

## Week 3

### CHE 3332 – Organic Chemistry 2

#### Hello and Welcome to the weekly resources for CHE 3332 – Organic Chemistry 2!

This week is Week 3 of class, and typically in this week of the semester your professors are covering these topics below. If you do not see the topics your particular section of class is learning this week, please take a look at other weekly resources listed on our website for additional topics throughout the semester.

We also invite you to **look at the group tutoring chart on our website to see if this course has a group tutoring session offered this semester**. If you have any questions about these study guides, group tutoring sessions, private 30 minute tutoring appointments, the Baylor Tutoring YouTube channel or any tutoring services we offer, please visit our website [www.baylor.edu/tutoring](http://www.baylor.edu/tutoring) or call our drop in center during open business hours. M-Th 9am-8pm on class days 254-710-4135.

**Keywords:** Alcohols, Ethers, Epoxides, Reduction, Oxidation

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#### **TOPIC OF THE WEEK:** Alcohols and Their Reactions (Chapter 12)

What are Alcohols? They are molecules with:

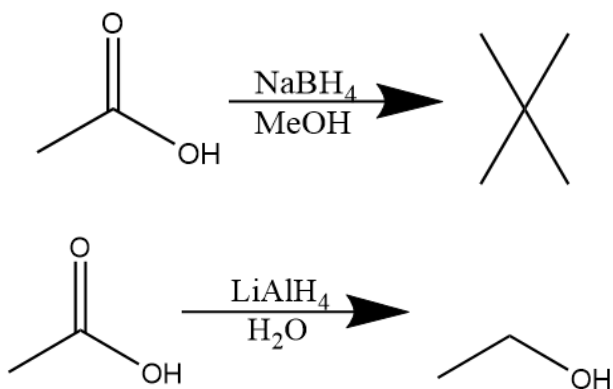
- A hydroxyl (-OH) attached to the carbon chain
- A higher pKa compared to a standard carbon chain, because of the hydroxyl
- Higher boiling points because of their ability to hydrogen bond

**Reactions of Alcohols:** Many reactions involving alcohols can be summed up easily in a table. They are all reactions that you actually touched upon in OChem 1, so its a great idea to be familiar with the material.

Mechanism	Reactant	Reagents	Product
S <sub>N</sub> 2	Primary Halide	NaOH (any strong -OH base)	Primary Alcohol

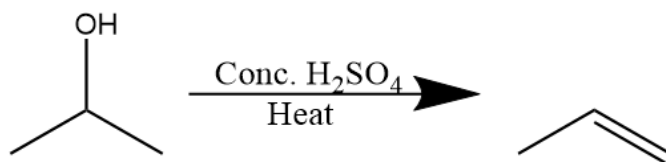
S <sub>N</sub> 1	Tertiary Halide	Water	Tertiary Alcohol
Addition (Acid Catalyzed)	Alkene	Dilute H <sub>2</sub> SO <sub>4</sub>	-OH is placed on the more substituted carbon
Addition (Oxymercuration Demercuration)	Alkene	1. Hg(OAc) <sub>2</sub> , H <sub>2</sub> O 2. NaBH <sub>4</sub>	-OH is placed on the more substituted carbon, added anti to the hydrogen
Addition (Hydroboration-Oxidation)	Alkene	1. BH <sub>3</sub> , THF 2. H <sub>2</sub> O <sub>2</sub> , NaOH	-OH is placed on the less substituted carbon, added syn to the hydrogen
Reduction	Carbonyl (Ketone or Aldehyde)	1. NaBH <sub>4</sub> 2. MeOH Or 1. LiAlH <sub>4</sub> 2. H <sub>2</sub> O	Can give any type of alcohol, depending on the starting reactant (primary, secondary, etc.)
Grignard Reaction	Carbonyl (Ketone or Aldehyde)	1. RMgX 2. H <sub>2</sub> O	Either a secondary or tertiary alcohol

**Important Note!** Not all reducing agents are equal in strength. Specifically, NaBH<sub>4</sub> **cannot** reduce molecules such as carboxylic acids, while LiAlH<sub>4</sub> can easily do so.

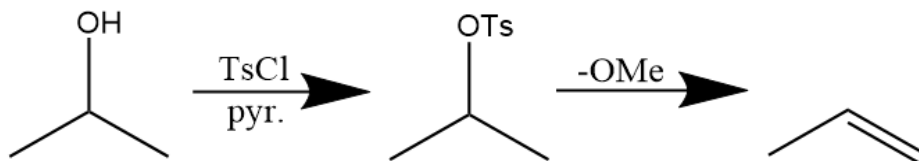


Alcohol Eliminations:

Two new reactions that you will learn about are in regards to the elimination of alcohols. The first one is quite simple, using concentrated acid to eliminate the hydroxyl group.



The second reaction uses a new reagent, tosyl chloride, to transform our hydroxyl into a tosylate (-OTs). While hydroxyls are poor leaving groups, tosylates are great at being pulled off a molecule, and will easily be eliminated using a strong base.



### HIGHLIGHT #1: Ethers and Epoxides

Ethers are compounds which contain an oxygen molecule within the carbon chain (**NOT** on the terminal ends). They can be cyclic, or in a straight chain.

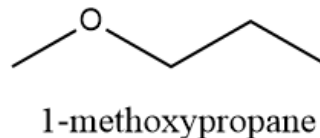
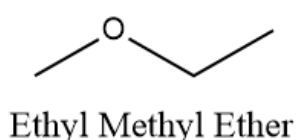
**Naming Ethers:** Ethers are special in that they can be named in two different ways, using either the IUPAC name or the common naming convention.

**Common Name:**

1. Identify the two R groups attached to the oxygen atom
2. Arrange both groups alphabetically, and add ether at the end

**IUPAC Name:**

1. Find the longer of the two R groups, this will be the parent chain
2. The shorter R group, will then be an alkoxy substituent, for example, a methyl bonded to an oxygen would be a methoxy substituent



**Reactions with Ethers:**

Mechanism	Reactant	Reagent	Product
Williamson Ether Synthesis	1°, 2°, or 3° alcohols	1. NaH 2. Primary or secondary halide	Either symmetrical or asymmetrical ether

Alkoxymercuration-demercuration	Alkene	1. $\text{Hg}(\text{OAc})_2$ , ROH 2. $\text{NaBH}_4$	-OR group is added to the more substituted carbon, and is anti to the hydrogen
Acidic Cleavage	Ether	1. Excess HX 2. Heat	Two alkyl halides, and water
Alcohol Dehydration	2 of the same primary alcohol	1. $\text{H}_2\text{SO}_4$ 2. Heat	A symmetrical ether

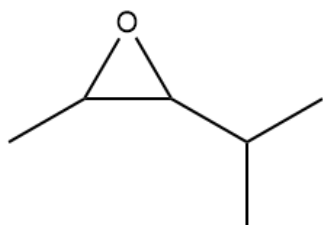
Not only do these conventions and reactions work best with straight chain ethers, but we can also work with cyclic ethers. These molecules are so important, that they actually have their own classification, epoxides.

### Naming epoxides:

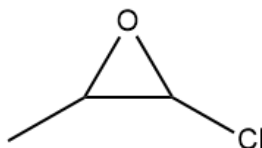
1. Find the longest carbon chain, including those in the epoxide
2. Using this chain as the parent chain, each branching point will be its own substituent.  
The oxygen portion of the epoxide will be an epoxy substituent.

Or

1. The oxirane is the parent portion, and will be the namesake of the molecule
2. Every carbon chain branching off the epoxide will be named as its own substituent.



2,3-epoxy-4-methylpentane



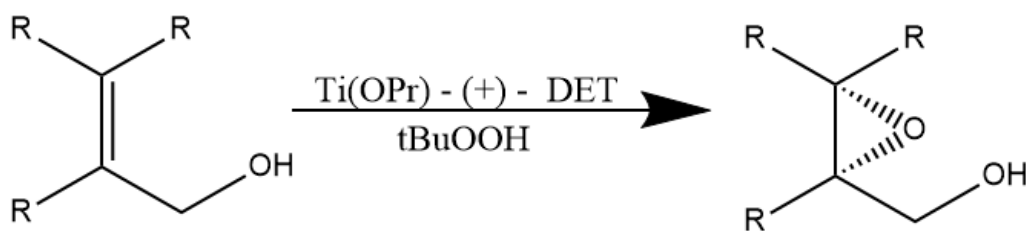
2-chloro-3-methyloxirane

### Reactions with Epoxides:

Mechanism	Reactant	Reagent	Product
Addition using Peroxy Acids	Alkene	1. mCPBA	Epoxide ring, retaining cis/ trans stereochemistry of the original molecule
Conversion of Halohydrins	Alkene	1. $\text{X}_2$ , $\text{H}_2\text{O}$ 2. NaOH	Epoxide ring, retaining cis/ trans

			stereochemistry of the original molecule
Ring Opening (Acid Catalyzed)	Epoxide	1. HX	The nucleophile prefers attacking at a 3° carbon, but favors 1° carbons over 2°, with inverted stereochemistry
Ring Opening (Base Catalyzed)	Epoxide	1. Strong base / nucleophile 2. H <sub>2</sub> O	The nucleophile attacks at the least substituted carbon, and inverting stereochemistry.
Ring Opening (Grignard Reagent)	Epoxide	1. RMgBr 2. H <sub>3</sub> O <sup>+</sup>	The nucleophile attacks at the least substituted carbon, inverting stereochemistry.

### Sharpless Asymmetric Epoxidation (SAE):



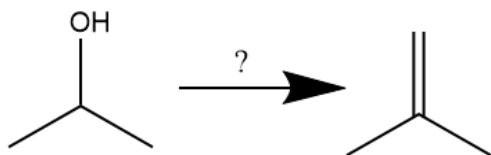
This is a very difficult type of reaction involving 3D space that you will need to know. It is good to understand how to accurately do this reaction each time.

1. Orient the alkene so that the hydroxyl substituent is facing towards the bottom right corner, by flipping and rotating the molecule.
2. Next determine which way the epoxide will face. If the reagent is (+)-DET, then the epoxide will face downwards, and when using (-)-DET, the epoxide will face upwards.
3. Now that the epoxide is created, re-orient the molecule to be in its original position. If it was flipped, this will change which direction the epoxide is facing. (If you flipped your molecule over, then a downward-facing epoxide would become an upward facing one).

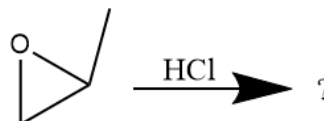
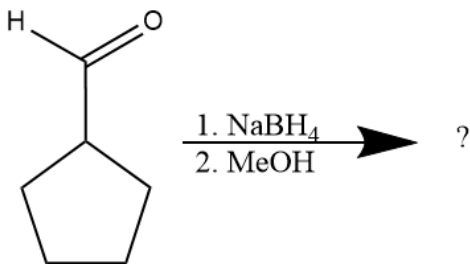
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## CHECK YOUR LEARNING:

Provide an efficient synthesis for this reaction:



Predict the product for each reaction:



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## THINGS YOU MAY STRUGGLE WITH:

- As mentioned above, SAE can be difficult because of the in & out of the page aspect. Having a model kit can be very helpful to visualize what is going on
- Memorize and **UNDERSTAND** what certain reagents will open epoxides the way they do. Also, make sure to keep track of whether or not the reaction is acid or base-catalyzed and the substituents present, this can get **TRICKY!**
- OChem 2 is focused a lot on reactions, mechanisms, and knowledge from OChem 1. Just because you finished OChem 1 doesn't mean you should forget it, instead you should be focused on keeping up with older material.
- For extra support, a good YouTube resource is the Organic Chemistry Tutor [https://www.youtube.com/watch?v=B\\_ketzJtY8&list=PL0o\\_zxa4K1BXP7TUO7656wg0uF1xYnwg](https://www.youtube.com/watch?v=B_ketzJtY8&list=PL0o_zxa4K1BXP7TUO7656wg0uF1xYnwg). Not only does he have videos about the important topics, he also has some of the more obscure reactions, which can be super helpful.

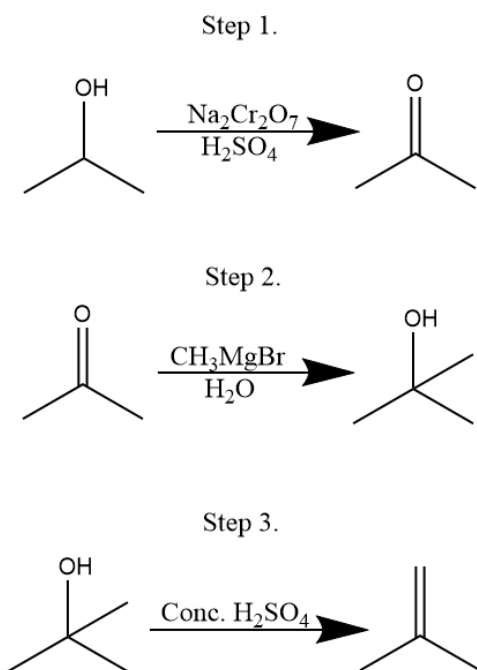
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Thanks for checking out these weekly resources!

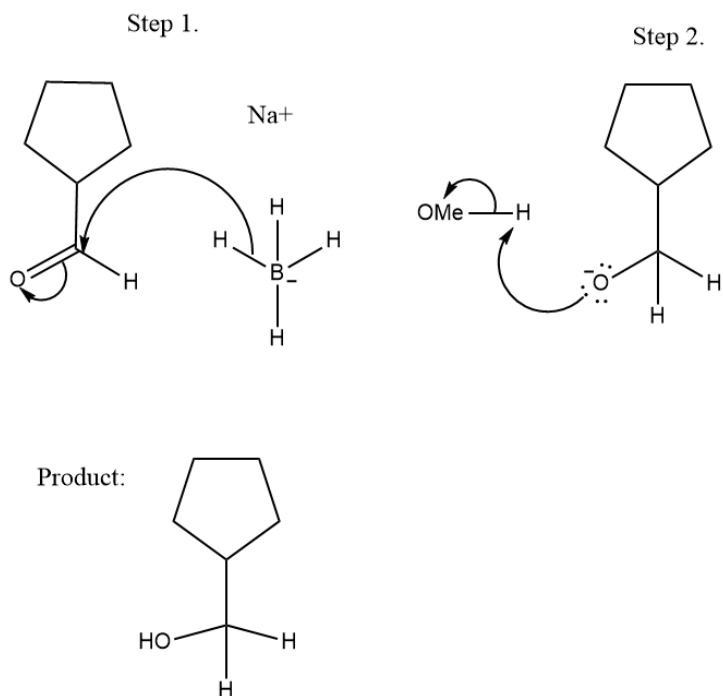
Don't forget to check out our website for group tutoring times, video tutorials and lots of other resources: [www.baylor.edu/tutoring](http://www.baylor.edu/tutoring)! Answers to check your learning questions are below!

### ANSWERS TO PRACTICE PROBLEMS:

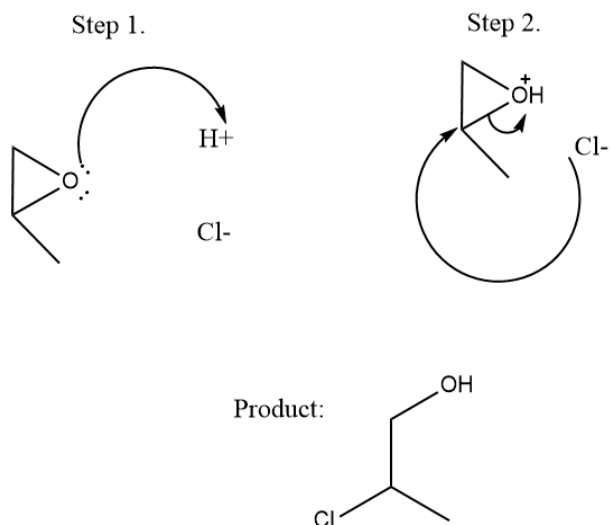
Problem 1:



Problem 2:



Problem 3:



*All tables are property of Organic Chemistry by David Klein. All diagrams and molecules were made by me.*