

Organic Chemistry – Reactions

ALKANES:

I **Combustion Reactions or Oxidation in Air:** (i.e. rapid reaction with O_2).

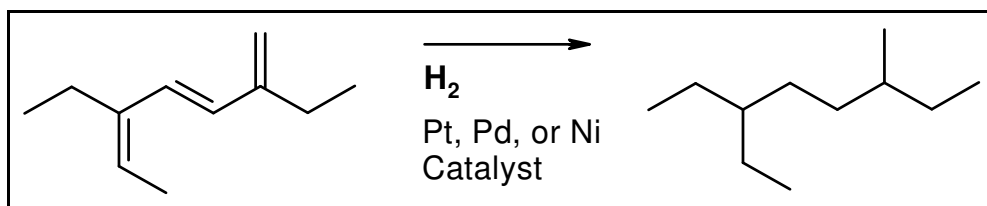
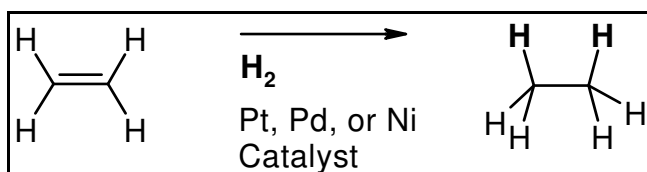


You should be able to balance any oxidation reaction.

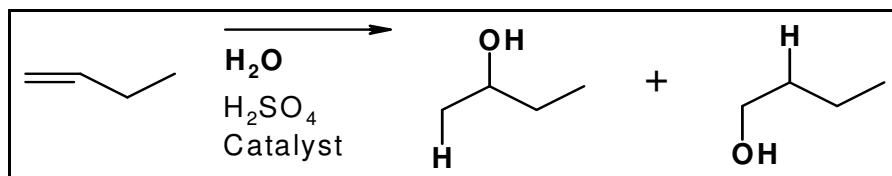
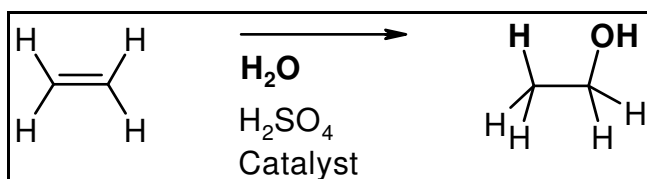
ALKENES:

I **Addition Reactions:** In an addition reaction one of the bonds in the double bond is broken and replaced by the addition of two fragments from the molecule being added.

a) **Hydrogenation:**

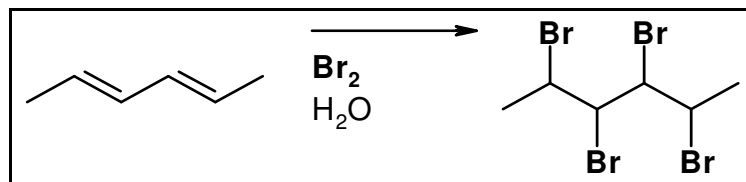
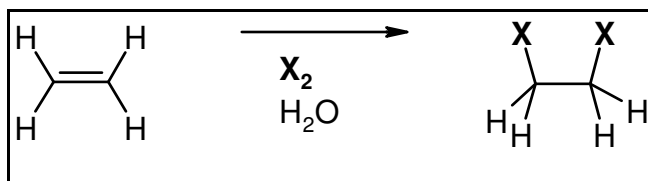


b) **Hydration:**

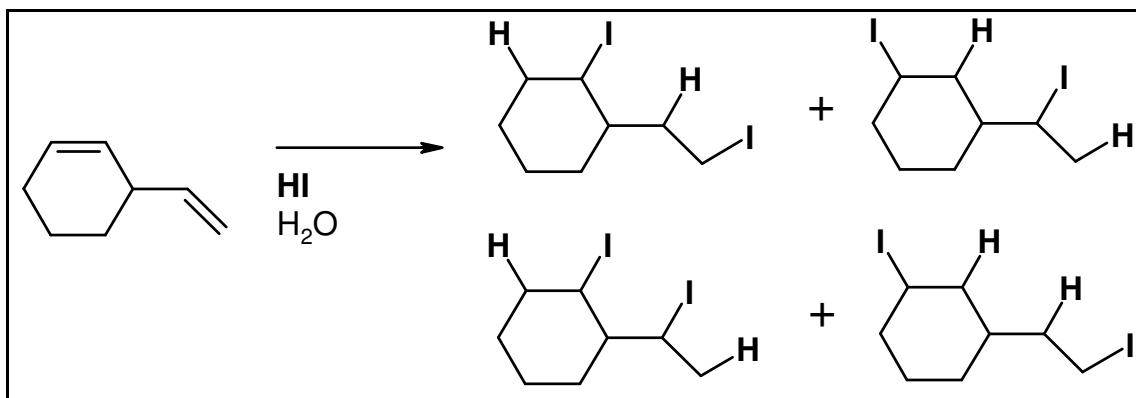
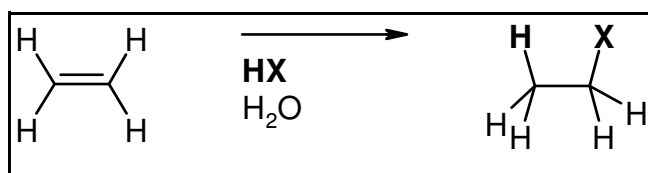


Note that in the previous example, two possible products can occur. This will happen whenever the organic reactant is asymmetric about the double bond AND the molecule added is also asymmetric such as H_2O or HCl

c) **Halogenation:** (X represents one of F, Cl, Br, I)



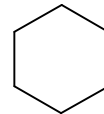
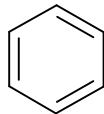
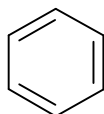
d) **Hydrohalogenation:**



Note that in the case of an asymmetric addition multiple products may be possible depending on the geometry of the starting material.

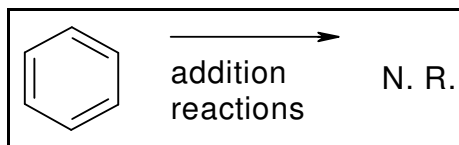
II Aromatic Compounds:

Aromatic compounds are carbon rings with alternating double bonds, often referred to as a **conjugated double bond** ring system. In such a system the second bond in a double bonds is said to undergo an **electronic resonance** in which this bond is able to flip position without breaking the valency rules for carbon. A six carbon conjugated aromatic ring system is very common. Two **resonant structures** for benzene are show below. The third structure shows a common representation for aromatic systems, in which the double bonds are replaced by a circle to indicate the smoothing out of three double bonds into six bond and a halves.

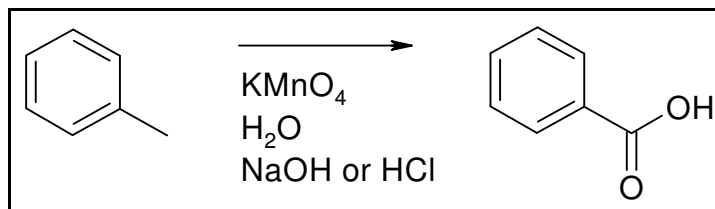


The double bonds flip position very rapidly (millions of times per second) resulting in an average of one and a half bonds per carbon - carbon bond. This adds stability to the "double bonds" in this system greatly lowering their reactivity. This is called **resonance stabilization**. This also results in **delocalized electrons** (electrons that are not confined to a particular atom or bond).

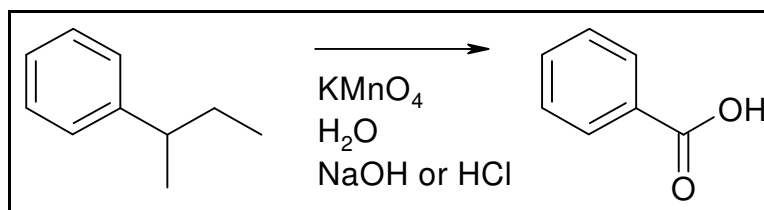
Any Addition Reaction:



Oxidation of Substituted Aromatic Rings:

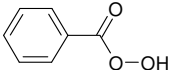


All substituted aromatic rings form carboxylic acid using only the first carbon in the side chain.

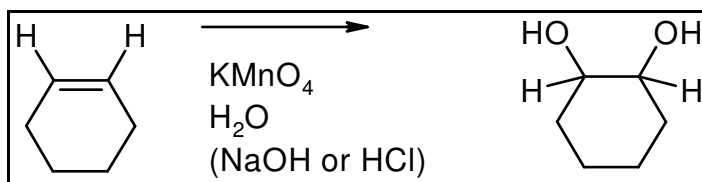


Note that KMnO_4 is one of many common oxidizing agents used in organic chemistry.

III Oxidation to Diols:

There are many different oxidizing agents in organic chemistry (e.g. $K_2Cr_2O_7$, O_3 ,  etc). The one that we will commonly use in

$KMnO_4$, which has a deep purple colour. In **organic chemistry** and **oxidation** will result in the **addition of oxygen** to a molecule **and/or the remove of hydrogen**. The opposite process, a **reduction** results in the **removal of oxygen** and or the **addition of hydrogen**.



Note in the above example:

two oxygens are added - therefore oxidation?

two hydrogens are added - therefore reduction?

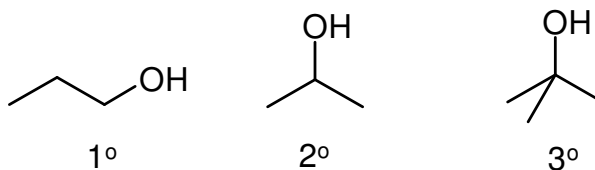
oxygen represents more significant oxidation, therefore this is an overall oxidation

Oxidation:	ADD OXYGEN	remove hydrogen
Reduction:	REMOVE OXYGEN	add hydrogen

ALCOHOLS:

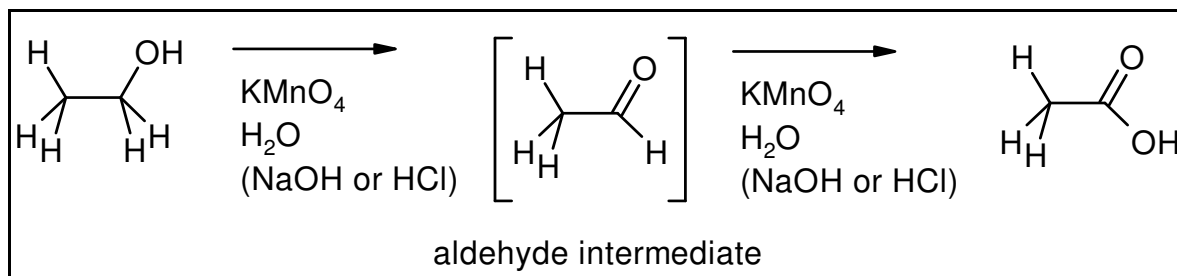
Alcohols are classified according to the number of carbon atoms directly attached to the alcohol carbon (the carbon to which the alcohol group is attached).

Number of Carbons Attached to the Alcohol Carbon	Degree of Alcohol
1 (or 0)	1° or Primary
2	2° or Secondary
3	3° or Tertiary

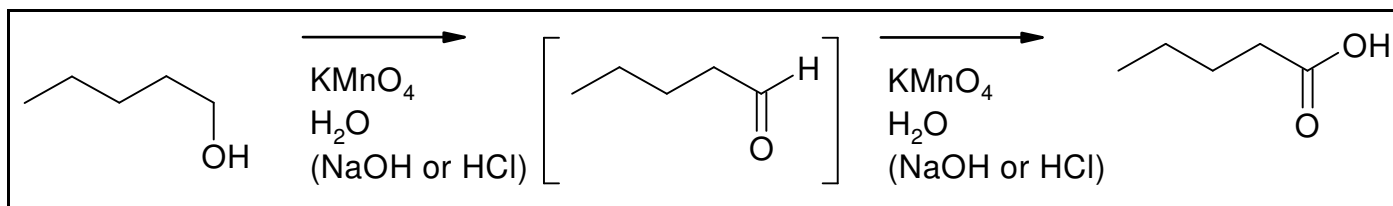


I Oxidation of Alcohols:

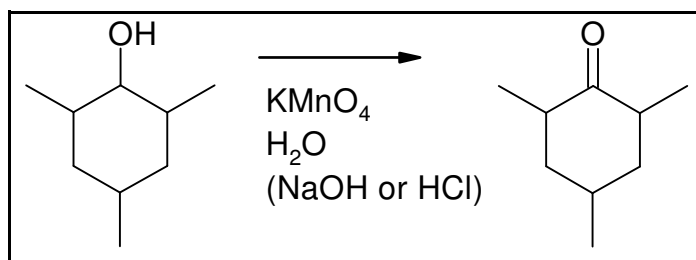
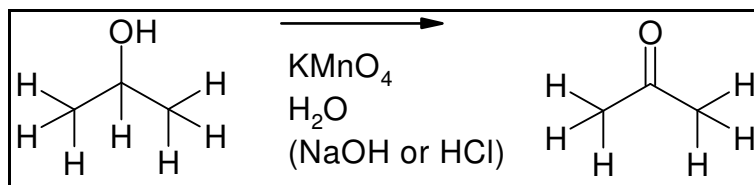
a) Primary Alcohols to Carboxylic Acid Product:



Note that the hydrogen in the alcohol group and a hydrogen on the alcohol carbon is removed to facilitate the formation of the double bond in the carbonyl group. This is the case for all oxidations of alcohols

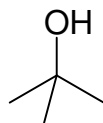


b) Secondary Alcohols to Ketone Product:



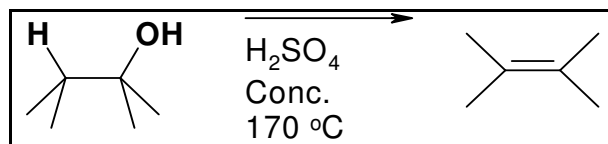
c) Tertiary Alcohols:

No reaction occurs. In the case of first and second degree alcohols, a hydrogen is removed from the alcohol carbon and a second hydrogen is removed from the alcohol group itself to facilitate the formation of the double carbonyl bond. Since no hydrogen is present on the alcohol carbon, no reaction takes place.

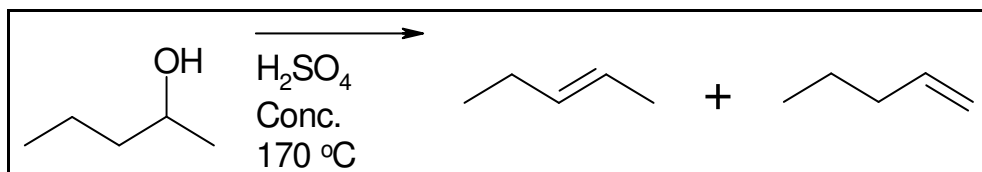


in this case, the alcohol carbon has no hydrogen available for removal and therefore no oxidation can occur

II Dehydration (Elimination of Water)

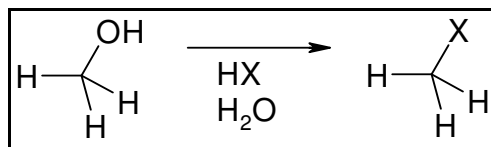


Water is produced as a by-product from the alcohol group and a hydrogen on the adjacent carbon.

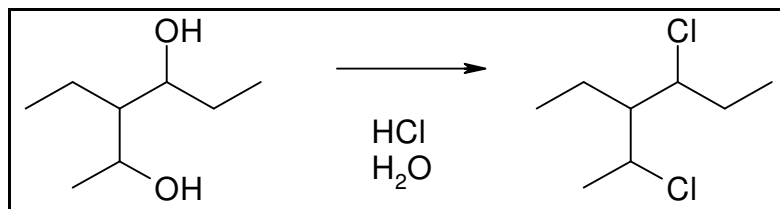


Notice the possibility of multiple products

III Substitution Reactions:

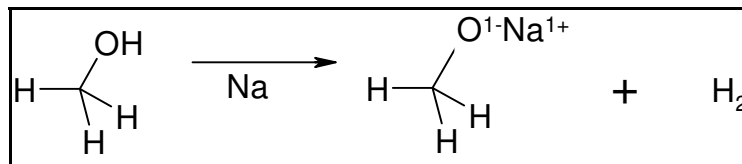


This is like an ion substitution, OH¹⁻ has been replaced by X¹⁻

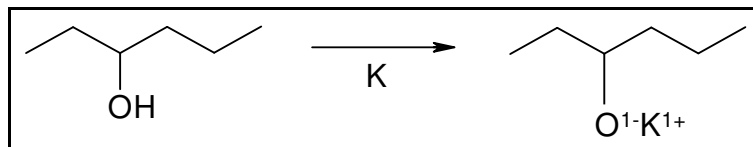


Substitution requires an attack from a nucleophile, which is a negative ion or a molecule with a negative lone pair of electrons. The hydroxyl group (i.e. the -OH of the alcohol) becomes a leaving group. In the above example Cl¹⁻ from the HCl performs the nucleophilic attack, and the OH¹⁻ group leaves. Water is a by product of this reaction.

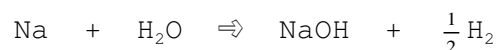
IV Reaction with Alkali Earth Metals:



An alkoxide product and a H_2 bi-product forms.



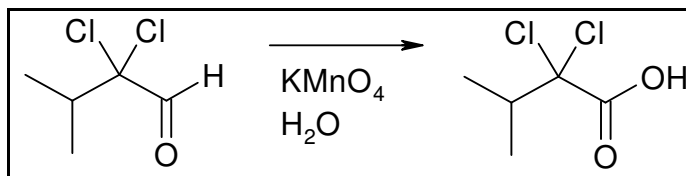
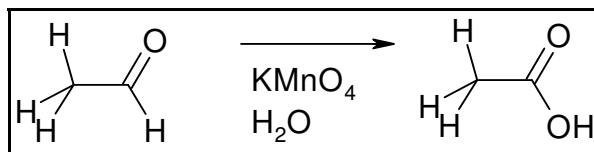
In both of these reactions H_2 is a by product. Note the negative charge on the oxygen and the positive charge on the sodium in the alkoxide product. This reaction is analogous to the reaction between water and an alkali earth metal.



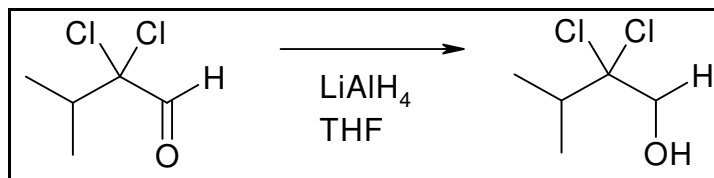
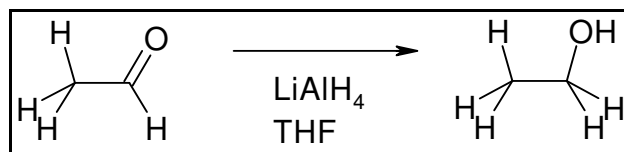
Here the sodium in sodium hydroxide has a positive charge and the oxygen has a negative charge. In the reaction with an alcohol, the hydrogen in the hydroxide group of the sodium hydroxide is replaced by a carbon chain.

ALDEHYDES:

I Oxidation to Carboxylic Acids:

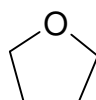


II Reduction to Primary Alcohols:



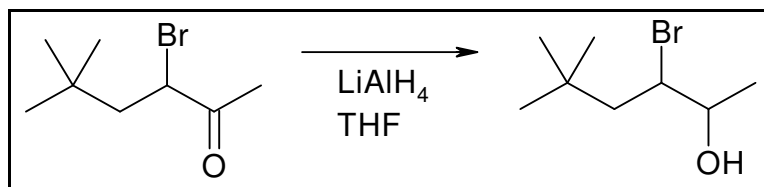
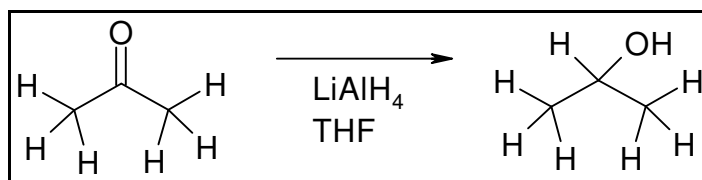
LiAlH_4 is a very dangerous and reactive compound with a 1- oxidation state on the hydrogen!

THF is short for tetrahydrofuran, a liver eating ether.



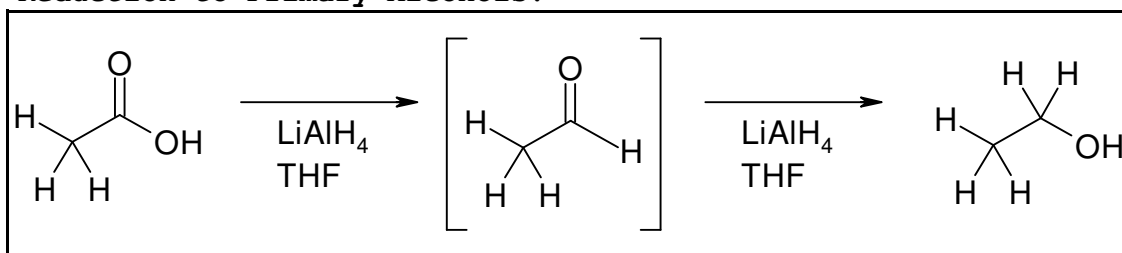
KETONES:

I Reduction to Secondary Alcohols:



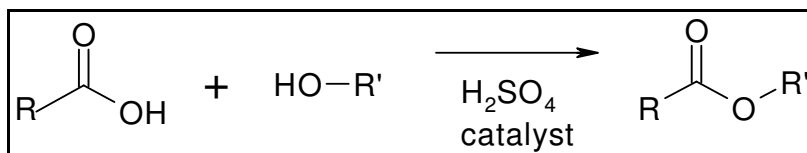
CARBOXYLIC ACIDS:

I Reduction to Primary Alcohols:

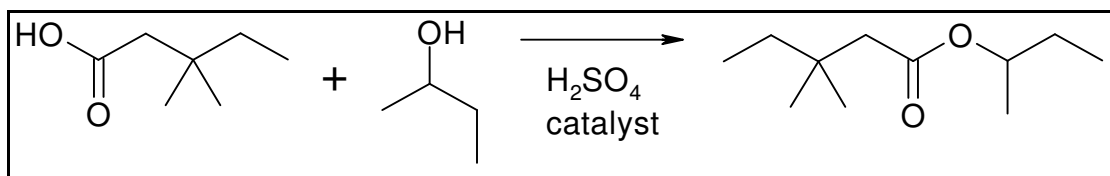


II Esterification (dehydration synthesis):

Water is a by-product in this reaction. The sulphuric acid catalyst serves two purposes. First, it acts as a catalyst by providing an alternative reaction mechanism with a lower activation energy making the reaction possible at room temperature. Second, it serves as a dehydration agent which removes the water by-product hence driving this equilibrium reaction forward according to Le Chatelier's Principle.



Note that a water bi product is produced. The water molecule has been proven to form from the -OH group on the carboxylic acid and the H from the alcohol group from the alcohol. This have been proven using radioactive labeling techniques.



3,3-dimethylpentanoic acid + secbutyl alcohol → secbutyl 3,3-dimethylpentanoate

ESTERS:

I Hydrolysis:

