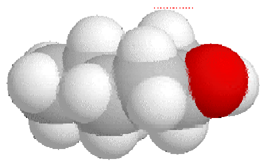
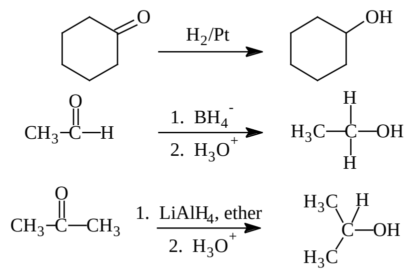
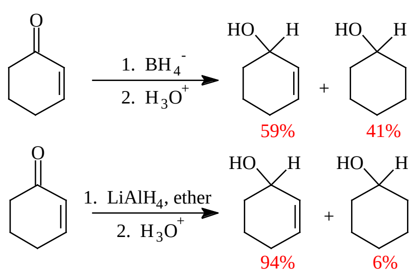
Alcohols, Ethers & Thiols



Reactions that Yield Alcohols

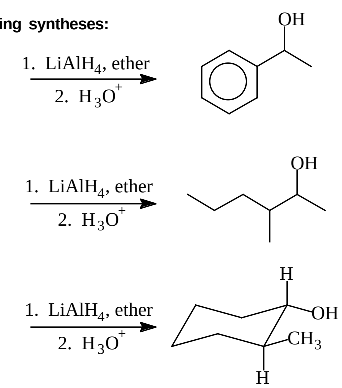
Preparation of Alcohols by Reduction of Aldehydes and Ketones





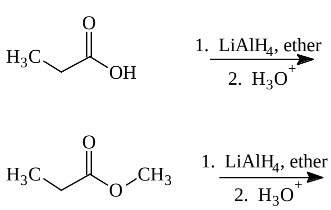
Aldehydes and ketones are readily reduced by $LiAlH_4$ and BH_4^- ; for safety reasons $NaBH_4$ is preferred, when it is equally effective.

Complete the following syntheses:



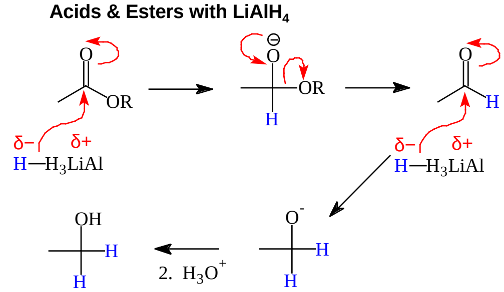
Reactions that Yield Alcohols

Preparation of Alcohols by Reduction of Carboxylic Acids & Esters with $LiAlH_4$

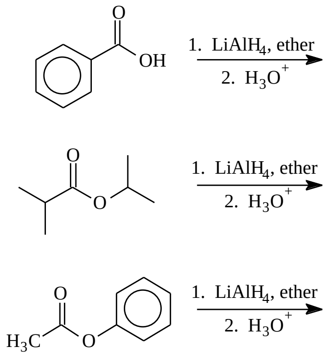


Reactions that Yield Alcohols

Preparation of Alcohols by Reduction of Carboxylic Acids & Esters with $LiAlH_4$

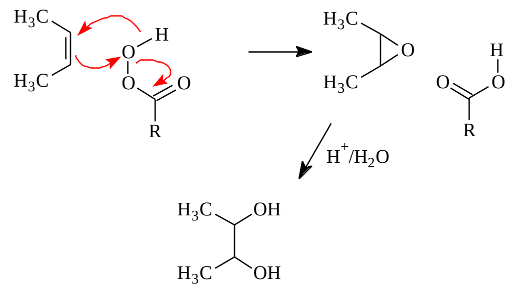


Predict the products for each of the following reactions.



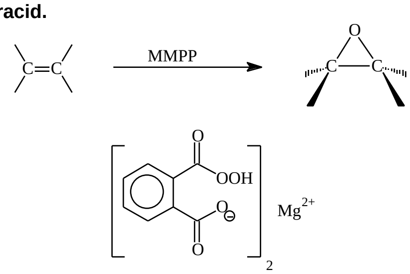
Reactions that Yield Alcohols

Preparation of Alcohols from Oxiranes (Epoxides or Oxacyclopropanes)



Reactions that Yield Epoxides

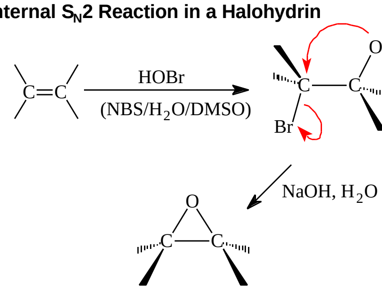
Magnesium monoperoxyphthalate is a convenient peracid.

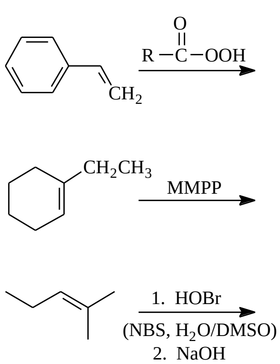


Magnesium Monoperoxyphthalate
(MMPP)

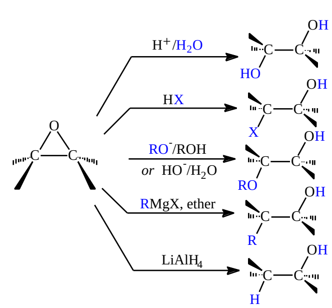
Reactions that Yield Epoxides

Internal S_N2 Reaction in a Halohydrin





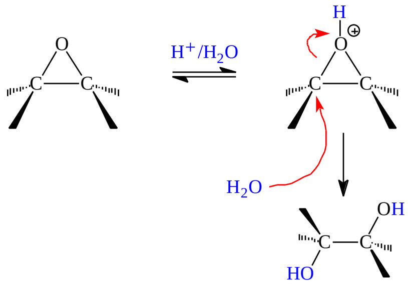
Reactions of Epoxides



In general, the attack is at the least hindered carbon.

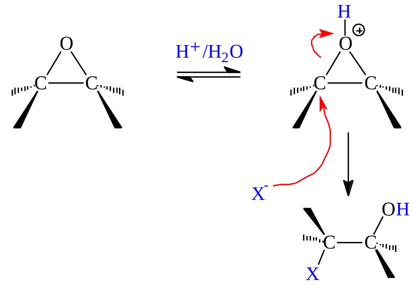
Reactions that Yield Alcohols

Acid-catalyzed hydrolysis of epoxides.



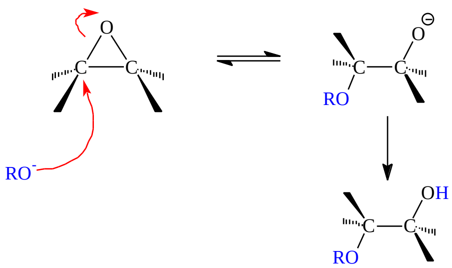
Reactions that Yield Alcohols

Addition of HX to epoxides.



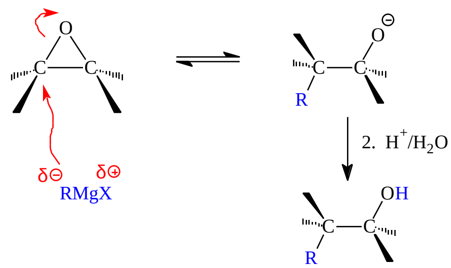
Reactions that Yield Alcohols

Addition of alkoxide anions to epoxides.



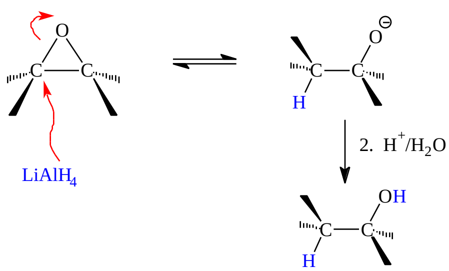
Reactions that Yield Alcohols

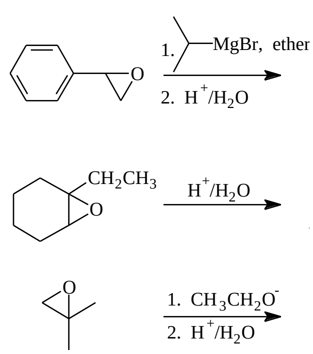
Grignard reagents also attack oxiranes to give alcohols which are elongated by two carbons.



Reactions that Yield Alcohols

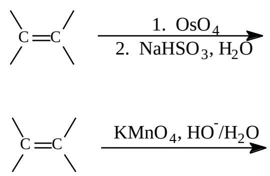
$LiAlH_4$ also attack oxiranes to give alcohols.





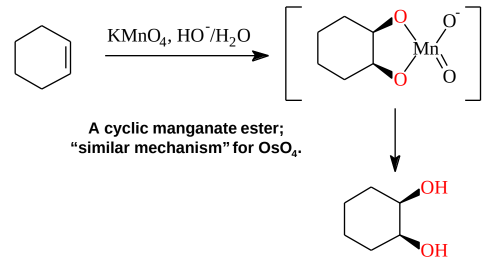
Reactions that Yield Alcohols

Oxidation of alkenes to give *cis*-diols.



Reactions that Yield Alcohols

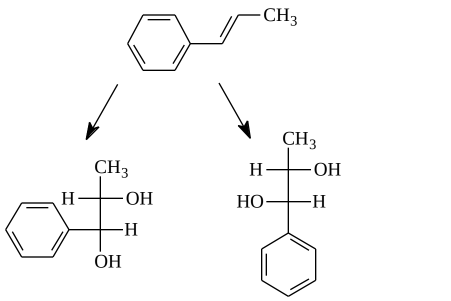
Oxidation of alkenes to give *cis*-diols.



A cyclic manganate ester; "similar mechanism" for OsO_4.

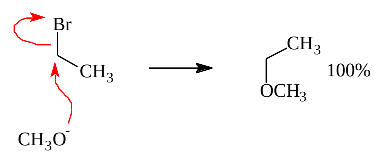
Synthesis:

Suggest methods to convert *trans*-1-propenylbenzene into the diols shown below.



Reactions of Alcohols

The Williamson Ether Synthesis: a Simple S_N2 Reaction



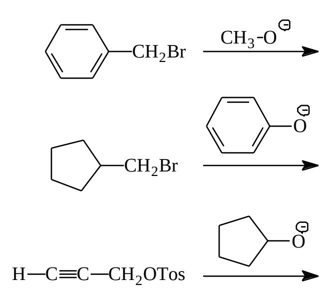
Reactions of Alcohols

The Williamson Ether Synthesis: a Simple S_N2 Reaction

Factors Favoring S_N2 Reactions

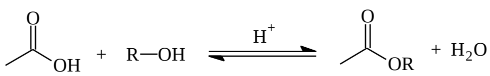
- **Unhindered Substrate** (1° > 2° > 3°)
- **Non-Polar or Polar Aprotic Solvents** (DMF or DMSO)

Predict the products of the following substitution reactions.

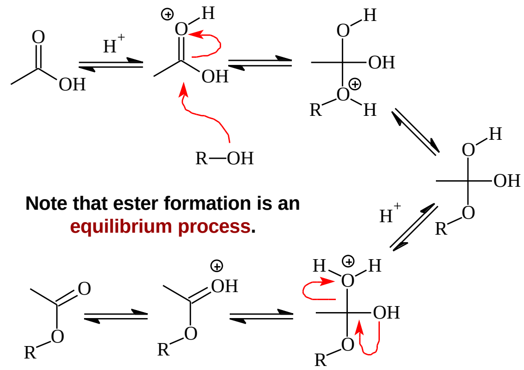


Reactions of Alcohols

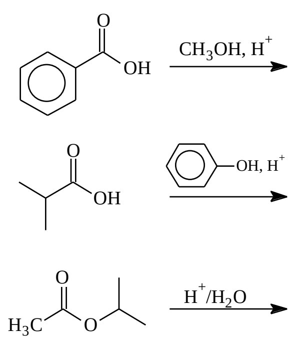
Fischer esterification.



In **Fischer esterification**, a carboxylic acid and an alcohol react to form a **carboxylate ester**.

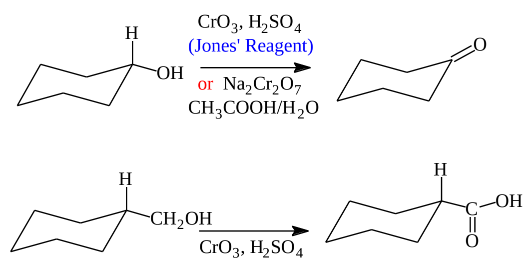


Note that ester formation is an equilibrium process.



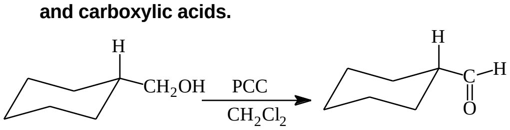
Reactions of Alcohols

Oxidation of alcohols to yield aldehydes, ketones and carboxylic acids.

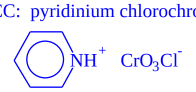


Reactions of Alcohols

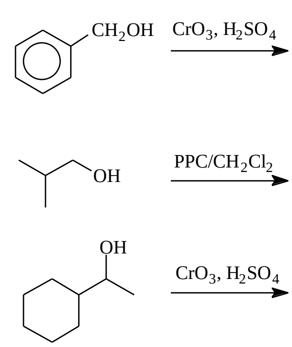
Oxidation of alcohols to yield aldehydes, ketones and carboxylic acids.



PCC: pyridinium chlorochromate

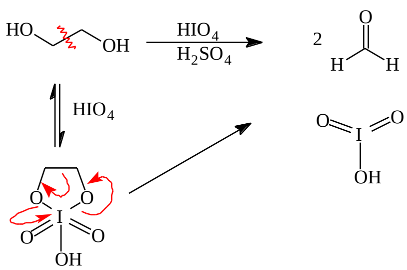


Primary alcohols are smoothly oxidized to aldehydes using PCC

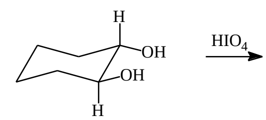


Reactions of Alcohols

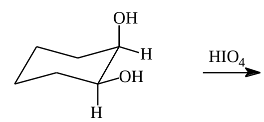
Oxidative cleavage of 1,2-Diols by HIO_4 to give aldehydes and ketones.



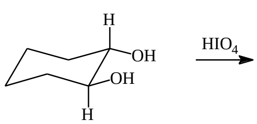
***trans*-1,2-Cyclohexanediol undergoes rapid cleavage by HIO_4, while the *cis*-isomer reacts slowly. Explain.**



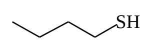
Draw the cyclic iodate ester for each compound.



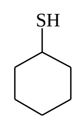
Predict the product for the HIO_4 cleavage of *trans*-1,2-Cyclohexanediol.



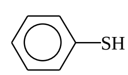
Thiols, the Sulfur Analog of Alcohols



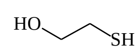
butane thiol



cyclohexane thiol



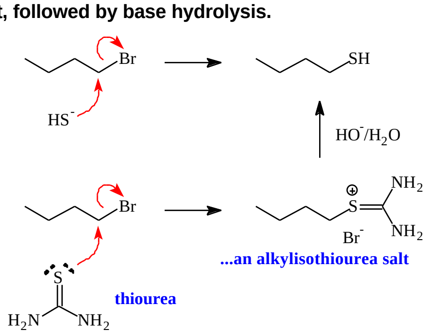
benzene thiol



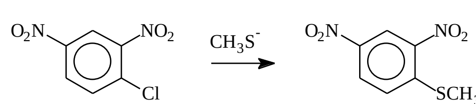
2- mercapto ethanol

The suffix of *thiol* is used; when the SH group is a substituent on another compound, it is called a *mercapto* group.

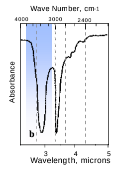
Thiols can be prepared from alkyl halides by S_N2 displacement, or by conversion to an alkylisothiourea salt, followed by base hydrolysis.

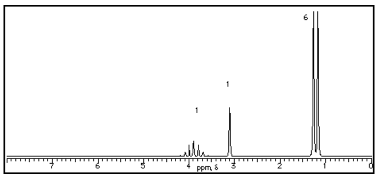


Thiolate anions are powerful nucleophiles in S_N2 reactions and in nucleophilic aromatic substitution.



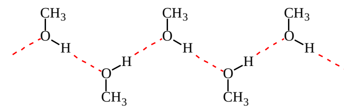
Spectroscopy of Alcohols & Thiols

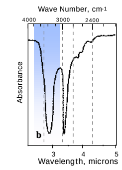




Infrared Spectroscopy

Alcohols display strong broad O-H stretching bands in the region **3800-3100 cm^{-1}**. The bands are broadened due to hydrogen bonding and a sharp 'non-bonded' peak can often be seen at around 3400 cm $^{-1}$.

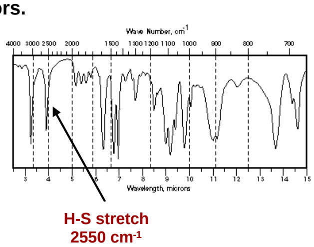


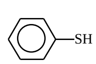


Partial infrared spectrum of 2–propanol as a liquid film.

Infrared Spectroscopy

Thiols display a strong sharp O-H stretching band in the region around **2550 cm^{-1}**. The bands are not broadened because thiols are poor hydrogen bond donors.

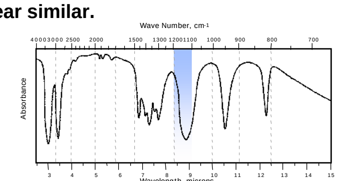




Infrared spectrum of benzenethiol.

Infrared Spectroscopy

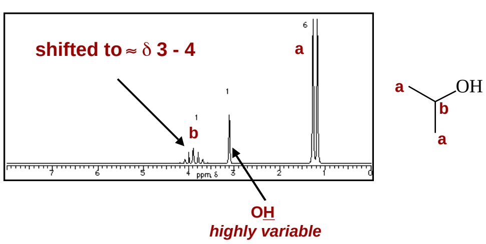
Carbon-oxygen single bonds display stretching bands in the region **1100-1200 cm $^{-1}$**. The bands are generally strong and broad. You should note that many other functional groups have bands in this region which appear similar.



Infrared spectrum of 2–propanol; the C–O stretch is a strong band at 1120 cm^{-1}.

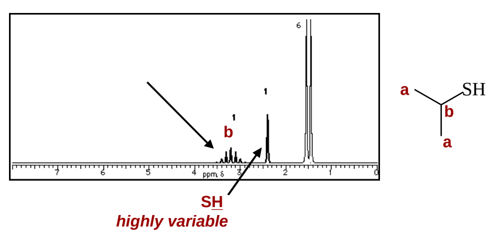
^{1}H NMR Spectroscopy

Alcohols display highly variable O-H absorbances in the ^{1}H NMR. The electronegative oxygen tends to deshield adjacent protons, shifting them to around 4 ppm.



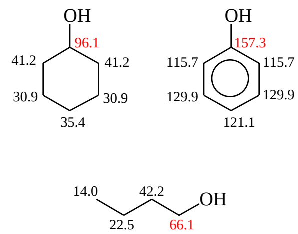
^{1}H NMR Spectroscopy

Thiols also display highly variable S-H absorbances in the ^{1}H NMR. The sulfur tends to deshield adjacent protons, shifting them to around 3 ppm.



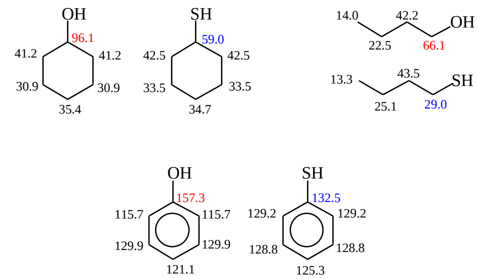
^{13}C NMR Spectroscopy

Carbons attached to electronegative hydroxyl groups are deshielded and are shifted downfield (to larger δ values) by 40 - 50 ppm.

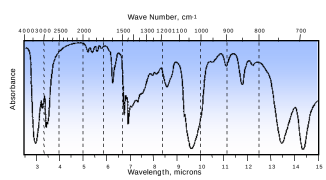


^{13}C NMR Spectroscopy

Carbons attached to sulfhydryl groups are only slightly deshielded and are shifted downfield (to larger δ values) by 5 - 20 ppm.



IR Data: $C_8H_{10}O$



NMR Data:

The peak at 4.15 ppm in the ^{1}H NMR disappears if the compound is exposed to D_2O. ^{13}C Spectral Data: singlet, 140.2 ppm; doublet, 128.4 ppm; doublet, 127.9 ppm; doublet, 125.7 ppm; triplet, 68.5 ppm; triplet, 44.6 ppm