**NAME (Print):** _____

**EID** _____

**SIGNATURE:** _____

**Chemistry 320M/328M**
**Dr. Brent Iverson**
**3rd Midterm**
**November 19, 2026**

**Please print the first three letters of your last name in the three boxes**

| | | |
|---|---|---|
| | | |

**Please Note:** Please take your time. We are giving you three hours to take this exam even though it is really a one hour exam. The idea is to give you enough time to show us what you know, not how fast you can draw structures. Please take all the time you need to draw the best possible structures that you can! Do not be surprised if you are comfortable leaving the exam long before 9 PM. That is to be expected!

# In this class students may not wear, access or use smart devices, artificial intelligence (AI) tools, or any other hand-written or external source of information or assistance during examinations.

This applies regardless of whether the device is actively being used or whether any use is observed: **Simply wearing a smart device during a quiz or exam constitutes a violation of this policy,** even if the student does not interact with it and is not seen doing so. Smart devices include, but are not limited to, smartphones, smartwatches, smart glasses, tablets, earbuds or other connected audio devices, and any other electronic device capable of storing, transmitting, receiving, or accessing information.

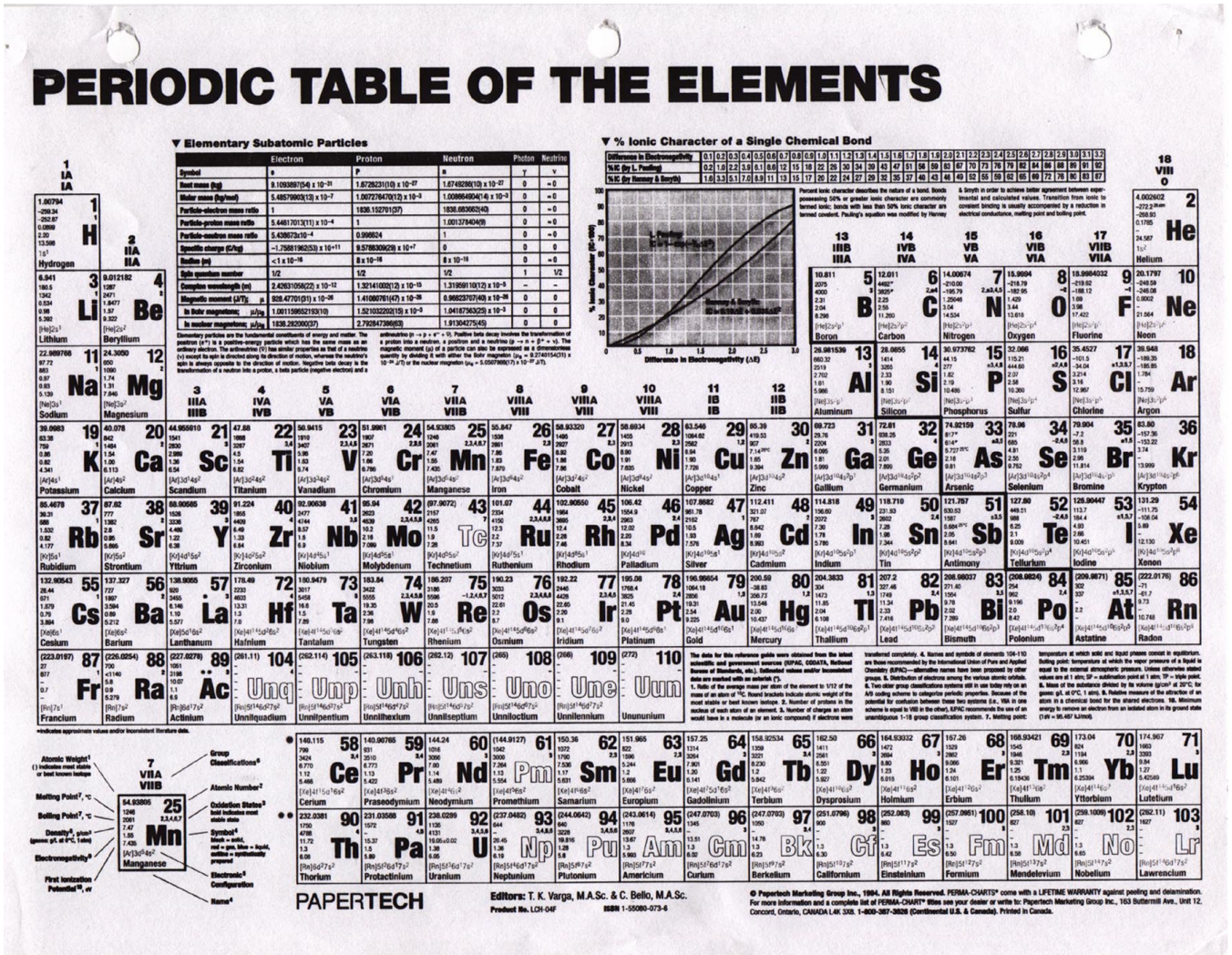
# Student Honor Code

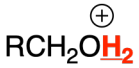
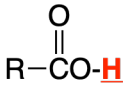
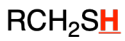
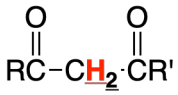
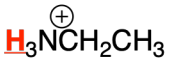
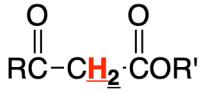
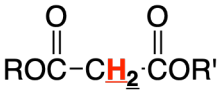
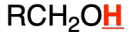
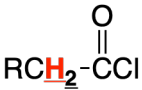
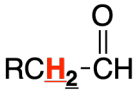
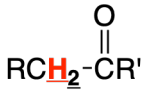
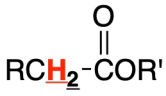
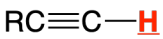
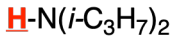
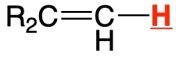
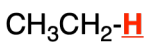
**I pledge, as a member of The University of Texas at Austin community, to do my work honestly, respectfully, and through the intentional pursuit of learning and scholarship.**

1. I pledge to be honest about what I create and to acknowledge what I use that belongs to others.
2. I pledge to value the process of learning in addition to the outcome, while celebrating and learning from mistakes.
3. This code encompasses all the academic and scholarly endeavors of the University community.

_____

(Your Signature)



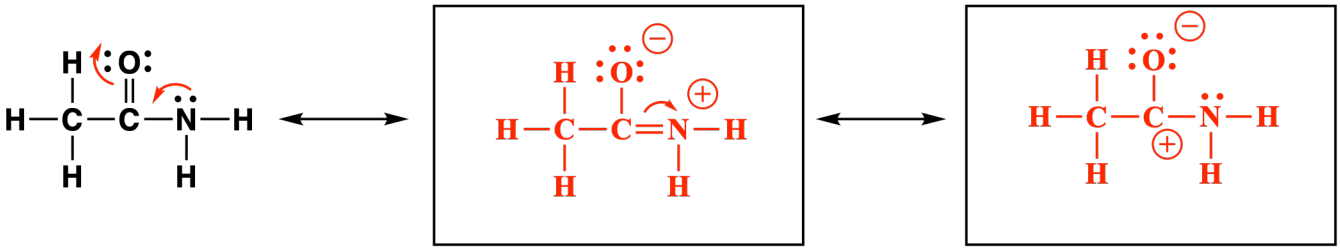
| Compound | | $pK_a$ |
|---|---|---|
| Hydrochloric acid |  | -7 |
| Protonated alcohol |  | -2 |
| Hydronium ion |  | -1.7 |
| Carboxylic acids |  | 3-5 |
| Thiols |  | 8-10 |
| Ammonium ion |  | 9.2 |
| β-Dicarbonyls |  | 10 |
| Primary ammonium |  | 10.5 |
| β-Ketoesters |  | 11 |
| β-Diesters |  | 13 |
| Water |  | 15.7 |
| Alcohols |  | 15-19 |
| Acid chlorides |  | 16 |
| Aldehydes |  | 18-20 |
| Ketones |  | 18-20 |
| Esters |  | 23-25 |
| Terminal alkynes |  | 25 |
| LDA |  | 40 |
| Terminal alkenes |  | 44 |
| Alkanes |  | 51 |

**Signature**_____ Pg 1 _____(28)

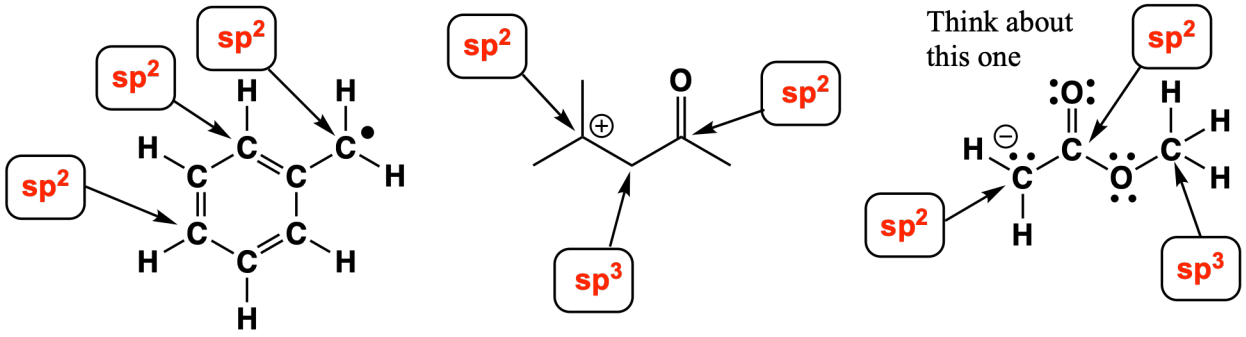
**1.** (2 pts) What is the most important question in organic chemistry?

**Where are the electrons?**

**2.** (9 pts) Amides are best represented as the hybrid of three contributing structures. Draw the second and third important contributing structures in the spaces provided, including all lone pairs and formal charges. **For the two structures on the left in each problem, use arrows to indicate the movement of electrons to give the structures you drew.** There is no need to draw any circles around any of these contributing structures. You might want to read these directions again to make sure you know what we want

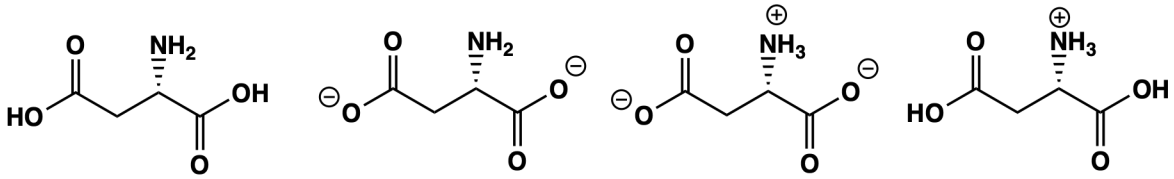


**3.** (9 pts.) On the following structures, indicate the hybridization state of each atom indicated with an arrow



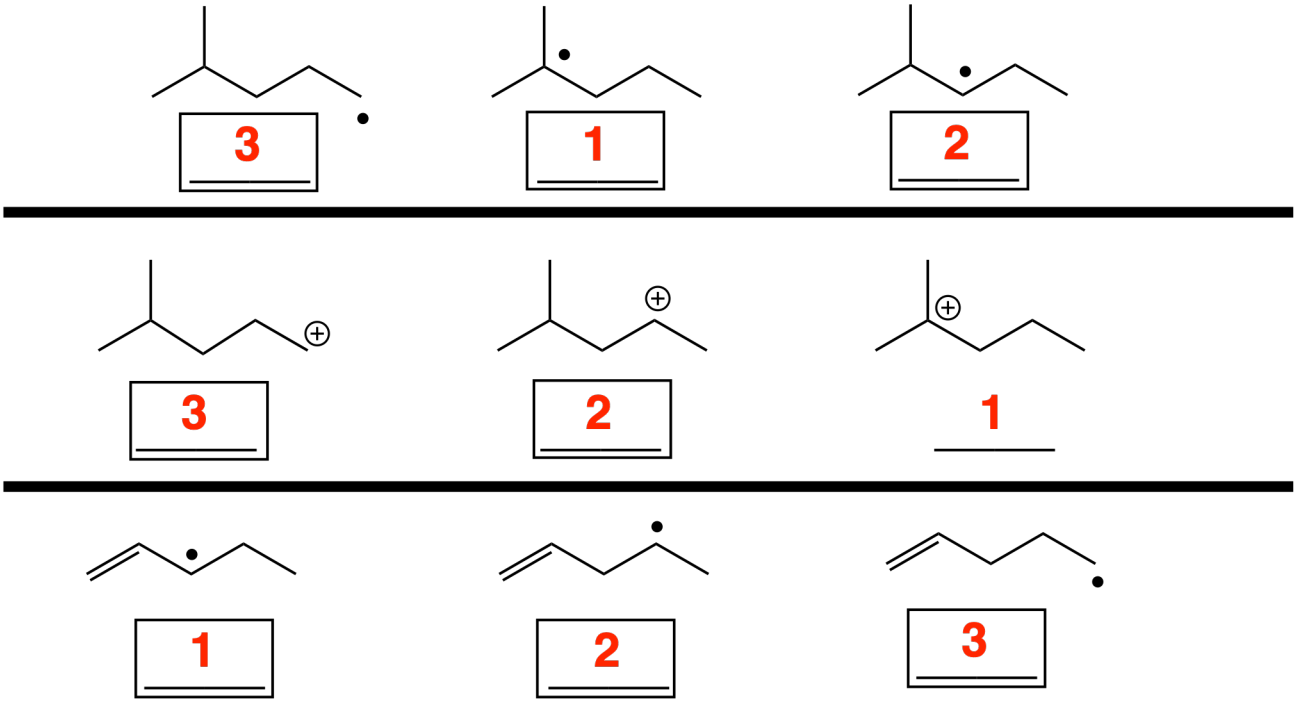

**4.** (8 pts.) Put a 2 under the species that will be the predominant one present at pH 2.0, put a 7 under the species that will be the predominant one present at pH 7.0, put a 12 under the species that will be the predominant one present at pH 12.0 and **put an "X" under a species that cannot predominant at any pH.**

**The pKa of a carboxylic acid ($RCO_2H$) is generally in the 4-5 range. The pKa of ammonium ions ($RNH_3^{\oplus}$) is in the 9-10 range.**

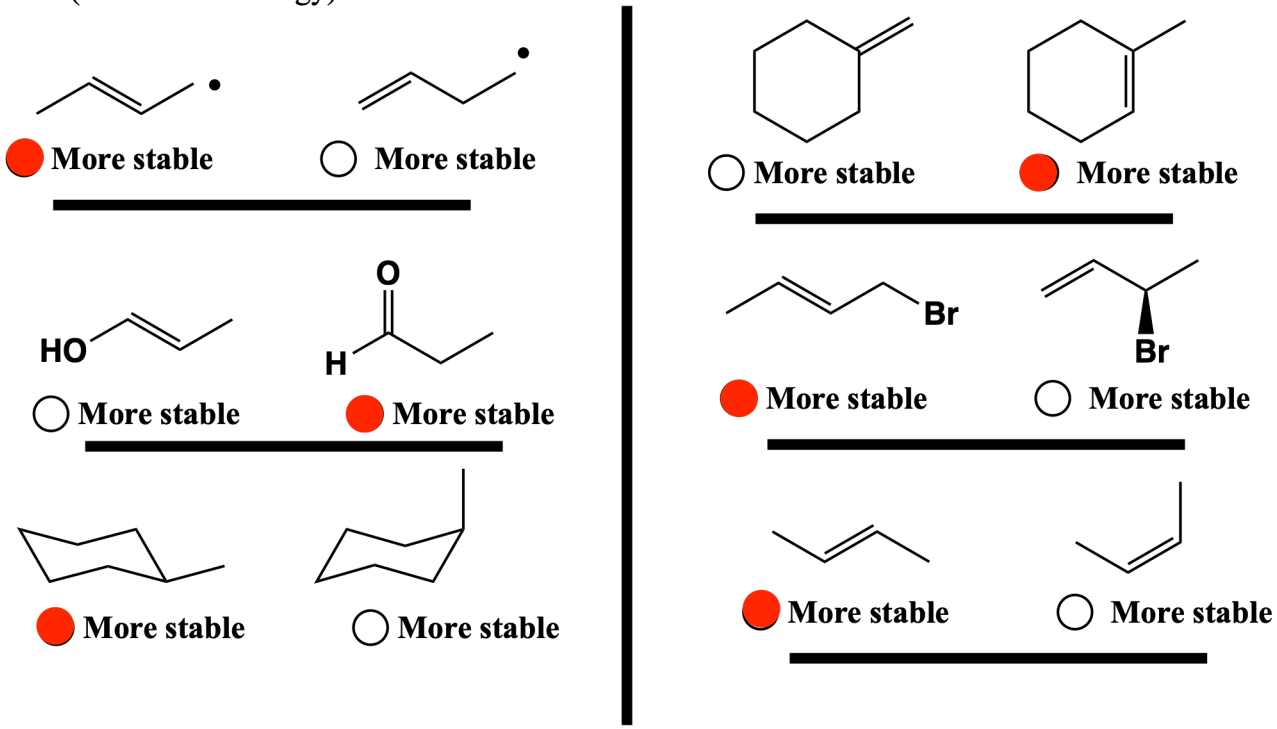


| X | 12 | 7 | 2 |
|---|---|---|---|

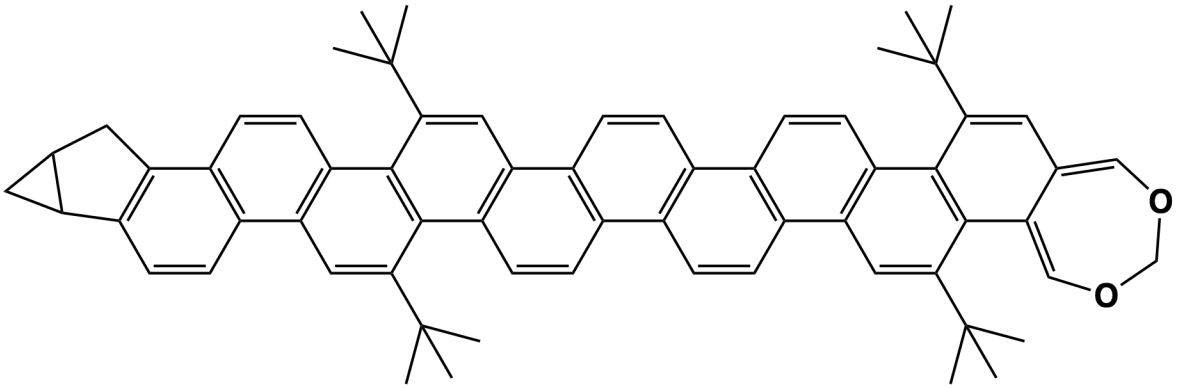
**5.** (9 pts) Rank the following sets of three molecules with respect to stability, **putting a 1 under the most stable and a 3 under the least stable in the series.**




**6.** (12 pts) For the following pairs of molecules or species, fill in the circle under the one that is more stable (i.e. lower in energy).



**This is where the nomenclature problems would have been!**



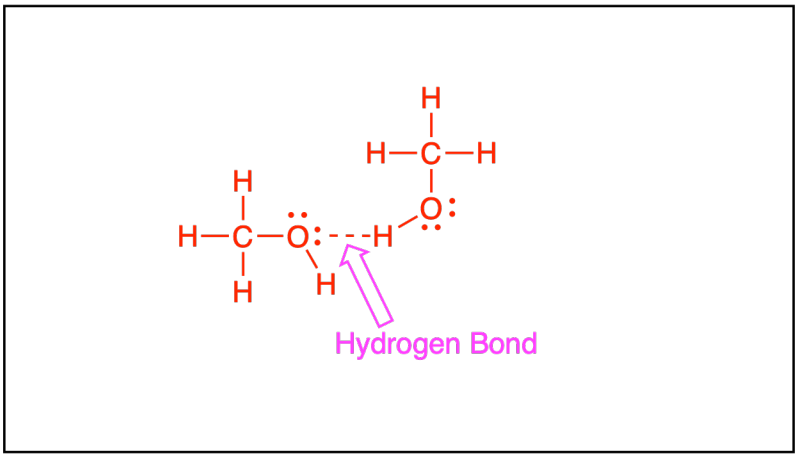

**3,9,16,22-tetra-*tert*-butyl-25b,26,26a,27-tetrahydrocyclopropa[3'',4'']cyclopenta[1'',2'':9',10']piceno[3',4':9,10]piceno[3,4-*e*][1,3]dioxepine**

**AKA "Polycyclic Salamander"**

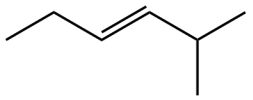
**7.** (16 pts) Consider the following statements that refer to **$S_N1$, $S_N2$, E1, E2**, and/or a **radical chain reaction** mechanism. Fill in the circles to indicate which mechanism(s) applies to each statement.

| | Mechanism(s) |
|---|---|
| **A. The reaction mechanism that will occur when HBr, peroxides and heat are used.** | ○ E1 ○ E2 ○ $S_N1$ ○ $S_N2$ ● Radical chain reaction |
| **B. The reaction that involves a carbocation intermediate.** | ● E1 ○ E2 ● $S_N1$ ○ $S_N2$ ○ Radical chain reaction |
| **C. The reaction that involves an InVERSiON of stereochemistry at the site of reaction.** | ○ E1 ○ E2 ○ $S_N1$ ● $S_N2$ ○ Radical chain reaction |
| **D. Favored for primary haloalkanes when any nucleophile is used** | ○ E1 ○ E2 ○ $S_N1$ ● $S_N2$ ○ Radical chain reaction |
| **E. Favored for tertiary haloalkanes when weak nucleophiles/weak bases are used** | ● E1 ○ E2 ● $S_N1$ ○ $S_N2$ ○ Radical chain reaction |
| **F. The reaction that involves an anti-periplanar transition state.** | ○ E1 ● E2 ○ $S_N1$ ○ $S_N2$ ○ Radical chain reaction |
| **G. The reaction mechanism that will occur when NBS and light are used.** | ○ E1 ○ E2 ○ $S_N1$ ○ $S_N2$ ● Radical chain reaction |
| **H. The reaction in which the predominant product is formally predicted by Zaitsev's rule** | ● E1 ● E2 ○ $S_N1$ ○ $S_N2$ ○ Radical chain reaction |
| **I. The reaction mechanism that can start with one pure enantiomer starting material and produce two enantiomer products, but not a racemic mixture.** | ○ E1 ○ E2 ● $S_N1$ ○ $S_N2$ ○ Radical chain reaction |
| **J. Favored for secondary haloalkanes when a nucleophile that is also a strong base is used.** | ○ E1 ● E2 ○ $S_N1$ ○ $S_N2$ ○ Radical chain reaction |
| **K. Favored for secondary haloalkanes when a nucleophile that is NOT a strong base and is also NOT a very weak base is used** | ○ E1 ○ E2 ○ $S_N1$ ● $S_N2$ ○ Radical chain reaction |
| **L. Favored for secondary haloalkanes when a nucleophile that is a very weak base is used** | ● E1 ○ E2 ● $S_N1$ ○ $S_N2$ ○ Radical chain reaction |

**8.** (8 pts) In the space provided, draw Lewis structures for two methanol molecules ($CH_3OH$) wih one hydrogen bond between them indicated by a dashed line. Make sure to include all appropriate lone pairs of electrons in your answer.




**9.** (8 pts) Consider what happens when (*E*)-2-methyl-3-hexene is reacted with NBS and heat.

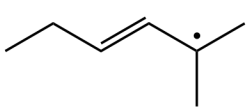


**(*E*)-2-methyl-3-hexene**

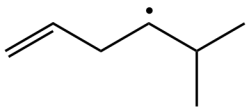
**NBS**
**heat**

*You will draw the predominant product of this reaction in the box at the bottom of the page*

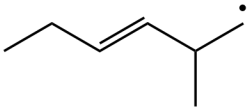
Fill in the circles to indicate ALL FOUR of the allyl radical contributing structures that are relevant and therefore should be considered when predicting the predominant product of the reaction.



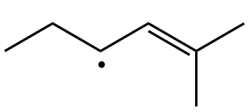
● This contributing structure should be considered



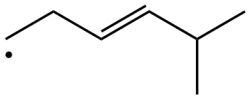
○ This contributing structure should be considered



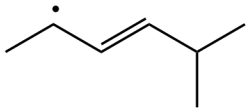
○ This contributing structure should be considered



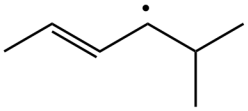
● This contributing structure should be considered



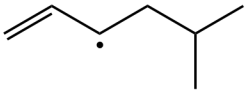
○ This contributing structure should be considered



● This contributing structure should be considered

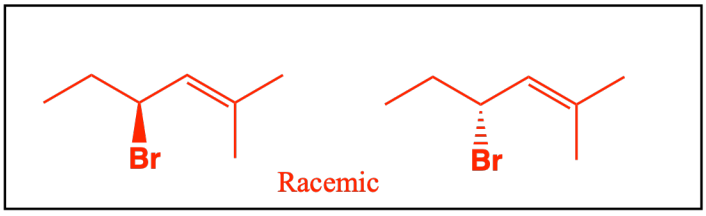


● This contributing structure should be considered

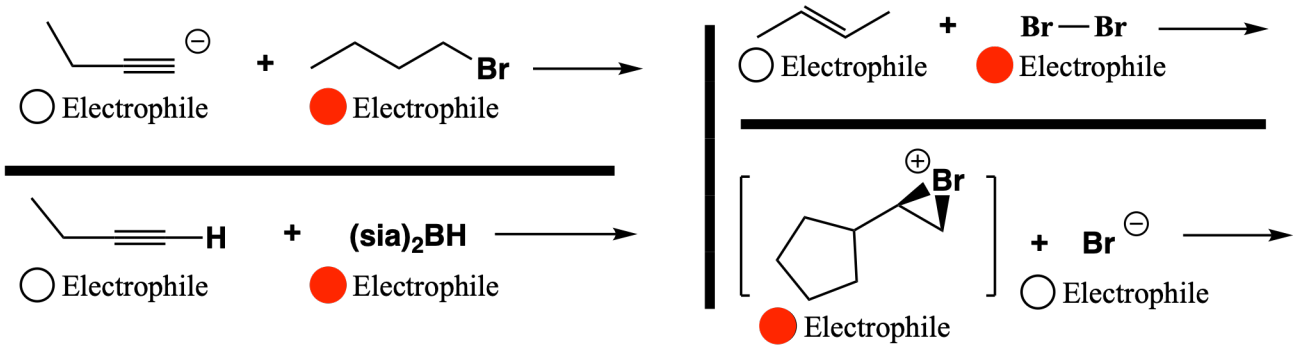


○ This contributing structure should be considered

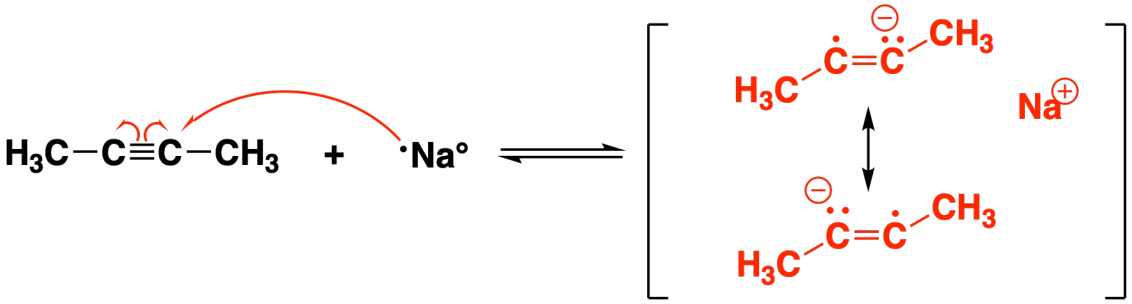
**(6 pts) Given your analysis of the above contributing structures, in the box provided, draw the predominant product(s) of the reaction of (*E*)-2-methyl-3-hexene with NBS and heat. Use wedges and dashes to indicate sterochemistry, and draw all relevant stereoisomers, indicating the product is racemic if appropriate.**



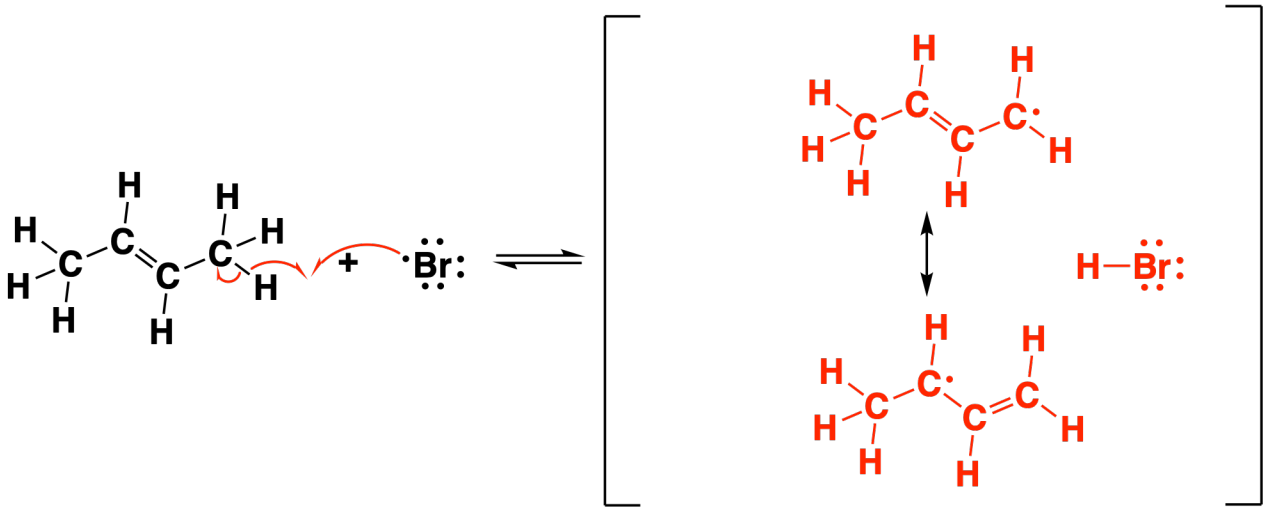
**10.** (2 pts each) For the following four pairs of reagents you have seen in various bond-making steps in mechanisms, **fill in the circle under the electrophile**.



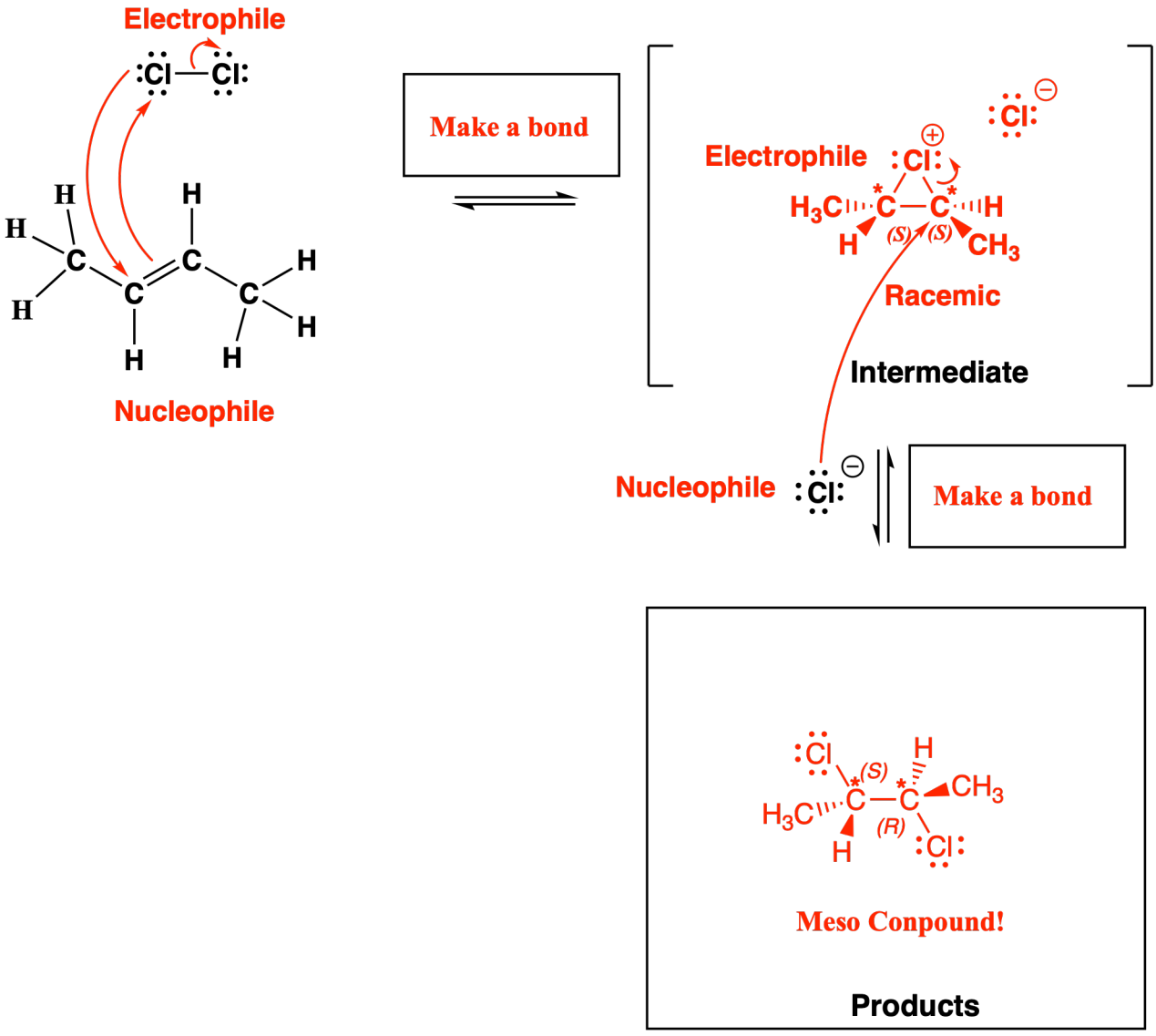

**11**. (14 pts) For the following sets of reagents use arrows to indicate the flow of electrons in the first step of each mechanism. Then draw only the first intermediate as indicated. Be sure to show arrows to indicate movement of <u>all</u> electrons, write <u>all</u> lone pairs, <u>all</u> formal charges, and <u>all</u> the products for this step. For each of the two intermediates, draw the two most important contributing structures as indicated by the ⟷. No need to draw any arrows on a contributing structure. As always, if the intermediate is chiral, only draw one enantiomer using wedges and dashes, then write "racemic" if appropriate.




**This next one is part of the NBS mechanism:**



**12.** (16 pts) This is from a while ago. Complete the mechanism for the following reaction of an alkene with $Cl_2$. **Be sure to show arrows to indicate movement of all electrons, write all lone pairs, all formal charges, and all the products for each step.** Remember, I said all the products for each step. **YOU ONLY NEED TO DRAW ONE STEREOISOMER OF A CHIRAL INTERMEDIATE OR PRODUCT (using wedges and dashes as appropriate) IF A NEW CHIRAL CENTER IS CREATED IN AN INTERMEDIATE OR PRODUCT, MARK IT WITH AN ASTERISK AND LABEL THE MOLECULE AS "RACEMIC" IF APPROPRIATE. In the boxes provided under/ beside the arrows, write which of the 4 most common mechanistic elements describes each step (make a bond, break a bond, etc.). Be sure to notice the question at the end.**



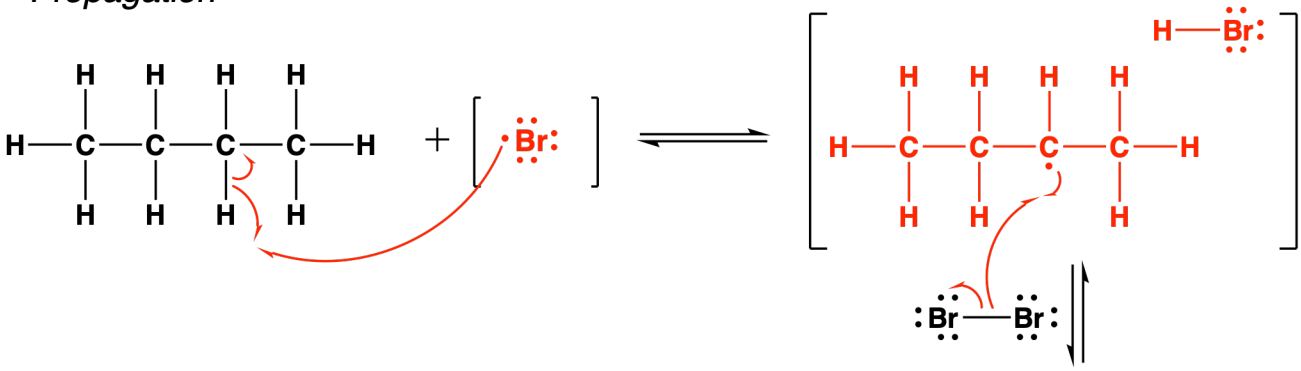

(2 pts) How many total stereoisomers are created as the final products? 1

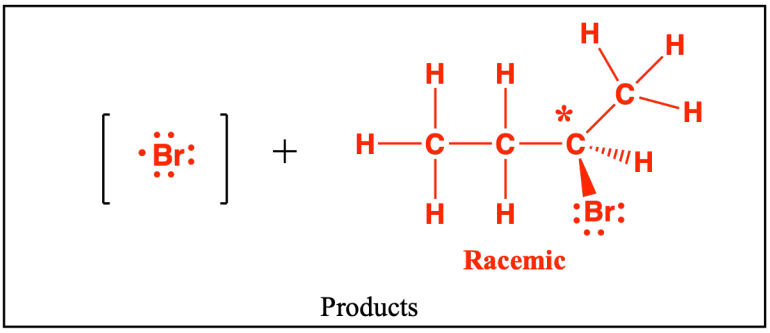
**13.** (28 pts) Complete the mechanism for the halogenation of an alkane. **Be sure to show arrows to indicate movement of all electrons, write all lone pairs, all formal charges, and all the products for each step.** Remember, I said all the products for each step. **YOU ONLY NEED TO DRAW ONE STEREOISOMER OF A CHIRAL INTERMEDIATE OR PRODUCT (using wedges and dashes as appropriate) IF A NEW CHIRAL CENTER IS CREATED IN AN INTERMEDIATE OR PRODUCT, MARK IT WITH AN ASTERISK AND LABEL THE MOLECULE AS "RACEMIC" IF APPROPRIATE. Note that for the termination step, you only need to draw one of the three possible examples of termination.**

*Initiation*

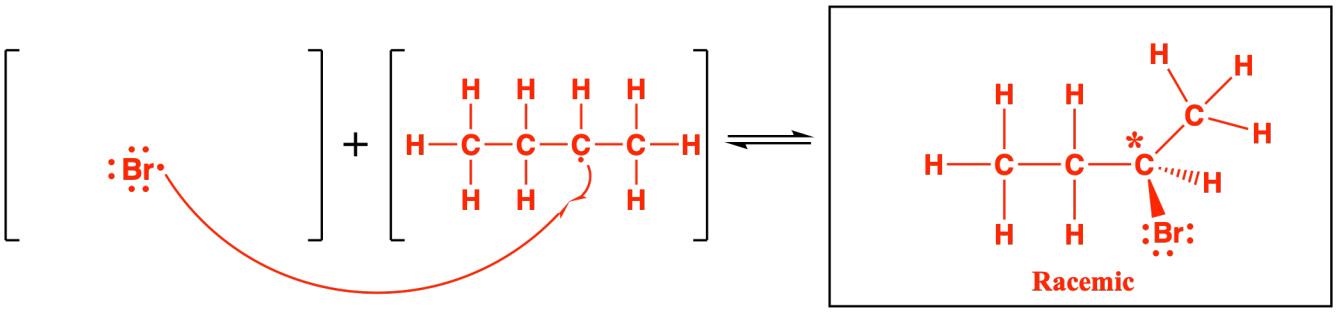



*Propagation*



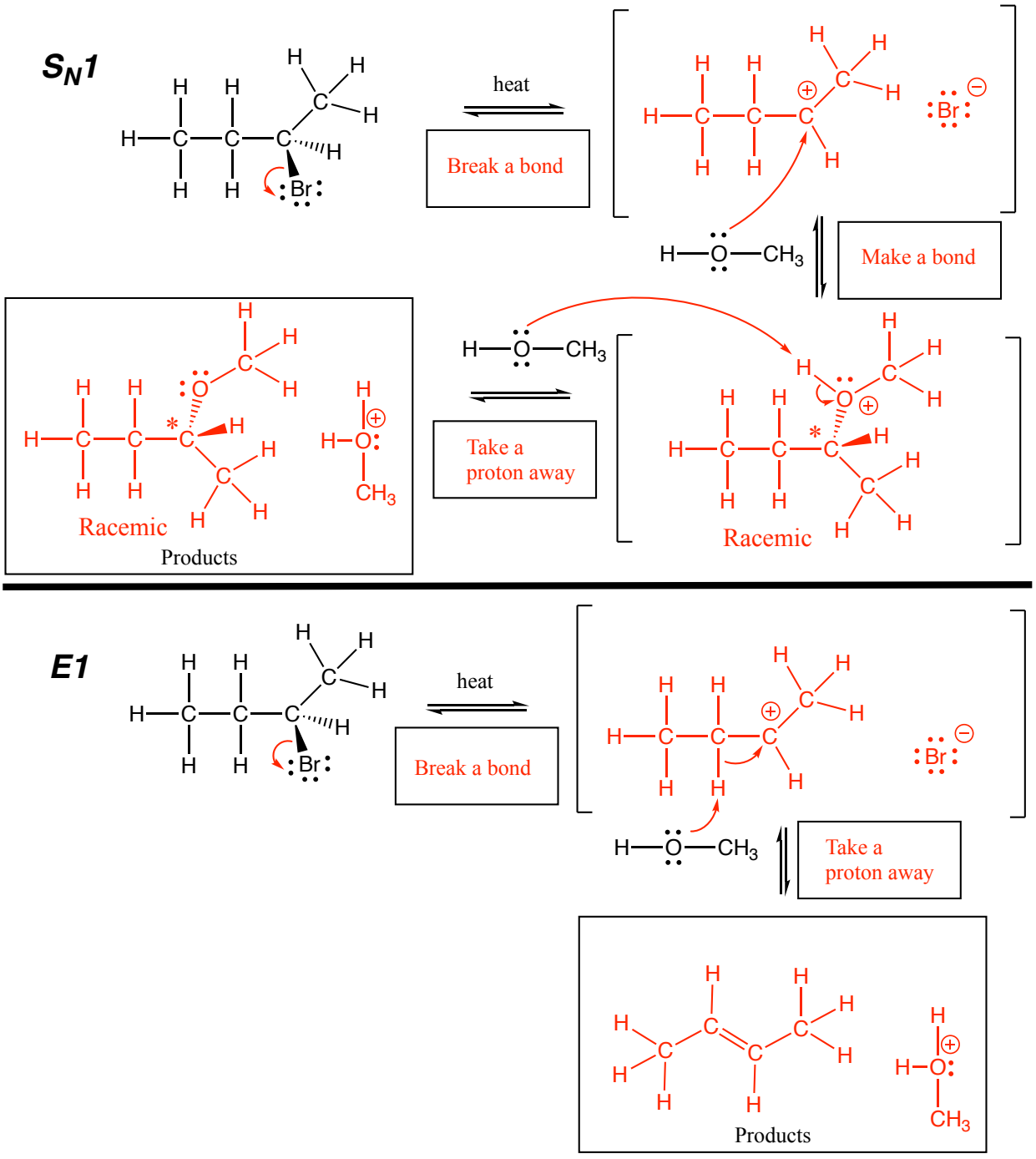



*Termination* (You only need to show one of the three possible termination steps)



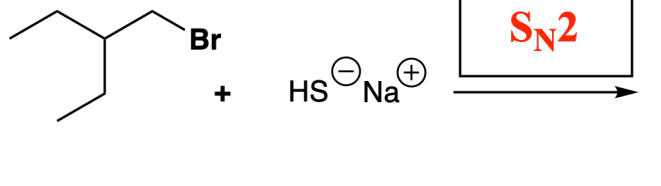

Any combination of these two radicals is correct for an example of a termination step

**14.** (26 pts total) Complete the following mechanism for substitution and elimination of a haloalkane. **Be sure to show arrows to indicate movement of all electrons, write all lone pairs, all formal charges, and all the products for each step. YOU ONLY NEED TO DRAW ONE STEREOISOMER OF A CHIRAL INTERMEDIATE OR PRODUCT (using wedges and dashes as appropriate) IF A NEW CHIRAL CENTER IS CREATED IN AN INTERMEDIATE OR PRODUCT, MARK IT WITH AN ASTERISK AND LABEL THE MOLECULE AS "RACEMIC" IF APPROPRIATE. In the boxes provided under/beside the arrows, write which of the 4 most common mechanistic elements describes each step. Note we break $S_N1$ and E1 into two separate mechanisms for clarity.**

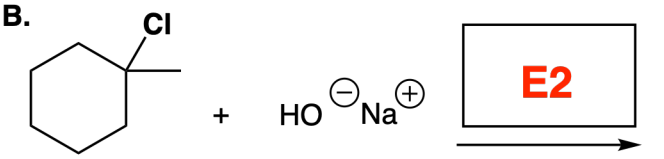


**15.** (27 pts) The following reactions all involve chemistry of haloalkanes. **Fill in the box above the arrow with the mechanism that will be followed ($S_N2$, E2, etc.). Then draw only the predominant product or products** and please remember that **you must draw the correct stereoisomers**. For $S_N1$/E1 reactions you must draw all significant products (including all stereoisomers).

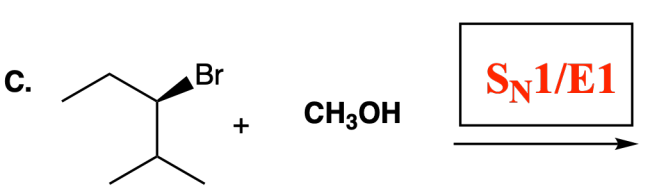
**A.**



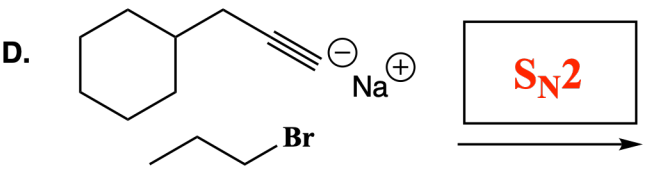

**B.**



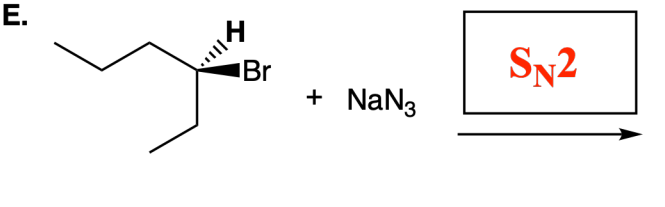

**C.**



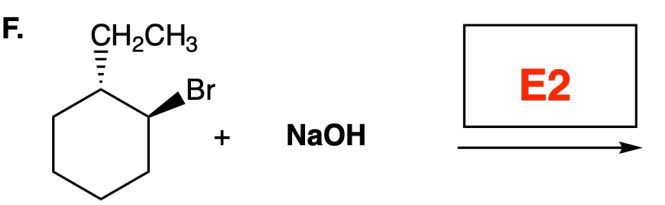

**D.**



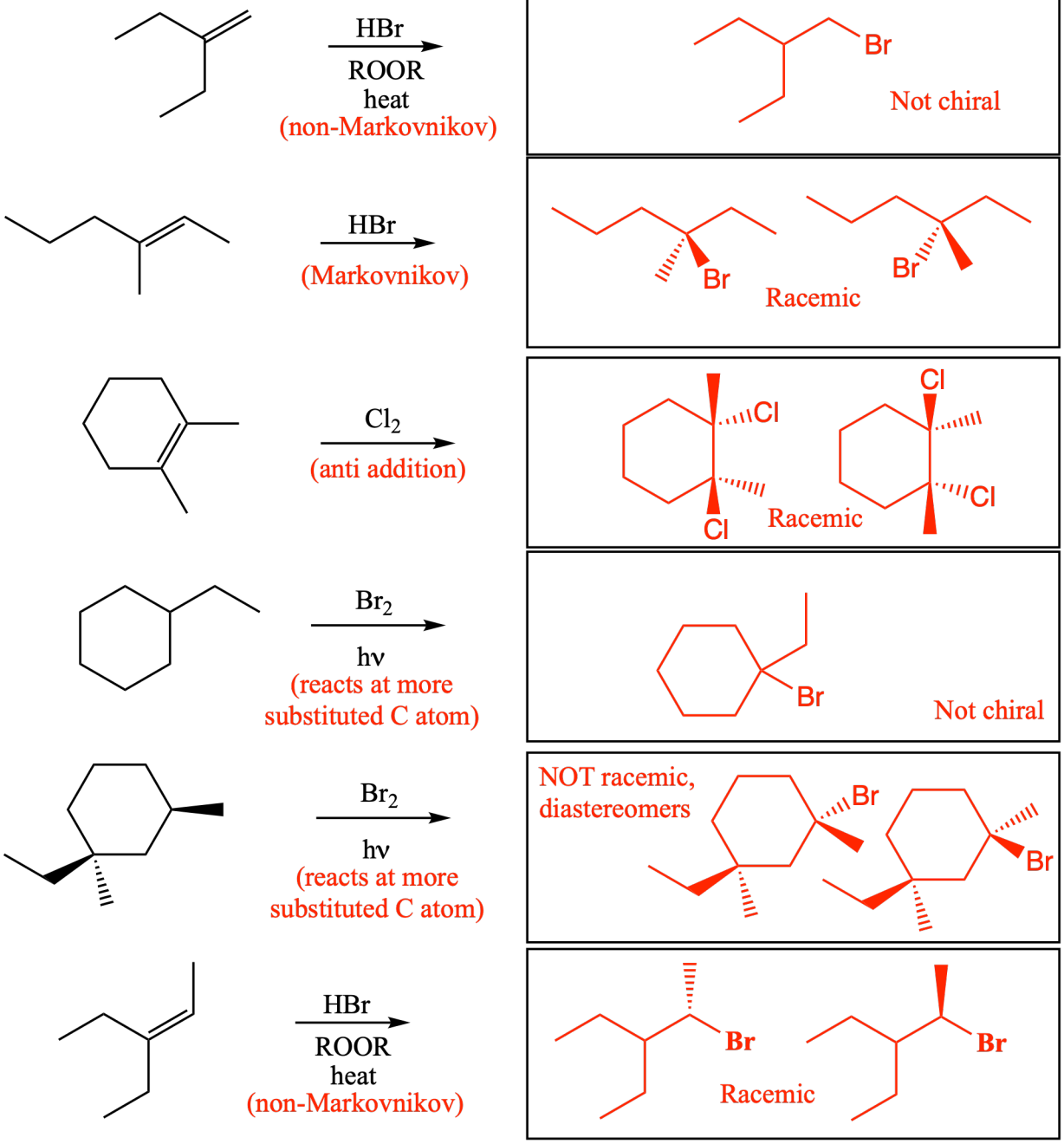

**E.**



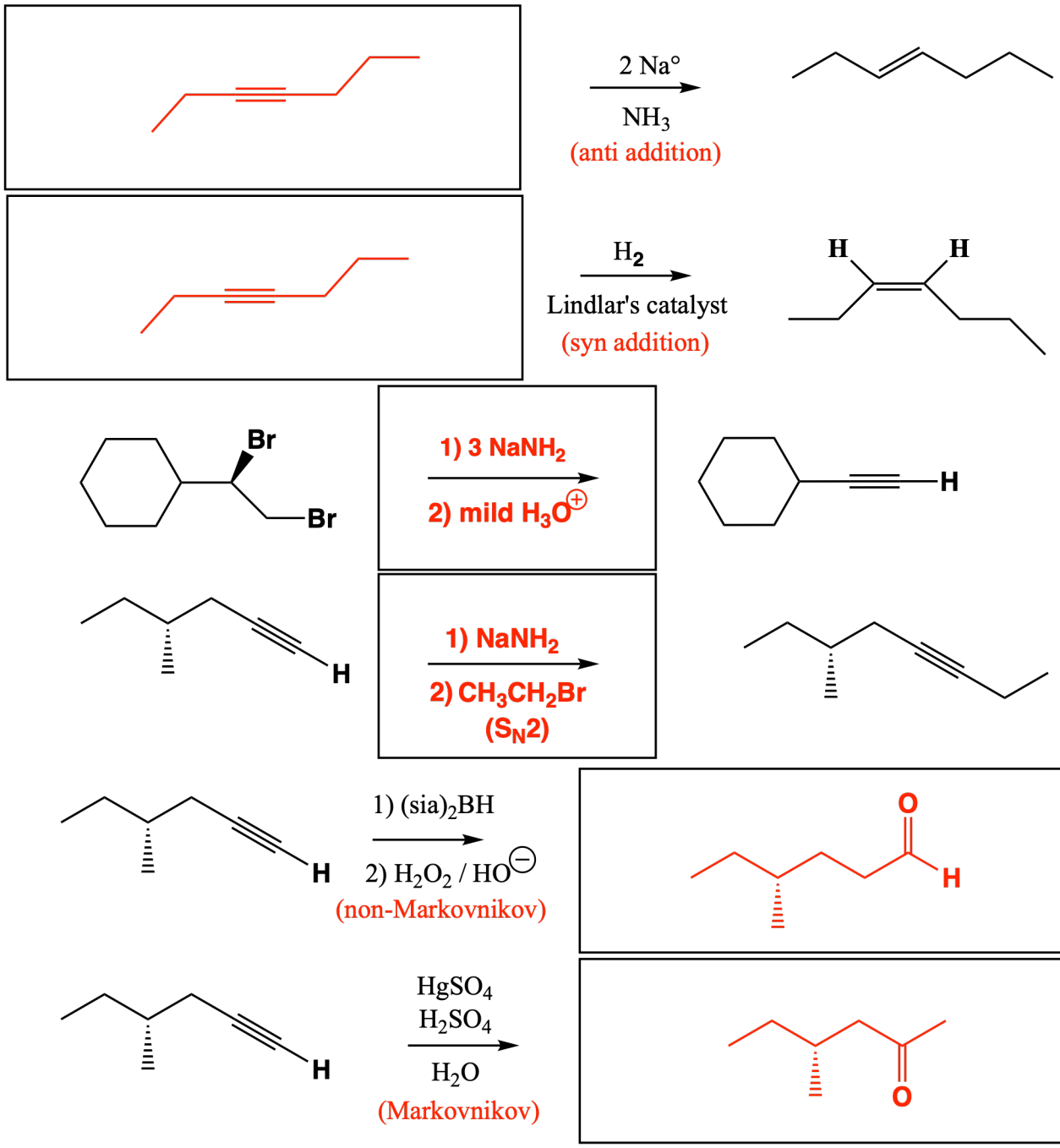

**F.**



**16.** (23 pts) Fill in the box with the product(s) that are missing from the chemical reaction equations. **Draw only the predominant regioisomer product or products (i.e. Markovnikov or non-Markovnikov, etc.)** and please remember that **you must draw the structures of all the product stereoisomers using wedges and dashes to indicate stereochemistry**. When a racemic mixture is formed, **you must write "racemic" under both structures EVEN THOUGH YOU DREW BOTH STRUCTURES**.

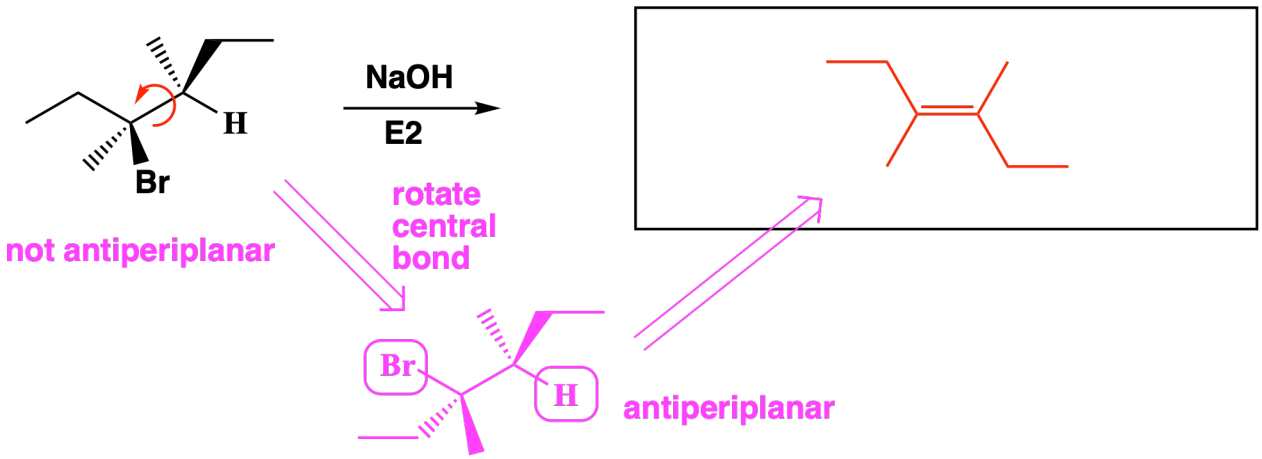


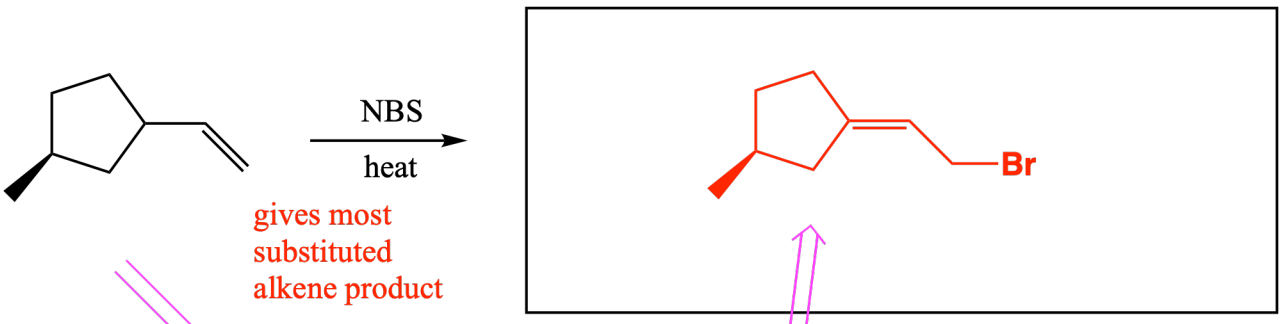
**17.** (18 pts) For the following reactions, fill in the box with the predominant **starting materials**, **product(s)** or **reagent(s)** necessary to complete the following syntheses. **You must indicate stereochemistry with wedges and dashes. You must draw all stereoisomers** produced as predominant products and **write "racemic"** under the structures when appropriate.



**18.** (8 pts) The following two reactions take a little more thought. Fill in the box with **only the predominant regioisomer product or products (i.e. Markovnikov or non-Markovnikov products)** and please remember that **you must draw the structures of all the product stereoisomers using wedges and dashes to indicate stereochemistry**. When a racemic mixture is formed, **you must write "racemic" under both structures EVEN THOUGH YOU DREW BOTH STRUCTURES**.

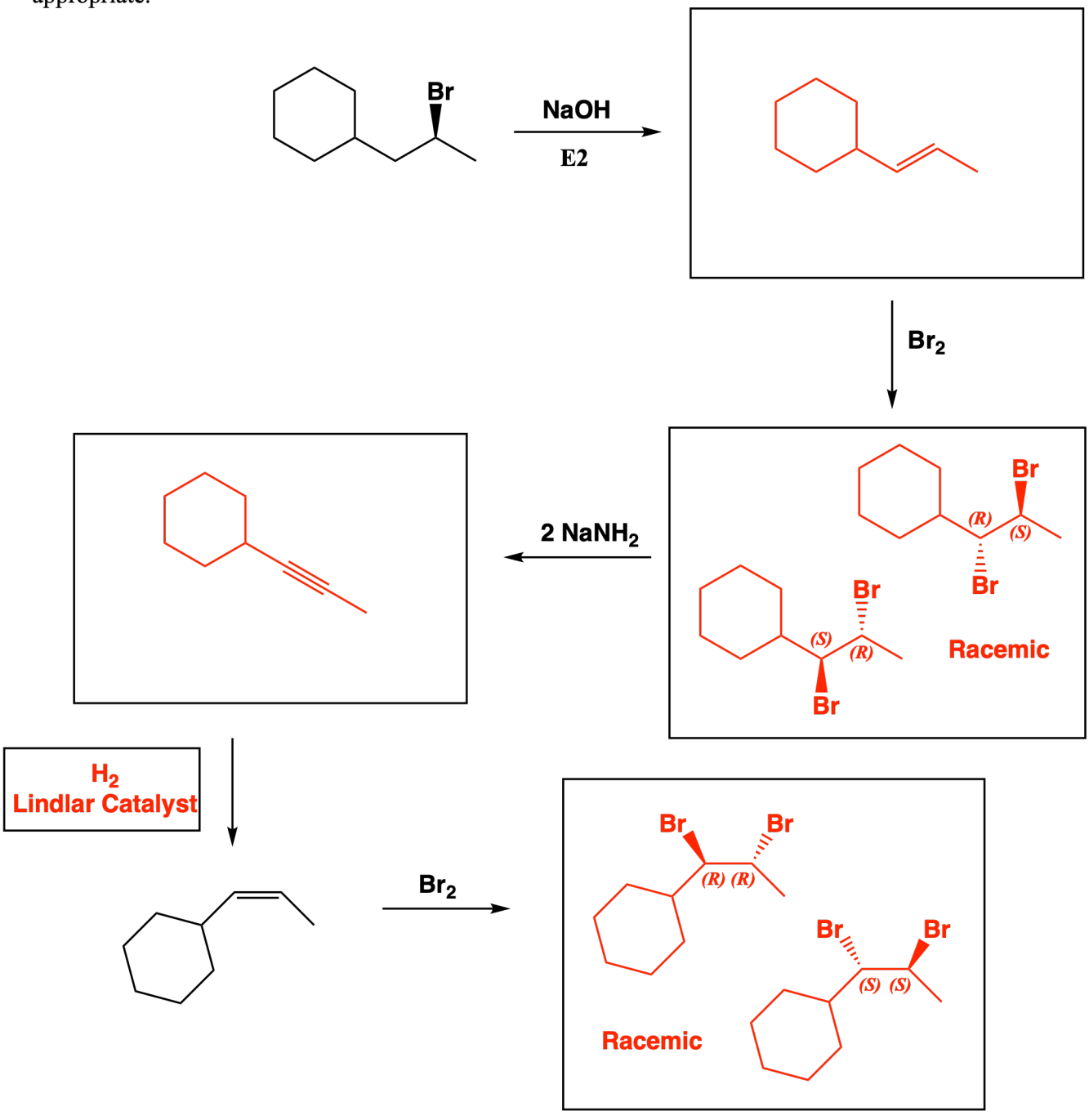
**I am giving you some extra room to work through these**



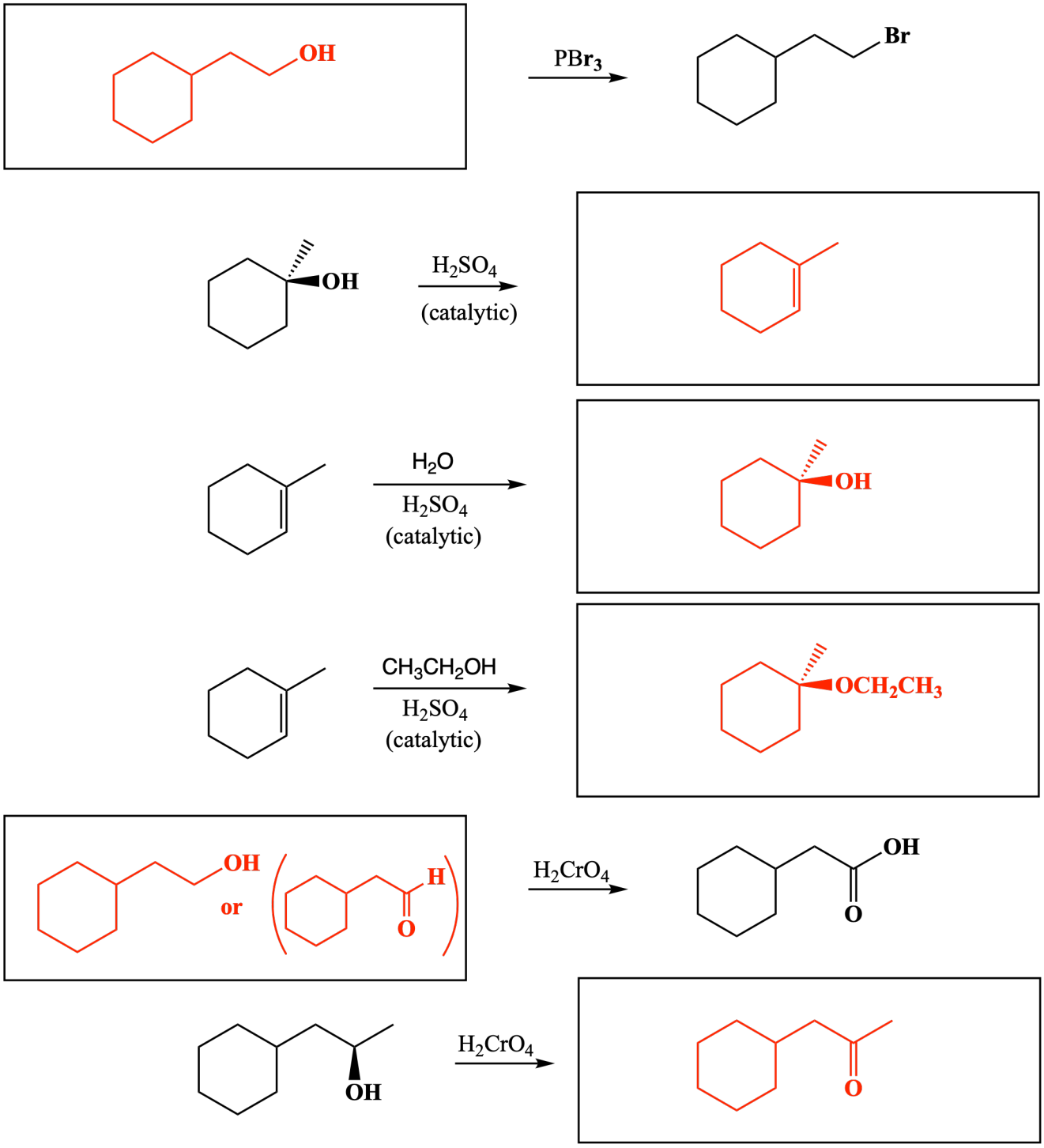






**19**. (18 pts) For the following reactions, fill in the box with the predominant **product(s)** or **reagent(s)** necessary to complete the following syntheses. **You must indicate stereochemistry with wedges and dashes. You must draw all stereoisomers** produced as predominant products and **write "racemic"** under the structures when appropriate.

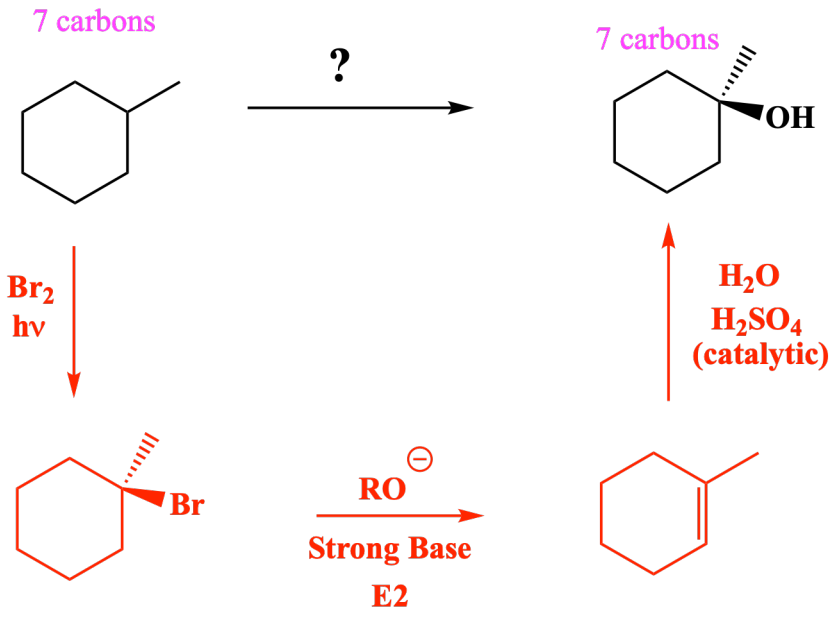


**20.** (18 pts) For the following reactions, fill in the box with the predominant **starting materials**, **product(s)** or **reagent(s)** necessary to complete the following reactions. **You must indicate stereochemistry with wedges and dashes. You must draw all stereoisomers** produced as predominant products and **write "racemic"** under the structures when appropriate.



**21.** (7 pts) These are synthesis questions. You need to show how the starting material can be converted into the product(s) shown. You may use any reactions we have learned. Show all the reagents you need including the correct number of equivalents if applicable. Show each molecule synthesized along the way and be sure to pay attention to the regiochemistry and stereochemistry preferences for each reaction because only predominant products can be used. All the carbon atoms of the product(s) must come from the starting material(s) shown.

A) 7 pts



**21.** (7 pts) These are synthesis questions. You need to show how the starting material can be converted into the product(s) shown. You may use any reactions we have learned. Show all the reagents you need including the correct number of equivalents if applicable. Show each molecule synthesized along the way and be sure to pay attention to the regiochemistry and stereochemistry preferences for each reaction because only predominant products can be used. All the carbon atoms of the product(s) must come from the starting material(s) shown.

B) 7 pts

