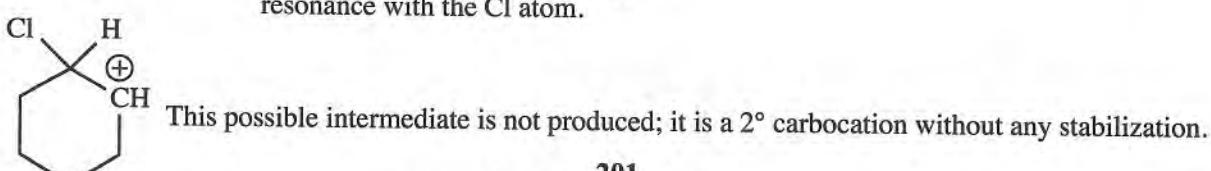
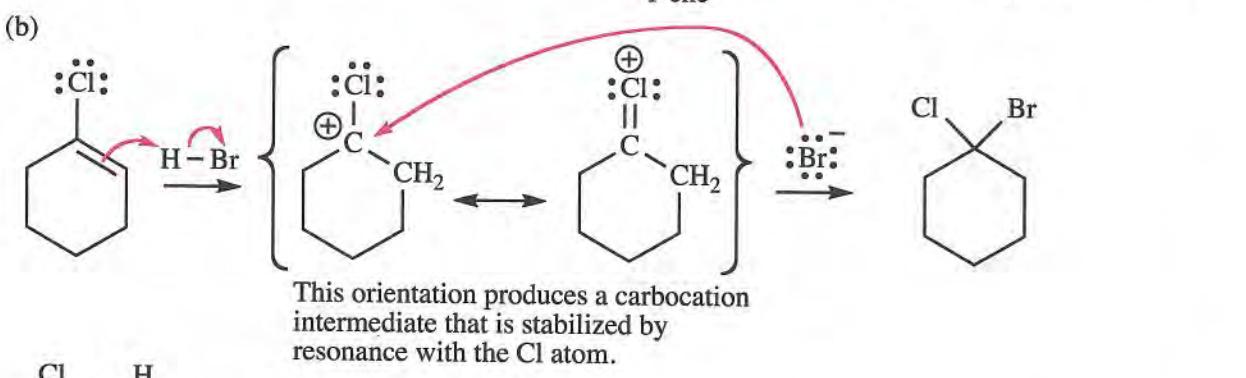
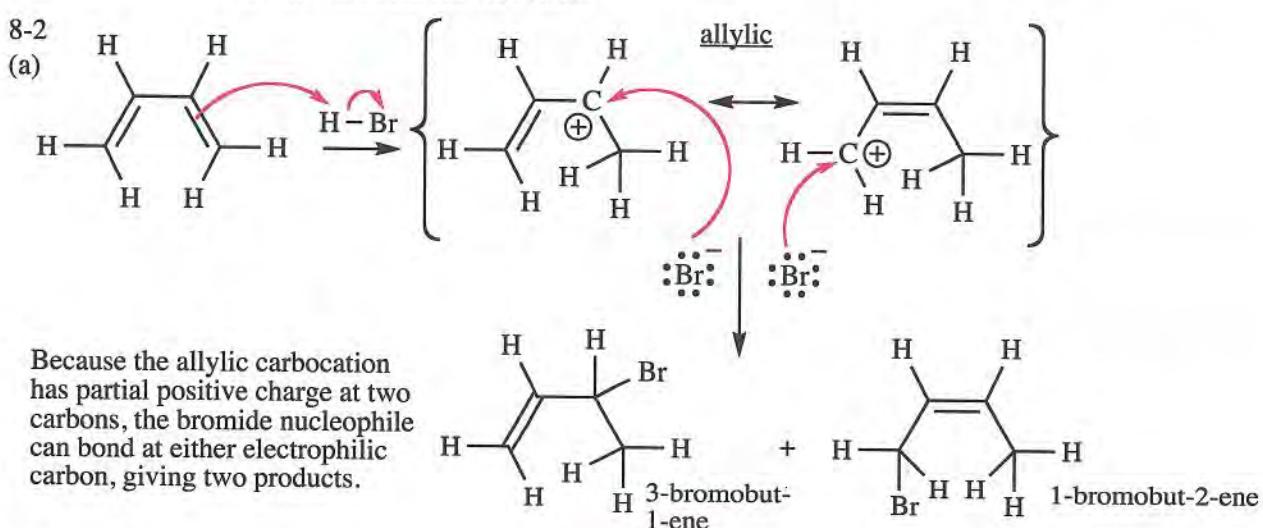
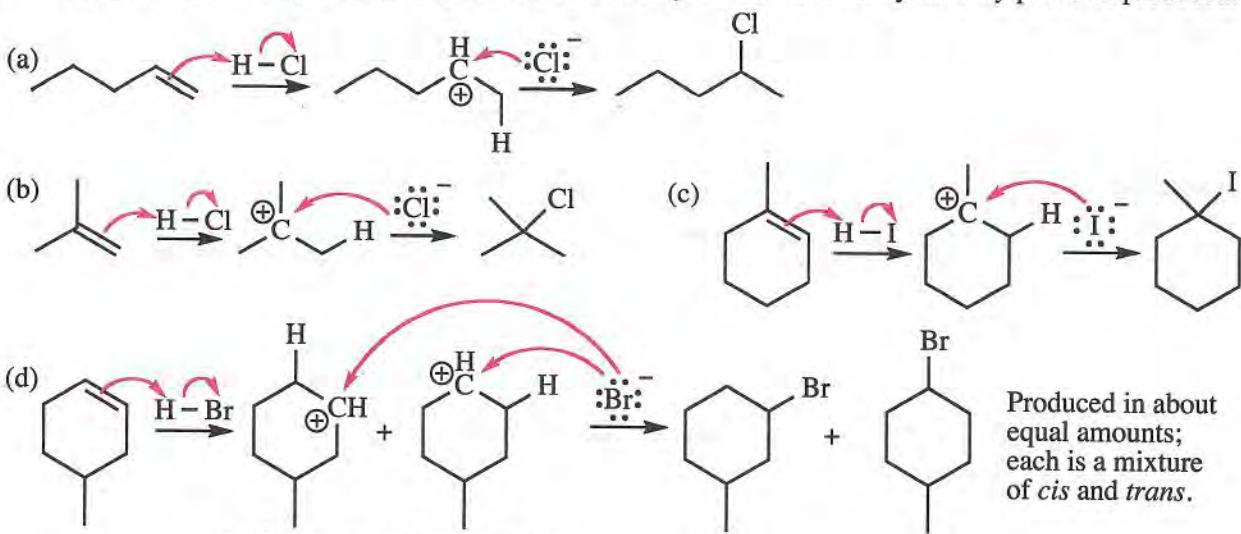
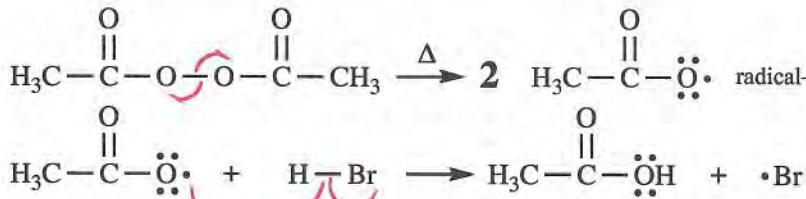
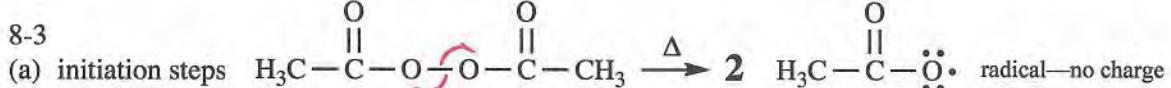


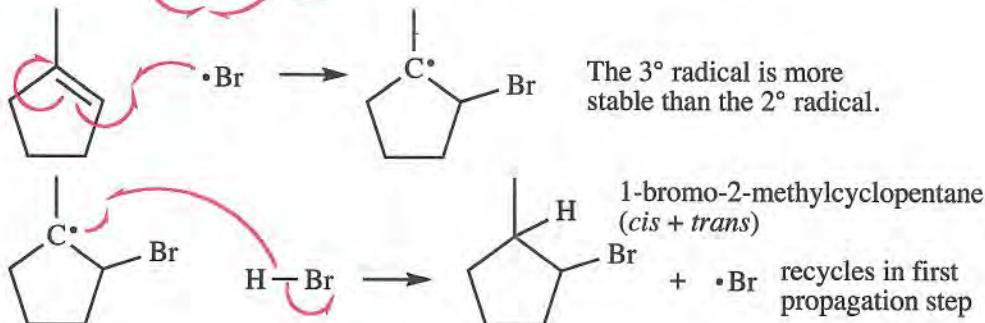
CHAPTER 8—REACTIONS OF ALKENES

8-1 Major products are produced in greatest amount; they are not necessarily the *only* products produced.

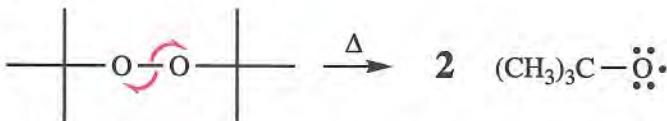




propagation steps

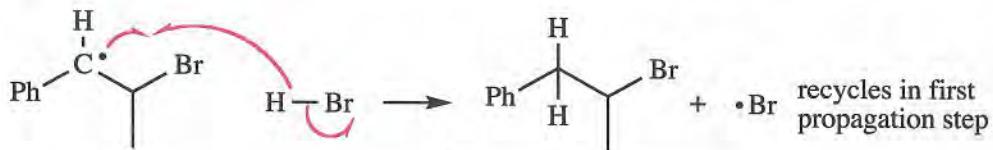
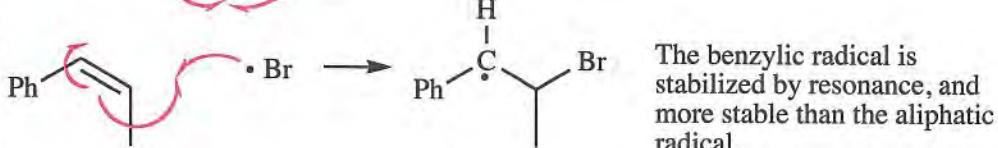


(b) initiation steps



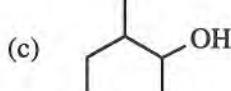
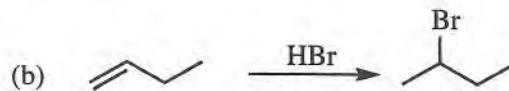
propagation steps

(Recall that "Ph" is the abbreviation for "phenyl".)

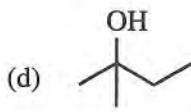


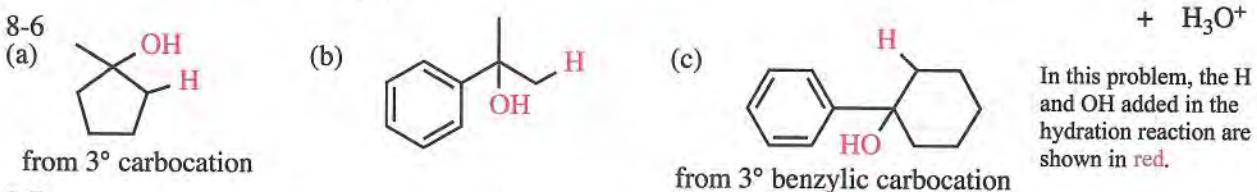
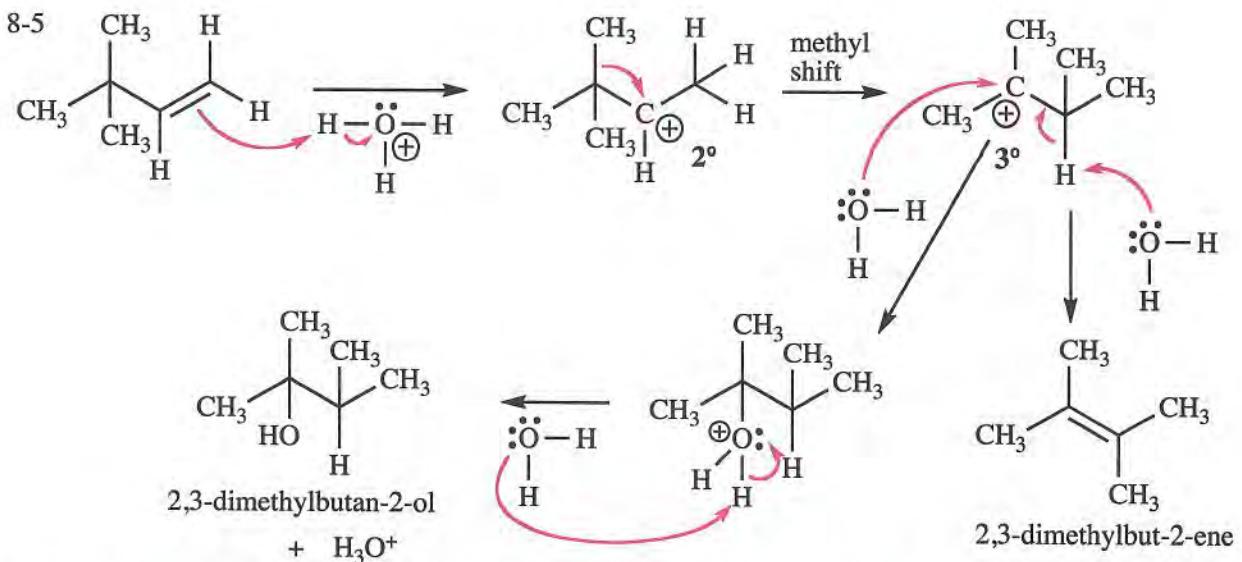
2-bromo-1-phenylpropane

8-4

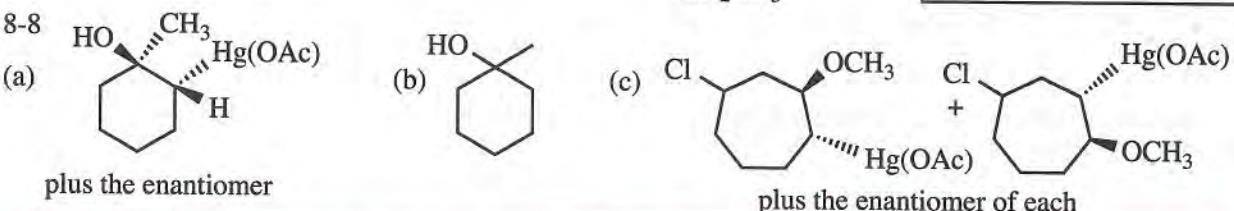
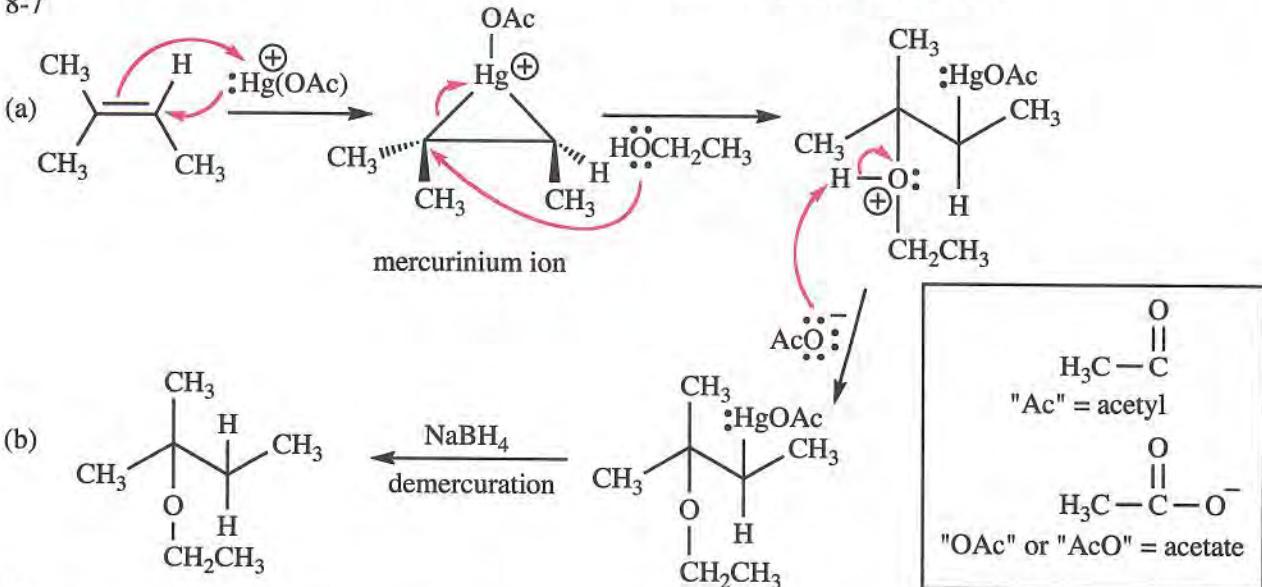


Note: A good synthesis uses major products as intermediates, not minor products. Knowing orientation of addition and elimination is critical to using reactions correctly.



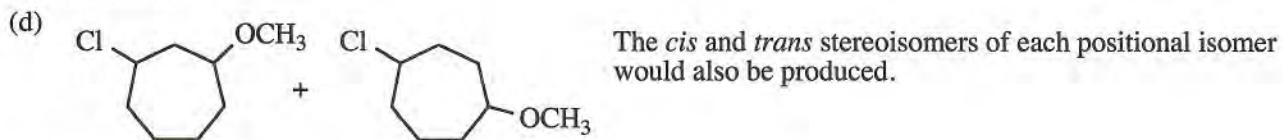


8-7

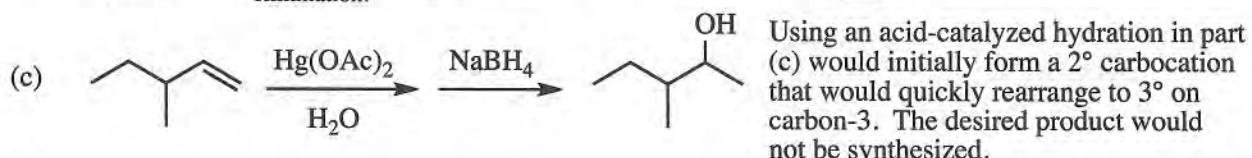
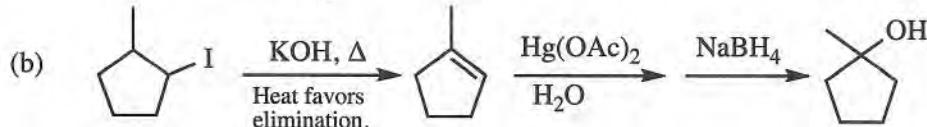
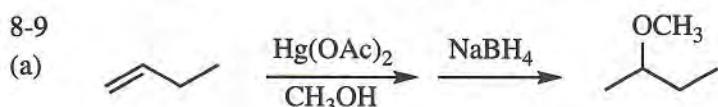


Note: When new chiral centers are generated from achiral or racemic reactants, the products are racemic mixtures. This book will indicate a racemic mixture by adding "plus the enantiomer".

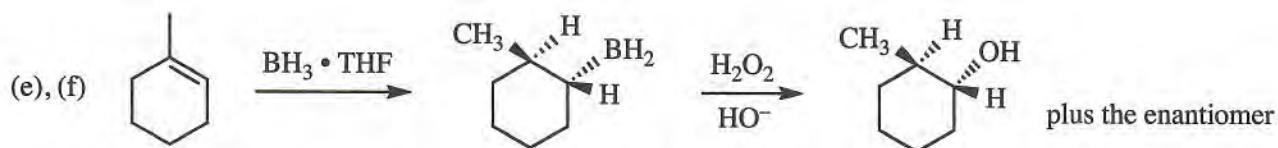
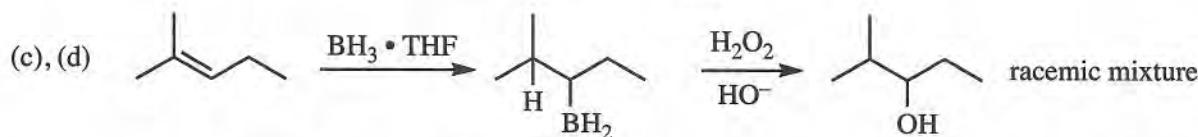
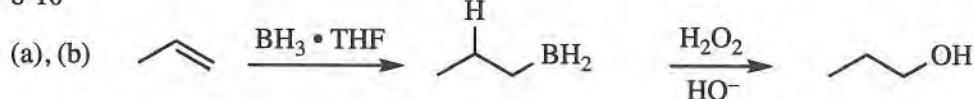
8-8 continued



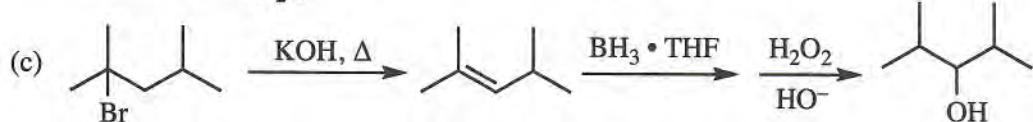
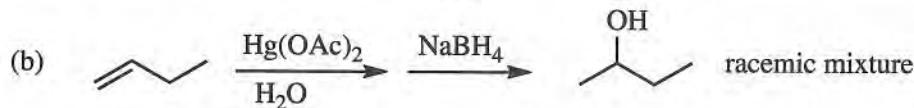
8-9



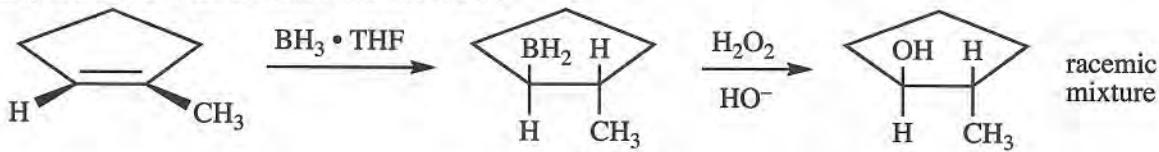
8-10



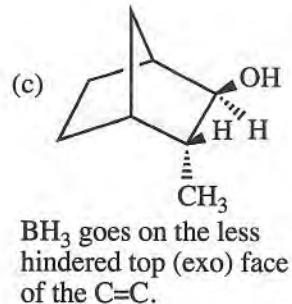
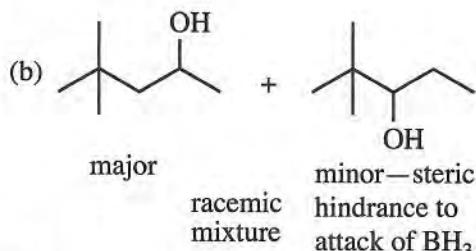
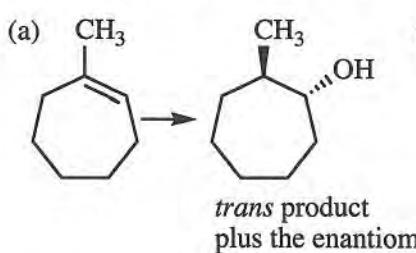
8-11



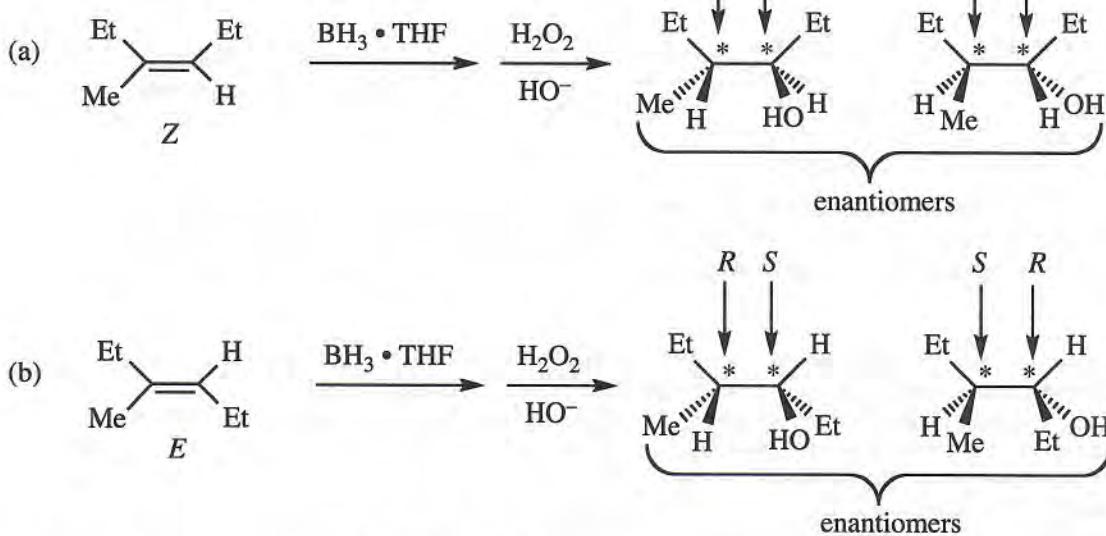
8-12 The attack of borane on 1-methylcyclopentene is equally likely from the top face or the bottom face, leading to a racemic mixture of the *trans* isomer.



8-13 The products are racemic.

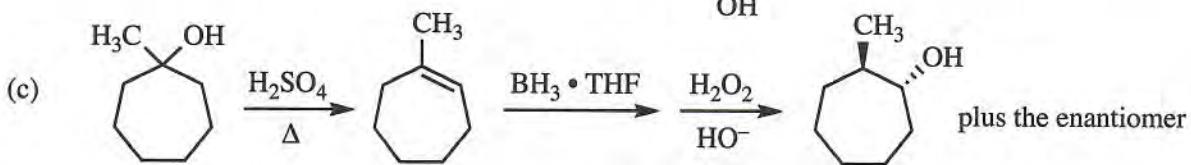
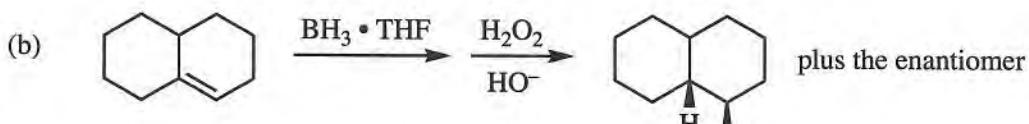
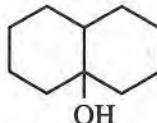
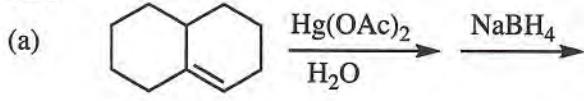


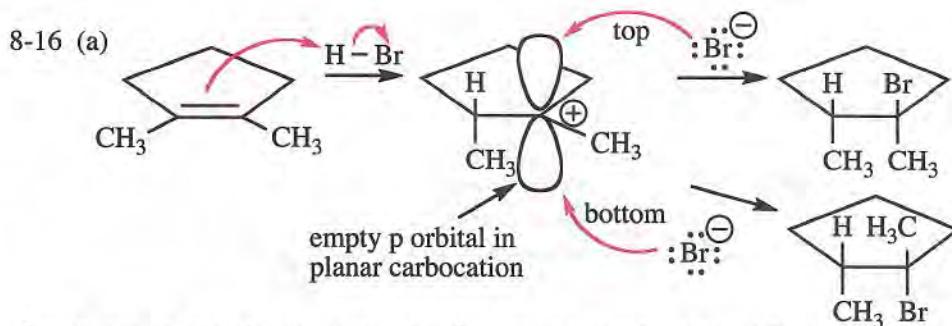
8-14



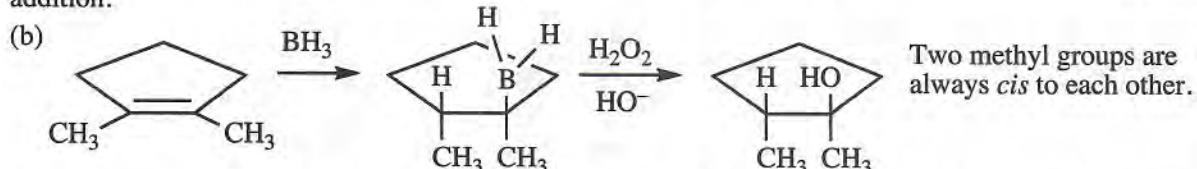
The enantiomeric pair produced from the *Z*-alkene is diastereomeric with the other enantiomeric pair produced from the *E*-alkene. Hydroboration-oxidation is stereospecific, that is, each alkene gives a specific set of stereoisomers, not a random mixture.

8-15





The *planar* carbocation is responsible for non-stereoselectivity. The bromide nucleophile can attack from the top or bottom, leading to a mixture of stereoisomers. The addition is therefore a mixture of *syn* and *anti* addition.

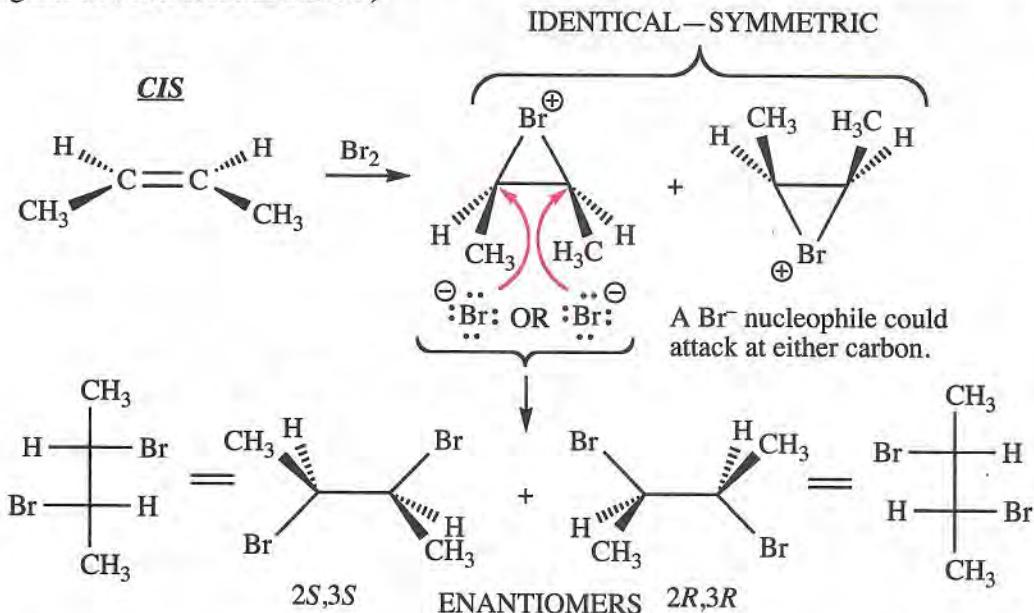


In contrast to part (a), hydroboration has no planar intermediate. Borane adds in a molecular addition with *syn* stereochemistry, and replacement of B with O proceeds with retention of stereochemistry. All of the steps in the process are stereospecific, so the product will be one diastereomer (although a racemic mixture).

8-17 During bromine addition to either the *cis*- or *trans*-alkene, two new chiral centers are being formed. Neither alkene (nor bromine) is optically active, so the product cannot be optically active.

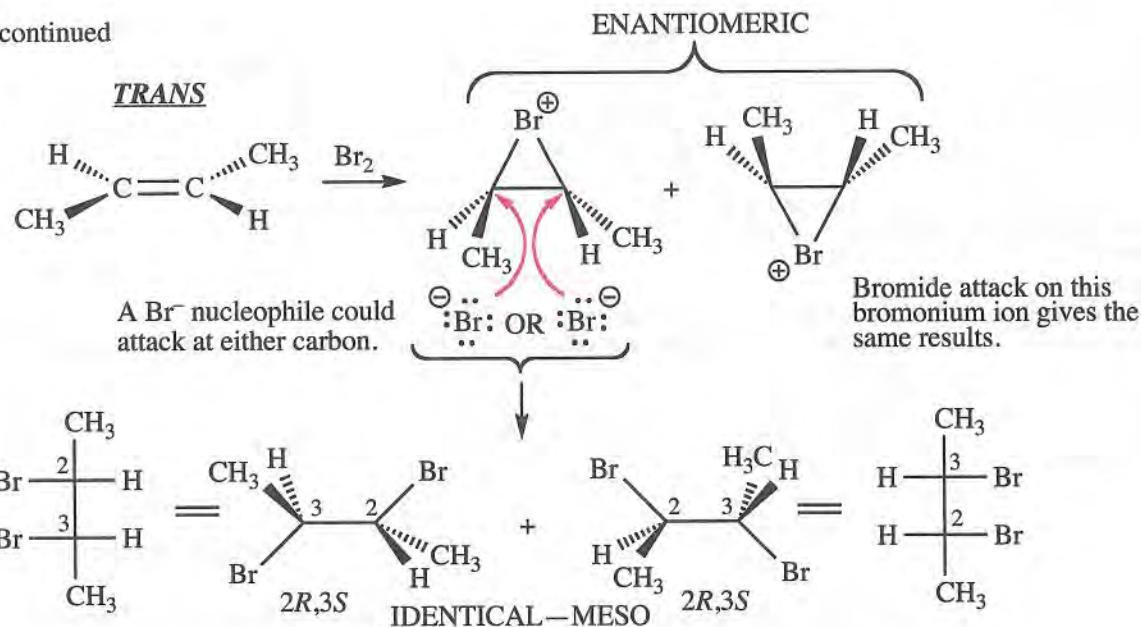
The *cis*-but-2-ene gives two chiral products, a racemic mixture. However, *trans*-but-2-ene (shown on the next page), because of its symmetry, gives only one *meso* product, that can never be chiral. The "optical inactivity" is built into this symmetric molecule.

This can be seen by following what happens to the configuration of the chiral centers from the intermediates to products, below. (The key lies in the symmetry of the intermediate and *inversion* of configuration when bromide attacks.)



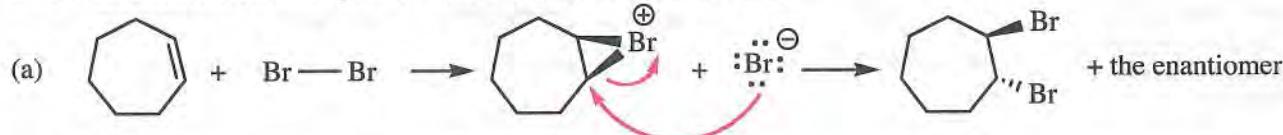
See the TRANS case on the next page.

8-17 continued

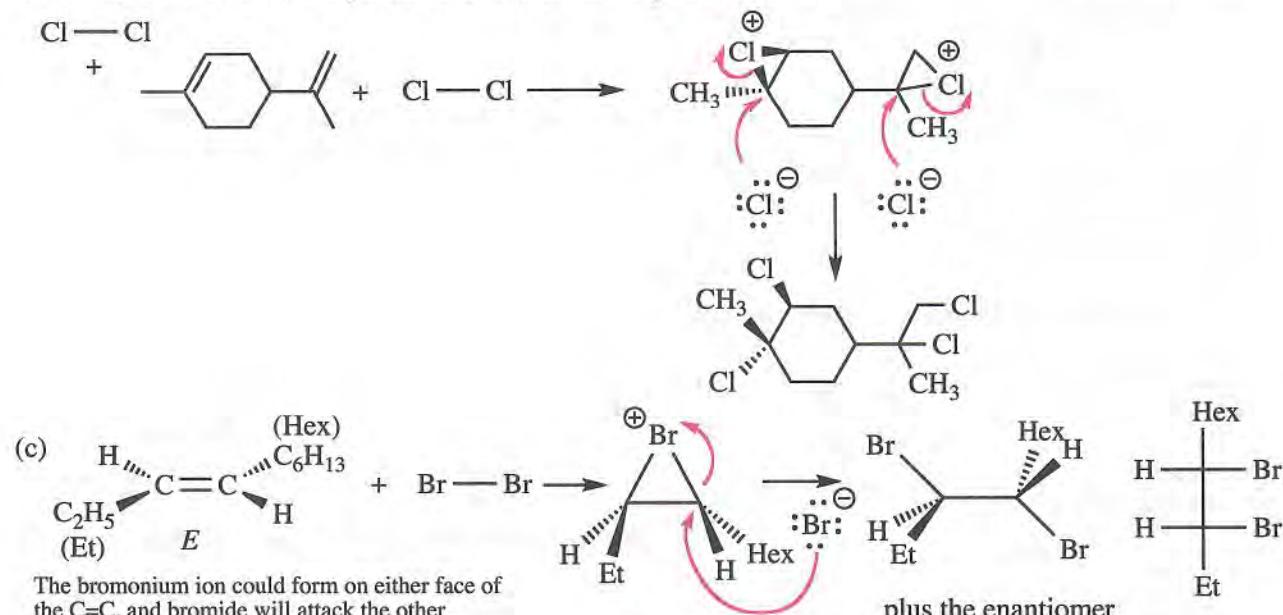


CONCLUSION: Anti addition of a symmetric reagent to a symmetric *cis*-alkene gives racemic product, while anti addition to a *trans*-alkene gives meso product. (We will see shortly that syn addition to a *cis*-alkene gives meso product, and syn addition to a *trans*-alkene gives racemic product. Stay tuned.)

8-18 Enantiomers of chiral products are also produced but not shown.



(b) Three new asymmetric carbons are produced in this reaction. All stereoisomers will be produced with the restriction that the two adjacent chlorines on the ring must be *trans*.

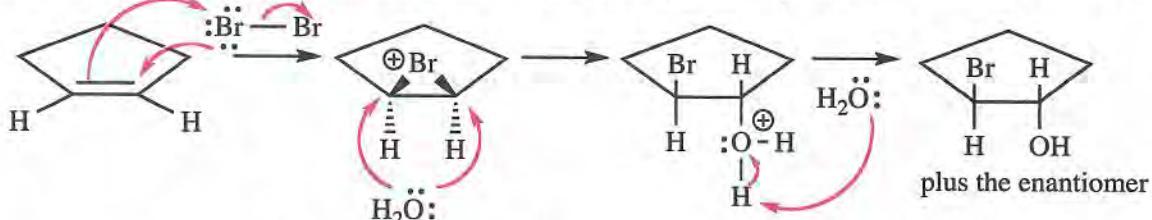


8-18 continued



The bromonium ion could form on either face of the C=C, and bromide will attack the other carbon of the bromonium ion as well. Either leads to equal amounts of the two enantiomers.

8-19 The *trans* product results from water attacking the bromonium ion from the face opposite the bromine. Equal amounts of the two enantiomers result from the equal probability that water will attack either C-1 or C-2.



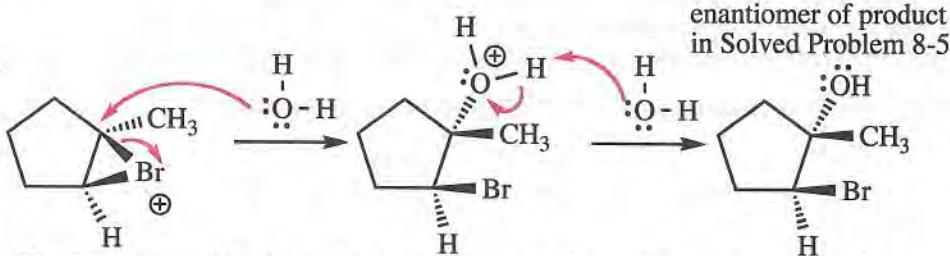
Water will do nucleophilic attack at either carbon.

equal amounts of enantiomers = racemic mixture

8-20

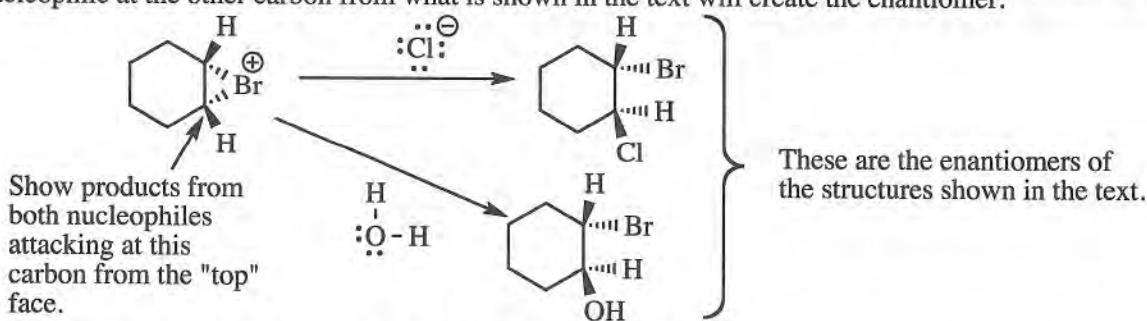
from Solved Problem 8-5

The bromonium ion shown here is the enantiomer of the one shown in Solved Problem 8-5.



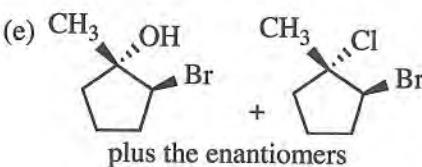
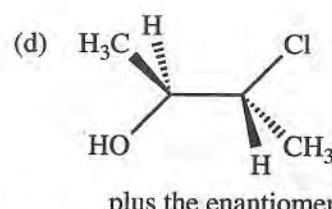
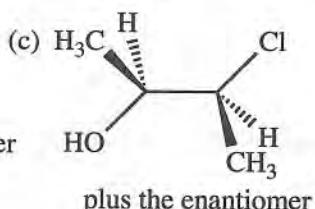
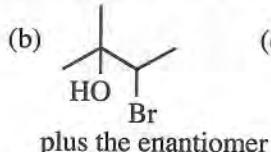
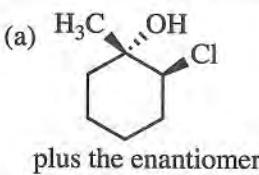
enantiomer of product in Solved Problem 8-5

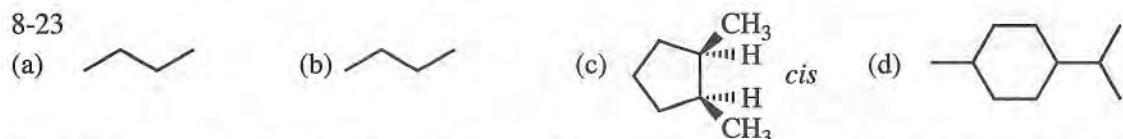
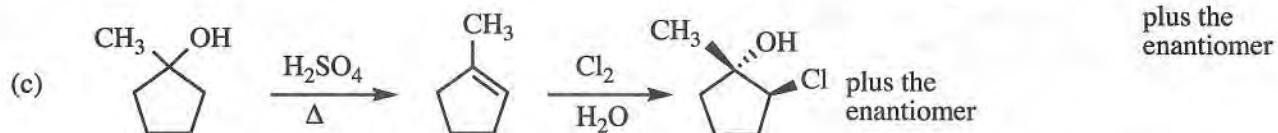
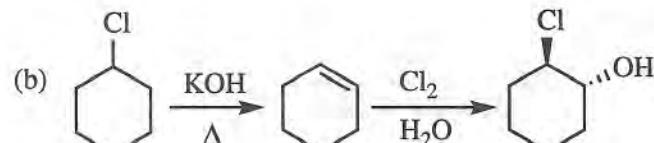
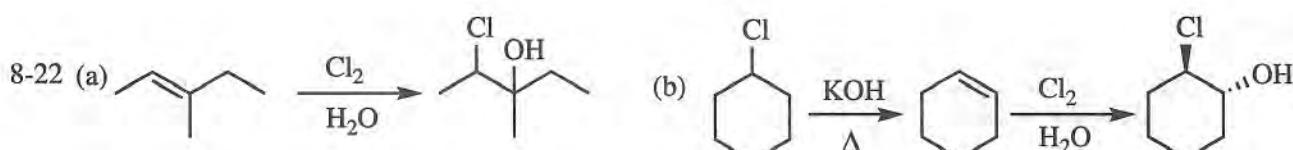
from Solved Problem 8-6: The bromonium ion shown is meso as it has a plane of symmetry; attack by the nucleophile at the other carbon from what is shown in the text will create the enantiomer.



These are the enantiomers of the structures shown in the text.

8-21 The chiral products shown here will be racemic mixtures.

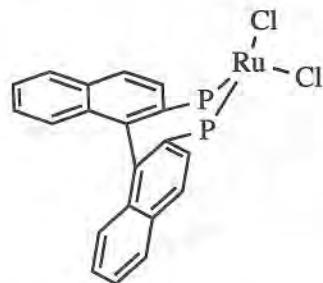




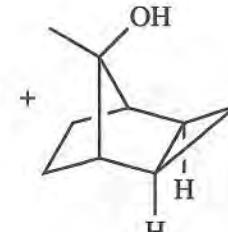
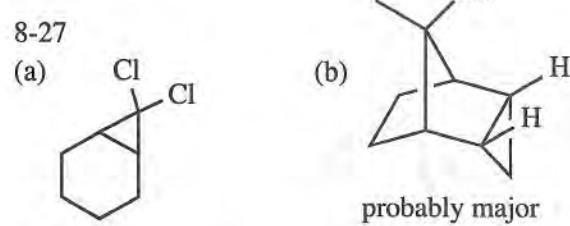
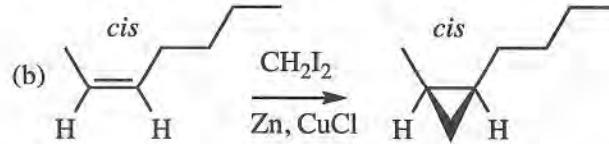
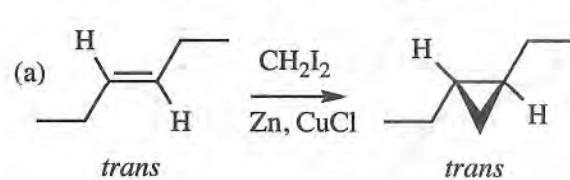
8-24 Limonene, $C_{10}H_{16}$, has three elements of unsaturation. Upon catalytic hydrogenation, the product, $C_{10}H_{20}$, has one element of unsaturation. Two elements of unsaturation have been removed by hydrogenation —these must have been pi bonds, either two double bonds or one triple bond. The one remaining unsaturation must be a ring. Thus, limonene must have one ring and either two double bonds or one triple bond. (The structure of limonene is shown in the text in Problem 8-23(d), and the hydrogenation product is shown above in the solution to 8-23(d).)

8-25 The BINAP ligand is an example of a conformationally hindered biphenyl as described in text section 5-9A and Figure 5-18. The groups are too large to permit rotation around the single bond connecting the rings, so the molecules are locked into one chiral twist or its mirror image.

This *simplified* three-dimensional drawing of one of the enantiomers shows that the two naphthalene rings are twisted almost perpendicular to each other. Molecular models will help visualize this concept.

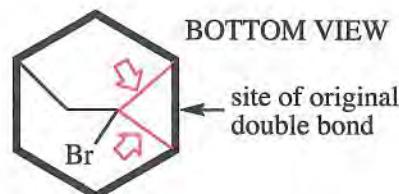
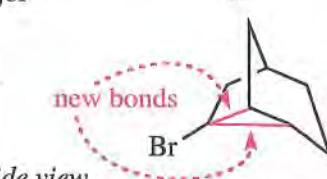


8-26 Stereochemistry of the starting material is retained in the product. Products are racemic.

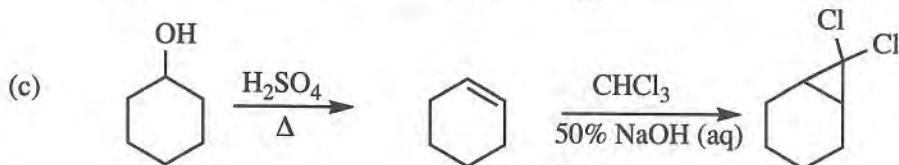
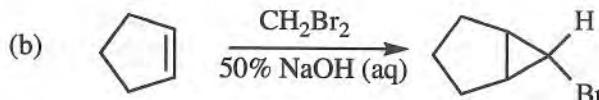
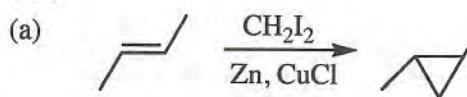


Probably minor—the OH crowds the top face of the C=C.

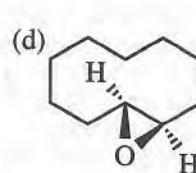
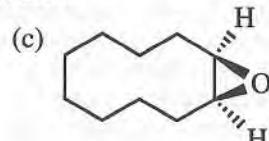
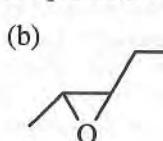
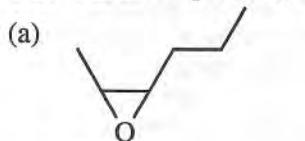
(c) The original 6-membered ring is shown in bold bonds; arrows point to new bonds.



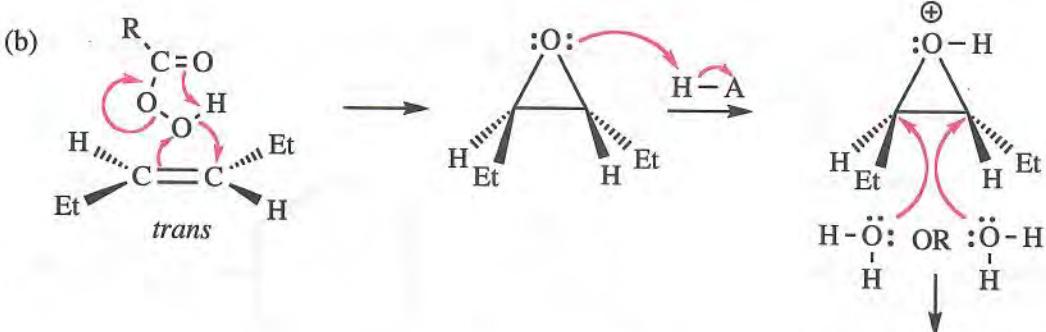
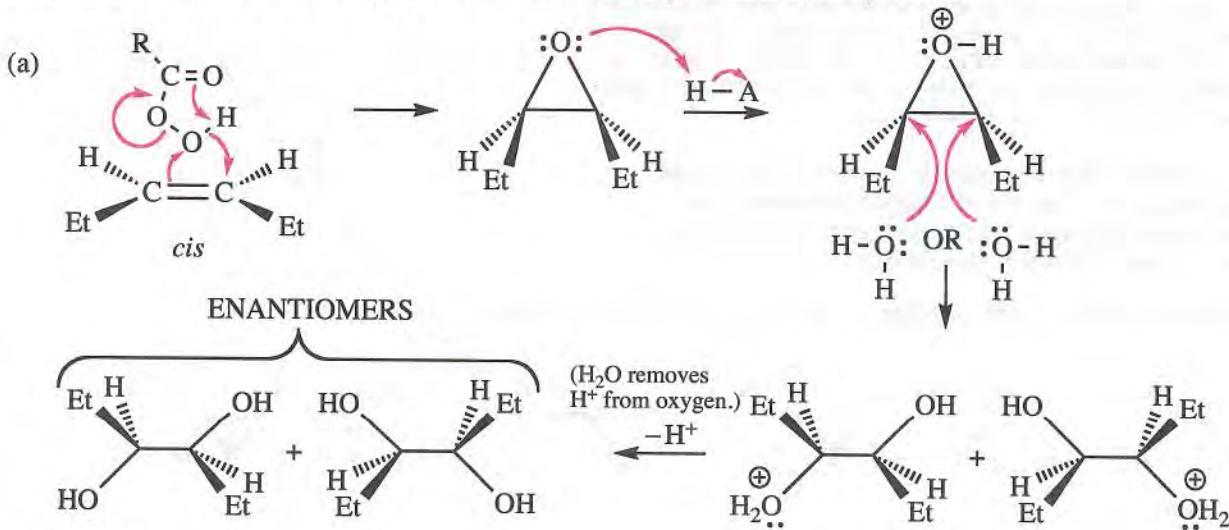
8-28



8-29 All chiral products in this problem are racemic mixtures.

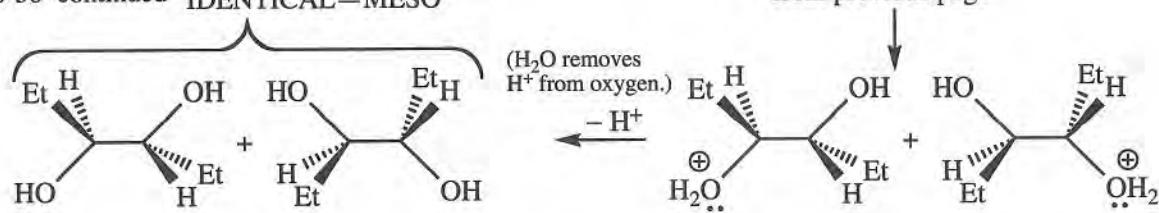


8-30 HA is a generic acid catalyst. It could be RCOOH produced in the epoxidation.

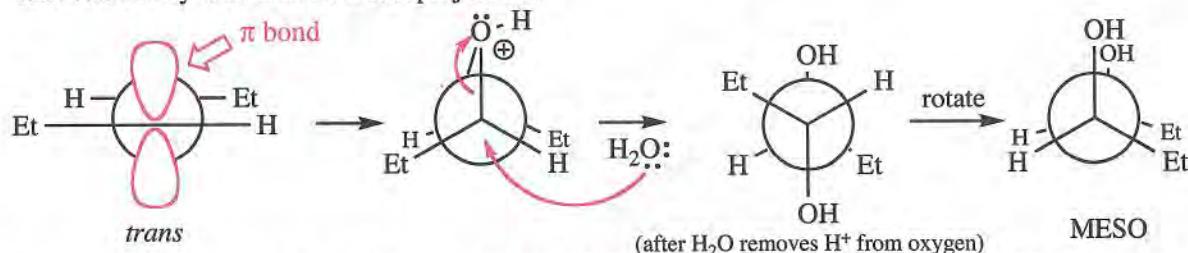


mechanism continued on next page

8-30 continued IDENTICAL—MESO

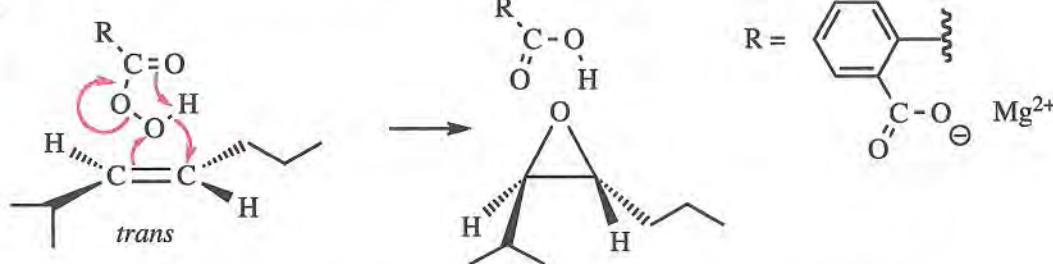


stereochemistry shown in Newman projections:

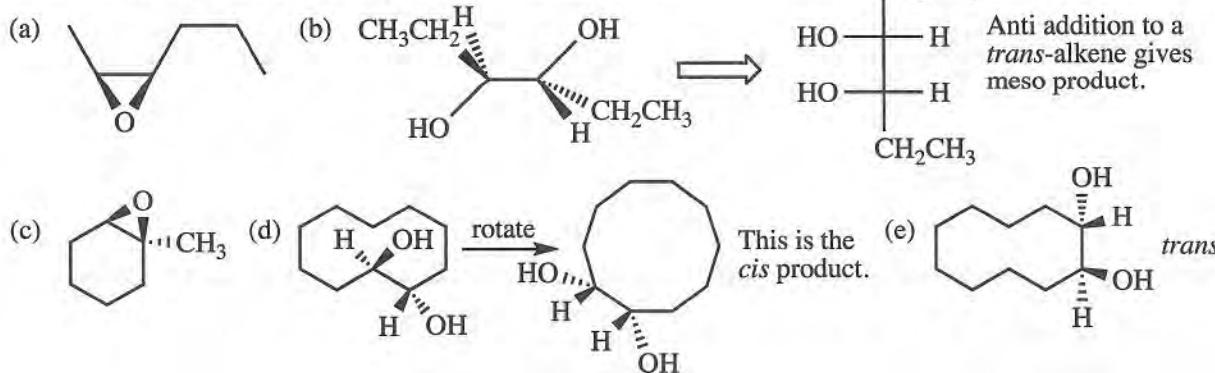


Remember the lesson from Problem 8-17: anti addition of a symmetric reagent to a symmetric *cis*-alkene gives racemic product, while anti addition to a *trans*-alkene gives meso product. This fits the definition of a *stereospecific* reaction, where different stereoisomers of the starting material (*cis* and *trans*) are converted into different stereoisomers of product (a *dl*-pair and *meso* form).

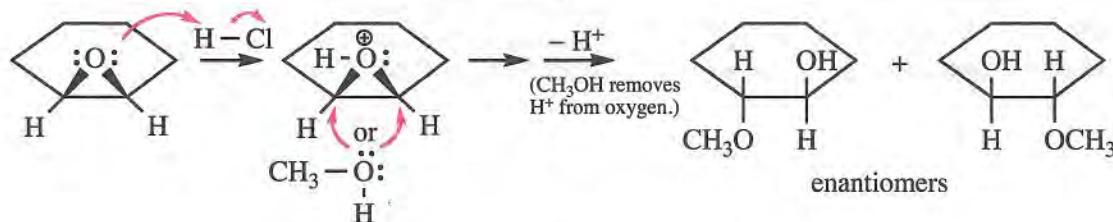
8-31



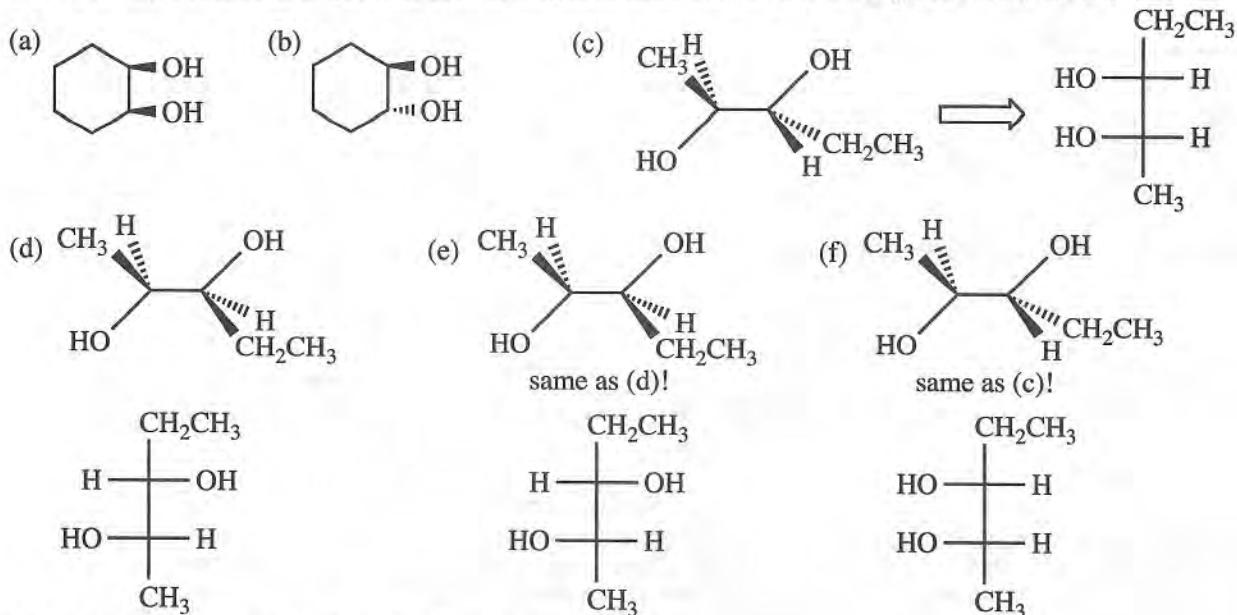
8-32 All chiral products in this problem are racemic mixtures.



8-33

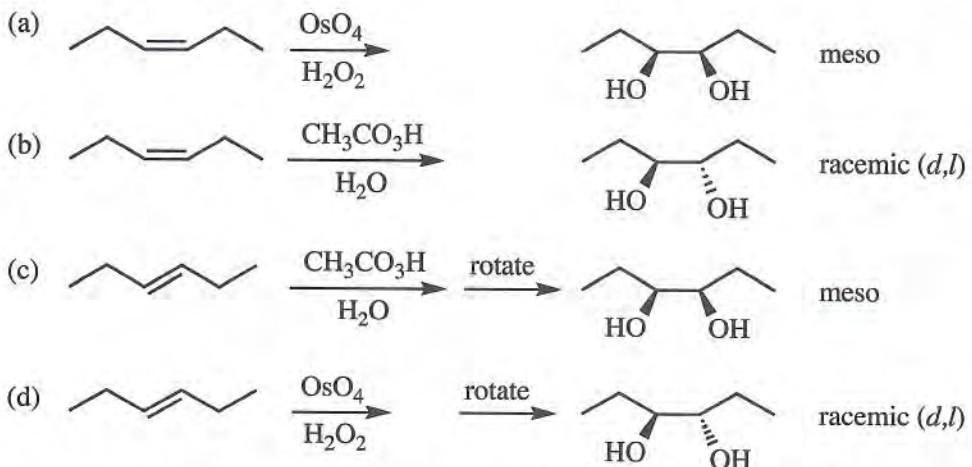


8-34 All these reactions begin with achiral reagents; therefore, all the chiral products are racemic.



Refer to the observation in the solution to Problem 8-35.

8-35



Have you noticed yet? For symmetric alkenes and symmetric reagents (addition of two identical X groups):

cis-alkene + **syn** addition → meso

cis-alkene + **anti** addition → racemic

trans-alkene + **syn** addition → racemic

trans-alkene + **anti** addition → meso

Assume that *cis*/syn/meso are "same", and *trans*/anti/racemic are "opposite". Then any combination can be predicted, just like math!

$$+1 \times +1 = +1$$

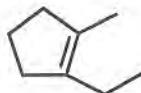
$$+1 \times -1 = -1$$

$$-1 \times +1 = -1$$

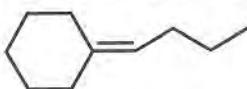
$$-1 \times -1 = +1$$

8-36 Solve these ozonolysis problems by working backwards, that is, by "reattaching" the two carbons of the new carbonyl groups into alkenes. Here's a hint. When you cut a circular piece of string, you still have only one piece. When you cut a linear piece of string, you have two pieces. Same with molecules. If ozonolysis forms only one product with two carbonyls, the C=C had to have been in a ring. If ozonolysis gives two molecules, the C=C had to have been in a chain.

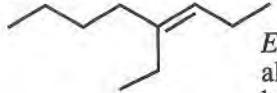
(a) Two carbonyls from ozonolysis are in a chain, so alkene had to have been in a ring.



(b) Two carbonyls from ozonolysis are in two different products, so alkene had to have been in a chain, not a ring.

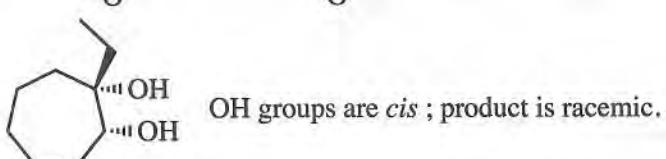
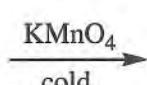
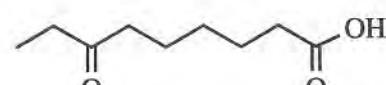
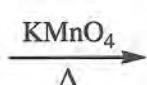
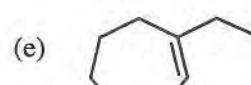
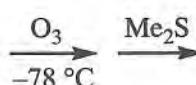
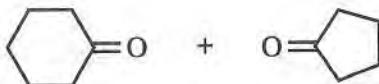
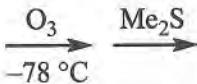
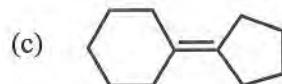
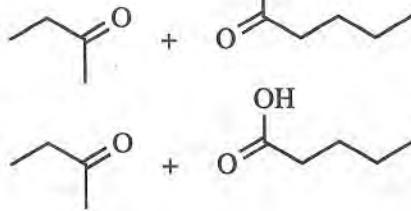
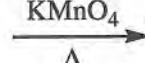
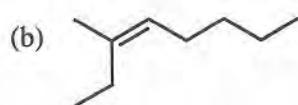
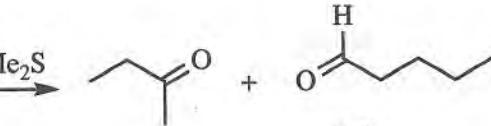
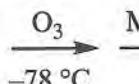
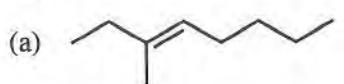


(c) Two carbonyls from ozonolysis are in two different products, so alkene had to have been in a chain, not a ring.

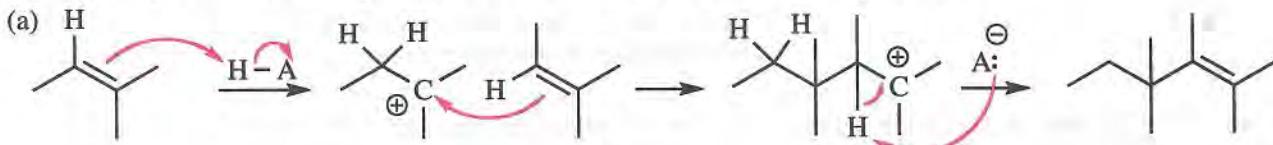


E or *Z* of alkene cannot be determined from products.

8-37

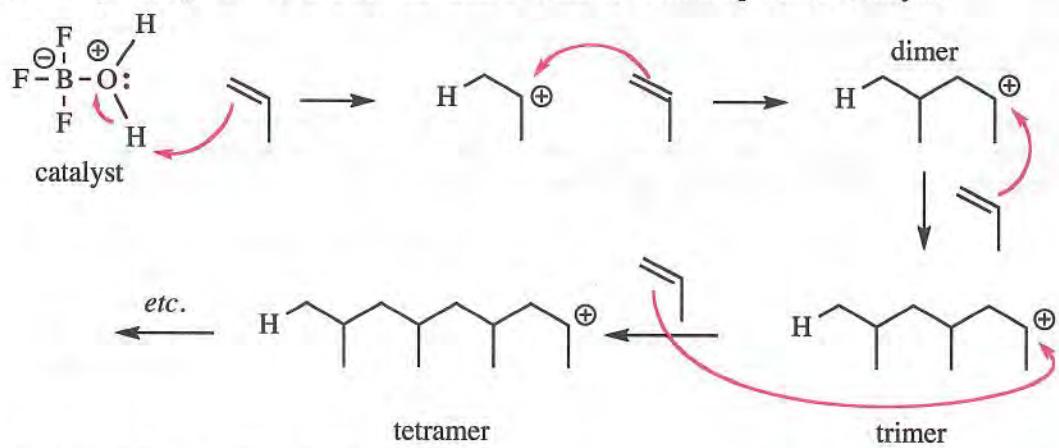


8-38 The representation for a generic acid is H—A, where A is the conjugate base.

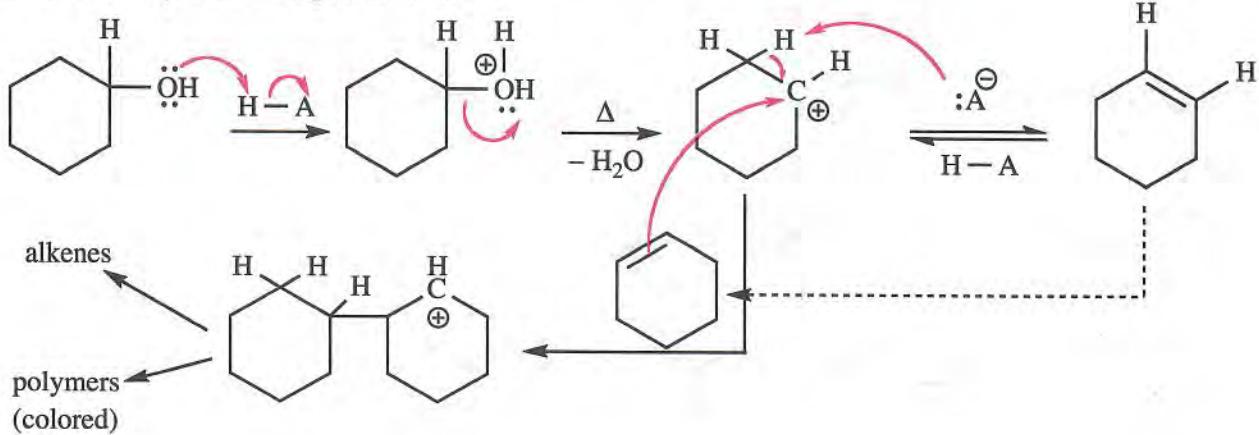


8-38 continued

(b) Catalytic BF_3 reacts with trace amounts of water to form the probable catalyst:

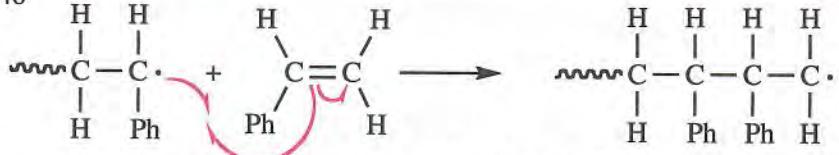


8-39 H—A symbolizes a generic acid.



Note: The wavy bond symbol is used in the following solutions to indicate the continuation of a polymer chain. ~~~~~~

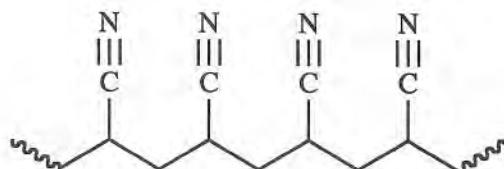
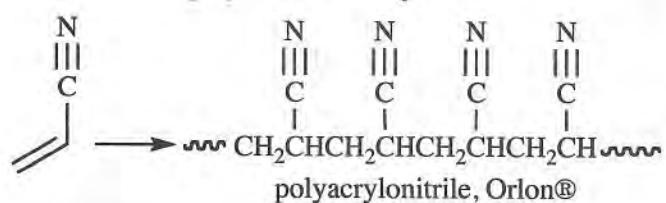
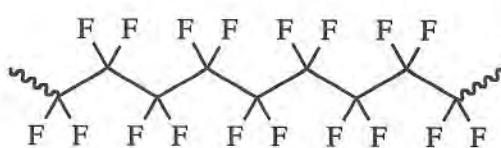
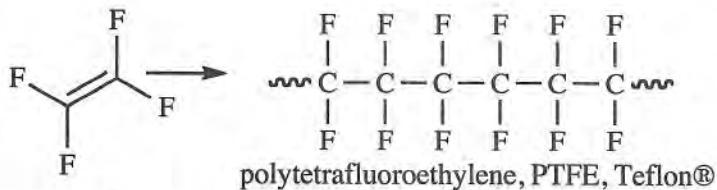
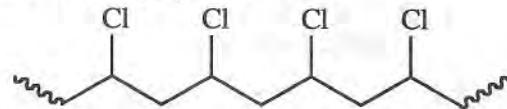
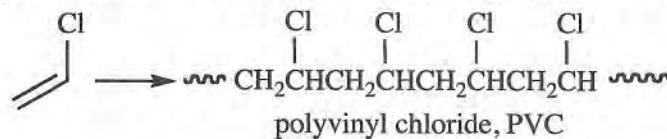
8-40



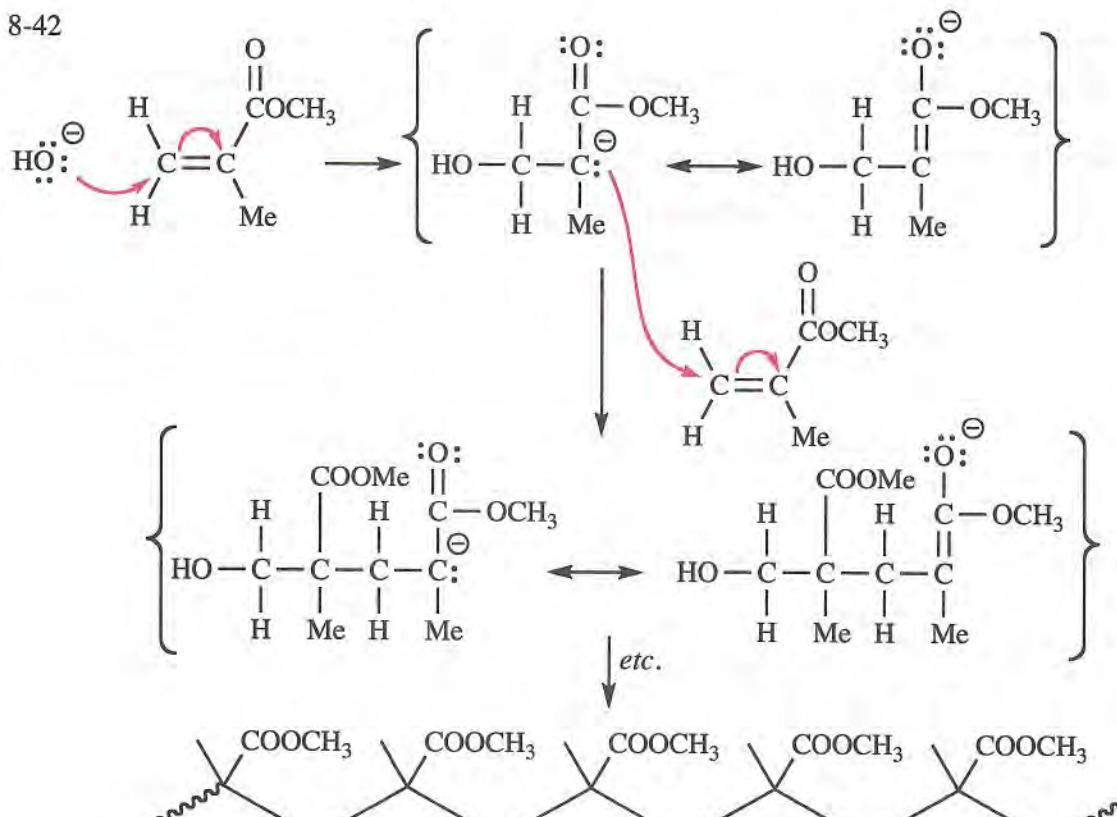
1° radical, and *not* resonance-stabilized—
this orientation is not observed

Orientation of addition always generates the more stable intermediate; the energy difference between a 1° radical (shown above) and a benzylic radical is huge. The phenyl substituents must necessarily be on alternating carbons because the orientation of attack is always the same—not a random process.

8-41 Each monomer has two carbons in the backbone, so the substituents on the monomer will repeat every two carbons in the polymer. Wavy bonds indicate continuation of the polymer chain.

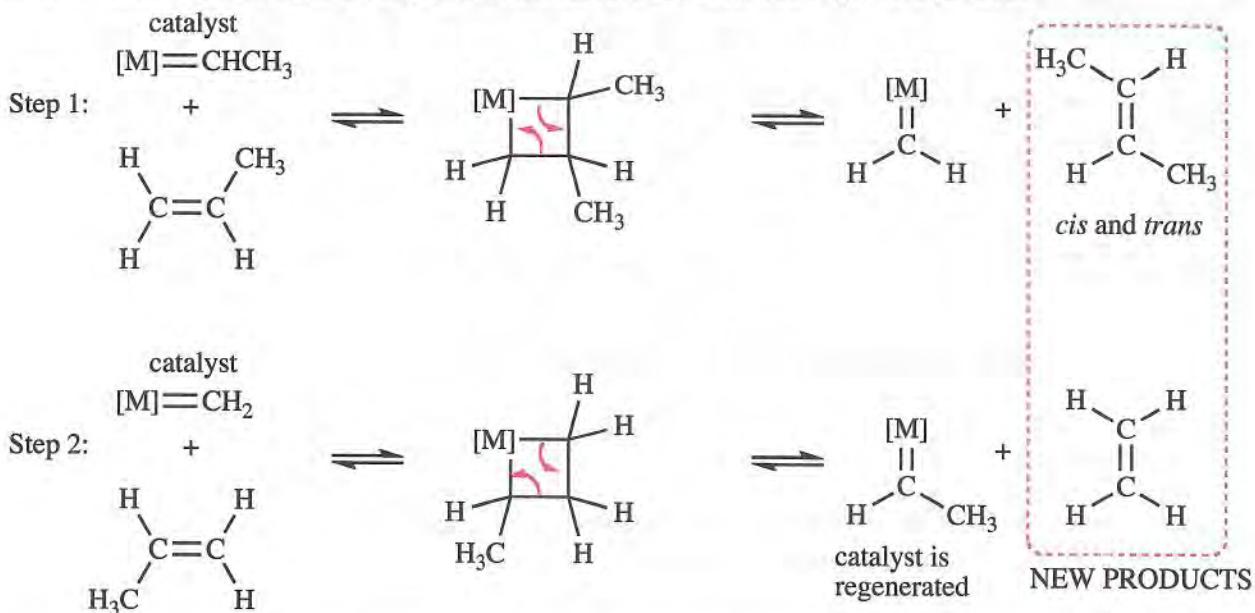


8-42



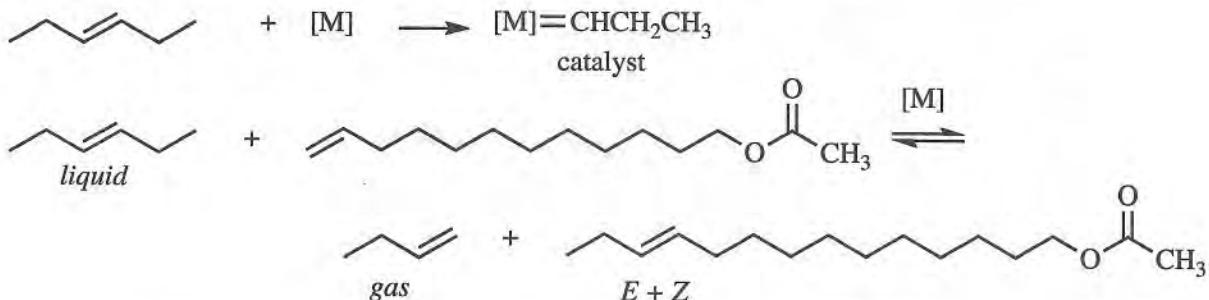
Wavy bonds mean that the chain continues.

8-43 The accepted mechanism of olefin metathesis includes an intermediate with a four-membered ring where one of the atoms in the ring is the metal catalyst, abbreviated [M]. All steps are equilibria.

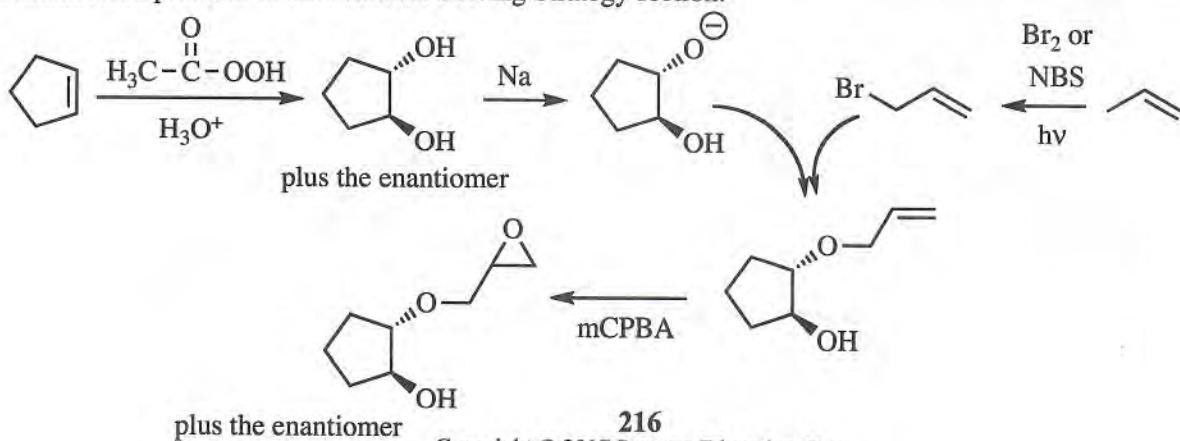


8-44 An excellent discussion of the olefin metathesis reaction is available at the Nobel Institute website:
http://www.nobelprize.org/nobel_prizes/chemistry/laureates/2005/ then click on Advanced Information

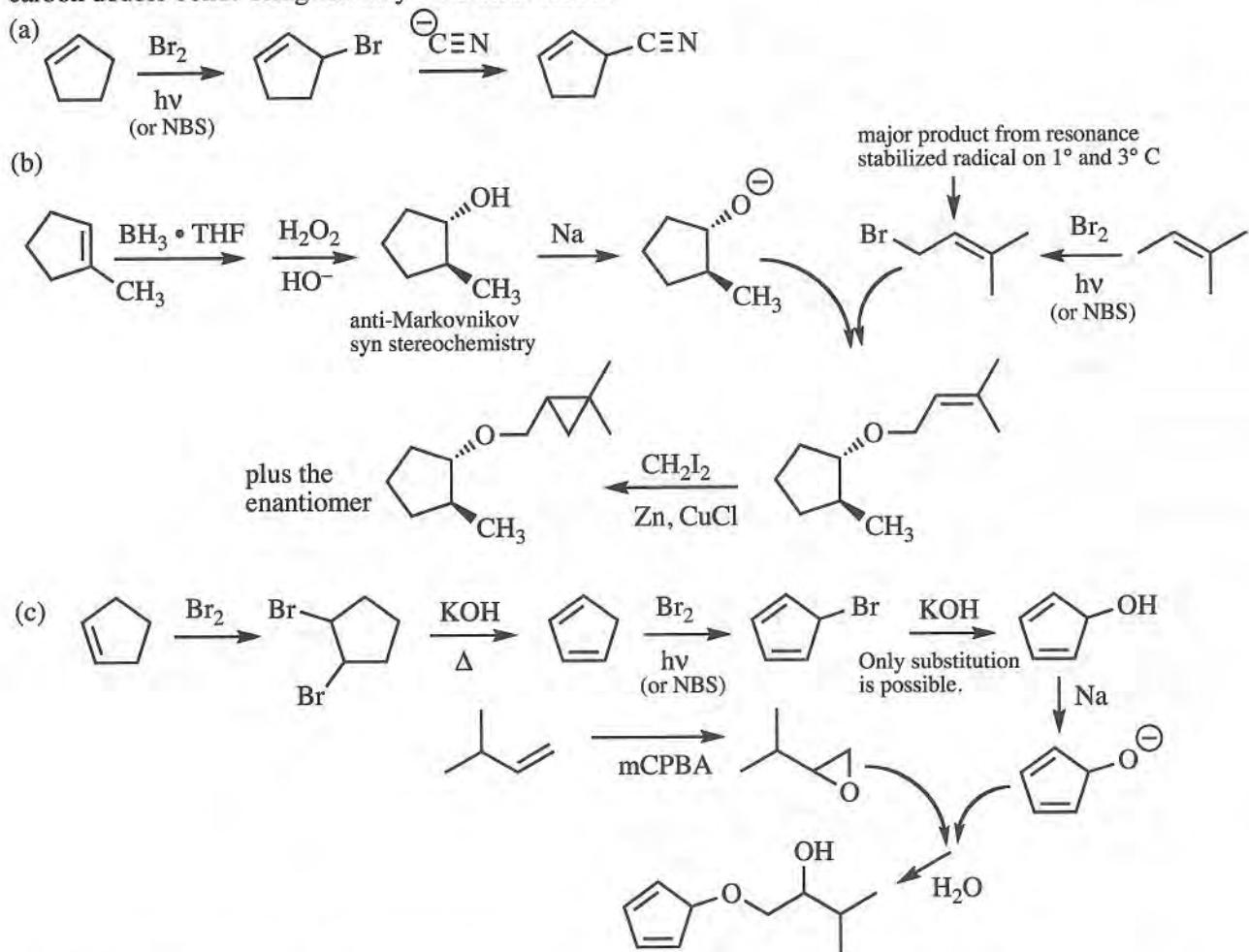
The catalyst needs to have the short end of the molecule attached to the metal:



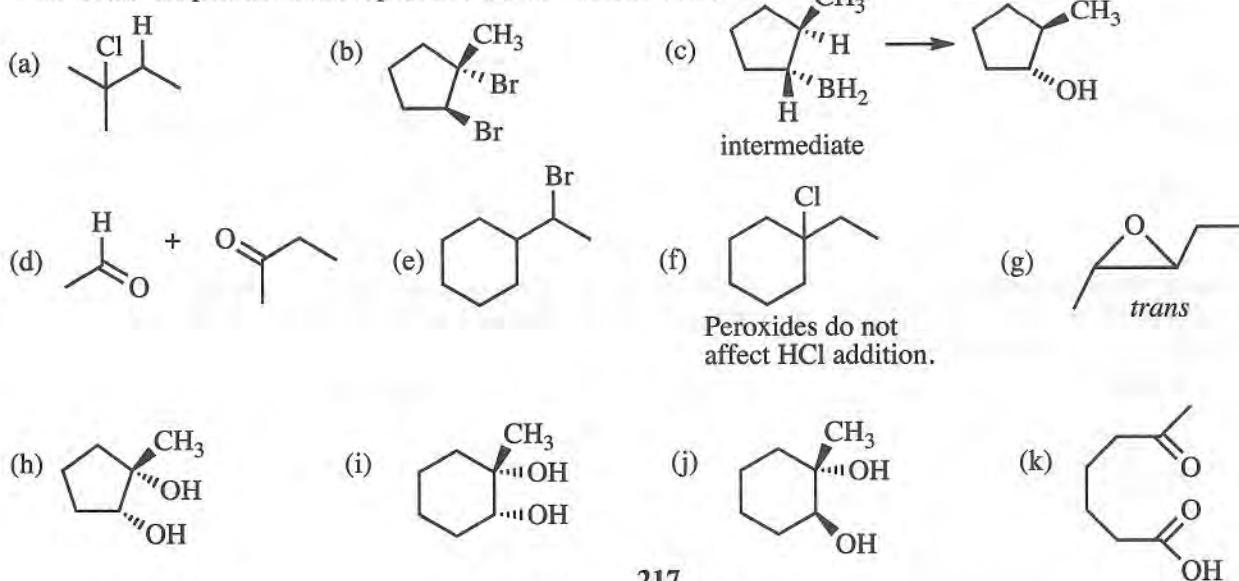
Unnumbered problem in the Problem-Solving Strategy section:



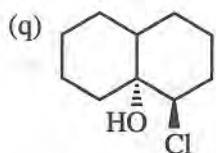
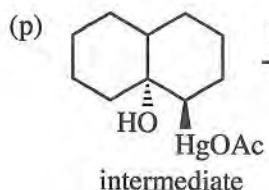
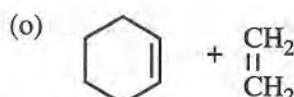
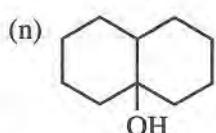
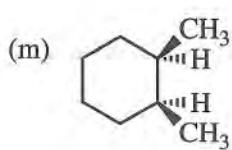
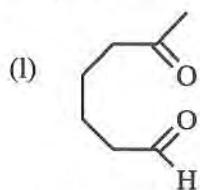
8-45 In the spirit of this problem, all starting materials will have six carbons or fewer and only one carbon-carbon double bond. Reagents may have other atoms.



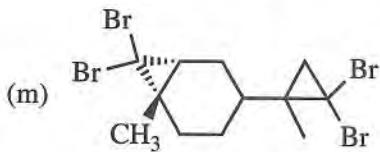
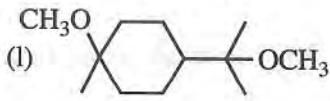
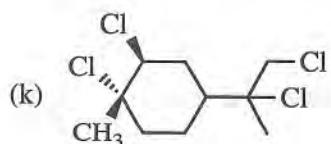
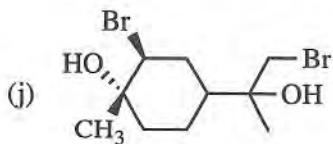
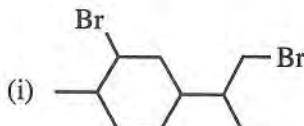
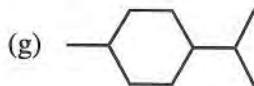
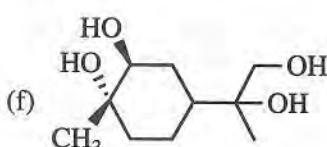
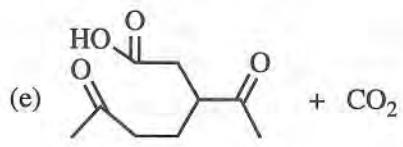
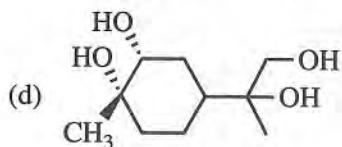
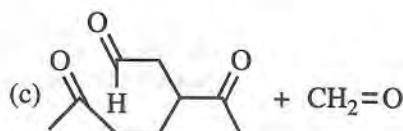
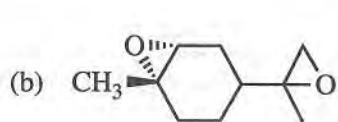
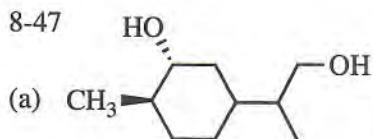
8-46 All chiral products in this problem are racemic mixtures.



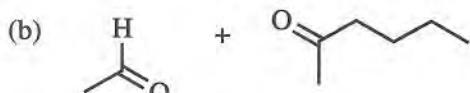
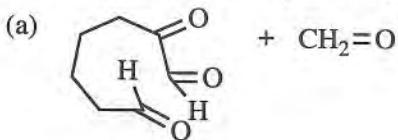
8-46 continued



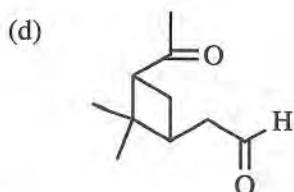
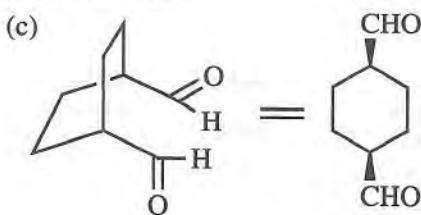
8-47



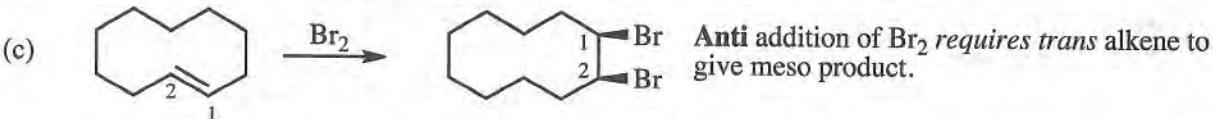
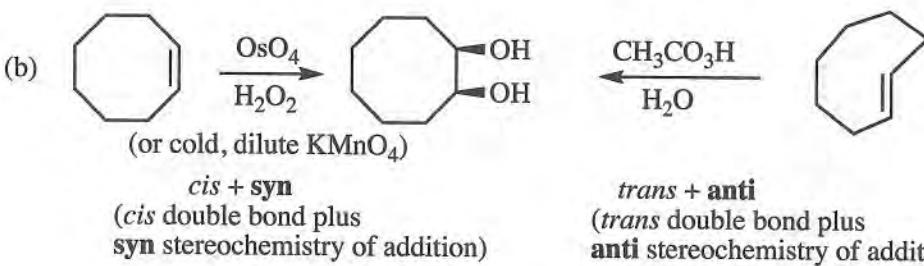
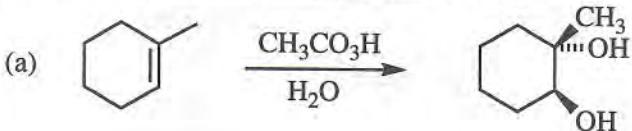
8-48 Recall these facts about ozonolysis: each alkene cleaved by ozone produces two carbonyl groups; an alkene in a chain produces two separate products; an alkene in a ring produces one product in which the two carbonyls are connected.



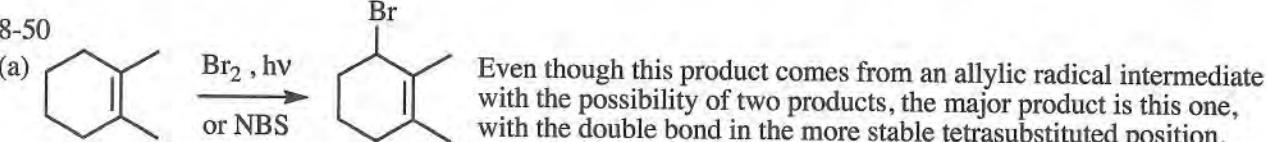
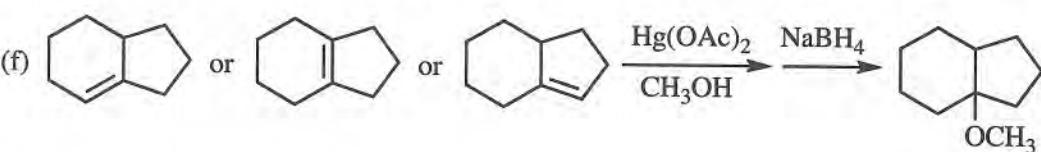
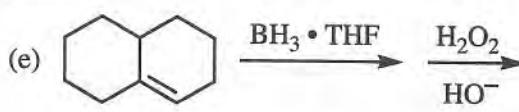
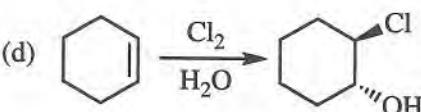
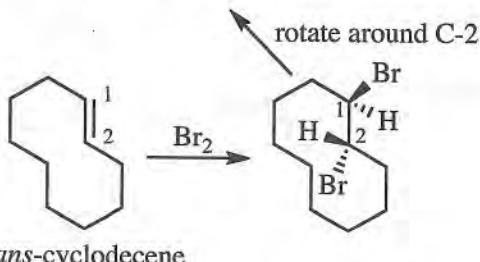
8-48 continued



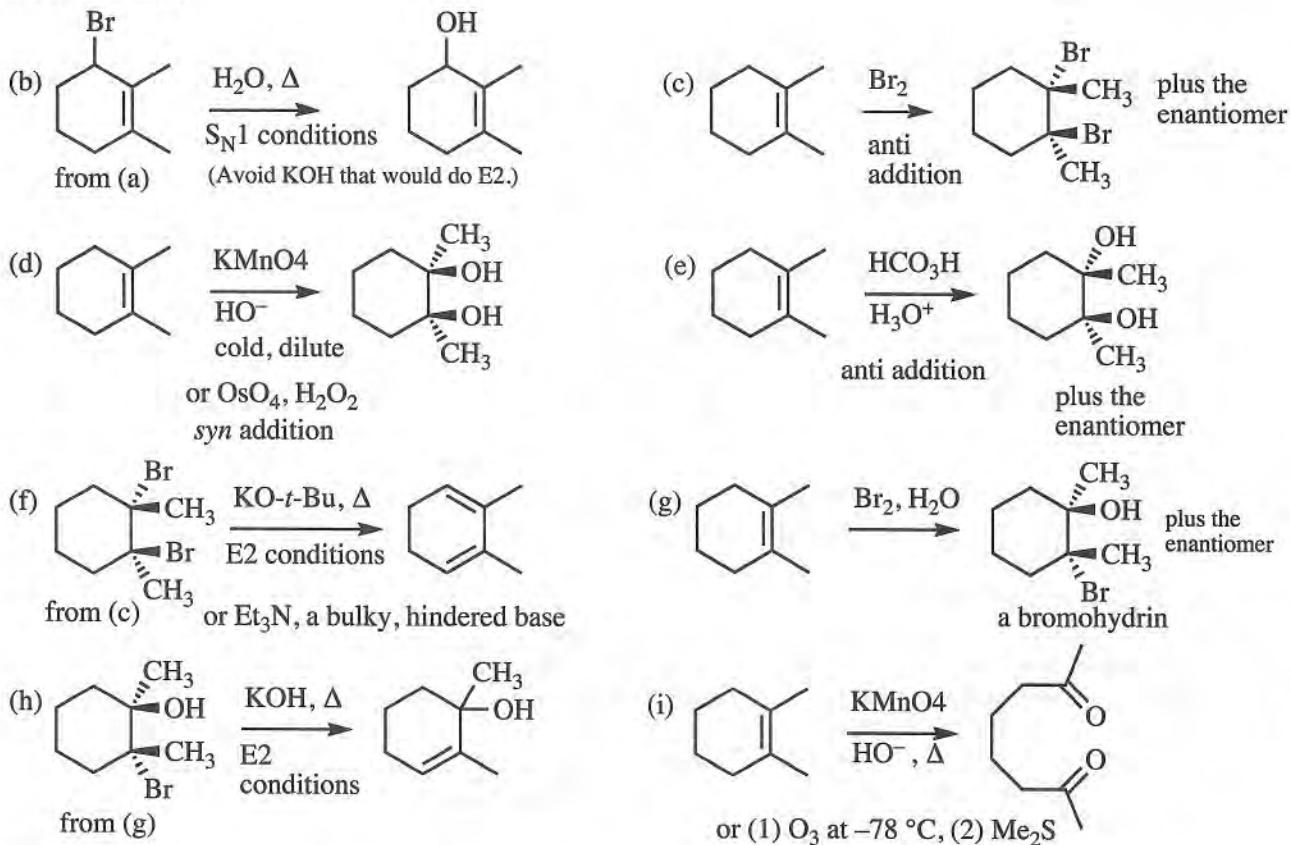
8-49 Chiral products in this problem are racemic.



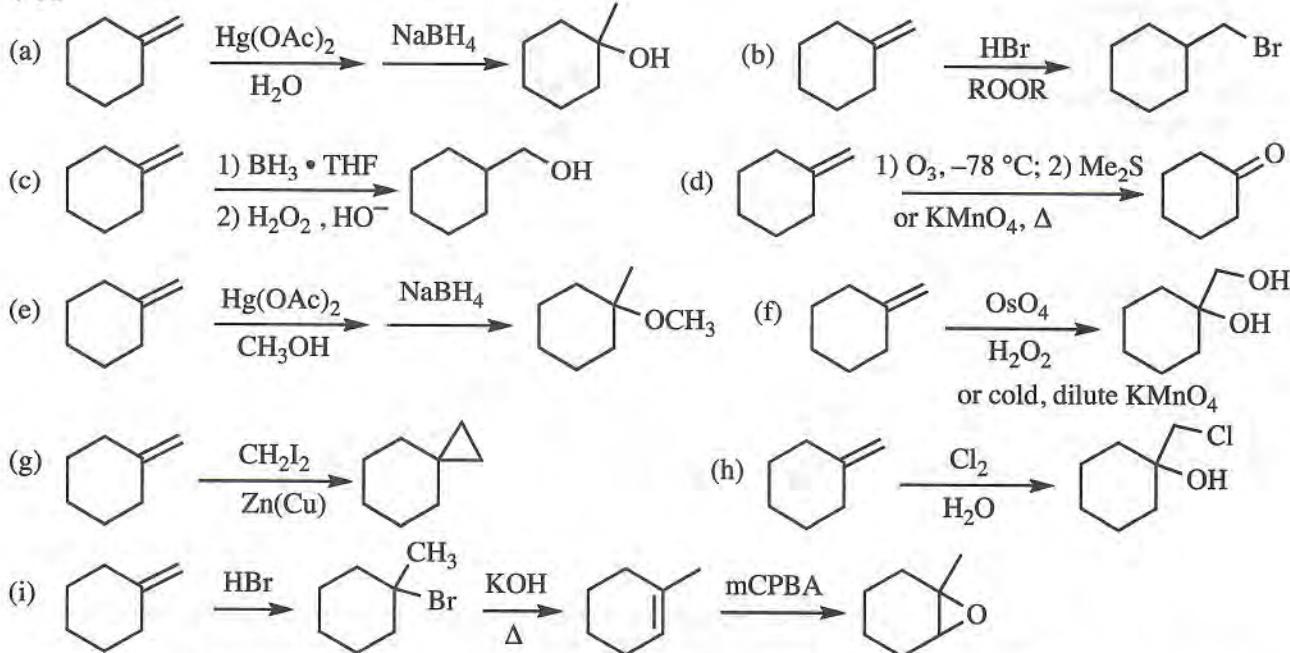
This structure shows a *trans* alkene in a 10-membered ring, just the rotated view of the structure to the right.



8-50 continued

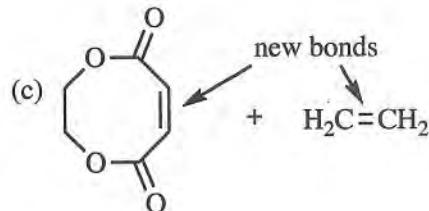
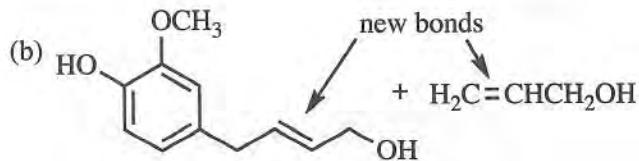
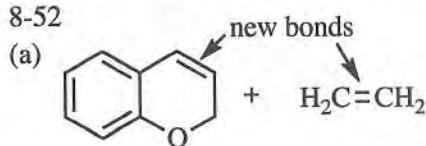


8-51

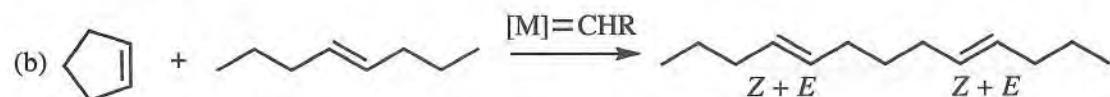
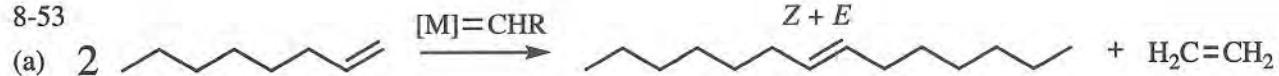


Alternatively, hydration followed by dehydration to methylcyclohexene would give the same product.

8-52

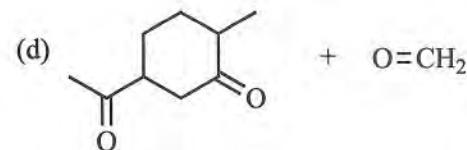
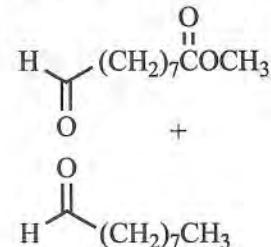
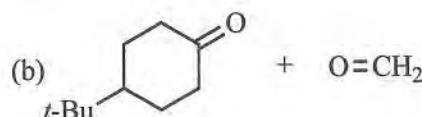
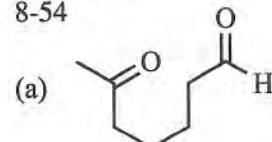


8-53

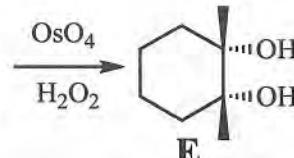
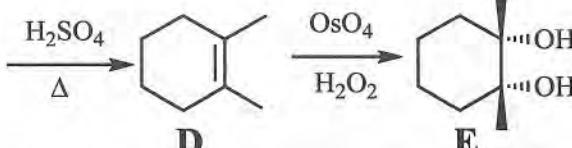
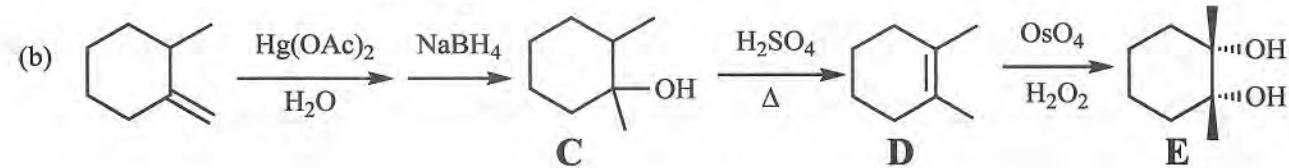
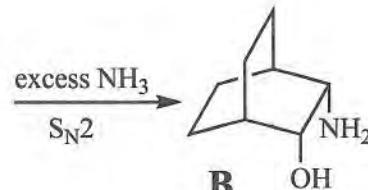
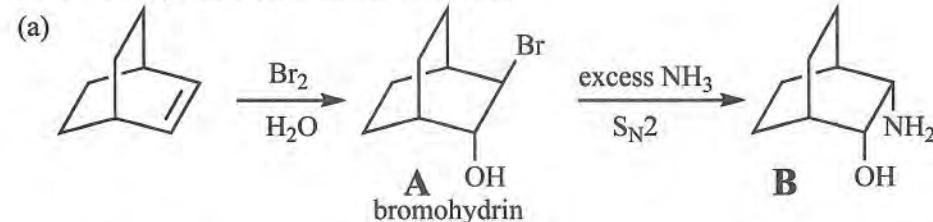


Ring-opening metathesis: the 5 carbons from cyclopentene become the middle 5 carbons of the product.

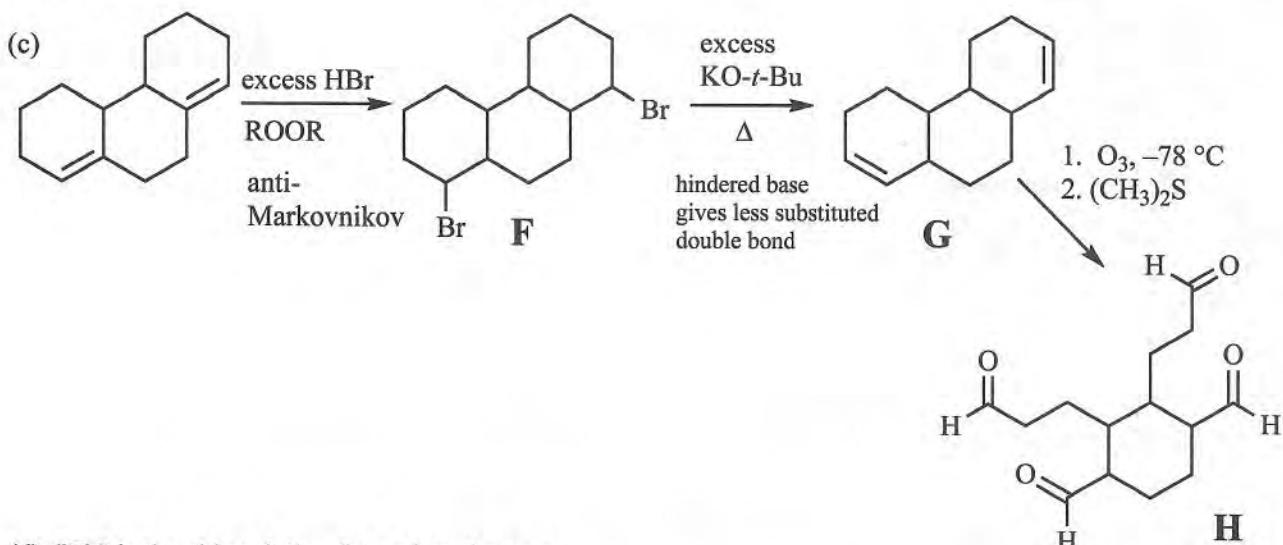
8-54



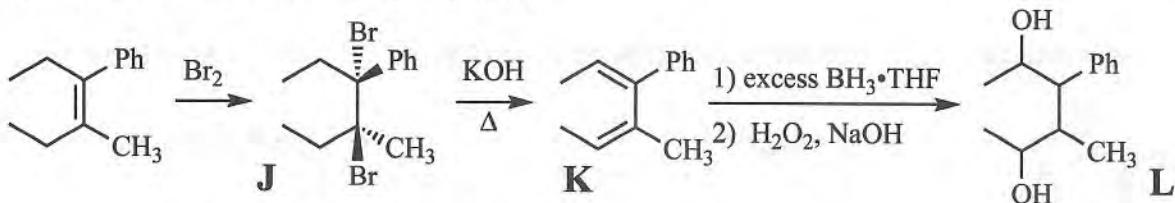
8-55 Chiral products are racemic mixtures.



8-55 continued



(d) "Ph" is the abbreviation for a phenyl group.

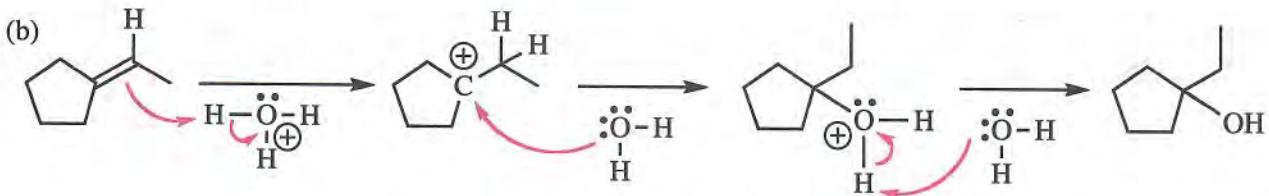
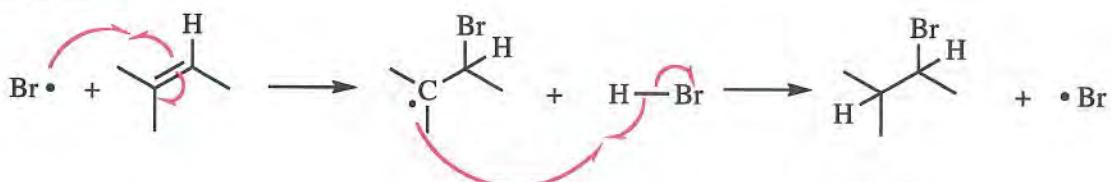


8-56 (a)

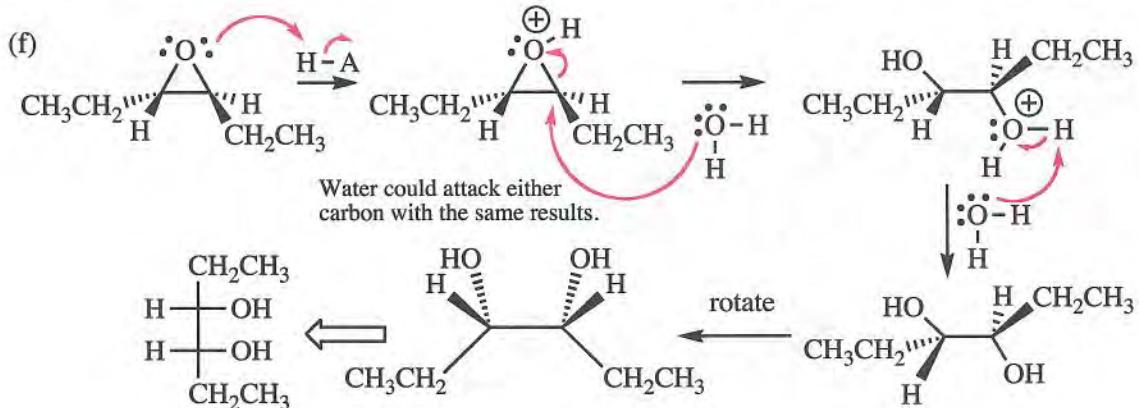
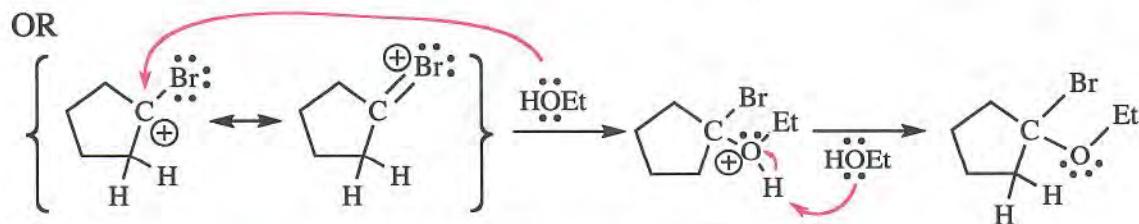
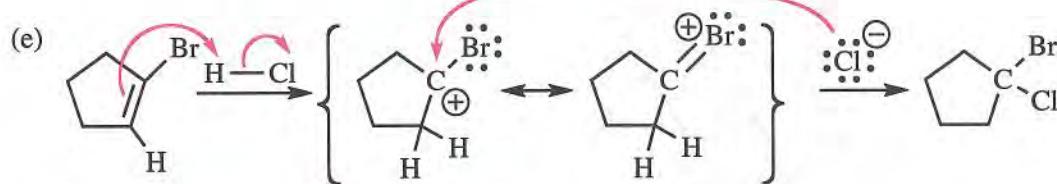
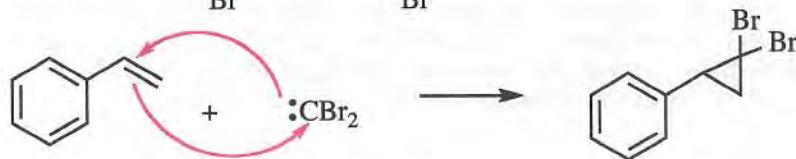
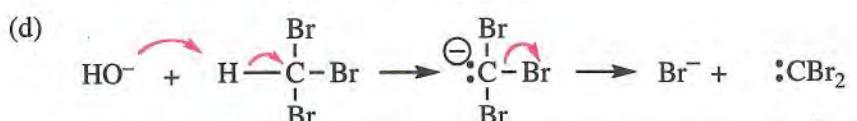
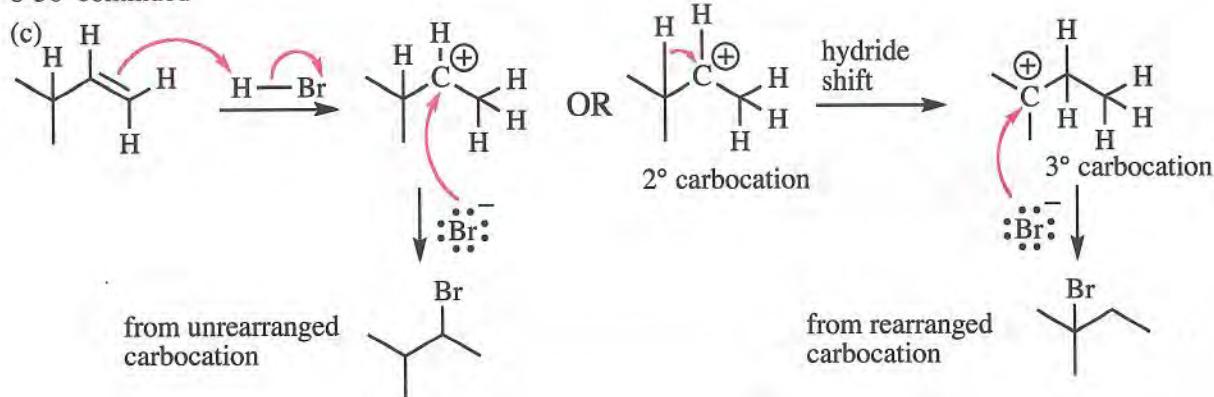
initiation



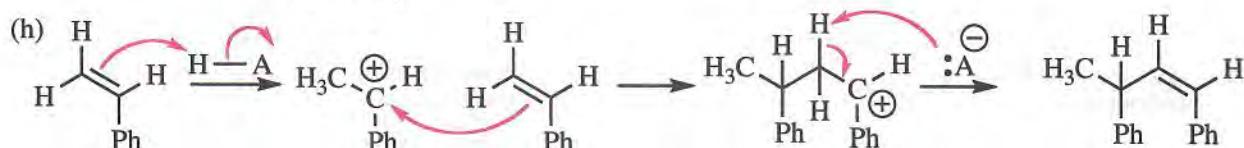
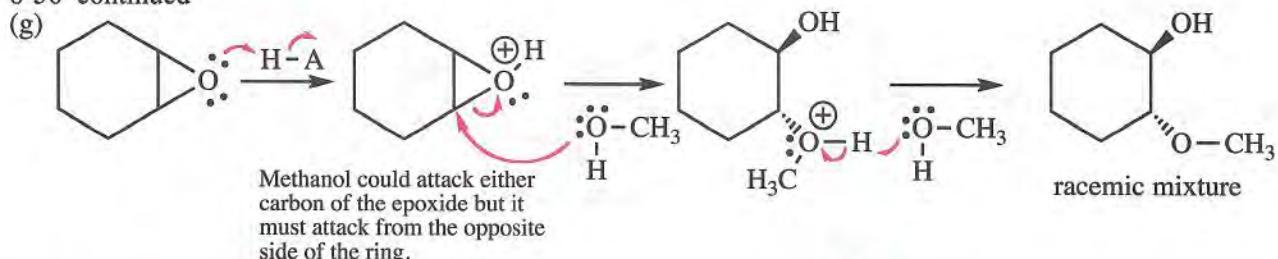
propagation



8-56 continued



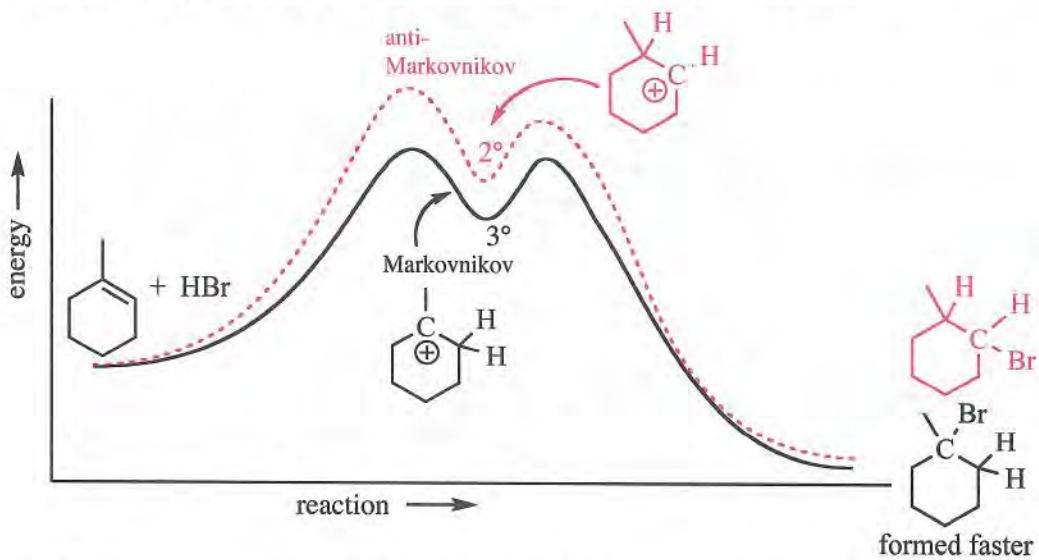
8-56 continued



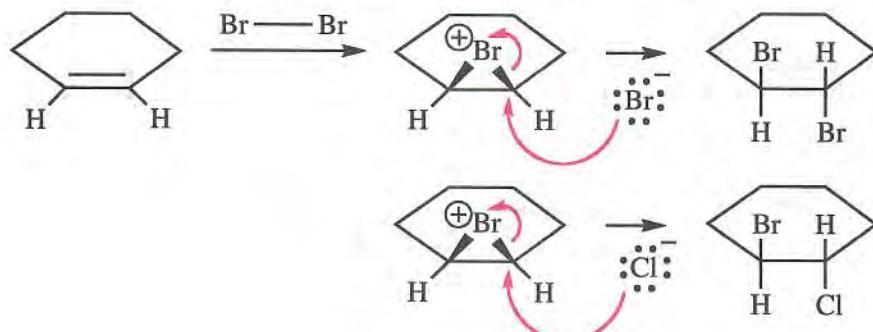
Recall that "Ph" is the abbreviation for phenyl.

8-57

The slow step is the first step, formation of the carbocation, in electrophilic addition. The major product is the one whose intermediate carbocation is formed faster, as it has the lower activation energy. Assume that the energy of the products will be roughly the same, and both pathways begin with the same reactants, so the only difference occurs in the transition states and the intermediates.

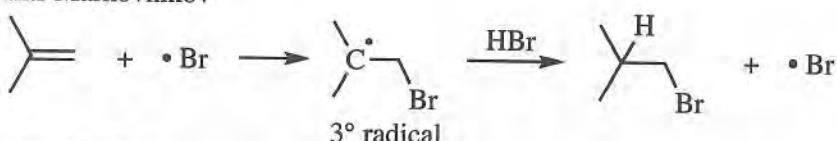


8-58 Once the bromonium ion is formed, it can be attacked by either nucleophile, bromide or chloride, leading to the mixture of products.

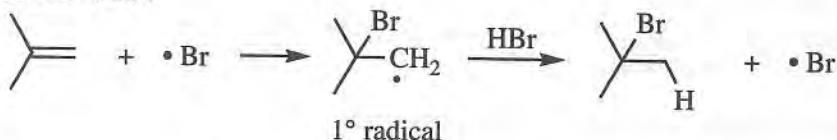


8-59 Two orientations of attack of bromine radical are possible:

(A) anti-Markovnikov



(B) Markovnikov

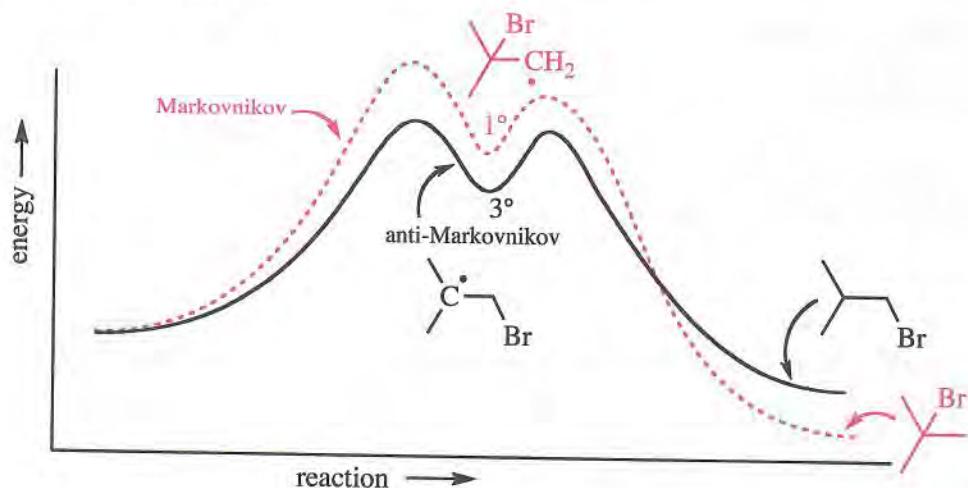


The first step in the mechanism is endothermic and rate determining. The 3° radical produced in anti-Markovnikov attack (A) of bromine radical is several kJ/mole more stable than the 1° radical generated by Markovnikov attack (B). Hammond's Postulate tells us that it is reasonable to assume that the activation energy for anti-Markovnikov addition is lower than for Markovnikov addition. This defines the first half of the energy diagram.

The relative stabilities of the final products are somewhat difficult to predict. (Remember that stability of final products does not necessarily reflect relative stabilities of intermediates; this is why a thermodynamic product can be different from a kinetic product.) From bond dissociation energies (kJ/mole) in Table 4-2:

<u>anti-Markovnikov</u>	<u>Markovnikov</u>
H to 3° C 403	H to 1° C 423
Br to 1° C <u>303</u> 706 kJ/mole	Br to 3° C <u>304</u> 727 kJ/mole

If it takes more energy to break bonds in the Markovnikov product, it must be lower in energy, therefore, more stable—OPPOSITE OF STABILITY OF THE INTERMEDIATES! Now we are ready to construct the energy diagram.



It is the anti-Markovnikov product that is the kinetic product, not the thermodynamic product; the anti-Markovnikov product is obtained since its rate-determining step has the lower activation energy.

8-60

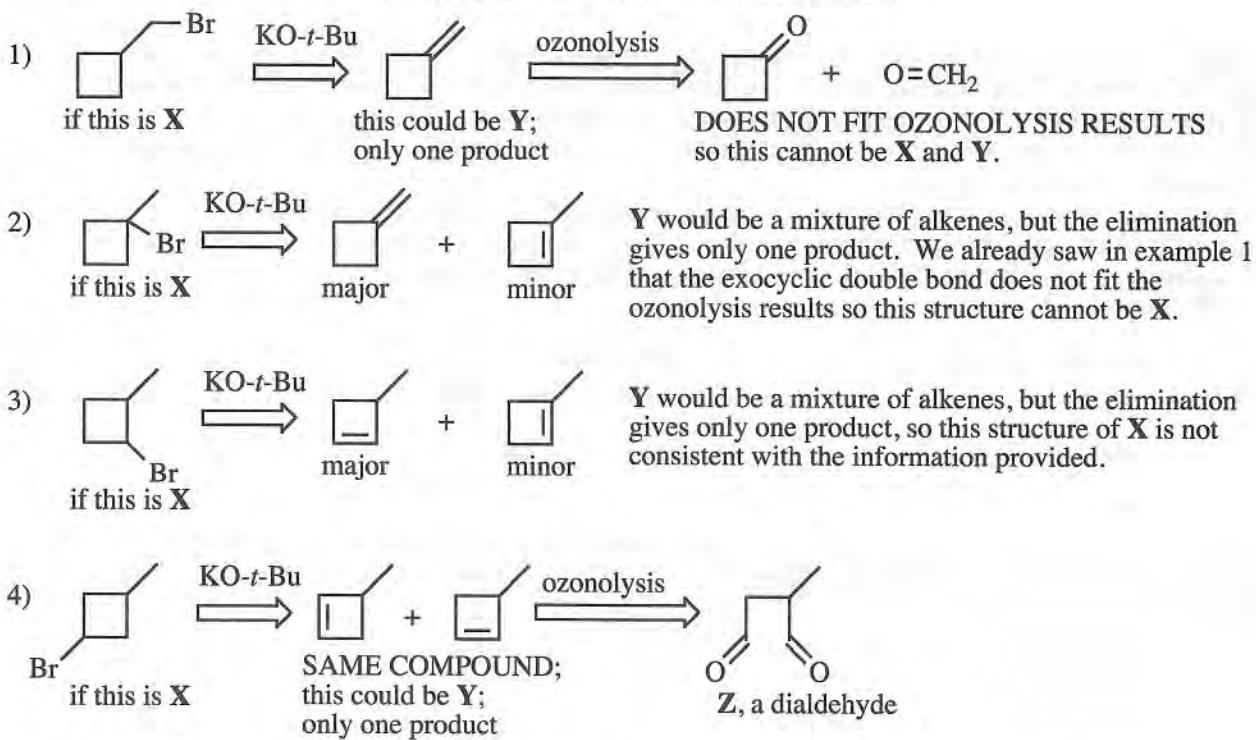
A) Unknown X, C_5H_9Br , has one element of unsaturation. X reacts with neither bromine nor $KMnO_4$, so the unsaturation in X cannot be an alkene; it must be a ring.

B) Upon treatment with strong base (*tert*-butoxide), X loses H and Br to give Y, C_5H_8 , which does react with bromine and $KMnO_4$; it must have an alkene and a ring. Only one isomer is formed.

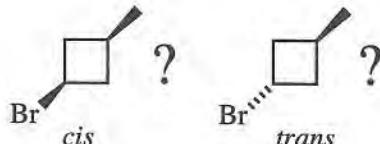
C) Catalytic hydrogenation of Y gives methylcyclobutane. This is a BIG clue because it gives the carbon skeleton of the unknown. Y must have a double bond in the methylcyclobutane skeleton, and X must have a Br on the methylcyclobutane skeleton.

D) Ozonolysis of Y gives a dialdehyde Z, $C_5H_8O_2$, which contains all the original carbons, so the alkene cleaved in the ozonolysis had to be in the ring.

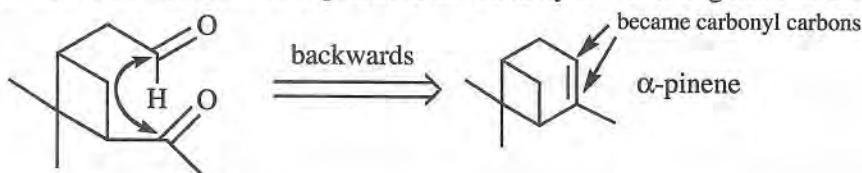
Let's consider the possible answers for X and see if each fits the information.



The correct structures for X, Y, and Z are given in the fourth possibility. The only structural feature of X that remains undetermined is whether it is the *cis* or *trans* isomer.



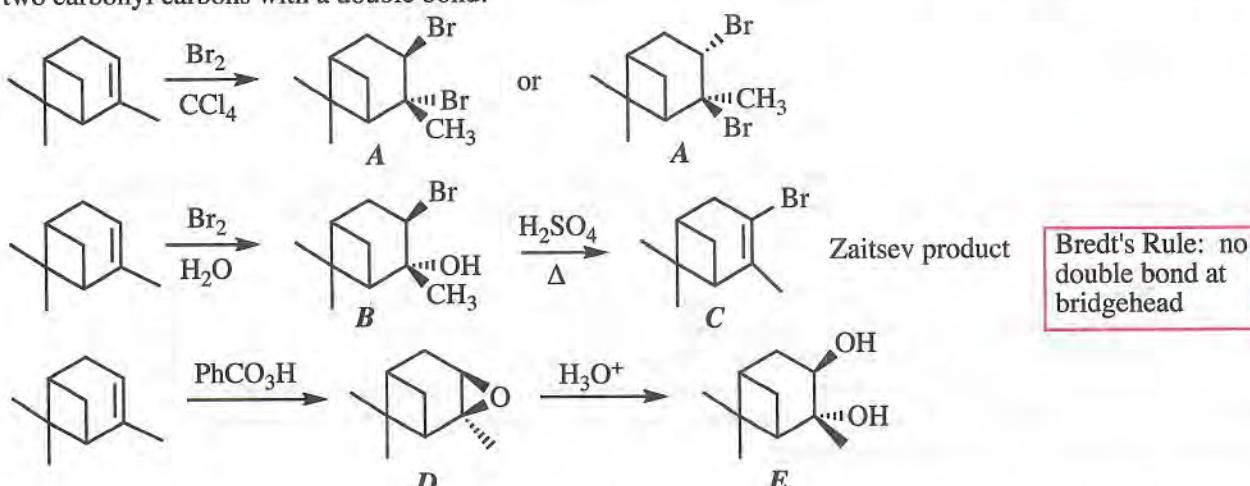
8-61 The clue to the structure of α -pinene is the ozonolysis. Working backwards shows the alkene position.



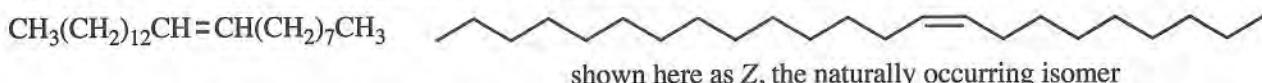
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8-61 continued

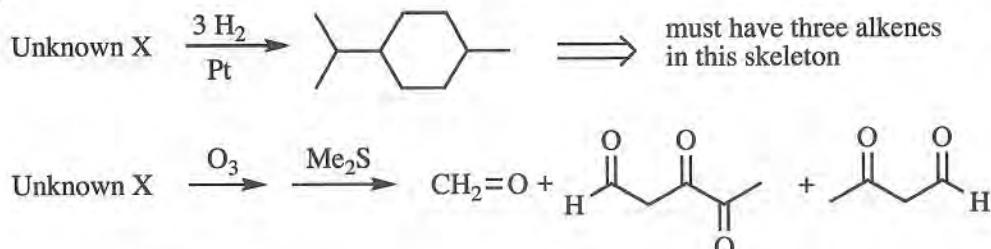
After ozonolysis, the two carbonyls are still connected; the alkene must have been in a ring, so reconnect the two carbonyl carbons with a double bond.



8-62 The two products from permanganate oxidation must have been connected by a double bond at the carbonyl carbons. Whether the alkene was *E* or *Z* cannot be determined by this experiment.

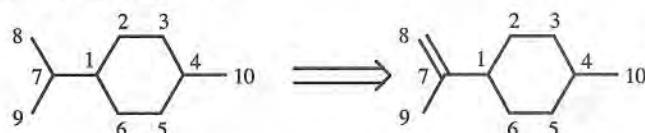


8-63



There are several ways to attack a problem like this. One is the trial-and-error method, that is, put double bonds in all possible positions until the ozonolysis products match. There are times when the trial-and-error method is useful (as in simple problems where the number of possibilities is few), but this is not one of them.

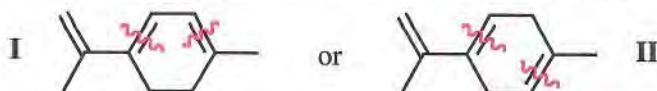
Let's try logic. Analyze the ozonolysis products carefully—what do you see? There are only two methyl groups, so one of the three terminal carbons in the skeleton (C-8, C-9, or C-10) has to be a =CH₂. Do we know which terminal carbon has the double bond? Yes, we can deduce that. If C-10 were double-bonded to C-4, then after ozonolysis, C-8 and C-9 must still be attached to C-7. However, in the ozonolysis products, there is no branched chain, that is, no combination of C-8 + C-9 + C-7 + C-1. What if C-7 had a double bond to C-1? Then we would have acetone, CH₃COCH₃, as an ozonolysis product—we don't. Thus, we can't have a double bond from C-4 to C-10. One of the other terminal carbons (C-8 or C-9) must have a double bond to C-7.



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8-63 continued

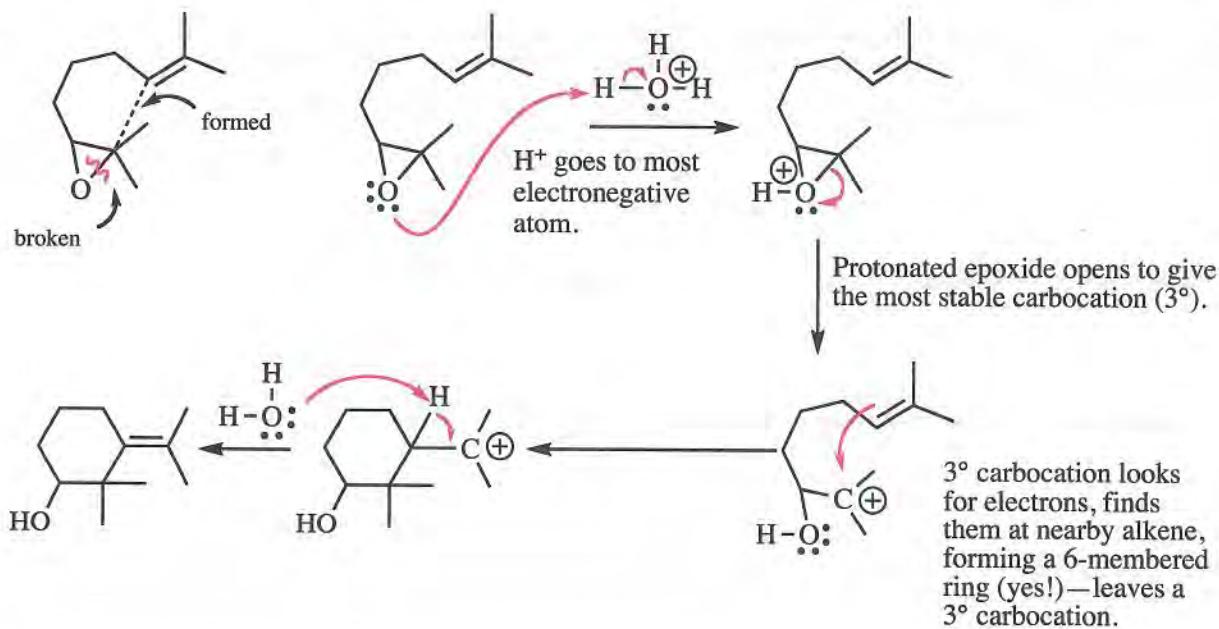
The other two double bonds have to be in the ring, but where? The products do not have branched chains, so double bonds must appear at both C-1 and C-4. There are only two possibilities for this requirement.



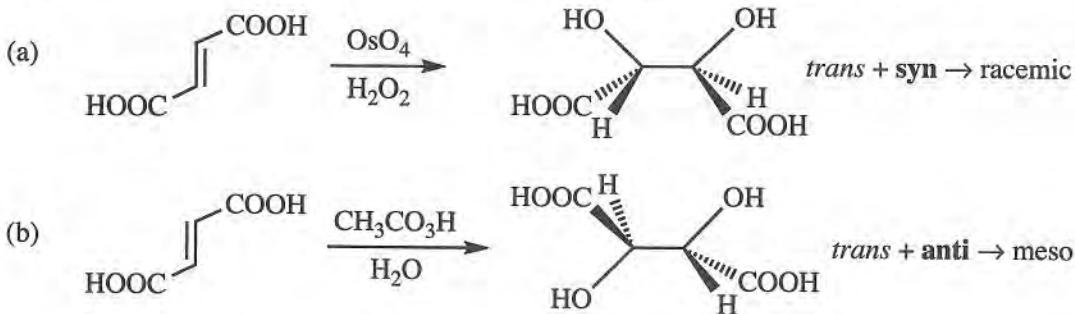
Ozonolysis of **I** would give fragments containing one carbon, two carbons, and seven carbons. Ozonolysis of **II** would give fragments containing one carbon, four carbons, and five carbons. Aha! Our mystery structure must be **II**.

Note to the student: Science is more than a collection of facts. The application of observation and logic to solve problems by *deduction* and *inference* is a critical scientific skill, one that distinguishes humans from algae.

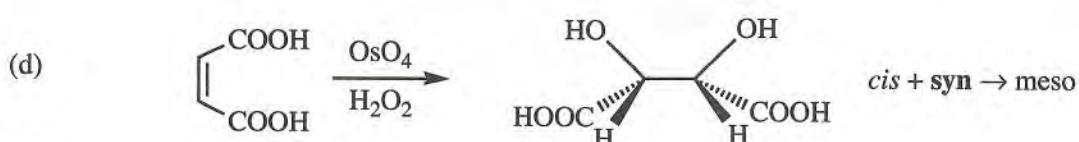
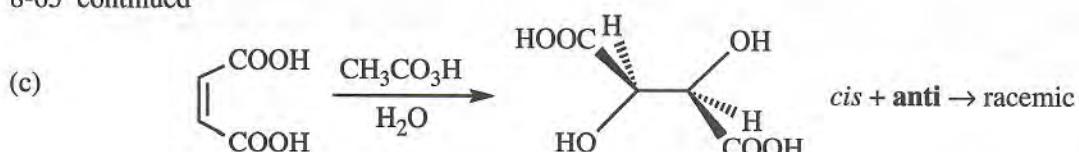
8-64 In this type of problem, begin by determining which bonds are broken and which are formed. These will always give clues as to what is happening.



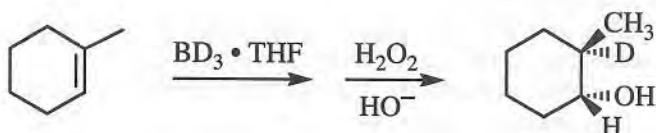
8-65 See the solution to Problem 8-35 for simplified examples of these reactions.



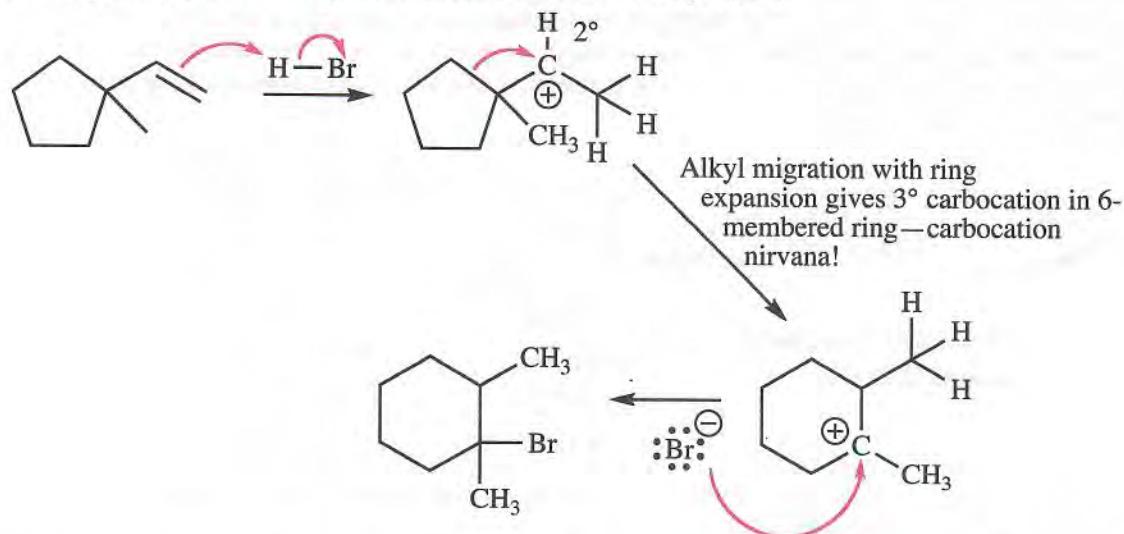
8-65 continued



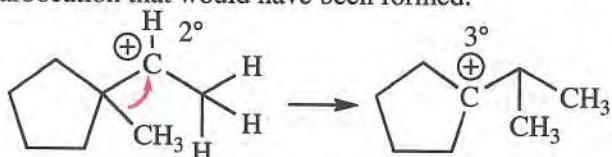
8-66



8-67 By now, these rearrangements should not be so "unexpected".

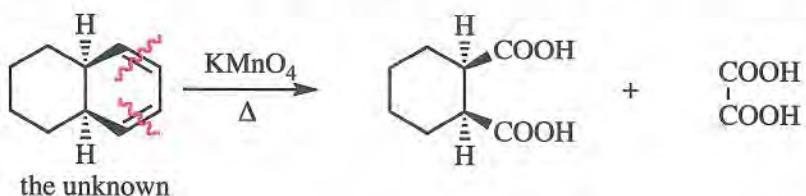


You must be asking yourself, "Why didn't the methyl group migrate?" To which you answered by drawing the carbocation that would have been formed:



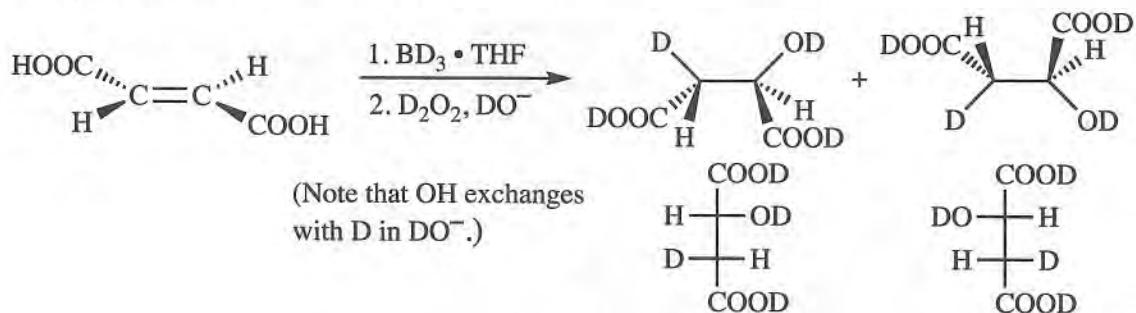
The new carbocation is indeed 3°, but it is only in a 5-membered ring, not quite as stable as in a 6-membered ring. In all probability, some of the product from methyl migration would be formed, but the 6-membered ring would likely be the major product.

8-68 Each alkene will produce two carbonyls upon ozonolysis or permanganate oxidation. Oxidation of the unknown generated four carbonyls, so the unknown must have had two alkenes. There is only one possibility for their positions.

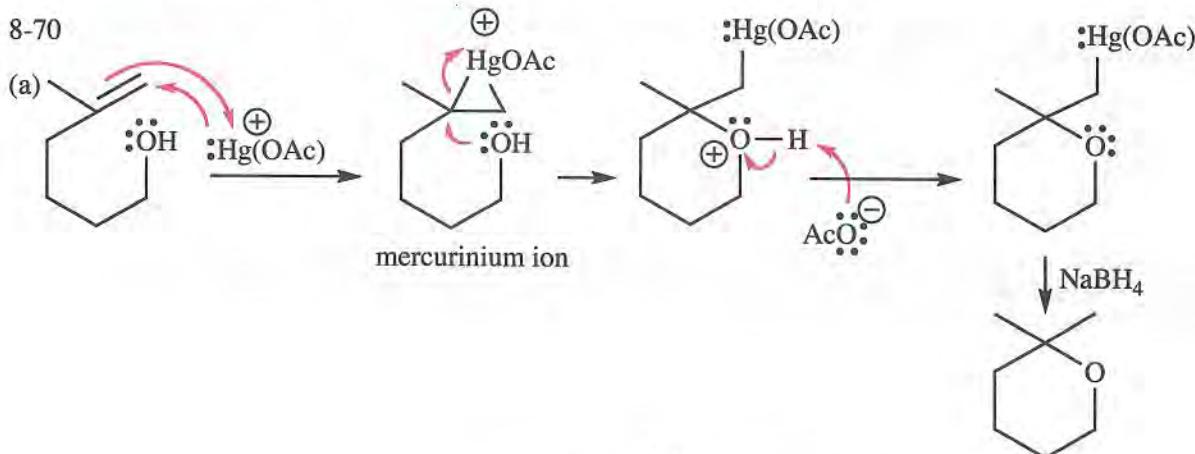


8-69

- Fumarase catalyzes the addition of H and OH, a hydration reaction.
- Fumaric acid is planar and cannot be chiral. Malic acid does have a chiral center and is chiral. The enzyme-catalyzed reaction produces only the *S* enantiomer, so the product must be optically active.
- One of the fundamental rules of stereochemistry is that optically inactive starting materials produce optically inactive products. Sulfuric-acid-catalyzed hydration would produce a racemic mixture of malic acid, that is, equal amounts of *R* and *S*.
- If the product is optically active, then either the starting materials or the catalyst were chiral. We know that water and fumaric acid are not chiral, so we must infer that fumarase is chiral.
- The D and the OD are on the "same side" of the Fischer projection (sometimes called the "erythro" stereoisomer). These are produced from either: (1) syn addition to *cis* alkenes, or (2) anti addition to *trans* alkenes. We know that fumaric acid is *trans*, so the addition of D and OD must necessarily be anti.
- Hydroboration is a syn addition.

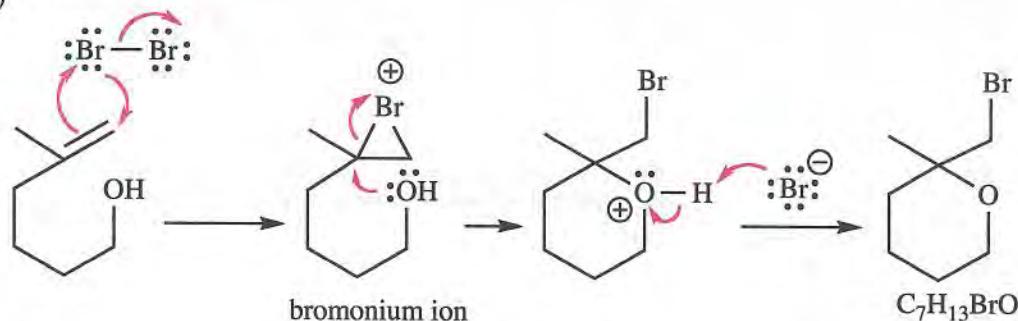


As expected, *trans* alkene plus syn addition puts the two groups on the "opposite" side of the Fischer projection (sometimes called "threo").



8-70 continued

(b)



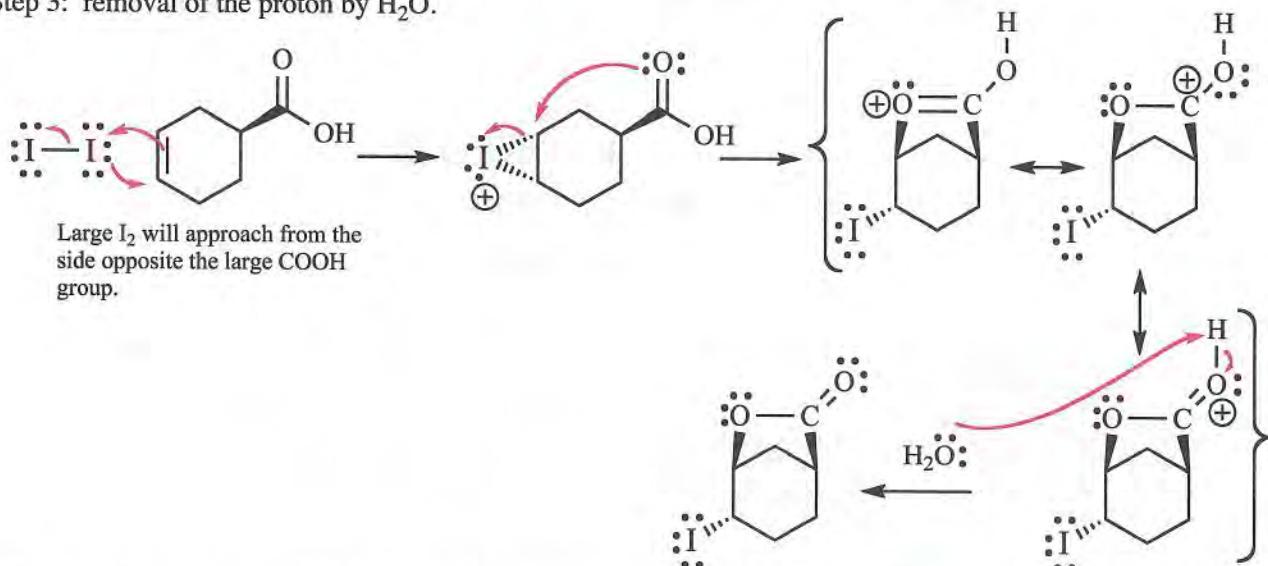
8-71

This mechanism is very similar to formation of a halohydrin (text Mechanism 8-8); the difference is that the nucleophile comes from the carboxylic acid on the other side of the molecule, making a new ring in the process.

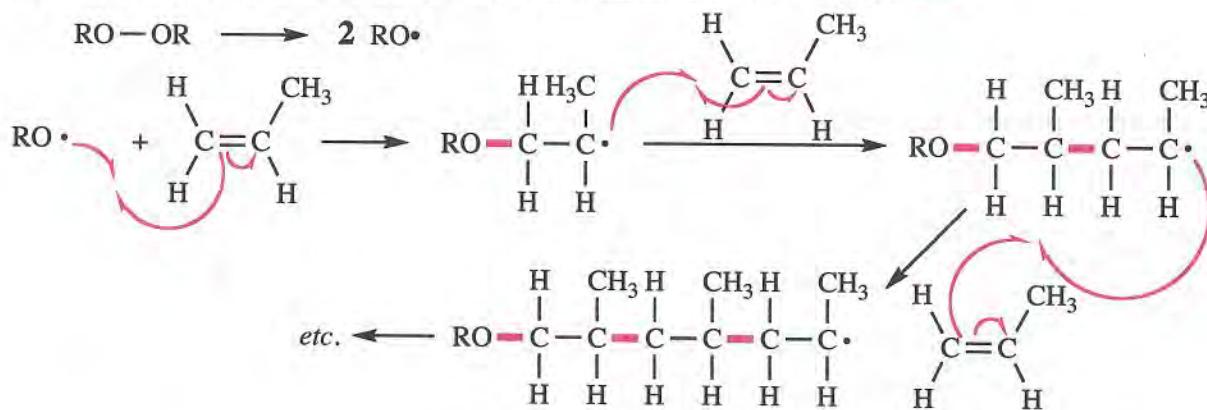
Step 1: formation of the iodonium ion;

Step 2: internal nucleophilic attack (the O of the C=O is more nucleophilic than the OH because of resonance stabilization of the intermediate);

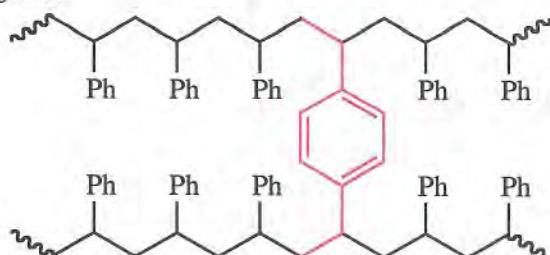
Step 3: removal of the proton by H₂O.



8-72 For clarity, the new bonds formed in this mechanism are shown in bold. —



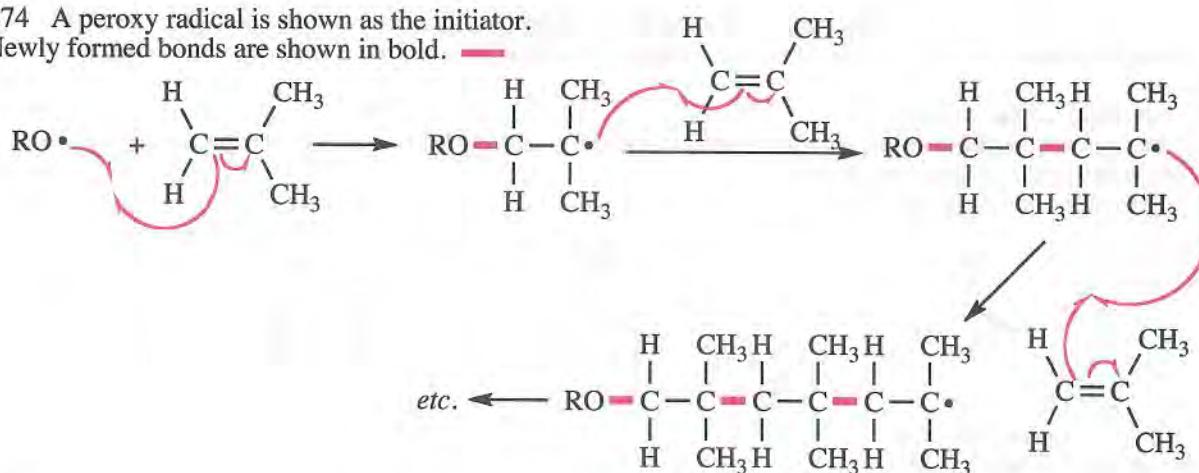
8-73 Without divinylbenzene, individual chains of polystyrene are able to slide past one another. Addition of divinylbenzene during polymerization forms bridges, or *crosslinks*, between chains, adding strength and rigidity to the polymer. Divinylbenzene and similar molecules are called crosslinking agents.



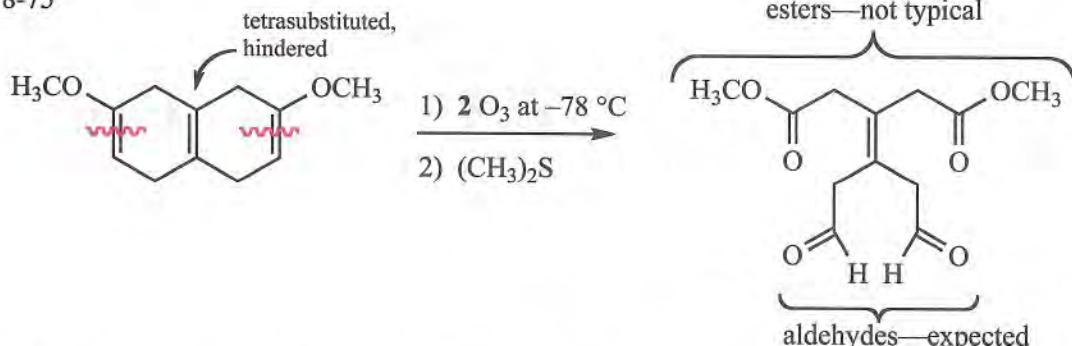
Two polystyrene chains crosslinked by a divinylbenzene monomer shown in red.



8-74 A peroxy radical is shown as the initiator. Newly formed bonds are shown in bold. —

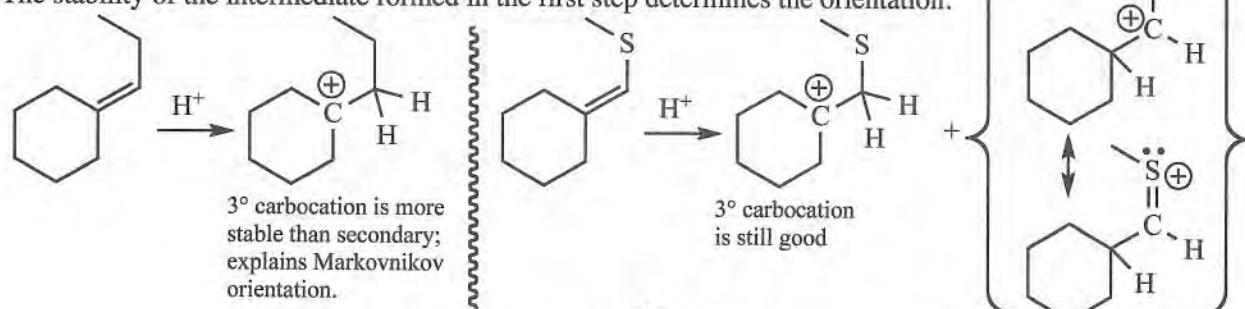


8-75

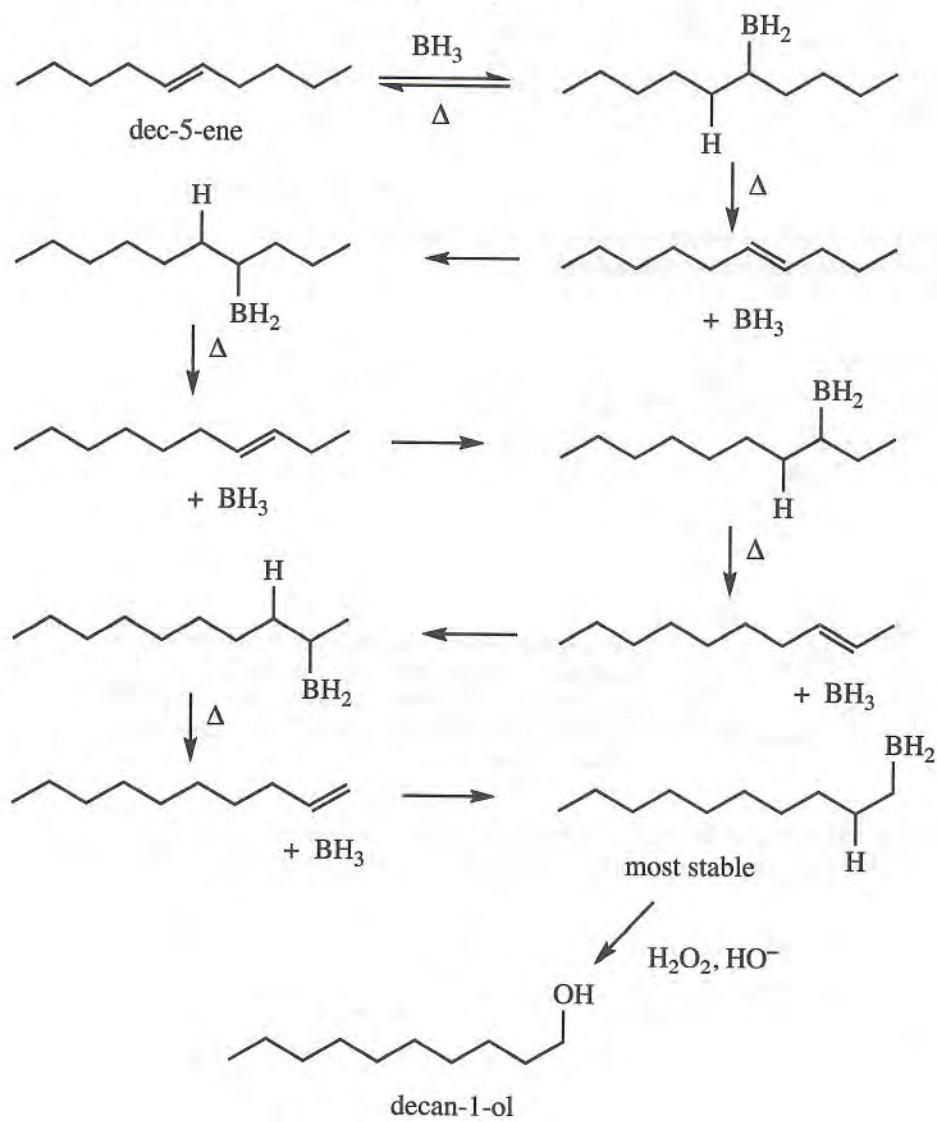


8-76

The stability of the intermediate formed in the first step determines the orientation.

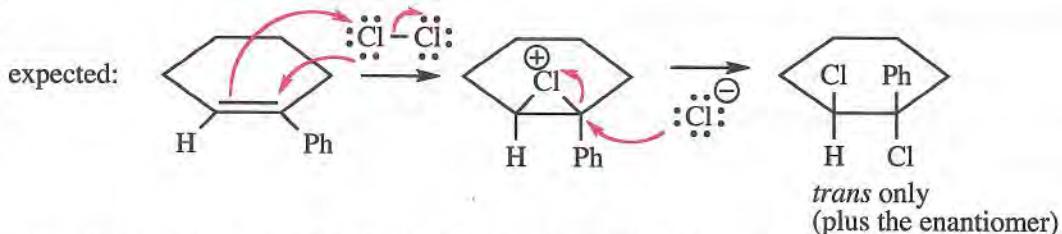


8-77 The addition of BH_3 to an alkene is reversible. Given heat and time, the borane will eventually "walk" its way to the end of the chain through a series of addition-elimination cycles. The most stable alkylborane has the boron on the end carbon; eventually, the series of equilibria leads to the ultimate borane product that is oxidized to the primary alcohol.

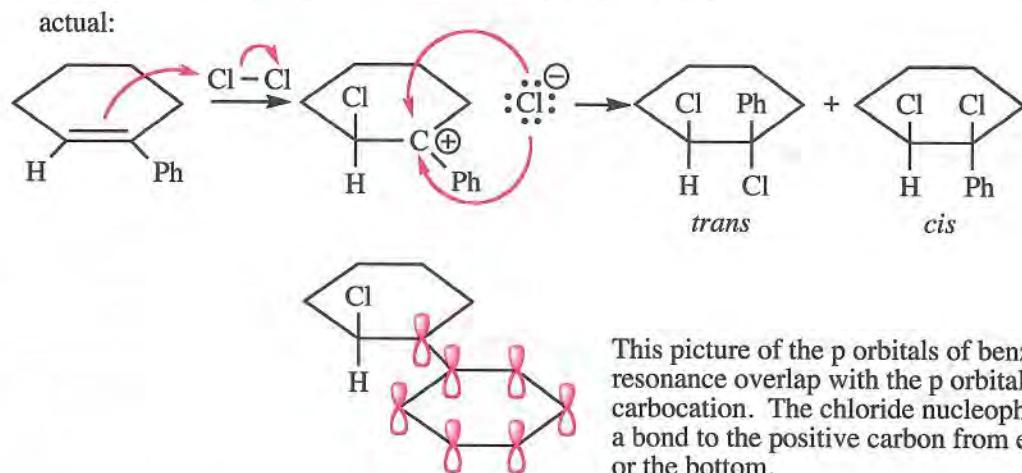


8-78 First, we explain *how* the mixture of stereoisomers results, then *why*.

We have seen many times that the bridged halonium ion permits attack of the nucleophile only from the opposite side.

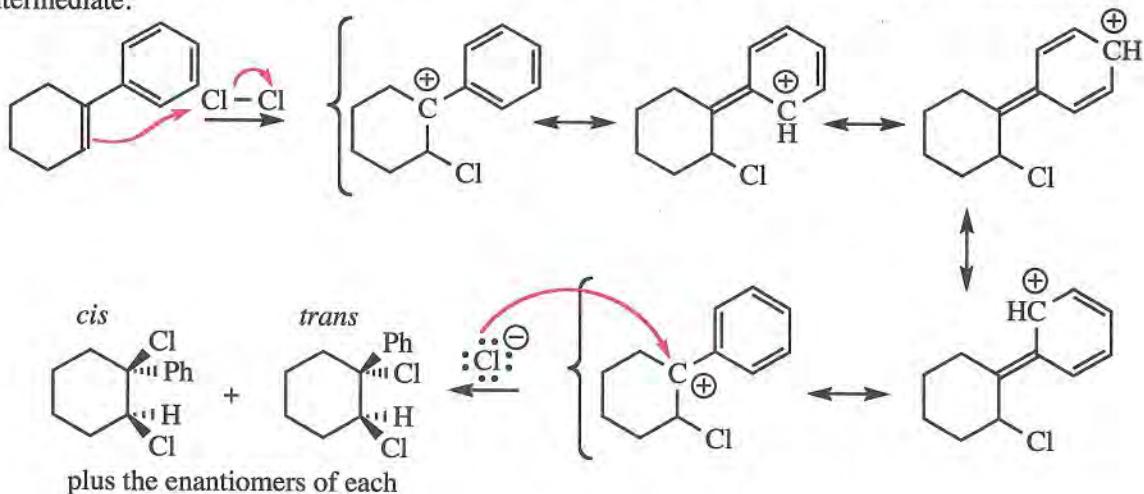


A mixture of *cis* and *trans* could result only if attack of chloride were possible from both top and bottom, something possible only if a carbocation existed at this carbon.



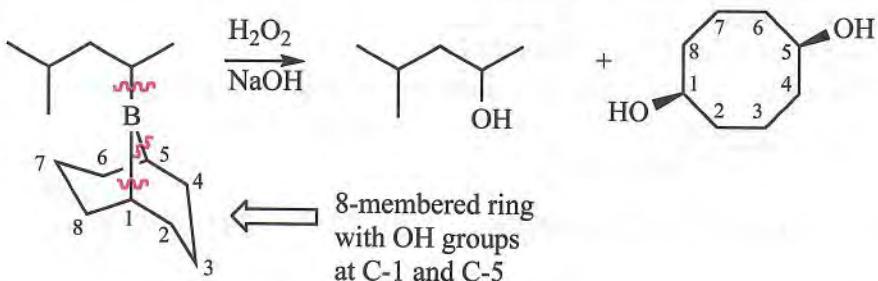
This picture of the p orbitals of benzene shows resonance overlap with the p orbital of the carbocation. The chloride nucleophile can form a bond to the positive carbon from either the top or the bottom.

Why does a carbocation exist here? Not only is it 3° , it is also next to a benzene ring (benzylic) and therefore resonance-stabilized. This resonance stabilization would be forfeited in a halonium ion intermediate.

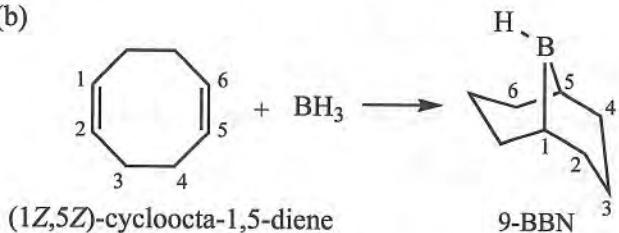


8-79

(a) The three bonds to boron, indicated by the squiggly line, will be replaced by an OH.



(b)



Note to the student: Chapter 8 introduces a type of graphical reaction summary called a "starburst" diagram. These are visually helpful in organizing the reactions, and very useful in reviewing before quizzes and exams. Your instructor may not cover all of the reactions in the chapter, so it would benefit you to customize the reaction diagrams to optimize their utility for your course.