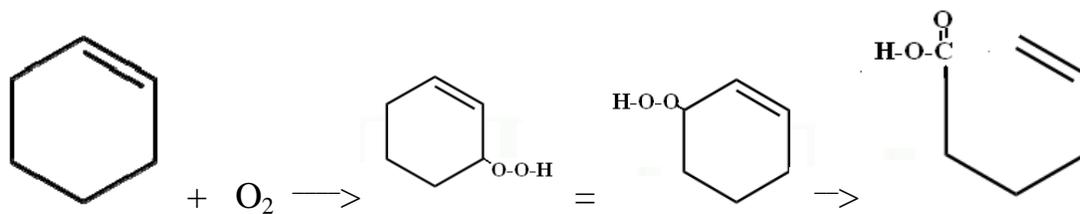
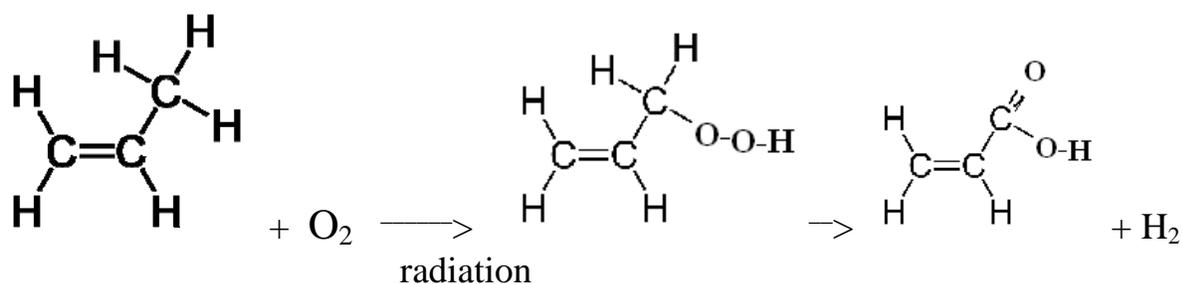


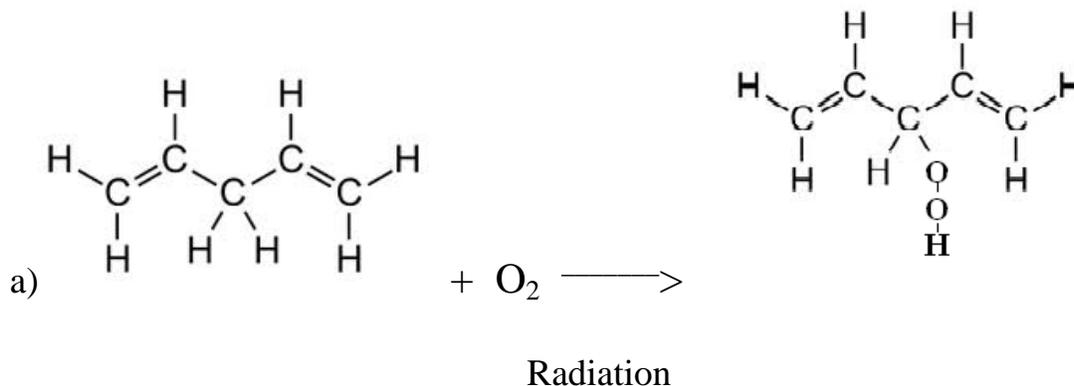
### 3.11 OXIDATION

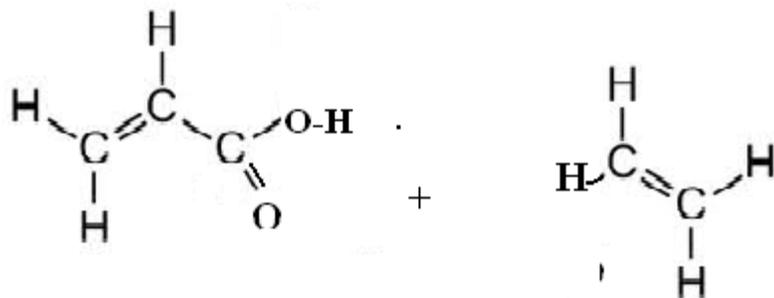
One last example of reactions of alkenes is oxidation, the addition of oxygen atoms to an alkene molecule. The exact nature of the oxidation products depends on what form of oxidizing agent is used. We will look at just one example, namely the oxidation of alkene molecules with molecular oxygen,  $O_2$ . Alkenes react with  $O_2$  to produce hydroperoxides which themselves are not very stable and can decompose to form two aldehyde or carboxylic acid functional groups.

Oxidation of alkenes is speeded up by exposure to radiation which can produce free radicals and the addition of the  $O_2$  molecule actually most commonly occurs at a C adjacent to the double bond (called an allylic C atom) as shown below.

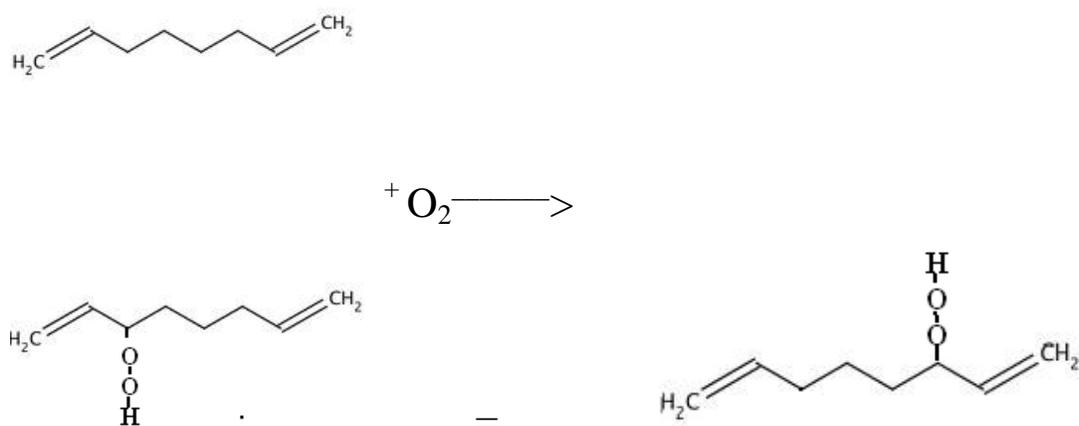


C atoms in between two  $C=C$  are even more susceptible to oxidation by  $O_2$ .

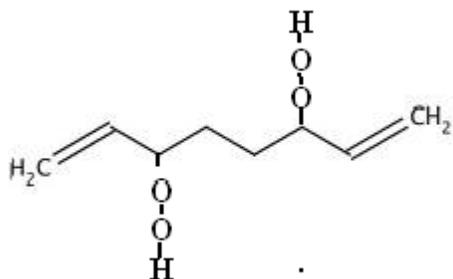




b)



If enough  $\text{O}_2$  is around long enough you could get hydroperoxides formed at both of the C atoms adjacent to the  $\text{C}=\text{C}$  (allylic C atoms).



Examples where alkene oxidation is important in the real world:

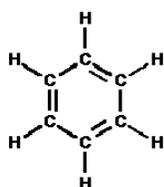
1. When oxygen oxidizes the double bonds in polyunsaturated vegetable oils, they form hydroperoxides which can decompose further to form carboxylic acids and give it a rancid taste. When polyunsaturated oils sit around open to the air they become rancid due to the production of carboxylic acids.

2. Polyunsaturated molecules in cell membranes can be oxidized during a cell's metabolism of food, causing damage to the membrane.
3.  $O_2$  and  $O_3$ (ozone) can also react with the  $C=C$  double bonds in latex rubber (see structure given previously) and break up the long chains of rubber molecules. The rubber molecules resemble long springs that “snap back” after being stretched. But when these springs are broken, the spring cannot snap back again and the rubber breaks. Cracks that appear in tires are an example of rubber oxidation.

### 3.12 AROMATIC MOLECULES: MOLECULES WITH *DELOCALIZED* ELECTRONS

These molecules really are no more or less literally “aromatic” than other organic molecules. A really correct chemical definition of aromatic is beyond the scope of this course. The examples of aromatic molecules discussed in this course are cyclic alkenes containing 3 alternating conjugated double bonds which give them some unique electronic properties different from other alkenes.

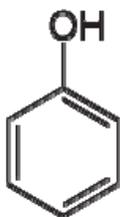
The primary aromatic molecule is benzene whose structure is shown below.



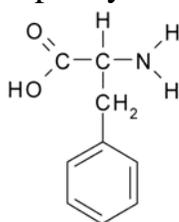
According to the naming rules we have given earlier, this would be named 1,3,5-cyclohexatriene. But it was named benzene by a German chemist at the time of its discover in 1833 and that name has been accepted as the systematic name.

When the benzene molecule was first isolated and studied, the Germans called it **benzene** while the French and British chemists called it **phene**. Although the German name won out, a benzene ring with an alcohol group is called phenol, and when we refer to a benzene ring as a side group of larger molecule it is referred to as a **phenyl** group.

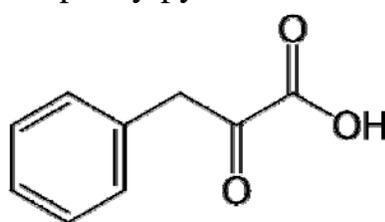
Phenol



phenylalanine



phenylpyruvic acid



Notice the alternating conjugated double bonds in the ring structure. Because of the double bonds the C=C bonds have a trigonal planar geometry with a C-C-C bond angle of 120°. This is the angle found in a flat hexagon, and hence benzene forms a flat molecule, unlike cyclohexane which forms a chair or boat conformation. Also note that the presence of the double bonds results in just one H