Chapter 11 - Alcohols and Ethers

11.1 - Structure and Nomenclature
- The common naming calls alcohols as alkyl alcohols (eg: methyl alcohol)
- The common names of ethers have the groups attached to the oxygen atom listed in alphabetical order followed by the word “ether” (eg: Ethyl methyl ether)
- The RO group is called an alkoxy group (eg: OCH$_3$ is methoxy)

11.2 - Physical Properties of Alcohols and Ethers
- Ethers have boiling points that are roughly comparable with those of hydrocarbons of the same molecular weight (unlike alcohols, which have higher)
- Ethers can form hydrogen bonds with other molecules (eg: water) but not with other ethers and are, therefore, similarly soluble to those of alcohols of the same molecular weight

11.4 - Synthesis of Alcohols from Alkenes
- Well, here’s where you cry yourself a river if you don’t remember (or want to remember) acid-catalyzed hydration of alkenes, oxymercuration-demercuration, and hydroboration-oxidation reactions
- What’s different about this chapter is that the starting reactants are alcohols, not alkenes/alkynes

11.5 - Reactions of Alcohols
- The reactions of alcohols has to do with improving the poor nature of the hydroxyl leaving group
- Protonation of the alcohol converts a poor leaving group (eg: OH) into a good one (eg: H$_2$O)
- In H$^+$, the hydroxyl group is protonated, becomes a good LG, and a nucleophile substitutes on
- If the nucleophile is ROH, OR substitutes on to make an ether

11.6 - Alcohols as Acids
- Alcohols are about as acidic as water
- Sterically hindered alcohols are less acidic/more basic
- All alcohols are stronger acids than terminal alkynes, hydrogen, ammonia, and alkanes
- Conjugate bases of compounds with higher $pK_a$ values than an alcohol will deprotonate it

11.7 - Conversion of Alcohols into Alkyl Halides
- Because OH is such a bad LG, it is typically converted to a better LG (weak base)

11.8 - Alkyl Halides from the Reaction of Alcohols with Hydrogen Halides
- $2^\circ$, $3^\circ$, allylic, and benzylic alcohols go through an $S_N1$ reaction with the protonated alcohol acting as the substrate when reacted with concentrated HX
- $1^\circ$ alcohols and methanol react to form alkyl halides in concentrated HX by an $S_N2$ mechanism where the halide anion substitutes for the water molecule LG
- Rearrangements still typically occurs here, as we’ve done time and time again in Chapter 8
- Racemic mixtures are produced due to the creation of the carbocation
- Elimination does not occur due to the high concentration of X$^-$ anions in the concentrated HX solution

*The following sections are skipped: autoxidation, 11.3, 11.12, 11.14A, and 11.16*
11.9 - Alkyl Halides from the Reaction of Alcohols with PBr₃ or SOCl₂
- PBr₃ or SOCl₂ can be used to convert a 1° or 2° alcohol to a leaving group without worrying about rearrangement
- The reaction of an alcohol with PBr₃ does not involve the formation of a carbocation, and, therefore, does not go through rearrangement
- $3 \text{ROH} + \text{PBr}_3 \rightarrow 3 \text{RBr} + \text{H}_3\text{PO}_3$, only where ROH is 1° or 2°

![](image)

- SOCl₂ converts 1° and 2° alcohols to alkyl chlorides with $\text{C}_2\text{H}_5\text{N}$ (pyridine) included to promote the reaction
- **Inversion of configuration occurs** with PBr₃ and SOCl₂ since it’s $S_N2$

11.10 - Tosylates, Mesylates, and Triflates: Leaving Group Derivatives of Alcohols
- The hydroxyl group of an alcohol can be converted to a good LG by conversion to a sulfonate ester derivative like the ones shown below,

![](image)

- We can prepare sulfonate esters with DMAP or pyridine and the chlorinated sulfonate derivative
- There is **retention of configuration** in the formation of a sulfonate ester because the C—O bond is not involved, as with pyridine

![](image)
11.11 - Synthesis of Ethers

- Alcohols can dehydrate to form alkenes, as done in Chapter 7. Also, 1° alcohols can dehydrate to form ethers

- Alkenes form too easily for 2° and 3° alcohols to form ethers
- Acid-catalyzed dehydration is not useful for preparing unsymmetrical ethers from different 1° alcohols because the reaction leads to a mixture of products (ROR, ROR', and R'OR')
- A **Williamson Synthesis** converts the hydroxyl group to an alkoxide ion

- When NaH is a reactant, the hydride anion acts as a base to form hydrogen gas thus turning the alcohol into a good nucleophile with O⁻
- Alkoxymercuration-demercuration is a method for synthesizing ethers directly from alkenes, like in the example below, and parallels oxymercuration-demercuration

- An OH group can be protected by converting the alcohol to a temporary ether
- The reaction of 2-methylpropene and H₂SO₄ with a primary alcohol can create a *tert*-butyl ether where the bulky substituent is a protecting group of the hydroxyl group
- Note: MTBE stands for methyl *tert*-butyl ether
- The protecting group can be removed if treated with H₃O⁺
- A hydroxyl group can also be protected by converting it to a silyl ether group with TBDMS-Cl (chicken-footed silicon structure) as a reactant
- A fluorine anion in THF will knock out the protecting group
11.12 - Ether Cleavage

11.13 - Epoxides, 11.15 - Anti 1,2-Dihydroxylation of Alkenes via Epoxides

- Epoxides are cyclic ethers with three-membered rings and can be prepared with an intramolecular $S_N2$ attack

- For this reaction to occur, make sure the stereochemistry of the reactant is in a way that can allow for a center of inversion of, what was originally, the halide atom

- Epoxidation is a syn addition that is stereospecific

- $RCO_3H$ can be used to make an epoxide from an alkene (syn)
11.14 - Reactions of Epoxides
- Two Types: Acid-Catalyzed and Base-Catalyzed (both ring-opening and anti-configuration)
- BLAM: Basic = Less Substituted  Acidic = More Substituted
- The acid-catalyzed ring opening is analogous to a halohydrin reaction (Br$_2$ in ROH)

- The following is an example of an epoxide reaction with stereochemistry shown,