

Sign Name Key Print Name _____
 (1 pt name above print & sign, 1 pts scantron name) (100 pts, 12 pages + scantron sheet)

Please show work on all questions for partial credit even on questions which do not specify. Please write legibly. If I cannot read your answer, I cannot grade your answer. (use back of exam for scratch paper. If you want me to grade something not in the space for the answer, clearly specify in writing. Telling me during the exam where to find the answer does not qualify because I will just vaguely remember someone telling me something during the exam not which one of 250 students told me what to grade on what page.)

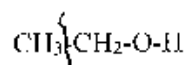
Circle answer on this form for backup to the scantron for the multiple choice. R=alkyl, not hydrogen on all parts of this exam.

1. Multiple Choice (2 pts each, 26 pts) Choose the one best statement in each question. There is no partial credit for showing work on the multiple choice questions.

1. For a mass spectrum, choose the one incorrect statement.

(a) A base peak is the tallest peak in a particular mass spectrum.

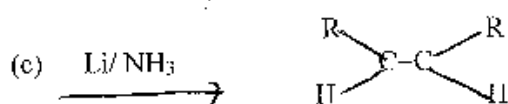
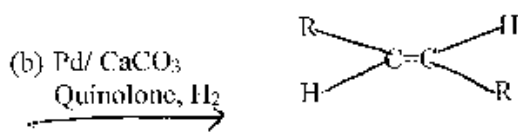
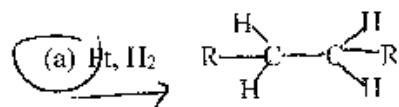
(b) An α cleavage peak for any functional group is the closest C-C bond nearest to the functional group for instance for the alcohol functional group the α cleavage line is shown below.



(c) The z in the m/z is almost always +1 so that the m/z is usually actually the mass of the molecular fragment.

(d) A base peak is the m/z peak for the entire molecule before it is fragmented.
molecular ion peak

2. Choose the best statement. $\text{R}-\text{C}\equiv\text{C}-\text{R}$ reacts with the following to give the product shown:

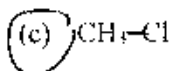
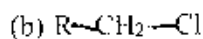
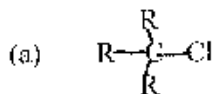


(d) All reactions are correct.

Lindlar is cis

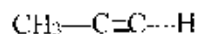
*dissolving metal
is trans*

3. For an S_N2 reaction mechanism reaction, choose the best substrate from the following substrates. (R = alkyl and not hydrogen)

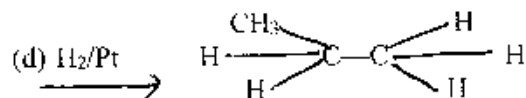
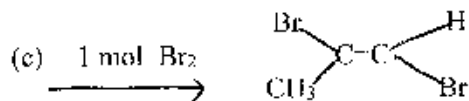
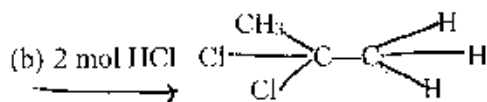
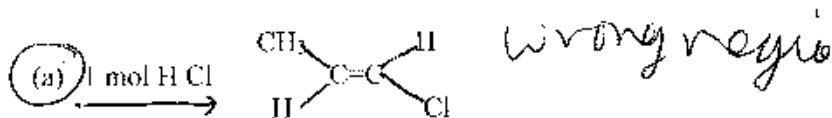


(d) All substrates are equally good substrates for the S_N2

4. Which of the following is the ~~best~~ statement for the reaction of the following molecule with each letter.

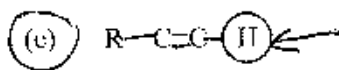
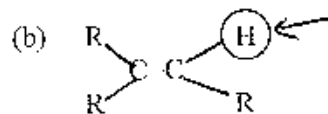
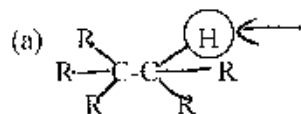


incorrect (typo) or best statement



(e) All are correct.

5. Given the following molecules, the most acidic proton, the circled proton, in the given molecule is:

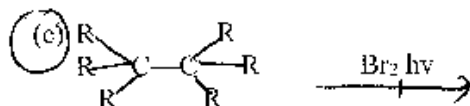
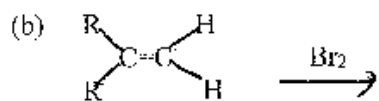
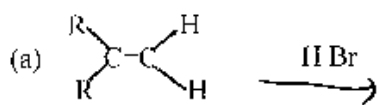


(d) All of the hydrogens are equal in acidity.

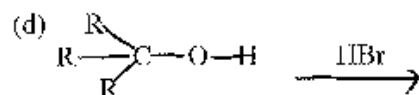
6. For reaction mechanisms which of the following are true or the best statement

- (a) E1 and E2 are both elimination reaction mechanisms which result in a substitution product.
- (b) S_N1 and S_N2 are both substitution reaction mechanism which results in an alkene product.
- (c) S_N1 and E1 reaction mechanisms have a ~~one~~ ² step reaction mechanism
- (d) S_N2 and E2 reaction mechanisms have bimolecular kinetics.
- (e) All of the above are true.

7. Which one of the following is not a synthetically useful way to make an alkyl halide? (Or which is the one best statement.)



gives mixtures



- (e) All of the above are synthetically useful ways to make an alkyl halide.

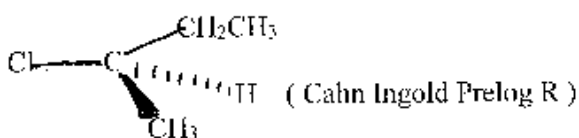
8. For elimination reactions choose the one best statement.

- (a) Both the E1 and E2 reaction mechanism result in Zaitsev's Rule products
- (b) Hoffmann's Rule products are the most stable alkene product
- (c) Zaitsev's Rule product is the least stable alkene products
- (d) All statements above are true.

9. Choose the one best statement.

- (a) alkynes are sp hybridized
- (b) alkynes consist of 2 π bonds and one σ bond
- (c) Most reactions of alkynes continue to alkanes because it is harder to break the 3rd bond to make an alkene and easier to break the 2nd bond to make an alkane.
- (d) all of the above statements are true
- (e) (a) and (b) are true

10. If the following reactant undergoes a reaction choose the best statement.



- (a) If the reaction goes by an S_N1 reaction mechanism the product will be racemic.
- (b) If the reaction goes by an S_N2 reaction mechanism the product will have Cahn Ingold Prelog S at the chiral center because the mechanism goes by inversion.
- (c) The molecule could undergo reaction by an elimination mechanism resulting in an alkene product.
- (d) All of the above statements are true.
- (e) All of the above statements are false.

11. Choose the one best statement.

- (a) If a reaction follows Markovnikov's Rule for an alkene reaction, then the alkyne reaction will follow ~~anti~~-Markovnikov's Rule.
- (b) For an alkyne, HX (X = halogen), can only be added ~~one time~~ ^{2 times} to result in an alkene.
- (c) When you add water (using H^+ and H_2O) to an Alkyne, you get no reaction.
- (d) When you add water to an Alkyne using the $Hg(OAc)_2$, you get an ~~anti~~-Markovnikov addition which then does a tautomerism

12. Given the following.

- (a) RO^- is a better nucleophile than HO^-
- (b) RO^- is a better nucleophile than ROH
- (c) HO^- is a better nucleophile than H_2O
- (d) Nucleophilicity is interaction with carbon while Basicity is interaction with hydrogen
- (e) All above statements are true.

13. Choose the best statement.

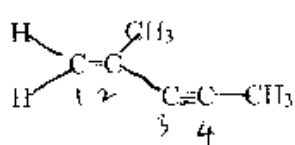
- (a) MS (mass spectrometry) uses the ~~UV-Vis~~ part of the electromagnetic spectrum to show whether the molecule has a conjugated π system in the molecule.
- (b) IR (infrared) uses the infrared part of the electromagnetic spectrum to cause molecular vibrations. The IR peaks show which functional groups are in the molecule.
- (c) NMR (nuclear magnetic spectra) uses nuclear spins in a magnetic field which when hit by the radio wave part of the electromagnetic spectrum to give information about the C, H frame of the organic molecule
- (d) UV-Vis spectra uses the electron beam to split molecules into molecular fragments which are sorted by m/z (mass / charge ratio)
- (e) (b) and (c) are correct.

Part II. Short Answers (40 pts)

A. Nomenclature: (2 pts each, 4 pts)

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

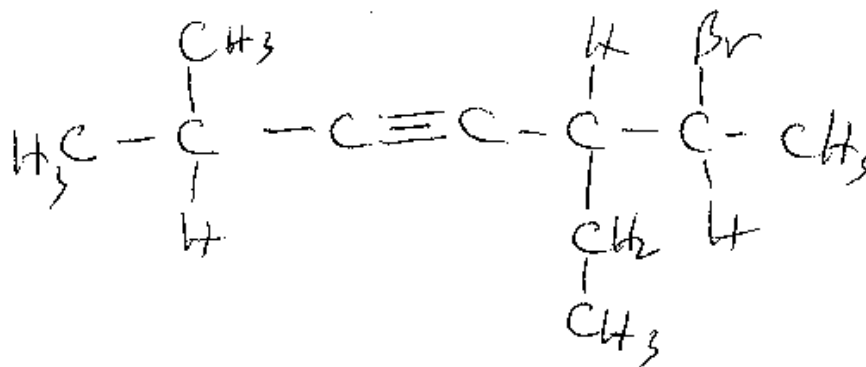
name 2-methyl pent-1-en-3-yne



pentane
1-en 3-yne
2-methyl

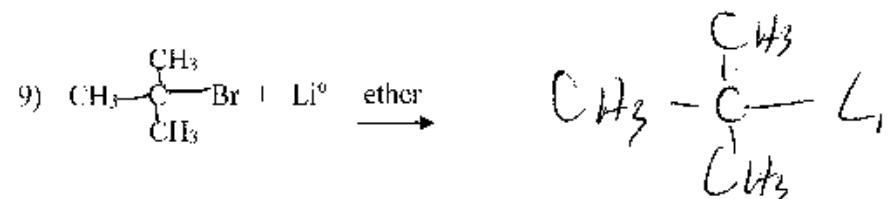
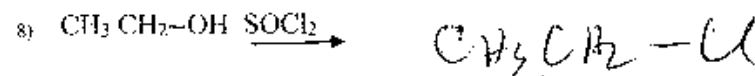
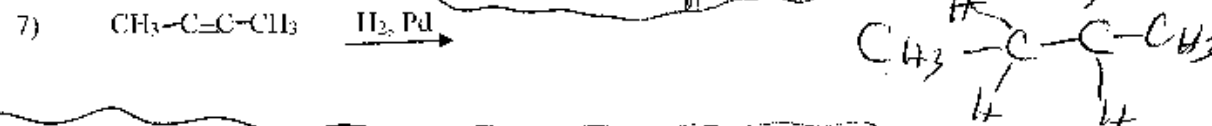
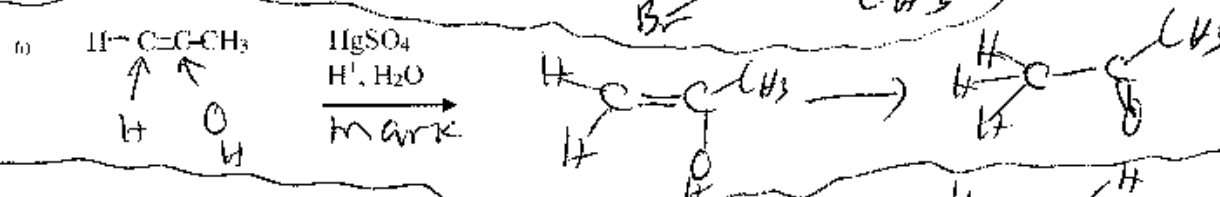
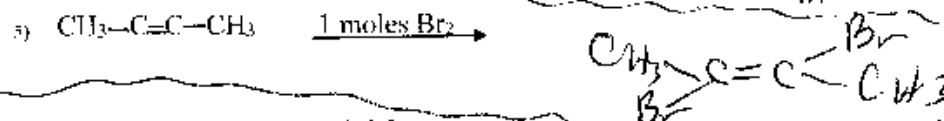
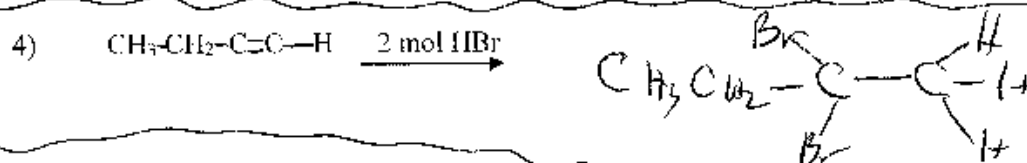
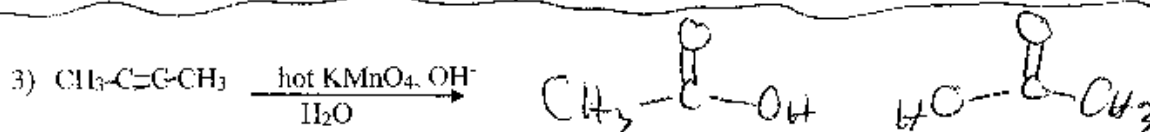
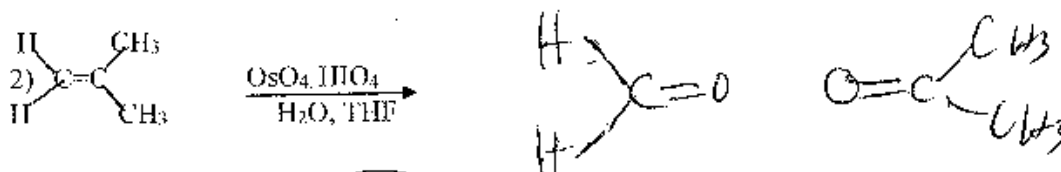
2. Given the following IUPAC name, draw a structural formula of the molecule (skeletal formula acceptable, condensed structure, Lewis Dot structure acceptable, molecular formula not acceptable - don't forget to show the hydrogens in your formula unless you are using the skeletal structure.)

6-bromo-5-ethyl-2-methyl-3-heptyne



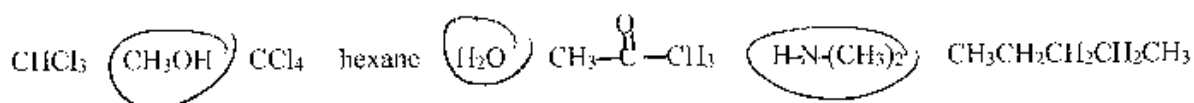
B. Reactions: Show the Organic Product for the following reactions by giving the structural formula of the product. (skeletal formula, condensed structure, Lewis Dot structure are all acceptable. Molecular Formula is not acceptable.) **DO NOT SHOW MECHANISMS.**

Circle the ~~first~~ # of the 6 reaction which you want counted. If you do not choose, I will just grade the first 6 reactions. (2 pts each, 12 pts total)

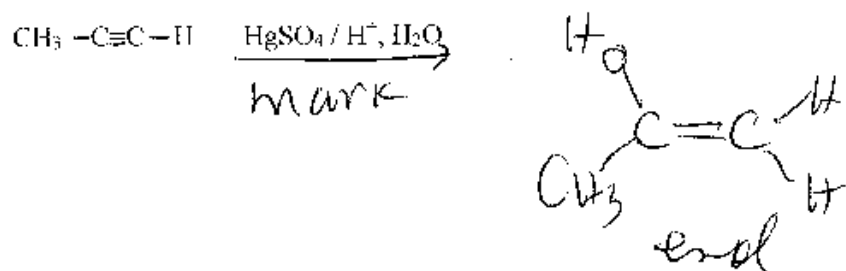


C. Short Answers part of Short Answers: (24 pts)

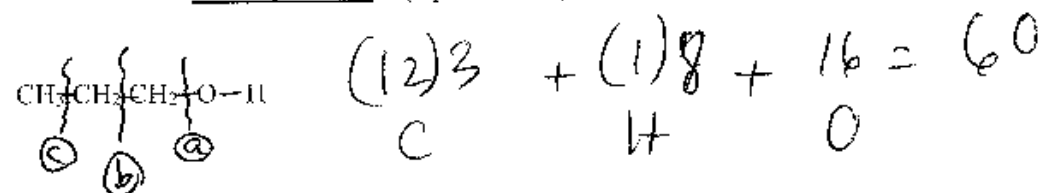
1. For the following list of solvents, **circle all** polar protic solvents (8 pts)



2. Starting with an alkyne, when you add "water" give the enol (8 pts)



2. a. Given the molecule below, **show your calculation** of the number for the **molecular ion peak** in a **mass spectrum**. (8 pts total, 4 pts)

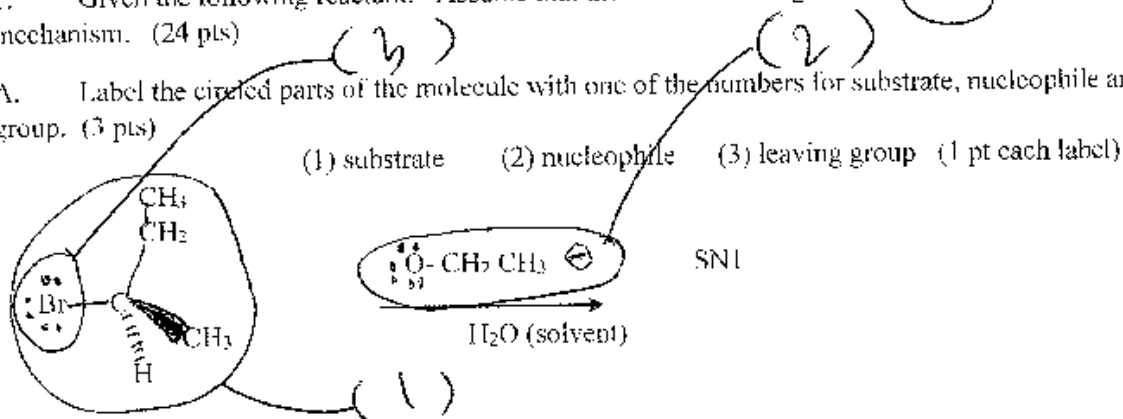


b. The correct α cleavage line from the letters given above is? b (4 pts)

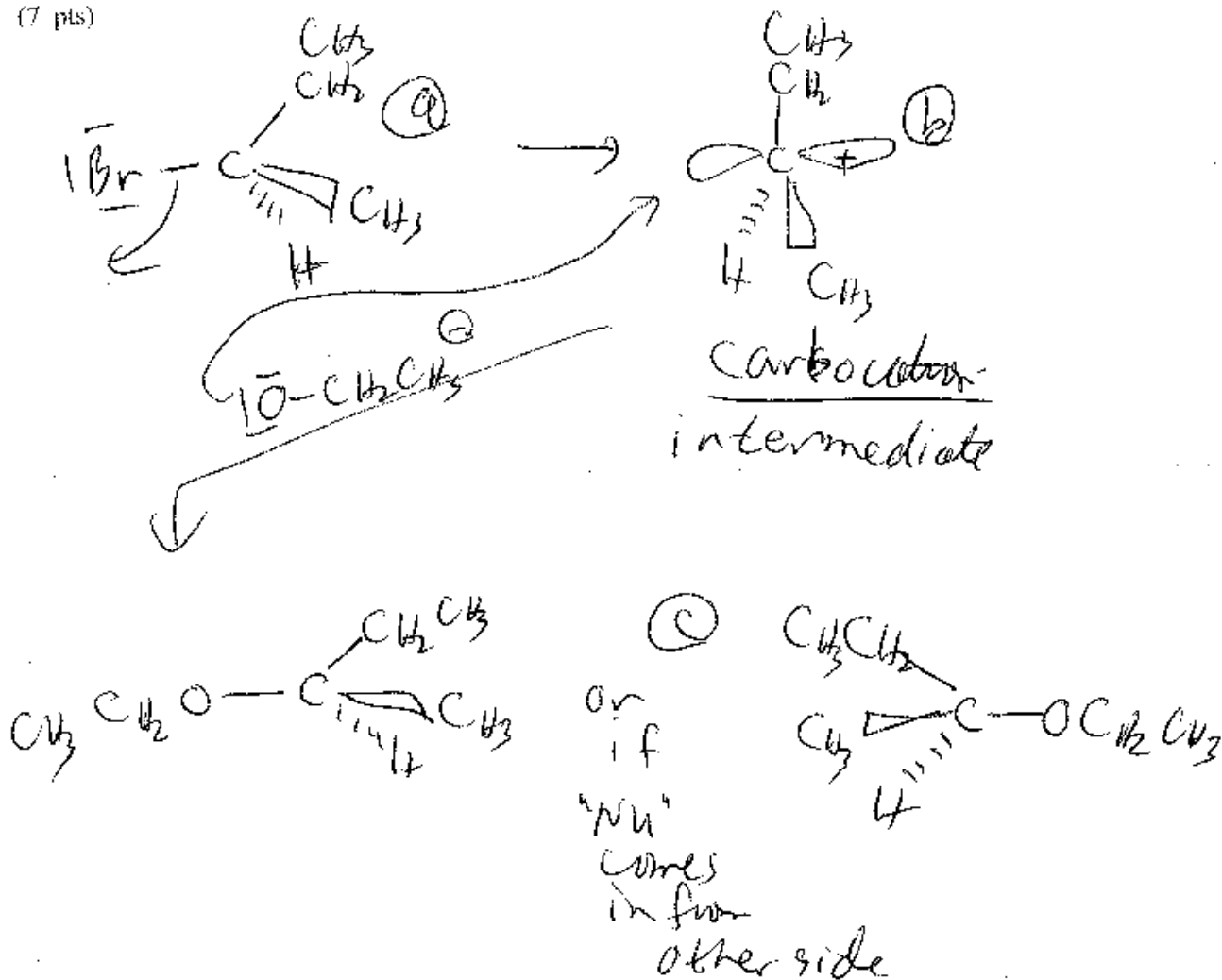
Part III. Long Answers (34 pts) Show work where applicable for partial and full credit.

1. Given the following reactant: Assume that the reaction undergoes an S_N1 reaction mechanism. (24 pts)

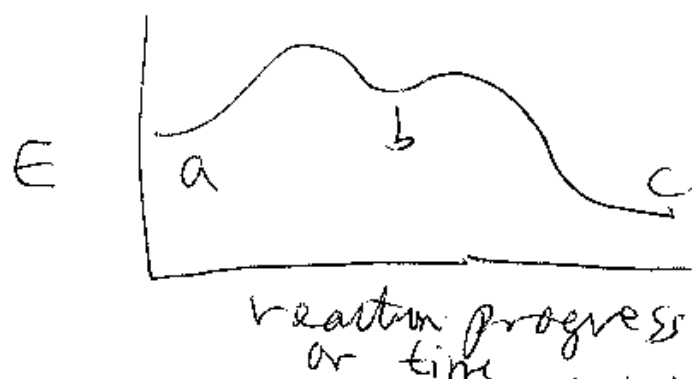
A. Label the circled parts of the molecule with one of the numbers for substrate, nucleophile and leaving group. (3 pts)



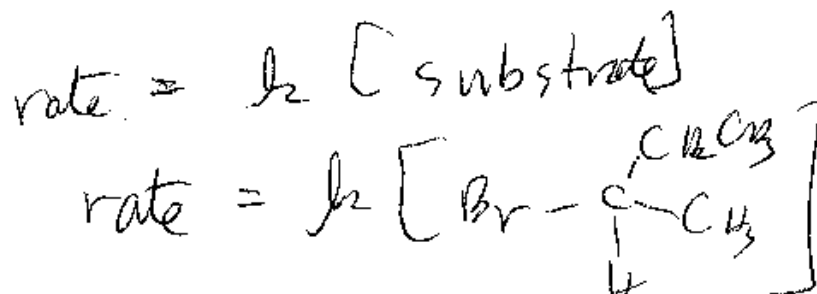
B. Please show the entire reaction mechanism including electron pushing arrows. Please show either the transition state or intermediate (depending on which is the correct one to show for the mechanism that you have) and the Organic Major Product. You do not need to show the reaction using a 3 D structure. (7 pts)



- C. Draw an energy diagram which matches the above mechanism. Label the above mechanism and then label your energy diagram to match your mechanism. (5 pts total)



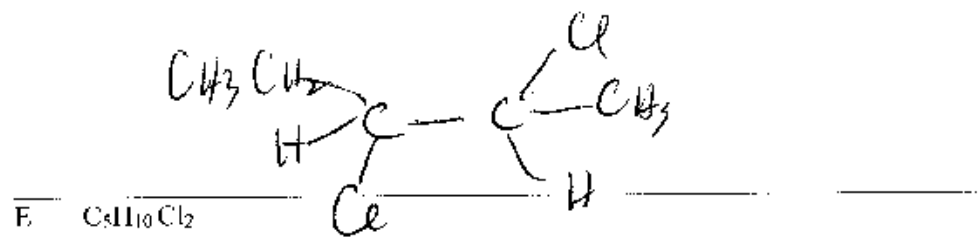
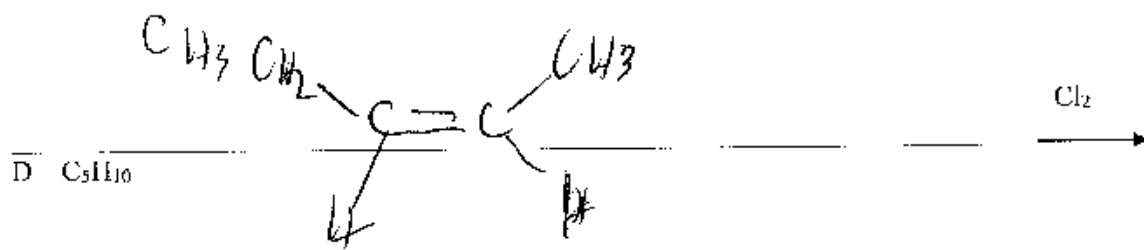
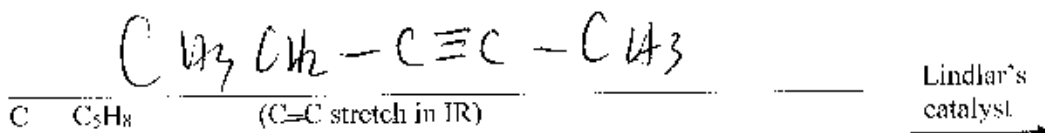
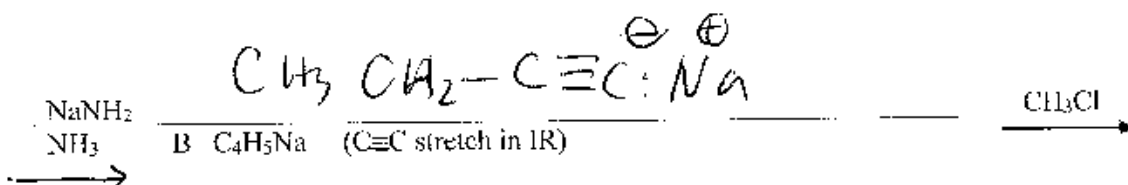
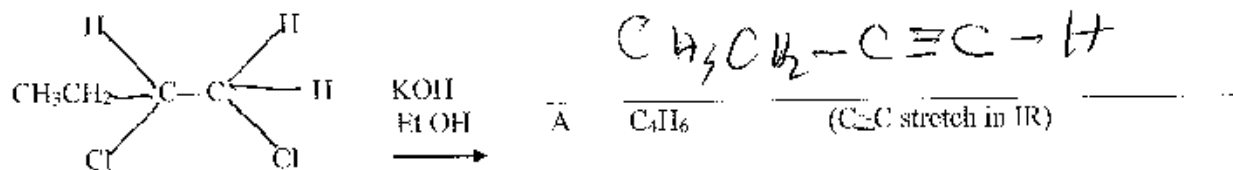
- D. Write the rate law for the reaction mechanism using the actual molecule in your reaction above. If you write the rate law using the words substrate or nucleophile, I will count off. (5 pts)



- E. If you start the reaction with chiral center (R or S) as shown, is your substitution product (R) or (S) or (racemic) (circle one) Explain in a sentence or two. (4 pts)

because the carbocation is sp^2 hybridized, the "Nu" would come in 50% retention + 50% inversion which would give a racemic product

2. Complete the following synthesis by filling in the blank. I have provided some hints to help you come up with the answers. NOTE: The way I grade this is for you to fill in reasonable molecules based on the immediate prior molecule. i.e. If you fill in part A with the wrong molecule and then do the next reaction to molecule B correctly you will get half credit for answering B correctly. If you fill in B with what you would have gotten if you got A correctly but which cannot possibly be generated from your wrong A, you will lose all credit even if it matches what you should have gotten. (There is no way that you can come up with this answer except perhaps by guessing.) (2 pts each, 10 pts total)



Sign Name Key Print Name _____

(1 pt above print & sign, 1 pt scantron name) (100 pts, 12 pages + scantron sheet)

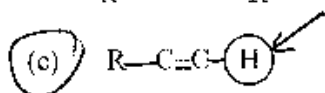
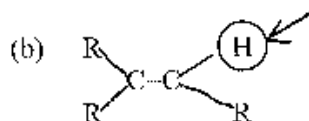
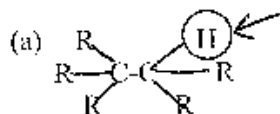
color

Please show work on all questions for partial credit even on questions which do not specify. Please write legibly. If I cannot read your answer, I cannot grade your answer. (use back of exam for scratch paper – If you want me to grade something not in the space for the answer, clearly specify in writing. Telling me during the exam where to find the answer does not qualify because I will just vaguely remember someone telling me something during the exam not which one of 250 students told me what to grade on what page.)

Circle answer on this form for backup to the scantron for the multiple choice.

I. Multiple Choice (2 pts each, 26 pts) Choose the **one** best statement in each question. There is no partial credit for showing work on the multiple choice questions.

1. Given the following molecules, the most acidic proton, the circled proton, in the given molecule is:



(d) All of the hydrogens are equal in acidity.

2. For reaction mechanisms which of the following are **true or the best statement**

(a) E1 and E2 are both elimination reaction mechanisms which result in a substitution product.

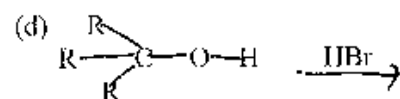
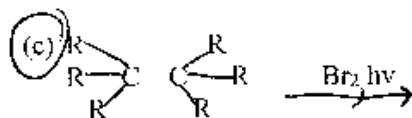
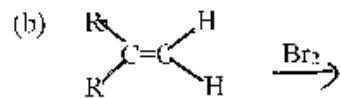
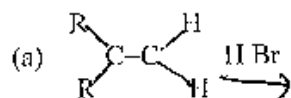
(b) S_N1 and S_N2 are both substitution reaction mechanism which results in an alkene product.

(c) S_N1 and E1 reaction mechanisms have a ~~one~~² step reaction mechanism.

(d) S_N2 and E2 reaction mechanisms have bimolecular kinetics.

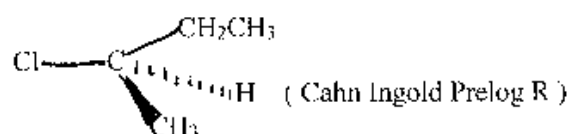
(e) All of the above are true.

3. Which one of the following is not a synthetically useful way to make an alkyl halide? (Or which is the one best statement.)



(e) All of the above are synthetically useful ways to make an alkyl halide.

4. If the following reactant undergoes a reaction choose the best statement.



(a) If the reaction goes by an $\text{S}_{\text{N}}1$ reaction mechanism the product will be racemic.

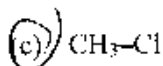
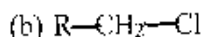
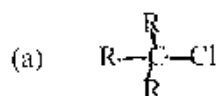
(b) If the reaction goes by an $\text{S}_{\text{N}}2$ reaction mechanism the product will have Cahn Ingold Prelog S at the chiral center because the mechanism goes by inversion.

(c) The molecule could undergo reaction by an elimination mechanism resulting in an alkene product.

(d) All of the above statements are true.

(e) All of the above statements are false.

5. For an S_N2 reaction mechanism reaction, choose the best substrate from the following substrates. (R = alkyl and not hydrogen)



(d) All substrates are equally good substrates for the S_N2

6. Given the following,

(a) RO^- is a better nucleophile than HO^-

(b) RO^- is a better nucleophile than ROH

(c) HO^- is a better nucleophile than H_2O

(d) Nucleophilicity is interaction with carbon while Basicity is interaction with hydrogen

(e) All above statements are true.

7. For elimination reactions choose the one best statement.

(a) Both the $E1$ and $E2$ reaction mechanism result in Zaitsev's Rule products

(b) Hoffmann's Rule products are the most stable alkene product

(c) Zaitsev's Rule product is the least stable alkene products

(d) All statements above are true.

8. Choose the one best statement.

(a). alkyne are sp hybridized

(b) alkynes consists of 2 π bonds and one σ bond

(c) Most reactions of alkyne continue to alkane because it is harder to break the 3rd bond to make an alkene and easier to break the 2nd bond to make an alkane.

(d) All of the above statements are true

(e) (a) and (b) are true

9. Choose the best statement.

- (a) MS (mass spectrometry) uses the UV-Vis part of the electromagnetic spectrum to show whether the molecule has a conjugated π system in the molecule.
- (b) IR (infrared) uses the infrared part of the electromagnetic spectrum to cause molecular vibrations. The IR peaks show which functional groups are in the molecule.
- (c) NMR (nuclear magnetic spectra) uses nuclear spins in a magnetic field which when hit by the radio wave part of the electromagnetic spectrum to give information about the C, H frame of the organic molecule.
- (d) UV-Vis spectra uses the electron beam to split molecules into molecular fragments which are sorted by m/z (mass / charge ratio).
- (e) (b) and (c) are correct.

10. For a mass spectrum, choose the one incorrect statement.

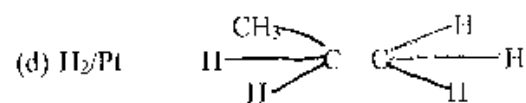
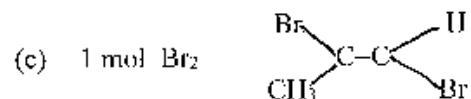
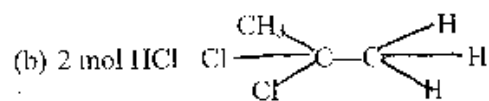
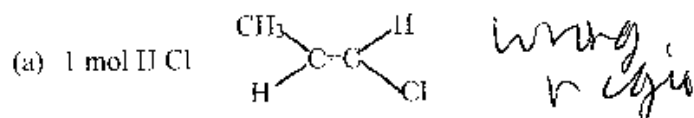
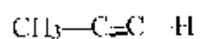
- (a) A base peak is the tallest peak in a particular mass spectrum.
- (b) A base peak is the m/z peak for the entire molecule before it is fragmented. *molecular ion*
- (c) An α cleavage peak for any functional group is the closest C-C bond nearest to the functional group for instance for the alcohol functional group the α cleavage line is shown below.
- $$\text{CH}_3\left\{\text{CH}_2\text{-O-H}\right.$$
- (d) The z in the m/z is almost always +1 so that the m/z is usually actually the mass of the molecular fragment.

11. Choose the one best statement.

- (a) If a reaction follows Markovnikov's Rule for an alkene reaction, then the alkyne reaction will follow ~~anti~~-Markovnikov's Rule.
- (b) For an alkyne, H X (X - halogen), can only be added ~~one~~ *2 + 1 time* to result in an alkene.
- (c) When you add water (using H^+ and H_2O) to an Alkyne, you get no reaction.
- (d) When you add water to an Alkyne using the $\text{Hg}(\text{OAc})_2$, you get an ~~anti~~ *504*-Markovnikov addition which then does a tautomerism.

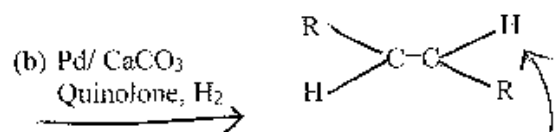
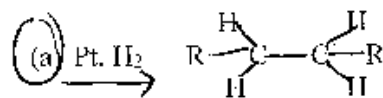
incorrect type

12. Which of the following is the ~~best~~ statement for the reaction of the following molecule with each letter.



(e) All are correct.

13. Choose the best statement. $\text{R}-\text{C}\equiv\text{C}-\text{R}$ reacts with the following to give the product shown:

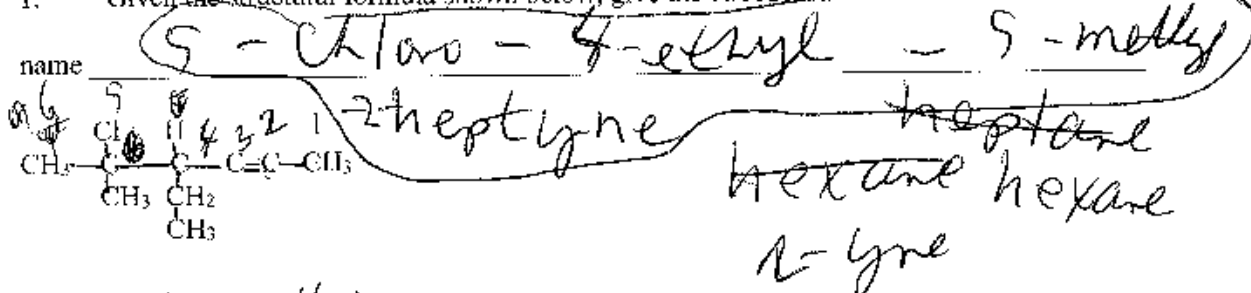


(d) All reactions are correct.

Part II. Short Answers (20 pts)

A. Nomenclature: (2 pts each, 4 pts)

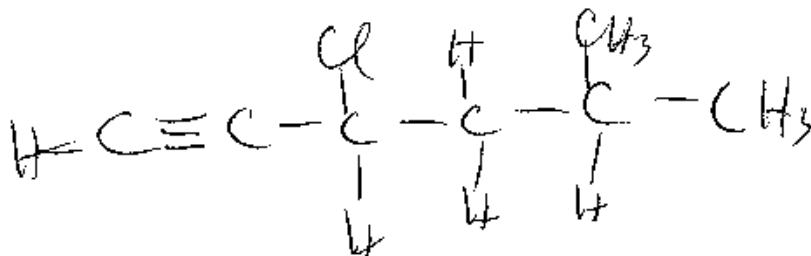
1. Given the structural formula shown below, give the IUPAC name of the molecule.



4-ethyl
5-chloro, 5-methyl

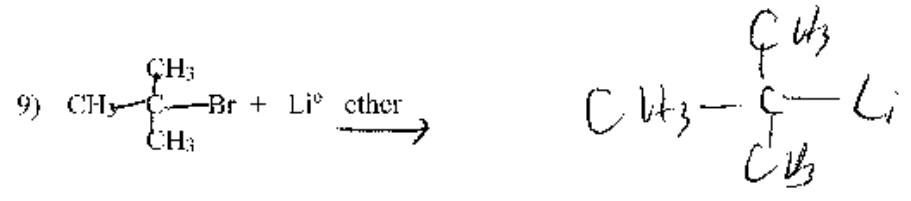
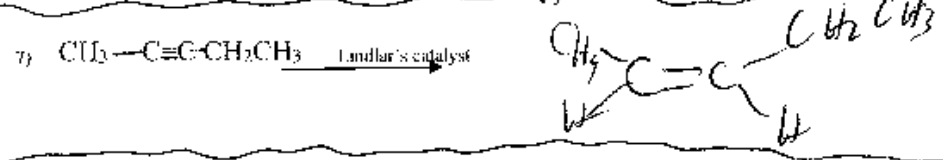
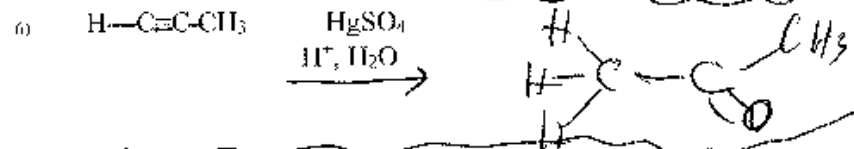
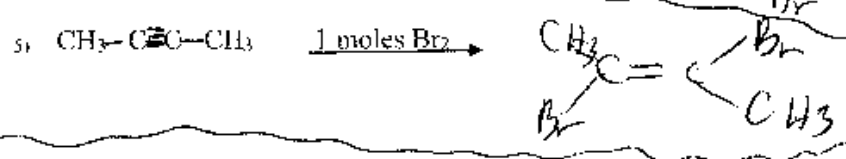
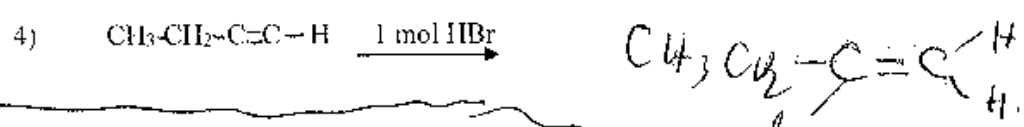
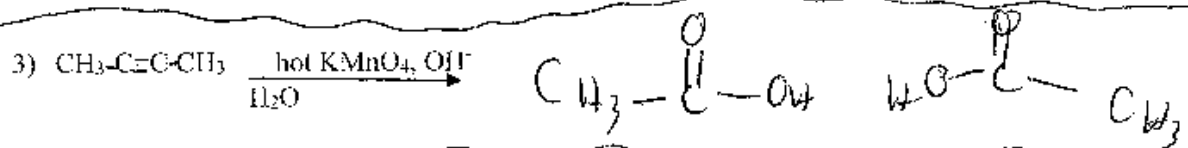
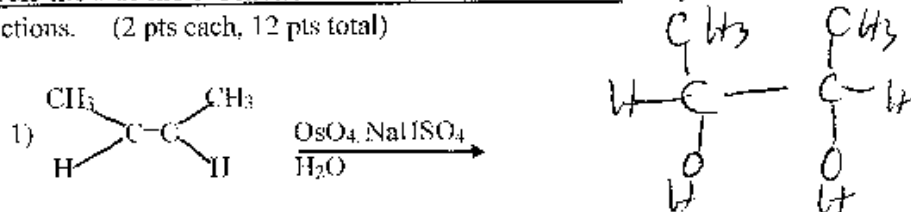
2. Given the following IUPAC name, draw a structural formula of the molecule (skeletal formula acceptable, condensed structure, Lewis Dot structure acceptable, molecular formula not acceptable - don't forget to show the hydrogens in your formula unless you are using the skeletal structure.)

3-chloro-5-methyl-1-hexyne



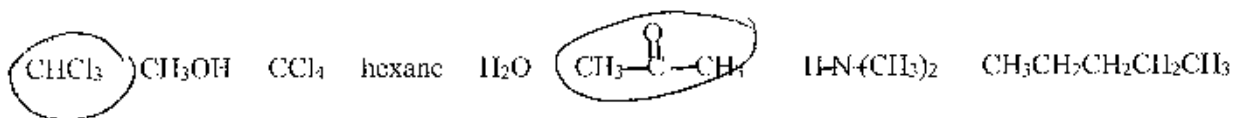
B. Reactions: Show the Organic Product for the following reactions by giving the structural formula of the product. (skeletal formula, condensed structure, Lewis Dot structure are all acceptable. Molecular formula is not acceptable.) **DO NOT SHOW MECHANISMS.**

Circle the # of the 6 reaction which you want counted. If you do not choose, I will just grade the first 6 reactions. (2 pts each, 12 pts total)

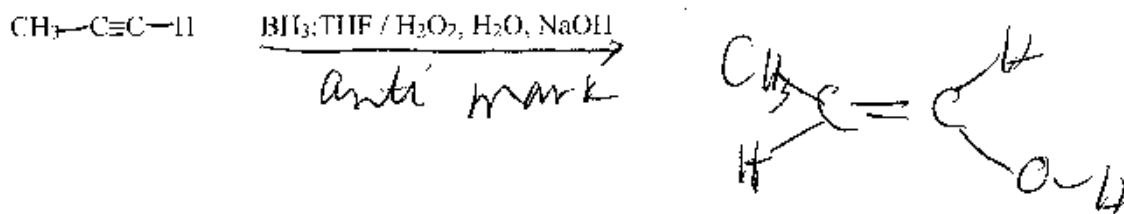


C. Short Answers part of Short Answers: (24 pts)

1. For the following list of solvents, **circle all** polar aprotic solvents (8 pts)



2. Starting with an alkyne, when you add "water" give the enol (8 pts)



2. a. Given the molecule below, **show your calculation** of the number for the **molecular ion peak** in a **mass spectrum**. (8 pts total, 4 pts)



$$(12) 9 + (1) 14 + 16 = 114$$

C H O

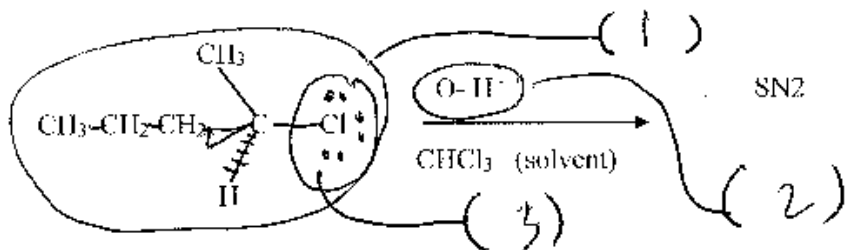
b. The correct α cleavage line from the letters given above is ? a (4 pts)

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

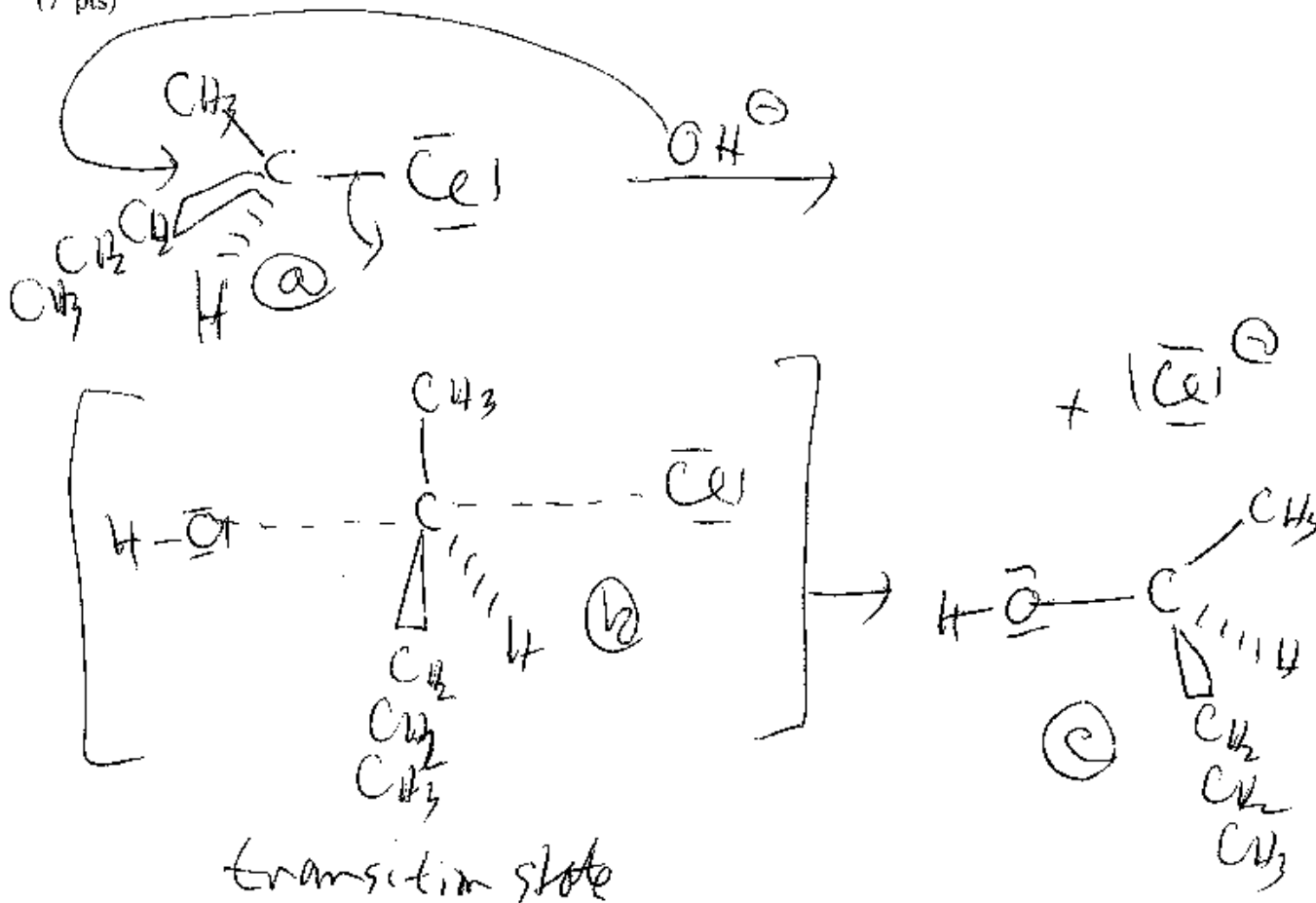
1. Given the following reactant: Assume that the reaction undergoes an **SN2** reaction mechanism. (24 pts)

A. Label the circled parts of the molecule with one of the numbers for substrate, nucleophile and leaving group. (3 pts)

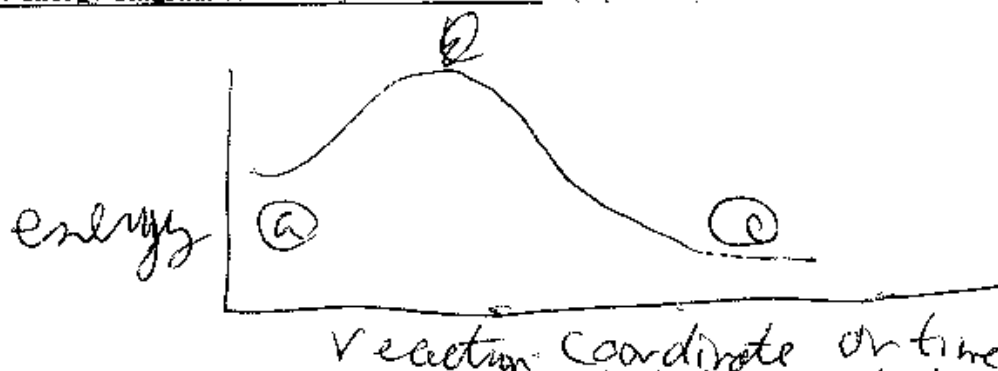
(1) substrate (2) nucleophile (3) leaving group (1 pt each label)



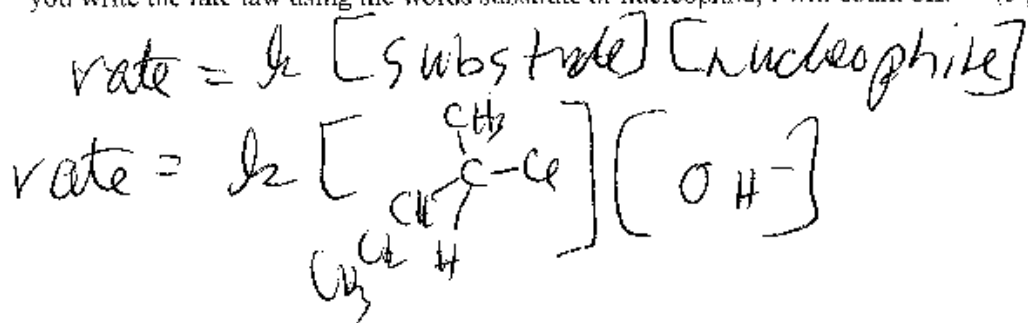
B. Please show the entire reaction mechanism including electron pushing arrows. Please show either the **transition state or intermediate** (depending on which is the correct one to show for the mechanism that you have) and the **Organic Major Product**. You do **not** need to show the reaction using a **3D structure**. (7 pts)



- C. Draw an energy diagram which matches the above mechanism. Label the above mechanism and then label your energy diagram to match your mechanism. (5 pts total)



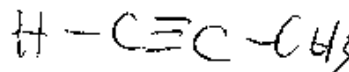
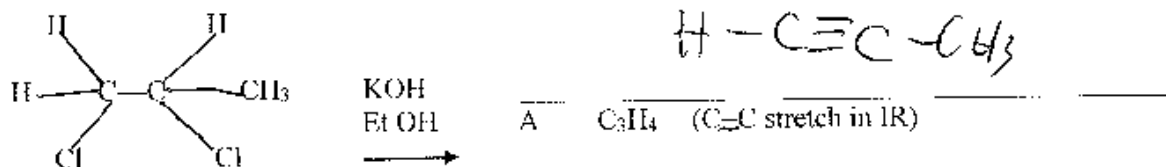
- D. Write the rate law for the reaction mechanism using the actual molecule in your reaction above. If you write the rate law using the words substrate or nucleophile, I will count off. (5 pts)



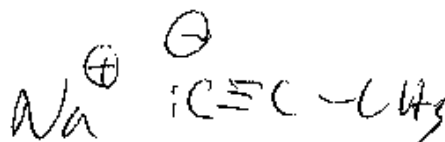
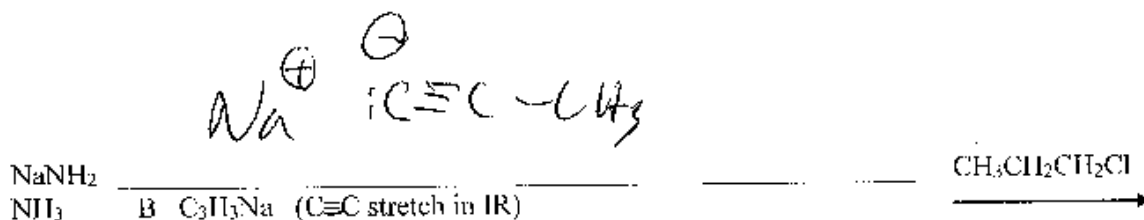
- E. If you start the reaction with chiral center (R) or (S) as shown, is your substitution product (R) or (S) or (racemic)] (circle one) Explain in a sentence or two. (4 pts)

The reaction goes with inversion, the nucleophile comes in at the same time that leaving group leaves so it would have to invert.

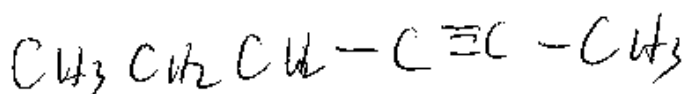
2. Complete the following synthesis by filling in the blank. I have provided some hints to help you come up with the answers. NOTE: The way I grade this is for you to fill in reasonable molecules based on the immediate prior molecule. I.e. If you fill in part A with the wrong molecule and then do the next reaction to molecule B correctly you will get half credit for answering B correctly. If you fill in B with what you would have gotten if you got A correctly but which cannot possibly be generated from your wrong A, you will lose all credit even if it matches what you should have gotten. (There is no way that you can come up with this answer except perhaps by guessing.) (2 pts each, 10 pts total)



A C_3H_4 ($\text{C} \equiv \text{C}$ stretch in IR)



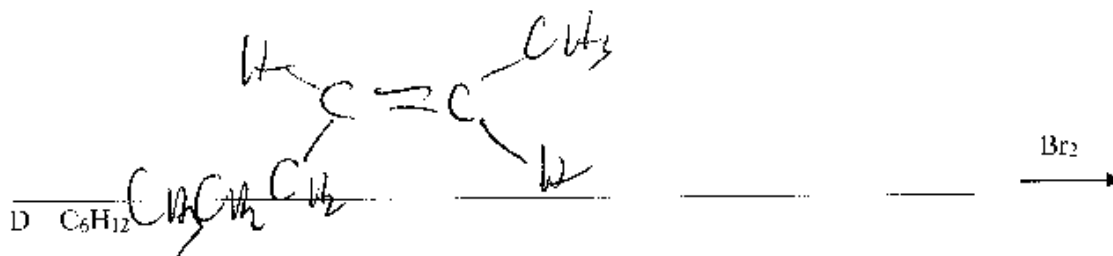
$\text{CH}_3\text{CH}_2\text{CH}_2\text{Cl}$



C C_6H_{10}

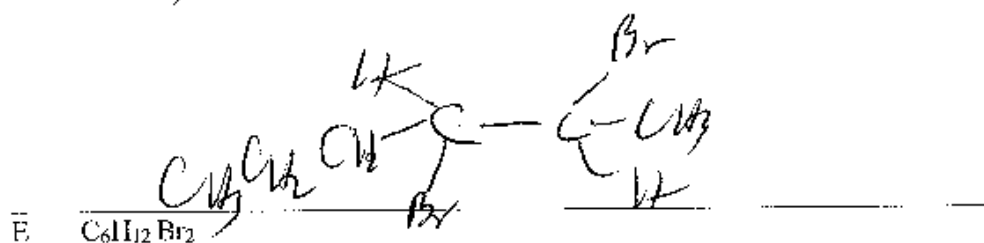
($\text{C} = \text{C}$ stretch in IR)

Na^+, NH_3



D C_6H_{12}

Br_2



E $\text{C}_6\text{H}_{12} \text{Br}_2$

Sign Name Key Print Name _____

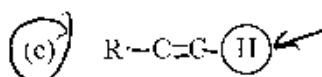
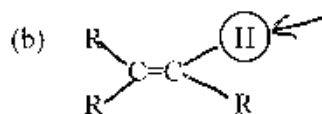
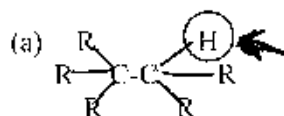
(1 pt name print & sign above 1 pts scantron name) (100 pts, 12 pages + scantron sheet)

Please show work on all questions for partial credit even on questions which do not specify. Please write legibly. If I cannot read your answer, I cannot grade your answer. (use back of exam for scratch paper – If you want me to grade something not in the space for the answer, clearly specify in writing. Telling me during the exam where to find the answer does not qualify because I will just vaguely remember someone telling me something during the exam not which one of 250 students told me what to grade on what page.)

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

I. Multiple Choice (2 pts each, 26 pts) Choose the one best statement in each question. There is no partial credit for showing work on the multiple choice questions.

1. Given the following molecules, the most acidic proton, the circled proton, in the given molecule is:



(d) All of the hydrogens are equal in acidity.

2. Choose the best statement.

(a) MS (mass spectrometry) uses the UV-Vis part of the electromagnetic spectrum to show whether the molecule has a conjugated π system in the molecule.

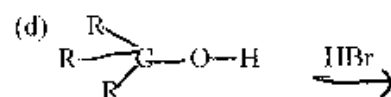
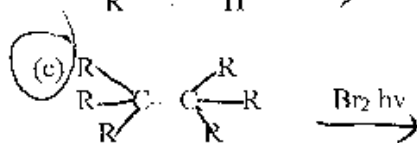
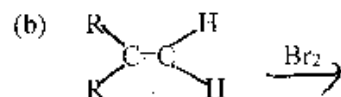
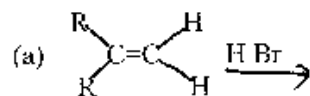
(b) IR (infrared) uses the infrared part of the electromagnetic spectrum to cause molecular vibrations. The IR peaks show which functional groups are in the molecule.

(c) NMR (nuclear magnetic spectra) uses nuclear spins in a magnetic field which when hit by the radio wave part of the electromagnetic spectrum to give information about the C, H frame of the organic molecule

(d) UV-Vis spectra uses the electron beam to split molecules into molecular fragments which are sorted by m/z (mass / charge ratio)

(e) (b) and (c) are correct.

3. Which **one** of the following is **not a, synthetically useful way** to make an alkyl halide ? (Or which is the one best statement.)



(e) All of the above are **synthetically useful** ways to make an alkyl halide.

4. For the S_N2 reaction mechanism,

(a) If you increase the concentration of the nucleophile by 2 times, the rate will increase by 2 times.

(b) If you decrease the concentration the substrate by $\frac{1}{2}$ times the rate will decrease by $\frac{1}{2}$ times.

(c) The concentration of the nucleophile has no effect on the rate.

(d) (a) and (b) are correct

(e) (a) (b) and (c) are all correct.

5. Choose the one best statement.

(a) alkynes are sp hybridized

(b) alkynes consists of 2 π bonds and one σ bond

(c) Most reactions of alkyne continue to alkane because it is harder to break the 3rd bond to make an alkene and easier to break the 2nd bond to make an alkane.

(d) All of the above statements are true

(e) (a) and (b) are true

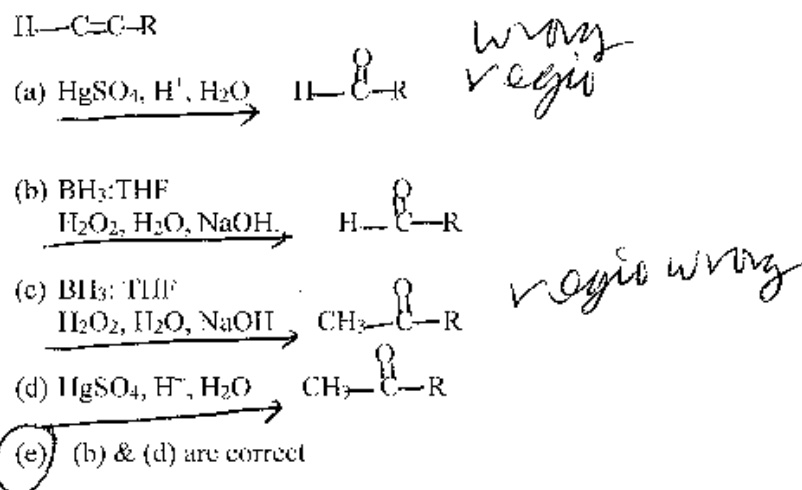
6. Choose the one best statement.

- (a) If a reaction follows Markovnikov's Rule for an alkene reaction, then the alkyne reaction will follow ~~anti~~-Markovnikov's Rule.
- (b) For an alkyne, HX (X - halogen), can only be added one time to result in an alkene.
- (c) When you add water (using H^+ and H_2O) to an Alkyne, you get no reaction.
- (d) When you add water to an Alkyne using the $Hg(OAc)_2$, you get an ~~anti~~-Markovnikov addition which then does a tautomerism

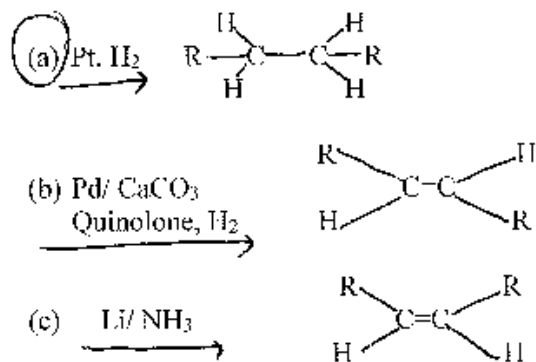
7. For elimination reactions choose the one best statement.

- (a) Both the E1 and E2 reaction mechanism result in Zaitsev's Rule products
- (b) Hoffmann's Rule products are the most stable alkene product
- (c) Zaitsev's Rule product is the least stable alkene products
- (d) All statements above are true.

8. Choose the best statement for the reaction of the molecule below with each letter.

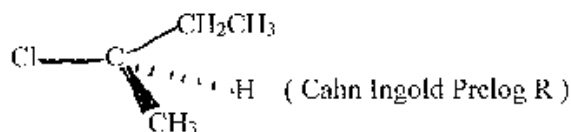


9. Choose the best statement. $R-C\equiv C-R$ reacts with the following to give the product shown:



(d) All reactions are correct.

10. If the following reactant undergoes a reaction choose the best statement.



(a) If the reaction goes by an S_N1 reaction mechanisms the product will be racemic.

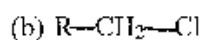
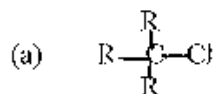
(b) If the reaction goes by an S_N2 reaction mechanism the product will have Cahn Ingold Prelog S at the chiral center because the mechanisms goes by inversion.

(c) The molecule could undergo reaction by an elimination mechanism resulting in an alkene product.

(d) All of the above statements are true.

(e) All of the above statements are false.

11. For an S_N2 reaction mechanism reaction, choose the best substrate from the following substrates. (R – alkyl and not hydrogen)



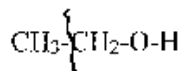
(d) All substrates are equally good substrates for the S_N2

12. Given the following,

- (a) RO^- is a better nucleophile than HO^-
- (b) RO^- is a better nucleophile than ROH
- (c) HO^- is a better nucleophile than H_2O
- (d) Nucleophilicity is interaction with carbon while Basicity is interaction with hydrogen
- (e) All above statements are true.

13. For a mass spectrum, choose the one incorrect statement.

- (a) A base peak is the tallest peak in a particular mass spectrum.
- (b) A base peak is the ~~m/z~~ *molecular ion* peak for the entire molecule before it is fragmented.
- (c) An α cleavage peak for any functional group is the closest C-C bond nearest to the functional group for instance for the alcohol functional group the α cleavage line is shown below.

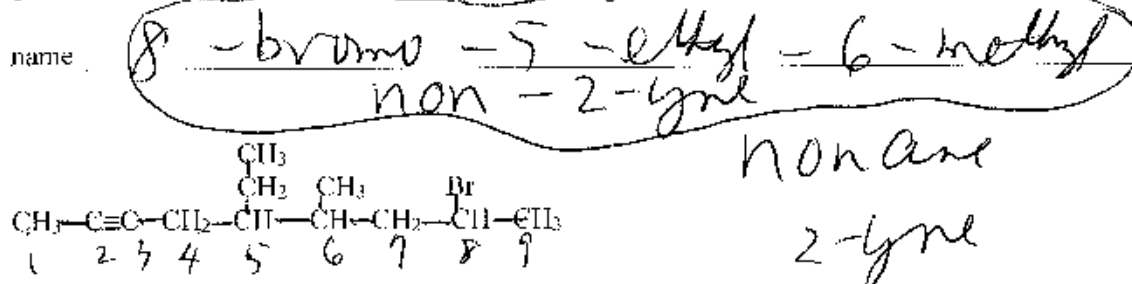


- (d) The z in the m/z is almost always +1 so that the m/z is usually actually the mass of the molecular fragment.

Part II. Short Answers (20 pts)

A. Nomenclature: (2 pts each, 4 pts)

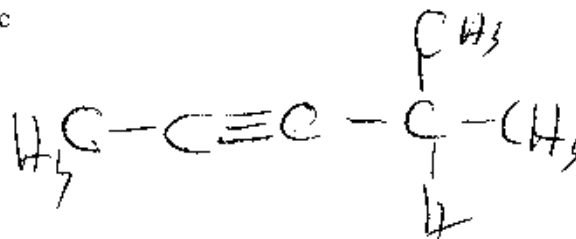
1. Given the structural formula shown below, give the IUPAC name of the molecule.



5-ethyl
6-methyl
8-bromo

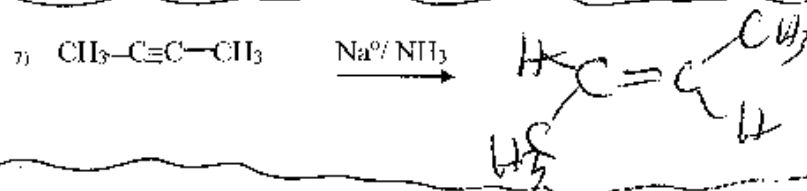
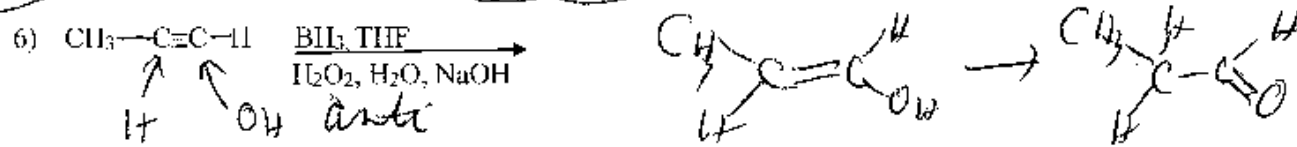
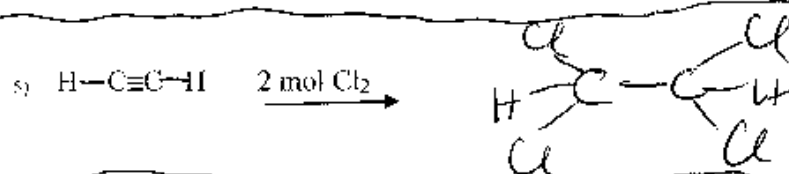
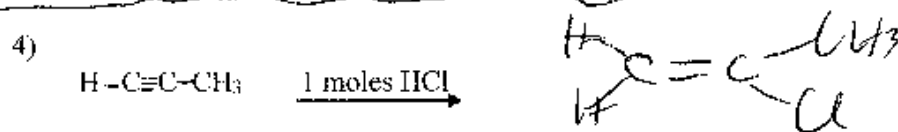
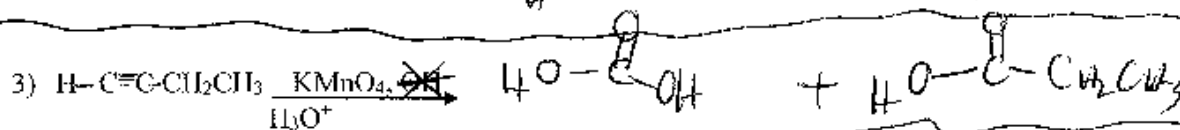
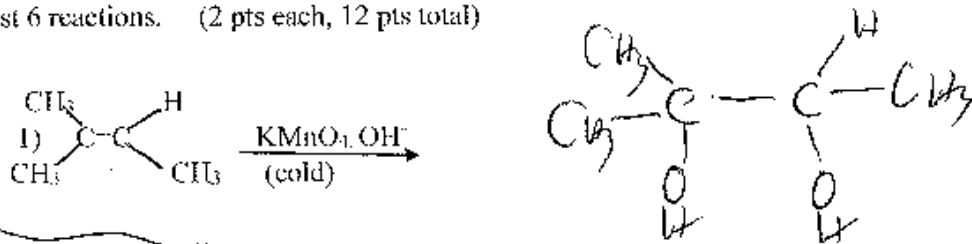
2. Given the following IUPAC name, draw a structural formula of the molecule (skeletal formula acceptable, condensed structure, Lewis Dot structure acceptable, molecular formula not acceptable - don't forget to show the hydrogens in your formula unless you are using the skeletal structure.)

4-methyl-2-pentyne



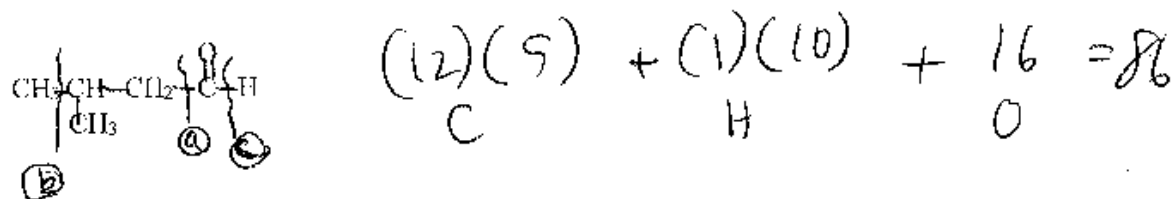
B. Reactions: Show the Organic Product for the following reactions by giving the structural formula of the product. (skeletal formula, condensed structure, Lewis Dot structure are all acceptable. Molecular Formula is not acceptable.) DO NOT SHOW MECHANISMS.

Circle the letter of the 6 reaction which you want counted. If you do not choose, I will just grade the first 6 reactions. (2 pts each, 12 pts total)



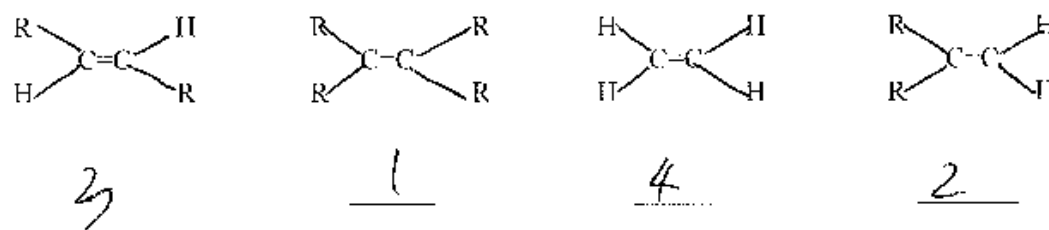
C. Short Answers part of Short Answers: (24 pts)

1. a. Given the molecule below, show your calculation of the number for the molecular ion peak in a mass spectrum. (8 pts total, 4 pts)



b. Given the lines shown, which is the letter of the α cleavage line? a (4 pts)

2. Put the following molecules in order from the most stable (1) to the least stable (4) alkene. (8 pts)



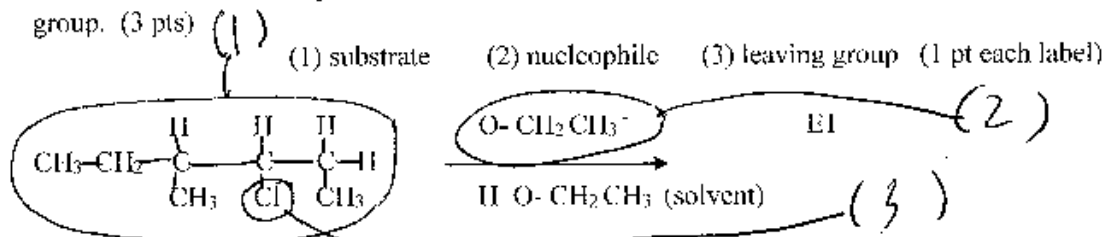
3. Answer the following by circling one, to as many as all of the reactions mechanisms under each letter. (8 pts. 2 pts each letter)

- a. A tertiary substrate is best for [(S_N2), (S_N1), (E2), (E1)] (circle all correct mechanism)
- b. A strong nucleophile or higher concentration nucleophile favors [(S_N2), (S_N1), (E2), (E1)] (circle all correct mechanism)
- c. A polar aprotic solvent favors [(S_N2), (S_N1), (E2), (E1)] (circle all correct mechanism)
- d. A strong bulky base but weak nucleophile favors [(S_N2), (S_N1), (E2), (E1)] (circle all correct mechanism)

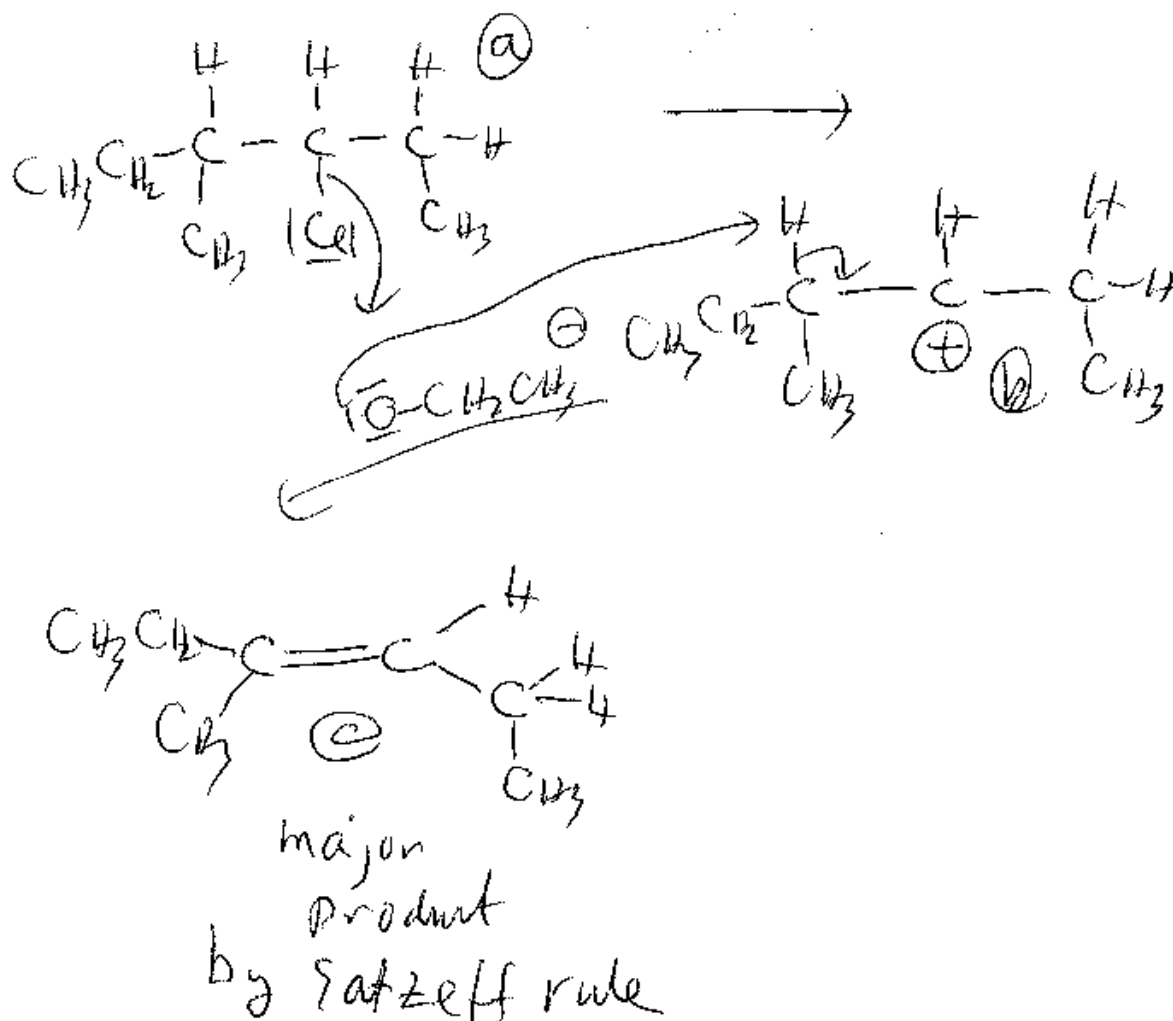
Part III. Long Answers (34 pts) Show work where applicable for partial and full credit.

1. Given the following reactant: Assume that the reaction undergoes an **E1** reaction mechanism. (24 pts)

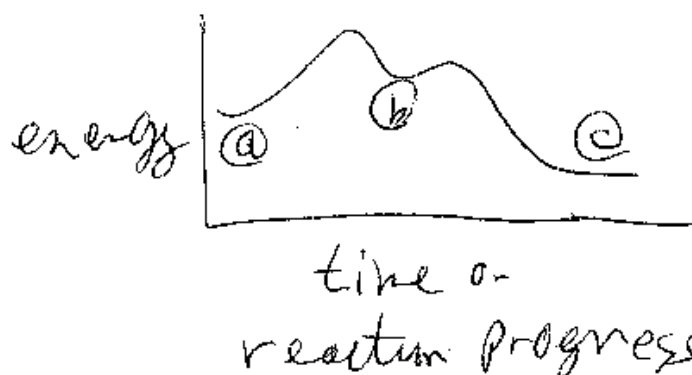
A. Label the circled parts of the molecule with one of the numbers for substrate, nucleophile and leaving group. (3 pts)



B. Please show the entire reaction mechanism including electron pushing arrows. Please show either the **transition state or intermediate** (depending on which is the correct one to show for the mechanism that you have) and the **Organic Major Product**. You do **not** need to show the reaction using a **3 D structure**. (7 pts)

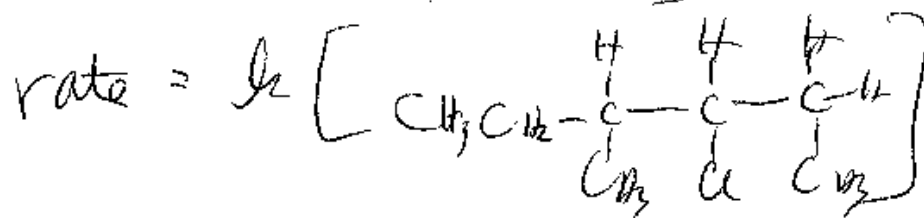


- C. Draw an energy diagram which matches the above mechanism. Label the above mechanism and then label your energy diagram to match your mechanism. (5 pts total)

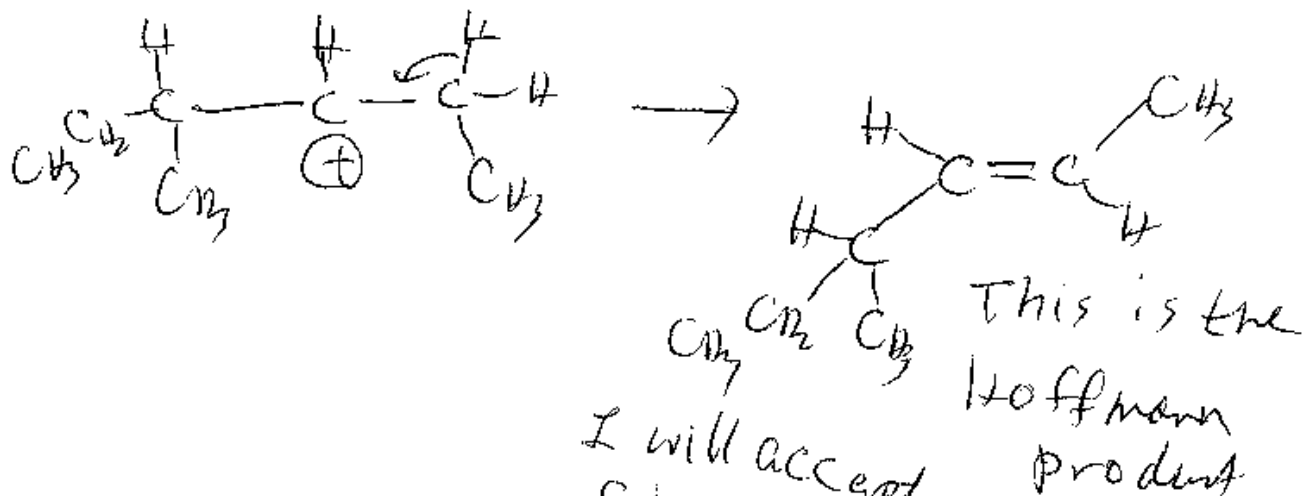


- D. Write the rate law for the reaction mechanism using the actual molecule in your reaction above. If you write the rate law using the words substrate or nucleophile, I will count off. (5 pts)

$$\text{rate} = k [\text{substrate}]$$

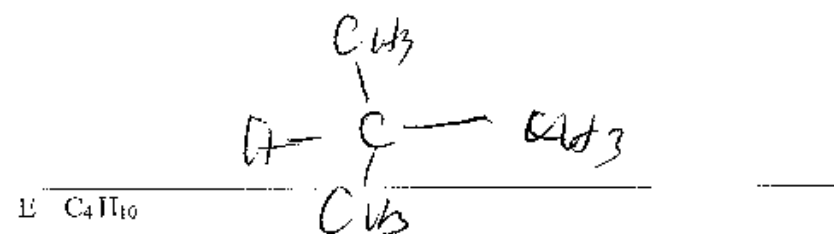
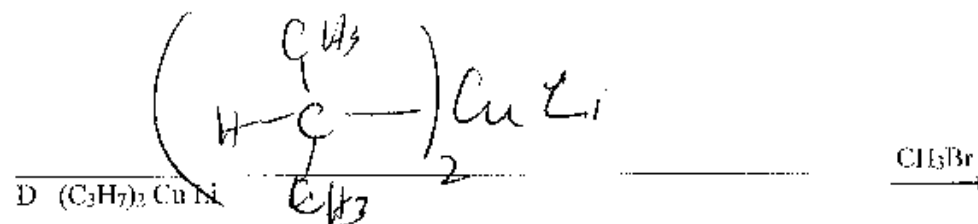
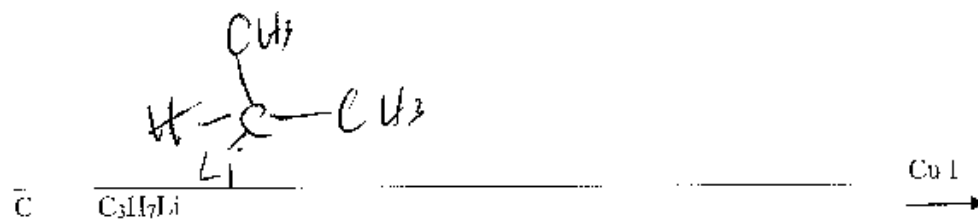
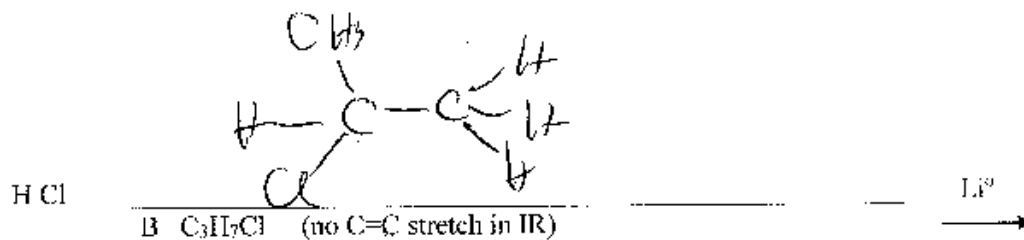
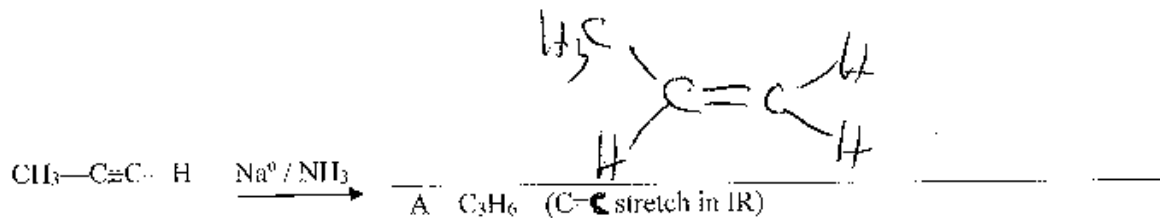


- E. If you showed the major product in part (A), what is the other possible regioisomer. Explain briefly why your product (which you showed in part B) is the major product. (4 pts)



I will accept cis product although this is more likely bc more stable

2. Complete the following synthesis by filling in the blank. I have provided some hints to help you come up with the answers. NOTE: The way I grade this is for you to fill in reasonable molecules based on the immediate prior molecule. i.e. If you fill in part A with the wrong molecule and then do the next reaction to molecule B correctly you will get half credit for answering B correctly. If you fill in B with what you would have gotten if you got A correctly but which cannot possibly be generated from your wrong A, you will lose all credit even if it matches what you should have gotten. (There is no way that you can come up with this answer except perhaps by guessing.) (2 pts each, 10 pts total)



Sign Name _____ Print Name _____
 (1 pt name above print & sign, 1 pts scantron name) (100 pts, 11 pages + scantron sheet)

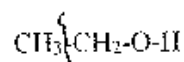
Please show work on all questions for partial credit even on questions which do not specify. Please write legibly. If I cannot read your answer, I cannot grade your answer. (use back of exam for scratch paper. If you want me to grade something not in the space for the answer, clearly specify in writing. Telling me during the exam where to find the answer does not qualify because I will just vaguely remember someone telling me something during the exam not which one of 250 students told me what to grade on what page.)

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

1. Multiple Choice (2 pts each, 26 pts) Choose the one best statement in each question. There is no partial credit for showing work on the multiple choice questions.

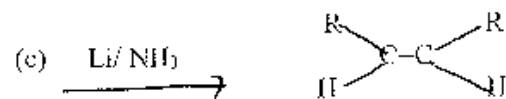
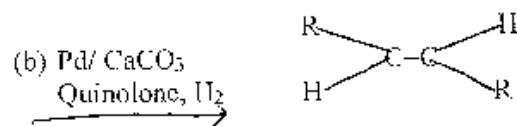
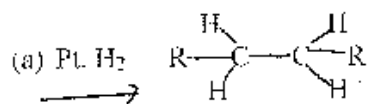
1. For a mass spectrum, choose the one incorrect statement.

- (a) A base peak is the tallest peak in a particular mass spectrum.
 (b) An α cleavage peak for any functional group is the closest C-C bond nearest to the functional group for instance for the alcohol functional group the α cleavage line is shown below.



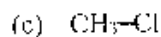
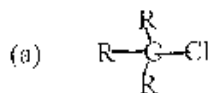
- (c) The z in the m/z is almost always -1 so that the m/z is usually actually the mass of the molecular fragment.
 (d) A base peak is the m/z peak for the entire molecule before it is fragmented.

2. Choose the best statement. $\text{R}-\text{C}\equiv\text{C}-\text{R}$ reacts with the following to give the product shown:



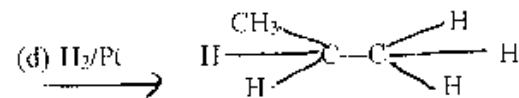
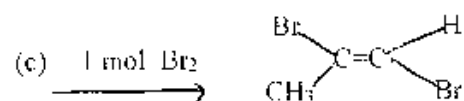
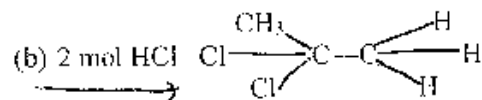
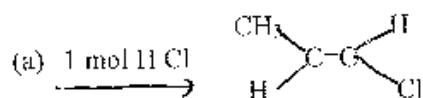
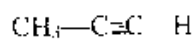
(d) All reactions are correct.

3. For an S_N2 reaction mechanism reaction, choose the best substrate from the following substrates. (R = alkyl and not hydrogen)



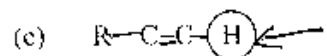
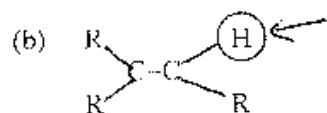
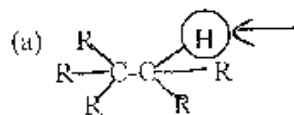
(d) All substrates are equally good substrates for the S_N2

4. Which of the following is the best statement for the reaction of the following molecule with each letter.



(e) All are correct.

5. Given the following molecules, the most acidic proton, the circled proton, in the given molecule is:

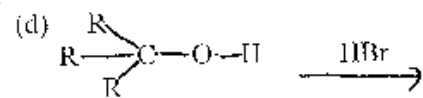
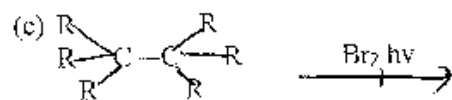
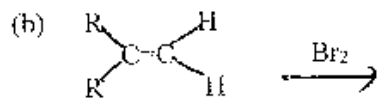
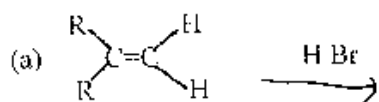


(d) All of the hydrogens are equal in acidity.

6. For reaction mechanisms which of the following are **true or the best statement**

- (a) E1 and E2 are both elimination reaction mechanisms which result in a substitution product.
- (b) S_N1 and S_N2 are both substitution reaction mechanism which results in an alkene product.
- (c) S_N1 and E1 reaction mechanisms have a one step reaction mechanism
- (d) S_N2 and E2 reaction mechanisms have bimolecular kinetics.
- (e) All of the above are true.

7. Which **one** of the following is **not a synthetically useful way** to make an alkyl halide ? (Or which is the one best statement.)



- (e) All of the above are **synthetically useful** ways to make an alkyl halide.

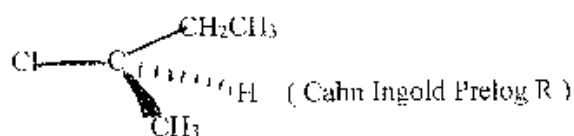
8. For elimination reactions choose the one best statement.

- (a) Both the E1 and E2 reaction mechanism result in Zaitsev's Rule products
- (b) Hoffmann's Rule products are the most stable alkene product
- (c) Zaitsev's Rule product is the least stable alkene products
- (d) All statements above are true.

9. Choose the one best statement.

- (a). alkynes are sp hybridized
- (b) alkynes consist of 2 π bonds and one σ bond
- (c) Most reactions of alkynes continue to alkanes because it is harder to break the 3rd bond to make an alkene and easier to break the 2nd bond to make an alkane.
- (d) all of the above statements are true
- (e) (a) and (b) are true

10. If the following reactant undergoes a reaction choose the best statement.



- (a) If the reaction goes by an S_N1 reaction mechanism the product will be racemic.
- (b) If the reaction goes by an S_N2 reaction mechanism the product will have Cahn Ingold Prelog S at the chiral center because the mechanism goes by inversion.
- (c) The molecule could undergo reaction by an elimination mechanism resulting in an alkene product.
- (d) All of the above statements are true.
- (e) All of the above statements are false.

11. Choose the one best statement.

- (a) If a reaction follows Markovnikov's Rule for an alkene reaction, then the alkyne reaction will follow anti-Markovnikov's Rule.
- (b) For an alkyne, HX ($X = \text{halogen}$), can only be added once to result in an alkene.
- (c) When you add water (using H^+ and H_2O) to an Alkyne, you get no reaction.
- (d) When you add water to an Alkyne using the $Hg(OAc)_2$, you get an anti-Markovnikov addition which then does a tautomerism

12. Given the following,

- (a) RO^- is a better nucleophile than HO^-
- (b) RO^- is a better nucleophile than ROH
- (c) HO^- is a better nucleophile than H_2O
- (d) Nucleophilicity is interaction with carbon while Basicity is interaction with hydrogen
- (e) All above statements are true.

13. Choose the best statement.

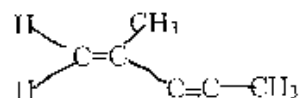
- (a) MS (mass spectrometry) uses the UV-Vis part of the electromagnetic spectrum to show whether the molecule has a conjugated π system in the molecule.
- (b) IR (infrared) uses the infrared part of the electromagnetic spectrum to cause molecular vibrations. The IR peaks show which functional groups are in the molecule.
- (c) NMR (nuclear magnetic spectra) uses nuclear spins in a magnetic field which when hit by the radio wave part of the electromagnetic spectrum to give information about the C, H frame of the organic molecule
- (d) UV-Vis spectra uses the electron beam to split molecules into molecular fragments which are sorted by m/z (mass / charge ratio)
- (e) (b) and (c) are correct.

Part II. Short Answers (40 pts)

A. Nomenclature: (2 pts each, 4 pts)

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

name _____

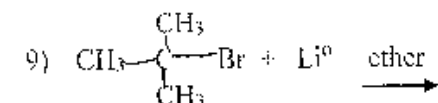
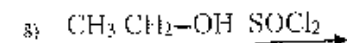
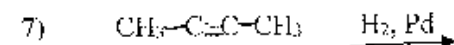
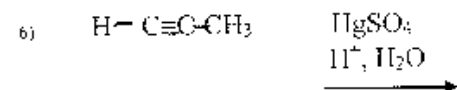
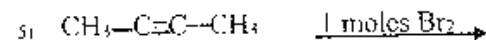
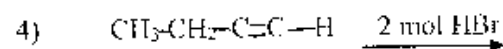
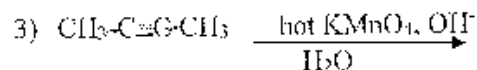
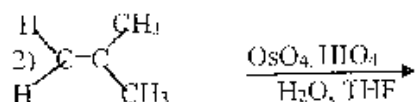
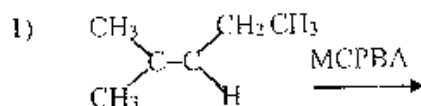


2. Given the following IUPAC name, draw a structural formula of the molecule (skeletal formula acceptable, condensed structure, Lewis Dot structure acceptable, molecular formula not acceptable - don't forget to show the hydrogens in your formula unless you are using the skeletal structure.)

6-bromo-5-ethyl-2-methyl-3-heptyne

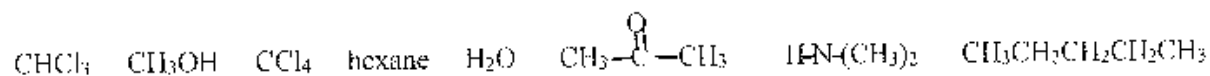
B. Reactions: Show the Organic Product for the following reactions by giving the structural formula of the product. (skeletal formula, condensed structure, Lewis Dot structure are all acceptable. Molecular formula is not acceptable.) DO **NOT** SHOW MECHANISMS.

Circle the ~~first~~[#] of the 6 reaction which you want counted. If you do not choose, I will just grade the first 6 reactions. (2 pts each, 12 pts total)

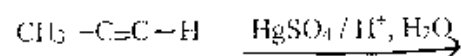


C. Short Answers part of Short Answers: (24 pts)

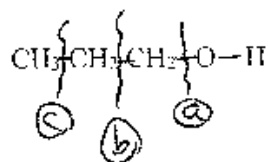
1. For the following list of solvents, **circle all** polar protic solvents (8 pts)



2. Starting with an alkyne, when you add "water" give the enol (8 pts)



2. a. Given the molecule below, **show your calculation** of the number for the **molecular ion peak** in a **mass spectrum**. (8 pts total, 4 pts)

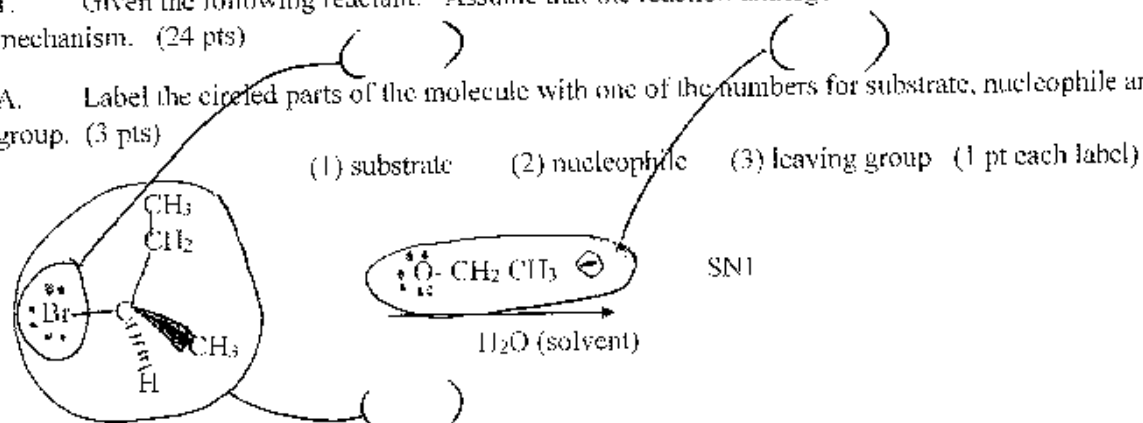


b. The correct α cleavage line from the letters given above is ? _____ (4 pts)

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

I. Given the following reactant: Assume that the reaction undergoes an S_N1 reaction mechanism. (24 pts)

A. Label the circled parts of the molecule with one of the numbers for substrate, nucleophile and leaving group. (3 pts)



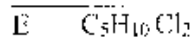
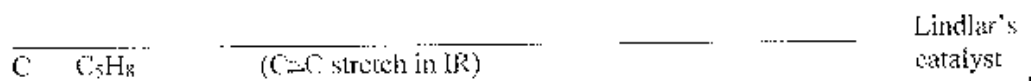
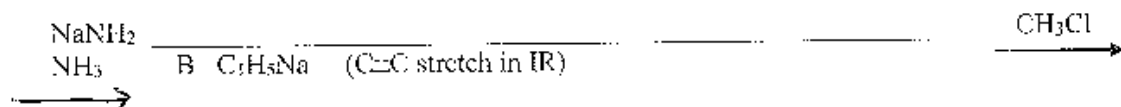
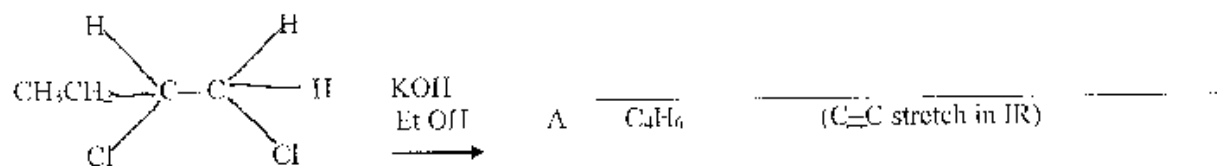
B. Please show the entire reaction mechanism including electron pushing arrows. Please show either the transition state or intermediate (depending on which is the correct one to show for the mechanism that you have) and the Organic Major Product. You do not need to show the reaction using a 3 D structure. (7 pts)

C. Draw an energy diagram which matches the above mechanism. Label the above mechanism and then label your energy diagram to match your mechanism. (5 pts total)

D. Write the rate law for the reaction mechanism using the actual molecule in your reaction above. If you write the rate law using the words substrate or nucleophile, I will count off. (5 pts)

E. If you start the reaction with chiral center (R or S) as shown, is your substitution product [(R) or (S) or (racemic)] (circle one) Explain in a sentence or two. (4 pts)

2. Complete the following synthesis by filling in the blank. I have provided some hints to help you come up with the answers. **NOTE:** The way I grade this is for you to fill in reasonable molecules based on the immediate prior molecule. i.e. If you fill in part A with the wrong molecule and then do the next reaction to molecule B correctly you will get half credit for answering B correctly. If you fill in B with what you would have gotten if you got A correctly but which cannot possibly be generated from your wrong A, you will lose all credit even if it matches what you should have gotten. (There is no way that you can come up with this answer except perhaps by guessing.) (2 pts each, 10 pts total)



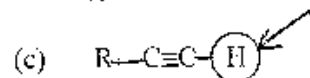
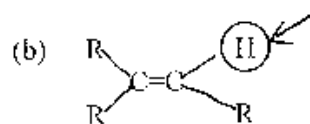
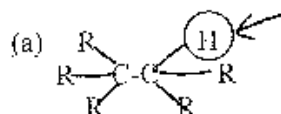
Sign Name _____ Print Name _____
 (1 pt above print & sign, 1 pt scantron name) (100 pts, 12 pages + scantron sheet) *color*

Please show work on all questions for partial credit even on questions which do not specify. Please write legibly. If I cannot read your answer, I cannot grade your answer. (use back of exam for scratch paper - If you want me to grade something not in the space for the answer, clearly specify in writing. Telling me during the exam where to find the answer does not qualify because I will just vaguely remember someone telling me something during the exam not which one of 250 students told me what to grade on what page.)

Circle answer on this form for backup to the scantron for the multiple choice.

I. Multiple Choice (2 pts each, 26 pts) Choose the **one** best statement in each question. There is no partial credit for showing work on the multiple choice questions.

1. Given the following molecules, the most acidic proton, the circled proton, in the given molecule is:



(d) All of the hydrogens are equal in acidity.

2. For reaction mechanisms which of the following are **true or the best statement**

(a) E1 and E2 are both elimination reaction mechanisms which result in a substitution product.

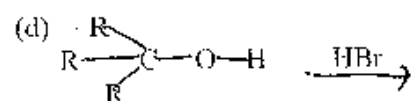
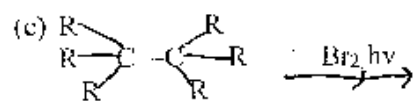
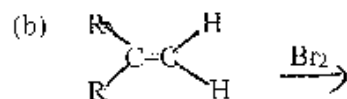
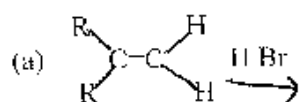
(b) S_N1 and S_N2 are both substitution reaction mechanism which results in an alkene product.

(c) S_N1 and E1 reaction mechanisms have a one step reaction mechanism

(d) S_N2 and E2 reaction mechanisms have bimolecular kinetics.

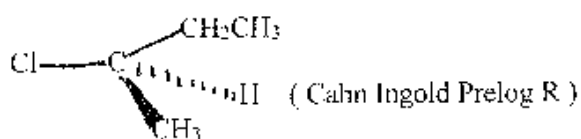
(e) All of the above are true.

3. Which **one** of the following is **not a synthetically useful way** to make an alkyl halide? (Or which is the one best statement.)



(e) All of the above are **synthetically useful** ways to make an alkyl halide.

4. If the following reactant undergoes a reaction choose the best statement.



(a) If the reaction goes by an S_N1 reaction mechanisms the product will be racemic.

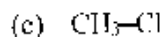
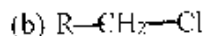
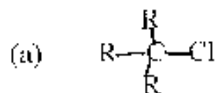
(b) If the reaction goes by an S_N2 reaction mechanism the product will have Cahn Ingold Prelog S at the chiral center because the mechanisms goes by inversion.

(c) The molecule could undergo reaction by an elimination mechanism resulting in an alkene product.

(d) All of the above statements are true.

(e) All of the above statements are false.

5. For an S_N2 reaction mechanism reaction, choose the best substrate from the following substrates. (R = alkyl and not hydrogen)



(d) All substrates are equally good substrates for the S_N2

6. Given the following,

(a) RO^- is a better nucleophile than HO^-

(b) RO^- is a better nucleophile than ROH

(c) HO^- is a better nucleophile than H_2O

(d) Nucleophilicity is interaction with carbon while Basicity is interaction with hydrogen

(e) All above statements are true.

7. For elimination reactions choose the one best statement.

(a) Both the $E1$ and $E2$ reaction mechanism result in Zaitsev's Rule products

(b) Hoffmann's Rule products are the most stable alkene product

(c) Zaitsev's Rule product is the least stable alkene products

(d) All statements above are true.

8. Choose the one best statement.

(a) alkyne are sp hybridized

(b) alkynes consists of 2 π bonds and one σ bond

(c) Most reactions of alkyne continue to alkane because it is harder to break the 3rd bond to make an alkene and easier to break the 2nd bond to make an alkane.

(d) all of the above statements are true

(e) (a) and (b) are true

9. Choose the best statement.

- (a) MS (mass spectrometry) uses the UV-Vis part of the electromagnetic spectrum to show whether the molecule has a conjugated π system in the molecule.
- (b) IR (infrared) uses the infrared part of the electromagnetic spectrum to cause molecular vibrations. The IR peaks show which functional groups are in the molecule.
- (c) NMR (nuclear magnetic spectra) uses nuclear spins in a magnetic field which when hit by the radio wave part of the electromagnetic spectrum to give information about the C, H frame of the organic molecule
- (d) UV-Vis spectra uses the electron beam to split molecules into molecular fragments which are sorted by m/z (mass / charge ratio)
- (e) (b) and (c) are correct.

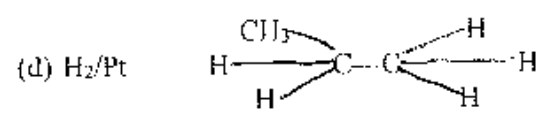
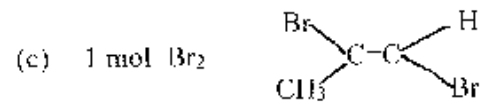
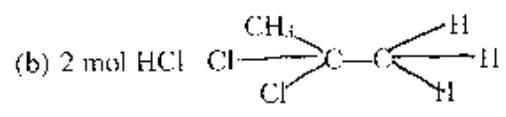
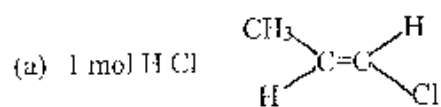
10. For a mass spectrum, choose the one incorrect statement.

- (a) A base peak is the tallest peak in a particular mass spectrum.
- (b) A base peak is the m/z peak for the entire molecule before it is fragmented.
- (c) An α cleavage peak for any functional group is the closest C-C bond nearest to the functional group for instance for the alcohol functional group the α cleavage line is shown below.
$$\text{CH}_3 \left\{ \text{CH}_2\text{-O-H} \right.$$
- (d) The z in the m/z is almost always +1 so that the m/z is usually actually the mass of the molecular fragment.

11. Choose the one best statement.

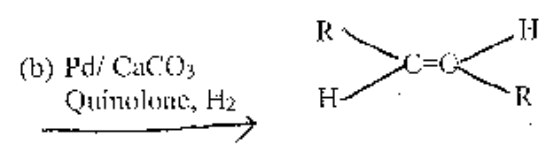
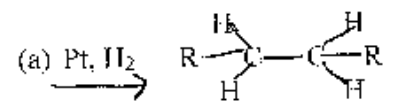
- (a) If a reaction follows Markovnikov's Rule for an alkene reaction, then the alkyne reaction will follow anti-Markovnikov's Rule.
- (b) For an alkyne, 11 X (X = halogen), can only be added one time to result in an alkene.
- (c) When you add water (using H^+ and H_2O) to an Alkyne, you get no reaction.
- (d) When you add water to an Alkyne using the $\text{Hg}(\text{OAc})_2$, you get an anti-Markovnikov addition which then does a tautomerism

12. Which of the following is the best statement for the reaction of the following molecule with each letter.



(e) All are correct.

13. Choose the best statement. R-C≡C-R reacts with the following to give the product shown:



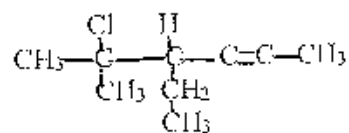
(d) All reactions are correct.

Part II. Short Answers (20 pts)

A. Nomenclature: (2 pts each, 4 pts)

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

name _____

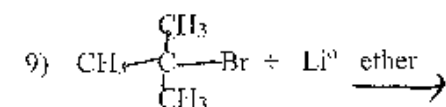
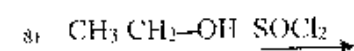
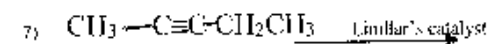
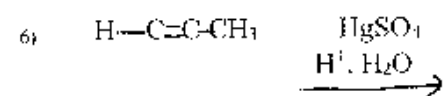
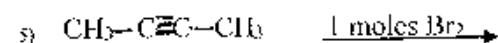
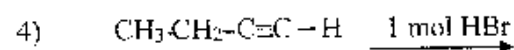
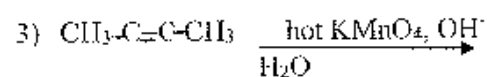
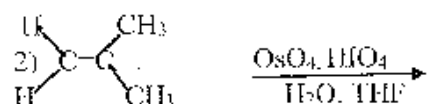
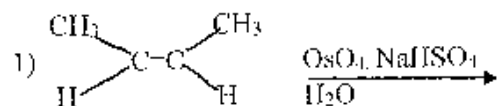


2. Given the following IUPAC name, draw a structural formula of the molecule (skeletal formula acceptable, condensed structure, Lewis Dot structure acceptable, molecular formula not acceptable - don't forget to show the hydrogens in your formula unless you are using the skeletal structure.)

3-chloro-5-methyl-1-hexyne

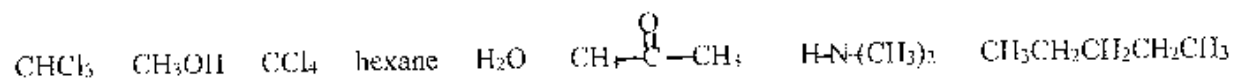
B. Reactions: Show the Organic Product for the following reactions by giving the structural formula of the product. (skeletal formula, condensed structure, Lewis Dot structure are all acceptable. Molecular Formula is not acceptable.) DO **NOT** SHOW MECHANISMS.

Circle the # of the 6 reaction which you want counted. If you do not choose, I will just grade the first 6 reactions. (2 pts each, 12 pts total)

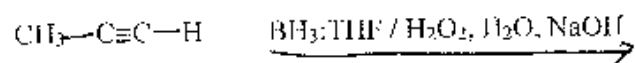


C. Short Answers part of Short Answers: (24 pts)

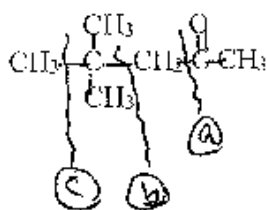
1. For the following list of solvents, **circle all** polar aprotic solvents (8 pts)



2. Starting with an alkyne, when you add "water" give the enol (8 pts)



2. a. Given the molecule below, **show your calculation** of the number for the **molecular ion peak** in a **mass spectrum**. (8 pts total, 4 pts)



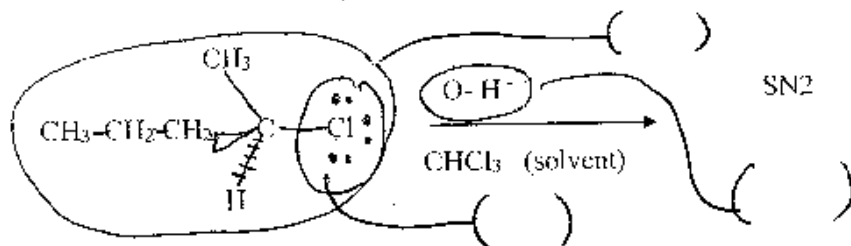
b. The correct α cleavage line from the letters given above is ? _____ (4 pts)

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

1. Given the following reactant: Assume that the reaction undergoes an S_N2 reaction mechanism. (24 pts)

A. Label the circled parts of the molecule with one of the numbers for substrate, nucleophile and leaving group. (3 pts)

(1) substrate (2) nucleophile (3) leaving group (1 pt each label)



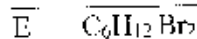
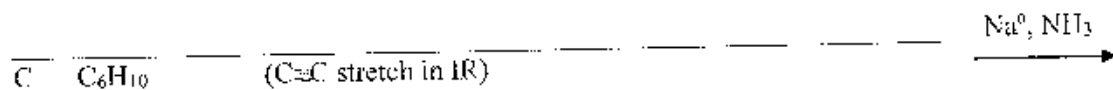
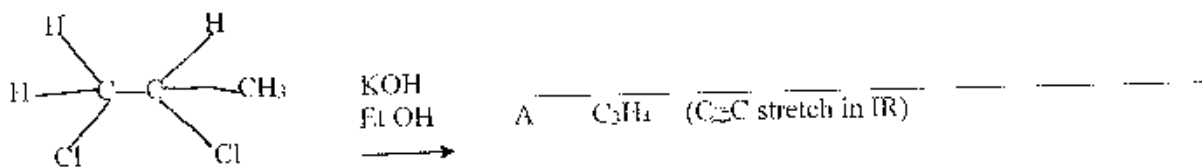
B. Please show the entire reaction mechanism including electron pushing arrows. Please show either the transition state or intermediate (depending on which is the correct one to show for the mechanism that you have) and the Organic Major Product. You do not need to show the reaction using a 3 D structure. (7 pts)

C. Draw an energy diagram which matches the above mechanism. Label the above mechanism and then label your energy diagram to match your mechanism. (5 pts total)

D. Write the rate law for the reaction mechanism using the actual molecule in your reaction above. If you write the rate law using the words substrate or nucleophile, I will count off. (5 pts)

E. If you start the reaction with chiral center (R or S) as shown, is your substitution product [(R) or (S) or (racemic)] (circle one) Explain in a sentence or two. (4 pts)

2. Complete the following synthesis by filling in the blank. I have provided some hints to help you come up with the answers. **NOTE:** The way I grade this is for you to fill in reasonable molecules based on the immediate prior molecule. i.e. If you fill in part A with the wrong molecule and then do the next reaction to molecule B correctly you will get half credit for answering B correctly. If you fill in B with what you would have gotten if you got A correctly but which cannot possibly be generated from your wrong A, you will lose all credit even if it matches what you should have gotten. (There is no way that you can come up with this answer except perhaps by guessing.) (2 pts each, 10 pts total)



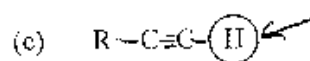
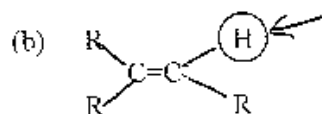
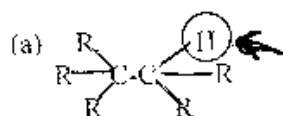
Sign Name _____ Print Name _____
 (1 pt name print & sign above, 1 pts scantron name) (100 pts, 12 pages + scantron sheet)

Please show work on all questions for partial credit even on questions which do not specify. Please write legibly. If I cannot read your answer, I cannot grade your answer. (use back of exam for scratch paper – If you want me to grade something not in the space for the answer, clearly specify in writing. Telling me during the exam where to find the answer does not qualify because I will just vaguely remember someone telling me something during the exam not which one of 250 students told me what to grade on what page.)

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

1. Multiple Choice (2 pts each, 26 pts) Choose the one best statement in each question. There is no partial credit for showing work on the multiple choice questions.

1. Given the following molecules, the most acidic proton, the circled proton, in the given molecule is:

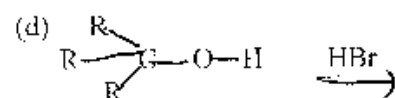
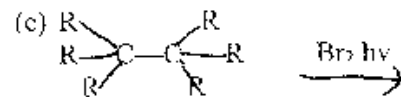
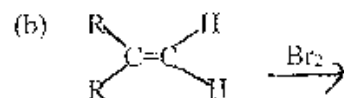
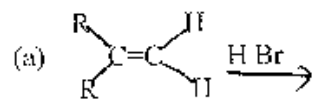


(d) All of the hydrogens are equal in acidity.

2. Choose the best statement.

- (a) MS (mass spectrometry) uses the UV-Vis part of the electromagnetic spectrum to show whether the molecule has a conjugated π system in the molecule.
- (b) IR (infrared) uses the infrared part of the electromagnetic spectrum to cause molecular vibrations. The IR peaks show which functional groups are in the molecule.
- (c) NMR (nuclear magnetic spectra) uses nuclear spins in a magnetic field which when hit by the radio wave part of the electromagnetic spectrum to give information about the C, H frame of the organic molecule
- (d) UV-Vis spectra uses the electron beam to split molecules into molecular fragments which are sorted by m/z (mass / charge ratio)
- (e) (b) and (c) are correct.

3. Which **one** of the following is **not a synthetically useful way** to make an alkyl halide? (Or which is the one best statement.)



(e) All of the above are **synthetically useful** ways to make an alkyl halide.

4. For the S_N2 reaction mechanism.

- (a) If you increase the concentration of the nucleophile by 2 times, the rate will increase by 2 times.
- (b) If you decrease the concentration the substrate by $\frac{1}{2}$ times the rate will decrease by $\frac{1}{2}$ times.
- (c) The concentration of the nucleophile has no effect on the rate.
- (d) (a) and (b) are correct
- (e) (a) (b) and (c) are all correct.

5. Choose the one best statement.

- (a). alkyne are sp hybridized
- (b) alkynes consists of 2 π bonds and one σ bond
- (c) Most reactions of alkyne continue to alkane because it is harder to break the 3rd bond to make an alkene and easier to break the 2nd bond to make an alkane.
- (d) all of the above statements are true
- (e) (a) and (b) are true

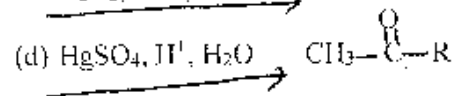
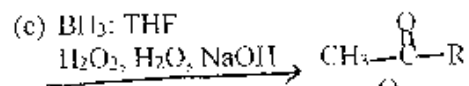
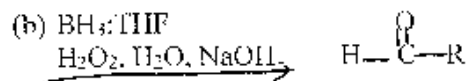
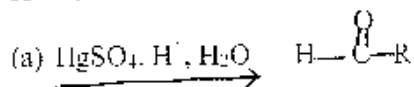
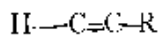
6. Choose the one best statement.

- (a) If a reaction follows Markovnikov's Rule for an alkene reaction, then the alkyne reaction will follow anti-Markovnikov's Rule.
- (b) For an alkyne, HX (X = halogen), can only be added one time to result in an alkene.
- (c) When you add water (using H^+ and H_2O) to an Alkyne, you get no reaction.
- (d) When you add water to an Alkyne using the $Hg(OAc)_2$, you get an anti-Markovnikov addition which then does a tautomerism

7. For elimination reactions choose the one best statement.

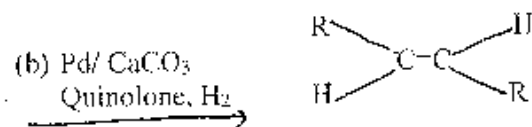
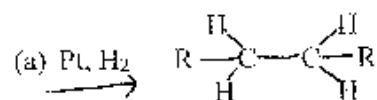
- (a) Both the E1 and E2 reaction mechanism result in Zaitsev's Rule products
- (b) Hoffmann's Rule products are the most stable alkene product
- (c) Zaitsev's Rule product is the least stable alkene products
- (d) All statements above are true.

8. Choose the best statement for the reaction of the molecule below with each letter.



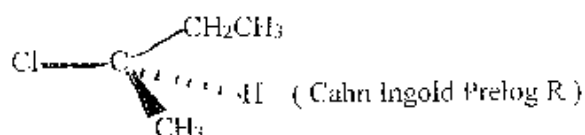
(e) (b) & (d) are correct

9. Choose the best statement. $R-C\equiv C-R$ reacts with the following to give the product shown:



(d) All reactions are correct.

10. If the following reactant undergoes a reaction choose the best statement.



(a) If the reaction goes by an S_N1 reaction mechanism the product will be racemic.

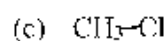
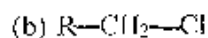
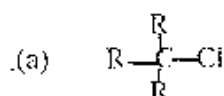
(b) If the reaction goes by an S_N2 reaction mechanism the product will have Cahn Ingold Prelog S at the chiral center because the mechanism goes by inversion.

(c) The molecule could undergo reaction by an elimination mechanism resulting in an alkene product.

(d) All of the above statements are true.

(e) All of the above statements are false.

11. For an S_N2 reaction mechanism reaction, choose the best substrate from the following substrates. (R = alkyl and not hydrogen)



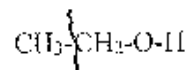
(d) All substrates are equally good substrates for the S_N2

12. Given the following.

- (a) RO^- is a better nucleophile than HO^-
- (b) RO^- is a better nucleophile than ROH
- (c) HO^- is a better nucleophile than H_2O
- (d) Nucleophilicity is interaction with carbon while Basicity is interaction with hydrogen
- (e) All above statements are true.

13. For a mass spectrum, choose the one incorrect statement.

- (a) A base peak is the tallest peak in a particular mass spectrum.
- (b) A base peak is the m/z peak for the entire molecule before it is fragmented.
- (c) An α cleavage peak for any functional group is the closest C-C bond nearest to the functional group for instance for the alcohol functional group the α cleavage line is shown below.



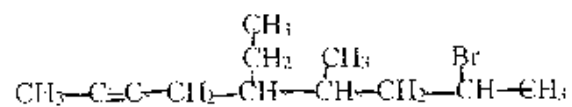
- (d) The z in the m/z is almost always +1 so that the m/z is usually actually the mass of the molecular fragment.

Part II: Short Answers (20 pts)

A. Nomenclature: (2 pts each, 4 pts)

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

name _____

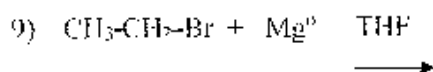
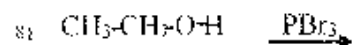
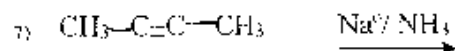
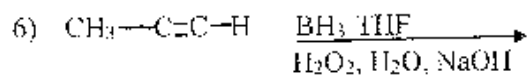
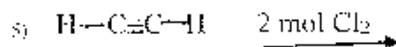
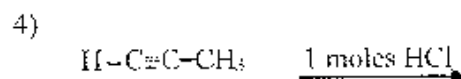
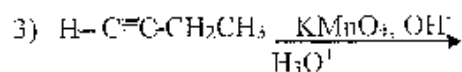
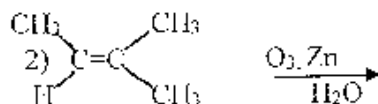
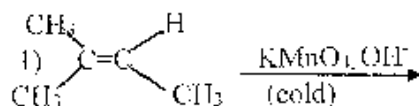


2. Given the following IUPAC name, draw a structural formula of the molecule (skeletal formula acceptable, condensed structure, Lewis Dot structure acceptable, molecular formula not acceptable - don't forget to show the hydrogens in your formula unless you are using the skeletal structure.)

4-dimethyl-2-pentyne

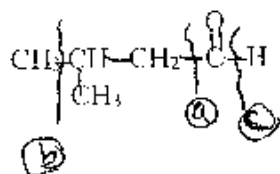
B. Reactions: Show the Organic Product for the following reactions by giving the structural formula of the product. (skeletal formula, condensed structure, Lewis Dot structure are all acceptable. Molecular Formula is not acceptable.) **DO NOT SHOW MECHANISMS.**

Circle the letter of the 6 reaction which you want counted. If you do not choose, I will just grade the first 6 reactions. (2 pts each, 12 pts total)



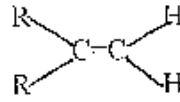
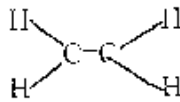
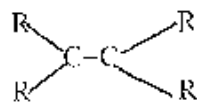
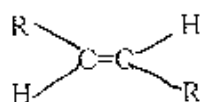
C. Short Answers part of Short Answers: (24 pts)

1. a. Given the molecule below, show your calculation of the number for the molecular ion peak in a mass spectrum. (8 pts total, 4 pts)



b. Given the lines shown, which is the letter of the α cleavage line? ____ (4 pts)

2. Put the following molecules in order from the most stable (1) to the least stable (4) alkene. (8 pts)



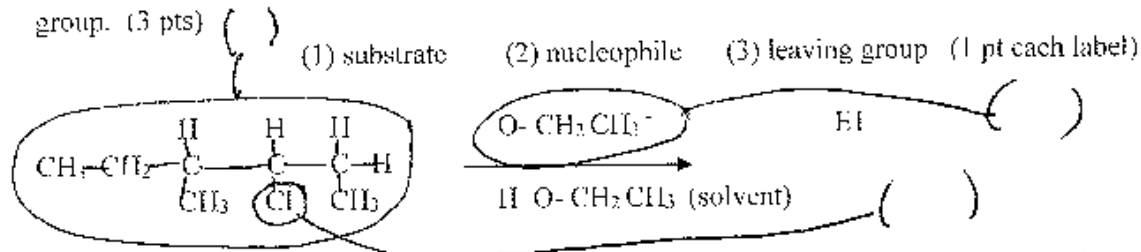
3. Answer the following by circling one, to as many as all of the reactions mechanisms under each letter. (8 pts, 2 pts each letter)

- A tertiary substrate is best for [(S_N2), (S_N1), (E2), (E1)] (circle all correct mechanism)
- A strong nucleophile or higher concentration nucleophile favors [(S_N2), (S_N1), (E2), (E1)] (circle all correct mechanism)
- A polar aprotic solvent favors [(S_N2), (S_N1), (E2), (E1)] (circle all correct mechanism)
- A strong bulky base but weak nucleophile favors [(S_N2), (S_N1), (E2), (E1)] (circle all correct mechanism)

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

1. Given the following reactant: Assume that the reaction undergoes an **E1** reaction mechanism. (24 pts)

A. Label the circled parts of the molecule with one of the numbers for substrate, nucleophile and leaving group. (3 pts)



B. Please show the entire reaction mechanism including electron pushing arrows. Please show either the **transition state or intermediate** (depending on which is the correct one to show for the mechanism that you have) and the **Organic Major Product**. You do **not** need to show the reaction using a **3 D structure**. (7 pts)

- C. Draw an energy diagram which matches the above mechanism. Label the above mechanism and then label your energy diagram to match your mechanism. (5 pts total)
- D. Write the rate law for the reaction mechanism using the actual molecule in your reaction above. If you write the rate law using the words substrate or nucleophile, I will count off. (5 pts)
- E. If you showed the major product in part (A), what is the other possible regioisomer. Explain briefly why your product (which you showed in part B) is the major product. (4 pts)

2. Complete the following synthesis by filling in the blank. I have provided some hints to help you come up with the answers. NOTE: The way I grade this is for you to fill in reasonable molecules based on the immediate prior molecule. i.e. If you fill in part A with the wrong molecule and then do the next reaction to molecule B correctly you will get half credit for answering B correctly. If you fill in B with what you would have gotten if you got A correctly but which cannot possibly be generated from your wrong A, you will lose all credit even if it matches what you should have gotten. (There is no way that you can come up with this answer except perhaps by guessing.) (2 pts each, 10 pts total)

