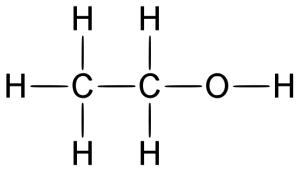
Alcohols, Ethers, and Thiols

Chapter 1.4

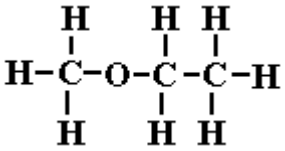
Alcohols, Ethers, and Thiols

- An **alcohol** is an organic compound that contains the hydroxyl (-OH) functional group



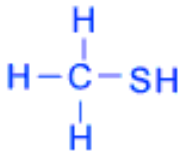
ethanol

- An **ether** is an organic compound containing an oxygen atom between two carbon atoms in a chain



methoxyethane

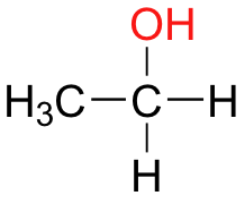
- A **thiol** is an organic compound that contains the sulfhydryl (-SH) functional group



methanethiol

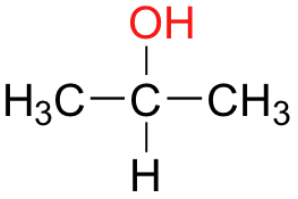
Classification of Alcohols

- A **primary alcohol** is an alcohol in which the hydroxyl group is bonded to a terminal carbon atom



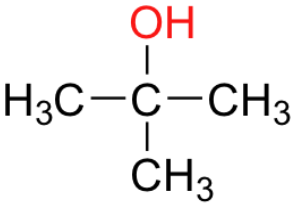
a primary alcohol

- A **secondary alcohol** is an alcohol in which the hydroxyl group is bonded to a carbon atom with two alkyl groups bonded to it



a secondary alcohol

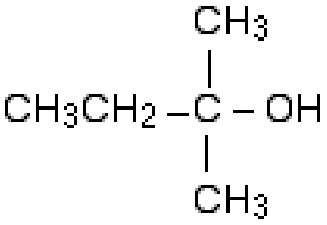
- A **tertiary alcohol** is an alcohol in which the hydroxyl group is bonded to a carbon atom with three alkyl groups bonded to it

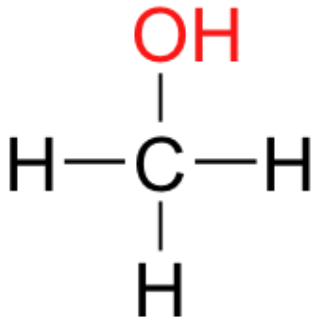


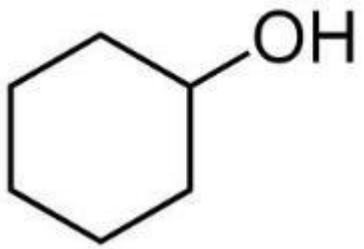
a tertiary alcohol

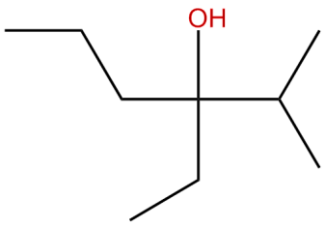
Practice

- Classify the following alcohols as primary, secondary, or tertiary:

a) 

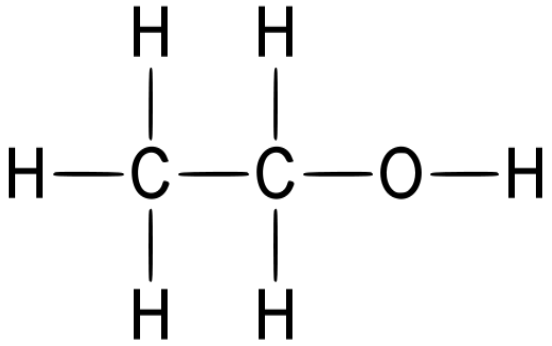
b) 

c) 

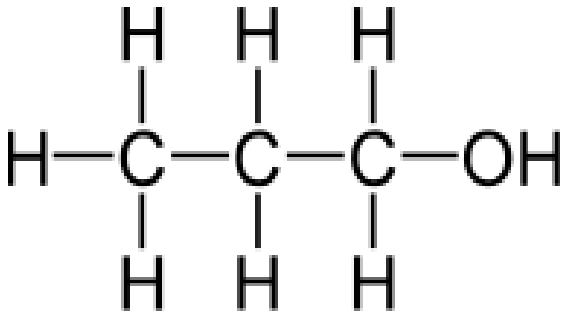
d) 

Naming Alcohols

- Use the suffix *–ol*
- Number the parent chain so that the hydroxyl group has the lowest number possible (ignore the location of other branches, and double or triple bonds)
- If necessary, include a number before the *–ol* suffix to indicate which carbon the hydroxyl group is attached to



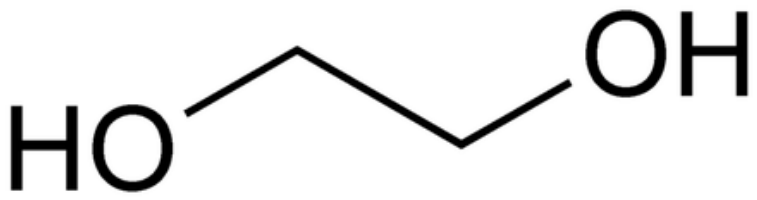
ethanol



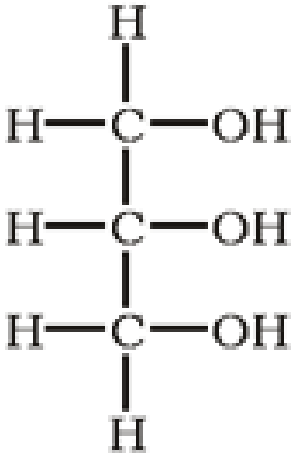
propan-1-ol

Naming Alcohols

- Alcohols containing more than one hydroxyl group are referred to as polyalcohols. Use the suffix –diol or –triol



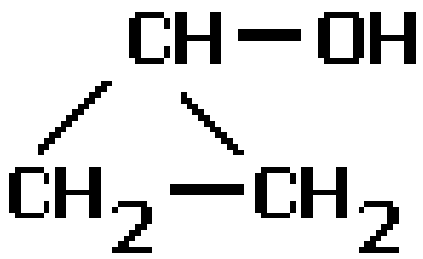
ethane-1,2-diol
(commonly called ethylene glycol and used as antifreeze)



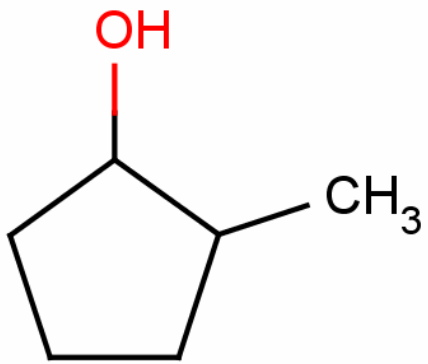
propane-1,2,3-triol
(commonly called glycerol and used in the pharmaceutical industry)

Naming Alcohols

- If the hydroxyl group is attached to a cyclic hydrocarbon, remember to number the ring so that the hydroxyl group has the lowest number possible, and use the prefix cyclo-



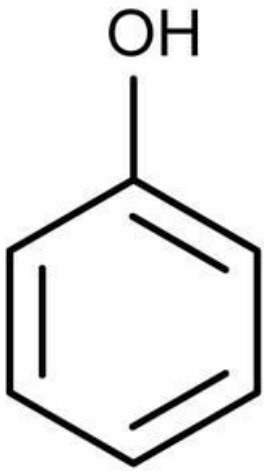
cyclopropanol



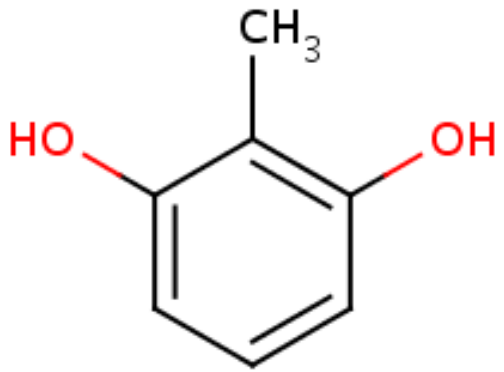
2-methylcyclopentanol

Naming Alcohols

- The hydroxyl group can also be attached to an aromatic hydrocarbon
- A benzene ring with one hydroxyl group bonded to it is called phenol
- If the benzene ring has multiple hydroxyl groups benzene is used as the root word



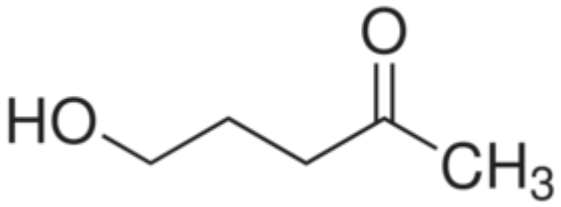
phenol



2-methylbenzene-1,3-diol

Naming Alcohols

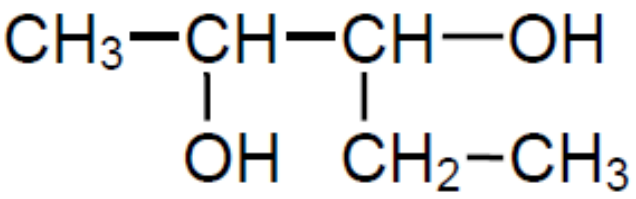
- Later, when we learn about aldehydes, ketones, and carboxylic acids we will see that sometimes it is necessary to name the (-OH) group as a branch
- In this case the prefix hydroxy- is uesd

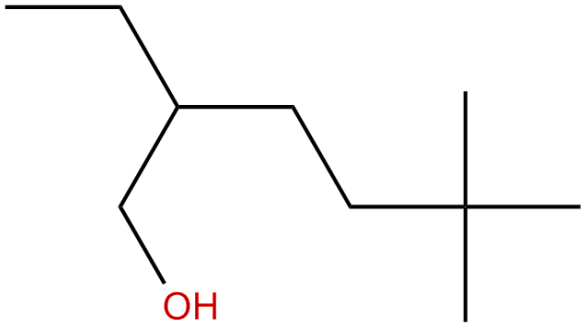


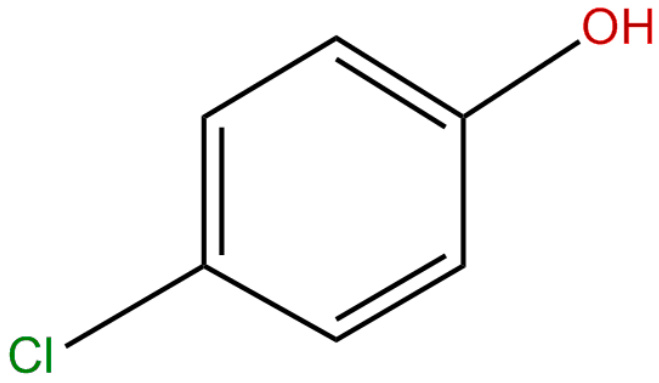
5-hydroxyheptan-2-one

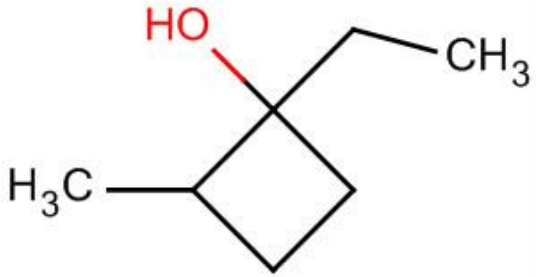
Practice

Name the following alcohols:

a) 

b) 

c) 

d) 

Practice

Draw structural diagrams for the following alcohols:

a) 3-ethyl-4-methylcyclohexanol

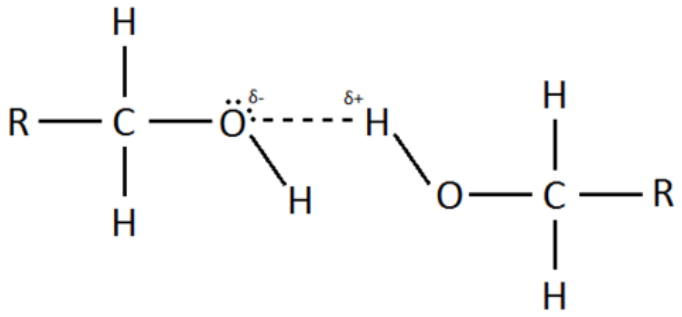
b) 2-chloropent-3-ene-1,1,3-triol

Properties of Alcohols

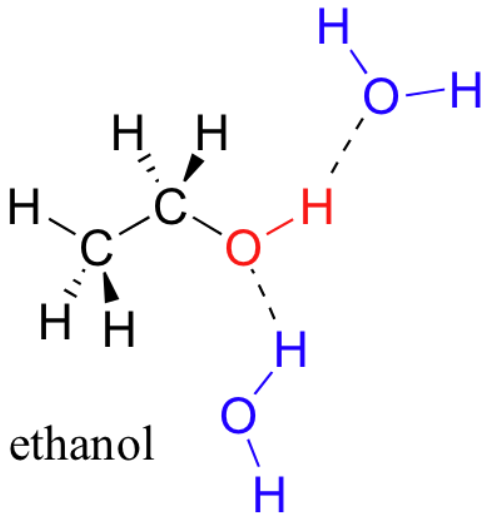
•The hydroxyl group makes alcohols **polar** and allows them to participate in **hydrogen bonding**

•**Hydrogen bonding** is a strong dipole-dipole force between a hydrogen atom attached to a highly electronegative atom (N, O, or F) in one molecule and a highly electronegative atom in another molecule

Hydrogen bonding between alcohols gives them **very high melting and boiling points**



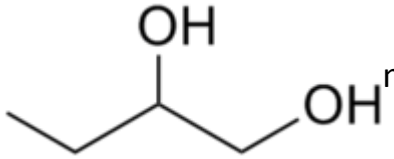
Hydrogen bonding between alcohols and water makes them **soluble**



Properties of Alcohols

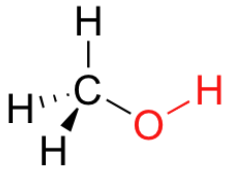
- Alcohols containing two or more hydroxyl groups have higher water solubility and boiling points than alcohols with one –OH group

less soluble in water
b.p. 117°C

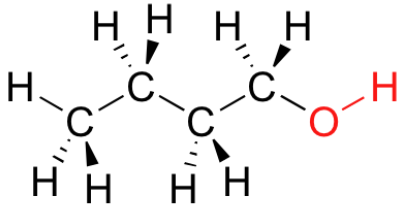


more soluble in water
b.p. 195°C

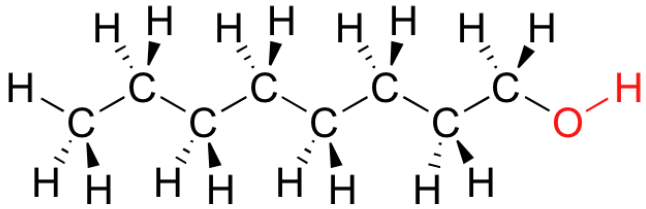
- Alcohols with high molecular weight are less soluble than alcohols with low molecular weight
- Alcohols with high molecular weight have higher boiling points than alcohols with low molecular weight



very soluble in water
b.p. 65°C



slightly soluble in water
b.p. 117°C

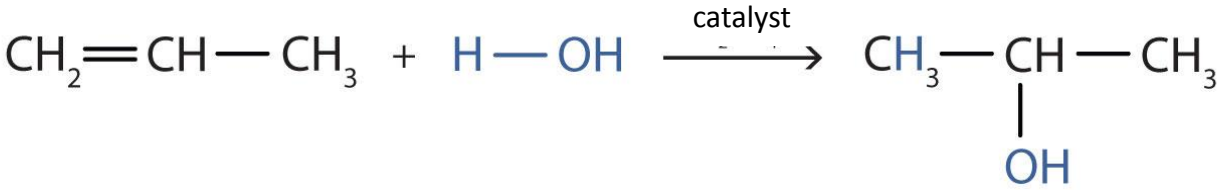


very insoluble in water
b.p. 195°C

Reactions Involving Alcohols

Preparing alcohols:

1) Addition – Hydration



2) Production of methanol

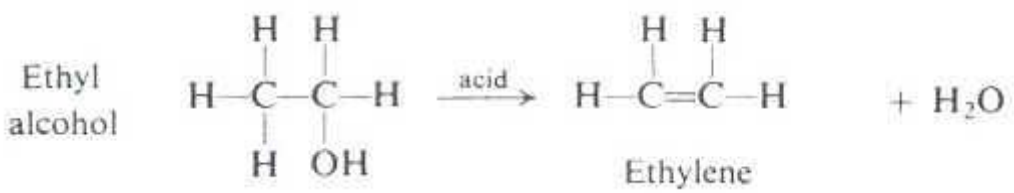
$$CO_{(g)} + 2H_{2(g)} \xrightarrow{\text{catalyst}} CH_3OH_{(l)}$$

3) Fermentation (Production of ethanol)

$$C_6H_{12}O_{6(aq)} \xrightarrow{\text{yeast}} 2CO_{2(g)} + 2C_2H_5OH_{(aq)}$$

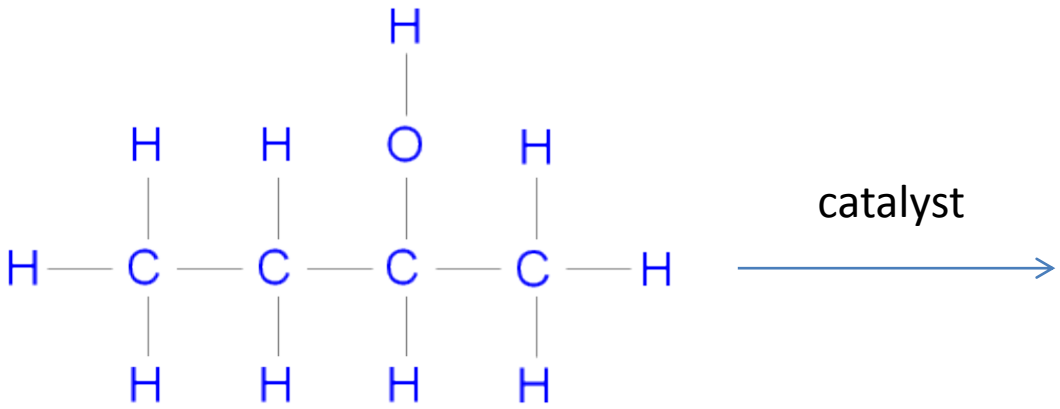
Reactions Involving Alcohols

- In addition to **combustion reactions**, alcohols also undergo elimination reactions
- An **elimination reaction** is a reaction in which two substituents are removed from a single molecule to form two molecules
- Elimination reactions are the opposite of addition reactions
- The specific type of elimination reaction that alcohols undergo is called dehydration
- A **dehydration reaction** is a reaction that involves the removal of a hydrogen atom and a hydroxyl group from the reactant, producing a slightly smaller molecule and water
- This reaction requires a catalyst



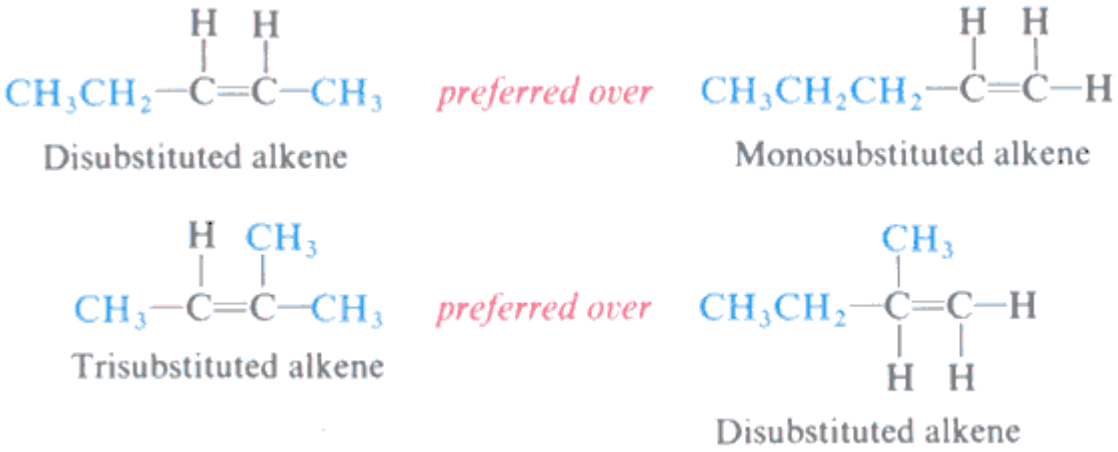
But wait! There's a PROBLEM!

- Predict the products of the dehydration of butan-2-ol



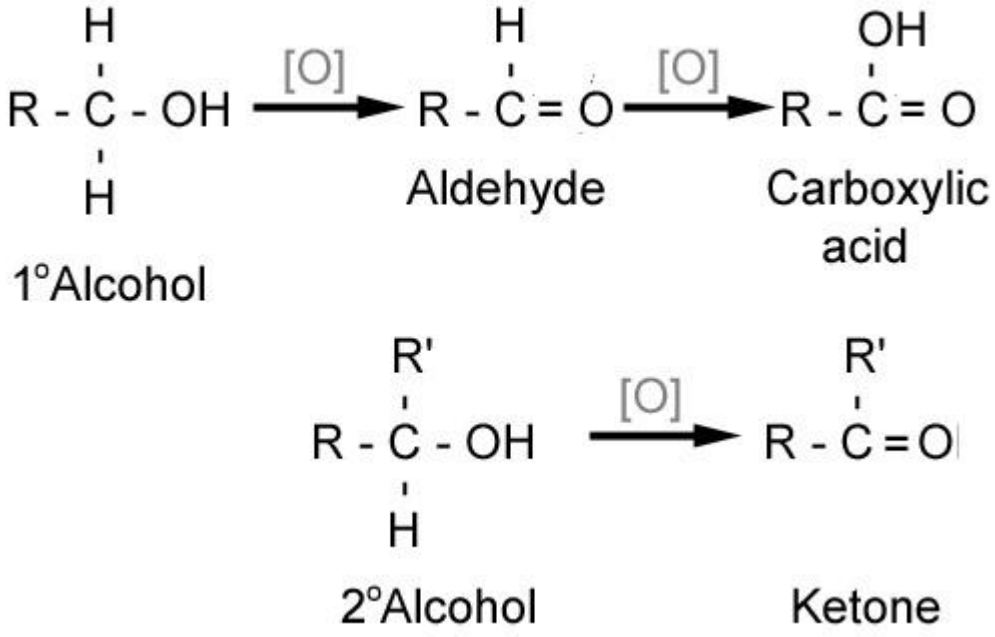
Rule of Thumb

- When more than one alkenes can result from dehydration of an alcohol, a mixture of products is usually fromed
- The major product in the mixture is the alkene that has the greater number of alkyl groups attached to the double-bonded carbons



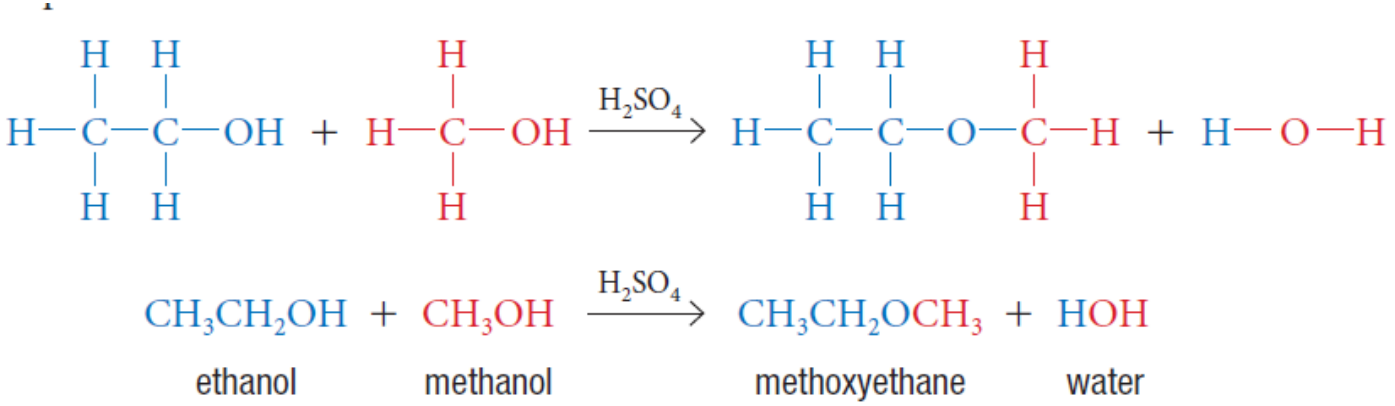
Reactions Involving Alcohols

- Alcohols also undergo **controlled oxidation** reactions
- **Primary** alcohols react to form aldehydes and further to form carboxylic acids
- **Secondary** alcohols react to form ketones
- **Tertiary** alcohols do not undergo controlled oxidation
- *We will learn more about controlled oxidation when we get to aldehydes and ketones*



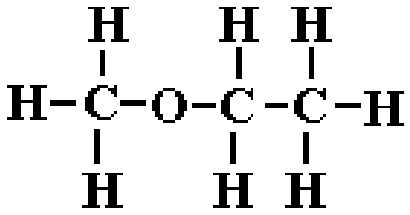
From Alcohols to Ethers

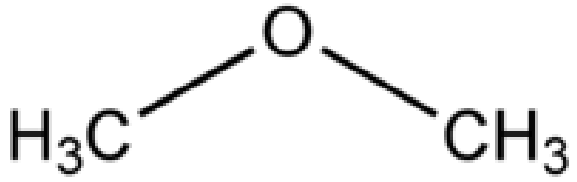
- Ethers can be synthesized from a condensation reaction involving two alcohols
- A **condensation reaction** is a chemical reaction in which two molecules combine to form a larger molecule and a small molecule, such as water
- This reaction requires an acid catalyst



Naming Ethers

- The IUPAC method is to add the suffix *–oxy* to the smaller hydrocarbon group that is bonded to the larger alkane group
- A number may be required to indicate the carbon atom that the oxygen is attached to on the longer chain
- A common naming system uses the names of the two hydrocarbon groups followed by the word “ether”





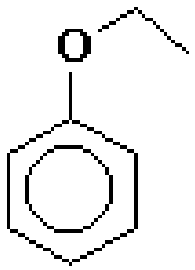
IUPAC: methoxyethane

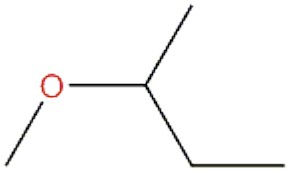
common: ethyl methyl ether

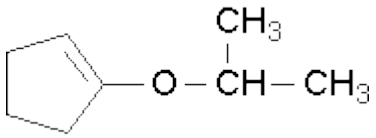
Practice

This one is a challenge!

1) Give the proper IUPAC name for:

a) 

b) 

c) 

2) Draw structural diagrams for:

a) 3-ethoxyheptane

b) methoxycyclopropane

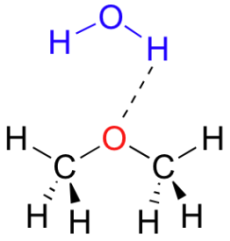
Properties of Ethers

TABLE 8.1 PROPERTIES OF ALCOHOLS, ETHERS, AND HYDROCARBONS OF SIMILAR MOLECULAR WEIGHT

Compound	Formula	bp	mol wt	Water solubility (g/100 mL, 20°C)
1-butanol	$CH_3CH_2CH_2CH_2OH$	118°C	74	7.9
diethyl ether	$CH_3CH_2—O—CH_2CH_3$	35°C	74	7.5
pentane	$CH_3CH_2—CH_2—CH_2CH_3$	36°C	72	0.03

- Notice that ethers are more like alkanes than alcohols when it comes to boiling point
- Intermolecular hydrogen bonding is not possible in alkanes or ethers while it is possible in alcohols

- Notice that ethers are more like alcohols than alkanes when it comes to solubility
- Hydrogen bonding with water is possible for ethers and alcohols but not for alkanes



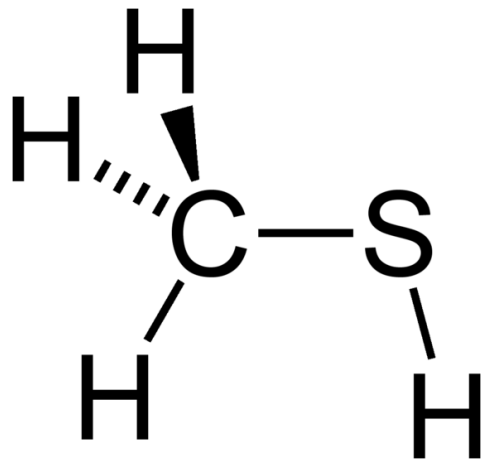
dimethylether

Reactions Involving Ethers

- Ethers are very unreactive compounds and thus only undergo combustion reactions

Thiols

- Thiols contain the sulfhydryl functional group (-SH)
- They have strong odours (garlic, skunk)
- To name thiols, add the suffix *–thiol* to the alkane name



methanethiol

HOMEWORK

Required Reading:

p. 32-39

Questions:

p. 34 #1-2

p. 37 #1-2

p. 38 #1-2

p. 39 #1-6