

CHEM 243
ORGANIC CHEMISTRY I - Fall 2024

Exam IV Information and Study Guide

CHEM 243 Exam IV is scheduled for Friday-Sunday, December 6-8, and will have two parts:

- Part I will be done in-class (in-person) on Friday, December 6 during your normal class time. You will have 50 minutes, plus the opportunity to start 10 minutes early, and stay 10 minutes after class has ended.
- Part II will be take-home. I will give you Part II when you complete Part I. You can not do Part II until you have completed Part I.
- Both Parts I & II will be equally weighted (50% each).
- This Study Guide is designed in two parts so you will have a good idea as to the format of Exam IV.
- **If you miss Part I on December 6 due to illness or a personal emergency, you can request a make-up exam on Monday, December 9. However, you must complete the entire exam, Parts I and II, in-person.**

Guidelines for Part II (take home):

- You can use all your class notes.
- You may not work together, or get help from any other person.
- You may not access the internet, the class web pages, Google, artificial intelligence, etc.
- You may not use the answer key to this Study Guide, or to any class worksheets.
- The Part II take home exam should be completed in two hours.
- You must return completed Part II to me in class on Monday, December 9. I will not accept the exam after 11:00 am on Monday.

Preparing for the Exam. You are responsible for developing a **Study Schedule** that will give you 5-7 days to thoroughly review material for this exam. Make a list of questions that can be answered during class meetings or office hours. The following course resources are available to help you study for this exam:

- (1) Lecture videos
- (2) Your class notebook
- (3) Class worksheets
- (4) Exam Study Guide

Study Guide. These problems are to help you review for the exam and should be included in your comprehensive review of the class material. This Study Guide is designed in the same format as the exam. The number of problems and length of this Study Guide does not necessarily reflect the length of the actual exam. **I will post an answer key to this Study Guide on the course web page by Monday.**

Study Session - PALS, PROF & PIZZA! Thursday, December 5, 4-6 pm, 4th floor lounge

Miscellaneous Notes:

1. You can use blue or black ink or black lead pencil.
2. Be neat! If I can't read your writing, I can't grade your answer.
3. You will be provided with a periodic table, and appropriate data. You need to bring your own pens and/or pencils. **You do NOT need a calculator for this exam.**
4. You will not be allowed to share any materials with another student during the exam.
5. Academic dishonesty on exams will result in dismissal from the class and an F course grade.

PLEASE READ!!! It is your responsibility to contact me if you can not take the exam! Students who have a documented illness (note from a physician) or personal emergency, can receive **ONE** make-up exam during the semester. All students also have the option to replace your lowest exam grade by taking the optional "Exam V" at the end of the semester.

If you are running late, please contact me, and you can still take the exam!

KEY CONCEPTS FOR REVIEW. Exam IV will cover relevant material from Exams I, II and III plus all new material on videos 7-5, 8-1, 8-2, 8-3, 11-1, 11-2, and Worksheets 25 to 28.

Chapter 7: Mechanism of rearrangements in carbocation reactions.

Chapter 8: Reactions, mechanism and stereochemistry of electrophilic addition reactions to alkenes (HX; acid-catalyzed addition of H₂O & ROH; X₂; X₂ + nucleophile).

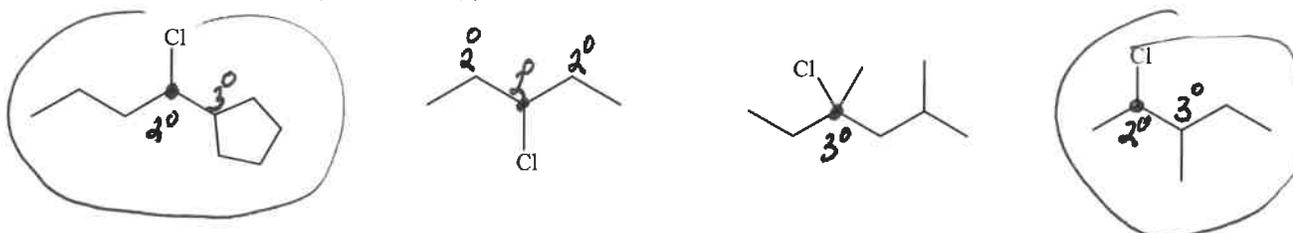
Chapter 11: Alcohol nomenclature; synthesis of alcohols and ethers by S_N1 and S_N2; acid-base reactions of alcohols; acid catalyzed alcohol dehydration (E1/E2 elimination); acid mediated substitution reactions of alcohols with HX; mechanism of acid-catalyzed ether synthesis.

SUPPLEMENTAL REVIEW PROBLEMS. These are additional problems to help you review for the exam; I will post an answer key by Monday. These problems should be included with your review of the lecture videos, class notes, worksheets, and the posted resources.

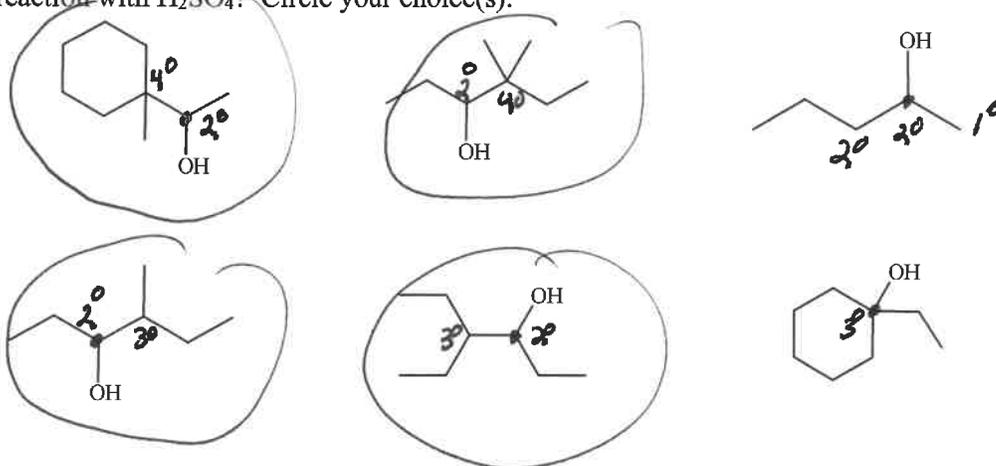
EXAM IV Study Guide - Part I Questions (in-person, Friday, December 6)

1. Answer the following questions as indicated.

(a) **Rearrangement Reactions.** Which of the following molecules will be most likely to undergo rearrangement in an S_N1 reaction with HI? Circle your choice(s).



(b) **Rearrangement Reactions.** Which of the following molecules will be most likely to undergo rearrangement in an E1 dehydration reaction with H₂SO₄? Circle your choice(s).



(c) **Rearrangement Reactions.** For (a) and (b) above, explain your reasoning. What are you looking for?

A potential rearrangement will occur when:

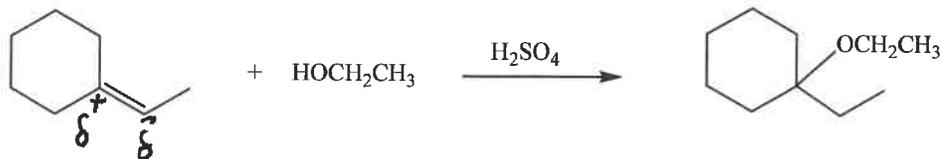
- 1) the leaving group is on a 2° carbon,
- 2) there is an adjacent 3° or 4° carbon.

(d) True or False.

SN1 + E1

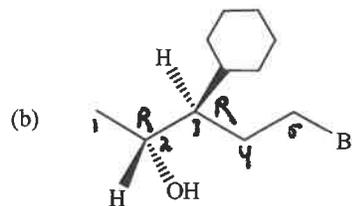
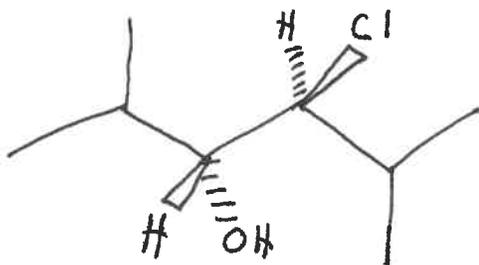
F A rearrangement can only occur in SN2 or E2 reactions.T In a typical rearrangement step, a 2° carbocation is transformed into a 3° carbocation.F In electrophilic addition reactions, the electrophile always has a negative charge. (\ominus or δ^-)T In electrophilic addition reactions, the more substituted sp² carbon has a partial positive charge and binds the nucleophile, and the less substituted sp² carbon has a partial negative charge and binds the electrophile.T In the electrophilic addition of Br₂ to an alkene, the two Br atoms add to the double bond by anti addition.

(e) Electrophilic Addition Reactions. Answer the following questions based on the reaction drawn below:

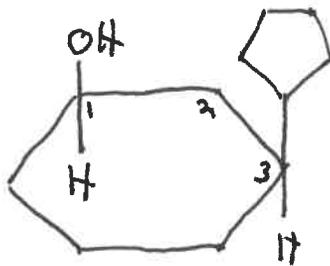
(i) Label the alkene double bond with δ^+ and δ^- (ii) (Circle the correct responses) The (HOCH₂CH₃, HSO₄⁻, H⁺) species becomes bonded to the δ^+ sp² carbon, and this species is referred to as the (nucleophile, electrophile, acid, base).(iii) (Circle the correct responses) The (HOCH₂CH₃, HSO₄⁻, H⁺) species becomes bonded to the δ^- sp² carbon, and this species is referred to as the (nucleophile, electrophile, acid, base).

2. Alcohol Nomenclature. If a name is given draw an accurate zig-zag structure (remember to use wedge and dash bonds for all chiral carbons). If a structure is drawn, give an accurate IUPAC name (don't forget to assign configurations using the R/S prefix).

(a) (3R, 4S)-4-chloro-2,5-dimethyl-3-hexanol

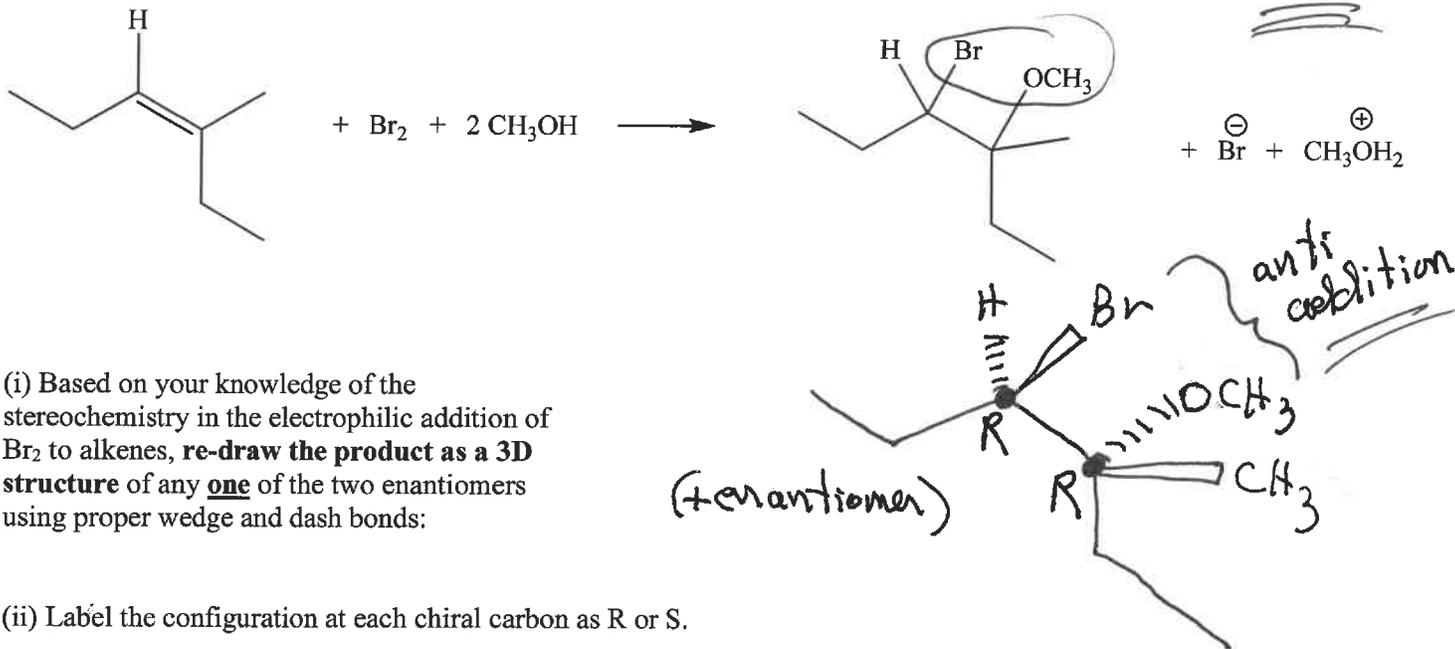
(2R, 3R) - 5 - bromo -
- 3 - cyclohexyl -
- 2 - pentanol

(c) cis-3-cyclopentyl-cyclohexanol



3. Stereochemistry in the Electrophilic Addition of Br₂ and Cl₂.

(a) The balanced equation for the electrophilic addition of Br₂ and an alcohol to an alkene is drawn below. Note that the product is drawn in its 2D form:

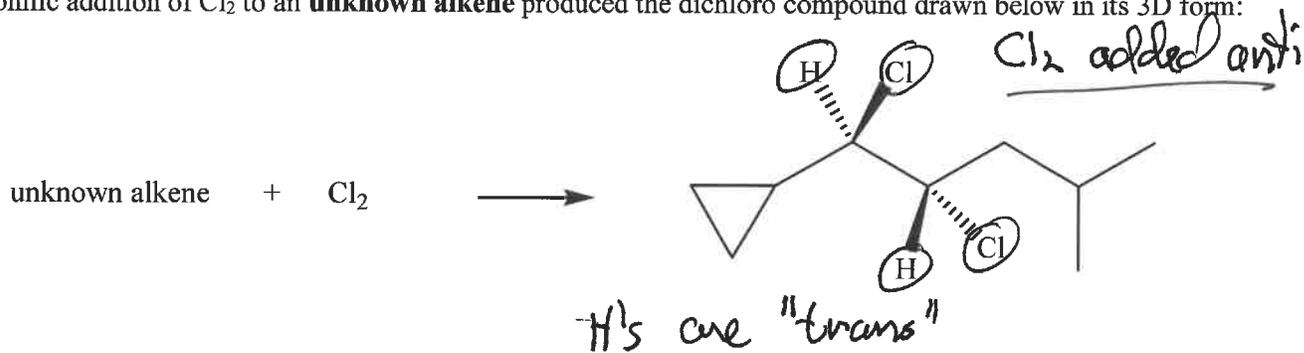


(i) Based on your knowledge of the stereochemistry in the electrophilic addition of Br₂ to alkenes, **re-draw the product as a 3D structure** of any one of the two enantiomers using proper wedge and dash bonds:

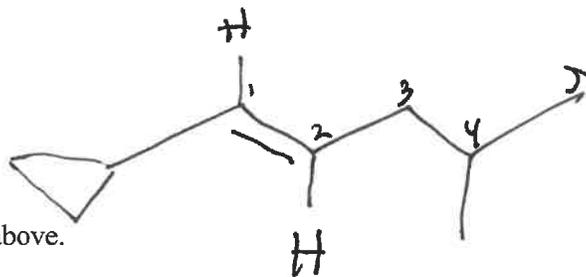
(ii) Label the configuration at each chiral carbon as R or S.

R, R or S, S

(c) Electrophilic addition of Cl₂ to an **unknown alkene** produced the dichloro compound drawn below in its 3D form:



(i) Based on your knowledge of the stereochemistry in the electrophilic addition of Cl₂ to alkenes, draw the structure of the **alkene reactant** with the correct geometry:

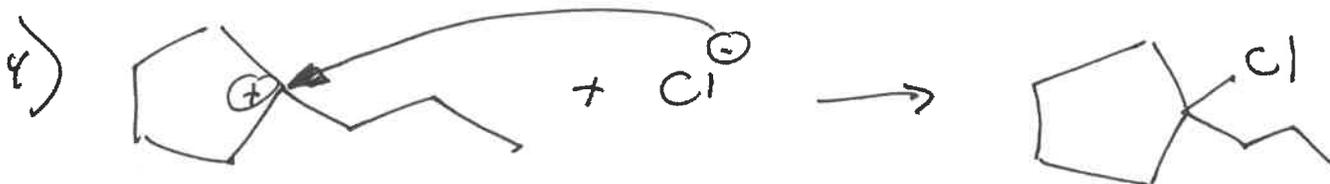
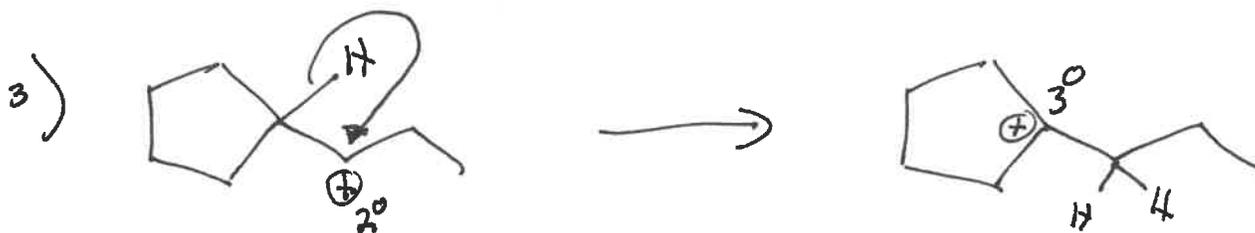
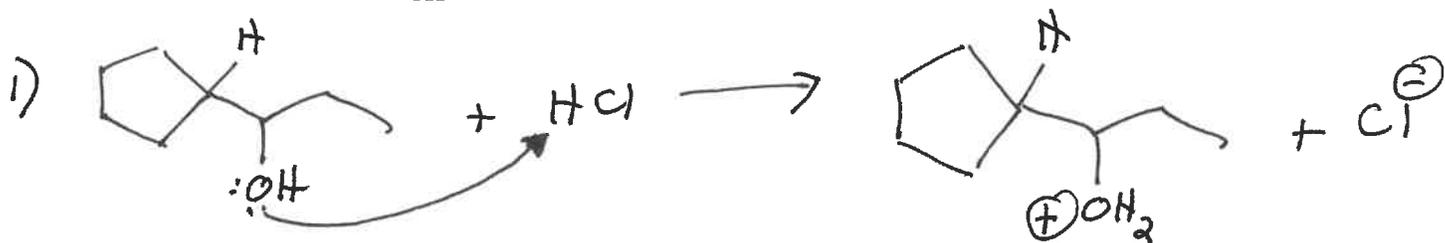


(ii) Provide an IUPAC name for the alkene you drew above.

(trans) - 1-cyclopropyl - 4-methyl - 1-pentene

4. Mechanism of the SN1 Addition of HCl to an Alcohol with rearrangement (4 steps).

(a) Write a complete mechanism that explains the formation of all products in the balanced Net Equation shown below. Your mechanism must consist of a series of individual, balanced chemical equations, and curved arrows to show electron pair movement.



(b) In the mechanism you wrote above, what roles are played by the HCl ions? CIRCLE all the best answer(s):

Nucleophile

Electrophile

Leaving Group

Catalyst

Acid

Base

(c) Explain what is happening in Step #2 of the mechanism you wrote above. Be specific!

In step #2 we have a good leaving group ($-\text{OH}_2^+$) which leaves to form H₂O and a 2° carbocation.

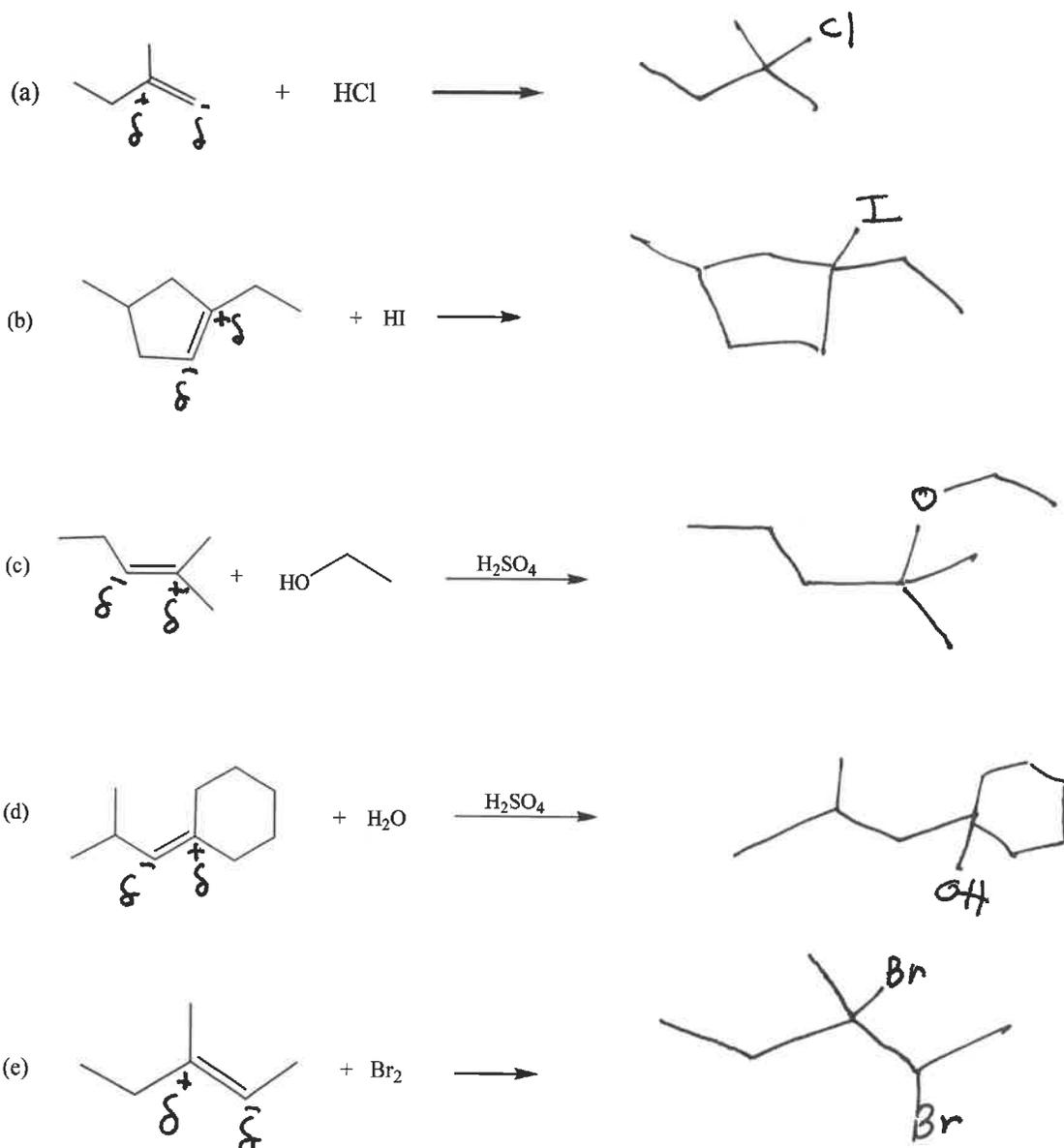
EXAM IV Study Guide - Part II Questions (take home, Friday-Sunday, December 6-8)

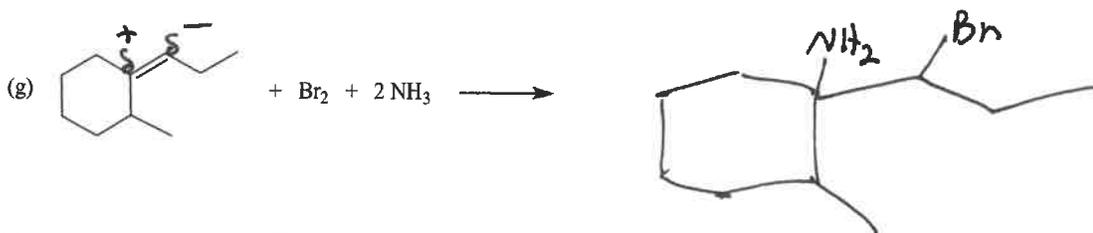
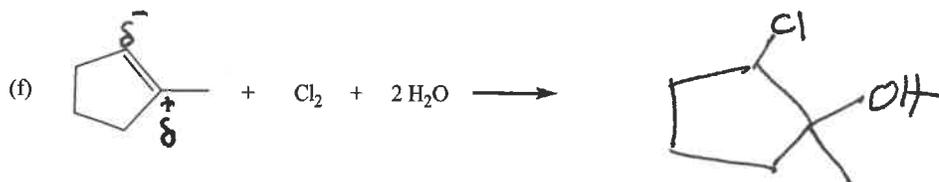
Guidelines for EXAM IV Part II (take home):

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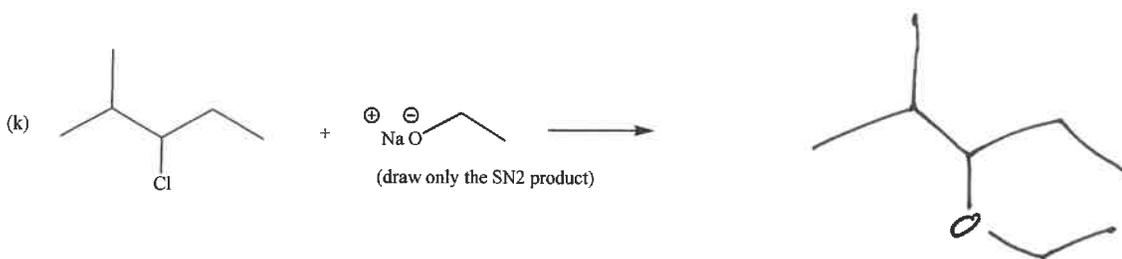
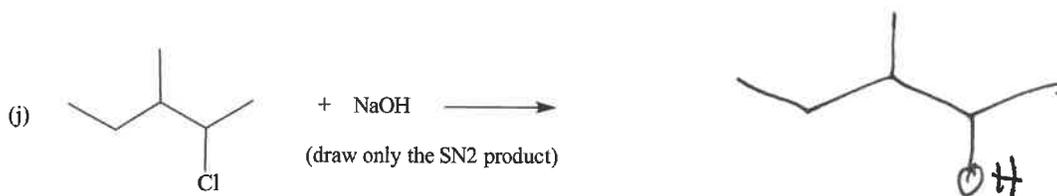
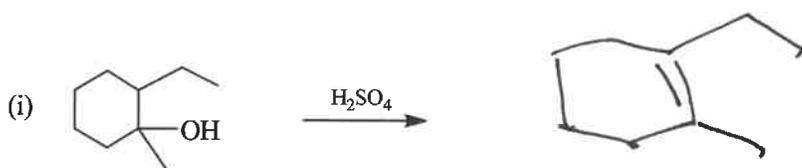
1. Reactions. Complete the reactions shown below by drawing the structure of the major, neutral organic products. It is NOT necessary to balance these reactions or write the mechanism. There are NO rearrangements and NO intramolecular reactions. **Do Not worry about stereochemistry.**

PART I: Electrophilic Addition Reactions





PART II: Reactions of Alcohols

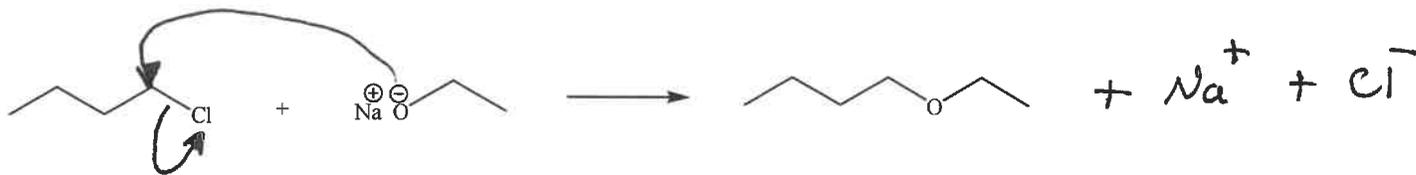


2. Mechanisms.

(a) Mechanism of SN2 Substitution of an Alkyl Halide with the conjugate base of an Alcohol (1 step).

For the partial reaction below:

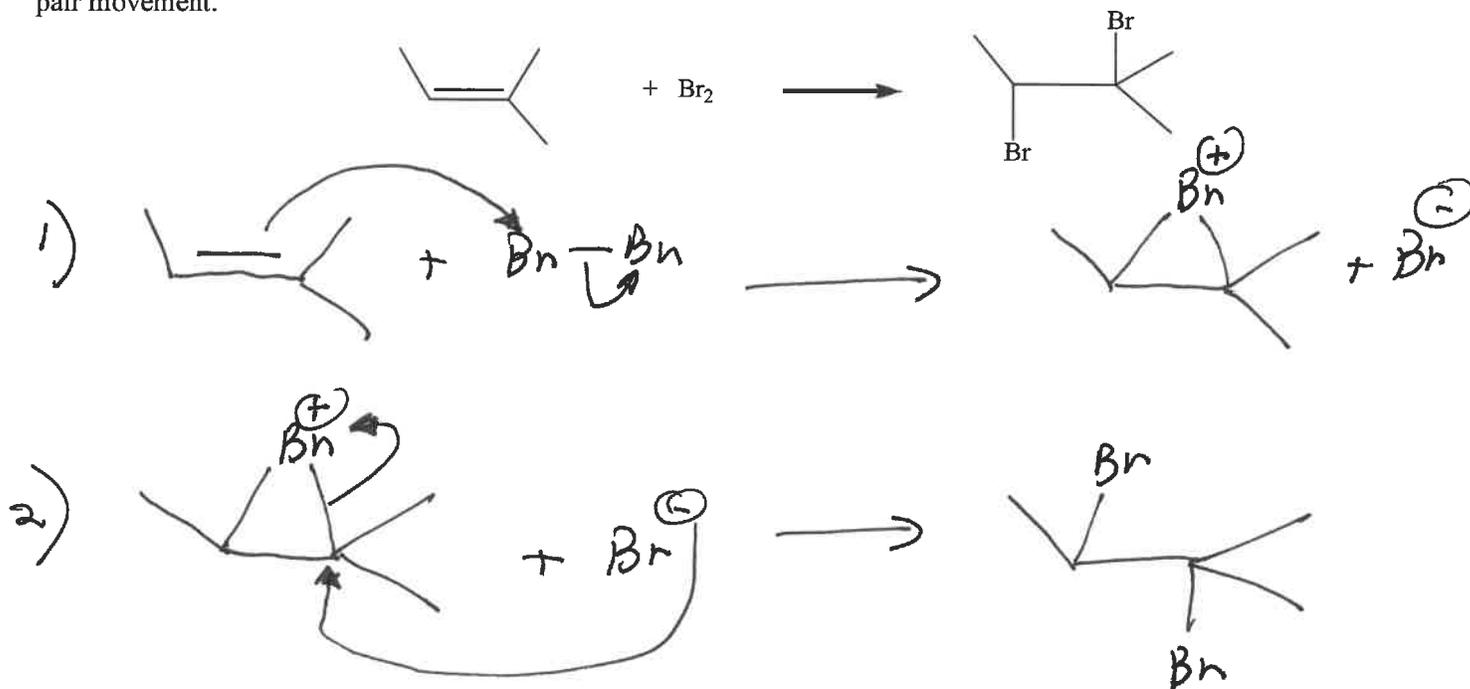
- Draw the proper curved arrows for the reactants
- Balance the products

(iii) What **two** characteristics of the **reactants** make this an SN2 reaction?

- 1° leaving group
- good nuc, strong base

(b) Electrophilic Addition Mechanism - Addition of Br₂ (2 steps).

(i) Write a complete mechanism that explains the formation of all products in the balanced net reaction shown below. Your mechanism must consist of a series of individual, balanced chemical equations, and curved arrows to show electron pair movement.

(ii) Which of the following best describes **all roles** played by the Br₂ atoms in this reaction? Circle all that apply.

Acid

Base

Electrophile

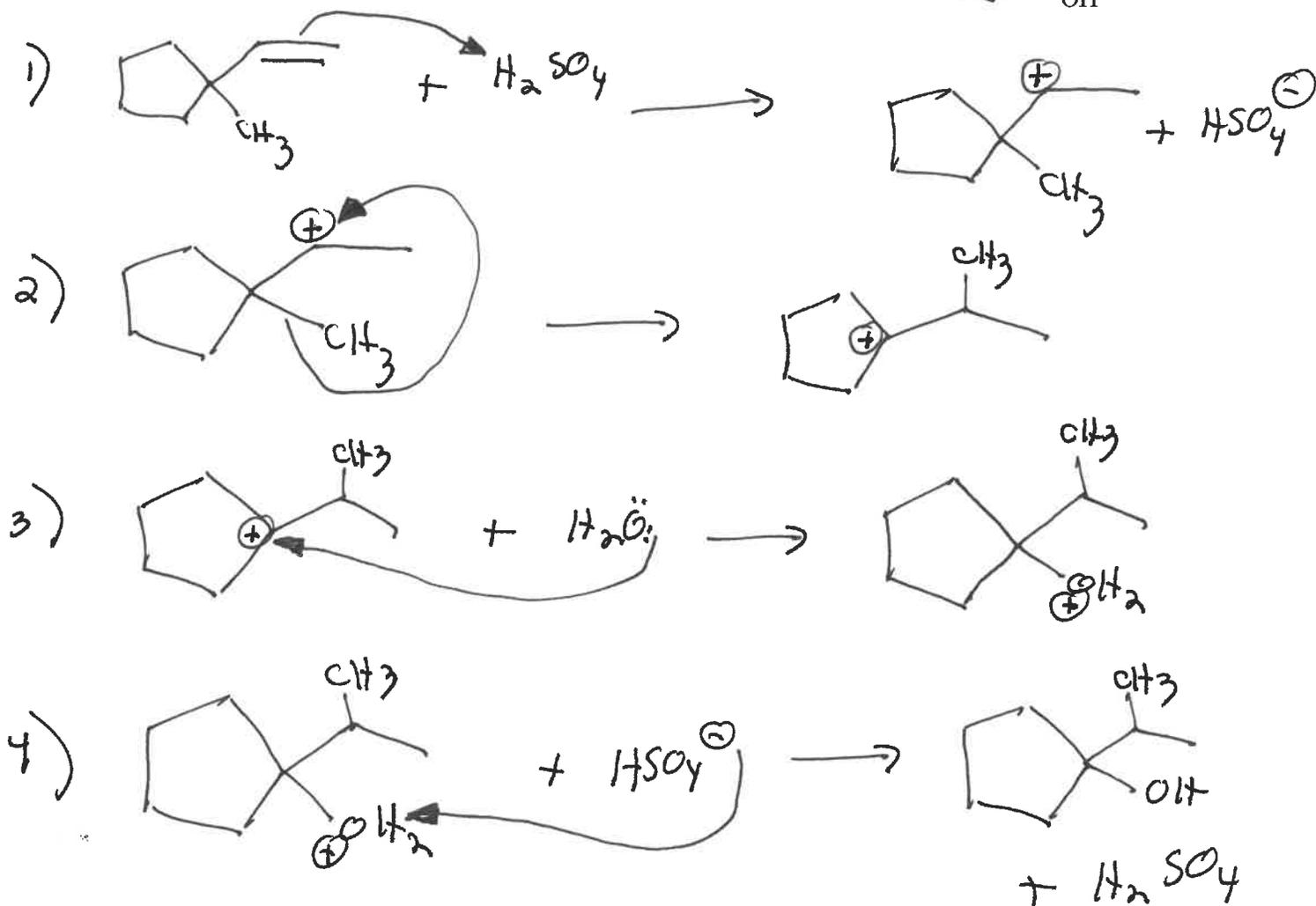
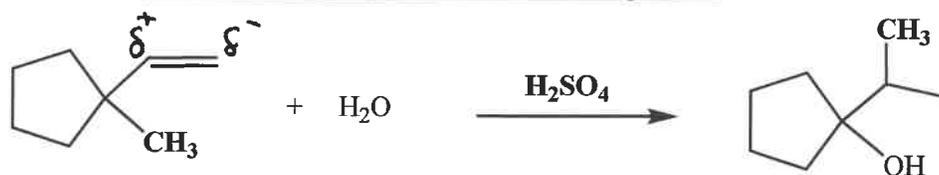
Nucleophile

Leaving group

Catalyst

(c) Electrophilic Addition of Water to an Alkene with Rearrangement (4 steps).

(i) Write a complete mechanism that explains the formation of all products in the balanced net reaction shown below. Your mechanism must consist of a series of individual, balanced chemical equations, and curved arrows to show electron pair movement.



(ii) What is the purpose of H_2SO_4 in your mechanism above, and in which Step is H_2SO_4 being used? **Be specific!**

H_2SO_4 is used in Step #1 as an acid catalyst to provide the electrophile (H^+) to the alkene + form a 2° carbocation.

(iii) Explain what is happening in Step #2 of your mechanism. **Be specific!**

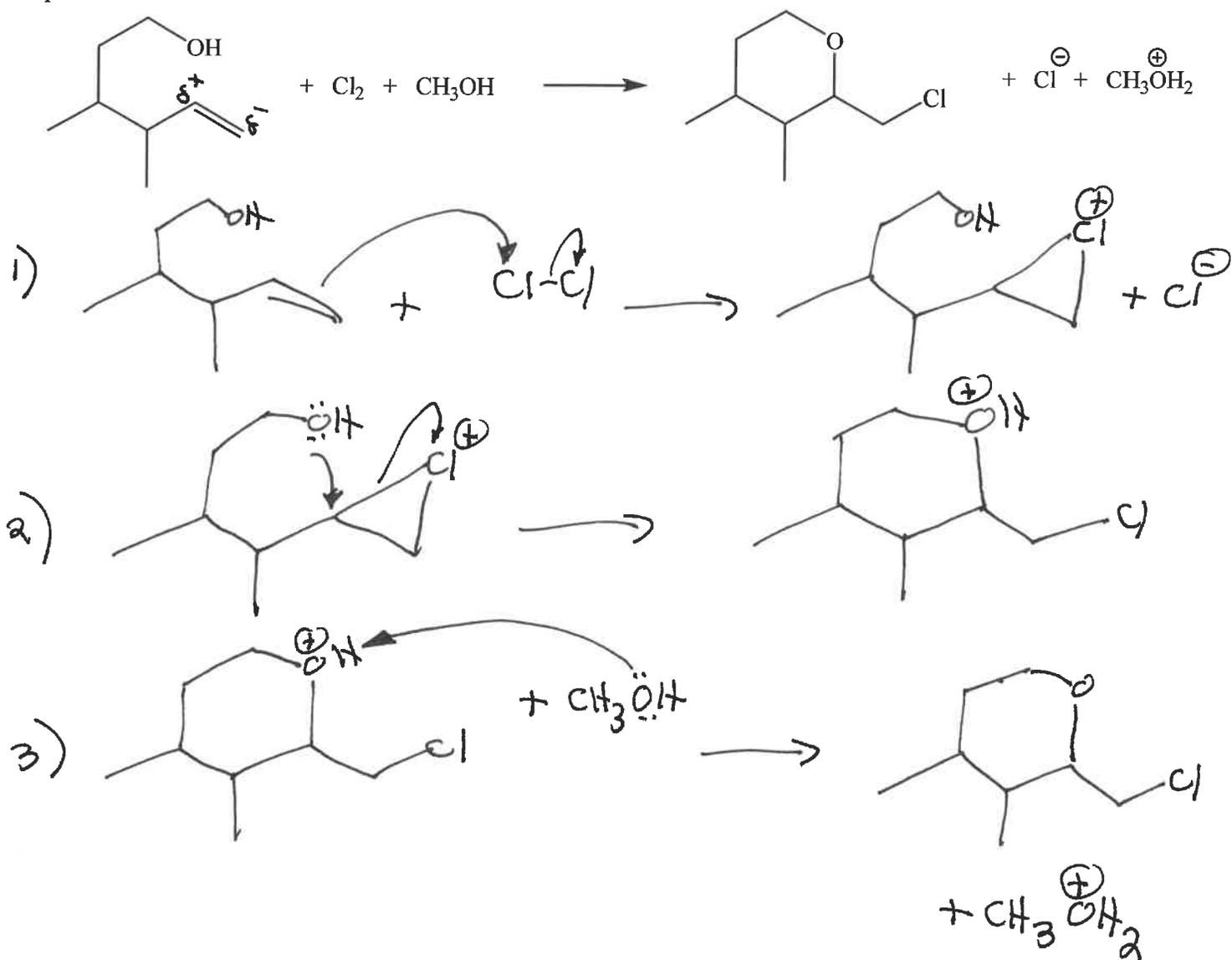
In step #2 there is a rearrangement of a 3° $-\text{CH}_3$ shifting to a 2° carbocation, forming a more stable 3° carbocation.

(iv) Explain what is happening in Step #4 of your mechanism. **Be specific!**

Step #4 is an acid/base step where HSO_4^- removes a proton to form the neutral product + regenerate the H_2SO_4 catalyst.

(d) Electrophilic Addition Mechanism – Intramolecular Addition of Cl_2 and a Nucleophile (3 steps).

(i) Write a complete mechanism that explains the formation of all products in the balanced net reaction shown below. Your mechanism must consist of a series of individual, balanced chemical equations, and curved arrows to show electron pair movement.



(ii) Based on the mechanism you wrote above, what is/are the role(s) of CH_3OH in your mechanism? Be specific!

In step # 3, CH_3OH acts as a base to grab an H^+ + form the neutral product and a conjugate acid (CH_3OH_2^+).