

Page	Points
<b>1</b>	<b>(10)</b>
<b>2</b>	<b>(16)</b>
<b>3</b>	<b>(22)</b>
<b>4</b>	<b>(18)</b>
<b>5</b>	<b>(27)</b>
<b>6</b>	<b>(21)</b>
<b>7</b>	<b>(21)</b>
<b>8</b>	<b>(23)</b>
<b>9</b>	<b>(15)</b>
<b>10</b>	<b>(20)</b>
<b>11</b>	<b>(15)</b>
<b>Total</b>	<b>(208)</b>
<b>T Score</b>	

Signature \_\_\_\_\_

Pg 1 \_\_\_\_\_ (10)

1. (10 pts) **Circle all the True statements.** (Do not circle any false statements) You may notice that many of these resemble rules of the day!

A.) **E2 reactions** involve an antiperiplanar arrangement of a hydrogen atom and leaving group in the key intermediate.

B.) **E2 reactions** involve an antiperiplanar arrangement of a hydrogen atom and leaving group in the transition state.

C.) An **S<sub>N</sub>2 reaction** on a primary alkyl halide has a lower overall energy barrier compared to a S<sub>N</sub>1 reaction on a primary alkyl halide, because in an S<sub>N</sub>2 reaction the nucleophile actually assists in breaking the carbon leaving group bond, while in an S<sub>N</sub>1 reaction the carbon leaving group bond must break on its own.

D.) For **cyclohexyl halides**, the requirement for an anti-periplanar transition state geometry in an E2 reaction means that the halide leaving group must be axial, never equatorial.

E.) **Alkenes** are more stable with more alkyl groups attached.

F.) **Polar protic solvents** have polar bonds with H atoms that cannot take part in hydrogen bonding.

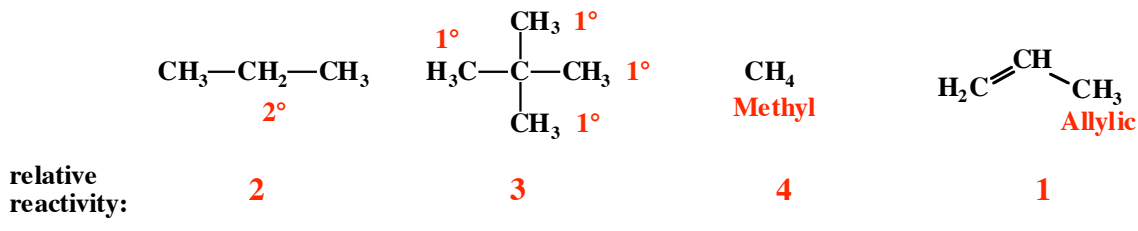
G.) **H-bonding** due to the OH group makes alcohols "sticky" so they have high boiling points and alcohols with three or less carbons dissolve completely in water.

H.) The OH group is not a leaving group, but several reactions involve the **conversion of the OH group into a good leaving group**, followed by a substitution or elimination reaction.

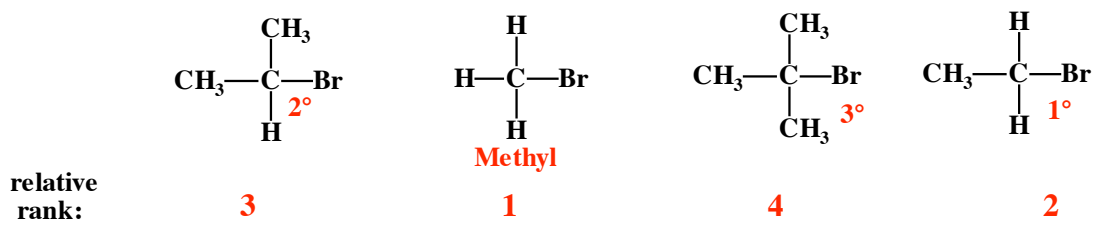
I.) **Primary and secondary alcohols react with PBr<sub>3</sub> and SOCl<sub>2</sub>** to give alkyl bromides and alkyl chlorides, respectively, via a mechanism involving a carbocation intermediate.

J.) **Alcohol dehydration is just the functional reverse of acid-catalyzed alkene hydration** because the process is actually an equilibrium, the position of which depends on the reaction conditions.

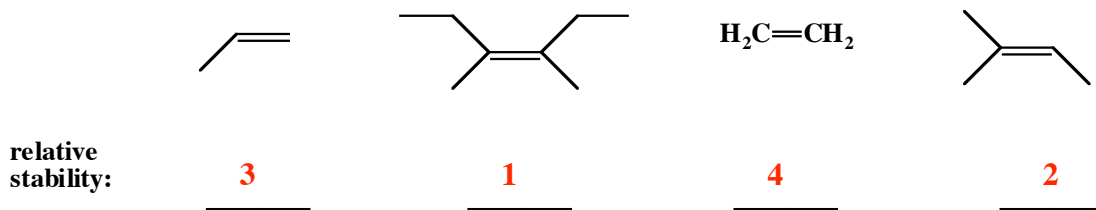
2. (4 pts total) For the following compounds, rank them in order of most to least reactive with Br radicals in a free radical halogenation reaction, with a **1 under the most reactive** and a **4 under the least reactive**.



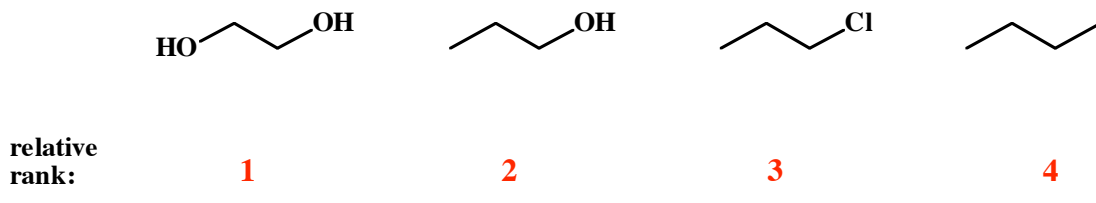
3. (4 pts total) For the following compounds, rank them in order of reaction rate from fastest to slowest with a nucleophile in an  $\text{S}_\text{N}2$  reaction, with a **1 under the fastest** and a **4 under the slowest**.



4. (4 pts total) For the following compounds, rank them in order of most to least stable alkene, with a **1 under the most stable** and a **4 under the least stable**.

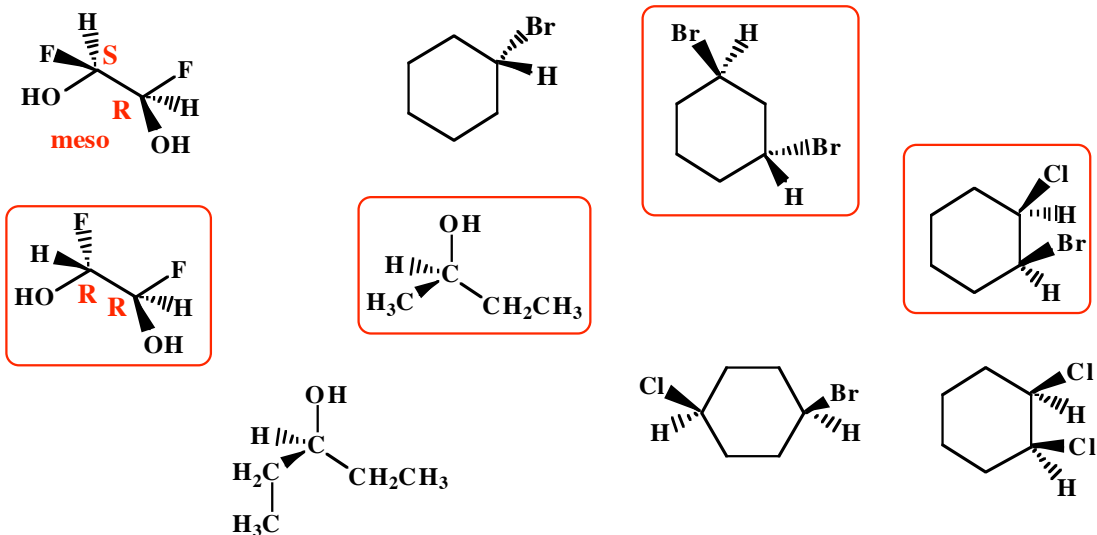


5. (4 pts total) For the following compounds, rank them in order of highest to lowest boiling point, with a **1 under the molecule with the highest boiling point** and a **4 under the molecule with the lowest boiling point**.



*Are you sure you ranked them in the correct order according to the directions???*

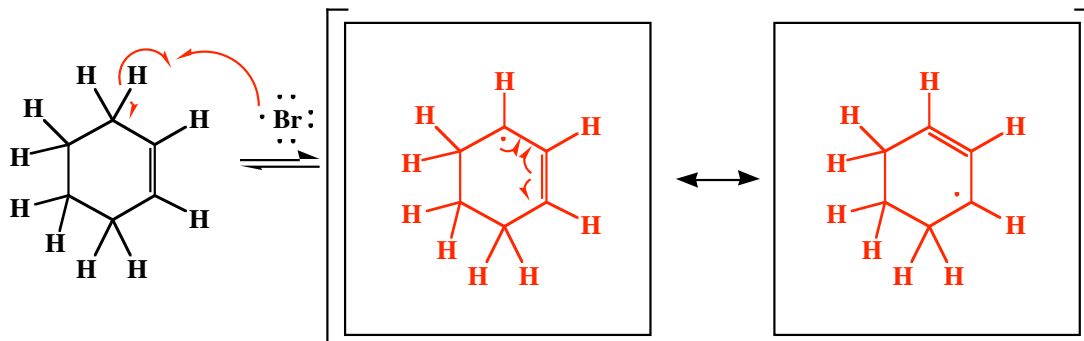
6. (9 pts total) You will recognize this from the last test. We felt that many of you needed more practice with chirality so here it is again. Of the molecules shown below, circle the ones that are optically active, that is the ones for which a sample would rotate the plane of plane polarized light. In other words, circle the molecules that are chiral. By the way, just to keep you honest we moved the molecules around so do not try to remember the location of the circled answers from last test.



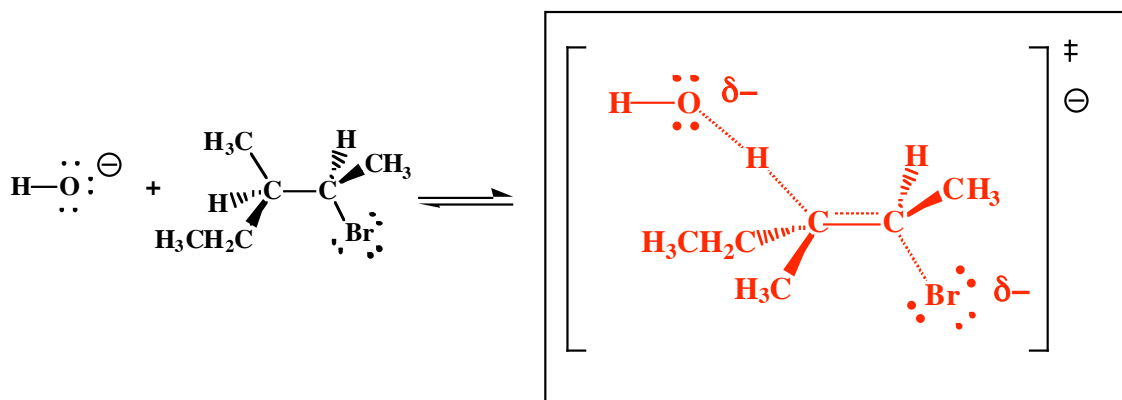
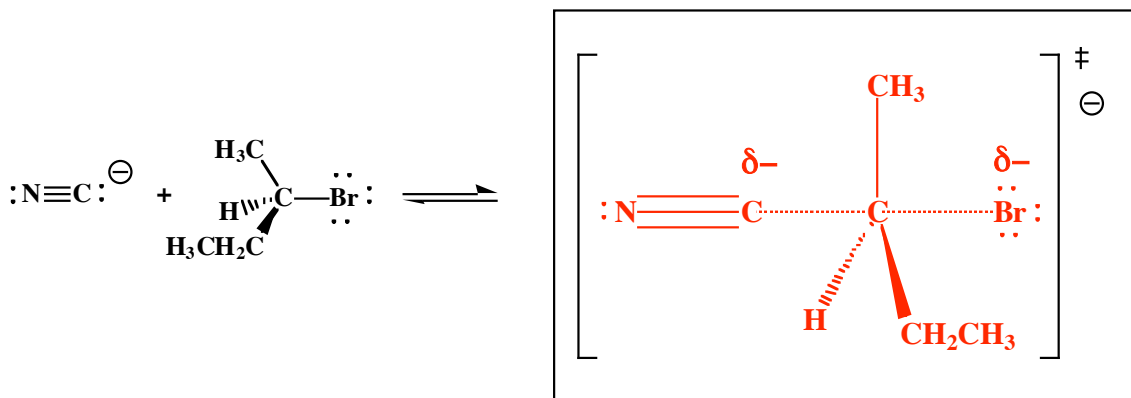
6. (13 pts total) For the following, fill in each blank with  $S_N1$ ,  $S_N2$ , E1, or E2 in order to best complete the following statements.

- A. Scrambled stereochemistry results from an  $S_N1$  reaction at a stereocenter.
- B.  $S_N2$  reactions always result in inversion of stereochemistry
- C. Primary alcohols react with concentrated  $H_2SO_4$  by protonation followed by an  $E2$  reaction to yield an alkene.
- D.  $S_N1$  and  $E1$  involve the formation of carbocation intermediates.
- E. The reaction rate of  $S_N2$  and  $E2$  reactions can be altered by changing the concentration of the nucleophile/base or the alkyl halide.
- F. The reaction rate of  $S_N1$  and  $E1$  reactions can only be altered by changing the concentration of the alkyl halide.
- G. Polar protic solvents accelerate  $S_N1$  and  $E1$  reactions.
- H. Zaitsev's rule applies to  $E2$  and  $E1$  reactions.

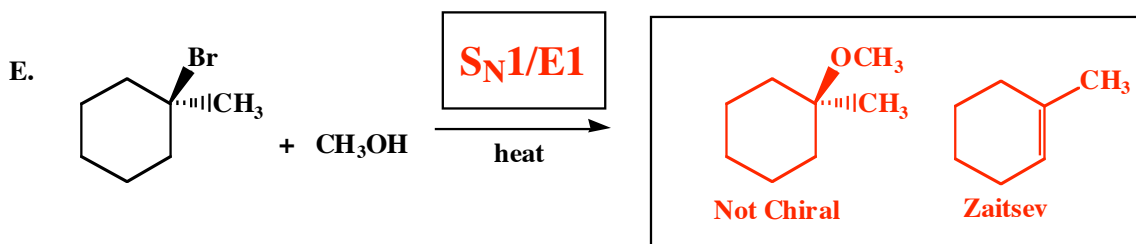
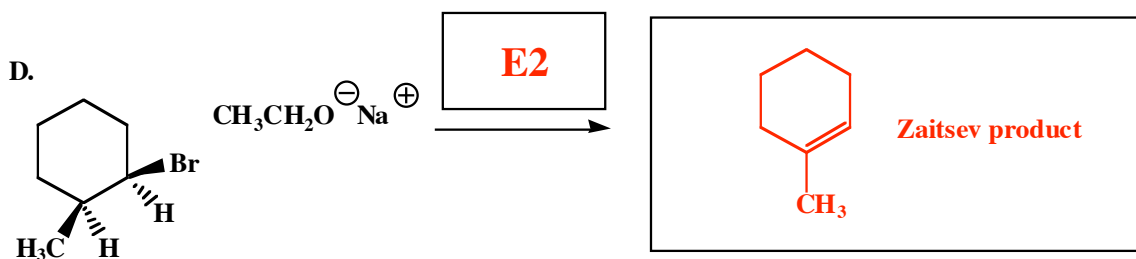
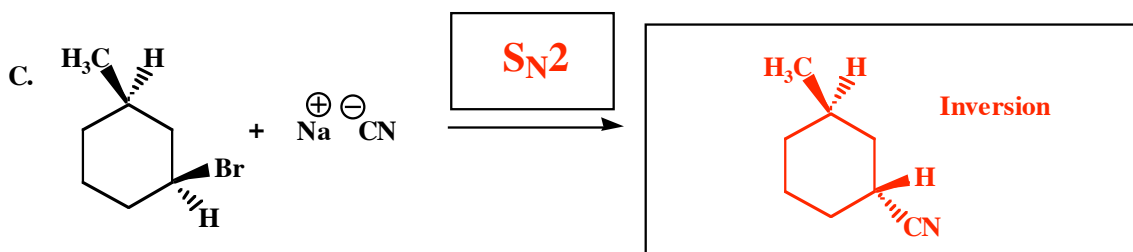
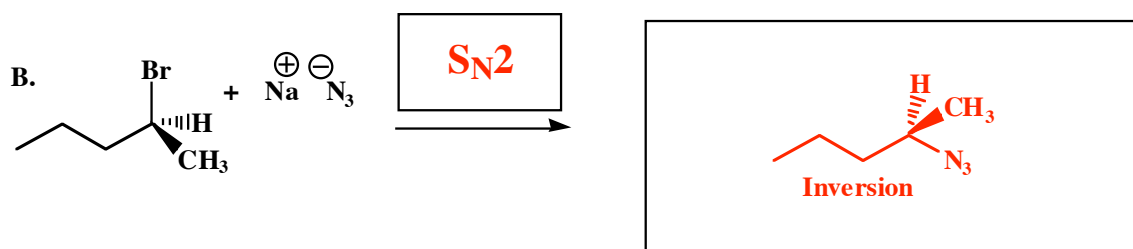
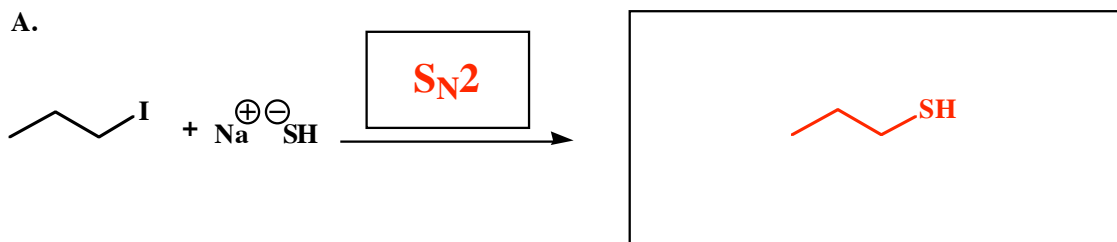
7. (8 pts total) We have encountered some resonance stabilized intermediates in class recently. The allyl radical is a good example. In the spaces provided, draw two resonance contributing structures of the radical intermediate formed when cyclohexene reacts with a bromine radical. Use arrows to indicate the flow of **all** electrons.



8. (10 pts total)  $\text{S}_{\text{N}}2$  and  $\text{E}2$  reactions each occur via a key transition state. In the boxes provided, draw the transition states for the given  $\text{S}_{\text{N}}2$  and  $\text{E}2$  reactions. No need to draw any arrows here, but use dashed lines to indicate bonds that are being broken or formed in the transition state. Make sure to show all lone pairs. Notice that we gave you a lot of room so please make your drawings clear for us to grade.

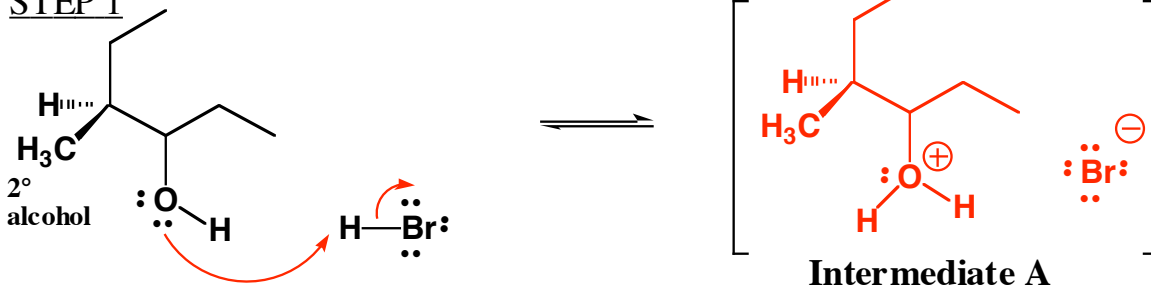


9. (5 or 7 pts each) The following reactions all involve substitution and/or elimination. **Fill in the box above the arrow with the mechanism that will be followed ( $S_N2$ , E2, etc.). Then draw only the predominant product or products** and please remember that **you must draw the correct stereoisomers**. When a scrambled mixture is formed, **you must write "scrambled" under both structures EVEN THOUGH YOU DREW BOTH STRUCTURES**. For  $S_N1/E1$  reactions you must draw both types of products.

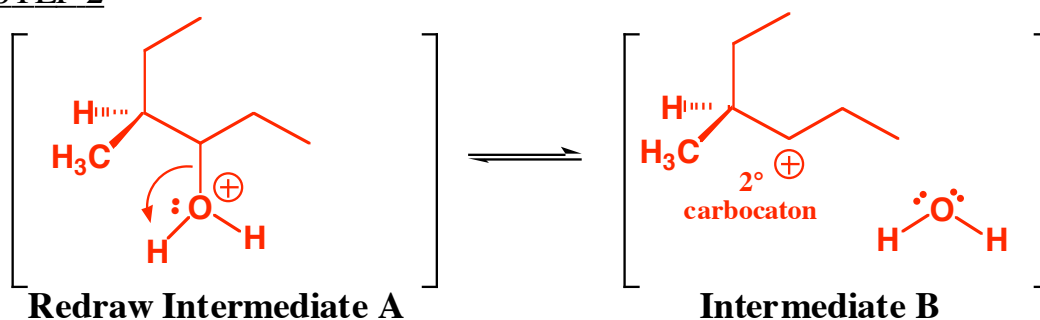


10. (21 pts.) Read these directions carefully. Read these directions carefully. (It was worth repeating) For the reaction shown below, fill in the details of the mechanism. Draw the appropriate chemical structures and use arrows to show how pairs of electrons are moved to make and break bonds during the reaction of the indicated alcohol with H-Br. Hint: *There is a rearrangement step in this reaction.* Make sure to draw all lone pairs of electrons, all formal charges, and all products (including stereoisomers) produced along the way.

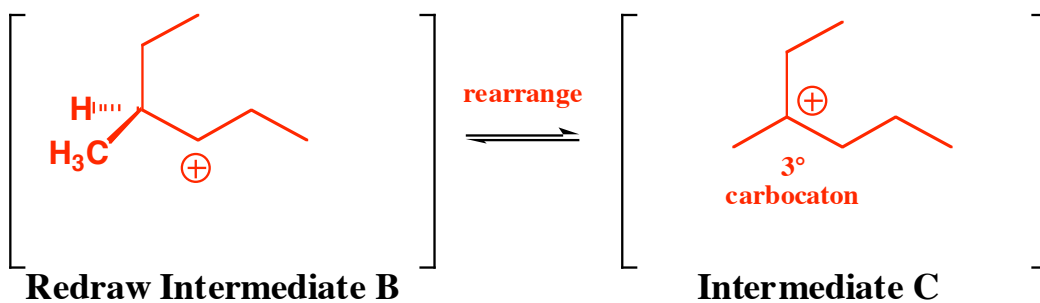
## STEP 1



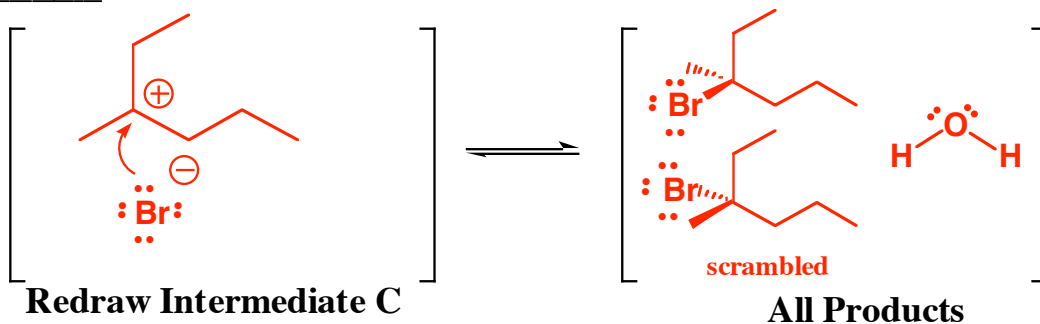
## STEP 2



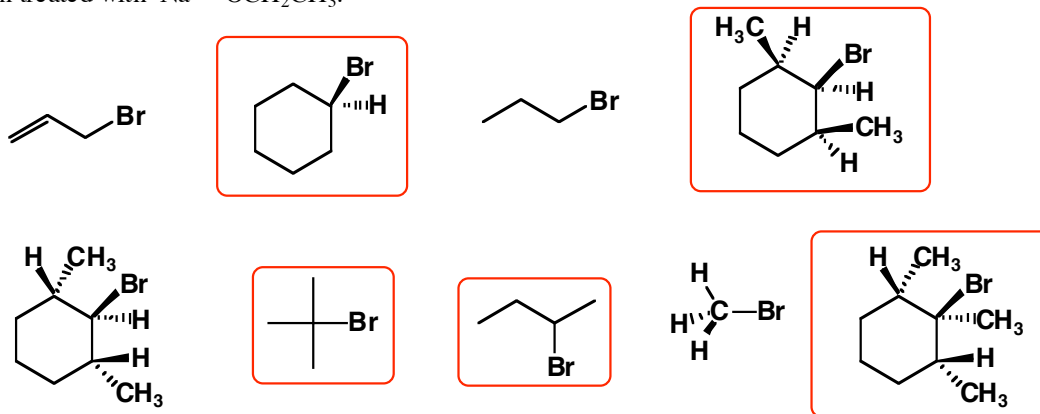
## STEP 3



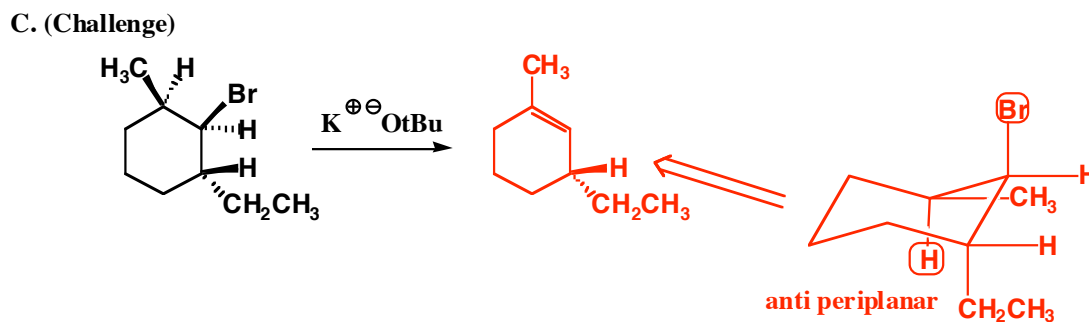
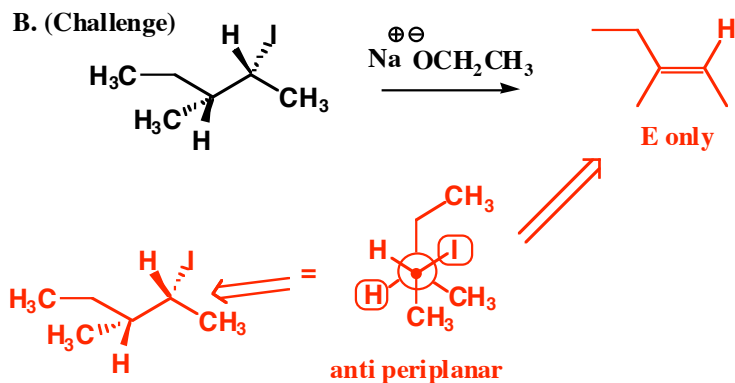
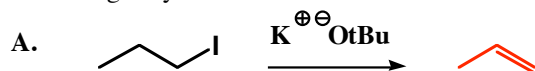
## STEP 4



10. (9 pts.) For the following, circle all of the molecules that will primarily react via an E2 mechanism when treated with  $\text{Na}^{\oplus} \text{OCH}_2\text{CH}_3^{\ominus}$ .

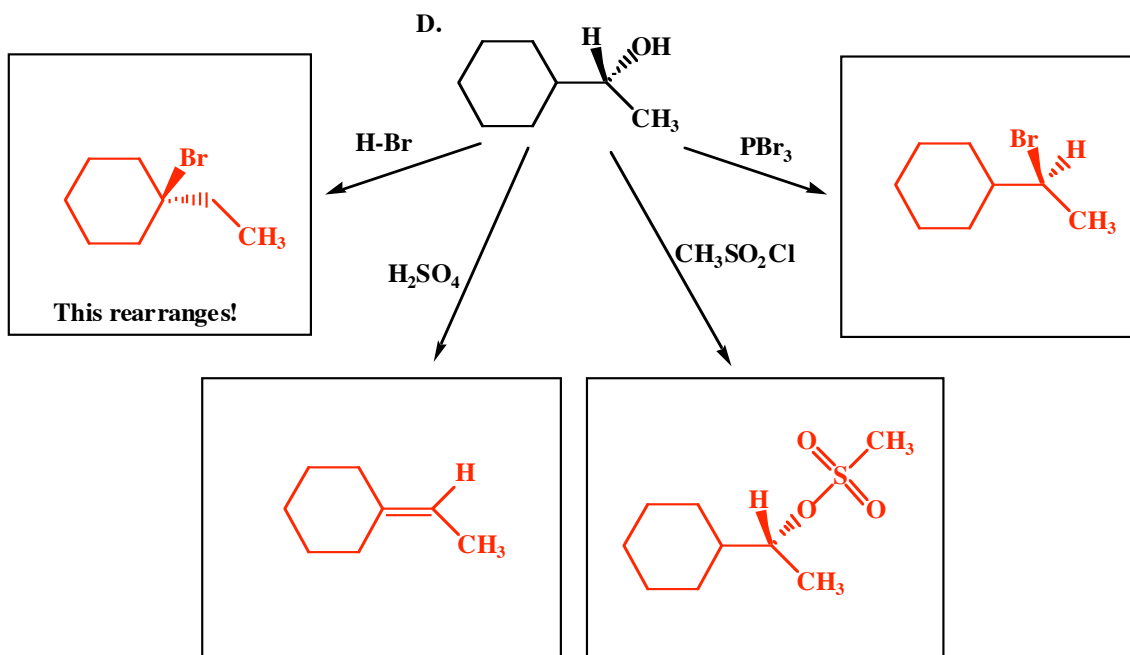
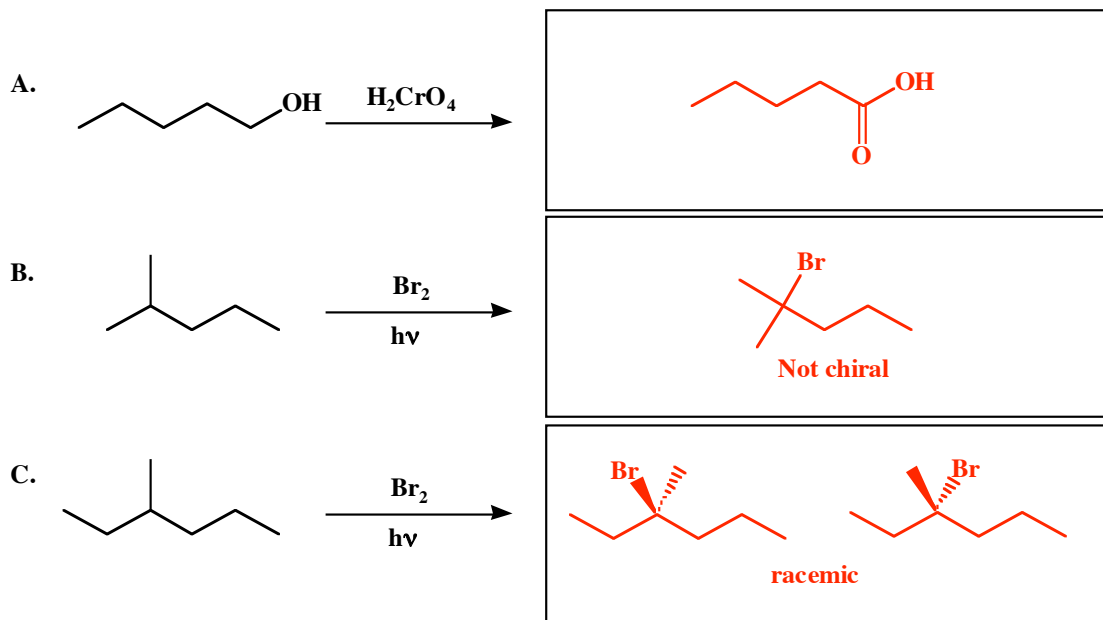


11. (12 pts.) Draw the predominant product that results from the following E2 elimination reactions. We gave you a little extra room to work the harder ones.

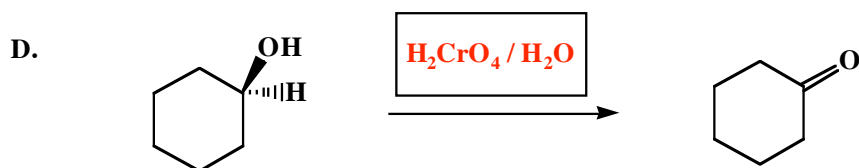
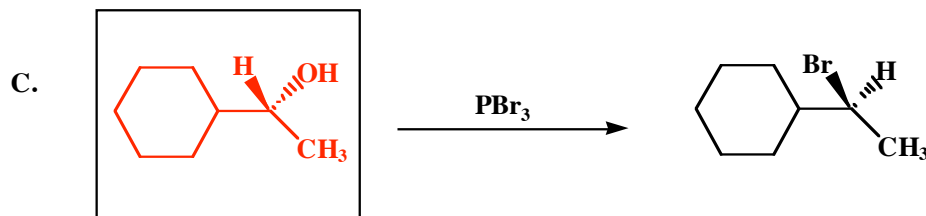
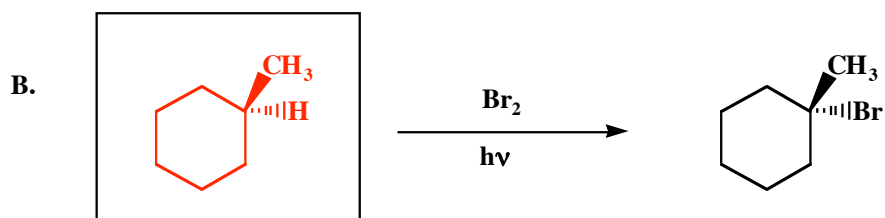
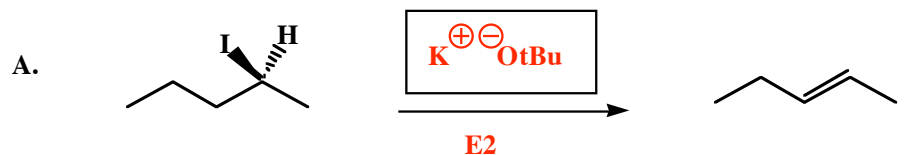




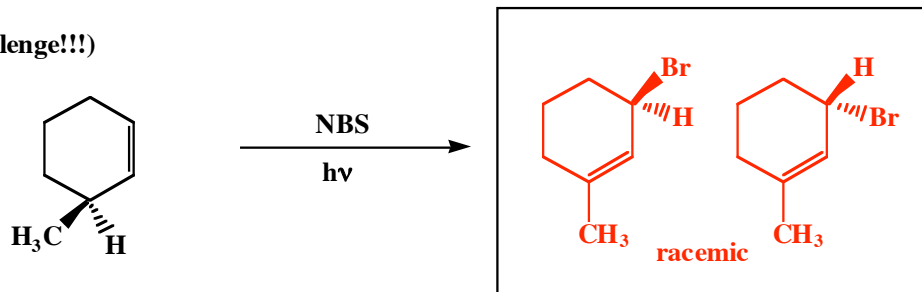
12. (3-5 pts each) Fill in the box with the product or products that are missing from the following chemical reaction equations. **Draw only the predominant product or products** and please remember that **you must draw the structures of all the predominant product stereoisomers**. When a racemic mixture is formed, **you must write "racemic" under both structures EVEN THOUGH YOU DREW BOTH STRUCTURES**. If a scrambled mixture is produced, you need to write "scrambled".



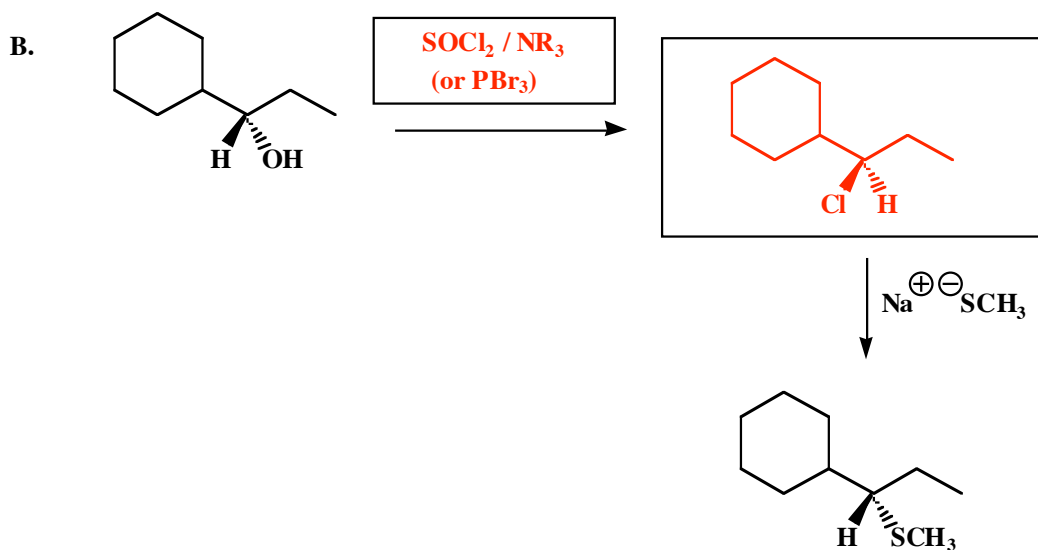
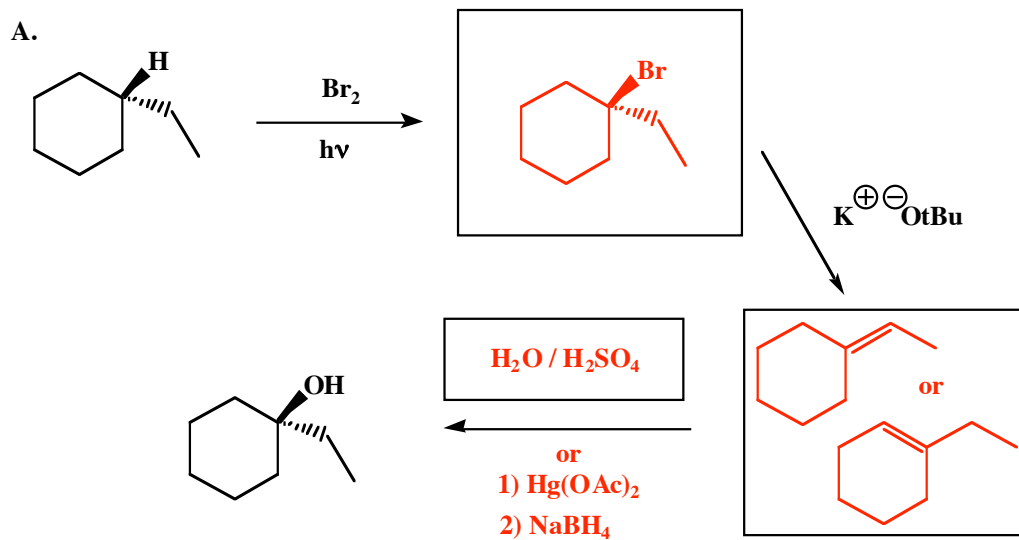
13. (3 pts each) Fill in the box with the product, starting material or reagents that are missing from the following chemical reaction equations. **Draw only the predominant product or products** and please remember that **you must draw the structures of all the predominant product stereoisomers**. When a racemic mixture is formed, **you must write "racemic" under both structures EVEN THOUGH YOU DREW BOTH STRUCTURES**. If a scrambled mixture is produced, you need to write "scrambled". You do not need to refer to the solvent unless it is one of the reagents.



E. (Challenge!!!)



14. (4 pts each) This is similar, but not identical to the last one. Fill in the boxes with the product, starting material or reagents that are missing from the following chemical reaction equations. **Draw only the predominant product or products** and please remember that **you must draw the structures of all the predominant product stereoisomers**.



15. (15 pts) **Definitely save this until the end!!!** There are at least five different molecules that will react with H-Br to give the indicated product as the **predominant** product. Draw them in the boxes provided. **Hint 1; At least two involve a rearrangement and Hint 2; Different stereoisomers are considered different molecules**

