CHEM 2311 Final Review Worksheet – Fall 2018

I. Multiple-choice Questions

1. Which of the following compounds is the weakest base?

   a. $CH_3CO_2^-$
   b. CH_3CH_2OH
   c. NH_3
   d. CH_3O^-
   e. NH_2^-

2. Which of the following functional groups is indicated by a strong and broad infrared absorption around 3300 cm^{-1}?

   a. Carbonyl
   b. Alkene
   c. Alkane
   d. Alcohol
   e. Amine

3. A particular signal within a ^1H NMR spectrum has the shape of a quartet. How many equivalent (or nearly equivalent) protons are within coupling distance of the protons corresponding to this signal?

   a. 1
   b. 2
   c. 3
   d. 4
   e. Additional information is required to answer this question.

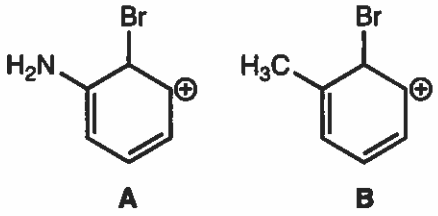
4. What type of information is provided by a ^{13}C DEPT experiment?

   a. Information about which protons are connected to which carbons
   b. The number of hydrogens linked to each carbon
   c. The electron density at or near each carbon
   d. The connectivity of the carbon skeleton of the molecule
   e. The hybridization of each carbon

5. Two molecular ion peaks of nearly equal height separated by two *m/z* units in a mass spectrum is indicative of which of the following elements?

   a. Silicon
   b. Nitrogen
   c. Bromine
   d. Boron
   e. Chlorine

6. Which stability factor best accounts for the greater stability of **A** relative to **B**?



A **B**

a. Electronegativity of the charge-bearing atoms
b. Resonance delocalization
c. Hybridization
d. Inductive effects
e. Steric effects

7. Which of the following electrophiles cannot react (i.e., reacts extremely slowly) with a nucleophile by an S_N2 mechanism?

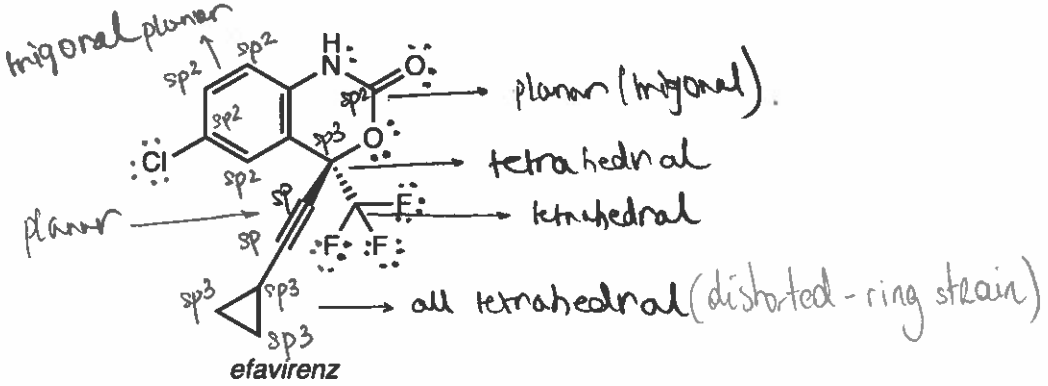
a. CH_3Br
b. CH_3CH_2Br
c. Br_2
d. $(CH_3)_3CBr$
e. $(CH_3)_2CHBr$

8. Which of the following reaction conditions produces a *trans* alkene from an alkyne?

a. Li, $NH_3(l)$
b. H_2, Pt
c. H_2, Lindlar catalyst
d. H_3O^+ (cat.), H_2O
e. 1. BH_3; 2. NaOH, H_2O_2

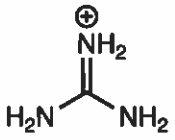
II. Short-answer Questions

1. Draw a Lewis structure for efavirenz that includes all implied hydrogen atoms and lone pairs. Then, identify the hybridization and geometry of each atom in efavirenz.

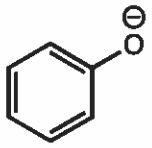


efavirenz

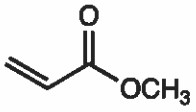
2. Draw all contributing resonance forms of the molecules below.



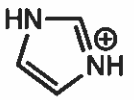
guanidinium



phenolate

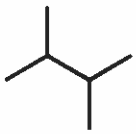


methyl acrylate

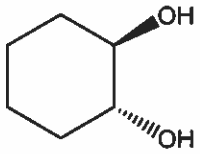


imidazolium

3. Draw a conformation versus potential energy diagram for 2,3-dimethylbutane from the C2-C3 bond. Recall that in these diagrams, energy is plotted on the *y*-axis and dihedral angle on the *x*-axis.



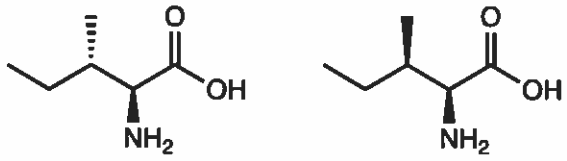
4. Draw the most stable chair conformer of trans-1,2-cyclohexanediol.



5. Identify the stereoisomeric relationship (same, different molecules, enantiomers, diastereisomers) between each pair of molecules below.

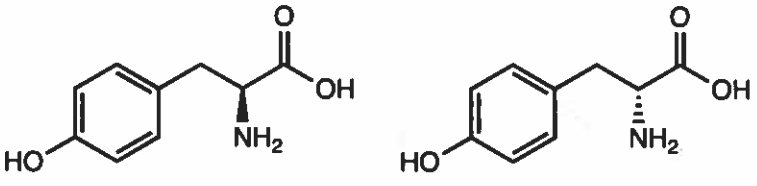
a.

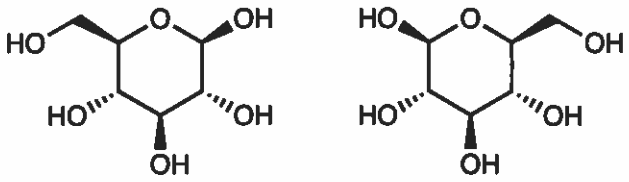
b.



c.

d.



e. 

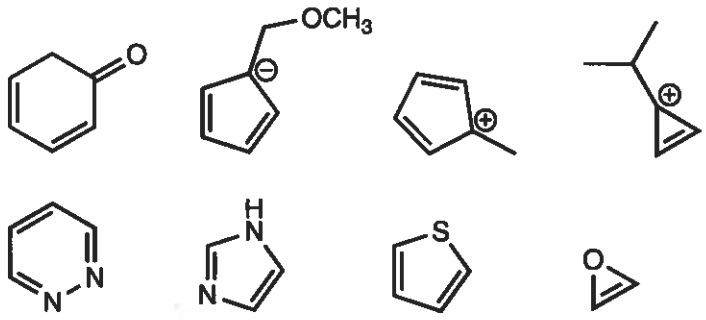
6. Propose structures consistent with the sets of data below. Consult correlation charts for infrared and NMR spectroscopy.

a.	$C_9H_{10}O$	*^{1}H NMR Spectrum* singlet δ 2.0 (3H) singlet δ 3.75 (2H) singlet δ 7.2 (5H)	*Infrared Spectrum (Key Peaks)* 3100, 3000, 1720, 740, 700 cm^{-1}
b.	$C_5H_7NO_2$	*^{1}H NMR Spectrum* triplet δ 1.2 (3H) singlet δ 3.5 (2H) quartet δ 4.2 (2H) *This molecule contains a nitro ($-NO_2$) group.*	*Infrared Spectrum (Key Peaks)* 2980, 2260, 1750 cm^{-1}

7. Draw the structure of an alkyl bromide that would be expected to engage in rearrangement when reacted with water in an S_N1 reaction.

8. Draw the structure of an alkene that would be expected to engage in rearrangement when reacted with hydrobromic acid.

9. Determine whether each of the molecules below is aromatic, antiaromatic, or nonaromatic.



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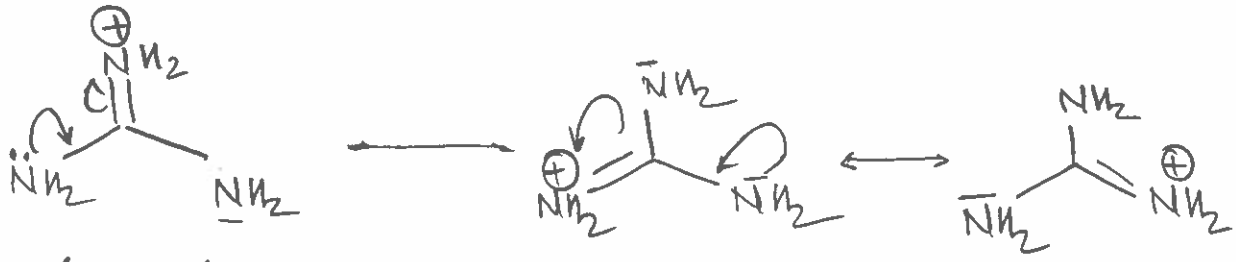
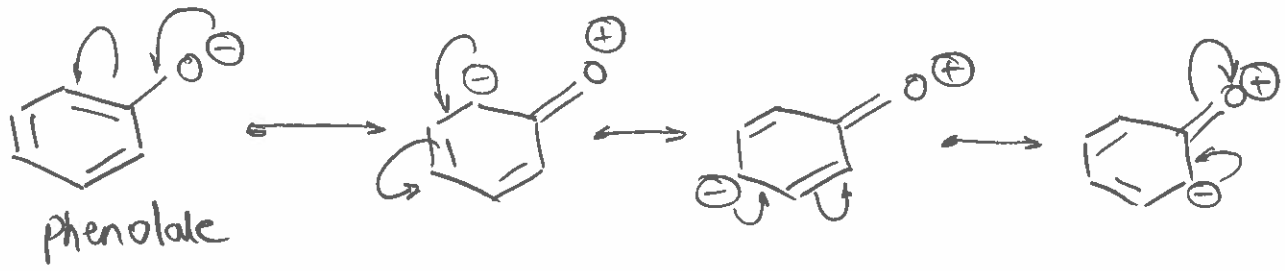
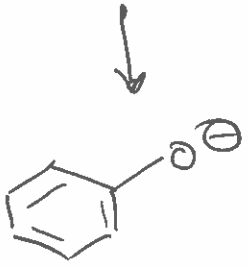
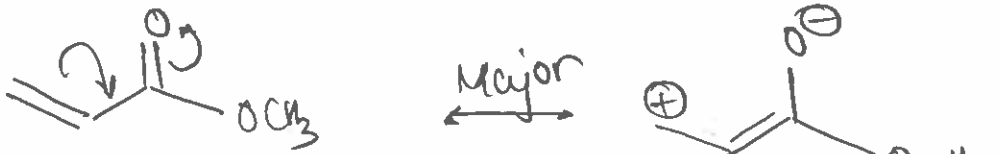


Guanidinium

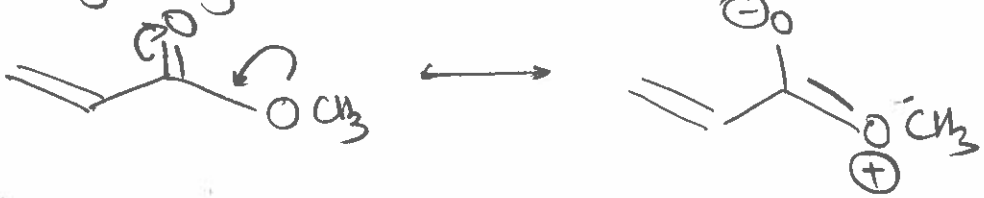


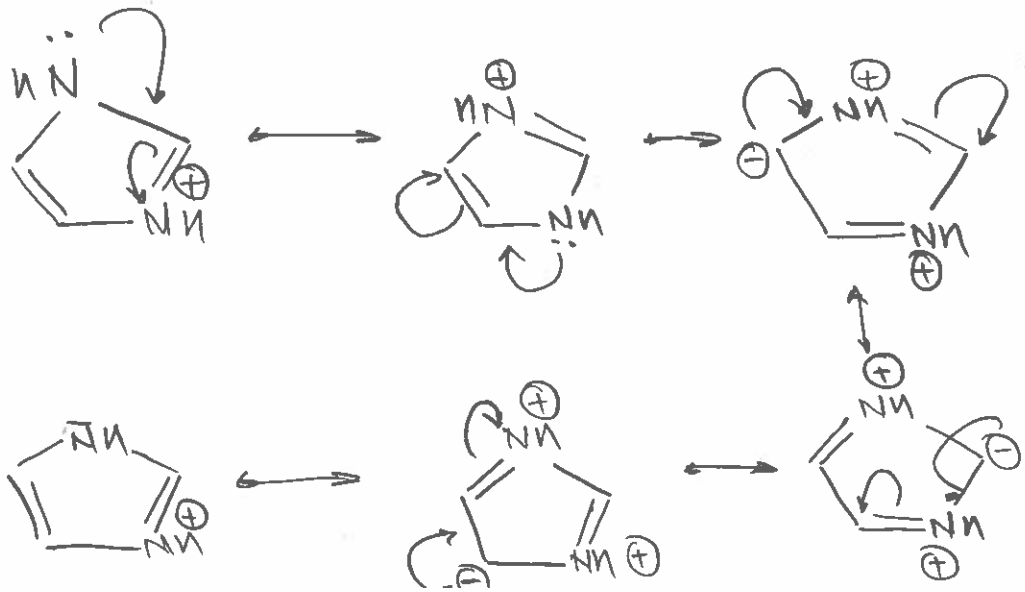
phenolate



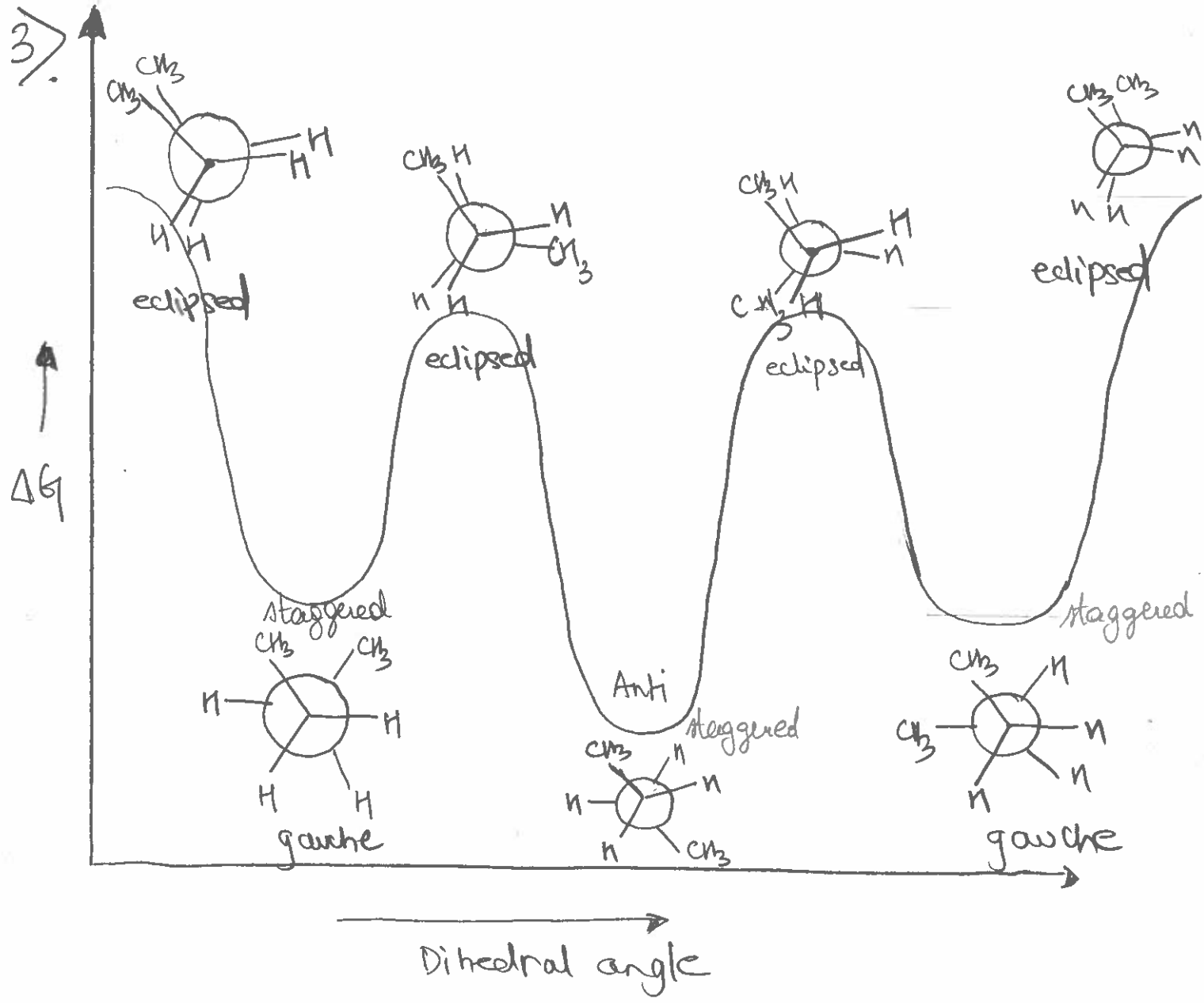


Methyl acrylate



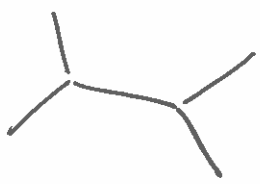


3)



Conformation vs potential energy for

2,3-dimethyl butane



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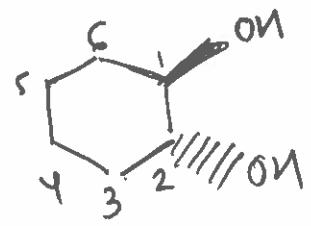
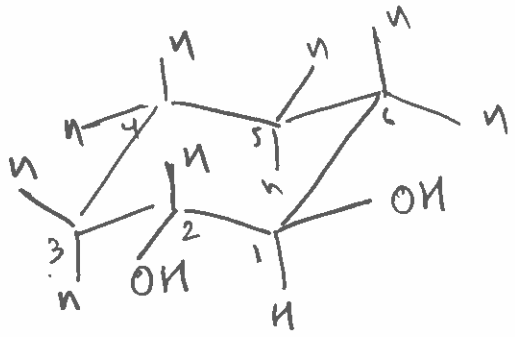
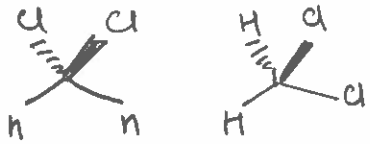


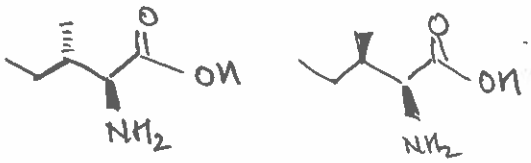


5)

a) Same molecule (not chiral)

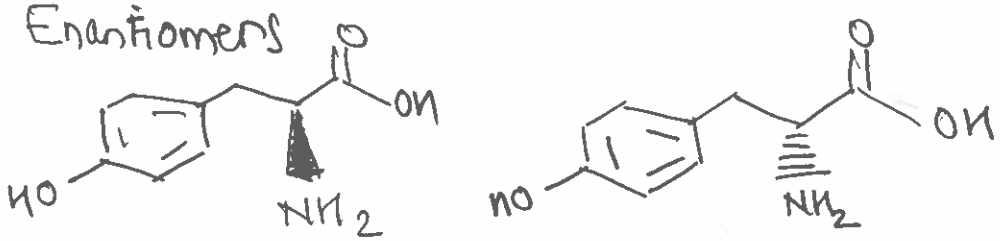


b) Diastereomer



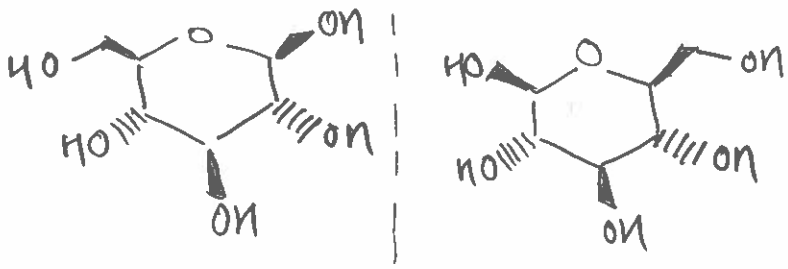
c) Enantiomers

d) Enantiomers



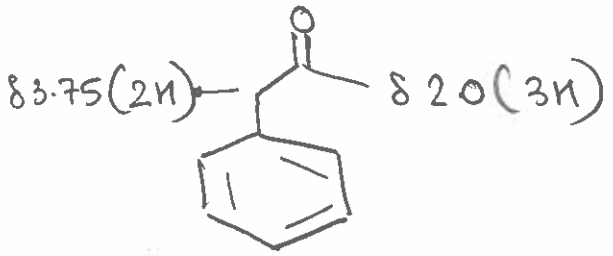
e) Enantiomers

mirror image



6) a) $C_9H_{10}O$

$$DOU = \frac{2\times9+2-10}{2} = \frac{20-10}{2} = 5.$$



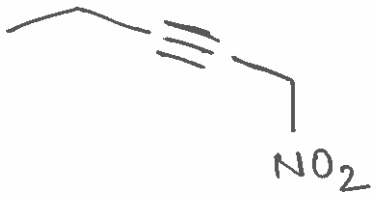
1-phenylpropane-2-one ✓

- 1720 cm^{-1} IR peak is for carbonyl
- singlet at 7.2 ppm in ^1H NMR with 5H is indicative of monosubstituted phenyl ring.

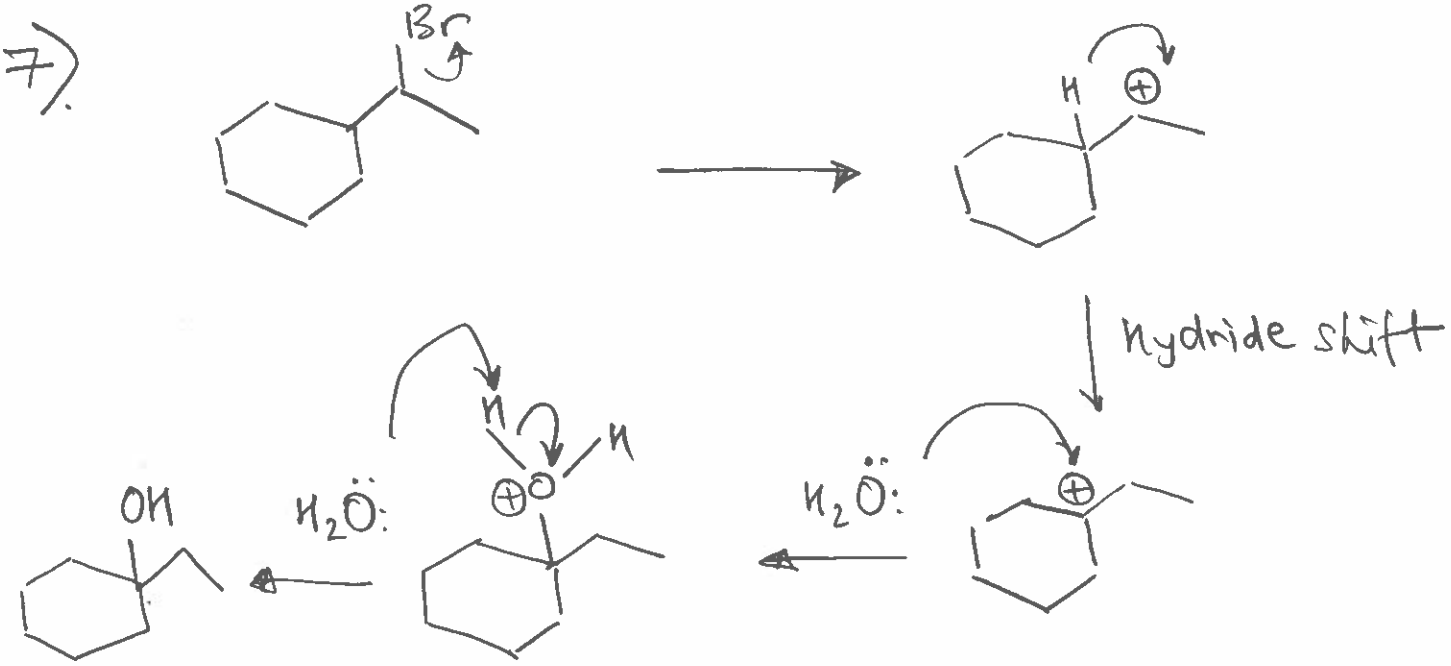
b) $C_5H_7NO_2$

$$DOU = \frac{2\times5+2+1-7}{2} = \frac{6}{2} = 3$$

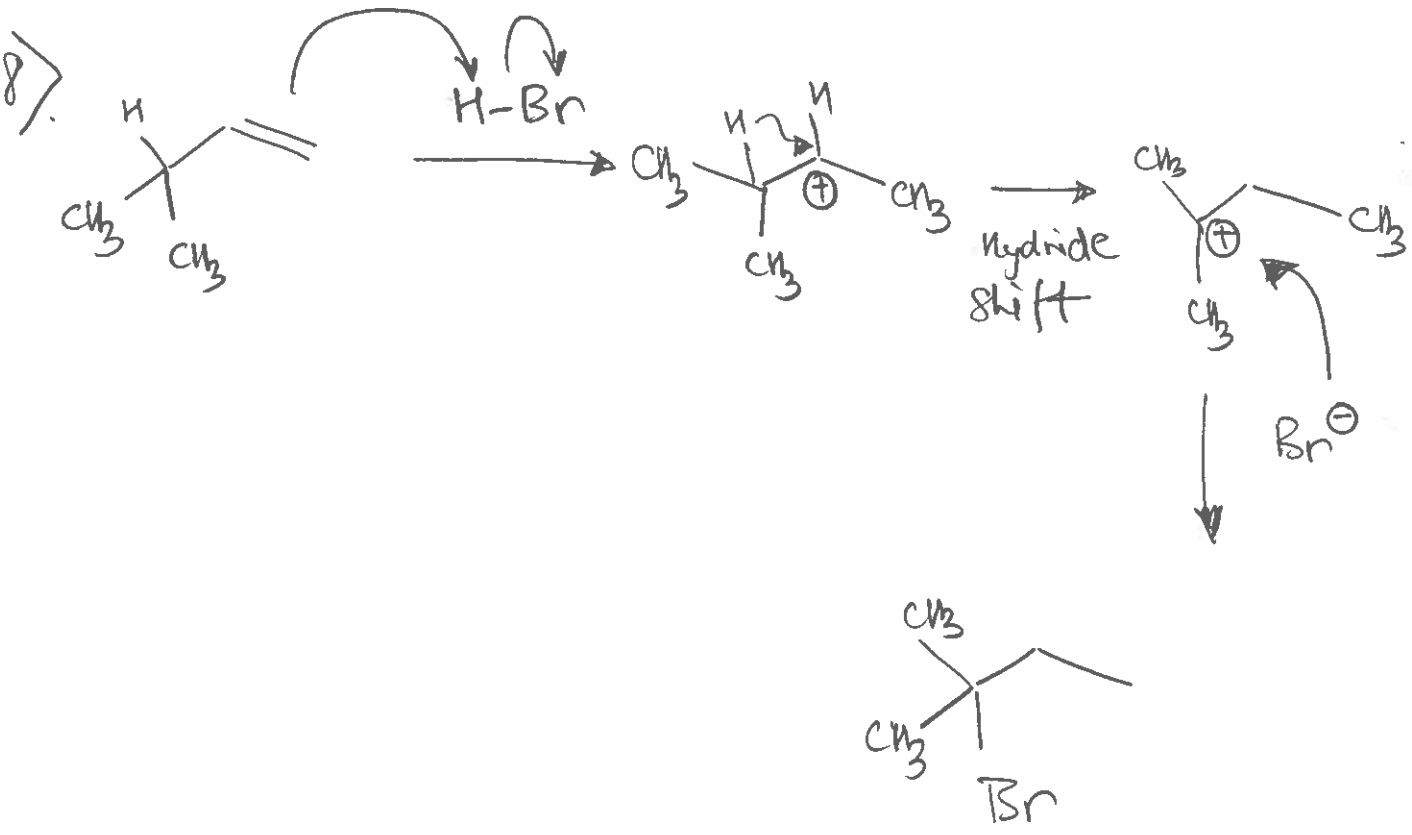
Molecule has NO_2 group.



7)

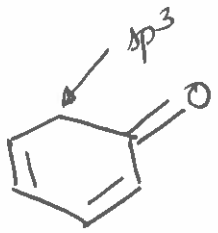

Br
H
hydride shift
OH
$H_2\ddot{O}$:
$H_2\ddot{O}$:

8)

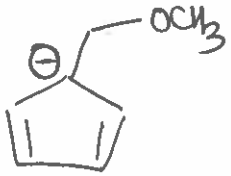

H
CH_3
CH_3
H-Br
H
H
CH_3
CH_3
CH_3
hydride shift
CH_3
CH_3
CH_3
$Br^{\ominus}$
CH_3
CH_3
Br

$4n+2 \Rightarrow$ Arom.
$4n \Rightarrow$ Anti-Arom

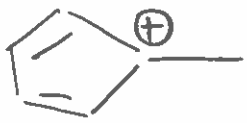
9)



Nonaromatic

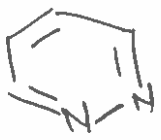


Aromatic (6e⁻)



Antiaromatic (4e⁻)

Aromatic (2e⁻)



Aromatic (6e⁻)

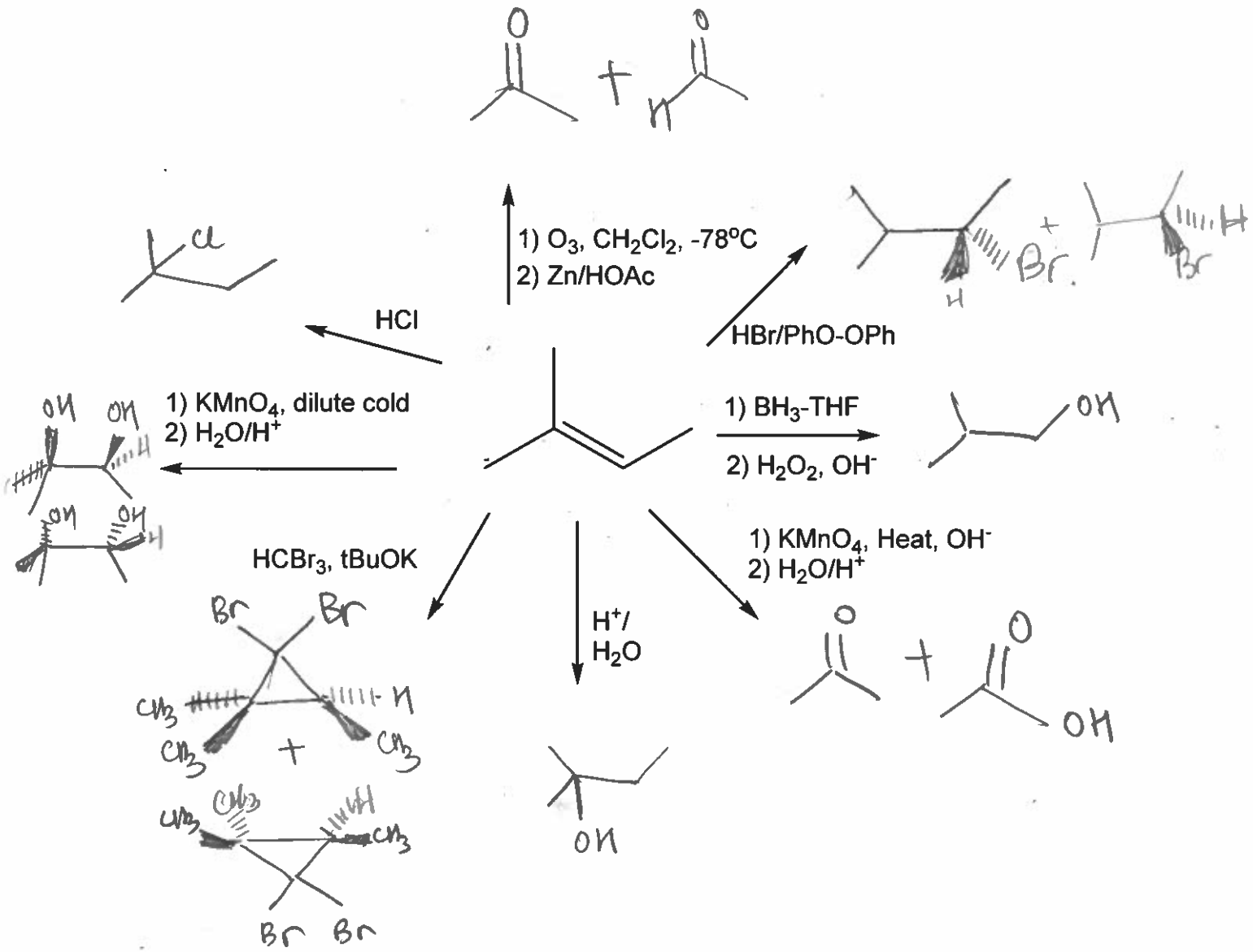
Aromatic. (6e⁻)

Aromatic (6e⁻)

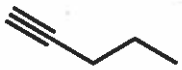
Antiaromatic (4e⁻)

III. Write Reagents and/or Predict the Products

1. Draw the products for each of the following reaction types, starting from 2-methyl-2-pentene. Include stereochemistry where necessary.



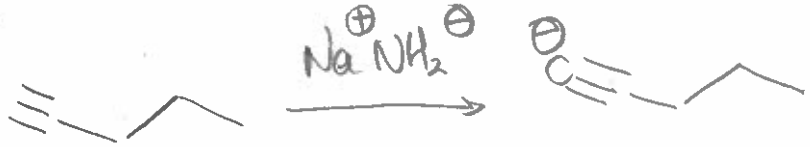
2. Write the reagents and draw the products for each of the following reaction types, starting from 1-pentyne. Include stereochemistry where necessary.

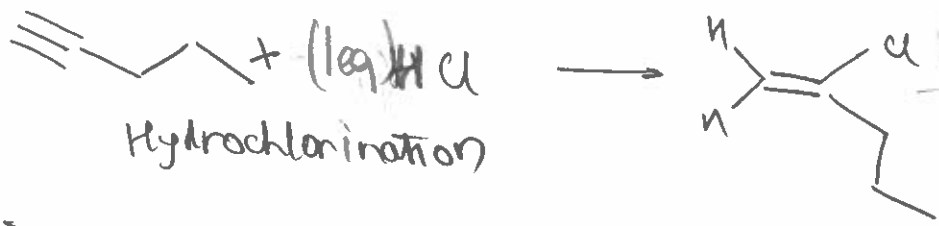


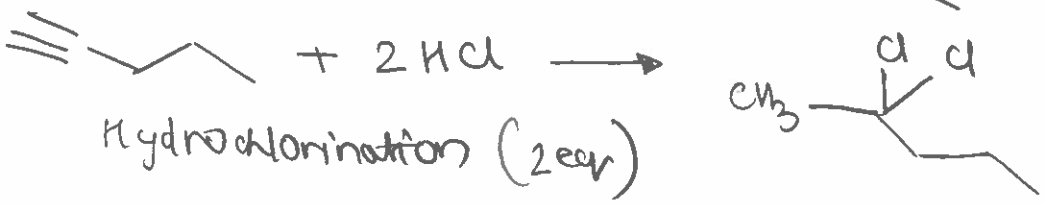
1-pentyne

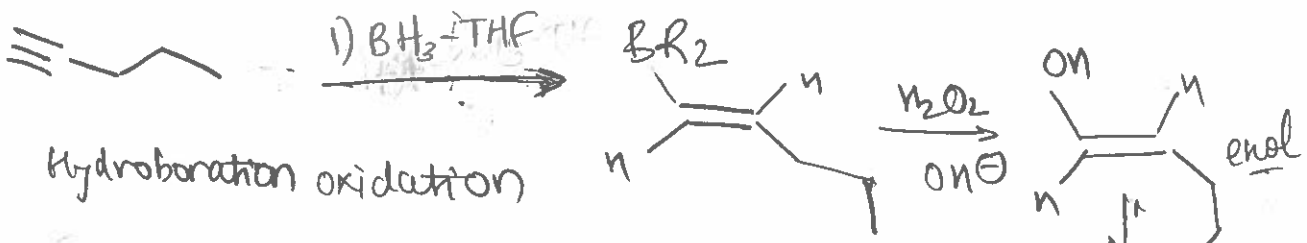
a. Deprotonation
b. Ionic hydrochlorination
c. Ionic hydrochlorination (2 equivalents)
d. Hydroboration-oxidation
e. Oxidative cleavage
f. Acid-catalyzed hydration
g. Oxymercuration-demercuration
h. Ozonolysis
i. Radical hydrobromination
j. Radical hydrobromination (2 equivalents)

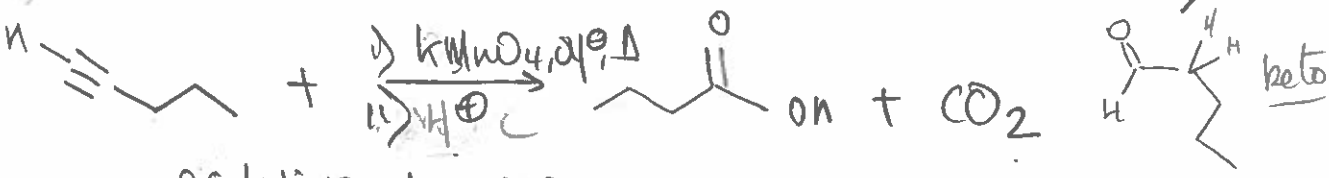
III 2)

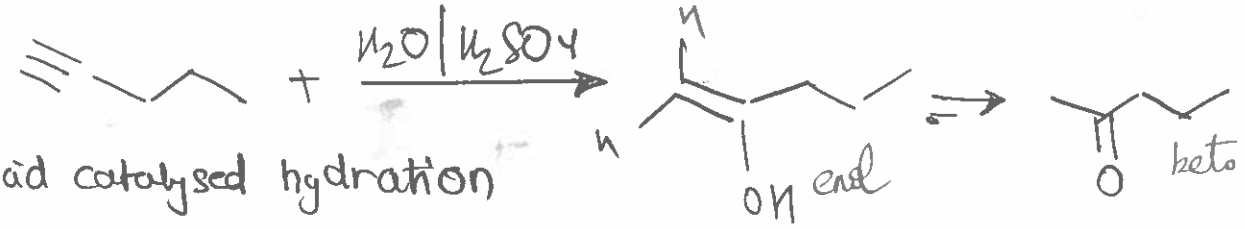
a) 

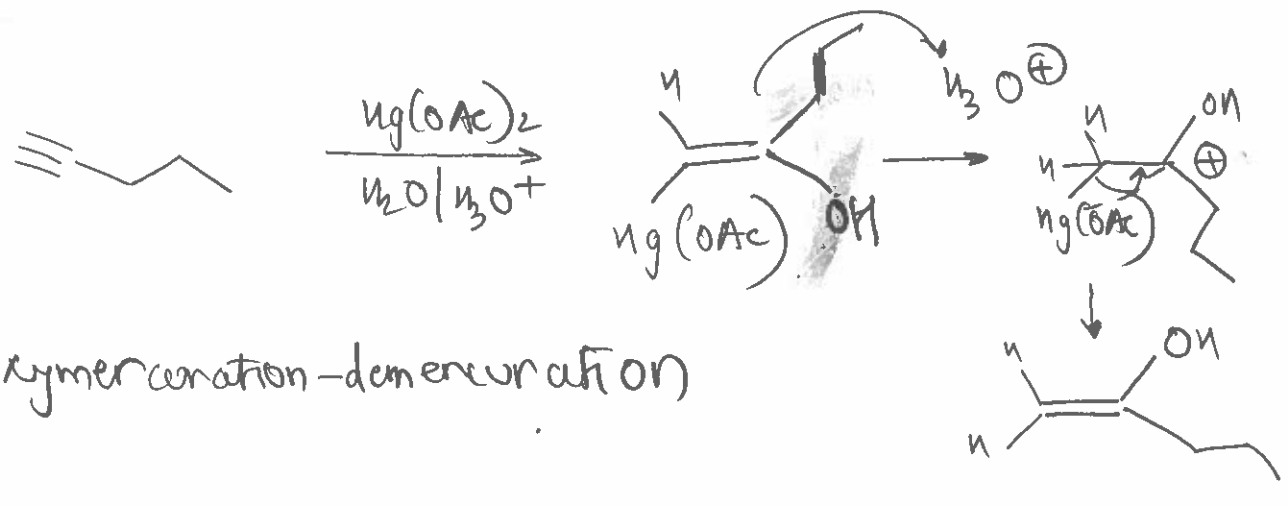
b) 

c) 

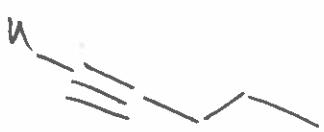
d) 

e) 

f) 

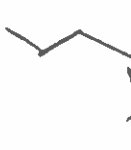
g) 

h)



O_3

(Zn / H_2O)



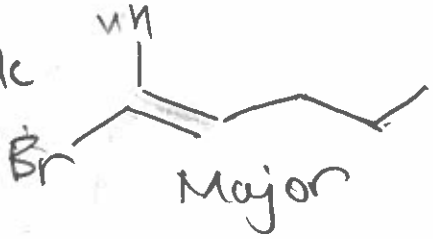
+ CO_2

Ozonolysis

i)

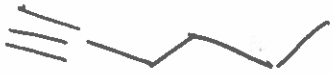
1eq

HBr / peroxide



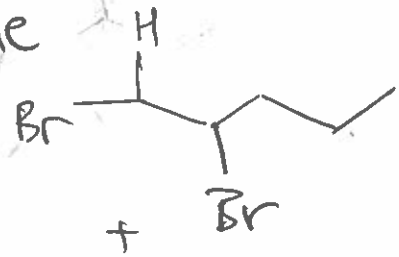
Major

j)

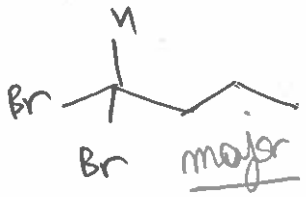


2eq

HBr / peroxide

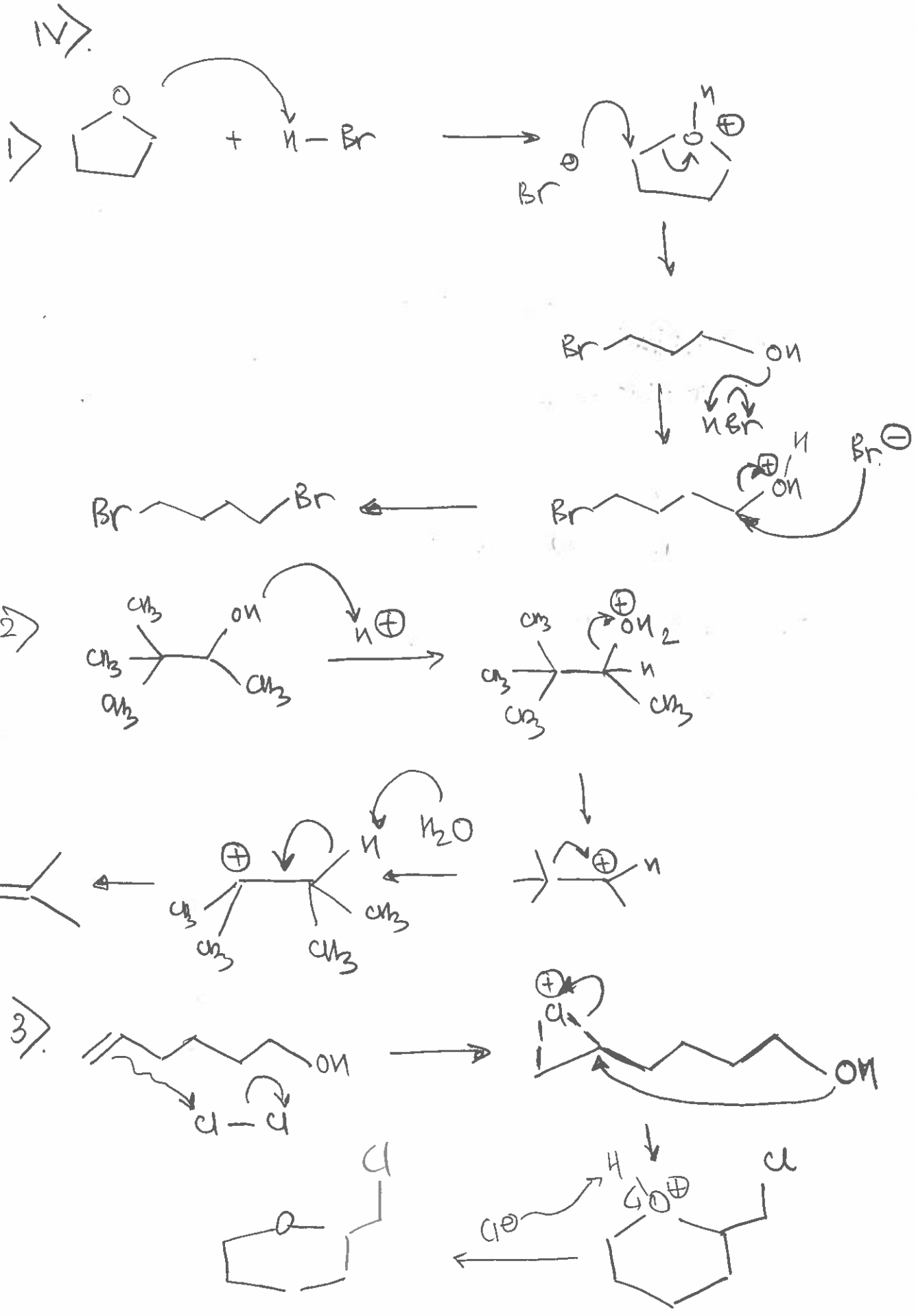


+

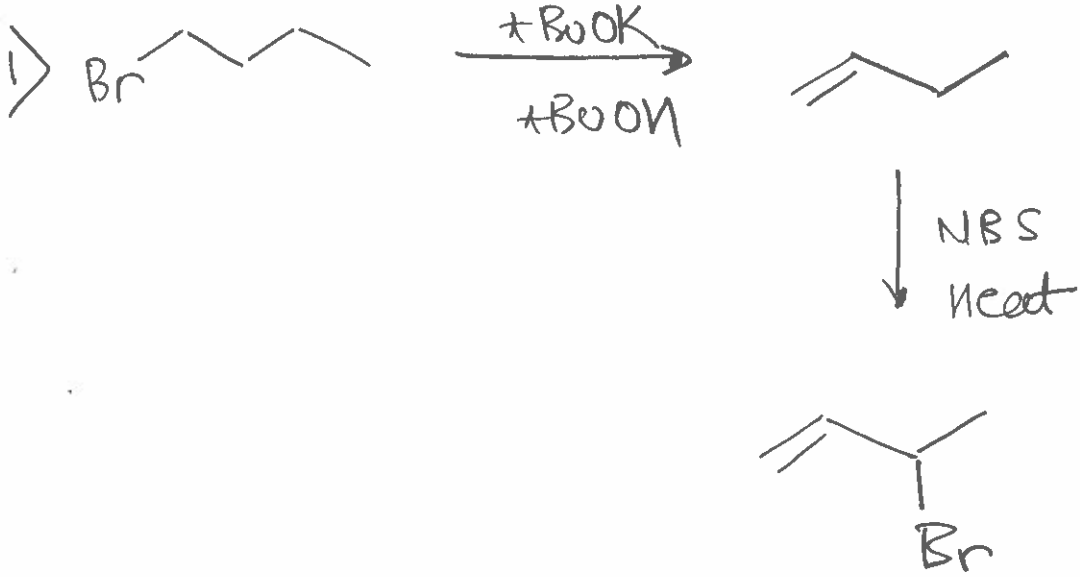


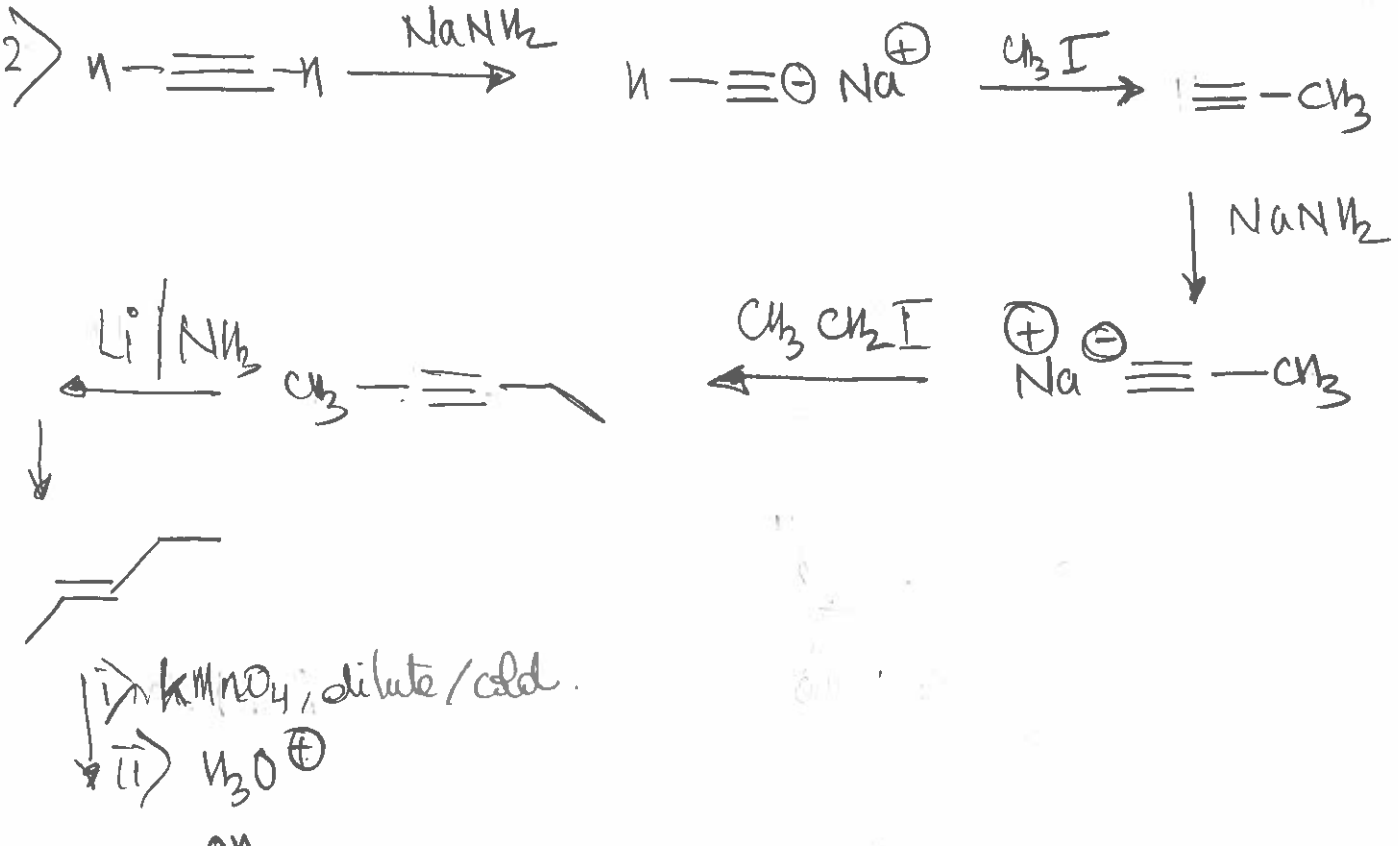
major

IV)

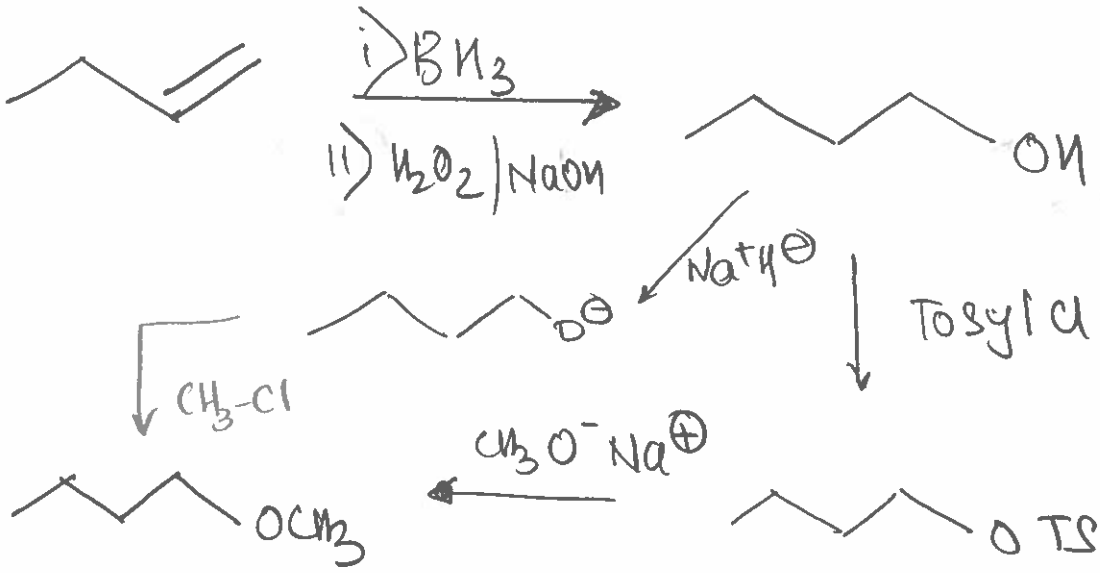

1)
+ H – Br
Br
OH
H Br
Br
OH
Br
Br
2)
CH3
OH
H⊕
CH3
CH3
CH3
OH2
H
CH3
CH3
CH3
H2O
H
CH3
CH3
CH3
CH3
3)
OH
Cl – Cl
Cl
OH
Cl
O
H
Cl⊕
Cl⊖
Cl

V) Multi step Synthesis

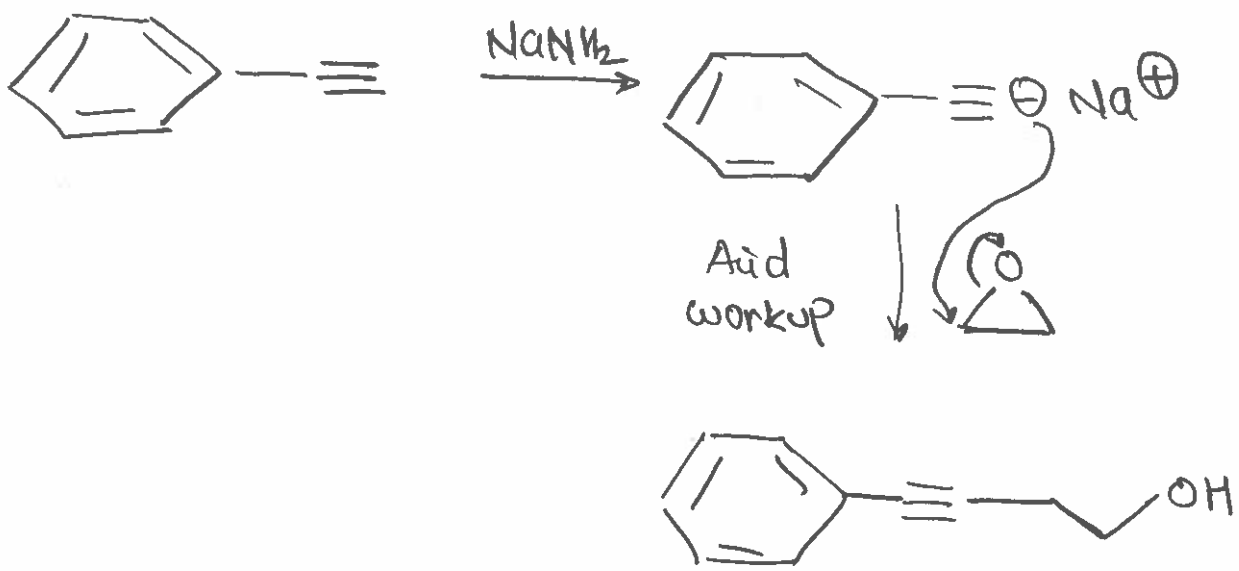
1) 

2) 

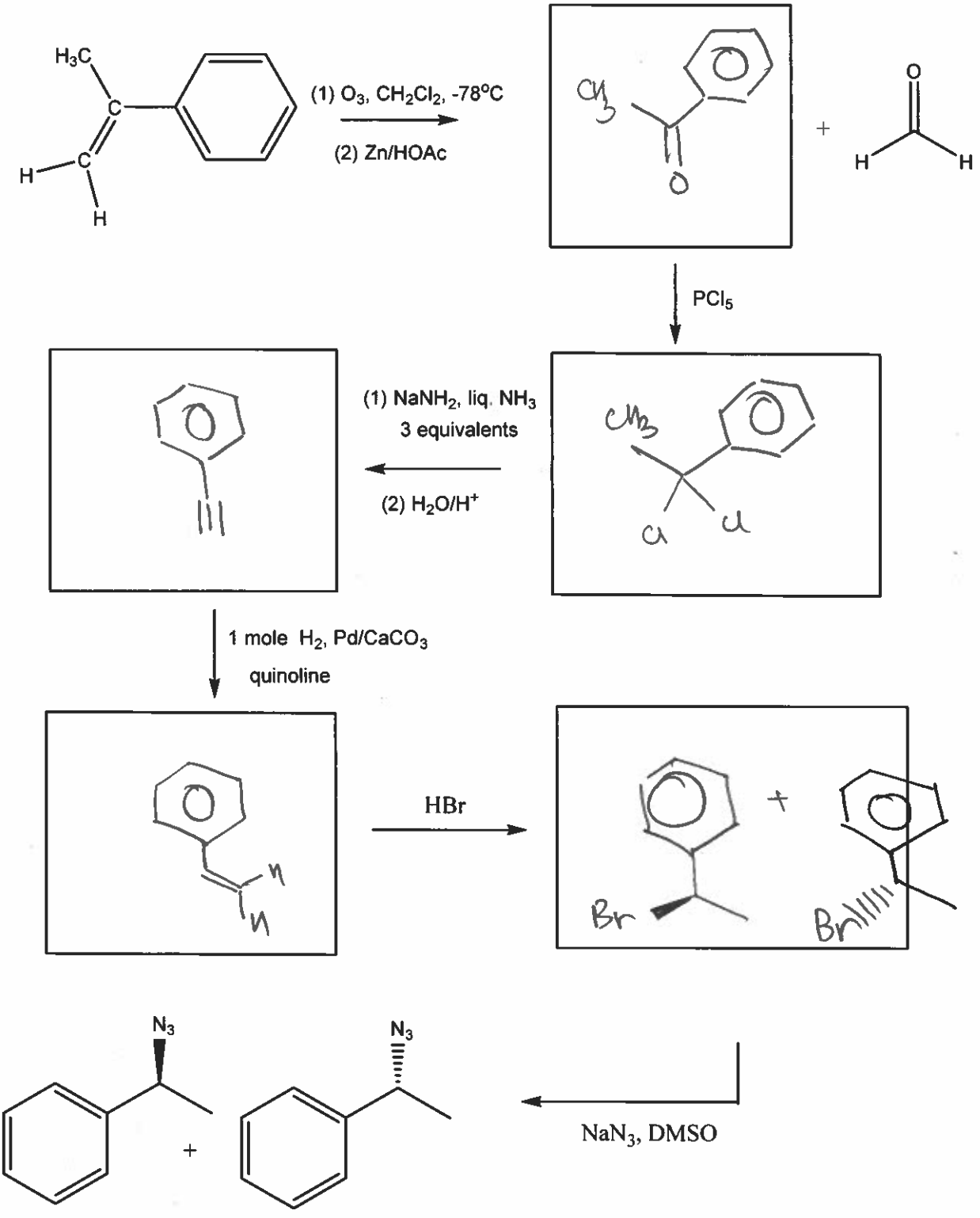
3)


i) BH_3
ii) H_2O_2/NaOH
OH
$Na^+H^\ominus$
$O^\ominus$
Tosyl Cl
CH_3-Cl
$CH_3O^-Na^\oplus$
OCH3
O TS

4)


$NaNH_2$
$\equiv\ominus Na^\oplus$
Acid workup
OH

Draw the structures for the products in each of the reactions in the following sequence



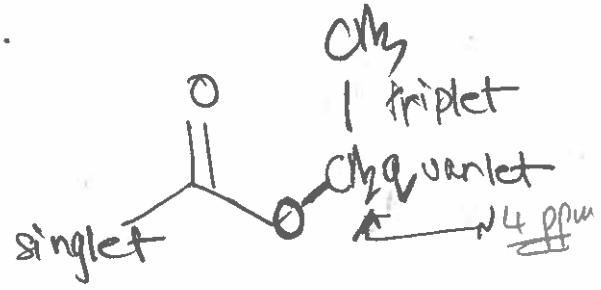
VI) $C_4H_8O_2$

i) $DOU = \frac{2\times4 + 2 - 8}{2} = \underline{1}$

ii) Has carbonyl peak around $1725cm^{-1}$
sp3 sp2 peaks around $3000cm^{-1}$

iii) 3H at ~ 1ppm = triplet ⟵ 3H ◁ 2H
3H at ~ 2ppm = singlet 3H ◁ ØH
2H at ~ 4ppm = quartet 2H ◁ 3H

iv) Structure.



$C_9H_{10}O_2$

i) $DOU = \frac{(2 \times 9) + 2 - 10}{2} = \frac{10}{2} = 5$

ii) IR – peak at ≈ 1715 cm^{-1} indicative of carbonyl group

iii)

3H at 1.5 ppm – Triplet 3H & 2H ← 2H & 3H

2H at 4.5 ppm – quartet (attached to electronegative group)

5H at 7.5 – 8.5 ppm – multiplet (from phenyl)
5H ⇒ monosubstituted