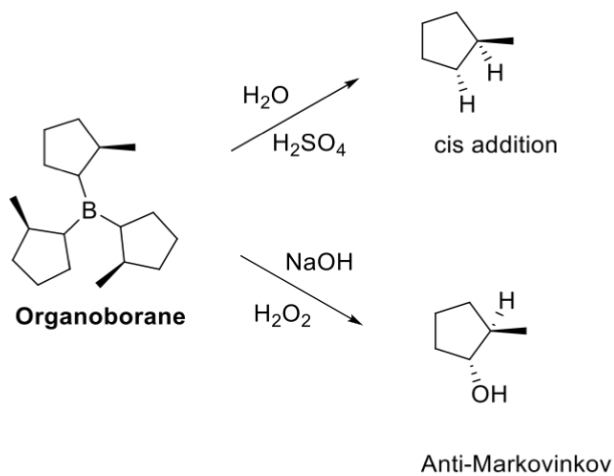
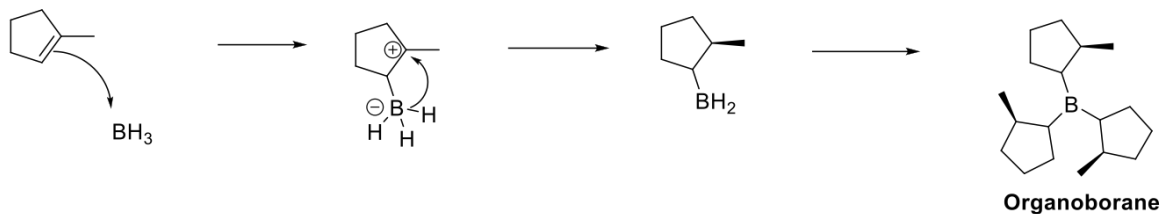
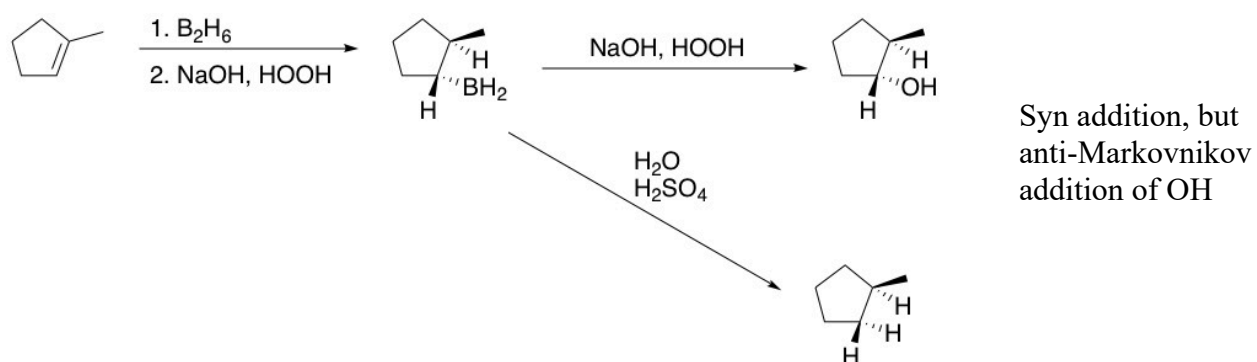
## Structure of borane

Exists as Diborane ( $B_2H_6$ ), but behaves like  $BH_3$

Borane  $BH_3$



## Example

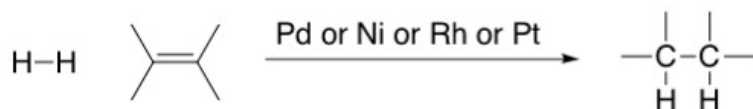


## Oxidation and Reduction

Oxidation- removal of electron

Reduction- Addition of electron

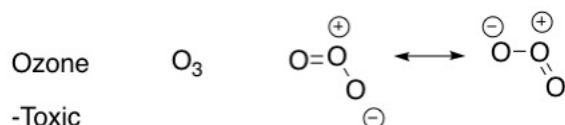
### Example of Reduction (Hydrogenation)



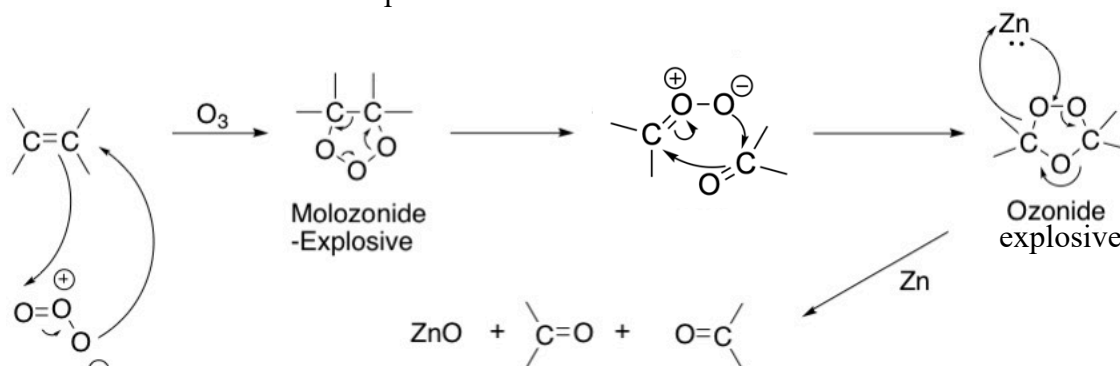
There are 12 electrons in the reagent side and 14 electrons in the product side. There is an addition of two electrons, therefore classified as **reduction**.

## Oxidation Reactions

**Ozonolysis** (lysis = cleavage) – cleavage by ozone ( $\text{O}_3$ )



- Use double-headed arrow to indicate resonance ( $\longleftrightarrow$ )
- 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**

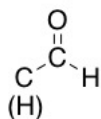
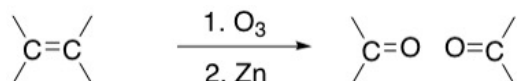
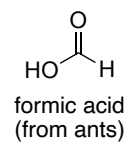
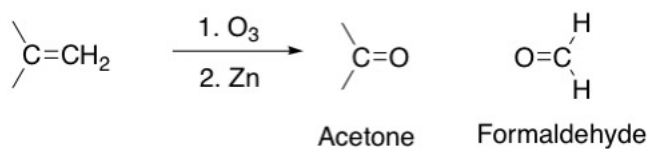
Carbonyl



Ketone



Aldehyde

**Reaction scheme of ozone****Example****More examples**