Ozonolysis

In determining the structural formula of an alkene, it is often necessary to find the location of the double bond within a given carbon framework. One way of accomplishing this would be to selectively break the double bond and mark the carbon atoms that originally formed that bond. For example, there are three isomeric alkenes that all give 2-methylbutane on catalytic hydrogenation. These are 2-methyl-2-butene (compound A), 3-methyl-1-butene (compound B) and 2-methyl-1-butene (compound C), shown in the following diagram. If the double bond is cleaved and the fragments marked at the cleavage sites, the location of the double bond is clearly determined for each case. A reaction that accomplishes this useful transformation is known. It is called ozonolysis.

Ozone, $O_3$, is an allotrope of oxygen that adds rapidly to carbon-carbon double bonds. Since the overall change in ozonolysis is more complex than a simple addition reaction, its mechanism has been extensively studied. Reactive intermediates called ozonides have been isolated from the interaction of ozone with alkenes, and these unstable compounds may be converted to stable products by either a reductive workup (Zn dust in water or alcohol) or an oxidative workup (hydrogen peroxide). The results of an oxidative workup may be seen by clicking the “Show Reaction” button a second time. Continued clicking of this button repeats the cycle. The chief difference in these conditions is that reductive workup gives an aldehyde product when hydrogen is present on a double bond carbon atom, whereas oxidative workup gives a carboxylic acid or carbon dioxide in such cases. The following equations illustrate ozonide formation, a process that is believed to involve initial syn-addition of ozone, followed by rearrangement of the extremely unstable molozonide addition product. They also show the decomposition of the final ozonide to carbonyl products by either a reductive or oxidative workup.

From this analysis and the examples given here, you should be able to deduce structural formulas for the alkenes that give the following ozonolysis products:
Glycol Cleavage

The vicinal glycols prepared by alkene hydroxylation (reaction with osmium tetroxide or permanganate) are cleaved to aldehydes and ketones in high yield by the action of lead tetraacetate \( \text{(Pb(OAc)}_4 \) or periodic acid \( \text{(HIO}_4 \). This oxidative cleavage of a carbon-carbon single bond provides a two-step, high-yield alternative to ozonolysis, that is often preferred for small scale work involving precious compounds. A general equation for these oxidations is shown below. As a rule, cis-glycols react more rapidly than trans-glycols, and there is evidence for the intermediacy of heterocyclic intermediates (as shown), although their formation is not necessary for reaction to occur.
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