Exam II Organic Chemistry I CHEM 340 Spring 16 3/30 W Dr. Hahn MWF 8 am Exam# _____

Sign Name Key Print Name _____

(2 pt name above print & sign, 2 pts scantron name) (100 pts, 11 pages + periodic table+ scantron sheet)

Please show work on all questions for partial credit even on questions which do not specify. Please write legibly. If I cannot read your answer, I cannot grade your answer. (use back of exam for scratch paper – If you want me to grade something not in the space for the answer, clearly specify in writing. Telling me during the exam where to find the answer does not qualify because I will just vaguely remember someone telling me something during the exam not which one of 200 students told me what to grade on what page of the exam.)

Please READ and FOLLOW directions. (ex: don't give me 5 structures if I only ask for one or you will lose points on this exam by **RUNNING OUT OF TIME**)

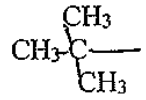
Circle answer on this form for backup to the scantron for the multiple choice. R=alkyl, not hydrogen on all parts of this exam.

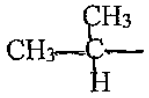
I. Multiple Choice (3 pts each, 27 pts) Choose the **one** best statement in each question.

grade key

key with points

1. Choose best statement.

(a) This is isopropyl 

(b) This is t-butyl 

(c) In naming cycloalkanes, if the number of carbons in the alkanes is less than or equal to the number of carbons in the ring, the name is alkyl cycloalkane.

(d) All above statements are true.

2. Choose the best statement.

(a) In general branched alkanes have lower BP/MP than normal alkanes because of the effect of van der Waals effect, surface area and effective packing.

(b) Larger molecule have smaller van der Waals effect because of greater surface area for van der Waals intermolecular interactions.

(c) In general for solubilities, "like dissolves like". This is why alkanes are soluble in other alkanes but why alkanes are insoluble in water.

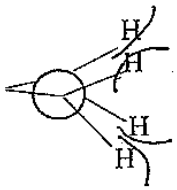
(d) All above statements are true.

3. Choose the one best statement.

(a) In cycloalkanes, angle strain is due to compression of the tetrahedral angle (109.5° angle required for an sp^3 hybridized carbon) to fit the angle of a cycloalkanes. So cyclopropane has an especially high angle strain because of the 60° angle required for a cyclopropane structure.

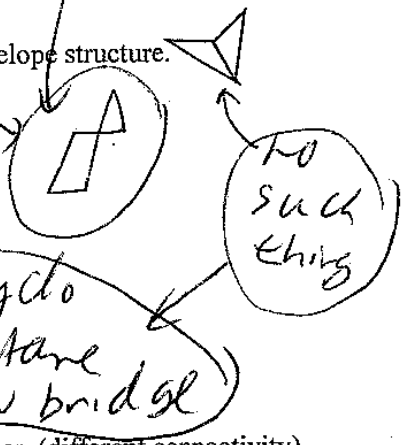
(b) The following shows angle strain in **cyclolpropane**.

torsional



envelope

(c) The following shows a **cyclopentane**, more stable than flat molecule envelope structure.



(d) A **cyclohexane** boat is more stable than a cyclohexane chair.

less

(e) (a) and (c) are true.

No such thing

cyclo butane w bridge

4. Choose the best statement.

(a) Stereoisomers are isomers which have atoms connected in a different order. (different connectivity)

(b) Structural isomers are isomers with the same connectivity but arranged differently in space.

(c) Enantiomers are a kind of stereoisomer which are NOT mirror images of each other.

(d) Diastereomers are stereoisomers that are not mirror images and include cis/trans isomers and diastereomers with more than one chiral center.

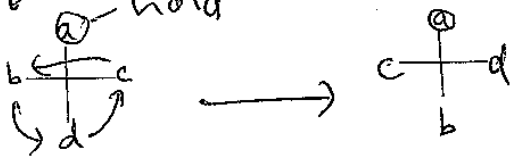
(e) All statements above are true.

5. Choose the best statement.

(a) In a Fisher Projection formula (which is not drawn as a 3D structure) , the horizontal bonds comes out towards the front from the plane of the paper and the vertical bonds go away towards the back from the plane of the paper.

(b) A Fisher Projection rotated 90° in the plane, gives the same molecule while a 180° rotation gives the enantiomer molecule.

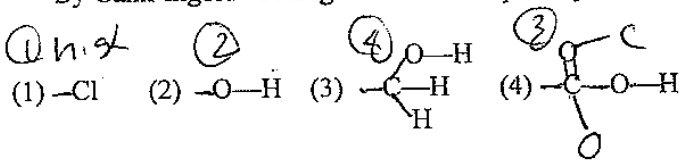
(c) A Fisher Projection in which you hold one of the 4 groups and rotates the other 3 results in an enantiomer



(d) A Fisher Projection in which you exchange just 2 of the groups results in the same molecule.

(e) All statements above are true.

6 By Cahn-Ingold –Prelog nomenclature priority for the following is:



(a) (1) > (2) > (3) > (4)

(b) (1) > (4) > (3) > (2)

(c) (2) > (1) > (4) > (3)

(d) The priority shown are all wrong.

7. Choose the best statement.

(a) A molecule with a chiral center is optically active. A pair of enantiomers with a single chiral center have the same physical properties except for optical activity.

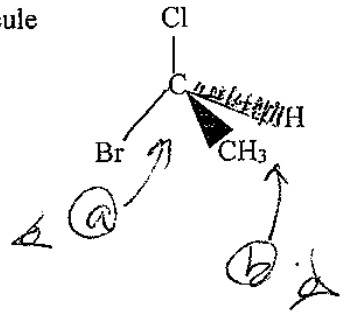
(b) A meso compound is not optically active and has an internal mirror plane.

(c) A racemic mixture which is a 50:50 mix of 2 enantiomers is not optically active and has different physical properties than either enantiomer.

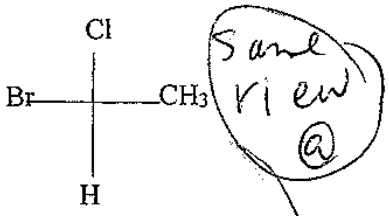
(d) A diastereomer with more than one chiral center is optically active a pair of diasteromers have different physical properties.

(e) All above statements are true.

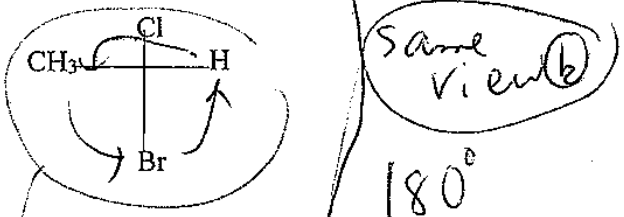
8. Which of the following are the same molecule as the molecule shown in 3D.



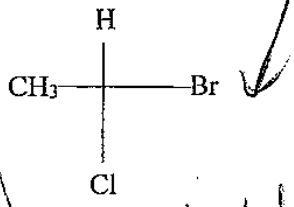
(a)



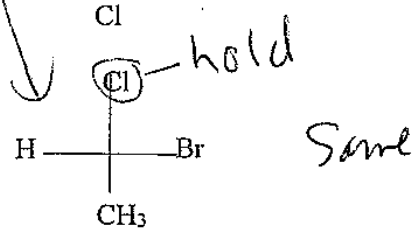
(b)



(c)

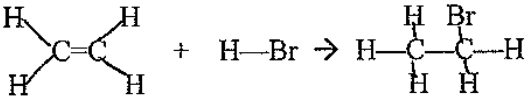


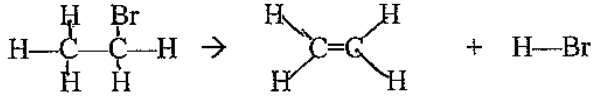
(d)

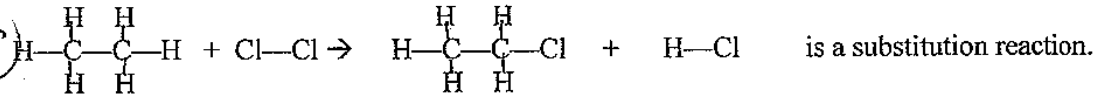


(e) All of the above are the same molecule as the original molecule.

9 Choose the one best statement.

(a)  is an elimination reaction

(b)  is an addition reaction

(c)  is a substitution reaction.

(d) (a) and (b) are true

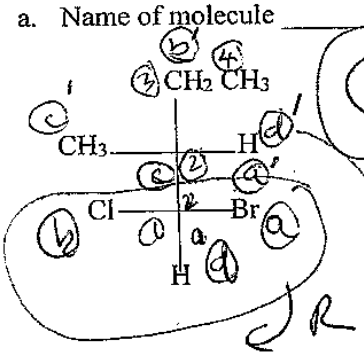
(e) (b) and (c) are true

II. Short Answers (44 pts)

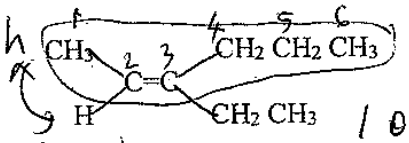
A. Nomenclature: (2 pts each, 6 pts)

1. Given the structural formula shown below, give the IUPAC name of the molecule.

a. Name of molecule (1R, 2R) - 1-bromo-1-chloro-2-methyl butane

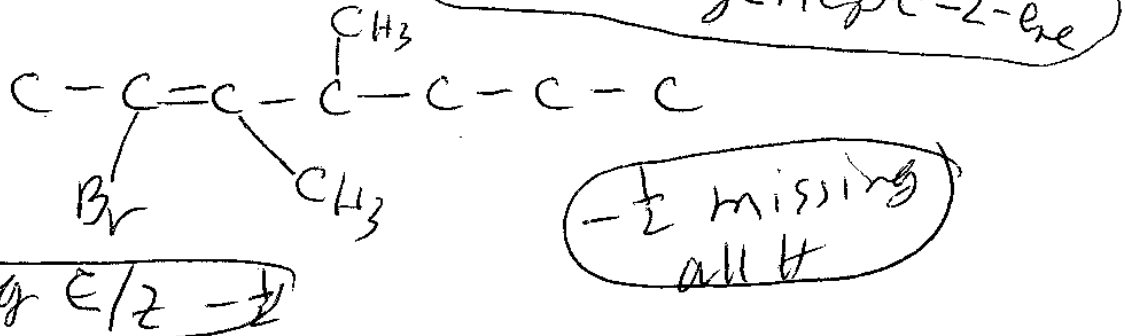


b. Name of molecule 3-ethyl Z-3-ethylhex-2-ene



2. Given the following IUPAC name, draw a structural formula of the molecule (skeletal formula acceptable, condensed structure, Lewis Dot structure acceptable, molecular formula not acceptable - don't forget to **show the hydrogens** in your formula unless you are using the skeletal structure.)

E-2-bromo-3,3-dimethylhept-2-ene

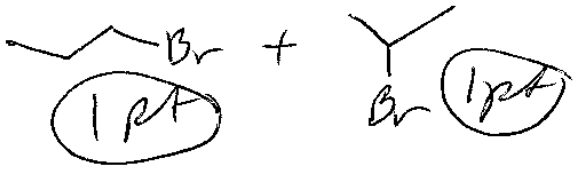


B. Reactions Part of Short Answers: (2 pts per reaction, 6 pts total)

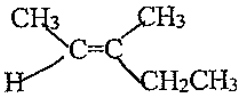
Given the following, what is the expected organic product ? Reactions do NOT need to be balanced.

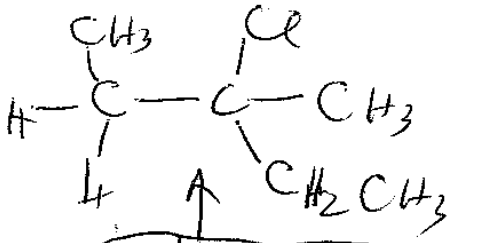
1) $CH_3-CH_3 + O_2 \rightarrow$ 1pt CO_2 + 1pt H_2O

(for this reaction, product is not organic so show all products)

2) $CH_3-CH_2-CH_3 + Br_2 \rightarrow$  1pt 1pt

give ALL monohalogenation products

3)  + H—Cl → mark

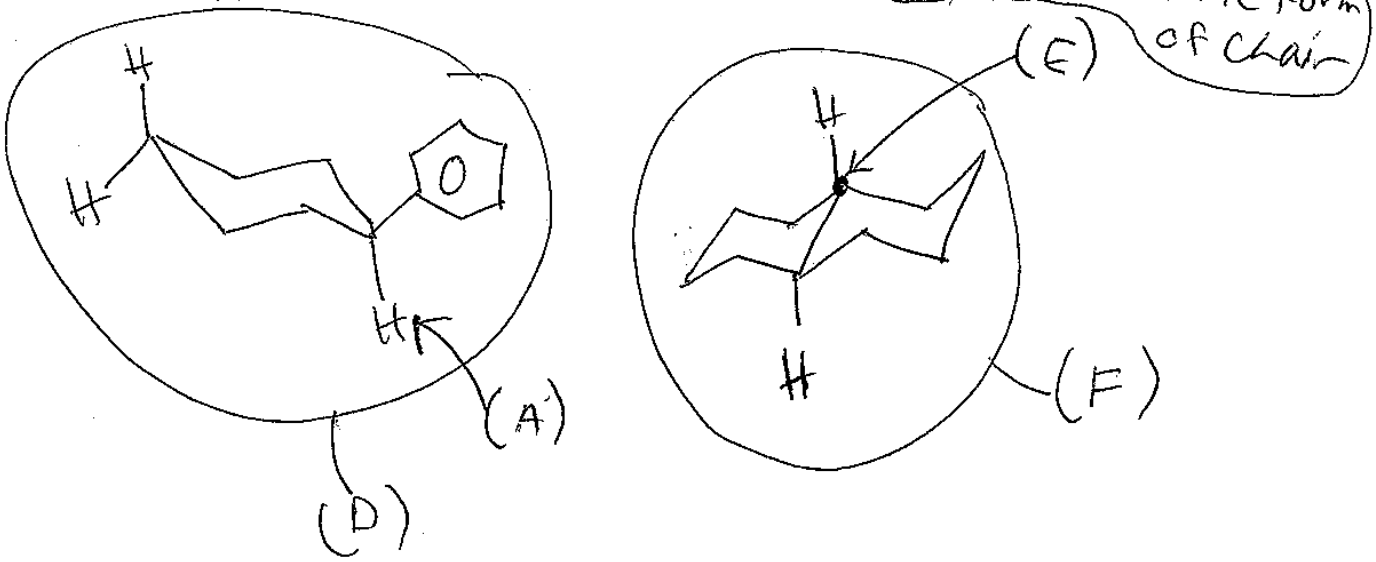


intermediate 1

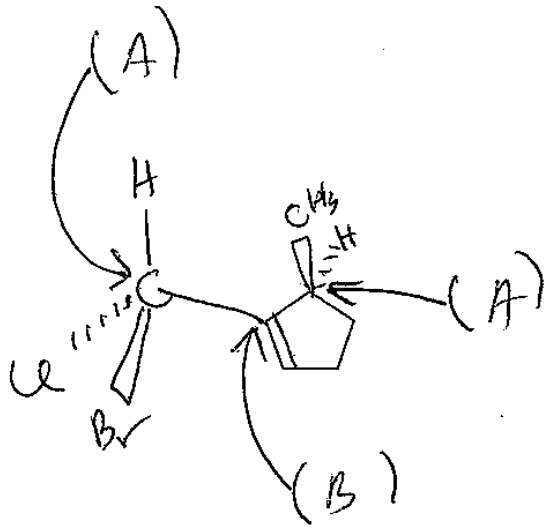
C. Short Answers Part of Short Answers (32 pts)

1. In the following diagram, fill in the blanks with the given letters. (2 pts each, 8 pts)

(A) Axial hydrogen (B) equatorial hydrogen (C) trans relationship (D) more stable form of chair (E) bridgehead carbons (F) trans decalin (G) cis decalin (H) less stable form of chair



2. In the molecule shown below, fill in the parenthesis with either (A) chiral center (B) not a chiral center (3 pts each, 9 pts)



attempt - 1½

3. For the following molecule, draw the most stable and most unstable Newman projection formula from the 2 in front towards the 3 carbon in the back.(3 pts each, ~~6 pts~~)

-2 BA each

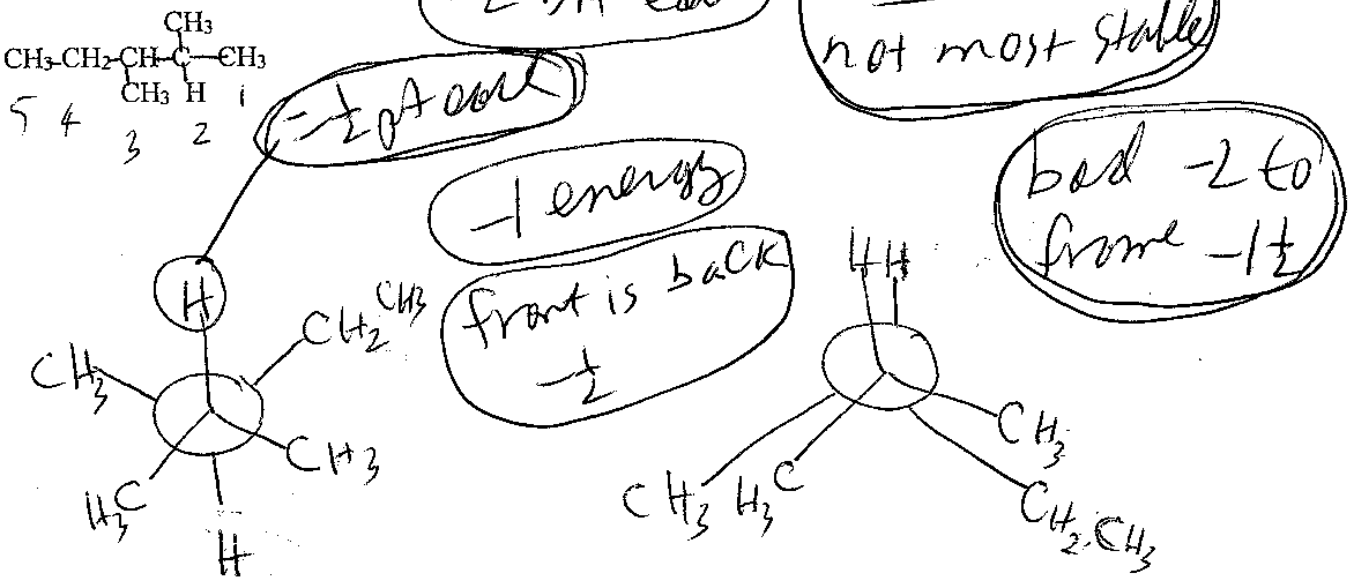
no pts off if not most stable

-½ pt each

bad -2 to from -1½

-1 energy

front is back -½



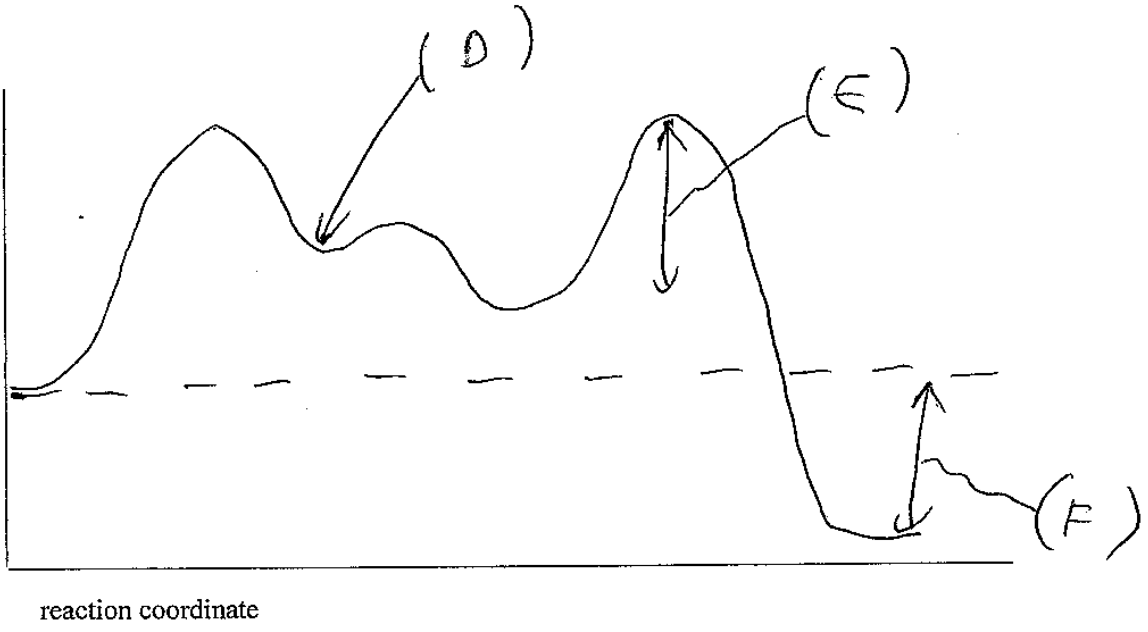
most stable (3 pts)

each back ward - eclipsed - most stable

most unstable (3 pts)

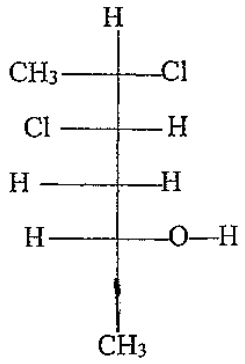
4. Given the following energy diagram, label by filling in the blank parenthesis with one of the following letters. (only one letter per blank) (3 pts each, 9 pts)

(A) reactant (B) product (C) transition state (D) intermediate (E) activation energy E_a or $\Delta G^{\ddagger}$ (F) ΔG°

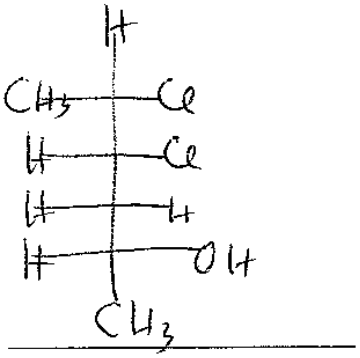


Part III. Long Answers (29 pts) Show work. Note that you earn partial credit for "attempt". "Attempt" is defined as not just rewriting the question but doing something towards getting the final answer.

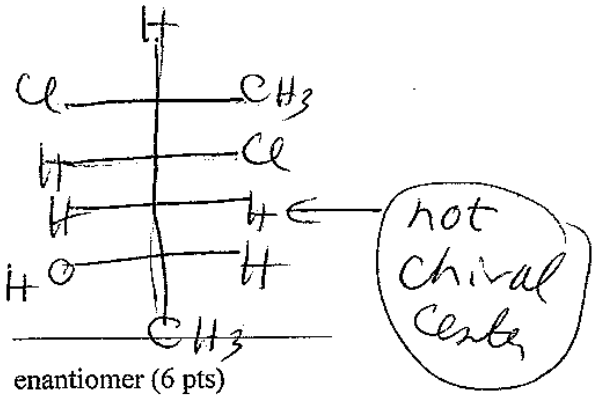
1. For the following molecule written as a Fisher Projection Formula, draw a diastereomer and an enantiomer (12 pts total)



original molecule



diastereomer (6 pts)



enantiomer (6 pts)

+ many more

enantiomer -3

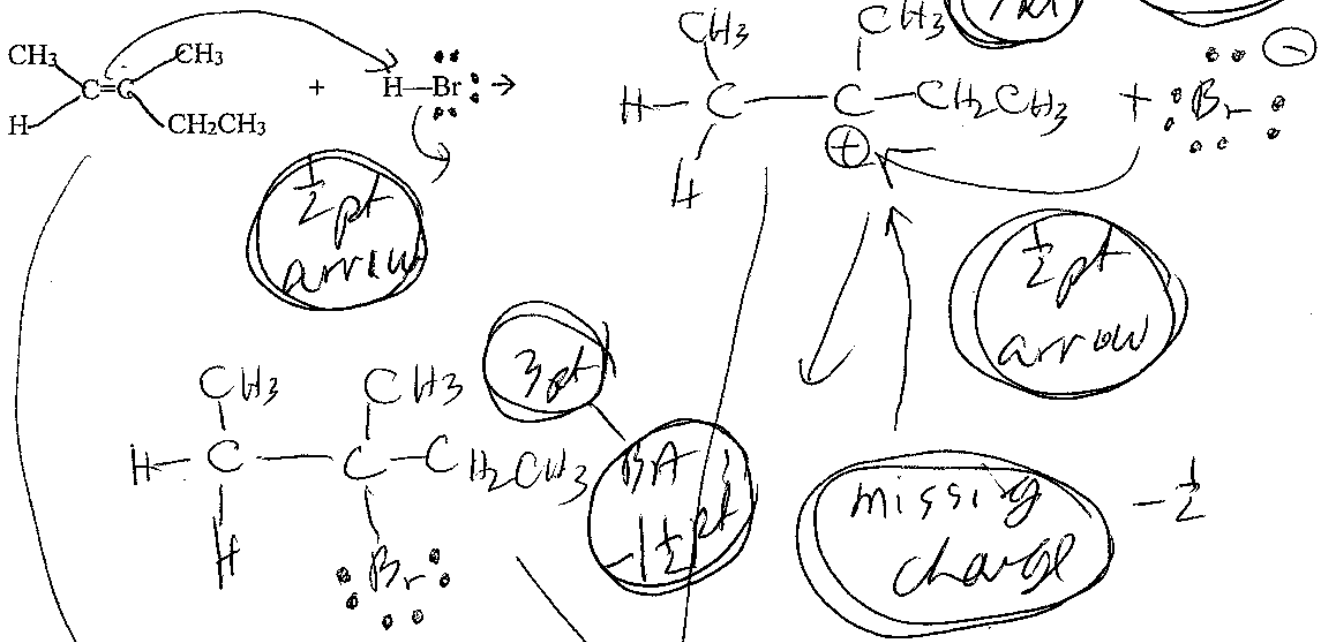
diastereomer -3

same w/ one change -3

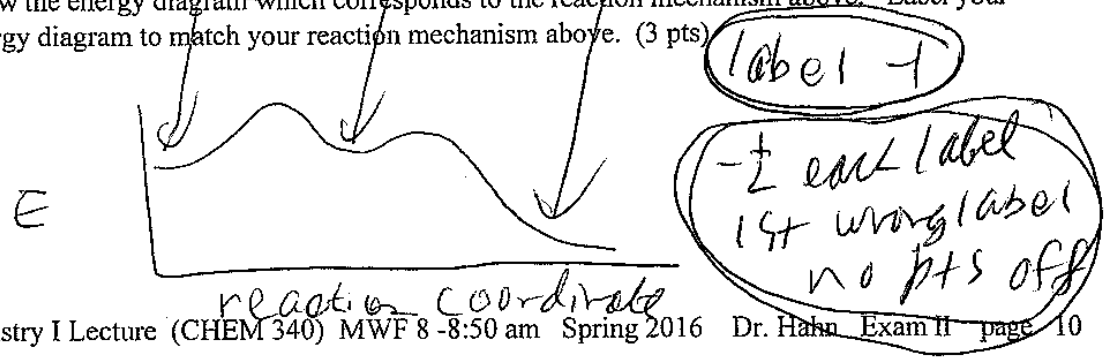
same no change -6

structural isomer -6

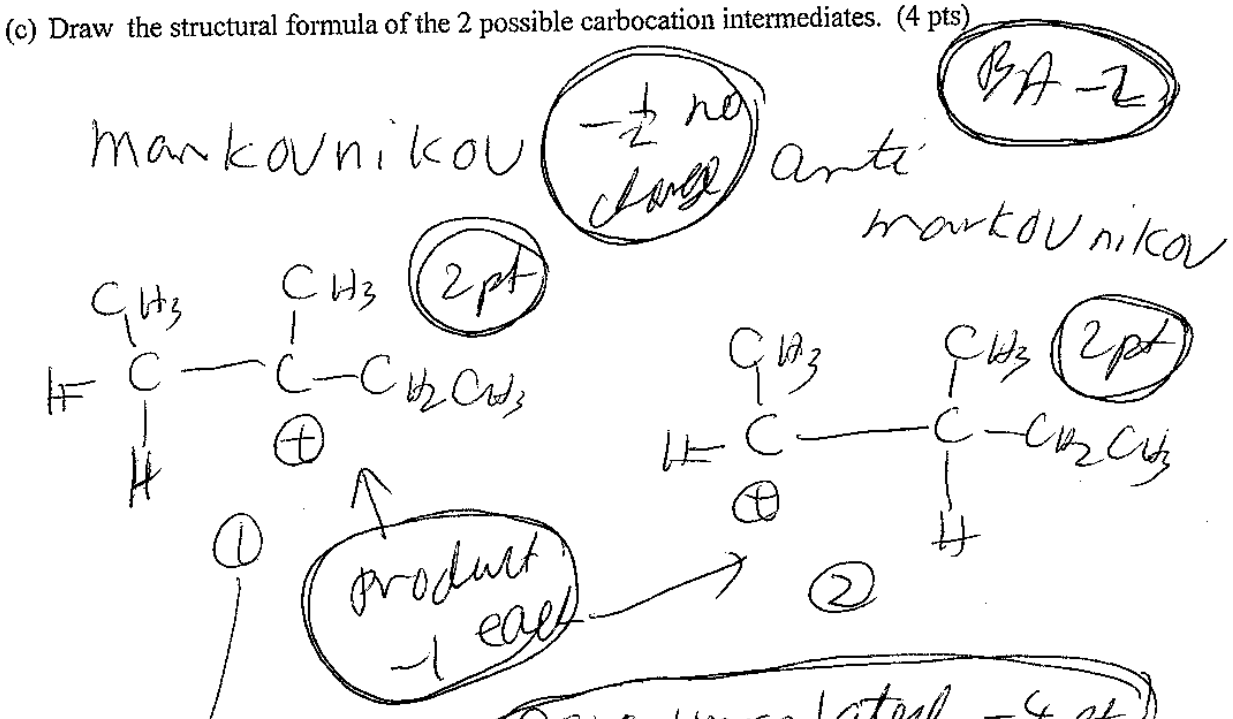
2. (a) Show the reaction mechanism of the Electrophilic Addition of H Br to the following alkene. You must show the intermediate, you do not need to show transition states, you must show electron pushing arrows and any charges on any molecule which you draw as a part of the reaction mechanism. (7 pts) (total 17 pts)



(b) Show the energy diagram which corresponds to the reaction mechanism above. Label your energy diagram to match your reaction mechanism above. (3 pts)



(c) Draw the structural formula of the 2 possible carbocation intermediates. (4 pts)



Gave unrelated -4 pt

(d) Give any of the definitions of Markovnikov's Rule for regioselectivity of the electrophilic addition of H Br to the alkene **mentioning carbocation stability**. (3 pts)

2pt 1pt

This is a 3° carbocation (tertiary). #2 is a secondary carbocation. Carbocation stability most stable 3° > 2° > 1° > methyl

BA -1½

So #1 has a more stable carbocation.

"E" addition goes by most stable carbocation.

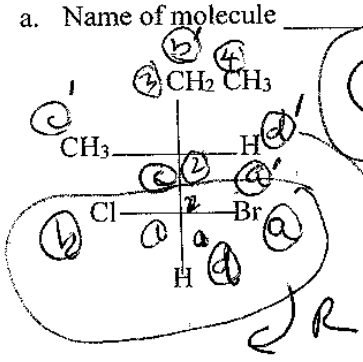
II. Short Answers (44 pts)

Key so can read answers

A. Nomenclature: (2 pts each, 6 pts)

1. Given the structural formula shown below, give the IUPAC name of the molecule.

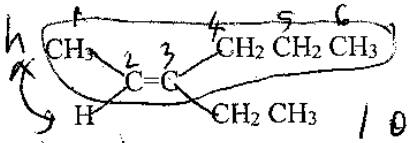
a. Name of molecule (1R, 2R) - 1-bromo-1-chloro-2-methyl butane



S

butane
1-chloro-1-bromo
2-methyl
lowest priority coming out
R

b. Name of molecule

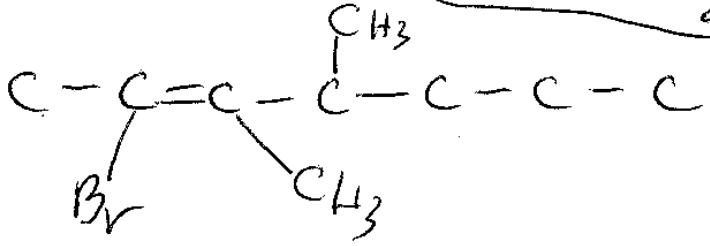


high
low
low

hex(ane)
2-ene
3-ethyl
Z-3-ethylhex-2-ene

2. Given the following IUPAC name, draw a structural formula of the molecule (skeletal formula acceptable, condensed structure, Lewis Dot structure acceptable, molecular formula not acceptable - don't forget to **show the hydrogens** in your formula unless you are using the skeletal structure.)

E-2-bromo-3,3-dimethylhept-2-ene typo → E-2-bromo-3,4-dimethylhept-2-ene

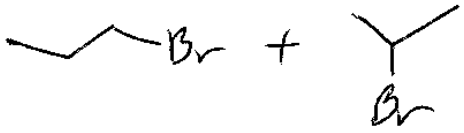


B. Reactions Part of Short Answers: (2 pts per reaction, 6 pts total)

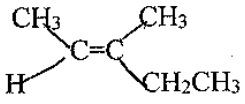
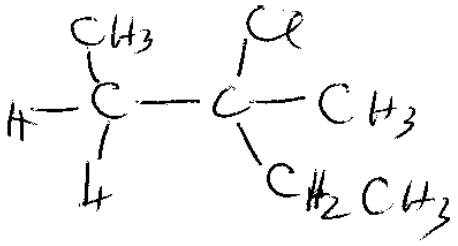
Given the following, what is the expected organic product ? Reactions do NOT need to be balanced.

1) $CH_3{-}CH_3 + O_2 \rightarrow$ $CO_2 + H_2O$

(for this reaction, product is not organic so show all products)

2) $CH_3{-}CH_2{-}CH_3 + Br_2 \rightarrow$ 

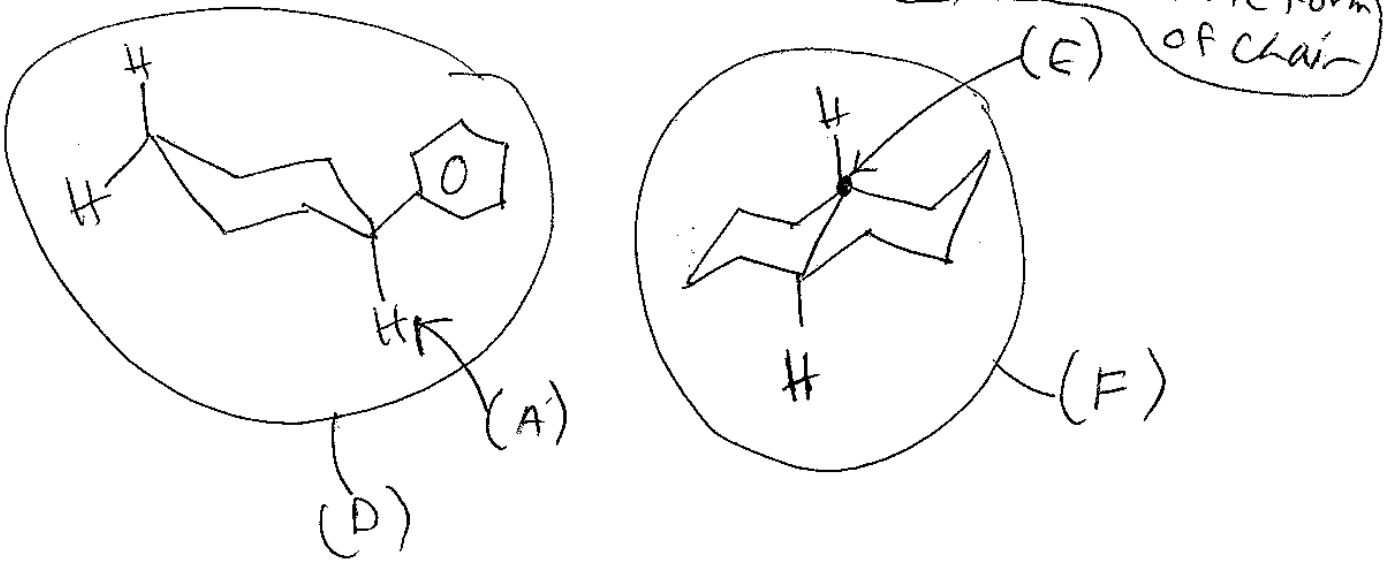
give ALL monohalogenation products

3)  + H—Cl → mark 

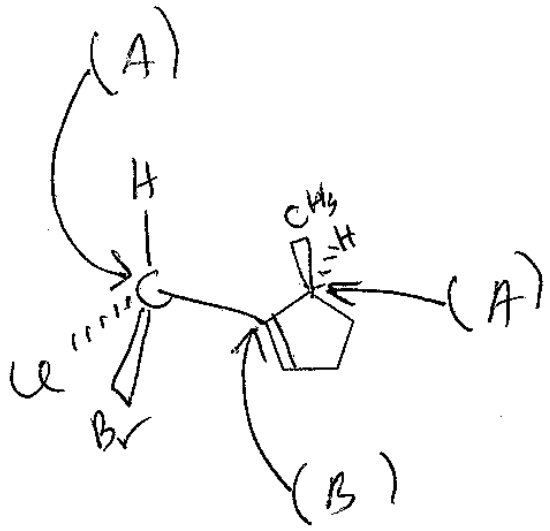
C. Short Answers Part of Short Answers (32 pts)

1. In the following diagram, fill in the blanks with the given letters. (2 pts each, 8 pts)

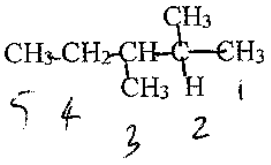
(A) Axial hydrogen (B) equatorial hydrogen (C) trans relationship (D) more stable form of chair (E) bridgehead carbons (F) trans decalin (G) cis decalin (H) less stable form of chair

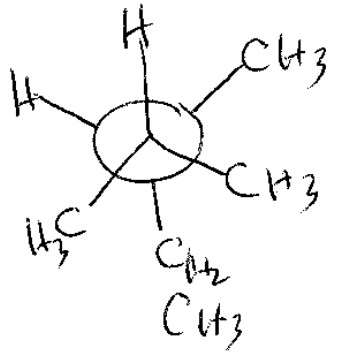


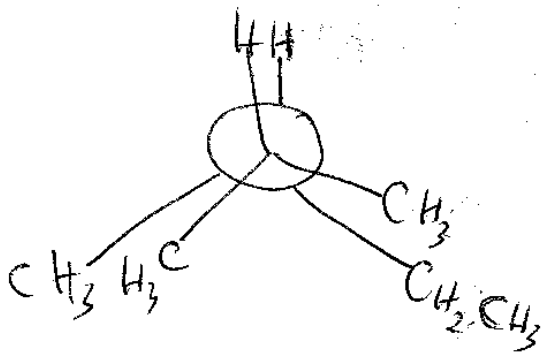
2. In the molecule shown below, fill in the parenthesis with either (A) chiral center (B) not a chiral center (3 pts each, 9 pts)



3. For the following molecule, draw the most stable and most unstable Newman projection formula from the 2 in front towards the 3 carbon in the back.(3 pts each, 6 pts)





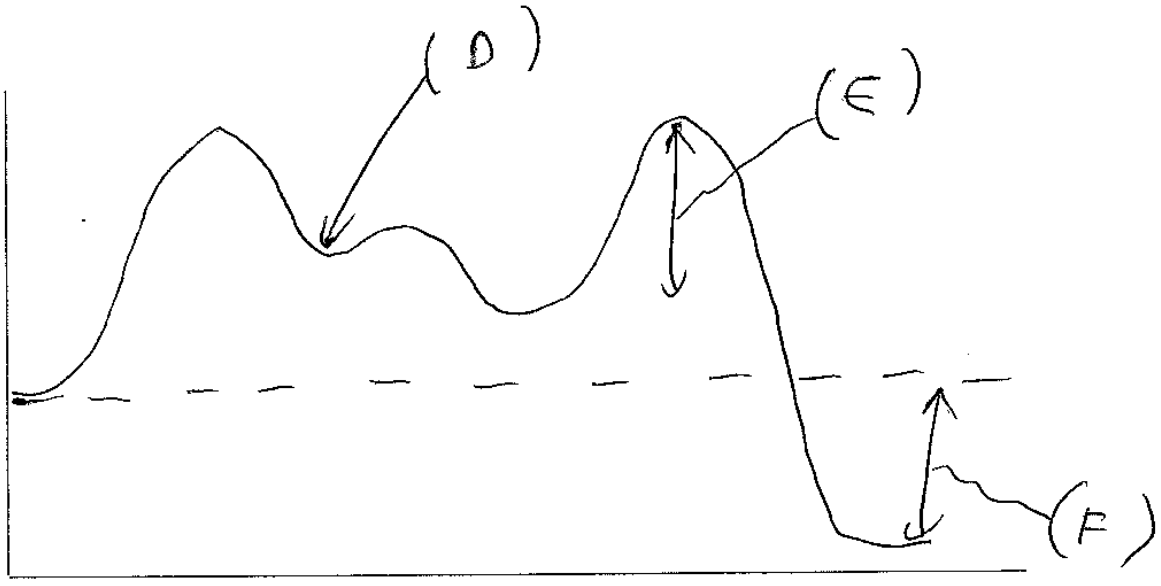


most stable (3 pts)

most unstable (3 pts)

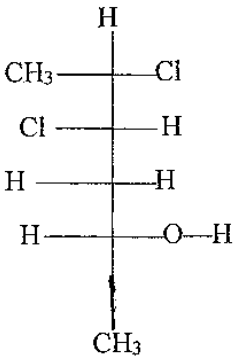
4. Given the following energy diagram, label by filling in the blank parenthesis with one of the following letters. (only one letter per blank) (3 pts each, 9 pts)

(A) reactant (B) product (C) transition state (D) intermediate (E) activation energy E_a or $\Delta G^{\ddagger}$ (F) ΔG^{o}

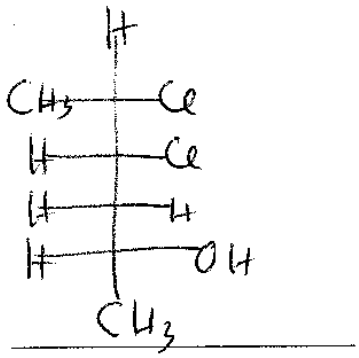


Part III. Long Answers (29 pts) Show work. Note that you earn partial credit for "attempt". "Attempt" is defined as not just rewriting the question but doing something towards getting the final answer.

1. For the following molecule written as a Fisher Projection Formula, draw a diastereomer and an enantiomer (12 pts total)

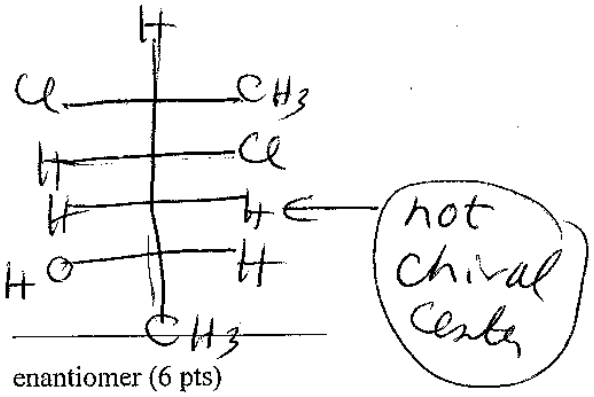


original molecule



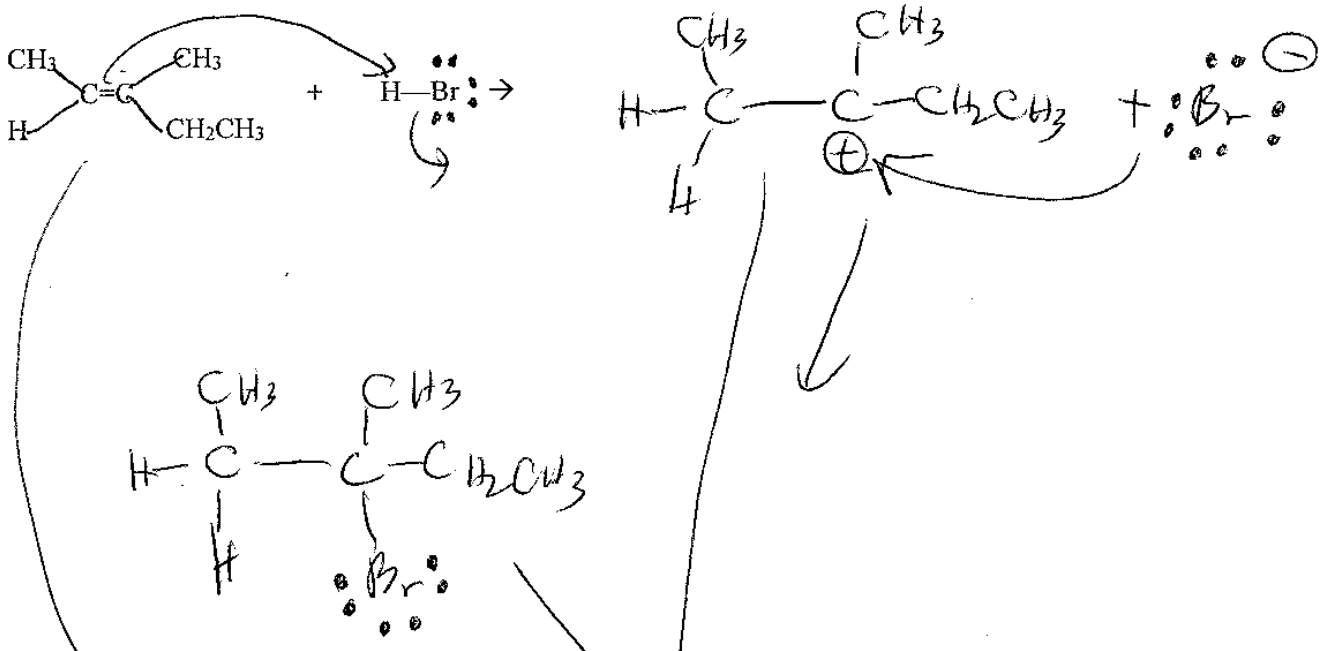
diastereomer (6 pts)

+ many more

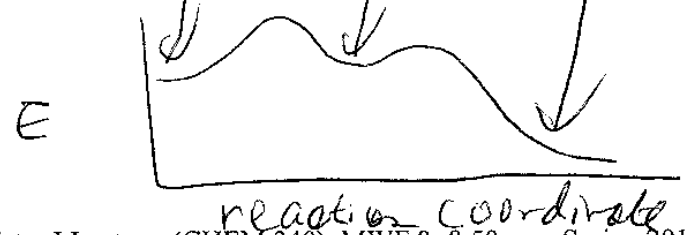


enantiomer (6 pts)

2. (a) Show the reaction mechanism of the Electrophilic Addition of H Br to the following alkene. You must show the intermediate, you do not need to show transition states, you must show electron pushing arrows and any charges on any molecule which you draw as a part of the reaction mechanism. (7 pts) (total 17 pts)

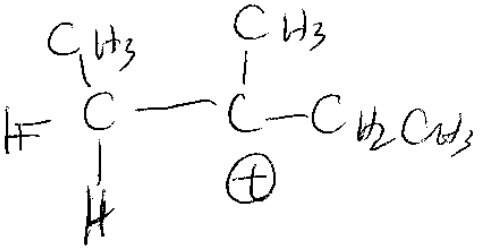


(b) Show the energy diagram which corresponds to the reaction mechanism above. Label your energy diagram to match your reaction mechanism above. (3 pts)



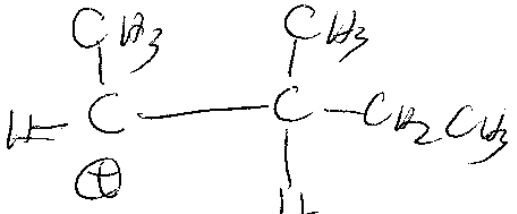
(c) Draw the structural formula of the 2 possible carbocation intermediates. (4 pts)

Markovnikov



①

anti markovnikov



②

(d) Give any of the definitions of Markovnikov's Rule for regioselectivity of the electrophilic addition of H Br to the alkene **mentioning carbocation stability**. (3 pts)

This is a 3° carbocation (tertiary). #2 is a secondary carbocation. Carbocation stability

most stable

$3^{\circ} > 2^{\circ} > 1^{\circ}$ methyl

So #① has a more stable carbocation.

"E" addition goes by most stable carbocation.

Exam II Organic Chemistry I CHEM 340 Spring 16 3/30 W Dr. Hahn MWF 8 am Exam# _____

Sign Name _____ Print Name _____
(2 pt name above print & sign, 2 pts scantron name) (100 pts, 11 pages + periodic table+ scantron sheet)

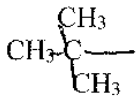
Please show work on all questions for partial credit even on questions which do not specify. Please write legibly. If I cannot read your answer, I cannot grade your answer. (use back of exam for scratch paper – If you want me to grade something not in the space for the answer, clearly specify in writing. Telling me during the exam where to find the answer does not qualify because I will just vaguely remember someone telling me something during the exam not which one of 200 students told me what to grade on what page of the exam.)

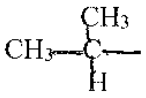
Please READ and FOLLOW directions. (ex: don't give me 5 structures if I only ask for one or you will lose points on this exam by **RUNNING OUT OF TIME**)

Circle answer on this form for backup to the scantron for the multiple choice. R=alkyl, not hydrogen on all parts of this exam.

I. Multiple Choice (3 pts each, 27 pts) Choose the **one** best statement in each question.

1. Choose best statement.

(a) This is isopropyl 

(b) This is t-butyl 

(c) In naming cycloalkanes, if the number of carbons in the alkanes is less than or equal to the number of carbons in the ring, the name is alkyl cycloalkane.

(d) All above statements are true.

2. Choose the best statement.

(a) In general branched alkanes have higher BP/MP than normal alkanes because of the effect of van der Waals effect, surface area and effective packing.

(b) Larger molecule have smaller van der Waals effect because of greater surface area for van der Waals intermolecular interactions.

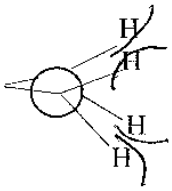
(c) In general for solubilities, "like dissolves like". This is why alkanes are soluble in other alkanes but why alkanes are insoluble in water.

(d) All above statements are true.

3. Choose the one best statement.

(a) In cycloalkanes, angle strain is due to compression of the tetrahedral angle (109.5° angle required for an sp^3 hybridized carbon) to fit the angle of a cycloalkanes. So cyclopropane has an especially high angle strain because of the 60° angle required for a cyclopropane structure.

(b) The following shows angle strain in **cyclolpropane**.



(c) The following shows a **cyclopentane**, more stable than flat molecule envelope structure.

(d) A **cyclohexane** boat is more stable than a cyclohexane chair.

(e) (a) and (c) are true.

4. Choose the best statement.

(a) Stereoisomers are isomers which have atoms connected in a different order. (different connectivity)

(b) Structural isomers are isomers with the same connectivity but arranged differently in space.

(c) Enantiomers are a kind of stereoisomer which are NOT mirror images of each other.

(d) Diastereomers are stereoisomers that are not mirror images and include cis/trans isomers and diastereomers with more than one chiral center.

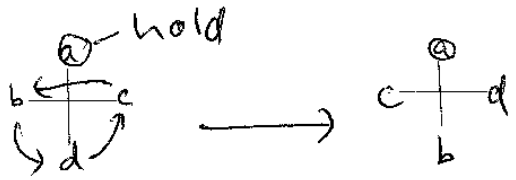
(e) All statements above are true.

5. Choose the best statement.

(a) In a Fisher Projection formula (which is not drawn as a 3D structure) , the horizontal bonds comes out towards the front from the plane of the paper and the vertical bonds go away towards the back from the plane of the paper.

(b) A Fisher Projection rotated 90° in the plane, gives the same molecule while a 180° rotation gives the enantiomer molecule.

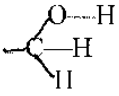
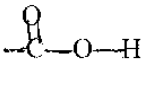
(c) A Fisher Projection in which you hold one of the 4 groups and rotates the other 3 results in an enantiomer



(d) A Fisher Projection in which you exchange just 2 of the groups results in the same molecule.

(e) All statements above are true.

6 By Cahn-Ingold –Prelog nomenclature priority for the following is:

(1) –Cl (2) –O–H (3)  (4) 

(a) (1) > (2) > (3) > (4)

(b) (1) > (4) > (3) > (2)

(c) (2) > (1) > (4) > (3)

(d) The priority shown are all wrong.

7. Choose the best statement.

(a) A molecule with a chiral center is optically active. A pair of enantiomers with a single chiral center have the same physical properties except for optical activity.

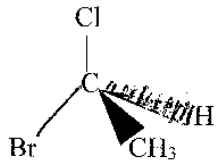
(b) A meso compound is not optically active and has an internal mirror plane.

(c) A racemic mixture which is a 50:50 mix of 2 enantiomers is not optically active and has different physical properties than either enantiomer.

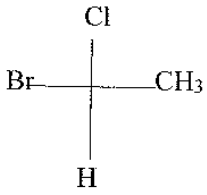
(d) A diastereomer with more than one chiral center is optically active a pair of diasteromers have different physical properties.

(e) All above statements are true.

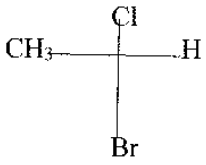
8. Which of the following are the same molecule as the molecule shown in 3D.



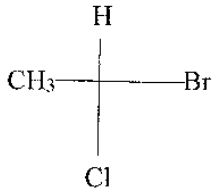
(a)



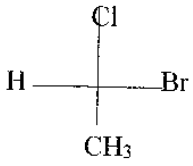
(b)



(c)

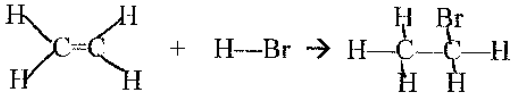


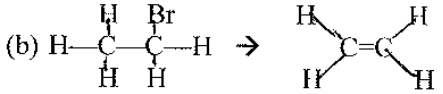
(d)

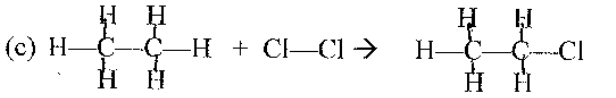


(e) All of the above are the same molecule as the original molecule.

9 Choose the one best statement.

(a)  is an elimination reaction

(b)  is an addition reaction

(c)  is a substitution reaction.

(d) (a) and (b) are true

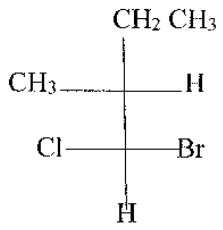
(e) (b) and (c) are true

II. Short Answers (44 pts)

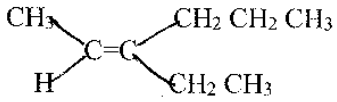
A. Nomenclature: (2 pts each, 6 pts)

1. Given the structural formula shown below, give the IUPAC name of the molecule.

a. Name of molecule _____



b. Name of molecule _____



2. Given the following IUPAC name, draw a structural formula of the molecule (skeletal formula acceptable, condensed structure, Lewis Dot structure acceptable, molecular formula not acceptable - don't forget to **show the hydrogens** in your formula unless you are using the skeletal structure.)

E-2-bromo-3,4-dimethylhept-2-ene

B. Reactions Part of Short Answers: (2 pts per reaction, 6 pts total)

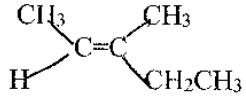
Given the following, what is the expected organic product ? Reactions do NOT need to be balanced.

1) $CH_3{-}CH_3 + O_2 \rightarrow$

(for this reaction, product is not organic so show all products)

2) $CH_3{-}CH_2{-}CH_3 + Br_2 \rightarrow$

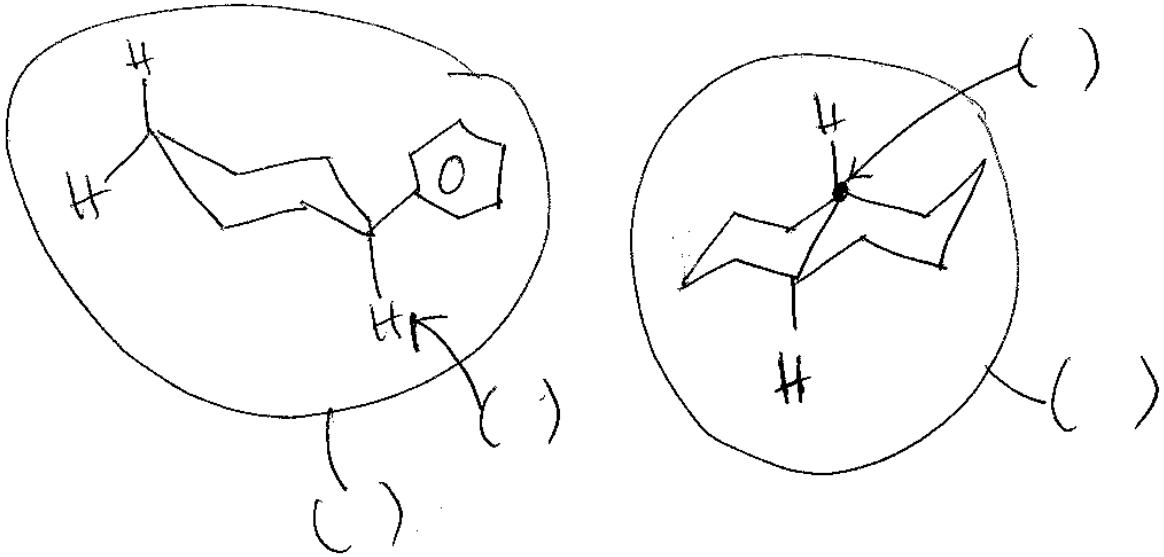
give ALL monohalogenation products

3)  + H—Cl →

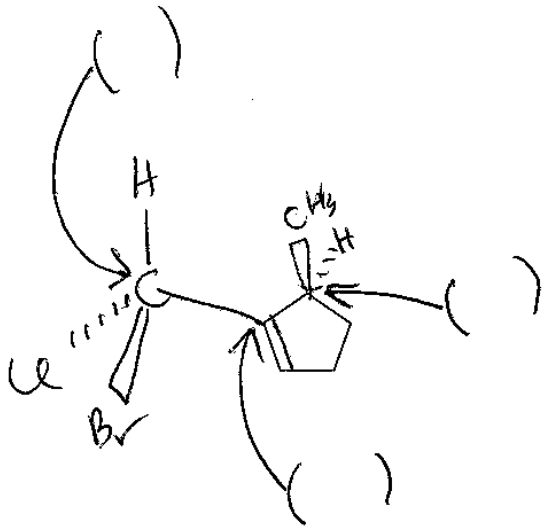
C. Short Answers Part of Short Answers (32 pts)

1. In the following diagram, fill in the blanks with the given letters. (2 pts each, 8 pts)

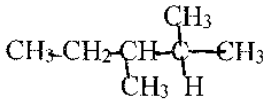
(A) Axial hydrogen (B) equatorial hydrogen (C) trans relationship (D) more stable form of chair (E) bridgehead carbons (F) trans decalin (G) cis decalin



2. In the molecule shown below, fill in the parenthesis with either (A) chiral center (B) not a chiral center (3 pts each, 9 pts)



3. For the following molecule, draw the most stable and most unstable Newman projection formula from the 2 in front towards the 3 carbon in the back.(3 pts each, 6 pts)

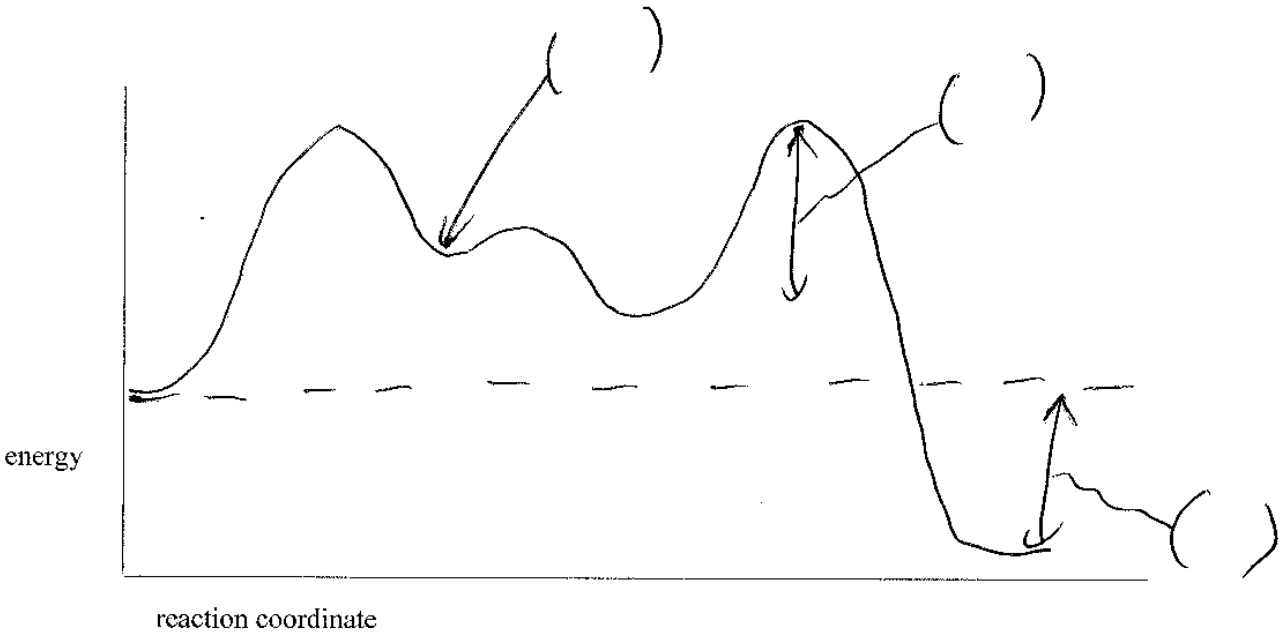


most stable (3 pts)

most unstable (3 pts)

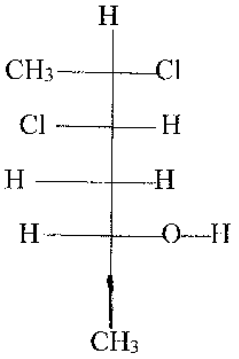
4. Given the following energy diagram, label by filling in the blank parenthesis with one of the following letters. (only one letter per blank) (3 pts each, 9 pts)

(A) reactant (B) product (C) transition state (D) intermediate (E) activation energy E_a or $\Delta G^{\ddagger}$ (F) ΔG^{o}



Part III. Long Answers (29 pts) Show work. Note that you earn partial credit for "attempt". "Attempt" is defined as not just rewriting the question but doing something towards getting the final answer.

1. For the following molecule written as a Fisher Projection Formula, draw a diastereomer and an enantiomer (12 pts total)

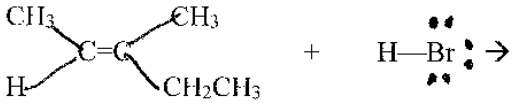


original molecule

diastereomer (6 pts)

enantiomer (6 pts)

2. (a) Show the reaction mechanism of the Electrophilic Addition of H Br to the following alkene. You must show the intermediate, you do not need to show transition states, you must show electron pushing arrows and any charges on any molecule which you draw as a part of the reaction mechanism. (7 pts) (total 17 pts)



(b) Show the energy diagram which corresponds to the reaction mechanism above. Label your energy diagram to match your reaction mechanism above. (3 pts)

(c) Draw the structural formula of the 2 possible carbocation intermediates. (4 pts)

(d) Give any of the definitions of Markovnikov's Rule for regioselectivity of the electrophilic addition of H Br to the alkene **mentioning carbocation stability**. (3 pts)