

Sign Name \_\_\_\_\_ Print Name Key

Please show work for all questions for partial and full credit (except multiple choice questions) even on questions which do not specify work. Only answers which are clearly readable will be graded. If you write the answer other than in the intended space without clear indication of where, I will not grade it. (I am grading 250 x 10 page exams. by myself I am not going to spend 3 hours looking for your answer somewhere on the exam and I am not going to contact 250 people to tell me what they meant to write if I can't clearly read what you wrote. No Points for erased answers which are still somewhat visible. No points for errors going from the exam to the scantron. No Points for anything other than normal organic chemistry formulas showing enough information to answer the question. (2 pts print & sign name)

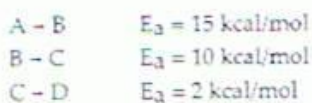
(total number of pages of the exam = 9 pages + periodic table + scantron Check number of pages. If you turn in less than 10 pages, it is your own responsibility for not completing the exam.)

Part I Multiple Choice (2 pts each, 26 pts total) Fill in your answer on the hardcopy of the exam as backup for your scantron in case you erased so much that there is a computer error in grading.

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

- 1) A radical reaction mechanism is NA = not attempt 1) B  
 A) done so as to produce the more stable pair of ions NW = no work  
 B) homolytic BA = bad attempt  
 C) via hydrogenation  
 D) heterolytic RBA = real bad attempt  
 E) none of the above RRBA = real real BA
- 2) What synthetic goal is achieved by subjecting an alkene to an oxymercuration-demercuration sequence? 2) A  
 A) Markovnikov addition of H<sub>2</sub>O wherein skeletal rearrangement is prevented  
 B) Markovnikov addition of H<sub>2</sub>O wherein skeletal rearrangement is promoted  
 C) syn-hydroxylation  
 D) anti-Markovnikov addition of H<sub>2</sub>O wherein skeletal rearrangement is prevented  
 E) anti-Markovnikov addition of H<sub>2</sub>O wherein skeletal rearrangement is promoted
- 3) Which of the following statements correctly pertains to a pair of enantiomers? 3) D  
 A) They have different melting points.  
 B) They rotate the plane of polarized light by differing amounts and in opposite directions.  
 C) They have the same melting point, but they have different boiling points.  
 D) They rotate the plane of polarized light by exactly the same amount and in opposite directions.  
 E) They rotate the plane of polarized light by differing amounts and in the same direction.

4) Consider the three-step mechanism for the reaction of A through intermediates B and C to produce D shown below. 4) A



Which of the three steps is rate-limiting (slowest step)?

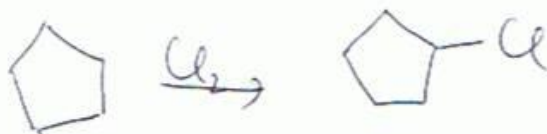
- A) The reaction of A to B.  
B) The reaction of B to C.  
C) The reaction of C to D.  
D) All three steps occur at the same rate; there is no rate-limiting step.  
E) You can't tell from the information given.
- 5) Which of the following intermediates is thought to occur in the mechanism by which alkenes are hydrated in the presence of acid? 5) A

- A) carbocation  
B) carbanion  
C) free radical  
D) carbene  
E) alkyne

- 6) For a given reaction, if  $\Delta G^\circ$  is greater than zero (positive), then: 6) C
- A) The reaction is going downhill in energy and will go to product.  
B) The reaction is going really fast.  
C) The reaction is going uphill in energy and will not go to product.  
D) All statements are true.  
E) All statements are false.

7) How many distinct monochlorinated products can result when cyclopentane is subjected to free radical chlorination? 7) A

- (A) 1                      B) 2                      C) 3                      D) 4                      E) 5



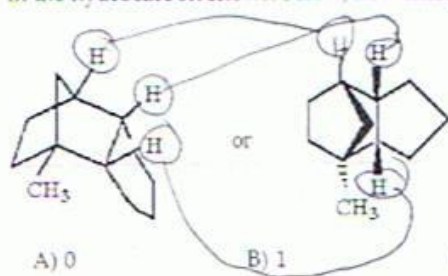
8) In the reaction of  $\text{Cl}_2$  with ethane and UV light, which of the following reactions would be a chain termination event(s)?

8) C

- I)  $\text{Cl}\cdot + \text{CH}_3\text{-CH}_3 \rightarrow \text{CH}_3\text{-CH}_2\text{-Cl} + \text{H}\cdot$
  - II)  $\text{Cl}\cdot + \text{CH}_3\text{-CH}_3 \rightarrow \text{CH}_3\text{-H}_2\text{C}\cdot + \text{HCl}$
  - III)  $\text{Cl}\cdot + \text{CH}_3\text{-H}_2\text{C}\cdot \rightarrow \text{CH}_3\text{-CH}_2\text{-Cl}$
  - IV)  $\text{Cl}_2 + \text{CH}_3\text{-H}_2\text{C}\cdot \rightarrow \text{CH}_3\text{-CH}_2\text{-Cl} + \text{Cl}\cdot$
  - V)  $\text{Cl}_2 + \text{UV light} \rightarrow \text{Cl}\cdot + \text{Cl}\cdot$
- A) reactions I and II  
 B) reaction V  
 C) reaction III  
 D) reactions I and IV  
 E) reactions III and IV

9) In the hydrocarbon shown below, how many tertiary hydrogens are present?

9) D



- A) 0      B) 1      C) 2       D) 3      E) 4

10) Which of the following is a carbene?

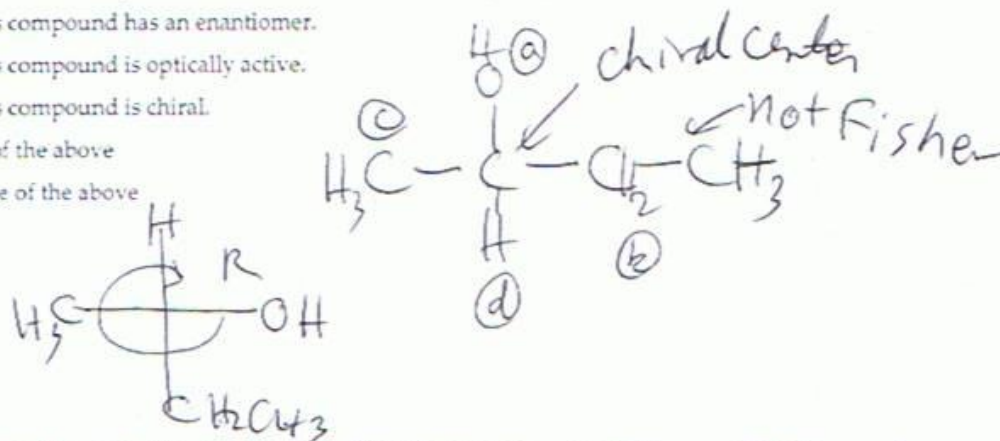
10) E

- A)  $\text{CH}_3\text{CH}_2\cdot$
- B)  $\text{CH}_2=\text{CHO}\cdot$
- C)  $\text{NCO}\cdot$
- D)  $\text{CH}_3\text{CH}_2$
- E)  $:\text{CCl}_2$

11) Which of the following statements is (are) true for the compound (R)-2-butanol?

11) D

- A) This compound has an enantiomer.
- B) This compound is optically active.
- C) This compound is chiral.
- D) All of the above
- E) none of the above



12) Which of the following best describes the geometry about the carbon-carbon double bond in the alkene below?

12) C



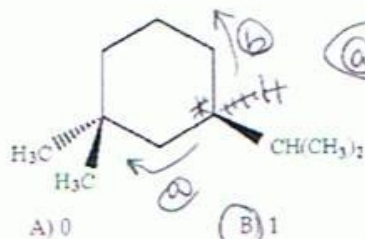
A) Z

B) E

C) neither E nor Z

13) How many asymmetric carbon atoms are present in the following compound?

13) B



A) 0

B) 1

C) 2

D) 3

E) 4

at least 2 same things

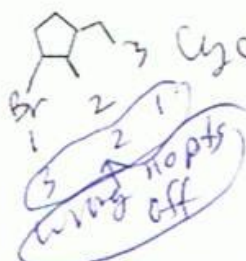
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Part II. Short Answers (40 pts)

A. Nomenclature: (2 pts each, 8 pts)

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

a. name 1-bromo-3-ethyl-2-methylcyclopentane



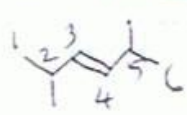
Cyclopentane

Cyclopentane

ethyl  
methyl

bromo

b. name E-2,5-dimethylhex-3-ene



hexene + ene

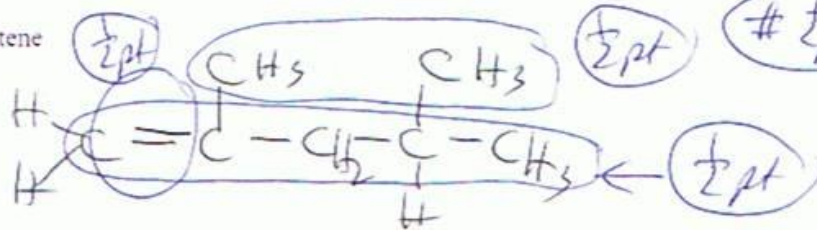
2-methyl

5-methyl

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.)

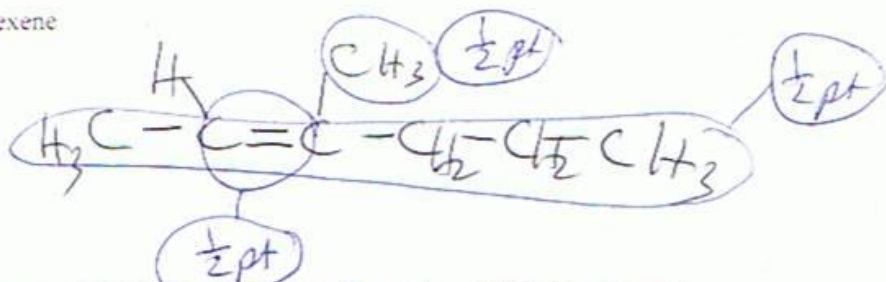
a. 2,4-dimethyl-1-pentene

few too many  
OK



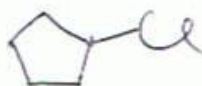
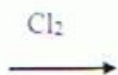
b. E-3-methyl-2-hexene

E or #  
- 1/2 pt



B. Reactions: Show the Organic Product in the following reactions by giving the structural formula of the product. (skeletal formula, condensed structure, Lewis Dot structure are all acceptable. Molecular Formula is not acceptable.) DO NOT SHOW MECHANISMS. (2 pts each, 10 pts)

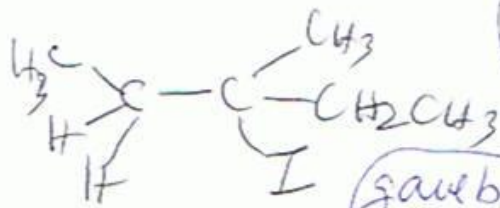
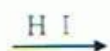
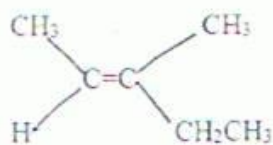
1



not mono  
-2

by (show all monochlorination products)

2

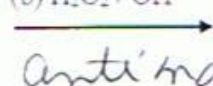
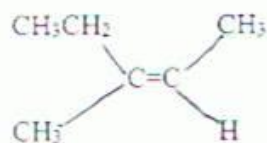


regio  
-1

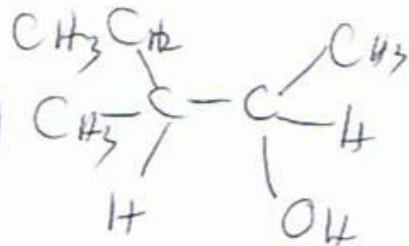
"mark"

gave both  
-1/2 pt

3

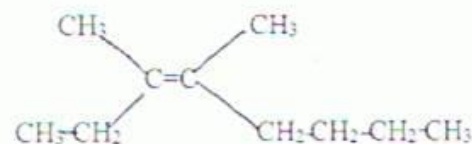


regio  
-1

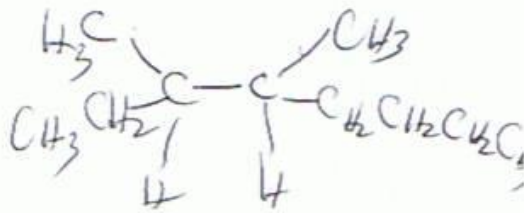


anti mark

4

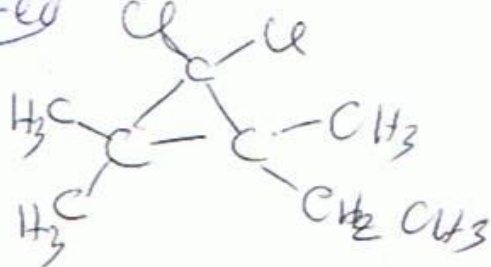
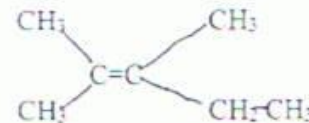


syn



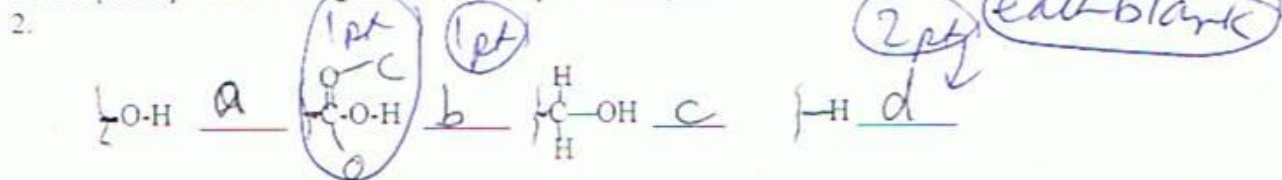
no pts  
off stereo

5

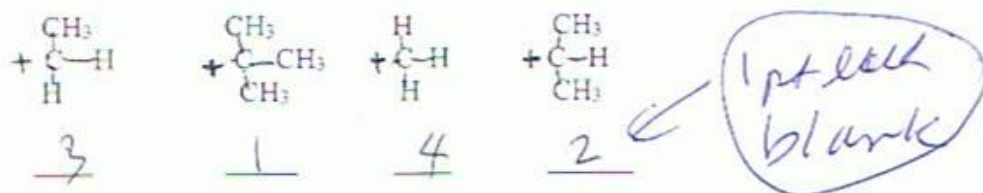


C. Short Answers (22 pts)

1. Given the following groups attached to a chiral carbon, put in order of (a) highest priority to (d) lowest priority. Show all "ghost" atoms. (2 pts each, 8 pts)



3. Given the following carbocations, label from most stable to least stable by filling in the blank below the molecule with the number (1) for most stable to (4) for least stable (1 pt each, 4 pts)



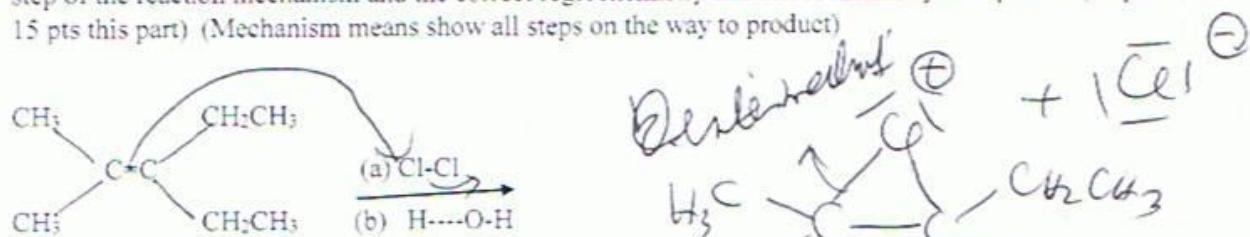
4. Given the following energy diagram, (2 pt each, total 10 pts)



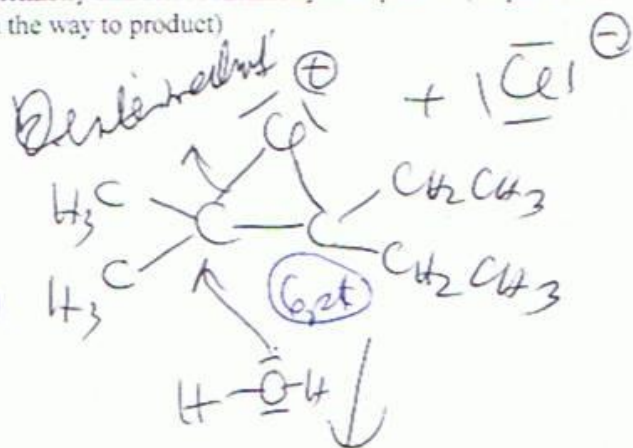
- a) How many steps is in the reaction mechanism shown [(1), (2), (3), (4)] (circle one)
- b) Which of the steps is the slowest step [(1<sup>st</sup> step) (2<sup>nd</sup> step) (3<sup>rd</sup> step)] (circle one) (note: just because I gave 3 potential steps does not necessarily mean that there are actually 3 steps – it could be less)
- c) How many intermediates? [(1), (2), (3), (4)] (circle one)
- d) How many transition states [(1), (2), (3)] (circle one)
- e) Is the reaction energetically favored to go forward to product? [(yes) (no)] (circle one)

Part III. Long Answers (34 pts) Show all work for partial and full credit.

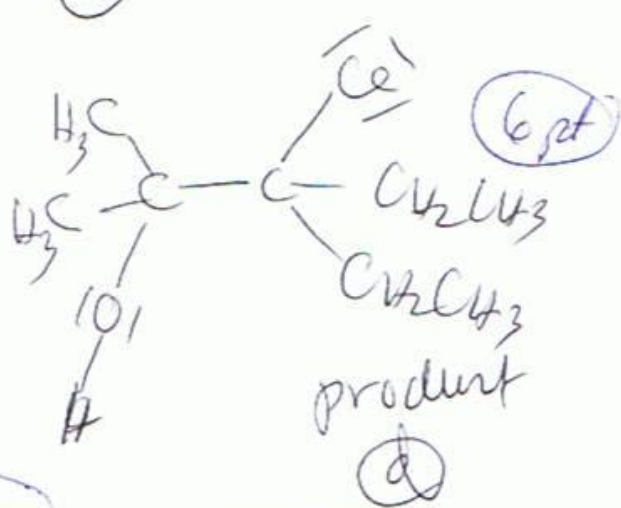
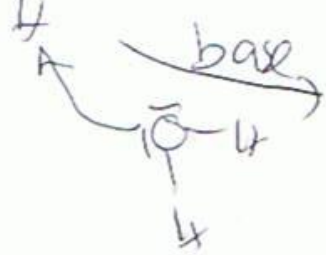
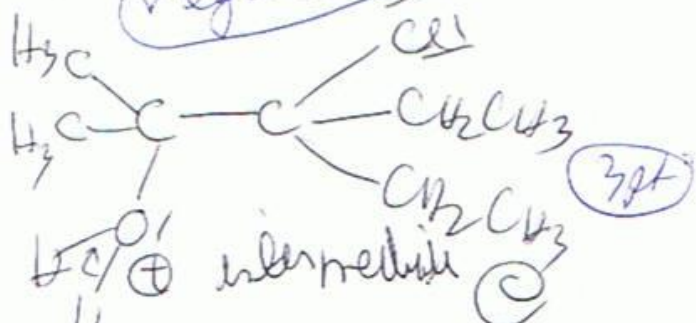
1. a. Complete the following reaction mechanism. Show all intermediates but not the transition state structures. Show electron pushing arrows and completely drawn Lewis Dot (or Kekule) structures for each step of the reaction mechanism and the correct regiochemistry and stereochemistry if required. (20 pts total, 15 pts this part) (Mechanism means show all steps on the way to product)



reactant @



regio marks off



attempt each step 1/2 pts

treated as 2 different rxn - 5

extra intermediate - 3

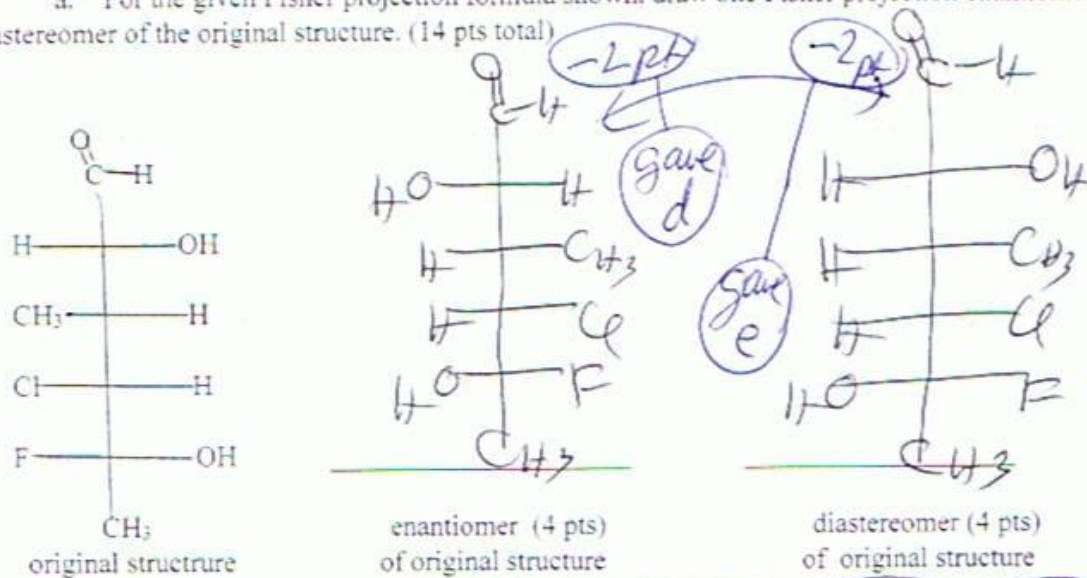
BA - 8pt  
 RBA - 10pt  
 RRBA - 11pt



b Draw an energy diagram which matches your reaction mechanism showing all intermediates in your mechanism above. Label reactants, products, all intermediates above in your mechanism with the letters (a), (b), (c), ... etc. and then label your energy diagram. Guess at probable relative energies because obviously you can't have an accurate idea of relative energies in your energy diagram without doing an experiment. (5 pts)

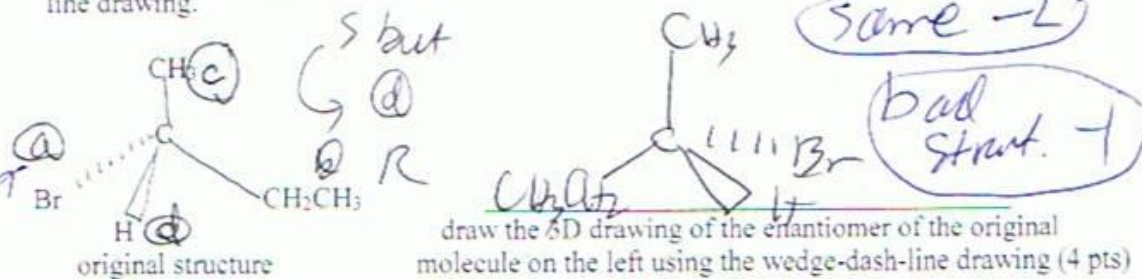


2. a. For the given Fischer projection formula shown, draw one Fischer projection enantiomer & diastereomer of the original structure. (14 pts total)



~~Structural isomer - 4 pts ok~~

b. Given the following 3D structure, draw an enantiomer of the original structure using a wedge-dash-line drawing.



The original molecule (not the enantiomer) has orientation [(R) or (S)] circle one. (2 pts)

~~Work OK wrong here - 1 pt~~

Sign Name \_\_\_\_\_ Print Name Kelly Color \_\_\_\_\_

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**MULTIPLE CHOICE.** Choose the one alternative that best completes the statement or answers the question.

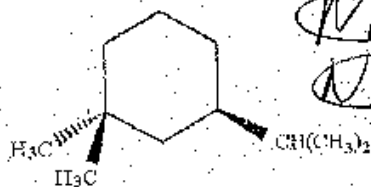
1) What synthetic goal is achieved by subjecting an alkene to an oxymercuration–demercuration sequence? 1) A

- A) Markovnikov addition of H<sub>2</sub>O wherein skeletal rearrangement is prevented.
- B) Markovnikov addition of H<sub>2</sub>O wherein skeletal rearrangement is promoted.
- C) syn-hydroxylation
- D) anti-Markovnikov addition of H<sub>2</sub>O wherein skeletal rearrangement is prevented.
- E) anti-Markovnikov addition of H<sub>2</sub>O wherein skeletal rearrangement is promoted.

2) How many distinct monochlorinated products can result when cyclopentane is subjected to free radical chlorination? 2) A

- A) 1
- B) 2
- C) 3
- D) 4
- E) 5

3) How many asymmetric carbon atoms are present in the following compound? 3) B



- A) 0
- B) 1
- C) 2
- D) 3
- E) 4

NA = not attempted  
NW = no work

BA = bad attempt  
RBA = real bad attempt  
RRBA = real real BA

4) In the reaction of  $\text{Cl}_2$  with ethane and UV light, which of the following reactions would be a chain termination event(s)?

4) C

- I)  $\text{Cl}^\bullet + \text{CH}_3\text{-CH}_3 \rightarrow \text{CH}_3\text{-CH}_2\text{-Cl} + \text{H}^\bullet$
- II)  $\text{Cl}^\bullet + \text{CH}_3\text{-CH}_3 \rightarrow \text{CH}_3\text{-CH}_2\text{-Cl} + \text{HCl}$
- III)  $\text{Cl}^\bullet + \text{CH}_3\text{-H}_2\text{C}^\bullet \rightarrow \text{CH}_3\text{-CH}_2\text{-Cl}$
- IV)  $\text{Cl}_2 + \text{CH}_3\text{-H}_2\text{C}^\bullet \rightarrow \text{CH}_3\text{-CH}_2\text{-Cl} + \text{Cl}^\bullet$
- V)  $\text{Cl}_2 + \text{UV light} \rightarrow \text{Cl}^\bullet + \text{Cl}^\bullet$

- A) reactions I and II
- B) reaction V
- C) reaction III
- D) reactions I and IV
- E) reactions III and IV

5) Which of the following statements is (are) true for the compound (*R*)-2-butanol?

5) D

- A) This compound has an enantiomer.
- B) This compound is optically active.
- C) This compound is chiral.
- D) all of the above
- E) none of the above

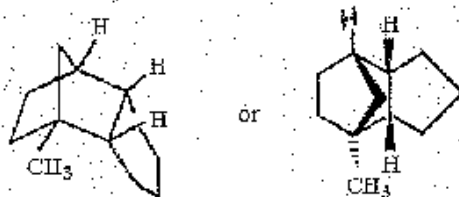
6) For a given reaction, if  $\Delta G^\circ$  is greater than zero (positive), then:

6) C

- A) The reaction is going downhill in energy and will go to product.
- B) The reaction is going really fast.
- C) The reaction is going uphill in energy and will not go to product.
- D) All statements are true.
- E) All statements are false.

7) In the hydrocarbon shown below, how many tertiary hydrogens are present?

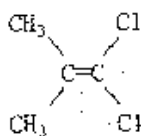
7) D



- A) 0
- B) 1
- C) 2
- D) 3
- E) 4

8) Which of the following best describes the geometry about the carbon-carbon double bond in the alkene below?

8) C



A) Z

B) E

C) neither E nor Z

9) Which of the following is a carbene?

9) E

A) CH<sub>3</sub>CH<sub>2</sub><sup>+</sup>

B) CH<sub>2</sub>=CHO<sup>-</sup>

C) NCO<sup>-</sup>

D) CH<sub>3</sub>CH<sub>2</sub><sup>-</sup>

E) :CCl<sub>2</sub>

10) A radical reaction mechanism is:

10) B

A) done so as to produce the more stable pair of ions

B) homolytic

C) via hydrogenation

D) heterolytic

E) none of the above

11) Which of the following statements correctly pertains to a pair of enantiomers?

11) D

A) They have different melting points.

B) They rotate the plane of polarized light by differing amounts and in opposite directions.

C) They have the same melting point, but they have different boiling points.

D) They rotate the plane of polarized light by exactly the same amount and in opposite directions.

E) They rotate the plane of polarized light by differing amounts and in the same direction.

12) Which of the following intermediates is thought to occur in the mechanism by which alkenes are hydrated in the presence of acid?

12) A

A) carbocation

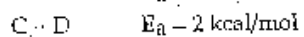
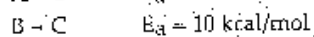
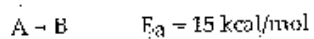
B) carbanion

C) free radical

D) carbene

E) alkyne

13) Consider the three-step mechanism for the reaction of A through intermediates B and C to produce D shown below. 13) A



Which of the three steps is rate-limiting (slowest step)?

- A) The reaction of A to B.  
 B) The reaction of B to C.  
 C) The reaction of C to D.  
 D) All three steps occur at the same rate; there is no rate-limiting step.  
 E) You can't tell from the information given.

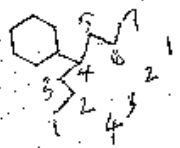
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Part II. Short Answers (40 pts)

A. Nomenclature: (2 pts each, 8 pts)

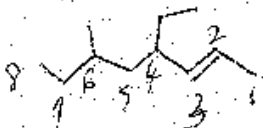
1. Given the structural formula shown below, give the IUPAC name of the molecule.

a. name 4-cyclohexylheptane



heptane  
cyclohexane yl

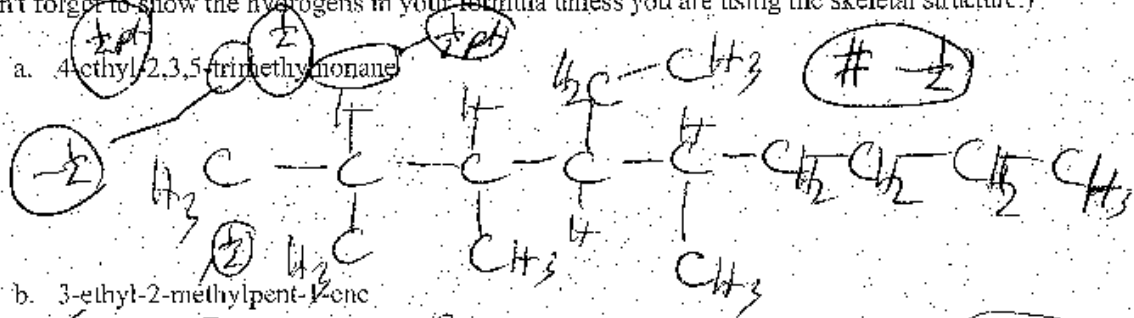
b. name E-4-ethyl-6-methyloct-2-ene



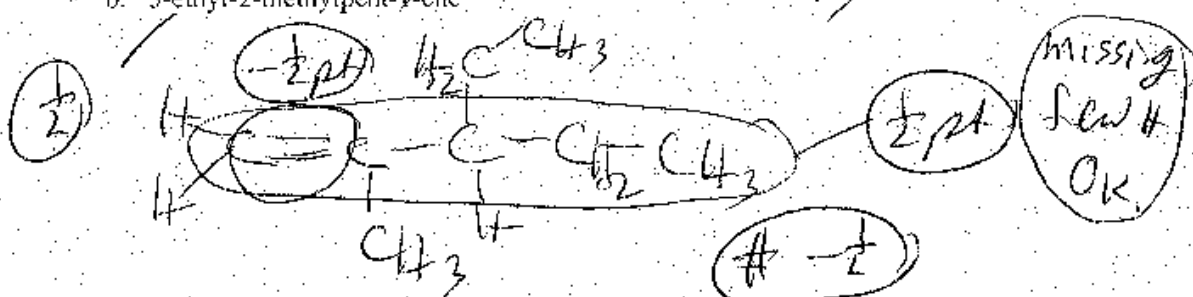
E-2-octene  
4-ethyl yl  
6-methyl yl

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.)

a. 4-ethyl-2,3,5-trimethylnonane

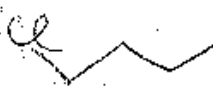
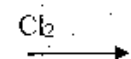
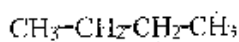


b. 3-ethyl-2-methylpent-1-ene

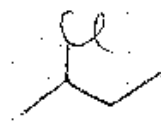


B. Reactions: Show the Organic Product in the following reactions by giving the structural formula of the product. (skeletal formula, condensed structure, Lewis Dot structure are all acceptable. Molecular Formula is not acceptable.) DO NOT SHOW MECHANISMS. (2 pts each, 10 pts)

1



hv (give all monohalogenation products)

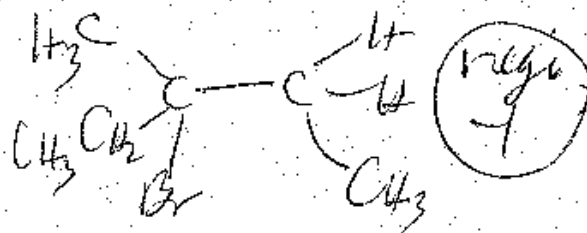
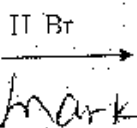
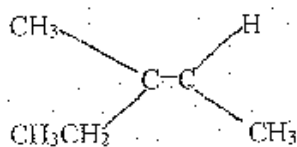


Gave Cl<sub>2</sub>-2

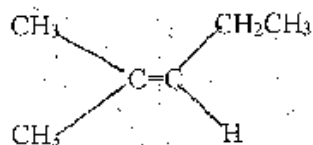
Let me 2

repeated molecule no pts off

2



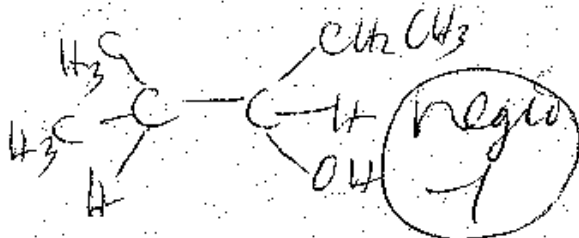
3



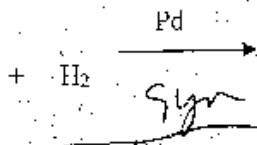
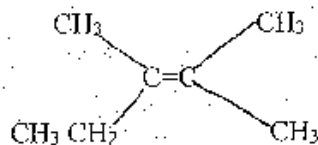
(a) THF:  $\text{BH}_3$

(b)  $\text{H}_2\text{O}_2$  / OH<sup>-</sup>

anti mark



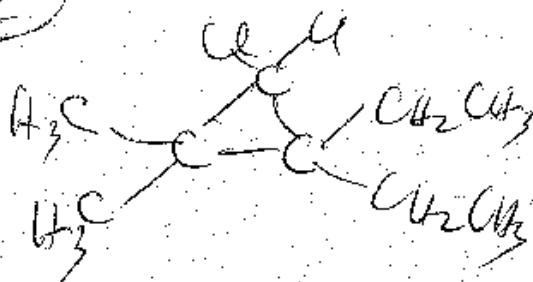
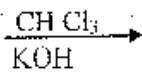
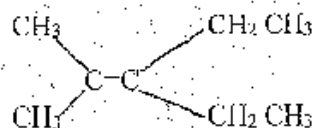
4



stereos no pts off

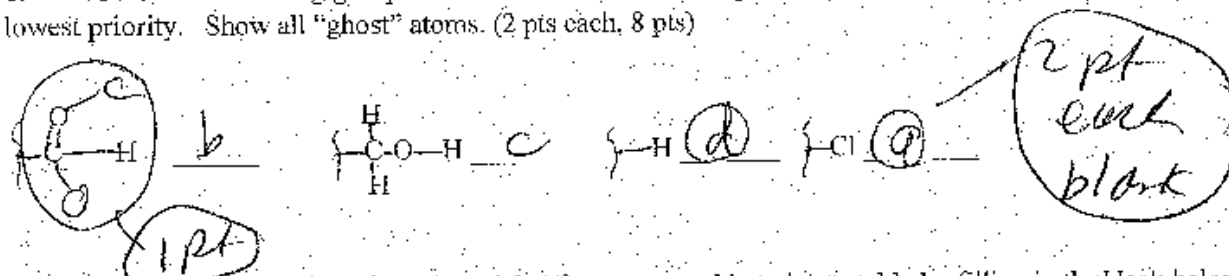


5

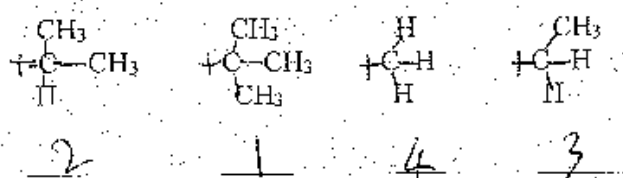


C. Short Answers (22 pts)

1. Given the following groups attached to a chiral carbon, put in order of (a) highest priority to (d) lowest priority. Show all "ghost" atoms. (2 pts each, 8 pts)

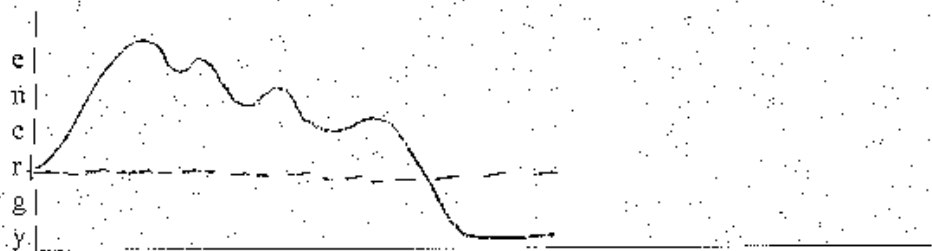


2. Given the following carbocations, label from most stable to least stable by filling in the blank below the molecule with the number (1) for most stable to (4) for least stable (1 pt each, 4 pts)



1 pt each blank

3. Given the following energy diagram, (2 pt each, total 10 pts)



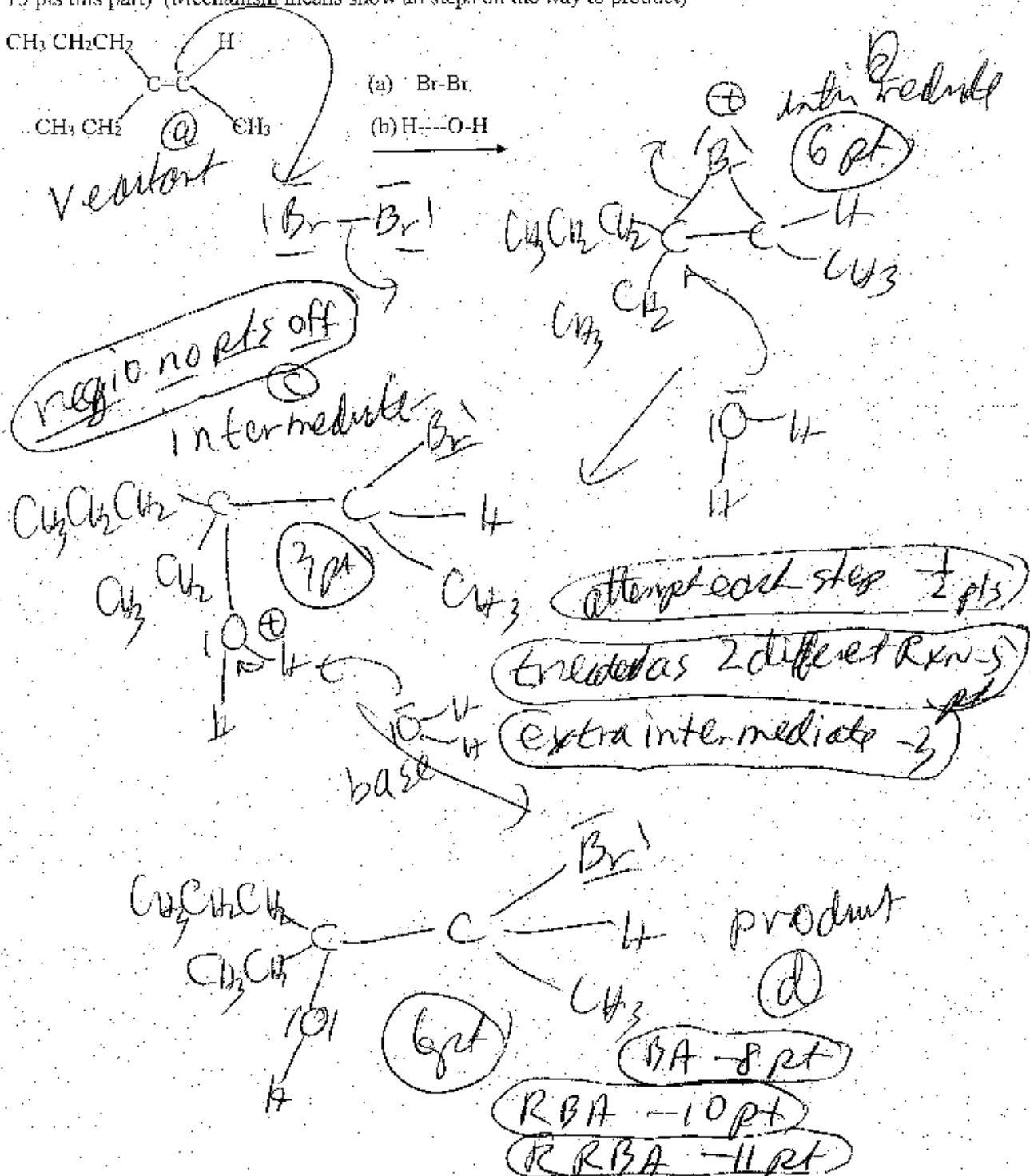
Reaction Progress

- a) How many steps is in the reaction mechanism shown [(1), (2), (3), (4)] (circle one)
- b) Which of the steps is the slowest step [(1<sup>st</sup> step), (2<sup>nd</sup> step), (3<sup>rd</sup> step)] (circle one) (note: just because I gave 3 potential steps does not necessarily mean that there are actually 3 steps – it could be less)
- c) How many intermediates? [(1), (2), (3), (4), (5)] (circle one)
- d) How many transition states [(1), (2), (3), (4), (5)] (circle one)
- e) Is the reaction energetically favored to go forward to product? [(yes), (no)] (circle one)

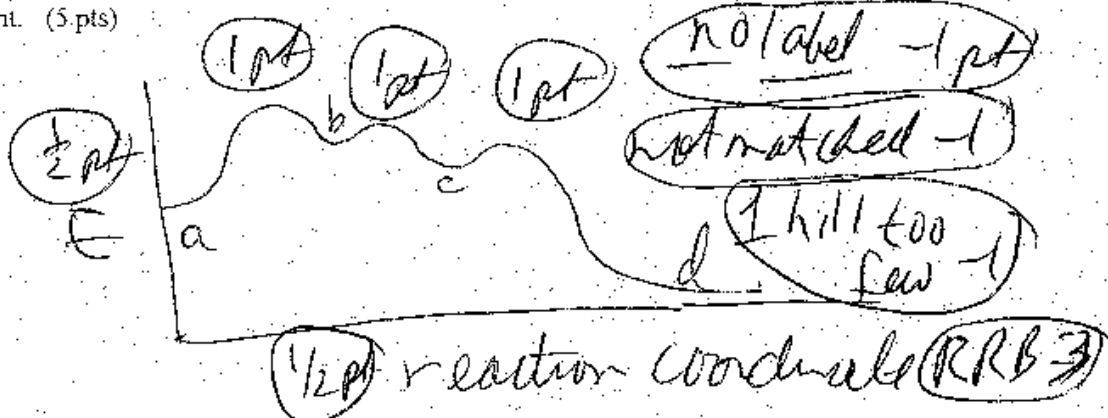


Part III. Long Answers (34 pts) Show all work for partial and full credit.

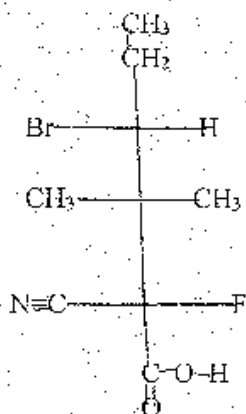
1. a. Complete the following reaction mechanism. Show all intermediates but not the transition state structures. Show electron pushing arrows and completely drawn Lewis Dot (or Kekule) structures for each step of the reaction mechanism and the correct regiochemistry and stereochemistry if required. (20 pts total, 15 pts this part) (Mechanism means show all steps on the way to product)



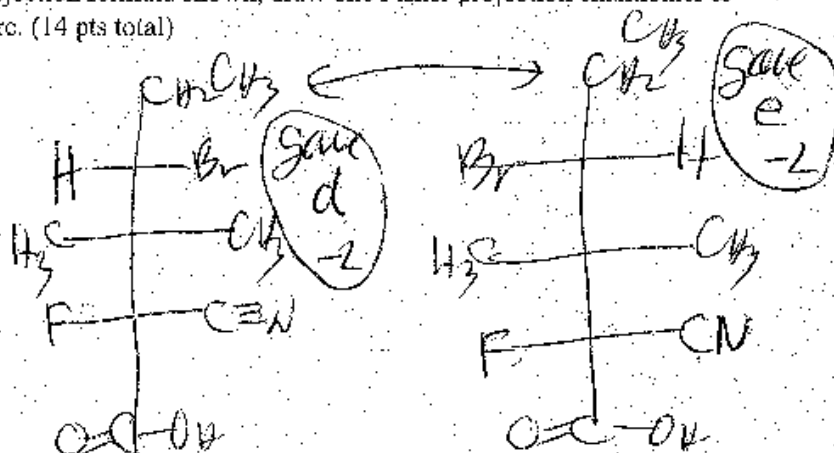
b. Draw an energy diagram which matches your reaction mechanism showing all intermediates in your mechanism above. Label reactants, products, all intermediates above in your mechanism with the letters (a), (b), (c), ... etc. and then label your energy diagram. Guess at probable relative energies because obviously you can't have an accurate idea of relative energies in your energy diagram without doing an experiment. (5 pts)



2. a. For the given Fischer projection formula shown, draw one Fischer projection enantiomer & diastereomer of the original structure. (14 pts total)



original structure

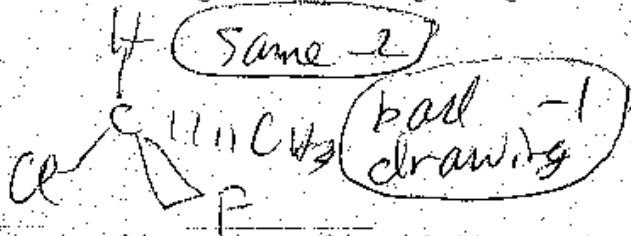
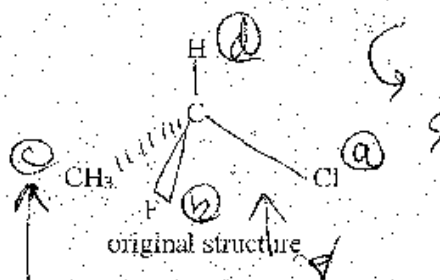


enantiomer (4 pts)  
of original structure

diastereomer (4 pts)  
of original structure

~~structural isomer - all pts off - 4 pt each~~

b. Given the following 3D structure, draw an enantiomer of the original structure using a wedge-dash-line drawing.



draw the 3D drawing of the enantiomer of the original molecule on the left using the wedge-dash-line drawing (4 pts)

The original molecule (not the enantiomer) has orientation [(R) or (S)] circle one. (2 pts)

~~work ok, wrong here -1 pt~~

Sign Name \_\_\_\_\_ Print Name Key

Please show work for all questions for partial and full credit (except multiple choice questions) even on questions which do not specify work. Only answers which are clearly readable will be graded. If you write the answer other than in the intended space without clear indication of where, I will not grade it. (I am grading 250 x 10 page exams. by myself I am not going to spend 3 hours looking for your answer somewhere on the exam and I am not going to contact 250 people to tell me what they meant to write if I can't clearly read what you wrote. No Points for erased answers which are still somewhat visible. No points for errors going from the exam to the scantron. No Points for anything other than normal organic chemistry formulas showing enough information to answer the question. (2 pts print & sign name)

(total number of pages of the exam = 9 pages + periodic table + scantron Check number of pages. If you turn in less than 10 pages, it is your own responsibility for not completing the exam.)

Part 1 Multiple Choice (2 pts each, 26 pts total) Fill in your answer on the hardcopy of the exam as backup for your scantron in case you erased so much that there is a computer error in grading.

**MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.**

1) How many distinct monochlorinated products can result when cyclopentane is subjected to free radical chlorination? 1) A

- A) 1                      B) 2                      C) 3                      D) 4                      E) 5

2) What synthetic goal is achieved by subjecting an alkene to an oxymercuration-demercuration sequence? 2) A

- A) Markovnikov addition of H<sub>2</sub>O wherein skeletal rearrangement is prevented  
 B) Markovnikov addition of H<sub>2</sub>O wherein skeletal rearrangement is promoted  
 C) syn-hydroxylation  
 D) anti-Markovnikov addition of H<sub>2</sub>O wherein skeletal rearrangement is prevented  
 E) anti-Markovnikov addition of H<sub>2</sub>O wherein skeletal rearrangement is promoted

3) Which of the following intermediates is thought to occur in the mechanism by which alkenes are hydrated in the presence of acid? 3) A

- A) carbocation  
 B) carbanion  
 C) free radical  
 D) carbene  
 E) alkyne

NA = not attempt

NW = no work

BA = bad attempt

RBA = real bad attempt

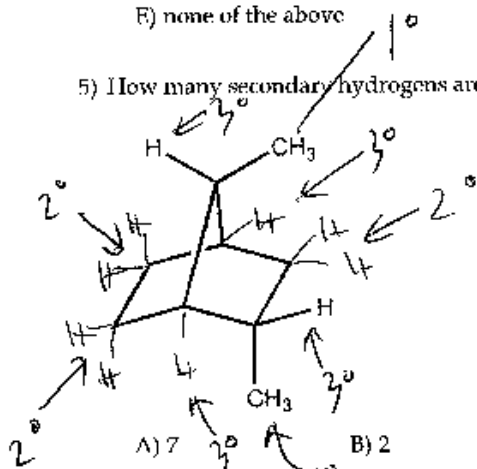
RRBA = real real bad attempt

4) A mixture of equal amounts of two enantiomers \_\_\_\_\_

- A) is optically inactive
- B) is called a racemic mixture
- C) implies that the enantiomers are meso forms
- D) both A and B
- E) none of the above

4) D

5) How many secondary hydrogens are present in the hydrocarbon below?



5) D

6) Which of the following is not a possible termination step in the free radical chlorination of methane?

- A)  $\bullet\text{CH}_3 + \bullet\text{Cl}_3 \rightarrow \text{CH}_3\text{CH}_3$
- B)  $\bullet\text{Cl}_3 + \text{Cl}\bullet \rightarrow \text{CH}_3\text{Cl}$
- C)  $\bullet\text{CH}_3 + \text{Cl}_2 \rightarrow \text{CH}_3\text{Cl} + \text{Cl}\bullet$
- D) None are termination steps.
- E) All shown steps are termination steps.

6) C

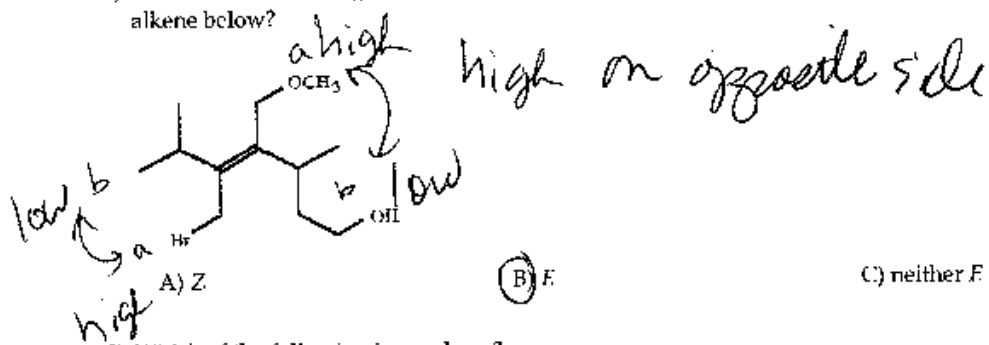
7) A radical reaction mechanism is:

- A) done so as to produce the more stable pair of ions
- B) homolytic
- C) via hydrogenation
- D) heterolytic
- E) none of the above

7) B

8) Which of the following best describes the geometry about the carbon-carbon double bond in the alkene below?

8) B



9) Which of the following is a carbene?

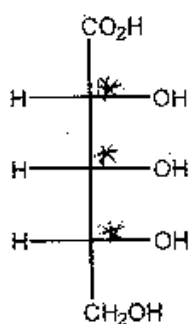
9) E

- A)  $\text{CH}_3\text{CH}_2^+$
- B)  $\text{CH}_2=\text{CHO}^-$
- C)  $\text{NCO}^-$
- D)  $\text{CH}_3\text{CH}_2$

E)  $\text{:CCl}_2$

10) How many diastereomers are there of the molecule shown below?

10) E



# chiral centers = 3 (marked with \*)

$$2^3 = 8$$

A) 3

B) 2

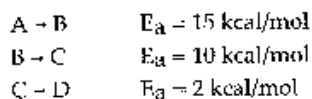
C) 0

D) 1

E) 6

types in test bank question

11) Consider the three-step mechanism for the reaction of A through intermediates B and C to produce D shown below. 11) A



Which of the three steps is rate-limiting slowest step?

- A) The reaction of A to B.
- B) The reaction of B to C.
- C) The reaction of C to D.
- D) All three steps occur at the same rate; there is no rate-limiting step.
- E) You can't tell from the information given.

12) Which of the following statements is (are) true for the compound (*R*)-2-butanol? 12) D

- A) This compound has an enantiomer.
- B) This compound is optically active.
- C) This compound is chiral.
- D) all of the above
- E) none of the above

13) For a given reaction, if  $\Delta G^\circ$  is greater than zero (positive), then: 13) C

- A) The reaction is going downhill in energy and will go to product.
- B) The reaction is going really fast.
- C) The reaction is going uphill in energy and will not go to product.
- D) All statements are true.
- E) All statements are false.

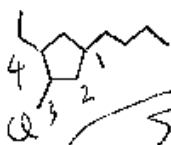
Please show work on all questions for partial credit even on questions which do not specify. Please write legibly. If I cannot read your answer, I cannot grade your answer. (use back of exam for scratch paper)

Part II. Short Answers (40 pts)

A. Nomenclature: (2 pts each, 8 pts)

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

a. name 1-butyl-3-chloro-4-ethylcyclopentane



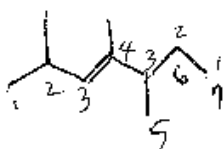
should # alphabetize

cyclopentane 3-chlorine

1-butyl  
4-ethyl

# 1/2 pt is # 10x

b. name E-2,4,5-trimethylhept-3-ene



hept-3-ene  
E-2,4,5-trimethyl

# 1/2 pt

1/2 pt

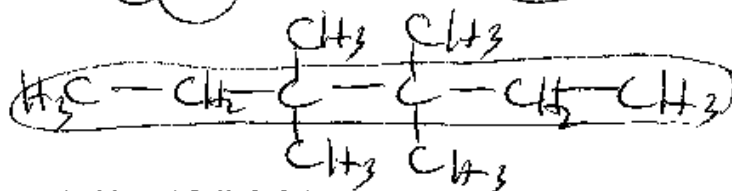
1/2 pt

1/2 pt

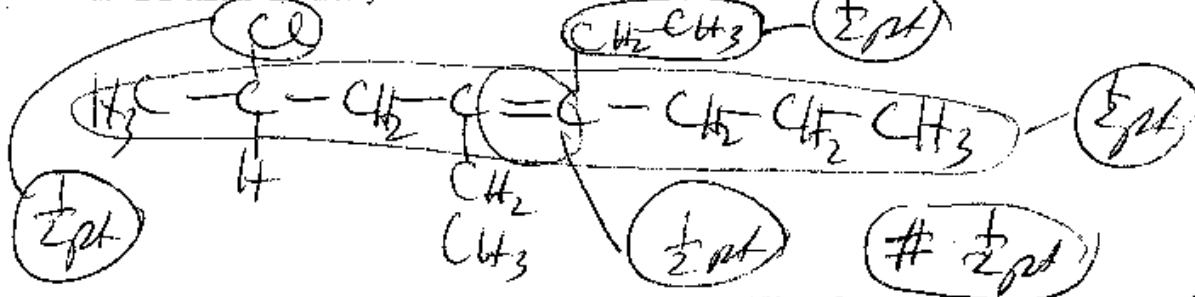
1/2 pt

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.)

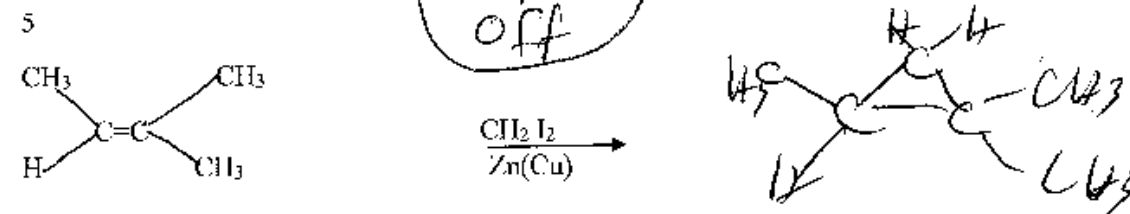
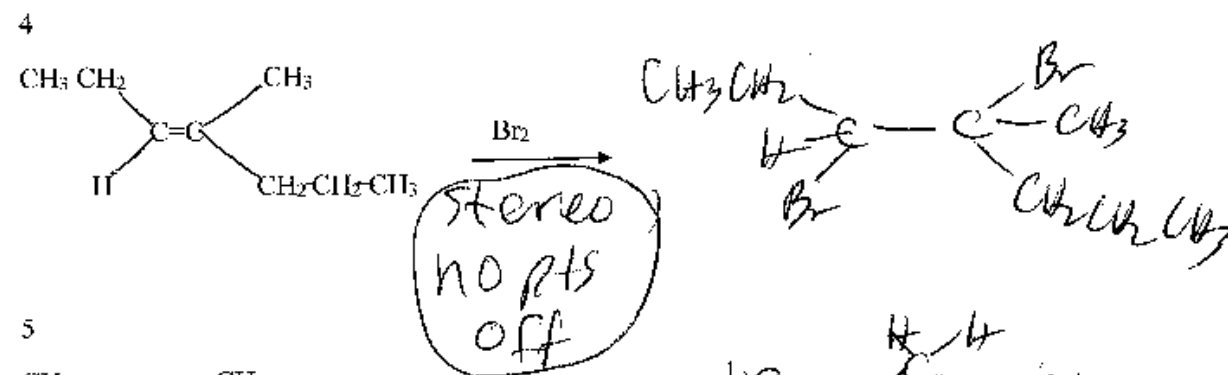
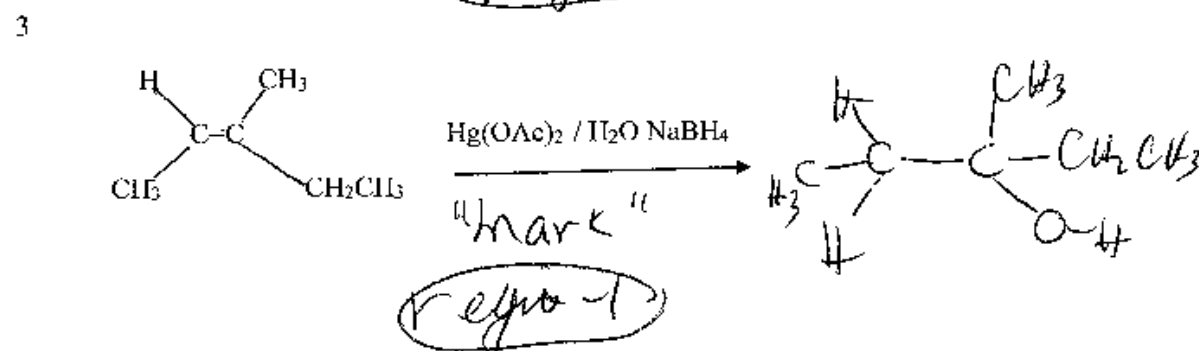
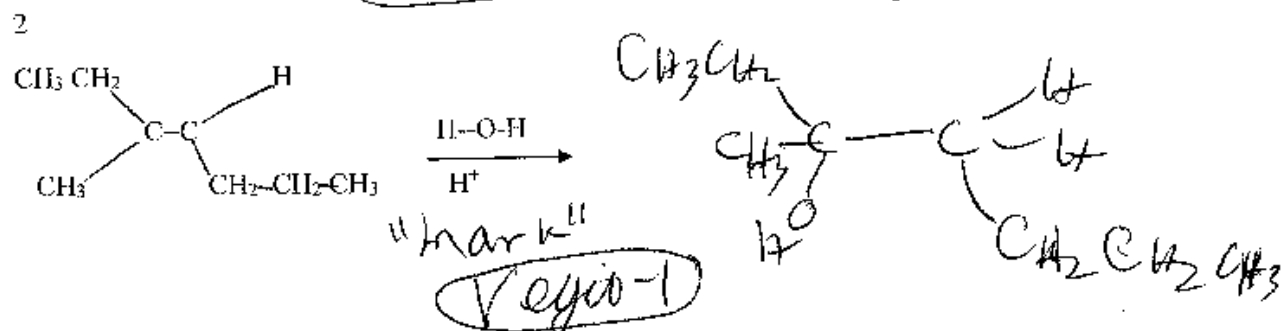
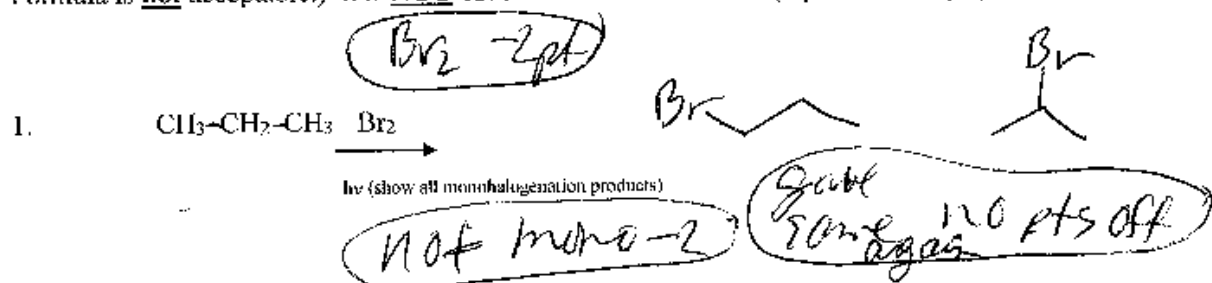
a. 3,3,4,4-tetramethylhexane



b. E-2-chloro-4,5-diethyl-4-octene



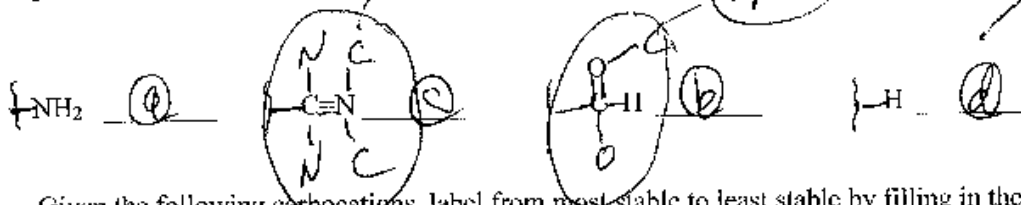
13. Reactions: Show the Organic Product in the following reactions by giving the structural formula of the product. (skeletal formula, condensed structure, Lewis Dot structure are all acceptable. Molecular Formula is not acceptable.) **DO NOT SHOW MECHANISMS.** (2 pts each, 10 pts)



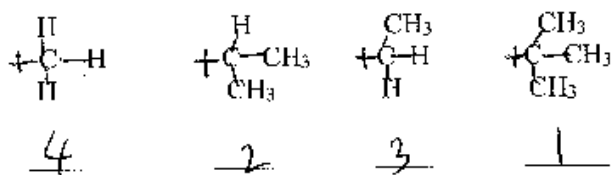


C. Short Answers (22 pts)

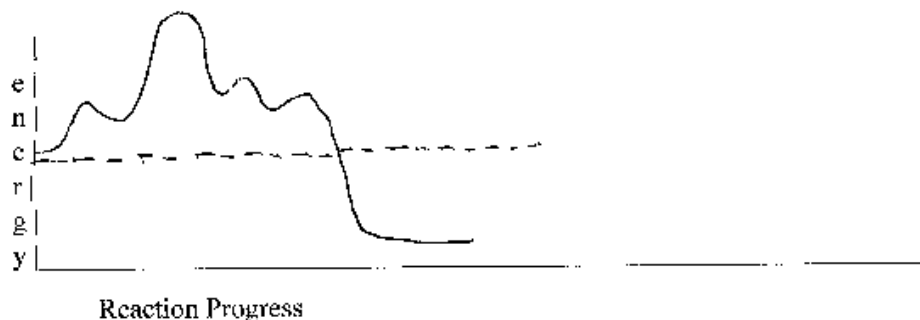
1. Given the following groups attached to a chiral carbon, put in order of (a) highest priority to (d) lowest priority. Show all "ghost" atoms. (2 pts each, 8 pts)



2. Given the following carbocations, label from most stable to least stable by filling in the blank below the molecule with the number **(1) for most stable** to **(4) for least stable** (1 pt each, 4 pts)



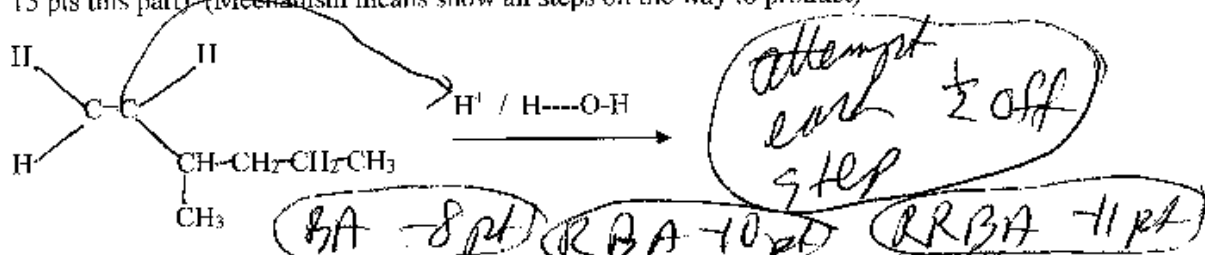
3. Given the following energy diagram, (2 pt each, total 10 pts)



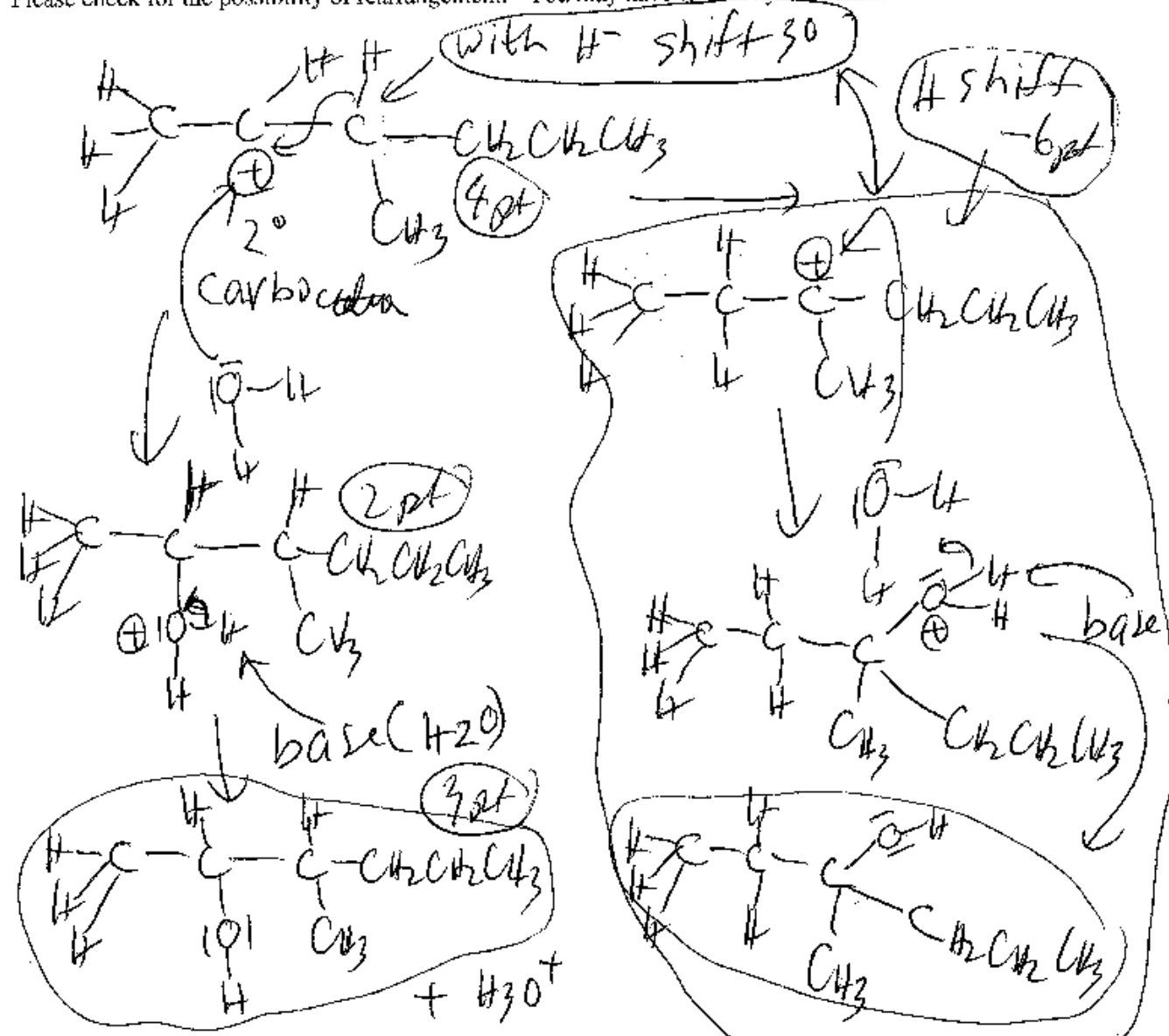
- a) How many steps is in the reaction mechanism shown [(1), (2), (3), (4)] (circle one)
- b) Which of the steps is the slowest step [(1<sup>st</sup> step), (2<sup>nd</sup> step), (3<sup>rd</sup> step)] (circle one) (note: just because I gave 3 potential steps does not necessarily mean that there are actually 3 steps - it could be less)
- c) How many intermediates? [(1), (2), (3), (4)] (circle one)
- d) How many transition states [(1), (2), (3), (4)] (circle one)
- e) Is the reaction energetically favored to go forward to product? [(yes), (no)] (circle one)

Part III. Long Answers (34 pts) Show all work for partial and full credit.

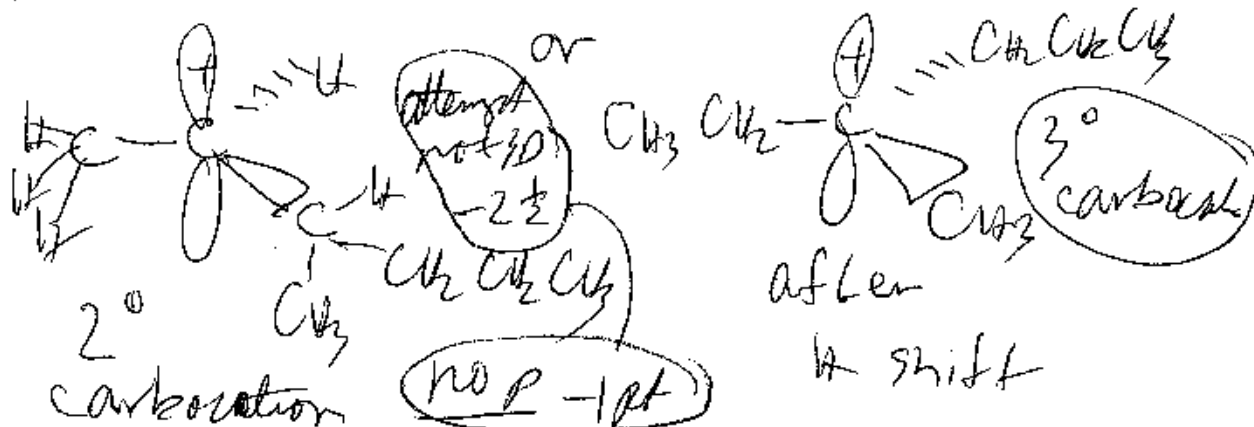
I. a. Complete the following reaction mechanism. Show all intermediates but not the transition state structures. Show electron pushing arrows and completely drawn Lewis Dot (or Kekule) structures for each step of the reaction mechanism and the correct regiochemistry and stereochemistry if required. (20 pts total, 15 pts this part) (Mechanism means show all steps on the way to product)



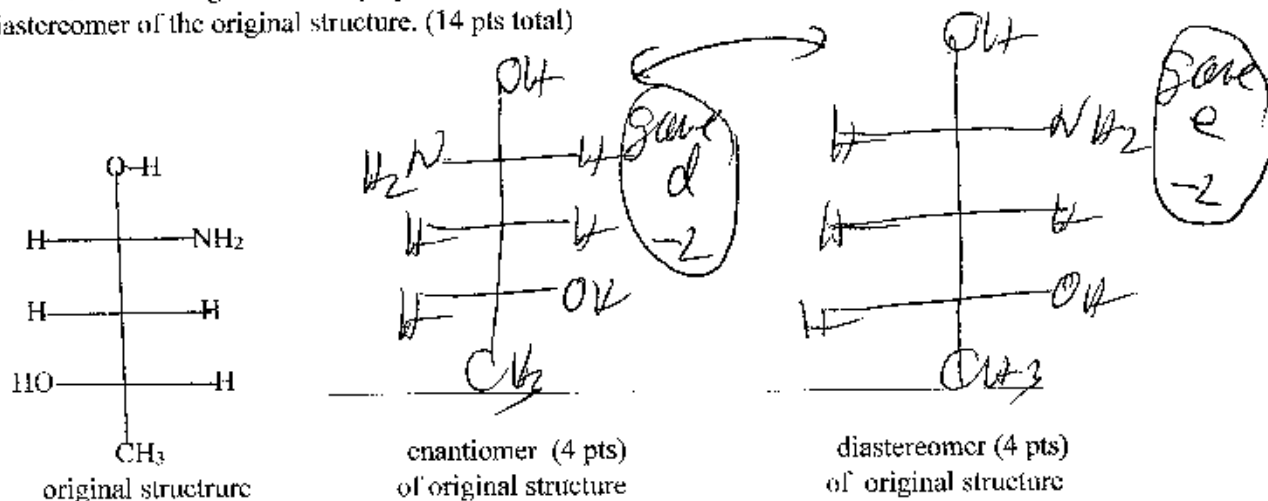
Please check for the possibility of rearrangement. You may have to do a hydride shift.



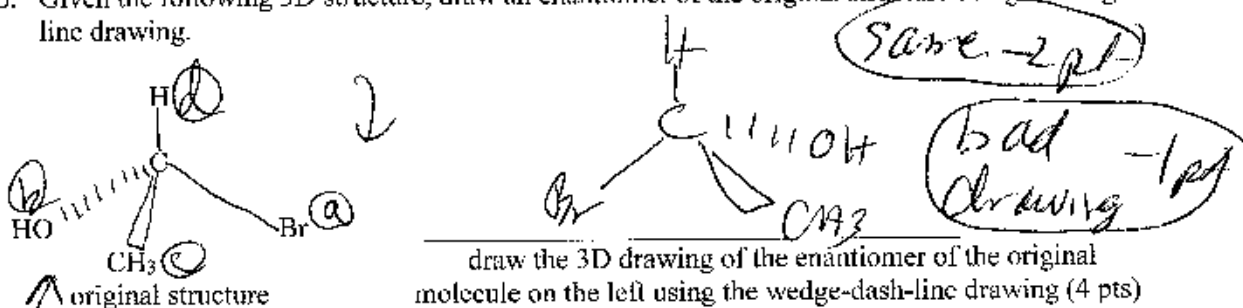
b Draw a 3D structure of the **first intermediate** above showing the + charge localized on the empty p orbital. (3D structure need only be on the carbocation) (5 pts)



3. a. For the given Fisher projection formula shown, draw one Fisher projection enantiomer & diastereomer of the original structure. (14 pts total)



b. Given the following 3D structure, draw an enantiomer of the original structure using a wedge-dash-line drawing.



The original molecule (not the enantiomer) has orientation [(R) or (S)] circle one. (2 pts)

Handwritten: "work OK but wrong" with a circled (R) and an arrow pointing to the original structure.

Sign Name \_\_\_\_\_ Print Name \_\_\_\_\_

Please show work for all questions for partial and full credit (except multiple choice questions) even on questions which do not specify work. Only answers which are clearly readable will be graded. If you write the answer other than in the intended space without clear indication of where, I will not grade it. (I am grading 250 x 10 page exams, by myself I am not going to spend 3 hours looking for your answer somewhere on the exam and I am not going to contact 250 people to tell me what they meant to write if I can't clearly read what you wrote. No Points for erased answers which are still somewhat visible. No points for errors going from the exam to the scantron. No Points for anything other than normal organic chemistry formulas showing enough information to answer the question. (2 pts print & sign name)

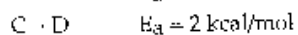
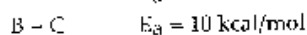
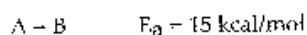
(total number of pages of the exam = 9 pages + periodic table + scantron Check number of pages. If you turn in less than 10 pages, it is your own responsibility for not completing the exam.)

Part I Multiple Choice (2 pts each, 26 pts total) Fill in your answer on the hardcopy of the exam as backup for your scantron in case you erased so much that there is a computer error in grading.

**MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.**

- 1) A radical reaction mechanism is: 1) \_\_\_\_\_
- A) done so as to produce the more stable pair of ions
  - B) homolytic
  - C) via hydrogenation
  - D) heterolytic
  - E) none of the above
- 2) What synthetic goal is achieved by subjecting an alkene to an oxymercuration-demercuration sequence? 2) \_\_\_\_\_
- A) Markovnikov addition of H<sub>2</sub>O wherein skeletal rearrangement is prevented
  - B) Markovnikov addition of H<sub>2</sub>O wherein skeletal rearrangement is promoted
  - C) syn-hydroxylation
  - D) anti-Markovnikov addition of H<sub>2</sub>O wherein skeletal rearrangement is prevented
  - E) anti-Markovnikov addition of H<sub>2</sub>O wherein skeletal rearrangement is promoted
- 3) Which of the following statements correctly pertains to a pair of enantiomers? 3) \_\_\_\_\_
- A) They have different melting points.
  - B) They rotate the plane of polarized light by differing amounts and in opposite directions.
  - C) They have the same melting point, but they have different boiling points.
  - D) They rotate the plane of polarized light by exactly the same amount and in opposite directions.
  - E) They rotate the plane of polarized light by differing amounts and in the same direction.

4) Consider the three-step mechanism for the reaction of A through intermediates B and C to produce D shown below. 4) \_\_\_\_\_



Which of the three steps is rate-limiting (slowest step)?

A) The reaction of A to B.

B) The reaction of B to C.

C) The reaction of C to D.

D) All three steps occur at the same rate; there is no rate-limiting step.

E) You can't tell from the information given.

5) Which of the following intermediates is thought to occur in the mechanism by which alkenes are hydrated in the presence of acid? 5) \_\_\_\_\_

A) carbocation

B) carbanion

C) free radical

D) carbene

E) alkyne

6) For a given reaction, if  $\Delta G^\circ$  is greater than zero (positive), then: 6) \_\_\_\_\_

A) The reaction is going downhill in energy and will go to product.

B) The reaction is going really fast.

C) The reaction is going uphill in energy and will not go to product.

D) All statements are true.

E) All statements are false.

7) How many distinct monochlorinated products can result when cyclopentane is subjected to free radical chlorination? 7) \_\_\_\_\_

A) 1

B) 2

C) 3

D) 4

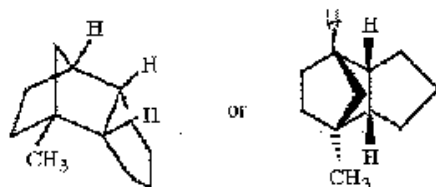
H) 5

8) In the reaction of  $\text{Cl}_2$  with ethane and UV light, which of the following reactions would be a chain termination event(s)? 8) \_\_\_\_\_

- I)  $\text{Cl}^\bullet + \text{CH}_3\text{-CH}_3 \rightarrow \text{CH}_3\text{-CH}_2\text{-Cl} + \text{H}^\bullet$
- II)  $\text{Cl}^\bullet + \text{CH}_3\text{-CH}_3 \rightarrow \text{CH}_3\text{-H}_2\text{C}^\bullet + \text{HCl}$
- III)  $\text{Cl}^\bullet + \text{CH}_3\text{-H}_2\text{C}^\bullet \rightarrow \text{CH}_3\text{-CH}_2\text{-Cl}$
- IV)  $\text{Cl}_2 + \text{CH}_3\text{-H}_2\text{C}^\bullet \rightarrow \text{CH}_3\text{-CH}_2\text{-Cl} + \text{Cl}^\bullet$
- V)  $\text{Cl}_2 + \text{UV light} \rightarrow \text{Cl}^\bullet + \text{Cl}^\bullet$

- A) reactions I and II
- B) reaction V
- C) reaction III
- D) reactions I and IV
- E) reactions III and IV

9) In the hydrocarbon shown below, how many tertiary hydrogens are present? 9) \_\_\_\_\_



- A) 0
- B) 1
- C) 2
- D) 3
- E) 4

10) Which of the following is a carbene? 10) \_\_\_\_\_

- A)  $\text{CH}_3\text{CH}_2^\bullet$
- B)  $\text{CH}_2=\text{CHO}^\bullet$
- C)  $\text{NCO}^\bullet$
- D)  $\text{CH}_3\text{CH}_2^\bullet$
- E)  $^\bullet\text{C}(\text{Cl})_2$

11) Which of the following statements is (are) true for the compound (*R*)-2-butanol? 11) \_\_\_\_\_

- A) This compound has an enantiomer.
- B) This compound is optically active.
- C) This compound is chiral.
- D) all of the above
- E) none of the above



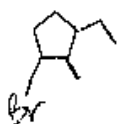
Please show work on all questions for partial credit even on questions which do not specify. Please write legibly. If I cannot read your answer, I cannot grade your answer. (use back of exam for scratch paper)

Part II. Short Answers (40 pts)

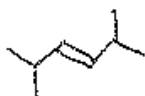
A. Nomenclature: (2 pts each, 8 pts)

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

a. name \_\_\_\_\_



b. name \_\_\_\_\_



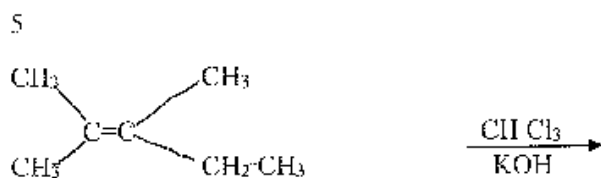
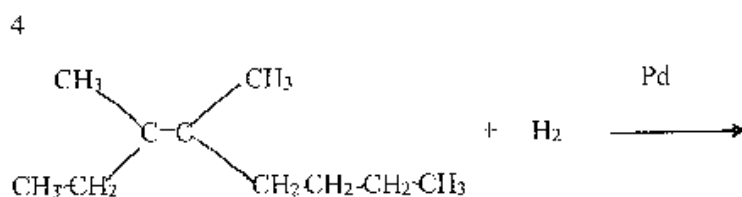
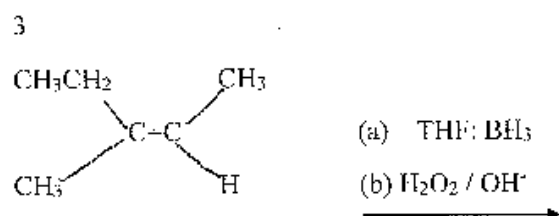
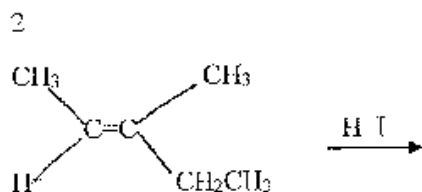
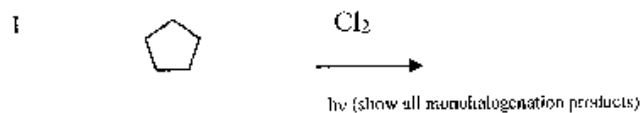
2. Given the following IUPAC name, draw a structural formula of the molecule (skeletal formula acceptable, condensed structure, Lewis Dot structure acceptable, molecular formula not acceptable - don't forget to show the hydrogens in your formula unless you are using the skeletal structure.)

a. 2,4-dimethyl-1-pentene

b. E-3-methyl-2-hexene



B. Reactions: Show the Organic Product in the following reactions by giving the structural formula of the product. (skeletal formula, condensed structure, Lewis Dot structure are all acceptable. Molecular Formula is **not** acceptable.) **DO NOT SHOW MECHANISMS.** (2 pts each, 10 pts)



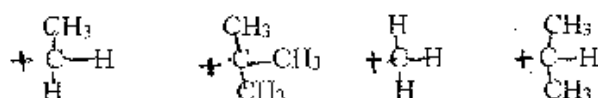
C. Short Answers (22 pts)

1. Given the following groups attached to a chiral carbon, put in order of (a) highest priority to (d) lowest priority. Show all "ghost" atoms. (2 pts each, 8 pts)

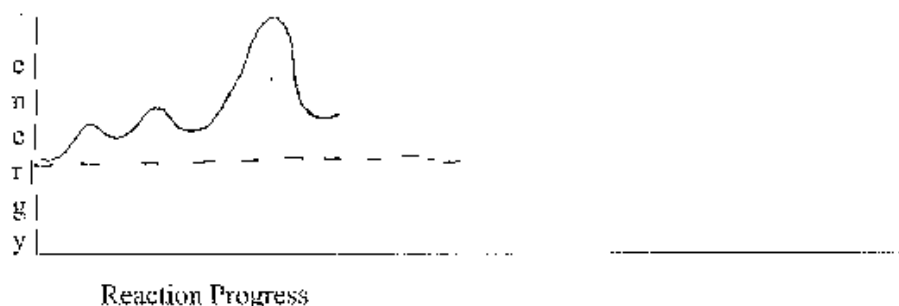
2.



3. Given the following carbocations, label from most stable to least stable by filling in the blank below the molecule with the number **(1) for most stable** to **(4) for least stable** (1 pt each, 4 pts)



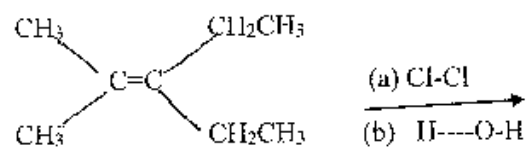
4. Given the following energy diagram, (2 pt each, total 10 pts)



- How many steps is in the reaction mechanism shown [(1),(2),(3)(4)] (circle one)
- Which of the steps is the slowest step [(1<sup>st</sup> step) (2<sup>nd</sup> step) (3<sup>rd</sup> step)] (circle one) (note: just because I gave 3 potential steps does not necessarily mean that there are actually 3 steps – it could be less)
- How many intermediates ? [(1),(2),(3)(4)] (circle one)
- How many transition states [(1),(2),(3)] (circle one)
- Is the reaction energetically favored to go forward to product ? [(yes) (no)] (circle one)

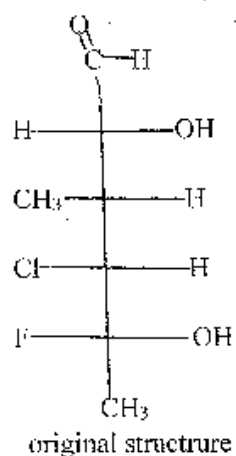
Part III. Long Answers (34 pts) Show all work for partial and full credit.

1. a. Complete the following reaction mechanism. Show all intermediates but not the transition state structures. Show electron pushing arrows and completely drawn Lewis Dot (or Kekule) structures for each step of the reaction mechanism and the correct regiochemistry and stereochemistry if required. (20 pts total, 15 pts this part) (Mechanism means show all steps on the way to product)



b Draw an energy diagram which matches your reaction mechanism showing all intermediates in your mechanism above. Label reactants, products, all intermediates above in your mechanism with the letters (a), (b), (c), ... etc. and then label your energy diagram. Guess at probable relative energies because obviously you can't have an accurate idea of relative energies in your energy diagram without doing an experiment. (5 pts)

2. a. For the given Fischer projection formula shown, draw one Fischer projection enantiomer & diastereomer of the original structure. (14 pts total)



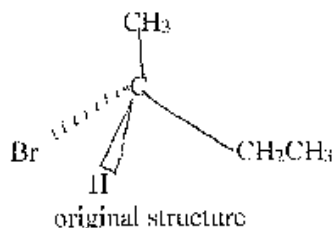
\_\_\_\_\_

enantiomer (4 pts)  
of original structure

\_\_\_\_\_

diastereomer (4 pts)  
of original structure

b. Given the following 3D structure, draw an enantiomer of the original structure using a wedge-dash-line drawing.



\_\_\_\_\_

draw the 3D drawing of the enantiomer of the original molecule on the left using the wedge-dash-line drawing (4 pts)

The original molecule (not the enantiomer) has orientation [(R) or (S)] circle one. (2 pts)

Sign Name \_\_\_\_\_ Print Name \_\_\_\_\_ Cola

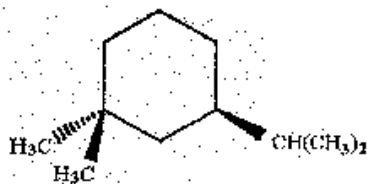
Please show work for all questions for partial and full credit (except multiple choice questions) even on questions which do not specify work. Only answers which are clearly readable will be graded. If you write the answer other than in the intended space without clear indication of where, I will not grade it. (I am grading 250 x 10 page exams, by myself I am not going to spend 3 hours looking for your answer somewhere on the exam and I am not going to contact 250 people to tell me what they meant to write if I can't clearly read what you wrote. No Points for erased answers which are still somewhat visible. No points for errors going from the exam to the scantron. No Points for anything other than normal organic chemistry formulas showing enough information to answer the question. (2 pts print & sign name)

(total number of pages of the exam = 9 pages + periodic table + scantron Check number of pages. If you turn in less than 11 pages, it is your own responsibility for not completing the exam.)

Part I Multiple Choice (2 pts each, 26 pts total) Fill in your answer on the hardcopy of the exam as backup for your scantron in case you erased so much that there is a computer error in grading.

**MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.**

- 1) What synthetic goal is achieved by subjecting an alkene to an oxymercuration-demercuration sequence? 1) \_\_\_\_\_
- A) Markovnikov addition of  $\text{H}_2\text{O}$  wherein skeletal rearrangement is prevented  
 B) Markovnikov addition of  $\text{H}_2\text{O}$  wherein skeletal rearrangement is promoted  
 C) syn-hydroxylation  
 D) anti-Markovnikov addition of  $\text{H}_2\text{O}$  wherein skeletal rearrangement is prevented  
 E) anti-Markovnikov addition of  $\text{H}_2\text{O}$  wherein skeletal rearrangement is promoted
- 2) How many distinct monochlorinated products can result when cyclopentane is subjected to free radical chlorination? 2) \_\_\_\_\_
- A) 1                      B) 2                      C) 3                      D) 4                      E) 5
- 3) How many asymmetric carbon atoms are present in the following compound? 3) \_\_\_\_\_



- A) 0                      B) 1                      C) 2                      D) 3                      E) 4

4) In the reaction of  $\text{Cl}_2$  with ethane and UV light, which of the following reactions would be a chain termination event(s)? 4) \_\_\_\_\_

- I)  $\text{Cl}\cdot + \text{CH}_3\text{-CH}_3 \rightarrow \text{CH}_3\text{-CH}_2\text{-Cl} + \text{H}\cdot$
- II)  $\text{Cl}\cdot + \text{CH}_3\text{-CH}_3 \rightarrow \text{CH}_3\text{-H}_2\text{C}\cdot + \text{HCl}$
- III)  $\text{Cl}\cdot + \text{CH}_3\text{-H}_2\text{C}\cdot \rightarrow \text{CH}_3\text{-CH}_2\text{-Cl}$
- IV)  $\text{Cl}_2 + \text{CH}_3\text{-H}_2\text{C}\cdot \rightarrow \text{CH}_3\text{-CH}_2\text{-Cl} + \text{Cl}\cdot$
- V)  $\text{Cl}_2 + \text{UV light} \rightarrow \text{Cl}\cdot + \text{Cl}\cdot$

- A) reactions I and II
- B) reaction V
- C) reaction III
- D) reactions I and IV
- E) reactions III and IV

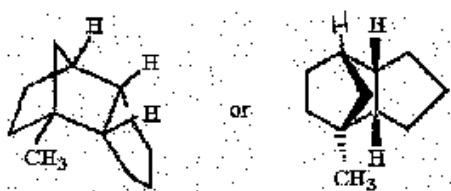
5) Which of the following statements is (are) true for the compound (*R*)-2-butanol? 5) \_\_\_\_\_

- A) This compound has an enantiomer.
- B) This compound is optically active.
- C) This compound is chiral.
- D) all of the above
- E) none of the above

6) For a given reaction, if  $\Delta G^\circ$  is greater than zero (positive), then: 6) \_\_\_\_\_

- A) The reaction is going downhill in energy and will go to product.
- B) The reaction is going really fast.
- C) The reaction is going uphill in energy and will not go to product.
- D) All statements are true.
- E) All statements are false.

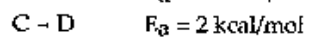
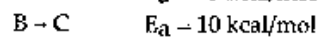
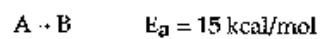
7) In the hydrocarbon shown below, how many tertiary hydrogens are present? 7) \_\_\_\_\_



- A) 0
- B) 1
- C) 2
- D) 3
- E) 4



13) Consider the three-step mechanism for the reaction of A through intermediates B and C to produce D shown below. 13) \_\_\_\_\_



Which of the three steps is rate-limiting (slowest step)?

- A) The reaction of A to B.
- B) The reaction of B to C.
- C) The reaction of C to D.
- D) All three steps occur at the same rate; there is no rate-limiting step.
- E) You can't tell from the information given.



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)

Part II. Short Answers ( 40 pts)

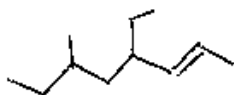
A. Nomenclature: (2 pts each, 8 pts)

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

a. name \_\_\_\_\_



b. name \_\_\_\_\_



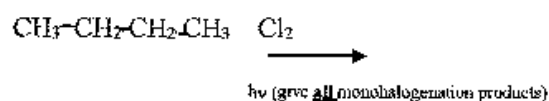
2. Given the following IUPAC name, draw a structural formula of the molecule (skeletal formula acceptable, condensed structure, Lewis Dot structure acceptable, molecular formula not acceptable - don't forget to show the hydrogens in your formula unless you are using the skeletal structure.)

a. 4-ethyl-2,3,5-trimethylnonane

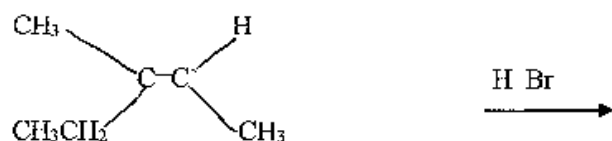
b. 3-ethyl-2-methylpent-1-ene

B. Reactions: Show the Organic Product in the following reactions by giving the structural formula of the product. (skeletal formula, condensed structure, Lewis Dot structure are all acceptable. Molecular Formula is not acceptable.) DO **NOT** SHOW MECHANISMS. (2 pts each, 10 pts)

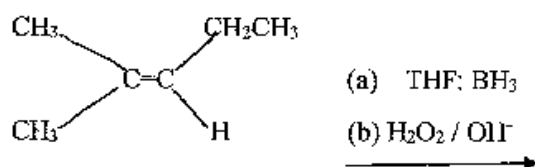
1



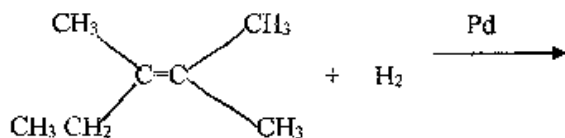
2



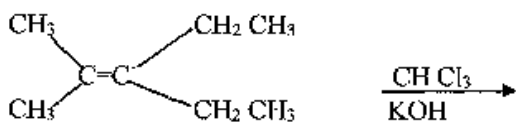
3



4

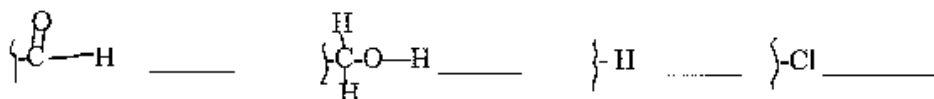


5

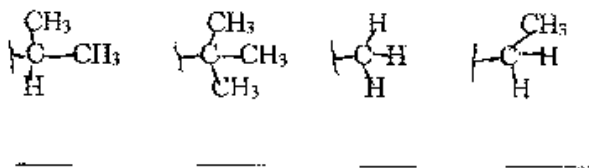


C. Short Answers (22 pts)

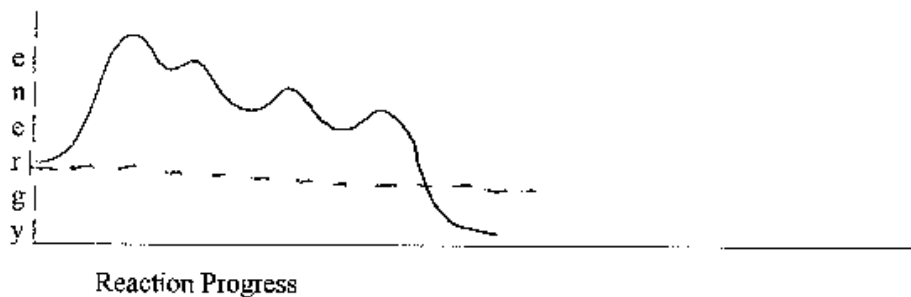
1. Given the following groups attached to a chiral carbon, put in order of (a) highest priority to (d) lowest priority. Show all "ghost" atoms. (2 pts each, 8 pts)



2. Given the following carbocations, label from most stable to least stable by filling in the blank below the molecule with the number **(1) for most stable** to **(4) for least stable** (1 pt each, 4 pts)



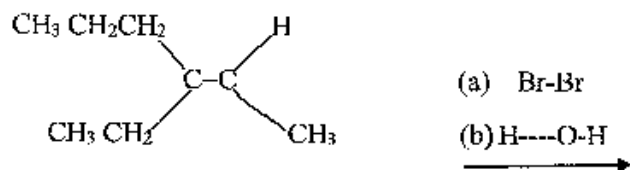
3. Given the following energy diagram, (2 pt each, total 10 pts)



- How many steps is in the reaction mechanism shown [(1), (2),(3)(4)] (circle one)
- Which of the steps is the slowest step [(1<sup>st</sup> step) (2<sup>nd</sup> step) (3<sup>rd</sup> step)] (circle one) (note: just because I gave 3 potential steps does not necessarily mean that there are actually 3 steps – it could be less)
- How many intermediates ? [(1),(2),(3)(4)(5)] (circle one)
- How many transition states [(1),(2),(3)(4)(5)] (circle one)
- Is the reaction energetically favored to go forward to product ? [(yes) (no)] (circle one)

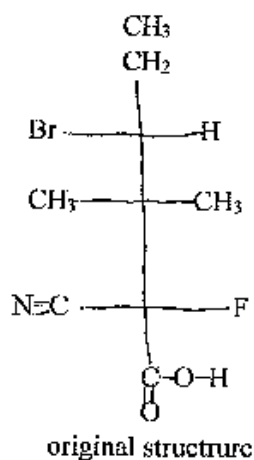
Part III. Long Answers (34 pts) Show all work for partial and full credit.

1. a. Complete the following reaction mechanism. Show all intermediates but not the transition state structures. Show electron pushing arrows and completely drawn Lewis Dot (or Kekule) structures for each step of the reaction mechanism and the correct regiochemistry and stereochemistry if required. (20 pts total, 15 pts this part) (Mechanism means show all steps on the way to product)



b Draw an energy diagram which matches your reaction mechanism showing all intermediates in your mechanism above. Label reactants, products, all intermediates above in your mechanism with the letters (a), (b), (c), ... etc. and then label your energy diagram. Guess at probable relative energies because obviously you can't have an accurate idea of relative energies in your energy diagram without doing an experiment. (5 pts)

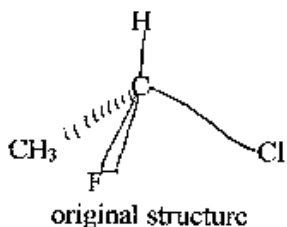
2. a. For the given Fisher projection formula shown, draw one Fisher projection enantiomer & diastereomer of the original structure. (14 pts total)



\_\_\_\_\_   
 enantiomer (4 pts)   
 of original structure

\_\_\_\_\_   
 diastereomer (4 pts)   
 of original structure

b. Given the following 3D structure, draw an enantiomer of the original structure using a wedge-dash-line drawing.



\_\_\_\_\_   
 draw the 3D drawing of the enantiomer of the original   
 molecule on the left using the wedge-dash-line drawing (4 pts)

The original molecule (not the enantiomer) has orientation [(R) or (S)] circle one. (2 pts)

Sign Name \_\_\_\_\_ Print Name \_\_\_\_\_

Please show work for all questions for partial and full credit (except multiple choice questions) even on questions which do not specify work. Only answers which are clearly readable will be graded. If you write the answer other than in the intended space without clear indication of where, I will not grade it. (I am grading 250 x 10 page exams. by myself I am not going to spend 3 hours looking for your answer somewhere on the exam and I am not going to contact 250 people to tell me what they meant to write if I can't clearly read what you wrote. No Points for erased answers which are still somewhat visible. No points for errors going from the exam to the scantron. No Points for anything other than normal organic chemistry formulas showing enough information to answer the question. (2 pts print & sign name)

(total number of pages of the exam = 9 pages + periodic table + scantron Check number of pages. If you turn in less than 10 pages, it is your own responsibility for not completing the exam.)

Part I Multiple Choice (2 pts each, 26 pts total) fill in your answer on the hardcopy of the exam as backup for your scantron in case you erased so much that there is a computer error in grading.

**MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.**

- 1) How many distinct monochlorinated products can result when cyclopentane is subjected to free radical chlorination? 1) \_\_\_\_\_  
 A) 1 B) 2 C) 3 D) 4 E) 5
- 2) What synthetic goal is achieved by subjecting an alkene to an oxymercuration-demercuration sequence? 2) \_\_\_\_\_  
 A) Markovnikov addition of H<sub>2</sub>O wherein skeletal rearrangement is prevented  
 B) Markovnikov addition of H<sub>2</sub>O wherein skeletal rearrangement is promoted  
 C) syn-hydroxylation  
 D) anti-Markovnikov addition of H<sub>2</sub>O wherein skeletal rearrangement is prevented  
 E) anti-Markovnikov addition of H<sub>2</sub>O wherein skeletal rearrangement is promoted
- 3) Which of the following intermediates is thought to occur in the mechanism by which alkenes are hydrated in the presence of acid? 3) \_\_\_\_\_  
 A) carbocation  
 B) carbanion  
 C) free radical  
 D) carbene  
 E) alkyne

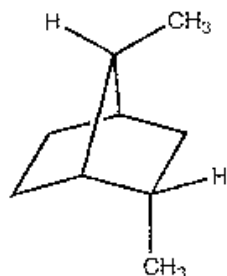
4) A mixture of equal amounts of two enantiomers \_\_\_\_\_

4) \_\_\_\_\_

- A) is optically inactive
- B) is called a racemic mixture
- C) implies that the enantiomers are meso forms
- D) both A and B
- E) none of the above

5) How many secondary hydrogens are present in the hydrocarbon below?

5) \_\_\_\_\_



- A) 7
- B) 2
- C) 16
- D) 6
- E) 8

6) Which of the following is not a possible termination step in the free radical chlorination of methane?

6) \_\_\_\_\_

- A)  $\cdot\text{CH}_3 + \cdot\text{CH}_3 \rightarrow \text{CH}_3\text{CH}_3$
- B)  $\cdot\text{CH}_3 + \text{Cl}\cdot \rightarrow \text{CH}_3\text{Cl}$
- C)  $\cdot\text{CH}_3 + \text{Cl}_2 \rightarrow \text{CH}_3\text{Cl} + \text{Cl}\cdot$
- D) None are termination steps.
- E) All shown steps are termination steps.

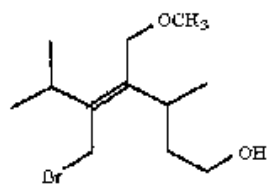
7) A radical reaction mechanism is:

7) \_\_\_\_\_

- A) done so as to produce the more stable pair of ions
- B) homolytic
- C) via hydrogenation
- D) heterolytic
- E) none of the above

8) Which of the following best describes the geometry about the carbon-carbon double bond in the alkene below?

8) \_\_\_\_\_



A) Z

B) E

C) neither E nor Z

9) Which of the following is a carbene?

9) \_\_\_\_\_

A)  $\text{CH}_3\text{CH}_2^+$

B)  $\text{Cl}_2=\text{CHO}^-$

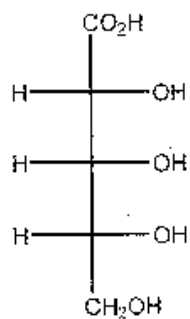
C)  $\text{NCO}^-$

D)  $\text{ClI}_3\text{CH}_2^-$

E)  $\text{C}=\text{C}=\text{C}$

10) How many diastereomers are there of the molecule shown below?

10) \_\_\_\_\_



A) 3

B) 2

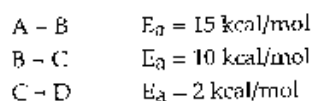
C) 0

D) 1

E) 6



11) Consider the three-step mechanism for the reaction of A through intermediates B and C to produce D shown below. 11) \_\_\_\_\_



Which of the three steps is rate-limiting (slowest step)?

- A) The reaction of A to B.
  - B) The reaction of B to C.
  - C) The reaction of C to D.
  - D) All three steps occur at the same rate; there is no rate-limiting step.
  - E) You can't tell from the information given.
- 12) Which of the following statements is (are) true for the compound (*R*)-2-butanol? 12) \_\_\_\_\_
- A) This compound has an enantiomer.
  - B) This compound is optically active.
  - C) This compound is chiral.
  - D) all of the above
  - E) none of the above

- 13) For a given reaction, if  $\Delta C^\circ$  is greater than zero (positive), then: 13) \_\_\_\_\_
- A) The reaction is going downhill in energy and will go to product.
  - B) The reaction is going really fast.
  - C) The reaction is going uphill in energy and will not go to product.
  - D) All statements are true.
  - E) All statements are false.

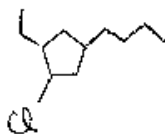
Please show work on all questions for partial credit even on questions which do not specify. Please write legibly. If I cannot read your answer, I cannot grade your answer. (use back of exam for scratch paper)

Part II. Short Answers (40 pts)

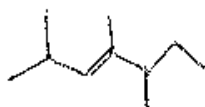
A. Nomenclature: (2 pts each, 8 pts)

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

a. name \_\_\_\_\_



b. name \_\_\_\_\_

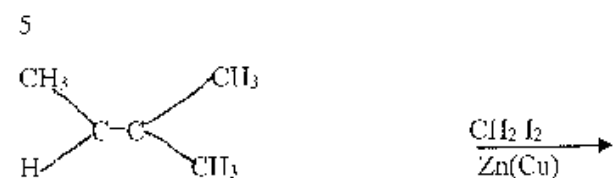
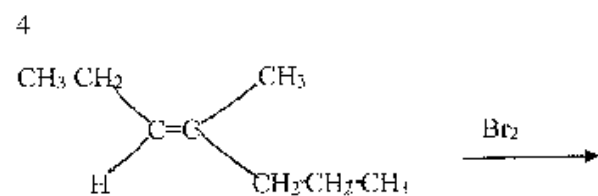
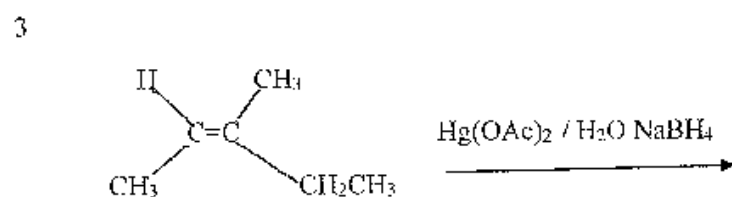
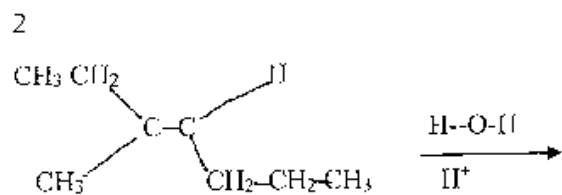
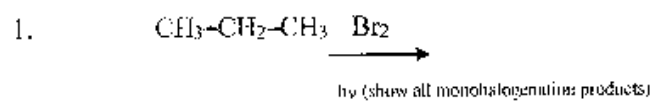


2. Given the following IUPAC name, draw a structural formula of the molecule (skeletal formula acceptable, condensed structure, Lewis Dot structure acceptable, molecular formula not acceptable - don't forget to show the hydrogens in your formula unless you are using the skeletal structure.)

a. 3,3,4,4-tetramethylhexane

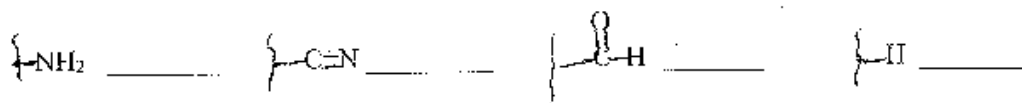
b. E-2-chloro-4,5-diethyl-4-octene

B. Reactions: Show the Organic Product in the following reactions by giving the structural formula of the product. (skeletal formula, condensed structure, Lewis Dot structure are all acceptable. Molecular Formula is not acceptable.) DO NOT SHOW MECHANISMS. (2 pts each, 10 pts)

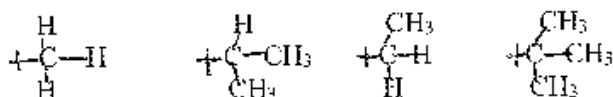


C. Short Answers (22 pts)

1. Given the following groups attached to a chiral carbon, put in order of (a) highest priority to (d) lowest priority. Show all "ghost" atoms. (2 pts each, 8 pts)

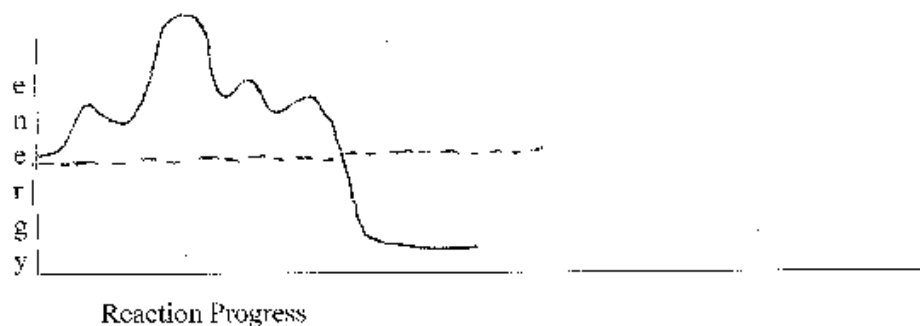


2. Given the following carbocations, label from most stable to least stable by filling in the blank below the molecule with the number **(1) for most stable to (4) for least stable** (1 pt each, 4 pts)



\_\_\_\_\_

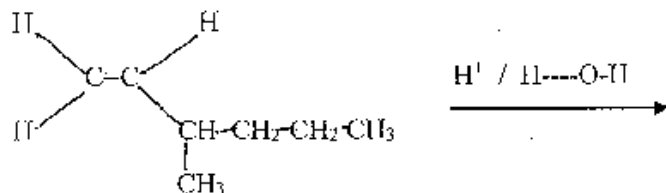
3. Given the following energy diagram, (2 pt each, total 10 pts)



- How many steps is in the reaction mechanism shown [(1),(2),(3)(4)] (circle one)
- Which of the steps is the slowest step [(1<sup>st</sup> step) (2<sup>nd</sup> step) (3<sup>rd</sup> step)] (circle one) (note: just because I gave 3 potential steps does not necessarily mean that there are actually 3 steps – it could be less)
- How many intermediates ? [(1),(2),(3)(4)] (circle one)
- How many transition states [(1),(2),(3)(4)] (circle one)
- Is the reaction energetically favored to go forward to product ? [(yes) (no)] (circle one)

Part III. Long Answers (34 pts) Show all work for partial and full credit.

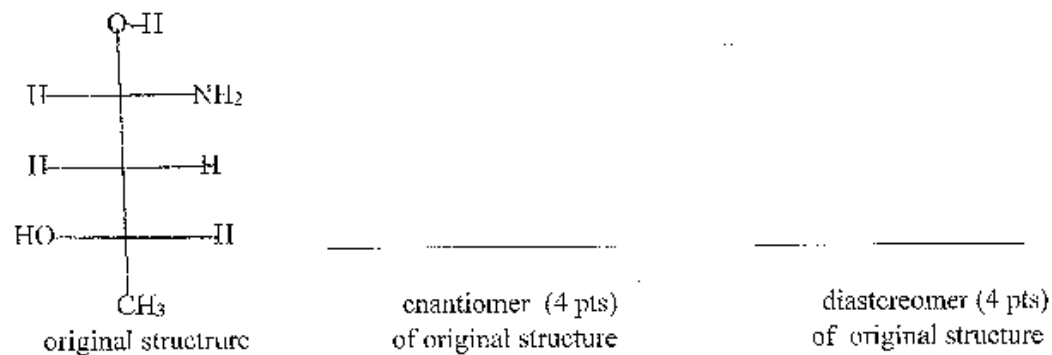
1. a. Complete the following reaction mechanism. **Show all intermediates** but not the transition state structures. Show electron pushing arrows and completely drawn Lewis Dot (or Kekule) structures for each step of the reaction mechanism and the correct regiochemistry and stereochemistry if required. (20 pts total, 15 pts this part) (Mechanism means show all steps on the way to product)



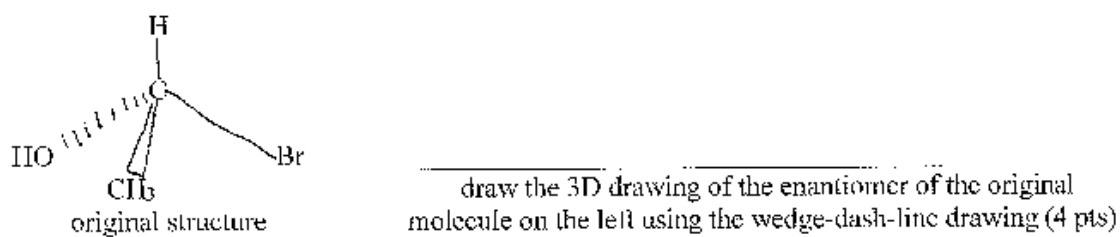
Please check for the possibility of rearrangement. You may have to do a hydride shift.

b Draw a 3D structure of the **first intermediate** above showing the  $\pi$  charge localized on the empty p orbital. (3D structure need only be on the carbocation) (5 pts)

3. a. For the given Fisher projection formula shown, draw one Fisher projection enantiomer & diastereomer of the original structure. (14 pts total)



b. Given the following 3D structure, draw an enantiomer of the original structure using a wedge-dash-line drawing.



The original molecule (not the enantiomer) has orientation [(R) or (S)] circle one. (2 pts)