

Sign Name Key Print Name _____

(5 pt name above print & sign – If I can't tell who you are from NO NAME above, I have to go back to the exam taking map and hope that I can read your name on that or I may end up with an exam with no identity permanently), (5 pts scantron name – if you don't bubble in I get a grade with no name and I have to hold everyone's final grades until I figure out whose exam it is.) (100 pts, 14 pages + scantron sheet, periodic table)

Please show work on all questions for partial credit even on questions which do not specify. Please write legibly. **I will only grade what I can read (obviously).** I am not going to make up an answer for you based on writing I can't read. (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. There is no partial credit for showing work in the multiple choice. COLOR FORM

In all questions on all parts of this exam, R is not equal to hydrogen but is an alkyl. Color

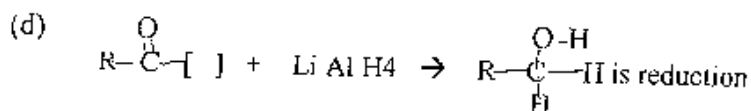
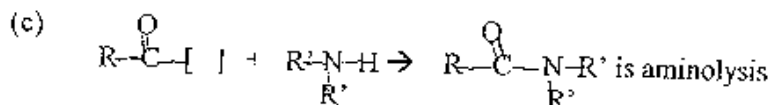
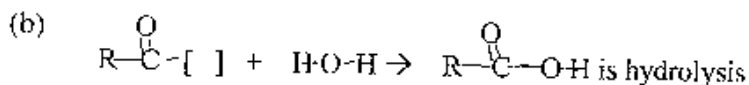
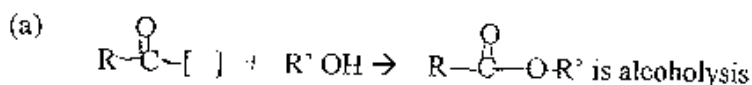
1. Multiple Choice (2 pts each, 26 pts) Choose the **one** best statement in each question.

1. UV spectroscopy measures the energy required to promote an electron from the _____ molecular orbital to the _____ molecular orbital.

- (a) lowest occupied, lowest unoccupied
 (b) lowest occupied, highest unoccupied
 (c) highest occupied, highest unoccupied
 (d) highest occupied, lowest unoccupied
 (e) None of the above.

LUMO → HOMO

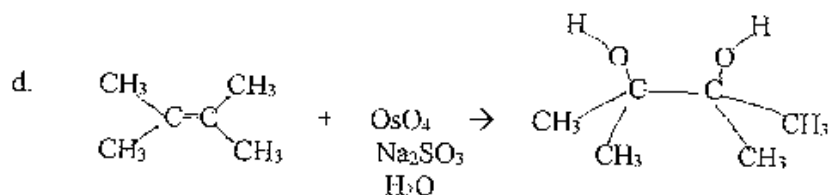
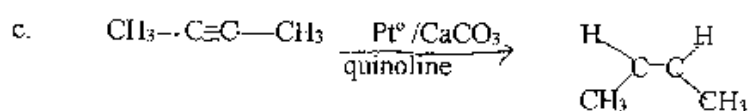
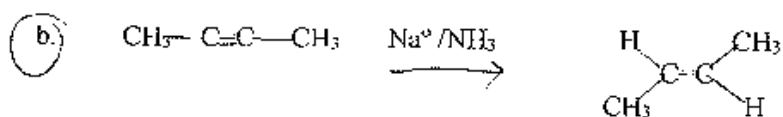
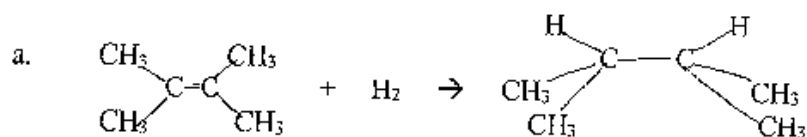
2. Choose the best reaction for carboxylic acid and carboxylic acid derivatives where [] is the nucleophile part of the carboxylic acid and carboxylic acid derivative.



(e) All of the above reactions work for almost all carboxylic acid derivatives.

3. What is the major difference between an antiaromatic and aromatic compounds.
- (a) Aromatic compounds cannot have a charged atom in the structure.
 - (b) The structure must be cyclic for aromatic but not antiaromatic compounds.
 - (c) Antiaromatic compounds have at least a sp^3 hybridized atom in the ring.
 - (d) Antiaromatic compounds can assume a chair like structure while aromatic compounds are nearly flat.
 - (e) Only aromatic compounds follow Hückle's rule.
4. For the element As, circle the one incorrect statement.
- a. The atomic mass is 75
 - b. The number of valence electrons is 5
 - c. The number of electrons for a neutral atom is 5
 - d. The atomic number is 33
5. Circle the one statement below which is incorrect.
- a) In an energy diagram, a transition state is in general between either the reactant & product or between the reactant and the intermediate.
 - b) An "Electrophile" loves electrons while a "Nucleophile" loves nuclei
 - c) In an energy diagram, an intermediate is always at the top of an energy hill.
 - d) A heterocyclic arrow looks like → *Valley*

6. Which of the following reactions does not show a syn product?



7. What type of orbitals do the lone pair electrons on oxygen occupy in ethanol?

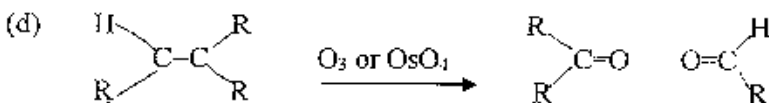
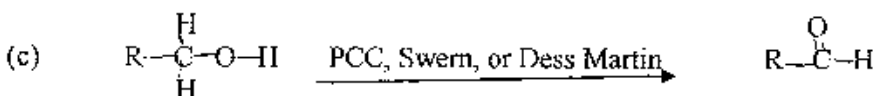
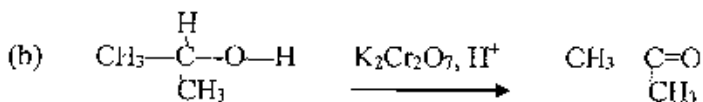
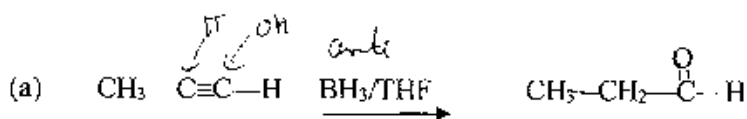
- (a) sp^3 (b) sp (c) π (d) p (e) σ

8. What descriptive term is applied to the type of diene represented by 1,5-octadiene?

- (a) Isolated diene
 (b) Conjugated diene
 (c) Alkynyl diene
 (d) Cumulated diene
 (e) None of the above

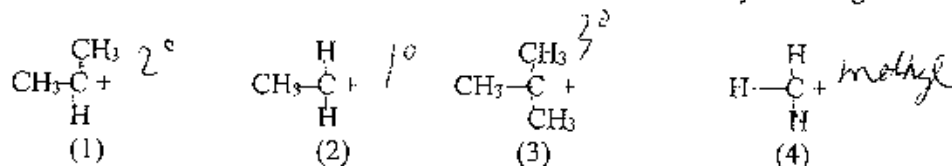


9. Which of the following are valid ways to make ketone and aldehydes



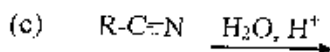
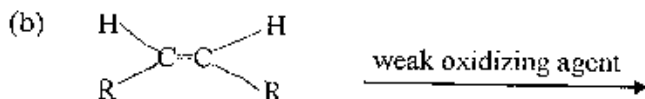
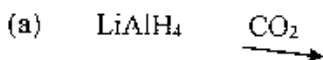
(e) All are correct

10. Put in order of most stable to least stable carbocation by choosing the one best choice:



- a) Most stable carbocation to least stable carbocation is (4) > (2) > (1) > (3)
 b) Most stable carbocation to least stable carbocation is (2) > (1) > (3) > (4)
 (c) Most stable carbocation to least stable carbocation is (3) > (1) > (2) > (4)
 d) Most stable carbocation to least stable carbocation is (1) > (2) > (3) > (4)

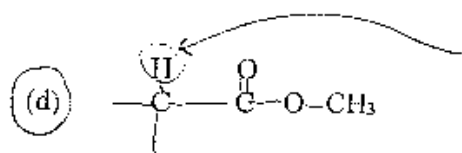
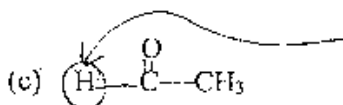
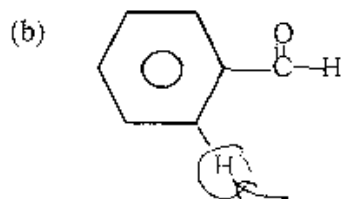
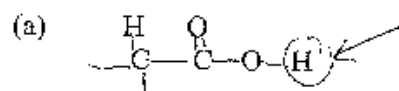
11. Which of the following are ways to get a carboxylic acid? Choose the best statement. (R not equal H)



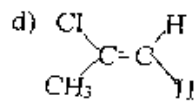
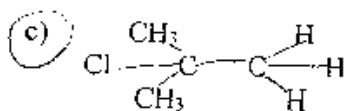
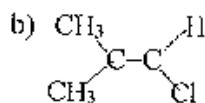
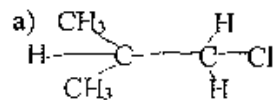
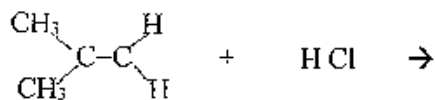
(d) (a) and (c) will produce carboxylic acid.

(e) All of the above results in a carboxylic acid.

12. Which of the following is an α hydrogen ?



13. For the Markovnikov's electrophilic reaction of H Cl to the alkene below the alkene the product would be: _____

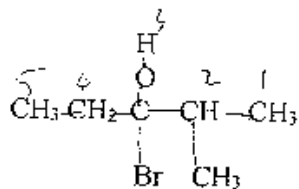


II. Short Answers (36 pts)

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

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

a. name 3-bromo-2-methylpentan-3-ol



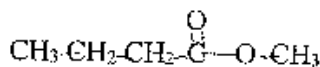
2-methyl

3-bromo

pentane

3-ol

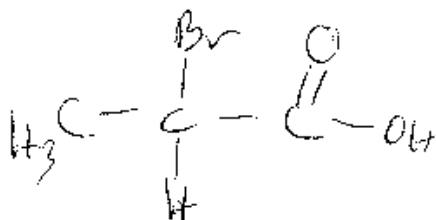
b. name methyl butanoate



butanoate
~~acid~~
methyl

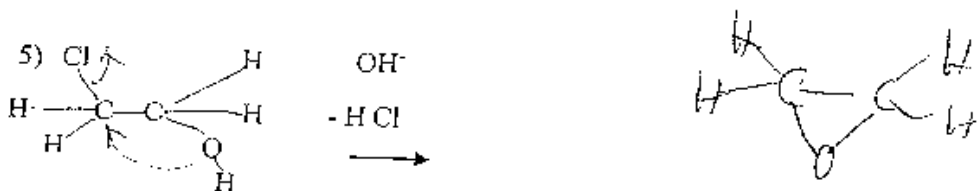
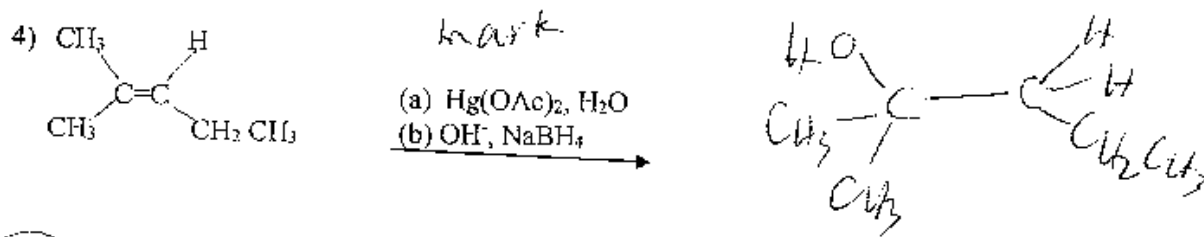
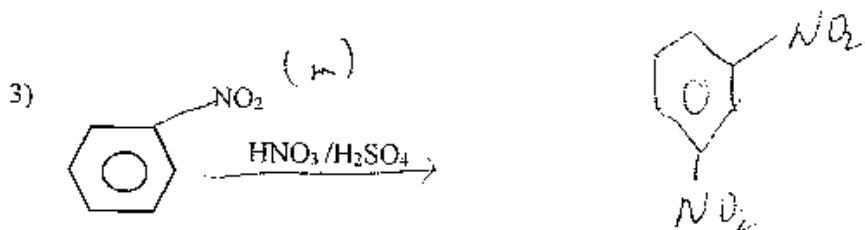
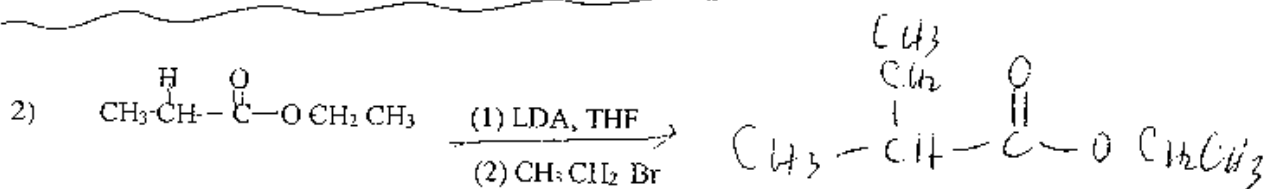
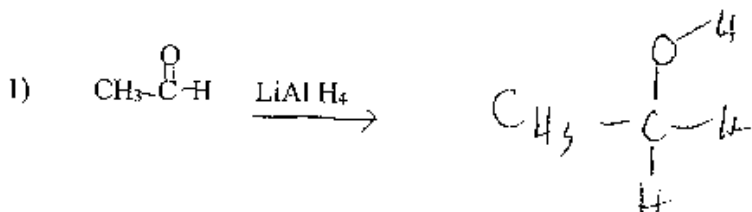
2. Given the following name, draw a structural formula of the molecule (skeletal formula acceptable, condensed structure, Lewis Dot structure acceptable, molecular formula, abbreviations not acceptable - don't forget to show the hydrogens in your formula unless you are using the skeletal structure.)

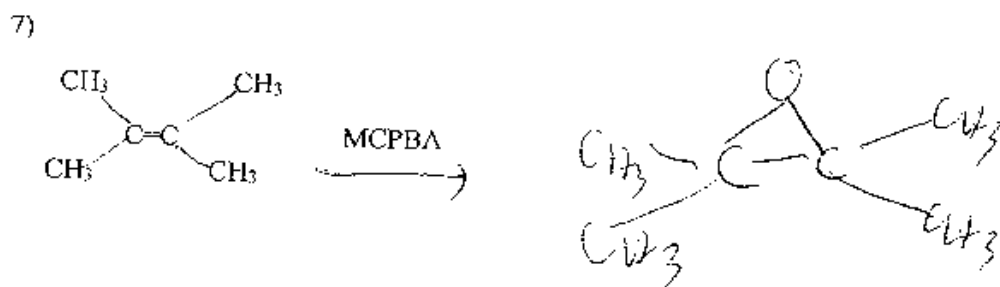
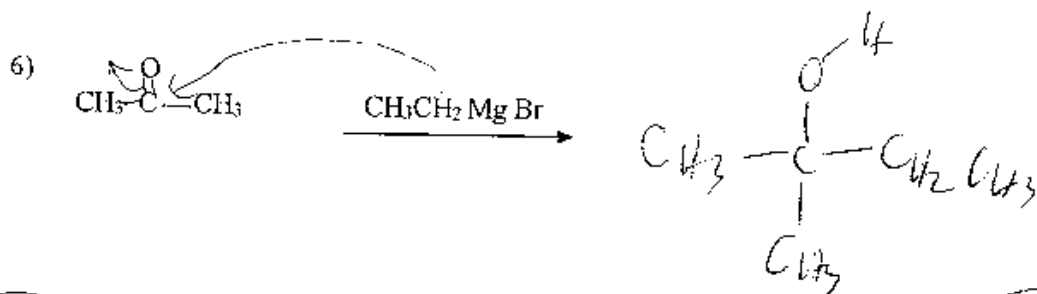
2-bromopropanoic acid



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, abbreviations are **not** acceptable.) DO **NOT** SHOW MECHANISMS. (2 pts each, 10 pts)

Circle the number of the 5 reaction which you want counted. If you do not choose, I will just grade the first 5 reactions. I **will not** grade all the reactions and give you points on only your best 5 reactions.

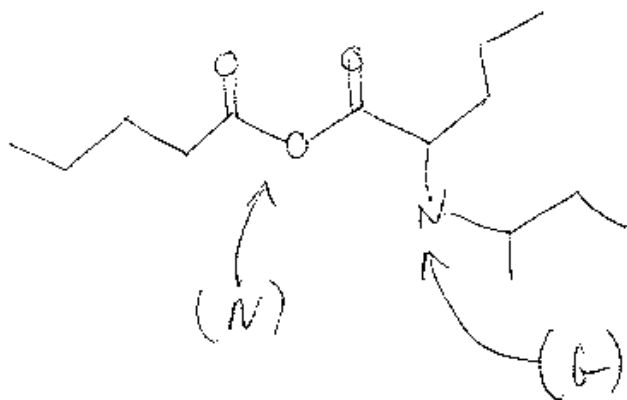




B. Short Answers part of Short Answers: (20 pts)

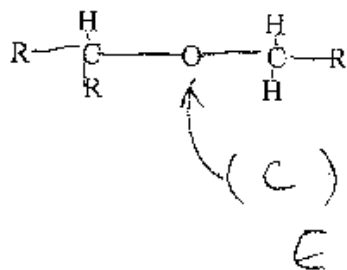
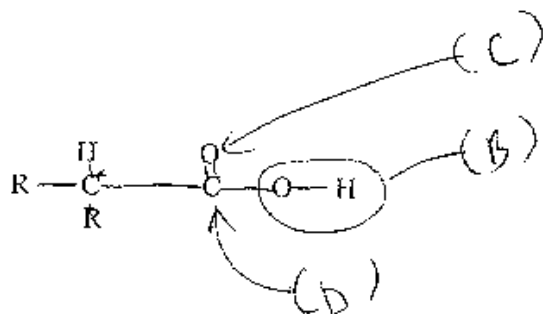
1. Given the following molecule, fill in the parenthesis with the letter of the functional group.

(A) alkene (B) alkyne (C) arene (D) alkyl halide (E) alcohol (F) ether (G) amine
 (H) aldehyde (I) ketone (J) carboxylic acid (K) ester (L) amide (M) acid halide (N) acid
 anhydride (You may use all the letters or none of the letters and may use the same letter multiple times)
 (3 pts each, 6 pts total)

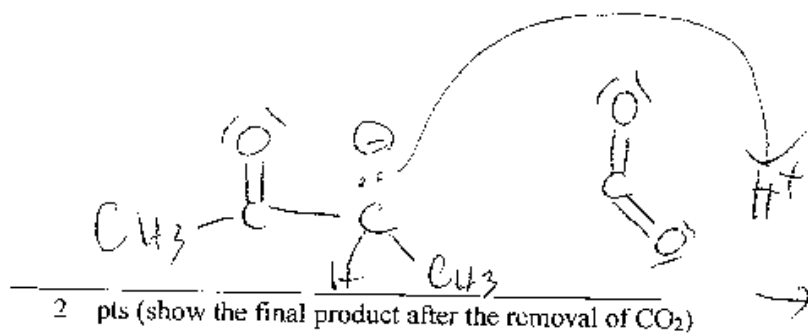
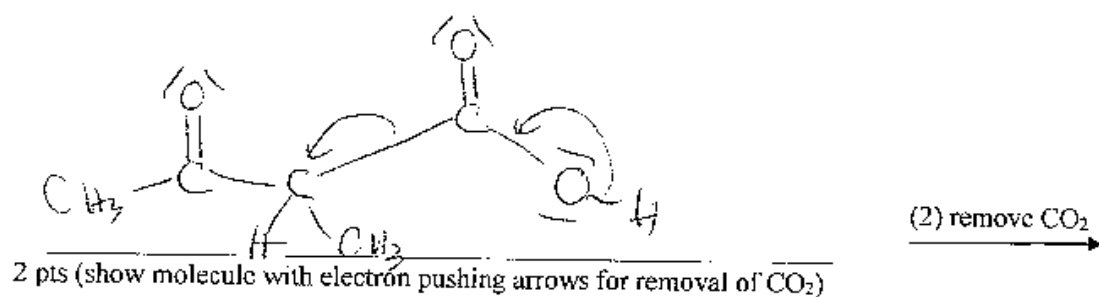
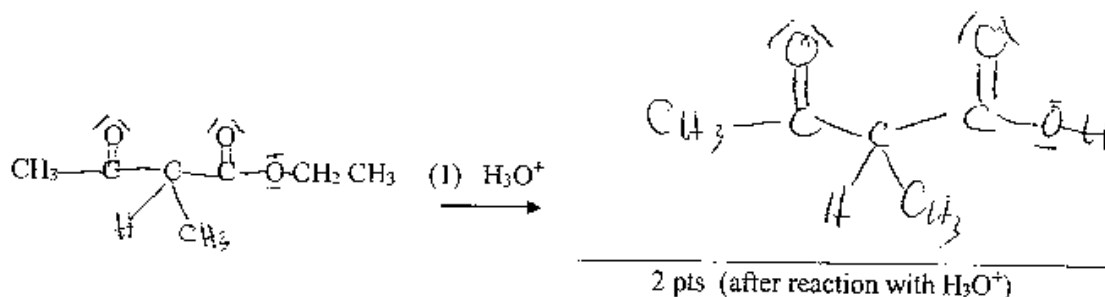


2. Label the following with a letter per parenthesis. You may use each letter one time, or multiple times. (A) acidic hydrogen (B) Leaving group (C) reacts with H^+ (D) reacts with nucleophile (E) acts as nucleophile

(Some of the parenthesis may have more than one correct answer but if you fill the parenthesis with **ONE correct letter, that is sufficient**. If you fill the parenthesis with one correct and some incorrect answers, you will lose some points.) (2 pts each, 8 pts total)

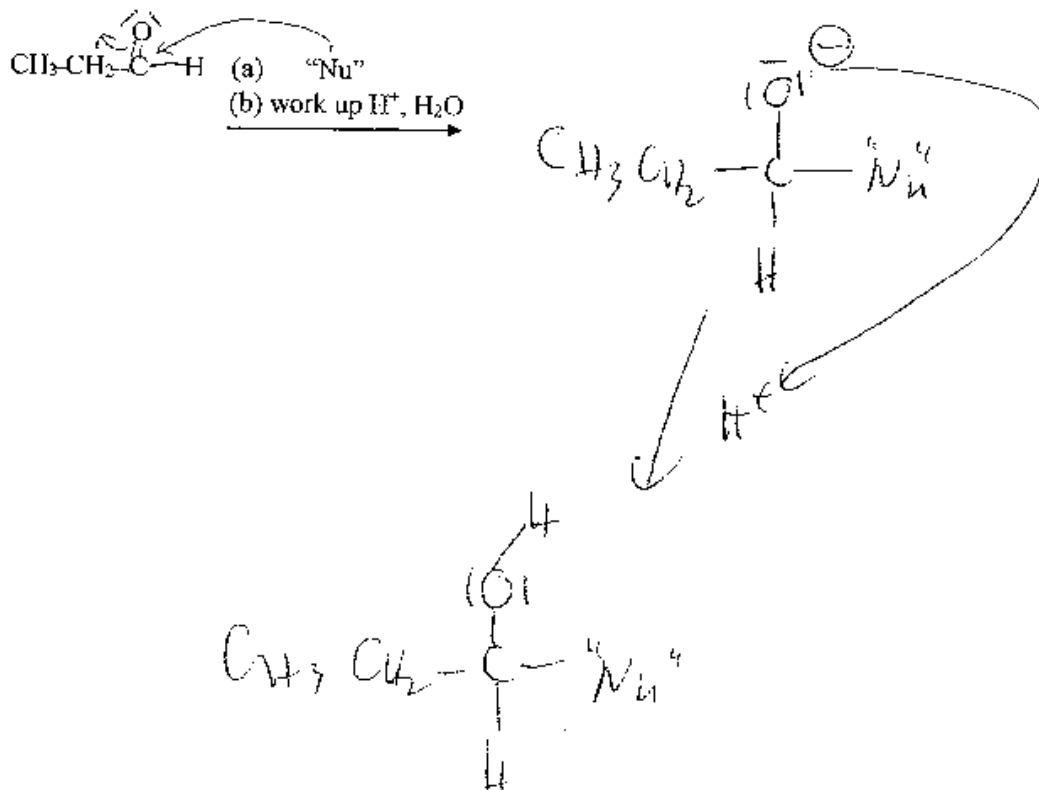


3. Complete the mechanism of the removal of CO_2 in the acetoacetic acid synthesis or malonic acid synthesis. (note: before you get to remove the CO_2 you will have to do a reaction) Show electron pushing arrows. (note: this step is the acetoacetic acid synthesis or malonic acid synthesis half way into the synthesis) (6 pts total)

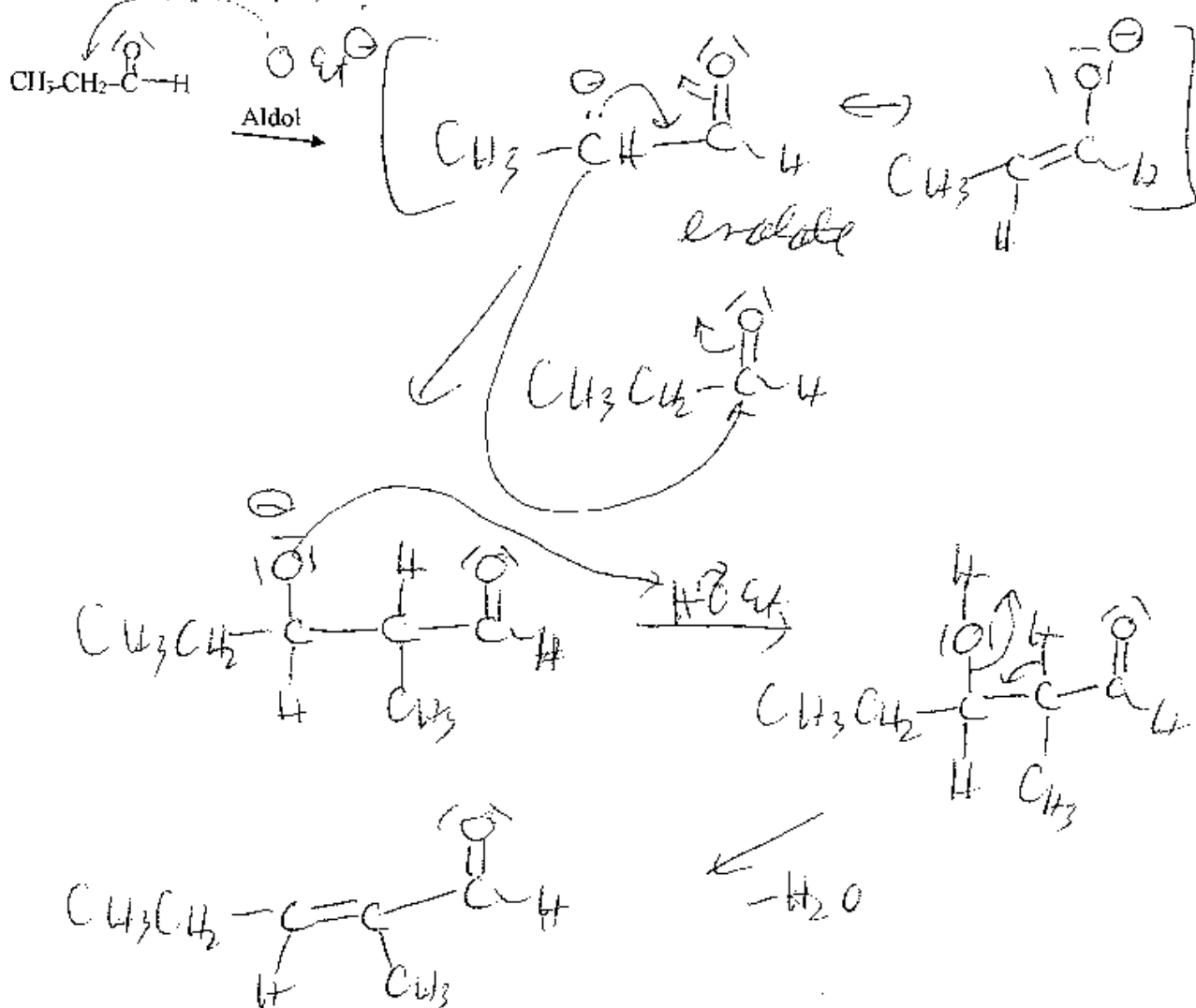


Part III. Long Answers (38 pts) Show work where applicable.

1. (A) Keeping in mind the general reaction mechanism of the addition of a nucleophile to a ketone or aldehyde, complete the following "GENERALIZED" reaction mechanism. (MECHANISM means you show all intermediates. If you just give reaction products, you will LOSE LOTS OF POINTS.) (total pts for question # 1, 14 pts, 6 pts for part (A))



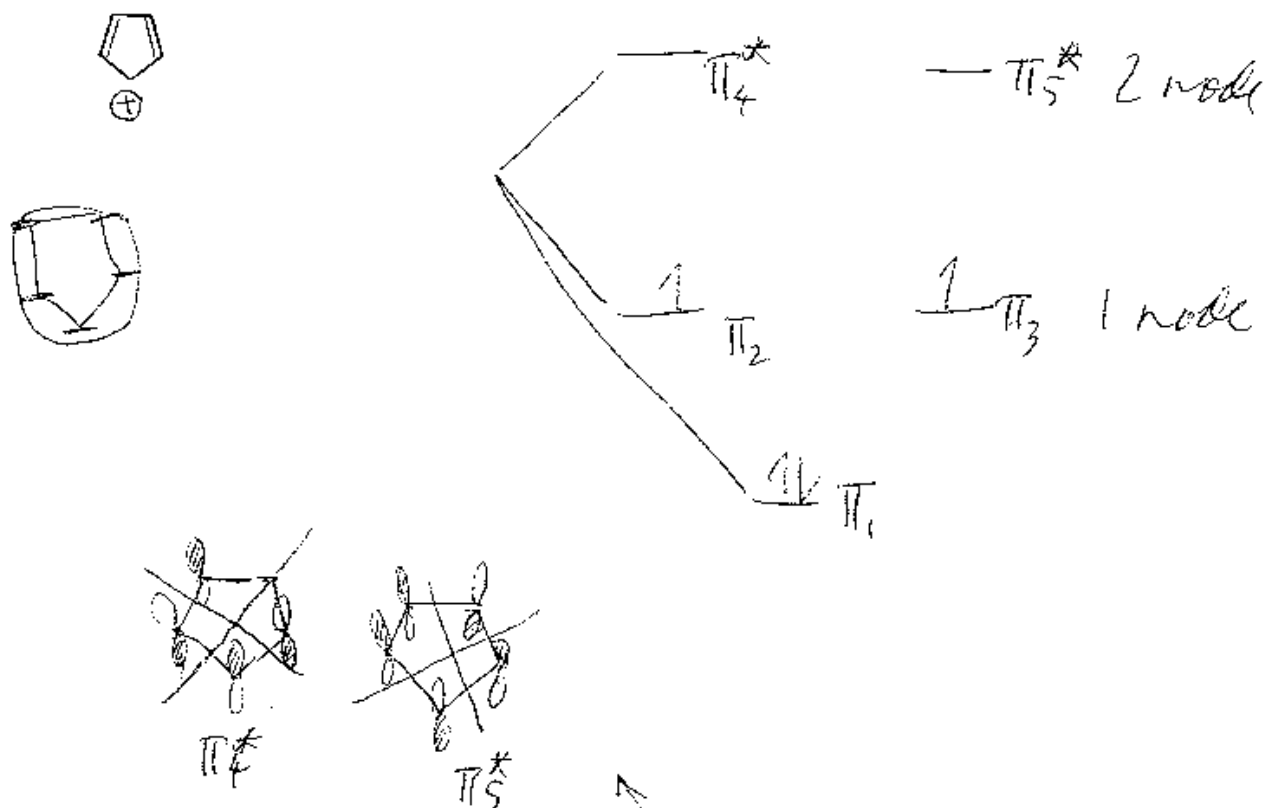
(B) Show the Aldol Condensation Reaction mechanism. The stuff over the arrow is: NaOEt, EtOH and remove water. (6 pts this part)



(C) Explain in a sentence or two the relationship between the reaction mechanism which you showed in the step A & B above. (4 pts).

A & B are both "Nu" addition mechanism
 B just has a larger nucleophile than
 A.

2 (a) Draw the MO energy diagram for cyclopentadiene cation in the space given. (5 pts this letter, 15 pts total)



(b) Show the p orbital atomic orbital combination for the highest π^* MO in your energy diagram above in part (a) by the MO which matches. Represent the math sign of your p orbital lobes by shading in one of the lobes in all of the p orbitals. Show the nodes. (3 pts)

(c) Fill your MO energy diagram [which you drew above in (a)] with the appropriate number of electrons for the cyclopentadiene cation. Use up and down arrows to represent electrons. (3 pts) $4e^-$

(d) Show a Huckel rule explanation of the stability/instability of your cyclopentadiene cation (Huckel Rule is $4n+2 = \# \pi \text{ electrons}$) (3 pts)

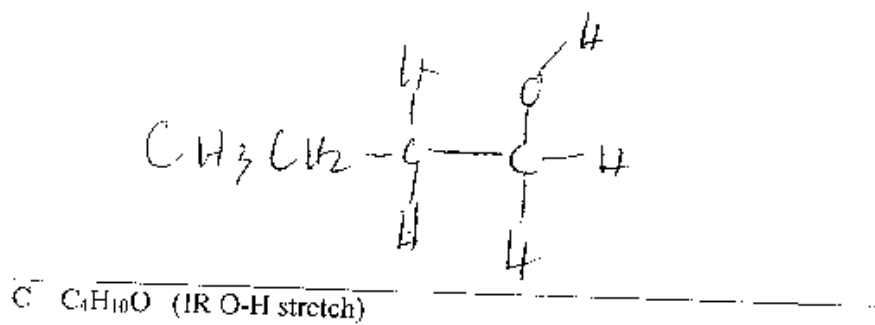
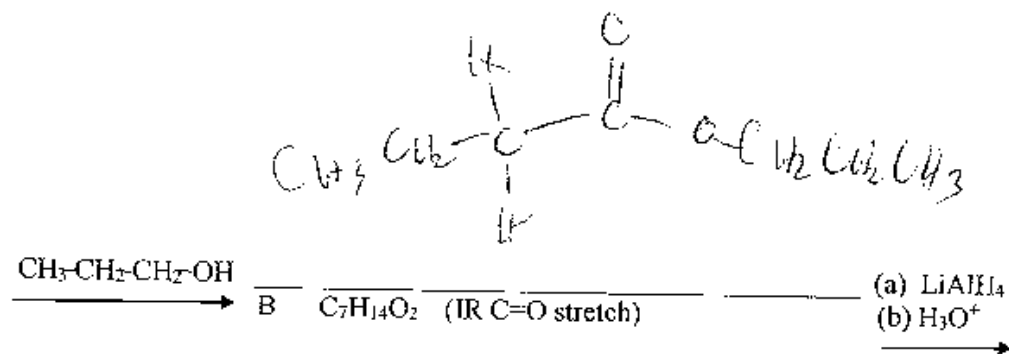
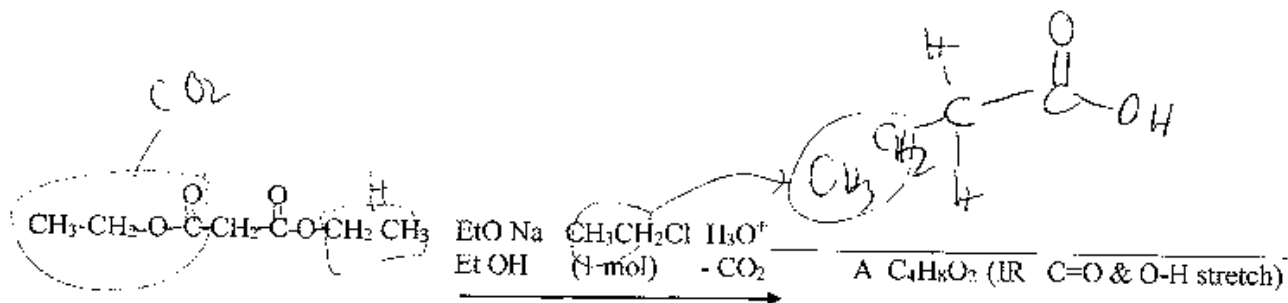
$n = \frac{1}{2}$

$4e^- = 4n + 2$ not aromatic

$4 - 2 = 4n$

$\frac{4-2}{4} = n = \frac{2}{4}$

3. 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.) (3 pts each, 9 pts total)



Sign Name _____ Key _____ Print Name _____

(5 pt name above print & sign – If I can't tell who you are from NO NAME above, I have to go back to the exam taking map and hope that I can read your name on that or I may end up with an exam with no identity permanently), (5 pts scantron name – if you don't bubble in I get a grade with no name and I have to hold everyone's final grades until I figure out whose exam it is.) (100 pts, 14 pages+ scantron sheet, periodic table)

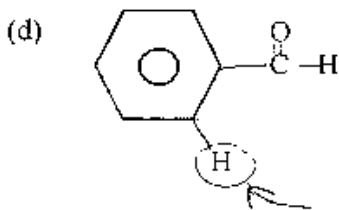
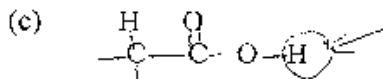
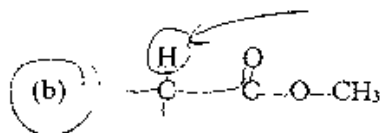
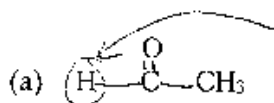
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Circle answer on this form for backup to the scantron. There is no partial credit for showing work in the multiple choice.

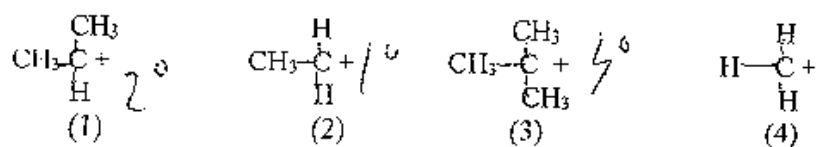
In all questions on all parts of this exam, R is not equal to hydrogen but is an alkyl.

I. Multiple Choice (2 pts each, 26 pts) Choose the **one** best statement in each question.

1. Which of the following is an α hydrogen ?

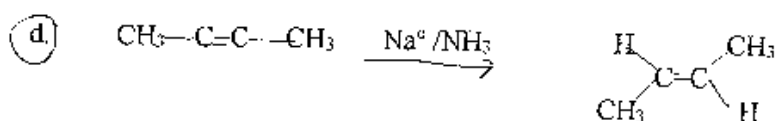
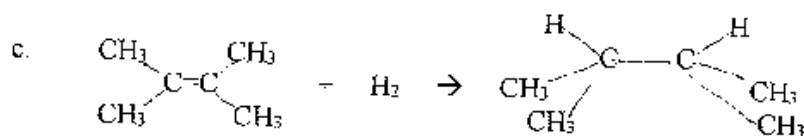
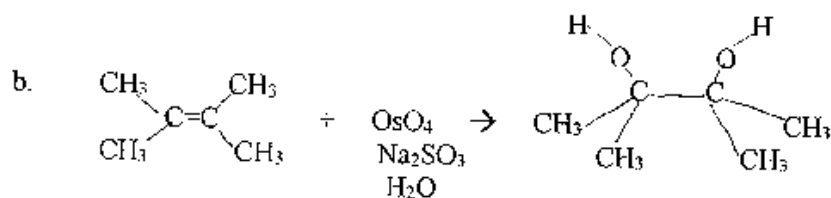
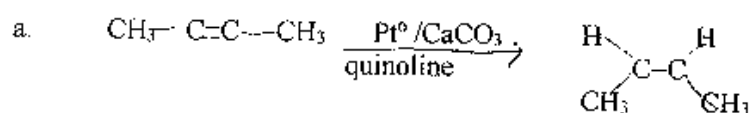


2. Put in order of most stable to least stable carbocation by choosing the one best choice:



- a. Most stable carbocation to least stable carbocation is (4) > (2) > (1) > (3)
 b. Most stable carbocation to least stable carbocation is (1) > (2) > (3) > (4)
 c. Most stable carbocation to least stable carbocation is (2) > (1) > (3) > (4)
 d. Most stable carbocation to least stable carbocation is (3) > (1) > (2) > (4)

3. Which of the following reactions does **not** show a **syn** product?



4. What type of orbitals do the lone pair electrons on oxygen occupy in ethanol?

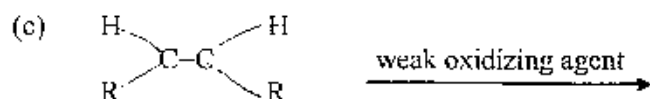
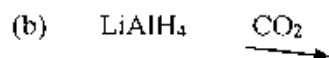
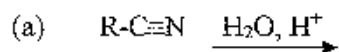
- (a) σ (b) sp^3 (c) sp (d) π (e) p

5. What descriptive term is applied to the type of diene represented by 1,5-octadiene?

- (a) Conjugated diene
 (b) Cumulated diene
 (c) Isolated diene
 (d) Alkynyl diene
 (e) None of the above



6. Which of the following are ways to get a carboxylic acid? Choose the best statement.
(R not equal H)



(d) (a) and (b) will produce carboxylic acid.

(e) All of the above results in a carboxylic acid.

7. What is the major difference between an antiaromatic and aromatic compounds.

(a) Aromatic compounds cannot have a charged atom in the structure.

(b) The structure must be cyclic for aromatic but not antiaromatic compounds.

(c) Antiaromatic compounds have at least a sp^3 hybridized atom in the ring.

(d) Antiaromatic compounds can assume a chair like structure while aromatic compounds are nearly flat.

(e) Only aromatic compounds follow Huckle's rule.

8. For the element As, circle the one incorrect statement.

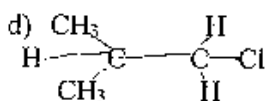
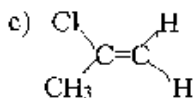
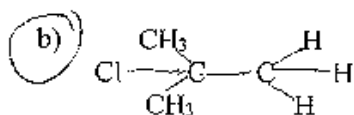
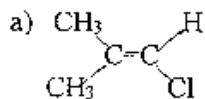
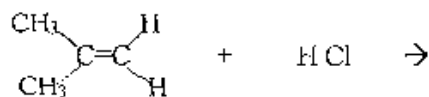
a. The number of electrons for a neutral atom is 5

b. The atomic number is 33

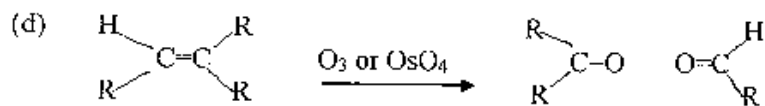
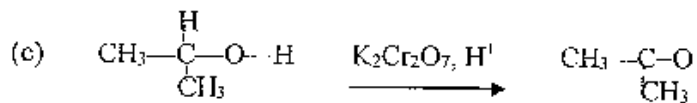
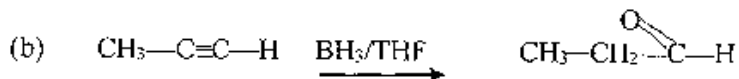
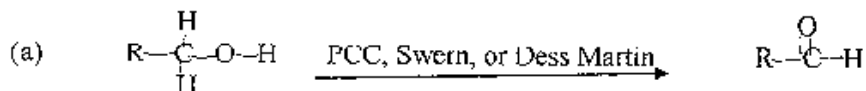
c. The atomic mass is 75

d. The number of valence electrons is 5

9. For the Markovnikov's electrophilic reaction of HCl to the alkene below the alkene the product would be:



10. Which of the following are valid ways to make ketone and aldehydes



(c) All are correct

11. Circle the one statement below which is incorrect.

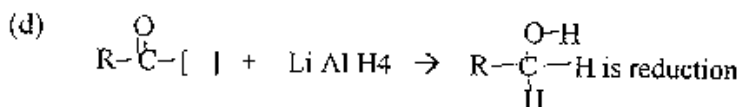
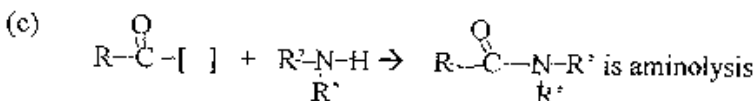
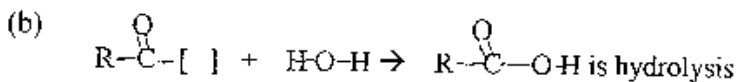
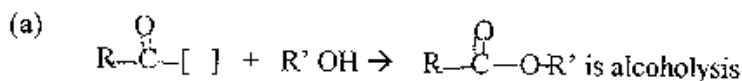
- (a) An "Electrophile" loves electrons while a "Nucleophile" loves nuclei
(b) In an energy diagram, an intermediate is always at the top of an energy hill
(c) In an energy diagram, a transition state is in general between either the reactant & product or between the reactant and the intermediate.
(d) A heterocyclic arrow looks like \rightarrow

12. UV spectroscopy measures the energy required to promote an electron from the ___ molecular orbital to the ___ molecular orbital.

- (a) lowest occupied, highest unoccupied
(b) highest occupied, lowest unoccupied
(c) highest occupied, highest unoccupied
(d) lowest occupied, lowest unoccupied
(e) None of the above.

LUMO \rightarrow HOMO

13. Choose the best reaction for carboxylic acid and carboxylic acid derivatives where [] is the nucleophile part of the carboxylic acid and carboxylic acid derivative.



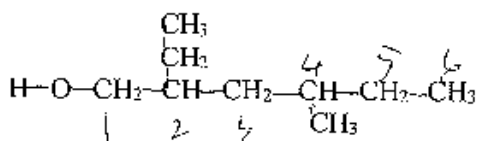
(e) All of the above reactions work for almost all carboxylic acid derivatives.

II. Short Answers (36 pts)

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

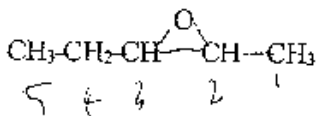
1. Given the structural formula shown below, give the IUPAC name of the molecule.

a. name 2-ethyl-4-methylhexan-1-ol



2-ethyl
4-methyl
-1-hexanol

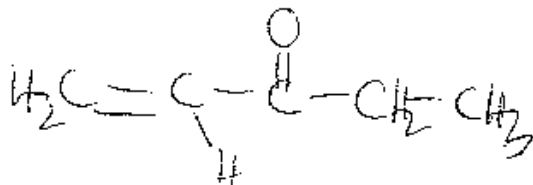
b. name _____



2,3-epoxypentane

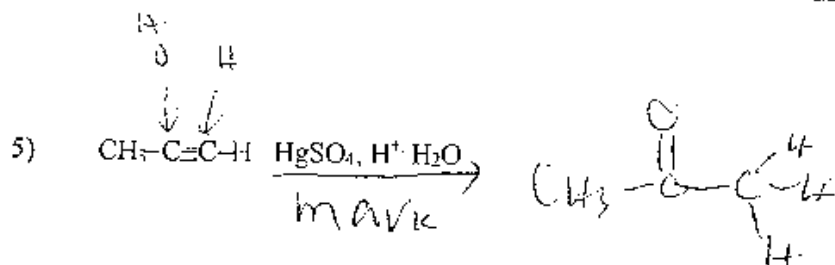
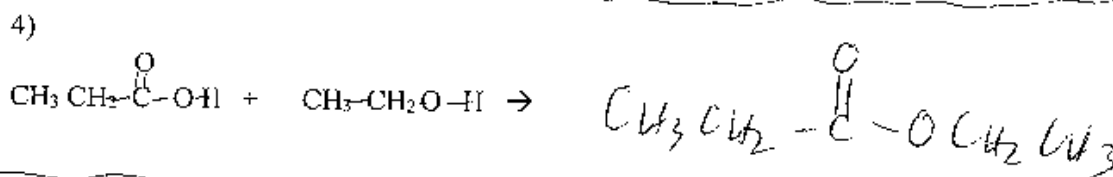
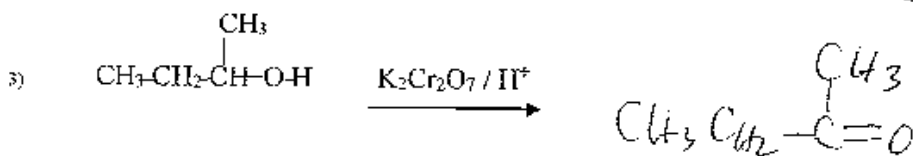
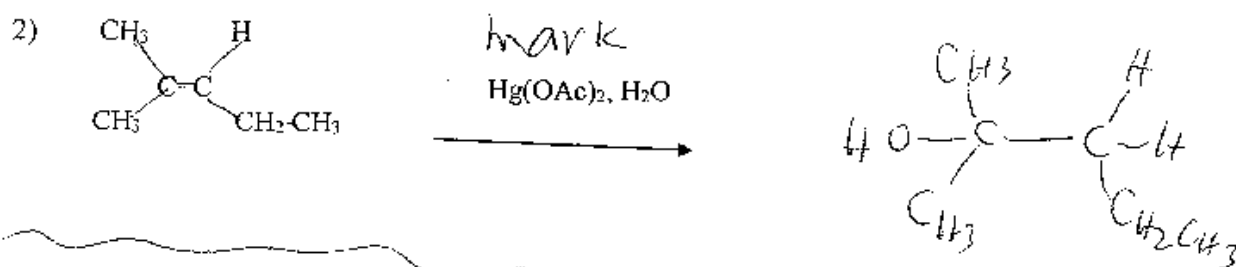
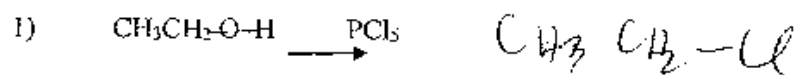
2. Given the following name, draw a structural formula of the molecule (skeletal formula acceptable, condensed structure, Lewis Dot structure acceptable, molecular formula, abbreviations not acceptable - don't forget to show the hydrogens in your formula unless you are using the skeletal structure.)

pent-1-en-3-one

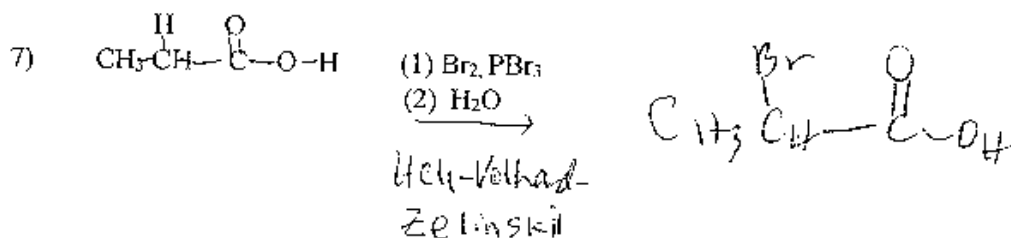
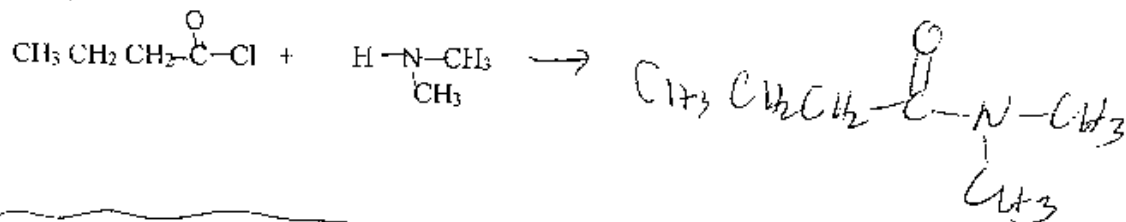


B. Reactions: Show the Organic Product for the following reactions by giving the structural formula of the product. (skeletal formula, condensed structure, Lewis Dot structure are all acceptable. Molecular Formula, abbreviations are not acceptable.) **DO NOT SHOW MECHANISMS.** (2 pts each, 10 pts)

Circle the number of the 5 reaction which you want counted. If you do not choose, I will just grade the first 5 reactions. I **will not** grade all the reactions and give you points on only your best 5 reactions.



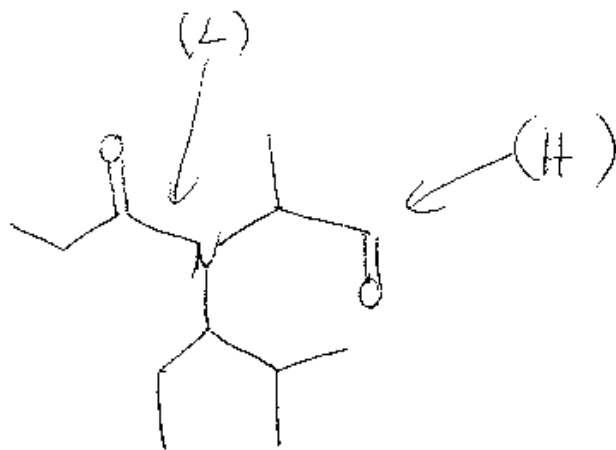
6)



B. Short Answers part of Short Answers: (20 pts)

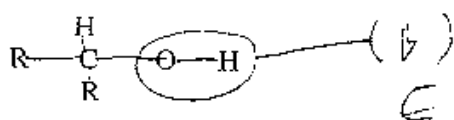
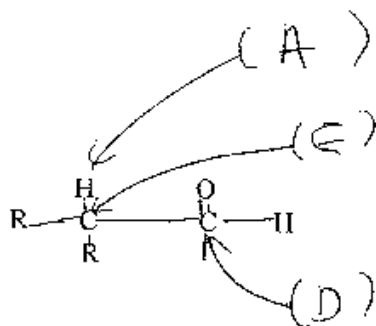
1. Given the following molecule, fill in the parenthesis with the letter of the functional group.

(A) alkene (B) alkyne (C) arene (D) alkyl halide (E) alcohol (F) ether (G) amine
(H) aldehyde (I) ketone (J) carboxylic acid (K) ester (L) amide (M) acid halide (N) acid anhydride (You may use all the letters or none of the letters and may use the same letter multiple times)
(3 pts each, 6 pts total)

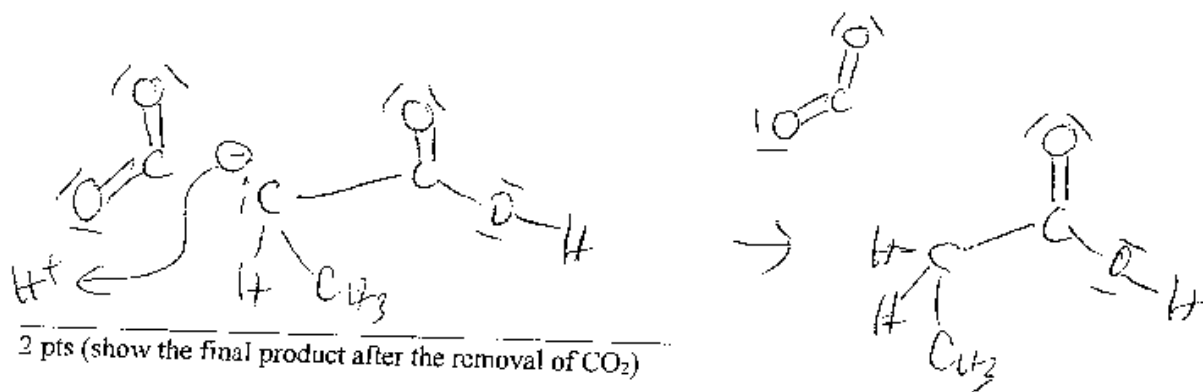
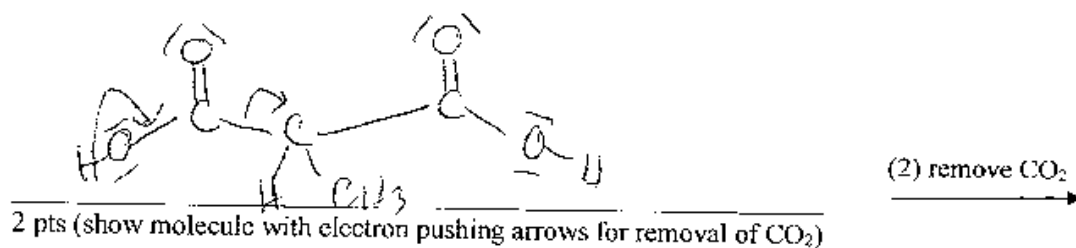
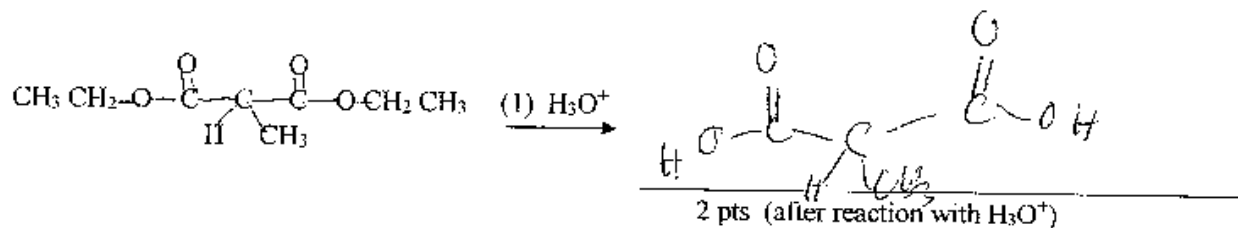


2. Label the following with a letter per parenthesis. You may use each letter one time, or multiple times. (A) acidic hydrogen (B) Leaving group (C) reacts with H^+ (D) reacts with nucleophile (E) acts as nucleophile

(Some of the parenthesis may have more than one correct answer but if you fill the parenthesis with ONE correct letter, that is sufficient. If you fill the parenthesis with one correct and some incorrect answers, you will lose some points.) (2 pts each, 8 pts total)

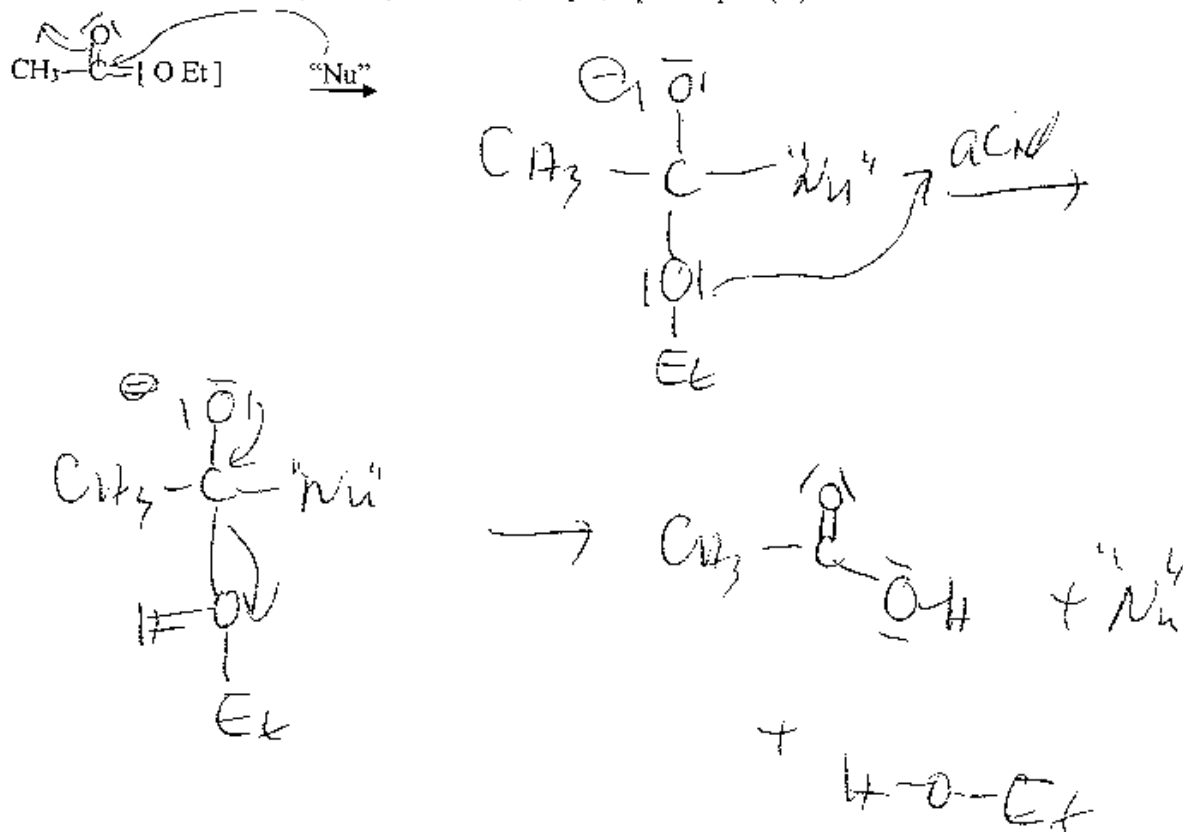


3. Complete the mechanism of the removal of CO_2 in the acetoacetic acid synthesis or malonic acid synthesis. (note: before you get to remove the CO_2 you will have to do a reaction) Show electron pushing arrows. (note: this step is the acetoacetic acid synthesis or malonic acid synthesis half way into the synthesis) (6 pts total)

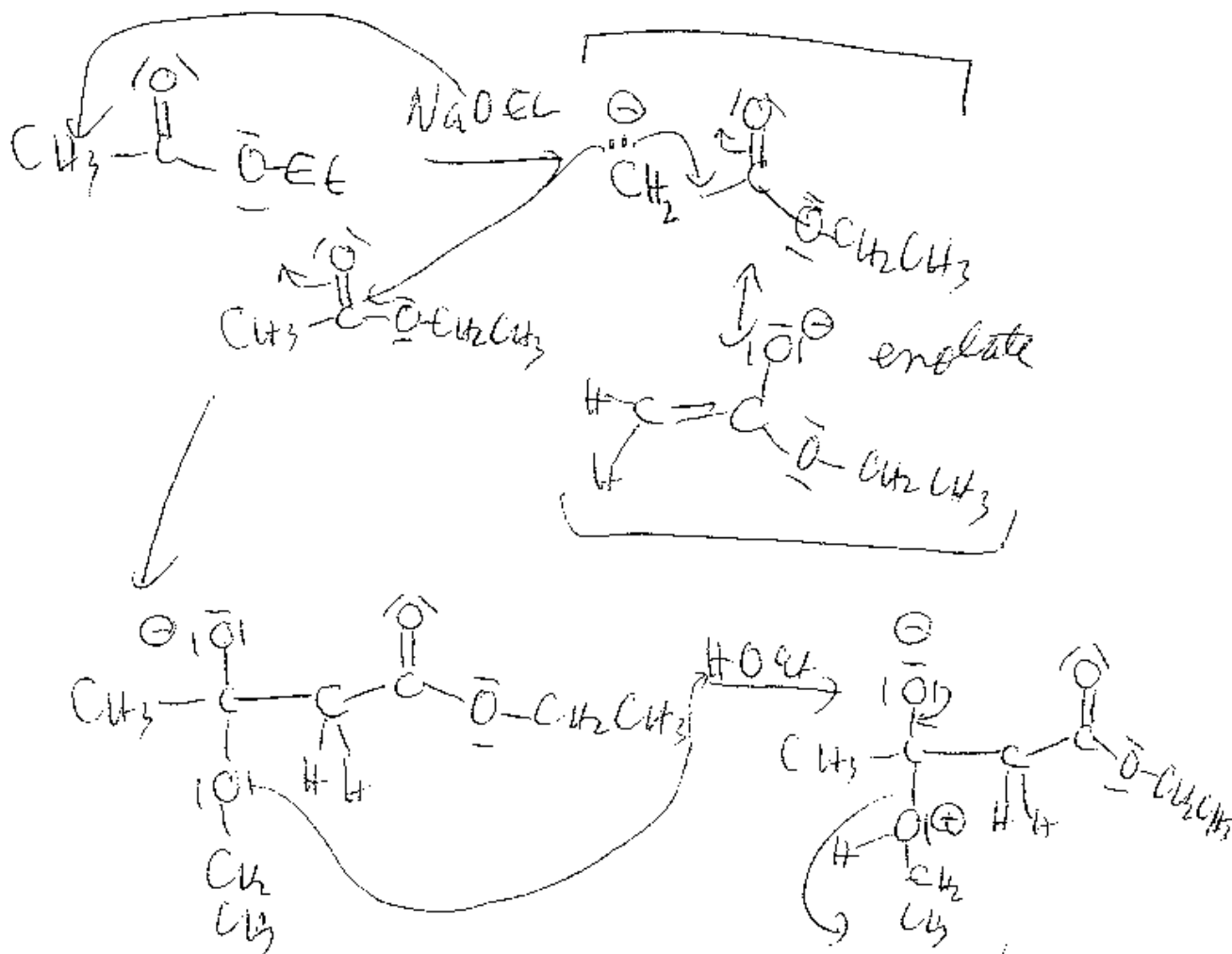
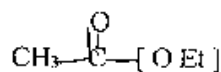


Part III. Long Answers (38 pts) Show work where applicable.

1. (A) Keeping in mind the general reaction mechanism of the addition of a nucleophile to carboxylic acid derivative, complete the following "GENERALIZED" reaction mechanism. (MECHANISM means you show all intermediates. If you just give reaction products, you will LOSE LOTS OF POINTS.) (total pts for question # 1, 14 pts, 6 pts for part (A))

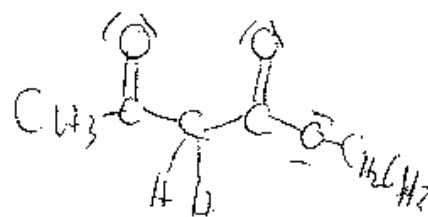


(B) Show the Claisen Condensation Reaction Mechanism. The stuff over the arrow is: NaOEt, EtOH
(6 pts)

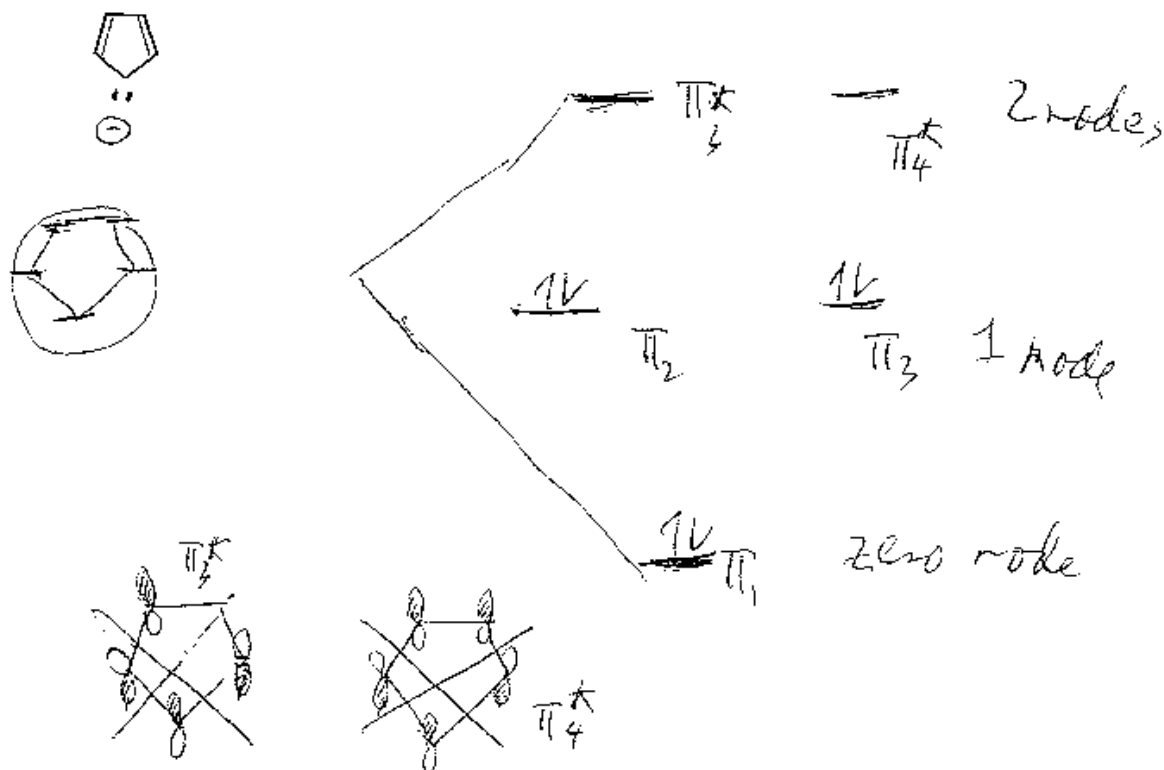


(C) Explain in a sentence or two the relationship between the reaction mechanism which you showed in the step (A) above and step (B) (4 pts).

A & B are same mechanism except B has a large nucleophile



2 (a) Draw the MO energy diagram for cyclopentadiene anion in the space given. (5 pts this letter, 15 pts total)



(b) Show the p orbital atomic orbital combination for the highest π^* MO in your energy diagram above in part (a) by the MO which matches. Represent the math sign of your p orbital lobes by shading in one of the lobes in all of the p orbitals. Show the nodes. (3 pts)

(c) Fill your MO energy diagram [which you drew above in (a)] with the appropriate number of electrons for the cyclopentadiene anion. Use up and down arrows to represent electrons. (3 pts) $6e^-$

(d) Show a Huckel rule explanation of the stability/instability of your cyclopentadiene anion (Huckel Rule is $4n+2 = \# \pi$ electrons) (3 pts)

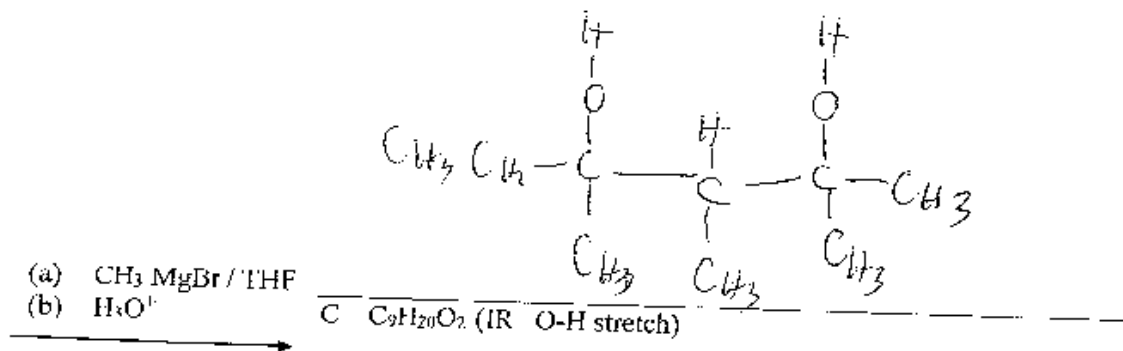
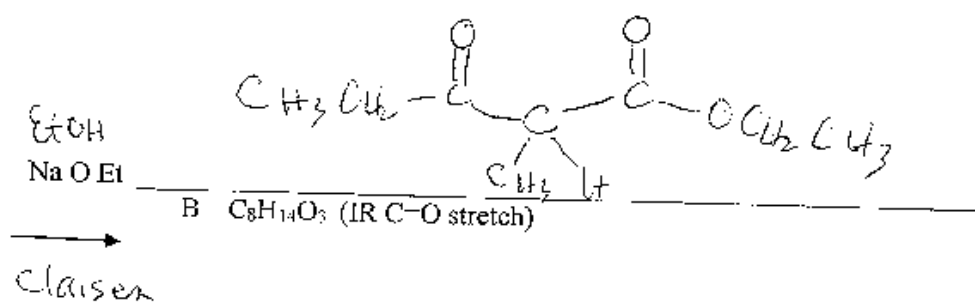
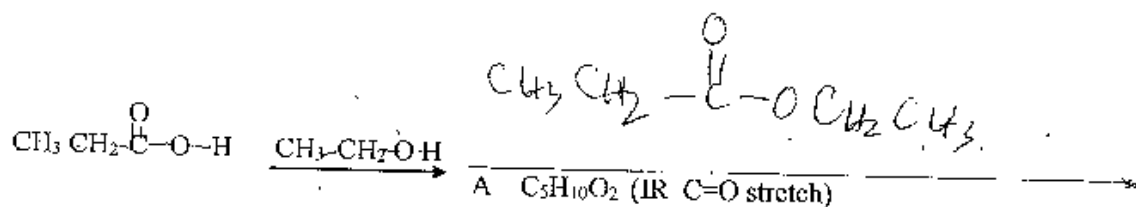
$n = 1$

$$6e^- = 4n + 2 \quad \text{aromatic}$$

$$6 - 2 = 4n$$

$$\frac{4}{4} = n = 1$$

3 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.) (3 pts each, 9 pts total)



Sign Name _____ Print Name _____

(5 pt name above print & sign – If I can't tell who you are from NO NAME above, I have to go back to the exam taking map and hope that I can read your name on that or I may end up with an exam with no identity permanently), (5 pts scantron name – if you don't bubble in I get a grade with no name and I have to hold everyone's final grades until I figure out whose exam it is.) (100 pts, 14 pages + scantron sheet, periodic table)

Please show work on all questions for partial credit even on questions which do not specify. Please write legibly. **I will only grade what I can read (obviously).** I am not going to make up an answer for you based on writing I can't read. (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.)

color

Circle answer on this form for backup to the scantron. There is no partial credit for showing work in the multiple choice. COLOR FORM

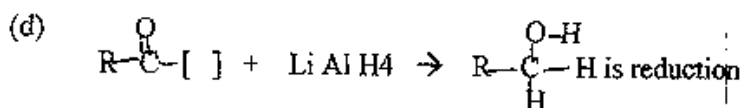
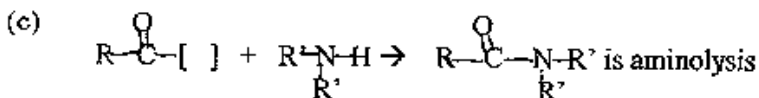
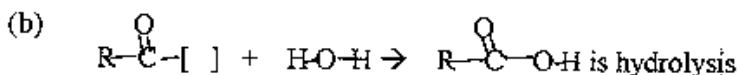
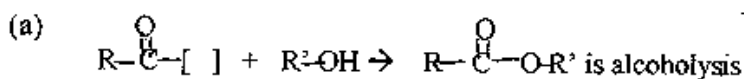
In all questions on all parts of this exam, R is not equal to hydrogen but is an alkyl.

I. Multiple Choice (2 pts each, 26 pts) Choose the one best statement in each question.

1. UV spectroscopy measures the energy required to promote an electron from the _____ molecular orbital to the _____ molecular orbital.

- (a) lowest occupied, lowest unoccupied
- (b) lowest occupied, highest unoccupied
- (c) highest occupied, highest unoccupied
- (d) highest occupied, lowest unoccupied
- (e) None of the above.

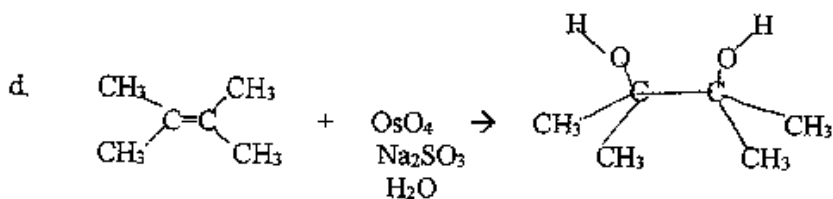
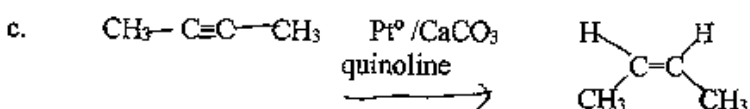
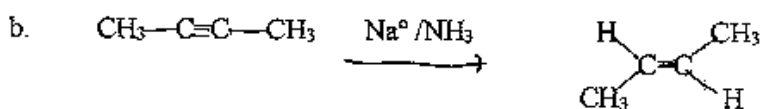
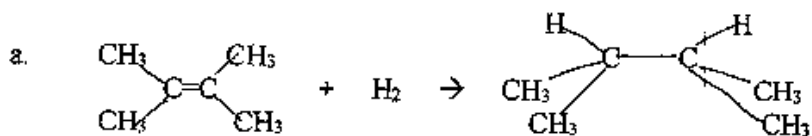
2. Choose the best reaction for carboxylic acid and carboxylic acid derivatives where [] is the nucleophile part of the carboxylic acid and carboxylic acid derivative.



(e) All of the above reactions work for almost all carboxylic acid derivatives.

3. What is the major difference between an antiaromatic and aromatic compounds.
- (a) Aromatic compounds cannot have a charged atom in the structure.
 - (b) The structure must be cyclic for aromatic but not antiaromatic compounds.
 - (c) Antiaromatic compounds have at least a sp^3 hybridized atom in the ring.
 - (d) Antiaromatic compounds can assume a chair like structure while aromatic compounds are nearly flat.
 - (e) Only aromatic compounds follow Huckle's rule.
4. For the element As, circle the one incorrect statement.
- a. The atomic mass is 75
 - b. The number of valence electrons is 5
 - c. The number of electrons for a neutral atom is 5
 - d. The atomic number is 33
5. Circle the one statement below which is incorrect.
- a) In an energy diagram, a transition state is in general between either the reactant & product or between the reactant and the intermediate.
 - b) An "Electrophile" loves electrons while a "Nucleophile" loves nuclei
 - c) In an energy diagram, an intermediate is always at the top of an energy hill.
 - d) A heterocyclic arrow looks like \rightarrow

6. Which of the following reactions does not show a syn product?



7. What type of orbitals do the lone pair electrons on oxygen occupy in ethanol?

- (a) sp^3 (b) sp (c) π (d) p (e) σ

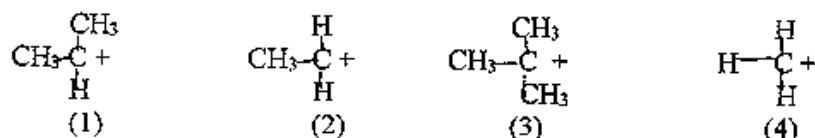
8. What descriptive term is applied to the type of diene represented by 1,5-octadiene?

- (a) Isolated diene
(b) Conjugated diene
(c) Alkynyl diene
(d) Cumulated diene
(e) None of the above

9. Which of the following are valid ways to make ketone and aldehydes

- (a) $\text{CH}_3\text{-C}\equiv\text{C-H} \xrightarrow{\text{BH}_3/\text{THF}} \text{CH}_3\text{-CH}_2\text{-C(=O)-H}$
- (b) $\text{CH}_3\text{-}\overset{\text{H}}{\underset{\text{CH}_3}{\text{C}}}\text{-O-H} \xrightarrow{\text{K}_2\text{Cr}_2\text{O}_7, \text{H}^+} \text{CH}_3\text{-}\overset{\text{H}}{\underset{\text{CH}_3}{\text{C}}}\text{-O}$
- (c) $\text{R-}\overset{\text{H}}{\underset{\text{H}}{\text{C}}}\text{-O-H} \xrightarrow{\text{PCC, Swern, or Dess Martin}} \text{R-C(=O)-H}$
- (d) $\begin{array}{c} \text{H} \quad \text{R} \\ \diagdown \quad / \\ \text{C}=\text{C} \\ / \quad \diagdown \\ \text{R} \quad \text{R} \end{array} \xrightarrow{\text{O}_3 \text{ or } \text{OsO}_4} \begin{array}{c} \text{R} \\ | \\ \text{C}=\text{O} \\ | \\ \text{R} \end{array} \quad \begin{array}{c} \text{H} \\ | \\ \text{O}=\text{C} \\ | \\ \text{R} \end{array}$
- (e) All are correct

10. Put in order of most stable to least stable carbocation by choosing the one best choice:

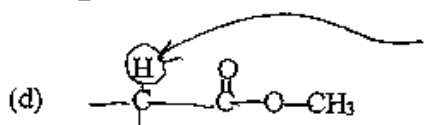
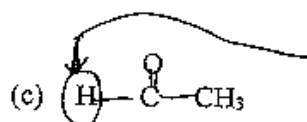
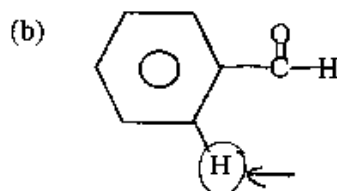
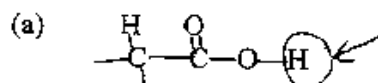


- a) Most stable carbocation to least stable carbocation is (4) > (2) > (1) > (3)
 b) Most stable carbocation to least stable carbocation is (2) > (1) > (3) > (4)
 c) Most stable carbocation to least stable carbocation is (3) > (1) > (2) > (4)
 d) Most stable carbocation to least stable carbocation is (1) > (2) > (3) > (4)

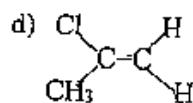
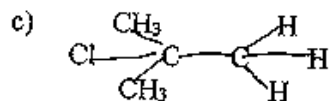
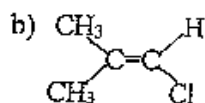
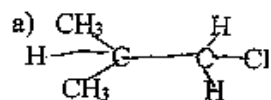
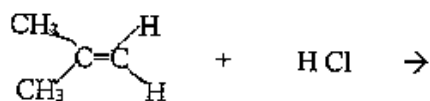
11. Which of the following are ways to get a carboxylic acid? Choose the best statement. (R not equal H)

- (a) $\text{LiAlH}_4 \xrightarrow{\text{CO}_2}$
- (b) $\begin{array}{c} \text{H} \quad \text{H} \\ \diagdown \quad / \\ \text{C}=\text{C} \\ / \quad \diagdown \\ \text{R} \quad \text{R} \end{array} \xrightarrow{\text{weak oxidizing agent}}$
- (c) $\text{R-C}\equiv\text{N} \xrightarrow{\text{H}_2\text{O}, \text{H}^+}$
- (d) (a) and (c) will produce carboxylic acid.
- (e) All of the above results in a carboxylic acid.

12. Which of the following is an α hydrogen ?



13. For the Markovnikov's electrophilic reaction of HCl to the alkene below the alkene the product would be:

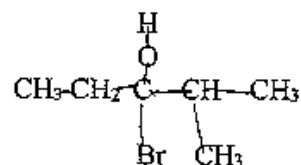


11. Short Answers (36 pts)

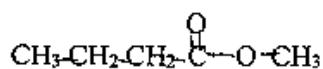
A. Nomenclature: (2 pts each, 6 pts)

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

a. name _____



b. name _____

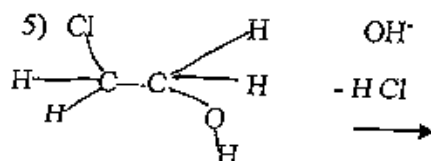
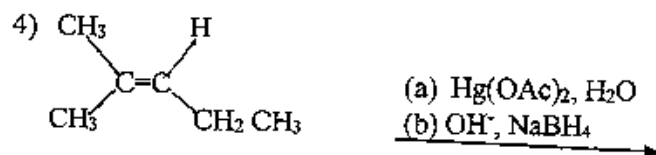
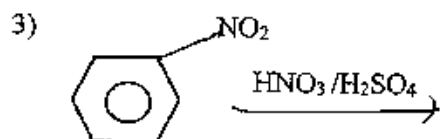
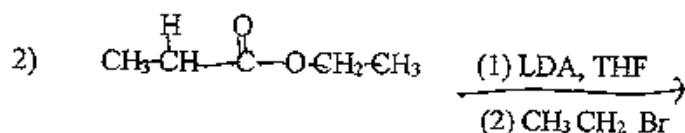
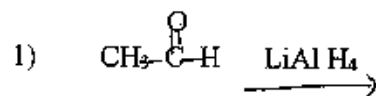


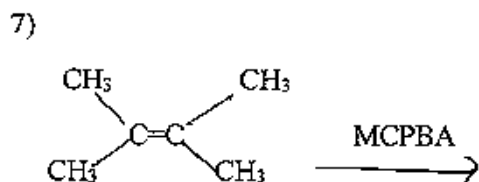
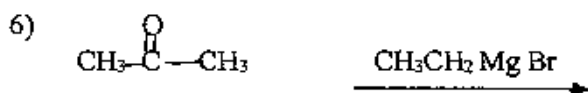
2. Given the following name, draw a structural formula of the molecule (skeletal formula acceptable, condensed structure, Lewis Dot structure acceptable, molecular formula, abbreviations not acceptable - don't forget to show the hydrogens in your formula unless you are using the skeletal structure.)

2-bromopropanoic acid

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, abbreviations are not acceptable.) **DO NOT SHOW MECHANISMS.** (2 pts each, 10 pts)

Circle the number of the 5 reaction which you want counted. If you do not choose, I will just grade the first 5 reactions. I will not grade all the reactions and give you points on only your best 5 reactions.

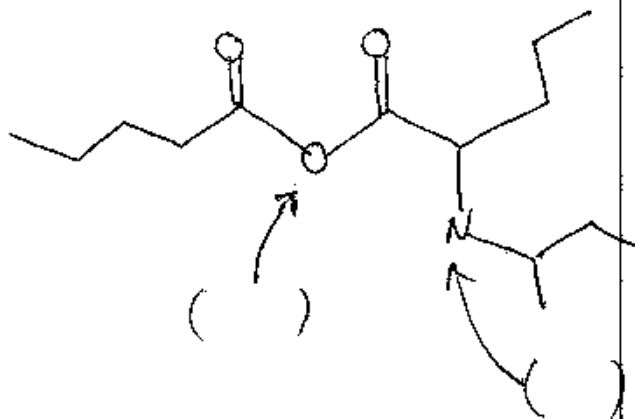




B. Short Answers part of Short Answers: (20 pts)

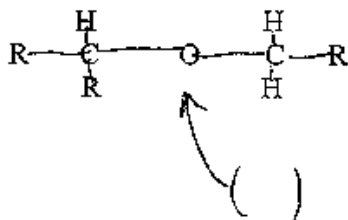
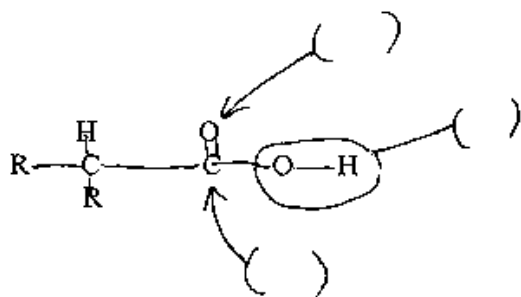
1. Given the following molecule, fill in the parenthesis with the letter of the functional group.

(A) alkene (B) alkyne (C) arene (D) alkyl halide (E) alcohol (F) ether (G) amine
 (H) aldehyde (I) ketone (J) carboxylic acid (K) ester (L) amide (M) acid halide (N) acid
 anhydride (You may use all the letters or none of the letters and may use the same letter multiple times)
 (3 pts each, 6 pts total)

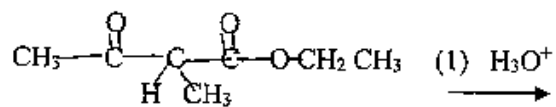


2. Label the following with a letter per parenthesis. You may use each letter one time, or multiple times. (A) acidic hydrogen (B) Leaving group (C) reacts with H^+ (D) reacts with nucleophile (E) acts as nucleophile

(Some of the parenthesis may have more than one correct answer but if you fill the parenthesis with ONE correct letter, that is sufficient. If you fill the parenthesis with one correct and some incorrect answers, you will lose some points.) (2 pts each, 8 pts total)



3. Complete the mechanism of the removal of CO_2 in the acetoacetic acid synthesis or malonic acid synthesis. (note: before you get to remove the CO_2 you will have to do a reaction) Show electron pushing arrows. (note: this step is the acetoacetic acid synthesis or malonic acid synthesis half way into the synthesis) (6 pts total)



2 pts (after reaction with H_3O^+)

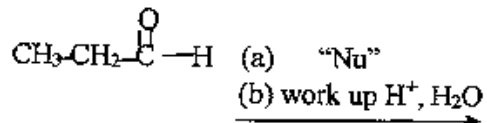
(2) remove CO_2 \longrightarrow

2 pts (show molecule with electron pushing arrows for removal of CO_2)

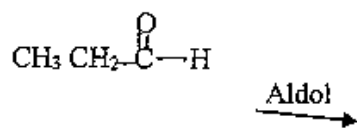
2 pts (show the final product after the removal of CO_2)

Part III. Long Answers (38 pts) Show work where applicable.

1. (A) Keeping in mind the general reaction mechanism of the addition of a nucleophile to a ketone or aldehyde, complete the following "GENERALIZED" reaction mechanism. (MECHANISM means you show all intermediates. If you just give reaction products, you will LOSE LOTS OF POINTS.) (total pts for question # 1, 14 pts, 6 pts for part (A))



(B) Show the Aldol Condensation Reaction mechanism. The stuff over the arrow is: NaOEt, EtOH and remove water. (6 pts this part)



(C) Explain in a sentence or two the relationship between the reaction mechanism which you showed in the step A & B above. (4 pts).

2 (a) Draw the MO energy diagram for cyclopentadiene cation in the space given. (5 pts this letter, 15 pts total)



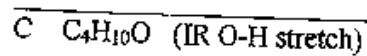
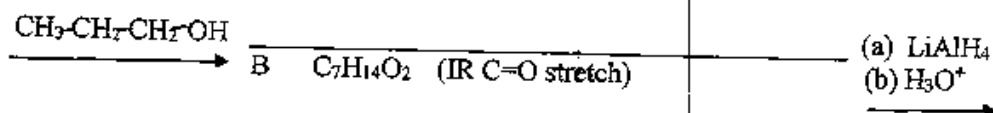
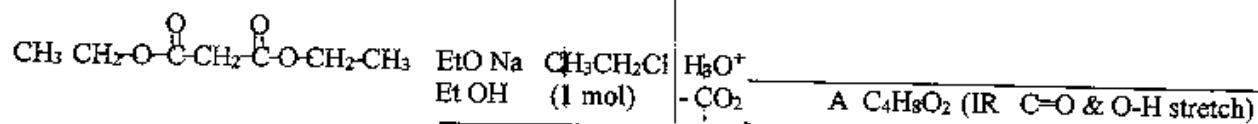
(b) Show the p orbital atomic orbital combination for the highest π^* MO in your energy diagram above in part (a) by the MO which matches. Represent the math sign of your p orbital lobes by shading in one of the lobes in all of the p orbitals. Show the nodes. (3 pts)

(c) Fill your MO energy diagram [which you drew above in (a)] with the appropriate number of electrons for the cyclopentadiene cation. Use up and down arrows to represent electrons. (3 pts)

(d) Show a Huckel rule explanation of the stability/instability of your cyclopentadiene cation (Huckel Rule is $4n+2 = \# \pi$ electrons) (3 pts)

n = _____

3. 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.) (3 pts each, 9 pts total)



Sign Name _____ Print Name _____

(5 pt name above print & sign – If I can't tell who you are from NO NAME above, I have to go back to the exam taking map and hope that I can read your name on that or I may end up with an exam with no identity permanently), (5 pts scantron name – if you don't bubble in I get a grade with no name and I have to hold everyone's final grades until I figure out whose exam it is.) (100 pts, 14 pages+ scantron sheet, periodic table)

Please show work on all questions for partial credit even on questions which do not specify. Please write legibly. **I will only grade what I can read (obviously).** I am not going to make up an answer for you based on writing I can't read. (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.)

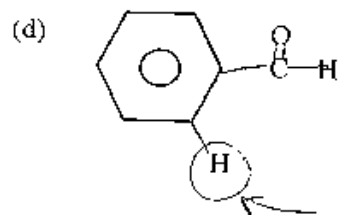
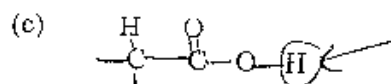
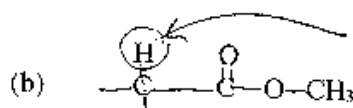
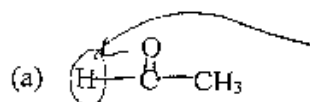
white

Circle answer on this form for backup to the scantron. There is no partial credit for showing work in the multiple choice.

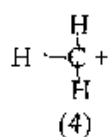
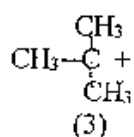
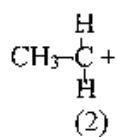
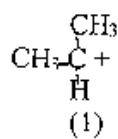
In all questions on all parts of this exam, R is not equal to hydrogen but is an alkyl.

I. Multiple Choice (2 pts each, 26 pts) Choose the **one** best statement in each question.

1. Which of the following is an α hydrogen ?

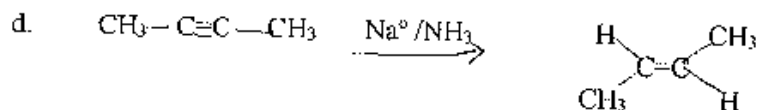
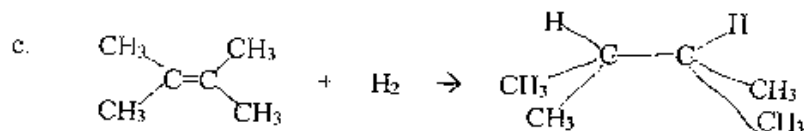
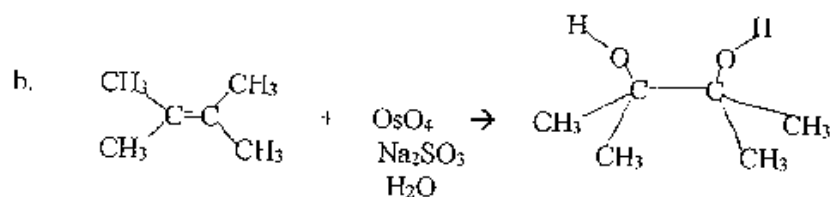
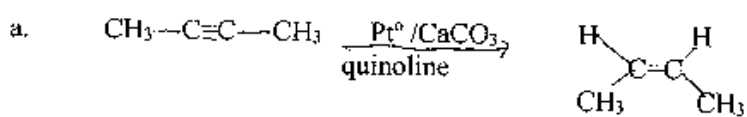


2. Put in order of most stable to least stable carbocation by choosing the one best choice:



- a. Most stable carbocation to least stable carbocation is (4) > (2) > (1) > (3)
 b. Most stable carbocation to least stable carbocation is (1) > (2) > (3) > (4)
 c. Most stable carbocation to least stable carbocation is (2) > (1) > (3) > (4)
 d. Most stable carbocation to least stable carbocation is (3) > (1) > (2) > (4)

3. Which of the following reactions does not show a syn product?



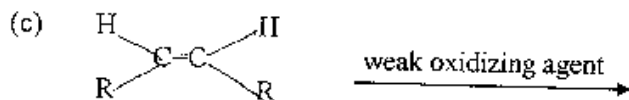
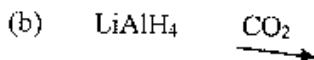
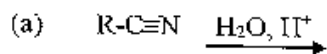
4. What type of orbitals do the lone pair electrons on oxygen occupy in ethanol?

- (a) σ (b) sp^3 (c) sp (d) π (e) p

5. What descriptive term is applied to the type of diene represented by 1,5-octadiene?

- (a) Conjugated diene
 (b) Cumulated diene
 (c) Isolated diene
 (d) Alkynyl diene
 (e) None of the above

6. Which of the following are ways to get a carboxylic acid? Choose the best statement.
(R not equal H)



(d) (a) and (b) will produce carboxylic acid.

(e) All of the above results in a carboxylic acid.

7. What is the major difference between an antiaromatic and aromatic compounds.

(a) Aromatic compounds cannot have a charged atom in the structure.

(b) The structure must be cyclic for aromatic but not antiaromatic compounds.

(c) Antiaromatic compounds have at least a sp^3 hybridized atom in the ring.

(d) Antiaromatic compounds can assume a chair like structure while aromatic compounds are nearly flat.

(e) Only aromatic compounds follow Huckle's rule.

8. For the element As, circle the one incorrect statement.

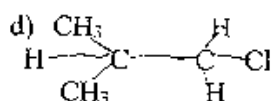
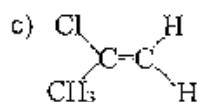
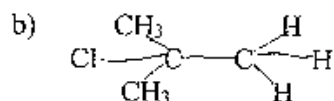
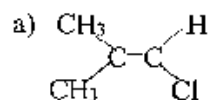
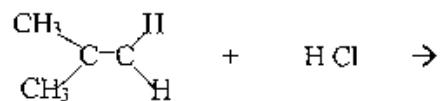
a. The number of electrons for a neutral atom is 5

b. The atomic number is 33

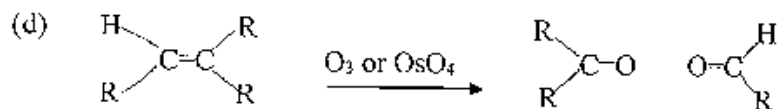
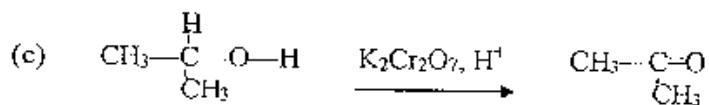
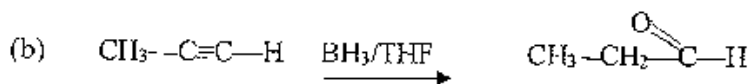
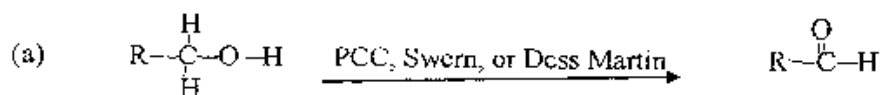
c. The atomic mass is 75

d. The number of valence electrons is 5

9. For the Markovnikov's electrophilic reaction of HCl to the alkene below the alkene the product would be:



10. Which of the following are valid ways to make ketone and aldehydes



(e) All are correct

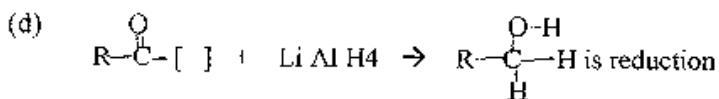
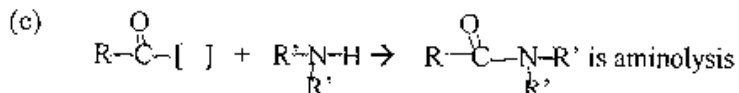
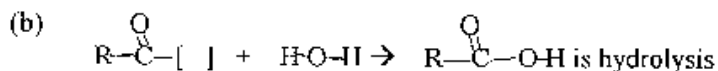
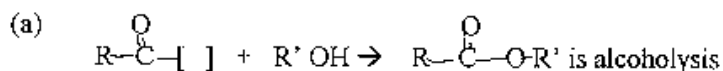
11. Circle the one statement below which is incorrect.

- (a) An "Electrophile" loves electrons while a "Nucleophile" loves nuclei
- (b) In an energy diagram, an intermediate is always at the top of an energy hill
- (c) In an energy diagram, a transition state is in general between either the reactant & product or between the reactant and the intermediate.
- (d) A heterocyclic arrow looks like \rightarrow

12. UV spectroscopy measures the energy required to promote an electron from the _____ molecular orbital to the _____ molecular orbital.

- (a) lowest occupied, highest unoccupied
- (b) highest occupied, lowest unoccupied
- (c) highest occupied, highest unoccupied
- (d) lowest occupied, lowest unoccupied
- (e) None of the above.

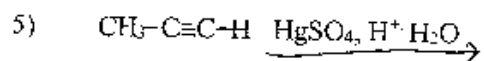
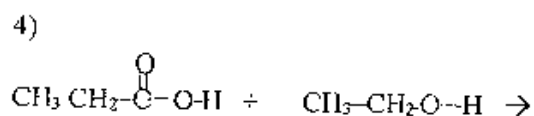
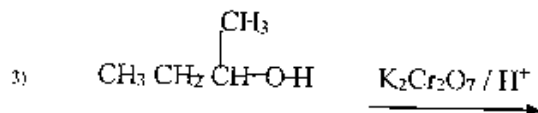
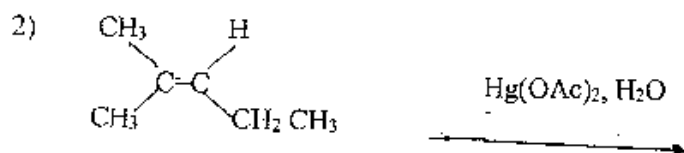
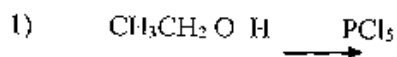
13. Choose the best reaction for carboxylic acid and carboxylic acid derivatives where [] is the nucleophile part of the carboxylic acid and carboxylic acid derivative.



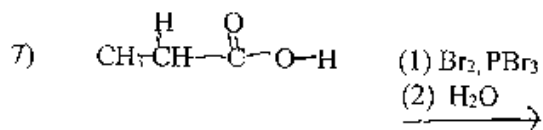
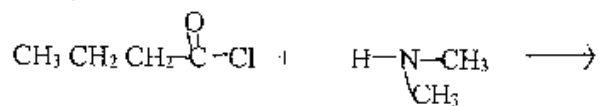
(e) All of the above reactions work for almost all carboxylic acid derivatives.

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, abbreviations are not acceptable.) **DO NOT SHOW MECHANISMS.** (2 pts each, 10 pts)

Circle the number of the 5 reaction which you want counted. If you do not choose, I will just grade the first 5 reactions. I **will not** grade all the reactions and give you points on only your best 5 reactions.



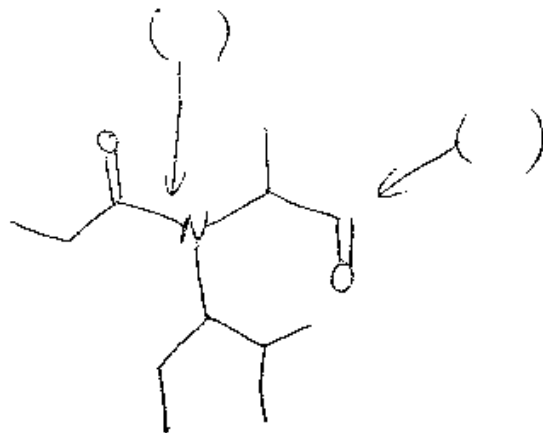
b)



B. Short Answers part of Short Answers: (20 pts)

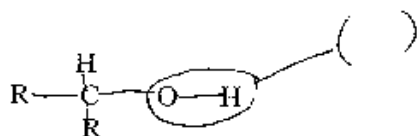
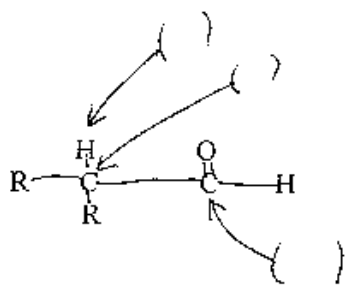
1. Given the following molecule, fill in the parenthesis with the letter of the functional group.

(A) alkene (B) alkyne (C) arene (D) alkyl halide (E) alcohol (F) ether (G) amine
(H) aldehyde (I) ketone (J) carboxylic acid (K) ester (L) amide (M) acid halide (N) acid
anhydride (You may use all the letters or none of the letters and may use the same letter multiple times)
(3 pts each, 6 pts total)

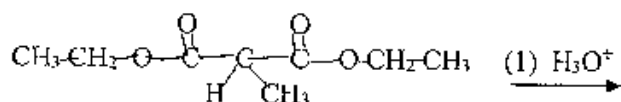


2. Label the following with a letter per parenthesis. You may use each letter one time, or multiple times. (A) acidic hydrogen (B) Leaving group (C) reacts with H^+ (D) reacts with nucleophile (E) acts as nucleophile

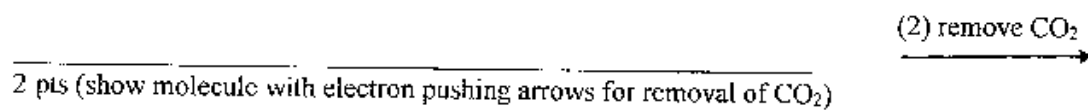
(Some of the parenthesis may have more than one correct answer but if you fill the parenthesis with ONE correct letter, that is sufficient. If you fill the parenthesis with one correct and some incorrect answers, you will lose some points.) (2 pts each, 8 pts total)



3. Complete the mechanism of the removal of CO_2 in the acetoacetic acid synthesis or malonic acid synthesis. (note: before you get to remove the CO_2 you will have to do a reaction) Show electron pushing arrows. (note: this step is the acetoacetic acid synthesis or malonic acid synthesis half way into the synthesis) (6 pts total)



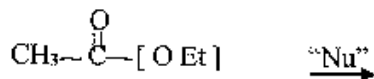
2 pts (after reaction with H_3O^+)



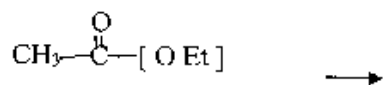
2 pts (show the final product after the removal of CO_2)

Part III. Long Answers (38 pts) Show work where applicable.

1. (A) Keeping in mind the general reaction mechanism of the addition of a nucleophile to carboxylic acid derivative, complete the following "GENERALIZED" reaction mechanism. (MECHANISM means you show all intermediates. If you just give reaction products, you will LOSE LOTS OF POINTS.) (total pts for question # 1, 14 pts, 6 pts for part (A))



(B) Show the Claisen Condensation Reaction Mechanism. The stuff over the arrow is: NaOEt, EtOH
(6 pts)



(C) Explain in a sentence or two the relationship between the reaction mechanism which you showed in the step (A) above and step (B) (4 pts).

2 (a) Draw the MO energy diagram for cyclopentadiene anion in the space given. (5 pts this letter, 15 pts total)



(b) Show the p orbital atomic orbital combination for the highest π^* MO in your energy diagram above in part (a) by the MO which matches. Represent the math sign of your p orbital lobes by shading in one of the lobes in all of the p orbitals. Show the nodes. (3 pts)

(c) Fill your MO energy diagram [which you drew above in (a)] with the appropriate number of electrons for the cyclopentadiene anion. Use up and down arrows to represent electrons. (3 pts)

(d) Show a Huckel rule explanation of the stability/instability of your cyclopentadiene anion (Huckel Rule is $4n+2 = \# \pi$ electrons) (3 pts)

n = _____

3 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.) (3 pts each, 9 pts total)

