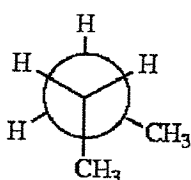
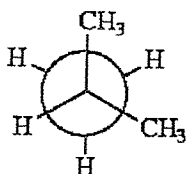


Name key (print) Name _____ (sign)

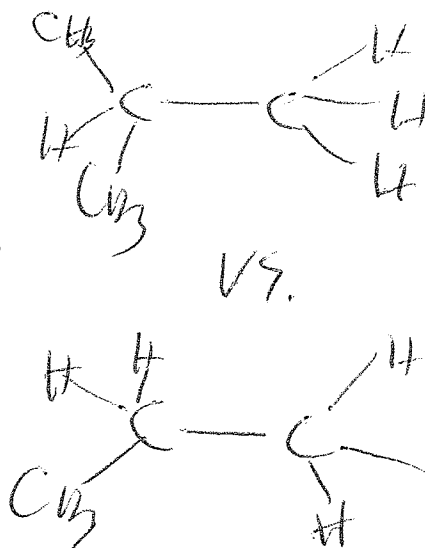
Please show work for partial credit and full credit on the Long Answers and in some of the Short Answer Questions. Multiple choice questions have no partial credit. Please write anything you want graded legibly. If you run out of space, please continue on the empty back pages but clearly label where the remaining answer can be found. (If I can't find your answer or cannot read it, I obviously cannot grade it). Return your entire exam including the periodic table. (Please count your exam pages and make sure there are real pages + periodic table)

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question. (2 pts each, 26 pts total)

1) The structures below are _____.



- A) cis-trans isomers
- B) structural isomers**
- C) conformational isomers
- D) not isomers
- E) both B and D



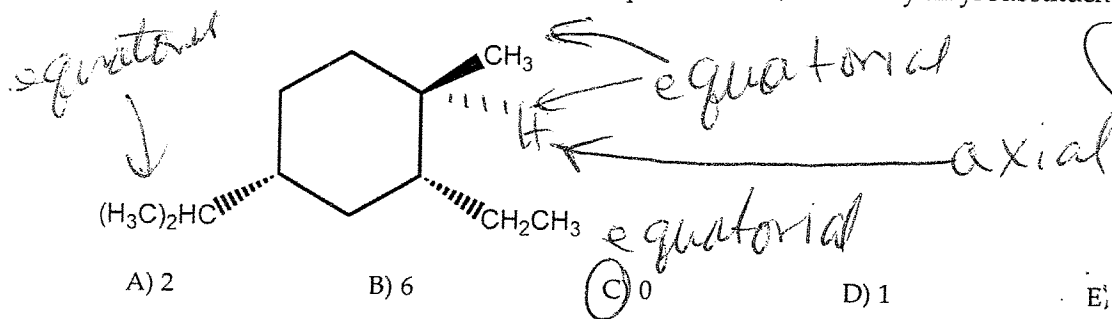
1) B

BA = bad attempt

NA = not attempted

NW = no work

2) In the lowest energy conformation of the compound below, how many alkyl substituents are axial?

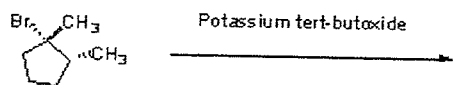


- A) 2
- B) 6
- C) 0**
- D) 1
- E) 3

BBA bad bad attempt

2) C

3) Identify the major product of the reaction below.



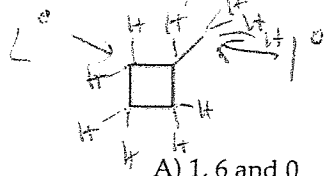
Handwritten: Hoffmann product

- A)
- B)**
- C)
- D)

3) B

4) For the compound below, the number of 1°, 2° and 3° hydrogens, respectively is _____.

4) C



A) 1, 6 and 0

B) 1, 3, and 1

C) 3, 6 and 1

D) 3, 6 and 2

5) A mixture of equal amounts of two enantiomers _____.

5) D

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

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

6) D

A) $\cdot\text{CH}_3 + \text{wall} \rightarrow \text{CH}_3\text{-wall}$

B) $\cdot\text{CH}_3 + \text{Cl}\cdot \rightarrow \text{CH}_3\text{Cl}$

C) $\cdot\text{CH}_3 + \cdot\text{CH}_3 \rightarrow \text{CH}_3\text{CH}_3$

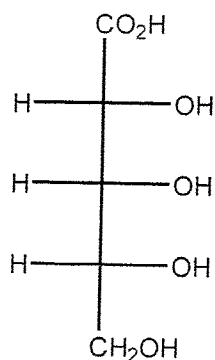
D) $\cdot\text{CH}_3 + \text{Cl}_2 \rightarrow \text{CH}_3\text{Cl} + \text{Cl}\cdot$

E) $\text{Cl}\cdot + \text{Cl}\cdot \rightarrow \text{Cl-Cl}$

← not termination
radical on right side

7) How many enantiomers are there of the molecule shown below?

7) D



A) 6

B) 0

C) 3

D) 1

E) 2

8) Which of the following mechanisms (S_N1, S_N2, E1, E2) feature(s) a carbocation intermediate?

8) E

A) S_N2 only

B) S_N1 only ←

C) E2 only

D) E1 only ←

E) both S_N1 and E1

9) If (S)-glyceraldehyde has a specific rotation of -8.7°, what is the specific rotation of (R)-glyceraldehyde?

9) B

A) -8.7°

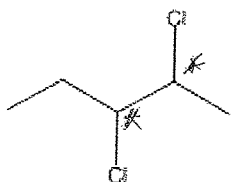
B) +8.7°

C) 0.0°

D) cannot be determined from the information given

10) How many asymmetric carbon atoms are present in the molecule shown?

10) 2



2 chiral C - C with 4 different attached

A) 0

B) 1

C) 2

D) 3

E) 4

11) In which of the following mechanisms (SN1, SN2, E1, E2) are alkenes the major reaction products?

11) E

A) SN2 only

B) SN1 only

C) E2 only

D) E1 only

E) both E1 and E2

elimination gives alkenes

12) A branched alkane has lower boiling point relative to the isomeric linear alkane. There are less London force interactions in the branched alkane.

12) A

A) a lower; weaker

B) the same; similar

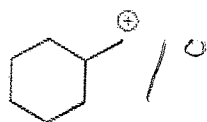
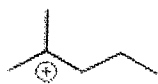
C) a lower; stronger

D) a higher; stronger

E) a higher; weaker

13) Rank the following carbocations in order of stability. (The most stable is first.)

13) A



3° I

A) I > III > II

B) I > II > III

C) II > I > III

D) III > I > II

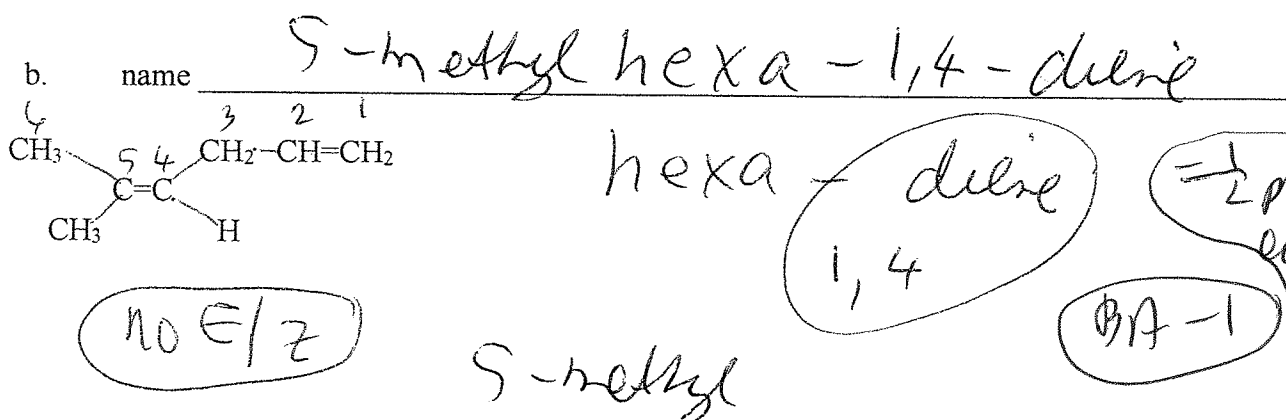
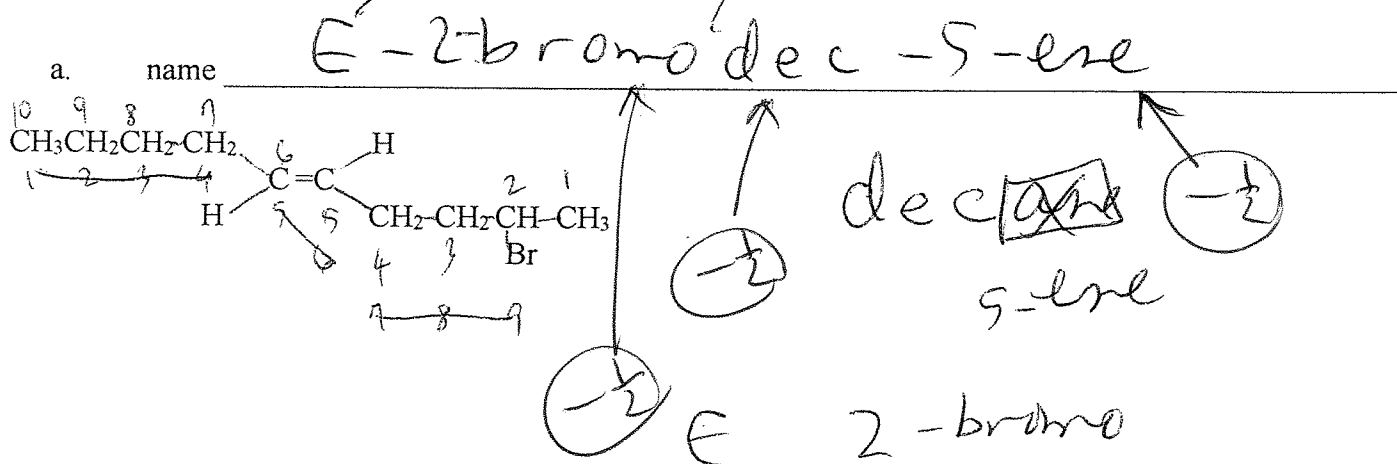
3° > 2° > 1°

I > III > II

Part II: Short Answers (40 pts)

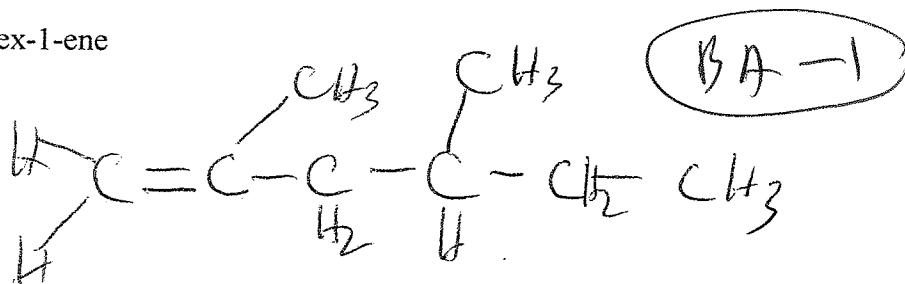
A. Nomenclature: (2 pts each, 6 pts)

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

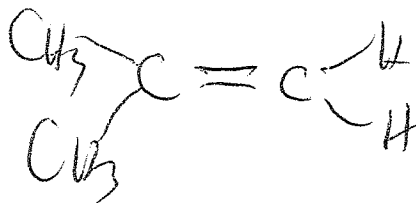
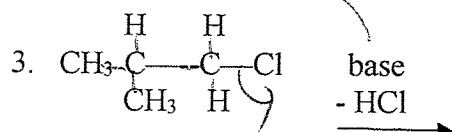
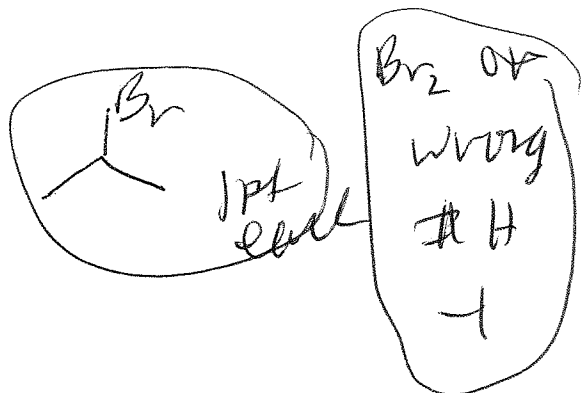
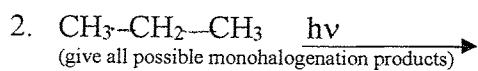


2. Given the following IUPAC name, draw a structural formula of the molecule (skeletal formula acceptable, condensed structure, Lewis Dot structure acceptable, molecular formula not acceptable - don't forget to show the hydrogens in your formula unless you are using the skeletal structure.)

a. 2,4-dimethylhex-1-ene

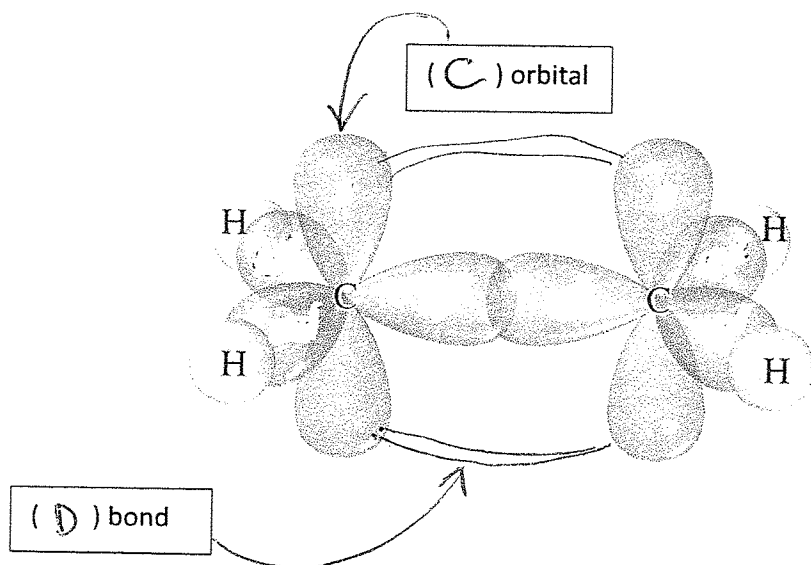


B. Reactions: (2 pts each, 6 pts) give the expected organic product for the following reaction.

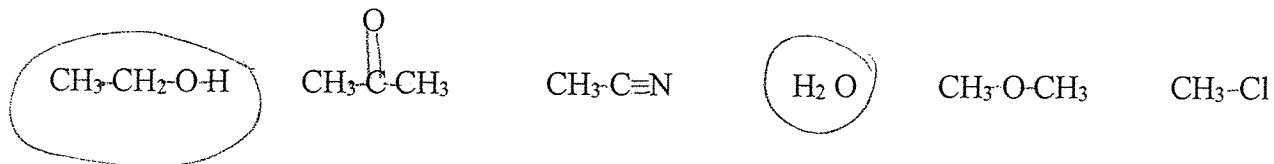


C. Short Answer Part of Short Answer:

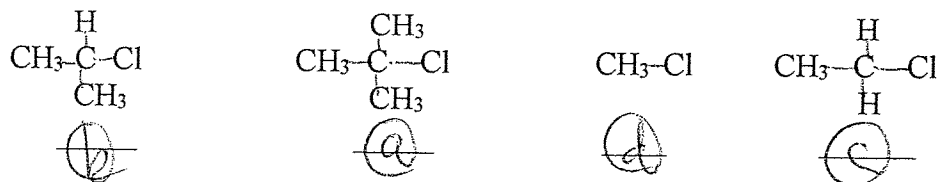
1. Match the labeling in the following parenthesis. Each parenthesis can hold one to multiple letters. Each letter may be used once, no time or multiple times (A) sp^3 hybridized orbitals (B) sp^2 hybridized orbitals (C) unhybridized p orbital (D) π bond (E) σ bond (F) s orbital (6 pts, 3 pts each)



2 Given the following list of solvents, circle every apolar protic solvent (6 pts total, 1 pt each)



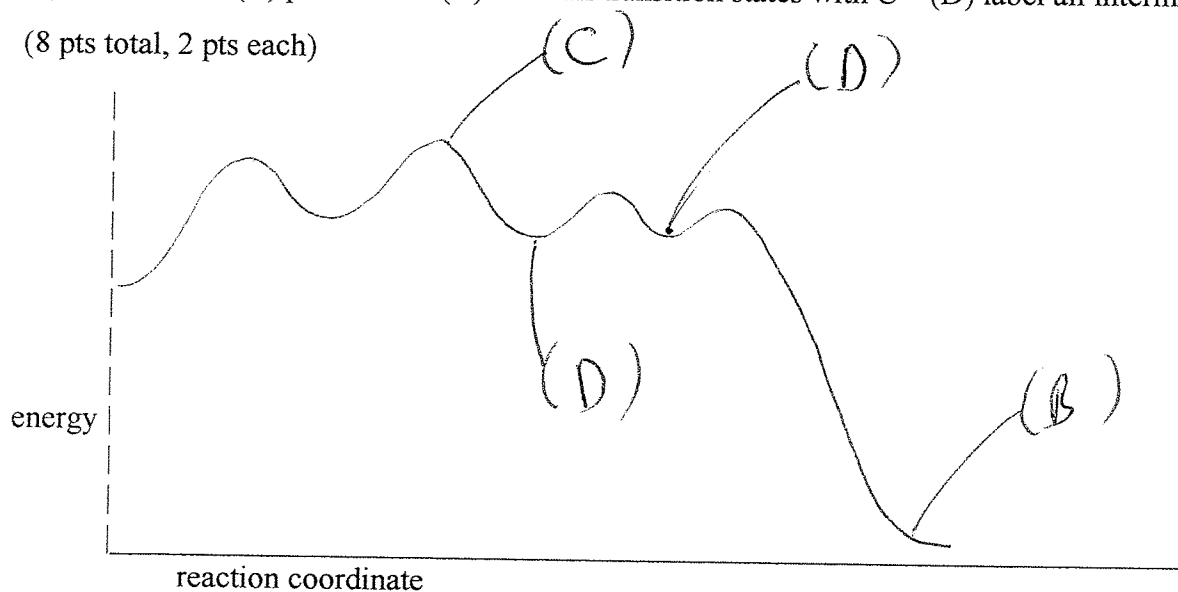
3 List the following from best (a) S_N1 substrate to worst (d) S_N1 substrate (8 pts total, 2 pts each)



4 Given the following energy diagram, label by filling in all parenthesis with one and only one letter.

(A) reactant (B) product (C) label all transition states with C (D) label all intermediates as D

(8 pts total, 2 pts each)



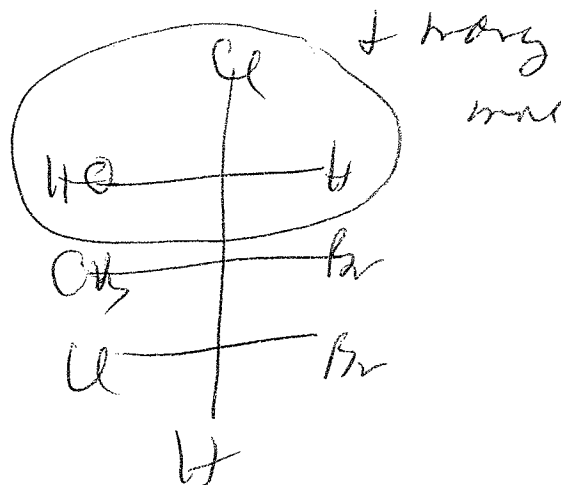
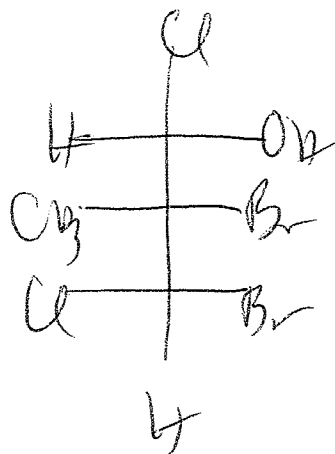
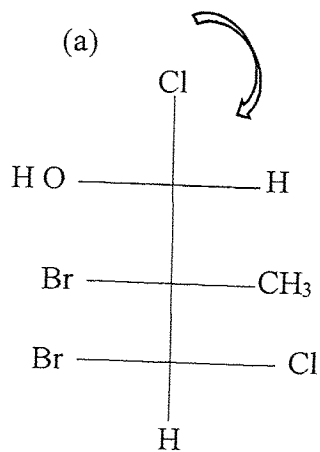
Part III: Long Answers (34 pts)

1. For the following molecule, answer the following: (16 pts total, 4 pts each)

Original molecule

(b). Enantiomer of original (a)

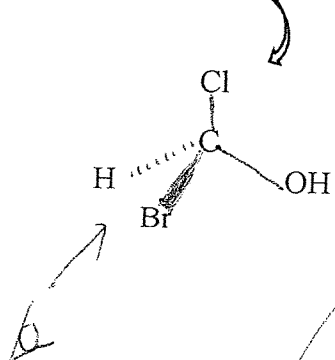
(c). diastereomer of the original (a)



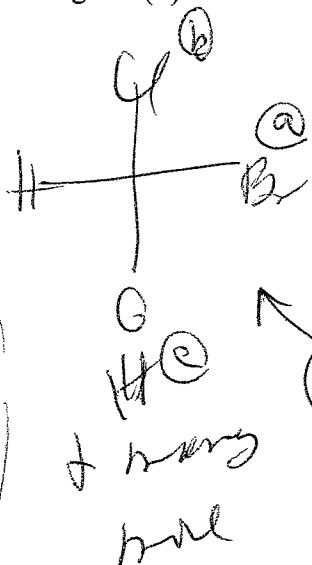
Strukturisomer - 4

Same as (a) - 4

(d) Original



(e) Fischer of original (d)



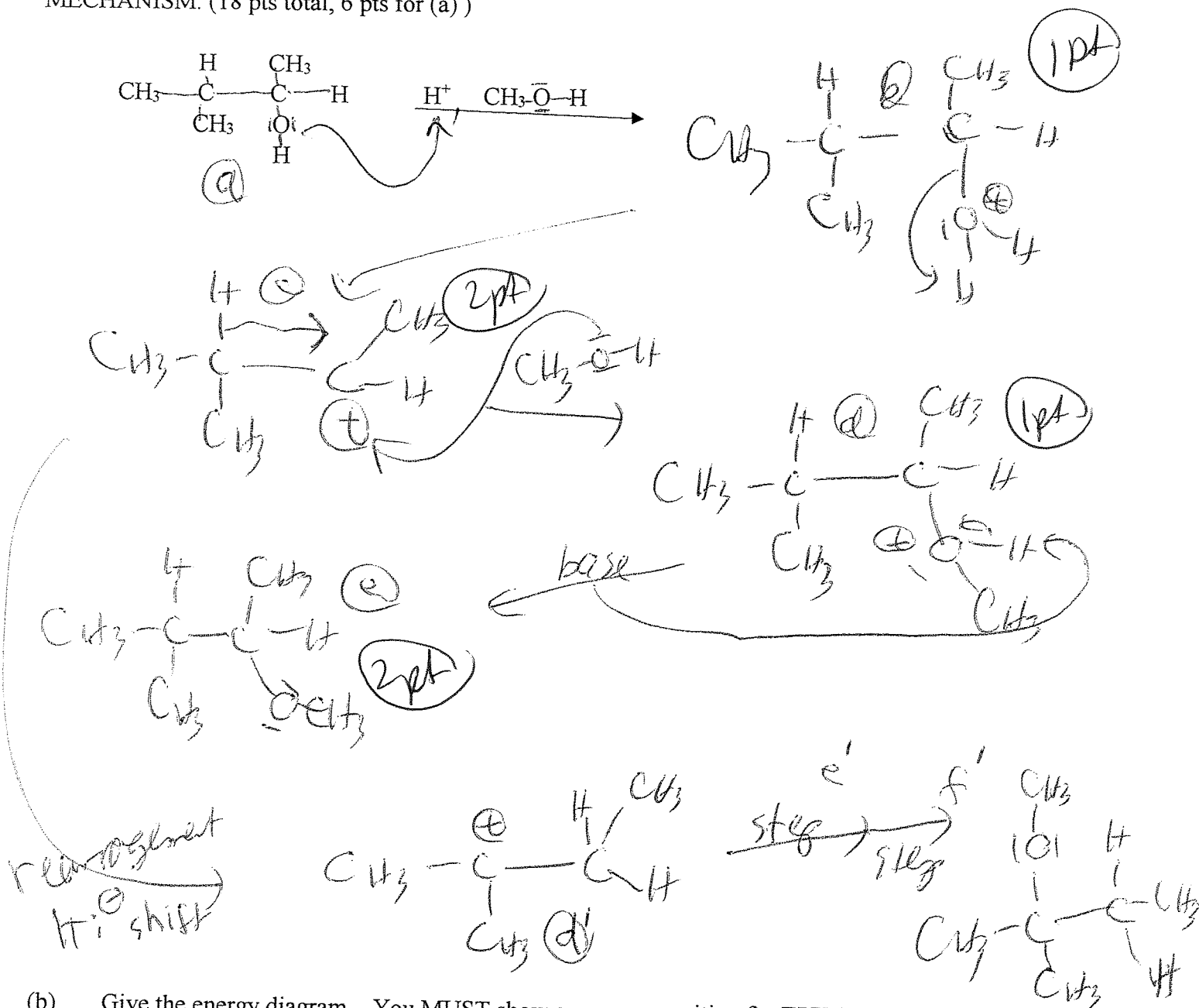
(f) what is the Cahn-Ingold-Prelog R,S of The original in (d) explain

S
but
H
comes
out

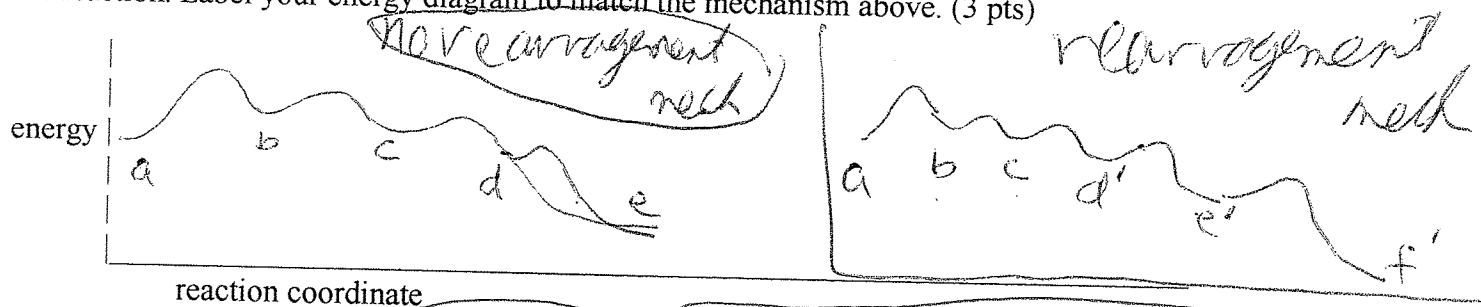
enantiomer
- 2

R

2. (a) Give the reaction mechanism of the following reaction assuming **SN1 (substitution nucleophilic unimolecular)** mechanism. Must show all steps stepwise. Just showing the intermediate is NOT a MECHANISM. (18 pts total, 6 pts for (a))

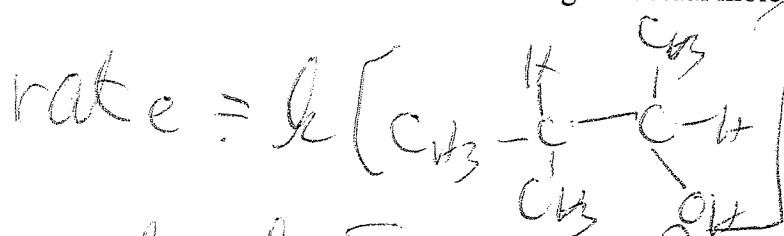


(b) Give the energy diagram. You MUST show an energy position for **EVERY INTERMEDIATE** in the reaction. Label your energy diagram to match the mechanism above. (3 pts)



mis labeled - 1/2 pt mis labeled out - 1/2 pt

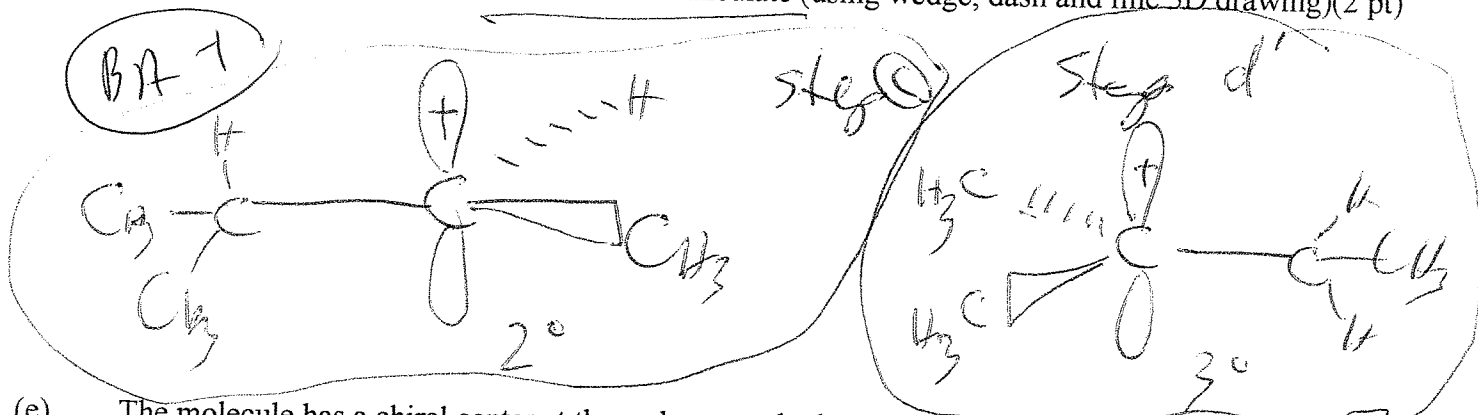
(c) Write the rate law for the reaction showing the actual molecule in the reaction. (3 pts)



BA-1/2



(d) Show a 3D structure of the carbocation intermediate (using wedge, dash and line 3D drawing) (2 pt)

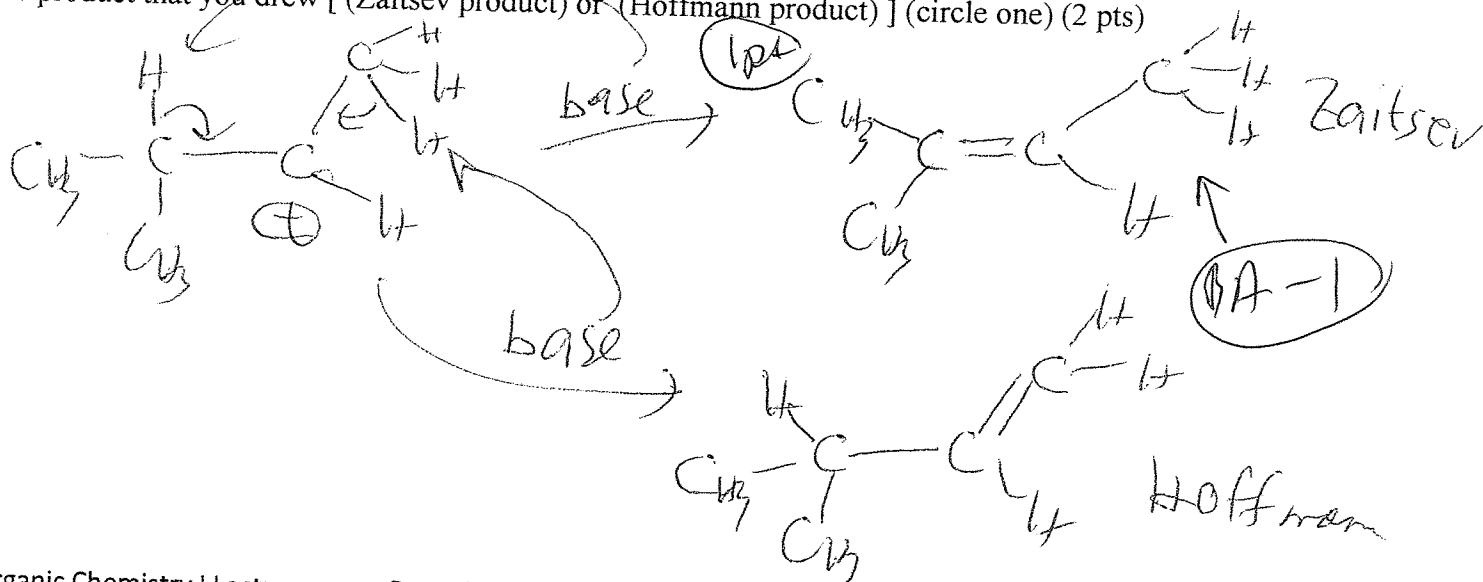


(e) The molecule has a chiral center at the carbon attached to the OH. If the starting molecule was R Cahn Ingold Prelog orientation, after the reaction what would be the Cahn Ingold Prelog orientation of the product? Explain briefly. (2 pts)

50:50 R+S - carbocation is flat so
get both inversion + retention - slightly
more inversion

BA-1

(f) If the reaction undergoes an elimination instead of substitution draw the expected product below. Is the product that you drew [(Zaitsev product) or (Hoffmann product)] (circle one) (2 pts)



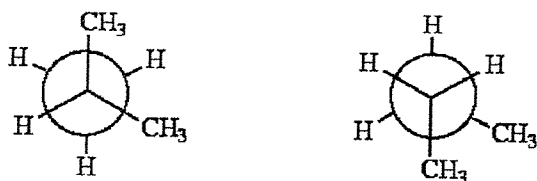
Name _____ (print) Name _____ (sign)

Please show work for partial credit and full credit on the Long Answers and in some of the Short Answer Questions. Multiple choice questions have no partial credit. Please write anything you want graded legibly. If you run out of space, please continue on the empty back pages but clearly label where the remaining answer can be found. (If I can't find your answer or cannot read it, I obviously cannot grade it). Return your entire exam including the periodic table. (Please count your exam pages and make sure there are real pages + periodic table)

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question. (2 pts each, 26 pts total)

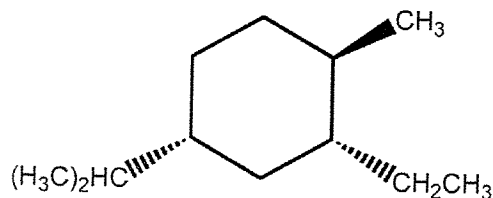
1) The structures below are _____.

1) _____



- A) cis-trans isomers
- B) structural isomers
- C) conformational isomers
- D) not isomers
- E) both B and D

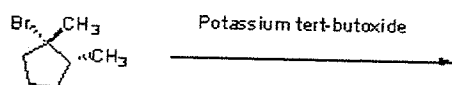
2) In the lowest energy conformation of the compound below, how many alkyl substituents are axial? 2) _____



- A) 2
- B) 6
- C) 0
- D) 1
- E) 3

3) Identify the major product of the reaction below.

3) _____



- A)
- B)
- C)
- D)

4) For the compound below, the number of 1°, 2° and 3° hydrogens, respectively is _____. 4) _____



- A) 1, 6 and 0 B) 1, 3, and 1 C) 3, 6 and 1 D) 3, 6 and 2

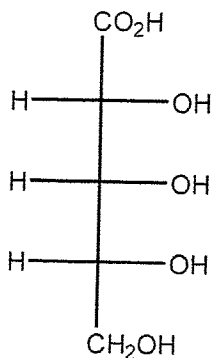
5) A mixture of equal amounts of two enantiomers _____. 5) _____

- 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

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

- A) $\cdot\text{CH}_3 + \text{wall} \rightarrow \text{CH}_3\text{-wall}$
B) $\cdot\text{CH}_3 + \text{Cl}\cdot \rightarrow \text{CH}_3\text{Cl}$
C) $\cdot\text{CH}_3 + \cdot\text{CH}_3 \rightarrow \text{CH}_3\text{CH}_3$
D) $\cdot\text{CH}_3 + \text{Cl}_2 \rightarrow \text{CH}_3\text{Cl} + \text{Cl}\cdot$
E) $\text{Cl}\cdot + \text{Cl}\cdot \rightarrow \text{Cl-Cl}$

7) How many enantiomers are there of the molecule shown below? 7) _____



- A) 6 B) 0 C) 3 D) 1 E) 2

8) Which of the following mechanisms (S_N1, S_N2, E1, E2) feature(s) a carbocation intermediate? 8) _____

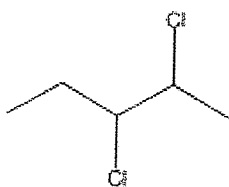
- A) S_N2 only
B) S_N1 only
C) E2 only
D) E1 only
E) both S_N1 and E1

9) If (S)-glyceraldehyde has a specific rotation of -8.7°, what is the specific rotation of (R)-glyceraldehyde? 9) _____

- A) -8.7°
B) +8.7°
C) 0.0°
D) cannot be determined from the information given

10) How many asymmetric carbon atoms are present in the molecule shown?

10) _____



A) 0

B) 1

C) 2

D) 3

E) 4

11) In which of the following mechanisms (S_N1, S_N2, E1, E2) are alkenes the major reaction products?

11) _____

A) S_N2 only

B) S_N1 only

C) E2 only

D) E1 only

E) both E1 and E2

12) A branched alkane has _____ boiling point relative to the isomeric linear alkane. There are _____ London force interactions in the branched alkane.

12) _____

A) a lower; weaker

B) the same; similar

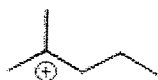
C) a lower; stronger

D) a higher; stronger

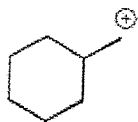
E) a higher; weaker

13) Rank the following carbocations in order of stability. (The most stable is first.)

13) _____



I



II



III

A) I > III > II

B) I > II > III

C) II > I > III

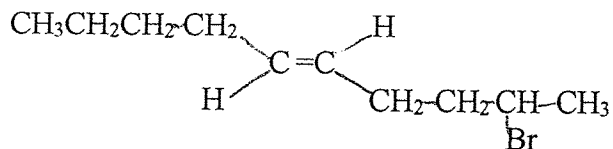
D) III > I > II

Part II: Short Answers (40 pts)

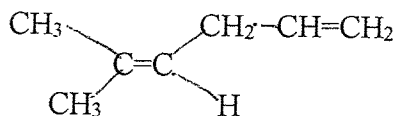
A. Nomenclature: (2 pts each, 6 pts)

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

a. name _____



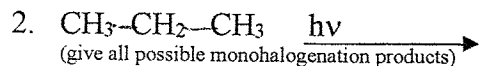
b. name _____



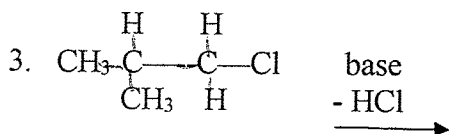
2. Given the following IUPAC name, draw a structural formula of the molecule (skeletal formula acceptable, condensed structure, Lewis Dot structure acceptable, molecular formula not acceptable - don't forget to show the hydrogens in your formula unless you are using the skeletal structure.)

a. 2,4-dimethylhex-1-ene

B. Reactions: (2 pts each, 6 pts) give the expected organic product for the following reaction.

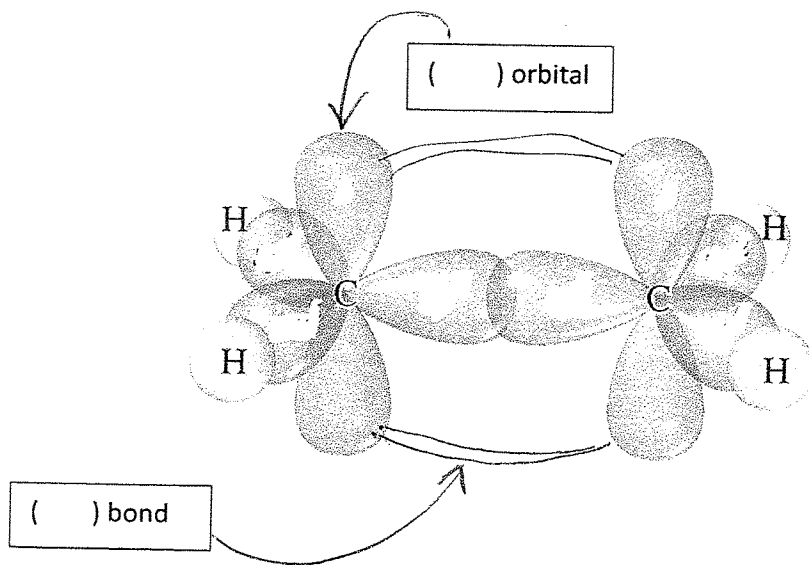


Br_2

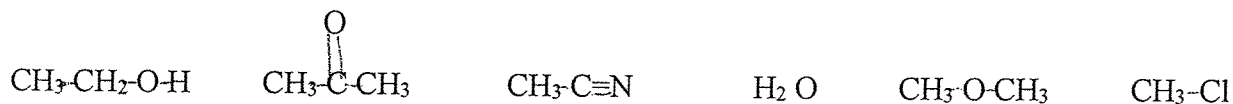


C. Short Answer Part of Short Answer:

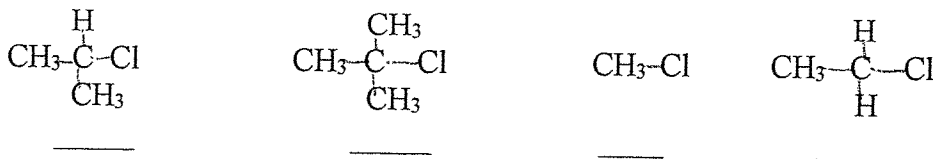
1. Match the labeling in the following parenthesis. Each parenthesis can hold one to multiple letters. Each letter may be used once, no time or multiple times (A) sp^3 hybridized orbitals (B) sp^2 hybridized orbitals (C) unhybridized p orbital (D) π bond (E) σ bond (F) s orbital (6 pts, 3 pts each)



2 Given the following list of solvents, circle every apolar protic solvent (6 pts total, 1 pt each)



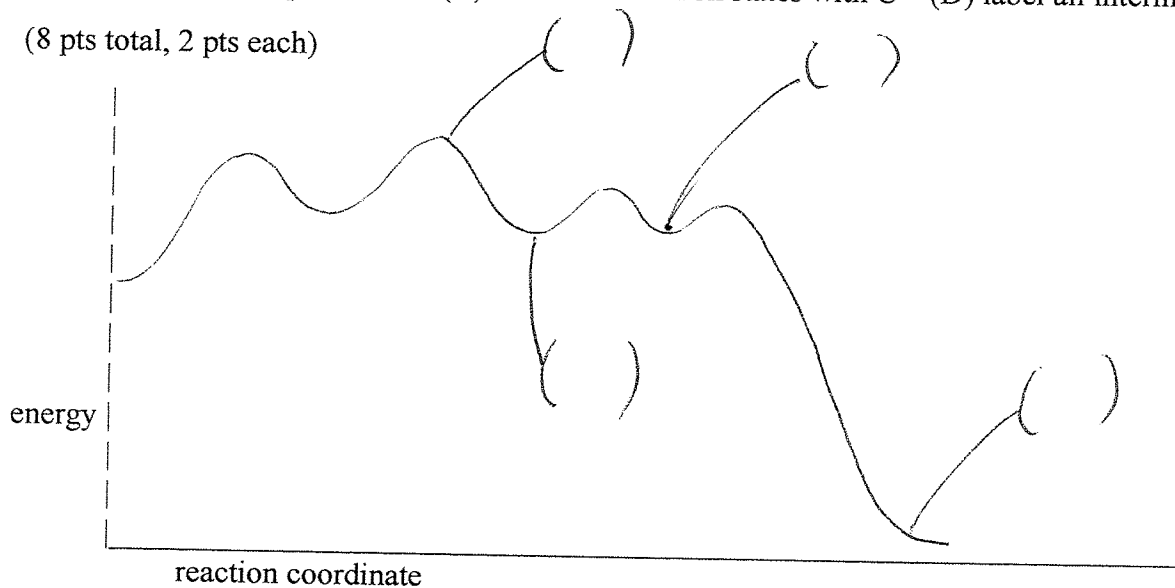
3 List the following from best (a) $\text{S}_{\text{N}}1$ substrate to worst (d) $\text{S}_{\text{N}}1$ substrate (8 pts total, 2 pts each)



4 Given the following energy diagram, label by filling in all parenthesis with one and only one letter.

(A) reactant (B) product (C) label all transition states with C (D) label all intermediates as D

(8 pts total, 2 pts each)



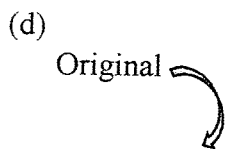
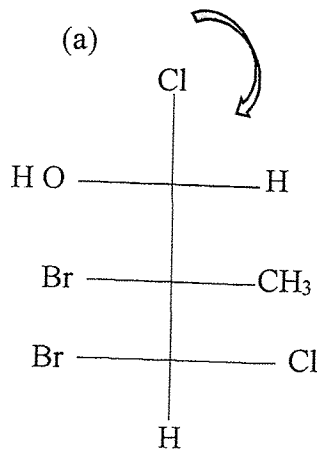
Part III: Long Answers (34 pts)

1. For the following molecule, answer the following: (16 pts total, 4 pts each)

Original molecule

(b). Enantiomer of original (a)

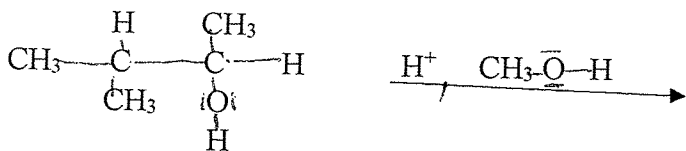
(c). diastereomer of the original (a)



(e) Fischer of original (d)

(f) what is the Cahn-Ingold-Prelog R,S of The original in (d) explain

2. (a) Give the reaction mechanism of the following reaction assuming **S_N1 (substitution nucleophilic unimolecular)** mechanism. Must show all steps stepwise. Just showing the intermediate is NOT a MECHANISM. (18 pts total, 6 pts for (a))



- (b) Give the energy diagram. You MUST show an energy position for **EVERY INTERMEDIATE** in the reaction. Label your energy diagram to match the mechanism above. (3 pts)



- (c) Write the rate law for the reaction showing the actual molecule in the reaction. (3 pts)
- (d) Show a 3D structure of the carbocation intermediate (using wedge, dash and line 3D drawing)(2 pt)
- (e) The molecule has a chiral center at the carbon attached to the OH. If the starting molecule was R Cahn Ingold Prelog orientation, after the reaction what would be the Cahn Ingold Prelog orientation of the product? Explain briefly. (2 pts)
- (f) If the reaction undergoes an elimination instead of substitution draw the expected product below. Is the product that you drew [(Zaitsev product) or (Hoffmann product)] (circle one) (2 pts)