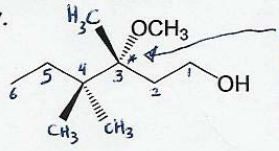
CHEM221 Section 01 Dr. C. Rogers **NAME:** Rogers

INTRODUCTORY ORGANIC CHEMISTRY I --- PROBLEM SET #3

INSTRUCTIONS: HAND IN STAPLED, COMPLETED ASSIGNMENT (no extra pages please) **AT THE BEGINNING OF CLASS on Tues.Nov.29.** LATE SUBMISSIONS WILL **NOT** BE ACCEPTED (EARLY IS OK). ANSWER ALL QUESTIONS, ALL MATERIAL WILL BE COVERED BEFORE THE DUE DATE.

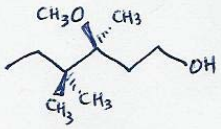
 # 1. Provide complete systematic (IUPAC) names for the following molecules, including R/S configuration where appropriate. Also, if the molecule is chiral, draw its enantiomer; if it is achiral, indicate why.

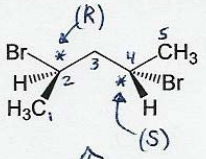
i) 

hexanol
3-methoxy
3,4,4-trimethyl

(S)-3-methoxy-3,4,4-trimethylhexanol

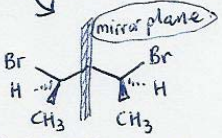
enantiomer: (R)-3-methoxy-3,4,4-trimethylhexanol



ii) 

pentane
2,4-dibromo
mirror plane! → meso (ACHIRAL)

ROTATE AROUND C3-C4 BOND...

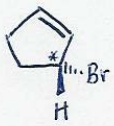


meso ∴ named so that C* with lower # is "R"

(2R,4S)-2,4-dibromopentane

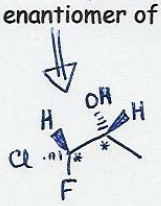
 # 2. Draw skeletal (line) structures of the following molecules, showing stereochemistry. Also, indicate each chiral center in your structures using an asterisk (*).

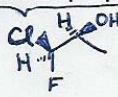
i) (R)-3-bromocyclopentene



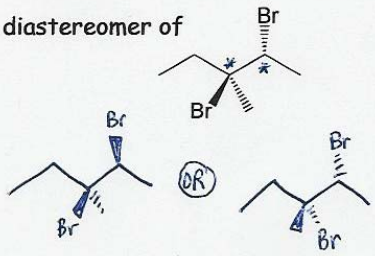
ii) the enantiomer of (1S, 2S)-fluorochloropropan-2-ol,

= (1R, 2R)-fluorochloropropan-2-ol

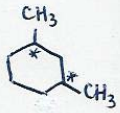


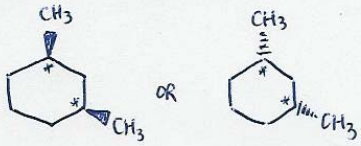


iii) a diastereomer of



iv) an achiral isomer of 1,3-dimethylcyclohexane





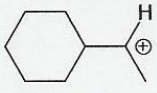
 # 3. Rank these carbocations according to their relative stability. Justify your choice with a few words about each structure.

NOTE: your textbook does not clearly specify relative stability of 2° benzyl vs 3° carbocations, but in other texts I found 2° benzyl ?3°

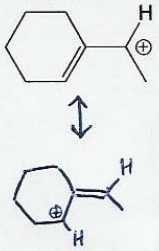
you will get marks even if you guessed it the other way...

3°
high degree of inductive stabilization
+9 different conformations in which hyperconjugation can occur

really quite stable, but not as well delocalized as when have resonance...

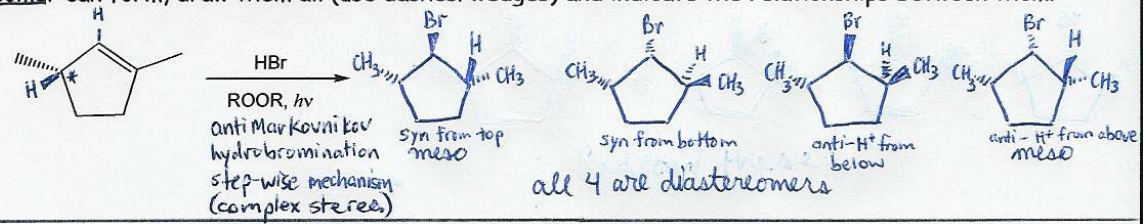


2°
LEAST STABLE
moderate inductive stabilization
+6 conformations with hyperconjugation

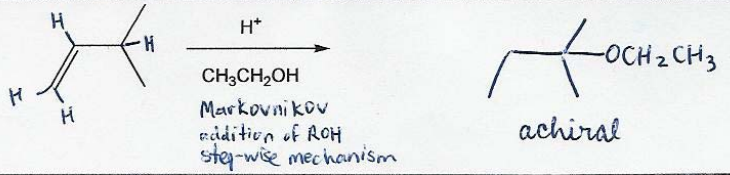


2° ∴ moderate inductive stabilization + 6 conformers with hyperconjugation
+ resonance-stabilized
likely the MOST STABLE

 # 4. Draw structures of the major regiochemical products of the following reactions. If more than one stereoisomer can form, draw them all (use dashes/wedges) and indicate the relationships between them.

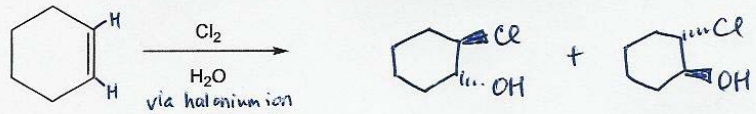
a) 

all 4 are diastereomers

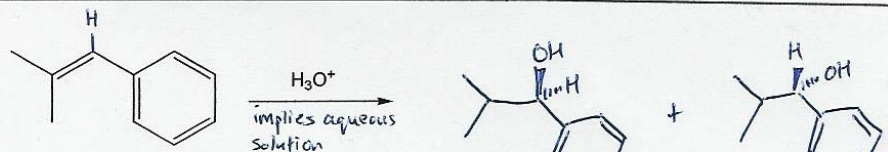
b) 

achiral

after rearrangement of 2° cation to 3° cation

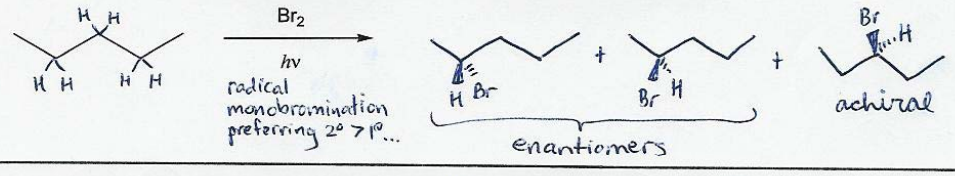
c) 

enantiomers.

d) 

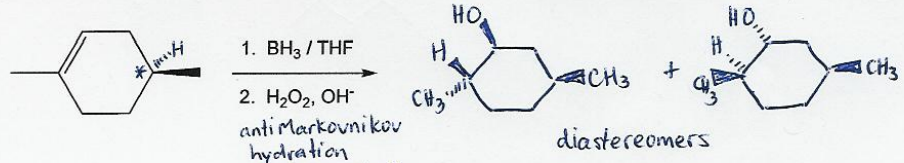
enantiomers

via rearrangement of 3° carbocation to 2° resonance-stabilized cation

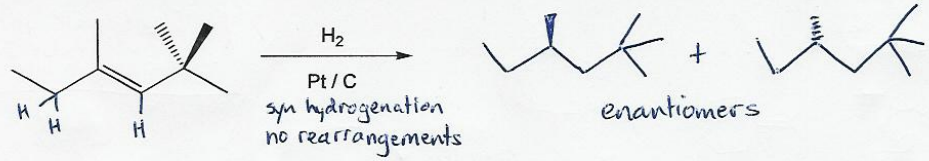
e) 

enantiomers

achiral

f) 

diastereomers

g) 

enantiomers

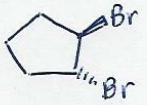
add Br_2 to alkene

 # 5. Imagine you are going to brominate cyclopentene in the lab. You plan to use cyclohexane as the solvent for your reaction. Your supervisor told you to cover your flask with foil during the reaction.

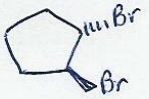
a) What reagent and conditions will you use to bring about the bromination of cyclopentene? (typo)

Bromination means "add Br_2" when describing reaction with an alkene. To add just one Br would involve adding HBr and is called hydrobromination. Thus, the reagent needed is Br_2, and this should be done in a non-nucleophilic solvent (no O, N...) at room temp., so cyclohexane is not a bad choice.

b) What is the desired product(s) of your bromination reaction? Include stereochemistry.



and its enantiomer



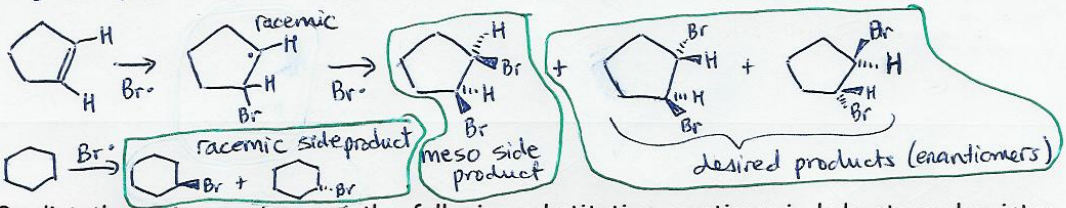
names not required:
(1R,2R)-dibromocyclopentane
or (1S,2S)-dibromocyclopentane

c) Explain why it is a good idea to cover your flask with foil for this reaction.

In the presence of light, Br_2 homolytically cleaves to yield Br· radicals, which react with alkenes + alkanes also. This would cause us to lose control of the outcome of the reaction. Foil is used because it will block the light from the room from interfering with our desired reaction. Both cyclopentene AND the solvent cyclohexane would react with Br·. [Note: even room light contains enough UV photons to cause some radical side reactions, although intense sunlight would be worse....]

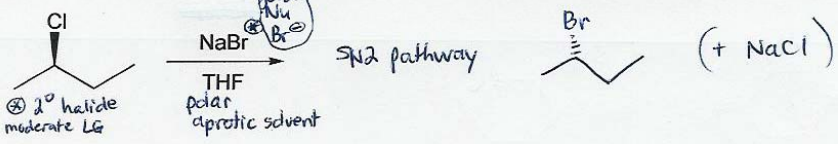
d) What side product(s) might you obtain if you did not cover your flask with foil? Include stereochemistry.

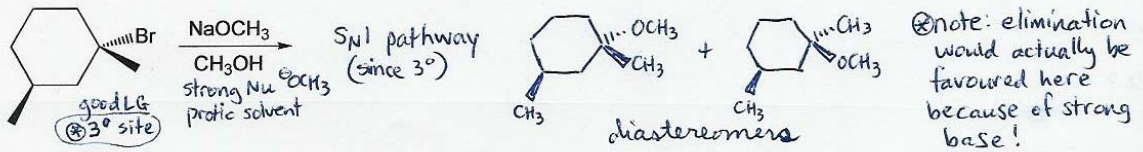
① $Br_2 \xrightarrow{h\nu} 2\,Br\cdot$ which will react with most reactive site in cyclopentene & with cyclohexane.

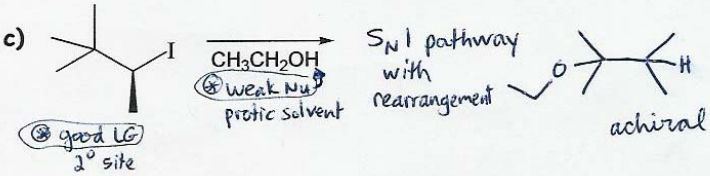
② 

③

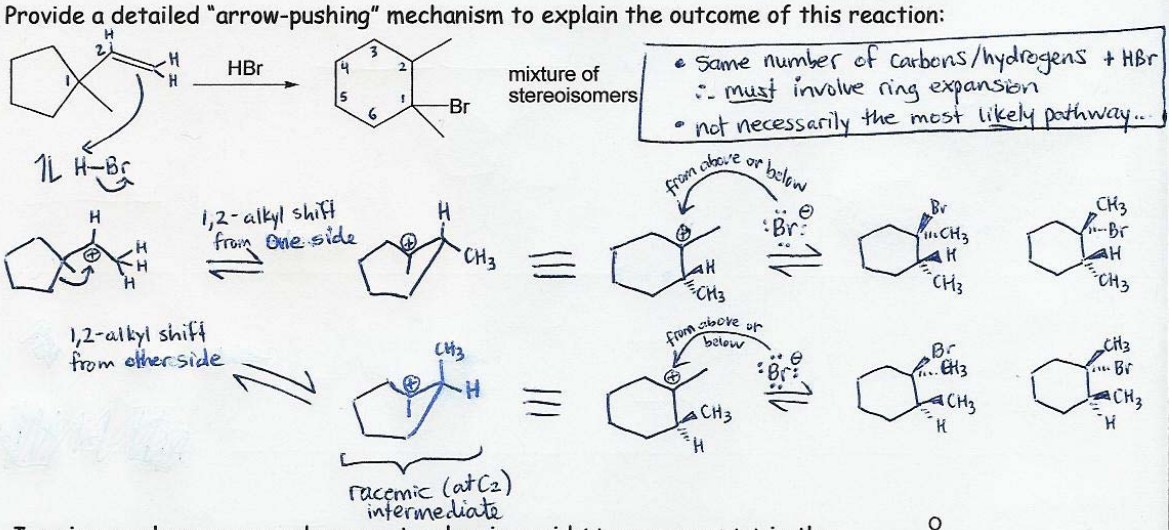
 # 6. Predict the major products of the following substitution reactions; include stereochemistry. Identify the mechanism (S_N1 vs. S_N2) that would lead to the products you have chosen.

a) 

b) 

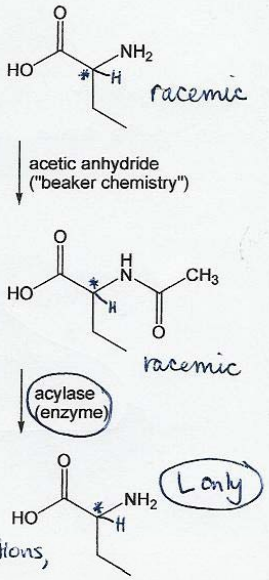
c) 

 # 7. Provide a detailed "arrow-pushing" mechanism to explain the outcome of this reaction:



- Same number of carbons/hydrogens + HBr ∴ must involve ring expansion
- not necessarily the most likely pathway...

 # 8. Imagine you have prepared an unnatural amino acid (shown at top right) in the lab. The synthetic pathway you used yielded a racemic mixture, and you want to prepare a pure sample of the L enantiomer, as amino acids are found in nature. Instead of taking advantage of reversible acid-base chemistry to separate diastereomeric salts, you have chosen to use a different approach. To resolve the enantiomers, you will first react the racemate with a compound that yields a new set of "acylated" enantiomers (shown at middle right; don't worry about the reaction involved); secondly, you will treat the mixture with an enzyme called *acylase*, which cleaves bonds between N atoms & carbonyl C atoms. This will regenerate the amino acid (shown at bottom right). Because the enzyme is chiral and evolved to react with L amino acids, your D enantiomer will be left in the "acylated" form after the enzymatic step.



a) If you measure the optical rotation of the initial mixture of amino acid enantiomers, what will you observe? Why?

The initial enantiomers are present in a 1:1 ratio because the rxn that produced them yielded a racemic mixture. Each enantiomer will rotate the plane of polarized light by the same amount but in opposite directions, so the net rotation will be ZERO.

b) Why should you be able to separate the L amino acid and the "acylated" D amino acid using typical physical methods?

The two compounds have different functional groups, so should have different physical properties, such as solubility. The acylated amino acid has fewer H-bond donors, but an extra H-bond acceptor site, compared to the L amino acid. Even if the differences in properties would be hard to predict, they should still be significant. Stereochemistry has little effect here since the chemical structures' differences are much more significant.

c) Describe briefly how you could use optical rotation to help you while separating the L amino acid and the "acylated" D amino acid.

Let's assume we are purifying using successive recrystallizations. The L-amino acid + D-acyl-amino acid would likely have opposite directions of rotation, since the D-acyl amino acid did form from the D-amino acid. As steps are taken to purify the L-amino acid, optical rotation would be measured after each step; for example, after each recrystallization, it could be measured. At first, we would expect large changes in optical rotation (specific rotation, to be precise) as our crystals become more + more enriched in one of the compounds. When the ~~optical~~ specific rotation stops changing ~~between~~ after an extra recrystallization is done, we would assume the same is now pure. Hopefully we can couple this with some other technique that could give us information about the compound's structure + purity (eg. NMR - see Chem 222).